FL970801064C

CN040435

MARCH 1997

MANATEE PROTECTION PLAN
AT SELECTED NAVIGATION & WATER CONTROL STRUCTURES (PART II) IN CENTRAL AND SOUTHERN FLORIDA

FINAL INTEGRATED PROJECT MODIFICATION REPORT AND ENVIRONMENTAL ASSESSMENT

US Army Corps of Engineers
Jacksonville District

MANATEE PROTECTION PLAN AT SELECTED NAVIGATION AND WATER CONTROL STRUCTURES IN CENTRAL AND SOUTHERN FLORIDA

PART II
FINDING OF NO SIGNIFICANT IMPACT

I have reviewed the integrated planning document and environmental assessment of the proposed action. Based on the information analyzed in the report, reflecting pertinent data obtained from cooperating Federal and State agencies having jurisdiction by law and/or special expertise, and from the interested public, I conclude that the considered action will have no significant impact on the quality of the human environment.

In summary, the reasons for this conclusion are as follows:

1. The Phase I Report for this project was coordinated and has a signed FONSI that remains applicable to Phase II.

2. There is an ongoing informal Section 7 consultation with the U.S. Fish and Wildlife Service. They have so far concurred with the determination of no adverse impacts to any threatened or endangered species.

3. There is an ongoing coordination with the State of Florida through the Department of Environmental Protection, Bureau of Protected Species and with the South Florida Water Management District as the local sponsor.

4 April 1997
Date

for TERRY L. RICE
Colonel, U.S. Army
District Engineer

TABLE OF CONTENTS

* Asterisk identifies all items which satisfy requirements of the National Environmental Policy Act (NEPA)

SYLLABUS

This report is in partial response to authorization and appropriations provided in the Energy and Water Development Appropriation Act of 1994 (P.L. 103-126). The results of engineering and environmental studies are presented for the implementation of the Manatee Protection Plan, Part II at seven selected sector gate locks in Central and Southern Florida. As a response to recent manatee mortality trends associated with water control structures, the purpose of the project is to provide operational changes and implement the installation of a manatee protection system at locks. The beneficial outcome of this project will be the reduction of risk, injury, and mortality of the manatee which is an endangered species in Florida.

The recommended plan is to install manatee detection systems on the sector gates at navigational locks. Hydroacoustic and pressure sensitive devices will immediately stop the gates when an object is detected between the closing gates. These systems will transmit an alarm and signal to stop the gate movement when a manatee is detected. When the gate sensors are activated by an object or manatee, the gate will stop and open approximately six inches to release a manatee. As a result, a manatee will be able to travel between the open gates. After the gate opens, the operator can fully close the gate unless an object remains between the gates. Then, the opening process will repeat the cycle as the sensors are activated again. Due to these structural modifications, manatees will be at a significantly less risk as they encounter sector gate locks. The project modification has a total estimated cost of $2,007,000. The Federal and non-Federal costs for the recommended plan are $1,811,000 and $196,000, respectively.

MANATEE PROTECTION PLAN AT SELECTED NAVIGATION & WATER CONTROL STRUCTURES IN CENTRAL AND SOUTHERN FLORIDA PART II

SECTION I

INTRODUCTION

1.1 AUTHORITY

Specific authorization and appropriations for this project are provided by the Energy and Water Development Appropriation Act of 1994 (P.L. 103-126). The conference report on the act states:

"The committee commends the efforts of the South Florida Water Management District for its efforts to develop innovative and relatively low cost pass-through gates for Manatees on existing Central and Southern Florida project flood protection structures. The Committee has provided $3,000,000 to install these gates on the S-25B, S-28, S-20F, S-20G, S-21, S-21A, S-22, S-26, S-27, S-123, S-13, S-29, and S-33 spillways and on the S-193, S-135, S-302, S-127, S-131 and Henry Creek locks, and directs the Corps of Engineers to expeditiously move their construction ahead on cooperation with the South Florida Water Management District."

1.2 STUDY PURPOSE

The purpose of this study is to develop a recommended plan and the appropriate documentation in compliance with environmental statutes for the operational and structural modifications of water control structures to reduce manatee risk and mortality. At the Federal level, manatees are protected by the Marine Mammal Protection Act of 1972 and the Endangered Species Act of 1973, as amended. Protection of the manatee at water control structures is a part of the long range recovery goal of the Florida Manatee Recovery Plan directed by the Endangered Species Act of 1973, to maintain "the health and stability of the marine ecosystem" and to determine and maintain manatee numbers at "optimum sustainable population" in the southeastern United States.

1.3 LIMITS OF STUDY SCOPE

The Manatee Protection Plan was divided into a two part study. Part I of the study was limited to operational changes and the selective installation of a manatee protection system on the twenty vertical lift gate water control structures. The Final Part I report was submitted for approval in September 1995. Revisions to the cost sharing of the project were completed in March and July 1996, and the report was re-submitted for approval in July 1996.

Part II of the study addresses the installation of manatee protection systems at seven sector gate locks which include S-193, S-310, Ortona Lock, St. Lucie Lock, Port Mayaca Lock, Moore Haven Lock, and W. P. Franklin Lock. Separate studies were initiated because the manatee protection devices initially developed for vertical lift gates were not functional on sector gates; therefore, an effective protection system for sector gates required further development. If the study had not been divided into two parts, the installation of protective devices on the vertical lift gates would have been delayed awaiting the development of effective protection devices for sector gates.

For the Part II study, existing information was used to the fullest extent possible for the acoustical, hydraulic, mechanical, and electrical designs; environmental benefits; and resulting recommendations. The Part II study is incorporating by reference the Part I Environmental Assessment and signed Finding of No Significant Impact statement (signed October 3, 1995). The proposed protection system incorporates devices to be designed, constructed, and installed on selected lock sector gates. Manatee protection systems were specifically authorized for two sector gate structures under the authority of the Energy and Water Development Appropriation Act of 1994. The Henry Creek Locks were deleted from the Part I study since they were not constructed or operated with Federal funds. Five additional sector gate structures which are owned and operated by the U.S. Army Corps of Engineers (USACE) were included in this study due to the potential for manatee mortalities to occur or continue at these structures. Thus, a total of seven sector gate locks were included in this Part II study.

This study will include measures to reduce risk, injury, and mortality of the manatee which is listed as an endangered species in Florida. In response to recent manatee mortality trends associated with water control structures, this study identifies actions at locks to prevent further decline and assist in the recovery of manatee populations.

1.4 LOCATION

The proposed modifications for manatee protection are located at selected Central and Southern Florida (C&SF) Project navigation locks, as shown in Figure 1. The Central and Southern Florida region encompasses most of 18 southern counties covering some 16,000 square miles and running south of Cape Canaveral-Orlando, down the center and east coast of the peninsula, to include the Florida Keys. This region is geographically dominated by Lake Okeechobee, a large shallow, fresh water lake in the center of this region. The lake is the principal natural reservoir in southern Florida. The lake's largest outlets include the St. Lucie Canal eastward to the ocean and the Caloosahatchee Canal and River westward to the Gulf of Mexico.

This study includes structures located at Lake Okeechobee, St. Lucie Canal, and Caloosahatchee Canal. These structures and their location are shown in Table 1. Appendix E, "General Description of Lock Operations" provides a description of the structures. Two of these seven structures are operated by the South Florida Water Management District (SFWMD) in accordance with criteria specified by the USACE. The remaining five structures are operated by the USACE. Figure 1 shows the locations of the locks and water control structures.

TABLE 1. CENTRAL AND SOUTHERN FLORIDA PROJECT SECTOR GATE LOCKS INCLUDED IN PART II STUDY

STRUCTURE	LOCATION	OPERATED BY/ DATE CONSTRUCTED	AUTHORIZATION
Moore Haven Lock* (S-77 Lock)	Glades Co.	CESAJ/1935	1930 Rivers and Harbors Act
Ortona Lock (at S-78)	Glades Co.	CESAJ/1937	1930 Rivers and Harbors Act
W.P. Franklin Lock (at S-79)	Lee Co.	CESAJ/1965	Flood Control Act of 1958
St. Lucie Lock (at S-80)	Martin Co.	CESAJ/1941	1930 Rivers and Harbors Act
S-193 Lock*	Okeechobee Co.	SFWMD/1973	Flood Control Act of 1948
Port Mayaca Lock (at S-308B)	Martin Co.	CESAJ/1977	Flood Control Act of 1958
S-310 Lock*	Hendry Co.	SFWMD/1980	Flood Control Act of 1958

*NOTE: Hurricane Gate Structure No. 1 (HGS-1) and Moore Haven Lock were completed in 1935. In 1966, S-77 Spillway was added to the site of the combined hurricane gate and lock. HGS-6 was completed in the 1930's, and construction to convert it into S-193 was completed in 1973. HGS-2 was also completed in the 1930's, and construction to convert it into S-310 was completed in 1980.

1.5 DESCRIPTION OF SECTOR GATE LOCKS

The water control structures addressed in this report are sector gate locks which are briefly described below:

A navigation lock can be thought of as a kind of "boat elevator", into which a boat enters through one side and exits through the other side. The bodies of water immediately upstream and downstream of a lock are referred to as the upper and lower pools, respectively. The lock chamber lies between the two pools. A lock allows a boat to "step" from the water level in the lower pool to the water level in the upper pool, or vice versa. Closure gates are required at both ends of the lock chamber so that the water level inside the lock chamber can be varied to coincide with the water levels in the upper and lower pools.

Sector gate locks are named for the shape of their gates, sectors of a circle or pie-shaped sections. Sector gates are used in pairs, meeting at the center of the lock when in the closed position and swinging into recesses in the lock walls for the open position. The gate closing operation occurs as these two structural steel sectors pivot from their narrowest sections to interface, or seal, along their upstream vertical edge. Steel plating on the upstream facing structure closes off the water in the channel. A moving seal located along the lower edges and a flexible j-seal at the vertical mating edges completes the channel closure when sectors meet. As the gates open, the sectors pivot and move into recesses in the lock walls. The recesses contain the entire sector thereby offering a relatively unobstructed passageway for boats to move into the lock chamber. After boat traffic enters the lock chamber, the gates through which the boats have just passed are closed. Then, the sector gates at the opposite end of the channel structure are opened slightly to allow the water levels to equalize. When the water levels equalize, these gates are opened to allow the boat traffic to safely travel out of the lock chamber.

The SFWMD operated locks have approximately three to five feet of water differential between the lock chamber and the upstream and downstream water levels. The lock gates are opened approximately 2 to 2.5 feet to allow the lock chamber water level to equalize. The gates are manually halted for 30 seconds at a gate opening of 2.5 feet prior to closure of the gates. At this opening, manatees can pass through the gates without injury. In August 1995, the SFWMD installed additional circuitry at S-193 that allowed the gates to move at a slower rate over the last 2.5 feet of closure. Following the manual stoppage of the gates, the lock tender engages a second gate closing circuit switch to complete the slow closure of the gates.

Most USACE operated locks have higher water differentials between the lock chamber and the upstream and downstream water levels. At St. Lucie Lock, the water difference can be as high as sixteen feet. Therefore, the USACE locks are initially opened about eight to twelve inches to allow water equalization. This smaller opening restricts the majority of manatees traveling through the opening gates.

Figure 2 shows a typical sector gate lock. A more thorough description of the water control structures in this project can be found in Appendix E "General Description of Sector Gated Lock Operations".

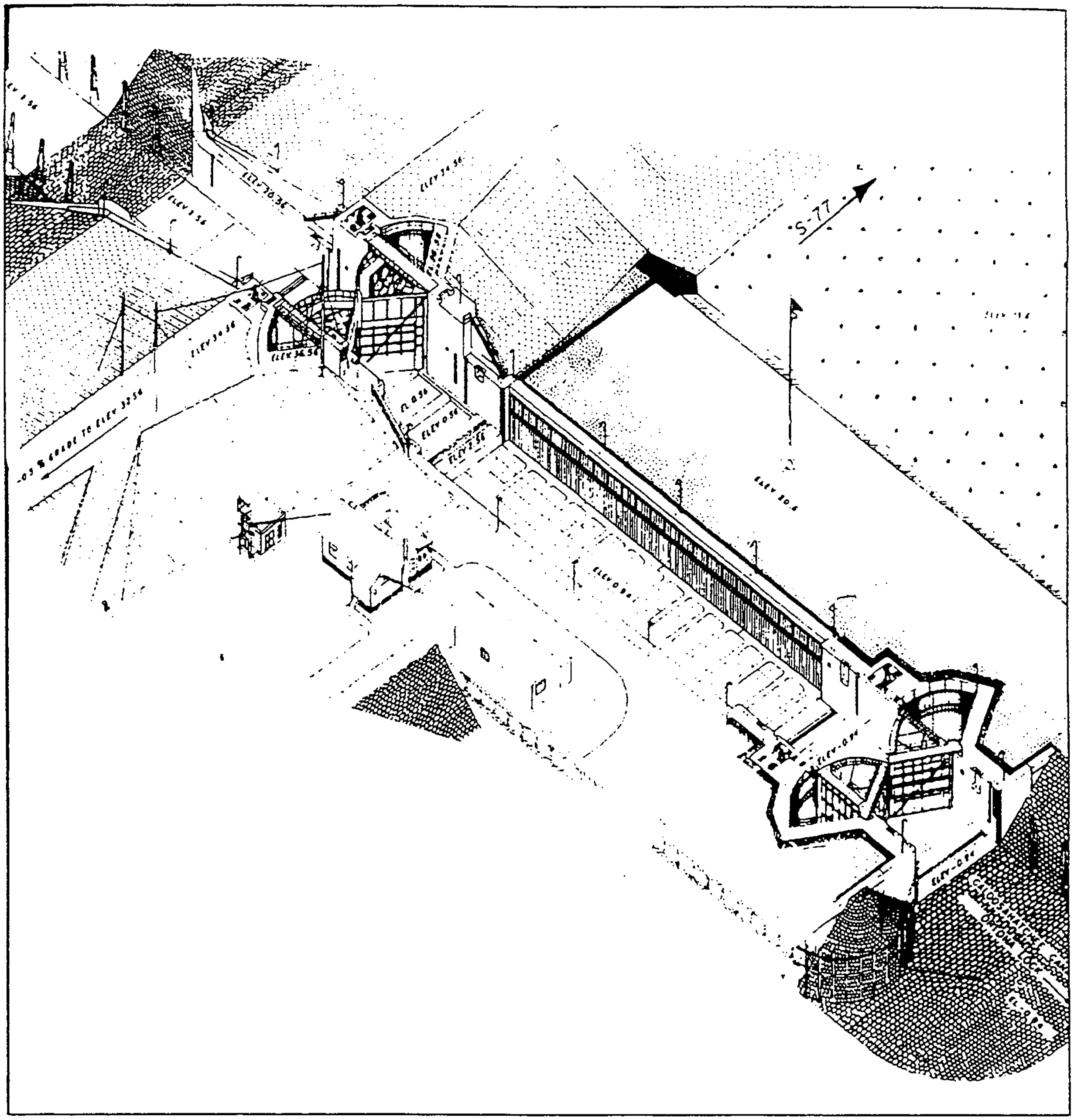


Figure 2 Moore Haven Lock- typical lock with sector gates.

1.6 NATIONAL ENVIRONMENTAL POLICY ACT REQUIREMENTS

The National Environmental Policy Act of 1969 (NEPA), as amended, is the nation's charter for environmental protection. NEPA establishes policy, sets goals, and provides means for carrying out the policy. The Federal regulations for implementing the procedural provisions of NEPA were published by the Council on Environmental Quality (CEQ) in the Code of Federal Regulations (CFR) as 40 CFR Parts 1500-1508 (43 Federal Register 55978-56007, November 29, 1978).

This report consists of a main report with integrated NEPA documentation and numerous Technical appendices. Integration is based on the CEQ provision to combine documents, which states that *"any environmental document in compliance with NEPA may be combined with any other agency document to reduce duplication and paperwork"* (40 CFR 1506.4). Sections in this integrated report that include NEPA-required discussions are marked with an asterisk in the Table of Contents.

1.7 REPORT PARTICIPANTS AND COORDINATION

The USACE initially proposed to the SFWMD that a study encompassing a comprehensive manatee protection program at water control structures should be undertaken. On June 1, 1993, the SFWMD sent a letter of intent to act as the non-Federal sponsor of this study. The USACE, Jacksonville District, had the primary responsibility of preparing this document. The SFWMD and the Jacksonville District coordinated and conducted the research and development of sensor devices for this study.

An Inter-Agency Manatee Task Force was established in 1991 to recommend means to reduce water control structure related manatee mortalities. Members of the Manatee Task Force include: Dade County Department of Environmental Resources Management, Florida Department of Environmental Protection, South Florida Water Management District, U. S. Army Corps of Engineers Jacksonville District, and U. S. Fish and Wildlife Service (USFWS). Throughout this study, the Jacksonville District attended Manatee Task Force meetings and maintained contact with members of the task force concerning issues and developments of this study. The Manatee Task Force was instrumental in providing information pertaining to alternatives for protecting manatees at water control structures and identifying crucial manatee mortality issues. The USFWS provided the Coordination Act Report which was used to prepare this report.

The Jacksonville District furnished appropriate Federal, state, and local agencies with a scoping letter. A scoping letter was also sent to many private and non-profit interest groups, as well as other interested parties. The purpose of the scoping letter is to identify potential problems concerning policy and the acceptability of the project as early as possible in the planning process. Other purposes of a scoping letter are to seek suggestions, alternative methods, or comments on a concept set forth in the letter. The scoping component is a source of communicating the USACE's study with interested persons, and it enables the USACE to receive valuable feedback. Responses to the scoping letter were incorporated into the plan formulation process. The scoping process also satisfies the NEPA scoping requirements for the project.

1.8 EXISTING PROJECT HISTORY

The modifications for manatee protection are proposed at structures which are part of the C&SF Project. The C&SF Project continues to be a large undertaking of the USACE, Jacksonville District. The C&SF Project covers a large area and includes the following sub-areas: the Upper St. Johns River Basin, the Kissimmee River Basin, Lake Okeechobee and the Everglades Agricultural Area, Everglades National Park and the South Dade Conveyance Canals, and the Lower East Coast Canals.

The Everglades Drainage District initially built a number of canals in the study area for the purpose of drainage. After two hurricanes devastated communities bordering Lake Okeechobee in 1926 and 1928, Congress authorized flood control and navigation in the Rivers and Harbors Act of 1930. The 1930 Act included, among other provisions, improvements to the Caloosahatchee River and Canal from Lake Okeechobee to the Gulf of Mexico to provide a 2,500 cfs capacity outlet from Lake Okeechobee and a navigation channel at least 6 feet deep. The 1930 Act also provided improvements to the St. Lucie River to provide a channel 6 feet deep. These works were constructed by the USACE. This project was known as the Caloosahatchee River and Lake Okeechobee Drainage Areas (CR&LODA) Project.

Under the Flood Control Act of 1948, the CR&LODA Project was modified and expanded. This act created the C&SF Project. The completed work under the CR&LODA project that did not pertain to navigation has been maintained as a part of the C&SF Project since 1950, and the navigation project since then has been known as the Okeechobee Waterway. Under the C&SF Project, Lake Okeechobee serves a number of purposes including flood control; navigation; water supply for agricultural irrigation, municipalities and industry, and Everglades National Park; regional groundwater control, and salinity control; and enhancement of fish and wildlife; and recreation.

The 155-mile Okeechobee Waterway originally consisted of three navigation locks operated and maintained by the USACE: St. Lucie, Moore Haven, and Ortona. Hurricane Gate Structure No. 1 (HGS-1) and Moore Haven Lock were completed in 1935. HGS-2 was completed in the 1930's and converted into the S-310 Lock in the 1973. HGS-6 was also completed in the 1930's and converted into the S-193 Lock in 1980. In 1966, S-77 Spillway was added to the site of the combined hurricane gate and lock. The navigational lock near Ortona was substantially completed, except for a few items of work, at the end of the fiscal year 1937. Replacing the old St. Lucie Locks 1 and 2, the new St. Lucie Lock was completed in 1941. W.P. Franklin Lock and its adjacent spillway, S-79, were added to the project in 1965. Originally called the Olga Lock and Dam, it was renamed in 1967, the W.P. Franklin Lock and Dam. The lock and spillway (S-308) at Port Mayaca were added in 1977.

SECTION 2

PROBLEM IDENTIFICATION

2.1 EXISTING CONDITIONS

In the United States, the largest population of West Indian manatees is comprised of the Florida manatee. The West Indian manatee is a large herbivorous aquatic mammal that predominantly inhabits subtropical or tropical waters in coastal, estuarine, and riverine habitats. The Florida species of the West Indian manatee, *(Trichechus manatus latirostris)*, can be found throughout Florida and Georgia's southern coast. The habitat requirements for this species include access to shallow channels, freshwater sources, aquatic vegetation, and warm water refugia in the colder months of the year.

The Florida manatee is listed as Endangered throughout its range by the U.S. Department of the Interior (Federal Register, July 22, 1985. Vol 50 (140): 29900-29909). Except for isolated individuals, Florida harbors the entire United States population in the winter. High mortality, associated with human activity, as well as a low reproductive rate and loss of habitat have caused the population of manatees to decrease and threaten the species' future. The threats to the Florida manatee, as documented in the "Florida Manatee Recovery Plan", are predominantly human-related. The most common causes of death are collisions with watercraft, crushing by water control structures, and entanglement in crab lines and fishing nets. Other sources of mortality include poaching, red tides, cold stress, and natural causes. As a result, government agencies, universities, private conservation groups, and concerned corporations have responded by promoting research and identifying actions needed to promote the recovery of manatee populations.

In 1974, the Manatee Salvage Program was established. The primary focus of the program involved research and conservation efforts to identify and quantify manatee mortality. Information gathered through the Manatee Salvage Program has led to the identification of some manatee mortality causes which include: boat/barge collisions, loss of habitat, crushing or drowning in flood gates, poaching, ingestion of fish hooks and monofilament line, entanglement in crab trap lines, cold water temperatures, and "red tide", known as algal blooms.

Manatee mortalities are associated with water control structures if the carcass is recovered at or near a structure with one or more of the following indicators: external scrapes, bruises, impressions, massive internal trauma, and/or drowning with the absence of hemorrhaging. These injuries have been speculated to be caused by the entrapment of an animal in closing gates, floor depressions, or lock recesses during gate motion. Each reported carcass is examined for the causes of death, and a necropsy is performed by the Florida Department of Environmental Protection's Florida Marine Research Institute (FMRI). Depending on the responsible structure, other agencies are involved in the investigation of the mortality, and they prepare a report concerning the incident. Mortality determinations are based on necropsy reports, observations of water control structure operators, unusual circumstances, equipment failure, and other specific monitoring data.

In January 1996 and February 1996, two inter-agency synoptic manatee aerial surveys were coordinated by the FMRI. Counts were made on Florida's east coast at warm water sites from Brunswick, Georgia to Ft. Pierce, Florida, and contiguously from Ft. Pierce south to the upper Florida Keys. Sites on the St. Johns River were also surveyed. Counts were made on the west coast in Wakulla, Citrus, and Levy Counties, and from Tampa Bay contiguously south to Whitewater Bay in the Everglades. During the January survey, 2,274 manatees were counted. During the February survey, 2,639 manatees were counted. Due mostly to excellent counting conditions, these counts were higher than previous synoptic counts.

Because aerial and ground counts at winter refuges are highly variable depending on weather, water clarity, manatee behavior, and other factors, interpretation of analyses for temporal trends is difficult. Direct counting methods have been unable to account for uncertainty in the number of animals that may be away from refuges at a certain time, the number of animals not seen because of turbid waters, and other factors. As a result, there is no evidence that manatees are any less endangered or ongoing manatee conservation strategies should be halted. To the contrary, the record number of documented deaths in recent years remains a major impediment to the recovery of the species. In 1995, the number of deaths (201) was the second highest on record in Florida. Very high mortality has continued in early 1996 during the cold winter and red-tide event in southwest Florida. In 1996, 415 manatee deaths were verified in Florida - nearly twice the previous high of 214 deaths in 1990. Even without the red-tide event, the total of 264 deaths from other causes would have exceeded the previous annual mortality record by nearly 25 percent.

Because manatee mortalities associated with locks and water control structures are the second leading cause of human-related manatee mortality, means to reduce these deaths are imperative. From 1974 through December 1996, the Manatee Salvage Program data set shows that 129 manatee mortalities were associated with Florida water control structures. According to this data set, 45 manatee mortalities occurred at five of the water control structures included in this study: Moore Haven Lock, Ortona Lock, St. Lucie Lock , S-193, and Port Mayaca Lock. At most of these structures, manatees are undetectable, unless they are observed surfacing for air or feeding close to the water surface. The post-mortem evaluations indicate that manatees are trapped between or against sector gates during closure.

Due to the fact that all of the seven water control structures in this study operate with sector gates which pose a danger to manatees, the continuing possibility of future manatee mortalities exists at all of the structures in this study. Although there have not been any manatee mortalities attributed to W.P. Franklin Lock and Dam (S-79) and the S-310 Lock, manatees travel through these locations. According to lock tender records of manatee sightings for the period of January 1991 through September 1994, a total of 2,450 manatees were sighted at W.P. Franklin Lock and Dam. As a result of the potential danger for manatees at all of the structures in the project, a low-cost and effective protection system is recommended to be implemented to protect manatees at all seven of the water control structures.

2.2 PROJECT GOAL AND OBJECTIVES

2.2.1 General Goal

The primary goal of this project is to reach zero structure-caused manatee deaths. Striving to meet this goal, this project addresses modifications devised to protect manatees at water control structures.

2.2.2 Project Objectives

The project objectives are to design and install manatee sensing devices at sector gate locks for manatee protection. As stated in the project authority, an economic constraint for this project involves devising relatively low cost pass through gates for manatees on existing C&SF Project water control structures. Due to this constraint, a value engineering approach is emphasized to implement the most efficient and cost effective protection at all of the seven structures in this study. A time constraint is also involved, since the USACE has been directed to "expeditiously move their construction ahead in cooperation with the South Florida Water Management District."

SECTION 3

PLAN FORMULATION

3.1 PREVIOUS EFFORTS TO REDUCE MANATEE DEATHS

Over the past ten years, project field offices made operational improvements and modifications to place the manatee at less risk at locks. The following manatee protection efforts were implemented at the sector gate locks included in this study: recess screens, operation protocol changes, and idle speed zones.

3.1.1 Recess Screens

Manatee protection recess screens were installed at the following sector gate locks: S-193, S-310, W. P. Franklin Lock (1981), Ortona Lock (1982), St. Lucie Lock (1983), Port Mayaca Lock (1991), and Moore Haven Lock (1976). The purpose of the screens is to prevent manatee access to sector gate bottom recesses where there is a possibility of manatees becoming crushed while the gates are in motion.

3.1.2 Operational Protocol

Through interagency coordination in 1992, the USACE South Florida Operations Office implemented much of the operational protocol for locks and spillways as contained in the draft Project Operations Manatee Protection Plan for Water Control Structures (Appendix C) on an interim basis. This plan outlines lock operating procedures designed to place the manatees at less risk while they are in the vicinity of the locks. These procedures include recording manatee sightings and issuing precautions to assure manatee safety around the sector gates. Information on water management criteria is available in water control plans and manuals. Also, both the SFWMD and the USACE use a three volume set of USACE manuals for guidance on operational protocol entitled "Operations and Maintenance Manual - Central and Southern Florida Flood Control Project". The USACE also uses the following manuals for navigation structures included in this study: "Operation Manual Ortona Lock", "Operation Manual Moore Haven Lock", and "Operation Manual St. Lucie Lock and Dam".

3.1.3 Speed Zones

In the spring of 1994, the USACE established idle speed zones in the form of "No Wake" restrictions around locks and spillways. These zones were primarily designated for public safety near locks where boat traffic can be excessive; however, the protection of manatees is another beneficial effect of this restriction. Within approximately 1,000 feet of the lock, "Idle Speed" signs are posted and enforced by USACE staff. Manatees often traverse through the Okeechobee Waterway and various navigation lock chambers in conjunction with heavy boat traffic. The zones ensure that boats are traveling at idle speed in the congested lock area, thereby reducing the risk of public safety and potential injury to manatees. Although the USACE does not have regulatory guidance to establish and enforce state mandated "manatee zones", the USACE will continue to enforce the idle wake zones that benefit manatees.

In the September 7, 1995 SFWMD Manatee Mortality Report, the SFWMD has also recommended that the management of boat speeds be improved near the S-193 structure to afford appropriate protection in a manner consistent with other lock systems surrounding Lake Okeechobee and the Okeechobee Waterway.

3.1.4 Results of Previous Efforts To Reduce Manatee Deaths

The aforementioned operational improvements and modifications were implemented to place manatees at less risk at locks, yet the numbers of manatee deaths associated with the water control structures in this study have not been reduced due to these efforts. According to the Manatee Mortality Data set showing the yearly distribution of manatee mortality associated with the C&SF Project water control structures in this study, shown in Table 2a in Appendix G, the numbers of manatee mortalities have not declined after the implementation of these efforts. As a result, manatee protection devices will be necessary to significantly reduce manatee mortality and injury at the locks in this study.

3.2 RELATED EFFORTS

Currently, additional manatee protection device measures are being prototype tested and developed for structures not included in the Part II study. These efforts that include protection devices for vertical lift gate structures are outlined in Part I of the Manatee Protection Plan. At the end of July 1996, the non-Federal sponsor completed the installation of piezo-electric pressure sensitive devices at the vertical lift gated structure S-26. These devices will be tested for a period of approximately six months to test their effectiveness. The findings and results of this test will provide beneficial information towards applying this technology at the sector gates.

3.3 DESCRIPTION OF ALTERNATIVES

Operational and structural modifications to all seven of the water control structures in this study are crucial for reducing or eliminating manatee risk or mortality by preventing a gate from closing on a manatee. Manatees travel through all of the sector gate locks included in this study; therefore, protection devices on these gates are necessary to reduce harm to these manatees. A manatee detection system is required to protect manatees in the sector gates' critical zone defined as the final two to five feet of the sector gate closing where a manatee may be critically injured or killed. The following alternatives were evaluated to protect manatees at the seven structures for this study:

1. No Action
2. Pressure Sensitive Device Systems
3. Hydroacoustic Device Systems
4. Combined Pressure Sensitive Device and Hydroacoustic Device Systems

3.3.1 Plan 1: No Action

The "No Action" alternative would not provide modifications to the water control structures for manatee protection.

3.3.2 Plan 2: Pressure Sensitive Devices

Currently, the USACE and the SFWMD are developing three pressure activated systems for the sector gates: the hinge plate switch, j-seal piezo electric film contact sensor, and the hydraulic tube system. Plan 2 would involve the selection and installation of pressure sensitive device systems on both sector gates at each lock structure.

3.3.2.1 Hinge Plate Switch

The SFWMD, working in coordination with the USACE, Jacksonville District, developed a pressure activated system comprised of a hinge plate switch depicted in Appendix D, Plate ME-2. The hinge plate would be located at the leading and trailing edges of the sector gate's contact edges. If a manatee is caught in a closing gate, a spring-loaded "hinge-plate" would activate a limit switch and stop gate motion. An audible alarm and visible light are activated to alert the operator. Then, the operator would open the gate a required distance to allow the manatee to safely pass while ensuring the safety of boat traffic.

The "hinge-plate" assembly consists of a half-inch thick stainless steel backer plate with a quarter-inch thick stainless steel "hinge". The rounded "hinge" has a smooth surface that would not harm a manatee. In addition, water-borne debris can easily move over the curved surface. The limit switch protrudes through a "window" in the "hinge" that allows the limit switch cam to smoothly follow the curved "hinge" while closing. The location of the limit switch is within the upper portion of the device, approximately four feet above the normal water level. The "hinge-plate" assembly may be twenty or more feet in length depending on lock water depth. Previously located studs hold the backer plate to the lock, and the assembly can be lowered in place with a crane. Divers are required to guide and fasten the assembly underwater while other workers fasten the assembly at the surface. The hinge plate details are shown on Plate ME-2 in Appendix D. The estimated average cost to install the system on both gates at one structure is approximately $50,000.

3.3.2.2 Hydraulic Tube Sensor

Another type of pressure sensitive device, a hydraulic tube, was developed by the USACE, Jacksonville District. In order to protect a manatee from being caught between the edges of the gates, a hydraulic tube (a flexible tube filled with biodegradable hydraulic fluid) would be installed at the J-seal and/or the bumper block line. Compression of the tube increases the contained fluid pressure and activates an electrical device that sends a signal to control sector gate action. Then, a microswitch is activated to relay a signal to detect the presence of a manatee and stop the gate.

Early testing of this device indicated that manatees could be protected with the hydraulic tube sensor. As shown on Plate ME-4 in Appendix D, two hoses would be installed at each gate to protect manatees from both directions as they enter and leave the lock chamber. The dual hose concept includes one tube on the upstream side of the gate and the other about fourteen inches on the downstream side of this same gate. The tube sensors are joined by a tee fitting with a single control hose connected to the control panel (Plate ME-4). The single gate side installation eliminates lengthy signal wiring and duplication of hydraulic and electrical components while maintaining maximum alarm capabilities.

As the gates close, a manatee in contact with the gates would compress one or both sensor tubes increasing the pressure in the tube and activating the hydraulic/electrical switch. The pressure sensing switch, set to a system static pressure of ten pounds per square inch, is activated when system pressure reaches twelve pounds per square inch. The Manatee protection electrical circuit for the hydraulic tube sensor consists of a hydraulic pressure activated AC relay contact switch. The AC relay contacts are interlocked with the gate open/close AC operating circuit. (The electrical control circuit and wiring details are described on Plates ME-5 and ME-6 in Appendix D.) When the electric relay contacts are activated by the increased pressure of a compressed hose sensor by a passing manatee, the gates are stopped. The lock operator is alerted by an audible and visual alarm signal. After the lock operator determines boat traffic and lock water levels are within safe limits, the gates can be opened farther to allow the manatee to pass through the gates. Also, a low pressure setting of eight pounds per square inch alerts the operator the system pressure is low and a possible leak condition may exist. The estimated cost of installing the hydraulic tube sensor at all seven structures is approximately $282,000 as shown in the cost estimate in Appendix B. The average cost to install the system on both gates at one structure is $40,000.

3.3.2.3 Piezo-Electric Film Sensor

In August 1995, the piezo-electric sensor device was introduced as a new technology that could sense the presence of a manatee between closing gates by Harbor Branch Oceanographic Institute, Inc. (HBOI). Piezo film, a thin flexible material manufactured from polyvinylidene fluoride plastic, converts mechanical energy to an electrical response. When the film is stressed, a charge is generated on the surface of the film proportional to the applied stress. As described in HBOI's report in Appendix I, three approaches to using piezo-electric film sensors were designed, fabricated, and subjected to preliminary testing. The three approaches were: a hard-backed area contact sensor, a J-seal contact sensor, and a flat plate contact sensor.

3.3.2.3.1 Hard-Backed Area Contact Sensor (Proof of Concept). The hard-backed contact sensor was tested by HBOI to prove the concept of using a piezo film sensor as a detection device on the closing edge of the sector gates. The sensor was fabricated in three layers: the hard back aluminum alloy plate, the ridge sheet fabricated out of neoprene rubber bonded to the hard back, and the cover layer fabricated from neoprene sheet. The piezo film was sandwiched between the ridge sheet and cover layer. When contact was made with the protective cover layer, the piezo film was stressed and generated an output signal. This test proved that the hard-backed area contact sensor detected constant pressure.

3.3.2.3.2 J-Seal Contact Sensor. The j-seal contact sensor was designed and tested by HBOI. The j-seal sensor was fabricated by sandwiching the piezo film between the j-seal and a protective neoprene cover layer. This j-seal sensor would replace the original j-seal on the gates. The sensor would connect to junction box assemblies that contain the gate trip and alarm connections. This junction box would contain the sensor condition module used to report contacts over a cable run to the control room. A control room junction box would contain the gate trip and alarm connections, in addition to the hardwired connections to the present gate closure circuitry. The detected presence of a manatee in contact with the j-seal would stop the gate closure and activate the alarm. The manatee protection circuit and gate operation would proceed in the same manner as described in the Manatee Protection Circuit and Operation section. Also, an override switch would allow the system to be bypassed and restore operator control. As shown in the cost estimate in Appendix B, the total estimated cost of installing the j-seal contact sensor on all seven sector gates would be approximately $350,000. The average cost of installing the system on both gates at one structure is $50,000.

3.3.2.3.3 Flat Plate Contact Sensor (Proof of Concept). The flat plate contact sensor was fabricated to simulate a section of an extrusion that would extend the length of the edge of the sector lock gate. The piezo film would be placed between a cover layer of neoprene rubber and a rubber plate. Similar to the j-seal sensor, the piezo film was stressed when direct contact pressure is applied to the plate in the proof of concept test..

3.3.3 Plan 3: Hydroacoustic Device Systems

The U.S. Army Corps of Engineers Waterways Experiment Station (WES) evaluated the effectiveness and feasibility of several acoustic systems to detect manatees. The use of hydroacoustic devices would involve a non-contact detection method of manatees in locks.

Hydroacoustics is the application of controlled sound energy for observing and measuring underwater objects. Active acoustical methods were evaluated that employed a sound source (transducer) and a sound receiver (hydrophone). Both imaging and non-imaging systems were tested by WES. Imaging sonar is a hydroacoustic system that produces the image of the insonified object on a screen or monitor. Non-imaging systems include ranging sensors and interrupted beam sensors that do not produce insonified object images on the monitor of an imaging system. A reflectance sensor that detects the presence of a manatee based on reflection or signal return of the manatee's body. Interrupted beam sensors detect the presence of a manatee between a transducer and a hydrophone.

Initially, preliminary tests were conducted to determine whether hydroacoustic devices could effectively detect manatees in the critical zone or final two to five feet of the sector gate closing where a manatee could be critically injured or killed. In May 1995, personnel from WES and the SFWMD participated in a pilot field test at Port Mayaca Lock (S-308). The acoustical equipment used in this test was the Furuno Color video sounder Model #FCV-522 with a Furuno narrow angle transducer, Model #200B-8B-15M. Although manatees were detected in this pilot test, limitations of using this device included reflection scatter from the lock chamber walls and limited coverage of the area of the lock chamber. The results of this pilot study indicated that further field testing of more sophisticated types of hydroacoustic devices would be viable to evaluate the effectiveness of hydroacoustic devices for detecting manatees at water control structures.

In August 1995, WES began the assessment of other acoustical systems to: 1) evaluate the effectiveness of each system for detecting manatees and 2) investigate the installation, implementation, and maintenance requirements of each system at sector gate locks. All of the systems detected the designated manatee targets; however, the displayed image and degree of interference noise of each system varied with influences of water turbidity and air bubbles; changing water depths; boat traffic; reflections from walls, gates, water surface, and bottom; movement of gates; and environmental factors.

Plan 3 involves the selection and installation of acoustical detection devices on the sector gates at the seven lock structures. The following section outlines the acoustic categories and systems that were included in WES's evaluations.

3.3.3.1 Single-Beam Systems

Single-beam systems consist of a single beam transducer that uses one conical-shaped beam to display the returned echo of an underwater object. Varying degrees of training in acoustics would be required for an operator of these systems. The following single-beam systems were evaluated: Furuno Color Video Sounder FCV-522, BioSonics DT 4000, and Simrad 800 Series Echosounder.

3.3.3.1.1 Furuno Color Video Sounder FCV-522. The Furuno Color Video Sounder FCV-522 is designed for use as a depth sounder on boats. The system has an all solid state microprocessor-controlled 200 or 50 kHz single frequency, 500 watt, 16 color CRT video sounder which displays on a 6-inch diagonal screen. The transducers of this system would be permanently mounted to the bottom of the lock chamber. During testing, the background acoustic image of the sector gates was displayed as a solid red bar on the monitor of the acoustical equipment. When the gates opened, the solid red bar separated into two narrow lines indicating a view of the critical zone between the gates. A six degree beam angle was tested over a range of 100 feet or 30.5 meters. A maximum diameter of 3.2 meters of insonified area at the critical zone. As a result, multiple transducers would be required to insonify the entire water column of the critical zone. The cost for the equipment at the two gates of one structure was estimated by WES to be $20,000.

3.3.3.1.2 BioSonics DT 4000. The BioSonics DT-4000 is a digital hydroacoustic sounder that is designed for use in fisheries research applications. This system would be mounted to the bottom of the lock chamber. A six degree beam angle of 420 kHz was tested over a range of 200 feet or 61 meters producing a maximum diameter of 6.5 meters of insonified area at the critical zone. Data were displayed and stored on a notebook PC which runs the Biosonics operating software. To insonify the entire water column of the critical zone, multiple transducers of reduced angle would be necessary. WES estimated cost of the equipment to be $60,000 for multiple transducers installed at two gates of one structure.

3.3.3.1.3 Simrad 800 Series Echosounder. The Simrad 800 Series Echosounder Modules are designed for instrumentation, data acquisition and vessel positioning. This series has transmitter, receiver, and signal processing circuitry built into the unit, thereby only requiring power and an indicator for a complete echosounder. The echo sounder module operates on a frequency of 200 kHz and uses a ten degree conical beam. The transducer of this device would be attached to the sector gate at the upper water level on a gimbal mount attached to a hydraulic ram mounted between the existing wood timbers on the gate. The hydraulic ram arm extends 2 to 2.5 feet in the critical zone between the open gates and retracts when the gate is in the closing mode. The data received from the transducer is interpreted by a computer program and run on a standard 486 laptop computer. This system utilizes a simple, beam break feedback loop which generates an immediate warning signal and stop command to the gate control switch when a manatee is detected. Full scale system development and assemblage were not conducted with the Simrad 800 Series Echosounder. WES's estimated cost of the equipment for the two gates of one structure is $25,000.

3.3.3.2 Multiple beam - Scanning Sonar

A multiple beam - scanning sonar system is an acoustical system in which the sound field is rotated or panned through an area. This type of system uses two or more beams that work simultaneously to provide a more detailed display of the returned echo of an underwater object. The following multiple beam - scanning sonar systems were evaluated: Sonatech STA-014

NARWHAL and UDI Wimpol Sonavision 2000. Training in acoustics would be required for an operator of these systems. The transducers of these systems would be mounted to the bottom of the lock and oriented perpendicular to the center meeting point of the sector gates.

3.3.3.2.1 Sonatech STA-014 NARWAL. The STA-014 NARWHAL is a multi-beam forward looking sonar designed for object detection and avoidance on remotely operated vehicles. The transducer has an operating frequency of 530 kHz and utilizes ten beams to obtain horizontal coverage of 62 degrees. During field tests of the Sonatech STA-014 NARWHAL, the critical zone could only be completely insonified by turning the transducer perpendicular to its normal presentation. This modification to the equipment was necessary to change the beam pattern geometry from 62 degrees wide horizontal by 6.4 degrees vertical to a narrow horizontal and wide vertical configuration. With this configuration, the sonar coverage extended approximately 13 feet (4 meters) fore and aft of the gate opening. Data are transmitted to the surface equipment based on a 66 MHZ, 486 PC with a 15 inch Super VGA high resolution monitor. WES's estimated cost of the equipment would be $250,000 for the two gates of one structure.

3.3.3.2.2 UDI Wimpol Sonavision 2000. The UDI Wimpol Sonavision 2000 is designed for object detection with remotely operated vehicles and seabed operations. The sonar system consists of a 500 kHZ pinger transducer connected to a 486-based computer. The movement of the acoustic beam is provided by a mechanically rotating transducer head, covering from 0 to 360 degrees in the horizontal plane. The system has a 27 degree vertical beam width that was tested over a range of ten meters and produced a maximum of insonified area at the critical zone of only 4.8 meters. To insonify the entire water column of the critical zone, the beam width would require modifications or multiple transducers would be necessary. WES's estimated cost of the equipment for this system is $40,000 for the two gates of one structure.

3.3.3.3 Multiple beam - Imaging/Scanning Sonar

A multiple beam - imaging/scanning sonar system is an acoustical system that uses a multi-beam transducer design to produce the image of the insonified object. The following multiple beam - imaging/scanning sonar systems were evaluated: Reson SeaBat 6012 and Simrad MS-900. Training in acoustics would be required for an operator of these systems. The transducers of these systems would be mounted to the bottom of the lock and oriented perpendicular to the center meeting point of the sector gates.

3.3.3.3.1 Reson SeaBat 6012. The SeaBat 6012 is a forward looking sonar designed for use with remotely operated vehicles for object detection, navigation, and other seabed operations. The system uses multiple beams to detect objects ahead of the curved array transducer operating on a frequency of 455 kHz. A total of sixty beams, each measuring 1.5 degrees horizontal and 15 degrees vertical, simultaneously provide a complete sonar image displayed in real time on a high resolution monitor. The 15 degree vertical beam width was tested over a range of ten meters which produced a maximum diameter of insonified area at the critical zone of only 2.6 meters. Modifications to the beam width or the use of multiple transducers would be required to insonify the entire water column of the critical zone. According to WES, the estimated cost for the equipment for two gates at one structure is $250,000 for two systems with one sonar head each.

3.3.3.3.2 Simrad MS-900. The Simrad MS 900 system is designed for general purpose use in search and salvage operations, offshore construction, cable and pipeline surveys, and hydrographic and geological studies. During the tests of system, the 330 kHz transducer was able to detect live manatees. A sharp image resolution and image return near real time were displayed on the monitor of this system. The 30 degree vertical beam width tested over a range of 10 meters produced a maximum diameter of 5.4 meters of insonified area at the critical zone. To insonify the entire water column of the critical zone would require modifications to the beam width or use of multiple transducers. WES's estimated cost of the equipment for this system at two gates of one structure is $60,000.

3.3.3.4 Alternative Acoustic Approaches

The following three alternative acoustic systems were designed to be mounted on the gate: Techsonics H3DW, AMP Piezo-electric Acoustic Ladder Array, and Delavan Sonac 220 Acoustic Ladder Array. The non-imaging methods tested were ranging sensors and interrupted beam sensors. The Techsonics H3DW system is a reflectance sensor that detects the presence of a manatee based on reflection or signal return of the manatee's body. The ladder array systems are interrupted beam sensors, similar to electric eye sensors on automatic garage doors. The ladder array systems utilize a simple, beam break feedback loop that generates an immediate warning signal, stops the gates, and opens the gates approximately six inches when a manatee is detected in the water column of the critical zone between the closing gates.

3.3.3.4.1 Techsonics H3DW. The Techsonics H3DW is an advanced high frequency fish finder that was tested on fixed targets and humans in reflective environments by HBOI. The system operates at a frequency of 455 kHz. The transducer has a six element array producing a fanshaped area of coverage 53 degrees horizontal and 16 degrees vertical. This system would interface with the present gate closure circuitry which would be triggered when a manatee interrupts the beam path. When the manatee approaches the closing sector gates, a signal is reflected off the manatee. This signal is interpreted by the signal processing circuitry as a depth which is sent to a serial port of a laptop or PC computer. Then, the computer generates an alarm, and the gate would stop. According to WES, the cost of the equipment for this system at both sector gates on one lock structure would be less than $20,000.

3.3.3.4.2 AMP Piezo-electric Acoustic Ladder Array. The AMP piezo-electric acoustic ladder array system uses AMP piezo electric copolymer tiles as 'beam breaking' emitter-receiver pairs set up to form an acoustic ladder array. The acoustic emitter-receiver pairs are made by imbedding piezo-electric copolymer tile in hard rubber silicon. The co-polymer tiles will be formed into circular bands that will be hard back mounted on the outside of a stainless steel tube at the selected interval. The sensor array tubes encapsulated in polyurethane and PVC would be the only components that would be placed in the water. This ladder-type set up of emitters on one gate and receivers on the other gate would be spaced approximately eight inches apart. The beams of these transducers would range from four to nine degrees. A manatee located between gates closing at a specified distance would interrupt at least two beams to activate an alarm, stop the gate, and open the gate approximately six inches .

During the testing of this device, signals from the transducer were received by the receiver placed about 3.3 feet (1 meter) away. Both the emitter and receiver operate on a frequency of 1 Mhz. According to WES, the equipment costs for protection systems at both sector gates at one lock structure would be less than $20,000. As shown in the cost estimate in Appendix B, the total estimated cost of installing the complete AMP piezo-electric acoustic ladder array system on all seven structures would be approximately $674,000 or $96,000 per structure.

3.3.3.4.3 Delavan Sonac 220 Acoustic Ladder Array. The Delavan Sonac 220 Acoustic ladder array was demonstrated for proof of concept purposes. This acoustical system is similar in design to the piezo-electric ladder array. A series of multiple emitter-receiver pairs form an acoustic ladder array mounted on the leading edges of the sector gates. The system consists of an amplifier control box and two identical and interchangeable transducer sensors. One sensor is connected to the input of the amplifier serves as a microphone, and one sensor is connected to the output of the amplifier serves a speaker. A feedback loop occurs when the two sensors face each other, and the path is unobstructed between the two sensors. The system has two light emitting diodes (LED) which function as indicators. A yellow LED is illuminated when the system is energized, while a red LED is illuminated when an object interrupts the emitter-receiver path. The acoustic ladder array design requires multiple amplifier/sensor pairs to be connected to one interface box which would be connected to the gate control hardware and computer system for operator control. The transmitter operates on a frequency of 38 kHz. According to WES, the equipment system cost for protection at both sector gates at one lock structure would be less than $20,000.

3.3.4 Plan 4: Combined Pressure Sensitive Device System and Hydroacoustic Device System

Plan 4 involves the selection and installation of a combined pressure sensitive device and hydroacoustic system of protection at the sector gates of the locks. Sector gate locks with manatee mortalities would be protected with a dual system of protection. The most feasible recommended pressure sensitive device and acoustical sensor device would be used in combination at locks with manatee mortalities attributed to them. The locks with zero mortalities would be protected by one recommended type of acoustical system, due to the low risk of future manatee mortalities at these structures. The acoustical system would be a non-contact detection method of manatees in locks; therefore, this type of system would be most beneficial as the primary detection system.

3.4 EVALUATION OF ALTERNATIVES

3.4.1 Plan 1: No Action

The "No Action" alternative would not be a practical solution. According to the USFWS, manatees will continue using the Okeechobee Waterway and the Central and South Florida area. The trends of manatee mortality indicate that the future of the manatee could be adversely affected if no action is taken.

3.4.2 Plan 2: Pressure Sensitive Device Systems

3.4.2.1 Hinge-Plate Switch

In January 1995, hinge plates were installed at the SFWMD sector gate lock, S-193. Several problems occurred with this device. When the hinge plates were installed, the dimensions of the hinge plate assembly impaired the gates from fully recessing. Although this is not a problem at S-193 since the lock is used by small boats that can pass through the partially opened gates, it is a potential problem at other structures used by larger vessels. Another problem arose when one of the hinges was damaged by a fishing boat. As a result, the hinge plates were removed, repaired, and reinstalled in the summer of 1995. Then, in the late summer of 1995, a problem occurred with the rebound of the hinge plate. The confined space of the closed hinge restricted the spring size, and the existing coil spring located at the bottom of the hinge plate was inadequate to fully open the hinge. When the hinge plates were depressed, they remained in a closed position. In this situation, the circuits were triggered, but they could not be reset.

In October 1995, the SFWMD installed a revised hinge plate system on S-193. This system was revised to include modified springs and hinge plate edges to allow the hinge plate to fully re-open after it is activated. Due to high wind and wave surges that caused the plates to move and falsely activate, the lakeside hinge plates were removed and replaced to increase the tension of the springs in the fall of 1995. To date, the system is mounted on the gates at S-193 until a preferable solution is developed. No manatee mortalities have been associated with this lock since August 1994.

The space constraints of the open gates into the channel wall recesses prohibits installing "hinge-plates" on sector gates that need to be fully opened. This is due to the hinge protruding about six inches above the outer skin plates covering the outer gate faces. Hinge springs located at the upper and lower ends of the assembly also interfere with the opening the gate completely. As a result, this system is not practical for installation at the structures operated and maintained by the USACE.

3.4.2.2 Hydraulic Tube Sensor

In May and July 1995, the USACE tested the hydraulic tube protection device at the Port Mayaca Lock. During the first test, the device interfered with the complete closure of the gate. Since the diameter of the cap was larger than the diameter of the tube, the gate could not close properly. For the second test, the newly designed device had beveled end caps welded to each end. These caps had a smaller diameter than the original caps; therefore, they did not impede the complete closure of the gate. After a prototype was assembled, initial trials demonstrated the signaling pressures and assembly techniques were sound. During the second test, the tube detected pressure; however, a leakage problem developed and a new assembly device was required.

In January 1996, the hydraulic tube was reinstalled at Port Mayaca Lock. The device was fastened to a slotted base bar with screw clamps every two feet, and a new o-ring assembly of copper seal washers was used to prevent leakage. Initial testing followed the installation of the hydraulic system, including the control panel, to demonstrate the sensitivity of the system. Lacking electrical power to the hydraulic/electrical switch, a battery-powered electrical signal device was attached to the hydraulic/electrical switch circuit. A six-gallon plastic drum filled with water and positioned between the gates acted as a model manatee. As the gates closed slightly on the drum, the hydraulic tube was compressed, and the increase in pressure resulted in the electrical switch light almost instantaneously activating the signal and stopping the gate. Following the gate stop switch activation, gate movement was negligible.

Electrical power to the control panel and gate control circuitry was completed in March 1996. A major advantage of this system is the off-the-shelf availability for all of the parts that afforded ease of assembly and low cost of the concept. However, during the past six months of testing and monitoring leakage problems have continued to occur. Objects have punctured the tube, and the brackets are not holding the tube in place. Although the concept for this device is sound, field testing has shown that the hydraulic tube device has not been successful due to the field conditions at the lock.

3.4.2.3 Piezo-Electric Film Sensor

HBOI's preliminary evaluation of the piezo-electric film sensor is provided in Appendix I. The piezo-electric film sensors were tested and evaluated in HBOI's laboratory. The hard-backed area contact sensor and flat plate sensor proved that the piezo-electric film concept was sound, but the j-seal sensor was superior over these two approaches because an external device would not be added to the gates. The j-seal sensor would replace the original j-seal, thereby serving as a j-seal for the gate and a pressure sensitive device that detects manatees as the gates close.

3.4.2.4 J-Seal Contact Sensor. Advantages of the piezo electric film j-seal contact sensor are described in HBOI's report. The ability of the sensors to null out stresses, the lack of any moving parts, and the innate toughness of the sensors provides high reliability of the device. Since the sensors are fabricated from heavy sections of solid, durable rubber, the piezo film will be protected from moisture, abrasion, and compression. Another major maintenance and reliability advantage of the sensors are their ability to null out stresses. Whether deformations occur due to the installation process, thermal expansion and contraction, collisions or aging, the sensors will naturally adapt to these conditions without requiring recalibration or adjustment.

HBOI also tested the sensors for false triggering of the sensors due to impacts from light debris and flow noise from the motion of the gate during closing. These tests demonstrated that neither flow noise or light debris would be sources of false triggering of the sensor devices. By constructing the sensors out of heavy sections of rubber, relatively little energy is transferred by light, sudden impacts of debris. Also, the large film areas increase the capacitance of the sensor and provide the required sensitivity to detect manatees. As a result, the sensor has a long time constant that is relatively insensitive to small, sharp local impacts, yet very sensitive to broad movements that a manatee would generate.

Ease of repair, installation, and operation of the piezo-electric film sensors are other advantages of the device. The installation of the sensor on the gate edge will be essentially the same procedure that is currently employed for the existing gate j-seals. Also, the sensor should be subject to the same service and maintenance conditions as the existing gate j-seals. Since the piezo-electric film sensor is incorporated in the gates' existing j-seals without any additional moving parts, the maintenance of this device is anticipated to be less than the maintenance for the other pressure sensitive device systems. Due to the advantages of this type of sensor, further evaluation and field testing of the piezo-electric film sensor is planned to determine its actual effectiveness.

3.4.3 Plan 3: Hydroacoustic Device Systems

WES evaluated the effectiveness and feasibility of ten acoustic systems to detect manatees in sector gate locks. The results demonstrated that conventional single-beam and multiple-beam systems were not as effective or feasible as the acoustic ladder array systems for full-scale implementation as manatee detection systems. Specifically, major disadvantages common to the conventional single-beam and multiple-beam systems were problems with bottom mounted transducers and dependence on operator interaction and recognition.

The bottom mounted transducer design of these systems would present problems for normal lock operations and flow of boat traffic. The bottom mounted transducers would be highly vulnerable to damage from deep drafted vessels, dropped or dragged objects, biofouling, and sediment and debris accumulation. Boat noise and changing water depths would also adversely affect the bottom mounted transducer. Furthermore, the maintenance and installation of these bottom mounted devices would require extensive use of divers and/or dewatering of the lock.

Except for the Simrad 800 Series Echosounder, the other single-beam and multiple beam systems would require continual operator interaction with the equipment and software to identify manatees in the lock. Because these systems do not have automatic target recognition capabilities, the systems cannot easily warn the operator of detected manatees if the lock or system malfunctions. According to WES, the development of an automated recognition system would be extremely complex, costly and impractical for the systems tested.

WES recommended that the ladder array designs for alternative acoustic techniques warranted further development and field testing due to these systems' automated target recognition capabilities. The simple, beam-break feedback loop design for these systems requires minimal operator training and interaction while maintaining a high detection probability. These systems would be mounted on the gate and interface with the present gate closure circuitry. The installation and maintenance of the systems would require minimal use of divers and limited interruptions in lock operations, since most of the installation and maintenance for these systems could be accomplished from the surface. The AMP piezo-electric acoustic ladder array was determined to be the most effective and most feasible system for further testing and implementation as a manatee detection system at sector gate locks.

Advantages and disadvantages specific to each acoustical system are summarized in the following sections.

3.4.3.1 Single-Beam Systems

The following single-beam systems were evaluated: Furuno Color Video Sounder FCV-522, BioSonics DT 4000, and Simrad 800 Series Echosounder.

3.4.3.1.1 Furuno Color Video Sounder FCV-522. The Furuno Color Video Sounder FCV-522 effectively detected a SCUBA diver and live manatee target in the lock chamber. The targets were viewed as large red images on a monitor that indicated their position and depth. However the speed of the image display return and update were too slow to permit timely identification of a manatee target in the critical zone. Also, the system did not produce a clear image of the sector gates in comparison to the other tested systems. Multiple reflections of the lock chamber walls and sector gates shown on the monitor caused a significant reduction of image resolution.

3.4.3.1.2 BioSonics DT 4000. The BioSonics DT 4000 detected manatees within the lock chamber, but the strong acoustic return from the gate prevented adequate detection of manatees in the critical zone or near the gates. Also, the speed of the image display return and update was too slow to allow timely identification of a manatee target. Significant modifications to the current transducer beam geometry and six degree beam angle would be required to reduce the reflective scatter from the water surface, bottom, and gates.

3.4.3.1.3 Simrad 800 Series Echosounder. The Simrad 800 Series Echosounder was not developed and assembled for full-scale testing by WES; therefore, this system would require further development for field testing. Maintenance requirements of this echosounder are expected to be less than bottom mounted transducers. Yet, WES predicted that the ruggedness and durability of the acoustic ladder array systems were better than this system. The transducer would be mounted external to the gate structure and forward of the gate movement path; therefore, it would be vulnerable to being damaged by sweeping into debris. The transducer could also be damaged by large objects or debris passing through the lock opening.

3.4.3.2 Multiple beam - Scanning Sonar

The following multiple beam - scanning sonar systems were evaluated: Sonatech STA-014 NARWHAL and UDI Wimpol Sonavision 2000.

3.4.3.2.1 Sonatech STA-014 NARWHAL. By turning the transducer perpendicular to its normal position, the Sonatech STA-014 Narwhal system completely insonified the critical zone. Although the system detected a mock manatee in various orientations in the critical zone, image resolution was reduced and difficult to interpret. Also, the system did not adequately detect the mock manatee when it was close to the sector gates. Other major disadvantages of this system are its high cost and required modifications to the equipment to change the beam pattern geometry.

3.4.3.2.2 UDI Wimpol Sonavision 2000. The UDI Wimpol Sonavision 2000 system effectively detected a mock manatee at all water depths and orientations to the transducer head. The speed of the image display returns was rapid. A major disadvantage of this system is the mechanically rotating end of the transducer could malfunction from continuous use in the lock environment. The rotating parts would collect debris and require excessive maintenance and cleaning. Also, multiple transducers or modifications to the beam width would be required to insonify the entire water column of the critical zone.

3.4.3.3 Multiple beam - Imaging/Scanning Sonar

The following multiple beam - imaging/scanning sonar systems were evaluated: Reson SeaBat 6012 and Simrad MS-900.

3.4.3.3.1 Reson SeaBat 6012. The Reson SeaBat 6012 system effectively detected a mock manatee, live manatees, fish and sector gates with real time image returns displayed on the monitor. The system beam pattern reduced excess back scattering and reverberation to produce an increased image resolution; however, the curvature of the metal gates produced some backscatter. A major disadvantage of this system is its high cost and need for additional modifications. To insonify the entire water column of the critical zone would require modifications to the beam width or the use of multiple transducers.

3.4.3.3.2 Simrad MS-900. The Simrad MS-900 system produced the clearest image display of the sector gates compared to the other bottom mounted transducer systems. Near real time images of the mock manatee, live manatees, and fish were detected in the lock chamber and critical zone. A major disadvantage of this system is the mechanically rotating end of the transducer could malfunction from continuous use in the lock environment. The rotating parts would collect debris and require excessive maintenance and cleaning. Also, multiple transducers or modifications to the beam width would be required to insonify the entire water column of the critical zone.

3.4.3.4 Alternative Acoustic Approaches

The following three alternative acoustic systems were designed to be mounted on the gate: Techsonics H3DW, AMP Piezo-electric Acoustic Ladder Array, and Delavan Sonac 220 Acoustic Ladder Array.

3.4.3.4.1 Techsonics H3DW. The Techsonics H3DW system was tested on fixed targets and human subjects in reflective environments. This system detected a mock manatee during proof-of-concept field tests, but full scale system development and assemblage of this system would be required if further field tests were determined to be feasible. A major disadvantage of the system is its dependence on the accurate placement and orientation of the transducers. Correct alignment of the transducers may be problematic during installation and maintenance. Furthermore, the transducers are vulnerable to damage, since the they would be mounted external to the gate structure and in front of the gate path movement. In this fish-finder based system, a failed transducer could go undetected if the failure is limited, and the system would produce a false "all clear" output. Another concern is other fishing boats with similar fish finders could pose an interference problem with this system.

3.4.3.4.2 <u>AMP Piezo-electric Acoustic Ladder Array</u>. The AMP Piezo-electric Acoustic Ladder Array detected a mock manatee during proof-of-concept field tests. Full scale system development and assemblage of this system would be required for further field tests. Advantages of this system include ruggedness, high reliability, low maintenance, and ease of installation and operation.

The AMP Piezo-electric Acoustic Ladder Array is rugged in construction. The emitters and receivers are embedded in a resilient and acoustically transparent compound which makes them resistant to impact damage or vandalism. The emitter-receiver array would be built in the I-beam pocket and protected by the structure of the gate. The sensor array tubes are simple in construction. The modular design, incorporating simple bolt-on assemblies in accessible locations would be used to minimize down time and effort in the installation and replacement of components.

Also, the emitter-receiver is "fail safe", since a transducer failure results in a false trigger. Since the system is inherently separated into multiple independent channels with yes/no outputs, trouble shooting and diagnostics are simplified. The system is self-diagnostic and well suited for simple "replace the module" repairs. A manatee's presence between the gates would trip-out the gate closure and activate an alarm, requiring minimal operator intervention. As the system is micro controller based, the system readily lends itself to data logging applications. Data could be stored in nonvolatile memory and connected to a PC to allow logging of statistical information, such as the number of potential manatee targets, date, time and location of the manatee in the critical zone. The system could also be used to temporarily trigger video recorders or other devices. As a result of these advantages, the AMP Piezo-electric Acoustic Ladder Array was determined to be the most effective and feasible acoustic system evaluated.

3.4.3.4 <u>Delavan Sonac 220 Acoustic Ladder Array</u>. The Delavan Sonac 220 Acoustic Ladder Array was only tested for proof of concept demonstrations; as a result, full scale development and assemblage would be required for the field testing of this system. Also, modifications would be required to adapt the current system for underwater use at sector gate locks. Similar to the piezo electric acoustic ladder approach, this automated system would be installed on the I-beams of the sector gates and interface with the present gate circuitry. The transmitter receiver pairs are waterproof and resistance to environmental changes; however, the extensive number of cables needed for the system would present installation and implementation problems at a structure.

Table 2 Advantages and Disadvantages of Manatee Protection Devices

SYSTEM	ADVANTAGES	DISADVANTAGES	AVG. COST/ STRUCTURE
Hinge Plate Switch	Temporary solution	Gate opening interference Maintenance intensive (additional moving parts) False activation occurrences Vulnerable to damage	$50,000
Hydraulic Tube Sensor	Off-the-shelf parts Sound Concept	Leakage problems Maintenance intensive (additional moving parts) Vulnerable to damage	$40,000
J- Seal Contact Sensor	Precludes external moving parts (replaces existing j-seal) Durable Low maintenance Targets detected in proof-of-concept tests	Requires field development and testing	$50,000
Furuno FCV-522	Targets detected in the lock chamber Non-contact detection	Reduced image resolution Continual operator interaction Slow image return and update Maintenance intensive Vulnerable to damage Targets not detected in critical zone	*$20,000
Biosonics DT400	Targets detected in the lock chamber Non-contact detection	Reduced image resolution Continual operator interaction Slow image return and update Maintenance intensive Vulnerable to damage Targets not detected in critical zone	*$60,000
Simrad 800 Echo Module	Non-contact detection	Requires field development and testing Maintenance intensive Vulnerable to damage	*$25,000
Sonatech Narwhal STA-014	Targets detected in the critical zone Non-contact detection	Continual operator interaction Vulnerable to damage Reduced image resolution Requires major modifications to the equipment	*$250,000

* NOTE: These cost estimates were estimated by WES for the equipment for the systems; therefore, these estimates are low since installation costs were not included. Average cost estimates per structure for items without an asterisk include the total estimated cost of installing the complete system at each structure.

Table 2 (continued)

SYSTEM	ADVANTAGES	DISADVANTAGES	AVG. COST/ STRUCTURE
UDI Wimpol Sonavision 2000	Targets detected in the critical zone Non-contact detection	Continual operator interaction Vulnerable to damage Maintenance intensive Requires multiple transducers and modifications to the equipment	*$40,000
Reson SeaBat 6012	Targets detected in the critical zone Non-contact detection	Continual operator interaction Vulnerable to damage Requires multiple transducers and modifications to the equipment	*$250,000
Simrad MS-900	Targets detected in the critical zone Produced clearest image display Non-contact detection	Continual operator interaction Vulnerable to damage Maintenance intensive Requires multiple transducers and modifications to the equipment	*$60,000
Techsonics H3DW	Targets detected in proof-of-concept tests Non-contact detection	Requires field development and testing Vulnerable to damage Installation/Implementation problems Interference problems Potential false output	*$20,000
Piezo-Electric Array	Targets detected in proof-of-concept tests Durable Low maintenance Self-diagnostic system Non-contact detection	Requires field development and testing	$96,000 (*$20,000)
Delvan Sonac 220 Array	Targets detected in proof-of-concept tests Non-contact detection	Requires field development and testing Installation/Implementation problems due to cables Vulnerable to damage	*$20,000

* NOTE: These cost estimates were estimated by WES for the equipment for the systems; therefore, these estimates are low since installation costs were not included. Average cost estimates per structure for items without an asterisk include the total estimated cost of installing the complete system at each structure.

3.3.4 Plan 4: Combined Pressure Sensitive Device System and Hydroacoustic Device System

Plan 4 includes phased installation of a combination of the most feasible recommended pressure sensitive and acoustical detection devices at the sector gate structures. Ortona Lock, St. Lucie Lock, S-193 Lock, Port Mayaca Lock, and Moore Haven Lock would be retrofitted by both the most feasible pressure sensitive and acoustical detection device systems. Since several manatee mortalities have been attributed to these structures, a pressure sensitive device back-up system would provide manatee protection if the primary acoustical system failed. At W.P. Franklin Lock and S-310, the acoustic detection system would be the sole system for manatee detection at these structures due to the lower risk of manatee mortality occurrences, as indicated in past records.

Table 2 summarizes the advantages and disadvantages of each manatee protection device evaluated. A major advantage of using a hydroacoustic device at each of the seven locks would be the implementation of a non-contact method of detecting manatees in the critical zone between the closing sector gates. The advantages of the AMP piezo-electric acoustic ladder array system also include rugged construction, high reliability, low maintenance, and ease of installation and operation. These advantages also apply to the back-up J-Seal contact sensor system. Although the J-seal contact sensor system comes in contact with manatees, a major benefit of this device is no additional external parts would be added to the lock gates.

The recommended manatee protection systems utilizing pressure sensitive and acoustic devices would be tested, evaluated, and implemented in a phased approach at the seven structures. These systems include: the AMP piezo-electric hydroacoustic ladder array system and the j-seal piezo-electric film contact sensor system. Future improvements in the technology of these detection devices will be incorporated during the testing and implementation of these manatee protection systems.

SECTION 4

SELECTED PLAN

4.1 GENERAL

Plan 4 was determined to be the best low cost, effective plan that will produce significant environmental benefits by protecting manatees at sector gate structures. Plan 4 consists of the phased installation of a combination of pressure sensitive and hydroacoustic manatee protection systems on seven selected sector gate locks in Central and Southern Florida.

At this point, manatee protection systems utilizing pressure sensitive and acoustic devices have been chosen for further testing, evaluation, and implementation: the AMP piezo-electric hydroacoustic ladder array system and the piezo-electric film sensor system. As described in the previous sections, these systems are the most feasible and advantageous for implementation at the structures. The primary manatee protection and detection system would be the AMP piezo-electric acoustic ladder array. This acoustic ladder array system is non-contact detection method comprised of a ladder-type set up of beam-breaking emitters on one gate and receivers on the other gate. A manatee located between gates closing at a specified distance would interrupt at least two beams to activate an alarm, stop the gate, and open the gate approximately six inches. The secondary fail-safe system of manatee protection and detection would be the j-seal contact sensor system. The j-seal contact sensor system is actuated by pressure (by a passing manatee, for example), which activates an electrical switch. The activated electrical switch generates a signal to stop the gate and modify the gate open/close circuit accordingly.

Future advancements in the technology of detection devices will also be incorporated in the selected manatee protection system. All of these chosen systems have similar circuitry, testing and monitoring procedures, and operation and maintenance requirements as described below.

4.1.2 Manatee Protection Circuit

The electrical activation and deactivation of the manatee protection circuit in the recommended plan are the same. Therefore, the gate open-close cycle as activated by the manatee protection circuit is also the same. A detailed description of the manatee protection circuit is in the DESCRIPTION OF ALTERNATIVES section.

4.1.2.1 Testing and Monitoring

The manatee protection system installation and testing would proceed on selected structures with high risk to manatees prior to committing to a final installation design. In the Spring of 1997, the USACE plans to begin working with HBOI to prepare, construct, install, and performance test the AMP Piezo-electric hydroacoustic array system at St. Lucie Lock. HBOI will analyze the system's resistance to impact, abrasion, water intrusion, corrosion, biofouling and lightening strike. After the system is installed at the lock, testing of the device will include: 1) exposure to high head flow during gate openings; 2) reliability over repetitive trials; 3) failure mode and reset capabilities; 4) gate control time lapse; 5) model detection at depth and distance; 6) ease of sensor removal and replacement; 7) resistance of the sensor container to the elements; 8) resistance to impacts; and 9) activation of audio and visual alarms. Both small and large manatee models will be used for testing

Standard product and quality control criteria will be used for the installation of the Manatee Protection system at each structure. Testing with manatee models will also be implemented with the piezo-electric film sensor system. These models would be situated along the gate edges, and the sensors would be verified by activating the gate closing operation. Measuring gate motion after alarm activation and observation of the manatee model would be a portion of acceptance criteria.

In coordination with the USFWS, additional effective field testing procedures that have been proven to be successful by the SFWMD and USACE will be incorporated in the testing of the devices. The effectiveness of proposed protection systems can be determined by comparing manatee sitings and/or number of device activations at the structure with any mortalities attributed to the structure.

Structures operating under the test and implementation modes would be closely monitored under a variety of conditions for a period sufficient to ascertain the effectiveness of the operational and structural changes. Monitoring of the effectiveness of the selected pressure sensitive device system will transpire prior to further installations of the system. Improved technology in the development of pressure sensitive and hydroacoustic devices will also be adapted in providing manatee protection on sector gates.

4.1.2.2 Inspection and Operation and Maintenance (O&M)

Continued reliability for each manatee protection system would be assured through scheduled testing of the manatee protection systems. This testing is contemplated to be included in the daily operational instructions. More intensive reliability testing would be scheduled for biannual, or more frequent intervals, if determined necessary. Regularly scheduled O&M would involve repairing/replacing those parts subject to wear as determined during operations of the structures with the Manatee protection devices.

4.2 IMPLEMENTATION SCHEDULE

4.2.1 Considerations

The installation of manatee protection devices will require coordination between the USACE, USFWS, and SFWMD. During the Plans and Specifications phase, schedules will be developed using the following considerations and new information as it becomes available.

4.2.1.2 Manatee Mortality Considerations

The most important considerations in the implementation schedule are the number of manatee mortalities and the cost of installing protection devices at each structure. Table 3 lists the number of manatee mortalities attributed to each of the seven structures in this study. At S-77, S-78, S-79, S-80, and S-308C, a spillway and lock are present, and manatees' carcasses are recovered at the vicinity of these structures. As shown in Appendix G, the probable causes of mortalities are not always attributed specifically to either the lock or spillway at these locations. However, the numbers of deaths indicate that protection is necessary at both the locks and spillways. Manatee protection at spillways is addressed under the Part I Manatee Protection Plan.

During the Plans and Specifications Phase, the testing of the piezo electric film j-seal contact sensor and the piezo electric acoustic ladder array system will be necessary to determine their reliability and effectiveness. After a six month period of testing, the selected manatee protection devices would be installed and tested in a phased approach at structures that have the most manatee fatalities associated with them. A phased implementation approach will allow the inclusion of further refinements or technical modifications before implementing the installation of protection devices on the remaining structures. The mortality information presented in Appendix G and the construction costs for each structure's protection system from the Cost Estimates in Appendix B were used to prioritize the implementation of manatee protection devices at structures as shown in Table 3.

TABLE 3. IMPLEMENTATION ORDER ACCORDING TO MANATEE MORTALITY CONSIDERATIONS

STRUCTURE	MANATEE MORTALITIES	COST
Ortona Lock (at S-78)	15	$144,854
St. Lucie Lock (at S-80)	12	$145,154
S-193 Lock	7	$136,534
Moore Haven Lock (at S-77)	6	$143,447
Port Mayaca Lock (at S-308B)	5	$145,154
W.P. Franklin Lock (at S-79)	0	$94,408
S-310 Lock	0	$91,712

NOTE: Total costs for each structure include overhead, profit, bond, home office, and contingencies. These costs were determined from the Cost Estimate in Appendix B.

The costs of the AMP piezo-electric hydroacoustic ladder array system and the j-seal piezo-electric film contact sensor system were used for the Ortona Lock, St. Lucie Lock, S-193 Lock, Port Mayaca Lock, and Moore Haven Lock. The cost of the AMP piezo-electric hydroacoustic ladder array system was used at W.P. Franklin Lock (S-79 Lock) and S-310.

4.2.1.2 Water Management Considerations

Manatee protection device installation at Okeechobee Waterway and Lake Okeechobee locks should be coordinated with the regularly scheduled maintenance dewatering of these structures. During the dewatering phase for routine maintenance of the structures, preliminary gate preparation (hole drilling) for the installation of the devices can be completed so that divers can install the system at a later date.

4.2.1.3 Navigation Considerations

The manatee protection devices should be installed during regularly scheduled maintenance programs, if possible. Coordination between USACE, USFWS, and SFWMD will be necessary to include the installation of the manatee protection devices. At those Okeechobee Waterway locks at which manatee sensor device installation will be performed with divers instead of dewatering, work should only be scheduled between the hours of 9:00 a.m. and 3:00 p.m. The purpose of this requirement is to allow partial lock operations during the day. At these same structures, it is also permissible for work to be done between the hours of 10:00 p.m. and 6:00 a.m. However, at those structures where the installation will be done "in the dry", work may be performed at any time of the day.

4.2.1.4 Contract Considerations

After the installation and testing of the protection devices at the structures that pose the greatest risk to manatees, a separate contract would include the remaining Lake Okeechobee and Okeechobee Waterway structures. Specifying the maximum number of structures to be worked on concurrently will require coordination between USACE Engineering and Construction-Operations Divisions to ensure satisfactory supervision and inspection. Specifying order of work will require coordination between the USACE and SFWMD unless a requirements contract (delivery order) is written with separate bid items for each structure.

4.2.1.5 Operation and Maintenance Considerations

The SFWMD structures' maintenance program is excellent and should not be compromised to accommodate the manatee protection plan; that is, new dewatering equipment will be required if SFWMD needs their dewatering equipment for maintenance at other structures. Coordination between USACE and SFWMD will be necessary to make optimum use of the existing needle beams.

The USACE and SFWMD have schedules (in Appendix F) that identify when a structure will be dewatered to perform scheduled maintenance. Whenever possible, coordination between USACE and SFWMD will be necessary to include the preliminary gates preparation or installation of the manatee protection devices at scheduled dewaterings.

4.2.1.6 Dewatering Requirements

The dewatering requirements will be those performed for typical maintenance work. Bulkhead and needle systems will generally be used to isolate the gate. Once the stoplogs are in position, dewatering will commence to allow installation of the necessary manatee protection devices in the dry.

4.2.1.7 Dewatering Equipment

An inventory of Jacksonville District stoplogs (bulkhead and needle systems) is included in Appendix F; this equipment will be available for dewatering.

As-built information and existing information on needle beam systems used at SFWMD structures are also included in Appendix F. Coordination between USACE and SFWMD will be necessary to make optimum use of the existing needle beams.

4.2.1.8 Time of Construction

Approximately one month for each water control structure will be required to install the manatee protection device. The installation and maintenance of the manatee protection devices will be done during regularly scheduled maintenance periods (without additional down time) or with divers.

4.2.1.9 Contracts

The plan will be implemented under a phased approach with two possible separate construction contracts. The first contract will include model tests. After successfully implementing the first contract, phased installation/field testing on the remaining structures will be implemented with the second contract, since further refinements or technical modifications may be required.

4.2.1.9.1 First Contract. At least six months of field testing of the j-seal piezo-electric film contact sensor and AMP Piezo-electric hydroacoustic array systems will be necessary prior to further installation at the next priority structure. In the Spring of 1997, the USACE plans to contract with HBOI to prepare, construct, install, and performance test the AMP Piezo-electric hydroacoustic array system at St. Lucie Lock.

4.2.1.9.2 Second Contract. The second contract will include the implementation of the manatee protection system in a phased approach as prioritized at the highest risk structures. During the Plans and Specifications phase of the project, the SFWMD, USFWS, and USACE will coordinate the schedule for the remaining structures on the Okeechobee Waterway and Lake Okeechobee for inclusion in this contract.

4.3 IMPLEMENTATION RESPONSIBILITIES

The authorities to cost share the Manatee Protection Plan project are the Flood Control Act of 1948 (P.L. 858) and the Flood Control Act of 1958 (House Document 186). The non-Federal sponsor will be required to provide the following amounts towards construction of the project modifications:

1) 15 Percent of total project costs for modifications to structures S-193 Lock. (Authorized in Section 203 of the Flood Control Act of 1948.)

2) 20 Percent of total project costs for the modifications to structures W. P. Franklin Lock, Port Mayaca Lock, and S-310 Lock. (Authorized in Section 203 of the Flood Control Act of 1958.)

3) 0 Percent of total project costs at the Moore Haven, Ortona and St. Lucie locks, since these locks were built by the USACE with 100% Federal funds.

Cost sharing for the recommended plan is shown below in Table 4. Construction costs are shown for each structure in Table 4. The Non-Federal cost sharing for the total project costs for one of the seven structures is 15 percent. As shown in Table 4, this factor is used in determining the non-Federal cost sharing for the construction management costs. Three of the seven structures are cost shared according to the policy established in 1958, requiring the non-Federal sponsor to make a cash contribution of 20 percent of the sum of the total project costs. The remaining three structures were built with 100% Federal funds; therefore, the non-Federal sponsor would not be required to cost share the modifications to these structures. Also shown in Table 4, this factor is used in determining the non-Federal cost sharing for the construction management.

The draft Project Cooperation Agreement contains a complete listing of Federal and non-Federal implementation responsibilities. Construction costs will be reapportioned during the implementation period to meet the cost-sharing requirements. The Federal and non-Federal costs for the recommended plan are $1,811,000 and $196,000, respectively. These costs were determined from the cost estimate prepared for the j-seal piezo electric film contact sensor and the hydroacoustic ladder array systems. After the evaluation and refinement of the most effective and cost efficient pressure sensitive device, value engineering will prevail in the selection of the best pressure sensitive device system. A summary of the Plans and Specifications cost is shown in Appendix A, and the Construction cost estimates for the hydraulic tube sensor, j-seal piezo electric strip contact sensor, and hydroacoustic ladder array are provided in Appendix B.

TABLE 4
COST SHARING

	TOTAL COST	PROPORTION	FEDERAL		NON-FEDERAL
REPORT		1/7th	85%		15%
			$ 76,500		$ 13,500
		3/7ths	80%		20%
			$ 216,000		$ 54,000
		3/7ths	100%		
			$ 270,000		
TOTAL REPORT COSTS	$ 630,000		$ 562,500		$ 67,500
PLANS & SPECIFICATIONS		1/7th	85%		15%
			$ 29,871		$ 5,271
		3/7ths	80%		20%
			$ 84,343		$ 21,086
		3/7ths	100%		
			$ 105,429		
TOTAL PLANS & SPECIFICATIONS	$ 246,000		$ 219,643		$ 26,357
CONSTRUCTION					
			85%		15%
S-193	$ 136,534		$ 116,054		$ 20,480
SUBTOTAL	$ 136,534		$ 116,054		$ 20,480
			80%		20%
W.P. Franklin Lock at S-79	$ 94,408		$ 75,526		$ 18,882
Port Mayaca at S-308B	$ 145,154		$ 116,123		$ 29,031
S-310	$ 91,712		$ 73,370		$ 18,342
SUBTOTAL	$ 331,274		$ 265,019		$ 66,255
			100%		
Moore Haven Lock at S-77	$ 143,447		$ 143,447		
Ortona Lock at S-78	$ 144,854		$ 144,854		
St. Lucie at S-80	$ 230,746		$ 230,746		
SUBTOTAL	$ 519,047		$ 519,047		
TOTAL CONSTRUCTION COSTS	$ 986,855		$ 900,120		$ 86,735
CONSTRUCTION MANAGEMENT		1/7th	85%		15%
			$ 17,510		$ 3,090
		3/7ths	80%		20%
			$ 49,440		$ 12,360
		3/7ths	100%		
			$ 61,800		
TOTAL CONSTRUCTION MANAGEMENT	$ 144,200		$ 128,750		$ 15,450
TOTAL PROJECT COSTS	$ 2,007,055		$ 1,811,013		$ 196,042
AVERAGE TOTAL PROJECT COSTS	$ 2,007,000		$ 1,811,000		$ 196,000

NOTE: Total Costs at each structure includes overhead, profit, bond, home office, and contingencies. These costs were determined from the Cost Estimate in Appendix B. The costs of the AMP Piezo-electric hydroacoustic ladder array system and piezo-electric film sensor system were used for S-78, S-80, S-193, S-308b, and S-77. The cost of the AMP Piezo-electric hydroacoustic ladder array system was used for S-79 and S-310. Study costs include hydraulic tube testing and WES research.

**Construction costs for St. Lucie include $180,000 for the first test and installation of the Piezo-electric hydroacoustic ladder array system by HBOI.

4.4 OPERATIONS AND MAINTENANCE REQUIREMENTS

The modifications described in this report are not expected to have any incremental OMRR&R costs. Therefore, the operation and maintenance responsibilities and/or requirements as provided in the existing authorized project are applicable. The SFWMD will be responsible for operations and maintenance of SFWMD structures, and the USACE will be responsible for operations and maintenance of USACE structures as listed in Table 1.

Operations and maintenance of the recommended project modifications for Manatee Protection at USACE structures will require the following:

(1) Daily operational checks to ensure proper operation of the Manatee Protection circuits.

The daily operational checks for testing the Manatee Protection circuits are not currently in the Appendix C, Draft Manatee Protection Plan for Water Control Structures Operated by the USACE, Jacksonville District; however, the plan will be updated to include these checks as they are developed.

(2) Scheduled maintenance to test, repair, and/or replace parts.

Scheduled maintenance will occur biannually to conduct more intense reliability testing of Manatee Protection circuits. Necessary maintenance will be performed upon detection of any problem to ensure proper working condition. Inspection and maintenance that is not immediately necessary should be combined when possible and performed in conjunction with the existing structure's inspection and maintenance schedule. These intervals include scheduled dewaterings at 4-year intervals, periodic inspections without dewatering at 5-year intervals and major maintenance at 12-year intervals.

These project modifications will create additional operations and maintenance responsibilities, although it is not expected that these additional responsibilities will be very significant. Scheduled maintenance will involve repair and/or replacement of parts subject to wear and/or corrosion. However, it is difficult to quantify specific O&M requirements and cost until installation and evaluation.

(3) The following items constitute a contingency plan for the case in which the proposed devices fail:

a. As an additional manatee protection precaution at structures where devices have been installed, the operational procedures specified in the

Manatee Protection Plan will remain in effect whether the devices are operational or not.

b. If during a scheduled maintenance event, or at any other time, repair and/or replacement of parts are found to be necessary to ensure proper operation of the devices, the South Florida Operations Office (CESAJ-CO-S) and Operations Technical Support Branch, Operations and Maintenance Technical Support Section (CESAJ-CO-OM) will be notified. Coordination within the Jacksonville District will be performed to determine how to solve the problem, and repair and/or replacement work will be accomplished as soon as possible. Coordination will also be performed to determine whether it is desirable, and if desirable, feasible, to modify structure operations in the interim before the repair and/or replacement work can be accomplished. It should be noted that water management needs may preclude deviations from normal operations.

4.5 REAL ESTATE REQUIREMENTS

Project lands to support this project consist of selected project structures located within the Central & Southern Florida Project. Underlying lands supporting the selected structures are owned in fee either by the State of Florida or the U. S. Government. Access roads to the project are either on state-owned lands, government-owned lands, or are accessible by public roads. The entire project is located on existing C&SF Project lands owned by the State of Florida or U. S. Government and no additional real estate interest is required to support this project.

4.6 ENVIRONMENTAL ASSESSMENT

This Environmental Assessment was prepared by the Jacksonville District to evaluate the proposed alternatives and the selected plan for their possible impacts on the environment. The Environmental Assessment was prepared for the Part I study, and it is applicable to the Part II study. The Environmental Assessment will be reviewed by the District Engineer to determine a Finding of No Significant Impact (FONSI). A listing of applicable Federal statutes and compliance status is shown in Table 5. The Environmental Assessment has resulted in a determination that:

a. Protection of the Florida manatee from risk and mortalities associated with the operation of the water control structures in the study is required;

b. Water quality of the Okeechobee Waterway and Canal system of the Central and Southern Florida Project area will not be degraded;

c. Site survey and coordination have determined that the planned action will not adversely impact historical or archeological resources;

d. In the vicinity of each installation site, there is no potential for the presence of hazardous, toxic, or radiological materials;

e. No documented adverse impacts to the human and natural environment.

4.6.1 Summary Of Compliance With Applicable Environmental Requirements

4.6.1.1 Archeological Resources Preservation Act, as amended, 1974

(ARPA, also called the Archeological Data Recovery Act, the Reservoir Salvage Act of 1960 as amended and the Moss-Bennett Act) This Act requires agencies to notify the Secretary of the Interior with their actions that will cause the loss or destruction of archeological data. The agency can then either recover such data itself or cooperate with the Secretary, and transfer up to one percent of project funds to the Secretary, in order to carry out data recovery.

Compliance with ARPA will be coordinated for each structure during the Plans and Specification phase of the project.

4.6.1.3 Clean Air Act, as amended, 42 U.S.C. 7401 et seq.

Any official of a Federal agency having jurisdiction over any property or facility constituting an emission's source shall be subject to and comply with Federal, state, interstate or local requirements respecting control and abatement of pollution. All Federal projects, licenses, permits, financial assistance and other activities must conform to EPA approved or promulgated state implementation plans. The assurance of such conformity is an affirmative responsibility of the head of the Federal agency involved. Sections 118, 176(c), and 309, 42 U.S.C. Executive Order 12088, Federal Compliance with Pollution Control Standards, 13 October 1978.

The only project-related sources of such emissions would be the motorized construction equipment. All vehicles, generators, pumps and construction-related engines will conform to State of Florida emissions' standards. The project is not expected to cause significant new atmospheric emissions. Applicable air quality regulations will be strictly followed.

4.6.1.3 <u>Clean Water Act (Federal Water Pollution Control Act), as amended. 33 U.S.C. 1251 et seq. (PL 92-500)</u>

Any official of a Federal agency having jurisdiction over any property or facility or engaged in any activity that may result in the discharge or runoff of pollutants shall be subject to, and shall comply with federal, state, interstate and local requirements, both substantive and procedural, respecting control and abatement of pollution. Federal agencies are not exempt from the requirement to obtain certification from the state or interstate agency for any discharge into navigable waters (except as provided in Section 404(r)). Executive Order 12088, 13 October 1978. EPA guidelines, 33 U.S.C. 1344b. CEQ Memorandum 17 November 80, guidance to apply Sec. 404(r) to a Federal project.

These proposed actions will not result in runoff or discharge of fill or pollutants into water bodies. Temporary dewatering will occur but will not result in any long-term adverse effects on the water column and its composition.

4.6.1.4 <u>Coastal Barrier Resources Act</u>

The Act prohibits certain types of development on designated coastal barrier islands or portions thereof (CBRA units) and requires that a project located in a CBRA unit be subjected to comments by the Secretary of the Interior.

None of the seven project locations are located in a designated CBRA unit.

4.6.1.5 <u>Coastal Zone Management Act of 1972, as amended. 16 U.S.C. 1451 et seq</u>.

Any activity that a Federal agency conducts or supports that directly affects the coastal zone, and any development project in the coastal zone, shall be, to the maximum extent practicable, consistent with approved state management programs. NOAA Regulations, 15 CFR Part 930 revised 15 June 1979, 44 F.R. 37142.

In a letter dated August 4, 1994, the State of Florida Department of Community Affairs deemed this project consistent with the Coastal Zone Management Act. The state concurred that the project would not significantly affect the coastal waters and adjacent shorelines of the state.

4.6.1.6 Endangered Species Act of 1973, as amended. 16 U.S.C. 1531 et seq.

Federal agencies shall, in consultation with and with the assistance of the Secretary (Interior or Commerce), utilize their authorities in furtherance of the purposes of the Act by carrying out programs for the conservation of listed endangered and threatened species and by taking such action as necessary to insure that actions they authorize, fund, or carry out are not likely to jeopardize the continued existence of such endangered or threatened species or result in the destruction or modification of habitat of such species which the Secretary, after consultation as appropriate with the affected States, has determined to be critical. USDI and USDC, NOAA, Rules on Endangered Species Exemption Applications, 50 CFR Parts 451, 45 F.R. 8264 (8 Feb 80), and 50 CFR Parts 450, 451, 452 and 453, 45 F.R. 23354 and 49083.

The nature of this project focuses on the protection of an endangered species, the Florida manatee (*Trichechus manatus latirostris*). Coordination under the Endangered Species Act with the U.S. Fish and Wildlife Service (USFWS) has occurred throughout the lifetime of this project. Formal Section 7 consultation with the USFWS will be initiated once the plans and specifications phase of the project has begun, upon their request. The USFWS's informal comments on this project can be found as the Coordination Act Report in Appendix J of this document. It is the USACE's opinion that the project will not adversely impact the Florida manatee. The project will, in fact, improve the manatees' ability to navigate within its habitat without harm. Protective measures, testing procedures, and contingency plans have all been designed to implement this project without adversely impacting the manatee.

4.6.1.7 Estuary Protection Act. 16 U.S.C. 1221 et seq. (PL 9454, 3 August 1968).

In planning for use or development of water and land resources, all Federal Agencies shall give consideration to estuaries and their natural resources, and their importance for commercial and industrial developments. All project plans and reports affecting estuaries and their natural resources that are submitted to Congress shall contain a discussion by the Secretary of the Interior concerning the estuaries and their resources and effects of the project on them and his recommendation thereon.

This law provides for Federal designation of Estuaries of National Significance, and consultation with the Secretary of the Interior for projects that may impact such estuaries. The structures are not part of such a designated area.

4.6.1.8 Federal Water Project Recreation Act, as amended. 16 U.S.C. 4601-12 et seq.

Any Federal navigation, flood control, hydroelectric, or multipurpose project planning shall include full consideration of opportunities afforded by the project for outdoor recreation and fish and wildlife enhancement.

No new recreational opportunities were identified as being potentially generated by the proposed project.

4.6.1.9 Fish and Wildlife Coordination Act, as amended. 16 U.S.C. 661 et seq.

For any proposal or Federal work affecting any stream or other body of water, the Federal agency proposing such work must first consult with the Fish and Wildlife Service and state wildlife agency with a view to preventing losses and damages to wildlife resources and to providing for development and improvement of wildlife resources. Reports of the Secretary of the Interior and state wildlife agency shall be an integral part of any report to Congress.

The proposed project has been coordinated with the Jacksonville Field Office and the Vero Beach Office of the U.S. Fish and Wildlife Service. A Coordination Act Report (CAR) is in Appendix J. The CAR recommends the installation of the sensing devices, with a caveat to continue searching for additional protection strategies at water control structures. The USACE is exploring other protection measures, as recommended by the USFWS. USAE Waterways Experiment Station was tasked with various monitoring and development projects to further evaluate protection of manatees at water control structures. The USFWS's recommendation to install the devices on a few structures and monitor them for effectiveness will be implemented. The USACE also recommends this same strategy to ensure the ability of the device to prevent future manatee mortalities and to work effectively.

4.6.1.10 Land and Water Conservation Fund Act of 1965, as amended. 16 U.S.C. 4601-4 et seq.

No financial assistance may be given under any other Federal program for any project with respect to which such assistance to a state has been given or promised under this statute. No property acquired or developed with assistance from the Land and Water Conservation Fund shall, without the approval of the Secretary of the Interior, be converted to other than outdoor recreation uses. No implementing directives.

4.6.1.11 Marine Protection, Research, and Sanctuaries Act of 1972, as amended. 33 U.S.C. 1401 et seq.

In connection with Federal projects involving dredged material, the Secretary of the Army may issue permits for the ocean discharge of dredged material, applying the same criteria which apply to EPA issuance of permits for ocean dumping of other material. Executive Order 12088, Federal Compliance with Pollution Control Standards, 13 October 78.

Ocean disposal of dredged material is not proposed. No properties affected by this act are involved in the recommended project area.

4.6.1.12 National Environmental Policy Act of 1969, as amended. 42 U.S.C. 4321 et seq. PL 91-190, as amended

All Federal agencies shall include a detailed Environmental Impact Statement (EIS) in every recommendation or report on proposals for legislation and other major Federal actions significantly affecting the quality of the human environment. Prior to making an EIS, the responsible Federal official shall consult with and obtain comments from any Federal agency which has jurisdiction by law or special expertise with respect to any environmental impact involved. The EIS and comments and views of appropriate Federal state and local agencies which are authorized to develop and enforce environmental standards shall be available to the President, CEQ and the public, and shall accompany the proposal through the existing agency review process. Executive Order 11593, 13 May 71; E.O. 11988, 24 May 77; E.O. 1990, 24 May 1977; E.L. 11991, 24 May 77; E.L. 12088, 13 October 78; E.L. 12114, 4 Jan 79; CEQ Regulations 40 CFR Parts 1500-1508, 29 November 78; CEQ Memorandum 30 August 76.

In consultation with the State of Florida and the U.S. Fish and Wildlife Service the Jacksonville District made a determination that the proposed major Federal action will not significantly affect the human environment. The Draft Integrated Project Modification Report and EA will be submitted to the responsible Federal, State and local officials for comment. The comments will be reviewed and considered during the process of project finalization. The result of the Finding of No Significant Impact is the conclusion that an EIS is not required.

4.6.1.13 National Historic Preservation Act of 1966, as amended. 16 U.S.C. 470 et seq., as amended by PL 102-575, 2 November 92.

The head of any Federal agency having direct or indirect jurisdiction over a proposed Federal or Federally assisted undertaking shall, prior to approving expenditure of any Federal funds on that undertaking, take into account its effect on any district, site, building, structure, or Places. The head of the Federal agency shall afford the Advisory Council on Historic Preservation a reasonable opportunity to comment with regard to such undertaking. Advisory Council on Historic Preservation Regulations, 36 CFR Part 800, 44 F.R. 6068, 30 January 79.

In-house cultural resource analysis and coordination with the Florida State Preservation Officer (SHPO) were completed according to the requirements established in the National Historic Preservation Act, the Archeological and Historic Preservation Act, and 36 CFR Part 800. Coordination of the District's no adverse effect determination is documented in a November 1, 1994 letter from the SHPO, a copy of which was included in Appendix J of the report.

TABLE 5
RELATIONSHIP OF PROPOSED PLAN TO ENVIRONMENTAL STATUTES

Federal Statute	Compliance Status
Archeological and Historic Preservation Act, as amended	In compliance.
National Historic Preservation Act, as amended	In compliance. The SHPO's concurrence is attached to the main document.
Clean Air Act, as amended	In compliance. No adverse effects to air quality. The EA will be coordinated with U.S. Environmental Protection Agency as required by Section 176(c) and 309 of the Act.
Clean Water Act	In compliance. No adverse effects to water quality. The Environmental Assessment was coordinated with State and Federal agencies with regulatory responsibility for the Clean Water Act.
Endangered Species Act of 1973, as amended	Compliance pending formal consultation with the USFWS during Plans and Specifications phase. Informal coordination has occurred throughout the life of the project.
Fish and Wildlife Coordination Act, as amended	In compliance. This project was coordinated with the U.S. Fish and Wildlife Service. A USFWS Coordination Act Report is in Appendix J.
National Environmental Policy Act of 1969, as amended	In compliance. Completion of Environmental Assessment process.
Executive Order 11990 (Protection of Wetlands)	In compliance. No wetlands affected by the project.
Archeological Resources Protection Act	Compliance will be coordinated for each structure during the Plans and Specifications Phase.
Resource Conservation Recovery Act	In compliance.
Comprehensive Environmental Response and Compensation Liabilities Act	In compliance.

SECTION 5

SUMMARY OF PROJECT EFFECTS

5.1 HYDRAULICS

All of the water control structures in this study have been designed as conventional USACE structures. Installation of manatee alarm switches at locks would not appreciably affect the operation of locks. The proposed switch arrangement would have a negligible effect on the pattern of flow entering or leaving the lock chamber.

5.2 WATER MANAGEMENT

The operation of the protection system at sector gate locks involves the triggering of an alarm and cessation of gate movement. The decision of whether to open or close the gates is left to the locktender. Therefore, existing water management plans will not be adversely impacted by the installation of the protection systems. The above analysis, for all proposed manatee sensor devices, assumes that the dewatering and scheduling constraints imposed to meet water management and navigation needs will be adhered to.

5.3 GEOTECHNICAL

The recommended plan will have no adverse effects from a geotechnical perspective.

5.4 MECHANICAL AND ELECTRICAL

The recommended plan will have minimal impact on the existing mechanical and electrical systems at lock structures. The main operating machinery, and the electrical power and distribution system will remain the same. The operation of locks will change as explained in SELECTED PLAN.

The location of all structures is shown on plate ME-1 in Appendix D. Further, Table 1 of Appendix D gives the gate dimensions, number of gates and operational features. The existing mechanical and electrical machinery for each structure is explained in Appendix D. Information on the j-seal piezo-electric film contact sensor system can be found in Appendix I.

5.5 STRUCTURAL

The structural effects associated with attaching the pressure sensitive device system on sector gates will be minimal. The attachment will primarily be accomplished through the use of bolted connections. Stainless steel bolts will be used to help facilitate any future removal that may be required for maintenance and repair.

5.6 REAL ESTATE

The recommended plan will have no adverse effects from a real estate perspective. Due to the requirements of this project, there is no scheduled acquisition of real estate.

5.7 ENVIRONMENTAL EFFECTS

5.7.1 Affected Environment

The study area is the Okeechobee Waterway (OWW) geographical location. The proposed project will impact the following counties within the Okeechobee Waterway area: Glades, Okeechobee, Martin, Hendry and Lee counties. Lake Okeechobee lies at the center of the Okeechobee Waterway. Access to this lake is provided by the St. Lucie Canal, the West Palm Beach Canal, the Hillsboro Canal, the North New River Canal, and the Miami Canal on the east and by the Industrial Canal, the Caloosahatchee River, Fisheating Creek, the Harney Pond Canal, the Indian Prairie Canal, the Kissimmee River and Taylor Creek on the east and to the north. Much of what is known about manatee use of this waterway is restricted to the coastal reaches of this system.

In Martin and Palm Beach counties, manatees are seasonally abundant. Peak numbers are present during the winter season. Winter use patterns are typified by an initial southerly influx of manatees from the north to warm water refugia in south Florida. Manatees wintering at Florida Power and Light's (FPL) Riviera Plant in Palm Beach County generally use the plant during cold days and shift to waters along the Intracoastal Waterway in Martin County on warmer days to forage. In Martin County, based on mortality records, manatees are present year-round; the St. Lucie River and Canal are used throughout the year. Manatees are also present throughout the year in Palm Beach County.

On Florida's west coast, the Caloosahatchee River traverses Lee, Hendry, and Glades counties between Lake Okeechobee and Matlacha Pass in coastal Lee County. Manatee use of this river occurs throughout the year.

Manatee numbers peak during the winter when manatee activity focuses on FPL's Fort Myers Plant near the junction of the Orange River and the Caloosahatchee River. Manatees appear at this warm water refugia primarily from sites located either in coastal Lee County or from areas to the north. The W.P. Franklin Lock, upriver of the plant, is known to offer refuge to wintering manatees. Manatees occasionally seek refuge near the W. P. Franklin Lock where deep waters cool more slowly than waters in the lower Caloosahatchee River in colder times of the year. Subsequent to this event, manatees are occasionally seen resting in the general area of the locks during the winter.

Manatee distribution, abundance, and activity patterns are relatively unknown within the inner reaches of the Okeechobee Waterway. Aerial surveys were flown intermittently over the last 15 years documenting the presence of manatees in the northwest reaches of the Rim Canal in Lake Okeechobee, in the Caloosahatchee River between Moore Haven and La Belle, the upper Caloosahatchee, and at the mouth of Lake Hicpochee.

5.7.1.1 Air Quality

Air quality in the OWW is generally good. There are no non-attainment areas within the vicinity of each installation site.

5.7.1.2 Water Quality

The water quality of Lake Okeechobee is classified as Class I by the State of Florida. This classification identifies Lake Okeechobee as a potable water supply.

5.7.1.3 Cultural, Historic and Archeological Resources

All of the structures which will be modified under the proposed plan are located along the OWW of the C&SF Project area. The majority of the seven structures were built within the last 35 years; however, S-77 was constructed more than 50 years ago. This historic structure contributes to the significance of the OWW and is eligible for inclusion in the National Register of Historic Places as part of the OWW.

5.7.1.4 Aesthetic Resources

Aesthetic resources are defined as "those resources and cultural features of the environment that elicit a pleasurable response" in the observer, most notably from the visual sense. The vast majority of structures proposed for modification for manatee protection devices are located in a rural setting with little or no additional development around them. The main locks on the OWW are the primary exception to this rural setting. These locks are usually found in an area with additional development in the close proximity. These man-made structures contrast with and provide a human scale to the water bodies and vegetation provided by nature.

5.7.1.5 Hazardous, Toxic, and Radiological Wastes

In the vicinity of each of the installation sites, there is no potential for hazardous, toxic, or radiological wastes.

5.7.1.6 Fish and Wildlife Resources

In the Okeechobee Waterway, a variety of fish and wildlife species are expected to be found at the project locations. Typical fish found in the OWW include those usually found in freshwater lakes and streams in Florida: Bass, crappie catfish, sunfish, gar, shad and shiners. A wide variety of bird species inhabit Lake Okeechobee. Wading birds such as herons, egrets, various ibis species, wood storks, bald eagles and many others are also common in the vicinity of the project sites.

5.7.1.7 Endangered and Threatened Species

Endangered and threatened species occurring in and around Lake Okeechobee include the bald eagle, wood stork, Everglades kite, Okeechobee gourd, and Florida manatee. The main species of concern for effects from the proposed project is the Florida manatee (*Trichechus manatus latirostris*). The Florida manatee, due to its habitat requirements can be found in the vicinity of all of the structures addressed in the study.

5.7.1.8 Public Facilities and Services

Each of the structures in the study provides functions and services to the public. The structures found in the OWW all contribute to the overall project purposes of the OWW. Examples of public services that the structures provide include: navigation, flood control, recreation, water supply, and fish and wildlife management. Adjacent to S-77, S-79, and S-308C exist public recreation facilities for outdoor enjoyment and camping.

5.7.2 Environmental Consequences Of Proposed Action

5.7.2.1 Unavoidable Adverse Effects

There are no unavoidable adverse effects due to the selected plan.

5.7.2.2 Relationship Between Short-Term Uses Of The Human Environment And Maintenance And Enhancement Of The Long Term Productivity

The environment at all of the project locations is being protected for long-term use. The proposed action will not have any adverse effects on the long term productivity of the sites.

5.7.2.3 Irreversible or Irretrievable Commitments of Resources

No environmental resources will be permanently removed or altered by the proposed action.

5.7.2.4 Possible Conflicts Between The Proposed Action And The Objectives Of Federal, Regional, State, And Local (Including Indian Tribes) Land Use Plans, Policies, And Controls For The Study Area

No conflicts will result from the implementation of this project. The proposed modifications are in accordance with the planned land use of each project location.

5.7.2.5 Community Growth, Cohesion, and Displacement of People and Businesses

There will be no adverse effects on the community or economy from the implementation of this project.

5.7.2.6 Air Quality

The proposed project will have no impact on the air quality in the respective project areas. A temporary increase in emissions will be due to the mobilization of increased personnel for the installation and monitoring of the structures and devices.

5.7.2.7 Water Quality

The proposed project will have no adverse effects on the water quality at each of the seven project sites. There will be no impact on the substrate adjacent to each lock and spillway since device installation will occur on a previously constructed spillway gate. Dewatering will be required at several structures, but will most likely be coordinated during annual maintenance periods. Temporary dewatering (estimated to take one month) will have no adverse effects on the water quality of the OWW system.

5.7.2.8 Cultural, Historic, and Archeological Resources

Manatee protection devices will be added to the existing sector lock gates. No historic material will be removed or altered by the installation. It is the Jacksonville District's determination that significant cultural resources will not be adversely affected by the installation of the manatee protection devices, as proposed. This determination was coordinated with the Florida State Historic Preservation Officer (SHPO). In a November 1, 1994 letter, the SHPO concurred with the District determination. A copy of this letter is included in Appendix J of the main report.

5.7.2.9 Aesthetic Resources

During modification of the structures to install the manatee protection devices, the gate areas will be dewatered. Dewatering occurs intermittently during scheduled maintenance on these structures. Therefore, dewatering will not be an unusual event and will not take any longer to accomplish than routine maintenance. No unusual noise, air quality or water quality conditions will exist during the time the structures are dewatered. Almost all of the protection devices will be located below the water surface at the gate structures and will not be visible. Once the project modifications have been completed, only close observation will detect the manatee protection devices in place. Therefore, the devices will have no impact upon the aesthetics of the area.

5.7.2.10 Noise

The existing noise levels in and around the lock structures are contributed to by both the sector gate operations and the boat traffic utilizing the locks. The installation of pressure sensitive and hydroacoustic devices at the locks will not significantly add to the existing noise levels. Specifically, the proposed hydroacoustic ladder array device is intended to be set so that the beams are running at a frequency of 1 MHz. This should keep the audio input well out of the range of a manatee's hearing. According to ongoing research being conducted by Edward Gerstein of the Florida Atlantic University's (FAU) Psychology Department at the Lowry Park Manatee Tanks of Tampa, the hearing range of manatees is between 500 Hz and 40 kHz. The optimum hearing range is between 6 and 20 kHz (per telephone correspondence). This data has been published as a master's thesis and is available at the FAU library. Final results of the study were completed in 1995 and are currently under review for publishing in a technical journal. There may also be some temporary increases in noise levels during the installation period; however, these increases in noise levels will be minor and of very short duration. Thus, it is our determination that the recommended plan in this study will have no adverse impacts on the noise levels of the lock environment.

5.7.2.11 Hazardous, Toxic, and Radiological Wastes

There is no potential for any effects on the environment from Hazardous, Toxic and Radiological Wastes. Toxic and Radiological wastes will not be used in the construction of the project and are not present at any of the installation sites. Hazardous material use will be minimal (limited to items such as gasoline for the trucks carrying construction personnel, any metal shavings from drilling, etc.). All material will be segregated and handled in accordance with the Site Safety and Health Plan (SSHP).

5.7.2.12 Fish and Wildlife Resources

There will be no adverse effects to the fish and wildlife resources as a result of this project. Dewatering for the installation of the sensing devices will displace fish and wildlife species temporarily; however, the habitat area will be restored within one month. Fish and wildlife species are expected to reinhabit the lock areas immediately after restoration.

5.7.2.13 Endangered and Threatened Species

Although many endangered and threatened species are present in the OWW system, the only species the project could potentially affect is the manatee. Manatees utilize the OWW for travel, resting, and foraging routes. Their presence in the project locations has necessitated the implementation of this project. Many measures (i.e. Contingency planning, model testing, dry testing, monitoring, etc.) will be implemented by the USACE and SFWMD to ensure that no adverse effects to the manatee will result from this project. The Federal and State "Standard Manatee Construction Precautions" will be strictly followed. This project is expected to improve the manatee's ability to travel through the OWW and the C&SF Project area unharmed. The pressure sensitive and hydroacoustic devices to be installed at the selected structures in this study were designed to decrease risk and mortalities of manatees at water control structures.

During the construction period, a 24 hour manatee watch will be followed. Before dewatering or construction is initiated, the area will be checked for manatees. Standard State and Federal manatee construction precautions will be instituted.

Following the installation of the devices, dry testing of the system with manatee models will be required of the Contractor by the government. Models will be situated along gate edges and the sensors verified by activating the gate closing operation. Once the dry testing is complete, testing of the system will be included in the daily operational instructions at each structure. Reliability testing of each system on a biannual basis (or other required intervals) will be performed. Regularly scheduled O&M will involve repairing/replacing the system parts which are subject to wear to ensure the system is functional to provide for the consistent protection of manatees.

In order to protect the manatee population should a system fail, the USACE has developed operating contingency plans for the operation of their respective structures. The plan is in Appendix C. This plan provides policies, guidelines, and operating procedures for the effective long-term management and operation of water control structures to minimize manatee mortality. These procedures will be strictly followed if a device fails at a structure.

There will be no adverse effects to the manatee as a result of the implementation of this project. The project will, in fact, improve the manatee's ability to navigate within its natural habitat without harm.

5.7.2.14 Public Facilities and Services

Public services provided by the canal systems and the locks will not be adversely impacted by the project. Temporary closure of these structures (estimated at one month per structure) will occur in order to install the systems. Boaters will be routed through other canals and rivers while each structure is retrofitted. Use of recreational areas adjacent to the S-77, S-79, and S-308C will not be curtailed, unless the area is required for temporary staging of construction material. In most cases, if staging is necessary in these areas, only a portion of the recreational area will be closed.

5.7.2.15 Cumulative Effects

There will be no cumulative adverse effects expected from the proposed project. The installation of pressure sensitive and hydroacoustic devices at all the structures in the study is expected to have an overall positive effect on manatee populations. Manatees will be able to reproduce, travel, and feed in their habitat without risk of mortality caused by water control structures.

SECTION 6

CONCLUSIONS

The four alternatives selected for study were evaluated on the basis of environmental benefits and project goals met. Plan 4 was determined to be the most effective plan producing the greatest environmental benefits, as required under Federal guidelines for water resources development.

Plan 4 consists of the implementation of operational changes and the phased installation of a manatee protection system on selected sector lock gates at seven water control structures in Central and Southern Florida. In the recommended plan, an operational protocol was devised for locks as specified in the Manatee Protection Plan for Water Control Structures; and the acoustical ladder array and pressure sensitive device system were selected to be installed on selected water control structure gates. The non-Federal sponsor supports the use of piezo-electric film technology in the hydroacoustic and pressure sensitive device manatee protection systems.

This plan is in the best overall public interest and is the most beneficial environmental plan for implementation. Since the second highest source of human-related manatee mortality was attributable to water control structures, the project will promote the recovery of the endangered species. There will be substantial environmental benefits by protecting manatees and reducing manatee injury and mortality at sector gate locks.

This plan meets the designated criteria for participation by the Federal Government in project modifications for improving the quality of the environment. It also conforms to the guidelines for Federal water resource project development as provided under the Principles and Guidelines. There are no identified plans which are more cost efficient, address the primary study objectives, and achieve significant manatee protection at the selected navigation and water control structures. The effects of the proposed plan are deemed beneficial overall and the plan is considered to be in full compliance with all pertinent environmental statutes as well as other Federal laws and directives regarding water resource project development.

Pertinent economic cost estimates for the recommended plan are as follows:

Estimated Federal Cost	$1,811,000
Estimated Non-Federal Cost	$196,000
Total Estimated Cost:	$2,007,000

Based on an analysis of overall economic, environmental, and social aspects, the above plan was found to be in the Federal interest and justified for implementation. Therefore, this project modification plan for manatee protection at selected navigation and water control structures is recommended for approval for Federal construction.

SECTION 7

RECOMMENDATIONS

I have weighed the accomplishments to be obtained from the proposed project modification manatee protection plan at select navigation and water control structures in the Central and Southern Florida Project area against project costs and have considered the alternatives, effects, and scope of the proposed project. In my judgment, the proposed project is a justified expenditure of Federal funds. I recommend that the Secretary of the Army approve the Manatee Protection Plan, Part II. The total estimated cost of the project is $2,007,000 (of which $1,811,000 would be the Federal cost). The remaining $196,000 would be non-Federal funds provided by South Florida Water Management District. I further recommend that funds be allocated to initiate preparation of plans and specifications.

a. The sharing of costs between the Federal Government and non-Federal interests for the recommended plan is contained in the authorization of Section 203 of the Flood Control Act of 1948 and Section 203 of the Flood Control Act of 1958. The above recommendations are made with the provision that prior to project implementation, the non-Federal sponsor shall enter into a binding agreement with the Secretary of the Army or his designated representative to provide 15 Percent of total project costs for modifications to structure S-193; 20 Percent of the total project costs for the modifications to structures S-310, W.P. Franklin Lock, and Port Mayaca Lock; and 0 Percent of total project costs at the Moore Haven, Ortona and St. Lucie locks, since these locks were built by the USACE with 100% Federal funds.

b. Provide all land, easements, and rights-of-way necessary for the implementation, operation, and maintenance of the Project Modification, when and as required;

c. For so long as the Project Modification remains authorized, operate, maintain, repair, replace, and rehabilitate the completed Project Modification, or functional portion of the Project Modification at structures operated by the non-Federal sponsor, at no cost to the Federal Government. The non-Federal sponsor will be responsible for operations and maintenance of structures operated by the non-Federal sponsor, and the Federal Government will be responsible for operations and maintenance of structures operated by the Federal Government;

d. Give the Federal Government a right to enter, at reasonable times and in a reasonable manner, upon property that the non-Federal sponsor, now or hereafter, owns or controls for access to the Project Modification for the purpose of inspection, and, if necessary after failure to perform by the non-Federal sponsor for the purpose of completing, operating, maintaining, replacing, or rehabilitating the Project Modification;

e. Hold and save the United States free from damages due to the construction, operation, and maintenance of the project works;

f. Assume financial responsibility for all costs incurred in cleanup of hazardous materials located on project lands covered under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), for which no cost sharing credit shall be given, and operate, maintain, repair, replace, and rehabilitate the project in a manner that liability will not arise under CERCLA.

The recommendations contained herein reflect information available at this time and current Departmental policies governing formulation of individual projects. Consequently, the recommendations may be modified before they are approved for implementation.

Richard E. Bonner

for Terry L. Rice
Colonel, U.S. Army
District Engineer

SECTION 8

REFERENCES

ACOUSTIC CURTAIN MANATEE DETECTION SYSTEM FOR LAKE OKEECHOBEE SECTOR GATES. CONTRACT SUMMARY REPORT SUBMITTED TO USAE WATERWAYS EXPERIMENT STATION FOR CONTRACT #DACW39-95-M-4194, December 1995 Harbor Branch Oceanographic Institution. 1995.

DRAFT WATER CONTROL MANUAL, EAST COAST CANALS. Central and Southern Florida Project for Flood Control and Other Purposes. U.S. Army Corps of Engineers, Jacksonville District, June 1992.

DRAFT EVALUATION OF HYDROACOUSTIC TECHNIQUES FOR DETECTING MANATEES AT WATER CONTROL STRUCTURES. U.S. Army Corps of Engineers Waterways Experiment Station, February 1996.

FINAL ENVIRONMENTAL IMPACT STATEMENT SOUTH DADE CONVEYANCE CANALS AND EAST COAST BACKPUMPING (CENTRAL AND SOUTHERN FLORIDA). U.S. Army Corps of Engineers, Jacksonville District, June 1975.

LAKE OKEECHOBEE IMPLEMENTATION OF 15.65 TO 16.75 (RUN 25) REGULATION SCHEDULE. Environmental Assessment, U.S. Army Corps of Engineers, Jacksonville District, September 1994.

MANATEE DETECTION SYSTEM FOR LAKE OKEECHOBEE SECTOR GATES. CONTRACT SUMMARY REPORT SUBMITTED TO SOUTH FLORIDA WATER MANAGEMENT DISTRICT. Harbor Branch Oceanographic Institution, August 1995.

MANATEE PROTECTION PLAN AT SELECTED NAVIGATION AND WATER CONTROL STRUCTURES (PART I) IN CENTRAL AND SOUTHERN FLORIDA FINAL PROJECT MODIFICATION REPORT AND ENVIRONMENTAL ASSESSMENT. U.S. Army Corps of Engineers, Jacksonville District, September 1995, Revised March 1996.

MANATEE RECOVERY PLAN. U.S. Fish and Wildlife Service, Atlanta, Georgia, 1989.

MANATEE TECHNICAL ADVISORY COUNCIL UPDATE ed. by Kipp Frolich and Bonnie J. Abellera. Florida Department of Environmental Protection, January - March 1996.

MARINE MAMMAL COMMISSION ANNUAL REPORT TO CONGRESS 1996, Marine Mammal Commission, January 1997

RARE AND ENDANGERED BIOTA OF FLORIDA Vol.I Mammals ed. by Stephen R. Humphrey, University Press of Florida Gainesville, 1992.

SFWMD MANATEE MORTALITY REPORT FDEP Case Numbers MSE 9414 and MSW 9418. South Florida Water Management District, September 1995.

LIST OF PREPARERS

The following persons were responsible for the evaluation and contents of this Environmental Assessment:

Preparer's Name	Expertise	Responsibility
Kimberly Koelsch/ Therese Fretwell	Biologists	EA preparation/ Principal Compilers
Amy Hill	Civil Engineer	Study Manager
Melissa Dollar	Civil Engineer	Project Manager
Janice Adams	Archeologist	Cultural Resources
Annon Bozeman	Outdoor Recreation Planner	Aesthetics, Recreation
Eric Holand	Hydraulic Engineer	Hydrology and Hydraulics
Adam Stuart	Hydraulic Engineer	Water Management Effects
Shashi Makker	Electrical Engineer	Design
Dick Grollo	Mechanical Engineer	Design
Brent Trauger	Civil Engineer	Design
Donnie Kinard	Biologist	Construction Operations
Dena Dickerson	Biologist	Hydroacoustics

APPENDIX A

TABLE A-1

ESTIMATED COST FOR PLANS & SPECIFICATIONS

ITEM	ESTIMATED COST
Hydraulic Design and Water Management	$10,000
Structures	$24,000
Mechanical and Electrical	$75,000
Specifications	$90,500
Geotechnical	$3,000
Cost Engineering	$20,000
Real Estate	$2,500
Planning	$21,000
Total, Plans & Specifications	$246,000

APPENDIX B

MANATEE PROTECTION
CENTRAL AND SOUTH FLORIDA

Designed By: JACKSONVILLE DISTRICT OFFICE
Estimated By: E.P.C.

Prepared By: E.P.CAMPA

Preparation Date: 06/05/96
Effective Date of Pricing: 08/30/94

Sales Tax: 6.00%

This report is not copyrighted, but the information contained herein is For Official Use Only.

ADVANCE COPY
SUBJECT TO CORRECTION

PRELIMINARY

SUMMARY REPORTS SUMMARY PAGE

DETAILED ESTIMATE DETAIL PAGE

No Backup Reports...

* * * END TABLE OF CONTENTS * * *

** PROJECT OWNER SUMMARY - Contract **

	QUANTITY UOM	CONTRACT	CONTING	TOTAL COST	UNIT COST
05 HYDRAULIC HOSE SENSOR		244,783	36,717	281,500	
06 PIEZO - ELECTRIC FILM SENSOR		304,663	45,699	350,363	
07 PIEZO ELEC.ACOUSTIC LADDER ARRAY		585,819	87,873	673,692	
TOTAL MANATEE PROTECTION		1,135,266	170,290	1,305,555	

** PROJECT INDIRECT SUMMARY - Contract **

	QUANTITY UOM	DIRECT	OVERHEAD	HOME OF	PROFIT	BOND	TOTAL COST	UNIT COST
05 HYDRAULIC HOSE SENSOR		192,409	15,393	14,546	20,011	2,424	244,783	
06 PIEZO - ELECTRIC FILM SENSOR		239,478	19,158	18,105	24,907	3,016	304,663	
07 PIEZO ELEC.ACOUSTIC LADDER ARRAY		460,477	36,838	34,812	47,891	5,800	585,819	
MANATEE PROTECTION		892,364	71,389	67,463	92,809	11240	1,135,266	
CONTING							170,290	
TOTAL INCL OWNER COSTS							1,305,555	

** PROJECT DIRECT SUMMARY - Contract **

	QUANTITY UOM	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
05 HYDRAULIC HOSE SENSOR		113,889	5	78,516	0	192,409	
06 PIEZO - ELECTRIC FILM SENSOR		157,389	0	82,089	0	239,478	
07 PIEZO ELEC.ACOUSTIC LADDER ARRAY		188,829	0	271,648	0	460,477	
MANATEE PROTECTION		460,107	5	432,252	0	892,364	
OVERHEAD						71,389	
SUBTOTAL						963,753	
HOME OFC						67,463	
SUBTOTAL						1,031,216	
PROFIT						92,809	
SUBTOTAL						1,124,025	
BOND						11,240	
TOTAL INCL INDIRECTS						1,135,266	
CONTING						170,290	
TOTAL INCL OWNER COSTS						1,305,555	

05. HYDRAULIC HOSE SENSOR

05- A. CONSTRUCTION	QUANTY UOM	CREW ID	OUTPUT	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
05. HYDRAULIC HOSE SENSOR									
05- A. CONSTRUCTION									
05- A/01. ST. LUCIE LOCK									
USR AA 3 " FLAT BAR S.S. W/BOLT				118.00	0.33	195.04	0.00	313.37	
S	2.00 EA		0.00	236	1	390	0	627	313.37
USR AA FLEXIBLE HYDRAULIC TUBE				4.00	0.00	40.28	0.00	44.28	
15 LFEA	30.00 LF		0.00	120	0	1,208	0	1,328	44.28
USR AA BELLS AND WHISTLES,				181.00	0.00	760.02	0.00	941.02	
INCLUDES INDICATING PANEL,FLASHING LIGHT,AND ALARM HORN	1.00 LS		0.00	181	0	760	0	941	941.02
USR AA MISC S.S. FITTING				30.00	0.00	15.90	0.00	45.90	
	20.00 EA		0.00	600	0	318	0	918	45.90
USR AA CABLE				0.46	0.00	0.47	0.00	0.93	
	300.00 LF		0.00	138	0	140	0	278	0.93
USR AA PVC CONDUIT 1/2" SCH 40				4.34	0.00	2.70	0.00	7.04	
	300.00 LF		0.00	1,302	0	811	0	2,113	7.04
USR AA JUNCTION BOX				150.00	0.00	1959.94	0.00	2109.94	
INCLUDES GAGE,ACCUMLATOR ,AND ELEC/HYD SWITCH	2.00 EA		0.00	300	0	3,920	0	4,220	2109.94
USR AA DEWATER LOCK				6000.00	0.00	0.00	0.00	6000.00	
	1.00 EA		0.00	6,000	0	0	0	6,000	6000.00
USR AA HYD SENSOR TUDE one each				4.00	0.00	85.39	0.00	89.39	
end	60.00 LF		0.00	240	0	5,124	0	5,364	89.39
USR AA CONTROL RM PANEL W/ INTE				800.00	0.00	59.36	0.00	859.36	
RFACE 2 ELECTRICIANS X 1 DAY=16MHRSX $50 =$800	1.00 EA		0.00	800	0	59	0	859	859.36
USR AA TESTING				1600.00	0.00	0.00	0.00	1600.00	
	1.00 EA		0.00	1,600	0	0	0	1,600	1600.00
USR AA LIMIT SWITCH & CONTROLS/				750.00	0.00	265.00	0.00	1015.00	
GATE ZOG	2.00 EA		0.00	1,500	0	530	0	2,030	1015.00

05. HYDRAULIC HOSE SENSOR

05- A. CONSTRUCTION	QUANTY	UOM	CREW ID	OUTPUT	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
USR AA MISC LABOR					2000.00	0.00	0.00	0.00	2000.00	
	1.00	LS		0.00	2,000	0	0	0	2,000	2000.00
TOTAL ST. LUCIE LOCK					15,017	1	13,260	0	28,278	
05- A/02. PORT MAYACA LOCK										
USR AA 3 " S.S FLAT BAR W/ BOLT					118.00	0.33	206.74	0.00	325.07	
S	2.00	EA		0.00	236	1	413	0	650	325.07
USR AA FLEXIBLE HYDRAULIC TUBE					4.00	0.00	40.28	0.00	44.28	
	30.00	LF		0.00	120	0	1,208	0	1,328	44.28
USR AA BELLS AND WHISTLES					181.00	0.00	760.02	0.00	941.02	
INCLUDES INDICATING PANEL,FLASHING LIGHTS,ALARM HORN	1.00	LS		0.00	181	0	760	0	941	941.02
USR AA MISC S.S. FITTING					30.00	0.00	15.90	0.00	45.90	
	20.00	EA		0.00	600	0	318	0	918	45.90
USR AA CABLE					0.46	0.00	0.47	0.00	0.93	
	450.00	LF		0.00	207	0	210	0	417	0.93
USR AA PVC CONDUIT 1/2" SCH 40					4.34	0.00	2.70	0.00	7.04	
	450.00	LF		0.00	1,953	0	1,216	0	3,169	7.04
USR AA JUNCTION BOX					150.00	0.00	1959.94	0.00	2109.94	
INCLUDES GAGE, ACCUMULAT OR AND HYD/ELEC SWITCH	2.00	EA		0.00	300	0	3,920	0	4,220	2109.94
USR AA HYD SENSOR TUDE ONE EACH					4.00	0.00	90.51	0.00	94.51	
END	60.00	LF		0.00	240	0	5,431	0	5,671	94.51
USR AA DIVERS TO INSTALL					50.00	0.00	0.00	0.00	50.00	
3 DIVERS X 72HRS =216MHR S X $50= 10,800	216.00	HRS		0.00	10,800	0	0	0	10,800	50.00
USR AA CONTROL ROOM PANEL W/ IN					800.00	0.00	59.36	0.00	859.36	
TERFACE	1.00	EA		0.00	800	0	59	0	859	859.36
USR AA TESTING					1600.00	0.00	0.00	0.00	1600.00	
	1.00	LS		0.00	1,600	0	0	0	1,600	1600.00

05. HYDRAULIC HOSE SENSOR

05- A. CONSTRUCTION	QUANTY	UOM	CREW ID	OUTPUT	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
USR AA LIMIT SWTCH & CTRLS FOR					750.00	0.00	265.00	0.00	1015.00	
GATE ZON	2.00	EA		0.00	1,500	0	530	0	2,030	1015.00
USR AA MISC LABOR					2000.00	0.00	0.00	0.00	2000.00	
	1.00	LS		0.00	2,000	0	0	0	2,000	2000.00
TOTAL PORT MAYACA LOCK					20,537	1	14,066	0	34,604	
05- A/03. MOORE HAVEN LOCK										
USR AA 3" FLAT BAR S.S. W/ BOLT					118.00	0.33	195.04	0.00	313.37	
S	2.00	EA		0.00	236	1	390	0	627	313.37
USR AA FLEXIBLE HYDRAULIC TUBE					4.00	0.00	40.28	0.00	44.28	
	30.00	LF		0.00	120	0	1,208	0	1,328	44.28
USR AA BELLS AND WHISTLES					181.00	0.00	760.02	0.00	941.02	
INCLUDES INDICATING PANE	1.00	LS		0.00	181	0	760	0	941	941.02
L										
FLASHING LIGHT, ALARM HORN										
USR AA MISC S.S. FITTING					30.00	0.00	15.90	0.00	45.90	
	20.00	EA		0.00	600	0	318	0	918	45.90
USR AA CABLE					0.46	0.00	0.47	0.00	0.93	
	300.00	LF		0.00	138	0	140	0	278	0.93
USR AA PVC CONDUIT 1/2" SCH 40					4.34	0.00	2.70	0.00	7.04	
	300.00	LF		0.00	1,302	0	811	0	2,113	7.04
USR AA JUNCTION BOX					150.00	0.00	1959.94	0.00	2109.94	
INCLUDES GAGE, ACCUMULAT	2.00	EA		0.00	300	0	3,920	0	4,220	2109.94
OR AND										
HYD/ELEC SWITCH										
USR AA DEWATER LOCK					6000.00	0.00	0.00	0.00	6000.00	
	1.00	EA		0.00	6,000	0	0	0	6,000	6000.00
USR AA HYD SENSOR TUBE ONE EACH					4.00	0.00	85.39	0.00	89.39	
END	30.00	LF		0.00	120	0	2,562	0	2,682	89.39
USR AA CONTROL ROOM PANEL W/ IN					800.00	0.00	59.36	0.00	859.36	
TERFACE	1.00	EA		0.00	800	0	59	0	859	859.36

05. HYDRAULIC HOSE SENSOR

05- A. CONSTRUCTION	QUANTY	UOM	CREW ID	OUTPUT	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
USR AA TESTING					1600.00	0.00	0.00	0.00	1600.00	
	1.00	LS		0.00	1,600	0	0	0	1,600	1600.00
USR AA LIMIT SMTCH/CTRS FOR GAT					750.00	0.00	265.00	0.00	1015.00	
E ZONING	2.00	EA		0.00	1,500	0	530	0	2,030	1015.00
USR AA MISC LABOR					2000.00	0.00	0.00	0.00	2000.00	
	1.00	LS		0.00	2,000	0	0	0	2,000	2000.00
TOTAL MOORE HAVEN LOCK					14,897	1	10,698	0	25,596	
05- A/04. ORTONA LOCK										
USR AA 3" S.S. FLAT BAR W/ BO					118.00	0.33	195.04	0.00	313.37	
LTS	2.00	EA		0.00	236	1	390	0	627	313.37
USR AA FLEXIBLE HYDRAULIC TUBE					4.00	0.00	40.28	0.00	44.28	
	30.00	LF		0.00	120	0	1,208	0	1,328	44.28
USR AA BELLS AND WHISTLES					181.00	0.00	760.02	0.00	941.02	
INCLUDES INDICATING PANEL,FLASHING LIGHT, ALARM HORN	1.00	LS		0.00	181	0	760	0	941	941.02
USR AA MISC S.S. FITTING					30.00	0.00	15.90	0.00	45.90	
	20.00	EA		0.00	600	0	318	0	918	45.90
USR AA CABLE					0.46	0.00	0.47	0.00	0.93	
	300.00	LF		0.00	138	0	140	0	278	0.93
USR AA PVC CONDUIT 1/2" SCH 40					4.34	0.00	2.70	0.00	7.04	
	300.00	LF		0.00	1,302	0	811	0	2,113	7.04
USR AA JUNCTION BOX					150.00	0.00	1959.94	0.00	2109.94	
INCLUDES GAGE,ACCUMULATO R, AND HYD/ELEC SWITCH	2.00	EA		0.00	300	0	3,920	0	4,220	2109.94
USR AA DEWATER LOCK					6000.00	0.00	0.00	0.00	6000.00	
	1.00	EA		0.00	6,000	0	0	0	6,000	6000.00
USR AA HYD SENSOR TUBE ONE EACH					4.00	0.00	85.39	0.00	89.39	
END	30.00	LF		0.00	120	0	2,562	0	2,682	89.39
USR AA CONTROL RM PANEL W/ INTE					800.00	0.00	59.36	0.00	859.36	
RFACE	1.00	EA		0.00	800	0	59	0	859	859.36

05. HYDRAULIC HOSE SENSOR

05- A. CONSTRUCTION	QUANTY UOM	CREW ID	OUTPUT	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
USR AA TESTING				1600.00	0.00	0.00	0.00	1600.00	
	1.00 LF		0.00	1,600	0	0	0	1,600	1600.00
USR AA LIMIT SWTCH/CTRLS FOR GA				750.00	0.00	265.00	0.00	1015.00	
TE ZONIG	2.00 EA		0.00	1,500	0	530	0	2,030	1015.00
USR AA MISC LABOR				2000.00	0.00	0.00	0.00	2000.00	
	1.00 LS		0.00	2,000	0	0	0	2,000	2000.00
TOTAL ORTONA LOCK				14,897	1	10,698	0	25,596	
05- A/05. W.P.FRANKLIN LOCK									
USR AA 3" S.S. FLAT BAR W/BOLT				118.00	0.33	195.04	0.00	313.37	
S	2.00 EA		0.00	236	1	390	0	627	313.37
USR AA FLEXIBLE HYDRAULIC TUBE				4.00	0.00	40.28	0.00	44.28	
	34.00 LF		0.00	136	0	1,370	0	1,506	44.28
USR AA BELLS AND WHISTLES				181.00	0.00	760.02	0.00	941.02	
INCLUDES INDICATING	1.00 LS		0.00	181	0	760	0	941	941.02
PANEL,FLASHING LIGHT,ALARM HORN									
USR AA MISC S.S. FITTING				30.00	0.00	15.90	0.00	45.90	
	20.00 EA		0.00	600	0	318	0	918	45.90
USR AA HYD SENSOR TUBE ONE EACH				4.00	0.00	85.39	0.00	89.39	
END	34.00 LF		0.00	136	0	2,903	0	3,039	89.39
USR AA CABLE				0.46	0.00	0.47	0.00	0.93	
	500.00 LF		0.00	230	0	233	0	463	0.93
USR AA PVC CONDUIT 1/2" SCH 40				4.34	0.00	2.70	0.00	7.04	
	500.00 LF		0.00	2,170	0	1,352	0	3,522	7.04
USR AA JUNCTION BOX				150.00	0.00	1959.94	0.00	2109.94	
INCLUDES GAGE,ACCUMULATO	2.00 EA		0.00	300	0	3,920	0	4,220	2109.94
R AND									
HYD/ELEC SWITCH									
USR AA DEWATER LOCK				6000.00	0.00	0.00	0.00	6000.00	
	1.00 EA		0.00	6,000	0	0	0	6,000	6000.00
USR AA CONTROL RM PANEL W/INTER				800.00	0.00	59.36	0.00	859.36	
FACE	1.00 EA		0.00	800	0	59	0	859	859.36

05. HYDRAULIC HOSE SENSOR

05- A. CONSTRUCTION	QUANTY UOM	CREW ID	OUTPUT	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
USR AA TESTING				1600.00	0.00	0.00	0.00	1600.00	
	1.00 LS		0.00	1,600	0	0	0	1,600	1600.00
USR AA LIMIT SWTCH/CTRLS FOR GA				750.00	0.00	265.00	0.00	1015.00	
TE ZONIN	2.00 EA		0.00	1,500	0	530	0	2,030	1015.00
USR AA MISC LABOR				2000.00	0.00	0.00	0.00	2000.00	
	1.00 LS		0.00	2,000	0	0	0	2,000	2000.00
TOTAL W.P.FRANKLIN LOCK				15,889	1	11,835	0	27,725	
05- A/06. S-193 LOCK									
USR AA 3" S.S. FLAT BAR W/BOL				118.00	0.33	206.74	0.00	325.07	
TS	2.00 EA		0.00	236	1	413	0	650	325.07
USR AA FLEXIBLE HYDRAULIC TUBE				4.00	0.00	40.28	0.00	44.28	
	20.00 LF		0.00	80	0	806	0	886	44.28
USR AA BELLS AND WHISTLES				181.00	0.00	760.02	0.00	941.02	
INCLUDES INDICATING	1.00 LS		0.00	181	0	760	0	941	941.02
PANEL,FLASHING LIGHTS,ALARM									
HORN									
USR AA MISC S.S. FITTING				30.00	0.00	15.90	0.00	45.90	
	20.00 EA		0.00	600	0	318	0	918	45.90
USR AA HYD TUBE SENSOR ONE EACH				4.00	0.00	90.51	0.00	94.51	
END	20.00 LF		0.00	80	0	1,810	0	1,890	94.51
USR AA CABLE				0.46	0.00	0.47	0.00	0.93	
	120.00 LF		0.00	55	0	56	0	111	0.93
USR AA PVC CONDUIT 1/2" SCH 40				4.34	0.00	2.70	0.00	7.04	
	120.00 LF		0.00	521	0	324	0	845	7.04
USR AA JUNCTION BOX				150.00	0.00	1959.94	0.00	2109.94	
INCLUDES GAGE,ACCUMULATO	1.00 EA		0.00	150	0	1,960	0	2,110	2109.94
R, HYD/									
ELEC SWITCH									
USR AA DIVERS TO INSTALL				50.00	0.00	0.00	0.00	50.00	
3 DIVERS X72HRS =216 MHR	216.00 HRS		0.00	10,800	0	0	0	10,800	50.00
S X $50									
= $10,800									

05. HYDRAULIC HOSE SENSOR

05- A. CONSTRUCTION	QUANTY	UOM	CREW ID	OUTPUT	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
USR AA CONTROL RM PANEL W/INTER					800.00	0.00	59.36	0.00	859.36	
FACE	1.00	EA		0.00	800	0	59	0	859	859.36
USR AA TESTING					1600.00	0.00	0.00	0.00	1600.00	
	1.00	LS		0.00	1,600	0	0	0	1,600	1600.00
USR AA LIMIT SWTHS/CTRLS FOR GA					750.00	0.00	265.00	0.00	1015.00	
TE ZONIN	2.00	EA		0.00	1,500	0	530	0	2,030	1015.00
USR AA MISC LABOR					2000.00	0.00	0.00	0.00	2000.00	
	1.00	LS		0.00	2,000	0	0	0	2,000	2000.00
TOTAL S-193 LOCK					18,603	1	7,037	0	25,641	
05- A/07. S-310 LOCK										
USR AA 3" S.S. FLAT BAR W/BOLT					118.00	0.33	195.04	0.00	313.37	
S	2.00	EA		0.00	236	1	390	0	627	313.37
USR AA FLEXIBLE HYDRAULIC TUBE					4.00	0.00	40.28	0.00	44.28	
	20.00	LF		0.00	80	0	806	0	886	44.28
USR AA BELLS AND WHISTLES					181.00	0.00	760.02	0.00	941.02	
INCLUDES INDICATING	1.00	LS		0.00	181	0	760	0	941	941.02
PANEL,FLASHING LIGHT,AND ALARM										
HORN										
USR AA MISC S.S. FITTING					30.00	0.00	15.90	0.00	45.90	
	20.00	EA		0.00	600	0	318	0	918	45.90
USR AA CABLE					0.46	0.00	0.47	0.00	0.93	
	120.00	LF		0.00	55	0	56	0	111	0.93
USR AA PVC CONDUIT 1/2" SCH 40					4.34	0.00	2.70	0.00	7.04	
	120.00	LF		0.00	521	0	324	0	845	7.04
USR AA JUNCTION BOX					150.00	0.00	1959.94	0.00	2109.94	
INCLUDES GAGE,ACCUMULATO	2.00	EA		0.00	300	0	3,920	0	4,220	2109.94
R,AND										
HYD/ELEC SWITCH										
USR AA DEWATER LOCK					6000.00	0.00	0.00	0.00	6000.00	
	1.00	EA		0.00	6,000	0	0	0	6,000	6000.00
USR AA HYD SENSOR TUBE ONE EACH					4.00	0.00	85.39	0.00	89.39	
END	44.00	LF		0.00	176	0	3,757	0	3,933	89.39

05. HYDRAULIC HOSE SENSOR

05- A. CONSTRUCTION	QUANTY	UOM	CREW ID	OUTPUT	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
USR AA CONTROL RM PANEL W/INTER					800.00	0.00	59.36	0.00	859.36	
FACE	1.00	EA		0.00	800	0	59	0	859	859.36
USR AA TESTING					1600.00	0.00	0.00	0.00	1600.00	
	1.00	LS		0.00	1,600	0	0	0	1,600	1600.00
USR AA LIMIT SWTHS/CTRS FOR GAT					750.00	0.00	265.00	0.00	1015.00	
E ZONING	2.00	EA		0.00	1,500	0	530	0	2,030	1015.00
USR AA MISC LABOR					2000.00	0.00	0.00	0.00	2000.00	
	1.00	LS		0.00	2,000	0	0	0	2,000	2000.00
TOTAL S-310 LOCK					14,049	1	10,921	0	24,970	
TOTAL CONSTRUCTION					113,889	5	78,516	0	192,409	
05- B. NON-CONSTRUCTION										
TOTAL NON-CONSTRUCTION					0	0	0	0	0	
TOTAL HYDRAULIC HOSE SENSOR					113,889	5	78,516	0	192,409	

06- A. CONSTRUCTION	QUANTY	UOM	CREW ID	OUTPUT	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
06. PIEZO - ELECTRIC FILM SENSOR										
06- A. CONSTRUCTION										
06- A/01. ST. LUCIE LOCK										
USR AA FILM					0.00	0.00	2809.00	0.00	2809.00	
	1.00	LS		0.00	0	0	2,809	0	2,809	2809.00
USR AA POTTING COMPOUND					0.00	0.00	674.16	0.00	674.16	
	1.00	LS		0.00	0	0	674	0	674	674.16
USR AA ELECTRICAL SENSOR CABLE					0.00	0.00	246.98	0.00	246.98	
	1.00	LS		0.00	0	0	247	0	247	246.98
USR AA CABLE CONNECTORS					500.00	0.00	1696.00	0.00	2196.00	
	1.00	LS		0.00	500	0	1,696	0	2,196	2196.00
USR AA SENSOR CONDITIONER MODUL					500.00	0.00	1547.60	0.00	2047.60	
E	1.00	LS		0.00	500	0	1,548	0	2,048	2047.60
USR AA CABLE TO CONTROL RM 1000					1000.00	0.00	1187.20	0.00	2187.20	
SPOOL	1.00	LS		0.00	1,000	0	1,187	0	2,187	2187.20
USR AA CABLE TIES,FITTING ETC					400.00	0.00	795.00	0.00	1195.00	
	1.00	LS		0.00	400	0	795	0	1,195	1195.00
USR AA CONTROL RELAYS, J-BOXES					400.00	0.00	795.00	0.00	1195.00	
ETC	1.00	LS		0.00	400	0	795	0	1,195	1195.00
USR AA FILM SENSOR LABOR					3500.00	0.00	0.00	0.00	3500.00	
	1.00	LS		0.00	3,500	0	0	0	3,500	3500.00
USR AA DEWATER LOCK					6000.00	0.00	0.00	0.00	6000.00	
	1.00	LS		0.00	6,000	0	0	0	6,000	6000.00
USR AA PVC CONDUIT 1/2" SCH 40					4.34	0.00	2.55	0.00	6.89	
	550.00	LF		0.00	2,387	0	1,405	0	3,792	6.89
USR AA TESTING					1600.00	0.00	0.00	0.00	1600.00	
	1.00	LS		0.00	1,600	0	0	0	1,600	1600.00
USR AA ALARM SYSTEM					181.00	0.00	760.02	0.00	941.02	
	1.00	LS		0.00	181	0	760	0	941	941.02
USR AA STRIP MTGS/INSTALL ON GA					750.00	0.00	199.28	0.00	949.28	
TES	4.00	EA		0.00	3,000	0	797	0	3,797	949.28

06. PIEZO - ELECTRIC FILM SENSOR

06- A. CONSTRUCTION	QUANTY	UOM	CREW ID	OUTPUT	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
USR AA MISC LABOR					2000.00	0.00	0.00	0.00	2000.00	
	1.00	LS		0.00	2,000	0	0	0	2,000	2000.00
USR AA LIMIT SWITCH ZONING					1500.00	0.00	0.00	0.00	1500.00	
	1.00	LS		0.00	1,500	0	0	0	1,500	1500.00
TOTAL ST. LUCIE LOCK					22,968	0	12,713	0	35,681	
06- A/02. PORT MAYACA LOCK										
USR AA FILM					0.00	0.00	2809.00	0.00	2809.00	
	1.00	LS		0.00	0	0	2,809	0	2,809	2809.00
USR AA POTTING COMPOUND					0.00	0.00	674.16	0.00	674.16	
	1.00	LS		0.00	0	0	674	0	674	674.16
USR AA ELECTRICAL SENSOR CABLE					0.00	0.00	246.98	0.00	246.98	
	1.00	LS		0.00	0	0	247	0	247	246.98
USR AA CABLE CONNECTORS					500.00	0.00	1696.00	0.00	2196.00	
	1.00	LS		0.00	500	0	1,696	0	2,196	2196.00
USR AA SENSOR CONDITIONER MODUL					500.00	0.00	1547.60	0.00	2047.60	
E	1.00	LS		0.00	500	0	1,548	0	2,048	2047.60
USR AA CABLE TO CONTROL RM 1000					1000.00	0.00	1187.20	0.00	2187.20	
' SPOOL	1.00	LS		0.00	1,000	0	1,187	0	2,187	2187.20
USR AA CABLE TIES,FITTING ETC					400.00	0.00	795.00	0.00	1195.00	
	1.00	LS		0.00	400	0	795	0	1,195	1195.00
USR AA CONTROL RELAYS,J-BOXES E					400.00	0.00	795.00	0.00	1195.00	
TC	1.00	LS		0.00	400	0	795	0	1,195	1195.00
USR AA FILM SENSOR LABOR					3500.00	0.00	0.00	0.00	3500.00	
	1.00	LS		0.00	3,500	0	0	0	3,500	3500.00
USR AA DEWATER LOCK					6000.00	0.00	0.00	0.00	6000.00	
	1.00	LS		0.00	6,000	0	0	0	6,000	6000.00
USR AA PVC CONDUIT 1/2" SCH 40					4.34	0.00	2.55	0.00	6.89	
	550.00	LF		0.00	2,387	0	1,405	0	3,792	6.89
USR AA TESTING					1600.00	0.00	0.00	0.00	1600.00	
	1.00	LS		0.00	1,600	0	0	0	1,600	1600.00

06. PIEZO - ELECTRIC FILM SENSOR

06- A. CONSTRUCTION	QUANTY UOM	CREW ID	OUTPUT	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
USR AA ALARM SYSTEM				181.00	0.00	760.02	0.00	941.02	
	1.00 LS		0.00	181	0	760	0	941	941.02
USR AA STRIP MTNG/INSTALL ON GA TE				750.00	0.00	199.28	0.00	949.28	
	4.00 EA		0.00	3,000	0	797	0	3,797	949.28
USR AA MISC LABOR				2000.00	0.00	0.00	0.00	2000.00	
	1.00 LS		0.00	2,000	0	0	0	2,000	2000.00
USR AA LIMIT SWITCH ZONING				1500.00	0.00	0.00	0.00	1500.00	
	1.00 LS		0.00	1,500	0	0	0	1,500	1500.00
TOTAL PORT MAYACA LOCK				22,968	0	12,713	0	35,681	
06- A/03. MOORE HAVEN LOCK									
USR AA FILM				0.00	0.00	2809.00	0.00	2809.00	
	1.00 LS		0.00	0	0	2,809	0	2,809	2809.00
USR AA POTTING COMPOUND				0.00	0.00	674.16	0.00	674.16	
	1.00 LS		0.00	0	0	674	0	674	674.16
USR AA ELECTRICAL SENSOR CABLE				0.00	0.00	246.98	0.00	246.98	
	1.00 LS		0.00	0	0	247	0	247	246.98
USR AA CABLE CONNECTORS				500.00	0.00	1696.00	0.00	2196.00	
	1.00 LS		0.00	500	0	1,696	0	2,196	2196.00
USR AA SENSOR CONDITIONER MODUL E				500.00	0.00	1547.60	0.00	2047.60	
	1.00 LS		0.00	500	0	1,548	0	2,048	2047.60
USR AA CABLE TO CONTROL RM 1000 'SPOOL				1000.00	0.00	1187.20	0.00	2187.20	
	1.00 LS		0.00	1,000	0	1,187	0	2,187	2187.20
USR AA CABLE FITTING,TIES ETC				400.00	0.00	795.00	0.00	1195.00	
	1.00 LS		0.00	400	0	795	0	1,195	1195.00
USR AA CONTROL RELAYS, "J" BOXE S ETC				400.00	0.00	795.00	0.00	1195.00	
	1.00 LS		0.00	400	0	795	0	1,195	1195.00
USR AA FILM SENSOR LABOR				3500.00	0.00	0.00	0.00	3500.00	
	1.00 LS		0.00	3,500	0	0	0	3,500	3500.00
USR AA DEWATER LOCK				6000.00	0.00	0.00	0.00	6000.00	
	1.00 LS		0.00	6,000	0	0	0	6,000	6000.00

06. PIEZO - ELECTRIC FILM SENSOR

06- A. CONSTRUCTION	QUANTY UOM	CREW ID	OUTPUT	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
USR AA PVC CONDUIT 1/2" SCH 40				4.34	0.00	2.55	0.00	6.89	
	550.00 LF		0.00	2,387	0	1,405	0	3,792	6.89
USR AA TESTING				1600.00	0.00	0.00	0.00	1600.00	
	1.00 LS		0.00	1,600	0	0	0	1,600	1600.00
USR AA ALARM SYSTEM				181.00	0.00	760.02	0.00	941.02	
	1.00 LS		0.00	181	0	760	0	941	941.02
USR AA STRIP MNTS/INSTALL ON GA				750.00	0.00	199.28	0.00	949.28	
TE	4.00 EA		0.00	3,000	0	797	0	3,797	949.28
USR AA MISC LABOR				2000.00	0.00	0.00	0.00	2000.00	
	1.00 LS		0.00	2,000	0	0	0	2,000	2000.00
USR AA LIMIT SWITCH ZONING				1500.00	0.00	0.00	0.00	1500.00	
	1.00 LS		0.00	1,500	0	0	0	1,500	1500.00
TOTAL MOORE HAVEN LOCK				22,968	0	12,713	0	35,681	
06- A/04. ORTONA LOCK									
USR AA FILM				0.00	0.00	2650.00	0.00	2650.00	
	1.00 LS		0.00	0	0	2,650	0	2,650	2650.00
USR AA POTTING COMPOUND				0.00	0.00	636.00	0.00	636.00	
	1.00 LS		0.00	0	0	636	0	636	636.00
USR AA ELECTRICAL SENSOR CABLE				0.00	0.00	233.20	0.00	233.20	
	1.00 LS		0.00	0	0	233	0	233	233.20
USR AA CABLE CONNECTORS				500.00	0.00	1696.00	0.00	2196.00	
	1.00 LS		0.00	500	0	1,696	0	2,196	2196.00
USR AA SENSOR CONDITIONER MODUL				500.00	0.00	1547.60	0.00	2047.60	
E	1.00 LS		0.00	500	0	1,548	0	2,048	2047.60
USR AA CABLE TO CONTROL RM 1000				1000.00	0.00	1187.20	0.00	2187.20	
'SPOOL	1.00 LS		0.00	1,000	0	1,187	0	2,187	2187.20
USR AA CABLE TIES,FITTING ETC				400.00	0.00	795.00	0.00	1195.00	
	1.00 LS		0.00	400	0	795	0	1,195	1195.00
USR AA CONTROL RELAYS "J" BOXES				400.00	0.00	795.00	0.00	1195.00	
, ETC	1.00 LS		0.00	400	0	795	0	1,195	1195.00

06. PIEZO - ELECTRIC FILM SENSOR

06- A. CONSTRUCTION	QUANTY	UOM	CREW ID	OUTPUT	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
USR AA FILM SENSOR LABOR					3500.00	0.00	0.00	0.00	3500.00	
	1.00	LS		0.00	3,500	0	0	0	3,500	3500.00
USR AA DEWATER LOCK					6000.00	0.00	0.00	0.00	6000.00	
	1.00	LS		0.00	6,000	0	0	0	6,000	6000.00
USR AA PVC CONDUIT 1/2" SCH 40					4.34	0.00	2.55	0.00	6.89	
	550.00	LF		0.00	2,387	0	1,405	0	3,792	6.89
USR AA TESTING					1600.00	0.00	0.00	0.00	1600.00	
	1.00	LS		0.00	1,600	0	0	0	1,600	1600.00
USR AA ALARM SYSTEM					181.00	0.00	760.02	0.00	941.02	
	1.00	LS		0.00	181	0	760	0	941	941.02
USR AA STRIP MNTS/INSTALL ON GA					750.00	0.00	199.28	0.00	949.28	
TE	4.00	EA		0.00	3,000	0	797	0	3,797	949.28
USR AA MISC LABOR					2000.00	0.00	0.00	0.00	2000.00	
	1.00	LS		0.00	2,000	0	0	0	2,000	2000.00
USR AA LIMIT SWITCH ZONING					1500.00	0.00	0.00	0.00	1500.00	
	1.00	LS		0.00	1,500	0	0	0	1,500	1500.00
TOTAL ORTONA LOCK					22,968	0	12,502	0	35,470	
06- A/06. S-193 LOCK										
USR AA FILM					0.00	0.00	1325.00	0.00	1325.00	
	1.00	LS		0.00	0	0	1,325	0	1,325	1325.00
USR AA POTTING COMPOUND					0.00	0.00	318.00	0.00	318.00	
	1.00	LS		0.00	0	0	318	0	318	318.00
USR AA ELECTRICAL SENSOR CABLE					0.00	0.00	116.60	0.00	116.60	
	1.00	LS		0.00	0	0	117	0	117	116.60
USR AA CABLE CONNECTIONS					500.00	0.00	1696.00	0.00	2196.00	
	1.00	LS		0.00	500	0	1,696	0	2,196	2196.00
USR AA SENSOR CONDITIONER MODUL					500.00	0.00	1547.60	0.00	2047.60	
E	1.00	LS		0.00	500	0	1,548	0	2,048	2047.60
USR AA CABLE TO CONTROL RM 500'					500.00	0.00	593.60	0.00	1093.60	
SPOOL	1.00	LS		0.00	500	0	594	0	1,094	1093.60

06. PIEZO - ELECTRIC FILM SENSOR

06- A. CONSTRUCTION	QUANTY	UOM	CREW ID	OUTPUT	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
USR AA CABLE TIES,FITTING ETC					400.00	0.00	795.00	0.00	1195.00	
	1.00	LS		0.00	400	0	795	0	1,195	1195.00
USR AA CONTROL RELAYS,"J" BOXES					400.00	0.00	795.00	0.00	1195.00	
ETC	1.00	LS		0.00	400	0	795	0	1,195	1195.00
USR AA FILM SENSOR LABOR					3500.00	0.00	0.00	0.00	3500.00	
	1.00	LS		0.00	3,500	0	0	0	3,500	3500.00
USR AA DEWATER LOCK					6000.00	0.00	0.00	0.00	6000.00	
	1.00	LS		0.00	6,000	0	0	0	6,000	6000.00
USR AA PVC CONDUIT 1/2" SCH 40					4.34	0.00	2.55	0.00	6.89	
	275.00	LF		0.00	1,194	0	703	0	1,896	6.89
USR AA TESTING					1600.00	0.00	0.00	0.00	1600.00	
	1.00	LS		0.00	1,600	0	0	0	1,600	1600.00
USR AA ALARM SYSTEM					181.00	0.00	760.02	0.00	941.02	
	1.00	LS		0.00	181	0	760	0	941	941.02
USR AA STRIP MNTS/INSTALL ON GA					750.00	0.00	199.28	0.00	949.28	
TE	4.00	EA		0.00	3,000	0	797	0	3,797	949.28
USR AA MISC LABOR					2000.00	0.00	0.00	0.00	2000.00	
	1.00	LS		0.00	2,000	0	0	0	2,000	2000.00
USR AA LIMIT SWITCH ZONING					1500.00	0.00	0.00	0.00	1500.00	
	1.00	LS		0.00	1,500	0	0	0	1,500	1500.00
TOTAL S-193 LOCK					21,275	0	9,446	0	30,721	
06- A/07. S-310 LOCK										
USR AA FILM					0.00	0.00	1325.00	0.00	1325.00	
	1.00	LS		0.00	0	0	1,325	0	1,325	1325.00
USR AA POTTING COMPOUND					0.00	0.00	318.00	0.00	318.00	
	1.00	LS		0.00	0	0	318	0	318	318.00
USR AA ELECTRICAL SENSOR CABLE					0.00	0.00	116.60	0.00	116.60	
	1.00	LS		0.00	0	0	117	0	117	116.60
USR AA CABLE CONNECTIONS					500.00	0.00	1696.00	0.00	2196.00	
	1.00	LS		0.00	500	0	1,696	0	2,196	2196.00

06. PIEZO - ELECTRIC FILM SENSOR

06- A. CONSTRUCTION	QUANTY UOM	CREW ID	OUTPUT	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
USR AA SENSOR CONDITIONER MODUL				500.00	0.00	1547.60	0.00	2047.60	
E	1.00 LS		0.00	500	0	1,548	0	2,048	2047.60
USR AA CABLE TO CONTROL RM 500				500.00	0.00	593.60	0.00	1093.60	
SPOOL	1.00 LS		0.00	500	0	594	0	1,094	1093.60
USR AA CABLE TIES,FITTING ETC				400.00	0.00	795.00	0.00	1195.00	
	1.00 LS		0.00	400	0	795	0	1,195	1195.00
USR AA CONTROL RELAYS, "J" BOXE				400.00	0.00	795.00	0.00	1195.00	
S ETC	1.00 LS		0.00	400	0	795	0	1,195	1195.00
USR AA FILM SENSOR LABOR				3500.00	0.00	0.00	0.00	3500.00	
	1.00 LS		0.00	3,500	0	0	0	3,500	3500.00
USR AA DEWATER LOCK				6000.00	0.00	0.00	0.00	6000.00	
	1.00 LS		0.00	6,000	0	0	0	6,000	6000.00
USR AA PVC CONDUIT 1/2" SCH 40				4.34	0.00	2.55	0.00	6.89	
	275.00 LF		0.00	1,194	0	703	0	1,896	6.89
USR AA TESTING				1600.00	0.00	0.00	0.00	1600.00	
	1.00 LS		0.00	1,600	0	0	0	1,600	1600.00
USR AA ALARM SYSTEM				181.00	0.00	760.02	0.00	941.02	
	1.00 LS		0.00	181	0	760	0	941	941.02
USR AA STRIP MNTS/INSTALL ON GA				750.00	0.00	199.28	0.00	949.28	
TE	4.00 EA		0.00	3,000	0	797	0	3,797	949.28
USR AA MISC LABOR				2000.00	0.00	0.00	0.00	2000.00	
	1.00 LS		0.00	2,000	0	0	0	2,000	2000.00
USR AA LIMIT SWITCH ZONING				1500.00	0.00	0.00	0.00	1500.00	
	1.00 LS		0.00	1,500	0	0	0	1,500	1500.00
TOTAL S-310 LOCK				21,275	0	9,446	0	30,721	
06- A/05. W.P. FRANKLIN LOCK									
USR AA FILM				0.00	0.00	2650.00	0.00	2650.00	
	1.00 LS		0.00	0	0	2,650	0	2,650	2650.00
M AA POTTING COMPOUND				0.00	0.00	674.16	0.00	674.16	
	1.00 LS		0.00	0	0	674	0	674	674.16

06. PIEZO - ELECTRIC FILM SENSOR

06- A. CONSTRUCTION	QUANTY	UOM	CREW ID	OUTPUT	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
USR AA ELECTRICAL SENSOR CABLE					0.00	0.00	246.98	0.00	246.98	
	1.00	LS		0.00	0	0	247	0	247	246.98
USR AA CABLE CONNECTIONS					500.00	0.00	1696.00	0.00	2196.00	
	1.00	LS		0.00	500	0	1,696	0	2,196	2196.00
USR AA SENSOR CONDITIONER MODUL					500.00	0.00	1547.60	0.00	2047.60	
E	1.00	LS		0.00	500	0	1,548	0	2,048	2047.60
USR AA CABLE TO CONTROL RM 1000					1000.00	0.00	1187.20	0.00	2187.20	
'SPOOL	1.00	LS		0.00	1,000	0	1,187	0	2,187	2187.20
USR AA CABLE TIES,FITTING ETC					400.00	0.00	795.00	0.00	1195.00	
	1.00	LS		0.00	400	0	795	0	1,195	1195.00
USR AA CONTROL RELAYS, "J" BOXE					400.00	0.00	795.00	0.00	1195.00	
S ETC	1.00	LS		0.00	400	0	795	0	1,195	1195.00
USR AA FILM SENSOR LABOR					3500.00	0.00	0.00	0.00	3500.00	
	1.00	LS		0.00	3,500	0	0	0	3,500	3500.00
USR AA DEWATER LOCK					6000.00	0.00	0.00	0.00	6000.00	
	1.00	LS		0.00	6,000	0	0	0	6,000	6000.00
USR AA PVC CONDUIT 1/2" SCH 40					4.34	0.00	2.55	0.00	6.89	
	550.00	LF		0.00	2,387	0	1,405	0	3,792	6.89
USR AA TESTING					1600.00	0.00	0.00	0.00	1600.00	
	1.00	LS		0.00	1,600	0	0	0	1,600	1600.00
USR AA ALARM SYSTEM					181.00	0.00	760.02	0.00	941.02	
	1.00	LS		0.00	181	0	760	0	941	941.02
USR AA STRIP MNTS/ INSTALL ON G					750.00	0.00	199.28	0.00	949.28	
ATE	4.00	EA		0.00	3,000	0	797	0	3,797	949.28
USR AA MISC LABOR					2000.00	0.00	0.00	0.00	2000.00	
	1.00	LS		0.00	2,000	0	0	0	2,000	2000.00
USR AA LIMIT SWITCH ZONING					1500.00	0.00	0.00	0.00	1500.00	
	1.00	LS		0.00	1,500	0	0	0	1,500	1500.00
TOTAL W.P. FRANKLIN LOCK					22,968	0	12,554	0	35,522	

06. PIEZO - ELECTRIC FILM SENSOR

06- A. CONSTRUCTION	QUANTY	UOM	CREW ID	OUTPUT	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
TOTAL CONSTRUCTION					157,389	0	82,089	0	239,478	
06- B. NON-CONSTRUCTION										
TOTAL NON-CONSTRUCTION					0	0	0	0	0	
TOTAL PIEZO - ELECTRIC FILM SE					157,389	0	82,089	0	239,478	

07- A. CONSTRUCTION	QUANTY UOM	CREW ID	OUTPUT	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
07. PIEZO ELEC.ACOUSTIC LADDER ARRAY									
07- A. CONSTRUCTION									
07- A/01. ST.LUCIE LOCK									
USR AA PIEZO FILM 144SQIN/GATEX				0.00	0.00	15264.00	0.00	15264.00	
$25x4 GT	1.00 LS		0.00	0	0	15,264	0	15,264	15264.00
USR AA CONTROL MODULE/DISPLAY				0.00	0.00	5300.00	0.00	5300.00	
	1.00 LS		0.00	0	0	5,300	0	5,300	5300.00
USR AA POTTING COMPOUND				0.00	0.00	1060.00	0.00	1060.00	
	1.00 LS		0.00	0	0	1,060	0	1,060	1060.00
USR AA CABLE,CONNECTORS,FASTENE				0.00	0.00	2650.00	0.00	2650.00	
RS ETC.	1.00 LS		0.00	0	0	2,650	0	2,650	2650.00
USR AA ACCOUSTIC LADDER ARRAY L				13120.00	0.00	0.00	0.00	13120.00	
ABOR	1.00 LS		0.00	13,120	0	0	0	13,120	13120.00
USR AA DIVERS TO INSTALL				50.00	0.00	0.00	0.00	50.00	
	144.00 HRS		0.00	7,200	0	0	0	7,200	50.00
USR AA PVC CONDUIT 1/2" SCH 40				4.34	0.00	2.55	0.00	6.89	
	550.00 LF		0.00	2,387	0	1,405	0	3,792	6.89
USR AA GCI SIGNAL CONDITIONERS				0.00	0.00	5300.00	0.00	5300.00	
	2.00 EA		0.00	0	0	10,600	0	10,600	5300.00
USR AA ELASTOMERIC FABRIC				0.00	0.00	1060.00	0.00	1060.00	
	1.00 EA		0.00	0	0	1,060	0	1,060	1060.00
USR AA TESTING				1600.00	0.00	0.00	0.00	1600.00	
	1.00 LS		0.00	1,600	0	0	0	1,600	1600.00
USR AA ALARM SYSTEM				181.00	0.00	760.02	0.00	941.02	
	1.00 LS		0.00	181	0	760	0	941	941.02
USR AA MISC LABOR				2000.00	0.00	0.00	0.00	2000.00	
	1.00 LS		0.00	2,000	0	0	0	2,000	2000.00
USR AA LIMIT SWITCH FOR ZONING				1000.00	0.00	795.00	0.00	1795.00	
	1.00 LS		0.00	1,000	0	795	0	1,795	1795.00
TOTAL ST.LUCIE LOCK				27,488	0	38,894	0	66,382	

07. PIEZO ELEC.ACOUSTIC LADDER ARRAY

07- A. CONSTRUCTION	QUANTY	UOM	CREW ID	OUTPUT	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
07- A/02. PORT MAYACA LOCK										
USR AA PIEZO FILM 144SQ/INX$25X					0.00	0.00	15264.00	0.00	15264.00	
4 GATES	1.00	LS		0.00	0	0	15,264	0	15,264	15264.00
USR AA CONTROL MODULE/DISPLAY					0.00	0.00	5300.00	0.00	5300.00	
	1.00	LS		0.00	0	0	5,300	0	5,300	5300.00
USR AA GCI SIGNAL CONDITIONERS					0.00	0.00	5300.00	0.00	5300.00	
	2.00	EA		0.00	0	0	10,600	0	10,600	5300.00
USR AA ELASTOMERIC FABRIC					0.00	0.00	1060.00	0.00	1060.00	
	1.00	LS		0.00	0	0	1,060	0	1,060	1060.00
USR AA POTTING COMPOUND					0.00	0.00	1060.00	0.00	1060.00	
	1.00	LS		0.00	0	0	1,060	0	1,060	1060.00
USR AA CABLE,CONNECTORS,FASTENE					0.00	0.00	2650.00	0.00	2650.00	
RS ETC.	1.00	LS		0.00	0	0	2,650	0	2,650	2650.00
USR AA ACCOUSTIC LADDER ARRAY L					13120.00	0.00	0.00	0.00	13120.00	
ABOR	1.00	LS		0.00	13,120	0	0	0	13,120	13120.00
USR AA DIVERS TO INSTALL					50.00	0.00	0.00	0.00	50.00	
	144.00	HRS		0.00	7,200	0	0	0	7,200	50.00
USR AA PVC CONDUIT 1/2" SCH 40					4.34	0.00	2.55	0.00	6.89	
	550.00	LF		0.00	2,387	0	1,405	0	3,792	6.89
USR AA TESTING					1600.00	0.00	0.00	0.00	1600.00	
	1.00	LS		0.00	1,600	0	0	0	1,600	1600.00
USR AA ALARM SYSTEM					181.00	0.00	760.02	0.00	941.02	
	1.00	LS		0.00	181	0	760	0	941	941.02
USR AA MISC LABOR					2000.00	0.00	0.00	0.00	2000.00	
	1.00	LS		0.00	2,000	0	0	0	2,000	2000.00
USR AA LIMIT SWITCH FOR ZONING					1000.00	0.00	795.00	0.00	1795.00	
	1.00	LS		0.00	1,000	0	795	0	1,795	1795.00
TOTAL PORT MAYACA LOCK					27,488	0	38,894	0	66,382	

07. PIEZO ELEC.ACOUSTIC LADDER ARRAY

07- A. CONSTRUCTION	QUANTY	UOM	CREW ID	OUTPUT	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
07- A/03. MOORE HAVEN LOCK										
USR AA PIEZO FILM 144SQ/INX$25X					0.00	0.00	15264.00	0.00	15264.00	
4 GATES	1.00	LS		0.00	0	0	15,264	0	15,264	15264.00
USR AA CONTROL MODULE/DISPLAY					0.00	0.00	5300.00	0.00	5300.00	
	1.00	LS		0.00	0	0	5,300	0	5,300	5300.00
USR AA GCI SIGNAL CONDITIONERS					0.00	0.00	5300.00	0.00	5300.00	
	2.00	EA		0.00	0	0	10,600	0	10,600	5300.00
USR AA ELASTOMERIC FABRIC					0.00	0.00	1060.00	0.00	1060.00	
	1.00	LS		0.00	0	0	1,060	0	1,060	1060.00
USR AA POTTING COMPOUND					0.00	0.00	1060.00	0.00	1060.00	
	1.00	LS		0.00	0	0	1,060	0	1,060	1060.00
USR AA CABLE,CONNECTIONS,FASTEN					0.00	0.00	2650.00	0.00	2650.00	
ERS ETC.	1.00	LS		0.00	0	0	2,650	0	2,650	2650.00
USR AA ACCOUSTIC LADDER ARRAY L					13120.00	0.00	0.00	0.00	13120.00	
ABOR	1.00	LS		0.00	13,120	0	0	0	13,120	13120.00
USR AA DEWATER LOCK					6000.00	0.00	0.00	0.00	6000.00	
	1.00	LS		0.00	6,000	0	0	0	6,000	6000.00
USR AA PVC CONDUIT 1/2" SCH 40					4.34	0.00	2.55	0.00	6.89	
	550.00	LF		0.00	2,387	0	1,405	0	3,792	6.89
USR AA TESTING					1600.00	0.00	0.00	0.00	1600.00	
	1.00	LS		0.00	1,600	0	0	0	1,600	1600.00
USR AA ALARM SYSTEM					181.00	0.00	760.02	0.00	941.02	
	1.00	LS		0.00	181	0	760	0	941	941.02
USR AA MISC LABOR					2000.00	0.00	0.00	0.00	2000.00	
	1.00	LS		0.00	2,000	0	0	0	2,000	2000.00
USR AA LIMIT SWITCH FOR ZONING					1000.00	0.00	795.00	0.00	1795.00	
	1.00	LS		0.00	1,000	0	795	0	1,795	1795.00
TOTAL MOORE HAVEN LOCK					26,288	0	38,894	0	65,182	

07. PIEZO ELEC.ACOUSTIC LADDER ARRAY

07- A. CONSTRUCTION	QUANTY	UOM	CREW ID	OUTPUT	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
07- A/04. ORTONA LOCK										
USR AA PIEZO FILM 144SQ/INX$25X					0.00	0.00	15264.00	0.00	15264.00	
4 GATES	1.00	LS		0.00	0	0	15,264	0	15,264	15264.00
USR AA CONTROL MODULE/DISPLAY					0.00	0.00	5300.00	0.00	5300.00	
	1.00	LS		0.00	0	0	5,300	0	5,300	5300.00
USR AA GCI SIGNAL CONDITIONERS					0.00	0.00	5300.00	0.00	5300.00	
	2.00	EA		0.00	0	0	10,600	0	10,600	5300.00
USR AA ELASTOMERIC FABRIC					0.00	0.00	1060.00	0.00	1060.00	
	1.00	LS		0.00	0	0	1,060	0	1,060	1060.00
USR AA POTTING COMPOUND					0.00	0.00	1060.00	0.00	1060.00	
	1.00	LS		0.00	0	0	1,060	0	1,060	1060.00
USR AA CABLE,CONNECTORS,FASTENE					0.00	0.00	2650.00	0.00	2650.00	
RS ETC.	1.00	LS		0.00	0	0	2,650	0	2,650	2650.00
USR AA ACCOUSTIC LADDER ARRAY L					13120.00	0.00	0.00	0.00	13120.00	
ABOR	1.00	LS		0.00	13,120	0	0	0	13,120	13120.00
USR AA DIVERS TO INSTALL					50.00	0.00	0.00	0.00	50.00	
	144.00	HRS		0.00	7,200	0	0	0	7,200	50.00
USR AA PVC CONDUIT 1/2" SCH 40					4.34	0.00	2.55	0.00	6.89	
	550.00	LF		0.00	2,387	0	1,405	0	3,792	6.89
USR AA TESTING					1600.00	0.00	0.00	0.00	1600.00	
	1.00	LS		0.00	1,600	0	0	0	1,600	1600.00
USR AA ALARM SYSTEM					181.00	0.00	760.02	0.00	941.02	
	1.00	LS		0.00	181	0	760	0	941	941.02
USR AA MISC LABOR					2000.00	0.00	0.00	0.00	2000.00	
	1.00	LS		0.00	2,000	0	0	0	2,000	2000.00
USR AA LIMIT SWITCH FOR ZONING					1000.00	0.00	795.00	0.00	1795.00	
	1.00	LS		0.00	1,000	0	795	0	1,795	1795.00
TOTAL ORTONA LOCK					27,488	0	38,894	0	66,382	

07. PIEZO ELEC.ACOUSTIC LADDER ARRAY

07- A. CONSTRUCTION	QUANTY	UOM	CREW ID	OUTPUT	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
07- A/05. W.P.FRANKLIN LOCK										
USR AA PIEZO FILM 144SQ/INX$25X					0.00	0.00	15264.00	0.00	15264.00	
4 GATES	1.00	LS		0.00	0	0	15,264	0	15,264	15264.00
USR AA CONTROL MODULE/DISPLAY					0.00	0.00	5300.00	0.00	5300.00	
	1.00	LS		0.00	0	0	5,300	0	5,300	5300.00
USR AA GCI SIGNAL CONDITIONERS					0.00	0.00	5300.00	0.00	5300.00	
	2.00	EA		0.00	0	0	10,600	0	10,600	5300.00
USR AA ELASTOMERIC FABRIC					0.00	0.00	1060.00	0.00	1060.00	
	1.00	LS		0.00	0	0	1,060	0	1,060	1060.00
USR AA POTTING COMPOUND					0.00	0.00	1060.00	0.00	1060.00	
	1.00	LS		0.00	0	0	1,060	0	1,060	1060.00
USR AA CABLE,CONNECTIONS,FASTEN					0.00	0.00	2650.00	0.00	2650.00	
ERS ETC	1.00	LS		0.00	0	0	2,650	0	2,650	2650.00
USR AA ACCOUSTIC LADDER ARRAY L					13120.00	0.00	0.00	0.00	13120.00	
ABOR	1.00	LS		0.00	13,120	0	0	0	13,120	13120.00
USR AA DIVERS TO INSTALL					50.00	0.00	0.00	0.00	50.00	
	144.00	HRS		0.00	7,200	0	0	0	7,200	50.00
USR AA PVC CONDUIT 1/2" SCH 40					4.34	0.00	2.55	0.00	6.89	
	550.00	LF		0.00	2,387	0	1,405	0	3,792	6.89
USR AA TESTING					1600.00	0.00	0.00	0.00	1600.00	
	1.00	LS		0.00	1,600	0	0	0	1,600	1600.00
USR AA ALARM SYSTEM					181.00	0.00	760.02	0.00	941.02	
	1.00	LS		0.00	181	0	760	0	941	941.02
USR AA MISC LABOR					2000.00	0.00	0.00	0.00	2000.00	
	1.00	LS		0.00	2,000	0	0	0	2,000	2000.00
USR AA LIMIT SWITCH FOR ZONING					1000.00	0.00	795.00	0.00	1795.00	
	1.00	LS		0.00	1,000	0	795	0	1,795	1795.00
TOTAL W.P.FRANKLIN LOCK					27,488	0	38,894	0	66,382	

07. PIEZO ELEC.ACOUSTIC LADDER ARRAY

07- A. CONSTRUCTION	QUANTY	UOM	CREW ID	OUTPUT	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
07- A/06. S-193 LOCK										
USR AA PIEZO FILM 144SQ/INX$25X					0.00	0.00	15264.00	0.00	15264.00	
4 GATES	1.00	LS		0.00	0	0	15,264	0	15,264	15264.00
USR AA CONTROL MODULE/DISPLAY					0.00	0.00	5300.00	0.00	5300.00	
	1.00	LS		0.00	0	0	5,300	0	5,300	5300.00
USR AA GCI SIGNAL CONDITIONERS					0.00	0.00	5300.00	0.00	5300.00	
	2.00	EA		0.00	0	0	10,600	0	10,600	5300.00
USR AA ELASTOMERIC FABRIC					0.00	0.00	1060.00	0.00	1060.00	
	1.00	LS		0.00	0	0	1,060	0	1,060	1060.00
USR AA POTTING COMPOUND					0.00	0.00	1060.00	0.00	1060.00	
	1.00	LS		0.00	0	0	1,060	0	1,060	1060.00
USR AA CABLE,CONNECTIONS,FASTEN					0.00	0.00	2650.00	0.00	2650.00	
ERS ETC.	1.00	LS		0.00	0	0	2,650	0	2,650	2650.00
USR AA ACCOUSTIC LADDER ARRAY L					13120.00	0.00	0.00	0.00	13120.00	
ABOR	1.00	LS		0.00	13,120	0	0	0	13,120	13120.00
USR AA DIVERS TO INSTALL					50.00	0.00	0.00	0.00	50.00	
	144.00	HRS		0.00	7,200	0	0	0	7,200	50.00
USR AA PVC CONDUIT 1/2" SCH 40					4.34	0.00	2.55	0.00	6.89	
	275.00	LF		0.00	1,194	0	703	0	1,896	6.89
USR AA TESTING					1600.00	0.00	0.00	0.00	1600.00	
	1.00	LS		0.00	1,600	0	0	0	1,600	1600.00
USR AA ALARM SYSTEM					181.00	0.00	760.02	0.00	941.02	
	1.00	LS		0.00	181	0	760	0	941	941.02
USR AA MISC LABOR					2000.00	0.00	795.00	0.00	2795.00	
	1.00	LS		0.00	2,000	0	795	0	2,795	2795.00
USR AA LIMIT SWITCH FOR ZONING					1000.00	0.00	795.00	0.00	1795.00	
	1.00	LS		0.00	1,000	0	795	0	1,795	1795.00
TOTAL S-193 LOCK					26,295	0	38,987	0	65,281	

07. PIEZO ELEC.ACOUSTIC LADDER ARRAY

07- A. CONSTRUCTION	QUANTY	UOM	CREW ID	OUTPUT	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
07- A/07. S-310 LOCK										
USR AA PIEZO FILM 144SQ/INX$25X					0.00	0.00	15264.00	0.00	15264.00	
4 GATES	1.00	LS		0.00	0	0	15,264	0	15,264	15264.00
USR AA CONTROL MODULE/DISPLAY					0.00	0.00	5300.00	0.00	5300.00	
	1.00	LS		0.00	0	0	5,300	0	5,300	5300.00
USR AA GCI SIGNAL CONDITIONERS					0.00	0.00	5300.00	0.00	5300.00	
	2.00	EA		0.00	0	0	10,600	0	10,600	5300.00
USR AA ELASTOMERIC FABRIC					0.00	0.00	1060.00	0.00	1060.00	
	1.00	LS		0.00	0	0	1,060	0	1,060	1060.00
USR AA POTTING COMPOUND					0.00	0.00	1060.00	0.00	1060.00	
	1.00	LS		0.00	0	0	1,060	0	1,060	1060.00
USR AA CABLE,CONNECTORS,FASTENE					0.00	0.00	2650.00	0.00	2650.00	
RS ETC	1.00	LS		0.00	0	0	2,650	0	2,650	2650.00
USR AA ACCOUSTIC LADDER ARRAY L					13120.00	0.00	0.00	0.00	13120.00	
ABOR	1.00	LS		0.00	13,120	0	0	0	13,120	13120.00
USR AA DIVERS TO INSTALL					50.00	0.00	0.00	0.00	50.00	
	144.00	HRS		0.00	7,200	0	0	0	7,200	50.00
USR AA PVC CONDUIT 1/2" SCH 40					4.34	0.00	2.55	0.00	6.89	
	275.00	LF		0.00	1,194	0	703	0	1,896	6.89
USR AA TESTING					1600.00	0.00	0.00	0.00	1600.00	
	1.00	LS		0.00	1,600	0	0	0	1,600	1600.00
USR AA ALARM SYSTEM					181.00	0.00	760.02	0.00	941.02	
	1.00	LS		0.00	181	0	760	0	941	941.02
USR AA MISC LABOR					2000.00	0.00	0.00	0.00	2000.00	
	1.00	LS		0.00	2,000	0	0	0	2,000	2000.00
USR AA LIMIT SWITCH FOR ZONING					1000.00	0.00	795.00	0.00	1795.00	
	1.00	LS		0.00	1,000	0	795	0	1,795	1795.00
TOTAL S-310 LOCK					26,295	0	38,192	0	64,486	
TOTAL CONSTRUCTION					188,829	0	271,648	0	460,477	

07. PIEZO ELEC.ACOUSTIC LADDER ARRAY

07- B. NON-CONSTRUCTION	QUANTY	UOM	CREW ID	OUTPUT	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
07- B. NON-CONSTRUCTION										
TOTAL NON-CONSTRUCTION					0	0	0	0	0	
TOTAL PIEZO ELEC.ACOUSTIC LADD					188,829	0	271,648	0	460,477	
TOTAL MANATEE PROTECTION					460,107	5	432,252	0	892,364	

No errors detected...

*** END OF ERROR REPORT ***

APPENDIX C

Jacksonville District, Corps of Engineers
CESAJ-CO-OR P.O. Box 4970
Jacksonville, Florida 32232-0019

CESAJ SOP No. 1130-2-3 DATE

Project Operations
MANATEE PROTECTION PLAN
FOR WATER CONTROL STRUCTURES
OPERATED BY THE JACKSONVILLE DISTRICT
U.S. ARMY CORPS OF ENGINEERS

1. Authority and Applicability.

The Project Operations Manatee Protection Plan for the Jacksonville District is prepared in accordance with ER 1130-2-400, Management of Natural Resources and Outdoor Recreation at Civil Works Water Resource Projects, 1 June 1986; the Florida Manatee Recovery Plan, revised 24 July 1989; the Marine Mammal Protection Act of 1972; and the Endangered Species Act of 1973, as amended; and the approved water control plans and manuals for Central and Southern Florida Project; and is applicable to all Jacksonville District Field Operating Activities, (FOA), having Civil Works water control structure responsibilities.

2. Purpose and Objectives.

The purpose of this plan is to provide policies, guidelines, and operating procedures for the effective long-range management and operation of water control structures to minimize manatee risk. Water control structure-related manatee deaths (navigation structures, floodgates, culverts, and other structures) are second only to boat and barge collisions as an identified source of human-caused mortality. This plan will serve to address operational tasks identified in the Florida Manatee Recovery Plan, prepared by the Florida Manatee Recovery Team, in order to meet our objective.

The objective is to eliminate U.S. Army Corps of Engineers water control structure-related manatee mortality by:

a. Identifying problem structures through site-specific structure-related mortality investigations.

b. Testing and implementing alternative operational methods, schedules, and/or partial or complete structural modifications.

c. Following proper operational protocol and procedures for assuring that the manatee receives safety consideration when in the vicinity of a U.S. Army Corps of Engineers water control structure.

3. <u>Background</u>.

The U.S. Army Corps of Engineers is enjoined under Section 2 of the Endangered Species Act of 1973, as amended (the Act) to seek to conserve endangered species and threatened species. The Jacksonville District, U.S. Army Corps of Engineers, is a partner with the U.S. Fish and Wildlife Service and other Federal, State and local agencies to provide for an environment whereby the Florida subspecies of the West Indian Manatee is assured consideration regarding safety and recovery. The Corps has accepted this challenge and many manatee protection tasks have already been completed by our project operations offices. These actions include screens placed on lock gates to prevent manatee access to sector gate recesses, reduced lock gate closure speeds, and establishment of flood gate operational protocols. These innovative actions have resulted in less risk to the manatee. As a partner in the Florida Manatee Recovery Plan, the Jacksonville District is committed to meeting its charge under Section 7 of the Act by reducing manatee risk caused by Corps water control structures.

4. <u>Policies and Procedures</u>.

It is the policy of the Jacksonville District to investigate specific cases of reported structure-related mortality by conducting site-specific studies to identify the precise problem(s) at structures; to comply with established procedures as set forth in this plan for lock, flood gate, culvert and/or other structure operations; and to comply with District reporting requirements.

a. <u>Investigate specific cases of reported structure-related mortality by conducting site-specific studies to identify the precise problem(s) at structures</u>.

(1) Upon official notification by the Florida Department of Environmental Protection (FDEP), and/or the U.S. Fish and Wildlife Service (FWS), the U.S. Army Corps of Engineers (COE), with the assistance of both DEP and FWS, will conduct investigations of reported structure-related mortality to identify the precise problem at structures.

(2) Operations Branch, Project Operations Section will provide Planning Division, Environmental Studies Section (the District Point of contact for endangered species and a District representative on the Manatee Protection Task Force), Engineering Division, Water Management and Meteorology Section (also a District representative on the Manatee Protection Task Force) and the affected FOA, a copy of the official FDEP notification. Planning Division, Environmental Studies Section, upon receipt of a manatee necropsy report attributing a manatee death to a Jacksonville District water control structure, will provide a copy of said report to Operations Branch, Project Operations Section. (See Appendix A, Manatee Protection Plan Point of Contact List)

(3) The FOA will conduct a preliminary onsite investigation of the incident.

(4) Upon completion of the preliminary onsite investigation, a written report including an analysis of the incident and recommendations for corrective actions will be completed by the FOA and forwarded through Operations Branch, Project Operations Section and coordinated with both Engineering and Planning Divisions prior to submittal to FDEP and FWS. (See Appendix B, Sample Jacksonville District Manatee Mortality Investigation Report)

(5) When a structure has been identified as a responsible agent in a manatee mortality, the affected FOA will test and/or implement the corrective action plan as soon as it is reasonably possible.

(6) When it has been determined that the corrective action is beneficial to the safety of the manatee, does not adversely affect the structural integrity of the structure, and does not alter the water management function of the structure, modifications will be made permanent as soon as possible within the scope of authorities and funding. All similar structures posing an immediate risk will be similarly modified within a period of twelve months, if possible.

b. Operational protocol for locks, flood control/spillway gates, culverts and/or other structures.

Safety consideration will be given to manatees that come near COE navigation locks, flood control spillways, culverts and other water control structures. Each lock, spillway and culvert structure may differ due to design and water elevations. The following procedures are designed to place the manatee at less risk when in the vicinity of these systems.

(1) Lock Operations.

The following standard operating procedures are in effect for safely locking manatees at Canaveral Lock, St. Lucie Lock, Port Mayaca Lock, Moore Haven Lock, Ortona Lock and W.P. Franklin Lock:

(a) Lock operators will be attentive as to the location and number of manatees in the lock chamber and approaches at all times, as well as aware that manatees may be present even if not visible.

(b) Manatee sightings will be recorded on a Florida Department of Environmental Protection Manatee Sighting Form. These forms are to be submitted monthly to the Florida Department of Environmental Protection, Office of Protected Species Management, 3900 Commonwealth Boulevard, MS 245, Tallahassee, Florida, 32399-3000, with the FOA retaining a file copy for record.

(c) Every effort will be made to avoid hindering the passage of manatees through the locks and to assure their safety around vessels. Special lockages will be provided for manatees that demonstrate a desire to pass in a particular direction. According to the judgement of the lock operator on duty, vessels may be locked with manatees or delayed until the next lockage. At the W.P. Franklin Lock it will be necessary to turn off the bubbler system to allow manatees to enter and exit the lock chamber.

(d) When manatees are first observed in the lock area, lock operators will inform approaching vessels of any manatees in the area and their locations, so craft can use extra caution. Lock operators will then assure that vessels are at idle speed upon entering the approach channels and inform vessels of any manatee movements necessary to their safety.

(e) Every effort will be made not to crowd manatees in the lock chamber, especially with barges and tugs. Sufficient distance between vessels and gates will be maintained at all times.

(f) Precautions will be made to assure manatee safety around sector gates. Operate sector gates at slowest speeds possible for the first minute to avoid manatees being trapped in strong currents. Operate both sector gates simultaneously; leaving one gate closed for any reason other than an emergency or malfunction should be avoided. However, at Canaveral Lock one sector gate may be left closed when not needed for lockage.

(g) Delay vessels or lockage temporarily if imminent danger to a manatee exists by continuing operations. When locking manatees and vessels together delay vessels after lockage to assure manatees enough time to clear the area and gain access to safe water. Vessel operators should then be warned to proceed with caution at idle speed. If there is doubt that the manatee has exited the chamber, the gates shall be left open to assure safe passage.

(h) The FOA will perform inspections of manatee exclusion screening devices on lock gates every 6 months and any time damage is suspected. Deficiencies will be corrected as soon as possible.

(2) Flood Control/Spillway Gate Operations.

The following standard operating procedures, in conjunction with the operating criteria contained in the approved water control plans and manuals for the Central and Southern Florida Project, are designed to reduce manatee risk during spillway operations. These procedures, however, are not intended for use at structures where manatee barriers (whether temporary or permanent) prevent manatee access to the spillway gates. The procedures below should only be used at spillways without barriers, or at spillways where barriers have been removed or are otherwise not fully functional. At spillways where barriers are functional and prevent manatee access to the spillway gates, gates should be operated in accordance with the operating criteria set forth in the water control plans and manuals.

(a) Standard operating procedure for S-78, Ortona; and S-80, St. Lucie.

The following procedures are designed to put the manatee at less risk during spillway operations and are based on the water surface profile (difference between the upper and lower pools) of the S-78 spillway (9' to 11') and S-80 spillway (12' to 14').

(1) On initial gate openings stop gate for 30 second period upon first sign of water movement. (Approximately .01 to .03 feet).

(2) Stop at .05' increments for 30 seconds until a .3' opening is acquired. Observe for a continuous flow across the full gate width at each increment.

(3) Continue opening gate in increments not to exceed .3' until gate is at desired opening. Operator will continuously observe for obstructions in gate opening during this procedure.

(4) If voids appear (interruptions of even water flow across the full gate width) the operator will determine to the best of his/her ability the source of the voids and make the following decision.

(a) If it appears to be trash or debris that is caught in the gate (aquatic plants, trees or other such debris) the operator will continue to open the gate at .3' increments at 30 second periods until the debris has passed through the gate and then lower the gate at .3' increments at 30 second periods until the desired gate setting is obtained.

(b) If it appears that a manatee has been entrapped, the gate should be operated as follows: If the current gate opening is less than or equal to 0.6 feet, the gate is to be closed to a height of 0.3 feet so that the manatee will be able to free itself. The gate may then be raised to the desired opening; this raising should be done in increments not to exceed 0.3 feet and with continual observations for obstructions. However, if the current gate opening is greater than 0.6 feet, then the gate should be immediately opened to allow the manatee to be washed through (up to a maximum of 2.5 feet) and then adjusted to the desired opening.

(5) Gates will always be maintained at the smallest possible opening across all gates. The minimum gate opening when more than 1 gate is in operation, will be .5 feet. This will allow debris to be flushed through the gate without being caught. The maximum single gate openings will be .9 feet.

(6) Spillway operations will be accomplished only by qualified operators, through on-the-job training, who are able to perform the standard operation procedures for manatee protection described herein.

(b) General rule for operating SINGLE OR MULTIPLE GATES at S-77, Moore Haven; S-79, W.P. Franklin; S-308, Port Mayaca; S-351; S-352; and S-354, when the difference between headwater and tailwater elevations, or head, across these structures is less than or equal to 3.0 feet.

(1) To allow manatees to pass under the gates, the minimum opening for any gate under the "less than or equal to 3.0 feet of head" condition is 2.5 feet. One or more gates may be opened to 2.5 feet, subject to the following constraints: The operator should open the more central gates of the structure first, proceeding outward to those gates further from the center. The operator should also open gates on alternating sides of the structure. Thus, if there are four gates numbered 1-4 from left to right, a correct sequence for opening them would be: Gates 2, 3, 1, and 4. An equally correct sequence would be: Gates 3, 2, 4, and 1. Gates should be closed in reverse order.

(2) Gate openings greater than 2.5 feet should not be made until all gates have been opened to 2.5 feet, at which time additional gate openings may be made as follows: The operator may increase each gate opening in equal increments, in turn, in accordance with the Maximum Allowable Gate Opening (MAGO) curves until the predetermined opening is attained. At the end of the gate opening sequence, all of the gates must be set at approximately equal gate openings, all in accordance with the MAGO curves. As a practical consideration the spillway gates should not be adjusted such that gate openings differ by more than one foot.

(3) This procedure should be used at S-77 only if the tail water is above +9.0 feet, NGVD; and at S-79 only if the tail water is above -2.0 feet, NGVD. In other words, in the rare event that these conditions are not met, do not exceed the maximum allowable gate opening criteria.

(4) Gate openings greater than 2.5 feet shall be accomplished according to the operational criteria specified in the approved water control plans and manuals for the Central and Southern Florida Project.

(5) Spillway operations will be accomplished only by qualified operators, through on-the-job training, who are able to perform the standard operating procedures for manatee protection as described herein.

(6) The procedures above are only applicable for heads less than or equal to 3.0 feet. Procedures for heads exceeding 3.0 feet are described in the paragraphs that follow. If, while operating under the low head procedures above, the head across the

structure should exceed 3.0 feet, the following steps should be taken: The gates should be closed, in reverse order, to openings permitted by the Maximum Allowable Gate Opening (MAGO) curves. The operating procedures applicable to heads greater than 3.0 feet should then be used.

(c) General rule for operating a SINGLE GATE at S-77, S-79, S-308, S-351, S-352, and S-354, provided that the difference between headwater and tailwater elevations, or head, across these structures is greater than 3.0 feet.

(1) If it is predetermined that an opening smaller than or equal to 2.5 feet would be needed for the gate:

The gate may be initially opened to a maximum of 2.5 feet and held at that opening for up to one (1) minute. Forces of the water should "flush-through" any manatee that may be resting against the gate or in the immediate vicinity while the gate is at the 2.5-foot opening. Within the one minute period, the gate must be closed to the predetermined opening. If the predetermined opening is not permitted by the Maximum Allowable Gate Opening (MAGO) curves, the operator must close the gate to a permitted opening and wait until the discharge raises the tailwater elevation so that the opening can be increased to the predetermined opening in accordance with the MAGO curves.

(2) If it is predetermined that an opening larger than 2.5 feet would be needed for the gate:

The gate may be initially opened to a predetermined opening larger than 2.5 feet, provided that such an opening would be permitted by the Maximum Allowable Gate Opening (MAGO) curves. If the predetermined opening would not be permitted by the MAGO curves, the gate may be initially opened to 2.5 feet and held at that opening for up to one (1) minute. Forces of the water should "flush-through" any manatee that may be resting against the gate or in the immediate vicinity while the gate is at the 2.5-foot opening. Within the one minute period, the operator must close the gate to a permitted opening in accordance with the MAGO curves and wait until the discharge raises the tailwater elevation. As the tailwater rises, the gate opening may be increased to the predetermined opening in accordance with the MAGO curves.

(3) This procedure should be used at S-77 only if the tail water is above +9.0 feet, NGVD; and at S-79 only if the tail water is above -2.0 feet, NGVD. In other words, do not exceed

the maximum allowable gate opening criteria in the rare event that these conditions are not met.

(4) Gate openings greater than 2.5 feet shall be accomplished according to the operational criteria specified in the approved water control plans and manuals for the Central and Southern Florida Project.

(5) Spillway operations will be accomplished only by qualified operators, through on-the-job training, who are able to perform the standard operating procedures for manatee protection as described herein.

(d) General rule for operating MULTIPLE GATES at S-77, S-79, S-308, S-351, S-352, and S-354, provided that the difference between headwater and tailwater elevations, or head, across these structures is greater than 3.0 feet.

(1) If it is predetermined that an opening smaller than or equal to 2.5 feet would be needed for the gates: One gate may be initially opened to a maximum of 2.5 feet and held at that opening for up to one (1) minute. Forces of the water should "flush-through" any manatee that may be resting against the gate or in the immediate vicinity of the gate. Within the one-minute period, the gate must be closed to the predetermined setting. If the predetermined opening would not be permitted by the Maximum Allowable Gate Opening (MAGO) curves, then the operator must lower the gate to a permitted smaller opening. This same procedure would then be repeated for opening the remaining gates. As the tailwater rises because of the discharge, the operator may increase each gate opening in equal increments, in turn, in accordance with the MAGO curves until the predetermined opening is attained. At the end of the gate opening sequence, all of the gates must be set at approximately equal gate openings, all in accordance with the MAGO curves. As a practical consideration the spillway gates should not be adjusted such that gate openings differ by more than one foot.

(2) If it is predetermined that an opening larger than 2.5 feet would be needed for the gates:

One gate may be initially opened to a predetermined opening larger than 2.5 feet, if such an opening would be permitted by the Maximum Allowable Gate Opening (MAGO) curves. The remaining gates must also be opened to the same opening. If the MAGO curves do not permit a 2.5-foot opening, one gate may be opened to 2.5 feet and then closed to a permitted opening within a maximum period of one (1) minute.

Forces of the water should "flush-through" any manatee that may be resting against the gate or in the immediate vicinity while the gate is at 2.5-foot opening. This same procedure must be repeated for opening the remaining gates. As the tailwater rises because of the discharge, the operator may increase each gate opening in equal increments, in turn, in accordance with the MAGO curves until the predetermined opening is attained. At the end of the gate opening sequence, all of the gates must be set at approximately equal gate openings, all in accordance with the MAGO curves. As a practical consideration the spillway gates should not be adjusted such that gate openings differ by more than one foot.

(3) This procedure should be used at S-77 only if the tail water is above +9.0 feet, NGVD; and at S-79 only if the tail water is above -2.0 feet, NGVD. In other words, do not exceed the maximum allowable gate opening criteria in the rare event that these conditions are not met.

(4) Gate openings greater than 2.5 feet shall be accomplished according to the operational criteria specified in the approved water control plans and manuals for the Central and Southern Florida Project.

(5) Spillway operations will be accomplished only by qualified operators, through on-the-job training, who are able to perform the standard operating procedures for manatee protection as described herein.

(3) Culvert Operations.

The following standard operating procedures are in effect to reduce manatee risk at H.H. Dike and these extension levee culverts; 1, 1-A, 2, 3, 4-A, 5, 5-A, 6, 7, 8, 9, 10, 10-A, 11, 12, 12-A, 13, 14, 16, and the following pipe culverts 1 (L-50); 1, 2, 3, 4, 5, 6 (Harney Pond Canal); 1, 2, 3 (Indian Prairie Canal); 1, 2, 3, 4 (Kissimmee River) and (50) pipe culverts on C-43, Caloosahatchee River, C.M.P. with risers.

(a) When the vertical lift gates are being opened from the closed position, they will be raised to an initial opening of 2.5 feet and then closed to the desired setting. This will allow a resting manatee to be flushed through the culvert rather than being pinned and drowned at the point of the gate opening.

(b) When the flap gate culverts are being opened by winch or crane, the shape of the flap gate and the slow operation will alert the manatee to move before a strong current could trap it at the point of the gate opening.

(c) If manatees are observed during culvert operations, they will be discouraged from passing through to the smaller canal system in order to prevent entrapment in shallow water, possible harassment in developed areas and potential starvation.

c. District and interagency reporting requirements.

(1) Sightings of dead, injured, sick or newly calved manatees, as well as sightings of manatees in smaller, shallower canal systems associated with Corps water control structures but outside Lake Okeechobee and Okeechobee Waterway, will be immediately reported to the Manatee Hotline at 800 DIAL-FMP (342-5367). It will be the responsibility of the FOA to promptly notify the Jacksonville District Office, Operations Branch, Project Operations Section. (See Appendix A, Manatee Protection Plan Point of Contact List)

(2) Prior to FDEP manatee rescue operations or investigations requiring diving by any agency at U.S. Army Corps of Engineers structures, coordination of dive plans will be submitted by the requesting agency through the FOA to the Jacksonville District Office, Operations Branch, Plant Section. (See Appendix A, Manatee Protection Plan Point of Contact List)

(3) The COE (Operations Branch, Project Operations Section) will notify FDEP and FWS well in advance of scheduled maintenance construction.

(4) The COE (Operations Branch, Project Operations Section) will provide an annual report NLT 31 January to FDEP and FWS that outlines the previous years structural and operational changes and goals for the upcoming year.

5. Summary.

This project operations manatee protection plan was developed to provide policy and procedure for the effective long-range management and operation of water control structures to minimize and reduce manatee risk at such structures. We believe this plan accurately addresses structure-related problem areas, and presents workable standard operating procedures to assist in the recovery of the Florida Manatee. In order to meet the objective of this plan, all involved must continually monitor and recommend any necessary revisions for update that will minimize conflicts between the manatee and the intended uses of these structures.

FOR THE COMMANDER:

JAMES A. CONNELL
LTC, Corps of Engineers
Deputy Commander

2 APPENDICES
APP A - Manatee Protection Plan Point of Contact List
APP B - Sample Jacksonville District Manatee Mortality Investigation Report

APPENDIX A

Manatee Protection Plan Point of Contact List

Florida Department of Environmental Protection
Marjory Stoneman Douglas Building
3900 Commonwealth Boulevard
Tallahassee, Florida 32399

Mr. Pat Rose	(904) 922-4330
Mr. Kipp R. Frohlich	(904) 922-4330

U.S. Fish and Wildlife Service
6620 Southpoint Dr., South
Suite 310
Jacksonville, FL 32216

Mr. Robert Turner	(904) 232-2580
Mr. Jim Valade	(904) 232-2580

South Florida Water Management District
Post Office Box 24680
West Palm Beach, FL 33416

Mr. Frank Lund	(407) 687-6631
Mr. Robert Chamberlain	(407) 338-1668

U.S. Army Corps of Engineers
P.O. Box 4970
Jacksonville, FL 32232

Planning Division, Environmental Studies Section, (CESAJ-PD-ES)

Mr. Elmar Kurzbach	(904) 232-2325
Ms. Therese Fretwell	(904) 232-3271

Engineering Division, Water Management and Meteorology Section, (CESAJ-EN-HW)

Mr. James Vearil	(904) 232-2142
Mr. Adam Stuart	(904) 232-2116

Mechanical and Electrical Section, (CESAJ-EN-DM)

Ms. Shashi Makker	(904) 232-1112

Operations Branch, Project Operations Section, (CESAJ-CO-OR)

Mr. Bill Zattau	(904) 232-2215
Mr. Donnie Kinard	(904) 232-2255

South Florida Operations Office (CESAJ-CO-S)
525 Ridgelawn Road
Clewiston, FL 33440

Mr. Pete Milam	(813) 983-8101
Mr. Ron Miedema	(813) 983-8101

APPENDIX B

Sample
Jacksonville District
Manatee Mortality Investigation Report

REPORT DATE: (Date report is prepared)

CASE/LOCATION: (Field ID number from DEP necropsy report and location of incident)

DESCRIPTION: (Description of incident from DEP official letter of notification/necropsy report. Include reported cause of death and any other pertinent information.)

PERSONAL ACCOUNTS: (Document any actions and/or observations by lock personnel, others, etc.)

EQUIPMENT MALFUNCTIONS or UNUSUAL MANATEE OBSERVATIONS: (Document any equipment malfunctions or unusual manatee observations, etc, that may have bearing on the incident.)

C&SF WATER CONDITIONS SUMMARY (NUMBER OF GATE CHANGES AND LOCKAGES) FOR PERIOD OF / / - / / : (Provide dates for period.)

DATE	UPPER	LOWER	WINDS	RAINFALL	S-SPILLWAY	LOCKAGES
6/16	1454	1159	CALM	2.93	CLO	20

(An analysis of openings and closings for both the navigation lock and the water control structure should be provided for the week prior to the carcass recovery as shown in the above example.)

SUMMARY: (Provide findings, conclusions and recommendations regarding the reported incident.)

REPORT FILED BY: (Name of individual completing report, office symbol, and telephone number).

APPENDIX D

APPENDIX D

Mechanical & Electrical Description of Sector Gate Locks

I. SFWMD STRUCTURES:

a. General: All SFWMD locks are manually operated. Except for S-193, none of the SFWMD locks are retrofitted with telemetry system. The telemetry system at S-193 is used to monitor water levels. The basic operating system used throughout the locks managed by SFWMD is described as follows:

b. Hydraulic Type: The operating unit for each gate sector consists of a hydraulic motor driving in turn a gear-type speed reducer and a double wire rope drum. A spring-set, electrically released brake is mounted on an extension of the reducer input shaft. Limits of gate travel and slow-speed control when approaching the limits of travel are automatically effected by lever-type switches actuated by trip bars mounted on the outer face of the gate. All of the above components, except the limit switches, are assembled as a unit on a structural steel base, and they are located in the machinery house recess below the floor plate. Two ropes, one from each section of the drum, extend through a series of rollers and sheaves and wrap around the outer face of the gate sector with the two ropes fastening at opposite ends of the gate. Due to the opposite hand scoring of the two sections of the drum, as the drum is turned, one rope pays in as the other pays out, thereby affecting the desired direction of gate movement. The rope-to-gate attachment includes a turnbuckle for adjusting the rope length. Reversal of direction of gate travel is accomplished by shifting hydraulic directional control valves in order to reverse the rotation of the rope drum. Limits of gate travel would be affected by lever-type switches actuated by trips mounted on the periphery of the gate.

All hydraulic system valves and controls required to operate the gate sectors are solenoid-actuated so that their entire operation may be handled remotely from the control panel stands. The hydraulic system is designed to provide two basic speeds of gate operation. The fast speed has a peripheral gate speed of approximately 10 to 12 feet per minute. The manually variable slow speed of 0 to 2 feet per minute is obtained by reducing the quantity of oil flowing to the hydraulic motor by means of a variable flow bleed-off or bypass system. Slow speed will be considered as effecting a nominal peripheral gate speed of 2 feet per minute. Starting and stopping of the power unit, and the selection of gate direction and fast or slow speed are to be generally manually controlled by the operator.

The gates are operated from hydraulic control panels in the machinery houses located adjacent to the gates. Each gate has its own machinery house. The following structures fall within this category:

(1) S-310

(2) S-193

2. COE STRUCTURES:

a. General: All locks are manned structures. Two basic operating systems are used throughout the locks managed by the COE. They are as follows:

i. Hydraulic Type: This system is identical to hydraulic system as described above. Machinery is located in machinery house adjacent to each gate. The lock is operated from central panel at a machinery house; except Moore Haven Lock is operated from central panel in main control room. The following structures fall within this category:

(1) Moore Haven Lock

(2) W.P. Franklin Lock

(3) Port Mayaca Lock (S-308B)

ii. Non-Hydraulic Type: These units are installed in the machinery houses and are normally operated by electric power; however, a provision is made on each unit for emergency operation with manual power. A driving rack is installed around the outside face of each sector gate, and movement is effected by rack and pinion drive. The following structures fall within this category:

(1) Ortona Lock - old DC operating system. Gates are operated from machinery houses adjacent to the gates.

(2) St. Lucie Lock - electrical manual and programmable system, using AC frequency drives. The lock is operated from a control house.

b. Electrical System: All COE structures have commercial power and stand-by LPG genset ranging in sizes from 7.5 to 15 KW. An automatic transfer switch (ATS) transfers operation from commercial power to emergency power as necessary. Contrary to the SFWMD structures, all COE structures have single phase systems.

c. Manatee Protection: Port Mayaca Lock was selected as a test site that has been retrofitted with the hydraulic hose sensor manatee protection system.

d. Stilling Wells: Except for St. Lucie Lock, all COE structures have stilling wells.

e. Telemetry System: None of the COE managed structures have been retrofitted with a telemetry system.

TABLE 1 SUMMARY OF SECTOR GATE STRUCTURES

STRUCTURE #/NAME	SECTOR GATES HEIGHT & (LOCK WIDTH)	PROPOSED OPERATION	OPERATED BY
S-193	27' upper 20' lower (50')	manual*	SFWMD
S-310	32' upper 26.1' lower (50')	"	"
MOORE HAVEN	32' upper 21.5' lower (50')	"	COE
ORTONA	21.5'upper 32' lower (50')	"	"
W.P. FRANKLIN	24.5' (56')	"	"
ST. LUCIE	21.5' upper 32' lower (50')	"	"
PORT MAYACA S-308B	35.5'upper 30.5'lower (56')	"	"

TABLE 1 NOTES:

* After presence of a manatee is detected and an alarm goes off alerting the operator, operation of gates will be done manually by the operator.

APPENDIX E

DESCRIPTION OF CENTRAL AND SOUTHERN FLORIDA PROJECT LOCK STRUCTURES

I. GENERAL DESCRIPTION OF SECTOR GATED LOCK OPERATIONS

This section provides a basic description of the sector gated locks in Central and Southern Florida. An understanding of these structures should aid in properly evaluating the measures being proposed for preventing manatee fatalities. A description of other types of water control structures can be found in Appendix E of the Manatee Protection Plan Part I, "General Description of Lock and Spillway Operations." Some of the information, illustrations, and photographs from that description are included in this report as supplemental information.

A. Locks. A navigation lock can be thought of as a kind of "boat elevator", into which a boat enters through one side and exits through the other side. The bodies of water immediately upstream and downstream of a lock are referred to as the upper and lower pools, respectively. The lock chamber lies between the two pools. A lock allows a boat to "step" from the water level in the lower pool to the water level in the upper pool, or vice versa. Closure gates are required at both ends of the lock chamber so that the water level inside the lock chamber can be varied to coincide with the water levels in the upper and lower pools. The sequence of "locking" a vessel upstream is: first, lower the water level in the lock chamber to the downstream water level; second, open the lower gate and move the vessel into the lock chamber; third, close the lower gate and fill the lock chamber to the level of the upper pool; and finally, open the upstream gate and move the vessel out of the lock. Lockage of a vessel downstream involves a similar sequence in reverse order.

(1) Sector-Gated Lock. A sector gate is a pie slice- or wedge-shaped gate similar to a tainter gate, except that it is oriented to rotate horizontally (i.e., about a vertical axis). Sector gates are used in pairs, meeting at the center of the lock when in the closed position and swinging into recesses in the lock walls for the open position. Figure 3 shows Moore Haven Lock, a typical lock with sector gates. Photographs F, G, H, and I show sector gates at sector-gated locks. Photographs J, K, and L contain close-up views of the locations where sector gates meet when closed and where, correspondingly, manatees can be injured.

Locks S-310 and S-193, and all Okeechobee Waterway locks (St. Lucie, Port Mayaca, Moore Haven, Ortona, and W.P. Franklin), are sector-gated locks. The lock chambers are all either 50 or 56 feet wide. The sector gate heights vary from 20 feet to 35 feet, and sometimes the upper gates differ in height from that of the lower gates. Sector gates have two speed settings, a low and a high speed, at which they operate. As the gate swings from the fully open position to the closed position, it begins moving at the low speed and soon changes to the high speed. The gate continues most of its motion at the high speed setting, slowing down to the low speed 18 inches on each side of the closure point before reaching the point of gate closure. The gates travel at the low speed until they finally meet.

Another danger to manatees at sector-gated locks is the possibility that manatees could swim into the sector gate recesses and be crushed. Access has been possible either through the "sides" of the sector gate wedge, or through depressions in the floor of the lock chamber. Screens have been installed on the side and bottom of the gates at certain structures to prevent manatees from swimming into the sector gate recesses.

(2) Vertical Lift-Gated Lock. Instead of a pair of sector gates, this type of lock has a single vertical lift gate on each end. This type of lock was described in the Manatee Protection Part I report. None of the locks within the scope of the Manatee Protection Plan Part II study are vertical lift-gated locks.

II. LAKE OKEECHOBEE AND OKEECHOBEE WATERWAY STRUCTURES

Lake Okeechobee, a natural lake, is located about 30 miles from the Atlantic coast and 60 miles from the Gulf of Mexico in south central Florida. Local flood protection levees of the C&SF Project completely encircle the lake, forming a major multi-purpose reservoir. The lake is regulated to provide flood control; navigation; water supply for agricultural irrigation, municipalities and industry, Everglades National Park; regional groundwater control and salinity control; enhancement of fish and wildlife; and recreation. The drainage area, including the lake area, is about 5,600 square miles. The Okeechobee Waterway, which crosses the lake, is 154.6 miles long and 8 feet deep from Fort Myers on the west coast to the Intracoastal Waterway near Stuart on the east coast. Table 1 contains the optimum water control elevations for the project structures in this study. Below are descriptions of these structures. In Table 1 and in the descriptions, information on spillways adjacent to the locks is provided for information purposes.

A. Structure 80 (St. Lucie Lock and Dam). S-80 is located in Martin County along the St. Lucie Canal (C-44) approximately 15.5 miles above the intersection of the St. Lucie River with the Intracoastal Waterway. The lock serves the purpose of navigation and as an emergency flood control facility. The connecting spillway structure is a control structure for flood control and for regulatory control of flow through the St. Lucie Canal for control of the level of water in Lake Okeechobee. The first lock was built at this site by the Everglades Drainage District in 1925 and is hereby referred to as the old lock. The new lock was completed by the Corps of Engineers in 1941 at which time the old lock became designated as an auxiliary lock. The main spillway with temporary wooden flashboards was completed in 1944, and in 1950 seven steel tainter gates were installed. The Flood Control Act of 1948 authorized an enlarging of the discharge capacity of the spillway and was assigned the project name of S-80. The enlargement of the spillway was later deleted from the project in connection with the 1968 Water Resources Plan, but the name (S-80) remains in use to describe the lock and spillway structures. The spillway is a concrete structure having an overall width between abutment piers of 170 feet. It is provided with 7 electrically-operated structural steel tainter gates, each having a length of 20 feet and a height of 10.5 feet. The sill is at elevation 0.56 ft., NGVD. The lock is a sector gate type lock, providing 50-foot clear navigation width and a 250-foot usable length of lock chamber. Upper and lower sills are at NGVD elevations of -0.94 and -12.44 feet, respectively, providing 10-foot navigable depth at extreme low water.

B. Structure 308B and C (Port Mayaca Lock and Spillway). S-308B and C are located in Martin County, in Lake Okeechobee at Port Mayaca. Their purpose is to permit the raising of regulatory levels in Lake Okeechobee and to mitigate the effects of higher lake stages along the St. Lucie Canal (C-44). The spillway, S-308C, is required in the St. Lucie Canal to regulate water levels in the lake and to pass normal and standard project flood (SPF) discharges at non-eroding velocities. The structure consists of a reinforced concrete ogee-type spillway with 4 vertical lift steel gates and a horizontal stilling basin with end sill and one row of baffle blocks. An 11-foot reinforced concrete breastwall with a crest elevation of 40.0 ft., NGVD, provides protection from a hurricane for the area downstream of the structure. The design discharge is 14,800 cfs with a headwater elevation of 24.9 ft., NGVD, and a tailwater elevation of 23.2 feet,NGVD. The purpose of the lock, S-308B, is to permit use of the federal navigation project by navigation interests. The lock is 56 feet wide and 400 feet long (usable dimensions). The upstream and downstream sill elevation is -3.5 ft., NGVD, which provides a depth of 14.0 feet at the minimum lake stage of 10.5 ft., NGVD.

C. Structure 77 and Moore Haven Lock. Spillway S-77 is located on the Caloosahatchee River (C-43), in Levee D3 about 530 feet east of the Moore Haven Lock, near the town of Moore Haven in Glades County, Florida. Hurricane Gate Structure No. 1 (HGS-1) and Moore Haven Lock were completed in 1935. In 1966, S-77 Spillway was added to the site of the combined hurricane gate and lock. The spillway provides control of regulatory discharge from Lake Okeechobee to the Caloosahatchee River; restricts discharge during floods to that which will not cause damaging velocities or stages downstream; passes sufficient discharge during low-flow periods to maintain stages and satisfy irrigation demands downstream. It is a 4-bay reinforced-concrete ogee-type spillway, provided with 20.0 feet wide by 11.9 feet high vertical lift steel gates. Each gate is operated by a hydraulically operated cable hoist mounted on a reinforced concrete operating platform. The design capacity of this structure is 9,300 cfs when there is no local inflow into the canal downstream. Discharges should be controlled to prevent the tailwater from exceeding 13.1 ft., NGVD. The navigation lock, 56 feet wide by 400 feet in usable length, is of reinforced concrete rigid-frame type construction containing upper and lower sector gates. The sill elevation is -14 ft., NGVD, at both the upper and lower sills.

D. Structure 78 and Ortona Lock. S-78 is located on the Caloosahatchee River (Canal 43) in Glades County, near Ortona, Florida. It is on the existing by-pass channel around Ortona Lock, which is a navigation link of the Okeechobee Waterway, about 15.5 miles below Moore Haven. The spillway provides water control in the areas upstream; to control discharges during 30 percent standard project flood without exceeding desirable stages; to restrict discharge during floods to that which will not cause damaging velocities downstream; to pass the Lake regulation discharge of 9,300 cfs without exceeding desirable stages or velocities. No discharge would be passed through the lock. The structure is a 4-bay spillway, two bays of which are controlled by means of electric-motor-operated taintor gates; flow through the remaining two bays is controlled by electro-hydraulically operated vertical-lift gates. The navigation lock and spillway with two taintor gates were built in 1937; the two vertical lift gates were added in 1964. During periods of regulatory discharge from Lake Okeechobee, (up to 8,660 cfs under ultimate conditions) the spillway will be operated to maintain a headwater elevation of 10.6 ft., NGVD. The navigation lock, 56 feet wide by 400 feet useable length, is of reinforced concrete rigid-frame type construction containing upper and lower sector gates.

E. Structure 79 (W.P. Franklin Lock and Dam). This lock and spillway structure is located on the Caloosahatchee River (Canal 43) approximately 10 miles upstream from Fort Myers in Lee County, Florida. It is along the navigation canal of the Okeechobee Waterway between State Roads 78 and 80 immediately above Olga. The purpose of the S-79 spillway structure is to provide salinity and water control to lands adjacent to the Caloosahatchee River, prevent excessive depletion of ground water during normal or dry periods, and to provide regulatory discharge capacity for Lake Okeechobee. S-79 will pass all discharges up to the design capacity of 30% of the Standard Project Flood, or 28,000 cfs, without exceeding the design stage of 4.4 feet, MSL. The structure will also restrict discharges during larger-than-design floods to 28,900 cfs without causing damaging velocities downstream. The purpose of the lock is to permit use of the Federal navigation interests. An earthen dam is to the north of the spillway and was constructed to serve as the closure for the existing river and also to provide roadway access to the spillway and lock from the north. The spillway consists of 8 gated, reinforced concrete units located north of the lock, opposite the upper sector gate of the lock. The gates, 38 feet by 19.2 feet, are structural steel vertical lift type. The two outer gates function as skimmer gates while one of the center gates is provided with an automatic control. The automatic control allows water passage while regulating the headwater and stabilizes discharge by rising and falling with the tide. The spillway has a design discharge of 28,900 cfs and a weir elevation of -15.0 ft., NGVD. The navigation lock, 56 feet wide by 400 feet useable length, is of reinforced concrete rigid-frame type construction containing upper and lower sector gates. The sill elevation is -14 ft.,NGVD, at both the upper and lower sills.

F. S-193 (Lock) and Hurricane Gate Structure No. 6. S-193 is located in Okeechobee County on the northeast shore of Lake Okeechobee, 6 miles southeast of the city of Okeechobee. S-193 is in L-D4 at the mouth of Taylor Creek. This structure was originally built as HGS-6 with gates that were normally left open to permit unrestricted navigation between the lake and Taylor Creek. During hurricane alerts or when there was a threat of flooding from Lake Okeechobee the hurricane gate structure would be closed to protect the area from wind tides. S-193 was built as a lock structure to allow the use of HGS-6 for navigation when the Lake Okeechobee regulation schedule was raised to the 15.5- to 17.5-foot range. HGS-6, the lakeside set of sector gates, now a part of the lock, must still be closed and function as a hurricane protection barrier during hurricanes. The lock is 50 feet wide and has a usable length of 60 feet. Both sills are at elevation 5.5 ft., NGVD, which provides a depth of 7.5 feet of water over the sills under optimum conditions and 4.0 feet under the most severe drought conditions.

G. S-310 Lock (formerly Hurricane Gate Structure No. 2). Structure 310 (S-310) is located in Hendry County along the southwest shore of Lake Okeechobee, just north of the city of Clewiston. S-310 is in Levee D2 of the Herbert Hoover Dike at the mouth of the Industrial Canal. The structure was originally built as Hurricane Gate Structure No. 2 (HGS-2) in 1935. The gates of the structure were normally left open to permit unobstructed navigation between the lake and the Industrial Canal which allowed the canal stage to fluctuate with the lake stage. During hurricane alerts or when there was a threat of flooding from Lake Okeechobee the hurricane gate structure would be closed to protect the Clewiston area from flooding. In 1980 work was completed on the conversion of HGS-2 to lock Structure 310 enabling lake levels to be regulated independently of canal stages and navigation could continue without interruption when the Lake Okeechobee Regulation Schedule was raised to the 15.5 to 17.5 foot range. When the lake stage is above 15.5 ft., NGVD, the lock will be operated. The lock will remain open at all times when the lake stage is below 15.5 ft., NGVD. The optimum water level in the Industrial Canal is 15.0 ft., NGVD when the lock is in operation. While S-310 is closed, flood runoff from the Industrial Canal tributary area would be discharged westward through S-169 into C-21, then pumped into Lake Okeechobee by Pumping Station 4. Protection grade on the lake side is 36.7 ft., NGVD.

TABLE 1

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

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

TABLE 1 (Continued)

Optimum Water Control Elevations For
Okeechobee Waterway and Lake Okeechobee

Notes:

(1) Optimum water control elevations have been developed through operating experience. All elevations are referenced to National Geodetic Vertical Datum 1929.

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

This schedule does not significantly impact water supply, or lake stages but it does reduce the occurrence of large discharges to the estuaries. It is similar to the 1978 Regulation Schedule (previous regulation schedule) in that regulatory releases occur at relatively high lake stages from 15.65 ft. to 16.75 ft. compared to 15.5 to 17.5 ft. The largest difference between the current regulation schedule and the 1978 Regulation Schedule is that regulatory releases to the estuaries occur in a more graduated fashion. The first zone of releases (Zone D) incorporates pulse releases to the estuaries. Pulse releases are low level releases that mimic the natural runoff from a rainstorm event. Zone D releases to the estuaries and flows to the Water Conservation Areas have been successfully used several times in the past to avoid larger regulatory releases. Even though these releases are low in volume compared to other flood control releases, they may cause problems in the estuaries if used too frequently. However, it is still an environmentally sensitive approach to release water to these ecosystems and provides a compromise that can possibly avoid more harmful larger releases.

Lake stages can occur outside the regulation schedule. The minimum Lake elevation is 9.5 ft., NGVD. The 30-day average SPF stage is 24.8 ft., NGVD.

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

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

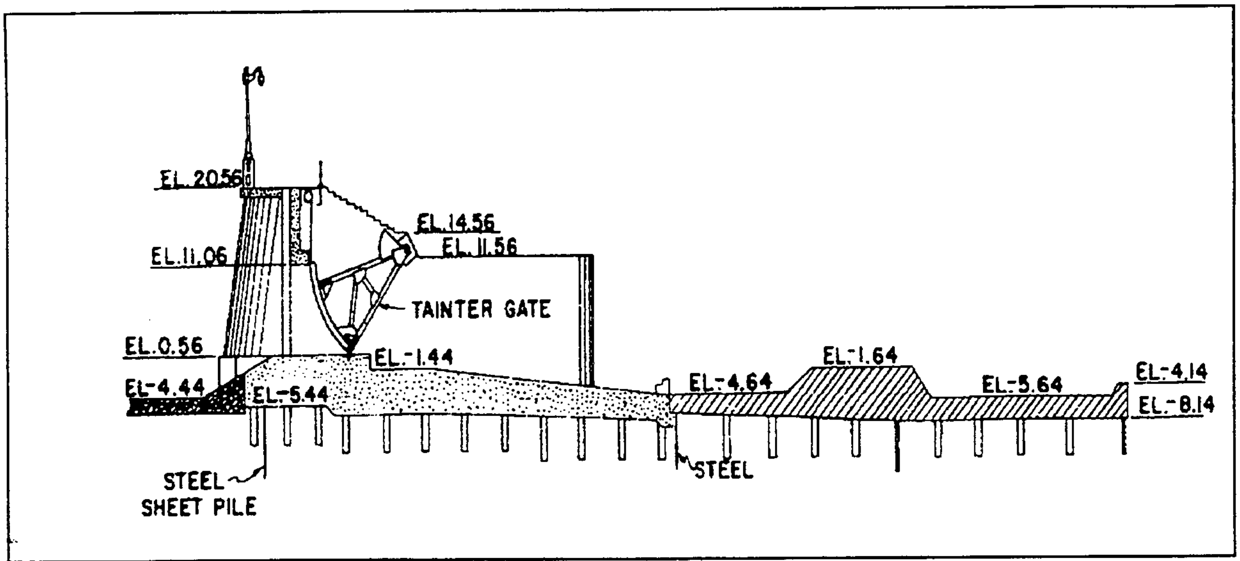


Figure 1: Cross section of St. Lucie Spillway. A typical tainter gate.

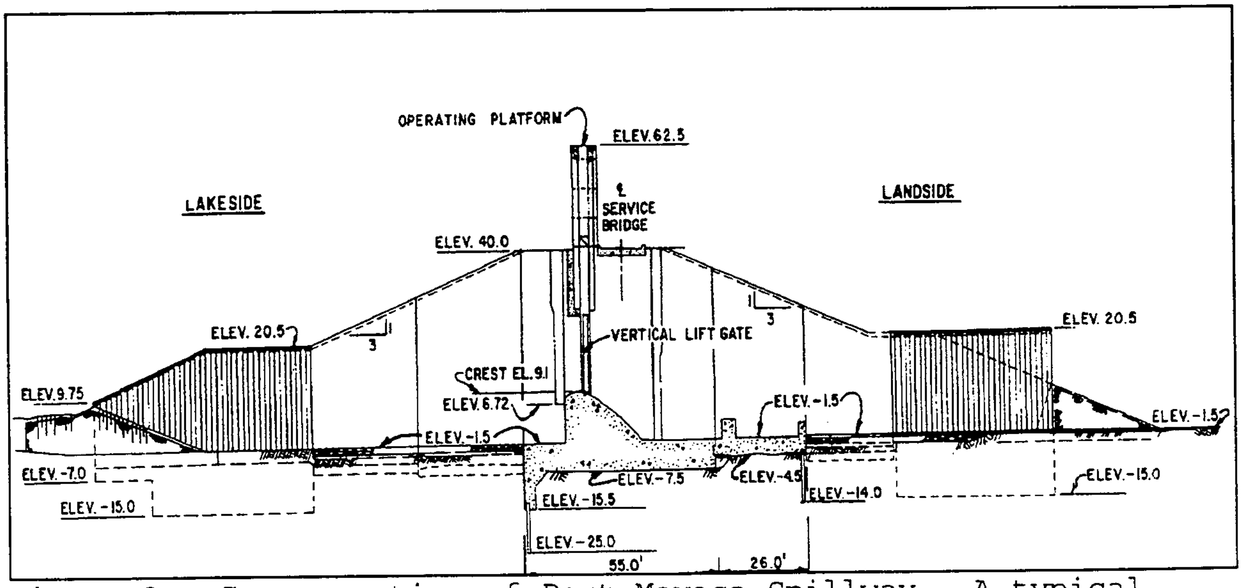


Figure 2: Cross section of Port Mayaca Spillway. A typical vertical gate.

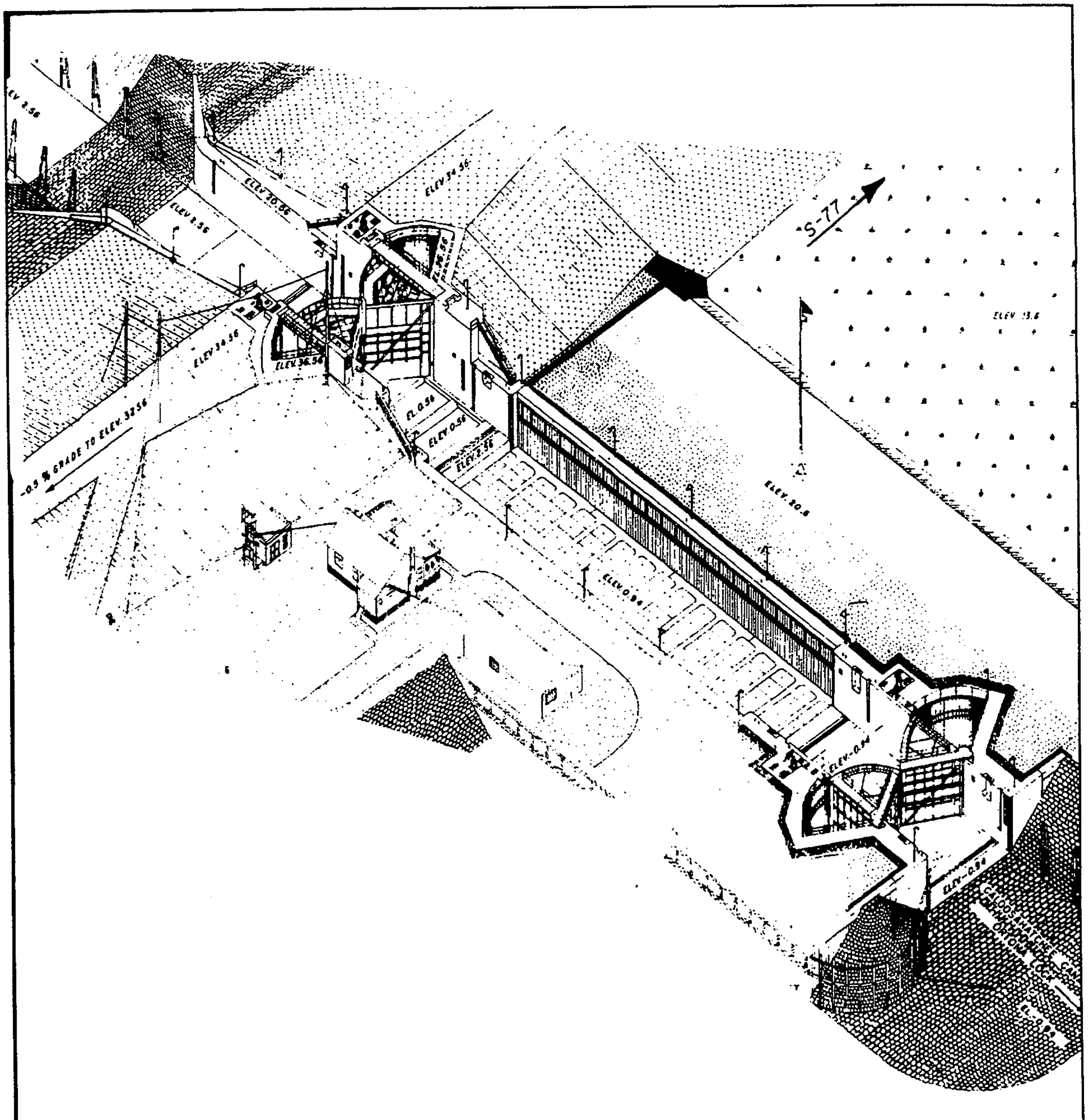
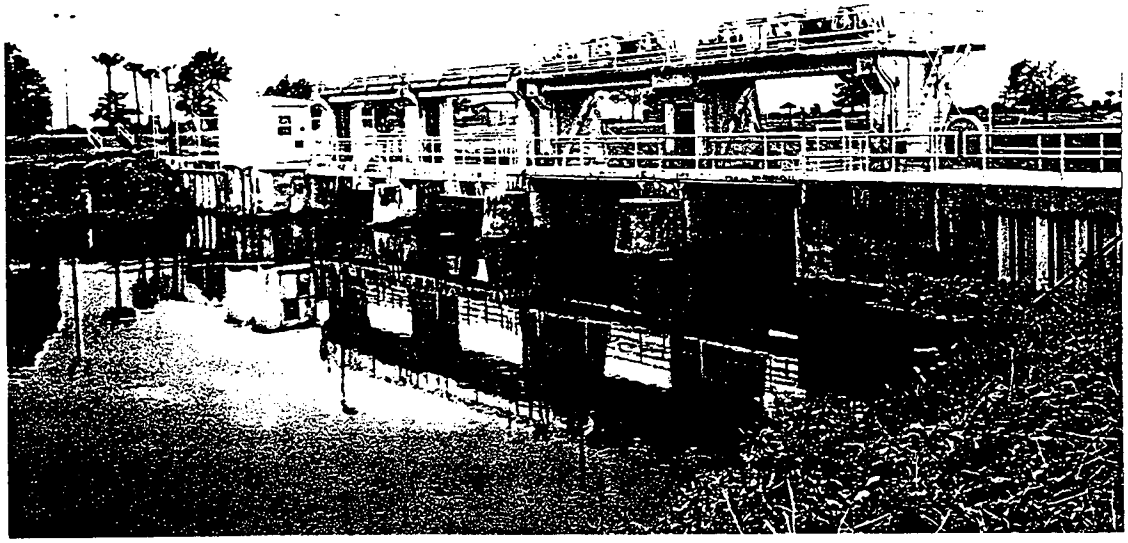
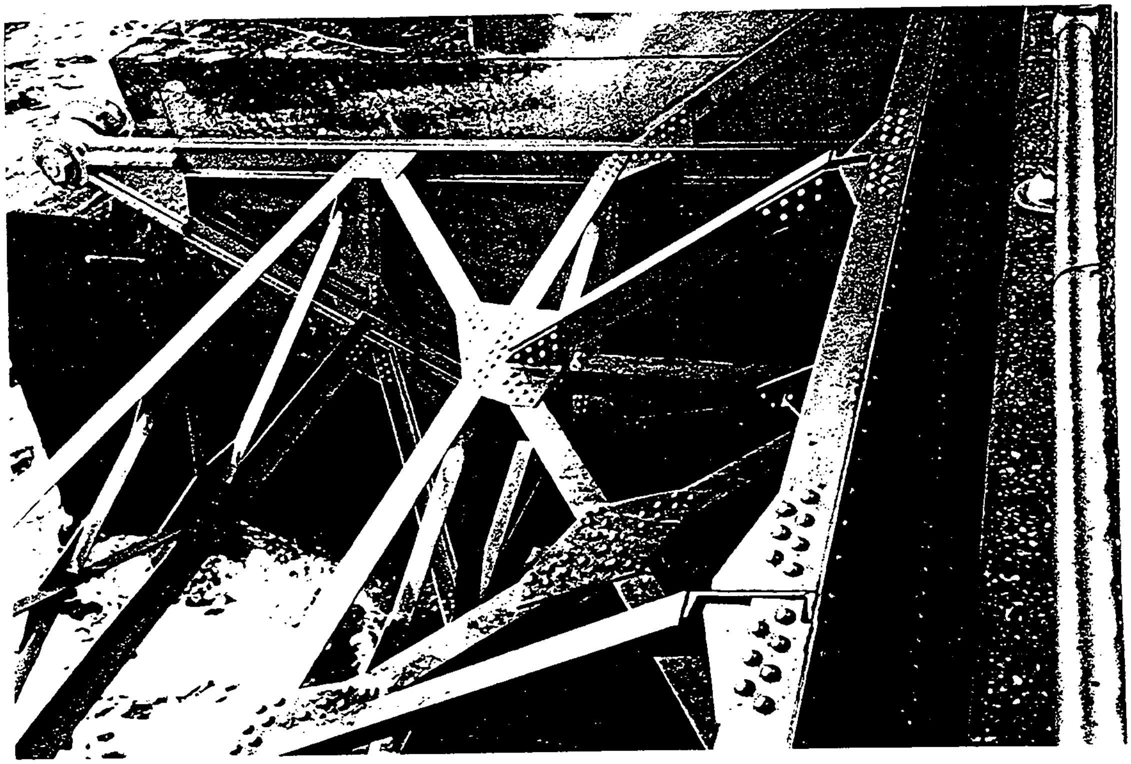


Figure 3: Moore Haven Lock- typical lock with sector gates.

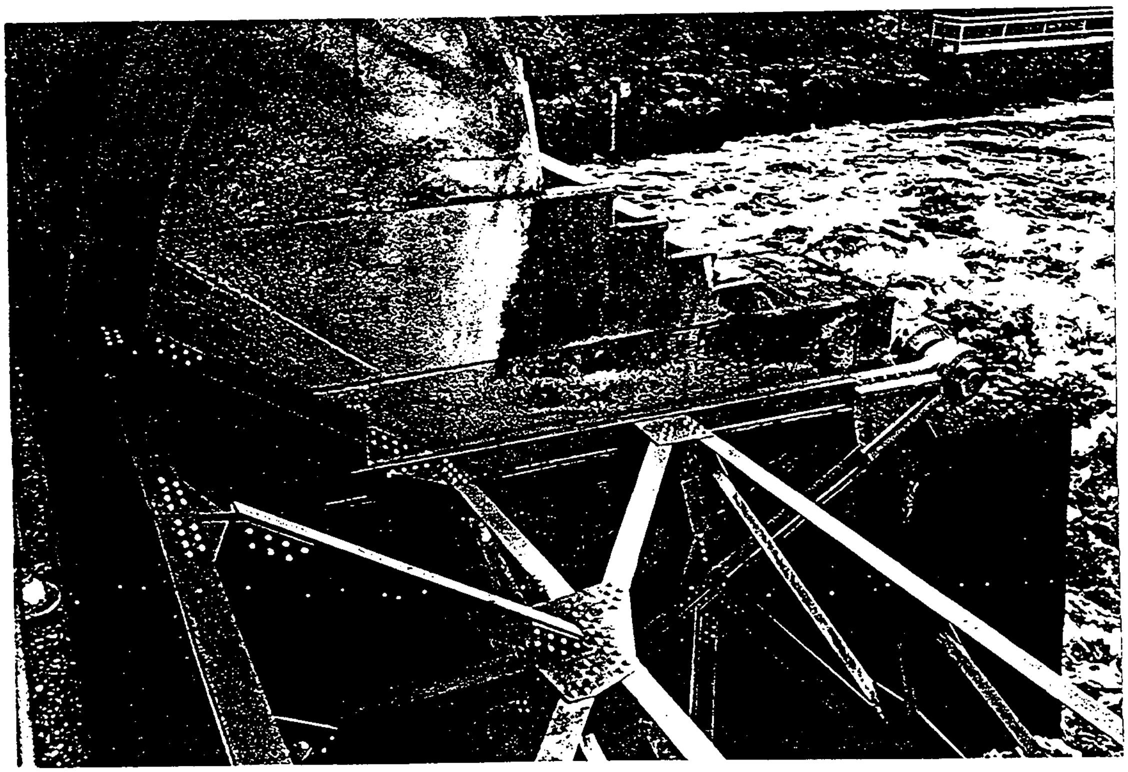


Photograph A. S-78 Spillway, upstream side. The two gates to the right are tainter gates; the two gates to the left are vertical lift gates.

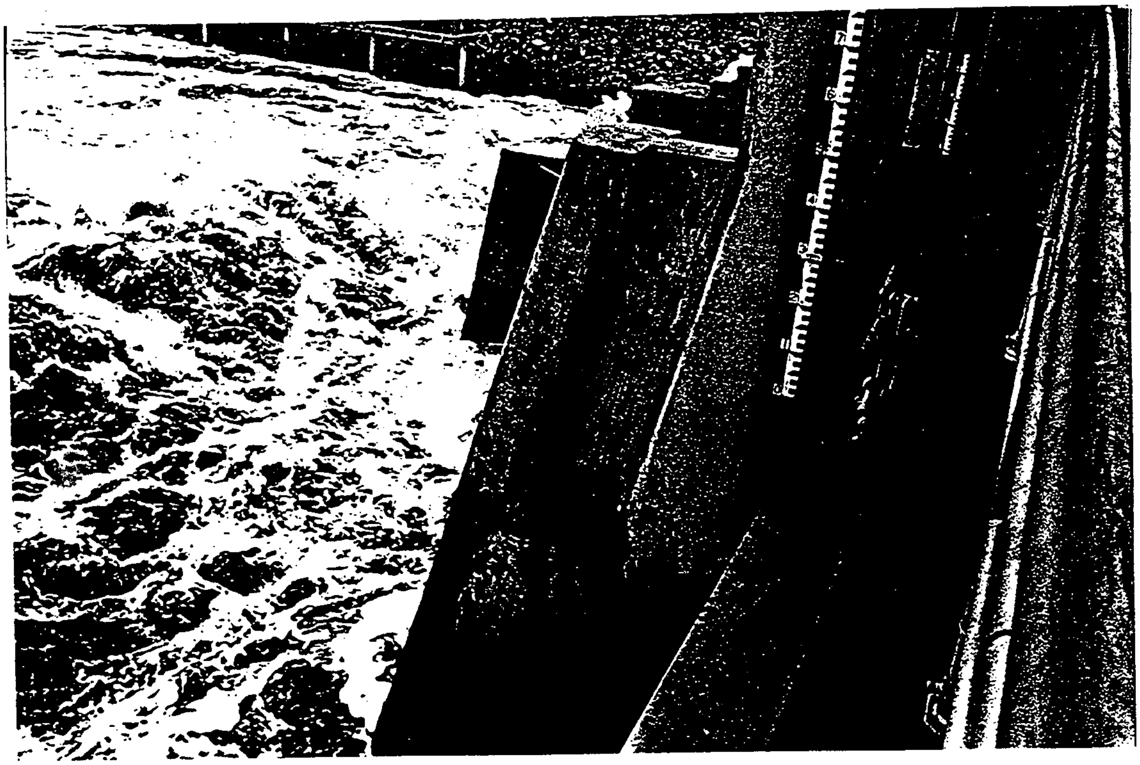
Photograph B. S-78 Spillway, downstream side. The two tainter gates are on the left; the two vertical lift gates are on the right.



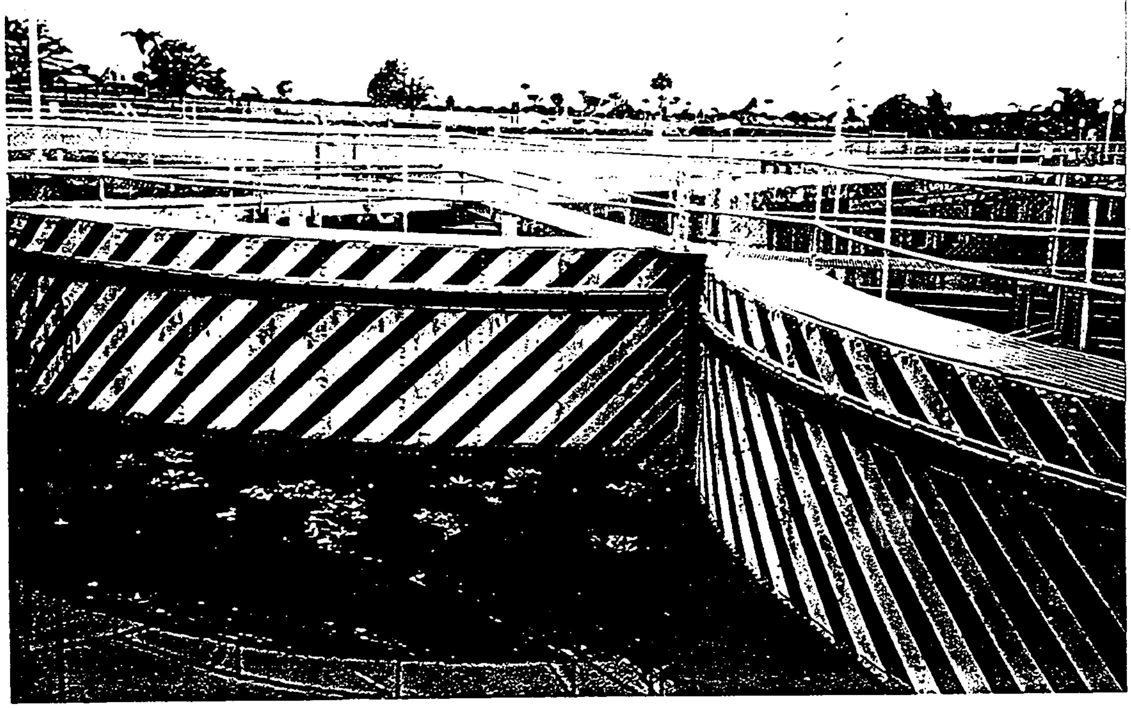
Photograph C. S-78 Spillway, tainter gate. Upstream is to the right. Note that a tainter gate is a segment of a cylinder mounted on radial arms which rotate about trunnions, one of which is visible in the upper left corner.



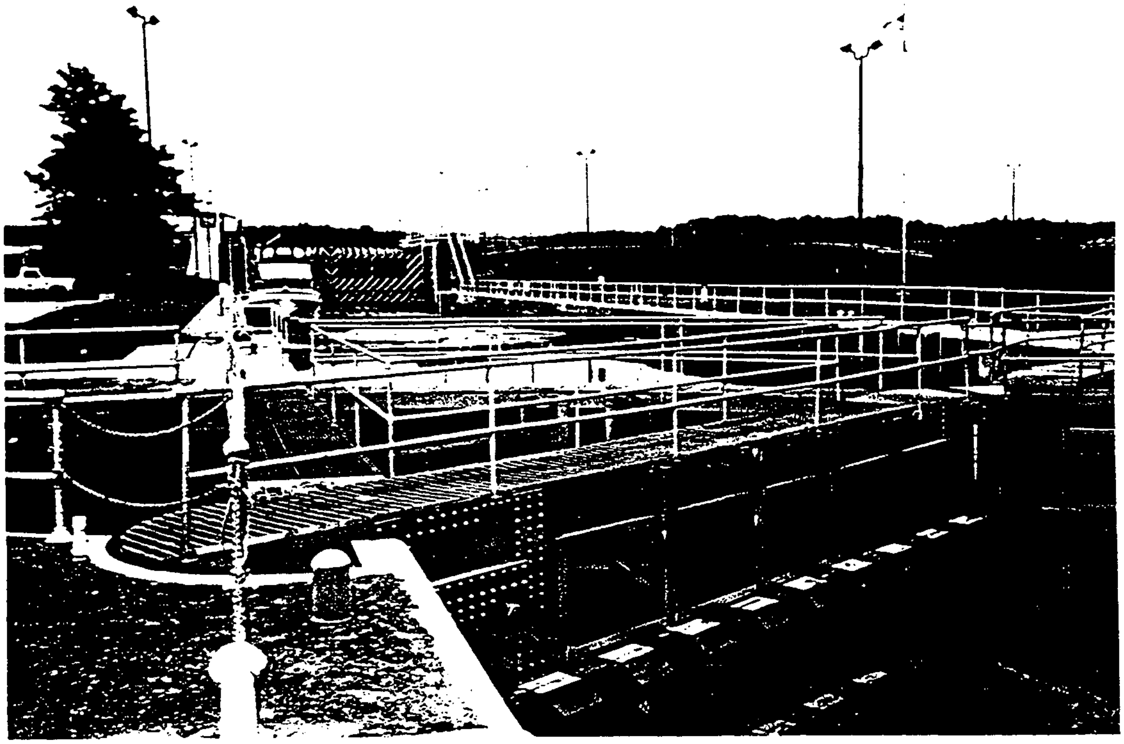
Photograph D. S-78 spillway, tainter gate. In this picture upstream is to the left. One of the hoist chains and the 3 ft. gate setting can be discerned (upper left).



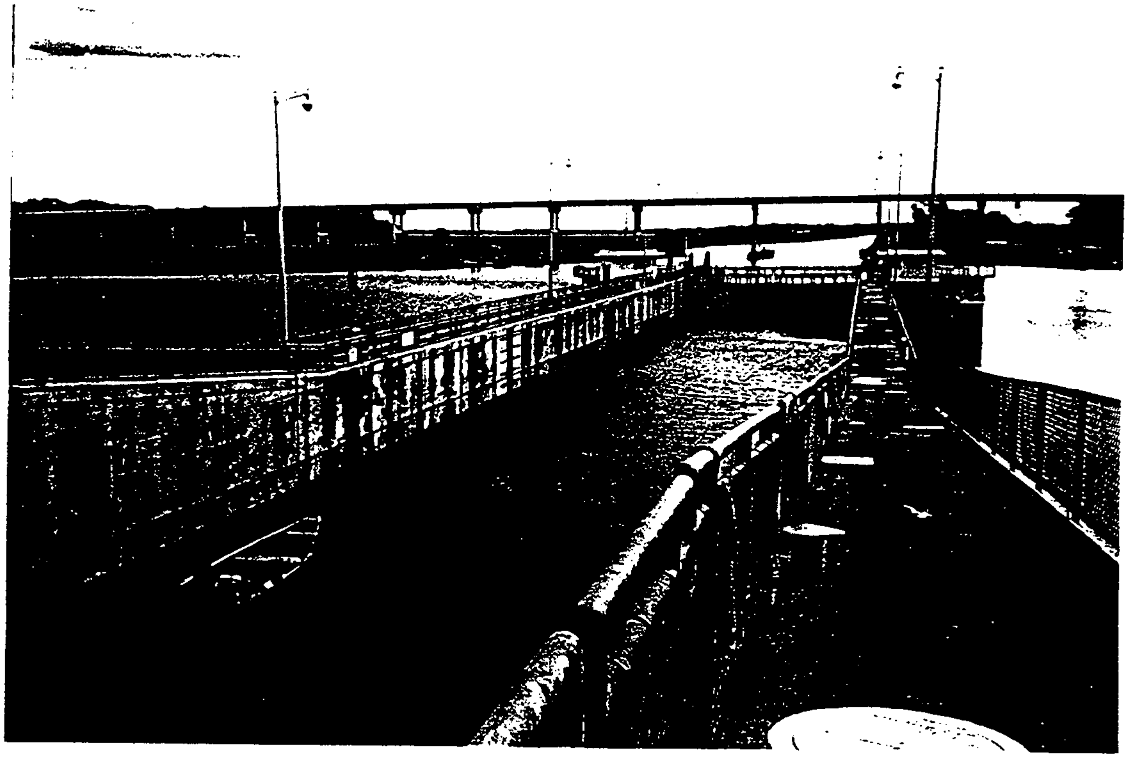
Photograph E. S-78 spillway, vertical lift gate. Upstream is to the right. One of the hoist cables, as well as the 3 ft. gate setting, can be seen (right). Most of the spillway gates in Central and Southern Florida are vertical lift gates.



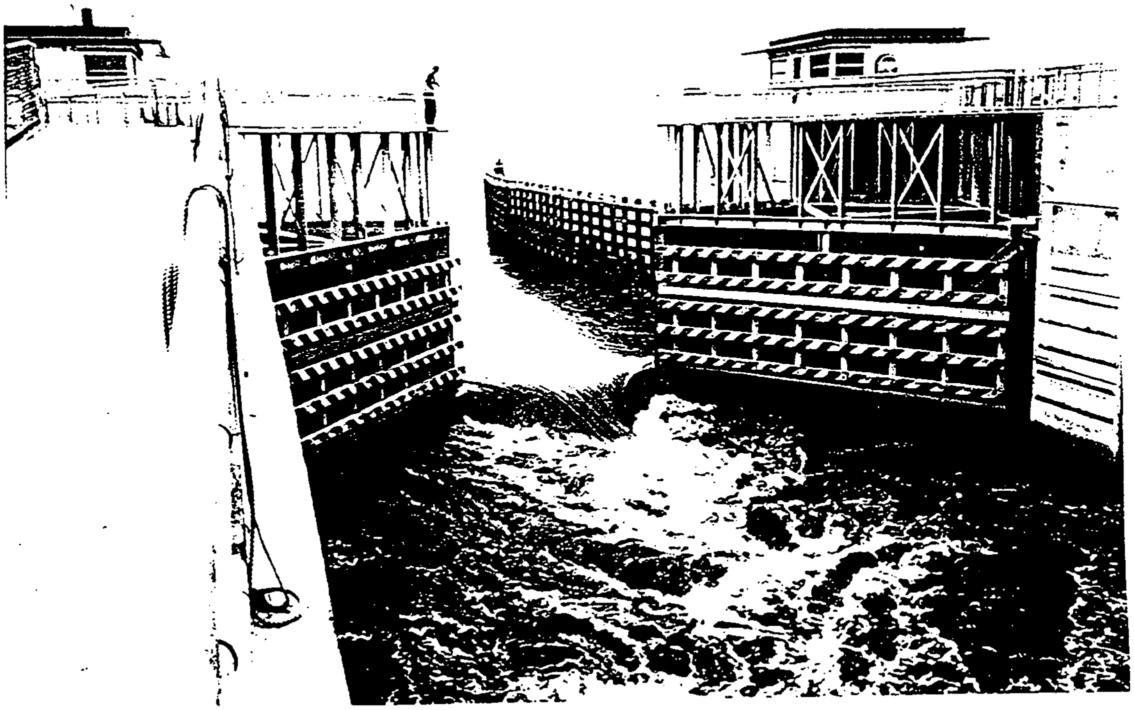
Photograph F. Ortona Lock, upstream sector gates. This photograph was taken standing upstream of the lock chamber.



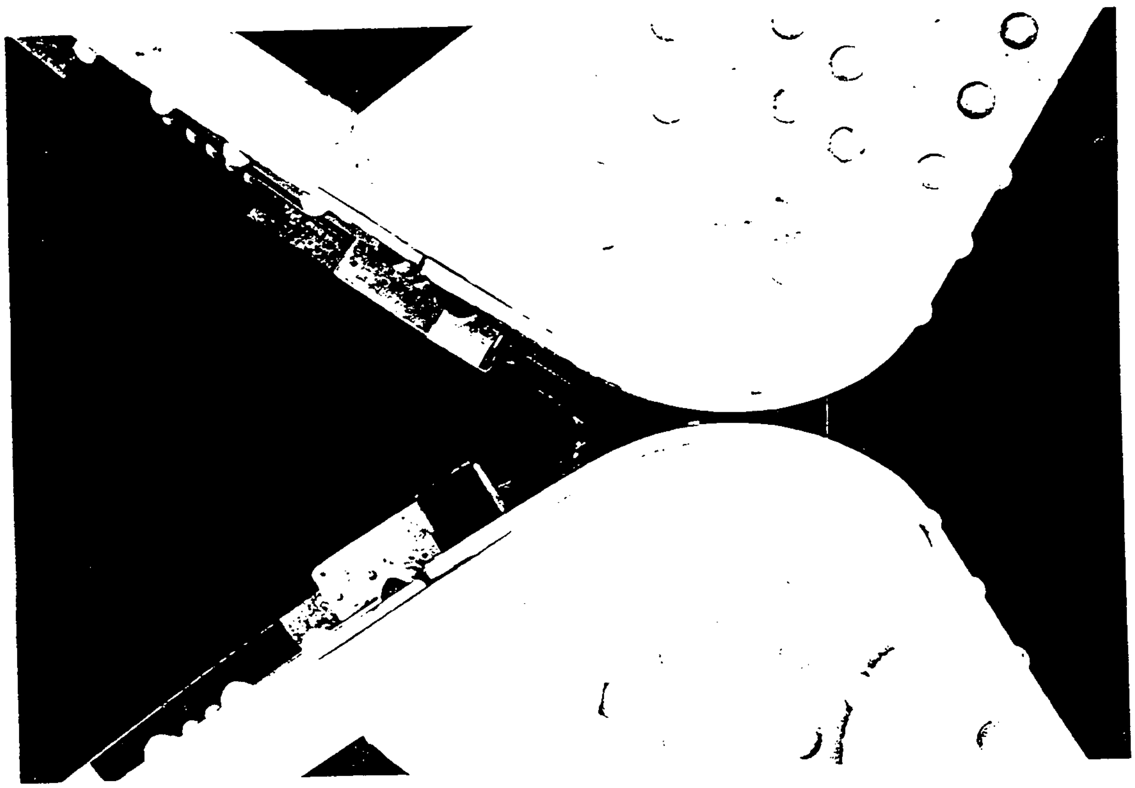
Photograph G. Moore Haven Lock, facing upstream. The two sector gates in the foreground are the downstream gates, and the two sector gates in the background are the upstream gates. In this photograph the viewer is facing the flat sides of the sector gates and not their curved skin plates, which face upstream. Note the boat moored along the left side of the lock chamber. While the upstream sector gates are closed, the downstream gates are open slightly in order to lower the water level inside the lock chamber to the level of the lower pool. When the level of the lower pool is reached, the downstream gates are opened fully and the boat may pass through.



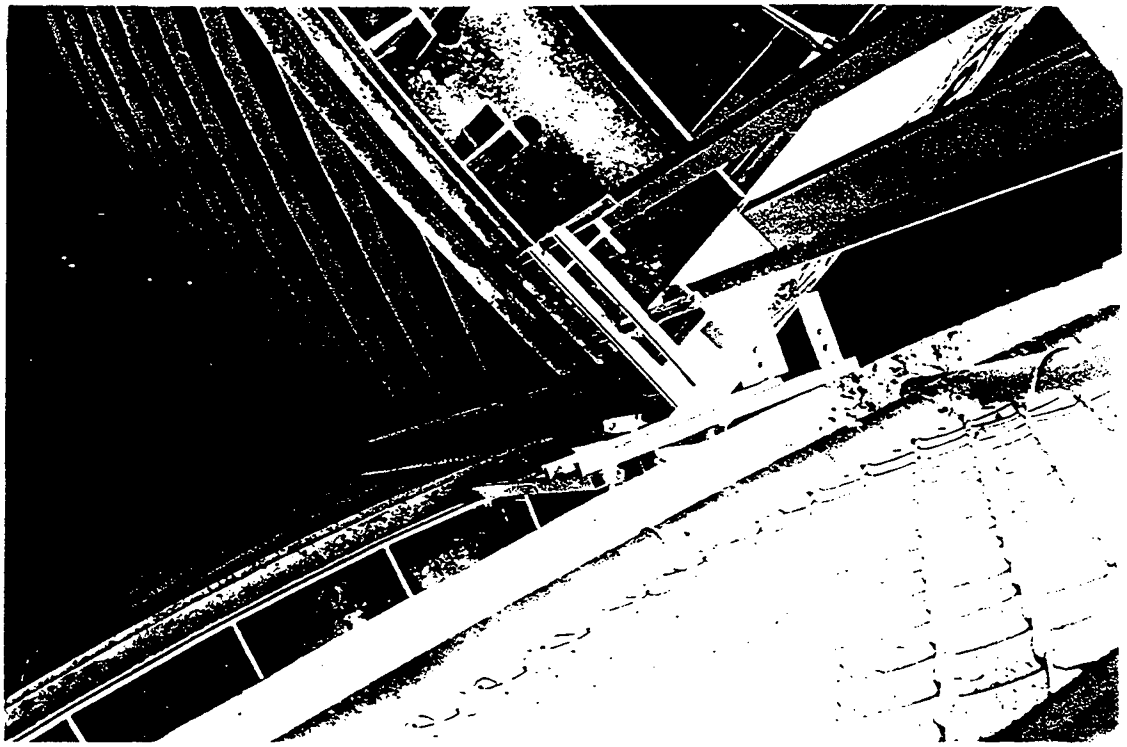
Photograph H. Port Mayaca Lock, facing downstream towards the St. Lucie Canal. This photograph, which shows the downstream sector gates, was taken from a point near the upstream sector gates; thus, the upstream gates cannot be seen in this picture.



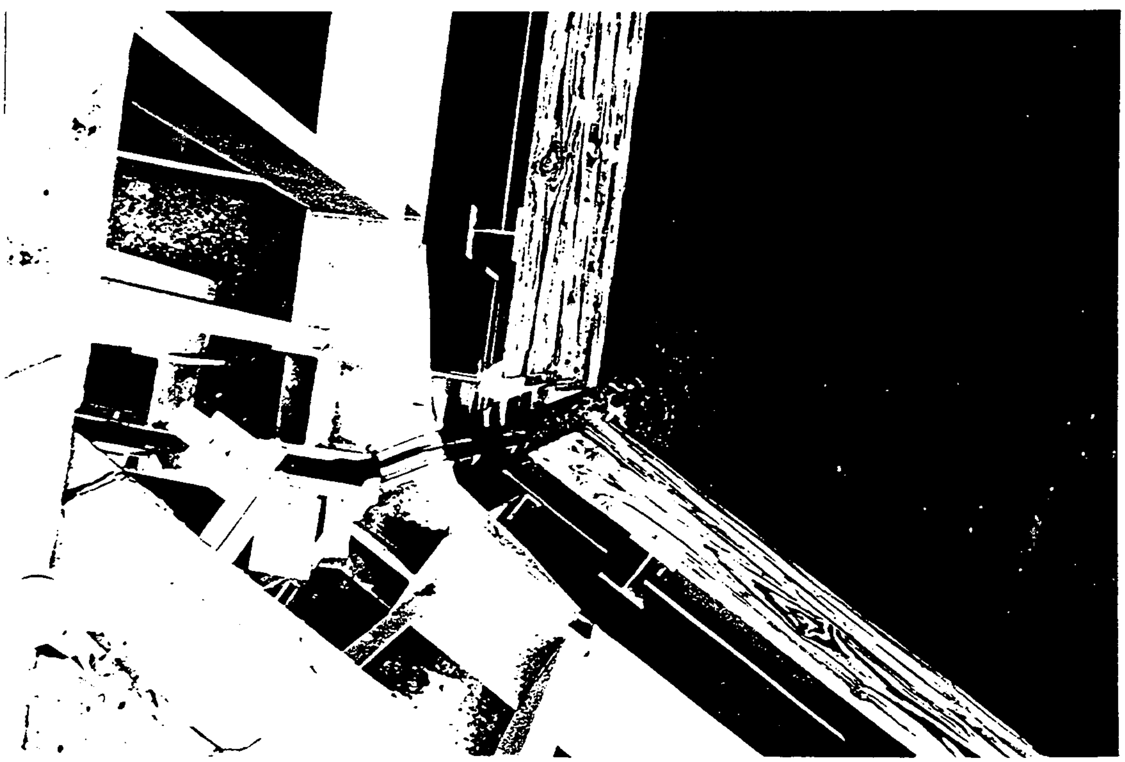
Photograph I. Port Mayaca Lock, facing upstream towards Lake Okeechobee from inside the lock chamber.



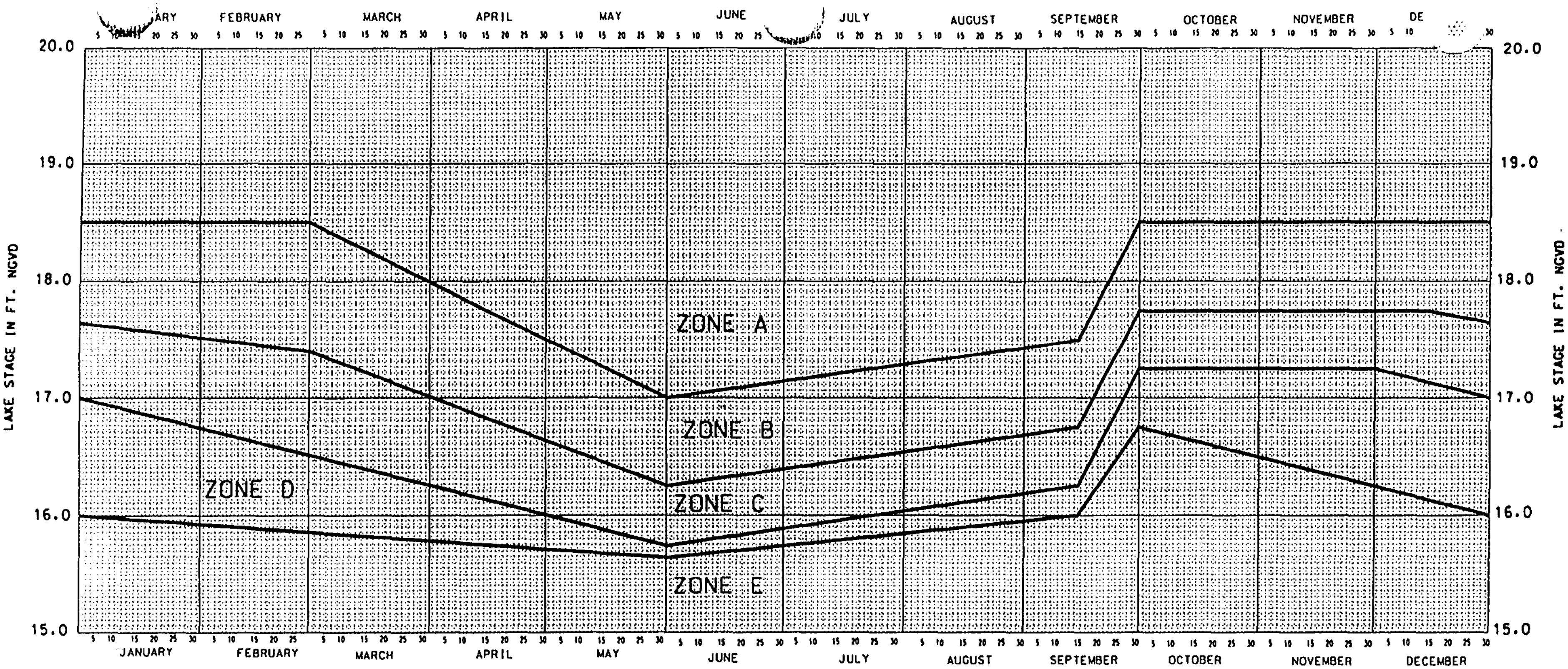
Photograph J. Moore Haven Lock. The vicinity where the two upstream sector gates meet when closed.



Photograph K. Port Mayaca Lock, upstream sector gates. The viewer is looking down just to the left of the point of gate closure. The lock chamber is to the right.



Photograph L. Port Mayaca Lock, upstream sector gates. Looking down, just to the right of the point of gate closure. The water on the right is in the lock chamber.



RELEASE THROUGH OUTLETS AS INDICATED

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

NOTES: (1) RELEASES THROUGH VARIOUS OUTLETS MAY BE MODIFIED TO MINIMIZE DAMAGES OR OBTAIN ADDITIONAL BENEFITS.

(2) SUBJECT TO FIRST REMOVAL OF LOCAL RUNOFF.

(3) EXCEPT WHEN EXCEEDED BY LOCAL INFLOW.

CENTRAL AND SOUTHERN FLORIDA
INTERIM REGULATION SCHEDULE
LAKE OKEECHOBEE

DEPARTMENT OF THE ARMY, JACKSONVILLE DISTRICT
CORPS OF ENGINEERS, JACKSONVILLE, FLORIDA
DATED: 11 MAY 1992

FIGURE 4

RUN 25

APPENDIX F

MAJOR MAINTENANCE FOR LOCKS & SPILLWAYS

FY1996 - FY2008

STRUCTURE	LAST SB&P		FY1996	FY1997	FY1998	FY1999	FY2000	FY2001	FY2002	FY2003	FY2004	FY2005	FY2006	FY2007	FY2008
St. Lucie Lock	1994		M				I				I				M
Pt. Mayaca Lock	1991				I				M				I		
Moore Haven Lock	1988				I		M				I				I
Ortona Lock	1985		I		M				I				I		
WP Franklin Lock	1993						I				M				
Canaveral Lock	1992		I				I			M				I	
St. Lucie Spillway	1988					M									
Pt. Mayaca Spillway	1992											M			
Moore Haven Spillway	1994												M		
Ortona Spillway	1985			M											
WP Franklin Spillway	1985				M										
S-351 Spillway	1988						M								
S-352 Spillway	1989							M							
S-354 Spillway	1990								M						
S-10 Spillway	1994												M		
S-11 Spillway	1994													M	
S-12 Spillway	1994													M	

M DENOTES SCHEDULED MAINTENANCE FOR SANDBLASTING & PAINTING INCLUDING MECHANICAL AND ELECTRICAL REPAIRS. SCHEDULED AT 12 YEAR INTERVALS.

I DENOTES SCHEDULED DEWATERING FOR INSPECTION AND MINOR MAINTENANCE, IF NEEDED. SCHEDULED AT 4 YEAR INTERVALS.

SOUTH FLORIDA WATER MANAGEMENT DISTRICT
Lock Overhaul and Inspection Schedule

Structure	FY94	FY95	FY96	FY97	FY98	FY99	FY00	FY01
S-193								
Design & Spec.								
Construction								
5 Year Inspection								
S-310								
Design & Spec.								
Construction								
5 Year Inspection								
S-65E								
Design & Spec.								
Construction								
5 Year Inspection								
S-65D								
Design & Spec.								
Construction								
5 Year Inspection								
S-65								
Design & Spec.								
Construction								
5 Year Inspection								
S-61								
Design & Spec.								
Construction								
5 Year Inspection								
S-65A								
5 Year Inspection								
S-65B								
5 Year Inspection								
S-65C								
5 Year Inspection								

S-65B & C are not scheduled for overhaul due to possible removal.
Overhaul was performed at S-65A in FY93.

INVENTORY OF JACKSONVILLE DISTRICT STOPLOGS
Bulkhead and Needle systems

Structures	Needles or Bulkheads	No. of Needles (Material)/Needle Beams (Material) No. of Bulkheads (Material)/Pickup Beams (Material)	Storage Location
LOCKS:			
Canaveral Lock 11-29,676 (40-44)	Needles	62 (timber)/2 (steel) with 2 tripod supports (steel)	Canaveral Lock
Ortona Lock Moore Haven Lock St. Lucie Lock	Needles	52* (aluminum)/2 (riveted steel built in 30's or 40's - 126-33,612, sht 1) or 52* (aluminum)/2 (welded steel built in 1972 - 120-31,384, sht 60)	Clewiston
Port Mayaca Lock 400-32,596 (78-81) W.P. Franklin Lock 471-29,059 (53-55)	Bulkheads	12 (steel)/1 (steel)	Moore Haven Lock
SPILLWAYS:			
S-79 (Franklin) Spillway 471-29,059 (26-28)	Bulkheads	20 (steel)/2 (steel)	W.P. Franklin Lock and Spillway
Port Mayaca Spillway 400-32,596 (127-129)	Bulkheads	10 (steel)/1 (steel)	Port Mayaca Spillway
St. Lucie Spillway 131-12,234 (380/2-380/9A)	Bulkheads	3 (steel)/1 (steel)	St. Lucie Spillway
S-78 (Ortona) Spillway 471-28,941	Needles	10* (aluminum)/0 for tainter gates 12* (aluminum)/0 for vert lift gates	Clewiston
S-351 Spillway S-77 (Moore Haven) Spillway 471-28,862	Bulkheads	10 (steel)/1 (steel)	S-77 (Moore Haven) Spillway
S-10 Spillway 471-36,321 (3/9)	Needles	220 (timber)/4 (steel)	Clewiston
S-11 Spillway 422-22,351 (8)	Needles	56 (timber)/3 vertical (aluminum) or 12* (aluminum)/0	Clewiston
S-12 Spillway 472-28,223 (33 of 44)	Needles	56 (timber)/3 (aluminum) or 12* (aluminum)/0	Clewiston
S-352 Spillway S-354 Spillway 400-34,780 (6/10-6/12)	Bulkheads	8 (steel)/1 (steel)	S-354 Spillway

* aluminum needles were fabricated for the Government by Purchase Order in 1987

AS-BUILT INFORMATION ON NEEDLE DAM SYSTEMS AT SFWMD STRUCTURES			
STRUCTURE (AS-BUILT D.O. FILE NO.)	BAY WIDTH/ NUMBER	NEEDLE BEAMS PROVIDED BY STRUCTURE CONSTRUCTION CONTRACT	STOPLOGS PROVIDED BY STRUCTURE CONSTR. CONTRACT
S-29 (419-22,395)	22'/4	2 @ 24WF100 23'-11" LENGTH	70 8X8 TIMBERS 16' LENGTH
S-33 (440-22,676)	20'/1	2 @ 12WF40 21'-11" LENGTH	
S-310 LOCK S-193 LOCK	50'/2	CORPS OWNS FOUR 54' LONG BOX GIRDER NEEDLE BEAMS; THESE BEAMS ARE USED TO DEWATER CORPS STRUCTURES (MOORE HAVEN LOCK, ORTONA LOCK, ST. LUCIE LOCK)	CORPS OWNS TWELVE 3'X22' AND FORTY 4'X22' ALUMINUM NEEDLES (ENOUGH TO DEWATER TWO LOCKS CONCURRENTLY)
S-127 LOCK (477-28,725) S-131 LOCK (477-28,725) S-135 LOCK	15'/2 15'/2 15'/2 15'/2	NONE	24 10X10 TIMBERS 16'-2" LENGTH (FROM S-127 & 131)

APPENDIX G

Table 1a. Manatee deaths (1974 through 31December 1996) associated with Central and Southern Florida locks and water control structures.

Structure	Type	County Location	Operated By Date Constructed	Total Structure caused Manatee Deaths*
S-27	Spillway	Dade	SFWMD/1958	16
S-29	Spillway	Dade	SFWMD/1953	12
S-80 St. Lucie	Spillway & Lock	Martin	CESAJ/1941, 1944	12
S-78 Ortona	Spillway & Lock	Glades	CESAJ/1937	15
S-22	Spillway	Dade	SFWMD/1956	6
S-193	Lock	Okeechobee	SFWMD/1973	7
S-308 C Pt. Mayaca	Spillway & Lock	Martin	CESAJ/1977	5
S-28	Spillway	Dade	SFWMD/1962	3
S-13	Spillway	Broward	SFWMD/1954	3
S-25B	Spillway	Dade	SFWMD/1976	5
S-26	Spillway	Dade	SFWMD/1974	4
S-77 Moore Haven	Spillway & Lock	Glades	CESAJ/1935, 1966	6
S-20F	Spillway	Dade	SFWMD/1967	5
S-135	Lock	Martin	SFWMD/1969	2
S-33	Spillway	Broward	SFWMD/1954	1
S-21	Spillway	Dade	SFWMD/1961	1
S-36	Spillway	Broward	SFWMD	1
S-25	Culvert	Dade	SFWMD/1976	0
S-21A	Spillway	Dade	SFWMD/1966	0
S-20G	Spillway	Dade	SFWMD/1966	0
S-79 W.P. Franklin	Spillway & Lock	Lee	CESAJ/1965	0
S-127	Lock	Glades	SFWMD/1963	0
S-310	Lock	Hendry	SFWMD/1980	0
S-131	Lock	Glades	SFWMD/1963	0
S-123	Spillway	Dade	SFWMD/1966	0

*** (From FL Dept. of Env. Protect. data set)** **Total 104**

Table 1b. Additional manatee deaths (1974 through 31December 1996) associated with Florida locks and water control structures other than Central and Southern Florida.

Structure	County Location	Manatee Deaths*
Canaveral	Brevard	10
Rodman	Putman	7
Buckman	Putman	2
Rocky	Hillsborough	2
Inglis	Levy Citrus	1 1
Henry (G-36)	Okeechobee	2
	Total	**25**

*** (Data summary from FL Dept. of Env. Protect. data set)**

Table 2a. Yearly distribution of manatee mortality associated with Central and Southern Florida locks and water control structures. (Number in parenthesis indicates manatee record number. See Appendix A-D for additional individual information.)

Structure	1975	1976	1977	1978	1979	1980	1981	Total
S-27			9 May (1)			4 Feb (2)		2
S-29		24 Nov (17)	28 Jun (18) 28 Jun (19) 23 Sep (20)	15 Sep (21) 13 Nov (22)	16 May (23) 1 Sep (24) 30 Oct (25) 15 Nov (26)			10
S-80					12 May (29)	11 Mar (30)		2
S-78						24 Dec (41)	23 May (42)	2
S-22		22 Nov (56) 29 Nov (57)	3 Jun (58)	18 Jun (59) 26 Jun (60) 26 Oct (61)				6
S-193				1 Jun (62)				1
S-308C					11 Jan (69)			1
S-28	27 Jun (74)			31 Dec (75)		23 Jul (76)		3
S-13						15 Jun (77)		1
S-25B				26 Sep (80) 12 Nov (81)				2
S-26		16 Sep (85)			10 Sep (86)			2
S-77								0
S-20F								0
S-135								0
S-33								0
S-21								0
S-36								0
S-21A								0
S-20G								0
S-79								0
S-127								0
S-310								0
S-131								0
S-123								0
Total	1	4	5	9	7	5	1	32

Table 2a. (Continued).

Structure	1982	1983	1984	1985	1986	1987	1988	Total
S-27	26 Aug (3)			23 Mar (4)		30 Nov (5)	11 Jan (6) 26 Jan (7) 16 May (8) 27 Jun (9) 2 Sep (10) 8 Sep (11)	9
S-29		21 Jun (27)				16 Jul (28)		2
S-80		20 Dec (31)	1 Jan (32)			15 Jul (33)		3
S-78		19 Mar (43) 28 Mar (44)	6 Dec (45)			3 Oct (46)	26 Dec (47)	5
S-22								0
S-193								0
S-308C						19 May (70)		1
S-28								0
S-13	30 Mar (78)			5 Nov (79)				2
S-25B	21 May (82)							1
S-26								0
S-77			16 Mar (89)					1
S-20F								0
S-135								0
S-33								0
S-21								0
S-36								0
S-21A								0
S-20G								0
S-79								0
S-127								0
S-310								0
S-131								0
S-123								0
Total	3	4	3	2	0	5	7	24

Table 2a. (Continued).

Structure	1989	1990	1991	1992	1993	1994	1995	1996	Total
S-27		28 Nov (12)			25 Jan (13)	24 Jan (14) 5 Nov (15)		23 May (16)	**5**
S-29									**0**
S-80	8 May (34) 21 May (35)		10 Apr (36)	22 Feb (37)	14 Dec (38)	25 Sep (39)	10 Feb (40)		**7**
S-78					30 Apr (48)	26 Apr (49) 16 Jun (50) 4 Aug (51) 31 Aug (52) 27 Oct (53) 6 Nov (54)	25 Sep (55)		**8**
S-22									**0**
S-193			18 Oct (63) 31 Oct (64)	14 Jun (65)	19 Oct (66)	10 Jul (67) 27 Aug (68)			**6**
S-308C		23 Mar (71)	9 Aug (72)			18 Jul (73)			**3**
S-28									**0**
S-13									**0**
S-25B				8 Oct (83)		20 Sep (84)			**2**
S-26							18 Aug (87)	30 Sept (88)	**2**
S-35									**0**
S-77				23 Jun (90)		20 Feb (91) 26 Dec (92)		26 June (93) 15 July (94)	**5**
S-20F			30 Nov (95)		29 Dec (96)	30 Dec (97)	12 Oct (98)	17 Dec (99)	**5**
S-135				7 Jul (100)				5 July (101)	**2**
S-33			13 Jun (102)						**1**
S-21							10 Sep (103)		**1**
S-36							26 Oct (104)		**1**
S-21A									**0**
S-20G									**0**
S-79									**0**
S-127									**0**
S-310									**0**
S-131									**0**
S-123									**0**
Total	2	2	6	5	5	16	6	6	48

Table 2b. Yearly distribution of additional manatee mortality associated with Florida locks and water control structures. (Number in parenthesis indicates manatee record number. See Appendix A-D for additional individual information.)

Structure	1975	1976	1977	1978	1979	1980	1981	Total
Canaveral						20 Aug (106)	8 Nov (107)	2
Rodman					11 May (116)			1
Buckman			23 Oct (123)			30 Jun (124)		2
Rocky								0
Inglis						2 Nov (127)		1
Henry								0
Total	0	0	1	0	1	3	1	6

Structure	1982	1983	1984	1985	1986	1987	1988	Total
Canaveral								0
Rodman		22 Jun (117) 23 Jun (118) 8 Aug (119)						3
Buckman								0
Rocky					16 Jul (125) 24 Jul (126)			2
Inglis					8 Jul (128)			1
Henry				9 Dec (105)				1
Total	0	3	0	1	3	0	0	7

Structure	1989	1990	1991	1992	1993	1994	1995	1996	Total	Total (All Years)
Canaveral	29 Apr (108)	12 Oct (109)	4 Jun (110) 21 Sep (111)					11 May (112) 23 June (113) 27 July (114) 16 Oct (115)	8	10
Rodman			24 Jun (120)				9 Aug (121) 20 Aug (122)		3	7
Buckman									0	2
Rocky									0	2
Inglis									0	2
Henry							26 Oct (129)		1	2
Total	1	1	3	0	0	0	3	4	12	25

Table 3a. Monthly distribution of manatee mortality (1974 through 31 December 1996) associated with Central and Southern Florida locks and water control structures.

Structure	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
S-27	4	1	1	0	3	1	0	1	2	0	3	0	**16**
S-29	0	0	0	0	1	3	1	0	3	1	3	0	**12**
S-80	1	1	1	1	3	0	1	0	1	0	0	3	**12**
S-78	0	0	2	2	1	1	0	2	1	2	1	3	**15**
S-22	0	0	0	0	0	3	0	0	0	1	2	0	**6**
S-193	0	0	0	0	0	2	1	1	0	3	0	0	**7**
S-308C	1	0	1	0	1	0	1	1	0	0	0	0	**5**
S-28	0	0	0	0	0	1	1	0	0	0	0	1	**3**
S-13	0	0	1	0	0	1	0	0	0	0	1	0	**3**
S-25B	0	0	0	0	1	0	0	0	2	1	1	0	**5**
S-26	0	0	0	0	0	0	0	1	3	0	0	0	**4**
S-77	0	1	1	0	0	2	1	0	0	0	0	1	**6**
S-20F	0	0	0	0	0	0	0	0	0	1	1	3	**5**
S-135	0	0	0	0	0	0	2	0	0	0	0	0	**2**
S-33	0	0	0	0	0	1	0	0	0	0	0	0	**1**
S-21	0	0	0	0	0	0	0	0	1	0	0	0	**1**
S-36	0	0	0	0	0	0	0	0	0	1	0	0	**1**
S-21A	0	0	0	0	0	0	0	0	0	0	0	0	**0**
S-20G	0	0	0	0	0	0	0	0	0	0	0	0	**0**
S-79	0	0	0	0	0	0	0	0	0	0	0	0	**0**
S-127	0	0	0	0	0	0	0	0	0	0	0	0	**0**
S-310	0	0	0	0	0	0	0	0	0	0	0	0	**0**
S-131	0	0	0	0	0	0	0	0	0	0	0	0	**0**
S-123	0	0	0	0	0	0	0	0	0	0	0	0	**0**
Total	**6**	**3**	**7**	**3**	**10**	**15**	**8**	**6**	**13**	**10**	**12**	**11**	**104**

Table 3b. Monthly distribution of additional manatee mortality associated with Florida locks and water control structures.

Structure	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Canaveral	0	0	0	1	1	2	1	1	1	2	1	0	**10**
Rodman	0	0	0	0	1	3	0	3	0	0	0	0	7
Buckman	0	0	0	0	0	1	0	0	0	1	0	0	**2**
Rocky	0	0	0	0	0	0	2	0	0	0	0	0	**2**
Inglis	0	0	0	0	0	0	1	0	0	0	1	0	**2**
Henry	0	0	0	0	0	0	0	0	0	1	0	1	**2**
Total	**0**	**0**	**0**	**1**	**2**	**6**	**4**	**4**	**1**	**4**	**2**	**1**	**25**

Appendix A. Distribution of Manatee mortality by structure, county and waterway, to include date of mortality, sex identification and total body length (cm).

Record #	Field ID #	Structure	County	Waterway	Date of Mortality	Sex	Total Length (cm)
1	M7716	S-27	Dade	Little River	9 May 77	M	267
2	M8006	S-27	Dade	Little River	4 Feb 80	M	291
3	M8252	S-27	Dade	Little River	26 Aug 82	M	300
4	M8514	S-27	Dade	Little River	23 Mar 85	M	303
5	M8718	S-27	Dade	Little River	30 Nov 87	F	214
6	MSW135	S-27	Dade	Little River	11 Jan 88	M	272
7	KDL8804	S-27	Dade	Little River	26 Jan 88	M	236
8	MSW148	S-27	Dade	Little River Canal	16 May 88	F	252
9	MSE8803	S-27	Dade	Little River	27 Jun 88	M	330
10	KDL8854	S-27	Dade	Little River	2 Sep 88	F	272
11	MSE8805	S-27	Dade	Little River	8 Sep 88	F	243
12	MSE9023	S-27	Dade	Little River	28 Nov 90	F	308
13	MSE9302	S-27	Dade	Little River	25 Jan 93	F	287
14	MSE9401	S-27	Dade	Little River	24 Jan 94	M	263
15	MSE9424	S-27	Dade	Little River	5 Nov 94	F	322
16	MSW96202	S-27	Dade	Little River	23 May 96	F	271
17	M7628	S-29	Dade	Snake Creek	24 Nov 76	M	278
18	M7720	S-29	Dade	Snake Creek	28 Jun 77	F	229
19	M7721	S-29	Dade	Snake Creek	28 Jun 77	M	295
20	M7729	S-29	Dade	Snake Creek	23 Sep 77	F	285
21	M7835	S-29	Dade	Snake Creek	15 Sep 78	M	257
22	M7842	S-29	Dade	Snake Creek	13 Nov 78	M	255
23	M7912	S-29	Dade	Snake Creek	16 May 79	F	331
24	M7919	S-29	Dade	Snake Creek	1 Sep 79	M	296
25	M7923	S-29	Dade	Snake Creek	30 Oct 79	M	263

Appendix A. (Continued)

Record #	Field ID #	Structure	County	Waterway	Date of Mortality	Sex	Total Length (cm)
26	M7924	S-29	Dade	Snake Creek	15 Nov 79	M	235
27	M8327	S-29	Dade	Snake Creek	21 Jun 83	M	317
28	M8713	S-29	Dade	Snake Creek Canal	16 Jul 87	M	310
29	M150	S-80 St. Lucie	Martin	St. Lucie Canal	12 May 79	F	289
30	M8010	S-80 St. Lucie	Martin	St. Lucie Canal	11 Mar 80	M	324
31	M8340	S-80 St. Lucie	Martin	St. Lucie Canal	20 Dec 83	M	259
32	M8402	S-80 St. Lucie	Martin	St. Lucie Canal	1 Jan 84	M	288
33	KDL8736	S-80 St. Lucie	Martin	Okeechobee Waterway	15 Jul 87	F	280
34	MSE8906	S-80 St. Lucie	Martin	St. Lucie Canal	8 May 89	M	309
35	KDL8932	S-80 St. Lucie	Martin	St. Lucie Canal	21 May 89	M	320
36	MSE9106	S-80 St. Lucie	Martin	Okeechobee Canal	10 Apr 91	M	263
37	MSE9207	S-80 St. Lucie	Martin	St. Lucie Canal	22 Feb 92	M	271
38	MSE9320	S-80 St. Lucie	Martin	St. Lucie Lock	14 Dec 93	F	285
39	MSE9421	S-80 St. Lucie	Martin	St. Lucie Lock	25 Sep 94	M	282
40	MSE9505	S-80 St. Lucie	Martin	St. Lucie Lock	10 Feb 95	M	297

Appendix A. (Continued)

Record #	Field ID #	Structure	County	Waterway	Date of Mortality	Sex	Total Length (cm)
41	M8028	S-78 Ortona	Glades	Okeechobee Waterway	24 Dec 80	M	250
42	M8152	S-78 Ortona	Glades	Caloosahatchee River	23 May 81	F	375
43	M8313	S-78 Ortona	Glades	Okeechobee	19 Mar 83	M	283
44	M8315	S-78 Ortona	Glades	Okeechobee Waterway	28 Mar 83	F	308
45	MSW038	S-78 Ortona	Glades	Okeechobee Waterway	6 Dec 84	M	239
46	MSW122	S-78 Ortona	Glades	Okeechobee Waterway	3 Oct 87	M	290
47	MSW184	S-78 Ortona	Glades	Okeechobee Waterway	26 Dec 88	F	302
48	MSW9316	S-78 Ortona	Glades	Okeechobee Waterway	30 Apr 93	M	331
49	MSW9416	S-78 Ortona	Glades	Okeechobee Waterway	26 Apr 94	M	349
50	MSW9433	S-78 Ortona	Glades	Okeechobee Waterway	16 Jun 94	F	271
51	MSW9443	S-78 Ortona	Glades	Okeechobee Waterway	4 Aug 94	M	282
52	MSW9451	S-78 Ortona	Glades	Okeechobee Waterway	31 Aug 94	M	271
53	MSW9462	S-78 Ortona	Glades	Okeechobee Waterway	27 Oct 94	F	271
54	MSW9464	S-78 Ortona	Glades	Okeechobee Waterway	6 Nov 94	M	319
55	MSW9547	S-78 Ortona	Glades	Okeechobee Waterway	25 Sep 95	F	260

Appendix A. (Continued)

Record #	Field ID #	Structure	County	Waterway	Date of Mortality	Sex	Total Length (cm)
56	M7626	S-22	Dade	Snapper Creek	22 Nov 76	M	142
57	M7629	S-22	Dade	Snapper Creek	29 Nov 76	F	335
58	M7719	S-22	Dade	Snapper Creek	3 Jun 77	M	353
59	M7830	S-22	Dade	Snapper Creek	18 Jun 78	F	245
60	M7832	S-22	Dade	Snapper Creek	26 Jun 78	M	285
61	M7839	S-22	Dade	Snapper Creek	26 Oct 78	F	300
62	M7829	S-193 Taylor	Okeechobee	Okeechobee Rim Canal	1 Jun 78	M	292
63	MSW9135	S-193 Taylor	Okeechobee	Lake Okeechobee	18 Oct 91	F	249
64	MSW9137	S-193 Taylor	Okeechobee	Lake Okeechobee	31 Oct 91	M	289
65	MSE9220	S-193 Taylor	Okeechobee	Taylor Creek	14 Jun 92	M	278
66	MSE9317	S-193 Taylor	Okeechobee	Taylor Creek	19 Oct 93	M	242
67	MSE9414	S-193 Taylor	Okeechobee	Taylor Creek	10 Jul 94	F	329
68	MSE9418	S-193 Taylor	Okeechobee	Taylor Creek	27 Aug 94	M	258
69	M7902	S-308 Pt. Mayaca	Martin	St. Lucie Canal	11 Jan 79	M	202
70	M8711	S-308 Pt. Mayaca	Martin	Lake Okeechobee	19 May 87	F	329
71	MSW262	S-308 Pt. Mayaca	Martin	Lake Okeechobee	23 Mar 90	M	288
72	MSE9115	S-308 Pt. Mayaca	Martin	Lake Okeechobee	9 Aug 91	M	292
73	MSE9416	S-308 Pt. Mayaca	Martin	St. Lucie Canal	18 Jul 94	M	255

Appendix A. (Continued)

Record #	Field ID #	Structure	County	Waterway	Date of Mortality	Sex	Total Length (cm)
74	M7511	S-28	Dade	Biscayne Canal	27 Jun 75	F	310
75	M7844	S-28	Dade	Biscayne Canal	31 Dec 78	M	230
76	M8018	S-28	Dade	Biscayne Canal	23 Jul 80	M	305
77	M8016	S-13	Broward	Dania Cutoff Canal	15 Jun 80	F	311
78	M8230	S-13	Broward	Dania Cutoff Canal	30 Mar 82	M	320
79	M8523	S-13	Broward	Dania Cutoff Canal	5 Nov 85	F	355
80	M7836	S-25B	Dade	Miami River	26 Sep 78	F	360
81	M7841	S-25B	Dade	Tamiami Canal	12 Nov 78	F	302
82	M8238	S-25B	Dade	Tamiami Canal	21 May 82	M	245
83	MSE9229	S-25B	Dade	Tamiami Canal	8 Oct 92	M	269
84	MSE9520	S-25B	Dade	Tamiami Canal	20 Sep 94	F	272
85	M7621	S-26	Dade	Miami River	16 Sep 76	F	285
86	M7920	S-26	Dade	Miami River	10 Sep 79	F	326
87	MSE9520	S-26	Dade	Miami River	18 Aug 95	F	272
88	MSE9623	S-26	Dade	Miami River	23 May 96	F	297

Appendix A. (Continued)

Record #	Field ID #	Structure	County	Waterway	Date of Mortality	Sex	Total Length (cm)
89	MSW017	S-77 Moorehaven	Glades	Okeechobee Waterway	16 Mar 84	M	231
90	MSW9227	S-77 Moorehaven	Glades	Calooschatchee River	23 Jun 92	M	290
91	MSW9408	S-77 Moorehaven	Glades	Calooschatchee River	20 Feb 94	*	*
92	MSW9469	S-77 Moorehaven	Glades	Calooschatchee River	26 Dec 94	M	*
93	MSW96202	S-77 Moorehaven	Glades	Calooschatchee River	26 June 96	F	360
94	MSW96208	S-77 Moorehaven	Glades	Calooschatchee River	15 July 96	M	273
95	MSE9122	S-20F	Dade	Mowry Canal	30 Nov 91	M	315
96	MSE9323	S-20F	Dade	Biscayne Bay	29 Dec 93	F	321
97	MSE9430	S-20F	Dade	Biscayne Bay	30 Dec 94	M	313
98	MSE9525	S-20F	Dade	Mowry Canal	12 Oct 95	M	323
99	MSE9628	S-20F	Dade	Mowry Canal	17 Dec 96	M	315
100	MSE9223	S-135	Martin	Lake Okeechobee	7 Jul 92	F	264.8
101	MSE9621	S-135	Martin	Lake Okeechobee	5 July 96	M	303
102	MSE9111	S-33	Broward	C-12 Canal	13 Jun 91	F	299
103	MSE9524	S-21	Dade	Black Creek	10 Sep 95	M	248
104	MSE9529	S-36	Broward	C-13 Canal	26 Oct 95	F	358

Appendix A. (Continued)

Record #	Field ID #	Structure	County	Waterway	Date of Mortality	Sex	Total Length (cm)
105	M8525	Henry	Okeechobee	Okeechobee Canal	9 Dec 85	F	350
106	M199	Canaveral	Brevard	Port Canaveral	20 Aug 80	F	294
107	M255	Canaveral	Brevard	Banana River	8 Nov 81	M	314
108	KDL8924	Canaveral	Breward	Banana River	29 Apr 89	M	323
109	UCF9058	Canaveral	Brevard	Banana River	12 Oct 90	F	290
110	UCF9120	Canaveral	Brevard	Banana River	4 Jun 91	M	310
111	UCF9134	Canaveral	Brevard	Banana River	21 Sep 91	M	335
112	MEC9629	Canaveral	Brevard	Banana River	11 May 96	F	302
113	MEC9644	Canaveral	Brevard	Banana River	23 June 96	F	313
114	MEC9651	Canaveral	Brevard	Banana River	27 July 96	F	252
115	MEC9662	Canaveral	Brevard	Banana River	16 Oct 96	F	310
116	M149	Rodman	Putnam	Rodman Dam	11 May 79	F	263
117	M338	Rodman	Putnam	Rodman Dam	22 Jun 83	F	340
118	M339	Rodman	Putnam	Rodman Dam	23 Jun 83	M	291
119	M344	Rodman	Putnam	Rodman Dam	8 Aug 83	F	310
120	MNE9113	Rodman	Putman	Oklawaha River	24 Jun 91	M	275
121	MNE9514	Rodman	Putnam	Oklawaha River	9 Aug 95	M	313
122	MNE9515	Rodman	Putnam	Oklawaha River	20 Aug 95	M	279
123	M093	Buckman	Putnam	Cross Fl Barge Canal	23 Oct 77	M	310
124	M195	Buckman	Putnam	Cross Fl Barge Canal	30 Jun 80	F	276
125	SWFTM8639	Rocky	Hillsborough	Old Tampa Bay	16 Jul 86	F	165
126	SWFTM8642	Rocky	Hillsborough	Old Tampa Bay	24 Jul 86	F	279

Appendix A. (Continued)

Record #	Field ID #	Structure	County	Waterway	Date of Mortality	Sex	Total Length (cm)
127	SWFTM8635	Inglis	Citrus	Withlacoochee River	8 Jul 86	F	343
128	M212	Inglis	Levy	Cross Fl Barge Canal	2 Nov 80	F	272
129		Henry	Okeechobee	Okeechobee Canal	26 Oct 95		

Appendix B. Distribution of localities for structure caused manatee mortality from 1974 through 31 December 1996

Record #	Locality
1	Little River Flood Control Dam (S-27, C-4).
2	Miami, Little River at 79th Street, below flood control dam.
3	Miami, Little River, Flood control dam S-27, NE 82nd St. & 4th Avenue.
4	Little River flood control dam, S-27.
5	Miami, just downstream of SFWMD flood gate S-27 in the Little River.
6	Miami, S-27 dam, just below flood gates on Little River at 82nd St. NE.
7	Miami, behind 8240 N.E. 4th Place, just below S-27.
8	Miami, Little River Canal, Next to U.S. 1.
9	Miami, at N.E. 82nd St. and 4th Ct. just below S-27 floodgate.
10	Miami, in Little River Canal at S-27 floodgate.
11	Miami, fifty meters above floodgate S-27 in the Little River.
12	Miami, Little River Just E. of Biscayne Blvd. Bridge.
13	North Miami, north of C-7, S-27 flood control structure, behind Biscayne Shopping Center at NE 4th Court and 79th Street.
14	Miami, Just outside and South of the mouth of the Little River.
15	Little River
16	Little River
17	Canal near flood gate, Biscayne Blvd. and N.E. 169th Street. Gate S-29.
18	North Miami, Greynolds Park, flood control dam.
19	North Miami, Greynolds Park, flood control dam.
20	North Miami, Greynolds Park, flood control dam at Biscayne Blvd. and NE 169th St.
21	North Miami, Snake Creek (C-9), Greynolds Park Flood Dam (S-29).
22	North Miami, Snake Creek at flood control structure (S-29).
23	North Miami, in canal below Greynolds Park Flood Control structure, Maule Lake, NE 165 Street and 26 Avenue.
24	North Miami, 2919 Pt. East Drive, S-29 Greynolds Park Dam.
25	North Miami, Greynolds Park Flood Control Dam.
26	North Miami, Greynolds Park Flood Control Dam.

Appendix B. (Continued)

Record #	Locality
27	North Miami, Maule Lake, near flood dam S-29, Greynolds Park.
28	North Miami Beach, downstream of Greynolds Park flood control dam.
29	Stuart, St. Lucie Canal at buoy 50, near St. Lucie Lock (downstream).
30	St. Lucie Waterway at Phipps Park.
31	St. Lucie Canal, marker 47, just downstream of Locks.
32	St. Lucie Canal, just downstream of Lock\Dam structure.
33	Palm City, St. Lucie Lock and Dam, canal side of Okeechobee Waterway.
34	Stuart, just downstream (salt side) of the St. Lucie Locks.
35	Stuart, just downstream (salt side) of St. Lucie Locks.
36	Tropical Park, in Okeechobee Waterway just downstream of St. Lucie Lock and Dam near channel marker 34.
37	Tropical Farms, St. Lucie Locks. Inside the structure of the NW triangle section of the West gate. Gate S-80 Navigational Lock.
38	Tropical Farms, St. Lucie Canal (C-44), St. Lucie Lock, inside lock chamber.
39	Tropical Farms, just downstream of St. Lucie Lock, (C-44) Inside lock chamber.
40	Tropical Farms; St. Lucie Canal east bank, just downstream of the St. Lucie Lock (S-80)
41	Ortona Locks, by flood gate, west side.
42	Caloosahatchee River, 1/4 mile west of Ortona Locks
43	Caloosahatchee River, west (downstream) of Ortona Lock, 4 miles east of Port La Belle Marina, near mile markers 96 and 97.
44	Caloosahatchee River, 1.5 miles east of Port La Belle.
45	Down stream from Ortona Locks.
46	Ortona, downstream side of water control structure #2, trapped by eddy of flowing water.
47	Ortona, caught in NE gate of Ortona Locks.
48	Ortona Locks, Navigational Lock S-78, floating inside of lock chamber near E. gate.
49	Ortona Lock, floating on the down stream side of spillway gate #3, S-78
50	Ortona Lock, Just downstream of spillway #2.

Appendix B. (Continued).

Record #	Locality
51	Ortona, floating against N. bank of Caloosahatchee Canal, approx. 1 mile downstream from the Ortona Locks.
52	Ortona Lock, S. bank approx. 500 feet downstream of the spillway.
53	Ortona, Ortona Locks, in the turbulence directly downstream of spillway #3.
54	Ortona, Ortona Locks, floating against N. Bank, approximately 500 yds. Downstream of spillway #2.
55	Ortona Locks, floating in the recessed well for the NW gate.
56	Snapper Creek
57	Snapper Creek flood control dam.
58	Snapper Creek flood dam.
59	Snapper Creek flood control dam.
60	Snapper Creek automatic flood control dam.
61	Snapper Creek at Red Road and 112th Street S.W. by flood dam (S-22)
62	Taylor Creek, north end of Lake Okeechobee.
63	Okeechobee, just north of Lock at Taylor Creek.
64	Okeechobee, 100 yds. N. of Lock at Taylor Creek. At the convergence of Taylor Creek, Rim Canal, and Lake Okeechobee.
65	Okeechobee, at S-193 Navigational Lock. At the joining of Taylor Creek, Lake Okeechobee and the Rim Canal.
66	Okeechobee, S-193 navigational canal on Taylor Creek. Lock connects Taylor Creek to Lake Okeechobee.
67	Okeechobee, Just outside and E. of Taylor Creek in Lake Okeechobee (S-193).
68	Okeechobee, Just outside and N. of Taylor Creek Lock in Taylor Creek (S-193).
69	Port Mayaca Locks, St. Lucie Canal
70	Port Mayaca Lock between Okeechobee and St. Lucie Canal.
71	Port Mayaca, in lock canal.
72	Port Mayaca, just downstream from the canal locks.

Appendix B. (Continued).

Record #	Locality
73	Port Mayaca, St. Lucie Canal, Just outside and S. Of Port Mayaca Lock #308
74	Miami Shores, Biscayne Canal, Just east of flood control dam.
75	Miami Shores, Biscayne Canal, dwonstream from dam (S-28), between NE 104 &105 St.
76	North Miami, Canal between NE 90 Street, NE 91 Street, Miami Shores.
77	Dania Cutoff Canal at Florida Power and Light
78	Fort Lauderdale, Dania Cutoff Canal, New River Canal South, at Dam S-13.
79	Upstream side of pumping station S-13.
80	Miami River, flood control dam (S-25B) - downstream.
81	Tamiami Canal at flood dam (S-25B).
82	Miami River, South Branch, Tamiami Canal, downstream of flood control dam S-25B.
83	Miami, West Tamiami Canal, 0.25 mi.. E of water control structure S-25B, drop gate.
84	Miami, just SE of the NW 37th Ave. Bridge, dwonstream of the S-25B SFWMD Structure
85	Miami River at flood control dam near Lejeune Road, at airport.
86	Miami, in Miami River near Jones Boatyard.
87	Miami, floating in the Miami River behind the residence at 3600 NW North River Drive.
88	Miami River
89	Moore Haven, downstream of the Moore Haven Locks.
90	Moore Haven, on W. bank of river, 500 yds. SW of lock chamber (S-77), near intersection of River Road and Avenue 0.
91	Moore Haven approx. 2000 ft. W. of Moore Haven Lock, across the canal from Alvin E. Ward Memorial Boat Ramp.
92	Calooschatchee River Flood Gate, Glades County
93	Calooschatchee River
94	Calooschatchee River
95	Biscayne National Park, S.W. side of water control structure S-20F.
96	Homestead, just outside and E. of Mowry Canal in Biscayne Bay, N. of spoil island.
97	Homestead, Biscayne Bay, ½ way between Turkey Point and Convoy Point.
98	Homestead, Biscayne National Park, E Side of the S20F flood control sturcture.
99	Mowry Canal
100	Port Mayaca, L-47 canal, E. of S-135 SFWMD water control structure drop gate. At the vegetation barrier.

Appendix B. (Continued)

Record #	Locality
101	Lake Okeechobee
102	Ft. Lauderdale, S-33 flood gate, just W. NW 34th Avenue and Sunrise Blvd. intersection.
103	Homestead, Black Point Park, Black Creek Canal, just downstream of the S-21 Floodgate.
104	Oakland Park, against E. Side of SFWMD S036 structure at 2400 NW 39th Street.
105	Henry Creek Lock on east side of Lake Okeechobee.
106	Port Canaveral, in canal Lock.
107	East shore Banana River, Port Canaveral, west end of canal Lock, on north side.
108	Cape Canaveral (5 km NW) in locks between Banana River and Canaveral Barge Canal at Port Canaveral.
109	Cape Canaveral, W. Side of the Lock at Port Canaveral.
110	Cape Canaveral, approximately 0.8 km NW, small cove N. of SR A1A, just W. of Port Canaveral Locks.
111	Cape Canaveral, found near W. end of Port Canaveral Locks at Ski Island.
112	Cape Canaveral Lock
113	Cape Canaveral Lock
114	Cape Canaveral Lock
115	Cape Canaveral Lock
116	In boat canal just S of Rodman Dam, Approx. 100 yds from lock.
117	Rodman Dam, under flood gate.
118	Rodman Dam, under flood gate.
119	Rodman Dam, under flood gate.
120	Palatka, 1/2 mile downstream of Rodman Dam in overflow canal.
121	Palatka, floating 200 yards down river of the Rodman reservior dam.
122	Palatka, in the Oklawaha River floating 500 yeards dwonstream from the Rodman Dam.
123	Buckman Locks at E. end of the Cross Florida Barge Canal.
124	Cross Florida Barge Canal, Buckman Lock,
125	Tampa, off Old Tampa Bay at flood gate at north end of Rocky Creek.

Appendix B. (Continued)

Record #	Locality
126	Tampa, off Old Tampa Bay in Rocky Creek east of bridge over Sheldon Road.
127	Near Inglis, in Withlacoochee River just east of US Highway 19 Bridge.
128	Inglis, Cross Florida Barge Canal, Inglis Lock, immediately downstream of west gate.
129	Henry Creek Lock

Appendix C. Distribution of probable cause of death for structure related manatee mortality from 1974 through 31 December 1996

Record #	Probable Cause of Death
1	Crushed in flood gate-thoracic and pleural cavity trauma. Gate marks.
2	Crushed in flood dam S-27
3	Crushed in flood gate - hemidiaphragms ruptured.
4	Crushed in flood gate
5	Flood gate impression on back parallel to body axis. Six left ribs broken; left lung lacerated.
6	Flood gate: animal found just below dam. External marks and internal damage indicates post-mortem crushing. Probably drowned prior to crushing.
7	Flood gate: both lungs punctured by broken ends of 9 ribs with associated hemorrhaging. 1/2 Liter of blood present in left pleural sac.
8	Fresh longitudinal impression on both sides of body. Left ribs 4-7 disarticulated or fractured, vertebrae at 4th and 5th rib separated.
9	Longitudinal impressions on dorsum, 9 fractured ribs, food present in mouth.
10	Killed by crushing blow to the chest. Multiple luxated ribs, separated spine, Lacerated lung and diaphragm, damage to mandible and teeth.
11	Disarticulated ribs, clotted blood around heart, two liters of food in stomach.
12	Severe trauma to heart, trachea, and adjacent organs; 3 anterior ribs disarticulated.
13	Animal appeared to have been caught by its head within the flood control structure. There was substantial cranial trauma along with a broken neck.
14	Flood gate, vertebral separation, 1 luxated & 6 broken ribs on L. side, 1 luxated and 4 subluxated ribs on R. side, L. lung torn, blood clots.
15	Vertebral separation in two places; luxated, subluxated and broken ribs; both lungs torn; circular and banded impressions on dorsal and ventral body.
16	
17	Crushed in flood control gate.
18	Crushed in flood gate.
19	Crushed in flood gate.
20	Crushed in flood gate - external gate marks present, no internal damage.
21	Crushed in flood control gate.
22	Crushed in flood control gate - gate marks on back, ribs broken.
23	Crushed/Drowned in flood control structure.

Appendix C. (Continued).

Record #	Probable Cause of Death
24	Crushed\Drowned in flood gate.
25	Crushed\Drowned in flood control dam, gate impressions on left side.
26	Crushed\Drowned in flood control dam.
27	Crushed in flood gate, gate impression across shoulders.
28	Crushed, gate mark across shoulders; tissue trauma; body cavity filled with clotted blood; no broken bones. Massive internal hemorrhage.
29	Crushed in canal lock - massive internal damage.
30	Crushed\Drowned in flood gate or canal lock. Rivet impressions on back.
31	Crushed in flood gate. Gate impression on left side. Left diaphragm ruptured.
32	Crushed\Drowned in flood gate - gate marks on left side, 7 left broken ribs.
33	Internal lesions indicate death from crushing. Stomach contents were pushed forward under the neck and chin. 10 cm separation of T-13 and T-14.
34	Fractured ribs, separation fracture of cervical spine.
35	Separation fracture of cervical vertebrae; severed trachea.
36	Abrasions on mid-dorsal and mid-ventral sides, Luxated ribs with damage to respiratory organs and abdominal aorta.
37	Canal lock, drowned\crushed. two small lacerations on the right dorsal lobe of the liver were present. Subdermal bruising and laceration on the head.
38	Trauma from navigational locks, torn right hemi-diaphragm, left lung completely collapsed from previous chronic infection.
39	Black marks and bolt impressions with associated scrapes on dorsal and ventral body, broken ribs, internal damage.
40	Muscle damage and hemorrhaging on the central aspect of the skull and jaws, major bronchi were filled with a serosanguinous plug, inflamed bronchi.
41	Crushed in flood gate - disarticulated ribs R 2-9, L 10, 12, 13, 14.
42	Crushed\Drowned in canal lock. Hematoma extending length of Left side of body.
43	Crushed in flood gate or canal lock. Intracerebral hemorrhage.
44	Crushed in flood gate or canal lock. Skull crushed.
45	Fresh scars indicative of being crushed in locks.

Appendix C. (Continued).

Record #	Probable Cause of Death
46	Carcass had pattern of bruises along both sides that appeared to be regularly spaced, corresponding to rivets or bolts on a lock structure.
47	Manatee died of severe internal trauma caused by being crushed between a navigational lock gate and its recessed concrete wall.
48	Complete vertebral separation at rib #7, Luxated ribs, black rubber marks around body on the ventral surface.
49	Bolt impressions along dorsal & lateral left side, blood clots throughout neck region, abdominal and pleural cavities, tear in GI Tract.
50	Exsanguination; subdermal hemorrhage on dorsal and left body, right side of head and jaw hemorrhagic.
51	Black mark and periodic scrape marks along entire left side, sternum, stomach, transverse colon, and right lung were pushed forward of normal location.
52	Black mark on left dorsum from neck to peduncle, torn stomach, subdermal hemorrhage above luxated ribs, left ribs # 2-5 luxated.
53	Black marks and bolt impressions on dorsal and ventral right body, kidney and lung trama, exsanguination into right pleural cavity.
54	Hemmorhaging beneath skin; torn colon; right kidney hemmorhaging; right hemi-diaphragm; black scrapes and marks on dorsal and ventral body.
55	Broken ribs on both sides of the body. Vertebral separation. Skull and jawbone shattered. Internal organs badly decomposed.
56	Crushed in flood control gate.
57	Crushed in flood gate- gate marks across shoulders.
58	Crushed in flood control gate.
59	Crushed in flood control gate - massive internal damage, marks from gate.
60	Crushed in flood control gate - imprint of gate on animal's back.
61	Crush in flood control gate - stuck in dam.
62	Crushed in flood gate - internal damage.
63	Crushed, Left ribs all but one fractured, R rib 7 fractured, all but 3 luxated or sublaxated, massive damage to organs, blood clots free in abdomen.
64	Crushed in lock, massive damage to organs (especially to lower body).
65	Blood clots in neck region, dislocated and broken ribs, vertebral separation (3), severed heart and urinary bladder, fractured kidneys, displaced organs.

Appendix C. (Continued).

Record #	Probable Cause of Death
66	Multiple broken and luxated ribs, GI tract torn in several places, ruptured hemi-diaphragms, complete vertebral separation, both kidneys lacerated.
67	Blood clots in abdominal cavity, uterus & urinary bladder pinched, left and right ribs broken and luxated, muscle trauma along vertebral column.
68	Canal lock, black impressions and scrape marks externally, blood clots in abdomen, torn stomach, liver displaced, aorta severed, ribs broken/luxated.
69	Drowned in flood gate - flood gate mark parallel to body.
70	Crushed by canal lock. 3 left ribs disarticulated. Ruptured aorta. Right scapula broken. Pleural cavities filled with blood.
71	Ribs 4, 5, 6, and 7 disarticulated and pushed through lung and diaphragm, sternum fractured, hematoma just posterior to sternum.
72	Gate impressions on dorsal and ventral sides, luxated ribs, ruptured trachea, right lung collapsed.
73	Black marks and bolt impressions on dorsum and ventrum, gastric gland torn from stomach, lungs torn, vertebral separation, ribs luxated and broken.
74	Crushed in flood control gate.
75	Crushed in flood control gate - gate marks on back.
76	Crushed\Drowned in flood gate S-28 - flood gate impression marks on back.
77	Crushed in flood gate S-13 - located just downstream of flood dam.
78	Crushed in flood gate - head crushed.
79	Head caught in flood control gate and crushed.
80	Crushed in flood control gate.
81	Crushed in flood control gate - massive internal damage.
82	Crushed\Drowned in flood gate - flood dam gate marks across body.
83	Crushed in flood gate. Complete vertebral separation, and displacement, another partial vertebral separation, four severed ribs.
84	Parallel marks across dorsum, GI tract torn in several places, both hemi-diaphragms torn, vertebral separation between ribs # 10 and 11.
85	Crushed in flood control gate - several ribs broken.
86	Crushed\Drowned in flood control gate or canal lock - probable S-26

Appendix C. (Continued).

Record #	Probable Cause of Death
87	Broken and luxated ribs on both sides, two areas of vertebral separation, tears in both lungs, right lobe of liver torn.
88	
89	Crushed\Drowned in canal lock. Right ribs 5-13 broken. Large bruise on Rt. side.
90	Disarticulated ribs, separation in spinal column.
91	Vertebral separation, luxated and subluxated ribs on both sides, blood clots throughout neck region, abdominal and pleural cavities, tear in GI tract.
92	Crushed\Drowned in flood gate S-77
93	
94	
95	Separated vertebrae, 7 luxated ribs. Numerous pressure marks on external dorsal and ventral surface, including marks from Hex. bolts, gate seal.
96	Impression mark on dorsal body, blood clots in abdominal cavity, vertebral separation at rib #4, multiple broken and luxated ribs on both sides.
97	Blood clots in abdomen, esophagus crushed, liver fractured, heart crushed, blood and clots in both pleural cavities, fractured and luxated bones.
98	Broken and luxated ribs on both sides of the body with associated muscle trauma adjacent to this area, 8 cm. Vertebral separation.
99	
100	Crushed. A 64 cm impression on dorsum. Complete separation between 3-4 thoracic vertebra and left 1-3 thoracic rib and vertebra.
101	
102	Eight luxated ribs on left side with associated damage to respiratory system, impressions dorsal side of right flank, abdominal cavity ruptured.
103	Complete vertebral separation, broken and luxated ribs, both lungs had tears, heart and pericardium were displaced, regurgiated food in esophagus.
104	Vertebral separation and luxated ribs.
105	Animal caught mid-body by navigation lock. Vertebral column separated; aorta, vena cava, diaphragm ruptured. No external sign of injury.
106	Crushed in lock - trauma suggest animal was crushed in lock.
107	Crushed in canal lock - death due to acute massive pressure.
108	Multiple broken ribs and fractured ribs.
109	Bilateral rib injury, 2-8 luxated, vertebrate separation at 8, left rib #7 fractured at head.

Appendix C. (Continued)

Record #	Probable Cause of Death
110	Left ribs 13-15. Right 16 & 17, fractured, one lumbar vertebral process fractured. Bilateral injuries indicate animal was squeezed.
111	Vertebral separation between ribs 6-7, Left ribs 6, 7 luxated, Left rib 7 fractured, stomach ruptured, food and clotted blood throughout body cavity.
112	
113	
114	
115	
116	Crushed in flood gate - massive internal damage.
117	Crushed\Drowned in flood gate-fresh scrapes and rivet marks on body.
118	Crushed\Drowned in flood gate-fresh scraped and rivets marks on left side.
119	Crushed\Drowned in flood gate-fresh scrapes and rivet marks on body.
120	Animal died in the water control gates of the Rodman Dam. Distinctive marking on carcass corresponds to structures on the gates.
121	External trauma; uniformly spaced circular impressions, bilateral tears in diaphragms; subdermal and musculature trauma next to external impressions.
122	Complete vertebral separation between ribs #9 and 10 and #12 and 13. Left ribs #9 and 12 subluxated, #10 luxaed, #12-13 broken. Torn muscle tissue.
123	Probably caught in the lock - massive hemorrhaging in head and shoulder area.
124	Drowned in canal lock - scrape marks on skin suggest that manatee was pinned.
125	Extreme bruising in head and neck area indicated crushing injury although no fractures were observed.
126	Found just below flood gate with traumatic fracture of thoracic vertebrae 8 and 9.
127	Massive trauma to cranial vault and soft tissue damage around sternum suggest a 2 sided crushing injury.
128	Drowned in canal lock - parallel superficial scrapes present on body.
129	

Appendix D. Listing of additional remarks about manatee carcasses referenced to structure caused mortality from 1974 through 31 December 1996

Record #	Additional Remarks About Carcass
1	Stomach full, rapid death. No body fat, muscular fat yellow in color, about 1 cm thick. Photos taken. Deposited and necropsied at So. Dade Zoo. Wt. 626 Lbs.
2	Wedged in perpendicular to dam axis. Probably tried to get through and got stuck. No sperm in S. vesicles or epididymis.
3	GI tract full but little fat present. FMP Case No. 1003.
4	Known animal: RB310.
5	Heavy abdominal fat deposits. Stomach full of ingesta.
6	Although physical damage appeared to be post-mortem, robust health of the animal indicated by abundant fat deposits and full GI tract made disease seem unlikely. No bruising or blood clots observed
7	Trauma caused bilateral pneumothorax and total atelectasis of the lungs. Apparently healthy animal with fat deposits, full GI tract, and no signs of illness.
8	Necropsy was observed by Dr. Hunt Scheuerman, Lee County Examiners Office.
9	No Additional Comments.
10	No Additional Comments.
11	Right ribs 1 and 2 disarticulated, clotted blood around the heart, food in stomach; possible trauma around head and thorax.
12	Animal was lactating
13	Two pressure point injuries were observed on the ventral jaw area, a single pressure point injury was located on the cranium.
14	No Additional Comments
15	Lactating female. Animal had recently calved (less than 1 month). Culture results from kidney revealed mod. To heavy growth of 100% clostridium species.
16	No additional comments.
17	Entire carcass returned to RSMAS for necropsy. Tissue samples preserved. Entire skeleton saved. Sexually mature. Sperm in epididymis.
18	Stomach full. Weight: 450 pounds.
19	Stomach full. Weight: 950 pounds.
20	Entire carcass, skeleton, reproductive organs, stomach and GI tract contents.
21	Skeleton, GI tract, eyes, thyroid, spleen, adrenal, testes, epididymis, seminal vesicles and fluid, urine and histopath samples recovered. Died at 0700 hrs. - floating didn't sink.

Appendix D. (Continued).

Record #	Additional Remarks About Carcass
22	Skelton, reproductive tract, urine, seminal fluid, GI tract, data recovered. Prob. died 11 Nov. low numbers of sperm in seminal fluid. Photos taken. Organ weights available.
23	Yellow fluid in peritoneal cavity. Numerous healed prop. scars on body, none fresh. Blood and water flowed from nostrils.
24	Skull, thoracic rib, L. flipper. Carcass had drifted into Maule Lake at recovery time,
25	Monofilament line wrapped around L. flipper resulting in healed scar tissue under the line. Gut was full. Major organs unparasitized.
26	Right ribs 6-17 either disarticulated or broken. No sperm in epididymis.
27	FMP Case No. 1121.
28	Light nasal fluke infestation; field necropsy; animal could not be towed from site by boat.
29	Left ribs 10-14 disarticulated, right ribs 6-10 disarticulated, 11-16 broken. Thoracic 13 free. UF No. G79-80.
30	No nasal flukes.
31	Tissue beneath gate marks crushed/bruised. GI tract full, heavy fat deposits. FMP Case No. 1202.
32	Left lung punctured. Heavy fat deposits, GI tract full. FMP Case No. 1210.
33	16th right rib broken, dorsal arches of 16-17 thoracic vertebrae broken hemorrhage on ribs. Digestive tract filled with fresh blood indicating good health at the time of death.
34	No Additional Comments.
35	This is the second manatee killed in the St. Lucie Locks during May. This animal was a known animal DC03
36	Abundant fat and full GI tract.
37	External bruises and abrasions. Postmortem luxation of the Right 8th rib. Unilateral mild to moderate suppurative pneumonia, left side.
38	This animal appeared to have been caught in the navigational locks and was distended with gas; therefore, girths were not taken.
39	Animal slightly bolated, but girth measurements taken.
40	Micro. Results of the lung showed no growth after 48 hours.
41	Animal was very fat. Carcass was very dry, hardly messy at all. Blood and juices drained out.

Appendix D. (Continued).

Record #	Additional Remarks About Carcass
42	Musculature on left side noticeably more decomposed. Conditions suggest crushing. No reproductive organs found, sex determination based on absence of penis.
43	Right tympanic broken, middle ear filled with clotted blood. Skin abrasion at right ear. Numerous 1-2 mm subdermal abscesses. Heavy nematode infection in duodenum. FMP Case No. 1066
44	Left and right diaphragms ruptured at ribs 2-5, tissue at site necrotic. FMP Case No. 1073.
45	Carcass had fresh external scars indicative of being crushed in locks, internal damage of disarticulated right ribs # 7-11, and disarticulated vertebrae. No FMP Case #.
46	No Additional Comments.
47	Lockmaster found manatee after lock gate would not open completely. It is unclear how such a large manatee managed to get into the area behind the lock gate.
48	Found inside lock chamber. Lock tender reported having difficulty in closing lock. Game and Fish Commission # 93-1-937.
49	No blubber or girth measurements taken due to deomposition. Game and Fish Commission Case # 94-01-0855. Towed by GFC Officer Malone.
50	Animal slightly bloated, but measurements taken.
51	Carcass too decomposed, no girth or blubber measurements. Game and Fish Commission # 94-01-1607.
52	Carcass bloated, no girth\ blubber measurements taken. Towed by COE Ranger Sullivan
53	GFC case number: 94-01-2086.
54	No Additional Comments.
55	This was a known captive animal (MSTM9202C) born to Romeo and Naples. Also known as "Andrea" she had been belted (TTB40) and PIT tagged by DEP. PIT Tag: Right #00 0134 283D, Left #00 01DB 73F8.
56	Possible drowning, trauma to head, neck, shoulder area. Ductus arteriosus open. Found near flood gate.
57	Head and two ribs collected. Animal not removed from site. Possible mother of 76-26 which was found in the same area on 22 Nov. 1976.
58	Head collected.
59	Head, reproductive tract, digestive tract, flippers and four ribs recovered for RSMAS, remainder to S. Dade Zoo. Very fat. Ribs on left side disarticulated.

Appendix D. (Continued).

Record #	Additional Remarks About Carcass
60	Head and two ribs recovered, remainder disposed of. Fish hook, without line, caught in upper lip.
61	Entire carcass and caecum contents recovered. Stomach empty. Dead several days. Photos taken.
62	Entire carcass recovered. Killed at approx 0730 hrs, on 1 Jun in Taylor Creek Lock. Organ weights available.
63	20 cm wide (est.) black marks around body about 50 cm caudal to pectoral flippers.
64	Numerous sets of black marks around body. Lock tender reported problems closing lock gates previous evening.
65	There were distinct marks on the carcass that corresponded to the lock gates leading edges.
66	Carcass weight 674 pounds.
67	Culture results revealed no growth at 48 hours.
68	No Additional Comments
69	Dam closed approx 1200 hrs, 10 Jan had been opened 6 in. St. Lucie (combination lock and flood control). No scars C. Dennis FGFWFC observed necropsy.
70	Light fluke infestation in caecum/upper lower intestine. No stomach nematodes. No nasal flukes. GI tract full of vegetation. Old white prop. wound on right caudal peduncle.
71	No Additional Comments.
72	No Additional Comments.
73	No Additional Comments.
74	Skull and two ribs recovered, post cranial skeleton buried. Scar pattern on back indicated crushing in gate. Right ribs were disarticulated and heads driven through lung, diaphragm and stomach.
75	Crushed carcass recovered. Photos taken. Data available.
76	Animal was probably killed at 104 street NE flood dam (S-28), and floated to recovery site after 3 or 4 days.
77	Animal very fat and digestive tract full. No parasites observed. Male fetus 112 cm long (m-80-16F), (fetus = UF 15194) evidence of crushing was noted in the right and left thorax, brachial area.
78	First flood dam fatality in approximately two years. FMP Case No. 872.
79	Anterior organs more decomposed than posterior, related to crushed head.
80	Skull recovered. Hydrilla leaves in mouth. Carcass taken to dump. Photos taken.

Appendix D. (Continued).

Record #	Additional Remarks About Carcass
81	Entire skeleton and data recovered. Killed 11 Nov., 3 other manatees with it, one trying to copulate. Possible animal in estrus. Cervical trauma, cervical separated from skull. Hemorrhagic. Photos taken.
82	Typical flood dam gate marks across body. Ribs on right side broken.
83	External impression from drop gate seal, bolt marks, and 2 parallel lines perpendicular to the sea mark. Incidental to being crushed the manatee had an active infection.
84	No girth measurements, bloated.
85	Head and three ribs collected. Animal originally reported on 6 Sep in same location. length estimated
86	Calf seen all day on 11 Sep with dead female. Miami seaquarium attempted rescue unsuccessfully. Calf was large enough (Approx. 4.5 feet) that survival is very possible.
87	Girths were not taken because animal was bloated.
88	No additional comments.
89	Back bruised. Blood clots throughout pleural cavities. Three nails on each flipper. Left pelvic bone lost. FMP Case No. 1279
90	No Additional Comments.
91	1307 pounds. Animals badly decomposed and bloated. No skin or blubber measurements taken. Game and Fresh Water Fish Commission Case # 316.
92	Animal slightly bloated, no girth measurements taken.
93	No additional comments.
94	No additional comments.
95	Pressure marks present dorsally and ventrally on epidermis. Two of these were parallel and exactly 45 cm. in length.
96	Manatee weight: 1560 pounds.
97	No Additional Comments.
98	No Additional Comments.
99	No Additional Comments.
100	The primary bronchi of both lungs were filled with red fluid. Mscular tissue surrounding the trachea was torn, with separations observed on either side (~16 cm each). Possible pregnancy.
101	GI tract full, uterus distended and ruptured. 83 cm fetus found at same location.
102	No additional comments.
103	No Additional Comments.
104	No Additional Comments.
105	Right horn of uterus enlarged and filled with non-odorous gray mucous. Generally fresh but lung and liver decomposition enhanced by internal damage. Mammary gland enlarged but little milk. Heavy fat.

Appendix D. (Continued).

Record #	Additional Remarks About Carcass
106	Fresh scrapes on left side, perpendicular to long axis of body. Heart ruptured. Left ribs 2, 3, 4, 5, disarticulated; Right ribs 1-11 broken.
107	Several bones fractured and vertebral column split between T13 and T14. Both hemidiaphragms ruptured. Left lung punctured. Inferior vena cava ruptured. 3 long bands of bruising along musculature.
108	Anterior face of scapula broken. Known as BC146.
109	No Additional Comments.
110	Blood from genital opening, clotted blood in abdominal cavity. Large intestine, mesentery, small intestine and kidneys damaged.
111	Known animal: BC130.
112	No additional comments.
113	No additional comments.
114	No additional comments.
115	No additional comments.
116	Right ribs 8 & 9 broken. Left ribs 6-13 broken approx. 5 cm from proximal end. Break in Vert. column between thoracic 8 & 9. Pleural cavity full of clotted blood. Dermis in head and shoulder region hemorrhaging.
117	Dermis bruised. Lungs saturated with blood. GI tract full. Heavy fat deposits present. Three nails on each flipper. FMP Case No. 1122
118	Severe ante-mortem bruising of musculature on left side from flipper to mid-fluke. Lungs saturated with blood. GI tract full. Heavy fat deposits present. FMP Case No. 1126.
119	Massive ante-mortem bruising of musculature beneath scrapes. Left scapula broken, Large hematoma. Shock syndrome; ischemic kidneys, little blood in heart. Left flipper missing beyond humerus.
120	Game and Fish Commission number: 1240.
121	GFC Case # 1029.
122	No Additional Comments.
123	Scrapes marks on head
124	Manatee had scrape marks and concrete abrasions on body suggesting that it was pinned between lock gate and wall during gate opening. GI tract full. No broken bones or hemorrhagic tissue present.
125	GI tract contained ingesta; feces in colon.
126	No external lesions or wounds. GI tract full of ingesta. Ovaries contained many little follicles in various stages of maturity. Uterus slightly enlarged. Lumen contained grey fluid sectioned for histologic examination.

Appendix D. (Continued)

Record #	Additional Remarks About Carcass
127	Focal uterine enlargement and presence of milk in the mammaries indicated calving in the near past. The canal lock at Lake Rousseau is suspected of crushing the animal during the operation on July 5th.
128	Pathological conditions indicate death due to shock resulting from trauma; massive hemorrhaging along ribs, patchy serosal hemorrhaging on intestinal walls, lungs dark and heavy, kidneys pale.
129	No additional comments.

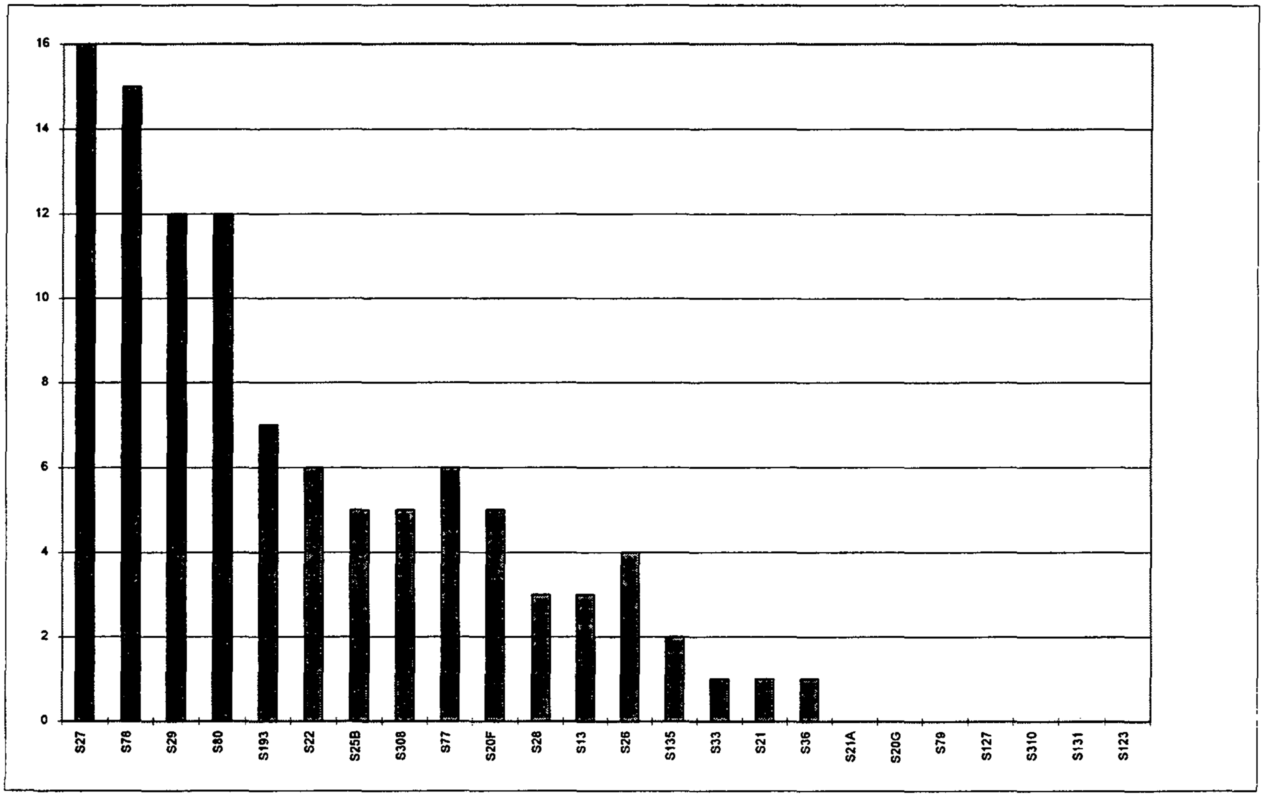


Figure 1a. Frequency of manatee mortality (1974 through 31 December 1996) associated with C&SF locks and water control structures.

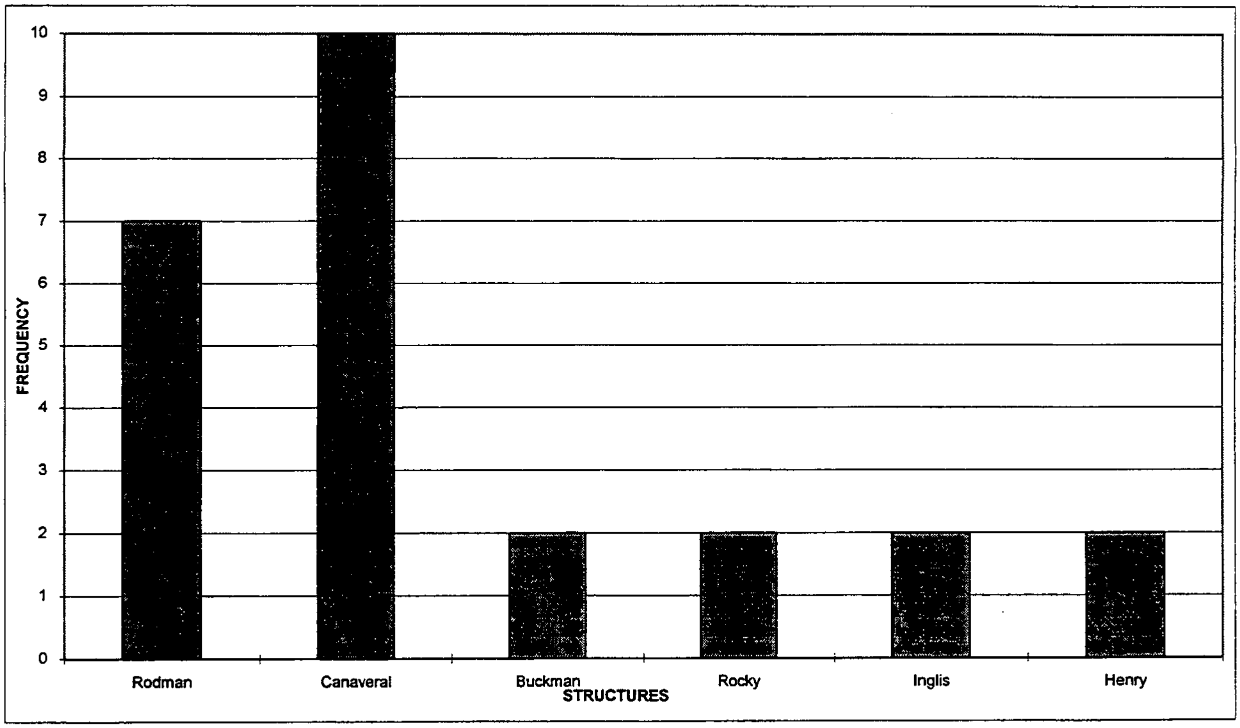


Figure 1b. Frequency of additional manatee mortality (1974 through 31 December 1996) associated with Florida locks and water control structures other than C&SF.

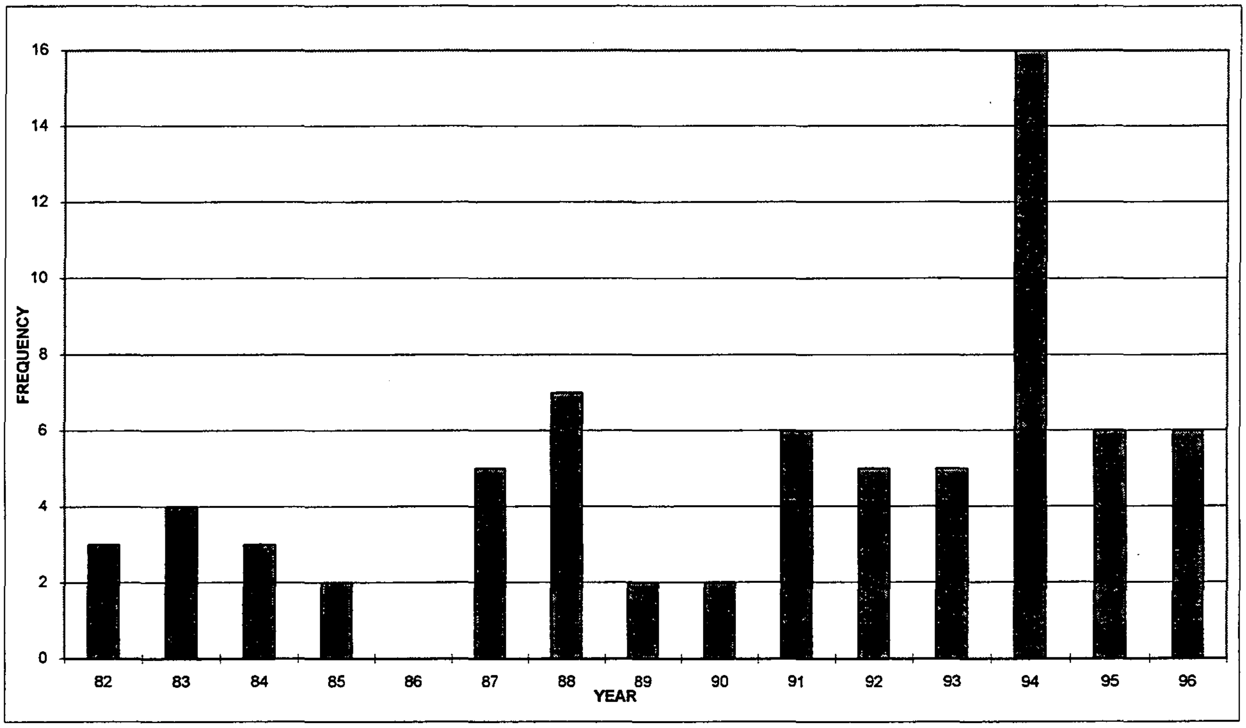


Figure 2a. Yearly distribution of manatee mortality (1974 through 31 December 1996) associated with C&SF locks and water control structures.

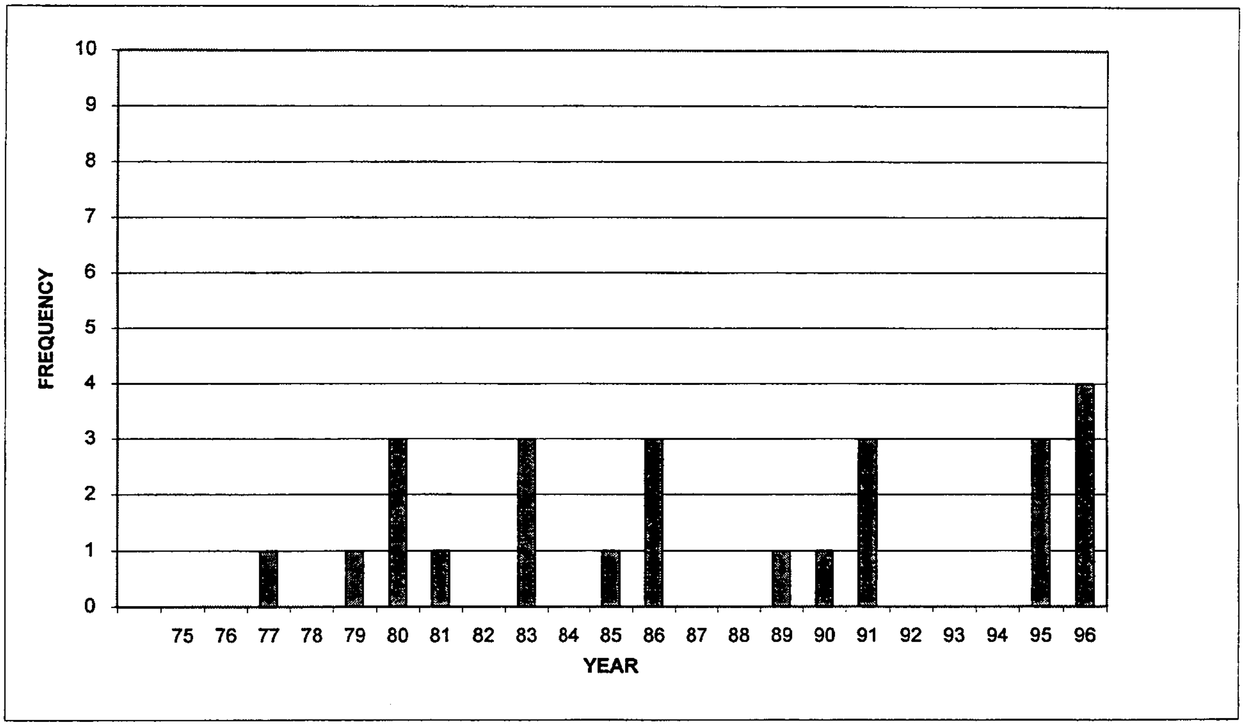


Figure 2b. Yearly distribution of manatee mortality (1974 through 31 December 1996) associated with Florida locks and water control structures other than C&SF.

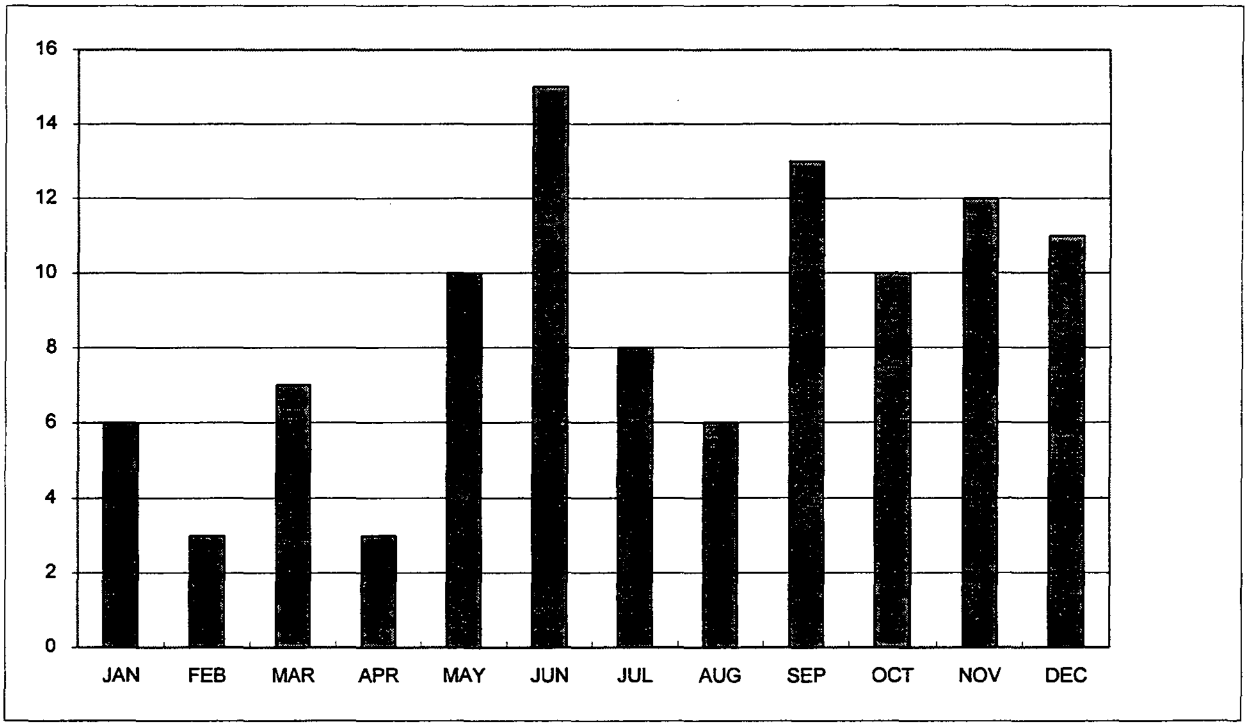


Figure 3a. Monthly distribution of manatee mortality (1974 through 31 December 1996) associated with C&SF locks and water control structures.

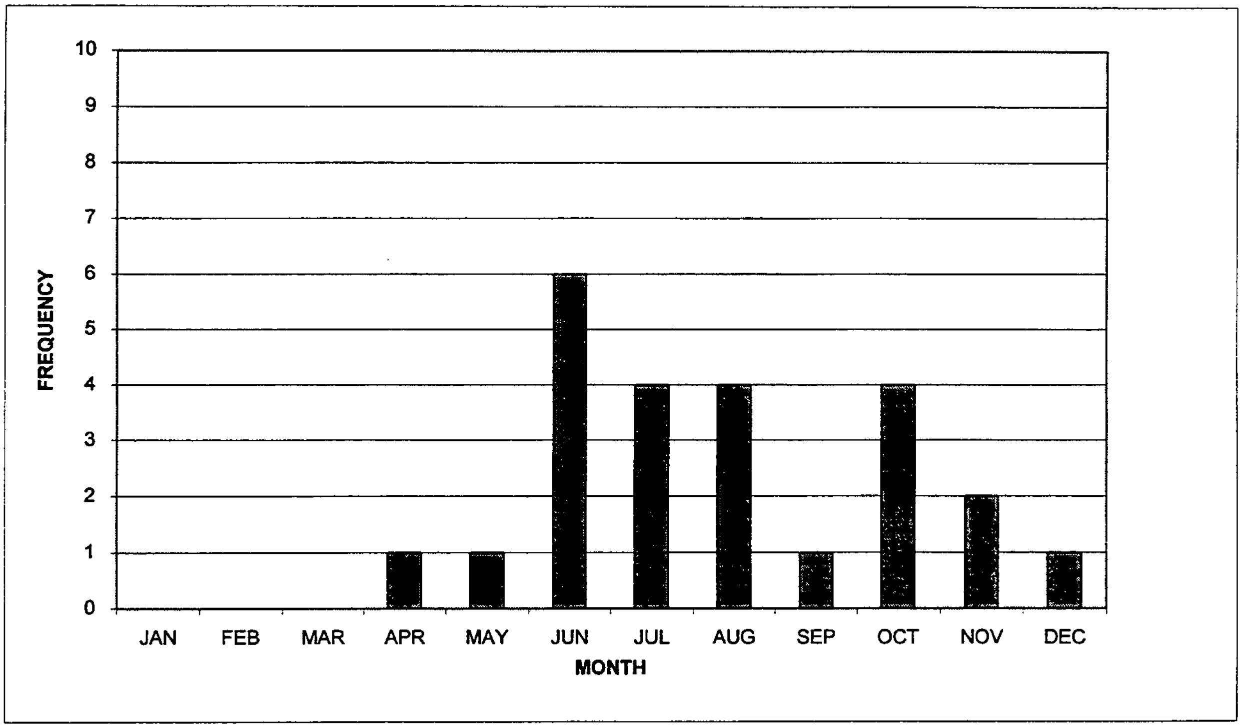


Figure 3b. Monthly distribution of manatee mortality (1974 through 31 December 1996) associated with Florida locks and water control structures other than C&SF.

APPENDIX H

BRIEF REAL ESTATE PLAN
MANATEE PROTECTION AT SELECTED NAVIGATION & WATER CONTROL STRUCTURES IN CENTRAL AND SOUTHERN FLORIDA
PART II

STATEMENT OF PURPOSE

This Real Estate Plan (REP) is tentative in nature for planning purposes only and both the final real property acquisition lines and the real estate cost estimates provided may be subject to change following approval of the Feasibility Report.

PROJECT AUTHORIZATION

Specific authorization and appropriations for this project are provided by the Energy and Water Development Appropriation Act of 1994 (P.L. 103-126).

PROJECT LOCATION

The project area consists of selected project structures located within the Okeechobee Waterway and Central and Southern Florida Flood Control Project, as identified below:

STRUCTURE	LOCATION	OPERATED BY/ DATE CONSTRUCTED
Moore Haven Lock* (S-77 Lock)	Glades Co.	CESAJ/1935
Ortona Lock (S-78 Lock)	Glades Co.	CESAJ/1937
W.P. Franklin Lock (S-79 Lock)	Lee Co.	CESAJ/1965
St. Lucie Lock (S-80)	Martin Co.	CESAJ/1941
S-193 Lock	Okeechobee Co.	SFWMD/1973
Port Mayaca Lock (S-308B Lock)	Martin Co.	CESAJ/1977
S-310 Lock	Hendry Co.	SFWMD/1980

*NOTE: Hurricane Gate Structure No. 1 (HGS-1) and Moore Haven Lock were completed in 1935. In 1966, S-77 Spillway was added to the site of the combined hurricane gate and lock. HGS-6 was completed in the 1930's, and construction to convert it into S-193 was completed in 1973. HGS-2 was also completed in the 1930's, and construction to convert it into S-310 was completed in 1980.

PROJECT DESCRIPTION

Structural modifications to selected Project structures are proposed to reduce Manatee risk and mortality. Pressure sensitive devices and acoustical sensor devices would be designed, constructed, and installed on lock sector gates. The objective would be that whenever a manatee is detected between closing gates, the gate operator would be alerted by an alarm, and the gate would stop. Then, the operator can reverse the gate to free the animal before it is injured.

GOVERNMENT-OWNED LAND

The Government owns the land, in fee, for those spillways and locks for which it has the responsibility of operating. Refer to chart under Project Location for individual identification.

SPONSOR-OWNED LAND

The Sponsor has easements for those spillways, culvert and locks for which it has the responsibility of operating. Refer to chart under Project Location for individual identification.

ATTITUDE OF OWNERS

All project lands are owned by the State or the Government which fully support the Project.

RELOCATION ASSISTANCE (PUBLIC LAW 91-646)

There are no persons or businesses that would be relocated due to project implementation.

RELOCATIONS (Utilities, Structures and Facilities, Cemeteries, and Towns)

There are no known utilities, structures and facilities, cemeteries, and towns to be affected as part of the federal project.

NON-FEDERAL OPERATION/MAINTENANCE RESPONSIBILITIES

OMRR&R requirements are consistent with the existing authorized project.

LOCAL SPONSOR'S AUTHORITY TO PARTICIPATE IN THE PROJECT

The Sponsor's authority to participate in the project is consistent with the Sponsor's existing authority, for the existing authorized project.

HAZARDOUS AND TOXIC WASTES (HTW)

There have not been any hazardous and toxic wastes identified within the project area.

RECREATION RESOURCES

There are no separable recreational lands identifies for the project.

CULTURAL RESOURCES

There are no known cultural resources that have been identified as being affected by the project.

OUTSTANDING RIGHTS

There are no known outstanding rights in the project area.

MINERALS

There exist no known minerals of value in the project area.

STANDING TIMBER AND VEGETATION COVERS

There exist no timber or unusual vegetative cover in the project area.

MITIGATION

There is no mitigation associated with this project.

APPRAISAL INFORMATION

The entire project will be implemented on existing project lands.
No additional real estate interest will be required of the Sponsor to implement this project. No appraisal is to be requested or required for valuing of lands and damages associated with the proposed Project.

ESTIMATED COSTS OF LANDS, EASEMENTS, RIGHTS-OF-WAY AND RELOCATIONS

Lands and Damages	$ 0.00
Acquisition/Administrative Cost	
Federal	$ 1,000.00
Non Federal	$ 1,000.00
Public Law 91-646	$ 0.00
Contingencies (25%)	$ 500.00
Total Estimated Real Estate Cost	**$ 2,500.00**

REAL ESTATE ACQUISITION SCHEDULE

Due to the requirements of this Project, there is no scheduled acquisition of real estate.

APPENDIX I

FINAL REPORT

ACOUSTIC CURTAIN
MANATEE DETECTION SYSTEM
FOR
LAKE OKEECHOBEE
SECTOR GATES

Submitted by

Harbor Branch Oceanographic Institution, Inc.
5600 US 1 North
Ft. Pierce, Florida 34946

Prepared for

Army Corps of Engineers
Waterways Experiment Station
3909 Halls Ferry Road
Vicksburg, MS 39180-6199

20 December 1995

INTRODUCTION

The use of sound waves is perhaps the first method that comes to mind for the non-contact detection of objects under water. The manatee, due to it's size, flesh, and the air volume of it's lungs, is well suited to acoustic detection in the close proximity environment of the locks. Methods divide into passive and active schemes with attention focused on active methods employing a sound source (transducer) and a sound receiver (hydrophone). Passive methods were not considered for this application due to the perceived complexities of the signal processing and lack of hard information on manatee acoustic emissions. Active methods considered included imaging and non-imaging systems. There is no doubt that a trained operator with a modern high frequency short range imaging sonar could accurately detect, and probably characterize as well, a manatee in the lock region. Attention focused instead on autonomous, comparatively low cost, methods that do not depend on the vigilance, training, and recognition memory of a human operator. These methods include field disturbance sensors, interrupted beam sensors, and ranging sensors. Field disturbance sensors sense a change in a static acoustic environment, primarily by sensing changes in standing waves. Due to the movement of the gates, the presence and variety of barges and of boats, field disturbance sensors are unsuited for this application. Interrupted beam sensors, similar in nature to the electric eye sensors on garage doors, would detect the presence of a manatee between an acoustic source (transducer) and a receiver (hydrophone). Reflectance sensors (ranging sensors), similar to common fish finders, would detect the presence of a manatee based on the reflection (signal return) of the manatees body.

Acoustic Reflectance Array
Operating Principle

Acoustic reflectance sensors (ranging sensors) can be continuous modulated wave (amplitude or frequency), or pulsed. Continuous wave sensors typically sense the presence of an obstruction by detecting a change in relative amplitude, a change in phase, or a combination of both. Problems with continuous wave sensors in the lock acoustic environment involve separating out signals that continuously reach the receiver over other paths than the direct path reflection from the target. These multipath effects result in signal interference. Solutions involve various modulation methods and the use of ultrasonic frequencies grater than 500KHz to increase attenuation. The same problems and solutions apply to pulsed sensors as well. Pulsed sensors emit a short burst of sound at a fixed pulse repetition rate. When the emitted acoustic pulse encounters a manatee, part of it is absorbed (flesh and fat layers can be highly attenuating), part passes by, part is scattered, and a small portion of the pulse is reflected back towards the receiver. By measuring the time it takes from the emission of the pulse to the return of the echo, the range to the manatee can be determined. The amplitude of the return pulse provides information as to the size of the object the sound is reflecting off of. Modern fish finders employ this method to discriminate fish from the bottom return; when corrected for range, a fish will have a much smaller return than the bottom.

Proof of Concept Sensor Demonstration

An advanced high frequency fish finder (Techsonics H3DW) was selected and tested on fixed targets and human subjects in reflective environments. The fish finder was modified and a serial port added to access depth information from the signal processing section. The operating frequency was 455KHz with a pulse power of 1000 watts RMS / 8000 watts peak to peak. The transducer (SHS-7W) has a 6 element array producing a fan shaped area of coverage 53° wide and 16° thick. The transducer was placed upside down and aiming upward as shown in Figure 1. The resultant beam pattern is shown in Figure 2. In operation, when the manatee enters the danger zones shone in Figures 3-4, the signal reflected off of the manatee is interpreted by the signal processing circuitry of the fish finder as a depth, and sent to the serial port of a laptop computer. The software in the laptop incorporates the position of the transducer and the depth of the water with the depth (range) data from the fish finder to determine if the manatee has entered the danger zone. For a manatee in the danger zone, the computer generates an audible alarm and displays a warning icon.

Acoustic Emitter-Receiver Array
Operating Principle

Interrupted beam sensors can be continuous wave (modulated or unmodulated), or pulsed. Continuous wave sensors typically sense the presence of an obstruction by detecting a change in relative amplitude, a change in phase, or a combination of both. Problems with continuous wave sensors in the lock acoustic environment involve multipath effects resulting in signal interference. Solutions involve various modulation methods and the use of ultrasonic frequencies to increase attenuation. At 1MHz, from 4°-30°C and salinity ranging from fresh to sea water at 35ppt, the attenuation due to absorption is between 0.1 and 0.2 dB/m. Pulsed interrupted beam sensors emit a short burst of sound at a fixed pulse repetition rate. This allows the receiver to be gated on only during the first reception of the pulse, reducing the effects of multipaths.

Proof of Concept Sensor Demonstration

A simple emitter-detector pair was set up in water and tested (Figure 5). The emitter and detector are of identical construction, and are interchangeable. The emitter was excited with pulsed 1 MHz signal bursts 50 μ seconds wide (50 cycles), at a pulse repetition rate of 74 Hz. Maximum pulse amplitude was 7 volts peak. Estimated peak power was less than 2mW, estimated average emitted acoustic power was less than 8 μW. Signals were received by the detector placed about 40 inches away from the emitter. The signal from the detector traveled through approximately 40 feet of cable to the receiver electronics. The receiver electronics are based on standard industrial grade low cost FM cellular phone IC's. The receiver has a maximum gain of 124 dB and provides a Received Signal Strength Indicator (RSSI) output with an 80 dB dynamic range. The amplitude of the RSSI signal during reception of a pulse is compared to a reference to generate a transmission signal present (logical high) or transmission beam blocked (logical low) TTL output.

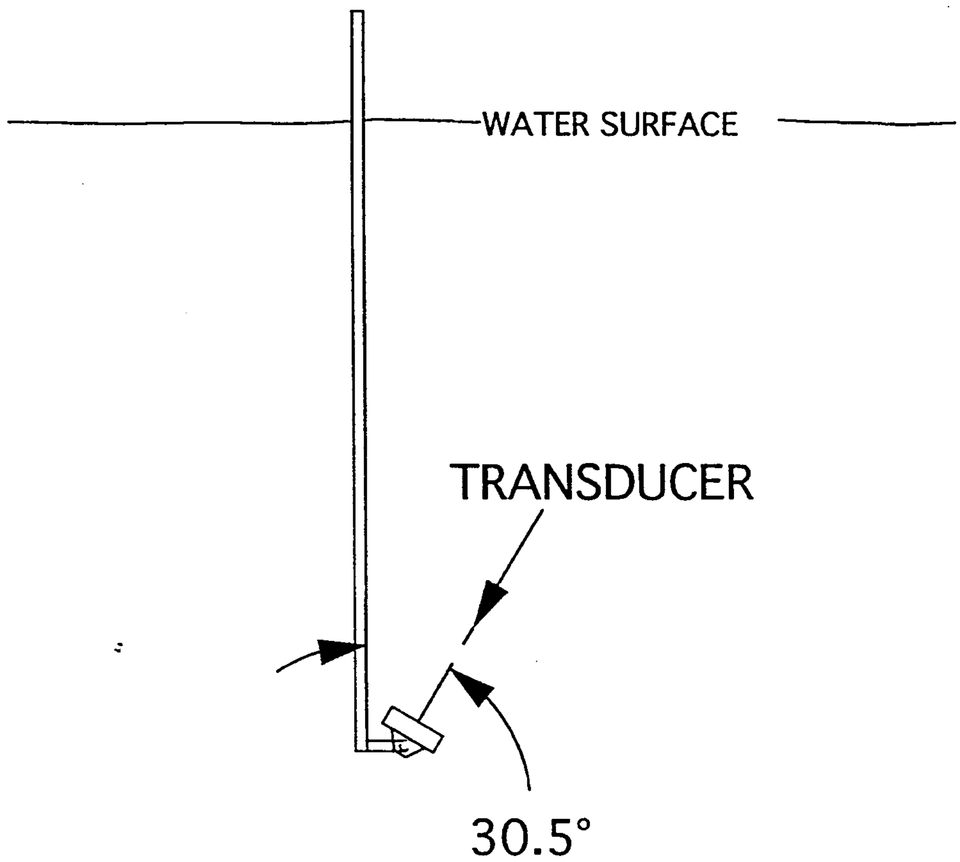


Figure 1: SHS-7W Transducer Mounting

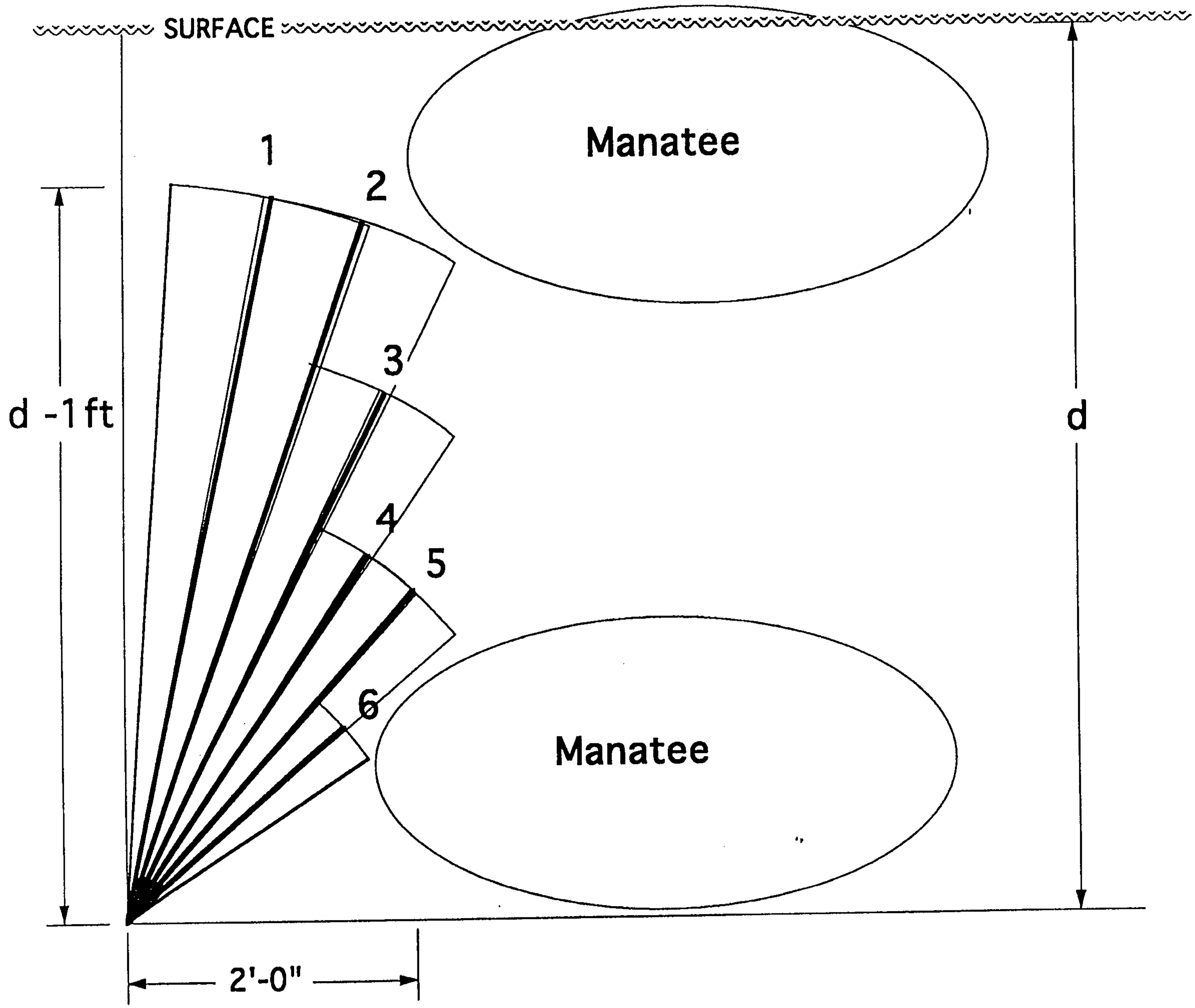


Figure 2: Transducer Beam Pattern Truncated at the Alarm Ranges by Beam Number

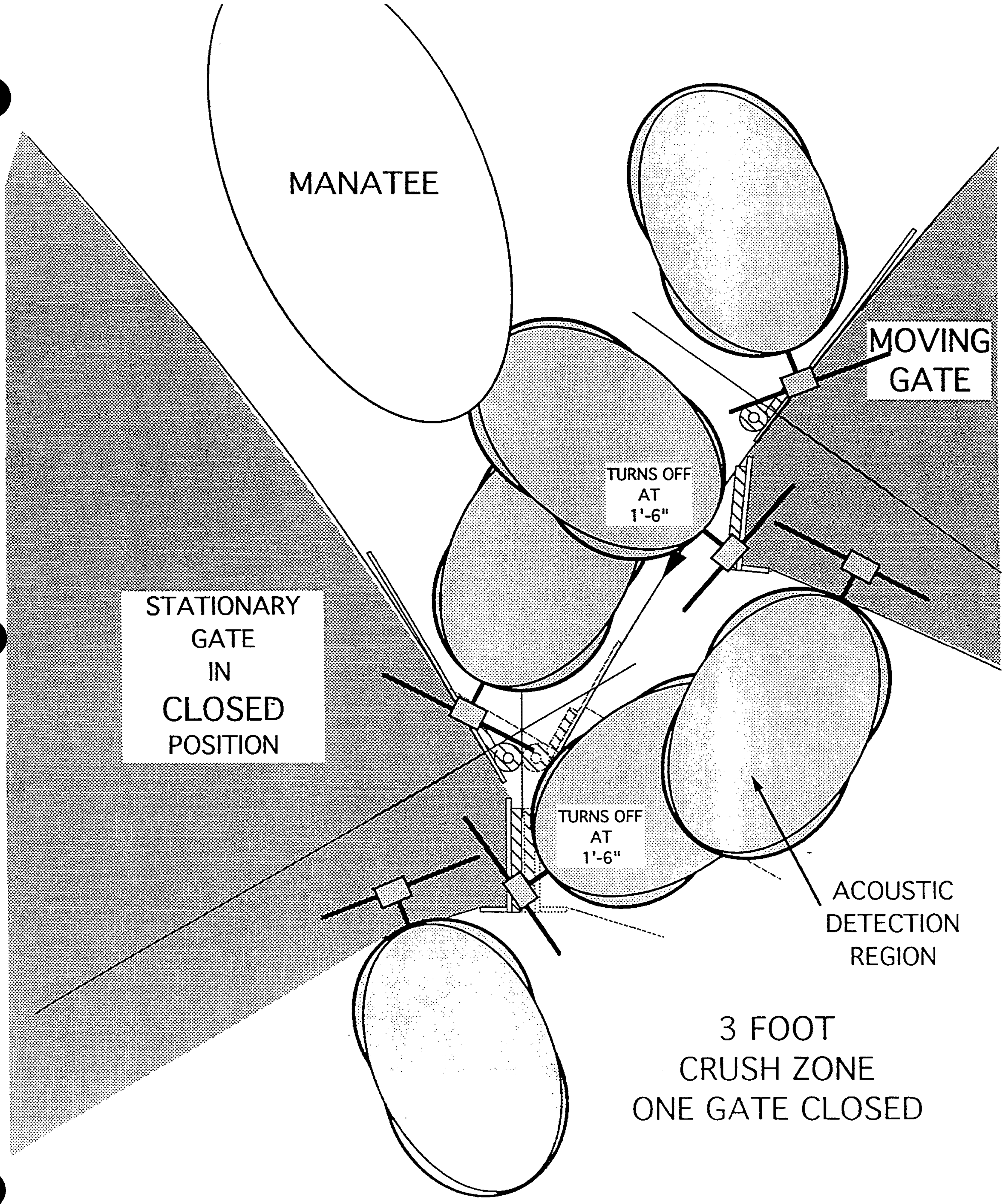
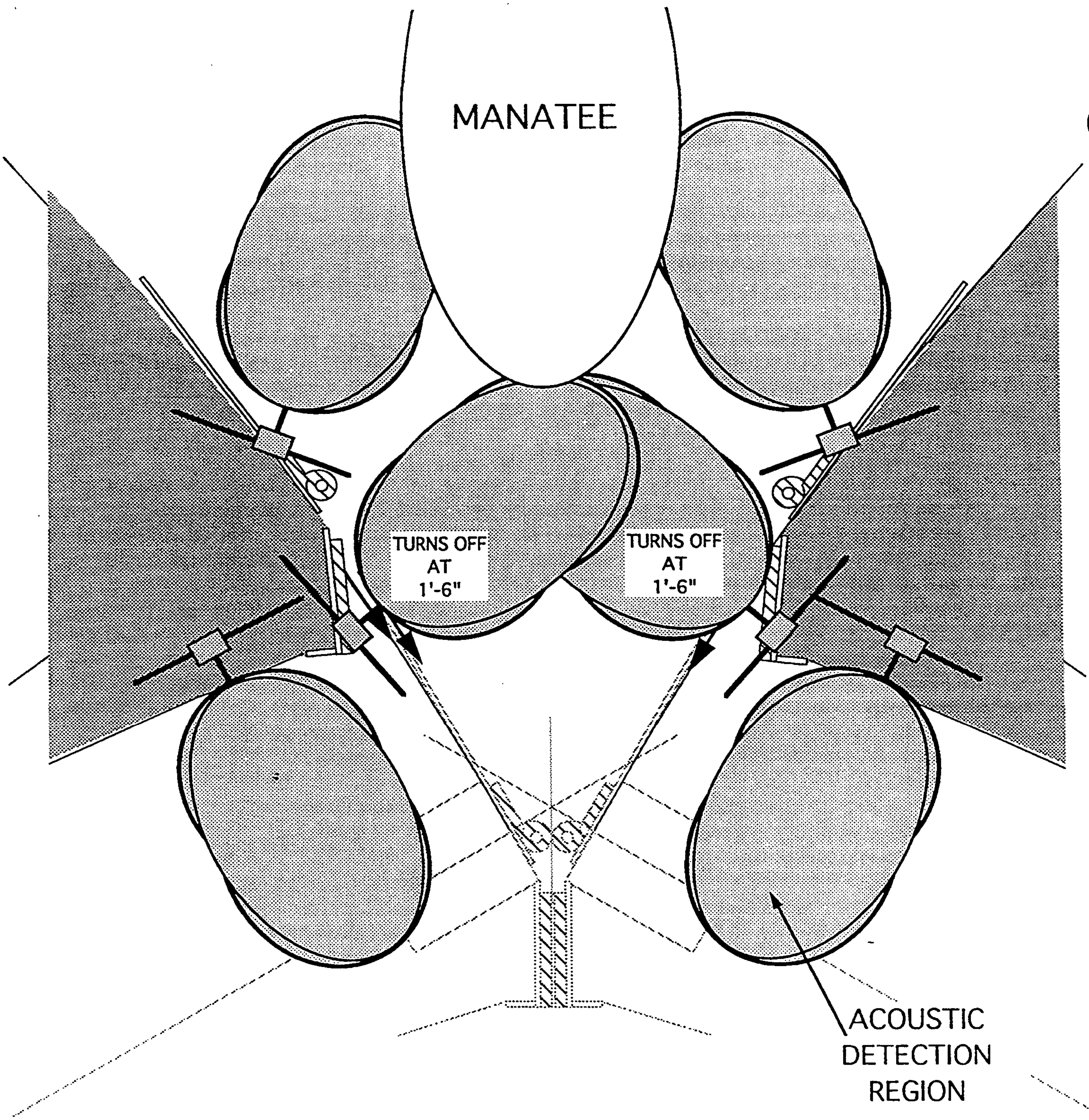

MANATEE
MOVING GATE
TURNS OFF AT 1'-6"
STATIONARY GATE IN CLOSED POSITION
TURNS OFF AT 1'-6"
ACOUSTIC DETECTION REGION
3 FOOT CRUSH ZONE ONE GATE CLOSED

Figure 3



CRUSH ZONE
SYMMETRIC MOTION
3 FEET OPEN
BOTH GATES MOVING

Figure 4

Port Mayaca Test Configuration

A simple emitter-detector pair was mounted on a portable aluminum frame (see Figure 5) and placed between the open lock gates. An audio signal (a sonalert) continuously sounded to indicate an intact beam path. The acoustic path was then interrupted by passing the manatee simulator in the middle between the emitter and detector. When the beam was interrupted the signal present output went low, turning off the sonalert.

A modified SHS-7W fish finder transducer array was mounted on a PVC frame (see Figure 1) and placed between the open lock gates. When the manatee simulator passed through the alarm zone (Figure 2) the laptop produced an alert sound and displayed the warning icon.

HBOI Test Configuration

A second emitter-detector pair was mounted on the portable aluminum frame (see Figure 6) and placed in a tank of water. The 15 ft diameter cylindrical epoxy coated fiberglass tank used for the test was filled to a depth of 3.5 feet. The tank is free standing in air and elevated above the floor, resulting in a closely limited and highly reflective acoustic environment. The emitter's were connected in parallel. A second receiver was added and the output of the receivers tied to green light emitting diodes to provide a visual indication of an intact beam path. Each of the two green LED's remained lit while their respective beams remained unbroken. Breaking a beam caused the respective LED to go dark, indicating an obstruction in that respective path. The sonalert was re configured to sound only when both beams were broken.

A human test subject was used to simulate a manatee to demonstrate the ability of flesh to interrupt the beams. Both beams were easily blocked by a single leg, demonstrating that blocking by flesh alone is sufficient to indicate an obstruction. The test also showed that multipath effects are not a problem, even with identical emitters and receivers with identical signal arrival times, and even in the harsh acoustic environment of the highly reflective test tank.

A modified SHS-7W fish finder transducer array was mounted on a PVC frame (see Figure 1) and placed in a tank of water. When the human test subject passed through the alarm zone the laptop produced an alert sound and displayed the warning icon.

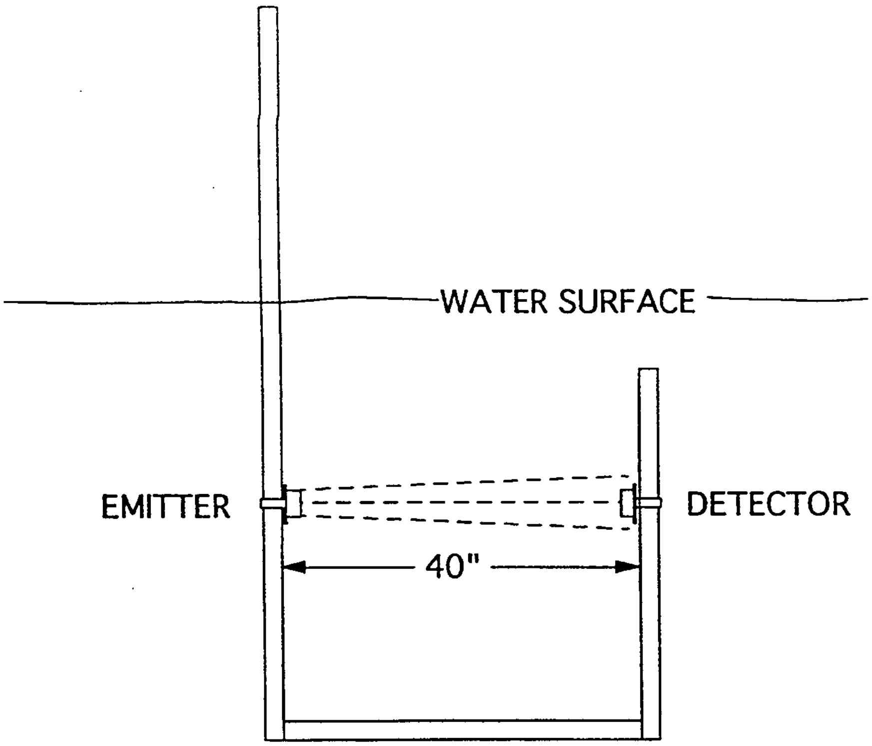


Figure 5: Emitter-Detector Pair at Port Mayaca

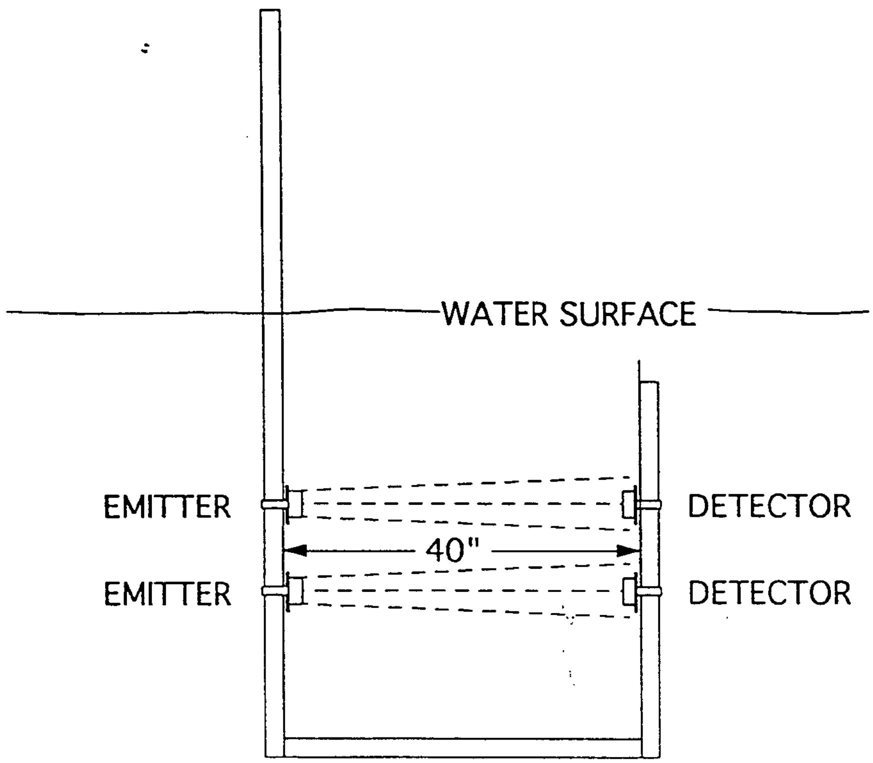


Figure 6: Emitter-Detector Pairs at HBOI

Evaluation Criteria

Both systems worked as expected. The results were clear and unambiguous, with both the manatee simulator and the human test subject, test objectives were realized. With the experience gained in putting together the systems we recommend the acoustic emitter-receiver array sensor as the better long term solution. This recommendation is based principally on the following:

False Triggering
Recent wave action at Sector Gate 193 leads us to believe that in rough water conditions false triggering may be a problem for the fish finder based detector. Another concern is the packing of the lock with fishing boats loaded with similar fish finders that could pose an interference problem.

Protection of components
The fish finder transducers must be mounted external to the gate structure and forward of the gate movement path on the bottom. This may make them vulnerable to being damaged or obscured by sweeping into debris on the bottom. The emitter-receiver array is in the protected I-beam pocket and protected by the structure of the gate.

Fault Tolerance
In the emitter-receiver array a failed transducer is immediately detected. The emitter-receiver array fails safe, that is a transducer failure can only result in a false trigger. In the fish-finder based system a failed transducer can go undetected if the failure is limited. This would result in the fish finder based system producing a false "all clear" output.

A working manatee acoustic emitter-receiver array sensor could be built, operating at a frequency of 1 MHz. A possible geometry would employ small, high frequency transducers, acting as both emitters and receivers, mounted in a string 8" apart, along the edge of each gate. As currently envisioned, the transducers would be simple circular bands, fabricated from 1" by 12" strips of 500S copolymer hydrophone tile, forming a fan shaped beam pattern. The pairs would be mounted at 8 inch intervals. Please see Figures 7-9.

- **False Triggering**

By spacing the beams close enough to ensure that 2 or more beams are broken by a manatee at the same time (Figure 7), and observing over a fixed time interval with a high update rate, false triggers are reduced. When a passing fish breaks a beam, it only breaks one beam for a short interval. Even multiple fish breaking multiple beams will only produce a flickering of broken beams in time, and not the steady multiple beam occlusion produced by a manatee.

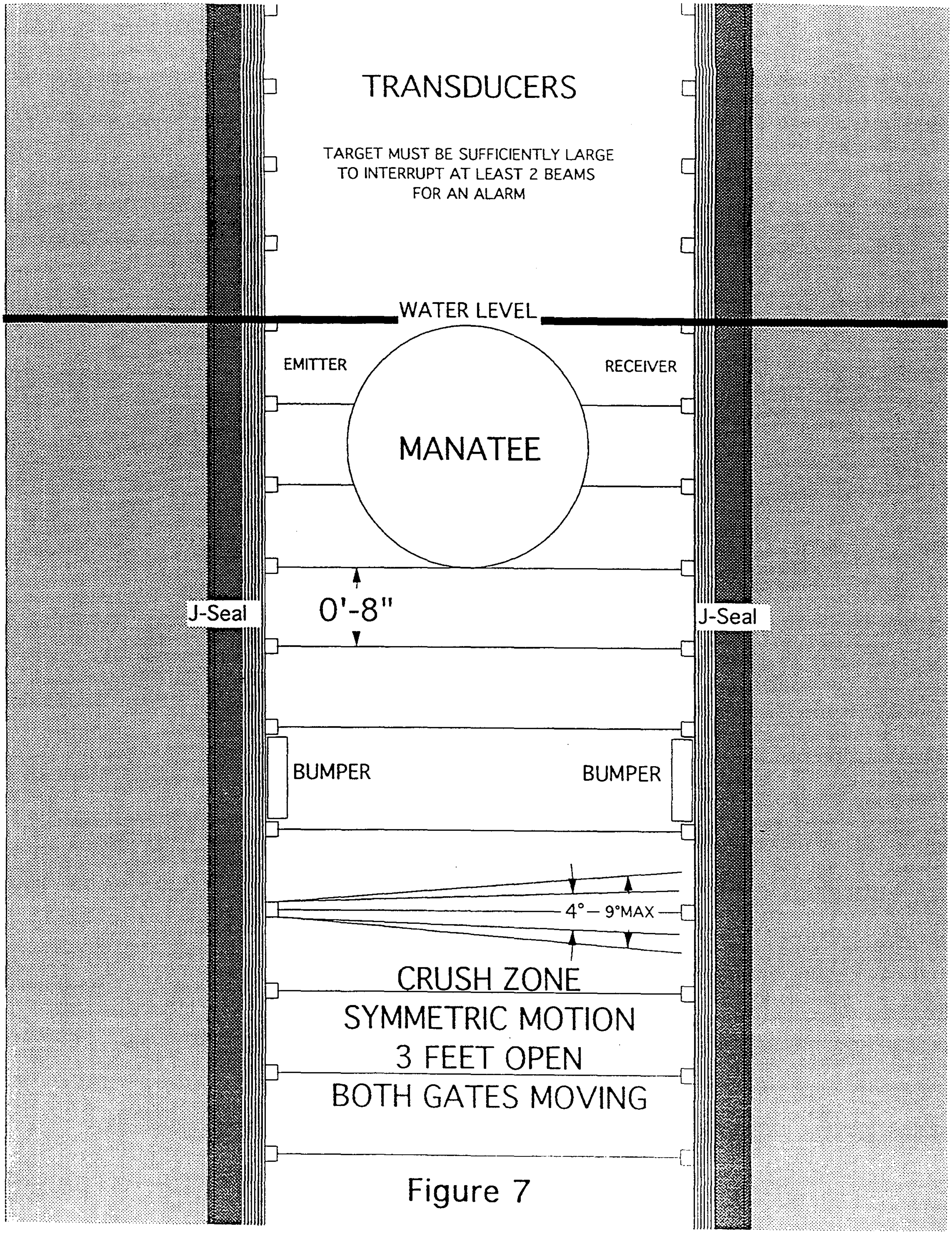
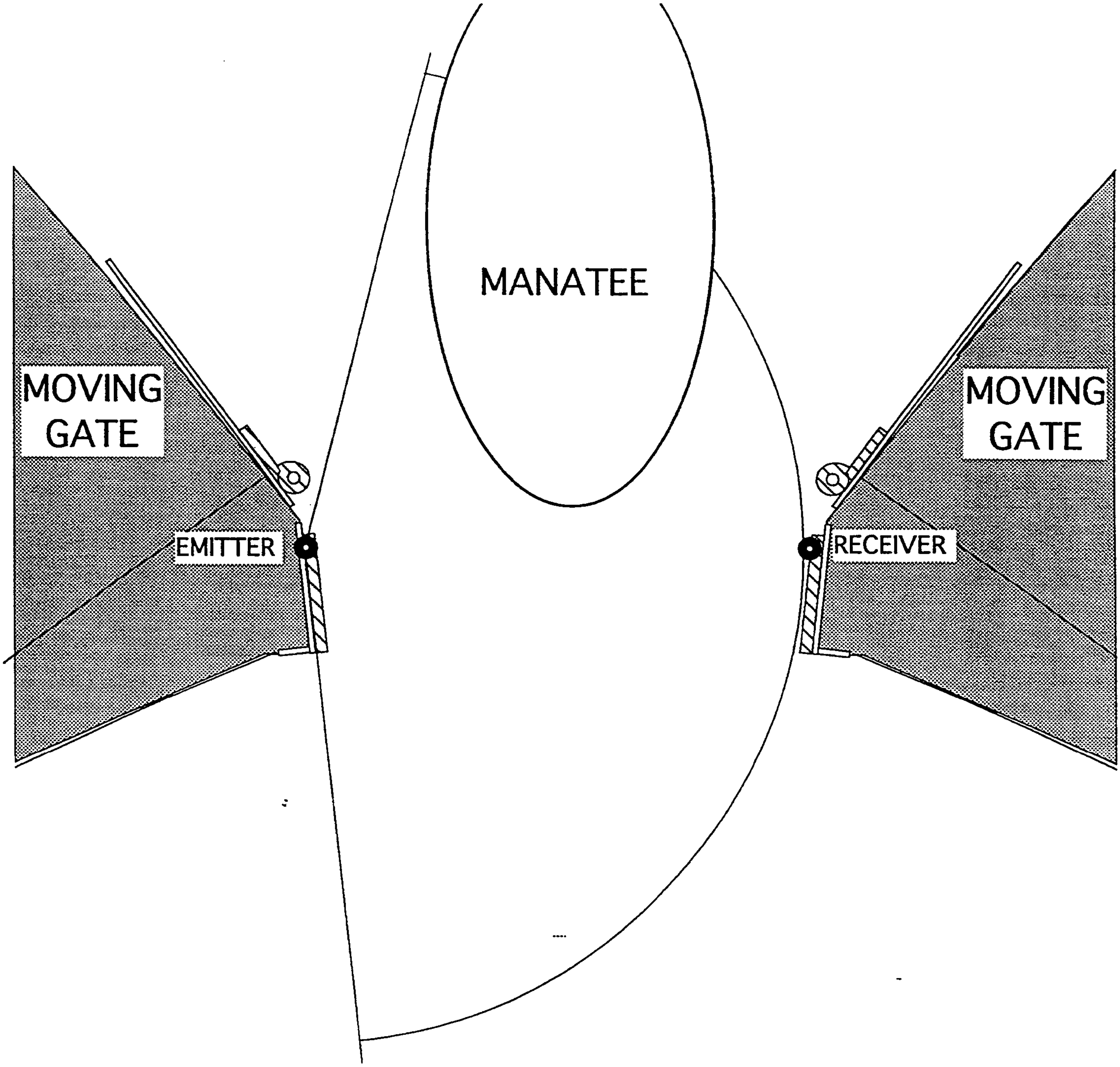
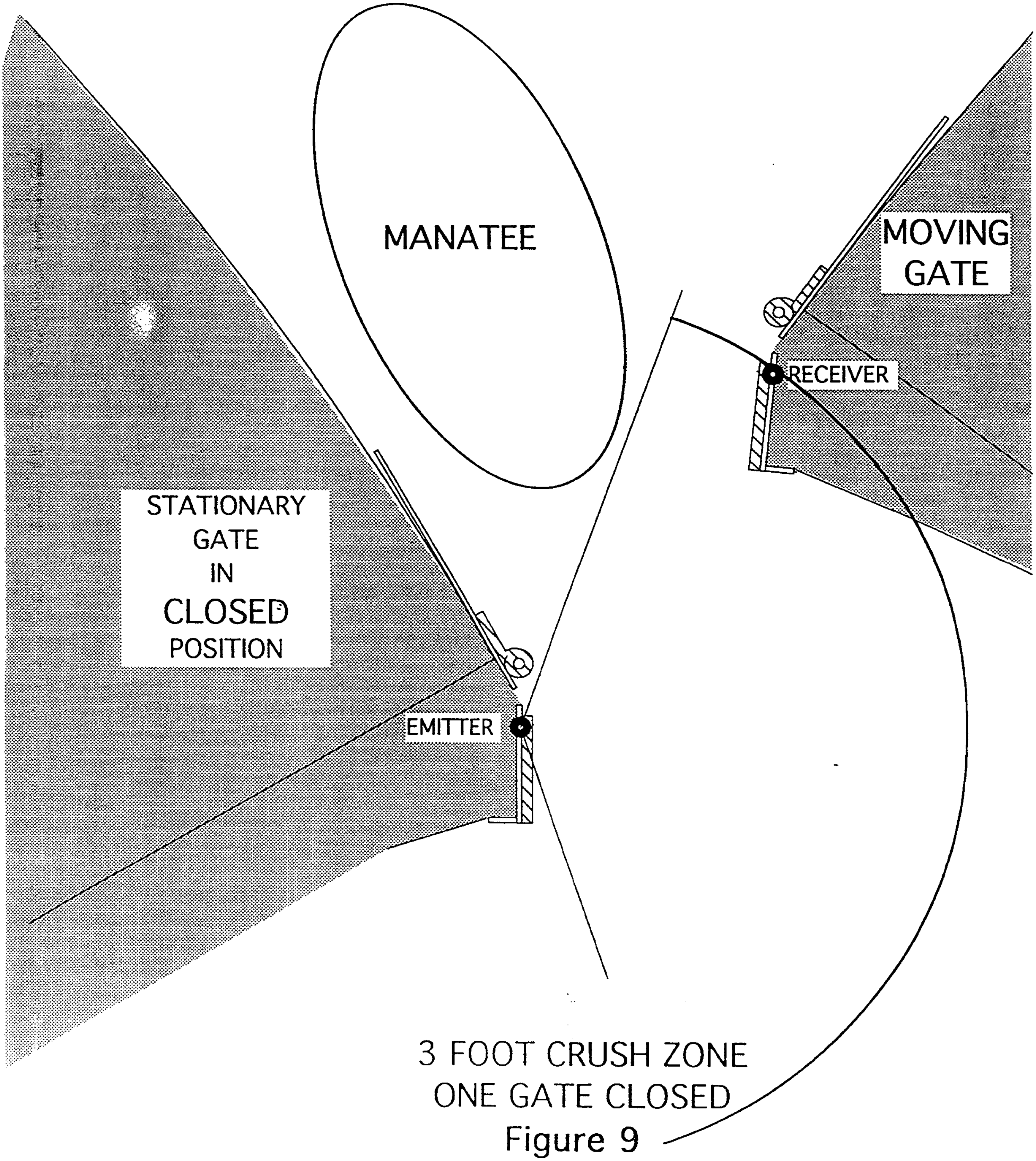

TRANSDUCERS
TARGET MUST BE SUFFICIENTLY LARGE
TO INTERRUPT AT LEAST 2 BEAMS
FOR AN ALARM
WATER LEVEL
EMITTER
RECEIVER
MANATEE
J-Seal
0'-8"
J-Seal
BUMPER
BUMPER
4° – 9°MAX
CRUSH ZONE
SYMMETRIC MOTION
3 FEET OPEN
BOTH GATES MOVING

Figure 7



CRUSH ZONE
SYMMETRIC MOTION
3 FEET OPEN
BOTH GATES MOVING

Figure 8



3 FOOT CRUSH ZONE
ONE GATE CLOSED
Figure 9

- **Ruggedness / Reliability.**

Due to the reliability of properly designed modern low power solid state electronics, not subjected to extremes of temperature, failure is expected to be the result of external factors.

Encapsulent

Submergence in fresh or salt water is not expected to pose a problem as long as the encapsulant remains intact. Impact from boats or barges could damage the transducers mechanically, by crushing, cracking, debonding electrical connections, or damaging the encapsulant, resulting in transducer failure. This risk can be reduced by designing tough arrays, and by placing the sensor arrays in protected locations. The I-beam pocket just inboard of the J-seal is such a location.

Lightning Strikes

Lightning strikes are a particular hazard to the sensitive pre-amplifier electronics. By mounting all of the electronics for each gate in an easily serviced junction box accessibly mounted on the gate, circuit protection is simplified.

Sedimentation

Sedimentation, due to the smooth featureless surface and vertical orientation of the sensor array tubes, is not considered a problem.

Biofouling

Biofouling, in certain locations in particular, could degrade sensor performance, but is not expected to stop the sensors from functioning. The large area of the sensor bands (presently envisioned as 12 square inches), high receiver gain (124 dB) and large received signal strength dynamic range (80 dB) allow the system to adapt easily to the biofouling attenuation expected to occur over the years.

Saline Influence

At present the target structures are all fresh water. Operation in saltwater presents no particular acoustic challenge. Unlike frequencies below 100 KHz where ionic relaxation is the dominant cause of absorption in sea water, at 1MHz the expected variation in temperature far exceeds the possible variations in absorption due to salinity. At 1MHz, from 4°-30°C and salinity ranging from fresh to sea water at 35ppt, the attenuation due to absorption is between 0.1 and 0.2 dB/m. The variation is almost entirely due to the temperature range.

Each of the above concerns would have to be carefully addressed and verified by testing and field trials.

In any system selected, installation, and in particular, maintenance, must involve minimal diver effort. Reliability and maintainability is a key concern for all components. Dry components are designed for simple modular replacement with minimal effort. Wet component reliability is crucial. Repairs requiring the scheduling and utilization of divers would be expensive and inevitably result in downtime. The part that goes in the water must be tough enough to handle the rough service environment of the locks. A major advantage of the co-polymer tile is that it is easy to work with. The flat tile sheets can be cut, by shearing with appropriate fixturing, or with a fine toothed scroll saw, to basic shape. This is how the sensors used in the demonstration were fabricated. The basic shapes can be formed (bent) into a circular arc to form bands. The circular bands can be hard back mounted on the outside of a stainless steel tube at the selected interval. At present we envision a vertical band spacing interval of 8 inches center to center (Figure 7), based on at least 2 beams being interrupted by a manatee. The tube would then be encapsulated in polyurethane and PVC to form an easy to install sensor array tube of convenient length for mounting and handling. The sensor array tubes, the only components that go in the water, are of rugged construction, and contain no moving parts, no electronic components, and are of a simple uncomplicated design.

- **Low Maintenance**

The sensor array tubes are simple in construction, and should be able to handle the same kind of service conditions as the existing gate components. Modular design, incorporating simple bolt-on assemblies, in accessible locations, would be used to limit down time and minimize effort in the installation and replacement of components. Little or no maintenance is expected.

Minimize Downtime

A simple, modular, functional block approach to the design is used to minimize down time, in the rare event of system failure, to the replacement of failed modules. The exception to this would be the cable runs. Cable runs accidentally damaged or cut could be spliced, or redundant runs installed.

Ease of Repair

As the system is inherently separated into multiple independent channels with yes/no outputs, trouble shooting and diagnostics is greatly simplified. System status is obvious. The system, for the most part, is self diagnostic, and well suited for simple "replace the module" type repairs. Parts of the system that could be damaged; the signal conditioners, relays and indicator lamps, can be designed for high reliability and ease of maintenance. Redundant indicator lamps would be designed for easy replacement, as well as socketed relays, and transient protection components.

- **Ease of Installation**

Installation of the sensor on the gate would consist of bolting the array tubes into the I beam pocket behind the J-seal mounting plate. This location is shown in Figure 10. Cables would run up through the array tubes to a junction box at the top of the gate. The junction box would be connected by a cable run to the control room (Figure 11). A control room junction box would contain an indicator lamp/bell, and necessary connections to the gate control switches. Remote control, or unattended operation features could also be implemented.

- **Ease of Operation**

Presence of a manatee between the gates would trip-out the gate closure and activate the alarm, requiring no operator intervention. System designs to interface with the lock operations will require coordination with COE mechanical engineers and lock personnel. As the system is micro controller based, the system readily lends itself to data logging applications. Data would be stored in non volatile memory and a simple serial connection to a portable or desktop PC could be implemented to allow logging of statistical information such as number of potential manatee targets, time of day, date, and where the animal went through (i.e. top, mid, or bottom of the water column, etc.). The system could also be used to temporarily trigger video recorders or other devices.

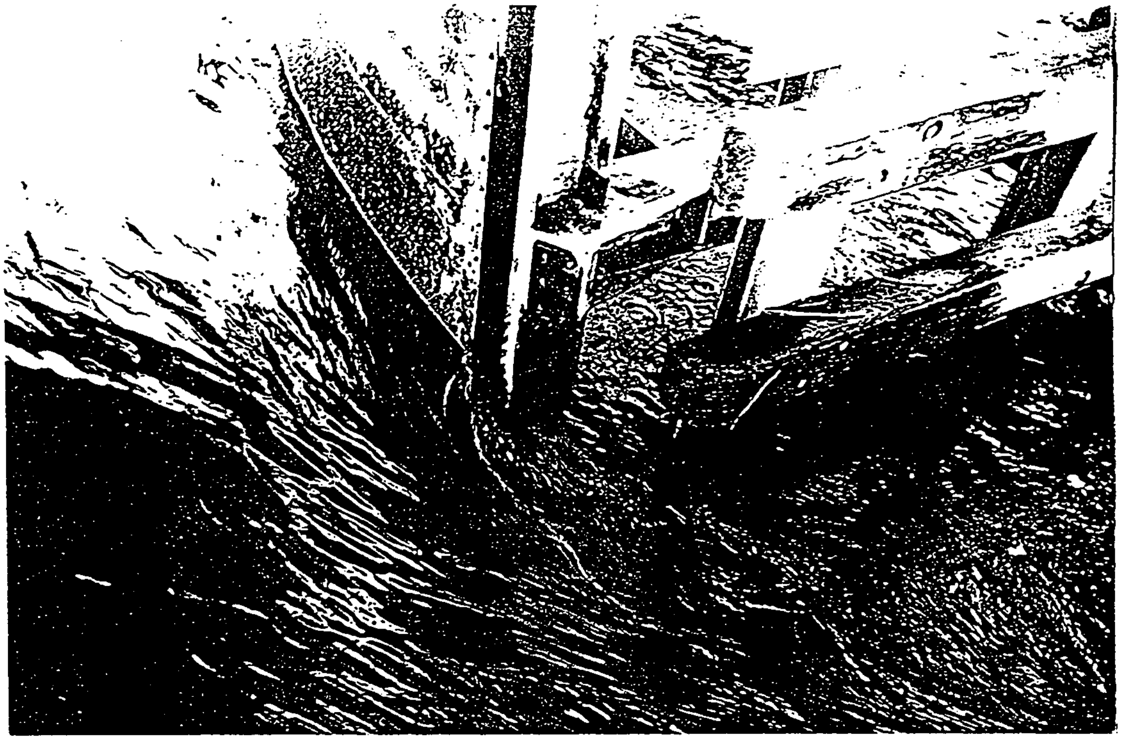


Figure 10: I Beam Pocket Behind The J-seal Mounting Plate

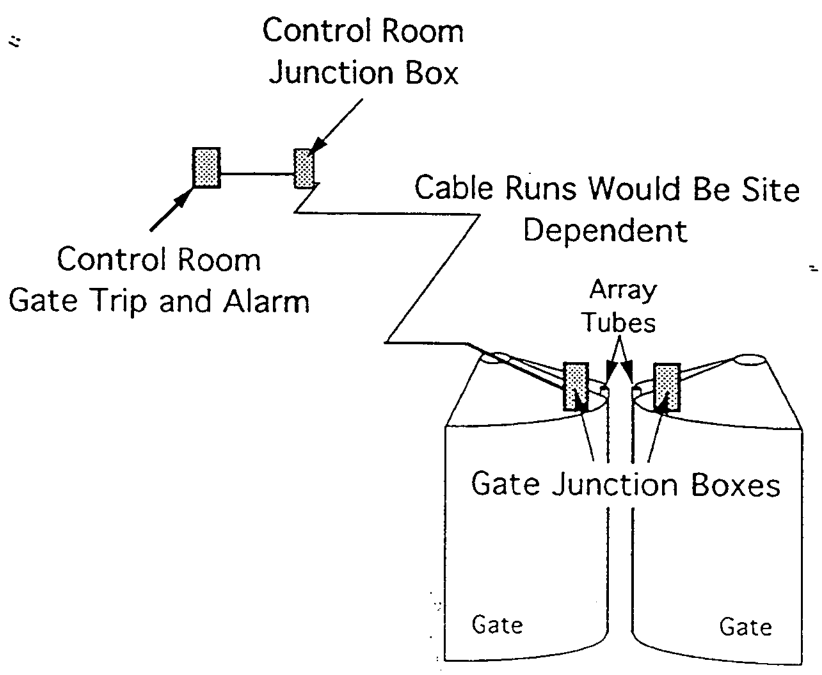


Figure 11: Layout for First Installation

MANATEE DETECTION SYSTEM
FOR
LAKE OKEECHOBEE
SECTOR GATES

Submitted by

Harbor Branch Oceanographic Institution, Inc.
5600 US 1 North
Ft. Pierce, Florida 34946

Prepared for

South Florida Water Management District
3301 Gun Club Road
West Palm Beach, FL 33406

28 August 1995

TABLE OF CONTENTS

EXECUTIVE SUMMARY

Harbor Branch Oceanographic Institution, Inc. (HBOI) was contracted by South Florida Water Management District (SFWMD) to evaluate the problem of manatee mortality at their Sector Gate 193 on Lake Okeechobee, Florida and propose a solution. HBOI identified a number of candidate technologies which could sense the presence of a manatee between closing gates. These technologies included; three different applications of Piezo-electric film, fiber optics and acoustical devices. Each of these sensor types underwent testing and evaluation at HBOI's laboratory. Described in the accompanying report are the data and findings of these tests. HBOI recommends the instrumentation of existing J-seals with Piezo-film. Included is a recommended design for the system with an estimated cost to implement of approximately $2,500 per gate in quantities. Also included is a proposed prototype and cost for a prototype system to be installed at Sector Gate 193.

1.0 BACKGROUND

Harbor Branch Oceanographic Institution, Inc. (HBOI) was contacted by the South Florida Water Management District (SFWMD) to evaluate sector gates at Lake Okeechobee as they relate to manatee mortality. On 4 May 1995, three HBOI engineers accompanied three SFWMD personnel to Sector Gate 193 to observe the geometry and operation of the lock system. On site were some prototype mechanical hinge/limit switch detectors put together by SFWMD. Their operation and installation was described to HBOI. A number of different potential approaches were discussed at the field site. During the HBOI site visit, a manatee was observed transiting the lock. On 9 May 1995, representatives of SFWMD traveled to HBOI's laboratories in Ft. Pierce to see firsthand some of the technologies discussed as possible solutions to the problem.

2.0 SCOPE

HBOI has conducted an intensive investigation to identify a manatee detection system for SFWMD's sector gates. The investigation focused on proven technologies with which the designers have substantial experience. Among the salient features of the candidates surveyed are:

- **Ruggedness.** Subject to submergence, impact from boats and debris, vandalism, lightening strikes and sedimentation.
- **Reliability.** Gates are operated sunrise to sunset, seven days per week. Assume MTBF > 1.8 M cycles.
- **Low Maintenance.** The system shall be designed in order to minimize the downtime and simplicity to repair with minimal diver effort.
- **Ease of Installation.** It is highly desirable to develop a system requiring minimal effort to install (i.e., not "drying-in" lock, etc.). Ideally, the installation would be a simple operation similar to present J-Seal replacement.
- **Ease of Operation.** The system must be sufficiently robust that it can be simply hardwired into the present gate closure circuitry. Presence of a manatee between the doors would trip-out the gate closure and activate the alarm, requiring no operator intervention.
- **Cost.** Cost is evaluated based on initial installation and life cycle.

- **Vertical Gates**

The District has requested that HBOI also provide an opinion as to the potential applicability of the studied technologies to vertical gates at coastal structures. It is preferred by the District that the system be non-mechanical (e.g., delete the use of the existing plunger system). The criteria for vertical gates is the same as previously listed.

The USACOE has recommended the use of a "strip switch" for vertical gate protection. The District provided this switch to HBOI for testing. HBOI has tested the switch for durability and resistance to leakage.

The switch was pressurized to 75 psig in fresh water for 30 minutes. No visible damage or water intrusion occurred as a result of pressure testing. The switch was found to still function, and maintained an open resistance of >2000 MΩ @ 100V.

Biofouling tests are presently underway, and the switches will be reevaluated at the end of the trial period. However, the effort required to activate the switch, without some sort of mechanical intensifier, is deemed unacceptable in terms of the force exerted on a manatee. In order to activate the switch, an excessive amount of force is required when distributed over an area representative of a manatee contact. Repeated deadweight tests performed on these switches indicate that they require a pressure of 45 $lb./in^2$ to sense the presence of contact. One potential application of the strip switch would be to place it behind the finger-like plungers currently used by the District on vertical gates, in place of the present magnetic flux/reed switches. However, there is presently no data to determine how well these switches would withstand the repeated point loadings requisite in this application. Without further testing, there is no indication that the strip switch would provide better reliability than the magnetic flux switches. Failures of the systems currently in the field are typically associated with the mechanical travel of the plungers, and adoption of the strip switch would not eliminate these problems.

The results of this investigation indicate that piezo film is an excellent candidate for the vertical gate application. The design proposed in Section 6.0 of this report would be readily adapted to the vertical gate application with very minor modification.

3.0 APPROACH

3.1 Study

HBOI has conducted a preliminary investigation to examine a number of candidate technologies and associated issues. Among them were:

- Piezo-electric film-contact sensor
- Piezo-electric spiral cable with mechanical amplification
- Fiber-optic strain/deformation sensor
- Acoustic emitter-receiver array

Based upon the results of this preliminary study and data obtained from SFWMD, it was determined that the Piezo-electric sensor approach is the best candidate for this application.

The investigation subsequently intensified the focus to include:

- Acquisition of drawings, general arrangements and operational considerations from SFWMD
- Literature survey including acquisition of sensor specifications, vendor sourcing, cost and delivery data
- CAD/CAM geometric model and analysis to determine "kill zones" and contact areas to be instrumented.
- Laboratory testing/analysis of sensor orientation and composition to optimize sensitivity and ruggedness.
- Design/fabrication instrumented mockups of Sector Gate 193 gates for test and analysis.
- Design/fabrication test apparatus to perform repeatable cyclic tests at very low loadings.
- Monitor, record, analyze excitation and response data from low-load cycles.
- Conduct in water testing of mockups to determine signal-to-noise, effect of moving water, etc.
- Monitor, record, analyze data from in water tests.

4. GEOMETRY CONSIDERATION

An engineering drawing package of Sector Gate 193 was obtained from the District. Dimensions from these drawings were used to develop a CAD/CAM computer model used to evaluate all the various possible geometries encountered during operation, e.g., two gates in motion in phase; two gates in motion out of phase; one gate fixed, one in motion; etc. Figure 1 is a partial view of one of the District provided drawings. The following figures in this section depict the "crush zones" or "kill zones" created by the different geometries. This analysis indicates that two areas of each gate must be instrumented; the J-seal as well as the flat bumper portion.

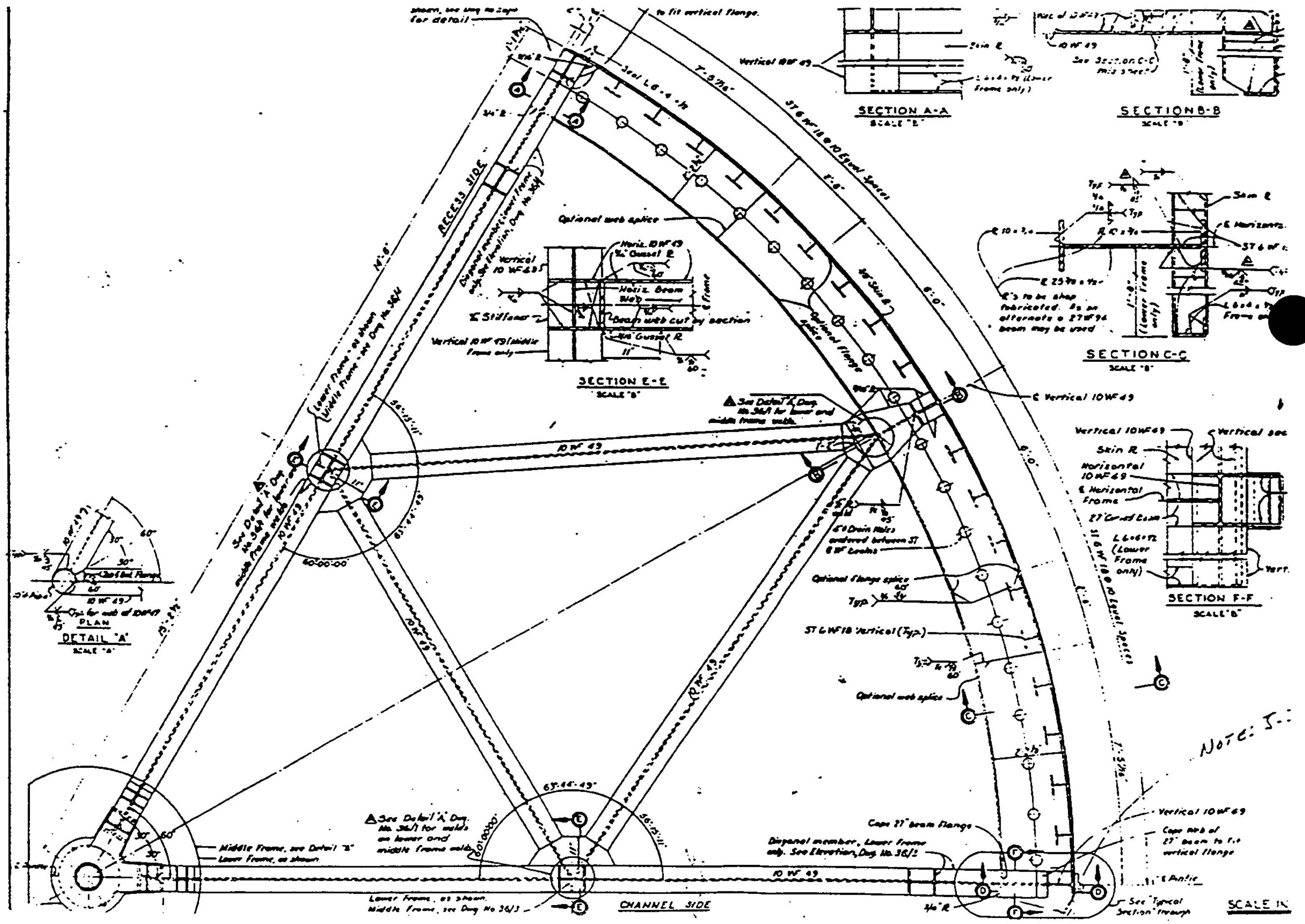
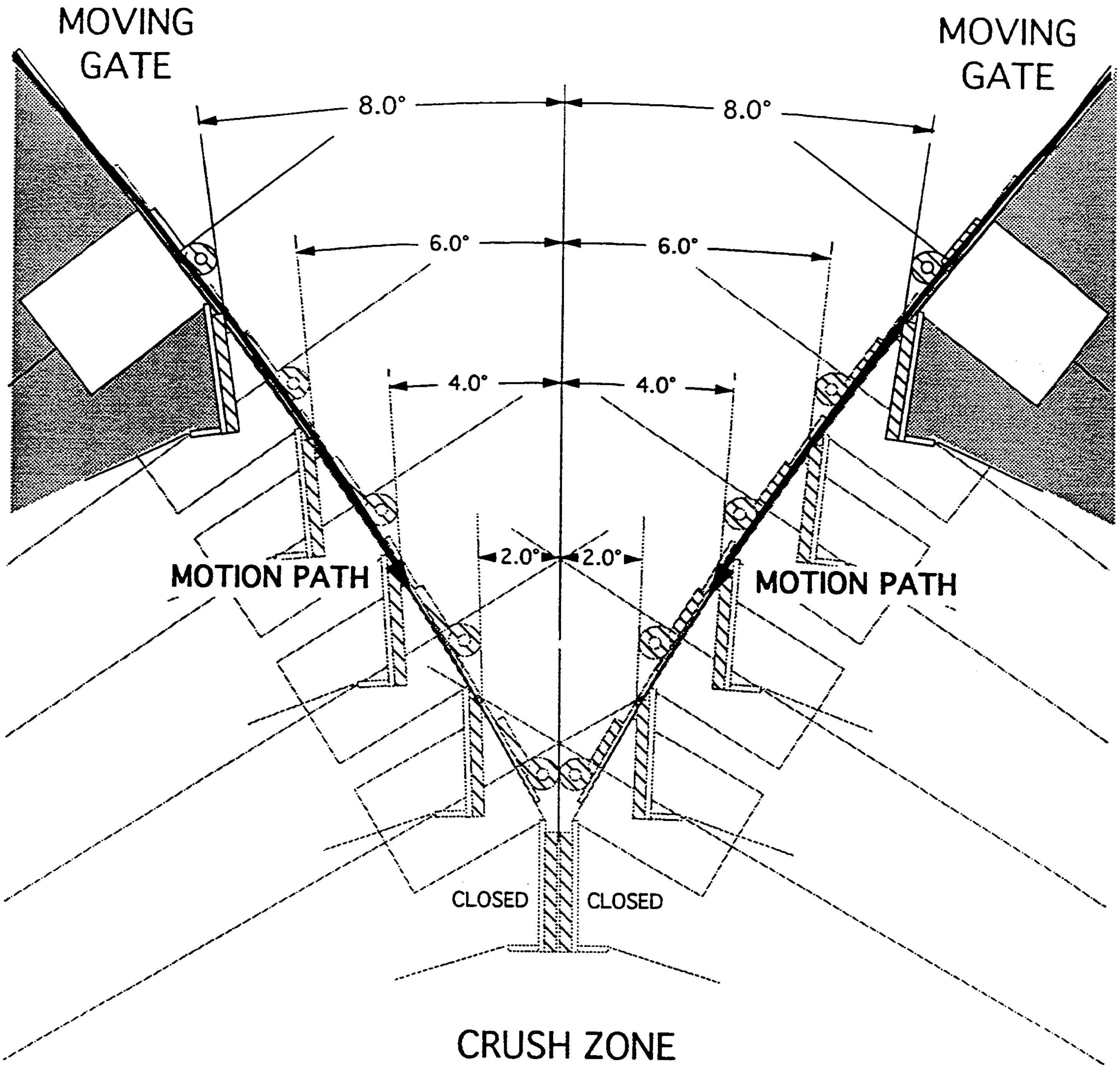
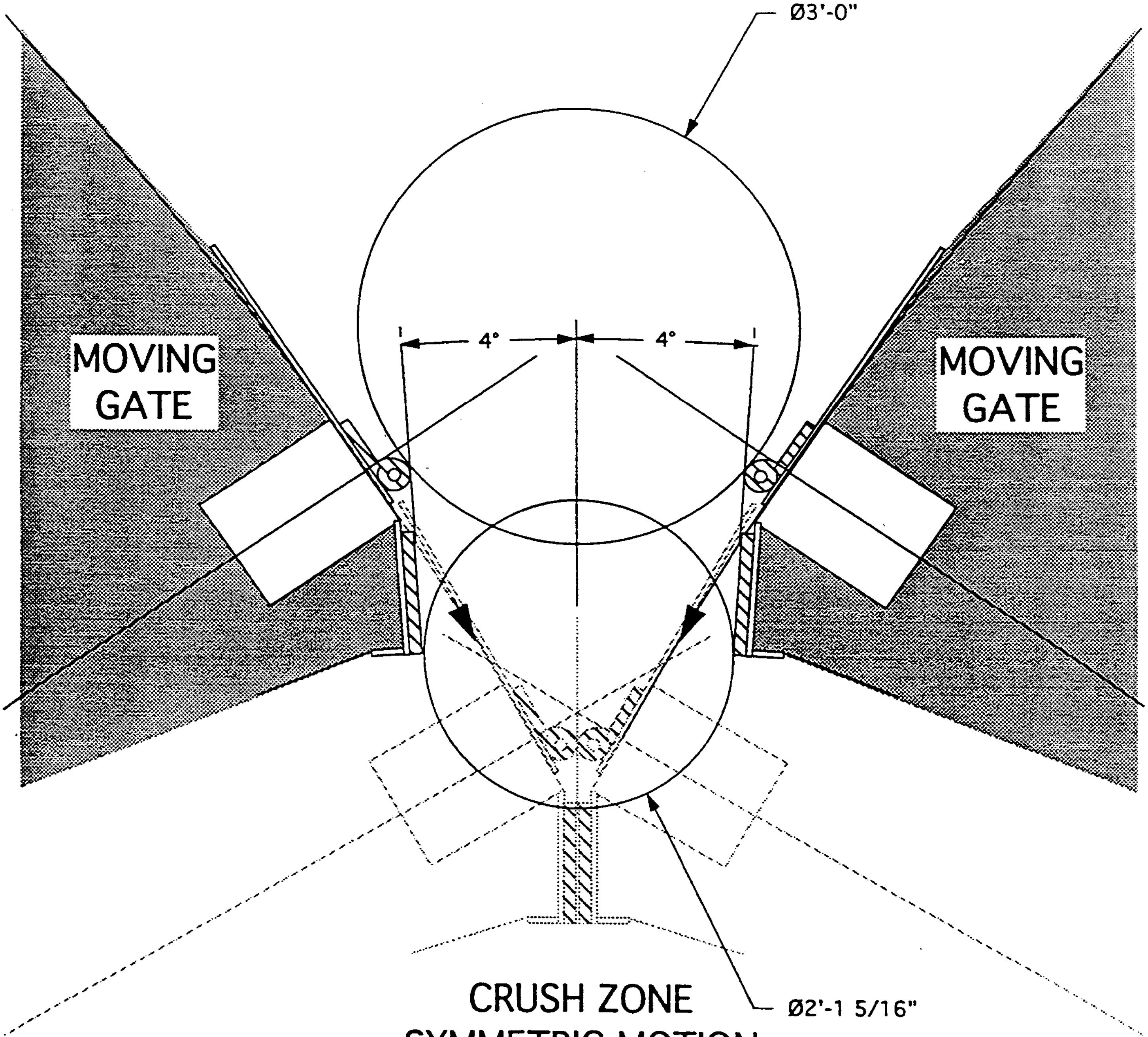


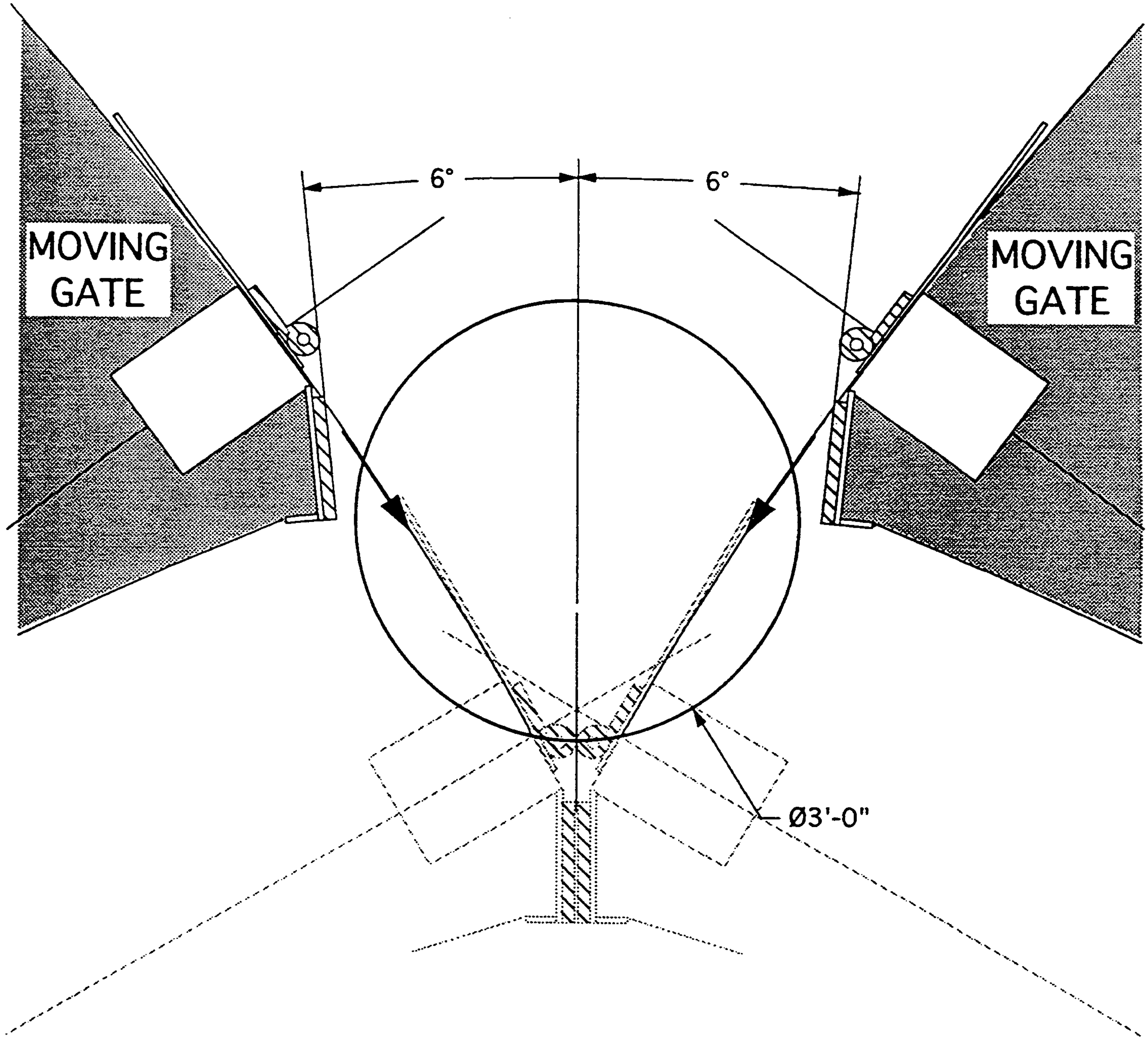
FIGURE 1



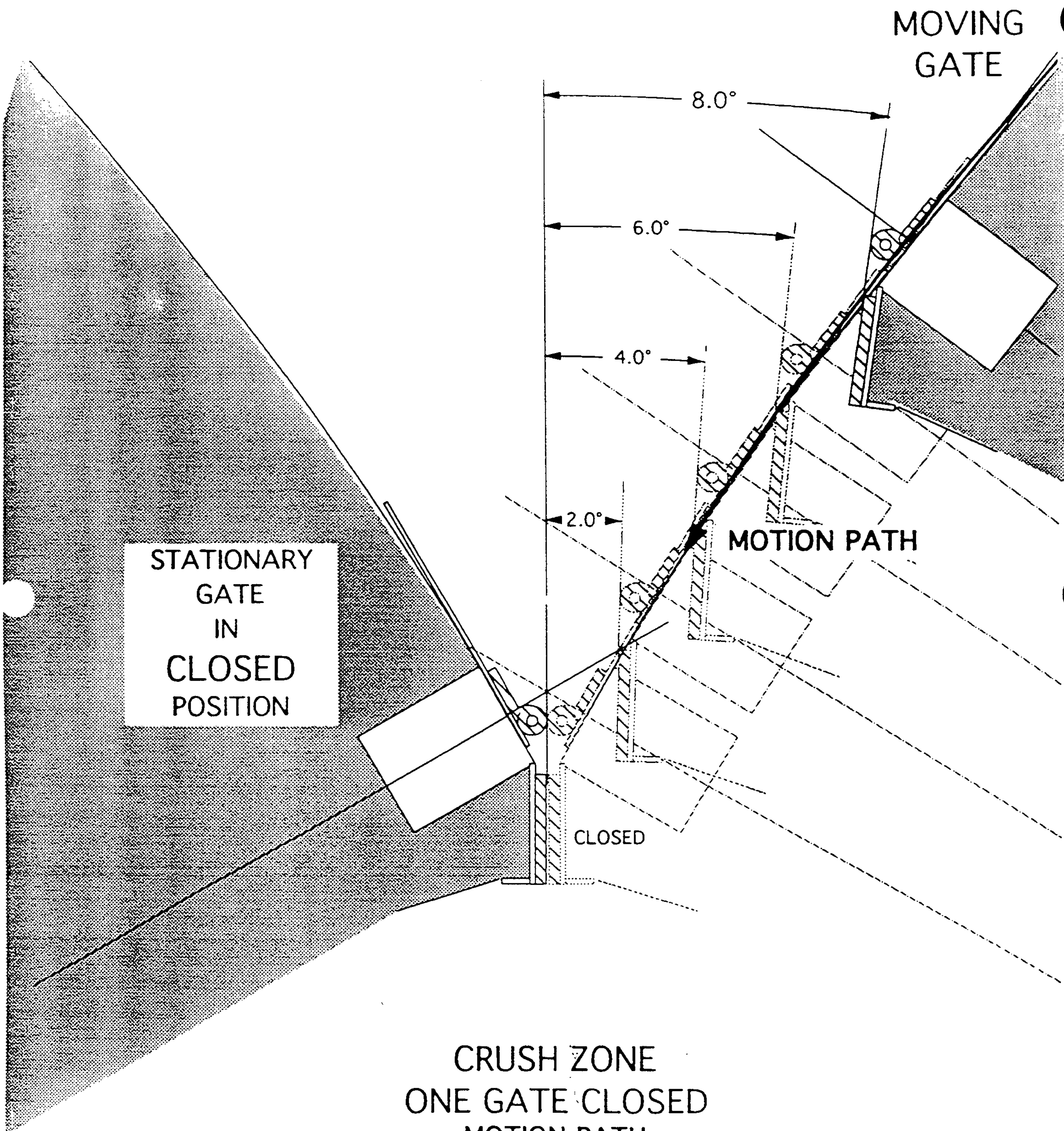
CRUSH ZONE
BOTH GATES IN MOTION
MOTION PATH
24 feet from base to Top of frame A



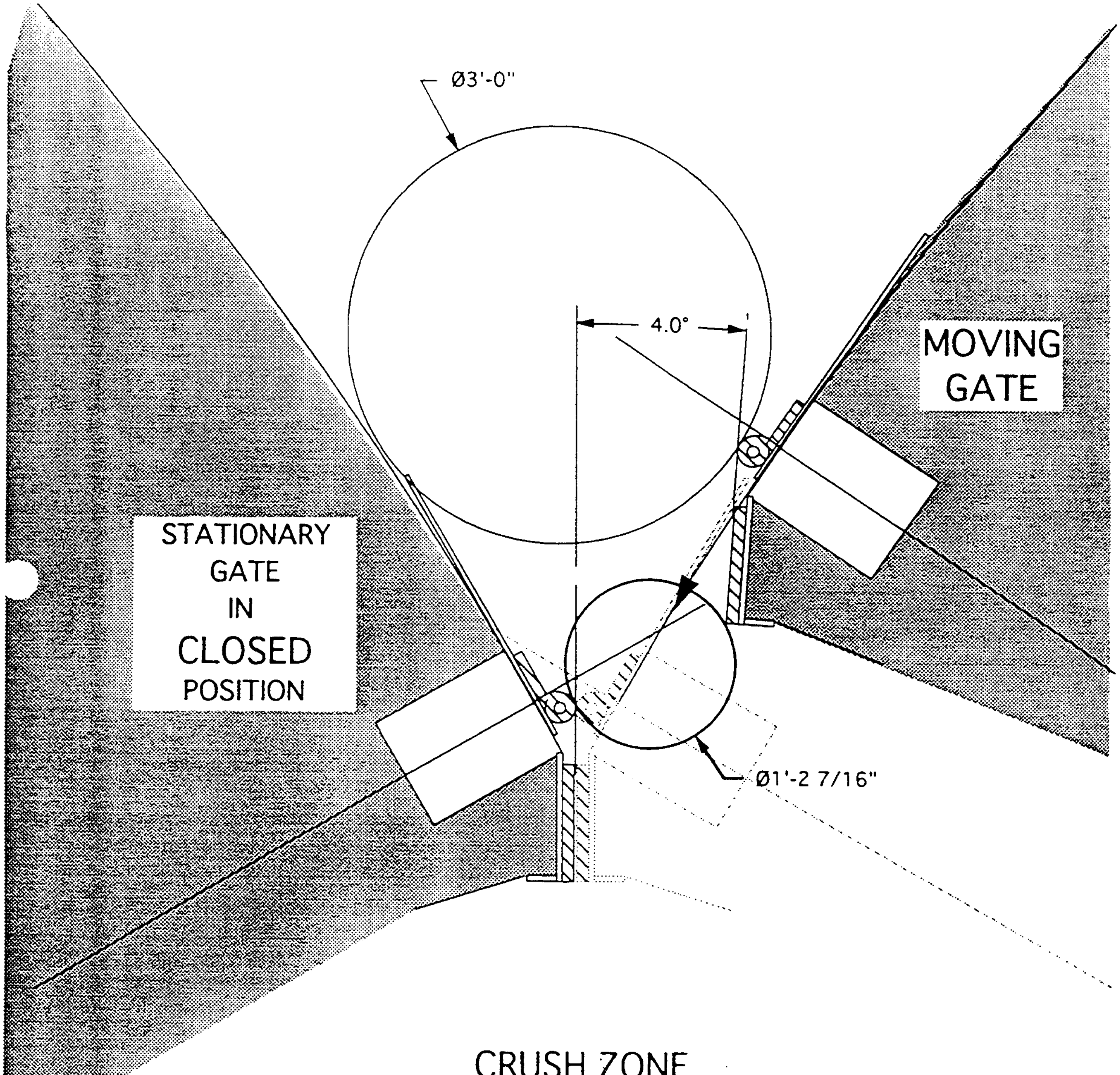
CRUSH ZONE
SYMMETRIC MOTION
BOTH GATES MOVING
4.0°-4.0°



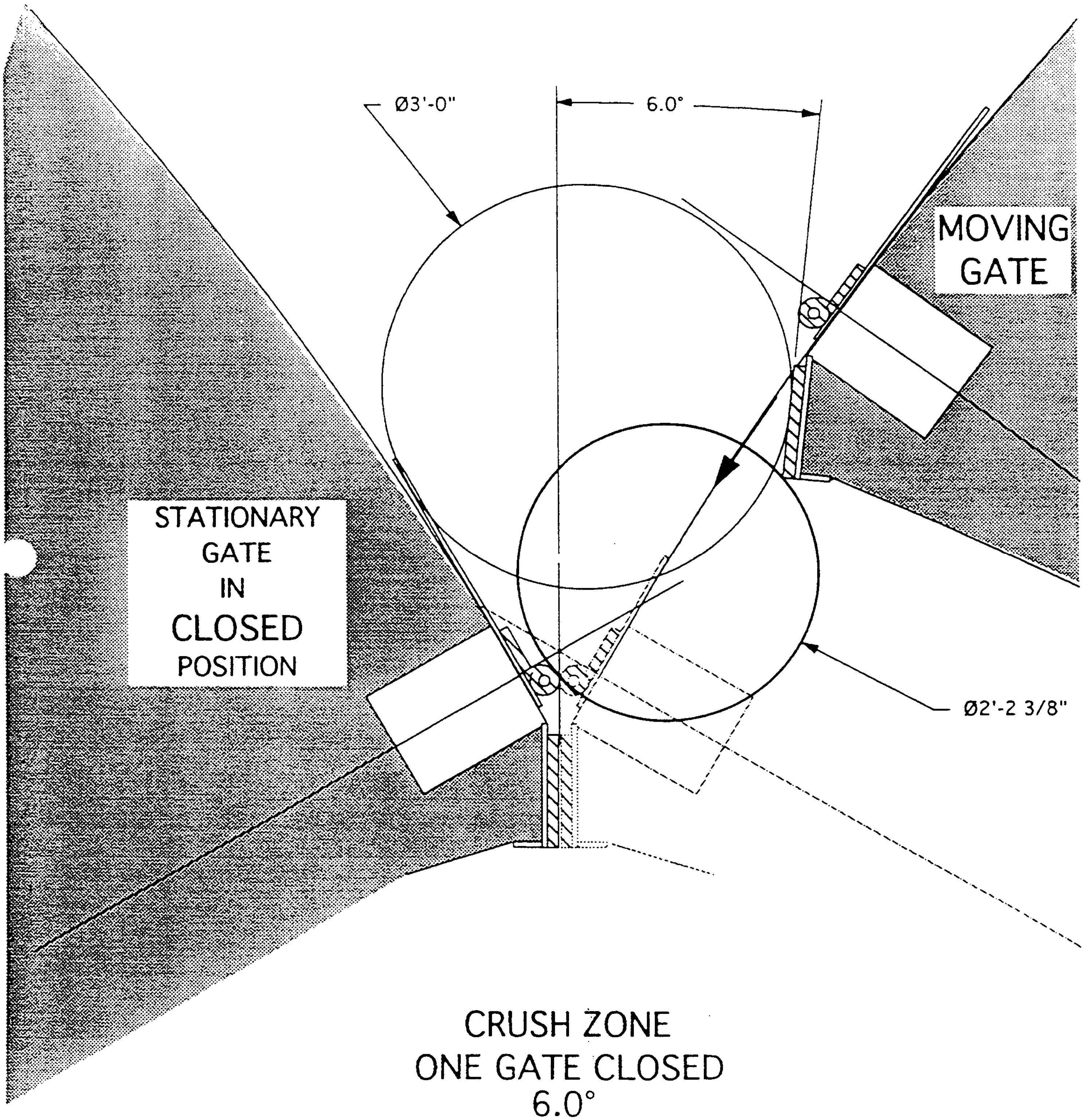
CRUSH ZONE
SYMMETRIC MOTION
BOTH GATES MOVING
6.0°-6.0°



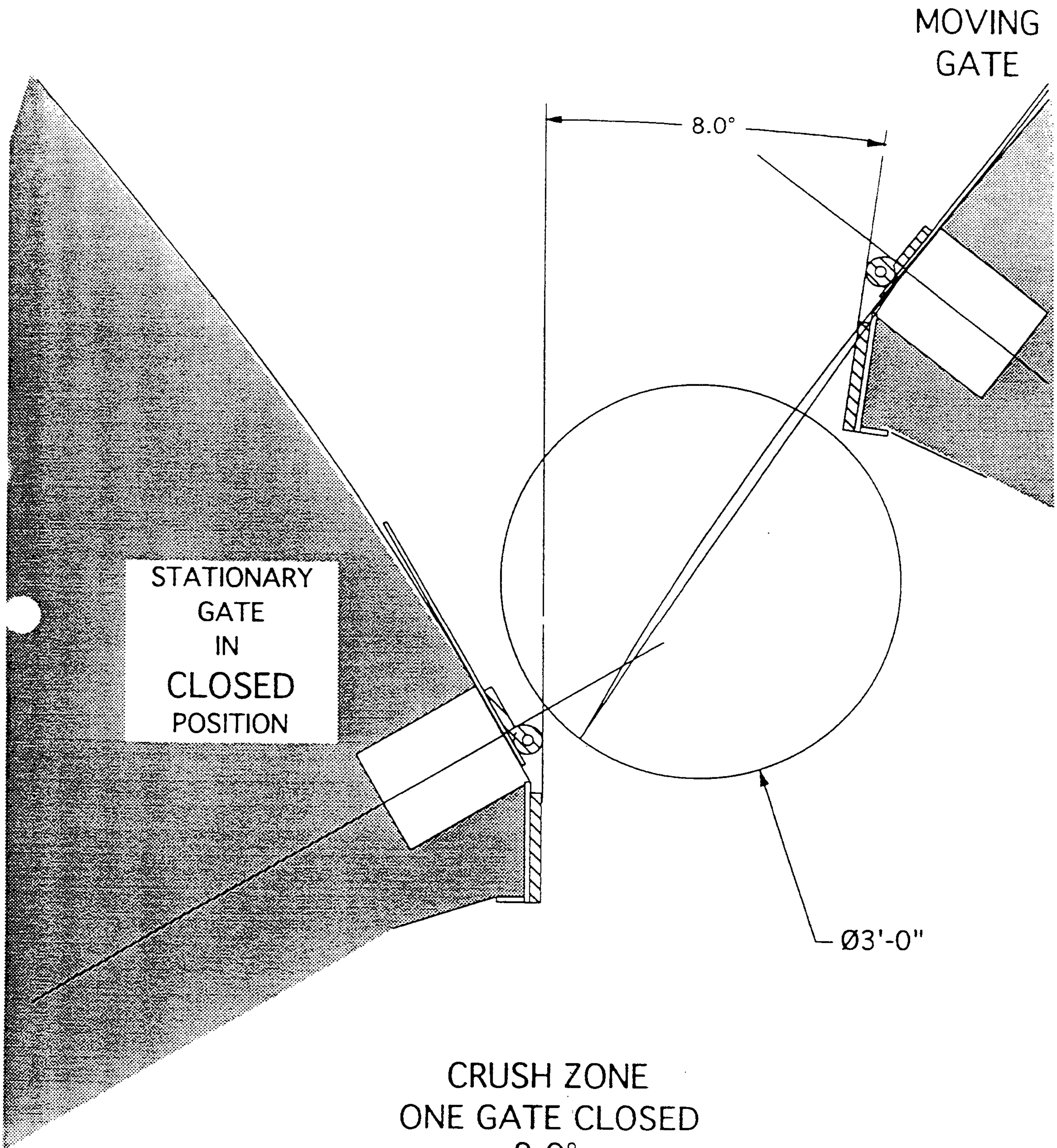
CRUSH ZONE
ONE GATE CLOSED
MOTION PATH



CRUSH ZONE
ONE GATE CLOSED
4.0°
24 feet from base to Top of frame A



CRUSH ZONE
ONE GATE CLOSED
6.0°



CRUSH ZONE
ONE GATE CLOSED
8.0°

5.0 Findings of Sensor Evaluation

Piezo-electric film based contact sensors are recommended for the implementation of the manatee detection system for SFWMD's sector gates. Information is provided on three piezo film based sensors constructed for testing. Section 6.0 describes in detail the design recommended for installation at Sector Gate 193.

Of the non-mechanical manatee sensing methods considered, four were deemed most practical, and chosen for demonstration. These sensing methods were: piezo-electric film based contact sensing, piezo-electric cable based contact sensing, acoustic beam interruption, and fiber optic cable based contact sensing. Of the above methods by far the most practical and robust are contact sensors based on piezo-film.

Information is provided in the Appendices on the three other methods of non-mechanical sensing that were built and demonstrated in Harbor Branch labs that could also be developed into workable solutions.

5.1 Piezo-electric Film Sensor Evaluation

Description and Operating Principle

Piezo film is a thin, tough, flexible material manufactured from polyvinylidene fluoride (PVDF) plastic. The PVDF is extruded, mechanically oriented by stretching, and polarized by exposure to an intense electric field. The resultant film, typically 1 or 2 thousandths of an inch thick, is then coated on both sides with a conductor to form the charge collecting electrodes.

Piezo film converts mechanical energy to electrical response. When the film is stressed, a charge is generated on the surface of the film proportional to the applied stress.

Piezo films are therefore very effective as dynamic strain sensors. They can cover large areas, require no external power source, and typically generate signals orders of magnitude greater than those from strain gages. Frequency response is thus free from limitations imposed by the need for the high gains required in conventional strain gage circuits. Piezo films respond only to time varying excitations, static excitation produces no response. Application of a constant stress will generate an initial level followed by an exponential decay of output signal.

A discussion of salient piezo-film properties is provided in Appendix 1

Sensor Development

Three approaches to manatee contact detection using piezo-electric film sensors were considered, designed, fabricated and subjected to preliminary testing. The three approaches were a hard-backed area contact sensor, a J Seal contact sensor, and a flat plate contact sensor. All three methods are intended to demonstrate a line sensor running along the edge of a gate. Various electrical contact and methods of water proofing were experimented with.

Hard-Backed Area Contact Sensor Proof of Concept

The sensor was fabricated from available neoprene rubber to save time, similar sensor performance is expected from the rubber used in the field. The sensor was fabricated in 3 layers, the hard-back, the ridge sheet, and the cover layer. The hard-back was fabricated from 3/4" 6061 T6 aluminum alloy plate to provide rigidity and a convenient mounting surface for testing. The ridge sheet, fabricated out of neoprene rubber, was bonded to the hard-back with contact cement. The 1 13/16" by 12 3/8" strip of 28 µm thick piezo-film was sandwiched between the ridge sheet and the cover layer. The piezo film is laid out so that its length direction, the 1 direction, is perpendicular to the ridges. The cover layer was fabricated from 3/8" neoprene sheet, and bonded to the stack with contact cement. A cross-section of the stack, dimensions, and film placement is shown in Figure 9 and Figure 10. Electrical connections to the silver ink electroded film surfaces were made with thin copper foil backed with conductive adhesive at the top 1/4" of the film strip. Output leads were soldered to the copper foil and brought out along the grooves of the ridged sheet.

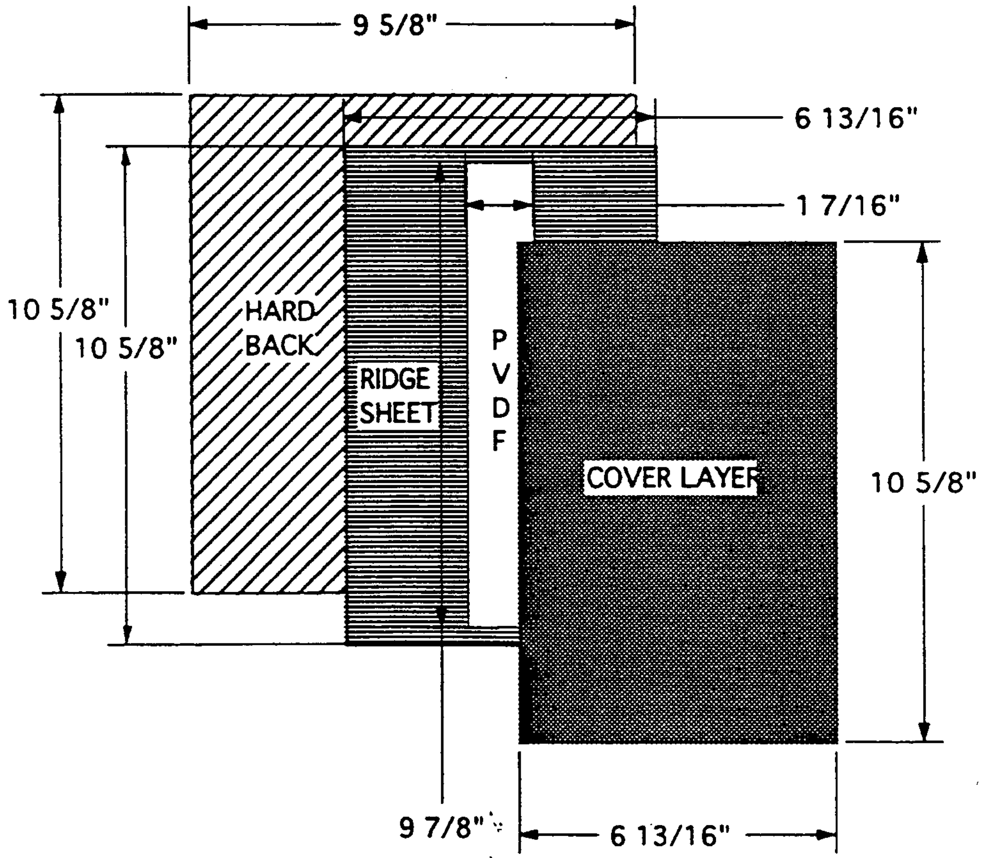


Figure 9: Hard Backed Sensor Components

Operation

When contact is made with the protective cover layer, the compliant cover is compressed against the ridges, which also deform, resulting in localized tension on the bottom surface of the cover layer. The compliant cover indents over the contact area on top of the ridges and bows down into the free span between them, both actions serving to stretch the bottom surface of the compliant cover layer in the direction perpendicular to the direction of the ridges. The piezo film, bonded to the bottom surface of the cover and clamped between the cover and the ridges, is positively stressed (tension) in the 1 direction, and negatively stressed (compression) in the 3 direction. As g_{33} is negative and g_{31} is positive, both conditions result in charge being generated on the electroded film surfaces, the 1 direction tension being the dominant charge generator, with a polarity opposite that of the poling voltage and proportional to stress and area of film under stress.

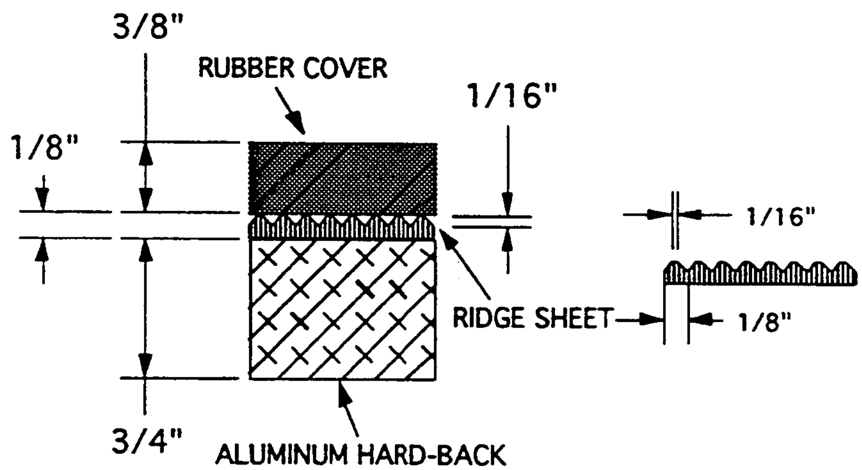


Figure 10: Cross section of Hard Backed Sensor

J-Seal Contact Sensor

The sensor was fabricated from a length of scrap J-seal. As this is the material actually used at present on the gates and is subject to routine periodic replacement, methods for gate installation are well established. The J seal served as the substrate on which various film mounting geometry's were tested. The film was sandwiched between the J -seal and a protective neoprene cover layer. Various arrangements of ridge sheets and cover layers were tested, and are shown in Figure 11.

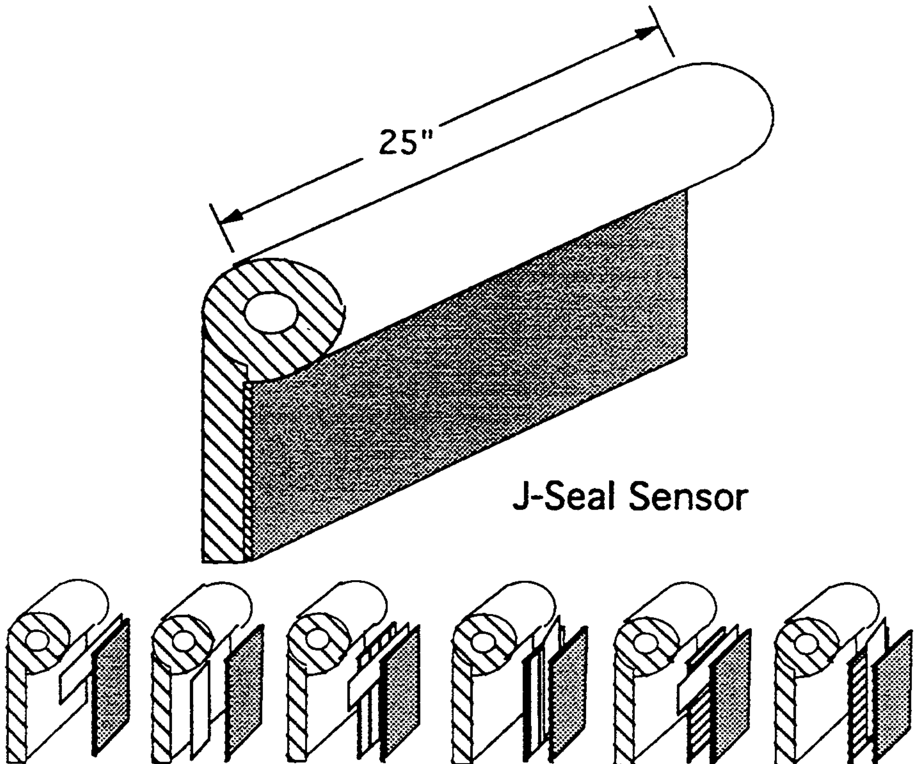
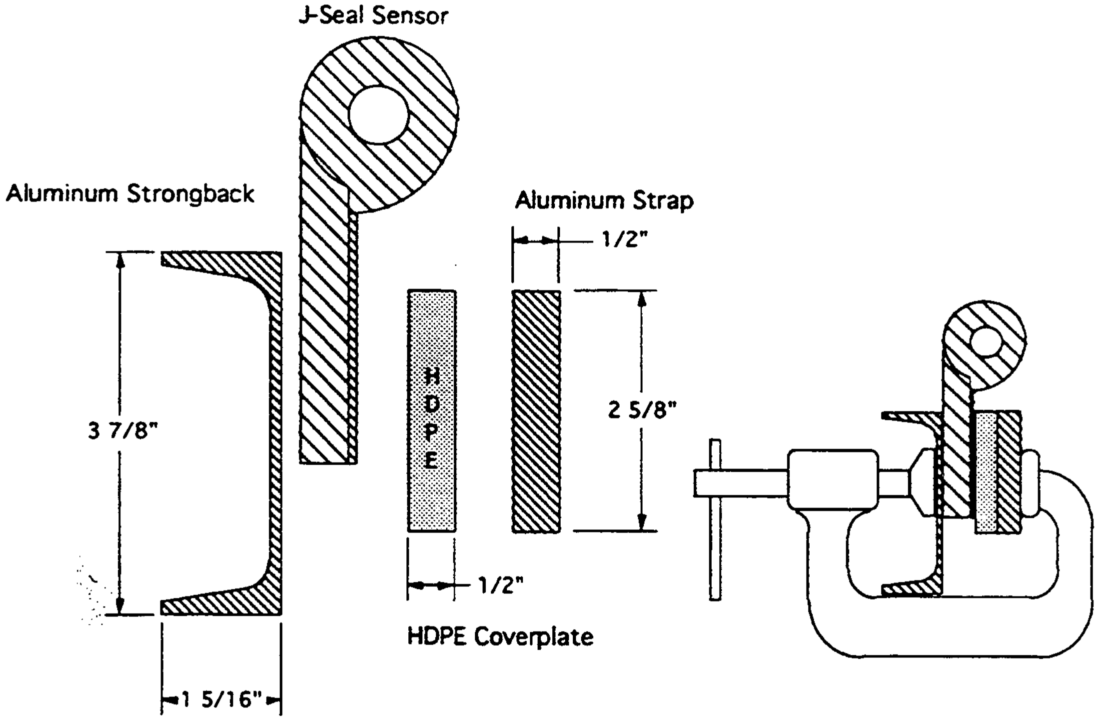


Figure 11: J-Seal arrangements of ridge sheets and cover layers

To facilitate changes in the film arrangement, adhesive bonding was not used, instead a simple clamped test set-up was employed and held together with C-clamps. This arrangement worked quite well, and allowed fairly easy modifications to the sensor. The test set-up, shown in Figure 12, consisted of a 6" extruded aluminum channel as the strong back, the J-seal sensor under test, a 1/2" thick HDPE cover plate, and a 1/2" thick aluminum strap. The stack was held together with C-clamps along the center line.



J-Seal Test Fixture

Figure 12: J-Seal test fixture setup

Operation

The design of the J-seal sensor exploits the geometry of the J-seal and it's positioning on the gate of the lock. When contact is made with the bulb of the J-seal, the contact force results in a negative bending moment at the position of the sensor proportional to the contact force and the separation distance (the bending moment increases along the length of the cantilever). This bending moment is converted by the thickness of the J-seal into a tensile stress at the piezo-film mounting point proportional to the magnitude of the bending moment, and the distance between the surface of the J-seal, where the piezo film is mounted, and the neutral axis of bending (about half the thickness). The piezo film bonded to the top surface of the J-seal, see Figure 11, is then positively stressed (tension) in the 1 direction, and to a lesser extent in the 2 direction. Both conditions result in charge being generated on the electroded film surfaces, the 1 direction tension being the dominant charge generator, with a polarity opposite that of the poling voltage and proportional to stress and area of film under stress. It is important to note that the clamping forces, being static, produce no response. This is a major advantage of the piezo-film approach as compared to conventional strain gages. Installation deformations and operational strains over time would render conventional strain gages out of range and useless, while piezo film can adjust to changes in a mater of minutes, without significant change in sensitivity.

Flat Plate Contact Sensor

The flat plate contact sensor was fabricated to simulate a section of an extrusion that would extend the length of the edge of the lock gate. The sensor was fabricated in three layers, a pedestal layer of 1/4" neoprene rubber, a flat plate of 2" rubber, and a cover layer of 3/8" neoprene. The 28 μm thick piezo film was mounted as shown in Figure 13 and Figure 14, sandwiched between the 3/8" cover layer and the 2" rubber plate. Electrical connections to the silver ink electroded film surfaces were backed with 5 mil mylar for reinforcement and riveted at the top 1/4" of the film strip. Output leads were brought out along grooves cut in the flat plate. Polyurethane electrical potting compound 3M2130 was used to bond and waterproof the cover layer to the 2" rubber plate, fully encapsulating the film, contacts, and leads.

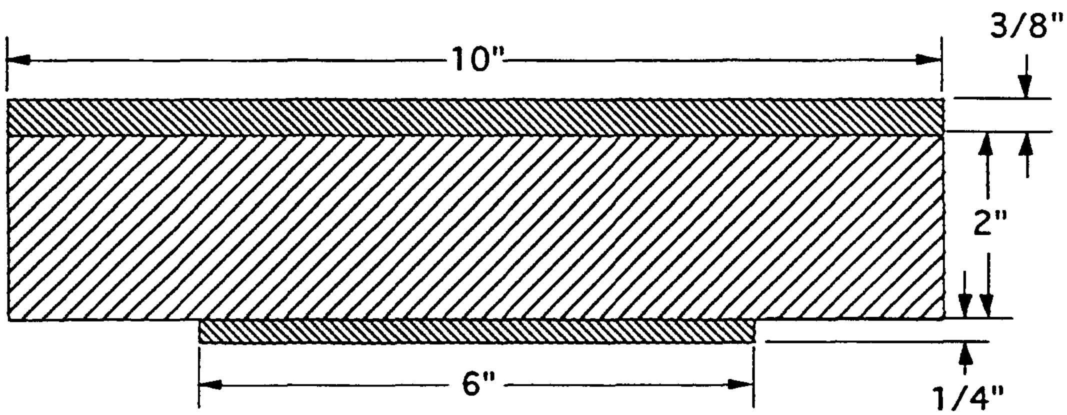


Figure 13: Top view of flat plate sensor

Operation

The flat plate contact sensor, similar to the J-seal contact sensor, utilizes mechanical amplification through the use of a cantilever. When contact is made with the plate, the contact force results in a negative bending moment at the position of the sensor proportional to the contact force and the separation distance (the bending moment increases along the length of the cantilever). This bending moment is converted by the thickness of the contact plate into a tensile stress at the piezo-film mounting point proportional to the magnitude of the bending moment, and the distance between the mounting plane of the piezo film, and the neutral axis of bending (about half the thickness of the plate). The piezo film is positioned to be positively stressed (tension) in the 1 direction, and to a lesser extent in the 2 direction. Both conditions result in charge being generated on the electroded film surfaces, the 1 direction tension being the dominant charge generator, with a polarity opposite that of the poling voltage and proportional to stress and area of film under stress.

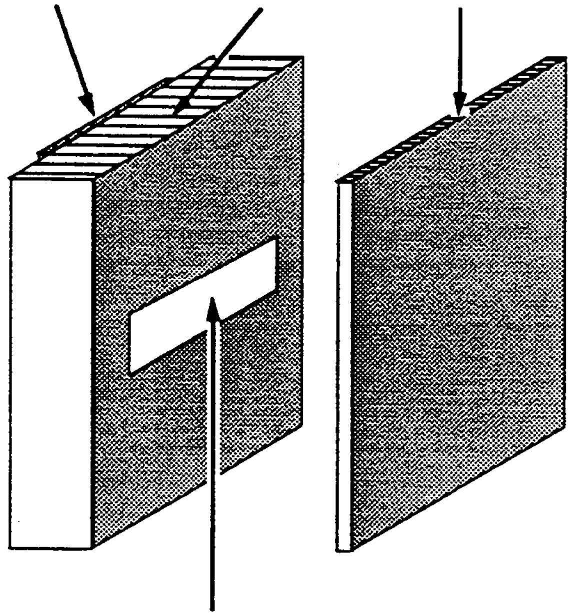


Figure 14: Flat plate sensor components

General Test Observations

Air Piston Tests

A simple air piston test set-up was used to provide mechanical stimulus to the sensors in the laboratory. The test set-up is shown in Figure 8. A foam padded plate is pushed against the sensor surface by a small air cylinder. The pressure in the air cylinder is monitored by an electronic pressure sensor. The pressure signal and sensor electrical response are measured and recorded with a digital storage oscilloscope. A valve and regulator system was used to vary the onset of load and peak load at the push plate. The system was used to provide two different mechanical loads; a high loading of 4.6 psi and a low loading of 0.8 psi, both with an onset of load of about a half second.

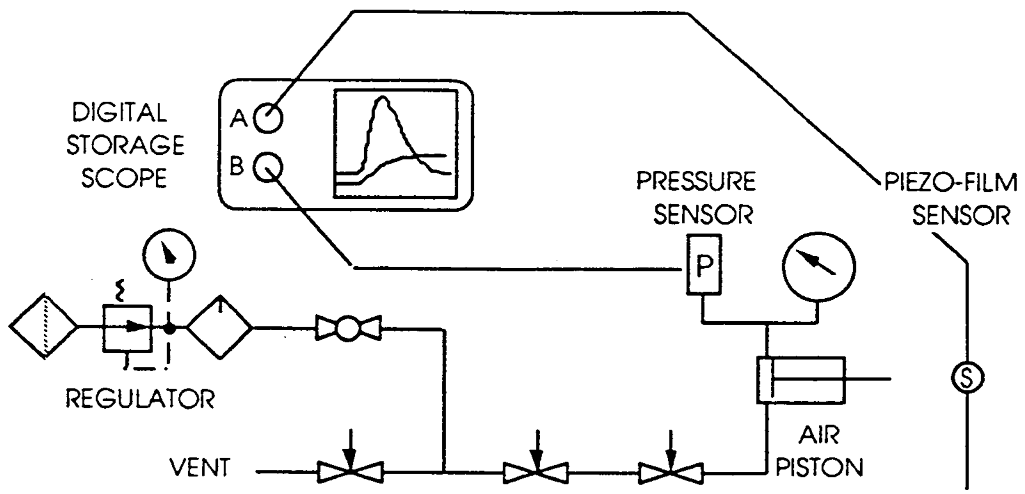


Figure 15: Air piston test set-up

Bias Force Test

The sensors were tested with and without a bias force to get an idea of the effects of installation distortions on performance. No perceivable difference was noted.

Flow Noise Test

A major initial concern to be addressed was the question of false triggering. Primary concerns addressed included impact from light debris and flow noise due the motion of the gate through the water during closing.

The signals produced by light debris are impulsive in nature, small, sharp, sudden impacts, with little energy content. By constructing the sensor of heavy sections of rubber, relatively little energy is transferred by these light impacts. The large film areas utilized to provide the required sensitivity also increase the capacitance of the sensor. This combination of mass, large film area, and capacitance result in a sensor with a long time constant that is relatively insensitive to small sharp local impacts, and yet is very sensitive to a broad shove or wiggle that a manatee would probably generate. A manatee, even an infant, would have a softer contact over a comparatively larger area, deforming a large area of film at a slower rate. This results in a broader, lower frequency signal that would be smoothed rather than filtered out. It should be noted that a large piece of debris in the same or higher mass range as a manatee would result in a trigger being generated to stop the gate. An object caught between the two gates would also result in a triggering event being generated.

When a gate is opening, large amounts of water can rush past the seals. When the gate is closing, the water is comparatively still, with the gate rotating slowly and steadily through the water. The unsupported drag area of the sensors are comparatively small, and the water velocity is low. This results in low drag forces. The sensors are designed for maximum sensitivity in the pinch direction. The drag forces are, for the most part, at right angles to the direction of pinch, reducing the sensors sensitivity to flow noise. At gate closing speeds, flow noise is not significant. Therefore, flow noise will not be a source of false triggering.

To quantify the flow noise generated by the sensor's *movement in* water, the flat plate contact sensor was mounted on a flat aluminum plate and moved through the water at approximately 1 m/s. The test set-up is shown in Figure 16. The sensor was moved both "edge to flow" and "face to flow".

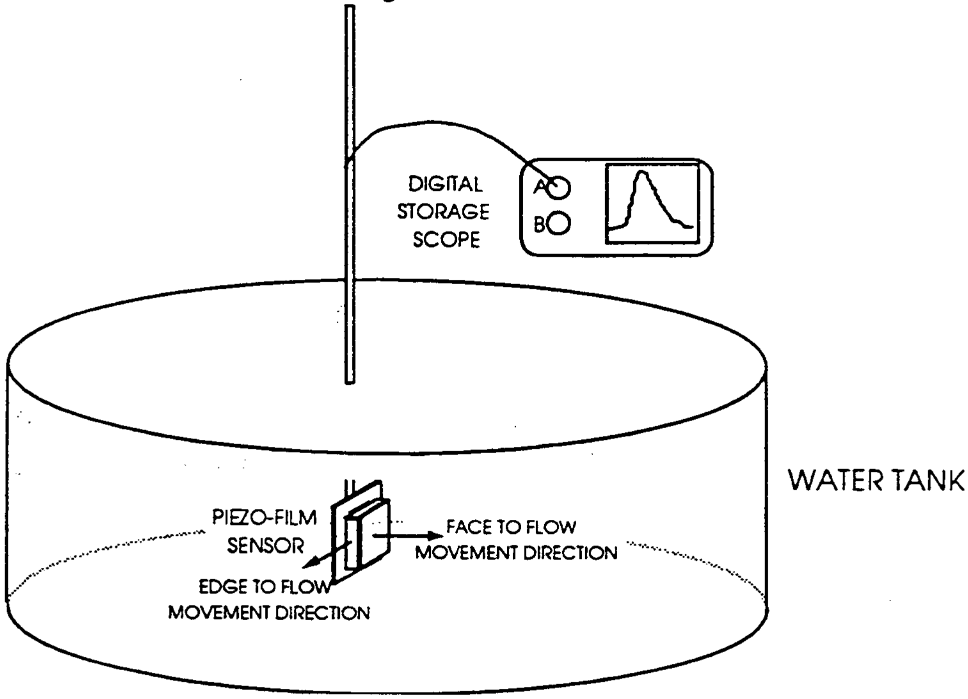


Figure 16: Flow noise and biologist impact test set-up

The flow noise signal was captured with a digital storage oscilloscope for observation. Flow noise plots are shown in Figures 17, 18, and, 19. The flow noise was somewhat lower than expected for an unshielded sensor, due in part to the rigidity of the backing plate. As the gate would provide backing in service, these levels are representative. The speed of slightly over 1 m/s was used for a worst case trial. At 1/4 m/s electrical noise was predominant. Edge to flow, (Figure 18), produced lower but similar levels of flow noise. CAD models show that the edge to flow will be encountered in service (see Figure 2). Figure 19 shows the flow noise plotted in the same scale as the signal response, 100mV/div, for ease of comparison. Testing verifies that flow noise due to the motion of the gate through the water during closing is not a significant source of noise, and is insignificant compared to the expected manatee contact signal (see Figures 19 and 20). Flow noise during closing will not be a source of false triggering.

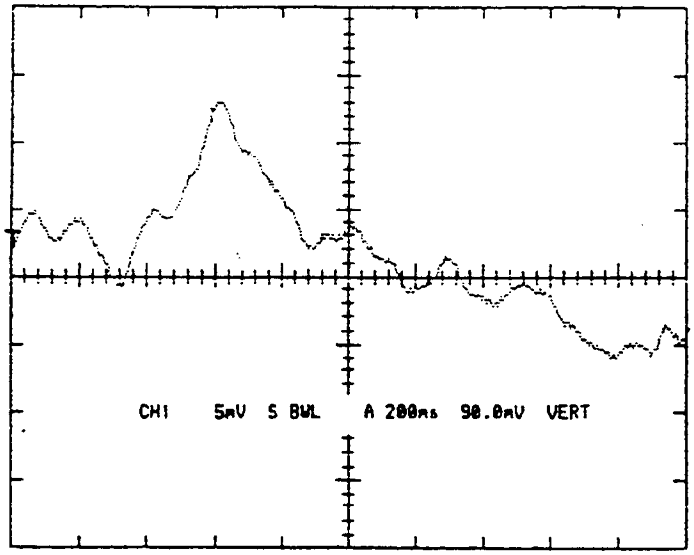


Figure 17: Amplified Flow Noise, 5mV/div, Face to Flow at >1 m/s

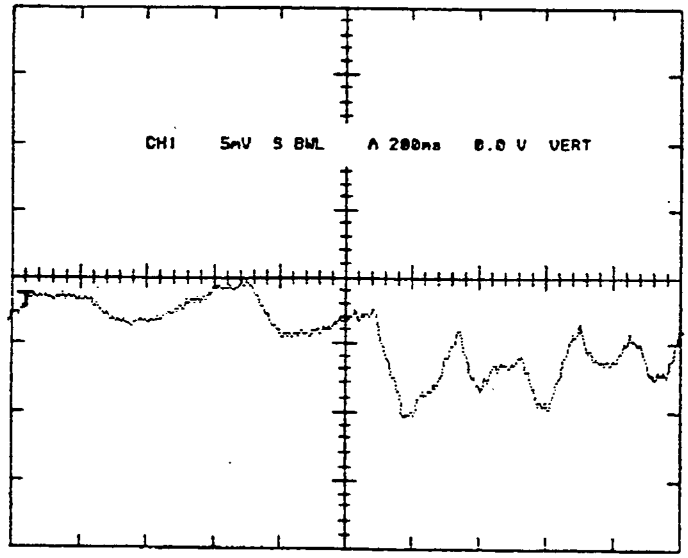
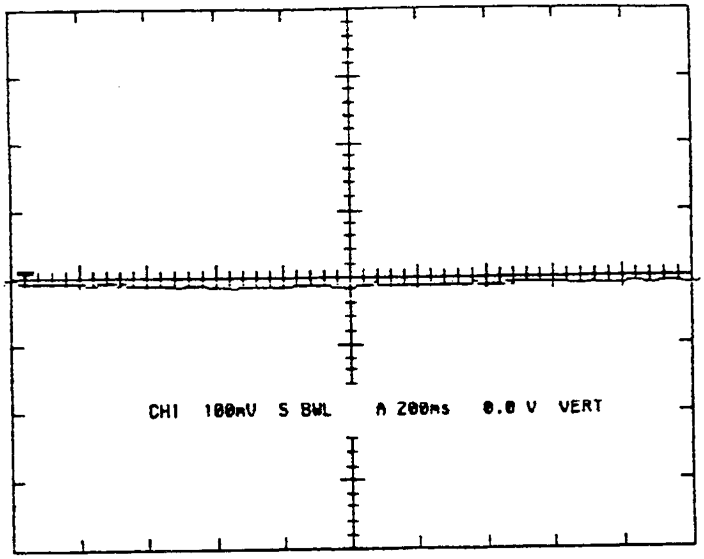


Figure 18: Amplified Flow Noise, 5mV/div, Edge to Flow at >1 m/s



Biologist Impact Flow Noise, 100mV/div, Edge to Flow at >1 m/s

Soft Body Impact In Water

To gain a qualitative feel for the response of the sensor in service, the sensor was moved through the water, face to flow, at about 1/4 m/s and run into a 185 lb. floating biologist in a fetal position to provide a soft body impact. The resulting soft body impact signal was captured with a digital storage oscilloscope for observation, and is presented in Figure 20.

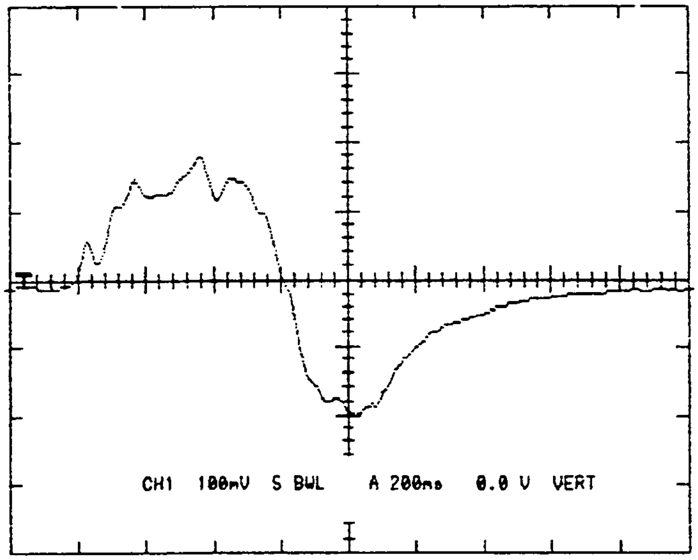


Figure 20: Trigger event signal, 100 mV/div, 200mS/div
Soft Body Impact, floating biologist, fetal position, fleshy region.

Evaluation Criteria

- **Ruggedness**

The piezo film based manatee contact sensor would be a solid monolithic block of tough, compliant rubber. It has no moving parts, no electronic components, and has a simple uncomplicated design.

Submergence

The piezo film and associated wiring on the gate will be solidly potted in a tough, flexible, elastic plastic, probably polyurethane, selected for environmental resistance. The years of experience HBOI has gained in the solid compliant encapsulation of electrical systems and devices designed for submergence in thousands of feet of seawater will be applied to the design and encapsulation of the manatee contact sensors. Testing of the water proofing method and materials selected can be carried out using the HBOI high pressure test facility.

Impact from Boats and Debris

The sensors are fabricated from heavy sections of solid, durable, rubber. The rubber and potting serve to protect the piezo film from abrasion and moisture. As the piezo film is a tough, flexible, elastic plastic, the sensors should be able to handle boat impacts and compression about as well as the existing gate seals.

Vandalism

The sensors should be fairly resistant to vandalism. Sledge hammers would have little or no effect, similarly, they should be resistant to hydrostatic shock from underwater explosives, unless the explosives are placed in close or direct contact with the surface of the sensor. Pry bars could be used to separate the sensor from the gate edge, or damage cable runs. Cutting torches or fire bombs could destroy or damage the sensor severely. Probably the greatest protection the sensors have from vandalism is that they will be unobtrusive. Fabricated from similar looking materials as the existing gate seals, and attached in a similar manner, they should attract little or no attention, and blend into the existing structure in a way that the change would not be readily apparent to the casual observer.

Lightning Strikes

The sensor itself should be fairly resistant to damage due to lightning. As the sensor contains no electronics, the isolation provided by the thick rubber, shielding, and simple circuit protection, as well as the mounting position on the steel gate, should prove effective against most disturbances short of a direct strike. Special care will be taken in the design and construction of the electronic signal conditioner to reduce lightning damage as well. The signal conditioner will be designed as a junction box module to allow replacement without disturbing the sensor or entering the water.

Sedimentation

The vertical orientation of the sensors place them, for the most part, above the sediment layer. As the sensor has no moving parts, "binding" by settling sediment is eliminated.

- **Reliability**

The simplicity of the approach, the ability of the sensors to null out stresses, the lack of any moving parts, and the innate toughness of the sensors themselves, should provide years of trouble free service. Continuous sunrise to sunset operation 365 days a year should be practical. The MTBF>1.8 M seems readily achievable.

- **Low Maintenance**

The sensor itself is simple in construction, and should be able to handle the same kind of service conditions as the existing gate seals. Little or no maintenance beyond that normally employed for the existing gate seals is expected.

Minimize Downtime

A simple, modular, functional block approach to the design is used to minimizes down time, in the rare event of system failure, to the replacement of failed modules. The exception to this would be the cable runs. Cable runs accidentally damaged or cut could be spliced, or redundant runs installed.

Ease of Repair

Parts of the system that could be damaged; the signal conditioners, relays and indicator lamps, would be designed for high reliability and ease of maintenance. Redundant indicator lamps would be designed for easy replacement, as well as socketed relays, and surge protection components.

- **Ease of Installation**

Installation of the sensor on the gate edge is anticipated to be essentially the same procedure as is currently employed for the existing J-seals. The electrical installation would consist of a junction box and cable run to the control room, a control room indicator lamp/bell, and necessary connections to the gate control switches.

- **Ease of Operation**

Presence of a manatee between the doors would trip-out the gate closure and activate the alarm, requiring no operator intervention.

6.0 Proposed Design

Based on our investigations and our experience with the design, fabrication, operation, and maintenance of high reliability underwater systems, we recommend contact sensors based on piezo film for the instrumentation of the sector gates at Lake Okeechobee. Piezo-film contact sensors offer the best mix of salient features of the candidates surveyed, the technology is well established, relatively low cost, and the components are available now.

In any system selected, installation, and in particular, maintenance, must involve minimal diver effort. Reliability and maintainability is a key concern for all components. Dry components are designed for simple modular replacement with minimal effort. Wet component reliability is crucial. Repairs requiring the scheduling and utilization of divers would be expensive and inevitably result in downtime. The part that goes in the water must be tough enough to handle the rough service environment of the locks. This is a principle advantage of the piezo film sensor based system: the contact sensor that goes in the water is a solid monolithic block of tough, compliant rubber. It has no moving parts, no electronic components, and has a simple uncomplicated design.

A defining feature of film based sensors is their ability to null out stresses. Deformations will inevitably occur. Whether the deformations occur during the installation process, or are due to other factors such as thermal expansion and contraction, collisions, or just due to the passage of the years, the ability of the sensors to naturally adapt without requiring recalibration or adjustment, is a major maintenance and reliability advantage.

A schematic of the proposed system is shown in Figure 21. Sensor construction details are provided in Figures 22 and 23. Each Sector gate would have the contact sensors in the water, mounted on the gate at the pinch point. The sensor would be of the J-Seal type, replacing the original J-Seal. The sensor would connect to a Junction Box accessibly mounted on the gate. The Junction Box would contain the sensor conditioner module used to report contacts over the cable run to the control room. The cable runs would connect each gate sensor Junction Box to a Junction Box in the control room. The control room Junction Box would contain the gate trip and alarm connections, and the hardwired connections to the present gate closure circuitry.

The presence of a manatee between the doors would trip-out the gate closure and activate the alarm, requiring no operator intervention. An override switch will allow the system to be bypassed and restore operator control in the event that it is necessary.

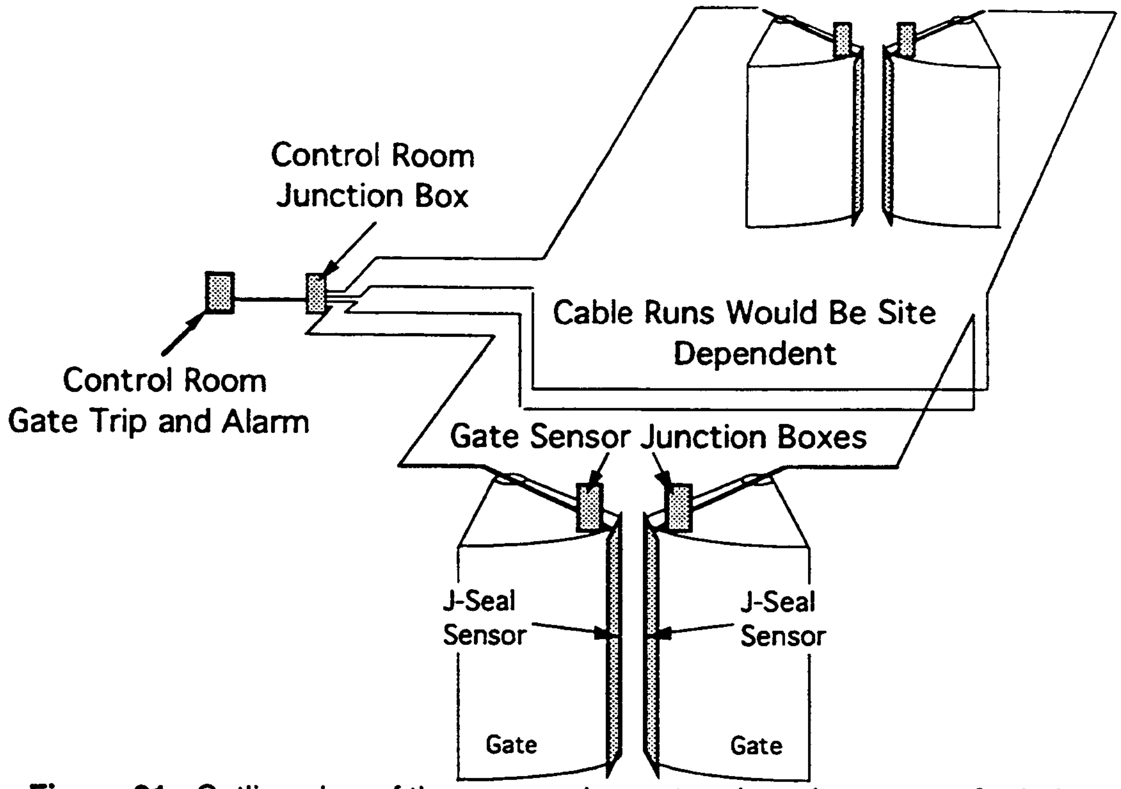


Figure 21: Outline view of the proposed manatee detection system for Lake Okeechobee sector gates.

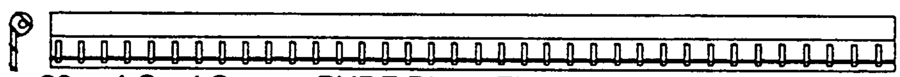


Figure 22:: J-Seal Sensor PVDF Piezo-Film Layout (cover layer removed)

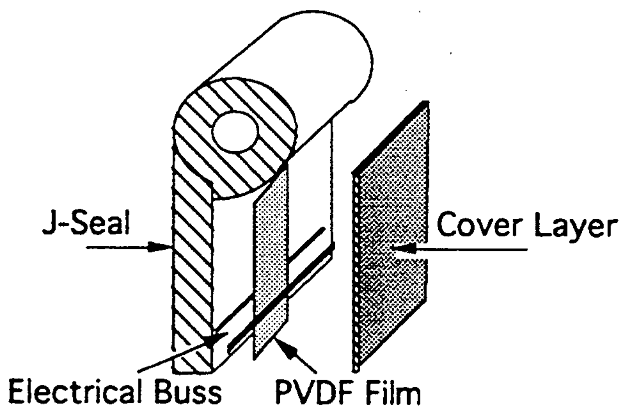


Figure 23: Section view of J-Seal Sensor

7. COST

7.1 Installation

7.1.1 First Prototype System

Due to the initial research, development and manufacturer's setup charges, the cost for the first two J-seal prototypes and control system at Sector Gate 193 is unrepresentatively high. It should not be extrapolated as a unit cost for multiple installations, primarily due to the high labor costs required in developing the initial prototype.

Materials			
Piezo-Sensors			
Manufacturer's setup charges			$2,500
Film (for 2 J-seals)			4,000
Polyurethane potting compound (for 2 J-seals)			900
Electrical sensor cable			160
Cable connectors			800
Sensor conditioner module (2)			2,745
Cable to control room (1000-ft. spool)			1,650
Cable ties, fittings, etc.			500
Control room relays, box, etc.			750
			14,005
Labor	**Rate**	**Hours**	
Sr. R&D Engineer	60	100	6,000
Engineer	40	300	12,000
Technician	35	200	7,000
			25,000
			39,005
5% institutional overhead			1,950
			$40,955

7.1.2 Estimate for Production Runs

8 J-SEALS PER LOCATION

Materials	
Piezo-Film	
Manufacturer's setup charges	N/A
Film (for 8 J-seals)	$ 5,000
Polyurethane potting compound (for 8 J-seals)	1,200
Electrical sensor cable	220
Cable connectors	1,600
Sensor conditioner module (8)	2,920
Cable to control room (1000-ft. spool)	1,120
Cable ties, fittings, etc.	750
Control room relays, box, etc.	750
	13,560
Labor	
Assembly (8)	7,000
Total for 8 instrumented J-seals and control system	$20,560

7.2 Life Cycle Costs

There is no periodic maintenance required for the instrumented J-seals and, therefore, no recurring maintenance costs. Considerable effort has been taken to ensure a very simple, rugged and robust system. However, as with any electrical system some failures may occur. Each controller is modular to facilitate rapid remove/replace maintenance methodology. At a cost of less than $400 each, this represents a component which may be practically inventoried in an on site spares locker. If the system were to take a direct lightening strike, many or all components might be damaged. However, as discussed in the Evaluation Criteria Section, special attention was directed during the design to harden the system against this damage. The instrumented J-seal itself is impervious to impact, even from large masses (barges, etc.).

Not included in the sensor costs above are the costs for a standard J-Seal, since these are required for the operation of the Sector Gate with or without the detector system. Presumably, these are periodically replaced as routine maintenance. HBOI has obtained a quote for J-Seals from the District's current vendor of approximately $360 each in quantities of 40 (see Appendix). It is presumed that J-Seal replacements are already included in the Life Cycle Costs of operating these Sector Gates.

Appendices

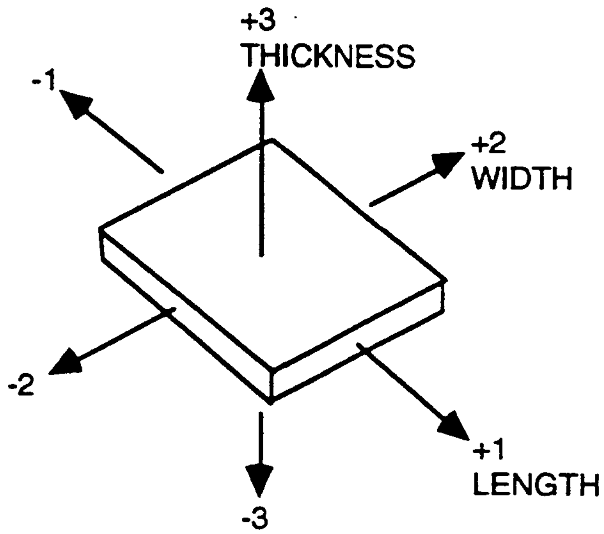
Appendix 1 Piezo-Electric Film

Description

Piezo film sensors are manufactured from polyvinylidene fluoride (PVDF) plastic. The PVDF is extruded, mechanically oriented by stretching, and polarized by exposure to an intense electric field. The resultant film, typically 1 or 2 thousandths of an inch thick, is then coated on both sides with a conductor to form the charge collecting electrodes.

Operating Principle

Piezo film converts mechanical energy to electrical response. When the film is stressed, a charge is generated on the surface of the film proportional to the applied stress. The electrical response is anisotropic, that is, the developed charge depends on both the magnitude of the stress and the direction in which the stress is applied. A two digit subscript numbering system is used to denote the piezo-electric constants in terms of the relevant film directions, or axes. These axis are shown below.



NUMBERED AXES

The piezo film is uniaxially oriented, stretched in only one direction, called the length direction, or machine axis, defined as the 1 axis. The 2 axis is transverse to the stretch direction, and is called the width direction. The 3 axis is called the thickness direction. Polarization is applied in the thickness (3) direction using the faces of the film as the poling surfaces; the electric field is parallel to the 3 axis, positive poling potential in the +3 direction. In standard two subscript notation, the first number indicates the polarization axis, 3, and the second number indicates the axis of mechanical stimulation.

Compressive stress or strain is defined as negative, and tension defined as positive. The piezoelectric stress constant, "g", varies considerably with direction. In the 3 direction g_{33} is negative and for the 1 direction g_{31} is positive. The material has the lowest stress constant in the 2 axis, width direction; typically g_{32} is only a few percent of g_{31}. Typical values are:

$$g_{31} = 216 * 10^{-3} \; {}^{V/m}/_{N/m^2}$$

$$g_{33} = -339 * 10^{-3} \; {}^{V/m}/_{N/m^2}$$

The low thickness of the film results in a low cross sectional area, causing relatively small longitudinal forces to create very large stresses in the material. This effect tends to predominate in most circumstances, resulting in the ratio of effective sensitivity in the 1 and 3 directions typically being 1000 to 1. The resulting open circuit voltage for the 1 direction is given by:

$$v = g_{31} \, T \, t$$

v = resulting open circuit voltage
g_{31} = piezoelectric stress constant in the 1 (machine) direction
T = applied stress
t = thickness of the piezo film

Piezo films are therefore very effective as dynamic strain sensors. They can cover large areas, require no external power source, and typically generate signals orders of magnitude greater than those from strain gages. Frequency response is thus free from limitations imposed by the need for the high gains required in conventional strain gage circuits. Piezo films respond only to time varying excitations, static excitation produces no response. Application of a constant stress will generate an initial level followed by an exponential decay of output signal.

Appendix 2 Piezo-Electric Spiral Cable

Description

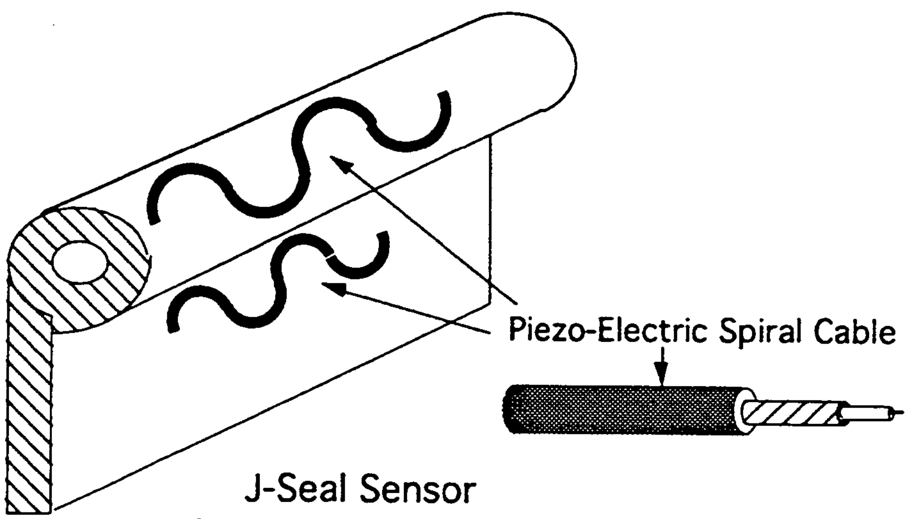
Piezo-electric sensor cable looks like standard coaxial cable, but is constructed with a piezoelectric polymer insulation layer between the copper braided inner conductor and the outer shield. The cable is protected by a polyurethane jacket.

Operating Principle

Separating the cable from the axis of bending provides mechanical amplification of strain, increasing the deformation of the cable. When the cable is deformed, it generates a charge proportional to the deformation. The generated charge is then detected and amplified by an electrometer to provide the signal output.

Sensor Demonstration

A length of piezo-cable was attached to a section of bumper material. Sinusoidal layout was used to increase the bending coverage and length of the cable. A high input impedance digital volt meter was used to monitor the sensor response. Characteristic wave forms were observed on an oscilloscope at 10 MΩ.



Spiral Cable With Mechanical Amplification

Evaluation Criteria

At present the signal levels obtained from the present available piezo-cables are marginal for detection purposes using the heavy sections of rubber used in the gate seal. A piezo-cable sensor would be ideal in an application involving greater compressive deformations at a faster rate. Development is continuing on these sensors.

- **Ruggedness / Reliability.** One of the great advantages of piezo-cable is its ruggedness and simplicity. The cables tough polyurethane jacket has good adherence to polyurethane and other rubber potting compounds, and excellent water resistance. Impact from boats or barges would have no effect other than to generate a large signal. Lightning strikes are a particular hazard to the sensitive pre-amplifier electronics, but the fact that the cable is coaxial shielded cable would reduce signal pickup. Sedimentation, and biofouling are not expected to have any effect on sensor performance. The ability of piezo cable to self adjust to installation or other deformations and still maintain full sensitivity, as is the case with piezo-film, is a great advantage.

- **Ease of Installation / Maintenance / Operation.** Modular design, incorporating simple bolt-on assemblies, would be used to limit down time and minimize diver effort in the installation and replacement of sensors. The cables advantages of low cost, very good uniformity, and ability to be produced in long lengths, simplify both manufacture and maintenance. Operation would be automatic, the system would be hardwired into the existing gate closure circuitry. Presence of a manatee between the doors would trip-out the gate closure and activated the alarm, requiring no operator intervention.
- **Cost.** Much development work needs to be done, but the potential cost savings are worth considering. Although piezo cable will never achieve the sensitivity or directional selectivity of piezo film, development of piezo-cable sensors promise low cost, extreme simplicity, long life, and superb environmental durability.

Appendix 3 Fiber Optic Strain/Deformation Sensor

Description

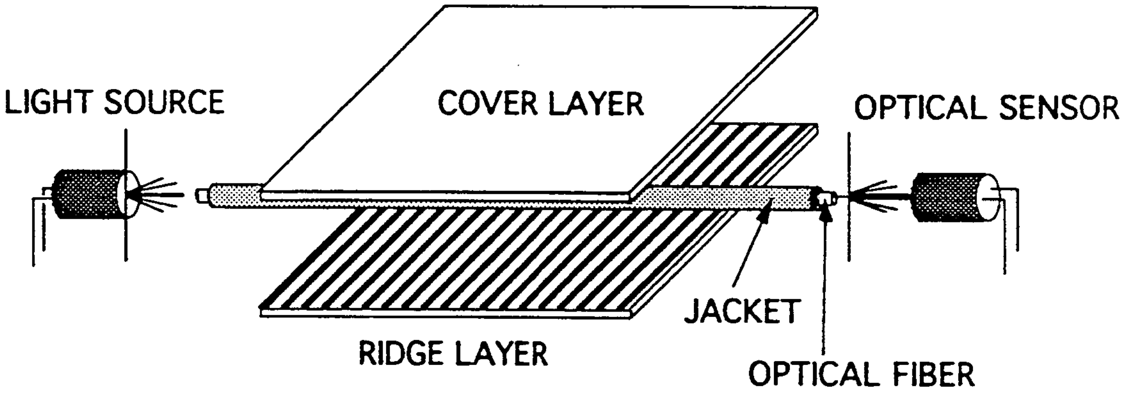
A unique multi-mode optical fiber made out of compliant optical rubber jacketed in polyurethane was selected for strain recovery characteristics. The compliant nature of the optical fiber makes it all but unbreakable in embedded applications.

Operating Principle

When an optical fiber is locally deformed, the resulting optical discontinuity results in increased light loss from the fiber in the region of the discontinuity. Two methods for the detection of the local deformation were considered, optical time domain reflectometry (OTDR), and a change total optical loss. The OTDR approach involves mapping the optical fiber over its length for discontinuities, and then looking for changes in the map. Due to the expense of OTDR equipment, and the limitations that are imposed on fiber selection, OTDR methods were discounted for the present. The optical loss method is both simple and practical, comparing the input power to the fiber with the output power to determine the loss.

Sensor Demonstration

A length of optical fiber was sandwiched between two layers of ridged rubber sheet. A LED light source was used to inject light into one end of the fiber, and a PIN diode optical sensor used to detect the output at the other end. The input light level, the stability of the LED light source was considered sufficient for the laboratory demonstration. Observations consisted of observing changes in output level on an oscilloscope from an established baseline. The compliant fiber optic rubber used shows excellent recovery effects, however permanent changes in baseline under large loads was observed.



Fiber Optic Area Contact Sensor

Evaluation Criteria

A working manatee optical strain sensor or area contact sensor could be built, but as the optical loss is a function of deformation, and not the rate of change of deformation, it does not have self nulling characteristics. Null would have to be accomplished in the control system by variation of the light source intensity, or establishing reference levels used as adjustable baselines, or a combination of both methods.

- **Raggedness / Reliability.** Due to the reliability of properly designed modern low power solid state electronics, not subjected to extremes of temperature, failure is expected to be the result of external factors. Submergence in fresh or salt water is not expected to pose a problem. Impact from boats or barges could damage glass optical fibers, or permanently deform plastic fibers, resulting in transducer failure. Lightning strikes pose no EMP hazard to fiber optic sensors due to the absence of a conductor. Sedimentation, and biofouling in certain locations in particular, could degrade sensor performance by introducing permanent strains that would have to be nulled out electrically. Each of the above concerns would have to be carefully addressed and verified by testing and field trials to meet the MTBF > 1.8M requirement.
- **Ease of Installation / Maintenance / Operation.** Modular design, incorporating simple bolt-on assemblies, would be used to limit down time and minimize diver effort in the installation and replacement of sensors. Care would be required in the installation not to introduce strains that could not be nulled out after installation. Maintenance would consist of periodic loss checks and replacement of the fiber optic light source. Operation would be automatic, the system would be hardwired into the existing gate closure circuitry. Presence of a manatee between the doors would trip-out the gate closure and activated the alarm, requiring no operator intervention.
- **Cost.** Costs, particularly development costs, could be high. The best fiber identified so far, and used in the demonstration sensor, is a jacketed fiber optic rubber, available in limited quantities from the national laboratories, but not at present in production. The development of the control, signal processing, discrimination, and decision making system would require significant effort, with the bulk of the work in coding.

Appendix 4 Acoustic Emitter-Receiver Array

Description

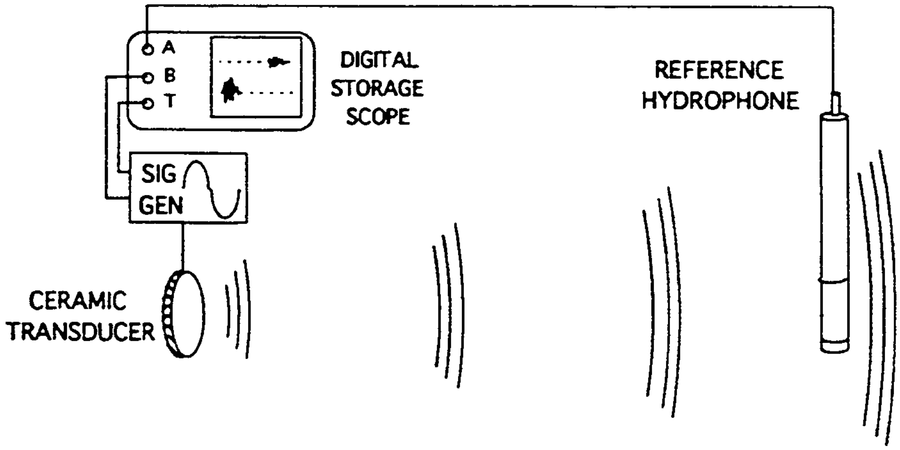
The use of sound waves is perhaps the first method that comes to mind for the non-contact detection of objects under water. The manatee, due to it's size and the air volume of it's lungs, is well suited to acoustic detection in the close proximity environment of the locks. Methods divide into passive and active schemes with attention focused on active methods employing a sound source (transducer) and a sound receiver (hydrophone). Passive methods were not considered for this application due to the perceived complexities of the signal processing and lack of hard information on manatee acoustic emissions. Active methods considered included imaging and non-imaging systems. There is no doubt that a trained operator with a modern high frequency short range imaging sonar could accurately detect, and probably characterize as well, a manatee in the lock region. Attention focused instead on autonomous, comparatively low cost, methods that do not depend on the vigilance, training, and recognition memory of a human operator. These methods include field disturbance sensors, interrupted beam sensors, and ranging sensors. Field disturbance sensors employ a broad transmission and sense a change in the acoustic environment. Due to the movement of the gates, the presence and variety of barges and of boats, field disturbance sensors are unsuited for this application. Interrupted beam sensors, similar in nature to the electric eye sensors on garage doors, would detect the presence of a manatee between an acoustic source (transducer) and a receiver (hydrophone). Ranging sensors, similar to common fish finders, would detect the presence of a manatee based on the reflection (signal return) of the manatees body.

Operating Principle

Interrupted beam sensors can be continuous wave (modulated or unmodulated), or pulsed. Continuos wave sensors typically sense the presence of an obstruction by detecting a change in relative amplitude, a change in phase, or a combination of both. Problems with continuous wave sensors in the lock acoustic environment involve multipath effects resulting in signal interference. Solutions involve various modulation methods and the use of ultrasonic frequencies to increase attenuation. Pulsed interrupted beam sensors emit a short burst of sound at a fixed pulse repetition rate. This allows the receiver to be gated on only during the first reception of the pulse, reducing the effects of multipaths.

Sensor Demonstration

A simple emitter-detector pair was set up in a tank of water. The transducer was excited with continuos wave and pulsed repetition rate acoustic signals over the range 5 KHz- 500 KHz. Signals were received by a hydrophone placed 2 feet away from the transducer. The acoustic path was then interrupted by placing a hand or small block of foam in the middle between the transducer and hydrophone. The received hydrophone signal was observed with an oscilloscope. A delayed trigger, triggered off of the signal to the transducer, simulated a gated receiver. In the water tank used, multipaths resulted in poor performance below 100KHz for the pulsed transducer, and poor performance at all tested frequencies for the continuous wave demonstration.



Acoustic Emitter-Receiver Array Sensor

Evaluation Criteria

A working manatee acoustic emitter-receiver array sensor could be built, operating in the frequency range of 500 KHz to 10 MHz. A possible geometry would employ small, high frequency transducers, acting as both emitters and receivers, mounted in a string about 6" to 12" apart, along the edge of each gate.

- **Ruggedness / Reliability.** Due to the reliability of properly designed modern low power solid state electronics, not subjected to extremes of temperature, failure is expected to be the result of external factors. Submergence in fresh or salt water is not expected to pose a problem as long as the encapsulant remains intact. Impact from boats or barges could damage the transducers mechanically, by crushing, cracking, debonding electrical connections, or damaging the encapsulant, resulting in transducer failure. Lightning strikes are a particular hazard to the sensitive pre-amplifier electronics. Sedimentation, and biofouling in certain locations in particular, could degrade sensor performance. Each of the above concerns would have to be carefully addressed and verified by testing and field trials to meet the MTBF > 1.8M requirement.
- **Ease of Installation / Maintenance / Operation.** Modular design, incorporating simple bolt-on assemblies, would be used to limit down time and minimize diver effort in the installation and replacement of sensors. The shop repair of failed encapsulated components would be labor intensive due to the difficulties involved in digging assemblies out of the potting compound. Operation would be automatic, the system would be hardwired into the existing gate closure circuitry. Presence of a manatee between the doors would trip-out the gate closure and activated the alarm, requiring no operator intervention.

- **Cost.** Costs, particularly development costs, could be high. For best performance, a separate driver/receiver pre-amp package, in close proximity, would be required for each transducer. The development of the control, signal processing, discrimination, and decision making system would require significant effort, with the bulk of the work in coding.

APPENDIX J

The following comments are in response to correspondence received during the public review phase for the Environmental Assessment of the Manatee Protection Plan at Selected Navigation and Water Control Structures (Part II) in Central and Southern Florida. Comments are keyed numerically to the correspondence.

1. The Corps of Engineers feels that the environmental documentation for this project is sufficient.

2. No scientific evidence is available to date to confirm an increase in manatee population or that any ongoing manatee conservation methods should be halted. Because aerial and ground counts at winter refuges are highly variable depending on weather, water clarity, manatee behavior, and other factors, interpretation of analyses for temporal trends is difficult. Direct counting methods have been unable to account for uncertainty in the number of animals that may be away from refuges at a certain time, the number of animals not seen because of turbid waters, and other factors. As a result, there is no evidence that manatees are any less endangered or ongoing manatee conservation strategies should be halted. To the contrary, the record number of documented deaths in recent years remains a major impediment to the recovery of the species. In 1996, 415 manatee mortalities were reported which resulted in the highest number of manatee deaths ever recorded. This record was nearly twice the previous record of 214 manatee deaths in 1990. The increase was due to several causes: an epizootic event which claimed more than 150 manatee mortalities, as well as an unusually high number of boater associated deaths, and a near-record level of mortalities associated with flood control structures and navigation locks. Because manatee mortalities associated with locks and water control structures are the second leading cause of human-related manatee mortality, means to reduce these deaths are imperative. The purpose of this project is to reduce risk, injury, and mortality of the manatee which is listed as an endangered species in Florida.

3. Refer to comment response 2, above.

4. Integrated NEPA documentation is sufficient for this project. Integration is based on the CEQ provision to combine documents, which states that *"any environmental document in compliance with NEPA may be combined with any other agency document to reduce duplication and paperwork"* (40 CFR 1506.4). Sections in this integrated report that include NEPA-required discussions are marked with an asterisk in the Table of Contents. The designation of NEPA related sections was intended as a referencing tool.

5. Comment noted. Copies of this report have been forwarded to Congressmen Hastings and Goss. A scoping letter for this project was sent

out on June 3, 1993. Also, numerous news articles have been published in local newspapers about manatee protection efforts relating to this project to inform the public about this effort. Requests to be added to the mailing list for this project will be honored.

6. Refer to comment response 2, above.

7. Appendix C provides sufficient documentation concerning Project Operations: Manatee Protection Plan for Water Control Structures operated by the Jacksonville District U.S. Army Corps of Engineers.

8. The "No Action" alternative would not provide modifications to the water control structures for manatee protection; therefore, manatee moralities would continue to occur at water control structures. As stated in the letter from the Fish and Wildlife Service dated March 24, 1993, "the Service is convinced that these devices will be crucial to attainment of our goal of "zero mortality" from locks and other water control structures." Five additional sector gate structures which are owned and operated by the U.S. Army Corps of Engineers were included in this study due to the potential for manatee mortalities to occur or continue at these structures. The USACE as a federal agency is required by law to uphold the Endangered Species Act. There is no exemption process available under the existing law. The USACE is currently involved in an ongoing Section 7 consultation with the USFWS covering all aspects of the Manatee Protection Plan including testing phases on structures. Furthermore, the West Indian Manatee's status as listed by the USFWS is endangered. The USFWS Manatee Recovery Plan has identified a zero level mortality goal as being a vital component of this species' recovery. Therefore, an incidental take can not be granted to the USACE for the mortality events at water control and navigation structures. The agency has no choice but to do everything feasible to eliminate mortality at structures.

9. Potential problems requiring maintenance of each system are discussed for each device in the Description of Alternatives section. Table 2 summarizes the advantages and disadvantages of each manatee protection device evaluated. The advantages of the AMP piezo-electric acoustic ladder array system include rugged construction, high reliability, low maintenance, and ease of installation and operation. These advantages also apply to the back-up J-Seal contact sensor system. Future advancements in the technology of detection devices will also be incorporated in the selected manatee protection system.

10. Refer to comment response 9, above.

11. Refer to comment response 8, above.

12. The operation of gates with the hinge plate, hydraulic tube sensor, piezo electric film j-seal contact sensor and the piezo electric acoustic ladder array system are the same; therefore, there is no basis for the public being impacted differently by any particular device installed on the gates. During the Plans and Specifications Phase, the testing of the piezo electric film j-seal contact sensor and the piezo electric acoustic ladder array system will be necessary to determine their reliability and effectiveness. A phased implementation approach will allow the inclusion of further refinements or technical modifications before implementing the installation of protection devices on the remaining structures.

13. Refer to comment responses 9 and 12, above.

14. Refer to comment response 12, above. Due to manual overrides in the lock gate operation system, the gates will not become inoperable due to the failure of the manatee protection system. As a result, there will be no increase of navigation or flood control risk due to the manatee protection system.

15. Refer to comment response 14, above.

16. The report has been revised to state that the installation and maintenance of the manatee protection devices will be done during regularly scheduled maintenance periods (without additional down time) or with divers.

17. Refer to comment response 16, above.

18. Copies of this report have been forwarded to FIND.

19. Comment noted. Refer to comment response 16, above.

20. Comment noted. Refer to comment response 16, above.

21. Refer to comment response 14, above.

22. The Corps of Engineers feels that the need for an Environmental Impact Statement is unwarranted for this project. Coordination of an Environmental Assessment is sufficient to address the concerns raised by the general public. Upon completion of the review process, our Commander, Col. Rice, will make a determination as to whether or not there are significant environmental impacts.

23. The USACE as a federal agency is required by law to uphold the Endangered Species Act. There is no exemption process available under the existing law. The USACE is currently involved in an ongoing Section 7 consultation with the USFWS covering all aspects of the Manatee Protection Plan including testing phases on structures. Furthermore, the West Indian Manatee's status as listed by the USFWS is endangered. The USFWS Manatee Recovery Plan has identified a zero level mortality goal as being a vital component of this species' recovery. Therefore, an incidental take can not be granted to the USACE for the mortality events at water control and navigation structures. The agency has no choice but to do everything feasible to eliminate mortality at structures.

24. Refer to comment response 5, above.

25. Refer to comment response 14, above.

26. Comment noted. Because manatee mortalities associated with locks and water control structures are the second leading cause of human-related manatee mortality, means to reduce these deaths are imperative. The purpose of this project is to reduce risk, injury, and mortality of the manatee which is listed as an endangered species in Florida.

27. Refer to comment response 14, above.

28. Refer to comment response 14, above.

29. The Corps of Engineers feels that no conflicts will result in land use plans, policies, and controls for the study area. The entire project is located on existing C&SF Project lands owned by the State of Florida or U.S. Government.

30. Refer to comment responses 14 and 16, above. The Corps of Engineers feels that the minor inconvenience during installation and maintenance to boaters will not adversely affect public services and commerce.

31. Refer to comment responses 14 and 16, above. The Corps of Engineers feels that the minor inconvenience during installation and maintenance to boaters will not adversely affect public services. During the previous testing phases of this project at Port Mayaca, there were not any complaints expressed from the public due to this minor inconvenience.

32. Refer to comment responses 14 and 16, above.

33. The purpose of the list of preparers is to list individuals who prepared the report.

34. The USACE planning to propose the installation of a manatee protection system at Canaveral Lock under Section 1135(b) of the 1986 Water Resources Development Act (WRDA), as amended.

35. Additional details concerning testing of the manatee protection systems have been incorporated in the Final report. Additional specific details pertaining to testing of the devices will be included in the plans and specifications and testing phase of the devices.

36. Comment noted and incorporated in the Final report.

37. In 1982, these screens were specifically called manatee protection screens. Screens were installed in 1976, but they were likely called "trash screens" at that time. Despite this terminology, these screens have protected manatees since 1976.

38. Comment noted and incorporated in the Final report.

39. Comment noted and incorporated in the Final report.

40. Comment noted. Refer to comment response 16, above.

GERALD M. WARD, P.E.
Consulting Engineer
Coastal - Environmental
P.O. Box 10441
Riviera Beach, Florida 33419

VIA FEDERAL EXPRESS 10 January 1997
VIA FACSIMILE
904/232-1213

Office Location:
Suite 202
31 W 20th Street
Telephones:
561/863-1215
561/863-1216 FAX
E-Mail:
wardgm@gate.net

Colonel Terry Rice
District Engineer
US Army Corps of Engineers
400 West Bay Street
Jacksonville, Florida 32202

Re: **DRAFT MANATEE PROTECTION PLAN AT SELECTED NAVIGATION AND WATER CONTROL STRUCTURES IN CENTRAL AND SOUTHERN FLORIDA PART II - PROPOSED FINDING OF NO SIGNIFICANT IMPACT**

Dear Colonel Rice:

In addition to providing comments on the so-called Part II Plan or proposed FONSI enclosed with this letter, I have been talking this week with your Study Manager Amy Hill (Page 67) about the Environmental Document for Part I (See George M. Strain, Acting Chief, Planning Division memorandum of December 12, 1996, first paragraph). I have been advised that approval of such document has been accomplished, but, that no copies of the approved document are available. I would appreciate a copy of the Part I document and the reported modifications accomplished by higher authority including any approvals. If this request needs to be pursuant to the Freedom of Information Act, it is.

As indicated in my comments, I was initially very concerned about the Public Coordination process. After further thought and discussion with your staff I am extremely concerned that such process is being conducted without much concern for accuracy or understanding of the importance of involving the public. Please initiate a review of your Public Coordination process.

Very truly yours,

Gerald M. Ward

Gerald M. Ward, P.E.

9703COEA
Enclosure
cc: George M. Strain, Acting Chief Planning CESAJ-PD (232-2238)
Engineering & Technical Support, CESAD-ET-E (404/331-6716)
Division Engineer (404/331-6711) (404/331-1269 FAX)
Let Mon Lee, Project Manager, CECW-PE - HQ USACOE
Okeechobee Waterway Association
Association of Special Districts
Marine Industries Association of Florida, Inc.
Congressman Mark Foley
Congressman Alcee Hastings
Congressman Porter Goss

GERALD M. WARD, P.E.
Consulting Engineer
Coastal - Environmental
P.O. Box 10441
Riviera Beach, Florida 33419

Office Location:
Suite 202
31 W 20th Street
Telephones:
561/863-1215
561/863-1216 FAX
E-Mail:
wardgm@gate.net

VIA FEDERAL EXPRESS
VIA FACSIMILE
904/232-1213

10 January 1997

Colonel Terry Rice
District Engineer
US Army Corps of Engineers
400 West Bay Street
Jacksonville, Florida 32202

Re: DRAFT MANATEE PROTECTION PLAN AT SELECTED NAVIGATION AND WATER CONTROL STRUCTURES IN CENTRAL AND SOUTHERN FLORIDA
PART II - PROPOSED FINDING OF NO SIGNIFICANT IMPACT

Dear Sir:

Referenced document dated August 1996 (67 Pages with 10 Appendices) dealing in large part with the Corps of Engineers Okeechobee Waterway (OWW) has been reviewed with major disagreement as to your proposed languages and determination of no significant impact. The following issues or items are identified as points of major deficiencies:

PART II - FINDING OF NO SIGNIFICANT IMPACT

Second sentence, last phrase: If you will review the document closely, you will find almost no evaluation or statements evaluating the "impact on **human** environment". Either this Environmental Assessment needs to be rewritten to evaluate the substantial impacts on humans (in accord with NEPA) or needs to be elevated to the Environmental Impact Statement process.

The three draft reasons cited are inadequate in that sentences:

1. Citing the "signed FONSI for Phase I" does not provide clearance for the major impediments to navigation being proposed.

2. Choosing the least cost environmental action has not been shown to occur. Further, if you proceed with just what USFWS may desire then, you have not exhausted your administrative remedies, particularly including Exemption.

3. It is always interesting to see government rely on internal coordination. Coordination without full involvement of the public certainly biases your perspective. The Jacksonville District staff has become extremely focused on avoiding public input during project planning and environmental review. Often claiming full "coordination", but, hiding behind FOIA to obstruct the public's determination of where such process is going. Coordination with governmental and particularly environmental groups does not satisfy the law and regulation requirements.

SECTION I - INTRODUCTION

TITLE

In reality the last line of the Title should at least read ...IN **THE** CENTRAL AND SOUTHERN FLORIDA **PROJECT**... (See Authority)

1.1 AUTHORITY

Reading of the sole authority clearly indicates that Congress did 1
not accomplish the needed NEPA process, so accomplishment of environmental review is warranted.

1.2 STUDY PURPOSE

The last sentence on page 1 and the observation numbers of manatees for 22 years in only **portions** of Florida (partially cited within the report) clearly indicates that the Corps and its predecessors (State of Florida TIITF, Diston, the Everglades 2
Drainage District and the federal project(s) local sponsor(s), etc.) have greatly increased the manatee population within Florida and without question increased the marine (and freshwater) ecosystem habitat for manatees throughout the Central and Southern Florida project.

1.3 LIMITS OF STUDY SCOPE

Although you profess that this section is outside NEPA, it is not. The last paragraph, last sentence is particularly offensive 3
and totally not supported by the document or the facts. Strike the phrase "to prevent further decline and assist in the recovery of the manatee population". No decline has been shown, rather, increased population is evident.

1.6 NATIONAL ENVIRONMENTAL POLICY ACT REQUIREMENTS

The recognition of the provision of 40 CFR 1506.4 is admirable and should be publicized throughout your District, in as much as 4
numerous other District contemporary environmental documents are being promulgated as separate documents. As noted in 1.3 above, I do take issue that you may not limit (or pick and choose) which paragraphs that you consider NEPA related.

1.7 REPORT PARTICIPANTS AND COORDINATION

Nicely, and for the particular attention of the copied 5
Congressmen, you have in the first paragraph summarized that this is once again an agency created project of major dollars which is later shown by the statistics not to be of prime need. The 1993 or before Corps proposal should be included within Appendix J for future reference.

The third paragraph, demonstrates significant restriction on general public input. The Jacksonville District's process of targeting notice to principally groups or governments favorable to a concept substantially biases overall public input. This report's coordination notice is enclosed herewith as example and for incorporation within any action document you may produce.

The omission of organizations setup as representatives of major users of the Central and Southern Florida Project have never been copied. They are the Okeechobee Waterway Association and the Association of Special Districts. The first focuses on navigation issues and the second on flood control capacities. In reality the numerous Water Control Districts which discharge to the Okeechobee Waterway should be fully involved in the process.

SECTION 2 - PROBLEM IDENTIFICATION

2.1 EXISTING CONDITIONS

As the first full paragraph on Page 13 indicates a partial survey of manatee waters by aerial means was able to count in the mid-two thousand animal range. The US Fish & Wildlife own studies would indicate that only 1/3 to 7/12 of the manatees are even observed on these surveys for the area surveyed (See Ref. cite). As you describe, the majority of the lesser populated areas were not surveyed at all (mostly because of manpower and aircraft limitations). Particularly, difficult to aerial survey are the extensive undeveloped areas of Monroe County which have few landmarks for local reference during surveys (one mangrove tidal channel after another!). Documented increases in numbers of observed manatees is just one aspect of requiring the action to consider other alternatives rather than spending great quantities of money for minimal benefits. (6)

Second, the last sentence clearly reflects the District's lack of dollar appreciation. "Low cost" is not what is being recommended. I recognize that some District employees are biased by obtaining big dollars for a bigger empire, but, the mood of the public-at-large is not to continue such antics.

The bottom paragraph on Page 13, going on to Page 14 reflects two issues. First (based upon a conscious effort by lock tenders in the 1980's) you later have later observed that decreases in recoveries occurred in the past. You have failed to adequately investigate actual manatee behavioral patterns in the OWW. Obviously, if one of the structures has never recorded a recovery, yet 2450 manatees were documented over a 3 3/4 year period, then something different must be occurring at this structure.

SECTION 3 - **PLAN FORMULATION**

3.3 DESCRIPTION OF ALTERNATIVES

Operational modifications are not included within a separate category even though you clearly consider them to be crucial! Revision and inclusion of a fifth category of alternatives is mandated. (7)

3.3.1 Plan 1: No Action

A short dismissal of this action is not appropriate. The Authority by Congress appears intentionally limiting on what structures and what actions the Corps of Engineers is to accomplish. Only one (S-193) of the seven structures included in the Phase II Study is cited within the Authority (See Table 1., Page 4 for quick reference). How do you reconcile this? (8)

Further, given the Reason 2. cited in the FONSI statement the District Engineer is being asked to sign, you have not pursued the full Section 7 process, including Exemption, if the US Fish and Wildlife Service should disagree with No Action.

3.3.2 Plan 2: Pressure Sensitive Devices

The entire discussion of the three pressure devices indicates each was of potential use, however, only the third or latest concept was described without reference to adequate experience. (9)

3.3.3 Plan 3: Hydroacoustic Device Systems

As with most "display" electronic devices, cost and interpretation become an immediate factor. Almost completely un-discussed is the maintenance aspect of these systems. (10)

3.4. EVALUATION OF ALTERNATIVES

3.4.1 Plan 1: No Action

Without question you continue to give short dismissal for this action. Congress although giving authority for work only one of the seven proposed structures, clearly required you to go thorough the NEPA process of determining impact on the human environment. The No Action alternative (and a not evaluated Operational Modifications alternative) clearly continues to be a viable alternative. Completion of the Section 7 process and its appeal through the Exemption process is mandated. (11)

3.4.2 Plan 2: Pressure Sensitive Device Systems

The lead time (experience) of the first two concepts (Hinge-Plate Switch and Hydraulic-Tube Sensor) produced failures which appear to unduly bias the staff recommendation process. The discussion indicates that these two concepts do not impact the public to the (12) major degree as does the film sensor concept, but, also have mechanical properties which are already at a second generation level. The film sensor concept has no evaluation of electrical system longevity.

3.4.3 Plan 3: Hydroacoustic Device Systems

As noted above in 3.3.3, these systems are labor intensive and failure prone because of man inputs as well as expensive in first (13) cost. Maintenance is labor intensive both from the man-hours required as well as level of technician competence. Electronic parts are not cheap nor necessarily available over the expected life of the structure. In other words, other than probably good statistical censusing devices, they will not last.

3.3.4 Plan 4: Combined Pressure Sensitive Device System Hydroacoustic Device System

Selection of this alternative is both expensive in first cost and does not even consider the operational and maintenance costs to (14) the government as well as to the public in impediments in navigation and flood control risk. All of these direct costs and risks need to be incorporated into the document prior to any decision.

SECTION 4 - SELECTED PLAN

4.1 GENERAL

The selection of and installation of the acoustic ladder array as the primary system requires establishment of a disable procedure to assure that gate openings are not unreasonably restricted in (15) time by even simple failures such as blockage of two beams by either debris, water conditions or electrical failure. Under no circumstances should the gates become inoperative for more than a short time because of these types of failures. (Add into 4.4)

Selection of Plan 4 clearly inconveniences the waterway navigation users or increases the flood risks to discharge users.

4.2.1.2 Water Management Considerations

No mention is made of additional risk incurred for reduced flood (16) flows capabilities by the required dewatering of the structure for installation and undoubtedly some future maintenance.

4.2.1.3 Navigation Considerations

The words ", if possible" should be removed from the first sentence. The Jacksonville District's operational history of maintenance of navigation in the Okeechobee Waterway has been extremely poor. Scheduled downtime of structures has seldom been as scheduled. As a result, the waterway users have taken the first steps to progressively change the local sponsor such that eventually local districts will provide full operation and maintenance of the waterway. Although the Florida Inland Navigation District (FIND) is now the local sponsor only to the downstream of S-80, it is incumbent upon the Jacksonville District to fully involve the FIND in any shut down of the waterway. If dewatering is truly necessary, it should only be allowed during scheduled dewaterings. (17)

4.2.1.4 Contract Considerations

The last sentence of this paragraph needs to be rewritten. First, to include coordination with FIND as stated above. Second, to split off or eliminate whatever you are trying to say with the phrase beginning with "unless". (18)

4.2.1.5 Operation and Maintenance Considerations

The last sentence (top of Page 41) is not warranted in that no attempt has been made to quantity the costs and aggravation to the user public or the risks to the flood control users. (19)

4.2.1.8 Time of Construction

As is stated elsewhere this time out-of-service just for construction is an major imposition of the waterway users. (20)

4.4 OPERATION AND MAINTENANCE REQUIREMENT

As is particularly addressed in the comments on 4.1, this paragraph needs to be modified to clearly provide that the waterway users can not be inconvenienced by failures of these systems, if these proposals should go forward. (21)

4.6 ENVIRONMENTAL ASSESSMENT

I disagree with both proposed determinations a. and e. Determination a. has not exhausted its administrative process in considering all alternatives. Determination e. is without any evaluation of adverse impacts to the user human public. A Finding of No Significant Impact can not be made until both of these issues are addressed. The latter when reviewed more likely will require consideration of an Environmental Impact Statement. (22)

4.6.1.6 Endangered Species Act of 1973 as amended

Waiting until you have spent more money (a quarter of a million dollars (See Table A-1) above the half million for this report (See Table 4) is contrary to implementing regulations and other Memorandum of Understandings with the USF&WS/NMFS. Action should be taken now to rectify the Section 7 process. (23)

4.6.1.12 National Environmental Policy Act of 1969, as amended

The last paragraph further implies the absence of the public in the process. Compliance requires public review and comment not the limited dissemination omitting waterway users evident in the notice of December 12, 1996. (24)

SECTION 5 SUMMARY OF PROJECT EFFECTS

5.2 WATER MANAGEMENT

The second sentence needs to be re-emphasized (and as recommended added into 4.4). The third sentence is not backed up based upon risk analysis for structure utilization for maximum flood flows including emergency conditions. (25)

5.7 ENVIRONMENTAL EFFECTS

5.7.1 Affected Environment

The last paragraph (Page 55) should re-emphasize that without the Central & Southern Florida Flood Control Project and its predecessors this greatly expanded habitat would not be available to the manatee. (26)

5.7.1.3 Cultural, Historic and Archeological Resources

The last sentence, if retained, should be modified to clearly reflect that if ever included it should be "without any imposition on operation, maintenance, reconstruction or improvement by the owning agency." The letter reporting on coordination with the State Historic Preservation Officer (Appendix J) does not mention any designation of S-77! (27)

5.7.2 Environmental Consequences of Proposed Action

5.7.2.1 Unavoidable Adverse Effects

This one sentence statement is false. Major impediments and risks will result to the waterway users. Upon restudy and evaluation of the true effects to the waterway users revision to this paragraph should be evident in the EIS or revised EA. (28)

5.7.2.4 Possible Conflicts Between The Proposed Action and The Objectives of Federal, Regional, State and Local Land Use Plans, Policies, and Controls For The Study Area

Martin, Palm Beach, Hendry, Glades and Lee Counties all are trying to develop increased commerce (whether it be tourism, recreation or heavy industrial traffic) on the Okeechobee Waterway. To dismiss each of their Land Use Plans in the manner of two short sentences is unconsciousable. Land Use conflicts go beyond the physical property in which the Corps or the Water Management District have some interest in. 29

5.7.2.5 Community Growth, Cohesion and Displacement of People and Businesses

The EA has not once evaluated the damages done to even a small group of landowners and businessowners near the center of transportation/communications for South Florida in Martin County. Each segment of the Waterway needs substantial economic analysis for the damages to be caused by the dewatering option selected. Day-to-day inconvenience or damages have not been estimated. 30
To say ...There **will be no adverse effects** on the community or economy from the implementation of this project... is just plain false.

5.7.2.14 Public Facilities and Services

Likewise to say ... Public services provided by the canal systems and the locks **will not be adversely affected** by the project... is equally false. Seven structures estimated to be closed for one month per structure is major impact and damages. Even more ludicrous is the statement "Boaters will be routed through other canals and rivers while each structure is retrofitted." No other canals are available for five of the structures and no other river, except the so-called river of grass for airboats, is available. Just what does your sentence mean? 31

SECTIONS 6 - CONCLUSIONS AND SECTION 7 - RECOMMENDATIONS

Both need revision upon review of a further alternative and evaluation of the true impacts to the waterway users. 32

LIST OF PREPARERS (Page 67)

The list implies (hopefully because of simple omission) that the both the middle and upper management of the Jacksonville District has not participated in this draft document. The concept of providing a List of Preparers in a NEPA document was clearly implemented to establish a responsibility record. Please include the in-house management reviewers names. 33

Summary

Remand to the Jacksonville District Planning Division with a mandate to:

1) Additionally evaluate an Operational Modifications Alternative
2) accomplish Section 7 Coordination to possible exhaustion of the administrative process, including the Exemption process.
3) either accomplish an Environmental Impact Statement or completely update the Environmental Assessment to evaluate the impacts to the human environment, particularly the waterway users.
4) further and future re-coordination (and involvement!) to be with all waterway user entities and local governments. Such should include addressed notice distribution to all facilities on the Okeechobee Waterway from Fort Myers to Stuart. Include the Counties involved, Martin, Palm Beach, Hendry, Glades & Lee, not Dade County. Include Congressmen Hastings & Goss, who along with Foley these structures are in their Districts.

Please keep me informed as to just what you intend to do and are doing, with regard to this matter including all correspondence with higher authority.

Very truly yours,

Gerald M. Ward

9703MPWC

Gerald M. Ward, P.E.

Enclosure

cc: George M. Strain, Acting Chief Planning CESAJ-PD (232-2238)
Engineering & Technical Support, CESAD-ET-E (404/331-6716)
Division Engineer (404/331-6711) (404/331-1269 FAX)
South Atlantic Division
77 Forsyth Street, SW, Room 313
Atlanta, Georgia 30303
Let Mon Lee, Project Manager, CECW-PE
HQ USACOE
20 Massachusetts Avenue, NW Wash., D.C.20314
Okeechobee Waterway Association
Association of Special Districts
Marine Industries Association of Florida, Inc.
Congressman Mark Foley
Congressman Alcee Hastings
Congressman Porter Goss

Reference: Correction Factors for Observability of Manatees during Aerial Surveys - US Fish & Wildlife Service

Department of Environmental Protection

Lawton Chiles
Governor

Marjory Stoneman Douglas Building
3900 Commonwealth Boulevard
Tallahassee, Florida 32399-3000

Virginia B. Wetherell
Secretary

January 14, 1997

George M. Strain
Planning Division
Ecosystem Restoration Division
U.S. Army Corps of Engineers
Jacksonville, Florida 32232-019
Attn: CESAJ-PD-PR

RE: Draft report <u>Manatee Protection Plan at selected Navigation & Water Control Structures (Part II)</u>

Dear Mr. Strain:

Thank you for providing the above referenced draft report for our review. We concur with the approach proposed in the plan and are very pleased to see that the manatee/structure problem is being addressed by the USACE. We have the following comments:

It is understood that the Canaveral Locks in Brevard County are not a part of the Central & South Florida Project area. However, we encourage the USACE to pursue funding to retrofit this structure with manatee protection technology. The Canaveral Structure has been deadly to manatees in recent years, and from a risk stand point (level of manatee use X level of lock use) should actually have higher priority than some of the structures in the Central & South Florida area. 34

Testing the prototype as well as subsequent installations will be critical to the long term success. The types and frequency of tests as well as success criteria should be explained. For example, will some type of simulated manatee be used to test the acoustic array? Will a pressure gage be used to determine actual activation pressure when testing the J-seal piezo strip ? Will observational tests with manatees be pursued? Is there some level of error (either type 1 or type 2) that will be tolerated? These details should be included in the plan. 35

The remaining comments are minor editorial suggestions:

Page 13, paragraph 1 Change: "... by the FMRI in cooperation with the Florida 36

[illegible]

Department of Environmental Protection."
to:
"...by the Florida Department of Environmental Protection's Florida Marine Research Institute (FMRI)."

Page 15, paragraph 2. The dates listed for the installation of manatee protection screens are suspect, particularly the date of 1976 for Moore Haven. There had been no formal recommendation from DEP or FWS to the USACE to install these barriers at that time. If screens were in fact installed, it is likely they were for the purpose of keeping trash out and not the stated purpose of protecting manatees. 37

Page 2 of the CESAJ SOP mentions FDNR. It should reference FDEP. 38

Table 1a. The column reads " Total; Manatee Deaths". This is misleading. There have actually been many more manatees deaths recorded near these structures. The numbers given are only for those that were confirmed to have been killed by the structure. We suggest changing column heading to "Total structure-caused manatee deaths". 39

We appreciate the opportunity to review this document and will continue to work closely with the USACE to resolve the manatee/structure problem.

Sincerely,

DIVISION OF MARINE RESOURCES

R. Kipp Frohlich
Biological Administrator III
Protected Species Management

rkf\data\doc\structures0114.ltr

Okeechobee Waterway Association

canalgail@aol.com

(561) 287-7033
FAX (561) 287-9399

4968 S.E. Dixie Highway
Stuart, Florida 34997

January 7, 1997

Mrs. Amy Houser FAX (904) 232-1888
Ecosystems Restoration Section
U.S. Army Corps of Engineers
P.O. Box 497
Jacksonville, Fl. 32232-0019

Re: Draft Manatee Protection Plan at Selected Navigation and Water Control Structures in Central & Southern Florida Part II - Proposed Finding of No Significant Impact [FONSI]

As discussed today, the Okeechobee Waterway Association would like to be copied with the reports you are preparing, and most importantly would appreciate the opportunity for commenting. I understand that as of today the comment time frame is until January 3., 1997. We request an extension of this time.

The USACOE schedule of lock closings for maintenance has recently been streamlined with public input from across the State. Budget restraints cause periodic closings of one lock at a time. Even with this improved schedule and adaptation of subcontracts there are continual interruptions of unexpected events causing delays. If necessary, we will attempt to prove the economic impact of lock closings. **Closing one lock closes down the Canal across-State.** 40

We are very interested in the testing and possibilities for a device to show manatee presence, it's cost, and potential to prevent manatee deaths. We are familiar with Harbor Branch which is located closeby. Please keep us informed. Thank you for your time today.

Yours truly

Gail A. Byrd, Treasurer

cc: Congressman Mark Foley
John P. Milam, USACOE
Wm. Guy, Jr., Pres. Marine Industries Assoc. of Florida
Michael Kiefer, Pres. Marine Industries Assoc. of Treasure Coast
Robert Cooley, Pres. SW Florida Marine Trades
Gerald M. Ward, P.E.

FLORIDA DEPARTMENT OF STATE
Sandra B. Mortham
Secretary of State
DIVISION OF HISTORICAL RESOURCES

January 29, 1997

Mr. George M. Strain
Planning Division
Ecosystem Restoration Section
Department of the Army
Jacksonville District Corps of Engineers
P. O. Box 4970
Jacksonville, Florida 32232-0019

In Reply Refer To:
Robin D. Jackson
Historic Sites Specialist
(904) 487-2333
Project File No. 965315

RE: Cultural Resource Assessment Request
Manatee Protection Plan at Selected Navigation & Water Control Structures (Part II) in Central and Southern Florida

Dear Mr. Strain:

In accordance with the procedures contained in 36 C.F.R., Part 800 ("Protection of Historic Properties"), we have reviewed the referenced project(s) for possible impact to historic properties listed, or eligible for listing, in the National Register of Historic Places. The authority for this procedure is the National Historic Preservation Act of 1966 (Public Law 89-665), as amended.

It is the opinion of this agency that because of the project nature it is considered unlikely that archaeological or historical sites will be affected. Therefore, it is the opinion of this office that the proposed project will have no effect on any sites listed, or eligible for listing in the National Register. The project may proceed without further involvement with this agency.

If you have any questions concerning our comments, please do not hesitate to contact us. Your interest in protecting Florida's historic properties is appreciated.

Sincerely,

Laura L. Kammerer
for George W. Percy, Director
Division of Historical Resources
and
State Historic Preservation Officer

GWP/Jrj

South
Florida
Regional
Planning
Council

January 9, 1997

Col. Terry L. Rice
Department of the Army
Jacksonville District Corps of Engineers
P.O. Box 4970
Jacksonville, Florida 32232-0019

RE: SFRPC #96-1214 - Response to the U.S. Army Corps of Engineers request for comments on the Manatee Protection Plan at selected navigation and water control structures, U.S. Army Corps of Engineers, Florida.

Dear Col. Rice:

We have reviewed the above-referenced plan and have the following comments:

- Council staff supports the implementation of the plan for the purpose of preventing structure caused manatee deaths. The West Indian manatee is identified as a Natural Resource of Regional Significance in the *Strategic Regional Policy Plan for South Florida (SRPP)*. A description of this designation is illustrated in Chapter IV(3) - Natural Resources of Regional Significance, Appendix 4 - List of Significant Regional Resources and Facilities and Appendix 5 - Maps and Descriptions of Natural Resources of Regional Significance. Specifically, the Manatee Protection Plan will further the following goals and policies of the *SRPP:*

Strategic Regional Goal

3.1 Eliminate the inappropriate uses of land by improving the land use designations and utilize land acquisition where necessary so that the quality and connectedness of Natural Resources of Regional Significance and suitable high quality natural areas is improved.

Regional Policies

3.1.1 Natural Resources of Regional Significance and other suitable natural resources shall be preserved and protected. Mitigation for unavoidable impacts will be provided either on-site or in identified regional habitat mitigation areas with the goal of providing the highest level of resource value and function for the regional system. Endangered faunal species habitat and populations documented on-site shall be preserved on-site. Threatened faunal species and populations and species of special concern documented on-site, as well as critically imperiled, imperiled and rare plants shall be preserved on-site unless it is demonstrated that off-site mitigation will not adversely impact the viability or number of individuals of the species.

3.1.9 Degradation or destruction of Natural Resources of Regional Significance, including listed species and their habitats will occur as a result of a proposed project only if :

a) the activity is necessary to prevent or eliminate a public hazard, and
b) the activity is in the public interest and no other alternative exists, and

3440 Hollywood Boulevard, Suite 140, Hollywood, Florida 33021
Broward (954) 985-4416, Area Codes 305 and 561 (800) 985-4416
SunCom 473-4416, FAX (954) 985-4417, SunCom FAX 473-4417
e-mail sfadmin@sfrpc.com

c) the activity does not destroy significant natural habitat, or identified natural resource values, and
d) the activity does not destroy habitat for threatened or endangered species, and
e) the activity does not negatively impact listed species that have been documented to use or rely upon the site.

Regional Policies

3.4.4 Require the use of ecological studies and site and species specific surveys in projects that may impact natural habitat areas to ensure that rare and state and federally listed plants and wildlife are identified with respect to temporal and spatial distribution.

3.4.5 Identify and protect the habitats of rare and state and federally listed species. For those rare and threatened species that have been scientifically demonstrated by past or site specific studies to be relocated successfully, without resulting in harm to the relocated or receiving populations, and where *in-situ* preservation is neither possible nor desirable from an ecological perspective, identify suitable receptor sites, guaranteed to be preserved and managed in perpetuity for the protection of the relocated species that will be utilized for the relocation of such rare or listed plants and animals made necessary by unavoidable project impacts. Consistent use of the site by endangered species, or documented endangered species habitat on-site shall be preserved on-site.

Strategic Regional Goal

3.8 Enhance and preserve natural system values of South Florida's shorelines, estuaries, benthic communities, fisheries, and associated habitats, including but not limited to, Florida Bay, Biscayne Bay and the coral reef tract.

Regional Policy

3.8.5 Enhance and preserve habitat for endangered and threatened marine species by the preservation of identified endangered species habitat and populations. For threatened species or species of critical concern, on-site preservation will be required unless it is demonstrated that off-site mitigation will not adversely impact the viability or number of individuals of the species.

Thank you for the opportunity to comment. We would appreciate being kept informed on the progress of this plan. Please do not hesitate to call if you have any questions or comments.

Sincerely,

Eric Silva
Regional Planner

ES/cp

cc: Ralph Cantral, FCMP
Michael Wanchick, Broward County
Guillermo E. Olmedillo, Dade County
Timothy McGarry, Monroe County

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 4
ATLANTA FEDERAL CENTER
100 ALABAMA STREET, S.W.
ATLANTA, GEORGIA 30303-3104

District Engineer, Jacksonville
P.O. Box 4970
Jacksonville, FL 32232

Attn: Mr. George M. Strain (CESAJ-PD-PR)
Chief, Planning Division

Subject: Environmental Assessment (EA) and Finding of No Significant Impact (FONSI) for Modifications to Seven Navigation and Water Control Structures (Central and Southern Region) in an Effort to Protect the Florida Manatee

Dear Sir:

Pursuant to Section 309 of the Clean Air Act, EPA, Region 4 has reviewed the subject document which discusses the consequences of retrofitting manatee detection devices on the sector gates at the noted navigation facilities. It is anticipated that these hydracoustic and pressure sensitive devices will offer protection to manatees traversing from either upstream or downstream locations. Specifically, they are designed to immediately stop the gates when an object is detected within the arc of the closing gates. The system will be tested, evaluated, and implemented in a phased approach at the seven structures to ensure it is working properly and/or if additional modification is necessary.

From the background information in the EA we do not foresee any adverse impacts to the natural environment resulting from the proposed gate modifications; moreover, it appears that their use will significantly reduce manatee mortality from locking operations. Therefore, we have no objections to the use of an EA as the evaluation model rather than the more comprehensive environmental impact statement format.

Thank you for the opportunity to comment on this action. If we can be of further assistance in this matter, Dr. Gerald Miller (404-562-9626) will serve as initial point of contact.

Sincerely,

Heinz J. Mueller, Chief
Office of Environmental Assessment

United States Department of the Interior

OFFICE OF THE SECRETARY
OFFICE OF ENVIRONMENTAL POLICY AND COMPLIANCE
Richard B. Russell Federal Building
75 Spring Street, S.W.
Atlanta, Georgia 30303

January 24, 1997

ER-96/801

Mr. George M. Strain
Acting Chief, Planning Division
ATTN: CESAJ-PD-PR
Jacksonville District Corps of Engineers
P. O. Box 4970
Jacksonville, Florida 32232-0019

Dear Mr. Strain:

The Department of the Interior has reviewed the Manatee Protection Plan at Selected Navigation & Water Control Structures (Part II) in Central and Southern Florida: Draft Integrated Project Modification Report and Environmental Assessment, dated August 1996, as requested. The plan includes proposed modifications to selected Okeechobee Waterway and Central and Southern Florida navigation locks and water control structures for the purpose of protecting the Florida manatee during lock and water control structure operations.

The Fish and Wildlife Service's Manatee Recovery Coordinator and South Florida Ecosystem Field Office have concluded that the proposed modifications and supportive environmental assessment are consistent with efforts to reduce and eliminate manatee mortality associated with these structures. The Corps' plan selection process was thorough and the proposal to selectively test planned modifications prior to installation at all sites should ensure the effectiveness of these measures.

The Fish and Wildlife Service looks forward to continuing to work with you on this important project. Thank you for the opportunity to comment.

Sincerely,

James H. Lee

James H. Lee
Regional Environmental Officer

STATE OF FLORIDA
DEPARTMENT OF COMMUNITY AFFAIRS

EMERGENCY MANAGEMENT • HOUSING AND COMMUNITY DEVELOPMENT • RESOURCE PLANNING AND MANAGEMENT

LAWTON CHILES
Governor

February 20, 1997

JAMES F. MURLEY
Secretary

Mr. A. J. Salem
Department of the Army
Jacksonville District Corps of Engineers
Post Office Box 4970
Jacksonville, Florida 32232-0019

RE: U.S. Department of the Army - Endangered Species Protection - Manatee Protection Plan at Selected Navigation and Water Control Structures (Part 2) - Draft Integrated Project Modification Report and Environmental Assessment - Central and Southern Florida
SAI: FL9505080422CR

Dear Mr. Salem:

The Florida State Clearinghouse, pursuant to Presidential Executive Order 12372, Gubernatorial Executive Order 95-359, the Coastal Zone Management Act, 16 U.S.C. §§ 1451-1464, as amended, and the National Environmental Policy Act, 42 U.S.C. §§ 4321, 4331-4335, 4341-4347, as amended, has coordinated a review of the above-referenced project.

The Department of Environmental Protection (DEP) offers general comments regarding retrofitting priorities, as well as several editorial suggestions. Please refer to the enclosed DEP comments.

Based on the information contained in the environmental assessment and the enclosed comments provided by our reviewing agencies, the state has determined that the above-referenced project is consistent with the Florida Coastal Management Program.

Thank you for the opportunity to review this project. If you have any questions regarding this letter, please contact Ms. Keri Akers, Clearinghouse Coordinator, at (904) 922-5438.

Sincerely,

Chris McCay

for Ralph Cantral, Executive Director
Florida Coastal Management Program

RC/cc

Enclosures

cc: Jim Wood, Department of Environmental Protection

Department of Environmental Protection

Marjory Stoneman Douglas Building
3900 Commonwealth Boulevard
Tallahassee, Florida 32399-3000

Lawton Chiles
Governor

Virginia B. Wetherell
Secretary

January 27, 1997

Keri Akers
State Clearinghouse
Department of Community Affairs
2555 Shumard Oak Boulevard
Tallahassee, Florida 32399-2100

RE: COE/Draft Integrated Project Modification Report and Environmental Assessment, Manatee Protection Plan at Selected Navigation and Water Control Structures (Part II) in Central and Southern Florida
SAI: FL9505080422CR

Dear Ms. Akers:

The Department of Environmental Protection has completed its review of the Corps of Engineers' Manatee Protection Plan (Part II). Based upon the information provided, the proposed activities are consistent with the Department's authorities in the Florida Coastal Management Program. The Bureau of Protected Species Management (BPSM) in the Department's Division of Marine Resources, which has coordinated closely with the Corps during the development of this plan, offers the following comments:

It is understood that the Canaveral Locks in Brevard County are not a part of the Central & South Florida Project area. However, we encourage the Corps to pursue funding to retrofit this structure with manatee protection technology. The Canaveral Structure has been deadly to manatees in recent years, and from a risk standpoint (level of manatee use X level of lock use) should actually have higher priority than some of the structures in the Central & South Florida area.

Testing the prototype as well as subsequent installations will be critical to the long term success. The types and frequency of tests as well as success criteria should be explained. For example, will some type of simulated manatee be used to test the acoustic array? Will a pressure gage be used to determine actual activation pressure when testing the J-seal piezo strip? Will observational tests with manatees be pursued? Is there some level of error (either type 1 or type 2) that will be tolerated? These details should be included in the plan.

The remaining comments are minor editorial suggestions:

Page 13, paragraph 1. Change: "... by the FMRI in cooperation with the Florida Department of Environmental Protection" to "...by the Florida Department of Environmental Protection's Florida Marine Research Institute (FMRI)."

Page 15, paragraph 2. The dates listed for the installation of manatee protection screens are suspect, particularly the date of 1976 for Moore Haven. There had been no formal recommendation from DEP or FWS to the USACE to install these barriers at that time. If screens were in fact installed, it is likely they were for the purpose of keeping trash out and not the stated purpose of protecting manatees.

Page 2 of Appendix C (CESAJ SOP) mentions FDNR. It should reference FDEP.

Table 1a. in Appendix G has a column which reads "Total Manatee Deaths." This is misleading as there have actually been many more manatees deaths recorded near these structures. The numbers given are only for those that were confirmed to have been killed by the structure. We suggest changing the column heading to "Total Structure-caused Manatee Deaths."

The Department appreciates the opportunity to review this plan. If I may be of further assistance, please contact me at (904) 487-2231.

Sincerely,

Jim Wood
Environmental Specialist
Office of Intergovernmental Programs

/jw

cc: Fritz Wettstein, Marine Resources
Kipp Frohlich, Marine Resources

COUNTY: Manatee/ 5

Message:

DATE:	12/23/96
COMMENTS DUE-2 WKS:	01/06/97
CLEARANCE DUE DATE:	02/06/97
SAI#:	FL9505080422

STATE AGENCIES	WATER MANAGEMENT DISTRICTS	OPB POLICY UNITS
Commerce Community Affairs Environmental Protection X Game and Fresh Water Fish Comm Marine Fisheries Commission State Transportation	South Florida WMD Southwest Florida WMD St. Johns River WMD	Environmental Policy/C & ED

RECEIVED JAN 08 1997 State of Florida Clearinghouse

RECEIVED BY GFC JAN 06 1997 OFFICE OF ENVIRONMENTAL SERVICES

RECEIVED BY GFC DEC 26 1996 OFFICE OF ENVIRONMENTAL SERVICES

The attached document requires a Coastal Zone Management Act/Florida Coastal Management Program consistency evalutation and is categorized as one of the following:

___ Federal Assistance to State or Local Government (15 CFR 930, Subpart F). Agencies are required to evaluate the consistency of the activity.

_X_ Direct Federal Activity (15 CFR 930, Subpart C). Federal Agencies are required to furnish a consistency determination for the State's concurrence or objection.

___ Outer Continental Shelf Exploration, Development or Production Activities (15 CFR 930, Subpart E). Operators are required to provide a consistency certification for state concurrence/objection.

___ Federal Licensing or Permitting Activity (15 CFR 930, Subpart D). Such projects will only be evaluated for consistency when there is not an analogous state license or permit.

Project Description:

Department of the Army - Manatee Protection Plan At Selected Navigation and Water Control Structures (Part 2) In Central and Southern Florida - Draft Integrated Project Modification Report and Environmental Assessment - Florida.

NJ

To: **Florida State Clearinghouse**
Department of Community Affairs
2555 Shumard Oak Boulevard
Tallahassee, FL 32399-2100
(904) 922-5438 (SC 292-5438)
(904) 487-2899 (FAX)

EO. 12372/NEPA

- [x] No Comment
- [ ] Comments Attached
- [ ] Not Applicable

Federal Consistency

- [ ] No Comment/Consistent
- [ ] Consistent/Comments Attached
- [ ] Inconsistent/Comments Attached
- [ ] Not Applicable

RECEIVED JAN 0 2 1997

From:

Division/Bureau: FG+FWFC - OES - Vero Beach, FLA.

Reviewer: Stephen R. Lau [illegible]

Date: January 3, 1996

COUNTY: Manatee

Message:

DATE:	12/23/96
COMMENTS DUE-2 WKS:	01/06/97
CLEARANCE DUE DATE:	02/06/97
SAI#:	FL9505080422C

STATE AGENCIES	WATER MANAGEMENT DISTRICTS	OPB POLICY UNITS
Commerce Community Affairs Environmental Protection Game and Fresh Water Fish Comm X Marine Fisheries Commission State Transportation RECEIVED DEC 26 1996 MARINE FISHERIES COMMISSION	South Florida WMD Southwest Florida WMD St. Johns River WMD	Environmental Policy/C & ED RECEIVED JAN 06 1997 State of Florida Clearinghouse

The attached document requires a Coastal Zone Management Act/Florida Coastal Management Program consistency evalutation and is categorized as one of the following:

___ Federal Assistance to State or Local Government (15 CFR 930, Subpart F). Agencies are required to evaluate the consistency of the activity.

_X_ Direct Federal Activity (15 CFR 930, Subpart C). Federal Agencies are required to furnish a consistency determination for the State's concurrence or objection.

___ Outer Continental Shelf Exploration, Development or Production Activities (15 CFR 930, Subpart E). Operators are required to provide a consistency certification for state concurrence/objection.

___ Federal Licensing or Permitting Activity (15 CFR 930, Subpart D). Such projects will only be evaluated for consistency when there is not an analogous state license or permit.

Project Description:

Department of the Army - Manatee Protection Plan At Selected Navigation and Water Control Structures (Part 2) In Central and Southern Florida - Draft Integrated Project Modification Report and Environmental Assessment - Florida.

To: **Florida State Clearinghouse**
Department of Community Affairs
2555 Shumard Oak Boulevard
Tallahassee, FL 32399-2100
(904) 922-5438 (SC 292-5438)
(904) 487-2899 (FAX)

EO. 12372/NEPA

☐ No Comment
☐ Comments Attached
☐ Not Applicable

Federal Consistency

☐ No Comment/Consistent
☐ Consistent/Comments Attached
☐ Inconsistent/Comments Attached
☒ Not Applicable

From:
Division/Bureau: MARINE FISHERIES COMMISSION, 2540 EXECUTIVE CENTER CIRCLE WEST, SUITE 106, TALLAHASSEE, FLORIDA 32301
Reviewer: [signature]
Date: 1-2-97

COUNTY: Manatee

Message:

DATE: 12/23/96
COMMENTS DUE-2 WKS: 01/06/97
CLEARANCE DUE DATE: 02/06/97
SAI#: FL9505080422(

STATE AGENCIES	WATER MANAGEMENT DISTRICTS	OPB POLICY UNITS
Commerce Community Affairs Environmental Protection Game and Fresh Water Fish Comm Marine Fisheries Commission X State Transportation	South Florida WMD Southwest Florida WMD St. Johns River WMD OK RECEIVED JAN 10 1997 State of Florida Clearinghouse	Environmental Policy/C & ED MANATEE SAI-EA·CORPS XIMI:951770 965233

The attached document requires a Coastal Zone Management Act/Florida Coastal Management Program consistency evalutation and is categorized as one of the following:

___ Federal Assistance to State or Local Government (15 CFR 930, Subpart F). Agencies are required to evaluate the consistency of the activity.

_X_ Direct Federal Activity (15 CFR 930, Subpart C). Federal Agencies are required to furnish a consistency determination for the State's concurrence or objection.

___ Outer Continental Shelf Exploration, Development or Production Activities (15 CFR 930, Subpart E). Operators are required to provide a consistency certification for state concurrence/objection.

___ Federal Licensing or Permitting Activity (15 CFR 930, Subpart D). Such projects will only be evaluated for consistency when there is not an analogous state license or permit.

Project Description:

Department of the Army - Manatee Protection Plan At Selected Navigation and Water Control Structures (Part 2) In Central and Southern Florida - Draft Integrated Project Modification Report and Environmental Assessment - Florida.

To: **Florida State Clearinghouse**
Department of Community Affairs
2555 Shumard Oak Boulevard
Tallahassee, FL 32399-2100
(904) 922-5438 (SC 292-5438)
(904) 487-2899 (FAX)

EO. 12372/NEPA

- [x] No Comment
- [ ] Comments Attached
- [ ] Not Applicable

Federal Consistency

- [x] No Comment/Consistent
- [ ] Consistent/Comments Attached
- [ ] Inconsistent/Comments Attached
- [ ] Not Applicable

RECEIVED
DEC 2 ? 1996
COMPLIANCE & REVIEW SECTION

From:
Division/Bureau: Division of Historical Resources
Reviewer: [signature] Laura L. Kammerer
Date: 1/7/97 1-7-97

COUNTY: Manatee

Message:

DATE: 12/23/96
COMMEN... DUE-2 WKS: 01/06/97
CLEARANCE DUE DATE: 02/06/97
SAI#: FL9505080422CF

STATE AGENCIES	WATER MANAGEMENT DISTRICTS	OPB POLICY UNITS
Commerce Community Affairs Environmental Protection Game and Fresh Water Fish Comm Marine Fisheries Commission State X Transportation	South Florida WMD Southwest Florida WMD St. Johns River WMD	Environmental Policy/C & ED

The attached document requires a Coastal Zone Management Act/Florida Coastal Management Program consistency evalutation and is categorized as one of the following:

___ Federal Assistance to State or Local Government (15 CFR 930, Subpart F). Agencies are required to evaluate the consistency of the activity.

_X_ Direct Federal Activity (15 CFR 930, Subpart C). Federal Agencies are required to furnish a consistency determination for the State's concurrence or objection.

___ Outer Continental Shelf Exploration, Development or Production Activities (15 CFR 930, Subpart E). Operators are required to provide a consistency certification for state concurrence/objection.

___ Federal Licensing or Permitting Activity (15 CFR 930, Subpart D). Such projects will only be evaluated for consistency when there is not an analogous state license or permit.

Project Description:

Department of the Army - Manatee Protection Plan At Selected Navigation and Water Control Structures (Part 2) In Central and Southern Florida - Draft Integrated Project Modification Report and Environmental Assessment - Florida.

To: **Florida State Clearinghouse**
Department of Community Affairs
2555 Shumard Oak Boulevard
Tallahassee, FL 32399-2100
(904) 922-5438 (SC 292-5438)
(904) 487-2899 (FAX)

EO. 12372/NEPA

- [x] No Comment
- [ ] Comments Attached
- [ ] Not Applicable

Federal Consistency

- [x] No Comment/Consistent
- [ ] Consistent/Comments Attached
- [ ] Inconsistent/Comments Attached
- [ ] Not Applicable

From:
Division/Bureau: Environmental Management Office
Reviewer: Gary Evink
Date: 1/2/97

COUNTY: ~~Manatee~~

Message:

DATE: 12/23/96
COMMENTS DUE-2 WKS: 01/06/97 06
CLEARANCE DUE DATE: 02/06/97 12
SAI#: FL9505080422C

STATE AGENCIES	WATER MANAGEMENT DISTRICTS	OPB POLICY UNITS
Commerce Community Affairs Environmental Protection Game and Fresh Water Fish Comm Marine Fisheries Commission State Transportation	South Florida WMD Southwest Florida WMD X St. Johns River WMD RECEIVED JAN 09 1997 State of Florida Clearinghouse	Environmental Policy/C & ED DEC 26 1996

The attached document requires a Coastal Zone Management Act/Florida Coastal Management Program consistency evalutation and is categorized as one of the following:

___ Federal Assistance to State or Local Government (15 CFR 930, Subpart F). Agencies are required to evaluate the consistency of the activity.

_X_ Direct Federal Activity (15 CFR 930, Subpart C). Federal Agencies are required to furnish a consistency determination for the State's concurrence or objection.

___ Outer Continental Shelf Exploration, Development or Production Activities (15 CFR 930, Subpart E). Operators are required to provide a consistency certification for state concurrence/objection.

___ Federal Licensing or Permitting Activity (15 CFR 930, Subpart D). Such projects will only be evaluated for consistency when there is not an analogous state license or permit.

Project Description:

Department of the Army - Manatee Protection Plan At Selected Navigation and Water Control Structures (Part 2) In Central and Southern Florida - Draft Integrated Project Modification Report and Environmental Assessment - Florida.

To: Florida State Clearinghouse
Department of Community Affairs
2555 Shumard Oak Boulevard
Tallahassee, FL 32399-2100
(904) 922-5438 (SC 292-5438)
(904) 487-2899 (FAX)

EO. 12372/NEPA

- ☐ No Comment
- ☐ Comments Attached
- ☐ Not Applicable

Federal Consistency

- ☒ No Comment/Consistent
- ☐ Consistent/Comments Attached
- ☐ Inconsistent/Comments Attached
- ☐ Not Applicable

Not in our District

From:

Division/Bureau: Policy and Planning

Reviewer: Margaret H. Spontak

Date: 1/7/97

United States Department of the Interior

FISH AND WILDLIFE SERVICE
P.O. Box 2676
Vero Beach, Florida 32961-2676

IN REPLY REFER TO:

July 1, 1996

Mr. A. J. Salem
Chief, Planning Division
Jacksonville District
U.S. Army Corp of Engineers
P.O. Box 4970
Jacksonville, Florida 32232-0019

Attn: Elmar Kurzbach

Dear Mr. Salem:

The U.S. Fish and Wildlife Service (FWS) has reviewed the information submitted by the U.S. Army Corps of Engineers (COE) on May 28, 1996, concerning the Manatee Protection at Water Control Structures study and the Acoustic Ladder Array to be tested at Port Mayaca Lock in Martin County. As part of our continuing informal section 7 consultation, we are providing the following comments in accordance with the Endangered Species Act of 1973, as amended (16 U.S.C. 1531 et seq.). We have assigned FWS Log Number 4-1-96-424 to this consultation.

The proposed action involves the development and testing of an Acoustic Ladder Array at the Port Mayaca Lock. The Acoustic Ladder Array is intended to detect the endangered West Indian manatee (*Trichechus manatus latirostris*) in the critical zone of the lock before the gates come in contact with the manatee. The Acoustic Ladder Array involves an emitter-detector pair that emits intact beams in a frequency outside the hearing range of the manatee. When one or more of these beams are interrupted, the gate closure will reverse, thereby avoiding contact with the manatee.

Water control locks have taken a toll on manatees, and the FWS supports any efforts to reduce the number of deaths. The Acoustic Ladder Array appears to be an encouraging method to use for detecting manatees in the critical zone of the locks. Therefore, the FWS has concluded that the proposed Phase One test at the Port Mayaca Lock is not likely to adversely affect the manatee.

We look forward to continuing work with the COE as you develop the Acoustic Ladder Array and test the device at Port Mayaca. Please provide us with the results of the test.

Thank you for the opportunity to comment on this project. If you have any questions regarding this matter, please contact Diane Bowen at (407) 562-3909.

Sincerely yours,

Craig Johnson
Supervisor, South Florida Ecosystem Office

cc:
FDEP (OPSM), Tallahassee, FL
FWS, Jacksonville, FL

MANATEE PROTECTION AT WATER CONTROL STRUCTURES

Fish and Wildlife
Coordination Act Report

Prepared by:

Department of the Interior
U.S. Fish and Wildlife Service
Jacksonville Field Office
Jacksonville, Florida

U.S. Fish and Wildlife Service
Southeast Region
Atlanta, Georgia

November, 1994

TABLE OF CONTENTS

1.0 Introduction

The West Indian manatee (*Trichechus manatus latirostris*) is an endangered species protected under the Endangered Species Act of 1973, as amended (Act). The Act promotes actions necessary to recover endangered species. Actions specific to manatees are outlined in the "Florida Manatee (*Trichechus manatus latirostris*) Recovery Plan" (Plan) (U.S. Fish and Wildlife Service, 1989). The Plan delineates and schedules actions necessary to restore the manatee as a "viable self-sustaining element of its ecosystem".

To document causes of manatee mortality in Florida, a manatee carcass recovery program was initiated in 1974 (O'Shea *et al.* 1985). This program identified the various ways by which manatees die and demonstrated that a significant number of manatees die as a result of human activities. Between 1974 and 1992, 2074 manatee deaths were documented; 673 (or 32.4%) died from human-related causes. The majority of these deaths were caused by watercraft (522). The second highest source of human-related manatee mortality was attributable to water control structures (89) (Ackerman *et al.*, 1994).

The Plan promotes the recovery of the manatee through actions which will result in the reduction of manatee mortality and the protection of manatee habitat. Task 13 specifically seeks to minimize manatee mortality caused by water control structures. Efforts to reduce this source of mortality began in 1979 when the U.S. Fish and Wildlife Service (Service), the U.S. Army Corps of Engineers (Corps), the South Florida Water Management District (SFWMD) and the University of Miami met to review these deaths and to make recommendations by which to reduce these mortalities (Oberheu, 1979). A task force was developed as a result of these efforts. The task force reviews water control structure-related deaths and develops and implements strategies to reduce such mortality.

The Corps is an active member of the interagency task force and participates in the development and implementation of manatee protection strategies at water control structures. The Corps is currently involved in a study authorized under Section 1135(b) of the Water Resources Development Act of 1986, as amended. The study seeks "to design manatee protective structures or operational modifications at selected navigation locks and water control structures in the Okeechobee Waterway and Central and Southern Florida Flood Control Projects" (Salem, 1994). (Table 1).

This Fish and Wildlife Coordination Act Report summarizes information about manatee use of waterways regulated by water control structures and reviews water control structure-related manatee mortality and methods by which to minimize mortality.

NOTE: Since submittal of this report, the study authorization has changed. This report is in partial response to authorization and appropriations provided in the Energy and Water Development Appropriations Act of 1994 (P.L. 103-126).

Table 1.

Section 1135 Manatee Protection Study Structures

The affected structures are located in the Okeechobee Waterway and Central and Southern Florida Flood Control Project, as indicated in the table below.

Structure	Location	Date Constructed	Manatee Deaths (1974 - 1993)
S-27	Dade Co.	1958	13[1]
S-29	Dade Co.	1953	12[1]
St. Lucie Lock/ S-80 Spillway	Martin Co	1941/1944	9
Ortona Lock/ S-78 Spillway	Glades Co.	1937	7
S-22	Dade Co.	1956	6
S-193	Okeechobee Co.	1973	4
Port Mayaca Lock/ S-308C Spillway	Martin Co.	1977	4
S-28	Dade Co.	1962	3
S-13	Broward Co.	1954	3
S-25B	Dade Co.	1976	3
S-26	Dade Co.	1974	3
Moore Haven Lock/ S-77 Spillway	Glades Co.	1935/1966	2
S-20F	Dade Co.	1967	1
S-135	Martin Co.	1969	1
S-33	Broward Co.	1954	1
S-25	Dade Co.	1976	1
S-21	Dade Co.	1961	0
S-21A	Dade Co.	1966	0
S-20G	Dade Co.	1966	0
S-79	Lee Co.	1965	0
S-127	Glades Co.	1963	0
S-310	Hendry Co.	1980	0
S-131	Glades Co.	1963	0

Footnote (1): These structures are operated by the South Florida Water Management District. They have already been modified by installation of plunger-type mechanical sensing devices along the lower edge of the vertically-closing gates which can reverse gate closure automatically. The effectiveness of the modifications is still under evaluation.

Data on manatee mortality were furnished by the Florida Department of Environmental Protection, Authorized Purposes: Navigation, Flood Control, Water Supply.

2.0 Site Description

The twenty-three water control structures selected for this study are located in the Okeechobee Waterway and in the Central and Southern Florida Flood Control Project area. The Okeechobee Waterway structures are found in Martin, Okeechobee, Glades, Hendry and Lee counties in south central Florida. Flood Control Project sites are located in Broward and Dade counties on the southeast coast of Florida (Map 1).

South central and southeast Florida lie at the northern edge of the subtropics. The study site locations involve a variety of habitats, inclusive of but not limited to coastal marshes, dry prairies, flatwoods, and significantly, freshwater marshes, lakes and riverine systems (Ward, 1979). These habitats were altered primarily for agricultural purposes (Ewel, 1990).

Habitats were initially altered in the 1880's when a series of canals and dikes were built to create fast land for farming purposes. Lands were further converted in the early 1900's and late 1920's for the purpose of building roads and controlling flood waters (Ewel, 1990). The Corps completed the Okeechobee Waterway in 1937 to better control the release of flood waters and to promote interstate shipping. The Corps, in conjunction with SFWMD, subsequently developed a complex water management system to manage this network of dikes and waterways, control flooding, and protect water supplies (U.S. Army Corps of Engineers, undated).

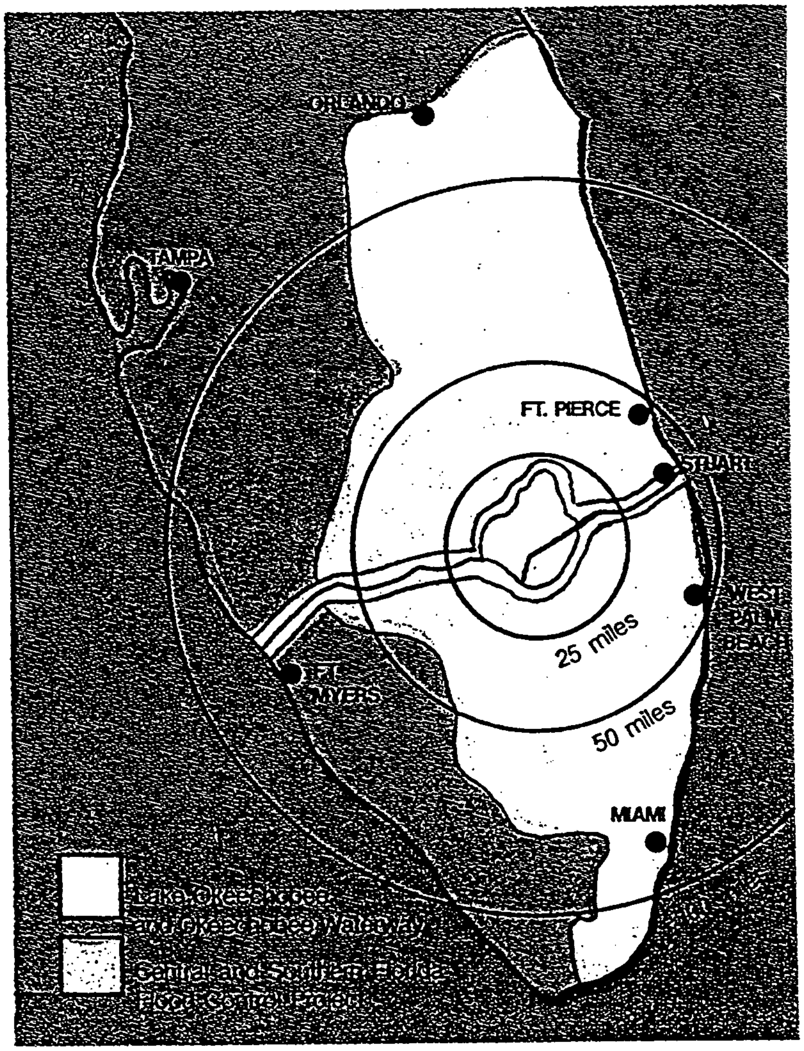
Ten of the twenty-three water control structures are located within the 152-mile-long Okeechobee Waterway. Water control structures within the Waterway typically involve both locks and spillways. The thirteen remaining structures in Dade and Broward counties are spillways.

3.0 Biological Background

The Florida manatee is one of two subspecies of manatee commonly referred to as the West Indian manatee. The Florida manatee (hereafter referred to as manatee) typically ranges throughout Florida and southern Georgia. The population is thought to be almost equally divided between the east and west coasts of peninsular Florida. While there has been no definitive count of the number of manatees found in this area, aerial surveys conducted in January, 1992, confirmed the presence of at least 1,856 manatees (Ackerman, 1992). Subsequent surveys completed in February, 1995, counted 1,822 manatees.

Manatees are seasonally distributed. This pattern reflects an intolerance for cold temperatures. Historically, manatees ranged to their northern limit during warmer times of the year. Conversely, during colder times of the year, manatees were restricted in their

Map 1. Location of Lake Okeechobee, the Okeechobee Waterway and the Central and Southern Florida Flood Control Project sites.



range to those areas south of Sebastian Inlet on Florida's east coast and south of Charlotte Harbor on the west coast (Moore, 1951). These wintering areas were complemented by several natural, warm water springs in northern areas. While historical distribution patterns persist, the number of wintering sites has increased in recent times due to the proliferation of artificial warm water effluents associated with power generating plants and paper mills (Beeler and O'Shea, 1988).

During warmer months, manatees disperse and may travel as far north as the Carolinas. Typically, female manatees remain within a given area for some time during the summer. Males will travel from female to female, presumably to ascertain the reproductive status of these individuals (Bengston, 1981). A female in estrus will mate several times with different males. A pregnant manatee will carry a calf for approximately 13 months. The calf is dependent upon the mother for a period of about two years (Rathbun *et al.*, 1992).

Assessments of manatee abundance, distribution, and behavior have demonstrated "that manatees exhibit both opportunism and independence in their distribution and movement [patterns]" (U.S. Fish and Wildlife Service, 1994). Manatees have readily adapted to the presence of man-made systems including artificial warm water refugia, freshwater discharges, water control structures, and navigation locks. Their presence at water control structures and navigation locks has been primarily documented through anecdotal sighting reports and the manatee carcass recovery program.

3.1 Manatee Use of the Southern and Central Flood Control Project Area

(The Southern and Central Flood Control Project Area includes that area on Florida's east coast from Volusia County to Dade County. The following discussion is restricted to Broward and Dade counties, where the study-selected water control structures are located).

Manatees can be found in Broward and Dade counties throughout the year. Manatee numbers peak during the winter season and small numbers remain during warmer times of the year (Dade County, 1994). Manatee use of warm water refugia is restricted primarily to periods following the passage of severe cold fronts. As temperatures increase, manatees leave these sites to forage and to engage in other activities. Wintering manatees in these counties use Florida Power & Light's (FPL) Port Everglades Plant and Lauderdale Plant in Broward County and the upstream reaches of numerous small rivers and canals in Dade County. Both site-fidelity and movements in-between wintering sites are known to occur (Reid *et al.*,1991; Sirenia Project, 1993). Water temperatures in the deeper rivers and canals are usually warmer than temperatures found in open shallow bay waters (Dade County, 1994). Dade County's canal system is used by as many as 90 different manatees (Markley *et al.*, 1994). In Dade County, the Coral Gables Waterway is commonly used during the winter by manatees (Beeler and O'Shea, 1988).

Foraging sites in Broward and Dade counties include areas noted for the presence of submerged, emergent, and overhanging vegetation. In particular, Dumfoundling Bay, northern Biscayne Bay, and Virginia Key in Dade County attract large numbers of manatees because of the presence of seagrass beds (Dade County, 1994). Animals wintering in Broward County will travel to Lake Worth in Palm Beach County to feed on seagrasses found there (Broward County, 1991). Manatees also forage in rivers and canals, areas which provide vegetation either from shoreline fringes or from mats of accumulated floating vegetative debris (Hartman, 1974; Curtin, pers. comm., 1994). Beeler and O'Shea (1988) identified feeding sites in Broward County; these sites include the Dania Cut-Off Canal, the New River, and the North and South New River Canals. They further speculate that Hillsboro and Pompano Canals may afford manatees with feeding sites. Some manatees travel upstream of salinity control structures into fresh water canal/lake systems to feed on fresh water vegetation (Dade County, 1994).

"A daily pattern has been observed by manatee trackers in Dade [County] during cold weather months: many manatees leave Biscayne Bay in the morning and travel up rivers and canals to salinity control structures where they drink fresh water. They may rest in these areas occasionally feeding on shoreline vegetation, or move to a nearby open area to rest, play, mate, or nurse. In the latter part of the afternoon, many manatees head downstream into Biscayne Bay where they feed in seagrass beds during the evening". (Dade County, 1994).

Manatees in marine or estuarine environments are attracted to fresh water. Sources include fresh water creeks and rivers, sewage outfalls, water hoses, artesian springs, culverts and other sources of surface water runoff (O'Shea and Kochman, 1990). The Black Point Marina basin in Dade County is typical of those sites which attract manatees to freshwater. Water control structures are an important source of freshwater within the Flood Control Project area. These structures regulate large volume flows of fresh water into brackish water systems; when closed, small amounts of fresh water leak through the structures. Manatees are attracted to these fresh water sources and are known to use them on a routine basis (Dade County, 1994).

Travel corridors have been identified in Broward County's "Manatee Protection & Boating Safety Plan" (1991) and in Dade County's ""Draft Dade County Manatee Protection Plan" (1994). In Broward County, the New River system, the Dania Cut-Off Canal, and the Intracoastal Waterway are used as primary manatee travel corridors. In Dade County, the county plan identifies the channel area within the Intracoastal Waterway as being the primary manatee travel corridor in that county; the plan further describes preferred travel paths on the west side of Biscayne Bay and mentions daily east-west travel in major rivers and canals.

Canals, rivers, and streams managed by water control structures are an integral part of manatee habitat in Broward and Dade counties. Hartman (1974) states that manatees "are known to ascend all the canals of the Southern and Central Flood Control [Project Area]." These waterbodies provide manatees with winter refugia, foraging sites, watering sites, and access to and from open bays and waterways. They are found at these locations throughout the year, albeit primarily during the cold weather months. Specific sites are listed in Table 2. These canals and their respective water control structures have altered manatee distribution and movement patterns and the structures have become a significant source of mortality (Ackerman *et al.*, 1994).

3.2 Manatee Use of the Okeechobee Waterway

Lake Okeechobee lies at the center of the Okeechobee Waterway. Lake Okeechobee drainages are provided by the St. Lucie, West Palm Beach, Hillsboro, North New River, and Miami Canals on the east and by the Industrial Canal, the Caloosahatchee River, Fisheating Creek, Harney Pond Canal, Indian Prairie Canal, Kissimmee River, and Taylor Creek on the east and north. Much of what is known about manatee use of this waterway is restricted to the coastal reaches of this system. (Manatee use of the coastal reaches of the Hillsboro, North New River, and Miami Canals has been described in the previous section.)

The St. Lucie Canal originates in Martin County and runs between Lake Okeechobee and the south fork of the St. Lucie River. The West Palm Beach Canal is found in Palm Beach County and crosses between Lake Okeechobee and the Intracoastal Waterway south of Lake Worth. In Martin and Palm Beach counties, manatees are seasonally abundant. Peak numbers are present during the winter season. Winter use patterns are typified by an initial southerly influx of manatees from the north to warm water refugia in south Florida (Reid, *et al.*, 1991; Sirenia Project, 1993). Manatees wintering at FPL's Riviera Plant in Palm Beach County generally use the plant during cold days and shift to waters along the Intracoastal Waterway in Palm Beach and Martin counties on warmer days to forage; others continue their migration south to Port Everglades. In Martin County, based on mortality records, manatees are present year-round; the St. Lucie River and Canal are used throughout the year. Manatees are also present throughout the year in Palm Beach County (Beeler and O'Shea, 1988). Beeler and O'Shea (1988) listed specific locations where manatees had been seen in these counties. These lists include canals and waterways controlled by water control structures (Table 3).

On Florida's west coast, the Caloosahatchee River traverses Lee, Hendry, and Glades counties between Lake Okeechobee and Matlacha Pass in coastal Lee County. Manatee use of this river occurs throughout the year. Manatee numbers peak during the winter when manatee activity focuses on FPL's Fort Myers Plant near the junction of the Orange River and the Caloosahatchee River. Manatees appear at this warm water refugia

Table 2. Manatee sighting locations from Broward and Dade counties (within the South and Central Florida Flood Control Project area). Selected water control structures associated with sighting locations appear in ( ). (Adapted from Beeler and O'Shea, 1988)

- Broward County
    - Hillsboro River (Intracoastal Waterway)
        - Hillsboro Canal
        - Lake Santa Barbara
            - Cypress Creek (aka Pompano) Canal
        - Middle River
            - North Fork
            - South Fork
                - Middle River (aka Midriver or Oakland Park) Canal
        - New River
            - North Fork (S-33)
                - North New River Canal
            - South Fork (site of the Lauderdale Plant)
                - South Fork New River (aka South New River) Canal
        - Lake Mabel (site of Port Everglades and the Port Everglades Plant)
            - Inlet, Port Everglades
            - Nova University Boat Basin
            - US Coast Guard Station
    - Intracoastal Waterway
        - Dania Cut-Off Canal (S-11)
- Dade County
    - Intracoastal Waterway (continued)
        - Golden Beach
        - Dumfoundling Bay
            - Canal between Dumfoundling Bay and Maule Lake
        - Maule Lake
            - Snake Creek (aka Royal Glades or Greynolds Park) Canal (S-29)
            - Oleta River
        - Bal Harbour
        - New Arch Creek
        - Indian Creek
        - Arch Creek
        - Biscayne Bay
            - Biscayne Canal (S-28)
            - Little River (S-27)
                - Little River Canal
                - Surprise Lake (aka Lake Surprise)

Table 2. Manatee sighting locations from Broward and Dade counties (within the South and Central Florida Flood Control Project area). Selected water control structures associated with sighting locations appear in ( ). Continued.

- Dade County (continued)
  - Intracoastal Waterway
    - Biscayne Bay
      - Dodge Island (Port of Miami)
      - Virginia Key
      - Bear Cut
      - Coral Gables Canal (aka Coral Gables Waterway)
      - Snapper Creek Canal (S-22)
      - Biscayne Canal
      - Kings Bay
      - Cutler Ridge Plant
      - Black Creek Canal
      - Goulds Canal (S-21)
      - Canal C-102 (S-21A)
      - Military Canal (S-20G)
      - Mowry Canal (aka C-102) (S-20F)
      - Miami River
        - Wagner Creek (aka Seybold Channel) (S-25)
        - South Fork (S-25B)
          - Blue Lagoon
          - Tamiami Canal
        - North Fork (S-26)
          - Miami Canal

Table 3. Manatee sighting locations from Martin, Okeechobee, Glades, Hendry, and Lee counties (within the region of the Okeechobee Waterway). Selected water control structures associated with sighting locations appear in ( ). (Adapted from Beeler and O'Shea, 1988)

Martin County

- St. Lucie Inlet
- Indian River
- Intracoastal Waterway
- St. Lucie River
  - Sewall Point
  - Hell Gate
  - Hooker Cove
  - A1A Bridge
  - Warner Creek
  - Roosevelt Bridge (Highway 5)
  - North Fork, St. Lucie River
    - Lighthouse Point Canals
    - Bessey Creek
  - South Fork, St. Lucie River
    - Palm City Bridge (Highway 314)
    - St. Lucie Canal (St. Lucie Lock/S-80 Spillway and Port Mayaca Lock/S-308C Spillway)
      - Indiantown
- Lake Okeechobee (S-135)

Okeechobee County

- Lake Okeechobee
  - Henry Creek
  - Nubbin Slough
  - Taylor Creek (S-193)
  - Kissimmee River
  - Coe's Cove

Glades County

- Lake Okeechobee
  - Indian Prairie (aka C-40) Canal
  - Harney Pond (aka C-41) Canal
  - Fisheating Bay
  - Fisheating Creek
  - LD-3 Canal
  - Old Moore Haven Canal
    - Caloosahatchee River
      - Moore Haven (Moore Haven Lock/S-77 Spillway)
      - Lake Hicpochee
      - Ortona (Ortona Lock/S-78 Spillway)
      - LaBelle
  - Rim Canal

Table 3. Manatee sighting locations from Martin, Okeechobee, Glades, Hendry, and Lee counties (within the region of the Okeechobee Waterway). Selected water control structures associated with sighting locations appear in ( ). Continued.

Hendry County

- Lake Okeechobee
  - Rim Canal
- Caloosahatchee River
  - Fort Denaud

Lee County

- Caloosahatchee River
  - Cape Coral
    - Piney Point
    - Redfish Cove
    - Yuma Lake
    - Cape Coral Bridge
  - Fort Myers
    - Iona Point
    - Shell Point Village
    - Deep Lagoon
    - Whiskey (aka Wyomi) Creek
    - Peppertree Point
  - North Fort Myers
    - Hancock Creek
    - Powell Creek
    - Daughtrey Creek
  - Beautiful Island
  - Orange River
    - Orange Harbor
    - Fort Myers Plant
  - Owl Creek
  - Olga
  - Franklin Lock/S-79 Spillway
  - Alva Bridge

primarily from sites located either in coastal Lee County or from areas to the north (Beeler and O'Shea, 1988). The Franklin Locks upriver of the plant are known to offer refuge to wintering manatees. During the winter of 1985 the Fort Myers Plant did not generate warm water; manatees normally seeking refuge at this site sought refuge near the Franklin Locks where deep waters cool more slowly than waters in the lower Caloosahatchee River (Packard *et al.*, 1985). Manatees are occasionally seen resting in the general area of the locks throughout the year (Beeler and O'Shea, 1988; Reid, pers. comm.).

Manatee distribution, abundance, and activity patterns within the inner reaches of the Okeechobee Waterway are poorly known. Aerial surveys were flown over Florida's southwest coast from July through December 1979, inclusive of the Caloosahatchee River (Irvine *et al.*, 1982). The Florida Game and Fresh Water Fish Commission (GFC) flew surveys from the mouth of the St. Lucie River to Fort Myers on the Caloosahatchee River. These surveys were conducted from September to December 1981, January to June 1982, April to December 1983, January to November 1984, and in March 1985 (Beeler and O'Shea, 1988). Irvine sighted three manatee aggregations in the upper Caloosahatchee River, all in November (Irvine *et al.*, 1982). The GFC surveys documented the presence of manatees in the northwest reaches of the Rim Canal in Lake Okeechobee, in the Caloosahatchee River between Moore Haven and La Belle, and at the mouth of Lake Hicpochee. A total of 16 manatees were sighted during these surveys and sightings occurred throughout the course of the year (Beeler and O'Shea, 1988). A Service sponsored write-in sightings program received sighting reports from various locations within the Okeechobee Waterway; lock tenders participated in this program and maintained sighting logs (Beeler and O'Shea, 1988), (Table 3). Additional information has been obtained from the manatee carcass recovery program.

3.3 Manatee Mortality Associated With Water Control Structures

The carcass recovery program has identified water control structures which cause manatee mortality and identified structures responsible for the majority of such deaths. By analyzing this mortality database, seasonal trends, age patterns, and sex ratios have been determined. A review of manatee activity at the structures and of trauma associated with manatee carcasses has led to the development of theories describing how manatees are killed in water control structures.

From April 1974 through December 31, 1994, 110 manatees were killed by water control structures in Florida. Water control structures used for flood and salinity control and navigational purposes have been involved in these deaths . The majority of these structures are located within the area of the South and Central Florida Flood Control Project and within the Okeechobee Waterway. Other structures can be found in Brevard County, Putnam County, Citrus County, Levy County and in Hillsborough County. Ackerman *et al.* (1994) analyzed FDEP's manatee mortality database for the period 1974

Structure	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
Broward County													
S-13	0	0	1	0	0	1	0	0	0	0	1	0	3
S-33	0	0	0	0	0	1	0	0	0	0	0	0	1
Dade County													
Structure													
S-20	0	0	0	0	0	0	0	0	0	0	1	2	3
S-22	0	0	0	0	0	3	0	0	0	1	2	0	6
S-25B	0	0	0	0	1	0	0	0	4	1	1	0	7
S-27	4	1	1	0	2	1	0	1	2	0	3	0	15
S-28	0	0	0	0	0	1	1	0	0	0	0	1	3
S-29	0	0	0	0	1	3	1	0	3	1	3	0	12
Glades County													
Structure													
S-77	0	1	1	0	0	1	0	0	0	0	0	1	4
S-78	0	0	2	2	1	1	0	2	0	2	1	3	14
Martin County													
Structure													
S-80	1	1	1	1	3	0	1	0	1	0	0	2	11
S-135	0	0	0	0	0	0	1	0	0	0	0	0	1
S-308	1	0	1	0	1	0	1	1	0	0	0	0	5
Okeechobee County													
Structure													
Henry Creek	0	0	0	0	0	0	0	0	0	0	0	1	1
S-193	0	0	0	0	0	2	1	1	0	3	0	0	7
Total	6	3	7	3	9	14	6	5	10	8	12	10	93

to 1992. He noted the preponderance of manatee deaths associated with water control structures in southeast Florida and associated that number with the high density of such structures within this geographic area and with spring and fall migrations.

Ackerman's review of water control structure-related mortality trends and patterns demonstrated a tendency for such deaths to occur more frequently in the spring and fall, (Table 4). As discussed in Odell and Reynolds (1979), these periods coincide with periods of greatest rainfall in this area and, similarly, with greatest water control structure activity. Ackerman *et al.* (1994) also concluded that, in comparison with other causes of death, water control structure-related mortality included significantly more adults than did other causes. Furthermore, more males died in these structures than did females. These conclusions are generally consistent with observations made during earlier reviews of the mortality databases (Ackerman *et al.*, 1992; O'Shea *et al.*, 1985; Odell and Reynolds, 1979).

Researchers with the manatee carcass recovery program attribute manatee deaths to water control structures if the carcass was recovered at or near a water control structure and one or more of the following criteria apply:

1. External scrapes, impressions, and bruises may be present anywhere on the body, particularly if concrete walls, bottoms, or sills are present. Distinct impressions of gate edges are sometimes present (Bonde *et al.,* 1983).

2. Massive internal trauma involving broken and/or disarticulated ribs and shock syndrome (*eg.*, infiltration of blood vessels, haemotomas, and ischemia) may be present (O'Shea, 1983). Internal trauma may be coincident with external traumatic findings.

3. Drowning and an absence of hemorrhaging (Bonde *et al.*, 1983).

While these deaths have been carefully documented, the circumstances by which these manatees have died are not completely known. Reynolds and Odell (1979) theorized that manatees upstream of the water control structures become entrained by strong water currents which develop when structure gates open. The entrainment may draw the animal against the gate and then downward to the gate opening. If the opening is too narrow for the manatee to pass through, the manatee would be pinned in the opening, thus drowning the animal. A carcass pinned against a gate opening often displays scrapes, impressions, and/or bruises consistent with concrete walls, bottoms or sills, if present. Reynolds and Odell (1979) further postulated that crushing may be a secondary event, occurring after a manatee had been trapped and drowned. (Dade County [1994] reported that approximately 15% of water control structure-related mortality known to have taken place in Dade County was attributable solely to drowning).

The passage of manatees through closing structures may also result in manatees becoming entrapped and drowned. Reynolds and Odell (1979) stated that when the downstream current was weak, manatees were observed to swim upstream through a wide open gate. They also described the passage of a female downstream through a gate, an event motivated by the separation of that animal from its calf. Mobley (1994) described the passage of a large manatee through a closing gate. This manatee was pursuing two smaller manatees and went through a gate opening estimated at 20 inches. The manatee apparently turned sideways and pushed through, as evidenced by black markings observed on its flanks. Given such actions, manatees appear to be susceptible to entrapment while swimming through closing gates.

Navigation locks utilize paired doors (sector gates) which, when opened, withdraw into recesses built into the lock bulkheads. Interviews with Corps' personnel have demonstrated that these recesses accumulate floating vegetation and are prone to algal growth. Manatees have been seen foraging within the recesses and have been seen moving about within these structures (Gren, 1981). When the doors close, the doors press against the bulkheads and may crush animals found within the recesses. Closing lock doors may entrap and entrain manatees in a fashion similar to that postulated for gate structures (Frohlich and Bonde, 1983).

Within Broward and Dade Counties, 50 manatees have been killed in water control structures during the 1974 through September 30, 1994 period. Structures S-27 and S-29, on the Miami and Little Rivers respectively, have been implicated in the deaths of 27 manatees. Other structures accounting for more than 5 deaths per structure include S-22 and S-25B in Dade County. These deaths have occurred throughout the year, with most deaths during spring and fall, (Table 5).

Water control structures within the Okeechobee Waterway have killed 43 manatees during the same period. Heaviest mortality has been associated with the St. Lucie Lock and S-80 Spillway and with the Ortona Lock and S-78 Spillway (11 and 14 mortalities, respectively). The Port Mayaca Lock and S-308C Spillway and the Moore Haven Lock and S-77 Spillway have also caused manatee deaths. Deaths within these waterways have occurred throughout the year and are known to peak during the spring and fall, (Table 6).

4.0 Mortality Reduction Strategies

Subsequent to the 1979 meeting, agencies and researchers have been involved in numerous efforts to reduce mortality associated with water control structures. Mortality reduction strategies have included efforts to delay gate operations, "shooing" manatees away from structures, and deployment of remotely operated reversal mechanisms. Water control structure-related mortality declined during the mid-1980's. It was thought that this decline

Table 5. Annual Water Control Structure-related Mortality (1974 through December 31, 1994) at Selected Water Control Structures within the South and Central Florida Flood Control Project Area (Broward and Dade counties).

Broward County

Structure	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	T
S-13	0	0	0	0	0	0	1	0	1	0	0	1	0	0	0	0	0	0	0	0	0	3
S-33	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1

Dade County

Structure	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	T
S-20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1	3
S-22	0	0	2	1	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6
S-25B	0	0	1	0	2	1	0	0	1	0	0	0	0	0	0	0	0	0	1	0	1	7
S-27	0	0	0	1	0	0	1	0	1	0	0	1	0	1	6	0	1	0	0	1	2	15
S-28	0	1	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
S-29	0	0	1	3	2	4	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	12

Table 6. Annual Water Control Structure-Related Mortality (1974 through December 31, 1994) at Selected Structures within the Okeechobee Waterway area (Martin, Okeechobee, and Glades counties).

Martin County

Structure	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	T
S-80	0	0	0	0	0	1	1	0	0	1	1	0	0	1	0	2	0	1	1	1	1	11
S-135	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1
S-308	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	1	1	0	0	1	5

Okeechobee County

Structure																						
Henry	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1
S-193	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	2	1	1	2	7

Glades County

Structure																						
S-77	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	3	5
S-78	0	0	0	0	0	0	1	1	0	2	1	0	0	1	1	0	0	0	0	1	6	14

had been brought about by the implementation of successful mortality reduction efforts. However, despite this brief lull, mortality associated with water control structures persists.

4.1 Deterrents

In order to distract manatees from gates and doors, agencies and researchers have tested and implemented a variety of "disturbance" techniques. Initial efforts to drive manatees away from the structures were "not very successful" (precise methods used are unknown)(Mierau, 1991). Bubble screens were reviewed by both the Service and the Corps as a possible method by which to "scare" manatees away from gates and doors.

Brownell *et al.* (1981), Odell and Reynolds (1979), and Kinnaird (1983) theorized that, inasmuch as some manatees demonstrate a fear response to bubbles generated by SCUBA regulators, a bubble screen may provide an effective means with which to repel manatees from certain areas. The Corps installed bubble screens at the Franklin Locks (Lee County) and at the Buckman Locks (Putnam County) (Milleson, 1985; Bowman, 1991). The bubble screens were made up of dispersion tubes with holes in them; an air compressor was used to force air through the tubes. At the Buckman Locks, the screens were activated prior to lock operations.

The Corps, citing observations made by lock operators, determined that these devices were not an effective deterrent. Some operators thought that manatees "played" in the bubbles and that they were thus attracted to them. Other operators concluded that manatees were alerted by the bubbles to door operations and that it brought manatees to the doors. Bowman (1991) cited a perceived decrease in the number of manatees in Lake Ocklawaha and the number of manatees locking through the Buckman Locks; he speculated that this decrease may be attributable to the bubble screens.

Kinnaird (1983) and Brownell *et al.* (1981) considered the use of sound as an acoustic repellent. The broadcasting of high intensity sounds above a certain threshold is known to elicit avoidance response in certain marine mammals. The effectiveness of such methods is highly variable among species. Cursory efforts were made to investigate the effect of high intensity sounds on manatees (Kinnaird, 1983). These initial investigations elicited no response from the manatees. Further investigation into manatee hearing capacities has been conducted by Gerstein *et al.* (1994). Hearing ranges were determined for a single manatee. The manatee appeared to be sensitive to high frequency sound. This sensitivity may provide an opportunity with which to deter manatees from fixed locations such as canals and water control structures. The effectiveness of this method will require additional research.

4.2 Barriers

The use of fixed barriers to restrict manatees from specific sites has been reviewed and implemented by various agencies and researchers. Fixed barriers keep manatees from reaching certain sites. The permanent exclusion of manatees from certain habitats has been cited as a concern with these structures. Other difficulties associated with these barriers are primarily related to maintenance and cost.

An initial assessment of these structures was conducted by Odell and Reynolds (1979), who evaluated a mechanical barrier placed downstream of a water control structure in Dade County. The barrier was effective in preventing manatees from accessing the structure. However, despite the barrier's self-cleaning design, the barrier accumulated large amounts of trash which threatened gate operations. Other designs such as that at the Moore Haven water control structure experience similar problems, particularly with the accumulation of vegetative debris (Holand, 1994). Navigation lock door recesses have been successfully screened to keep manatees from accessing these sites. Barriers designed to preclude manatees from power plants, mill effluents and drainage pipes have failed due to bars and screens having rusted out (Valade, pers. obs.).

Redesigning water control structures to discharge water over the top of a gate may also effectively preclude manatees from accessing water control structures and upstream areas. Costs associated with the design, demolition of existing structures, and construction of these new structures are thought to be prohibitive (Mierau, 1994).

Barriers, if properly maintained, are effective in their ability to exclude manatees from certain areas. Barriers will prevent manatees from being killed in water control structures. These devices will need to placed at some structures in order to fully eliminate this source of mortality. The resultant loss of habitat will need to be weighed against the benefit of eliminating mortality.

4.3 Operating procedures

To avoid the entrainment of manatees against water control structure gates, gates at various structures have been programmed to open to an initial height of 2.5 feet. It is believed that, with an opening of this height, manatees will be swept through the structure without being held against the opening. Water control structure-related mortality declined after this strategy was employed; these procedures were thought to be an effective mortality reduction strategy. However, mortality subsequently increased. It was initially thought that a "yo-yo" effect (i.e., an increase in the number of openings and closings) was responsible for these increases in mortality. To minimize the number of operations, a computer algorithm was designed to decrease the number of oscillations and, thereby, the degree of risk to manatees travelling through the structures. While these algorithms have minimized the number of gate operations, the algorithms did not effectively reduce mortality (Markley *et al,*. 1994).

The Corps has developed a draft "Manatee Protection Plan for Water Control Structures Operated by the Jacksonville District, U.S. Army Corps of Engineers" (1994). This draft provides "policies, guidelines, and operating procedures for the effective long-range management of water control structures ... to minimize manatee risk." Operating procedures described in this plan require close visual monitoring of structures for manatees by lock tenders and the implementation of avoidance strategies, as needed.

4.4 Detection devices

Detection methods have been evaluated as a means by which to locate and to prevent injury and death to manatees. Such methods include the use of sonar to locate manatees and the use of remotely operated reversal mechanisms to sense the presence of manatees.

A variety of sonar devices have been evaluated for their potential to detect manatees. Kinnaird (1983) stated that such units were highly variable in their ability to locate manatees. Kinnaird's review summarized the findings of three investigators, one of whom reported the "reliable and successful detection of manatees" and two others who, using the same unit, could not detect manatees. Kinnaird further investigated a separate unit with similar, mixed results. In 1983, Kinnaird stated that "this technology does not appear to be a viable or practical management option." She additionally stated that "new, more sophisticated units that may be developed in the future" will warrant additional testing and consideration. SFWMD subsequently tested a sonar device. Test results were once again inconclusive, although the device's inability to operate in turbulence was of particular note (Mobley, 1994).

To avoid crushing manatees in water control structures, reversal mechanisms have been deployed with mixed results. These devices rely upon a pressure switch which, when triggered by the presence of an object such as a manatee, cause structure gates to open and to avoid crushing the object. Some navigation lock doors have an automatic shut-off switch that stops the doors when they meet resistance. Testing of these switches has demonstrated that these switch sensitivities are inadequate to prevent the crushing of manatees (Frohlich and Bonde, 1983). SFWMD has developed and deployed pressure sensitive devices. These pressure sensitive devices are more sensitive than the lock door switches and have been observed to open gates when they encounter manatees (Mobley, 1994). Subsequent to the installment of these devices on the S-27 water control structure in 1992, two manatees have been crushed, thus raising questions about the effectiveness of these devices, or at least the current design.

5.0 Selected plans

For the purposes of the 1135(b) study, the Corps reviewed several mortality reduction strategies as possible solutions to the problem of water control structure-related manatee mortality. The Corps considered deterrents (bubble curtains), barriers (folding screens and over the top control gate structures), and detection devices (including reversal mechanisms). The Corps elected to pursue the installation of reversal mechanisms at both gates and doors of selected water control structures, (Table 1).

The reversal mechanism selected for this study involves a variation on SFWMD's pressure sensitive device. Instead of using reed switches, the Corps proposes to use a urethane enclosed foil strip to activate a manatee protection circuit. The activated circuit will cause a lowering gate or closing door to reverse and/or trigger an audio/visual alarm when a manatee is present.

Automated vertical gates will open to 2.5 feet when triggered and will continue to open and close until the manatee either passes through the gate or when the gate closing reaches 2". A manually operated gate will stop when the device is triggered; the gate operator will then control the closure. When a manatee comes in contact with a closing navigation lock door, a switch will be triggered, alerting the lock operator to increase the door aperture as needed.

The Corps proposes to initially dry test each of the installations. Operational checks will then be conducted daily as part of the Draft Manatee Plan for Water Control Structures. Biannual maintenance will then occur and the structures will be monitored for effectiveness.

6.0 Review of selected plans

In order to eliminate water control structure-related manatee mortality, the Corps has elected to install reversal mechanisms on structures associated with manatee mortalities. This technology may prove to be an effective means by which to reduce or eliminate this cause of mortality. However, because mortality has been associated with structures outfitted with a current version of this device, consideration of this device as the only solution to this problem may be unrealistic. Other strategies may offer alternatives to these devices. Serious consideration should be given to the development and construction of barriers at selected water control structures where manatees will not be restricted from accessing important habitat.

7.0 Recommendations

1. While there are problems associated with the current reversal mechanism prototype, it is apparent that such devices have the potential to reduce manatee mortality. While the Corps has proposed to fit all selected structures with these devices, it may be prudent to install these mechanisms on a limited number of structures and to thoroughly test and monitor their effectiveness prior to installation on all structures.

2. In its selection of this plan, the Corps reviewed and elected not to pursue alternative plans and methodologies. The Service recommends that the Corps investigate other mortality reduction methods and that the Corps implement these as appropriate. Consideration should be given to building permanent barriers, such as those proposed on an emergency basis for the Ortona Spillway, at other similar structures. Acoustical deterrents should also be re-evaluated, particularly in light of recent studies which have better assessed manatee hearing capabilities. New advancements in sonar or other passive underwater detection methods may warrant further investigation (Dickerson, 1994).

3. Certain navigation lock structure recesses have been screened to prevent manatee access. While most structures have been screened, the status of each should be reviewed and, in the event that screening is absent or in need of repair, new screening should be installed.

4. The Corps selected 23 water control structures for this study. Chosen sites reflected incidences of manatee mortality or structural similarities with structures known to have killed manatees. The Henry Creek Lock, a structure located on the northeastern shore of Lake Okeechobee, is known to have killed a manatee in 1985. This structure should be included in this study.

5. While not addressed in this review, manatees are known to have been killed by watercraft operating in the vicinity of water control structures. Speed zones have been established at some of the structures. Caution signs have also been posted near certain structures and awareness materials are being distributed to alert watercraft operators of the presence of manatees. These efforts should be reviewed and, if needed, supplemented to further reduce manatee mortality.

6. Any construction activity associated with this effort should follow the Standard Manatee Construction Precaution Guidelines.

8.0 Conclusions

Water control structures are a significant source of manatee mortality. While there have been numerous efforts to reduce the number of structure-related deaths, these deaths continue to occur. Mathematical models suggest that increases in manatee mortality by even a few individuals could easily have a significant, adverse effect on the future of the manatee (Marmontel, 1994). By eliminating this source of mortality, the future of the manatee will be on a more secure footing. The Section 1135(b) study proposed by the Corps is a means by which to reduce or eliminate water control structure-related mortality. The installation of pressure-sensitive devices on selected structures may provide a partial solution to this problem. Other alternatives should be considered and additionally implemented, if appropriate. The Service recommends that permanent barriers be installed on all structures where the installation will not restrict the manatee's access to essential habitat.

9.0 Bibliography

Ackerman, B.B. 1992. Ongoing manatee aerial survey programs - a progress report. Pages 14-15 in O'Shea, T.J., B.B. Ackerman, and H.F. Percival (eds.). Interim report of the technical workshop on manatee population biology. Manatee Pop. Res. Rept. No. 10. Florida Cooperative Fish and Wildlife Research Unit. Univ. of Fla., Gainesville. 83p.

________, S.D. Wright, R.K. Bonde, D.K. Odell, and D.J. Banowetz. 1992. Trends and patterns in manatee mortality in Florida, 1974-1991. Abstract. p 22. in O'Shea, T.J., B.B. Ackerman, and H.F. Percival (eds.). Interim report of the technical workshop on manatee population biology. Manatee Pop. Res. Rept. No. 10. Florida Cooperative Fish and Wildlife Research Unit. Univ. of Fla., Gainesville. 83p.

________. 1994. Trends and patterns in manatee mortality in Florida, 1974-1992. In: T.J. O'Shea, B.B. Ackerman, and H.F. Percival, (eds.). Population Biology of the Florida manatee (*Trichechus manatus latirostris*). National Biological Survey, Biological Report Series. In press.

Beeler, I.E. and T.J. O'Shea. 1988. Distribution and mortality of the West Indian manatee (Trichechus manatus) in the southeastern United States: A compilation and review of recent information. Prepared by the Fish and Wildlife Service for the U.S. Army Corps of Engineers. PB 88-207 980/AS. Natl. Tech. Inf. Ser., Springfield, Va. 613p.

Bengtson, J.L. 1981. Ecology of manatees (Trichechus manatus) in the St. Johns River, Florida. Ph.D. Thesis. Univ. of Minnesota, Minneapolis. 126p.

Bonde, R.K., T.J. O'Shea, and C.A. Beck. 1983. A manual of procedures for the salvage and necropsy of carcasses of the West Indian manatee (Trichechus manatus). PB83-25573. Natl. Tech. Inf. Ser., Springfield, Va. 175p.

Bowman, D. 1991. Personal communication, dated July 8, 1991, from D. Bowman to J.A. Valade (from meeting held at the Buckman Locks, Lake Ocklawaha Recreational Area, Putnam County, Florida).

Broward County. 1991. Manatee Protection and Boating Safety Plan. Developed and approved by the Broward County Board of County Commissioners. 100p.

Brownell, R.L., K. Ralls, and R.R. Reeves. 1981. Report of the West Indian manatee workshop. Pp. 3-16 in R.L. Brownell and K. Ralls, eds. The West Indian manatee in Florida. Proc. Workshop, Orlando, Florida, 27-29 March 1978. Florida Dept. of Nat. Res. 154p.

Curtin, K. 1994. Personal communication, dated May 24, 1994, from K. Curtin to J.A. Valade (in meeting held at the NBS Sirenia Project Office, Gainesville, Florida).

Dade County. 1994. Re-revised 2nd Draft Dade County Manatee Protection Plan. Prepared by the Dade County Department of Environmental Resources Management. 100p.

Dickerson, D.D. 1994. Comments made during the Interagency Meeting on Interim Solutions for the Prevention of Manatee Mortalities, November 14, 1994.

Ewel, J.J. 1990. Introduction. Pages 3-10 in: Myers, R.L., and J.J. Ewel, eds. Ecosystems of Florida. University of Central Florida Press. Orlando, FL. 765p.

Frohlich, R.K. and R.K. Bonde. Lock-related manatee mortality trip report, dated May 25, 1983. 2p.

Gerstein, E.R., L. Gerstein, S. Forsythe, and J.E. Blue. 1994. Underwater audiogram of a West Indian manatee (*Trichechus manatus*) and ecological correlates of measured boat frequencies. First International Manatee and Dugong Research Conference. Hosted by the University of Florida, Gainesville, Florida, March 11- 13, 1994. Presentation and Conference Proceedings.

Gren, G.G. 1981. Letter dated August 10, 1981, to Donald J. Hankla, Area Manager, U.S. Fish and Wildlife Service, Jacksonville, Fla; with enclosures. 2p.

Hartman, D.S. 1974. Distribution, status, and conservation of the manatee in the United States. Rep. to U.S. Fish and Wildl. Serv., Natl. Fish and Wildl. Lab., Contract Rep. No. 14-16-0008-748, Natl. Tech. Inf. Ser. Publ. No. PB81-140725. 247p.

Holand, E. 1994. Presentation to the Interagency Meeting on Interim Solutions for the Prevention of Manatee Mortalities, November 14, 1994.

Husar, S.L. 1977. The West Indian manatee (Trichechus manatus). U.S. Fish and Wildlife Service. Wildl. Res. Rept. 7:1-22.

Irvine, A.B., J.E. Caffin, and H.I. Kochman. 1982. Aerial surveys for manatees and dolphins in western peninsular Florida. Fish. Bull. 80(3):621-630.

Kinnaird, M.F. 1983. Evaluation of potential management strategies for the reduction of boat-related mortality of manatees. Site-specific reduction of manatee boat/barge mortality. Rep. No. 3. Prepared for: U.S. Fish and Wildlife Service Coop. Agreement No. 14-16-0004-81-923. Florida Coop. Fish and Wildl. Res. Unit, Gainesville, FL. 43p.

Markley, S.M., K.E. Mayo, and R. Chamberlain. 1994. Manatee mortality and water control gates in Dade County: science, technology, and management provide solutions. First International Manatee and Dugong Research Conference. Hosted by the University of Florida, Gainesville, Florida, March 11- 13, 1994. Presentation and Conference Proceedings.

Marmontel, M. 1994. Age and reproductive parameter estimates in female Florida manatees. In: T.J. O'Shea, B. B. Ackerman, and H. F. Percival, (eds.). Population Biology of the Florida manatee (*Trichechus manatus latirostris*). National Biological Survey, Biological Report Series. In press.

Mierau, R.L. 1991. Letter, dated June 24, 1991, to Patrick M. Rose, Environmental Administrator, Florida Department of Natural Resources. 4p.

Mierau, R.L. 1994. Presentation to the Interagency Task Force Meeting, October 19, 1994.

Milleson, J.F. 1985. Letter dated March 6, 1985, to Patrick M. Rose, Manatee Coordinator, Florida Department of Natural Resources. 1p.

Mobley, V. 1994. Presentation to the Interagency Task Force Meeting, October 19, 1994.

Moore, J.C. 1951. The range of the Florida manatee. Quart. J. Fla. Acad. of Sci. 14(1):1-19.

Oberheu, J.C. 1979. Meeting notes from the interagency meeting on manatee mortality in automatic flood control structures. March 1, 1979.

Odell, D.K., and J.E. Reynolds. 1979. Observations on manatee mortality in south Florida. J. of Wildl. Mgmnt. 43:572-577.

O'Shea, T.J. 1983. Memorandum dated August 12, 1983, to Manatee Coordinator, U.S. Fish and Wildlife Service, with enclosures. 1p.

________, C.A. Beck, R.K Bonde, H.I. Kochman, and D.K. Odell. 1985. An analysis of manatee mortality patterns in Florida, 1976-1981. J. Wildl. Manage. 49:1-11.

________, and H.I. Kochman. 1990. Florida manatee distribution: geographical referenced data sets and ecological and behavioral aspects of habitat use. Fla. Mar. Res. Pub. No. 489:11-22.

Packard, J.M., R.K. Frohlich, J.E. Reynolds, III, and J.R. Wilcox. 1985. Manatee response to interrupted operation of the Fort Myers power plant, winter 1984/1985. Manatee population Res. Rep. No. 8, Tech. Rep. No. 8-8. Fla. Coop. Fish and Wildl. Res. Unit, Univ. of Florida, Gainesville, Florida. 20p.

Rathbun, G.B., J.P. Reid, R.K. Bonde, and J.A. Powell. 1992. Reproduction in free-ranging West Indian manatees (Trichechus manatus). Abstract. pp. 19-20. in O'Shea, T.J., B.B. Ackerman, and H.F. Percival (eds.). Interim report of the technical workshop on manatee population biology. Manatee Pop. Res. Rept. No. 10. Florida Cooperative Fish and Wildlife Research Unit. Univ. of Fla., Gainesville. 83p.

Reid, J.P. 1995. Letter, dated March 30, 1995, to Bob Turner, Manatee Recovery Coordinator, U.S. Fish and Wildlife Service, with enclosures. 1p.

______, and T.J. O'Shea. 1989. Three years operational use of satellite transmitters on Florida manatees: tag improvements based on challenges from the field. Pages 217 - 232. in Proceedings of the 1989 North American Argos Users Conference and Exhibit. Service Argos, Inc., Landover, MD. 36p.

______, G.B. Rathbun, and J.R. Wilcox. 1991. Distribution patterns of individually identifiable West Indian manatees (Trichechus manatus) in Florida. Mar. Mam. Sci. 7(2):180-190.

Salem, A.J. 1994. Letter dated June 21, 1994, to David J. Wesley, State Administrator, U.S. Fish and Wildlife Service, with enclosures. 1p.

Sirenia Project. 1993. Atlantic coast manatee telemetry 1986 - 1993 progress report, vols I and II. National Biological Survey, Gainesville, FL. 232p.

U.S. Army Corps of Engineers. Undated. Lake Okeechobee and Okeechobee Waterway. Brochure printed by the U.S. Army Corps of Engineers Natural Resource Office, Clewiston, FL.

________. 1994. Manatee Protection Plan for Water Control Structures Operated by the Jacksonville District, U.S. Army Corps of Engineers.

U.S. Fish and Wildlife Service. 1989. Florida Manatee (*Trichechus manatus latirostris*) Recovery Plan. Prepared by the Florida Manatee Recovery Team for the U.S. Fish and Wildlife Service, Atlanta, Georgia. 98p.

________. 1994. Draft Second Revision Florida Manatee Recovery Plan. U.S. Fish and Wildlife Service, Atlanta, GA. 176p.

Ward, D.B., ed. 1979. Rare and endangered biota of Florida. Vol. 5: Plants. Univ. Presses of Florida, Gainesville, FL. 175p.

United States Department of the Interior

FISH AND WILDLIFE SERVICE
P.O. Box 2676
Vero Beach, Florida 32961-2676

IN REPLY REFER TO:

July 1, 1996

Mr. A. J. Salem
Chief, Planning Division
Jacksonville District
U.S. Army Corp of Engineers
P.O. Box 4970
Jacksonville, Florida 32232-0019

Attn: Elmar Kurzbach

Dear Mr. Salem:

The U.S. Fish and Wildlife Service (FWS) has reviewed the information submitted by the U.S. Army Corps of Engineers (COE) on May 28, 1996, concerning the Manatee Protection at Water Control Structures study and the Acoustic Ladder Array to be tested at Port Mayaca Lock in Martin County. As part of our continuing informal section 7 consultation, we are providing the following comments in accordance with the Endangered Species Act of 1973, as amended (16 U.S.C. 1531 et seq.). We have assigned FWS Log Number 4-1-96-424 to this consultation.

The proposed action involves the development and testing of an Acoustic Ladder Array at the Port Mayaca Lock. The Acoustic Ladder Array is intended to detect the endangered West Indian manatee (*Trichechus manatus latirostris*) in the critical zone of the lock before the gates come in contact with the manatee. The Acoustic Ladder Array involves an emitter-detector pair that emits intact beams in a frequency outside the hearing range of the manatee. When one or more of these beams are interrupted, the gate closure will reverse, thereby avoiding contact with the manatee.

Water control locks have taken a toll on manatees, and the FWS supports any efforts to reduce the number of deaths. The Acoustic Ladder Array appears to be an encouraging method to use for detecting manatees in the critical zone of the locks. Therefore, the FWS has concluded that the proposed Phase One test at the Port Mayaca Lock is not likely to adversely affect the manatee.

We look forward to continuing work with the COE as you develop the Acoustic Ladder Array and test the device at Port Mayaca. Please provide us with the results of the test.

Thank you for the opportunity to comment on this project. If you have any questions regarding this matter, please contact Diane Bowen at (407) 562-3909.

Sincerely yours,

Craig Johnson
Supervisor, South Florida Ecosystem Office

cc:
FDEP (OPSM), Tallahassee, FL
FWS, Jacksonville, FL

South Florida Water Management District

3301 Gun Club Road, West Palm Beach, Florida 33406 • (407) 686-8800 • FL WATS 1-800-432-2045

CON 38 06 RF: 95065

November 28, 1994

Mr. A. J. Salem
Chief, Planning Division
Jacksonville District
US Army Corps of Engineers
P. O. Box 4970
Jacksonville, FL 32232

Dear Mr. Salem: Eddie

Thank you for your invitation to attend the meeting held last Friday in your offices regarding manatee protection efforts in the St. Lucie canal and Caloosahatchee River. Ms. Kim Koelsch of your staff had been kind enough to contact us in advance of your letter so that Mr. Frank Lund, our Manatee Coordinator, could attend.

As the new Executive Director at the South Florida Water Management District, I would like to take the opportunity to express my strong commitment to achieving our zero manatee mortality goal as quickly as possible. As you are aware, we have had additional deaths at the S-27 structure despite the installation of the prototype PSDs, as well as further losses at the Taylor Creek lock. I recently asked Mr. Lund to assume responsibility for expediting and coordinating our efforts to address these problems.

We appreciate the technical assistance that has been provided by your staff as we have developed the initial PSDs, and hope that we can cooperatively find solutions to the problems with both locks and spillgates. I encourage you to contact Mr. Lund at (407) 687-6631 if we can be of any assistance to your efforts at Ortona and St. Lucie locks.

Sincerely,

Samuel E. Poole III
Executive Director

SEP/kh

Mailing Address: P.O. Box 24680, West Palm Beach, FL 33416-4680

FLORIDA DEPARTMENT OF STATE
Jim Smith
Secretary of State
DIVISION OF HISTORICAL RESOURCES
R.A. Gray Building
500 South Bronough
Tallahassee, Florida 32399-0250
Director's Office (904) 488-1480
Telecopier Number (FAX) (904) 488-3353

November 1, 1994

Mr. A. J. Salem
Planning Division
Environmental Branch
Department of the Army
Jacksonville District Corps
of Engineers
P. O. Box 4970
Jacksonville, Florida 32232-0019

In Reply Refer To:
Robin D. Jackson
Historic Sites
Specialist
(904) 487-2333
Project File No. 943667

RE: Cultural Resource Assessment Request
Manatee Protection Devices at Selected
Navigational Locks and Water Control Structures
Okeechobee Waterway and Central and
Southern Florida Flood Control Project

Dear Mr. Salem:

In accordance with the procedures contained in 36 C.F.R., Part 800 ("Protection of Historic Properties"), we have reviewed the referenced project(s) for possible impact to historic properties listed, or eligible for listing, in the National Register of Historic Places. The authority for this procedure is the National Historic Preservation Act of 1966 (Public Law 89-665), as amended.

A review of the Florida Site File indicates that no significant archaeological or historical sites are recorded for or likely to be present within the project areas. Furthermore, because of the project location and/or nature it is unlikely that any such sites will be affected. Therefore, it is the opinion of this office that the proposed projects will have no effect on historic properties listed, or eligible for listing, in the National Register of Historic Places, or otherwise of historical or architectural value.

If you have any questions concerning our comments, please do not hesitate to contact us. Your interest in protecting Florida's historic properties is appreciated.

Sincerely,

Laura A. Kammerer

for George W. Percy, Director
Division of Historical Resources
and
State Historic Preservation Officer

GWP/Jrj

South Florida Water Management District

3301 Gun Club Road • P.O. Box 24680 • West Palm Beach, FL 33416-4680 • (407) 686-8800 • FL WATS 1-800-432-2045

CON 38-06 RF: 94335

MEMORANDUM

TO: Nathaniel P. Reed, Governing Board Member

FROM: Tilford C. Creel, Executive Director

DATE: August 9, 1994

SUBJECT: Manatees - Section 1135 Update

The Corps of Engineers in a cooperative effort with the District has embarked on a three-year effort to modify 25 water control structures, primarily in Dade County but also including navigation locks, servicing Lake Okeechobee and the Okeechobee waterway, operated by the Corps. This work is being done under Public Law Section 1135.

The program will be funded through a 75/25% cost-share program, with the Federal government picking up the largest share of the cost. This funding arrangement was granted conceptual approval by the South Florida Water Management Governing Board in November 1993. A Feasibility study, which will determine the best conceptual approach and provide an environmental assessment which is required for the federal funding, will be completed in November 1994.

Detailed design and contract specifications will then be prepared to allow the contractual process to begin in July 1995. It is currently anticipated that all modifications will be in place by 1998. It is unlikely that large contractual expenditures will be made in FY 95. To provide more specifics in regard to federal funding, we have requested that the Corps of Engineers clarify their budget procedure in a separate response.

District staff recognizes the lengthy process which is required to get an innovative Federal program of this magnitude implemented. In order to partially offset the long implementation time, the District plans to continue to improve the pressure sensitive devices and adapt them to structures in Dade County which have the most severe manatee fatality problems.

Modifications to the two structures which historically had the largest number of manatee fatalities have been completed. These two structures (S-27 and S-29) together account for more than half of the fatalities attributed to water control structures within Dade County It is noteworthy that eyewitness accounts and water control structure gate dynamics observed by our control room personnel indicate that the pressure sensitive devices at these structures are working.

Work is currently in progress to adapt the pressure sensitive device to S-193, the navigation lock at Taylor Creek in Okeechobee which continues to prove hazardous to manatees which frequent the area. In addition, gratings are being installed to keep manatees out of hazardous sector gate recesses. An improved design modification which will allow adaptation of the pressure sensitive device to navigation lock sector gate configurations is currently being fabricated and should be complete in September.

District staff has proposed FY95 funding in the amount of $58,400 which will allow the pressure sensitive device to be implemented on two additional structures (S-25B and S-26) in Dade County, while the Corps is completing their design phase. The Corps has interacted closely with District staff over the last several months which has resulted in further improvements in the pressure device prototype. The attached chart provides information on Project water control structures slated for manatee protection modifications over the next three years.

Joe Schweigart, Director of Operations and Maintenance Department, will personally ensure that you and the other board members are kept informed of significant developments in our manatee protection efforts.

TCC/bj

c: ✓Kim Brooks-Hall, COE - JAX
Samuel E. Poole III
Carol Rist, MPPRC
Robert Turner, USF&WS
John Twiss, USDOI
Bernie Yokel, FAS
Judith Delaney Valley
Governing Board Members

STATE OF FLORIDA
DEPARTMENT OF COMMUNITY AFFAIRS

2740 CENTERVIEW DRIVE • TALLAHASSEE, FLORIDA 32399-2100

LAWTON CHILES
Governor

LINDA LOOMIS SHELLEY
Secretary

August 4, 1994

Mr. A. J. Salem
Chief, Planning Division
Department of the Army
Corps of Engineers
Jacksonville District
Post Office Box 4970
Jacksonville, Florida 32232-0019

RE: Flood Control Projects - Development of Manatee Protection Modifications to Certain Water Control Structures in the Okeechobee Waterway and the Central and South Florida Project - Florida
SAI: FL9406080549C

Dear Mr. Salem:

The Florida State Clearinghouse, pursuant to Presidential Executive Order 12372, Governor's Executive Order 93-194, the Coastal Zone Management Act, 16 U.S.C. §§ 1451-1464, as amended, and the National Environmental Policy Act, 42 U.S.C. §§ 4321, 4331-4335, 4341-4347, as amended, has coordinated a review of the above-referenced project.

The Department of Environmental Protection (DEP) indicates that the Army Corps of Engineers is required to provide status reports on the study to the DEP's Office of Protected Species Management. Please refer to the enclosed DEP comments.

Although the applicant did not provide a federal consistency determination in accordance with the Coastal Zone Management Act, 16 U.S.C. §§ 1451-1464, as amended, the state has determined, based on the enclosed comments of the reviewing agencies, that the referenced project will not significantly affect the coastal waters and adjacent shorelands of the state. Therefore, the project, at this stage, is consistent with the Florida Coastal Management Program. All subsequent environmental documents

EMERGENCY MANAGEMENT • HOUSING AND COMMUNITY DEVELOPMENT • RESOURCE PLANNING AND MANAGEMENT prepared for this project will be reviewed to determine the project's continued consistency with the FCMP. The state's continued concurrence with the project will be based, in part, on the adequate resolution of issues identified during earlier reviews.

Very truly yours,

Mary Anne McMullen

Linda Loomis Shelley
Secretary

LLS/rk

Enclosures

cc: Susan Goggin, Department of Environmental Protection
George Percy, Department of State

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

June 21, 1994

REPLY TO
ATTENTION OF
Planning Division
Environmental Branch

Mr. David J. Wesley, Supervisor
U.S. Fish and Wildlife Service
Jacksonville Field Office
Suite 310
6620 Southpoint Drive, South
Jacksonville, Florida 32216-0912

Dear Mr. Wesley:

The Jacksonville District, U.S. Army Corps of Engineers has initiated the feasibility phase of a study to design manatee protective structures or operational modifications at selected navigation locks and water control structures in the Okeechobee Waterway and Central and Southern Florida Flood Control Projects. The study is authorized under Section 1135(b) of the Water Resources Development Act (WRDA) of 1986, as amended. We enclose a list of structures under consideration. We have excluded the two structures already modified/undergoing modification by the South Florida Water Management District.

At this time we wish to initiate a cooperative study under the Fish and Wildlife Coordination Act, as amended, leading to a Coordination Act Report on West Indian Manatee interactions with water control structures. This information should help us to prioritize structures and operational methods for modification; make full utilization of research and management scientists' input on remote sensing, manatee learning and behavior, and other data applicable to proposed changes in structure and operations.

A proposed Scope of Work (SOW) and cost estimate for the CAR is enclosed along with a Form DD 448 transferring $10,500.00 to cover the cost of the work. Estimates of person-days and travel required are based on our telephone and facsimile communication with Mr. Jim Valade of your office. If the SOW is acceptable, please sign and return it to the Jacksonville District office and process the Form 448 to transfer funds.

Sincerely,

A. J. Salem

A. J. Salem
Chief, Planning Division

Enclosure

South
Florida
Regional
Planning
Council

June 20, 1994

Mr. A. J. Salem, Chief, Planning Division
Department of the Army
Jacksonville District Corps of Engineers
P.O. Box 4970
Jacksonville, FL 32232-0019

RE: SFRPC #94-0609, - Feasibility-phase study of manatee protection at selected navigation locks and water control structures in South Florida..

Dear Mr. Salem:

- Council staff is supportive of efforts to reduce manatee mortality in drainage control structures. With sufficient peer review, the Army Corps of Engineers can develop a cost-effective and timely plan to accomplish this task.

- The goal of reducing manatee mortality is consistent with the goals and policies of the *Regional Plan for South Florida*, specifically:

GOAL 10.1	Beginning in 1991, maintain or increase the percentage of the area of natural systems in the Region based on the area documented in local government comprehensive plans.
Policy 10.1.7	Discourage incompatible development and human encroachment in and around areas that have been identified as unique and important natural plant or animal communities.
GOAL 10.2	By 1995, increase the effectiveness of regulations designed to protect and enhance the long-term productivity of natural systems.
Policy 10.2.1	Where feasible, degraded natural systems will be restored to a functional condition within a reasonable amount of time.
Policy 10.2.2	Encourage the maintenance and restoration of the natural vegetative wildlife habitat and hydrologic functions of the Everglades and Big Cypress Swamp.
Policy 10.2.3	Developments which are required to mitigate the impacts of their development through creation or enhancement programs, shall be required to maintain, monitor and report the status of those systems to the permitting agencies for a period of no less than five years.

3440 Hollywood Boulevard, Suite 140, Hollywood, Florida 33021
Broward (305) 961-2999, Dade and Monroe (305) 620-4266, FAX (305) 961-0322

Policy 10.2.4 The initiatives of the Save Our Everglades, Save our Keys, the East Everglades Resource Planning and Management Committee Implementation, Lake Okeechobee Everglades and Biscayne Bay SWIM plans and other resource protection plans shall be considered in land and water planning by local, regional and state agencies.

GOAL 10.3 To improve the status of five percent of the threatened and endangered species reduce the number of species becoming extinct in the Region by 1995.

Policy 10.3.1 Discourage activity reducing or adversely altering the habitat of an endangered or threatened species or species of special concern.

Policy 10.3.3 Encourage the development and maintenance of wildlife corridors.

Policy 10.3.4 Coordinate the efforts of agencies involved in regulation of endangered species programs to ensure the survival of threatened and endangered species.

Policy 10.3.5 Develop public education programs regarding habitat and behavior of endangered and threatened species to inform the public of potential hazardous actions to these organisms.

Policy 10.3.8 In the review process, developments which contain potentially significant habitat or species shall, at a minimum, be required to:

a) inventory the site with an approved methodology and provide the results of the survey to reviewing agencies; and

b) either preserve the habitat of the species with appropriate buffers or relocate the species and habitat if determined acceptable by the U.S. Fish and Wildlife Service and the Florida Game and Freshwater Fish Commission.

All inventories must occur during the time of year that the anticipated species or plant community may be observed.

GOAL 10.4 By 1995, reduce man-induced manatee deaths by 25 percent.

Policy 10.4.1 Local, regional, state and federal agencies should coordinate the approval of development and the formulation of resource protection plans to reduce human-related manatee mortality and prevent the continuing loss or degradation of manatee habitat.

Policy 10.4.3 Investigate structural, operational, or other methods for reducing manatee mortality caused by flood control structures and locks.

Policy 10.4.5 Any activity that has an adverse impact on manatees or their habitat shall be prohibited or mitigate their impacts.

GOAL 10.5 By 1995, identify lands and develop land acquisition and management practices in the Region which integrate and provide a sufficient water supply and protect wildlife and natural resources.

Thank you for the opportunity to comment. We would appreciate being kept informed of further developments with regard to this project.

Sincerely,

John E. Hulsey
Regional Planner

JEH/kc

cc: Suzanne Traub-Metlay, State Clearinghouse.

United States Department of the Interior

FISH AND WILDLIFE SERVICE
6620 Southpoint Drive, South
Suite 310
Jacksonville, Florida 32216-0912

JUN 13 1994

Mr. A. J. Salem, Chief
Planning Division
Environmental Studies Section
U.S. Army Corps of Engineers
P.O. Box 4970
Jacksonville, Florida 32232-0019

Dear Mr. Salem:

The U. S. Fish and Wildlife Service (Service) has received your request for information regarding issues and concerns pertinent to the development of manatee protection modifications to certain water control structures in the Okeechobee Waterway and the Central and South Florida Project.

The proposed project will consider the feasibility of installing structural modifications to flood control gates for the purpose of reducing manatee injury and mortality. As described in your request, the Service will be preparing a Coordination Act Report for the project.

The Service looks forward to working with you and your staff in the review, assessment, and development of modifications to the described structures for the purpose of safeguarding manatees. Thank you.

Sincerely,

David L. Martin for

Michael M. Bentzien
Acting Field Supervisor

South Florida Water Management District
3301 Gun Club Road • P.O. Box 24680 • West Palm Beach, FL 33416-4680 • (407) 686-8800 • FL WATS 1-800-432-2045

CON 38-06 RF: 94253

April 27, 1994

Mr. A. J. Salem
Chief, Planning Division
U.S. Army Corps of Engineers
Jacksonville District
P. O. Box 4970
Jacksonville, Florida 32232-0019

Dear Mr. Salem: Eddie

Subject: Section 1135 Study for Manatee Protection

Thank you very much for your letter of April 7, 1994 giving us the status of your Section 1135 study for Manatee Protection at Navigational Locks and Water Control Structures.

We would like to provide special encouragement to your efforts in developing the sonar manatee detection system. We agree that this effort should be conducted outside the scope of the current 1135 manatee program. Please let us know if we can be of further assistance in this effort.

Sincerely,

Til

Tilford C. Creel
Executive Director

TCC/bj

United States Department of the Interior

FISH AND WILDLIFE SERVICE
6620 Southpoint Drive, South
Suite 310
Jacksonville, Florida 32216-0912

FEB 2 9 1994

A. J. Salem, Chief
Planning Division
Flood Control and Flood Plain Management Section
Department of the Army
Jacksonville District Corps of Engineers
P.O. Box 4970
Jacksonville, Florida 32232-0019

Dear Mr. Salem:

I have received your letter of February 9, 1994, in which you requested comments addressing the alternatives concepts developed by the Section 1135 study team. In reviewing the concepts set forth for alternatives analysis, I believe that the selected alternatives provide a good basis for review and possible implementation.

In the Memorandum for Record enclosed with your letter, mention was made of a handout describing past efforts, a list of manatee alarm concepts and available assembly drawings of the S-29 PSD installation. It would be most helpful if we could be provided with copies of these materials.

While we regret not having been able to attend your initial meeting, the Service would like to be actively involved as planning progresses. Jim Valade of my staff should be your point of contact for the Service's involvement in this project. Please direct meeting notices and materials to his attention at this office.

We look forward to working with you.

Sincerely,

Robert O. Turner
Manatee Coordinator

cc: Kipp Frohlich, DEP, Tallahassee

South Florida Water Management District

3301 Gun Club Road • P.O. Box 24680 • West Palm Beach, FL 33416-4680 • (407) 686-8800 • FL WATS 1-800-432-2045

CON 38-06

May 26, 1993

Mr. A.J.Salem
Planning Division
Flood Control and Flood Plain Management Section
CESAJ-PD
Jacksonville District
U.S. Army Corps of Engineers
P. O. Box 4970
Jacksonville, Florida 32232-0019

Dear Mr. Salem:

We are pleased to accept your proposal regarding Section 1135 - funding for Manatee Protection devices. Your response was very helpful in clarifying the scope of our proposed program.

The governing board of the South Florida Water Management District granted conceptual approval to act as local sponsor for installation of the proposed manatee protection devices on 25 structures within the South Florida Water Management District at its May 13, 1993 meeting. As detailed in your previous proposal, the South Florida Water Management District's share will be 25% of an amount not to exceed $5,000,000. Implementation details and refined cost estimates will be established as a part of an initial feasibility study and project report.

The enclosed list of 25 structures includes the 15 structures listed in your initial proposal and 10 other structures where manatee fatalities are likely. This second group was referenced in our letter of March 12 and your reply of April 6, 1993.

Please contact Mr. Ronald Mierau, Director of Operations, at (407) 687-6107, if you have further questions or need additional information.

Sincerely,

T. MacVicar

Thomas K. MacVicar
Deputy Executive Director

TKM/bj
Enclosure

United States Department of the Interior

FISH AND WILDLIFE SERVICE
3100 University Blvd. South
Suite 120
Jacksonville, Florida 32216

MAR 24 1993

Mr. Eddy Salem
CESAJ-PD
400 W. Bay St.
P.O. Box 4970
Jacksonville, FL 32232-0019

Dear Mr. Salem,

The U.S. Fish and Wildlife Service is pleased that the Corps of Engineers is seeking Water Resources Development Act Section 1135 funds in order to modify their navigation locks and water control structures in Florida for manatee protection.

Manatee deaths from these structures has been an ongoing problem. Since record-keeping began in 1974, 72 manatees have been killed by Corps of Engineers' constructed structures in Florida. The Manatee Recovery Team has determined that preventing further deaths by modifying these structures is a Priority 1 Task in the federal Manatee Recovery Plan. The Team represents a task force made up of 17 federal, state, private, and conservation agencies and groups who are dedicated to protecting manatees.

The Corps has already made significant contributions towards manatee safety at these structures. They have modified their gate opening procedures to reduce the risk to manatees. By fencing off recesses at navigation locks, manatees will be less likely to be crushed by retracting gates. These tasks were accomplished without additional funding. The Corps is currently preparing regulations to reduce boat speeds in the vicinity of locks, which will allow manatees to more easily avoid being struck by boats. This, too, is being accomplished with present funding. However, after viewing the prototype model of the Pressure Sensor Devices that the South Florida Water Management District is developing, the Service is convinced that these devices will be crucial to the attainment of our goal of "zero mortality" from locks and other water control structures. Funding will be necessary to modify and install these devices on all Corps structures in manatee habitat. The Service strongly urges that Section 1135 funds be made available for this important and timely project.

If you have any questions, please do not hesitate to call me at (904) 232-2580. Thank you.

Sincerely yours,

Robert O. Turner
Manatee Coordinator

cc: FWE, Vero
FWE, Atlanta
FWE, Washington, DC
Pete Milam, COE Jax
Patti Thompson, SMC
Mr. David Laist. MMC
Ms. Lizabeth Manners, COE
Ms. Gina M. Ruiz, Center for Marine Conservation