DECEMBER 1993
(REVISED JUNE 1994)

MARTIN COUNTY, FLORIDA
SHORE PROTECTION PROJECT

GENERAL DESIGN MEMORANDUM
WITH ENVIRONMENTAL ASSESSMENT

US Army Corps
of Engineers
Jacksonville District

MARTIN COUNTY, FLORIDA

SHORE PROTECTION PROJECT

GENERAL DESIGN MEMORANDUM

DECEMBER 1993
(REVISED JUNE 1994)

PREPARED BY

JACKSONVILLE DISTRICT
SOUTH ATLANTIC DIVISION
U.S. ARMY CORPS OF ENGINEERS

SYLLABUS

This report summarizes the detailed planning and engineering for construction of the shore protection project for Martin County, Florida. Details of the engineering investigations and design are contained in Appendix A. Benefit analysis are summarized in Appendix B. Real estate requirements for construction are summarized in Appendix C. Pertinent correspondence is presented in Appendix D.

The project as authorized provides for a protective beach berm and storm dune 4.0 miles long at Hutchinson Island, Florida, with periodic nourishment of the restored beach and such adjacent shoreline as may be needed and justified for the life of the project. The recommended plan described within this report would modify the authorized project to provide for restoration of the beach and dune with periodic nourishment for about 3.75 miles of shoreline on Hutchinson Island.

Initial restoration of the project shoreline would require 1,297,500 cubic yards of material. The borrow area for initial and future renourishments is located within a shoal area about 3,000 feet offshore of the southern project area. Also, the restored beach will require about 589,600 cubic yards of material every 11 years to maintain project dimensions.

The estimated total first cost of the recommended project is $10,491,400, including additional monitoring and interest during construction. The annual cost, including interest and amortization of the first cost and periodic nourishment, is $1,142,000. Benefits generated by project construction include: $4,888,600 in storm damage reduction benefits, $83,200 for prevention of land loss, and $702,400 in incidental recreation benefits. The total annual benefits less the total annual costs equal the net benefits amounting to $4,532,200. The benefit to cost ratio is 5.0.

The Federal share of the initial costs of construction is $4,970,300. The non-Federal share of the costs for initial construction is $5,521,200. The Federal share of each future periodic nourishment is 46.59 percent of applicable nourishment costs. The non-Federal share of the cost of each future nourishment is 53.41 percent. The final percentage of cost apportionment shall be based on law, policy and regulation, shore ownership and use at the time of construction or subsequent periodic nourishment.

9
3

MARTIN COUNTY, FLORIDA
SHORE PROTECTION PROJECT
GENERAL DESIGN MEMORANDUM
PERTINENT DATA

PHYSICAL DATA	
Initial Fill Length	3.75 Miles
Initial Fill Volume	
Design Volume	337,500 Cubic Yards
Fill Behind Erosion Control Line	156,000 Cubic Yards
1992-1996 Anticipated Erosional Losses	214,400 Cubic Yards
Advance Nourishment	589,600 Cubic Yards
TOTAL INITIAL FILL QUANTITY	1,297,500 Cubic Yards
Borrow Area - Initial Fill	Offshore Hutchinson Island
Berm Height (MLW)	9.1 Feet
Berm Width	35 Feet
Dune Height (MLW)	13.6 Feet
Dune Width	20 Feet
Future Periodic Nourishment	589,600 Cubic Yards
Nourishment Interval	11 Years
Borrow Area - Periodic Nourishment	Offshore Hutchinson Island
FINANCIAL DATA	
First Cost	
Initial Restoration	
Initial Fill	6,265,600
Administrative Costs-Lands	314,000
Monitoring	128,000
Contingencies	1,548,800
Engineering and Design	1,031,000
Construction Management	448,000
	9,735,400
Additional Monitoring Years 1-11 **(Present Worth)**	756,000
TOTAL FIRST COST	10,491,400
Interest Rate	8.00 %
Annual Cost	
Initial Restoration	795,800
Additional Monitoring	61,800
Future Nourishment	252,000
Interest During Construction	32,400
TOTAL ANNUAL COST	1,142,000
Annual Benefits	
Storm Damage Reduction	4,888,600
Prevention of Loss of Land	83,200
Recreation	702,400
TOTAL ANNUAL BENEFITS	5,674,200

FINANCIAL DATA (Continued)

NET BENEFITS	4,532,200
BENEFIT-TO-COST RATIO	5.0

COST APPORTIONMENT

FEDERAL COST-INITIAL CONSTRUCTION	Percent	Amount
Initial Restoration		
Mob & Demob	46.59	782,700
Design Fill Volume	50.88	772,800
1992-1996 Anticipated Erosional Losses	50.88	490,900
Advance Nourishment Volume	46.59	1,236,100
Eill Behind ECL (Public and Private Developed)	50.88	302,700
Monitoring	46.59	71,600
Administrative Costs-Lands	46.59	182,900
Planning, Engineering and Design	46.59	527,900
Construction Management	46.59	250,500
Additional Monitoring Years 1-11 (Present Worth)	46.59	352,200
TOTAL FEDERAL COST-INITIAL WORK	47.37	4,970,300
PERCENT FEDERAL PARTICIPATION - EACH FUTURE NOURISHMENT	46.59	

NON-FEDERAL COST-INITIAL CONSTRUCTION	Percent	Amount
Initial Restoration		
Mob & Demob	53.41	897,300
Design Fill Volume	49.12	746,000
1992-1996 Anticipated Erosional Losses	49.12	473,900
Advance Nourishment Volume	53.41	1,417,100
Fill Behind ECL (Public and Private Developed)	49.12	292,200
(Private Undeveloped)	100.00	107,100
Monitoring	53.41	82,000
Lands, Easements, Rights-of-Way	100.00	0
Administrative Costs-Lands	53.41	209,600
Planning, Engineering and Design	53.41	605,100
Construction Management	53.41	287,100
Additional Monitoring Years 1-11 (Present Worth)	53.41	403,800
TOTAL NON-FEDERAL COST-INITIAL WORK	52.63	5,521,200
PERCENT NON-FEDERAL PARTICIPATION - EACH FUTURE NOURISHMENT	53.41	

11
5

MARTIN COUNTY, FLORIDA
SHORE PROTECTION PROJECT
GENERAL DESIGN MEMORANDUM

TABLE OF CONTENTS

Subject	Page No.
INTRODUCTION	1
Scope	1
THE AUTHORIZED PROJECT	1
Authorization and Description	1
Items of Project Cooperation	2
Modifications to the Items of Project Cooperation	3
Project Sponsorship	5
PROJECT DESIGN	6
Modifications to the Authorized Project	6
Project Description	6
Project Length Modifications	6
Project Berm Modifications	7
Project Dune Modifications	7
Modifications to Volume of Fill Required	7
Potential Sand Sources	8
Environmental Related Modifications	8
THE RECOMMENDED PROJECT MODIFICATION	8
Plan Description	8
Initial Restoration and Periodic Nourishment	8
Volume of Material	9
Fill Behind Erosion Control Line	9
Design Fill Volume	9
Anticipated Erosional Losses	9
Advance Nourishment	9
Future Periodic Nourishment	9
Overfill Volume	10
Borrow Sources	10
Magnetometer Survey	10
Environmental Considerations	10
Construction	11
Real Estate Requirements and Relocations	12
Schedule for Plans, Specifications, and Construction	12
Project Monitoring	12

TABLE OF CONTENTS (Continued)

Subject	Page No.
ECONOMICS OF THE RECOMMENDED PROJECT MODIFICATIONS	14
Cost Estimates	14
Interest and Amortization of First Costs	14
Interest During Construction	14
Annual Cost of Future Nourishment	14
Benefits Summary	27
Economic Justification	27
PLAN IMPLEMENTATION	27
Cost Apportionment	27
Federal Responsibility	34
Non-Federal Responsibility	34
Other Non-Federal Requirements	34
Views of the Non-Federal Sponsor	36
Financial Analysis	36
Non-Federal Sponsor Financing Plan and Financial Statement	36
State Financing Plan	36
Financing Assessment	36
DEPARTURES FROM THE AUTHORIZED PROJECT	37
Physical Changes	37
Financial Changes	39
Costs	39
Benefits	39
Cost Apportionment	39
STUDY SUMMARY	39
FLOOD PLAIN DEVELOPMENT	40
COST EFFECTIVENESS OF DESIGN	40
PUBLIC ACCESSIBILITY	41
CONCLUSIONS	41
RECOMMENDATIONS	41
Disclaimer	41
BIBLIOGRAPHY	42

13

7

TABLE OF CONTENTS (Continued)

Subject	Page No.
APPENDIX A - ENGINEERING DESIGN AND COST ESTIMATES	
APPENDIX B - BENEFIT ANALYSIS	
APPENDIX C - REAL ESTATE PLAN	
APPENDIX D - PERTINENT CORRESPONDENCE	

LIST OF TABLES

Titles	Table No.	Page No.
Monitoring Schedule	1	13
Initial Cost-Beach Nourishment	2	15
Total Project Cost Summary	3	16
Economic Summary Recommended Project	4	28
Apportionment of Cost	5	29
Total Project Cost Sharing	6	35
Summary of Changes to the Authorized Project	7	38

LIST OF FIGURES

Titles	Figure No.
Location Map - Authorized Project	1

LIST OF PLATES

Titles	Plate No.
Selected Plan - Location Map	1
Selected Plan	2
Selected Plan	3
Selected Plan	4
Selected Plan	5
Selected Plan	6
Selected Plan	7
Selected Plan	8
Selected Plan	9
Selected Plan	10
Borrow Area, Core Boring Locations And Geologic Section Location	11
Geologic Cross Sections	12

MARTIN COUNTY, FLORIDA
SHORE PROTECTION PROJECT
GENERAL DESIGN MEMORANDUM

INTRODUCTION

1. The purpose of this report is to reaffirm the basic planning decisions, update environmental impacts, advance the level of engineering and design, and reconfirm the economic feasibility of the authorized project for shore protection at Martin County, Florida. The plan presented in this report, when approved, will be the basis for preparation and approval for plans and specifications.

SCOPE

2. The investigations made during the preparation of this report involved an updating and expansion of previous data and findings. Additional economic, environmental, and engineering studies provided more detail to better compare costs, benefits, and other impacts to identify what, if any, portion of the authorized project is feasible for construction. Consequently, the scope of technical analyses are sufficient for the final design of project features and the preparation of accurate cost estimates. Studies and analyses were in accordance with guidance for the preparation of post authorization studies presented in Engineering Regulation 1110-2-1150. Items of work during the study included detailed subsurface investigations of potential borrow areas, topographic and hydrologic surveys, coastal processes analysis including SBEACH and GENESIS shoreline change modeling, review of environmental impacts including the determination of nearshore hardbottom impacts, and the determination of costs and economic benefits arising from the construction of beach fill.

THE AUTHORIZED PROJECT

AUTHORIZATION AND DESCRIPTION

3. The shore protection project for Martin County, Florida, is described in feasibility report titled, "Beach Erosion Control Study for Martin County, Florida, with Environmental Impact Statement", dated September 1985 (Revised June 1986). The project was authorized by the Water Resource Development Act of 1990 (Public Law 101-640). The final Environmental Impact Statement was filed with the Environmental Protection Agency in 1986. The authorized plan consisted of restoration of 4 miles of shorefront southward from the St. Lucie County line to near the limit of Stuart Public Beach park. The plan would include restoration of the primary dune as needed to an elevation of 12.5 feet above mean sea level (MSL) and a top width of 20 feet.

A 35-foot-wide protective berm would be provided at an elevation of 8.0 feet MSL with a 1 foot vertical on 8.5 foot horizontal foreshore slope to mean low water then a 1 foot vertical on 20 foot horizontal slope to the existing bottom. In order to maintain the protective beach, advance nourishment is included in the initial beach fill, and periodic nourishment would be provided at 8 year intervals to replace anticipated erosion losses. The project is described in the 1985 feasibility report. Figure 1 displays a map of the project area.

ITEMS OF PROJECT COOPERATION

4. The authorization of a shore protection project for Martin County, Florida, was made with the provision that Federal cost sharing would be in accordance with policy established by existing law, and the percentages based on conditions of shore ownership and use existing at the time of construction: Provided that, prior to construction, local interests furnish assurances satisfactory to the Secretary of the Army that they will:

a. Provide without cost to the United States all necessary lands, easements, rights-of-way, and relocations required for construction, operation, and maintenance of the project, including that required for periodic nourishment;

b. Hold and save the United States free from claims for damages which may result from construction and subsequent operation, maintenance, and public use of the project, except damages due to the fault or negligence of the United States or its contractors;

c. Assure continued conditions of public ownership and use of the shore upon which the amount of Federal participation is based during the economic life of the project;

d. Assure maintenance and repair during the economic life of the project as required to serve the intended purposes, in accordance with regulations prescribed by the Secretary of the Army;

e. Provide and maintain necessary access roads, parking areas, and other public use facilities, open and available to all on equal terms, and as required to realize the benefits upon which Federal participation is based;

f. Provide a cash contribution for beach erosion control equal to the appropriate percentage of the final construction cost allocated to this function, exclusive of lands, easements, rights-of-way, alterations, and relocations, the percentage to be in accordance with existing law and based on shore ownership at the time of implementation;

g. Provide a cash contribution for periodic nourishment for the life of the project, such contribution to be made prior to each nourishment, with the actual amount to be based on existing law and conditions of ownership at the time of each nourishment; and

h. Provide a cash contribution for the cost of beach fill placed landward of the erosion control line on private lands, during initial construction or subsequent nourishment, the cost to be determined at the time of construction or periodic nourishment.

MODIFICATIONS TO THE ITEMS OF PROJECT COOPERATION

5. The Water Resources Development Act of 1986 (Public Law 99-662) specifies new cost sharing for water resource projects, including shore protection. Allocation of project costs in accordance with current law and policy is discussed in detail later under cost apportionment.

6. Section 103(i) of the Act specifies that the non-Federal interests shall provide all lands, easements, rights-of-way, and disposal areas necessary for construction, and perform all necessary relocations. Section 103(i) also specifies that the value of any contributions under the preceding sentence shall be included in the non-Federal share of the project cost.

7. Section 103(j)(l) of the Act specifies that a project shall be initiated only after non-Federal interests have entered into binding agreements with the Secretary of the Army to pay 100 percent of the operation, maintenance, and replacement and rehabilitations costs of the project, to pay the non-Federal share of the costs of construction, and to hold and save the United States free from damages due to the construction or operation and maintenance of the project, except for damages due to the fault or negligence of the United States or its contractors. A Project Cooperation Agreement (PCA) will be entered for construction of this project if approved by the Assistant Secretary of the Army (Civil Works).

8. Section 103(j)(2) of the Act specifies that the agreement specified in Section 103(j)(l) shall be in accordance with the requirements of Section 221 of the flood control Act of 1970.

9. Section 402 of the Act, as amended by Section 14 of the Water Resources Development Act of 1988, requires that "before construction of any project for local flood protection or any project for hurricane or storm damage reduction, the non-Federal interests shall agree to participate in and comply with applicable Federal flood plain management and flood insurance programs.: An item of project cooperation was added to insure compliance with Section 402. The PCA will reflect this requirement.

10. The items of project cooperation have been revised to reflect the current legislation and are presented as follows:

a. Provide to the United States all necessary lands, easements, and rights-of-way, and relocations including suitable borrow and disposal areas as determined by the Chief of Engineers to be required for construction of the project, including that required for periodic nourishment;

b. Provide a cash contribution of initial construction cost based upon 35 percent of the total cost of initial construction attributable to hurricane and storm damage reduction, 50 percent of the total initial construction cost attributable to recreation and 100 percent of the total cost of initial construction attributable to protection of lands not open to the public (the cumulative percentage will be based on the conditions of shore ownership and use at time of construction);

c. Pay cash contributions in a lump sum prior to the start of construction or, as may be permitted by the Chief of Engineers, in installments prior to the start of pertinent project units or sections and in accordance with his construction schedules;

d. Provide all costs of construction for placement of fill on lands not open to the public and share in the costs of construction for placement of fill on public lands landward of the Corps Construction Line (CCL).

e. Provide a cash contribution for periodic nourishment based upon 35 percent of the total cost of periodic nourishment attributable to hurricane and storm damage reduction, 50 percent of the periodic nourishment cost attributable to recreation and 100 percent of the total cost of periodic nourishment attributable to protection of lands not open to the public (the cumulative percentage will be based on the conditions of shore ownership and use at time of construction);

f. Hold and save the United States free from damages due to the construction, operation, maintenance, repair, replacement, and rehabilitation of the project and any project-related betterments, except for damages due to the fault or negligence of the United States or its contractors;

g. Assure continued conditions of public ownership and use of the shore upon which the amount of Federal participation is based during the economic life of the project;

h. Provide and maintain necessary access roads, parking areas, and other public use facilities, open and available to all on equal terms;

i. Agree to pay 100 percent of the operation, maintenance, and replacement and rehabilitation costs of the project, or functional element thereof;

j. Participate in and comply with applicable Federal flood plain management and flood insurance programs prior to initiation of construction and during the economic life of the project;

k. Comply with the applicable provisions of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, Public Law 91-646, as amended by Title IV of the Surface Transportation and Uniform Relocation Assistance Act of 1987, Public Law 100-17, and the Uniform Regulations contained in 49 CFR Part 24, in acquiring lands, easements, and rights-of-way, and maintenance, of the project, and inform all affected persons of applicable benefits, policies, and procedures in connection with said Act;

l. Comply with applicable Federal and State laws and regulations, including Section 601 of Title VI of the Civil Rights Act of 1964, Public Law 88-352, and Department of Defence Directive 5500.II issued pursuant thereto and published in Part 300 of Title 32, case of Federal Regulations, as well as Army Regulations 600-7, entitled "Nondiscrimination on the Basis of Handicap in Programs and Activities Assisted or Conducted by the Department of the Army";

m. Maintain and repair the protective measures and/or structures during the economic life of the project as required to serve the intended purposes and in accordance with regulations prescribed by the Secretary of the Army;

n. Grant the Government a right to enter, at reasonable times and in a reasonable manner, upon land which the non-Federal Sponsor owns or controls for access to the project for the purpose of completing, operating, maintaining, repairing, replacing, or rehabilitating the project;

o. Perform, or cause to be performed, such investigations for hazardous substances as are determined necessary to identify the existence and extent of any hazardous substances regulated under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), 42 USC 9601-9675, on lands necessary for project construction, operation, and maintenance; and,

p. To the maximum extent practicable, operate, maintain, repair, replace, and rehabilitate the project in a manner that will not cause liability to arise under CERCLA.

PROJECT SPONSORSHIP

11. The Martin County Board of Commissioners is the non-Federal sponsor for the project. The county expressed their desire to serve as the non-Federal interest that will share in the costs of the project in the letter of intent dated October 2, 1985 and reiterated their intent to sponsor the project by letter dated June 9, 1994. Copies of

these letters are contained in the correspondence appendix. The non-Federal sponsor has consistently demonstrated their strong support of this project and their desire that it be constructed in a timely manner.

PROJECT DESIGN

MODIFICATIONS TO THE AUTHORIZED PROJECT

12. Project Description. The authorized project provided for restoration of 21,120 feet of beachfront on Hutchinson Island at Stuart, Florida. The initial beach fill was comprised of 942,000 cubic yards of material which included 8 years advance nourishment with an overfill ratio of 1.15. The annual nourishment rate for this reach was 61,000 cubic yards. The cross section of the beach fill consisted of a restored primary dune with a 20-foot-wide crest at +12.5 feet MSL, a berm 35 feet wide at an elevation of +8 feet MSL, and seaward slopes of 1V:8.5H to an elevation of mean low water, then 1V:20H to the existing bottom. The selected borrow area for beach fill material was located from 1/2 mile to 1 mile offshore of Stuart Public Beach park. Approximately 8 million cubic yards of sand were estimated to be located in this shoal area. An overfill ratio of 1.15 was estimated for material from this borrow area. Renourishment of 488,000 cubic yards was estimated to be required at 8-year intervals to replace anticipated losses. The cost of the initial beach fill was estimated at $9,521,000. The average annual benefits for the recommended plan were estimated at $2,225,000. The average annual cost of construction was $1,340,000 with a resulting benefit to cost ratio of 1.7 to 1.

13. Project Length Modifications. Since initiation of the GDM, numerous investigations including side-scan sonar with ground truthing, aerial photography, and underwater diver-verified reef characterization studies, have been conducted along the project reach. Although these investigation revealed the presence of hard bottom communities throughout the project area, it was apparent that those located between DEP monuments R-21 through R-25 at the southern end of the project, would especially be impacted by the fill due to their close proximity to shore. Coordination with the State of Florida Department of Environmental Protection (DEP) indicated that project construction within this area, even with associated mitigation, was unacceptable. Therefore, the authorized beach nourishment of this segment is considered to be non-implementable. Coordination indicated that construction from the St. Lucie/Martin County line to DEP monument R-21 with a gradual taper of the fill to zero width at R-23 would be acceptable. Construction of the dune system along the entire project reach to monument R-23 would also be acceptable. It is recommended that the length of the project fill be reduced by about 1,800 feet with the southern limit terminating at DEP monument R-23.

14. Project Berm Modifications. The authorized project berm elevation is 8.0 feet mean sea level with a width of 35 feet. Based on the maximization of net storm damage reduction benefits alone, the 35 foot authorized beach width should be increased to a 100 foot wide berm extension. However, construction of a larger beach section would impact the nearshore hardground areas by direct burial of the hardgrounds from the adjusted fill sections. Based upon current policies of the State and the Department of the Army, proposals for construction should not result in any net adverse impacts to the environment. The U.S. Army Corps of Engineers policy requires that environmental aspects of all projects must not only be given consideration, but must bare equal standing among other plan formulation criteria. Only after adverse impacts are minimized, can the National Economic Development plan (NED) be determined and unavoidable impacts compensated through appropriate mitigation. In order to reduce adverse impacts to the maximum extent practicable from the coverage of nearshore hardbottom communities by the adjusted fill, the Jacksonville District has determined that the authorized 35-foot design is the maximum acceptable design section which will not significantly impact the environment. The proposed berm elevation of 9.1 feet mean low water is equivalent to the authorized level and is selected to coincide with the natural berm elevation in the problem area.

15. Project Dune Modifications. The authorized project includes a beach dune 20 feet wide at an elevation of 12.5 feet mean sea level with a 1 on 5 slope down to the intersection with the recommended project beach berm. The proposed dune elevation of 13.6 feet mean low water is equivalent to the authorized elevation. The proposed dune width of 20 feet is identical to the authorized project dimension.

16. Modifications to Volume of Fill Required. The original authorized project fill requirement for the Hutchinson Island segment of the Martin County project was 942,000 cubic yards. Of this volume, 454,000 cubic yards was the design beach fill quantity including the dune, 424,000 cubic yards was the advance nourishment for anticipated erosion losses, and 64,000 cubic yards was the additional yardage required due to an overfill ratio of 1.15. Corresponding volumes required for the currently recommended plan include 493,500 for the design berm and dune fill and 589,600 for the advance nourishment volume. There is no volume associated with the overfill ratio since the current estimate of the ratio is 1.00. Variation in the design fill volume is due to the altered beach fill cross section based on current survey data and the reduction of the overall beach fill length by 1,800 feet. A different advance nourishment volume arises due to an update of the annual volumetric losses within the project length and a renourishment interval optimizing economically at 11 years versus 8 years as contained within the authorized project.

17. Potential Sand Sources. Two potential borrow areas were identified during the feasibility stage of investigations. The northern site is referred to as Gilbert Shoal and is located approximately three miles north of St. Lucie Inlet, 4,000 feet offshore. The southern site consisted of a shore parallel strip roughly 4,000 feet wide extending along the developed portion of Jupiter Island which is south of St. Lucie Inlet. Due to the close proximity to the project site and the availability of about 6 million cubic yards with 5 percent or less silt content, the Gilbert Shoal was chosen as the borrow area for the currently recommended project fill. The offshore borrow area is shown on Plate 11.

18. Environmental Related Modifications. Recent environmental investigations have resulted in the mapping and characterization of numerous hardbottom communities within the project area. From coordination and cooperative site visits with personnel of the United States Fish and Wildlife Service and the State of Florida Department of Environmental Protection, it has been determined that this resource would not be directly impacted with the project fill as currently recommended. However, extensive multi-year monitoring is being recommended to ascertain what secondary impacts, if any, have occurred to hardbottom habitat and associated flora and fauna due to beach fill activities. Mitigation will be undertaken should monitoring determine it is required. The authorized project did not include monitoring nor mitigation.

THE RECOMMENDED PROJECT MODIFICATION

19. The authorized project provides for initial restoration of about 4.0 miles of shoreline on Hutchinson Island with future renourishment as needed and justified. The recommended plan contained within this report is equivalent to that authorized except for a length reduction of about 1,800 feet from the southern end of the project. It has been determined in Appendix B, Economic Analysis, that this plan is economically justified. The engineering details are also contained within Appendix A.

PLAN DESCRIPTION

20. Initial Restoration and Periodic Nourishment. The recommended plan for Martin County provides for restoration of a protective beach along 3.75 miles of shoreline. The north limit of initial restoration is the St. Lucie/Martin County line. The south limit is at DEP survey monument R-23. A total of 1,297,500 million cubic yards of sand would be placed during the initial construction. This material consists of fill placed behind the Erosion Control Line, design beach section fill, advance nourishment fill and anticipated erosional losses expected from the date of the survey (1992) through the time of construction (1996). Each of these quantities is discussed as follows.

VOLUME OF MATERIAL

21. Fill Behind Erosion Control Line. The State of Florida requires that the non-Federal sponsor establish an erosion control line (ECL) at the existing mean high water line. The purpose of the line is to establish where state-owned bottom land ends and private uplands begin. Plates 2 through 10 show the estimated location of this line. A portion of the project fill is contained landward of the ECL. It is estimated that about 156,000 cubic yards of sand will be placed landward of the ECL over the entire 3.75 mile project fill.

22. Design Fill Volume. The existing beach profile cross-sections were compared with the considered design section to determine the average area of fill between two adjacent profile lines. The average area was then multiplied by the distance between the survey lines to estimate the volume. Summation of these quantities then resulted in the total fill for the entire project length. The design sections were developed using the berm widths and elevations discussed previously. The estimated volume of the fill required for the design berm exclusive of the amount behind the ECL, anticipated erosional losses and advance nourishment is 337,500 cubic yards.

23. Anticipated Erosional Losses. Since the survey was accomplished in 1992, it is expected that the project scope will grow due to additional erosion prior to construction. The estimated construction completion date is 1996, approximately 4 years following the 1992 survey. The anticipated erosional volume is based on the long-term annual losses for this project, approximately 53,600 cubic yards based on comparative surveys taken from 1971 to 1992). The estimated additional volume required to offset anticipated erosional losses is 214,400 cubic yards (53,600 X 4).

24. Advance Nourishment. In anticipation of continuing erosion of the shoreline after the project fill has been placed, a sacrificial volume of material called advanced nourishment is also included to offset these losses. The volume of advanced nourishment is based on the long-term erosion losses and the anticipated renourishment interval. As mentioned above, the long-term annual losses were estimated to be 53,600 cubic yards. The number of years of advance nourishment placed during initial construction is dependent upon an economic determination of the least average annual equivalent cost. Nourishment intervals from one to twenty years were evaluated as contained in the cost estimate section of Appendix A. A renourishment interval of 11 years resulted in the lowest equivalent annual cost. The associated volume without overfill is 589,600 cubic yards.

25. Future Periodic Nourishment. After project construction, performance monitoring of the placed material would be required to determine with greater accuracy the future periodic nourishment requirements. For the purpose of this report, the amount of future periodic nourishment required is based on the historic

pre-project volumetric losses. This quantity is the same amount as that required for advanced nourishment without overfill.

26. Overfill Volume. The overfill quantity is determined by multiplying the overfill ratio by the quantity of material expected to undergo the sorting action of waves on the beach. This quantity of material is the advance nourishment volume. The overfill ratio is a measure of stability of the individual grain size from the borrow area compared to that of the native beach material. The overfill ratio for material from the Martin County borrow site is 1.0, indicating that the material has a grain size equal to or larger than that on the native beach. Therefore, there will be no additional volume required to be placed on the beach to offset losses attributable to borrow site grain size.

27. Borrow Sources. The borrow area for the initial and periodic future renourishments is shown on Plate 11. Geologic sections for the borrow site are shown on Plate 12. The borrow area consists of a shoal located about 3,000 feet offshore of southern Hutchinson Island and about 3 miles northeast of St. Lucie Inlet. The site is irregularly shaped and about 3,000 feet wide and about 6,750 feet long at a maximum. It is estimated that this area contains about 6.0 million cubic yards of beach quality material. The mean grain size is 0.38 millimeters and sorting of 1.39. The borrow material is estimated to contain less than 5 percent silt within a deposit 10 to 16 feet thick.

28. Magnetometer Survey. A magnetometer survey of the borrow site was conducted between February 22-26, 1993. The results of this investigation are contained within a report titled "A Cultural Resource Magnetometer Survey of Proposed Borrow Area, Martin County, Florida" prepared by Wes Hall, Mid-Atlantic Technology. No potentially significant submerged archeological resources were identified in the offshore borrow area which will be used for the recommended project. The results of the survey have been coordinated with the State of Florida.

ENVIRONMENTAL CONSIDERATIONS

29. The environmental impacts of the Martin County shore protection project were described in the Final Environmental Impact Statement (FEIS) on beach erosion control, which was filed in 1986 with the Environmental Protection Agency. A draft Environmental Assessment has been prepared for the recommended plan and was forwarded for coordination by letter dated 23 December 1993. The major change from the plan as considered in the 1985 FEIS is the reduction of the overall project length for nourishment by about 1,800 feet.

30. In the course of preparation of the 1985 Feasibility Report and the 1985 FEIS, information on all considered borrow areas and the project fill area was furnished by the U.S. Fish and Wildlife Service pursuant to the Fish and Wildlife Coordination

Act. The FWS investigations showed that there were hard bottom biological communities located throughout the project fill area but none within or immediately adjacent to the borrow area offshore of Hutchinson Island. The FWS recommended that the toe of the beach fill not be allowed to encroach farther seaward than the landward extent of the nearshore reef (hardbottom) and that the borrow area be located a minimum of 1,000 feet from any reef structure. FWS also recommended that due to the extremely high density of sea turtle nesting along Hutchinson Island that the nourishment of the four mile segment between the Martin/St. Lucie County line to a point south of Stuart public beach not be conducted during the period from April to November. In addition, no material should be used for beach nourishment that exceeds the maximum silt and clay content recommended by a Waterways Experiment Station (WES) which due to its compaction would adversely affect sea turtle nesting.

31. The currently recommended project has been altered to reduce associated environmental impacts to minimum levels. Of primary importance is the impact of project construction on sea turtle nesting. In order to avoid these impacts, the construction of the Martin County shore protection project is scheduled to occur between the first of November and the fifteenth of April. In addition, sea turtle nest monitoring and relocation would occur between the first of March through the fifteenth of April as required. To reduce the potential impacts on nearshore hardbottoms, the project length has been reduced by 1,800 feet resulting in no hardbottom loss. As stated previously, the borrow material is comparable in grain size to the native beach and its estimated to contain 5 percent or less of silt and fines. As such, compaction effects on sea turtle nesting are expected to be minimized. However, if during construction and subsequent monitoring it becomes apparent that the compaction of fill is excessive, tilling of the beach surface would be initiated.

CONSTRUCTION

32. Due to the environmental dredging window, beach nourishment would be accomplished by mobilizing two cutterhead pipeline type dredges with discharge directly onto the project beach. The initial discharge of material would be formed into a shore parallel dike which would advance alongshore ahead of the construction template backfill. The dike would help to contain the discharge effluent allowing time for sediments to drop from the flow. Construction would generally commence at the south end of the project and work toward the north with the actual shaping of the construction template being performed by land based heavy equipment. Assuming a production rate of 209,000 pay cubic yards per month per dredge, the actual time required for placing the total volume on the beach is 3.1 months. The time required for mobilization and demobilization is 30 days. In addition, 30 days is generally allowed for a contractor to initiate mobilization after receiving their "notice to proceed". Therefore, total construction time from initiation to completion of the project would be close to 5 months.

REAL ESTATE REQUIREMENTS AND RELOCATIONS

33. Temporary construction easements are needed from the upland property owners for access to the construction site and to place dredged material on private lands behind the Corps Construction Line (CCL) to avoid creating a gap between the toe of the dune and retaining walls or structures. The CCL is defined, herein, as the landward limit required for construction and maintenance of the proposed project dimensions. Permanent easements will be required along the beach front on the private land landward from the ECL to the CCL for initial beach fill, periodic nourishment, and dune nourishment, as well as making the area open to the public. The costs of construction are cost shareable and administrative costs for lands are creditable in front of developed private lots where perpetual easements make the land open to the public. However, in front of undeveloped private lands, the cost of construction and lands are 100% non-Federal as there is no Federal interest. A detailed evaluation of real estate requirements is contained within Appendix C.

SCHEDULE FOR PLANS, SPECIFICATIONS, AND CONSTRUCTION

34. The anticipated time for preparation of plans and specifications, and initial construction is about 18 months. Construction time for future nourishments is estimated at five months for each nourishment including time for mobilization and demobilization. Construction schedules are contingent upon project Federal and non-Federal funding, acquisition of appropriate permits, and the execution of the Project Cooperation Agreement (PCA) between the U.S. Army Corps of engineers and the non-Federal sponsor.

PROJECT MONITORING

35. An "as-built" beach profile survey is taken of the constructed beach nourishment project by the contractor. This survey allows verification of in-place material, and would be used as the base survey for the physical performance monitoring of the completed work. Physical monitoring will include profile line beach/hydrographic surveys, measurements of dry beach widths taken seasonally and after major storms, aerial photography, and bathymetric surveys of the borrow area. In addition to the physical monitoring plan extensive environmental monitoring is proposed. Pre-project conditions based on 9 permanent ecological offshore transects including evaluation of sediment on hardbottoms, organisms on hardbottom habitat, fish census at hardbottoms, and turbidity monitoring would again serve as a project baseline. These monitoring items would be repeated at selected time intervals to monitor project performance. The proposed schedule for physical and environmental monitoring is presented in Table 1, Project Monitoring Requirements.

TABLE 1
MONITORING SCHEDULE

REQUIREMENT TYPE	FREQUENCY OF REQUIREMENT													
	Pre-Const. FY-1994	Pre-Const. FY-1995	Const. FY-1996	1 FY-1997	2 FY-1998	3 FY-1999	4 FY-2000	5 FY-2001	6 FY-2002	7 FY-2003	8 FY-2004	9 FY-2005	10 FY-2006	11 FY-2007
Physical Monitoring														
Beach / Hydro Surveys *	X**	X**	X	X****	X			X			X			X
(At FDEP monument locations, from 150 feet behind monuments to 2000 feet offshore)														
Dry Beach Widths				X	X			X			X			X
(Post-construction MHW to base of dune at FDEP monument locations for seasonal changes)														
Aerial Survey	X***			X	X			X			X			X
(Uncontrolled, but based on location of known landmarks)														
Bathymetry at Borrow Site	X**	X**		X	X			X			X			X
Environmental Monitoring +														
Reef Tracts Ecological Characterization	X ++													
Set-up Sampling Transect Stations	X ++													
(9 permanent transect stations)														
Sea Turtle Protection Plan			X	X	X			X			X			X
(As required)														
Sediment on Hardbottoms	X ++	X	X	X	X			X			X			X
(Sediment trap comparison of project beach and south of project beach)														
Organisms on Hardbottom Habitat	X ++	X	X	X	X			X			X			X
(Photogrammetric comparison of permanent quadrats along 9 transect lines)														
Fish Census at Hardbottoms	X ++	X	X	X	X			X			X			X
(Modified Bohnsack technique at selected reef tracts)														
Turbidity Monitoring	X ++	X	X	X	X			X			X			X
(At beach and north/south of project area for background)														
TOTAL COSTS (w/o contingencies, E&D, S&I)	$195,000	$166,000	$128,000	$157,000	$157,000			$157,000			$157,000			$157,000

* And after storms as required.
** Plans and Specs scope surveys.
*** Flown in May 1992.
**** To be surveyed 6 months after construction.

\+ Estimates are based on 6 visits to the site per year (quarterly and two times after possible storm events).
++ For FY94, total costs include setup of monitoring stations necessary for environmental monitoring.

ECONOMICS OF THE RECOMMENDED PROJECT MODIFICATIONS

COST ESTIMATES

36. Project cost estimates are based on December 1993 price levels. The cost estimates include 20 percent contingencies with an additional 15 percent included for the remaining engineering and design and for construction management. An interest rate of 8 percent was used to determine the equivalent average annual costs.

37. Interest and Amortization of First Costs. Interest and amortization of the project costs are determined by multiplying the initial work capital recovery factor (0.081743 @ 8 percent) times the cost of the work accomplished during initial construction. Interest and amortization of the initial cost of construction ($795,800) plus the annualized cost of project performance monitoring during the first 11 years of the project life ($61,800) was estimated to be $857,600.

38. Interest During Construction. Interest during construction accounts for the cost of capital incurred during the construction period. The cost of a project to be amortized is the investment incurred up to the time that the project begins to produce benefits, or the time when it is placed in operation. The investment cost at that time is the sum of the construction and other initial costs plus interest during construction. Interest during construction for this project was computed in accordance with accounting practices which provide for interest from the middle of the month in which expenditures are made to the in-service date of the function or separable unit thereof. The in-service date is the first of the month following availability for service. Interest during construction was calculated and annualized at 8.00% over the 50-year project life and was estimated to be $32,400.

39. Annual Cost of Future Beach Nourishment. The cost of each future beach nourishment utilizing the recommended offshore borrow area is $4,194,000. The equivalent annual cost of the nourishment based on 11 year intervals is $252,000.

40. Engineering Circular 1110-2-538 dated 28 February 1989 requires the establishment and consistent use of a standard code of accounts to be used when estimating costs for civil works projects. Cost estimates for the initial construction of the recommended project are presented in Table 2 and are listed by the specified code of accounts for each separable item. Table 3 shows the cost estimates in the standard code of accounts for future project construction based upon December 1993 price levels. Quantities required for future construction were determined following methods

TABLE 2
MARTIN COUNTY, FLORIDA
INITIAL COST - BEACH NOURISHMENT

ACCOUNT CODE	ITEM	QUANTITY	UNIT	UNIT PRICE	AMOUNT
17.00.01	Mob. & Demob.	1	JOB	L.S.	1,400,000
17.00.16	Pipeline Dredging				
	Design Volume	337,500	CY	3.75	1,265,600
	Fill Behind ECL	156,000	CY	3.75	585,000
	Advance Nourish.	589,600	CY	3.75	2,211,000
	Anticip. Erosion	214,400	CY	3.75	804,000
06.03.73	Monitoring	1	JOB	L.S.	128,000
	Subtotal, Construction Costs				6,393,600
01.--.--	Lands and Damages				314,000
30.--.--	Planning, Engineering, and Design				1,031,000
31.--.--	Construction Management				448,000
17.00.Z	Contingencies				1,548,800
	TOTAL CONSTRUCTION COSTS*				9,735,400

* Excludes Interest During Construction

TABLE 3
TOTAL PROJECT COST SUMMARY

TOTAL - ALL CONTRACTS **** TOTAL PROJECT COST SUMMARY **** PAGE 1 OF 11

THIS ESTIMATE IS BASED ON THE SCOPE CONTAINED IN THE GDM, DATED: DEC 93

PROJECT: MARTIN COUNTY BEC
LOCATION: MARTIN COUNTY, FLORIDA

DISTRICT: JACKSONVILLE
P.O.C.: MILTON WITT, CHIEF, COST ENGINEERING

		CURRENT MCACES ESTIMATE PREPARED: DEC 93 EFFECTIVE PRICING LEVEL: DEC 93				AUTHORIZ./BUDGET YEAR: 1996 EFFECT. PRICING LEVEL: 1 OCT 94			.....FULLY FUNDED ESTIMATE.....		
ACCOUNT NUMBER	FEATURE DESCRIPTION	COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	COST ($K)	CNTG ($K)	TOTAL ($K)	COST ($K)	CNTG ($K)	FULL ($K)
06---	FISH AND WILDLIFE	1,425	285	20%	1,710	1,450	295	1,745	2,461	503	2,964
17---	BEACH REPLENISHMENT	17,909	3,581	20%	21,490	18,297	3,660	21,957	37,271	7,455	44,726
	TOTAL CONSTRUCTION COSTS =====>	19,334	3,866	20%	23,200	19,747	3,955	23,702	39,732	7,958	47,690
01---	LANDS AND DAMAGES	314	79	25%	393	317	83	400	330	87	417
30---	PLANNING, ENGINEERING AND DESIGN	2,068	308	15%	2,376	2,099	316	2,415	3,697	639	4,336
31---	CONSTRUCTION MANAGEMENT	1,355	271	20%	1,626	1,385	278	1,663	2,878	579	3,457
	TOTAL PROJECT COSTS ==========>	23,071	4,524	20%	27,595	23,548	4,632	28,180	46,637	9,263	55,900

TOTAL FEDERAL COSTS ==========> 25,600

TOTAL NON-FEDERAL COSTS ==========> 30,300

THIS TPCS REFLECTS A PROJECT COST CHANGE OF $(56,900,000)

THE MAXIMUM PROJECT COST IS =======> $ _____

DISTRICT APPROVED:

_____ CHIEF, COST ENGINEERING
_____ CHIEF, REAL ESTATE
_____ CHIEF, PLANNING
_____ CHIEF, ENGINEERING
_____ CHIEF, CON-OPS
_____ CHIEF, PROGRAMS MANAGEMENT
_____ PROJECT MANAGER
_____ DDE (PM)

DIVISION APPROVED:

_____ CHIEF, COST ENGINEERING
_____ DIRECTOR, REAL ESTATE
_____ CHIEF, PROGRAMS MANAGEMENT
_____ DIRECTOR OF PPMD

APPROVED DATE: _____

TABLE 3 (Continued)
TOTAL PROJECT COST SUMMARY

INITIAL FILL AND ADVANCE NOURISHMENT **** TOTAL CONTRACT COST SUMMARY **** PAGE 2 OF 11

THIS ESTIMATE IS BASED ON THE SCOPE CONTAINED IN THE GDM, DATED: DEC 93

PROJECT: MARTIN COUNTY BEC
LOCATION: MARTIN COUNTY, FLORIDA

DISTRICT: JACKSONVILLE
P.O.C.: MILTON WITT, CHIEF, COST ENGINEERING

		CURRENT MCACES ESTIMATE PREPARED: DEC 93 EFFECTIVE PRICING LEVEL: DEC 93				AUTHORIZ./BUDGET YEAR: 1996 EFFECT. PRICING LEVEL: 1 OCT 94				.....FULLY FUNDED ESTIMATE.....				
ACCOUNT NUMBER	FEATURE DESCRIPTION	COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	OMB (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	FEATURE MID PT	OMB (%)	COST ($K)	CNTG ($K)	FULL ($K)
06---	FISH AND WILDLIFE FACILITIES	128	26	20%	154	1.9%	130	27	157	FEB 96	3.8%	135	28	163
17---	BEACH REPLENISHMENT	6,265	1,253	20%	7,518	2.2%	6,401	1,280	7,681	FEB 96	3.9%	6,653	1,330	7,983
	TOTAL CONSTRUCTION COSTS =====>	6,393	1,279	20%	7,672		6,531	1,307	7,838			6,788	1,358	8,146
01---	LANDS AND DAMAGES	314	79	25%	393	1.8%	317	83	400	MAR 96	4.3%	330	87	417
30---	PLANNING, ENGINEERING AND DESIGN	1,031	102	10%	1,133	1.3%	1,042	106	1,148	MAR 95	0.5%	1,046	108	1,154
31---	CONSTRUCTION MANAGEMENT	448	89	20%	537	2.4%	458	92	550	FEB 96	5.8%	485	97	582
	TOTAL COSTS ==========>	8,186	1,549	19%	9,735		8,348	1,588	9,936			8,649	1,650	10,299

TABLE 3 (Continued)
TOTAL PROJECT COST SUMMARY

Monitoring (1997) **** TOTAL CONTRACT COST SUMMARY **** PAGE 3 OF 11

THIS ESTIMATE IS BASED ON THE SCOPE CONTAINED IN THE GDM, DATED: DEC 93

PROJECT: MARTIN COUNTY BEC
LOCATION: MARTIN COUNTY, FLORIDA

DISTRICT: JACKSONVILLE
P.O.C.: MILTON WITT, CHIEF, COST ENGINEERING

		CURRENT MCACES ESTIMATE PREPARED: DEC 93 EFFECTIVE PRICING LEVEL: DEC 93				AUTHORIZ./BUDGET YEAR: 1996 EFFECT. PRICING LEVEL: 1 OCT 94				.....FULLY FUNDED ESTIMATE.....				
ACCOUNT NUMBER	FEATURE DESCRIPTION	COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	OMB (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	FEATURE MID PT	OMB (%)	COST ($K)	CNTG ($K)	FULL ($K)
06---	FISH AND WILDLIFE FACILITIES	157	31	20%	188	2.1%	160	32	192	MAR 97	7.3%	172	34	206
	TOTAL CONSTRUCTION COSTS =====>	157	31	20%	188		160	32	192			172	34	206
01---	LANDS AND DAMAGES													
30---	PLANNING, ENGINEERING AND DESIGN	13	2	15%	15	0.0%	13	2	15	JUN 96	6.7%	14	2	16
31---	CONSTRUCTION MANAGEMENT	11	2	18%	13	0.0%	11	2	13	MAR 97	7.7%	12	2	14
	TOTAL COSTS ==========>	181	35	19%	216		184	36	220			198	38	236

TABLE 3 (Continued)
TOTAL PROJECT COST SUMMARY

MONITORING (1998) **** TOTAL CONTRACT COST SUMMARY **** PAGE 4 OF 11

THIS ESTIMATE IS BASED ON THE SCOPE CONTAINED IN THE GDM, DATED: DEC 93

PROJECT: MARTIN COUNTY BEC
LOCATION: MARTIN COUNTY, FLORIDA

DISTRICT: JACKSONVILLE
P.O.C.: MILTON WITT, CHIEF, COST ENGINEERING

		CURRENT MCACES ESTIMATE PREPARED: DEC 93 EFFECTIVE PRICING LEVEL: DEC 93				AUTHORIZ./BUDGET YEAR: 1996 EFFECT. PRICING LEVEL: 1 OCT 94				.....FULLY FUNDED ESTIMATE.....				
ACCOUNT NUMBER	FEATURE DESCRIPTION	COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	OMB (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	FEATURE MID PT	OMB (%)	COST ($K)	CNTG ($K)	FULL ($K)
06---	FISH AND WILDLIFE FACILITIES	157	31	20%	188	2.1%	160	32	192	MAR 98	10.9%	178	35	213
	TOTAL CONSTRUCTION COSTS =====>	157	31	20%	188		160	32	192			178	35	213
01---	LANDS AND DAMAGES													
30---	PLANNING, ENGINEERING AND DESIGN	13	2	15%	15	0.0%	13	2	15	JUN 97	13.3%	15	2	17
31---	CONSTRUCTION MANAGEMENT	11	2	18%	13	0.0%	11	2	13	MAR 98	15.4%	13	2	15
	TOTAL COSTS ==========>	181	35	19%	216		184	36	220			206	39	245

TABLE 3 (Continued)
TOTAL PROJECT COST SUMMARY

MONITORING (2001) **** TOTAL CONTRACT COST SUMMARY **** PAGE 5 OF 11

THIS ESTIMATE IS BASED ON THE SCOPE CONTAINED IN THE GDM, DATED: DEC 93

PROJECT: MARTIN COUNTY BEC
LOCATION: MARTIN COUNTY, FLORIDA

DISTRICT: JACKSONVILLE
P.O.C.: MILTON WITT, CHIEF, COST ENGINEERING

		CURRENT MCACES ESTIMATE PREPARED: DEC 93 EFFECTIVE PRICING LEVEL: DEC 93				AUTHORIZ./BUDGET YEAR: 1996 EFFECT. PRICING LEVEL: 1 OCT 94				.....FULLY FUNDED ESTIMATE.....				
ACCOUNT NUMBER	FEATURE DESCRIPTION	COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	OMB (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	FEATURE MID PT	OMB (%)	COST ($K)	CNTG ($K)	FULL ($K)
06---	FISH AND WILDLIFE FACILITIES	157	31	20%	188	2.1%	160	32	192	MAR 01	21.4%	194	39	233
	TOTAL CONSTRUCTION COSTS =====>	157	31	20%	188		160	32	192			194	39	233
01---	LANDS AND DAMAGES													
30---	PLANNING, ENGINEERING AND DESIGN	13	2	15%	15	0.0%	13	2	15	JUN 00	26.7%	16	3	19
31---	CONSTRUCTION MANAGEMENT	11	2	18%	13	0.0%	11	2	13	MAR 01	30.8%	14	3	17
	TOTAL COSTS ==========>	181	35	19%	216		184	36	220			224	45	269

TABLE 3 (Continued)
TOTAL PROJECT COST SUMMARY

MONITORING (2004) **** TOTAL CONTRACT COST SUMMARY **** PAGE 6 OF 11

THIS ESTIMATE IS BASED ON THE SCOPE CONTAINED IN THE GDM, DATED: DEC 93

PROJECT: MARTIN COUNTY BEC
LOCATION: MARTIN COUNTY, FLORIDA

DISTRICT: JACKSONVILLE
P.O.C.: MILTON WITT, CHIEF, COST ENGINEERING

		CURRENT MCACES ESTIMATE PREPARED: DEC 93 EFFECTIVE PRICING LEVEL: DEC 93				AUTHORIZ./BUDGET YEAR: 1996 EFFECT. PRICING LEVEL: 1 OCT 94				.....FULLY FUNDED ESTIMATE.....				
ACCOUNT NUMBER	FEATURE DESCRIPTION	COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	OMB (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	FEATURE MID PT	OMB (%)	COST ($K)	CNTG ($K)	FULL ($K)
06---	FISH AND WILDLIFE FACILITIES	157	31	20%	188	2.1%	160	32	192	MAR 04	32.8%	213	42	255
	TOTAL CONSTRUCTION COSTS =====>	157	31	20%	188		160	32	192			213	42	255
01---	LANDS AND DAMAGES													
30---	PLANNING, ENGINEERING AND DESIGN	13	2	15%	15	0.0%	13	2	15	JUN 03	40.0%	18	3	21
31---	CONSTRUCTION MANAGEMENT	11	2	18%	13	0.0%	11	2	13	MAR 04	38.5%	15	3	18
	TOTAL COSTS ==========>	181	35	19%	216		184	36	220			246	48	294

TABLE 3 (Continued)
TOTAL PROJECT COST SUMMARY

MONITORING (2007) **** TOTAL CONTRACT COST SUMMARY **** PAGE 7 OF 11

THIS ESTIMATE IS BASED ON THE SCOPE CONTAINED IN THE GDM, DATED: DEC 93

PROJECT: MARTIN COUNTY BEC
LOCATION: MARTIN COUNTY, FLORIDA

DISTRICT: JACKSONVILLE
P.O.C.: MILTON WITT, CHIEF, COST ENGINEERING

		CURRENT MCACES ESTIMATE PREPARED: DEC 93 EFFECTIVE PRICING LEVEL: DEC 93				AUTHORIZ./BUDGET YEAR: 1996 EFFECT. PRICING LEVEL: 1 OCT 94				.....FULLY FUNDED ESTIMATE.....				
ACCOUNT NUMBER	FEATURE DESCRIPTION	COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	OMB (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	FEATURE MID PT	OMB (%)	COST ($K)	CNTG ($K)	FULL ($K)
06---	FISH AND WILDLIFE FACILITIES	157	31	20%	188	2.1%	160	32	192	MAR 07	45.8%	233	47	280
	TOTAL CONSTRUCTION COSTS =====>	157	31	20%	188		160	32	192			233	47	280
01---	LANDS AND DAMAGES													
30---	PLANNING, ENGINEERING AND DESIGN	13	2	15%	15	0.0%	13	2	15	JUN 06	53.3%	20	3	23
31---	CONSTRUCTION MANAGEMENT	11	2	18%	13	0.0%	11	2	13	MAR 07	53.8%	17	3	20
	TOTAL COSTS ==========>	181	35	19%	216		184	36	220			270	53	323

TABLE 3 (Continued)
TOTAL PROJECT COST SUMMARY

NOURISHMENT 1 (2007) **** TOTAL CONTRACT COST SUMMARY **** PAGE 8 OF 11

THIS ESTIMATE IS BASED ON THE SCOPE CONTAINED IN THE GDM, DATED: DEC 93

PROJECT: MARTIN COUNTY BEC
LOCATION: MARTIN COUNTY, FLORIDA

DISTRICT: JACKSONVILLE
P.O.C.: MILTON WITT, CHIEF, COST ENGINEERING

		CURRENT MCACES ESTIMATE PREPARED: DEC 93 EFFECTIVE PRICING LEVEL: DEC 93				AUTHORIZ./BUDGET YEAR: 1996 EFFECT. PRICING LEVEL: 1 OCT 94				.....FULLY FUNDED ESTIMATE.....				
ACCOUNT NUMBER	FEATURE DESCRIPTION	COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	OMB (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	FEATURE MID PT	OMB (%)	COST ($K)	CNTG ($K)	FULL ($K)
06---	FISH AND WILDLIFE FACILITIES	128	26	20%	154	1.9%	130	27	157	JAN 07	45.2%	189	39	228
17---	BEACH REPLENISHMENT	2,911	582	20%	3,493	2.2%	2,974	595	3,569	JAN 07	44.9%	4,310	862	5,172
	TOTAL CONSTRUCTION COSTS =====>	3,039	608	20%	3,647		3,104	622	3,726			4,499	901	5,400
01---	LANDS AND DAMAGES													
30---	PLANNING, ENGINEERING AND DESIGN	243	49	20%	292	2.1%	248	50	298	APR 06	50.0%	372	75	447
31---	CONSTRUCTION MANAGEMENT	213	43	20%	256	2.3%	218	44	262	MAR 07	53.4%	334	68	402
	TOTAL COSTS ==========>	3,495	700	20%	4,195		3,570	716	4,286			5,205	1,044	6,249

TABLE 3 (Continued)
TOTAL PROJECT COST SUMMARY

THIS ESTIMATE IS BASED ON THE SCOPE CONTAINED IN THE GDM, DATED: DEC 93

PROJECT: MARTIN COUNTY BEC
LOCATION: MARTIN COUNTY, FLORIDA

DISTRICT: JACKSONVILLE
P.O.C.: MILTON WITT, CHIEF, COST ENGINEERING

		CURRENT MCACES ESTIMATE PREPARED: DEC 93 EFFECTIVE PRICING LEVEL: DEC 93				AUTHORIZ./BUDGET YEAR: 1996 EFFECT. PRICING LEVEL: 1 OCT 94				.....FULLY FUNDED ESTIMATE.....				
ACCOUNT NUMBER	FEATURE DESCRIPTION	COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	OMB (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	FEATURE MID PT	OMB (%)	COST ($K)	CNTG ($K)	FULL ($K)
06---	FISH AND WILDLIFE FACILITIES	128	26	20%	154	1.9%	130	27	157	JAN 18	102.5%	263	55	318
17---	BEACH REPLENISHMENT	2,911	582	20%	3,493	2.2%	2,974	595	3,569	JAN 18	102.9%	6,033	1,207	7,240
	TOTAL CONSTRUCTION COSTS =====>	3,039	608	20%	3,647		3,104	622	3,726			6,296	1,262	7,558
01---	LANDS AND DAMAGES													
30---	PLANNING, ENGINEERING AND DESIGN	243	49	20%	292	2.1%	248	50	298	APR 16	101.3%	499	101	600
31---	CONSTRUCTION MANAGEMENT	213	43	20%	256	2.3%	218	44	262	JAN 18	112.2%	463	93	556
	TOTAL COSTS ==========>	3,495	700	20%	4,195		3,570	716	4,286			7,258	1,456	8,714

TABLE 3 (Continued)
TOTAL PROJECT COST SUMMARY

NOURISHMENT 3 (2029) **** TOTAL CONTRACT COST SUMMARY **** PAGE 10 OF 11

THIS ESTIMATE IS BASED ON THE SCOPE CONTAINED IN THE GDM, DATED: DEC 93

PROJECT: MARTIN COUNTY BEC
LOCATION: MARTIN COUNTY, FLORIDA

DISTRICT: JACKSONVILLE
P.O.C.: MILTON WITT, CHIEF, COST ENGINEERING

		CURRENT MCACES ESTIMATE PREPARED: DEC 93 EFFECTIVE PRICING LEVEL: DEC 93				AUTHORIZ./BUDGET YEAR: 1996 EFFECT. PRICING LEVEL: 1 OCT 94				.....FULLY FUNDED ESTIMATE.....				
ACCOUNT NUMBER	FEATURE DESCRIPTION	COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	OMB (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	FEATURE MID PT	OMB (%)	COST ($K)	CNTG ($K)	FULL ($K)
06---	FISH AND WILDLIFE FACILITIES	128	26	20%	154	1.9%	130	27	157	JAN 29	183.4%	368	77	445
17---	BEACH REPLENISHMENT	2,911	582	20%	3,493	2.2%	2,974	595	3,569	JAN 29	183.7%	8,436	1,688	10,124
	TOTAL CONSTRUCTION COSTS =====>	3,039	608	20%	3,647		3,104	622	3,726			8,804	1,765	10,569
01---	LANDS AND DAMAGES													
30---	PLANNING, ENGINEERING AND DESIGN	243	49	20%	292	2.1%	248	50	298	APR 28	186.9%	712	143	855
31---	CONSTRUCTION MANAGEMENT	213	43	20%	256	2.3%	218	44	262	JAN 29	193.5%	640	129	769
	TOTAL COSTS ==========>	3,495	700	20%	4,195		3,570	716	4,286			10,156	2,037	12,193

TABLE 3 (Continued)
TOTAL PROJECT COST SUMMARY

NOURISHMENT 4 (2040) **** TOTAL CONTRACT COST SUMMARY **** PAGE 11 OF 11

THIS ESTIMATE IS BASED ON THE SCOPE CONTAINED IN THE GDM, DATED: DEC 93

PROJECT: MARTIN COUNTY BEC
LOCATION: MARTIN COUNTY, FLORIDA

DISTRICT: JACKSONVILLE
P.O.C.: MILTON WITT, CHIEF, COST ENGINEERING

		CURRENT MCACES ESTIMATE PREPARED: DEC 93 EFFECTIVE PRICING LEVEL: DEC 93				AUTHORIZ./BUDGET YEAR: 1996 EFFECT. PRICING LEVEL: 1 OCT 94				.....FULLY FUNDED ESTIMATE.....				
ACCOUNT NUMBER	FEATURE DESCRIPTION	COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	OMB (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	FEATURE MID PT	OMB (%)	COST ($K)	CNTG ($K)	FULL ($K)
06---	FISH AND WILDLIFE FACILITIES	128	26	20%	154	1.9%	130	27	157	JAN 40	296.8%	516	107	623
17---	BEACH REPLENISHMENT	2,911	582	20%	3,493	2.2%	2,974	595	3,569	JAN 40	298.1%	11,839	2,368	14,207
	TOTAL CONSTRUCTION COSTS =====>	3,039	608	20%	3,647		3,104	622	3,726			12,355	2,475	14,830
01---	LANDS AND DAMAGES													
30---	PLANNING, ENGINEERING AND DESIGN	243	49	20%	292	2.1%	248	50	298	APR 39	297.3%	985	199	1,184
31---	CONSTRUCTION MANAGEMENT	213	43	20%	256	2.3%	218	44	262	JAN 40	306.1%	885	179	1,064
	TOTAL COSTS ==========>	3,495	700	20%	4,195		3,570	716	4,286			14,225	2,853	17,078

previously described in this report. The costs for temporary construction easements, rights-of-ways, relocations and damages (LERRD) were determined as indicated in the attached Real Estate Appendix (Appendix C).

BENEFITS SUMMARY

41. The primary purpose of the Martin County shore protection project is to prevent physical damages. The project provides protection to over $7 million in private and commercial upland development, as well as infrastructure such as roads and utilities. Physical loss of land is prevented and incidental recreation are generated by increased recreational usage of the project beach. The project will increase usable nesting beach for endangered and threatened turtle species. The economic value of these benefits are summarized in Table 4. Detailed analysis of project benefits are presented in Appendix B.

ECONOMIC JUSTIFICATION

42. Table 4 summarizes the economic justification for the recommended project. Annual costs and benefits for an 8 percent interest rate are displayed. The benefit-to-cost ratio is 5.0 with net primary benefits of $3,829,800.

PLAN IMPLEMENTATION

COST APPORTIONMENT

43. Section 103(d) of the Water Resources Development Act of 1986 (Public Law 99-662) specifies that the cost of construction measures for beach erosion control are assigned to the appropriate purpose(s) specified in Section 103(c) of the Act. These purposes are normally hurricane and damage reduction and/or separable recreation, and shared in the same percentages as to the purposes to which the costs are assigned, except no costs are assigned to incidental recreation. Hurricane and storm damage reduction projects are cost shared at 65 percent Federal, and separable recreation projects are cost shared at 50 percent Federal. Cost sharing for beach erosion control measures must also consider shore ownership and use. Additional guidance on cost sharing for shore protection projects provided in Engineering Regulation 1165-2-130 dated June 15, 1989. A summary table of shore ownership and level of Federal participation for the 3.75 mile problem area is displayed in Table 5.

44. The Federal project consists of the project being built, both, seaward and landward of the ECL. The location of this line is defined on Plates 2 through 9. Construction landward of the ECL to the CCL on undeveloped private property is 100 percent non-Federal. However, cost of construction are cost shareable and lands

TABLE 4
ECONOMIC SUMMARY
RECOMMENDED PROJECT
(MODIFIED AUTHORIZED PROJECT)

ITEM	INTEREST RATE 8.00%
ANNUAL PROJECT COSTS	
Initial Restoration	795,800
Additional Monitoring	61,800
Future Beach Nourishment	252,400
Interest During Construction	32,400
TOTAL ANNUAL PROJECT COSTS	1,142,000
PRIMARY BENEFITS	
Prevention of:	
Damage to Development	4,888,600
Loss of Land	83,200
Total Primary Benefits	4,971,800
NET PRIMARY BENEFITS	3,829,800
INCIDENTAL BENEFITS	
Recreation Benefits	702,400
TOTAL PROJECT BENEFITS	5,674,200
BENEFIT-TO-COST RATIO	5.0

TABLE 5
MARTIN COUNTY, FLORIDA, SHORE PROTECTION PROJECT
APPORTIONMENT OF COST

PROFILE LINE NUMBER (A)	LOT DESCRIPTION (B)	LOT WIDTH (FT) (C)	SHORELINE DESCRIPTION (D)	WITHIN PROJECT LIMITS (E)	WITHIN 1/4 MILE OF ACCESS (F)	SHORE OWNERSHIP AND PROJECT PURPOSE 1/ (G)	LEVEL OF FEDERAL PARTN (H)	FEDERAL PARTICIPATION TIMES LOT WIDTH ((C)*(H)) (I)	DESIGN VOLUME (Cubic Yards) (J)	
R-1	HOUSE (PRIV.RES.)	110	DEVELOPED	Y	Y	II.A.	65.00%	71.5		
	D CONDO	210	DEVELOPED	Y	Y	II.A.	65.00%	136.5	3,929	
	subtotal	320					65.00%	208.0	2,554	FEDERAL SHARE OF VOLUME
R-2	D CONDO	450	DEVELOPED	Y	Y	II.A.	65.00%	292.5		
	HOUSE (PRIV.RES.)	190	DEVELOPED	Y	Y	II.A.	65.00%	123.5	13,489	
	PRIVATE LOT	450	UNDEVELOPED	Y	Y	IV.	0.00%	0.0		
	REALTY OFFICE	230	DEVELOPED	Y	Y	II.A.	65.00%	149.5		
	subtotal	1320					42.84%	565.5	5,779	FEDERAL SHARE OF VOLUME
R-3	JENSEN BEACH PK	1050	PUBLIC BEACH	Y	Y	II.B.	50.00%	525.0		
	CONCESSION STND	170	PUBLIC BEACH	Y	Y	II.B.	50.00%	85.0	11,457	
	subtotal	1220					50.00%	610.0	5,729	FEDERAL SHARE OF VOLUME
R-4	GAZEBO	230	PUBLIC BEACH	Y	Y	II.B.	50.00%	115.0		
	BATHHOUSE	280	PUBLIC BEACH	Y	Y	II.B.	50.00%	140.0	14,262	
	subtotal	510					50.00%	255.0	7,131	FEDERAL SHARE OF VOLUME
R-5	GAZEBO	180	PUBLIC BEACH	Y	Y	II.B.	50.00%	90.0		
	LIFEGUARD BLDING	670	PUBLIC BEACH	Y	Y	II.B.	50.00%	335.0	10,803	
	subtotal	850					50.00%	425.0	5,402	FEDERAL SHARE OF VOLUME
R-6	MOTEL	510	DEVELOPED	Y	Y	II.A.	65.00%	331.5		
	UNDEVELOPED LOT	790	UNDEVEL PUBLIC	Y	Y	II.B.	50.00%	395.0	16,229	
	subtotal	1300					55.88%	726.5	9,070	FEDERAL SHARE OF VOLUME
R-7	HOUSE (PRIV.RES.)	130	DEVELOPED	Y	N	III.	0.00%	0.0		
	HOUSE (PRIV. RES.)	100	DEVELOPED	Y	N	III.	0.00%	0.0		
	CONDO	180	DEVELOPED	Y	N	III.	0.00%	0.0		
R-11	BOB GRAHAM PK	4010	PUBLIC BEACH	Y	Y	II.B.	50.00%	2,005.0		
	HOUSE (PRIV.RES)	100	DEVELOPED	Y	Y	II.A.	65.00%	65.0	67,954	
	subtotal	4520					45.80%	2,070.0	31,121	FEDERAL SHARE OF VOLUME

TABLE 5 (Continued)
MARTIN COUNTY, FLORIDA, SHORE PROTECTION PROJECT
APPORTIONMENT OF COST

PROFILE LINE NUMBER (A)	LOT DESCRIPTION (B)	LOT WIDTH (FT) (C)	SHORELINE DESCRIPTION (D)	WITHIN PROJECT LIMITS (E)	WITHIN 1/4 MILE OF ACCESS (F)	SHORE 1/ OWNERSHIP AND PROJECT PURPOSE (G)	LEVEL OF FEDERAL PARTN (H)	FEDERAL PARTICIPATION TIMES LOT WIDTH ((C)*(H)) (I)	DESIGN VOLUME (Cubic Yards) (J)	
R-12U	GAZEBO	110	PUBLIC ACCESS	Y	Y	II.B.	50.00%	55.0		
	CONDO	200	DEVELOPED	Y	Y	II.A.	65.00%	130.0		
	POOL	130	DEVELOPED	Y	Y	II.A.	65.00%	84.5		
	CONDO	200	DEVELOPED	Y	Y	II.A.	65.00%	130.0	16,258	FEDERAL SHARE
	subtotal	640					62.42%	399.5	10,149	OF VOLUME
R-13	CONDO	330	DEVELOPED	Y	Y	II.A.	65.00%	214.5		
	PUBLIC LANDS	230	PUBLIC ACCESS	Y	Y	II.B.	50.00%	115.0		
	PRIVATE LOT	180	UNDEVELOPED	Y	Y	IV.	0.00%	0.0		
	HOUSE (PRIV.RES)	80	DEVELOPED	Y	Y	II.A.	65.00%	52.0	27,192	
	subtotal	820					46.52%	381.5	12,651	
R-14	CONDO	200	DEVELOPED	Y	Y	II.A.	65.00%	130.0		
	CONDO	270	DEVELOPED	Y	Y	II.A.	65.00%	175.5		
	CONDO	300	DEVELOPED	Y	Y	II.A.	65.00%	195.0	26,097	
	subtotal	770					65.00%	500.5	16,963	
R-15	CONDO	370	DEVELOPED	Y	Y	II.A.	65.00%	240.5		
	CONDO	150	DEVELOPED	Y	Y	II.A.	65.00%	97.5		
	THE M CONDO	120	DEVELOPED	Y	Y	II.A.	65.00%	78.0		
	THE M CONDO	120	DEVELOPED	Y	Y	II.A.	65.00%	78.0		
	THE M CONDO	150	DEVELOPED	Y	Y	II.A.	65.00%	97.5		
	VIRGINIA FOREST BC	450	PUBLIC BEACH	Y	Y	II.B.	50.00%	225.0	15,917	
	subtotal	1360					60.04%	816.5	9,556	FEDERAL SHARE OF VOLUME
R-16	HOUSE (PRIV.RES.)	210	DEVELOPED	Y	Y	II.A.	65.00%	136.5		
	HOUSE (PRIV.RES.)	110	DEVELOPED	Y	Y	II.A.	65.00%	71.5		
	HOUSE (PRIV.RES.)	130	DEVELOPED	Y	Y	II.A.	65.00%	84.5		
	PRIVATE LOT	150	UNDEVELOPED	Y	Y	IV.	0.00%	0.0	15,917	
	subtotal	600					48.75%	292.5	7,760	
R-17	PRIVATE LOT	560	UNDEVELOPED	Y	Y	IV.	0.00%	0.0		
	B CONDO	340	DEVELOPED	Y	Y	II.A.	65.00%	221.0		
	PRIVATE LOT	225	UNDEVELOPED	Y	N	IV.	0.00%	0.0	14,385	
	subtotal	1125					19.64%	221.0	2,826	

TABLE 5 (Continued)
MARTIN COUNTY, FLORIDA, SHORE PROTECTION PROJECT
APPORTIONMENT OF COST

PROFILE LINE NUMBER (A)	LOT DESCRIPTION (B)	LOT WIDTH (FT) (C)	SHORELINE DESCRIPTION (D)	WITHIN PROJECT LIMITS (E)	WITHIN 1/4 MILE OF ACCESS (F)	SHORE OWNERSHIP AND PROJECT PURPOSE (G)	1/ LEVEL OF FEDERAL PARTN (H)	FEDERAL PARTICIPATION TIMES LOT WIDTH ((C)*(H)) (I)	DESIGN VOLUME (Cubic Yards) (J)	
R-18	HH CONDO	190	DEVELOPED	Y	Y	II.A.	65.00%	123.5		
	HH CONDO	135	DEVELOPED	Y	Y	II.A.	65.00%	87.8		
	CLUBHOUSE	110	DEVELOPED	Y	Y	II.A.	65.00%	71.5		
	LOP CONDO	120	DEVELOPED	Y	Y	II.A.	65.00%	78.0		
	LOP CONDO	190	DEVELOPED	Y	Y	II.A.	65.00%	123.5	27,799	
	subtotal	745					65.00%	484.3	18,069	FEDERAL SHARE OF VOLUME
R-19	ST CONDO	440	DEVELOPED	Y	Y	II.A.	65.00%	286.0		
	CLUBHOUSE	160	DEVELOPED	Y	Y	II.A.	65.00%	104.0		
	TIGERS SHORES ACC	150	PUBLIC ACCESS	Y	Y	II.B.	50.00%	75.0	30,341	
	IS CONDO	140	DEVELOPED	Y	Y	II.A.	65.00%	91.0		
	subtotal	890					62.47%	556	18,955	
R-20	PRIVATE LOT	410	UNDEVELOPED	Y	Y	IV.	0.00%	0.0		
	HOUSE (PRIV.RES.)	100	DEVELOPED	Y	Y	II.A.	65.00%	65.0		
	HOUSE (PRIV.RES.)	120	DEVELOPED	Y	Y	II.A.	65.00%	78.0		
	HOUSE (PRIV.RES.)	85	DEVELOPED	Y	Y	II.A.	65.00%	55.3	16,938	
	subtotal	715					27.73%	198.25	4,696	FEDERAL SHARE OF VOLUME
R-21	PRIVATE LOT	1080	UNDEVELOPED	Y	Y	IV.	0.00%	0.0	0	
									0	
R-22	GAZEBO	230	PUBLIC BEACH	Y	Y	II.B.	50.00%	115.0		
	BOATHOUSE	300	PUBLIC BEACH	Y	Y	II.B.	50.00%	150.0		
	CONCESSION STAND	40	PUBLIC BEACH	Y	Y	II.B.	50.00%	20.0		
	GAZEBO	175	PUBLIC BEACH	Y	Y	II.B.	50.00%	87.5		
	BOATHOUSE	100	PUBLIC BEACH	Y	Y	II.B.	50.00%	50.0		
	LIFEGUARD TOWER	400	PUBLIC BEACH	Y	Y	II.B.	50.00%	200.0	6,645	
R-23	subtotal	1245					50.00%	622.5	3,323	

TABLE 5 (Continued)

MARTIN COUNTY, FLORIDA, SHORE PROTECTION PROJECT
APPORTIONMENT OF COST

PROFILE LINE NUMBER (A)	LOT DESCRIPTION (B)	LOT WIDTH (FT) (C)	SHORELINE DESCRIPTION (D)	WITHIN PROJECT LIMITS (E)	WITHIN 1/4 MILE OF ACCESS (F)	SHORE 1/ OWNERSHIP AND PROJECT PURPOSE (G)	LEVEL OF FEDERAL PARTN (H)	FEDERAL PARTICIPATION TIMES LOT WIDTH ((C)*(H)) (I)	DESIGN VOLUME (Cubic Yards) (J)
TOTALS FOR PROJECT		20,030	SHORELINE LENGTH (Feet)			SUM OF COLUMN (I) IN FE		9,333	171,731
		3.8	SHORELINE LENGTH (Miles)			TOTAL DESIGN VOLUME PLACED IN CUBIC			337,500

THE SUM OF COLUMN (I) DIVIDED BY 20,030 FEET = 46.59 PERCENT WHICH IS THE FEDERAL SHARE OF CONSTRUCTION COSTS SUCH AS ADVANCE NOURISHMENT COSTS WHICH ARE LINEARLY DISTRIBUTED ALONG THE PROJECT.

THE TOTAL SUM OF COLUMN (J) DIVIDED BY THE TOTAL DESIGN VOLUME IS EQUAL TO 50.00 PERCENT, WHICH IS THE FEDERAL SHARE OF NON-LINEAR PROJECT COSTS FOR THE DESIGN VOLUME.

1/ SHORE OWNERSHIP AND PROJECT PURPOSE
(As defined in ER 1165-2-130)

		Max Level Fed Participation Construct Costs
I.	Federally Owned	100.00%
II.	Publicly and Privately Owned - Protection Results in Public Benefits.	
A.	Hurricane and Storm Damage Reduction	65.00%
B.	Private and Public Land Open for Public Use - Recreation	50.00%
C.	Separable Recreation	50.00%
III.	Privately Owned, Use Limited to Private Interests	0.00%
IV.	Privately Owned, Undeveloped	0.00%

credible in front of developed private lots where perpetual easements make the lands open to the public. Normally, non-Federal public shores are dedicated to park and conservation areas, and the benefits of protecting such shores will be based on the loss of recreation outputs, with cost sharing 50 percent Federal and 50 percent non-Federal. Public parks and street ends in the project area are cost shared at 50 percent Federal/non-Federal since the primary project output for this shorefront is recreation. The cost sharing would be 65 percent Federal and 35 percent non-Federal for protection of privately owned shores resulting in public benefits.

45. The apportionment of project costs was determined for both linear and non-linear costs. The volume of design fill placed along any given reach of the project shoreline varies considerably. The cost to construct the design section is therefore a non-linear cost. The project was segmented into reaches based on profile lines as shown in Table 5. The volume for each reach was determined and is shown in the table. The appropriate Federal share of the design volume for each reach was then determined. The Federal share of the design volume of 337,500 cubic yards is 171,720 cubic yards, or 50.88 percent.

46. Linear costs are those project costs which are uniformly distributed throughout the length of the project (i.e., periodic nourishment and overfill costs). Linear costs are also costs applied to the project as a whole, such as mobilization and demobilization costs, monitoring, contingencies, engineering and design, contract supervision and contract administration. As indicated in Table 5, the Federal share of linear costs was determined to be 46.59 percent.

47. Revised Policy Guidance Letter 11 (issued by CECW-RP, 21 April 1989) directs the use of the "Federal rule of valuation" which provides for an offset of benefits in determining compensation for properties including severance. Lands seaward of the CCL may have value; credit for these lands will be based on the Federal rules of valuation. The non-Federal project sponsor is entitled to credit for administrative costs incurred in providing lands for the Federal project except for lands in front of vacant private lots. The administrative costs for upland temporary construction easements are not part of the Federal total project costs and are a non-Federal responsibility.

48. The cost of establishing the State's required erosion control line (ECL) is a non-Federal cost. Once this line has been approved by the Florida Cabinet, all project lands fronting the developed private shore within the project are considered open to use by the public. The cost sharing for developed private lands shown in Table 5 is based on the assumption that the ECL will be approved by the Florida Cabinet prior to project construction. Periodic nourishment is considered "construction" for cost sharing purposes.

49. Final apportionment is based on current law and conditions of shore ownership and use at the time of construction or subsequent nourishment. Cost sharing for non-linear costs (i.e., the quantity of design volume) would be based on the last physical survey of shoreline conditions prior to construction. This survey is normally the contract plans and specifications survey.

FEDERAL RESPONSIBILITY

50. The U.S. Army Corps of Engineers would be responsible for Federal funding and construction of the project features. The total cost of initial project construction is $10,491,400. This cost is defined as the total project cost in the PCA. The Federal share of the total project cost is presently estimated at $4,970,300 (47.37 percent). The Federal cost sharing by project feature is summarized in Table 6. The Federal share of the cost of each future periodic nourishment is $1,953,985 or 46.59 percent. Prior to construction the U.S. Army Corps of Engineers will prepare an operation and maintenance manual which will describe the non-Federal project sponsor's obligations toward operation, maintenance, repair, replacement, and rehabilitation of the completed project.

NON-FEDERAL RESPONSIBILITY

51. The non-Federal project sponsor would provide an up-front cash contribution for initial construction of the proposed project. The value of this contribution is estimated at $4,912,300 of the total project cost defined above. The non-Federal sponsor would also provide the entire cost of all material placed on undeveloped private land and share in the placement of fill on developed private lands and public lands landward of the ECL to the CCL. This cost is currently estimated to be $399,300. The cost for lands, easements, and rights-of-way and a portion of the administrative costs associated with land requirements ($209,600) is also a non-Federal responsibility. The total non-Federal responsibility for the initial work is $5,521,200 or about 52.63 percent of the total project cost. The non-Federal share of the cost of each future periodic nourishment is $2,240,015 or 53.41 percent.

OTHER NON-FEDERAL REQUIREMENTS

52. Other general non-Federal responsibilities including continued public use of the project beach, control of water pollution to safeguard the health of bathers, and operation and maintenance of the project beach must be assumed by the non-Federal sponsor. These costs are estimated at $833,000. Operation and maintenance includes beach berm reshaping and maintenance of storm drainage outfalls as contained within the operation and maintenance manual. The items of project cooperation are listed in the section entitled "Modifications to the Items of Project Cooperation" of this report. The delineation of Federal and non-Federal responsibility is defined in the project cooperation agreement (PCA).

TABLE 6
TOTAL PROJECT COST SHARING

ITEM	TOTAL COST	PERCENT FEDERAL	FEDERAL SHARE	PERCENT NON-FEDERAL	NON-FEDERAL SHARE
Initial Restoration					
Design Volume (337,500 c.y.)	$1,518,800	50.88%	$772,800	49.12%	$746,000
Anticipated Erosional Losses (214,400 c.y.)	$964,800	50.88%	$490,900	49.12%	$473,900
Advance Nourishment (589,600 c.y.)	$2,653,200	46.59%	$1,236,100	53.41%	$1,417,100
Fill Behind ECL (156,000 c.y.) *					
Public and Private Developed	$594,900	50.88%	$302,700	49.12%	$292,200
Private Undeveloped	$107,100	0.00%	$0	100.00%	$107,100
Mob, Demob & Prepatory Work	$1,680,000	46.59%	$782,700	53.41%	$897,300
Monitoring	$153,600	46.59%	$71,600	53.41%	$82,000
LERRD **	$0	0.00%	$0	100.00%	$0
LERRD Administration	$392,500	46.59%	$182,900	53.41%	$209,600
Planning, Engineering & Design	$1,133,000	46.59%	$527,900	53.41%	$605,100
Construction Management	$537,600	46.59%	$250,500	53.41%	$287,100
Add'l Monitoring Years 1-11 (Present Worth)	$756,000	46.59%	$352,200	53.41%	$403,800
TOTAL	$10,491,500	47.37%	$4,970,300	52.63%	$5,521,200
Total Non-Federal Responsibility					$5,521,200
Less LERRD					$0
Equals Total Non-Federal Cash Requirement					$5,521,200

* Public (85,299 c.y.) and Private (46,911 c.y.) Developed and Private Undeveloped (23,790 c.y.).

** Refer to Real Estate Appendix C, paragraph 9.f.

VIEWS OF THE NON-FEDERAL SPONSOR

53. The Martin County Board of County Commissioners provided a letter of intent dated October 2, 1985, which specifies the county intent to eventually serve as the non-Federal interest that will share in the costs of the project. By letter, dated June 9, 1994, Martin County has reiterated their intent to sponsor the recommended project as described in this report. Informal meetings were held in Jacksonville, Stuart, and Tallahassee during the preparation of the GDM to advise county and state interests of the status of the study and to coordinate areas of study interest which would avoid future permitting difficulties. The county has continued active support for the project as evidenced by letters contained within the pertinent correspondence appendix.

FINANCIAL ANALYSIS

54. Financial analysis is required for any plan being considered for Corps of Engineers implementation that involves non-Federal cost sharing. The ultimate purpose of the financial analysis is to ensure that the non-Federal sponsor understands the financial commitment involved and has a reasonable plan for meeting that commitment. The financial analysis includes the non-Federal sponsor's statement of financial capability, the non-Federal sponsor's financing plan, and an assessment of the sponsor's financial capability.

55. Non-Federal Sponsor Financing Plan and Financial Statement. The non-Federal sponsor is preparing it's financing plan and the statement of financial capability. The county's statement of financial capability and financing plan will be contained within the Project Cooperation Agreement (PCA) package following review of the GDM by the county. The financing plan will include the details of the county's financing plan and the State's contribution of funds. Since the county will be the only non-Federal signatory to the PCA, only the county need prepare a financing plan and statement for financial capability. The county, as part of its plan, will include evidence of the State's authority to provide state funding, along with evidence of the State's legal commitment to the non-Federal sponsor.

56. State Financing Plan. The State of Florida has authority to provide funds to county governments for shore protection projects. This authority is provided by Chapter 161, Florida Statutes. State funding is scheduled to be included in the State's Fiscal Year budget for 1995.

57. Financing Assessment. The Martin County Board of Commissioners is empowered by Chapter 161, Florida Statutes, to act as the county beach and shore preservation authority. Such powers specifically include the authority to make contracts and enter into agreements, to acquire and hold lands and property by any lawful means, to exercise the power of eminent domain, and to construct, acquire,

operate and maintain shore protection works and facilities. The county has the authority to tax property or issue bonds to meet the costs of the county beach and shore preservation program.

58. Chapter 161 also provides for state financial assistance in funding beach erosion control and shore preservation projects. Any county may make application to the Division of Beaches and Shores, Florida Department of Environmental Protection, for state funds for these projects. For Federal projects, the State is authorized to fund up to 75 percent of the non-Federal construction and maintenance costs of projects authorized by the Congress of the United States, subject to certain restrictions. The State is authorized to expend funds from the Erosion Control Trust Fund account for such projects.

59. The Board of County Commissioners has the authority and financial capability to provide the required non-Federal cash contribution for project construction, and to fulfill the other items of project cooperation. The county, through the assistance and authority of the Florida Department of Environmental Protection and the Trustees of the State Internal Improvement Trust Fund, can resolve the paramount issue of riparian rights by establishing an erosion control line, and thereby comply with the important non-Federal responsibility to furnish all lands, easements and rights-of-way needed for project construction.

DEPARTURES FROM THE AUTHORIZED PROJECT

60. Changes have occurred since the Martin County shore protection project was authorized in 1990. These changes include physical, economic, and cost apportionment differences. Table 7 summarizes differences between the authorized project and the proposed 1994 modified authorized project as described herein.

PHYSICAL CHANGES

61. Since the preparation of the feasibility report in 1985 and project authorization in 1990, the recession of the Martin County shoreline has continued. The length of shoreline considered for nourishment has been decreased from 21,120 to 19,800 feet primarily due the increased direct coverage of nearshore hardbottom with the longer project. Initial fill requirements have increased by 355,500 cubic yards. The project berm and dune width and elevation have remained as authorized. The design fill has increased from 454,000 to 493,500 cubic yards which includes 156,000 cubic yards behind the ECL. Advanced nourishment has increased from 488,000 to 589,600 cubic yards (including overfill) with the reduced project length being offset by increases in the anticipated long-term erosion losses. The determination that the lowest equivalent annual cost occurs with a renourishment interval of eleven years

TABLE 7
SUMMARY OF CHANGES TO THE AUTHORIZED PROJECT

ITEM	AUTHORIZED PROJECT (1985 FEASIBILITY RPT)	RECOMMENDED PROJECT MODIFICATIONS (REV. JUNE 1994 GDM)
Physical Data		
Fill Length (miles)	4.00	3.75
Berm Elevation (MLW)	9.10	9.10
Berm Width (feet)	35	35
Dune Elevation (MLW)	13.60	13.60
Dune Width (feet)	20	20
Initial Volume (cy)	942,000	1,297,500
Future Nourishment (cy)	488,000	589,600
Nourishment Interval (yrs)	8	11
Financial Data		
Price Levels	1984	1993
Interest Rate	8.625%	8.00%
Total First Cost ($)	9,521,000	10,491,400
Total Annual Cost ($)	1,340,000	1,142,000
Total Benefits ($)	2,225,000	5,674,200
Net Benefits ($)	884,700	4,532,200
Benefit-to-Cost Ratio	1.7	5.0
Cost Apportionment		
Federal Responsibility:		
Initial Construction		
Amount ($)	4,380,500	4,970,300
Percent	50.3	47.37
Future Nourishment		
Percent	50.3	46.59
Non-Federal Responsibility:		
Initial Construction		
Amount ($)	5,038,500	5,521,200
Percent	49.7	52.63
Future Nourishment		
Percent	49.7	53.41

represents an increase of three years over the authorized plan. The authorized project computed overfill (or sorting losses) by applying a factor of 1.15 to the advanced nourishment volume. A decrease in volume of overfill required is due to new geotechnical data which estimates the overfill factor at 1.00.

FINANCIAL CHANGES

62. Costs. The project cost has increased due to several factors. The primary factor is the additional monitoring recommended during the first 11 years of the project life. Additional monitoring is recommended in order to ascertain what secondary impacts,if any, the beach fill activities will have on the hardbottom habitat adjacent to the project area. Other factors, such as, increase in volume attributable to additional erosion occurring since authorization, reevaluation of long-term erosion rates, the change in overfill factor associated with the borrow area, have also contributed to the increase of project cost. In addition, price levels for mobilization and demobilization have increased due to the recommended use of two cutterhead pipeline dredges (in order to avoid turtle nesting season) versus one hopper dredge with pumpout through a nearshore monobouy, as authorized. The initial cost of construction of the modified project is $10,491,400.

63. Benefits. Benefits for the modified plan are estimated at $5,674,200 of which $4,971,800 is for storm damage reduction and prevention of loss of land, and $702,400 for recreation. This compares to values estimated within the feasibility report of $1,080,800 and $1,144,200, respectively. The benefit-to-cost ratio increased from 1.7 to 5.0.

64. Cost Apportionment. The Federal interest in the project has decreased from 50.3 to 47.37 percent for initial construction and from 50.3 to 46.59 for future periodic nourishment and is due primarily to a more detailed evaluation of ownership and use of shorefront property.

STUDY SUMMARY

This report summarizes the preconstruction studies conducted to ready the Martin County shore protection project for construction. Based on these studies, the following was concluded:

Storm damage is negatively impacting 3.75 miles of Atlantic shoreline on Hutchinson Island. About $7 million of shorefront development is threatened by storms.

67. A contributing factor to the susceptibility to storm damage is relative sea level rise. If the upper limit of relative sea level rise actually occurs, it will increase the shoreline recession and storm damages estimated within this report.

68. The most practical and economical means to prevent or reduce structural damages is to construct the authorized shore protection project as modified herein.

69. The non-Federal sponsor supports construction of the project.

FLOOD PLAIN DEVELOPMENT

70. The selected plan is in the base flood plain (100-year flood) and has been evaluated in accordance with Executive Order 11988. Relocation of the proposed project outside the flood plain would not be responsive to the problems and needs of the study area and was not considered further. A non-flood plain alternative for the potential development with the project would be to restrict all future development to those areas outside the flood plain or elevated above the flood plain. Potential flood plain development with the project would be restricted as a result of local ordinances and State law. Any induced potential damage as a result of local project implementation would be minimal. The project would have minimum impact on the natural and beneficial values of the flood plain. In the without project flood plain (that area immediately adjacent to the proposed project), there will be minimal loss of natural resources due to potential development. Implementation of any non-structural plans that would minimize potential damage to or within the flood plain beyond those laws and regulations already adopted by local and state interests are not viable solutions under the planning constraints of this study.

COST EFFECTIVENESS OF DESIGN

71. Section 911 of Public Law 99-662 requires a cost effectiveness review of the project design for any water resources project which has a total cost in excess of $10,000,000, and for which construction has not been initiated by November 17, 1986. The review shall employ cost control techniques which will ensure that such project is designed in the most cost-effective way for the life of the project. Engineering Circular No. 1110-2-259 dated February 1, 1989 provides guidance for implementing cost control techniques for projects in accordance with Section 911.

72. The District Engineer will certify, based on the recommendation of the project design review team, that the design achieved in the preconstruction, engineering and design phase is the most cost effective design. The District Engineer's letter of certification is provided in the correspondence appendix.

PUBLIC ACCESSIBILITY

73. In the determination of the Federal interest in cost-sharing, Federal participation was limited to the areas where adequate parking and access were provided. Federal participation is limited to those shoreline reaches within 1/4 mile from an access point, a reasonable walking distance for a beach visitor. The entire project fits this criteria, therefore, Federal participation is warranted.

CONCLUSIONS

74. Consideration has been given to all significant aspects of the authorized project in the overall public interest, including engineering feasibility, economic, social and environmental effects. The modifications to the authorized project described in this report provide the optimum solution for protection of upland development on Hutchinson Island.

RECOMMENDATIONS

75. It is recommended that the authorized project for Martin County, Florida be modified and Federal construction funding provided in accordance with the selected plan herein, with such modifications as in the discretion of the Chief of Engineers may be advisable.

DISCLAIMER

76. The recommendations contained herein reflect the information available at this time and current Departmental policies governing formulation of individual projects. They do not reflect program and budgeting priorities inherent in the formulation of a national Civil Works construction program nor the perspective of higher review levels within the Executive Branch. Consequently, the recommendations may be modified before they are transmitted to higher authority as proposals for project modification and/or implementation funding.

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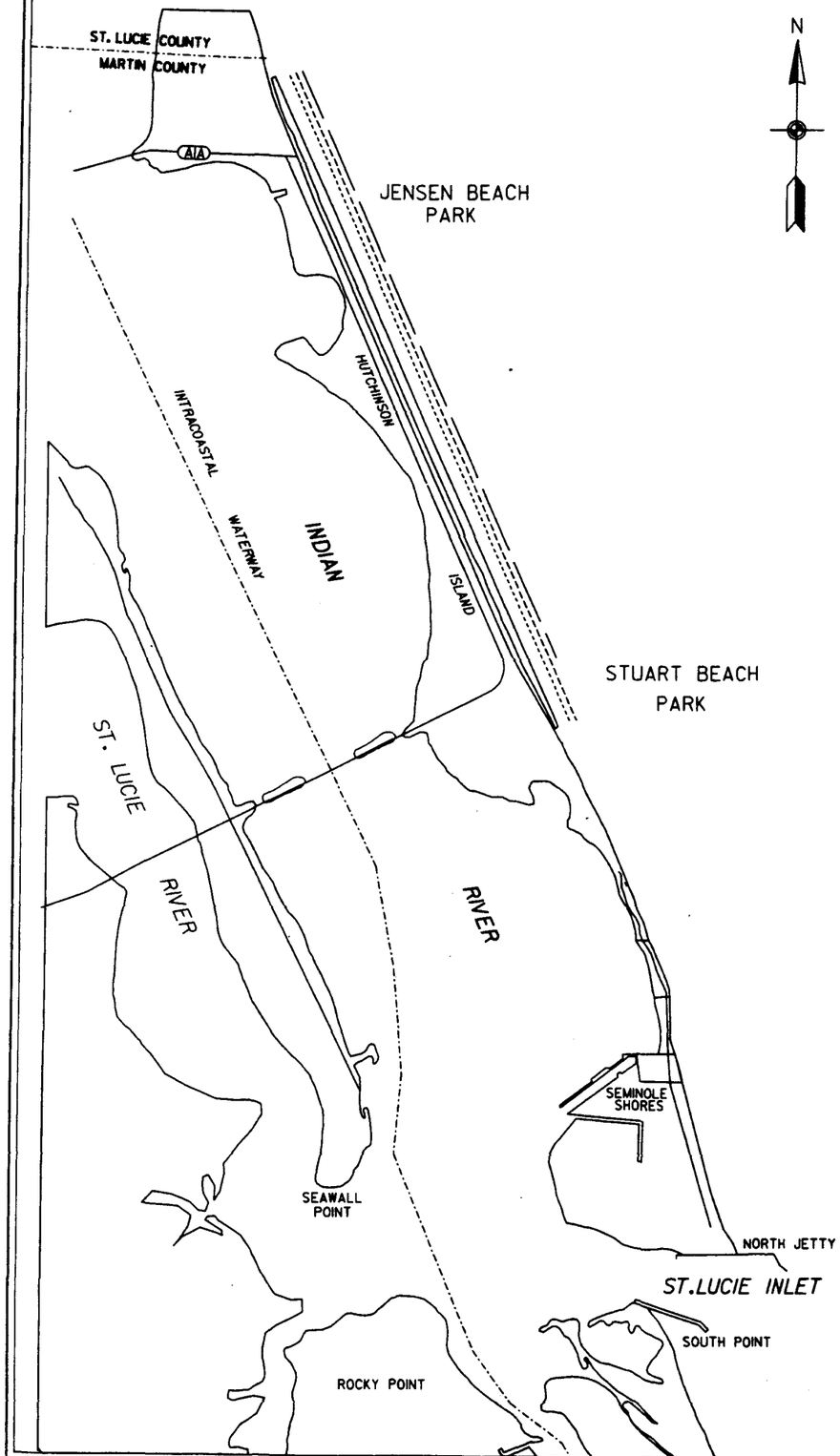
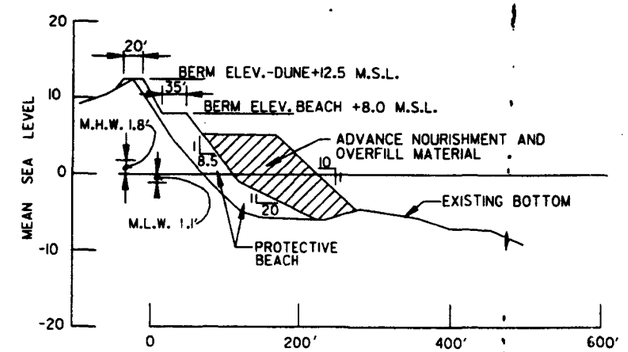
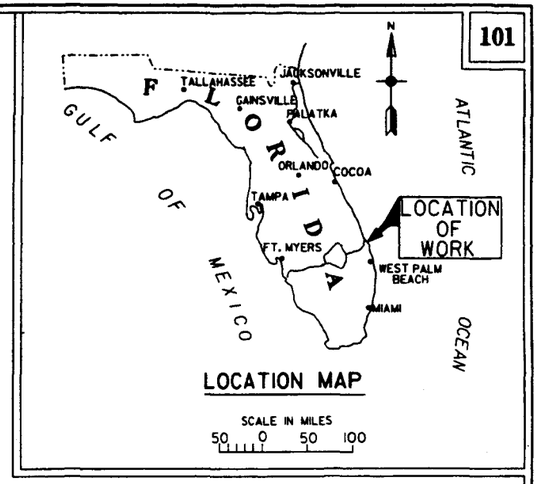
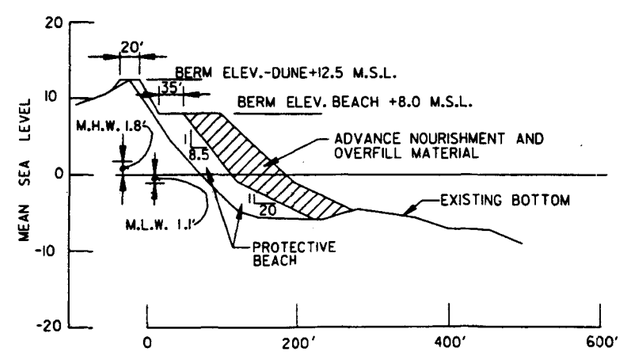




AUTHORIZED TYPICAL SECTION
VICINITY HUTCHINSON ISLAND
(JENSEN BEACH)



LOCATION MAP



PROPOSED TYPICAL SECTION
VICINITY HUTCHINSON ISLAND
(JENSEN BEACH)

LEGEND

- PERIODIC NOURISHMENT AS NEEDED AS AUTHORIZED
- INITIAL RESTORATION AS AUTHORIZED
- INITIAL RESTORATION AS PROPOSED

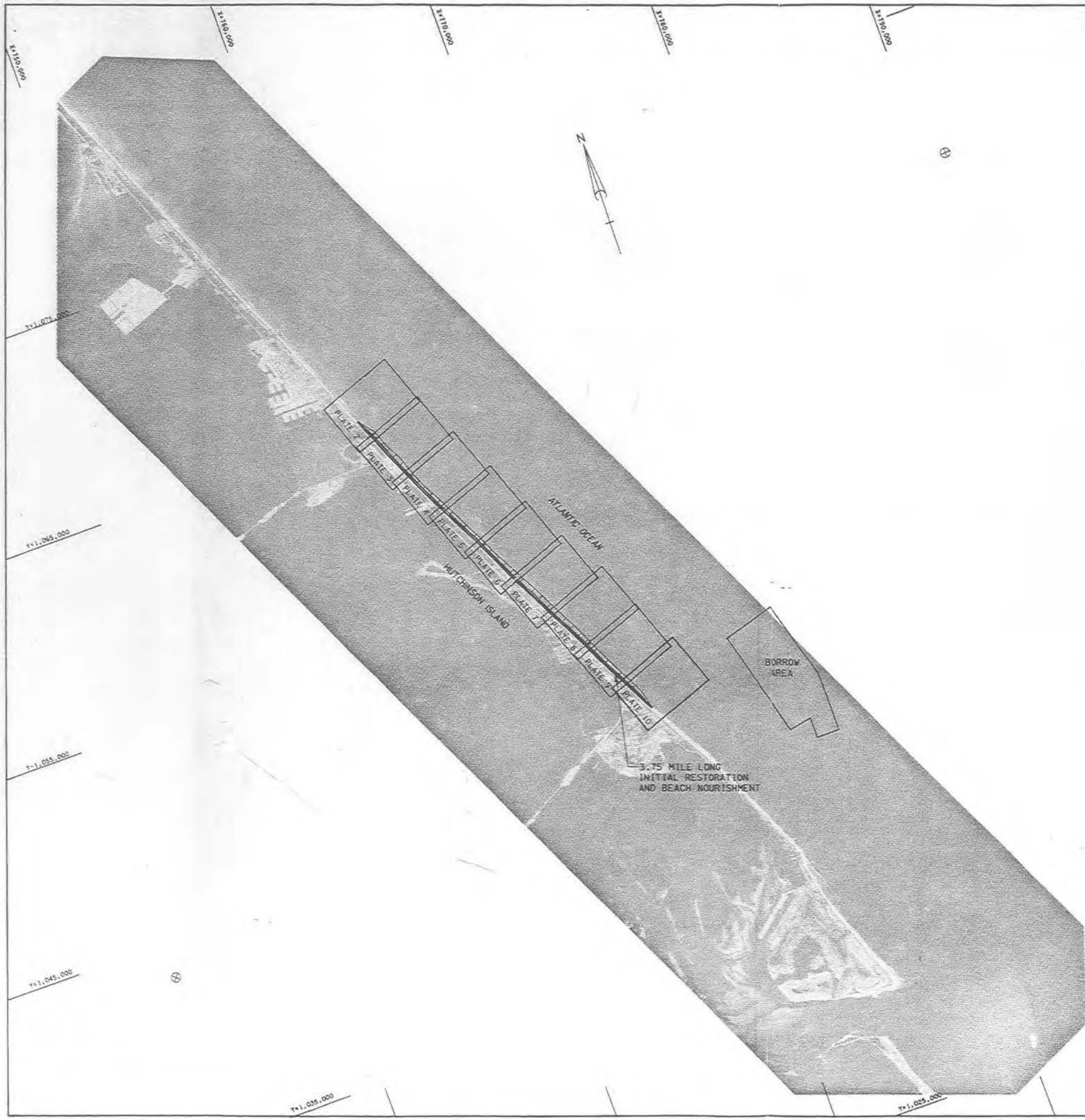
MARTIN COUNTY , FLORIDA
SHORE PROTECTION

SCALE IN MILES
1 ½ 0 1

SCALE AS SHOWN

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

FIGURE 1



NOTES:

1. DETAILS OF THE INITIAL RESTORATION ARE SHOWN ON PLATES 1 THROUGH 10.

2. BORROW AREA DETAILS ARE SHOWN ON PLATES 11 THROUGH 17.

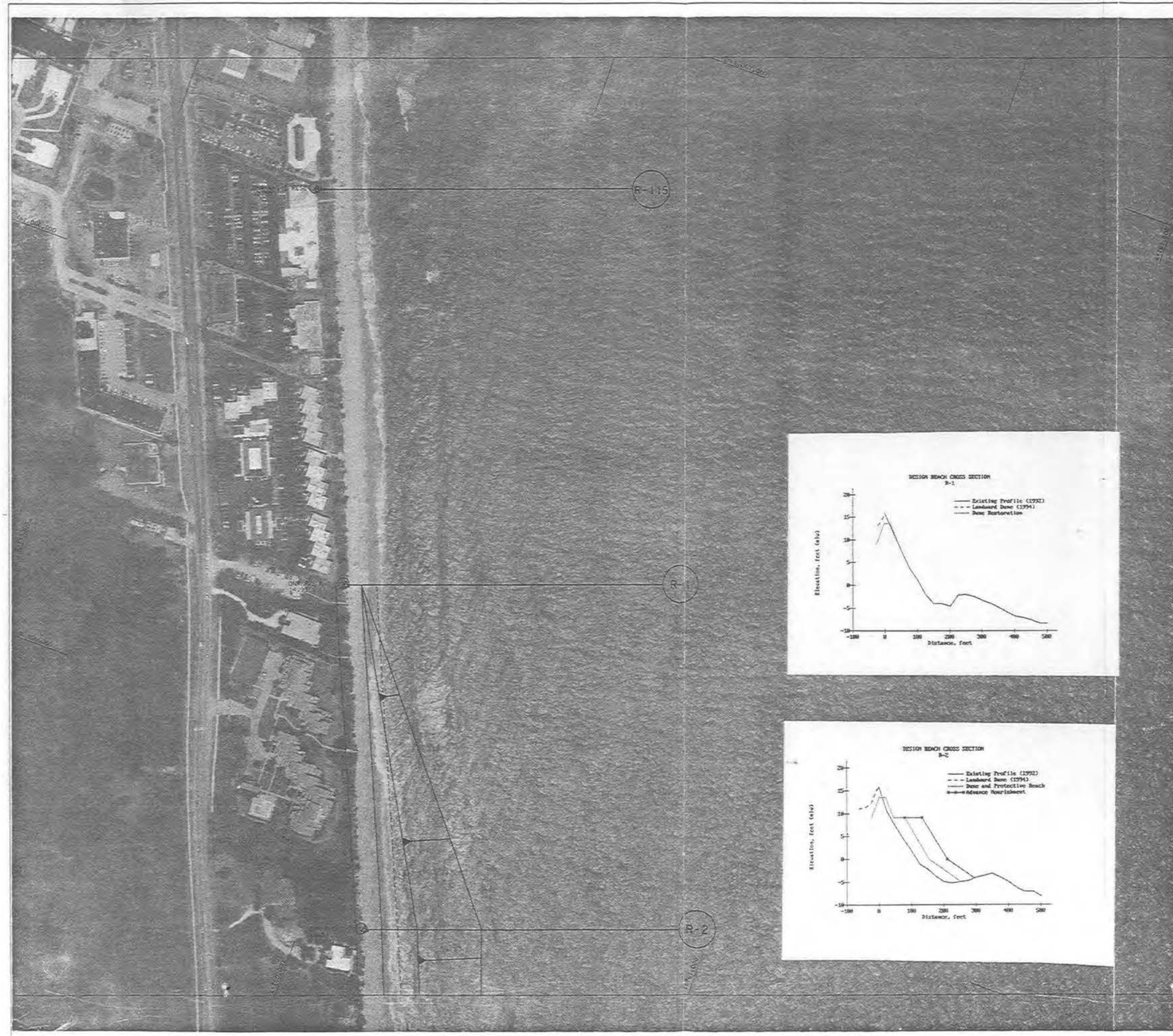
2000 0 2000 4000
SCALE IN FEET

MARTIN COUNTY, FLORIDA
SHORE PROTECTION PROJECT

SELECTED PLAN
COVER SHEET

SCALE AS SHOWN
DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT CORPS OF ENGINEERS
JACKSONVILLE, FLORIDA

DATED: DECEMBER 1993 D.O. FILE NO. 24-36,534



NOTES:

1. REFER TO SURVEY NO. 92-146
2. SOUNDINGS ARE IN FEET AND TENTHS AND REFER TO MEAN LOW WATER, WHICH IS 1.10 FEET BELOW NATIONAL GEODETIC DATUM OF 1929.
3. SOUNDINGS WERE OBTAINED USING A WB-12 BOAT, FALCON IV MINIRANGER INERSPACE ECHO SOUNDER.
4. ALL ELEVATIONS ARE BELOW THE REFERENCE PLANE UNLESS PRECEDED BY A PLUS (+) SIGN.
5. TIDAL REDUCTIONS WERE MADE FROM OBSERVATIONS AT TIDE STAFF SET RELATIVE TO BENCHMARK N-5.
6. PLANE COORDINATES ARE BASED ON THE TRANSVERSE MERCATOR PROJECTION FOR FLORIDA, EAST ZONE. MARCH 1991
7. ALL AZIMUTHS ARE GRID, RECKONED CLOCKWISE FROM SOUTH.
8. THE INFORMATION DEPICTED ON THIS MAP REPRESENTS THE RESULTS OF SURVEYS MADE ON THE DATE INDICATED AND CAN ONLY BE CONSIDERED AS INDICATING THE GENERAL CONDITIONS EXISTING AT THAT TIME.
9. THE INFORMATION [illegible]CTED ON THIS MAP REPRESENTS THE RESULTS OF SURV[illegible] MADE AS LISTED BELOW:

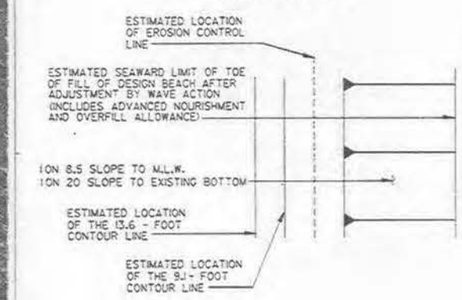
VESSEL		AREA	EPS CONTROL
WB-12	4/21/92 - [illegible]/31/92	EACH PROFILE LINE	

10. REFER TO FIELD BOOK(S): 92 MARTIN COUNTY 150 THRU 153.
11. THE CONSTRUCTION BERM WIDTH WILL VARY DEPENDING ON THE ACTUAL CONSTRUCTION SLOPE USED.
12. ALL PROFILES ARE REFERENCED TO MONUMENTS, WHICH ARE RANGE O, INCREASING SEAWARD.

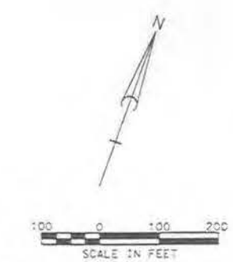
LEGEND

(R-5) PROFILE LINE NO.

△ APPROXIMATE LOCATION OF FLORIDA DEPARTMENT OF ENVIRONMENTAL PROTECTION MONUMENT.



PLAN VIEW LEGEND



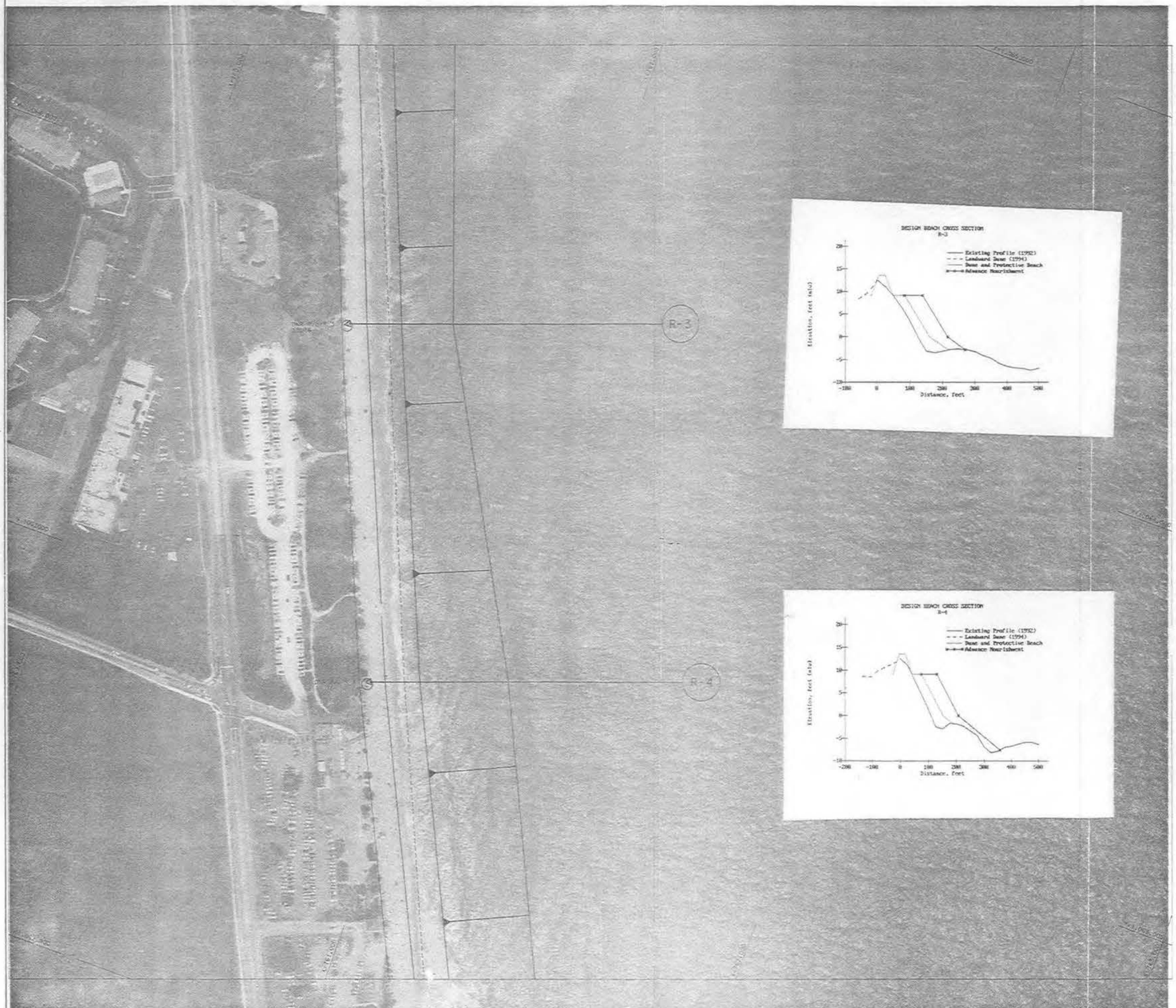
MARTIN COUNTY, FLORIDA
SHORE PROTECTION PROJECT

SELECTED PLAN

SCALE AS SHOWN

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

DATED: DECEMBER 1993 D.O. FILE NO. 24-26.534



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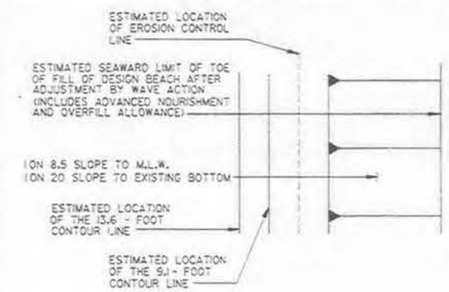

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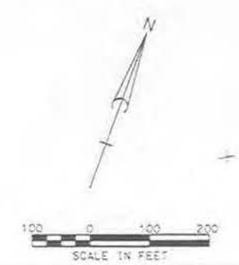


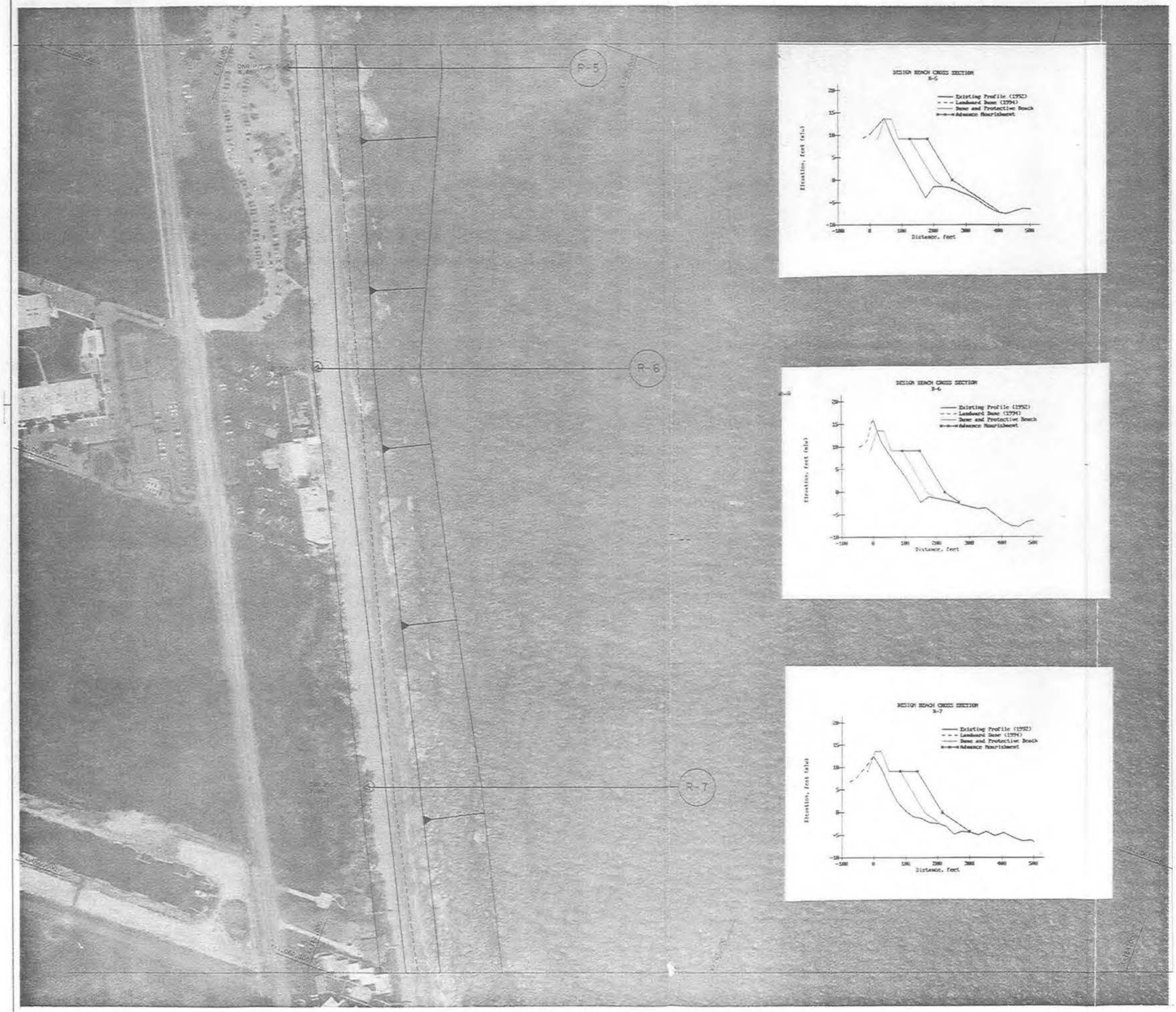
MARTIN COUNTY ,FLORIDA
SHORE PROTECTION PROJECT

SELECTED PLAN

SCALE AS SHOWN

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

DATED: DECEMBER 1993 D.O. FILE NO. 24-36.534



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LEGEND

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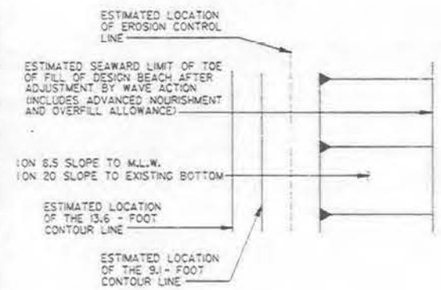

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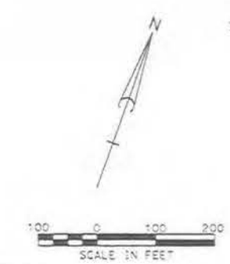


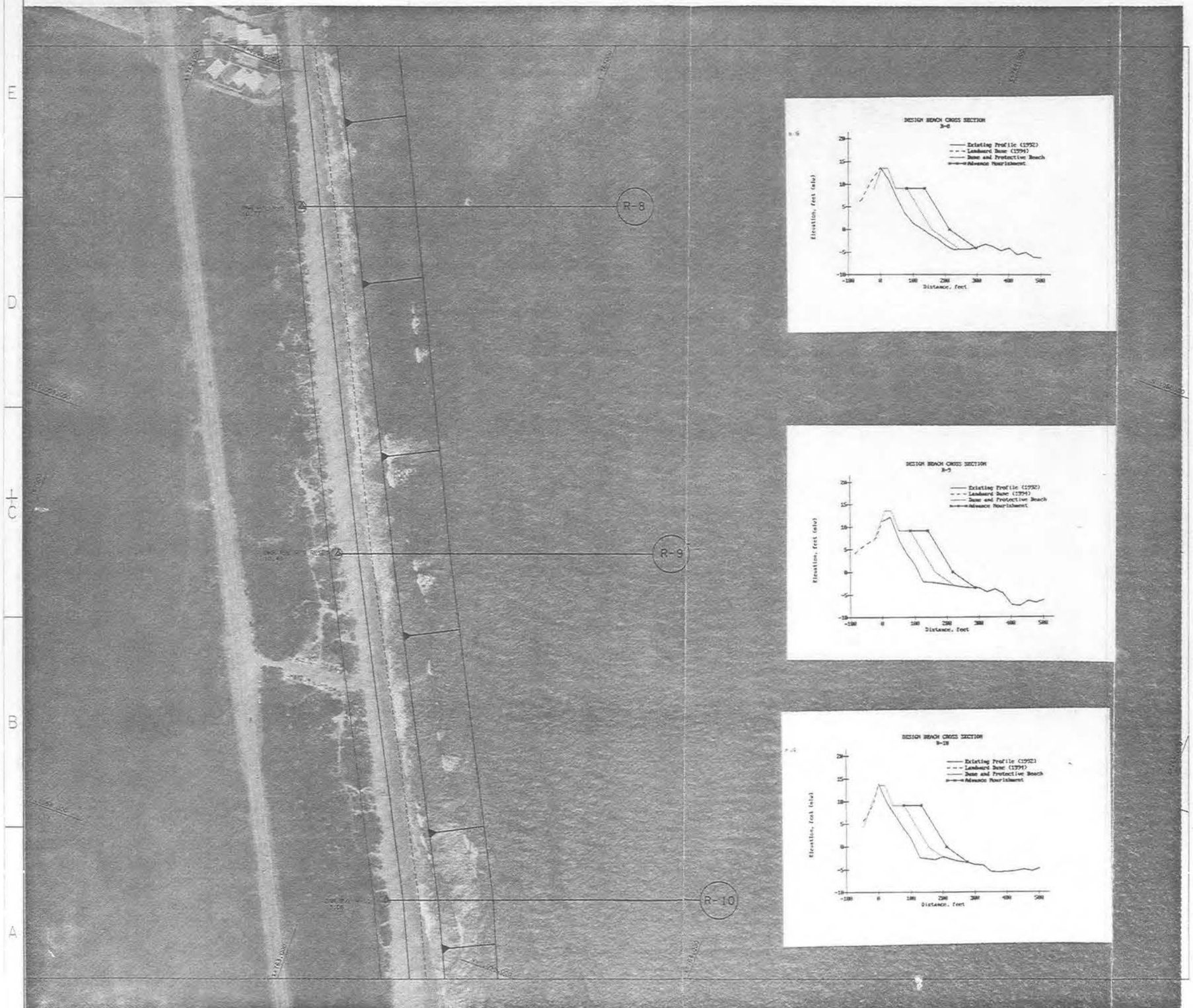
MARTIN COUNTY, FLORIDA
SHORE PROTECTION PROJECT

SELECTED PLAN

SCALE AS SHOWN

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

DATED: DECEMBER 1993 D.O. FILE NO. 24-38,534



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LEGEND

(R-8) PROFILE LINE NO.

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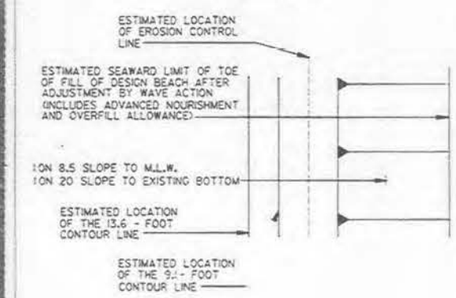
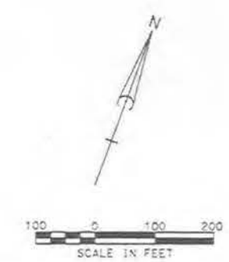


PLAN VIEW LEGEND



MARTIN COUNTY ,FLORIDA
SHORE PROTECTION PROJECT

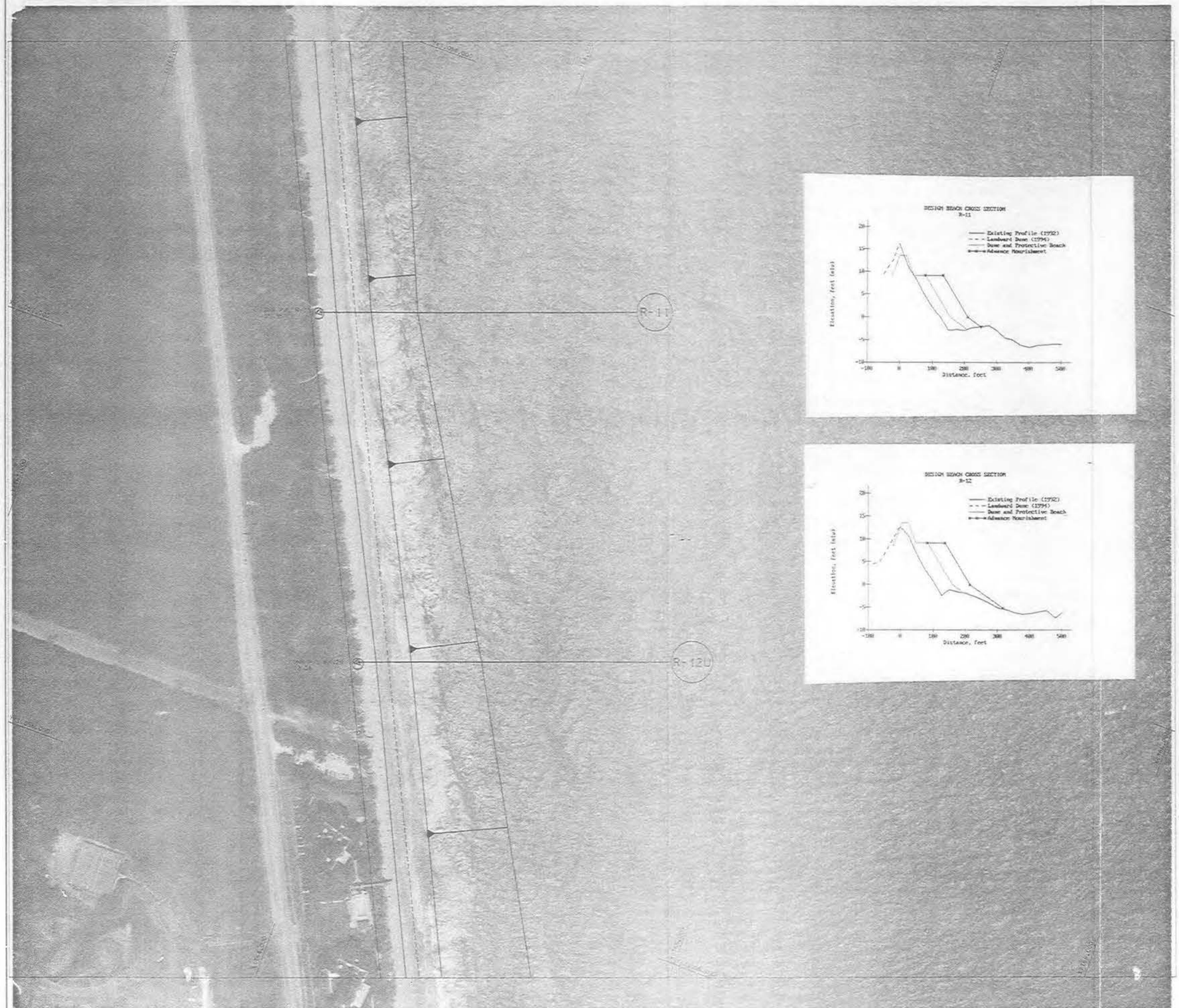
SELECTED PLAN

SCALE AS SHOWN

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

DATED: DECEMBER 1993 D.O. FILE NO. 24-36.534

PLATE 5



NOTES:

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LEGEND

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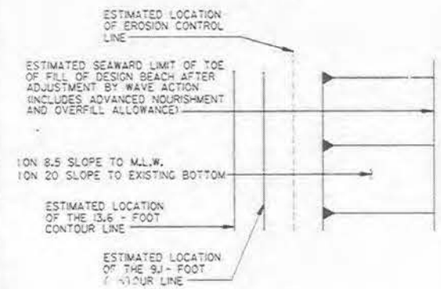

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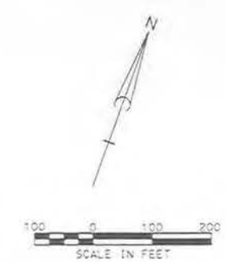

MARTIN COUNTY ,FLORIDA
SHORE PROTECTION PROJECT

SELECTED PLAN

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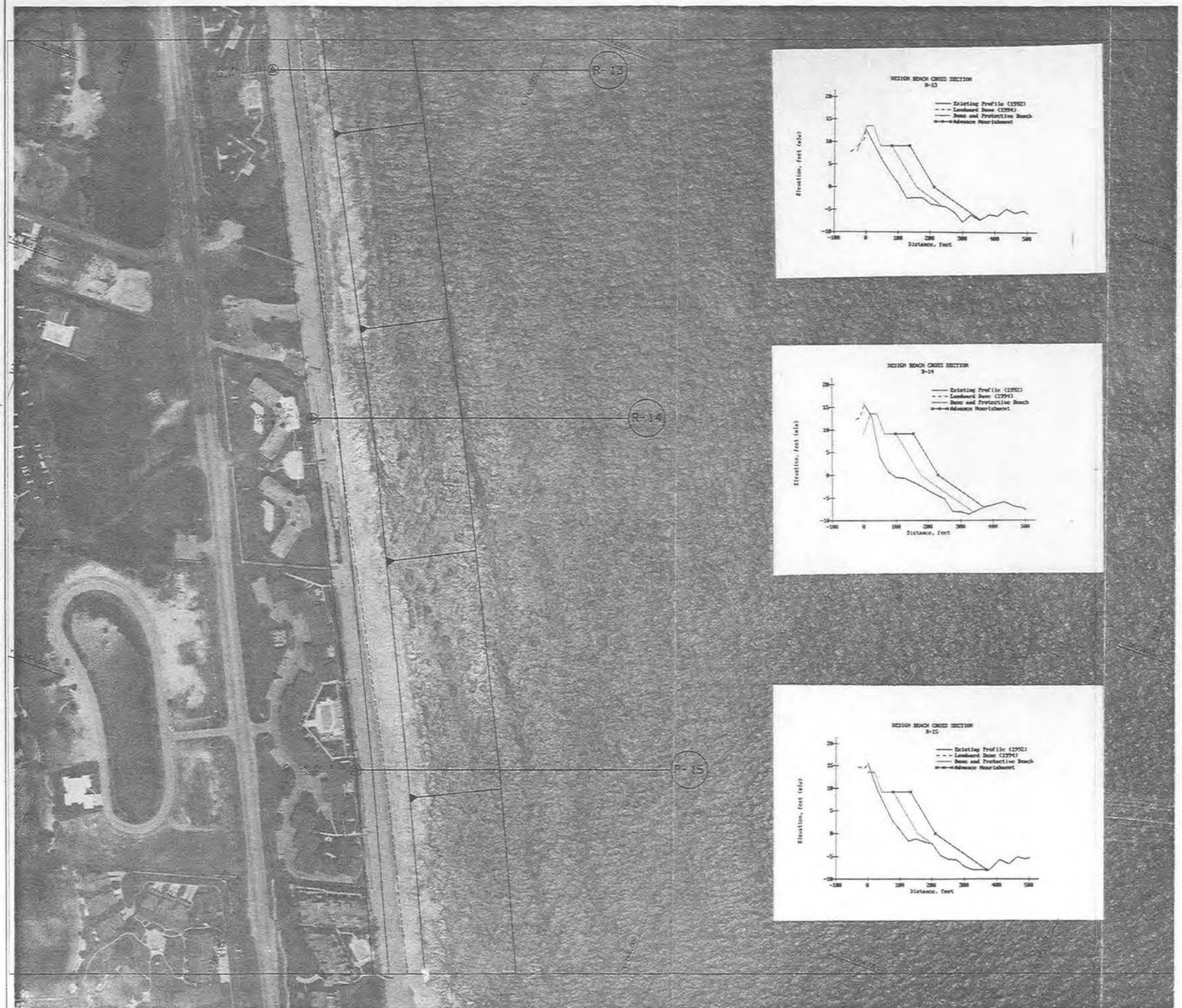
JACKSONVILLE DISTRICT CORPS OF ENGINEERS
JACKSONVILLE ,FLORIDA

DATED: DECEMBER 1993 D.O. FILE NO. 24-36.924



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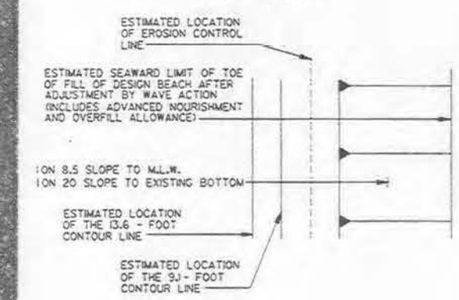
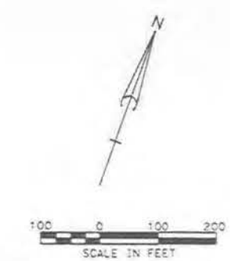


PLAN VIEW LEGEND



MARTIN COUNTY, FLORIDA
SHORE PROTECTION PROJECT

SELECTED PLAN

SCALE AS SHOWN

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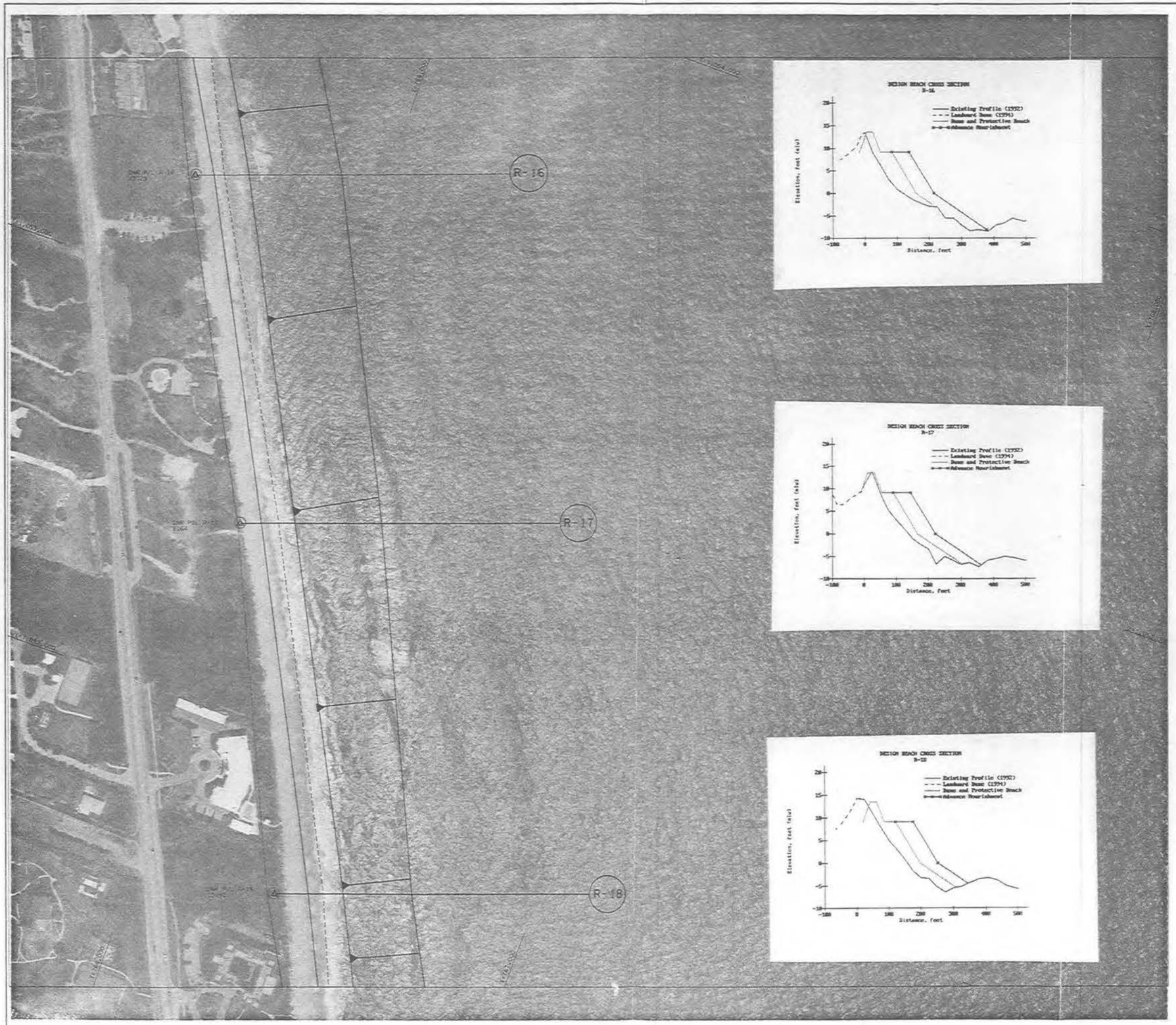
JACKSONVILLE DISTRICT CORPS OF ENGINEERS
JACKSONVILLE, FLORIDA

DATED: DECEMBER 1993 D.O. FILE NO. 24-36.534



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LEGEND

R-16 PROFILE LINE NO.

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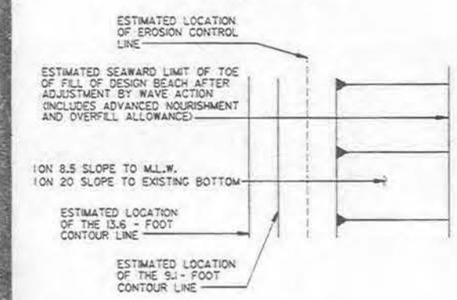
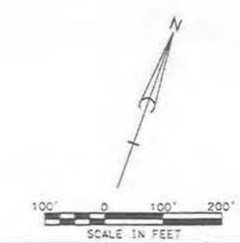


PLAN VIEW LEGEND



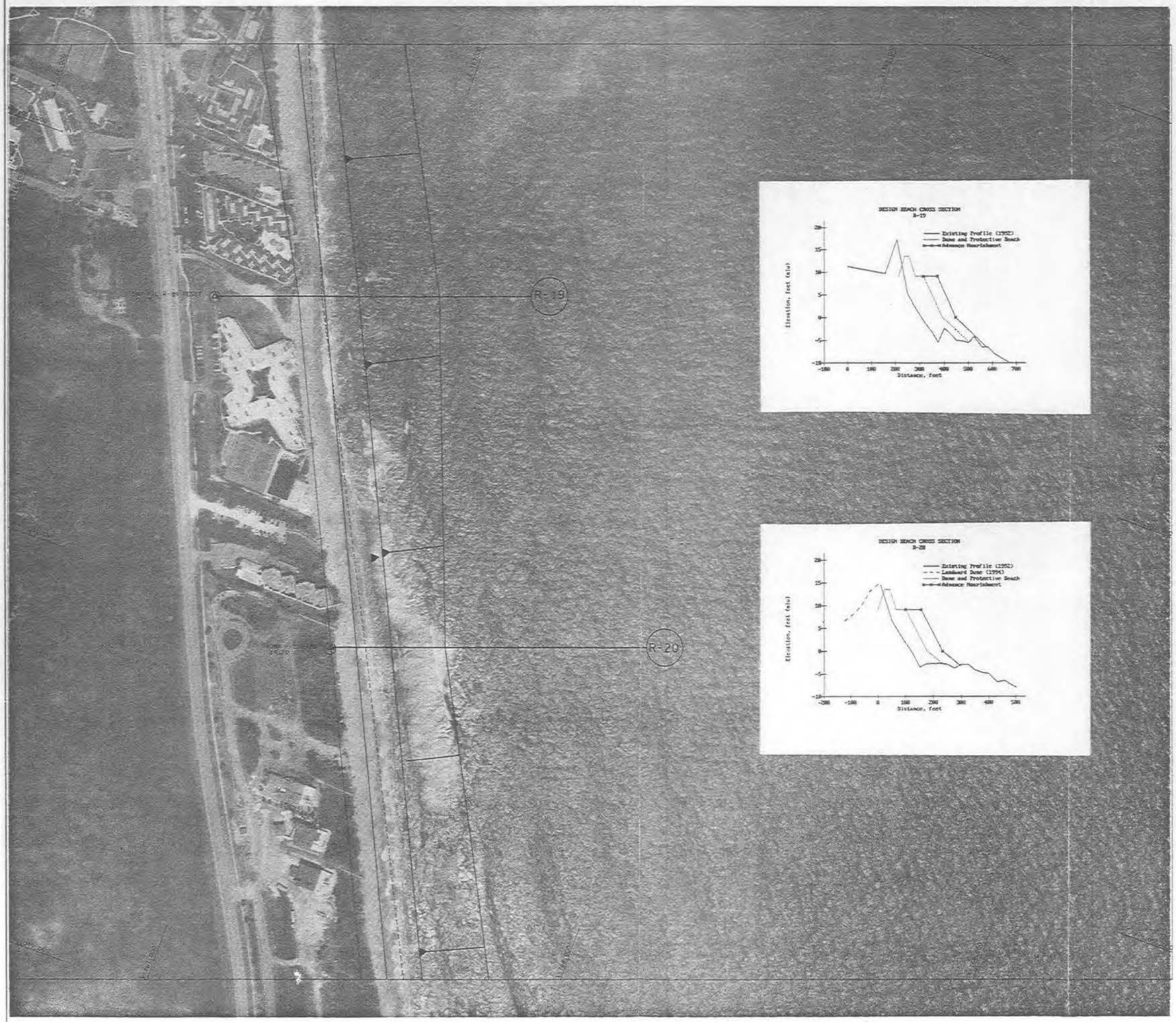
MARTIN COUNTY ,FLORIDA
SHORE PROTECTION PROJECT

SELECTED PLAN

SCALE AS SHOWN

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

DATED: DECEMBER 1993 D.O. FILE NO. 24-36.534



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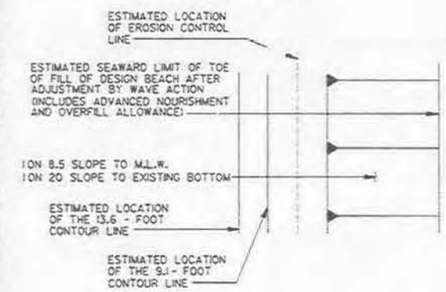
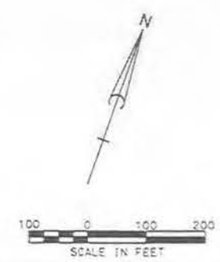


PLAN VIEW LEGEND



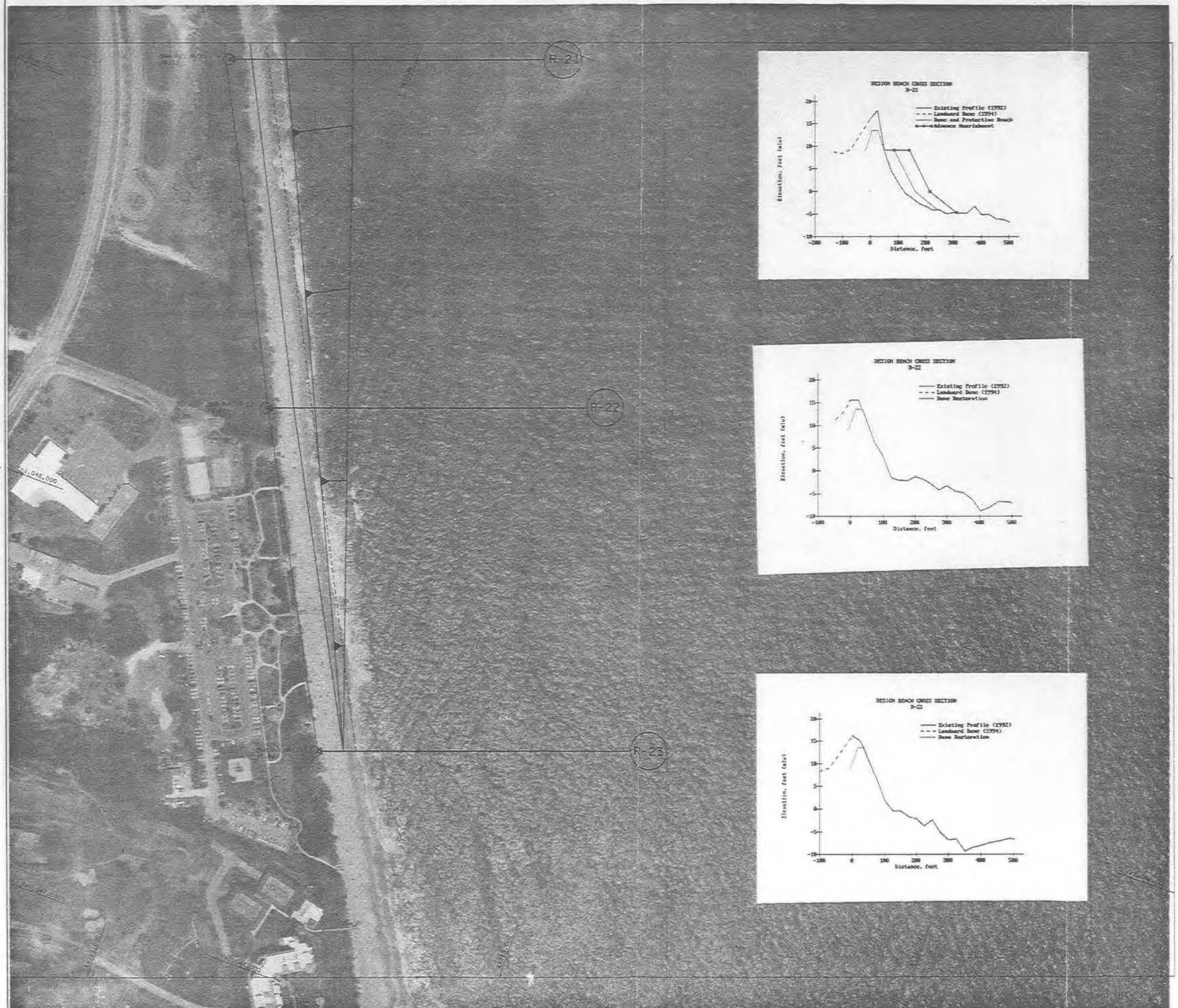
MARTIN COUNTY ,FLORIDA
SHORE PROTECTION PROJECT

SELECTED PLAN

SCALE AS SHOWN

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

DATED: DECEMBER 1993 D.O. FILE NO. 24-36,534



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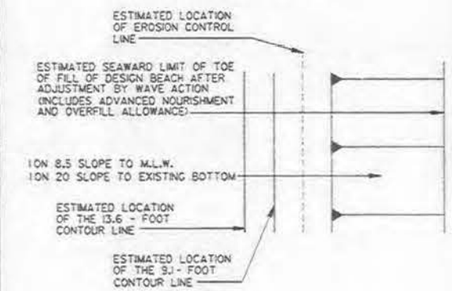
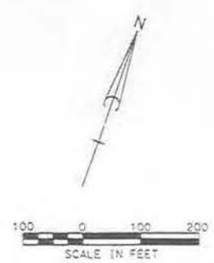


PLAN VIEW LEGEND



MARTIN COUNTY ,FLORIDA
SHORE PROTECTION PROJECT

SELECTED PLAN

SCALE AS SHOWN

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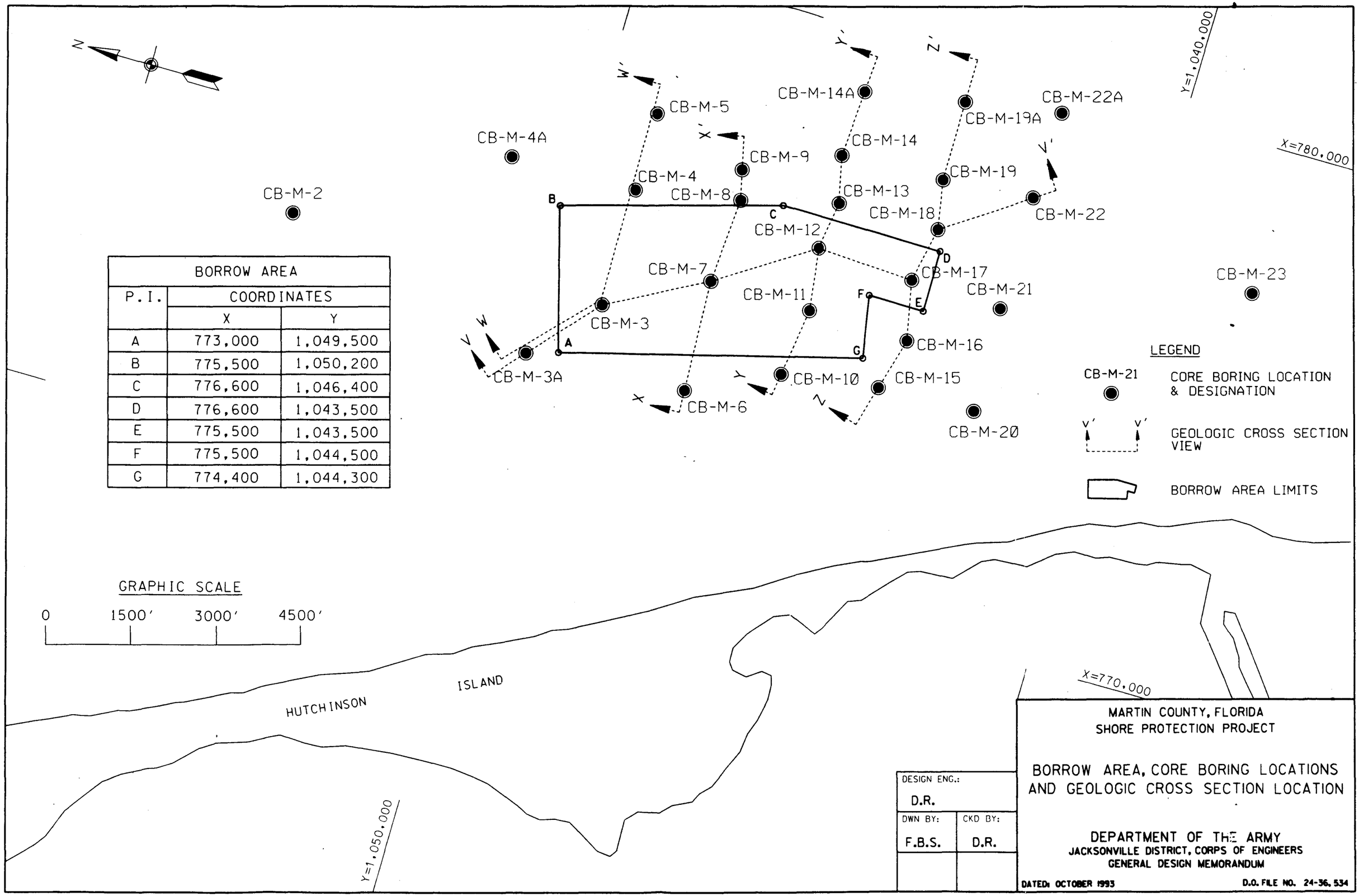
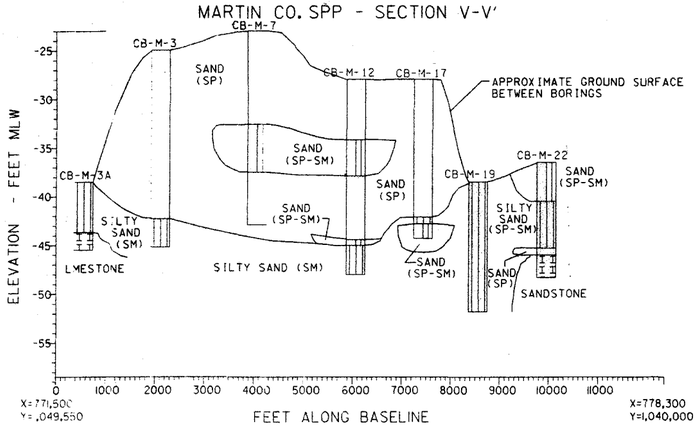
JACKSONVILLE DISTRICT CORPS OF ENGINEERS
JACKSONVILLE ,FLORIDA

DATED: DECEMBER 1993 D.O. FILE NO. 24-36.934

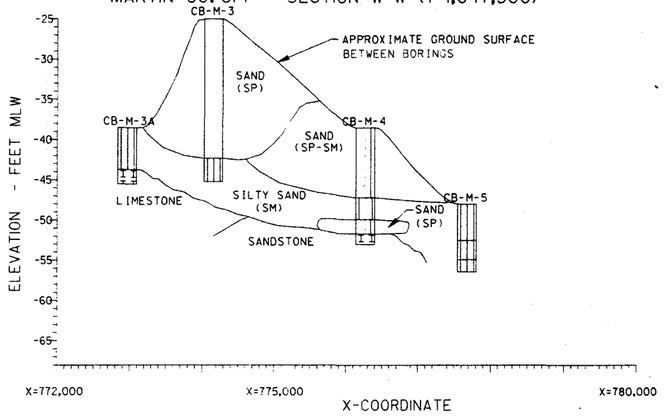


BORROW AREA		
P.I.	COORDINATES	
	X	Y
A	773,000	1,049,500
B	775,500	1,050,200
C	776,600	1,046,400
D	776,600	1,043,500
E	775,500	1,043,500
F	775,500	1,044,500
G	774,400	1,044,300

MARTIN CO. SPP - SECTION V-V'



MARTIN CO. SPP - SECTION W-W' (Y=1,047,300)



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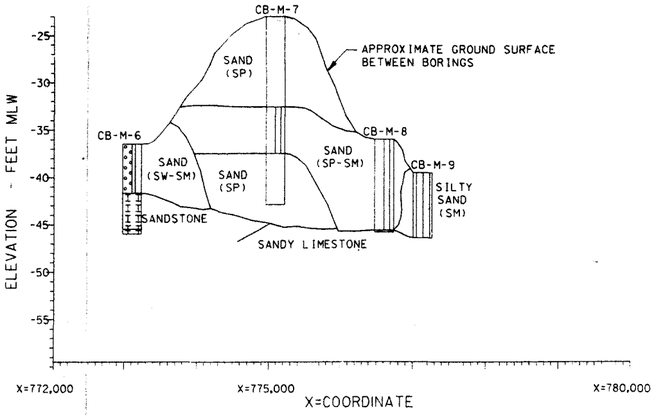
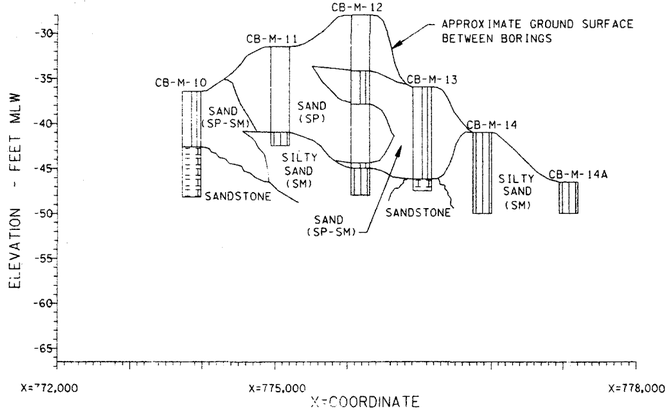


MARTIN CO. SPP - SECTION Y-Y' (Y=1,045,200)



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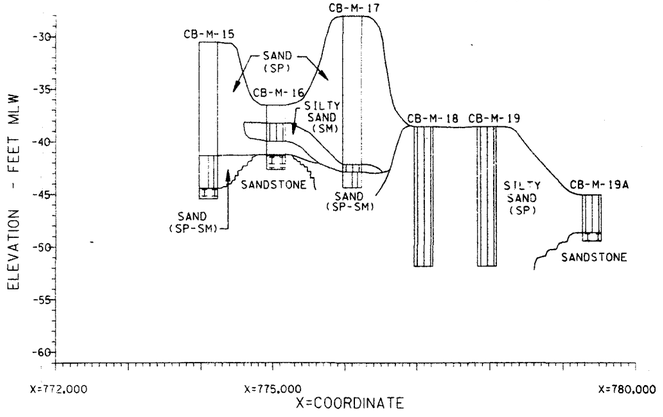


SAND, 0-5% FINES, (SP)

SAND, 5-12% FINES, (SP-SM)

SAND, LITTLE SILT, 12-50% FINES, (SM)

SAND, WELL GRADED, 5-12% FINES, (SW-SM)

LIMESTONE, MEDIUM HARD

SANDSTONE, MEDIUM HARD

MARTIN COUNTY, FLORIDA
SHORE PROTECTION PROJECT

GEOLOGIC CROSS SECTIONS

DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT, CORPS OF ENGINEERS
GENERAL DESIGN MEMORANDUM

DESIGN ENG.: D.R.	
DWN. BY: F.B.S.	CKD. BY: D.R.

DATED: OCTOBER 1993 D.O. FILE NO. 24-36, 534

PLATE 12

filename: cbsec.dgn

APPENDIX A
ENGINEERING DESIGN AND COST ESTIMATES
MARTIN COUNTY, FLORIDA
SHORE PROTECTION PROJECT
GENERAL DESIGN MEMORANDUM

PROBLEM IDENTIFICATION

A-1. The northernmost 4 miles of Hutchinson Island in Martin County, Florida has experienced considerable beach erosion over recent years. The combined effects of wind, waves and tides amplified during storms conditions has resulted in erosion and lowering of the beach profiles as well as recession of the shoreline. The shoreline has receded up to 65 feet in some areas within this 4-mile reach. This appendix provides the engineering analysis to advance the level of engineering and design for providing damage protection to Hutchinson Island in Martin County.

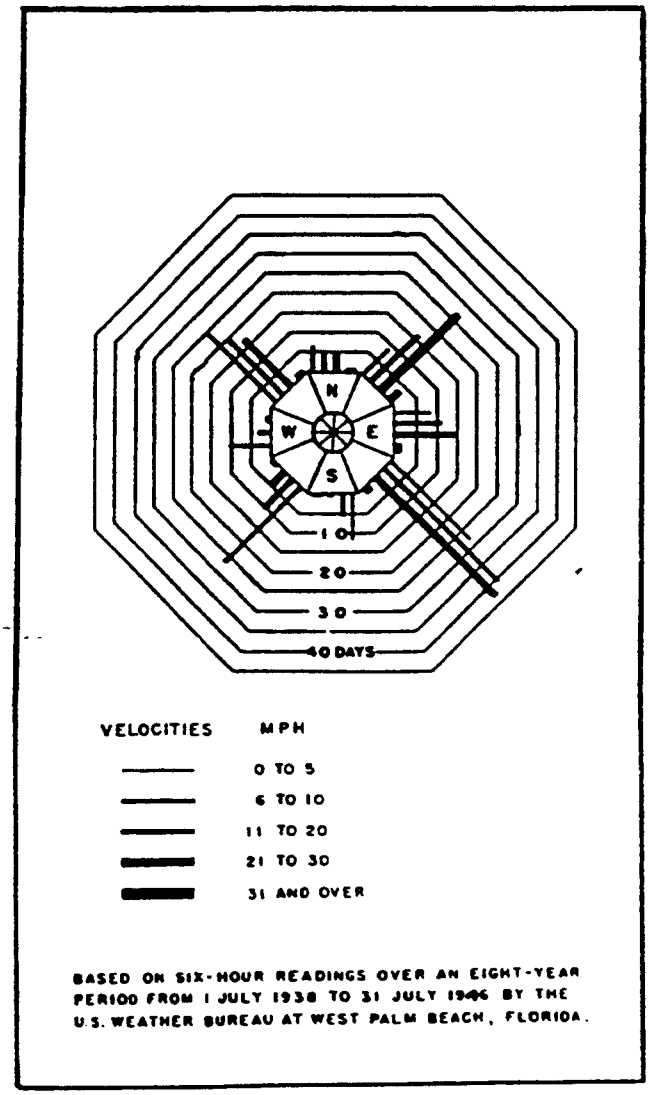
NATURAL FORCES

A-2. There are a number of contributing factors controlling the coastal processes along the shoreline of Martin County. The natural factors include winds, tides, currents, waves and storm events. The role of each of these factors and their contribution to the problem associated with the Martin County Shore Protection Project are described in the following paragraphs.

WINDS

A-3. Local winds are the primary generating mechanism of the short period waves experienced in the project area. The winds in the area vary notably with the seasons. The wind rose in Figure A-1 is based on data taken at the U.S. Weather Bureau Station in West Palm Beach, Florida during the 8-year period from July 1938 to July 1946. This diagram indicates that the prevailing winds are from the northeast through the southeast with the winds from the southeast occurring most often. During winter months (December through March), winds are often out of the northwest through the northeast. Cold fronts, associated with areas of low pressure generally traverse the continental U.S. from west to east. Severe northeasters can cause extensive beach erosion and shorefront damage. The summer months (June to September) are characterized by tropical weather systems traveling east to west in the lower latitudes. These tropical systems have the potential to develop into tropical storms and hurricanes, which can generate devastating winds. Southeast tradewinds make up the typical summer wind climate.

FIGURE A-1
AVERAGE DIRECTION, DURATION , AND VELOCITY OF WINDS
FOR ONE YEAR AT WEST PALM BEACH, FLORIDA



TIDES AND CURRENTS

A-4. Tides in the project area are a mixture of semi-diurnal and diurnal types. The mean range of tide in the Atlantic Ocean at Hutchinson Island is 2.6 feet; the spring range is 3.1 feet (National Ocean Service, NOAA 1993). All elevations, depths, and water levels in this report refer to mean low water (MLW) which is 1.1 feet below the 1929 NGVD and 2.9 feet below mean high water (MHW).

A-5. The most significant ocean current off the east coast of Florida is the Florida Gulf Stream. With the exception of intermittent local reversals, it flows northward. The average annual current velocity is approximately 28 miles per day, varying from an average monthly low of about 17 miles per day in November to an average monthly high of approximately 37 miles per day in July. The axis of the Florida Gulf Stream is about 30 nautical miles to the east of Hutchinson Island.

WAVES

A-6. The principal cause of beach erosion is the action of storm waves breaking on the beach and protective dune. Wave size and frequency of occurrence coupled with associated storm surge are the most important factors in shaping the shoreline of Hutchinson Island. Wind generated storm waves are the most familiar type, and the primary cause of losses of sand from the beaches in the project area.

A-7. The U.S. Army Waterways Experiment Station completed a wave hindcast study for the Atlantic coast of the United States, documented in Wave Information Study (WIS) Reports 2, 6 and 9. The time period considered in the hindcast extends over 20 years, from 1956 to 1975. Wave measurements made by the National Oceanic and Atmospheric Administration (NOAA) and the U.S. Army Corps of Engineers (USACE) during the 1980's and 1990's made verification of these WIS results possible. Comparisons indicated that the distribution of hindcast wave heights, periods and directions differed from the distributions of measured data. These comparisons led to the decision to revise the WIS information for the Atlantic coast for the period 1956-1975. The revised hindcast results are compiled in WIS Report 30 (Hubertz, Brooks, Brandon and Tracy, 1993) and supersedes the three phases of the previous study.

A-8. The wave statistics used in this report were obtained from Station 14 (WIS Report 30) located at latitude 27.25 north and longitude 80.00 west (Figure A-2). This station is located at a water depth of 180 feet offshore of Hutchinson Island, where the shoreline angle was taken to be 24° west of due north.

A-9. Tables A-1 to A-4 summarize the revised hindcast wave results for Station 14. Table A-1 contains the distribution of spectral wave height, peak period, and peak mean direction by month for the 20-year period. This table is useful in showing the

FIGURE A-2
LOCATION MAP - WIS STATION 14

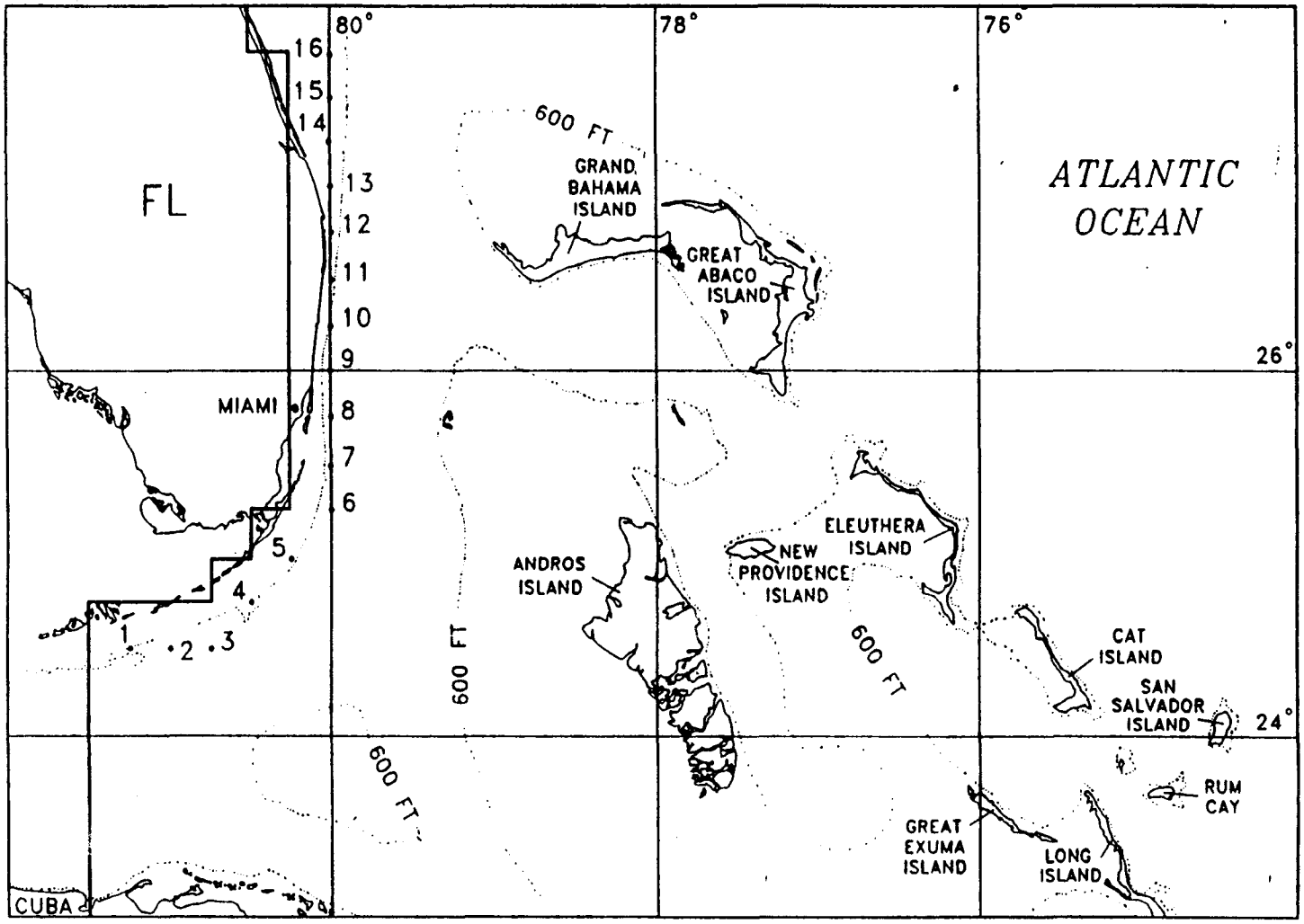


TABLE A-1
SUMMARY OF WAVE INFORMATION BY MONTH FOR ALL YEARS

STATION: 14

OCCURRENCES OF WAVE HEIGHT BY MONTH FOR ALL YEARS

Hmo(m)	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
0.00 - 0.49	131	200	315	404	776	1383	1739	1396	431	236	136	177	7324
0.50 - 0.99	1806	1692	2075	2227	2760	2750	2923	3259	2602	1630	1372	1624	26720
1.00 - 1.49	1527	1197	1487	1420	975	462	236	259	1114	1366	1546	1527	13116
1.50 - 1.99	817	752	731	526	329	118	41	43	358	804	899	823	6241
2.00 - 2.49	428	411	254	168	92	47	21	2	229	443	410	428	2933
2.50 - 2.99	153	210	69	43	26	11	.	1	34	253	207	225	1232
3.00 - 3.49	60	38	23	5	2	17	.	.	12	119	131	90	497
3.50 - 3.99	21	13	4	4	.	12	.	.	8	53	64	48	227
4.00 - 4.49	4	4	2	3	.	.	.	.	8	26	19	10	76
4.50 - 4.99	3	3	.	.	.	.	.	.	3	21	10	4	44
5.00 - 5.49	2	.	.	.	.	.	.	.	.	8	6	4	20
5.50 - 5.99	2	.	.	.	.	.	.	.	1	1	.	.	4
6.00 - 6.49	4	.	.	.	.	.	.	.	.	.	.	.	4
6.50 - 6.99	2	.	.	.	.	.	.	.	.	.	.	.	2
7.00 - 7.49	.	.	.	.	.	.	.	.	.	.	.	.	0
7.50 - 7.99	.	.	.	.	.	.	.	.	.	.	.	.	0
8.00 - 8.49	.	.	.	.	.	.	.	.	.	.	.	.	0
8.50 - 8.99	.	.	.	.	.	.	.	.	.	.	.	.	0
9.00 - 9.49	.	.	.	.	.	.	.	.	.	.	.	.	0
9.50 - 9.99	.	.	.	.	.	.	.	.	.	.	.	.	0
10.00 - GREATER	.	.	.	.	.	.	.	.	.	.	.	.	0
TOTAL	4960	4520	4960	4800	4960	4800	4960	4960	4800	4960	4800	4960	58440

STATION: 14

OCCURRENCES OF PEAK PERIOD BY MONTH FOR ALL YEARS

Tp(sec)	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
3.0 - 3.9	92	122	197	318	251	568	441	365	180	131	84	94	2843
4.0 - 4.9	469	597	779	661	689	902	804	907	610	389	367	466	7640
5.0 - 5.9	620	588	834	780	615	483	566	621	752	526	483	600	7468
6.0 - 6.9	695	689	777	774	713	481	331	415	560	555	696	615	7301
7.0 - 7.9	773	537	536	603	522	768	879	821	689	965	773	563	8429
8.0 - 8.9	747	532	458	399	764	736	1306	1148	740	903	720	599	9052
9.0 - 9.9	344	342	294	280	650	525	460	483	665	677	515	574	5809
10.0 - 10.9	278	249	270	309	386	204	90	120	297	349	293	496	3341
11.0 - 11.9	343	310	270	297	219	105	47	51	192	248	330	430	2842
12.0 - 12.9	267	245	258	155	76	27	12	23	66	120	221	271	1741
13.0 - 13.9	158	164	140	161	39	1	11	6	20	60	187	150	1097
14.0 - 14.9	95	85	59	48	19	.	13	.	8	22	70	74	493
15.0 - 15.9	52	32	42	15	9	.	.	.	6	10	45	20	231
16.0 - 16.9	19	3	23	.	5	.	.	.	8	3	12	7	80
17.0 - 17.9	6	16	13	.	1	.	.	.	4	2	3	1	46
18.0 - 18.9	1	6	7	.	2	.	.	.	2	.	1	.	19
19.0 - 19.9	1	1	3	.	.	.	.	.	1	.	.	.	6
20.0 - LONGER	.	2	.	.	.	.	.	.	.	.	.	.	2
TOTAL	4960	4520	4960	4800	4960	4800	4960	4960	4800	4960	4800	4960	58440

STATION: 14

OCCURRENCES OF PEAK DIRECTION BY MONTH FOR ALL YEARS

Dp(deg) DIRECTION BAND & CENTER	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
348.75 - 11.24 (0.0)	411	420	376	285	85	24	2	30	22	118	277	310	2360
11.25 - 33.74 (22.5)	557	475	410	374	252	211	46	147	343	507	564	502	4388
33.75 - 56.24 (45.0)	1482	1211	1311	1273	1235	968	494	752	1871	2117	1516	1564	15794
56.25 - 78.74 (67.5)	1093	769	787	877	1343	1152	1164	1230	1376	1409	1607	1365	14172
78.75 - 101.24 (90.0)	492	339	426	780	1178	1240	2387	2063	635	360	356	488	10744
101.25 - 123.74 (112.5)	132	160	194	242	321	315	390	340	173	119	99	127	2612
123.75 - 146.24 (135.0)	122	166	245	168	129	261	160	121	103	78	61	74	1688
146.25 - 168.74 (157.5)	99	151	193	125	112	155	44	61	50	58	33	72	1153
168.75 - 191.24 (180.0)	121	253	304	188	105	137	74	71	98	36	46	76	1509
191.25 - 213.74 (202.5)	44	49	67	43	52	78	59	45	35	14	17	23	526
213.75 - 236.24 (225.0)	40	42	46	39	19	73	20	37	35	5	29	22	407
236.25 - 258.74 (247.5)	32	29	44	43	20	94	45	12	32	5	12	24	392
258.75 - 281.24 (270.0)	53	63	119	128	48	88	64	32	16	28	23	38	700
281.25 - 303.74 (292.5)	67	84	138	64	31	2	10	9	6	29	35	56	531
303.75 - 326.24 (315.0)	96	131	141	51	17	1	.	8	3	27	45	101	621
326.25 - 348.74 (337.5)	119	178	159	120	13	1	1	2	2	50	80	118	843
TOTAL	4960	4520	4960	4800	4960	4800	4960	4960	4800	4960	4800	4960	58440

TABLE A-2
OCCURRENCES OF WAVE HEIGHT AND PEAK PERIOD FOR 45° DIRECTION BANDS

STATION: 14 (337.50 - 22.49) 0.0 DEG

Hmo(m)	Tp(sec) 3.0-4.9	5.0-6.9	7.0-8.9	9.0-10.9	11.0-12.9	13.0-14.9	15.0-16.9	17.0-18.9	19.0-20.9	21.0-LONGER	TOTAL
0.00 - 0.99	490	867	143	2	.	.	.	.	.	.	1502
1.00 - 1.99	108	1400	339	8	.	.	.	.	.	.	1855
2.00 - 2.99	.	189	325	23	3	.	.	.	.	.	540
3.00 - 3.99	.	.	76	29	.	.	.	.	.	.	105
4.00 - 4.99	.	.	1	11	.	.	.	.	.	.	12
5.00 - 5.99	.	.	.	.	.	.	.	.	.	.	0
6.00 - 6.99	.	.	.	.	.	.	.	.	.	.	0
7.00 - 7.99	.	.	.	.	.	.	.	.	.	.	0
8.00 - 8.99	.	.	.	.	.	.	.	.	.	.	0
9.00 - GREATER	.	.	.	.	.	.	.	.	.	.	0
TOTAL	598	2456	884	73	3	0	0	0	0	0	4014

STATION: 14 (22.50 - 67.49) 45.0 DEG

Hmo(m)	Tp(sec) 3.0-4.9	5.0-6.9	7.0-8.9	9.0-10.9	11.0-12.9	13.0-14.9	15.0-16.9	17.0-18.9	19.0-20.9	21.0-LONGER	TOTAL
0.00 - 0.99	1046	2748	3647	3036	2078	639	136	49	8	.	13387
1.00 - 1.99	105	2133	3529	2281	1680	636	116	7	.	.	10487
2.00 - 2.99	.	90	1386	596	257	136	18	2	.	.	2485
3.00 - 3.99	.	.	84	305	28	28	12	2	.	.	459
4.00 - 4.99	.	.	1	57	33	2	.	.	.	.	93
5.00 - 5.99	.	.	.	4	20	.	.	.	.	.	24
6.00 - 6.99	.	.	.	.	6	.	.	.	.	.	6
7.00 - 7.99	.	.	.	.	.	.	.	.	.	.	0
8.00 - 8.99	.	.	.	.	.	.	.	.	.	.	0
9.00 - GREATER	.	.	.	.	.	.	.	.	.	.	0
TOTAL	1151	4971	8647	6279	4102	1441	282	60	8	0	26941

STATION: 14 (67.50 - 112.49) 90.0 DEG

Hmo(m)	Tp(sec) 3.0-4.9	5.0-6.9	7.0-8.9	9.0-10.9	11.0-12.9	13.0-14.9	15.0-16.9	17.0-18.9	19.0-20.9	21.0-LONGER	TOTAL
0.00 - 0.99	3123	1666	6254	2400	355	83	4	2	.	.	13887
1.00 - 1.99	91	2679	662	243	113	52	25	3	.	.	3868
2.00 - 2.99	.	45	560	27	8	14	.	.	.	.	654
3.00 - 3.99	.	.	23	86	.	.	.	.	.	.	109
4.00 - 4.99	.	.	1	5	1	.	.	.	.	.	7
5.00 - 5.99	.	.	.	.	.	.	.	.	.	.	0
6.00 - 6.99	.	.	.	.	.	.	.	.	.	.	0
7.00 - 7.99	.	.	.	.	.	.	.	.	.	.	0
8.00 - 8.99	.	.	.	.	.	.	.	.	.	.	0
9.00 - GREATER	.	.	.	.	.	.	.	.	.	.	0
TOTAL	3214	4390	7500	2761	477	149	29	5	0	0	18525

STATION: 14 (112.50 - 157.49) 135.0 DEG

Hmo(m)	Tp(sec) 3.0-4.9	5.0-6.9	7.0-8.9	9.0-10.9	11.0-12.9	13.0-14.9	15.0-16.9	17.0-18.9	19.0-20.9	21.0-LONGER	TOTAL
0.00 - 0.99	1776	327	.	.	.	.	.	.	.	.	2103
1.00 - 1.99	39	1010	62	1	.	.	.	.	.	.	1112
2.00 - 2.99	.	24	117	4	.	.	.	.	.	.	145
3.00 - 3.99	.	.	17	13	.	.	.	.	.	.	30
4.00 - 4.99	.	.	.	3	.	.	.	.	.	.	3
5.00 - 5.99	.	.	.	.	.	.	.	.	.	.	0
6.00 - 6.99	.	.	.	.	.	.	.	.	.	.	0
7.00 - 7.99	.	.	.	.	.	.	.	.	.	.	0
8.00 - 8.99	.	.	.	.	.	.	.	.	.	.	0
9.00 - GREATER	.	.	.	.	.	.	.	.	.	.	0
TOTAL	1815	1361	196	21	0	0	0	0	0	0	3393

STATION: 14 (157.50 - 202.49) 180.0 DEG

Hmo(m)	Tp(sec) 3.0-4.9	5.0-6.9	7.0-8.9	9.0-10.9	11.0-12.9	13.0-14.9	15.0-16.9	17.0-18.9	19.0-20.9	21.0-LONGER	TOTAL
0.00 - 0.99	1037	344	3	.	.	.	.	.	.	.	1384
1.00 - 1.99	53	642	75	.	.	.	.	.	.	.	770
2.00 - 2.99	.	31	151	3	.	.	.	.	.	.	185
3.00 - 3.99	.	.	15	6	.	.	.	.	.	.	21
4.00 - 4.99	.	.	.	4	1	.	.	.	.	.	5
5.00 - 5.99	.	.	.	.	.	.	.	.	.	.	0
6.00 - 6.99	.	.	.	.	.	.	.	.	.	.	0
7.00 - 7.99	.	.	.	.	.	.	.	.	.	.	0
8.00 - 8.99	.	.	.	.	.	.	.	.	.	.	0
9.00 - GREATER	.	.	.	.	.	.	.	.	.	.	0
TOTAL	1090	1017	244	13	1	0	0	0	0	0	2365

TABLE A-2 (Continued)
OCCURRENCES OF WAVE HEIGHT AND PEAK PERIOD FOR 45° DIRECTION BANDS

STATION: 14 (202.50 - 247.49) 225.0 DEG

Hmo(m)	Tp(sec) 3.0-4.9	5.0-6.9	7.0-8.9	9.0-10.9	11.0-12.9	13.0-14.9	15.0-16.9	17.0-18.9	19.0-20.9	21.0-LONGER	TOTAL
0.00 - 0.99	579	3	.	.	.	.	.	.	.	.	582
1.00 - 1.99	193	58	.	.	.	.	.	.	.	.	251
2.00 - 2.99	.	3	.	.	.	.	.	.	.	.	3
3.00 - 3.99	.	.	.	.	.	.	.	.	.	.	0
4.00 - 4.99	.	.	.	.	.	.	.	.	.	.	0
5.00 - 5.99	.	.	.	.	.	.	.	.	.	.	0
6.00 - 6.99	.	.	.	.	.	.	.	.	.	.	0
7.00 - 7.99	.	.	.	.	.	.	.	.	.	.	0
8.00 - 8.99	.	.	.	.	.	.	.	.	.	.	0
9.00 - GREATER	.	.	.	.	.	.	.	.	.	.	0
TOTAL	772	64	0	0	0	0	0	0	0	0	836

STATION: 14 (247.50 - 292.49) 270.0 DEG

Hmo(m)	Tp(sec) 3.0-4.9	5.0-6.9	7.0-8.9	9.0-10.9	11.0-12.9	13.0-14.9	15.0-16.9	17.0-18.9	19.0-20.9	21.0-LONGER	TOTAL
0.00 - 0.99	837		.	.	.	.	.	.	.	.	837
1.00 - 1.99	289	52	.	.	.	.	.	.	.	.	341
2.00 - 2.99	.	9	.	.	.	.	.	.	.	.	9
3.00 - 3.99	.	.	.	.	.	.	.	.	.	.	0
4.00 - 4.99	.	.	.	.	.	.	.	.	.	.	0
5.00 - 5.99	.	.	.	.	.	.	.	.	.	.	0
6.00 - 6.99	.	.	.	.	.	.	.	.	.	.	0
7.00 - 7.99	.	.	.	.	.	.	.	.	.	.	0
8.00 - 8.99	.	.	.	.	.	.	.	.	.	.	0
9.00 - GREATER	.	.	.	.	.	.	.	.	.	.	0
TOTAL	1126	61	0	0	0	0	0	0	0	0	1187

STATION: 14 (292.50 - 337.49) 315.0 DEG

Hmo(m)	Tp(sec) 3.0-4.9	5.0-6.9	7.0-8.9	9.0-10.9	11.0-12.9	13.0-14.9	15.0-16.9	17.0-18.9	19.0-20.9	21.0-LONGER	TOTAL
0.00 - 0.99	336	19	5	2	.	.	.	.	.	.	362
1.00 - 1.99	381	289	2	1	.	.	.	.	.	.	673
2.00 - 2.99	.	141	3	.	.	.	.	.	.	.	144
3.00 - 3.99	.	.	.	.	.	.	.	.	.	.	0
4.00 - 4.99	.	.	.	.	.	.	.	.	.	.	0
5.00 - 5.99	.	.	.	.	.	.	.	.	.	.	0
6.00 - 6.99	.	.	.	.	.	.	.	.	.	.	0
7.00 - 7.99	.	.	.	.	.	.	.	.	.	.	0
8.00 - 8.99	.	.	.	.	.	.	.	.	.	.	0
9.00 - GREATER	.	.	.	.	.	.	.	.	.	.	0
TOTAL	717	449	10	3	0	0	0	0	0	0	1179

STATION: 14 ALL DIRECTIONS

Hmo(m)	Tp(sec) 3.0-4.9	5.0-6.9	7.0-8.9	9.0-10.9	11.0-12.9	13.0-14.9	15.0-16.9	17.0-18.9	19.0-20.9	21.0-LONGER	TOTAL
0.00 - 0.99	9224	5974	10052	5440	2433	722	140	51	8	.	34044
1.00 - 1.99	1259	8263	4669	2534	1793	688	141	10	.	.	19357
2.00 - 2.99	.	532	2542	653	268	150	18	2	.	.	4165
3.00 - 3.99	.	.	215	439	28	28	12	2	.	.	724
4.00 - 4.99	.	.	3	80	35	2	.	.	.	.	120
5.00 - 5.99	.	.	.	4	20	.	.	.	.	.	24
6.00 - 6.99	.	.	.	.	6	.	.	.	.	.	6
7.00 - 7.99	.	.	.	.	.	.	.	.	.	.	0
8.00 - 8.99	.	.	.	.	.	.	.	.	.	.	0
9.00 - GREATER	.	.	.	.	.	.	.	.	.	.	0
TOTAL	10483	14769	17481	9150	4583	1590	311	65	8	0	58440

range distribution of height, period, and direction throughout the year. Table A-2 shows the number of occurrences for eight different direction bands each 45° in width, and for all directions. This table is useful to find the dominant direction from which wave energy affects a given location of shoreline. It also identifies the distribution of wave height and period. For this station, 45,466 occurrences out of a

total of 58,440 are from directions between the compass directions NNE and ESE, and most of these are lower than 1 meter in height with a period between 7.0 to 8.9 seconds. The distribution of wind speed and direction, on a monthly basis, is shown in Table A-3. This table is valuable for understanding the climatology of winds at a site. Local sea conditions and wind-driven currents can be inferred form the wind climatology. At this station, winds are generally less than 7.5 m/sec and are from the northeast through the southeast. Table A-4 summarizes mean and maximum wave heights by month for each of the 20 years hindcast.

A-10. The hindcast provides a time history of wave height, period and direction, listed at three-hour intervals over the 20-year study period. The significant wave height (H_{mo}) represents the combination of sea and swell. The wave period (T_p) and direction are of the dominant wave. Wave direction (D_p) is measured clockwise in degrees from true north.

TABLE A-3
OCCURRENCES OF WIND SPEED AND DIRECTION BY MONTH FOR ALL YEARS

STATION: 14

OCCURRENCES OF WIND SPEED BY MONTH FOR ALL YEARS

WS(m/sec)	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
0.00 - 2.49	280	217	239	304	508	585	706	669	463	292	184	199	4646
2.50 - 4.99	1948	1778	1940	2165	2775	3192	3582	3523	2744	2134	1806	1852	29439
5.00 - 7.49	1364	1132	1588	1388	1155	714	592	684	1130	1232	1309	1433	13721
7.50 - 9.99	892	907	884	820	486	255	79	82	385	833	1035	1032	7690
10.00 - 12.49	330	327	223	86	28	35	1	2	51	343	341	315	2082
12.50 - 14.99	132	149	80	31	8	19	.	.	26	120	106	118	789
15.00 - 17.49	7	8	6	4	.	.	.	.	1	6	14	8	54
17.50 - 19.99	7	2	.	2	.	.	.	.	.	.	5	3	19
20.00 - GREATER													0
TOTAL	4960	4520	4960	4800	4960	4800	4960	4960	4800	4960	4800	4960	58440

STATION: 14

OCCURRENCES OF WIND DIRECTION BY MONTH FOR LL YEARS

WD(deg) DIRECTION BAND & CENTER	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
337.50 - 22.49 (0.0)	651	523	477	377	264	133	81	174	345	687	798	690	5200
22.50 - 67.49 (45.0)	976	659	577	630	643	450	259	559	1155	1732	1303	1221	10164
67.50 - 112.49 (90.0)	907	711	905	1320	1530	1286	1729	1762	1517	1119	1109	1090	14985
112.50 - 157.49 (135.0)	679	674	901	846	874	1109	1330	989	790	451	420	506	9569
157.50 - 202.49 (180.0)	404	530	582	450	531	591	615	565	278	169	180	338	5233
202.50 - 247.49 (225.0)	318	340	399	331	369	597	540	469	275	148	193	234	4213
247.50 - 292.49 (270.0)	417	449	527	482	478	494	350	287	254	249	307	319	4613
292.50 - 337.49 (315.0)	608	634	592	364	271	140	56	155	186	405	490	562	4463
TOTAL	4960	4520	4960	4800	4960	4800	4960	4960	4800	4960	4800	4960	58440

TABLE A-4
MEAN AND MAXIMUM WAVE HEIGHTS BY MONTH FOR ALL YEARS

STATION: 14

SUMMARY OF MEAN Hmo(m) BY MONTH AND YEAR

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN
1956	1.31	0.97	1.05	0.90	1.07	0.73	0.54	0.50	1.07	1.54	1.76	0.97	1.03
1957	1.24	1.23	0.84	1.12	0.71	0.71	0.45	0.63	0.87	1.41	1.33	1.59	1.01
1958	1.67	1.34	0.93	1.03	0.97	0.73	0.72	0.55	0.86	1.48	0.99	1.44	1.06
1959	1.41	1.12	1.22	1.05	0.85	0.54	0.60	0.69	1.14	0.84	1.61	1.65	1.06
1960	1.01	1.32	1.09	1.06	0.79	0.70	0.56	0.71	1.16	0.72	1.27	1.61	1.00
1961	1.23	1.06	0.83	0.91	0.74	0.65	0.50	0.60	0.98	1.77	1.21	1.03	0.96
1962	1.32	1.07	1.46	0.94	0.83	0.54	0.42	0.57	0.76	1.17	1.60	1.22	0.99
1963	1.29	1.24	0.98	0.94	0.91	0.61	0.53	0.48	1.05	1.82	1.54	1.19	1.05
1964	1.14	1.08	1.04	1.04	0.92	0.47	0.71	0.64	1.18	1.52	1.19	1.56	1.04
1965	1.17	1.30	0.94	0.77	0.71	0.78	0.52	0.50	1.38	1.19	1.36	1.41	1.00
1966	1.42	1.43	1.17	1.01	0.82	1.08	0.58	0.63	0.56	1.28	1.98	1.19	1.09
1967	1.11	1.27	1.20	1.14	0.74	0.72	0.55	0.55	1.04	1.34	1.50	1.22	1.03
1968	1.34	1.19	1.19	0.92	0.69	0.64	0.54	0.47	0.82	1.15	1.05	1.15	0.93
1969	1.48	1.62	1.25	1.14	1.08	0.55	0.52	0.69	0.92	1.75	1.67	1.10	1.14
1970	1.30	1.69	1.20	0.87	1.07	0.67	0.59	0.66	0.83	1.62	1.31	0.97	1.06
1971	1.07	1.26	1.03	0.76	0.65	0.46	0.51	0.61	1.00	0.74	1.50	1.57	0.93
1972	1.15	1.24	1.09	0.91	1.03	0.99	0.63	0.51	0.90	1.28	0.94	1.37	1.00
1973	1.28	1.41	1.22	1.25	0.69	0.67	0.51	0.62	0.72	1.45	1.04	1.14	1.00
1974	0.77	1.06	0.79	0.96	0.64	0.53	0.47	0.60	0.81	1.91	1.23	0.96	0.89
1975	1.34	0.85	1.21	1.02	0.59	0.46	0.72	0.57	0.95	0.92	1.66	1.87	1.02
MEAN	1.25	1.24	1.09	0.99	0.83	0.66	0.56	0.59	0.95	1.35	1.39	1.31	

STATION: 14

MAX Hmo(m)*10 WITH ASSOCIATED Tp(sec) AND Dp(deg/10) BY MONTH AND YEAR

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MAX
1956	29 835	22 7 9	31 8 0	26 718	26 7 8	17 611	14 5 7	10 431	25 9 3	4510 4	5411 3	19 531	5411 3
1957	39 9 5	32 8 5	19 530	29 8 9	18 7 8	17 619	8 421	15 7 3	16 6 7	34 8 1	39 9 5	34 8 1	39 9 5
1958	6812 4	31 819	24 713	24 734	18 610	18 6 7	16 6 9	12 511	21 6 9	3811 3	31 9 5	37 9 6	6812 4
1959	42 9 6	26 7 4	4310 8	31 8 2	29 8 8	15 617	18 6 7	13 5 8	29 8 6	20 7 9	34 9 1	3710 5	4310 8
1960	26 736	35 820	35 835	29 8 4	2311 5	23 7 5	20 719	18 6 8	40 914	16 615	24 8 7	4510 3	4510 3
1961	34 9 7	29 816	22 718	27 7 7	22 7 8	15 6 5	8 4 9	11 5 8	23 9 4	39 9 4	24 715	24 736	39 9 4
1962	31 7 0	42 9 1	3416 5	22 710	23 7 7	10 5 8	7 326	11 413	1811 4	31 8 6	4214 4	3614 4	4214 4
1963	29 8 6	30 813	34 9 4	29 8 6	31 7 8	17 7 4	12 5 8	12 5 9	2811 5	5111 6	31 8 6	4710 6	5111 6
1964	3011 5	29 819	20 6 1	24 7 8	3111 4	10 420	19 7 8	19 7 6	2610 4	31 8 4	36 9 6	31 8 3	36 9 6
1965	32 8 0	27 814	27 8 6	16 8 4	12 5 8	16 6 7	10 6 2	11 510	5611 3	31 8 5	43 9 5	32 8 2	5611 3
1966	32 735	42 918	2410 4	22 7 9	20 7 8	39 910	18 715	19 9 5	18 9 5	4810 7	4010 4	27 8 5	4810 7
1967	22 7 6	35 9 0	30 8 6	42 9 6	16 619	14 613	9 5 8	11 5 9	20 9 3	29 8 5	4510 4	39 9 1	4510 4
1968	38 9 5	2410 4	28 7 7	1714 5	24 8 7	39 912	12 510	12 5 8	1811 5	33 810	23 7 2	29 8 4	39 912
1969	29 7 4	37 813	27 815	21 7 8	19 8 7	15 512	9 5 8	14 614	18 9 4	37 9 5	37 9 3	35 819	37 9 3
1970	32 8 1	461118	26 815	1810 5	22 714	20 710	12 513	26 710	17 6 8	37 8 6	4510 3	24 7 7	461118
1971	36 835	31 817	22 534	19 617	18 611	8 410	11 5 8	18 6 8	2510 4	19 9 4	31 8 1	5410 4	5410 4
1972	40 9 1	29 8 2	26 8 4	24 7 9	25 8 7	37 915	14 5 8	910 7	16 8 4	29 8 6	23 715	35 8 3	40 9 1
1973	25 7 0	30 7 0	31 818	26 719	18 613	16 610	9 5 8	19 6 9	15 7 5	36 8 3	34 9 4	23 635	36 8 3
1974	16 8 4	31 8 0	17 7 5	29 8 9	22 718	26 718	8 418	12 510	2310 4	5712 5	28 7 4	24 710	5712 5
1975	26 716	26 819	24 810	26 810	11 414	9 7 5	2314 5	15 512	24 818	32 8 6	40 8 8	36 8 1	40 8.8
MAX	6812 4	461118	4310 8	42 9 6	3111 4	39 912	2314 5	26 710	5611 3	5712 5	5411 3	5410 4	

MAX Hmo(m): 6.8 MAX Tp(sec): 12. MAX Dp(deg): 40. DATE(gmt): 58010312

MAX WIND SPEED(m/sec): 19. MAX WIND DIRECTION(deg): 305. DATE(gmt): 62112812

A-11. Table A-5 summarizes wave statistics for Station 14 for the entire 20-year hindcast by return period. It should be noted that the direction of these waves was generally from north-northeast to east-southeast.

TABLE A-5
WAVE STATISTICS FOR STATION 14
(WIS REPORT 30)

RETURN PERIOD (Years)	SIGNIFICANT WAVE HEIGHT	
	(Meters)	(Feet)
20	6.8	22.3
10	5.7	18.7
5	5.4	17.7
2	4.5	14.8
1	4.0	13.1

STORM SURGE

A-12. Storm surge elevation is defined as the rise of the ocean surface above its normal high tide level during a storm. The increased elevation is attributable to a variety of factors which include waves, wind shear stress, and atmospheric pressure. An estimate of these water-level changes is essential for the design of the crest elevation of a beach fill area. An increase in water depth will allow larger storm waves to attack the shore.

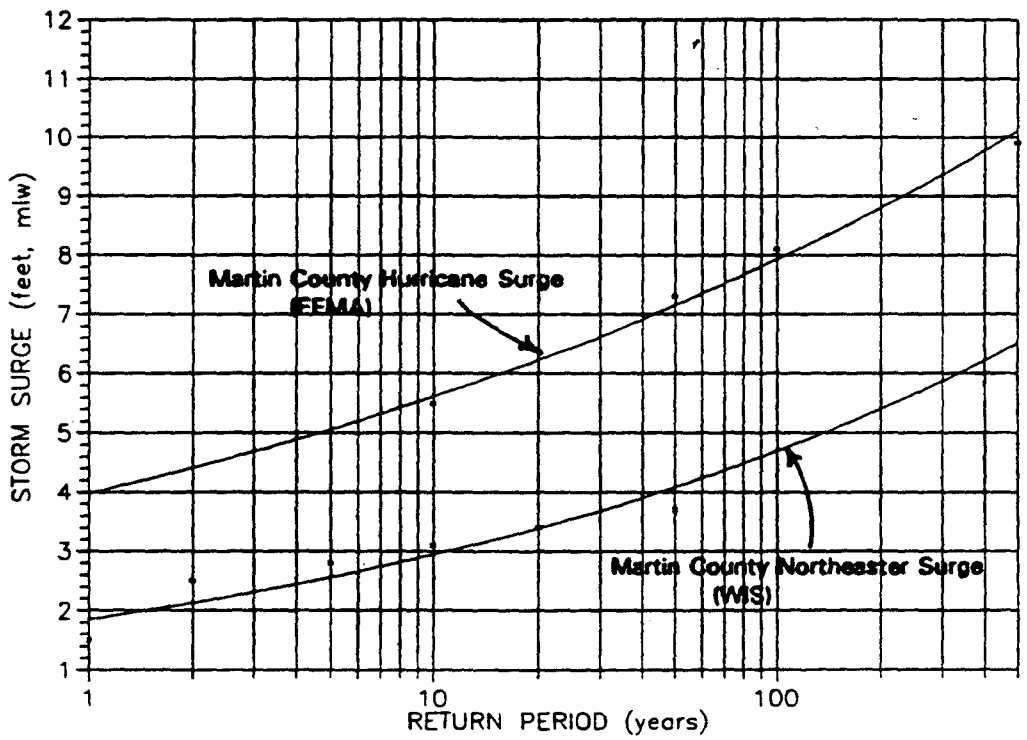
A-13. The major threats to the shoreline of Hutchinson Island are surge and waves caused by northeasters, subtropical and tropical storms, and hurricanes. It is possible to classify and predict storm surge elevations for various storms through the use of historical information and theoretical models.

A-14. The Federal Emergency Management Agency (FEMA) has developed still water flood elevation frequency relationships for hurricane storm events for Martin County (FEMA, July 1983). Methodology used in this study was developed by the National Academy of Sciences, and the results include the effects of waves. Assumptions made in the analysis include; 1) breaking wave heights are limited to 0.78 of the local still water depth, 2) the wave crest constitutes 70% of the wave height, and 3) waves are dissipated by features such as sand dunes, dikes and

seawalls, buildings, and vegetation. Regeneration of wave heights over areas of large fetch was also considered, and the maximum crest elevation at the Atlantic Ocean shoreline resulted to be 11 feet. Figure A-3 shows the elevations for hurricane surge levels at selected recurrence intervals for the Martin County Atlantic coast. The hurricane surge curve is based on data points for the 10-, 50-, 100-, and 500-year recurrence intervals.

A-15. Higher frequency of occurrence storms and storm surge elevations for other meteorological induced water-level anomalies (i.e northeaster type storms) were obtained from WIS Report 7 (Ebersole, 1982). Hindcasting of the northeaster storm surges was performed utilizing historical wind and pressure fields. The water levels given in WIS Report 7 are referenced to the still water level. The data for northeaster events for Martin County is based on interpolation between the storm surge data for Mayport and Miami Beach, Florida (See Figure A-3).

FIGURE A-3
STORM SURGE FREQUENCY CURVE
MARTIN COUNTY, FLORIDA



RECENT STORM HISTORY

A-16. Hurricanes. Hurricanes are severe tropical storms originating in the tropical and subtropical latitudes in the Atlantic Ocean north of the equator. Their formation invariably occurs over oceanic regions in areas where the existence of high water temperatures allows above normal convective activity. A hurricane is characterized by low barometric pressure, high winds over 75 miles per hour, heavy rainfall, large waves and tidal surges. The hurricane season runs from June to Late October, although tropical disturbances have affected Florida's coasts as early as March and as late as December.

A-17. A total of 50 hurricanes have passed within a radius of 150 miles of Martin County between 1830 and 1985 (Jacksonville District, USACE, 1986). Of that total, 19 hurricanes passed within a 50-mile radius. In recent years, Martin County has been relatively unaffected by hurricanes. Most of the notable storm events have been northeasters.

A-18. Northeasters. During storms in the North Atlantic, northeasterly winds blowing across the water surface for hundreds of miles produce wind setup and large waves. When combined with the accompanying storm surge, the beach and dune system are subjected to wave attack and runup at higher elevations than normal. A prolonged northeaster, combined with extraordinary high tides, can result in erosion which exceeds that of a tropical storm or hurricane. Erosion in the project area is a direct result of such storms.

A-19. Northeasters may form with little or no advance warning and persist for as long as a week to 10 days. The average duration of a northeaster, however, is only about 2 or 3 days. In the fall, winter and spring months, the Martin County shoreline is vulnerable to northeasters. Particularly severe northeasters that have affected the project area occurred in 1956, 1957, 1962, 1963, 1964, 1979, 1981, 1984 and 1990.

A-20. The northeast storm of November 20-26, 1984, locally referred to as the "Thanksgiving Day Storm", was a severe storm event that caused wide spread damage along the east coast of Florida. During the storm peak on November 23-24, wind gusts were estimated at 68-71 mph in Hutchinson Island. This storm, as related to Martin County, was estimated to be a once in fifteen year occurrence event. The storm occurred coincidentally with the highest or spring tide which occurs at or near the time of new or full moon. A tide station located at the mouth of the St. Lucie Inlet measured a total water elevation of 4.75 feet NGVD during the peak of the storm. Significant wave heights in excess of 12 feet were observed over a period of about 18 hours. Based on survey data taken in February-March 1984 and January 1985, the "Thanksgiving Day Storm" eroded 2.9 cubic yards per foot of shoreline above MSL, in the Martin County area (Balsillie, 1985).

YEARLY DEPTH LIMIT

A-21. For natural sand beaches, one depth useful in coastal engineering is the yearly limit to the very active nearshore profile. This is the depth beyond which repetitive surveys reveal little sand level change throughout the seasonal wave climate changes. Hallermeier (September 1978) has developed a procedure for estimating this profile close-out depth d_s. This depth is based on the approximate extreme wave condition for nearshore significant extreme waves, the following equation is used to calculate d_s:

$$d_s = 2.28\ H_e - 68.5\ (H_e/gT_e^2)$$

where,

H_e = nearshore extreme significant wave height
T_e = nearshore extreme significant wave period
g = acceleration of gravity constant, 32.2 ft/sec^2

A-22. Review of the hindcast wave statistics for station 14 (Revised Level II) reveals that waves between 3.0 to 3.99 meters with wave periods between 9.0 to 9.9 seconds occur 21.8 hours from the northeast direction (67.5 degrees). The limiting depth d_s was computed to be 29.3 feet in depth, using a 13-foot wave with an 9 second period.

SEA LEVEL RISE

A-23. Throughout geologic history, global sea level variations, both rise and fall, have occurred. Some authorities have found evidence to indicate that we may be entering a new ice age with a resultant sea level drop. Others argue that increasing atmospheric concentrations of carbon dioxide and other gases are causing the earth to warm, contributing to a sea level rise. Both global cooling or warming thus contribute to absolute global sea level change. Eustatic sea level change is defined as a global change of oceanic water level. Total relative sea level change is the difference between the eustatic sea level and any change in local land elevation.

A-24. The National Research Council (NRC) has recently published a book entitled Responding to Changes in Sea Level, Engineering Implications (NRC, 1987) which presents a mathematical procedure for developing the total relative sea level rise for any location with a known rate of land elevation change. Total relative sea level rise is the local component plus the eustatic component, computed by the following equation:

$$T(t) = (0.0012 + M/1000)t + bt^2$$

where,

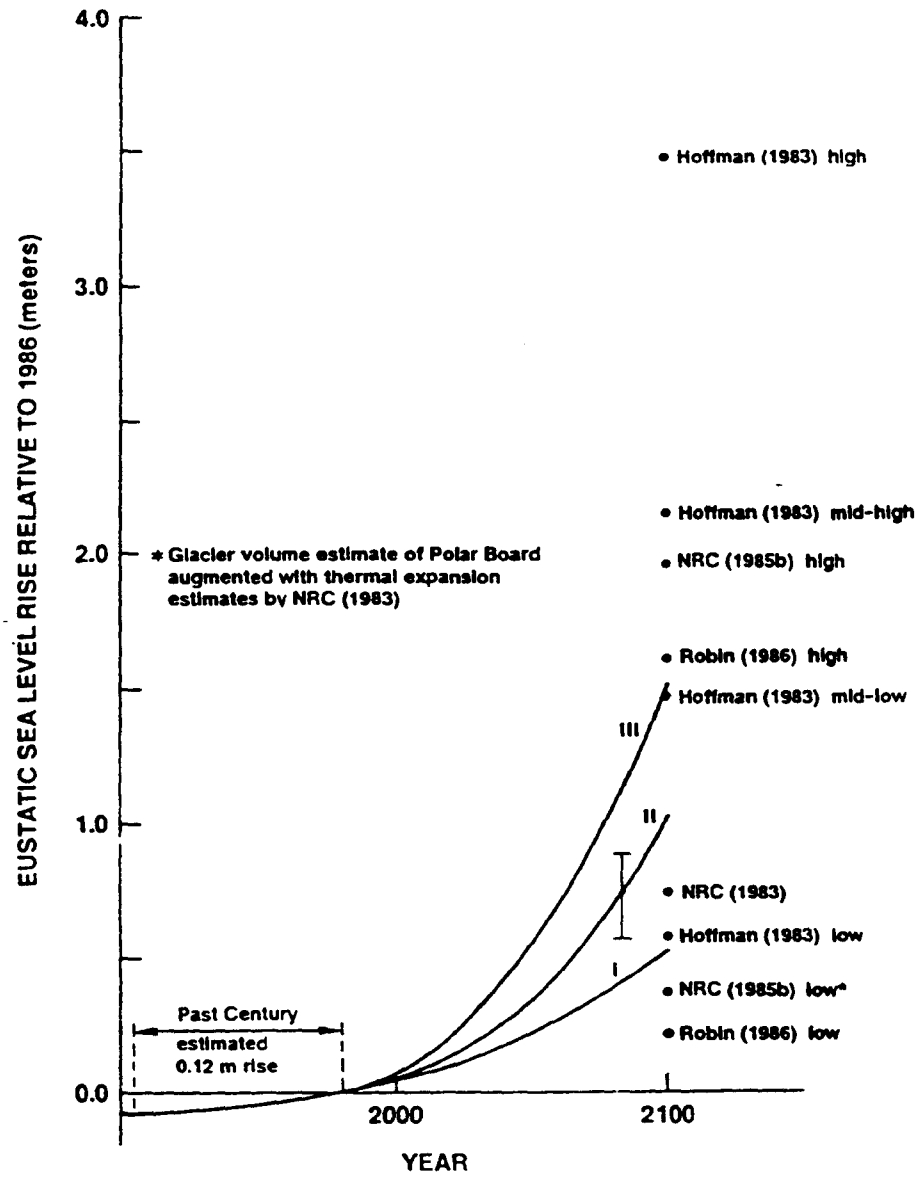
T(t)	=	total relative sea level rise in meters at time t.
0.0012	=	historic global sea level rise, expressed in meters per year, over the last century.
M	=	the rate of subsidence or uplift, in mm/yr.
t	=	any given year of interest, note t(0) = 1986.
b	=	the appropriate coefficient (in m/yr^2) for the three future sea level rise scenarios (Curve I, b = 0.000028; Curve II, b = 0.000066; and Curve III, b = 0.000105.

A-25. Figure A-4, shows three scenarios for eustatic sea level rise, reproduced from the NRC report. The three scenarios for eustatic sea level rise developed by the NRC approximate the three estimates of potential total eustatic rises of 0.5, 1.0 and 1.5 meters by the year 2100.

A-26. The rate of subsidence or uplift is unknown for the project area (M = 0). Therefore, the rate of uplift (M = $^{+}1.1$) for Miami Beach, Florida, which is the nearest area with a computed rate, will be used. The historic trend or "low" estimate, between 1940 through 1980, for the southern east coast of the U.S. is a relative rise of 0.006 feet per year. This estimate has a standard error of trend of plus or minus 0.0013 feet per year (Hicks, 1983). Using the equation above, the total relative sea level rise in feet by the year 2046 would be 0.32 feet base on the historic trend, and 1.47 feet based on Curve III or "high" estimate.

A-27. Shoreline Recession-Sea Level Rise. Per Brunn (1962) proposed a formula for computing the rate of shoreline recession from the rate of sea level rise that takes into account local topography and bathymetry. His contention is that with a rise in sea level, the beach profile attempts to reestablish the same bottom depths relative to the surfaces of the sea that existed before the sea level rise. If the along-shore littoral transport into and out of, a given shoreline is equal, then the quantity of material required to reestablish the nearshore slope must be derived from erosion of the shore. The historic estimate of relative sea level rise is 0.32 feet by the year 2046. The shoreline recession attributed to this low estimate along the shore of the project area would be 15 feet, or 0.28 feet per year. The Curve III "high" estimate of sea level rise by the year 2046 is 1.47 feet. The corresponding recession would be 68.9 feet, or 1.3 feet per year. These recessions were computed using Dr. Brunn's equation (Brunn's Rule) as follows:

FIGURE A-4
EUSTATIC SEA LEVEL RISE SCENARIOS
(NRC)



$$x = ab/(h+d)$$

where,

- x = shoreline recession (in feet) attributable to sea level rise.
- h = elevation of shoreline above mean sea level (+9.1 feet berm).
- d = MSL depth contour beyond which there is no significant sediment motion (29.3 feet, yearly depth limit).
- b = horizontal distance (1800 feet averaged) from the beach profile berm elevation to the depth contour d.
- a = specified relative sea level rise for time period t.

A-28. The Brunn procedure is applicable to long straight sandy beaches having an uninterrupted supply of sand. Little is known about the rate at which profiles respond to changes in water level. Therefore, this procedure should only be used for estimating long term changes. The procedure is not a substitute for the analysis of historical shoreline and profile changes. If little or no historical data is available, then historical analysis may be supplemented by this method to provide an estimate of long-term erosion rates attributable to sea level rise. The offshore contours in the project area are not entirely straight and parallel; however, Brunn's rule does show the potential order of magnitude in future shoreline changes within the project area attributable to the relative rise in sea level.

A-29. Shoreline Erosion-Sea Level Rise. It is assumed that an eroding shore maintains approximately the same profile above the seaward limit of significant transport while it erodes. Therefore, the erosion volume per foot of shoreline is the vertical distance from the dune base (+9.1 feet) or berm crest to the depth of the seaward limit of the active profile d_*, multiplied by the horizontal retreat of the profile, Δx. Using the "low" estimate of shoreline retreat of 15 feet for Δx, the potential erosion volume would be 0.4 cubic yard per foot of shoreline per year by the year 2046. Using the "high" estimate of shoreline retreat of 68.9 feet for Δx, the potential erosion volume would be 1.8 cubic yards per foot of shoreline per year by the year 2046.

A-30. Surge Levels-Sea Level Rise. Another result of long-term relative sea level rise is the increase in storm surge water elevations. Table A-6 displays the storm surge elevation frequency data computed by WIS and FEMA. Also displayed is the increase in surge elevations attributed to the "low" and "high" estimates of relative sea level rise by the year 2046. It is evident that the damage potential of storms will become greater as a result of the increase in relative sea level. For example, the 20-year storm surge level has an elevation of 3.4 feet. By the year 2046, using the "high" estimate of relative sea level rise, this former 20-year surge value would increase to a 3.7-foot elevation. The 3.4-foot surge elevation at the year 2046 would have a return interval of a 10-year event based on the WIS plus sea level rise curve.

TABLE A-6
SUMMARY OF SURGE ELEVATIONS
(YEAR 2046 CONDITIONS)

SOURCE	STORM SURGE ELEVATION, FEET (MLW)						
	RETURN PERIOD, YEARS						
	2*	5*	10*	20*	50	100	500
WIS, FEMA (No Rise)	2.5	2.8	3.1	3.4	7.3	8.1	9.9
WIS, FEMA (Historic**)	2.8	3.1	3.4	3.7	7.6	8.4	10.2
WIS, FEMA (High***)	4.0	4.3	4.6	4.9	8.8	9.6	11.4

* The 2-, 5-, 10-, and 20-year were taken from the WIS curve on Figure A-3. The 50-, 100- and 500-year surge elevations were taken from the FEMA curve.

** WIS, FEMA value plus 0.32 feet, based on historic rate (Year 2046).

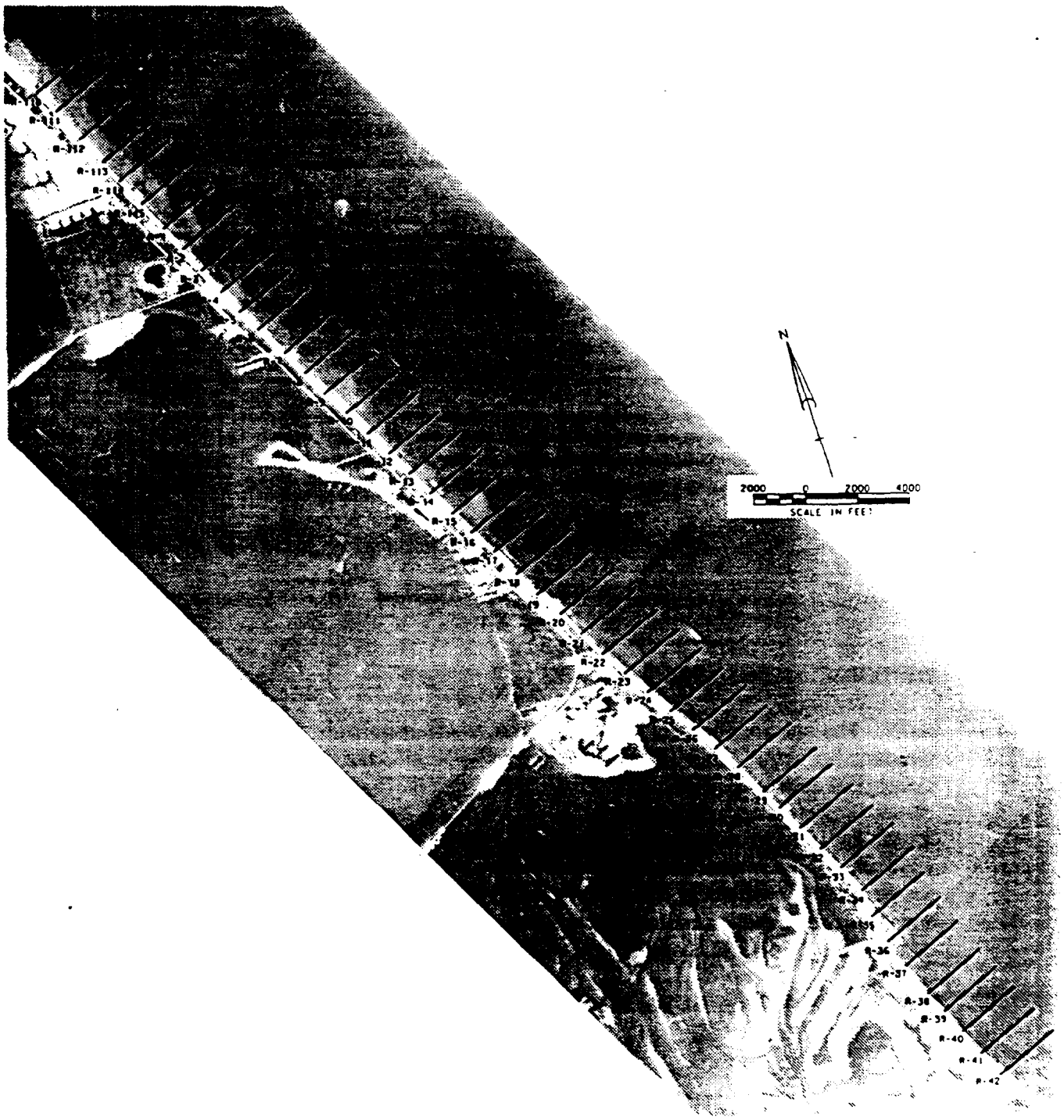
*** WIS, FEMA value plus 1.47 feet, based on NRC Curve III (Year 2046).

COASTAL PROCESSES

HISTORIC SHORELINE CHANGES

A-31. The mean high water in Martin County was mapped by the U.S. Coast and Geodetic Survey in 1882-1883, 1928-1930, 1940-1942, and 1966-1969; by the U.S. Geological Survey in 1942-1948, 1945-1949, 1967-1970 and 1980; and by the National Ocean Service in 1970-1973. The Florida Department of Environmental Protection (FDEP) surveyed the Martin County portion of Hutchinson Island in 1971, 1976 and 1982 for their coastal construction control line program; in 1984 and 1985 for post-storm conditions; and in 1984 and 1986 for shoreline conditions. FDEP surveyed the island's shoreline in St. Lucie County in 1972 and 1987 for their coastal construction control line program; and in 1983, 1984, 1987 and 1989 for shoreline conditions. Figure A-5 shows the location of FDEP's profiles on Hutchinson Island. The U.S. Army Corps of Engineers, Jacksonville District, surveyed the Hutchinson Island shoreline in 1992.

FIGURE A-5
FLORIDA DEPARTMENT OF ENVIRONMENTAL PROTECTION
PROFILES LOCATION MAP



A-32. Table A-7 shows the position of the mean high water shoreline for Hutchinson Island between 1883 and 1992. The data suggest both, shoreward and seaward movement of the shoreline for the period of record. Between 1883 and 1930, the shoreline receded over the entire length of the island (See Figure A-6). The phenomenal recession at the south end of the island was caused by the initial cut of St. Lucie Inlet through the barrier island in 1892. Between 1930 and 1948, the shoreline advanced seaward to a position which approximately coincided with the 1883 shoreline position. This recovery of the shoreline was due to the construction of a north jetty in 1929 which stabilized the north shore of St. Lucie Inlet. From 1948 through 1971, data shows the shoreline continued to advance over most of the island, especially the shoreline immediately north of the north jetty. Figure A-7 illustrates seaward and shoreward movement of the shoreline during the period 1971 to 1982. The receding problems on the south end of Hutchinson Island, between R-35 to R-38, are probably primarily due to a net flux of sand being transported offshore during the natural onshore/offshore seasonal motion of sand (Walton, 1974). For the period 1982 to 1992, the shoreline experienced substantial recession, due partly to major storms (1984 Thanksgiving Day Northeaster and 1990 Halloween Day Northeaster) which accelerated the recession of the shoreline and dunes, and lowered the beach profile.

A-33. The comparative positions of the shoreline for the study area during the period 1971 to 1992 are shown in Figure A-7. The study area (St. Lucie County R-110 to R-115 and Martin County R-1 to R-42) receded an average of 1.1 feet per year. The project area, R-1 to R-25, averaged 1.3 feet per year of recession. These rates are used as input in the analysis to determine future shoreline positions under the without project condition and calculating land loss and storm damage values.

HISTORIC VOLUMETRIC CHANGES

A-34. Volumetric changes for the study area were based on surveys which extended beyond wading depth (-6 feet MLW). Extensive surveys were performed in the Martin County portion of the study area (R-1 to R-42) by FDEP in 1971, 1982 and by Jacksonville District in 1992. However, the St. Lucie portion of study area (R-110 to R-115) was surveyed by FDEP in 1972, 1987 and by Jacksonville District in 1992. Based on the known data, St. Lucie County volume changes were estimated for the periods 1971-1982, 1982-1992 and 1971-1992 for consistency with the Martin County data. Volumetric changes in the study area are shown in Figure A-8.

A-35. Between 1971 and 1982, data suggest the shoreline accreted approximately 2,781,200 cubic yards along 42,400 feet of shoreline. Further analysis of the data revealed erosional and accretional patterns above mean low water along the entire length of the study area. Most of the accretion during this period occurred in the offshore portion of the beach profiles. The study area lost about 4,357,400 cubic yards of sand between 1982 and 1992. In the early 1980's, an extension to the St.

TABLE A-7
HISTORICAL SHORELINE POSITIONS

PROFILE LINE	DISTANCE FROM MONUMENT TO MHW, FEET SURVEY DATES 1883	1930	1948*	1971*	1982*	1992
R−110	302	208	240	148	140	161
R−111	250	119	186	135	98	111
R−112	236	153	225	151	157	159
R−113	238	148	247	193	195	183
R−114	170	77	177	133	130	109
R−115	165	90	214	162	108	117
R−1	116	31	143	87	97	72
R−2	110	29	151	94	94	89
R−3	151	73	153	101	107	89
R−4	174	111	180	112	123	92
R−5	187	80	212	123	129	95
R−6	202	68	203	130	120	86
R−7	216	55	107	106	112	69
R−8	226	60	75	88	100	83
R−9	229	59	115	128	132	86
R−10	165	28	63	86	115	89
R−11	141	41	116	122	126	93
R−12	154	29	127	108	113	79
R−13	145	23	102	108	109	64
R−14	155	46	87	103	104	47
R−15	132	61	74	97	89	75
R−16	162	66	80	103	93	68
R−17	142	50	112	125	124	103
R−18	155	78	90	112	116	126
R−19	368	275	277	318	301	275
R−20	156	105	92	135	118	90
R−21	175	115	82	125	132	90
R−22	184	136	141	128	119	102
R−23	207	114	116	158	132	95
R−24	180	95	93	135	125	105
R−25	135	86	120	117	113	111
R−26	148	84	84	150	137	120
R−27	147	144	107	149	147	149
R−28	126	92	67	62	123	117
R−29	99	38	14	60	74	---
R−30	131	72	70	108	119	107
R−31	133	71	73	108	116	105
R−32	129	78	66	101	155	140
R−33	153	77	54	105	121	93
R−34	130	94	67	124	133	115
R−35	258	169	193	280	238	141
R−36	241	96	42	347	156	141
R−37	27	−300	−168	290	118	101
R−38	19	−456	−242	144	131	103
R−39	21	−600	−278	127	183	134
R−40	−34	−727	−315	102	185	124
R−41	−191	−801	−353	119	219	152
R−42	−96	−862	−279	133	260	246

* Most of the monuments were surveyed in 1948, 1971 and 1982, except monuments R−110 to R−115, which are located immediately north of the project area, were surveyed in 1972 and 1987. Monuments R−1 to R−6 were surveyed in 1947.

285

280

FIGURE A-6
HISTORICAL SHORELINE CHANGES

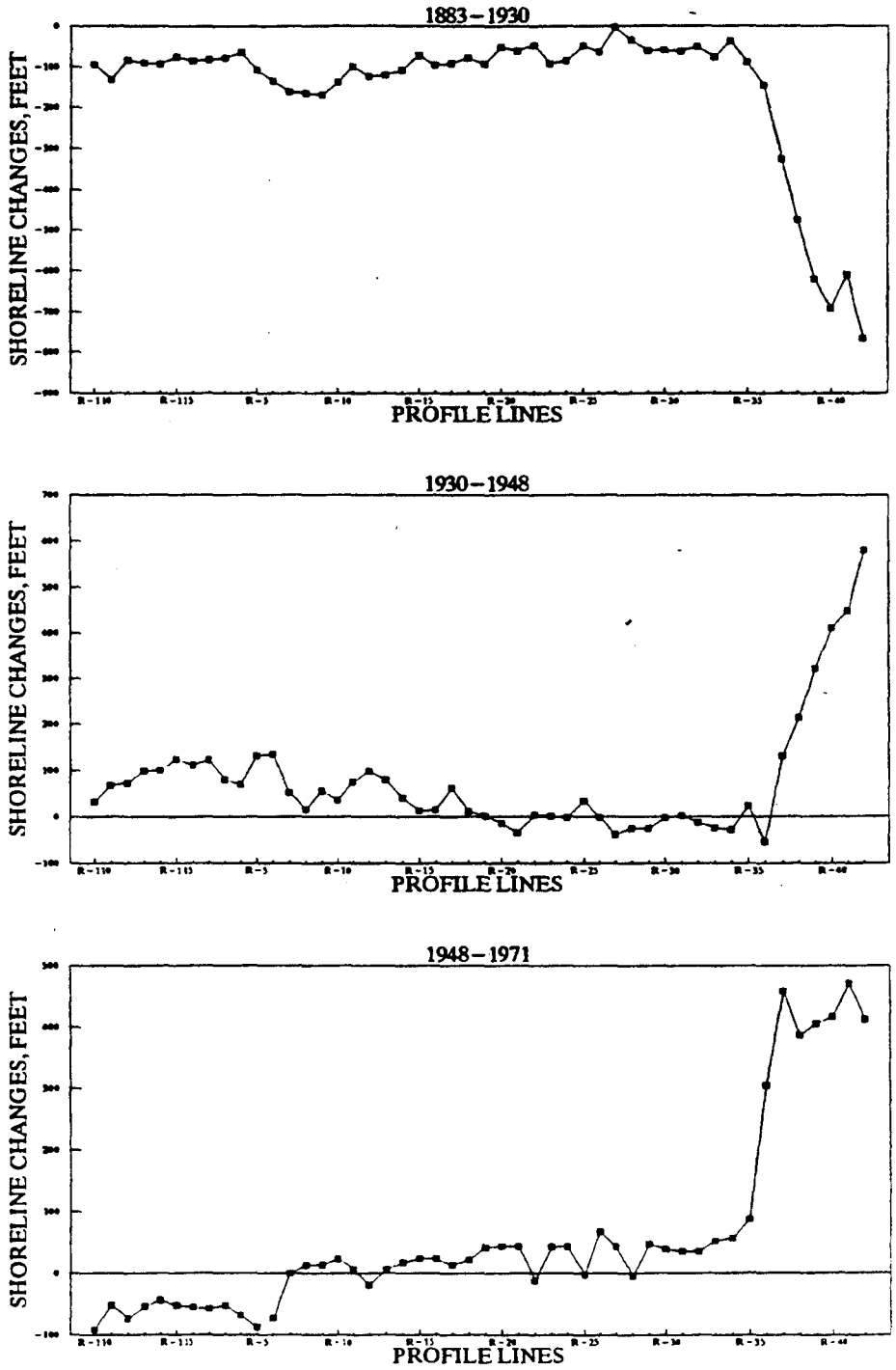
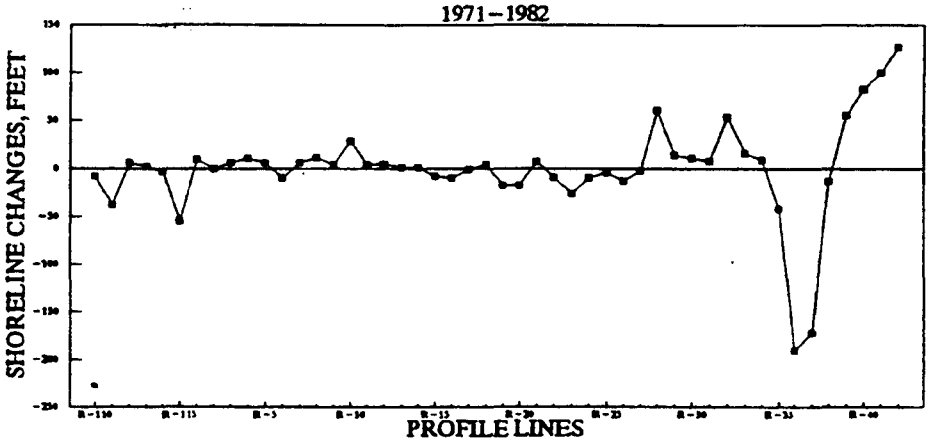
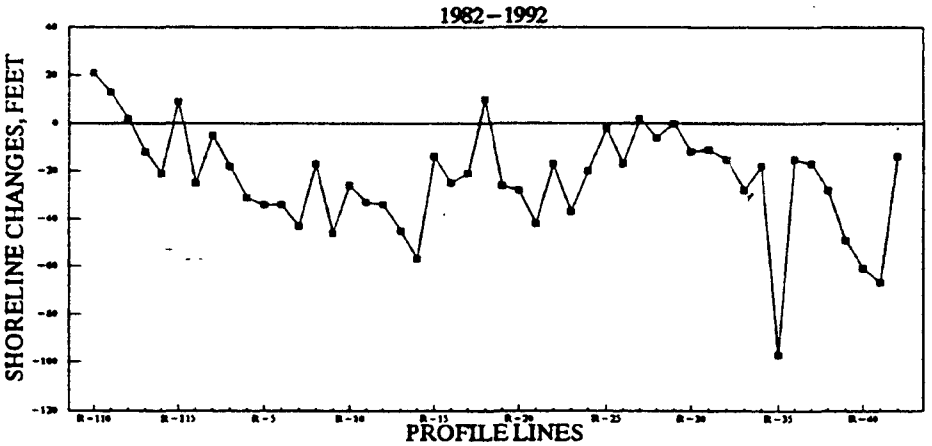


FIGURE A-7
HISTORICAL SHORELINE CHANGES





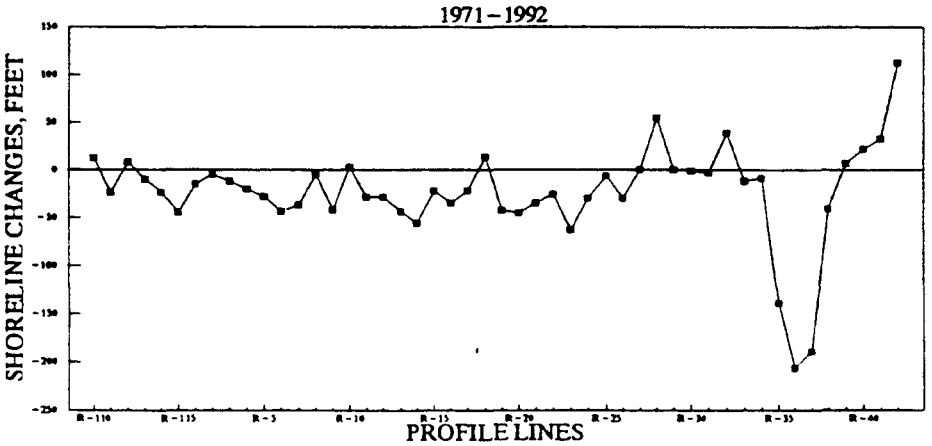
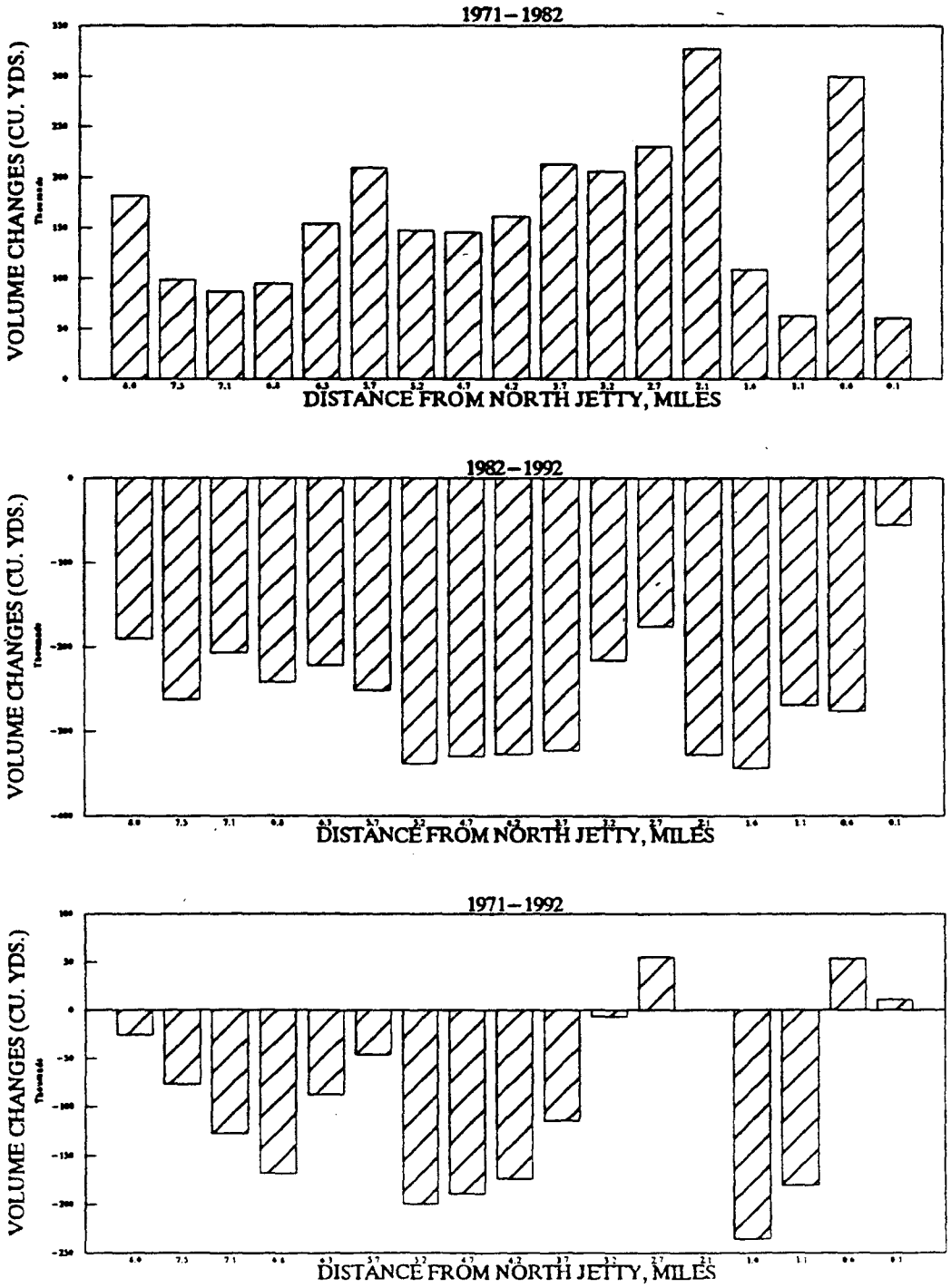


FIGURE A-8
HISTORICAL VOLUMETRIC CHANGES



Lucie Inlet's north jetty and a breakwater were constructed, however, these improvements only affected the southernmost shoreline. No other construction took place within the study area which can have altered the volumetric pattern from that of 1971 to 1982. The presence of two major storms (1984 Thanksgiving Day and 1990 Halloween Day northeasters) contributed to the erosion during this period of 1982 to 1992.

A-36. In the last 21 years, the study area has eroded an estimated 1,508,700 cubic yards, of which 1,104,000 cubic yards have eroded within the project area limits, R-1 to R-25. This results in an erosion rate of 53,600 cubic yards per year or 2.6 cubic yards per foot of shoreline per year for the project area. This erosion rate will be used to estimate future erosion losses with and without a project beach fill conditions.

INLET EFFECTS

A-37. Table A-8 presents the history of navigation improvements at St. Lucie Inlet. When the inlet was cut in 1892, the shoreline experienced a phenomenal initial recession on both sides of the inlet. By 1922, the inlet had widened to 2,600 feet. Between 1882 and 1928, the shoreline, up to 1.5 miles north of the inlet, receded considerably, with a maximum recession of about 2000 feet directly north of the inlet.

A-38. When the north jetty was constructed, the north shore of St. Lucie Inlet stabilized and, accretion on the north side of the jetty took place. However, the jetty functioned as a littoral barrier and continued causing erosion of the shore south of the inlet. Between 1946 and 1962, the mean high water shoreline directly north of the inlet had advanced 500 feet further, whereas the shoreline to the south of the inlet continued to recede up to a maximum of 720 feet.

A-39. Survey records reflect a pattern of shoreline erosion and accretion north of the inlet, and of continual erosion south of the inlet for the period 1971 to 1992. The beaches on the south portion of Hutchinson Island are not influenced by the St. Lucie Inlet's north jetty to nearly the same extent as are the beaches to the south of the inlet on Jupiter Island. The accretional influence of the jetty on the north shoreline is limited to approximately 2 miles north of the inlet. Whereas, the erosional problems experienced on the south shoreline of Jupiter Island extend a longer distance.

A-40. Maintenance dredging records from January 1965 to June 1993 indicate a total quantity of 2,482,195 cubic yards of material has been dredged from St. Lucie Inlet. The average annual quantity of sand removed from the inlet is 68,800 cubic yards.

TABLE A-8
HISTORY OF NAVIGATION IMPROVEMENTS ACCOMPLISHED AT ST. LUCIE INLET

1892 -	St. Lucie Inlet, located at the south end of Hutchinson Island, is reported to have been cut through the barrier island by local residents. Initially, the inlet was 30 feet wide and 5 feet deep.
1909 -	Federal interest in a navigation project recommended Federal funding of a 18-foot channel as well as a jetty along the north side of the channel.
1913 -	The 1913 River and Harbor Act provided initial appropriation of funds for experimental dredging of a channel 18 feet deep across the reef and ocean bar.
1916 -	Federal construction of the channel seaward from the mouth of the inlet began. The dredged portion of the project rapidly shoaled with sand and abandonment was recommended in 1917 and again in 1933, but no action was taken.
1929 -	Local interests build a 3,325-foot coquina stone jetty on the north shoreline of the inlet between 1926 and 1929. Martin and St. Lucie Improvement District dredged a turning basin at Port Sewall and a 150-foot wide by 10,000 feet long channel.
1948 -	A 10 by 200-foot channel about 750 feet across the seaward bar and reef was constructed under the authorization of the 1945 River and Harbor Act, which allowed a modification of the project.
1965 -	Emergency dredging in the St. Lucie entrance in accordance with the River and Harbor Act of 1945 was undertaken to restore a depth of at least 6 feet between the Intracoastal Waterway and the Atlantic Ocean.
1966 -	Federal legislation was passed modifying the St. Lucie Inlet project to include maintenance of a 6 by 100-foot channel along the best natural deep water alignment between the Federal bar-cut channel and the Intracoastal Waterway.
1974 -	An extension of the north jetty and modification to it for a weir section, excavation of a sand impoundment basin, construction of a south training jetty with a fishing walkway, a 10 by 500-foot channel thorough the bar-cut tapering to 150 feet through the inlet, and a 7 by 100-foot channel to the Intracoastal Waterway were authorized by Congress.
1982 -	Construction of the project was carried out with the addition of an offshore breakwater directly seaward of the south jetty.

EXISTING SHOREFRONT PROTECTIVE STRUCTURES

A-41. The shoreline in the study area has been armored with a limited number of seawalls and revetments, and the north jetty at St. Lucie Inlet. The existing seawalls and revetments lie within the project area between R-18 and R-20. The effect of the seawalls and revetments on the shore processes is minimal.

A-42. Details of the effect of the north jetty on the adjacent shorelines are explained in the previous section of this appendix, titled "Inlet Effects". The portion of the north jetty perpendicular to the shore (3,325 feet long), was built of coquina stone in 1929. Use of coquina stone, limited underlayers and weathering of the stone since the time it was constructed has made this section of the jetty extremely porous. The 650-foot angled extension of the jetty, built of granite stone in 1982, is less porous than the landward section. However, it functions as a breakwater to reduce wave transmission into the inlet and probably has a minimal effect on the accretion occurring on the south shoreline of Hutchinson Island.

A-43. The natural hardbottom features in the study area affect the shore processes as well as the manmade structures. Within the northern study area, numerous random hardbottoms exist which influence wave propagation. However, more notable effects of the hardbottoms are visible in the southernmost shoreline of Hutchinson Island. Coquina and worm rock reefs lie at the water line or the shallow water offshore. These features, known locally as Bathtub Reef, extend north from the entrance of St. Lucie Inlet to the approximate location of profile line R-35, where the reef intersects the shoreline. These reefs perform as a breakwater by dissipating wave energy and protecting the coastline from further erosion. Approximately 2.7 miles north of the inlet, extensive worm rock and coquina formations at the shoreline (in the vicinity of the present House of Refuge Museum) have prevented the barrier island from breaking through into the Indian River.

LITTORAL TRANSPORT

A-44. Littoral transport along Hutchinson Island is predominantly from north to south. Previously, the net littoral drift for the entire study area had been estimated to be approximately 230,000 cubic yards per year to the south.

A-45. Further analysis of the longshore transport within the study area has been possible with the use of the numerical model GENESIS. GENESIS results (discussed in detail later in this appendix) suggest extreme differences in localized net littoral drift patterns. For example, GENESIS runs show the annual net longshore transport rate to the south varying from 131,000 cubic yards at the northern limit of the Bathtub Reef area to less than 10,000 cubic yards in the vicinity of the rock outcrops just north of the reef area between 1971 and 1976. For the period 1976 to 1982,

again, the net longshore transport was to the south and varied from 102,000 cubic yards at the northern study boundary to less than 10,000 cubic yards in the vicinity of the rock outcrops north of Bathtub Reef.

A-46. Previous net littoral drift estimates were based on a wave climate interacting with straight and parallel contours. However, the bathymetry within the study area and its interaction with waves is far more complex. GENESIS presented reliable data of the processes that occurred during the period of 1971 to 1982.

SHORELINE RESPONSE MODELS

STORM-INDUCED BEACH CHANGE MODEL (SBEACH)

A-47. At present, no known theoretical model of beach profile change or dune erosion exists which can be applied for engineering purposes. However, there are several empirical dune erosion models. A cooperative study between investigators at the Coastal Engineering Research Center and the Department of Water Resources Engineering developed a numerical model called SBEACH (Storm-Induced Beach Change model) which simulates beach profile change under varying storm waves and water levels. Formation and movement of major morphologic features such as longshore bars, troughs, and berms produced by breaking waves are also simulated.

A-48. The SBEACH model is empirically based and was originally developed from a large data set of net cross-shore sand transport rates and beach profile changes observed in large wave tanks, then verified using high-quality field data. The model does not simulate longshore wave, current, and sediment transport processes. Basic assumptions underlying SBEACH are that (1) breaking waves and variations in water level are the major causes of sand transport and profile change, (2) the major part of cross-shore sand transport takes place in the surf zone, (3) conservation of mass exist, that is, the amount of material eroded must equal the amount deposited, (4) median grain diameter on the profile is reasonably uniform across-shore, (5) influence of structures blocking longshore transport is small, and the shoreline is straight (longshore effects are negligible), and (6) linear wave theory is applicable everywhere along the profile without shallow-water wave approximations.

A-49. SBEACH has significant capabilities that make it useful for quantitative study of beach profile response to storms. It accepts as input a pre-storm beach profile (either idealized or surveyed), time series of water level as produced by storm surge and tide, time series of wave height and period, median sediment grain size, three transport parameters and two characteristic slope parameters. The model allows for variable cross-shore grid spacing, wave refraction by specifying wave direction, randomization of input waves to better represent forcing conditions in the field, and

water level setup due to wind parameters imputed. Output data consists of a final calculated profile at the end of the simulation, simulated profiles at intermediate time steps, intermediate and maximum wave heights, intermediate and maximum total water elevations plus setup, maximum water depth, volume change and a record of various coastal processes that may occur at any time-step during the simulation (accretion, erosion, overwash, boundary-limited runup, and/or inundation).

A-50. Because of the empirical foundation of SBEACH and the natural variability that occurs along the beach during storms, the model requires calibration of the transport and slope parameters by using a pre- and post-storm profile with the wave and water level hydrographs of the storm.

A-51. Calibration. Calibration refers to the procedure of reproducing with SBEACH the change in profile shape, particularly in the dune and berm, produced by a storm of known intensity. The calibration procedure requires iteration among combinations of values of controlling parameters and ambiguous input data. The time required for calibrations is minimized if the initial values of the parameters are close to the final ones determined in the calibration.

A-52. The 1984 Thanksgiving Day northeaster storm was selected to be used for calibration of SBEACH as related to Martin County. The selection of the storm was based on the effects it had on the coast of Martin County and the availability of the data needed for input in to SBEACH. Input data for the calibration procedure was obtained from a variety of sources. Pre-storm and post-storm beach profile data was obtained from the October 1984 and January 1985 FDEP surveys. Total water elevation (storm surge and tide), wave height, wave direction, wind speed, wind direction and water temperature data was obtained from Florida Oceanographic Society in Stuart, Florida. Wave period data used was provided by the Coastal and Oceanographic Engineering Department at the University of Florida (UF). Median grain size of the beach material used was based on information presented later in this appendix.

A-53. SBEACH developers recommend beach profile data used for the calibration procedure be taken considerably before and after the storm erosion event to be modeled, 3 to 6 months before the storm and 1 to 3 months after the storm. The Thanksgiving Day storm affected the Martin County coast during November 21-26, 1984. The pre-storm survey was taken October 3,1984 and the post-storm survey was performed on January 8, 1985, well within the recommended time frame. Only limited number of profiles were surveyed to wading depth on both of these dates. One profile was chosen and subaqueous profile measurements obtained from other surveys were used to construct complete pre- and post-storm profiles.

A-54. Median grain size used, including shell content, was 0.27 mm. The water temperature, measured hourly throughout the duration of the storm, averaged 23°C. Measured wind speed and wind direction where imputed at 6-hour intervals. Wave height and direction used were recorded at Hutchinson Island, however, these parameters were not measured but observed. The water depth of the observed waves was assumed to be 25 feet. Wave period was obtained from data measured at a Marineland, Florida (offshore of St. Augustine) gage every six hours. The wave period data was shifted in accordance with the 24-hour delay of the storm when it reach Martin County. Total water elevation (storm surge and tide) was measured by a tidal gage located at on the north shore of St. Lucie Inlet. It is known that the tide at the inlet throat is lower and lags that of the ocean, however, adjustments to the water elevation were neglected since erosion of the dune was being reproduced adequately in the model runs.

A-55. After many runs (approximately 125 runs) of continuous iteration of the model parameters, a transport rate coefficient of 0.0000015 m^4/N, a slope dependent coefficient of 0.0015 m^2/s, and a transport rate decay factor of 0.40 provided the most acceptable calculated post-storm profile. The number of time steps used was 792 with value of time steps being 10 minutes. In order to control the amount of erosion on the dune, the maximum profile slope prior to avalanching was set at 30 degrees. The sum of squares of differences between measured and calculated profiles was 414.5 ft^2, one of the lowest values obtained. The calculated storm induced recession was 117 feet, 3 feet more than the measured 114 feet. Pre- and post-storm profiles along with the calculated final profile are shown in Figure A-9.

A-56. Verification. Verification refers to the procedure of applying the calibrated model to reproduce change on the same beach produced by another storm, or to reproduce changes on the same beach for the same storm as used in the calibration but at a different location on the beach. Due to the lack of pre and post-storm survey data for another storm event, a different profile was chosen to verify the model using the same storm used in calibration.

A-57. Using the same storm data as in calibration, the combinations of model parameters which gave the best calibration results were applied with a different profile. The best verification run was obtained with the same model parameters which provided the best calibration results. However, the degree of error between the profile calculated during verification and the post-storm profile was smaller than in the calibration procedure. The sum of squares of differences between measured and calculated profiles was 202.8 ft^2, the lowest value obtained. The calculated storm induced recession was 88 feet, 3 feet more than the measured 85 feet. Figure A-10 shows the pre- and post-storm profiles used and the final profile calculated during verification of the model.

FIGURE A-9
SBEACH CALIBRATION PROFILES

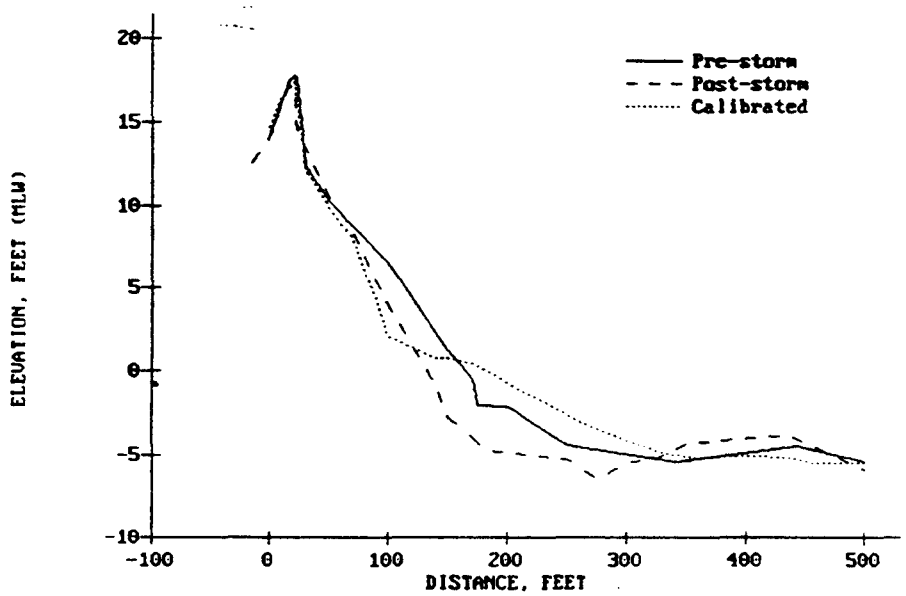
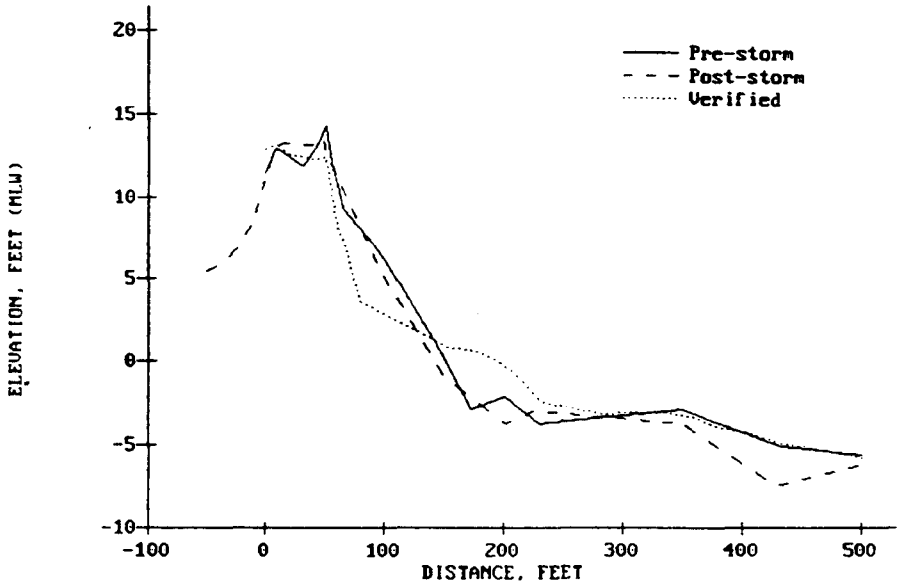


FIGURE A-10
SBEACH VERIFICATION PROFILES



A-58. Observations. In attempting to reproduce a measured post-storm profile utilizing SBEACH, many aspects were considered. Input data assumptions, storm-induced recession, conservation of mass, and difference in area between measured and calculated profiles were checked continuously throughout the calibration and verification procedures.

A-59. Several parameters related to the input data were assumed. Since the surveys were only performed to wading depth, offshore measurements from other surveys were utilized to complete the profiles used for calibration and verification. However, emphasis was given to reproducing the dune and berm features, not to offshore bars. Another parameter estimated was the water depth of the observed waves. The waves were observed at a certain distance before breaking. Calculations revealed waves were breaking at about the 18- to 20-foot depth contour depending on the height of the wave. Water depths of 35, 30 and 25 feet for the input waves were assumed and then used in SBEACH. The erosion on the dune and berm was reproduced more accurately with a water depth of 25 feet.

A-60. SBEACH overestimated, only by 3 feet, the storm-induced recession. However, it should be noted that the actual measured recession was based on a survey taken approximately a month after the storm. Recovery of the beach profile could have taken place during this period of time. SBEACH would not have simulated this amount of recovery.

A-61. Conservation of mass between the pre- and post-storm profiles was not achieved. Volume conservation could have been affected by longshore processes acting on the profiles. SBEACH conserves sand volume, and does not consider longshore transport. Therefore, no amount of calibration effort would fully reproduce beach change if volume was not conserved.

A-62. The difference in area between measured and calculated profiles was reduced considerably with new every run made. However, full reproduction of the post-storm profile was not attained. Most of the difference in area occurred in the offshore portion of the profiles. Measured offshore data immediately before and after the storm could have provided better SBEACH results.

A-63. Simulations. The SBEACH model, now calibrated and verified, was used to determined the probability of storm induced recession for existing beach conditions. Storm induced recession, as discussed herein, is defined as the horizontal distance from the pre-storm mean high water shoreline to the furthest landward extent of the storm erosion envelope. It is assumed the storm induced recession distance, defined herein as the distance d (ft), is the predicted median recession distance for a given storm surge event. It is recognized that during an actual storm event there are natural variations about the mean along a given stretch of shoreline subjected to the same

storm event. This variability occurs from several factors, such as man-made structures or certain geological features which are beyond the capabilities of the SBEACH model.

A-64. Pre-storm beach profile data for SBEACH simulations was obtained from the May 1992 Jacksonville District survey. The project area, which lies between R-1 to R-25, was divided into five reaches and one representative profile was chosen to depict each reach. After several SBEACH simulations, it was noticed that recessions of all the profiles were within $\pm$ 5 feet of each other. Based on the proximity of the recession results, one typical pre-storm profile was generated for use in all SBEACH simulations by averaging the representative profiles from each reach.

A-65. Measured wave and water level data for the project site are lacking, so hindcasts were used. WIS wave data was used in the simulations and it was obtained through the Coastal Engineering Data Retrieval System (CEDRS). Waves for the entire hindcast period where ranked based on height and return period. Storms events were extracted from the hindcast based wave height frequencies of 3 months, 6 months, 1 year, 2 years, 5 years, 10 years, and 20 years. These hindcast storms provided the remainder of the input data (height, direction, and period of waves, as well as, speed and direction of wind) necessary for SBEACH simulations with exception of the water level.

A-66. Records of measured tide data for the project site were provided by NOAA. Peak storm surge elevations used in SBEACH simulations were obtained from WIS Report 7. The storm surge data for Martin County is based on interpolation between the storm surge data for Mayport and Miami Beach, Florida. Since only peak storm surge elevations were obtained, storm surge time series were developed using a utility program provided by the Coastal Engineering Research Center (CERC). The surge curves generated by this utility program used a cosine-squared function and assumed symmetry about the peak of the surge. Time of occurrence and duration of the surge throughout the storm had to be determined based on storm characteristics and specified to the program. The generation of time histories of total water elevations were possible, with the use of another utility program from CERC, and the use of engineering judgement in phasing the tide and surge time series.

A-67. Coastal storms are generally categorized in terms of frequency of occurrence of storm surge, not frequency of occurrence of wave heights. At this time, no known source correlates wave height frequency and surge level frequency within storms. For the purposes of SBEACH, storms with surge level frequencies of 1, 2, 5, 10, 20, 50 and 100 years were simulated using different wave height scenarios. For example, three SBEACH simulations were performed for a storm with a surge level frequency of 5 years. All three simulations, however, had different wave conditions associated with same surge level. One simulation had extremely high wave conditions (5-year frequency waves), another simulation had high waves (2-year frequency waves) and a

third had moderate wave conditions (1-year frequency waves). Table A-9 shows the different scenarios of storm surge and waves conditions used for the SBEACH simulations.

TABLE A-9
SURGE AND WAVE SCENARIOS OF STORMS FOR SBEACH SIMULATIONS

STORM SURGE FREQUENCY (YEARS)	EXTREMELY HIGH WAVES FREQUENCY (YEARS)	HIGH WAVES FREQUENCY (YEARS)	MODERATE WAVES FREQUENCY (YEARS)
1	1	6 MONTHS	3 MONTHS
2	2	1	6 MONTHS
5	5	2	1
10	10	5	2
20	20	10	5
50	*	20	10
100	*	*	20

* The wave hindcast is limited to 20 years. Recessions for these storm conditions were extrapolated from the curves.

A-68. Using the approach mention above, cumulative frequency curves of storm induced recession were developed using SBEACH. With 18 storms simulated at various surge levels and wave conditions, the relationship between probability and shoreline recession was determined. The resulting cumulative frequency curves of storm-induced recession for existing conditions is shown in Figure A-11. Data for the three output curves is tabulated in Table A-10.

A-69. Modeling Summary. As mentioned above, the model's calculated storm-induced recessions for calibration and verification were within an acceptable range of error, $\pm$ 3%. Based on the proximity of these results to the measured data, overall model performance for simulating the storm induced recession for existing beach conditions was reasonable. Also, by simulating storm events of particular surge levels with diverse wave conditions, an envelope of shoreline recession probabilities was developed. Measured recession due to storm events is expected to be within this envelope of probability.

FIGURE A-11
CUMULATIVE FREQUENCY CURVES OF STORM INDUCED RECESSION
FOR HUTCHINSON ISLAND

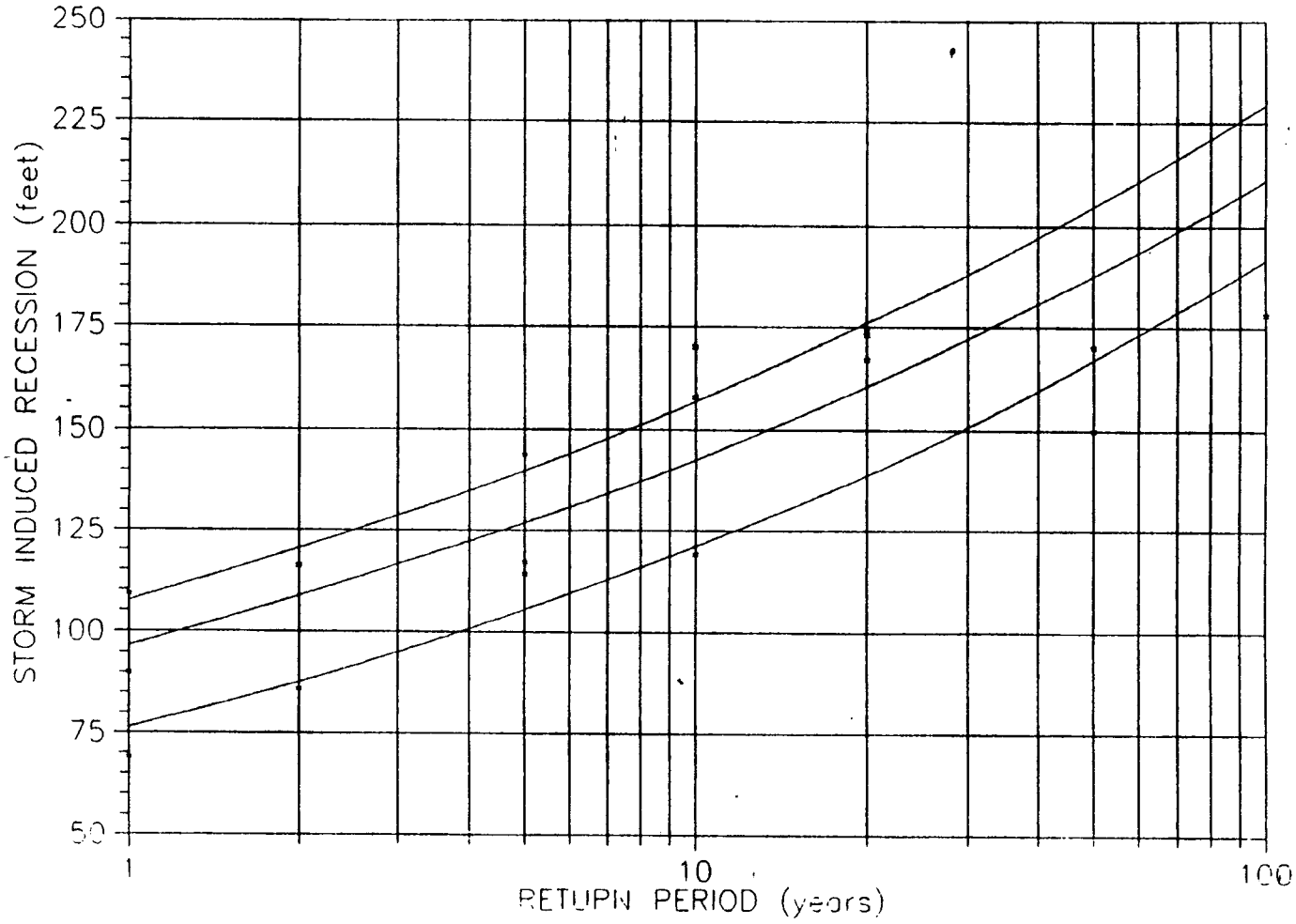


TABLE A-10
HUTCHINSON ISLAND STORM INDUCED RECESSION

RETURN PERIOD OF STORM (YEARS)	RECESSION, d (FEET)		
	EXTREMELY HIGH WAVES	HIGH WAVES	MODERATE WAVES
1	109	90	69
2	120	108	86
5	140	127	105
10	158	143	122
20	176	159	138
50	206*	188	166
100	230*	212*	192

* These values were extrapolated from the curves.

SHORELINE CHANGE MODEL (GENESIS)

A-70. A version of the GENESIS (Generalized Model for Simulating Shoreline Change) has been prepared by CERC for use with personal computers and was selected to model shoreline changes and transport quantities with and without a project beach fill in Martin County. The GENESIS model provides a long-term numerical method of determining shoreline change on an open coast as produced by spatial and temporal differences in longshore sand transport. This model is similar in theory to previous shoreline change models, but offers better calibration procedures to improve accuracy in computation of sediment movement. These procedures allow the model to be calibrated to site-specific conditions which are determined by shoreline surveys, sediment analysis, wave climate, offshore bathymetry, presence of coastal armoring, beach fills, and offshore breakwaters. Locations of the shoreline, coastal structures, and beach fills are referenced to a baseline that defines the orientation of the modeling grid which is divided into cells with each cell constituting a control volume. Longshore transport rates are calculated at the cell boundaries utilizing methodology described in the Shore Protection Manual (CERC, 1984). Site specific wave data (period, wave height, and direction) are used in the longshore transport equation at each time step to simulate the potential for movement of material through the cell boundaries. Two coefficients (K_1 and K_2) in the longshore transport equation can be adjusted to calibrate the model based on historical shoreline changes.

A-71. In addition, due to the complex bathemetry offshore of the study area, it was decided that some form of wave propagation model should be used to convert deep water wave conditions to that to be utilized as input to the GENESIS model. The numerical model RCPWAVE (Regional Coastal Processes Wave Propagation Model) is a short wave model used to predict linear, plane wave propagation over an open coast region of arbitrary bathemetry. RCPWAVE uses linear wave theory because it has been shown to yield fairly accurate first-order solutions to wave propagation problems at a relatively low cost. Refractive and bottom-induced diffractive effects are included in the model; however, the model cannot treat diffraction caused by surface-piercing structures. The model does not include nonlinear wave effects or a spectral representation of irregular waves.

A-72. Waves. Wave data used in the simulations originated from the Wave Information Study (WIS). The wave data was accessed through the Coastal Engineering Data Retrieval System (CEDRS). This hindcast data has been generated through atmospheric pressure and wind speed readings over the years 1956 to 1975 excluding tropical weather systems. The original time step of the WIS data was increased from 3 to 6 hours to decrease program run time. The wave data was then transformed from the deep water hindcast station to the offshore boundary of the RCPWAVE model grid with a specified shoreline orientation and water depth. All events which had a direction which would not contribute to alongshore transport within the study area were filtered from the 20 years of record. Finally, the wave events were grouped into 9 separate angle bands and 8 separate period bands to further simplify the RCPWAVE model for ultimate input into the GENESIS program. The results of this analysis are presented in Table A-11 .

A-73. An effort was made to determine which years of record produced sediment movement that was close to the 20 year average gross and net movement. This required that each years wave data be evaluated by use of the program SEDTRAN which estimates the regional potential longshore gross and net transport for that year. The results of this analysis are presented in Table A-12. The four years 1957, 1964, 1965, and 1969 best represented average conditions of sediment transport and therefore those years of wave data are utilized for shoreline modeling outside of the twenty years of WIS wave data record.

A-74. Shoreline Modeling Grids. Shoreline modeling required a two dimensional grid for RCPWAVE and a one dimensional grid for GENESIS. The two dimensional RCPWAVE bathymetric grid was prepared for the Jacksonville District by CERC. The grid was generated with a W 24° N rotation angle to approximate the study area shoreline orientation. Cell spacing was 500 feet alongshore and 250 feet onshore/offshore. This resulted in a grid consisting of 97 cells alongshore (48,500 feet) and 241 cells offshore (60,250 feet). Cell 92 is equivalent to the north jetty at St. Lucie Inlet. The input bathymetric data consisted of 48 profile lines (St. Lucie County R-110 to R-115 and Martin County R-1 to R-42) surveyed to approximately

TABLE A-11
SUMMARY OF WAVE EVENTS BY ANGLE AND PERIOD BAND

WAVE TYPE	ANGLE BAND	NUM OF EVENTS	AVG ANGLE	WAVE TYPE	PERIOD BAND	NUM OF EVENTS	AVG PERIOD
SEA		254	79.71	SEA		5207	3.93
SWELL	1	84	79.69	SWELL	1	3687	3.91
TOTAL		338	79.71	TOTAL		8894	3.92
SEA		2509	63.65	SEA		12585	5.5
SWELL	2	1345	64.34	SWELL	2	2882	5.35
TOTAL		3854	63.89	TOTAL		15467	5.47
SEA		4046	40.27	SEA		11475	7.48
SWELL	3	1135	41.55	SWELL	3	1233	7.46
TOTAL		5181	40.55	TOTAL		12708	7.48
SEA		14167	20.54	SEA		6076	9.38
SWELL	4	1914	21.02	SWELL	4	734	9.43
TOTAL		16081	20.60	TOTAL		6810	9.39
SEA		8209	−0.23	SEA		3192	11.37
SWELL	5	850	−0.47	SWELL	5	505	11.34
TOTAL		9059	−0.25	TOTAL		3697	11.37
SEA		5894	−20.36	SEA		1173	13.34
SWELL	6	1429	−24.15	SWELL	6	198	13.38
TOTAL		7323	−21.10	TOTAL		1371	13.35
SEA		2705	−46.11	SEA		227	15.23
SWELL	7	1536	−46.51	SWELL	7	57	15.28
TOTAL		4241	−46.25	TOTAL		284	15.24
SEA		2100	−67.86	SEA		26	17.19
SWELL	8	1006	−64.63	SWELL	8	9	17
TOTAL		3106	−66.81	TOTAL		35	17.14
SEA		77	−81.68	SEA		0	0
SWELL	9	6	−81.6	SWELL	9	0	0
TOTAL		83	−81.67	TOTAL		0	0.00

-30 feet MLW in 1992 and NOAA surveys collected in 1930 (nearshore) and 1967 (offshore). The rotated generated grid was contoured to check for any irregularities when the three data sources were merged. The contours seemed reasonable, and no large gaps or rapid depth changes were found. The offshore limit of the grid extended to the -200 foot depth contour however this seaward boundary was reduced by 18 offshore cells to simplify the RCPWAVE modeling. A three dimensional plot of the bathymetric grid is presented in Figure A-12.

A-75. The one dimensional GENESIS grid was configured to match the orientation of the RCPWAVE grid. The GENESIS grid cells were 250 feet alongshore and 250 feet offshore requiring that the output wave parameter information from each RCPWAVE cell would be applied to two corresponding GENESIS cells. The southern boundary of the GENESIS grid corresponds to the north jetty at St. Lucie Inlet and the northern boundary was set just north of DNR monument R-110 in St. Lucie County. The resulting modeled distance was about 43,500 feet or 174 cells.

TABLE A-12
REGIONAL TRANSPORT RATES FOR YEARS 1956-1975

ANGLE BAND #:		1		2		3		4		5		6		7		8		9		SED. TRANSPORT 1,000 CU. M/YR	
WAVE TYPE	YEAR	# OF EVENTS	AVE H	# OF EVENTS	AVE H	# OF EVENTS	AVE H	# OF EVENTS	AVE H	# OF EVENTS	AVE H	# OF EVENTS	AVE H	# OF EVENTS	AVE H	# OF EVENTS	AVE H	# OF EVENTS	AVE H	NET	GROSS
SEA		11.00	0.85	162.00	0.98	216.00	1.33	611.00	1.33	440.00	0.99	342.00	0.65	144.00	0.81	85.00	0.67	3.00	0.80	1200	1500
SWE	1956	13.00	0.86	91.00	0.75	67.00	0.60	73.00	0.58	52.00	0.60	73.00	0.57	48.00	0.62	19.00	0.53	0.00	0.00	23	59
COM		24.00	0.86	253.00	0.90	283.00	1.16	684.00	1.25	492.00	0.95	415.00	0.64	192.00	0.76	104.00	0.64	3.00	0.80	1300	1600
SEA		7.00	0.76	70.00	1.19	144.00	1.35	701.00	1.06	481.00	1.26	278.00	0.95	128.00	0.85	87.00	0.78	1.00	0.70	530	1000
SWE	1957			48.00	0.62	52.00	0.62	89.00	0.55	38.00	0.82	57.00	0.51	86.00	0.57	60.00	0.59			3	46
COM		7.00	0.76	118.00	0.96	196.00	1.16	790.00	1.00	519.00	1.23	335.00	0.88	214.00	0.74	147.00	0.70	1.00	0.70	530	1100
SEA		50.00	0.89	181.00	1.02	183.00	0.99	551.00	1.13	424.00	1.20	388.00	0.87	146.00	0.95	101.00	0.94	3.00	0.83	770	1300
SWE	1958	15.00	0.85	123.00	0.64	63.00	0.56	62.00	0.56	48.00	0.65	62.00	0.59	65.00	0.52	37.00	0.55			20	56
COM		65.00	0.88	304.00	0.87	246.00	0.88	613.00	1.07	472.00	1.14	450.00	0.83	211.00	0.82	138.00	0.84	3.00	0.83	790	1400
SEA		9.00	0.89	119.00	1.29	238.00	1.24	646.00	1.14	515.00	1.16	324.00	0.80	152.00	0.84	74.00	0.74	2.00	0.70	770	1200
SWE	1959	4.00	0.75	508.00	0.63															-11	68
COM		13.00	0.85	627.00	0.76	238.00	1.24	646.00	1.14	515.00	1.16	324.00	0.80	152.00	0.84	74.00	0.74	2.00	0.70	760	1300
SEA		14.00	0.71	194.00	1.01	343.00	1.09	604.00	1.09	352.00	1.14	285.00	0.69	72.00	0.81	128.00	0.95	7.00	0.80	720	1100
SWE	1960	2.00	0.75	42.00	0.67	98.00	0.64	84.00	0.54	28.00	0.68	52.00	0.58	55.00	0.61	34.00	0.65			12	50
COM		16.00	0.72	236.00	0.95	441.00	0.99	688.00	1.02	380.00	1.11	337.00	0.67	127.00	0.72	162.00	0.89	7.00	0.80	730	1100
SEA		21.00	0.74	162.00	0.84	192.00	1.04	622.00	1.08	363.00	1.05	326.00	0.82	170.00	0.89	129.00	0.78	5.00	0.76	390	910
SWE	1961			70.00	0.65	54.00	0.68	98.00	0.58	31.00	0.66	67.00	0.50	51.00	0.54	32.00	0.53			23	50
COM		21.00	0.74	232.00	0.78	246.00	0.96	720.00	1.01	394.00	1.02	393.00	0.77	221.00	0.81	161.00	0.73	5.00	0.76	420	960
SEA		20.00	0.91	125.00	1.25	225.00	1.30	895.00	1.10	343.00	0.93	194.00	0.65	71.00	0.80	85.00	0.70	5.00	0.74	1100	1300
SWE	1962	17.00	0.98	124.00	0.91	68.00	0.60	65.00	0.65	32.00	0.61	28.00	0.50	53.00	0.55	69.00	0.60			45	77
COM		37.00	0.94	249.00	1.00	293.00	1.14	960.00	1.07	375.00	0.90	222.00	0.63	124.00	0.58	154.00	0.66	5.00	0.74	1200	1400
SEA		13.00	0.74	138.00	0.95	268.00	1.19	773.00	1.20	338.00	1.43	228.00	0.81	81.00	0.74	89.00	0.84	3.00	0.77	910	1200
SWE	1963	6.00	0.63	94.00	0.70	57.00	0.68	123.00	0.64	46.00	0.66	58.00	0.55	50.00	0.60	31.00	0.60	3.00	0.87	33	72
COM		19.00	0.71	232.00	0.85	325.00	1.10	896.00	1.12	384.00	1.34	286.00	0.76	131.00	0.69	120.00	0.70	6.00	0.82	950	1300
SEA		10.00	0.85	121.00	0.96	227.00	1.23	747.00	1.07	383.00	1.24	249.00	0.88	136.00	0.91	164.00	0.81	8.00	0.73	640	1000
SWE	1964	3.00	0.83	80.00	0.65	52.00	0.63	125.00	0.54	17.00	0.66	66.00	0.64	65.00	0.66	78.00	0.63	1.00	1.10	7	67
COM		13.00	0.85	201.00	0.84	279.00	1.12	872.00	0.99	400.00	1.22	315.00	0.83	201.00	0.83	242.00	0.73	9.00	0.77	650	1100
SEA		7.00	0.84	109.00	0.94	259.00	1.08	684.00	1.05	478.00	1.18	294.00	0.74	112.00	0.85	117.00	0.98	1.00	0.80	610	1100
SWE	1965	2.00	0.75	58.00	0.63	39.00	0.55	121.00	0.63	64.00	0.77	77.00	0.58	74.00	0.54	67.00	0.56			7	50
COM		9.00	0.82	167.00	0.83	298.00	1.01	805.00	0.99	542.00	1.13	371.00	0.71	186.00	0.73	184.00	0.83	1.00	0.80	620	1200
SEA		6.00	0.77	159.00	1.05	173.00	1.23	712.00	1.17	439.00	1.20	302.00	1.00	175.00	0.98	108.00	1.00			620	1300
SWE	1966	3.00	0.67	100.00	0.70	62.00	0.70	124.00	0.57	48.00	0.81	79.00	0.56	113.00	0.60	46.00	0.55			16	77
COM		9.00	0.74	259.00	0.91	235.00	1.09	836.00	1.06	487.00	1.16	381.00	0.91	288.00	0.83	154.00	0.87	0.00	0.00	630	1400
SEA		3.00	0.80	70.00	1.16	249.00	1.29	936.00	1.07	348.00	1.30	299.00	0.64	137.00	0.82	59.00	0.79	4.00	0.75	960	1200
SWE	1967			49.00	0.55	51.00	0.78	77.00	0.75	27.00	0.72	85.00	0.59	96.00	0.54	31.00	0.60			25	70
COM		3.00	0.80	119.00	0.91	300.00	1.20	1033.00	1.05	375.00	1.26	384.00	0.63	233.00	0.70	90.00	0.72	4.00	0.75	980	1300

TABLE A-12 (Cont'd)
REGIONAL TRANSPORT RATES FOR YEARS 1956-1975

ANGLE BAND #1		1		2		3		4		5		6		7		8		9		SED. TRANSPORT 1,000 CU. M/YR	
WAVE TYPE	YEAR	# OF EVENTS	AVE H	# OF EVENTS	AVE H	# OF EVENTS	AVE H	# OF EVENTS	AVE H	# OF EVENTS	AVE H	# OF EVENTS	AVE H	# OF EVENTS	AVE H	# OF EVENTS	AVE H	# OF EVENTS	AVE H	NET	GROSS
SEA		14.00	0.79	124.00	1.03	139.00	1.07	803.00	0.98	395.00	1.16	242.00	0.71	67.00	1.17	37.00	1.26	3.00	0.80	410	850
SWE	1968	5.00	0.74	61.00	0.74	58.00	0.64	121.00	0.65	35.00	0.65	63.00	0.53	34.00	0.69	21.00	0.51			25	57
COM		19.00	0.78	185.00	0.93	197.00	0.94	924.00	0.94	430.00	1.12	305.00	0.67	101.00	1.01	58.00	0.99	3.00	0.80	430	900
SEA		16.00	0.85	98.00	1.16	122.00	1.47	769.00	1.18	648.00	1.22	341.00	0.86	123.00	0.93	97.00	0.89	4.00	0.77	460	1300
SWE	1969	4.00	0.75	116.00	0.71	94.00	0.71	120.00	0.64	55.00	0.76	45.00	0.72	77.00	0.66	58.00	0.63			62	94
COM		20.00	0.83	214.00	0.92	216.00	1.14	889.00	1.11	703.00	1.18	386.00	0.84	200.00	0.83	155.00	0.79	4.00	0.77	690	1300
SEA		17.00	0.74	136.00	1.26	215.00	1.25	542.00	1.15	494.00	1.11	371.00	0.87	155.00	0.88	112.00	1.00	2.00	0.80	630	1200
SWE	1970	5.00	0.70	61.00	0.61	46.00	0.57	86.00	0.60	77.00	0.64	78.00	0.64	84.00	0.58	75.00	0.59	1.00	0.70	−8	56
COM		22.00	0.73	197.00	1.06	261.00	1.13	628.00	1.07	571.00	1.05	449.00	0.83	239.00	0.77	187.00	0.84	3.00	0.77	620	1300
SEA		12.00	0.83	159.00	1.04	214.00	1.18	549.00	1.02	354.00	1.17	213.00	0.85	128.00	0.73	135.00	0.77	3.00	0.73	620	920
SWE	1971	1.00	0.70	37.00	0.67	44.00	0.57	82.00	0.58	29.00	0.71	65.00	0.62	85.00	0.62	43.00	0.63			−6	55
COM		13.00	0.82	196.00	0.97	258.00	1.08	631.00	0.96	363.00	1.13	278.00	0.80	213.00	0.69	178.00	0.74	3.00	0.73	620	980
SEA		9.00	0.72	85.00	1.02	159.00	1.20	776.00	1.10	424.00	1.19	246.00	1.02	120.00	0.90	106.00	0.86	3.00	0.77	520	1100
SWE	1972			17.00	0.51	36.00	0.51	81.00	0.52	21.00	0.69	87.00	0.53	99.00	0.55	53.00	0.53			−11	32
COM		9.00	0.72	102.00	0.94	195.00	1.07	857.00	1.05	445.00	1.17	333.00	0.89	219.00	0.74	159.00	0.75	3.00	0.77	510	1100
SEA		10.00	0.74	148.00	1.18	182.00	1.30	551.00	1.10	380.00	0.99	360.00	0.82	168.00	0.92	161.00	0.89	8.00	0.83	490	1000
SWE	1973	2.00	0.95	35.00	0.73	48.00	0.56	84.00	0.60	40.00	0.70	120.00	0.64	100.00	0.68	45.00	0.65			−20	74
COM		12.00	0.78	183.00	1.09	230.00	1.15	635.00	1.03	420.00	0.96	480.00	0.78	268.00	0.83	206.00	0.84	8.00	0.83	470	1100
SEA		3.00	0.63	101.00	0.84	112.00	1.17	772.00	1.03	259.00	1.21	324.00	0.77	165.00	0.81	91.00	0.77	5.00	0.88	740	1100
SWE	1974			27.00	0.47	42.00	0.58	84.00	0.67	37.00	0.74	110.00	0.52	56.00	0.51	37.00	0.48			10	39
COM		3.00	0.63	128.00	0.76	154.00	1.01	856.00	0.99	296.00	1.15	434.00	0.71	221.00	0.72	128.00	0.69	5.00	0.88	750	1100
SEA		2.00	0.65	48.00	1.11	186.00	1.05	903.00	0.93	371.00	1.14	288.00	1.01	255.00	0.96	135.00	0.94	7.00	0.84	260	1100
SWE	1975	2.00	0.75	45.00	0.77	55.00	0.66	121.00	0.55	75.00	0.80	77.00	0.90	152.00	0.64	115.00	0.61	1.00	0.70	−27	110
COM		4.00	0.70	93.00	0.95	241.00	0.96	1024.00	0.89	446.00	1.08	365.00	0.99	387.00	0.85	250.00	0.79	8.00	0.82	230	1200

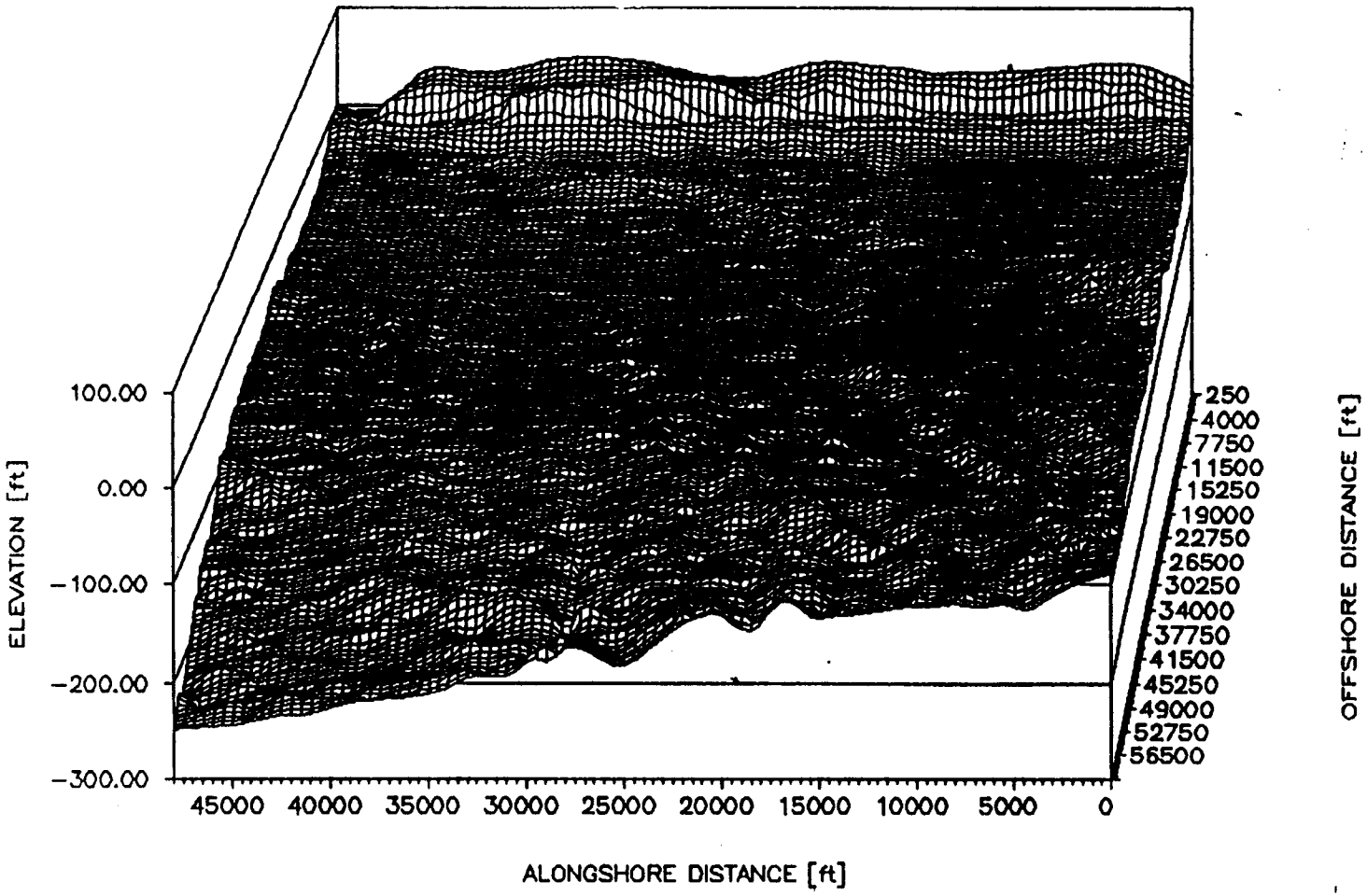
WAVE TYPE: SEA = SEA WAVE EVENTS; SWE = SWELL WAVE EVENTS; COM = COMBINED WAVE EVENTS;

COM	AVERAG	16.90	0.78	214.75	0.91	236.60	1.08	799.35	1.04	458.45	1.12	362.15	0.78	206.40	0.78	152.55	0.78	4.15	0.74	694.00	1207.00
COM	SIGMA:	13.67	0.07	110.84	0.09	59.16	0.09	132.67	0.08	89.02	0.10	63.73	0.10	62.88	0.09	48.31	0.08	2.41	0.18	253.19	171.03

AVG.+SIGMA:	30.57	0.86	324.79	1.01	315.76	1.17	932.02	1.12	539.47	1.23	425.88	0.88	269.28	0.86	200.86	0.86	6.56	0.92	947.19	1378.03
AVG.−SIGMA:	3.23	0.71	104.71	0.82	197.44	0.98	666.68	0.96	361.43	1.02	298.42	0.68	143.52	0.69	104.24	0.70	1.74	0.57	440.81	1035.97

YEAR:	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	
POINTS:	13	18	14	14	15	16	8	15	18	18	14	13	10	19	16	17	17	14	13	10	

FIGURE A-12
HUTCHINSON ISLAND'S OFFSHORE BATHEMETRY



A-76. Historical Shoreline Data. The majority of the study area and the entire project area lies within the northern portion of Martin County. The most extensive surveys for the project area were obtained by the Florida Department of Environmental Protection (FDEP) on 12 October 1971, 28 January 1976, 16 February 1982, and by the Jacksonville District on 21 May 1992. However, the portion of the study area north of Martin County in St. Lucie County was surveyed by FDEP in 1966, 1 June 1972, 11 February 1987 and by Jacksonville District on 21 May 1992. An effort was made to convert the known St. Lucie County shorelines to those dates consistent with the Martin County surveys by interpolating between known survey years. The result was four shorelines for the entire study area for the years 1971, 1976, 1982, and 1992. These four shorelines were rotated and translated from their initial state plane coordinates to a common baseline for input to GENESIS modeling. Following interpolation of these shorelines to 50-foot intervals, the data was filtered to obtain shoreline positions for each 250-foot GENESIS cell for each year to be imputed.

A-77. Manmade and Natural Coastal Armor. Manmade structures within the study area consist of a limited portion of seawalls and revetments and the north jetty at St. Lucie Inlet. The seawalls and revetments play a minimal role in the shore processes within the area. The north jetty serves as a boundary/barrier to material being transported south from the Bathtub Reef area and to material which may move to the north from the deposition spit inside the inlet to the beaches north of the jetty. The landward portion of the jetty is extremely porous due to the use of native limestone with limited underlayers and subsequent subsistence and weathering since its construction in the 1920's. The seaward angled 650 feet of the north jetty was constructed of granite with underlayer in the 1980's, and although not designed to be sand tight, it should be considered to be significantly less porous than the landward section. However, the seaward portion lies on and parallel to the southern portion of hardbottom known as Bathtub Reef. This structure performs as a breakwater similar to the reef itself but with significantly less wave transmission due to its elevation above water level.

A-78. Of greater significance to the study area are the natural hardbottom features themselves. Within the northern project area numerous random hardbottoms exist which would influence wave propagation. However, the output depth for RCPWAVE modeling is 30 feet. The GENESIS model then brings the waves to breaking using straight and parallel contours. Therefore, these features are not modeled in this case. North of Bathtub Reef extensive stretches of shoreline have significant outcroppings which alters both the immediate nearshore transport and the source of localized sediment supply. These areas have been modeled as a seawall at the shoreline. Bathtub Reef itself acts to diminish the wave action at the shoreline due to the relative water depth over the reef and the width of the reef. Bathtub Reef has been simulated by incorporating nine separate detached breakwaters with varying but relatively high wave transmissions coefficients.

A-79. Calibration. Calibration of the GENESIS model was conducted for the period 12 October 1971 through 28 January 1976. Longshore sand transport calibration coefficients, K_1 and K_2, were set at 0.10 and 0.10, respectively. Median grain size diameter, D_{50}, was 0.27 mm, active berm height 11 feet MLW, and average depth of closure -29 feet MLW. The calculated volume change over the period was an accretion of about 10,000 cubic yards per year over the entire reach modeled with an accretion of about 83,000 cubic yards per year within the project fill area. The annual net longshore transport rate was to the south and varied from about 131,000 cubic yards at the northern limit of the Bathtub Reef area to less than 10,000 cubic yards in the vicinity of the rock outcrops just north of the reef area. Shoreline changes were modeled within an average of about 25 feet over the entire study area when compared with the actual 1976 shoreline survey. Predicted and measured shoreline changes are shown in Figure A-13 and average annual net longshore transport rates are shown in Figure A-14.

A-80. Verification. The model was verified by using identical values for input variables from the calibration run and predicting the measured shoreline change from 1976 to 1982. Since the estimated WIS wave data was provided only to year 1975, a wave data file was assumed which consisted of the four years with the gross and net longshore transport most closely approximating the 20 year average. Volumetric accretion for this period was estimated to be about 85,000 cubic yards per year for the modeled reach with an accretion of about 69,000 cubic yards per year within the project area. Again, the annual net longshore transport rate was to the south and varied from about 102,000 cubic yards at the northern study boundary to less than 10,000 cubic yards in the vicinity of the rock outcrops north of Bathtub Reef. Shoreline change predicted was closer than in the calibration run with an average variance from the measured 1982 shoreline of about 21 feet. Predicted and measured shoreline changes also are shown in Figure A-15 and the average annual net longshore transport rate shown in Figure A-16.

A-81. Observations. During the period 1971 to 1982, the Martin County study area was generally accretive volumetrically with localized segments experiencing shoreline accretion and erosion. WIS wave data used to calibrate and verify a GENESIS model was directly related up to 1975 with average years wave data used from 1976 to 1982. The calibration and verification model runs were adjusted to provide the closest fit between predicted and known shoreline positions. To accomplish this fit, other considerations such a longshore transport and volume entering St. Lucie Inlet were allowed to be established contrary to previous studies and estimates. For example, previous Jacksonville District studies had estimated the net littoral drift for the entire study area to be in the magnitude of 230,000 cubic yards per year to the south. Also, dredging history at the inlet since the channel improvements of the early 1980's indicates a shoaling rate of 60,000 cubic yards of material from the north. The results of the calibration and verification runs, although within the approximate order of magnitude for the previous estimates, indicate a much more complex

FIGURE A-13
SHORELINE CHANGES
GENESIS CALIBRATION RUN

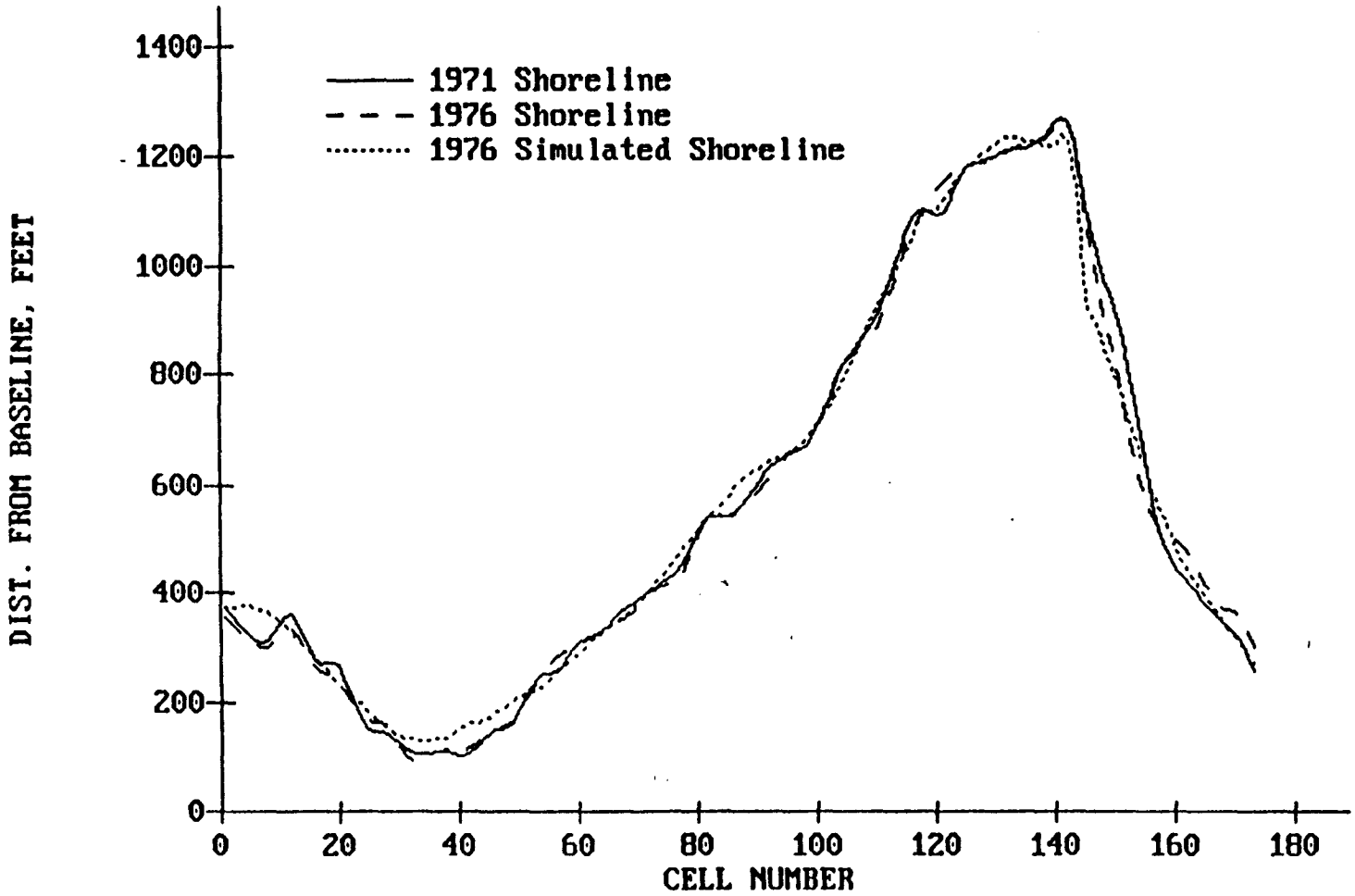


FIGURE A-14
AVERAGE ANNUAL NET LONGSHORE TRANSPORT RATES
GENESIS CALIBRATION RUN

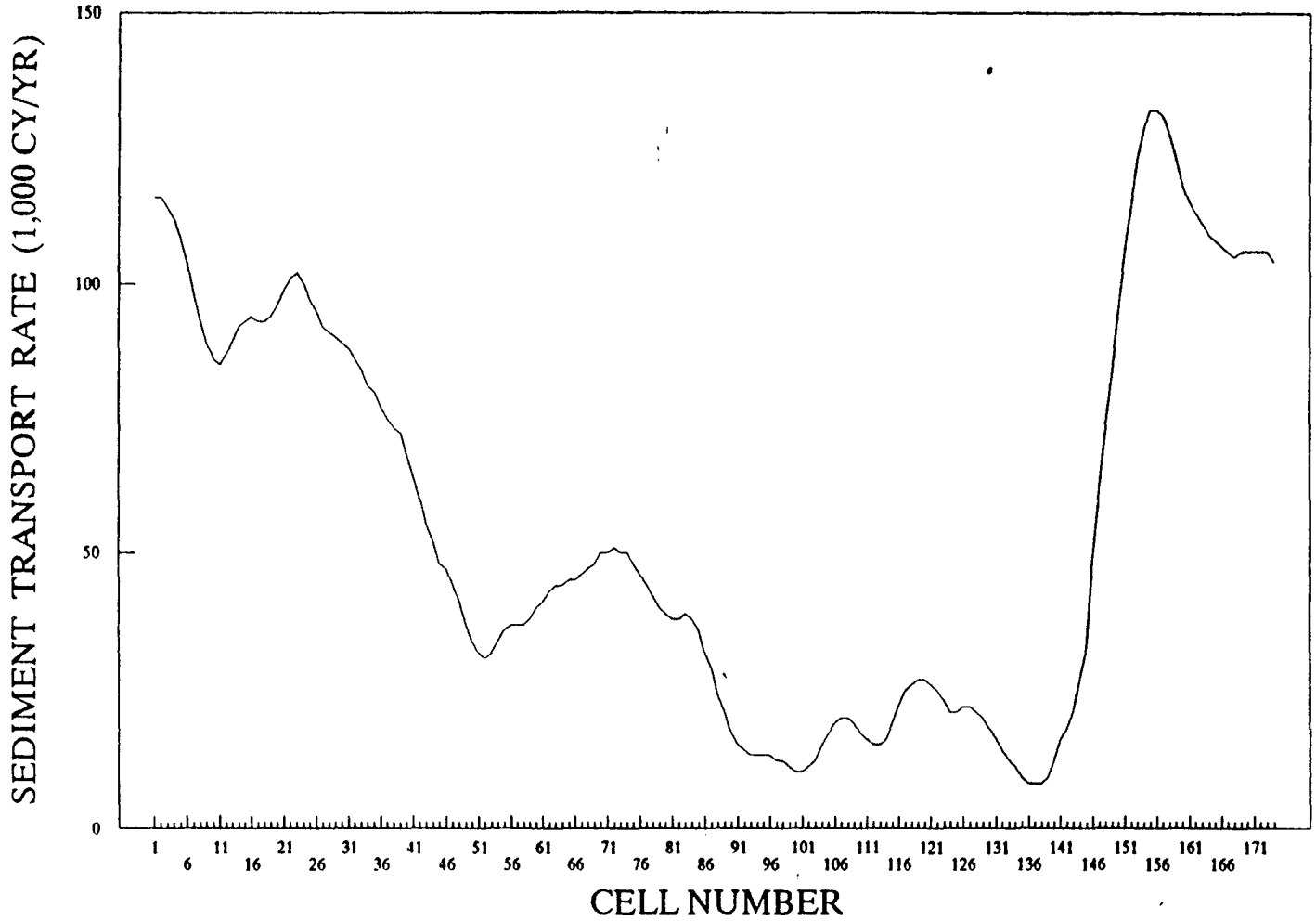


FIGURE A-15
SHORELINE CHANGES
GENESIS VERIFICATION RUN

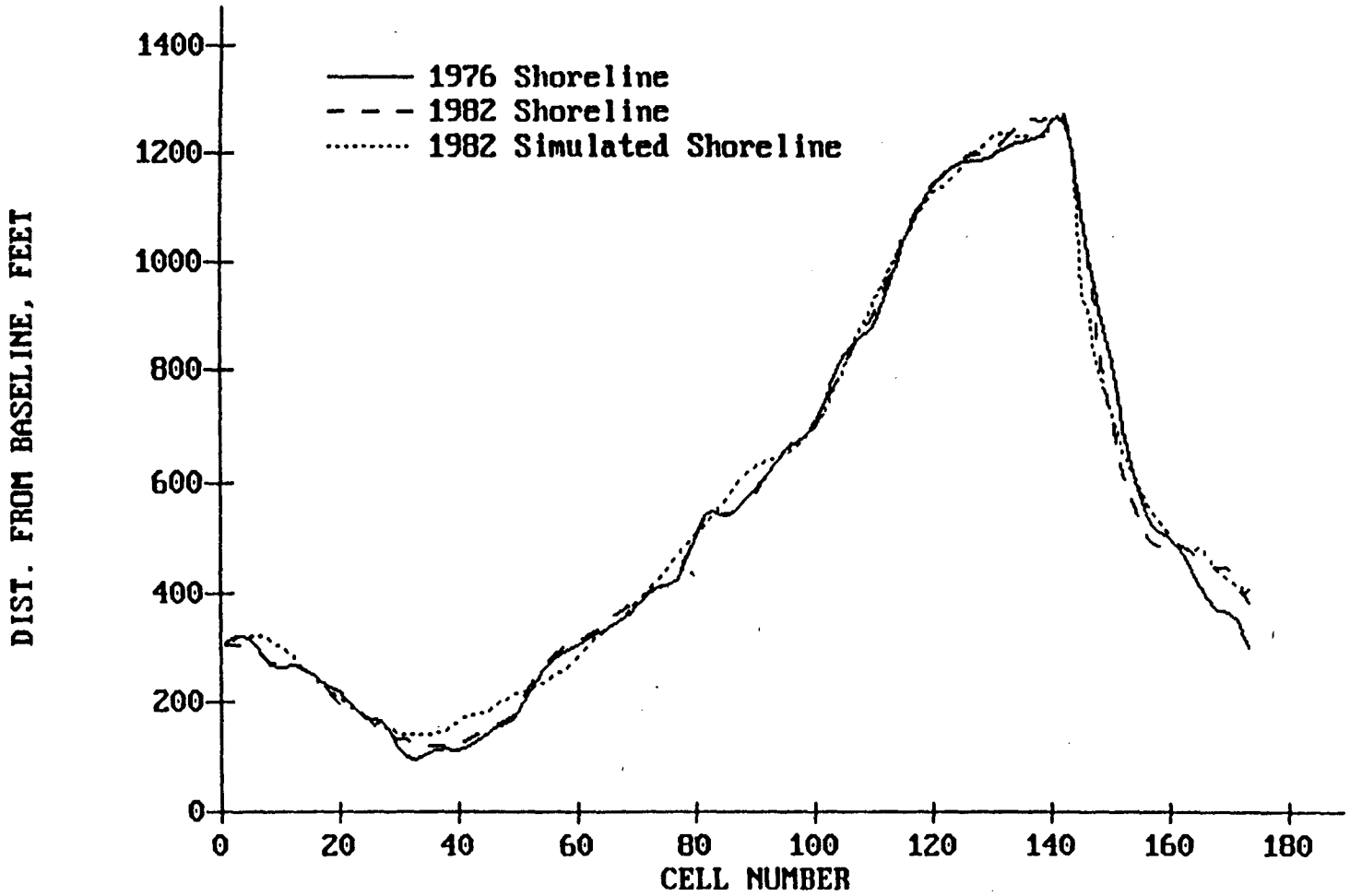
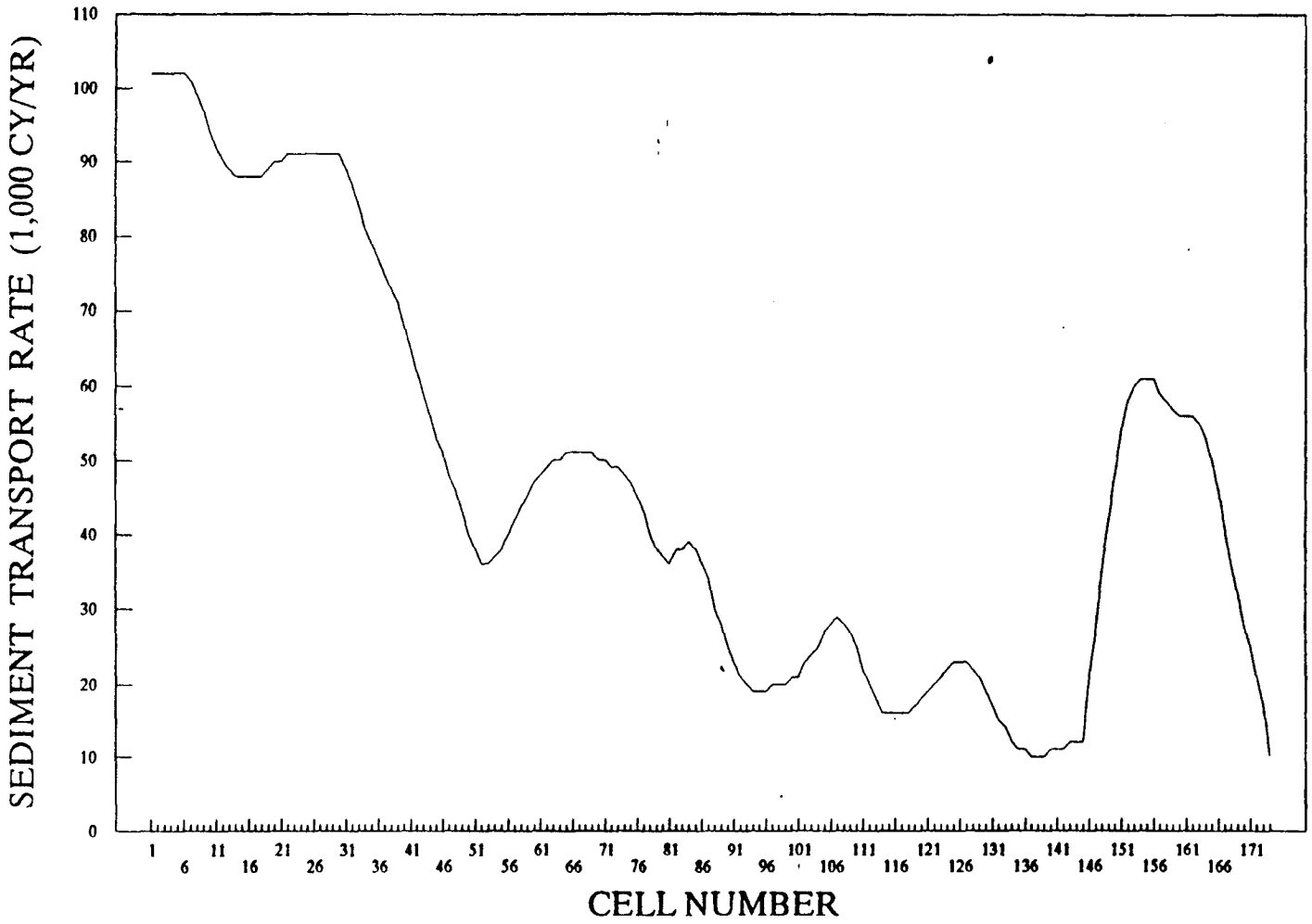


FIGURE A-16
AVERAGE ANNUAL NET LONGSHORE TRANSPORT RATES
GENESIS VERIFICATION RUN



interaction between wave forces (height, period, and direction), localized bathemetry (rock outcrops, nearshore hardbottoms, and reefs), and longshore transport. For example, simply adjusting the entire deepwater wave climate by plus or minus 15 degrees of incident angle resulted in extreme differences in the localized net littoral drift patterns. If anything, the use of the GENESIS model for this shoreline has indicated the failure of previous investigations to accurately portray the longshore processes. To simply estimate the net littoral drift (230,000 cubic yards to the south) based on a wave climate interacting with straight and parallel contours as a single value for the entire coastline is a gross simplification of the situation. The calibration and verification GENESIS runs are considered to portray an accurate representation of the processes which were occurring within the time period 1971 to 1982.

A-82. During the period 1982 to 1992, the entire study reach became erosional volumetrically with practically uniform shoreline retreat. Although the improvements to St. Lucie Inlet were accomplished during the early 1980's, it appears that the inlet's region of influence to the north is terminated by the northern limit of Bathtub Reef and the rock outcrops to the north which act as a breakwater and groin field, respectively. No other beach fills or updrift structures were constructed during this period which would so drastically alter the littoral regime in direct contrast to the 1971 to 1982 period. Another potential cause of this shift from accretion to erosion would be the localized wave climate (changes in direction, frequency, and height). However, with no corresponding long term offshore wave data (WIS or otherwise), changes in wave climate cannot be modeled during this study effort. Work is currently underway at CERC to update the WIS data to more recent time periods however, this data is not complete at the present time. Additionally, two major storms occurred within this ten year period (the 1984 Thanksgiving Day and 1990 Halloween Day northeaster storms) which contributed to the erosion during the period. Again, the effects of these storm systems cannot be modeled by this GENESIS study effort.

A-83. Simulation. The GENESIS model, adjusted for the period 1971 to 1982, was then used to predict the performance of the project fill from initial construction up to the first renourishment operation. A 1995 shoreline was estimated by applying the erosion rates from 1982 to 1992 to the known 1992 shoreline. A beach fill with a mean high water extension of 125 feet was added to the base 1995 shoreline and the GENESIS model was allowed to simulate the resulting shoreline after 11 years of average WIS wave input. The final GENESIS shoreline for year 2006 was adjusted to account for erosional losses during the 11 years simulated. This adjusted final GENESIS shoreline was compared to the estimated 2006 shoreline without a project fill to evaluate the relative impact of the shore protection project. The results of this investigation are presented in Table A-13 and Figure A-17.

TABLE A-13
GENESIS SHORELINE CHANGES WITH OR WITHOUT BEACH FILL

MONUMENT	CELL NO.	DISTANCE FROM NORTH	SHORELINE CHANGE, FEET 1992–1995	1995–2006 W/O FILL	1995–2006 WITH FILL	1992–2006 W/O FILL	1992–2006 WITH FILL
R-110	1	250	1.64	7.15	7.15	8.79	8.79
	2	500	0.09	0.39	0.58	0.47	0.67
	3	750	−1.47	−6.38	−3.88	−7.85	−5.35
R-111	4	1000	−3.04	−13.20	−7.80	−16.24	−10.84
	5	1250	−1.68	−7.32	0.89	−9.00	−0.80
	6	1500	−0.33	−1.43	8.97	−1.76	8.64
R-112	7	1750	1.01	4.40	16.20	5.41	17.21
	8	2000	0.56	2.42	15.82	2.98	16.38
	9	2250	0.10	0.44	18.24	0.54	18.34
	10	2500	−0.35	−1.54	21.66	−1.89	21.31
	11	2750	−0.81	−3.52	21.48	−4.33	20.67
R-113	12	3000	−1.26	−5.50	20.20	−6.77	18.93
	13	3250	−1.71	−7.43	20.37	−9.13	18.67
	14	3500	−2.15	−9.35	20.55	−11.50	18.40
	15	3750	−2.59	−11.27	22.33	−13.87	19.73
R-114	16	4000	−3.04	−13.20	26.40	−16.24	23.36
	17	4250	−3.71	−16.12	31.48	−19.82	27.78
	18	4500	−4.36	−18.98	33.32	−23.34	28.96
	19	4750	−5.03	−21.89	27.81	−26.92	22.78
R-115	20	5000	−5.69	−24.75	24.05	−30.44	18.36
	21	5250	−3.96	−17.21	36.38	−21.17	32.43
	22	5500	−2.21	−9.63	47.98	−11.84	45.76
	23	5750	−0.48	−2.09	58.11	−2.57	57.63
R-1	24	6000	−1.84	−8.02	57.58	−9.86	55.74
	25	6250	−1.44	−6.25	64.15	−7.69	62.71
	26	6500	−1.02	−4.44	67.96	−5.46	66.94
R-2	27	6750	−0.61	−2.67	71.53	−3.29	70.91
	28	7000	−0.84	−3.63	71.97	−4.47	71.13
	29	7250	−1.04	−4.54	70.96	−5.59	69.91
	30	7500	−1.27	−5.51	70.69	−6.77	69.43
R-3	31	7750	−1.48	−6.41	73.19	−7.89	71.71
	32	8000	−1.72	−7.48	76.02	−9.20	74.30
	33	8250	−1.97	−8.55	77.35	−10.52	75.38
	34	8500	−2.21	−9.62	78.18	−11.83	75.97
R-4	35	8750	−2.46	−10.69	80.21	−13.15	77.75
	36	9000	−2.79	−12.13	81.67	−14.92	78.88
	37	9250	−3.11	−13.52	82.88	−16.63	79.77
R-5	38	9500	−3.44	−14.97	82.33	−18.41	78.89
	39	9750	−4.09	−17.80	80.50	−21.89	76.41
	40	10000	−4.76	−20.69	79.51	−25.44	74.76
R-6	41	10250	−5.41	−23.52	78.98	−28.93	73.57
	42	10500	−5.19	−22.56	82.14	−27.74	76.96
	43	10750	−4.98	−21.65	84.65	−26.63	79.67
	44	11000	−4.77	−20.74	89.26	−25.51	84.49
R-7	45	11250	−4.55	−19.78	90.62	−24.33	86.07
	46	11500	−3.57	−15.50	92.90	−19.07	89.33
	47	11750	−2.58	−11.22	101.08	−13.81	98.49
	48	12000	−1.60	−6.95	110.05	−8.55	108.45
R-8	49	12250	−0.61	−2.67	114.53	−3.29	113.91
	50	12500	−1.76	−7.64	108.06	−9.40	106.30
	51	12750	−2.89	−12.56	103.44	−15.45	100.55
	52	13000	−4.03	−17.53	98.97	−21.56	94.94
R-9	53	13250	−5.16	−22.45	93.25	−27.61	88.09
	54	13500	−3.32	−14.43	101.37	−17.75	98.05
	55	13750	−1.48	−6.41	114.19	−7.89	112.71
R-10	56	14000	0.37	1.60	127.20	1.97	127.57
	57	14250	−0.61	−2.67	124.13	−3.29	123.51
	58	14500	−1.60	−6.95	119.35	−8.55	117.75
	59	14750	−2.58	−11.22	116.58	−13.81	113.99

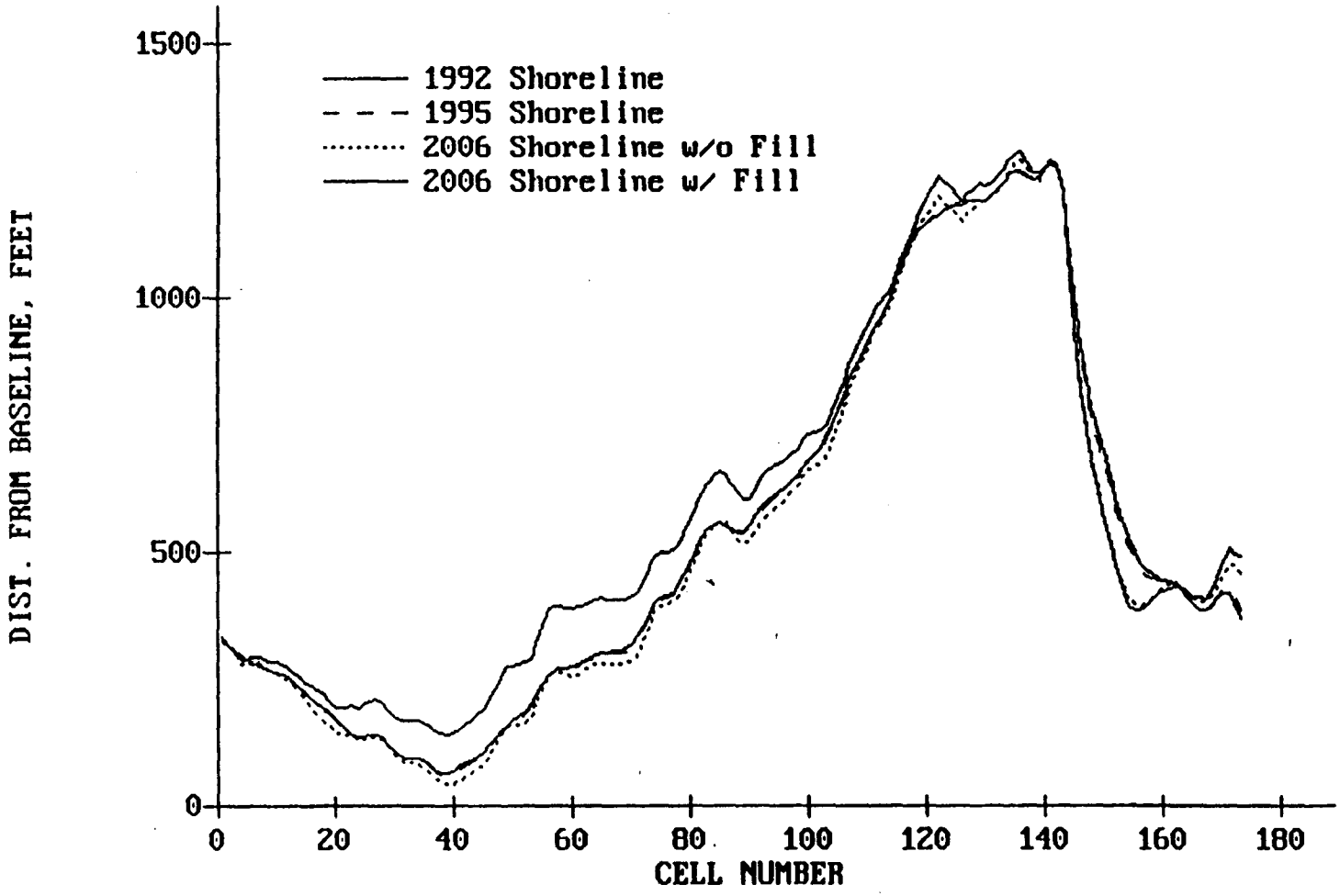
TABLE A-13 (Cont'd)
GENESIS SHORELINE CHANGES WITH OR WITHOUT BEACH FILL

MONUMENT	CELL NO.	DISTANCE FROM NORTH	SHORELINE CHANGE, FEET 1992–1995	1995–2006 W/O FILL	1995–2006 WITH FILL	1992–2006 W/O FILL	1992–2006 WITH FILL
R–11	60	15000	–3.57	–15.50	115.80	–19.07	112.23
	61	15250	–3.57	–15.50	113.40	–19.07	109.83
	62	15500	–3.57	–15.50	108.90	–19.07	105.33
	63	15750	–3.57	–15.50	108.10	–19.07	104.53
R–12	64	16000	–3.57	–15.50	109.40	–19.07	105.83
	65	16250	–3.93	–17.10	108.80	–21.04	104.86
	66	16500	–4.30	–18.71	106.09	–23.01	101.79
	67	16750	–4.67	–20.31	104.39	–24.98	99.72
	68	17000	–5.04	–21.91	102.79	–26.95	97.75
R–13	69	17250	–5.41	–23.52	100.58	–28.93	95.17
	70	17500	–6.15	–26.72	96.58	–32.87	90.43
R–14	71	17750	–6.88	–29.93	91.67	–36.82	84.78
	72	18000	–5.50	–23.89	94.11	–29.39	88.61
	73	18250	–4.09	–17.80	95.10	–21.89	91.01
R–15	74	18500	–2.70	–11.76	98.04	–14.46	95.34
	75	18750	–3.11	–13.52	94.18	–16.63	91.07
	76	19000	–3.50	–15.23	90.77	–18.74	87.26
	77	19250	–3.91	–17.00	87.50	–20.91	83.59
R–16	78	19500	–4.30	–18.71	84.49	–23.01	80.19
	79	19750	–3.91	–17.00	85.80	–20.91	81.89
	80	20000	–3.50	–15.23	87.07	–18.74	83.56
	81	20250	–3.11	–13.52	87.38	–16.63	84.27
R–17	82	20500	–2.70	–11.76	87.14	–14.46	84.44
	83	20750	–1.60	–6.95	92.35	–8.55	90.75
	84	21000	–0.49	–2.14	98.36	–2.63	97.87
	85	21250	0.61	2.67	100.87	3.29	101.49
R–18	86	21500	1.72	7.48	103.58	9.20	105.30
	87	21750	–0.61	–2.67	92.23	–3.29	91.61
	88	22000	–2.95	–12.83	80.77	–15.78	77.82
R–19	89	22250	–5.29	–22.98	65.32	–28.27	60.03
	90	22500	–5.37	–23.36	56.54	–28.73	51.17
	91	22750	–5.46	–23.73	58.67	–29.19	53.21
R–20	92	23000	–5.53	–24.05	65.85	–29.58	60.32
	93	23250	–5.29	–22.98	66.72	–28.27	61.43
	94	23500	–5.04	–21.91	63.09	–26.95	58.05
	95	23750	–4.79	–20.85	61.55	–25.64	56.76
	96	24000	–4.55	–19.78	60.62	–24.33	56.07
R–21	97	24250	–4.30	–18.71	57.99	–23.01	53.69
	98	24500	–3.85	–16.73	55.97	–20.58	52.12
	99	24750	–3.41	–14.81	55.59	–18.21	52.19
R–22	100	25000	–3.20	–13.90	57.30	–17.09	54.11
	101	25250	–4.71	–20.47	48.43	–25.18	43.72
	102	25500	–6.23	–27.10	37.50	–33.33	31.27
R–23	103	25750	–7.74	–33.67	28.23	–41.42	20.48
	104	26000	–6.74	–29.29	28.61	–36.03	21.87
	105	26250	–5.72	–24.85	28.35	–30.57	22.63
	106	26500	–4.70	–20.42	31.78	–25.11	27.09
R–24	107	26750	–3.69	–16.03	33.97	–19.72	30.28
	108	27000	–2.95	–12.83	34.27	–15.78	31.32
	109	27250	–2.21	–9.62	37.48	–11.83	35.27
	110	27500	–1.48	–6.41	36.39	–7.89	34.91
R–25	111	27750	–0.74	–3.21	35.49	–3.94	34.76
	112	28000	–1.48	–6.41	33.49	–7.89	32.01
	113	28250	–2.21	–9.62	27.78	–11.83	25.57
	114	28500	–2.95	–12.83	19.57	–15.78	16.62
R–26	115	28750	–3.69	–16.03	13.37	–19.72	9.68
	116	29000	–2.46	–10.69	20.01	–13.15	17.55
	117	29250	–1.23	–5.34	13.26	–6.57	12.03
	121	30250	5.08	22.07	61.07	27.15	66.15

TABLE A-13 (Cont'd)
GENESIS SHORELINE CHANGES WITH OR WITHOUT BEACH FILL

MONUMENT	CELL NO.	DISTANCE FROM NORTH	SHORELINE CHANGE, FEET 1992–1995	1995–2006 W/O FILL	1995–2006 WITH FILL	1992–2006 W/O FILL	1992–2006 WITH FILL
R–28	122	30500	6.76	29.40	70.40	36.16	77.16
	123	30750	3.23	14.06	55.86	17.29	59.09
	124	31000	–0.31	–1.34	40.06	–1.64	39.76
	125	31250	–3.84	–16.68	23.72	–20.51	19.89
R–29	126	31500	–7.38	–32.07	7.53	–39.45	0.15
	127	31750	–4.95	–21.54	17.46	–26.49	12.51
	128	32000	–2.54	–11.06	26.74	–13.61	24.19
R–30	129	32250	–0.12	–0.53	33.77	–0.66	33.64
	130	32500	–0.18	–0.80	28.50	–0.99	28.31
	131	32750	–0.25	–1.07	27.23	–1.31	26.99
	132	33000	–0.31	–1.34	27.46	–1.64	27.16
R–31	133	33250	–0.37	–1.60	25.60	–1.97	25.23
	134	33500	1.35	5.88	29.28	7.23	30.63
	135	33750	3.07	13.36	32.06	16.44	35.14
R–32	136	34000	4.79	20.85	35.75	25.64	40.54
	137	34250	2.70	11.76	25.16	14.46	27.86
	138	34500	0.61	2.67	15.57	3.29	16.19
R–33	139	34750	–1.48	–6.41	11.59	–7.89	10.11
	140	35000	–1.39	–6.04	–5.94	–7.43	–7.33
	141	35250	–1.29	–5.61	–5.61	–6.90	–6.90
	142	35500	–1.20	–5.24	–5.24	–6.44	–6.44
R–34	143	35750	–1.11	–4.81	–4.81	–5.92	–5.92
	144	36000	–5.10	–22.18	–22.18	–27.28	–27.28
	145	36250	–9.10	–39.55	–64.55	–48.65	–73.65
	146	36500	–13.09	–56.92	–76.72	–70.02	–89.82
R–35	147	36750	–17.09	–74.30	–73.00	–91.38	–90.08
	148	37000	–19.83	–86.21	–76.61	–106.04	–96.44
	149	37250	–22.58	–98.19	–91.99	–120.77	–114.57
R–36	150	37500	–25.32	–110.11	–115.51	–135.43	–140.83
	151	37750	–24.81	–107.86	–113.56	–132.67	–138.37
	152	38000	–24.28	–105.56	–111.16	–129.84	–135.44
	153	38250	–23.76	–103.32	–111.02	–127.08	–134.78
R–37	154	38500	–23.23	–101.02	–111.52	–124.26	–134.76
	155	38750	–19.60	–85.20	–97.20	–104.80	–116.80
	156	39000	–15.96	–69.38	–78.28	–85.33	–94.23
	157	39250	–12.32	–53.56	–59.36	–65.87	–71.67
	158	39500	–8.68	–37.74	–42.04	–46.41	–50.71
R–38	159	39750	–5.04	–21.91	–27.61	–26.95	–32.65
	160	40000	–3.07	–13.36	–21.86	–16.44	–24.94
	161	40250	–1.11	–4.81	–13.91	–5.92	–15.02
R–39	162	40500	0.86	3.74	–4.26	4.60	–3.40
	163	40750	1.48	6.41	–0.19	7.89	1.29
	164	41000	2.09	9.09	8.49	11.18	10.58
R–40	165	41250	2.70	11.76	11.66	14.46	14.36
	166	41500	3.05	13.26	20.76	16.30	23.80
	167	41750	3.38	14.70	21.50	18.08	24.88
	168	42000	3.72	16.20	30.50	19.92	34.22
R–41	169	42250	4.06	17.64	38.24	21.70	42.30
	170	42500	7.34	31.91	58.21	39.25	65.55
	171	42750	10.62	46.18	78.48	56.80	89.10
R–42	172	43000	13.89	60.40	82.00	74.29	95.89
	173	43250	17.16	74.62	105.62	91.78	122.78

FIGURE A-17
GENESIS SHORELINES WITH OR WITHOUT BEACH FILL



A-84. Modeling Summary. As stated previously, variations in the littoral processes from-pre 1982 to post-1982 and the lack of continuous time record wave data render GENESIS modeling questionable for current time periods. However, simulation modeling of the project fill should provide a conservative estimate of beach fill effects in that the final output shorelines would be as far seaward as could be expected. Generally, as shown in Table A-13, the project fill can be expected to spread from the immediate project area northward a distance of about 6,000 feet and to the south a distance of about 9,000 feet. Outside of the immediate project boundaries, the transported fill amounts to about 20 to 30 feet of shoreline advance over the 1992 shoreline with greater values occurring closer to the project fill boundaries.

PROBLEM SUMMARY

A-85. Based on field observations, examination of aerial photography, and beach profile surveys, a 4.0-mile long area of periodic erosion has been identified on Hutchinson Island. This area's northern boundary is at the St. Lucie/Martin County line, and the southern boundary is at profile line R-25. Within this area, storms threaten over $7 million in structural improvements, not including infrastructure and/or land. Certain areas within the project limits have been armored by various types of coastal structures. This armor was constructed in an attempt to provide some minimum level of protection from storms. The vulnerability of the shoreline to structural damage is evidenced by the passage of the 1984 Thanksgiving Day and 1990 Halloween Day Northeaster storms. Due to these storms, considerable structural damages and substantial beach erosion were sustained within this reach of shoreline. With the continuing erosion of the shoreline, damages from hurricanes, tropical storms and even northeaster events, will continue at a greater level than present.

GEOTECHNICAL INVESTIGATIONS

GEOLOGY

A-86. Peninsular Florida occupies a portion of the much larger geographic unit, the Florida Plateau. Deep water of the Gulf of Mexico is separated from deep water of the Atlantic Ocean by this partially submerged platform nearly 500 miles long and 250 to 450 miles wide. Since the Mesozoic Era, approximately 200 million years B.P. (before present), the plateau has been alternately dry land or covered by shallow seas. During that time, 4,000 to greater than 20,000 feet (north-central and southernmost Florida, respectively) of carbonate and marine sediments were deposited. Either following or concurrent with one of the later periods of emergence,

there appears to have been a tilting of the plateau about its longitudinal axis. The west coast was partially submerged, as indicated by the wide estuaries and offshore channels, while the east coast was correspondingly elevated, producing the Atlantic Coastal Ridge.

A-87. Martin County lies within the Coastal Lowlands physiographic region characterized by terraced level plains. The topography is largely controlled by a series of marine terrace deposits. The deposits were formed during Pleistocene time when sea level rose and fell in response to the advance and retreat of the continental ice sheets. When sea level is relatively stationary for long periods, shoreline features and marine plains develop. Shorelines above present sea level, not submerged by a subsequent transgression of the sea, are generally preserved.

A-88. During the last event of continental glaciers, the Wisconsin Glacial Stage, sea level stood 400 feet below the present level, beyond the edge of the continental shelf. The melting of these glaciers started approximately 20,000 years B.P., marking the beginning of the recent or, in geologic time, the Holocene Epoch. Sea level began a rapid rise at an average rate of 30 feet per 1000 years. About 7000 years B.P., the rate of sea level rise slowed at a sea level position about 30 feet below its present level. Since, sea level rise has progressed at a slower rate of 5 to 10 feet per 1000 years.

A-89. It was at this most recent slowing of sea level rise that the barrier islands of east peninsular Florida began to form and, with continued sea level rise, migrated westward to their present position. The primary cause of sea level rise today is the warming of the atmosphere, causing melting of the polar ice caps and thermal expansion of the ocean waters.

A-90. The Pleistocene Anastasia formation and Pamlico sand are the only formations exposed in Martin County. The Anastasia formation in Martin County consists mostly of sand, shell beds, and thin discontinuous layers of sandy limestone or sandstone. The consolidated coquina (shell) phase of the Anastasia formation crops out on the beach at Blowing Rocks, Jupiter Island and Sewall Point on Hutchinson Island. These beds of exposed coquina rock are not more than 20 feet thick.

PREVIOUS INVESTIGATIONS

A-91. Investigations for an offshore sand source started with the Coastal Engineering Research Center's inner continental shelf study. Reconnaissance and detail grids of geophysical surveys, and vibracore sampling was performed in the late 1960's, identifying potential offshore sand sources (Meisburger and Duane, 1971). Although Martin County had only reconnaissance geophysical survey coverage, a map of offshore sand shoals identified potential offshore sand resources.

A-92. In 1978, the Jacksonville District performed more detailed geophysical surveys and vibracore sampling offshore of Martin County. This work was in support of the Feasibility Study being conducted at the time. This study identified potential sand sources offshore most of the county, including Gilbert Shoal north of St. Lucie Inlet. Thirty-nine vibracore borings were drilled along the Martin County coast, located approximately 1/2 to 2 miles offshore. The boring locations were chosen to cover the coast and sample sand deposits. Core boring locations were determined by electronic positioning equipment. Selected samples were sent to the U.S. Army Corps of Engineers, South Atlantic Division Laboratory (SAD Laboratory) for grain size analysis. All core boring logs and grain size data are included in the Geotechnical Sub-Appendix A1 (Available from Jacksonville District).

A-93. Native beach surface samples were collected along 11 profile lines surveyed in 1965, which covered the entire county shoreline. The samples were collected from the dry beach, at mean high water, at mean low water, and at elevations -3, -6, -12 and -18 feet. Grain size analyses of the beach samples were performed at the SAD Laboratory.

RECENT INVESTIGATIONS

A-94. Applied Technology and Management, Inc. (ATM), under contract by the Martin County Board of County Commissioners, conducted coastal engineering and environmental studies in Martin County and updated information as needed. During this study, new native beach sampling was identified. In 1990, (ATM) collected surface beach samples along eight profile lines, approximately 1,000 to 3,000 feet apart, within the Hutchinson Island project limits. Samples were collected at elevations +10, +5, 0, -5, -10, -15 and -20 feet N.G.V.D. All samples were subjected to grain size analysis in accordance with ASTM D-422. The results were used to analyze the distribution of grain sizes throughout the project beach and perform suitability analysis. The complete report is included in Geotechnical Sub-Appendix A1.

NATIVE BEACH

A-95. The results of the 1965 native beach sampling showed very little material of a size smaller than 0.125 mm exists above mean high water, although finer grained material occurs in the zone from shoreline to a water depth of 6 to 12 feet. The largest grain sized material on the beach occurs at the shoreline. Shell fragments comprise a considerable part of the beach material. Composite mean grain size for the entire county, from the 1965 data was 1.51 phi (0.35 mm), and sorting of 1.74.

A-96. For the native beach sampling performed in 1990, within the Hutchinson Island project limits, the mean grain size is 1.91 phi (0.27 mm), with a sorting of 1.41. Table A-14 shows a summary of native sediment statistics. Figure A-18 illustrates the grain size frequency histogram of the native sediment grain size distribution. Comparison of the native beach and the borrow area cumulative grain size distributions are shown on Figure A-19. Results of all laboratory testing is included in Geotechnical Sub-Appendix A1. No gradation curves were produced for individual samples analysis, only tabulated laboratory results.

TABLE A-14
SUMMARY OF GRAIN SIZE STATISTICS

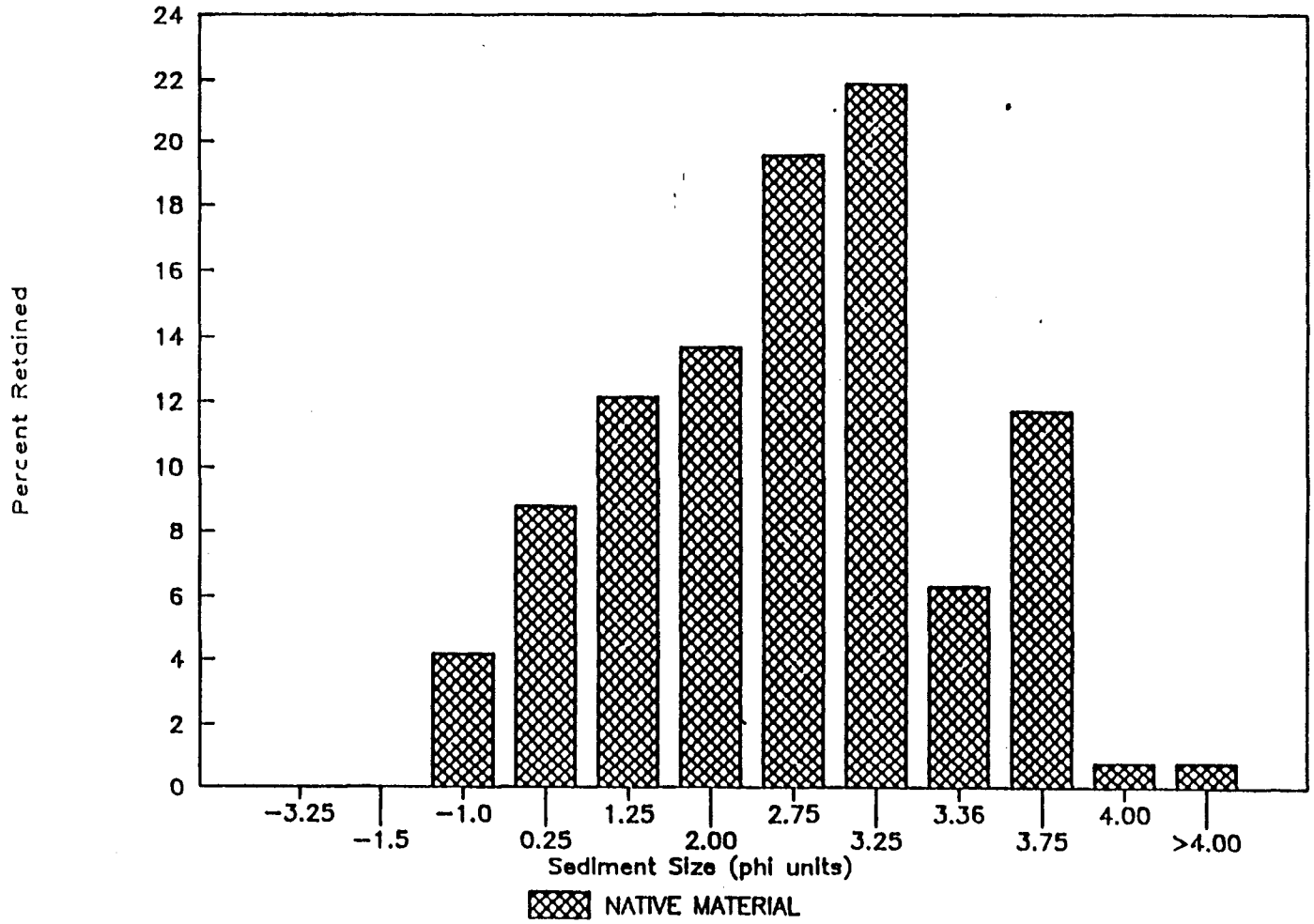
	Phi Mean Grain Size (mm)	Sorting	Adjusted SPM Overfill (Ra)
Native Beach-1965 County Wide	1.51 (0.35 mm)	1.74	----
Native Beach - 1990 Hutchinson Island	1.91 (0.27 mm)	1.41	----
Hutchinson Island Borrow Area Gilbert Shoal	1.41 (0.38 mm)	1.39	1.0

BORROW AREA

A-97. Gilbert Shoal is located approximately three miles north of St. Lucie Inlet, 4,000 feet offshore. The shoal was located by the Jacksonville District geophysical survey, and sampled with 25 vibracore borings. These borings refined the shape of the shoal leading to the borrow area shown on Plate 11 (end of main text), along with the core boring locations. Plate 12 shows the geologic cross-sections through the borrow area. The cross-sections show the distribution of the clean shoal sands from surrounding siltier sand. The borrow area shown on Plate 11 contains approximately 6 million cubic yards of clean sand, mostly containing less than 5 percent silt. This clean sand is in a deposit 10 to 16 feet thick.

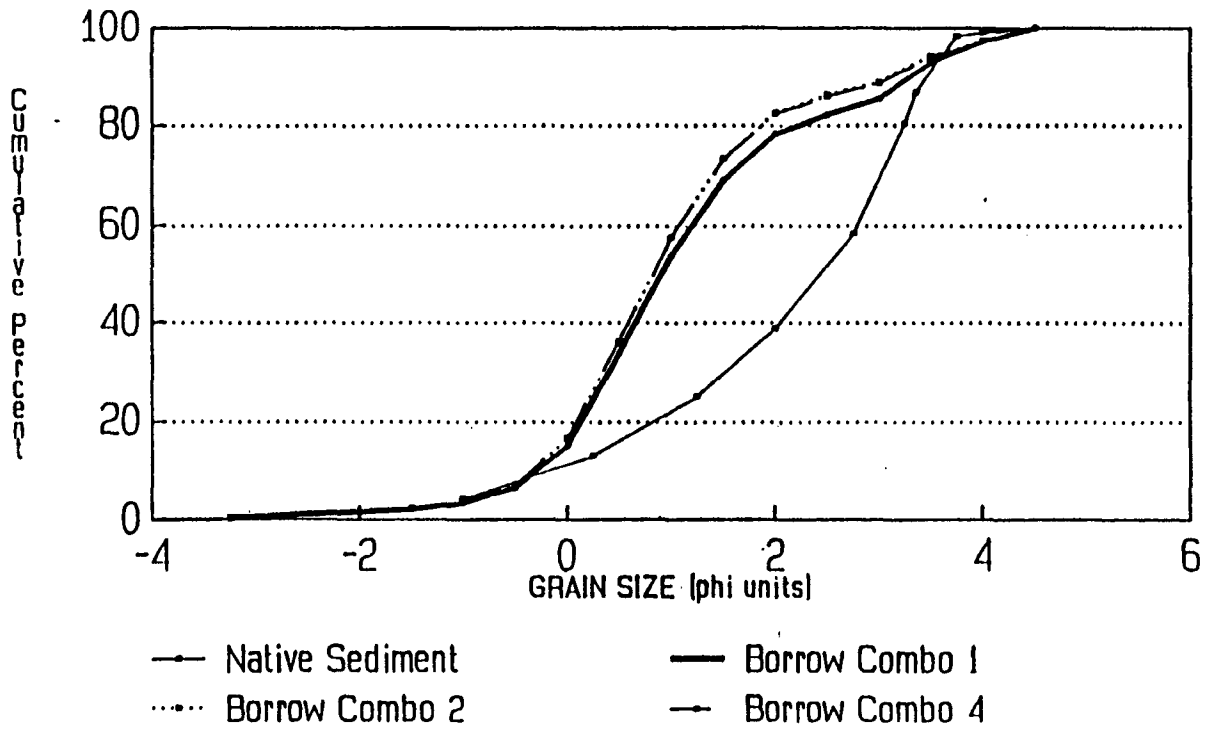
A-98. The mean grain size of the Gilbert Shoal borrow area is 1.41 phi (0.38 mm) and sorting of 1.39. The grain size frequency histogram graphically shows the distribution, Figure A-20. Cumulative grain size distribution curves are shown on Figure 19, along with the native beach curve.

FIGURE A-18
NATIVE SEDIMENT ANALYSIS



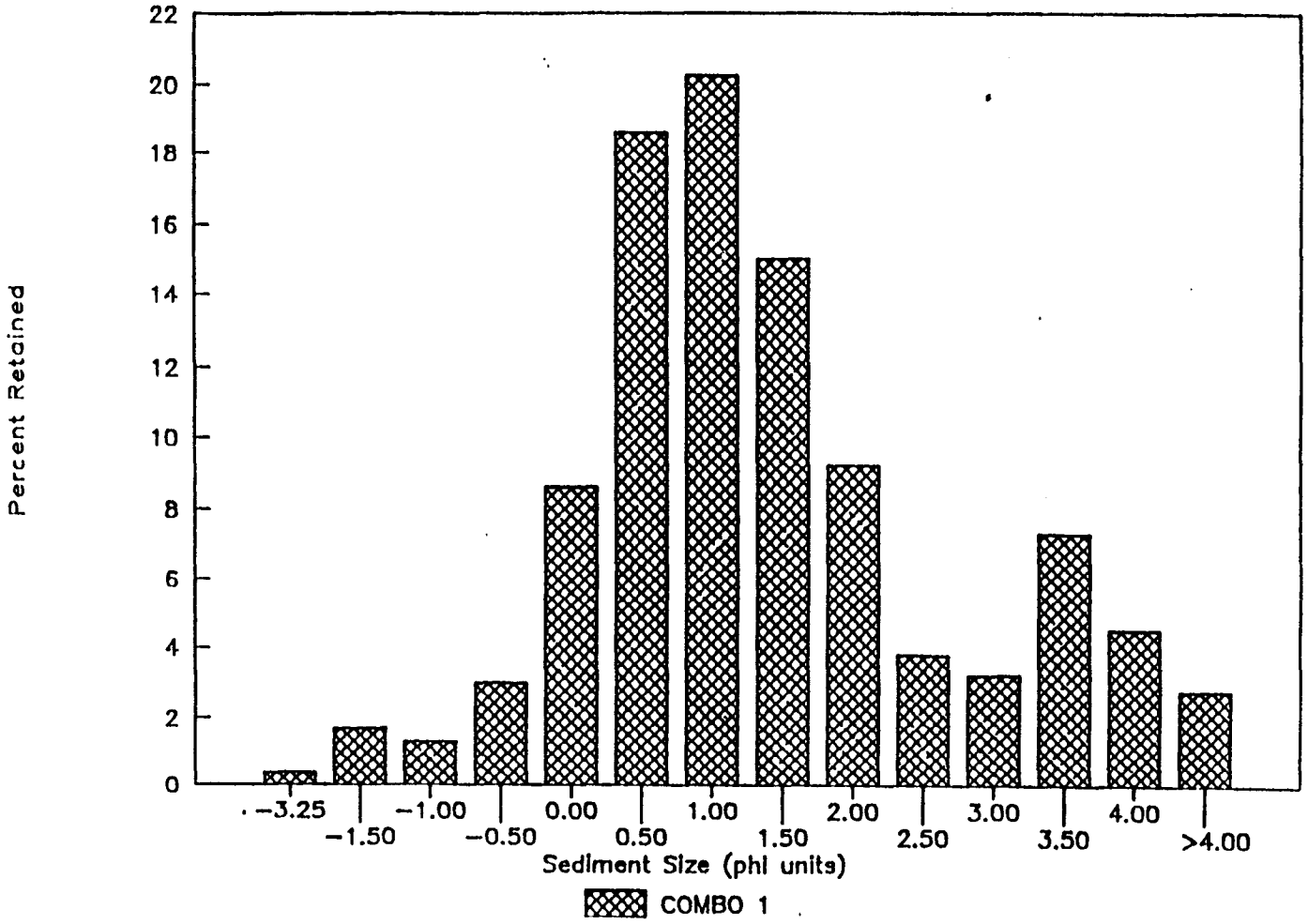
(ATM, 1991 - Figure 4-7)

FIGURE A-19
BORROW AND NATIVE SEDIMENT COMPARISON



(ATM, 1991 - Figure 4-8)

FIGURE A-20
BORROW MATERIAL ANALYSIS (COMBINATION 1)



(ATM, 1991 - Figure 4-4)

A-99. Additional core borings within the borrow area are being conducted at this time by ATM. These additional core borings will further define the quality of the borrow materials and provide sufficient detail data for plans and specifications design of the borrow area.

SUITABILITY ANALYSIS

A-100. The results of the grain size analysis is used to evaluate the suitability of the borrow area for use on the project beach. The Adjusted Shore Protection Manual Method (CERC, 1984) is used to compare the grain size distribution of the borrow area to the grain size distribution of the native beach. Discrepancies in grain sizes of the borrow area material will be compensated for by an overfill ratio, indicating the quantity of borrow material necessary to produce a unit volume of sand with the grain size distribution of the native material. The grain size statistics used in this comparison is summarized in Table A-14, along with the results of the suitability analysis.

A-101. Cumulative gradation curves for the native beach and borrow area are compared on Figure A-19. On Figure A-19, combinations (combo) 1, 2, and 4 represent different areas of the borrow area. These areas are very similar, but combination 1 data was used in this report as best representing the borrow area.

A-102. The results of the suitability analysis shows that the borrow material is coarser grained and has essentially the same sorting as the native beach material. This combination requires no overfill volume, resulting in an overfill ratio of 1.0.

SUMMARY

A-103. In 1978, the Jacksonville District drilled core borings to identify potential sand sources for beach nourishment offshore of Martin County. The core borings offshore of Hutchinson Island identified a borrow area that contained sufficient quantity of high quality sand available for use as a source of sand for beach nourishment. ATM, under contract by Martin County, conducted engineering and environmental studies in the project area. As part of these studies, ATM performed native beach sampling and analysis of compatibility of potential sand sources. The core borings identify a borrow area offshore of Hutchinson Island which contains approximately 6 million cubic yards of high quality sand for beach nourishment. The material requires no overfill volume to be added for differences in grain size from the native beach material.

PROTECTIVE BEACH DESIGN

PROJECT LENGTH

A-104. The authorized project beach fill extended 4.0 miles south from the St. Lucie/Martin County line. Natural hardbottoms lie in very shallow waters at the southern portion of the authorized project. By shortening the length of the protective beach by approximately 1800 direct hardbottom impacts will be avoided.

A-105. The north limit of the design berm is located at profile line R-2. Tapering of the design berm width will continue north an additional 900 feet to intersect the existing shoreline at profile lines R-1. This will locate the northern boundary of the project at the approximate location of the St. Lucie/Martin County line. The south limit of the design berm width is profile line R-21. A 1800-foot taper will extend the southern boundary of the project to profile line R-23. The protective dune will restore the existing dune between profile lines R-1 through R-23. The overall project length is therefore about 3.75 miles (19,830 feet) to include the tapering of the design berm and the protective dune.

DUNE AND BERM ELEVATIONS

A-106. The existing dune will be restored to an elevation of +13.6 MLW (+12.0 MSL) where required within the project length limits. This elevation approximates the natural dune elevation of the existing beach. Construction of a dune substantially higher than this may obstruct the view of shoreline residents or cause increased erosion due to wind blown sand or drainage/passenger routes cut through the dune. Protective dunes built too low may offer little protection to upland development or existing dunes. A dune of sufficient height can protect lower areas landward of the dune line from overtopping and flooding, however, it would not stop back island flooding caused by the rise of estuary levels during storms.

A-107. The design berm elevation for the project beach fill is +9.1 MLW (+8.0 MSL). As for dune elevation, the design berm elevation approximates the natural berm elevation of the existing beach. A berm constructed at a lower elevation would be overtopped excessively by high frequency occurrence events, while a higher berm elevation would probably allow ponding of water behind the restored dune as a result of high rainfall and/or wave overtopping.

DUNE AND BERM WIDTHS

A-108. Many berm widths were considered in order to determine the design berm width which provides the maximum net benefits. Plans that maintain the existing shoreline or add equivalent beach widths of 20, 35, 50, 75, and 100 feet were

developed. The selected design berm width for the project area is 35 feet. The restored dune will have crest width of 20 feet. The design beach fill limits are illustrated in Plates 1 through 10 at the end of the main report.

A-109. In order to maintain a design berm, the Corps of Engineers places advance nourishment with the design beach fill quantity. The Corps also adds additional material if the borrow material is somewhat finer than the native beach material, which is not the case in this project. The borrow material is coarser grained than the native beach material, therefore no overfill volume is required. At the time of initial construction, the advance nourishment material is added to the design volume, resulting in a much larger initial project beach profile.

BEACH SLOPES

A-110. The front slope of the beach fill placed at the time of construction or future renourishment will be steeper than that of the natural profile. The angle of repose of the hydraulically placed material depends upon the characteristics of the fill material and the wave climate in the project area. The estimate of the slope of the material after adjustment is based on averaging the beach profile slopes of the native beach from low-water datum to about the 18-foot depth contour. After adjustment and sorting of the placed material by wave action, the material will adjust to the native beach slope, which is about 1 on 8.5 above MLW and 1 on 20 below MLW. The protective dune slope is 1 on 5 from the crest of the dune to the toe of the dune.

A-111. It is unnecessary and usually impracticable to grade beach slopes artificially below the low-water elevation since they will be shaped by wave action. Fill material is placed to a construction berm width. With steep initial slopes, the material will quickly adjust to the flatter natural slopes. The actual construction profile slope and berm width will be determined during preparation of plans and specifications for construction of the project.

DESIGN FILL VOLUME

A-112. The design beach fill dimensions consist of the primary dune restored to a 20-foot wide crest at an elevation of +13.6 MLW over a distance of 3.75 miles (19,830 feet) and of a berm 35-feet wide at an elevation of +9.1 feet MLW over a distance of 3.4 miles (18,040 feet). A reduced berm width at the same elevation extends an additional 2700 feet to the north and south limits of the project. Design fill sections with these dimensions were compared to the 1992 survey profiles. The estimated design volume required (including fill behind the ECL) for the project is 493,500 cubic yards. Design fill sections for every profile line are shown on Plates 2 through 10.

FILL VOLUME LANDWARD OF EASEMENT LINE

A-113. The State of Florida requires that the non-Federal sponsor establish an erosion control line (ECL) at the existing mean high water line prior to project construction. The purpose of this line is to delineate State-owned land from private uplands. The baseline used for the purposes of this report was the mean high water line from the 1992 survey. Plates 2 through 10 show the approximate location of this line.

A-114. Usually, the design beach cross-section for a project is constructed seaward of the ECL, however this project authorized the restoration of the existing dune which lies landward of the mean high water line. In order to maintain the constant elevation from the natural profile, the design berm commenced, where possible, at the location of the existing (1992) 9.1-foot contour line. Fill placed landward of the ECL, on lands not open to the public and undeveloped private property, is a non-Federal responsibility with no Federal contribution to the construction cost. Comparison of the 1992 survey profiles and the design fill sections resulted in an estimated 156,000 cubic yards of material to be placed landward of the MHW line for the recommended project length.

ANTICIPATED EROSIONAL LOSSES

A-115. Since the survey was accomplished in 1992, it is expected that the project scope will grow due to additional erosion prior to construction. The estimated construction completion date is 1996, approximately 4 years following the 1992 survey. The anticipated erosional volume is based on the long-term annual losses for this project, approximately 53,600 cubic yards based on comparative surveys taken from 1971 to 1992). The estimated additional volume required to offset anticipated erosional losses is 214,400 cubic yards (53,600 X 4).

ADVANCE NOURISHMENT

A-116. In anticipation of continuing erosion of the shoreline after the project fill has been placed, an additional volume of material, called advance nourishment, is placed to offset these expected losses. The volume of advance nourishment is based in part on the long term historic volumetric losses and the economically determined interval between successive renourishment operations. The long term erosional losses for the project area were determined by comparing the 1971 and 1992 surveys. That comparison resulted in annual volumetric losses of 2.6 cubic yards of material per foot of shoreline. This is equivalent to 53,600 cubic yards per year for the project area.

A-117. The optimum number of years of advance nourishment placed during initial construction depends on an economic determination of the lowest average annual equivalent cost of maintaining the project. Table A-15 shows cost estimates for nourishment intervals from one to 20 years. The optimum renourishment interval is 11 years. The total volume required for advanced nourishment is computed by multiplying the long term annual losses times the renourishment interval (11 years), which results in approximately 589,600 cubic yards, without overfill.

FUTURE PERIODIC NOURISHMENT

A-118. The minimum protective cross-section of the project beach consists of a berm width of 35 feet. Depending on the coastal processes between nourishment operations, this minimum protective distance could be reached after or prior to the estimated 11-year renourishment interval. Monitoring throughout the project life would indicate the performance of the fill and the appropriate volume for the selected renourishment interval. However, for the purposes of this report, the amount of future periodic nourishment required is based on the historic pre-project volumetric losses. This quantity is the same amount as that required for advanced nourishment.

OVERFILL VOLUME

A-119. The overfill quantity is determined by multiplying the overfill ratio by the quantity of material expected to undergo the sorting action of waves. This quantity of material is the advanced nourishment volume. The results of the suitability analysis, discussed earlier in this appendix, shows that the borrow material is coarser grained than the native beach material, resulting in an overfill ratio of 1.0. Therefore no overfill volume is required.

COST ESTIMATES

A-120. From conception to completion of the project, the project cost estimate is a paramount management document. It is a guide to further refinement of uncertain features and leads to high confidence in the Federal Government's ability to award and execute contract construction within prescribe cost and time limits. Uncertainty exists in all estimates. The goal is to identify the uncertainty associated with a cost element, to forecast the risk of cost or time growth associated with the uncertainty and to assign a contingency to the cost element that will express the cost which, within a high degree of confidence, will not be exceeded when further detailed information is available. During pre-construction engineering and design, the focus is on detailed investigations and design and a significant increase in the detail of the cost estimate and decrease in the contingencies.

TABLE A-15
AVERAGE ANNUAL EQUIVALENT COST VS. RENOURISHMENT INTERVAL

OPTIMIZATION OF BEACH RENOURISHMENT INTERVAL FOR MARTIN COUNTY, FLORIDA (35-FOOT BERM WIDTH)

ECONOMIC ANALYSIS PERIOD =	50 YEARS	MOBILIZATION COST =	$1,400,000.00	
INTEREST RATE =	8.000 PERCENT	PRICE PER CUBIC YARD =	$3.75	
ANNUAL EROSION RATE =	53,600 CUBIC YARDS	MONTHLY PRODUCTION RATE =	418,000	PAY CUBIC YARDS
FILL BEHIND E. LINE =	156,000 CUBIC YARDS	PHYSICAL/ENV. MONITORING =	$128,000	
DESIGN FILL QUANTITY =	337,500 CUBIC YARDS	ADD'L MONIT. (YRS 1-11 ONLY) =	$756,000	(PRESENT WORTH INCLUDES CONTING., E&D, S&I)
OVERFILL FACTOR =	1.00	LANDS & DAMAGES =	$314,000	
'92-'96 ANTICIPATED		IDC - INITIAL RESTORATION	$32,400	(AAE COST)
EROSIONAL LOSSES =	214,400 CUBIC YARDS	CONTINGENCY =	20.0%	
		E&D, S&I =	15.0%	

CAPITAL RECOVERY FACTOR = 0.081743 — DECEMBER 1993 PRICE LEVELS

DESIGN FILL + ECL FILL + ANTICP. EROSION (CUBIC YARDS)	NOURISHMENT INTERVAL (YEARS)	ADVANCE NOURISHMENT W/ OVERFILL (CUBIC YARDS)	TOTAL INITIAL FILL W/ OVERFILL (CUBIC YARDS)	ESTIMATED CONSTRUCTION TIME (MONTHS) *	INITIAL COST	INTEREST AND AMMORTIZATION	NOURISHMENT QUANTITY W/ OVERFILL (CUBIC YARDS)	NOURISHMENT COST	ANNUAL COST OF NOURISHMENT	TOTAL AVERAGE ANNUAL EQUIVALENT COST
707,900	1	53,600	761,500	3.8	$7,554,200	$617,500	53,600	$1,420,100	$1,420,100	$2,070,000
707,900	2	107,200	815,100	4.0	$7,847,900	$641,500	107,200	$1,697,500	$816,100	$1,490,000
707,900	3	160,800	868,700	4.1	$8,141,600	$665,500	160,800	$1,974,900	$608,300	$1,348,200
707,900	4	214,400	922,300	4.2	$8,435,400	$689,500	214,400	$2,252,300	$499,800	$1,258,700
707,900	5	268,000	975,900	4.3	$8,729,100	$713,500	268,000	$2,529,600	$431,200	$1,209,100
707,900	6	321,600	1,029,500	4.5	$9,022,800	$737,500	321,600	$2,807,000	$382,600	$1,179,500
707,900	7	375,200	1,083,100	4.6	$9,316,500	$761,600	375,200	$3,084,400	$345,700	$1,161,700
707,900	8	428,800	1,136,700	4.7	$9,610,200	$785,600	428,800	$3,361,800	$316,100	$1,151,100
707,900	9	482,400	1,190,300	4.8	$9,904,000	$809,600	482,400	$3,639,200	$291,400	$1,145,400
707,900	10	536,000	1,243,900	5.0	$10,197,700	$833,600	536,000	$3,916,600	$270,400	$1,143,400
707,900	11	589,600	1,297,500	5.1	$10,491,400	$857,600	589,600	$4,194,000	$252,000	$1,142,000
707,900	12	643,200	1,351,100	5.2	$10,785,100	$881,600	643,200	$4,471,400	$235,600	$1,149,600
707,900	13	696,800	1,404,700	5.4	$11,078,800	$905,600	696,800	$4,748,800	$220,900	$1,158,900
707,900	14	750,400	1,458,300	5.5	$11,372,500	$929,600	750,400	$5,026,200	$207,600	$1,169,600
707,900	15	804,000	1,511,900	5.6	$11,666,300	$953,600	804,000	$5,303,600	$195,300	$1,181,300
707,900	16	857,600	1,565,500	5.7	$11,960,000	$977,600	857,600	$5,581,000	$184,000	$1,194,000
707,900	17	911,200	1,619,100	5.9	$12,253,700	$1,001,700	911,200	$5,858,400	$173,600	$1,207,700
707,900	18	964,800	1,672,700	6.0	$12,547,400	$1,025,700	964,800	$6,135,700	$163,800	$1,221,900
707,900	19	1,018,400	1,726,300	6.1	$12,841,100	$1,049,700	1,018,400	$6,413,100	$154,700	$1,236,800
707,900	20	1,072,000	1,779,900	6.3	$13,134,800	$1,073,700	1,072,000	$6,690,500	$146,200	$1,252,300

* Includes one month for mob & demob and one month after NTP to start work.

A-121. The cost estimate for the recommended project is based on December 1993 price levels. Quantities for the beach fill design are based on conditions of the shoreline in May 1992, the time of the last beach profile survey. The cost estimates include about 20 percent for project contingencies and 15 percent for remaining planning, engineering and design, and construction management. Annual costs were computed using an 8 percent interest rate. Following are detailed MCACES cost estimates for the recommended project (Levels 1, 2 and 6). MCACES cost estimates exclude interest during construction.

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U.S. ARMY CORPS OF ENGINEERS
JACKSONVILLE DISTRICT

FINAL
ENVIRONMENTAL ASSESSMENT

MARTIN COUNTY SHORE PROTECTION PROJECT
HUTCHINSON ISLAND, MARTIN COUNTY, FLORIDA

JUNE 1994

MARTIN COUNTY SHORE PROTECTION PROJECT
HUTCHINSON ISLAND, MARTIN COUNTY, FLORIDA

FINDING OF NO SIGNIFICANT IMPACT

I have reviewed the planning document and the attached Environmental Assessment for the proposed project. Based on the information analyzed in the Environmental Assessment and on pertinent data obtained from cooperating Federal agencies having jurisdiction by law and/or special expertise, and information obtained from the interested public, I conclude that the considered action will have no significant impact on the quality of the human environment. Reasons for this conclusion are, in summary:

a. Measures to prevent or minimize impacts to sea turtles, in accordance with the Biological Opinion from the U.S. Fish and Wildlife Service, will be implemented during and after project construction. Both the National Marine Fisheries Service and the U.S. Fish and Wildlife Service have concurred that there will be no adverse impacts to other threatened or endangered species.

b. Measures to eliminate, reduce, or avoid potential adverse impacts to fish and wildlife resources will be implemented during project construction.

c. State water quality standards will be met.

d. There will be no adverse impacts to known sites of cultural or historical significance. The Florida State Historic Preservation Officer has indicated that the beach nourishment project will have no effect on any sites listed, or eligible for listing, in the *National Register of Historic Places*.

e. Benefits to the public will be the protection of upland residences and businesses as well as associated infrastructure along an erosive beach from storm generated wave energy. A wider beach will also provide more space for both active and passive saltwater recreational activities for residents and visitors.

In consideration of the information summarized, I find that the considered action does not require an Environmental Impact Statement.

Date: June 13, 1994

Terrence C. Salt
Colonel, U.S. Army
District Engineer

ENVIRONMENTAL ASSESSMENT

Table of Contents

Paragraph No.		Page No.
	SUMMARY	EA-iii
	LIST OF FIGURES	EA-vi
	LIST OF TABLES	EA-vii
1.00	**INTRODUCTION**	EA-1
2.00	**PROJECT LOCATION**	EA-1
3.00	**NEED FOR THE PROPOSED ACTION**	EA-1
4.00	**PROPOSED ACTION**	EA-5
5.00	**ALTERNATIVES TO THE PROPOSED PLAN**	EA-5
6.00	**SOURCE OF BEACH FILL MATERIAL**	EA-5
7.00	**EXISTING ENVIRONMENTAL CONDITIONS**	EA-10
	7.01 General Environmental Setting	EA-10
	7.02 Fish and Wildlife Resources	EA-13
	7.03 Threatened and Endangered Species	EA-17
	7.04 Historic, Cultural, and Archeological Resources	EA-17
	7.05 Water Quality	EA-20
	7.06 Hazardous, Toxic & Radioactive Wastes	EA-20
	7.07 Aesthetic Resources	EA-20
	7.08 Coastal Barrier Resources	EA-20
	7.09 Acoustical Quality	EA-21
	7.10 Air Quality	EA-21
	7.11 Recreation	EA-21
8.00	**IMPACT OF THE PROPOSED ACTION**	EA-21
	8.01 General Environmental Setting	EA-21
	8.02 Fish and Wildlife Resources	EA-22
	8.03 Threatened and Endangered Species	EA-24
	8.04 Historic, Cultural, and Archeological Resources	EA-29
	8.05 Water Quality	EA-29
	8.06 Hazardous, Toxic & Radioactive Wastes	EA-31
	8.07 Aesthetic Resources	EA-31
	8.08 Coastal Barrier Resources	EA-31
	8.09 Acoustical Quality	EA-31
	8.10 Air Quality	EA-31
	8.11 Recreation	EA-32

9.00 **ENVIRONMENTAL COMMITMENTS** EA-32

10.00 **COMPLIANCE WITH ENVIRONMENTAL STATUES** EA-33

10.01 National Environmental Policy Act of 1969 ..... EA-33
10.02 Endangered Species Act of 1973 ..... EA-33
10.03 Fish and Wildlife Coordination Act of 1958 ..... EA-34
10.04 National Historical Preservation Act of 1966 ..... EA-35
10.05 Archeological and Historic Preservation Act (PL 93-291) EA-35
10.06 Executive Order 11593 ..... EA-35
10.07 Clean Water Act of 1977 ..... EA-35
10.08 Clean Air Act of 1972 ..... EA-35
10.09 Coastal Zone Management Act of 1972 .... EA-35
10.10 Farmland Protection Policy Act of 1981 . EA-36
10.11 Wild and Scenic Rivers Act of 1968 ..... EA-36
10.12 Marine Mammal Protection Act of 1972 ... EA-36
10.13 Estuary Protection Act of 1968 ..... EA-36
10.14 Federal Water Project Recreation Act ... EA-36
10.15 E.O. 11990, Protection of Wetlands EA-36
10.15 E.O. 11988, Floodplain Management EA-36

11.00 **COORDINATION** EA-36

12.00 **PUBLIC INVOLVEMENT** EA-36

13.00 **LIST OF PREPARERS** EA-38

14.00 **LIST OF REVIEWERS** EA-38

14.00 **REFERENCES** EA-39

15.00 **APPENDICES** EA-40

SUMMARY

The Martin County Shore Protection Project was authorized in the Water Resources Development Act of 1990. The authorized project allows for the restoration of a protective and recreational beach along the 4.0 miles (6.4km) of shoreline from the St.Lucie/Martin County line (monument R-1) south to approximately 0.25 miles (0.4km) south of monument R-25. Beach compatible material (silt content of approximately 5%-7%) will be obtained from an offshore borrow area located northwest of the St. Lucie Inlet in approximately 30.0 feet (9.1m) of water.

Aerial photographs of the nearshore project area were taken in 1990. A side scan sonar survey to identify hardbottom habitat locations along the Martin County portion of Hutchinson Island from the county line south to the St. Lucie Inlet was completed in June, 1993. The hardbottom maps produced as a result of this survey were groundtruthed by an interagency (U.S. Army Corps of Engineers (Corps), U.S. Fish and Wildlife Service (FWS), Florida Department of Environmental Protection (DEP), and Martin County) team of scientists utilizing SCUBA in July, 1993. Hardbottom reef tracts consisting of ephemeral limestone outcrops and the marine bristle worm, *Phragmatoma lapidosa*, are found scattered along the project beach between monuments R-1 and R-22 with the western edge beginning approximately 500 feet (152m) seaward of the 1992 shoreline. From monument R-23 and continuing southward to the St. Lucie Inlet, the hardbottom habitat is fairly continuous and much closer to shore (some areas such as Bathtub Reef beginning at monument R-34 are aerially exposed at low tide).

In order to reduce the threat of adverse impacts to the hardbottom areas located to the south, the beach fill project has been shortened by approximately 2,000 feet (606m). A 35 foot (10.6m) wide berm will be constructed onto the eroded project beach between monuments R-2 and R-21 with the material gradually tapered between R-1 and R-2 as well as R-21 and R-23. With the aid of computer models and coastal engineering analysis, it is currently predicted that no nearshore hardbottom habitat will be directly impacted by the nourished sand sloughing seaward as it seeks equilibrium with the ocean bottom. It is also predicted that between initial construction and the next periodic renourishment (11 years), sand will gradually erode from the project beach and flow south due to the longshore current in this area. During this 11 year period, the eroded sand may flow onto or around as much as 20.5 acres of hardbottom habitat south of the project area between monuments R-23 and R-42. A restored dune system will be constructed along the entire reach of the project between monuments R-1 to R-23.

As has been mentioned, eroded sand from the project area may

eventually come into contact with as much as 20.5 acres of hardbottom habitat south of the project area between monuments R-23 and R-34 (a distance of approximately 2.2 miles/3.5km) over an 11 year period. This southern transport of sand represents a potential secondary impact to these hardbottom structures and associated flora and fauna. Whether or not the potential impact to this habitat is realized depends upon a number of variables. It is anticipated that the time it takes the sand to reach these areas will be relatively gradual and not episodic. It is likely that this will reduce the chance of the hardbottom areas being directed buried by eroding sand. From the side scan sonar survey, it appears that the overall relief of these hardbottom areas south of the project is generally low (less than 1.5 feet/0.5m) with the western edge of the hardbottom beginning within 200 feet/60.6m from the 1992 mean high water line. It is likely that these areas are naturally subjected to high rates of sedimentation, elevated turbidity, and sand scouring. The composition of the hardbottom areas is predominantly worm rock (*P. lapidosa*). These annelid structures generally favor environments with high suspended sediment and usually lack significant permanent sessile and encrusting communities because of periodic sand scouring and elevated turbidity. Because of the resiliency of the hardbottom habitat (being periodically aerially exposed, buried, and re-exposed) in this area, it is likely that these organisms would be able to survive in highly turbid conditions that may be present on a temporary basis because of the beach nourishment project.

The dynamic physical conditions of the nearshore waters in this area are such that there are natural fluctuations of turbidity levels and sand scouring events. Because of the naturally occurring high turbidity and sand scouring along the nearshore in this area, it seems unlikely that secondary impacts brought about by gradually eroding sand from the beach project area will produce a significant ecological change in this area. Whether these secondary impacts produce significant ecological consequences depends upon the elevation of turbidity levels (and longevity) and the increase in the number of sand scouring occurrences. Since it is extremely difficult to accurately predict impacts to hardbottom areas in highly dynamic areas such as Hutchinson Island, a thorough quantifiable monitoring and mitigation plan will be undertaken by the Corps. The definition of impact, the cause and effect of these impacts, and the possibility of future mitigation requirements will be discussed and agreed upon by the Corps, FWS, and DEP prior to commencement of the beach fill project. Because of the dynamic physical oceanographic conditions that currently exist in the nearshore environment and the resiliency of the hardbottom habitat along this shoreline, the Corps currently predicts that no significant adverse impact will occur south of the project area as a result of the beach nourishment project. Because of this, the Corps does not anticipate having to mitigate for any hardbottom habitat

south of the project area.

Thorough discussions of the various habitat types along with the associated flora and fauna of each habitat type can be found in section 8.00 of the attached Environmental Assessment (EA). Exact locations of hardbottom areas along with the predicted seaward influence of the project (equilibrium toe line) is included in the EA as Appendix D. Presentation of the proposed monitoring and mitigation activities can be found in Appendix E.

Hutchinson Island is one of the most important sea turtle nesting areas in the world. In order to eliminate or reduce the risk of impacting nesting sea turtles, it is estimated that beach construction activities will commence as soon after the sea turtle nesting season ends (November 1) as possible and will end prior to the beginning of the main nesting season (April 15th). The FWS has agreed to this time period for allowing construction of the beach fill project. Environmental commitments to ensure the safety of endangered and threatened species is discussed in section 9.00 of the EA.

List of Figures

Figure	Title of Figure	Page
1	General location of map of Hutchinson Island	2
2	General location map of Martin County, Florida	3
3	Project area from R-1 to R-25	4
4	Location map indicating beach nourishment area and offshore borrow site	6
5	Design profile for authorized beach fill	7
6	Approximate bathymetry of offshore borrow area	9
7	Side scan map of borrow area	11
8	Locations of geotechnical core boring samples	12
9	Distribution of Florida reef assemblages	14
10	Closeup of the marine bristle worm (*Phragmatopoma lapidosa*) collecting sand grains for tube	16
11	Estimate of mean number of incubating sea turtle nests through time for south Hutchinson Island restoration area, based on 1985-1991 monitoring data	25

List of Tables

Table	Title of Table	Page
1	Possible nonstructural and structural solutions to the erosion problem at south Hutchinson Island	8
2	List of Federally listed threatened and endangered species and candidates for Federal listing that may be present in south Hutchinson Island, Martin County	18
3	Endangered and threatened species and critical habitats under National Marine Fisheries Service jurisdiction	19
4	Sea turtle nesting data for the loggerhead (*Caretta caretta*) sea turtle (1985-1990) along Hutchinson Island, Martin County, Florida	26
5	Sea turtle nesting data for the green (*Chelonia mydas*) sea turtle (1985-1990) along Hutchinson Island, Martin County, Florida	27
6	Sea turtle nesting data for the leatherback (*Dermochelys coriacea*) sea turtle (1985-1990) along Hutchinson Island, Martin County, Florida	28
7	Quantitative ranking of sea turtle mortality associated with human activities	30

FINAL ENVIRONMENTAL ASSESSMENT
MARTIN COUNTY SHORE PROTECTION PROJECT
HUTCHINSON ISLAND, MARTIN COUNTY, FLORIDA

1.00 INTRODUCTION. A Congressional Resolution was adopted by the Public Works Subcommittee on May 18, 1973, requesting that the U.S. Army Corps of Engineers (Corps) investigate shore protection alternatives for Martin County, Florida. A *Feasibility Report With Environmental Impact Statement* was published in June 1986. This feasibility report identified much of the Atlantic shoreline of Hutchinson Island and Jupiter Island as experiencing significant erosion problems. The feasibility report indicated that it was not economically justified to recommend a Federal project for Jupiter Island at that time. In the same report, it was recommended that Hutchinson Island receive a protective and recreational beach to retard the erosional problems caused by storm wave attack.

2.00 PROJECT LOCATION. Geologically, Hutchinson Island is considered a young shoreline which has emerged from the ocean with the shifting sands comprising the barrier island separating a semi-enclosed lagoon from the coastal ocean (Dolan et al. 1980). Hutchinson Island is an elongated barrier island approximately 24.5 miles (39.2km) long and generally only a mile (1.6km) or less wide separated from mainland Florida by inlets and the Indian River Lagoon (Figure 1). The Martin County Atlantic coastline is located in the southeastern section of Florida (Figure 2) with the Indian River Lagoon to the west, the Atlantic Ocean to the east, St. Lucie Inlet to the south, and St. Lucie County to the north (Figure 3). The seriously eroded beach stretches for 4.0 miles (6.4km) from the St. Lucie/Martin County line to about 0.25 mile (0.4km) south of the southern boundary of Stuart Public Beach Park (Figure 3).

3.00 NEED FOR THE PROPOSED ACTION. The problem along the project area is one of sand erosion and lowering of the beach profile with subsequent recession of the beach and dunes. Severe northeast storms frequently occurring during the winter months have caused considerable erosion and damage to shoreline structures. Seawalls, dune walkways, and shorefront buildings are currently in danger of being significantly impacted by storm generated waves. It is currently estimated that the present shoreline has receded approximately 200 feet (61m) since an 1882 coastal survey was undertaken by the U.S. Coast and Geodetic Survey and continues to erode at approximately 1.3 feet (0.4m) per year.

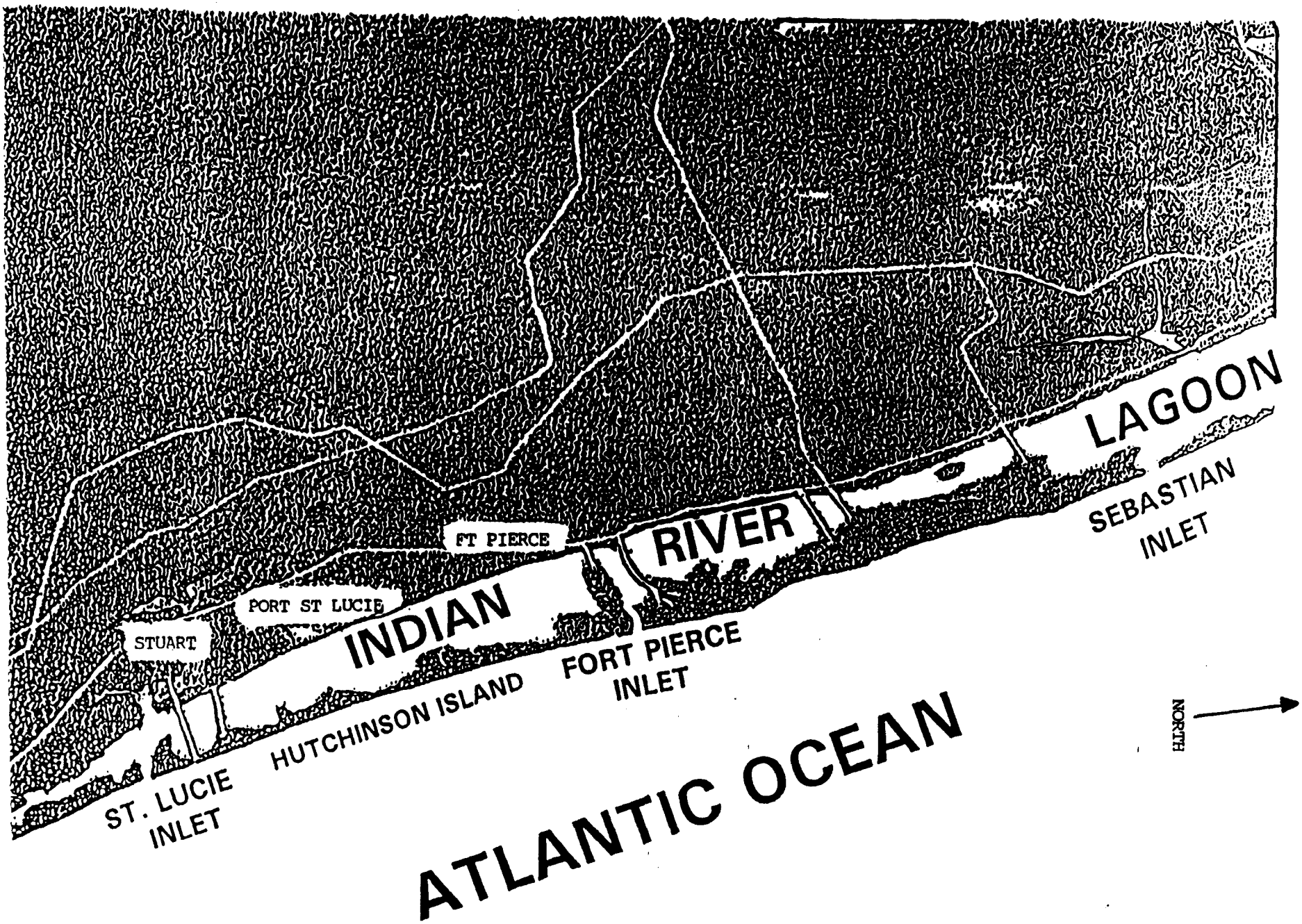


Figure 1. General location of Hutchinson Island, Florida.

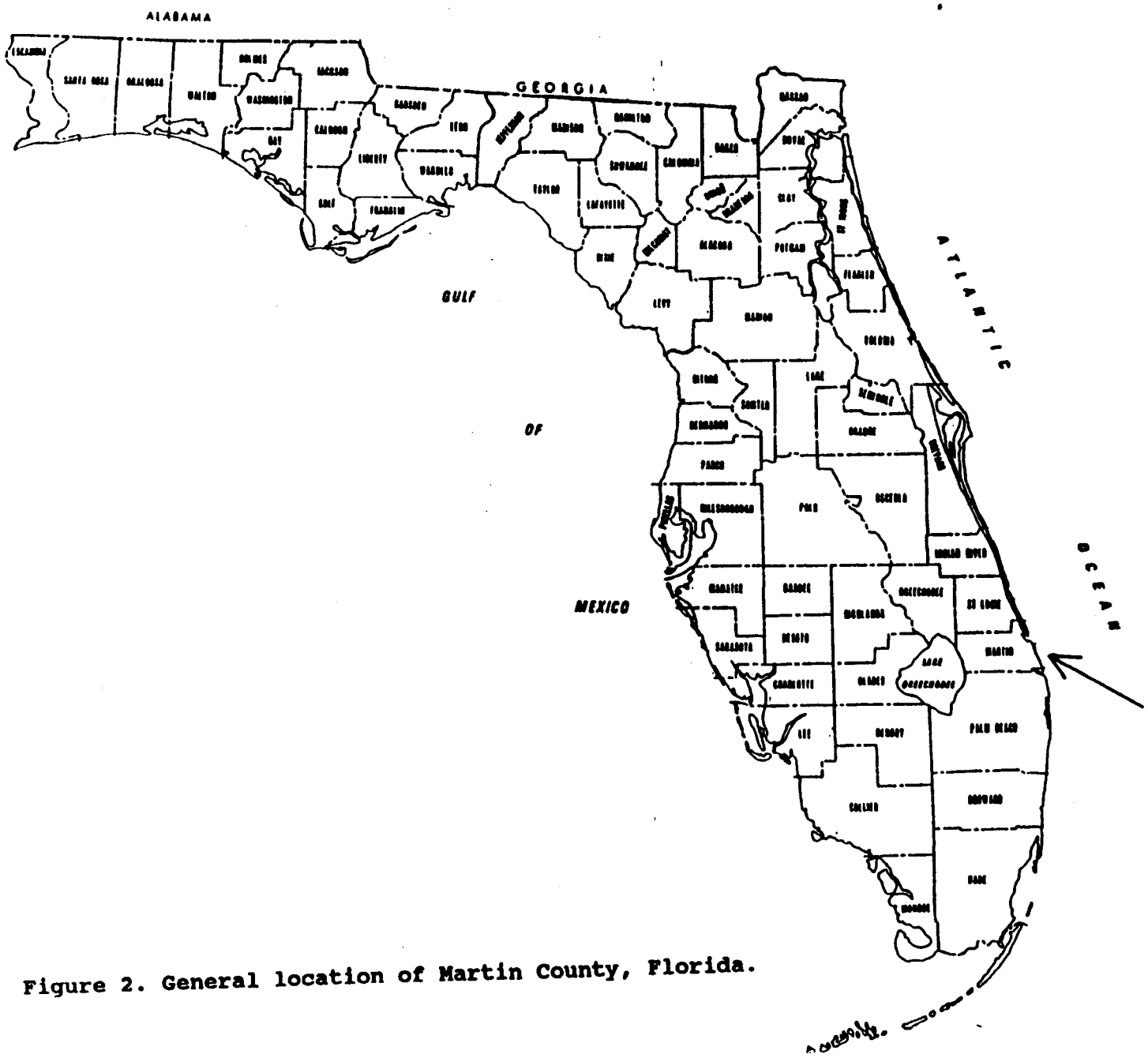


Figure 2. General location of Martin County, Florida.

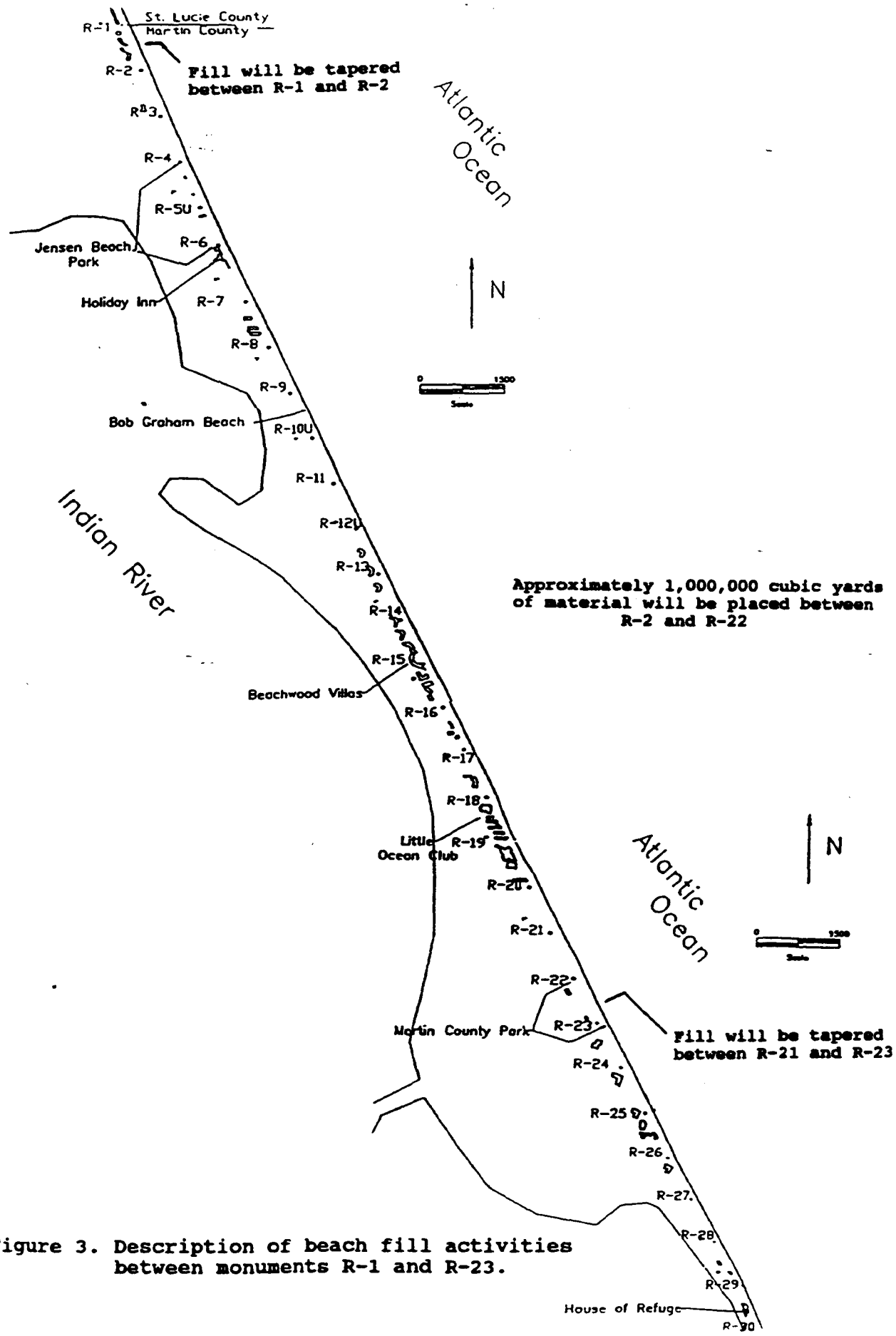
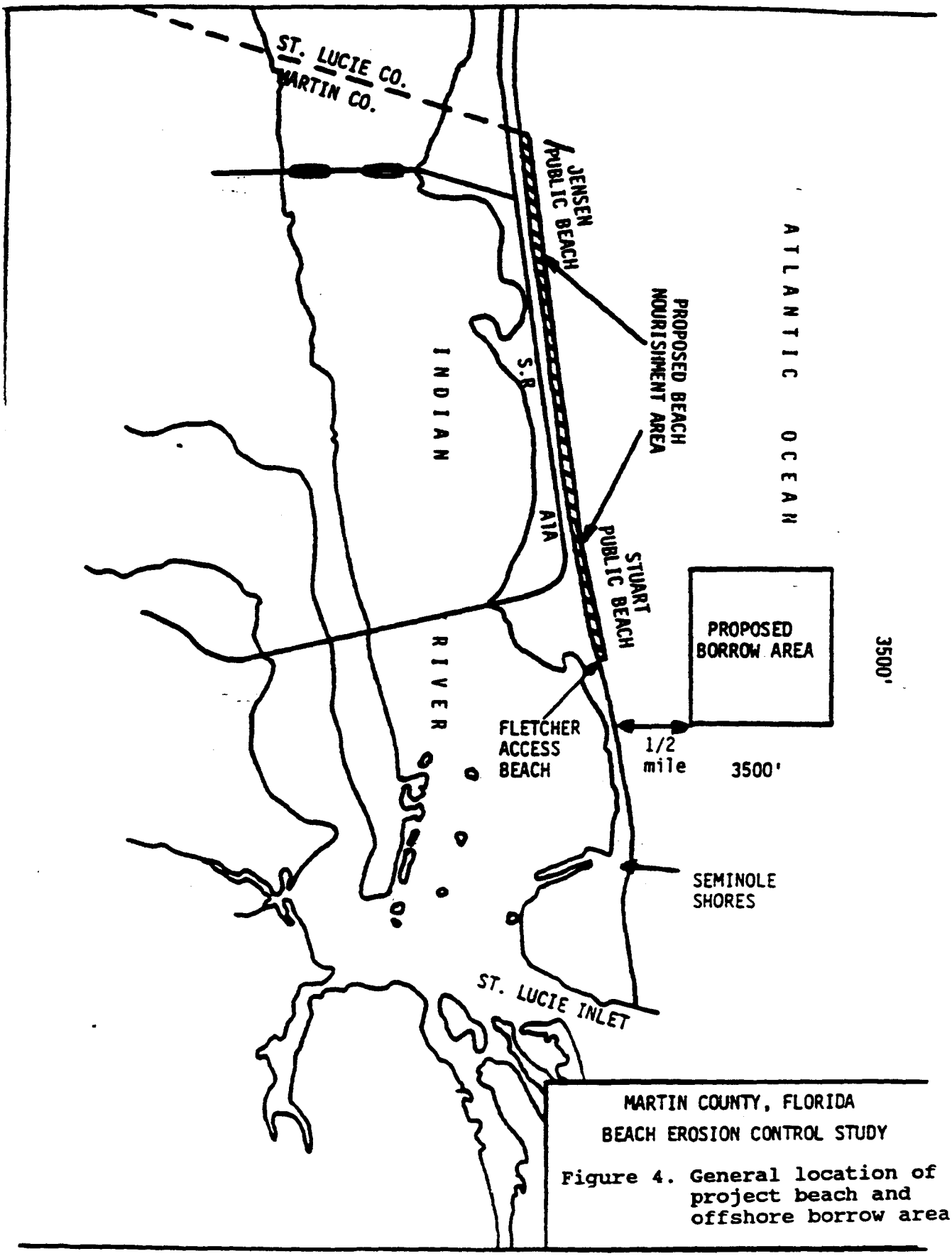


Figure 3. Description of beach fill activities between monuments R-1 and R-23.

4.00 PROPOSED ACTION. The authorized plan provides for 4.0 miles (6.4km) of continuous beach fill from the north county line to about 0.25-miles (0.4km) south of the southern boundary of Stuart Public Beach Park (Figure 4). In order to reduce or eliminate possible impacts to nearshore hardbottom habitat at the southern end of the project, the initial beach fill will place approximately 1,000,000 cubic yards of beach compatible material between monuments R-2 and R-22 (Figure 3). The beach fill will then be tapered between R-1 and R-2 as well as R-22 and R-23. The annual erosion rate for this reach is approximately 53,600 cubic yards. The beach fill design cross section will provide a restored primary dune crest 20-feet (6.1m) wide at 13.6 feet (4.1m) mean low water (mlw), along a 3.75 mile (6.0km) authorized project length (between monuments R-1 to R-23), a 35-foot (10.6m) wide beach berm at 9.1 feet (2.8m) mlw (between R-2 & R-21), and seaward slopes of 1V:8.5H to 0 mlw, then 1V:20H to the existing bottom (Figure 5). Advance nourishment is included in the initial beach fill and periodic nourishment will be provided at 11 year intervals.

5.00 ALTERNATIVES TO THE PROPOSED PLAN. Efforts to plan possible solutions to the erosion problem on Hutchinson Island consist of the "no action plan", eight nonstructural solutions, and twelve structural solutions (Table 1). Each alternative is given very serious consideration during the planning process. Alternatives are eliminated from further consideration if they do not fully meet local planning objectives, maximize benefits as required by the National Economic Development Benefit Evaluation Procedures and the Water Resource Council's "Principles and Guidelines". After careful consideration, the plan which places beach fill on the eroded beach to offer protection from storm waves and inclusion of periodic nourishment for future protection (Plan S-2 in Table 1) is the preferred plan. A thorough discussion of each alternative plan is discussed in the 1986 feasibility report.

6.00 SOURCE OF BEACH FILL MATERIAL. Geotechnical analysis of material was conducted offshore of Martin County at the general locations seen in Figure 6. As a result of these investigations, suitable quantities of sand material are known to exist offshore. An offshore borrow area is considered to be the most environmentally acceptable source of sand. Two potential sand sources are considered as borrow sources for the project. The primary borrow site is located 4,000 feet (1212m) offshore of the project beach and about 3 miles (4.8km) northeast of the entrance to St. Lucie Inlet (Figure 4). This borrow area contains an estimated 6.0 million cubic yards of beach fill material. A secondary borrow area has been located and is offshore of Jupiter Island just south of St. Lucie Inlet and runs northward for a length of 5.5 miles (8.8km) parallel to shore. This secondary or



MARTIN COUNTY, FLORIDA
BEACH EROSION CONTROL STUDY

Figure 4. General location of project beach and offshore borrow area.

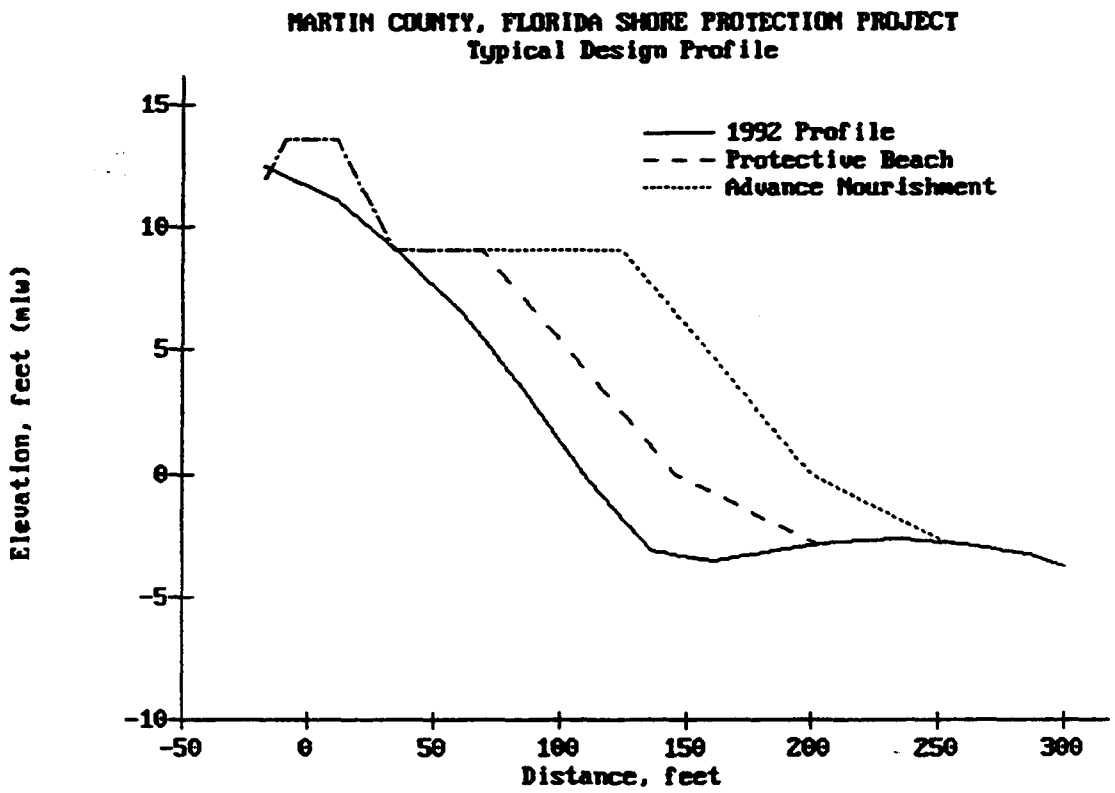


Figure 5. The design profile of the authorized beach fill project.

Table 1. Possible nonstructural and structural solutions to the erosion problem at south Hutchinson Island

POSSIBLE MEASURES		LOCAL PLANNING OBJECTIVES				PRINCIPLES AND GUIDELINES[2]			
		PB	FP	EC	TBE	NED	EQ	OSE	RD
NA	NO ACTION	0[3]	0	0	0	0	0	0	0
	NONSTRUCTURAL MEASURES								
NS-1	Rezoning of beach area	0	P	0	P	0	0	P	P
NS-2	Modification of building codes	0	P	0	0	0	0	P	0
NS-3	Construction setback line	0	P	0	P	0	P	P	P
NS-4	Moratorium on construction	0	P	0	0	0	0	0	0
NS-5	Flood insurance	0	0	0	P	0	0	P	0
NS-6	Evacuation planning	0	0	0	0	0	0	P	0
NS-7	Establish a no-growth program	0	0	0	0	0	0	0	0
NS-8	Other recreational facilities	0	0	0	0	0	0	0	0
	STRUCTURAL MEASURES								
S-1	Modification of St. Lucie Inlet	P	P	P	P	P	P	P	P
S-2	Beach fill with periodic nourishment	F	P	F	F	F	F	F	F
S-3	Beach fill with hurricane surge protection sand dune and periodic nourishment	F	P	F	P	P	P	0	P
S-4	Beach fill with periodic nourishment and offshore breakwater	F	P	P	P	P	P	0	P
S-5	Corps 1968 Plan of Improvement	P	P	P	P	P	0	P	P
S-6	Hurricane surge protection-sand dune	P	P	P	P	0	P	P	0
S-7	Revetment	0	P	P	0	0	0	P	0
S-8	Seawall	0	P	P	P	P	0	P	0
S-9	Stabilization of beaches and dunes by vegetation	0	P	P	0	0	P	0	0
S-10	Modification of building codes and rezoning of beach area	0	P	P	0	P	P	0	0
S-11	Flood proofing of structures	0	P	0	0	0	0	P	0
S-12	Condemnation of land and relocation of structures	0	P	0	0	0	0	P	0

NOTES:

[1] PB - Provision of recreation beach
FP - Protection of flooding and wave damage
EC - Beach erosion control
TBE - Protection of tourist base economy

[2] NED - National Economic Development
EQ - Environmental Quality
OSE - Other Social Effects
RD - Regional Development

[3] F - Meet fully objective
P - Meet partially objective
0 - Not meeting objective

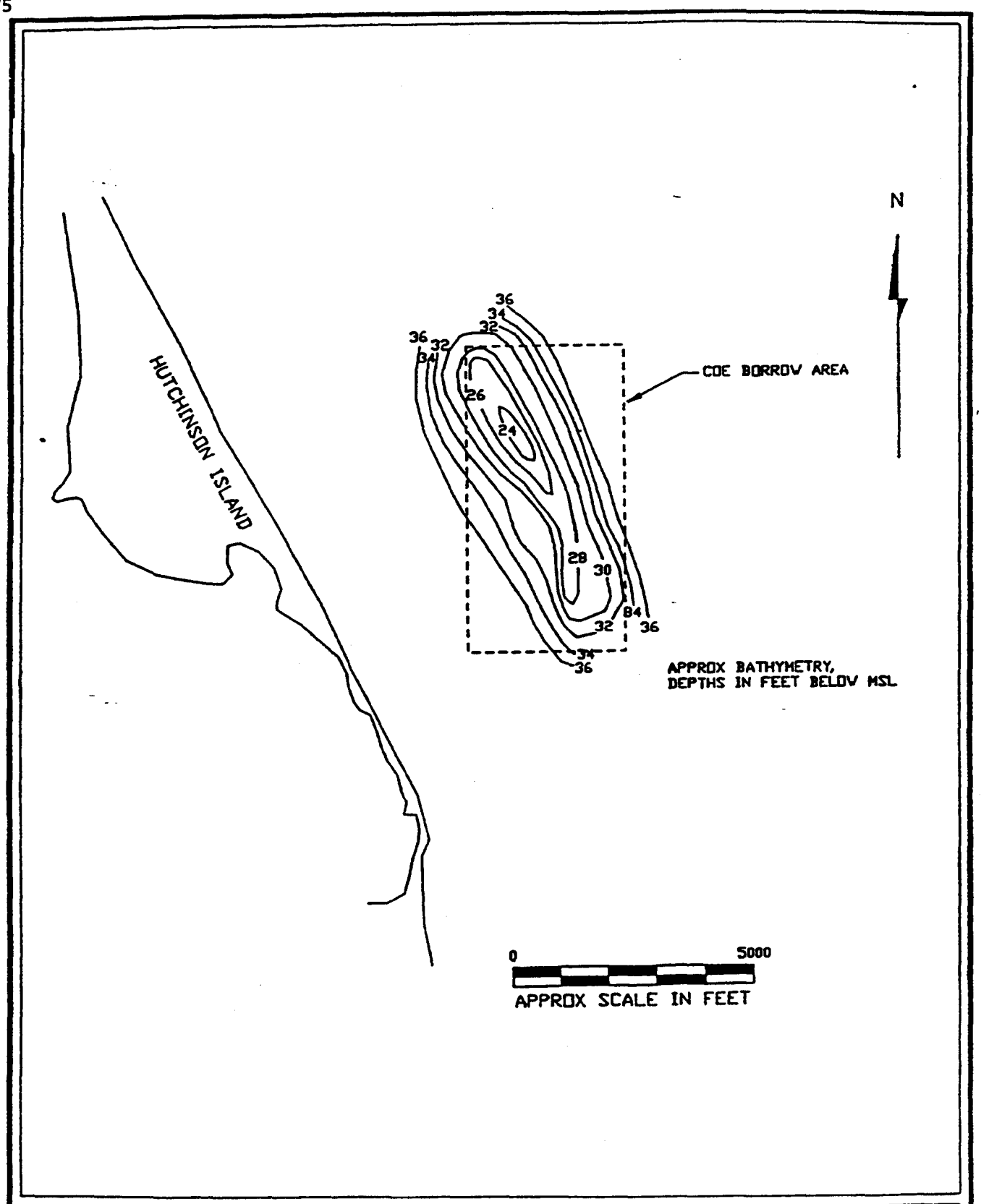


Figure 6. Approximate bathymetry around offshore borrow area.

SOURCE:

Applied Technology and Management, Inc. 1991.

backup borrow area contains approximately 77.0 million cubic yards of beach fill material. The primary borrow site lies in 24 feet (7.3m) to 30 feet (9.1m) of water (Figure 6) and was visually inspected by an interagency team of scientists in July of 1993. This visual inspection confirmed that no hardbottom or seagrass habitat exists within the borrow site. An unidentified object was indicated by the side scan sonar survey (Figure 7). A visual inspection utilizing SCUBA did not reveal any object existing at the indicated coordinates. The borrow area consisted entirely of sand with the bottom scattered throughout with sand dollars. Exploratory borings were drilled offshore of Martin County in and immediately adjacent to the borrow area in 1978 and in 1993 (Figure 8). A geotechnical description of the sand from this borrow area can be found in Appendix A of this report.

7.00 EXISTING ENVIRONMENT CONDITIONS.

7.01 General Environmental Setting. The State of Florida is a portion of the Floridan Plateau, the plateau being exposed as dry land during periods of drop in sea level. Each retreat of the sea left behind a wide variety of hard marine deposits, which subsequently have been moved about by waves and currents. The movements of these deposits have formed present day sandy beaches, offshore bars, and barrier islands (Kennett 1982). Shore processes over time have enlarged and extended these barrier islands. Hutchinson Island is a 24 mile (38 kilometer) long and narrow barrier island with the Fort Pierce Inlet to the north, the St. Lucie Inlet to the south, the Indian River Lagoon to the west, and the Atlantic Ocean to the east (Figure 1). The general project area is composed primarily of multifamily homes, small condominium complexes, and large hotels facing either the Indian River Lagoon to the west or the Atlantic Ocean to the east. The project shoreline also includes a number of public parks. The dune system in this area that affords some protection of the shorefront development is subject to being overwashed and eroded away during severe winter storms. Because of this, erosion of the protective beach along Hutchinson Island is a severe seasonal problem. Much of the vegetation in the project area consists primarily of small grasses, herbs, and scrubs. In recent years, much of Florida's shoreline has become dominated by larger exotic vegetation such as the Australian pine (*Casuarina litorea*). These trees have a very shallow root system and tend to be more prone to being uprooted during very strong winds. The invasion of this destabilizing exotic species can be detrimental to nesting sea turtles as fallen trees and shallow root systems can entangle both turtle eggs as well as emergent hatchlings (National Research Council 1990).

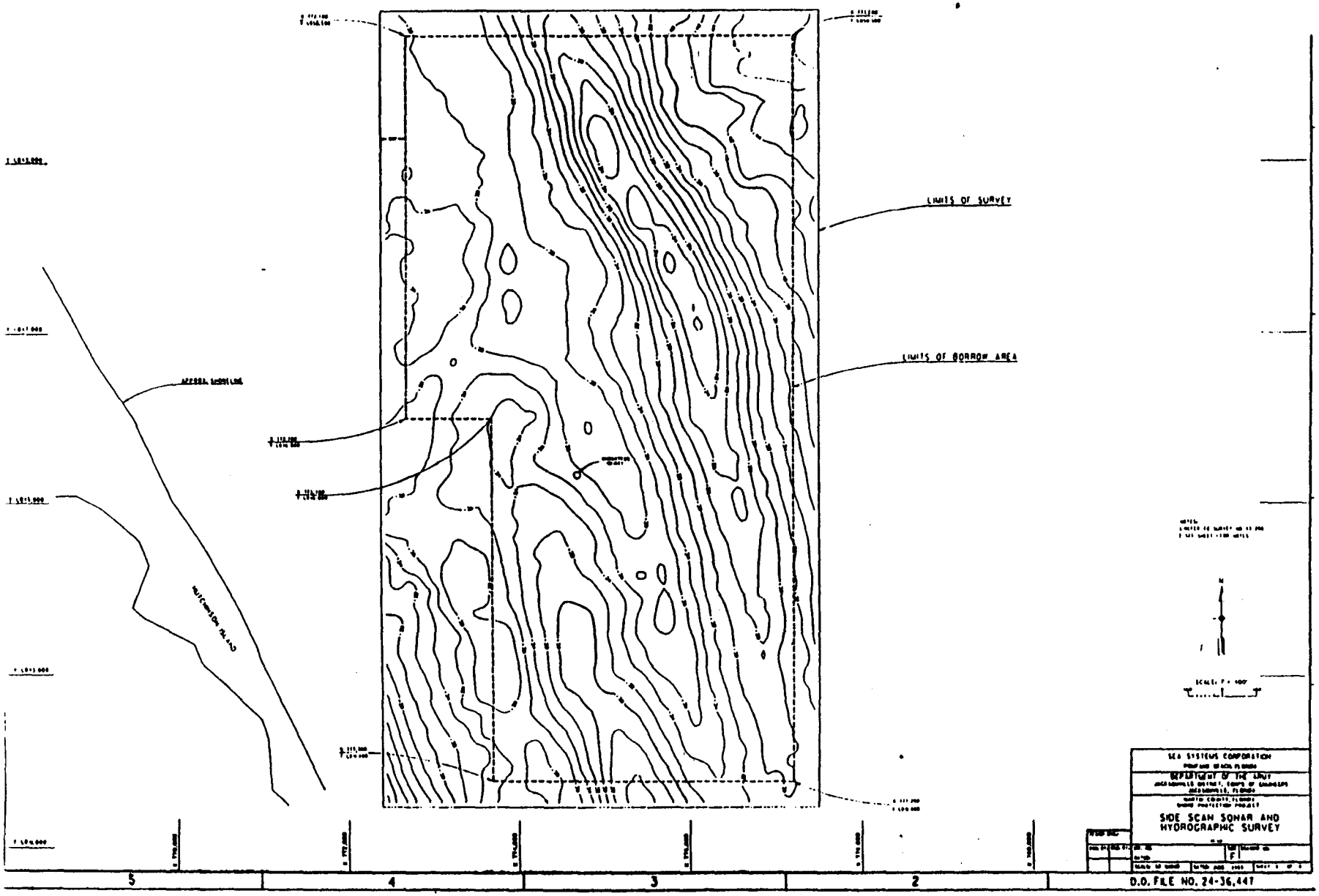


Figure 7. Side scan/bathymetric map of offshore borrow area.

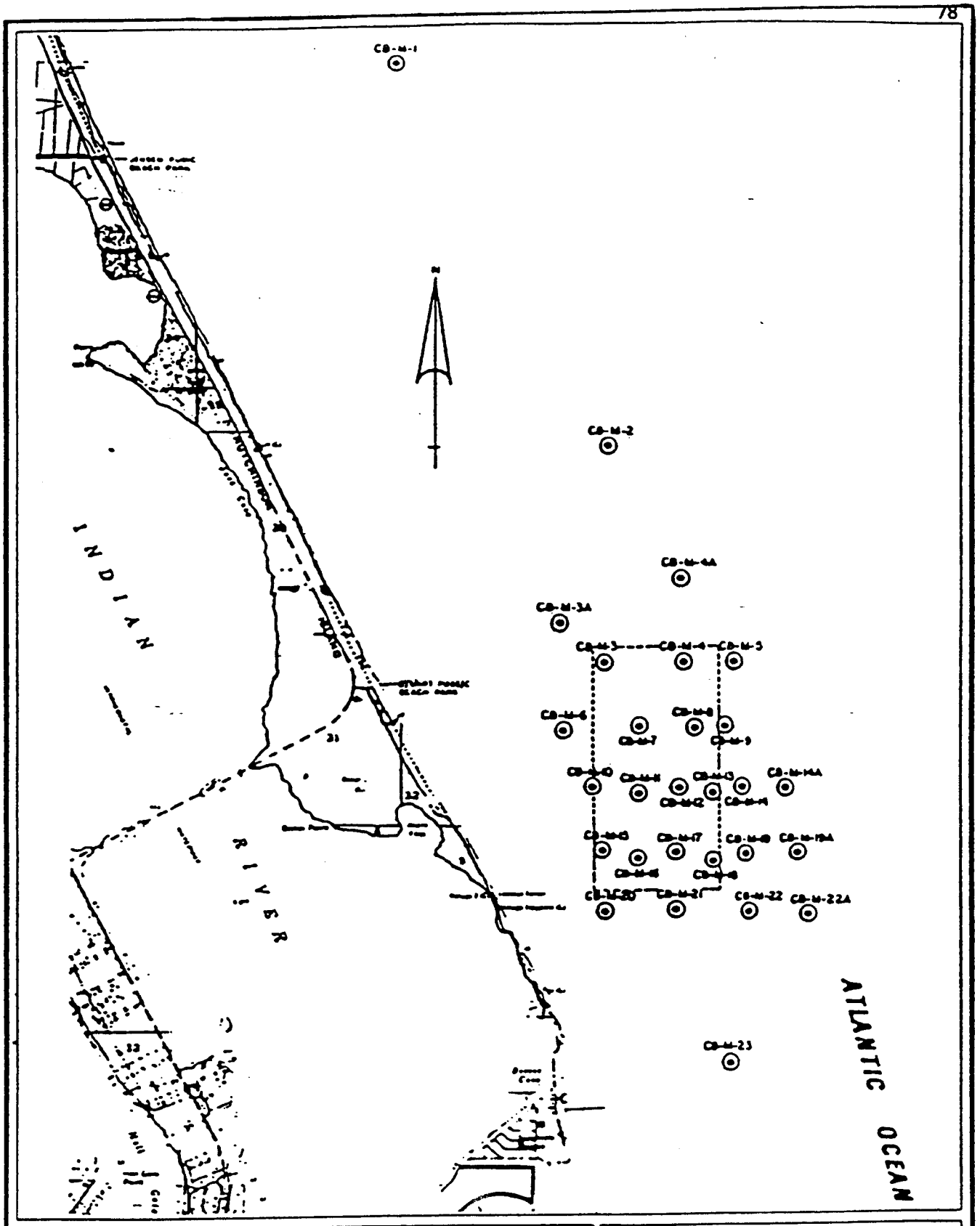


Figure 8. General locations indicating where geotechnical core borings were obtained.

SOURCE:

Applied Technology and Management, Inc. 1991.

7.02 Fish and Wildlife Resources. The biological communities found in the general project area are all well adapted to the particular physiochemical and hydrodynamic conditions associated with the supralittoral beach zone, intertidal swash zone, nearshore reefs, offshore reefs and the offshore borrow area. Because of the intermittent extensive development found throughout the project area, the majority of wildlife inhabiting the supralittoral zone likely consists of small rodents and reptiles. The motility of these species allows these organisms to seek protective refuge and forage for food in the beach grasses and tree stands that comprise a portion of this area. The beaches of Martin County are typical of south-central Atlantic coastal areas which are subject to very dynamic and stressful conditions. Inhabitants in the intertidal swash zone must cope with diurnal tides which leave many of these organisms aerially exposed for up to six hours at a time as well as being subjected to the high energy of the ocean waves. Typically, these habitats have low species diversity because of the harshness of the environmental conditions present. However, animals that are able to adapt to these dynamic conditions are faced with very little competition from other organisms. Hence, the populations that are able to survive in this dynamic zone usually consist of a very large number of individuals.

The Atlantic coquina clam (*Donax variabilis*) is a very common small mollusk that is well suited to living in areas of dynamic conditions where resuspension of material caused by wave action continually buries their burrows. With the passage of each wave, the clams rapidly dig a new burrow with their muscular foot appendage. Smaller crustaceans such as haustoriid amphipods have to continually burrow into the sand as each passing wave tends to wash away their burrows. Receding waves tend to wash amphipods and isopods out of their burrows and suspend these organisms into the nearshore water column where they serve as an important food source for many nearshore fish such as the Florida pompano (*Trachinotus carolinus*) and permit (*T. falcatus*). A variety of polychaete worms are also highly specialized for life in this dynamic environment and successfully adapt to these more turbid conditions. These intertidal organisms also provide an important food source for foraging shore and wading birds. Highly visible decapod crustaceans of the supralittoral zone include the ghost crab (*Ocypode quadrata*), mole crab (*Emerita talpoida*), and Atlantic fiddler crab (*Uca pugilator*). These organisms are highly motile and burrow into the moist sand for refuge and to retard water evaporation from their bodies during aerial exposure (Barnes 1974).

Both nearshore and offshore reefs are found along the entire Atlantic coast of Florida (Figure 9) and significantly contribute to the high biodiversity found in these areas. Limestone depositions which forms ridges and rocky outcrops and contributes

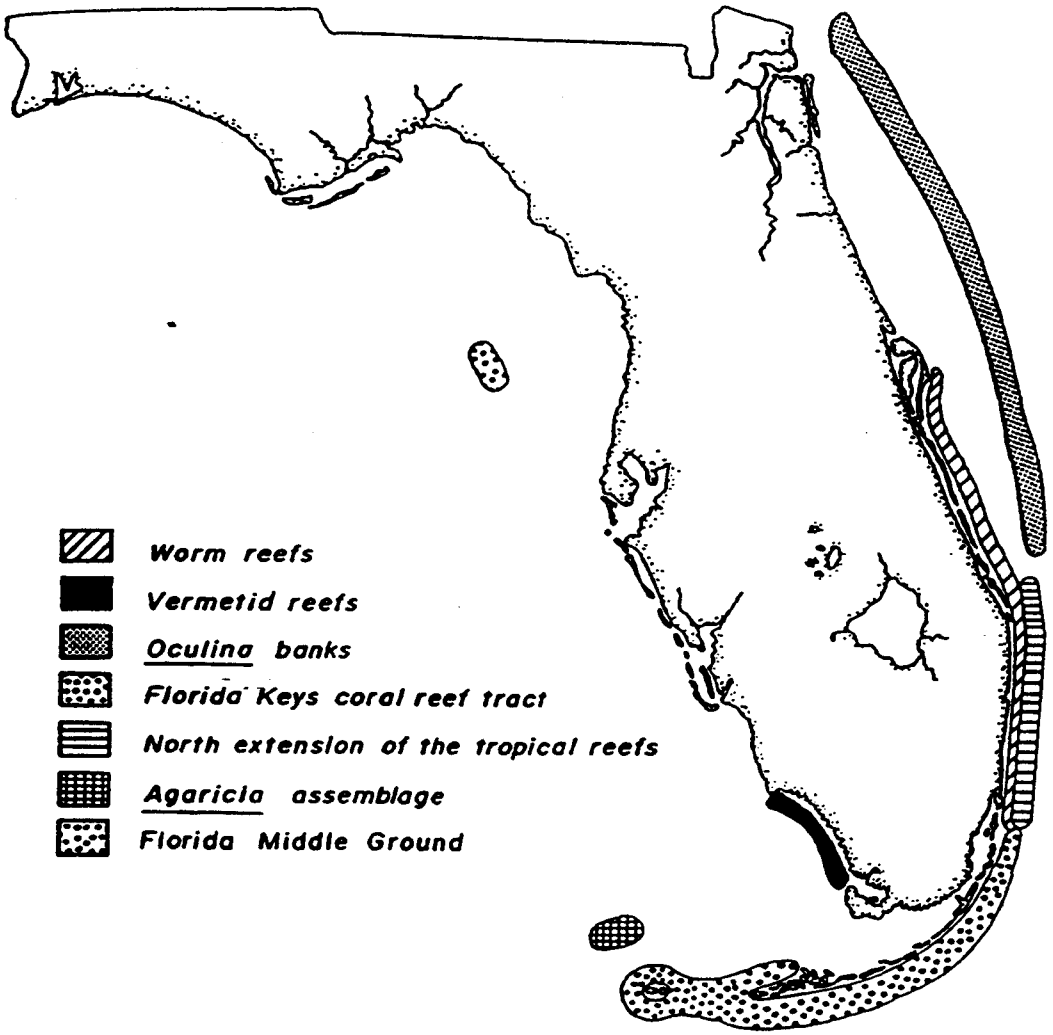


Figure 9. Distribution of Florida reef assemblages. Map units describe extent of potential habitat distribution; actual occurrences are often disjunct (patchy).

SOURCE: Japp, W. C. and P. Hallock. 1990. Coral Reefs. IN: R. L. Myers and J. J. Ewel (eds.). P. 574 - 616. Ecosystems of Florida. University of Central Florida Press. Orlando.

to live-bottom communities are found along the entire length of the project area. Live-bottom biota are among the most widely distributed benthic communities in Florida waters. Many of the rocky outcrops are carved and shaped by sand scouring and through bioerosion caused by rock-boring organisms such as clionid sponges and clams. From these erosional forces, the overall surface area of the rock structures is increased (an increase in rugosity) and forms important attachment sites for sessile organisms. The first inhabitants of these rocks usually are the attached algae. Herbivory by nearby crustaceans is well documented (Barnes and Hughes 1988) and the attached algae provide the primary food source for a wide variety of invertebrates. Crevices in these limestone outcrops provide important refuge for commercially important crustaceans such as the stone crab (*Menippe mercenaria*), blue crab (*Callinectes sapidus*) and spiny lobster (*Panulirus argus*). These limestone outcrops that form three dimensional structures provide the only vertical habitat found along vast expanses of sandy substrate. Large carnivores such as Great barracuda (*Sphyraena barracuda*), lane snapper (*Lutjanus synagris*) and yellowtail snapper (*Ocyurus chrysurus*), grouper (*Epinephelus sp.*) and sea bass (*Centropristis sp.*) are frequently found around these rocky structures. Smaller reef fish such as the sheepshead (*Archosargus probatocephalus*), porkfish (*Anisotremus virginicus*), hairy blenny (*Labrisoma nuchipinnis*), slippery dick (*Halichoeres bivittata*), and doctorfish (*Acanthurus chirurgus*) are also commonly seen foraging around the hardbottom habitat. A quantitative fish census was undertaken by the U.S. Fish and Wildlife Service and is reported in the Coordination Act Report (Appendix C).

Off the east coast of central Florida, varying vertical relief hardbottom structures are constructed by the tropical sabellarid marine bristle worm *Phragmatopoma lapidosa* (Figure 10). These worms collect sand grains of suitable size and the sand is then cemented together by mixing the sand grains with a protein mucus (Barnes 1974). The worm reefs expand as worm larvae settle on existing worm tubes and the entire process is continually repeated (Kirtley 1974, Jaap and Halloack 1991). These worm reefs provide two very important functions. First, as hardened structures, the reefs tend to help dissipate destructive wave energy. Second, the reefs provide attachment area for livebottom plants and structural habitat for a wide variety of invertebrates and fishes. Although these worm reefs are found from Cape Canaveral to Key Biscayne (Figure 9), they are best developed between St. Lucie and Martin counties off the Hutchinson Island coast.

The offshore borrow area is located in 24-36 feet (7.3m -10.9m) of water approximately 3,000 feet (909m) offshore of Hutchinson Island (Figure 4, Figure 6). Numerous species of relatively nonmotile infaunal invertebrates (mollusks) as well as motile

Figure 10. A closeup view of the marine bristle worm (*Phragmatopoma lapidosa*) collecting sand grains (white areas) for tube construction.

epifaunal invertebrates (crustaceans) may inhabit the borrow area. A side scan sonar survey of the borrow area revealed no hardbottom habitat exists within this area. An interagency team of scientists groundtruthed the borrow area utilizing SCUBA and verified that no hardbottom habitat exists within the borrow site. A team of diver biologists dove the borrow area in 1991 and collected benthic macroinvertebrates in the area as well as made a video recording of each sampling station. The substrate was described as containing fine to medium grain sand with a mixture of shell hash. The area consisted entirely of sand with no epifauna organisms seen except for the arrowhead sand dollar (*Encope emarginata*). A similar dive of the borrow area in 1993 revealed the same results. A strong current was present (approximately 0.5-1.0 knots) with arrowhead sand dollars (*E. emarginata*) scattered throughout the sandy substrate.

7.03 Threatened or Endangered Species. The approximate 206 mile (330 kilometer) stretch of beach along the Atlantic coast of Florida between St. Johns County and Palm Beach County (Figure 2) supports the largest number of nesting sea turtles in the western Atlantic (National Research Council 1990). The supralittoral zone of the project area provides nesting habitat for the endangered leatherback sea turtle (*Dermochelys coriacea*), threatened loggerhead sea turtle (*Caretta caretta*) and green sea turtle (*Chelonia mydas*). In addition, the endangered West Indian manatee (*Trichechus manatus*) frequently migrates in and out of the Indian River Lagoon through the Fort Pierce Inlet (Figure 1). During the winter months, the Atlantic coast of Florida is inhabited by migrating cetaceans such as the endangered right whale (*Eubaleana glacialis*). Table 2 and Table 3 list potential endangered and threatened species which may be found within the general project area and are under the jurisdiction of the U.S. Fish and Wildlife Service (Table 2) and National Marine Fisheries Service (Table 3). There is no designated or proposed critical habitat vital to the continued existence of any endangered or threatened species in the study area (Table 3).

7.04 Historic, Cultural, and Archeological Resources. Archival research, literature review, and coordination with the State Historic Preservation Officer (SHPO) have been completed for the Martin County Shore Protection Project. In compliance with 36 CFR Part 800, a magnetometer survey of the chosen offshore borrow area located northeast of the St. Lucie Inlet (Figure 4, Figure 8) was conducted between February 22-26, 1993. The report resulting from the fieldwork is titled *A Cultural Resource Magnetometer Survey for a Proposed Borrow Area, Martin County, Florida* by Wes Hall, Mid-Atlantic Technology. No potentially significant submerged archeological resources were identified in the offshore borrow area which will be used for the authorized project. In a May 7, 1993 letter, the SHPO concurred with the District's determination that no significant cultural resources

Table 2. List of Federally listed threatened and endangered species and candidates for Federal listing that may be present in south Hutchinson Island, Martin County

Scientific Name	Common Name	Status
Amphibians and Reptiles		
Alligator mississippiensis	American alligator	T(S/A)
Caretta caretta caretta	Atlantic loggerhead turtle	T
Chelonia mydas mydas	Atlantic green turtle	E
Dermochelys coriacea	Leatherback turtle	E
Drymarchon corais couperi	Eastern indigo snake	T
Eretmochelys imbricata imbricata	Atlantic hawksbill turtle	E
Gopherus polyphemus	Gopher tortoise	C2
Heterodon simus	Southern hognose snake	C2
Lepidochelys kempi	Atlantic ridley turtle	E
Ophisaurus compressus	Island glass lizard	C2
Pituophis melanoleucus mugitus	Florida pine snake	C2
Pseudobranchus striatus lustricolus	Gulf hammock dwarf siren	C2
Rana areolata aesopus	Florida Crawfish frog	C2
Sceloporus woodi	Florida scrub lizard	C2
Birds		
Aphelocoma coerulescens coerulescens	Florida scrub jay	T
Charadrius melodus	Piping plover	T
Dendroica kirtlandii	Kirtland's warbler	E
Falco peregrinus tundrius	Arctic peregrine falcon	T
Falco sparverius paulus	Southeastern American kestrel	C2
Haliaeetus leucocephalus	Bald eagle	E
Lanius ludovicianus migrans	Migrant loggerhead shrike	C2
Mycteria americana	Wood stork	E
Picoides borealis	Red-cockaded woodpecker	E
Polyborus plancus audubonii	Audubon's crested caracara	T
Vermivora bachmanii	Bachman's warbler	E
Mammals		
Blarina carolinensis (=brevicauda) shermani	Sherman's short-tailed shrew	C2
Neofiber alleni	Round-tailed muskrat	C2
Peromyscus (= Podomys) floridanus	Florida mouse	C2
Plecotus rafinesquii	Southeastern big-eared bat	C2
Scalopus aquaticus bassi	Englewood mole	C2
Trichechus manatus latirostris	West Indian manatee	E
Ursus americanus floridanus	Florida black bear	C2
Plants		
	Family Anonaceae	
Asimina tetramera	Four-petal pawpaw	E

Table 3. Endangered and threatened species and critical habitats under National Marine Fisheries Service jurisdiction

Florida: Atlantic Coast

Listed Species	Scientific Name	Status	Date Listed
finback whale	*Balaenoptera physalus*	E	12/02/70
humpback whale	*Megaptera novaeangliae*	E	12/02/70
right whale	*Eubaleana glacialis*	E	12/02/70
sei whale	*Balaenoptera borealis*	E	12/02/70
sperm whale	*Physeter catodon*	E	12/02/70
green sea turtle	*Chelonia mydas*	Th	07/28/78
hawksbill sea turtle	*Eretmochelys imbricata*	E	06/02/70
Kemp's (Atlantic) ridley sea turtle	*Lepidochelys kempi*	E	12/02/70
leatherback sea turtle	*Dermochelys coriacea*	E	06/02/70
loggerhead sea turtle	*Caretta caretta*	Th	07/28/78

SPECIES PROPOSED FOR LISTING
None

LISTED CRITICAL HABITAT
None

PROPOSED CRITICAL HABITAT
None

will be affected by the authorized project. No terrestrial archeological sites are recorded for the 4 mile (6.4km) eroded project beach segment of Hutchinson Island.

7.05 Water Quality. The State of Florida classifies surface waters from I (drinking water quality) to V (industrial water discharge quality). The biological composition of Class V waters is minimal due to the high toxicity of the water. The water quality around the St. Lucie Inlet and Atlantic Ocean has a State classification of III. This designation means that the surrounding waters are acceptable for recreational bathing, fishing, and wildlife management.

7.06 Hazardous, Toxic and Radioactive Wastes (HTRW). A Phase 1 HTRW study was performed. County records and numerous site inspections have shown that the area along the project shoreline consists primarily of residences and motels and is void of any heavy industry or repair shops. No hazardous or toxic wastes are believed to be in the project area or are knowingly discharged into the waters of the Indian River Lagoon or Atlantic Ocean. Due to the recreational nature of the Florida coastline, it is probable that some amount of petroleum byproduct from recreational boats and jet skies is discharged into the coastal waters adjacent to the project beach.

7.07 Aesthetic Resources. Consideration of aesthetic resources within the project study area is required by the National Environmental Policy Act of 1969 (NEPA), as amended and ER 1105-2-100. Aesthetic resources are defined as "those natural and cultural features of the environment that elicit a pleasurable response" in the observer, most notably from the predominantly visual sense. The four miles of project area public beaches have been eroded by past high tides and strong winds which have deteriorated the aesthetic character and qualities of the area. The authorized shore protection area is developed commercially and residentially and appears to be severely eroded. Residences protected by seawalls and bulkheads have been exposed due to intense wave action. Residential development appears to be in scale with the existing treeline and blends with it when viewed from a distance. Aesthetic resources of the proposed project area have been degraded annually by shoreline erosion.

7.08 Coastal Barrier Resources. The Coastal Barrier Resources Act of 1982 (Public Law 97-348) encouraged implementation of conservation measures on largely undeveloped coastal barrier islands along the Atlantic and Gulf of Mexico coasts. These conservation measures were designed to help conserve critical habitat for a variety of island flora and fauna. Due to the urbanization and highly developed nature of much of Hutchinson Island, there is little pristine or available terrestrial habitat along the immediate project area to support considerable biodiversity. The northern (St. Lucie County) half and southern

(Martin County) half of Hutchinson Island is not part of the Coastal Barrier Resources System.

7.09 Acoustical Quality. The shoreline along Hutchinson Island supports a considerable amount of human development, public recreation areas, as well as water sports such as fishing, boating, and jet skiing. As with much of the Florida coastline, noticeable noise levels are always present and normally seasonal in amplitude.

7.10 Air Quality. The coastal area of Hutchinson Island consists primarily of automobiles and heavy trucks/buses associated with human development and the tourist trade. The area consists of single family and multifamily homes, condominium complexes, and large hotels. The project area along the island does not support any heavy industry that could be associated with airborne particulates. The airborne particulates produced by motor vehicles are dispersed away from the project area with the aid of offshore ocean breezes. Martin County is designated as an attainment area for the criteia pollutants under the Clean Air Act.

7.11 Recreation. The recreation capacity and potential of the Martin County public beaches in the project area have been reduced due to the erosion of the barrier island. The eroded beach conditions do not present an appealing atmosphere for active or passive recreation use in the project area. During high tide there is very little dry beach available for passive or active recreation activities. Public parks have spent a considerable amount of money to enhance and preserve beaches for public use along high energy shorelines.

8.00 IMPACT OF THE PROPOSED ACTION.

8.01 General Environmental Setting. Numerous areas along the Hutchinson Island shoreline are primarily developed for residential, resort, and tourist accommodation purposes. Development includes restaurants, hotels, condominium complexes, and other service establishments catering directly or indirectly to tourists and other seasonal residents visiting the shore. The erosion of the shoreline along the project beach threatens to destroy many of these complexes. Extending the beach segment will make these developed areas less vulnerable to wave damage. The new beach will likely have a positive impact on the present dune system as well. Besides providing protection for the dunes from wave energy, the grasses and other beach vegetation will tend to trap wind blown sand, thereby further building up the dune system in the project area.

8.02 Fish and Wildlife Resources. Aerial photographs, side scan sonar surveys, and underwater visual assessments conducted by interagency teams of scientists have attempted to locate and "categorize" (as to their perceived ecological importance) all hardbottom reef tracts which exist adjacent to the project beach. Based upon these observations, the locations of all hardbottom areas can be found in Appendix D. Whether or not the beach nourishment project negatively impacts these hardbottom areas depends upon such variables as their distance from shore, relief, and composition (hermatypic coral, worm rock, or limestone).

Based upon 1992 shoreline surveys, expected geochemical composition of beach fill material (% fines), hydrodynamics of the nearshore project area (waves and currents), and position of hardbottom reef tracts (generally south of the project), Corps coastal engineers and biologists currently estimate that no hardbottom areas south of the project will be directly impacted (buried) by placing beach compatible sand onto the eroded project beach north of monument R-23.

Computer models have indicated that no direct impacts are expected to nearshore (depths less than -8.0 ft./-2.4m) low relief (less than 1.5 ft./0.5m) hardbottom reef tracts from implementing the project. Due to frequent scouring caused by wave energy which occurs around the hardbottom areas within the nearshore zone in depths of water less than 10-12 feet (3.0m to 3.6m), shallow water ephemeral coquina limestone outcrops and worm rock (*P. lapidosa*) generally do not support a large diversity of permanent plant and animal communities. Hard surfaces are continually scoured by resuspended sand. Encrusting soft coral, sponges, and sessile algae have a difficult time becoming established on hard surfaces in shallow water because of the constant sand scouring. The loss of these organisms represents a loss of organic carbon to the ecosystem and has a cascading "bottom up" control of higher trophic levels such as invertebrate scavengers and fish. Although these scoured ephemeral hardbottom areas are usually not of high biological quality, high relief (greater than 2 ft./0.6m) rock structures serve as important concentration areas for a large variety of commercial and sport fish. Within the nearshore project area (depths within -8.0 feet/ 2.4m), this nearshore hardbottom habitat is also potentially important to divers and snorklers. It is important to note that underwater visibility is generally poor (less than 2.0 feet/0.6m) during the winter months and throughout much of the year during periods of high wind and rain.

Sand is continually resuspended into the water column during heavy wave events. This increase in resuspended sand potentially buries low relief coquina limestone rock, scours off encrusting and sessile organisms, and negatively impacts the ability of site-dependent carnivores to visually locate their prey. Sand scouring can also create holes, crevices and ledges throughout

the rocky areas. These holes, crevices, and landward facing rock ledges formed by scouring create an excellent refuge for cryptic small fish and commercially important epibenthic invertebrates such as the stone crab (*M. mercenaria*) and spiny lobster (*P. argus*). The sloughing of beach fill sand will tend to increase sedimentation and scouring of nearshore hardbottom areas until the beach fill reaches equilibrium. In low relief ephemeral areas, this increase will present little, if any, problems since these reef areas are generally scoured or temporarily buried periodically anyway.

In reef areas that are permanent and subjected to less scouring events either through an increase in relief or distance from shore, increased sedimentation will likely cause no significant ecological impacts. Current computer models predict and Corps coastal engineers concur that it is likely that no reef tracts outside the project's influence or south of the project area will be directly impacted by the beach nourishment project. Secondary impacts from eroding sand may be experienced by hardbottom habitat and associated flora and fauna located seaward of the project beach as well as nearshore areas south of the project beach towards St. Lucie Inlet. Secondary impacts such as encrusting sponges and sessile algae being scoured off rock surfaces due to the increase in water column turbidity may occur. Holes, crevices, and hanging rock ledges may be partially or fully filled in from the increase in sand sloughing along the bottom. With the loss of autotrophic and heterotrophic invertebrates, small fish lose a valuable food source. When a protective refuge is lost, small fish become easy prey for the larger carnivores. Increases in water column sedimentation and burial of hardbottom areas may also be felt by divers and snorklers in the area as well. However, increases in turbidity and sedimentation are expected to be temporary in nature. Because background turbidity and sedimentation levels are naturally high in this area, no significant changes attributable to the beach nourishment project are expected.

Computer models currently estimate that the renourished material placed onto the project beach is expected to eventually drift south over the 11 year period until the next renourishment. The southern littoral drift of sand caused by the longshore current may eventually come into contact with up to 20.5 acres of hardbottom habitat (monument R-23 to R-42). The sand is expected to slough seaward of the project area (mainly between monuments R-2 and R-22) and gradually move south toward the St. Lucie Inlet over the 11 year period. Because of this gradual movement and naturally occurring dynamic conditions which exist south of the project area, no significant changes to these southern reef tracts are expected to occur because of the beach nourishment project. Since it is extremely difficult to accurately predict what, if any, impact will occur to these hardbottom areas without the implementation of a well planned, quantifiable monitoring

plan, a detailed description of the methods to be used to quantify and assess changes in the nearshore environment can be found in Appendix E.

As previously described in section 6.00, an underwater assessment of the borrow area indicated that no hardbottom habitat existed in this area. Because of the lack of benefits associated with high relief structures, little, if any, fish and epibenthic invertebrates are thought to permanently inhabit this area. Dredging will therefore have little, if any, impact on these organismal groups. The underwater assessment did note a large number of arrowhead sand dollars (*E. emarginata*) scattered throughout the sandy substrate. Dredging may directly impact these organisms by removing them and the increase in turbidity may bury them. These highly fecund invertebrates are expected to repopulate this area after dredging activity ceases.

8.03 Threatened or Endangered Species. Placing sand on the eroded beach has the potential to directly or indirectly harm threatened and endangered birds, mammals, and reptiles. Table 2 and Table 3 list the threatened and endangered species which may be found in and around the project area. Of the listed species, the Florida scrub jay (*Aphelocoma coerulescens coerulescens*) and the piping plover (*Charadrius melodus*) are birds which most likely may be found foraging in the supralittoral zone; the loggerhead sea turtle (*C. caretta*), the green sea turtle (*C. mydas*), and leatherback sea turtle (*D. coriacea*) will be found swimming in the offshore reefs and using the supralittoral zone for nesting; and the West Indian manatee (*T. manatus*) will be found foraging the nearshore reefs for drift algal mats as well as migrating in and out of St. Lucie Inlet.

Hutchinson Island supports the greatest concentration of sea turtle nesting activity in Florida and one of the largest loggerhead (*C. caretta*) nesting aggregates in the world (Ross 1982). Between 1985-1990, the project area produced 7,638 loggerhead (*C. caretta*), 189 green (*C. mydas*), and 55 leatherback (*D. coriacea*) sea turtle nests (Applied Biology, Inc.). As found elsewhere in Florida, the vast majority of the nests are laid during June, July, and August (Figure 11). Peak nesting activity is May through August for *C. caretta* (Table 4), June through August for *C. mydas* (Table 5), and April through June for *D. coriacea* (Table 6). Common sense tells us that widening an eroding beach will only serve to increase the total amount of nesting compatible beach available to nesting sea turtles. It is currently estimated that dredging will commence in either November or December and will continue through late March to April 15. Between 1985-1990 (6 years), a cumulative total of 2 nests were successfully dug in all of Martin County in March (an average of 0.33 nests/year) and 35 nests in April (an average of 5.8 nests/year). With this information in mind, possible impacts to nesting sea turtles are expected to minimal. Tilling of the

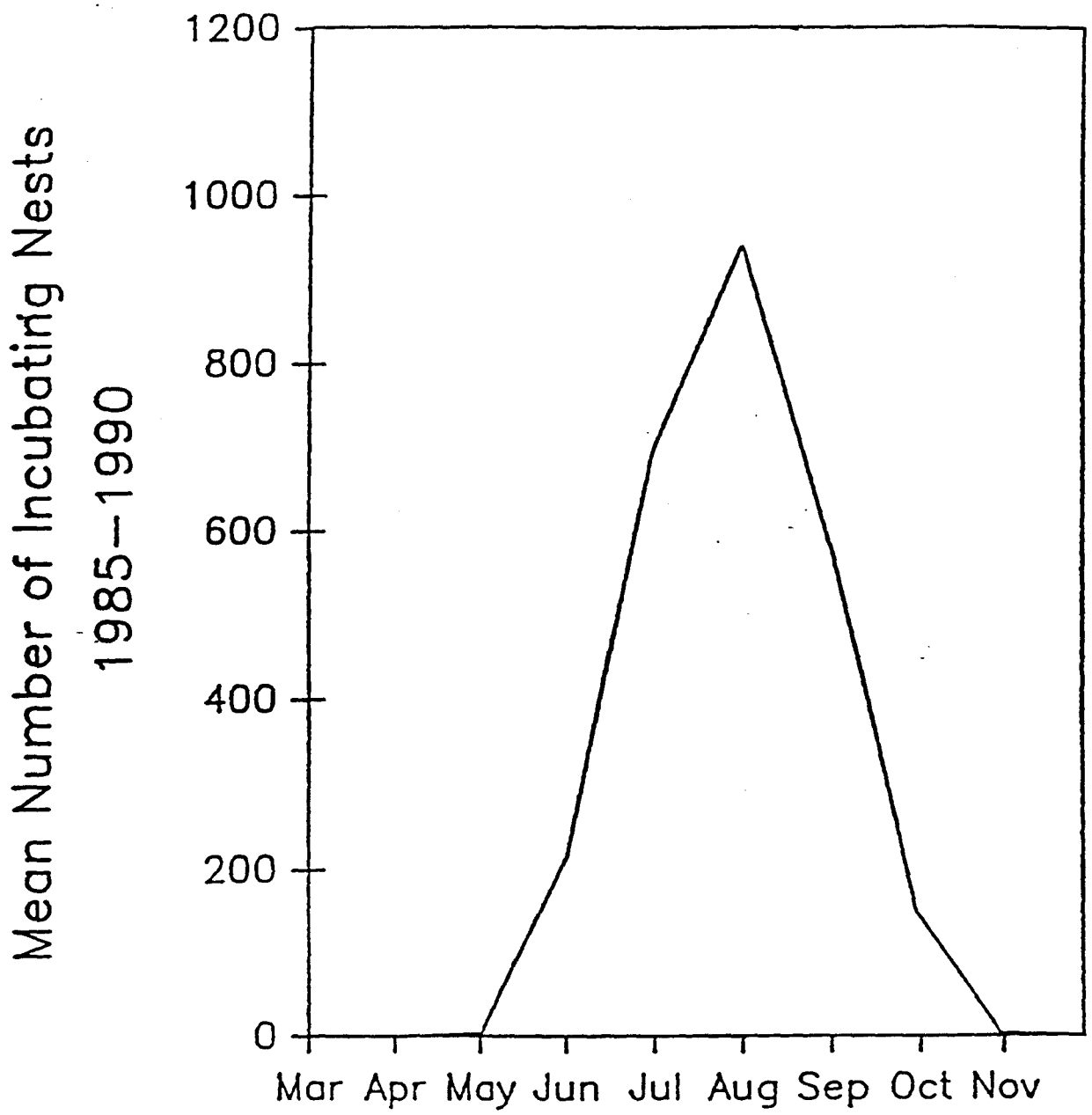


FIGURE 11. ESTIMATE OF MEAN NUMBER OF INCUBATING TURTLE NESTS THROUGH TIME FOR THE SOUTH HUTCHINSON ISLAND RESTORATION AREA, BASED ON 1985-1991 MONITORING DATA

Source: Mote Marine Laboratory, Inc., 1991.

Applied Technology and Management, Inc.

Table 4. Sea Turtle Nesting Data for the Loggerhead Turtle (*Caretta caretta*) for Hutchinson Island, Martin County, Florida: Survey Areas X Thru Inlet

	MONTH							
Year	March	April	May	June	July	Aug	Sept	Total
1985	0	2	386	827	657	217	1	2090
1986	0	2	302	892	717	177	9	2099
1987	0	0	232	663	710	317	11	1933
1988	0	0	249	840	784	185	3	2061
1989	0	4	380	613	723	216	0	1936
1990	0	17	491	866	762	703	1	2340
TOTAL	0	25	2040	4701	4353	1315	25	12459
MEAN	0.0	4.2	340.0	783.5	725.5	219.2	4.2	2076.5
STD	0.00	5.90	89.36	105.87	40.34	46.18	4.26	135.83
MIN	0	0	232	613	657	177	0	1933
MAX	0	17	491	892	784	317	11	2340

Source: Applied Biology, Inc., Stuart, Florida.

Table 5. Sea Turtle Nesting Data for the Green Turtle (*Chelonia mydus*) for Hutchinson Island, Martin County, Florida: Survey Areas X Thru Inlet

	MONTH							
Year	March	April	May	June	July	Aug	Sept	Total
1985	0	0	0	7	12	11	1	31
1986	0	0	0	4	13	8	2	27
1987	0	0	0	6	16	22	4	48
1988	0	0	0	3	14	13	3	33
1989	0	0	0	8	13	12	0	33
1990	0	0	0	15	28	17	0	60
TOTAL	0	0	0	43	96	83	10	232
MEAN	0.0	0.0	0.0	7.2	16.0	13.8	1.7	38.7
STD	0.00	0.00	0.00	3.89	5.51	4.52	1.49	11.56
MIN	0	0	0	3	12	8	0	27
MAX	0	0	0	15	28	22	4	60

Source: Applied Biology, Inc., Stuart, Florida.

Table 6. Sea Turtle Nesting Data for the Leatherback Turtle (*Dermochelys coriacea*) for Hutchinson Island, Martin County, Florida: Survey Areas X Thru Inlet

	MONTH							
Year	March	April	May	June	July	Aug	Sept	Total
1985	1	1	7	4	0	0	0	13
1986	0	0	2	3	0	0	0	5
1987	0	0	6	5	1	0	0	12
1988	1	0	5	8	0	0	0	14
1989	0	6	7	2	2	0	0	17
1990	0	3	3	1	1	0	0	8
TOTAL	2	10	30	23	4	0	0	69
MEAN	0.3	1.7	5.0	3.8	0.7	0.0	0.0	11.5
STD	0.47	2.21	1.91	2.27	0.75	0.00	0.00	3.95
MIN	0	0	2	1	0	0	0	5
MAX	1	6	7	8	2	0	0	17

Source: Applied Biology, Inc., Stuart, Florida.

beach fill, monitoring of the project beach, and relocation to the nearest and safest beach segment will be implemented. Details on this plan can be found in section 9.00 of this EA. Hydraulic dredging risks entanglement and entrapment of pelagic sea turtles. Placing borrow material that is significantly different than the sand currently found on the beach in terms of color and texture can seriously impact the ability of sea turtles to nest and the embryonic development of the eggs in the underground chamber. Past projects have seen low silt dark material lightened when oxidized and exposed to sunlight. Lighter colored sand would make the egg chamber cooler and darker colored material warmer. Each temperature change could alter the sex ratios of the developing hatchlings (Dalrymple et al. 1985). Smaller grain sizes of sand placed on the beach may increase sand compaction (Nelson 1985, Nelson and Dickerson 1988), and make it difficult or even impossible for nesting sea turtles to successfully dig an egg chamber (National Research Council 1990). Although dredging, boat traffic, and construction equipment associated with the beach nourishment project each represents potential harm to nesting sea turtles, the National Research Council (1990) has assigned a "low" or "unimportant" qualitative ranking to these activities as they relate to mortality factors of nesting sea turtles (Table 7). Section 9.00 details the safety commitments that will be undertaken by the dredge operators as well as the earth moving construction crew to ensure the safety of pelagic sea turtles as well as their eggs.

8.04 Historic, Cultural, and Archeological Resources. As stated in section 7.04, no potentially significant archeological resources were identified in the offshore borrow area which will be used for the proposed Martin County Shore Protection Project. Placement of dredged material on the beach will not affect any known terrestrial archeological resources. The State Historic Preservation Officer (SHPO) concurred with the District's no effect determination in a May 7, 1993 letter.

8.05 Water Quality. Implementation of the beach fill plan will likely create a temporary elevation in turbidity levels during the dredging, construction, beach fill, and periodic nourishment phases. The quality and general characteristics of the material used to nourish the beach is the most important variable in assessing if the beach fill material can be considered environmentally acceptable to the nearshore area. The borrow material has an acceptable silt content (5%-7%) and is coarse enough that it is expected to settle out of the water column. The composition (ephemeral limestone, worm rock) of the nearshore hardbottom habitat will likely determine the extent to which these areas may be impacted from the placement of sand onto the eroded project beach. Ephermeral low relief coquina limestone rock may be buried because of increased sedimentation but will likely be re-exposed during future sand scouring. Being a temporary entity anyway, the overall impact on these ephemeral

Sea Turtle Mortality Associated with Human Activities

Table 7. A qualitative ranking of the relative importance of various mortality factors on juveniles or adults, eggs, and hatchlings with an indication of mortality caused primarily by human activities. Sources are listed in order of importance to juveniles or adults, because this group includes the life stages with greatest reproductive values.

		Life Stage		
Source of Mortality	Primarily Human Caused	Juveniles to Adults	Eggs	Hatchlings
Shrimp trawling	yes	high	none	unimportant
Other fisheries	yes	medium to low	none	unimportant
Non-human predators	no	low	high	high
Weather	no	low	medium	low
Beach development	yes	low	medium	low
Disease	no	low	unimportant	low
Dredging	yes	low	unimportant	unimportant
Entanglement	yes	low	unimportant	low
Oil-platform removal	yes	low	none	unimportant
Collisions with boats	yes	low	none	unimportant
Directed take	yes	low	medium	unimportant
Power plant entrainment	yes	low	none	unimportant
Recreational fishing	yes	low	none	unimportant
Beach vehicles	yes	low to unimportant	medium	unimportant
Beach lighting	yes	low to unimportant	unimportant	medium
Beach replenishment	yes	unimportant	low	low
Toxins	yes	unknown	unknown	unknown
Ingestion of plastics, debris	yes	unknown	none	unknown

SOURCE: National Research Council. 1990. Decline of the Sea Turtles Causes and Prevention. National Academy Press. Washington.

reef areas is considered negligible. Worm rock (*P. lapidosa*) may actually benefit from a temporary increase in turbidity if the increase is not exceedingly large or long in duration. *P. lapidosa* is capable of using the resuspended sand grains to further build and enlarge their rock tubes. As has been discussed throughout this EA, the beach nourishment project is not expected to directly impact any hardbottom habitat within the project area or south toward St. Lucie Inlet. Although eroded sand from the renourished beach is expected to flow south, this sand is not expected to significantly adversely impact any hardbottom areas south of the project beach. However, the overall short-term and long term impact of increased turbidity and sedimentation will be quantitatively assessed with the aid of an extensive monitoring plan (Appendix E). In any instance, State water quality standards will not be exceeded (within 29 NTUs of background conditions) for turbidity.

8.06 Hazardous, Toxic and Radioactive Wastes (HTRW). The offshore dredge, onshore staging area, and the vehicles and earth moving equipment all represent potential polluters due to the possibility of accidental spillage. All motorized vehicles will be maintained and appropriate precautions taken to ensure that no hazardous or toxic wastes are dumped either on the beach or into the nearshore waters.

8.07 Aesthetic Resources. The project beach aesthetics will be improved with the restoration of the primary dune crest, construction of a 35 foot (10.6m) wide beach berm, and seaward slopes to more gradually connect the beach with the ocean. The renourished beach will resemble a more scenic oceanside setting that will represent higher aesthetic value than the existing eroded conditions. The aesthetics of the borrow area for beach quality sand will not be adversely affected by the proposed project. Temporary construction impacts to aesthetics could include some increase in noise and air pollution. Some temporary increase in water turbidity might also occur.

8.08 Coastal Barrier Resources. There are no designated coastal barrier resources within the project area that will be affected by implementation of this project. The project area is not part of the Coastal Barrier Resources System.

8.09 Acoustical Quality. There may be increases in noise levels during the beach nourishment project due to the localized increase in vehicles and machinery. This short-term increase in noise levels will be localized in nature to the project area and will cease once the beach nourishment project is completed.

8.10 Air Quality. Small amounts of air toxicants can be expected to originate from project vehicles and machinery during the beach fill construction phase. These vehicles and machines

will be well maintained in order to reduce the unnecessary release of air toxicants into the atmosphere. Regardless, any toxicant released into the atmosphere is expected to be rapidly dispersed away from the project area by ocean generated breezes.

8.11 Recreation. Recreation on the public beaches will be temporarily interrupted by the shore protection project. The project beach recreation quality, capacity and potential will most likely increase with the shore protection project. The public beach areas will regain their appeal for passive and active recreation use. The entire project area will be restored to a pleasant and enjoyable resource again.

9.00 ENVIRONMENTAL COMMITMENTS.

The U.S. Army Corps of Engineers as well as Martin County and its contractors commit to avoiding, minimizing or mitigating for adverse effects during and after construction activities by including the following commitments in the project contract plans and specifications:

(1) The contractor shall inform dredge personnel of the potential presence of sea turtles in the project area, the turtles' endangered status, the need for precautionary measures, and the Endangered Species Act prohibition on taking sea turtles. Every effort will be made to undertake this project primarily during the winter months (November-March) when any sea turtle in the area will be offshore of Hutchinson Island foraging on the offshore reefs. The project beach will be monitored and any nest in danger of construction activities will be relocated. A complete discussion of the precautions that will ensure the safety of nesting sea turtles can be found in section 8.03 of this EA as well as Appendix C.

(2) Precautions will be taken by the contractor during construction activities to insure the safety of the manatee. To insure the contractor and his/her personnel are aware of the potential presence of the manatee foraging in the project area, its endangered status and the need for precautionary measures, the contract specifications will include the standard protection clauses concerning the manatee.

(3) The contractor will instruct all personnel associated with construction of the project about the potential presence of manatees in the borrow area, nearshore reef areas, the entrance to the St. Lucie Inlet and the need to avoid collisions with manatees. All personnel will be advised that there are civil and criminal penalties for harming, harassing, or killing manatees, which are protected under the Endangered Species Act and the Marine Mammal Protection Act. The contractor shall be held

responsible for any manatee harmed, harassed, or killed as a result of the construction of this project.

(4) If a manatee is sighted within 100 yards (90.9m) of the dredging area, appropriate safeguards will be taken by the contractor, including suspension of dredging, if necessary, to avoid injury to manatees.

(5) Turbidity will be monitored at both the dredging and discharge sites. Should the monitoring reveal turbidity levels above State standards in the vicinity of the dredge, work will be suspended until turbidity levels return to within State standards.

(6) All practical measures will be taken by the construction crew to avoid adverse impacts to hardground habitat and associated communities. These measures have included predredging surveys to locate all hardground areas. Above water surveys have been completed by the U.S. Fish and Wildlife Service and underwater surveys have been conducted by an interagency team of diver biologists. Anchoring of any dredge barge will be permitted in sandy areas only.

(7) The project area and the area south toward the St. Lucie Inlet will be monitored to document and quantify what changes, if any, are occurring to the hardbottom habitat south of the project (monuments R-23 to R-42). A proposed monitoring and mitigation plan can be found attached as Appendix E of this Final EA.

10.00 COMPLIANCE WITH ENVIRONMENTAL REQUIREMENTS.

10.01 National Environmental Policy Act of 1969, as amended. Environmental information on the project has been compiled and this Draft Environmental Assessment (DEA) was prepared and circulated to appropriate local, State, and Federal agencies as well as interested academic institutions and citizens prior to finalization in accordance with the National Environmental Policy Act (NEPA). Comments received from these sources have been addressed in the Final Environmental Assessment. Letters of comment are included in Appendix G.

10.02 Endangered Species Act of 1973, as amended. A list of endangered, threatened, proposed, or candidate species was received from the U.S. Fish and Wildlife Service (FWS) dated December 16, 1992, and from the National Marine Fisheries Service (NMFS) dated November 16, 1992. Consultation was initiated with the NMFS on August 27, 1993, with the submittal of a Biological Assessment (BA). Concurrence with the determination that populations of endangered/threatened species under the purview of the NMFS will not be adversely affected by the project was

completed on September 15, 1993. Consultation was initiated with USFWS on November 3, 1992, with a request for a list of Federal threatened and endangered plants and animals that may be potentially present in and around the borrow area and beach nourishment project area. The BA was sent to the FWS on August 23, 1993. Previously, the USFWS provided the Corps with a Biological Opinion (BO) dated February 8, 1989. Under Section 9 of the Endangered Species Act, this BO allowed for the relocation of sea turtle eggs, where necessary (see Appendix C). This policy has recently been changed to further minimize incidental take of sea turtles and the FWS now recommends that beach nourishment activities be conducted outside of the nesting season (approximately March 1-November 30 in this area). The Corps does not believe that this recommendation is scientifically justified (Section 8.03) and has recently brought this turtle nesting data information to the attention of the FWS (Appendix F). Based on this information, the Corps was notified on November 3, 1993, via telephone that the FWS would modify their BO to allow dredging between November 1 and April 15. Refer to the summary section in the Fish and Wildlife Coordination Act Report, Appendix C. This project has been fully coordinated under the Endangered Species Act; therefore, is in full compliance with the Act.

10.03 Fish and Wildlife Coordination Act of 1958, as amended. The purpose of this Act is to require the Corps to consult with the FWS and the appropriate State fish and wildlife agencies to seek their expert input into how best to manage and modify, if needed, the selected project plan that will help minimize or eliminate any potential adverse impacts to these biological resources. The Corps has been in close contact throughout the field assessment and planning process with FWS and the Florida Department of Environmental Protection. The FWS has assessed the biological resources of the project area and their analysis, comments, and recommendations concerning potential impacts of the project can be found in the attached *Fish and Wildlife Coordination Act Report* (Appendix C). To summarize, the FWS recommends that (1) aerial photographs of the nearshore project area be taken to further quantify the amount of hardbottom habitat which exists adjacent to the project area; (2) impacts to the nearshore hardbottom habitat within the southern 2,500 feet (758m) be avoided (anything south of monument R-23) because of the presence of nearshore hardbottom habitat; (3) all impacted hardbottom habitat should be mitigated for; (4) at least one acre of designed reef should be deployed before sandpumping begins; and (5) all beach nourishment activities be conducted outside of the sea turtle nesting season (the FWS Turtle Coordinator advises after November 1 and before April 15). This Draft Environmental Assessment (EA) with the Proposed Hardbottom Monitoring and Mitigation Plan (Appendix E) responds and addresses these recommendations. With the above consultations, the requirements put forth by this Act have been met.

10.04 National Historic Preservation Act of 1966, as amended. 16 USC 470 et seq., as amended by PL 102-575, 2 Nov 92. The head of any Federal Agency having direct or indirect jurisdiction over a proposed Federal or Federally assisted undertaking shall take into account its effect on any district, site, building, structure, or object that is included, or is eligible for inclusion in the National Register of Historic Places (Advisory Council on Historic Preservation Regulations, 36 CFR Part 800, 44 F.R. 6068, 30 Jan 79).

Consideration of effects are addressed in the body of this NEPA document and comments have been received from the State Historic Preservation Officer (SHPO). The SHPO concurred with the District's determination that there are no significant cultural resources in the proposed borrow area and that placement of sand on the beach will not affect cultural resources included in or eligible for inclusion in the National Register of Historic Places.

10.05 Archeological and Historic Preservation Act (PL 93-291). Cultural resource coordination with the SHPO was conducted for the proposed beach nourishment project. In a May 7, 1993 letter, the SHPO concurred with the District's determination that the proposed project would have no effect on significant cultural resources.

10.06 Executive Order 11593. In compliance with this Executive Order, cultural resource investigations were conducted and the beach nourishment project was coordinated with the SHPO. No known resources included in or eligible for inclusion in the National Register of Historic Places will be affected by the proposed project.

10.07 Clean Water Act of 1972, as amended. This study is in partial compliance. Full compliance will be achieved with issuance of a Section 401 permit from the State. A Section 404(b) Evaluation is included in this report as Appendix A.

10.08 Clean Air Act of 1972, as amended. Martin County is designated as an attainment area for the criteria pollutants under the Act and is not governed by a State Implementation Plan (SIP). Since the project area is within an attainment area the EPA rules for conformity determination do no apply. No permits will be required for this project. The project is in full compliance with the Act.

10.09 Coastal Zone Management Act of 1972, as amended. A Federal consistency determination in accordance with 15 CFR 930 Subpart C is included in this EA as Appendix B. The GDM and draft EA was reviewed for consistency by the State of Florida. In a letter dated March 9, 1994 (Appendix G), the State Clearinghouse stated that the project is consistent with the

Florida CZMP at this stage. Final consistency will be obtained when water quality certification is issued by the State.

10.10 Farmland Protection Policy Act of 1981. No prime or unique farmland will be impacted by implementation of this project. This act is not applicable.

10.11 Wild and Scenic River Act of 1968, as amended. No designated Wild and Scenic river reaches will be affected by project related activities. This act is not applicable.

10.12 Marine Mammal Protection Act of 1972, As Amended. Incorporation of the safe guards used to protect threatened or endangered species during dredging and disposal operations will also protect any marine mammals in the area, therefore, this project is in compliance with the Act.

10.13 Estuary Protection Act of 1968. No designated estuary will be affected by project activities. This act is not applicable.

10.14 Executive Order 11990, Protection of Wetlands. There is no submerged aquatic vegetation within the project area. Therefore, the goals of this Executive Order are not applicable.

10.15 Executive Order 11988, Floodplain Management. The selected plan is in the base floodplain (100-year flood) and has been evaluated in accordance with Executive Order 11988. Refer to the main body of the GDM. This project is in compliance with the goals of this Executive Order.

11.00 COORDINATION. This proposed project has been coordinated with the following agencies: U.S. Fish and Wildlife Service, National Marine Fisheries Service, U.S. Environmental Protection Agency, Florida State Historic Preservation Officer (SHPO), and the Florida Department of Environmental Protection. A Draft Environmental Assessment (DEA) was circulated for agency review prior to its preparation as a Final Environmental Assessment. Letters of comment on the DEA can be found in Appendix G.

12.00 PUBLIC INVOLVEMENT. A Scoping Letter describing the project and soliciting comments was sent to interested governmental agencies, academic institutions, and the interested public on December 10, 1992. Letters of comment resulting from scoping can be found in Appendix F. The DEA was circulated for a forty-five (45) day public review. Letters of comment on the DEA and responses to any significant comments are in Appendix G.

The Draft Environmental Assessment was sent to the following agencies and interested parties:

U.S. Environmental Protection Agency, Washington, D.C.
U.S. Department of Commerce (NOAA), Washington, D.C.
Federal Maritime Commission, Washington, D.C.
Federal Emergency Management Administration, Washington, D.C.
Department of the Interior, Washington, D.C.
Department of Energy, Washington, D.C.
Advisory Council on Historic Preservation, Washington, D.C.
Department of Housing and Urban Development, Atlanta, Georgia
Regional Director, U.S. Fish and Wildlife Service, Atlanta, GA
U.S. Fish and Wildlife Service, Vero Beach, Florida
Seventh Coast Guard District, Miami, Florida
U.S. Environmental Protection Agency (Region 4), Atlanta, Georgia
Insurance and Mitigation Division (FEMA), Atlanta, Georgia
U.S. Geological Survey, Stuart, Florida
National Marine Fisheries Service, Panama City, Florida
National Marine Fisheries Service, St. Petersburg, Florida
Florida State Clearinghouse, Tallahassee, Florida
Florida Department of Environmental Protection, Tallahassee, FL
Florida Dept. of Env. Protection, Port St. Lucie, Florida
Florida Division of Historic Resources, Tallahassee, Florida
Florida Game and Fresh Water Fish Commission, Vero Beach, Florida
Florida Marine Fisheries Commission, Tallahassee, Florida
South Florida Water Management District, West Palm Beach, Florida
Treasure Coast Regional Planning Council, Palm City, Florida
Indian River Lagoon National Estuary Program, Melbourne, Florida
St. Lucie County Department of Public Works, Fort Pierce, Florida
Board of County Commissioners, Stuart, Florida
Superintendent of Beach & Waterways, Martin Co., Stuart, Florida
County Engineer, Martin County, Stuart, Florida
Honorable Connie Mack, Tallahassee, Florida
Honorable Bob Graham, Tallahassee, Florida
Honorable Tom Lewis (16th District), Palm Beach Gardens, Florida
Florida Audubon Society, Maitland, Florida
Florida Wildlife Federation, Tallahassee, Florida
Wilderness Society, Coral Gables, Florida
Prof. John Gifford, University of Miami (RSMAS), Miami, Florida
Harbor Branch Oceanographic Inst., Fort Pierce, Florida
Florida Shore & Beach Preservation Association, Stuart, Florida
Applied Technology & Management, Inc., West Palm Beach, Florida
Applied Technology & Management, Inc., Gainesville, Florida
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16.00 APPENDICES.

Appendix A - Section 404(b) Evaluation

Appendix B - Florida Coastal Zone Management Program Federal Consistency Evaluation

Appendix C - Fish and Wildlife Coordination Act Report

Appendix D - Location of Hardbottom Habitat

Appendix E - Proposed Hardbottom Monitoring and Mitigation Plan

Appendix F - Relevant Correspondence

Appendix G - Comments and Responses to the Draft Environmental Assessment

Appendix A

Section 404 Evaluation Report

Martin County Shore Protection Project

Hutchinson Island, Martin County, Florida

SECTION 404 (b) EVALUATION REPORT
MARTIN COUNTY SHORE PROTECTION PROJECT
HUTCHINSON ISLAND, MARTIN COUNTY, FLORIDA

I. Project Description

a. Location. Martin County is located along the southeastern Atlantic coast of Florida approximately 38 miles (61km) north of the City of West Palm Beach. The coastal City of Stuart is located in the eastern portion of the county facing the Indian River Lagoon. The project beach is located on a barrier island with the Indian River Lagoon (and Stuart) to the west. Hutchinson Island is a 24.0 mile (38.4km) long barrier island with Fort Pierce Inlet to the north, St. Lucie Inlet to the south, the Indian River Lagoon to the west, and the Atlantic Ocean to the east.

b. General Description of Project. The beach nourishment project authorizes construction of a protective and recreational beach along a 4.0 mile (6.4km) reach of eroded shoreline from Florida Department of Environmental Protection (DNR) monument number R-1 at the St. Lucie/Martin County line to 0.25 miles (0.4km) south of the southern boundary of Stuart Public Beach Park (monument R-25). In order to eliminate or reduce the risk of beach fill impacting nearshore hardbottom habitat along the project area, the project has been shortened by approximately 2,000 feet (606m). Beach fill will be placed between monuments R-1 and R-23 (the hardbottom habitat begins just south of R-22). The fill will be tapered between R-21 and R-23 (Figure 3) to avoid direct impacts to hardbottom habitat. No beach fill will be put on the beach south of monument R-23. Fill material will be obtained from a borrow area located approximately 3,000 feet (909m) offshore of the barrier island. The dune system which currently affords some protection of the existing residential and commercial development in the project area are low and have been observed to be receding each year. The dune system will be rebuilt along the entire length (R-1 to R-25) of the authorized project.

c. Authority and Purpose. A study of the erosion problems occurring along the Martin County shoreline was conducted at the request of the Committee on Public Works in a resolution dated 18 May 1973. The Martin County Shore Protection Project was authorized in the Water Resources Development Act of 1990. The authorized project allows for the restoration of a protective and recreational beach along the 4.0 miles (6.4km) of shoreline from the St. Lucie/Martin County line (monument R-1) south to 0.25 miles (0.4km) south of monument R-25. The *Revised Feasibility Report with Environmental Impact Statement* was published in June of 1986.

d. General Description of Dredged or Fill Material

(1) General Characteristics of Material. The most recent geotechnical investigations were undertaken in 1990. The existing beach material varies in shell and silt content throughout the beach. The composite mean grain size is 1.91 phi (0.27mm) with a composite sorting (+/- standard deviation) of 1.41 or moderately sorted. The estimates of shell content ranged from 1 to 95 percent, with a mean value of 27 percent. Silt content along the existing beach has a mean value of approximately 5 percent. The offshore borrow material from Gilbert Shoal is generally coarse to medium calcareous sand with a grain size averaging 1.41 phi (0.38mm). As the calcareous material is composed of shell with a low silt content (approximately 5%), it has been determined that the shoal material is suitable for beach nourishment.

(2) Quantity of Material. It has been estimated that the offshore Gilbert Shoal borrow area contains approximately 6.0 million cubic yards of clean sand, the majority of which has a silt content of less than 5%-7%. The majority of the material is coarse calcareous sand with varying amounts of quartz. A geotechnical comparison (mean grain size and silt content) between the material currently on the beach and the material in the offshore borrow area demonstrates that these materials are similar and would be compatible as a beach nourishment source. It is estimated that the project beach will require approximately 1,000,000 cubic yards of beach compatible fill material.

(3) Source of Material. The shoal of interest (borrow area) is located 3.0 miles (4.8km) north of St. Lucie Inlet and 3,000 feet (909m) offshore of the southern portion of Hutchinson Island in approximately 30 feet (9.1) of water. An underwater visual assessment undertaken by an interagency team of diver biologists revealed that no productive habitat (seagrass, coquina limestone rock, worm rock) exists anywhere within the boundaries of the borrow area.

e. Description of the Proposed Discharge Site

(1) Location. The authorized project calls for construction of a protective and recreational beach along a 4.0 mile (6.4km) reach of shore beginning just south of the St. Lucie/Martin County line (monument R-1) and continuing south to approximately 0.25 miles (0.4km) south of monument R-25. The sand currently in the project area experiences severe erosional problems from the dynamic oceanographic conditions common to this area of the Atlantic coast of Florida. Sand is continually scoured away and redistributed during winter northeast storms and

summertime thunderstorms. Because of the presence of nearshore hardbottom habitat, the authorized project has been redesigned (shortened to 3.75 miles/6.0km) to lessen possible environmental impacts.

(2) Size. It is currently estimated that approximately 1,000,000 cubic yards of beach compatible fill material will be placed upon a portion of the significantly eroded beach along the southern half Hutchinson Island in Martin County between monuments R-2 and R-22. The beach fill will be tapered at the northern (R-1 to R-2) and southern (R-21 to R-23) ends of the redesigned project.

(3) Type of Site. The disposal site is a segment of eroded beach consisting primarily of existing calcareous sand, sparse salt-tolerant beach vegetation and a low lying dune system. Because of the steep slope of the beach and the vulnerability of this coastline to severe northeast storms, the nearshore zone is extremely dynamic with sand scouring and ephemeral conditions present throughout.

(4) Type of Habitat. The supralittoral zone habitat consists primarily of eroding carbonate and shell sand. A low lying dune system is present with sparse grasses and other salt tolerant vegetation inhabiting this area. The intertidal swash zone is thought to consist of primarily infaunal mollusks, crustaceans, and polychaete worms. Seaward of these zones, the inshore reef habitat is influenced by storm wave scour which periodically buries these structures. Sabellarid tropical worm reefs are located throughout the project area at various distances from shore. The majority of the nearshore hardbottom habitat is located at the southern end of the project area between monuments R-22 and R-25.

(5) Timing and Duration of Discharge. The initial construction phase of the authorized project is estimated to begin approximately December 1994. Once construction activities commence, it is anticipated that the project will require approximately 4 months to complete. Every effort to adhere to this schedule will be made in order to lessen any possible impacts to nesting sea turtles (the major portion of the nesting season generally begins along the project beach by mid-April). The U.S. Fish and Wildlife Service recommends that construction activities commence after November 1 and end prior to April 15.

f. Description of Disposal Method. Beach compatible fill will be excavated from the offshore Gilbert Shoal borrow area. The material will be graded and shaped by earthmoving equipment in order to achieve the desired beach profile.

II. Factual Determinations

a. Physical Substrate Determinations.

(1) Substrate Elevation and Slope. The cross-sectional configuration of the beach fill for the redesigned project provides for a protective and recreational beach from just south of the St. Lucie/Martin County line (Florida Department of Environmental Protection (DNR) monument marker R-2) to just south of DNR monument marker R-22. The beach fill will be tapered between DNR monuments R-1 and R-2 at the northern end and between R-21 and R-23 at the southern end. The beach fill design cross section will restore a primary dune crest 20 feet (6.1m) wide at +12.5 feet (3.8m) mean sea level (MSL), a 35 foot (10.6m) wide beach berm at +8.0 feet (2.4m), and seaward slopes of 1V:8 1/2H to 0 mean low water (MLW), then 1V:20H to the existing bottom.

(2) Sediment Type. The beach compatible sand to be used as beach fill material will be obtained from the offshore Gilbert Shoal borrow area. The sand is primarily calcareous with a mixture of shell and contains a small (5%-7% or less) amount of silt.

(3) Dredge/Fill Material Movement. The fill material will be subject to erosion by waves with the net movement of fill and upland material expected to be seaward, forming an offshore bar. This bar will be subject to littoral transport to the south by longshore currents. The eroded beach fill material is expected to move offshore and south towards the St. Lucie Inlet. Approximately 20.5 acres of hardbottom habitat exists south of the project area between R-23 and R-42. An assessment of the environmental consequences of this movement on hardbottom areas has been thoroughly discussed throughout the Final EA.

(4) Physical Effects on the Benthos. Non-motile benthic organisms may be directly buried by the beach fill and those found in the borrow site could be excavated. Some burrowing organisms may be able to burrow up through the fill material. Attached epifauna seaward of the project area may be impacted by both direct burial and short-term increases in turbidity levels. Because of the high fecundity and high turnover rate of many benthic invertebrates, recolonization in the project and borrow area by these species is expected in a relatively short period of time (usually within a matter of months). A significant portion of the benthos along the nearshore zone adjacent to the project beach consists of tropical sabellarid worm (*Phragmatopoma lapidosa*) and ephemeral coquina limestone reefs. These structures are periodically buried and reappear due to shifting sand. Because of the dynamic conditions that they are readily adapted to (sand scouring, periodic burial), it is unclear as to

whether placing beach compatible material on an eroding beach will have any long term adverse impacts to these reefs. Further speculation and discussion of possible impacts along with proposed monitoring and mitigation is discussed in considerable detail in Appendix E of this Final EA.

(5) Other Effects. Elevated turbidity levels attributed to the beach nourishment project in the nearshore swash zone will be a temporary condition. Organisms inhabiting the intertidal zone are primarily burrowers which are readily adapted to being periodically buried by resuspended material as well as sabellarid worms which use resuspended material to build their hardened tubes. Dynamic conditions that currently exist in the nearshore zone adjacent to the project area have forced organisms living in this area to adapt to natural conditions such as periodic resuspension of material into the water column as well as sand scouring and burial.

b. Water Circulation, Fluctuation and Salinity Determinations

(1) Water.

(a) Salinity. Because of water movement in and out of the project area from the dynamic oceanographic conditions found along the Atlantic coast in this area, placement of carbonate and shell fill is not expected to cause any change to the salinity of nearshore waters.

(b) Water Chemistry. The shell and carbonate fill does not readily break down in water. Therefore, no significant long term changes in the chemical makeup of the nearshore environment are anticipated.

(c) Clarity. There will be a temporary increase in turbidity during the construction process. The fill material is dense (low silt content) and will resist resuspension in the water column. The oceanographic conditions in this area are very dynamic and beach material is constantly being eroded away and resuspended by wave energy. Therefore, short-term elevated turbidity levels during the construction phase are not expected to significantly alter background water clarity seaward of the project area.

(d) Color. Fill placement will have no long-term or significant impact.

(e) Odor. The fill material is an odorless mixture of

shell and carbonate sand.

(f) Taste. Beach compatible fill material will have no effect on the taste of nearshore waters.

(g) Dissolved Gas Levels. Even with elevated turbidity levels during construction and possible reduction in autotrophic organisms normally associated with this condition, no reduction in dissolved gas levels is expected. Because of the nearshore water agitation caused by breaking waves, dissolved oxygen levels in the water column should not experience any significant reduction.

(h) Nutrients. The beach fill material consists primarily of a mixture of calcareous sand and shell with small amounts of quartz. Because of the low silt content of the material (5%-7% or less), no increase in nutrient levels is expected.

(i) Eutrophication. Because of water exchanges from tides and currents, no significant buildup of macronutrients in the project area is expected. Therefore, there will be no change in the trophic status of the nearshore waters.

(2) Current Patterns and Circulation.

(a) Current Patterns and Flow. The most significant ocean current that exists off the east coast of Florida is the Gulf Stream. With the exception of intermittent local reversals, its flow is northward. The average annual current velocity is approximately 28 miles (45km) per day, about 17 miles (27 km) per day in November and about 37 miles (59km) per day in July. In the study area, offshore and longshore transport of materials is also seasonal in nature. In the winter, the southward littoral movement is the dominant direction of the longshore current.

(b) Velocity. Based on available data (1978), the average wave period that strikes the shoreline along much of Hutchinson Island is about 6.7 seconds. Placing beach fill on an eroding beach is not expected to impede or change water movement along the shoreline. The project would have no adverse impact. The wind generated waves and currents are the primary causes of losses of sand from the beaches, and cause most of the shoreline damage in the project area.

(c) Stratification. Because of the dynamic oceanographic conditions and currents originating from the Fort Pierce Inlet, it is highly unlikely that thermal or haline stratification ever exists. The project will have no adverse impact.

(d) Hydrologic Regime. The project will have no adverse impact.

(3) Normal Water Level Fluctuations. - Tides along Hutchinson Island are semidiurnal (two nearly equal high waters and two nearly equal low waters each tidal day). The mean range of tides along Hutchinson Island is 2.6 feet (0.8m), and the spring tidal range is approximately 3.0 feet (0.9m). Wind set-up (piling up of water on the shoreline) has significantly more effect on seasonal and long-term water fluctuations than astronomical tides. The average annual wave height seaward of the intertidal swash zone along Hutchinson Island is about 2.1 feet (0.6m). The project will present no changes to the tidal regime along Hutchinson Island as the tidal ranges along the shoreline are influenced by both astronomical as well as climatic factors.

(4) Salinity Gradients. Because of constant water exchange from tidal and wind generated forces, salinity in the project area is approximately at open ocean levels (35 parts per thousand). The project will have no impact.

c. Suspended Particulate/Turbidity Determinations.

(1) Expected Changes in Suspended Particulates and Turbidity Levels in Vicinity of Disposal Site. It is anticipated that there will be a temporary increase in turbidity levels seaward of the project area during construction. This short-term increase may have an adverse impact on nonmotile autotrophs and heterotrophs such as periphyton, drifting phytoplankton, sponges, soft corals, and mollusks. These highly fecund organisms usually repopulate the project shoreline within a matter of weeks to months. This elevated turbidity level will be temporary in nature and isn't expected to be significant as state standards for turbidity will not be exceeded (less than 29 NTUs above background levels).

(2) Effects on Chemical and Physical Properties of the Water Column.

(a) Light Penetration. The placement of fill material will temporarily reduce light transmission in the intertidal zone during construction due to elevated levels of suspended particulates. Because of the density of the fill material, this adverse impact is expected to be temporary and short-term in nature.

(b) Dissolved Oxygen. Due to the low level of organic material in the borrow/fill material, anoxic layers of sediment exposed by dredging are anticipated to be minimal. An underwater visual inspection of the borrow site revealed clean sand throughout the area with no sightings of organic muds.

(c) Toxic Metals. Due to the clean nature of the calcareous borrow/fill material, toxic materials will not be introduced into the water column.

(d) Pathogens. No pathogenic material is expected to be involved with the project.

(e) Aesthetics. Aesthetic quality will be temporarily reduced during the beach construction period, but there will be a long term increase in the aesthetic quality of the project area once the eroded beach is restored.

(3) Effect on Biota.

(a) Primary Production/Photosynthesis. Elevated turbidity levels from resuspended beach fill may have an insignificant adverse impact on drifting autotrophic organisms in the immediate nearshore waters adjacent to the project beach. It is anticipated that this will be a temporary and short-term phenomenon. Exposed intertidal rock provides a valuable attachment surface for photosynthetic algae. If these intertidal rock structures are permanently buried, these organisms and their ecological functions will be lost. Ephemeral hardbottom habitat is subjected to periodic burial as well as scouring from resuspended sand. Every time this condition occurs, it is likely that a portion of the sessile autotrophic population is lost. Because of nearshore water exchange from tidal and wind generated currents, it is probable that photosynthetic organisms are continuously carried into and out of the project area. The transport of these organisms provides a dependable source of carbon to the higher trophic level organisms inhabiting the project area. Since placement of beach fill material will not alter the transport of nutrients or organic carbon into and out of the project area, no long term impacts to photosynthetic organisms are expected.

(b) Suspension/Filter-Feeders. Beach fill material resuspended into the water column may contribute to the clogging of siphons of filter-feeders. This is expected to be a temporary and short-term condition. Because of high fecundity and turnover rates, rapid repopulation of these organisms is expected.

(c) Sight Feeders. Elevated turbidity levels will have a short-term adverse impact on visually dependent carnivores.

However, these organisms are highly motile and are able to migrate into more favorable areas to fulfill their nutritional requirements and ecological functions.

d. Contaminant Determinations. Deposited shell and calcareous fill material is similar to the existing beach material in the surrounding area and will not introduce, relocate or increase contaminants in nearshore waters.

e. Aquatic Ecosystem and Organism Determinations.

(1) Effects on Plankton. Decreased light transmission caused by suspended beach material may have a temporary adverse impact on plankton. However, this is expected to be short-term and insignificant. The Atlantic coast of Florida is highly dynamic in this particular area and resuspension of material is likely a natural phenomenon. Elevated turbidity levels will be a temporary condition and floating planktonic organisms may be removed from the project area via tides and currents. Because of this physical transport mechanism, placement of beach fill on an eroding beach is not expected to have a long term or permanent impact on planktonic organisms.

(2) Effects on Benthos. Those benthic species not able to migrate from the project area will be covered. Because of the high fecundity and high turnover rate of benthic invertebrates, repopulation of benthic communities should occur within a few months once the construction has ceased.

(3) Effects on Nekton. Direct impacts to motile organisms will be insignificant because of the ability of these organisms to avoid unacceptable conditions. Adjacent hardbottom habitat is periodically covered because of scouring and shifting sand. Any hardbottom structure that is permanently buried will have an adverse impact on nektonic (especially cryptic) species. These organisms will lose a protective refuge and a foraging area. Any secondary impact to hardbottom structure through construction of the project will be fully mitigated (refer to Appendix E in the Final EA).

(4) Effects on Aquatic Food Web. Beach nourishment activities are likely to have a temporary and insignificant short-term impact on hardbottom areas and organisms found around these reef habitats seaward of the project area. The nearshore project area is highly dynamic in nature and likely experiences significant seasonal variability. Because of this instability, it is likely that organisms that inhabit this area are highly adaptable to changing conditions (including increased turbidity and sedimentation). Because the nonmotile organisms are quickly able to repopulate nourished intertidal zones, no long term adverse impacts to higher trophic level organisms are expected.

(5) Effects on Special Aquatic Sites. Tropical sabellarid worm reefs are located primarily just south of the project area (mainly south of monument R-22 and continuing to the Ft. Pierce Inlet). The nourishing of the project beach is not expected to have any long term significant adverse impact to these communities. As the beach seeks equilibrium, resuspended sand may settle on these structures. However, the project area lies within highly dynamic oceanographic conditions where resuspended bottom material settling around and on these habitats is not uncommon. The worm, *Pharagmatopoma lapidosa*, utilizes the suspended material to build protective tubes and increase the acreage of available hardbottom habitat. Although eroded sand from the beach fill area is expected to gradually flow south of the project towards the St. Lucie Inlet, no significant adverse impacts to the hardbottom habitat located south of the project area is expected (see Appendix E for further details concerning monitoring and mitigation activities).

(a) Santuaries and Refuges. No Federal or State santuaries, refuges, or preserves exist in or adjacent to the project area.

(b) Wetlands. There are no intertidal marshes or submerged seagrasses seaward or adjacent to the project area.

(c) Vegetated Shallows. Because of the dynamic oceanographic conditions common to the project area, it is not uncommon for beach material to be resuspended into the water column. Because of these physical conditions, no submerged rooted aquatic vegetation exists seaward of the project area. The scoured depressions that form within the nearshore zone tend to collect large amounts of drifting macroalgae. Construction of a nourished beach is not expected to significantly alter the average amount of nearshore macroalgae that collects in these scoured depressions.

(d) Coral Reefs. Nearshore sabellarid worm reefs (*P. lapidosa*) and ephemeral coquina limestone outcrops are an important hardbottom feature that can be found just seaward and primarily south of the project area. The organisms that comprise these reefs are adapted to highly dynamic conditions with continuous resuspended material that periodically buries these communities. Temporary increases in the amount of resuspended sand during the placement of beach fill material is not expected to significantly alter the abundance or composition of these communities. No significant adverse impacts to the hardbottom areas located to the south of the project area are expected. An assessment of the movement of eroded sand to the south and the possible impact to the hardbottom habitat to the south is discussed in the proposed monitoring and mitigation plan (see Appendix E).

(6) Threatened and Endangered Species. In accordance with Section 7 of the Endangered Species Act, the U.S. Fish and Wildlife Service (FWS) and the National Marine Fisheries Service (NMFS) have concurred that implementation of the proposed project would not adversely affect threatened or endangered species under their purview. Important safeguards to be implemented to assure that no adverse impacts from the project are experienced by threatened or endangered species are documented in section 9.00 of the FEA, Appendix C and Appendix F (refer to FWS Biological Opinion) of this report. On the advice of the FWS, the project is expected to be constructed almost entirely out of the main portion of the sea turtle nesting season (after November 1 before April 15th). Furthermore, widening of an eroding beach will increase the amount of suitable nesting beach area available to sea turtles. This may aid in the population recovery of these threatened and endangered animals.

(7) Other Wildlife. Renourishing sections of the eroded Atlantic shoreline of south Hutchinson Island in Martin County between monuments R-1 and R-23 is not expected to have a long term significant adverse impact on wading birds or terrestrial foraging animals. These organisms are highly motile animals that are able to actively seek favorable environmental conditions for foraging and nesting and will be able to avoid any unfavorable areas during construction. The widening of an eroding beach may provide more intertidal foraging opportunities for wading birds. Buildup of the dune system is likely to be rapidly invaded by opportunistic grasses and salt-tolerant vegetation. These areas will provide additional protective refuge for small reptiles and mammals.

(8) Actions to Minimize Impacts. All practical safeguards will be taken during construction to preserve and enhance aesthetic, recreational, and economic values in the project area (refer to section 9.00 of the FEA as well as other sections within this report).

f. Proposed Disposal Site Determinations.

(1) Mixing Zone Determination. The fill material will not cause unacceptable changes in the mixing zone that the Florida Department of Environmental Protection (DEP) is expected to specify in the Water Quality Certificate in relation to: depth, current velocity and direction, variability, degree of turbulence, stratification, or ambient concentrations of constituents.

(2) Determination of Compliance with Applicable Water Quality Standards. Class III State water quality standards will not be violated outside of the established mixing

zone. At no time will nearshore turbidity levels exceed 29 NTUs above background conditions.

(3) Potential Effects on Human Use Characteristics.

(a) Municipal and Private Water Supply. No municipal or private water supplies will be impacted by the implementation of the project.

(b) Recreational and Commercial Fisheries. Finfish are highly motile animals and are well equipped to seek favorable environmental conditions elsewhere. Highly motile finfish likely relocate to other nearshore hardbottom tracts or offshore hardbottom habitat during winter storm events which produce significant turbidity and scouring. As long as the nearshore reefs and hardbottom structures are not permanently buried, no significant adverse impacts to pelagic organisms are expected.

(c) Water Related Recreation. The placement of fill will generate a temporary inconvenience for those using the beach for recreational purposes. Once construction has ceased, water related recreation will be preserved as well as enhanced by the creation of additional beach area.

(d) Aesthetics. A temporary decrease in aesthetics will occur with the presence of earthmoving equipment. However, the stabilization of an eroding beach will only improve beachfront aesthetics.

(e) Parks, National and Historical Monuments, National Seashores, Wilderness Areas, Research Sites, and Similar Preserves. The widening of an eroding beach will increase the amount of available recreation beach at the county parks within the project area. Widening the eroded beach will offer storm protection to these county parks.

g. Determination of Cumulative Effects on the Aquatic Ecosystem. It is not anticipated that the placement of beach compatible material on an eroding beach will have any significant negative impacts that would result in degradation of the natural, cultural, or recreational resources of the project area. The project will have no cumulative impacts that result in major impairment of water resources and will not interfere with the productivity and water quality of the existing aquatic ecosystem.

h. Determination of Secondary Effects on the Aquatic Ecosystem. No secondary effects are anticipated. Although eroded sand is expected to move south of the project

area via the longshore current, no significant secondary impacts from increases in turbidity and sedimentation are expected to occur to the 20.5 acres of nearshore hardbottom areas that exist south of the project area (monuments R-23 to R-42). Reasons for this no effect determination include the time it will take for the eroded sand to move south (gradual movement over a period of years) and the naturally occurring dynamic conditions that currently exist south of the project area. Several sections of this Draft EA discuss in great detail the movement of sand and possible impacts to hardbottom habitat and associated flora and fauna.

III. Findings of Compliance or Non-Compliance With the Restrictions on Discharge.

1. No significant adaptations of the guidelines were made relative to this evaluation.

2. In addition to considering the basic assumption of the "no action" alternative, a total of 8 nonstructural and 12 structural alternatives were also considered. No practical alternative exists which fully meets the study objectives and National Economic Development Benefit Evaluation Procedures that does not involve discharge of beach compatible fill into waters of the United States.

3. The discharge of beach compatible fill material to be dispersed will not cause or contribute to violation of any applicable State water quality standards for Class III waters.

4. The discharge of calcareous shelly carbonate sand will not cause or contribute to violations of any applicable State water quality standards for Class III waters. The discharge operation will not violate the Toxic Effluent Standards of Section 307 of the Clean Water Act.

5. The placement of beach compatible fill material will not jeopardize the continued existence of any species listed as threatened or endangered, or result in the likelihood of destruction or adverse modification of any critical habitat as specified by the Endangered Species Act of 1973, as amended.

6. There will be no adverse impact on the water supply of the City of Stuart, City of Jensen Beach, or Martin County from the implementation of this project.

7. Direct (burial) and indirect (increased sedimentation and turbidity) adverse impacts may be felt by nearshore (within approximately 450 feet/136m of the 1992 mean high water line) sabellarid worm reefs and ephemeral coquina limestone rock outcrops. Cryptic fishes may lose a protective refuge habitat if these hardbottom structures are permanently buried. Non-motile sessile invertebrates may be buried by the beach fill and autotrophic and encrusting organisms may lose an attachment surface if the hardbottom structures are permanently buried. Hydrodynamic movements may redistribute offshore larvae of many of these organisms into the project area. Because of the high fecundity of many of these organisms, repopulation and biodiversity is expected to rebound in the project area over time (generally in a matter of months). Currently, computer models predict hardbottom habitat will not receive any primary impacts from the beach nourishment project. In addition, computer models estimate that the renourished sand will eventually be moved through littoral drift south of the project area. It is currently estimated that approximately 20.5 acres of hardbottom habitat exists from the southern end of the project (monument R-23) south towards the St. Lucie Inlet (R-42). As previously alluded to, no significant secondary impact to these hardbottom areas are anticipated due to the nearshore dynamic conditions which naturally exist in the area as well as the fact that many of the high relief areas are emergent during low tide (Bathtub Reef, for example). The accuracy of this hypothesis will be quantified by thorough pre- and post-monitoring data collections (see Appendix E).

8. Short-term elevated turbidity levels during the construction phase may have an adverse impact on attached autotrophic organisms if nearshore hardbottom reef tracts are permanently buried. As turbidity is expected to return to background levels with the cessation of construction, it is anticipated that this impact overall will prove insignificant and temporary.

9. There will not be a direct adverse impact on highly motile organisms. These organisms will be able to actively avoid any unfavorable condition during beach construction. Indirectly, any permanent loss of hardbottom structures such as worm reefs and limestone outcrops represents a loss of juvenile refuge and a food source for foraging adult species. Any loss of hardbottom habitat will be fully mitigated for and these areas monitored.

10. Non-motile infaunal organisms such as bivalve mollusks

in the immediate project area will be buried by the beach fill but are expected to repopulate the area in a matter of months. Motile epifaunal species such as recreationally and commercially important crustaceans should not be adversely affected by the proposed project.

11. It is anticipated that there will be no significant or long term changes in biodiversity of the nearshore areas around Hutchinson Island from the implementation of this project. As much significant hardbottom habitat (as it pertains to vertical relief and surface area) within the equilibrium toe of fill and reef buffer zone (approximately 450 feet/136m seaward of the mean high water line) as possible will be photogrametrically assessed utilizing underwater photography. Photo quadrats will be analyzed in terms of percent coverage of organisms and biodiversity and any statistically significant negative impact that has occurred and can be attributed to the beach nourishment project will be mitigated for. A complete discussion of the proposed monitoring and mitigation plan can be found in Appendix E.

12. The composition of the beach fill material obtained from the offshore borrow area (calcareous shelly sand with a similar silt content as existing beach material) is such that it will not contribute organics or pollutants to the aquatic environment. Earthmoving equipment is not expected to operate in water (below mean low water) and this will therefore minimize the likelihood that hydrocarbons from machinery will pollute the surrounding water. All responsible precautions will be taken to assure that no hazardous materials (oil, gas) are discharged from any construction equipment.

13. On the basis of the guidelines, the proposed disposal site for the discharge of fill material is specified as complying with the requirements of the Clean Water Act.

Appendix B

Florida Coastal Zone Management Program
Federal Consistency Evaluation Procedures
Martin County Shore Protection Project
Hutchinson Island, Martin County, Florida

FLORIDA COASTAL ZONE MANAGEMENT PROGRAM
FEDERAL CONSISTENCY EVALUATION PROCEDURES
MARTIN COUNTY SHORE PROTECTION PROJECT
HUTCHINSON ISLAND, MARTIN COUNTY, FLORIDA

1. Chapter 161, Beach and Shore Preservation.

The intent of the coastal construction permit program established by this chapter is to regulate construction projects located seaward of the line of mean high water and what might have an effect on natural shoreline processes.

Response: The primary purpose of this project is to provide shore protection to residential and tourist development. Consideration is given during the planning process to impacts upon natural coastal processes, activity and use criteria, natural vegetation, and adjacent property. Detailed analyses of each of these areas are presented in the 1986 *Feasibility Report with Environmental Impact Statement* and this Final Environmental Assessment (FEA). The goals set forth in this chapter have been met through continuous consultation with appropriate Federal, State, and local agencies.

2. Chapters 186 and 187, State and Regional Planning.

These chapters establish the State Comprehensive Plan which sets goals that articulate a strategic vision of the State's future. It's purpose is to define in a broad sense, goals, and policies that provide decision-makers directions for the future and provide long-range guidance for an orderly social, economic and physical growth.

Response: Information regarding this shore protection project has been fully coordinated with appropriate Federal, State, and local governmental agencies. This project meets the primary goal of the State Comprehensive Plan for beaches through preservation of a protective beach. As this project would increase recreational opportunities in the area, it is also considered advantageous to the local economy and would provide for economic growth.

3. Chapter 252, Disaster Preparation, Response and Mitigation.

This chapter creates a state emergency management agency, with the authority to provide for the common defense; to protect public peace, health and safety; and to preserve the lives and property of the people of Florida.

Response: The disposal of beach compatible material onto an eroded beach will help protect the eroded beach from further erosion and reduce potential damage resulting from storms to the residential and commercial property and roads adjacent to the Atlantic coast along the southern end of Hutchinson Island. Therefore, this project will be consistent with the efforts of the Division of Emergency Management.

4. Chapter 253, State Lands.

This chapter governs the management of submerged state lands and resources within state lands. This includes archeological and historical resources; water resources; fish and wildlife resources; beaches and dunes; submerged grass beds and other benthic communities; swamps, marshes and other wetlands; mineral resources; unique natural resources; submerged lands; spoil islands; and artificial reefs.

Response: This beach nourishment project will create a wider recreational beach and provide necessary storm protection for residential and commercial development and infrastructure along the Atlantic shoreline of Hutchinson Island. Restoring a dune system will add refuge and foraging areas for avifauna. Widening an eroded beach will increase the beach area that is available to endangered and threatened nesting sea turtles.

In a letter dated 7 May 1993, the Florida State Historic Preservation Officer (SHPO) stated that no significant cultural resources will be affected by the beach nourishment project. A magnetometer survey undertaken between 22-26 February 1993 determined that no potentially significant submerged archeological resources were identified in the borrow area which will be used as the project's sand source.

Motile organisms such as fish and epifaunal crustaceans may experience insignificant short-term adverse impacts due to temporary loss of habitat during construction. The short-term adverse impact is likely to be felt primarily by the nonmotile infaunal invertebrates and sessile autotrophic organisms. Because of the high fecundity and high turnover rate of these organisms, it is not anticipated that a numerically significant loss of these communities would be a long-term condition.

The nearshore hardbottom habitats in this area are adapted to a highly dynamic oceanographic environment with constant resuspension and scouring of sand. Because of this, the nearshore hardbottom areas are periodically buried from shifting sand. Placement of beach compatible fill material onto the eroding beach is not expected to significantly increase, retard, or alter this periodic burial and reappearance of hardbottom habitat. At this time no hardbottom habitat is expected to be

buried by fill material. However, any hardbottom habitat that is permanently buried or significantly degraded as a result of this beach nourishment project will be fully mitigated for by placing like material seaward of the impacted habitat. This project therefore complies with the intent of this chapter.

5. Chapters 253, 259, 260, and 375, Land Acquisition.

This chapter authorizes the state to acquire land to protect environmentally sensitive areas.

Response: Much of the southern end of Hutchinson Island in Martin County is in public ownership and the beach has numerous public access points from adjacent parking areas and County/State parks. Therefore, this chapter does not apply.

6. Chapter 258, State Parks and Aquatic Preserves.

This chapter authorizes the state to manage state parks and preserves. Consistency with this statute would include consideration of projects that would directly or indirectly adversely impact park property, natural resources, park programs, management or operations.

Response: There are three (3) locally managed (County/City) parks along the Atlantic coast in the Martin County project area. The addition of beach compatible material to increase the berm width of the eroded beach will provide protection for these parks from storm generated wave energy as well as have a positive influence on recreational opportunities in the park/beach area. The beach compatible fill material near the existing dune system will quickly be invaded by opportunistic grasses and other salt tolerant vegetation. The beach flora will add refuge and foraging areas for small mammals and reptiles that may inhabit the project area. Therefore, the project is consistent with the intent of this chapter.

7. Chapter 267, Historic Preservation.

This chapter establishes the procedures for implementing the Florida Historic Resources Act responsibilities.

Response: A magnetometer survey of the offshore borrow area has been conducted and the results have been coordinated with the State Historic Preservation Officer (SHPO). The SHPO has concluded that excavation of sand from the offshore borrow area and placement of the beach compatible sand onto the eroded project beach will not have an adverse effect on terrestrial or marine cultural resources (see Appendix F).

8. Chapter 288, Economic Development and Tourism.

This chapter directs the state to provide guidance and promotion of beneficial development through encouraging economic diversification and promoting tourism.

Response: The shore protection project will provide protection of residential and commercial development and infrastructure along the southern end of Hutchinson Island and more area for recreational opportunities throughout the area. This will be compatible with tourism for this area and is therefore consistent with the goals of this chapter.

9. Chapters 334 and 339, Public Transportation.

This chapter authorizes the planning and development of a safe and efficient transportation system.

Response: No long-term adverse impacts to public transportation systems are anticipated by this project.

10. Chapter 370, Saltwater Living Resources.

This chapter directs the state to preserve, manage and protect the marine, crustacean, shell and anadromous fishery resources in state waters; to protect and enhance the marine and estuarine environment; to regulate fishermen and vessels of the state engaged in the taking of such resources within or without state waters; to issue licenses for taking and processing products of fisheries; to secure and maintain statistical records of the catch of each such species; and, to conduct scientific, economic, and other studies of research.

Response: Motile species such as fish and epifaunal crustaceans will be able to avoid the area during construction and seek favorable environmental conditions. Any hardbottom habitat negatively expected to be impacted due to the beach nourishment project (currently estimated to be approximately 0.5 acre) will be fully mitigated for by the Corps. Non-motile autotrophic organisms and infaunal invertebrates will be temporarily lost. As demonstrated from past scientific investigations concerning the recolonization success of the benthic communities seaward of nourished beaches, the loss of nonmotile invertebrates is expected to be a short-term situation. Contract specifications will contain protective measures specifically designed to avoid adverse impacts to manatees and sea turtles which may be foraging in the area (refer to section of 9.00 in the EA).

11. Chapter 372, Living Land and Freshwater Resources.

This chapter establishes the Game and Freshwater Fish Commission and directs it to manage freshwater aquatic life and wild animal life and their habitat to perpetuate a diversity of species with densities and distributions which provide sustained ecological, recreational, scientific, educational, aesthetic, and economic benefits.

Response: The disposal of beach compatible material onto the eroded project beach has been coordinated with the U.S. Fish and Wildlife Service (FWS) and National Marine Fisheries Service (NMFS) for compliance under Section 7 of the Endangered Species Act. Both agencies have concurred with the Corps' determination that populations of threatened/endangered species under their purview will not be adversely affected by the proposed action. Upon the advice of the FWS, every effort will be made to complete beach construction prior to the commencement of the main part of the sea turtle nesting season (prior to April 15th). Further discussion of the main portion of the sea turtle nesting season (after November 1 and prior to April 15) and appropriate safeguard requirements can be found in Appendix C (Fish and Wildlife Coordination Act Report) and Appendix F (Relevant Correspondence) of this report. There exists adjacent vegetated areas where small mammals and reptiles could actively seek temporary shelter during beach construction activities. Placement of sand on the beach will likely be quickly invaded by opportunistic grasses and other salt tolerant beach vegetation. This new habitat will provide refuge and foraging opportunities for small species and promote biodiversity in the project area. This project complies with the goals of this chapter.

12. Chapter 373, Water Resources.

This chapter provides the authority to regulate the withdrawal, diversion, storage, and consumption of water.

Response: This project does not involve groundwater or surface water resources as described by this chapter.

13. Chapter 376, Pollutant Spill Prevention and Control.

This chapter regulates the transfer, storage, and transportation of pollutants and the cleanup of pollutant discharges.

Response: This project does not involve transportation of any toxic substances. All precautions will be taken during the construction phase to assure that no hydrocarbons or other toxins are expelled into the environment by dredging or earthmoving equipment.

14. Chapter 377, Oil and Gas Exploration and Production.

This chapter authorizes the regulation of all phases of exploration, drilling, and production of oil, gas, and other petroleum products.

Response: This project does not involve the exploration, drilling or production of gas, oil or petroleum products and therefore does not apply.

15. Chapter 380, Environmental Land and Water Management.

This chapter establishes criteria and procedures to assure that local land development decisions consider the regional impact nature of proposed large-scale development.

Response: Beach disposal on the modified project length of 3.75 miles (6.0km) of southern Hutchinson Island in Martin County is unlikely to have any regional impact on resources found along the southeastern Atlantic coast of Florida. The project is consistent with the established goals of this chapter.

16. Chapter 388, Arthropod Control.

This chapter provides for a comprehensive approach for abatement or suppression of mosquitoes and other pest arthropods within the state.

Response: The project would not further the propagation of mosquitoes or other pest arthropods.

17. Chapter 403, Environmental Control.

This chapter authorizes the regulation of pollution of the air and waters of the state by the Florida Department of Environmental Regulation.

Response: A temporary increase in air pollution particulates from dredge and construction equipment as well as accompanying vehicles is expected to be insignificant due to strong prevailing coastal winds, and only due to increased vehicular traffic during the construction phase. Water pollution is expected to be minor and short-term, manifesting in construction generated nearshore and borrow area turbidity increases. Monitoring for turbidity during the beach nourishment process will assure compliance with all applicable water quality standards. With adherence to the environmental conditions to be set forth in the Water Quality Certification (WQC) permit, this project will be in full compliance with the intent of this chapter.

18. Chapter 582, Soil and Water Conservation.

This chapter establishes policy for the conservation of the state soil and water through the Department of Agriculture. Land use policies will be evaluated in terms of their tendency to cause or contribute to soil erosion or to conserve, develop, and utilize soil and water resources both onsite or in adjoining properties affected by the project. Particular attention will be given to the project on or near agricultural lands.

Response: The shore protection project is not located near or on any agricultural lands. The authorized project is designed to restore and protect an eroding public beach which offers protection for both property and human health against storm generated wave energy as well as recreational opportunities for both the visitor and the resident of the area.

Appendix C

Fish and Wildlife Coordination Act Report
Martin County Shore Protection Project
Hutchinson Island, Martin County, Florida

141
137

HUTCHINSON ISLAND
MARTIN COUNTY, FLORIDA

BEACH RENOURISHMENT PROJECT

Fish and Wildlife Coordination Act Report

Submitted to:
Department of the Army
Jacksonville District
Corps of Engineers
Jacksonville, Florida

U.S. Fish and Wildlife Service
Ecological Services
Vero Beach, Florida

JANUARY, 1994

United States Department of the Interior

FISH AND WILDLIFE SERVICE
P.O. BOX 2676
VERO BEACH, FLORIDA 32961-2676

January 24, 1994

Colonel Terrence Salt
District Engineer
U.S. Army Corps of Engineers
P.O. Box 4970
Jacksonville, FL 32232-0019

Attn: Planning Division

Dear Colonel Salt:

In accordance with the Fiscal Year 1992 Transfer Fund Agreement between The U.S. Fish and Wildlife Service (Service) and the Jacksonville District Corps of Engineers (Corps), this letter represents a Final Coordination Act Report on the proposed Martin County, Florida, Beach Erosion Control Project. The Corps has requested an evaluation of the environmental effects of nourishing 4.0 miles of beaches along the coastline of Martin County with material dredged from an offshore borrow area. This information is needed to enable the Corps to reformulate and evaluate the authorized project to assure that it conforms to current needs and criteria. This report is presented in fulfillment of the Fish and Wildlife Coordination Act (16 U.S.C. 1531 et seq.) and constitutes the final report of the Secretary of the Interior as required by Section 2(b) of the Act.

The Service distributed a Draft Coordination Act Report on the subject project to the Florida Game and Freshwater Fish Commission and the National Marine Fisheries Service. Letters of concurrence have been received by the Service from those agencies and a copy of each may be found in the attachments section of the report.

Sincerely yours,

David L. Ferrell
Field Supervisor

cc:
EPA, Atlanta, GA
NMFS, Panama City, FL
FG&FWFC, Tallahassee, FL
FG&FWFC, Vero Beach, FL
DEP Tallahassee, FL
FWS, Jacksonville, FL

145

141

Hutchinson Island
Martin County
Beach Nourishment Project

Fish and Wildlife
Coordination Act Report

Submitted to Jacksonville District
U.S. Army Corps of Engineers
Jacksonville, Florida

Prepared by: Charles W. Sultzman, Project Biologist
Approved by: David L. Ferrell, Field Supervisor

Vero Beach, Florida, Field Office
U.S. Fish and Wildlife Service
Vero Beach, Florida

January, 1994

Table of Contents

Page

List of Tables and Figures iii
Executive Summary iv

I. Introduction 1

II. Project Description 1

III. Description of Study Area 1

IV. Fish and Wildlife Resources 1

A. Community Descriptions 3
B. Important Species and Taxa 3

V. Fish and Wildlife Service Observations 5

A. Mapping Efforts 5
B. Biological Studies 6

VI. Discussion and Impacts 11

VII. Mitigation 12

VIII. Fish and Wildlife Service Recommendations 13

A. Project Design 13
B. Mitigation 13
C. Sea Turtles 15

IX. Summary 16

X. Literature Cited 17

XII. Appendices 19

A. Side Scan Reef Maps 20
B. Epibenthic Community 25

XIII. Attachments 26

List of Tables and Figures

Tables | Page

Table 1. Epibenthos Observed on Reef at R-25 8
Table 2. Reef Fish Observed at R-25 10

Figures

Fig. 1. Nourishment Site and Borrow Area 2
Fig. 2. Transect Locations at R-25 7

EXECUTIVE SUMMARY

The Corps of Engineers (Corps) has requested a Fish and Wildlife Coordination Act Report from the U.S. Fish and Wildlife Service (Service) regarding the environmental impacts of a proposed beach nourishment project at Martin County, Florida. Sand fill for the project would be obtained from an offshore borrow area. Silt and clay content of the fill is approximately 10%. Biological surveys of the area by the Corps' contractors have shown that there are rock outcrop reefs immediately offshore of the beaches proposed for renourishment. U.S. Fish and Wildlife Service observations indicate that there are currently approximately 13 acres of nearshore reef within the project area; but, further quantification reef acreage through aerial photography and groundtruthing is warranted. Our observations also show that these reef areas currently provide habitat for a diverse community of fishes and invertebrates.

The Fish and Wildlife Service recommends that impacts to reefs at the southern end of the project be avoided. Remaining unavoidable impacts may be mitigated for with artificial reef construction if carefully designed and deployed. Careful design could reduce acreage ratio requirements for full habitat value replacement. The biological rational supporting this mitigation recommendation is provided in the report.

At least one acre of designed reef should be deployed before sandpumping begins to provide alternative habitat for motile organisms displaced by the project. A subsequent study of population densities on the pilot reef should allow the Corps to estimate the appropriate acreage of mitigation required for full habitat value replacement. The Service estimates that an ineffective design may require as much as 2 acres of mitigation per acre of natural reef lost; an effective design could reduce mitigation acreage requirements by more than half.

A prior Biological Opinion on this project allowed for nest relocation of threatened and endangered sea turtles. To further minimize incidental take of sea turtles due to nest relocation, the Service now recommends that beach nourishment activities occur between November 1 and April 15, provided the beaches are surveyed for unhatched nests prior to beach fill deposit

I. INTRODUCTION

A Congressional Resolution adopted May 18, 1974 by the Public Works Committee authorized the Corps to conduct a beach erosion control study for Martin County. The Service has provided the Corps with several reports during the planning process. These reports addressed project impacts to marine habitats and nesting sea turtles at various design phases. A Feasibility Report with Final EIS was distributed in June, 1986. This report contained the Services' Biological Opinion, dated December 6, 1985, addressing project impacts to nesting sea turtles and a Fish and Wildlife Coordination Act Report which summarized Service input and discussed potential impacts to nearshore reefs. The Coordination Act Report also recommended that the project not be constructed during sea turtle nesting season, from April to November.

II. PROJECT DESCRIPTION

The presently considered project calls for the construction of a protective beach along a 4 mile reach of shore from DNR monument number R-1 at the north Martin County line to DNR monument R-27 (see Figure 1.). The berm, which would be constructed from 942,000 cubic yards of fill material, would be 35 feet wide at +8 ft. N.G.V.D. This would slope at 1 foot vertical to 8.5 feet horizontal shoreward of the intertidal zone. Waterward of this the slope would be 1 to 20 extending the fill approximately 700 ft. seaward of the current high tide line after settling (calculated from maps in Project Summary, Coastal Technology, 199-1). The fill material would be obtained from an area approximately one half mile offshore of the southern end of the proposed fill area.

III. DESCRIPTION OF STUDY AREA

Martin County is situated on the Atlantic coast of east-central Florida. Hutchinson Island is located in the northernmost part of the county on the Atlantic Ocean. West of this barrier Island is the Indian River which has inlets to the ocean approximately 1.5 miles to the south (St. Lucie Inlet) of the proposed project (See Figure 1) and 16 miles to the north (Ft. Pierce Inlet).

IV. FISH AND WILDLIFE RESOURCES

Fish and Wildlife habitats in the project area which could be affected by this beach erosion control project include the intertidal beach zone, borrow area, nearshore reefs and the supralittoral beach which serves as nesting habitat for at least three species of threatened and endangered sea turtles.

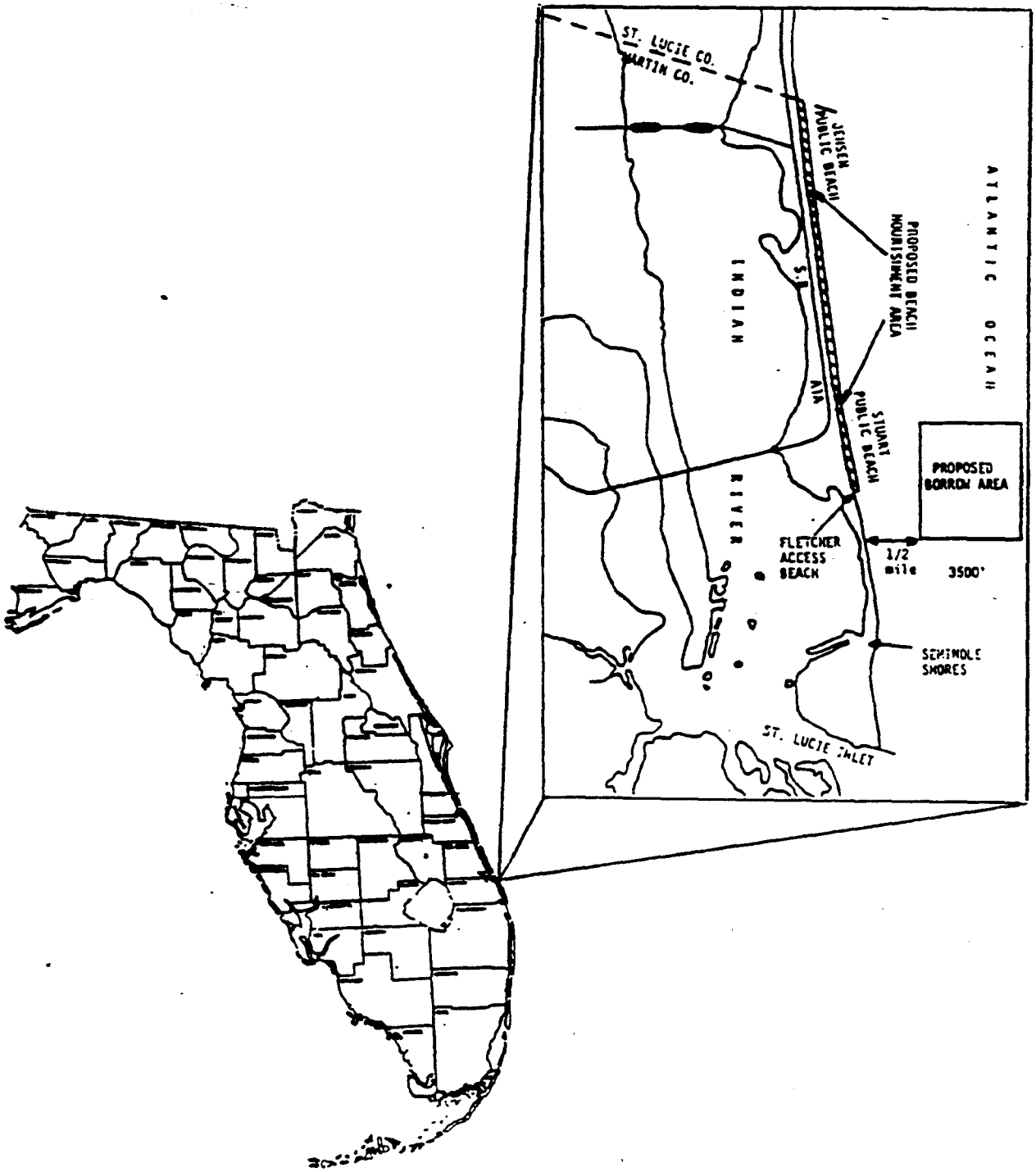

FIGURE 1-1 PROPOSED BEACH NOURISHMENT SITE AND BORROW AREA

Source: U.S. Corps of Engineers Report 1985/Feb. 1986

A. Community Descriptions

Intertidal Beach Zone. The beaches of Palm Beach County are typical of other east-central Florida beaches which are subject to the full force of ocean waves. These beaches usually have low species diversity, but populations of individual species are often very large. Species such as coquina clams, ghost crabs, annelid worms, mole crabs and sand drum are highly specialized to survive in this high energy environment.

Borrow Area. Numerous species of macro-invertebrates inhabit the proposed borrow area. These include, hydrozoan, bivalves, gastropods, annelids, crustaceans, sea cucumbers, brittlestars, etc. These will be unavoidably lost during dredging. However, this habitat is not unique and the area will likely recover within one year (Courtenay, et. al. 1974). Motile fauna expected to inhabit this area would include penaeid shrimp, callenectid crabs, flounder and sole. These species should easily avoid the dredge and no adverse effects to them are anticipated.

Nearshore Reefs. Coquina limestone reefs occur adjacent to and seaward of the project area. The first attempt to map the reefs was undertaken by Coastal Technology and Management, Inc. using aerial photography in 1991. Reef features were mapped with side scan sonar by C-systems, Inc., Broward County, in the spring of 1993. The two maps resulting from these efforts bear little resemblance to each other. The side scan reef maps have been found through extensive groundtruthing to be the more accurate. Copies of the side scan maps have been reduced in size and are presented as Appendix 1.

B. Important Species and Taxa

Epibiota

The most abundant and evident producers on the reefs are the algae. The exposed rock provides stable substrate for these organisms which, through photosynthesis, produce basic organic material on which much of the reef's food web is based. Carbon fixed far offsite is also concentrated on the reefs. Attached filter feeding organisms contribute to this organic base by trapping nutrient rich phytoplankton as it is swept past the reef by wave and wind generated currents. Sessile cnidaria such as anemones and stinging hydroids capture zooplankton and other larger organisms which drift to them.

Fishes and Motile Invertebrates.

In addition to the algal food which grows on the reefs, fish and motile invertebrates are attracted to the basic structure of the reef. The numerous crevices, holes, and undercut ledges provide refuge from larger predatory fish. It also provides a barrier to currents and substrate for attachment of demersile adhesive eggs.

Sea Turtles

The loggerhead turtle (Caretta caretta) nests primarily on beaches from North Carolina to Florida. Approximately ninety percent of loggerhead nesting within the U.S. occurs in Florida (Murphy and Hopkins, 1984). The highest density nesting beaches in Florida occur from Canaveral National Seashore, Volusia County, south to John U. Lloyd State Recreation Area in Broward county (Conley and Hoffman, 1986). Nesting densities vary from less than one nest per km on the average for some beaches in the northeast, southeast, and panhandle of Florida to over 600 nests per km on some stretches of beach in south Brevard County (Ehrhart and Witherington, 1986). The most recent estimate for total annual nesting effort in the southeastern U.S. is 58,000 nests based on aerial surveys conducted in 1983 (Murphy and Hopkins, 1984). The U.S. loggerhead nesting population, one of the two most significant nesting populations in the world, may represent up to 30 percent of the worldwide loggerhead nesting population (Ross, 1982). This is in contrast to other sea turtle species where nesting occurs largely outside the U.S. The loggerhead nesting season is from late April to August, with most nesting occurring in June and July.

Green turtle (Chelonia mydas) nesting within the U.S. occurs principally along east central Florida beaches. Nesting densities are much lower than for the loggerhead and range from 1-5 nests per km on most beaches within its major nesting range, to 13-20 nests per km on high density green turtle nesting beaches in south Brevard County and south Jupiter Island in Palm Beach County (Conley and Hoffman, 1986; Ehrhart and Witherington, 1986). Nesting occurs from May to September with the peak nesting occurring in July and August.

The leatherback (Dermochelys imbricata), rarely nests in the continental U.S. Eighty-nine leatherback nests were recorded on the Florida east coast beaches in 1985 (Conley and Hoffman, 1986). Nesting begins as early as late February and terminates by late July. Much of the nesting is centered in Palm Beach county but scattered nesting has been recorded on almost all Florida east coast county beaches with the most northerly record from Blackbeard Island, Georgia (Conley and Hoffman, 1986; Seyle, 1985).

The hawksbill (Eretmochelys imbricata) is a rare nester on southeastern U.S. beaches with only 1-2 nests recorded annually in Florida (Conley and Hoffman, 1986; Lund, 1985; Mcmurtray and Richardson, 1985). Nesting has been recorded for the months of June, July, August, and October and from Volusia, Martin, and Dade Counties (Dalrymple et. al., 1985; Lund 1985; McMurtray and Richardson, 1985).

V. FISH AND WILDLIFE SERVICE OBSERVATIONS

I. Mapping Efforts

Methods

The Service accompanied a Corps Biologist and representatives for Martin County on field trips to the project site on July 13-15 and July 19-21, 1993. Using the reef maps drawn by C-Systems, Inc., approximately 10 reef areas were located and measured. Edges of each reef area were buoyed and a range azimuth positioning system used to verify the shape and location of the feature depicted on the reef map. A search of the proposed fill area was also made in an effort to locate reef areas which did not appear on the reef map. Control sites for future monitoring of project impacts were located, buoyed and their coordinates recorded. On August 12, reef features depicted on the side scan maps were planimetered and the acreage of these features which lie within the proposed fill area calculated.

Results

Groundtruthing the side scan maps revealed pitfalls involved in drawing reef maps from aerial photography. During most of the field trips, the water was clear enough to allow individual rock outcrops to be located from the surface by boat. From the surface, however, some of the features appeared to differ in shape from the illustrations on the map. This, it was found, is because only the highest portions of the outcrops are overgrown with dark (red, brown or green) pigmented algae. These algal encrusted areas were easily seen through the water from the surface. Low relief rock areas are constantly scoured clean, bear no contrast to the surrounding sand and are not visible to the naked eye from the surface. Nor would they show up in an aerial photograph. Positive identification of these areas as hard bottom is only possible by close subsurface inspection.

Additional difficulty was found in attempting to identify map features because of the presence of large amounts of drift algae. Large dark areas were visible from the surface by boat but subsurface inspection revealed many of these areas to be unattached algae over sand bottom.

Because of these problems with photogrametric mapping, the Service believes that side scan mapping has been demonstrated to be most reliable means of delineating reef features. (See reduction of side scan maps in Appendix A.). The use of side scan in this and future projects of this type will allow the Service and the Corps to make the most accurate estimates of reef acreage.

Despite the greater accuracy of the side scan based maps, at least two reef areas are under represented on the maps. During groundtruthing, the Corps and Service divers found substantial reef area immediately east and north of R-16. This area is represented on the map by a cluster of north-south lines which appear to be a system of narrow ledges (See Appendix A). Actually, this is a solid reef area up to 75 ft. in width; only the seaward edge of which is shown. The second area found occurs approximately 300 feet seaward between DNR monuments R-22 through R-27. Again, this area is represented by a north-south line east of R-23 through 25 (Appendix A). In fact, the reef exceeds 100 feet in width in some places and encompasses several acres.

One additional reef area was located by the Service on August 26. This area lies off of the Jensen Public Beach access. It is not shown on the side scan maps. Poor water clarity did not enable the Service to estimate the acreage of this feature.

II. Biological Studies

Methods

Of the reef areas inspected during groundtruthing dives with the Corps Biologist and representatives for Martin County, the nearshore reef off of R-25 appeared to hold the greatest in numbers and variety of marine fishes and invertebrates. To more closely examine these areas, the Service made an underwater biological survey of the area east northeast of R-25 (Figure 2.). This survey was done on August 26, 1993. Two timed transects of 300' each were run parallel to the shoreline. The first was approximately 420 feet east of the limits of dune vegetation as determined by a Rangematik MK 5 rangefinder. The second was approximately 100 feet inshore of the first (See Figure 2.).

Fish counts were made, samples of epibenthic organisms were collected and photographs were taken along each transect. Prior to arrival at the site, the Service had intended to use the Bohnsak method of stationary sampling to quantify the fish population density. This methods involves picking sampling stations and counting all fish seen within a certain radius from the center. The recommended radius is 24 ft. (see Bohnsak, 1986). Upon arrival, seeing that underwater visibility only about 10 feet, it was decided that the number of fish seen at each station would be too low to adequately represent the population at large. Therefore, all fish seen while swimming along each transect were lumped into a single sample.

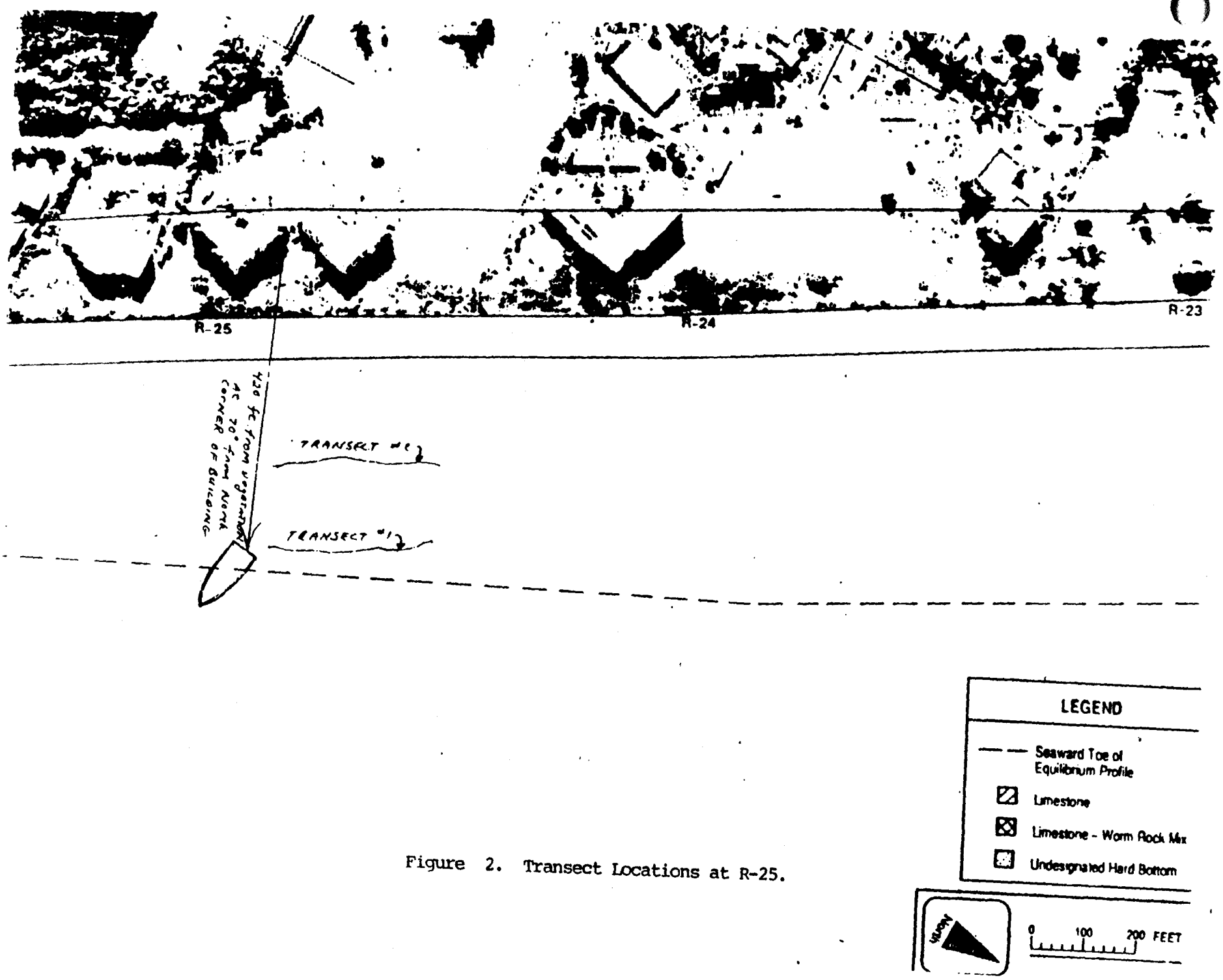

Figure 2. Transect Locations at R-25.

Results

The Service has attempted to illustrate this by providing the following data from transects 1 and 2. Photographs taken along transects 1 and 2 are shown in appendix 2. Table 1 below lists the organisms collected from the encrusting community in the subject area.

Table 1. Sessile Species and Commensals Collected Along Nearshore Transects at R-25.

Algae

- Dictyota bartayresii
- D. dichotoma
- D. cervicornis
- unidentified dictyota species
- Caulerpa taxifolia
- C. sertularoides
- C. cupressoides
- C. prolifera
- Padina sanctae-crucis
- Halymenia floresia
- Gracilaria tikvahiae
- Hypnea musciformis
- Halimeda goreaui
- Codium isthmocladum
- C. intertextum
- Ceramium sp.

Bryozoans

- Bugula neritina
- unidentified white encrusting bryozoan (order Cheilostomata)

Sponges

- Strongylacidon sp.
- Speciospongia vesparium
- Tedania ignis (?)

Tunicates

Botrylloides nigrum (?)
Ascidia nigra
Clavelina sp. (?)
unidentified tunicates

Polychaetes

unidentified feather duster worm (sabellidae)
Sabellastarte magnifica
Phragmatopoma lapidosa (reef building tube worm)
unidentified polychaetes

Cnidarians

Pterogorgia citrina (Yellow sea whip)
Halopteris carinata (Thread hydroid)
Sertularella speciosa (Branching hydroid)
Macrorhynchia philippina (stinging hydroid)
Muricea muricata (Spiny Muricea)
Campanularia sp. (wineglass hydroid)
unidentified red encrusting zooanthid
unidentified anemonies

Crustaceans

Stenorhynchus seticornis (arrow crab)
unidentified spider crab (Family Majidae)
unidentified hermit crab (Family Diogenidae)
Alphaeus sp. (Brown snapping shrimp, Family Alphaeidae)
unidentified skeleton shrimp
Jassa falcata (mottled tubemaker)
Gonobactylus oerstedii (swollen-claw squilla)
Panulirus argus (Spiny lobster)
unidentified barnacles

Echinoderms

Echinometra lacunter (rock boring urchin)
Lytechinus variegatus (variegated urchin)

Molluscs

Terebra dislocata (common atlantic auger)
Cerithidea costata (costate horn snail)
unidentified dove snail (Family Columbellidae)
welk (Family Nassariidae)

Over 60 species from 9 phylla were collected within the 45 minutes taken to complete the transects. The photographs in appendix 2 show the per cent coverage and allow the reader to estimate the approximate biomass of the encrusting community. However, it should be noted that the worm rock built by Phragmatopoma lapidosa dominates the sessile community in this area covering approximately 20% of the existing substrate along the transects.

The notion that there would be too few fish to count within the 10 foot radius allowed by water conditions at this nearshore reef area was erroneous. Stationary sampling would have been the proferred method because the large number of fish within the transect area at large overwhelmed the diver. Table 2 gives approximate numbers of species seen during the 45 minute time required to complete the both transects.

Table 2. Number and Species of Fish Seen on Nearshore Reefs off R-25, Martin County.

Transect 1	Transect 2
14 Labrisoma nuchipinnis (hairy blenny)	10 L. nuchipinnis
8 Diplodus argenteus (silver porgy)	20 D. argenteus
16 Pomacentrus variabilis (coco damselfish)	16 P. variabilis
20 unident.juvenile pomadasyidids(grunts)	40 juv. grunts
26 Halichoeres bivittata (slippey dick)	25 H. bivittata
1 Archosargus probatocephalus (sheepshead)	1 A. probatocephalus
28 Lutjanus synagris (lane snapper)	16 L. synagris
15 Anisotremus virginicus (porkfish)	10 A. virginicus
1 Mulloides martinicus (yellow goatfish)	1 Ocyurus chrysurus (yellowtail snapper)
1 Pomacentrus dorsopunicans (dusky damsel)	4 Acanthurus chirurgus (doctorfish)
1 Pomacanthus paru (French angelfish)	8 Abudefduf saxatilis

The upper eight species in Table 2 list the species which both transects share in common; the lower 6 species (separated by a space) are species found in only one transect. Two hundred eighty two individuals from 14 species were observed in 45 minutes. In addition, one stoplight parrot fish, one spotted scorpionfish, a nurse shark and one spotted moray were seen outside the limits of the transect lines in transit to and from the boat.

It is important to note that one of the most abundant fin fish counted is the lane snapper. The individuals observed were from 1 to 3 inches long (standard length). Adult lane snappers may reach 18 inches and are important to the recreational fishery of Martin County. At the time of this inspection, the reef area censused was serving as a nursery for these fish.

VI. DISCUSSION AND IMPACTS

Beach zone. Since sandy beaches are populated by small, short-lived organisms with great reproductive potential, in most instances these communities recover quickly from environmental disturbances. The impacts of this beach erosion project on the beach zone fauna will depend primarily on the quality of the nourishment material. Since silt within the sand proposed to be used for this project will eventually be winnowed out, the remaining material should be of similar composition to the natural beach, recovery of the beach fauna should occur in a few months.

Nearshore Reef Zone. Using the estimated limits of the equilibrium toe of fill depicted in the project description provided by Coastal Technology Inc. (1991), along with the side scan maps provided to us by the Corps of Engineers through C-Systems, Inc., the Service has determined that a minimum of 13 acres of nearshore reef will be buried by beach fill if this project is implemented as proposed. This figure includes an estimate of acreage for the two reef areas discovered by Corps and Service divers during groundtruthing. It does not include the reef area discovered by the Service off Jensen Public Beach. Precise delineation and acreage calculation of these reef areas remains to be completed.

The immediate effect of the depositing of fill according to current project plans will be the loss of most of the 13 acres of nearshore reef that lie within the project area. That which is not destroyed by burial will be degraded by an increase in scouring, turbidity and sedimentation. Some of the reef will eventually be re-exposed and become productive. However, without the project, additional reef acreage exposed by continued erosion would be added to the existing acreage. If the project is implemented, continued erosion will only re-expose a small fraction of reef acreage which now exists. The deficit of 13 acres of reef persists.

Sea Turtles. The project will result in an increase in nesting suitability for endangered and threatened sea turtles. Some adverse effects may still result during construction if the project is done during the nesting season. These include:

1. Scarp development at the edge of the beach fill, rendering the beach inaccessible to nesting turtles,

2. Entrapment of the hatchlings in the vehicle tracks,

3. Alterations in moisture levels or other aspects of the microhabitat within the nest cavity,

4. Alteration of unknown beach signature components which may disrupt nest site fidelity,

5. Compaction and cementation of beach sediments which causes reduced nesting success (nesting emergences/total emergence x 100), and aberrant nest cavity construction which in turn can result in broken eggs.

VII. MITIGATION

We estimate that, at a minimum, 13 acres of nearshore rock will be either buried or severely degraded by beach fill as a result of this project. Many of the habitat values lost by project construction are replaceable. This could be accomplished by providing new limestone substrate in the form of an artificial reef of equivalent surface area, if carefully planned and constructed.

Too often, artificial reefs are created without a clearly defined purpose and without sufficient planning. The United States has pursued an unsophisticated and frugal approach to artificial reef planning and construction. The use of scrap and discarded rubble, because of its low cost, is most commonly used (McGurrin, et. al., 1989) despite its inadequacy in providing suitable habitat for targeted species. In contrast, the Japanese have invested billions of dollars in developing techniques to create new habitat and increase seafood production (Grove, et. al., 1989; Sonu et. al., 1985). These efforts have been reported by Sheehy (1983), and Brock and Norris (1989) to have resulted in much more efficient reef technology. While costs per area of reef are higher, the increase in reef fish and epibenthic organism abundance per area over traditional U.S. reef technology (Sheehy, 1983; Brock and Norris, 1989) may offset this cost (Sato, 1985).

To correct the deficiencies in and fragmentation of the U.S. artificial reef program, the Secretary of Commerce was directed, under the provisions of the National Fishing Enhancement Act of 1984 to develop and publish a long-term National Artificial Reef Plan to promote and facilitate responsible and effective artificial reef use based on the best scientific information available. A working plan was published by the National Marine Fisheries Service in 1985 under the authorship of Richard B. Stone. To conform to the plan each project should have a clearly defined list of species targeted for habitat enhancement and user group intended to benefit. In this case, the largest user groups which we expect will incur losses by the project are local and vacationing snorkelers. Artificial reefs intended to mitigate for this project should keep benefits to these groups as the primary objective. This will require certain design features. The structures must provide a scenic, safe, and accessible replacement for the structure lost due to project impacts.

Some fundamental features which should be incorporated into the design are: 1) extensive unshaded horizontal surface area for the attachment and growth of gorgonians and macroalgae; 2) openings near the bottom, for Spiny lobster, depth of at least 2 ft. and height of no more than 1 ft.; 3) interstitial spaces of approximately 10 cubic ft.; 4) large overhanging ledges to provide shaded resting space for large fish; 5) numerous projections, crevices, and holes ranging in size from one to three inches in width and up to 1 foot in length (projections) and depth (holes and crevices) to provide refugia for small fish and for juvenile fishes, as well as to provide additional surface area for epibiotic growth.

Any structure intended to mitigated for the loss of limestone substrate should, likewise, be built of limestone rather than concrete. To date, no comprehensive scientific study of substrate selectivity for epibentic organisms on limestone verses other artificial reef building materials has been done. It may be that unnatural materials inhibit the settlement or growth of certain species of encrusting organisms. This could, in turn, alter the structure of the resulting associated fish community.

Limestone, however, cannot be formed into desired shapes like other material such as steel or concrete. A possible solution to the potential problems associated with substrate selectivity in fouling organisms while taking advantage of the moldability of concrete, would be to embed limestone rock in the surface of molded concrete pieces. If such pieces were to be constructed into a carefully designed artificial reef project of high relief, it may be possible to exceed the habitat values of the existing natural reef for certain species. This would reduce the acreage of mitigation needed to replace lost reef carrying capacity.

In our opinion, because of the low relief of much of the existing natural reef, a carefully planned artificial reef could reduce by as much as 50% mitigative reef acreage needed to recover impacted reef value. Final acreage calculations will have to await aerial mapping and groundtruthing of the two areas previously discussed. We would welcome the opportunity to work with Corps staff and that of Martin County in developing a suitable yet economical reef design and in monitoring the effectiveness of that design.

VIII. FISH AND WILDLIFE SERVICE RECOMMENDATIONS

The Fish and Wildlife Service recommends that the following be included in future project planning:

A. <u>Project Design</u>

1. The nourishment area should shortened by approximately 2500 feet at the southern end. This would place the southern limit of the project at R-23 or in front of the Stuart Public Beach. This modification would eliminate impacts to the nearshore reefs which extend south of R-23 and reduce mitigation needs.

front of the Stuart Public Beach. This modification would eliminate impacts to the nearshore reefs which extend south of R-23 and reduce mitigation needs. Eventually, sand would be transported by natural littoral drift to beaches further south.

B. Reef Mitigation

1. A new set of aerial photographs of the nearshore should be taken and groundtruthed. A precise measurement of the reef area which will be buried by the project should then be made. Once this is done, final mitigation acreage necessary to compensate for this burial can be calculated.

2. We estimate that approximately 13 acres of reef will be buried. We recommend that at least 1 acre of artificial reef is deployed prior to project construction. This will provide an alternative refuge for some of the fish displaced by the project. In addition, with detailed monitoring of population densities on the initial reef deployed, the carrying capacity per acre of the designed reef could be estimated and the appropriate acreage ratio required for full habitat value replacement could be determined.

3. The artificial reef structure selected for mitigation for unavoidable impacts should be designed to provide habitat for species which are of interest to local SCUBA divers and snorkelers. Its surface should consist of limestone. Design features should include: a) extensive unshaded horizontal surface area; b) openings near the bottom for Florida lobster; d) interstitial spaces approximately 10 cubic feet; e) large overhanging ledges; f) numerous projections, crevices and holes.

4. Assuming that the artificial structure is carefully designed and will have approximately twice as much surface area per acre above the scour zone as the natural reef, we tentatively recommend a mitigation ratio of no less than 0.5 to 1, pending review of the final design and monitoring of a pilot reef (see 2 above). However, an ineffective design could require more acreage than existing natural reefs buried.

5. Surveys of the area of deployment of the designed reef should be made to ensure that it is placed on a solid foundation. There may be areas low relief rock just offshore of the fill area where scouring and periodic burial have reduced reef habitat values to near zero. Such area should be located and utilized for reef placement.

biomass, macroepifloral biomass and macroepifaunal biomass at the designed reef and at nearby natural reefs. Fin fish communities at both reef types should be censused and compared in number, species and biomass (estimated). Fish communities should also be compared at both reef types using similarity indexing. Sampling should take place once in each season for three years or until it is clear that community structure has stabilized.

8. The Fish and Wildlife Service should be funded by the Corps of Engineers to participate in the monitoring of the designed reefs. This will promote a better understanding of design effects on artificial reef communities and facilitate the development of an increasingly effective artificial reef strategy and better informed decision making for future Civil Works projects.

9. The reef mitigation plan described above should be included as a Federal project feature subject to cost-sharing (i.e. 60% Federal, 40% local) to defray the project sponsor's cost of mitigation.

C. Threatened and Endangered Sea Turtles

1. The Fish and Wildlife Service prepared a Biological Opinion addressing project impacts to threatened and endangered sea turtles on February 8, 1989 (see attachments). This opinion made allowances for relocation of sea turtle nests under Section 9 of the Endangered Species Act. The Service has recently recommended against this practice in our review of several Florida beach nourishment projects. Because there is some evidence that nest relocation may alter emergent sea turtle nest ratios, the Service recommends that the Corps not allow beach construction between November 1 and April 15, provided there are now unhatched nests found on the beaches following November.

Although this does not constitute a Biological Opinion described under Section 7 of the Endangered Species Act, it does fulfill the requirements of the Act, and no further action is required. If modifications are made in the project or if additional information involving potential impacts on listed species becomes available, please notify our office (407-562-3909).

IX. SUMMARY

The Corps of Engineers (Corps) has requested a Fish and Wildlife Coordination Act Report from the U.S. Fish and Wildlife Service (Service) regarding the environmental impacts of a proposed beach nourishment project at Martin County, Florida. Sand fill for the project would be obtained from an offshore borrow area. Silt and clay content of the fill is approximately 10%. Biological surveys of the area by the Corps' contractors have shown that there are rock outcrop reefs immediately offshore of the beaches proposed for renourishment. U.S. Fish and Wildlife Service observations indicate that further quantification reef acreage through aerial photography and groundtruthing is warranted, but that there are currently approximately 13 acres of nearshore reef within the project area. Our observations also show that these reef areas currently provide habitat for a diverse community of fishes and invertebrates.

The Fish and Wildlife Service recommends that impacts to reefs at the southern end of the project be avoided. Remaining unavoidable impacts may be mitigated for with artificial reef construction if carefully designed and deployed. Careful design could reduce acreage ratio requirements for full habitat value replacement. The biological rational supporting this mitigation recommendation is provided in the report.

At least one acre of designed reef should be deployed before sandpumping begins to provide alternative habitat for motile organisms displaced by the project. A subsequent study of population densities on the pilot reef should allow the Corps to estimate the appropriate acreage of mitigation required for full habitat value replacement. The Service estimates that an ineffective design may require as much as 2 acres of mitigation per acre of natural reef lost; an effective design could reduce mitigation acreage requirements by more than half.

A prior Biological Opinion in 1989 on this project allowed for nest relocation of threatened and endangered sea turtles. To further minimize incidental take of sea turtles due to nest relocation, the Service now recommends that beach nourishment activities occur between November 1 and April 15, provided the beaches are surveyed for unhatched nests prior to beach fill deposit.

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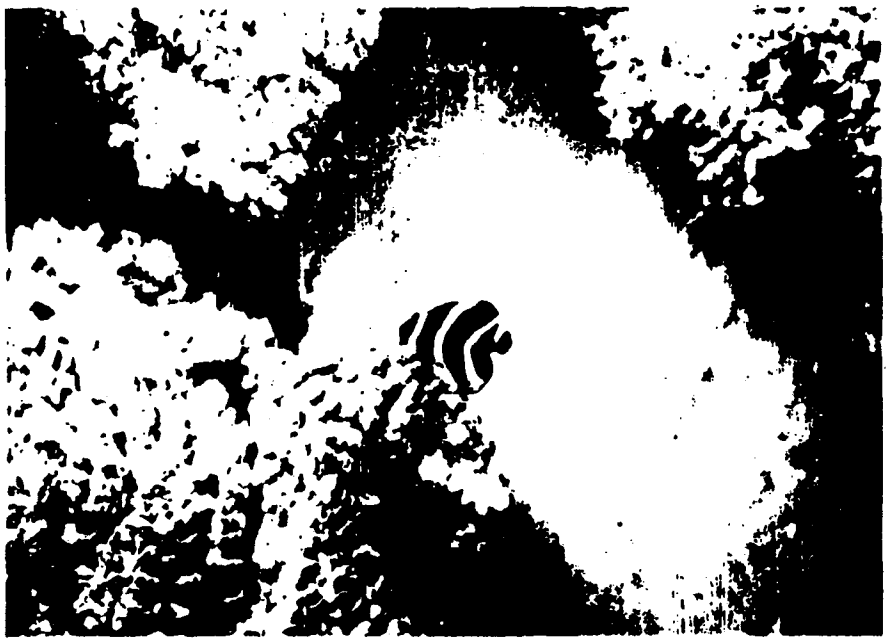


Appendix B. Epibenthic Community

ATTACHMENTS

United States Department of the Interior
FISH AND WILDLIFE SERVICE
P.O. BOX 2676
VERO BEACH, FLORIDA 32961-2676

February 8, 1989

Colonel Robert L. Herndon
District Engineer
U.S. Army Corps of Engineers
P.O. Box 4970
Jacksonville, FL 32232-0019

Dear Colonel Herndon:

This represents the Biological Opinion of the U.S. Fish and Wildlife Service, (Service), in accordance with Section 7 of the Endangered Species Act (ESA), of 1973, as amended, regarding the proposed beach erosion control project on Hutchinson Island, Martin County, Florida (FWS Log Number 4-1-89-050). An official record of this consultation is on file in this office.

PROJECT DESCRIPTION

Approximately 942,000 cubic yards of sand would be dredged from an offshore borrow site and placed along 4 miles of beach on Hutchinson Island from the north Martin County line to 0.25 miles south of Stuart Public Beach. Sand grain size based on core borings averages 0.29mm from the offshore borrow material compared to 0.35mm natural beach material. Silt content approximates 6-7 percent by weight.

CONSULTATION HISTORY

On December 6, 1985, the Service provided a Biological Opinion (FWS Log No. 4-1-85-135) to the Corps on the proposed project. On October 20, 1988, the Service responded to a September 13, 1988, Corps request for comments to the Final Environmental Impact Statement for the proposed project. In this response the Service requested the Corps reintiate Section 7 consultation based on new information relative to beach nourishment impacts to sea turtles. The Corps reinitiated consultation with a November 17, 1988 letter to the Service.

BIOLOGICAL OPINION

Three species of sea turtles nest regularly on Florida beaches including the area to be affected by the present proposed activity. The biology of these sea turtles, especially as it relates to nesting of these species in Florida, has been documented in several past Biological Opinions to the Corps (FWS Log No. 4-1-88-251, October 4, 1988; FWS Log No. 4-1-87-149, May 14, 1987). The potential impacts of beach renourishment projects on nesting sea turtles has also been documented and discussed in these Biological Opinions.

Annual nesting activity for Hutchinson Island has averaged 137 loggerhead, 1.6 green, and 0.5 leatherback nests per kilometer between 1985-1987. Based on this information over 875 loggerhead, 10 green and 3 leatherback nests could be affected by the proposed activities.

The Corps indicates in its Biological Assessment that efforts will be made to conduct the proposed dredging and beach disposal outside the nesting season. The Corps has proposed a nest relocation program, should the work be conducted during the nesting season. Even with a nest relocation program, some nests will likely be missed and subsequently buried by the nourishment material or crushed by heavy equipment. In spite of the best intentions, or efforts by persons relocating nests, wind, rain, and tides can quickly obscure tracks and prevent workers from finding nests. Turtle activities also can often obscure nest locations making them difficult to find; especially if searchers are inexperienced or lack motivation. Impacts, such as increased false crawls, aberrant nests, and broken eggs, could occur subsequent to nourishment within the project area due to beach compaction.

Other potential adverse impacts to sea turtles have been discussed in recent Biological Opinions as noted above. The adverse effects resulting from the deposition of dredged material on the area could affect approximately 900 nests. This represents approximately two to three percent of annual nesting activity in Florida. It is our opinion therefore, that the proposed activity is not likely to jeopardize the continued existence of listed sea turtles. We do however believe that adverse impacts to sea turtles could result, particularly when viewed cumulatively in the context of other nourishment projects. The Reasonable and Prudent Measures provided with the Incidental Take Statement will reduce take and adverse impacts to sea turtles.

INCIDENTAL TAKE

Section 7(b)(4) of the Act requires that once a proposed agency action is found to be consistent with Section 7(a)(2) of the Act and the proposed action is likely to result in the take of some individuals of the listed species incidental to the action, the Service will issue a statement that specifies the amount or extent of the impact of such incidental taking. It also states that reasonable and prudent measures, coupled with terms and conditions to implement those measures, be provided to minimize such impacts. The Service must also specify procedures to be used to handle or dispose of any individual specimens taken. Reasonable and prudent measures are <u>requirements</u> of the action agency.

We have reviewed the biological information and other information relevant to this action and based on our review incidental take is authorized for all nests missed by a nest relocation program within the area included in the project boundary. This is inclusive of the direct impacts of nest burial or crushing and the indirect impacts of aberrant nests and broken eggs which result from sand compaction in nesting seasons subsequent to nourishment activities.

The Service believes the following reasonable and prudent measures are necessary and appropriate to minimize the take.

1. Construction activities will not occur during the main portion of the sea turtle nesting season.

2. Nourished beaches will be tilled if compaction occurs.

Section 9 of the Endangered Species Act prohibits the taking of listed species without a special exemption. In order to be exempt from the prohibitions of Section 9 of the Act, the following terms and conditions, which implement the reasonable and prudent measures described above, must be complied with.

1. The sea turtle nesting season in this area is between March 1 and November 30. To minimize the need for nest relocation and, therefore, reduce the possibility of nest burial or crushing of missed nests, beach nourishment will be started after October 5 or completed before May 30 (preferably after November 5 or before May 1).

2. Nourished beaches will be plowed to a depth of at least 36 inches immediately following completion of beach nourishment if sand compaction is greater than 500 p.s.i. This must be accomplished within the time frame identified for nourishment completion in term and condition #1.

3. Nest relocation activities must begin 65 days prior to nourishment activities which occur within the nesting season (March 1 - November 30) or March 1, whichever is shorter.

4. Nest surveys and relocations will be conducted by personnel with prior experience and training in nest survey and relocation procedures, and with a valid Florida Department of Natural Resource permit. This is essential to reduce the number of missed nests.

5. Nests shall be relocated between sunrise and 10 a.m. each day, and the relocation will be to a nearby self-release beach hatchery in a secure setting and such that artificial lighting will not conflict with hatchling orientation.

6. A report describing the actions taken to implement the terms and conditions will be submitted to this office within 60 days of completion of the proposed project. This report will include dates of actual construction activities, names and qualifications of personnel involved in nest surveys and relocation activities, description and location of hatcheries, nest survey and relocation results and hatching success of nests.

In the event a turtle nest is dug up by beach construction activities the following procedures should be followed:

1. Immediately notify the Florida Department of Natural Resources permitted individual responsible for nest relocation on the project for removal of the nest to the beach hatchery. Before eggs are relocated the top of each egg will be marked with a non-toxic felt tip pen and individually and gently placed on 2-3 inches of moist sand in a rigid-walled container, being careful not to change the axis of the eggs. Eggs will be covered with a fine mesh nylon and then 2-3 inches of moist sand, shaded from the sun, and transported to the hatchery immediately. Eggs will be placed in the constructed nest chamber one at a time insuring that axis of the eggs remains the same.

CONSERVATION MEASURES

To further insure that the project will not affect sea turtles, we request that the Corps include the following conservation measures as conditions in the project plans.

1. Turtle nesting surveys should be conducted for 3 years following nourishment to gather better information on nest success, and hatchling success subsequent to future nourishment. Daytime surveys should be conducted a minimum of 6 days/week, and a sample of the nests should be marked to determine their fate. A sample of these nests should also be analyzed to determine hatching and emergence success. Details of this study should be coordinated with the Fish and Wildlife Service.

2. Sea oats or other appropriate dune vegetation should be planted on nourished beaches to enhance dune restoration. The Florida Department of Natural Resources, Division of Beaches and Shores, can provide technical assistance on the specifications for the design and implementation.

3. Lighting on offshore dredge equipment and beach equipment should be minimized by screening, or use of low pressure sodium lights, reducing intensity, or eliminating lighting where possible, to reduce adverse impacts to nesting turtles and hatchlings.

This completes consultation under Section 7 of the Act. If modifications are made in this project or if additional information becomes available relating to endangered species, reinitiation of consultations may be necessary.

Sincerely yours,

David L. Ferrell
Field Supervisor

cc:
FWE, Jacksonville, FL
FWE, Atlanta, GA
FWE, Washington, D.C.
DNR, St. Petersburg, FL
Molly Palmer, FDNR, Tallahassee, FL
Barbara Schroeder, FDNR, Stuart, FL
Chuck Oravetz, NMFS, St. Petersburg, FL

ATTACHMENT B

CONCURRENCE LETTERS

RECEIVED
NOV 30 1993

FLORIDA GAME AND FRESH WATER FISH COMMISSION

MRS. GILBERT W. HUMPHREY Miccosukee
JOE MARLIN HILLIARD Clewiston
J. BEN ROWE Gainesville
JULIE K. MORRIS Sarasota
QUINTON L. HEDGEPETH, DD Miami

ALLAN L. EGBERT, Ph.D., Executive Director

110 43rd Avenue, S.W.
Vero Beach, Florida 32968
November 23, 1993

Mr. David L. Ferrell
U.S. Fish and Wildlife Service
P.O. Box 2676
Vero Beach, FL 32961-2676

RE: Draft Fish and Wildlife Coordination Act Report for Hutchinson Island Beach Renourishment Project, Martin County

Dear Mr. Ferrell,

The Office of Environmental Services of the Florida Game and Fresh Water Fish Commission has reviewed the above referenced document and concurs with the report's findings and the recommendations. If we can be of further assistance, please do not hesitate to call.

Sincerely,

Stephen R. Lau
Biological Administrator

ENV 1-4-2
SL/MS/rs
hutch.fws

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
Southeast Regional Office
9450 Koger Boulevard
St. Petersburg, Florida 33702

October 18, 1993

RECEIVED
OCT 21 1993

David L. Ferrell
Field Supervisor
U.S. Department of the Interior
Fish and Wildlife Service
P.O. Box 2676
Vero Beach, Florida 32961-2676

Dear Mr. Ferrell:

The National Marine Fisheries Service (NMFS) has reviewed the Draft Fish and Wildlife Coordination Act Report for the proposed beach renourishment project at Hutchinson Island, Martin County, Florida. The report was submitted to us by cover letter dated September 21, 1993.

Based on the information included in the report, we concur with the Fish and Wildlife Service recommendations outlined in pages 13 - 15. We particularly support the recommendations to avoid impacts to reefs at the southern end of the project and to mitigate remaining impacts with artificial reef construction. While we also agree that acreage ratio requirements for the mitigation could be reduced by careful and appropriate artificial reef design, we wish to emphasize the importance of monitoring a pilot reef to ensure that sufficient mitigation is included in the project. Post construction monitoring of the created reefs would certainly be beneficial in future project evaluations, as indicated in recommendation B7.

Thank you for the opportunity to review this draft report. If we can provide additional assistance, please contact Ms. Shelley Du Puy of our Miami Field Office at 305/595-8352.

Sincerely,

Shelley D. Du Puy

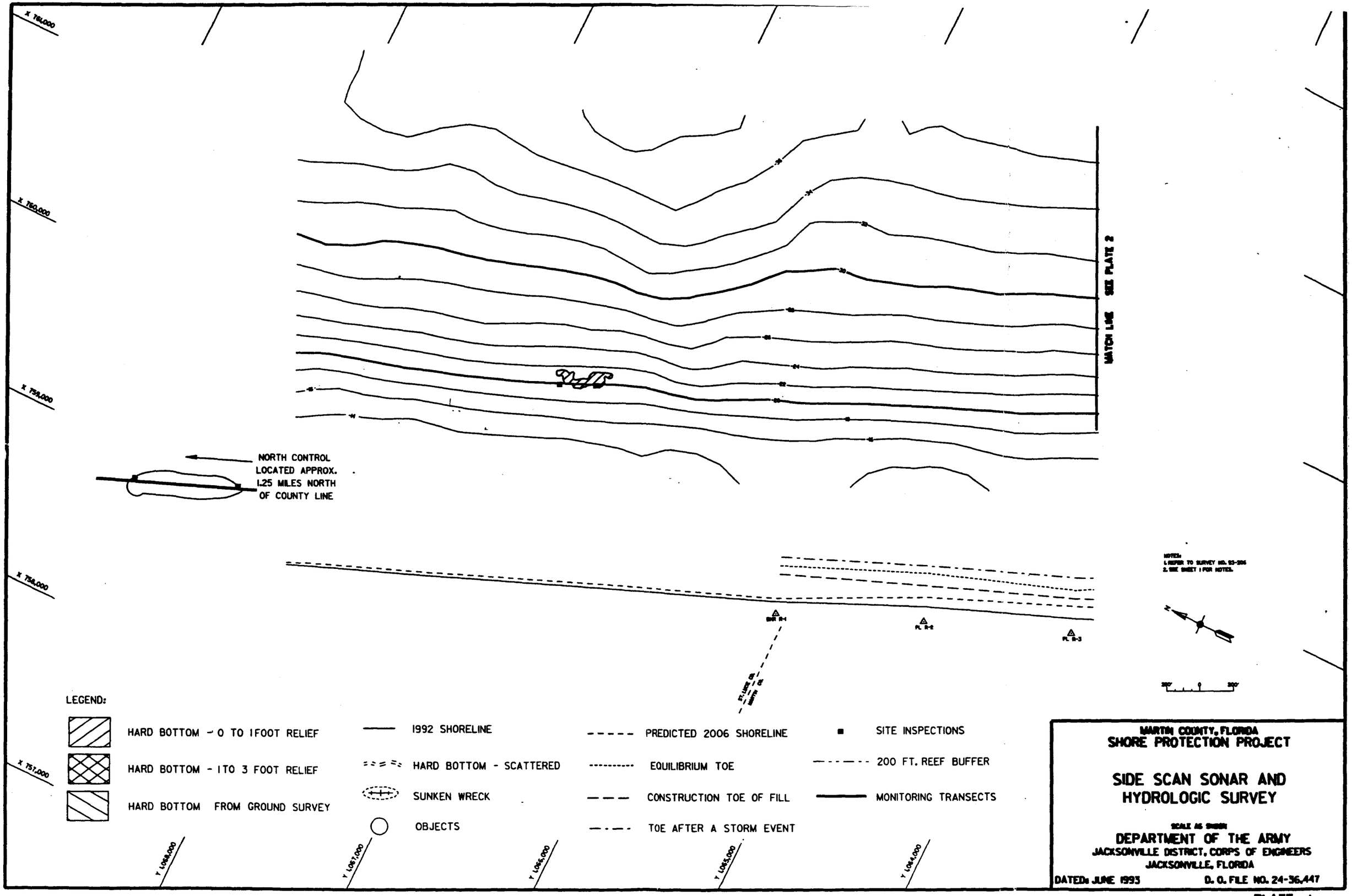
for Andreas Mager, Jr.
Assistant Regional Director
Habitat Conservation Division

Appendix D

Location of Hardbottom Habitat

Martin County Shore Protection Project

Hutchinson Island, Martin County, Florida



MARTIN COUNTY, FLORIDA
SHORE PROTECTION PROJECT

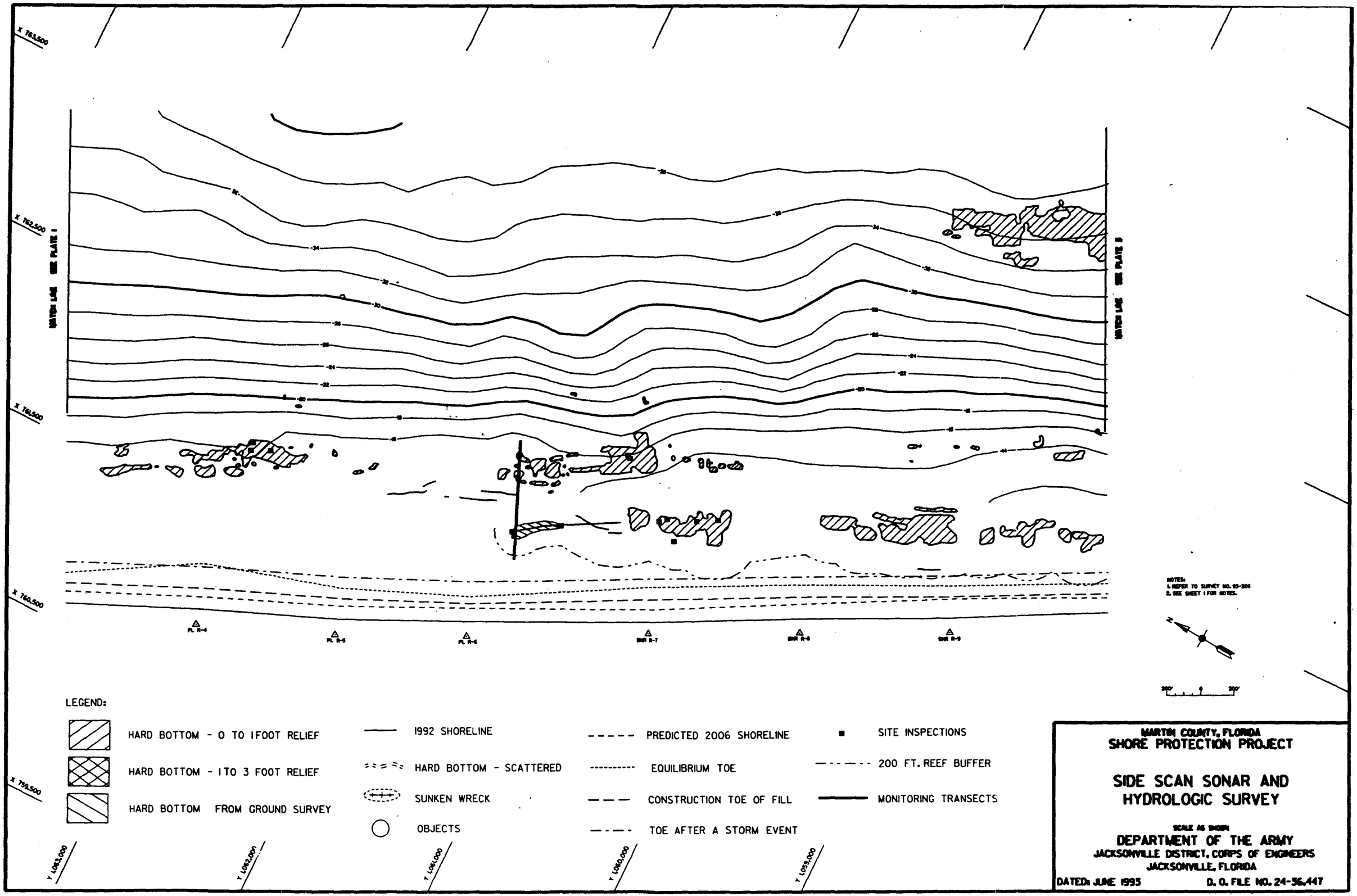
SIDE SCAN SONAR AND
HYDROLOGIC SURVEY

SCALE AS SHOWN

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

DATED: JUNE 1993 D. O. FILE NO. 24-36,447

PLATE 1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1. REFER TO SURVEY NO. 93-206
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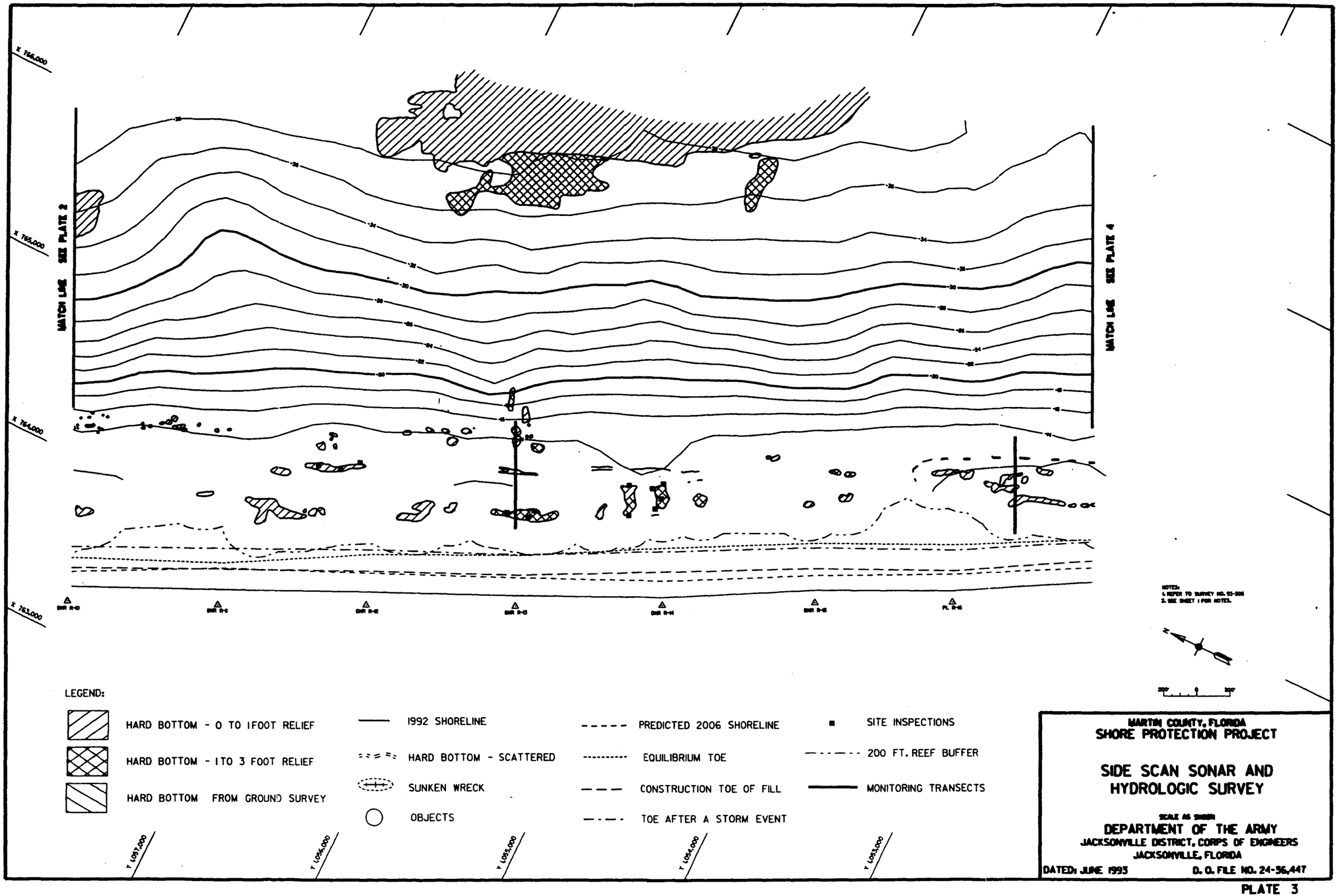
TOE AFTER A STORM EVENT
SITE INSPECTIONS
200 FT. REEF BUFFER
MONITORING TRANSECTS
MARTIN COUNTY, FLORIDA
SHORE PROTECTION PROJECT
SIDE SCAN SONAR AND
HYDROLOGIC SURVEY
SCALE AS SHOWN
DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT, CORPS OF ENGINEERS
JACKSONVILLE, FLORIDA
DATED: JUNE 1995
D. O. FILE NO. 24-36,447

PLATE 2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MARTIN COUNTY, FLORIDA
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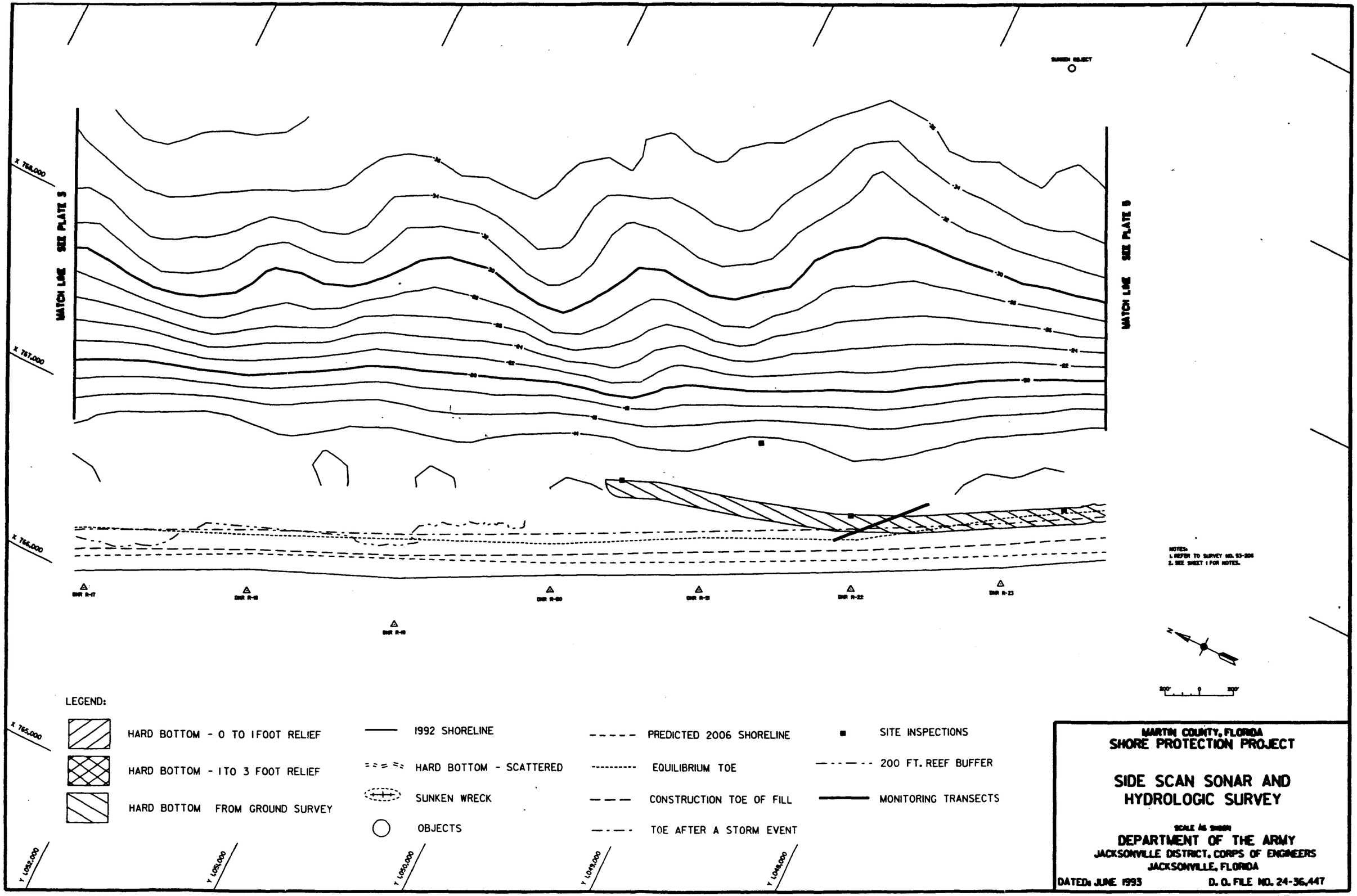
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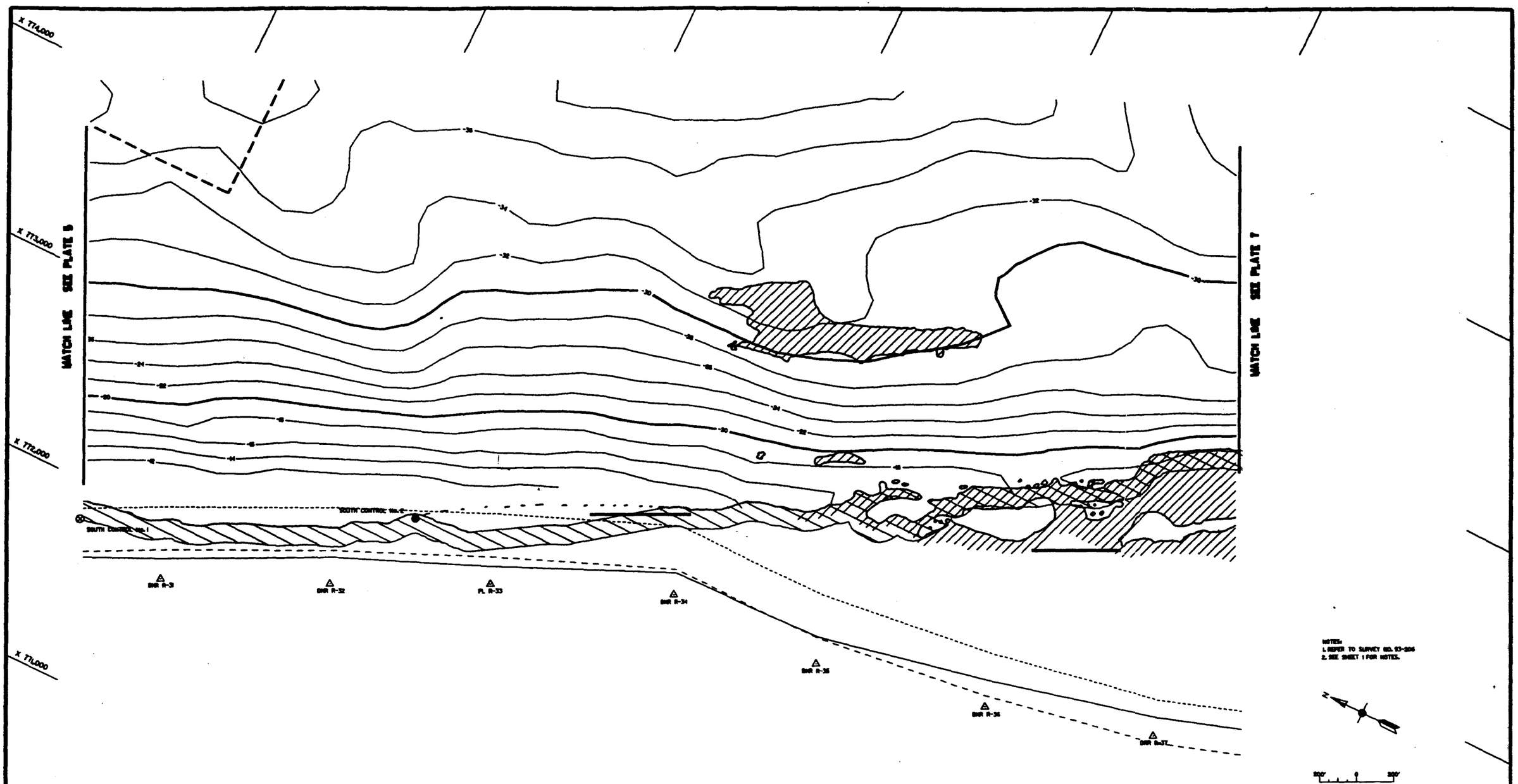

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MARTIN COUNTY, FLORIDA
SHORE PROTECTION PROJECT

SIDE SCAN SONAR AND HYDROLOGIC SURVEY

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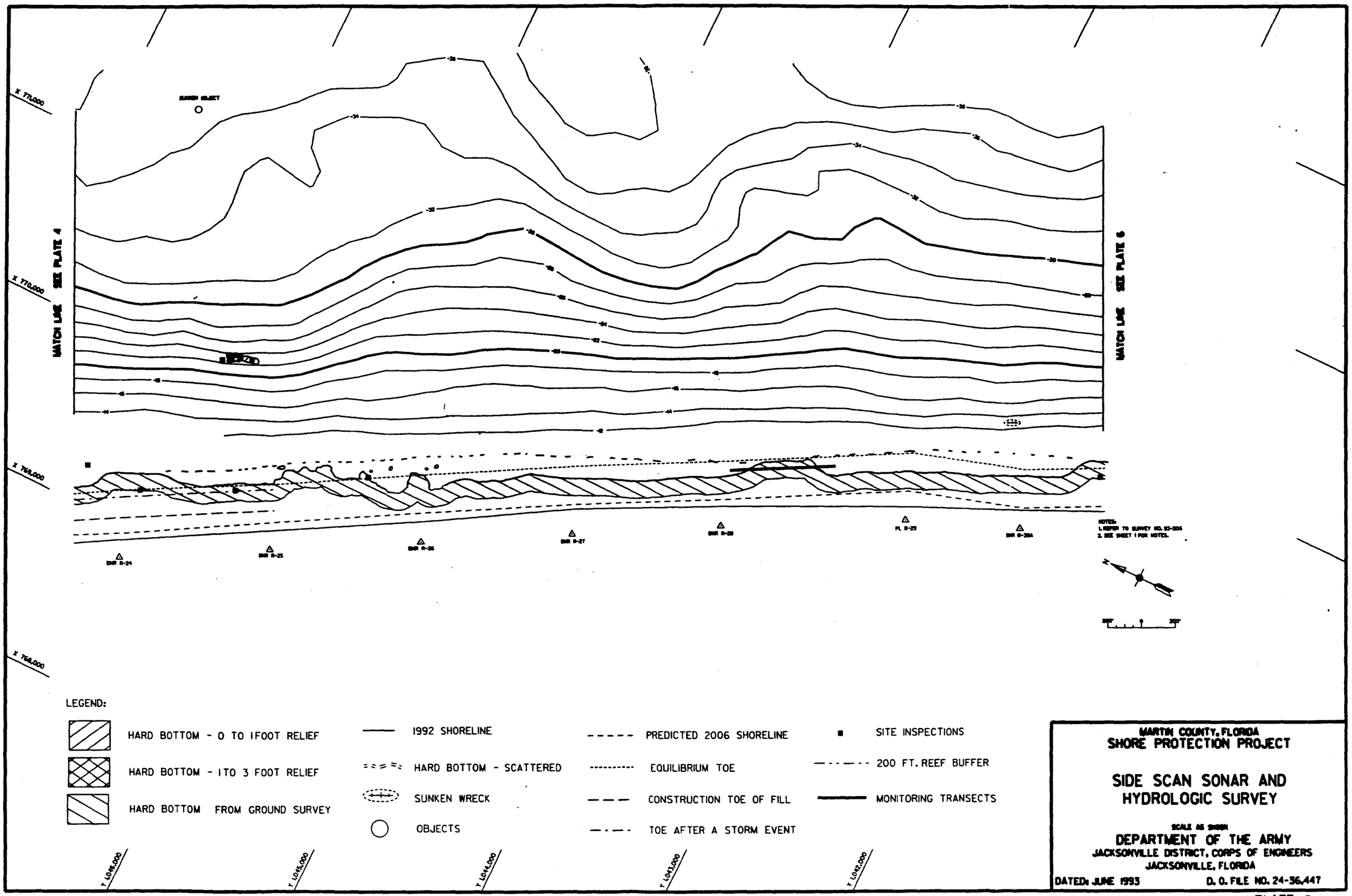
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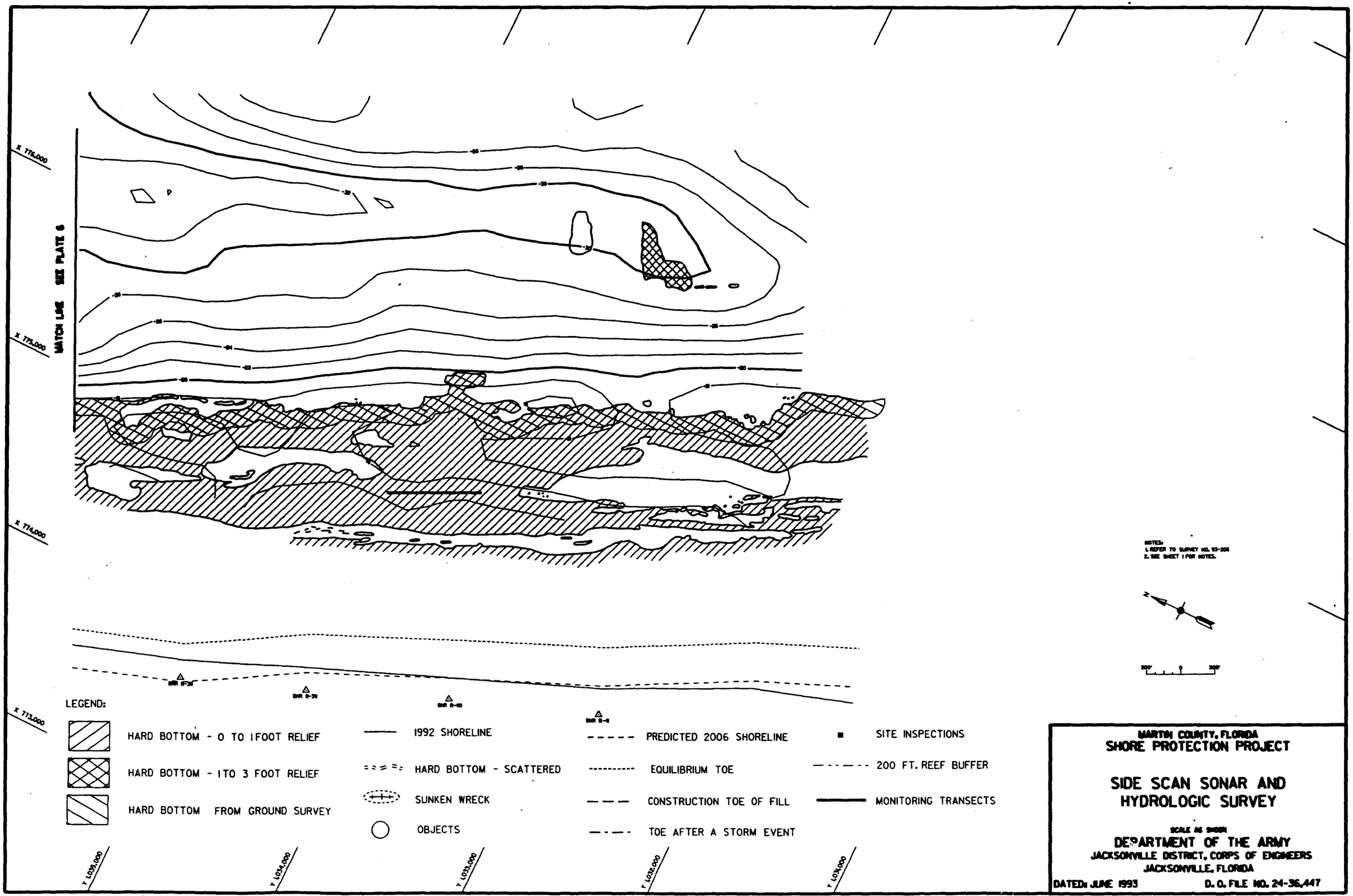
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APPENDIX B

ECONOMIC ANALYSIS

ECONOMIC ANALYSIS
APPENDIX B
MARTIN COUNTY, FLORIDA
SHORE PROTECTION PROJECT
GENERAL DESIGN MEMORANDUM

TABLE OF CONTENTS

SUBJECT	Page No.
Project Benefits	B-1
Primary Benefits - Storm Damage Prevention Benefits	B-1
Storm Damage ($) Model	B-2
Model Assumptions	B-3
Model Input	B-4
Existing and Future Shoreline Position	B-4
Frequency-Shoreline Recession Relationship	B-4
Coastal Protective Armor	B-4
Structural Improvement Value	B-4
Physical Dimensions	B-10
Miscellaneous Information	B-10
Damage Prevention Benefits	B-10
Shoreline Stability Benefits	B-19
Maximization of Net Benefits	B-22
Recreation	B-31
Study Area	B-32
Recreation Demand Computation	B-32
Participation Rates	B-33
Regional Demand	B-34
Recreation Supply Computation	B-38
Beach Accessibility Parking Constraints	B-41
Demand Allocation Based Upon Supply	B-41
Daily Demand	B-49
Determination Of Willingness To Pay - Travel Cost Method	B-50
Origin Zones	B-50
Zone Per Capita Use Rate	B-51
Travel Distance Computation	B-51
Average Value of Travel	B-54
Value of Recreation	B-55
Recreation Demand Computation	B-56
Method	B-56
Computational Observations	B-57
Summary Of Total Project Benefits And Cost	B-60

LIST OF TABLES

Title	Table Number	Page Number
Storm Damage Model Input	B-1	B-6
Storm Damage Model Input Summary	B-2	B-7
Recession - Damage Tables		
Without Project	B-3	B-12
With Project	B-4	B-13
With Project - Modified Plan	B-4b	B-13b
Storm Damage Calculations	B-5	B-14
Average Annual Damage Summary		
Without Project	B-6	B-15
Authorized Plan - With Project	B-7	B-16
Modified Plan - With Project	B-8	B-17
Damage Prevention Benefit Summary	B-9	B-18
Estimate of Land Value	B-10	B-20
Nearshore Sales Information	B-11	B-20
Existing and Future Year Loss of Land Benefits		
Authorized Plan	B-12	B-23
Modified Plan	B-13	B-26
Martin County Economic Summary	B-14	B-29
Recommended Plan Summary - Recreation Benefits Excluded	B-15	B-31
Resident and Tourist Participation Rates	B-16	B-34
Total Regional Demand In User Occasions	B-17	B-35
Allocation of County Demand	B-18	B-37
Recreation Beach Infrastructure	B-19	B-39
Without Project Supply in Square Feet	B-20	B-40
With Project Supply in Square Feet Modified Plan	B-21	B-42
Without Project Supply in People Per Day	B-22	B-43
With Project Supply in People Per Day Modified Plan	B-23	B-44
Without Project Supply - Parking Constraints	B-24	B-45
With Project Supply - Parking Constraints Modified Plan	B-25	B-46

LIST OF TABLES (Continued)

Without Project Demand - In Yearly User Occasions	B-26	B-47
With Project Demand - In Yearly User Occasions Modified Plan	B-27	B-48
Martin Beach Count 1984	B-28	B-49
Beach Participation Zone Characteristics	B-29	B-52
Average Variable Cost to Operate an Automobile	B-30	B-53
Per Trip Costs	B-31	B-54
Travel Cost Demand Curve Points	B-32	B-56
Project Benefit Computations (1996)	B-33	B-58
Average Annual Benefits Summary	B-34	B-59
Summary of Costs and Benefits	B-35	B-60

LIST OF FIGURES

Title	Figure	
Shore Ownership and Lands Subject to Recession	B-1	B-30