ST. LUCIE COUNTY, FLORIDA

COASTAL STORM RISK MANAGEMENT PROJECT
FINAL INTEGRATED FEASIBILITY STUDY
AND ENVIRONMENTAL ASSESSMENT

August 2017

US Army Corps of Engineers ®
Jacksonville District

Using this Document

Report Reference Materials: To ease navigation through the report, prompts are provided throughout the document, alerting the reader to reference additional sections or graphics, or to explain the purpose of an ensuing discussion. In this report, these prompts can be identified by this blue box format.

Additionally, informational foldouts **REF-1, REF-2, REF-3, and REF-4** are provided at the end of the report to be used while reading the document to serve as reference maps with key points and landmarks. In addition, an overall table of contents is provided, along with detailed tables of contents as well as an index at the end of the report.

Organization of this report follows Exhibit G-7 (Feasibility Report Content) provided in Appendix G of ER 1105-2-100 (30 June 2004), documenting the iterative U.S. Army Corps of Engineers (USACE) Plan Formulation Process. The planning process consists of six major steps:

(1) Specification of problems and opportunities
(2) Inventory, forecast, and analysis of existing conditions within the study area
(3) Formulation of alternative plans
(4) Evaluation of the effects of the alternative plans
(5) Comparison of the alternative plans
(6) Selection of the recommended plan based upon the comparison of the alternative plans.

Steps may be repeated as problems become better understood and new information becomes available.

Steps 1 and 2 are discussed in Chapters 1-2, and provide the foundation for developing alternative plans and selection of a recommended plan outlined in Chapter 3.

Each chapter and summary graphic, as well as the executive summary, describes plan development as it progresses through the four integrated environments that shape a coastal storm risk management (CSRM) project: the built environment (upland development, etc.); the natural environment (species of concern and their habitat); the physical environment (currents, tides, sea level rise, etc.), and the economic environment (vulnerability of built environment to damages). Concerns relative to plan formulation and National Environmental Policy Act (NEPA) review are summarized and encapsulated in the discussions of these four main environments.

The recommended format of an Environmental Assessment (EA) is provided in 40 CFR 1502.10 and has been integrated into the Feasibility Report. The basic table of contents for the report outlines how the EA format has been integrated into the planning process to develop a recommended plan that meets the requirements of both USACE Plan Formulation Policy and NEPA.

Note that sections pertinent to the NEPA analysis are denoted with an asterisk.

US Army Corps of Engineers
JACKSONVILLE DISTRICT

FINDING OF NO SIGNIFICANT IMPACT

ST. LUCIE COUNTY, FLORIDA
COASTAL STORM RISK MANAGEMENT
INTEGRATED FEASIBILITY STUDY AND ENVIRONMENTAL ASSESSMENT

The U.S. Army Corps of Engineers, Jacksonville District (Corps), has conducted an environmental assessment in accordance with the National Environmental Policy Act of 1969, as amended. The Corps assessed the effects of the following actions in the Final Integrated Feasibility Report and Environmental Assessment (IFR/EA), dated August 2017 for the St. Lucie County Coastal Storm Risk Management Study, Florida. The final recommendation is contained in the report of the Chief of Engineers, dated 15 December 2017. These reports are incorporated herein by reference. The recommended plan includes the following:

- Beach and dune nourishment within the South Hutchinson Island reach;
- The design includes construction of a 20- foot equilibrated berm extension from the +7.0 foot 1988 North Atlantic Vertical Datum (NAVD88) contour between the R monuments R98.5 and R115+1000 feet to the Martin County line along 3.3 miles of shoreline;
- The project template will include a dune feature that reflects the average 2008 dune position;
- Tapers of a maximum length of one thousand feet will extend from the northern and southern ends of the berm extension, connecting the extension to the existing shoreline. The addition of tapers results in sand placement from R97.5 to R002 along 3.7 miles of shoreline.

Initial construction will require approximately 422,000 cubic yards of sand, and each periodic nourishment event will require approximately 390,000 cubic yards. The periodic nourishment interval is expected to be approximately 18 years, equaling 2 periodic nourishment events in addition to initial construction over the 50-year period of Federal participation.

The sand source identified for the project is the St. Lucie Shoals, located approximately 3.5 miles offshore from the project. There is approximately 10.6 million cubic yards of beach quality sand in the St. Lucie Shoal complex. This volume is more than adequate to meet the initial construction volume. The periodic nourishment volume is approximately 390,000 cubic yards every 18 years.

Native vegetation will be planted on areas of the existing dune disturbed by construction, as well as the newly constructed dune to stabilize the fill.

It is assumed that dune planting will only be necessary for initial construction and that vegetation will naturally grow and spread to any areas that are nourished in the future.

In addition to the "no action" alternative, a final array of five alternatives with varying levels of benefits and costs were evaluated, including the recommended plan. The alternative with the highest net-benefits is the 20 foot extension of the existing berm and maintenance of the existing dune, and with a benefit-cost ratio greater than 1.0, it becomes the National Economic Development Plan and the recommended plan. There is not a locally preferred plan. The recommended plan is also the environmentally preferable alternative.

All practicable means to avoid and minimize adverse environmental effects have been incorporated into the recommended plan. Environmental commitments as detailed in the IFR/EA will be implemented to minimize impacts.

Pursuant to the Clean Water Act of 1972, as amended, any discharge of dredged or fill material associated with the recommended plan have been found to be compliant with section 404(b)(1) Guidelines (40 CFR 230). The Clean Water Act Section 404(b)(1) Guidelines evaluation is found in Attachment G, Attachment 1 of the IFR/EA.

The Florida Department of Environmental Protection (DEP) has concluded that the proposed St. Lucie County Coastal Storm Risk Management Project is consistent with the Florida Coastal Zone Management Program and its associated statutes. DEP stated that the project would likely qualify for a Joint Coastal Permit, which would include water quality certification. A water quality certification pursuant to section 401 of the Clean Water Act will be obtained from DEP prior to construction. All conditions of the water quality certification will be implemented in order to minimize adverse impacts to water quality.

Pursuant to section 7 of the Endangered Species Act of 1973, as amended, coordination with the US Fish and Wildlife Service and the National Marine Fisheries Service has been completed.

Coastal Barrier Resources System Unit P11 occupies a portion of the project area. In coordination with the U.S. Fish and Wildlife Service, it was determined that the portion of the project (Dollman Park) located on non-Federal public lands in P11 is compliant with the Coastal Barrier Resources Act because it meets the Section 6 (G) exception (16 U.S.C. § 3505) permitting Federal expenditures on this publically owned parcel. The non-Federal sponsor shall be responsible for all costs associated with the portion of the project located on privately-owned lands within Unit P11.

Pursuant to section 106 of the National Historic Preservation Act of 1966 (NHPA), as amended, the Florida State Historic Preservation Officer and the Seminole Tribe of Florida concurred with the Corps determination of no effect to historic properties.

Public review of the draft IFR/EA was completed on 30 June 2016. All comments submitted during the public comment period were responded to in the Final IFR/EA.

Technical, environmental, economic, and cost-effectiveness criteria used in the formulation of alternative plans were those specified in the Water Resource Council's 1983 Economic and Environmental Principles for Water and Related Land Resources Implementation Studies. All applicable laws, executive orders, regulations, and local government plans were considered in the evaluation of the alternatives. Based on these reports, the reviews by other Federal, State and local agencies, Tribes, input of the public, and the review by my staff, it is my determination that the recommended plan would not significantly affect the human environment; therefore, preparation of an Environmental Impact Statement is not required.

Date: 7 Sep 18

Andrew D. Kelly, Jr.
Colonel, U.S. Army
District Commander

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FINAL INTEGRATED FEASIBILITY REPORT
AND ENVIRONMENTAL ASSESSMENT
St. Lucie County, Florida

Please refer to informational foldouts REF-1, REF-2, REF-3, and REF-4.

EXECUTIVE SUMMARY

Introduction

Infrastructure along the St. Lucie County shoreline is subject to damage from waves, erosion, and inundation caused by coastal storms. Developed areas, as well as portions of State Road A1A (SR A1A), the major evacuation route for the region, are vulnerable. This study investigates alternatives for a unified plan that addresses these vulnerabilities, as well as provides incidental opportunities for habitat restoration and recreation for four reaches along the Atlantic shoreline of St. Lucie County, Florida.

Purpose and Need

This report is an interim response to the study authority contained in two resolution dockets by the Committee on Transportation and Infrastructure of the U.S. House of Representatives**: Resolution Docket 2634 St. Lucie County, Florida Shore Protection (11 April 2000)** and **Resolution Docket 2757 St. Lucie County, Florida Shore Protection (23 July 1998).** This single purpose Coastal Storm Risk Management (CSRM) study focuses on the erosion problems and potential storm vulnerability of structures on the southern portion of Hutchinson Island along the shoreline bordering the Atlantic Ocean in St. Lucie County, Florida. The non-federal sponsor is St. Lucie County, Florida.

Study Area

The study area is from Florida Department of Environmental Protection (FDEP) range monument (R) R-77 to the Martin County line (approximately R-1), and covers the following four reaches, from north to south: North Hutchinson Island reach, Power Plant reach, Narrows of Hutchinson Island reach, and South Hutchinson Island reach. **(Figure REF-1)**

Alternative Plans and the Recommended Plan

Federal Interest Determination and the Description of the Recommended Plan

It has been determined there is Federal Interest in a project along the southern portion of Hutchinson Island, based on the Recommended Plan (recommended plan) identified using the U.S. Army Corps of Engineers (USACE) Planning Process. The Benefit-to-Cost Ratio (BCR) for the recommended plan is 2.20.

Plan Formulation

A description of the alternatives, their performance in terms of benefits and costs, and the methods used for screening are provided in the subsections that follow.

Management Measures

Management measures are specific structural or nonstructural actions that would take place at geographical locations within the project areas. For the first iteration of evaluating measures, the entire project area was split into two geographical locations:

1) The Power Plant, North Hutchinson Island, and Narrows of Hutchinson Island reaches were grouped together due to their proximity and similarity in physical and built features.
2) The South Hutchinson Island reach was evaluated separately due to its erosive nature and more densely developed coastline.

Structural management measures initially considered included: seawalls, revetments, sand covered soft structures, beach nourishment, groins, submerged artificial reefs, nearshore berm placement, emergent breakwaters, and dunes with vegetation.

Non-structural management measures initially considered included: no-action, coastal construction control line, moratorium on construction, establishment of a no-growth program, relocation of structures, floodproofing of structures, and acquisition of land and structures.

During the plan formulation process, management measures were screened using the four Federal accounts, planning objectives, and constraints using a qualitative assessment in a matrix. Ultimately, most of these measures were screened out, and the three northern reaches (Power Plant, North Hutchinson Island, and Narrows of Hutchinson Island) were screened from further consideration , due mainly to the few structures in the area and as a result, few damages. The South Hutchinson Island reach, with a length of approximately 3.4 miles, was carried forward to the modeling stage with two structural measures: 1) beach nourishment and 2) dunes with vegetation. The beach nourishment measure would include initial construction of a beach fill and future periodic nourishment at planned intervals. The dune and vegetation measure would include placement of beach compatible material, from either upland or offshore sources, as an extension of the existing dune feature. Vegetation would be planted after initial placement of the dune material. The screening process is described in detail in **Chapter 3** of the main report.

Alternative Development

An alternative plan is a set of one or more management measures functioning in tandem to address project objectives.

Dunes and Vegetation: Preliminary engineering design work concluded that the most feasible plan for dunes and vegetation would be extending the existing dune by either 10 or 20 feet. This measure was expanded into two alternatives, known as“Dune10” and “Dune20” respectively. Periodic nourishment triggers would occur once the extended dunes were fully eroded and construction would be completed with dredging material from an offshore sand source.

Beach Nourishment**:** The measure was further expanded into five different “design berm” template alternatives which included various widths as follows: 1) maintaining the existing berm width, or 0-foot berm (ABerm), 2) 20-foot berm (BBerm), 3) 40-foot berm (CBerm), 4) 60-foot berm (DBerm), and 5) 80-foot berm (EBerm). Using these design berm template alternatives, a “sacrificial fill” amount was then

considered in 20-foot increments. Much like the dunes and vegetation alternatives, periodic nourishment triggers would occur once sacrificial berm lengths have been fully eroded. Using truck transportation of fill was considered as a possible option for beach nourishment but was found to be cost prohibitive. As a result, dredging material from an offshore sand source would be used for these measures as well.

For a more detailed explanation of periodic nourishment triggers and related specifications please refer to the **Engineering Appendix** of this report.

Through the process described above, the 2 measures of dunes with vegetation (dune extension) and beach nourishment (maintain the existing dune with beach nourishment berm extensions) were then expanded into a total of 42 alternatives for initial modeling, as well as the no-action alternative, which considers a scenario where a project is not built. The two dune extension options (10-foot and 20-foot) were modeled individually and also in combination with the beach nourishment berm extensions.

After initial modeling it was apparent that the only economically justifiable design template was maintaining the existing berm (a 0-foot design berm extension[1]) (A), and only sacrificial fill extensions up to 40-feet. The various alternatives provided nearly the same level of total benefits, but the costs increased greatly with the size of the project. Dune extensions, in combination with beach nourishment berm extensions, were also unjustifiable, but a stand-alone project of Dune10 was carried forward to the final array. Upon realizing larger projects had no justification, the decision was made to add alternatives and model sacrificial-fill amounts in 10-foot increments. The alternatives carried into the final array for Beach-fx modeling (100 iterations) were as follows: no-action, ABerm10DuneEx[2], ABerm20DuneEx, ABerm30DuneEx, ABerm40DuneEx, and Dune10[2].

Alternative Comparison

All of the alternatives described above were modeled in Beach-fx using full (100 iteration) life cycle simulations in order to calculate benefits and costs, resulting in the information in **Table ES-1-1**. These plans were evaluated using FY2017 price levels and the FY2017 Federal water resources discount rate of 2.875%. The evaluation covered the span of a 50-year period of analysis with a base year of 2020. Benefit values in this table include those derived from land loss estimations and incidental recreation benefits. It is important to note that this table represents costs and benefits estimated during the alternative evaluation process based on the best available information at that time.

The alternative with the highest net-benefits is the 20 foot extension of the existing berm and maintenance of the existing dune, and with a BCR greater than 1.0, it becomes the National Economic Development (NED) Plan and the recommended plan. There is not a locally preferred plan.

[1] 0-foot berm refers to using the existing berm width as the "design", where "0" would be the starting reference point for sacrificial fill.

[2] These alternatives were determined too small for dredging so trucking costs were used in Beach-fx modeling.

Table ES-1-1. Average Annual Equivalent (AAEQ) Benefits and Costs for Final Array of Alternatives.[3]

Alternative Name	Total AAEQ Costs	Net Benefits	BCR
No-action	-	-	-
20-foot Berm (R-98.5 to Martin County line)	**$1,314,927**	**$1,650,356**	**2.26**
30-foot Berm (R-98.5 to Martin County line)	$1,462,493	$1,503,541	2.03
10-foot Berm (R-98.5 to Martin County line)	1,411,990	$1,545,923	1.82
10-foot Dune (R-98.5 to Martin County line)	1,485,348	$1,441,501	1.97
40-foot Berm (R-98.5 to Martin County line)	$1,627,343	$1,335,742	1.82

The recommended plan consists of beach nourishment and periodic nourishment along approximately 3.3 miles of shoreline between FDEP monuments R-98.5 and the Martin County line, to include an additional taper with a maximum length of 1,000 feet on the north and sound boundary (from R-97.5 to R-98.5 and from R-001 to R-002) for a total of 3.7 miles. The design beach fill template is characterized by a 20-foot berm extension (+7 ft-NAVD88) from the toe of the 2008[4] dune profile. Beach fill material required under the base sea level rise (SLR) case includes an average of 422,000 cubic yards for initial construction of the design beach profile and approximately 2 periodic nourishment events averaging 390,000 cubic yards each. It is important to clarify that the placed volume will be referenced throughout this report; however, the dredged volume is notably important as well for coordination of sand sources. The dredged volume is anticipated to be approximately 30% greater than placed volume. This project proposes to use sand from St. Lucie Shoal, which contains material compatible with the native sand within the study area, and has a sufficient quantity for a 50-year period of analysis. The St. Lucie Shoal sand resources identified for this project are located greater than three nautical miles offshore within Outer Continental Shelf (OCS) waters and are under the jurisdiction of the Bureau of Ocean Energy Management (BOEM).

Benefits of the Recommended Plan

The economic benefits of the plan are generated in the USACE certified Beach-fx model by reductions in erosion, wave, and inundation damages. The model results suggest that the recommended plan is highly effective at reducing nearly all damages. The 20-foot berm extension protects St. Lucie County from 98% of all damages in the period of analysis and nets $1,616,660 Average Annual Equivalent (AAEQ) worth of benefits.

[3] October 1, 2017 Price Level @ 2.875% (2017) discount rate. This table presents inclusion of storm damage reduction, land loss and recreation benefits. OMRR&R and IDC were not yet factored in at this point of the process; they are included, however, in the recommended plan economic costs and benefits.

[4] In order to ensure that emergency nourishment efforts in response to the 2004 and 2005 hurricane season, and local fill project completed in May 2013 did not influence the outcome of the ongoing feasibility study, it was agreed that the "without-project" shoreline for the study would be established using survey data collected in the summer of 2006. However, subsequent analysis of the data showed that the 2006 survey did not provide adequate foreshore and offshore coverage of the project area to complete the Beach-fx analysis. A comparison of the available portions of the 2006 survey and a comprehensive shoreline survey taken in August 2008 showed insignificant difference in shoreline dimensions between the two. Therefore, the 2008 shoreline was determined to be a good representative of the 2006 shoreline and was adopted as the "without-project" condition.

Sea Level Rise (SLR)

The recommended plan performs satisfactorily in each SLR scenario (base, intermediate, and high) and establishes itself as a robust option when considering risk and uncertainty. Benefits increase at a much greater magnitude than costs and the BCR increases by over 50% from base SLR to intermediate SLR. There is also a significant increase in BCR from the intermediate SLR to the high SLR. The recommended plan remains an efficient and effective plan for any of the three possible SLR scenarios.

Environmental Considerations

In accordance with permits issued by the State of Florida and USACE, St. Lucie County constructed a 60 foot berm consisting of beach quality material from R-98 to the St. Lucie / Martin County Line in 2012/2013. The permits required that the County construct 1.89 acres of artificial reef to mitigate for impacts to naturally occurring hardbottom. USACE Regulatory Division has determined that the beach placement, mitigation, and monitoring have been performed in compliance with the County's permit SAJ-2009-03448. The compliance letter dated 3 April 2017 can be found in Appendix G, Attachment 3. A total of 1.93 acres of artificial reef were constructed (refer to Section 2.2.5 for more information). The Recommended Plan consists of a 20 foot berm and would be constructed from R-99 to the St. Lucie/ Martin County Line. This is a smaller template both in length and width of berm than the project built by St. Lucie County. Based on the equilibrated profile determination and the equivalence of sand grain size characteristics proposed for placement and those previously placed, the Recommended Plan would have no additional impact on hardbottom resources lying within the equilibrium toe of fill. Therefore, no additional mitigation is proposed.

The beneficial effects of periodic nourishment along the proposed project area include establishing a larger buffer beach to protect upland infrastructure against coastal storm inundation, erosion, and wave attack, and additional habitat for beach flora and fauna, as well as more space for recreational activities. The National Marine Fisheries Service (NMFS) has designated loggerhead sea turtle critical habitat within the study area.

The proposed project would likely produce more favorable environmental conditions than exist at present, although construction operations would produce some temporary adverse effects. The affected resources would return to pre-construction conditions either immediately after dredging, with respect to resources such as aesthetics and noise, or within one or two years, with respect to sea turtle nesting and benthic resources.

Coastal Barrier Resource System (CBRS) unit P11 occupies approximately 15% (roughly R-98 to R-98+210 and R-101.5 to R-103.5) of the project area proposed by the recommended plan. The purposes of the Coastal Barrier Resources Act (CBRA) include minimizing the loss of human life, wasteful expenditure of Federal revenues, and damage to fish, wildlife, and other natural resources associated with CBRS units. There are limits to Federal expenditures related to actions that could affect a unit. Section 6 of CBRA (16 U.S.C. § 3505) permits certain Federal expenditures assistance within the CBRS if it meets one of the exceptions A-G and it is also consistent with the three purposes of CBRA, which include: 1) minimize the loss of human life; 2) minimize wasteful expenditure of Federal revenues; and 3) minimize damage to fish, wildlife, and other natural resources. There are a small number of privately owned parcels within the project area, and within P11, which are not under any perpetual conservation designation. Federal

expenditures for any alternative implementation, including beach nourishment, in this area would be prohibited by the CBRA due to the fact that such action could encourage development. A Section 6 CBRA exception would only apply if these private parcels were covered under a perpetual conservation easement, which is not the case. However, non-federal funds could be used to nourish the beach in this area. Dollman Park, a publicly owned parcel within the project area, does meet the Section 6 exception since development is prohibited in this location; therefore, Federal funds could be used to nourish the beach adjacent to the park. The U.S. Fish and Wildlife Service, by letter dated 2 November 2016, determined that the Recommended Plan meets the section 6 (G) exception and is consistent with three purposes of CBRA. Exception 6 (G) is for nonstructural shoreline stabilization that is designed to mimic, enhance, or restore a natural stabilization system (refer to Appendix H: Pertinent Correspondence).

Cost Estimate and Implementation

Table ES-1-2. Pertinent Project Information.

Recommended Plan Description	The Recommended Plan includes:
Average # Nourishment Events	1 initial construction event, approximately 2 periodic nourishment events
Average Volume of Initial Construction	422,000 cubic yards
Average Volume of Each Periodic Nourishment	First nourishment: 390,000 cubic yards Second nourishment: 390,000 cubic yards
Average Periodic Nourishment Interval	approximately 18years
Initial Construction Duration	approximately 4 months
Recommended Plan project first cost (including contingency)	$ 53,296,000 (October 1, 2017 (FY18) Price Level)
Cost sharing	Initial construction: 35% Federal / 65% non-federal Periodic nourishments: 27% Federal / 73% non-federal
Benefit-to-Cost Ratio (BCR)	2.20 @ 2.875% discount rate (FY17).

As shown in Table ES-1-3, the total cost of initial project construction, based on average volume requirements, is estimated at $20,276,000. Total future periodic nourishment costs are estimated at $33,020,000, with periodic nourishment expected at approximately 18 year intervals[5]. Under the base SLR case, an estimate of the total cost incurred over the 50-year period of Federal participation is $53,296,000.

[5] Note that vegetating the dune for periodic nourishment events (after initial construction) is a non-federal responsibility and cost, per U.S. Army Corps of Engineers (USACE) Policy Guidance Letter No. (PGL) 27, dated 17 November 1992. For this project, it is assumed that dune vegetation for periodic nourishment will occur by natural recruitment, and therefore no cost is associated with periodic dune vegetation.

Table ES-1-3. Recommended Plan Cost Summary (Project First Cost)(FY 18 Price Levels).

		Initial Construction	Periodic Nourishments
WBS Code	**Item**	**Total Project First Cost (FY18)**	**Total Project First Cost (FY18)**
017	Mob/Demob	$4,303,000	$8,606,000
017	Beach Fill	$8,227,000	$15,046,000
017	Associated General Items	$1,235,000	$802,000
	Subtotal	$13,764,000	$24,454,000
01	Lands and Damages		
	- lands and damages		
	- administrative		
	-Federal Admin	$1,041,000	$47,000
	-non-federal Admin	$694,000	$31,000
30	PED	$1,492,000	$4,151,000
31	Construction Management	$2,012,000	$2,931,000
30	Post-Project Monitoring	$1,273,000	$1,406,000
			(x 2 periodic nourishments)
	Total Project First Cost	**$20,276,000**	**$33,020,000**
	Total Project Cost for 50 year period of Federal participation = $53,296,000		

Operation and Maintenance (also known as Operation, Maintenance, Repair, Replacement, Rehabilitation, or OMRR&R) include all activities which are not related to the initial or periodic nourishments, and are borne 100% by the non-federal sponsor. Based on the size and scope of the Recommended Plan and the cost of similar activities for similar projects, the annual average costs for OMRR&R are estimated to be $32,245 per year, as shown in Table ES-1-4, which also includes interest during construction (IDC).

Table ES-1-4. Equivalent Annual Benefits and Costs.

Costs and Benefits	
(Constant Dollar Basis is FY17 Price Level, Average Equivalent Uses 50-Year POA and 2.875% Discount Rate)	
Cost	
Initial Construction (Constant Dollars)	$ 20,276,000
1st Periodic Nourishment (Constant Dollars)	$ 16,629,000
2nd Periodic Nourishment (Constant Dollars)	$ 16,391,000
Total First Cost (Constant Dollars)	$ 53,296,000
Interest During Construction (IDC)	$ 54,900
Total Investment Cost	**$ 53,350,900**
Average Yearly OMRR&R (100% non-federal)	$ 32,245
Total Average Annual Equivalent Cost	**$ 1,348,623**
Benefits	
Average Annual Equivalent Storm Damages Reduction Benefits (Inlcuding Land-Loss)	$ 2,399,612
Average Annual Equivalent Recreation Benefits	$ 565,671
Average Annual Equivalent Total Benefits	**$ 2,965,283**
Average Annual Equivalent Net-Benefits	**$ 1,616,660**
Benefit-Cost Ratio	2.20

Activities which are needed in direct relationship to the initial and periodic nourishments are cost shared, as described below. Assessing the performance of the project is a two-part process consisting of 1) shoreline monitoring and 2) assessing measured wind, wave, and water level information, in conjunction with sea level rise assessments.

First, physical monitoring of the project is necessary to assess project performance and to ensure that project functionality is maintained throughout the 50-year period of analysis. The monitoring plan will include systematic measurements of the beach profile shape. Profile surveys should provide accurate assessments of dune and beach fill volumes and a basis for assessing post-construction dune and beach fill adjustments, as well as variation in the profile shape due to seasonal changes and storms. Monitoring will play a vital role in determining if project periodic nourishment is necessary.

Post-construction monitoring activities include topographic and bathymetric surveys of the placement area on an annual basis for 3 years following construction and then biannually until the next construction event. Other monitoring efforts include bathymetric mapping of the borrow site to assess capacity, which will be done as part of the engineering and design prior to each periodic nourishment.

Second, measured wind, wave, and water level information will be obtained from the best available existing data sources. This data will be applied in support of the shoreline and borrow site monitoring efforts. It will also be used to periodically assess the state of sea level rise and to determine if reassessment of the project volumes, and/or periodic nourishment intervals based on an acceleration of sea level rise is required.

Coordination with Agencies and the Public

An initial scoping period for the project was conducted from 31 May through 30 June 2006. The NMFS Habitat Conservation Division (HCD) responded to the scoping letter with concerns about hardbottom impacts, the proposed dredging of the offshore shoals, and requested that the EFH assessment and NEPA documents on this action be prepared with sufficient detail. Subsequent scoping for the local project was conducted from 21 April through 20 June 2010. Finally, the draft integrated report was made available for public and agency review in May 2016.

The NMFS responded to the draft integrated report with concerns about the hardbottom mitigation previously provided by St. Lucie County. The EFH assessment is included in Sections 2.2.6 and 5.1.6 of this report. Information on the hardbottom mitigation previously provided by St. Lucie County is provided in Section 2.2.5 and Appendix G, Attachment 3. Essential Fish Habitat conservation recommendations provided by NMFS, as well as USACE responses to the recommendations, including the dredging of the offshore shoals, are provided in Section 6.4. The NMFS letter, dated 9 June 2016, and the USACE response letter, dated 28 December 2016, a subsequent NMFS letter dated 9 January 2017, and the USACE response dated 31 March 2017 are also provided in Appendix G, Attachment 3. The NMFS letter dated 9 January 2017 expressed additional concerns regarding compliance with the Department of Army permit issued to St. Lucie County (refer to Appendix G, Attachment 3). Specifically, these concerns are in regard to the beach nourishment project previously constructed by St. Lucie County, and mitigation that the County provided for impacts to hardbottom habitat (refer to Section 2.2.5 and Appendix G, Attachment 3 for more info). USACE Regulatory Division has determined that the Federal project beach placement, mitigation, and monitoring have been performed in compliance with the County's permit SAJ-2009-03448, and this determination has been coordinated with NMFS. The compliance letter dated 3 April 2017 can be found in Appendix G, Attachment 3.

The Florida State Clearinghouse of the Florida Department of Environmental Protection (FDEP) coordinated a review of the scoping letter and the proposed project with the appropriate state agencies. By letter dated 8 July 2016, FDEP stated that "based on the information contained in the submittal, the state finds that the proposed Draft Environmental Assessment is consistent with the Florida Coastal Management Program (FCMP). The state's continued concurrence will be based on the activities' compliance with FCMP authorities, including Federal and state monitoring of the activities to ensure their continued conformance, and the adequate resolution of issues identified during this and subsequent regulatory reviews. The state's final concurrence of the project's consistency with the FCMP will continue to be determined during the ongoing state's environmental permitting process, in accordance with Section 373.428, Florida Statutes." By letter dated 9 August 2017, FDEP reiterated that "the proposed St. Lucie County Coastal Storm Risk Management Project is consistent with Florida's Coastal Zone Management Program and its associated statutes." FDEP also stated that "it is likely the project would qualify for a Joint Coastal Permit, which would include water quality certification (see Appendix H)."

St. Lucie County was issued USACE and state permits for the local beach nourishment project conducted in the study area in 2012/2013. An Environmental Impact Statement (EIS) was prepared and completed in 2012 as part of the issuance of the USACE permit, which was subsequently coordinated with the agencies and general public. In accordance with 43 CFR 46.140, the EA for this study tiers off of that EIS.

USACE, in coordination with St. Lucie County Erosion District, held a public meeting on 2 June 2016, during the public review period for this document. The format of the meeting included an overview of the Recommended Plan as well as a formal comment period. Meeting comments are summarized in Section 6.4 of this document.

All correspondence associated with this NEPA scoping process is included in Appendix H and Appendix G, Attachment 3 of the main report.

Residual Risk

The proposed project would greatly reduce, but not completely eliminate, future coastal storm risk and damages. Coastal storm damages, caused primarily by erosion, are reduced by approximately 98% (not including prevention of land loss) in the location of the recommended plan over the 50 year period of analysis; therefore, the residual damages would be 2% in this area. The volumes and damages discussed throughout the report are averages. The methods of monitoring and data assessment, while periodically revisiting sea level rise trends described earlier, will be crucial for adaptive management to manage risk.

The Recommended Plan will reduce damages but does not have a specific design level. In other words, the project is not designed to fully withstand a certain category of hurricane or a certain frequency storm event. During study scoping, it was determined that the vast majority of coastal storm risk is within 600 feet landward from the dune line and therefore this boundary was selected as the landward extent of the study area. As a result, the project is not claiming any benefits beyond this designation as damages to structures past this extent were not calculated. Notably, infrastructure on the backside of the barrier island on which the project area is located, although outside of the project area, are susceptible to impacts from sea level rise in the future. Structures within the project area would continue to be subject to damage from hurricane winds and windblown debris. Even new construction is not immune to damage, especially from these processes. The project purpose is coastal storm risk management, and the recommended plan is not designed to prevent loss of life. Public safety risks can be reduced by actions taken at the local, state, and Federal levels.

1 Introduction

1 INTRODUCTION*

Please refer to informational foldout REF-1 throughout Chapter 1.

1.1 FEDERAL PROJECT PURPOSE*

The Water Resources Development Act (WRDA) of 1986 assigns costs of Federal projects to appropriate project purposes. Project reaches that provide hurricane and storm damage reduction are assigned a 65% Federal share for initial construction. Specifically for beach periodic nourishment projects, WRDA 1999 assigned a 50% Federal share for future periodic nourishments. Project reaches that provide for separable recreation are not federally cost shared. The Federal government does not participate in work realizing separable recreation benefits such as constructing a beach only for recreational purposes, and not hurricane and storm damage reduction purposes, or constructing recreation facilities. Recreation is not considered to be a high priority output or primary project output under current Department of Army policy, as described in ER 1105-2-100. This policy precludes Federal funds to support construction of CSRM projects which depend on separable recreation benefits for economic justification, or for which incidental recreation benefits are greater than 50% needed for justification (ER 1105-2-100 section 3-4.b(4)(a)).

The BOEM is authorized under Public Law 103-426 [43 United States Code (U.S.C.) 1337(k)(2)] to negotiate on a non-competitive basis the rights to outer Continental Shelf (OCS) sand resources for coastal storm risk management projects. BOEM may undertake a connected action (i.e., authorize use of the OCS sand source areas) that is related to, but unique from USACE's proposed action. BOEM's proposed action is to issue a negotiated agreement authorizing use of the sand source areas at the request of St. Lucie County and USACE.

1.2 STUDY BACKGROUND AND LOCATION*

St. Lucie County is located along the east coast of south-central Florida, approximately 225 miles south of Jacksonville and 100 miles north of Miami (REF-1). The St. Lucie County, Florida shoreline consists of a 25-mile-long narrow barrier island named Hutchinson Island, bordered by the Atlantic Ocean to the east, and the Indian River Lagoon (Atlantic Intracoastal Waterway) to the west. As a point of reference, St. Lucie Inlet is located approximately 7 miles south of the study area, in Martin County.

The scope of the feasibility study includes a 7.4[6] mile stretch of shoreline located on Hutchinson Island. This area extends along the southern region of St. Lucie County's Atlantic coastline, from FDEP survey range monuments[7] R-77, which corresponds to a region of shoreline extending from approximately 1 mile north of the Florida Power and Light Nuclear Power Plant (FPL power plant) southward to the St. Lucie County/Martin County line.

[6] See Section 1.5 for a discussion on the study area length and authorities.
[7] FDEP reference (R) monuments are located approximately every 1,000 feet along the shoreline and serve as geographic reference points for historic and contemporary shoreline monitoring. They are used as reference points throughout this report.

The study area is largely dominated by a large U.S. Fish and Wildlife Service (USFWS) designated Coastal Barrier Resource System (CBRS) unit, known as CBRS unit P11.

According to the USFWS website, Congress recognized that certain actions and programs of the Federal government have historically subsidized and encouraged development on coastal barriers, resulting in the loss of natural resources, threats to human life, health, and property, and the expenditure of millions of tax dollars each year. To remove the Federal incentive to develop these areas, the Coastal Barrier Resource Act of 1982 designated relatively undeveloped coastal barriers along the Atlantic and Gulf coasts as part of the John H. Chafee Coastal Barrier Resources System (CBRS), and made these areas ineligible for most new Federal expenditures and financial assistance. CBRA encourages the conservation of hurricane prone, biologically rich coastal barriers by restricting Federal expenditures that encourage development, such as Federal flood insurance. Areas within the CBRS can be developed provided that private developers or other non-federal parties bear the full cost.

In particular, CBRS unit P11 extends from approximately R-77 to R-103, with three relatively small gaps, known as "excluded" areas, at approximately R-80 to R-84, R-88.5 to R-90, R-98+600 feet to R-101, and from R-103 to R-115+1000 feet (REF-1). Of the approximate 7.4 miles of shoreline within the study area, roughly 3.4 miles of shoreline are in the CBRS. The three CBRS excluded areas have a total length of about 1.4 miles of shoreline. The non-CBRS affected shoreline is the southernmost part of St. Lucie County and stretches 2.6 miles from approximately R-103 to the St. Lucie/Martin County line at approximately R-001. Altogether, the CBRS comprises about 46% of the study area.

The area has been delineated into four reaches:

- North Hutchinson Island (R-77 to R-80): This reach is approximately .57 miles long, with an average erosion rate of -1.8 feet per year. There is no development in this reach and it is entirely within the CBRS unit.
- Power Plant Area (R-80 to R-90): This reach is approximately 1.9 miles long, with an average shoreline change rate of +0.06 feet per year (slightly accretional). The only structure in this reach is the Florida Power and Light (FPL) Nuclear Power Plant. With the exception of the power plant, the remainder of the reach is entirely within the CBRS unit.
- Narrows of Hutchinson Island (R-90 to R-98): This reach is approximately 1.5 miles long and the average erosion rate is -1.0 feet per year. The area consists of low density development within the CBRS unit, with the exception of one excluded area with one condominium development.
- South Hutchinson Island (R98 to R115 plus 1,000 feet (to the Martin County line)): This reach is approximately 3.4 miles long and the average erosion rate is -.4 feet per year. A small portion of the CBRS unit ends at approximately 200 feet south of R-98, and begins again at roughly R-101.5 to R-103.5 (Dollman Park), and then ends for the remainder of the reach.

State Road A1A is the only north/south access road for Hutchinson Island and is the island's only hurricane evacuation route. Development along the study area portion of Hutchinson Island consists mainly of the FPL power plant near the north end of the project area, parks and multi-story condominiums on the east (ocean) side of SR A1A, and a couple of single-family residential developments west of A1A in the southern

portion of the study area. The Nettles Island community is located west of R-106 and the Waveland community is located between R-111 and R-115. There is no coastal armoring, such as seawalls or revetments, within the study area.

Within the study area, there are 7 public access points which provide public parking and beach access. As of June 2017, St. Lucie County has created an additional 3 public access points which use existing parking. Public access and related parking are discussed in Chapter 2 and Chapter 3.

1.3 STUDY SPONSOR

The non-federal sponsor is St. Lucie County, Florida, represented by the Board of County Commissioners. A Feasibility Cost Sharing Agreement was executed on 29 June 2004.

1.4 STUDY PURPOSE AND NEED

The purpose of this study is to determine whether there is economic justification and Federal interest in coastal storm risk management (CSRM) within the study area of the St. Lucie County, Florida coastline. St. Lucie County's barrier Islands can be eroded by frequent winter storms (northeasters) as well as tropical storms and hurricanes.

Offshore sand resources identified to support CSRM alternatives for this project are located greater than three nautical miles offshore within OCS waters and are under the jurisdiction of BOEM. According to the Outer Continental Shelf Lands Act (OCSLA, 43 U.S.C. §§ 1331 et seq.), outer Continental Shelf (OCS) mineral resources are subject to the jurisdiction, control, and power of the United States (43 U.S.C. § 1332(1)). These minerals, which include sand and gravel, are a vital national resource reserve, which should be made available for expeditious and orderly development, subject to environmental safeguards (43 U.S.C. §§ 1332(3) and 1337(k)(2)(A)). BOEM is the Federal agency charged with managing OCS sand and gravel resources. These resources are not reserved or held for the exclusive use of any particular jurisdiction or entity, especially in a noncompetitive use context. BOEM is authorized under Public Law 103-426 [43 United States Code (U.S.C.) 1337(k)(2)] to negotiate on a non-competitive basis the rights to OCS sand resources for coastal storm risk management projects. BOEM may undertake a connected action (i.e., authorize use of the OCS sand source areas) that is related to, but unique from USACE's proposed action. BOEM's proposed action is to issue a negotiated agreement authorizing use of the sand source areas at the request of St. Lucie County and USACE. BOEM is serving as a cooperating agency under the National Environmental Policy Act (NEPA), with USACE as the lead agency due to the potential use of offshore sand sources located within OCS waters.

There is a need to reduce the damages to coastal infrastructure during hurricane and tropical storm events in the southern portion of Hutchinson Island along the shoreline bordering the Atlantic Ocean in St. Lucie County, Florida. Based on National Hurricane Center (NHC) records, 55 hurricanes and tropical storms have passed within a 50-mile radius from the center of the study area over the 159-year period of record, averaging one storm every 2.8 years.

Historic records for St. Lucie County indicate that the most memorable and damaging storms affected the county in September 1928, September 1933, September 1947, August 1949, October 1964 (Hurricane

Isbell), March 1962 (the "Ash Wednesday northeaster"), 1979 (David), 1999 (Irene), and 2004 (Frances and Jeanne), and 2012 (Hurricane Sandy).

- During the 1947 hurricane, storm tides at Ft. Pierce were over 5 feet above mean sea level.
- The 1962 Ash Wednesday northeaster produced tides of over 6 feet above mean sea level at Ft. Pierce and caused the most severe beach erosion on record in St. Lucie County (Bush et al, 2004).
- Hurricane Irene in 1999, a Category 2 storm, caused significant erosion and cost approximately $6 million in damages to St. Lucie County as it made landfall on the west coast of Florida and exited the east coast directly over the county (Bush et al, 2004).
- In 2004, Hurricanes Frances and Jeanne significantly impacted St. Lucie County, prompting emergency dune restoration efforts in the southern half of the county.
- In 2012, Hurricane Sandy passed through St. Lucie County, with 49 mile-per-hour winds, damaging boardwalks, sand dunes, and beach crosswalks. The storm was reported to cause nearly $12 million in damages along the Treasure Coast, which includes Indian River County, St. Lucie County and Martin County, according to county officials.

The purpose and scope of this study are also influenced by USACE Environmental Operating Principles and USACE Campaign Plan Fiscal Year (FY) 2015-2019, which are discussed further in Chapter 2.

1.5 STUDY AUTHORITIES

A Reconnaissance Study (Section 905(b), WRDA 1986 Analysis) was initiated on 25 February 2002 as an initial response to two resolutions by the Committee on Transportation and Infrastructure of the U.S. House of Representatives. The two resolutions are listed below:

> **Resolution Docket 2634 St. Lucie County, Florida Shore Protection dated 11 April 2000 states:** *Resolved by the Committee on Transportation and Infrastructure of the United States House of Representatives, That the Secretary of the Army is requested to review the report of the Chief of Engineers for Fort Pierce Beach, Florida, published as House Document 84, 89th Congress, 1st Session, and other pertinent reports with a view to determining if modifications to the recommendations contained therein are advisable at the present time, with particular reference to providing improvements in the interest of shore protection and hurricane and storm damage reduction to the shoreline areas in St. Lucie County in the area north of the Ft. Pierce Inlet, the southern five miles of St. Lucie County, and adjacent shorelines.*
>
> **Resolution Docket 2757 St. Lucie County, Florida Shore Protection dated 23 July 1998 states:** *Resolved by the Committee on Transportation and Infrastructure of the United States House of Representatives, That the Secretary of the Army is requested to review the report of the Chief of Engineers for Fort Pierce Beach, Florida, published as House Document 84, 89th Congress, 1st Session, and other pertinent reports with a view to determining if modifications to the recommendations contained therein are advisable at the present time, with particular reference to providing improvements in the interest of shore protection and hurricane and storm damage*

reduction to the shoreline areas in St. Lucie County from the current project for Ft. Pierce Beach, Florida southward to the Martin County Line.

The final St. Lucie County, Florida Section 905(b) Reconnaissance Study was approved on 1 August 2003 and resulted in the finding that there was a Federal interest in proceeding into the feasibility phase.

The USACE South Atlantic Division (SAD) approved moving from the reconnaissance study phase into the feasibility study phase in a memorandum dated 1 August 2003.

At the initiation of the study, there was discussion within the USACE vertical team as to whether the full study area boundary of 7.4 miles (R-77 to the Martin County line) fits within the Authorization. The discussion was resolved in favor of pursuing the 7.4 mile study area, given that 1) The 905(b) Reconnaissance Report included a map of the 7.4 mile area, 2) the 1998 resolution docket referenced an area between Ft. Pierce to the Martin County line, which would include the additional length, and 3) the 2000 resolution docket mentioned studying not only the southernmost 5 miles of St. Lucie County and the area north of Ft. Pierce, but also the adjacent shorelines. This was taken to mean including the shorelines in between those two points in the study area.

1.6 RELATED DOCUMENTS*

1.6.1 RELATED USACE AND NEPA STUDIES

A summary of primary Federal study most relevant to this study is as follows:

- Section 905(b) (WRDA 86) Analysis, St. Lucie County, FL, Hurricane and Storm Damage Reduction Study November 2002, APPROVED August 2003. This report concluded that there is Federal interest in participating in a cost-shared feasibility study for hurricane and storm damage reduction in the study area of Hutchinson Island, St. Lucie County, Florida.

  The only prior Federal study of the subject project area is the section 905(b), WRDA 1986 analysis which was approved in August 2003 and subsequently authorized this feasibility study for the southern 5 miles of St. Lucie County and "adjacent shorelines." Given the close proximity and influence of the Fort Pierce Inlet Project and Fort Pierce Hurricane and Storm Damage Reduction project to the north, there are several other Federal studies completed for Fort Pierce which are relevant to this particular study. A list of Federal reports pertaining to Fort Pierce Inlet and the hurricane and storm damage reduction project is provided below:

- U.S. Army Corps of Engineers (USACE). 1963. Beach Erosion Control Report on Cooperative Study of Fort Pierce, Florida. October 1963. This report recommended restoration of 1.3 miles of shoreline south of Fort Pierce Inlet with periodic nourishment as needed for a period of ten years following initial construction of the project. The authorization allowed for project construction by the non-federal sponsor, St. Lucie County, with subsequent reimbursement of the Federal share of costs.

- U.S. Army Corps of Engineers (USACE). 1982. Section 111 Report for Fort Pierce Beach, St. Lucie County, Florida. This study disclosed that the combined effects of the jetties and the required maintenance dredging of the Federal Navigation Project at Fort Pierce Inlet causes about 60% of the historical erosion along 6,900 feet of shoreline immediately south of the inlet.

- U.S. Army Corps of Engineers (USACE). 2004 Fort Pierce Shore Protection Project, St. Lucie County, Florida. General Re-evaluation Report (GRR) with Draft Environmental Assessment. April 2004. This GRR was submitted in September 2004 to USACE Jacksonville District by Taylor Engineering, Inc. on behalf of St. Lucie County, the local sponsor. The September 2004 draft GRR evaluated project alternatives, including shoreline stabilization structures, for both 15-year and 50-year analysis periods. The 15-year project evaluated the project over its remaining authorized life, currently scheduled to expire in 2020. The 50-year project evaluation, conducted at the request of the local sponsor, examined the project over a renewed 50-year life, beginning circa 2005. A crucial recommendation of the Independent Technical Review (ITR) was to split the September 2004 draft GRR into two documents: 1) a Limited Reevaluation Report (LRR) to address the 15-year period of analysis remaining in the original authorization and 2) a GRR to address the renewed 50-year period of analysis. This report also provides a comprehensive list of Federal and non-federal studies pertaining to Fort Pierce Inlet and shore protection.

- U.S. Army Corps of Engineers (USACE). 2005. Project Information Report (PIR), Rehabilitation Effort for the Fort Pierce, Florida, Hurricane and Storm Damage Reduction Project. USACE Jacksonville District prepared this report in support of the 2005 Fort Pierce Shore Protection Project (SPP) periodic nourishment. The report provides a history of the project and the 2004 hurricane season and summarizes the economics for emergency rehabilitation efforts and the requirements to restore the Federal project.

- U.S. Army Corps of Engineers (USACE). 2006. Fort Pierce Shore Protection project, St. Lucie County, Florida. Limited Reevaluation Report (LRR) including Final Environmental Assessment (1998) and Final Environmental Impact Statement (2002). This Limited Reevaluation Review (LRR) evaluated and updated the Fort Pierce SPP for current conditions as of 2004. The report summarized a cooperative cost-shared feasibility study on shore protection problems along the shoreline of Fort Pierce, St Lucie County, Florida. This LRR stemmed from the Independent Technical Review (ITR) process of the 1998 General Reevaluation Report (GRR) for the Fort Pierce Shore Protection Project.

- Final Environmental Impact Statement, St. Lucie County South Beach and Dune Restoration Project, St. Lucie County, Florida, Prepared by Taylor Engineering, February 2012. This document was prepared by Taylor Engineering on behalf of the St. Lucie County Erosion District for a local nourishment from R-87.7 to R-90.3 and R-98 to the St. Lucie/Martin County line at R-115+1000 feet, consisting of a beach fill and dune restoration. BOEM served as a cooperating agency in the development of this document.

1.6.2 PRIOR NON-FEDERAL STUDIES

Many studies and reports relevant to the project have been completed by non-federal interests in relation to the shorelines of St. Lucie County. A list of the most relevant studies is provided in the references of

this report. Included is a select list of historic and current studies which were evaluated during the development of this feasibility study for southern St. Lucie County:

- University of Florida (UF). 1958. Coastal Engineering Study of Fort Pierce Beach, Florida. University of Florida, Coastal Engineering Laboratory. Gainesville, Florida. September 1958. This report is one of the first detailed coastal engineering studies completed for St. Lucie County. It was completed for the Fort Pierce Beach Erosion District (FPBED). The report provides data on beach erosion and accretion in the FPBED, the quantity of littoral drift, the development and stability of beach and offshore profiles, recommendations for protective measures, including an estimate of the amount of material needed for artificial nourishment of the beach, and measures to prevent breakthrough of the barrier island south of Fort Pierce Inlet during extreme storm and tide conditions.

- Coastal Technology Corporation. 2007. St. Lucie County, Florida, South County Beach Project Conditions Assessment. This report provides data on environmental resources, as well as shoreline conditions.

- Coastal Technology Corporation. Updated January 2010. St. Lucie County, South County, Beach and Dune Restoration Project, Design Document. This report documents the rationale, data, and design for the local St. Lucie County beach and dune restoration project.

1.7 FEDERAL PROJECTS NEAR THE STUDY AREA

Fort Pierce Federal Navigation Project

Fort Pierce Inlet is located in central St. Lucie County and serves as the northern terminus of the Fort Pierce Shore Protection Project. Fort Pierce Inlet is a manmade inlet initially cut in 1921. The existing north and south jetties were built in 1926, 900 feet apart and 1,800 and 1,200 feet long. The Federal government assumed responsibility for maintaining the inlet and jetties in 1935. The St. Lucie County Port and Airport Authority is the non-federal sponsor for authorized modifications to the existing Federal Navigation Project at Fort Pierce Harbor. Fort Pierce Harbor was last modified between June 1995 and April 1996.

Maintenance-dredged beach quality material from the Federal Navigation Project at Fort Pierce Harbor has been placed on the shoreline south of Fort Pierce Inlet since 1973 between R-34 to R-37; the northern 3,000 feet of the Federal Fort Pierce Shore Protection Project (SPP).

Fort Pierce Shore Protection Project

The Rivers and Harbors Act of 1965 (PL 89-298, 79 Stat. 1089, 1092) in accordance with the recommendations of the Chief of Engineers in House Document (HD) 84, 89th Congress, authorized the Fort Pierce, Florida Shore Protection Project in St. Lucie County[8]. The authorization provided for the restoration of 1.3 miles of shoreline (R-34-R-41) south of Fort Pierce Inlet and for periodic nourishment as needed. Initially constructed in 1970, the current period of Federal participation extends until 2020.

[8] This document was also an authorization for the St. Lucie County study.

Initial construction occurred in 1970 with 718,000 cubic yards of fill placed along the 1.3-mile project shoreline. A Limited Reevaluation Report (LRR), completed in 2006, resulted in a change of the periodic nourishment interval and updated cost-sharing to include results of a Section 111 Study for Fort Pierce, approved in 1982. The current draft General Reevaluation Report (GRR), being completed by the local sponsor, evaluates alternatives over a new 50-year period.

Martin County Beach Erosion Control Project

The Martin County Beach Erosion Control Project was authorized by the Water Resource Development Act (WRDA) of 1990 (Public Law 101-640) in accordance with the Chief of Engineers Report dated 20 November 1989. The project is 4 miles long, extending southward from the St. Lucie County line to near the limit of Stuart Public Park; Florida Department of Environmental Protection, FDEP, monuments R-1 to R-25. The initial project periodic nourishment interval was 11 years, but was later revised to a periodic nourishment interval, for full beach nourishment, of 13 years. Initial construction was completed in 1996. During the summer of 2000, 6 acres of nearshore artificial reef was created to mitigate for impacts to nearshore hardbottom in the project area. Partial nourishments were constructed in 2001 and 2002. The project was fully nourished in 2005 using Flood Control and Coastal Emergencies (FCCE) funds in response to 2004 hurricane impacts. Finally, the last renourishment was completed in 2013 using a new OCS borrow area.

1.8 OTHER NON-FEDERAL STUDIES AND PROJECTS ADJACENT OR NEAR TO STUDY AREA

In the past decade several Beach Erosion Control activities have been undertaken by St. Lucie County and other private interests, including the following:

- From November 1999 through February 2000 an FDEP field permit was issued for temporary placement of sand bags along the shoreline 400 feet north and south of R-099.

- In February 2002, an FDEP field permit was issued for beach scarping from approximately R-099 to R-101.

- In February 2004, an FDEP field permit for dune restoration by truck haul was issued, permitting placement of approximately 4,000 cubic yards of sand from an upland sand source to the beaches between approximately R-099 and R-101.

Following Hurricanes Frances and Jeanne in 2004, a regional emergency dune restoration project was permitted:

- Initial dune restoration was conducted from March to May 2005 by St. Lucie County. This material was hauled in by truck and included placement of about 162,000 cubic yards of sand along the dune from R-098.4 to R-101.5, and from R-103.3 to the Martin County line (PBS&J, 2005). This dune restoration provided over 15,500 feet of dune, corresponding to a fill density of about 10 cubic yards/foot.

- A February through March 2006 dune remediation event required removal of approximately 80,000 cubic yards of previously placed material. This material was replaced with dune overwash material that was removed and screened from Blind Creek, a coastal wetland extending from R-075.5 to -R079.

- Another dune segment, previously untouched, was restored by truck haul in February 2007 with approximately 11,000 cubic yards of material trucked in from an upland borrow area. This event nourished dunes from R-088.5 to R-090.3.

- In April 2011 the St. Lucie County Mosquito Control and Coastal Management Services Department initiated an emergency dune fill project which added 60,000 cubic yards of sand (100 feet of beach width) to 1,700 feet of shoreline immediately south of Ft. Pierce Inlet.

- In 2012/2013, in a response to Hurricane Sandy in 2012, as well as damage from the 4 hurricanes in 2004/2005, St. Lucie County constructed a local beach one-time fill and dune restoration project, placing a total of approximately 658,654 cubic yards of fill on approximately 3.4 miles of shoreline from R-98 to the St. Lucie/Martin County line at R-115+1000 feet. More details on this effort is described in Chapter 2, existing conditions.

2 Existing and Future Conditions

2 EXISTING AND FUTURE WITHOUT-PROJECT CONDITIONS

2.1 GENERAL SETTING*

Please refer to informational foldout REF-1 and REF-2 throughout Chapter 2.

ASSUMPTIONS

In a letter of response to the Sponsor, signed by the Deputy Director of Civil Works dated 12 October 2006 (**Appendix H**) it was agreed that a reasonable eroded shoreline would define the "without-project" condition for the Feasibility study. In order to ensure that emergency nourishment efforts in response to the 2004 and 2005 hurricane season and local nourishment project (completed in May 2013) did not influence the outcome of the ongoing feasibility study, it was agreed that the "without-project" shoreline for the study would be established using survey data collected in the summer of 2006. However, subsequent analysis of the data showed that the 2006 survey did not provide adequate foreshore and offshore coverage of the project area to complete the Beach-fx analysis. A comparison of the available portions of the 2006 survey and a comprehensive shoreline survey taken in August 2008 showed insignificant difference in shoreline dimensions between the two. Therefore, the 2008 shoreline was determined to be a good representative of the 2006 shoreline and was adopted as the "without-project" condition.

This chapter describes conditions as they currently exist, and as they are projected to exist if a project is not implemented, within the southern portion of Hutchinson Island along the shoreline bordering the Atlantic Ocean in St. Lucie County, Florida. Information gathered in this step helps to describe the problems and opportunities and forecast future conditions. The future without-project (FWOP) condition is the most likely condition of the study area without construction of a Federal project over the next 50 years. The future without-project (FWOP) condition is also the no-action alternative for the purposes of the National Environmental Policy Act (NEPA) process, and this report uses both terms interchangeably.

The St. Lucie County, South Hutchinson Island study area, totals approximately 7.4 miles, spanning 4 island segments. The islands are separated from the mainland by the southern Indian River Lagoon and the Atlantic Intracoastal Waterway (IWW).

The Coastal Barrier Resource System (CBRS) unit P11 comprises about 46% of the study area. Of the approximate 7.4 miles of shoreline within the study area, roughly 3.4 miles of shoreline are in the CBRS. The 3 excluded areas have a total length of about 1.4 miles of shoreline. The non-CBRS shoreline is the southernmost part of St. Lucie County and stretches 2.6 miles from approximately R-103.5 to the St. Lucie/Martin County line at R-115+1000 feet (approximately R-001).

The study area shoreline consists of a naturally narrow sandy beach, bounded along the landward side by a thin line of dunes. The natural beach berm width along the majority of the study area is relatively thin. The natural beach slope is fairly steep, typically about 1 vertical to 8 horizontal, sloping directly from the sand dunes downward to the waterline with very little flat berm width. This type of beach is common along southeast Florida and has relatively coarse grained, carbonate rich, beaches. Several areas of

environmentally sensitive nearshore limestone and worm rock formations exist within the littoral zone throughout the study area, and in various densities.

Existing ground elevations along Hutchinson Island are generally less than 10 feet mean low water (MLW), and the width of the island varies from over a mile in the vicinity of the Florida Power and Light (FPL) power plant (R-082) to less than 500 feet along the central portion of the study area (The Narrows of Hutchinson Island, R-095).

There is no coastal armoring in the study area, with the exception of revetment in front of the FPL power plant, on the northernmost reach. This is due to the coastal construction control line (CCCL) pursuant to Section 161.053, Florida Statutes, which restrict coastal armoring in St. Lucie County, unless specific triggers are met.

The biological communities found in the general project area are comprised of the sandy beach shoreline and the open waters of the Atlantic Ocean. The sand substrate is dominated by crustaceans, mollusks, and polychaete worms, in relatively low concentrations, typical of nearshore and surf zone sand habitats. Nesting sea turtles and shore/seabirds use the sandy beach shoreline within the project area. The nearshore waters of the project area are composed of sand bottom with mapped hardbottom resources. Additional hardbottom occurs north and south of the project area. Hardbottom habitats identified in the general nearshore project area are differentiated by the amount of relief above the general floor of the ocean and the number and density of flora and fauna inhabitants. This hardbottom habitat may serve as developmental and foraging habitat for juvenile sea turtles and essential fish habitat (EFH) for coral/hardbottom biota and reef fishes. The offshore project area is unvegetated sand bottom at the southwest end of the St. Lucie Shoal complex. Typical inhabitants include relatively low densities of polychaete worms, bivalves, and nematodes, with some echinoids and small crustaceans.

There are currently 7 suitable parking and access points within the study area of R-77 to R-115+1000 feet to R-001. From north to south: Walton Rocks, Ocean Bay, Herman's Bay Beach, Normandy Beach, Dollman Park, Waveland Beach and Glascock Beach, which is located on the Martin County line (approximately R-001).

2.2 NATURAL (GENERAL) ENVIRONMENT*

2.2.1 VEGETATION

EXISTING CONDITIONS

Vegetation consisting of beach morning glory (*Ipomoea imperati*), railroad vine (*Ipomoea pes-capre*), sea grapes (*Coccoloba uvifera*), sea oats (*Uniola paniculata*), sea purslane (*Sesuvium sp.*), and beach elder (*Iva imbricata*) typically dominate the dune area. Due to the severe impact of Hurricanes Frances and Jeanne in 2004, St. Lucie County implemented a dune restoration/revegetation project in the southern portion of the county (Coastal Tech 2009). The dune system from R-98 to R-101.4 and from R-103.3 to the St. Lucie/Martin County line was revegetated primarily with sea oats with occasional railroad vine, sea grapes, and sea purslane interspersed.

FUTURE WITHOUT-PROJECT CONDITIONS (NO-ACTION ALTERNATIVE)

The no-action alternative could affect vegetation within the project area. Continued erosion of the beach would result in loss of vegetated beach and dune habitats. Additionally, continued erosion could cause landowners to implement alternative armoring measures such as revetments to protect their property. These measures could result in negative impacts to the dune system by altering the beach profile and displacing vegetation.

2.2.2 FISH AND WILDLIFE RESOURCES (OTHER THAN THREATENED AND ENDANGERED SPECIES)

EXISTING CONDITIONS

2.2.2.1 NEARSHORE SOFT BOTTOM COMMUNITIES

Soft bottom macrobenthic and infaunal communities located within the nearshore portion of the project area experience highly dynamic conditions due to the high energy wave action in the intertidal surf zone. A portion of this environment comprises hardbottom (worm rock and exposed Anastasia rock formations). The remainder of the nearshore environment consists of medium to coarse quartz sand and shell hash

coarse carbonate/quartz sand bottom with the assemblages of plants and animals that use these soft bottom habitats.

The project area also includes three large shore-parallel sand gaps that lack nearshore hardbottom structures or feature only very small patches of exposed hard substrate. These areas are located between FDEP reference monuments R-98 to R-99, R-107 to R-109, and R-112 to R-2 and consist of primarily fine, unconsolidated sand substrate. In tropical and subtropical areas, the ghost crab genus Ocypode typically dominates the upper beach area. Mole crabs (*Emerita*), haustoriid amphipods, and bivalves (*Donax*) are numerical dominants in the intertidal area, while polychaetes, other amphipod species, and bivalves increase in abundance in the subtidal nearshore areas (Pearse et al. 1942, Dahl 1952, Spring 1981).

Gorzelany and Nelson (1987) studied the effects of beach nourishment on intertidal and subtidal infaunal communities in the Indialantic and Melbourne Beach area. The study listed 99 taxa with *Donax* spp. as the numerically dominant group followed by the polychaete *Happloscoloplos fragilis*, the amphipods *Parahaustorius longimerus* and *Bathyporeia parkeri*, and the polychaete *Paraonis fulgens*. Species richness and density decreased in winter, increased in spring and summer, and decreased in fall. These population shifts did not seem attributable to beach nourishment effects, but rather to natural seasonal variations.

2.2.2.2 OFFSHORE BORROW AREA SOFT BOTTOM COMMUNITIES

Infaunal organisms present in the soft bottoms offshore central east Florida are predominantly common invertebrates including crustaceans, echinoderms, mollusks, polychaetous annelids, and interstitial bryozoans. Infaunal populations exhibit both seasonal and spatial variability in distribution and abundance, due to temperature, sediment topography, bathymetry, and sediment composition, including particle size and organic content (Hammer et al. 2005).

Epifaunal invertebrates commonly occurring on the soft bottoms offshore central east Florida include lady crabs (*Ovalipes* spp.), calico scallop (*Argopecten gibbus*), calico box crab (*Hepatus epheliticus*), iridescent swimming crab (*Portunus gibbesii*), brown shrimp (*Farfantepenaeus aztecus*), white shrimp (*Litopenaeus setiferus*), striped sea star (*Luidia clathrata*), and arrowhead sand dollar (*Encope michelini*). The distribution on the epifaunal invertebrates listed above exhibit distributions that are depth-, temperature-, and sediment type-related (Hammer et al. 2005).

Distribution of interstitial bryozoans has recently been studied at shoals located offshore St. Lucie County, including the St. Lucie Shoal. In a study conducted for the U.S. Army Corps of Engineers, Brostoff (2002) identified an average of 19 different species located within the samples from the St. Lucie Shoal, with *Cupuladria doma* the exceedingly dominant species collected. Previous studies of Capron Shoal (north of St. Lucie Shoal) by Winston and Håkansson (1986) described the bryozoan population as adapting to varying interstitial conditions. Such adaptations include small size, simplified colony structure, and very early reproduction. The distribution of encrusting bryozoans extends along sandy continental shelves, providing a food source for crustaceans, echinoderms, and mollusks (Winston and Håkansson 1986).

2.2.2.3 NEARSHORE HARDBOTTOM FISH ASSEMBLAGES

An investigation conducted during 2009 documented the fish assemblage associated with the nearshore hardbottom of the project area. The extant assemblage comprised primarily reef-associated species

generally expected for the region (Gilmore et al. 1981, CSA International 2009b). Although the assemblage consisted of 70 species, numerical dominants included black margate (*Anisotremus surinamensis*), silver porgy (*Diplodus argenteus*), newly settled grunts (*Haemulon* spp.), sailors choice (*H. parra*), hairy blenny (*Labrisomus nuchipinnis*), and porkfish (*A. virginicus*). The grunt family (Haemulidae), represented by nine taxa, dominated taxonomically in the project area.

CSA International identified 24 federally managed species during 2009 surveys of the nearshore hardbottom. Represented primarily by the grunt and jack families, many of these managed species also occurred as newly settled or juvenile stage individuals, indicating that the area serves as effective juvenile habitat for most of the managed species recorded. The South Atlantic Fishery Management Council (SAFMC 1998) includes most of the 24 managed species reported in as members of the snapper-grouper complex. The CSA survey also reported two other managed species, a coastal pelagic species (Spanish mackerel, *Scomberomorus maculatus*) and a coastal shark (nurse shark, *Ginglymostoma cirratum*). Other economically important or notable species observed near or over hardbottom, but not formally recorded during timed swims or in strip transects during the survey include snook (*Centropomus undecimalis*), bonnethead shark (*Sphyrna tiburo*), tarpon (*Megalops atlanticus*), cobia (*Rachycentron canadum*), king mackerel (*Scomberomorus cavalla*), and Florida pompano (*Trachinotus carolinus*). Although not a federally managed fishery species, the striped croaker (*Bairdiella sanctaeluciae*), a federally designated species of special concern (Gilmore and Snelson 1992) was recorded at five of the survey transects.

2.2.2.4 COASTAL PELAGIC FISH

The major coastal pelagic families occurring in inshore and coastal waters of the project area include ladyfish, anchovies, herrings, mackerels, jacks, mullets, bluefish, and cobia. Coastal pelagic species migrate over the region's shelf waters throughout the year. Some species form large schools (e.g., Spanish mackerel), while others (e.g., cobia) travel alone or in smaller groups. Many coastal pelagic species inhabit the nearshore environment along beaches and barrier islands of eastern Florida (Gilmore et al., 1981; Peters and Nelson 1987). Commonly occurring species in the project area include anchovies (*Anchoa* spp.), menhaden (*Brevoortia* spp.), scaled sardine (*Harengula jaguana*), striped mullet (*Mugil cephalus*), hardhead catfish (*Ariopsis felis*), and Florida pompano (*Trachinotus carolinus*). Concentrations of anchovies, herrings, and mullets in nearshore areas may attract larger predatory species, particularly bluefish, blue runner, jack crevalle, sharks, and Spanish mackerel. The presence and density of most coastal pelagic fish species depend on water temperature and quality, which vary spatially and seasonally.

2.2.2.5 SEABIRDS AND SHOREBIRDS

A number of seabirds and shorebirds may occur along the beach and offshore the project area, including a number of species considered birds of conservation concern by the Migratory Bird Treaty Act of 1918 (MBTA). These species are likely to become candidates for listing under the Endangered Species Act. According to the Florida Natural Areas Inventory (FNAI 2010), all of the migratory species listed in the MBTA, except for the Audubon's shearwater, marbled godwit, and the semipalmated sandpiper, have been observed within St. Lucie County. These species all use sandy beaches for foraging and/or nesting and, therefore, could occur along the project area both onshore and offshore.

FUTURE WITHOUT-PROJECT CONDITIONS (NO-ACTION ALTERNATIVE)

Species that utilize the beach environment may decrease in number due to continued erosion of the beach and dune system in the future without-project condition. No changes to fish and wildlife resources that reside below the swash zone would occur in the future without-project condition.

2.2.3 THREATENED AND ENDANGERED SPECIES

The project area lies within the coastal area of St. Lucie County, Florida. The U.S. Fish and Wildlife Service (USFWS) and National Marine Fisheries Service (NMFS) have identified the threatened and endangered species listed in **Table 2-1** as potentially occurring in St. Lucie County. Of the species listed in **Table 2-1**, the species most likely to occur within the project vicinity are the following: the five species of sea turtles, manatees, humpback and right whales, smalltooth sawfish, piping plover, rufa red knot, and beach jacquemontia.

Table 2-1. Federally Listed Threatened and Endangered Species that May Occur in St. Lucie County, Florida, or marine environments.

Common Name	Scientific Name	Listing Status	
		USFWS	NMFS
PLANTS			
Fragrant prickly-apple	*Cereus eriophorus var. fragrans*	Endangered	-
Lakela's mint	*Dicerandra immaculata*	Endangered	-
Tiny polygala	*Polygala smallii*	Endangered	-
Beach jacquemontia	*Jacquemontia reclinata*	Endangered	
BIRDS			
Audubon's crested caracara	*Polyborus plancus audubonii*	Threatened	-
Everglade snail kite	*Rostrhamus sociabilis plumbeus*	Endangered	-
Florida scrub-jay	*Aphelocoma coerulescens*	Threatened	-
Kirtland's Warbler	*Dendroica kirtlandii*	Endangered	-
Piping plover	*Charadrius melodus*	Threatened	-
Rufa Red knot	*Calidris canutus rufa*	Threatened	
Red-cockaded woodpecker	*Picoides borealis*	Endangered	-
Wood stork	*Mycteria americana*	Endangered	-
MAMMALS			
Florida panther	*Puma concolor coryi*	Endangered	
Southeastern beach mouse	*Peromyscus polionotus niveiventris*	Threatened	
West Indian manatee	*Trichechus manatus*	Endangered	
Blue whale	*Balaenoptera musculus*	-	Endangered

Finback whale	*Balaenoptera physalus*	-	Endangered
Sei whale	*Balaenoptera borealis*	-	Endangered
Sperm whale	*Physeter macrocephalus*	-	Endangered
North Atlantic right whale	*Eubalaena glacialis*	-	Endangered
REPTILES			
American alligator	*Alligator mississippiensis*	Threatened/SA*	-
American crocodile	*Crocodylus acutus*	Threatened	-
Eastern indigo snake	*Drymarchon corais couperi*	Threatened	-
Green sea turtle	*Chelonia mydas*	Threatened	Threatened
Hawksbill sea turtle	*Eretmochelys imbricata*	Endangered	Endangered
Kemp's ridley sea turtle	*Lepidochelys kempii*	Endangered	Endangered
Leatherback sea turtle	*Dermochelys coriacea*	Endangered	Endangered
Loggerhead sea turtle	*Caretta caretta*	Threatened	Threatened
FISH			
Smalltooth sawfish	*Pristis pectinata*	-	Endangered

2.2.3.1 SEA TURTLES

EXISTING CONDITIONS

St. Lucie County is within the normal nesting areas of three species of sea turtles: loggerhead sea turtle (*Caretta caretta*), green sea turtle (*Chelonia mydas*), and leatherback sea turtle (*Dermochelys coriacea*). The loggerhead and green are listed as threatened species, while the leatherback is listed as endangered under the U.S. Endangered Species Act of 1973. In St. Lucie County, the Florida Fish and Wildlife Conservation Commission defines 1 March through 31 October as the official nesting season for all species of sea turtles.

NESTING HABITAT

Sea turtle nesting occurs in south St. Lucie County within the project area. Loggerhead, green, and leatherback turtles currently account for all nests in the project area (EAI 2007, 2008, 2009a; personal communication, Beth Brost, FWC, March 2016).

Between 2011 and 2015, approximately 89.6% of the total sea turtle nests in the study area were loggerhead, followed by 9% green, and 1.4 % leatherback. During this time period, there were a total of 17,368 loggerhead, 1,745 green, and 280 leatherback sea turtle nests recorded in the study area for a grand total of 19,393 nests. The data are only for the survey period of 15 May - 31 August, and nesting does occur outside those dates (personal communication, Beth Brost, FWC, March 2016).

The study area has been delineated into four reaches, and these reaches overlap with the Index Nesting Beach Survey (INBS). Sea turtle nesting for each of these reaches is provided in **Figures 2-1, 2-2, 2-3 and 2-4.**

Figure 2-1. Sea turtle nesting data for North Hutchinson Island (R77 to R80, INBS Zones 13-14) for loggerheads (CC), greens (CM), and leatherbacks (DC) from 2011 to 2015. The data are only for the survey period of 15 May - 31 August, and nesting does occur outside those dates. Source Florida Fish and Wildlife Conservation Commission.

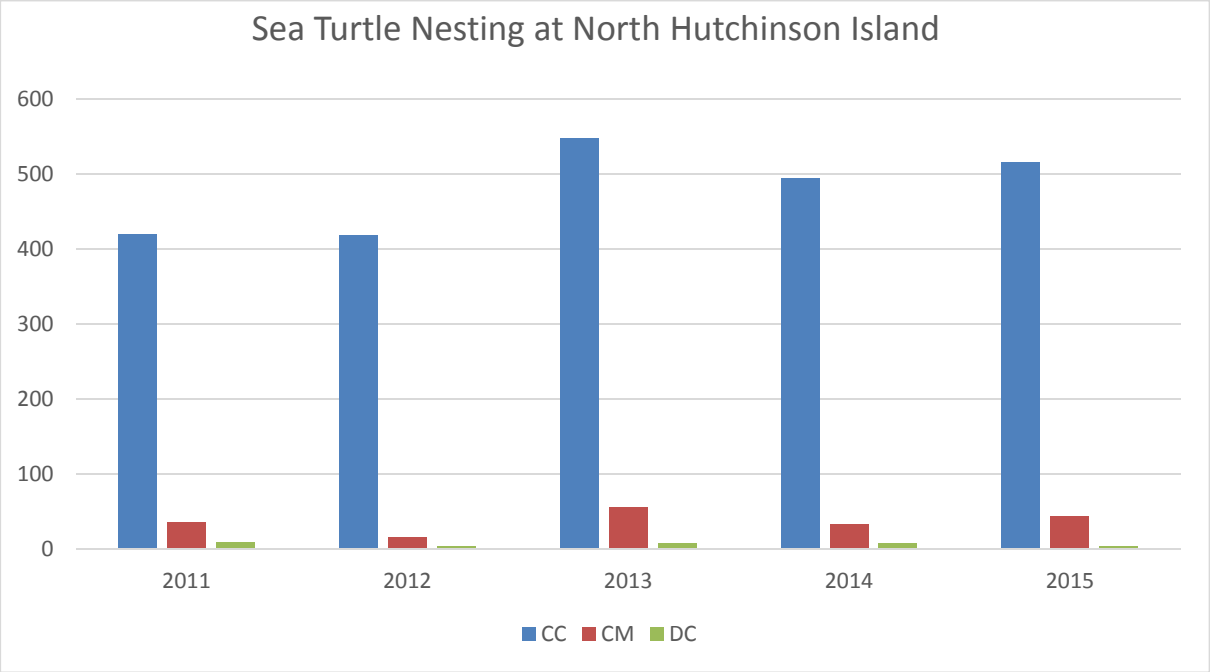


Figure 2-2. Sea turtle nesting data for Power Plant Area (R-80 to R-90, INBS Zones 15-17) for loggerheads (CC), greens (CM), and leatherbacks (DC) from 2011 to 2015. Source Florida Fish and Wildlife Conservation Commission.

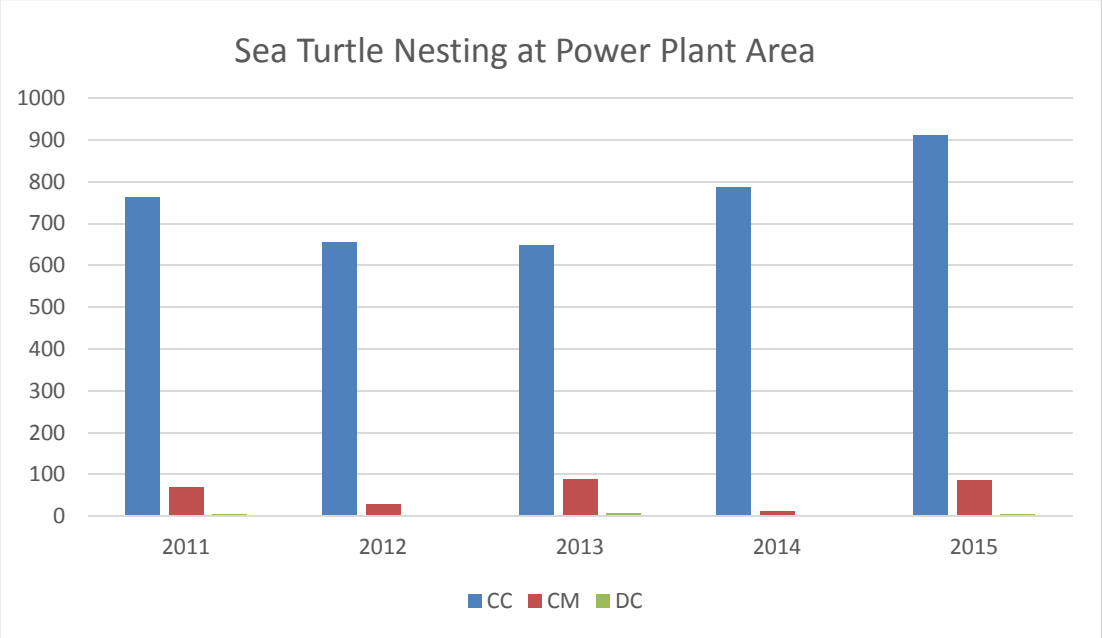


Figure 2-3. Sea turtle nesting data for Narrows of Hutchinson Island (R-90 to R-98, INBS Zones 18-20) for loggerheads (CC), greens (CM), and leatherbacks (DC) from 2011 to 2015. Source Florida Fish and Wildlife Conservation Commission.

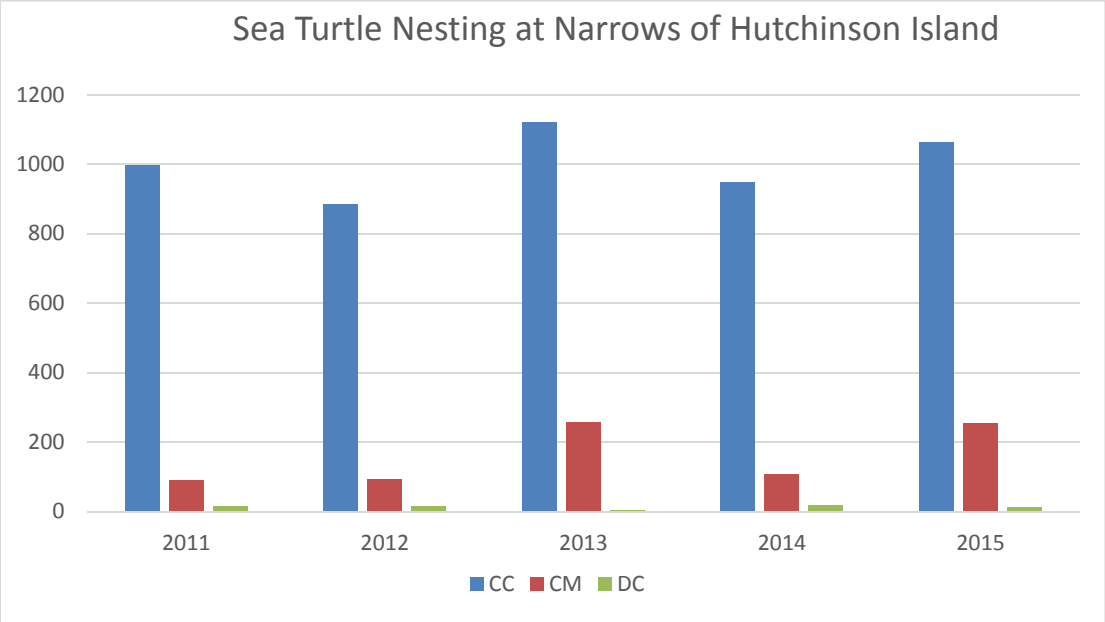
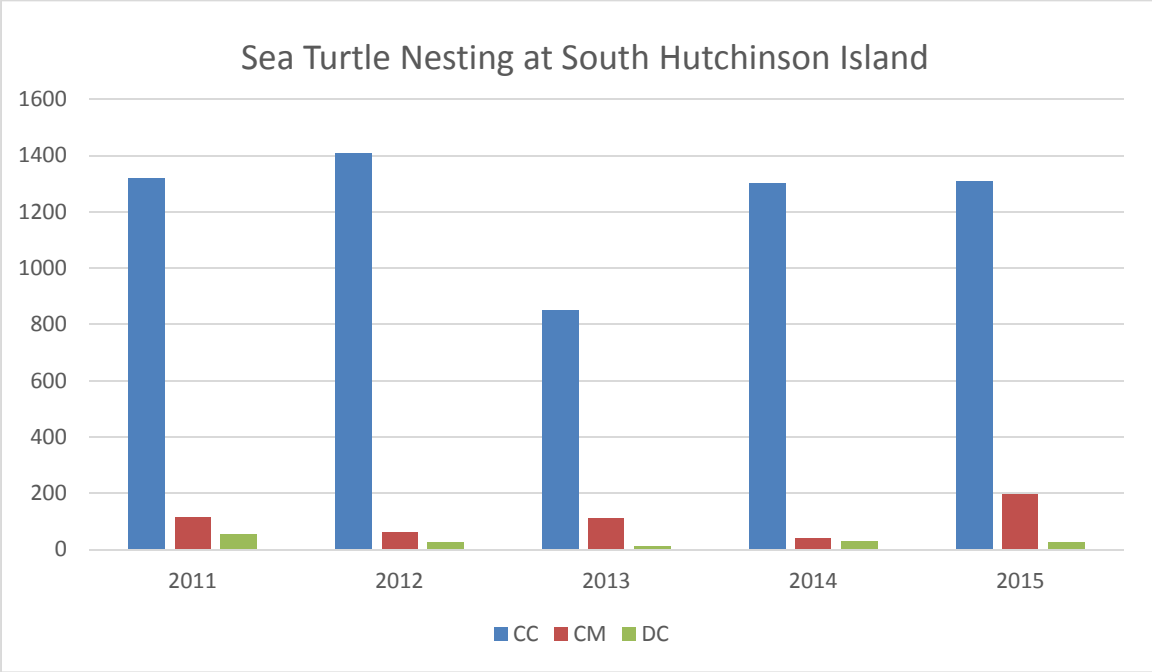


Figure 2-4. Sea turtle nesting data for South Hutchinson Island (R-98 to R-115 plus 1,000 feet, INBS Zones 20-25) for loggerheads (CC), greens (CM), and leatherbacks (DC) from 2011 to 2015. Source Florida Fish and Wildlife Conservation Commission.



INNER SHELF HABITAT

Five sea turtle species occur on the eastern Florida inner shelf; shoreline to the 20-meter isobath. In order of abundance, based on results of sea turtle monitoring conducted in the project area, these species are the loggerhead, green, leatherback, hawksbill, and Kemp's ridley turtles (**Table 2-2**). The table orders several species from highest to lowest abundance.

Table 2-2. Sea Turtle Species Potentially occurring on the Eastern Florida Inner Shelf (Adapted from: NMFS and USFWS, 1991a, b; 1992a, b; 1993; EAI, 2007, 2008, 2009a).

Common and Scientific Names	Status[1]	Life Stages Present	Abundance Within the Project Area	Seasonal Presence	Nesting Season
Loggerhead turtle (*Caretta caretta*)	T	Adults, subadults, juveniles, and hatchlings	Abundant	Year-round (most abundant during spring and fall migrations)	April to September
Green turtle (*Chelonia mydas*)	T	Adults, subadults, juveniles, and hatchlings	Common	Year-round	July to August
Leatherback turtle (*Dermochelys coriacea*)	E	Adults, subadults, juveniles, and hatchlings	Rare	March to October	March to July
Hawksbill turtle (*Eretmochelys imbricata*)	E	Adults, subadults, juveniles, and hatchlings	Rare	Year-round	June to September
Kemp's ridley turtle (*Lepidochelys kempi*)	E	Juveniles and subadults	Rare	Year-round (most abundant during spring and fall migrations)	(no nesting in area)

[1] Status: E = endangered, T = threatened under the Endangered Species Act of 1973.

LOGGERHEAD TURTLE

Loggerhead turtles (*Caretta caretta*) are present year-round in Florida waters, with peak abundance occurring during spring and fall migrations. Data suggest that nesting adult females are short-term residents that migrate into east Florida waters at 2 to 3-year intervals and reside elsewhere during non-nesting years (Henwood 1987; Schroeder and Thompson 1987). Adult males do not seem to migrate with adult females but may reside in the vicinity of nesting beaches throughout the year. Following nesting activities, many adult loggerheads disperse to the seas around islands in the Caribbean Sea, waters off southern Florida, and the Gulf of Mexico (Meylan and Bjorndal 1983; Nelson 1988). Subadult loggerheads forage opportunistically along the Atlantic seaboard, although evidence suggests that a resident population of subadults overwinter in the Canaveral area each year (Henwood 1987). In Brevard, Indian River, and St. Lucie Counties, juvenile and subadult loggerheads occur throughout the year in estuarine habitats (Ehrhart 1983, 1992; Henwood 1987; Ehrhart and Redfoot 1996; Bresette et al. 2000; Ehrhart et al. 2001; Holloway-Adkins 2005; Provancha et al. 2005).

Juvenile loggerheads, which researchers believe overwinter along the eastern Florida inner shelf, depart in the spring (March – April) when adult males that migrate into the area to mate (Ryder et al. 1994)

replace them. The adult loggerhead population (males and females) in Florida waters increases during the nesting season (Magnuson et al. 1990). In general, the eastern coast of Florida appears to provide an important year-round habitat for loggerhead sea turtles along both the inner shelf (0 to 20 meters) and middle shelf (20 to 40 meters) depths. The nearshore rock resources in these areas appear to represent a travel corridor to nesting sites rather than a main foraging or developmental habitat (Ryder et al. 1994). Juvenile loggerhead turtles generally feed on insects and invertebrates from within *Sargassum* mats (not present in the project area), while subadult and adult loggerheads primarily feed on bottom dwelling invertebrates (crabs, mollusks, shrimp) and macroalgae (Ryder et al. 1994). The study area beach lies within designated critical habitat unit LOGG-T-FL-09. Marine waters adjacent to the beach lie within designated nearshore reproductive and migratory critical habitat unit LOGG-N-18.

On project beaches, hatchling turtles normally emerge between July and September during the night and swim offshore to begin a pelagic existence within *Sargassum* rafts, drifting in current gyres and convergence zones for several years (Carr 1987; Marine Turtle Expert Working Group 1996a; Witherington 2002). Post-hatchlings from the Florida coast eventually enter currents of the North Atlantic Gyre. At a carapace length of approximately 40 to 60 centimeters, they leave the pelagic environment and move into nearshore habitats (Carr 1987; Bowen et al. 1993).

GREEN TURTLE

The USFWS considers the green turtle (*Chelonia mydas*) as common within the inner shelf waters off the project area. All life stages of green turtles occur during different times of the year in and around the project area. Ecological Associates, Inc. [EAI], (2009a, b, c, d, e, f, g) consistently observed all life stages adjacent to the southern portion of the project area during all seasons, with the most observations in June. Juvenile green turtles (approximately 2 to 5 years of age) also may move into shallow coastal and estuarine waters along the entire east coast of Florida (CSA International 2009b; Schmid 1995; Hirth 1997).

Florida comprises the major feeding grounds for green turtles in U.S. waters, where the turtles forage mainly on algae and the seagrass *Thalassia testudinum* (Burke et al. 1992). The nearshore waters of the project area include no seagrass. There is no designated critical habitat for this species within the project area.

Subadult green turtle habitats on the east coast of Florida include shallow estuarine environments such as the Indian River Lagoon (Ehrhart et al. 1996; Provancha et al. 1998; Bresette et al. 2000), deeper coral and limestone reefs in South Florida (Wershoven and Wershoven 1992; Makowski et al. 2002; Makowski 2004), and shallow nearshore habitats in Brevard, Indian River, and St. Lucie counties (Bresette et al. 1998; Ehrhart et al. 2001; Holloway-Adkins et al. 2002). Subadults also inhabit manmade environments such as shipping channels and turning basins (Henwood 1987; Redfoot 1997).

Several researchers have found juvenile green turtles over nearshore hardbottom habitats in the project area foraging on species of red algae (Ehrhart et al. 1996; Holloway-Adkins 2001; Holloway-Adkins 2005). The most frequently-consumed species were *Gelidium* spp., *Bryothamnion seaforthii*, *Hypnea* spp., *Gracilaria* spp., *Laurencia* spp., and *Bryocladia cuspidata*. The same reports also described juvenile green turtle consumption of a variety of small invertebrates and occasional portions of jellyfish. However, the overall results indicate juvenile green turtles in nearshore hardbottom habitats feed as herbivores (Holloway-Adkins 2001; Gilbert 2005, Holloway-Adkins and Provancha 2005). Sand, pieces of rock, and shell debris found in foraging samples indicate green turtles forage close to the substrate and, either

incidentally or selectively, ingest these non-nutritional items for unknown reasons. Stranding events and foraging studies indicate that sea turtles at all life stages are susceptible to ingesting anthropogenic debris (Balazs 1985; Carr 1987; Witherington 2002).

LEATHERBACK TURTLE

Adult leatherback (*Dermochelys coriacea*) turtles reportedly occur in east Florida waters primarily during summer; aerial surveys also have sighted leatherback turtles off northeast Florida from October through April (Schroeder and Thompson 1987, Knowlton and Weigle 1989, CSA 2002). During these surveys, leatherbacks occurred on the mid-shelf and inner shelf but not usually near shore (CSA 2002). However, historical data suggest that leatherbacks also may use inner shelf waters during periods of local thermal fronts that concentrate food resources (Thompson and Huang, 1993). The cryptic behavior of hatchling and/or juvenile leatherback turtles has resulted in little knowledge of their pelagic distribution. Leatherback turtles occur very rarely in the nearshore waters of the project area. There is no designated critical habitat for this species within the project area.

HAWKSBILL TURTLE

Hawksbill turtles (*Eretmochelys imbricata)* occur in tropical and subtropical seas of the Atlantic, Pacific, and Indian oceans. In the western Atlantic, hawksbill turtles generally inhabit clear tropical waters near coral reefs, including the southeast Florida coast, Florida Keys, the Bahamas, Caribbean Sea, and southwestern Gulf of Mexico (NMFS and USFWS 1993).

Pelagic hatchling hawksbills drift with *Sargassum* rafts. Available data suggest they are herbivorous during this period but become more omnivorous as they age (Ernst et al. 1994). Juveniles shift to a benthic foraging existence in shallow waters, progressively moving to deep waters as they grow and become capable of deeper dives for sponges (Meylan 1988, Ernst et al. 1994). Adult hawksbills typically associate with coral reefs and similar hardbottom areas where they forage on invertebrates, primarily sponges. No nesting or boat survey performed during 2006, 2007, and 2008 observed any hawksbill nests or animals in the project area (EAI 2007, 2008, 2009a, b, c, d, e, f, and g). There is no designated critical habitat for this species within the project area.

KEMP'S RIDLEY TURTLE

The Kemp's ridley (*Lepidochelys kempi*) is the smallest and most endangered of the sea turtles. Its distribution includes the Gulf of Mexico and southeast U.S. coast, although some individuals have ventured as far north along the eastern seaboard as Nova Scotia and Newfoundland (Marine Turtle Expert Working Group, 1996b). Adult Kemp's ridley turtles occur almost exclusively in the Gulf of Mexico, primarily on the inner shelf (Byles 1988). Kemp's ridley hatchlings inhabit offshore *Sargassum* mats and drift lines associated with convergences, eddies, and rings. Gulf and Atlantic surface currents widely disperse the hatchlings. After reaching a size of about 20 to 60 centimeters carapace length, juveniles enter shallow coastal waters (Marine Turtle Expert Working Group 2000).

Post-pelagic (juvenile, subadult, and adult) Kemp's ridley turtles feed primarily on portunid crabs, but also occasionally eat mollusks, shrimp, dead fishes, and vegetation (Mortimer 1982, Lutcavage and Musick 1985, Shaver 1991, NMFS and USFWS 1992a, Burke et al. 1993, Werner and Landry 1994). The Kemp's ridley is considered very rare in nearshore waters of the project area. No nesting or boat survey

performed during 2006, 2007, and 2008 observed any Kemp's ridley nests or animals in the project area (EAI 2007, 2008, 2009 a, b, c, d, e, f, and g). Critical habitat has not been designated for this species.

FUTURE WITHOUT-PROJECT CONDITIONS (NO-ACTION ALTERNATIVE)

In the Future Without-Project Condition, the beach is predicted to continue to erode. This will reduce the shoreline area available for nesting sea turtles. It will also increase turtle nest vulnerability to storm washout, as nests would be located closer to the mean high water line. As adjacent shorelines are currently available for nesting, it is unknown whether the overall nesting would be affected. In addition to increased erosion, it is likely that the length of shoreline hardened by structures would increase. This could further decrease the area available for nesting sea turtles due to the fact that the hard structures constructed would likely be seawalls and revetments (where permitted) that could negatively impact the width of beach available for nesting if not constructed in conjunction with beach nourishment.

2.2.3.2 MARINE MAMMALS

Three federally-listed species of marine mammals occur on the inner shelf (shoreline to the 20-meter isobath) of the project area (**Table 2-3**). The table orders the several species by relative abundance (highest to lowest).

Table 2-3. Endangered Marine Mammal Species Potentially Occurring on the Eastern Florida Inner Shelf. (Wiley et al. 1995, USFWS 2001, http://www.neaq.org)

Common and Scientific Names	Status[1]	Life Stages Present	Abundance within the Project Area	Seasonal Presence
Florida manatee (*Trichechus manatus latirostris*)	E	Adults, subadults, and juveniles	Common	Year-round (most abundant during winter)
North Atlantic right whale (*Eubalaena glacialis*)	E	Adults, subadults, and juveniles	Rare	December to March

[1] Status: E = endangered.

FLORIDA MANATEE

EXISTING CONDITIONS

The West Indian manatee is one of the most endangered marine mammals in coastal waters of the U.S. In the southeastern U.S., manatees are limited primarily to Florida and Georgia. This group constitutes a separate subspecies called the Florida manatee (*Trichechus manatus latirostris*) that comprises four recognized populations or management stocks (Atlantic Coast, Southwest, Upper St. John's River, and Northwest), based on regional manatee wintering sites (http://www.nefsc.noaa.gov/nefsc/publications/tm/tm213/F2009App6.pdf; USFWS, 2001). Adult Florida manatees average about 3.0 m (9.8 ft.) in length and 1,000 kg (2,200 lbs.) in weight. Their maximum lifespan is approximately 59 years. Age of first pregnancy is 3 to 4 years, and their gestation period for a single calf is 11 to 14 months, with an average interbirth interval of 2.5 years (USFWS 2001).

Manatees are seen mostly as solitary individuals or in groups of up to six individuals. Some larger aggregations may occur, such as feeding groups that may number up to approximately 20 individuals and winter aggregations near sources of warm water (such as power plant outfalls) that may contain hundreds of individuals (Jefferson et al. 2008).

Most manatees in the southeastern U.S. migrate between a summer range and a winter range, determined by water temperature changes. During winter months, the Florida manatee population confines itself to coastal waters of the southern half of peninsular Florida and to springs and warm water outfalls as far north as southeastern Georgia (USFWS 2001). As water temperatures rise in spring, individuals disperse from these winter aggregation areas, some migrating as far north as coastal Virginia (USFWS 2001). Manatees inhabit both salt and fresh water of sufficient depth (1.5 meters to usually less than 6 meters) throughout their range. They are usually found in canals, rivers, estuarine habitats, and saltwater bays, but on occasion have swum as far as 3.7 miles off the Florida coast (USFWS 2001). Within St. Lucie County, manatees are most frequently observed in the Indian River Lagoon and other inland waters. Individual and small groups of manatees are regularly sighted within shallow nearshore waters off St. Lucie County, including the Ft. Pierce Inlet (personal communication, non-federal sponsor's consultant, August 2010) and may graze on the algae present on the intermittent nearshore exposed hardbottom present in the project area.

In 1976, the USFWS designated critical habitat for this species. All of the critical habitat areas are located in peninsular Florida, predominantly along the inland waters of the southwest and southeast coasts (USFWS 2001). However, the project area is not designated as critical habitat.

FUTURE WITHOUT-PROJECT CONDITIONS (NO-ACTION ALTERNATIVE)

The Future Without-Project Conditions for the Florida manatee are not expected to be different from the Existing Conditions described above.

HUMPBACK WHALE

EXISTING CONDITIONS

On September 8th 2016 NMFS published a final rule to divide the globally-listed humpback whale into 14 Distinct Population Segments (DPSs) and list 4 DPSs as endangered and 1 as threatened. The West Indies DPS for humpback whales (*Megaptera novaeangliae*) was one of nine DPSs not warranted for listing. The humpback whale is a large baleen whale with a maximum length of about 52 feet (16 meters). Humpback whales range from the Arctic to the West Indies. During summer, at least five geographically distinct feeding aggregations occur in the northern Atlantic (Blaylock et al., 1995). During fall, humpbacks migrate south to the Caribbean where calving and breeding occurs from January to March (Blaylock et al. 1995). Aerial surveys during the Cetacean and Turtle Assessment Program (CETAP) detected only a few humpback whale sightings from New Jersey southward during any season (Winn 1982). However, subsequently there have been numerous sightings and strandings off the mid-Atlantic and southeastern U.S. coast, particularly during winter and spring (Swingle et al. 1993, Wiley et al. 1995). Most of the stranded animals were juveniles, suggesting that the area may provide an important developmental habitat (Wiley et al., 1995). Humpbacks feed largely on euphausiids and small fishes such as herring, capelin, and sand lance, and Blaylock et al. (1995) correlated their distribution largely to prey species

distribution and abundance. Calving and breeding occurs in the Caribbean from January to March (Tove 2000).

The humpback whale is rarely sighted within the vicinity of St. Lucie County during its spring/fall migration. Critical habitat has not been designated for this species.

FUTURE WITHOUT-PROJECT CONDITIONS (NO-ACTION ALTERNATIVE)

The Future Without-Project Conditions for the humpback whale are not expected to be different from the Existing Conditions described above.

NORTH ATLANTIC RIGHT WHALE

EXISTING CONDITIONS

The North Atlantic right whale (*Eubalaena glacialis*) is one of the most endangered whales in the world. The New England Aquarium's Atlantic right whale research and conservation initiative estimates a total world population of about only 400 (New England Aquarium 2010). North Atlantic right whales range from Iceland to eastern Florida, primarily in coastal waters. This species uses the waters around Cape Cod and Great South Channel to feed, nurse, and mate during summer (Kraus et al. 1988, Schaeff et al. 1993). From June to September, most animals feed north of Cape Cod. Southward migration occurs offshore from mid-October to early January (Kraus et al. 1993). Coastal waters of the southeastern U.S. (off Georgia and northeastern Florida) are important wintering and calving grounds for North Atlantic right whales. Migration northward along the North Carolina coast may begin as early as January but primarily occurs during March and April (Firestone et al 2008, Minerals Management Service [MMS] 1990).

Designated critical habitat for the North Atlantic right whale includes portions of Cape Cod Bay and Stellwagen Bank and the Great South Channel (off Massachusetts) and a strip of near coastal waters extending from southern Georgia to Sebastian Inlet, Florida; therefore, the project area lies south of the critical right whale habitat . The southern critical habitat area widens near the Georgia-Florida boundary where the highest concentrations of individual whales gather during their winter calving season (typically December through March, with peak calving in December and January). During this time, the population consists primarily of mothers and newborn calves, some juveniles, and occasionally some adult males and noncalving adult females (http://www.neaq.org). Sightings of North Atlantic right whales within waters off Florida are limited to late fall to early spring months. Sightings are concentrated near northeastern Florida and southeastern Georgia; however, sightings of individual whales have been reported as far south as Palm Beach County, Florida.

FUTURE WITHOUT-PROJECT CONDITIONS (NO-ACTION ALTERNATIVE)

The Future Without-Project Conditions for the right whale are not expected to be different from the Existing Conditions described above.

2.2.3.3 SMALLTOOTH SAWFISH

EXISTING CONDITIONS

The smalltooth sawfish (*Pristis pectinata*), currently listed as endangered by NMFS, rarely occurs within the project area. This species has become rare along the southeastern Atlantic and northern Gulf of Mexico coasts of the U.S. during the past 30 years, with its known primary range now reduced to the coastal waters of Everglades National Park in extreme southern Florida. Fishing and habitat degradation have extirpated the smalltooth sawfish from much of this former range. There is no designated critical habitat for this species within the project area.

The smalltooth sawfish, distributed in tropical and subtropical waters worldwide, normally inhabits shallow waters (10 m or less), often near river mouths or in estuarine lagoons over sandy or muddy substrates, but may also occur in deeper waters (20 m) of the continental shelf. Shallow water less than 1 m deep appears an important nursery area for young smalltooth sawfish. Maintenance and protection of habitat is an important component of the smalltooth sawfish recovery plan (NMFS, 2006). Recent studies indicate that key habitat features (particularly for immature individuals) nominally consist of shallow water, proximity to mangroves, and estuarine conditions. Smalltooth sawfish grow slowly and mature at about 10 years of age. Females bear live young, and the litters reportedly range from 15 to 20 embryos requiring a year of gestation (NMFS 2006a). Their diet consists of macroinvertebrates and fishes such as herrings and mullets. The smalltooth sawfish reportedly uses its saw to rake surficial sediments in search of crustaceans and benthic fishes or to slash through schools of herrings and mullets (NMFS 2006a).

FUTURE WITHOUT-PROJECT CONDITIONS (NO-ACTION ALTERNATIVE)

The Future Without-Project Conditions for the sawfish are not expected to be different from the Existing Conditions described above.

2.2.3.4 PIPING PLOVER

EXISTING CONDITIONS

The piping plover *(Charadrius melodus)* is a rare to uncommon winter resident that can occur along both the Gulf and Atlantic coasts between September and April. Although found on both coasts, they are more common along the Gulf of Mexico. The piping plover is listed as endangered in Canada and the inland United States, and is threatened along the coast. This small shorebird can occur inland but prefers sandy beaches and tidal mudflats where it forages along the waterline or high up the beach along the wrack line. Piping plovers eat a variety of insects and aquatic invertebrates. Declines have resulted from direct and unintentional harassment by people, dogs, and vehicles; destruction of beach habitat for development; and changes in water level regulation (Haig 1992).

A winter census stated that approximately 20 – 30 piping plovers occur along the Atlantic coast from Duval County south to Brevard, St. Lucie, and Miami-Dade Counties (Florida Natural Areas Inventory [FNAI] 2001). Ecological Associates, Inc. (EAI) conducted a piping plover survey in the vicinity of the project area (St. Lucie Inlet) from January to May 2009 in support of permitting planned dune restoration project at

Bathtub Beach Park on Hutchinson Island. According to Robert Ernest, EAI documented one sighting of a piping plover in or near the project area, but its occurrence there is very rare, given the high amount of human use and associated disturbances. Only one solitary bird has been observed on the Atlantic beaches of Hutchinson Island, located a considerable distance from the inlet (personal communication, Robert Ernest, EAI August 2009). Designated critical habitat for wintering piping plovers occurs south of the project area on Jupiter Island, Martin County, Florida. No critical habitat is designated within the project area.

FUTURE WITHOUT-PROJECT CONDITIONS (NO-ACTION ALTERNATIVE)

The continued erosion of the shoreline in the proposed placement area may reduce some habitat that could potentially be utilized by the plover; however, the infrequent usage of this area by this species suggests that the Future Without-Project Conditions would be similar to the Existing Conditions with respect to the plover.

2.2.3.5 RUFA RED KNOT

EXISTING CONDITIONS

The rufa subspecies of the red knot (*Calidris canutus rufa*), listed as threatened, is a small shorebird that can occur along the Atlantic and Gulf coasts during migration. It is also known to overwinter in low numbers along both coasts. Florida is home to the largest concentration of wintering *rufa* in the United States, with the main concentration occurring in the greater Tampa Bay region (A.C. Schwarzer et al. 2012). In migration and winter, it prefers coastal mudflats, tidal zones, and sometimes open sandy beaches where it feeds on small invertebrates such as small mollusks, marine worms, and crustaceans (Kaufman 1996). The knot population has declined primarily due to reduced food availability from increased harvests of horseshoe crabs (USFWS 2015). Their numbers appear to have stabilized in the past few years, but they remain at low levels relative to earlier decades (USFWS 2015). Critical Habitat has not been designated for this species.

Red knots have been observed at Fort Pierce Jetty Park in St. Lucie County (St. Lucie Audubon 2014), and have also been known to occur in St. Lucie Inlet Preserve State Park (FDEP 2014). They may occasionally occur within the study area.

FUTURE WITHOUT-PROJECT CONDITIONS (NO-ACTION ALTERNATIVE)

The continued erosion of the shoreline in the proposed placement area may reduce some habitat that could potentially be utilized by the knot; however, the infrequent usage of this area by this species suggests that the Future Without-Project Conditions would be similar to the Existing Conditions with respect to the knot.

2.2.3.6 BEACH JACQUEMONTIA

EXISTING CONDITIONS

Beach jacquemontia *(Jacquemontia reclinata),* or beach clustervine*,* is an endangered coastal dune plant endemic to the southeastern coast of Florida. This low-growing, creeping vine typically inhabits the lee side of stable, vegetated dunes, disturbed openings in maritime hammocks, coastal strand, and coastal scrub. The species produces somewhat fleshy leaves up to 3 cm long and white, star-shaped flowers. Currently, only a few populations remain along the east coast of Florida from Martin County south to Dade County. The primary threats to its continued existence include habitat loss and fragmentation from coastal development and erosion, and displacement from non-native, invasive species such as Brazilian pepper (*Schinus terebinthifolius*).

In its letter dated 14 December 2011, the USFWS indicated that based on observations made in January 2010, the endangered beach jacquemontia may occur within the project area. The potential location(s), quantity, and current vegetative state are unknown for beach jacquemontia specimens that may occur within the project area. Critical Habitat has not been designated for this species.

FUTURE WITHOUT-PROJECT CONDITIONS (NO-ACTION ALTERNATIVE)

In the Future Without-Project Condition, the upper beach and dune may continue to erode. This may reduce the habitat for jacquemontia.

2.2.4 HARDBOTTOM HABITAT

EXISTING CONDITIONS

Nearshore hardbottom features along the project area comprise marine components of the Anastasia formation, including lithified shell fragments (especially coquina clam), quartz sand, and calcium carbonate (Cooke and Mossom 1929, Cooke 1945). These features parallel the shoreline, extend through the intertidal and subtidal zones, and range from relatively wide expanses of pavement-like platforms with ledges to isolated patches of rocks. The ledges typically have exposed vertical faces and overhangs along the shoreward edges. Nearshore hardbottom in this area is ephemeral in nature due to high wave energy and a dynamic sedimentary environment. The majority of hardbottom observed in the project area includes partially exposed rock with sand veneers of varying depths.

The sabellariid tubeworm *Phragmatopoma lapidosa* (also known as *P. caudata*) colonizes nearshore hardbottom in portions of the project area. This colonial species settles in intertidal and subtidal hardbottom areas and uses sand particles in concert with a mucoprotenaceous cement to construct dwelling tubes resulting in construction of reef-like structures (Gore et al. 1978, Nelson and Demetriades 1992; Kirtley 1994; Drake et al. 2007). This “worm rock” is somewhat ephemeral, as storm waves and burial by sediments may destroy the structures (CSA International 2009b) and the species typically constructs the worm rock only from early summer through fall. Although *P. lapidosa* is capable of spawning year-round (Eckelbarger, 1976; McCarthy et al. 2003), spawning peaks in summer and fall (McCarthy et al., 2003). Sabellariid worms have an opportunistic life history typified by fast-growth, short time to sexual maturity, and hardiness regarding physical disturbance (McCarthy et al. 2003). Although

P. lapidosa is quite resilient to turbidity (Main and Nelson 1988), studies evaluating sediment burial tolerance of *P. lapidosa* colonies within St. Lucie and Brevard counties found increased mortality linked to both depth of sediment cover and duration of burial (Main and Nelson 1988, Sloan and Irlandi 2008).

Off the east coast of Florida, the structure provided by nearshore hardbottom and associated worm rock supports locally moderate to high diversities and abundances of algae, fishes, and invertebrate groups including sponges, hydroids, mollusks, crustaceans, bryozoans, ascidians, and cnidarians (Kirtley 1966, Gore et al. 1978, Nelson 1989, Lindeman and Snyder 1999, Coastal Planning and Engineering 2006a). Considered important nursery habitat for juvenile fishes (Sloan and Irlandi 2008), nearshore hardbottom also provides shelter and/or foraging grounds for sea turtles (Ehrhart et al. 1996, Wershoven and Wershoven 1992, Holloway-Adkins 2001, CSA International 2009b). Corals and/or octocorals occur only rarely in the project area due to seasonal changes (decreases) in water temperature; however, hardbottom areas in deeper water further offshore support octocorals and several genera of scleractinian corals including *Oculina*, *Siderastrea*, and *Phylangia*.

Substantial geological evidence suggests that nearshore hardbottom and/or worm rock are also important in the maintenance and persistence of beaches and barrier islands by dissipating wave energy and retaining sediments, and thus increasing the volume of standing sand on beaches adjacent to large worm rock habitat (Gram 1965; Kirtley 1966, 1967; Multer and Milliman 1967; Kirtley and Tanner 1968; Mehta 1973; Kirtley 1974).

In the northern section of the project area, between reference monuments R-87.7 and R-90.3, hardbottom includes an often discontinuous, low- to medium-relief landward edge with a significant worm rock component. The landward edge of hardbottom is relatively close to shore (within 10 to 20 meters of the mean high water line – MHWL). Hardbottom continues seaward as a series of well-exposed, shore-parallel ledges with vertical relief of 0.5 to 1.0 meters, alternating with partially-exposed, pavement-like platforms. Generally, hardbottom covers the nearshore area in a relatively continuous distribution.

Data from the first 50 meters seaward of the shore along each of two monitoring transects surveyed (located at reference monuments R-88.7 and R-90.4) during summer 2009 provided detailed estimates of biological benthos. Percent cover of macroalgae ranged from 10% to 70% at individual sampling locations (*in situ* 0.5 square meter quadrats), with an average cover of 35.8%. Red algae dominated the algal community with an average cover of 20.3%, followed by turf algae at 9.5%. Dominant species of red algae included *Laurencia* sp., *Bryothamnion seaforthii*, *Chondria* sp., and *Hypnea musciformes*. Cover of sessile macroinvertebrates ranged from 0% to 15% at individual sampling locations, with an average cover of 1.3%. *P. lapidosa* dominated the invertebrate community, although other observed invertebrates included hydroids, solitary (*Cinachyra* sp.) and encrusting sponges, encrusting tunicates, holothuroids (*Holothuria grisea*), and various small crabs and other mollusks.

In the southern section of the project area, between reference monuments R-99.5 and R-107, hardbottom occurs as a discontinuous landward edge. The landward edge of hardbottom in this region generally occurs as an undercut coquina rock ledge with low relief (of 0.25 to 1.0 meter or 9-39 inches vertical rise) and relatively less biotic cover than the northern section.

Between monuments R-98.5 to just north of R-104, the landward edge of hardbottom is located approximately 40 meters from the MHWL, whereas from just south of monument R-104 to R-107, the landward edge of hardbottom lies approximately 17 to 40 meters from the MHWL. Hardbottom continues seaward as a series of low-relief ledges with a vertical relief of 0.25 to 1.0 meters, alternating with partially-exposed, pavement-like platforms. Worm rock occurs in the intertidal zone near monuments R101, R-104.5, and R-105.9; hardbottom (including worm rock) in this section showed more evidence of sand-scouring and a dynamic sedimentary environment with minimal to moderate algal cover dominated by turf algae.

Data from the first 50 meters seaward of the shore along each of the six monitoring transects (located at monuments R-100, R-101, R-102, R-103.2, R-104.5, and R-105.9) surveyed during summer 2009 provided more detailed estimates of biological benthos. Cover of macroalgae ranged from 0% to 60% at individual sampling locations, with an average cover of 25%. Turf algae dominated the vegetative community with an average cover of 18.5%, followed by green algae at 4.7%. *Caulerpa prolifera* almost completely dominated the green algae component present along the transects. This species commonly occurs on hardbottom outcrops in the intertidal zone in St. Lucie and Indian River counties (CSA International 2009c). Sessile macroinvertebrates on transects located between monuments R-100 and R-103.2 provided only a small fraction of total cover (0% to 3% at individual sampling locations) and included no worm rock.

Cover of sessile macroinvertebrates at monuments R-104.5 and R-105.9 ranged from 0% to 100% due to localized abundance of worm rock in the intertidal zone. Other invertebrates observed along these transects included barnacles, hydroids, solitary (*Cinachyra* sp.) and encrusting sponges, encrusting tunicates, holothuroids (*Holothuria grisea*), and various small crabs and other mollusks. **Table 2-4** provides a synopsis of dominant hardbottom community components, ordered by relative abundance.

Table 2-4. Taxa on Nearshore Hardbottom Habitat in Eastern Central Florida. (CSA International 2010a)

Common and Scientific Names	Life Stages Present	Abundance Within the Project Area	Seasonal Presence
Macroalgae	Spores and adults	Common	Year-round (perennial species) and May-October (annual species)
Invertebrates (crustaceans, echinoderms, and mollusks)	Larvae, juveniles, and adults	Common	Year-round
Sponges	Larvae, recruits, and adults	Common	Year-round
Sabellariid worm rock (*Phragmatopoma lapidosa*)	Larvae, recruits, and adults	Common to Occasional	Year-round
Scleractinian Corals (e.g. *Phylangia americana*, *Siderastrea* spp., *Oculina* spp.)	Larvae, recruits, and adults	Rare	Year-round
Octocorals	Larvae, recruits, and adults	Rare	Year-round

An additional hardbottom community consists of faunal species that were not observed in the more nearshore hardbottom areas including spiny lobster (*Panulirus argus*), octocorals (*Leptogorgia sp.*), holothuroids, and a variety of encrusting sponges. The hardbottom is characterized by large (1 to 3 m diameter), flat rock structures found in deeper (3 to 4 m) water farther from the shoreline than the communities previously described. Octocorals were observed in this hardbottom community, which is located further offshore and would not be impacted by the implementation of the project.

During the 2010 monitoring event, three scleractinian coral polyps were observed in one quadrat on one transect (R-104.5). No scleractinian corals were observed in any quantitative or qualitative video transects. One octocoral was observed during the point count analysis of one transect (R-78.7). Octocorals constituted less than 1% mean coverage along transect R-78.7, which is outside the project area. One stony coral species (*Phyllangia americana*, cup coral) also constituted less than 1% mean coverage along transect R-110.5, a transect that starts 188 m from the mean high water line and would not be affected by the project.

2.2.5 REEF/HARDBOTTOM MITIGATION

St. Lucie County constructed the South Beach Project (local project) between March 30 and April 29, 2013. The work was authorized by USACE permit (No. SAJ-2009-03448) and Florida Department of Environmental Protection (FDEP) permit (No. 0154626-001-JC), and entailed placement of 645,164 cubic yards of beach quality sand on 3.4 miles of beach between FDEP Range Monument R-98 in St. Lucie County south to the Martin County line (approximately 1,000 m from R-115). The placement material was dredged from a sand source located within the St. Lucie Shoal complex and within state waters. Sand placement impacted approximately 0.57 acres of hardbottom.

The permits required 1.89 acres of artificial reef be constructed to mitigate for the impacts to the naturally occurring hardbottom. As reflected in the August 2015 “as-built survey (see Appendix G, Attachment 3)” and as cited in the corresponding September 18, 2015 “Mitigation Reef Certification Report (see Attachment 3)”, a total of 1.93 acres of mitigation reef were constructed in 2013 & 2015 – in excess of the 1.89 acres required by the permits. Adjustments to specific reef cell locations were made to comply with water depth requirements prescribed by USACE and FDEP. At low tide these areas are expected to have ambient water depths between 9.37 and 12.37 feet. The monitoring report “Year One Post-Construction Mitigation Artificial Reef Monitoring Survey for the St. Lucie County South Beach Project” dated January 2017 indicates that in 2016 the artificial reef was providing suitable habitat for benthic faunal communities at or above the level provided by the nearshore hardbottom impacted by the County’s project. USACE Regulatory Division has determined that the constructed mitigation and monitoring have been performed in compliance with the County’s permit SAJ-2009-03448, and this determination has been coordinated with NMFS, BOEM, and St. Lucie County. The compliance letter dated 3 April 2017, monitoring reports, and other relevant documents can be found in Appendix G, Attachment 3.

FUTURE WITHOUT-PROJECT CONDITIONS (NO-ACTION ALTERNATIVE)

The quality of hardbottom habitat in the study area is not likely to be different from the existing conditions if the project were not constructed.

2.2.6 ESSENTIAL FISH HABITAT (EFH)

EXISTING CONDITIONS

The Magnuson-Stevens Fishery Conservation and Management Act requires identification of habitats needed to create sustainable fisheries and comprehensive fishery management plans with habitat inclusions. The act also requires preparation of an EFH assessment and coordination with NMFS when EFH impacts occur.

EFH is defined as "those waters and substrates necessary to fish for spawning, breeding, feeding or growth to maturity" [16 U.S.C. § 1801(10)]. Waters are defined as aquatic areas and their associated physical, chemical, and biological properties that fish use during each stage of their cycle. Substrate includes "sediment, hardbottom, structures underlying the waters, and associated biological communities". Necessary is defined as "the habitat required to support a sustainable fishery and the managed species' contribution to a healthy ecosystem." Fish includes finfishes, mollusks, crustaceans, and all other forms of marine animal and plant life other than marine mammals and birds, whereas "spawning, breeding, feeding, or growth to maturity" covers the complete life cycle of species of interest.

The SAFMC (South Atlantic Fisheries Management Council) holds responsibility for managing fisheries and habitat in the waters of the project area and has produced several Fisheries Management Plans (FMPs) for single and mixed groups of species. All of these FMPs — including those for penaeid shrimp, spiny lobster, red drum, snapper-grouper (reef fishes) and coastal migratory pelagics — were amended in a single document (SAFMC 1998) to address EFH within the South Atlantic region. In addition to the FMPs prepared by the SAFMC, highly migratory species (e.g., tunas, billfishes, sharks, and swordfish) are managed by the Highly Migratory Species Management Unit, Office of Sustainable Fisheries, NMFS. This Office prepared an FMP for highly migratory species that includes descriptions of EFH for sharks, swordfish, and tunas (NMFS 1999). The SAFMC recently prepared a Fishery Ecosystem Plan (SAFMC 2009) that expands many of the EFH descriptions provided in the Habitat Plan (SAFMC, 1998). Note that some of the species managed by SAFMC and NMFS also fall under the jurisdiction of the Atlantic States Marine Fisheries Commission (ASMFC) in order to further coordinate the conservation and management of the states' shared fishery resources.

Of the species or species groups managed by the SAFMC and NMFS, the following may occur within the project area for at least a portion of their life history:

- *Sargassum*
- Coral, coral reefs, and live/hardbottom habitats
- Penaeid shrimp
- Spiny lobster
- Coastal pelagic fishes
- Reef fishes (snapper-grouper complex)
- Dolphin and wahoo
- Highly migratory species

The following subsections accounts briefly describe the EFH for these species and their respective life stages.

2.2.6.1 SARGASSUM

Sargassum, a seaweed that permanently drifts at the surface in warm waters of the Atlantic Ocean (SAFMC 2002), normally occurs in scattered individual clumps ranging from 10 to 50 centimeters (4 to 20 inches) in diameter. Accumulation of *Sargassum* and other flotsam in lines often indicates a convergence zone between water masses. Convergence zones are sites of considerable biological activity; many species (including juvenile sea turtles and pelagic fishes) gather along these zones regardless of whether *Sargassum* or other flotsam is present (Carr 1986).

Floating *Sargassum* provides habitat for as many as 100 fish species at some point in their life cycle, but only two spend their entire lives there: the sargassum fish and the sargassum pipefish (Adams 1960, Dooley 1972, Bortone et al. 1977, SAFMC 2002). Most fishes associated with *Sargassum* are temporary residents (e.g., juveniles of jacks, triggerfishes, flying fishes, and filefishes). Adults of these species reside in shelf or coastal waters (McKenney et al. 1958, Dooley 1972, Bortone et al. 1977, Moser et al. 1998, Comyns et al. 2002). In addition, several larger species of recreational or commercial importance, including dolphin, yellowfin tuna, blackfin tuna, skipjack tuna, little tunny, and wahoo, feed on the small fishes and invertebrates attracted to *Sargassum* (Morgan et al. 1985). *Sargassum* is considered a Habitat of Particular Concern (HAPC) for dolphin and wahoo (SAFMC 2003).

2.2.6.2 CORAL, CORAL REEFS, AND LIVE/HARDBOTTOM HABITATS

The FMP for coral, coral reefs, and live/hardbottom habitats covers a range of organisms and structural features including reef-building stony corals, black corals, octocorals, sea pens, sea pansies, and live/hardbottom.

The regional distributions and ecological requirements of sea pens and sea pansies are not well known, but their recognized EFH includes muddy, silty bottoms in subtidal to outer shelf depths within a range of salinity and light penetration that includes the offshore borrow site proposed for this project.

The live/hardbottom FMP category also includes nearshore hardbottom. On a broad scale, nearshore hardbottom occurs in patches along the east coast of Florida. Considered EFH for coastal pelagic and reef fish management units (SAFMC 1998, 2009), these patches provide important ecological functions for plants, invertebrates, marine turtles, and fishes of the region (CSA International 2009b). The reef-building polychaete *Phragmatopoma lapidosa* augments the structural complexity of nearshore hardbottom.

The only HAPC for coral, coral reefs, and live/hardbottom within the project area is the *P. lapidosa* worm reefs found on nearshore hardbottom in water depths of 0 to 4 m.

2.2.6.3 PENAEID SHRIMP

Penaeid shrimp managed by the SAFMC and found in the project area include brown shrimp (*Farfantepenaeus aztecus*), pink shrimp (*F. duorarum*), and white shrimp (*Litopenaeus setiferus*).

EFH for penaeid shrimp encompasses the series of habitats used during their life history, which has two basic phases: the adult/juvenile benthic phase and the planktonic larval/post-larval phase (SAFMC 1998).

Benthic adults aggregate to spawn in shelf waters over coarse, calcareous sediments. Eggs attached to the females' abdomen hatch into planktonic larvae. These larvae and subsequent post-larval shrimp feed on zooplankton in the water column and make their way into inshore waters. For the inshore phase of the life history, post-larval shrimp settle to the bottom and resume a benthic existence in estuaries that provide rich food sources as well as shelter from predation. Young penaeid shrimp prefer shallow-water habitats with nearby sources of organic detritus such as estuarine emergent wetlands or mangrove fringe.

2.2.6.4 SPINY LOBSTER

EFH for spiny lobster (*Panulirus argus*) consists of hardbottom, coral reefs, crevices, cracks, and other structured bottom in shelf waters. Juvenile habitat, located in nearshore waters, ranges from massive sponges, mangrove roots, and seagrass meadows to soft bottom with macroalgal clumps. Spiny lobster has a complex series of planktonic larvae transported by small-scale currents as well as the Gulf Stream (SAFMC 1998). At least two life stages (adults and planktonic larvae) occur in the project area. Adult spiny lobster frequently occur in holes, crevices, and under ledges provided by regional nearshore and offshore hardbottom habitats. On occasion these adults migrate, walking in groups or single file lines along the open seafloor. Thus, this species would likely occur in the project area, including the borrow site and nearshore hardbottom habitat.

2.2.6.5 COASTAL PELAGIC FISHES

The major coastal pelagic families occurring in nearshore waters of the project area are ladyfish (*Elops saurus*), anchovies (*Anchoa* spp.), herrings (Harengula spp, *Opisthonema oglinum*, and *Sardinella aurita*), mackerels (*Scomberomorus* spp.), jacks (*Caranx* spp., *Trachinotus* spp), mullets (*Mugil* spp.), bluefish (*Pomatomus saltatrix*), and cobia (*Rachycentron canadum*). Coastal pelagic species migrate over the region's shelf waters throughout the year. Some species form large schools (e.g., Spanish mackerel *[Scomberomorus maculatus*]), while others travel alone or in smaller groups (e.g., cobia). Many coastal pelagic species inhabit the nearshore environment along beaches and barrier islands of eastern Florida (Gilmore et al. 1981, Peters and Nelson 1987). Commonly occurring species in the project area include anchovies, menhaden (*Brevoortia* spp.), scaled sardine (*Harengula jaguana*), striped mullet (*Mugil cephalus*), hardhead catfish (*Ariopsis felis*), and Florida pompano (*Trachinotus carolinus*). Larger concentrations of anchovies, herrings, and mullets that aggregate in nearshore soft or hardbottom areas may attract larger predatory species particularly bluefish, blue runner (*Caranx crysos*), jack crevalle (*Caranx hippos*), requiem sharks (*Carcharhinus* spp., *Negaprion brevirostris*, and *Galeocerdo cuvier*) and Spanish and king mackerel (*Scomberomorus cavalla*). The distribution of most species depends on water temperature and quality, which vary spatially and seasonally.

Coastal pelagic species managed by the SAFMC include cobia, Spanish mackerel, king mackerel, cero (*Scomberomorus regalis*), and little tunny (*Euthynnus alletteratus*) (SAFMC 1998). Various life stages of all these species may occur in the project area.

EFH for coastal pelagic species includes *Phragmatopoma* reefs (worm reefs) off the central coast of Florida; ocean high-salinity surf zone; and nearshore hardbottom located south of Cape Canaveral. This EFH also includes sandy shoals of capes and offshore bars and high-profile rocky bottom and barrier island ocean-side waters from the surf zone to the shelf break zone from the Gulf Stream shoreward (including *Sargassum)*. In addition, EFH for coastal migratory pelagic species includes all coastal inlets and state-designated nursery habitats (SAFMC 1998).

2.2.6.6 REEF FISHES (SNAPPER-GROUPER COMPLEX)

The Reef Fish Management Unit comprises 73 species from 10 families. Although the fisheries and adult habitat of most of these species exist well offshore of the project area, the young stages of several reef fishes use nearshore hardbottom (e.g., Gilmore et al. 1981, SAFMC 1998, Lindeman and Snyder 1999, Lindeman et al. 2000). SAFMC (1998) identified the following habitats as EFH for early life stages of reef fishes: attached macroalgae, seagrasses, salt marshes, tidal creeks, mangrove fringe, oyster reefs and shell banks, soft sediments, artificial reefs, coral reefs, and hard/live bottom. The project and surrounding areas include soft bottom and hard/live bottom. Nearshore hardbottom has been identified as an important habitat for many of the 73 members of the Reef Fish Management Unit (SAFMC 1998).

Generally, reef fishes spawn offshore and then release eggs and larvae into the water column. Reef fishes such as lane snapper (*L. synagris*) and grunts (*Haemulon* spp., *Anisotremus surinamensis*, and *A. virginicus*) have similar life cycles, and their early life stages also occur in the inshore waters of the project area (CSA International 2009b, Lindeman et al. 2000). Nearshore hardbottom provides an important connection to the cross-shelf developmental pathways undertaken by many reef species (Lindeman et al. 2000).

2.2.6.7 DOLPHIN AND WAHOO

Dolphin (*Coryphaena hippurus*) and wahoo (*Acanthocybium solandri*) are oceanic species associated with the western edge of the Gulf Stream. Dolphin and wahoo travel near this edge as they migrate through the project area near the offshore borrow site. Closely associated with the Gulf Stream, all life stages (eggs, larvae, juveniles, and adults) of these species could occur in the project vicinity near the offshore borrow site. Dolphin, tunas, and wahoo feed on small fishes and invertebrates associated with drifting *Sargassum* and other flotsam (Manooch et al. 1983, Manooch and Mason 1984, Morgan et al. 1985). HAPC for dolphin and wahoo is *Sargassum*.

2.2.6.8 HIGHLY MIGRATORY SPECIES

Worm et al. (2003) identified eastern Florida as an area supporting a high diversity of oceanic predators, such as sharks, billfishes (Istiophoridae), and tunas (*Thunnus* spp. and *Katsuwonus pelamis*), considered under the Highly Migratory Species Management Unit.

Many species, including tunas, swordfish (*Xiphias gladius*), and billfishes, may occur in the project area near the offshore borrow site because of its proximity to the Gulf Stream current. Swordfish and bluefin tuna (*Thunnus thynnus*) migrate through the Florida Straits and into the eastern Gulf of Mexico to spawn (NMFS 1999, 2009). *Sargassum* is important habitat for various life stages of the swordfish, billfishes, and tunas. Sailfish (*Istiophorus platypterus*), blue marlin (*Makaira nigricans*), and white marlin (*Tetrapturus albidus*) regularly occur offshore east Florida.

Coastal sharks are managed under the highly migratory species group. These species commonly occur during various life stages in inland and nearshore shelf waters of east Florida. In the project area, several managed shark species occur, including nurse (*Ginglymostoma cirratum*), hammerheads (*Sphyrna* spp.), and requiem sharks (Gilmore et al. 1981, CSA International 2009b, Gilmore 2009). Some of these species are very wide-ranging and loosely associated with a variety of habitats (e.g., soft bottom, hardbottom, and the water column). Others, particularly the nurse shark, are associated closely with hardbottom habitats.

The reef-building activities of the sabellariid polychaete *P. lapidosa* augment the nearshore hardbottom features in the project area. This species, defined as a foundational or structural species, forms large colonies commonly referred to as worm rock (Kirtley and Tanner 1968, McCarthy 2001). In addition to fish species, worm rock supports associated assemblages of organisms, such as decapod crustaceans (Gore et al. 1978).

FUTURE WITHOUT-PROJECT CONDITIONS (NO-ACTION ALTERNATIVE)

The quality of EFH in the study area is not likely to be different from the existing conditions if the project were not constructed.

2.2.7 OFFSHORE SAND SOURCES

EXISTING CONDITIONS

St. Lucie Shoal, the proposed sand source, is a sandy shoal occurring 3-5 miles offshore of the project area in Federal and State waters with water depths of about -40 feet NAVD88. The shoal is a well-developed shore-face connected and isolated linear shoals oriented north-to-south. These features, depositional in nature, exhibit varying degrees of morphological change in response to local hydrodynamic conditions. Sand shoals form as an irregularity on the seafloor and then grow in response to local coastal processes such as waves, tides, and currents.

Surveys (CPE 2006b) of the proposed borrow area identified clean sand layers from 4 to 20 feet thick. Side-scan and magnetometer investigations conducted during the surveys indicated no hardbottom habitats near the borrow area (CPE 2006b).

Hammer et al. (2005) performed a study to examine the implications of sand removal from potential borrow areas off the east central Florida coastal shelf. The study, focused on Federal waters seaward of the current St. Lucie Shoal borrow area, found that waves passing over the shoals turned toward the shoreline sooner than in other areas the same distance offshore. The study concluded that waves refracting over the shoals within the entire investigation area produced area region of increased wave heights landward of each shoal and a corresponding region of decreased wave heights immediately south of the sites. However, the wave refraction over the entire St. Lucie Shoal (Federal waters and state waters portion) is potentially more significant than the impact to waves from the other shoals located farther offshore because the St. Lucie shoal area of influence is more focused along the shoreline (Hammer et al. 2005).

Sedimentary habitats such as sand shoals support a variety of invertebrates and demersal fishes. Invertebrates using shoals include infaunal and epifaunal species represented primarily by annelid worms, gastropods, bivalves, crustaceans, and echinoderms. Demersal feeding fishes prey on most of these species. A number of sand shoal studies conducted along the eastern coast of the U.S. have documented the use of sand shoals as fish habitat (Able and Hagan 1995, Slacum et al. 2006, Walsh et al. 2006, Vassilides and Able 2008, Gimore 2009). CSA International et al. 2009a) generally characterized use of sand shoals by fishes at several spatial scales. At broad scales (1 to 100 square kilometers), fishes may use shoal features as guideposts during migrations, local movements, or spawning. At intermediate scales

(tens to hundreds of square meters), different parts of individual shoals may represent different foraging areas or shelter from predators or waves and currents. At smaller scales (e.g., meters to centimeters), sediment texture (fine sand to shell fragments), variable bedform structures, and biogenic structures may provide important predator refuge or foraging areas. Considering this spatial framework, most fundamental ecological functions of shoals for fishes fall into the categories of spawning, shelter, or foraging.

Gilmore (2009) synthesized unpublished information and data and interviewed local anglers to determine the importance of the east Florida sand shoals, including the St. Lucie Shoal, to fishes. The report inferred from the various data sources that more than 200 species potentially use shoals for orientation, refuge, spawning, and feeding sites. Interviews with anglers confirmed that shoals served as aggregating points for small pelagic fishes such as menhaden, Spanish sardine, thread herring, and false pilchard. These species are important prey for numerous managed species, particularly from the coastal pelagic and highly migratory groups. Additional information on St. Lucie Shoal can be found in Appendix D, Geotechnical.

FUTURE WITHOUT-PROJECT CONDITIONS (NO-ACTION ALTERNATIVE)

The Future Without-Project Conditions of the offshore borrow area resources are not expected to be different from the Existing Conditions described above. However, the borrow area may be used for other projects.

2.2.8 COASTAL BARRIER RESOURCES

EXISTING CONDITIONS

In 1982, Congress signed the Coastal Barrier Resources Act (CBRA) prohibiting Federal expenditures (direct or indirect) for development of designated undeveloped coastal barriers and their associated aquatic habitat, including wetlands, estuaries, and inlets. The three primary goals of the CBRA include

- Minimize loss of human life by discouraging development in high risk areas
- Reduce wasteful expenditure of Federal resources
- Protect the natural resources associated with coastal barriers

One Coastal Barrier Resource System (CBRS) map unit, P11 (Hutchinson Island), lies partially within and adjacent to the project area (**see REF-1**).

The May 27, 2009 FWS CBRA Consistency Determination letter (**Appendix H**) describes the project area CBRS Unit P11 as follows:

> This area supports suitable habitat for species listed under the Endangered Species Act of 1973, as amended (87 Stat. 884; 16 U.S.C. 153 1 *et seq*.), including the threatened piping plover (*Charadrius melodus*), threatened loggerhead sea turtle (*Caretta caretta*), endangered green sea turtle (*Chelonia mydas*), endangered leatherback sea turtle (*Dermochelys coriacea*), and endangered hawksbill sea turtle (*Eretmochelys imbricata*). The beaches of St. Lucie County support the fifth highest nesting density of sea turtles in Florida.

FUTURE WITHOUT-PROJECT CONDITIONS (NO-ACTION ALTERNATIVE)

The Future Without-Project Conditions of the CBRS unit are not expected to be different from the Existing Conditions described above.

2.2.9 WATER QUALITY

EXISTING CONDITIONS

The State of Florida classifies the waters offshore of the project area as Class III waters, which are designated as suitable for recreation, propagation, and maintenance of a healthy, well-balanced population of fish and wildlife. The predominant issue that affects water quality in offshore waters in south Florida is turbidity, considered a good measure of water quality. Turbidity is a measure of the loss in transparency of water due to the presence of suspended particulates — the more total suspended solids in the water, the cloudier it appears and the higher the turbidity. Turbidity is measured in nephelometric turbidity units (NTUs), which is measured by the intensity of light scattered passing through the water sample.

FUTURE WITHOUT-PROJECT CONDITIONS (NO-ACTION ALTERNATIVE)

The water quality in the study area is not likely to change from the Existing Conditions in the Future Without-Project Conditions.

2.2.10 HAZARDOUS, TOXIC, AND RADIOACTIVE WASTE

EXISTING CONDITIONS

The coastline within the project area is located adjacent to predominantly residential, commercial, and recreational areas. No known industrial activities produce hazardous, toxic, and/or radioactive wastes adjacent to the project site; no known industrial activities discharge effluents near the shoreline; and no known records of such past activities exist. Sediments within the littoral zones of the project area, as well as sediments from the borrow areas, comprise particles of a large grain-size. Normally, contaminants do not adhere to materials with such properties. Sediments in the potential borrow sites are sufficiently removed from shipping lanes or other potential contaminant sources. Hence, pollutants are unlikely to have contaminated them.

The closest Formerly Used Defense Site to the project area was the Fort Pierce Naval Amphibious Training Base. Heavy ordnance activities associated with this base took place to the north of the project area, on North Hutchinson Island in Indian River County. There were no offshore activities as far south as the project area. Unexploded ordinance has not been observed in previous dredging events within St. Lucie Shoals or during beach placement activities.

FUTURE WITHOUT-PROJECT CONDITIONS (NO-ACTION ALTERNATIVE)

The absence of hazardous or toxic wastes in the study area is not likely to change from the Existing Conditions in the Future Without-Project Conditions.

2.2.11AIR QUALITY

EXISTING CONDITIONS

St. Lucie County lies within the Southeast Florida Intrastate Air Quality Region, as established by 40 CFR Part 81.49. The U.S. Environmental Protection Agency (EPA) (40 CFR Part 81.310) designates St. Lucie County as being in attainment with National Ambient Air Quality Standards for ozone, nitrogen dioxide, carbon monoxide, particulate matter, and sulfur dioxide. Air quality in St. Lucie County exceeds national standards. The EPA has not made a designation for lead in southeastern Florida.

Ambient air quality along coastal St. Lucie County is generally good due to prevalent ocean breezes from the northeast through the southeast. Coastal development and the popularity of the beaches area all contribute to the presence of motorized vehicles and vessels in the project area at any given time. The usually present sea breezes along the Ft. Pierce shore readily disperse airborne pollutants. This project, regardless of the alternative implemented, would not require air quality permits.

FUTURE WITHOUT-PROJECT CONDITIONS (NO-ACTION ALTERNATIVE)

The air quality in the study area is not likely to change from the Existing Conditions in the Future Without-Project Conditions.

2.2.12 NOISE

EXISTING CONDITIONS

Ambient sources of noise within the project area include beach and nearshore recreational activities, breaking surf, boat and vehicular traffic, and noise from adjacent residences. Because St. Lucie County has many seasonal residents and tourists, many more residents are present in the homes and condominiums located along the project area during the winter months. Their presence results in more ambient noise along the beach front as well as more boating traffic during the winter tourist season.

FUTURE WITHOUT-PROJECT CONDITIONS (NO-ACTION ALTERNATIVE)

While the area may experience a slight decrease in tourist activity, noise levels in the study area are not likely to change significantly from the Existing Conditions in the Future Without-Project Conditions.

2.2.13 AESTHETIC RESOURCES

EXISTING CONDITIONS

An aesthetic or visual resource is a broad term used to identify the particular scenic qualities that define a place or landscape. The sandy beaches and blue waters of the Atlantic Ocean found along South Hutchinson Island define the aesthetic resources within the project area. Upland development consisting of high and low rise commercial and residential development, vacant lands, and recreational beach access areas backs the coastline. Vacant lands and beach access areas are generally vegetated with low lying shrubby dune plants such as sea oats (*Uniola paniculata*), with occasional interspersed railroad vine

(*Ipomoea pescapre*), sea grapes (*Coccoloba uvifera*), and sea purslane (*Sesuvium* sp.). Residents and guests of the numerous condominiums, resorts, and hotels within the project area enjoy the aesthetically pleasing panoramas of the Atlantic Ocean. However, the general project area does not include sites designated under 40 CFR 81.407 as a Class I Federal Area, where visibility is an important value.

Erosional processes currently occurring within the project area distract from the aesthetics and will continue to reduce the width of the beach area and related aesthetic value. According to the Conditions Assessment Report (Coastal Tech 2009: Attachment P), an average 60 feet of dune separated the buildings and the sandy beach. The analysis found project area beaches generally eroded and the shoreline generally in retreat, with the greatest volumetric loss occurring between reference monuments R-90 and R-100. From R-103 to R-109, the slightly accreted beaches advanced slightly seaward.

FUTURE WITHOUT-PROJECT CONDITIONS (NO-ACTION ALTERNATIVE)

The aesthetics of the study area are anticipated to decline in the Future Without-Project Condition due to increased erosion and the continued narrowing of the beach.

2.2.14 RECREATION RESOURCES

EXISTING CONDITIONS

Beaches within the project area are somewhat less congested than other nearby beaches due to limited public beach access points (there are 7 throughout the study area from R-77 to the Martin County line) and distance from the heavily populated areas of Ft. Pierce, Port St. Lucie, and Stuart. Project area beaches provide an appealing and relaxing South Florida atmosphere.

Recreational usage along the beaches within the project area includes shore-based water sports such as scuba diving, snorkeling, surfing, surf fishing, and kayaking. Additionally, visitors use area beaches for sunbathing, picnicking, and exercising. Boating is a popular recreational pastime for many residents and tourists to the area. Fishing, lobstering, scuba diving, and snorkeling often start from boats in nearshore hardbottom areas. Offshore angling may occur near the proposed borrow site despite the absence of known, identified fish havens near the borrow area. Numerous boat ramps and marinas in Ft. Pierce, Jensen Beach, and Stuart provide access to the Atlantic Ocean through the Ft. Pierce Inlet located approximately 10 miles north and the St. Lucie Inlet located 7.5 miles south of the project area.

FUTURE WITHOUT-PROJECT CONDITIONS (NO-ACTION ALTERNATIVE)

The recreational usage of the study area is anticipated to decline in the Future Without-Project Condition due to increased erosion and the continued narrowing of the beach, which will make it less suitable for recreating.

2.2.15 CULTURAL RESOURCES AND HISTORIC PROPERTIES

EXISTING CONDITIONS

All portions of the proposed project area, including the offshore borrow area and the sand placement template have been subjected to cultural resource surveys. New South Associates conducted a Phase I cultural resources survey of the sand placement area in October 2007 (Smith et al. 2008). The survey extended from the Martin/St. Lucie County line to approximately 0.5 miles north of the Florida Power and Light (FPL) Nuclear Power Plant and included the area currently under review. The Phase I survey consisted of background research, surface reconnaissance, systematic shovel testing, metal detection in areas adjacent to recorded locations of historic shipwrecks, artifact identification and analysis, and report preparation. Background research indicated that all previously recorded historic and prehistoric sites are located outside of the current project area — on or west of the back dune along or west of U.S. A1A. No cultural resources were identified as a result of the surface and sub-surface testing.

The study recommended that the project avoid areas near previously recorded underwater sites and undisturbed areas of back dune where previously recorded sites are located. The report recommended a finding of no effect on cultural resources listed or eligible for listing in the National Register of Historic Properties (NRHP), and recommended no further investigation of the project area. The State Historic Preservation Office (SHPO) reviewed the survey report and concurred with the final report findings and recommendations in a letter to USACE dated 27 July 2010 (DHR File No. 2008-02141-B) (**Appendix H**).

A remote sensing survey of the proposed offshore borrow location was conducted by SEARCH between October 2007 and June 2008 (Krivor 2008). An additional remote sensing survey of a portion of the proposed shoal borrow area not previously investigated was also conducted by SEARCH in December 2010 (Krivor 2010). These surveys utilized a magnetometer, side scan sonar, and sub bottom profiler to identify any potentially significant submerged cultural resources. In addition to the remote sensing surveys, SEARCH conducted a refinement survey of reported wreck sites near the project area, including the *America* (8SL28) and the *Halsey* (8SL30).

As a result of the 2007-2008 survey, SEARCH identified one cluster of magnetic anomalies associated with side scan sonar imaging within the project area. The cluster of magnetic targets were not evaluated by a diver; however, the magnetic signature suggests these targets may represent a potentially significant submerged cultural resource (Krivor 2008). The *Halsey* was relocated outside of the current borrow area; however, the *America* was not relocated as a result of the remote sensing survey, and is believed to be south of the coordinates provided by the Florida Master Site File. No potentially significant submerged cultural resources were identified as a result of the 2010 SEARCH survey.

The 2007-2008 remote sensing survey recommended that the project avoid submerged cultural resources during dredging by utilizing a 500-foot buffer zone around the cluster of magnetic anomalies and recommended no further investigation of the area. Based on these recommendations, the proposed project was determined to have no effect on cultural resources listed or eligible for listing in the NRHP. The SHPO reviewed both reports and issued letters dated 20 January 2011 concurring with the report findings and recommendations (DHR File No. 2011-00114 and 2011-00231) (**Appendix H**).

FUTURE WITHOUT-PROJECT CONDITIONS (NO-ACTION ALTERNATIVE)

The future without-project conditions of cultural resources are similar to the existing conditions described above. Selection of the No-action alternative would have no effect on cultural resources listed or eligible for listing in the NRHP.

2.2.16 NATIVE AMERICANS

EXISTING CONDITIONS

No portion of the proposed project area exists within or adjacent to known Native American-owned lands, reservation lands, or Traditional Cultural Properties. However, Native American groups have lived throughout this region in the past, and their decedents continue to live within the State of Florida and throughout the United States. Pursuant to Section 106 of the National Historic Preservation Act (16 USC 470), obligations regarding USACE Trust Responsibilities to federally-recognized Native American Tribes, and in consideration of the Burial Resources Agreement between USACE and the Seminole Tribe of Florida, prior consultation on the project has not indicated any historic use of the project area.

FUTURE WITHOUT-PROJECT CONDITIONS (NO-ACTION ALTERNATIVE)

The future without-project conditions of Native American groups are similar to the existing conditions described above. Selection of the No-action alternative would have no effect on Native American groups.

2.2.17 PUBLIC SAFETY

EXISTING CONDITIONS

Issues of public safety along the beach placement area principally include those typically associated with beach- and water-related recreation, including sun exposure and injuries or drowning from high surf or run-outs. The submerged rock outcrops in shallow water along the shoreline can also result in injuries to bathers. Most public beach parks are staffed by County or municipal lifeguards during periods of normal to high beach use. Crime and related activities are of a low to moderate nature and are not considered to be of a significant nature.

FUTURE WITHOUT-PROJECT CONDITIONS (NO-ACTION ALTERNATIVE)

The public safety of the study area is not anticipated to significantly change in the Future Without-Project Condition; however, due to increased erosion and the continued narrowing of the beach, the number of people recreating on the beach is expected to decline and this may affect public safety statistics for this area.

2.3 PHYSICAL ENVIRONMENT (Conditions)

The study area consists of an open sandy coast subject to frequent storm events. Adjacent properties to the shoreline can be categorized as urban and include residential, commercial, and recreational properties. Many factors influence the coastal processes characteristic to the St. Lucie County, Florida shoreline. Factors include winds, tides, currents, waves, storm effects, and sea level rise. Human-related factors include other coastal storm risk management projects, navigation projects, and development. The role of each of these factors and their contribution to beach erosion in St. Lucie County are briefly described in the following paragraphs.

2.3.1 STUDY REACHES

EXISTING CONDITIONS

The area has been delineated into four reaches. The Florida Department of Environmental Protection (FDEP) has designated four erosion reaches in St. Lucie County. The FDEP defines a critically eroded area as "a segment of the shoreline where natural processes or human activity have caused or contributed to erosion and recession of the beach or dune system to such a degree that upland development, recreational interests, wildlife habitat, or important cultural resources are threatened or lost". The reaches are discussed below:

- North Hutchinson Island (R-77 to R-80): This reach is approximately .57 miles long, with an average erosion rate of -1.8 feet per year. There is no development in this reach and it is entirely within the CBRS unit. This reach is designated as non-critically eroded by FDEP.
- Power Plant Area (R-80 to R-90.3): This reach is approximately 1.9 miles long, with an average shoreline change rate of +0.06 feet per year (slightly accretional). The only structure in the reach is the Florida Power and Light (FPL) Nuclear Power Plant. With the exception of the power plant, the remainder of the reach is entirely within the CBRS unit. This reach is designated as critically eroded by FDEP.
- Narrows of Hutchinson Island (R-90 to R-98): This reach is approximately 1.5 miles long and the average erosion rate is -1.0 feet per year. The area consists of low development within the CBRS unit, with the exception of one excluded area with one condominium development. This reach is designated as non-critically eroded by FDEP.

- South Hutchinson Island (R-98 to R-115 plus 1000 feet): This reach is approximately 3.4 miles long and the average erosion rate is -.4 feet per year. There is a small CBRS unit which ends 600 feet south of R-98, begins again at roughly R-101.5 to R-103.5 (Dollman Park), and then ends for the remainder of the reach. This reach is designated as critically eroded by FDEP.

FUTURE WITHOUT-PROJECT CONDITIONS (NO-ACTION ALTERNATIVE)

The reaches will generally remain the same in the future without-project condition.

2.3.2 GEOLOGY

EXISTING CONDITIONS

South Hutchinson Island is part of a chain of sandy barrier islands separated by narrow inlets from Cape Canaveral to Palm Beach. These barrier islands rarely exceed one mile in width or 20 feet in elevation. Separating South Hutchinson Island form the mainland is the Indian River, a shallow lagoon, approximately 2 miles in width. During high seas and storms, the island may be overwashed by the sea, which spreads the sands into the lagoon, forming a fan or delta shape.

Offshore of the beaches and modern barrier islands is the continental shelf. It is a broad, shallow, low relief shelf that extends from 80 miles offshore near Jacksonville, to only a few miles offshore near Miami. The shelf contains relic Pleistocene and Holocene terraces and submerged beach sand ridges. The wave climate and sediment transportation system creates a linear sandy coastline.

The east coast of Florida, from the state line at the Georgia border to Miami Beach (350 miles), consists of a series of sandy barrier islands broken occasionally by inlets. The barrier islands are characterized by dunes and shore parallel beach ridges. Many of the islands display relic beach ridges formed during higher stands of sea level. The barrier islands often have a distinctive drumstick-shape with an accreting bulbous end and a slender eroding end. These barrier islands were formed from waves and longshore currents reworking marine and fluvial sediments. Lagoons and marshes are typically located between the barrier islands and the mainland.

The quartz component of the modern barrier island sand was deposited from sand migrating southward along the Atlantic coast, from the reworking of the Pamlico Sand that was previously deposited over the entire region. The remaining component of coastal sediments are typically carbonates, locally produced by calcite-producing plants and animals. Additional carbonate materials are from reworked materials from outcropping Pleistocene formations offshore (Duane and Meisburger, 1969).

FUTURE WITHOUT-PROJECT CONDITIONS (NO-ACTION ALTERNATIVE)

The geology in the future without-project condition would be expected to function and/or change according to the conditions described above.

2.3.3 NATIVE BEACH

EXISTING CONDITIONS

The native beach on South Hutchinson Island was sampled by Coastal Tech in February 2007 to characterize the recent native beach sediments and assess compatibility with the potential sand source material. The project beach area has not previously been nourished. Sixty (60) native beach sediment samples were obtained from R-77, R-80, R-85, R-90, R-95, R-98, R-100, R-105, R-110, and R-115. Samples were collected from the toe of dune, mid-berm, mean high water, mean low water and near the -3-foot contour. Samples were obtained from approximately 5" below the surface (Coastal Tech, 2010). More details can be found in the **Geotechnical Appendix**.

FUTURE WITHOUT-PROJECT CONDITIONS (NO-ACTION ALTERNATIVE)

The future without-project conditions of the native beach are similar to the existing conditions described above.

2.3.4 SAND SOURCES

EXISTING CONDITIONS

Several offshore sand sources were investigated in 2006 by Coastal Planning & Engineering. However, St. Lucie Shoal (designated SL4-R98 during the Sediment Assessment and Needs Determination (SAND) study, 2014) is the main area of focus for this report (see **REF-4**). The shoal is located in Federal water, approximately three to seven miles offshore of the study area**,** and is comprised of two main parts: the North St. Lucie Shoal and the South St. Lucie Shoal. The North St. Lucie Shoal covers an area of approximately 2 square miles and contains approximately 8.3 million cubic yards of beach-quality material. The South St. Lucie Shoal sand source covers an area of approximately 1.2 square miles. The South St. Lucie Shoal contains approximately 2.3 million cubic yards of beach-quality material.

In general, the beach-quality material encountered within the St. Lucie Shoal consists of olive brown to olive gray, fine to medium-grained skeletal sand with few to some fine-grained quartz and few to some gravel-size shell. More details can be found in the **Geotechnical Appendix.**

Other nearby sand sources have been investigated in recent studies or used in past projects. The "Dade County, FL, Beach Erosion Control and Hurricane Protection Project, Limited Reevaluation Report" investigated SL10-T41 and M4-R105, located about 10 miles from the St. Lucie Shoal. The Martin County Federal project uses sand source SL7-R104. The local St. Lucie County one-time nourishment used SL3-R107 (a portion of St. Lucie Shoals, which is located in State Water).

FUTURE WITHOUT-PROJECT CONDITIONS (NO-ACTION ALTERNATIVE)

In the future, it is possible that this sand source could be mined for sand by another agency or for another Federal project. However, at this time, there are no construction plans by any agency to use it.

2.3.5 SHORELINE CHANGE AND EROSION RATES

EXISTING CONDITIONS

Due to a combination of geographic and natural factors, the St. Lucie County shoreline experiences regions of both erosion and accretion. Based on all available survey data (January 1970 to August 2008), the northern (less developed) portion of the project (R-77 to R-99) experiences an annual erosion rate of -0.31 feet per year, while the southern (significantly developed) portion of the study(R-100 to R-115+1000 feet) experiences an annual erosion rate of -0.18 feet per year. The most developed, southernmost portion of the study which is not in the CBRS unit (R-104 to R-115) has experienced an average annual erosion rate of -0.12 feet per year during this time period. Overall, the study area (R-77 to R-115+1000 feet), has fairly uniform erosion as a whole with an annual erosion rate of -0.26 feet per year.

Prior to the 2004 hurricane season, the northern and southern portions of the project experienced an average annual shoreline change rates of +0.18 feet per year and -0.36 feet per year, respectively. The southernmost portion of the project had an annual shoreline change rate of -0.38 feet per year for the same time period. The overall average annual erosion rate for the same time period was -0.04 feet per year. This indicates that prior to the impact of severe storms, the northern portion of the project experienced mild accretion while the southern portions of the project have been historically erosional.

Both the north and south portions of the project experienced dramatic erosion due to the 2004 and 2005 storm seasons. This has been followed by significant post-storm recovery.

Shoreline erosion is detailed further in the **Engineering Appendix**.

FUTURE WITHOUT-PROJECT CONDITIONS (NO-ACTION ALTERNATIVE)

The future without-project shoreline profile is assumed to be the 2008 profile (see explanation earlier in this chapter), with erosion until the base year of 2020, and forecasted out to 2070[9]. The shoreline should experience similar rates of erosion and accretion in the future without-project condition as described in the existing conditions section above.

2.3.6 WINDS

EXISTING CONDITIONS

Local winds in the project area are the primary means of generating the small-amplitude, short period waves which are the primary mechanisms of daily (non-storm related) sand transport along the south-central Florida shoreline.

Predominant winds from the east-southeast quadrant are generally mild in nature and occur in the spring and summer months. Elevated wind speeds from the north-northeast quadrant in fall and winter months occur during passage of northeasters which can cause extensive beach erosion and shorefront damage.

[9] Technically the modeling year started at 2020 as year 1, and therefore 2069 is 50 years is the end of the period of the analysis. However, for planning purposes of this report, 2070 will be the end of Federal participation.

Occasionally the area is impacted by the passage of tropical storms that can generate devastating winds, waves, and storm surge, which can cause direct damage to coastal structures and infrastructure. The **Engineering Appendix** provides additional detail on winds.

FUTURE WITHOUT-PROJECT CONDITIONS (NO-ACTION ALTERNATIVE)

The future without-project conditions of winds are similar to the existing conditions described above.

2.3.7 WAVES

EXISTING CONDITIONS

The wave energy dissipation that occurs as waves enter the nearshore zone and break is the principle driver for sediment transport. Wave height, period, and direction, in combination with tides and storm surge, are the most important factors influencing the behavior of the beach and dune system.

The St. Lucie County study area is exposed to the open ocean toward the northeast. This orientation makes the coastline vulnerable to wave attack from distant storms as well seasonal conditions. Most hurricanes and tropical storms traversing northward through the Atlantic within several hundred miles of the east coast will produce large swells which are capable of causing erosion along the St. Lucie County shoreline.

Open-ocean swells originating from south of due east are blocked by two large shoals north and west of the Bahamas known as the Little Bahama Bank and the Great Bahama Bank, respectively. Water depths across the Bahama Banks average about 30 feet, so longer-period swells are reduced or eliminated by bottom friction or the presence of land masses as they traverse the Bank. The minimum fetch between the western edge of the Banks and the St. Lucie County study area is about 65 miles, which allows ample distance for the generation of shorter-period wind waves in the deep waters of the Florida Straits. During severe storm events such as hurricanes and tropical storms, high wind velocities can generate large, damaging waves over the relatively short distance between the Bahamas and Florida.

The study area experiences daily (non-storm related) sediment transport due to typical seasonal wave conditions. This results in variable, generally low level, rates of erosion and accretion dependent on incident wave direction and intensity. Prolonged periods of daily erosion can lead to the undermining of structures and roads over time. However, the main cause of damage to the St. Lucie County shoreline and upland development are produced primarily by tropical and extra tropical disturbances, as described above.

The **Engineering Appendix** provides additional detail on waves.

FUTURE WITHOUT-PROJECT CONDITIONS (NO-ACTION ALTERNATIVE)

The future without-project conditions of waves are similar to the existing conditions described above.

2.3.8 ASTRONOMICAL TIDES

EXISTING CONDITIONS

Astronomical tides are created by the gravitational pull of the moon and sun and are well understood and predictable in magnitude and timing. The National Oceanic and Atmospheric Administration (NOAA) regularly publishes tide tables for selected locations along the coastlines of the United States and selected locations around the world. These tables provide times of high and low tides, as well as predicted tidal amplitudes.

Tides in the St. Lucie County area are semidiurnal: two high tides and two low tides per tidal day (24 hours 50 minutes). Two measures of tidal range are commonly used: the mean tide range is defined as the difference between Mean High Water (MHW) and Mean Low Water (MLW), and represents an average range during the entire lunar cycle (27.3 days). The range of tidal elevations between successive high and low tides is typically greater at any location during periods of a new or full moon. The spring tide range is the average semidiurnal range which occurs semimonthly when the moon is new or full.

Tide ranges are relatively low along the St. Lucie County region of Florida's east coast. The nearest tide station to the study area is NOAA Tide Station #8722212, located at the Ft. Pierce Inlet south jetty, about 12 miles north of the center of the study area. The mean tide range at this station is found to be 2.56 feet and the spring tide range is 3.59 feet (based on 2010 averages).

FUTURE WITHOUT-PROJECT CONDITIONS (NO-ACTION ALTERNATIVE)

The future without-project conditions of tides are similar to the existing conditions described above.

2.3.9 CURRENTS

EXISTING CONDITIONS

The primary ocean current in the project area 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 17 miles per day in November to an average monthly high of approximately 37 miles per day in July. The Gulf Streams lies approximately 25 miles offshore of the project area.

The near-shore currents in the project vicinity are not directly influenced by the Gulf Stream, but may be influenced indirectly via interaction with incident waves. Littoral currents affect the supply and distribution of sediment on the sandy beaches of St. Lucie County. Longshore currents, induced by oblique wave energy, generally determine the long-term direction and magnitude of littoral transport. Cross-shore currents may have a more short term impact, but can result in both temporary and permanent erosion. The magnitude of these currents is determined by the wave characteristics, angle of waves from offshore, local tides, configuration of the beach and the nearshore profile. For St. Lucie County beaches, the net sediment transport is from north to south.

Influence of Ft. Pierce Inlet and St. Lucie Inlet ebb and flood currents on local currents is negligible. In both cases the distance between the inlet and the project area (8 miles and 7 miles, respectively) places the study area outside the influence of inlet tidal fluctuations.

FUTURE WITHOUT-PROJECT CONDITIONS (NO-ACTION ALTERNATIVE)

The future without-project conditions of currents are similar to the existing conditions described above.

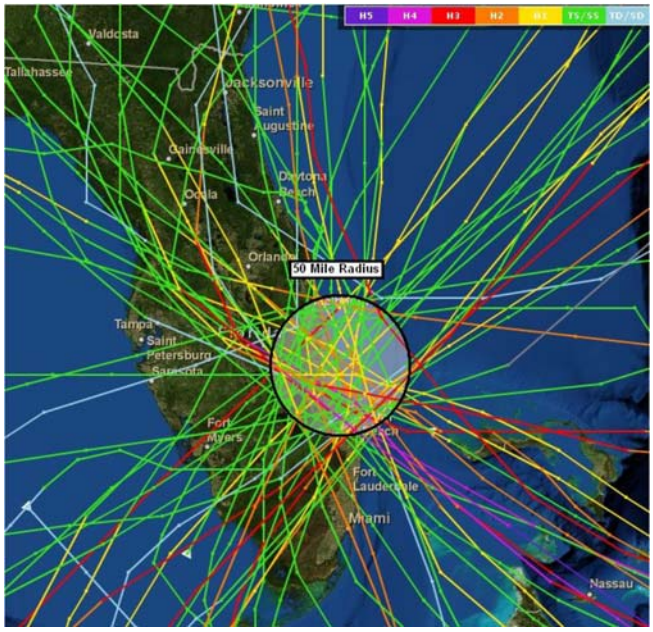
2.3.10 STORM EFFECTS

EXISTING CONDITIONS

The study area is located in a region of considerable hurricane activity, resulting in relatively frequent hurricane impacts. **Figure 2-5** shows historic tracks of hurricanes and tropical storms from 1851 to 2010, as recorded by the National Hurricane Center (NHC) and available from the NOAA website. The circle in the center of this figure indicates a 50 mile radius from the center of the study area. Based on NHC records, 55 hurricanes and tropical storms have passed within this 50-mile radius over the 159-year period of record, averaging one storm every 2.8 years.

The 50-mile radius was chosen for display purposes because any tropical disturbance passing within this distance, even a weak tropical storm, would be likely to produce some damage along the shoreline. Stronger storms are capable of producing significant damage to the coastline from far greater distances. For example, Hurricane Andrew made landfall in southern Dade County in 1992 as a Category 5 storm. This storm produced significant coastal erosion along St. Lucie County, over 120 miles north of the storm track.

Figure 2-5. Hurricanes within 50 miles radius of St. Lucie over 159-year period.



In recent years, a number of named storms have significantly impacted the project area, including hurricanes Mitch (1998), Irene (1999), and Tropical Depression #4 (2000). However, the most severe storm events in recent years are due to the multiple storms of the 2004 and 2005 hurricane seasons. In August 2004 the study area was impacted by hurricane Charley, followed by Hurricanes Frances, Jeanne, Ivan, and a strong northeaster in September 2004. Of these storms, Hurricanes Frances and Jeanne were considered to be 100-year storm events, and caused considerable erosion along this coastline. Hurricanes Frances and Jeanne made landfall only three weeks apart and within 2 miles of each other. This season marked the first time that Florida (or any individual state) has been impacted by four hurricanes in one tropical season since weather records began in 1851. In 2005 the St. Lucie County area was again impacted, by Hurricanes Dennis (July), Katrina (August), Ophelia (September), Rita (September), and Wilma (October).

Damages to coastal storm risk management projects from these combinations of storms in 2004 and 2005 included substantial erosion and damage from wind, wave, and water action beyond that which would ordinarily be expected by an individual storm. This is due, in part, to the fact that protective beach fill initially moved offshore by a storm did not have ample time to return onshore before the beach was impacted by the next storm. The large size of these hurricanes also contributed to damage levels along the St. Lucie County coastline as several storms inflicted damages far from their landfall points.

Since the study area is exposed to the open ocean toward the northeast, the coastline is vulnerable to wave attack from distant storms as well. Most hurricanes and tropical storms traversing northward through the Atlantic within several hundred miles of the east coast are capable of producing large swells which are capable of causing erosion along the study area, within the St. Lucie County shoreline.

FUTURE WITHOUT-PROJECT CONDITIONS (NO-ACTION ALTERNATIVE)

The future without-project conditions of storm effects are similar to the existing conditions described above.

2.3.11 STORM SURGE

EXISTING CONDITIONS

Storm surge is defined as the rise of the ocean surface above its astronomical tide level due to storm forces. Surges occur primarily as a result of atmospheric pressure gradients and surface stresses created by wind blowing over a water surface. Strong onshore winds pile up water near the shoreline, resulting in super-elevated water levels along the coastal region and inland waterways. In addition, the lower atmospheric pressure which accompanies storms also contributes to a rise in water surface elevation. The combination of extremely high wind velocities coupled with low barometric pressures (such as those experienced in tropical storms, hurricanes, and very strong northeasters) can produce very high, damaging water levels. In addition to wind speed, direction and duration, storm surge is also influenced by water depth, length of fetch (distance over water), and frictional characteristics of the nearshore sea bottom. An estimate of storm surge is required for a complete assessment of shoreline response and coastal storm risk. An increase in water depth may increase the potential for coastal flooding and allow larger waves to attack the shore.

The study area is a low, flat barrier island and is particularly susceptible to overtopping from storm surges. Topographic surveys show that much of the island is less than 5 feet in elevation. Maximum elevations of 10-15 feet occur, but are almost exclusively along the oceanfront dune line. A series of existing hurricane storm-surge maps have been produced by the Florida Division of Emergency Management of all of Florida's coastal counties.

FUTURE WITHOUT-PROJECT CONDITIONS (NO-ACTION ALTERNATIVE)

The future without-project conditions of storm effects are similar to the existing conditions described above.

2.3.12 SEA LEVEL CHANGE

EXISTING CONDITIONS

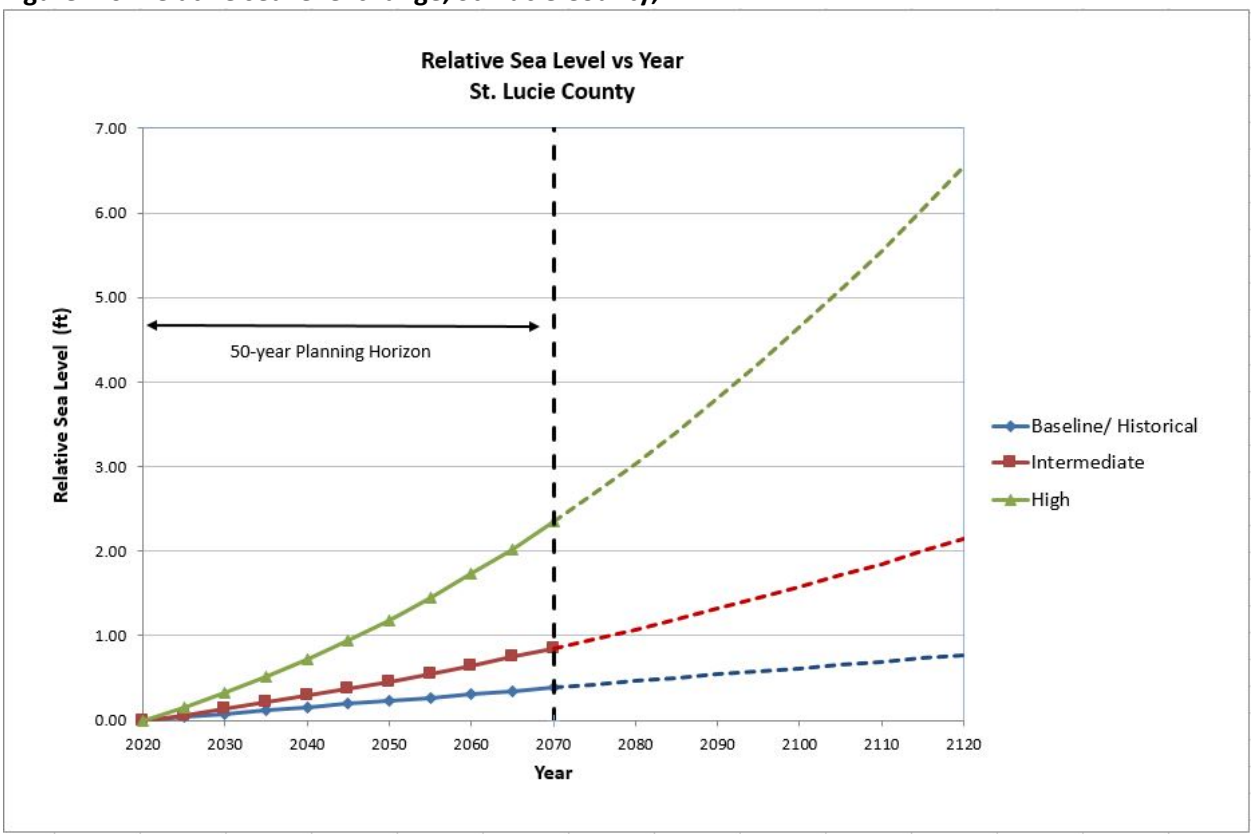
It is anticipated that the global mean sea level will rise within the next 100 years. To incorporate the direct and indirect physical effects of projected future sea level change on design, construction, operation, and maintenance of coastal projects, the U.S. Army Corps of Engineers (USACE) has provided guidance in the form of Engineering Regulation, ER 1100-2-8162 and Engineering Technical Letter (ETL) 1100-2-1. Three estimates are required by the guidance, a Baseline (or "Low") estimate, which is based on historic sea level rise and represents the minimum expected sea level change; an Intermediate estimate; and a High estimate representing the maximum expected sea level change.

The study area is located approximately 101 miles from the NOS gage #8723170 at Miami Beach, Florida, and approximately 132 miles from NOS gage #8721120 at Daytona Beach Shores, Florida. Due to the distance, the historic sea level change at St. Lucie was approximated by a linear interpolation between the Miami and Daytona gages. The resulting averaged historical sea level change rate for St. Lucie County then equals 2.36 mm/yr. Given a project base year of 2020 a table of sea level change rates was produced for each of the three required scenarios through the 50-year period of analysis and up to the year 2120. Additional detail on sea level change is provided in the Engineering Appendix.

FUTURE WITHOUT-PROJECT CONDITIONS (NO-ACTION ALTERNATIVE)

Figure 2-6 provides a graphic representation of the three levels of projected future sea level change over a 100-year period. The project area can expect to see sea level rise .4 to 2.2 feet above its current position within the 50-year period of analysis as predicted by the low and high sea level change rates, respectively.

Figure 2-6. Relative sea level change, St. Lucie County, FL.



2.3.12.1 SHORELINE CHANGE RESULTING FROM SEA LEVEL RISE

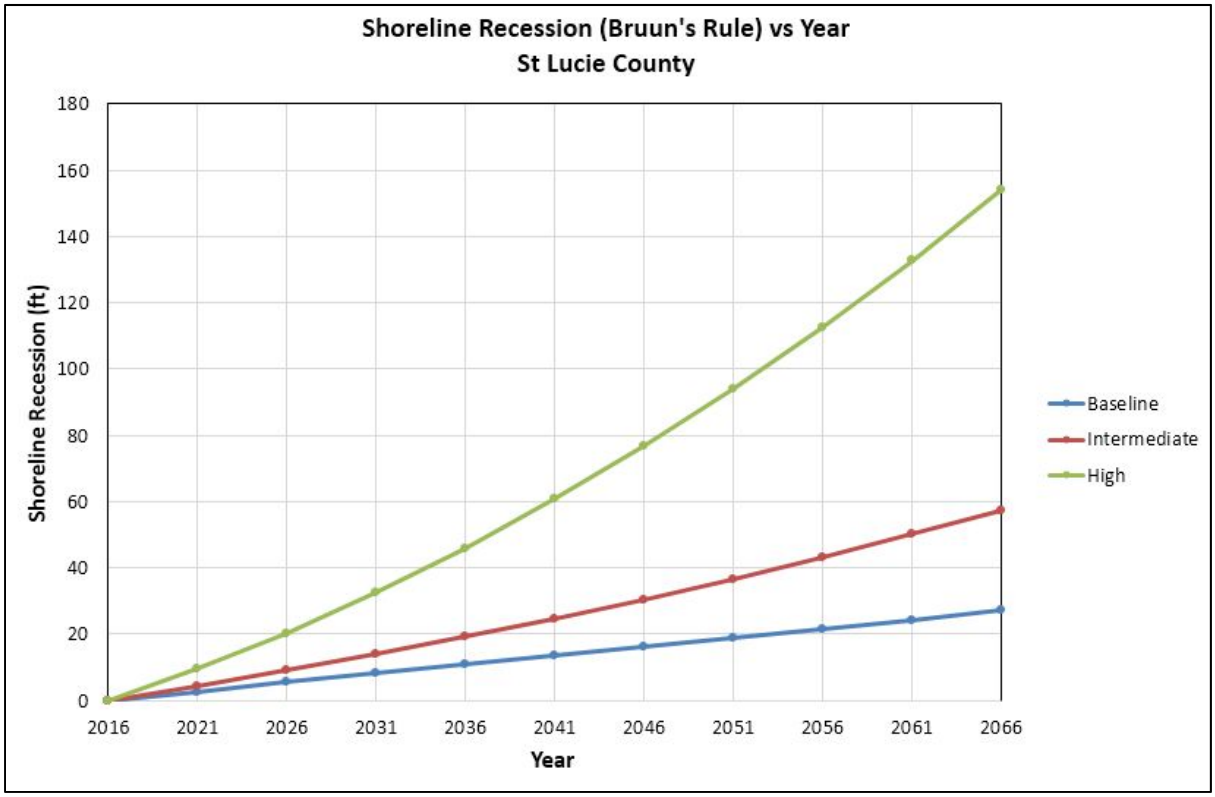
An estimate of the rate of shoreline recession can be based on the local rate of sea level change in some cases. With a change in sea level, the beach profile will attempt to reestablish the same bottom depths relative to the surface of the sea that existed prior to sea level change. That is, the natural profile will be translated upward and shoreward to maintain equilibrium. If the longshore littoral transport in and out

of a given shoreline is equal, then the quantity of material required to re-establish the nearshore slope must be derived from erosion of the shore.

The above estimation is applicable to long straight sandy beaches with an uninterrupted supply of sand and should only be used for estimating long-term changes. Additional detail is given in the **Engineering Appendix.**

Figure 2-7 provides an estimate of the potential shoreline changes within the project area attributable to projected changes in sea level.

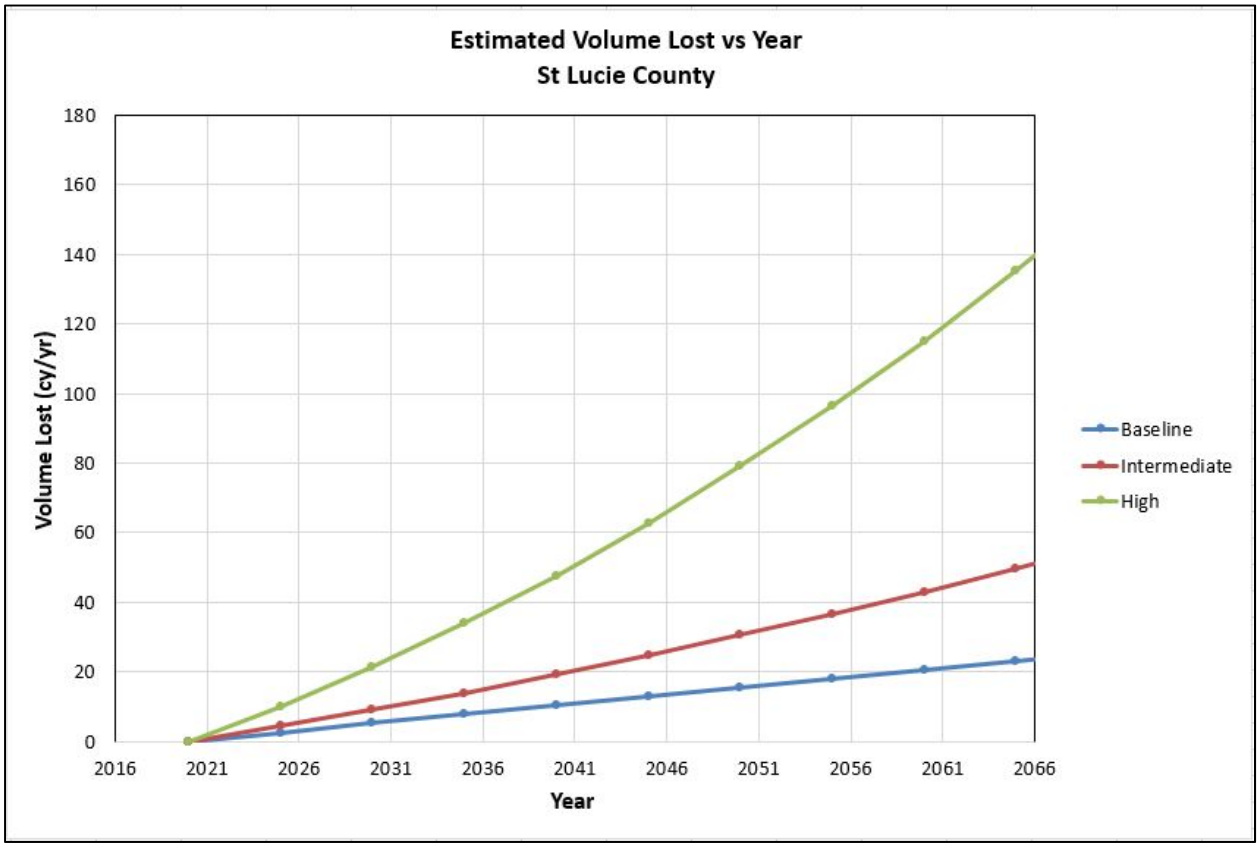
Figure 2-7. Estimated shoreline recession rate due to sea level rise.



2.3.12.2 VOLUMETRIC CHANGE RESULTING FROM SEA LEVEL RISE

Engineering Manual (EM) 1110-2-3301 (USACE, 1995) gives guidance on how to calculate beach volume based on berm height, depth of closure, and translation of the shoreline (in this case, shoreline recession). **Figure** 2-8 provides an estimate of the shoreline volume loss as a result of the three Sea Level Rise scenarios.

Figure 2-8. Estimated volume lost per year due to sea level rise.



2.3.12.3 INCORPORATION OF ER 1100-2-8162 AND ETL 1100-2-1: GUIDANCE FOR SEA LEVEL CHANGE

The Sea-Level Change (SLC) Engineering Technical Letter (ETL) 1100-2-1 supporting ER 1100-2-8162, suggests a tiered analysis to determine the risk of potential SLC and resulting incorporation into the plan formulation process. Incorporation of potential SLC into the USACE Planning process will require active focus on risk-based scoping to define pertinent needs, opportunities, and the appropriate level of detail for conducting investigations. In particular, close attention is needed at the beginning of each study in order to screen planning/scoping decisions. The tiered analysis for SLC is incorporated into the 6-step planning process used in this report. Mean Sea Level (MSL) is used as an elevation reference in this section of the report as it is generally more intuitive for readers when describing changes to existing water elevations.

In order to evaluate SLC impacts to infrastructure, critical resources, and the population residing in the study area, a qualitative matrix was developed in **Table 2-5,** which evaluates the resources on which the study area depends. Resources evaluated in the matrix were based on those identified by the USACE Coastal Systems Portfolio Initiative (CSPI). CSPI describes the resource risk in a project area relative to the density of the resource, the population density that the resource serves, or in the case of environment/habitat and recreation, the value placed on the resource. See http://navigation.usace.army.mil/CSPI for more information. The evaluation criteria shown in the table

is from, *Technical Review of Coastal Projects: Storm Risk Management, Navigation and Ecosystem Restoration for Nation's Coastlines* (USACE, Spring 2012.)

In addition to the CSPI evaluation criteria, **Table 2-5** evaluates the vulnerability to resources from potential SLC, or Sea Level Rise (SLR) in the case of the study area. Averaging the "Vulnerability from SLR" to resources gives an average of 1.7, equating to a low to medium overall resource vulnerability within the 50 year period of analysis.

Table 2-5. Qualitative Matrix describing vulnerability of resources from potential accelerations in SLC (50 year period of analysis, base, intermediate, and high SLC scenarios).

Resource	Risk Rating from CSPI - Value or density of resource or dependent population (3=high, 2=med, 1=low, x=none present)	Description	Vulnerability from SLR (3=high, 2=medium, 1=low, x =none present)	Description
Residential/Commercial Structures	2	Mostly residential (condominiums). Most ground floor elevations of structures are built on the existing ground level elevation, roughly 4.5 feet NAVD88. Most ground floor elevations with the Tentatively Selected Plan (TSP) area are approximately 4.5 feet NAVD88.	2	Projected high SLC would place Mean Sea Level (MSL) near infrastructure within the 50 year year planning horizon. Typical storm tide expected in the 50 year planning horizon was reported to be +8.6 feet NAVD88 (FDOT, 2003). This indicates that the high SLR scenario combined with the potential 8.6 foot of storm tide could reach the top of the dune.
Environmental and Habitat	3	Beach/dune habitat. Fairly narrow steep beach backed by dune which averages 11.5 feet high NAVD88.	2	Beach berm and dune system is located between 5 and 11.5 feet NADV88 throughout the study area. Sub aerial habitat is located thorought this system.
Infrastructure (roads, water/sewer lines, boardwalks, navigation structures)	2	Water/sewer lines, septic tanks, and dune walkovers exist. State Road A1A is located at an average of 5 feet NAVD88 throughout the study area and TSP area. Most other infrastructure would not be impacted until water level, including storm surge, reached above this point.	1	See explanantion for State Road A1A in Eveacuation routes. Other infrastructure is located at or above this elevation is also adequately elevated. Wooden boardwalks have portions lower than this elevation and are more subject to damage. However, they are not high value or critical infrastructure.
Critical Facilities (police, fire, schools, hospitals, and nursing homes)	3	FPL Power Plant is located in northern portion of study area; however, it is not within the TSP area.	2	The most critical facility (FPL) is elevated 20 feet and would remain above MSL under any SLC scenario. Additionally, the power plant is not in the TSP area.
Evacuation routes	3	State Road A1A is the main north/south evacuation route, located approximately 5 feet NAVD88 within the TSP area.	2	State road A1A is set back from the shoreline by a mininum of approx. 350 feet. In the TSP area, in some locations it is roughly midway between the ocean side and marsh side; in other areas, it is buffered by both the offset to the shoreline and marsh. It could be potentially affected under the high SLC scenario past the 50 year horizon, or as a result of the high storm tide plus high SLC on the ocean side towards the end of the 50 year planning horizon.
Recreation	3	Reasonable recreational use of beaches.	1	Beach berm is between 5 and 11.5 feet NAD88 throughout the study area. Recreational use of beach is high around public access points.
		Average =	1.7	Low to Medium Vulnerability

PROJECT VULNERABILITY TO SLC

Upland elevations within the study area (Atlantic Ocean side of the island) average approximately 4.5 ft-NAVD88. These uplands are fronted by a dune system with an average elevation of 11 ft-NAVD88 over a majority of the project area (R-98 to R-111). South of R-111 (R-112 to the county line), however, the average dune elevation rises to 13 ft-NAVD88. Elevations on the marsh side of the island also average approximately 4.5 ft-NAVD88. Although the marsh side of the island is not within the current study area, stakeholders should be aware of increased risk to infrastructure as sea level rises. Based on lidar topographic survey data, contoured over the barrier island between R-77 and R-115, key cross-island ground elevations were identified. **Table 2-6** provides the key ground elevations according to R-

monument and grouped by similar shoreline dimensions (see the **Engineering Appendix** for details on profile groupings).

Table 2-6. Key Elevations Along Cross-Island Profiles.

R-Monument	Ground Elevations (feet-NAVD88)			
	Average Dune Elevation	State Road A1A	Atlantic Side Structures	Marsh Side Structures
77-80, 84-102	11	4.5	4.5	4.5
81-83	13	4.5	5	4.5
103-104	11	5	5	5
105-106	11	5	3	5
107-110	11	5	3	5
111	11	5	6	4.5
112	14	5	5	5
113-115	13	5	5	5
Average for Study Area (R-98 to R-115)	11.5	5.0	4.5	4.5

A representative island profile, taken in the vicinity of R-107, is show in **Figure 2-9**. Note that the topographic survey from which the profile was drawn was not "bare earth". Therefore elevations include vegetation and structures. The profile was positioned to avoid structures, but vegetation is evident, particularly on the marsh side. The ground elevations in **Table 2-6**, determined from full contour plots, are the most representative of the project area.

The width of the barrier island varies over the length of the project. Typically the marsh side of the island is fronted by an expanse of heavy vegetation. In some regions, however, development extends from seaside to marsh side.

A key question when assessing the vulnerability of the study area to SLC is when critical elevation based thresholds related to flooding or other project objectives will be reached and exceeded. Throughout the study area, the dune crest height represents a critical elevation threshold. The average dune height from **Table 2-6** is 11.5 ft-NAVD88. SR A1A and other infrastructure are located at a lower elevation, approximately 4.5- to 5.0 ft-NAVD88. Since the dune lies between the ocean and infrastructure, the dune height will be the ocean side critical elevation.

Figure 2-9. Cross-island Profile in the Vicinity of R-107.

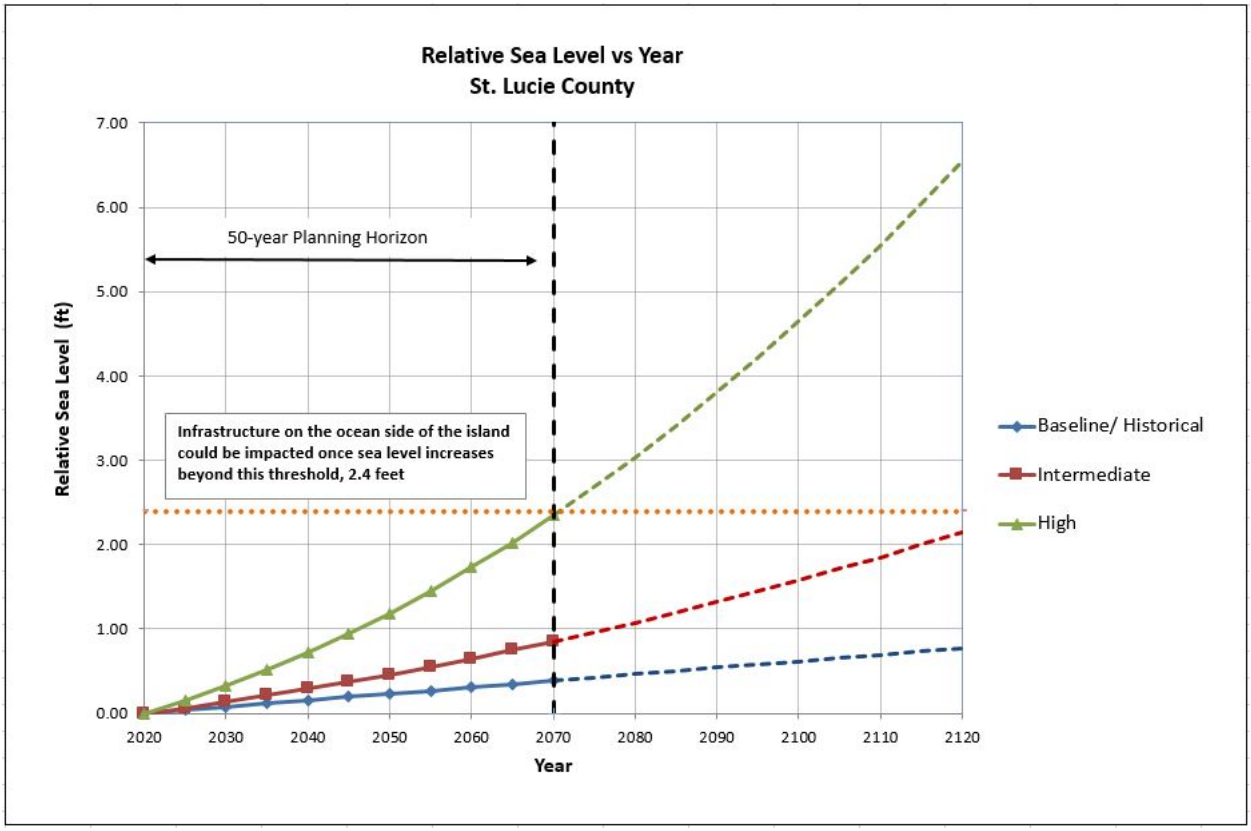
The 50-year storm tide elevation for the study area has been determined to be +8.6 ft-NAVD88 (FDOT, 2003). Water elevations during such storm events will reach the top of the dunes once sea level increases by 2.4 feet (8.6 feet of storm tide + 2.4 feet of SLC = 11 feet) (between R-98 to R-111). Because overtopping of the dune north of R-111 would cause flooding over the full extent of the project, the higher dune crests (R-112 to county line) are not considered to have any preventative significance against inundation due to SLC (although they still contribute to reducing damages due to wave attack and erosion).

The average dune crest critical elevation has been defined in terms of a relative sea level rise target of 2.4 feet for comparison to multiple scenarios.

Figure 2-10 shows the elevation-time trajectories developed for the three SLC scenarios as net change in sea level, versus the project performance target of 2.4 feet. The plot shows that the 2.4-foot sea level change threshold is only exceeded with the High SLC scenario in year 50. Adaptive measures designed to

maintain performance above 2.4 feet of sea level rise may be triggered should relative sea level increase approaches 2.4 feet.

Figure 2-10. Threshold Vulnerability on the Ocean Side of the Island.



Reference: Florida Department of Transportation (FDOT), 2003. "Design Storm Surge Hydrographs for the Florida Coast", University of Florida, Gainesville, Florida.

PROJECT ADAPTABILITY

General

Sea level change is a growing concern in coastal regions of the United States. It is therefore necessary to ensure that coastal projects are adaptable to changing conditions. Constructing or elevating shoreline structures (seawalls, revetments, groins, etc.), raising dunes, floodproofing infrastructure, and implementing storm warning and evacuation plans are some types of coastal adaptation methods.

Assessing adaptation requirements of the project most often requires considering SLC impacts to the project beyond the 50 year period of analysis (as shown previously in **Table 2-8**). **Table 2-7** provides an alternative qualitative view of project vulnerability by updating **Table 2-5** for an extended 100 year Horizon.

Table 2-7. Qualitative Matrix describing vulnerability of resources from potential accelerations in SLC (100 year period of analysis, base, intermediate, and high SLC scenarios).

Resource	Risk Rating from CSPI-Value or density of resource or dependent population (3=high, 2=med, 1=low, x=none present)	Description	Vulnerability from SLR (3=high, 2=medium, 1=low, x=none present)	Description
Residential/Commercial Structures	2	Mostly residential (condominiums). Most ground floor elevations of structures are built on the existing ground level elevation, roughly 4.5 feet NAVD88. Most ground floor elevations with the TSP area are approximately 4.5 feet NAVD88.	2	No change from 50 year Planning Horizon: Although High SLC is projected to reach the top of the dune near the end of the 50 year planning horizon and exceeds the elevation of the average dune from the first 50 year period to the end of 100 year horizon, the dune can be raised with the addition of material or with the introduction of elevated "hard" structures such as revetments or seawalls. Due to the adaptability of the dune (raised or armored), the vulnerability from SLC remains unchanged over the full 100 years. The liklihood that the structures themselves will require direct adaptation is low.
Environmental and Habitat	3	Beach/dune habitat. Fairly narrow steep beach backed by dune which averages 11.5 feet NAVD88 high.	3	Increased vulnerability: The existing dune system will become submerged near the 50 year mark of the 100 year horizon for the high SLC scenario. While the berm will elevate naturally in response to rising seas and the dune may be raised with the placement of additional of material, it may become cost prohibitive to maintain a "natural" shoreline favorable as habitat under increasing adverse conditions (rising water levels, increased wave energy, more frequent storms). The increasingly adverse conditions along with the introduction of "hard" structures such as revetments and seawalls in response to SLC will have a dramatic impact to shoreline habitat.
Infrastructure (roads, water/sewer lines, boardwalks, navigation structures)	2	Water/sewer lines, septic tanks, and dune walkovers exist. State Road A1A is located at a average of 5 feet NAVD88 throughout the study area and TSP area. Most other infrastructure would not be impacted until water level, including storm surge reached above this point.	3	Increased vulnerability: Currently water/sewer lines are susceptible to storm surge on a short term basis (the duration of the surge). Outflows and sub-surface water levels are not protected by the elevation of the dune (i.e. raising the dune will offer little mitigation from impacts of SLC). Short term flooding due to storm surge will increase throughout the 100 year horizon. Additionally as projected SLC elevations exceed these infrastructure independent of storm activity, flooding will become chronic without significant structural changes. A1A and other infrastructure are less susceptible as SLC impacts can be mitigated by raising the dune rather than by adapting the structures directly.
Critical Facilities (police, fire, schools, hospitals, and nursing homes)	3	FPL Power Plant is located in northern portion of study area; however, it is not within the TSP area.	2	No change from 50 year Planning Horizon (due primarily to existing elevation)
Evacuation Routes	3	State Road A1A is the main north/south evacuation route, located approximately 5 feet NAVD88 within the TSP area.	2	No change from 50 year Planning Horizon. The vulnerability of A1A remains tied to the elevation of the dune. It is assumed that the dune will be raised or a seawall with adequate elevation will be placed in order to protect critical infrastructure. The likelihood that A1A itself will require adaptation does not change between the 50 year mark and the end of the 100 year Planning Horizon.
Recreation	3	Reasonable recreational use of beaches.	2	Increased vulnerability: Similar to Environment and Habitat, natural elevating of the berm in response to rising seas and raising of the dune may become prohibitively costly under increasing adverse conditions (rising water levels, increased wave energy, more frequent storms). In the event that "hard" structures such as seawalls and revetments are introduced, natural erosion exacerbated by wave reflection will remove a significant portion of what would be recreational beach. Recreational use of the beach would be reduced.

Dune Raising

For the St Lucie CSRM project, the most efficient and (currently) environmentally acceptable means of adapting the project is to raise the crest elevation of the existing dune. The active portion of the shoreline profile, the berm and foreshore, will adjust naturally with rising tide levels. The dune, however, will require additional material to raise its elevation.

Based on the high sea level change curve, a 50-year storm surge will begin to exceed the St Lucie lowest project dune crest elevation near the year 2070 (the end of the 50-year period of analysis). By the end of the 100-year period of analysis, the high sea level curve predicts that existing dune crest will be overtopped by approximately 4.1 feet. Within the 100-year period of analysis, a 100-year storm surge might be considered. The 100-year surge, +9.6 ft-NAVD88 would exceed the existing dune crest by 5.1 feet by the end of 100-year period of analysis.

While the existing dune elevation is adequate to prevent overtopping from a 50-year storm surge through the 50-year period of analysis, to adapt the project to resist overtopping from the same surge through the 100-year period of analysis, it would be necessary to raise the crest to a minimum elevation of 15.1 ft-NAVD88. To resist overtopping from the 100-year surge, the crest would need to be raised to a minimum of 16.1 ft-NAVD88. Due to construction tolerances these elevations would be rounded up to the nearest half of a foot or 15.5 ft-NAVD88 and 16.5 ft-NAVD88, respectively.

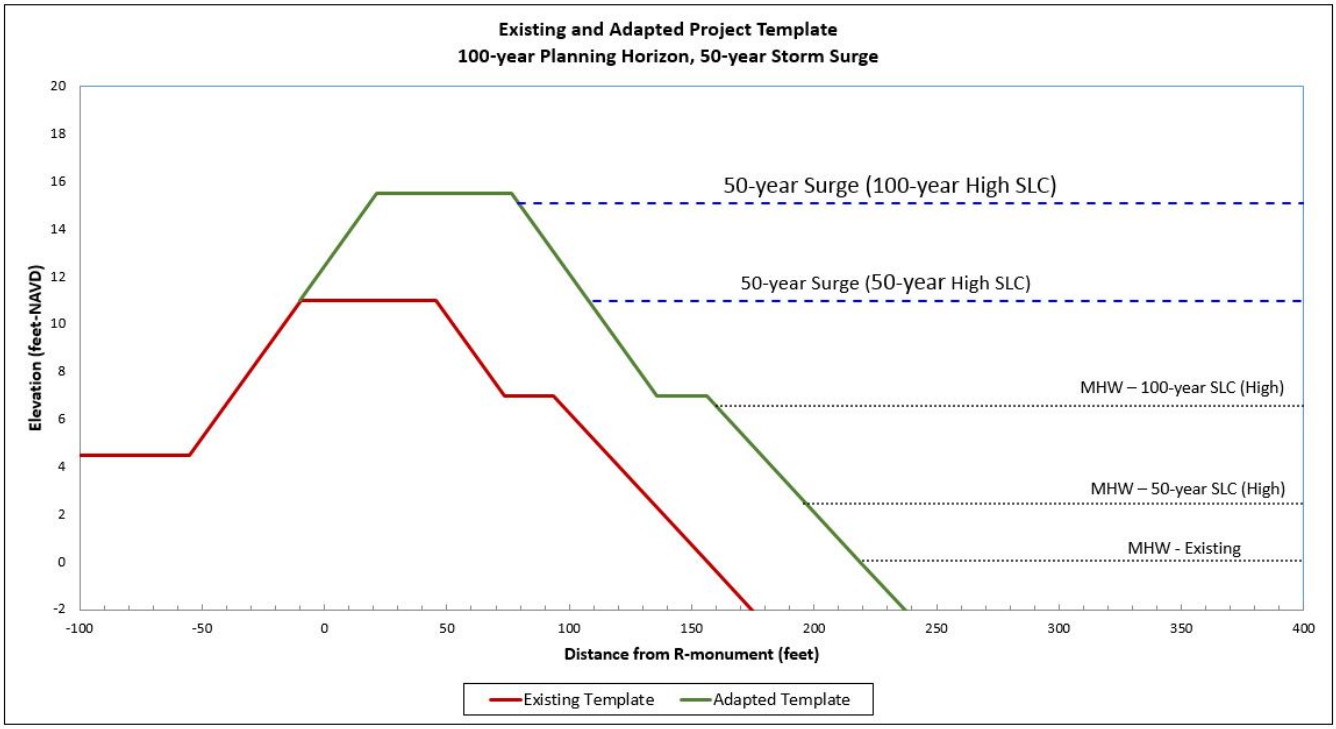
Although dune raising is outside of the current project authority, with an approved decision document this adaption is physically feasible within the planning period and may be assessed in the future if sea level rise approaches the critical elevation threshold of 2.4 feet. Dune raising extends the dune's footprint seaward, rather than landward, ensuring that there is sufficient land/real estate to make the adaptation without interfering with upland infrastructure (**Figure 2-11**). Based on design profiles, it is estimated that raising the dune to 15.5 feet would require approximately 700,000 cubic yards of material. Raising the dune to 16.5 feet would require approximately 1,000,000 cubic yards. While dunes of this elevation occur throughout the coastal regions of eastern Florida, dune elevations directly adjacent to the project have elevations nearer to the existing dunes. Therefore, while raising the dune over the length of the project would provide increased protection from wave and erosion damage, infrastructure behind the dunes would still be vulnerable to indirect flooding from adjacent areas.

Hard Structures

Presently hard structures such as seawalls and revetments are prohibited in St Lucie County. This is due to the fact that such structures can lead to increased erosion of the berm and foreshore due to wave reflection and have an adverse impact to sea turtle and shore bird habitat. However, if sea level change follows the high sea level curve, environmental and aesthetic concerns may become secondary to the protection of upland infrastructure and the increased risk to human life.

If hard structures are permitted in the future, it is feasible that previously screened out alternatives would become viable and possibly cost effective.

Figure 2-11. Existing and Adapted Project Profile.



Floodproofing

Dune raising and/or the introduction of revetments or seawalls are adaptations that deal directly with the shoreline feature (dune system) that provides the maximum level of protection from inundation, erosion, and wave damage. Much like an inland levee, the dune system provides a single continuous barrier between the water and the land.

Flood proofing also consists of a type of barrier. However, floodproofing solutions apply localized barriers (new construction, sealing/waterproofing existing structural elements, and/or raising lower elevation structures) to individual structures. Depending on the density of infrastructure in the upland, floodproofing can be logistically challenging and expensive. Different structure types would require different floodproofing solutions. Because it is assumed that sea levels would be allowed to overtop the dune and flood the general project site, each solution would also require a design that resists failure due to erosive undermining and from direct wave attack. Projects where the density of upland structures is low would have less logistical and cost concerns, but would still require individual specialized design.

In addition to logistics and cost, peripheral damages must also be considered. If the general project site is allowed to be inundated by seas overtopping the dune some “structures” would likely remain highly vulnerable despite floodproofing. These include roads, walkways, boardwalks, utility posts/boxes/outlets, and other structural features that would be difficult or not cost effective to floodproof individually. Peripheral damages would also include landscaping, park lands, open habitat, and other non-structural, but important community upland features.

It should also be noted that floodproofing predominantly safeguards against direct physical damage to structures. This alternative does not consider potential risks to human life due to flooding in the vicinity of the protected structures. It is recommended that this alternative be combined with a storm warning and evacuation system specifically designed for expected SLC.

Storm Warning and Evacuation Plans

Development or improvement of storm warning and evacuation plans is not a standalone alternative. While the development and implementation of site specific storm warning systems and evacuation plans can be costly, there are no traditional benefits by which to offset those costs. Note that traditional benefits depend predominantly on physical damages to property. However, the development and implementation of such storm warning and evacuation plans could have a significant impact on safeguarding human life. Combined with an alternative that produces traditional benefits, this alternative could be justified for a Federal project.

Assessment of Potential Adaptation Paths

As discussed in previous sections, not all methods of adaptation are equal when applied to combating the impacts sea level change (SLC). Some are more effective than others and are more complete or acceptable. **Table 2-8** provides a qualitative assessment to the potential adaptation paths that could be applied to the St Lucie CSRM Project.

Table 2-8. Qualitative Assessment of Adaptation Paths.

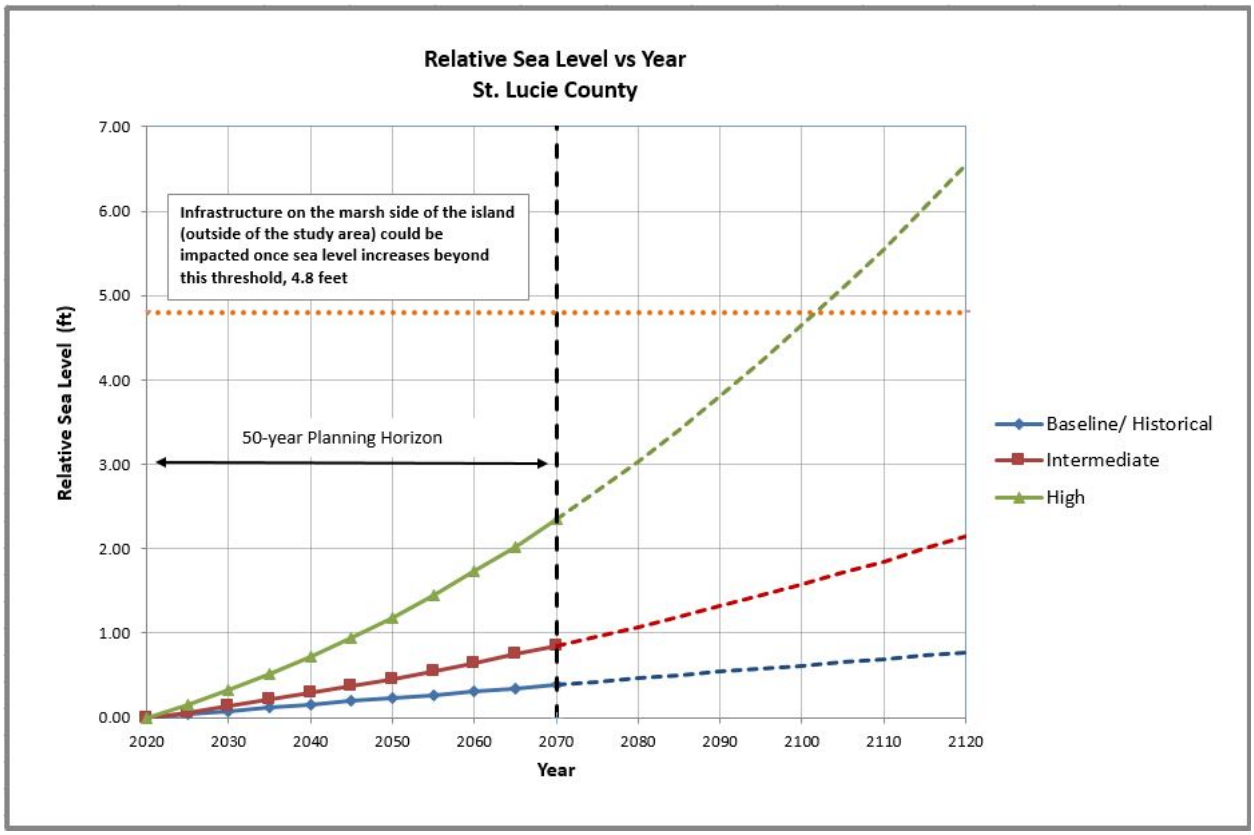
Measure	Effectiveness	Efficiency	Completeness	Acceptability
Dune Raising	High	High	High	High
Hard Structures	High	High (Medium, if the structure is non-continuous with gaps)	High (Medium, if the structure is non-continuous with gaps)	Low (may change if damages outweigh environmental concerns)
Flood Proofing	Medium (limited to certain structure types and only effective for inundation)	Medium (limited to specific structures)	Low (Vulnerable to wave attack and erosion, peripheral damages)	Low (limited benefit, peripheral damages, prohibited in high hazard flood zones)
Storm Warning and Evacuation Plans	Low (When applied only to traditional damages; rating does not include risk to human life)	Low (does not address inundation, wave attack, or erosion)	Low (does not affect traditional damages)	Low (limited benefit unless combined with another alternative)

EXTERNAL VULNERABILITY

ETL 1100-2-1 recommends that systems related to, but existing outside, the study area should also be evaluated for vulnerability to SLC. The marsh side of the island does not contain any critical infrastructure on which the study area depends, such as hospitals or emergency services. This analysis only brings attention to the vulnerability of the marsh side of the island for stakeholder knowledge.

Infrastructure on the marsh side is generally built at approximately 4.5 ft-NAVD88. Tidal range on the marsh side of the island is smaller than the ocean side. Mean Higher High Water (extreme high tide) is -0.28 ft-NAVD88 on the marsh side (+0.28 ft-NAVD88 on the ocean side). For comparison, a critical elevation threshold is defined in terms of potential sea level change over the 100 year planning period. Factoring in extreme high tide, infrastructure could be periodically impacted once sea level increases by about 4.8 feet (-0.28 feet + 4.8 feet = 4.5 feet). At the end of 50 years, sea level is not expected to rise as much as 4.5 feet for any of the SLC scenarios (**Figure 2-12)**. Projected out 100 years, only the High SLC scenario predicts levels exceeding 4.8 feet (between the years 2100 and 2105). In such a case, infrastructure on the back side of the island would be impacted during higher high tide events, dependent on current and future construction to protect against elevated water levels such as seawalls and bulkheads. The marsh side of the barrier is not within the project area. Any adaptation to mitigate SLC will be under the authority of local governments.

Figure 2-12. **Relative SLC Critical Elevation Threshold versus SLC scenarios on Marsh Side of the Island.** Reference: Florida Department of Transportation (FDOT), 2003. "Design Storm Surge Hydrographs for the Florida Coast", University of Florida, Gainesville, Florida.



2.3.13 EFFECTS OF OTHER COASTAL STORM RISK MANAGEMENT (CSRM) AND NAVIGATIONPROJECTS

EXISTING CONDITIONS

OTHER CSRM PROJECTS

To date, no Federal large-scale beach projects have been constructed along the study area (R-77 to R-115). However, several Federal beach fill placements have been made on either side of the study area.

To the north of the study area, several large-scale placements of material have been made under the authority of the Federal coastal storm risk management projects at Ft. Pierce, with the Ft. Pierce Shore Protection Project (SPP). Additionally, numerous placements of smaller volumes of material dredged from the Federal navigation project at Ft. Pierce Inlet have been made along this same reach of shoreline over the past 26 years. These two Federal projects result in the periodic placement of large volumes of material along the shoreline about 12 miles north of the study area of this report. Due to the predominant southward littoral transport of material along this region of coast, these fill placements may provide indirect nourishment of the study area.

South of the study area, the Martin County Shore Protection project extends from Stuart Public Beach Park (R-25) northward to the Martin County/St. Lucie County line (R-1), which is the southern limit of this study. Material placed along northern Martin County near the county line can be transported northward from the fill area by diffusion (end) losses, and may provide a source of nourishment along the southernmost reach of the St. Lucie County study area.

In addition to the large-scale Federal projects at Ft. Pierce and Martin County, several small-scale shore protection projects have been implemented along the study area. In 1990, a beach-scraping project was performed along the southern reach of the project. Several privately-funded shore protection measures have also been constructed in front of individual properties.

Each of the various projects as mentioned above is described in more detail in the **Engineering Appendix.**

OTHER NAVIGATION PROJECTS

Ft. Pierce Inlet is a Federal navigation project located in northern St. Lucie County in the proximity of R-33 and R-34. Following completion of the initial dredging of the Ft. Pierce navigation project by local interests in 1930, severe scouring occurred along the channel across the Indian River, leading to an increase in the volume of littoral material and a resulting pattern of accretion along most of the shoreline adjacent to the inlet. After the inlet channel stabilized (1930-1935), erosion began to occur along the shoreline south of the inlet. Research conducted in support of the Ft. Pierce SPP has determined that there is no evidence that the inlet has significantly affected sediment transport processes further south of the inlet than 14,000 feet (R-48) (USACE, 2000).

St. Lucie Inlet is a Federal navigation project located in northern Martin County (just south of St. Lucie County) in the proximity of R-44 and R-45. Initially excavated in 1892, St. Lucie Inlet separates Hutchinson Island to the north and Jupiter Island to the south. The introduction of a north jetty in the late 1920 worsened erosional patterns already present due to construction of the inlet. The north jetty trapped

south moving sand, stabilizing the northern shoreline (southern Hutchinson Island) while causing shoreline erosion on Jupiter Island. Due to the predominantly southern transport of material, inlet impacts are to the south of the inlet channel, along approximately 5.8 miles of Jupiter Island shoreline (FDEP, 1995).

FUTURE WITHOUT-PROJECT CONDITIONS (NO-ACTION ALTERNATIVE)

The future without-project conditions of other CSRM and navigation projects are similar to the existing conditions described above.

2.4 BUILT ENVIRONMENT

2.4.1 HURRICANE EVACUATION ROUTES AND ZONES

EXISTING CONDITIONS

National Scenic Highway, Florida State Road A1A (SR A1A), is the only evacuation route for the region and a major north-south thoroughfare for the area.

For the 4 reaches in study area, this highway is a major evacuation route, but is set back from the shoreline to avoid damages in most instances. The Florida Department of Transportation (FDOT) maintains this road and has not expressed interest or need for a Federal project.

FUTURE WITHOUT-PROJECT CONDITIONS (NO-ACTION ALTERNATIVE)

In the future without-project condition the FDOT would continue to operate and maintain A1A.

2.4.2 PAST LOCAL PROJECT

EXISTING CONDITIONS

The St. Lucie County Erosion District completed a one-time local nourishment in 2012/2013 due to 4 severe storms which impacted the area in 2004/2005, as well as 2012. The project from R-87.7 to R-90.3 and R-98 to the St. Lucie/Martin County line at R-115+1000 feet, consisting of a beach fill and dune

restoration, for a total of 658,654 cubic yards of material (initially 485,900 cubic yards and modified to include an additional 172,754 cubic yards due to severe storm erosion near the time of construction). The EIS found that the project would impact .57 acres of hardbottom habitat.

FUTURE WITHOUT-PROJECT CONDITIONS (NO-ACTION ALTERNATIVE)

Although the sponsor has built a one-time project in this location in the past, there is a need for the Federal government to construct a project over a 50 year period of Federal participation. Based on conversations with the non-federal sponsor, the future without-project condition is that the sponsor would not build another large fill project, as was performed in 2012/2013. The local project in 2012/2013 was constructed due to extraordinary hurricane events, as well as an opportunity in cost sharing with state funding, with the knowledge that it was a one-time project and that a project with Federal partnership was in progress. The letter sent in 2006 from USACE, Deputy Director of Civil Works, confirms the sponsor's intent. The information below supports the future without-project assumptions.

1. **Funding Constraints**: Funding for this one-time non-federal local beach and dune project included three funding sources: State funding at 43%, Erosion District Zone E reserve funding at 23% and Special Assessment District (property owners) funding at 34%. The large contribution by the state was crucial and is unlikely to occur again in the future. Additionally, St. Lucie County has other competing Federal project funding commitments (Ft. Pierce), and it is very unlikely that local contributions could occur in this capacity again.

2**. Federal commitment**: The Feasibility study began 2000, with Feasibility Cost Sharing Agreement (FCSA) signed in 2004, signaling Federal involvement. The area was hit by Francis and Jeanne in 2004, followed by Wilma in 2005, and the level of protection within the study area was severely compromised. There was an urgent need to do one-time project, with the knowledge that the Federal process would be time intensive.

3. **Coordination, Effort and Timeframe**: The planning for the local project was initiated in 2006. After numerous meetings, workshops and public hearings, the Board approved several actions on October 2, 2012, including the award of a construction contract for the project. Construction was complete in April 2013.

2.4.3 PUBLIC ACCESS AND PARKING

EXISTING CONDITIONS

Federal participation in CSRM projects involving placement of sand is limited to shorelines open to public use. Guidance is provided in Engineering Regulation (ER) 1105-2-100 and ER 1165-2-130. Cost sharing for any recommended plan is based on shoreline ownership, use, and the availability of public access.

There are currently 7 suitable parking and access points within the study area of R-77 to R-115+1000 feet to R-001, with three new access points created by St. Lucie County which use existing parking. From north to south: Walton Rocks, Ocean Bay, Herman's Bay Beach, Normandy Beach, Dollman Park (which now includes not only the previous access point in the central portion of the park but also two new access points on the northern and southern boundary), Waveland Beach (which now includes not only the

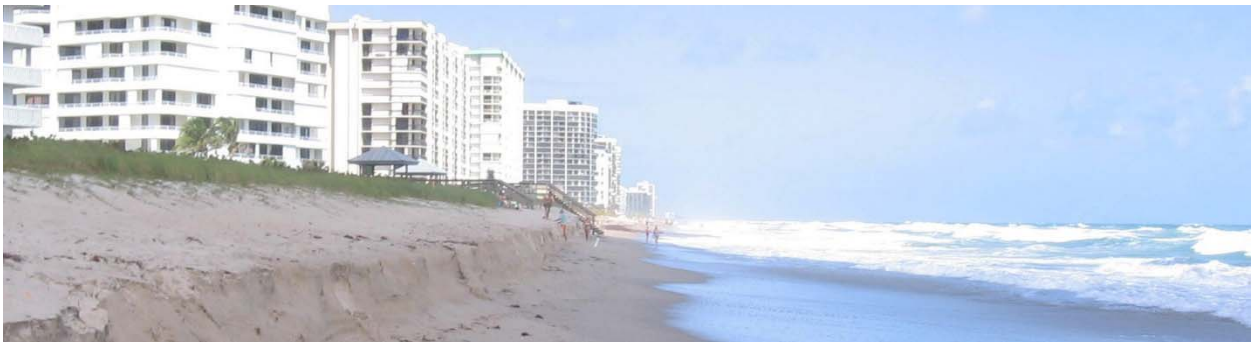
previous access point but also one on the northern boundary) and Glascock Beach, which is located on the Martin County line (approximately R-001).

USACE policy in ER-1105-2-100 states: "Lack of sufficient parking facilities for the general public (including nonresident users) located reasonably near and accessible to the project beaches may constitute a restriction on public access and use, thereby precluding eligibility for USACE participation…Generally, parking on free or reasonable terms should be available within a reasonable walking distance of the beach…Reasonable access is access approximately every one-half mile or less."

Based on existing information, there are gaps larger than ½ mile between the existing parking/access. The non-federal sponsor, St. Lucie County, is willing to create additional public access/parking as needed to qualify for maximum Federal cost-sharing. More information can be found in Chapter 4 The Recommended Plan.

FUTURE WITHOUT-PROJECT CONDITIONS (NO-ACTION ALTERNATIVE)

In the future without-project condition, in absence of a Federal project, there is sufficient access and parking (particularly in the large Dollman Park public access area) for recreational use and St. Lucie County would generally not have a need to create additional public access.



2.5 ECONOMIC ENVIRONMENT

EXISTING CONDITIONS

Information on the existing economic conditions along the St. Lucie County coastline was collected for economic modeling purposes. The information on the coastal assets detailed in this section was collected from St. Lucie County mapping resources, site visits, and contractors.

2.5.1 DAMAGE ELEMENTS – STRUCTURE AND CONTENTS VALUE

Beach-fx is an event-driven life-cycle model that estimates damages and associated costs over a period of analysis based on storm probabilities, tidal cycle, tidal phase, beach morphology and many other factors. Damages to developed shorelines include damages to buildings, pools, patios, parking lots, roads, utilities, seawalls, revetments, bulkheads, replacement of lost backfill, etc., all classified as "damage elements."

Economists, real estate specialists, and engineers have collected and compiled detailed information on damage elements within the study area[10] including:

- 1 single family residence
- 1 multi-family residence
- 52 commercial structures (including traditional commercial structures, as well condominiums and hotels)
- 35 dune walks
- Several parking lots, gazebos, garages, pools, tennis courts, and bath houses

In total, attribute information for 241 separate damage elements was populated for economic modeling using Beach-fx. The proximity of these damage elements to the beach makes them potentially vulnerable to erosion, wave attack, and inundation.

Beach-fx handles economic considerations at the damage element level. These considerations include extent of damage, cost to rebuild, and time to rebuild. Real Estate professionals from SAJ provided updated depreciated replacement costs for all of the damage elements in April 2015. An uncertainty of +/- 15% was assigned to these costs. The value of contents was assumed to be 50% of the structure value for all habitable structures per ER 1105-2-100. Non-habitable structures (dune walks, bathhouses, pools, etc...) had zero contents value.

2.5.2 STRUCTURE INVENTORY

The economic value of the existing structure inventory represents the depreciated replacement costs of damageable structures and their associated contents within the study area along the coastline. The damage element inventory includes 236 damageable structures with an overall estimated value of $669,000,000, with structure and content valuations of $579,000,000 and $91,000,000 respectively. **Table 2-14** provides the distribution of structure and content values broken down by Beach-fx Reach.

Table 2-14. Distribution of Structures and Structure Value by Reach.

Reach	Structure Value	Content Value	% Total Value	# Damage Elements	% Total Damage Elements
Reach	Structure Value	Content Value	% Total Value	# Damage Elements	% Total Damage Elements
R-099	$ 70,328,170	$ 11,335,909	12.2%	18	7.6%
R-100	$ 65,393,015	$ 8,938,156	11.1%	7	3.0%
R-101	$ 33,292,909	$ 4,583,021	5.7%	12	5.1%
R-102	$ 510,685	$ 0	0.1%	2	0.8%
R-103	$ 382,169	$ 0	0.1%	1	0.4%

[10] This references South Hutchinson Island reach only, which is the only reach where damage elements were collected, due to screening of the upper 3 reaches during plan formulation. More information can be found in Chapter 3.

R-104	$	59,638,936	$	8,233,070	10.1%	16	6.8%
R-105	$	50,671,441	$	6,935,733	8.6%	12	5.1%
R-106	$	38,827,604	$	5,262,028	6.6%	10	4.2%
R-107	$	23,131,259	$	3,342,885	4.0%	14	5.9%
R-108	$	67,674,190	$	9,683,231	11.6%	16	6.8%
R-109	$	36,383,413	$	5,941,502	6.3%	18	7.6%
R-110	$	23,862,725	$	3,165,472	4.0%	11	4.7%
R-111	$	26,672,082	$	4,018,670	4.6%	20	8.5%
R-112	$	31,434,922	$	4,406,246	5.4%	12	5.1%
R-113	$	26,669,670	$	6,969,432	5.0%	19	8.1%
R-114	$	1,393,215	$	217,112	0.2%	17	7.2%
R-115	$	22,365,140	$	7,626,235	4.5%	31	13.1%
Total	**$**	**578,631,545**	**$**	**90,658,701**	**100%**	**236**	**100%**

2.5.3 BEACH-FX MODEL SET-UP

FUTURE WITHOUT-PROJECT CONDITIONS

The **Economic Appendix** provides a complete description of the Beach-fx model set-up and use. Data on historic storms, beach survey profiles, and private, commercial and public structures within the project area is used as input to the Beach-fx model. The model is then used to estimate future damages resulting from hurricanes and coastal storms.

The future without-project damages are used as the base condition against which potential alternatives will be compared. The difference between with and without-project damages are used to determine project benefits.

2.5.4 BEACH-FX MODEL ASSUMPTIONS

- **Start Year:** The year in which the simulation begins is 2019
- **Base Year:** The year in which the benefits of a constructed Federal project would be expected to begin accruing is 2020.
- **Period of Analysis:** 50 years (2020 to 2069[11])
- **Discount Rate:** 2.875% FY2017 Federal Water Resources Discount Rate

Damage Functions: For the vast majority of structures within this study the damage functions used were those developed by the Institute for Water Resources (IWR), within the Coastal Storm Damage Workshop

[11] Technically the modeling year started at 2020 as year 1, and therefore 2069 is 50 years is the end of the period of the analysis. However, for planning purposes of this report, 2070 will be the end of Federal participation.

(CSDW), Coastal Storm Damage Relationships Based on Expert Opinion Elicitation in 2002. However, early review of the model results demonstrated a potential overstatement of damages to high-rise structures from wave attack. Additional research was conducted for these structures to determine the relationship between the structure value, maximum number of floors, and expected damages from wave attack. The research focused on results from FEMA's Mitigation Assessment Team Report (MAT) from Hurricane Sandy and Hurricane Katrina with specific respect to the structural performance of high-rise buildings. After additional model runs were completed, damages to high-rise structures were reviewed and calibrated against the findings from FEMA's MAT and were found to be in line with actual damages experienced. This information is described in more detail in the **Economic Appendix**.

Coastal Armor: There is no existing coastal armor in the project area. In St. Lucie County the use of armoring is generally prohibited under local county ordinances, and was therefore omitted from the model.

Number of Times Rebuilding Allowed: The rebuilding parameter within Beach-fx allows the economic modelers to restrict the amount of monetary investment allocated to structural repair for any specific building type in order to most accurately reflect real-world behavior. Rebuilding does not refer to a total rebuild event (i.e. 100% of structure value), but rather a repair event (i.e. some non-zero percent of value intended to restore the structure). Allowing for an unlimited amount of rebuilding in the period of analysis may be unrealistic for a CSRM study and can potentially overstate damages in the FWOP. However, issuing emergency permits for rebuilding on lots meeting a minimal setback restriction is generally the rule, not the exception in Florida. Common practice and historical evidence also show that rebuilding lost structures, provided setback restrictions are met, occurs frequently[12]. Additionally, county records dating back to 1994 demonstrate that there have been no known rejections to rebuilding requests. As a result, the number of rebuilds within the model has been limited to reflect this behavior as follows:

- Public Access Structures[13]: 124X
- Commercial Recreation Facilities[14]: 62X
- Remaining: 31X

Additionally, after long-term erosion has claimed more distance on the oceanfront lot than the building requires the model ceases to reinstate the same property. The model also considers a lot "condemned" once 50%[15] of the total value of that lot is damaged. There is also a control feature that allows an individual damage element to become condemned once 50% of the original structure value has been damaged at which point the damage element undergoes a "time to rebuild" period where no additional damages can accrue. These assumptions will prevent overestimation of the without-project damages. A sensitivity analysis was conducted and the result demonstrates that a change in the number of rebuilds has a negligible effect on the proportion of high-value to low-value rebuilds.

[12] Reference Florida Office of General Counsel order 12-1453 and 12-1264 as examples.
[13] Examples of public access structures include dunewalks, shelters, guard shacks and roads
[14] Examples of commercial recreation facilities include pools, parking areas, and tennis courts
[15] This amount, the lot condemnation ratio, can be manipulated within the model as needed but is set to 50% for this study.

2.5.5 BEACH-FX FUTURE WITHOUT-PROJECT DAMAGE RESULTS

- Structure Damage: Economic losses resulting from the structures situated along the coastline being exposed to wave attack, inundation, and erosion damages. Structure damages account for approximately 71% of the damages for the future without-project (FWOP) damages.

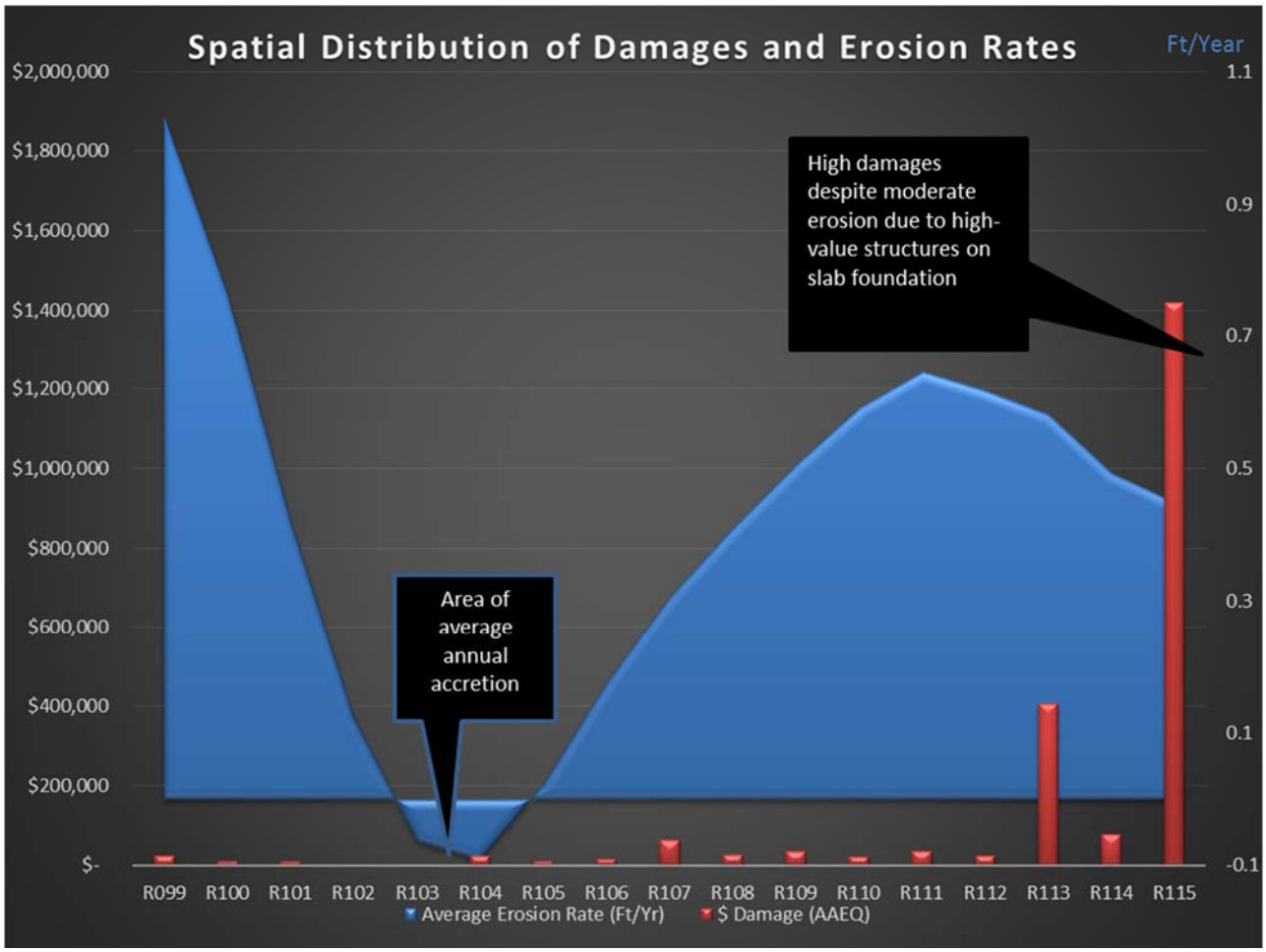
- Contents Damage: The material items housed within the aforementioned structures (usually air-conditioned and enclosed) that are potentially subject to damage. Content damages are approximately 29% of the total damages.

- Damage Distribution by Structure Category and Type: The coastal inventory was categorized as 'Commercial', 'Public Access & Recreation', and 'Residential'.
    - Commercial: The St. Lucie shoreline is dotted with various commercial real estate subject to damage. The structures are primarily condominium complexes or large hotels and represent 88% of all the damages in the FWOP. Again, some of these condominiums may be used primarily as permanent residences and thus deemed residential in real estate appendices. However, for purposes of economic damage aggregation the delineation between condominiums was not made and they are deemed commercial.
    - Residential: The only type of residential structure in the project area is the three-story single-family residence. The damage incurred to these structures is minimal (<1%) and makes up less than one-percent of overall damages.
    - Public Access and Recreation Structures: A public access structure refers to those that provide the general public with safe access to beaches and shorelines throughout St. Lucie County which include, but are not limited to, roads, dune walks, public shower and bathroom facilities, and life-guard stations. This category represents 12% of the damages in the FWOP. A recreation structure refers to items such as pools, patios and tennis courts.

2.5.5.1 SPATIAL DISTRIBUTION OF WITHOUT-PROJECT DAMAGES

Reaches R-113 to R-115 account for around 83% of the damages, while the remainder of the damages are relatively evenly distributed; R-098, R-100 to R-103 are the only reaches that account for less than one-percent of damages. R-115 accounts for 65% of the total damage due in large part to several groups of valuable condominium complexes situated very near the dune that are on slab foundations instead of deep-pile. Structures on slab foundation are far more susceptible to damages from erosion than those with a deep-pile foundation**.** **Figure 2-13** illustrates the spatial distribution of erosion rate, existing structure value, and FWOP damages and costs by reach.

Figure 2-13. Spatial Distribution of Damages and Erosion Rates by Reach.



2.5.5.2 DAMAGE DISTRIBUTION BY DAMAGE DRIVING PARAMETER

Most of the FWOP damages and costs are attributable to erosion. The distribution of damages by driving parameter is as follows:

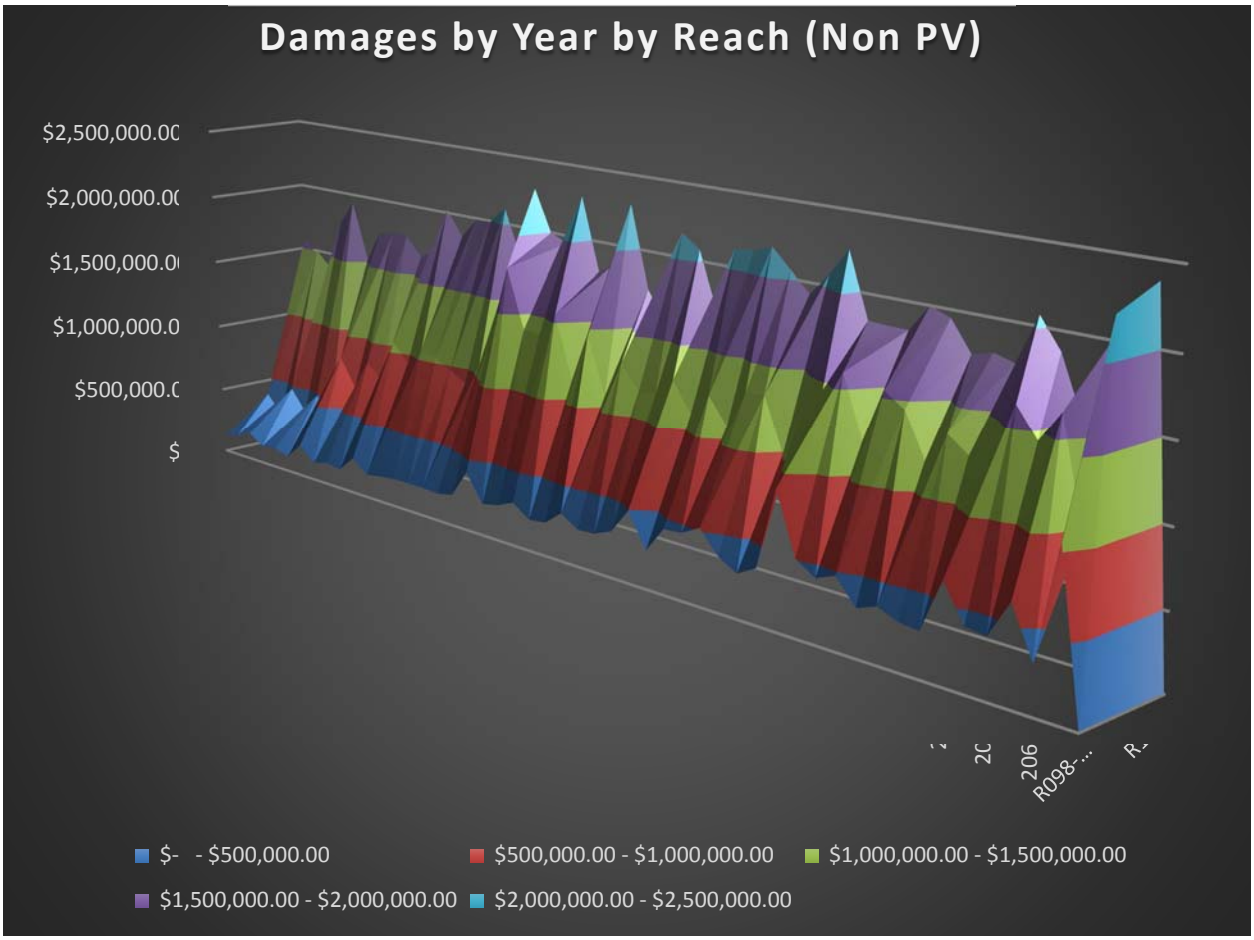
- Erosion: 97.29%
- Inundation: 2.55%
- Wave Attack: .16%

2.5.5.3 TEMPORAL DISTRIBUTION OF DAMAGES

Damages begin to rise steadily from the base year until 2042, beyond which they remain relatively constant on a yearly basis. The pattern is somewhat intuitive as one would expect the cumulative impact of erosion to take a toll on nearshore structures.

Figure 2-14 illustrates the damages over time by condensed reaches[16] in non-present value. In years 2036-2046 there are a series of small spikes in damages and that pattern continues throughout the remaining years culminating in a final peak in 2069. The pattern of damage spikes brings to light the frequent vulnerability of the St. Lucie shoreline to the powerful effects of storms and hurricanes.

Figure 2-14. Damages Over Time by Combined Reaches (Non-PV$).



2.5.5.4 EVACUATION ROUTE FLOODING

Florida State Road (SR) A1A is South Hutchinson Island's hurricane evacuation route and provides vital access to critical infrastructure and services. In order to gauge the potential impact of flooding on SR A1A Beach-fx was adjusted to model two different scenarios with the statistics from the National Weather Service (NWS) used as a framework. In the first scenario, 38% of iterations experienced one foot or more of flooding at some point in the 50-year period of analysis. In the second scenario, 31% of iterations experienced two or more feet of flooding.

[16] For graphical display purposes the reaches were grouped as R-099 to R-107, R-108 to R-114, and R-115. R-102 and R-103 were not displayed as damages remain at zero throughout the period of analysis.

This potential flooding could present a hazard to all residents of Hutchinson Island both within and outside of the project area boundaries. Additionally, if the southern portions of SR A1A are impassable, the result is that traffic might be rerouted approximately 16 miles during evacuations.

2.5.5.5 FWOP DAMAGES IN ALTERNATIVE SEA LEVEL RISE (SLR) SCENARIOS

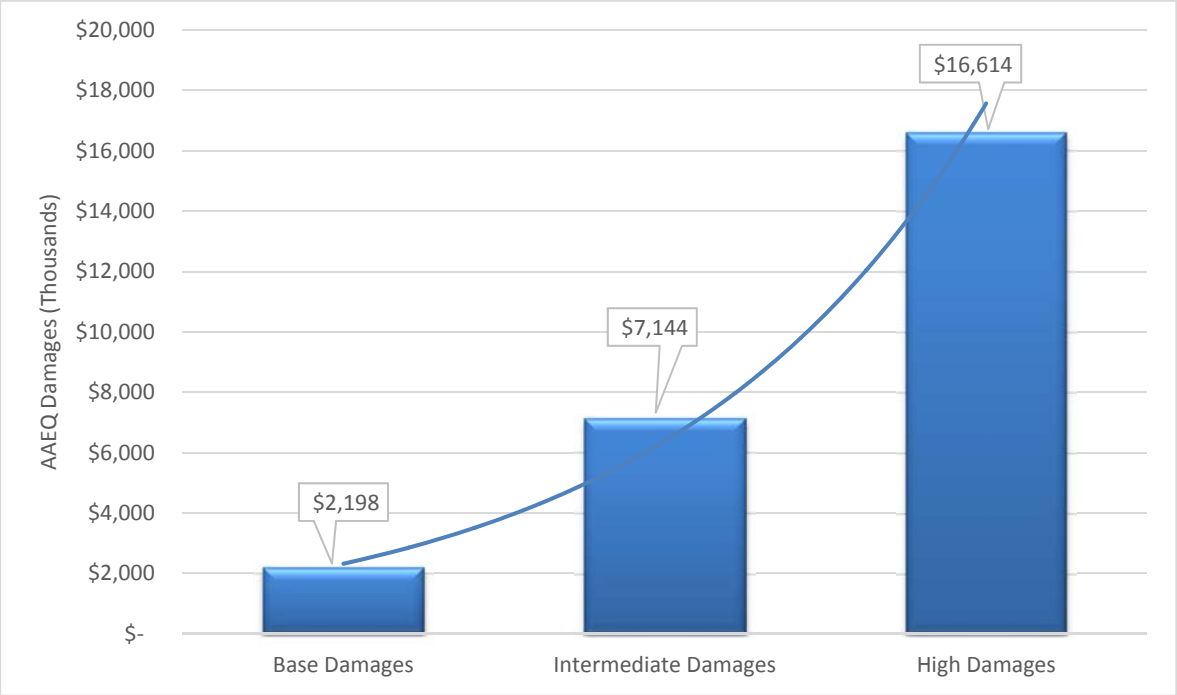
The FWOP condition was modeled for three Sea Level Rise (SLR) scenarios. ER 1110-2-8162 provides both a methodology and a procedure for determining a range of sea level rise estimates based on the local historic sea level rise rate, the construction (base) year of the project, and the design life over the 50-year period of Federal participation. The Beach-fx results presented above refer to the baseline scenario, which is based on the historic erosion rate. The results associated with the other two SLR scenarios are presented here.

Figure 2-15 provides an overall summary of FWOP average present value damage in each SLR scenario. The SLR results are intuitive in the sense that one would expect damages to be positively correlated with water levels (i.e. as water levels increase throughout the period of analysis, so do damages). What is important to note, however, is the magnitude of the effect. From the base to intermediate SLR scenario the difference in average SLR was .0086 ft./year, yet resulted in an increase of roughly 225%, or roughly $5 million AAEQ, worth of damages. From intermediate to high SLR, there was a .0276 ft./year average rise with a corresponding increase of 133%, or $9.5 million AAEQ, in damages. From base to high SLR, damages increase over 655%.

There is also an interesting shift in what drives the damages in each scenario. It is very common for erosion to be the main cause of damages in Florida CSRM studies. However, as sea levels rise, inundation begins to take on more of the share of damages. In the high SLR scenario, damages caused by erosion fall from 95% to 51% with inundation accounting for most of the difference.

Additional detail on results from the SLR analysis is provided in the **Economics Appendix.**

Figure 2-15. Total Damages by SLR Scenario.



2.5.5.6 FUTURE WITHOUT-PROJECT CONDITION CONCLUSION

The following points summarize the future without-project (FWOP) conditions:

- Damages are largely driven by storm induced erosion events instead of gradual long-term erosion.
- The overwhelming majority of the damage is structural in nature. Commercial structures account for well over half of all damages.
- Proximity to the shoreline, vulnerability of structure type (i.e. slab foundation) and exposure to recurring damages are the most important factors for determining structure damage.
- Damages in the FWOP increase dramatically in the SLR scenarios.

3 Plan Formulation

3 PLAN FORMULATION

3.1 PLAN FORMULATION RATIONALE

Please refer to informational foldouts REF-2 and REF-3 for Chapter 3.

The Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies, established by the U.S. Water Resources Council on March 10, 1983, have been developed to guide the formulation and evaluation studies of the major Federal water resources development agencies. These principles and guidelines are commonly referred to as the "P&G," and will be cited throughout the plan formulation sections of this report.

Plan formulation is the process of developing alternative plans to address a given problem. The first step in plan formulation involves identifying all potential management measures for the given problems. A management measure is a structural or nonstructural action that can be implemented at a specific geographic site to address one or more planning objectives.

An alternative plan includes one or more management measures to address the problem. Alternative plans can differ by types of measures, or how measures are combined or defined, including dimensions, quantities, materials, locations or implementation time frames.

Four accounts (P&G 1983) facilitate the evaluation of management measures and display the effects of alternative plans.

- National Economic Development (NED) account: Includes consideration of a measure's potential to meet the planning objective to reduce storm damages, as well as decrease costs of emergency services, lower flood insurance premiums, and consider project costs. Costs and benefits used to fully evaluate the NED objective are not calculated at this stage; however, estimates can be made to gage the overall cost-effectiveness of a measure for this initial screening. Effects of sea-level change and a measure's adaptability to such change were considered under the National Economic Development (NED) account.

- Environmental Quality (EQ) account: Considers ecosystem restoration, water circulation, noise level changes, public facilities and services, aesthetic values, natural resources, air and water quality, cultural and historic preservation, and other factors covered by the National Environmental Policy Act (NEPA).

- Other Social Effects (OSE) account: Includes considerations for the preservation of life, health, and public safety; community cohesion and growth; tax and property values; and, the displacement of businesses and public facilities. For evaluation purposes, the OSE account is inclusive of the

planning objectives to maintain recreation and maintain a safe evacuation route, and the planning constraint to avoid conflict with legal requirements.

- Regional Economic Development (RED) account: Considers the potential impacts on the local economy including employment, income, and sales volume.

The P&G require the NED plan to be selected as the recommended plan, unless an exception is granted. The NED plan must also be evaluated in consideration of the P&G criteria of completeness, effectiveness, efficiency, and acceptability. Each alternative plan is formulated in consideration of these four criteria.

Preliminary plans were formulated by combining management measures. Each plan was formulated in consideration of the following four criteria described in the Principles and Guidelines (P&G):

1. **Completeness:** Extent to which the plan provides and accounts for all necessary investments or actions to ensure realization of the planning objectives
2. **Effectiveness:** Extent to which the plan contributes to achieving the planning objectives
3. **Efficiency:** Extent to which the plan is the most cost-effective means of addressing the specified problems and realizing the specified opportunities, consistent with protecting the nation's environment
4. **Acceptability:** Workability and viability of the alternative plan with respect to acceptance by Federal and non-federal entities and the public, and compatibility with existing laws, regulations, and public policies

3.2 SCOPING*

3.2.1 FEDERAL

An initial scoping period for the project was conducted from May 31 through June 30, 2006. The National Oceanic and Atmospheric Administration (NOAA) responded to the scoping letter with concerns about the proposed dredging of the offshore shoals as a sand source and that the Essential Fish Habitat (EFH) assessment and NEPA documents on this action should be prepared with sufficient detail. This assessment is included in Sections 2.3.4 and 4.1.10 of this report. The Florida Department of Environmental Protection (FDEP) coordinated a review of the scoping letter and the proposed project with the appropriate state agencies. FDEP stated that "based on the information contained in the public notice and the enclosed state agency comments, the state has determined that, at this stage, the proposed activity is consistent with the Florida Coastal Management Program." FDEP also stated that "it is likely the project would qualify for a Joint Coastal Permit, which would include water quality certification." Other stakeholders raised concerns regarding the use of St. Lucie Shoal as a borrow site, impacts to hardbottom resources, and cumulative impacts.

All correspondence associated with this NEPA scoping process is included in **Appendix H**.

3.3 PROBLEMS AND OPPORTUNITIES*

A problem is an existing undesirable condition to be changed. An opportunity is a chance to create a future condition that is desirable.

The purpose of this feasibility study is to develop an implementable and acceptable plan to change the future condition and address specific problems and opportunities in the study area. Problems and opportunities have been identified by the Project Delivery Team (PDT) in several ways, including previous USACE studies, reports completed by private contractors for St. Lucie County, as well as scoping letter comments received from local residents and stakeholders.

3.3.1 PROBLEMS

Existing problems in the study area include:

- Storm damages due to erosion, inundation, and waves threatening infrastructure
- Loss of natural habitat
- Shoreline erosion threatening recreational opportunities

Erosion, mainly storm induced, is the greatest problem in the study area as a negative impact to infrastructure. Additional problems associated with the eroding shoreline include loss of recreational resources and loss of natural habitat. Sea level rise and coastal storms will continue to exacerbate erosion in the study area.

Per the Florida coastal construction control line (CCCL) program and in conjunction with county management ordinances, St. Lucie County is prohibited from installing coastal armoring, unless the situation meets certain triggers. There is no coastal armoring in the area to date, other than the revetment at the FPL power plant described earlier in the report. To combat damages from storms, St. Lucie County has performed small truck fills after large storms, and an overall larger local nourishment in 2012/2013.

3.3.2 OPPORTUNITIES

Opportunities are positive conditions in the study area that may result from implementation of a Federal project such as:

- Reduction of storm damage to residential and commercial properties along the St. Lucie County shoreline
- Restoration of natural dune function, where possible, in the study area

- Protection of habitat for nesting sea turtles, benthic invertebrates, and shore birds
- Protection of the current hurricane evacuation route along Hutchinson Island
- Maintenance of existing recreation and tourism levels

These opportunities may be realized by implementing a single management measure or a combination of management measures which may be structural and/or non-structural. Management measures such as beach nourishment and dune creation/remediation include additional opportunities to protect natural habitat for sea turtles, shore birds, etc. While some natural functions, such as sea turtle nesting, may be disrupted during construction activities, there is an opportunity for long-term benefits in preserving the beach habitat.

3.4 CONSTRAINTS

3.4.1 PLANNING CONSTRAINTS

A constraint is a restriction that limits the extent of the planning process; it is a statement of effects that alternative plans should avoid. Constraints are designed to avoid undesirable changes between without and with-project future conditions. The planning constraint for this study area is to avoid conflict with Federal regulations, as stated in Federal law, USACE regulations, and executive orders.

3.4.2 LOCAL CONSTRAINTS

Local and state laws, such as Florida State statutes, do not constrain NED formulation. However, they may be considered in the selection of a Locally Preferred Plan (LPP).

3.5 OBJECTIVES

3.5.1 FEDERAL OBJECTIVES

The Federal objective, as stated in the P&G, is to contribute to national economic development (NED) consistent with protecting the nation's environment, pursuant to national environmental statutes, applicable executive orders, and other Federal planning requirements. Contributions to NED are increases in the net value of the national output of goods and services, expressed in monetary units. Contributions to NED are the direct net economic benefits that accrue in the study area and the rest of the nation.

The Federal objective is to maximize net benefits to the nation, and as such, it does not seek to identify specific targets within objectives. For example, targeting a pre-defined storm frequency (100-year storm) relative to the storm damage reduction objective would be inappropriate. Rather, the planning process includes formulation of alternative plans to maximize benefits relative to costs. The Federal objective to maximize net benefits would supersede any project-specific target output.

3.5.1.1 PLANNING OBJECTIVES

The overarching goal of this study is to formulate an alternative for coastal study risk management to determine if Federal participation in reduction of the damages caused by erosion and coastal storms to shorefront structures and infrastructure within the study area is warranted and economically justified. Specific study objectives have been developed to provide a means of determining whether individual management measures are capable of solving the study area's problems while taking advantage of the opportunities identified and avoiding the constraints. The following study objectives have been developed based on the St. Lucie County feasibility study area problems, opportunities, goals, and Federal and state objectives and regulations.

1. Objective 1: Reduce storm damages to property and infrastructure, including SR A1A (a major hurricane evacuation route), within the project area over a 50-year period of analysis period of analysis (2020 – 2070).
2. Objective 2: Maintain environmental quality in the project area and adjacent areas, for human and natural use, sea turtle habitat and aesthetics over a 50-year period of analysis period of analysis (2020 – 2070).
3. Objective 3: Maintain recreational use of beach and nearshore areas in the project area including beach going, surfing, fishing, and wildlife viewing over a 50-year period of analysis period of analysis (2020 – 2070).

3.5.1.2 FEDERAL ENVIRONMENTAL OBJECTIVES

USACE strives to balance the environmental and development needs of the nation in full compliance with the National Environmental Policy Act (NEPA) and other authorities provided by Congress and the Executive Branch. Public participation is encouraged early in the planning process to help define problems and environmental concerns relative to the study. Therefore, significant environmental resources and values that would likely be impacted, favorably as well as adversely, by an alternative under consideration are identified early in the planning process. All plans are formulated to avoid to the fullest extent practicable any adverse impact on significant resources. Significant adverse impacts that cannot be avoided are mitigated as required by Section 906(d) of WRDA 1986.

This report is an integrated feasibility study and environmental document. As with a separate NEPA document, it discusses and documents the environmental effects of the recommended plan and summarizes compliance with Federal statutes and regulations.

3.5.1.3 ENVIRONMENTAL OPERATING PRINCIPLES

Consistent with the NEPA, USACE has formalized its commitment to the environment by creating a set of "Environmental Operating Principles" applicable to all its decision making and programs. These principles foster unity of purpose regarding environmental issues and ensure that environmental conservation and preservation, and restoration are considered in all USACE activities. Section 6.6.27 includes a discussion of the USACE Environmental Operating Principles and how the study addresses them.

3.5.1.4 CAMPAIGN PLAN OF THE U.S. ARMY CORPS OF ENGINEERS (USACE)

USACE Campaign Plan goals and objectives are derived, in part, from the Commander's intent, the Army Campaign Plan, and the Office of Management and Budget. The four campaign plan goals and their associated objectives also build on prior strategic planning efforts. Each campaign plan goal and objective is led by a USACE senior leader who manages and oversees actions to reach the goal and objectives.

The successful achievement of the campaign plan goals and objectives are dependent on actions implemented by the entire USACE team. The implementing actions supporting each goal and objective are contained in the headquarters staff and Major Subordinate Command (MSC) implementation guidance for the Campaign Plan. The four goals of the Campaign Plan are:

Goal 1: Deliver innovative, resilient, and sustainable solutions to the Department of Defense (DoD) and the nation.

Goal 2: Deliver enduring and essential water resource solutions, utilizing effective transformation strategies.

Goal 3: Deliver support that responds to, recovers from, and mitigates disaster impacts to the nation.

Goal 4: Build resilient People, Teams, Systems and Processes to sustain a diverse culture of collaboration, innovation and participation to shape and deliver strategic solutions.

These Campaign Plan goals and associated objectives will be addressed through the course of this feasibility study.

3.5.2 STATE AND LOCAL OBJECTIVES

The State of Florida is empowered by the Federal Coastal Zone Management Act (CZMA) and its implementation of regulations per 15 CFR 930 to review Federal activities within or adjacent to its coastal zone to determine whether the activity is consistent with the requirements of the state's approved management program for its coastal zone. The Federal CZMA requires Federal activities to be consistent with a state's coastal zone program to the maximum extent practicable; it does not require compliance with a state's program. Florida's Coastal Zone Management Program was established under the Coastal Management Act of 1978 (Chapter 380.20, Florida Statutes) and approved by the Federal Coastal Zone Management Office in 1981. Florida does not regulate its coastal zone through one comprehensive law but rather through several state statutes and administrative codes. Through Florida's comprehensive planning act, local governments are also given the opportunity to determine whether these activities are consistent with their coastal goals and policies. The FDEP is the lead state agency for the implementation of the Federal CZMA.

The Beach and Shore Preservation Act (Chapter 161, Florida Statutes) is Florida's primary statute for developing and implementing the state's strategic coastal management plan, regulating coastal

construction seaward of the mean high water line, and regulating activities seaward of the coastal construction control lines. The act, administered by the FDEP, was first passed in 1965 and has since been significantly amended. The objective of the Beach and Shore Preservation Act is to preserve and protect Florida's sandy beaches and adjacent beach and dune systems. The FDEP strives to accomplish this objective with the following programs: Coastal Construction Control Lines, Joint Coastal Permit Program, Erosion Setbacks, Coastal Building Zone, Erosion Control Program, Erosion Control Line, and Inlet Management.

3.5.2.1 LOCAL COMPREHENSIVE PLANNING

The state's Local Government Comprehensive Planning Act of 1985 (Chapter 163) requires that all local governments prepare, adopt, and implement comprehensive plans that address community growth and development needs. It requires that local, regional, and state comprehensive plans be consistent with each other and requires coastal counties and cities to include a "coastal management element" in their local plans. This section of the plan must be based on an inventory of the beach/dune system and existing coastal land uses and an analysis of the effects of future land uses on coastal resources. Local governments must also address disaster mitigation and redevelopment, designation of coastal high-hazard areas, beach protection, and shoreline use.

The St. Lucie County Comprehensive Plan 2015 outlines unique features of the area, key coastal elements and related goals, objectives and policies, as well as existing and future land use.

3.6 SUMMARY OF MANAGEMENT MEASURES

Management measures are specific structural or nonstructural actions that would take place at geographical locations within the project areas. For the first iteration of evaluating measures, the entire project area was split into two geographical locations (REF-2):

1) The Power Plant, North Hutchinson Island, and Narrows of Hutchinson Island reaches were grouped together due to their proximity and similarity in physical and built features.
2) The South Hutchinson reach was evaluated separately due to its erosive nature and higher development.

3.6.1 IDENTIFICATION OF MANAGEMENT MEASURES

Management measures were selected to accomplish at least one of the planning objectives for the St. Lucie County study. Both nonstructural (NS) measures and structural (S) measures were identified. All possible measures were considered, including those beyond the authority of USACE to implement. The following is a summary of the management measures considered for St. Lucie County.

Non-Structural

NS-1: No-action: The no-action plan represents future conditions without the implementation of a project. Although this measure does not address any specific problems, it provides a comparison for all other measures. Information to describe this measure was collected during the inventory of existing conditions. The rate of shoreline change will be assumed to continue over the 50-year period of analysis. Present structures and replacement costs will be used into the future.

NS-2: Coastal Construction Control Line: A Coastal Construction Control Line (CCCL) that does not prohibit construction, but does provide stringent structural restrictions, was established in 1988 by the State of Florida for all of St. Lucie County. Evaluation of this management measure considers potential changes to the CCCL or building regulations that could be implemented by the State of Florida. Such changes could include moving the CCCL landward, increasing the setback for construction, or increasing the standards for construction to reduce storm damages. Erosion of the shoreline will be considered to continue at the present average rate, unabated by this measure.

NS-3: Moratorium on Construction: This management measure would not permit new construction in the area vulnerable to storm damages adjacent to the study area. As properties are damaged, reconstruction would not be permitted. The erosion of the shoreline would continue at the present rate, unabated by this measure. Although not a congressionally-authorized activity, this measure could be implemented by state or local governments.

NS-4: Establish a No-Growth Program: This management measure would allow for limited reconstruction of existing structures following storm damage, but would not allow for an increased number of new structures within the area vulnerable to storm damages adjacent to the study area. The erosion of the shoreline would continue at the present rate, unabated by this measure. Although not a congressionally-authorized activity, this measure could be implemented by state or local governments.

NS-5: Relocation of Structures: The relocation of structures measure will assume that shorelines in the study area will continue to erode. Vulnerable structures may be identified within the study which may be moved further landward on their parcels to escape storm damages. This would be accomplished as a Federal partnership with the non-federal sponsor, with the non-federal sponsor acting as the lead agency to oversee the process.

NS-6: Floodproofing of Structures: This management measure considers that various methods for non-structural floodproofing are available which may be implemented by homeowners and/or homeowners associations within the study area in the form of wet or dry floodproofing. Wet floodproofing involves making a series of modifications to a structure to allow an enclosed area below the base flood elevation to flood – it protects the building but not the contents of the building. Dry floodproofing makes building and site modifications to prevent water from entering during a flooding event. In the study area, the majority of affected buildings are condominiums, where dry floodproofing would be the least cost and most practical means to floodproof. Flood shields could be a potential type of dry floodproofing that could apply to condominium structures.

NS-8: Acquisition of Land and Structures:
This measure would allow the shoreline to erode in the study area with a loss of land. Structures within the area vulnerable to storm damage would be identified for acquisition. Structures on the acquired parcels would be demolished and natural areas restored. Such parcels would become public property and would reduce the number of structures vulnerable to storm damages.

Structural

S-1: Seawalls: The construction of concrete seawalls could provide a significant degree of storm damage protection. Seawalls could be constructed at some position seaward of the structures which they are designed to protect.

S-2: Revetments: This measure would involve placement of large rock, designed to withstand the wave environment, seaward of structures which are most vulnerable to storm damages which may result from shoreline erosion. The engineered structure would have a sloped profile designed to dissipate wave energy before it reaches the protected structures. The revetment could be covered by a dune or some degree of beach fill for additional protection and for aesthetic reasons. Construction would be from the beach, with intermittent access from roads. Impacts to the nearshore resources during construction would be avoided.

S-3: Sand Covered Soft Structures: This management measure includes construction of a dune composed of geotextile sand-filled forms (typically tubes or bags) and covered with sand. This forms a sand dune with a structured core. When storm erosion causes the structured geotextile core to become exposed the soft structure acts as armoring to prevent erosion from reaching further inland. Sand depth over the geotextile core would be maintained to an adequate depth to allow the dune to function as habitat and not inhibit sea turtle nesting.

S-4: Beach Nourishment: This management measure includes initial construction of a beach fill and future periodic nourishments at periodic intervals. Periodic nourishment of the beach would be undertaken periodically to maintain the recreational and storm damage reduction features within design dimensions. Dimensions of the beach fill would be based on the degree of protection desired or economically justified, storm damage protection of given widths of beach, and the environmental impact to the nearshore resources. Beach nourishment material (sand) would need to be available in adequate quantities. Geotechnical investigations would be conducted to identify potential offshore sand sources. The potential for use of upland sources, as well as the beneficial use of beach quality dredged material from other sources in the region would also be investigated.

S-5: Groins: A series of groins in the problem area would help hold a beach in front of existing development and prevent further losses of land. The construction of groins would have to be supplemented with beach nourishment so that adjacent beaches would not be starved of sand. For this reason, groins are considered a method to help hold the fill in place and to reduce periodic nourishment requirements. The beach nourishment material would come from the sources discussed in the beach nourishment structural measure, S-4. The groins would be constructed of large rocks, designed to

interlock together, with a foundation designed to avoid subsidence. The groins would be placed perpendicular to the shoreline and would extend from above the mean high water line out into shallow water. The length, orientation, and head of the structure (T-head or not) would be designed based on wave conditions, storms, and sediment transport.

S-6: Submerged Artificial Reefs: This management measure would use the perched beach concept to limit the amount of underwater fill and retain the dry beach for a longer period. This would be accomplished by placement of a submerged artificial reef in shallow water with beach fill material placed "perched" landward of the reef structure. This measure may reduce initial fill quantities, reduce periodic nourishment requirements and offer mitigation for the environmental impacts of potential nearshore hardbottom burial. The submerged artificial reef may be constructed using one of many various materials, and would sit on top of a foundation-type material to avoid subsidence. The beach fill material would come from the sources discussed in the beach nourishment structural measure, S-4.

S-7: Nearshore Berm Placement: Dredged material would be placed in the nearshore to provide wave attenuation benefits, passive nourishment of the active profile, or a combination of both. This method allows placement in water depths 15 feet and deeper, avoiding direct placement covering any potential nearshore hardbottom. This management measure assumes that a portion of the sand placed in shallow water will move towards the beach under normal wave conditions. Over time following construction, the sand bar will migrate towards the beach through natural sediment transport processes, become transported onto the beach, and shaped into the natural equilibrium profile of the beach, thus adding material and enlarging the beach. The dredged material would come from the sources discussed in the beach nourishment structural measure, S-4.

S-8: Emergent Breakwaters: The construction of breakwaters offshore along the Flagler County study area is considered as a management measure to stabilize the beach. Such structures reduce the amount of wave energy reaching the shoreline. As a result, the rate of annual erosion would decrease. The breakwaters would be constructed of large rock with foundation materials to prevent subsidence. The breakwaters would be trapezoidal in profile and would be placed parallel to the shoreline in shallow water. The breakwater would be constructed in segments, separated from each other, to prevent infilling between the beach and the breakwater. The elevation and length of each breakwater segment and the distance between segments would be designed considering the local wave and sediment transport characteristics.

S-10 - Dunes and Vegetation: The presence of dunes is essential if a beach is to remain stable and able to accommodate the natural forces applied by unpredictable storms and extreme conditions of wind, wave, and elevated sea surface. Dunes maintain a sand repository that, during storms, provides sacrificial sand reserves to the eroding beach profile before upland structures would be damaged. Following large erosional events, dunes are generally replenished by natural forces provided by the calmer weather conditions following a storm. The dune system provides a measure of public safety and property protection. Proper vegetation on dunes increases sand erosion resistance by binding the sand together via extensive root masses penetrating deep into the sand. Further, such vegetation promotes dune growth through its sand trapping action when significant wind action transports substantial quantities of sand. Additionally, healthy dune systems are visually attractive to beach visitors and contribute to the

recreational beach experience and the general appearance of the beach community. This measure would include placement of beach compatible material, from either upland or offshore sources, in a dune feature adjacent to the existing bluff. The top elevation of the dune would tie into the bluff. The front slope of the dune would be a function of the material grain size and construction equipment. Vegetation would be planted after placement of the dune material.

3.7 SCREENING OF MANAGEMENT MEASURES

Screening is the ongoing process of eliminating measures which will no longer be considered, based on planning criteria.

3.7.1 PRELIMINARY SCREENING

Criteria for the St. Lucie Coastal Storm Risk Management (CSRM) Project were derived from the specific project objectives, four P&G accounts, as well as constraints. During this process, the interdependency, as well as the exclusivity of measures, is identified. This process serves to eliminate some measures from further consideration. Costs and benefits are not calculated at this stage.

In order to provide a metric for appraisal of the various management measures, a numeric score was applied by judging a measure's ability to meet planning objectives, avoid constraints, and to contribute to each of the four P&G accounts. The management measures were evaluated and rated in **Table 3-1** as follows: 0 = does not meet criteria, 1 = partially meets criteria, and 2 = fully meets criteria. If the total rating equals a number greater than 8, the measure partially meets, at least, over half of the objectives and constraints and is carried forward for further analysis. If the total rating is equal to or less than 8, the measure is not considered further. The final total rating should not be inferred to be a ranking of measures against one another. A measure's rating is only an indication of how likely it is to meet objectives given constraints and therefore carried forward or not. Conclusions from the matrixes are discussed below.

Table 3-1. Preliminary screening matrix.

St. Lucie County - Structural Management Measures for South Hutchinson Island Reach											
	Management Measures	**Planning Objectives**			**Constraints**	**Principles and Guidelines Accounts**					
		Reduce Storm Damages	Maintain Environmental Quality	Maintain Recreation Opportunities	Avoid conflict with Federal and State Regulations	**National Economic Development (NED)**	**Environmental Quality (EQ)**	**Other Social Effects (OSE)**	**Regional Economic Development (RED)**	**Total Points**	**Carried Forward**
S-1	**Seawalls**	This measure could provide storm damage reduction to landward infrastructure during extreme storm conditions however, adjacent properties would become more vulnerable. Partially meets objective.	In the long term, sea walls can intensify erosion of the seaward profile and adjacent shorelines. This would reduce beach habitat. Does not meet objective.	This measure will likely cause decreased beach width over time. Does not meet the objective.	This measure is likely to be inconsistent with the state's Coastal Zone Management Plan when implemented at the scale being considered here. Partially meets objective.	Benefits not likely to out weigh costs of this measure as a stand alone measure. Could provide storm damage reduction if implemented in conjunction with a beach fill project. Partially meets objective. Sea Level Rise (SLR): Could be affected and could require modifications.	Likely to have negative impacts on sea turtle nesting habitat. Not aesthetically appealing. Does not meet objective.	While this measure would provide a degree of storm damage reduction, reflection of wave energy off the seawall will likely intensify erosion and cause a range of public concerns. Does not meet this objective.	Increased erosion of the existing berm due to the seawall may negatively affect local tourism.		No
		1	0	0	1	1	0	0	0	3	
S-2	**Revetments**	This measure could provide storm damage reduction to landward infrastructure during extreme storm conditions however, adjacent properties would become more vulnerable. Partially meets objective.	In the long term, revetments can intensify erosion of the seaward profile and adjacent shorelines. This would reduce beach habitat. Does not meet objective.	This measure will likely cause decreased beach width over time. Does not meet the objective.	This measure is likely to be inconsistent with the state's Coastal Zone Management Plan when implemented at the scale being considered here. Partially meets objective.	Benefits not likely to out weigh costs of this measure as a stand alone measure, but could provide storm damage reduction if implemented in conjunction with a beach fill project. Partially meets objective. Sea Level Rise (SLR): Could be affected and could require modifications.	Likely to have negative impacts on sea turtle nesting habitat. Not aesthetically appealing. Does not meet objective.	While this measure would provide a degree of storm damage reduction, reflection of wave energy off the seawall will likely intensify erosion and cause a range of public concerns. Does not meet this objective.	Increased erosion of the existing berm may negatively affect local tourism.		No
		1	0	0	1	1	0	0	0	3	
S-3	**Sand Covered Soft Structures**	This measure could provide storm damage reduction as a stand alone measure however requires a significant amount of maintenance and can become very aesthetically unappealing. Partially meets objective.	If sand cover is not maintained over the structure then environmental quality is lost. Partially meets objective	This measure may preserve, but not enhance, existing recreational opportunities. Partially meets the objective.	This measure has not been a favored alternative of the State in the past due to aesthetic and structural quality issues experienced in recent similar projects. Partially meets objective.	Benefits could possibly out weigh costs of this measure as a stand alone measure. Would provide some degree of storm damage reduction if implemented. Partially meets objective. Sea Level Rise (SLR): Could be affected and could require modifications.	Sand would need to be maintained on top of the soft structures to ensure environmental quality. Would protect dune habitat, but could be detrimental if it became uncovered and remained that way. Partially meets objective.	Could provide storm damage reduction although these are not aesthetically pleasing when not maintained. Could cause some public concerns. Partially meets this objective.	Could possibly have a minor positive impact on the regional economy. Partially meets this objective.		No
		1	1	1	1	1	1	1	1	8	
S-4	**Beach Nourishment**	This measure would reduce storm damages to infrastructure landward of the nourished area and would not create erosion problems for adjacent shorelines. Could function as a stand alone measure. Fully meets objective.	Could result in impacts to nearshore hard bottom habitat, depending on width, however may preserve beach habitat. Could require mitigation. Partially meets objective.	This measure will enhance existing recreation opportunities. Fully meets the objective.	Not likely to conflict with any State or Federal regulations. Fully meets objective.	This measure could contribute to NED if size and scale are optimized based on economics. Partially meets objective. Sea Level Rise (SLR): Could be affected and could require modifications.	Could result in impacts to nearshore resources although sea turtle nesting habitat will likely be maintained. Partially meets objective.	The recreational beach berm would be extended although nearshore recreation and resources will be affected. Does not conflict with any laws. This is the sponsor's favored alternative. Partially meets the objective.	Likely to positively impact on the regional economy. Partially meets this objective.		Yes
		2	1	2	2	1	1	1	1	11	
S-5	**Groins**	In combination with a beach fill. Groins could be used to stabilize "hot spot" erosional areas and maximize storm damage reduction. Fully meets objective.	This measure may have a minor affect on nearshore habitat but would help preserve beach habitat to a degree. Partially meets objective.	This measure may help preserve recreation and may enhance some recreational opportunities such as surfing and fishing. Partially meets the objective.	Likely to not be permitted by the state. Partially meets objective.	Could possibly contribute to NED if economically justified. Partially meets objective. Sea Level Rise (SLR): Could be affected and could require modifications.	Periodic nourishments could be reduced. Positive impacts to sea turtle nesting habitat. Possible entrapment hazard for hatchling sea turtles. Partially meets objective.	Because only select areas would benefit, groins would not likely receive support from the entire community. In select areas the recreational beach berm would be extended. Nearshore recreation such as surfing and fishing may be affected. Partially meets this objective.	Could possibly have a minor positive impact on the regional economy. Needs to be implemented with a beach fill. Partially meets this objective.		Yes
		2	1	1	1	1	1	1	1	9	

St. Lucie County - Structural Management Measures for South Hutchinson Island Reach

	Management Measures	Planning Objectives			Constraints	Principles and Guidelines Accounts					
		Reduce Storm Damages	Maintain Environmental Quality	Maintain Recreation Opportunities	Avoid conflict with Federal and State Regulations	National Economic Development (NED)	Environmental Quality (EQ)	Other Social Effects (OSE)	Regional Economic Development (RED)	Total Points	Carried Forward
S-6	Submerged Artificial Reefs	Could provide storm damage reduction if constructed in conjunction with a beach fill. Fully meets objective.	Could potentially enhance nearshore habitat although it is likely that there may already be exposed hard bottom habitat in much of the area where this measure would need to be constructed. Partially meets objective.	May help to maintain the recreational beach berm. Could have positive and/or negative effects on other nearshore recreation activities such as surfing or fishing. Partially meets the objective.	May not be permitted by the state. Partially meets objective.	Could possibly contribute to NED if economically justified. Partially meets objective. Sea Level Rise (SLR): Could be affected and could require modifications.	Could enhance nearshore fish and beach habitat. Partially meets objective.	May create a safety hazard for swimmers. The recreational beach berm would be maintained. Nearshore recreation such as surfing and fishing will be affected. This measure will be significant to the public. Partially meets this objective.	Could possibly have a minor positive impact on the regional economy. Partially meets this objective.		Yes
		2	1	1	1	1	1	1	1	9	
S-7	Nearshore Berm Placement	This measure could hypothetically reduce some degree of storm damages in the project area. Partially meets objective.	This measure would likely have a significant impact on existing nearshore resources. Does not meet objective.	May help maintain beach recreation but is likely to negatively interfere with other recreation opportunities. Partially meets the objective.	Likely to not be permitted by the state and/or Federal government due to environmental impacts. Does not meet this objective.	Could possibly contribute to NED if environmentally justified. Partially meets objective. Sea Level Rise (SLR): Could be affected and could require modifications.	Would have impacts on nearshore resources, but to a lesser extent than upper reaches. Partially meets this objective.	This measure is most likely to have all negative public perceptions because of environmental impacts and minimal storm damage protection. This is opposed by the public and does not meet the objectives.	Could possibly have a minor positive impact on the regional economy. Partially meets this objective.		No
		1	0	1	0	1	1	0	1	5	
S-8	Emergent Breakwaters	Could provide storm damage reduction if constructed in conjunction with a beach fill. Partially meets objective.	This measure could create some degree of nearshore habitat however would likely impact existing resources. Partially meets objective.	May help maintain beach recreation but is likely to negatively interfere with other recreation opportunities. Partially meets the objective.	May not be permitted by the state. Partially meets objective.	Could possibly contribute to NED if economically and environmentally justified. Partially meets objective. Sea Level Rise (SLR): Could be affected and could require modifications.	Could affect the nearshore resources, but to a lesser extent than the upper reaches. May affect turtle nesting lanes. Could create nearshore habitat. May have a negative effect on adjacent shorelines. Partially meets the objective.	May not be aesthetically pleasing. Could be a navigational hazard for boaters and may pose a safety risk for swimmers. Not favored by the public or the sponsor. Does not meet objectives.	Could possibly have a minor positive impact on the regional economy. Partially meets this objective.		No
		1	1	1	1	1	1	0	1	7	
S-9	Dunes and Vegetation	This measure could provide a significant degree of storm damage reduction as a stand alone measure. Fully meets objective.	Dune habitat would be enhanced and expanded. Not likely to have negative impacts on existing resources. Fully meets objective.	Existing recreational opportunities would not be affected. Partially meets the objective.	Not likely to conflict with any State or Federal regulations. Fully meets objective.	This measure is most likely to contribute to NED based on the low relative cost and potential for effective storm damage reduction. Fully meets objective. Sea Level Rise (SLR): Could be affected and could require modifications.	Dune habitat would be enhanced and expanded. Not likely to have any negative impacts. Aesthetically appealing. Fully meets objective.	This measure is currently supported by the community. Stable dunes maintain beach and nearshore recreation without negatively affecting environmental resources. Several local dune rehabilitation projects have been completed successfully in the past. Fully meets the objective.	This measure would maintain the existing regional economic conditions associated with storm damage protection and beach recreation. Could possibly have a minor positive impact on the regional economy. Partially meets this objective.		Yes
		2	2	1	2	2	2	2	1	14	

Carried Forward | Eliminated | 2 Fully Meets Objective | 1 Partially Meets Objective | 0 Does Not Meet Objective

St. Lucie County - Non-Structural Management Measures for South Hutchinson Island Reach

	Management Measures	Planning Objectives			Constraints	Principles and Guidelines Accounts					
		Reduce Storm Damages	Maintain Environmental Quality	Maintain Recreation Opportunities	Avoid conflict with Federal and State Regulations	National Economic Development (NED)	Environmental Quality (EQ)	Other Social Effects (OSE)	Regional Economic Development (RED)	Rank	Carried Forward
NS-1	No-Action	This measure makes no attempt to reduce storm damages to coastal infrastructure. Does not meet the objective.	The beach berm and dunes will continue to function naturally through time. There is a potential for loss of habitat for shorebirds, sea turtles, etc. Nearshore hardbottoms will remain undisturbed. Existing conditions remain Fully meets the objective.	Existing conditions would continue into the future, not affecting current recreation opportunities. Fully meets objective.	Does not conflict with any laws. Fully meets objective.	No NED benefits are realized through this measure. No damages are prevented. No project costs. Makes no attempt to keep infrastructure from being damaged. No change in economic outputs. Does not contribute to this account/objective.	The beach berm and dunes will continue to erode naturally through time, causing a potential loss of habitat for shorebirds, sea turtles, etc., this may be offset by private dune restoration measures which could benefit dune habitat and storm damage protection. Nearshore hardbottoms will remain undisturbed. Partially	Coastal residents may experience loss of property and land, small scale protection measures may be implemented by home/condo owners, no storm damage reduction is provided, property values may decrease, public facilities likely unaffected. Partial OSE result.	Does not contribute to RED.		yes*
		0	2	2	2	0	1	1	0	8	
NS-2	Coastal Construction Control Line	Relocating the CCCL or increasing construction setbacks will not meet this objective. A majority of this reach is already highly developed, with a small portion protected by CBRA. Does not meet objective.	This reach is generally already fully developed and rezoning would in general have little to no impact on environmental quality, except in a few undeveloped areas. Partially meets objective	Existing conditions would continue into the future, not affecting current recreation opportunities. Public recreation could be partially limited by decreased beach width. Partially meets objective.	Would require changes to State law. Partially meets objective.	Would only provide damage reduction benefits for potential future structures. NED benefits would be minimal. This measure could partially contribute to NED. Sea Level Rise (SLR) rates: Does not impact storm damages to existing inventory.	Enforcing setbacks will improve safety and improve the quality of the dunes. Individual private shore protection measures may affect dune habitat. Partially meets objective.	Ocean front property owners may not like this. Beach berm may continue to erode causing a gradual loss of beach recreation. Near shore recreation will not be affected. Would require changes to state law. Does not contribute positively to OSE objectives.	Does not contribute to RED.		No
		0	1	1	1	1	1	0	0	5	
NS-3	Moratorium on Construction	This would have little impact on storm damage reduction to existing infrastructure. Does not meet objective	This reach is generally already fully developed and rezoning would in general have little to no impact on environmental quality, except in a few undeveloped areas. Partially meets objective	Existing conditions would continue into the future, not affecting current recreation opportunities. Public recreation could be partially limited by decreased beach width. Partially meets objective.	Attempts to implement moratoriums on construction have resulted in lawsuits in the past. Changes to local laws would be needed. This measure does not avoid conflict with existing laws and regulations.	Would only provide damage reduction benefits for potential future structures. NED benefits would be minimal. Makes no attempt to keep existing infrastructure from being damaged, but would reduce damages in the future. Partially meets objective. Sea Level Rise (SLR) rates: Does not impact storm damages to existing inventory.	Quality of the existing coastal habitat could be preserved but there is also continued possibility of loss of habitat from continued erosion. Partially meets objective.	Property and tax revenue may decrease. May have an unfavorable public perception. Attempts to change local laws may result in lawsuits. OSE contribution is mostly negative.	Does not contribute to RED.		No
		0	1	1	0	1	1	0	0	4	
NS-4	Establish a No-Growth Program	This would have no impact on storm damage reduction to existing infrastructure. Does not meet objective	This reach is generally already fully developed and rezoning would in general have little to no impact on environmental quality, except in a few undeveloped areas. Partially meets objective	Existing conditions would continue into the future, preserving current recreation opportunities. This measure may limit future private property restrictions. Partially meets objective.	Changes to local laws would be needed. This measure may conflict with existing laws and regulations.	Makes no attempt to keep prevent damages to existing infrastructure but may reduce potential damage in the future. May partially contribute to NED benefits. Sea Level Rise (SLR) rates: Does not impact storm damages to existing inventory.	The quality of existing coastal habitats would be maintained but they would also be at risk to future increased erosion. Partially contributes to EQ.	Property and tax revenue may decrease. Existing conditions will continue in regard to the environment and recreation. This may require changes to local law. Partial OSE result.	Potential for loss of property value and tax revenue.		No
		0	1	1	0	1	1	1	0	5	
NS-5	Relocation of Structures	If feasible this measure could reduce storm damages to infrastructure however, most vulnerable structures are too large to be relocated. Partially meets the storm damage reduction objective.	This reach is highly developed and it would be cost probitive to relocate the many condominiums. If the most vulnerable structures were able to relocated, natural environmental quality may be partially preserved.	This measure would have no impact on existing recreation unless the structures to be moved were related to existing public facilities. Partially meets objective.	There would likely be no conflict with laws unless trying to relocate a historic structure. Partially meets objective.	Benefits not likely to out weigh costs in this reach. The structures in the most vulnerable areas are mostly large condos which are too big to be reasonably relocated. Sea Level Rise (SLR) rates: Does not impact storm damages to existing inventory.	Moving buildings back from the coast would provide more area for natural beach and dune habitat. If feasible, this measure could produce positive EQ benefits. However, habitat would be at risk to future to future increased erosion. Partially contributes to EQ.	This measure would displace large amounts of people during implementation. Not likely to be feasible or cost-effective, public likely to dissent. Does not result in favorable OSE.	Does not contribute to RED.		No
		1	1	1	1	0	1	0	0	5	
NS-6	Flood Proofing of Structures	Various forms of flood proofing could provide significant storm damage reduction benefits from inundation and some wave attack, but not erosion. Partially meets objective.	This measure will have no impact on existing environmental quality. Existing environmental conditions will continue into the future. Fully meets objective.	This measure will have no impact on recreation. Existing recreation opportunities will continue into the future. Fully meets objective.	The dry flood proofing does not comply with Section 2.1.7 of ASCE 24 (per FEMA), where dry flood proofing is not permitted in Coastal High Hazard Areas (Zone V)	Damage reduction benefits for structures would be realized. Flood proofing could significantly reduce structural and content damages to buildings from inundation and some wave attack. However, it would not reduce erosion based damages. Partially meets objective to contribute to NED. Sea Level Rise (SLR) rates: Does not impact storm damages to existing inventory unless structural upgrades to existing structures are required. Impacts more structures than NS-2.	No adverse effects would be created by this measure, nor would any positive benefits be realized. Partially meets objective.	This will improve safety, reduce storm damages and reduce insurance premiums. Natural coastal conditions will continue and beach and near shore recreation will not be affected. May be implemented privately at a cost to home/condo owners. Partial OSE result .	Does not contribute to RED.		No
		1	2	2	0	1	1	1	0	8	
NS-7	Acquisition of Land and Structures	This would not reduce storm damages, rather allow them to take their course. Does not meet objective.	Acquired land could be used to create public environmental and recreational preserves. Erosional conditions will continue at natural rates. Given the amount of condominiums in the study area, this would likely be cost prohibitive. Partially meets objective.	Acquired land could be used to create public environmental and recreational preserves. Erosional conditions will continue at natural rates. Partially meets objective.	By law, a government could, in the public interest, condemn land or structures. This alternative is most reasonable in undeveloped areas. Public agencies are very unlikely to receive authority to condemn private structures in developed areas. Partially meets objective.	Benefits could possibly outweigh the costs. Condemnation of most at risk structures and conversion of land to a natural areas will eliminate damages to infrastructure. This is likely to be met with extreme legal opposition. Partially meets objective. Sea Level Rise (SLR) rates: Would not impact	Condemnation of structures and their removal would provide more area for dune habitat and could improve environmental quality through creation of natural areas. Fully meets objective.	Acquired land could be converted to public property. Shorefront property owners would not like this. Likely to be met with extreme legal opposition from current property owners. OSE likely mostly negative.	Acquired land used for public parks could contribute to regional recreation and tourism economic benefits but necessarily create an economic boom. Partial contribution to RED.		No
		0	1	1	1	1	2	0	1	7	

Carried Forward | Eliminated | 2 Fully Meets Objective | 1 Partially Meets Objective | 0 Does Not Meet Objective

*The no-action plan is always carried forward.

St. Lucie County - Structural Management Measures for North, Power Plant, and Narrows

	Management Measures	Planning Objectives			Constraints	Principles and Guidelines Accounts					
		Reduce Storm Damages	Maintain Environmental Quality	Maintain Recreation Opportunities	Avoid conflict with Federal and State Regulations	National Economic Development (NED)	Environmental Quality (EQ)	Other Social Effects (OSE)	Regional Economic Development (RED)	Total Points	Carried Forward
S-1	Seawalls	This measure could provide storm damage reduction to landward infrastructure during extreme storm conditions however, adjacent properties would become more vulnerable. Partially meets objective.	In the long term, sea walls can intensify erosion of the seaward profile and adjacent shorelines. This would reduce beach habitat. Does not meet objective.	This measure will likely cause decreased beach width over time. Does not meet the objective.	This measure is likely to be inconsistent with the state's Coastal Zone Management Plan when implemented at the scale being considered here. Partially meets objective.	Benefits not likely to out weigh costs of this measure as a stand alone measure due to little to zero structures to protect in the area. Does not meet objective. Sea Level Rise (SLR): Could be affected and could require modifications.	Likely to have negative impacts on sea turtle nesting habitat. Not aesthetically appealing. Does not meet objective.	While this measure would provide a degree of storm damage reduction, reflection of wave energy off the seawall will likely intensify erosion and cause a range of public concerns. Does not meet this objective.	Increased erosion of the existing berm due to the seawall may negatively affect local tourism.		No
		1	0	0	1	0	0	0	0	2	
S-2	Revetments	This measure could provide storm damage reduction to landward infrastructure during extreme storm conditions however, adjacent properties would become more vulnerable. Partially meets objective.	In the long term, revetments can intensify erosion of the seaward profile and adjacent shorelines. This would reduce beach habitat. Does not meet objective.	This measure will likely cause decreased beach width over time. Does not meet the objective.	This measure is likely to be inconsistent with the state's Coastal Zone Management Plan when implemented at the scale being considered here. Partially meets objective.	Benefits not likely to out weigh costs of this measure as a stand alone measure due to little to zero structures to protect in the area. Partially meets objective. Sea Level Rise (SLR): Could be affected and could require modifications.	Likely to have negative impacts on sea turtle nesting habitat. Not aesthetically appealing. Does not meet objective.	While this measure would provide a degree of storm damage reduction, reflection of wave energy off the seawall will likely intensify erosion and cause a range of public concerns. Does not meet this objective.	Increased erosion of the existing berm may negatively affect local tourism.		No
		1	0	0	1	1	0	0	0	3	
S-3	Sand Covered Soft Structures	This measure could provide storm damage reduction as a stand alone measure however requires a significant amount of maintenance and can become very aesthetically unappealing. Partially meets objective.	If sand cover is not maintained over the structure then environmental quality is lost. Partially meets objective	This measure may preserve, but not enhance, existing recreational opportunities. Partially meets the objective.	This measure has not been a favored alternative of the State in the past due to aesthetic and structural quality issues experienced in recent similar projects. Partially meets objective.	Benefits could possibly out weigh costs of this measure as a stand alone measure, but there are little to zero structures to protect. Would provide some degree of storm damage reduction if implemented. Partially meets objective. Sea Level Rise (SLR): Could be affected and could require modifications.	Sand would need to be maintained on top of the soft structures to ensure environmental quality. Would protect dune habitat, but could be detrimental if it became uncovered and remained that way. Partially meets objective.	Could provide storm damage reduction although these are not aesthetically pleasing when not maintained. Could cause some public concerns. Partially meets this objective.	Could possibly have a minor positive impact on the regional economy. Partially meets this objective.		No
		1	1	1	1	1	1	1	1	8	
S-4	Beach Nourishment	This measure would reduce storm damages to infrastructure landward of the nourished area and would not create erosion problems for adjacent shorelines. Could function as a stand alone measure. Partially meets objective (lack of infrastructure to protect will likely not have benefits to outweigh the cost).	Would result in permanent negative impacts to nearshore resources (hardbottoms are in close proximity to the shoreline in these reaches) although sea turtle nesting habitat will likely be maintained. Significant mitigation would likely be required. Does not meet this objective.	This measure will enhance existing recreation opportunities. Fully meets the objective.	Not likely to conflict with any State or Federal regulations. Fully meets objective.	This measure could contribute to NED if size and scale are optimized based on economics, but unlikely as there are little to zero structures to protect. Does not meet objective. Sea Level Rise (SLR): Could be affected and could require modifications.	Would result in permanent negative impacts to nearshore resources (hardbottoms are in close proximity to the shoreline in these reaches) although sea turtle nesting habitat will likely be maintained. Significant mitigation would likely be required. Does not meet this objective.	The recreational beach berm would be extended although nearshore recreation and resources will be affected. Does not conflict with any laws. This is the sponsor's favored alternative. Partially meets the objective.	Could possibly have a minor positive impact on the regional economy. Partially meets this objective.		No
		1	0	2	2	0	0	1	1	7	
S-5	Groins	In combination with a beach fill. Groins could be used to stabilize "hot spot" erosional areas and maximize storm damage reduction. However, lack of damages in this area and costs will likely outweigh the benefits.	This measure may have a minor affect on nearshore habitat but would help preserve beach habitat to a degree. Partially meets objective.	This measure may help preserve recreation and may enhance some recreational opportunities such as surfing and fishing. Partially meets the objective.	Likely to not be permitted by the state. Partially meets objective.	Unlikely to contribute to NED due to lack of infrastructure in the area - costs will likely outweigh benefits. Does not meet objective. Sea Level Rise (SLR): Could be affected and could require modifications.	Periodic nourishments could be reduced. Positive impacts to sea turtle nesting habitat. Possible entrapment hazard for hatchling sea turtles. Partially meets objective.	Because only select areas would benefit, groins would not likely receive support from the entire community. In select areas the recreational beach berm would be extended. Nearshore recreation such as surfing and fishing may be affected. Partially meets this objective.	Could possibly have a minor positive impact on the regional economy. Needs to be implemented with a beach fill. Partially meets this objective.		No
		1	1	1	1	0	1	1	1	7	

St. Lucie County - Structural Management Measures for North, Power Plant, and Narrows

	Management Measures	Planning Objectives			Constraints	Principles and Guidelines Accounts					
		Reduce Storm Damages	Maintain Environmental Quality	Maintain Recreation Opportunities	Avoid conflict with Federal and State Regulations	National Economic Development (NED)	Environmental Quality (EQ)	Other Social Effects (OSE)	Regional Economic Development (RED)	Total Points	Carried Forward
S-6	Submerged Artificial Reefs	Could provide storm damage reduction if constructed in conjunction with a beach fill; however, lack of damages in this reach may cause costs to outweigh benefits. Partially meets objective.	Could potentially enhance nearshore habitat although it is likely that there may already be exposed hard bottom habitat in much of the area where this measure would need to be constructed. Partially meets objective.	May help to maintain the recreational beach berm. Could have positive and/or negative effects on other nearshore recreation activities such as surfing or fishing. Partially meets the objective.	May not be permitted by the state. Partially meets objective.	Could possibly contribute to NED if economically justified but unlikely due to lack of damages in these reaches. Does not meet objective. Sea Level Rise (SLR): Could be affected and could require modifications.	Could enhance nearshore fish and beach habitat although would likely affect existing nearshore hardbottom resources. Does not meet objective.	May create a safety hazard for swimmers. The recreational beach berm would be maintained. Nearshore recreation such as surfing and fishing will be affected. This measure will be significant to the public. Partially meets this objective.	Could possibly have a minor positive impact on the regional economy. Partially meets this objective.		No
		1	1	1	1	0	0	1	1	6	
S-7	Nearshore Berm Placement	This measure could hypothetically reduce some degree of storm damages in the project area. Partially meets objective.	This measure would likely have a significant impact on existing nearshore resources. Does not meet objective.	May help maintain beach recreation but is likely to negatively interfere with other recreation opportunities. Partially meets the objective.	Likely to not be permitted by the state and/or Federal government due to environmental impacts. Does not meet this objective.	Could possibly contribute to NED if environmentally justified. Partially meets objective. Sea Level Rise (SLR): Could be affected and could require modifications.	Would have significant impacts on nearshore hardbottom resources. Does not meet this objective.	This measure is most likely to have all negative public perceptions because of environmental impacts and minimal storm damage protection. This is opposed by the public and does not meet the objectives.	Could possibly have a minor positive impact on the regional economy. Partially meets this objective.		No
		1	0	1	0	1	0	0	1	4	
S-8	Emergent Breakwaters	Could provide storm damage reduction if constructed in conjunction with a beach fill. Partially meets objective.	This measure could create some degree of nearshore habitat however would likely impact existing resources. Partially meets objective.	May help maintain beach recreation but is likely to negatively interfere with other recreation opportunities. Partially meets the objective.	May not be permitted by the state. Partially meets objective.	Unlikely for cost to outweigh benefits in these reaches where damages are low. Does not meet objective. Sea Level Rise (SLR): Could be affected and could require modifications.	Could affect the nearshore hardbottom resources. May affect turtle nesting lanes. Could create nearshore habitat. May have a negative effect on adjacent shorelines. Does not meet objective.	May not be aesthetically pleasing. Could be a navigational hazard for boaters and may pose a safety risk for swimmers. Not favored by the public or the sponsor. Does not meet objectives.	Could possibly have a minor positive impact on the regional economy. Partially meets this objective.		No
		1	1	1	1	0	0	0	1	5	
S-9	Dunes and Vegetation	This measure could provide a significant degree of storm damage reduction as a stand alone measure. However, dunes may not reduce all damages. Partially meets the objective.	Dune habitat would be enhanced and expanded. Not likely to have negative impacts on existing resources. Fully meets objective.	Existing recreational opportunities would not be affected. Partially meets the objective.	Supported by Federal law except in CBRA zone. Partially meets objective.	This measure is most likely to contribute to NED based on the low relative cost and potential for effective storm damage reduction, but there are little to no structures to protect. Does not meet objective. Sea Level Rise (SLR): Could be affected and could require modifications.	Dune habitat would be enhanced and expanded. Not likely to have any negative impacts. Aesthetically appealing. Dredging operations during placement could potentially affect nearshore hardbottoms in these reaches. Partially meets objective.	This measure is currently supported by the community. Stable dunes maintain beach and nearshore recreation without negatively affecting environmental resources, although will be to a lesser extent in these reaches. Partially meets the objective.	Could possibly have a minor positive impact on the regional economy. Partially meets this objective.		No
		1	2	1	1	0	1	1	1	8	

Carried Forward | Eliminated | 2 Fully Meets Objective | 1 Partially Meets Objective | 0 Does Not Meet Objective

St. Lucie County - Non-Structural Management Measures for North, Power Plant, and Narrows

	Management Measures	Planning Objectives			Constraints	Principles and Guidelines Accounts					
		Reduce Storm Damages	Maintain Environmental Quality	Maintain Recreation Opportunities	Avoid conflict with Federal and State Regulations	National Economic Development (NED)	Environmental Quality (EQ)	Other Social Effects (OSE)	Regional Economic Development (RED)	Rank	Carried Forward
	Nonstructural Measures (NS)										
NS-1	**No-Action**	This measure makes no attempt to reduce storm damages to coastal infrastructure. Does not meet the objective.	The beach berm and dunes will continue to function naturally through time. There is a potential for loss of habitat for shorebirds, sea turtles, etc. Nearshore hardbottoms will remain undisturbed. Existing conditions remain Fully meets the objective.	Existing conditions would continue into the future, not affecting current recreation opportunities. Fully meets objective.	Does not conflict with any laws. Fully meets objective.	No NED benefits are realized through this measure. No damages are prevented. No project costs. Makes no attempt to keep infrastructure from being damaged. No change in economic outputs. Does not contribute to this account/objective.	The beach berm and dunes will continue to erode naturally through time, causing a potential loss of habitat for shorebirds, sea turtles, etc., this may be offset by private dune restoration measures which could benefit dune habitat and storm damage protection. Nearshore hardbottoms will remain undisturbed. Partially meets the objective.	Coastal residents may experience loss of property and land, small scale protection measures may be implemented by home/condo owners, no storm damage reduction is provided, property values may decrease, public facilities likely unaffected. Partial OSE result.	Does not contribute to RED.		yes*
		0	2	2	2	0	1	1	0	8	
NS-2	**Coastal Construction Control Line**	Relocating the CCCL or increasing construction setbacks will not meet this objective. A majority of these reaches are undeveloped and protected by CBRA, southern shorelines are fully developed mostly with large, permanent structures. Does not meet objective	Rezoning in these reaches could provide additional protection for existing environmental resources which are already protected by CBRA. The southern-most areas are already fully developed. Partially meets objective	Existing conditions would continue into the future, not affecting current recreation opportunities. Public recreation could be partially limited by decreased beach width. Partially meets objective.	Would require changes to State law. Partially meets objective.	Would only provide damage reduction benefits for potential future structures, which is unlikely due to area in CBRA zone. This line already exists, no NED benefits to be gained. Sea Level Rise (SLR) rates: Does not impact storm damages to existing inventory.	Setbacks are already in place.	This already exists. Near shore recreation will not be affected. Does not contribute positively to OSE objectives.	Does not contribute to RED.		No
		0	1	1	1	0	0	0	0	3	
NS-3	**Moratorium on Construction**	This would have little impact on storm damage reduction to existing infrastructure. Does not meet objective	The majority of these reaches already have permanent status as public land, and is protected by CBRA. The southern study is already fully developed. Does not meet objective.	Existing conditions would continue into the future, not affecting current recreation opportunities. Public recreation could be partially limited by decreased beach width. Partially meets objective.	Attempts to implement moratoriums on construction have resulted in lawsuits in the past. Changes to local laws would be needed. This measure does not avoid conflict with existing laws and regulations.	Would only provide damage reduction benefits for potential future structures, which is unlikely due to area in CBRA zone. NED benefits would be minimal. Makes no attempt to keep existing infrastructure from being damaged, but would reduce damages in the future. Sea Level Rise (SLR) rates: Does not impact storm damages to existing inventory.	Quality of the existing coastal habitat could be preserved but this is already being done passively through CBRA zone.	This is already passively being done through CBRA. Property and tax revenue may decrease. May have an unfavorable public perception. Attempts to change local laws may result in lawsuits. OSE contribution is mostly negative.	Does not contribute to RED.		No
		0	0	1	0	0	0	0	0	1	
NS-4	**Establish a No-Growth Program**	This would have no impact on storm damage reduction to existing infrastructure. Does not meet objective	The majority of these reaches already have permanent status as public land, and is protected by CBRA. This measure would preserve existing coastal habitat. Partially meets objective.	Existing conditions would continue into the future, preserving current recreation opportunities. This measure may limit future private property restrictions. Partially meets objective.	Changes to local laws would be needed. This measure may conflict with existing laws and regulations.	Makes no attempt to prevent damages to existing infrastructure but may reduce potential damage in the future, which is unlikely due to area in CBRA zone. May partially contribute to NED benefits. Sea Level Rise (SLR) rates: Does not impact storm damages to existing inventory.	The quality of existing coastal habitats would be maintained but they would also be at risk to future increased erosion. Already being done through CBRA. Partially contributes to EQ.	Property and tax revenue may decrease. Existing conditions will continue in regard to the environment and recreation. Already being done through CBRA. This may require changes to local law. Partial OSE result.	Potential for loss of property value and tax revenue.		No
		0	1	1	0	1	1	1	0	5	
NS-5	**Relocation of Structures**	If feasible this measure could reduce storm damages to infrastructure however, most vulnerable structures are too large to be relocated. Partially meets the storm damage reduction objective.	This measure has minimal potential to affect shorelines in the northern study areas and is impractical in the southern areas. If most vulnerable structures were relocated, natural environmental quality may be partially preserved.	This measure would have no impact on existing recreation unless the structures to be moved were related to existing public facilities. Partially meets objective.	There would likely be no conflict with laws unless trying to relocate a historic structure. Partially meets objective.	Benefits not likely to out weigh costs in this study area. The structures in the most vulnerable areas are mostly large condos which are to big to reasonably relocate. Sea Level Rise (SLR) rates: Does not impact storm damages to existing inventory.	Moving buildings back from the coast would provide more area for natural beach and dune habitat. If feasible, this measure could produce positive EQ benefits. However, habitat would be at risk to future to future increased erosion. Partially contributes to	This measure would displace large amounts of people during implementation. Not likely to be feasible or cost-effective, public likely to dissent. Does not result in favorable OSE.	Does not contribute to RED.		No
		1	1	1	1	0	1	0	0	5	
NS-6	**Flood Proofing of Structures**	Various forms of flood proofing could provide storm damage reduction benefits from inundation and possibly wave attack, but it would not prevent erosion based damages. Partially meets objective.	This measure will have no impact on existing environmental quality. Existing environmental conditions will continue into the future. Fully meets objective.	This measure will have no impact on recreation. Existing recreation opportunities will continue into the future. Fully meets objective.	The dry flood proofing does not comply with Section 2.1.7 of ASCE 24 (per FEMA), where dry flood proofing is not permitted in Coastal High Hazard Areas (Zone V)	There are few to zero structures to protect in this area. Very few structures would benefit from the reduction in inundation and wave attack damages, and erosion would continue to be a problem. Does not meet objective to contribute to NED. Sea Level Rise (SLR) rates: Does not impact storm damages to existing inventory unless structural upgrades to existing	No adverse effects would be created by this measure, nor would any positive benefits be realized. Partially meets objective.	There are few to zero structures to protect in this area. No OSE result .	Does not contribute to RED.		No
		1	2	2	0	0	1	0	0	6	
NS-7	**Acquisition of Land and Structures**	This would not reduce storm damages, rather allow them to take their course. Does not meet objective.	Acquired land could be used to create public environmental and recreational preserves. Erosional conditions will continue at natural rates. Partially meets objective.	Acquired land could be used to create public environmental and recreational preserves. Erosional conditions will continue at natural rates. Partially meets objective.	By law, a government could, in the public interest, condemn land or structures. This alternative is most reasonable in undeveloped areas. Public agencies are very unlikely to receive authority to condemn private structures in developed areas. Partially meets objective.	There are few to zero structures in this area. Does not meets objective. Sea Level Rise (SLR) rates: Would not impact.	There are few to zero structures in this area. Does not meet objective.	There are few to zero structures in this area. Does not meet objective. No OSE result.	Does not contribute to RED.		No
		0	1	1	1	0	0	0	0	3	

Carried Forward | Eliminated | 2 Fully Meets Objective | 1 Partially Meets Objective | 0 Does Not Meet Objective

*The no-action plan is always carried forward.

The measures in North Hutchinson Island, Power Plant, and Narrows of Hutchinson Island reaches were jointly screened due to their similarities and proximity to one another. For these reaches, structural management measures were not carried forward, due to the cost of construction as well as minimal damageable structures in the area, other than the Florida Power and Light (FPL) Power Plant in the Power Plant reach. Further, all three reaches are almost entirely within the CBRS unit, with the exception of the shoreline immediately in front of the FPL Power Plant which has a revetment, indicating that FPL Plant has already taken measures to protect the plant (including its existing elevation of 20 feet above sea level). For these reaches, there are little to no structures to protect, with the exception of A1A. This highway is a major evacuation route, but is set back from the immediate project area in the upper reaches, with the exception of the Narrows of Hutchinson Island reach. In the Narrows of Hutchinson Island reach where A1A is most potentially vulnerable to storm damage, USACE contacted Florida Department of Transportation (FDOT) to discuss potential needs for a Federal project to protect A1A. According to discussions with FDOT, needs have been met for A1A and will continue to be met by FDOT in specific locations, with no need for a Federal project at this time. Additionally, the CBRS unit effectively rules out any Federal participation. Most non-structural measures are already in place or are being accomplished passively through the CBRA unit. After careful consideration and evaluation of all measures, and discussion with the Sponsor, all non-structural and structural measures were screened out, except for the no-action measure. For all the reasons described above, it was assumed there would be no-action for these reaches.

The South Hutchinson Island reach was screened as a stand-alone reach, with a length of approximately 3.4 miles. The CBRS unit is present in this reach from R-98 to R-98 +200 feet and from R-101.5 to R-103.5. The non-CBRS shoreline is the southernmost part of St. Lucie County and stretches 2.6 miles from approximately R-103 to the St. Lucie/Martin County line at R-115+1000 feet. The following structural measures were carried forward: S-4 Beach Nourishment, S-5 Groins, S-6 Submerged Artificial Reefs, and S-9 Dunes and Vegetation. Most non-structural measures are already being pursued by the local sponsor, or were not feasibly implementable. Acquisition of land and structures was cost prohibitive due to the high cost to buy condominiums, the main damageable structures in the study area. These costs were estimated during the Value Engineering (VE) Study process, which can be referenced in Appendix I for the full documentation of this idea and for all other ideas considered during the VE process. . Flood proofing of structures (dry), such as flood shields, does not comply with FEMA ASCE 24 (Section 6.2.1) where dry floodproofing in not permitted in Coastal High Hazard Areas (Zone V). The following non-structural measures were carried forward: NS-1 No-action.

Management measures that were carried forward after initial screening include:

<u>North Hutchinson Island, Power Plant, Narrows of Hutchinson Island reaches</u>
NS-1: No-action

<u>South Hutchinson Island reaches</u>
NS-1: No-action
S-4: Beach Nourishment
S-5: Groins (low-profile)
S-6: Submerged Artificial Reefs
S-9: Dunes and Vegetation

3.7.2 FORMULATION STRATEGY

Measures, used singularly or in combination with others, create alternatives; and varying scales of each create additional alternatives. An alternative may be implementable for a portion of a reach but not for an entire reach. The combination of management measures results in alternatives that merit further analysis.

The CBRS (Coastal Barrier Resource System) unit is present from R-98 to R-98 + 200 feet, which is part of a privately owned undeveloped parcel and from R-101.5 to R-103.5, which is part of St. Lucie owned land for a public park. At this point, the alternatives with structural measures were avoided in the CBRS unit, with the exception of S-4 Beach Nourishment and S-9 Dunes and Vegetation (which are considered non-structural by USFWS). The length of R-98 to R-98 + 200 feet is a very small part of study area and has a remaining additional 70 feet of non-CBRA on the same private undeveloped parcel. In this case, it assumed that any alternatives which are not beach or dunes would begin at R-98 + 270 feet where a new parcel begins which is owned by St. Lucie County and a public park, rather than R-98 to avoid the CBRS unit in that area, as well as the small remaining distance on the private undeveloped parcel.

Avoidance of impacts to hardbottom was a prevalent part of the rationale, both from an environmental standpoint and cost standpoint, and played a large part in determination of feasible alternative combinations.

Non-Structural – Combinability Discussion

NS-1: No-action. This measure is a stand-alone alternative which could be used per reach.

Throughout the study area nonstructural risk reduction measures including education efforts, maintenance of evacuation route signage, zoning codes, and setback requirements were carried forward as elements of any complete systematic package of risk reduction measures. Many of these additional nonstructural efforts are currently being pursued by St. Lucie County and would be performed locally.

Structural Measures– Combinability Discussion

S-4: Beach Nourishment: This measure could be a stand-alone alternative or could be combined with S-5, S-6, or S-9.

S-5: Groins: This measure would need to be combined with S-4, in order to avoid starving downdrift areas of sand.

S-6: Submerged Artificial Reefs: This measure could be a stand-alone alternative or could be combined with S-4.

S-9: Dunes and Vegetation: This measure could be a stand-alone alternative or could be combined with S-4.

These measures were combined into alternatives, based on the combinability rationale discussed above, and using engineering judgment to assess the most effective combinations given the conditions in the study area. This included minimum and maximum nourishment templates, which would mimic a smaller

beach berm versus a larger beach berm, as well as a much smaller beach nourishment fill, where the purpose would be to fill in low lying areas which potentially act as a conduit for water flow and flooding. A truck haul option with an upland sand source versus offshore sand source was also detailed in the alternatives.

The resulting alternatives are listed below:

- Alternative 1 – No-action
- Alternative 2 – Dunes with Vegetation
- Alternative 3 – Beach Nourishment (smaller template)
- Alternative 4 – Beach Nourishment (smaller template) with trucking
- Alternative 5 – Beach Nourishment (smaller template) AND Dunes with Vegetation
- Alternative 6 – Beach Nourishment (larger template) with Hardbottom Mitigation
- Alternative 7 – Beach Nourishment (larger template) with Hardbottom Mitigation AND Dunes with Vegetation
- Alternative 8 – Submerged Artificial Reefs
- Alternative 9 – Submerged Artificial Reefs AND beach nourishment (one-time event)
- Alternative 10 – Groins (low-profile) AND Beach Nourishment (smaller template)

3.8 SECONDARY SCREENING: SCREENING WITH PRELIMINARY COSTS PRIOR TO BEACH-FX

During the process of developing screening level costs, the beach nourishment alternatives, or alternatives which include it, were expanded to minimum and maximum berms for both the smaller and larger templates. This offers a range for the alternatives to better focus on the efficiency of varying berm widths with regard to reducing storm damages. Additionally, the dune with vegetation alternatives, or alternatives which include it, were expanded to minimum and maximum dune extensions. This exercise created variations within the alternatives, the full list which is listed below:

- Alternative 1 – No-action
- Alternative 2 – Dunes with Vegetation
    - 2A: Minimum dune extension 10 feet
    - 2B: Maximum dune extension 20 feet
- Alternative 3 - Beach Nourishment (smaller template)
    - 3A: Minimum Berm 20 feet
    - 3B: Maximum Berm 40 feet
- Alternative 4 – Beach Nourishment (smaller template) with trucking
    - 4A: Minimum Berm 20 feet
    - 4B: Maximum Berm 40 feet
- Alternative 5 - Beach Nourishment (smaller template) AND Dunes with Vegetation
    - 5A: Minimum dune extension 10 feet + Minimum Berm 20 feet
    - 5B: Maximum dune extension 20 feet + Maximum Berm 40 feet
- Alternative 6 – Beach Nourishment (larger template) with Hardbottom Mitigation
    - 6A: Minimum Berm 60 feet
    - 6B: Maximum Berm 100 feet
- Alternative 7 – Beach Nourishment (larger template) with Hardbottom Mitigation AND Dunes with Vegetation

  - 7A: Minimum dune extension 10 feet + Minimum Berm 60 feet
  - 7B: Maximum dune extension 20 feet + Maximum Berm 100 feet
- Alternative 8 – Submerged Artificial Reefs
- Alternative 9 – Submerged Artificial Reefs AND beach nourishment (one-time event)
  - 9A: Minimum Berm 20 feet
  - 9B: Maximum Berm 40 feet
- Alternative 10 – Groins (low-profile) AND Beach Nourishment (smaller template)
  - 10A: Minimum Berm 20 feet
  - 10B: Maximum Berm 40 feet

Screening with Screening Level Costs Prior to Beach-fx

In order to screen the alternatives prior to Beach-fx modeling, preliminary costs were developed for each of the alternatives. The preliminary costs were developed using information from historical projects. These costs were brought to present value (PV) based on maintenance assumptions over 50 years.

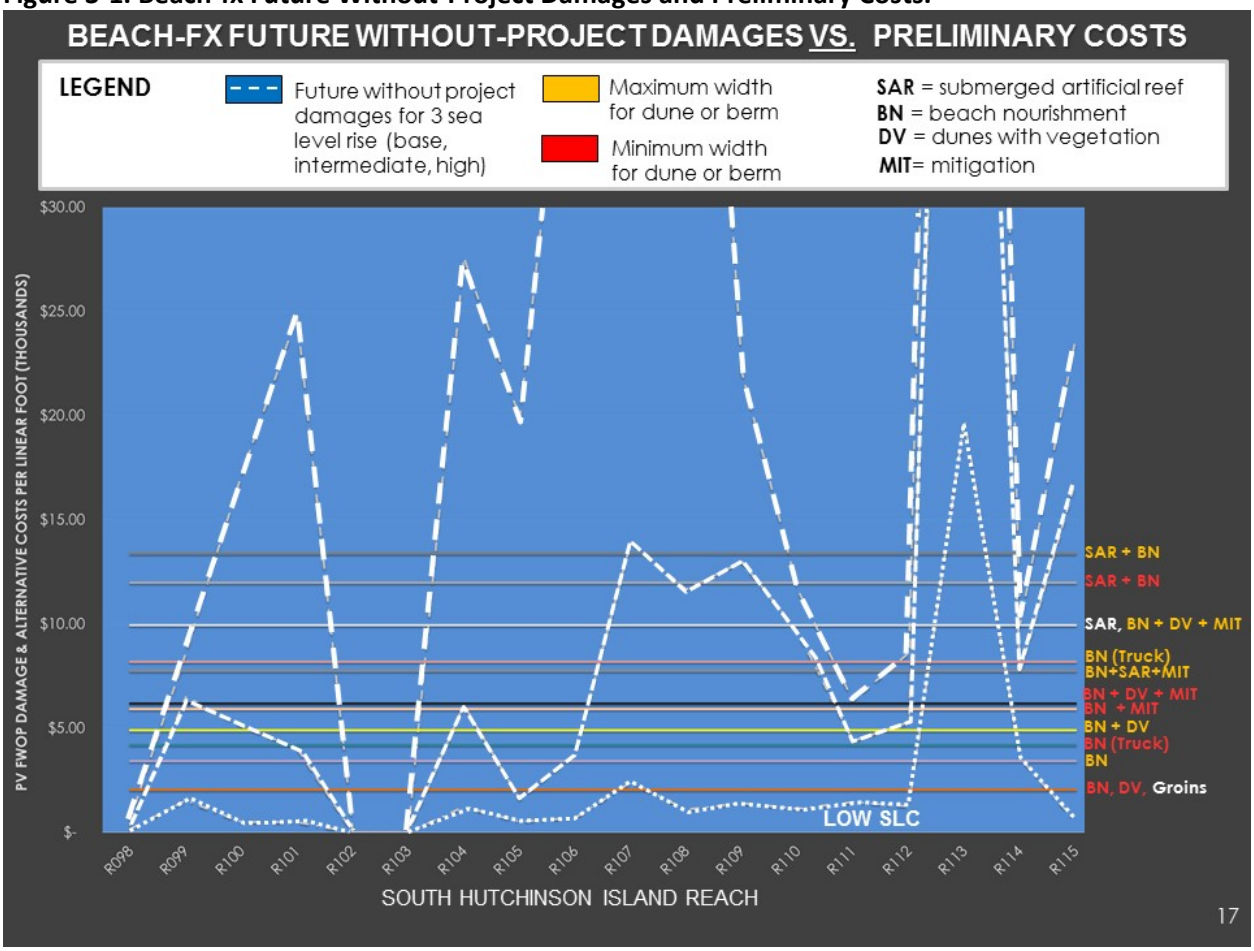
Beach-fx, Future without-project Condition, and Sea-Level Change (SLC)

Beach-fx was run for the future without-project (FWOP) condition using each of the three Sea Level Change (SLC) scenarios prescribed by ER 1100-2-8162.

A project's benefit-to-cost ratio (B/C ratio) must be greater than 1.0 in order for an alternative to be justified and implementable; in short, the benefits must be greater than the costs. Benefits equal damages prevented, or the difference between without-project damages and damages resulting after implementation of an alternative.

At this point in the study, damages are used as a proxy for benefits. Using the value of without-project damages as a substitute for the benefits will overestimate the benefit provided by any measure since this assumes that 100 percent of damages have been averted. Therefore if the cost of implementing an alternative is equal to, or less than the without-project damages, the B/C ratio can be assumed to approximate 1. **Figure 3-1 d**isplays the costs in addition to damages along the shoreline for each of the three SLC scenarios. Wherever damages were far below an alternative's implementation costs, it was assumed that the alternative would not be justified along that shoreline length and the alternative was screened out.

Figure 3-1. Beach-fx Future Without-Project Damages and Preliminary Costs.



Where damages are near or above preliminary costs it was assumed that the alternative was justified and was carried forward. This comparison not only helps in screening, but it also serves to scope alternatives that are carried forward.

The cost of an alternative's implementation may vary depending on the SLC scenario used for design. Because of this it is important to note that there is uncertainty regarding future costs, and alternatives with costs just above projected damages should not be screened out prematurely. Other measures may have the same implementation cost for any scenario.

In **Figure 3-1**, damages are shown for each preliminary Beach-fx sub-reach within the main South Hutchinson Island reach. Straight horizontal lines are the preliminary costs for the alternatives. The damages include damages to infrastructure (roads, houses, condos, dune walkovers, etc.).

Many combinations had preliminary costs that far exceed the expected damages along lengths of shoreline of sufficient length to realistically implement an alternative and were screened out.

This step was helpful to discern the alternatives which were too costly to provide BCRs above 1 in any of the sub-reaches. The alternatives screened out from this effort and reasons are listed below:

- All artificial reef alternatives, as the highest cost alternatives, were screened out (Alternatives 10 and 11).
- Alternative 7: All of the options for nourishment, dunes with vegetation, and hardbottom mitigation are screened out.
- Alternative 4: Although this alternative shows a different method of achieving the same goal as the other beach nourishment alternatives, it shows that at this time the trucking option is not viable for the maximum berm option. Trucking in general is more costly than the currently proposed offshore borrow area, and will be screened out at this time, but can be considered later if needed and viable.

The FWOP damages in the sub-reaches vary and the costs alone did not necessarily help to screen out alternatives. For additional screening, all alternatives were evaluated against planning objectives, constraints, P&G accounts, and criteria of completeness, effectiveness, efficiency, and acceptability. As a result, the following additional alternatives were screened out: Alternative 12 – Groins and Alternative 6 – Beach nourishment (large template) with hardbottom mitigation. The no-action alternative does not meet any of the planning objectives because it does not address any specific problems; however, it provides a comparison for all other alternatives.

A summary of the reasons for screening out the above alternatives are described below:

- Alternative 6 – Beach nourishment (large template) with hardbottom mitigation: Hardbottom mitigation is to be avoided within the study area, as stated in formulation strategy rationale, and would be environmentally unfavorable and as well costly.

- Alternative 12 – Groins: The erosion rate in this area is fairly uniform, and applying structures in a specific area could negatively alter the natural forces and erosion rates in adjacent areas.

This resulted in the following alternatives carried forward to final screening:

- Alternative 1 – No-action
- Alternative 2 – Dunes with Vegetation
    - 2A: Minimum dune extension 10 feet
    - 2B: Maximum dune extension 20 feet
- Alternative 3 - Beach Nourishment (smaller template)
    - 3A: Minimum Berm 20 feet
    - 3B: Maximum Berm 40 feet
- Alternative 5 - Beach Nourishment (smaller template) AND Dunes with Vegetation
    - 5A: Minimum dune extension 10 feet + Minimum Berm 20 feet
    - 5B: Maximum dune extension 20 feet + Maximum Berm 40 feet

3.9 FINAL SCREENING: FUTURE WITH-PROJECT MODELING IN BEACH-FX

The 3 remaining alternatives, with minimum and maximum variations, were then modeled in Beach-fx, to evaluate future with-project (FWP) damages. Comparing “future without” to “future with” project damages results in the damage prevention provided by the alternative, where damage prevention is equivalent to storm damage reduction benefits.

The broad alternatives of 1, 2, 3, and 5 listed above in the previous section were then expanded to show possible berms widths, dune widths, and combinations of both berms and dunes. The alternatives were designated as follows:

- No-action represents an alternative where a project is not implemented. This alternative is always considered during the planning process.

- **A**BermxDuneEx represents maintenance of the existing berm (0-foot design berm), with an x foot extension, and maintenance of the 2008 dune ("existing condition").

- **B**BermxDuneEx represents a 20-foot design berm, with an x-foot extension, and maintenance of the 2008 dune ("existing condition").

- **C**BermxDuneEx represents a 40-foot design berm, with an x-foot extension, and maintenance of the 2008 dune ("existing condition").

- DuneEx: represents maintenance of the 2008 dune only

- DuneX: represents maintenance of the 2008 dune with an additional x foot extension

The array shown in **Table 3-2** presents the results of the alternatives after running the Beach-fx model for 25 iterations (compared to 100 iterations). This allowed a preliminary output in a shorter timeframe, rather than running 100 iterations which would be more time consuming and would give similar outputs. The results give storm damage reduction benefits, and are organized by highest net benefits to lowest net benefits, and show that only nine alternatives have the highest net benefits which would then translate to benefit to cost ratios which are over 0.5. Selecting the alternatives with a BCR over 0.5 gives reasonable assurance that an alternative could then be justified {BCR over 1} after adding recreation and land loss benefits.

Table 3-2. Expanded Array of Alternatives[17].

Alternative Name	Avg Total Project Vol (CY)	Avg Renourishment Interval (Years)	Mob, PED, S&A Cost ($AAEQ)	Additional Initial Costs ($AAEQ)	Alternative iteration.csv Avg Place Costs ($AAEQ)	Total Cost ($AAEQ)	FWOP Avg Damages ($AAEQ)	FWP Avg Damages ($AAEQ)	Avg Total Project Benefits ($AAEQ)	Net Benefits ($AAEQ)	BCR
ABERM10DuneEx	6,006,856	12	$ 321,119	$ 9,218	$ 534,271	$ 864,608	$ 978,091	$ 87,470	$ 890,621	$ 26,013	1.03
ABerm20DuneEx	10,649,836	16	$ 236,709	$ 46,753	$ 695,119	$ 978,581	$ 978,091	$ 90,409	$ 887,682	$ (90,898)	0.91
Dune10	6,626,298	12	$ 322,037	$ 112,105	$ 584,394	$ 1,018,536	$ 978,091	$ 94,089	$ 884,003	$ (134,533)	0.87
ABerm30DuneEx	15,688,521	19	$ 202,908	$ 27,655	$ 858,963	$ 1,089,526	$ 978,091	$ 96,707	$ 881,384	$ (208,141)	0.81
ABerm10Dune10	10,089,763	15	$ 275,250	$ 116,969	$ 769,961	$ 1,162,180	$ 978,091	$ 87,790	$ 890,302	$ (271,879)	0.77
ABerm40DuneEx	20,003,186	20	$ 193,283	$ 69,025	$ 1,036,247	$ 1,298,555	$ 978,091	$ 95,265	$ 882,826	$ (415,729)	0.68
Dune20	10,575,649	14	$ 285,845	$ 219,558	$ 834,055	$ 1,339,458	$ 978,091	$ 94,463	$ 883,628	$ (455,830)	0.66
BBerm30DuneEx	7,424,509	9	$ 429,293	$ 27,655	$ 984,323	$ 1,441,271	$ 978,091	$ 82,305	$ 895,786	$ (545,485)	0.62
ABerm60DuneEx	28,788,703	22	$ 183,737	$ 55,310	$ 1,389,344	$ 1,628,391	$ 978,091	$ 93,546	$ 884,545	$ (743,845)	0.54
ABerm40Dune10	21,780,431	17	$ 240,041	$ 144,624	$ 1,425,512	$ 1,810,178	$ 978,091	$ 88,548	$ 889,543	$ (920,635)	0.49
ABerm20Dune20	12,840,428	12	$ 328,178	$ 233,938	$ 1,251,632	$ 1,813,748	$ 978,091	$ 81,806	$ 896,285	$ (917,463)	0.49
ABerm80DuneEx	37,709,339	23	$ 173,412	$ 73,746	$ 1,701,669	$ 1,948,828	$ 978,091	$ 101,274	$ 876,817	$ (1,072,010)	0.45
BBerm60DuneEx	22,527,784	16	$ 261,768	$ 55,310	$ 1,644,761	$ 1,961,838	$ 978,091	$ 86,620	$ 891,471	$ (1,070,366)	0.45
BBerm40Dune10	13,591,156	11	$ 358,104	$ 144,624	$ 1,469,265	$ 1,971,993	$ 978,091	$ 81,786	$ 896,305	$ (1,075,689)	0.45
CBerm60DuneEx	16,982,751	12	$ 336,329	$ 55,310	$ 1,691,130	$ 2,082,769	$ 978,091	$ 82,460	$ 895,631	$ (1,187,137)	0.43
ABerm40Dune20	23,019,924	16	$ 257,148	$ 258,821	$ 1,668,656	$ 2,184,625	$ 978,091	$ 88,444	$ 889,647	$ (1,294,978)	0.41
ABerm60Dune10	30,872,571	18	$ 228,857	$ 163,060	$ 1,880,769	$ 2,272,686	$ 978,091	$ 92,393	$ 885,698	$ (1,386,988)	0.39
BBerm40Dune20	14,388,859	10	$ 387,414	$ 252,374	$ 1,710,127	$ 2,349,916	$ 978,091	$ 82,281	$ 895,811	$ (1,454,105)	0.38
BBerm60Dune10	23,736,751	15	$ 283,048	$ 163,060	$ 1,920,849	$ 2,366,957	$ 978,091	$ 85,241	$ 892,851	$ (1,474,106)	0.38
BBerm80DuneEx	32,070,152	17	$ 241,386	$ 73,746	$ 2,095,143	$ 2,410,275	$ 978,091	$ 88,853	$ 889,238	$ (1,521,037)	0.37
CBerm60Dune10	17,689,214	11	$ 368,051	$ 163,060	$ 1,972,853	$ 2,503,964	$ 978,091	$ 82,601	$ 895,490	$ (1,608,474)	0.36
CBerm80DuneEx	21,354,281	12	$ 338,117	$ 73,746	$ 2,142,950	$ 2,554,812	$ 978,091	$ 83,945	$ 894,146	$ (1,660,666)	0.35
ABerm60Dune20	32,351,472	17	$ 240,570	$ 270,811	$ 2,137,063	$ 2,648,444	$ 978,091	$ 90,838	$ 887,253	$ (1,761,191)	0.34
ABerm80Dune10	39,240,918	20	$ 219,843	$ 181,497	$ 2,269,825	$ 2,671,165	$ 978,091	$ 87,318	$ 890,773	$ (1,780,392)	0.33
BBerm60Dune20	24,912,910	13	$ 298,651	$ 270,811	$ 2,170,489	$ 2,739,952	$ 978,091	$ 84,810	$ 893,281	$ (1,846,670)	0.33
BBerm80Dune10	33,976,671	17	$ 248,645	$ 181,497	$ 2,329,114	$ 2,759,256	$ 978,091	$ 84,513	$ 893,578	$ (1,865,677)	0.32
Cberm60Dune20	18,631,403	10	$ 380,926	$ 270,811	$ 2,181,420	$ 2,833,157	$ 978,091	$ 83,391	$ 894,700	$ (1,938,457)	0.32
CBerm80Dune10	21,905,423	11	$ 356,877	$ 181,497	$ 2,392,275	$ 2,930,648	$ 978,091	$ 83,579	$ 894,512	$ (2,036,136)	0.31
ABerm80Dune20	41,391,623	18	$ 229,143	$ 289,248	$ 2,553,427	$ 3,071,817	$ 978,091	$ 89,147	$ 888,944	$ (2,182,873)	0.29
BBerm80Dune20	34,933,321	16	$ 259,840	$ 289,248	$ 2,564,408	$ 3,113,496	$ 978,091	$ 84,768	$ 893,323	$ (2,220,173)	0.29
CBerm80Dune20	22,729,709	11	$ 377,167	$ 289,248	$ 2,648,912	$ 3,315,326	$ 978,091	$ 84,822	$ 893,269	$ (2,422,057)	0.27

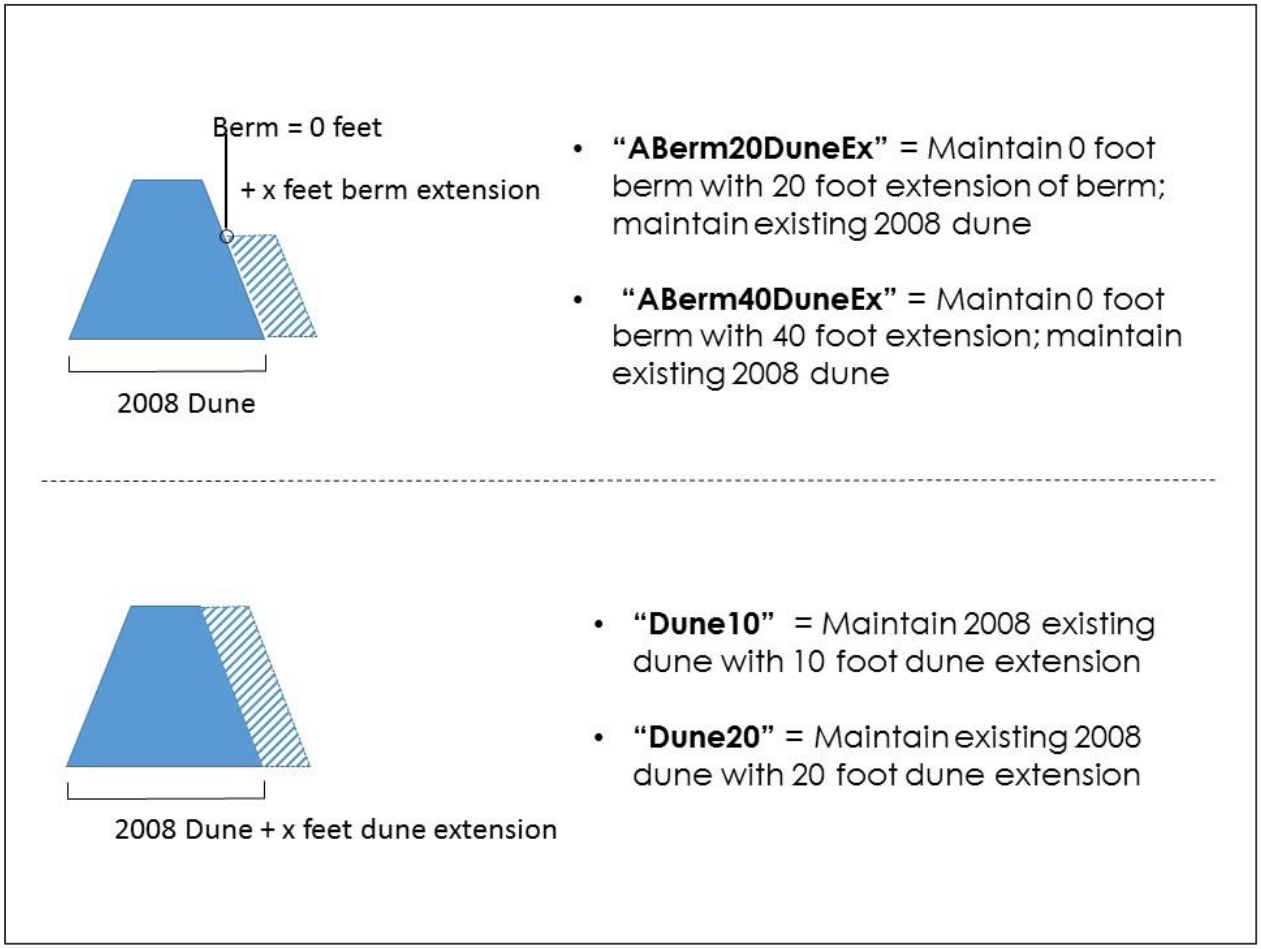
These nine alternatives are highlighted in blue on **Table 3-2**, and graphic examples are shown in **Figure 3-2**. They are also listed below, in order of highest net benefits to lowest:

- **No-action**
- **2008 Dune + 10 ft. Berm Extension (ABerm10DuneEx):** 0-foot design berm, Maintain existing berm with 10-foot extension; maintain existing dune
- **2008 Dune + 20 ft. Berm Extension (ABerm20DuneEx):** Maintain existing berm with 20-foot extension; maintain existing dune
- **2008 Dune + 10 ft. Dune Extension (Dune10):** Maintain existing dune with 10-foot extension
- **2008 Dune + 30 ft. Berm Extension (ABerm30DuneEx):** 0-foot design berm, Maintain existing berm with 30-foot extension; maintain existing dune
- **2008 Dune + 40 ft. Berm Extension (ABerm40DuneEx):** 0-foot design berm , Maintain existing berm with 40-foot extension; maintain existing dune
- **2008 Dune + 20 ft. Dune Extension (Dune20):** Maintain existing dune with 20-foot extension

[17] Additional Initial Costs include associated costs to cover incidental work prior to initial construction of each alternative such as dune vegetation, turbidity monitoring, beach tilling, escarpment removal, environmental monitoring, traffic maintenance, etc.

- **2008 Dune + 20 ft. Design Berm+ 10-foot Berm Extension (BBerm30DuneEx):** 20-foot design berm, 10-foot extension; maintain existing dune
- **2008 Dune + 60 ft. Berm Extension (ABerm60DuneEx):** 0-foot design berm, Maintain existing berm with 60-foot extension; maintain existing dune

Figure 3-2. Examples of Dune and Berm Alternatives.



After the preliminary results were obtained as discussed in the previous section, the top five[18] alternatives were chosen to be carried forward. Five was deemed to be a reasonable number of alternatives that could be modeled within the given timeframe, and had the best chance at being economically justified, as well as reasonably maximizing net benefits within the study area. The top five alternatives, along with the no-action alternative, were:

- **No-action**
- **2008 Dune + 10 ft. Berm Extension (ABerm10DuneEx)** = Maintain existing berm with 10-foot extension; maintain existing dune

[18] ABerm10Dune10 was screened from Table 3-2 since it is not realistic from a constructability standpoint.

- **2008 Dune + 20 ft. Berm Extension (ABerm20DuneEx)** = Maintain existing berm with 20-foot extension; maintain existing dune
- **2008 Dune + 10 ft. Dune Extension (Dune10)** = Maintain existing dune with 10-foot extension
- **2008 Dune + 30 ft. Berm Extension (ABerm30DuneEx)** = Maintain existing berm with 30-foot extension; maintain existing dune
- **2008 Dune + 40 ft. Berm Extension (ABerm40DuneEx)** = Maintain existing berm with 40-foot extension; maintain existing dune

For the numbers shown in **Table 3-2**, a preliminary cost was used for all alternatives which included dredging from the ocean borrow site and placement for all alternatives. At this point, benefits were influenced by three main factors. First, the rebuild assumption in the Beach-fx model was set at a very conservative numbers at this stage, which capped potential FWOP and FWP benefits. Second, benefits from R-115 to the Martin County line had not yet been incorporated. Third, the model runs were performed for 25 iterations only. For this table, only storm damage reduction benefits were included.

After more discussions, the 10-foot alternatives (both ABerm10DuneEx and Dune10) were considered to be too small to be reasonably constructed through a dredging operation. Therefore, at this level of consideration and screening, a revised preliminary cost was used for both 10-foot alternatives to show truck haul from an upland borrow site.

For the final round of screening, the 5 alternatives carried forward as described above were then modeled in Beach-fx using full (100 iterations) life-cycle simulations, with updated benefits for the portion from R-115 to Martin County line, and with rebuild assumptions that were more likely to occur, and with the truck haul estimates for ABerm10DuneEx and Dune10. The results of these simulations were used to select the NED Plan, presented in **Table 3-3**. The combination of storm damages reduction benefits and land loss are typically relied on for plan formulation and plan selection and are therefore both shown in **Table 3-3.** Recreation benefits in this case are shown after the recommended plan is determined. The Economics Appendix shows additional level of detail.

The 20-foot berm extension alternative, ABerm20DuneEx, was determined to be the NED plan, as the alternative with the highest net benefits, and meets the planning objectives, constraints, and P&G accounts and criteria as described above. It meets the Federal criteria of being economically justified, with a BCR equal to or more than 1.0.

Table 3-3. AAEQ Benefits and Costs for Final Array of Alternatives.[19]

Alternative Name	Total Primary Benefits	Total Costs	Primary Net Benefits	BCR
No-action	-	-	-	-
20-foot Berm (R-98.5 to Martin County line)	$ 2,399,612	$ 1,314,927	$ 1,084,685	1.82
10-foot Berm (R-98.5 to Martin County line)	$ 2,392,243	$ 1,411,990	$ 980,253	1.69
30-foot Berm (R-98.5 to Martin County line)	$ 2,400,363	$ 1,462,493	$ 937,870	1.64
10-foot Dune (R-98.5 to Martin County line)	$ 2,361,179	$ 1,485,348	$ 875,831	1.59
40-foot Berm (R-98.5 to Martin County line)	$ 2,397,415	$ 1,627,343	$ 770,072	1.47

Table 3-4 lists alternatives considered in the environmental assessment and summarizes the major features and consequences of the future without-project (No-action Plan); the existing dune and 10-foot berm extension, and the 10-foot dune extension (both less than the recommended plan); the Recommended Plan which is the existing dune and 20-foot berm extension; and the existing dune and 30-40-foot berm (both greater than the recommended plan). As noted in the table, the effects are similar for all alternatives, except for minor differences in magnitude of effect, and therefore only the recommended plan is carried forward for detailed analysis in Chapter 5.

Costs were developed by SAJ District Cost Engineering personnel in FY17 dollars. Benefits are in FY17 discount rate.

Table 3-4. Summary of Direct and Indirect Impacts.

ALTERNATIVE ENVIRONMENTAL FACTOR	10-foot Dune OR 10-foot Berm (smaller footprint than Recommended Plan)	20-foot Berm (Recommended Plan)	30-foot Berm OR 40-foot Berm (greater footprint than Recommended Plan)	No-Action Plan
GENERAL ENVIRONMENTAL SETTING (refer to Sections 2.1 and 5.1.1)	Increased protection of infrastructure as well as creation of additional beach habitat. Temporary adverse effects including, but not necessarily limited to sea turtles, benthic resources, aesthetics, and noise. Minor magnitude and duration changes with each berm width alternative. Effects would be slightly less than the Recommended Plan.	Increased protection of upland infrastructure as well as creation of additional habitat. Temporary adverse effects including, but not necessarily limited to sea turtles, benthic resources, aesthetics, and noise.	Increased protection of upland infrastructure as well as creation of additional beach habitat. Temporary adverse effects including, but not necessarily limited to sea turtles, benthic resources, aesthetics, and noise. Minor magnitude and duration changes with each berm width alternative. Effects would be slightly greater than the Recommended Plan.	Loss of beach habitat from continuing erosion. (Other factors such as sea level rise would affect the general environmental setting).
Vegetation (refer to Sections 2.2.1 and 5.1.2)	Reduced erosion and reduced loss of dune vegetation. Minor magnitude and duration changes with each berm width alternative. Effects would be slightly less than the Recommended Plan.	Reduced erosion and reduced loss of dune vegetation.	Reduced erosion and reduced loss of dune vegetation. Minor magnitude and duration changes with each berm width alternative. Effects would be slightly greater than the Recommended Plan.	Continued erosion of the beach and dune would result in the loss of vegetation. Additional landowners may install armoring measures which would alter the remaining dune system and displace vegetation.
FISH AND WILDLIFE RESOURCES (refer to Sections 2.2.2 and 5.1.3)	Beach placement would temporarily impact fish and wildlife species that utilize the beach placement area. Minor magnitude and duration changes with each berm width alternative. Effects would be slightly less than the Recommended Plan.	Beach placement would temporarily impact fish and wildlife species that utilize the beach placement area.	Beach placement would temporarily impact fish and wildlife species that utilize the beach placement area. Minor magnitude and duration changes with each berm width alternative. Effects would be slightly greater than the Recommended Plan.	Species that utilize the beach may decrease in number due to erosion. No changes in fish and wildlife resources that occur below the swash zone are anticipated.

ALTERNATIVE ENVIRONMENTAL FACTOR	10-foot Dune OR 10-foot Berm (smaller footprint than Recommended Plan)	20-foot Berm (Recommended Plan)	30-foot Berm OR 40-foot Berm (greater footprint than Recommended Plan)	No-Action Plan
SEA TURTLES (refer to Sections 2.2.3 and 5.1.4)	Dredging and beach placement activities may affect sea turtles. Minor magnitude and duration changes with each berm width alternative. Protective measures would be implemented. Effects would be slightly less than the Recommended Plan.	Dredging and beach placement activities may affect sea turtles. Protective measures would be implemented.	Dredging and beach placement activities may affect sea turtles. Minor magnitude and duration changes with each berm width alternative. Protective measures would be implemented. Effects would be slightly greater than the Recommended Plan.	Beach erosion would result in less nesting habitat. An increase in armoring would also result in less nesting habitat.
MANATEE (refer to Sections 2.2.3 and 5.1.4)	Dredging operations may affect, but are not likely to adversely affect the manatee. Minor magnitude and duration changes with each berm width alternative. Protective measures would be implemented. Effects would be slightly less than the Recommended Plan.	Dredging operations may affect, but are not likely to adversely affect the manatee. Protective measures would be implemented.	Dredging operations may affect, but are not likely to adversely affect the manatee. Minor magnitude and duration would change with each berm width alternative. Protective measures would be implemented. Effects would be slightly greater than the Recommended Plan.	No effect.
SMALLTOOTH SAWFISH (refer to Sections 2.2.3 and 5.1.4)	Dredging operations may affect, but are not likely to adversely affect the sawfish. Minor magnitude and duration changes with each berm width alternative. Protective measures would be implemented. Effects would be slightly less than the Recommended Plan.	Dredging operations may affect, but are not likely to adversely affect the sawfish. Protective measures would be implemented.	Dredging operations may affect, but are not likely to adversely affect the sawfish. Minor magnitude and duration changes with each berm width alternative. Protective measures would be implemented. Effects would be slightly greater than the Recommended Plan.	No effect.

ALTERNATIVE ENVIRONMENTAL FACTOR	10-foot Dune OR 10-foot Berm (smaller footprint than Recommended Plan)	20-foot Berm (Recommended Plan)	30-foot Berm OR 40-foot Berm (greater footprint than Recommended Plan)	No-Action Plan
PIPING PLOVER AND RUFA RED KNOT (refer to Sections 2.2.3 and 5.1.4)	Beach placement operations may affect, but are not likely to adversely affect the plover and knot. Minor magnitude and duration changes with each berm width alternative. Protective measures would be implemented. Effects would be slightly less than the Recommended Plan.	Beach placement operations may affect, but are not likely to adversely affect the plover and knot. Protective measures would be implemented.	Beach placement operations may affect, but are not likely to adversely affect the plover and knot. Minor magnitude and duration changes with each berm width alternative. Protective measures would be implemented. Effects would be slightly greater than the Recommended Plan.	Beach erosion would result in less habitat for piping plovers and rufa red knots.
WHALES (refer to Sections 2.2.3 and 5.1.4)	Dredging operations within offshore borrow sites may affect, but are not likely to adversely affect whales. Minor magnitude and duration changes with each berm width alternative. Protective measures would be implemented. Effects would be slightly less than the Recommended Plan.	Dredging operations within offshore borrow sites may affect, but are not likely to adversely affect whales. Protective measures would be implemented.	Dredging operations may affect, but are not likely to adversely affect whales. Minor magnitude and duration changes with each berm width alternative. Protective measures would be implemented. Effects would be slightly greater than the Recommended Plan.	No effect
BEACH JAQUEMONTIA (refer to Sections 2.2.3 and 5.1.4)	Beach placement operations may affect, but are not likely to adversely affect the beach jacquemontia. Minor magnitude and duration changes with each berm width alternative. Protective measures would be implemented. Effects would be slightly less than the Recommended Plan.	Beach placement operations may affect, but are not likely to adversely affect the beach jaquemontia. Protective measures would be implemented.	Beach placement operations may affect, but are not likely to adversely affect the beach jacquemontia. Minor magnitude and duration changes with each berm width alternative. Protective measures would be implemented. Effects would be slightly greater than the Recommended Plan.	Dune erosion would result in less habitat for beach jacquemontia.

ALTERNATIVE ENVIRONMENTAL FACTOR	10-foot Dune OR 10-foot Berm (smaller footprint than Recommended Plan)	20-foot Berm (Recommended Plan)	30-foot Berm OR 40-foot Berm (greater footprint than Recommended Plan)	No-Action Plan
HARDBOTTOM HABITAT (refer to Sections 2.2.4 and 5.1.5)	Dredging and beach placement would not exceed previous impacts to nearshore habitat. Mitigation for previous impacts to hardbottom has been successfully completed.	Dredging and beach placement would not exceed previous impacts to nearshore habitat. Mitigation for previous impacts to hardbottom has been successfully completed.	Dredging and beach placement would not exceed previous impacts to nearshore habitat. Mitigation for previous impacts to hardbottom has been successfully completed.	No effect.
ESSENTIAL FISH HABITAT (refer to Sections 2.2.5 and 5.1.6)	Dredging and beach placement would directly affect EFH. Minor magnitude and duration changes with each berm width alternative. Mitigation for previous impacts to hardbottom has been successfully completed. Effects would be slightly less than the Recommended Plan.	Dredging and beach placement would directly affect EFH. Mitigation for previous impacts to hardbottom has been successfully completed.	Dredging and beach placement would directly affect EFH. Minor magnitude and duration changes with each berm width alternative. Additional surveys to determine impacts to EFH may be required. Effects would be slightly greater than the Recommended Plan.	No effect.
OFFSHORE BORROW AREA SOURCES (refer to Sections 2.2.6 and 5.1.7)	Dredging of St. Lucie Shoals would directly affect bottom habitat. Minor magnitude and duration changes with each berm width alternative. Effects would be slightly less than Recommended Plan.	Dredging of St. Lucie Shoals would directly affect bottom habitat. Protective measures would be implemented.	Dredging of St. Lucie Shoals would directly affect bottom habitat. Minor magnitude and duration changes with each berm width alternative. Effects would be slightly greater than Recommended Plan.	No effect.
COASTAL BARRIER RESOURCES (refer to Sections 2.2.7 and 5.1.8)	Additional beach habitat would be created. Federal funds within Unit P 11 would be expended in accordance with the USFWS determination (see USFWS letter dated November 2, 2016 in Appendix H: Pertinent Correspondence).	Additional beach habitat would be created. Federal funds within Unit P 11 would be expended in accordance with the USFWS determination (see USFWS letter dated November 2, 2016 in Appendix H: Pertinent Correspondence).	Additional beach habitat would be created. Federal funds within Unit P 11 would be expended in accordance with the USFWS determination (see USFWS letter dated November 2, 2016 in Appendix H: Pertinent Correspondence).	No effect.

ALTERNATIVE ENVIRONMENTAL FACTOR	10-foot Dune OR 10-foot Berm (smaller footprint than Recommended Plan)	20-foot Berm (Recommended Plan)	30-foot Berm OR 40-foot Berm (greater footprint than Recommended Plan)	No-Action Plan
WATER QUALITY (refer to Sections 2.2.8 and 5.1.9)	Dredging and beach placement would temporarily impact water quality. Minor magnitude and duration changes with each berm width alternative. Water quality would be monitored and protection measures implemented. Effects would be slightly less than the Recommended Plan.	Dredging and beach placement would temporarily impact water quality. Water quality would be monitored and protection measures implemented.	Dredging and beach placement would temporarily impact water quality. Minor magnitude and duration changes with each berm width alternative. Water quality would be monitored and protection measures implemented. Effects would be slightly greater than the Recommended Plan.	No effect.
HAZARDOUS, TOXIC, RADIOACTIVE WASTE (HTRW) (refer to Sections 2.2.9 and 5.1.10)	Encountering HTRW would not be anticipated.	Encountering HTRW is not anticipated.	Encountering HTRW would not be anticipated.	No effect.
AIR QUALITY (refer to Sections 2.2.10 and 5.1.11)	Slight increase in air pollution would be predicted. Minor magnitude and duration changes with each berm width alternative. Effects would be slightly less than the Recommended Plan.	Slight increase in air pollution is predicted.	Slight increase in air pollution is predicted. Minor magnitude and duration changes with each berm width alternative. Effects would be slightly greater than the Recommended Plan.	No effect.
NOISE (refer to Sections 2.2.11 and 5.1.12)	Construction noise levels would comply with local regulations. Construction noise would not be anticipated to exceed 55 dBA at noise sensitive areas. Minor magnitude and duration changes with each berm width alternative. Effects would be slightly less than the Recommended Plan.	Construction noise levels would comply with local regulations. Construction noise is not anticipated to exceed 55 dBA at noise sensitive areas.	Construction noise levels would comply with local regulations. Construction noise would not be anticipated to exceed 55 dBA at noise sensitive areas. Minor magnitude and duration changes with each berm width alternative. Effects would be slightly greater than the Recommended Plan.	No effect.

ALTERNATIVE ENVIRONMENTAL FACTOR	10-foot Dune OR 10-foot Berm (smaller footprint than Recommended Plan)	20-foot Berm (Recommended Plan)	30-foot Berm OR 40-foot Berm (greater footprint than Recommended Plan)	No-Action Plan
AESTHETICS (refer to Sections 2.2.12 and 5.1.13)	Beach placement would temporarily impact aesthetics. Minor magnitude and duration changes with each berm width alternative. Effects would be slightly less than the Recommended Plan.	Beach placement would temporarily impact aesthetics.	Beach placement would temporarily impact aesthetics. Minor magnitude and duration changes with each berm width alternative. Effects would be slightly greater than the Recommended Plan.	Continued beach erosion would adversely affect aesthetics.
RECREATION (refer to Sections 2.2.13 and 5.1.14)	Beach placement would temporarily impact recreation. Minor magnitude and duration changes with each berm width alternative. Effects would be slightly less than the Recommended Plan.	Beach placement would temporarily impact recreation.	Beach placement would temporarily impact recreation. Minor magnitude and duration changes with each berm width alternative. Effects would be slightly greater than the Recommended Plan.	Beach erosion would result in less recreational area.
CULTURAL RESOURCES (refer to Sections 2.2.14 and 5.1.15)	Dredging would not adversely affect cultural resources with protective buffers in place. Beach placement would have no effect.	Dredging would not adversely affect cultural resources with protective buffers in place. Beach placement would have no effect.	Dredging would not adversely affect cultural resources with protective buffers in place. Beach placement would have no effect.	No effect.
NATIVE AMERICANS (refer to Sections 2.2.15 and 5.1.16)	The Seminole Tribe of Florida have concurred with USACE determination of no effect.	The Seminole Tribe of Florida have concurred with USACE determination of no effect.	The Seminole Tribe of Florida have concurred with USACE determination of no effect.	No effect.

*All alternatives include maintenance of the existing (2008) dune.

3.10 THE RECOMMENDED PLAN

Typically, the NED plan becomes the Recommended Plan unless the non-federal sponsor opts to pursue a Locally Preferred Plan (LPP) which differs from the NED plan. An LPP is subject to the requirements described in ER 1105-2-100. The option of selecting an LPP was coordinated with the local sponsor, who opted not to pursue an LPP. The NED plan therefore is the Recommended Plan.

The 20-foot berm (7 ft-NAVD88) and maintenance of the existing dune is the Recommended Plan. The average initial construction volume over 100 Beach-fx iterations is 422,000 cubic yards (cy). The average volume of individual future periodic nourishments over 100 iterations is 390,000 cubic yards (cy).

Beach-fx reaches correspond, approximately, with FDEP range monuments (R-monuments). The shoreline extent of the Recommended Plan corresponds to a shoreline length spanning from R-monument R-98.5 to the Martin County Line (approximately R-115 plus 1000 feet). A detailed description of the Recommended Plan is included in the next chapter.

3.10.1 INCREMENTAL JUSTIFICATION OF THE RECOMMENDED PLAN

Model Reaches versus Geographic Reaches

Model reaches are 1000 feet long, centered on an R-monument. Therefore, model reach R-99 encompasses geographic reach R-98.5 to R-99.5.

Incremental analysis has been incorporated in the plan formulation process. The original project included the entire reach from R-97.5 to the Martin County line. During the incremental analysis, geographic location R-97.5 to R-98.5 (model reach 98) was not economically justified. Due to its location at the end of the project, and incidental length, R-97.5 to R-98.5 is not included in the full project length, and the project northern boundary is now geographic location R-98.5.

The nature of beach and dune nourishment is that performance of the project as a whole depends on the overall volume of sand placed and the dimensions of the placement. It is difficult to further divide the remaining segment (from R-98.5 to R-115) due to potential negative impacts on the overall project however to determine incremental justification of the Recommended Plan.

As defined in Engineering Regulation (ER) 1105-2-100, incremental analysis is a process used in plan formulation to help identify plans that deserve further consideration in an efficient manner. The analysis consists of examining increments of plans or project features to determine their incremental costs and incremental benefits. Increments of plans continue to be added and evaluated as long as the incremental benefits exceed the incremental costs. The recommended plan was divided into three planning reaches for the incremental analysis.

On a long, straight sandy coast like the project area, it is assumed that a project of less than approximately one mile of shoreline length would not be implemented as a separate action or project. Therefore, the recommended plan area was divided into three planning reaches of roughly one mile. **Table 3-5** shows that each planning reach has positive net benefits, demonstrating that each is incrementally justified and recommended.

Table 3-5. Incremental Justification.

Geographic Planning Reach #	Model Reach #	Primary Benefits	Recreation Benefits	Certified Placement Cost	Net Benefits (without rec)	BCR (without Rec)	Net Benefits (with Rec)	BCR (With Rec)
R-98.5-R-104.5	R-99 to R-104	$126,888	$159,520	$197,818	($70,930)	0.64	$88,590	1.45
R-104.5 – R-110.5	R-105-R-110	$248,645	$130,173	$199,771	$48,873	1.24	$179,046	1.90
R-110.5-R-115	R-111-R-115	$2,024,080	$275,978	$178,272	$1,845,808	11.35	$2,121,786	12.90

***Plus 1000 feet to the Martin County line.**

4 The Recommended Plan

4 RECOMMENDED PLAN

The recommended plan for St. Lucie County is a protective berm that extends the entire (2008) beach profile (7 ft-NAVD88) 20 feet seaward from the toe of the existing dune. The project construction reference line was established based on the 2008 "existing" dune and profile survey. The elevation of the construction reference line is a consistent +7 ft-NAVD88 (the nourishment template berm elevation). This will include restoration and/or leveling of the 2008 dune behind the construction reference line as well as extension of the berm.

The average initial construction volume over 100 iterations is 422,000 cubic yards (cy). The average volume of each future periodic nourishment over 100 iterations is 390,000 cubic yards (cy). It is important to clarify that the placed volume will be referenced throughout this report; however, the dredged volume is notably important as well for coordination of sand sources. The dredged volume is estimated to be 30% greater than the placement volume.

Traditionally, in CSRM studies, a fixed periodic nourishment interval is defined and optimized for 50 year period of Federal participation. In Beach-fx, rather than having a fixed periodic nourishment interval, periodic nourishment events are triggered when specific criteria are met. The triggers were set up to simulate a point at which the berm extension erodes to at least half its equilibrated width. Based on these parameters, the average time interval between nourishment events over all 100 iterations is 18 years. In reality, this interval could vary significantly depending on erosion and storm events. More information about the periodic nourishment triggers is provided in the Engineering Appendix. Ultimately, planning based on life-cycle modeling results in plans that are more resilient and adaptable. Life-cycle modeling allows planners to design projects while recognizing the inherent uncertainty that exists when future events are simulated.

Beach-fx reaches correspond, approximately, with FDEP range monuments (R-monuments). The shoreline extent of the recommended plan, ABerm20DuneEx from Beach-fx corresponds to a shoreline length spanning from R-monument R-98.5 to the Martin County line (approximately R-001).

The economic results presented in this chapter reflect incorporation of storm damage reduction, land loss and recreation benefits, interest during construction (IDC) and operations, maintenance, repair, rehabilitation, and replacement (OMRR&R), as well as the refined costs in the Total Project Cost Summary (TPCS) found in **Appendix B – Cost Engineering and Risk Analysis**. Therefore the cost and economic results presented here will differ slightly from the values presented in previous chapters. A description of the recommended plan is shown in **Table 4-1.**

Table 4-1. Description of the Recommended Plan.

Recommended Plan Description	The Recommended Plan includes:
Average # Nourishment Events	1 initial construction event, approximately 2 periodic nourishment events
Average Volume of Initial Construction	422,000 cubic yards
Average Volume of Each Periodic Nourishment	First nourishment: 390,000 cubic yards Second nourishment: 390,000 cubic yards
Average Periodic Nourishment Interval	approximately 18 years
Initial Construction Duration	approximately 4 months
Recommended Plan project first cost (including contingency)	$ 53,296,000 (October 1, 2017 (FY18) Price Level)
Cost sharing	Initial construction: 35% Federal / 65% non-federal Periodic nourishments: 27% Federal / 73% non-federal
Benefit-to-Cost Ratio (BCR)	2.20 @ 2.875% discount rate (FY17))

4.1 PROJECT DESIGN

The project design can be described by three factors: the dimensions of the dune, dimensions of the berm, and shoreline slopes.

4.1.1 PROJECT DUNE

Existing dune elevations in the Recommended Plan area are between 11 and 14 feet NAVD88 (Table 4-2). Evaluation of the design alternatives has shown that the existing elevations, when combined with berm and/or dune extension, provide sufficient protection. Therefore, no additional elevation is included in the selected design plan.

Table 4-2: Generalized Dune Characteristics of the Recommended Plan Area.

R monuments	Dune Height (ft-NAVD88)	Dune Width (ft.)
R-98.5 to R-102	11	55
R-103 to R-104	11	50
R-105 to R-106	11	120
R-107 to R-110	11	40
R-111	11	60
R-112	14	25
R-113 to Martin County	13	50

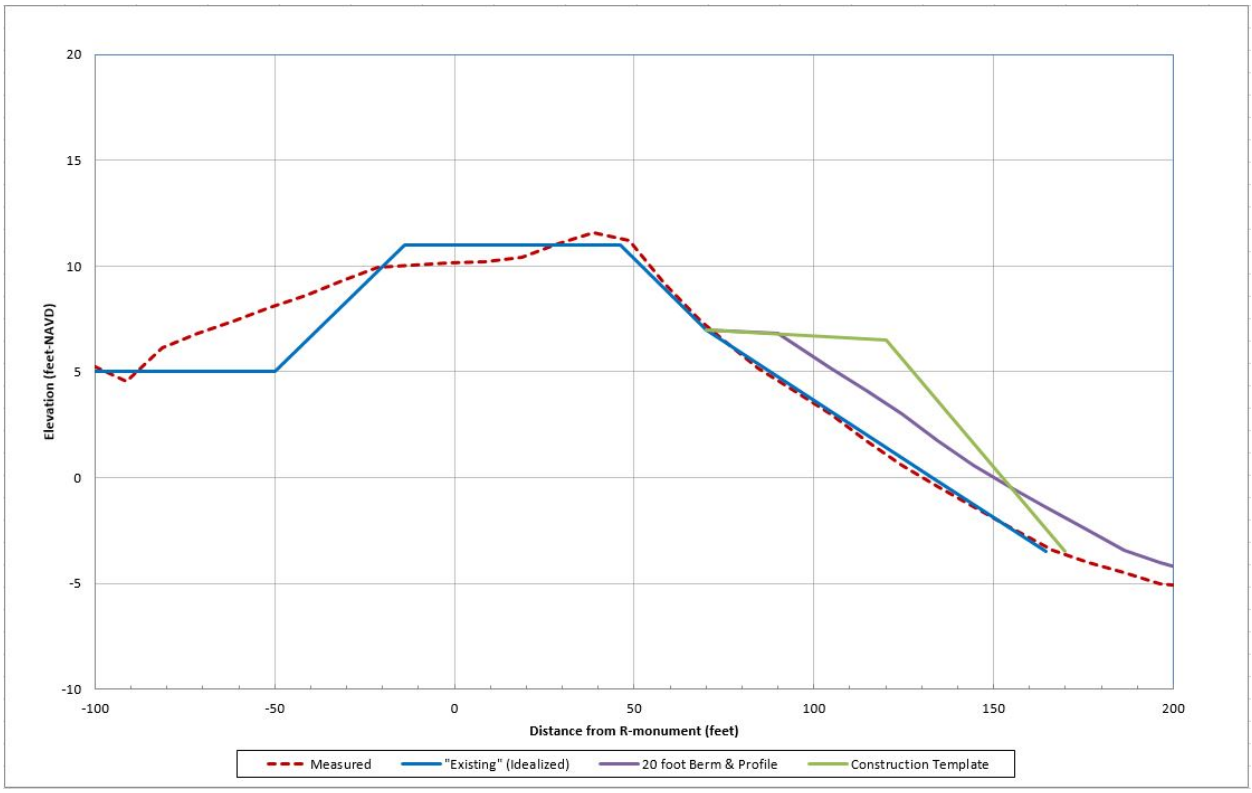
Within the area encompassed by the Recommended Plan, the average dune width ranges between 25 feet and 120 feet. Although the Recommended Plan does not include widening the existing dune, any erosion of material from the existing idealized dune template (i.e. the 2008 generalized profile) will be replaced during nourishment events. Therefore, the existing 2008 idealized dune template will be restored accordingly during initial construction and periodic nourishment of the project and is noted as an important feature of the project.

4.1.2 PROJECT BERM

The design berm elevation for the project area is 7 feet NAVD88, which is approximately at the natural berm elevation.

The project berm template consists of 20 feet of sacrificial fill (traditionally referred to as "advance" fill) designed to protect and maintain the existing dune between periodic nourishment events.

Figure 4-1: Existing profile and nourishment template for R-100 to R-111.



4.1.3 PROJECT BEACH SLOPES

After waves adjust and sort the placed sand, the sand is expected to settle into an equilibrium beach slope, similar to the native beach. In St. Lucie County, the native beach slopes in the project area are approximately 1 (vertical) on 6 (horizontal) at the dune, 1 on 10 from the berm to MLW (-2.5 ft-NAVD88), and 1 on 40 to 1 on 70 below MLW. The estimate of the slope of the material after adjustment is based on averaging the beach profile slopes of the native beach from the mean low water datum to the approximate location of the 15-foot depth contour. Sand from the project borrow site was determined to be a near match to the gradation and shell content of the existing beach. This will allow the beach fill to equilibrate to a shape similar to the existing profile.

It is unnecessary and impractical to artificially grade beach slopes below the low water elevation since they will be shaped by wave action. For this reason, the front slope of the beach fill placed at the time of

construction or future periodic nourishment may differ from that of the natural profile. The angle of repose of the hydraulically placed material depends on the characteristics of the fill material and the wave climate in the project area. With steep initial slopes, the material will quickly adjust to the natural slopes.

4.1.4 PROJECT VOLUMES

The average initial construction volume over 100 Beach-fx iterations is 422,000 cubic yards (cy). The average volume of individual future periodic nourishments over 100 iterations is 390,000 cubic yards (cy). It should be emphasized that these are average volumes based on Beach-fx modeling. The Engineering Appendix includes detailed description on how these averages are reached and the variability that can be expected.

4.1.5 PROJECT CONSTRUCTION

The Recommended Plan for St. Lucie County results in a protective berm that extends the entire (2008) beach profile (7 ft-NAVD88 to depth of closure) 20 feet seaward from the existing dune. Due to erosion, foot traffic, and intermittent repairs and maintenance, the project shoreline does not have a smooth, consistent dune feature. In order for the nourishment project to provide the maximum benefit and perform as predicted during the Beach-fx shoreline analysis, it is necessary to establish a smooth, relatively straight base construction reference line and to ensure that the dune is free of gaps and low points that would allow storm surge to penetrate at elevations inconsistent with the representative dune height(s) specified for the model reaches.

As previously discussed, the front slope of the beach fill placed at the time of construction, or future periodic nourishment, may differ from that of the natural profile. This reflects the capabilities of the construction equipment that will be used to build the coastal storm risk management project. Within the first year or two after placement of the beach fill, the construction profile will be reshaped by waves into an equilibrium profile, causing the berm to retreat to a position more characteristic of the project design template.

Based on the estimated average initial fill volume and constructability considerations, a construction template applicable to ABerm20DuneEx was determined. The construction template consists of a variable width berm with a 1 on 100 slope and foreshore fill extending to approximately -5.0 ft-NAVD88 with a slope of 1 on 5. This template, dimensioned for constructability, will then equilibrate into the project (20-foot berm and profile extension) template. The volume of material in the equilibrated profile (between the template and the “existing” condition) represents the material that is expected to erode between successive nourishment events.

4.1.6 PERIODIC NOURISHMENT EVENTS

As stated, the Recommended Plan includes a 20-foot berm extension of the existing berm, and maintenance of the existing dune.

Traditionally, periodic nourishment events take place based on both an economically optimized periodic nourishment interval and the physical performance of the project. Project performance, in the past, has been determined by assessing the condition of the design template. Should the design template be breached, the project is no longer providing the required level of protection and is considered for periodic nourishment. Part of this consideration is how close the project may be to the designated periodic nourishment interval.

While the basic principles of periodic nourishment still apply, due to the probabilistic nature of Beach-fx and the way in which the model assesses periodic nourishment requirements, a new means of assessing project performance must be employed. The former concepts of "design template" and "advance fill" are only loosely applicable. The entire 20-foot berm and beach profile extension template acts as the "advance fill", while the existing beach profile is the minimum acceptable profile (making it akin to what was formerly the "design template").

Assessing the performance of the project fill now has two stages. First, a survey of the project area (such as a monitoring or post-storm survey) will be assessed to determine if the shoreline at any of the R-monument locations within the project have receded past the pre-project (2008) condition. If recession beyond the pre-project condition has occurred at one or more of the R-monuments, then a summation of the volume required to restore those profiles to the initial construction template will be made. If the total volume required to restore the receded profiles exceeds the threshold volume (280,000 cubic yards), then a periodic nourishment event is recommended. The decision to periodically nourish may then be made based on traditional concerns, including such factors as budget cycle and available funding.

With an average time interval of 18 years, the nourishment years would be 2020 for initial construction, followed by periodic nourishment in 2038 and 2056.

4.1.7 PROJECT MONITORING

Physical monitoring of the recommended project is necessary to assess project performance and to ensure that project functionality is maintained throughout the 50-year period of Federal participation in the project. The monitoring plan will be directed primarily toward accomplishing systematic measurements of the beach profile shape. Profile surveys should provide accurate assessments of dune and beach fill volumes and a basis for assessing post-construction dune and beach fill adjustments, as well as variation in the profile shape due to seasonal changes and storms. Monitoring will play a vital role in determining if project periodic nourishment is necessary. Post construction monitoring activities include topographic and bathymetric surveys of the placement area and adjacent areas on an annual basis for 3 years following construction and then biannually until the next construction event. Other monitoring efforts include bathymetric surveying of the sand source, which will be done prior to each periodic nourishment. Measured wind, wave, and water level information will be obtained from the best available existing data sources. This data will be applied in support of previously discussed monitoring efforts. It will also be used to periodically assess the state of sea level rise and to determine if reassessment of the project volumes and/or periodic nourishment intervals is required.

4.1.8 OPERATIONS AND MAINTENANCE CONSIDERATIONS

33 U.S. Code § 426e (Federal aid in protection of shores) states, "When in the opinion of the Chief of Engineers the most suitable and economical remedial measures would be provided by periodic beach nourishment, the term "construction" may be construed for the purposes of sections 426e to 426h–1 of this title to include the deposit of sand fill at suitable intervals of time to furnish sand supply to project shores for a length of time specified by the Chief of Engineers." By this provision, periodic nourishment is considered construction and not maintenance, and therefore is cost shared. The Recommended Plan involves initial construction and periodic nourishment, and is technically "beach nourishment." Physical (topographic and bathymetric) and environmental surveys supporting beach nourishment are cost-shared activities included in the total project cost. The operations, maintenance, repair, rehabilitation, and

replacement (OMRR&R) anticipated for this project includes any necessary long-term topographic and bathymetric surveys (different from those supporting beach nourishment activities) of the placement area and adjacent areas, and a monitoring report on an annual basis for 3 years following construction and then biannually until the next construction event. Other OMRR&R items may include revegetating the dune as needed between nourishment activities (per Policy Guidance Letter No. 27 (11/17/92)), scarp repair, and beach tilling. The operations and maintenance will also include the items of local cooperation. These items entail publicizing floodplain information, ensuring continued conditions of public ownership and use of the shore, performing surveillance of the beach, and any specific directions prescribed by the government. Based on the size and scope of the Recommended Plan and the cost of similar activities for similar projects, the annual average costs for OMRR&R are estimated to be $32,245 per year.

Operations and maintenance is borne 100% by the non-federal sponsor and is detailed in a Project Partnership Agreement (PPA). An Operations and Maintenance Manual will be completed by USACE and provided to the sponsor following completion of initial construction.

4.2 RECOMMENDED SAND SOURCE

The recommended plan will require approximately 1,202,400 cubic yards of sand over a 50 year period. The initial construction volume of 422,000 [20] cubic yards and the periodic nourishment volume is 390,000 cubic yards every 18 years on average.

As detailed in the **Geotechnical Appendix**, there is adequate beach quality sand (meeting FDEP permitting requirements for beach placement) to meet the estimated sand needs of the recommended plan. Currently, there is approximately 10.6 million cubic yards of compatible sand available within the St. Lucie Shoals, which is composed of the north and south shoals (8.3 million in the north and 2.3 million in the south). This volume is more than adequate to meet the average total forecasted project volume.

4.3 SEA LEVEL CHANGE CONSIDERATIONS

An important aspect about the recommended plan is its performance under different Sea Level Change scenarios. As discussed earlier in this report, the study area is experiencing Sea Level Rise (SLR). Each of the SLR scenarios described earlier are considered equally likely to occur. Therefore, if the project does not perform, then it cannot be considered a completely effective plan. **Table 4-3** shows the average BCRs and net benefits of the NED recommended plan under the three SLR scenarios. As shown below, the recommended plan performs satisfactorily in each SLR scenario.

[20] Note that these volumes are from Beach-fx and are approximate averages, due to the probabilistic nature of the model (randomly generated storm seasons over the life of the project). Volumes needed could me slightly more or less over the life cycle of the project. The Engineering Appendix, Table 6-2, provides a discussion of the project volume breakdown and confidence interval information.

Table 4-3. Average PV Benefits and Costs for the recommended plan in different SLR scenarios.

	Nourishment Interval (Years)	Total Cost	Total Benefits	Net Benefits	BCR
Base -SLR1	19	$ 1,314,927	$ 2,165,474	$ 850,547	1.65
Intermediate - SLR2	7	$ 2,729,218	$ 7,098,469	$ 4,369,251	2.60
High - SLR3	4	$ 5,169,728	$ 16,546,952	$ 11,377,224	3.20

4.4 BENEFITS OF THE RECOMMENDED PLAN

4.4.1 ECONOMIC SUMMARY

St. Lucie County is highly susceptible to hurricane and storm damage. This is particularly true for the large and high-value commercial structures and more pronounced in the southern section of the project area. Beach-fx modeling has demonstrated that, in the absence of a Federal project, significant economic damage from coastal forces can be expected to occur over the next 50 years. When factoring in the potential for sea levels to rise in excess of baseline projections those economic damages could average almost half of a billion dollars in present-value terms.

The model results suggest that the recommended plan is highly effective at reducing nearly all damages, with primary economic benefits of the plan generated by reductions in erosion, wave, and inundation damages. The recommended plan is effective in the following ways:

Types of Damages: The project will reduce the number of structure types that are receiving damage. In the FWOP, 20 different structure types were being damaged (reference the Economic Appendix) whereas under the recommended plan only six different structure types receive damage; residential property, roads, and all high-rise structure are notably not among those 6 categories.

Effective over time: The recommended plan is also effective over time and requires only two periodic nourishment events throughout the 50-year period of analysis of the project.

Conclusion: The recommended plan prevents 98% of economic damages across 50 years with only two periodic nourishments and nets $1,617,000 AAEQ worth of benefits. The project yields $2.20 in benefits for every $1.00 spent (i.e. BCR is 2.20). The plan is efficient, acceptable and complete. It is also increasingly efficient and resilient under sea level change scenarios. Though the recommended plan is relatively small in scope and scale, it represents the most prudent investment of Federal and sponsor dollars. The economic summary is shown in **Table 4-4.**

Table 4-4. Economic Summary in AAEQ of the Recommended Plan. (FY17 Price level and FY17 Water Resources Discount rate (2.875%).

ECONOMIC SUMMARY	STORM RISK MANAGEMENT BENEFITS ONLY	STORM RISK MANAGEMENT + LAND LOSS BENEFITS (PRIMARY)	STORM RISK MANAGEMENT + LAND LOSS + RECREATION BENEFITS
Storm Risk Management Benefits	$2,165,000	$2,165,000	$2,165,000
Land Loss Benefits	$0	$234,000	$234,000
Recreation Benefits	$0	$0	$566,000
Total Benefits	$2,165,000	$2,400,000	$2,965,000
Total Cost	$1,349,000	$1,349,000	$1,349,000
Net-Benefits	$817,000	$1,051,000	$1,617,000
Benefit Cost Ratio	**1.61**	**1.78**	**2.20**

4.4.2 LAND LOSS AND RECREATION BENEFITS

LAND LOSS BENEFITS

In outlining the process and procedures to be used in the evaluation of coastal storm risk management projects, ER-1105-2-100 mentions the inclusion of land loss due to erosion, stating that such damages should be computed as the market value of the average annual area expected to be lost. Prevention of land loss is a component of primary storm damage reduction benefits but is not computed within the Beach-fx model. Thus, calculation of land loss benefits must be completed external to the model and added to the structure and contents damage benefits to obtain the total storm damage reduction benefits of the project.

Following the guidance provided, two key pieces of information are needed to calculate land loss benefits of a storm damage reduction project: (1) the square footage of the land lost each year and (2) the market value of land in the project footprint. The Economics Appendix provides detail on how the square footage of land loss each year was calculated. As the second component of the land loss benefits calculation, ER 1105-2-100 instructs that nearshore land values be used to estimate the value of land lost. The Jacksonville District Real Estate Department estimated a nearshore land value of $14.00 per square foot for the St. Lucie study area.

Using the analysis technique described, the total present value of land loss benefits over the 50 year period of analysis estimated at $234,000 AAEQ.

RECREATION BENEFITS

According to ER-1105-2-100, incidental recreation benefits can be calculated for Coastal Storm Risk Management (CSRM) projects. While recreation benefits cannot make up more than 50% of the total benefits needed for project justification, the guidance states, “if the criterion for participation is met, then all recreation benefits are included in the benefit to cost analysis.” Recreation benefits represent a vital component of a CSRM project and access for the public to use and recreate on the beach is the foundation for Federal interest in the project. Though recreation cannot be used for plan formulation, and though

the recommended plan is economically justified on primary benefits alone, recreation benefits play a significant role in increasing net-benefits.

Additionally, ER-1105-2-100 specifies that benefits arising from recreation opportunities created by a project be measured in terms of willingness to pay. As described in the **Economics Appendix**, the unit day value (UDV) method was used to calculate the incidental recreation benefit provided by the recommended plan resulting in an estimated total present value of recreation benefits of $565,000 AAEQ.

4.4.3 BENEFITS WITH REGARD TO THE FOUR P&G ACCOUNTS

As mentioned earlier in the Plan Formulation Rationale, the four accounts NED, RED, EQ and OSE are always used as criteria in formulation and selection of a plan. In this case, this particular plan not only has significant NED benefits, but also has a number of worthy considerations in the OSE category, as well as other points that should be made which were key in plan formulation or engineering for the entire reach of South Hutchinson Island. These points are listed and briefly summarized below:

- Plan Formulation Rationale:
    - Florida Department of Environmental Protection (FDEP) Designation of Critically Eroded: The entire increment of R-98 to Martin County has been identified as being critically by FDEP Report on Critically Eroded Beaches in Florida, Division of Water Resource Management, FDEP, June 2015.
    - Early screening of project reaches: The original project scope included a total of four FDEP designated reaches. During the plan formulation process, the northern most upper three reaches were screened out, leaving one reach, South Hutchinson Island, as the study scope.
- Engineering considerations:
    - Constructability – Constructing the full project reach benefits the project in terms of stability, and efficiency of construction methods. If a gap were to occur where Dollman Park is for a small stretch, tapers north and south would overlap, creating an inefficient construction method compared to a continuous stretch, involving the same volume of sand.
    - Sea level rise scenarios – The project gains effectiveness from a continuous stretch, when faced with not only baseline but increasing potential damages under a without-project condition in the intermediate and high scenarios.
- Evaluation criteria (OSE):
    - Importance of Evacuation Route – The overall project experiences prevents flooding on A1A, and protects the entire project length from a potential breach in the barrier island. Such a breach could cut off access north or south to the nearest evacuation route, rerouting residents for a delay of up to 20 miles.
    - Public Access – There is considerable public access and parking and in the Dollman Park area, which also transcends aesthetics and general accessibility for the public in the area to the rest of the project area.

- Amount of residents in northern extent: Despite the small length of a few thousand feet in the area of R-99 to R-101.5, this area contains five condominiums with upwards of 500 homeowners. A project over the entire reach protects these structures and homeowners who are vulnerable to hurricane and storm damages, under base, intermediate, and high sea level rise scenarios.

4.4.4 BENEFITS TO EVACUATION ROUTE STATE ROAD A1A

The recommended plan was modeled to obtain how effective it would be at preventing flooding of both one foot or more and two feet or more to Florida State Route A1A. The recommended plan was effective in achieving both of these goals since 0% of the iterations experienced flooding of either one or two feet. Thus, the recommended plan performs satisfactorily in keeping A1A accessible as an evacuation route.

4.5 FEDERAL IMPEMENTATION RESPONSIBILITIES

USACE is responsible for budgeting for the Federal share of future Federal construction projects. Federal funding is subject to budgetary constraints inherent in the formation of the national civil works budget in a given fiscal year. USACE would perform the necessary preconstruction engineering and design (PED) needed prior to construction. USACE would meet requirements for the use of Federal lands at the borrow area, obtain water quality certification, coordinate with the state as required by the Coastal Zone Management Act, and construct the project. Cost sharing of PED, initial construction, and periodic nourishment will be in accordance with WRDA 1986, as amended, subject to the availability of appropriations.

4.6 NON-FEDERAL IMPLEMENTATION RESPONSIBILITIES

The non-federal sponsor for the CSRM project will be St. Lucie County. The non-federal project sponsor would provide an up-front cash contribution for initial construction costs of the proposed project. The amount of the non-federal up-front cash contribution would be based on cost sharing principles reflecting shoreline use, ownership, and public access in existence at the time of construction. The non-federal sponsor shall provide the entire cost of all material placed on or seaward of private undeveloped lands and developed private lands (which are inaccessible to the public). The non-federal sponsor shall provide lands, easements, and rights-of-way and bear a portion of the administrative costs associated with land requirements. Other general non-federal responsibilities, such as continuing public use of the project beach, for which benefits are claimed in the economic justification of the project, and controlling water pollution to safeguard the health of bathers, must also be assumed by the non-federal sponsor before the project can be constructed. The non-federal project sponsor will be responsible for all costs of operation, maintenance, repair, rehabilitation, and replacement of project features. Section 402 of the 1986 Water Resources Development Act (33 USC 701b-12) as amended by Section 14 of the 1988 Water Resources Development Act, states that "Before construction of any project for local flood protection or any project for hurricane or storm damage reduction, that involves Federal assistance from the Secretary, the non-federal interests shall agree to participate in and comply with applicable Federal floodplain management and flood insurance programs." The non-federal sponsor and communities must be enrolled in, and in compliance with, the National Flood Insurance Program (NFIP) to receive Federal funding for a

recommended storm damage reduction project. St. Lucie County is enrolled in, and in compliance with, the NFIP.

4.7 RECOMMENDED PLAN COST

Cost-sharing percentages are based on ownership and use of parcels landward of where the full 20-foot equilibrated berm extension (and maintenance of the 2008 dune) will be placed. Parcels landward of the 1,000 foot tapers are not used to calculate cost sharing, but construction of the tapers will be cost shared in the calculated amount. For full Federal cost sharing, public access with adequate parking (or another way for the public to reach access, such as a public bus or beach shuttle) must be provided every ½ mile. There are currently 4 public access and parking sites within the recommended plan area, plus three additional access points created by St. Lucie County as of June 2017 which use existing parking (REF-3). **Figure 4-2** includes public access and parking locations for the Recommended Plan area, depicting the shoreline lengths that are covered by adequate public access and parking.

Figure 4-2. Public Access and Parking within the Recommended Plan Area.

The current cost share estimates are based on policy guidance provided by ER 1105-2-100, Appendix E and ER 1165-2-130. Cost sharing for this project is determined by section 103(c)(5)of WRDA 1986, which establishes a maximum cost share of 65% (Federal)/35% (non-Federal) for CSRM. This maximum initial cost sharing percentage is then subject to further considerations as described in Appendix F. To provide for other than the cost sharing established in section 103, statutory language directing a different cost sharing percentage would have been required. The WRDA of 1999 changed the cost sharing policy previously provided by WRDA 1986 by setting the non-federal share of periodic nourishment carried out after January 1, 2003 to 50% for projects authorized for construction after December 31st, 1999. Planting of dune vegetation following initial construction is cost shared with the Federal government. However, per Policy Guidance Letter No. 27 (11/17/92), the replacement of dune vegetation following periodic nourishment is a non-federal responsibility. **Table 4-5** shows the Federal and non-federal cost sharing for the Recommended Plan. Additional detail on how percentages were calculated is given in Appendix F. Changes to shoreline ownership and use prior to construction could change the stated cost sharing percentages. Cost sharing for initial construction is 35% Federal / 65% non-federal. Cost sharing for periodic nourishments is 27% Federal / 73% non-federal. **Table 4-5** includes approximately 150 feet of privately owned parcels within CBRS Unit P11. Federal expenditures for any alternative implementation, including beach nourishment, in this area would be prohibited by the CBRA due to the fact that such action could encourage development.

Table 4-5. Recommended Plan Cost Sharing.

	INITIAL CONSTRUCTION				PERIODIC NOURISHMENT		
Shore Ownership and Project Purpose (as defined in EC 1105-2-100)	Maximum Level of Federal Participation in Construction Costs	Shoreline Length (feet)	Length of Federal Participation (feet)	Length of non-Federal Participation (feet)	% of Federal Participation for Periodic Nourishment	Length of Federal Participation (feet)	Length of non-Federal Participation (feet)
I. Federally Owned	100%	0	0	0	100%	0	0
II. Publically and Privately Owned, Protection Results in Public Benefits							
A. Coastal Storm Risk Management (CSRM) on Developed Lands	65%	7,196	4,678	2,519	50%	3,598	3,598
B. CSRM on Undeveloped Public Lands	65%	2130	1,385	746	50%	1,065	1,065
III. Privately Owned, Use Limited to Private Interests (No public access within 1/4 mile)	0%	7,196	0	7,196	0%	0	7,196
IV. Privately owned, undeveloped	0%	626	0	626	0%	0	626
V. CBRA	0%	150	0	150	0%	0	150
	Total Distance:	17,299	6,062	11,237	Total Distance:	4,663	12,636
	Cost Shares:		35.0%	65.0%	Cost Shares:	27.0%	73.0%

4.8 RECOMMENDED PLAN COST SHARING

The current cost share estimates are based on policy guidance provided by ER 1105-2-100 Appendix E and ER 1165-2-130. The Water Resources Development Act (WRDA) of 1999 changed the cost sharing policy previously provided by WRDA 1986 by setting a maximum Federal share of periodic nourishment carried out after 1 January 2003 to 50% for projects authorized for construction after 31 December 1999.

The recommended plan total project cost including contingency is $53,296,000 (October 1, 2017 (FY18) Price Level). The **Cost Appendix** provides additional detail.

Table 4-6 shows the breakdown between initial project cost and periodic nourishments for each main project item for the recommended plan. **Table 4-7** shows the Federal and non-federal cost sharing for the recommended plan. Changes to shoreline ownership and use prior to construction could change the

stated cost sharing percentages. Cost sharing for initial construction is 35% Federal / 65% non-federal. Cost sharing for periodic nourishments is 27% Federal / 73% non-federal.

Table 4-6. Recommended Plan Cost Summary (Project First Cost, FY18 Price Levels).

		Initial Construction	Periodic Nourishments
WBS Code	**Item**	**Total Project First Cost (FY18)**	**Total Project First Cost (FY18)**
017	Mob/Demob	$4,303,000	$8,606,000
017	Beach Fill	$8,227,000	$15,046,000
017	Associated General Items	$1,235,000	$802,000
	Subtotal	$13,764,000	$24,454,000
01	Lands and Damages		
	- lands and damages		
	- administrative		
	-Federal Admin	$1,041,000	$47,000
	-non-federal Admin	$694,000	$31,000
30	PED	$1,492,000	$4,151,000
31	Construction Management	$2,012,000	$2,931,000
30	Post-Project Monitoring	$1,273,000	$1,406,000
			(x 2 periodic nourishments)
	Total Project First Cost	**$20,276,000**	**$33,020,000**
	Total Project Cost for 50 year period of Federal participation = $53,296,000		

Table 4-7. Recommended Plan Cost Sharing (Project First Cost, FY18 Price Levels).

St. Lucie County, FL CSRM Project					
Summary of Project Cost Sharing (Project First Costs) (FY18 Price Levels)					
R98.5 - R115+1000 feet (total placement area, with additional potential maximum tapers up to 1000 feet north and south)					
Initial Construction					
Item	Federal Cost Share	Federal Cost	Non-feder	Non-federal Cost	Project First Cost
Coastal Storm Risk Management Costs	35.0%	$7,097,000	65.0%	$13,179,000	$20,276,000
Non-federal LERRD Contribution*				$725,000	
Non-federal Cash Contribution***				$12,454,000	
Periodic Nourishments					
Periodic Nourishment**	27.0%	$8,915,000	73.0%	$ 24,105,000	$33,020,000
Initial Construction + Periodic Nourishments					
Final Project Cost Share and Cost (50 years)		$16,737,000		$36,559,000	$53,296,000
* Includes non-federal admin costs only. Non-federal LERRD contribution is not cost shared but is part of the Project First Cost. Displayed cost sharing percentages take this into account.					
**Per Policy Guidance Letter No. 27 (Nov. 17, 1992), the replacement of dune vegetation following periodic nourishment is a non-Federal responsibility. There is currently no cost for dune replanting in the periodic nourishment cost due to rationale that natural recruitment of seagrasses will occur.					
***A taper longer than 200 feet past R98.5 (northen project boundary) would extend into CBRS unit P11 and would change cost apportionment amounts due to the CBRA which would constitute no Federal cost sharing in that area (approx 750 feet). Taper length will be determined in PED and cost apportionment as affected will be refined at that time for initial nourishment and periodic nourishments.					

As public access and parking relates to Federal Interest, the sponsor is actively working with their contractor, and the liaison to the condominium association, to investigate ways to implement additional access and associated parking to reduce their cost share. Already as a part of their commitment, the sponsor has added three additional access points which use existing parking. The sponsor's intentions are documented in a letter by the sponsor sent on July 12, 2016. Future efforts could include potential expansion of city transit with additional bus stops at new public access locations or easements. The sponsor and their contractor have drafted a scope of work for this specific issue, which will be carried out in the upcoming weeks. While the sponsor's share is currently 65% (initial construction), preliminary estimates show that maximization of public access intervals and associated parking could potentially significantly decrease the non-federal share.

CBRS unit P11 has been taken into account for cost sharing purposes. There are three portions of P11 in the recommended plan area. The first is a portion of P11 for a length of approximately 750 feet in the potential taper area at the northern boundary of the project. If the taper extends beyond 200 feet north of R98.5, the cost sharing for this length would be allocated 100% non-federal sponsor cost due to the a. CBRS unit and b. privately developed parcel. This is noted in **Table 4-6** and if the taper extends into the CBRA, the cost sharing will be refined during Pre-construction, Engineering and Design (PED). The second portion of P11 is just north of Dollman Park for a length of approximately 150 feet. This portion will be 100% non-federally funded due to the presence of the CBRS unit. The third portion of P11 is within Dollman Park (for a length of approximately 1800 feet), which is publically owned by St. Lucie County. Coordination with USFWS indicates that this third portion, but not the second portion, is "exempt" from the CBRA under Section 6 because this is a public park where development is prohibited, and therefore Federal cost-sharing in this third portion could occur. Therefore, this length has been allocated 65% Federal cost sharing and 35% non-federal cost sharing, according to Appendix E from ER 1105-2-100 and ER 1165-2-130. More information on cost sharing can be found in the **Public Access and Cost Sharing Appendix.**

4.9 FINANCIAL ANALYSIS OF NON-FEDERAL SPONSOR'S CAPABILITIES

A financial analysis is required for any plan being considered for USACE 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 reasonable plans for meeting that commitment. By memorandum dated April 24, 2007, the Assistant Secretary of the Army (Civil Works), granted approval of the self-certification of non-federal sponsors for their ability to pay the non-federal share of projects. The self-certification is required prior to submission of the Project Partnership Agreement, typically during the PED phase of the project. Included with the self-certification, the financial analysis shall include 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.

4.10 VIEWS OF THE NON-FEDERAL SPONSOR

St. Lucie County is the non-federal sponsor for the Recommended Plan. They have been an integral part of the project team from the conception of the project. At each step of the process, St. Lucie

County has contributed to the available information, participated in the formulation, and reviewed the products. St. Lucie County fully supports the Recommended Plan.

4.11 RISK AND UNCERTAINTY

First, as an event-based Monte Carlo life-cycle simulation, Beach-fx fully incorporates risk and uncertainty to determine an optimized plan under many future scenarios. Second, a Cost Schedule Risk Analysis (CSRA) has been completed, which addresses risks to project implementation and construction. Based on the results of the analysis, the Jacksonville District recommends a contingency value of $11.9M or 28%. This contingency includes risks related to costs for the effect of schedule delay on overall project cost. There are no high risks associated with this project and remaining risks are typical of civil works projects, such as those related to quantity estimates or unforeseen environmental risks. In the future, the risks will continue to be assessed and managed in the design and construction phase of the project.

4.11.1 RESIDUAL RISK

The proposed project would greatly reduce, but not completely eliminate, future coastal storm risk and damages. Coastal storm damages, caused primarily by erosion, are reduced by approximately 98% (not including prevention of land loss) in the location of the recommended plan over the 50 year period of analysis; therefore, the residual damages would be 2% in this area. It is important to note that the volumes and damages discussed throughout the report are averages. The methods of monitoring and data assessment, while periodically revisiting sea level rise trends, described earlier will be crucial for adaptive management to manage risk.

The Recommended Plan will reduce damages but does not have a specific design level. In other words, the project is not designed to fully withstand a certain category of hurricane or a certain frequency storm event. During study scoping, it was determined that the vast majority of coastal storm risk is within 600 feet landward from dune line and therefore this boundary was set as the extent of the study area. As a result, the project is not claiming any benefits beyond this designation as damages to structures past this extent were not calculated. Notably, infrastructure on the backside of the barrier island on which the project area is located, although outside of the project area, are susceptible to impacts from sea level rise in the future. Structures within the project area would continue to be subject to damage from hurricane winds and windblown debris. Even new construction is not immune to damage, especially from these processes. The project purpose is coastal storm risk management, and the recommended plan is not designed to prevent loss of life. Public safety risks can be reduced by actions taken at the local, state, and Federal levels.

5 Effects of The Recommended Plan

5 EFFECTS OF THE RECOMMENDED PLAN*

This section is the scientific and analytic evaluation of effects that would result from implementing the Recommended Plan. Chapter 2 of this report provides information on existing conditions as well as effects resulting from the "no-action alternative," or the "Future Without-Project Conditions." **Table 3-4** provides a summary of direct and indirect effects of the final array of alternatives. The following section focuses on anticipated changes to the existing environment including direct, indirect, and cumulative effects as a result of the Recommended Plan, or the "Future With-Project Conditions."

5.1 NATURAL (GENERAL) ENVIRONMENT

5.1.1 GENERAL ENVIRONMENTAL EFFECTS

FUTURE WITH-PROJECT (RECOMMENDED PLAN)

In accordance with permits issued by the State of Florida and USACE, the non-federal sponsor has previously placed beach quality material from the designated offshore borrow site along this shoreline. The Recommended Plan proposes to continue to use the same borrow site and construct a smaller berm along a shorter reach of this same placement area. Impacts to hardbottom resources within this area have been previously mitigated by the sponsor.

The beneficial effects of continued sand nourishment along the proposed project area include establishing a larger buffer beach to protect upland infrastructure and populations against storms and flooding. Sand nourishment also creates additional habitat for beach flora and fauna as well as more space for recreational activities.

The proposed project would likely produce more favorable environmental conditions than exist at present, although construction operations would produce some temporary adverse effects. These effects would be primarily temporary in nature, and most affected resources would return to pre-construction conditions either immediately after dredging, with respect to resources such as aesthetics and noise, or within one or two years, with respect to sea turtle nesting and benthic resources.

5.1.2 VEGETATION

FUTURE WITH-PROJECT (RECOMMENDED PLAN)

The plan would result in minor, short-term impacts to herbaceous dune vegetation that inhabits the upper beach and foredune. Fill placement would not occur landward of the dune crest. The proposed beach restoration would help stabilize and protect the dune vegetative communities from storm surge and erosion. Adding sand to the system would promote further dune habitat development.

If needed, the plant community could be reestablished by planting a mix of native dune species that, depending on nursery availability, may include sea oats (*Uniola paniculata*), beach sunflower (*Helianthus debilis*), railroad vine (*Ipomoea pes-caprae*), and dune panic grass (*Panicum amarum*).

5.1.3 FISH AND WILDLIFE RESOURCES (OTHER THAN THREATENED AND ENDANGERED SPECIES)

FUTURE WITH-PROJECT (RECOMMENDED PLAN)

Effects that could potentially affect fish and wildlife resources include:

- Alteration (burial) of exposed nearshore hardbottom and associated epibenthos during and subsequent to nourishment activities.
- Disturbance of the sand bottom habitats and associated macroinfauna of the shoal borrow area and beach fill sites during nourishment activities.
- Modification of the St. Lucie Shoal feature.
- Turbidity.
- Underwater noise and vibration from dredging activities.
- Construction noise.

Alteration (Burial) of Exposed Nearshore Hardbottom

Approximately 0.57 acres of exposed nearshore hardbottom habitat within the study area was impacted by prior sand placement activities. St. Lucie County provided mitigation to offset these impacts. The Recommended Plan, with its smaller placement area, would not exceed previous impacts and, therefore, no additional mitigation is proposed. Please refer to Section 2.2.5 and to **Appendix G, Attachment 3** for more information on the mitigation previously provided by the non-federal sponsor.

Disturbance of Sand Bottom Habitats

Dredging activities within the shoal borrow area and beach fill sites would continue to impact the demersal and pelagic fish species, macrofaunal invertebrates, and infaunal benthic invertebrates. The potential disturbances to the sand bottom habitats include anchoring of the hopper barge during pump out activities, vibrations caused from the pump out activities, and placement of the pump out and conveyance pipes. Injuries to infaunal invertebrates and any motile macrobenthic invertebrate species would most likely occur during entrainment as part of the dredging and sand pumping operations. Some benthic infaunal invertebrates would survive and recolonize parts of the submerged beach fill area, but any aerially exposed on the new beach berm are not anticipated to survive nourishment activity.

Greene (2002) summarized a number of studies of benthic invertebrate recovery rates. These studies show that benthic invertebrate communities' recovery can occur in as few as two weeks but often with an assemblage dissimilar to the preconstruction infaunal community composition. Recovery of the populations typically occurs two to seven months after nourishment, given that organisms living in the high-energy beach environment, especially the intertidal area, are adapted to disturbances (Atlantic States Marine Fisheries Commission 2002). Recovery of organisms in soft-sediments typically occurs through larval transport and post-settlement life-stages (juveniles and adults) and varies with the season, habitat, and the species' life history characteristics. Active dredging operations during project activities would displace motile macrobenthic invertebrates and especially demersal and pelagic fish species that use the soft bottom habitats, shoal areas and beach fill areas, unless these groups avoid the dredging areas. Dredging activities would restrict motile macrobenthic invertebrates and demersal/pelagic fishes from feeding on the infauna and flora living in and on the soft bottom habitat.

Numerous studies have examined the impacts to the infaunal communities of borrow areas including (but not limited to) Turbeville and Marsh (1982), Byrnes et al. (2003), Hammer et al. (2005), Byrnes et al. (2004), and Burlas et al. (2001, 2002). Those studies determined that the community composition, diversity, and abundance recovered to pre-dredge condition within two years.

Wilber and Stern (1992) found that while borrow sites may remain in an early successional stage for two to three years, within those years the sites they considered still developed infaunal biomass that provided a food source for fish and macrocrustaceans. In addition, Turbeville and Marsh (1982) examined an offshore dredging operation off Hillsboro Beach in 1972. They determined that although the faunal similarity analysis indicated a qualitative change in the fauna of the borrow area had occurred, the change was not detrimental. They concluded that the offshore dredging operations conducted caused no observable adverse effects in terms of reduced numbers of species, reduced faunal abundance, or reduced species diversity within the borrow area.

Hammer et al. (2005) found that physical, chemical, and biological factors influence the composition of benthic assemblages. Although excavation of sand borrow areas can expose underlying sediments and change the sediment structure and composition, their research found that the vertical sediment composition in the borrow pits offshore of central Florida tended to be uniform. Therefore, recolonization would likely proceed if, as proposed for the St. Lucie County project, dredging does not cut below the depth of the adjacent grade. In addition, warmer waters (e.g., the Atlantic Ocean waters of central Florida including St. Lucie County) may shorten infaunal recolonization time.

Hammer et al. (2005) also determined that dredging at the sand borrow sites located in central east Florida would not likely adversely affect pelagic fish populations unless dredging disrupts specific spawning, aggregation, or migratory areas. Impacts from routine dredging operations and accidents would be avoided and minimized with the appropriate management of dredging operations and use of best management practices.

Infaunal sampling performed by CSA (2011) included sampling of the St. Lucie Shoal borrow area, the refuge patch proposed by the non-federal sponsor for the 2013 beach nourishment project and an adjacent sand habitat reference site. The analysis of these data indicated that although more total organisms occurred within samples collected at the borrow area sites (11,553) than in the reference site samples (6,268), the same taxa occurred in both locations in similar percentages. The density of organisms per m^2 within the three sampled areas were also similar with 33,483 organisms per m^2 for the reference sites, 49,372 organisms per m^2 for the borrow area sites, and 45,641 organisms per m^2 for the refuge patch sites. The primary difference in the numbers occurred because of greater numbers of annelids and other taxa sampled in the reference site. In addition, the percentage of organism groupings differed significantly between the refuge patch and the other two sites (the borrow area site and reference site). Such differences are typical of benthic infauna distribution, characterized by patchiness and wide variability in numbers of individuals. The results of this sampling effort indicated that with the excavation of a portion of the St. Lucie Shoal, although the infaunal community would experience impacts, numerous organisms would remain within the refuge patch and the surrounding area to provide feeding opportunities for demersal/pelagic fishes and for recovery of the organisms within the dredged area.

The temporal duration of construction would be short. Technical literature suggests that soft bottom infaunal invertebrate assemblages typically recover relatively rapidly (two to three years). While recovery

of the infaunal invertebrate assemblage takes place, feeding opportunities would be present in the surrounding areas.

Modification of the St. Lucie Shoal Feature

Offshore sand shoal habitats have been shown to provide fundamental ecological functions for demersal/pelagic fish species and motile macrobenthic invertebrates that include categories of spawning, shelter, or foraging. Offshore shoal habitats have been identified as important benthic habitats along the eastern U.S. and South Florida. Vasslides and Able (2008) found the richest fish assemblages at study sites off the coast of southern New Jersey associated with sand ridges in the 9 – 14 m depth range.

Recent studies by Gilmore (2009) have determined that as many as 200 species of fish use sand shoal habitats within their life cycle, particularly during their cross-shelf migration, an important phase to the demersal reef fish population. These shoal habitats also function as aggregating points for small pelagic fishes, important prey for numerous managed species, particularly from the coastal pelagic and highly migratory groups. Modification of the St. Lucie Shoal feature could impact the demersal/pelagic fish and invertebrate assemblages that use this feature. Depending on the dredging design and execution, this action could alter this shoal structure permanently and could affect the local ecological processes occurring at this location. The St. Lucie Shoal accounts for only a small fraction of the total sand bottom habitat in the region. The adjacent un-dredged areas would provide the infaunal source to recolonize the excavated area. The excavation would not result in long-term negative impacts to benthic populations or the benthic community.

USACE will continue to collect additional geotechnical and geophysical data within the proposed St. Lucie Shoal borrow area during Preconstruction Engineering and Design (PED). These more refined data will inform the final borrow area design parameters prior to construction. The overall goal is to ensure that physical and biological processes following dredging are maintained within the St. Lucie shoal complex to the maximum extent practicable.

Based on the geophysical and geotechnical data that is currently available, the proposed borrow area design includes a dredging template that is oriented with the long axis of the shoal to minimize impacts to the overall shoal complex. Additionally, USACE and BOEM are currently investigating the feasibility of maintaining a refuge patch at maximum shoal elevations to promote quicker biological recovery following dredging. However, additional analysis will need to be performed during PED to better understand the cumulative volume of sediment within the shoal complex relative to the identified volume of sediment needed to support the Federal project.

In addition, borrow pits are known to attract numerous fishes and have also been known to provide resting places for sea turtles (Spring, K. and D. Snyder, CSA International, personal observations). Slacum et al. (2006, 2010) have indicated that for similar sand shoal habitats in the mid-Atlantic bight off the coasts of Maryland and Delaware, winter dredging may provide the least impactful period for dredging as that period includes the lowest use of the habitat by finfishes and invertebrates. Diaz et al. (2004) characterized seasonal changes in invertebrate fauna, concluding that appropriate project timing and engineering could lessen impacts on fishes by reducing stress on crustaceans that serve as primary prey items. The proposed project (and future projects) would use a dredging window from November through April in order to comply with the U.S. Fish and Wildlife Service Statewide Programmatic Biological Opinion and avoid beach placement during the primary sea o turtle nesting season. Thus, the dredging period could also minimize potential impacts on shoal resources if the site exhibits similar biological cycles to those described in recent

literature. Scott (2007), studying benthic communities of sand shoals off Cape May, New Jersey, concluded that continued dredging of the study area had not resulted in impacts to benthic taxa, abundance, or biomass. Based on differences in benthic assemblages in dredged and non-dredged areas, Scott and Burton (2005) concluded that "developing dredging plans for beach replenishment activities to limit the creation of dredge pits over at least a depth of 10 feet could reduce the chances of causing changes in benthic community, bottom sediment and water quality parameters detected in this study." They found no significant differences in the finfish communities associated with the study sites and stated, "Since the fish community did not display an impact, the change in water quality and the benthic community observed in this study may have little impact on higher living resources."

Turbidity

Several activities during construction are anticipated to affect water quality. The main source of water quality impacts — borrow area dredging and sand placement on the beach face — would produce turbidity at the borrow site and along the shoreline. Even if it does not kill fish, turbidity has been shown to have negative impacts during extreme natural events (Robins 1957). The nearshore hardbottom fish assemblages would most likely avoid any extreme turbidity conditions. Impacts may occur to fishes in planktonic stages of development and to some juveniles related to turbidity. However, past offshore dredging efforts by USACE, while monitored closely, have not produced visible kills of juvenile fishes. Most fishes able to do so would likely avoid the area until the water quality returns to acceptable levels.

At the borrow site, the vibracore samples logs indicated that the sand layer exposed within the proposed borrow area after dredging contains less than 4% fines. This is the same percent of fines present in the existing exposed top layer of sediment on the shoal in the area to be excavated. Mobile species would move out of the dredge area during dredging activities due to the short-term disruption to the area from the construction activities. Once dredging ceases, the mobile species are anticipated to return to the area and, based on the geotechnical data, are not expected to experience more turbidity after dredging than prior to dredging. No reports or observations of fish impacts sufficient to harm a species significantly could be identified.

Implementation of proper design and BMPs could reduce the magnitude and extent of impact resulting from proposed project activities, which would likely be limited in extent and short in duration.

Underwater Noise and Vibration from Dredging Activities

In general, the expected short-term sources and levels of underwater noise and vibration generated during a dredging project such as proposed should cause only negligible impacts on marine mammals, fish, and other wildlife present in the project area. Wildlife that may visit the project area during the construction period are likely to move from or avoid disturbance caused by construction activities.

Construction Noise

In general, the sources and noise generated during the project construction activities would include temporary sources of noise and could result in short-term, minor, adverse effects to shorebirds and seabirds in the vicinity of both the beach fill and borrow area sites. Shorebirds and seabirds that may visit the project area during the construction period are likely to move from or avoid disturbance caused by construction activities.

5.1.4 THREATENED AND ENDANGERED SPECIES

FUTURE WITH-PROJECT (RECOMMENDED PLAN)

USACE and BOEM have determined that the Recommended Plan may affect nesting sea turtles and sea turtles in the water. Also, the plan may affect, but is not likely to adversely affect manatees, whales, smalltooth sawfish, piping plover, or the rufa red knot. The terms and conditions of the 1997 NMFS South Atlantic Division Regional Biological Opinion (SARBO), 2015 USFWS Statewide Programmatic Biological Opinion, and 2013 Programmatic Piping Plover Biological Opinion will be followed for these species. Additional consultation between USACE, BOEM, and USFWS has been performed on the rufa red knot.

USACE and BOEM have also determined that the proposed dredging and beach placement could temporarily impact the physical or biological features (PBF) and primary constituent elements (PCE) of loggerhead critical habitat unit LOGG-T-FL-09 and LOGG-N-18 during construction. Hatchling egress from the water's edge to open water and nesting female transit back and forth between the open water and the nesting beach during nesting season could be hindered by the presence of the dredge and pipeline. However, the construction phase would typically last 3-5 months approximately every 18 years (erosion due to storms could require more frequent events) and the daily construction activity would occur within only a small area at a time. Hatchling egress from the water's edge to open water and nesting female transit back and forth between the open water and the nesting beach during nesting season could be hindered by the presence of the dredge and pipeline. Finally, the placement of sand may increase sea turtle nesting habitat if the placed sand is highly compatible (i.e., grain size, shape, color, etc.) with naturally occurring beach sediments in the area, and compaction and escarpment remediation measures are incorporated into the project (i.e. the project complies with the terms and conditions of the SPBO). Therefore, USACE has determined that the project will not destroy or adversely modify loggerhead critical habitat.

The USFWS concurred with USACE and BOEM determinations by letter dated November 21, 2016 (refer to Appendix H: Pertinent Correspondence). USACE and BOEM also notified the NMFS by letter dated June 16, 2016, that all consultation responsibilities for dredging and beach placement activities associated with the Recommended Plan would be covered under the existing 1997 SARBO and/or superseding documents associated with the ongoing reinitiated SARBO consultation (refer to **Appendix H: Pertinent Correspondence**).

Sea Turtle Nesting Habitat

Of the threatened and endangered species found in coastal St. Lucie County, nourishment activities are more likely to impact sea turtles, simply by their ubiquity during nesting season. Escarpments obstructing beach accessibility, altered beach profiles, different sand color characteristics, and increased sand compaction often hinder nesting success the first year after nourishment (USFWS, 2015). Impacts of a nourishment project on sea turtle nesting habitat are typically short-term because natural processes rework a nourished beach in subsequent years. Constant wave and current action reworks the beach, and reduces sand compaction and the frequency of escarpment formation while the sun bleaches darker sand (USFWS 2015).

The non-federal sponsor initiated an emergency beach fill project in 2005 due to damages to project area beach and dunes during hurricanes Frances and Jeanne in 2004. The upland sand used in the 2005 emergency fill project was incompatible with the native beach (PBS&J 2005). A dune remediation project excavated, removed, and replaced the incompatible sand with more carefully characterized beach-compatible sand (Coastal Tech 2009: Design Document). The area of sand replacement provided an opportunity for an unplanned experiment comparing turtle nesting on natural sand with turtle nesting on replacement beach sand. Below, the term "nourished" applies to the section of beach that required remediation and "natural" to the adjacent sections of beach not impacted and remediated.

Nesting success provides a gauge of beach nesting suitability (Ecological Associates, Inc. [EAI] 2009a). Less suitable beaches tend to have lower nesting success (a higher false crawl to nest ratio). EAI performed sea turtle nesting surveys for the St. Lucie beach before the storms and after replacement of poor quality sand with suitable quality sand (EAI 2007, 2008, 2009a). **Table 5-1** summarizes nesting success between 2003 and 2009 for the three sea turtle species nesting on nourished and natural beach sections of the project area beach (EAI 2009a; personal communication, Beth Brost, FWC; personal communication, Jonathan Gorham, Inwater Research Inc., 2010).

During 2005, all three marine turtle species exhibited lower nesting success on the nourished beach than on the natural beach. Loggerhead and green turtles exhibited the greatest differences (**Table 5-1**). During the years before the emergency nourishment (2003 – 2004) and the years following 2005 (2006 – 2009), all three species displayed similar or greater nesting success on the nourished beach than on the natural beach. EAI (2009a) attributed the apparent improvement in the suitability of the restored beach for nesting to changes in beach conditions resulting from the dune remediation project.

With the exception of 2005, the nourished area generally showed higher loggerhead and green turtle nest densities (**Table 5-2**: nests per kilometer). In 2005, all three species showed lower nest densities on the nourished beach than on the natural beach. Beginning in 2006, however, loggerhead and green turtle have since maintained nest densities on the nourished beach similar to or greater than densities on the natural beach. According to EAI (2009a), the shift back to pre-2005 patterns in the relative distribution of loggerhead and green turtle nest densities in the nourished beach suggests that the remediation project succeeded in mitigating the negative effects of the poor quality sand placed during the 2005 dune restoration project and in providing nesting habitat similar to natural conditions.

Table 5-1. Sea Turtle Nesting Success (%) in Project Area: Restored (INBS Zone V-X) vs. a Natural (L-N) Beach.

	2003		2004		2005		2006		2007		2008		2009	
Species	**Nourished**	**Natural**	**Nourished**	**Natural**	**Nourished**	**Natural**	**Nourished**	**Natural**	**Nourished**	**Natural**	**Nourished**	**Natural**	**Nourished**	**Natural**
Loggerhead	65.7	54.2	59.6	49.6	14.1	33.0	55.9	49.5	52.1	50.6	58.9	56.3	57.3	46.2
Green	75	37.5	46.8	50	11.4	39.6	42.0	30.0	41.3	27.0	65.1	47.4	54.3	45.8
Leatherback	80	87.5	80	74.1	31.0	40.0	78.6	80.0	80.8	83.3	78.4	77.8	76.9	74.3

Source Data 2003, 2004, 2009: INSB Zones L, V-X - personal communication: Beth Brost, Florida Fish and Wildlife Commission Index Nesting Beach Survey Database as of July 1, 2010. Zones L, V-X include data between May 15 and August 31. INSB Zones M and N - personal communication: Jonathan Gorham, Inwater Research Group, Inc. May 6, 2010. Zones M and N are year totals.
Source Data 2005 to 2008: EAI, 2009a

Table 5-2. Sea Turtle Nesting Density (nests/km) in Project Area: Restored (INBS Zone V-X) vs. a Natural (L-N) Beach.

	2003		2004		2005		2006		2007		2008		2009	
Species	**Nourished**	**Natural**	**Nourished**	**Natural**	**Nourished**	**Natural**	**Nourished**	**Natural**	**Nourished**	**Natural**	**Nourished**	**Natural**	**Nourished**	**Natural**
Loggerhead	224.3	164.3	175.3	170.3	110	205	205.0	117.3	163.3	123.3	211.7	157.7	198.3	133.3
Green	6	1	7.3	6	9.7	12.3	5.3	9.0	30.7	9.3	11.0	8.0	8.3	7.3
Leatherback	4	9.3	2.7	6.7	0.3	5.3	1.3	3.0	6.7	7.7	4.0	5.0	6.7	8.7

Source Data 2003, 2004, 2009: INSB Zones L, V-X - personal communication: Beth Brost, Florida Fish and Wildlife Commission Index Nesting Beach Survey Database as of July 1, 2010. Zones L, V-X include data between May 15 and August 31. INSB Zones M and N - personal communication: Jonathan Gorham, Inwater Research Group, Inc. May 6, 2010. Zones M and N are year totals.
Source Data 2005 to 2008: EAI, 2009a

Note regarding data sources: The tables include year totals when available, seasonal totals otherwise. FWC and Inwater Research Group data span May 15 – August 31; EAI data include the entire year. EAI (2009a) provided **Table 5-1** data between 2006 and 2008, while the FWC dataset provided data for years 2003, 2004, and 2009. For consistency, nesting density per kilometer of shoreline in **Table 5-2** contains only data from Inwater Research and FWC. Leatherback nest densities did not show the same post-remediation increase in nest densities seen in loggerhead and green turtle nest densities (**Table 5-2**, EAI, 2007, 2008). Leatherback nest densities remained lower on the nourished beach throughout the study period. During all seven years (2003 – 2008), fewer leatherback turtles nested on the nourished beach than on the natural beach. These data suggest that the changes in beach conditions between 2003 and 2008 affected leatherback nesting to a lesser extent than loggerhead or green turtle nesting.

The data presented above supports the hypothesis that impacts from beach nourishment to sea turtle nesting and habitat are short term (about one year) assuming the placement of appropriate quality sand. The data also suggest that the beach nourishment could have positive effects on sea turtle nesting through the creation of additional high quality beach habitat. Continuous monitoring of the sea turtle activity in the project area would dictate whether the changes observed between 2003 and 2009 will repeat themselves in the next projects.

In summary, within a year following the project (construction year up to a year post- construction), impacts to sea turtles associated with the project may include:

- Disturbance of nesting female turtles attempting to nest within the construction area or on adjacent beaches as a result of construction activities
- Behavior modification of nesting females from beach escarpment formation during a nesting season. Example: Behavioral changes could result in false crawls or selection of marginal or unsuitable nesting areas to deposit eggs.
- Destruction, damage, or burial of existing nests during nourishment activities
- Effects to eggs and hatchlings from changes in the physical and chemical characteristics of the nourished beach. Example: The quality of the placed sand could affect the ability of female turtles to nest, the suitability of the nest incubation environment, and the ability of hatchlings to emerge from the nest.
- Lighting-induced disorientation of hatchling turtles on beaches adjacent to the construction area as they emerge from the nest and crawl to the water
- Alteration (burial) of nearshore exposed hard substrate (feeding grounds to sea turtle juveniles) during and subsequent to nourishment activities

USFWS biological opinions for similar projects recognize that placement of sand on a critically eroded beach can enhance sea turtle nesting habitat if the sand placed is highly compatible (i.e., grain size, shape, color, etc.) with naturally occurring beach sediments at the recipient site, and compaction and escarpment remediation measures are properly adopted (USFWS 2015). State permit requirements for beach nourishment projects usually address avoidance and minimization of potential impacts to nesting turtles and nesting habitat. Permit conditions may include consideration of:

- Sand quality: a major component of the beach nourishment permitting process is to assure the sand placed on the beach is compatible with the natural beach.

- Timing of construction activities: USFWS has jurisdiction over sea turtles (nesting adults, incubating eggs, and hatching young) on the beach. In St. Lucie County, USFWS requires that nourishment activities avoid the peak nesting season from May 1 through October 31 to minimize the impact to nesting sea turtles. If projects require nighttime construction activities, State permits would restrict nighttime construction to specific areas, usually no more than 500 feet in length.
- Pre-nesting season compaction monitoring, mechanical tilling, and grading of the beach: these activities can greatly reduce or eliminate the effects of increased sand compaction and scarp formation. Post-construction compaction monitoring or tilling before nesting season is a state and Federal permit requirement after nourishment activities, and for three years after project completion. State and Federal agencies require tilling the project area beaches if penetrometer testing demonstrates compaction in excess of 500 pounds per square inch at any two adjacent sampling stations or depths. Additionally, leveling of escarpments greater than 18 inches in height or 100 feet in length must occur before nesting season begins.
- Relocation of sea turtle nests: USFWS requires monitoring and relocating sea turtle nests between March 1 and April 30 if nourishment activities occur during that period.
- Hardbottom impacts: avoidance and minimization of hardbottom impacts also comprise major considerations during review of any beach nourishment permit application.

Because the proposed project would use sand with characteristics very similar to the native beach sand, sand quality is unlikely to have negative effects on sea turtle nesting or hatchling emergence. However, the Recommended Plan may still have negative effects on nesting sea turtles resulting from construction-related impacts during and after construction. These impacts could include nesting disturbance, sand compaction, scarp formation, and artificial lighting.

As natural processes rework the nourishment area and the beach equilibrates, the increase in beach area provided by this alternative could have a long-term benefit on sea turtle nesting..

5.1.4.1 INNER SHELF SEA TURTLE HABITAT

Effects associated with the plan including offshore dredging that could potentially affect sea turtles include:

- Vessel traffic
- Entrainment by hopper dredge drag heads
- Turbidity
- Underwater noise and vibration from dredging activities

<u>Vessel Traffic</u>

Dredge, dredge support, and construction vessel traffic raises a chance of these vessels colliding with sea turtles. The risk would vary depending upon location, vessel speed, and visibility. Most sea turtles occur within nearshore waters off St. Lucie County and waters of the continental shelf. All life stages (hatchling, juvenile or subadult, and adult) may occur within the project area. During the hatching season, researchers believe that hatchling turtles leave their nesting beaches and swim offshore to areas of mass convergence. A moving vessel could have difficulty spotting hatchling and juvenile turtles in these areas, especially when

the individuals lie within patches of floating *Sargassum*. Adult turtles are generally visible at the surface during periods of daylight and clear visibility.

To reduce the risk of impacts from dredging and vessel strikes, the project would comply with the "Sea Turtle and Smalltooth Sawfish Construction Conditions" (NMFS 2006b) and "Vessel Strike Avoidance Measures and Reporting for Mariners" issued by NOAA Fisheries, Southeast Region. Operators and crews receive instructions to maintain a vigilant lookout for turtles during offshore transits and maneuvers.

Despite these precautions, turtles could prove very difficult to spot from a moving vessel when resting below the water surface, during nighttime, and during periods of inclement weather. A collision between a sea turtle and a slow moving vessel may occur. Adult, subadult, and perhaps juvenile turtles are often capable of avoiding moving dredge related vessels when these vessels operate within limited areas at slow to relatively slow speeds.

Entrainment by Hopper Dredge Drag Heads

Entrainment within hopper dredge drag heads could injure or kill sea turtles, particularly within areas of soft sediment in ship channels where turtles are known to bury themselves partially when resting (National Research Council Committee on Sea Turtle Conservation 1990). Sea turtles have also been observed to partially bury themselves in soft sediments that have settled into previous dredge borrow pits (Michals 1997p; Keith Spring and David Snyder, personal communication: observations of sea turtles using borrow pits off Hobe Sound, Florida). Numerous methods have been implemented to reduce the number of turtle takes during hopper dredge operations, including special turtle deflecting hopper dredge drag heads, relocation trawling, dredging windows, and the implementation of trained protected species observers during dredging operations (http://el.erdc.usace. army.mil/tessp/pdfs/ 1997SADBO.pdf).

The numerous areas of emergent hard substrate in the general project area represent high quality shelter for turtles. The proposed offshore borrow area presents a lower quality refuge, as it is an area of bare sand positioned along the inner continental shelf, proximal to hardbottom habitat.

NMFS-approved protected species observers would be stationed on hopper dredges, which would come equipped with a sea turtle deflecting drag head deflector within the proposed borrow site (http://el.erdc.usace.army.mil/seaturtles/docs/observercriteria.pdf) during all dredging operations. Even with these measures in place, incidental take(s) of sea turtles during dredging remains a possibility.

Alteration (Burial) of Exposed Nearshore Hardbottom

Approximately 0.57 acres of exposed nearshore hardbottom habitat within the study area was impacted by prior sand placement activities. St. Lucie County provided mitigation to offset these impacts. The Recommended Plan, with its smaller placement area, would not exceed previous impacts and, therefore, no additional mitigation is proposed. Please refer to Section 2.2.5 and to **Appendix G, Attachment 3** for more information on the mitigation previously provided by the non-federal sponsor.

Turbidity

Several activities during construction would affect water quality. Dredging and sand placement on the beach face would produce turbidity at the borrow site and along the shoreline. The limited extent and short duration of the reduced water clarity should reduce the magnitude and extent of temporary impacts of project activities. Turbidity generation would cease at the completion of construction.

Underwater Noise and Vibration from Dredging Activities

Little is known how turtles may respond to noise from offshore activities. In contrast to marine mammals, relatively little is known about sea turtles' hearing ability or their dependency on sound, passive or active, for survival cues. Only two species, loggerhead and green sea turtles, have undergone any auditory investigations. The anatomy of the sea turtle ear does not lend itself to aerial conduction; rather, it lends itself to sound conduction through bone and water (Békésy 1948, Lenhardt 1982, Lenhardt and Harkins 1983). Auditory testing and behavioral studies show that turtles can detect low frequency sounds (Ridgway et al. 1969, Bartol et al. 1999).

Sea turtles could likely hear low frequency underwater noise from construction activities and possibly experience some disturbance. The main noise sources include vessel engines. The most likely impacts would include short-term behavioral changes such as evasive maneuvers, disruption of activities, or short-term departure from the area.

5.1.4.2 MARINE MAMMALS

Effects associated with the proposed action that could potentially affect listed marine mammals include:

- Vessel traffic
- Turbidity
- Underwater noise and vibration from dredging activities

Vessel Traffic

Dredge, dredge support, and construction vessel traffic associated with the proposed action raises the chance these vessels could collide with listed marine mammals. The risk would vary depending upon location, vessel speed, and visibility. North Atlantic right whales may occur in the project area during the wintering and calving period. Humpback whales may also travel through the middle shelf, offshore of the project area; however, as anticipated, they would not occur within the borrow area or within nearshore waters. Both of these species are large and readily visible at the surface during periods of daylight and clear visibility. Florida manatees may, but are unlikely to occur within the project area. On-board trained and NMFS approved protected species observers would be stationed on dredges during all dredging operations, and dredge support vessel operators and crews would receive instructions to maintain a constant lookout for marine mammals during transits and maneuvers.

Despite these precautions, these species could prove very difficult to spot from a moving vessel when they are resting below the water surface, during nighttime, and during periods of inclement weather. However,

these animals are capable of avoiding moving dredge-related vessels, especially when these vessels operate within limited areas at slow to relatively slow speeds.

Turbidity

Several activities during construction would affect water quality. Turbidity created by borrow area dredging and sand placement on the beach face represents the primary source of water quality impacts at the borrow site and along the shoreline. Turbidity generation would cease at the completion of construction. Due to the limited extent and short duration of reduced water clarity, potential project impacts on marine mammals should be negligible.

Underwater Noise and Vibration from Dredging Activities

Potential effects of the elevated background noise levels caused by operator-generated noise to marine mammals include the following:

- Limiting the detection by the mammals of natural sounds
- Disturbing their normal behavior, resulting in possible displacement from areas
- Causing temporary or permanent reductions in hearing sensitivity

The potential effects depend on the type of marine mammal involved because different marine mammals hear at different frequencies. The levels and types of ambient noise also strongly influence the potential area or zone of influence of an operator-generated sound. An animal's sensitivity to different sounds varies with frequency, and its response to a sound likely depends strongly on the presence and levels of sound in the frequency band or range of frequencies to which it is sensitive (Ports Corporation of Queensland 2005). Although underwater noise can affect marine mammals (Richardson et al. 1995), the project does not involve any high energy sound sources that could cause temporary or permanent auditory damage. In general, the sources and levels of underwater noise and vibration generated during the project should cause only minor impacts on marine mammals. The most likely impacts are temporary behavioral responses such as avoidance or altered diving or swimming behavior.

The North Atlantic right whale uses the project area as part of the species' migratory route and as potential calving grounds during the winter months; however, these whales are rare to the project area. The humpback whale is rarely present within the vicinity of St. Lucie County during its spring/fall migration. Manatees have been observed along the coast in the shallow, nearshore waters, though only rarely. Marine mammals would likely avoid areas where a dredge is operating. The project area is an extremely small area when compared to the overall waters used for migration and calving. Standard protective measures would be taken during placement activities to ensure the safety of manatees and other marine mammals.

5.1.4.3 SMALLTOOTH SAWFISH

Effects associated with the proposed action that may potentially impact smalltooth sawfish include:

- Turbidity
- Underwater noise and vibration from dredging activities

- Entrainment by hopper dredge drag heads

Turbidity

Several activities during construction could affect water quality. The main sources of water quality impacts are borrow area dredging and sand placement on the beach face, which would produce turbidity at the borrow site and along the shore. Turbidity could cause temporary impacts to about one acre of hardbottom habitat. Proper implementation of the approved design and construction BMPs should limit the level and extent of construction-related turbidity. Turbidity generation would cease at the completion of construction. Due to the limited extent and short duration of the reduced water clarity, any potential impacts on smalltooth sawfish should be negligible.

Underwater Noise and Vibration from Dredging Activities

In general, the sources and short-term levels of underwater noise and vibration generated during the project should cause only negligible impacts on smalltooth sawfish. Smalltooth sawfish that may visit the project area during the construction period are likely to move from or avoid disturbance caused by construction activities. These temporary avoidance behaviors should cause negligible impacts on smalltooth sawfish.

Entrainment by Hopper Dredge Drag Heads

The smalltooth sawfish normally inhabits shallow waters (10 m or fewer) often near river mouths or in estuarine lagoons over sandy or muddy substrates, but may also occur in deeper waters of the continental shelf at depths greater than 20 meters (NMFS 2006a). Sawfish encounter a small risk of being entrained in the hopper dredge drag head as it extracts sand from the St. Lucie Shoal. To reduce the risk of impacts from dredging and vessel strikes, the project would comply with the "Sea Turtle and Smalltooth Sawfish Construction Conditions" (NOAA Fisheries 2006). Mitigation measures would minimize entrainment risks. Measures would include the use of sea turtle deflecting drag head deflector, which would also help deflect smalltooth sawfish.

Disturbances from ongoing activities could displace smalltooth sawfish that may visit the project area during the construction period. These disturbances could result in temporary movement or avoidance of the area, but the species would likely return when the temporary disturbance ended.

5.1.4.4 PIPING PLOVER AND RUFA RED KNOT

Wintering grounds and migration stopovers for piping plovers and red knots include Hutchinson Island. While coastal development has reduced important beach habitat for wintering bird species, beach nourishment can restore beach habitat for many shore birds. However, during the beach periodic nourishment construction phase, some short-term displacement of foraging and resting birds, including piping plovers and red knots, could occur. During construction activities, displaced species may use habitats with similar characteristics north and south of the project area.

Beach nourishment activities are more likely to affect birds that use the beach for nesting and breeding than birds that use the area for feeding and resting during migration (Greene 2002). Dredges, pipelines, and other equipment along the beach could displace piping plovers, or could cause them to avoid foraging along the shore if they are aurally affected (Peterson et al. 2000). If the sand placed on the beach is too coarse or high in shell content, it can inhibit the birds' ability to extract food particles from the sand (Greene 2002). Fine sediment that reduces water clarity can also decrease the feeding efficiency of birds (Peterson et al. 2000).

Minimal direct impacts to plovers and knots should occur from project construction because motile birds can avoid construction activities. The placement of sand on the beach may temporarily interrupt foraging and resting activities of shorebirds that use the project beach area. This limited interruption would occur on the immediate area of placement and last for the duration of construction. A temporary reduction to the prey base for many shorebirds, which includes benthic organisms, would also occur in the project area. Recovery from this short-term reduction should occur within about one year after sand placement.

5.1.4.5 BEACH JACQUEMONTIA

In its letter dated December 14, 2011, the USFWS indicated that based on observations made in January 2010, the endangered beach jacquemontia may occur within the project area. The potential location(s), quantity, and current vegetative state are unknown for beach jacquemontia specimens that may occur within the project area.

Fill placement would not occur landward of the dune crest. The primary habitat for beach jacquemontia occurs landward of the dune crest on the more stable portions of the dune system.

The implementation of protective measures would avoid and minimize potential impacts to beach jacquemontia. Protective measures would likely include a pre-construction survey to locate and mark beach jacquemontia growing within or adjacent to the project area. For beach jacquemontia identified outside of the project fill footprint, creation of a minimum 25-foot protective buffer around each individual would exclude construction activities within that area. Measures to minimize potential impacts to beach jacquemontia growing within the project fill footprint may include transplanting individual plants to suitable habitat out of harm's way. If transplanting is necessary, the USFWS staff must review and approve a detailed plan before initiating transplanting activities.

5.1.5 HARDBOTTOM

FUTURE WITH-PROJECT (RECOMMENDED PLAN)

Effects associated with the applicant's preferred alternative that may potentially affect nearshore hardbottom include:

- Alteration (burial) of exposed nearshore hardbottom and associated epibenthos during and subsequent to nourishment activities
- Alteration of exposed nearshore hardbottom and associated epibenthos resulting from the sand delivery pipelines

- Turbidity

Alteration (Burial) of Exposed Nearshore Hardbottom

Approximately 0.57 acres of exposed nearshore hardbottom habitat within the study area was impacted by prior sand placement activities. St. Lucie County provided mitigation to offset these impacts. The Recommended Plan, with its smaller placement area, would not exceed previous impacts and, therefore, no additional mitigation is proposed. Please refer to Section 2.2.5 and to **Appendix G, Attachment 3** for more information on the mitigation previously provided by the non-federal sponsor.

Re-exposure of hardbottom likely occurs due to high-energy dynamics of the area and downdrift and cross-shore erosion of the fill material after equilibration of beach fill. Worm rock, turf, and macroalgae would likely recolonize these re-exposed hard substrates in the same fashion they colonize any previously buried hardbottom. Organisms with high recruitment capabilities dominate the nearshore hardbottom community; coverage and re-exposure of hardbottom substrate is a common occurrence in the project area. Pipeline placement would use corridors previously used to the maximum extent practicable.

5.1.6 ESSENTIAL FISH HABITAT (EFH)

FUTURE WITH-PROJECT (RECOMMENDED PLAN)

Effects associated with the plan that could potentially affect EFH include:

- Alteration (burial) of previously mitigated and subsequently re-exposed nearshore hardbottom and associated epibenthos during and subsequent to nourishment activities
- Disturbance of the sand bottom habitats and associated macroinfauna of the shoal borrow area and beach fill sites during nourishment activities
- Modification of the St. Lucie Shoal feature
- Turbidity

Alteration (Burial) of Exposed Nearshore Hardbottom

As previously stated, approximately 0.57 acres of exposed nearshore hardbottom habitat within the study area was impacted by prior sand placement activities. St. Lucie County provided mitigation to offset these impacts. The Recommended Plan, with its smaller placement area, would not exceed previous impacts and, therefore, additional mitigation is not proposed. Please refer to Section 2.2.5 and to **Appendix G, Attachment 3** for more information on the mitigation previously provided by the non-federal sponsor.

Disturbance of the Sand Bottom Habitats

Members of the penaeid shrimp EFH management groups use soft bottom habitats contiguous with the surf zone and nearshore hardbottom as forage or shelter habitats. Spiny lobsters use soft bottom habitats contiguous with the nearshore hardbottom as foraging areas. The potential disturbances to the sand bottom habitats include anchoring of the hopper barge during pump out activities, vibrations caused from the pump out activities, and placement of the pump out and conveyance pipes.

Modification of the St. Lucie Shoal Feature

The plan would continue to alter the local bathymetric profile in the borrow area. Sand shoals include EFH for coastal pelagic species and some highly migratory species, particularly coastal sharks. In addition, offshore sand shoal habitats have been shown to provide fundamental ecological functions for demersal/pelagic fish species and motile macrobenthic invertebrates that include categories of spawning, shelter, or foraging (CSA International et al. 2009). Studies (Gilmore 2009) have determined that 200 fish species use the sand shoal habitats along southeast Florida. Gilmore (2009) postulates that the shoal habitats are an intermediate habitat integrated in the cross-shelf migration used by many EFH managed groups. These shoal habitats also function as aggregation areas for small pelagic fishes, important prey for the coastal pelagic fish, dolphin and wahoo, and highly migratory species groups.

Removal of or modification of the St. Lucie Shoal feature could impact the EFH for multiple SAFMC-managed species groups that use this feature. The proposed dredging action could conceivably alter the shoal structure and change the fundamental ecological processes within and near this feature. Dibajnia and Nairn (2010) summarized field investigations and modeling studies intended to recommend offshore dredging guidelines to protect and maintain the integrity of ridge and shoal found on the OCS. They found that for shoals fewer than 30 meters deep, the shoal they studied reformed itself with the remaining (smaller) volume. They concluded, "There was no indication that there exists a critical threshold for dredging that once crossed, ridge and shoal features may deflate, losing their morphologic integrity."

The St. Lucie Shoal covers approximately 1.04 x 107 m^2 including state and Federal waters (Hammer et al. 2005, Coastal Tech 2009, Design Document). The St. Lucie Shoal represents only a portion of the offshore shoals in the central Florida OCS. In addition, Hammer et al. 2005 determined that dredging at the sand borrow sites located in the central Florida OCS is not likely to adversely affect pelagic fish populations unless specific spawning, aggregation, or migratory areas are disrupted. With the appropriate management, impacts of routine dredging operations could be reduced using best management practices.

USACE will continue to collect additional geotechnical and geophysical data within the proposed St. Lucie Shoal borrow area during Preconstruction Engineering and Design (PED). These more refined data will inform the final borrow area design parameters prior to construction. USACE and the Bureau of Ocean Energy Management (BOEM) will coordinate with NMFS to develop a refined borrow area design that provides a sufficient volume of compatible sediment to support the project objectives while maintaining overall shoal integrity. The overall goal is to ensure that physical and biological processes following dredging are maintained within the St. Lucie shoal complex to the maximum extent practicable.

Based on the geophysical and geotechnical data that is currently available, the proposed borrow area design includes a dredging template that is oriented with the long axis of the shoal to minimize impacts to the overall shoal complex. Additionally, USACE and BOEM are currently investigating the feasibility of maintaining a refuge patch at maximum shoal elevations to promote quicker biological recovery following dredging. However, additional analysis will need to be performed during PED to better understand the cumulative volume of sediment within the shoal complex relative to the identified volume of sediment needed to support the Federal project. USACE and BOEM will continue to coordinate with NMFS as additional information becomes available.

In addition, numerous studies have examined the impacts to the infaunal communities of borrow areas including (but not limited to) Turbeville and Marsh (1982), Byrnes et al. (2003), Hammer et al (2005), Byrnes et al. (2004), and Burlas et al. (2001). Those studies determined that the community composition, diversity, and abundance recovered to pre-dredge conditions within two years.

Hammer et al. (2005) found that physical, chemical, and biological factors influence the composition of benthic assemblages. Although excavation of sand borrow areas can expose underlying sediments and change the sediment structure and composition, their research found that the vertical sediment composition in the borrow pits offshore of central Florida tended to be uniform. In addition, recovery times of infaunal recolonization may be shorter in warmer (e.g., central Florida) waters than in colder waters. With the appropriate management of dredging operations using best management practices the proposed dredging could avoid and minimize impacts to EFH and managed species within the study area.

Wilber and Stern (1992) found that while borrow sites may remain in an early successional stage for two to three years, within those years the sites they considered still developed infaunal biomass that provided a food source for fish and macrocrustaceans. In addition, Turbeville and Marsh (1982) examined an offshore dredging operation off Hillsboro Beach in 1972. They determined that although the faunal similarity analysis indicated that a qualitative change in the fauna of the borrow area had occurred the change was not detrimental. They concluded that the offshore dredging operations conducted caused no observable adverse effects in terms of reduced numbers of species, reduced faunal abundance, or reduced species diversity within the borrow area.

Infaunal sampling performed by CSA included sampling of the St. Lucie Shoal borrow area, the refuge patch maintained by the non-federal sponsor during the previous dredging event, and an adjacent sand habitat reference site. The analysis of these data indicated that although more total organisms occurred within samples collected at the borrow area sites (11,553) than in the reference site samples (6,268), the same taxa occurred at both locations in similar percentages. The density of organisms per m^2 within the three sampled areas were also similar with 33,483 organisms per m^2 for the reference sites, 49,372 organisms per m^2 for the borrow area sites, and 45,641 organisms per m^2 for the refuge patch. The primary difference in the numbers occurred because of greater numbers of annelids and other taxa sampled in the reference site. In addition, the percentage of organism groupings differed significantly between the refuge patch and the other two sites (the borrow area site and reference site). Such differences are typical of benthic infauna distribution, characterized by patchiness and wide variability in numbers of individuals. These results indicate that although the infaunal community would experience impacts with the excavation of a portion of the St. Lucie Shoal, numerous organisms present within the refuge patch and the surrounding area could provide feeding opportunities for demersal/pelagic fishes and for recovery of the organisms within the dredged area.

Dredging activities within the shoal borrow area could also entrain multiple South Atlantic Fish Management Council (SAFMC) managed species groups, both fish and invertebrates, including the penaeid shrimp, and spiny lobster. Settle (2003) working for the National Oceanic and Atmospheric Administration (NOAA)/National Ocean Service, National Centers for Coastal Ocean Science, prepared a report entitled *Assessment of Potential Larval Entrainment Mortality Due to Hydraulic Dredging of Beaufort Inlet*. In this assessment, Settle estimated that entrainment mortality of larval fish, even under the worst-case scenario, is minimal (0.1 %/day). Under the worst case scenario the dredge operated 24 hours/day, all larvae were

located in the navigation channel, on the bottom, and with poor retention in the estuary following flood stage. Settle further stated that "the impact at the population level (of larval fish) would be insignificant."

Similarly, Burton, Weisberg, and Jacobson (1992) utilized an Empirical Transport Model to simulate a "worst case scenario" of entrainment of striped bass (*Morone saxatilis*), herring (*Alosa spp.*) and white perch (*Morone americana*) larvae involving the simultaneous operation of four hydraulic dredges in the Delaware River. For species such as striped bass, the study concluded that less than 1 percent of the total larval population would be entrained by dredges. They concluded that the effects of these entrainment rates on larval populations for these and similar species would be minimal. It is expected that dredging activities within the shoal area would result in even less entrainment since it is a relatively large feature.

Turbidity

Several activities during construction are anticipated to affect water quality. The main source of water quality impacts is borrow area dredging and sand placement within the beach fill sites. These activities would produce increased turbidity levels in both areas. Turbidity has been shown to negatively impact and sometimes cause fish mortality during extreme natural events of increased turbidity (Robins 1957). The nearshore reef fish assemblages would most likely avoid any extreme turbidity conditions. The limited dredge and fill extent and short duration of the reduced water clarity, along with implementation of BMPs and proper design are expected to minimize adverse effects.

5.1.7 OFFSHORE BORROW AREA RESOURCES

The proposed offshore sand source is the portion of the St. Lucie Shoal (**see REF-4**) located in Federal waters, approximately three to seven miles offshore of the proposed fill template (refer to **Appendix D**, Plate B - 1). The proposed preliminary sand source locations and associated vibracores are depicted on Plate B - 2 and Plate B - 3 of Appendix D. Use of the shoal would require completion of a lease agreement with the Department of Interior, Bureau of Ocean Energy Management (BOEM). BOEM is authorized under Public Law 103-426 [43 United States Code (U.S.C.) 1337 (k) (2)] to negotiate on a non-competitive basis the rights to OCS sand resources for coastal storm risk management projects. BOEM is expected to be requested to undertake a connected action (i.e., authorize use of the OCS borrow areas) that is related to, but unique from, the USACE proposed action. BOEM's proposed action is to issue a negotiated agreement authorizing use of the sand source areas at the request of the local sponsor and USACE.

Effects associated with the Recommended Plan potentially impacting offshore borrow area resources include:

- Disturbance of the shoal borrow area sand bottom habitat and associated macroinfauna during nourishment activities
- Modification of the St. Lucie Shoal feature
- Turbidity
- Underwater noise and vibration from dredging activities

Modification of the St. Lucie Shoal Feature

Benthic species' ability to perform life functions (e.g., burrowing, feeding, or settling as larvae) varies with sediment quality, and members of the current benthic community may or may not have the same success in the physical characteristics of the underlying sediment as in the existing sediment. A literature synopsis by the U.S. Geological Survey (USGS) in 2004 examined community composition, diversity, and abundance to determine the recovery and/or recolonization time of benthic communities. Studies such as Burlas and Clarke (2001), Byrnes et al. (2004, 2005), Hammer et al. (2005), and Turbeville and Marsh (1982) found that recovery durations could range from three months to 2.5 years. Hammer et al. (2005) found evidence to suggest that recovery times of infaunal recolonization are shorter in warmer waters (such as the east central Florida shelf) than in colder waters. Recovery of the original community composition has been suggested to potentially take a substantial amount of time, especially in sand mining areas used repeatedly. However, Wilber and Stern (1992) found that while borrow sites may remain in an early successional stage for two to three years, within those years, sites still continue to develop infaunal biomass providing a food source for commercially and recreationally important fishes and invertebrates.

The literature review of infaunal density and species richness studies examining benthic composition of dredged shoals found no consistent pattern of faunal response to dredging (USGS, 2004). For example, Byrnes et al. (2004) determined that infaunal community recovery was dependent primarily on the depth of excavation where shallow excavation areas were impacted less than areas of deep excavation. Similarly, Hammer et al. (2005) found that recolonization was dependent on physical, chemical, and biological factors within the vertical sediment structure of the borrow pit. Hammer et al. (2005) studied borrow areas on the east central Florida shelf and demonstrated that initial recolonization would begin within days and later successional stages would proceed, even if dredged shoals were not completely reestablished, as long as the depth of dredging did not cut below the adjacent grade (as with the proposed project) and impact the vertical sediment composition in the borrow pit. Finally, Turberville and Marsh (1982) examined an offshore dredging operation off Hillsboro, Florida and concluded that while dredging operations resulted in a qualitative change in fauna of the borrow area, dredging caused no observable adverse effects in terms of reduced numbers of species, reduced faunal abundance, or reduced species diversity. Given the short temporal duration of proposed dredging activities and relatively rapid recovery of the soft bottom infaunal invertebrate assemblage, short duration impacts to soft bottom assemblages within the borrow site are expected.

Excavation alters the seabed topography, creating pits that may refill rapidly or cause detrimental impacts to the benthic community for extended periods. In contrast, dredging can also create habitats different from the surrounding area, which could result in increased habitat complexity and biodiversity of the area. Studies have shown that some borrow areas located within highly depositional areas have a relatively short filling time, whereas other areas may take up to 12 years to return to pre-dredge topography (Wright 1977). In general, shallow dredging over large areas causes less change than smaller deep pits. Borrow pits excavated in small deep pits reduce current velocities at the bottom, which can cause the deposition of fine particulate matter and potentially create a biological assemblage much different in composition from the original (Hammer et al. 2005). This action could alter this shoal structure permanently and locally affect the seabed topography within the borrow site. However, these potential changes in the shoal structure may not cause long-term changes in the benthic community species abundance and richness but could alter the community composition. St. Lucie County sampled infauna at the south end of the St.

Lucie Shoal borrow area within their proposed "refuge patch" within the borrow area and within an adjacent sand habitat reference site. Analysis of those samples indicated that although more total organisms occurred within the borrow area site than within the reference site, the same taxa occurred in both locations in similar percentages. The primary difference in the numbers occurred because of greater numbers of annelids and other taxa sampled in the reference site. In addition, the percentage of organism groupings differed significantly between the refuge patch and the other two sites (the borrow area site and reference site) and is typical of benthic infauna distribution, which is characterized by patchiness and wide variability in numbers of individuals. Dredging related changes could shift the percent composition of a set of species common to the general area.

As previously stated, based on the geophysical and geotechnical data that is currently available, the proposed borrow area design includes a dredging template that is oriented with the long axis of the shoal to minimize impacts to the overall shoal complex. Additionally, USACE and BOEM are currently investigating the feasibility of maintaining a refuge patch at maximum shoal elevations to promote quicker biological recovery following dredging. However, additional analysis will need to be performed during PED to better understand the cumulative volume of sediment within the shoal complex relative to the identified volume of sediment needed to support the Federal project.

In addition, borrow pits are known to attract numerous fishes and have also been known to provide resting places for sea turtles (Spring, K. and D. Snyder, CSA International, personal observations). The St. Lucie Shoal accounts for only a small fraction of the total sand bottom habitats in the region. The adjacent unimpacted areas would provide a source for recolonization of the excavated area and reduce the potential for long-term negative impacts to the benthic community.

Offshore sand shoal habitats have been shown to provide fundamental ecological functions for demersal/pelagic fish species and motile macrobenthic invertebrates that include categories of spawning, shelter, or foraging. Offshore shoal habitats have been identified as important benthic habitats along the eastern U.S. and South Florida. Vasslides and Able (2008) found the richest fish assemblages at study sites off the coast of southern New Jersey associated with sand ridges in the 9 – 14 m depth range.

Recent studies by Gilmore (2009) have determined that as many as 200 species of fish use sand shoal habitats within their life cycle, particularly during their cross-shelf migration, an important phase to the demersal reef fish population. These shoal habitats also function as aggregating points for small pelagic fishes, important prey for numerous managed species, particularly from the coastal pelagic and highly migratory groups. Modification of the St. Lucie Shoal feature could impact the demersal/pelagic fish and invertebrate assemblages that use this feature. Depending on the dredging design and execution, this action could alter this shoal structure permanently and could affect the local ecological processes occurring at this location. St. Lucie Shoal accounts for only a small fraction of the total sand bottom habitat in the region. The adjacent un-dredged areas would provide the infaunal source to recolonize the excavated area. The excavation would not result in long-term negative impacts to benthic populations or the benthic community.

USACE will continue to collect additional geotechnical and geophysical data within the proposed St. Lucie Shoal borrow area during Preconstruction Engineering and Design (PED). These more refined data will inform the final borrow area design parameters prior to construction. The overall goal is to ensure that

physical and biological processes following dredging are maintained within the St. Lucie shoal complex to the maximum extent practicable.

Based on the geophysical and geotechnical data that is currently available, the proposed borrow area design includes a dredging template that is oriented with the long axis of the shoal to minimize impacts to the overall shoal complex. Additionally, USACE and BOEM are currently investigating the feasibility of maintaining a refuge patch at maximum shoal elevations to promote quicker biological recovery following dredging. However, additional analysis will need to be performed during PED to better understand the cumulative volume of sediment within the shoal complex relative to the identified volume of sediment needed to support the Federal project.

In addition, borrow pits are known to attract numerous fishes and have also been known to provide resting places for sea turtles (Spring, K. and D. Snyder, CSA International, personal observations). Slacum et al. (2006, 2010) have indicated that for similar sand shoal habitats in the mid-Atlantic bight off the coasts of Maryland and Delaware, winter dredging may provide the least impactful period for dredging as that period includes the lowest use of the habitat by finfishes and invertebrates. Diaz et al. (2004) characterized seasonal changes in invertebrate fauna, concluding that appropriate project timing and engineering could lessen impacts on fishes by reducing stress on crustaceans that serve as primary prey items. Thus, the dredging period could also minimize potential impacts on shoal resources if the site exhibits similar biological cycles to those described in recent literature. Scott (2007), studying benthic communities of sand shoals off Cape May, New Jersey, concluded that continued dredging of the study area had not resulted in impacts to benthic taxa, abundance, or biomass. Based on differences in benthic assemblages in dredged and non-dredged areas, Scott and Burton (2005) concluded that "developing dredging plans for beach replenishment activities to limit the creation of dredge pits over at least a depth of 10 feet could reduce the chances of causing changes in benthic community, bottom sediment and water quality parameters detected in this study." They found no significant differences in the finfish communities associated with the study sites and stated, "Since the fish community did not display an impact, the change in water quality and the benthic community observed in this study may have little impact on higher living resources."

Turbidity

Increased turbidity levels could result from dredging sediments at the borrow area and from suspending fine grained fractions of the borrow material in the water column. Suspended sediments could create a visible, turbid plume in the water column. In addition, excess seawater, decanted and discharged overboard by the hopper dredge, could temporarily increase turbidity during construction. If the borrow material contains only a small portion of fine grained materials, turbidity should diminish rapidly and have little impact on organisms in the area; however, if the fine grained portion is high, turbidity can remain for longer periods or, in some cases, persist over the long term.

Underwater Noise and Vibration from Dredging Activities

Potential effects of the elevated background noise levels caused by dredge operator noise to marine mammals include:

- Limiting the detection by mammals of natural sounds

- Disturbing their normal behavior, resulting in possible displacement from areas
- Causing temporary or permanent reductions in hearing sensitivity

The potential effects depend on the type of marine mammal involved because different marine mammals have different hearing frequencies. The levels and types of ambient noise also strongly influence the potential area or zone of influence of a dredge-made sound. Clarke et al. (2002) characterized underwater sounds generated by bucket, hydraulic cutterhead, and hopper dredging operations, but have not reported the relationships between such noises and faunal behavioral changes associated with those noises. An animal's sensitivity to different sounds varies with frequency, and its response to a sound likely depends strongly on the presence and levels of sound in the frequency band or range of frequencies to which it is sensitive (Ports Corporation of Queensland 2005). Underwater noise can affect marine mammals (Richardson et al. 1995). However, the project does not involve any high-energy sound sources that could cause temporary or permanent auditory damage. In general, the sources and levels of underwater noise and vibration generated during the project are expected to cause only minor impacts on marine mammals. The most likely impacts are temporary behavioral responses such as avoidance or altered diving or swimming behavior.

The proposed dredging activity would occur in part of the North Atlantic right whales migratory route and potential calving grounds during the winter months; however, these whales are rare to the project area which is an extremely small area when compared to the overall waters used by the North Atlantic right whale for migration and calving. The humpback whale is rarely present within the vicinity of St. Lucie County during its spring/fall migration. As manatees use the open ocean relatively infrequently, manatees would not likely occur in the offshore shoal area. Marine mammals would likely avoid areas where the dredge is operating.

Thomsen et al. (2009) studied the possible noise sensitivity of marine life off the coast of England. They found that dredging noises occurred at frequencies between high level noise (e.g., low frequency sonar and pile driving) and lower-level noise (e.g., normal vessel traffic). They identified specific vertebrate and invertebrate species in their study area potentially impacted by dredging noises. However, they gave no indication that such noise had the potential for permanent adverse effects. They concluded that the main issues with dredging noise included the lack of information about the noise generated by dredging operations and the lack of any experimental study of potential impacts.

5.1.8 COASTAL BARRIER RESOURCES

FUTURE WITH-PROJECT (RECOMMENDED PLAN)

Coastal Barrier Resource System (CBRS) unit P11 occupies approximately 15% (roughly R-98 to R-98+210 and R-101.5 to R-103.5) of the project area proposed by the recommended plan. The purposes of the Coastal Barrier Resources Act (CBRA) include minimizing the loss of human life, wasteful expenditure of Federal revenues, damage to fish, wildlife, and other natural resources associated with CBRS units. There are limits to Federal expenditures related to actions that could affect a unit. Section 6 of the CBRA provides an exception to this limitation if the Federal expenditure is for non-structural[1] shoreline stabilization projects that are designed to mimic, enhance, or restore a natural stabilization system. There are a small

[1] FWS includes beach and dune features as non-structural options.

number of privately owned parcels within the project area, and within P11, which are not under any perpetual conservation designation. Federal expenditures for any alternative implementation (including beach nourishment) in this area would be prohibited by the CBRA due to the fact that such action could encourage development. A Section 6 CBRA exception would only apply if these private parcels were covered under a perpetual conservation easement which is not the case. However, non-federal funds could be used to nourish the beach in this area. Dollman Park, a publicly owned parcel within the project area, does meet the Section 6 exception since development is prohibited in this location; therefore, Federal funds could be used to nourish the beach adjacent to the park. The U.S. Fish and Wildlife Service, by letter dated November 2, 2016, concurred with this determination (refer to **Appendix H: Pertinent Correspondence**).

Any of the beach nourishment alternatives could benefit adjacent coastal barrier resources by dispersing sand into those areas as the project beach subsequently erodes. Placement of sand within the project area is anticipated to contribute to the sand-sharing system and provide feeder benefits to adjacent shorelines.

5.1.9 WATER QUALITY

FUTURE WITH-PROJECT (RECOMMENDED PLAN)

Implementing the plan would likely cause temporary increases in turbidity levels due to the dredging of sediments at the borrow area and placement of sediments on the beach. Turbidity results from the suspension in the water column of fine grained fractions of the borrow material. Suspended sediments create a visible, turbid plume in the water column. This turbid plume can cause physical or behavior impacts to invertebrates, particularly sessile organisms on the nearshore hardbottom areas. If the borrow material contains only a small portion of fine grained materials, turbidity should diminish rapidly and have little impact on organisms in the area; however, if the fine grained portion is high, turbidity can linger for longer periods or, in some cases, persist long term.

During project construction, turbidity monitoring would provide information to demonstrate compliance with state water quality standards at the mixing zone boundary. Monitoring would occur at both the borrow area and at material placement locations. Background monitoring at the borrow material placement site would occur approximately 65 m from shore and 150 m up-current from the fill discharge or placement location. Compliance monitoring would occur no more than 65 m from shore within the densest portion of any visible turbidity plume, 150 m down current of the discharge point.

5.1.10 HAZARDOUS, TOXIC, AND RADIOACTIVE WASTE

FUTURE WITH-PROJECT (RECOMMENDED PLAN)

The plan is not anticipated to affect hazardous, toxic, or radioactive waste sites or producers in the project area, including the FPL Hutchinson Island Nuclear Power Plant. No impacts associated with the disturbances of such sites are anticipated. The proposed project would not involve placement, use, or storage of hazardous and toxic materials in or near the project area. A potential for hydrocarbon spills exists with dredging and construction equipment in the area, but accident and spill prevention plans delineated in the contract specifications should prevent most spills. The construction contract would include requirements to properly manage, store, and dispose of all materials generated by the project.

5.1.11 AIR QUALITY

FUTURE WITH-PROJECT (RECOMMENDED PLAN)

The short-term impacts from emissions by dredges and other construction equipment associated with the project are not anticipated to affect onshore or offshore air quality significantly. Exhaust emissions from vehicles, vessels, and construction equipment associated with the project would have a temporary and localized effect on air quality. Offshore sea breezes are anticipated to disperse pollutants. This project requires no air quality permits. The analysis below estimates emissions from the non-federal sponsor's preferred plan, but the emissions levels of the other build alternatives are sufficiently similar to reach the same conclusion concerning air quality impacts as provided below.

An analysis was performed to estimate emissions from the project previously completed by the non-federal sponsor (Taylor 2012). The analysis included calculation of total project emissions of nitrogen oxides (NO_x), sulfur dioxide (SO_2), carbon monoxide (CO), volatile organic compounds (VOCs), and particulate matter (PM) less than 10 microns and greater than 2.5 microns.

Power requirements, duration of operations, and emission factors for the various equipment types used in project construction provided the basis for estimates of air pollutant emissions resulting from construction of the non-federal sponsor's preferred alternative.

The product of horsepower (hp) rating, activity rating factor (percent of total power), and operating time provided the estimate of project energy use. The energy use value multiplied by an engine-specific emission factor yielded emission estimates. Operational data reported in the Martin County FEIS (USACE 2010) for a beach nourishment project of similar size immediately south of the proposed project area provided power requirements and duration for each phase of the proposed dredging activity.

The hp rating of the dredge plant considered propulsion (3,500 hp), dredging (2,565 hp), pumping (2000 hp), and auxiliary (600 hp). Different rating or loading factors were used for dredging, propulsion, and pumping. The air quality analysis contains the following assumptions:

- The previously constructed non-federal project placed an estimated 645,164 cubic yards within the beach template. The proposed Federal project would dredge 422,000 cubic yards for initial construction of the design beach profile and approximately 2 periodic nourishment events averaging 390,000 cubic yards each.
- Dredging cycle time (dredging, travel to transfer point, pump-out, and return to dredge site, and idle time) would last five hours.
- Each dredging cycle would move on the order of 2,000 cubic yards of material, requiring approximately 243 loads to excavate enough material to place 485,900 cubic yards of sand on the beach.
- Dredging could last 65 to 181 days.
- Distance from dredge site to transfer point would span three-seven miles.
- Placement and relocation of nearshore mooring buoys used during pump out may involve up to two tender tugboats, a derrick barge, two work barges, and pipeline hauler/crane.

- Construction would include moving the buoy (and the subline) five times during the project; each move would require approximately 12 hours of machine operation.
- Crew/supply vessel operation would approach four hours per day.

The analysis assumed that all dredging, hopper transport, and crew/supply vessel activities would occur over state waters and at the placement site. The beach fill related estimates assumed the use of up to four bulldozers/pipeline movers and two trucks, each operating 80% of the time for the duration of the project.

Emission factors for the diesel engines on the hopper dredge, barge, and tugboats came from EPA's *Compilation of Air Pollutant Emissions Factors, AP-42, Volume 1* (2002). Derived emission factors for tiered equipment used in beach construction came from NONROAD model (5a) estimates.

Any of the action alternatives may result in small, localized, and temporary increases in concentrations of NO_x, SO_2, CO, VOCs, and PM (**Table 5-3**). Because the project is located in an air quality attainment area, the EPA requires no preliminary air quality conformity assessment. The proposed Federal project would result in approximately 35% less emissions for initial construction, and approximately 40% less emissions for the 2 proposed periodic nourishment events as compared to the non-federal sponsor's previously constructed project.

Emissions associated with the dredge plant would provide the largest contribution to the inventory. However, the total project emissions represent a minor percentage of the existing point and nonpoint and mobile source emissions in St. Lucie County (**Table 5-3**). Prevailing winds would quickly disperse any pollutant released into the atmosphere from the project area. Since the recommended plan of the proposed Federal project is smaller in size, the resulting emissions would be even less significant. Green House Gas emissions would minimally effect global emissions or total United States emissions. Dune vegetation planted would contribute to Green House Gas reduction through carbon sequestering.

Emission quantities vary with the number of trips and total operating time required to dredge the necessary quantity of sand. The calculated emissions of the non-federal sponsor's project would fall between those with lower sand volume and related construction activity requirements and those with greater sand requirements. The no-action alternative would have no impact on air quality.

Table 5-3. Estimated Emissions of the Non-Federal Sponsor's Previously Constructed Project.

Activity	Emissions (tons)					
	NO_x	SO_2	CO	VOC	$PM_{2.5}$	PM_{10}
Dredge Plant (Hopper)						
Dredging/Operation	11.1	0.2	2.5	0.3	0.2	0.2
Turning/Sail	23.3	0.4	5.3	0.6	0.4	0.4
Pump-out	6.2	0.1	1.4	0.2	0.1	0.1
Idle/Connect- Disconnect	2.2	0.0	0.5	0.1	0.0	0.0
Supporting Offshore Activities	6.8	0.1	1.6	0.2	0.1	0.1

Beach Fill	4.6	0.8	2.2	0.3	0.4	0.4
Total Project Emissions	**54.2**	**1.7**	**13.5**	**1.6**	**1.2**	**1.2**
2002 Countywide Emissions Nonpoint + Mobile	9,509	1,661	70,230	12,636	1,480	6,646
2002 Countywide Emissions Point and Nonpoint + Mobile	10,037	1,681	70,777	14,162	1,551	6,743

St. Lucie County 2002 emissions from EPA National Emission Inventory http://www.epa.gov/air/data/

5.1.12 NOISE

FUTURE WITH-PROJECT (RECOMMENDED PLAN)

Project construction activities could result in short-term minor adverse effects to the noise environment in the vicinity of both the beach fill and borrow area sites. Construction would include temporary sources of noise. This noise has the potential to disturb biological resources such as fishes, sea turtles, marine mammals, and seabirds. Sound would likely dissipate significantly over the three-mile+ distance between the dredging area and shoreline.

Proper maintenance of construction, dredging, and pumping equipment would minimize the noise impacts, and construction activities would likely occur for a short period. Construction noise may have a short-term, minor effect on sound levels in the vicinity of the construction activities.

5.1.13 AESTHETIC RESOURCES

FUTURE WITH-PROJECT (RECOMMENDED PLAN)

Effects associated with the plan include:

- Presence of construction equipment
- Noise
- Turbidity

The pipeline coming out of the water and along the beach, earthmoving equipment spreading sand along the beach, and associated construction activities would temporarily affect the aesthetics in the project area. Earth moving equipment used to distribute the sand would temporarily create visual disturbance as well as noise and exhaust fumes, which would decrease the overall aesthetic value in the immediate vicinity of the project activities. Earth moving equipment would operate from along the beach front to distribute the sand effectively after initial placement on the beach from the discharge pipes. Sand placement would cause short-term turbidity increases in the nearshore waters, resulting in a change in water color and clarity, and resulting in temporary minor impacts.

Analysis of grain size, color, and hue of the proposed borrow area sand area indicates that the dredged sand would be similar to the existing sand. With restoration of the currently eroded beaches, the overall aesthetic value within the project beach area is anticipated to increase.

The view within the proposed borrow area during project implementation may be affected by the presence and operation of equipment performing dredging and beach fill operations.

Any of the build alternatives could result in diminished aesthetic values as the beach continues to erode and narrow. Dispersion of sand from the south segment could partially offset this erosion.

5.1.14 RECREATION RESOURCES

FUTURE WITH-PROJECT (RECOMMENDED PLAN)

Effects associated with the plan include:

- Limited and/or restricted access
- Turbidity

Recreational use of the beaches and coastal waters would temporarily decrease in the immediate vicinity of active nourishment and borrow dredging efforts. Temporary public safety restrictions would keep beachgoers and recreational users from the areas of active construction on the beach and at the borrow site. The active construction areas would shift along the project area beach; recreational users could access areas already nourished. Increased turbidity and resulting decrease in visibility would reduce or eliminate scuba diving and snorkeling in the project construction zone and in the mixing zone down current of the project area beach, where temporary increased turbidity could occur. The project would not likely affect nearshore coastal boating and fishing, which could continue as usual during nourishment activities. Project implementation could result in overall short-term impacts to recreational opportunities.

The Recreational Benefits Assessment conducted from 2007 to 2008 (Stronge 2008) surveyed beach users on south Hutchinson Island in St. Lucie County from R-77 to the Martin/St. Lucie County line to determine the amount beach users would willingly pay during each visit to use the beach. Based on the amount that beach users would willingly pay, Stronge concluded that nourishment would add a recreational use benefit of $549,690 compared to the existing beach, resulting in a positive impact to recreation from project implementation.

5.1.15 CULTURAL RESOURCES AND HISTORIC PROPERTIES

As discussed in the Section 2: Existing Conditions and Future Without-Project Conditions portion of this document, substantial cultural resources work and investigations have been conducted throughout various portions of the project area. This project has been coordinated with the Florida SHPO and the appropriate federally-recognized tribes in accordance with Section 106 of the NHPA, as amended (16 USC 470) and it's implementing regulations (36 CFR 800) and consideration given under the NEPA.

FUTURE WITH-PROJECT (RECOMMENDED PLAN)

The Recommended Plan would see shoreline impacts occurring between FDEP Range Monuments R-98 and the Martin County line. No cultural resources have been identified within this portion of the project area. As discussed in Section 2, this area was previously surveyed in 2007 and no cultural resources were identified as a result of this survey. Additionally, there are no previously identified historic properties or districts adjacent to the sand placement template; however, beach nourishment will benefit those structures that may be potentially eligible for listing in the NRHP by minimizing the potential of erosion. The SHPO reviewed the survey record and concurred with the recommendation of no effect on cultural resources in a letter to USACE dated 27 July 2010 (DHR File No. 2008-02141-B) (**Appendix H**).

Based on remote sensing surveys conducted between 2007 and 2010 of the proposed offshore borrow locations, one cluster of magnetic anomalies was identified in the southern borrow area and two historic wreck sites are located adjacent to the northern borrow area. No diver evaluations were performed on the magnetic targets, and a buffer of 200 feet was recommended to avoid effects on the potentially significant resource. In a letter dated 31 July 2008 USACE determined that a 500-foot buffer of the anomalies would be utilized during dredging to avoid impacts (Appendix H). This letter also noted that the two previously recorded historic shipwrecks are located outside of the project area and determined that, contingent upon the preservation of the anomaly cluster with a 500-foot buffer zone, no historic properties would be affected by dredging. The SHPO concurred with the determination of effects in a letter dated 4 September 2008 (DHR File No. 2008-05091) (**Appendix H**).

During implementation of the Recommended Plan, USACE will continue to protect these cultural resources by maintaining the 500-foot buffer previously implemented during dredging. Contingent upon maintaining the buffer, USACE has determined that the Recommended Plan will have no effect on historic properties listed or eligible for listing in the NRHP. As a result of consultation, both the Florida SHPO and the Seminole Tribe of Florida concur with USACE determination of no effect to historic properties in letters dated May 3, 2016 and April 27, 2016 respectively (**Appendix H**). The Miccosukee Tribe of Indians of Florida declined to comment.

5.1.16 NATIVE AMERICANS

FUTURE WITH-PROJECT (RECOMMENDED PLAN)

As part of the development of this project, the Recommended Plan has been coordinated with the appropriate federally-recognized tribes within the immediate area of potential effect. As discussed in Chapter 3, there are no known Native American properties within the project area and the project will have no effects to Native Americans. Consultation with the Miccosukee Tribe of Indians of Florida and the Seminole Tribe of Florida has been undertaken. As a result of this consultation, the Seminole Tribe of Florida concurred with USACE determination of no effect and the Miccosukee Tribe of Indians did not provide comment (**Appendix H**).

5.1.17 PUBLIC SAFETY

FUTURE WITH-PROJECT (RECOMMENDED PLAN)

As a public safety measure, beach and water-related recreation in the immediate vicinity of the discharge pipe would be prohibited during project construction. Likewise, water related activities near the dredge site would also be prohibited during project construction. Recreational access to these areas would return to pre-construction conditions following completion of the project. Long-term effects are not anticipated.

5.1.18 NATURAL OR DEPLETABLE RESOURCES

FUTURE WITH-PROJECT (RECOMMENDED PLAN)

No natural energy resources occur within the proposed project area. The St. Lucie Shoal proposed as a source for beach fill is considered a depletable resource. Project dredging would reduce the quantity of shoal sand.

Excavation of sediments from borrow sites exposes underlying sediments and can change the sediment structure and composition of the borrow site. This can lead to changed benthic community composition. Benthic species' ability to perform life functions (e.g. burrowing, feeding, or settling as larvae) varies with sediment quality and members of the current benthic community may or may not have the same success in the physical characteristics of the new sediment as in the existing sediment. In addition, excavation alters the seabed topography, creating pits that that may refill rapidly or remain for extended periods. Studies have shown that some borrow areas located within highly depositional areas have a relatively short filling time, whereas other areas may take up to 12 years returning to pre-dredge topography. In general, shallow dredging over large areas causes less change than smaller deep pits. If borrow pits are excavated in small deep pits, current velocity is reduced at the bottom, which can cause the deposition of fine particulate matter and potentially create a biological assemblage much different in composition than the original (Hammer et al. 2005). These assemblages may not provide the same trophic support as the original benthic community. However, the project dredging design provides a maximum dredging depth of only 10 feet below the existing surface (a relatively shallow dredging template) and the dredge footprint comprises a very small portion of the total benthic habitat area. Predators on the benthic community would still have ample forage area after dredging ends.

Structurally, however, dredging could alter this shoal structure permanently and locally affect the seabed topography within the borrow site. BMPs applied to the design of the dredging profile of the shoal including avoidance of dredging across the shoal and maintaining a refuge patch at the highest shoal elevations would help minimize the impacts to the shoal habitat. In addition, based on physical geological models of shoal formations, there does not appear to be a mechanism that supports the idea that structural integrity of a shoal feature would "deflate" or "unravel" when subject to repeated dredging events (CSA International et al. 2009a), which has been suggested by Michel et al. (2001). Dibajnia and Nairn (2010) summarizing field and modeling studies of shoal behavior with dredging indicated that dependent upon dredging location, shoals will reform and retain existing original height after completion of dredging.

However, not all impacts from dredge pits are detrimental. Borrow pits are known to attract numerous fishes and have been known to provide resting places for sea turtles (K. Spring and D. Snyder, personal observations off Hobe Sound, Florida).

5.1.19 ENERGY REQUIREMENTS AND CONSERVATION

FUTURE WITH-PROJECT (RECOMMENDED PLAN)

Energy requirements for the proposed alternative would be limited to the fuel for the dredging and pumping equipment, labor transportation, and construction equipment associated with beach placement. The use of sand from the proposed borrow areas would require less energy expenditure than obtaining sand from any other distant source.

5.1.20 IRREVERSIBLE AND IRRETRIEVABLE COMMITMENT OF RESOURCES

FUTURE WITH-PROJECT (RECOMMENDED PLAN)

5.1.20.1 IRREVERSIBLE

An irreversible commitment of resources is one in which the ability to use a resource is lost forever. The use of sand from offshore or upland borrow areas would irreversibly commit those sand resources to this project and preclude their use for future nourishment projects. However, the offshore borrow area for this project is estimated to contain 10.6 million cubic yards of beach-compatible sand, which is more than adequate for the sand required by the project.

Use of sand from offshore borrow areas would also irreversibly preclude its current use as habitat for benthic organisms. However, portions of the existing shoals may be left undisturbed as “refuge patches” to minimize impacts to existing benthic resources and to provide for re-colonization of disturbed borrow areas. Sufficient remaining sand reserves within and adjacent to the borrow area would provide for recolonization of benthic organisms. Due to the dynamic nature of nearshore benthic environments, sand used to nourish the beach would eventually disperse in the nearshore areas and create habitat for shallow water benthic communities.

Impacts of beach restoration on nearshore hardbottom communities have been previously mitigated. These nearshore hardbottom areas are also cyclically covered and exposed due to seasonal and other temporal changes in beach profiles. In view of the natural, highly dynamic fluctuations in exposure and burial of the nearshore rock resource and the modest scale of the proposed beach fill activity, abandonment of the project at any point can be reasonably anticipated to result in the near or wholly complete recovery of existing conditions.

5.1.20.2 IRRETRIEVABLE

An irretrievable commitment of resources means that opportunities for other uses are foregone for the period of the Proposed Action. Typically, it refers to the use of renewable resources, including human effort, and to other utilization opportunities foregone in favor of the Proposed Action.

The loss of hardbottom habitat has been previously mitigated through the implementation of a program to construct nearshore artificial reef. As noted, impacts of beach restoration on nearshore hardbottom communities are reversible and do not represent an irretrievable commitment of these resources for project use.

5.1.21 UNAVOIDABLE ADVERSE ENVIRONMENTAL IMPACTS

FUTURE WITH-PROJECT (RECOMMENDED PLAN)

The main unavoidable adverse impact of the plan would be impacts to nearshore hardbottom habitat; however, this impact has been previously offset by the non-federal sponsor. Re-exposure of hardbottom is also possible due to high-energy dynamics of the area and equilibration of beach fill. Recolonization of re-exposed hard substrates by worm rock and turf and macroalgae is probable as these organisms have high recruitment capability.

Other unavoidable adverse impacts of fill projects to the marine environment include:

- Burial of infauna and non-motile epifauna in nearshore sand bottom areas due to placement of beach fill. Recovery would depend on the ability of buried organisms to burrow through the sediment layer and the ability of adjacent populations to recolonize the area. However, the affected area is a small percentage of the total sand bottom habitat in the region.
- Impacts to infaunal communities in the offshore borrow area due to sand removal and habitat alteration. These impacts are reversible, as the affected areas would gradually fill with sand from adjacent areas and be recolonized by infauna. Portions of the existing shoals are proposed to be left undisturbed as “refuge patches” to minimize impacts to existing benthic resources and also provide for recolonization of benthic resources in the disturbed borrow areas.
- Temporary, localized water column turbidity in the offshore borrow area and along the project shoreline. BMPs implemented during construction should reduce the magnitude and extent of turbidity and the project should result in only minor, temporary adverse effects on water quality. Turbidity would be monitored during construction to ensure that turbidity from construction activities conforms to State water quality standards at the mixing zone boundary.
- Temporary, localized air quality and noise impacts due to emissions from offshore and onshore construction equipment.
- Temporary aesthetic/visual impacts due to the presence of construction equipment in the offshore borrow area and along the project shoreline.
- Temporary loss of recreational use of the beach and adjacent nearshore areas during construction. Minor impacts to recreational opportunities would likely occur. The project area comprises a small percentage of the total area available for similar recreational activities in St. Lucie County.

5.1.22 LOCAL SHORT-TERM USES AND MAINTENANCE / ENHANCEMENT OF LONG-TERM PRODUCTIVITY

FUTURE WITH-PROJECT (RECOMMENDED PLAN)

The plan is expected to produce localized, short-term impacts on nearshore benthic communities and water quality, but it is not expected to cause significant adverse impacts on long-term productivity. Shoreline protection using periodic beach nourishment is an ongoing activity along much of the Florida shoreline. Beach nourishment projects have a temporary and short-term impact on nearshore biological resources and local offshore biological communities when offshore dredging supplies the nourishment sand. Most motile organisms (fishes, crabs, and some sand dwelling organisms) within the offshore borrow area and nearshore fill zone should be able to escape these areas during construction. Less-motile individuals that are unable to escape from construction would be lost, but lost populations of those individuals typically recolonize rapidly after project completion. The plan would produce temporary increases in turbidity but would not result in significant long-term water quality degradation. Short-term reductions in primary productivity and reproductive and feeding success of invertebrate species and fish are expected. These impacts should not negatively affect the sustainability of these populations given the localized scale of impacts and the creation of mitigation reefs.

5.1.23 INDIRECT EFFECTS

FUTURE WITH-PROJECT (RECOMMENDED PLAN)

Some prior studies have concluded that beach nourishment projects lead to greater development, tourism, investment, and subsequently greater long-term requirements for shoreline protection (National Research Council Committee on Beach Nourishment and Protection 1995, Pilkey and Dixon 1996, Dean 1999). However, other studies concluded that shoreline development is fostered mainly by economic factors other than public investment in shoreline protection (Cordes and Yezer 1998, Cordes et al. 2001). If allowed to occur, increased shoreline development could result in additional indirect ecological impacts such as adverse effects on sea turtle nesting due to increased artificial lighting, etc.

Few sites in the uplands adjacent to the project area remain open for development, so there is little or no opportunity for future development growth adjacent to the project beach. The existing shoreline includes a mix of residential, commercial (lodging), and public park facilities. More importantly, the potential for indirect development effects has been minimized in the design of the build alternatives. The non-federal sponsor has delineated the project area to (a) include that portion of the study area that is designated by FDEP as “critically eroded.” The project qualified for state cost-sharing where beach nourishment appears feasible for obtainment of a FDEP permit, but (b) excludes shoreline segments where minimal or no beach-front development exists and where little or no storm damage prevention benefits would be realized via beach nourishment.

5.1.24 COMPATIBILITY WITH FEDERAL, STATE, AND LOCAL OBJECTIVES

FUTURE WITH-PROJECT (RECOMMENDED PLAN)

Recognizing the importance of the state's beaches, the Florida Legislature in 1986 adopted a posture of protecting and restoring the state beaches through a comprehensive beach management planning program. Under the program, the FDEP's Bureau of Beaches and Coastal Systems evaluates beach erosion problems throughout the state seeking viable solutions. The primary vehicle for implementing the beach management planning recommendations is the Florida Beach Erosion Control Program, a program established to work in concert with local, state, and Federal governmental entities to achieve the protection, preservation, and restoration of the coastal sandy beach resources of the state. Eligible activities include beach restoration and nourishment activities, project design and engineering studies, environmental studies and monitoring, inlet management planning, inlet sand transfer, dune restoration and protection activities, and other beach erosion prevention activities consistent with the adopted Strategic Beach Management Plan.

The FDEP has classified most of the south St. Lucie County beaches as "critically eroded areas," a level of erosion that threatens substantial development, recreational, cultural, or environmental interests. One way to restore eroded beaches is through beach nourishment where sand is collected from an offshore location by a dredge and is piped onto the beach. A slurry of sand and water exits the pipe on the beach and once the water drains away, only sand is left behind. Bulldozers move this new sand on the beach until the beach matches the design profile. Beach nourishment comprises a preferred way to add sand to a system because it provides a significant level of storm protection benefit for upland properties and includes the relatively few impacts to the coastal system. An additional benefit of beach restoration projects is that such projects quickly restore shorebird and marine turtle habitat.

The St. Lucie County coastline is a valuable resource providing storm protection, recreation, economic value, and wildlife habitat. The preservation of this coastline is a long-term, ongoing non-federal sponsor commitment. The non-federal sponsor's main objective is to abate ongoing and historical beach erosion; specific non-federal sponsor criteria for plan formulation include optimizing project performance and cost effectiveness — generally consistent with USACE planning regulations for coastal storm risk management projects, and minimizing environmental impacts to the extent feasible.

Along many coastal areas, including the project area, erosion threatens oceanfront properties. Beach and dune restoration is necessary to help prevent the loss of property and/or the construction of numerous emergency shoreline armoring structures and other stopgap measures that would very likely continue to narrow the beach. With beach narrowing, sea turtle nesting habitat diminishes until (ultimately) no nesting habitat remains. While narrow beaches may still support nesting, if high tides reach a dune line on a regular basis, hatching success dramatically decreases from nest inundation and washout. In addition, recreational use of narrowed beaches diminishes. Therefore, the proposed project is consistent with Federal, state, and local objectives.

5.1.25 CONFLICTS AND CONTROVERSY

FUTURE WITH-PROJECT (RECOMMENDED PLAN)

The NMFS expressed concerns regarding the beach nourishment project previously constructed by St. Lucie County, and mitigation that St. Lucie County provided for impacts to hardbottom habitat (refer to Section 2.2.5 and Appendix G, Attachment 3 for more info). The NMFS requested continued coordination between the Jacksonville District and the NMFS Habitat Conservation Division until these issues are fully resolved. These concerns shall be fully addressed by USACE Regulatory Division prior to construction of the Federal project.

5.1.26 UNCERTAIN, UNIQUE, OR UNKNOWN RISKS

FUTURE WITH-PROJECT (RECOMMENDED PLAN)

The proposed activity (i.e. beach nourishment) is commonly conducted, and has previously been permitted and conducted in St. Lucie County. To date, USACE has identified no uncertain, unique, or unknown associated with the plan considered in this EA.

5.1.27 REUSE AND CONSERVATION POTENTIAL

FUTURE WITH-PROJECT (RECOMMENDED PLAN)

There is no potential for reuse associated with the proposed project activities; therefore, this is not applicable to the proposed periodic nourishment project. Energy requirements for the proposed alternatives would be confined to fuel for the dredge, labor transportation, and other construction equipment.

5.1.28 URBAN QUALITY

FUTURE WITH-PROJECT (RECOMMENDED PLAN)

No direct permanent impacts related to urban quality are expected as a result of the proposed project. Implementation of the proposed project would indirectly and positively impact urban quality by restoring an eroded beach, by increasing the recreational beach activity, and by increasing the tax revenue and tourism commerce.

The commercial businesses and residential properties along the project beach could benefit from the storm protection afforded by the project and incur less risk of property damage. The presence of construction equipment could temporarily detract from the aesthetics of the environment, possibly temporarily affecting the localized visual aesthetics associated with south Hutchinson Island.

5.1.29 SOLID WASTE

FUTURE WITH-PROJECT (RECOMMENDED PLAN)

No impacts related to solid waste are expected due to this project. Precautionary measures anticipated in the contract specifications would identify and require proper disposal of solid wastes. Precautionary measures include proper containment and avoidance of overflow conditions by emptying containers on a regular schedule. Disposal of any solid waste material into Atlantic waters would not be permitted.

5.1.30 SCIENTIFIC RESOURCES

FUTURE WITH-PROJECT (RECOMMENDED PLAN)

There are no known scientific resources associated with the plan.

5.1.31 DRINKING WATER

FUTURE WITH-PROJECT (RECOMMENDED PLAN)

The proposed plan would have no effect on drinking water.

5.2 CUMULATIVE IMPACTS

Cumulative impacts are those that result from "the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or non-federal) or person undertakes such other actions" (40 CFR 1508.7). Cumulative impacts result from spatial (geographic) and temporal (time) crowding of environmental perturbations. The impacts may result from the accumulation of similar effects or the synergistic interaction of different effects (Council on Environmental Quality 1997).

Table 5-4 summarizes cumulative impacts by identifying the past, present, and reasonably foreseeable future condition of the various resources with and without the project.

5.2.1 CUMULATIVE ACTIVITIES SCENARIO

The geographic scope of this analysis includes the shoreline of St. Lucie County and Martin County between Ft. Pierce Inlet and St. Lucie Inlet (about 22 miles of shoreline) and Atlantic Ocean sand shoals between about three and six miles offshore of the Central Florida coastline. The project impact area extends from R-96.5 in St. Lucie County to R-1.5 in Martin County due to the proposed mixing zone (150 meters from the point of sand discharge) and potential downdrift (southerly) transport of sand in the nearshore area. Other similar projects to the north and south and all the other reasonably foreseeable actions along the shoreline of Hutchinson Island could, together with the proposed project, result in cumulative impacts. In addition to the coastline, the area includes the offshore borrow area located in a sand ridge (St. Lucie Shoal) three miles offshore of R-88 to R-115 in water depths of approximately 36 to 43 feet. Cumulatively, the project and other similar projects could impact sand shoals three to five miles offshore.

5.2.1.1 PAST CONDITIONS AND ACTIVITIES

A Conditions Assessment Report (Coastal Tech 2009) summarizes historical shoreline changes from R-77 through R-115. Except for the segment from R-103 to R-109, the shoreline within the study area predominantly retreated from 1972 to 2006. A volumetric study conducted by USACE indicates that from 1997 to June 2004, the beaches of the study area cumulatively experienced slight erosion. From June 2004 to November 2004, following landfall of hurricane Frances and Jeanne (September 2004), a much stronger trend of erosion occurred.

Following hurricanes Frances and Jeanne, emergency dune restoration was conducted by the non-federal sponsor — including placement of about 162,000 cubic yards of sand along the dune from R-98.4 to R-101.5, and from R-103.3 to the Martin County line (PBS&J, 2005) — over about 15,500 feet of dune and corresponding to a fill density of about 10 cubic yards/foot. Individual property owners have also undertaken dune restoration projects; placed quantities are unknown, but the non-federal sponsor believes these amounts are relatively minor. North of the project area, the Federal Ft. Pierce Shore Protection Project area (about 1.3 miles in length) has received nourishment sand since 1971, before the Federal project was defined. The Federal project began in 1980. Since that time, 14 nourishments have placed sand on various portions of the project beach. Abutting the proposed project to the south, the Federal Martin County Shore Protection Project, initiated in 1995, has renourished a four-mile project three times with the last renourishment completed in 2013. In addition, Martin County nourished Bathtub Beach, about 1,000 feet of shoreline, in spring 2010. Sail Fish Point Beach, just south and about 1,500 feet in length, received sand in 2005 and 2009.

Table 5-4. Summary of Cumulative Impacts.

Resource	Past and Present (Baseline/Existing Condition)	Future Without-Project	Future With-Project
Threatened and Endangered Species: Sea Turtles	Five sea turtle species occur in the area (loggerhead, green, hawksbill, Kemp's ridley, and leatherback). Loggerhead, green, and leatherback turtles nest on area beaches. Juvenile green turtles use nearshore hardbottom areas for feeding (macroalgae), resting, and shelter from predators. Past and current threats to sea turtle populations include artificial lighting, beach armoring, anthropogenic disturbance, trawling, dredging, vessel strikes, fishing gear entanglement, and ingestion of discarded anthropogenic marine debris.	Sea turtle nesting and nearshore habitat use would continue in the area. Project-specific impacts would be avoided, but ongoing threats to sea turtle populations would continue. In the absence of the project, property owners may armor their shoreline to protect their property, which may result in loss of nesting habitat and possible impacts on nearshore hardbottom habitat.	In addition to ongoing threats, the project would result in loss of a small defined area of juvenile developmental habitat (nearshore hardbottom). Sea turtles may be disturbed by turbidity and noise during construction. There is a small risk of sea turtles being struck by a construction vessel or entrained in the hopper dredge draghead; these risks would be minimized through vessel-strike avoidance and dredge related impact mitigation measures. Due to the small spatial extent and short duration of project impacts, no significant cumulative impacts are anticipated.
Threatened and Endangered Species: Marine Mammals	Three endangered marine mammal species may occur in the area: Florida manatee, humpback whale, and North Atlantic right whale. Only the manatee is common. Past and current threats to marine mammal populations include vessel strikes, fishing gear entanglement, ingestion of marine debris, pollution, and underwater noise.	Marine mammals would continue to occur in the area. Project-specific impacts would be avoided, but ongoing threats to marine mammal populations would continue.	In addition to ongoing threats, marine mammals may be disturbed by turbidity and noise during construction. There is a small risk of marine mammals being struck by a construction vessel or entrainment within a hopper dredge draghead. Mortality of a manatee or North Atlantic right whale would represent a significant cumulative impact due to the small population of these species. The risk would be minimized through vessel-strike avoidance and dredge impact – related mitigation measures.
Threatened and Endangered Species: Smalltooth Sawfish	The smalltooth sawfish is an endangered species inhabiting shallow, nearshore waters. Historically, its population and range have declined, mainly due to fisheries bycatch. Other past and current threats are habitat loss and degradation, entanglement in marine debris, pollution, and anthropogenic disturbance.	Smalltooth sawfish would continue to inhabit the area. Project-specific impacts would be avoided, but ongoing threats to sawfish populations would continue and may result in further decreases in population size and range.	In addition to ongoing threats, sawfish may be disturbed by turbidity and noise during construction. There is a small risk of sawfish being entrained in the hopper dredge draghead, which would be minimized through mitigation measures. Due to the small spatial extent and short duration of project impacts, the smalltooth sawfish would not likely incur other than minor impacts.
Nearshore Hardbottom	Two nearshore hardbottom communities occur in the area. One consists of low- to medium-relief habitat with worm rock and supports hydroids, encrusting sponges, macroalgae, and turf algae. The other consists of low-relief coquina ledges with little or no epibiotic cover. These communities have historically been subjected to the dynamics of the nearshore environment including sand movement, scouring, and alternating burial/exposure.	Nearshore hardbottom areas would continue to exist in the area, subject to the natural dynamics of the nearshore environment including sand movement, scouring, and alternating burial/exposure. In the absence of the project, property owners may construct shoreline armoring to protect their property, which may result in impacts to nearshore hardbottom.	Impacts to the nearshore hardbottom from previous beach placement activities have been mitigated.

Resource	Past and Present (Baseline/Existing Condition)	Future Without-Project	Future With-Project
Fish and Wildlife Resources	Nearshore soft bottom habitats including sand shoals support a variety of invertebrates and demersal fishes. Invertebrates using shoals include infaunal and epifauna species represented primarily by annelid worms, gastropods, bivalves, crustaceans, and echinoderms. Most of these species are used as food by demersal fishes.	Project-specific impacts would be avoided, but soft bottom communities would continue to be affected by natural sand movement. In the absence of the project, property owners may armor their shoreline to protect their property, which may result in impacts to nearshore soft bottom communities. Regionally, other sand shoal areas are likely to be used in support of future beach nourishment projects.	In addition to ongoing processes affecting soft bottom fish and wildlife resources, there would be localized effects of dredge and fill activities along the beach and in the offshore borrow area that may persist for a few months to a few years. Major long-term effects are not anticipated because resident fish and wildlife species are wide-foraging or migratory and spend only a portion of their life cycle at the borrow area and beach fill sites.
Essential Fish Habitat	Managed species and species groups in the project area include *Sargassum*; coral, coral reefs, and live/hardbottom habitats; penaeid shrimp; spiny lobster; red drum; coastal pelagic fishes; reef fishes; dolphin and wahoo; and highly migratory pelagic species. Habitats of Particular Concern (HAPCs) for coral, coral reefs, and live/hardbottom habitats of the eastern Florida area include the *Phragmatopoma* worm reefs found in nearshore waters; nearshore hardbottom found in water depths of 0 to 4 m; and hardbottom found in water depths of 5 to 30 m.	Project-specific impacts would be avoided, but the acreage of nearshore hardbottom Essential Fish Habitat (EFH) would fluctuate with natural sand movement. Increased exposure of hardbottom may provide increased habitat for surf zone fishes, increased foraging habitat for green sea turtles, and increased refuge for juvenile fishes. In the absence of the project, property owners may construct armoring to protect their property, which may result in impacts to nearshore EFH.	Approximately 0.57 acres of exposed nearshore hardbottom habitat within the study area was impacted by prior sand placement activities. St. Lucie County provided mitigation to offset these impacts. The recommended plan, with its smaller placement area, would not exceed previous impacts and, therefore, additional mitigation is not proposed. Please refer to Section 2.2.5 and to Appendix G, Attachment 3 for more information on the mitigation.
Water Quality	The project area consists of Class III waters, which are designated as suitable for recreation, propagation, and maintenance of a healthy, well balanced population of fish and wildlife. The predominant issue that affects water quality in the area is turbidity, which varies significantly under natural conditions (e.g., during storms), sometimes exceeding 29 NTU. Historically, coastal water quality has been affected by unrelated anthropogenic sources such as stormwater and effluent runoff resulting in increased nutrients and freshwater inputs. Urbanization and population growth in the region contributes to coastal water quality degradation.	Project-specific impacts would be avoided, but turbidity would continue to occur intermittently due to storm activity, rainfall, currents, and other natural phenomena. Water quality may deteriorate due to unrelated anthropogenic sources such as stormwater and effluent runoff.	In addition to the ongoing natural and anthropogenic fluctuations in water quality, local, short-term turbidity would occur adjacent to the beach fill sites and offshore borrow area. BMPs would be implemented during construction to reduce the magnitude and extent of turbidity, and adverse effects on water quality are expected to be minor. Turbidity would be monitored during construction to ensure that State water quality standards are met at the mixing zone boundary. Due to the small spatial extent and short duration of project impacts, no long-term effects are expected.

5.2.1.2 . PRESENT/ONGOING ACTIVITIES

There are no ongoing beach restoration activities in the project area. The St. Lucie shoal is not currently being used for any other beach restoration projects. Recreational usage along the beaches within the project area includes shore based water sports such as scuba diving, snorkeling, surfing, surf fishing, and kayaking. Additionally, the area beaches are used for sunbathing, picnicking, and exercising. Boating is a popular recreational pastime for many residents and tourists to the area. Fishing, scuba diving, and snorkeling are often done from boats in nearshore hardbottom areas close to the shore. These shallow nearshore hardbottom areas are attractive areas for scuba diving and lobster fishing as well as angling from small vessels. Angling may occur near the proposed borrow site, although there are no known fish havens near the borrow area.

5.2.1.3 REASONABLY FORESEEABLE FUTURE ACTIVITIES

To provide for future periodic nourishment of the project, a conceptual 50-year borrow area dredge plan has been proposed based upon the report titled "St. Lucie County Sand Search – Geotechnical Investigations – Reconnaissance Level Investigations" (Coastal Tech 2010c). The periodic nourishment interval and volume are 18 years and 390,000 cubic yards, respectively. The proposed borrow area for project periodic nourishment is located offshore St. Lucie County in reasonable proximity to the project fill area. The borrow area can also likely yield the 50-year total estimated volume of beach compatible sand.

The Martin County Beach Erosion Control Project authorizes construction of a protective and recreational beach along four miles of shorefront southward from the St. Lucie County line to near the limit of Stuart Public Beach Park (R-1 to R-25). The authorized project was initially constructed in 1996 with a planned periodic nourishment interval of 11 years. Federal participation (cost sharing) is authorized for 50 years from date of initial construction and expires in 2046. The previously approved borrow area, used for initial construction, was depleted after the 2005 renourishment. Subsequently, Martin County and USACE investigated three sand shoals including portions of the St. Lucie Shoal complex located approximately three to seven miles offshore Martin and St. Lucie Counties on the OCS. The USACE and BOEM completed an EIS in 2011which authorized a borrow area southeast of the St. Lucie Shoal on the OCS as a source of beach-compatible sand. The new Martin County OCS borrow area was used for the 2013 renourishment. The total sand needed for the remainder of the 50-year period of Federal participation is estimated to total between 2.4 and 4.0 million cubic yards.

Regionally, beach nourishment is expected to continue in the coming years, compounding opportunities for recurring impacts. In southeast Florida alone, approximately 100 nourishment events are projected to occur between 1969 and 2050 dredging at least 100,000,000 cubic yards of sediment from an area 4 miles wide by 120 miles long (from Dade County to Martin County) (USACE 1996).

Future periodic nourishment projects at the proposed site would require less sand (390,000 cubic yards) than the initial nourishment on a 18-year periodic nourishment cycle. This results in a requirement of about 1.2 million cy over the 50-year project period of analysis. This amount comprises approximately 12% of the sand resources in the St. Lucie Shoal. Additionally, based on recent beach nourishment projects, construction of a 390,000 cubic yard project using upland sand sources can reasonably occur within a single annual period outside turtle nesting season. A future periodic nourishment project proposal should carefully evaluate the use of upland sand for construction.

The non-federal sponsor provides local sponsorship to the State of Florida for implementing the state Ft. Pierce Inlet Management Plan. Part of that sponsorship has included investigations to meet and maintain sand bypassing requirements across Ft. Pierce Inlet identified in the sand management plan. In 2004, Taylor Engineering completed a study for the non-federal sponsor to identify an annual bypassing operation that could either meet the state adopted bypassing requirements or, at a minimum, supplement the USACE coastal storm risk management project just south of Ft. Pierce Inlet (Taylor Engineering 2004). The bypassing operation could buffer high erosion rates seen immediately south of the Ft. Pierce Inlet south jetty and maintain the Federal beach restoration project's design template over its periodic nourishment interval. The study identified two alternatives — north jetty sand tightening with mobile sand bypassing plant and north jetty sand tightening with nearshore dredging — as reasonably attractive alternatives to bypass sand across the inlet. The non-federal sponsor has recently completed a feasibility study of a third alternative — construction of a sediment basin in the inlet (Taylor Engineering 2010). An effective deposition basin in the inlet would capture incoming sediments and provide a sand source for bypassing operations. A deposition basin (sand trap) would create an area of deep water, effectively decreasing flow velocities within the basin and causing sediment to deposit there, rather than further in the navigation channel and inlet interior. Past experience at several east coast Florida inlets has proven the effectiveness of channel deposition basins as replenishing sand sources for bypassing projects. At Ft. Pierce Inlet, a deposition basin within the inlet with periodic dredging could potentially fulfill or supplement sand bypassing volume requirements. The non-federal sponsor's Board of County Commissioners has recently directed non-federal sponsor staff to move ahead with design and permitting of a sand trap in the northwest corner of the inlet, adjacent to Ft. Pierce Inlet State Park. Bypass sand quality would likely equal or exceed that available from other sources (offshore or upland) and might in the long-term serve to improve the general quality of the sand and the nearshore environment along Hutchinson Island. The sand trapped in the impoundment comes from beaches updrift (north) of the inlet rather than from offshore or upland sources, and so provides very similar quality sand to the Hutchinson Island nearshore system that it received prior to construction of the inlet. This sand would ultimately make its way to the south St. Lucie County beaches.

5.2.1.4 SEA-LEVEL CHANGE

Potential relative sea-level change must be considered in every USACE coastal activity as far inland as the extent of estimated tidal influence. Future sea-level change is likely to result in both direct and indirect impacts on nearshore marine resources in the project area. Direct impacts could include changes in the areal extent of exposed hardbottom habitat due to sand movement. Indirect impacts could result from increased beach erosion, which may prompt more frequent (and possibly more extensive) beach nourishment projects in the area. The largest uncertainty is predicting the level and types of human activities that may be conducted to protect the shoreline in response to advancing sea level.

USACE Circular No. 1165-2-211 provides estimates of sea level rise ranging from 0.39 ft. (0.12 m) to 2.1 ft. (0.63 m) over the next 50 years. The U.S. Climate Change Science Program (CCSP 2009) Synthesis and Assessment Product 4.1 (SAP 4.1) *Coastal Sensitivity to Sea-Level Rise: A Focus on the MidAtlantic Region* details both how sea-level change affects coastal environments and what planners should address to protect the environment and sustain economic growth. SAP 4.1 represents implications of rising sea levels and possible adaptive responses. Many options are available for protecting land from inundation, erosion, and flooding ("shore protection"), or for minimizing hazards and environmental impacts by removing development from the most vulnerable areas ("retreat"). However, policymakers have not decided whether the practice of protecting development should continue as sea level rises, or be modified to avoid adverse environmental consequences and increased costs of shore protection. Most shore protection

structures are designed for the current sea level, and retreat policies that rely on setting development back from the coast are designed for the current rate of sea level rise. Those structures and policies would not necessarily accommodate a significant acceleration in the rate of sea-level rise.

5.2.1.5 CONCLUSIONS

Ongoing beach restoration activities in the area include USACE coastal storm risk management projects at Ft. Pierce and the Martin County Shore Protection Project immediately south of the proposed project area. Long-term monitoring of those projects has not revealed cumulative impacts, and USACE and FDEP have found the mitigation projects have reached the anticipated ecological success. Regionally, dredging projects for beach nourishment are expected to continue, compounding opportunities for recurring impacts. Ongoing recreational usage of the nearshore environment includes fishing, boating, diving, snorkeling, and beach recreation activities.

Future sea-level change may result in significant direct and indirect impacts to nearshore marine resources in the project area. Direct impacts could include changes in the areal extent of exposed hardbottom habitat due to sand movement. Indirect impacts could result from increased beach erosion, which may prompt more frequent (and possibly more extensive) beach nourishment projects in the area. Predicting sea level rise and the level and types of human activities that may be conducted to protect the shoreline in response to advancing sea level comprise the largest uncertainties in estimating cumulative impacts.

Over the next 50 years without the project, important factors affecting the nearshore environment are likely to include sea-level change and ongoing, low-impact human uses such as fishing, diving and snorkeling, and boating. If the project is not implemented, property owners may construct revetments or other armoring to protect their property, which may result in indirect impacts to nearshore hardbottom by exacerbating erosion, sand movement and scour.

6
Environmental Compliance

6 ENVIRONMENTAL COMPLIANCE

This chapter discusses the status of coordination and compliance of the Recommended Plan with environmental requirements. Additionally, it shows how the Recommended Plan meets USACE environmental operating principles.

6.1 SCOPING

An initial scoping period for the project was conducted from May 31 through June 30, 2006. The National Marine Fisheries Service (NMFS) responded to this early scoping letter with concerns about the proposed dredging of the offshore shoals and that the EFH assessment and NEPA documents on this action should be prepared with sufficient detail. This assessment is included in Sections 2.3.5 and 5.1.6 of this report. The Florida Department of Environmental Protection (FDEP) coordinated a review of the early scoping letter and the proposed project with the appropriate state agencies. FDEP stated that "based on the information contained in the public notice and the enclosed state agency comments, the state has determined that, at this stage, the proposed activity is consistent with the Florida Coastal Management Program." FDEP also stated that "it is likely the project would qualify for a Joint Coastal Permit, which would include water quality certification." Other stakeholders raised concerns regarding the use of St. Lucie Shoal as a borrow site, impacts to hardbottom resources, and cumulative impacts.

The non-federal sponsor was issued a USACE permit (No. SAJ-2009-03448) and State permit (No. 0154626-001-JC) for a larger beach nourishment project in this area in 2012. An Environmental Impact Statement (EIS) was prepared as part of the issuance of the USACE permit. USACE subsequently coordinated the EIS with the agencies and general public. In accordance with 43 CFR 46.160, this Integrated Feasibility Report and Environmental Assessment (IFR/EA) tiers off of that EIS. The USACE permit and draft EIS were also provided to the agencies and public for review and comment.

A Notice of Availability (NOA) of the Draft IFR/EA was issued on May 2, 2016 to the agencies and general public (see Appendix H: Pertinent Correspondence). As stated in the NOA, the draft IFR/EA was placed on USACE Jacksonville District's website and hard copies were placed in the St. Lucie Library-Fort Pierce Branch. The comment period on the draft IFR/EA ended on June 17, 2016. The NOA also served as an invitation to a public scoping meeting which was held on June 2, 2016. The meeting provided stakeholders an opportunity to further discuss the proposed work. The format of the meeting included an overview of the Recommended Plan as well as a formal comment period.

Pertinent correspondence associated with this NEPA scoping process is included in **Appendix H**.

6.2 COOPERATING AGENCIES

This proposed project has been coordinated with, but not limited to the following agencies: Bureau of Ocean Energy Management (BOEM), U.S. Fish and Wildlife Service, NMFS, U.S. Environmental Protection Agency, Florida State Clearinghouse, Florida State Historic Preservation Officer (SHPO), Florida Department of Environmental Protection, and Florida Fish and Wildlife Conservation Commission. BOEM by letter dated February 9, 2016 accepted USACE's invitation to participate as a cooperating agency in this study. As a cooperating agency, BOEM participated and provided input in the NEPA process, developed

information and provided analysis for which BOEM has special expertise, and provided comments on the draft IFR/EA. The NMFS by letter dated February 22, 2016 also accepted USACE's invitation to participate as a cooperating agency. As a cooperating agency, NMFS provided comments on the draft IFR/EA and participated in teleconferences. Correspondence from all Federal and State agencies in included in **Appendix H**.

6.3 LIST OF RECIPIENTS

The NOA of the draft IFR/EA and Draft FONSI was mailed to those listed in Appendix H, NEPA Mailing List.

6.4 COMMENTS RECEIVED AND RESPONSE

Comments received on the draft IFR/EA or from the public scoping meeting are as follows:

PUBLIC COMMENTS

Comment No. 1: What can be done to decrease sponsor cost-share?

Response: The sponsor will need to add more public access, with associated parking, to cover the gaps between ¼ mile lengths from existing access points, via easements, land acquisition or transportation.

Comment No. 2: Can the project be constructed sooner than 2020?

Response: That is the earliest the project can be constructed, as the study still has many more steps, processes and approval points to go through.

Comment No. 3: Why were the upper three reaches screened out of the project?

Response: This was due to lack of damageable infrastructure (making it economically unjustified), as well as the presence of hardbottoms, and an extensive portion of the CBRS unit in the area.

FLORIDA DEPARTMENT OF ENVIRONMENTAL PROTECTION COMMENTS (see **Appendix H: Pertinent Correspondence**)

Comment: Based on the information contained in the submittal, the state finds that the proposed Draft Environmental Assessment is consistent with the Florida Coastal Management Program (FCMP). The state's continued concurrence will be based on the activities' compliance with FCMP authorities, including Federal and state monitoring of the activities to ensure their continued conformance, and the adequate resolution of issues identified during this and subsequent regulatory reviews. The state's final concurrence of the project's consistency with the FCMP will continue to be determined during the ongoing state's environmental permitting process, in accordance with Section 373.428, Florida Statutes. FDEP also stated that "it is likely the project would qualify for a Joint Coastal Permit, which would include water quality certification."

FLORIDA STATE HISTORIC PRESERVATION OFFICER (see **Appendix H: Pertinent Correspondence**)

Comment: We have reviewed the above referenced TSP from the Feasibility Study. This office concurs that there will likely be no effect on historic properties conditioned upon the maintenance of 500-foot buffers around shipwrecks and anomaly clusters located in the borrow areas.

NMFS ESSENTIAL FISH HABITAT (EFH) CONSERVATION RECOMMENDATIONS/COMMENTS (see **Appendix G, Attachment 3** for more information and attachments)

The NMFS provided the following EFH conservation recommendations by letter dated June 9, 2016. The USACE and BOEM requested additional time to respond to the NMFS letter via email dated July 4, 2016, and the NMFS acknowledged the additional time to respond. The USACE and BOEM provided the following responses by letter dated December 28, 2016.

Recommendation No. 1: The remaining 0.79 acres of mitigation reef should be constructed as described in the Federal permit in addition to any mitigation needed to offset the longer temporal lag that has resulted between burial of the live/hardbottom and establishment of the mitigation reefs.

Response: As reflected in the August 2015 "as-built survey (see attachment A)" and as cited in the corresponding September 18, 2015 "Mitigation Reef Certification Report (see Attachment B)", a total of 1.93 acres of mitigation reef were constructed in 2013 & 2015 – in excess of the 1.89 acres required by USACE permit (Permit No: SAJ-2009-03448 [IP-GGL]). In addition, note that as identified in the August 31, 2015 "AS-BUILT CERTIFICATION BY PROFESSIONAL ENGINEER" submitted to USACE:

- Overall, the mitigation reef was built in substantial compliance with the plans and permit conditions. Adjustments to specific reef cell locations were made to comply with water depth requirements prescribed by USACE and Florida Department of Environmental Protection (DEP) permits.
- Ocean Bay Site 5 was moved to the northeast and only ten cells were constructed at that site due to limited water depths within the limits of the archeological survey. No cells were constructed at Ocean Bay Site 6 due to too shallow water depths. The ten cells that were unable to be constructed at Ocean Bay due to too shallow of water depths were moved to Blind Creek. Five cells were added to the south end of Site 4 at Blind Creek; one cell to the south end of Blind Creek Site 3; four cells to the south end of Site 2.
- In addition, at Blind Creek Site 1 Cell 7 could not be constructed in the permitted location due to insufficient corridor width between cells and the previously constructed reef. This cell was moved to the south end of Site 2.

Recommendation No. 2: The final IFR/EA should describe quantitatively the status of the existing 1.1 acres of mitigation reef with regard to the established biological performance standards.

Response: Please see Attachment C, the 2015 Monitoring Report and Attachment D, the Florida Department of Environmental Protection review letter. In addition, ongoing monitoring results, including assessment of permit compliance, will be provided to NMFS upon completion of the associated reports. Natural hardbottom impacts are expected to be concluded in concert with the forthcoming 2016 monitoring report expected by January 2017. Although the 2016 report will assess fulfillment of permit

conditions relative to the artificial mitigation reef, continued monitoring of the mitigation reef is expected through 2018 as required by the FDEP permit (Permit No. 0154626-001-JC), including documentation of compliance with "biological performance standards". All of these pending reports will be provided to NMFS upon completion. Reference to the recently completed monitoring reports describing the status of the existing mitigation reef and the commitment to provide NMFS with future reports to ensure compliance with "biological performance standards" will be documented in the final IFR/EA.

Recommendation No. 3: The final IFR/EA should provide the amount of mitigation reef constructed in water depths less than 4.0 meters.

Response: As reflected in the as-built survey, 1.93 acres of mitigation reef were constructed in areas with ambient bottom elevations between -12' and -15' NAVD 88, consistent with the drawings (see Attachment A) approved by USACE and included in the original USACE permit. At low tide these areas are expected to have ambient water depths between 9.37' and 12.37', less than 13.1' or 4m. In addition, note that the ocean bottom area surrounding the mitigation reef:

- is within the active nearshore littoral system – landward of the "depth of closure",
- was observed to accrete about 2 feet of sand associated with the passage of Hurricane Sandy in 2012, and
- has apparently experienced scouring around the individual reef cells after the reef construction – as is common with such structures in the nearshore region.

This summary related to the amount of mitigation reef constructed in water depths less than 4.0 meters will be documented in the final IFR/EA.

Recommendation No. 4: The final IFR/EA should include a synthesis of the available post construction monitoring reports and quantify direct and indirect impact predictions to live/hardbottom habitats seaward of the Equilibrium Toe of Fill.

Response: Construction of the Mitigation Reef was initiated in the summer of 2013, but was not completed until the summer of 2015. As identified in Special Conditions 32 and 33 of the USACE permit, it is anticipated that "success" of the Mitigation Reef will be assessed after 3 years following completion of the construction in 2018. Upon completion of the 2018 monitoring report, NMFS will be provided a copy for review and concurrence that "success" criteria have been met. To date, hardbottom impacts associated with the 2013 non-federal beach fill project appear to be within the "impact predictions". Per Specific Conditions 46 and 47 of the FDEP permit, the forthcoming 2016 Report (expected by January 2017) constitutes the "first (a year after construction)" year monitoring report, a "second and third" annual mitigative artificial reef monitoring report shall be provided to NMFS upon completion. These monitoring reports are to address fulfillment of "all permit conditions." A summary of the status of post construction monitoring reports and commitment to provide NMFS with the 2018 monitoring report for review and concurrence that "success" criteria have been met will be integrated into the final IFR/EA.

Recommendation No. 5: The final IFR/EA should estimate temporal and direct impacts to nearshore live/hardbottom occurring as a result of project construction during 2013 based on the year 2 monitoring report (and year 3 if that information is available) and evaluate compliance with permit condition 44(i)(6).

Response: See response to NMFS Recommendation 4 cited above. Actual impacts to natural hardbottom are expected to be concluded by the forthcoming 2016 monitoring report – expected by January 2017. The 2016 report constitutes the final natural hardbottom monitoring report as required by Specific Condition 38 of the FDEP permit. A summary of the status of post construction monitoring reports and commitment to provide NMFS with future monitoring reports for review will be integrated into the final IFR/EA.

Recommendation No. 6: The year 3 monitoring report should reflect sampling and analysis of 10 reference areas the District agreed in July 2012.

Response: Ongoing monitoring and the year 3 monitoring report do and will reflect FDEP and USACE permit requirements to sample/analyze reference areas. The Scope of Work specifically cites for monitoring of natural hardbottom areas:

> A total of twenty (20) monitoring transects will be surveyed: ten (10) within the Project area, two (2) downdrift in Martin County, and eight (8) updrift in St. Lucie County, previously established in 2008/2009 and/or pre-construction monitoring in 2012.
> Transect positions and lengths are to be permanent.

Recommendation No. 7: The final IFR/EA should summarize results from the infaunal monitoring at the borrow site.

Response: Infaunal monitoring results will be made available to NMFS upon completion of 2016 monitoring and completion of the associated report. The final IFR/EA will summarize these results.

Recommendation No. 8: Dredging at the borrow site should limit dredging to the prevailing downdrift flanks of the shoals, limiting the depths of the dredge cuts to 3 to 6 feet, and limit the dredging to the portions of the shoal expected to fill in most quickly once dredging has stopped.

Response: This recommendation implies that the proposed borrow area located within the St. Lucie shoal complex may recover through active littoral processes following dredging. However, this shoal complex is considered a relic feature and is not connected to the active littoral system. USACE will continue to collect additional geotechnical and geophysical data within the proposed borrow area during Preconstruction Engineering and Design (PED). These more refined data will inform the final borrow area design parameters prior to construction. USACE and BOEM will coordinate with NMFS to develop a refined borrow area design that provides a sufficient volume of compatible sediment to support the project objectives while maintaining overall shoal integrity. The overall goal is to ensure that physical and biological processes following dredging are maintained within the St. Lucie shoal complex to the maximum extent practicable.

Based on the geophysical and geotechnical data that is currently available, the proposed borrow area design includes a dredging template that is oriented with the long axis of the shoal to minimize impacts to the overall shoal complex. Additionally, USACE and BOEM are currently investigating the feasibility of maintaining a refuge patch at maximum shoal elevations to promote quicker biological recovery following dredging. However, additional analysis will need to be performed during PED to better understand the cumulative volume of sediment within the shoal complex relative to the identified volume of sediment needed to support the Federal project. USACE and BOEM will continue to coordinate with NMFS as

additional information becomes available. The final IFR/EA will document a commitment to continue coordination with NMFS during PED as the borrow area design is refined.
Recommendation No. 9: A biological monitoring and adaptive management plan that reflects substantive input from NMFS for the nearshore hardbottom impacts is provided prior to the commencement of any new work in the project area.

Response: The DEP/USACE permits for the 2013 non-federal beach fill project reference the approved Biological and Physical Monitoring Plans. Comparable monitoring (a) should be adequate for the reduced footprint associated with the proposed Federal project, and also (b) will likely be required for monitoring of the Federal project per the associated State Water Quality Certification (DEP permit).

The NMFS issued a second letter dated January 9, 2017, which expressed additional concerns regarding the implementation of the Department of Army permit issued to St. Lucie County (refer to Appendix G, Attachment 3). Specifically, these concerns are in regard to the beach nourishment project previously constructed by St. Lucie County, and mitigation that St. Lucie County provided for impacts to hardbottom habitat. USACE Regulatory Division has determined that the beach placement, mitigation, and monitoring have been performed in compliance with the County's permit SAJ-2009-03448. The USACE and BOEM provided a joint response to NMFS dated April 3, 2017, which included the compliance letter also dated April 3, 2017. All correspondence with NMFS can be found in Appendix G, Attachment 3.

6.5 ENVIRONMENTAL COMMITMENTS

USACE shall comply with all terms and conditions of the USFWS letter dated November 21, 2016, the revised Statewide Programmatic Biological Opinion (SPBO; 2015), the Conservation Measures of the Programmatic Piping Plover Biological Opinion (PB3O; 2013), and the South Atlantic Regional Biological Opinion (SARBO; 1997), and the State's Joint Coastal Permit (JCP). The PB3O conservation measures will also minimize effects to red knots.

NESTING SEA TURTLES

- All Reasonable and Prudent Measures and the Terms and Conditions identified in the revised SPBO will be implemented. The SPBO can be accessed at the following link:

http://www.saj.usace.army.mil/About/Divisions-Offices/Planning/Environmental-Branch/Environmental-Documents/

SEA TURTLES IN THE WATER

- All Reasonable and Prudent Measures and the Terms and Conditions identified in the SARBO will be implemented. The SARBO can be accessed at the following link:

http://www.saj.usace.army.mil/About/Divisions-Offices/Planning/Environmental-Branch/Environmental-Documents/

MANATEES

- All personnel associated with the project shall be instructed about the presence of manatees and manatee speed zones, and the need to avoid collisions with and injury to manatees. The permittee shall advise all construction personnel that there are civil and criminal penalties for harming, harassing, or killing manatees, which are protected under the Marine Mammal Protection Act, the Endangered Species Act, and the Florida Manatee Sanctuary Act.

- All vessels associated with the construction project shall operate at "Idle Speed/No Wake" at all times while in the immediate area and while in water where the draft of the vessel provides less than a 4-foot clearance from the bottom. All vessels will follow routes of deep water whenever possible.

- Siltation or turbidity barriers shall be made of material in which manatees cannot become entangled, shall be properly secured, and shall be regularly monitored to avoid manatee entanglement or entrapment. Barriers must not impede manatee movement.

- All on-site project personnel are responsible for observing water-related activities for the presence of manatee(s). All in-water operations, including vessels, must be shut down if a manatee(s) comes within 50 feet of the operation. Activities will not resume until the manatee(s) has moved beyond the 50-foot radius of the project operation, or until 30 minutes elapses if the manatee(s) has not reappeared within 50 feet of the operation. Animals must not be herded away or harassed into leaving.

- Any collision with or injury to a manatee shall be reported immediately to the FWC Hotline at 1-888-404-FWCC. Collision and/or injury should also be reported to the U.S. Fish and Wildlife Service in Jacksonville (1-904-7313336) for north Florida or Vero Beach (1-772-562-3909) for south Florida.

- Temporary signs concerning manatees shall be posted prior to and during all in-water project activities. All signs are to be removed by the permittee upon completion of the project. Awareness signs that have already been approved for this use by the Florida Fish and Wildlife Conservation Commission (FWC) must be used (see MyFWC.com). One sign, which reads *Caution: Boaters* must be posted. A second sign measuring at least 8"/2" by"11" explaining the requirements for "Idle Speed/No Wake" and the shutdown of in-water operations must be posted in a location prominently visible to all personnel engaged in water-related activities.

BEACH JACQUEMONTIA

- Surveys shall be performed preconstruction to determine the presence of beach jacquemontia. Surveys must be performed during the growing season (May through November) or, at a minimum, when dormant vegetation is present. Plant locations must be recorded using a Global Position System, photographs, and written descriptions of the location and extent of growth. To preclude intentional or unintentional disturbance or harm, the exact location of plants should not be marked until necessary for construction design, surveys, and implementation. Marking of plant locations must use noninvasive, temporary techniques such as pin flagging. Surveys must be performed by personnel who have training or experience in identification of beach jacquemontia.

- All construction personnel shall be educated concerning the presence and location of beach jacquemontia and the minimization measures to be implemented to avoid all potential impacts to the plant.

- A 25-ft buffer shall be created between any existing beach jacquemontia and construction activities, equipment storage, and beach access corridors.

- Unless otherwise directed by the Service, all plant site markings must be removed post construction.

- All marked sites shall be reinspected post construction. Any disturbance or other impacts to beach jacquemontia shall be photographed and recorded in a narrative report and immediately shared with the USFWS South Florida Ecological Services Office. Based on the Service's review, remedial action may be necessary.

PIPING PLOVER

- One preconstruction winter shorebird survey will be conducted within a 10-day timeframe beginning the first Friday in February, as outlined in the Florida Shorebird Alliance's Winter Shorebird Survey (http: flshorebirdalliance.org). If the February preconstruction survey is not possible, two preconstruction winter shorebird surveys will be conducted as close as possible to the February dates and at least 15 days apart, and reported to the FWC (https: public.myfwc.com/crossdoi/ shorebirds/loginform.aspx).

Preconstruction surveys will not be conducted between May 16 and July 14. If piping plovers are documented during the preconstruction survey, the Service will be contacted for potential implementation of additional conservation measures prior to construction commencement. In addition, a February winter shorebird survey will be conducted as outlined above, for 2 years post-construction. All shorebird survey data will be forwarded to the Service annually upon completion.

- The person(s) conducting the surveys must demonstrate the qualifications and ability to identify shorebird species and be able to provide the information outlined in the Winter Shorebird Survey.

RED KNOT

- All Conservation Measures identified in the P3BO shall be implemented. The P3BO can be accessed at the following link:

http://www.saj.usace.army.mil/About/Divisions-Offices/Planning/Environmental-Branch/Environmental-Documents/

TURBIDITY

- The Contractor shall monitor water quality (turbidity) at the dredging and beach placement sites, as required by the JCP and the 401 Water Quality Certification.

- If turbidity values at the dredging site exceed permitted values, the Contractor shall suspend all dredging activities. Dredging shall not continue until water quality meets state standards.

In addition USACE commits to the following:

- Migratory birds (adult birds, eggs and chicks) shall be protected during construction activities.
- Essential Fish Habitat conservation recommendations shall be implemented or responded to (refer to Section 6.4, and Appendix G, Attachment 3 for more info).
- In the event that cultural resources are discovered (i.e. at new or expanded upland quarries), then protective measures shall be utilized.
- Air emissions such as vehicular exhaust and dust shall be controlled.
- The contracting officer would notify the contractor in writing of any observed noncompliance with Federal, state, or local laws or regulations, permits and other elements of the contractor's Environmental Protection Plan.
- The contractor would train his personnel in all phases of environmental protection.
- The environmental resources within the project boundaries and those affected outside the limits of permanent work would be protected during the entire period of work.
- An oil spill prevention plan shall be required.

6.6 COMPLIANCE WITH ENVIRONMENTAL REQUIREMENTS

6.6.1 NATIONAL ENVIRONMENTAL POLICY ACT (NEPA) OF 1969

Environmental information on the project has been compiled and this Environmental Assessment has been prepared. A scoping letter on the proposed work was mailed out to all Federal, State, and local agencies and public stakeholders on May 31, 2006. The draft IFR/EA was coordinated with interested stakeholders for review and comment. A public scoping meeting was held on June 2, 2016. The project is in full compliance with the National Environmental Policy Act.

6.6.2 ENDANGERED SPECIES ACT OF 1973

This project falls under the scope of the November 25, 1991 South Atlantic Regional Biological Opinion (SARBO; amended 1997) for federally listed marine species. USACE and BOEM notified the NMFS by letter dated June 16, 2016, that all consultation responsibilities for dredging and beach placement activities associated with the Recommended Plan would be covered under the existing 1997 SARBO and/or superseding documents associated with the ongoing reinitiated SARBO consultation. USACE and BOEM determined that the sand placement activities associated with this project fall within the scope of the USFWS SPBO (2011), as amended in 2015, and the P3BO (2013). The USFWS concurred with USACE and

BOEM determinations by letter dated November 21, 2016. All correspondence can be found within Appendix H: Pertinent Correspondence. This project is in full compliance with the Endangered Species Act.

6.6.3 FISH & WILDLIFE COORDINATION ACT OF 1958

In accordance with an interagency agreement between the USFWS and USACE, coordination with the USFWS shall be conducted through the NEPA scoping process and the Endangered Species Act. The signed agreement can be found in Appendix H: Pertinent Correspondence. This project is in full compliance with the Act.

6.6.4 NATIONAL HISTORIC PRESERVATION ACT OF 1966 (*INTER ALIA*)

The Proposed Action is in compliance with Section 106 of the National Historic Preservation Act, as amended (PL89-665). As part of the requirements and consultation process contained within the National Historic Preservation Act implementing regulations of 36 CFR 800, this project is also in compliance through ongoing consultation with the Archaeological and Historic Preservation Act, as amended (PL93-29), Archeological Resources Protection Act (PL96-95), American Indian Religious Freedom Act (PL 95-341), Native American Graves Protection and Repatriation Act (NAGPRA), Executive Order 11593, 13007, and 13175, the Presidential Memo of 1994 on Government to Government Relations and appropriate Florida Statutes. Consultation with the Florida SHPO, appropriate federally recognized tribes, and other interested parties has been initiated. The Florida SHPO and the Seminole Tribe of Florida concurred with the USACE determination of no effect to historic properties in letters dated May 3, 2016 and April 27, 2016 respectively.. The Proposed Action is in compliance with the goals of this Act.

6.6.5 CLEAN WATER ACT OF 1972

The Florida State Clearinghouse coordinated a review of the Draft Environmental Assessment (DEA) under the following authorities: Presidential Executive Order 12372; § 403.061(42), *Florida Statutes*; the Coastal Zone Management Act, 16 U.S.C. §§ 1451-1464, as amended; and the National Environmental Policy Act, 42 U.S.C. §§ 4321-4347, as amended. Based on the information contained in the submittal, the state found that the proposed DEA consistent with the Florida Coastal Management Program (FCMP). FDEP also stated that "it is likely the project would qualify for a Joint Coastal Permit, which would include water quality certification." A Section 401 water quality certification (State permit) application will be submitted to the FDEP, and USACE will obtain this certification prior to construction. All state water quality requirements would be met. A Section 404(b) evaluation is included in this report as Appendix G, Attachment 1. The project shall be in full compliance with this Act.

6.6.6 CLEAN AIR ACT OF 1972

The short-term impacts from construction equipment associated with the project would not significantly impact air quality. No air quality permits would be required for this project. St. Lucie County is designated as an attainment area for Federal air quality standards under the Clean Air Act. Because the project is located within an attainment area, USEPA's General Conformity Rule to implement Section 176(c) of the Clean Air Act does not apply and a conformity determination is not required.

6.6.7 COASTAL ZONE MANAGEMENT ACT OF 1972

The Florida State Clearinghouse by letter dated July 8, 2016, coordinated a review of the project in response to USACE's Notice of Availability of the draft IFR/EA. The state has determined that, at this stage, the proposed activity is consistent with the Florida Coastal Management Program. A Federal consistency determination in accordance with 15 CFR 930 Subpart C is included in this report as Appendix G-2. USACE has determined that the project is consistent with the Florida Coastal Management Plan (FCMP). The state's final concurrence of the project's consistency with the FCMP will be determined during the environmental permitting process, in accordance with the 2006 Interagency Coordination Agreement. At this time, this project is in compliance with this Act.

6.6.8 FARMLAND PROTECTION POLICY ACT OF 1981

No prime or unique farmland would be impacted by implementation of this project. This Act is not applicable to the project.

6.6.9 WILD AND SCENIC RIVER ACT OF 1968

No designated Wild and Scenic river reaches would be affected by project related activities. This project is in compliance with this Act.

6.6.10 MARINE MAMMAL PROTECTION ACT OF 1972

USACE does not anticipate the take of any marine mammal during any activities associated with the project. Should a hopper dredge be utilized, a trained, government-certified sea turtle and marine mammal observer will be stationed on the dredge during all water-related construction activities. Appropriate actions will be taken to avoid adverse effects to listed and protected marine mammal species during project construction. Therefore, this project is in compliance with this Act.

6.6.11 ESTUARY PROTECTION ACT OF 1968

In the Estuary Protection Act of 1968, Congress declared that "many estuaries in the United States are rich in a variety of natural, commercial, and other resources, including environmental natural beauty, and are of immediate and potential value to the present and future generations of Americans." This Act is intended to protect, conserve, and restore estuaries in balance with developing them to further the growth and development of the Nation. There are no estuaries of national significance located in the study area; therefore, this project is consistent with the purposes of this Act.

6.6.12 FEDERAL WATER PROJECT RECREATION ACT

The principles of the Federal Water Project Recreation Act, as amended, 16 U.S.C. 460-1 (12), *et seq*. P.L. 89-72, do not apply to this project.

6.6.13 MAGNUSON-STEVENS FISHERY CONSERVATION AND MANAGEMENT ACT OF 1976

Pursuant to the 1999 Finding between USACE and NMFS, USACE's Notice of Availability of the draft IFR/EA initiated consultation under the Magnuson-Stevens Fishery Conservation and Management Act. NMFS by letter dated June 6, 2016 provided Essential Fish Habitat (EFH) Conservation Recommendations in response to USACE's request for scoping comments (May 2, 2016). USACE and BOEM requested additional time to respond to the recommendations. The response letter was issued on December 28, 2016. Refer to Section 6.4 and Appendix G, Attachment 3 for more information including EFH Conservation Recommendations and USACE responses. The NMFS issued a second letter dated January 9, 2017, which expressed additional concerns regarding the implementation of the Department of Army permit issued to St. Lucie County. Specifically, these concerns are in regard to the beach nourishment project previously constructed by St. Lucie County, and mitigation that St. Lucie County provided for impacts to hardbottom habitat (refer to Section 2.2.5 and Appendix G, Attachment 3 for more info). USACE Regulatory Division has determined that the beach placement, mitigation, and monitoring have been performed in compliance with the County's permit SAJ-2009-03448. The USACE and BOEM provided a joint response to NMFS dated April 3, 2017, which included the compliance letter also dated April 3, 2017. The project is in compliance with the Act.

6.6.14 SUBMERGED LANDS ACT OF 1953

The project would occur on submerged lands of the State of Florida. The project is being coordinated with the State, and shall be in compliance with the Act.

6.6.15 COASTAL BARRIER RESOURCES ACT AND COASTAL BARRIER IMPROVEMENT ACT OF 1990

The Coastal Barrier Resources Act (CBRA) and the Coastal Barrier Improvement Act of 1990 (CBIA) limit federally subsidized development within the CBRA Units to limit the loss of human life by discouraging development in high risk areas, to reduce wasteful expenditures of Federal resources, and to protect the natural resources associated with coastal barriers. CBIA provides development goals for undeveloped coastal property held in public ownership, including wildlife refuges, parks, and other lands set aside for conservation ("otherwise protected areas," or OPAs). These public lands are excluded from most of the CBRA restrictions, although they are prohibited from receiving Federal Flood Insurance for new structures.

There are limits to Federal expenditures related to actions that could affect a unit. Section 6 of the CBRA provides an exception to this limitation if the Federal expenditure is for non-structural[22] shoreline stabilization projects that are designed to mimic, enhance, or restore a natural stabilization system. There are a small number of privately owned parcels within the project area, and within Unit P11, which are not under any perpetual conservation designation. Federal expenditures for any alternative implementation (including beach nourishment) in this area would be prohibited by the CBRA due to the fact that such action could encourage development. A Section 6 CBRA exception would only apply if these private parcels were covered under a perpetual conservation easement which is not the case. However, non-federal funds could

[22] FWS includes beach and dune features as non-structural options.

be used to nourish the beach in this area. Dollman Park, a publicly owned parcel within the project area, does meet the Section 6 exception since development is prohibited in this location; therefore, Federal funds could be used to nourish the beach adjacent to the park. The U.S. Fish and Wildlife Service, by letter dated November 2, 2016, concurred with this determination (please refer to Appendix H: Pertinent Correspondence). This project is in compliance with the Act.

6.6.16 RIVERS AND HARBORS ACT OF 1899

The proposed work would temporarily obstruct navigable waters of the United States. The proposed action will be subject to the public notice, public hearing, and other evaluations normally conducted for activities subject to the Act. The project is in compliance with this Act

6.6.17ANADROMOUS FISH CONSERVATION ACT

This Act authorizes the Secretaries of the Interior and Commerce to enter into cooperative agreements with the States and other non-federal interests for conservation, development, and enhancement of anadromous fish and to contribute up to 50 percent as the Federal share of the cost of carrying out such agreements. As this project is not receiving funding for these purposes, this Act does not apply.

6.6.18 MIGRATORY BIRD TREATY ACT AND MIGRATORY BIRD CONSERVATION ACT

Migratory birds would be minimally affected by dredging at the proposed sand source locations. USACE will include our standard migratory bird protection requirements in the project plans and specifications and will require the Contractor to abide by those requirements. Periodic nourishment activities at the beach placement site will be monitored at dawn or dusk daily during the nesting season to protect nesting migratory birds. If nesting activities occur within the construction area, appropriate buffers will be placed around nests to ensure their protection. The project is in compliance with these Acts.

6.6.19 MARINE PROTECTION, RESEARCH AND SANCTUARIES ACT (OCEAN DUMPING ACT)

The term "dumping" as defined in the Act 33 U.S.C. 1402 does not apply to the disposal of material for beach nourishment or to the placement of material for a purpose other than disposal (i.e. placement of rock material as an artificial reef or the construction of artificial reefs as mitigation). Therefore, the Marine Protection, Research, and Sanctuaries Act does not apply to this project. The disposal activities addressed in this EA have been evaluated under Section 404 of the Clean Water Act (see Appendix G-1).

6.6.20 UNIFORM RELOCATION ASSISTANCE AND REAL PROPERTY ACQUISITION POLICIES ACT OF 1970.

The purpose of PL 91-646 is to ensure that owners of real property to be acquired for Federal and federally assisted projects are treated fairly and consistently and that persons displaced as a direct result of such acquisition will not suffer disproportionate injuries as a result of projects designed for the benefit of the public as a whole.

While one of the alternatives considered during plan formulation included the acquisition of real property, this is not part of the Recommended Plan. Therefore, this project does not involve any real property acquisition or displacement of property owners or tenants. Therefore, this Act is not relevant to this project.

6.6.21 EXECUTIVE ORDER (EO) 11990, PROTECTION OF WETLANDS

No wetlands would be affected by project activities. This project is in compliance with the goals of this Executive Order.

6.6.22 E.O 11988, FLOOD PLAIN MANAGEMENT

To comply with EO 11988, the policy of USACE is to formulate projects that, to the extent possible, avoid or minimize adverse effects associated with the use of the floodplain and avoid inducing development in the floodplain unless there is no practicable alternative. No activities associated with this project are located within a floodplain, which is defined by EO 11988 as an "area which has a one percent or greater chance of flooding in any given year." The project is located within the Coastal High Hazard Area (CHHA), as defined by EO 11988 as an "area subject to inundation by one-percent-annual chance of flood, extending from offshore to the inland limit of a primary frontal dune along an open coast and any other area subject to high velocity wave action from storms." The project shoreline is significantly developed, and further development is anticipated to be minimal.

CSRM projects are inherently located in coastal areas, and are often located in CHHAs based on the problems the project is seeking to alleviate. The primary objective of the St. Lucie County Coastal Storm Damage Reduction Project is to reduce infrastructure damage. There is no practicable alternative that could be located outside of the CHHA that would achieve this objective.

For the reasons stated above, the project shall be in compliance with EO 11988, Floodplain Management.

6.6.23 E.O. 12898, ENVIRONMENTAL JUSTICE

On February 11, 1994, the President of the United States issued Executive Order 12898, *Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations*. The Executive Order mandates that each Federal agency make environmental justice part of the agency mission and to address, as appropriate, disproportionately high and adverse human health or environmental effects of the programs and policies on minority and low-income populations.

Any potential adverse effects of the proposed action would be more likely to affect those of higher socioeconomic status, such as large watercraft owners or those living in the coastal area surrounding the project. The beneficial effect of a wider, more sustainable beach would benefit all members of the public who are able to obtain transportation to access the beach. The storm damage reduction benefits are primarily benefitting the landowners in this area. There are no disproportionate adverse impacts to minority or low income populations resulting from the implementation of the project.

6.6.24 E.O. 13045, DISPARATE RISKS INVOLVING CHILDREN

On April 21, 1997, the President of the United States issued Executive Order 13045, *Protection of Children from Environmental Health Risks and Safety Risks*. The Executive Order mandates that each Federal agency make it a high priority to identify and assess environmental health risks and safety risks that may disproportionately affect children and ensure that its policies, programs, activities, and standards address disproportionate risks to children that result from environmental health risks or safety risks.

As the proposed action does not affect children disproportionately from other members of the population, the proposed action would not increase any environmental health or safety risks to children.

6.6.25 E.O. 13089, CORAL REEF PROTECTION

The EO refers to "those species, habitats, and other natural resources associated with coral reefs." There are no coral reefs in the project area. This EO does not apply.

6.6.26 E.O. 13112, INVASIVE SPECIES

The proposed action will require the mobilization of dredge equipment from other geographical regions. Dredge equipment has the potential to transport species from one region to another, introducing them to new habitats where they are able to out-compete native species. The benefits of the proposed project outweigh the risks associated with the very slight potential for introducing non-native species to this region. The action takes place primarily in Atlantic Ocean waters, minimizing risk to more sheltered coastal habitats.

6.6.27 ENVIRONMENTAL OPERATING PRINCIPLES

1. Foster sustainability as a way of life throughout the organization.

The recommended plan proposes to use the St. Lucie Shoal, a sand source which is within the local ecological system. The plan also has a long periodic nourishment interval, on average 18 years, which means the sand placed on the beach will provide benefits for an extended period of time with little to no maintenance.

2. Proactively consider environmental consequences of all USACE activities and act accordingly.

The integration of the EA into the feasibility study requires all members of the Project Delivery Team to acknowledge the impact that the proposed project will have on the environment. This helps to ensure the project is designed from the beginning with the environment as a central focus.

3. Create mutually supporting economic and environmentally sustainable solutions.

The recommended plan will provide resilience to the community during and after storm events, providing stability to the economic environment, while also providing nourishment at extended intervals for environmental habitat.

4. Continue to meet our corporate responsibility and accountability under the law for activities undertaken by USACE, which may impact human and natural environments.

This report includes all information necessary to document how the project meets USACE's corporate responsibility and accountability requirements for actions that may impact human and natural environments.

5. Consider the environment in employing a risk management and systems approach throughout the life cycles of projects and programs.

The team is involved throughout the study process to ensure that environmental considerations are taken into account for the life of the project.

6. Leverage scientific, economic and social knowledge to understand the environmental context and effects of USACE actions in a collaborative manner.

The entire Project Delivery Team understands the need to consider the environment during its decision-making process, and worked collaboratively with agencies to foster education and sharing of policies and best management practices.

7. Employ an open, transparent process that respects views of individuals and groups interested in USACE activites.

The actions taken to involve the public, resource agencies, and NGOs who may be interested in the project are outlined in Section 6.1 through 6.4 of this report.

7 Recommendations

7 RECOMMENDATIONS

I have given consideration to all significant aspects in the overall public interest including engineering feasibility, economic, social, cost and risk analysis, and environmental effects. The Recommended Plan described in this final report provides the optimum solution for coastal storm risk management benefits within the study area that can be developed with the framework of the formulation concepts. Implementation of the St. Lucie County, Florida Coastal Storm Risk Management (CSRM) Project is recommended at this time, with such modification as in the discretion of the Commander, Headquarters, U.S. Army Corps of Engineers (HQUSACE), may be advisable.

The Recommended Plan, shown in REF-2, is the National Economic Development (NED) Plan including beach and dune nourishment within the South Hutchinson Island reach. The design includes construction of a 20-foot equilibrated berm extension between R monuments R-98.5 and the R-115 plus 1000 feet, along 3.3 miles of shoreline. The project template will include maintenance of the existing dune feature, reflecting the average 2008 dune position. Tapers of a maximum length of one thousand feet will extend from the northern and southern ends of the berm extension, connecting the extension to the existing shoreline. The addition of tapers results in a maximum sand placement from R-97.5 to R-002, which is approximately 3.7 miles.

7.1 ITEMS OF LOCAL COOPERATION

Recommendations for provision of Federal participation in the Recommended Plan described in this report would require the project sponsor to enter into a written Project Partnership Agreement (PPA), as required by Section 221 of Public Law 91-611, as amended, to provide local cooperation satisfactory to the Secretary of the Army. Such local cooperation shall include:

a. Per WRDA 1986, as amended, provide 35% of initial project costs assigned to hurricane and storm damage reduction, plus 100% of initial project costs assigned to protecting undeveloped private lands and other private shores which do not provide public benefits; and 50% of periodic nourishment costs assigned to hurricane and storm damage reduction, plus 100% of periodic nourishment costs assigned to protecting undeveloped private lands and other private shores which do not provide public benefits and as further specified below:

    1) Enter into an agreement that provides, prior to construction, 35% of design costs;
    2) Provide all lands, easements, and rights-of-way, and perform or ensure the performance of any relocations determined by the Federal Government to be necessary for the initial construction, periodic nourishment, and operation and maintenance of the project;
    3) Provide, during construction, any additional amounts as are necessary to make their total contribution equal to 35% of initial project costs assigned to hurricane and storm damage reduction, plus 100% of initial project costs assigned to protecting undeveloped private lands and

other private shores which do not provide public benefits; and 50% of periodic nourishment costs assigned to hurricane and storm damage reduction, plus 100% of periodic nourishment costs assigned to protecting undeveloped private lands and other private shores which do not provide public benefits;

b. For so long as the project remains authorized, operate, maintain, and repair the completed project, or functional portion of the project, at no cost to the Federal Government, in a manner compatible with the project's authorized purposes and in accordance with applicable Federal and state laws and regulations, and any specific directions prescribed by the Federal Government;

c. Give the Federal Government a right to enter, at reasonable times and in a reasonable manner, upon property that the non-federal sponsor, now or hereafter, owns or controls for access to the project for the purpose of inspecting, operating, maintaining, repairing, replacing, rehabilitating, or completing the project. No completion, operation, maintenance, repair, replacement, or rehabilitation by the Federal Government shall relieve the non-federal sponsor of responsibility to meet the non-federal sponsor's obligations, or to preclude the Federal Government from pursuing any other remedy at law or equity to ensure faithful performance;

d. Hold and save the United States free from all damages arising from the initial construction, periodic nourishment, mitigation, 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;

e. Keep and maintain books, records, documents, and other evidence pertaining to costs and expenses incurred pursuant to the project in accordance with the standards for financial management systems set forth in the Uniform Administrative Requirements for Grants and Cooperative Agreements to State and Local Governments at 32 Code of Federal Regulations (CFR) Section 33.20;

f. Perform, or cause to be performed, any investigations for hazardous substances that are determined necessary to identify the existence and extent of any hazardous substances regulated under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), Public Law 96-510, as amended, 42 U.S.C. 9601-9675, that may exist in, on, or under lands, easements, or rights-of-way that the Federal Government determines to be required for the initial construction, periodic nourishment, operation, and maintenance of the project. However, for lands that the Federal Government determines to be subject to the navigation servitude, only the Federal Government shall perform such investigations unless the Federal Government provides the non-federal sponsor with prior specific written direction, in which case the non-federal sponsor shall perform such investigations in accordance with such written direction;

g. Assume complete financial responsibility for all necessary cleanup and response costs of any CERCLA regulated materials located in, on, or under lands, easements, or rights-of-way that the Federal Government determines to be necessary for the initial construction, periodic nourishment, operation, or maintenance of the project;

h. Agree that the non-federal sponsor shall be considered the operator of the project for the purpose of CERCLA liability, and to the maximum extent practicable, operate, maintain, and repair the project in a manner that will not cause liability to arise under CERCLA;

i. If applicable, 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, required for the initial construction, periodic nourishment, operation, and maintenance of the project, including those necessary for relocations, borrow materials, and dredged or excavated material disposal, and inform all affected persons of applicable benefits, policies, and procedures in connection with said act;

j. Comply with all applicable Federal and state laws and regulations, including, but not limited to, Section 601 of the Civil Rights Act of 1964, Public Law 88-352 (42 U.S.C. 2000d), Department of Defense Directive 5500.11 issued pursuant thereto, as well as Army Regulation 600 7, entitled "Nondiscrimination on the Basis of Handicap in Programs and Activities Assisted or Conducted by the Department of the Army," and all applicable Federal labor standards requirements including, but not limited to, 40 U.S.C. 3141- 3148 and 40 U.S.C. 3701 – 3708 (revising, codifying and enacting without substantial change the provisions of the Davis-Bacon Act (formerly 40 U.S.C. 276a *et seq.*), the Contract Work Hours and Safety Standards Act (formerly 40 U.S.C. 327 *et seq.*), and the Copeland Anti-Kickback Act (formerly 40 U.S.C. 276c *et seq.*);

k. Provide the non-federal share of that portion of the costs of data recovery activities associated with historic preservation that are in excess of 1% of the total amount authorized to be appropriated for the project in accordance with the cost sharing provisions of the agreement;

l. Participate in and comply with applicable Federal floodplain management and flood insurance programs;

m. Do not use Federal funds to meet the non-federal sponsor's share of total project costs unless the Federal granting agency verifies in writing that the expenditure of such funds is authorized;

n. Prescribe and enforce regulations to prevent obstruction of or encroachment on the project that would reduce the level of protection it affords or that would hinder future periodic nourishment and/or the operation and maintenance of the project;

o. Not less than once each year inform affected interests of the extent of protection afforded by the project;

p. Publicize floodplain information in the area concerned, provide this information to zoning and other regulatory agencies for their use in preventing unwise future development in the floodplain, and adopt such regulations as may be necessary to prevent unwise future development and to ensure compatibility with protection levels provided by the project;

q. For so long as the project remains authorized, the non-federal sponsor shall ensure continued conditions of public ownership and use of the shore upon which the amount of Federal participation is based;

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

s. Recognize and support the requirements of Section 221 of Public Law 91-611, Flood Control Act of 1970, as amended, and Section 103 of the Water Resources Development Act of 1986, Public Law 99-662, as amended, which provides that the Secretary of the Army shall not commence the construction of any water resources project, or separable element thereof, until the non-federal sponsor has entered into a written agreement to furnish its required cooperation for the project or separable element;

t. At least twice annually, and after storm events, perform surveillance of the beach to determine losses of nourishment material from the project design section and provide the results of such surveillance to the Federal government; and

u. Comply with Section 402 of the Water Resources Development Act of 1986, as amended (33 U.S.C. 701b-12), which requires the non-federal sponsor to participate in and comply with applicable Federal floodplain management and flood insurance programs, prepare a floodplain management plan within one year after the date of signing the project partnership agreement (PPA), and implement the plan no later than one year after project construction is complete.

7.2 DISCLAIMER

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. The recommendations herein for provision of a coastal storm risk management project for St. Lucie County, Florida do not include any provisions for work which would result in any new Federal expenditures or financial assistance prohibited by the Coastal Barrier Resources Act (Public Law 97-348); nor were funds obligated in past years for this project for purposes prohibited by this act. The only exception is a 2,000-foot area within Dollman Park (R101.5 to R103.5) which is a publicly owned parcel. This parcel meets Section 6 of CBRA (16 U.S.C. § 3505, the U.S. Fish and Wildlife Service, by letter dated 2 November 2016, which determined that the Recommended Plan meets the Section 6 (G) exemption and is consistent with three purposes of CBRA.

7.3 CERTIFICATION OF PUBLIC ACCESSIBILITY

As part of the obligations established in the project partnership agreement (PPA) for the St. Lucie County, Florida, Coastal Storm Risk Management (CSRM) Project, the non-federal sponsor shall assure continued conditions of public ownership and public use of the shore upon which Federal participation is based during the economic life of the project. The non-federal sponsor shall also provide and maintain necessary access roads, parking areas, and other public use facilities, open and available to all on equal terms. In the determination of the Federal interest in cost sharing, Federal participation was limited to areas where public beach access and adequate parking are available. For shoreline reaches farther than ¼ mile from public access with adequate parking, Federal participation was not provided. The maximum Federal participation allowable for each land use category is applied for cost sharing. I therefore conclude that there is reasonable public availability of the project beaches in all areas where Federal participation is provided.

Jason A. Kirk, P.E.
Colonel, U.S. Army
District Commander

8 List of Preparers

8 LIST OF PREPARERS

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8.2 REVIEWERS

This report was reviewed by the following personnel:

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9 References and Index

9 REFERENCES AND INDEX

9.1 REFERENCES

Adams, J.A. 1960. A contribution to the biology and postlarval development of the sargassum fish, *Histrio* (Linnaeus), with a discussion of the Sargassum complex. Bulletin of Marine Science of the Gulf and Caribbean. 10(1):55-82.

Balazs, G.H. 1985. Impact of ocean debris on marine turtles: entanglement and ingestion, pp. 387-489. In: R.S. Shomura and H.O. Yoshida (eds.), Workshop on the Fate and Impact of Marine Debris. U.S. Department of Commerce, Honolulu, HI.

Bartol, S.M., J.A. Musick, and M. Lenhardt. 1999. Auditory evoked potentials of the loggerhead sea turtle (*Caretta caretta*). Copeia 99(3):836-840.

Blaylock, R.A., J.W. Hain, L.J. Hansen, D.L. Palka, and G.T. Waring. 1995. U.S. Atlantic and Gulf of Mexico Marine Mammal Stock Assessments. NOAA Technical Memorandum. NMFS-SEFSC-363. 211 pp.

Bodge, K. R. 1998. Beach Fill Stabilization with Tuned Structures: Experience in the Southeastern U.S.A. and Caribbean. Coastlines, Structures and Breakwaters. N.W.H. Allsop (ed.) Thomas Telford Publishing, London. pp. 82-93.

Bortone, S.A., P.A. Hastings, and S.B. Collard. 1977. The pelagic-Sargassum ichthyofauna of the eastern Gulf of Mexico. Northeast Gulf Science. 1(2):60-67.

Bowen, B., J.C. Avise, J.I. Richardson, A.B. Meylan, D. Margaritoulis, and S.R. Hopkins-Murphy. 1993. Population structure of loggerhead turtles (*Caretta caretta*) in the northwestern Atlantic Ocean and Mediterranean Sea. Conservation Biology 7(4):834-844.

Bresette, M.J., J. Gorham, and B. Peery. 1998. Size fidelity and size frequencies of juvenile green turtles (*Chelonia mydas*) utilizing near shore reefs in St. Lucie County, Florida. Marine Turtle Newsletter 82:5.

Bresette, M.J., J.C. Gorham, and B.D. Peery. 2000. Initial assessment of sea turtle in the southern Indian River Lagoon system, Ft. Pierce, Florida. pp. 271-273. In: A. Mosier, A. Foley, and B. Brost (eds.), Twentieth Annual Symposium on Sea
Turtle Biology and Conservation. NOAA Technical Memorandum. NMFSSEFSC-477, Orlando, FL.

Brostoff, W. N. 2002. Interstitial bryozoan fauna from Capron Shoal, Florida and adjacent areas: Final Report. US Army Corps of Engineers Research & Development Center, Vicksburg, MS. Prepared for USACE Jacksonville District.

Burke, V.J., E.A. Standora, and S.J. Morreale. 1993. Diet of juvenile Kemp's ridley and loggerhead sea turtles from Long Island, New York. Copeia 1,176-1,180.

Burke, V.J., S.J. Morreale, P. Logan, and E.A. Standora. 1992. Diet of green turtles (Chelonia mydas) in the waters of Long Island, New York. pp. 140-142. In: M. Salmon and J. Wyneken (eds.), Proceedings of the Eleventh Annual Workshop on Sea Turtle Biology and Conservation, NOAA Technical Memorandum. NMFS-SEFC-302.

Burlas, M., G.L. Ray D. Clarke. 2001. The New York District's Biological Monitoring Program for the Atlantic Coast of New Jersey, Asbury Park to Manasquan Section Beach Erosion Control Project. Final Report". U.S. Army Engineer District, New York and U.S. Army Engineer Research and Development Center, Waterways Experiment Station.

Burlas, M, D.G. Clark; G.L. Ray, and D. Wilber. 2002. Biological Monitoring of Beach Nourishment Operations in Northern New Jersey, USA: Linkage between Benthic Impacts and Higher Trophic Levels.

Burton, W., Weisberg, S., and Jacobson, P. (1992). "Entrainment effects of maintenance hydraulic dredging in the Delaware River Estuary on Striped Bass Ichthyoplankton," report submitted to the Delaware Basin Fish and Wildlife Management Cooperative, Trenton, NJ, by Versar, Inc.

Byles, R.A. 1988. Satellite telemetry of Kemp's ridley sea turtle, *Lepidochelys kempii*, in the Gulf of Mexico. National Fish and Wildlife Foundation. 40 pp.

Byrnes, M.R., R.M. Hammer, B.A. Vittor, S.W. Kelley, D.B. Snyder, J.M. Cote, J.S. Ramsey, T.D. Thibaut, N.W. Phillips, and J. D. Wood. 2003. Collection of Environmental Data within Sand Resource Areas Offshore North Carolina and the Environmental Implications of Sand Removal for Coastal and Beach Restoration. U.S. Department of the Interior, Minerals Management Service, Leasing Division, Sand and Gravel Unit, Herndon, VA. OCS Report MMS 2000056, Volume I: Main Text 256 pp. + Volume II: Appendices 69 pp.

Byrnes, M.R., R.M. Hammer, S.W. Kelley, J.L. Baker, D.B. Snyder, T.D. Thibaut, S.A. Zichichi, L.M. Lagera, S.T. Viada, B.A. Vittor, J.S. Ramsey, and J.D. germane, 2004. Environmental Surveys of Potential Borrow Areas Offshore Northern New Jersey and Southern New York and the Environmental Implications of Sand Removal for Coastal and Beach Restoration. U.S. Department of the Interior, Minerals Management Service, Leasing Division, Sand and Gravel Unit, Herndon, VA. OCS Report MMS 2004-044, Volume I: Main Text 264 pp. + Volume II: Appendices 194 pp.

Carr, A.F. 1962. Orientation problems in the high seas travel and terrestrial movements of marine turtles. American Scientist 50:359-374.

Carr, A.F. 1986. Rips, FADS, and little loggerheads. Bioscience 36(2):92-100.

Carr, A.F. 1987. New perspectives on the pelagic stage of sea turtle development. Conservation Biology 1:103-121.

CEQ. 1997. *Considering Cumulative Effects under the National Environmental Policy Act.* Accessed May 2010 at: http://ceq.hss.doe.gov/nepa/ccenepa/ccenepa.htm.

Coastal Planning & Engineering (CPE). 2006. South St. Lucie County Hurricane and Storm Damage Reduction Project, 2006 Offshore Geotechnical Investigations to Identify Sand Sources. Boca Raton, FL.

Coastal Planning & Engineering. (CPE). 2006. South St. Lucie County Hurricane and Storm Damage Reduction Project, 2006 Offshore Geotechnical Investigations to Identify Sand Sources. Boca Raton, Florida. Prepared for St. Lucie County. Prepared by Coastal Planning and Engineering, Boca Raton, FL 33431

Coastal Planning and Engineering, Inc. (CPE). 2006a. South St. Lucie County Hurricane and Storm Damage Reduction Project, Revised 2006 Nearshore Hardbottom Mapping and Characterization Study. Prepared for St. Lucie County, Florida. 34 pp.

Coastal Planning and Engineering, Inc. (CPE). 2006b. South St. Lucie County Hurricane and Storm Damage Reduction Project. 2006 Offshore Geotechnical Investigations to Identify Sand Sources. Prepared for St. Lucie County, Ft. Pierce, Florida. 34 pp.

Coastal Technology Corporation (Coastal Tech). 1995. Ft. Pierce, Florida Shore Protection Project: Geotechnical and Borrow Area Investigation: Phase I Reconnaissance Level. Prepared for St. Lucie County Erosion District Board.

Coastal Technology Corporation (Coastal Tech). 1996. Ft. Pierce, Florida Shore Protection Project: Geotechnical and Borrow Area Investigation: Phase II: Plans and Specifications Level Report. Prepared for St. Lucie County Erosion Control District Board.

Coastal Technology Corporation (Coastal Tech). 2009. St. Lucie County South County Beach & Dune Restoration Project Joint Coastal Permit Application No 0154626001-JC, St. Lucie County, Florida. Prepared for St Lucie County. September 2009.

Coastal Technology Corporation (Coastal Tech). 2010a. Additional Alternatives Evaluated in Detail. Draft revision of St. Lucie County South County Beach & Dune Restoration Project Design Document September 15, 2009 (revised July 6, 2010): Section 2: Alternatives Evaluated in Detail. Email attachment provided by applicant's consultant, October 19, 2010.

Coastal Technology Corporation (Coastal Tech). 2010b. St. Lucie County South County Beach & Dune Restoration Project Design Dredge and Fill Permit Application SAJ 2009-03448 (IP_GGL) RAI #1 Response. September 2010.

Coastal Technology Corporation (Coastal Tech). 2010c. St. Lucie County Sand Search – Geotechnical Investigations, Reconnaissance Level Investigation. Prepared for St. Lucie County. May 2010. 42 pp.

Coastal Technology Corporation (Coastal Tech). 2011 St. Lucie County South County Beach & Dune Restoration Project Joint Coastal Permit Application No 0154626001-JC, St. Lucie County, Florida. Design Document Prepared for St Lucie County. September 2009, revised January 31, 2011.

Comyns, B.H., N.M. Crochet, J.S. Franks, J.R. Hendon, R.S. Waller. 2002. Preliminary Assessment of the Association of Larval Fishes with Pelagic Sargassum Habitat and Convergence Zones in the North Central Gulf of Mexico. Proceedings of the Fifty-Third Annual Gulf and Caribbean Fisheries Institute. No. 53. 636-645 pp.

Continental Shelf Associates, Inc. 2002. Summary report on aerial surveys (1996/97, 1997/98, 1998/99) of northern right whales and other listed species in Atlantic waters from Charleston, South Carolina to Cape Canaveral, Florida. Department of the Navy, Southern Division, Charleston, South Carolina. 47 pp. + app.

Cooke, C.W. 1945. Geology of Florida. Florida Geological Survey, Vol. 29. 339 pp.

Cooke, C.W. and S. Mossom. 1929. Geology of Florida. In: Twentieth Annual Report of Florida Geological Survey. Pp. 29-228.

Cordes, J.J. and A.M.J. Yezer. 1998. In harm's way: Does federal spending on beach enhancement and protection induce excessive development in coastal areas? Land Economics 74(1):128-145.

Cordes, J.J., D.H. Gatzlaff, and A.M.J. Yezer. 2001. To the water's edge, and beyond: Effects of shore protection projects on beach development. Journal of Real Estate Finance and Economics 22:287-302.

Council on Environmental Quality 1997. Considering Cumulative Effects under the National Policy Act. Council on Environmental Quality. Executive Office of the President. January 1997. 64pp+ Accessed at: http://ceq.hss.doe.gov/ publications/ cumulative _effects.html

CSA International, Inc. 2008. Status report of nearshore hard bottom characterization activities in 2008 for the St. Lucie County South Beach Project. Prepared and submitted as a Letter Report for Coastal Technology Corporation. 8 pp. + app.

CSA International, Inc., Applied Coastal Research and Engineering, Inc., Barry A. Vittor & Associates, Inc., C.F. Bean, L.L.C., and Florida Institute of Technology. 2009a. Analysis of Potential Biological and Physical Impacts of Dredging on Offshore Ridge and Shoal Features. Prepared by CSA International, Inc. in cooperation with Applied Coastal Research and

Engineering, Inc., Barry A. Vittor & Associates, Inc., C.F. Bean, L.L.C., and the Florida Institute of Technology for the U.S. Department of the Interior, Minerals Management Service, Leasing Division, Marine Minerals Branch, Herndon, VA. OCS Study MMS 2009-XXX. 184 pp. + apps.

CSA International, Inc. 2009b. Ecological Functions of Nearshore Hardbottom habitats in East Florida: A Literature Synthesis. Prepared for the Bureau of Beaches and Coastal Systems, Florida Department of Environmental Protection. June 2009. 266 pp.

CSA International, Inc. 2009c. Indian River County Sectors 1 and 2 Beach Nourishment Project: Year 1 Post-Construction Monitoring Survey. Prepared for Applied Technology and Management, West Palm Beach, FL. 113 pp + apps.

CSA International, Inc. 2010a. Baseline Nearshore Hard Bottom Characterization Survey for the St. Lucie County South Beach Project. Prepared for Coastal Technology Corporation, Vero Beach, FL. 50 pp + apps.

CSA International, Inc. 2010b. St. Lucie County South Beach Project: Characterization of hard bottom fish assemblages. A report prepared for St. Lucie County, Ft. Pierce, Florida. 29 pp.

CSA International, Inc. 2011. St. Lucie Beach and Borrow Area Infaunal Report. A report prepared for Coastal Technology Corporation. 64 pp.

Dahl, E. 1952. Some aspects of the ecology and zonation of the fauna on sandy beaches. Oikos 4:1-27

Dean, C. 1999. Against the Tide: The battle for America's beaches. Columbia University Press, New York. 279p

Diaz, R.J., G.R. Cutter, Jr. & K.W. Able 2003. The Importance of Physical and Biogenic Structure to Juvenile Fishes on the Shallow Inner Continental Shelf. Estuaries 26(1): 12-20

Diaz, R.J.; Cutter, Jr., G.R., and Hobbs, Iii, C.H., 2004. Potential Impacts of Sand Mining offshore of Maryland and Delaware: Part 2—Biological Considerations. Journal of Coastal Research, 20(1):61–69.

Dibajnia, M. and R.B. Nairn. 2010. Investigation of Dredging Guidelines to Maintain and Protect the Geomorphic Integrity of Offshore Ridge and Shoal Regimes. Detailed Morphological Evaluation of Offshore Shoals. OCS Study 2010-XXXX. 150 pp. + appendices. Draft Report revised April 2010, in review.

Dooley, J.K. 1972. Fishes associated with the pelagic Sargassum complex with a discussion of the Sargassum community. Contributions in Marine Science University of Texas. 16:1-32.

Drake, C.A., D.A. McCarthy, and C.D. Doheln. 2007. Molecular relationships and species divergence among *Phragmatopoma* spp. (Polychaeta: Sabellariidae) in the Americas. Marine Biology 150: 345-358.

Eckelbarger, K.J. 1976. Larval development and population aspects of the reef-building polychaete Phragmatopoma lapidosa from the east coast of Florida. Bulletin of Marine Science 26(2):117-132.

Ecological Associates, Inc. (EAI). 2007. South St. Lucie County Berm Remediation Project, Results of 2006 Sea Turtle Monitoring. St. Lucie County, FL. 43 pp.

Ecological Associates, Inc. (EAI). 2008. South St. Lucie County Berm Remediation Project, Results of 2007 Sea Turtle Monitoring. St. Lucie County, FL. 46 pp.

Ecological Associates, Inc. (EAI). 2009a. South St. Lucie County Berm Remediation Project, Results of 2008 Sea Turtle Monitoring. St. Lucie County, FL. 46 pp.

Ecological Associates, Inc. (EAI). 2009b. Quarter 1, 2009 boat-based survey for marine turtles in the nearshore waters off Hutchinson Island, Florida. Prepared in support of the St. Lucie County South Beach Project letter report to Coastal Technology Corporation. May 2009. 4 pp.

Ecological Associates, Inc. (EAI). 2009c. Quarter 2, 2009 Boat-based survey for marine turtles in the nearshore waters off Hutchinson Island, Florida. Prepared in support of the St. Lucie County South Beach Project letter report to Coastal Technology Corporation. July 2009. 4 pp.

Ecological Associates, Inc. (EAI). 2009d. June 2009 Boat-based survey for marine turtles in the nearshore waters off Hutchinson Island, Florida. Prepared in support of the St. Lucie County South Beach Project letter report to Coastal Technology Corporation. July 2009. 6 pp.

Ecological Associates, Inc. (EAI). 2009e. July 2009 Boat-based survey for marine turtles in the nearshore waters off Hutchinson Island. Florida. Prepared in support of the St. Lucie County South Beach Project letter report to Coastal Technology Corporation. July 2009. 4 pp.

Ecological Associates, Inc. (EAI). 2009f. August 2009 Boat-based survey for marine turtles in the nearshore waters off Hutchinson Island, Florida. Prepared in support of the St. Lucie County South Beach Project letter report to Coastal Technology Corporation. September 2009. 5 pp.

Ecological Associates, Inc. (EAI). 2009g. Quarter 4 2008 Boat-based survey for marine turtles in the nearshore waters off Hutchinson Island, Florida. Prepared in support of the St. Lucie County South Beach Project letter report to Coastal Technology Corporation. April 2009. 4 pp.

Ehrhart, L.M. 1983. Marine turtles of the Indian River Lagoon system. Florida Scientist 46:337-346

Ehrhart, L.M. 1992. Turtles of the worm-rock reefs. The Florida Naturalist 65:9-11.

Ehrhart, L.M. and W.E. Redfoot. 1996. Assessment of green turtle relative abundance in the Cape Canaveral AFS Port area, Trident Submarine Basin. Final Report to USAE Waterways Experiment Station, Coastal Ecology Group, Environmental Laboratory, Vicksburg, MS.

Ehrhart, L.M., D.A. Bagley, W.E. Redfoot, S.A. Kubis, and S. Hirama. 2001. In-water population studies of marine turtles on the East-Central Florida coast; September, 1999 through December, 2000. NOAA/NMFS.

Ehrhart, L.M., W.E. Redfoot, and D.A. Bagley. 1996. A study of the population ecology of in-water marine turtle populations on the east central coast of Florida. Comprehensive final report to NOAA. NMFS. 164 pp.

Ernst, C., J. Lovich, and R. Barbour. 1994. Turtles of the United States and Canada. 1st ed. Smithsonian Institution Press. Washington, DC.

Field, M.E. and D.B. Duane. 1974. The Diet of Worms: A Study of Polychaete Feeding Guilds. Oceanography and Marine Biology Annual Review. 17:193-284.

Florida Department of Environmental Protection (FDEP). 2007. Critical Beach Erosion Areas in Florida. Office of Beaches and Coastal Systems, Tallahassee, FL.

FDEP 2004. *2004 Hurricane Recovery Plan for Florida's Beach and Dune System* Division of Water Resource Management Bureau of Beaches and Coastal Systems. November 30, 2004

FDEP 2008. Letter from Robert Brantley, FDEP to Michael Walther, PE, Coastal Technology Corporation, responding to a Coastal Technology Corporation Request on behalf of St. Lucie County to recognize the beach in St. Lucie County between FDEP R-Monuments 90.3 and R-98 as "critically eroded. December 5 2008.

FDEP 2008. Florida Department of Environmental Protection Bureau of Beaches and Coastal Systems Strategic Beach Management Plan for the Central Atlantic Coast Region. Subregions Cape Canaveral Indian River Coast St. Lucie Beaches Treasure Coast. May 2008. Accessed August 2010 at: http://www.dep.state.fl.us/beaches/publications/pdf/SBMP/Central Atlantic Coast Region.pdf

FDEP. 2010. Critically Eroded Beaches of Florida Updated June 2010. Bureau of Beaches and Coastal Systems Division of Water Resource Management Department of Environmental Protection, State of Florida. Accessed August 2010 at http://www.dep.state.fl.us/beaches/programs/bcherosn.htm

FDEP. 2014. http://www.dep.state.fl.us/parks/planning/parkplans/StLucieInletPreserveStatePark.pdf

Firestone, Jeremy, Shannon B. Lyons, Chengfeng Wang, and James J. Corbett 2008. *Statistical Modeling of North Atlantic Right Whale Migration along the MidAtlantic Region of the Eastern Seaboard of the United States.* Biological Conservation 141(1):221-232 January 2008.

Florida Natural Areas Inventory. 2010. http://fnai.org/bioticssearch.cfm. Accessed February 6, 2010.

Gilbert, E.I. 2005. Juvenile green turtle (*Chelonia mydas*) foraging ecology: feeding selectivity and forage nutrient analysis. Master's thesis. University of Central Florida, Orlando, FL.

Gilmore, Jr., R.G., C.J. Donohoe, D.W. Cooke, and D.J. Herrema. 1981. Fishes of the Indian River Lagoon and adjacent waters. Harbor Branch Tech. Rep. No. 41. 64 pp.

Gilmore, R.G. and F.F. Snelson. 1992. Striped croaker, Bairdiella sanctaeluciae (Jordan), pp 218-222. In: C.R. Gilbert (ed.), Rare and endangered biota of Florida, Volume II. Fishes. University Press of Florida, Gainesville, FL.

Gilmore, R.G., Jr. 2009. St. Lucie County South Beach Project initial essential fish habitat assessment of Potential Borrow Areas. Final Report. March 2009. Estuarine, Coastal and Ocean Sciences, Inc. Vero Beach, FL 32968

Gore, R.H., L.E. Scotto, and L.J. Becker. 1978. Community composition, stability, and trophic partitioning in decapod crustaceans inhabiting some subtropical sabellariid wormreefs. Bulletin Marine Science 28(2):221-248.

Gorzelany, J.F. and W.G. Nelson. 1987. The effects of beach replenishment on the benthos of a sub-tropical Florida beach. Marine Environmental Research 21:7594.

Gram, R. 1965. A Florida Sabellariidae reef and its effect on sediment distribution. Journal of Sedimentary Petrology 38:863-868.

Greene, K. 2002. Beach Nourishment: A Review of the Biological and Physical Impacts. Atlantic States Marine Fisheries Commission Habitat Management Series #7. 174 pp. November 2002.

Hammer, R.M., M.R. Byrnes, D.B. Snyder, T.D. Thibaut, J.L. Baker, S.W. Kelley, J.M. Côté, L.M. Lagera, Jr., S.T. Viada, B.A. Vittor, J.S. Ramsey, and J.D. Wood. 2005. Environmental surveys of potential borrow areas on the central east Florida Shelf and the Environmental Implications of Sand Removal for Coastal and Beach Restoration. Prepared by Continental Shelf Associates, Inc. in cooperation with Applied Coastal Research and Engineering, Inc., Barry A. Vittor & Associates, Inc., and the Florida Geological Survey for the U.S. Department of the Interior, Minerals Management Service, Leasing Division, Marine Minerals Branch, Herndon, VA. OCS Study MMS 2004-037, 306 pp. + apps.

Haig, S.M. 1992. Piping plover. In, The Birds of North America, No. 2. A. Poole, P. Stettenheim, and F. Gill (eds.). Acad. of Nat. Sciences, Philadelphia, PA and Amer. Ornith. Union, Washington, D.C. pp. 1-18.

Henwood, T.A. 1987. Movements and seasonal changes in loggerhead turtle *Caretta* aggregations in the vicinity of Cape Canaveral, Florida (1978-84). Biological Conservation 40:191-202.

Hirth, H.F. 1997. Synopsis of the biological data on the green turtle *Chelonia mydas* (Linnaeus, 1758). U.S. Fish and Wildlife Service Biological Report 97(1). 120 pp.

Holloway-Adkins, K.G. 2001. A comparative study of the feeding ecology of Chelonia mydas (green turtle) and the incidental ingestion of Prorocentrum spp. Master's thesis, Department of Biology. University of Central Florida, Orlando, FL. 168 pp.

Holloway-Adkins, K.G. 2005. Green turtles using nearshore reefs in Brevard County, Florida as developmental habitat; a preliminary investigation. In: 25th Annual Symposium on Sea Turtle Biology and Conservation. NOAA-SENMFS, Savannah, GA.

Holloway-Adkins, K.G. and J.A. Provancha. 2005. Abundance and foraging activity of marine turtles using nearshore rock resources along the Mid Reach of Brevard County, Florida. Dynamac, Jacksonville, FL. 45 pp.

Holloway-Adkins, K.G., M.J. Bresette, and L.M. Ehrhart. 2002. Juvenile green turtles of the Sabellariid worm reef. In: J.A. Seminoff (ed.), Twenty-Second Annual Symposium on Sea Turtle Biology and Conservation. NOAA Technical Memorandum NMFS-SEFSC-503, Miami. FL.

Intergovernmental Panel on Climate Change (IPCC). 2007. IPCC Fourth Assessment Report Annex 1: Glossary. In: S. Solomon, D. Qin, M. Manning, Z. Chen, M. Marquis, K. B. Averyt, M. Tignor, and H. L. Miller (eds.), Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA. http://www.ipcc.ch/publications_and_data/ar4/wg1/en/contents.html

IPCC 2007. Climate Change 2007: The Physical Science Basis, Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. In: Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K. B. Averyt, M. Tignor, and H. L. Miller, (eds.).Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA. http://ipccwg1.ucar.edu/wg1/wg1-report.html

Jefferson, T.A., M.A. Webber, and R.L. Pitman. 2008. Marine Mammals of the World. Academic Press, London. 573 pp.

Kelley, Sean W., John S. Ramsey, and Mark R. Byrnes 2004. Evaluating Shoreline Response to Offshore Sand Mining for Beach Nourishment. Journal of Coastal Research 20(1): 89–100. Winter 2004

Kirtley, D.W. 1966. Intertidal reefs of Sabellariidae (Annelida: Polychaeta) along the coasts of Florida. Master's thesis. Florida State University, Tallahassee, FL. 104 pp.

Kirtley, D.W. 1967. Worm reefs as related to beach stabilization. Journal of the American Shore and Beach Preservation Association 35:31-34.

Kirtley, D.W. 1974. Geological significance of the polychaetous annelid family Sabellariidae. Ph.D. dissertation, Florida State University, Tallahassee, FL. 270 pp.

Kirtley, D.W. 1994. A review and taxonomic revision of the family Sabellariidae, Johnston, 1865 (Annelida: Polychaeta). Sabecon Press Science Series 1, Vero Beach, FL. 223 pp.

Kirtley, D.W. and W.F. Tanner. 1968. Sabellariid worms: Builder of a major reef type. Journal of Sedimentary Petrology 38(1):73-78.

Knowlton, A.R. and B. Weigle. 1989. A note on the distribution of leatherback turtles *Dermochelys coriacea* along the Florida coast in February 1988. pp. 83-85. In:
S.A. Eckert, K.L. Eckert, and T.H. Richardson (comps.), Proceedings of the Ninth Annual Workshop on Sea Turtle Conservation and Biology. NOAA Technical Memorandum. NMFS-SEFSC-232.

Kraus, S. D., M. J. Crone, and A. R. Knowlton 1988. *The North Atlantic Right Whale*.
Pages 684-698 in W. J. Chandler, ed. Audubon Wildlife Report, 19881 1989. Academic Press, New York, NY.

Krivor, M.C. 2008. *Historic Assessment and Submerged Cultural Resources Remote Sensing Survey of Four Borrow Areas for Martin and St. Lucie Counties Shore Protection Projects, Florida*. Report prepared for U.S. Army Corps of Engineers, Jacksonville District. Report prepared by Southeastern Archaeological Research Inc., Jonesville, Florida.

Krivor, M.C. 2010. *Submerged Cultural Resources Remote Sensing Survey of Proposed Offshore Sand Source Area 5 St. Lucie County, Florida*. Report prepared for Coastal Technology Corporation, Vero Beach, Florida. Report prepared by Southeastern Archaeological Research Inc., Newberry, Florida.

Lenhardt M.L. and S.W. Harkins. 1983. Turtle shell as an auditory receptor. Journal of Auditory Research 23:251-260.

Lenhardt, M.L. 1982. Bone conduction hearing in turtles. Journal of Auditory Research 22:153-160.

Lindeman, K.C. and D.B. Snyder. 1999. Nearshore hardbottom fishes of southeast Florida and effects of habitat burial by caused by dredging. Fisheries Bulletin 95:508-525.

Lindeman, K.C., R. Pugliese, G.T. Waugh, and J.S. Ault. 2000. Developmental patterns within a multispecies reef fishery: Management applications for essential fish habitats and protected areas. Bulletin of Marine Science 66(3):929-956.

Lutcavage, M. and J.A. Musick. 1985. Aspects of the biology of sea turtles in Virginia.

Copeia 1985(2):449-456.

Magnuson, J.J., K.A. Bjorndal, W.D. DuPaul, G.L. Graham, F.W. Owens, C.H. Peterson, P.C.H. Pritchard, J.I. Richardson, G.E. Saul, and C.W. West. 1990. Decline of Sea Turtles: Causes and Prevention. National Academy Press, Washington, D.C. 259 pp.

Main, M.B. and W. G. Nelson. 1988. Tolerance of the Sabellariid polychaete *Phragmatopoma lapidosa* Kinberg to burial, turbidity and hydrogen sulfide. Marine Environmental Research 26:39-55.

Makowski, C. 2004. Home range and movements of juvenile Atlantic green turtles (Chelonia mydas L.) on shallow reef habitats in Palm Beach, Florida, USA. Department of Biology. Florida Atlantic University, Boca Raton, FL.

Makowski, C., R. Slattery, and M. Salmon. 2002. "Shark fishing": a technique for estimating the distribution of juvenile green turtles (*Chelonia mydas*) in shallow water developmental habitats, Palm Beach County, Florida USA. p. 241. In: J.A. Seminoff (ed.), Twenty-Second Annual Symposium on Sea Turtle Biology and Conservation. NOAA Technical Memorandum NMFS-SEFSC-503, Miami, FL.

Manooch, C.S., III and D.L. Mason. 1984. Comparative food habits of yellowfin tuna, *Thunnus albacares*, and blackfin tuna, *Thunnus atlanticus*, collected along the South Atlantic and Gulf coasts of the United States. Brimleyana 11:33-52.

Manooch, C.S., III, D.L. Mason, and R.S. Nelson. 1983. Food and gastrointestinal parasites of dolphin *Coryphaena hippurus*, collected along the southeastern and gulf coasts of the United States. NOAA (Natl. Ocean. Atmos. Adm.) Tech. Memo. NMFS (Nat. Mar. Fish. Serv.) SEFC (Southeast Fish. Cent.) 124:1-36.

Martin Thomas R and J. Bailey Smith. 1997. Coastal Engineering Technical Note Analysis of the Performance of the Prefabricated Erosion Prevention (P.E.P.)
Reef System Town of Palm Beach, Florida. Publication CETN-II-36, US Army Engineer Waterways Experiment Station. March 1997. Available at
http://chl.erdc.usace.army.mil/library/publications/chetn/pdf/cetn-ii-36.pdf

McCarthy, D.A. 2001. Life-history patterns and the role of disturbance in intertidal and subtidal populations of the polychaete *Phragmatopoma lapidosa* (Kinberg 1867) in the tropical Western Atlantic. Ph.D. Dissertation. King's College, London. 237 pp.

McCarthy, D.A., C.M. Young, and R.H. Emson. 2003. Influence of wave-induced disturbance on seasonal spawning patterns in the sabellariid polychaete *Phragmatopoma lapidosa*. Marine Ecology Progress Series 256:123-133.

McKenney, T.W., E.C. Alexander, and G L. Voss. 1958. Early development and larval development of the carangid fish, *Caranx crysos* (Mitchill). Bulletin of Marine Science Gulf and Caribbean 8(2):167-200.

Mehta, A.J. 1973. Coastal engineering study of Sabellariid reefs: Report of hydraulic model study to the Harbor Branch Foundation Laboratory, Ft. Pierce, FL. Coastal Oceanography Engineering Laboratory, Engineering. Industrial. Experiment. Station. University of Florida, Gainesville, FL. 67 pp.

Meylan, A. 1988. Spongivory in hawksbill turtles: a diet of glass. Science 239:393-395.

Meylan, A.B. and K.A. Bjorndal. 1983. Sea turtles nesting at Melbourne Beach, Florida, II. Post-nesting movements of *Caretta*. Biological Conservation 26:79-90.

Michel, J., R. Nairn, J.A. Johnson, and D. Hardin. 2001. Development and design of biological and physical monitoring protocols to evaluate the long-term impacts of offshore dredging operations on the marine environment: U.S. Department of Interior, Minerals Management Service, OCS Report MMS 2001-089. 116 pp.

Miller, C. and V. Kosmynin. 2008. The effects of hurricane-deposited mud on coral communities in Florida. Proceedings of the 11th International Coral Reef Symposium, Ft. Lauderdale, FL, 7-11 July 2008.

Morgan, S.G., C.S. Manooch, III, D.L. Mason, and J.W. Goy. 1985. Pelagic fish predation on *Ceratapsis*, a rare larval genus of oceanic penaeoids. Bulletin of Marine Science. 36(2):249-259.

Mortimer, J.A. 1982. Feeding ecology of sea turtles. pp. 103-109. In: K.A. Bjorndal (ed.), Biology and Conservation of Sea Turtles. Smithsonian Institution Press, Washington, DC.

Moser, M.L., P.J. Auster, and J.B. Bichy. 1998. Effects of mat morphology on large Sargassum-associated fishes: Observations from a remotely operated vehicle (ROV) and free-floating video camcorders. Environmental Biology of Fishes 51:391-398.

Multer, H.G. and J.D. Milliman. 1967. Geologic aspects of Sabellarian reefs, southeastern Florida. Bulletin of Marine Science 17:257-267.

National Marine Fisheries Service (NMFS). 1991. Recovery Plan for the Humpback Whale (*Megaptera novaeangliae*). Prepared by the Humpback Whale Recovery Team for the National Marine Fisheries Service, Silver Spring, MD.
http://www.nmfs.noaa.gov/pr/pdfs/recovery/whale_humpback.pdf

National Marine Fisheries Service (NMFS). 1999. Fishery Management Plan for Atlantic tunas, swordfish, and sharks, Volume II. National Marine Fisheries Service Division of Highly Migratory Species, Office of Sustainable Fisheries, Silver Spring, MD. 302 pp.

National Marine Fisheries Service (NMFS). 2005. Recovery Plan for the North Atlantic Right Whale (*Eubalaena glacialis*). National Marine Fisheries Service, Silver Spring, MD. http://www.nmfs.noaa.gov/pr/pdfs/recovery/whale_right_ northatlantic.pdf

National Marine Fisheries Service (NMFS). 2006a. Draft recovery plan for smalltooth sawfish (*Pristis pectinata*). Prepared by the Smalltooth Sawfish Recovery Team for the National Marine Fisheries Service, Silver Spring, Maryland.

National Marine Fisheries Service (NMFS). 2006b. Sea Turtle and Smalltooth Sawfish Construction Conditions. http://www.dep.state.fl.us/water/wetlands/erp/forms.htm

National Marine Fisheries Service (NMFS). 2009. Recovery Plan for Smalltooth Sawfish (*Pristis pectinata*). Prepared by the Smalltooth Sawfish Recovery Team for the National Marine Fisheries Service, Silver Spring, MD. http://www.nmfs.noaa.gov/pr/pdfs/recovery/smalltoothsawfish.pdf

National Marine Fisheries Service (NMFS) and U.S. Fish and Wildlife Service (USFWS). 1991a. Recovery Plan for U.S. Population of Atlantic Green Turtle. National Marine Fisheries Service, Washington, DC. 52 pp. http://www.nmfs.noaa.gov/pr/pdfs/recovery/turtle_green_atlantic.pdf

National Marine Fisheries Service (NMFS) and U.S. Fish and Wildlife Service (USFWS) 1991b. Recovery plan for the U.S. population of the loggerhead turtle. National Marine Fisheries Service, Washington, DC. 52 pp.

National Marine Fisheries Service (NMFS) and U.S. Fish and Wildlife Service (USFWS). 1992a. Recovery Plan for the Kemp's ridley Sea Turtle (*Lepidochelys kempii*). National Marine Fisheries Service, St. Petersburg, FL. 40 pp. http://www.nmfs.noaa.gov/pr/pdfs/recovery/turtle_kempsridley.pdf

National Marine Fisheries Service (NMFS) and U.S. Fish and Wildlife Service (USFWS). 1992b. Recovery Plan for Leatherback Turtles in the U.S. Caribbean, Atlantic and Gulf of Mexico. National Marine Fisheries Service, Washington, DC. http://www.nmfs.noaa.gov/pr/pdfs/recovery/turtle_leatherback_atlantic.pdf

National Marine Fisheries Service (NMFS) and U.S. Fish and Wildlife Service (USFWS). 1993. Recovery Plan for Hawksbill Turtles in the U.S. Caribbean Sea, Atlantic Ocean, and Gulf of Mexico. National Marine Fisheries Service, St. Petersburg, FL. 47 pp. http://www.nmfs.noaa.gov/pr/pdfs/recovery/turtle_hawksbill_ atlantic.pdf

National Marine Fisheries Service (NMFS) and U.S. Fish and Wildlife Service (USFWS). 2008. Recovery Plan for the Northwest Atlantic Population of the Loggerhead Sea Turtle (*Caretta caretta*). Second Revision. National Marine Fisheries Service, Silver Spring, MD. http://www.nmfs.noaa.gov/pr/pdfs/recovery/turtle_ loggerhead_atlantic.pdf

National Research Council Committee on Beach Nourishment and Protection. 1995. Beach Nourishment and Protection. National Academy Press, Washington, DC.

National Research Council Committee on Sea Turtle Conservation. 1990. Decline of the Sea Turtles. National Academy Press. 259 pp.

Nelson, D.A. 1988. Life History and Environmental Requirements of Loggerhead Turtles. U.S. Fish and Wildlife Service Biological Report 88(23). U.S. Army Corps of Engineers Technical Report EL-86-2(Rev.). 34 pp.

Nelson, W.G. 1989. Beach periodic nourishment and hardbottom habitats: The case for caution. Proceedings: 1989 National Conference on Beach Preservation Technology. Florida Shore and Beach Preservation Association. Tallahassee, FL. Pp. 109-116.

Nelson, W.G. and L. Demetriades. 1992. Peracariids associated with sabellariid worm rock (*Phragmatopoma lapidosa* Kinberg) at Sebastian Inlet, Florida, U.S.A. Journal of Crustacean Biology 12(4):647-654.

New England Aquarium. North Atlantic Right Whale (accessed July 2010) http://www.neaq.org/animals_and_exhibits/animals/northern_right_whale/index.p hp

New South Associates. 2008. Cultural Resources Survey; St. Lucie County Shoreline Protection Project; St. Lucie County Florida. Prepared for U.S. Army Corps of Engineers Jacksonville District. 70 pp.

Olsen Associates 2009. Coastal Engineering Review of Proposed Shore Protection Structures at Ft. Pierce Inlet. Prepared for Ocean Village Property Owners Association, Ft. Pierce, FL. Prepared by Olsen Associates. Jacksonville, Florida 32210

Pearse, A.S., H.J. Humm, and G.W. Wharton. 1942. Ecology of sand beaches at Beaufort, North Carolina. Ecological Monographs 12:135-140.

PBS&J, 2005. Post Construction Assessment of Fill Material for the South St. Lucie County Emergency Dune Restoration and Revegetation Project. Prepared for Florida Department of Environmental Protection Bureau of Beaches and Coastal Systems. Contract BS013, Task Order No. 25. Prepared by PBS&J, 5300 West Cypress Streed, Suite 200, Tampa Florida 33607. July 2005

Peters, D.J. and W.G. Nelson. 1987. The seasonality and spatial patterns of juvenile surf zone fishes of the Florida East coast. Florida Scientist 50(2):85-99.

Peterson, C.H., D.H.M. Hickerson, and G.G. Johnson. 2000. Short-term consequences of nourishment and bulldozing on the dominant large invertebrates of a sandy beach. Journal Coastal Research 16(2): 368-378.

Pilkey, O.H. and K.L. Dixon. 1996. The Corps and the Shore. Island Press, Washington, DC.

Ports Corporation of Queensland (PCQ). 2005. *Abbot Point Approved Environmental Management Plan (EMP)*. PCQ: Brisbane.

Provancha, J.A., M.J. Mota, K.G. Holloway-Adkins, E.A. Reyier, R.H. Lowers, D.M. Scheidt, and M. Epstein. 2005. Mosquito Lagoon sea turtle cold stun event of January 2003, Kennedy Space Center/Merritt Island National Wildlife Refuge. Florida Scientist 68:114-121.

Provancha, J.A., R.H. Lowers, D.M. Scheidt, M.J. Mota, and M. Corsello. 1998. Relative abundance and distribution of marine turtles inhabiting Mosquito Lagoon, Florida. pp. 78-79. In: S.P. Epperly and J.A. Braun (eds.), 17th Annual Sea Turtle Symposium. NOAA Technical Memorandum NMFS-SEFSC-415.

Redfoot, W.E. 1997. Population structure and feeding ecology of green turtles utilizing the Trident Submarine Basin, Cape Canaveral, Florida as developmental habitat. Department of Biology. University of Central Florida, Orlando, FL. 72 pp

Richardson, W.J., C.R. Greene, Jr., C.I. Malme, and D.H. Thomson. 1995. Marine mammals and noise. Academic Press, San Diego, CA. 576 pp.

Robins, C.R. 1957. Effects of storms on the shallow-water fish fauna of southern Florida with records of fishes from Florida. Bulletin of Marine Science of the Gulf and Caribbean 7(3):266-275.

Ryder, T.S., E. Standora, M. Eberle, J. Edbauer, K. Williams, S. Morreale, and A. Bolten. 1994. Daily movements of adult male and juvenile loggerhead turtles (*Caretta caretta*) at Cape Canaveral, Florida. p. 131. In: K.A. Bjorndal, A.B. Bolten, D.A. Johnson, and P.J. Eliazar (comps.), Proceedings of the Fourteenth Annual Symposium on Sea Turtle Biology and Conservation, NOAA Technical Memorandum. NMFS-SEFSC-351.

Schmid, J.R. 1995. Marine turtle populations on the east-central coast of Florida: results of tagging studies at Cape Canaveral, Florida, 1986-1991. Fishery Bulletin 93:139-151.

Schroeder, B.A. and N.B. Thompson. 1987. Distribution of the loggerhead turtle, *Caretta*, and the leatherback turtle, *Dermochelys coriacea*, in the Cape Canaveral, Florida area: Results of aerial surveys. pp. 45-53. In: W.N. Witzell (ed.), Ecology of East Florida Sea Turtles, Proceedings of a Cape Canaveral, Florida Sea Turtle Workshop, Miami, Florida, February 26-27, 1985, NOAA Tech. Rep. NMFS 53.

Schwarzer, A.C., J.A. Collazo, L.J. Niles, J.M. Brush, N.J. Douglas, and H. F. Percival. 2012. Annual survival of red knots (*Calidris canutus rufa*) wintering in Florida. *Auk* 129(4):725-733. BioOne.

Scott, Lisa C. 2007. Preconstruction Benthic Monitoring and Evaluation at The Cape May City and Lower Cape May Meadows Beachfill Borrow Areas. Prepared for U.S. Army Corps of Engineers Philadelphia District 100 Penn Square East
Philadelphia, PA 19107 Prepared by Versar, Inc. 9200 Rumsey Road Columbia, MD 21045 Contract No. W912BU-06-D-0003 Delivery Order No. 1. January 2007.

Scott, Lisa C. and William H. Burton. 2005. Baseline Biological Monitoring Of Two Offshore Sand Sources along the Delaware Atlantic Coast (Fenwick Island Borrow Area and Area E). Prepared for U.S. Army Corps of Engineers Philadelphia District 100 Penn Square East Philadelphia, PA 19107. Prepared by Versar, Inc. 9200 Rumsey Road Columbia, MD 21045. Contract No. DACW6100-D-0009 Delivery Order No. 00046. May 2005.

Settle, Lawrence R. 2003. Assessment of potential larval entrainment mortality due to hydraulic dredging of Beaufort Inlet. National Centers for Coastal Ocean Science, Center for Coastal Fisheries and Habitat Research.

Shaver, D.J. 1991. Feeding ecology of wild and head started Kemp's ridley sea turtles in South Texas waters. Journal of Herpetology 25(3):327-334.

Slacum, H.W. Jr., W.H. Burton, J.H. Vølstad, J. Dew, E. Weber, R. Llansó, D. Wong. 2006. Comparisons between marine communities residing on sand shoals and uniform-bottom substrate in the mid-Atlantic bight. Final Report to the U.S. Department of the Interior, Minerals Management Service, International Activities and Marine Minerals Division, Herndon, VA. OCS Report MMS 2005-042. 149 pp. + app.

Slacum, H.S. Jr., W.H. Burton, E.T. Methratta, E.D. Weber, R.J. Llamso, J. Dew-Baxter. 2010. Assemblage Structure in Shoal and Flat-bottom Habitats on the Inner Continental Shelf of the Middle Atlantic Bight, USA. Marine and Coastal Fisheries: Dynamics, Management, and Ecosystem Science 2:227-298.
American Fisheries Society.

Sloan, N.J.B. and E.A. Irlandi. 2008. Burial tolerances of reef-building Sabellariid worms from the east coast of Florida. Estuarine, Coastal, and Shelf Science 77:337-344.

Smith, G.C. 2008. *Cultural Resources Survey St. Lucie County Shoreline Protection Project St. Lucie County, Florida*. Report prepared for U.S. Army Corps of Engineers, Jacksonville District. Report prepared by New South Associates, St. Augustine, Florida.

South Atlantic Fishery Management Council (SAFMC). 1998. Comprehensive Amendment Addressing Essential Fish Habitat in Fishery Management Plans of the South Atlantic Region. South Atlantic Fishery Management Council. Charleston, SC.

South Atlantic Fishery Management Council (SAFMC). 2002. Fishery Management Plan for pelagic Sargassum habitat of the South Atlantic Region. South Atlantic Fishery Management Council. SC. 152 pp. + apps.

South Atlantic Fishery Management Council (SAFMC). 2003. Fishery Management Plan for the dolphin and wahoo fishery of the Atlantic. South Atlantic Fishery Management Council. Charleston, SC. 309 pp. + apps.

South Atlantic Fishery Management Council (SAFMC). 2009. Fishery ecosystem plan of the south Atlantic Region, Volume II: South Atlantic habitats and species. South Atlantic Fishery Management Council. Charleston, SC.

Spring, K.D. 1981. A study of spatial and temporal variations in the nearshore macrobenthic populations of the central Florida east coast. Master's Thesis, Florida Institute of Technology, Melbourne, FL. 67 pp.

Stauble D.K. and J.R. Tabar. 2003. The Use of Submerged Narrow-Crested Breakwaters for Shoreline Erosion Control. Journal of Coastal Research, 19(3), 684–722. West Palm Beach (Florida), ISSN 0749-0208.

Stronge, W. 2008. Recreational Benefits Assessment. In: Response to Request for Additional Information (RAI #2), submitted by Coastal Technology Corporation, July 2010. JCP File Number 0154626-001-JC, St. Lucie County.

St. Lucie Audubon. 2014.
http://stlucieaudubon.org/sightings.htm

Swingle, W.M., S.G. Barco, T.D. Pitchford, W.A. McLellan, and D.A. Pabst. 1993. Appearance of juvenile humpback whales feeding in the nearshore waters of Virginia. Marine Mammal Science 9(3):309-315.

Taylor Engineering, Inc. 2004. Ft. Pierce Inlet Sand Bypassing Feasibility Study, St. Lucie County, Florida, Jacksonville, Florida. Prepared for St. Lucie County, Florida by Taylor Engineering, Inc. Jacksonville FL

Taylor Engineering, Inc. 2007. Martin County Upland Sand Source Reconnaissance. Prepared for Martin County, Florida.

Taylor Engineering, Inc. 2009. Southeast Atlantic Regional Sediment Management Plan for Florida. Prepared for US Army Corps of Engineers, Jacksonville District.

Taylor Engineering, Inc. 2010. St. Lucie Nuclear Discharge Canal Headwall Stabilization Report Seawall Feasibility Design Development Report, St. Lucie County, Florida. Prepared for FPL, St Lucie County, Florida

Taylor Engineering, Inc. 2011. Ft. Pierce Inlet Sand Bypassing Preliminary Design and Permitting Final Project Report. Prepared for St. Lucie County, Florida in Partnership with the Florida Department of Environmental Protection by Taylor Engineering, Inc. May 2011.

Thompson, N.B. and H. Huang. 1993. Leatherback turtles in southeast U.S. waters. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Southeast Fisheries Science Center, Miami, FL. NOAA Technical Memorandum NMFS-SEFSC-318. 11 pp.

Thomsen, Frank, Sophy McCully, Daniel Wood, Federica Pace and Paul White. 2009. A generic investigation into noise profiles of marine dredging in relation to the acoustic sensitivity of the marine fauna in UK waters with particular emphasis on aggregate dredging: PHASE 1 Scoping and review of key issues. MEPF Ref No. MEPF/08/P21 CEFAS Contract Report C3312f. Centre for Environment, Fisheries & Aquaculture Science (CEFAS), Pakefield Road, Lowestoft, Suffolk, NR33 0HT. 20 February 2009.

Tove, Michael H. 2000. Guide to the Offshore Wildlife of the Northern Atlantic. University of Texas Press, Austin. 250 pp.

Turbeville D.B. and G. A Marsh. 1982. Benthic Fauna of an Offshore Borrow Area in Broward County, Florida. Miscellaneous Report No. 82-1. Prepared for U.S. Army, Corps of Engineers, Coastal Engineering Research Center, Fort Belvoir, VA. 54 pp.

Turtle Expert Working Group (TEWG). 1996a. Status of the Loggerhead Turtle Population (*Caretta caretta*) in the Western North Atlantic. 50 pp.

Turtle Expert Working Group (TEWG). 1996b. Kemp's ridley sea turtle (*Lepidochelys kempii*) Status Report. 49 pp.

Turtle Expert Working Group (TEWG). 2000. Assessment update for the Kemp's ridley and loggerhead sea turtle populations in the western north Atlantic. U.S. Department of Commerce, NOAA Technical Memorandum. NMFS-SEFSC-444. 115 pp.

U.S. Army Corps of Engineers (USACE) 1996. Coast of Florida Erosion and Storm Effects Study: Region III with Final Environmental Impact Statement. Department of the Army, U.S. Army Corps of Engineers Jacksonville District, Jacksonville, FL

U.S. Army Corps of Engineers (USACE). 2001. Dade County, Florida, Beach Erosion

Control and Hurricane Protection Project, Evaluation Report. Department of the Army, U.S. Army Corps of Engineers Jacksonville District, Jacksonville, FL

U.S. Army Corps of Engineers (USACE). 2006. Project Information Report: Rehabilitation Effort for the Martin County Erosion Control and Hurricane Protection Project, Martin County, Florida. Department of the Army, U.S. Army Corps of Engineers Jacksonville District, Jacksonville, FL, September 18, 2006.

U.S. Army Corps of Engineers (USACE). 2008. Preliminary Draft Environmental Impact Statement, Martin County Beach Erosion Control Project: New Borrow Area, Hutchinson Island, Martin County, Florida. Department of the Army, U.S. Army Corps of Engineers Jacksonville District, Jacksonville, FL

U.S. Army Corps of Engineers (USACE). 2009. Water Resource Policies and Authorities Incorporating Sea-Level Change Considerations in Civil Works Programs. Circular No. 1165-2-211 1 July 2009. CECW-CE Washington, DC 20314-1000. Expires 1 July 2011

U.S. Army Corps of Engineers (USACE). 2010. Letter from Donald W. Kinard, USACE Jacksonville District, to James Bennett, Bureau of Ocean Energy Management, Regulation, and Environment, Environmental Division Branch of Environmental Assessment. 16 August 2010

U.S. Army Corps of Engineers (USACE). 2010. Martin County, Florida Hurricane and Storm Damage Reduction Project. Draft Supplemental Environmental Impact Statement Department of the Army, U.S. Army Corps of Engineers Jacksonville District, Jacksonville, FL. September 2010 http://www.saj.usace.army.mil/ Divisions/Planning/Branches/Environmental/DocsNotices_OnLine_MartinCo.htm.

U.S. Climate Change Science Program. 2009. Coastal Sensitivity to Sea-Level Rise: A Focus on the Mid-Atlantic. Synthesis and Assessment Product 4.1. January 2009. http://www.epa.gov/climatechange/effects/coastal/sap4-1.html

U.S. Fish and Wildlife Service (USFWS). 2001. Florida Manatee Recovery Plan (*Trichechus manatus latirostris*). Third Revision. U.S. Fish and Wildlife Service, Atlanta,GA.http://www.fws.gov/northflorida/manatee/Documents/Recovery Plan/MRP-start.pdf

U.S. Fish and Wildlife Service (USFWS). 2005. Biological Opinion: Martin County Shore Protection Project. South Florida Ecological Services Office, Vero Beach, Florida. January 5, 2005. Service Log No: 4-1-05-F-10476.

U.S. Fish and Wildlife Service (USFWS). 2007. In preparation 2007. Regional Biological Assessment for Beach Activities along the Atlantic and Gulf Coast of Florida.

U.S. Fish and Wildlife Service (USFWS). 2009. Letter to Eric Summa, Acting Chief, Environmental Branch, USACE Jacksonville District from Paul Sosza, Field Supervisor, South Florida Ecological Services Office, USFWS re Service Log No.: 4 1420-2009-FA-0389 Date Received: February 9,2009 County: U.S. Army Corps of Engineers. Project: Beach Periodic nourishment in CBRS Unit PI1. May 27, 2009.

U.S. Fish and Wildlife Service (USFWS). 2013. Programmatic Piping Plover Biological Opinion. South Florida Ecological Services Office, Vero Beach, Florida. May 22, 2013. Consultation Code: 04EF1000-2013-F-0124.

U.S. Fish and Wildlife Service (USFWS). 2015. Statewide Programmatic Biological Opinion. South Florida Ecological Services Office, Vero Beach, Florida. May 13, 2015. Service Log No: 41910-2011-F-0170.

U.S. Fish and Wildlife Service (USFWS). 2014.
http://www.fws.gov/northeast/redknot/

Vasslides, J.M. and K.W. Able. 2008. Importance of shoreface sand ridges as habitat for fishes off the northeastern coast of the United States. Fishery Bulletin 106:93107.

Walsh, H.J., K.E. Marancik, and J.A. Hare. 2006. Juvenile fish assemblages collected on unconsolidated sediments of the southeast United States continental shelf. Fishery Bulletin 104: 256-277.

Werner, S.A. and A.M. Landry, Jr. 1994. Feeding ecology of wild and head started Kemp's ridley sea turtles (*Lepidochelys kempii*). p. 163. In: K.A. Bjorndal, A.B. Bolten, D.A. Johnson, and P.J. Eliazar (comps.), Proceedings of the Fourteenth Annual Symposium on Sea Turtle Biology and Conservation, NOAA Technical Memorandum. NMFS-SEFSC-351.

Wershoven, J.L. and R.L. Wershoven. 1992. Juvenile green turtles in their nearshore habitat of Broward County, Florida: a five year review. In: M. Salmon and J. Wyneken (eds.), Eleventh Annual Workshop on Sea Turtle Biology and Conservation, Jekyll Island, GA. pp. 121-123

Wilber, P. and M. Stern. 1992. A Re-examination of infaunal studies that accompany beach nourishment projects. In: New Directions in Beach Management: Proceedings of the 5th Annual National conference on Beach Preservation Technology. Prepared for: The Florida Shore & Beach Preservation Association.
pp. 242-257.

Wiley, D.N., R.A. Asmutis, T.D. Pitchford, and D.P. Gannon. 1995. Stranding and mortality of humpback whales, *Megaptera novaeangliae*, in the mid-Atlantic and southeast United States, 1985-1992. Fishery Bulletin 93:196-205.

Winn, H.E., (ed.). 1982. A characterization of marine mammals and turtles in the mid- and north Atlantic areas of the U.S. outer continental shelf. Final report of the Cetacean and Turtle Assessment Program. University of Rhode Island, Kingston,

RI, Prepared for U.S. Department of the Interior, Bureau of Land Management, Washington, DC, Available through National Technical Information Service, Springfield, VA, PB83-215855.

Winston, J. E. and E. Håkansson. 1986. The Interstitial Bryozoan Fauna from Capron Shoal, Florida. American Museum of Natural History, No. 2865, pp 1-50.

Witherington, B.E. 2002. Ecology of neonate loggerhead turtles inhabiting lines of downwelling near a Gulf Stream front. Marine Biology 140:843-853.

Worm, B., H.K. Lotze, and R.A. Myers. 2003. Predator diversity hotspots. Proceedings of the National Academy of Sciences 100(17):9,884-9,888.

Wright, D.G.. 1977. Artificial Islands in the Beaufort Sea: A Review of Potential Impacts. Department of Fisheries and Environment, Winnipeg, Manitoba, 38 pp.

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Reference Maps

ST. LUCIE COUNTY

COASTAL STORM RISK MANAGEMENT
FEASIBILITY STUDY & INTEGRATED ENVIRONMENTAL ASSESSMENT

STUDY BACKGROUND

Location

St. Lucie County is located along the east coast of south-central Florida, approximately 225 miles south of Jacksonville and 100 miles north of Miami. The St. Lucie County, Florida shoreline consists of a 25-mile-long narrow barrier island named Hutchinson Island, bordered by the Atlantic Ocean to the east, and the Indian River Lagoon (Atlantic Intracoastal Waterway) to the west. The study area extends from R77 to the Martin County line. St. Lucie Inlet is approximately 7 miles south of the study area, in Martin County.

Nearby Federal Projects

The Fort Pierce Project spans 1.3 miles, just south of the Ft. Pierce Inlet. The Martin County Project is 4 miles long, and begins just south of the Martin County line.

Purpose

The purpose of this study is to investigate the feasibility of providing coastal storm risk management within the southern five miles of the St. Lucie County, Florida coastline, and adjacent shorelines.

Problem and Need

There is a need to reduce the damages to coastal infrastructure on the shoreline of South Hutchinson Island, during hurricane and tropical storm events, and in consideration of future potential sea level rise effects.

Atlantis Condominium September 2004

Hutchinson Island Inn September 2004

Sponsor

St. Lucie County, Florida

Authorization

Resolution Docket 2634, 11 April 2000 and
Resolution Docket 2757, 23 July 1998

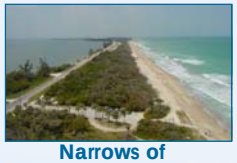
UNIQUE CONSIDERATIONS

- The study area is largely dominated by a large U.S. Fish and Wildlife Service (USFWS) designated Coastal Barrier Resource System (CBRS) unit, known as CBRS unit P11 (46% of the study area.
- The Coastal Barrier Resource Act of 1982 designated relatively undeveloped coastal barriers along the Atlantic and Gulf coasts as part of the John H. Chafee Coastal Barrier Resources System (CBRS), making these areas ineligible for most new federal expenditures and financial assistance. CBRA encourages the conservation of hurricane prone, biologically rich coastal barriers by restricting federal expenditures that encourage development, such as federal flood insurance. Areas within the CBRS can be developed provided that private developers or other non-federal parties bear the full cost.

STUDY AREA (R77 TO Martin County line)

North Hutchinson Island (NHI) Reach
R77 to R80, .57 miles

Power Plant Area (PP) Reach
R80 to R90, 1.9 miles



Narrows of Hutchinson Island (NHI) Reach
R90 to R98, 1.5 miles

South Hutchinson Island (SHI) Reach
R98 to R001, 3.4 miles

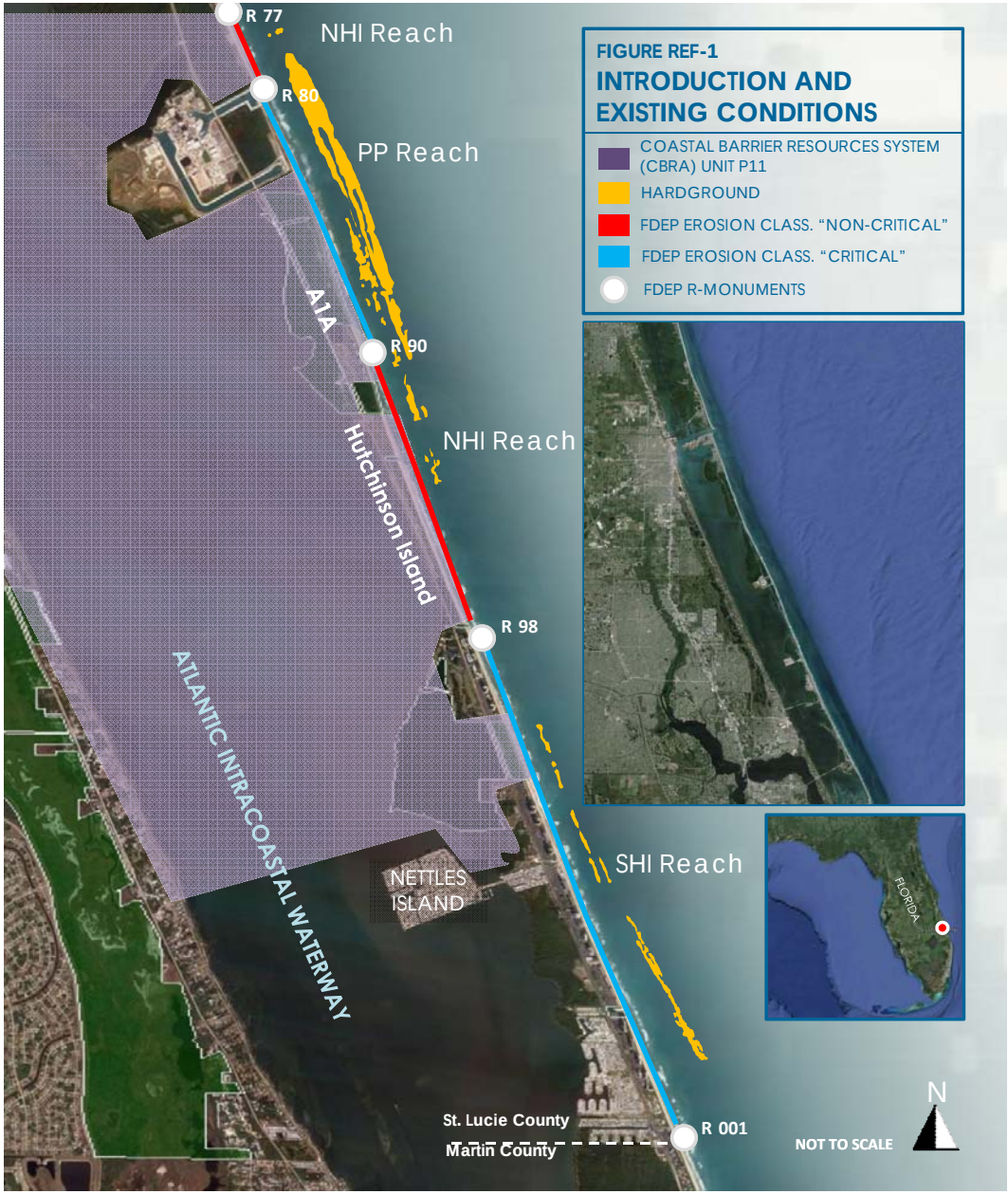


FIGURE REF-1
INTRODUCTION AND EXISTING CONDITIONS

- COASTAL BARRIER RESOURCES SYSTEM (CBRA) UNIT P11
- HARDGROUND
- FDEP EROSION CLASS. "NON-CRITICAL"
- FDEP EROSION CLASS. "CRITICAL"
- FDEP R-MONUMENTS

RECOMMENDED PLAN

SOUTH HUTCHINSON ISLAND REACH ST. LUCIE COUNTY

NATURAL/HUMAN ENVIRONMENT

Existing Conditions/Future With Project

- Coastal Barrier Resource System (CBRS) unit P11 (refer to map)
- Hardbottom resources
- Sea turtle nesting and shore bird habitat

Turtle Nesting

Worm Rock Reefs/Hardground

Future with Project

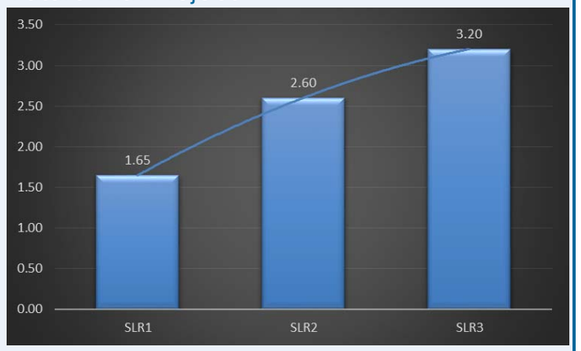
- Section 6 exception from U.S. Fish & Wildlife Service (FWS) will allow placement of sand in CBRS unit P11 on public land (R101.5 to R103.5) with Federal cost sharing
- No direct impact to hardbottom resources
- Borrow Source: St. Lucie Shoals (SL4-R98) (using Florida Department of Environmental Protection (FDEP) 50-year mining strategy); Average 4 miles offshore; adequate amount for 50 year planning horizon and compatible with native sand

PHYSICAL ENVIRONMENT

Existing Conditions/Future With Project

- Most recent damaging hurricanes and storms: 2004 (Frances and Jeanne); 2011 (Sandy)
- Uniform erosion across reach (~.4 ft. per year)
- SLC in 50 year planning horizon ~ Base: .5 feet; Intermediate: .9 feet; High: 2.4 feet

Future with Project



Recommended Plan increasingly efficient in light of sea level rise

Note: BCR based on storm damage reduction only

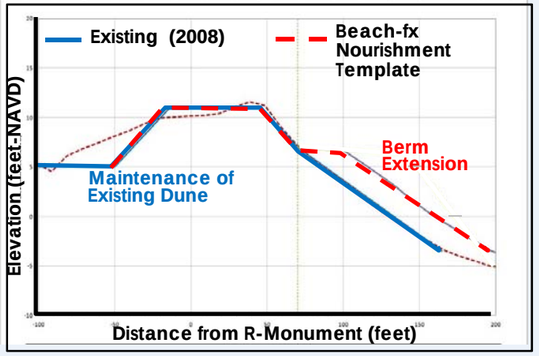
BUILT ENVIRONMENT

Existing Conditions/Future With Project

- 2012/2013 St. Lucie County local nourishment project:
  - R88 to Martin County line
  - Dune and berm; ~ 650,000 cubic yards of sand
- No coastal armoring
- 4 public access areas
- SR A1A evacuation route

Future with Project

- Recommended Plan (Base Sea Level Rise)
- Initial Placement: 20-foot extension of the berm from the 2008 dune shoreline profile and maintenance of the existing dune
- Average of 422,000 cubic yards of sand
- Average Periodic Nourishment: 18 year interval with average 390,000 cubic yards of sand



ECONOMIC ENVIRONMENT

Existing Conditions/Future With Project

- 241 damageable elements in the project area

Future with Project

- Reduces damages by 98%
- Increasingly efficient with intermediate and High SLC

ECONOMIC SUMMARY	STORM RISK MANAGEMENT BENEFITS ONLY	STORM RISK MANAGEMENT + LAND LOSS BENEFITS (PRIMARY)	STORM RISK MANAGEMENT + LAND LOSS + RECREATION BENEFITS
PRICE LEVEL	FY 17	FY 17	FY 17
FY 17 WATER RESOURCES DISCOUNT RATE	2.875%	2.875%	2.875%
STORM RISK MANAGEMENT BENEFITS	$2,165,000	$2,165,000	$2,165,000
LAND LOSS BENEFITS	$0	$234,000	$234,000
RECREATION BENEFITS	$0	$0	$566,000
TOTAL BENEFITS	$2,165,000	$2,400,000	$2,965,000
TOTAL COST	$1,349,000	$1,349,000	$1,349,000
NET BENEFITS	$ 817,000	$1,051,000	$1,617,000
BENEFIT COST RATIO (BCR)	1.61	1.78	2.20

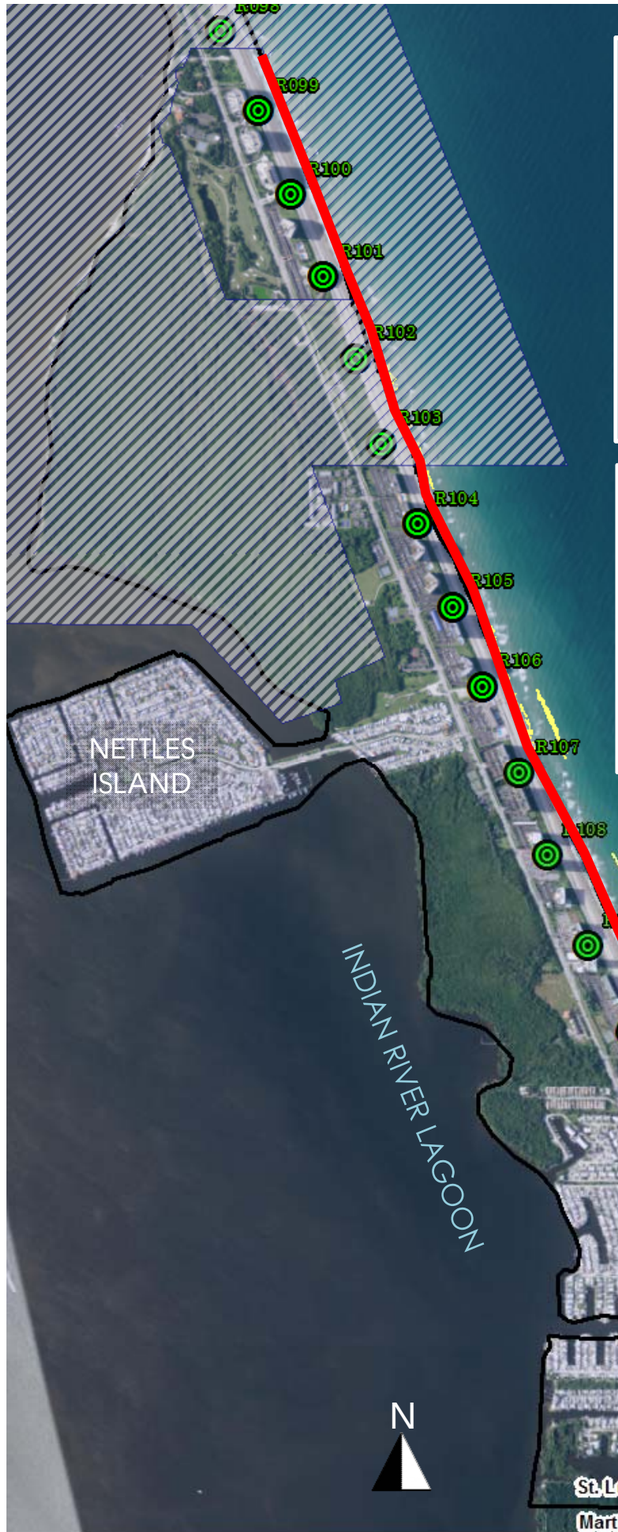


FIGURE REF-2

Recommended Plan

- FDEP COASTAL RANGE MONUMENTS
- COASTAL BARRIER RESOURCES SYSTEM (CBRA) UNIT P11
- HARDBOTTOM
- RECOMMENDED PLAN: 3.3 MILES; 20-FT BEACH NOURISHMENT & MAINTENANCE OF THE EXISTING DUNE PLUS TAPERS UP TO 1,000 FEET NORTH AND SOUTH

TOTAL PROJECT COST*
$53,296,000
* includes contingency; FY18 price level

BCR (FY17 discount rate and FY17 price level)
2.20

Sand Source
St. Lucie Shoals (SL4-R98, see REF-4)

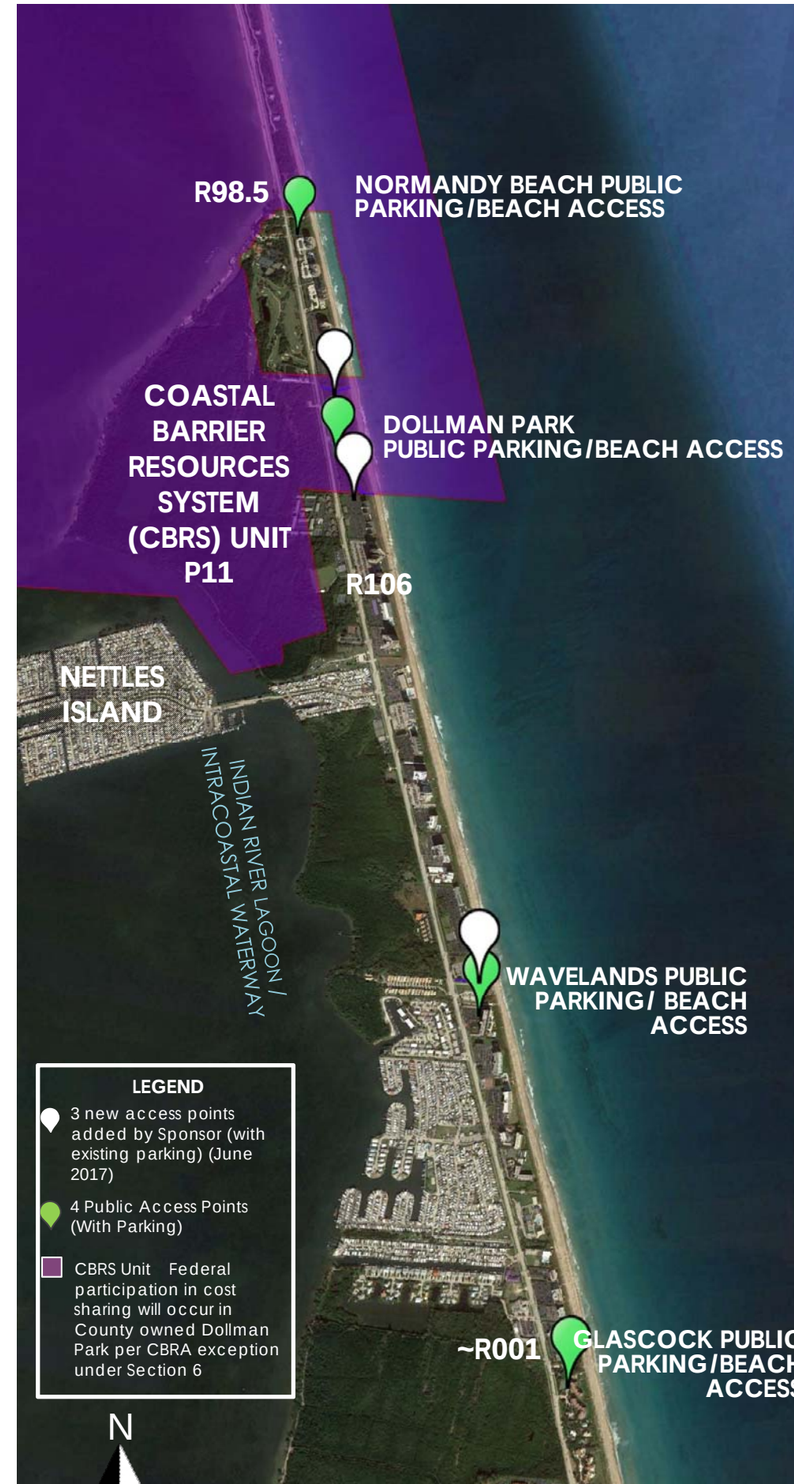


FIGURE REF-3

COST SHARING & PARKING/ACCESS

Normandy Beach Public Access (R98+300S to R98+400S)

Dollman Park Public Beach Access (R101+400S to R103+300S)

Wavelands Public Beach Access (R-110+600S to R111+200S)

Glascock Public Beach Access (Martin County line: R001)

SAND SOURCE FOR THE RECOMMENDED PLAN

COASTAL STORM RISK MANAGEMENT
FEASIBILITY STUDY & INTEGRATED ENVIRONMENTAL ASSESSMENT

FIGURE REF-4