Martin County, Florida
Hurricane and Storm Damage Reduction Project

FINAL LIMITED REEVALUATION REPORT and FINAL SUPPLEMENTAL ENVIRONMENTAL IMPACT STATEMENT

October 2011

US Army Corps of Engineers
JACKSONVILLE DISTRICT

THIS PAGE INTENTIONALLY LEFT BLANK

Martin County, Florida
Hurricane and Storm Damage Reduction Project

FINAL LIMITED REEVALUATION REPORT and FINAL SUPPLEMENTAL ENVIRONMENTAL IMPACT STATEMENT

October 2011

US Army Corps of Engineers
JACKSONVILLE DISTRICT

THIS PAGE INTENTIONALLY LEFT BLANK

Martin County, Florida
Hurricane and Storm Damage Reduction Project

Limited Reevaluation Report

Table of Contents

THIS PAGE INTENTIONALLY LEFT BLANK

Martin County, Florida
Hurricane and Storm Damage Reduction Project

Final Limited Reevaluation Report of the Beach Erosion Control Project

October 2011

Introduction

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. This report authorized 942,000 cubic yards (cy) of beach fill to be placed on 4 miles of shorefront southward from the St. Lucie County line to near the limit of Stuart Public Park (Florida Department of Environmental Protection, FDEP, monuments R1 – R25). Periodic nourishment was calculated to be 424,000 cy every 8 years based on 53,000 cy/yr of erosion. A range of nonstructural and structural measures were evaluated to reduce beach, land, and property losses resulting from erosion, storms, and hurricanes along Hutchinson Island. The recommended plan of beach nourishment using an offshore sand source was carried forward as the preferred alternative as it maximized net NED benefits, meets the federal objectives of storm damage reduction, and considers the recreational and environmental needs of the study area. According to the 1994 General Design Memorandum (GDM), the updated initial construction fill was 1,083,100 cy with periodic nourishment authorized at an interval of 11 years, with an estimated loss of 589,600 cy every 11 years. This was based on a predicted 53,600 cy/yr erosion rate.

Initial construction of the 4 mile project was completed in 1996. In the summer of 2000, nearshore artificial reef was created to mitigate for impacts to nearshore hardbottom in the project area. Following the initial construction, Martin County and the U.S. Army Corps of Engineers (USACE) constructed nourishments in 2001, 2002 and 2005. Due to the 2004 hurricane impacts, the project was fully restored in spring of 2005 utilizing sand from the previously approved borrow area (Gilbert Shoal). Approximately 269,500 cy of material were used to restore the project to pre-storm conditions at 100% federal cost using Flood Control and Coastal Emergencies (FCCE) funds, and approximately 625,500 cy were used to restore to full design conditions using construction general (CG) funds. **Table 1** and **Figure 1** provide the details and locations of all past nourishments of the Martin County Project.

Table 1: Martin County SPP Placement History

	1995-1996	2001	2002	2005*
FDEP R-monument	R1-R25	R16.2-R22.3	R13.5-R16.2	R1-R25.6
Design Dune Elev (ft) MSL	12.5	12.5	12.5	12.5
Design Dune Width (ft)	20	20	20	20
Design Berm Elev (ft) MSL	8	8	8	8
Design Berm Width (ft)	35	35	35	35
Actual Constructed Fill (cy)	1,340,000	178,000	126,000	895,000
* 269,500 cy were from emergency FCCE funds due to 2004 hurricanes				

Figure 1: Martin County SPP Limits and Reference Areas (Taylor Engineering, 2009)

The next periodic nourishment is scheduled for 2012. As part of Planning Engineering, and Design (PED), the volume of beach quality material needed was not found to be available in the previous borrow area. A new borrow area has been identified. In addition, an opportunity was identified through discussion with United States Fish and Wildlife Service (USFWS) to modify the construction template to alleviate concerns over lost sea turtle nests immediately following construction. This report documents 1) any differences in scope from the authorized project, including borrow areas 2) an updated benefit to cost ratio and nourishment interval 3) National Environmental Protection Act (NEPA) documentation status 4) a section 902 limit analysis and 5) cost-sharing for construction. Attachments to this document include an economic appendix, cost estimate, and sea level rise appendix.

1. Changes in Project Scope

The proposed 2012 nourishment will continue the federally-authorized Martin County Hurricane and Storm Damage Reduction Project (formerly referred to as a Beach Erosion Control or Shore Protection Project), originally constructed in 1996 with periodic nourishment placed between monuments R1 and R25. The 2012 nourishment will be constructed using alternating 2000-foot (ft) fill template segments with 700 ft transitions. One template would include the construction berm identical to the 1996 – 2005 projects, and the other "turtle-friendly" template would essentially comprise a sloped berm transitioning to a reduced slope foreshore (Taylor Engineering, 2009). The alternating segments would be constructed at the request of the sponsor and environmental agencies so that monitoring may be implemented in a controlled environment to scientifically verify the performance of the turtle friendly template, without compromising storm damage reduction benefits. The turtle-friendly monitoring costs would be the responsibility of the agencies and sponsor, and are not included in the project cost estimate. The March 2010, Biological Opinion, allows for alternating template construction in 2012. Following nourishments will be constructed entirely with one template, likely to be the turtle friendly template, taking into consideration monitoring following the 2012 nourishment. Project specifications from years 1989, 1994, and 2012 are further detailed in **Table 2**. The 35 ft design berm width in **Table 2** does not include the advanced construction fill. **Figure 2** shows how the turtle friendly profile compares to traditional construction and design profiles.

In general, traditional beach nourishment construction templates have zero slope berm fill segments and foreshore slopes ranging between 1V:10H to 1V:15H; this allows the template to equilibrate naturally to a shallower slope. "The Assessment of Alternative Construction Template for Beach Nourishment Projects", 2007, concluded and recommended that turtle-friendly construction templates provide advanced equilibration by sloping the fill berm between 1V:40H to 1V:100H, foreshore slopes of 1V:10H to 1V:25H above the water line, and submerged slopes ranging from 1V:30H to 1V:50H. (Taylor Engineering, 2009)

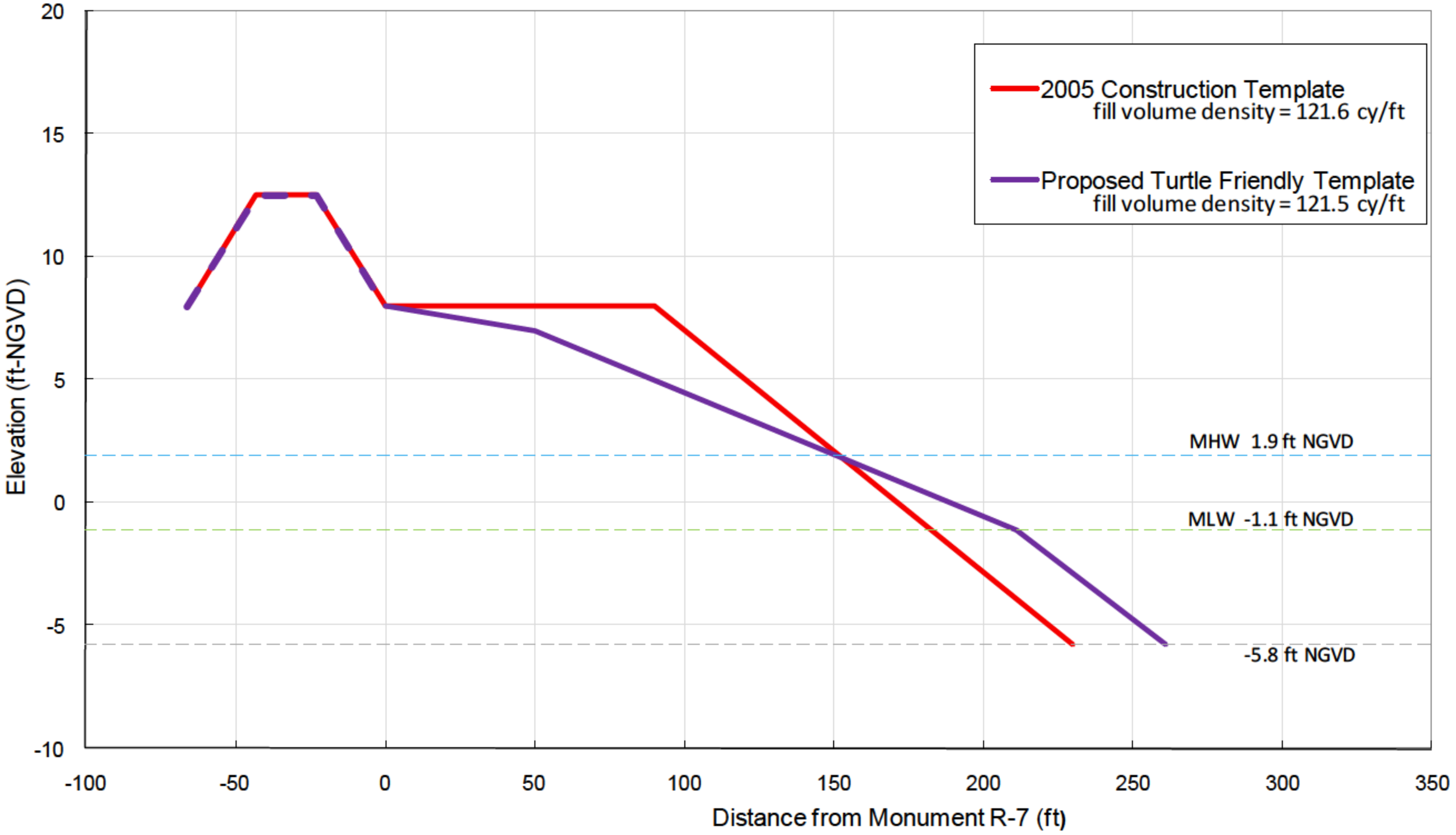
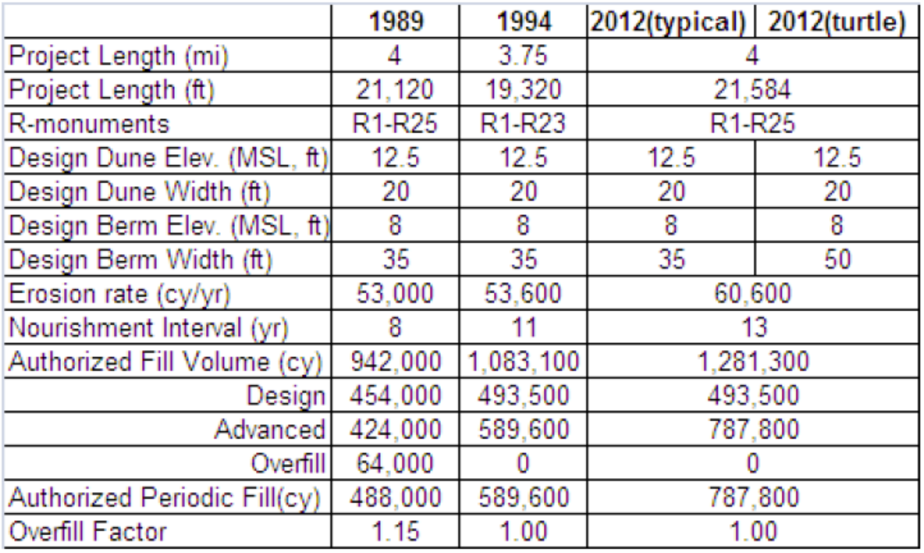


Figure 2: Proposed Turtle-Friendly Template and Traditional Construction Template (Taylor Engineering, 2009, modified)

The Martin County turtle-friendly template has a sloping berm, 50 ft wide with gradient 1V:50H, followed by a gentle upper foreshore slope of gradient 1V:20H to Mean Low Water (MLW). Below MLW, it follows the slope of the 2005 (and typical) construction template at 1V:10H as a pre-equilibrium slope typical of hydraulically placed fill. Both templates would be constructed using the same general methods and equipment; however construction of the turtle friendly template is anticipated to have increased hydraulic losses during construction and reduced daily effective work times due to the amount of sand that needs to be placed seaward of Mean High Water (MHW).

Table 2: Table of Project Details



	1989	1994	2012(typical)	2012(turtle)
Project Length (mi)	4	3.75	4	
Project Length (ft)	21,120	19,320	21,584	
R-monuments	R1-R25	R1-R23	R1-R25	
Design Dune Elev. (MSL, ft)	12.5	12.5	12.5	12.5
Design Dune Width (ft)	20	20	20	20
Design Berm Elev. (MSL, ft)	8	8	8	8
Design Berm Width (ft)	35	35	35	50
Erosion rate (cy/yr)	53,000	53,600	60,600	
Nourishment Interval (yr)	8	11	13	
Authorized Fill Volume (cy)	942,000	1,083,100	1,281,300	
Design	454,000	493,500	493,500	
Advanced	424,000	589,600	787,800	
Overfill	64,000	0	0	
Authorized Periodic Fill(cy)	488,000	589,600	787,800	
Overfill Factor	1.15	1.00	1.00	

The proposed turtle-friendly template is compatible to the 2005 (traditional) construction template in providing erosion protection. The fully adjusted profiles for both templates will be essentially the same; specifically the upper end of the berm is the same height for both templates, both templates have nearly identical mean high water line extensions, and the fill volume density is the same for both templates. **Figure 3** shows the equilibrium profiles for the turtle friendly and traditional templates. The turtle friendly construction template is likely to equilibrate faster and with less scarping than the traditional profile. This will provide an advantage for nesting sea turtles as well as improve safety for beach goers. The equilibrium toe of fill (ETOF) marking the seaward extent of the expected fill dispersion following construction was calculated prior to initial construction. Mitigation for hardbottom landward of the ETOF was completed by Martin County. Since the fill volume density is the same for both templates, the equilibrated toe for both construction templates will lie within the previously mitigated area and no additional mitigation will be required (Taylor Engineering, 2009).

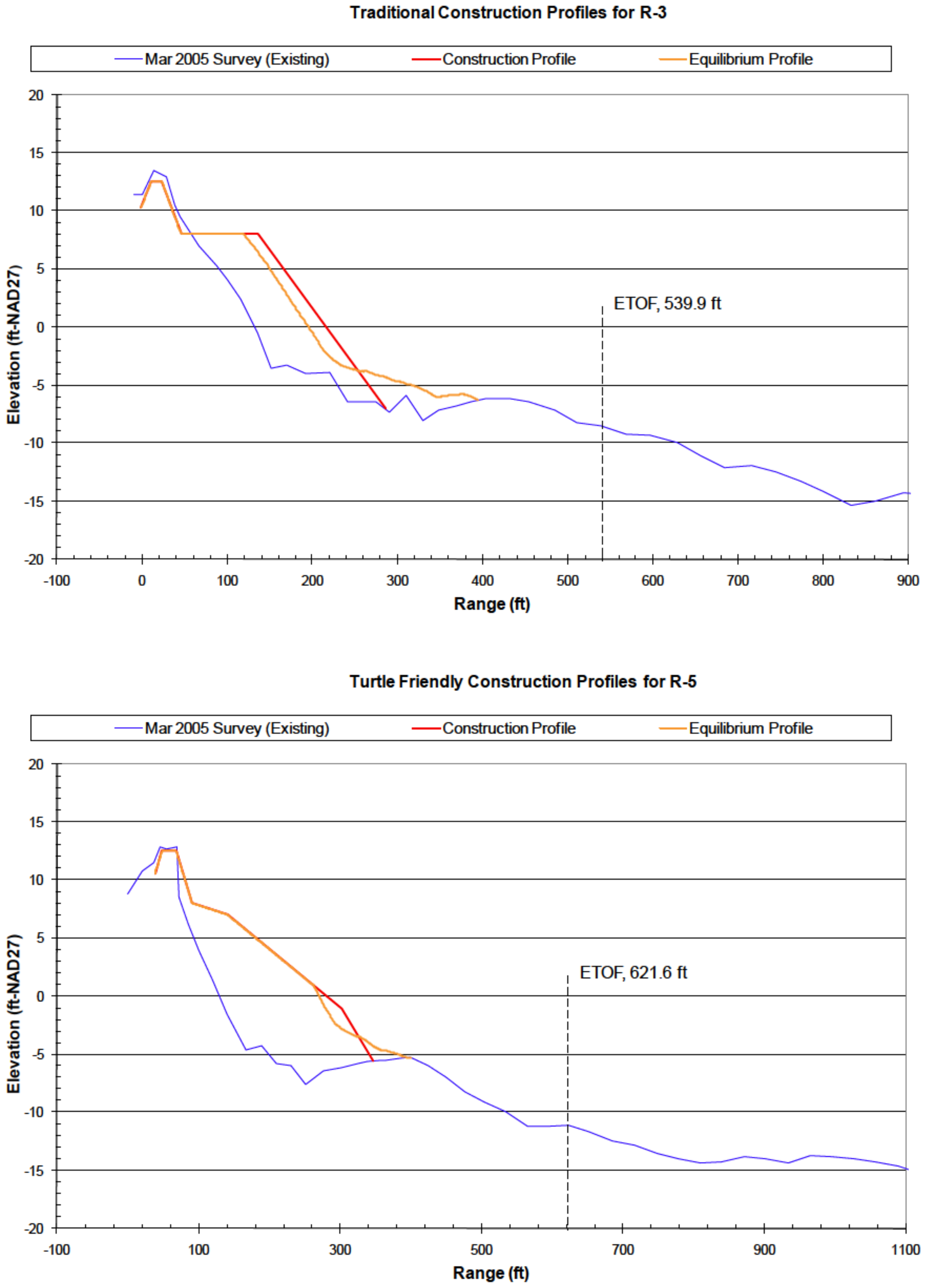


Figure 3: Construction and Equilibrium Profiles for Traditional and Experimental Templates (Taylor Engineering, 2009, modified)

The originally authorized borrow area, Gilbert Shoal, is located approximately three miles north of St. Lucie Inlet and 3000 feet offshore. Gilbert Shoal has a mean grain size of .38 mm (Phi = 1.41) and a sorting of 1.41; it was used as the borrow area for the 1995/1996 initial fill and 2001/2002 and 2005 fills. Gilbert Shoal is now depleted, so three offshore sand sources from the Drilling Data Report dated May 2008 were considered. A 2004 study commissioned by the Mineral Management Service (MMS, currently known as the Bureau of Ocean Energy Management, Regulation, and Enforcement, BOEMRE) indicated that two possible borrow areas on the St. Lucie Shoal could have potential impacts to near shore wave climate and sediment transport if a majority of the material in the shoals were dredged. Additionally these two areas along St. Lucie shoal are of relatively high relief. Area B, located about 3 miles south-southeast of the St. Lucie Shoal, was determined to have the most desirable sand characteristics, and was selected as the most usable site for the next nourishment. Area B, Gilbert Shoal, and the St. Lucie Shoal Complex borrow areas are shown in **Figure 4**.

The proposed borrow area lies approximately 6 miles offshore St. Lucie and Martin Counties in water depths of 47 to 63 ft. Roughly rectangular in shape, the site encompasses approximately 1000 acres, with its long axis oriented parallel to the shoreline and a maximum length and width of 12,100 ft and 5,000 ft respectively. The 2012 project will likely require approximately 787,800 cy of beach quality sand for the advanced fill volume. The water quality certificate, or Joint Coastal Permit, will cover at least 150% of the required beach fill volume from Area B. (Taylor Engineering, 2009) In 2006, 30 vibracores were taken from the St. Lucie Shoal Complex to identify potential sand sources. “Area B” was determined most promising, and 40 more vibracores were taken in 2007 to develop a limited evaluation. (USACE, 2008) Additional geotechnical data was collected in 2009 at the request of FDEP.

“Area B,” as shown in **Figure 4**, has been identified as the potential borrow area; the northern portion is the proposed area in the Joint Coastal Permit (JCP) Application by Taylor Engineering. “Area B” is not actually a shoal, but is a large open area with very little relief. The approximate change in height across the entire borrow area is the equivalent of a one foot change in height across a 500 foot length. **Figure 4** compares the location of “Area B” with Gilbert Shoal and the HSDR Project, while **Figure 5** illustrates the lack of relief in “Area B”.

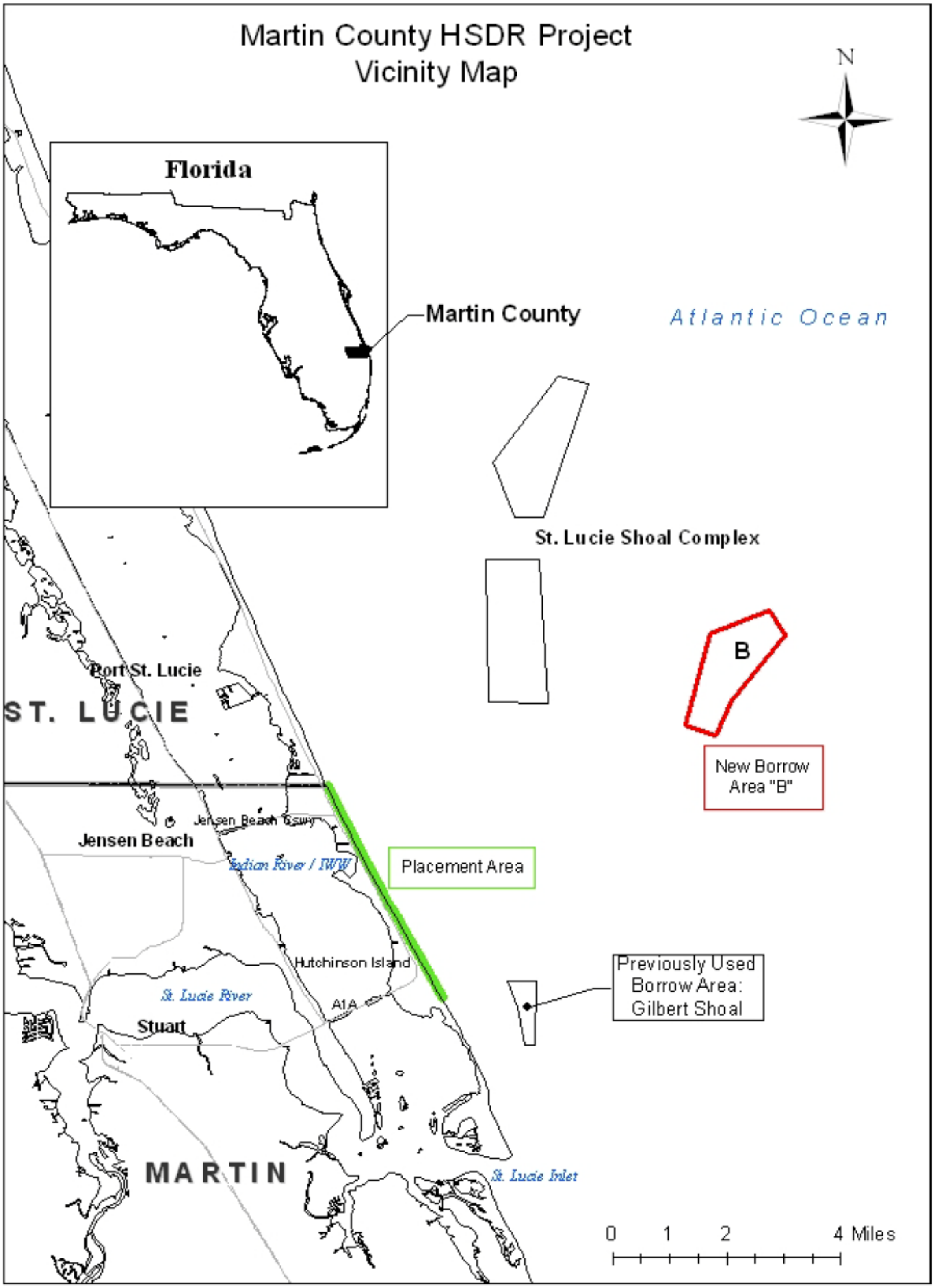


Figure 4: Project Vicinity Map

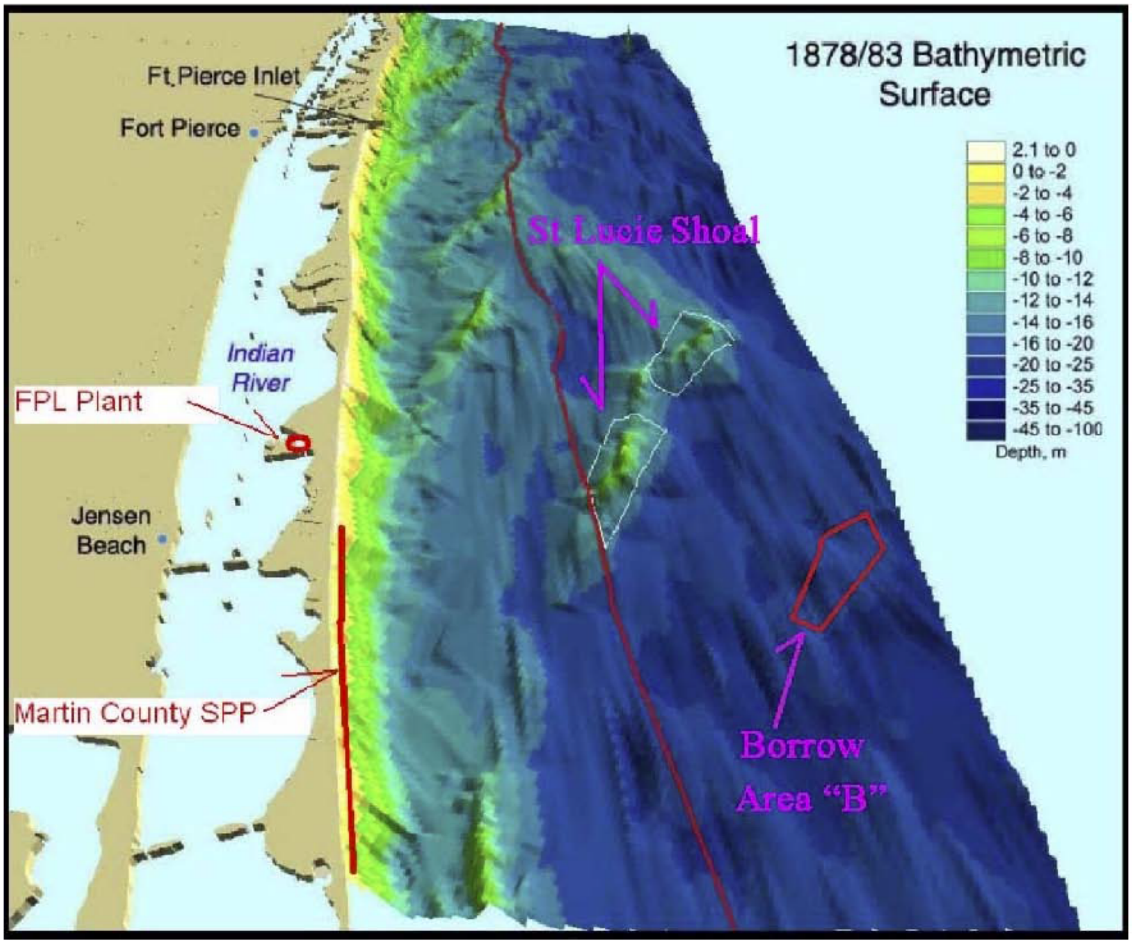


Figure 5: Bathymetric view of St. Lucie Shoals and Borrow Area B (MMS 2004, modified)

"Area B" is located approximately 6 miles offshore Jensen Beach and its sediment characteristics are outlined in **Tables 3** and **4**. Taylor Engineering found that the proposed borrow area is compatible with native sand and will preserve the integrity of the beach, as well as having an overfill factor of 1.00. 787,800 cy of beach quality sand is needed for the 2012 periodic nourishment; the remaining period of Federal participation in the project requires an estimated 2,121,000 cy to last until 2046. Only the northern section (containing 1,330,000 cy) of the proposed borrow area is under review in the JCP Application, but the entire "Area B" contains approximately 17,000,000 cy of sand (Taylor Engineering, 2009 and USACE, 2008).

Sea level rise was evaluated for the project area in accordance to Engineering Circular 1165-2-211. The historical sea level rise rate is accounted for in the erosion rate used for the current analysis. Future nourishments could be adaptable should the impacts of accelerated sea level rise start to take effect. The sea level rise evaluation, including potential shoreline recession and volume losses associated with intermediate and high seal level rise scenarios, is located in **Attachment 3**.

Table 3: Native Beach, Existing Beach, and Entire Borrow Area Comparison (USACE, 2009)

	Mean Grain Size	Sorting	Overfill Ratio
Native Beach-1965 County Wide	1.51 phi (.35 mm)	1.74	
Existing Beach-1990 Hutchinson Island	1.91 phi (.27 mm)	1.41	
Area B-2007	1.27 phi (.45 mm)	1.01	1.0

Table 4: Native Beach and Top Section of Borrow Area Comparison (Taylor Engineering, 2009)

Characteristic	Native Beach Composite	Borrow Area Composite	Beach Fill Acceptable Limits
Required Volume(cy)	887,663	1,330,000*	1,330,000*
Mean Grain Size(mm)	.26-.39	0.39	.18-.75**
Mean Grain Size(phi)	1.34-1.93	1.37	-
Sorting (phi)	.31-.47	1.14	-
Silt Content	.6%-1.6%	2.47%	0%-2.5%
Carbonate Content	26%-66%	83.45%	<93%***
Moist Munsell Color	Hues of 2.5Y, 5Y Value 5 or lighter Chroma lighter than 3	Hues of 10YR Value 5 or lighter Chroma lighter than 3	Hues of 2.5Y, 5Y,10YR Value 5 or lighter Chroma lighter than 3
*This value equals 150% of the fill volume **Range of the July 2007 data, carbonate removed ***Based on range of native beach carbonate data			

2. Economics Evaluation

It was determined in a vertical team meeting with South Atlantic Division (SAD) on 28 October 2009 that the Martin County Shore Protection Project GDM (Revised June 1994) would be used as a basis for this update; this assumed a nourishment volume of 589,600 cy every 11 years. The annual cost including interest and amortization of the first cost and periodic nourishment is $1,142,000. **Table 6** summarizes the assumptions used to revise cost estimates and optimize the nourishment interval for the remaining period of Federal participation.

The costs for future nourishment has increased due to the use of a new off shore borrow area. The dredging cost increase based solely on the change in borrow area location is approximately 30%. Updated costs for a single beach nourishment event were based on using one medium Hopper Dredge with a pumpout capability rather than the 30” Cutterhead Pipeline Dredge that was used in the original 1994 GDM cost estimate. This change was due to the further distance of the proposed new offshore borrow area from the beach placement area, which restricts the type of dredge that can perform the work to a Hopper Dredge only. The cost estimate for the new turtle friendly construction template considers a 10% increase in hydraulic losses and four hours in reduced daily effective work times due to placement of material out to mean low water for the new template. This translates to a unit price increase of $2.64 per cubic yard from the traditional construction template. Planning, engineering, and design (PED), construction management (S&I), and monitoring prices were based on recent projects having similar scopes of work. The benefits used for analysis are taken from the 1994 GDM, as a windshield survey conducted in August 2009 and review of recent aerials has verified that there have been no significant changes to the structure inventory.

An erosion rate of 60,600 cy/yr was used in computing new costs rather than the 53,600 cy/yr used in the 1994 GDM to more accurately reflect erosion over the project history. Surveys dating back to 1971 have been used to analyze volume and shoreline changes in the project area. Past nourishments have not exactly reflected the predicted nourishment intervals based on historical erosion rate predominantly as a result of intense storm seasons. Three hurricanes affected the project area in 1999 prior to the partial nourishments in 2001-2002, and two major hurricanes making landfall back to back in 2004 prompted the emergency nourishment in 2005. However, not enough data is available to make predictions about how storms will affect the nourishment interval in the future so the nourishment interval is assumed using the erosion rate throughout the project history. The new erosion rate reflects the average annual erosion in the project area from November 1995 – July 2009, after factoring out the atypical erosion losses during the unusually intense 2004 storm season. (Taylor 2009)

The 2010 Biological Opinion (BO) states that beach nourishment must occur between November 1st and May 1st, and that no construction equipment may be stored on the beach outside of this window. This leaves a six month period for starting and finishing construction. There is a risk and uncertainty involved with inclement weather during beach nourishment that may cause unforeseen delays in construction. Estimated construction times were determined for different nourishment intervals, using one and two dredges. Nourishing at intervals having estimated construction times over 5 months would not be considered because of the risk that the construction may not be able to be completed within the construction window. Using two dredges reduces the estimated construction time, but doubles the mobilization costs. Annual nourishment costs using two dredges were seen to be more expensive then with one dredge. In addition to the construction window the main driver for optimizing the nourishment interval was costs. Effective annual benefits are assumed to remain constant since all nourishment intervals considered assume that the design berm width, which benefits are based on, will be maintained throughout the project. It should be noted that the average annual costs for nourishment intervals of 11, 12, and 13 years are within 3.2 percent of each other. **Table 5** compares costs for different nourishment intervals. The optimal periodic nourishment was determined to be a volume of 787,800 cubic yards every 13 years. While optimal nourishment intervals are recommended based on an average historic erosion rate and economics, it is survey data reflecting the short term storm events in the project area that is used to determine when the periodic nourishments are actually needed (this may or may not be on the identified optimal renourishment interval). In addition, budget requests for construction money need to be made some years prior to construction, before the actual conditions at the time of anticipated construction are known. The project is currently scheduled for construction in 2013 due to project delays. This report is not seeking a budget submission for a full project renourishment.

Table 5: Optimization of Periodic Nourishment Interval

INTERVAL (YEARS)	ESTIMATED CONSTRUCTION TIME (MONTHS)	# OF DREDGES	ADVANCED NOURISHMENT W/ OVERFILL (CUBIC YARDS)	2012 NOURISHMENT COST	ANNUAL COST OF NOURISHMENT	# OF NOURISHMENTS
1	1.3	1	60,600	$3,193,300	$3,188,915	35
2	1.5	1	121,200	$3,855,300	$1,974,274	18
3	1.8	1	181,800	$4,521,000	$1,566,321	12
4	2.0	1	242,400	$5,183,000	$1,366,386	9
5	2.3	1	303,000	$5,848,700	$1,244,839	7
6	2.5	1	363,600	$6,510,700	$1,177,063	6
7	2.8	1	424,200	$7,176,400	$1,123,709	5
8	3.0	1	484,800	$7,838,400	$1,108,389	5
9	3.3	1	545,400	$8,504,100	$1,068,783	4
10	3.5	1	606,000	$9,166,100	$1,062,155	4
11	3.8	1	666,600	$9,831,800	$1,062,101	4
12	4.0	1	727,200	$10,493,800	$1,031,249	3
13	4.3	1	787,800	$11,159,500	$1,029,668	3
13	2.7	2	787,800	$12,387,000	$1,090,380	3
14	2.8	2	848,400	$13,045,300	$1,089,154	3
15	2.9	2	909,000	$13,703,500	$1,091,442	3
16	3.0	2	969,600	$14,361,700	$1,096,955	3
17	3.2	2	1,030,200	$15,023,700	$1,105,305	3
18	3.3	2	1,090,800	$15,681,900	$1,060,868	2
19	3.4	2	1,151,400	$16,340,200	$1,060,401	2
20	3.5	2	1,212,000	$16,998,400	$1,061,698	2

Table 6: Assumptions used in Beach Nourishment

	2012	Remaining Nourishments
Mobilization and Demobilization per Dredge	$1,287,486	$1,287,486
Renourishment Cost ($/CY)	$9.48	$10.80
Planning, Engineering, and Design	$250,000	$250,000
Construction Management	$946,319	$946,319
Real Estate	$6,250	$6,250
Monitoring per month	$37,500 per month	$37,500 per month
Production Rate	276,421 cubic yards per month	238,727 cubic yards per month
Annual Erosion Rate	60,600 cubic yard per year	60,600 cubic yard per year
FY 11 Discount Rate	4 1/8 % (4.125 %)	4 1/8 % (4.125 %)
Remaining Period of Federal Participation	35 years	35 years

The benefits and costs were computed for the current FY11 discount rate of 4.125 percent, authorized rate of 8.0 percent, and OMB discount rate of 7.0 percent. The cost in the summary table was adjusted to the price levels of the 1994 GDM using the beach replacement indexes from 30 September 2009 Civil Works Construction Cost Index System. The remaining benefits to remaining cost ratio (RBRCR) reflect the December 1993 price levels of the 1994 GDM. The RBRCR from the time of the 2012 nourishment through the remaining period of Federal participation at the current interest rate is 18.77 to 1. **Table 7** presents a summary table of all cost and benefits for all interest rates.

Table 7: Summary of Costs and Benefits

	4.125 percent	7.0 percent	8.0 percent
Present Value of Renourishments	$18,902,960	$15,142,540	$14,221,890
Interest during construction (IDC)	$109,940	$187,210	$214,210
Total Present Value of IDC and Renourishment	$19,012,900	$15,329,750	$14,436,100
Annual cost (Feb 2010)	$1,036,020	$1,183,980	$1,238,660
Deflation factor	0.61033	0.61033	0.61033
Annual cost (Dec 1993)	$632,310	$722,610	$755,990
Annual Benefits (Dec 1993)			
Storm Damage Benefits	$10,210,360	$6,413,860	$5,535,190
Loss of land	$89,700	$89,700	$89,700
Recreation Benefits	$1,567,660	$1,447,970	$1,411,530
Total Benefits	$11,867,720	$7,951,530	$7,036,430
Net Benefits	$11,235,410	$7,228,920	$6,280,430
Remaining Benefits to Remaining Cost Ratio	18.77	11.00	9.31

3. NEPA Documentation Summary

NEPA documentation was first prepared as a Final Environmental Impact Statement (EIS) in conjunction with the 1986 Feasibility Study. A Martin County Shore Protection Project General Design Memorandum with Final Environmental Assessment (EA) was prepared in 1994. Based on the GDM and the included EA, the Jacksonville District Engineer signed a Finding of No Significant Impact (FONSI) document. The 2011 Supplemental EIS (SEIS) prepared for the proposed changes, including the new borrow area and turtle-friendly design template, is attached. The preferred alternative, Beach Nourishment Using an Offshore Sand Source, addresses the federal and local planning objectives, anticipates beach erosion losses, and considers the needs of the study area.

The 2011 SEIS found that there will be some unavoidable adverse environmental effects in the borrow area vicinity. Species of relatively non-motile infaunal invertebrates that inhabit the borrow area will unavoidably be lost during dredging. Those species that are not able to escape the construction area are expected to recolonize after project completion. There would be an unavoidable reduction in water clarity and increased turbidity and sedimentation that would be limited to the immediate areas of dredging and beach fill operations. This impact will be temporary and should disappear shortly after construction activities cease. No new impacts are expected due to fill placement on the beach, and no new mitigation is required. A contingency mitigation plan has been developed by the sponsor to cover unanticipated secondary impacts. The SEIS concludes that the Martin County Beach Erosion Control Project is in the national interest and can be constructed while protecting the environment from unacceptable impacts. An Essential Fish Habitat Assessment is included as **SEIS Appendix E**.

Several issues have been raised in response to the Notice of Intent (NOI). Florida State Historic Preservation Office (SHPO) raised concerns that known and unidentified shipwreck sites within and adjacent to the proposed Martin County borrow areas may be impacted by sand borrowing activities. Between September 2007 and June 2008, Southeastern Archaeological Research, Inc. (SEARCH) conducted an underwater remote sensing survey of proposed borrow areas and it was determined that no historic properties would be effected by the proposed dredging projects. National Marine Fisheries Service (NMFS) raised several issues that require detailed evaluation, including the potential for significant adverse effects from excavation of offshore shoals on shoreline and living marine resources. USACE ran a wave model (STWAVE) which concluded that dredging to the maximum limits in Area B would not cause significant changes to the nearshore wave environment. Hesperides Group, LLC conducted diver surveys for the sponsor in 2009 confirming that the proposed borrow area contains no hardbottom resources. Jensen Beach and Nettles Island residents are concerned that Martin County will be using sand resources located within St. Lucie County that should be reserved to renourish St. Lucie County beaches, which are also critically eroded. However, the selected borrow area, Area B, is in Federal waters managed by the BOEMRE. Despite these issues, USFWS, Florida Fish and Wildlife Conservation Commission (FFWCC), and FDEP requested the development of the turtle-friendly design and remain supportive of the project.

The Draft SEIS was released for a 60 day public review period with a Notice of Availability published in the Federal Register on November 5, 2010. A public workshop for the project was held on December 16, 2010 in Stuart, Florida. Comments were received from United States Environmental Protection Agency (USEPA), Audubon of Florida, NMFS, BOEMRE, and 12 people from the local community. These comments were incorporated into the Final SEIS and can be found in **SEIS Appendix C**.

4. Section 902 Limit Analysis

The Water Resource Development Act (WRDA) of 1986, Section 902 states that in order to insure against cost overruns, each total cost for a project shall be the maximum cost of that project, except that such maximum amount may be increased by the Secretary for modifications which do not materially alter the scope or functions of the project as authorized, but not by more than 20 percent of the total cost stated for the project. For beach nourishment projects there is a separate 902 limit for initial construction and periodic nourishment. Based on the Chief of Engineers report dated 20 November 1989, the 902 limit for initial construction is $13,476,000 and the 902 limit for periodic nourishment is $79,245,000. The 902 limit was formulated using Appendix G of ER 1105-2-100 and is documented in **Attachment 4**. **Table 8** shows expenditures for pre-construction, from 1995 and 2009, and projected costs for the remaining 35 years, and compares these totals to the section 902 limits. The anticipated 2012 nourishment would be considered the third periodic nourishment. The recommended costs for remaining periodic nourishments of $29,791,030 is less than the Section 902 limit of $60,872,000 (includes 20% from 902 analysis in ER 1105-2-100, Appendix G), for remaining nourishments beginning with the third periodic nourishment. Based on the changes in cost of future periodic nourishments beginning in 2012, the total project cost for periodic nourishment remains below the section 902 limit and is within the discretionary authority of the Assistant Secretary of the Army of Civil Works (ASA-CW). A project cost increase fact sheet is included in **Attachment 4**.

Table 8: Project Costs and 902 Limit Comparisons

Project Year	**Fiscal Year**	**Phase**		**Expenditures**
Pre-Construct	1992-1995			$1,220,757.09
1-5	1996-2000	Initial Construction		$10,682,675.55
6-9	2001-2004	1st Renourishment (Partial)		$4,442,070.83
10-14	2005-2009	2nd Renourishment (no FCCE)		$9,549,795.49
		Already Spent	*Subtotal*	$25,895,298.96
15-16	2010-2011			**Recommended Cost**
17	2012	3rd Renourishment		$10,104,476.00
30	2025	4th Renourishment		$11,155,076.00
43	2038	5th Renourishment		$8,531,478.00
50	*ends FY 2046	Future	*Subtotal*	**$29,791,030.00**
		Total Project Cost		$55,686,328.96
		Authorized 902 Limit for Initial Construciton		$13,476,000.00
		Authorized 902 Limit for Periodic Nourishment		$79,245,000.00
		Authorized 902 Limit for Remaining Periodic Nourishment		**$60,872,000.00**

5. Cost Sharing

The costs of water resources studies and projects developed by the Corps are shared between Federal and non-Federal entities as defined in laws and administrative provisions. Cost sharing for HSDR projects is determined based on the shoreline ownership and public access at time of construction. The 1989 Chiefs Report established the Federal interest in periodic nourishment at 50.3%. The cost sharing for periodic nourishment was re-established in the 1994 GDM as 46.59% Federal and 53.41% Non-Federal, due primarily to a more detailed evaluation of ownership and use of shorefront property (see **Attachment 5)**. A reevaluation of shoreline conditions conducted for the 2004 Project Inspection Report (PIR) along with a 2009 windshield survey and review of recent aerials found that the difference in the cost sharing would increase the Federal share from 46.59% to 47.0%, an amount within the margin of error for this type of evaluation of shoreline conditions. The cost sharing percentages established in the 1994 GDM will be used for the 2012 periodic nourishment (see **Table 9**). There are no changes to the items of local cooperation for the Martin County HSDR Project. The Project Cooperation Agreement (PCA) executed on August 3, 1995 is applicable to the authorized project and reflects applicable cost sharing.

Table 9: Federal and Non-Federal Cost Sharing for 2012 Nourishment

	Total Cost	**Federal Cost (46.59%)**	**Non-Federal Cost (53.41%)**
Mob/Demob	$1,287,486	$599,840	$687,646
LERRD	$6,250	$2,912	$3,338
PED	$250,000	$116,475	$133,525
Monitoring	$150,000	$69,885	$80,115
Periodic Nourishment Fill	$7,464,421	$3,477,674	$3,986,747
Construction Management (S&I)	$946,319	$440,890	$505,429
Total 2012 Periodic Nourishment	**$10,104,476**	**$4,707,675**	**$5,396,801**

The following items are cost shared as part of the construction contract: pre and post construction beach fill surveys, shorebird monitoring during construction, sea turtle monitoring during construction, and turbidity monitoring during construction. This cost is shown in **Table 9** under Monitoring for a total cost of $150,000. These items are consistent with Federal requirements in the water quality certification and biological opinion. Any other required monitoring is the responsibility of the non-Federal sponsor, Martin County.

6. Conclusions

The 2012 and future periodic nourishments include changes to the template shape to address sea turtle concerns and incorporates a new borrow source of material for the remainder of Federal participation in this project. These changes are within the scope of the authorized project. The selected plan is consistent with the Chief of Engineers Actions for Change, Campaign Plan Goals, and the USACE Environmental Operating Principles. The annual cost and RBRCR were updated for the remaining period of Federal participation to incorporate added costs associated with the new borrow area and are $1,036,020 and 18.77 to 1, respectively. These changes were determined to be within the section 902 limit for the authorized project. The items of local cooperation required by the 1994 General Design Memorandum and the 1995 Project Cooperation Agreement are still required to be performed by the non-Federal sponsor. The project remains environmentally acceptable, technically feasible, and economically justified.

7. Recommendations

It is recommended that the authorized project for Martin County, Florida be modified to use a new borrow area and turtle-friendly construction template, and Federal construction funding provided in accordance with the selected plan herein, with such modifications as in the discretion of the Chief of Engineers may be advisable.

Disclaimer: 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.

References

Mineral Management Service (MMS), Continental Shelf Associates, Inc. 2004. *Environmental Surveys of Potential Borrow Areas on the Central East Florida Shelf and the Environmental Implications of Sand Removal for Coastal and Beach Restoration.*

Taylor Engineering, Inc. April 2009. *Coastal Engineering Narrative, Martin County Beach Restoration Project.* Jacksonville, Florida.

U.S. Army Corps of Engineers (USACE). 1994. *Martin County, Florida, Shore Protection Project, General Design Memorandum with Environmental Assessment*, *December 1993, revised June 1994.* Jacksonville District, Jacksonville, Florida.

U.S. Army Corps of Engineers (USACE). February 2005. *Project Information Report, Rehabilitation Effort for the Martin County Hurricane/Shore Protection Project*. Jacksonville District, Jacksonville, Florida.

U.S. Army Corps of Engineers (USACE). January September 2006. *Project Information Report, Rehabilitation Effort for the Martin County, Erosion Control and Hurricane Protection Project*. Jacksonville District, Jacksonville, Florida.

U.S. Army Corps of Engineers (USACE). May 2008. *Martin County BEC Sand Search Investigations Offshore Drilling Report*. Jacksonville, Florida.

"Environmental Surveys of Potential Borrow Areas on the Central East Florida Shelf and the Environmental Implications of Sand Removal for Coastal and Beach Restoration.", Continental Shelf Associates, Inc., 2004.

THIS PAGE INTENTIONALLY LEFT BLANK

Martin County, Florida
Hurricane and Storm Damage Reduction Project

Draft Limited Reevaluation Report of the
Beach Erosion Control Project

Attachment 1

Economics Appendix

This Page is Intentionally Left Blank

Economic Appendix

Structure inventory

The Martin County, Florida Shore Protection Project, General Design Memorandum (GDM), Revised June 1994 contained plates with aerial photos dated December 1994 of the project area. These aerial photos with a scale of one inch = 200 feet were compared to recent aerial photos of structures in the project area. There were no significant changes in the structure inventory as defined in the Martin County, Florida Shore Protection Project, General Design Memorandum (GDM), Revised June 1994. A windshield survey was also conducted August 2009 of the project area to confirm that there were no significant changes in the structure inventory as defined in the 1994 Martin County GDM. The windshield survey verified that structures indentified in the 1994 Martin County GDM were still present or had been replaced on the same parcel and same foundation types which were mostly built slab on grade. The field trip confirmed that structures identified in the 1994 Martin County GDM were still present or had been replaced with similar damage susceptibility. Five homes have been built on vacant lots in the project area since the last approved report.

Cost of renourishment

Optimization of renourishment interval

The Martin County, Florida Shore Protection Project, General Design Memorandum (GDM), Revised June 1994 recommended an 11 year renourishment interval. The optimal renourishment interval for the remaining period of Federal participation and revised cost estimates was recomputed. The revised cost estimates are in February, 2010 price levels. The assumptions used to optimize the renourishment interval are found in Table 1. The construction window for sea turtle nesting was considered in determining the optimal nourishment interval for the Martin County Hurricane and Storm Damage Reduction Project. The 2010 Biological Opinion (BO) states that beach nourishment must occur between November 1st and May 1st, and that no construction equipment may be stored on the beach outside of this window. This leaves a six month period for starting and finishing construction. There is a risk and uncertainty involved with inclement weather during beach nourishment that may cause unforeseen delays in construction. Estimated construction times and costs were determined for different nourishment intervals, using one and two dredges. Renourishment intervals of 14 years and greater were eliminated due to increasing average annual cost with one dredge. Using two dredges reduces the estimated construction time, but doubles the mobilization costs. Annual nourishment costs using two dredges were found to be more expensive than with one dredge. The current discount rate of 4 1/8 (4.125) and a 35 year remaining period of Federal participation was used to optimize the renourishment interval. Table 2 summarizes the results of the optimization of the renourishment interval. After considering all factors the optimal nourishment interval was realized to be 13 years with a nourishment cost of $11,159,500 and an average annual equivalent cost of $1,029,668. It should be noted that the average annual cost for nourishment intervals of 11, 12, and 13 years are within 3.2 percent of each other. Once the optimal renourishment interval was computed a final MCACES estimate was prepared for each of the three renourishment cycles for years 2012, 2025, and 2038. The new MCACES estimates were used to compute the total average annual cost of the three renourishments. Table 3 shows the cost summaries for each of the renourishment intervals. Table 4 shows how the average annual equivalent cost of $1,030,030 was computed. The total average annual for the renourishments is $1,036,020 when interest during construction is included. It should be noted that the third renourishment in 2038 was adjusted to properly account for the remaining 9 years of the 50 year period of Federal participation ending in 2046.

Table 1: Assumptions used to optimize renourishment interval

	2012	2013 and remaining
Mobilization and Demobilization per Dredge	$1,287,486	$1,287,486
Renourishment Cost ($/CY)	$9.48	$10.80
Planning, Engineering, and Design	$250,000	$250,000
Construction Management	$946,319	$946,319
Real Estate	$6,250	$6,250
Monitoring per month	$37,500 per month	$37,500 per month
Production Rate	276,421 cubic yards per month	238,727 cubic yards per month
Annual Erosion Rate	60,600 cubic yard per year	60,600 cubic yard per year
FY 11 Discount Rate	4 1/8 % (4.125 %)	4 1/8 % (4.125 %)
Period of Federal Participation	35 years	35 years

Table 2: Optimization of renourishment interval for remaining period of Federal participation (35 years, 4.125 percent interest rate)

INTERVAL (YEARS)	ESTIMATED CONSTRUCTION TIME (MONTHS)	# OF DREDGES	ADVANCED NOURISHMENT W/ OVERFILL (CUBIC YARDS)	2012 NOURISHMENT COST	ANNUAL COST OF NOURISHMENT	# OF NOURISHMENTS
1	1.3	1	60,600	$3,193,300	$3,188,915	35
2	1.5	1	121,200	$3,855,300	$1,974,274	18
3	1.8	1	181,800	$4,521,000	$1,566,321	12
4	2.0	1	242,400	$5,183,000	$1,366,386	9
5	2.3	1	303,000	$5,848,700	$1,244,839	7
6	2.5	1	363,600	$6,510,700	$1,177,063	6
7	2.8	1	424,200	$7,176,400	$1,123,709	5
8	3.0	1	484,800	$7,838,400	$1,108,389	5
9	3.3	1	545,400	$8,504,100	$1,068,783	4
10	3.5	1	606,000	$9,166,100	$1,062,155	4
11	3.8	1	666,600	$9,831,800	$1,062,101	4
12	4.0	1	727,200	$10,493,800	$1,031,249	3
13	4.3	1	787,800	$11,159,500	$1,029,668	3
13	2.7	2	787,800	$12,387,000	$1,090,380	3
14	2.8	2	848,400	$13,045,300	$1,089,154	3
15	2.9	2	909,000	$13,703,500	$1,091,442	3
16	3.0	2	969,600	$14,361,700	$1,096,955	3
17	3.2	2	1,030,200	$15,023,700	$1,105,305	3
18	3.3	2	1,090,800	$15,681,900	$1,060,868	2
19	3.4	2	1,151,400	$16,340,200	$1,060,401	2
20	3.5	2	1,212,000	$16,998,400	$1,061,698	2

Table 3: Cost summary for recommended 13 year renourishment interval

	2012	2025	2038
Mobilization and Demobilization	$1,287,486	$1,287,486	$1,287,486
Renourishment Cost	$7,464,421	$8,515,012	$5,891,423
Real Estate	$6,250	$6,250	$6,250
Planning, Engineering, and Design	$250,000	$250,000	$250,000
Construction Management	$946,319	$946,319	$946,319
Monitoring	$150,000	$150,000	$150,000
Total Renourishment cost	$10,104,476	$11,155,067	$8,531,478

Table 4: Average Annual Equivalent computation for 13 year interval at 4.125 percent interest rate

	Year	Total Expenditure	Present Worth Factor	Present Worth
2011	0		1.000000	$0
2012	1	$10,104,476	0.960384	$9,704,179
2013	2		0.922338	$0
2014	3		0.885799	$0
2015	4		0.850707	$0
2016	5		0.817005	$0
2017	6		0.784639	$0
2018	7		0.753555	$0
2019	8		0.723702	$0
2020	9		0.695032	$0
2021	10		0.667498	$0
2022	11		0.641054	$0
2023	12		0.615658	$0
2024	13		0.591269	$0
2025	14	$11,155,067	0.567845	$6,334,349
2026	15		0.545349	$0
2027	16		0.523745	$0
2028	17		0.502996	$0
2029	18		0.483070	$0
2030	19		0.463932	$0
2031	20		0.445553	$0
2032	21		0.427902	$0
2033	22		0.410951	$0
2034	23		0.394671	$0
2035	24		0.379035	$0
2036	25		0.364019	$0
2037	26		0.349599	$0
2038	27	$8,531,478	0.335749	$2,864,434
2039	28		0.322448	$0
2040	29		0.309674	$0
2041	30		0.297406	$0
2042	31		0.285624	$0
2043	32		0.274309	$0
2044	33		0.263442	$0
2045	34		0.253005	$0
2046	35		0.242982	$0
			Total Accumulated	
			Present Worth =	$18,902,962
	0.04125	35 years		0.054490134
Average Annual Equivalent (AAEQ)				$1,030,030
Interest During Construction				$5,990
Total Average Annual Cost				$1,036,020

Project Benefits

Storm Damage Benefits

The benefits used for this analysis are from the Martin County, Florida Shore Protection Project, General Design Memorandum (GDM), Revised June 1994. The benefits for this project were recomputed using the storm damage data streams from the 1994 GDM and adjusted for the remaining 35 years of Federal participation and for the current discount rate of 4.125 percent, authorized rate of 8.0 percent and the Office of Management and Budget (OMB) discount rate of 7.0 percent discount rates. The benefits from the 1994 GDM are in December 1993 price levels. The without project storm damages from the 1994 GDM are found in table 5 and are the actual numbers used in the 1994 GDM modified plan. These damages prevented reflect the original four mile length to be constructed for future renourishments. The damages in table 5 from year 1 to year 35 were used to compute the average annual equivalent without project storm damages for the remaining 35 years ending in 2046 as noted in table 6. The damages for the authorized with project in the 1994 GDM are presented in table 7. The storm damage benefits are the difference between the average annual equivalent without project storm damages for the remaining 35 years and the with project storm damages. Table 7 displays the average annual equivalent storm damages prevented for each of the various interest rates.

Table 5: Without project storm damages from 1994 GDM

0	Year	Damage Upland Structures	Cost Backfill Vegetation	Damage Coastal Armor	Condemed Upland Structures	Modification Coastal Armor	Total Damages
1	1995	4780768	215157	91325	0	0	5,087,250
2	1996	5018833	220332	91325	0	0	5,330,490
3	1997	5140892	222898	91325	0	0	5,455,115
4	1998	5253111	225378	102611	0	0	5,581,100
5	1999	5476128	230412	110414	0	0	5,816,954
6	2000	5587636	232929	110414	0	0	5,930,979
7	2001	5702429	235408	110414	0	0	6,048,251
8	2002	5823595	237744	120842	0	0	6,182,181
9	2003	6056990	242508	127200	0	0	6,426,698
10	2004	6173687	244890	127200	0	0	6,545,777
11	2005	6291739	247246	127200	0	0	6,666,185
12	2006	6563952	251693	139308	0	0	6,954,953
13	2007	6716307	253850	139308	0	0	7,109,465
14	2008	6868661	256006	139308	0	0	7,263,975
15	2009	7174217	260093	139308	0	0	7,573,618
16	2010	7299234	261735	139308	0	0	7,700,277
17	2011	7424251	263377	139308	0		7,826,936
18	2012	7209252	267630	139308	0	35100	7,651,290
19	2013	7482860	270673	147357	0	0	7,900,890
20	2014	7614705	272244	175165	0	0	8,062,114
21	2015	7746550	273815	175165	0	0	8,195,530
22	2016	8010693	276949	175165	0	0	8,462,807
23	2017	8145764	278476	179933	0	0	8,604,173
24	2018	8282410	279905	190045	0	0	8,752,360
25	2019	8555702	282761	190045	0	0	9,028,508
26	2020	8690941	284190	190045	0	0	9,165,176
27	2021	8857287	285467	190045	0	0	9,332,799
28	2022	9038606	286637	190045	0	0	9,515,288
29	2023	9397510	288978	190045	0	0	9,876,533
30	2024	9571814	290148	190045	0	0	10,052,007
31	2025	9727848	291072	194163	0	0	10,213,083
32	2026	10055566	292544	194163	0	0	10,542,273
33	2027	10132078	295421	194163	0	26000	10,647,662
34	2028	10300570	296044	194163	0	0	10,790,777
35	2029	10635661	297241	215019	0	0	11,147,921
36	2030	10806592	297776	215019	0	0	11,319,387
37	2031	10661983	311374	215019	0	158600	11,346,976
38	2032	10853219	311222	215019	0	0	11,379,460
39	2033	11247873	310622	222603	0	0	11,781,098
40	2034	11452861	310248	222603	0	0	11,985,712
41	2035	11424259	315140	222603	0	79950	12,041,952
42	2036	11833207	313784	222603	0	0	12,369,594
43	2037	12035258	313091	233585	0	0	12,581,934
44	2038	12237309	312397	233585	0	0	12,783,291
45	2039	12619553	312884	233585	0	23400	13,189,422
46	2040	12801192	311995	233585	0	0	13,346,772
47	2041	12985028	311062	233585	0	0	13,529,675
48	2042	12419193	306709	276901	0	176800	13,179,603
49	2043	12798821	318915	233585	250500	0	13,601,821
50	2044	12990450	317277	233585	0	0	13,541,312

Table 6: Without project storm damages from 1994 GDM for remaining 35 years ending in 2046 at 4.125 interest rate

	Year	Present worth Factor 4.125 Percent	Damage Upland Structures	Cost Backfill Vegetation	Damage Coastal Armor	Modification Coastal Armor	Total Damages
1	2012	0.9603842	4,591,374	206,633	87,707	0	4,885,714
2	2013	0.9223377	4,629,059	203,221	84,232	0	4,916,512
3	2014	0.8857985	4,553,795	197,443	80,896	0	4,832,133
4	2015	0.8507069	4,468,858	191,731	87,292	0	4,747,880
5	2016	0.8170054	4,474,026	188,248	90,209	0	4,752,483
6	2017	0.784639	4,384,277	182,765	86,635	0	4,653,678
7	2018	0.7535549	4,297,093	177,393	83,203	0	4,557,689
8	2019	0.7237022	4,214,548	172,056	87,454	0	4,474,058
9	2020	0.6950321	4,209,803	168,551	88,408	0	4,466,761
10	2021	0.6674978	4,120,923	163,464	84,906	0	4,369,292
11	2022	0.6410543	4,033,347	158,498	81,542	0	4,273,387
12	2023	0.6156584	4,041,152	154,957	85,766	0	4,281,875
13	2024	0.5912686	3,971,141	150,094	82,368	0	4,203,603
14	2025	0.567845	3,900,335	145,372	79,105	0	4,124,812
15	2026	0.5453493	3,912,454	141,842	75,972	0	4,130,268
16	2027	0.5237449	3,822,936	137,082	72,962	0	4,032,980
17	2028	0.5029963	3,734,370	132,478	70,071	0	3,936,920
18	2029	0.4830696	3,482,571	129,284	67,295	16,956	3,696,106
19	2030	0.4639324	3,471,541	125,574	68,364	0	3,665,479
20	2031	0.4455533	3,392,757	121,299	78,045	0	3,592,102
21	2032	0.4279024	3,314,767	117,166	74,954	0	3,506,887
22	2033	0.4109507	3,292,000	113,812	71,984	0	3,477,796
23	2034	0.3946705	3,214,893	109,906	71,014	0	3,395,813
24	2035	0.3790353	3,139,326	106,094	72,034	0	3,317,453
25	2036	0.3640195	3,114,442	102,931	69,180	0	3,286,553
26	2037	0.3495986	3,038,340	99,352	66,439	0	3,204,132
27	2038	0.3357489	2,973,824	95,845	63,807	0	3,133,477
28	2039	0.3224479	2,914,480	92,426	61,280	0	3,068,185
29	2040	0.3096739	2,910,163	89,489	58,852	0	3,058,504
30	2041	0.2974059	2,846,714	86,292	56,521	0	2,989,526
31	2042	0.2856239	2,778,506	83,137	55,458	0	2,917,101
32	2043	0.2743087	2,758,329	80,247	53,261	0	2,891,837
33	2044	0.2634417	2,669,212	77,826	51,151	6,849	2,805,038
34	2045	0.2530052	2,606,098	74,901	49,124	0	2,730,123
35	2046	0.2429822	2,584,277	72,224	52,246	0	2,708,747
	Sum of Present Worth		125,861,732	4,649,631	2,549,736	23,805	133,084,905
	Average Annual Equivalent	35 years @ 4.125 Percent	10,799,347	398,954	218,776	2,043	11,419,119

Table 7: With and without project storm damages

Without Project						
Interest Rate	Damage Upland Structures	Cost Backfill Vegetation	Damage Coastal Armor	Modification Coastal Armor	Total Storm Damage	Damages prevented
4.125	$10,799,347	$398,954	$218,776	$2,043	$11,419,119	$10,210,363
7.0	$7,201,788	$274,801	$144,896	$1,130	$7,622,615	$6,413,859
8.0	$6,369,694	$245,501	$127,824	$930	$6,743,949	$5,535,193
With Project						
	$1,092,456	$100,653	$15,647	$0	$1,208,756	

Recreation Benefits

The recreation benefits used for this analysis are from the Martin County, Florida Shore Protection Project, General Design Memorandum (GDM), Revised June 1994. The recreation benefits for this project were recomputed using the recreation benefit streams from the 1994 GDM and adjusted for the remaining 35 years of Federal participation and discount rates. The recreation benefits from the 1994 GDM showing how the benefits were computed for an 8 percent interest rate are presented in table 8. This same procedure was used to compute recreation benefits for 4.125 and 7.0 percent.

Table 8: Recreation Benefits from 1994 GDM adjusted for 35 year remaining life at 8 percent interest rate

	Year	Recreation Benefits	Present Worth Factor	Present Worth
2009		$702,723		
2010		$760,458		
2011	0	$818,194	1.000000	
2012	1	$875,929	0.925926	$811,045
2013	2	$933,664	0.857339	$800,467
2014	3	$991,399	0.793832	$787,005
2015	4	$1,049,135	0.735030	$771,145
2016	5	$1,106,870	0.680583	$753,317
2017	6	$1,159,666	0.630170	$730,786
2018	7	$1,212,461	0.583490	$707,459
2019	8	$1,265,257	0.540269	$683,579
2020	9	$1,318,052	0.500249	$659,354
2021	10	$1,370,848	0.463193	$634,968
2022	11	$1,423,644	0.428883	$610,576
2023	12	$1,476,439	0.397114	$586,314
2024	13	$1,529,235	0.367698	$562,296
2025	14	$1,582,030	0.340461	$538,620
2026	15	$1,634,826	0.315242	$515,365
2027	16	$1,686,680	0.291890	$492,326
2028	17	$1,738,533	0.270269	$469,871
2029	18	$1,790,387	0.250249	$448,042
2030	19	$1,842,240	0.231712	$426,869
2031	20	$1,894,094	0.214548	$406,374
2032	21	$1,945,947	0.198656	$386,574
2033	22	$1,997,801	0.183941	$367,476
2034	23	$2,049,654	0.170315	$349,087
2035	24	$2,101,508	0.157699	$331,406
2036	25	$2,153,361	0.146018	$314,429
2037	26	$2,194,468	0.135202	$296,696
2038	27	$2,235,574	0.125187	$279,864
2039	28	$2,276,681	0.115914	$263,899
2040	29	$2,317,787	0.107328	$248,762
2041	30	$2,358,894	0.099377	$234,421
2042	31	$2,400,001	0.092016	$220,839
2043	32	$2,441,107	0.085200	$207,982
2044	33	$2,482,214	0.078889	$195,819
2045	34	$2,523,320	0.073045	$184,317
2046	35	$2,564,427	0.067635	$173,444
		Total Accumulated		
		Present Worth =		$16,450,797
	0.08	35 years		0.085803265
	Average Annual Equivalent (AAEQ)			$1,411,532

Summary of benefits and costs

The remaining benefits and remaining costs were computed for the current discount rate of 4.125, authorized rate of 8.0 percent and 7 percent and are presented in table 8. The cost in the summary table was adjusted to the price levels of the 1994 GDM using the beach replacement indexes from 30 September 2010 Civil Works Construction Cost Index System. The benefit to cost ratio reflect the December 1993 price levels of the 1994 GDM. Table 9 presents a summary table of all cost and benefits for all interest rates for the 35 years remaining life. The loss of land benefits shown are from the 1994 GDM and were computed from 1995 to 2045.

Table 9: Summary of Remaining Costs and Remaining Benefits

	4.125 percent	7 percent	8 percent
Present Value of Renourishments	$18,902,960	$15,142,540	$14,221,890
Interest during construction (IDC)	$109,940	$187,210	$214,210
Total Present Value of IDC and Renourishment	$19,012,900	$15,329,750	$14,436,100
Annual cost (Feb 2010)	$1,036,020	$1,183,980	$1,238,660
Deflation factor	0.61033	0.61033	0.61033
Annual cost (Dec 1993)	$632,310	$722,610	$755,990
Annual Benefits (Dec 1993)			
Storm Damage Benefits	$10,210,360	$6,413,860	$5,535,190
Loss of land	$89,700	$89,700	$89,700
Recreation Benefits	$1,567,660	$1,447,970	$1,411,530
Total Benefits	$11,867,720	$7,951,530	$7,036,430
Net Benefits	$11,235,410	$7,228,920	$6,280,430
Remaining Benefits to Remaining Cost Ratio	18.77	11.00	9.31

THIS PAGE INTENTIONALLY LEFT BLANK

ATTACHMENT 2

COST ENGINEERING APPENDIX

THIS PAGE INTENTIONALLY LEFT BLANK

TABLE OF CONTENTS

APPENDED TO APPENDIX C

APPENDIX C-2A– PROJECT COST AND SCHEDULE RISK ANALYSIS REPORT

THIS PAGE INTENTIONALLY LEFT BLANK

A. COST ESTIMATES

A.1 GENERAL INFORMATION

Corps of Engineers cost estimates for planning purposes are prepared in accordance with the following guidance:

- Engineer Technical Letter (ETL) 1110-2-573, Construction Cost Estimating Guide for Civil Works, 30 September 2008
- Engineer Regulation (ER) 1110-1-1300, Cost Engineering Policy and General Requirements, 26 March 1993
- ER 1110-2-1302, Civil Works Cost Engineering, 15 September 2008
- ER 1110-2-1150, Engineering and Design For Civil Works Projects, 31 August 1999
- ER 1105-2-100, Planning Guidance Notebook, 22 April 2000, as amended
- Engineer Manual (EM) 1110-2-1304 (Tables revised 31 March 2009), Civil Works Construction Cost Index System, 31 March 2000
- CECW-CP Memorandum For Distribution, Subject: Initiatives To Improve The Accuracy Of Total Project Costs In Civil Works Feasibility Studies Requiring Congressional Authorization, 19 Sep 2007
- CECW-CE Memorandum For Distribution, Subject: Application of Cost Risk Analysis Methods To Develop Contingencies For Civil Works Total Project Costs, 3 Jul 2007
- Cost and Schedule Risk Analysis Process, October 2010

The goals of the cost estimating for the Martin County Shore Protection Project Limited Reevaluation Report are to present a Total Project Cost (construction and non-construction costs) for the recommended plans at the current price level to be used for project justification/authorization and to project costs forward in time for budgeting purposes. In addition, the costing efforts are intended to produce a final product (cost estimate) that is reliable and accurate and that supports the definition of the Government's and the non-Federal sponsor's obligations. The cost estimating effort for the study also yielded a series of alternative plan formulation cost estimates for decision making. The final set of plan formulation cost estimates used for plan selection rely on construction feature unit pricing and are prepared in Civil Works Breakdown Structure (CWBS) format to the sub-feature level. The cost estimate supporting the National Economic Development (NED) plan (Recommended Plan/Locally Preferred Alternative Plan) is prepared in MCACES/MII format to the CWWBS sub-feature level. This estimate is supported by the preferred labor, equipment, materials and crew/production breakdown. A fully funded (escalated for inflation through project completion) cost estimate, the Baseline Cost Estimate or Total Project Cost Summary, has also been developed. A risk analysis was prepared that addresses uncertainties in and sets contingencies for the Recommended Alternative Plans cost items. The final Cost Schedule Risk Analysis Report produced by the Walla Walla District Cost Center of Expertise is appended to this appendix.

A.1.1 Recommended Alternative Plans

The final Recommended Plan (NED) was chosen by the Project Delivery Team according to Cost Effectiveness/Incremental Cost Analysis procedures and resulted directly from the plan formulation described above. The Economics Appendix fully describes the plan selection. The scope of work for the Recommended Alternative Plans is found in Appendix A, Engineering. The MCACES/MII cost estimate for the Recommended Alternative Plans (Section B.3, below) is based on that scope and is formatted in the CWBS. The notes provided in the body of the estimate detail the estimate parameters and assumptions. These include pricing at the Fiscal Year 2010 price level (1 October 2009-30 September 2010). For project justification purposes the estimate cost are categorized under the appropriate CWWBS code and include both construction and non-construction costs.

The construction costs fall under the following feature codes:

- 06 Fish and Wildlife Facilities
- 17 Beach Replenishment

The non-construction costs fall under the following feature codes:

- 01 Lands and Damages
- 02 Relocations
- 30 Planning, Engineering and Design
- 31 Construction Management

A.1.2 Construction Cost

The MCACES/MII estimate on the final Recommended Plan contains contingencies as noted in the estimate (below). These contingencies were determined as a result of the risk analysis. Additional information follows on the risk analysis. Major risk factors are shown in the sensitivity analyses.

A.1.3 Non-construction Cost

Non-construction costs include Real Estate, Planning, Engineering and Design (PED), and Construction Management (Supervision and Administration, S&A). Real Estate costs were provided by Real Estate Division. These costs are best described in the Real Estate Appendix, Appendix D. They include lands costs and administrative costs and are distinguished as non-Federal sponsor costs or government costs. Contingencies for the Real Estate costs were also determined during risk analysis based on direct input from the Real Estate PDT representative. The Real Estate risk analysis is further described below. Planning, Engineering and Design costs are broken down into Preconstruction, Engineering and Design (PED), or preparation of contract plans and specifications; Engineering During Construction (EDC); and the Project Implementation Report (PIR). PED costs were solicited from Engineering Division via the Project Manager, as suggested by the guidance Construction Management costs was solicited from Construction-Operations Division via the Project Manager, again as suggested by the guidance. A percentage of the total construction cost is used as the rate for Construction Management costs for the cost estimate for the Recommended Plan. This percentage is based on actual funds spent for construction management on past contracts. When this percentage is calculated by Construction Division for planning projects it is itemized to show amounts allocated for each task anticipated to occur during construction. Only the gross percentage is shown herein.

The main report details both cost allocation and cost apportionment for the Federal government and the non-Federal sponsor. Also included in the main report are the non-Federal sponsor's obligations (items of local cooperation).

A.1.4 **Plan Formulation Cost Estimates**

For the plan formulation cost estimates, unit prices for each major or variable construction element were developed in MCACES/MII. These unit prices were entered into spreadsheets that differentiated each plan by the quantities required to construct the plans. Designs and quantities for the construction elements were provided to Cost Branch by the Engineering Technical Lead (see the Engineering Appendix for construction methods, design assumptions and design data). Preconstruction, Engineering and Design costs and Construction Management costs were calculated using percentages at this level of estimating.

The plan formulation process for this study involved numerous iterations. Since the costs for the plans were calculated via spreadsheet software it was fairly simple to adjust them as time went by (for example, as unit prices increased due to changes in price level), as plan components changed and as plans were added or removed from consideration. Refer to the Economics Section in the Main Report for the final Plan Formulation cost tables.

A.1.5 **Construction Schedule**

A construction schedule was prepared by the Engineering PDT in conjunction with the Planning Technical Lead and the construction-operations team member that reflected all project construction components. The schedule considered not only durations of individual components but also timing of construction contracts. This schedule was coupled with the project schedule in preparation for the generation of the Total Project Cost Summary as well as for the completion of the risk analysis. The construction schedule will change as design of the project proceeds in the plans and specifications phase and then it will change again when the contract is awarded and the contractor provides his schedule, which may be based on multiple crews with shift work and overtime. Both the construction schedule and the project schedule are provided below. The official schedule is the project schedule and it is given precedence herein wherever a conflict appears between these two schedules.

A.1.6 **Total Project Cost Summary**

The Total Project Cost Summary includes escalation through project completion. The cost estimate for the Recommended Plan is prepared with an identified price level date. Inflation factors are used to adjust the pricing to the project schedule. This estimate is known as the Fully Funded Cost Estimate or Total Project Cost Summary. It includes all Federal and non-Federal costs: Lands, Easements, Rights of Way and Relocations; construction features; Preconstruction Engineering and Design; Construction Management; Contingency; and Inflation.

THIS PAGE INTENTIONALLY LEFT BLANK

A.2 PLAN FORMULATION COST ESTIMATES

Refer to the Economics Section in the Main Report.

A.3 MCACES Cost Estimate

Print Date Tue 14 December 2010
Eff. Date 2/1/2010

U.S. Army Corps of Engineers
Project 113164: Shore Protection Project, Martin County, Florida

Time 07:25:00

Title Page

(Includes final changes resulting from the Walla Walla DCX Cost Certification Review)
Limited Reevaluation Report - Revised Beach Renourishment Plan

Estimated by CESAJ-EN-C
Designed by Jacksonville District Office
Prepared by B. Blake
Preparation Date 12/14/2010
Effective Date of Pricing 2/1/2010
Estimated Construction Time Days

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

Table of Contents

Table of Contents

Designed by
Jacksonville District Office

Estimated by
CESAJ-EN-C

Prepared by
B. Blake

Design Document	2010 LRR MCACES COST REPORT
Document Date	
District	Jacksonville
Contact	CESAJ-PD-PN, Marty Durkin 904-232-2190
Budget Year	2010
UOM System	Original

Direct Costs
LaborCost
EQCost
MatlCost
SubBidCost
CEDEP

Timeline/Currency

Preparation Date	12/14/2010
Escalation Date	10/1/2009
Eff. Pricing Date	2/1/2010
Estimated Duration	0 Day(s)
Currency	US dollars
Exchange Rate	1.000000

Costbook CB08EB: MII English Cost Book 2008

Labor LFL2009: LABOR_FLORDIA_2009

Labor Rates
LaborCost1
LaborCost2
LaborCost3
LaborCost4

Equipment EP07R03: MII Equipment Region 3r 2007
Note: Revised Off-Road Diesel Rate as of 22 Feb 2010.

03 SOUTHEAST

Sales Tax	7.40
Working Hours per Year	1,530
Labor Adjustment Factor	0.83
Cost of Money	3.25
Cost of Money Discount	25.00
Tire Recap Cost Factor	1.50
Tire Recap Wear Factor	1.80
Tire Repair Factor	0.15
Equipment Cost Factor	1.00
Standby Depreciation Factor	0.50

Fuel

Electricity	0.090
Gas	2.650
Diesel Off-Road	2.350
Diesel On-Road	2.650

Shipping Rates

Over 0 CWT	10.26
Over 240 CWT	9.59
Over 300 CWT	8.41
Over 400 CWT	7.64
Over 500 CWT	4.49
Over 700 CWT	4.36
Over 800 CWT	4.99

Date	**Author**	**Note**
	MF	Planning Estimate for GRR, including Profit and Contingency Martin County, Shore Protection Project This estimate is for placing sand on the Martin County beach using two 30"cutterhead dredges. Dredging is only allowed during 3 months of the year. Refer to BMA 306.wk1 OCE dredge program for detail back up of dredg eproduction and cost.The most critical item for this type of dredging is the bank or depth of useable material in the borrow area. For these estimates it was assumed thatwe would have a bank of 6'. For the renourishment estimates in the future itwas assumed that the borrow area would be maintained to keep a minimum bank of 6'.All cost other than dredging cost were provided by Cynthia Murphy CESAJ-EN-HC. * - Updated the cost for a single Beach Renourishment event to current FY08 price level based on proposed new offshore borrow area as requested by CESAJ-EN-WC via email dated 24 January 2008. The beach nourishment quantity was taken from the final GRR MCACES cost report dated 16 December 1993. The updated dredging and beach fill cost were based on using one Medium Hopper Dredge with pumpout capability verses the 30" cutterhead pipeline dredge used in the original GRR cost estimate. This change is due to the further distance of the proposed new offshore borrow area from the beach placement area than the original borrow area. Production for the hopper dredge and beach fill was based on a previous Beach Renourishment contract administered on this project during 2005 using the Medium Hopper Dredge DODGE ISLAND.
2/6/2009	BCB	Revised previous FY08 updated MCACES to current FY09 Price Level using the Civil Works Construction Cost Index System (CWCCIS) Cost Indexes, EM 1110-2-1304, Appendix Dated 31 March 2009 for CWBS Category 17, Beach Replenishment.
11/20/2009	B. Blake	Revised previous FY08 updated MCACES to current FY10 Price Level using the Civil Works Construction Cost Index System (CWCCIS) Cost Indexes, EM 1110-2-1304, Appendix Dated 31 March 2009 for CWBS Category 17, Beach Replenishment.
3/1/2010	B. Blake	Fully revised the Final Report MCACES cost estimate to match the updated renourishment plan including the new offshore borrow area and revised beach renourishment design and beach fill volume. Also incorporated all ATR comment changes to the cost estimate submitted by Mr. James Henderson/SAD Regional Technical Specialist for Dredge Cost Estimating. Revised Estimate Assumptions: Increased the hauling speeds between the beach pumpout location and the new offshore borrow area based on historic production from another CESAJ project that had similar project conditions. Included beach fill operation shore equipments in the dredge mobilization and the beach placement costs. The estimate for the next project renourishment (number 9) is based on a test beach fill plan where one half of the total beach fill segment will be constructed based on the existing conventional beach fill template and the other one half will be constructed using the new turtle friendly template. Based on PDT input and concurrence further adjustments to the dredging and beach fill cost for the turtle friendly beach fill construction will include a 4 hour per day reduction in effective work time (EWT%) to account for working between the tides for seaward fill placement and an increase in anticipated hydraulic losses of 10 percent. This will allow a cost comparision of the two beach fill templates, since this design has not been constructed on this project before. Based on a CESAJ-PD-PN decision by Candida Bronson, all remaining future beach renourishments for the life of the project will use the turtle friendly beach fill design. Revised Estimated Construction Times (Base on One Medium Hopper dredge with direct beach pumpout). Renourishment Interval No. 17 (Full Renourishment Volume in 2012): Mobilization-Demobilization = 30 days. Conventional Beach Fill Template - 393,900 cyds = 1.20 mo or 36 days.

Date	Author	Note
		Turtle Friendly Beach Fill Template - 393,900 cyds = 1.65 mo. or 50 days. Total Estimated Construction Time = 3.85 mo or 116 days.
		Renourishment Interval No. 30 (Full Renourishment Volume in 2025):
		Mobilization-Demobilization = 30 days. Turtle Friendly Beach Fill Template - 787,800 cyds = 3.30 mo. or 100 days. Total Estimated Construction Time = 4.30 mos. or 130 days.
		Renourishment Interval No. 43 (Partial Renourishment Volume in 2038):
		Mobilization-Demobilization = 30 days. Turtle Friendly Beach Fill Template - 545,400 cyds = 2.28 mo. or 70 days. Total Estimated Construction Time = 3.28 mos. or 100 days.
10/18/2010	B. Blake	Completed the Cost Schedule Risk Analysis (CSRA) required by SAD as part of their review comments. CSRA based total consolidated contingency is 25 percent.
		Please refer to the separate CSRA Sub-Appendix in the Cost Engineering Appendix for details of the schedule and risk analysis in the Final Report.
12/3/2010	B. Blake	Includes corrections and changes suggested by the Walla Walla District Cost Center of Expertise via Dr. Checks comments submitted on 29 November 2010.
		Changed the effective pricing date of the estimate to 2 February 2010.

Description	Quantity	UOM	ContractCost	Escalation	Contingency	ProjectCost
Project Cost Summary Report – CWWBS Subfeature Level 2			23,832,817	0	5,958,204	29,791,021
17 Renourishment Interval 17 (2012) - 787,800 CY	1.00	LS	8,083,581	0	2,020,895	10,104,476
17 A Construction Cost	1.00	LS	7,121,526	0	1,780,382	8,901,908
06 Fish and Wildlife Facilities	1.00	LS	120,000	0	30,000	150,000
0603 Wildlife Facilities & Sanctuary	1.00	LS	120,000	0	30,000	150,000
17 Beach Replenishment	1.00	LS	7,001,526	0	1,750,382	8,751,908
010117001 Beach Replenishment - Mobilization & Demobilization	1.00	LS	1,029,989	0	257,497	1,287,486
010117002 Beach Fill (Estimated Quantity)	787,800.00	CY	5,971,537	0	1,492,884	7,464,421
17 B Non-Construction Cost	1.00	LS	962,055	0	240,514	1,202,569
01 Real Estate - Lands & Damages	1.00	LS	5,000	0	1,250	6,250
012303 Real Estate Analysis Documents	1.00	LS	5,000	0	1,250	6,250
30 Planning, Engineering and Design	1.00	LS	200,000	0	50,000	250,000
31 Construction Management (S&I)	1.00	LS	757,055	0	189,264	946,319
17 Renourishment Interval 30 (2025) - 787,800 CY	1.00	LS	8,924,053	0	2,231,013	11,155,067
17 A Construction Cost	1.00	LS	7,961,998	0	1,990,500	9,952,498
06 Fish and Wildlife Facilities	1.00	LS	120,000	0	30,000	150,000
0603 Wildlife Facilities & Sanctuary	1.00	LS	120,000	0	30,000	150,000
17 Beach Replenishment	1.00	LS	7,841,998	0	1,960,500	9,802,498
010117001 Beach Replenishment - Mobilization & Demobilization	1.00	LS	1,029,989	0	257,497	1,287,486
010117002 Beach Fill (Estimated Quantity)	787,800.00	CY	6,812,009	0	1,703,002	8,515,012
17 B Non-Construction Cost	1.00	LS	962,055	0	240,514	1,202,569
01 Real Estate - Lands & Damages	1.00	LS	5,000	0	1,250	6,250
012303 Real Estate Analysis Documents	1.00	LS	5,000	0	1,250	6,250
30 Planning, Engineering and Design	1.00	LS	200,000	0	50,000	250,000
31 Construction Management (S&I)	1.00	LS	757,055	0	189,264	946,319
17 Renourishment Interval 43 (2038) - 545,400 CY	1.00	LS	6,825,183	0	1,706,296	8,531,478
17 A Construction Cost	1.00	LS	5,863,128	0	1,465,782	7,328,910
06 Fish and Wildlife Facilities	1.00	LS	120,000	0	30,000	150,000
0603 Wildlife Facilities & Sanctuary	1.00	LS	120,000	0	30,000	150,000
17 Beach Replenishment	1.00	LS	5,743,128	0	1,435,782	7,178,910
010117001 Beach Replenishment - Mobilization & Demobilization	1.00	LS	1,029,989	0	257,497	1,287,486
010117002 Beach Fill (Estimated Quantity)	545,400.00	CY	4,713,139	0	1,178,285	5,891,423
17 B Non-Construction Cost	1.00	LS	962,055	0	240,514	1,202,569
01 Real Estate - Lands & Damages	1.00	LS	5,000	0	1,250	6,250
012303 Real Estate Analysis Documents	1.00	LS	5,000	0	1,250	6,250
30 Planning, Engineering and Design	1.00	LS	200,000	0	50,000	250,000
31 Construction Management (S&I)	1.00	LS	757,055	0	189,264	946,319

Description	Quantity	UOM	Contractor	DirectCost	SubCMU	CostToPrime	PrimeCMU	ContractCost
Contract Cost Summary Report – CWWBS Subfeature 2				18,153,518	0	14,907,353	5,679,299	23,832,817
17 Renourishment Interval 17 (2012) - 787,800 CY	1.00	LS		6,152,050	0	5,069,995	1,931,531	8,083,581
17 A Construction Cost	1.00	LS		5,189,995	0	5,069,995	1,931,531	7,121,526
06 Fish and Wildlife Facilities	1.00	LS		120,000	0	0	0	120,000
0603 Wildlife Facilities & Sanctuary	1.00	LS		120,000	0	0	0	120,000
17 Beach Replenishment	1.00	LS	AA Prime Dredging Contractor	5,069,995	0	5,069,995	1,931,531	7,001,526
010117001 Beach Replenishment - Mobilization & Demobilization	1.00	LS	AA Prime Dredging Contractor	745,843	0	745,843	284,146	1,029,989
010117002 Beach Fill (Estimated Quantity)	787,800.00	CY	AA Prime Dredging Contractor	4,324,152	0	4,324,152	1,647,385	5,971,537
17 B Non-Constrution Cost	1.00	LS		962,055	0	0	0	962,055
01 Real Estate - Lands & Damages	1.00	LS		5,000	0	0	0	5,000
012303 Real Estate Analysis Documents	1.00	LS		5,000	0	0	0	5,000
30 Planning, Engineering and Design	1.00	LS		200,000	0	0	0	200,000
31 Construction Management (S&I)	1.00	LS		757,055	0	0	0	757,055
17 Renourishment Interval 30 (2025) - 787,800 CY	1.00	LS		6,760,659	0	5,678,604	2,163,395	8,924,053
17 A Construction Cost	1.00	LS		5,798,604	0	5,678,604	2,163,395	7,961,998
06 Fish and Wildlife Facilities	1.00	LS		120,000	0	0	0	120,000
0603 Wildlife Facilities & Sanctuary	1.00	LS		120,000	0	0	0	120,000
17 Beach Replenishment	1.00	LS	AA Prime Dredging Contractor	5,678,604	0	5,678,604	2,163,395	7,841,998
010117001 Beach Replenishment - Mobilization & Demobilization	1.00	LS	AA Prime Dredging Contractor	745,843	0	745,843	284,146	1,029,989
010117002 Beach Fill (Estimated Quantity)	787,800.00	CY	AA Prime Dredging Contractor	4,932,761	0	4,932,761	1,879,249	6,812,009
17 B Non-Constrution Cost	1.00	LS		962,055	0	0	0	962,055
01 Real Estate - Lands & Damages	1.00	LS		5,000	0	0	0	5,000
012303 Real Estate Analysis Documents	1.00	LS		5,000	0	0	0	5,000
30 Planning, Engineering and Design	1.00	LS		200,000	0	0	0	200,000
31 Construction Management (S&I)	1.00	LS		757,055	0	0	0	757,055
	1.00	LS		5,240,809	0	4,158,754	1,584,373	6,825,183

Description	Quantity	UOM	Contractor	DirectCost	SubCMU	CostToPrime	PrimeCMU	ContractCost
17 Renourishment Interval 43 (2038) - 545,400 CY								
17 A Construction Cost	**1.00**	**LS**		**4,278,754**	**0**	**4,158,754**	**1,584,373**	**5,863,128**
06 Fish and Wildlife Facilities	**1.00**	**LS**		**120,000**	**0**	**0**	**0**	**120,000**
0603 Wildlife Facilities & Sanctuary	**1.00**	**LS**		**120,000**	**0**	**0**	**0**	**120,000**
17 Beach Replenishment	**1.00**	**LS**	**AA Prime Dredging Contractor**	**4,158,754**	**0**	**4,158,754**	**1,584,373**	**5,743,128**
010117001 Beach Replenishment - Mobilization & Demobilization	**1.00**	**LS**	**AA Prime Dredging Contractor**	**745,843**	**0**	**745,843**	**284,146**	**1,029,989**
010117002 Beach Fill (Estimated Quantity)	**545,400.00**	**CY**	**AA Prime Dredging Contractor**	**3,412,911**	**0**	**3,412,911**	**1,300,227**	**4,713,139**
17 B Non-Construction Cost	**1.00**	**LS**		**962,055**	**0**	**0**	**0**	**962,055**
01 Real Estate - Lands & Damages	**1.00**	**LS**		**5,000**	**0**	**0**	**0**	**5,000**
012303 Real Estate Analysis Documents	**1.00**	**LS**		**5,000**	**0**	**0**	**0**	**5,000**
30 Planning, Engineering and Design	**1.00**	**LS**		**200,000**	**0**	**0**	**0**	**200,000**
31 Construction Management (S&I)	**1.00**	**LS**		**757,055**	**0**	**0**	**0**	**757,055**

FINAL REPORT

Description	Quantity	UOM	Contractor	DirectLabor	DirectEQ	DirectMatl	DirectSubBid	DirectUserCost	DirectCost
Project Direct Costs Report – CWWBS Subfeature Level 2				1,398,310	1,322,995	0	3,261,303	12,170,911	18,153,518
17 Renourishment Interval 17 (2012) - 787,800 CY	1.00	LS		456,085	416,018	0	1,097,193	4,182,754	6,152,050
17 A Construction Cost	1.00	LS		456,085	416,018	0	135,138	4,182,754	5,189,995
06 Fish and Wildlife Facilities	1.00	LS		0	0	0	120,000	0	120,000
0603 Wildlife Facilities & Sanctuary	1.00	LS		0	0	0	120,000	0	120,000
17 Beach Replenishment	1.00	LS	AA Prime Dredging Contractor	456,085	416,018	0	15,138	4,182,754	5,069,995
010117001 Beach Replenishment - Mobilization & Demobilization	1.00	LS	AA Prime Dredging Contractor	120,846	52,131	0	0	572,866	745,843
010117002 Beach Fill (Estimated Quantity)	787,800.00	CY	AA Prime Dredging Contractor	335,239	363,887	0	15,138	3,609,888	4,324,152
17 B Non-Construction Cost	1.00	LS		0	0	0	962,055	0	962,055
01 Real Estate - Lands & Damages	1.00	LS		0	0	0	5,000	0	5,000
012303 Real Estate Analysis Documents	1.00	LS		0	0	0	5,000	0	5,000
30 Planning, Engineering and Design	1.00	LS		0	0	0	200,000	0	200,000
31 Construction Management (S&I)	1.00	LS		0	0	0	757,055	0	757,055
17 Renourishment Interval 30 (2025) - 787,800 CY	1.00	LS		535,139	525,967	0	1,082,055	4,617,497	6,760,659
17 A Construction Cost	1.00	LS		535,139	525,967	0	120,000	4,617,497	5,798,604
06 Fish and Wildlife Facilities	1.00	LS		0	0	0	120,000	0	120,000
0603 Wildlife Facilities & Sanctuary	1.00	LS		0	0	0	120,000	0	120,000
17 Beach Replenishment	1.00	LS	AA Prime Dredging Contractor	535,139	525,967	0	0	4,617,497	5,678,604
010117001 Beach Replenishment - Mobilization & Demobilization	1.00	LS	AA Prime Dredging Contractor	120,846	52,131	0	0	572,866	745,843
010117002 Beach Fill (Estimated Quantity)	787,800.00	CY	AA Prime Dredging Contractor	414,293	473,837	0	0	4,044,631	4,932,761
17 B Non-Construction Cost	1.00	LS		0	0	0	962,055	0	962,055

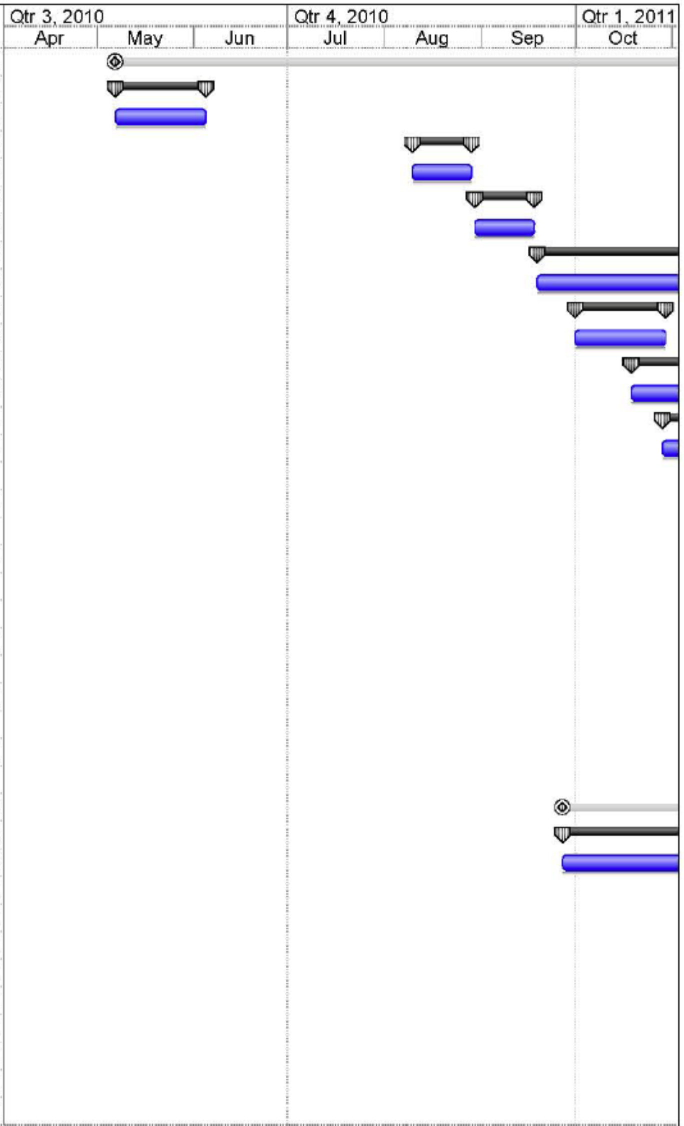
Description	Quantity	UOM	Contractor	DirectLabor	DirectEQ	DirectMatl	DirectSubBid	DirectUserCost	DirectCost
01 Real Estate - Lands & Damages	1.00	LS		0	0	0	5,000	0	5,000
012303 Real Estate Analysis Documents	1.00	LS		0	0	0	5,000	0	5,000
30 Planning, Engineering and Design	1.00	LS		0	0	0	200,000	0	200,000
31 Construction Management (S&I)	1.00	LS		0	0	0	757,055	0	757,055
17 Renourishment Interval 43 (2038) - 545,400 CY	1.00	LS		407,085	381,009	0	1,082,055	3,370,660	5,240,809
17 A Construction Cost	1.00	LS		407,085	381,009	0	120,000	3,370,660	4,278,754
06 Fish and Wildlife Facilities	1.00	LS		0	0	0	120,000	0	120,000
0603 Wildlife Facilities & Sanctuary	1.00	LS		0	0	0	120,000	0	120,000
17 Beach Replenishment	1.00	LS	AA Prime Dredging Contractor	407,085	381,009	0	0	3,370,660	4,158,754
010117001 Beach Replenishment - Mobilization & Demobilization	1.00	LS	AA Prime Dredging Contractor	120,846	52,131	0	0	572,866	745,843
010117002 Beach Fill (Estimated Quantity)	545,400.00	CY	AA Prime Dredging Contractor	286,239	328,879	0	0	2,797,794	3,412,911
17 B Non-Construction Cost	1.00	LS		0	0	0	962,055	0	962,055
01 Real Estate - Lands & Damages	1.00	LS		0	0	0	5,000	0	5,000
012303 Real Estate Analysis Documents	1.00	LS		0	0	0	5,000	0	5,000
30 Planning, Engineering and Design	1.00	LS		0	0	0	200,000	0	200,000
31 Construction Management (S&I)	1.00	LS		0	0	0	757,055	0	757,055

FINAL REPORT

THIS PAGE INTENTIONALLY LEFT BLANK

A.4 SCHEDULE

ID	ℹ	Task Name	Duration	Start	Finish
1		**LRR AND EIS**	**408 days**	**Thu 5/6/10**	**Fri 6/17/11**
2		**Submit EIS/LRR to SAD**	**30 days**	**Thu 5/6/10**	**Fri 6/4/10**
3	▦	SAD Review	30 days	Thu 5/6/10	Fri 6/4/10
4		**Comment Back to District**	**20 days**	**Mon 8/9/10**	**Sat 8/28/10**
5	▦	Comments incorporated	20 days	Mon 8/9/10	Sat 8/28/10
6		**Resubmit Report back to SAD**	**20 days**	**Sun 8/29/10**	**Fri 9/17/10**
7	▦	SAD Reviews and Provides Release of SEIS	20 days	Sun 8/29/10	Fri 9/17/10
8		**Publish 1st NOA**	**52 days**	**Sat 9/18/10**	**Mon 11/8/10**
9	▦	Prepare for CSRA	52 days	Sat 9/18/10	Mon 11/8/10
10		**Complete Cost Schedule Risk Analysis**	**30 days**	**Thu 9/30/10**	**Fri 10/29/10**
11	▦	NOA Comments Received	30 days	Thu 9/30/10	Fri 10/29/10
12		**NOA Period Ends**	**40 days**	**Mon 10/18/10**	**Fri 11/26/10**
13	▦	Public Meeting Preparations	40 days	Mon 10/18/10	Fri 11/26/10
14		**Public Meeting Held for DEIS**	**75 days**	**Thu 10/28/10**	**Mon 1/10/11**
15	▦	Update DEIS based on public comments	75 days	Thu 10/28/10	Mon 1/10/11
16		**Resubmit to DEIS to SAD**	**30 days**	**Sat 1/1/11**	**Sun 1/30/11**
17	▦	SAD Reviews DEIS	30 days	Sat 1/1/11	Sun 1/30/11
18		**SAD Comments Received**	**30 days**	**Mon 1/31/11**	**Tue 3/1/11**
19		Incorporate SAD Comments	30 days	Mon 1/31/11	Tue 3/1/11
20		**Publish 2nd NOA**	**30 days**	**Wed 3/2/11**	**Thu 3/31/11**
21	▦	Collect Comments	30 days	Wed 3/2/11	Thu 3/31/11
22		**NOA Period Ends**	**47 days**	**Fri 4/1/11**	**Tue 5/17/11**
23	▦	Comments Incorporated into EIS	47 days	Fri 4/1/11	Tue 5/17/11
24		**Submit EIS to SAD**	**31 days**	**Wed 5/18/11**	**Fri 6/17/11**
25	▦	Review	30 days	Wed 5/18/11	Thu 6/16/11
26		ROD Signed	1 day	Fri 6/17/11	Fri 6/17/11
27					
28		**PLANS AND SPECIFICATIONS - 2012**	**531 days**	**Sun 9/26/10**	**Fri 3/9/12**
29		**Issue WQC Permit**	**90 days**	**Sun 9/26/10**	**Fri 12/24/10**
30	▦	Surveys and Mapping	90 days	Sun 9/26/10	Fri 12/24/10
31		**Initiate Draft Plans and Specs**	**70 days**	**Sat 12/25/10**	**Fri 3/4/11**
32		Draft P&S and Sediment QA/QC	70 days	Sat 12/25/10	Fri 3/4/11
33		**Draft P&S Complete**	**14 days**	**Sat 3/5/11**	**Fri 3/18/11**
34		Generate Cost Estimate	14 days	Sat 3/5/11	Fri 3/18/11
35		**IGE Complete**	**14 days**	**Sat 3/19/11**	**Fri 4/1/11**
36		Draft Procurement Package	14 days	Sat 3/19/11	Fri 4/1/11
37		**Procument Package to CT**	**30 days**	**Sat 4/2/11**	**Sun 5/1/11**
38		BCOE Review Period	30 days	Sat 4/2/11	Sun 5/1/11
39		**Review Ends**	**21 days**	**Mon 4/4/11**	**Sun 4/24/11**



Project: Martin Co SPP Draft Schedule
Date: Fri 12/3/10

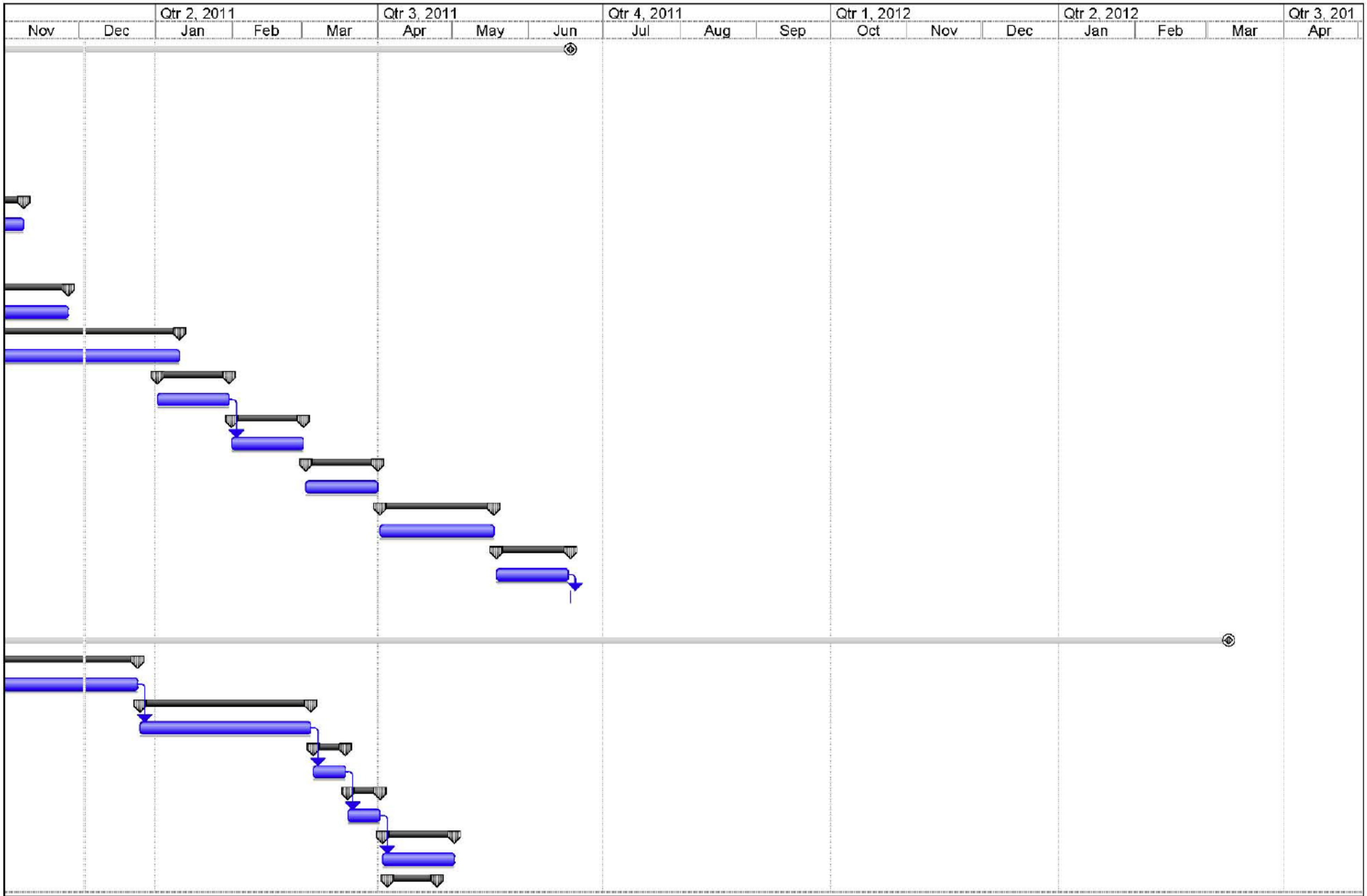
Task		Milestone	◆	External Tasks	
Split		Summary		External Milestone	◇
Progress		Project Summary		Deadline	⇩

Page 1

ID	ℹ	Task Name	Duration	Start	Finish	Qtr 3, 2010			Qtr 4, 2010			Qtr 1, 2011
						Apr	May	Jun	Jul	Aug	Sep	Oct
40	▦	Revise Draft P&S	21 days	Mon 4/4/11	Sun 4/24/11							
41		**Complete P&S**	**30 days**	**Mon 4/25/11**	**Tue 5/24/11**							
42		finalize P&S package	30 days	Mon 4/25/11	Tue 5/24/11							
43		**Finalize package and begin Certification**	**120 days**	**Wed 5/25/11**	**Wed 9/21/11**							
44		Draft Tri-Party MOU	120 days	Wed 5/25/11	Wed 9/21/11							
45		**Execute MMS MOU**	**15 days**	**Sun 4/24/11**	**Sun 5/8/11**							
46	▦	Prepare Synopsis	15 days	Sun 4/24/11	Sun 5/8/11							
47		**Synopsize in FEDBIZOPs**	**14 days**	**Thu 6/9/11**	**Wed 6/22/11**							
48	▦	BCO final review period	14 days	Thu 6/9/11	Wed 6/22/11							
49		**BCOE Cert**	**15 days**	**Wed 6/8/11**	**Wed 6/22/11**							
50	▦	Finalize revised P&S package	15 days	Wed 6/8/11	Wed 6/22/11							
51		**Package final**	**15 days**	**Thu 6/23/11**	**Thu 7/7/11**							
52		Route BCO package for sign off	15 days	Thu 6/23/11	Thu 7/7/11							
53		**BCO Certified/Advertise**	**130 days**	**Fri 7/8/11**	**Tue 11/15/11**							
54	▦	Advertise period	30 days	Fri 7/8/11	Sat 8/6/11							
55		Open Bids	1 day	Sun 8/7/11	Sun 8/7/11							
56	▦	Prepare award documents	30 days	Fri 9/16/11	Sat 10/15/11							
57	▦	Award + 10 days lag	0 days	Sun 10/16/11	Sun 10/16/11							
58	▦	Prepare NTP documents	30 days	Sun 10/16/11	Tue 11/15/11							
59		**Construction - Beach Renourishment**	**146 days**	**Sun 10/16/11**	**Fri 3/9/12**							
60		Mobilization	20 days	Sun 10/16/11	Fri 11/4/11							
61		Dredging and Beach Fill Work	116 days	Sat 11/5/11	Tue 2/28/12							
62		Demobilization	10 days	Wed 2/29/12	Fri 3/9/12							

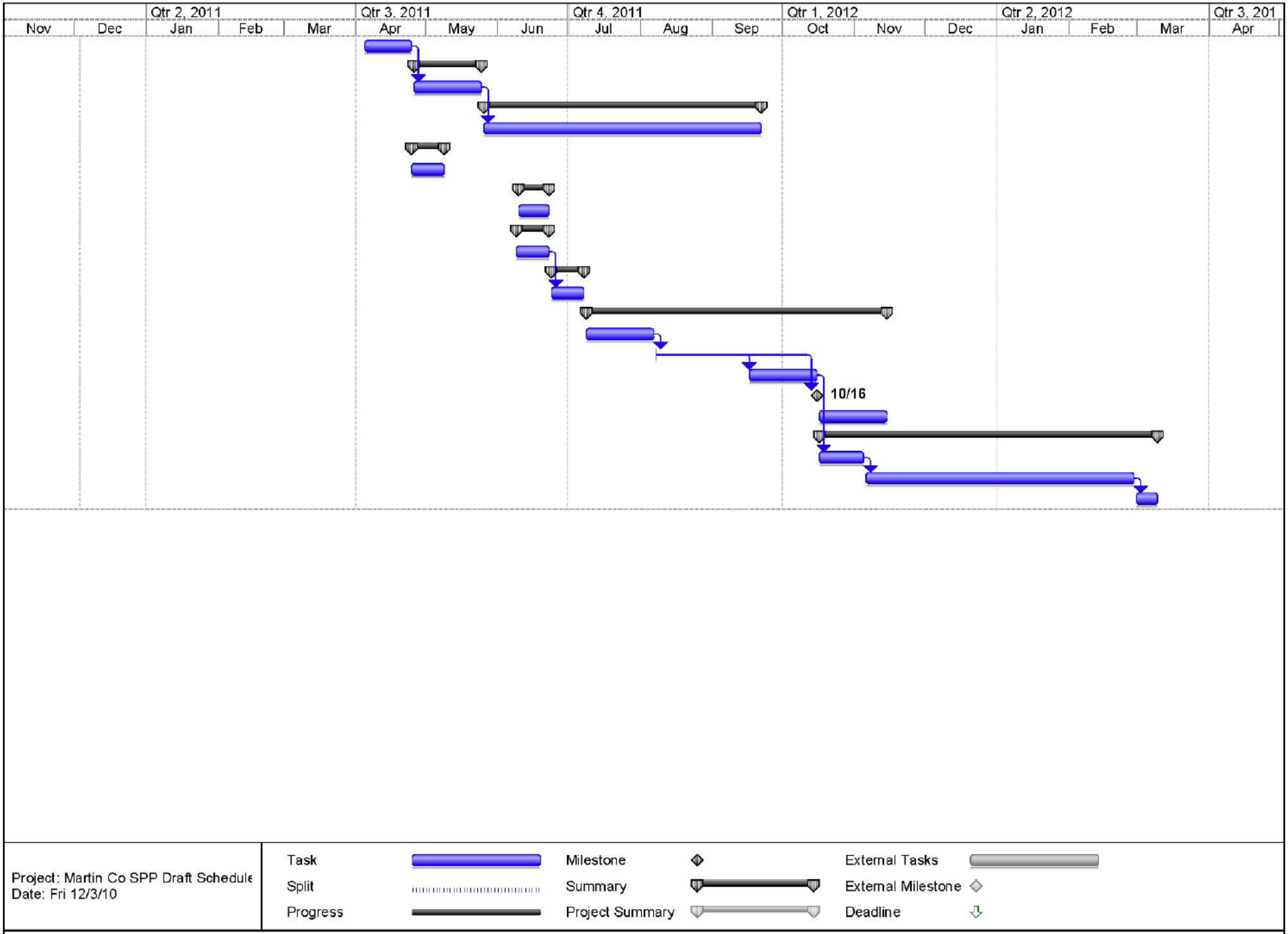
Project: Martin Co SPP Draft Schedule
Date: Fri 12/3/10

Task	▬	Milestone	◆	External Tasks	▬
Split	┈	Summary	▬	External Milestone	◆
Progress	▬	Project Summary	▬	Deadline	⇩



Project: Martin Co SPP Draft Schedule
Date: Fri 12/3/10

Task
Split
Progress
Milestone ◆
Summary
Project Summary
External Tasks
External Milestone ◇
Deadline ⇩

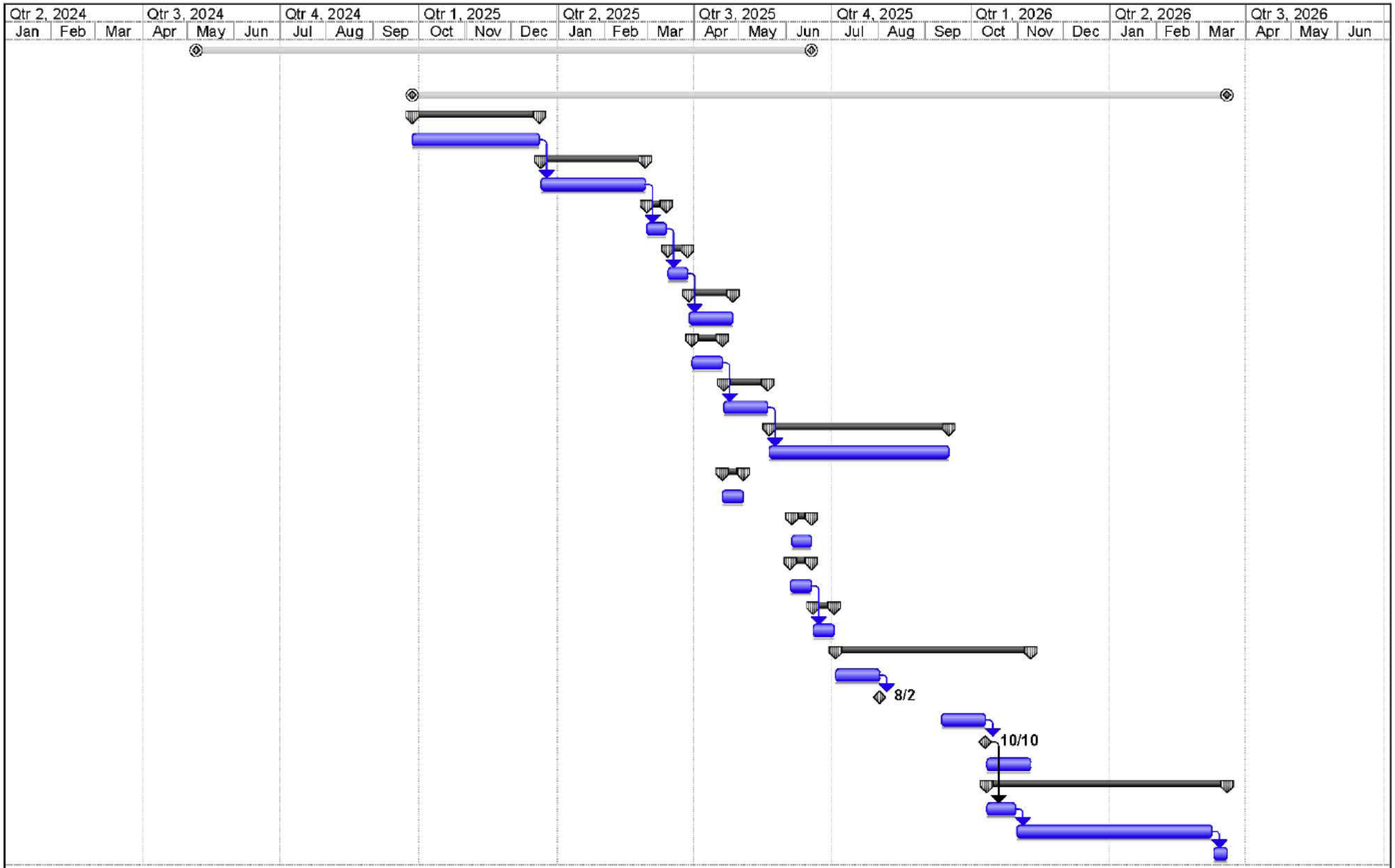

Qtr 2, 2011
Qtr 3, 2011
Qtr 4, 2011
Qtr 1, 2012
Qtr 2, 2012
Qtr 3, 201
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Jan
Feb
Mar
Apr
10/16
Project: Martin Co SPP Draft Schedule
Date: Fri 12/3/10
Task
Split
Progress
Milestone
Summary
Project Summary
External Tasks
External Milestone
Deadline

ID	ℹ	Task Name	Duration	Start	Finish
1		**LRR AND EIS**	**408 days**	**Mon 5/6/24**	**Tue 6/17/25**
27					
28		**PLANS AND SPECIFICATIONS - 2025**	**540 days**	**Thu 9/26/24**	**Thu 3/19/26**
29		**Issue WQC Permit**	**85 days**	**Thu 9/26/24**	**Thu 12/19/24**
30	▦	Surveys and Mapping	85 days	Thu 9/26/24	Thu 12/19/24
31		**Initiate Draft Plans and Specs**	**70 days**	**Fri 12/20/24**	**Thu 2/27/25**
32		Draft P&S and Sediment QA/QC	70 days	Fri 12/20/24	Thu 2/27/25
33		**Draft P&S Complete**	**14 days**	**Fri 2/28/25**	**Thu 3/13/25**
34		Generate Cost Estimate	14 days	Fri 2/28/25	Thu 3/13/25
35		**IGE Complete**	**14 days**	**Fri 3/14/25**	**Thu 3/27/25**
36		Draft Procurement Package	14 days	Fri 3/14/25	Thu 3/27/25
37		**Procument Package to CT**	**30 days**	**Fri 3/28/25**	**Sat 4/26/25**
38		BCOE Review Period	30 days	Fri 3/28/25	Sat 4/26/25
39		**Review Ends**	**21 days**	**Sun 3/30/25**	**Sat 4/19/25**
40	▦	Revise Draft P&S	21 days	Sun 3/30/25	Sat 4/19/25
41		**Complete P&S**	**30 days**	**Sun 4/20/25**	**Mon 5/19/25**
42		finalize P&S package	30 days	Sun 4/20/25	Mon 5/19/25
43		**Finalize package and begin Certification**	**120 days**	**Tue 5/20/25**	**Tue 9/16/25**
44		Draft Tri-Party MOU	120 days	Tue 5/20/25	Tue 9/16/25
45		**Execute MMS MOU**	**15 days**	**Sat 4/19/25**	**Sat 5/3/25**
46	▦	Prepare Synopsis	15 days	Sat 4/19/25	Sat 5/3/25
47		**Synopsize in FEDBIZOPs**	**14 days**	**Wed 6/4/25**	**Tue 6/17/25**
48	▦	BCO final review period	14 days	Wed 6/4/25	Tue 6/17/25
49		**BCOE Cert**	**15 days**	**Tue 6/3/25**	**Tue 6/17/25**
50	▦	Finalize revised P&S package	15 days	Tue 6/3/25	Tue 6/17/25
51		**Package final**	**15 days**	**Wed 6/18/25**	**Wed 7/2/25**
52		Route BCO package for sign off	15 days	Wed 6/18/25	Wed 7/2/25
53		**BCO Certified/Advertise**	**130 days**	**Thu 7/3/25**	**Sun 11/9/25**
54	▦	Advertise period	30 days	Thu 7/3/25	Fri 8/1/25
55	▦	Open Bids	0 days	Sat 8/2/25	Sat 8/2/25
56	▦	Prepare award documents	30 days	Thu 9/11/25	Fri 10/10/25
57	▦	Award + 10 days lag	0 days	Fri 10/10/25	Fri 10/10/25
58	▦	Prepare NTP documents	30 days	Sat 10/11/25	Sun 11/9/25
59		**Construction - Beach Renourishment**	**160 days**	**Sat 10/11/25**	**Thu 3/19/26**
60	▦	Mobililzation	20 days	Sat 10/11/25	Thu 10/30/25
61		Dredging and Beach Fill Work	130 days	Fri 10/31/25	Mon 3/9/26
62	▦	Demobililzation	10 days	Tue 3/10/26	Thu 3/19/26

2010 | Qtr 1, 2011 | Qtr 2, 2011 | Qtr 3, 2011 | Qt
Aug | Sep | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | J

Project: Martin Co SPP Draft Schedule
Date: Fri 12/3/10

Task	▬	Milestone	◆	External Tasks	▬
Split	┈	Summary	▬	External Milestone	◇
Progress	▬	Project Summary	▬	Deadline	⇩



Project: Martin Co SPP Draft Schedule
Date: Fri 12/3/10

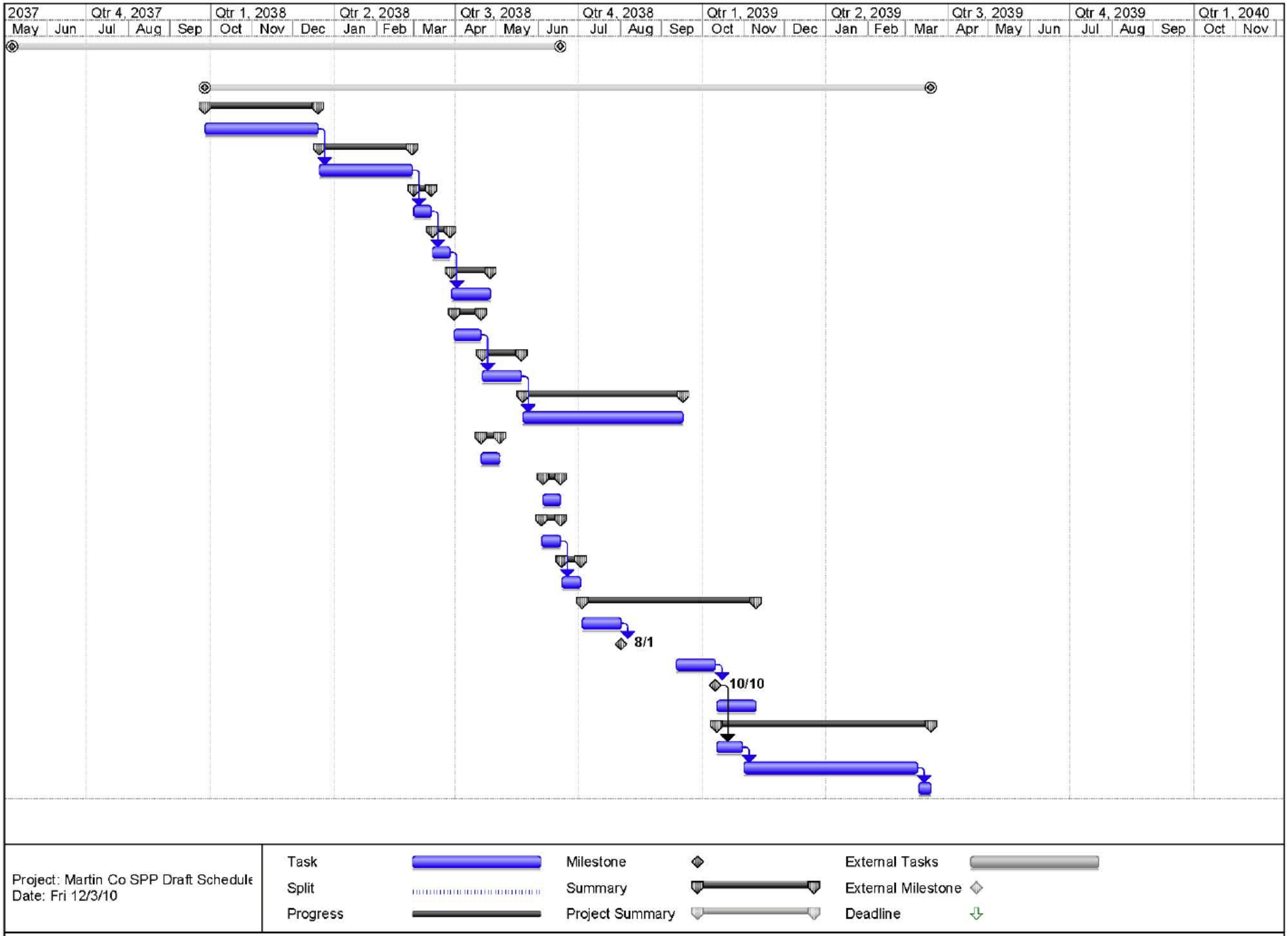
Task	▬	Milestone	◆	External Tasks	▬
Split	┄	Summary	▬	External Milestone	◇
Progress	▬	Project Summary	▬	Deadline	⇩

ID	ℹ	Task Name	Duration	Start	Finish
1		**LRR AND EIS**	**408 days**	**Wed 5/6/37**	**Thu 6/17/38**
27					
28		**PLANS AND SPECIFICATIONS - 2038**	**540 days**	**Sat 9/26/37**	**Sat 3/19/39**
29		**Issue WQC Permit**	**85 days**	**Sat 9/26/37**	**Sat 12/19/37**
30	▦	Surveys and Mapping	85 days	Sat 9/26/37	Sat 12/19/37
31		**Initiate Draft Plans and Specs**	**70 days**	**Sun 12/20/37**	**Sat 2/27/38**
32		Draft P&S and Sediment QA/QC	70 days	Sun 12/20/37	Sat 2/27/38
33		**Draft P&S Complete**	**14 days**	**Sun 2/28/38**	**Sat 3/13/38**
34		Generate Cost Estimate	14 days	Sun 2/28/38	Sat 3/13/38
35		**IGE Complete**	**14 days**	**Sun 3/14/38**	**Sat 3/27/38**
36		Draft Procurement Package	14 days	Sun 3/14/38	Sat 3/27/38
37		**Procument Package to CT**	**30 days**	**Sun 3/28/38**	**Mon 4/26/38**
38		BCOE Review Period	30 days	Sun 3/28/38	Mon 4/26/38
39		**Review Ends**	**21 days**	**Tue 3/30/38**	**Mon 4/19/38**
40	▦	Revise Draft P&S	21 days	Tue 3/30/38	Mon 4/19/38
41		**Complete P&S**	**30 days**	**Tue 4/20/38**	**Wed 5/19/38**
42		finalize P&S package	30 days	Tue 4/20/38	Wed 5/19/38
43		**Finalize package and begin Certification**	**120 days**	**Thu 5/20/38**	**Thu 9/16/38**
44		Draft Tri-Party MOU	120 days	Thu 5/20/38	Thu 9/16/38
45		**Execute MMS MOU**	**15 days**	**Mon 4/19/38**	**Mon 5/3/38**
46	▦	Prepare Synopsis	15 days	Mon 4/19/38	Mon 5/3/38
47		**Synopsize in FEDBIZOPs**	**14 days**	**Fri 6/4/38**	**Thu 6/17/38**
48	▦	BCO final review period	14 days	Fri 6/4/38	Thu 6/17/38
49		**BCOE Cert**	**15 days**	**Thu 6/3/38**	**Thu 6/17/38**
50	▦	Finalize revised P&S package	15 days	Thu 6/3/38	Thu 6/17/38
51		**Package final**	**15 days**	**Fri 6/18/38**	**Fri 7/2/38**
52		Route BCO package for sign off	15 days	Fri 6/18/38	Fri 7/2/38
53		**BCO Certified/Advertise**	**130 days**	**Sat 7/3/38**	**Tue 11/9/38**
54	▦	Advertise period	30 days	Sat 7/3/38	Sun 8/1/38
55	▦	Open Bids	0 days	Sun 8/1/38	Sun 8/1/38
56	▦	Prepare award documents	30 days	Sat 9/11/38	Sun 10/10/38
57	▦	Award + 10 days lag	0 days	Sun 10/10/38	Sun 10/10/38
58	▦	Prepare NTP documents	30 days	Mon 10/11/38	Tue 11/9/38
59		**Construction - Beach Renourishment**	**160 days**	**Mon 10/11/38**	**Sat 3/19/39**
60	▦	Mobilization	20 days	Mon 10/11/38	Sat 10/30/38
61		Dredging and Beach Fill Work	130 days	Sun 10/31/38	Wed 3/9/39
62	▦	Demobilization	10 days	Thu 3/10/39	Sat 3/19/39

2010 Aug Sep | Qtr 1, 2011 Oct Nov Dec | Qtr 2, 2011 Jan Feb Mar | Qtr 3, 2011 Apr May Jun | Qtr 4 Jul

Project: Martin Co SPP Draft Schedule
Date: Fri 12/3/10

Task	▬	Milestone	◆	External Tasks	▬
Split	┈	Summary	▬	External Milestone	◇
Progress	▬	Project Summary	▬	Deadline	⇩



Project: Martin Co SPP Draft Schedule
Date: Fri 12/3/10

A.5 RISK AND UNCERTAINTY ANALYSIS

A.5.1 Risk Analysis Methods

The risk analysis was conducted according to the procedure outlines in the manual entitled, 'Cost and Schedule Risk Analysis Process,' dated May 2009 and downloaded from the Corps' Cost Center of Expertise website. First, members of the PDT met to identify risk items, in both the construction cost estimate and the construction schedule. Then, the Risk Register was completed. After that, the Risk Model was customized using commercially available 'Crystal Ball' software. 'Most likely,' 'high,' and 'low' values were assigned to estimate items using the software's 'Assumption' function and the triangular distribution. 'Forecasts' were defined and the model run.

For the features costed by the Corps it is assumed that the work will be performed by a prudent contractor at a fair and reasonable cost. While the cost estimate analyzed in the risk analysis may contain adjustments due to quotations on direct and indirect costs, it contains no separate adjustment due to competitiveness or bid strategies (ETL 1110-2-573, 30 Sep 2008). Market conditions such as the current price of fuel are included in the estimate.

After the model was run the results were documented by extracting the sensitivity chart, the forecast chart and the percentiles table for major items. The percentiles were used to determine the contingency at the 80% confidence level. At this time, risk reduction efforts were discussed within the Engineering PDT for further discussion.

The appropriate contingencies were then applied to the MCACES/MII estimate for the NED and Locally Preferred Plans, producing the 'After Risk Analysis' cost estimate contained herein. Upon completion of this estimate the Total Project Cost Summary was prepared.

A.5.2 Risk analysis results

Refer to the Final Cost Schedule Risk Analysis Report produced by the Walla Walla District Cost Center of Expertise at the attached sub-appendix C-2A.

A.6 TOTAL PROJECT COST SUMMARY

The Total Project Cost Summary (TPCS) addresses inflation through project completion (accomplished by escalation to mid-point of construction per ER 1110-2-1302, Appendix C, Page C-2). It is based on the scope of the SAP and the official project schedule. The TPCS includes Federal and non-Federal costs for lands and damages, all construction features, PED, and S&A, along with the appropriate contingencies and escalation associated with each of these activities. The TPCS is formatted according to the WBS and uses Civil Works Construction Cost Indexing System factors for escalation (EM 1110-2-1304) of construction costs and Office of Management and Budget (EC 11-2-18X, 20 Feb 2008) factors for escalation of PED and S&A costs.

The Total Project Cost Summary prepared using the MCACES/MII cost estimate on the Recommended Plans with contingencies set by the risk analysis (and the exceptions as described above) and the official project schedule. In performing the risk analysis by meeting with the PDT to discuss the construction schedule to prepare the risk register, a schedule was derived that is slightly different from the official schedule in that it has slightly shorter construction duration. A risk analysis was run on that schedule taking into consideration variations in construction duration, authorization date and appropriation date, and yet a third schedule developed, this one based on the risk analysis results at the 80% confidence level. A TPCS (Figure A.7) was prepared using this schedule as well. They show the impact of delayed authorization and appropriation on the fully funded cost despite a slightly shorter construction duration.

The Cost Risk Analysis based total project contingency of 25 percent determined under the External Risk analysis in was applied to the Total Project Cost Summary along with the contingency adjusted total project schedule presented in Table A.7.

A.7 TOTAL PROJECT COST SUMMARY WITH COST RISK ANALYSIS, CONTINGENCY AND SCHEDULE ANALYSIS ESCALATION

****** TOTAL PROJECT COST SUMMARY ******

Printed:12/14/2010
Page 1 of 2

PROJECT: Shore Protection Project
LOCATION: Martin County, Florida

DISTRICT: SAJ
POC: CHIEF, COST ENGINEERING, Tracy T. Leeser, P.E.

PREPARED: 12/3/2010

This Estimate reflects the scope and schedule in report: Limited Revaluation Report (LRR)

						Program Year (Budget EC): 2012 Effective Price Level Date: 1 OCT 11				FULLY FUNDED PROJECT ESTIMATE				
WBS NUMBER	Civil Works Feature & Sub-Feature Description	COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	Spent Thru: 1-Oct-10 ($K)		COST ($K)	CNTG ($K)	FULL ($K)
A	*B*	*C*	*D*	*E*	*F*	*G*	*H*	*I*	*J*	*K*	*L*	*M*	*N*	*O*
	RENOURISHMENT INTERVAL 17 (2012)													
06	FISH & WILDLIFE FACILITIES	$120	$30	25%	$150	1.6%	$122	$30	$152			$122	$31	$153
17	BEACH REPLENISHMENT	$7,002	$1,750	25%	$8,752	2.1%	$7,150	$1,787	$8,937			$7,178	$1,795	$8,973
				-		-								
				-		-								
				-		-								
	CONSTRUCTION ESTIMATE TOTALS:	$7,122	$1,780		$8,902	2.1%	$7,272	$1,818	$9,089			$7,301	$1,825	$9,126
01	LANDS AND DAMAGES	$5	$1	25%	$6	1.6%	$5	$1	$6			$5	$1	$6
30	PLANNING, ENGINEERING & DESIGN	$200	$50	25%	$250	5.5%	$211	$53	$264			$211	$53	$264
31	CONSTRUCTION MANAGEMENT	$757	$189	25%	$946	5.5%	$799	$200	$998			$805	$201	$1,006
	PROJECT COST TOTALS:	$8,084	$2,021	25%	$10,104	2.5%	$8,286	$2,072	$10,358			$8,322	$2,080	$10,402

ESTIMATED FEDERAL COST:	**46.58%**	**$4,846**
ESTIMATED NON-FEDERAL COST:	**53.42%**	**$5,556**
ESTIMATED TOTAL PROJECT COST:		**$10,402**

________________ CHIEF, COST ENGINEERING, Tracy T. Leeser, P.E.

________________ PROJECT MANAGER, Daniel Haubner, P.E.

________________ CHIEF, REAL ESTATE, John Baker

________________ CHIEF, PLANNING,xxx

________________ CHIEF, ENGINEERING, xxx

________________ CHIEF, OPERATIONS, xxx

________________ CHIEF, CONSTRUCTION, xxx

________________ CHIEF, CONTRACTING,xxx

________________ CHIEF, PM-PB, xxxx

________________ CHIEF, DPM, xxx

**** TOTAL PROJECT COST SUMMARY ****

**** CONTRACT COST SUMMARY ****

PROJECT: Shore Protection Project
LOCATION: Martin County, Florida
This Estimate reflects the scope and schedule in report; Limited Revaluation Report (LRR)

DISTRICT: SAJ
POC: CHIEF, COST ENGINEERING, Tracy T. Leeser, P.E.
PREPARED: 12/3/2010

	Estimate Prepared: Effective Price Level:	30-Sep-10 1 OCT 10					Program Year (Budget EC): Effective Price Level Date:		2012 1 OCT 11			FULLY FUNDED PROJECT ESTIMATE		
WBS NUMBER A	Civil Works Feature & Sub-Feature Description B	COST ($K) C	CNTG ($K) D	CNTG (%) E	TOTAL ($K) F	ESC (%) G	COST ($K) H	CNTG ($K) I	TOTAL ($K) J	Mid-Point Date P	ESC (%) L	COST ($K) M	CNTG ($K) N	FULL ($K) O
	RENOURISHMENT INTERVAL 17 (2012)													
06	FISH & WILDLIFE FACILITIES	$120	$30	25%	$150	1.6%	$122	$30	$152	2012Q2	0.4%	$122	$31	$153
17	BEACH REPLENISHMENT	$7,002	$1,750	25%	$8,752	2.1%	$7,150	$1,787	$8,937	2012Q2	0.4%	$7,178	$1,795	$8,973
	CONSTRUCTION ESTIMATE TOTALS:	$7,122	$1,780	25%	**$8,902**		$7,272	$1,818	$9,089			$7,301	$1,825	$9,126
01	LANDS AND DAMAGES	$5	$1	25%	$6	1.6%	$5	$1	$6	2012Q1		$5	$1	$6
30	PLANNING, ENGINEERING & DESIGN													
	District PED Functions	$200	$50	25%	$250	5.5%	$211	$53	$264	2012Q1		$211	$53	$264
31	CONSTRUCTION MANAGEMENT													
	Construction Management (& EDC)	$757	$189	25%	$946	5.5%	$799	$200	$998	2012Q2	0.8%	$805	$201	$1,006
	Project Operation:			25%										
	Project Management			25%										
	CONTRACT COST TOTALS:	$8,084	$2,021		**$10,104**		$8,286	$2,072	$10,358			$8,322	$2,080	**$10,402**

**** TOTAL PROJECT COST SUMMARY ****

PROJECT: Shore Protection Project
LOCATION: Martin County, Florida

DISTRICT: SAJ
POC: CHIEF, COST ENGINEERING, Tracy T. Leeser, P.E.

PREPARED: 12/3/2010

This Estimate reflects the scope and schedule in report; Limited Revaluation Report (LRR)

						Program Year (Budget EC): 2026 Effective Price Level Date: 1 OCT 25				FULLY FUNDED PROJECT ESTIMATE				
WBS NUMBER	Civil Works Feature & Sub-Feature Description	COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	Spent Thru: 1-Oct-10 ($K)		COST ($K)	CNTG ($K)	FULL ($K)
A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
	RENOURISHMENT INTERVAL 30 (2025)													
06	FISH & WILDLIFE FACILITIES	$120	$30	25%	$150	29.8%	$156	$39	$195			$157	$39	$196
17	BEACH REPLENISHMENT	$7,842	$1,960	25%	$9,802	30.5%	$10,232	$2,558	$12,790			$10,278	$2,570	$12,848
	CONSTRUCTION ESTIMATE TOTALS:	$7,962	$1,990		$9,952	30.5%	$10,388	$2,597	$12,984			$10,435	$2,609	$13,043
01	LANDS AND DAMAGES	$5	$1	25%	$6	29.8%	$6	$2	$8			$6	$2	$8
30	PLANNING, ENGINEERING & DESIGN	$200	$50	25%	$250	66.8%	$334	$83	$417			$334	$83	$417
31	CONSTRUCTION MANAGEMENT	$757	$189	25%	$946	66.8%	$1,262	$316	$1,578			$1,269	$317	$1,586
	PROJECT COST TOTALS:	$8,924	$2,231	25%	$11,155	34.4%	$11,990	$2,997	$14,987			$12,043	$3,011	$15,054

CHIEF, COST ENGINEERING, Tracy T. Leeser, P.E.

PROJECT MANAGER, Daniel Haubner, P.E.

CHIEF, REAL ESTATE, John Baker

CHIEF, PLANNING,xxx

CHIEF, ENGINEERING, xxx

CHIEF, OPERATIONS, xxx

CHIEF, CONSTRUCTION, xxx

CHIEF, CONTRACTING,xxx

CHIEF, PM-PB, xxxx

CHIEF, DPM, xxx

ESTIMATED FEDERAL COST:	46.58%	$7,014
ESTIMATED NON-FEDERAL COST:	53.42%	$8,040
ESTIMATED TOTAL PROJECT COST:		**$15,054**

**** TOTAL PROJECT COST SUMMARY ****

**** CONTRACT COST SUMMARY ****

PROJECT: Shore Protection Project
LOCATION: Martin County, Florida
This Estimate reflects the scope and schedule in report; Limited Revaluation Report (LRR)

DISTRICT: SAJ
POC: CHIEF, COST ENGINEERING, Tracy T. Leeser, P.E.
PREPARED: 12/3/2010

	Estimate Prepared: 30-Sep-10 Effective Price Level: 1 OCT 10					Program Year (Budget EC): 2026 Effective Price Level Date: 1 OCT 25				FULLY FUNDED PROJECT ESTIMATE				
WBS NUMBER A	Civil Works Feature & Sub-Feature Description B	COST ($K) C	CNTG ($K) D	CNTG (%) E	TOTAL ($K) F	ESC (%) G	COST ($K) H	CNTG ($K) I	TOTAL ($K) J	Mid-Point Date P	ESC (%) L	COST ($K) M	CNTG ($K) N	FULL ($K) O
	RENOURISHMENT INTERVAL 30 (2025)													
06	FISH & WILDLIFE FACILITIES	$120	$30	25%	$150	29.8%	$156	$39	$195	2026Q2	0.5%	$157	$39	$196
17	BEACH REPLENISHMENT	$7,842	$1,960	25%	$9,802	30.5%	$10,232	$2,558	$12,790	2026Q2	0.5%	$10,278	$2,570	$12,848
	CONSTRUCTION ESTIMATE TOTALS:	$7,962	$1,990	25%	$9,952		$10,388	$2,597	$12,984			$10,435	$2,609	$13,043
01	LANDS AND DAMAGES	$5	$1	25%	$6	29.8%	$6	$2	$8	2026Q1		$6	$2	$8
30	PLANNING, ENGINEERING & DESIGN													
	District PED Functions	$200	$50	25%	$250	66.8%	$334	$83	$417	2026Q1		$334	$83	$417
31	CONSTRUCTION MANAGEMENT													
	Construction Management (& EDC)	$757	$189	25%	$946	66.8%	$1,262	$316	$1,578	2026Q2	0.5%	$1,269	$317	$1,586
	Project Operation:			25%										
	Project Management			25%										
	CONTRACT COST TOTALS:	$8,924	$2,231		$11,155		$11,990	$2,997	$14,987			$12,043	$3,011	$15,054

**** TOTAL PROJECT COST SUMMARY ****

PROJECT: Shore Protection Project
LOCATION: Martin County, Florida

DISTRICT: SAJ
POC: CHIEF, COST ENGINEERING, Tracy T. Leeser, P.E.

PREPARED: 12/3/2010

This Estimate reflects the scope and schedule in report; Limited Revaluation Report (LRR)

						Program Year (Budget EC): 2039				FULLY FUNDED PROJECT ESTIMATE				
						Effective Price Level Date: 1 OCT 38				Spent Thru: 1-Oct-10				
WBS NUMBER	Civil Works Feature & Sub-Feature Description	COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	($K)		COST ($K)	CNTG ($K)	FULL ($K)
A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
	RENOURISHMENT INTERVAL 43 (2038)													
06	FISH & WILDLIFE FACILITIES	$120	$30	25%	$150	58.0%	$190	$47	$237			$191	$48	$239
17	BEACH REPLENISHMENT	$5,743	$1,436	25%	$7,179	58.8%	$9,118	$2,279	$11,397			$9,201	$2,300	$11,501
	CONSTRUCTION ESTIMATE TOTALS:	$5,863	$1,466		$7,329	58.7%	$9,308	$2,327	$11,634			$9,392	$2,348	$11,740
01	LANDS AND DAMAGES	$5	$1	25%	$6	58.0%	$8	$2	$10			$8	$2	$10
30	PLANNING, ENGINEERING & DESIGN	$200	$50	25%	$250	104.2%	$408	$102	$510			$408	$102	$510
31	CONSTRUCTION MANAGEMENT	$757	$189	25%	$946	104.2%	$1,546	$386	$1,932			$1,546	$386	$1,932
	PROJECT COST TOTALS:	$6,825	$1,706	25%	$8,531	65.1%	$11,269	$2,817	$14,087			$11,354	$2,838	$14,192

CHIEF, COST ENGINEERING, Tracy T. Leeser, P.E.

PROJECT MANAGER, Daniel Haubner, P.E.

CHIEF, REAL ESTATE, John Baker

CHIEF, PLANNING,xxx

CHIEF, ENGINEERING, xxx

CHIEF, OPERATIONS, xxx

CHIEF, CONSTRUCTION, xxx

CHIEF, CONTRACTING,xxx

CHIEF, PM-PB, xxxx

CHIEF, DPM, xxx

ESTIMATED FEDERAL COST:	46.58%	$6,612
ESTIMATED NON-FEDERAL COST:	53.42%	$7,580
ESTIMATED TOTAL PROJECT COST:		$14,192

**** TOTAL PROJECT COST SUMMARY ****

**** CONTRACT COST SUMMARY ****

PROJECT: Shore Protection Project
LOCATION: Martin County, Florida
This Estimate reflects the scope and schedule in report; Limited Revaluation Report (LRR)

DISTRICT: SAJ PREPARED: 12/3/2010
POC: CHIEF, COST ENGINEERING, Tracy T. Leeser, P.E.

	Estimate Prepared: Effective Price Level:	30-Sep-10 1 OCT 10				Program Year (Budget EC): Effective Price Level Date:			2039 1 OCT 38	FULLY FUNDED PROJECT ESTIMATE				
WBS NUMBER *A*	Civil Works Feature & Sub-Feature Description *B*	COST ($K) *C*	CNTG ($K) *D*	CNTG (%) *E*	TOTAL ($K) *F*	ESC (%) *G*	COST ($K) *H*	CNTG ($K) *I*	TOTAL ($K) *J*	Mid-Point Date *P*	ESC (%) *L*	COST ($K) *M*	CNTG ($K) *N*	FULL ($K) *O*
	RENOURISHMENT INTERVAL 43 (2038)													
06	FISH & WILDLIFE FACILITIES	$120	$30	25%	$150	58.0%	$190	$47	$237	2037Q3	0.9%	$191	$48	$239
17	BEACH REPLENISHMENT	$5,743	$1,436	25%	$7,179	58.8%	$9,118	$2,279	$11,397	2037Q3	0.9%	$9,201	$2,300	$11,501
	CONSTRUCTION ESTIMATE TOTALS:	$5,863	$1,466	25%	$7,329		$9,308	$2,327	$11,634			$9,392	$2,348	$11,740
01	LANDS AND DAMAGES	$5	$1	25%	$6	58.0%	$8	$2	$10	2037Q1		$8	$2	$10
30	PLANNING, ENGINEERING & DESIGN													
	District PED Functions	$200	$50	25%	$250	104.2%	$408	$102	$510	2037Q1		$408	$102	$510
31	CONSTRUCTION MANAGEMENT													
	Construction Management (& EDC)	$757	$189	25%	$946	104.2%	$1,546	$386	$1,932	2037Q3		$1,546	$386	$1,932
	Project Operation:													
	Project Management													
	CONTRACT COST TOTALS:	$6,825	$1,706		$8,531		$11,269	$2,817	$14,087			$11,354	$2,838	$14,192

A.8 COST DX TPCS CERTIFICATION

SAJ MARTIN COUNTY SHORELINE PROTECTION PROJECT
USACE- JACKSONVILLE DISTRICT

COST ENGINEERING DX - TPCS ATR CERTIFICATION

The Walla Walla Cost Dx representatives have provided an adequate Agency Technical Review (ATR) of the 2012 Budget and Total Project Cost, studying the project scope, report, cost estimates, schedules, escalation, and risk-based contingencies in accordance with ER 1110-2-1150 Engineering and Design for Civil Works Projects and ER 1110-2-1302 Civil Works Cost Engineering.

As of 15 December 2010, the Walla Walla District, Cost Engineering Directory of Expertise (Dx) for Civil Works, certifies the Martin County Shoreline Protection project as presented by USACE Jacksonville District. The Cost DX agency technical review (ATR) resulted in the total project cost estimated values of:

RENOURISHMENT 2012:

FY 2012 Price Level:	$10,358,000
Fully Funded Amount:	$10,402,000 excluding spent costs

It remains the responsibility of the District to correctly reflect these cost values within the Final Report.

15 DEC 2010
Date

John P. Skarbek
Chief, Cost Engineering
Walla Walla District

APPENDIX C-2A

PROJECT COST AND SCHEDULE RISK ANALYSIS REPORT

US Army Corps
of Engineers®

Martin County Shore Protection Project
Limited Reevaluation Report (LRR)
Revised Beach Renourishment Plan
Project Cost and Schedule Risk Analysis Report

Prepared for:
U.S. Army Corps of Engineers,
Jacksonville District

Prepared by:
U.S. Army Corps of Engineers
Cost Engineering Directory of Expertise, Walla Walla

December 14, 2010

THIS PAGE INTENTIONALLY LEFT BLANK

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

EXECUTIVE SUMMARY

Under the auspices of the US Army Corps of Engineers (USACE), Jacksonville District, this report presents a recommendation for the total project cost and schedule contingencies for the Martin County Shore Protection Project (SPP) Limited Reevaluation Report (LRR), Revised Beach Renourishment Plan. In compliance with Engineer Regulation (ER) 1110-2-1302 CIVIL WORKS COST ENGINEERING, dated September 15, 2008, a formal risk analysis study was conducted for the development of contingency on the total project cost. The purpose of this risk analysis study was to establish project contingencies by identifying and measuring the cost and schedule impact of project uncertainties with respect to the estimated total project cost. Specific to the Martin County SPP, the most likely total project cost (at price level) is estimated at approximately $24 Million. Based on the results of the analysis, the **Cost Engineering Directory of Expertise for Civil Works (Walla Walla District) recommends a contingency value of $6 Million, or 25%. This contingency includes $1 Million (4%) for cost growth potential due to risk analyzed in the base cost estimate and $5 Million (21%) for cost growth potential due to risk analyzed in the baseline schedule.**

Walla Walla Cost Dx performed risk analysis using the *Monte Carlo* technique, producing the aforementioned contingencies and identifying key risk drivers.

The following table ES-1 portrays the development of contingencies. The contingency is based on an 80% confidence level, as per USACE Civil Works guidance.

Table ES-1. Contingency Analysis Table

Most Likely Cost Estimate	**$23,832,817**	
Confidence Level	**Value ($$)**	**Contingency (%)**
5%	$24,984,185	4.83%
50%	$27,716,086	16.29%
80%	**$29,707,491**	**24.65%**
95%	$32,035,914	34.42%

The following table ES-2 portrays the full costs of the recommended alternative based on the anticipated contracts. The costs are intended to address the congressional request of estimates to implement the project. The contingency is based on an 80% confidence level, as per accepted USACE Civil Works guidance.

Table ES-2. Cost Summary

MARTIN COUNTY SPP		**COST**	**CNTG**	**TOTAL**
		($1,000)	**($1,000)**	**($1,000)**
01	LANDS AND DAMAGES	15	4	19
06	FISH AND WILDLIFE FACILITIES	360	89	449
17	BEACH REPLENISHMENT	20,587	5,075	25,661
30	PLANNING, ENGINEERING AND DESIGN	600	148	748

31	CONSTRUCTION MANAGEMENT	2,271	560	2,831
	TOTAL PROJECT COSTS	**23,833**	**5,875**	**29,707**
	Schedule Completion with Contingency	**19 Mar 2039**	**142 months**	**23 Feb 2043**

Notes:
1) All costs include the recommended contingency of 25%.
2) Costs exclude O&M and Life Cycle Cost estimates.

C.0

KEY FINDINGS/OBSERVATIONS RECOMMENDATIONS

The key cost risk drivers identified through sensitivity analysis were Risks CON-1 (Change Orders During Construction) and EST-1 (Production Estimates), which together contribute 33 percent of the statistical cost variance. CON-1 (Change Orders During Construction) represents the concern that post-award changes may increase project costs. EST-1 (Production Estimates) represents the concern that inaccurate assumptions used for estimating dredging production may increase project costs.

The key schedule risk driver identified through sensitivity analysis is Risk PPM-1 (Project Review Authorization delays), Risk PR-3 (Court Injunctions), EST-3 (Equipment Availability), and PR-1 (Borrow Area MMS Tri-Party Agreement), which together contribute 45 percent of the statistical schedule variance. Risk PPM-1 (Project Review Authorization delays) represents the concern that protracted review and approval of project documents may cause cost overruns and schedule delay. Risk PR-3 (Court Injunctions) represents the concern that legal injunctions may cause significant delay in project implementation. EST-3 (Equipment Availability) represents the concern that availability of the most efficient floating plant to perform the project could cause inefficiencies or delay in completion of work. PR-1 (Borrow Area MMS Tri-Party Agreement) represents the concern that finalizing the Memorandum of Agreement (MOA), which requires approval by multiple agencies, could experience delay.

Recommendations, as detailed within the main report, include the implementation of cost and schedule contingencies, further iterative study of risks throughout the project life-cycle, potential mitigation throughout the PED phase, and proactive monitoring and control of risk identified in this study.

D.0 MAIN REPORT

E.0 1.0 PURPOSE

Under the auspices of the US Army Corps of Engineers (USACE), Jacksonville District, this report presents a recommendation for the total project cost and schedule contingencies for the Martin County Shore Protection Project (SPP) Limited Reevaluation Report (LRR), Revised Beach Renourishment Plan.

F.0 2.0 BACKGROUND

Specific to the Martin County Shore Protection Project, Revised Beach Renourisment Plan, this estimate is for placing sand on the Martin County beach using two 30-inch cutterhead dredges. Dredging is only allowed during three months of the year. For these estimates, it a bank of 6-feet was assumed. The renourishment estimates assumed that in the future, the borrow area would be maintained to keep a minimum bank of 6-feet.

The estimate serving the basis for this analysis was updated the cost for a single Beach Renourishment event to current FY 2008 prices. The updated dredging and beach fill cost were based on using one Medium Hopper Dredge with pump out capability verses the 30-inch cutterhead pipeline dredge used in the original GRR cost estimate. This change is due to the further distance of the proposed new offshore borrow area than the original borrow area. Production for the hopper dredge and beach fill was based on a previous Beach Renourishment contract administered on this project during 2005 using the Medium Hopper Dredge DODGE ISLAND.

As a part of this effort, Jacksonville District requested that the USACE Cost Engineering Directory of Expertise for Civil Works (Cost Engineering Dx) provide an agency technical review (ATR) of the cost estimate and schedule for Recommended Project Plan. That tasking also included providing a risk analysis study to establish the resulting contingencies.

G.0 3.0 REPORT SCOPE

The scope of the risk analysis report is to calculate and present the cost and schedule contingencies at the 80 percent confidence level using the risk analysis processes, as mandated by U.S. Army Corps of Engineers (USACE) Engineer Regulation (ER) 1110-2-1150, Engineering and Design for Civil Works, ER 1110-2-1302, Civil Works Cost Engineering, and Engineer Technical Letter 1110-2-573, Construction Cost Estimating Guide for Civil Works. The report presents the contingency results for cost risks for all project features. The study and presentation does not include consideration for life cycle costs.

3.1 Project Scope

The formal process included extensive involvement of the PDT for risk identification and the development of the risk register. The analysis process evaluated the most likely Micro Computer Aided Cost Estimating System (MCACES) cost estimate, schedule, and funding profiles using Crystal Ball software to conduct a *Monte Carlo* simulation and statistical sensitivity analysis, per the guidance in Engineer Technical Letter (ETL) CONSTRUCTION COST ESTIMATING GUIDE FOR CIVIL WORKS, dated September 30, 2008**.**
The project technical scope, estimates and schedules were developed and presented by the Jacksonville District. Consequently, these documents serve as the basis for the risk analysis. The scope of this study addresses the identification of problems, needs, opportunities and potential solutions that are viable from an economic, environmental, and engineering viewpoint.

3.2 USACE Risk Analysis Process

The risk analysis process for this study follows the USACE Headquarters requirements as well as the guidance provided by the Cost Engineering Dx. The risk analysis process reflected within this report uses probabilistic cost and schedule risk analysis methods within the framework of the Crystal Ball software. Furthermore, the scope of the report includes the identification and communication of important steps, logic, key assumptions, limitations, and decisions to help ensure that risk analysis results can be appropriately interpreted.

Risk analysis results are also intended to provide project leadership with contingency information for scheduling, budgeting, and project control purposes, as well as to provide tools to support decision making and risk management as the project progresses through planning and implementation. To fully recognize its benefits, cost and schedule risk analysis should be considered as an ongoing process conducted concurrent to, and iteratively with, other important project processes such as scope and execution plan development, resource planning, procurement planning, cost estimating, budgeting and scheduling.

In addition to broadly defined risk analysis standards and recommended practices, this risk analysis was performed to meet the requirements and recommendations of the following documents and sources:

- Cost and Schedule Risk Analysis Process guidance prepared by the USACE Cost Engineering Dx.
- Engineer Regulation (ER) 1110-2-1302 CIVIL WORKS COST ENGINEERING, dated September 15, 2008.
- Engineer Technical Letter (ETL) CONSTRUCTION COST ESTIMATING GUIDE FOR CIVIL WORKS, dated September 30, 2008.

H.0 4.0 METHODOLOGY / PROCESS

The Jacksonville cost engineer facilitated a risk identification and qualitative analysis meeting the Jacksonville PDT on September 1, 2010. The initial risk identification meeting also included qualitative analysis to produce a risk register that served as the framework for the risk analysis.

The Jacksonville cost engineer assisted in the creation of the cost and schedule risk analysis models, and obtained the assistance of the Walla Walla Cost Dx to complete the analysis and the report.

The initial cost and schedule risk models were completed and results reported on September 28, 2010. Revisions and iterations of the cost and schedule risk model took place between September 28, 2010 and October 14, 2010. The final results were completed and reported on October 14, 2010.

The risk analysis process for this study is intended to determine the probability of various cost outcomes and quantify the required contingency needed in the cost estimate to achieve any desired level of cost confidence.

In simple terms, contingency is an amount added to an estimate to allow for items, conditions or events for which the occurrence or impact is uncertain and that experience suggests will likely result in additional costs being incurred or additional time being required. The amount of contingency included in project control plans depends, at least in part, on the project leadership's willingness to accept risk of project overruns. The less risk that project leadership is willing to accept the more contingency should be applied in the project control plans. The risk of overrun is expressed, in a probabilistic context, using confidence levels.

The Cost Dx guidance for cost and schedule risk analysis generally focuses on the 80-percent level of confidence (P80) for cost contingency calculation. It should be noted that use of P80 as a decision criteria is a risk averse approach (whereas the use of P50 would be a risk neutral approach, and use of levels less than 50 percent would be risk seeking). Thus, a P80 confidence level results in greater contingency as compared to a P50 confidence level. The selection of contingency at a particular confidence level is ultimately the decision and responsibility of the project's District and/or Division management.

The risk analysis process uses *Monte Carlo* techniques to determine probabilities and contingency. The *Monte Carlo* techniques are facilitated computationally by a commercially available risk analysis software package (Crystal Ball) that is an add-in to Microsoft Excel. Cost estimates are packaged into an Excel format and used directly for cost risk analysis purposes. The level of detail recreated in the Excel-format schedule is sufficient for risk analysis purposes that reflect the established risk register, but generally less than that of the native format.

The primary steps, in functional terms, of the risk analysis process are described in the following subsections. Risk analysis results are provided in Section 6.

A.1

A.2 4.1 IDENTIFY AND ASSESS RISK FACTORS

Identifying the risk factors via the PDT is considered a qualitative process that results in establishing a risk register that serves as the document for the quantitative study using the Crystal Ball risk software. Risk factors are events and conditions that may influence or drive uncertainty in project performance. They may be inherent characteristics or conditions of the project or external influences, events, or conditions such as weather or economic conditions. Risk factors may have either favorable or unfavorable impacts on project cost and schedule.

Checklists or historical databases of common risk factors are sometimes used to facilitate risk factor identification. However, key risk factors are often unique to a project and not readily derivable from historical information. Therefore, input from the entire PDT was obtained using creative processes such as brainstorming or other facilitated risk assessment meetings.

Formal PDT meetings were held for the purposes of identifying and assessing risk factors. The formal meeting conducted on September 1, 2010 included the following:

No.	Name	Section	Title
1	Randy Murray	EN-C	Cost Engineer
2	Brian Blake	EN-C	Cost Estimator
3	Brian Hughes	EN-DW	Project Engineer
4	Tamela Kinsey	PD-EQ	Environmental Planning
5	Mariane Gruber	EN-GG	Project Geologist
6	Marty Durkin	PD-PN	Project Planning Lead
7	Dan Peck	PD-D	Economist
8	Dan Haubner	DP-C	Project Manager
9	Kathy Fitzpatrick	Martin Co.	Local Sponsor Representative
10	Paul Demarco	PD-EC	Environmental Planning
11	Son Vu	CD-M	Construction Management

The initial formal meetings focused primarily on risk factor identification using brainstorming techniques, but also included some facilitated discussions based on risk factors common to projects of similar scope and geographic location. Subsequent meetings focused primarily on risk factor assessment and quantification.

A.3 4.2 QUANTIFY RISK FACTOR IMPACTS

The quantitative impacts of risk factors on project plans were analyzed using a combination of professional judgment, empirical data and analytical techniques. Risk factor impacts were quantified using probability distributions (density functions) because risk factors are entered into the Crystal Ball software in the form of probability density functions.

Similar to the identification and assessment process, risk factor quantification involved multiple project team disciplines and functions. However, the quantification process relied more extensively on collaboration between cost engineering and risk analysis team members with lesser inputs from other functions and disciplines. This process used an iterative approach to estimate the following elements of each risk factor:

- Maximum possible value for the risk factor

- Minimum possible value for the risk factor
- Most likely value (the statistical mode), if applicable
- Nature of the probability density function used to approximate risk factor uncertainty
- Mathematical correlations between risk factors
- Affected cost estimate and schedule elements

The resulting product from the PDT discussions is captured within a risk register as presented in section 6 for both cost and schedule risk concerns. Note that the risk register records the PDT's risk concerns, discussions related to those concerns, and potential impacts to the current cost and schedule estimates. The concerns and discussions support the team's decisions related to event likelihood, impact, and the resulting risk levels for each risk event.

A.4

A.5 4.3 ANALYZE COST ESTIMATE AND SCHEDULE CONTINGENCY

Contingency is analyzed using the Crystal Ball software, an add-in to the Microsoft Excel format of the cost estimate and schedule. *Monte Carlo* simulations are performed by applying the risk factors (quantified as probability density functions) to the appropriate estimated cost and schedule elements identified by the PDT. Contingencies are calculated by applying only the moderate and high level risks identified for each option (i.e., low-level risks are typically not considered, but remain within the risk register to serve historical purposes as well as support follow-on risk studies as the project and risks evolve).

For the cost estimate, the contingency is calculated as the difference between the P80 cost forecast and the baseline cost estimate. Each option-specific contingency is then allocated on a civil works feature level based on the dollar-weighted relative risk of each feature as quantified by *Monte Carlo* simulation. Standard deviation is used as the feature-specific measure of risk for contingency allocation purposes. This approach results in a relatively larger portion of all the project feature cost contingency being allocated to features with relatively higher estimated cost uncertainty.

I.0 5.0 PROJECT ASSUMPTIONS

The following data sources and assumptions were used in quantifying the costs associated with the with- and without-project conditions at Tampa Harbor.

a. The MII MCACES (Micro-Computer Aided Cost Estimating Software) file "BMA107-MII FINAL PLAN WO CONT.mlp" was the basis for the cost and schedule risk analyses.

b. The cost comparisons and risk analyses performed and reflected within this report are based on design scope and estimates that are at the feasibility level.

c. The schedule was analyzed for impact to the project cost in terms of both uncaptured escalation (variance from OMB factors and the local market) and monthly recurring costs (unavoidable fixed contract costs and/or languishing federal administration costs incurred throughout delay).

d. Per the CWCCIS Historical State Adjustment Factors in EM 1110-2-1304, State Adjustment Factor for Florida is 0.92, meaning that this project is not susceptible to differential between the local market and OMB inflation factors for future construction.

e. Per the data in the estimate, the Job Office Overhead (JOOH) amount for the Contract Cost comprises approximately 10% of the Project Cost at Baseline. Thus, the assumed monthly recurring rate for this project is 10%. For the P80 schedule, this comprises approximately 21.17% of the total contingency due to the accrual of residual fixed costs associated with delay.

f. The Cost Dx guidance generally focuses on the eighty-percent level of confidence (P80) for cost contingency calculation. For this risk analysis, the eighty-percent level of confidence (P80) was used. It should be noted that the use of P80 as a decision criteria is a moderately risk averse approach, generally resulting in higher cost contingencies. However, the P80 level of confidence also assumes a small degree of risk that the recommended contingencies may be inadequate to capture actual project costs.

g. Only high and moderate risk level impacts, as identified in the risk register, were considered for the purposes of calculating cost contingency. Low level risk impacts should be maintained in project management documentation, and reviewed at each project milestone to determine if they should be placed on the risk "watch list" for further monitoring and evaluation.

J.0 **6.0 RESULTS**

The cost and schedule risk analysis results are provided in the following sections. In addition to contingency calculation results, sensitivity analyses are presented to provide decision makers with an understanding of variability and the key contributors to the cause of this variability.

A.1 **6.1 RISK REGISTER**

A risk register is a tool commonly used in project planning and risk analysis. The actual risk register is provided in Appendix A. The complete risk register includes low level risks, as well as additional information regarding the nature and impacts of each risk.

It is important to note that a risk register can be an effective tool for managing identified risks throughout the project life cycle. As such, it is generally recommended that risk registers be updated as the designs, cost estimates, and schedule are further refined, especially on large projects with extended schedules. Recommended uses of the risk register going forward include:

- Documenting risk mitigation strategies being pursued in response to the identified risks and their assessment in terms of probability and impact.

- Providing project sponsors, stakeholders, and leadership/management with a documented framework from which risk status can be reported in the context of project controls.
- Communicating risk management issues.
- Providing a mechanism for eliciting feedback and project control input.
- Identifying risk transfer, elimination, or mitigation actions required for implementation of risk management plans.

6.2 Cost Contingency and Sensitivity Analysis

Table 1 provides the raw construction cost contingencies calculated for the P80 confidence level and rounded to the nearest thousand. The construction cost contingencies for the P50 and P100 confidence levels are also provided for illustrative purposes only.

Contingency was quantified as approximately $5.9 Million at the P80 confidence level (25% of the baseline cost estimate). For comparison, the cost contingency at the P50 and P100 confidence levels was quantified as 16% and 63% of the baseline cost estimate, respectively.

Table 1. Project Cost Contingency Summary

Risk Analysis Forecast	Baseline Estimate	Project Contingency[1,2] ($)	Total Contingency (%)
50% Confidence Level			
Project Cost	$23,832,817	$3,883,269	16.29%
80% Confidence Level			
Project Cost	$23,832,817	$5,874,673	24.65%
100% Confidence Level			
Project Cost	$23,832,817	$15,003,553	62.95%

Notes:
1) These figures combine uncertainty in the baseline cost estimates and schedule.
2) A P100 confidence level is an abstract concept for illustration only, as the nature of risk and uncertainty (specifically the presence of "unknown unknowns") makes 100% confidence a theoretical impossibility.

A.1.1 6.2.1 Sensitivity Analysis

Sensitivity analysis generally ranks the relative impact of each risk/opportunity as a percentage of total cost uncertainty. The Crystal Ball software uses a statistical measure (contribution to variance) that approximates the impact of each risk/opportunity contributing to variability of cost outcomes during *Monte Carlo* simulation.

Key cost drivers identified in the sensitivity analysis can be used to support development of a risk management plan that will facilitate control of risk factors and their potential impacts throughout the project lifecycle. Together with the risk register, sensitivity analysis results can also be used to support development of strategies to eliminate, mitigate, accept or transfer key risks.

A.1.2

A.1.3 6.2.2 Sensitivity Analysis Results

The risks/opportunities considered as key or primary cost drivers are ranked in order of importance in contribution to variance bar charts. Opportunities that have a potential to reduce project cost and are shown with a negative sign; risks are shown with a positive sign to reflect the potential to increase project cost. A longer bar in the sensitivity analysis chart represents a greater potential impact to total project cost.

Figure 1 presents a sensitivity analysis for cost growth risk from the high level cost risks identified in the risk register. Likewise, Figure 2 presents a sensitivity analysis for schedule growth risk from the high level schedule risks identified in the risk register.

6.3 Schedule and Contingency Risk Analysis

Table 2 provides the schedule duration contingencies calculated for the P80 confidence level. The schedule duration contingencies for the P50 and P100 confidence levels are also provided for illustrative purposes.

The Martin County SPP includes three renourishment activities, scheduled to begin in 2012, 2025, and 2038. Schedule duration contingency was quantified as 47 months for each renourishment activity based on the P80 level of confidence. These contingencies were used to calculate the projected monthly recurring cost impact of project delays that are included in the Table 1 presentation of total cost contingency. The schedule contingencies were calculated by applying the high level schedule risks identified in the risk register for each option to the durations of critical path and near critical path tasks.

The schedule was not resource loaded and contained open-ended tasks and non-zero lags (gaps in the logic between tasks) that limit the overall utility of the schedule risk analysis. These issues should be considered as limitations in the utility of the schedule contingency data presented. Schedule contingency impacts presented in this analysis are based solely on projected monthly recurring costs.

Table 2. Schedule Duration Contingency Summary

Risk Analysis Forecast	Baseline Schedule Duration (months)	Contingency[1] (months)	Contingency (%)
50% Confidence Level			
Total Project Duration	67	31	47%
80% Confidence Level			
Total Project Duration	67	47	71%
100% Confidence Level			
Total Project Duration	67	122	182%

Notes:

---

1) The schedule was not resource loaded and contained open-ended tasks and non-zero lags (gaps in the logic between tasks) that limit the overall utility of the schedule risk analysis. These issues should be considered as limitations in the utility of the schedule contingency data presented in Table 2.

2) A P100 confidence level is an abstract concept for illustration only, as the nature of risk and uncertainty (specifically the presence of "unknown unknowns") makes 100% confidence a theoretical impossibility.

Figure 1. Cost Sensitivity Analysis

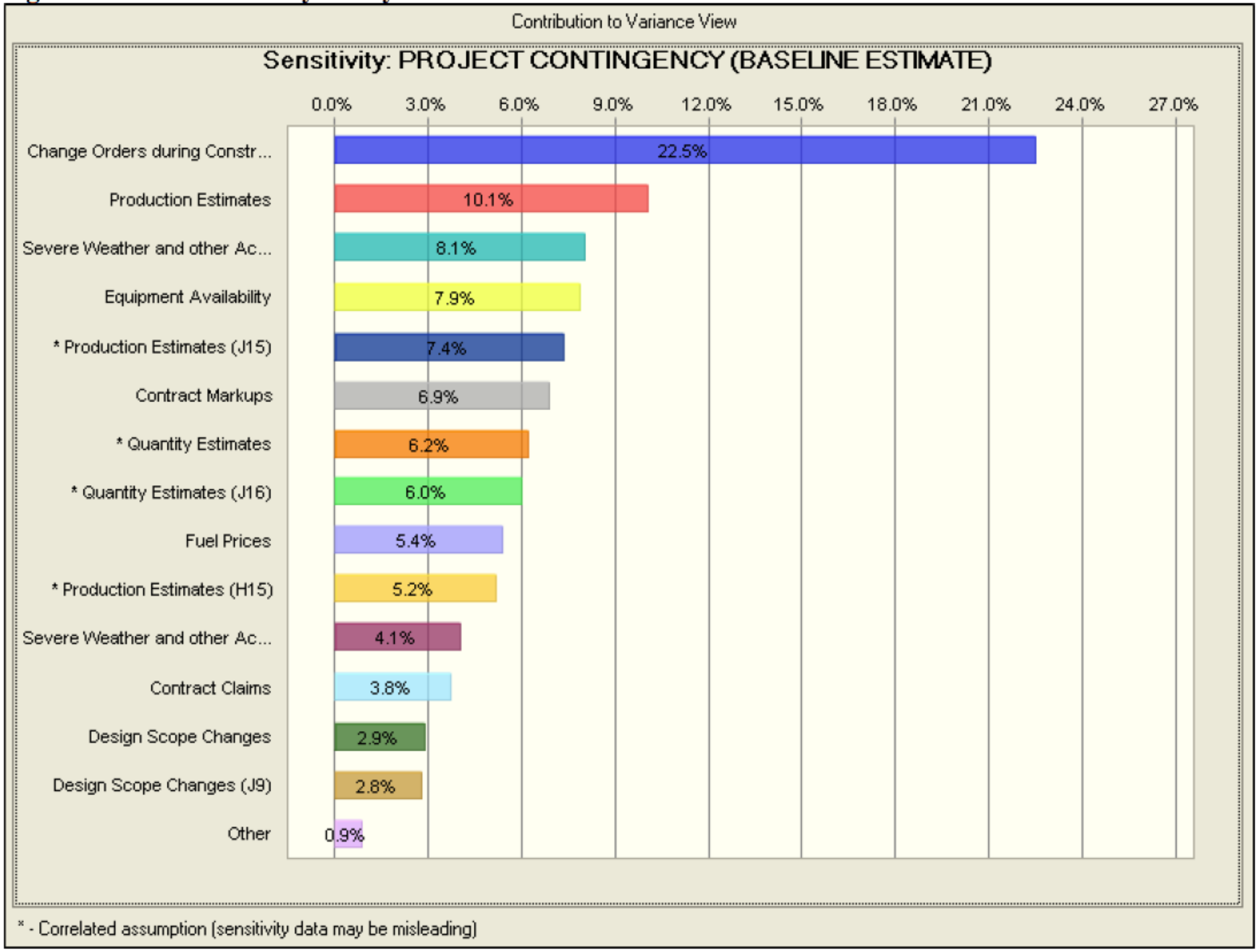
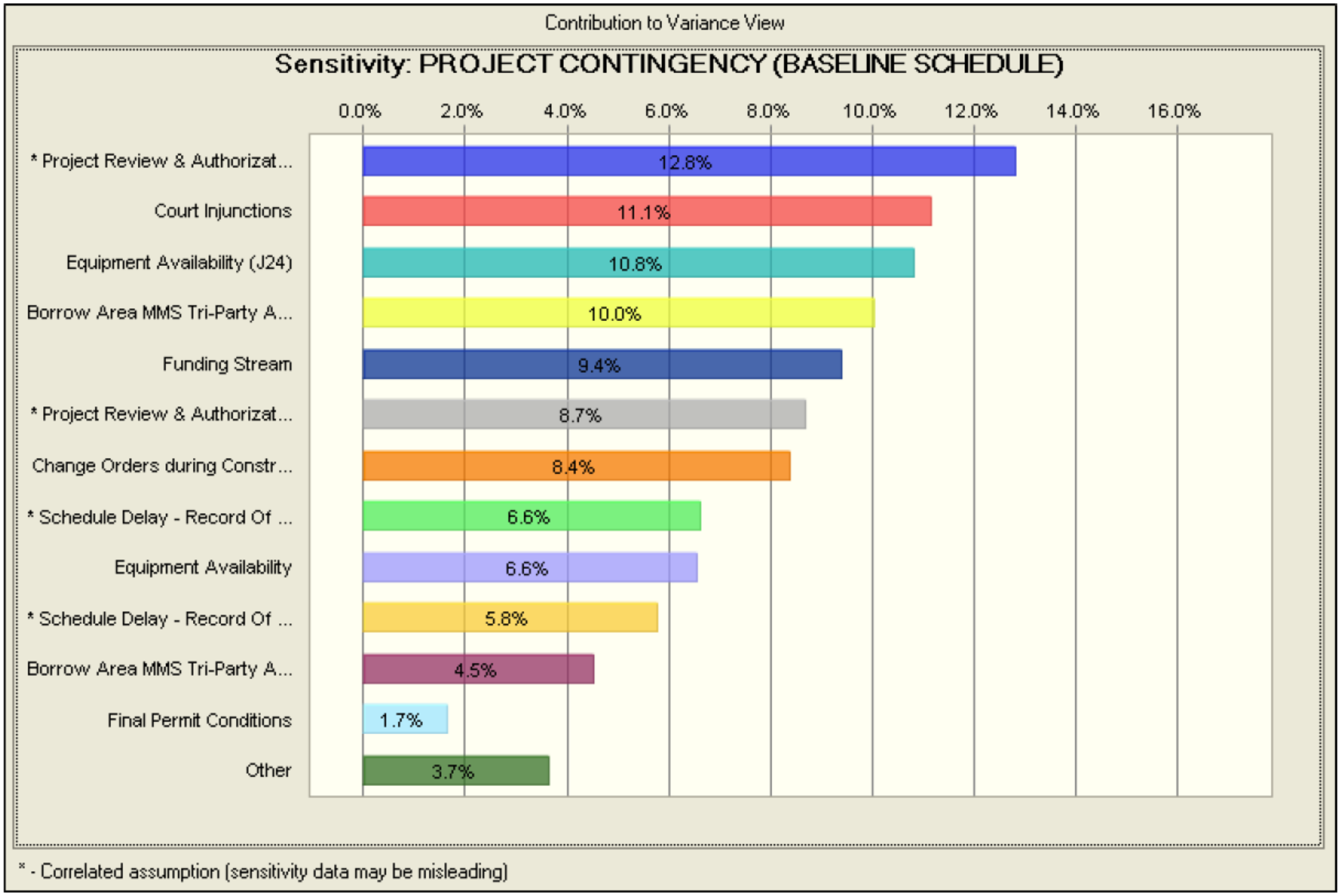


Figure 2. Schedule Sensitivity Analysis



K.0 7.0 MAJOR FINDINGS/OBSERVATIONS/RECOMMENDATIONS

This section provides a summary of significant risk analysis results that are identified in the preceding sections of the report. Risk analysis results are intended to provide project leadership with contingency information for scheduling, budgeting, and project control purposes, as well as to provide tools to support decision making and risk management as projects progress through planning and implementation. Because of the potential for use of risk analysis results for such diverse purposes, this section also reiterates and highlights important steps, logic, key assumptions, limitations, and decisions to help ensure that the risk analysis results are appropriately interpreted.

A.1 7.1 MAJOR FINDINGS/OBSERVATIONS

Total project cost comparison summaries are provided in Table 3 and Figure 3. Additional major findings and observations of the risk analysis are listed below.

1. The key cost risk drivers identified through sensitivity analysis were Risks CON-1 (Change Orders During Construction) and EST-1 (Production Estimates), which together contribute 33 percent of the statistical cost variance. CON-1 (Change Orders During Construction) represents the concern that post-award changes may increase project costs. EST-1 (Production Estimates) represents the concern that inaccurate assumptions used for estimating dredging production may increase project costs.

2. The key schedule risk driver identified through sensitivity analysis is Risk PPM-1 (Project Review Authorization delays), Risk PR-3 (Court Injunctions), EST-3 (Equipment Availability), and PR-1 (Borrow Area MMS Tri-Party Agreement), which together contribute 45 percent of the statistical schedule variance. Risk PPM-1 (Project Review Authorization delays) represents the concern that protracted review and approval of project documents may cause cost overruns and schedule delay. Risk PR-3 (Court Injunctions) represents the concern that legal injunctions may cause significant delay in project implementation. EST-3 (Equipment Availability) represents the concern that availability of the most efficient floating plant to perform the project could cause inefficiencies or delay in completion of work. PR-1 (Borrow Area MMS Tri-Party Agreement) represents the concern that finalizing the Memorandum of Agreement (MOA), which requires approval by multiple agencies, could experience delay.

3. The schedule was not resource loaded and contains open-ended tasks, and non-zero lags (gaps in the logic between tasks) that limit the overall utility of the schedule risk analysis. These issues should be considered as limitations in the utility of the schedule contingency data presented. Schedule contingency impacts presented in this analysis are based solely on projected monthly recurring costs. Resource impacts related to potential schedule delays could not be evaluated.

4. Operation and maintenance activities were not included in the cost estimate or schedules. Therefore, a full lifecycle risk analysis could not be performed. Risk analysis results or conclusions could be significantly different if the necessary operation and maintenance activities were included.

Table 3. Project Cost Comparison Summary

Confidence Level	Project Cost ($)	Contingency (%)
P0	$22,396,932	-6.02%
P5	$24,984,185	4.83%
P10	$25,503,499	7.01%
P15	$25,881,406	8.60%
P20	$26,174,507	9.83%
P25	$26,460,457	11.03%
P30	$26,717,325	12.10%
P35	$26,982,833	13.22%
P40	$27,227,619	14.24%
P45	$27,463,560	15.23%
P50	$27,716,086	16.29%
P55	$27,967,622	17.35%
P60	$28,243,794	18.51%
P65	$28,554,591	19.81%
P70	$28,864,577	21.11%
P75	$29,245,023	22.71%
P80	$29,707,491	24.65%
P85	$30,203,569	26.73%
P90	$30,923,188	29.75%
P95	$32,035,914	34.42%
P100	$38,836,370	62.95%

Figure 3. Project Cost Summary

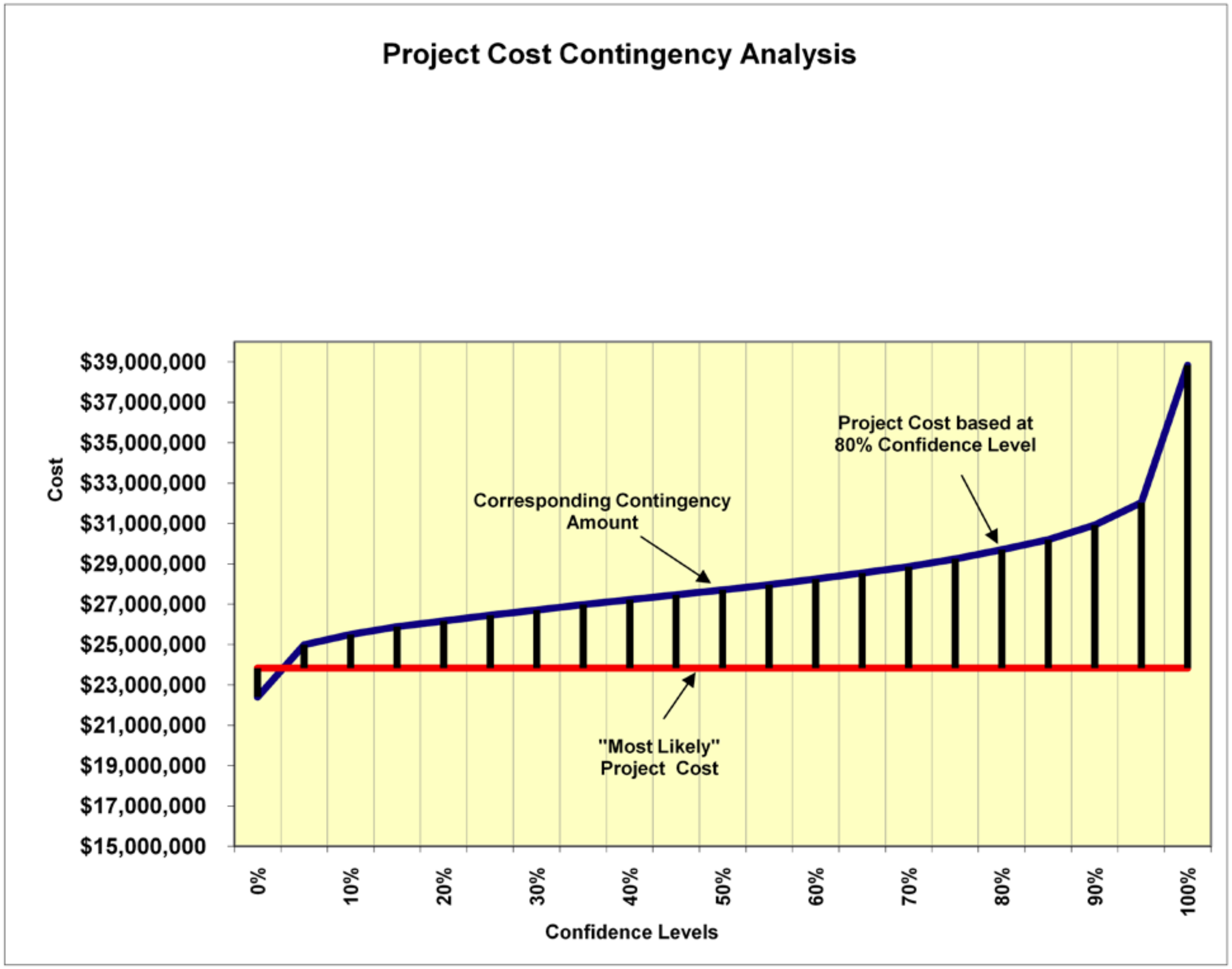
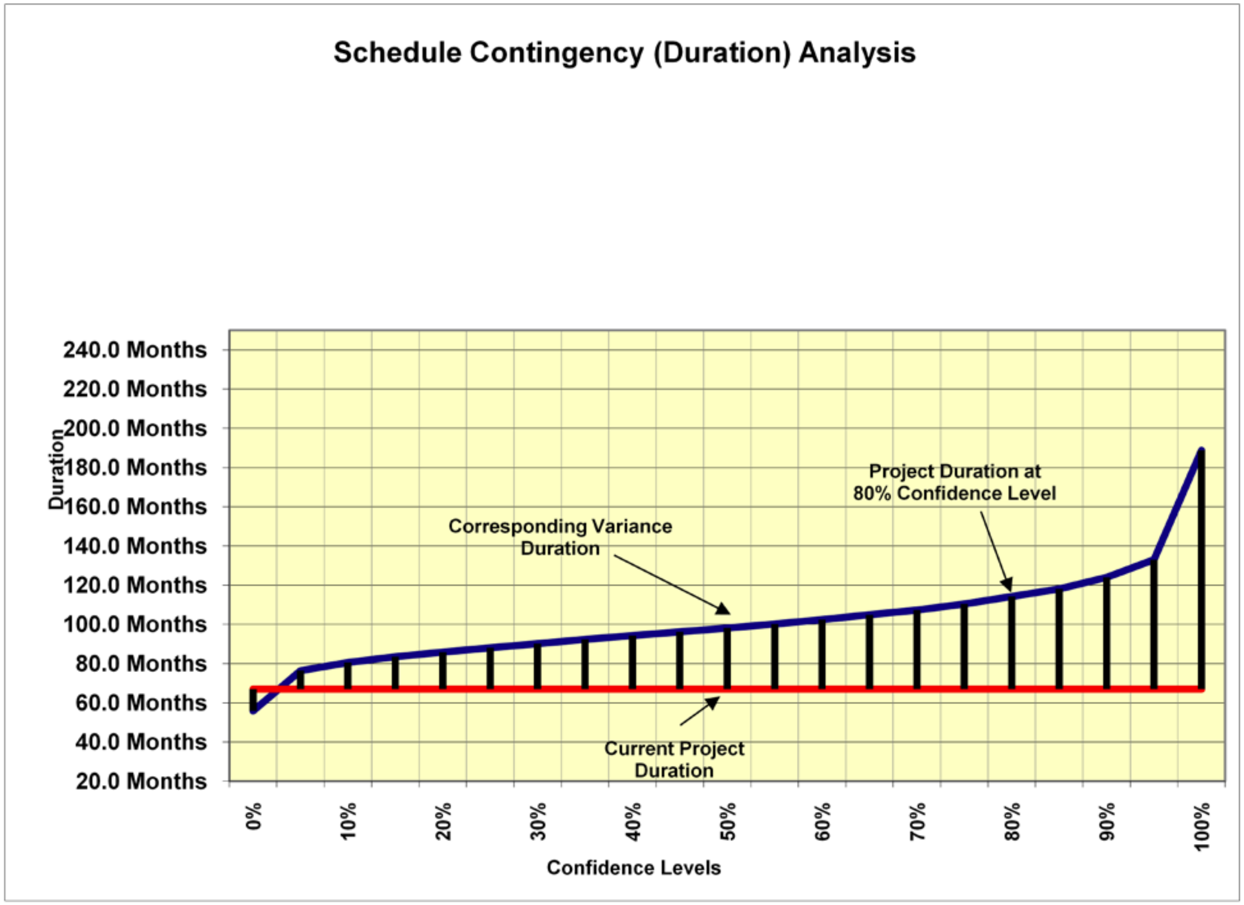


Figure 4. Project Duration Summary



A.2 7.2 RECOMMENDATIONS

Risk Management is an all-encompassing, iterative, and life-cycle process of project management. The Project Management Institute's (PMI) *A Guide to the Project Management Body of Knowledge (PMBOK® Guide)*, *4th edition*, states that "project risk management includes the processes concerned with conducting risk management planning, identification, analysis, responses, and monitoring and control on a project." Risk identification and analysis are processes within the knowledge area of risk management. Its outputs pertinent to this effort include the risk register, risk quantification (risk analysis model), contingency report, and the sensitivity analysis.

The intended use of these outputs is implementation by the project leadership with respect to risk responses (such as mitigation) and risk monitoring and control. In short, the effectiveness of the project risk management effort requires that proactive management of risks does not conclude with the study completed in this report.

The Cost and Schedule Risk Analysis (CSRA) produced by the PDT identifies issues that require the development of subsequent risk response and mitigation plans. This section provides a list of recommendations for continued management of the risks identified and analyzed in this study. Note that this list is not all inclusive and should not substitute a formal risk management and response plan.

1. Key Cost Risk Drivers: The key cost risk drivers identified through sensitivity analysis were Risks CON-1 (Change Orders During Construction) and EST-1 (Production Estimates), which together contribute 33 percent of the statistical cost variance.

> a) Change Orders During Construction: Project leadership should emphasize quality during the PED phase, as well as proactive monitoring control for the duration of the project. Formal change control should also be implemented and maintained throughout the project.
>
> b) Production Estimates: Project leadership should attempt to confirm the condition of the material and the factors that will ultimately drive effective work time for dredging during the construction of the project. This factor could be a risk or an opportunity, as the estimates rely heavily on the conditions for dredging configurations.

2. Key Schedule Risk Drivers: The key schedule risk driver identified through sensitivity analysis is Risk PPM-1 (Project Review Authorization Delays), Risk PR-3 (Court Injunctions), EST-3 (Equipment Availability), and PR-1 (Borrow Area MMS Tri-Party Agreement), which together contribute 45 percent of the statistical schedule variance.

> a) Project Review Authorization Delays Schedule Delay: Project leadership should take proactive measures with respect to the schedule and the timeline for budget approval and

disbursement of project funds. Changes to the anticipated timeline with respect to schedule should be controlled and reported to management for expeditious schedule recovery efforts. Ultimately, this is an external risk, and its impacts must be communicated to management, and funds should be maintained in project reserve for treatment of this risk.

b) Court Injunctions: Project leadership should attempt to communicate and coordinate effectively with District management and the other involved project partners and sponsors. Ultimately, this is an external risk, and its impacts must be communicated to management, and funds should be maintained in project reserve for treatment of this risk.

c) Equipment Availability: The PDT should conduct market research to determine the regional trends regarding the availability of equipment to meet the requirements in parallel to the general market research being conducted. The PDT may also consider changing the engineering requirements or methodologies to increase competition and/or the likelihood of equipment being available.

d) Borrow Area MMS Tri-Party Agreement: Project leadership proactively coordinate and communicate with District management and the other involved project partners and sponsors with the goal of developing and expediting the Tri-Party Agreement (Memorandum of Agreement). Ultimately, an amount and duration for this issue should be included and protected within the contingency and/or management reserve.

3. Risk Management: Project leadership should use of the outputs created during the risk analysis effort as tools in future risk management processes. The risk register should be updated at each major project milestone. The results of the sensitivity analysis may also be used for response planning strategy and development. These tools should be used in conjunction with regular risk review meetings.

4. Risk Analysis Updates: Project leadership should review risk items identified in the original risk register and add others, as required, throughout the project life-cycle. Risks should be reviewed for status and reevaluation (using qualitative measure, at a minimum) and placed on risk management watch lists if any risk's likelihood or impact significantly increases. Project leadership should also be mindful of the potential for secondary (new risks created specifically by the response to an original risk) and residual risks (risks that remain and have unintended impact following response).

Martin County, Florida
Hurricane and Storm Damage Reduction Project

Draft Limited Reevaluation Report of the
Beach Erosion Control Project

Attachment 3

Sea Level Rise Appendix

This Page is Intentionally Left Blank

Martin County – Project Future Sea Level Rise

Relative sea level (RSL) refers to local elevation of the sea with respect to land, including the lowering or rising of land through geologic processes such as subsidence and glacial rebound. It is anticipated that 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 an Engineering Circular, EC 1165-2-211.

EC 1165-2-211 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 of the project. Three estimates are required by the guidance, a baseline estimate representing the minimum expected sea level change, an intermediate estimate, and a high estimate representing the maximum expected sea level change.

Adjusting equation (2) to include the historic global mean sea-level change rate of 1.7 mm/year results in updated values for the variable b being equal to 2.36E-5 for modified NRC Curve I, 6.20E-5 for modified NRC Curve II, and 1.005E-4 for modified NRC Curve III.

$$\textit{Equation 2: } E(t) = 0.0017t + bt^2$$

Equation (3) of EC 1165-2-211 Appendix B calculates eustatic sea level change over the life of the project. E(t) is eustatic sea level change and b is a constant provided in EC 1165-2-211; t_1 is the time between the project's construction date and 1986 and t_2 is the time between a future date at which one wants an estimate for sea-level rise and 1986 (or $t_2 = t_1$ + number of years after construction (Knuuti, 2002)). For example, if a designer wants to know the projected eustatic sea-level rise at the end of a project's period of analysis, and the project is to have a fifty year life and is to be constructed in 2012, $t_1 = 2012 – 1986 = 26$ and $t_2 = 2062 – 1986 = 76$.

$$\textit{Equation 3: } E(t_2) – E(t_1) = 0.0017(t_2 – t_1) + b(t_2^2 – t_1^2)$$

Modifying equation (3) to include site-specific sea level change data results in an equation for Relative Sea Level (RSL). This equation is used to estimate baseline, intermediate, and high sea level rise values over the life of the project.

$$RSL(t_2) – RSL(t_1) = (e+M)\ (t_2 – t_1) + b(t_2^2 – t_1^2)$$

$RSL(t_1)$ and $RSL(t_2)$ are the total RSL at times t_1 and t_2, and the quantity $(e + M)$ is the local change in sea level in m/year that accounts for the eustatic change as well as uplift or subsidence. The quantity $(e+M)$ is found from the nearest tide gage with a tidal record of at least 40 years.

Based on historical sea level measurements taken from NOS gage 8723170 at Miami Beach, Florida, the historic sea level rise rate $(e+M)$ was determined to be 2.39 +/- .43 mm/year (0.0078 ft/year) (http://tidesandcurrents.noaa.gov/sltrends/index.shtml). The project base year was specified as 2012, and the project life was projected to be 50 years. Table 1 shows the results of equation (3) every five years, starting from the base year of 2012. From this table, the average baseline, intermediate, and high sea level rise rates were found to be 2.39 mm/year (0.0078 ft/year), 4.80 mm/year (0.016 ft/year), and 12.64 mm/year (0.0415 ft/year), respectively. Figure 1 shows the three levels of projected future sea level rise for the life of the project.

The local rate of vertical land movement is found by subtracting regional MSL trend from local MSL trend. The regional mean sea level trend is assumed equal to the eustatic mean sea level trend of 1.7 mm/year. Therefore in Martin County, there is 0.68 mm/year of subsidence.

Table 1: Regional Sea Level vs Year- Martin County

	Baseline (Historic)			Intermediate (Curve I)			High (Curve III)		
	Year	mm	ft	Year	mm	ft	Year	mm	ft
Base Year	2012	0.0	0.00	2012	0.00	0.00	2012	0.00	0.00
	2017	12.0	0.04	2017	18.7	0.06	2017	40.6	0.13
	2022	23.9	0.08	2022	38.5	0.13	2022	86.2	0.28
	2027	35.9	0.12	2027	59.6	0.20	2027	136.9	0.45
	2032	47.8	0.16	2032	81.8	0.27	2032	192.5	0.63
25 Year	2037	59.8	0.20	2037	105.2	0.35	2037	253.2	0.83
	2042	71.7	0.24	2042	129.8	0.43	2042	318.9	1.05
	2047	83.7	0.27	2047	155.5	0.51	2047	389.7	1.28
	2052	95.6	0.31	2052	182.4	0.60	2052	465.4	1.53
	2057	107.6	0.35	2057	210.6	0.69	2057	546.2	1.79
50 Year	2062	119.5	0.39	2062	239.9	0.79	2062	632.1	2.07

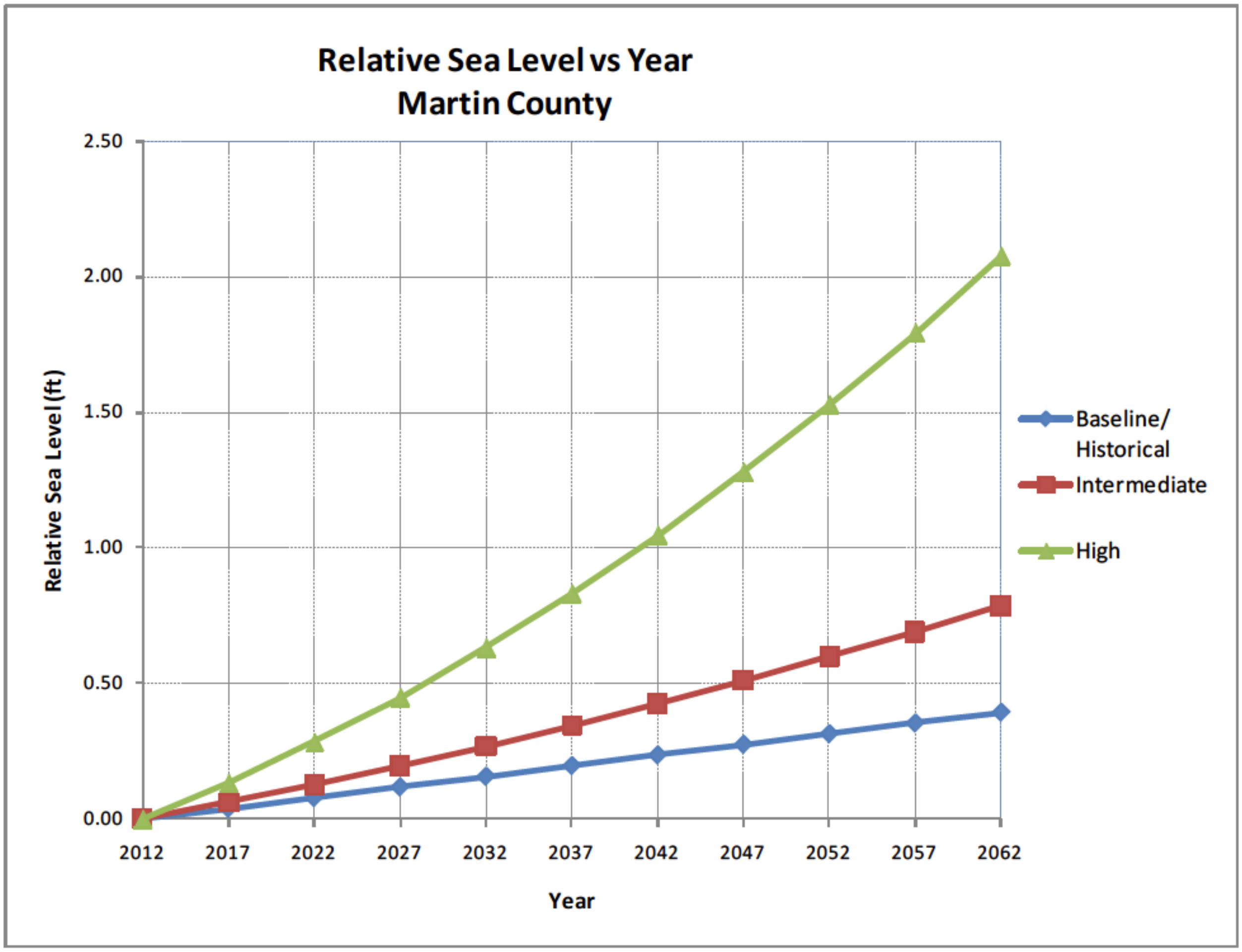


Figure 1. Regional Sea Level Rise, Martin County

Per Bruun (1962) proposed a formula for estimating the rate of shoreline recession based on the local rate of sea level rise. This methodology also includes consideration of the local topography and bathymetry. Bruun's approach assumes that with a rise 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. Shoreline recession, X, resulting from sea level rise can be estimated using Bruun's Rule, as defined below:

$$X = -SW_*/(h_*+B)$$

Berm height, B, for the project area is approximately 8 feet; depth of closure, h_*, is estimated to be -20 feet NGVD based on the Martin County Physical Monitoring Report (2009); the width of the active profile, W_*, is approximately 1800 feet. This formulation results in a Baseline recession rate of -0.51 feet of shoreline per year (ft/yr), an Intermediate recession rate of 1.03 ft/yr, and a High recession rate of 2.70 ft/yr that may occur as a result of sea level rise over the project life.

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

Engineering Manual (EM) 1110-2-3301 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) using equation (4-1). For this discussion, it is assumed that as an unarmored beach erodes, it maintains approximately the same profile above the seaward limit of significant transport; therefore, the volume change per unit beach width is the vertical height of the active profile, $h^* + B$, multiplied by the horizontal translation of the profile, X.

Equation 4-1: $V= (B+h^*)X$

This formulation results in an annualized Baseline volume change of 0.52 cubic yards per foot per year(cy/ft/yr), an Intermediate volume change of 1.05 cy/ft/yr, and a High volume change of 2.76 cy/ft/yr. The annualized rates of sea level rise, shoreline recession, and volume change (volume lost) are shown in Table 2.

Table 2: Annualized Rates of Sea Level Rise, Shoreline Recession and Volume Lost- Martin County

	Sea Level Rise	Shoreline Recession	Volume Lost
	(S) in ft/yr	(X) in -ft/yr	(V) in cy/ft/yr
Baseline	0.01	0.51	0.52
Intermediate	0.02	1.03	1.05
High	0.04	2.70	2.76

In order to illustrate what the shoreline recession and volume lost would be with the new NRC curves, the Baseline data was subtracted from the Intermediate and High data. The Baseline, or historical, curve is assumed to be the most probable without project condition; figures 2 and 3 show the cumulative changes in shoreline recession and volume change based on Intermediate and High sea level rise rates.

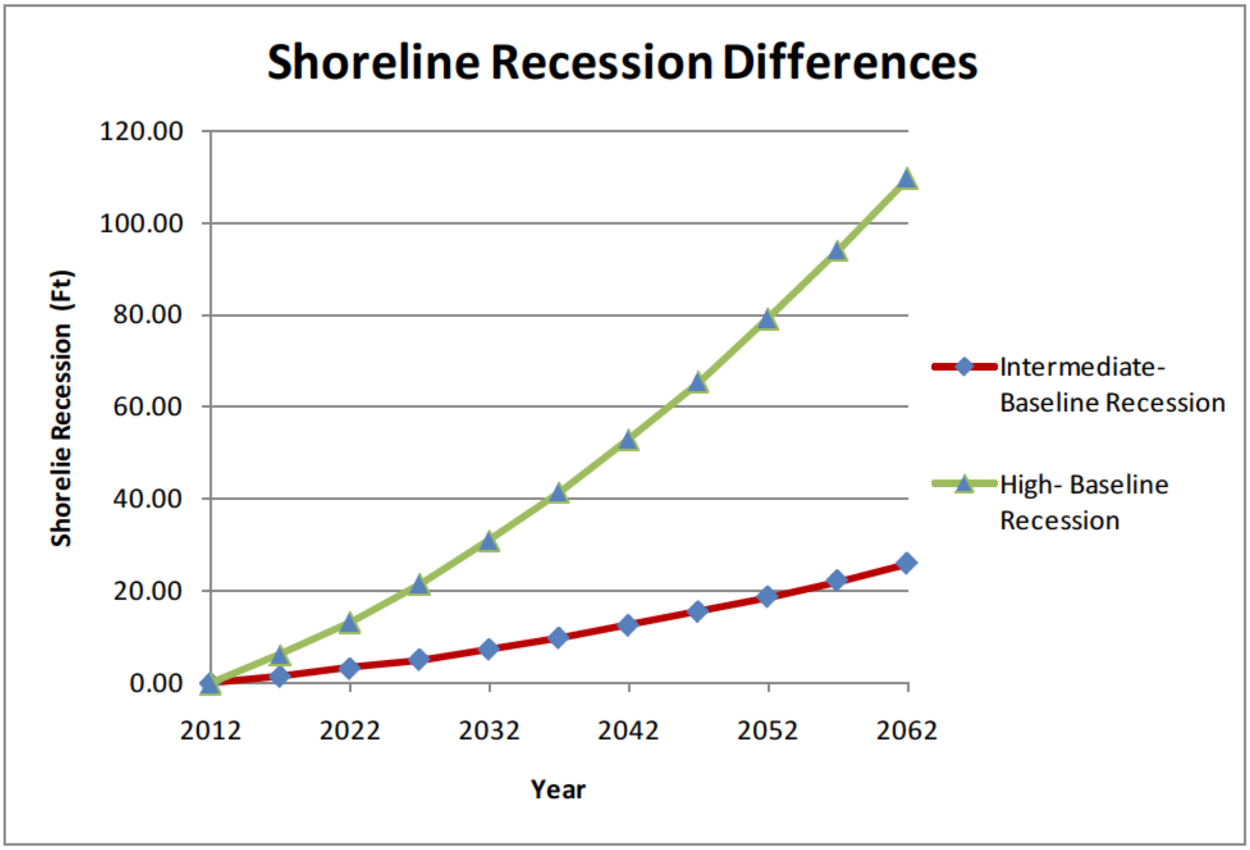


Figure 2: Shoreline Recession Differences- Martin County

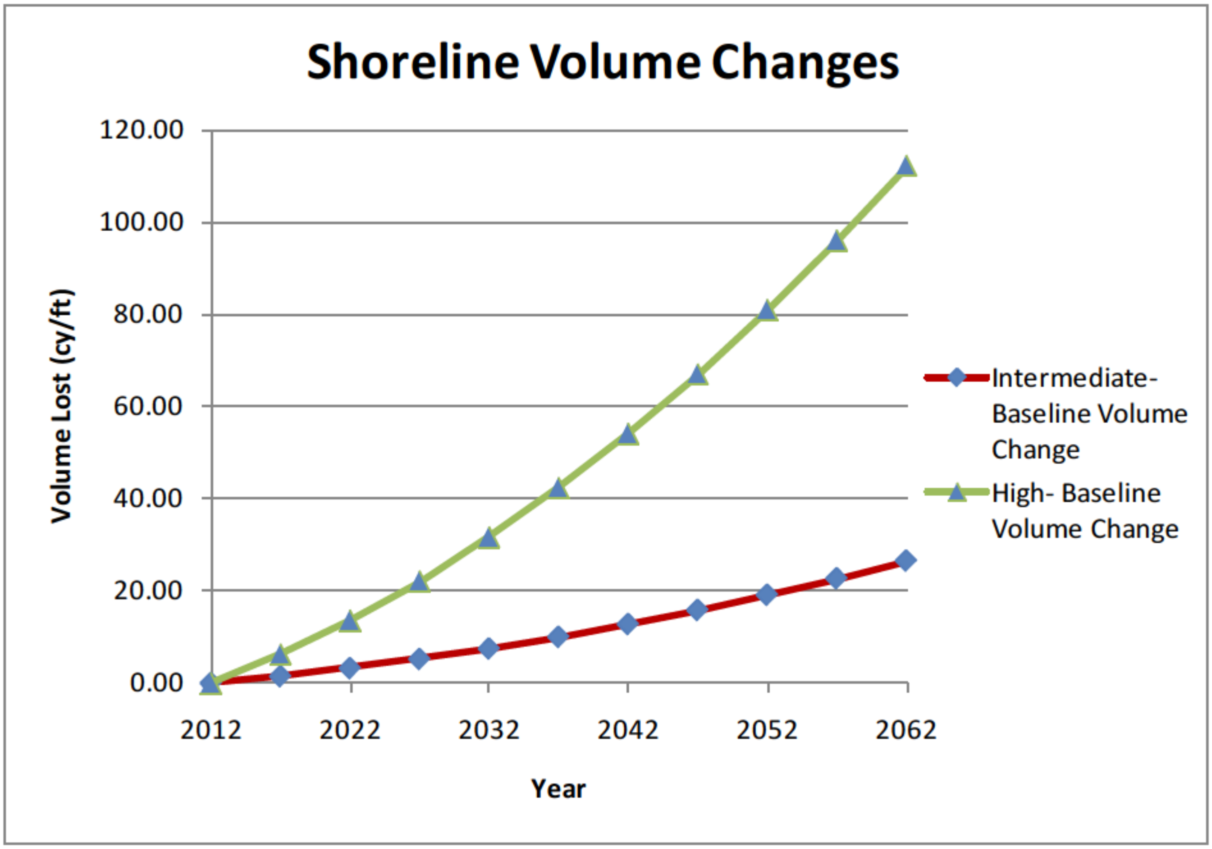


Figure 3: Shoreline Volume Changes(Losses)- Martin County

Martin County, Florida
Hurricane and Storm Damage Reduction Project

Draft Limited Reevaluation Report of the
Beach Erosion Control Project

Attachment 4

Section 902 Limit Analysis

This Page is Intentionally Left Blank

SECTION 902 LIMITS

The maximum project cost authorized by Congress for shore protection projects as set by Section 902 of WRDA 1986 applies to both initial construction and future renourishments. Prior to 1986, the total economic project cost (first cost of project implementation plus the sum of the present worth of each future renourishment) was generally considered to be the project cost. Subsequent to the enactment of Section 902 of WRDA 1986, the project cost consists of the first cost of implementing the project plus the sum of all future nourishment costs. An increase in the authorized costs, plus 20%, requires Congressional approval before implementing the project. The below table provides a comparison of the Section 902 project cost limit for the authorized project and the expenditures and recommended costs. The Section 902 limits for the authorized project, revised using current reporting methodology, are shown for completeness.

Comparison of 902 Limits

Project Year	**Fiscal Year**	**Phase**		**Expenditures**
Pre-Construct	1992-1995			$1,220,757.09
1-5	1996-2000	Initial Construction		$10,682,675.55
6-9	2001-2004	1st Renourishment (Partial)		$4,442,070.83
10-14	2005-2009	2nd Renourishment (no FCCE)		$9,549,795.49
		Already Spent	*Subtotal*	$25,895,298.96
15-16	2010-2011			**Recommended Cost**
17	2012	3rd Renourishment		$10,104,476.00
30	2025	4th Renourishment		$11,155,076.00
43	2038	5th Renourishment		$8,531,478.00
50	*ends FY 2046	Future	*Subtotal*	**$29,791,030.00**
			Total Project Cost	$55,686,328.96
			Authorized 902 Limit for Initial Construciton	$13,476,000.00
			Authorized 902 Limit for Periodic Nourishment	$79,245,000.00
			Authorized 902 Limit for Remaining Periodic Nourishment	**$60,872,000.00**

COMPARISON OF RECOMMENDED COSTS TO 902 LIMITS

Initial construction costs for the recommended plan of $11,903,433 (including pre-construction costs) is less than the Section 902 limit of $13,476,000 (includes 20% from 902 analyses in Appendix G).

Periodic Renourishment cost for the recommended plan of $43,782,896 (including actual cost for constructed periodic nourishments plus the 2010 cost estimate included in the LRR for the remaining nourishments) is less than the Section 902 limit of $79,246,000 (includes 20% from 902 analysis in Appendix G).

The recommended costs for remaining periodic nourishment of $29,791,030 is less than the Section 902 limit of $60,872,000 (includes 20% from 902 analysis in Appendix G), for remaining nourishments from the third periodic nourishment.

Section 902 allows for a 20% increase in costs over the authorized costs; therefore, in order to determine if the 902 limit is exceeded, 20% of the authorized costs is added to the total for the authorized project costs at current price levels. Again, the 20% is taken from the authorized costs at the authorized price level, not current price levels. Once the 20% is added to the authorized costs the total is compared to the recommended project's total cost; if the recommended cost exceeds the 902 limit the project must be approved by Congress. This project does not exceed the Section 902 limit.

12 January 2011

PROJECT COST INCREASE FACT SHEET
EXHIBIT G-11

1. Name of Project: Martin County, Florida, Hurricane and Storm Damage Reduction

2. Authorization: WRDA 1990 (PL 101-640) in accordance with the Chief of Engineers Report dated 20 November 1989.

3. Section 902 Limit on Project Cost: (**Initial Construction Only**)

a.	Authorized project cost (w/ Price level)	$ 9,391,000 (1989)
b.	Price level increase from date of authorize cost	$ 2,207,000
c.	Current project cost modifications required by law	$ 0
d.	20% of line 3a	$ 1,878,200
e.	Maximum project cost limited by Section 902	$ 13,476,000

4. Current Project Cost Including Inflation Through Construction: $ 11,903,433

5. Computation of Percentage Increase:

a.	Current estimate (actual project costs including pre-construction costs through initial construction)	$ 11,903,433
b.	Less total of lines 3a,b, and c	$ 11,598,000
c.	Subtotal	$ 305,433
d.	Percent Increase	2.6%

6. Section 902 Limit on Project Cost: (**Renourishment Only**)

a.	Authorized project cost (w/ Price level)	$ 31,278,000 (1989)
b.	Price level increase from date of authorize cost	$41,711,000
c.	Current project cost modifications required by law	$ 0
d.	20% of line 6a	$ 6,255,200
e.	Maximum project cost limited by Section 902	$ 79,245,000

7. Current Project Cost Including Inflation Through Construction: $43,782,896

8. Computation of Percentage Increase:

a.	Current estimate (actual cost for constructed nourishments & 2009 estimate included in LRR for remaining nourishments)	$43,782,896
b.	Less total of lines 6a,b, and c	$ 72,989,000
c.	Subtotal	-$29,206,104
d.	Percent Increase	0

9. Section 902 Limit on Project Cost: (**Remaining Renourishment Only**)
   The anticipated 2012 nourishment is considered the third periodic nourishment.

a.	Authorized project cost (w/ Price level)	$ 20,852,000(1989)
b.	Price level increase from date of authorize cost	$ 35,849,000
c.	Current project cost modifications required by law	$ 0
d.	20% of line 9a	$ 4,170,400
e.	Maximum project cost limited by Section 902	$ 60,872,000

10. Current Project Cost Including Inflation Through Construction: $29,791,030

11. Computation of Percentage Increase:

a.	Current estimate (2009 estimate included in LRR for remaining nourishments)	$29,791,030
b.	Less total of lines 9a,b, and c	$ 56,701,000
c.	Subtotal	-$26,909,970
d.	Percent Increase	0

12. Explain the indexes used in 3b, 6b and 9b: The Consumer Pricing Index (CPI) was used for hourly rates for the E&D and S&A, while the Civil Works Construction Cost Index System (CWCCIS) was used for construction related costs.

13. Explain increases in 3c, 6c, and 9c. N/A

14. Explain reasons for cost changes other than inflation. One of the major reasons for cost increase with respect to the remaining periodic nourishments is the need to use a new borrow area located further offshore. A hopper dredge with pump out capability is now required for dredging where the old borrow area was close enough to shore to use a suction pipeline dredge. The dredging cost increase is based solely on the change in borrow area location is approximately 30%.

15. Explain any changes in benefits and provide current BCR. The benefits used for this analysis are from the Martin County, Florida Shore Protection Project, General Design Memorandum (GDM), Revised June 1994. The benefits for this project were recomputed using the storm damage data streams from the 1994 GDM and adjusted for the remaining 35 years of Federal participation and for the current discount rate of 4.125 percent, authorized rate of 8.0 percent and 7.0 percent discount rates. The costs were adjusted to the price levels of the 1994 GDM using the beach replacement indexes from 30 September 2009 Civil Works Construction Cost Index System. For the remaining period of Federal participation the BCR computed for the current discount rate of 4.125 is 18.77to 1.

16. Provide detailed explanation of the status of the project. The project was initially constructed in 1996. Partial nourishments were constructed in 2001 and 2002. In 2005 the project was fully nourished using FCCE funds due to impacts of the 2004 hurricane season. The need to use a new borrow area has warranted this LRR. The next periodic nourishment is scheduled for 2012. This LRR and SEIS are currently going through the approval process at Division.

MARTIN COUNTY, FLORIDA
INITIAL FILL

Table P-4
MAXIMUM COST INCLUDING INFLATION THROUGH CONSTRUCTION
(OCT 09 Price Levels)

Line 1			
	a.	Current project estimate at current price levels:	11,701
	b.	Current project estimate, inflated through construction:	11,701
	c.	Ratio: Line 1b / line 1a	1.0000
	d.	Authorized cost at current price levels: Column (h) plus (i) from table P-3	11,598
	e.	Authorized cost, inflated through construction: Line c x Line d	11,598
Line 2		Cost of modifications required by law:	0
Line 3		20 percent of authorized cost: .20 x (table P-3, columns (f) + (g)	1,878
Line 4		Maximum cost limited by section 902: Line 1e + line 2 + line 3	13,476

Table P-3

FY	Current Project Cost			Current Sched (%)		Authorized Cost Sched		Auth Cost Inflat	
	Total (a)	Constr (b)	R.E. (c)	Constr (d)	R.E. (e)	Constr (f)	R.E. (g)	Constr (h)	R.E. (i)
89	0	0	0	0.00	0.00	0	0	0	0
90	0	0	0	0.00	0.00	0	0	0	0
91	0	0	0	0.00	0.00	0	0	0	0
92	168	168	0	1.44	0.00	135	0	150	0
93	321	321	0	2.74	0.00	258	0	295	0
94	385	385	0	3.29	0.00	309	0	362	0
95	347	347	0	2.97	0.00	278	0	335	0
96	9388	9388	0	80.23	0.00	7535	0	9323	0
97	461	461	0	3.94	0.00	370	0	468	0
98	192	192	0	1.64	0.00	154	0	199	0
99	439	439	0	3.75	0.00	352	0	466	0
00	0	0	0	0.00	0.00	0	0	0	0
01	0	0	0	0.00	0.00	0	0	0	0
02	0	0	0	0.00	0.00	0	0	0	0
03	0	0	0	0.00	0.00	0	0	0	0
04	0	0	0	0.00	0.00	0	0	0	0
05	0	0	0	0.00	0.00	0	0	0	0
06	0	0	0	0.00	0.00	0	0	0	0
07	0	0	0	0.00	0.00	0	0	0	0
08	0	0	0	0.00	0.00	0	0	0	0
09	0	0	0	0.00	0.00	0	0	0	0
Balance to complete	0	0	0	0.00	100.00	0	0	0	0
Total	11701	11701	0	100.00	100.00	9391	0	11598	0

Table P-1
CWCCIS INDEX
13

Item	(b)	(c)	Index (d)	Yearly Inflat Rate (e)	Cumul Inflat Rate (f)	Cumul rate to Begin FY (g)	One Half rate of Infl FY (h)	Tot Allow Inflat for FY (i)
Date of Price Level		10/1/1989 (CWBS 17)						
Authorized Estimate		9391	394.09		1			1
First Fiscal year		90		0.0355756		1	1.017787815	1.0177878
1st Qtr, 2nd yr	90		408.11		1.0355756			
Second Fiscal year		91		0.0327118		1.03557563	1.016355884	1.0525134
1st Qtr, 3rd yr	91		421.46		1.0694511			
Third Fiscal year		92		0.0228254		1.069451141	1.011412708	1.0816565
1st qtr, 4th yr	92		431.08		1.0938618			
Fourth Fiscal Year		93		0.0347963		1.093861808	1.017398163	1.112893
1st qtr, 5th yr	93		446.08		1.1319242			
Fifth fiscal year		94		0.024592		1.13192418	1.012296001	1.1458423
1st qtr, 6th yr	94		457.05		1.1597605			
Sixth fiscal year		95		0.0192102		1.159760461	1.009605076	1.1709
1st qtr, 7th yr	95		465.83		1.1820396			
Seventh fiscal yr		96		0.0359573		1.182039636	1.017978662	1.2032911
1st qtr, 8th fy	96		482.58		1.2245426			

Eighth fiscal year		97		0.0208463		1.224542617	1.010423142	1.2373062
1st qtr, 9th fy	97		492.64		1.2500698			
Ninth fiscal year		98		0.0221054		1.250069781	1.011052696	1.2638864
1st qtr, 10th fy	98		503.53		1.2777031			
Tenth fiscal year		99		0.0223224		1.277703063	1.011161202	1.2919638
1st qtr, 11th fy	99		514.77		1.3062245			
Eleventh fiscal year		00		0.025526		1.306224466	1.012762982	1.3228958
1st qtr, 12th fy	00		527.91		1.3395671			
Twelfth fiscal year		01		0.0243602		1.339567104	1.012180106	1.3558832
1st qtr, 13th fy	01		540.77		1.3721992			
Thirteenth fiscal year		02		0.0184737		1.372199244	1.009236829	1.384874
1st qtr, 14th fy	02		550.76		1.3975488			
Fourteenth fiscal year		03		0.0534534		1.397548783	1.026726705	1.4349007
1st qtr, 15th fy	03		580.2		1.4722525			
Fifteenth fiscal year		04		0.0226646		1.472252531	1.011332299	1.4889365
1st qtr, 16th fy	04		593.35		1.5056205			
Sixteenth fiscal year		05		0.0448808		1.505620544	1.022440381	1.5394072
1st qtr, 17th fy	05		619.98		1.5731939			
Seventeenth fiscal year		06		0.0495339		1.57319394	1.024766928	1.6121571
1st qtr, 18th fy	06		650.69		1.6511203			
Eighteenth fiscal year		07		0.0402496		1.651120302	1.020124791	1.6843488

1st qtr, 19th fy	07		676.88		1.7175772			
Nineteenth fiscal year		08		0.0351761		1.717577203	1.017588051	1.747786
1st qtr, 20th fy	08		700.69		1.7779949			
Twentieth fiscal year		09		0.0371491		1.777994874	1.018574548	1.8110203
1st qtr, 21st fy	09		726.72		1.8440458			
Twentyfirst fiscal year		10		0.0185491		1.844045776	1.009274549	1.8611485
1st qtr, 22nd fy	10		740.2		1.8782512			

CESAJ-DP-PB 12-Sep-09

MARTIN COUNTY, FLORIDA
RENOURISHMENT 01

Table P-4
MAXIMUM COST INCLUDING INFLATION THROUGH CONSTRUCTION
(OCT 09 Price Levels)

Line 1		
a.	Current project estimate at current price levels:	5,445
b.	Current project estimate, inflated through construction:	5,445
c.	Ratio: Line 1b / line 1a	1.0000
d.	Authorized cost at current price levels: Column (h) plus (i) from table P-3	7,904
e.	Authorized cost, inflated through construction: Line c x Line d	7,904
Line 2	Cost of modifications required by law:	0
Line 3	20 percent of authorized cost: .20 x (table P-3, columns (f) + (g)	1,043
Line 4	Maximum cost limited by section 902: Line 1e + line 2 + line 3	8,947

Table P-3

FY	Current Project Cost			Current Sched (%)		Authorized Cost Sched		Auth Cost Inflat	
	Total (a)	Constr (b)	R.E. (c)	Constr (d)	R.E. (e)	Constr (f)	R.E. (g)	Constr (h)	R.E. (i)
89	0	0	0	0.00	0.00	0	0	0	0
90	0	0	0	0.00	0.00	0	0	0	0
91	0	0	0	0.00	0.00	0	0	0	0
92	0	0	0	0.00	0.00	0	0	0	0
93	0	0	0	0.00	0.00	0	0	0	0
94	0	0	0	0.00	0.00	0	0	0	0
95	0	0	0	0.00	0.00	0	0	0	0
96	0	0	0	0.00	0.00	0	0	0	0
97	0	0	0	0.00	0.00	0	0	0	0
98	0	0	0	0.00	0.00	0	0	0	0
99	0	0	0	0.00	0.00	0	0	0	0
00	203	203	0	3.73	0.00	194	0	264	0
01	1968	1968	0	36.14	0.00	1884	0	2609	0
02	1422	1422	0	26.12	0.00	1361	0	1953	0
03	624	624	0	11.46	0.00	597	0	890	0
04	0	0	0	0.00	0.00	0	0	0	0
05	0	0	0	0.00	0.00	0	0	0	0
06	0	0	0	0.00	0.00	0	0	0	0
07	0	0	0	0.00	0.00	0	0	0	0
08	0	0	0	0.00	0.00	0	0	0	0
09	0	0	0	0.00	0.00	0	0	0	0
Balance to complete	1228	1228	0	22.55	100.00	1176	0	2188	0
Total	5445	5445	0	100.00	100.00	5213	0	7904	0

Table P-1
CWCCIS INDEX
13

Item	(b)	(c)	Index (d)	Yearly Inflat Rate (e)	Cumul Inflat Rate (f)	Cumul rate to Begin FY (g)	One Half rate of Infl FY (h)	Tot Allow Inflat for FY (i)
Date of Price Level		10/1/1989 (CWBS 17)						
Authorized Estimate		5213	394.09		1			1
First Fiscal year		90		0.0355756		1	1.017787815	1.0177878
1st Qtr, 2nd yr	90		408.11		1.0355756			
Second Fiscal year		91		0.0327118		1.03557563	1.016355884	1.0525134
1st Qtr, 3rd yr	91		421.46		1.0694511			
Third Fiscal year		92		0.0228254		1.069451141	1.011412708	1.0816565
1st qtr, 4th yr	92		431.08		1.0938618			
Fourth Fiscal Year		93		0.0347963		1.093861808	1.017398163	1.112893
1st qtr, 5th yr	93		446.08		1.1319242			
Fifth fiscal year		94		0.024592		1.13192418	1.012296001	1.1458423
1st qtr, 6th yr	94		457.05		1.1597605			
Sixth fiscal year		95		0.0192102		1.159760461	1.009605076	1.1709
1st qtr, 7th yr	95		465.83		1.1820396			
Seventh fiscal yr		96		0.0359573		1.182039636	1.017978662	1.2032911
1st qtr, 8th fy	96		482.58		1.2245426			

Eighth fiscal year		97		0.0208463		1.224542617	1.010423142	1.2373062
1st qtr, 9th fy	97		492.64		1.2500698			
Ninth fiscal year		98		0.0221054		1.250069781	1.011052696	1.2638864
1st qtr, 10th fy	98		503.53		1.2777031			
Tenth fiscal year		99		0.0223224		1.277703063	1.011161202	1.2919638
1st qtr, 11th fy	99		514.77		1.3062245			
Eleventh fiscal year		00		0.025526		1.306224466	1.012762982	1.3228958
1st qtr, 12th fy	00		527.91		1.3395671			
Twelfth fiscal year		01		0.0243602		1.339567104	1.012180106	1.3558832
1st qtr, 13th fy	01		540.77		1.3721992			
Thirteenth fiscal year		02		0.0184737		1.372199244	1.009236829	1.384874
1st qtr, 14th fy	02		550.76		1.3975488			
Fourteenth fiscal year		03		0.0534534		1.397548783	1.026726705	1.4349007
1st qtr, 15th fy	03		580.2		1.4722525			
Fifteenth fiscal year		04		0.0226646		1.472252531	1.011332299	1.4889365
1st qtr, 16th fy	04		593.35		1.5056205			
Sixteenth fiscal year		05		0.0448808		1.505620544	1.022440381	1.5394072
1st qtr, 17th fy	05		619.98		1.5731939			
Seventeenth fiscal year		06		0.0495339		1.57319394	1.024766928	1.6121571
1st qtr, 18th fy	06		650.69		1.6511203			
Eighteenth fiscal year		07		0.0402496		1.651120302	1.020124791	1.6843488

1st qtr, 19th fy	07		676.88		1.7175772			
Nineteenth fiscal year		08		0.0351761		1.717577203	1.017588051	1.747786
1st qtr, 20th fy	08		700.69		1.7779949			
Twentieth fiscal year		09		0.0371491		1.777994874	1.018574548	1.8110203
1st qtr, 21st fy	09		726.72		1.8440458			
Twentyfirst fiscal year		10		0.0185491		1.844045776	1.009274549	1.8611485
1st qtr, 22nd fy	10		740.2		1.8782512			

MARTIN COUNTY, FLORIDA
RENOURISHMENT 02

Table P-4
MAXIMUM COST INCLUDING INFLATION THROUGH CONSTRUCTION
(OCT 09 Price Levels)

Line 1		
a.	Current project estimate at current price levels:	8,663
b.	Current project estimate, inflated through construction:	8,663
c.	Ratio: Line 1b / line 1a	1.0000
d.	Authorized cost at current price levels: Column (h) plus (i) from table P-3	8,384
e.	Authorized cost, inflated through construction: Line c x Line d	8,384
Line 2	Cost of modifications required by law:	0
Line 3	20 percent of authorized cost: .20 x (table P-3, columns (f) + (g)	1,043
Line 4	Maximum cost limited by section 902: Line 1e + line 2 + line 3	9,427

Table P-3

FY	Current Project Cost			Current Sched (%)		Authorized Cost Sched		Auth Cost Inflat	
	Total (a)	Constr (b)	R.E. (c)	Constr (d)	R.E. (e)	Constr (f)	R.E. (g)	Constr (h)	R.E. (i)
89	0	0	0	0.00	0.00	0	0	0	0
90	0	0	0	0.00	0.00	0	0	0	0
91	0	0	0	0.00	0.00	0	0	0	0
92	0	0	0	0.00	0.00	0	0	0	0
93	0	0	0	0.00	0.00	0	0	0	0
94	0	0	0	0.00	0.00	0	0	0	0
95	0	0	0	0.00	0.00	0	0	0	0
96	0	0	0	0.00	0.00	0	0	0	0
97	0	0	0	0.00	0.00	0	0	0	0
98	0	0	0	0.00	0.00	0	0	0	0
99	0	0	0	0.00	0.00	0	0	0	0
00	0	0	0	0.00	0.00	0	0	0	0
01	0	0	0	0.00	0.00	0	0	0	0
02	0	0	0	0.00	0.00	0	0	0	0
03	0	0	0	0.00	0.00	0	0	0	0
04	428	428	0	4.94	0.00	258	0	396	0
05	8264	8264	0	95.39	0.00	4973	0	8017	0
06	-29	-29	0	-0.33	0.00	-17	0	-29	0
07	0	0	0	0.00	0.00	0	0	0	0
08	0	0	0	0.00	0.00	0	0	0	0
09	0	0	0	0.00	0.00	0	0	0	0
Balance to complete	0	0	0	0.00	100.00	0	0	0	0
Total	8663	8663	0	100.00	100.00	5213	0	8384	0

Table P-1
CWCCIS INDEX
13

Item	(b)	(c)	Index (d)	Yearly Inflat Rate (e)	Cumul Inflat Rate (f)	Cumul rate to Begin FY (g)	One Half rate of Infl FY (h)	Tot Allow Inflat for FY (i)
Date of Price Level		10/1/1989 (CWBS 17)						
Authorized Estimate		5213	394.09		1			1
First Fiscal year		90		0.0355756		1	1.017787815	1.0177878
1st Qtr, 2nd yr	90		408.11		1.0355756			
Second Fiscal year		91		0.0327118		1.03557563	1.016355884	1.0525134
1st Qtr, 3rd yr	91		421.46		1.0694511			
Third Fiscal year		92		0.0228254		1.069451141	1.011412708	1.0816565
1st qtr, 4th yr	92		431.08		1.0938618			
Fourth Fiscal Year		93		0.0347963		1.093861808	1.017398163	1.112893
1st qtr, 5th yr	93		446.08		1.1319242			
Fifth fiscal year		94		0.024592		1.13192418	1.012296001	1.1458423
1st qtr, 6th yr	94		457.05		1.1597605			
Sixth fiscal year		95		0.0192102		1.159760461	1.009605076	1.1709
1st qtr, 7th yr	95		465.83		1.1820396			
Seventh fiscal yr		96		0.0359573		1.182039636	1.017978662	1.2032911
1st qtr, 8th fy	96		482.58		1.2245426			

Eighth fiscal year		97		0.0208463		1.224542617	1.010423142	1.2373062
1st qtr, 9th fy	97		492.64		1.2500698			
Ninth fiscal year		98		0.0221054		1.250069781	1.011052696	1.2638864
1st qtr, 10th fy	98		503.53		1.2777031			
Tenth fiscal year		99		0.0223224		1.277703063	1.011161202	1.2919638
1st qtr, 11th fy	99		514.77		1.3062245			
Eleventh fiscal year		00		0.025526		1.306224466	1.012762982	1.3228958
1st qtr, 12th fy	00		527.91		1.3395671			
Twelfth fiscal year		01		0.0243602		1.339567104	1.012180106	1.3558832
1st qtr, 13th fy	01		540.77		1.3721992			
Thirteenth fiscal year		02		0.0184737		1.372199244	1.009236829	1.384874
1st qtr, 14th fy	02		550.76		1.3975488			
Fourteenth fiscal year		03		0.0534534		1.397548783	1.026726705	1.4349007
1st qtr, 15th fy	03		580.2		1.4722525			
Fifteenth fiscal year		04		0.0226646		1.472252531	1.011332299	1.4889365
1st qtr, 16th fy	04		593.35		1.5056205			
Sixteenth fiscal year		05		0.0448808		1.505620544	1.022440381	1.5394072
1st qtr, 17th fy	05		619.98		1.5731939			
Seventeenth fiscal year		06		0.0495339		1.57319394	1.024766928	1.6121571
1st qtr, 18th fy	06		650.69		1.6511203			
Eighteenth fiscal year		07		0.0402496		1.651120302	1.020124791	1.6843488

1st qtr, 19th fy	07		676.88		1.7175772			
Nineteenth fiscal year		08		0.0351761		1.717577203	1.017588051	1.747786
1st qtr, 20th fy	08		700.69		1.7779949			
Twentieth fiscal year		09		0.0371491		1.777994874	1.018574548	1.8110203
1st qtr, 21st fy	09		726.72		1.8440458			
Twentyfirst fiscal year		10		0.0185491		1.844045776	1.009274549	1.8611485
1st qtr, 22nd fy	10		740.2		1.8782512			

CESAJ-DP-PB 12-Sep-09

MARTIN COUNTY, FLORIDA
RENOURISHMENT 03

Table P-4
MAXIMUM COST INCLUDING INFLATION THROUGH CONSTRUCTION
(OCT 09 Price Levels)

Line 1		
a.	Current project estimate at current price levels:	10,257
b.	Current project estimate, inflated through construction:	10,651
c.	Ratio: Line 1b / line 1a	1.0384
d.	Authorized cost at current price levels: Column (h) plus (i) from table P-3	9,660
e.	Authorized cost, inflated through construction: Line c x Line d	10,031
Line 2	Cost of modifications required by law:	0
Line 3	20 percent of authorized cost: .20 x (table P-3, columns (f) + (g)	1,043
Line 4	Maximum cost limited by section 902: Line 1e + line 2 + line 3	11,074

Table P-3

FY	Current Project Cost			Current Sched (%)		Authorized Cost Sched		Auth Cost Inflat	
	Total (a)	Constr (b)	R.E. (c)	Constr (d)	R.E. (e)	Constr (f)	R.E. (g)	Constr (h)	R.E. (i)
89	0	0	0	0.00	0.00	0	0	0	0
90	0	0	0	0.00	0.00	0	0	0	0
91	0	0	0	0.00	0.00	0	0	0	0
92	0	0	0	0.00	0.00	0	0	0	0
93	0	0	0	0.00	0.00	0	0	0	0
94	0	0	0	0.00	0.00	0	0	0	0
95	0	0	0	0.00	0.00	0	0	0	0
96	0	0	0	0.00	0.00	0	0	0	0
97	0	0	0	0.00	0.00	0	0	0	0
98	0	0	0	0.00	0.00	0	0	0	0
99	0	0	0	0.00	0.00	0	0	0	0
00	0	0	0	0.00	0.00	0	0	0	0
01	0	0	0	0.00	0.00	0	0	0	0
02	0	0	0	0.00	0.00	0	0	0	0
03	0	0	0	0.00	0.00	0	0	0	0
04	0	0	0	0.00	0.00	0	0	0	0
05	0	0	0	0.00	0.00	0	0	0	0
06	0	0	0	0.00	0.00	0	0	0	0
07	463	463	0	4.51	0.00	235	0	411	0
08	607	607	0	5.92	0.00	309	0	559	0
09	0	0	0	0.00	0.00	0	0	0	0
Balance to complete	9187	9187	0	89.57	100.00	4669	0	8690	0
Total	10257	10257	0	100.00	100.00	5213	0	9660	0

Table P-1
CWCCIS INDEX
13

Item	(b)	(c)	Index (d)	Yearly Inflat Rate (e)	Cumul Inflat Rate (f)	Cumul rate to Begin FY (g)	One Half rate of Infl FY (h)	Tot Allow Inflat for FY (i)
Date of Price Level		10/1/1989	(CWBS 17)					
Authorized Estimate		5213	394.09		1			1
First Fiscal year		90		0.0355756		1	1.017787815	1.0177878
1st Qtr, 2nd yr	90		408.11		1.0355756			
Second Fiscal year		91		0.0327118		1.03557563	1.016355884	1.0525134
1st Qtr, 3rd yr	91		421.46		1.0694511			
Third Fiscal year		92		0.0228254		1.069451141	1.011412708	1.0816565
1st qtr, 4th yr	92		431.08		1.0938618			
Fourth Fiscal Year		93		0.0347963		1.093861808	1.017398163	1.112893
1st qtr, 5th yr	93		446.08		1.1319242			
Fifth fiscal year		94		0.024592		1.13192418	1.012296001	1.1458423
1st qtr, 6th yr	94		457.05		1.1597605			
Sixth fiscal year		95		0.0192102		1.159760461	1.009605076	1.1709
1st qtr, 7th yr	95		465.83		1.1820396			
Seventh fiscal yr		96		0.0359573		1.182039636	1.017978662	1.2032911
1st qtr, 8th fy	96		482.58		1.2245426			

Eighth fiscal year		97		0.0208463		1.224542617	1.010423142	1.2373062
1st qtr, 9th fy	97		492.64		1.2500698			
Ninth fiscal year		98		0.0221054		1.250069781	1.011052696	1.2638864
1st qtr, 10th fy	98		503.53		1.2777031			
Tenth fiscal year		99		0.0223224		1.277703063	1.011161202	1.2919638
1st qtr, 11th fy	99		514.77		1.3062245			
Eleventh fiscal year		00		0.025526		1.306224466	1.012762982	1.3228958
1st qtr, 12th fy	00		527.91		1.3395671			
Twelfth fiscal year		01		0.0243602		1.339567104	1.012180106	1.3558832
1st qtr, 13th fy	01		540.77		1.3721992			
Thirteenth fiscal year		02		0.0184737		1.372199244	1.009236829	1.384874
1st qtr, 14th fy	02		550.76		1.3975488			
Fourteenth fiscal year		03		0.0534534		1.397548783	1.026726705	1.4349007
1st qtr, 15th fy	03		580.2		1.4722525			
Fifteenth fiscal year		04		0.0226646		1.472252531	1.011332299	1.4889365
1st qtr, 16th fy	04		593.35		1.5056205			
Sixteenth fiscal year		05		0.0448808		1.505620544	1.022440381	1.5394072
1st qtr, 17th fy	05		619.98		1.5731939			
Seventeenth fiscal year		06		0.0495339		1.57319394	1.024766928	1.6121571
1st qtr, 18th fy	06		650.69		1.6511203			
Eighteenth fiscal year		07		0.0402496		1.651120302	1.020124791	1.6843488

1st qtr, 19th fy	07		676.88		1.7175772			
Nineteenth fiscal year		08		0.0351761		1.717577203	1.017588051	1.747786
1st qtr, 20th fy	08		700.69		1.7779949			
Twentieth fiscal year		09		0.0371491		1.777994874	1.018574548	1.8110203
1st qtr, 21st fy	09		726.72		1.8440458			
Twentyfirst fiscal year		10		0.0185491		1.844045776	1.009274549	1.8611485
1st qtr, 22nd fy	10		740.2		1.8782512			

MARTIN COUNTY, FLORIDA
RENOURISHMENT 04

Table P-4
MAXIMUM COST INCLUDING INFLATION THROUGH CONSTRUCTION
(OCT 09 Price Levels)

Line 1		
a.	Current project estimate at current price levels:	10,141
b.	Current project estimate, inflated through construction:	13,008
c.	Ratio: Line 1b / line 1a	1.2827
d.	Authorized cost at current price levels: Column (h) plus (i) from table P-3	9,702
e.	Authorized cost, inflated through construction: Line c x Line d	12,445
Line 2	Cost of modifications required by law:	0
Line 3	20 percent of authorized cost: .20 x (table P-3, columns (f) + (g)	1,043
Line 4	Maximum cost limited by section 902: Line 1e + line 2 + line 3	13,488

Table P-3

FY	Current Project Cost			Current Sched (%)		Authorized Cost Sched		Auth Cost Inflat	
	Total (a)	Constr (b)	R.E. (c)	Constr (d)	R.E. (e)	Constr (f)	R.E. (g)	Constr (h)	R.E. (i)
89	0	0	0	0.00	0.00	0	0	0	0
90	0	0	0	0.00	0.00	0	0	0	0
91	0	0	0	0.00	0.00	0	0	0	0
92	0	0	0	0.00	0.00	0	0	0	0
93	0	0	0	0.00	0.00	0	0	0	0
94	0	0	0	0.00	0.00	0	0	0	0
95	0	0	0	0.00	0.00	0	0	0	0
96	0	0	0	0.00	0.00	0	0	0	0
97	0	0	0	0.00	0.00	0	0	0	0
98	0	0	0	0.00	0.00	0	0	0	0
99	0	0	0	0.00	0.00	0	0	0	0
00	0	0	0	0.00	0.00	0	0	0	0
01	0	0	0	0.00	0.00	0	0	0	0
02	0	0	0	0.00	0.00	0	0	0	0
03	0	0	0	0.00	0.00	0	0	0	0
04	0	0	0	0.00	0.00	0	0	0	0
05	0	0	0	0.00	0.00	0	0	0	0
06	0	0	0	0.00	0.00	0	0	0	0
07	0	0	0	0.00	0.00	0	0	0	0
08	0	0	0	0.00	0.00	0	0	0	0
09	0	0	0	0.00	0.00	0	0	0	0
Balance to complete	10141	10141	0	100.00	100.00	5213	0	9702	0
Total	10141	10141	0	100.00	100.00	5213	0	9702	0

Table P-1
CWCCIS INDEX
13

Item	(b)	(c)	Index (d)	Yearly Inflat Rate (e)	Cumul Inflat Rate (f)	Cumul rate to Begin FY (g)	One Half rate of Infl FY (h)	Tot Allow Inflat for FY (i)
Date of Price Level		10/1/1989	(CWBS 17)					
Authorized Estimate		5213	394.09		1			1
First Fiscal year		90		0.0355756		1	1.017787815	1.0177878
1st Qtr, 2nd yr	90		408.11		1.0355756			
Second Fiscal year		91		0.0327118		1.03557563	1.016355884	1.0525134
1st Qtr, 3rd yr	91		421.46		1.0694511			
Third Fiscal year		92		0.0228254		1.069451141	1.011412708	1.0816565
1st qtr, 4th yr	92		431.08		1.0938618			
Fourth Fiscal Year		93		0.0347963		1.093861808	1.017398163	1.112893
1st qtr, 5th yr	93		446.08		1.1319242			
Fifth fiscal year		94		0.024592		1.13192418	1.012296001	1.1458423
1st qtr, 6th yr	94		457.05		1.1597605			
Sixth fiscal year		95		0.0192102		1.159760461	1.009605076	1.1709
1st qtr, 7th yr	95		465.83		1.1820396			
Seventh fiscal yr		96		0.0359573		1.182039636	1.017978662	1.2032911
1st qtr, 8th fy	96		482.58		1.2245426			

Eighth fiscal year		97		0.0208463		1.224542617	1.010423142	1.2373062
1st qtr, 9th fy	97		492.64		1.2500698			
Ninth fiscal year		98		0.0221054		1.250069781	1.011052696	1.2638864
1st qtr, 10th fy	98		503.53		1.2777031			
Tenth fiscal year		99		0.0223224		1.277703063	1.011161202	1.2919638
1st qtr, 11th fy	99		514.77		1.3062245			
Eleventh fiscal year		00		0.025526		1.306224466	1.012762982	1.3228958
1st qtr, 12th fy	00		527.91		1.3395671			
Twelfth fiscal year		01		0.0243602		1.339567104	1.012180106	1.3558832
1st qtr, 13th fy	01		540.77		1.3721992			
Thirteenth fiscal year		02		0.0184737		1.372199244	1.009236829	1.384874
1st qtr, 14th fy	02		550.76		1.3975488			
Fourteenth fiscal year		03		0.0534534		1.397548783	1.026726705	1.4349007
1st qtr, 15th fy	03		580.2		1.4722525			
Fifteenth fiscal year		04		0.0226646		1.472252531	1.011332299	1.4889365
1st qtr, 16th fy	04		593.35		1.5056205			
Sixteenth fiscal year		05		0.0448808		1.505620544	1.022440381	1.5394072
1st qtr, 17th fy	05		619.98		1.5731939			
Seventeenth fiscal year		06		0.0495339		1.57319394	1.024766928	1.6121571
1st qtr, 18th fy	06		650.69		1.6511203			
Eighteenth fiscal year		07		0.0402496		1.651120302	1.020124791	1.6843488

1st qtr, 19th fy	07		676.88		1.7175772			
Nineteenth fiscal year		08		0.0351761		1.717577203	1.017588051	1.747786
1st qtr, 20th fy	08		700.69		1.7779949			
Twentieth fiscal year		09		0.0371491		1.777994874	1.018574548	1.8110203
1st qtr, 21st fy	09		726.72		1.8440458			
Twentyfirst fiscal year		10		0.0185491		1.844045776	1.009274549	1.8611485
1st qtr, 22nd fy	10		740.2		1.8782512			

CESAJ-DP-PB 12-Sep-09

MARTIN COUNTY, FLORIDA
RENOURISHMENT 05

Table P-4
MAXIMUM COST INCLUDING INFLATION THROUGH CONSTRUCTION
(OCT 09 Price Levels)

Line 1			
	a.	Current project estimate at current price levels:	10,141
	b.	Current project estimate, inflated through construction:	16,055
	c.	Ratio: Line 1b / line 1a	1.5832
	d.	Authorized cost at current price levels: Column (h) plus (i) from table P-3	9,702
	e.	Authorized cost, inflated through construction: Line c x Line d	15,360
Line 2		Cost of modifications required by law:	0
Line 3		20 percent of authorized cost: .20 x (table P-3, columns (f) + (g)	1,043
Line 4		Maximum cost limited by section 902: Line 1e + line 2 + line 3	16,403

Table P-3

FY	Current Project Cost			Current Sched (%)		Authorized Cost Sched		Auth Cost Inflat	
	Total (a)	Constr (b)	R.E. (c)	Constr (d)	R.E. (e)	Constr (f)	R.E. (g)	Constr (h)	R.E. (i)
89	0	0	0	0.00	0.00	0	0	0	0
90	0	0	0	0.00	0.00	0	0	0	0
91	0	0	0	0.00	0.00	0	0	0	0
92	0	0	0	0.00	0.00	0	0	0	0
93	0	0	0	0.00	0.00	0	0	0	0
94	0	0	0	0.00	0.00	0	0	0	0
95	0	0	0	0.00	0.00	0	0	0	0
96	0	0	0	0.00	0.00	0	0	0	0
97	0	0	0	0.00	0.00	0	0	0	0
98	0	0	0	0.00	0.00	0	0	0	0
99	0	0	0	0.00	0.00	0	0	0	0
00	0	0	0	0.00	0.00	0	0	0	0
01	0	0	0	0.00	0.00	0	0	0	0
02	0	0	0	0.00	0.00	0	0	0	0
03	0	0	0	0.00	0.00	0	0	0	0
04	0	0	0	0.00	0.00	0	0	0	0
05	0	0	0	0.00	0.00	0	0	0	0
06	0	0	0	0.00	0.00	0	0	0	0
07	0	0	0	0.00	0.00	0	0	0	0
08	0	0	0	0.00	0.00	0	0	0	0
09	0	0	0	0.00	0.00	0	0	0	0
Balance to complete	10141	10141	0	100.00	100.00	5213	0	9702	0
Total	10141	10141	0	100.00	100.00	5213	0	9702	0

Table P-1
CWCCIS INDEX
13

Item	(b)	(c)	Index (d)	Yearly Inflat Rate (e)	Cumul Inflat Rate (f)	Cumul rate to Begin FY (g)	One Half rate of Infl FY (h)	Tot Allow Inflat for FY (i)
Date of Price Level		10/1/1989 (CWBS 17)						
Authorized Estimate		5213	394.09		1			1
First Fiscal year		90		0.0355756		1	1.017787815	1.0177878
1st Qtr, 2nd yr	90		408.11		1.0355756			
Second Fiscal year		91		0.0327118		1.03557563	1.016355884	1.0525134
1st Qtr, 3rd yr	91		421.46		1.0694511			
Third Fiscal year		92		0.0228254		1.069451141	1.011412708	1.0816565
1st qtr, 4th yr	92		431.08		1.0938618			
Fourth Fiscal Year		93		0.0347963		1.093861808	1.017398163	1.112893
1st qtr, 5th yr	93		446.08		1.1319242			
Fifth fiscal year		94		0.024592		1.13192418	1.012296001	1.1458423
1st qtr, 6th yr	94		457.05		1.1597605			
Sixth fiscal year		95		0.0192102		1.159760461	1.009605076	1.1709
1st qtr, 7th yr	95		465.83		1.1820396			
Seventh fiscal yr		96		0.0359573		1.182039636	1.017978662	1.2032911
1st qtr, 8th fy	96		482.58		1.2245426			

Eighth fiscal year		97		0.0208463		1.224542617	1.010423142	1.2373062
1st qtr, 9th fy	97		492.64		1.2500698			
Ninth fiscal year		98		0.0221054		1.250069781	1.011052696	1.2638864
1st qtr, 10th fy	98		503.53		1.2777031			
Tenth fiscal year		99		0.0223224		1.277703063	1.011161202	1.2919638
1st qtr, 11th fy	99		514.77		1.3062245			
Eleventh fiscal year		00		0.025526		1.306224466	1.012762982	1.3228958
1st qtr, 12th fy	00		527.91		1.3395671			
Twelfth fiscal year		01		0.0243602		1.339567104	1.012180106	1.3558832
1st qtr, 13th fy	01		540.77		1.3721992			
Thirteenth fiscal year		02		0.0184737		1.372199244	1.009236829	1.384874
1st qtr, 14th fy	02		550.76		1.3975488			
Fourteenth fiscal year		03		0.0534534		1.397548783	1.026726705	1.4349007
1st qtr, 15th fy	03		580.2		1.4722525			
Fifteenth fiscal year		04		0.0226646		1.472252531	1.011332299	1.4889365
1st qtr, 16th fy	04		593.35		1.5056205			
Sixteenth fiscal year		05		0.0448808		1.505620544	1.022440381	1.5394072
1st qtr, 17th fy	05		619.98		1.5731939			
Seventeenth fiscal year		06		0.0495339		1.57319394	1.024766928	1.6121571
1st qtr, 18th fy	06		650.69		1.6511203			
Eighteenth fiscal year		07		0.0402496		1.651120302	1.020124791	1.6843488

1st qtr, 19th fy	07		676.88		1.7175772			
Nineteenth fiscal year		08		0.0351761		1.717577203	1.017588051	1.747786
1st qtr, 20th fy	08		700.69		1.7779949			
Twentieth fiscal year		09		0.0371491		1.777994874	1.018574548	1.8110203
1st qtr, 21st fy	09		726.72		1.8440458			
Twentyfirst fiscal year		10		0.0185491		1.844045776	1.009274549	1.8611485
1st qtr, 22nd fy	10		740.2		1.8782512			

CESAJ-DP-PB 12-Sep-09

MARTIN COUNTY, FLORIDA
RENOURISHMENT 06

Table P-4
MAXIMUM COST INCLUDING INFLATION THROUGH CONSTRUCTION
(OCT 09 Price Levels)

Line 1			
	a.	Current project estimate at current price levels:	10,120
	b.	Current project estimate, inflated through construction:	19,677
	c.	Ratio: Line 1b / line 1a	1.9444
	d.	Authorized cost at current price levels: Column (h) plus (i) from table P-3	9,702
	e.	Authorized cost, inflated through construction: Line c x Line d	18,865
Line 2		Cost of modifications required by law:	0
Line 3		20 percent of authorized cost: .20 x (table P-3, columns (f) + (g)	1,043
Line 4		Maximum cost limited by section 902: Line 1e + line 2 + line 3	19,907

Table P-3

FY	Current Project Cost			Current Sched (%)		Authorized Cost Sched		Auth Cost Inflat	
	Total (a)	Constr (b)	R.E. (c)	Constr (d)	R.E. (e)	Constr (f)	R.E. (g)	Constr (h)	R.E. (i)
89	0	0	0	0.00	0.00	0	0	0	0
90	0	0	0	0.00	0.00	0	0	0	0
91	0	0	0	0.00	0.00	0	0	0	0
92	0	0	0	0.00	0.00	0	0	0	0
93	0	0	0	0.00	0.00	0	0	0	0
94	0	0	0	0.00	0.00	0	0	0	0
95	0	0	0	0.00	0.00	0	0	0	0
96	0	0	0	0.00	0.00	0	0	0	0
97	0	0	0	0.00	0.00	0	0	0	0
98	0	0	0	0.00	0.00	0	0	0	0
99	0	0	0	0.00	0.00	0	0	0	0
00	0	0	0	0.00	0.00	0	0	0	0
01	0	0	0	0.00	0.00	0	0	0	0
02	0	0	0	0.00	0.00	0	0	0	0
03	0	0	0	0.00	0.00	0	0	0	0
04	0	0	0	0.00	0.00	0	0	0	0
05	0	0	0	0.00	0.00	0	0	0	0
06	0	0	0	0.00	0.00	0	0	0	0
07	0	0	0	0.00	0.00	0	0	0	0
08	0	0	0	0.00	0.00	0	0	0	0
09	0	0	0	0.00	0.00	0	0	0	0
Balance to complete	10120	10120	0	100.00	100.00	5213	0	9702	0
Total	10120	10120	0	100.00	100.00	5213	0	9702	0

Table P-1
CWCCIS INDEX
13

Item	(b)	(c)	Index (d)	Yearly Inflat Rate (e)	Cumul Inflat Rate (f)	Cumul rate to Begin FY (g)	One Half rate of Infl FY (h)	Tot Allow Inflat for FY (i)
Date of Price Level		10/1/1989	(CWBS 17)					
Authorized Estimate		5213	394.09		1			1
First Fiscal year		90		0.0355756		1	1.017787815	1.0177878
1st Qtr, 2nd yr	90		408.11		1.0355756			
Second Fiscal year		91		0.0327118		1.03557563	1.016355884	1.0525134
1st Qtr, 3rd yr	91		421.46		1.0694511			
Third Fiscal year		92		0.0228254		1.069451141	1.011412708	1.0816565
1st qtr, 4th yr	92		431.08		1.0938618			
Fourth Fiscal Year		93		0.0347963		1.093861808	1.017398163	1.112893
1st qtr, 5th yr	93		446.08		1.1319242			
Fifth fiscal year		94		0.024592		1.13192418	1.012296001	1.1458423
1st qtr, 6th yr	94		457.05		1.1597605			
Sixth fiscal year		95		0.0192102		1.159760461	1.009605076	1.1709
1st qtr, 7th yr	95		465.83		1.1820396			
Seventh fiscal yr		96		0.0359573		1.182039636	1.017978662	1.2032911
1st qtr, 8th fy	96		482.58		1.2245426			

Eighth fiscal year		97		0.0208463		1.224542617	1.010423142	1.2373062
1st qtr, 9th fy	97		492.64		1.2500698			
Ninth fiscal year		98		0.0221054		1.250069781	1.011052696	1.2638864
1st qtr, 10th fy	98		503.53		1.2777031			
Tenth fiscal year		99		0.0223224		1.277703063	1.011161202	1.2919638
1st qtr, 11th fy	99		514.77		1.3062245			
Eleventh fiscal year		00		0.025526		1.306224466	1.012762982	1.3228958
1st qtr, 12th fy	00		527.91		1.3395671			
Twelfth fiscal year		01		0.0243602		1.339567104	1.012180106	1.3558832
1st qtr, 13th fy	01		540.77		1.3721992			
Thirteenth fiscal year		02		0.0184737		1.372199244	1.009236829	1.384874
1st qtr, 14th fy	02		550.76		1.3975488			
Fourteenth fiscal year		03		0.0534534		1.397548783	1.026726705	1.4349007
1st qtr, 15th fy	03		580.2		1.4722525			
Fifteenth fiscal year		04		0.0226646		1.472252531	1.011332299	1.4889365
1st qtr, 16th fy	04		593.35		1.5056205			
Sixteenth fiscal year		05		0.0448808		1.505620544	1.022440381	1.5394072
1st qtr, 17th fy	05		619.98		1.5731939			
Seventeenth fiscal year		06		0.0495339		1.57319394	1.024766928	1.6121571
1st qtr, 18th fy	06		650.69		1.6511203			
Eighteenth fiscal year		07		0.0402496		1.651120302	1.020124791	1.6843488

1st qtr, 19th fy	07		676.88		1.7175772			
Nineteenth fiscal year		08		0.0351761		1.717577203	1.017588051	1.747786
1st qtr, 20th fy	08		700.69		1.7779949			
Twentieth fiscal year		09		0.0371491		1.777994874	1.018574548	1.8110203
1st qtr, 21st fy	09		726.72		1.8440458			
Twentyfirst fiscal year		10		0.0185491		1.844045776	1.009274549	1.8611485
1st qtr, 22nd fy	10		740.2		1.8782512			

MARTIN COUNTY, FLORIDA
SUMMARY

Table P-4
MAXIMUM COST INCLUDING INFLATION THROUGH CONSTRUCTION
(OCT 09 Price Levels)

Line 1		Initial Fill	Ren 01	Ren 02	Ren 03	Ren 04	Ren 05	Ren 06	Summary
a.	Current project estimate at current price levels:	11,701	5,445	8,663	10,257	10,141	10,141	10,120	66,468
b.	Current project estimate, inflated through construction:	11,701	5,445	8,663	10,651	13,008	16,055	19,677	85,200
c.	Ratio: Line 1b / line 1a	1.0000	1.0000	1.0000	1.0384	1.2827	1.5832	1.9444	1.2818
d.	Authorized cost at current price levels: Column (h) plus (i) from table P-3	11,598	7,904	8,384	9,660	9,702	9,702	9,702	66,652
e.	Authorized cost, inflated through construction: Line c x Line d	11,598	7,904	8,384	10,031	12,445	15,360	18,865	84,587
Line 2	Cost of modifications required by law:	0	0	0	0	0	0	0	0
Line 3	20 percent of authorized cost: .20 x (table P-3, columns (f) + (g)	1,878	1,043	1,043	1,043	1,043	1,043	1,043	8,134
Line 4	Maximum cost limited by section 902: Line 1e + line 2 + line 3	13,476	8,947	9,427	11,074	13,488	16,403	19,907	92,721

Martin County, Florida
Hurricane and Storm Damage Reduction Project

Draft Limited Reevaluation Report of the
Beach Erosion Control Project

Attachment 5

Cost Sharing

This Page is Intentionally Left Blank

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

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

Cost Apportionment from 1994 GDM

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

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

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

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

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

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

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

THE TOTAL SUM OF COLUMN (J) DIVIDED BY THE TOTAL DESIGN VOLUME IS EQUAL TO 50.88 PERCENT, WHICH IS THE FEDERAL SHARE OF NON-LINEAR PROJECT COSTS FOR THE DESIGN VOLUME.

1/ SHORE OWNERSHIP AND PROJECT PURPOSE (As defined in ER 1165-2-130)		Max Level Fed Participation Construct Costs
I.	Federally Owned	100.00%
II.	Publicly and Privately Owned – Protection Results in Public Benfits.	
A.	Hurricane and Storm Damage Reduction	65.00%
B.	Private and Public Land Open for Public Use – Recreation	50.00%
C.	Separable Recreation	50.00%
III.	Privately Owned, Use Limited to Private Interests	0.00%
IV.	Privately Owned, Undeveloped	0.00%

Appendix K. Cost Estimate Data. (EN-C)

A reevaluation of shoreline conditions for the Martin County Federal project revealed no significant changes in shoreline ownership, use or public access. The following data is submitted. When compared to the cost sharing as outlined in the Project Cooperation Agreement, 46.59% Federal Participation, this represents a small change. This is insignificant and the sponsor desires to continue with the existing PCA as opposed to waiting on modifications.

Table K-1: Cost Apportionment

Cost Apportionment	**Public Lands**	**Developed Private Lands**	**Undeveloped Lands**	**Private - No Access**	**Total Shoreline Length**
Length	9085	7460	2425	1020	19990
Cost Allocation	50%	65%	0%	0%	
Federal Result	4542.5	4849	0	0	9391.5
			Federal Participation		47.0%

HUTCHINSON ISLAND BEACH NOURISHMENT

Project Boundary: DEP Range Monument R-1 to R-25
Approximate Shoreline Length: 21,990

Public Access	Parking Spaces
Glasscock	40
Jensen Beach*	316
Bob Graham	70
Alex's Beach	15+
Bryn Mawr	27
Stokes	10
Virginia Forest	26
Tiger Shores	31
Stuart Beach*	238

*Primary Beach Access

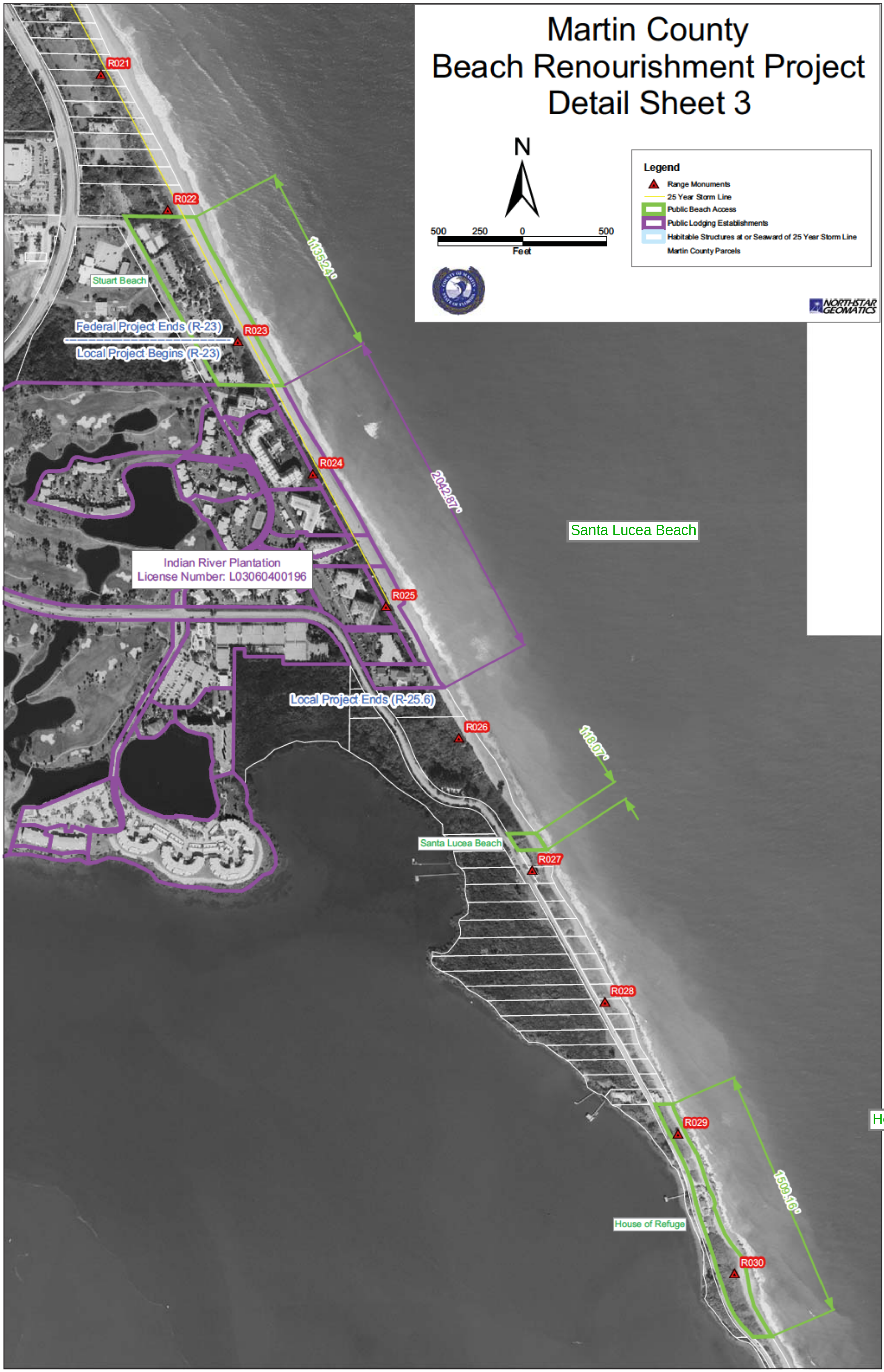
Areas determined to be publicly accessible:
R1 to 495' North of R15
325' South of R15 to 95' North of R17
200' South of R18 to R25

This Page is Intentionally Left Blank

Martin County
Beach Renourishment Project
Detail Sheet 1

Martin County Beach Renourishment Project Detail Sheet 2

Martin County
Beach Renourishment Project
Detail Sheet 3



This Page is Intentionally Left Blank

FINAL
SUPPLEMENTAL ENVIRONMENTAL IMPACT STATEMENT

MARTIN COUNTY HURRICANE AND STORM DAMAGE REDUCTION PROJECT
HUTCHINSON ISLAND, MARTIN COUNTY, FLORIDA

Contract No. W912EP-07-C-0034

LEAD AGENCY: Jacksonville District, U.S. Army Corps of Engineers

COOPERATING AGENCY: Bureau of Ocean Energy Management, Regulation, and Enforcement (formerly Minerals Management Service)

Prepared for:

U.S. Army Corps of Engineers
701 San Marco Boulevard
Jacksonville, FL 32207

Prepared by:

ANAMAR Environmental Consulting, Inc.
2106 NW 67th Place, Suite 5
Gainesville, FL 32653-1658
www.anamarinc.com

October 2011

THIS PAGE INTENTIONALLY LEFT BLANK

FINAL
SUPPLEMENTAL ENVIRONMENTAL IMPACT STATEMENT
October 2011

MARTIN COUNTY HURRICANE AND STORM DAMAGE REDUCTION PROJECT
HUTCHINSON ISLAND, MARTIN COUNTY, FLORIDA

LEAD AGENCY: Jacksonville District, U.S. Army Corps of Engineers

COOPERATING AGENCY: Bureau of Ocean Energy Management, Regulation, and Enforcement (formerly Minerals Management Service)

This Final Supplemental Environmental Impact Statement (SEIS) describes the proposed plan and the alternatives evaluated for the Martin County Hurricane and Storm Reduction Project (HSDR) (formerly referred to as the Beach Erosion Control Project or Shore Protection Project). The beach nourishment project authorizes construction of a protective and recreational beach along 4 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 renourishment interval of 11 years. Federal participation (cost-sharing) is authorized for 50 years from date of initial construction and expires in 2046. During the initial project authorization and planning process, a range of both nonstructural (NS) and structural (S) measures were evaluated, and placement of beach fill on the eroded beach to offer protection from storms and inclusion of periodic nourishment for future protection was selected as the preferred plan. However, the previously approved borrow area has been fully utilized. Therefore, this SEIS evaluates potential sources of beach-compatible sand including three offshore borrow areas (C1-A, C1-B, and C1-C) which lie primarily on the Federal Outer Continental Shelf (OCS) approximately 3 to 7 miles offshore Martin and St. Lucie Counties and several upland sand sources. The total sand needed for the remainder of the 50-year life of the project is estimated to be between 2.4 and 4.0 million cubic yards (mcy). The next renourishment phase is scheduled for 2012 and will involve the placement of approximately 787,800 cubic yards (cy) of material along the 4-mile project area. The preferred alternative, offshore borrow area C1-B, addresses the federal and local planning objectives, anticipated beach erosion losses, and considers the needs of the study area. To offset direct and secondary impacts to nearshore hardbottom located within the limits of the project fill area, nearshore artificial reef was created within three areas totaling 6 acres. Biological, sedimentation, and turbidity monitoring during all phases of project construction will be implemented to ensure protection of resources within and adjacent to the fill and borrow areas.

For more information, contact Paul DeMarco, U.S. Army Corps of Engineers, Planning Division, P.O. Box 4970, Jacksonville, Florida 32232-0019, phone (904) 232-1897 or facsimile (904) 232-3442.

U.S. Army Corps
of Engineers
Jacksonville District

THIS PAGE INTENTIONALLY LEFT BLANK

SUMMARY

FINAL SUPPLEMENTAL ENVIRONMENTAL IMPACT STATEMENT ON MARTIN COUNTY HURRICANE AND STORM DAMAGE REDUCTION PROJECT HUTCHINSON ISLAND, MARTIN COUNTY, FLORIDA

Need or Opportunity. Martin County is located on Florida's east coast 100 miles north of Miami and due east of Lake Okeechobee. The coastline consists of the Hutchinson Island area, which is an elongated barrier island approximately 24.5 miles long and generally only a mile or less wide. Hutchinson Island is separated from the mainland of Florida by the Ft. Pierce and St. Lucie Inlets and the Indian River Lagoon. Martin County's ocean front beaches extend for 21.5 miles between St. Lucie County and Palm Beach County.

The coastline of Martin County is low-lying and vulnerable to storm surge and other storm event damages. The problem along the project area is one of sand erosion and lowering of the beach profile with subsequent recession of the shoreline and dunes. The purpose and need for the shore protection project is to reduce both storm damage and beach erosion along the ocean shoreline of Martin County. Hurricanes and severe "northeasters" have caused considerable erosion and damage to shoreline structures within the project area. Along parts of the shoreline, erosion of beaches and dunes has made seawalls, buildings, and other structures vulnerable to severe storm damage.

The Martin County Hurricane and Storm Damage Reduction Project is designed to provide storm damage protection to structures that would otherwise be threatened by chronic shoreline retreat and storm-induced beach erosion while maintaining an area suitable for recreation and wildlife habitat. The beach nourishment project authorizes construction of a protective and recreational beach along 4 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 renourishment interval of 11 years. Federal participation (cost-sharing) is authorized for 50 years from date of initial construction and expires in 2046. The total amount of sand needed for the remainder of the 50-year life of the project is estimated to be between 2.4 and 4.0 million cubic yards (mcy). The next renourishment phase is scheduled for 2012 and will involve the placement of approximately 787,800 cubic yards (cy) of material along the 4-mile project area.

Fill material for initial project construction and subsequent renourishment events was obtained from Gilbert Shoal, a borrow area located approximately 3,000 feet offshore of the barrier island. However, this previously approved borrow area has been fully utilized; therefore, a new borrow area needs to be identified to provide enough beach-compatible sand for the remaining period of federal cost-sharing participation.

Alternatives. The scope of this SEIS considers alternative sand sources for fill material for the authorized beach nourishment project, evaluates the potential effects that may result from the use of a new borrow area, and re-evaluates the potential effects of entire beach nourishment project in light of new available environmental information. This SEIS tiers from the existing 1986 *Feasibility Report with Final SEIS* and the 1994 *General Design Memorandum (GDM) with Environmental Assessment (EA)* that was prepared during initial evaluation and authorization of the Martin County Shore Protection Project [U.S. Army Corps of Engineers (USACE) 1994]. During the initial planning process, a full range of both nonstructural (NS) and structural (S) measures were evaluated. This current SEIS does not re-consider all of the alternatives, it only evaluates potential sources of beach-compatible sand which will yield enough sand to last for the remaining period of federal cost-sharing participation for the authorized project. Alternatives considered in detail in this SEIS include three offshore borrow areas (C1-A, C1-B, and C1-C) which lie primarily on the Federal Outer Continental Shelf (OCS) approximately 3 to 7 miles offshore Martin and St. Lucie Counties and several upland sand sources.

1986 FR with SEIS and 1994 GDM Alternatives. As mentioned previously, a range of both nonstructural and structural measures were evaluated in the 1994 GDM (USACE 1994) to reduce beach, land, and property losses resulting from erosion, storms, and hurricanes along Hutchinson Island. They consisted of the No Action Alternative, seven nonstructural solutions, and eight structural solutions. The alternatives were evaluated for the potential to contribute to the project objectives and consistency with project constraints. Several alternatives were not evaluated further than the initial screening due to a combination of economic viability, effectiveness, and/or political or social acceptance. The screening process eliminated those alternatives that did not respond to the needs of the problem area or to the overall planning objectives from further consideration and detailed evaluation. The federal planning objectives, as determined by the Principles and Guidelines, are to address the erosion problem by identifying and selecting the best course of action. The local planning objectives were incorporated in the overall screening process based upon the expressed desires of the local sponsor. Only those alternatives that warranted consideration based upon the overall planning objectives were brought forward for further evaluation. Various methods of hardened shore protection, such as revetments and seawalls, were eliminated from further consideration because such measures would not function well in the study area, would not solve the erosion problem, and would not provide enhanced recreational and sea turtle nesting benefits. The nonstructural alternatives would minimize environmental impacts and would help to alleviate economic impacts on oceanside property owners, but would not meet study objectives because the beaches in the project area would continue to erode and result in a loss of recreational benefits and sea turtle nesting habitat.

Analysis of the economic feasibility of the various shore protection alternatives in Florida most often indicates that beach nourishment represents the optimum solution to the erosion problems within the framework of federal guidelines. Beach fill alternative designs are formulated to provide various levels of protection to development, prevention of loss of land, and recreational benefits. Since the beach nourishment alternative (S-3) offered a better course of action and opportunities to address the National Economic Development (NED) objective, it was carried forward for more detailed evaluation.

Supplemental EIS Alternatives: The additional alternatives discussed in the SEIS are a subset of the preferred alternative, Beach Nourishment (S-3), that was selected and authorized based on the initial planning and screening process (as described in the previous section). Sufficient quantities of beach-quality sand were available from the previously approved nearshore borrow area (Gilbert Shoal) for the 1996, 2001, 2002, and 2005 beach nourishment projects. However, that borrow area has been fully utilized; therefore, alternate sand sources are being evaluated in this SEIS to meet future nourishment requirements for the remaining life of the federal cost-sharing portion of this project which expires in 2046. The alternatives considered in the SEIS include:

- No Action Alternative
- S-3A: Beach Nourishment Using an Offshore Sand Source (Borrow Areas C1-A, C1-B, and C1-C)
- S-3B: Beach Nourishment Using an Upland Sand Source

Preferred Alternative. Beach Nourishment Using Offshore Borrow Area C1-B is selected as the Preferred Alternative because it addresses the erosion problem within the project area and fulfills Martin County's goals and objectives. Beach restoration using dredged material from the proposed offshore borrow area C1-B would provide a sufficient amount of beach-compatible sand at a more economical cost and with less transportation complications than beach sand from an upland borrow source. This site is located further away from shore than proposed borrow sites C1-A and C1-C, and wave analysis modeling results indicate that dredging this site for fill material would not result in unacceptable impacts to the wave climate and shoreline sediment transport from dredging this area. In addition, based on survey results, no submerged cultural resources or hardbottom resources have been identified within C1-B.

Major Findings and Conclusions. The authorized Martin County Hurricane and Storm Damage Reduction Project will be in the national interest and can be constructed while protecting the environment from unacceptable impacts. Federal and county objectives (benefits) include: (1) reducing expected storm damages through beach nourishment and other project alternatives; (2) re-establishing beaches as suitable recreational areas; (3) maintaining suitable beach habitat for nesting sea turtles, invertebrate species, and shorebirds; and (4) maintaining commerce associated with beach recreation in Martin County. This SEIS considers possible adverse impacts to the beach, nearshore hardbottom resources, and offshore sand borrow area resources and adjacent habitat. Significant issues addressed include potential long-term and cumulative effects on protected species, water quality, essential fish habitat (EFH), fish and wildlife resources, benthic communities, sediment transport, wave modification, cultural and socio-economic resources, and aesthetics and recreation.

Measures will be taken to avoid, minimize, and compensate for adverse impacts associated with obtaining offshore source material and nourishing 4 miles of shorefront. To offset direct and secondary impacts to nearshore hardbottom located within the limits of the beach fill project area (R-1 to R-25), 6.0 acres of nearshore artificial reef was created at three separate sites located approximately 900 feet offshore monuments R-12, R-18, and R-20. A biological monitoring plan has also been developed to assess direct, secondary, and long-term effects to nearshore hardbottom habitat associated with the proposed project. A sedimentation and turbidity monitoring plan has been established to assess, avoid, and/or minimize impacts to reef communities adjacent to the proposed borrow areas during project construction. The National Marine Fisheries Service (NMFS) and the Florida Fish and Wildlife Conservation Commission (FFWCC or FWC) comments have been addressed in the Final SEIS. Specific conditions as required in the Florida Department of Environmental Protection (FDEP) permit will also be followed accordingly to help minimize and avoid environmental impacts.

Issues Raised by the Public and Agencies. A Notice of Intent (NOI) to prepare the Draft SEIS for the Martin County Hurricane and Storm Damage Reduction Project located in Martin County, Florida was published in the Federal Register on June 1, 2007. The NOI was mailed to interested and affected parties by letter dated June 1, 2007, and coordination with relevant federal, state, and local agencies was conducted by USACE and Martin County. Issues of concern raised by respondents to the NOI are summarized below.

The Florida State Historic Preservation Office (SHPO) raised concerns that known and unidentified shipwreck sites within and adjacent to the proposed Martin County borrow areas may be impacted by sand-borrowing activities.

FDEP stated in their response to the NOI that, at this stage, the proposed activities are consistent with the Florida Coastal Management Program (FCMP); however, concerns raised by other reviewing agencies must be addressed prior to project implementation.

The Caribbean Conservation Corporation urged USACE to consider avenues for adequately funding an assessment of an alternate beach design template for the next renourishment. This is part of an effort that has been going on for more than a decade to adjust the traditional beach nourishment design template to ameliorate some of its negative effects on nesting sea turtles. The proposal is to construct alternating traditional and turtle friendly segments so that monitoring may be implemented in a controlled environment to scientifically verify the performance of the turtle friendly template, without compromising storm damage reduction benefits. This effort is supported by FDEP, Martin County, and the U. S. Fish and Wildlife Service (USFWS) among others.

The Town of Jupiter Island supports a study to identify new borrow sites for beach-compatible sand as long as sites would be developed and utilized in a non-exclusive manner so other municipalities could also access the sites.

NMFS raised several issues that require detailed evaluation, including the potential for significant adverse effects from excavation of offshore shoals on shoreline and living marine resources. NMFS also noted that mining the shoal for sand might alter the local wave climate and accelerate erosion that could affect EFH. Lastly, NMFS expressed concern that excavation of offshore borrow areas and placement of fill in nearshore areas could adversely affect hardbottom habitat, including corals and worm reefs colonized by *Phragmatopoma lapidosa.*

Public response originated primarily from St. Lucie County residents from Jensen Beach and Nettles Island who are opposed to the project. Their concern is that Martin County will be using sand resources that should be reserved to renourish St. Lucie County beaches along Hutchinson Island, which are also badly eroded.

Issues of concern raised by state and federal protection agencies relevant to the proposed renourishment project are addressed in this Final SEIS.

Areas of Controversy. Controversial issues raised by interested agencies and other parties during review of the Draft SEIS and the public meeting have addressed and incorporated into the Final SEIS.

Unresolved Issues. With the exception of the new borrow area location, the proposed Martin County Hurricane and Storm Damage Reduction Project does not include any areas that have not been previously used during past renourishment activities performed in Martin County. USACE and Martin County are committed to avoiding, minimizing, and mitigating for adverse effects during construction activities. Biological, sedimentation, and turbidity monitoring during all phases of project construction will be implemented to ensure protection of resources within and adjacent to the fill and borrow areas.

FINAL SUPPLEMENTAL ENVIRONMENTAL IMPACT STATEMENT
ON
MARTIN COUNTY HURRICANE AND STORM DAMAGE REDUCTION PROJECT
HUTCHINSON ISLAND, MARTIN COUNTY, FLORIDA

TABLE OF CONTENTS

3. AFFECTED ENVIRONMENT ... 59

APPENDICES

LIST OF FIGURES

LIST OF TABLES

ACRONYMS AND ABBREVIATIONS

ABI	Applied Biology, Inc.
ATM	Applied Technology and Management, Inc.
ASMFC	Atlantic States Marine Fisheries Commission
BCR	Bird Conservation Region
BMP	best management practice
BOEMRE	Bureau of Ocean Energy Management, Regulation, and Enforcement (formerly MMS)
CAR	Coordination Act Report
CBRA	Coastal Barrier Resources Act
CCCL	Coastal Construction Control Line
CDN	Coastal Data Network
CEQ	Council on Environmental Quality
ceta	Cetacean and Turtle Assessment Program
cm	centimeter
CO	carbon monoxide
CP&E	Coastal Planning and Engineering, Inc.
CSA	Continental Shelf Associates, Inc.
CWA	Clean Water Act
cy	cubic yards
CZMA	Coastal Zone Management Act
DEIS	Draft Environmental Impact Statement
DoN	Department of the Navy
EA	Environmental Assessment
EAI	Ecological Associates, Inc.
EFH	Essential Fish Habitat
EIS	Environmental Impact Statement
EQ	environmental quality
ERDC	Engineering Research and Development Center
ESA	Endangered Species Act
ETOF	equilibrium toe of fill
EWS	Early Warning System
FCCE	Flood Control and Coastal Emergency
FCMP	Florida Coastal Management Program
FDEP	Florida Department of Environmental Protection
FDS	Florida Department of State
FEMA	Federal Emergency Management Agency
FFWCC/FWC	Florida Fish and Wildlife Conservation Commission
FGS	Florida Geological Survey
FMP	Fishery Management Plan
FMRI	Florida Marine Research Institute
FNAI	Florida Natural Areas Inventory
FWRI	Fish and Wildlife Research Institute
GDM	General Design Memorandum
GRBO	Gulf Regional Biological Opinion
HAPC	Habitat Areas of Particular Concern
hp	Horsepower

HSDR	Hurricane Storm Damage Reduction
m	meters
mm	millimeters
mcm	million cubic meters
mcy	million cubic yards
mhw	mean high water
mlw	mean low water
MMS	Minerals Management Service (now BOEMRE)
msl	mean sea level
NEAQ	New England Aquarium
NED	National Economic Development
NEPA	National Environmental Policy Act
NGVD	National Geodetic Vertical Datum
NHPA	National Historic Preservation Act
NMFS	National Marine Fisheries Service
nmi	nautical mile
NOA	Notice of Availability
NOAA	National Oceanographic and Atmospheric Administration
NOI	Notice of Intent
NO_x	nitrates
NRC	National Research Council
NRHP	National Register of Historic Places
NS	nonstructural
NTU	nephelometric turbidity unit
OCS	Outer Continental Shelf
OCSLA	Outer Continental Shelf Lands Act
OSE	Other Social Effects
PCA	project cooperation agreement
PL	Public Law
PM	particulate matter
RBO	Regional Biological Opinion
RED	Regional Economic Development
S	structural
SAFMC	South Atlantic Fisheries Management Council
SDEIS	Supplemental Draft Environmental Impact Statement
SEARCH	Southeastern Archaeological Research, Inc.
SEIS	Supplemental Environmental Impact Statement
SHPO	(Florida) State Historic Preservation Office(r)
SLOPES	(USFWS) Standard Local Operating Procedures for Endangered Species
SO_2	sulfur dioxide
STWAVE	Steady State Spectral WAVE
TEWG	Turtle Expert Working Group
USACE	U.S. Army Corps of Engineers
USEPA	U.S. Environmental Protection Agency
USFWS	U.S. Fish and Wildlife Service
VOC	volatile organic compounds
WIS	Wave Information Studies

FINAL SUPPLEMENTAL ENVIRONMENTAL IMPACT STATEMENT
ON
MARTIN COUNTY HURRICANE AND STORM DAMAGE REDUCTION PROJECT
HUTCHINSON ISLAND, MARTIN COUNTY, FLORIDA

1. PROJECT PURPOSE AND NEED

1.1. GENERAL PROJECT LOCATION

Martin County is located on Florida's east coast 100 miles north of Miami and due east of Lake Okeechobee. The coastal area consists of Hutchinson Island, which is an elongated barrier island approximately 24.5 miles long and generally only a mile or less wide. Hutchinson Island is separated from mainland Florida by the Ft. Pierce and St. Lucie Inlets and the Indian River Lagoon. Martin County's ocean-front beaches extend 21.5 miles between St. Lucie County and Palm Beach County. The project area also includes the diverse inner shelf habitat offshore of St. Lucie and Martin counties, including the physically dominated surf zone, nearshore hardbottom habitat, and offshore sand borrow areas that may be targeted for beach fill. Chapter 3 provides a more detailed description of the project area and resources occurring within the region of interest.

1.2. PROJECT AUTHORITY

1.2.1. INITIAL AUTHORIZATION

A Congressional Resolution was adopted by the Public Works Subcommittee on May 18, 1973, requesting that the U.S. Army Corps of Engineers (USACE) investigate shore protection alternatives for Martin County, Florida. In June 1986, a *Feasibility Report with Final Environmental Impact Statement* was published and filed with the U.S. Environmental Protection Agency (USEPA). The project was authorized by the Water Resource Development Act of 1990 [Public Law (PL) 101-640]. The authorized plan consisted of construction of a protective and recreational beach along 4 miles of shorefront from the St. Lucie/Martin County line southward almost to the Public Beach Park (R-1 to R-25). (**Figure 1.2-1**). Prior to construction, a *General Design Memorandum (GDM) with Environmental Assessment (EA)* dated June 1994 was prepared. Discretionary authority was used to reduce the federal project length to 3.75 miles (R-1 to R-23) to avoid adverse environmental impacts to nearshore hardbottom habitat from infilling. The project berm was also tapered between R-23 to R-25 to further reduce adverse hardbottom impacts. The plan included restoring the primary dune to an elevation of 12.5 feet above mean sea level (msl) and a top width of 20 feet (**Figure 1.2-2**). In order to maintain the protective beach, advanced nourishment was included in the initial beach fill. The 1994 GDM optimized renourishment at 589,600 cy every 11 years; however, this interval has been revised to 13 years to maximize economics based on an updated erosion rate in the project area, a construction window from November 1 to May 1, and 35 years of remaining federal interest. A project cooperation agreement (PCA) was executed between the Department of the Army and the non-federal sponsor on August 3, 1995. The federal project is authorized for

50 years from the date of initial construction on December 13, 1995. The period of federal participation (cost-sharing) for this project expires in 2046. The total project fill requirement for the remainder of the 50-year life of the Martin County Hurricane and Storm Damage Reduction Project (HSDR) (formerly referred to as the Beach Erosion Control Project or Shore Protection Project) is estimated to be between 2.4 and 4.0 mcy. The next renourishment phase of the authorized project is scheduled for 2012.

The non-federal project sponsor is responsible for lands, easements, rights-of-way, relocations, and suitable borrow and/or disposal areas required for maintenance of the project. The sponsor is required to monitor the project annually to determine losses of nourishment material from the project footprint and assess impacts of project construction on sea turtle nesting. The sponsor is also required to reshape the beach and dune profile using material from within the project area and to maintain vegetation, public dune crossovers, and other project features associated with the beach and dunes.

The sponsor shall also keep access roads, parking areas, and other public-use facilities open and available to all on equal terms. Replacement of dune vegetation following periodic nourishment and replacement of dune crossovers is also a non-federal responsibility. The sponsor has fulfilled all of its non-federal responsibilities to date in accordance with the PCA.

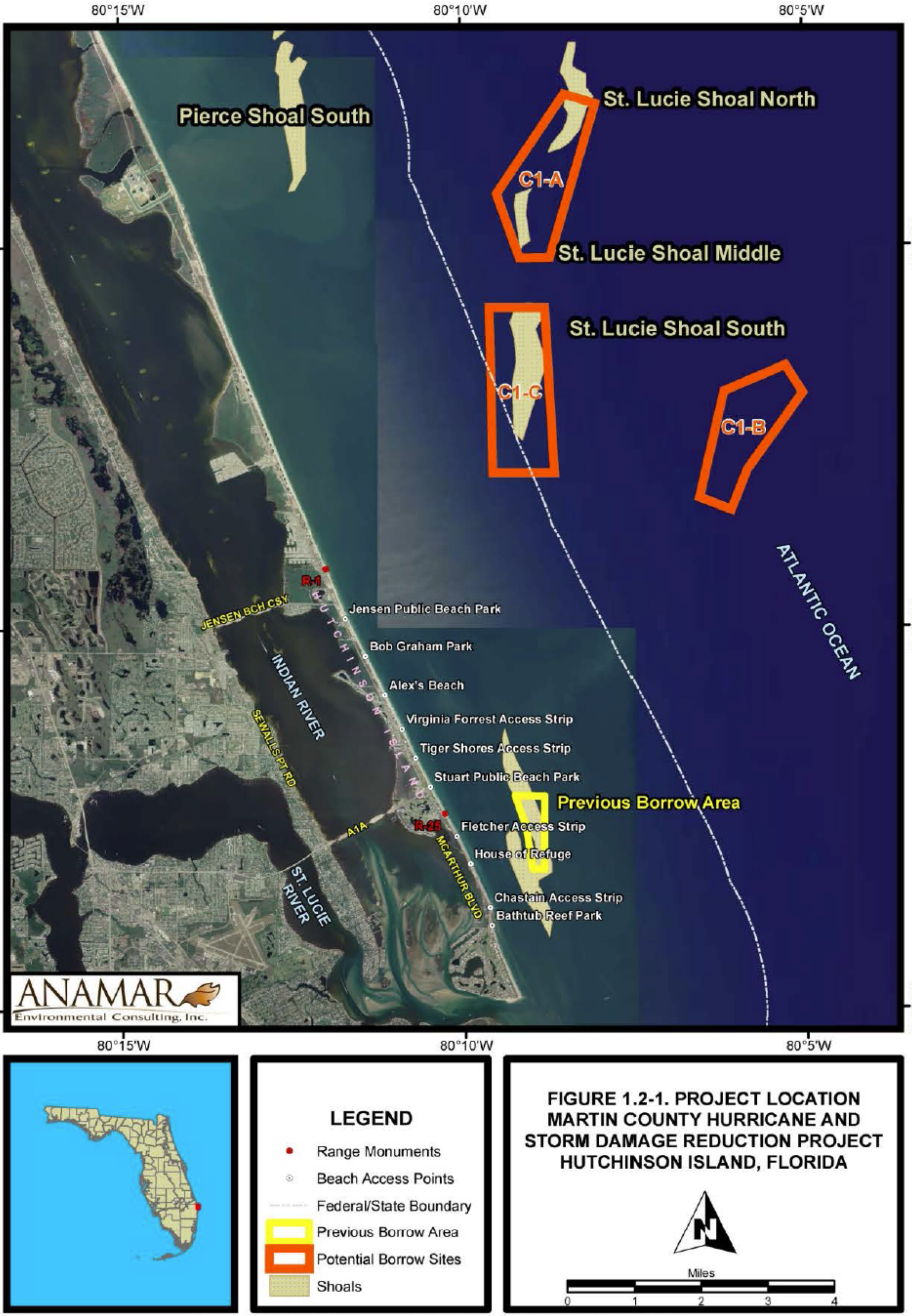
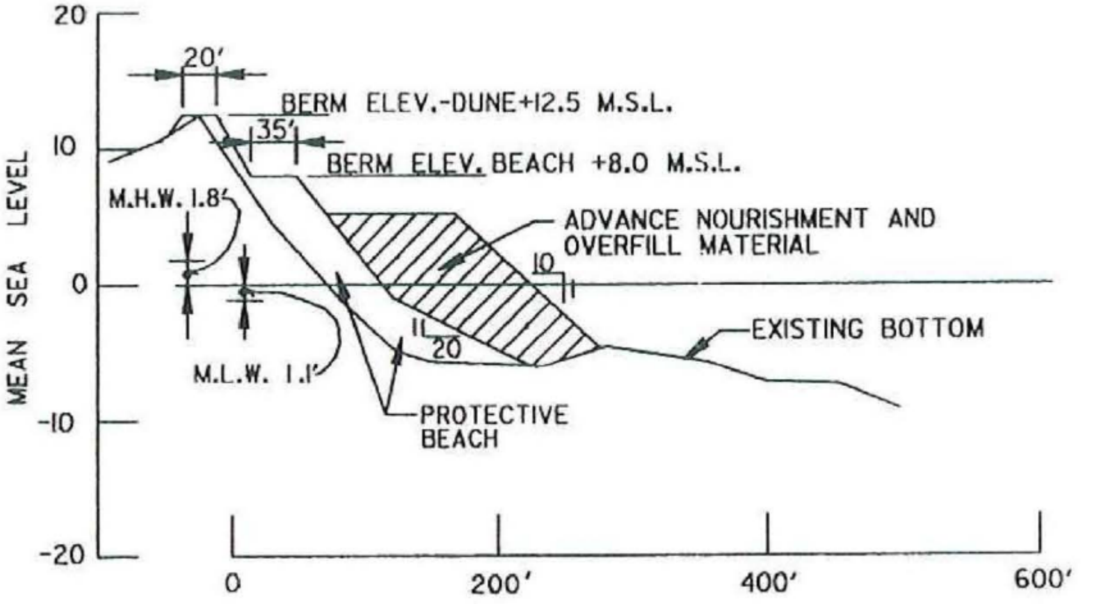


FIGURE 1.2-1. PROJECT LOCATION MARTIN COUNTY HURRICANE AND STORM DAMAGE REDUCTION PROJECT HUTCHINSON ISLAND, FLORIDA

This map and/or digital data is for planning purposes only and should not be used to determine the precise location of any feature.
Data provided as-is. Q:\GIS PROJECTS\EIS_MARTIN_CO\EIS\Figure updates 030211\figure1.2-1_vicinity_and_plan_view1_020711_2.mxd.mxd. Data sources: NOAA, USACE, USFWS.



TYPICAL SECTION
VICINITY HUTCHINSON ISLAND (JENSEN BEACH)

ANAMAR Environmental Consulting, Inc.

**FIGURE 1.2-2.
BEACH PROFILE AND CROSS-SECTION
MARTIN COUNTY HURRICANE AND
STORM DAMAGE REDUCTION PROJECT
HUTCHINSON ISLAND, FLORIDA**

*This map and/or digital data is for planning purposes only and should not be used to determine the precise location of any feature. Data provided as-is.
Q:\GIS PROJECTS\EIS_MARTIN_CO\EIS\Figure updates 012711\figure1.2-2_cross_section.mxd\.mxd. Data sources: LABINS, FGDL, FDEP, USACE.*

1.2.2. SUPPLEMENTAL APPROPRIATION

In a letter dated January 6, 1997, PL 84-99 assistance was requested for the Martin County Shore Protection Project following a severe "northeaster" storm event (USACE 2000). An evaluation of profile volume and shoreline position changes due the storm event was conducted to assess the damages caused by the storm (CP&E 1997). The evaluation determined that the November 1996 storm had resulted in moderate damage to the project area. However, the study also noted that much of the sand lost from the dry beach had been deposited in a nearshore storm bar, and the sand contained in the bar would likely migrate naturally to the beach within an acceptable time frame. The study concluded that the project was not eligible at that time for rehabilitation work under the provisions of PL 84-99. Consequently, no rehabilitation work was proposed.

In a letter dated November 1, 2004, PL 84-99 assistance was requested for the Martin County Shore Protection Project following Hurricanes Frances and Jeanne, which caused significant damage to the project area. Storm damages to the shore protection project resulted in a loss of approximately 269,500 cy of material from the project reach. This loss was deemed significant because it is equal to 45% of the periodic renourishment volume of approximately 590,000 cy (USACE 2005). The request met Flood Control and Coastal Emergency (FCCE) criteria, and emergency rehabilitation of the project area was approved under the authority of PL 84-99. Due to the 2004 hurricane impacts, the project was fully restored in spring of 2005 utilizing sand from the previously approved borrow area (Gilbert Shoal). Approximately 269,500 cy of material were used to restore the project to pre-storm conditions at 100% federal cost using FCCE funds, and approximately 625,500 cy were used to restore to full design conditions using construction general funds (USACE 2006).

In a letter dated February 23, 2006, PL 84-99 assistance was requested to restore the project area to pre-storm conditions as a result of damages incurred during the 2005 hurricane season (USACE 2006). Although significant damage was sustained, the project could not be completed before the next hurricane season began (June 1, 2007) due to lack of available beach-quality sand. Therefore, the project was ineligible for rehabilitation from impacts incurred during the 2005 hurricane season under PL 84-99.

1.2.3. PROJECT HISTORY

Construction of the Martin County HSDR Project occurred between December 13, 1995, and April 10, 1996, with placement of approximately 1.3 mcy of beach-quality sand from Gilbert Shoal, a borrow area located offshore of Stuart Public Beach. The project fill limits extended from the Martin/St. Lucie County line southward for 4 miles (R-1 to R-25). The 1994 GDM optimized renourishment at 590,000 cy every 11 years. However, from 1996 to 2005, the project area was nourished four times (1996, 2001, 2002, and 2005) to address the damage sustained from a series of significant storms, including a strong "northeaster" during project construction in 1996, three hurricanes in 1999, two hurricanes in 2004, and three hurricanes in 2005. The initial 1996 nourishment placed a much greater volume of sand on the beach (advanced nourishment) than the subsequent three nourishment events (**Table 1.2-1**).

The four nourishment events shown in **Table 1.2-1** differ in volume and location. The events in 1996 and 2005 covered the entire project area (R-1 to R-25). The 2001 event nourished most of the southern third of the project length, while the 2002 nourishment provided sand only to the central portion of the project area. The revised planned cycle of a 13-year interval for full beach nourishment is designed to allow for average annual erosion losses based on more current erosion rate data. However, this schedule does not preclude interim projects, such as those conducted in 2001 and 2002, to conduct partial nourishments to address erosional hotspots that may develop during the 13-year interval.

Table 1.2-1. Nourishments and Hurricanes Affecting the Project Area, 1996-2005

Event	Event Date	Cubic Yards
Northeaster (occurred during construction)	March 1996	N/A
Beach Nourishment – Initial Project Construction (R-1 to R-25)	December 1995 - April 1996	1,340,000
Hurricanes Dennis, Floyd, and Irene	Dennis (August 1999) Floyd (September 1999) Irene (October 1999)	N/A
Partial Beach Nourishment (R-16.2 to R-22.3)	January 2001 - Spring 2001	178,000
Partial Beach Nourishment (R-13.5 to R-16.2)	February 2002 - Spring 2002	126,000
Hurricanes Frances and Jeanne	Frances (August 2004) Jeanne (September 2004)	N/A
Full Beach Nourishment (R-1 to R-25.6)	Spring 2005	885,000
Hurricanes Dennis, Wilma, and Katrina	Dennis (July 2005) Katrina (August 2005) Wilma (September 2005)	N/A

Source: Stites et al. (2007), Taylor Engineering (2009c)

1.3. NEED AND PURPOSE OF PROPOSED ACTION

The purpose of the authorized Martin County HSDR Project is to provide storm damage protection to structures that would otherwise be threatened by chronic shoreline retreat and storm-induced beach erosion and to maintain an area suitable for recreation and wildlife habitat by performing periodic beach nourishment along the 4-mile project reach. The project is needed because recreational beach and beach habitat has been severely eroded, and hurricanes and storms present a significant risk to commercial and residential properties and sea turtle nesting habitat.

The authorized period of federal cost-sharing participation for this project is 50 years from initial project construction and expires in 2046. However, the previously approved nearshore borrow area (Gilbert Shoal) for this project has been fully utilized. The 1994 GDM estimated the area to contain approximately 6 mcy of beach quality material and between 1996 and 2005 approximately 3 mcy was mined from the area. However, state requirements for buffers between sand layers and fines restrictions as well as practical sand thicknesses that can be dredged all contribute to a reduction in volume. As a result, Gilbert Shoal no longer contains a sufficient quantity of beach quality material for the project and is no longer a viable sand source. Therefore, a new borrow area needs to be identified in support of the authorized beach nourishment project. The proposed action evaluated in this Supplemental EIS (SEIS) is to identify and approve an alternative sand source that will provide enough beach-compatible sand for the remaining authorized period of federal cost-sharing participation.

It is important to note that this SEIS tiers directly from the 1986 *Feasibility Report with Final EIS* and the 1994 *GDM with EA* in which a full suite of structural (S) and non-structural (NS) measures were considered. During the initial assessment and evaluation of plans, structural measure S-3, beach fill with periodic nourishment, was selected as the preferred alternative. This SEIS does not re-consider the full suite of alternatives evaluated during the initial planning process. The scope of the SEIS is to evaluate and compare alternative sources of beach-quality sand, including upland and offshore sources, to identify a new borrow area; compare costs associated with mining sand from these sources; assess impacts on the environment and coastal processes from removal of this sand; and address impacts from nourishing the beach with this sand. The SEIS also provides new environmental information that has become available since the publication of the previous National Environmental Policy Act (NEPA) documents.

1.4. AGENCY GOAL OR OBJECTIVE

1.4.1. FEDERAL AND COUNTY OBJECTIVES

- Reduce expected storm damages through beach nourishment and other project alternatives.
- Re-establish beaches as suitable recreational areas.
- Maintain suitable habitat for nesting sea turtles, invertebrate species, and shorebirds.
- Maintain commerce associated with beach recreation in Martin County.
- Obtain beach-quality material in the most cost-effective and environmentally sustainable manner possible.

1.4.2. PLANNING OBJECTIVES

The overall objective for water resource planning is to develop a plan that best satisfies present and projected beach erosion control needs for the area while preserving and/or enhancing natural and recreational resources. The specific planning objectives used to conduct the study included:

1. Determination of the nature and extent of the erosion problems along the Martin County shoreline;
2. Determination of the pertinent factors that influence shoreline erosion along Martin County;

3. Determination of expected growth and future needs of the area;
4. Determination of the existing shorefront condition and recreational needs and the probable impacts on same by alternative measures for preservation and/or enhancement of these resources.

1.5. RELATED ENVIRONMENTAL DOCUMENTS

Multiple reports, technical documents, and studies were reviewed during preparation of this SEIS including, but not limited to:

1. Challenge Engineering and Testing, Inc. 2007. *Final Report: Vibracore Sampling and Laboratory Testing.* Martin County Offshore Investigations Project. Prepared for U.S. Army Corps of Engineers, Jacksonville District. Geotechnical Branch. November 2007.
2. CSA. 2007. *Baseline Survey of Nearshore Hardbottom Habitats in Martin County, Florida.* CSA International, Jupiter, Florida.
3. CSA. 2011. *Hutchinson Island Shore Protection Project 2010 Hard Bottom Baseline Survey.* CSA International, Jupiter, Florida. January.
4. EAI. 2005. *Martin County Beach Nourishment and Dune Restoration Projects, Results of 2005 Sea Turtle Monitoring.* Ecological Associates, Inc., Jensen Beach, Florida. 11 pp. + tables, figures, and appendices.
5. EAI. 2006. *Martin County Monitoring Area, Hutchinson Island, Florida; Results of 2005 Sea Turtle Monitoring.* Ecological Associates, Inc., Jensen Beach, Florida. 15 pp. of figures and tables.
6. Gilmore, R.G., Jr. 2008. *Regional Fishery Resource Survey and Synthesis in Support of Martin County's Comprehensive Beach and Offshore Monitoring Program. Final Report.* Prepared for Martin County Engineering Department, Stuart, Florida. December 2008.
7. 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.
8. Harris, L.E. 2002-2006. *Monitoring of Martin County Nearshore Mitigation Reefs.* Performed for Martin County Engineering Department. Stuart, Florida.
9. Southeast Archeological Research, Inc. (SEARCH). 2008. *Historic Assessment and Submerged Cultural Resources Remote Sensing Survey of Four Borrow Areas for Martin and St. Lucie Counties Shore Protection Projects, Florida.*

10. Taylor Engineering, Inc. 2009. *FDEP Joint Coastal Permit Application.* Prepared for Martin County Engineering Department, Stuart, Florida. April 2009.
11. USACE. 1986. *Feasibility Report with Environmental Impact Statement: Beach Erosion Control Study, Martin County, Florida. September 1985.* Jacksonville District, South Atlantic Division.
12. USACE. 1994. *Martin County, Florida Shore Protection Project General Design Memorandum with Environmental Assessment.* June 1994. Jacksonville District, South Atlantic Division.
13. USACE. 2000. *PL 84-99 Rehabilitation Evaluation Report for the Martin County, Florida Shore Protection Project.* Prepared in February 2000 for USACE Jacksonville District by Coastal Systems International, Inc.
14. USACE. 2005. *Project Information Report: Rehabilitation Effort for the Martin County Hurricane/Shore Protection Project.* Prepared for Public Sponsor, Martin County Board of County Commissioners, Stuart, Florida. 2/24/2005.
15. 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, 18 September 2006.
16. USACE. 2009. *Wave Refraction Analysis, Martin County Borrow Area "B".* U.S. Army Corps of Engineers Jacksonville District, Jacksonville, FL.
17. 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.
18. USFWS. 2007. *Regional Biological Assessment for Beach Activities along the Atlantic and Gulf Coast of Florida.*

1.6. PUBLIC INVOLVEMENT

The proposed project was coordinated with the following agencies: U.S. Fish ansd Wildlife Service (USFWS), National Marine Fisheries Service (NMFS), U.S. Environmental Protection Agency (USEPA), Florida State Clearinghouse, Florida Fish and Wildlife Conservation Commission (FFWCC or FWC), Florida Department of Environmental Protection (FDEP), Florida State Historic Preservation Officer (SHPO), and other interested parties. Issues of concern raised by state and federal agencies relevant to the proposed nourishment project have been incorporated into this SEIS for detailed evaluation. The proposed action involves evaluation for compliance with guidelines pursuant to Section 404(b) of the Clean Water Act (CWA); application (to the State of Florida) for Water Quality Certification pursuant to Section 401 of the CWA; certification of state lands, easements, and rights of way; and determination of Coastal Zone Management Act consistency.

1.6.1. SCOPING PROCESS

NEPA regulations require an early and open process for determining the scope of issues that should be addressed prior to implementation of a proposed action. The scoping process as outlined by the Council on Environmental Quality (CEQ) was initiated to involve federal, state, and local agencies, affected Indian tribes, and other interested persons and organizations. On June 1, 2007, USACE published a Notice of Intent (NOI) to prepare a draft SEIS for the Martin County HSDR Project. The scoping letter was published and distributed to agencies, and requested their comments and concerns regarding environmental and cultural resources, study objectives, important features within the described project area, and suggested improvements. Copies of the scoping letter, NOI, the list of addresses used for distribution, and letters of response are included in Appendix C, Pertinent Correspondence.

The following is a summary of the responses to the scoping letter from agencies, local interests, and organizations regarding concerns and issues related to the proposed project:

- Florida SHPO response to the NOI raised concerns that both known and unidentified shipwreck sites within and adjacent to the proposed borrow areas may be impacted by sand-borrowing activities.
- FDEP responded that, at this stage, the proposed activities are consistent with the Florida Coastal Management Program (FCMP); however, concerns raised by other reviewing agencies must be addressed prior to project implementation.
- The Town of Jupiter Island supports a study to identify new borrow sites for beach-compatible sand as long as sites are developed and utilized in a non-exclusive manner, whereby other municipalities could also access the sites.
- NMFS raised several issues that require detailed evaluation, including the potential for significant adverse effects from excavation of offshore shoals on shoreline and living marine resources. NMFS also noted that mining the shoal for sand may alter the local wave climate, thereby accelerating erosion that could affect EFH and habitat areas of particular concern (HAPC). Lastly, NMFS expressed concern that excavation of nearshore borrow areas and placement of fill in nearshore areas could adversely affect hardbottom habitat, which includes corals and worm reefs colonized by the reef building polychaete, *Phragmatopoma lapidosa.*
- General public response was mostly from Jensen Beach and Nettles Island residents who are opposed to the project. Their concern is that Martin County will be depleting sand resources located within St. Lucie County that should be reserved to renourish St. Lucie County beaches, which are also critically eroded.

1.6.2. DRAFT SUPPLEMENTAL ENVIRONMENTAL IMPACT STATEMENT (DSEIS) PUBLIC COMMENT PROCESS

The DSEIS public review process provides the opportunity for stakeholders (including government agencies, special interest groups, and private citizens) to evaluate to the DSEIS and assist in determining whether it adequately addresses environmental issues of concern expressed during the scoping process. The DSEIS public comment period began when the Notice of Availability (NOA) was published in the *Federal Register* on November 5, 2010 (USEPA 2010). Throughout the 60-day public comment period, comments on the DSEIS were received and compiled for consideration during the preparation of the Final Environmental Impact Statement (FEIS).

The local sponsor sent media releases to local paper(s) announcing the notice of the availability of the SDEIS and the date, time, and location of the public workshop. A list of federal, state, and local elected officials, agencies, and organizations, as well as individuals who were mailed the notice of availability is provided in Appendix C. The DSEIS (hard copy or electronic copy) was also sent to the following:

- U.S. Environmental Protection Agency, Office of Federal Activities, EIS Filing Section, Ariel Rios Building (South Oval Lobby), Room 7220 1200 Pennsylvania Avenue, NW Washington, DC 20004 (5 hard copies)
- Blake Library, 2351 S.E. Monterey Road, Stuart, Florida 34996 (two hardcopies posted at reference desk)
- Lauren P. Milligan, Environmental Manager, Florida State Clearinghouse, Florida Department of Environmental Protection, 3900 Commonwealth Blvd, M.S. 47, Tallahassee, FL 32399-3000 (12 CDs)

An electronic version of the document was posted on the public access project website: http://www.saj.usace.army.mil/Divisions/Planning/Branches/Environmental/DocsNotices_OnLine_MartinCo.htm

The Martin County HSDR Public Project Workshop on the DSEIS was conducted on December 16, 2010 at the Indian River State College Chastain Campus, Wolf Center, 2400 SE Salerno Road, Stuart, Florida 34997 from 6:30 to 8:00 PM. The meeting began with a short presentation that provide a brief history of the purpose and need of the proposed action and alternatives. Then, attendees were invited to visit several poster stations set up around the room and talk with key personnel to find out more details about specific aspects of the project. Poster stations included:

- Project Overview: Project description and why is beach renourishment important along the Treasure Coast (economics, quality of life, storm damage), EIS/NEPA process, and timeline
- Sea Turtle Protection: Nesting habitat, historical use, turtle-friendly beach fill design, monitoring plan
- Sand Source/Modeling/Geotechnical Surveys: Sand samples, bathymetry and wave analysis results, video footage
- Nearshore Habitat/Monitoring Requirements: Nearshore hardbottom, mitigation reefs, Essential Fish Habitat

This meeting style provided interested persons an opportunity to review information, ask questions about the proposed action and alternatives, and voice their specific concerns to project representatives. All attendees were encouraged to sign in for the attendance record. According to the attendance record, the public meeting was attended by 31 persons (not including USACE and Martin County personnel and contractors participating in or facilitating the public meeting). The public was provided opportunities to submit written comments by mailing or emailing them to the USACE project manager or by submitting a comment card at the public meeting.

1.6.3. DSEIS COMMENTS

During the 60-day comment period, a total of 12 people from the local community and key personnel from USEPA, Audubon of Florida, NMFS, Coastal Working Group, and Bureau of Ocean Energy Management, Regulation, and Enforcement (BOEMR, formerly MMS) submitted comment cards and letters. Appendix C includes copies of all written comments and USACE responses. **Table 1.6-1** presents a categorization of the comment received during the DSEIS public review process.

Table 1.6-1 Summary of DSEIS Public Comment Topics

Comment Category	Comment Topic	Number of Commentators Addressing Topic[1]
General Questions/Comments	Where does sand go when it erodes from beach?	1
	Will we find out comment made by public?	1
	Why is there no discussion of impact on Intracoastal Waterway?	1
	Lessons learned from negative impacts of previous nourishment projects (i.e, New Jersey, Bathtub Beach)?	1
	Why “borrow” from a shoal that protects the beaches by breaking up kinetic energy in waves that erode the coastline?	1
	Are nearshore areas south of project going to be monitored?	1
	Why not use material from St. Lucie Inlet for beach nourishment?	
	Concern regarding long-term and unavoidable impacts	2
	Concern about lack of mitigation	2
Alternatives/Project Description	Analysis of alternatives is narrow	
	Recommend eliminating C1-A and C1-C from project design	
Water Resources	Impacts on water quality	1
Biological Resources	Impacts to nearshore hardbottom	2
	Sediment compatibility and the effect of temperature on sea turtle nesting	1
	Impacts on fish, shorebirds, and/or infauna	1
Vegetation	Lack of recent vegetation data	1
Cultural Resources	Include in appendix of FSEIS any updated cultural assessment surveys, correspondence with State Archeologist and SHPO, and concurrence letter	1
Socioeconomics	Impacts on local economy (i.e, surf shops, bait/tackle shops)	6
Recreation/tourism	Impacts to surfing, tourism, birdwatching	5
Permit Compliance	Demonstrate full compliance with Florida Coastal Management Program (FCMP) and Coastal Zone Management Act (CZMA)	1
Construction Template	Support of turtle-friendly template	2
Offshore Borrow Areas	Support non-exclusive use of offshore borrow areas	1
	Incorporate dredging BMPs	
Monitoring	Conduct more robust monitoring for all phases of construction and turtle-friendly beach template	5

[1] This column denotes the number of commenters addressing the topic. A single commenter may have addressed more than one topic.

1.7. MAJOR DIFFERENCES BETWEEN THE DSEIS AND FSEIS

Several of the comments received by the USACE during the DSEIS review period led to revisions to the body of the DSEIS in order to complete the FSEIS. Revisions to the text included minor clarifications and inclusion of updated and additional information. No major changes to the document content were warranted or conducted as a result of public comment and review. None of the changes made to the text are believed to have profound effect on the findings and conclusions that were presented in the DSEIS. The most significant modifications were to:

- Chapter 2, Alternatives has been re-organized to clarify that this SEIS tiers from previous NEPA documents and does not re-consider the full suite of alternatives. The proposed action in this SEIS is to identify a new borrow area and considers alternative sand sources to meet the needs for the remaining period of federal cost-sharing participation for the authorized beach nourishment project.
- Addition of more in-depth discussion in Chapters 3 and 4 on marine mammals, shorebirds, and migratory birds and potential effects of proposed action.
- Sea turtle nesting data has been updated with most recent survey results.

1.8. IMPACT MEASUREMENT

This section summarizes the means and rationale for measuring and comparing impacts of the proposed action and alternatives. Section 4.0, Environmental Effects, provides a more detailed discussion of impact measurement and comparison.

This SEIS considers the effects on federally listed threatened and endangered species and EFH with particular concern for nearshore hardbottom habitat. Other issues include health and safety, water quality, aesthetics and recreation, fish and wildlife resources, cultural resources, socio-economic resources, and any other issues identified through additional scoping and public involvement.

Cultural resources surveys in the proposed borrow areas were conducted by a professional underwater archaeologist using modern remote sensing technology that included magnetometer data, sidescan sonar data, and depth recorded capabilities. No cultural resources were identified in borrow area C1-B.

NMFS recommends that the EFH assessment include the results of an on-site inspection, input from recognized fishery experts on the habitat and species effects, a literature review, an analysis of alternatives to the proposed action, and analyses of the borrow site using methods similar to those recommended in Kelley et al. (2004).

The Minerals Management Service (MMS) conducted initial studies on the physical and environmental effects of the excavation of sands from these offshore shoals. Results are presented in a report titled: *Environmental Surveys of Potential Borrow Areas on the Central East Florida Shelf and the Environmental Implications of Sand Removal for Coastal and Beach Restoration* (Hammer et al. 2005). Computer modeling performed during the study indicates that limiting the depth of excavation can prevent effects to the shoreline adjacent to these borrow sites (Hammer et al. 2005).

1.9. PERMITS, LICENSES, AND ENTITLEMENTS

Refer also to Section 4.35, Compliance with Environmental Requirements.

A FDEP Joint Coastal Permit and Sovereign Submerged Lands Authorization will be acquired before project construction. A Joint Coastal Permit Application was prepared and submitted to FDEP in April 2009. A complete copy of the permit application and requests for additional information (RAI) and responses can be downloaded from the following website: http://bcs.dep.state.fl.us/envprmt/martin/pending/0295380_%20Martin_County_Beach_Restoration/001_JC/Completeness%20Review/

The proposed beach nourishment project is subject to the provisions of the Coastal Zone Management Act, and the State of Florida will evaluate the proposal for consistency with the goals and objectives of the act. Consultation with SHPO is also required before dredge and fill operations will be authorized by state and federal regulatory agencies. The project stipulates discharge of fill material into the waters of the United States, and is therefore subject to Section 404 of the CWA. Issuance of the FDEP permit represents compliance with the federal mandate for CWA compliance.

As a federal agency with jurisdiction to manage resources available on the Outer Continental Shelf (OCS), BOEMRE was invited in April 2007 by USACE to participate as a partner on the Martin County HSDR Project. This partnership was developed to fulfill BOEMRE's mandatory statutory environmental and leasing requirements for the issuance of a negotiated noncompetitive agreement for the use of OCS sand resources. As a cooperating agency, with respect to NEPA, BOEMRE

- Participated in the NEPA process;
- Participated in the scoping process;
- Assumed, at the request of USACE, responsibility for developing information and preparing environmental analyses for which BOEMRE has special expertise; and
- Made available staff support at the lead agency's request to enhance the interdisciplinary capability of USACE.

BOEMRE also agreed to participate in the required Endangered Species Act of 1973 (ESA) Section 7 consultation; the Magnuson-Stevens Fishery and Conservation Management Act Essential Fish Habitat consultation (Section 305); the National Historic Preservation Act (NHPA) Section 106 process; and the Coastal Zone Management Act Section 307 consistency determination. As the lead federal agency for ESA Section 7 and the Essential Fish Habitat consultations, USACE notified USFWS and NMFS of its lead role and BOEMRE's cooperating status. BOEMRE and USACE jointly submitted the ESA Section 7 and Essential Fish Habitat assessments to USFWS and NMFS. USACE also acted as the lead federal agency for Section 106 compliance in accordance with 36 CFR Part 800.2(2), while BOEMRE acted as a cooperating agency for Section 106 compliance, offering input and consultation as needed.

2. ALTERNATIVES

Chapter 2 describes in detail the No Action Alternative, the preferred alternative, and other reasonable alternatives that were studied in detail. This SEIS tiers directly from the 1986 *Feasibility Report with Final EIS* and the 1994 *GDM with EA* which previously considered a full suite of structural and non-structural measures. Since the beach nourishment alternative was selected as the preferred alternative and the project was constructed in 1995, this SEIS does not re-consider the full suite of alternatives evaluated during the initial planning process. The alternatives evaluated and compared in this SEIS include various sources of beach-quality sand with the purpose of identifying a new borrow area in support of the authorized beach nourishment project since the previously approved borrow area (Gilbert Shoal) has been depleted.

To provide background information on the initial planning process, Section 2.1 summarizes alternatives previously considered in the 1986 *Feasibility Report with Final EIS* and 1994 *GDM with EA* and the rationale for selection of the preferred alternative. Section 2.2 describes the alternatives evaluated for the current proposed action which is identification of a new borrow area, compares costs associated with mining sand from these sources and, summarizes impacts on the environment and coastal processes from removal of this sand. Section 2.3 provides information on the mitigation and monitoring program.

2.1. ALTERNATIVES PREVIOUSLY CONSIDERED

A broad range of nonstructural and structural measures were considered during the original planning and evaluation process to reduce beach, land, and property losses resulting from erosion, storms, and hurricanes along the project reach. These alternatives were presented in the 1986 *Feasibility Report with SEIS* and the 1994 *GDM with EA*. The alternatives considered include the No Action Alternative, seven nonstructural alternatives, and eight structural alternatives (**Table 2.1-1**). The nonstructural measures sought to preclude any significant form of physical development or construction and emphasized management measures rather than structural measures. The structural measures included use of revetments, seawalls, groins, and beach nourishment. Each alternative was given serious consideration during the planning process.

Section 2.1.1 describes the alternatives. Section 2.1.2 describes the issues and basis of choice for preferred alternative selection. Section 2.1.3 identifies alternatives that were eliminated from further consideration and discusses the rationale for elimination based on project planning objectives. Section 2.1.4 identifies alternatives not within the jurisdiction of the lead agency. Section 2.1.5 discusses the selection of the preferred alternative.

Table 2.1-1. 1994 GDM Evaluation of Potential Nonstructural (NS) and Structural (S) Measures to Address Beach Erosion along Hutchinson Island, Martin County, Florida

POSSIBLE MEASURES		Local Planning Objectives				Principles and Guidelines				
		Provision for Recreation Beach	Protection from Flooding and Wave Damage	Beach Erosion Control	Protection of Tourist-based Economy	National Economic Development	Environmental Quality	Other Social Effects	Regional Economic Development	
NONSTRUCTURAL MEASURES										**Eliminated or Carried Forward**
NS-1	No-Action	O	O	O	O	O	O	O	O	Carried forward for comparison purposes
NS-2	Coastal Construction Control Line	O	P	O	P	O	P	P	P	Eliminated; erosion would continue unabated
NS-3	Moratorium on Construction	O	P	O	O	O	O	O	O	Eliminated; erosion would continue unabated
NS-4	Establish a No-Growth Program	O	O	O	O	O	O	O	O	Eliminated; erosion would continue unabated
NS-5	Relocation of Structures	O	P	O	O	O	O	P	O	Eliminated; erosion would continue unabated
NS-6	Flood-Proofing of Structures	O	P	O	O	O	O	P	O	Eliminated; erosion would continue unabated
NS-7	Condemnation of Structures and Land Acquisition	O	P	O	O	O	O	P	O	Eliminated; erosion would continue unabated
STRUCTURAL MEASURES										**Eliminated or Carried Forward**
S-1	Seawalls	O	P	P	P	P	O	P	O	Eliminated, does not meet project objectives
S-2	Revetments	O	P	P	O	O	O	P	O	Eliminated, does not meet project objectives
S-3	Beach Nourishment	F	P	F	F	F	F	F	F	Carried forward, meets project objectives
S-4	Groins	P	P	O	O	P	O	O	O	Eliminated, does not meet project objectives
S-5	Submerged Artificial Reefs	F	P	P	P	P	O	O	P	Eliminated, does not meet project objectives
S-6	Nearshore Placement	P	P	P	P	P	O	O	P	Eliminated, does not meet project objectives
S-7	Breakwaters	P	P	P	O	P	O	O	O	Eliminated, does not meet project objectives
S-8	Dunes and Vegetation	O	P	P	O	O	P	O	O	Eliminated, does not meet project objectives

F – Fully meets project objectives
P – Partially meets project objectives
O – Does not meet project objectives

2.1.1. ALTERNATIVES DESCRIPTION

No Action Alternative (NS-1). The No Action Alternative would have perpetuated the receding and eroding beach conditions and provided no solution to existing problems. However, it also would have avoided any undesirable effect that may be associated with structural and nonstructural plans for beach erosion control. This option, although not favored by the local sponsor, was maintained throughout the study process to provide a basis for comparison of the effects of other alternatives. This plan provided no corrective measures and would have allowed tidal and shoreline processes to continue current trends. Development trends and local planning goals indicated that development and a steady influx of residents into the study area would have continued regardless of beach improvements. Even with reduced beach capacity, recreational use was expected to continue to increase. With the reduced beach width, the shoreline erosion would have continued to endanger the primary dunes and the structures landward of the beach and dune system.

Coastal Construction Control Line (NS-2). The state Coastal Construction Control Line (CCCL) was developed to control and regulate development in the sensitive dune and beach areas of many coastal counties, while assuring reasonable use of private property. Recognizing the value of the state's beaches, the Florida legislature initiated the CCCL Program to protect the coastal system from improperly sited and designed structures, which can destabilize or destroy the beach and dune system. Adoption of a CCCL establishes an area of jurisdiction in which special siting and design criteria are applied to construction and related activities. These standards are typically more stringent than those already applied in the rest of the coastal building zone because of the greater weather-related forces expected to occur in the more seaward zone of the beach during a storm event. Martin County's CCCL received state approval on May 23, 1972.

This NS alternative considered potential changes to the CCCL or building regulations that could have been implemented by the State of Florida. Such changes could have included moving the CCCL landward, increasing the setback for construction, or increasing the standards for construction to reduce storm damages. Beach rezoning and modification of building codes would likely have occurred with changes to the CCCL, which would have impacted land use planning. Erosion of the shoreline would have continued unabated by this measure.

Moratorium on Construction (NS-3). This management measure would not have permitted new construction in areas vulnerable to storm damages. As properties were damaged, reconstruction would not have been permitted. Erosion of the shoreline would have continued unabated by this measure. Although not in the federal interest, this measure could have been implemented by state or local governments. A moratorium on construction was rejected by local interests since the desired growth of the area was oriented towards tourism and recreation, attracting retirees, and promoting a stable construction industry.

Establish a No-Growth Program (NS-4). This management measure would have limited reconstruction following storm damage, but would not have allowed for new structures within areas adjacent to the study area that were vulnerable to storm damage. Erosion of the shoreline would have continued unabated by this measure. Although not in the federal interest, this measure could have been implemented by state or local governments. The establishment of a no-growth program was rejected by local interests. Growth in the area, particularly in connection with beach activities, was needed to provide economic depth to the communities.

Relocation of Structures (NS-5). With this management alternative, structures within the study area that were most vulnerable to storm damage would have been identified. Where feasible, those vulnerable structures would have been moved farther landward on their parcels to escape the storm-damage-prone areas.

Flood-Proofing of Structures (NS-6). Flood-proofing existing structures and more stringently regulating floodplain and shorefront development are management measures that state and local governments could have been implemented. This measure would have required changes to the building codes to prevent flood damages associated with coastal storms. New construction and substantial reconstruction would have been improved by regulation of new building codes, and existing structures could have been improved through incentives and aid programs.

Condemnation of Structures and Land Acquisition (NS-7). This measure would have allowed the shoreline to erode in the study area with a loss of land until the shoreline reached equilibrium. Those structures vulnerable to storm damage would have been acquired, demolished, and the natural areas restored. Such parcels would have become public property and would have reduced the number of structures vulnerable to storm damage. This alternative was rejected by local residents because it did not fulfill one of the primary project goals of protection of existing resources.

Seawalls (S-1). Concrete seawalls would have been constructed in front of vulnerable structures and improvements/maintenance would have been allowed for existing seawalls and stone revetment. These structural improvements would have provided a significant degree of protection to the existing structures.

Revetments (S-2). Revetments are a type of beach armor that involves installing rocks, bags, mats, or tubes along the slope of the beach to protect the beach from erosion. Revetments differ from seawalls as seawalls are vertical structures and revetments are sloped structures. Hardening of the shoreline by revetment would have protected upland structures, while reducing the impact of wave reflection to the nearshore profile, as seen in seawalls. A revetment for this project would have used large rocks that are designed to protect against the 40-year storm event. Revetments would have been placed on severely eroded beaches to provide limited and site-specific protection against erosion.

Beach Nourishment (S-3). Beach nourishment addressed federal and local planning objectives and anticipated beach erosion losses while considering the needs of the study area. Beach nourishment dimensions were designed to protect against the 40-year storm event; however, future beach renourishment would be undertaken periodically to maintain the recreational and erosion control features within design dimensions. Dimensions of the beach fill were based on the degree of protection desired, economics, a specified beach width for storm damage protection, and environmental impacts to nearshore hardbottom.

Groins (S-4). Groins would have been constructed of large, interlocked rocks, placed perpendicular to the shoreline. The groins would have extended from above the mean high water (mhw) line out into shallow water. The length, orientation, and head of the structure (T-head or not) would have been designed based on wave conditions, storms, and sediment transport. A series of groins would have helped anchor a beach in front of existing development and prevented further beach erosion. However, the beaches adjacent to the groins would have to be supplemented with nourishment so the adjacent beaches would not be starved of sand. Groins have been successfully used in "hot-spots" that exhibit accelerated erosion. Because the entire project area was experiencing significant erosion, the groin field would have extended the entire 4 miles. Therefore, groins were considered a method to help hold the fill in place and to reduce periodic renourishment requirements. The beach fill material would have come from either an offshore borrow area or an upland sand source.

Submerged Artificial Reefs (S-5). This management measure would have used the perched beach concept to limit the amount of underwater fill and retain the dry beach for a longer period. This would have been accomplished by placing a submerged artificial reef in shallow water with beach fill material "perched" landward of the reef structure. This measure may have reduced initial fill quantities, reduced renourishment requirements, and offered mitigation for the environmental impacts of nearshore rock outcropping burial. The submerged artificial reef would have been constructed out of large rocks with a foundation material to avoid subsidence. The beach fill material would have come from either an offshore borrow area or an upland sand source.

Nearshore Placement (S-6). Dredged material would have been placed in the nearshore in water depths of 15 feet and deeper to provide a combination of wave attenuation benefits and nourishment of the active beach profile. This method would have avoided placing dredged material directly over nearshore rock and assumed that a portion of the sand placed in shallow water would migrate towards the beach under normal wave conditions, attached to the beach, and shaped the beach into a normal equilibrium profile. Dredged material would have come from either an offshore borrow area or an upland sand source.

Breakwaters (S-7). Breakwaters offshore along the Martin County study area would have been constructed to stabilize the beach and reduce the wave energy reaching the shoreline in their lee. As a result, the rate of annual erosion would have decreased. The breakwaters would have been constructed of large rocks with foundation materials sufficient to prevent subsidence. The breakwaters would have been trapezoidal in profile and placed parallel to the shoreline in shallow water. The breakwater would have been 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 have been designed using wave and sediment transport characteristics.

Dunes and Vegetation (S-8). Dunes stabilize a beach and accommodate the damages wrought by storms and extreme conditions of wind, wave, and an elevated sea surface. Dunes maintain a sand repository during storms and provide sacrificial sand before structures would be damaged. In so doing, the dune system provides a measure of public safety and property protection. Vegetated dunes provide greater resistance to sand erosion by binding the sand to the extensive and deep-penetrating root system. Dune vegetation also promotes dune growth by trapping the sand that is transported by significant wind action. This measure would have entailed placement of beach-compatible material from either upland or offshore sources into dune features adjacent to the existing bluff. The top elevation of the dunes would have tied into the bluff. The front slope of the dune would have been a function of the material grain size and construction equipment. Vegetation would have been planted on the constructed dunes and the non-federal sponsor would have been responsible for watering the plants until the plants became established.

2.1.2. ISSUES AND BASIS OF CHOICE

The alternatives were evaluated for the potential to contribute to the project objectives and consistency with project constraints. Several alternatives were not evaluated further than the initial screening due to a combination of economic viability, effectiveness, and/or political or social acceptance. The screening process eliminated from further consideration and detailed evaluation those alternatives that did not respond to the needs of the problem area or the overall planning objectives. The federal planning objectives are to address beach erosion by identifying and selecting the best course of action. The local planning objectives were incorporated in the overall screening process based upon the expressed desires of the local sponsor. Only those alternatives that warranted consideration based upon the overall planning objectives were brought forward for further evaluation.

Alternatives were eliminated from further consideration if they did not fully meet local and federal planning objectives, maximize benefits as required by National Economic Development (NED) Benefit Evaluation Procedures, or adhere to the Water Resource Council's "Principles and Guidelines." The “Principles and Guidelines” require the systematic preparation and evaluation of alternative ways of addressing identified problems, needs, concerns, and opportunities under the objective of NED consistent with protecting the nation’s environment. The process also requires that the impacts of a proposed action be measured and the results displayed or accounted for in terms of contributions to the four accounts of: NED, Environmental Quality (EQ), Regional Economic Development (RED), and Other Social Effects (OSE).

Analyses of the economic feasibility of the various shore protection alternatives in Florida most often indicate that beach nourishment represents the optimum solution to the erosion problems within the framework of federal guidelines. Beach fill alternative designs are formulated to provide various levels of protection to development, prevent loss of land, and provide recreation benefits. Since the beach nourishment alternative (S-3) offers the better course of action and opportunities to address the NED objective, it is carried forward for more detailed evaluation.

2.1.3. ALTERNATIVES ELIMINATED FROM DETAILED EVALUATION

With the exception of the No Action Alternative, all nonstructural alternatives were eliminated from detailed evaluation because they did not meet the stated goals of the project as defined in Section 1.4. All of the structural measures except beach nourishment (S-3) were also eliminated. **Table 2.1-1** summarizes which structural and nonstructural measures did not meet, only partially met, or fully met project objectives and principles and guidelines.

In general, all of the nonstructural measures (NS-2 through NS-7) were eliminated because erosion along the project reach would have continued unabated. Continual erosion of the shoreline would not have protected structures, dunes, or sea turtle nests, and would have adversely affected recreation, tourism, and the economic health of the community.

With the exception of beach nourishment (S-3), the proposed structural measures only partially met some of the project objectives and principles and guidelines. Various structural methods of hardened shore protection, such as revetments and seawalls, were eliminated from further consideration because those measures would not function well in the study area, would not solve the beach erosion problem, and/or would not provide enhanced recreational and sea turtle nesting benefits. Details on the rationale for eliminating structural measures are provided below.

Seawalls (S-1). Construction of new concrete seawalls or improvement/maintenance of existing bulkheads/seawalls would provide a significant degree of protection to existing structures. The shoreline was expected to erode in front of the seawall but stabilize at the location of the seawall, counteracting any further storm-induced recession of the shoreline. Without renourishments at regular intervals, little dry beach would likely have remained in front of the seawall, resulting in substantial economic and environmental loss. Reflecting wave energy off existing seawalls and revetments would have steepened offshore profiles and caused hazardous bathing conditions due to increased undertow and runouts. Additionally, seawalls can interrupt the longshore flow of sand, exacerbating erosion problems in some areas and creating new erosion problems further downshore. Environmental concerns with this measure included loss of a healthy beach ecological community, including sea turtle nesting habitat, and potential loss of nearshore rock habitat as the nearshore beach profile adjusted to the new wave energy environment in front of the seawall. For these reasons, this alternative was eliminated from further consideration.

Revetments (S-2). Hardening of the shoreline by revetment would have protected upland structures, while reducing the impact of wave reflection to the nearshore profile as seen in seawalls. A revetment would have provided localized and site-specific protection to beach erosion, however hardening of the beach in one area would have likely transfered the problems of erosion further down the beach resulting in the loss of beach for recreation and sea turtle nesting. While initial construction of this measure would have avoided impacts to the nearshore rock outcropping habitat, adjustment of the nearshore profile may have caused increased scour around the rocks or increased the water depth. Changes to the nearshore beach profile may also have affected surfing and snorkeling. Construction of revetments did not meet several goals of the project, including maintenance of a sandy beach for nesting sea turtles and the provision of recreational areas and maintenance of the commerce associated with it; therefore, this alternative was eliminated from further consideration.

Groins (S-4). A groin field would have helped anchor a beach in front of existing development and reduced further beach erosion. Groins have been successfully used in "hot-spots" that exhibited accelerated erosion. As the entire project area has been experiencing significant erosion, the groin field may have extended the entire 4 miles. Beaches adjacent to the constructed groins would have needed to be supplemented with nourishment so that adjacent beaches would not be starved of sand. For this reason, groins are considered a method to help anchor beach sand and reduce periodic renourishment requirements. The recreational beach would have been stabilized, thus benefiting the tourism industry. However, large rock structures within the surf zone would have been a safety hazard and impacted surfing, snorkeling, and swimming. Impacts to sea turtle nesting activities were not entirely known. Groins did not fully address the project objectives; therefore, this alternative was eliminated from further consideration.

Submerged Artificial Reefs (S-5). This measure may have reduced initial fill quantities, reduced renourishment requirements, and offered mitigation for the environmental impacts of nearshore rock outcropping burial. However, the nearshore rocks in the study area are located in shallow water and would have likely been covered by the artificial reef and beach fill. The recreational beach would have been stabilized, thus benefiting the tourism industry. Impacts to the nearshore rock and profile would have impacted the fishing community and surfing community. As this measure could have impacted the entire natural rock outcropping and would not have provided improved benefits over other measures; therefore, this alternative was eliminated from further consideration.

Nearshore Placement (S-6). Dredged material placed in the nearshore in water depths of 15 feet and deeper to would have provided a combination of wave attenuation benefits and nourishment of the active beach profile. This measure may be more cost-effective than onshore disposal by hopper dredge and would have eliminated the need for pump-out facilities. However, this measure by itself would not have added the same level of beach nourishment or storm damage protection as direct beach nourishment (S-3). By placement in the nearshore, some material may have migrated to the beach and some material may be lost offshore. This would have necessitated dredging a greater volume of sand compared to the beach nourishment measure. The recreational beach would likely have been stabilized or widened, thus benefiting the tourism industry. However, impacts to the nearshore rock would have impacted the fishing community and the surfing community. This measure provided less storm damage protection and greater environmental impacts, but potentially some cost savings over the beach nourishment measure. Given this comparison, this alternative was eliminated from further consideration.

Breakwaters (S-7). Construction of breakwaters would have stabilized the beach and reduced the wave energy reaching the shoreline in their lee and decreased erosion. Breakwaters constructed seaward of the existing nearshore rock would have avoided direct impacts during construction. Shoreline accretion of sand would have occurred if the breakwaters were of sufficient size, but also caused burial of the nearshore rock. The breakwaters would also have changed the nearshore profile and may have affected longshore sediment transport and adjacent shores. A smaller sized breakwater to stabilize the shoreline but avoid accretion and sediment transport blockage would have had limited effects on storm damage prevention. Combining breakwaters with beach nourishment would have provided added beach elevations and beach width for storm damage reduction, but would have substantially increased project costs. Even without beach nourishment, breakwaters may have affected the nearshore profile such that some areas of rock would be buried and other areas would experience increased scour. The recreational beach would have been stabilized or widened, thus benefiting the tourism industry. However, impacts to the nearshore rock could have affected the fishing community and surfing community. Impacts to sea turtle nesting activities are not entirely known.

In 1993, an experimental breakwater shore protection project was constructed in Palm Beach, Florida. The Palm Beach breakwater prefabricated erosion prevention reef consisted of 330 interlocking concrete units (1.8 m H x 3.7 m L x 4.6 m W) placed along 1,260 meters of shoreline, and approximately 76 meters offshore. Post-construction monitoring of the submerged breakwater revealed an increase in longshore currents via ponding of water trapped behind the breakwater, which was then diverted alongshore. The annual volumetric erosion rate measured 2 years after breakwater construction was 2.3 times higher than the pre-project rate (Browder et al. 1996). Due to this acceleration of shoreline erosion, the breakwater reef was removed.

Potential increased erosion associated with offshore breakwater installation did not meet the project goals of maintaining beaches for nesting sea turtles and recreation. As this measure does not fully meet project objective; therefore, this alternative was eliminated from further consideration.

Dunes and Vegetation (S-8). The dune measure would have offered some storm damage protection and stabilized the beach at existing conditions. The vegetation would have increased sand erosion resistance and promoted dune growth through sand trapping. This measure provided environmental restoration of a vegetated dune system in areas where the historical dunes have been eroded away. Stabilizing the beach may also have provided some incidental benefits to recreation, tourism, and sea turtle nesting habitat. This measure would have had little, if any, impact on the nearshore rock and could have been implemented in combination with other plans. This measure is mutually exclusive with the seawall and revetment measures, as they occur in the same footprint. This measure did not fully meet the objectives because it did not provide the authorized level of beach protection and recreational; therefore, this alternative was eliminated from further consideration.

2.1.4. ALTERNATIVES NOT WITHIN THE JURISDICTION OFLEAD AGENCY

Alternatives Coastal Construction Control Line (NS-2), Moratorium on Construction (NS-3), Establish a No-Growth Program (NS-4), Flood Proofing of Structures (NS-6), and Condemnation of Structures and Land Acquisition (NS-7) were not within the jurisdiction of the lead agency and would have been exercised by the state or local sponsor if deemed feasible. The adoption of effective regulatory measures to prohibit development of homes, subdivisions, and commercial centers in hazardous flood areas is a local responsibility. Some of the components of these alternatives are included in the coastal zone management measures undertaken by Martin County. Those five alternatives, which are not within the jurisdiction of the lead agency, would have not prevented, control, or mitigate the erosion problem experienced along the study area. Therefore, those alternatives did not meet the needs of the study area or the study objectives and were not carried forward.

2.1.5. PREFERRED ALTERNATIVE – BEACH NOURISHMENT

The preferred alternative, Beach Nourishment (S-3) was the only practical solution that addressed the erosion problem within the project area and fulfilled Martin County's goals and objectives. The authorized beach nourishment plan maximized net NED benefits; met the federal objectives of restoring a protective beach with subsequent periodic nourishment to provide 40-year storm protection; considered the recreational and environmental needs of the study area; and minimized erosion losses over the life of the project. Therefore, this measure was carried forward as the preferred alternative during the initial planning process.

This measure authorized the initial beach nourishment (completed in 1996) that created the appropriate beach dimensions to serve as a buffer against wave attack and future renourishments at regular intervals. The authorized project area covered 4 miles of shoreline from the St. Lucie County line southward to near the southern limit of Stuart Public Beach Park. Plan S-3 included restoration of the primary dune as needed to an elevation of 12.5 feet above msl and a top width of 20 feet. A 35-foot-wide protective berm would be provided at elevation 8.0 feet above msl, with a 1V:8.5H foreshore slope to mlw, then a 1V:20H slope to the existing bottom (**Figure 1.2-2**). Beach nourishment along the project reach created a wider beach with a greater berm height, provided greater storm protection, provided enhanced recreational opportunities for tourists and the community, and created additional sea turtle habitat.

2.2. SUPPLEMENTAL EIS ALTERNATIVES

The additional alternatives presented in this section are a subset of the preferred alternative, Beach Nourishment (S-3), that was selected and authorized based on the initial planning and screening process (as described in the previous section). Sufficient quantities of beach-quality sand were available from the previously approved nearshore borrow area (Gilbert Shoal) for the 1996, 2001, 2002, and 2005 beach nourishment projects. However, that borrow area has been fully utilized; therefore, alternate sand sources are being evaluated in this SEIS to meet future nourishment requirements for the remaining life of the federal cost-sharing portion of this project which expires in 2046. The alternatives considered in the SEIS include:

- No Action Alternative
- S-3A: Beach Nourishment Using an Offshore Sand Source
- S-3B: Beach Nourishment Using an Upland Sand Source

Section 2.2.1 describes the alternatives considered in this SEIS. Section 2.1.2 describes the issues and basis of choice for preferred alternative selection. Section 2.1.3 identifies alternatives that were eliminated from further consideration and discusses the rationale for elimination based on project planning objectives. Section 2.1.4 discusses the selection of the preferred alternative and activities associated with the proposed action.

2.2.1. DESCRIPTION OF ALTERNATIVES

2.2.1.1. No Action Alternative

The No Action Alternative involves no beach construction or fill placement, borrow area excavation, or other actions associated with stabilizing and protecting the beach and the structures landward of the beach. The No Action Alternative means that no alternative sand source would be identified and approved to provide beach-compatible sand for the remaining authorized period of federal cost-sharing participation. This option, although not favored by the local sponsor, is maintained throughout the study process to provide a basis for comparison of the effects of other alternatives. The No Action Alternative provides no corrective measures and would allow tidal and shoreline processes to continue current trends resulting in unabated erosion along the project reach. With the reduced beach width, the shoreline erosion could endanger the primary dunes and the structures landward of the beach and dune system and potentially affect recreational opportunities, sea turtle habitat, tourism, and the local economy. However, it also would avoid any impacts that may be associated with periodic placement of beach fill along the project reach and mining sand from a new borrow area.

Note that under the USACE's No Action Alternative, authorization from BOEMRE would not be required; therefore, BOEMRE would not be undertaking a connected action.

2.2.1.2. Beach Nourishment Using an Offshore Sand Source (S-3A)

Lying along the inner shelf of the Atlantic coast are numerous sand shoals and low-relief areas containing millions of cubic meters of potential borrow material. Some sand shoals can be kilometers long, up to 10 meters thick, and hundreds of meters wide

(Hammer et al. 2005). Offshore bottom sediments are typically comprised of sorted sand with some fraction of silt and can potentially provide an economical source of beach nourishment material if the sand is determined to be compatible with the native beach sediment. Three borrow areas that lie primarily in federal waters and fall under the jurisdiction of the BOEMRE were initially considered as potential sand sources for this project: C1-A, C1-B, and C1-C (**Figure 1.2-1**). C1-A and C1-C are located within the St. Lucie Shoal complex, which is an elongated area of relatively high relief that runs northward from the Martin/St. Lucie county line 3 to 7 miles offshore in the Inner Shelf Plain zone (**Figure 2.2-1**). C1-B is located about 3 miles south-southeast of the St. Lucie Shoal in an area with relatively less vertical relief than C1-A and C1-C. A more detailed description of each proposed borrow area is provided below.

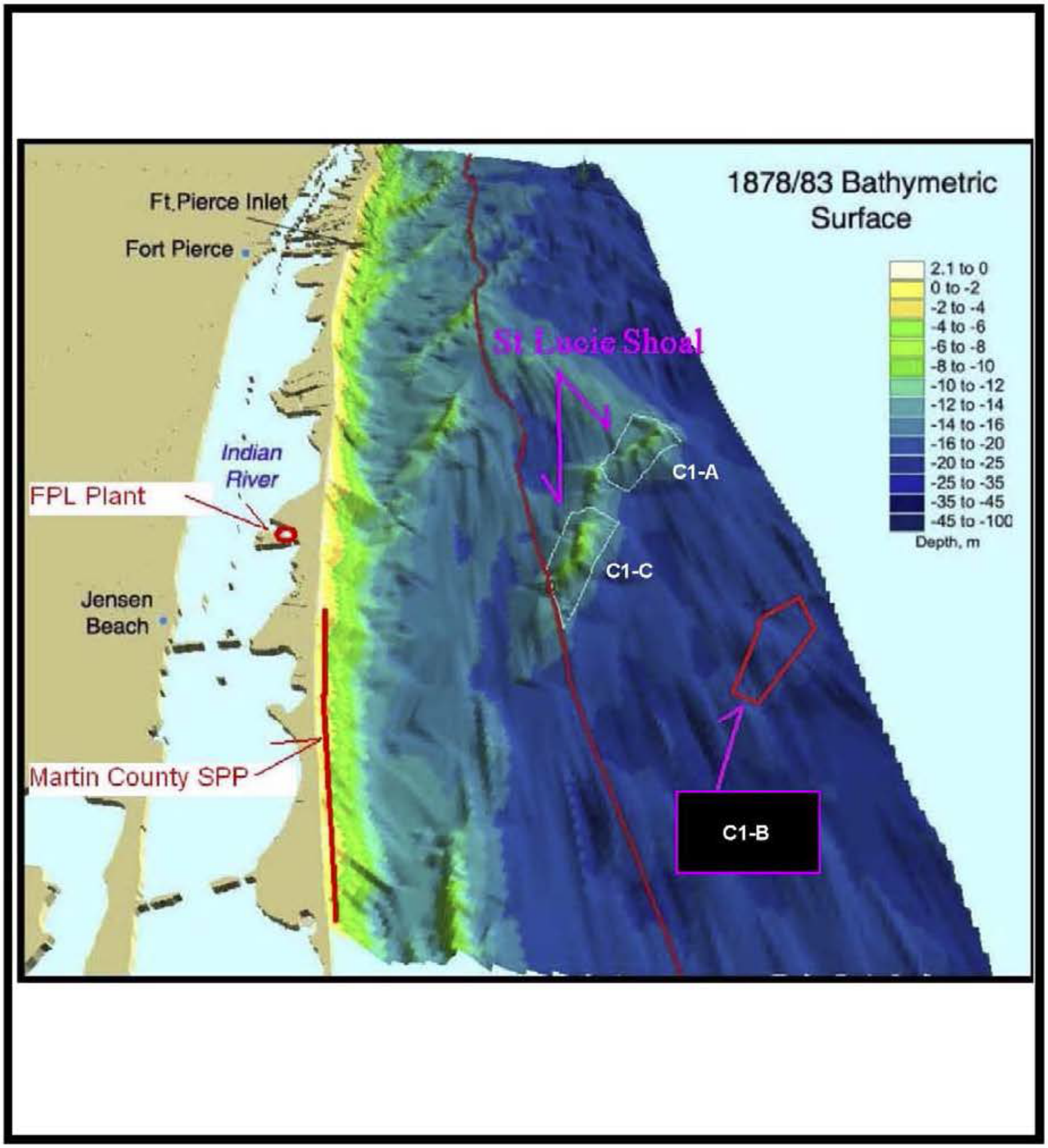


FIGURE 2.2-1.
3-D VIEW OF ST. LUCIE SHOAL AND
BORROW AREA "B"
MARTIN COUNTY HURRICANE AND
STORM DAMAGE REDUCTION PROJECT
HUTCHINSON ISLAND, FLORIDA

This map and/or digital data is for planning purposes only and should not be used to determine the precise location of any feature. Data provided as-is.
Q:\GIS PROJECTS\EIS_MARTIN_CO\EIS\Figure updates 030211\figure2 2-1_3-D St. Lucie Shoal.mxd Data sources: MMS 2004

Borrow Areas C1-A and C1-C

BOEMRE (formerly MMS) conducted a regional reconnaissance investigation of the federal waters along Florida's central-east coast to identify sources of beach-quality sand in federal waters offshore of Martin and St. Lucie Counties. This investigation titled: *Environmental Surveys of Potential Borrow Areas on the Central East Florida Shelf and the Environmental Implications of Sand Removal for Coastal and Beach Restoration* (Hammer et al. 2005) included a seismic survey, grab samples, vibracores, wave analysis, and sediment transport studies of the proposed borrow areas C1-A and C1-C located within the St. Lucie Shoal complex. The St. Lucie Shoal is complex is described as a shallow (5-12 m), well-defined, shore-oblique shoal (Hammer et al. 2005). These two sites are located within a larger area identified as Resource Area C1 in Hammer et al (2005).

Grab samples were collected to provide information on surface sediment characteristics and sand volume estimates were determined using vibracore data collected by the Florida Geological Survey (FGS) and BOEMRE. **Table 2.2-1** summarizes sand resource characteristics within areas C1-A and C1-C. Data indicate that the sediments are coarser at higher profile elevations and become finer with depth. Two vibracores collected from C1-C measured 6 to 7 meters of suitable sediment, and the sediments at approximately 3- to 5-meter depth were characterized as yellowish gray to light olive gray, moderately to poorly sorted, fine- to medium-grained sand (mean grain size of 0.54 mm), with approximately 86% carbonate content (Hammer et al. 2005). The surface area of the northern borrow site in Area C1 (C1-A) is 5.16 x 10^6 m^2. The maximum excavation depth was 12 meters, resulting in 5.8 million cubic meters (mcm) (7.6 mcy) of sand. The southern borrow site in Area C1 (C1-C) covers approximately 4.71 x 10^6 m^2 of seafloor. For an excavation depth of 12 meters, the resulting sand volume is 8.8 mcm (11.5 mcy).

Table 2.2-1. Sand Resource Characteristics at Offshore Borrow Areas C1-A and C1-B

Borrow Site	Borrow Site Surface Area (x 10^6 m^2)	Maximum Excavation Depth (m)	Borrow Site Sand Volume (mcy)	D10 (mm)	D50 (mm)	D90 (mm)
C1 north (C1-A)	5.16	12	7.6	1.96	0.61	0.26
C1 south (C1-C)	4.71	12	11.5	0.62	0.29	0.18

D10 = grain diameter above which 10% of the distribution is retained
D50 = median grain diameter
D90 = grain diameter above which 90% of the distribution is retained

Source: Hammer et al. (2005)

In 2004, a study funded by the Minerals Management Service (now BOEMRE), compared hypothetical pre-dredge and post-dredge scenarios on St. Lucie Shoal within borrow areas C1-C and C1-A. The post-dredge scenario assumed a maximum excavation depth of -7 meters, dredging the -5-meter shoal's crest down to adjacent water depths of approximately -12 meters. This cut depth over the affected footprint equates to dredging approximately 14.6 million cubic meters from areas C1-A and C1-C. The cumulative scenario assumed dredging resulted in near flat bed conditions. In this scenario, modeling showed the potential for unacceptable changes in longshore sediment transport potential, including the potential development of an erosional hotspot along a stretch of shoreline southeast of the C1-C borrow area. The study recommended that the maximum cut depth be reduced. The potential adverse effects of modifying offshore bathymetry generally increase with increasing footprint and depth of cut, as well as proximity to shoreline. The potential change in wave height and angle at the shoreline is foremost related to changes in shoal crest height and orientation relative to incident waves. The hypothetical cut depth of -7 meters across C1-A and C1-C was somewhat unrealistic since best-available geotechnical data suggests suitable sediment thicknesses within C1-A and C1-C of only -3 to -7 meters (Hammer et al. 2005). The study did not consider the consequences of relatively shallower depth cuts, which could have provided sufficient volume for several construction cycles and potentially had a negligible impact on longshore sediment transport.

In 2007 to 2008, a Historic Assessment and Submerged Cultural Resources Survey was conducted to assess the presence or absence of submerged cultural resources within four proposed borrow areas located off Martin and St. Lucie Counties, including sites C1-A and C1-C (SEARCH 2008). Results of the remote sensing survey identified no potentially significant submerged cultural resources within C1-A, and this area was cleared from an archaeological perspective. Within borrow area C1-C, one cluster of magnetic targets with an associated sidescan sonar image was identified. The magnetic signature suggests this target may represent a potentially significant submerged cultural resource and is therefore recommended for avoidance. If avoidance of these anomalies is not possible additional investigation in the form of diver investigations to positively identify the targets is recommended by a qualified underwater archaeologist to determine its significance and eligibility for listing on the National Register of Historic Places (NRHP).

In addition, sidescan sonar data collected during the archaeological survey was analyzed in more detail to determine the presence or absence of hardbottom within borrow areas C1-A and C1-C (ANAMAR 2009) (Appendix L). Analysis of sidescan sonar data identified seven targets within C1-A which revealed high backscatter that could indicate the presence of hardbottom (Figures 4 through 11 in Appendix L). No targets were identified within C1-C. It was recommended that further ground-truthing investigations of these features be conducted to verify the presence of hardbottoms, composition and structure of resources, and utilization by fish assemblages.

Borrow Area C1-B

C1-B is as a relatively deep (14-17 m), poorly-defined, low-relief shoal complex. It is 1.6 square miles (approximately 1000 acres) in size and consists of a large sandy mound which rises to a crest elevation of about -40 feet mlw in surrounding water depths of 60 feet or more (USACE 2009). Dredging depths of cut range from 6 to 12 feet over most of the extent of the borrow area.

In August 2007, USACE collected vibracores to characterize the sediment within borrow area C1-B (**Figure 2.2-2).** The vibracore borings revealed sands, silty sands, and shelly material throughout the C1-B borrow area, with clays and silts near the termination depths (Challenge Engineering and Testing 2007). The sand is primarily calcareous with a mixture of shell and contains a small (less than 5%) amount of silt. The sediment in C1-B has a mean grain size of 1.37 phi (0.39 mm), a sorting of 1.14 phi, contains 2.47% silt, and 100% of the sand in the borrow area has a moist Munsell value of 5 or higher (Taylor Engineering, Inc. 2009a). The colors of the materials were noted to change significantly from dark to lighter as the split core tubes were left open to air-dry. Carbonate content analyses suggest that the borrow area composite should not exceed the maximum acceptable carbonate content of 93% (Taylor Engineering, Inc. 2009a). Based on these results, the material was determined to be good beach-quality sand that would comply with the Florida state sand rule. A more detailed discussion of the results of the geotechnical studies is provided in Section 3.1.9.1 and the full report is provided in Appendix F.

Sand volume estimates within the C1-B borrow area based on vibracore data indicated 4 to 15 feet of suitable sediment in addition to the 2-foot required buffer. The excavation depth varies from -56 to -65 feet mlw, resulting in approximately 11.5 mcy of sand.

As with C1-A and C1-C, a study was conducted using the Steady State Spectral WAVE (STWAVE) model in borrow area C1-B to determine if excavating portions of this feature could potentially influence wave refraction patterns across the region, possibly resulting in wave energy focusing and increased erosion along the adjacent shoreline (USACE 2009). Different dredging configurations were analyzed to help develop a borrow area dredging plan that minimizes adverse impacts on the adjacent shoreline. Conclusions from this study indicate that no significant changes to the nearshore wave environment are expected as a result of dredging borrow area C1-B to the maximum limits of excavation. A complete copy of this report is provided in Appendix K.

In 2007 to 2008, a Historic Assessment and Submerged Cultural Resources Survey was conducted to assess the presence or absence of submerged cultural resources within four proposed borrow areas located off Martin and St. Lucie Counties, including site C1-B (SEARCH 2008). Results of the remote sensing survey identified no potentially significant submerged cultural resources within C1-B, and this area was cleared from an archaeological perspective.

In addition, sidescan sonar data collected during the archaeological survey was analyzed in more detail to determine the presence or absence of hardbottom within borrow area C1-B (ANAMAR 2008) (Appendix L). Analysis of sidescan sonar data identified two targets within C1-B which revealed high backscatter that could indicate the presence of hardbottom (**Figures 2.2-3 and 2.2-4**; Appendix L). It was recommended that further ground-truthing investigations of these features be conducted to verify the presence of hardbottoms, composition and structure of resources, and utilization by fish assemblages.

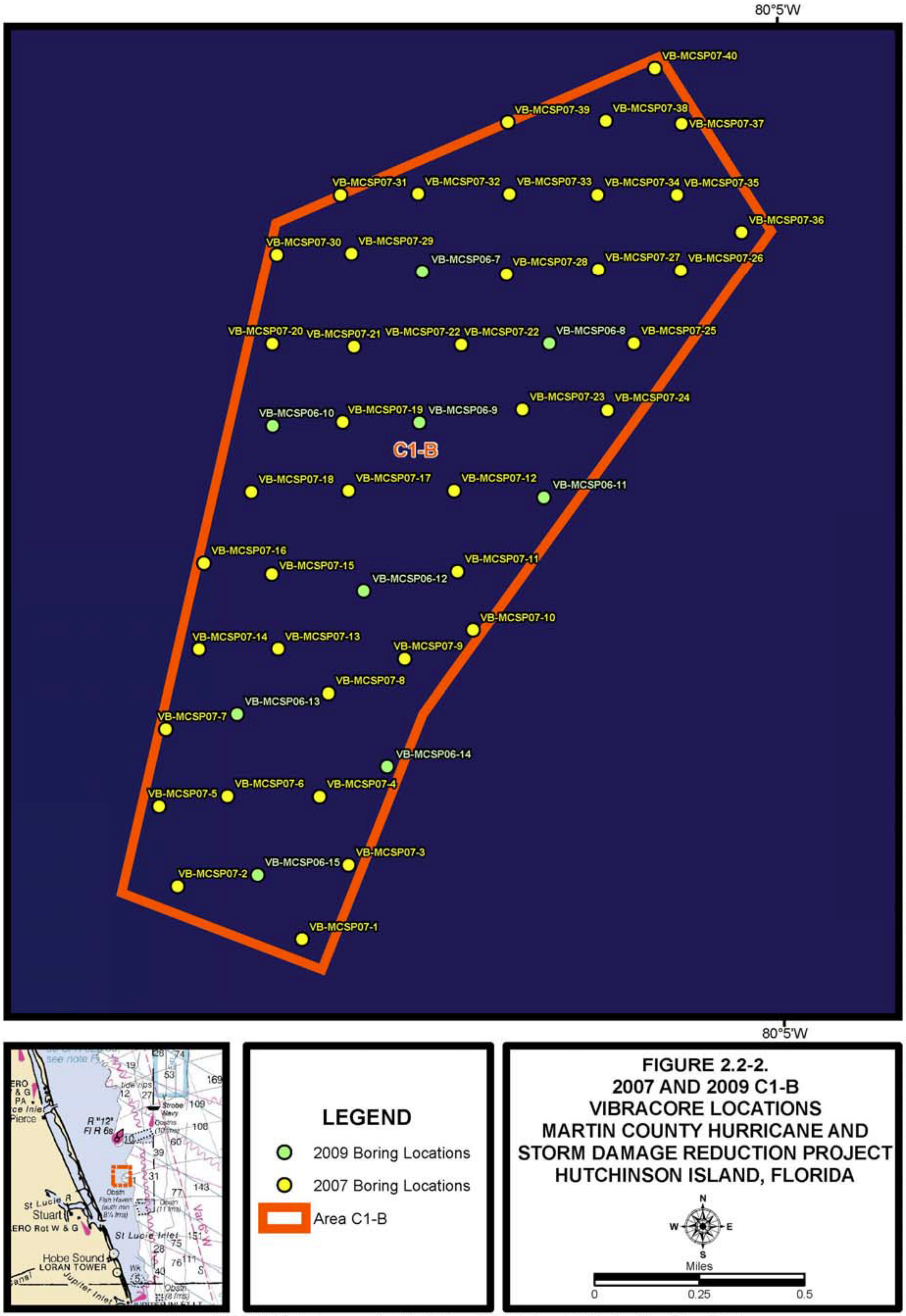


FIGURE 2.2-2.
2007 AND 2009 C1-B
VIBRACORE LOCATIONS
MARTIN COUNTY HURRICANE AND
STORM DAMAGE REDUCTION PROJECT
HUTCHINSON ISLAND, FLORIDA

This map and/or digital data is for planning purposes only and should not be used to determine the precise location of any feature. Data provided as-is.
Q:\GIS PROJECTS\EIS_MARTIN_CO\EIS\Figure updates 030211\figure2.2-2_boring_locations.mxd Data sources: LABINS, USACE, FDEP, ANAMAR.

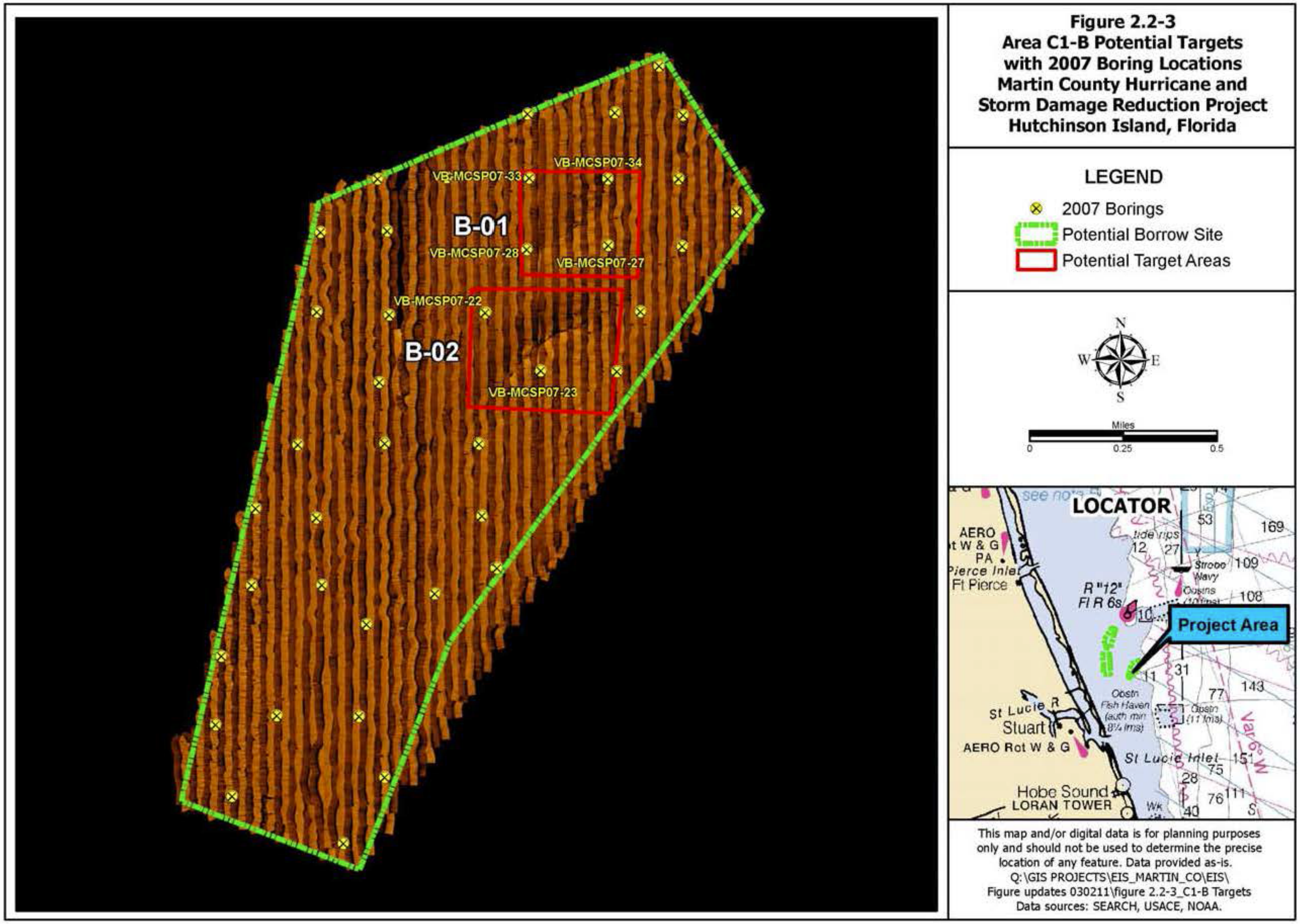


Figure 2.2-3
Area C1-B Potential Targets
with 2007 Boring Locations
Martin County Hurricane and
Storm Damage Reduction Project
Hutchinson Island, Florida

This map and/or digital data is for planning purposes only and should not be used to determine the precise location of any feature. Data provided as-is.
Q:\GIS PROJECTS\EIS_MARTIN_CO\EIS\
Figure updates 030211\figure 2.2-3_C1-B Targets
Data sources: SEARCH, USACE, NOAA.

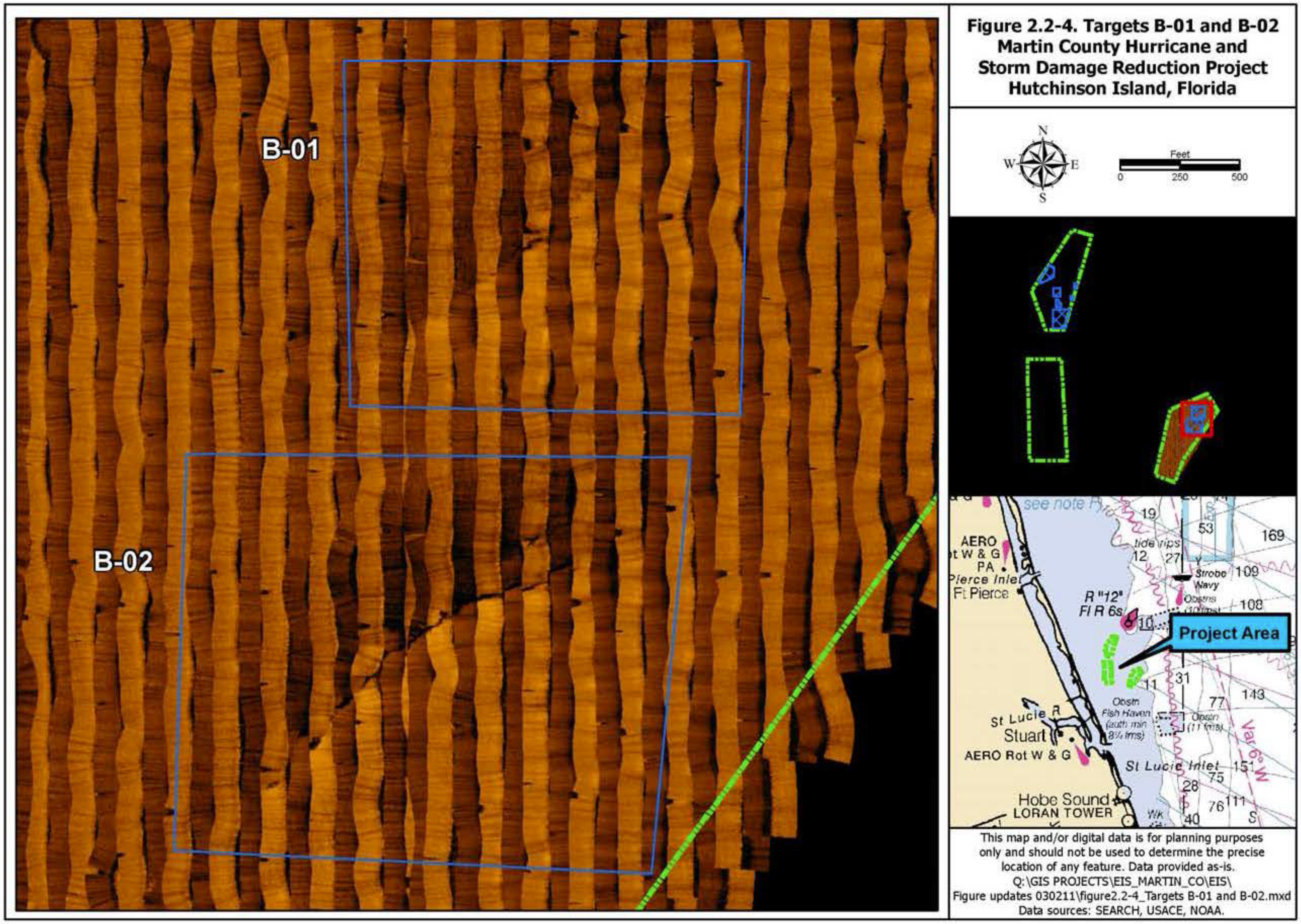


Figure 2.2-4. Targets B-01 and B-02
Martin County Hurricane and
Storm Damage Reduction Project
Hutchinson Island, Florida

This map and/or digital data is for planning purposes only and should not be used to determine the precise location of any feature. Data provided as-is.
Q:\GIS PROJECTS\EIS_MARTIN_CO\EIS\
Figure updates 030211\figure2.2-4_Targets B-01 and B-02.mxd
Data sources: SEARCH, USACE, NOAA.

During the geotechnical survey performed in August 2007, vibracores were collected near Targets B-01 and B-02 and results indicate mostly sand and shell but no consolidated rock (see core logs in Appendix F). As recommended, further groundtruthing was also conducted by the sponsor in July 2009 to characterize these two targets. The dive survey was designed to investigate the proposed borrow area substrate and the overlying water column for significant resources including hardbottom or reef habitats, aggregations of fishes, protected species such as sea turtles, or other biologically relevant conditions (Hesperides Group, LLC 2009). Teams of two divers collected flora and fauna lists, sediment descriptions, water temperature, depth, and visibility data.

The survey confirmed that the proposed borrow area is located on a relatively deep sand shoal with contains no hardbottom resources and observed few species that are normally associated with natural or artificial reefs (Hesperides Group, LLC 2009). Additionally, an investigation of the two small anomalies identified in the sidescan sonar survey revealed no significant benthic features, only small, current-induced sand ridges. A complete copy of this report is provided in Appendix O.

2.2.1.3. Beach Nourishment Using an Upland Sand Source (S-3B)

A considerable accumulation of sand exists along the upland portion of Florida. Generally, these accumulations are found in the form of relict sand dunes or in the landward portion of prograding shoreline areas (NOAA 2008b). Mining sand deposits from upland areas can reduce project costs if an adequate source of sand exists near the project area. However, upland areas with sufficient sand material are often not close enough to the beach nourishment site to provide for economical transportation. Also, the grain size of upland sand sources is often not large enough to provide resistance to wave action, and would therefore erode too quickly from the nourished site. However, assessment of the impacts of mining upland sand sources is typically much simpler than assessing offshore mining impacts (NRC 1995).

Upland commercial sand sources have been used at least five times in previous federal beach nourishment projects in Dade County. These projects constructed along Miami Beach and Sunny Isles were relatively small in scope, varying from 9,000 to 50,000 cy per project with a total placement of 150,000 cy for all five projects. Upland sources have yet to provide large quantities of sand for full-scale beach nourishment projects due primarily to the expense of transportation and logistical difficulties of construction. These difficulties are expected to be similar for the proposed Martin County HSDR Project, which is a large project requiring approximately 787,800 cy for the next renourishment phase in 2012.

Several sand mines with a potential source of nourishment material are located in Glades, Lake, Martin, Palm Beach, Polk, and St. Lucie counties (**Table 2.2-2**). The distance from the sand mine to the project area ranges from 12 to 148 miles. Sand could be transported by barge or rail and dump trucks, hauled to the beach, and dumped at designated access sites for redistribution along the beach. **Tables 2.2-3 and 2.2-4** summarize the sand grain size characteristics, costs, and available quantity of sand material from the multiple sand mines using 2007 estimates.

Grain size is critical to the feasibility of selecting a borrow site. Grain size from the sand mines varies from 0.26 to 0.68 millimeters (mm) and fines are less than 2 percent (**Table 2.2-3**). Vibracores taken offshore along the St. Lucie Shoal indicate there is a general coarsening upwards trend, with yellowish gray to light olive gray, moderately to poorly sorted fine- to medium-grained sand with a mean grain size of 0.54 mm (Hammer et al. 2005). The grain size of the native beach sand is 0.35 mm.

The price per cubic yard for many of the suppliers of upland sand exceeds the 2012 estimated total unit cost of $9.48/cy for sand from the offshore borrow areas (**Table 2.2-4**). The 2007 total unit cost of upland sand material delivered to the project area ranges from $9.00/cy (note: this price does not include delivery) to $32.00/cy. Therefore, the cost of 787,800 cy yards of sand from an upland source ranges from $7,090,200 to $25,209,800. It is important to consider that this estimate does not include equipment needed to move the sand to the desired grade and template design. These unit prices are likely to increase by 2012. In addition, only Palm City Sand Mine and Indiantown Sand Mine could meet the estimated quantities of 787,800 cy needed for the next renourishment phase.

The logistics involved with transportation of the sand from the inland borrow site to the project area is also expected to be an issue of concern among local residents since the project area, which is located on Hutchinson Island, is not easily accessible by highway and can be reached only by driving through the city of Stuart. Nourishing the beach by a trucking operation can have substantial secondary impacts associated with traffic congestion, road damage, spilled sand along roadways, noise, air pollution, and numerous safety and aesthetic concerns at the beach fill site where dump trucks must drive along the beach (NRC 1995). A typical street-legal dump truck carries about 9 to 16 cy of material; therefore, approximately 49,238 to 87,533 truck-loads must be hauled to the site to meet the renourishment requirement of 787,800 cy. Since USFWS requires that nourishment activities not be conducted during the peak sea turtle nesting season (May 1 through October 31), this leaves only 6 months, or 180 days, to construct the project. Even if this was a 7-days/week project, 274 to 486 dump trucks per day would have to arrive at the site to meet project requirements. Because of these potential drawbacks and the large number of truckloads involved, upland sand sources may be rejected as logistically and economically unpractical as a borrow source for large-scale nourishment projects such as this.

Table 2.2-2. Sand Mine Locations

Mine	City	County	Distance from Project Area (miles)
Dickerson's Indrio Pit	Ft. Pierce	St. Lucie	37
Stewart Mine (Indrio Pit)	Ft. Pierce	St. Lucie	37
Witherspoon Sand Plant	Moore Haven	Glades	91
E.R. Jahna Mine (Ortona Sand Mine)	Moore Haven	Glades	92
Star Pit	South Bay	Palm Beach	68
Palm Beach Aggregates	Loxahatchee	Palm Beach	62
Palmdale Sand Mine	Palmdale	Glades	93
Lake Wales Sand Mine	Lake Wales	Polk	109
Gator Sand Mine	Davenport	Polk	146
474 Sand Mine	Clermont	Lake	148
Indiantown Sand Mine	Indiantown	Martin	32
Palm City Sand	Palm City	Martin	12

Information compiled by Taylor Engineering, Inc. (2007)

Table 2.2-3. Description of Sand at Multiple Sand Mines

Mine	Mean Grain Size (mm)	Mean Grain Size (phi)	Fines (%)	Unified Soils Classification	Visual Description
Dickerson's Indrio Pit	0.68	0.55	1.6	Med sand	Light gray, fine sand and shell fragments
	0.32	1.63	1.8	Fine sand	Fine sand, little shell fragments
	0.36	1.49	0.9	Fine sand	Light brownish gray fine sand
	0.33	1.62	1.0	Fine sand	Light gray fine sand
Stewart Mine (Indrio Pit)	0.41	1.29	1.0	Fine to med sand	Light brownish gray
	0.32-0.36	1.47-1.64	<1.0	Fine sand	Quartz aggregate/silicate
E.R. Jahna Mine (Ortona Sand Mine)	0.53	0.92	No data provided	Med sand	Fine sand
Star Pit	0.60	0.73	No data provided	No data provided	No data provided
Palmdale Sand Mine	0.53	0.92	0.1	SP	Very light tan slightly silty fine sand
Lake Wales Sand Mine	0.52	0.96	0.0	SP	Very light tan slightly silty fine sand
Gator Sand Mine	0.46	1.11	0.1	SP	Very light tan slightly silty fine sand
474 Sand Mine	0.49	1.02	0.0	SP	Very light tan slightly silty fine sand
Indiantown Sand Mine	0.40	1.34	1.4	No data provided	Pale brown fine sand, little shell fragment
Palm City Sand	0.26	1.96	No data provided	No data provided	Light brown fine sand

Information compiled by Taylor Engineering, Inc. (2007)

Table 2.2-4. Sand Mine Supply and Cost Information (2007 Costs) (Page 1 of 2)

Mine	Supplier	Type	Material Delivered ($/cy)	Estimated Quantity Available	Processing Rate	Transport Rate
Dickerson's Indrio Pit	Dickerson Aggregates, Inc.	Indrio Dredge (Stab.)	$13.06/cy	--	--	--
	Wild Bros.	Light sand	$15.73/cy	22,500-30,000 cy	2,000 cy/day	--
		Tan sand	$17.06/cy	3,000-3,750 cy	1,000-1,500 cy/day	--
	Siboney Contracting Co.	Light Brownish Gray Sand	$9.33/cy + delivery	150,000 cy	--	--
Stewart Mine (Indrio Pit)	Stewart Mining Industries	Light Brownish Gray Sand	$9.33/cy + delivery	150,000 cy	--	--
	Siboney Contracting Co.	Light Brownish Gray Sand	$17.67/cy	150,000 cy	--	2,420-2,740 cy/day (150-170 trucks/day)
	Austin Tupler Trucking	Light Brownish Gray Sand	$20.67/cy + FL sales tax	150,000 cy	--	562-750 cy/day
	Eastman Aggregate Enterprises, LLC	Light Brownish Gray Sand	$18.67/cy	225,000 cy	1875 cy/day	4,500-6,000 cy/day
	Indian River Contracting	Light Brownish Gray Sand	$9.00/cy + delivery	150,000 cy	--	1,393 cy/day 10,000 cy/wk
	CKA and Associates, Inc.	Gray Fine Sand	18.32/cy	150,000 cy	--	2250-3750 cy/day/crew depending on conditions
	Sunshine Land Design	Stewart's Material	$18.00/cy	150,000 cy	--	Have over 100 trucks
Witherspoon Sand Plant	Florida Rock Industries	--	$10.67/cy + delivery	--	7,500 cy/day with notice	--
	Googe Transport, Inc.	--	$18.50/cy	--	--	645-806 cy/day (40-50 loads/day)
E.R. Jahna Mine (Ortona Sand Mine)	Austin Tupler Trucking	Light Gray Sand	$32.00/cy + FL sales tax	75,000 cy	--	562-750 cy/day

Table 2.2-4. Sand Mine Supply and Cost Information (2007 Costs) (Page 2 of 2)

Mine	Supplier	Type	Material Delivered ($/cy)	Estimated Quantity Available	Processing Rate	Transport Rate
Star Pit	Bergeron Sand and Rock Mining	Gray Sand w/ Trace Limestone Fragments	$16.00/cy	22,500-30,000 cy	--	--
Palmdale Sand Mine	Mulo Incorporated	Gray Sand w/ Trace Limestone Fragments	17.33/cy	--	--	403-806 cy/day (25-50 trucks)
	Rinker Florida Aggregate Sales, Inc.	--	$20.00/cy	--	--	2,000 cy/day
Lake Wales Sand Mine	Blue Goose Growers, Inc.	--	$22.53/cy	--	--	3,500 cy/day minimum
Gator Sand Mine		--	Prices depend on fuel costs	--	--	
474 Sand Mine		--	Prices depend on fuel costs	--	--	
Indiantown Sand Mine		Pale brown fine sand, little shell fragments	$16.00-$18.00/cy	700,000 cy	700,000 cy	
Palm City Sand	Poma & Sons, Inc.	Light brown fine sand	$10.97/cy ($2/mile, 24 miles round trip, 16 cy/truck)	1,000,000 cy	1,200-1,500 cy/day	Suggests about 10 trucks/day.

Information compiled by Taylor Engineering, Inc. (2007)

2.2.2. ISSUES AND BASIS OF CHOICE

Table 2.2-5 lists the alternatives considered and summarizes the direct and indirect impacts of these alternatives. The alternatives were evaluated for the potential to contribute to the project objectives and consistency with project constraints. Some alternatives were not evaluated further than the initial screening due to a combination of economic viability, unacceptable environmental impacts, and logistics. The screening process eliminated from further consideration and detailed evaluation those alternatives that did not respond to the needs of the problem area or the overall planning objectives. The federal planning objectives are to address beach erosion by identifying and selecting the best course of action. The local planning objectives were incorporated in the overall screening process based upon the expressed desires of the local sponsor. Only those alternatives that warranted consideration based upon the overall planning objectives were brought forward for further evaluation.

Alternative S-3B, Beach Nourishment Using an Upland Sand Source is not selected as the preferred alternative because it is not economically or logistically feasible to truck in the amount of sand needed for a project of this size.

Alternative S-3A, Beach Nourishment Using an Offshore Sand Source is selected as the most economically and logistically feasible alternative that meets the project objectives. Using offshore deposits provides the important benefit of adding sand to the beach/nearshore system rather than simply moving sand from the nearshore to the beach (Hammer et al. 2005). Furthermore, sand resources extracted from federal waters are less likely to change the bathymetry and modify existing physical oceanographic conditions than sand resources extracted from nearshore sites, thus causing less environmental and physical impacts. In relatively shallow nearshore waters, alterations to local currents and waves can dramatically affect nearshore and shoreline erosion and accretion. From a biological standpoint, excavation of sand further from the shoreline may also have less adverse impacts on essential fish habitats than sites closer to shore (Jordan 1999).

2.2.3. ALTERNATIVES ELIMINATED FROM FURTHER EVALUATION

Under the S-3A alternative, proposed offshore borrow areas C1-A and C1-C located within the St. Lucie Shoal complex were eliminated from further evaluation based the findings of the 2004 BOEMRE study, the 2008 archaeological survey, and the analysis of sidescan sonar data (as described in Section 2.2.1.2).

Based on information from these studies, proposed borrow areas C1-A and C1-C were eliminated from further evaluation due to:

1. The potential for unacceptable impacts to the wave climate and shoreline sediment transport from maximum deflation of these two borrow areas.
2. The identification of a magnetic signature within C1-C that suggests the target may represent a potentially significant submerged cultural resource that is recommended for avoidance or further investigation.

3. The potential for hardbottom within C1-A based on analysis of sidescan sonar which would require further ground-truthing investigations to verify features

It is important to note the hypothetical cut depth of -7 meters across C1-A and C1-C was somewhat unrealistic since best-available geotechnical data suggest suitable sediment thicknesses within C1-A and C1-C of only -3 to -7 meters (Hammer et al. 2005). The study did not consider the consequences of relatively shallower depth cuts, which could have provided sufficient volume for several construction cycles and potentially had a negligible impact on longshore sediment transport. If additional modeling is conducted using different dredging depths and dredging scenarios, the impacts to wave climate and shoreline sediment transport may become insignificant, and these sites could potentially be re-considered viable options for other beach nourishment projects in the area.

Table 2.2-5. Summary of Direct and Indirect Impacts of the Alternative Project Plans (Page 1 of 7)

ALTERNATIVE: **ENVIRONMENTAL FACTOR:**	**Plan S-3A** **Beach Nourishment Using an Offshore Sand Source C1-B Borrow Area**	**Plan S-3B** **Beach Nourishment Using an Upland Sand Source**	**No-Action** **Status Quo**
PROTECTED SPECIES – Sea Turtles	Direct adverse impacts – • Alteration of the beach face resulting in potential adverse impact to nesting and hatching success (including effects from grade changes, sediment material, over-compaction, escarpment formation, artificial lighting during construction) resulting in potential “incidental” take of sea turtles • Potential taking of sea turtles with hopper dredge Direct positive impacts – • Nesting area along project reach would increase with nourishment activities Indirect adverse impacts – • Burial of approximately 1.3 acres nearshore hardbottom habitat that serves as foraging habitat for juvenile sea turtles	Direct adverse impacts – • Alteration of the beach face resulting in potential adverse impact to nesting and hatching success (including effects from grade changes, sediment material, over-compaction, escarpment formation, artificial lighting during construction) resulting in potential “incidental” take of sea turtles Direct positive impacts – • Nesting area along project reach would increase with nourishment activities Indirect adverse impacts – • Burial of approximately 1.3 acres nearshore hardbottom habitat that serves as foraging habitat for juvenile sea turtles	Nesting will continue in the area without direct or cumulative effects on either nesting or hardbottom feeding and refuge by juvenile sea turtles. Sea turtle nesting would be negatively impacted as beaches erode.
PROTECTED SPECIES – Birds	Direct adverse impacts – • Potential destruction of nests • Potential disturbance to nesting adults and hatchlings Indirect adverse impacts – • Alteration of intertidal feeding habitat by burial	Same as S-3A	Local habitat use (feeding, resting, nesting) by listed birds is expected to continue

Table 2.2-5. Summary of Direct and Indirect Impacts of the Alternative Project Plans (Page 2 of 7)

ALTERNATIVE: ENVIRONMENTAL FACTOR:	Plan S-3A Beach Nourishment Using an Offshore Sand Source C1-B Borrow Area	Plan S-3B Beach Nourishment Using an Upland Sand Source	No-Action Status Quo
PROTECTED SPECIES – Manatees	Direct adverse impacts – • Possible encounters with manatees by dredge and support vessels during dredge and disposal operations.	No effects anticipated.	Local habitat use by manatees is expected to continue.
PROTECTED SPECIES – Whales	Direct adverse impacts – • Possible encounters with whales by dredge and support vessels during dredge and disposal operations, esp. at borrow area.	No effects anticipated.	Local habitat use by whales is expected to continue.
HARD GROUND	Direct adverse impacts – • Burial of nearshore hardgrounds • Potential for mechanical damage to hardgrounds along pipeline corridors Indirect adverse impacts - • Potential for secondary impacts to nearshore hardbottom adjacent to the ETOF resulting from sedimentation and/or turbidity • Loss of ecological functions important to local flora and fauna including substrate for attachment, nesting sites, spawning sites, and feeding sites.	Direct adverse impacts – • Burial of nearshore hardgrounds Indirect adverse impacts - • Potential for secondary impacts to nearshore hardbottom adjacent to the ETOF resulting from sedimentation and/or turbidity Loss of ecological functions important to local flora and fauna including substrate for attachment, nesting sites, spawning sites, and feeding sites.	Natural hardground exposure will fluctuate, and might increase with continued beach erosion.
SHORELINE EROSION	Would improve storm protection and minimize erosion losses over the life of the project, maintain or improve sand dune and beach, would improve recreation and nesting habitat. Dredging scenarios will be designed to prevent shoreline erosion from altered wave climate and sediment transport.	Would improve storm protection and minimize erosion losses over the life of the project, maintain or improve sand dune and beach, would improve recreation and nesting habitat.	Shoreline would continue to erode at its present rate.

Table 2.2-5. Summary of Direct and Indirect Impacts of the Alternative Project Plans (Page 3 of 7)

ALTERNATIVE: ENVIRONMENTAL FACTOR:	Plan S-3A Beach Nourishment Using an Offshore Sand Source C1-B Borrow Area	Plan S-3B Beach Nourishment Using an Upland Sand Source	No-Action Status Quo
FISH AND WILDLIFE RESOURCES	Direct adverse impacts – • Burial of nearshore hardbottom habitat which includes attached invertebrates and plants as well as less mobile fishes and crustaceans • Burial of softbottom areas along the surf zones and disturbance of softbottom areas in the borrow area will temporarily eliminate infaunal assemblages • Suspended sediment (turbidity) will negatively affect filter feeding organisms. Suspended sediment can abrade gill tissues on fishes and invertebrates. Indirect adverse impacts - • Feeding by visually oriented predators will be temporarily impacted during project construction • Temporary relocation of motile faunal population • Burial of hardbottom habitat will reduce amount of foraging habitat • Temporary infaunal diversity changes in the nearshore and offshore softbottom areas	Direct adverse impacts – • Burial of nearshore hardbottom habitat which includes attached invertebrates and plants as well as less mobile fishes and crustaceans • Burial of softbottom areas along the surf zones will temporarily eliminate infaunal assemblages • Suspended sediment (turbidity) will negatively affect filter feeding organisms. Suspended sediment can abrade gill tissues on fishes and invertebrates. • Mining of the upland borrow area may impact species utilizing habitat in or near the borrow site. Indirect adverse impacts - • Feeding by visually oriented predators will be temporarily impacted during project construction • Temporary relocation of motile faunal population • Burial of hardbottom habitat will reduce amount of foraging habitat	Local habitat use by fishes and invertebrates will continue in relation to natural variability of the physical environment. Continual erosion of the beach and dune areas would potentially decrease habitat for nesting turtles and birds and dune species.

Table 2.2-5. Summary of Direct and Indirect Impacts of the Alternative Project Plans (Page 4 of 7)

ALTERNATIVE: ENVIRONMENTAL FACTOR:	Plan S-3A Beach Nourishment Using an Offshore Sand Source C1-B Borrow Area	Plan S-3B Beach Nourishment Using an Upland Sand Source	No-Action Status Quo
FISH AND WILDLIFE RESOURCES	• Migratory birds and shorebirds may be temporarily discouraged from using areas during constructions activities	• Temporary infaunal diversity changes in the nearshore and offshore softbottom areas • Migratory birds and shorebirds may be temporarily discouraged from using areas during constructions activities	
MARINE MAMMALS	Possible encounters with marine mammals by dredge and support vessels during dredge and disposal operations, esp. at borrow area.	No anticipated effects.	No anticipated effects.
MIGRATORY BIRDS	Bird species that reside or winter in the project area may be temporarily displaced by disturbance from ongoing activities. Sand placement or grading activities may crush eggs or hatchlings. Potential indirect impacts as a result of dredging operations may include ship-following behavior, temporary reductions in prey items nearshore and offshore, and increased foraging in pump-out area.	Bird species that reside or winter in the project area may be temporarily or permanently displaced by disturbance from ongoing activities. Sand placement or grading activities may crush eggs or hatchlings.	Continued erosion of the project area may impact nesting or foraging habitat.
DUNE VEGETATION	Direct adverse impacts – • Potential for damage to existing dune vegetation during construction Direct positive impacts – • Density of existing dune plant species would increase in areas where planting has occurred. • Increased shoreline width would better protect dune communities during storm activities.	Same as S-3A	Existing dune vegetation could be impacted and possibly lost due to erosion.

Table 2.2-5. Summary of Direct and Indirect Impacts of the Alternative Project Plans (Page 5 of 7)

ALTERNATIVE: **ENVIRONMENTAL FACTOR:**	**Plan S-3A** **Beach Nourishment Using an Offshore Sand Source C1-B Borrow Area**	**Plan S-3B** **Beach Nourishment Using an Upland Sand Source**	**No-Action** **Status Quo**
WATER QUALITY	Direct adverse impacts – • Temporary increases in turbidity adjacent to the borrow site and beach fill area. Turbidity would be monitored during project construction and work would cease if turbidity is not in compliance with Florida water quality standards.	Same as S-3A	No anticipated effects.
CULTURAL RESOURCES	Direct adverse impacts – • No cultural resources have been documented during surveys. No anticipated effects.	Direct adverse impacts – • Potential impacts to undocumented archeological resources at the mine site.	No anticipated effects.
RECREATION	Direct adverse impacts – • Temporary disruption and/or localized suspension of recreation at beach and at offshore dredging location during construction activities. • Temporary increases in turbidity may degrade snorkeling and diving experiences around borrow and nourishment areas Direct positive impacts - • Provides increased recreational space for public use.	Direct adverse impacts – • Presence of dump trucks will impact beach activities during project construction (approx. 49,238 to 87,533 truck-loads of sand would be needed to meet the renourishment requirement of 787,800 cy). • Temporary increases in turbidity may degrade snorkeling and diving experiences around beach fill areas Direct positive impacts - • Provides increased recreational space for public use.	Beaches would continue to erode, resulting in decrease use of beach area; potential increase in nearshore hardground diving areas.

Table 2.2-5. Summary of Direct and Indirect Impacts of the Alternative Project Plans (Page 6 of 7)

ALTERNATIVE: **ENVIRONMENTAL FACTOR:**	**Plan S-3A** **Beach Nourishment Using an Offshore Sand Source C1-B Borrow Area**	**Plan S-3B** **Beach Nourishment Using an Upland Sand Source**	**No-Action** **Status Quo**
AESTHETICS	Direct adverse impacts – • Temporary aesthetic impacts associated with construction activities Direct positive impacts – • Provides a wider, more attractive beach for public use.	Same as S-3A	Aesthetic impacts associated with unabated beach erosion; landward advancement of surf zone.
NAVIGATION	Direct adverse impacts - • Temporary and localized increase in vessel traffic associated with transit of dredge and support vessels between fill area and offshore borrow area during dredge activities.	No anticipated effects.	No anticipated effects.
ECONOMICS	The 2012 cost of placing 787,800 cy of material from the proposed offshore borrow area is estimated at $10,104,476 or $9.48 per cubic yard. Short-term economic impacts to beach-associated tourism revenues during project construction. No permanent impacts on commercial or recreational fishing are expected.	The 2007 total unit cost of upland sand material delivered to project area ranges from $9.00/cy (note: this price does not include delivery) to $32.00/cy. Therefore, the cost of 787,800 cy yards of sand from an upland source ranges from $7,090,200 to $25,209,600. Short-term economic impacts to beach-associated tourism revenues during project construction. No permanent impacts on commercial or recreational fishing are expected.	Continued erosion of existing beach would result in increased potential of storm damage, increased energy requirements associated with post-storm clean-up activities, and a likely reduction in beach-associated tourism revenues, property tax, and jobs.
ENERGY REQUIREMENTS AND CONSERVATION	Insignificant energy requirements for beach construction project.	Insignificant energy requirements for beach construction project.	Energy requirements associated with clean-up after storm events would continue to increase concurrent with damages.

Table 2.2-5. Summary of Direct and Indirect Impacts of the Alternative Project Plans (Page 7 of 7)

ALTERNATIVE: **ENVIRONMENTAL FACTOR:**	**Plan S-3A** **Beach Nourishment Using an Offshore Sand Source C1-B Borrow Area**	**Plan S-3B** **Beach Nourishment Using an Upland Sand Source**	**No-Action** **Status Quo**
AIR QUALITY	Direct adverse impacts – • Small, localized, temporary increases in concentrations of nitrogen dioxide (NO2), SO2, CO, VOCs, and PM mostly associated with the dredge plant.	Direct adverse impacts – • Small, localized, temporary increases in concentrations of nitrogen dioxide (NO2), SO2, CO, VOCs, and PM mostly associated with dump trucks used to transport sand.	No anticipated impacts.
ESSENTIAL FISH HABITAT	Direct adverse impacts – • Temporary increases in turbidity will affect feeding and respiration of federally managed species, particularly in early life stages • Direct burial or removal of infaunal assemblages • Direct burial of hardbottom habitat potentially causing relocation of motile faunal populations, reductions in feeding success and recruitment of juvenile fish, and mortality of demersal fish species.	Direct adverse impacts – • Temporary increases in turbidity will affect feeding and respiration of federally managed species, particularly in early life stages • Direct burial of infaunal assemblages • Direct burial of hardbottom habitat potentially causing relocation of motile faunal populations, reductions in feeding success and recruitment of juvenile fish, and mortality of demersal fish species.	No anticipated impacts.
ESSENTIAL FISH HABITAT	• Dredging offshore borrow may impact coastal migratory species, snapper-grouper complex, red drum, and sailfish. • Impacts associated with mining the borrow area may include turbidity, sedimentation, disruption of feeding activities and migratory routes, and entrainment		

2.2.4. PREFERRED ALTERNATIVE – BEACH NOURISHMENT USING OFFSHORE BORROW AREA C1-B

Beach Nourishment Using Offshore Borrow Area C1-B is selected as the Preferred Alternative because it addresses the erosion problem within the project area and fulfills Martin County's goals and objectives. Beach restoration using dredged material from the proposed offshore borrow area C1-B would provide a sufficient amount of beach-compatible sand at a more economical cost and with less transportation complications than beach sand from an upland borrow source. This site is located further away from shore than proposed borrow sites C1-A and C1-C, and wave analysis modeling results indicate that dredging this site for fill material would not result in unacceptable impacts to the wave climate and shoreline sediment transport from dredging this area. In addition, based on survey results, no submerged cultural resources or hardbottom resources have been identified within C1-B.

The construction activities associated with the authorized Martin County HSDR are related periodic beach nourishment which involves placement of beach fill along the 4-mile project reach and shaping/contouring of the fill to meet template requirements. To avoid sea turtle nesting season, all construction must occur between November 1 and May 1, and no construction equipment may be stored on the beach outside of this window.

A hopper dredge would be used to excavate sand from the offshore borrow sites. A hopper dredge works by dredging sand from the borrow site into a hopper (storage area) and then transporting the material to a pump-out location just offshore of the nourishment area. Once the hopper dredge arrives at the pump-out location, the dredge connects to the discharge pipeline. The dredge then mixes the dredged material with seawater to form a slurry and pumps the slurry from the hopper, through the discharge pipeline which runs along the ocean floor, and up onto the beach nourishment area. If possible, previously established pipeline corridors will be used to transfer material from the dredge to the beach fill areas (**Figure 2.2-5 a,b**). However, the exact location of the pipelines will be determined prior to construction to make sure no hardbottom resources are present. The 3-foot-diameter pipelines may be collared to minimize contact with the ocean bottom. Anchors or spuds will be located entirely in sand bottom. Daily monitoring of all pipelines to shore will be performed to check for sand movement and leaks. Continuous leak monitoring will be required of the dredging contractor through fluctuation in pressure through the pipelines.

The initial discharge of material would be formed into a shore-parallel dike that would advance alongshore ahead of the construction template backfill. The dike would help to contain the discharge effluent, allowing time for sediments to drop from the flow. Construction would generally commence at the south end of the project and work toward the north. The material will be graded and shaped by earthmoving equipment in order to achieve the desired beach profile. The contractor will use earthmoving equipment and surveying techniques to achieve the desired beach profile. The traditional fill template will consist of a +8 foot National Geodetic Vertical Datum (NGVD) berm elevation, 90-foot berm width, a 1 vertical: 10 horizontal foreshore construction slope, and a

20-foot-wide dune crest with an elevation + 12.5 feet NGVD (**Figure 1.2-2**). The experimental fill ("turtle-friendly") template will consist of a construction berm commencing landward at an elevation of +8 foot NGVD with a 1 vertical:50 horizontal slope grading to a 1 vertical:20 horizontal slope to the mean low water line with a berm width of 50 feet (**Figure 2.2-6**). Each alternating experimental and traditional beach segment will be 2,000 feet in length with a 700-foot transition zone between each treatment. If the alternating fill template is not constructed, the entire project fill template will be constructed to either the traditional or experimental profile as outlined above.

All staging and beach access corridors are to be determined by the contractor and upland vegetation will be avoided to the maximum extent possible. USACE has proposed to plant sea oats (*Uniola paniculata*) as needed to replace lost vegetation.

Assuming the use of one medium-sized hopper dredge with pump-out capability, the anticipated 2012 construction event is estimated to have a total construction time of 3.85 months (116 days). Mobilization of the dredge, pipeline, and land-based equipment is expected to take 20 days. The dredging and beach fill work is expected to take 86 days. This entails the hopper dredge dredging sand from the borrow area, transporting the sand to the pump-out pipe line, and pumping sand onto the beach where it is graded to the construction template using dozers. Once the beach fill is complete it is expected to take 10 days to demobilize all equipment. Note, that this construction time assumes 787,800 cubic yards will be needed. So, if less sand is needed it will take less time to construct. Also, these estimates don't include unforeseen delays that may occur from bad weather conditions or equipment problems.

Borrow area C1-B covers approximately 1000 acres and is estimated to contain sufficient material (between 2.4 to 4 mcy) for the remaining period of Federal participation which expires in 2046. A typical renourishment event would require the excavation of approximately 787,800 cy of material. The next nourishment event scheduled for 2012. Each nourishment event is expected to impact approximately 125 acres within the borrow area. Anticipated maximum excavation depths would be approximately 10 feet which is anticipated to deflate higher areas within the borrow area down to the existing adjacent bottom elevations. The nourishment interval for this project is estimated at 13 years which is based on current erosion rates and economic data; however, more frequent nourishments may be required if storm activity erodes the beach faster than anticipated.

The 2012 cost of placing 787,800 cy of material from the proposed offshore borrow area is estimated at $10,104,476 or $9.48 per cubic yard. This cost estimate includes mobilization/demobilization, dredging and beach fill, tilling, construction/vibration controls and monitoring, endangered species observers, sea turtle trawling, and sea turtle relocation trawling. Pre- and post-construction monitoring would be paid for by the local sponsor as part of its cost share for the project and is not factored into this cost estimate.

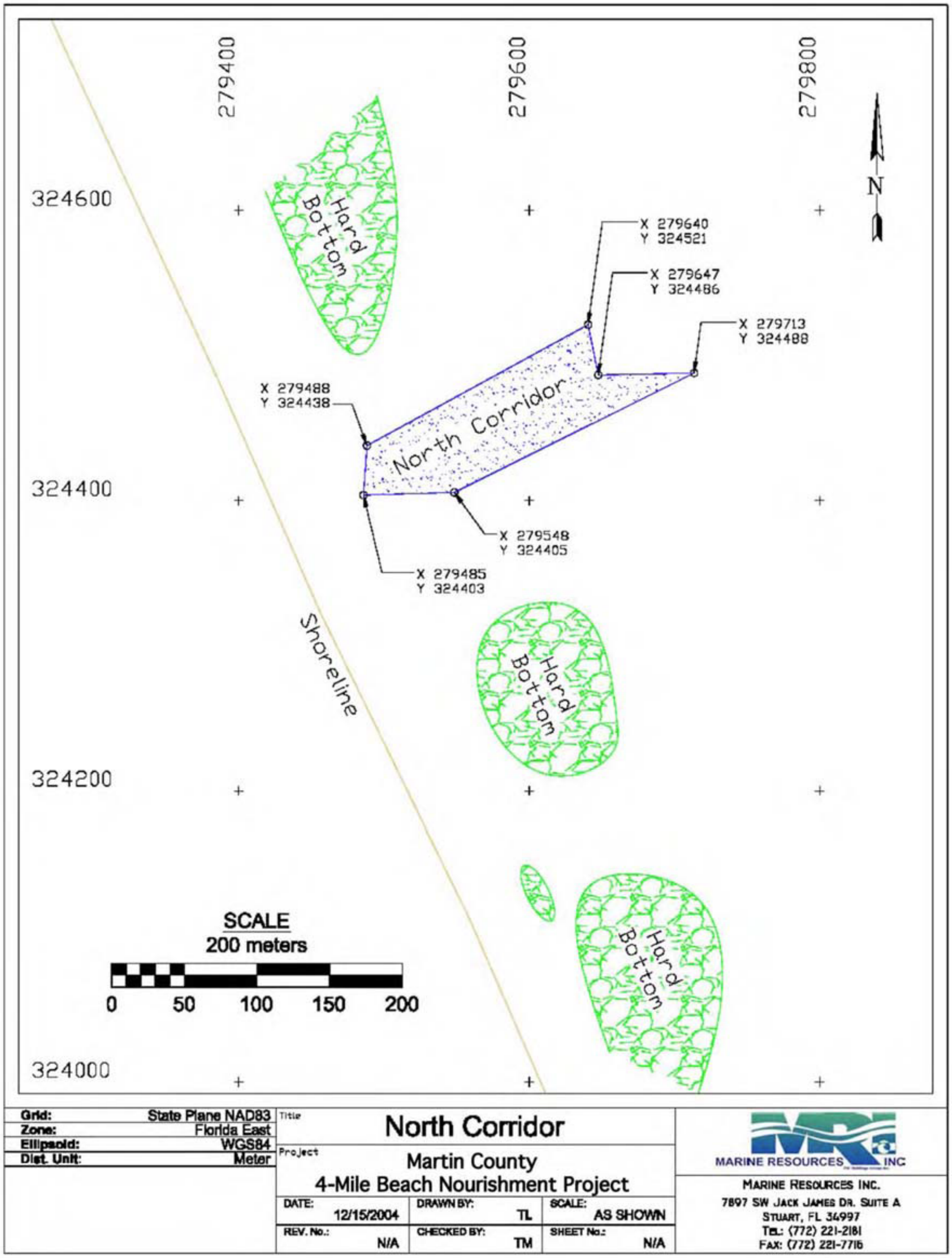


FIGURE 2.2-5a
NORTH PIPELINE CORRIDOR LOCATION
MARTIN COUNTY HURRICANE AND STORM DAMAGE REDUCTION PROJECT
HUTCHINSON ISLAND, FLORIDA

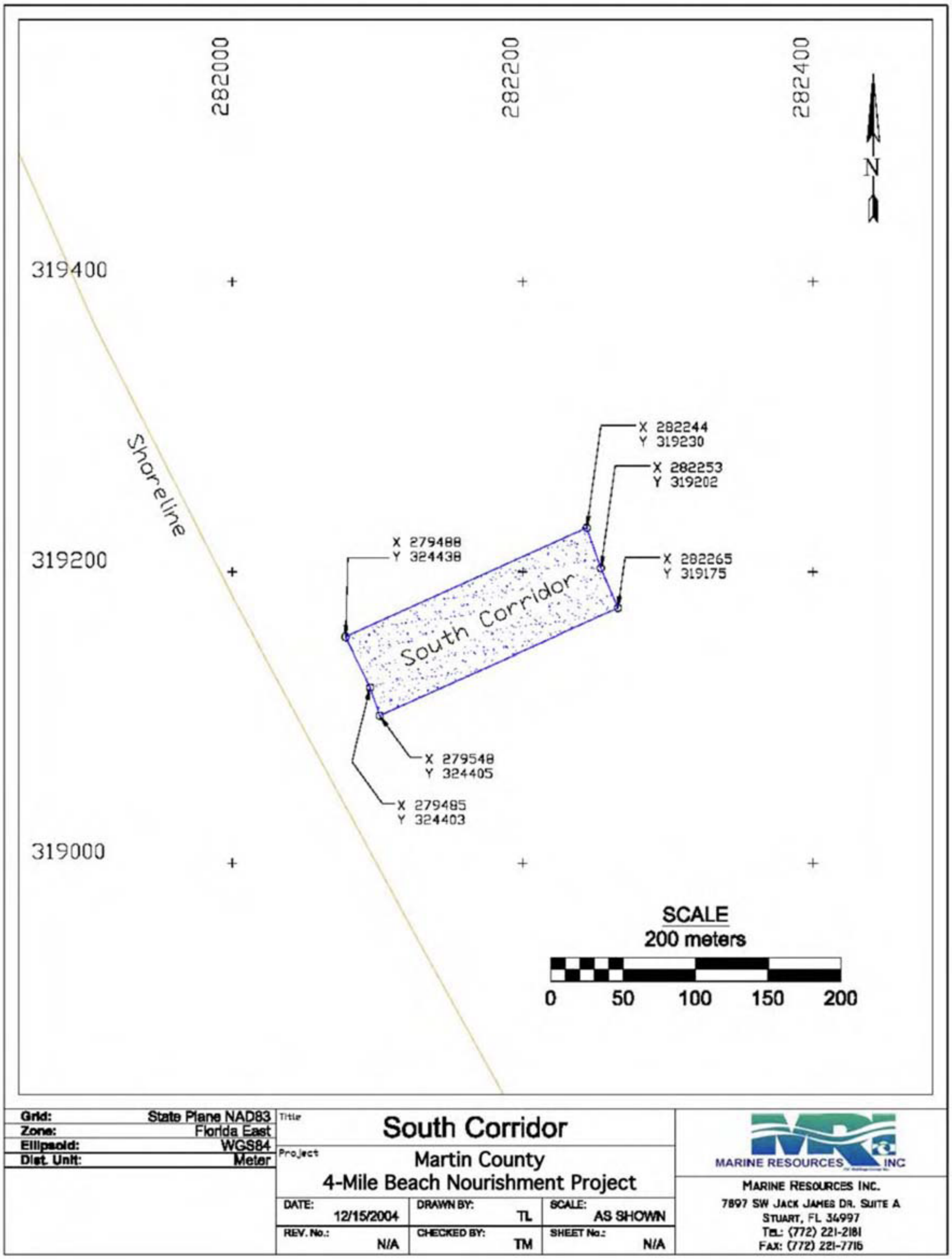


FIGURE 2.2-5b
SOUTH PIPELINE CORRIDOR LOCATION
MARTIN COUNTY HURRICANE AND STORM DAMAGE REDUCTION PROJECT
HUTCHINSON ISLAND, FLORIDA

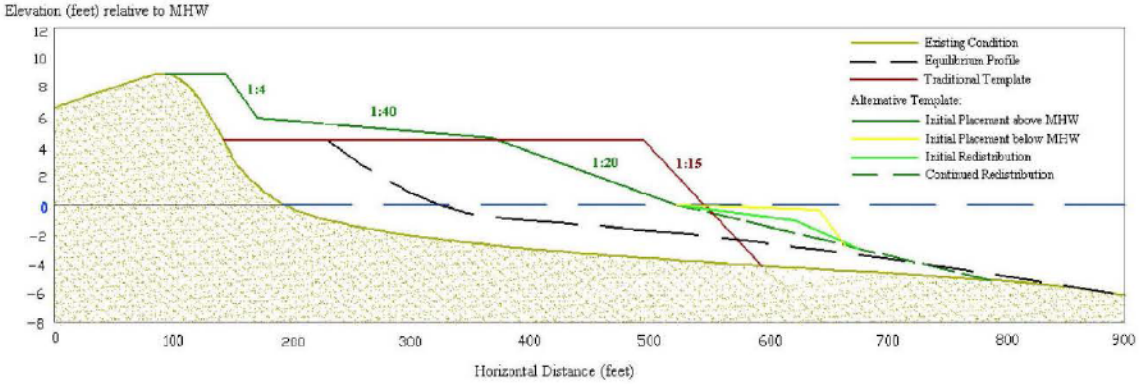


FIGURE 2.2-6.
CONCEPTUAL ALTERNATIVE TEMPLATE DESIGN
(ACTUAL SLOPE DEPENDENT ON
SITE-SPECIFIC CONSIDERATIONS)
MARTIN COUNTY HURRICANE AND
STORM DAMAGE REDUCTION PROJECT
HUTCHINSON ISLAND, FLORIDA

This map and/or digital data is for planning purposes only and should not be used to determine the precise location of any feature. Data provided as-is.
Q:\GIS PROJECTS\EIS_MARTIN_CO\EIS\Figure updates 030211\figure2.2-6_turtlebeach.mxd

Note that under Alternative S-3A, the BOEMRE's connected action is the issuance of a negotiated agreement that authorizes use of the offshore borrow area so that the USACE and local sponsor can obtain the necessary sand resources for beach nourishment. The BOEMRE action is needed since the USACE and local sponsor requested non-competitive access to the borrow area.

As described above, for the 2012 event, USACE is proposing alternate berm templates designed to allow the beach to equilibrate more rapidly to further minimize sea turtle nesting impacts. In a recent report prepared for FDEP, assessments of alternative construction templates for beach nourishment projects were evaluated to better identify aspects of traditional beach nourishment projects that negatively or positively impact sea turtles and provided recommendations for alternative design criteria that may improve the quality of nesting habitat (PBS&J and EAI 2007). The goal of the experiment is to design an alternative construction template that more closely mimics a natural beach profile, improves the quality of the built beach as sea turtle nesting habitat, and provides an acceptable level of shoreline protection. A conceptual alternative design template is provided in **Figure 2.2-6**.

2.3. MITIGATION AND MONITORING

This section describes the mitigation and monitoring plans for the Martin County HSDR project. Additional information on protective measures and contract specifications is provided in Section 4.35, Environmental Commitments.

2.3.1. MITIGATION

Compensatory mitigation has already been implemented for the authorized beach nourishment project to offset impacts to nearshore hardbottom habitat located within the project ETOF between monuments R-1 through R-25. Since the same template will be used for future nourishments, no additional impacts to nearshore hardbottoms are anticipated; therefore, no additional mitigation for these resources is proposed within the ETOF. However, a contingency mitigation plan has been developed by Martin County and details how unanticipated impacts outside of the ETOF would be compensated (Appendix I).

Nearshore artificial reef was created within three sites (A, B, and C) totaling 6 acres and located approximately 900 feet offshore monuments R-12, R-18, and R-20 (**Figure 2.3-1**). These reefs were constructed during the summer of 2000 using steel and concrete material from the dismantled Evans Crary Bridge. Reef monitoring has been conducted by the late Dr. Lee Harris, Florida Institute of Technology, Associate Professor of Ocean Engineering. Annual monitoring data were collected in 2002, 2003, 2004, and 2006. Monitoring was not completed in 2005 due to low visibility conditions. Mitigation monitoring reports are included in Appendix G. The reports include results of fish and benthic species identification and abundance. The most recent monitoring reports from 2006 suggest that the 2004 and 2005 hurricanes caused some burial of the reef structures. This was most notable in mitigation reef C where the clusters of reef material were less abundant and spaced further apart. Harris (2006) found more shallow water depths to the sand bottom as compared to previous monitoring events, so burial of a significant amount of artificial reef was suspected. There was some settlement (and/or burial) and scour around the bridge pieces that were located in 2006. The scour provides habitat similar to that provided by similar scour around nearshore natural reefs in the area. Many of the components that are stacked on top of each other appear to be stable, and are continuing to provide many overhangs and crevices, which are an excellent habitat for a variety of marine organisms to thrive (Harris 2006).

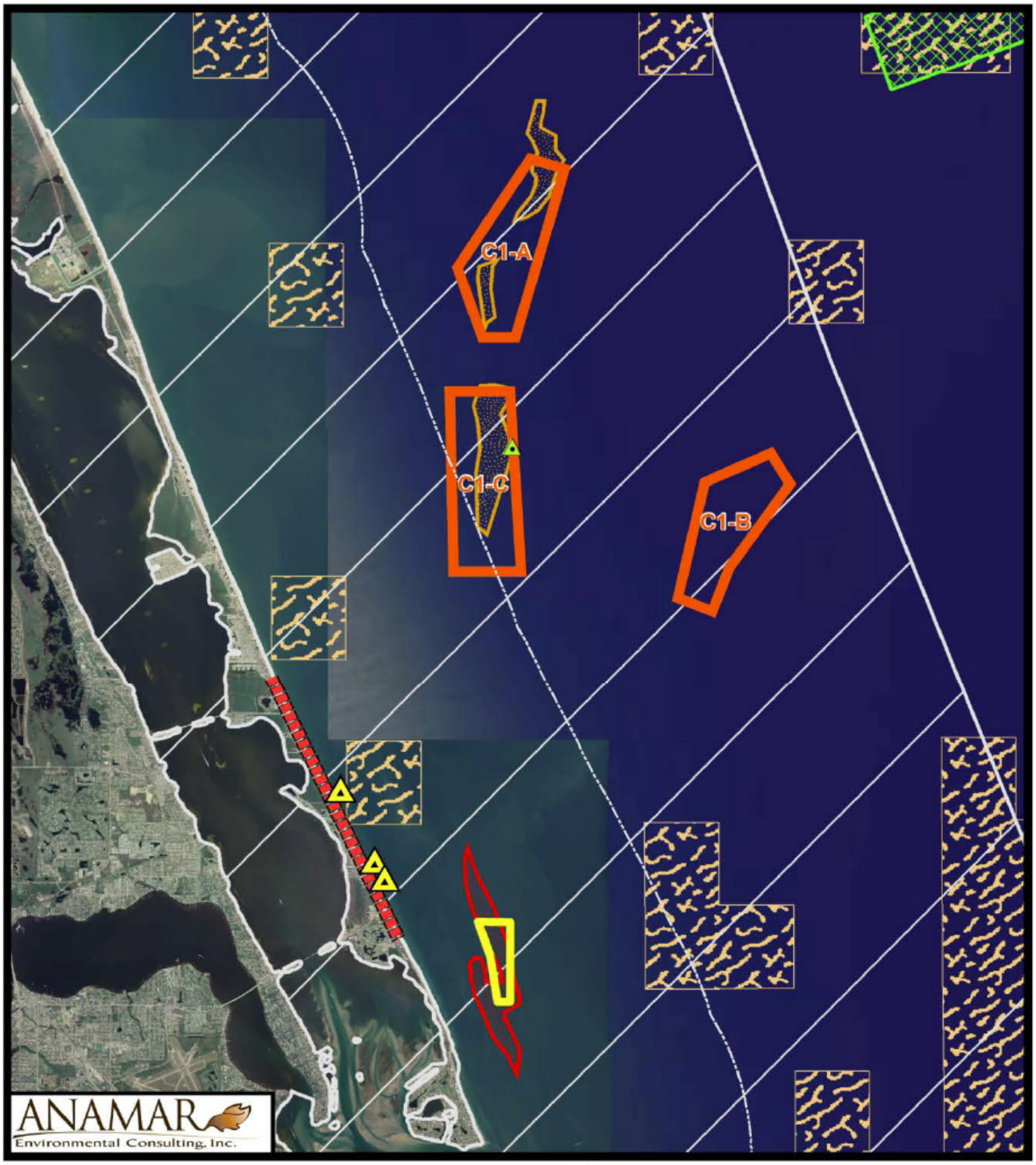


FIGURE 2.3-1.
EXTENT OF PROPOSED NOURISHMENT, BORROW AREAS, AND COASTAL AND MARINE RESOURCES
MARTIN COUNTY HURRICANE AND STORM DAMAGE REDUCTION PROJECT
HUTCHINSON ISLAND, FLORIDA

This map and/or digital data is for planning purposes only and should not be used to determine the precise location of any feature. Data provided as-is.
Q:\GIS PROJECTS\EIS_MARTIN_CO\EIS\Figure updates 030211\figure2.3-1_resources_020211.mxd. Data sources: Taylor Engineering, FGDL, FMRI, Martin Co.

2.3.2. MONITORING

FDEP-approved biological and physical monitoring plans are required as part of the Joint Coastal Permit Application (Appendix I). Project monitoring represents a cooperative effort between USACE Jacksonville District, FDEP Bureau of Beaches and Coastal Systems, USFWS, and Martin County.

Monitoring of the renourished beach will be required through acquisition of project-specific data to include, at a minimum, pre-construction and periodic post-construction topographic and bathymetric surveys of the beach, offshore, and borrow site areas; aerial photography; and engineering analysis. A pre-construction and "as-built" beach profile survey will be produced that depicts the changes and improvements in the beach profile after renourishment has occurred. Subsequent elevation surveys of the renourished beach will be performed to assess changes in the beach profile annually for the first 3 years after renourishment and semi-annually for the next 8 years (**Table 2.3-1**). The as-built survey will allow verification of design elevations, design profiles, and project dimensions, while the post-construction surveys will allow assessment of post-construction performance of the completed project. The post-construction beach surveys will also be used to plan, design, and optimize subsequent nourishment projects.

Extensive environmental and biological monitoring is proposed for the renourished beach, mitigation reef, adjacent beach, and control beach. This monitoring plan is summarized in **Table 2.3-2**. The monitoring plan will include onshore monitoring, nearshore monitoring, and turbidity monitoring. Onshore monitoring performed within the nourished beach footprint and adjacent areas will document marine turtle nesting activity, scarp formation, and sediment compaction. Nearshore monitoring, performed in both the beach construction area and control area, will document the extent, condition, and biota of the nearshore hardbottom reefs including marine turtle foraging habitat. Nearshore monitoring will also be conducted at the three mitigation reef sites and will assess the development of a hardbottom community, identify biota using the mitigation reefs, and document amount of scouring that is occurring at the base of the rock used to construct the reefs.

A control area will be monitored and will provide hardbottom data and marine turtle foraging habitat data for comparison with the beach construction area and mitigation area. This monitoring plan will first be implemented prior to construction activities (a pre-construction baseline event) and then repeated at specified time intervals as noted in **Table 2.3-2**.

Turbidity will be monitored at the renourished beach site and the borrow site to ensure construction activities are not causing an unacceptable increase in turbidity. Turbidity monitoring will be implemented at background and compliance locations at both construction sites and will be measured every 6 hours while construction activities are in progress.

Prior to construction, an FDEP Water Quality Certificate (WQC) will be issued. This permit will include general and specific conditions and requirements to be accomplished during project construction and post-project monitoring.

Table 2.3-1. Project Physical Monitoring Requirements

Requirement Type	Frequency of Requirement													
	Pre-Const	Pre-Const	Const.	1	2	3	4	5	6	7	8	9	10	11
	FY-2009	FY-2010	FY-2011	FY-2012	FY-2013	FY-2014	FY-2015	FY-2016	FY-2017	FY-2018	FY-2019	FY-2020	FY-2021	FY-2022
Topographic and Bathymetric Surveys of the Beach and Offshore		X*	X**	X	X	X		X		X		X		X
Aerial Survey			X	X	X	X		X		X		X		X
Bathymetry at Borrow Site		X*	X**		X		X							

* No more than 90 days before construction commences. ** No more than 60 days after construction completed.

Table 2.3-2. Project Biological and Environmental Monitoring Requirements

Activity	Frequency	Duration	Survey Season	Variables Measured	Reporting
Sediment Compaction Monitoring	Annually (Post-Construction)	Initial and 2 Years Post-Construction	Pre-Turtle Nesting Season (March 1)	Compaction (PSI)	Annual
Scarp Monitoring	Annually (Post-Construction)	Initial and 2 Years Post-Construction	Pre-Turtle Nesting Season (March 1)	Scarp Height	Annual
Marine Turtle Nest Monitoring	Annually, Daily March 1 – October 31	Initial and 3 Years Post-Construction	March 1 – October 31	Emergences, Nests, Reproductive Success	Annual
Shorebird Monitoring (Breeding and Non-Breeding)	Breeding Birds April 1 or 10 Days before Construction	Initial	April 1 (or 10 Days before Construction) – August 1	Breeding Activity	Within 24 Hours of Breeding Confirmation
	Non- Breeding Birds 2 Weeks before Construction	Initial through First Year Post-Construction	2 Weeks before Construction – August 31	Presence	One Month after Collection
Beach Lighting Survey	First Nesting Season (Post-Construction)	Pre-Construction and 1 Year Post-Construction	Before March 1	Beach Lights	March 15 (Pre-Nesting Report) December 1 (Year End Report)
Project Site Hardbottom Monitoring	Annually (Pre- and Post-Construction	Pre-Construction, Construction, and 3 Years Post-Construction	May 1 – September 30	Qualitative: Substrate Type, Benthic Assemblage Quantitative: Species Richness, Percent Cover	60 Days after Survey or December 1
Turbidity Monitoring	During Construction (Every 6 Hours)	During Construction	N/A	Turbidity (NTUs)	Within 1 Week of Collection

2.3.2.1. ONSHORE MONITORING

During the 3 years following fill placement and prior to the beginning of the marine turtle nesting season (March 1), sand compaction in the beach renourishment area will be measured to assess compaction and to determine if tilling is required to loosen the sand. Visual surveys for escarpments along the beach fill area will occur immediately following beach nourishment and for three subsequent years. All scarps that exceed 18 inches in height will be leveled or the beach profile reconfigured to minimize scarp formation.

Daily marine turtle nest monitoring will be conducted from March 1 through October 31 during the year construction occurs and for 2 years following construction. If construction occurs during the early sea turtle nesting season (March 1 to April 30), nighttime sea turtle nest surveys will occur. If construction occurs during the late sea turtle nesting season (November 1 to November 30), daily early morning sea turtle nest surveys will be conducted 65 days prior to project initiation and continue through September 30. Following construction, marine turtle nest surveys will continue daily during the nesting season and for the next two nesting seasons. Monitoring of nesting activity in the two seasons following construction shall include daily surveys and any additional measures required by FFWCC. A survey will be conducted of all lighting visible from the beach placement area immediately after construction and by March 15 each year for 2 years post-construction.

One-time comprehensive monitoring, in addition to that described above, is required for the alternating turtle friendly berm experiment in order to determine if statistically significant improvements in nest densities and hatchling production can be achieved through modifications to the traditional construction template. This would be as follows:

TASK	SUB-TASK
Daily Monitoring	Count of all crawls by type (nest or false crawl) and survey area
	GPS data collection for randomly selected crawls
	Documentation of abandoned digs along randomly selected crawls
Nest Marking & Monitoring	Marking of nests along randomly selected crawls
	Daily monitoring of marked nests
	Assessment of hatchling orientation for all marked nests
	Excavation of marked nests after hatching and evaluation of nest contents
Sediment Compaction Analyses	Measure compaction along randomly selected crawls
Scarp Monitoring	Measure scarps each week
Grain-size Analyses	Collect and analyze sediments at 32 locations twice a year
Characterization of Weather and Wave Conditions	Obtain and summarize weather and wave data from official websites
LiDAR Data Collection	Collect LiDAR data once each year
Engineering Profiles	Determine beach profiles (across dune and berm to approximately –4 feet NGVD) at approximately 500-foot intervals six times a year

(PBS&J, 2007, modified)

Marine turtle monitoring will occur in the nearshore to assess differences in marine turtle foraging activities in three distinct locations: the project area (including downdrift area), a control hardbottom site, and the three constructed reef mitigation areas. Marine turtle monitoring will occur quarterly for 1 year prior to construction (pre-construction), monthly during construction, and quarterly for 2 years post-construction. Monitoring will consist of documenting species and abundance of marine turtles at each monitoring location.

Monitoring of breeding shorebirds within the project boundaries shall begin on April 1 or 10 days before construction-related activities begin. Nesting surveys shall occur daily throughout the construction period or through August if no shorebird nesting activity is observed. Non-breeding shorebird monitoring within the project boundaries shall begin 2 weeks before construction-related activities begin and occur every 2 weeks for at least 1 year post-construction.

2.3.2.2. NEARSHORE MONITORING

A new baseline hardbottom survey was conducted in August 2010. Hardbottom monitoring, performed before construction, immediately after construction, and 2 years post construction, will document the sessile plant communities and animal communities that inhabit the nearshore reefs and sediment accumulation within the communities. Monitoring will occur annually in three distinct locations: project area (including downdrift area), a control hardbottom site, and the three constructed reef mitigation areas. Monitoring in the control area will provide data from a natural hardbottom site for comparison with hardbottom data from the beach construction and mitigation areas.

The nearshore hardbottom edge shall be mapped during the pre-construction monitoring event and all subsequent nourishment events. This information will be used to document conditions along the previously mapped nearshore hardbottom edge for comparison to the pre-construction survey. Transects will be established in the three hardbottom monitoring areas (project site, control site, and mitigation areas) and monitoring will occur in quadrats along each transect so changes in the benthic landscape including physical relief, sand cover, and species dominance/abundance can be recorded.

2.3.2.3. TURBIDITY MONITORING

Turbidity will be monitored at the renourished beach site and the borrow site to ensure that construction activities are not causing an unacceptable increase in turbidity. Turbidity monitoring will be implemented at background and compliance locations at both construction sites and will be measured every 6 hours while construction activities are in progress.

3. AFFECTED ENVIRONMENT

The Affected Environment section succinctly describes the existing environmental resources and how they may be affected if any of the alternatives are implemented. This section does not describe the entire suite of environmental resources, only those relevant to the project that would potentially be affected during or after construction activities. This section, in conjunction with the description of the No Action Alternative, forms the baseline conditions for determining the environmental impacts of the proposed action and reasonable alternatives.

3.1. GENERAL ENVIRONMENTAL SETTING

3.1.1. PROJECT LOCATION

The project area is located on Hutchinson Island in Martin County, Florida (**Figure 1.1-1**). The Martin County shoreline is composed of mainly developed coastal barrier islands separated from the mainland by tidal lands, lakes, and bays that are interconnected by a system of tidal waterways maintained as part of the Intracoastal Waterway. The barrier islands are low, varying in width from 200 feet to nearly a mile, and low in elevation, ranging from 5 to 25 feet above msl. St. Lucie Inlet at the north end of Jupiter Island connects the Atlantic Ocean with the Indian River, a lagoon that extends about 100 miles northward. St. Lucie Inlet is an artificial inlet opened into the Atlantic Ocean through the barrier island. Jupiter Inlet, a natural opening at the south end of Jupiter Island, connects the ocean with the Loxahatchee River. These inlets provide exchange of sediment and water between estuaries and the continental shelf, primarily as a function of tide.

The general project area is composed primarily of multifamily homes, small condominium complexes, and large hotels facing either west towards the Indian River Lagoon or east towards the Atlantic Ocean. Beaches line the eastern side of Hutchinson Island and are composed of shell fragments and fine sand. Coquina rock outcroppings occur periodically along the shore of the barrier island (**Figure 3.1-1**). Martin County beaches are used by multiple wildlife species including nesting sites for threatened and endangered sea turtles. The dune system along the landward side of the beach affords some protection to the shorefront development, but is subject to overwash and erosion during severe storms. Because of this, erosion of the protective beach along Hutchinson Island is a severe seasonal problem.

The project area also includes the diverse inner shelf habitat offshore of St. Lucie and Martin County, including the physically dominated surf zone, nearshore hard bottom habitat, and offshore sand borrow areas. The nearshore beach environment consists of primarily medium- to coarse grained sand mixed with carbonate. Anastasia Formation underlies the entire project area and is exposed in places along with more recent Holocene beach rock. The offshore borrow area is located approximately 7 miles offshore in the Inner Shelf Plain zone. Morphology of the continental margin offshore consists of reef features of Tertiary origin, littoral deposition from the Pleistocene era, and current-induced features. Repeated sea level changes resulted in a series of deposition events between glacial periods forming a complex stratigraphic sequence.

Figure 3.1-1. Example of Exposed Coquina Rock Outcroppings Located Approximately 2 Miles South of the Project Area (Bathtub Reef Park)

The underlying Anastasia Formation is present throughout the project area, which is confined to the Inner Shelf Plain Zone of the Florida Continental Shelf. The Inner Shelf Plain Zone lies between the Inner Smooth Zone to landward and the Deep Ridge Zone to seaward. Approximate depths are between 16 and 40 meters. The predominant sediment material is relict terrigenous sands and shell debris. **Figure 2.3-1** depicts marine resources in the area, including existing mitigation reefs, nearshore and offshore hardbottom areas, and special management areas (HAPC) in the vicinity.

Multiple factors control the coastal processes along the shoreline of Martin County including winds, tides, currents, waves, storm events, and geology and geomorphology. Sections 3.1.2 through 3.1.9 describe the role of each of these factors and their effect on beach erosion in the project area.

3.1.2. STORM EVENTS

The coastline of Martin County is low-lying and vulnerable to storm surge and other storm event damages. Tropical cyclones (tropical storms and hurricanes), typically occur between June and November, and generally originate in the tropical and subtropical latitudes in the Atlantic Ocean north of the equator. During the winter months (December-March), frontal weather patterns driven by cold arctic air masses reach Central Florida with greater frequency. These fronts typically generate southwest winds that shift to the northwest before frontal passage, and then to the northeast behind the front. If the northeaster occurs when the moon is in perigee, the winds are accompanied by abnormally high tides.

The surges and waves caused by cyclonic disturbances and northeaster storms present a major threat to the stability of the shoreline in Martin County. A total of 50 hurricanes passed within a radius of 150 miles of Martin County between 1830 and 1985 (USACE 1986). Of that total, 19 hurricanes passed within a 50-mile radius. In recent years, major storms that have affected Martin County include Hurricane Floyd (1999), Hurricane Irene (1999), Hurricane Jeanne (2004), Hurricane Frances (2004), Hurricane Dennis (2005), Hurricane Katrina (2005), Hurricane Ophelia (2005), and Hurricane Wilma (2005). Storm paths from the 2004 and 2005 hurricane seasons are depicted in **Figure 3.1-2**.

In the fall, winter, and spring months, the Martin County shoreline is vulnerable to northeasters, which may form with little or no advance warning and persist up to a week to 10 days. The average duration of a northeaster, however, is only about 2 to 3 days. Particularly severe northeasters that have affected the project area occurred in 1956, 1957, 1962, 1963, 1964, 1979, 1981, 1984 (Thanksgiving Day Storm), 1990, and 2004.

In 2004, Hurricanes Frances and Jeanne caused significant damage to the Martin County shore protection project area, causing substantial shoreline recession. Storm damages resulted in a loss of approximately 269,500 cy of material from the project reach, equal to 45% of the periodic renourishment volume of 590,000 cy (USACE 2005). Between early July and late October 2005, the Martin County shore protection project was severely impacted by three hurricanes (Katrina, Ophelia, and Wilma), all of which reached category 3 strength or higher. The individual storms had significant intensity and durations of impact; however, their cumulative destruction to the project area was extraordinary. This is in large part due to their nearly continuous occurrence which allowed no recovery time for material to migrate back onshore and provide protection against subsequent storm activity. The shoreline recession for the project area averaged 20.7 feet and resulted in a loss of 149,500 cy of material over the 4-mile project reach (USACE 2006).

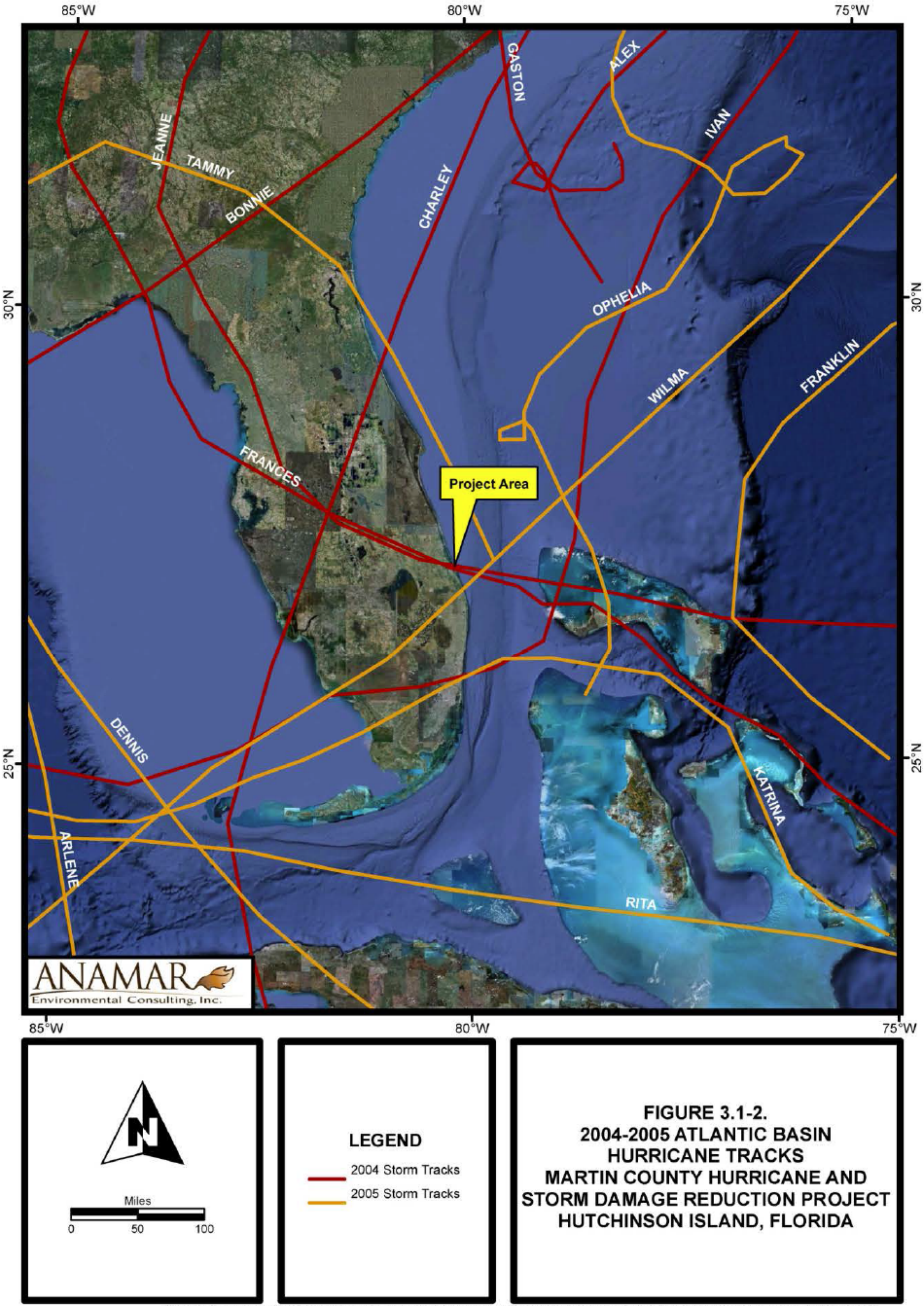


**FIGURE 3.1-2.
2004-2005 ATLANTIC BASIN
HURRICANE TRACKS
MARTIN COUNTY HURRICANE AND
STORM DAMAGE REDUCTION PROJECT
HUTCHINSON ISLAND, FLORIDA**

This map and/or digital data is for planning purposes only and should not be used to determine the precise location of any feature. Data provided as-is. Data sources: NHC, ESRI, ANAMAR.

3.1.3. WINDS

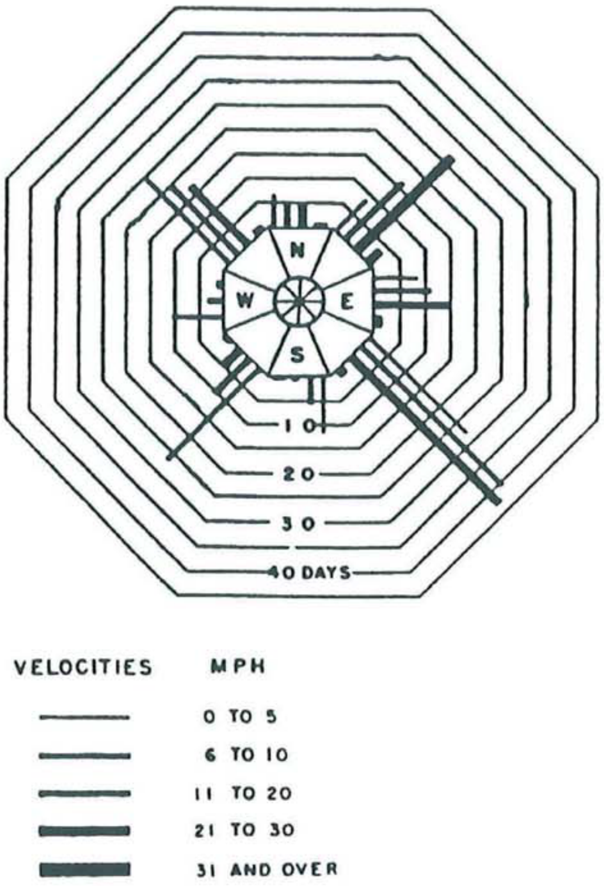
Local winds generate most of the short-period waves experienced in the project area, and vary notably by season. The wind rose in **Figure 3.1-3** is based on data taken at the U.S. Weather Bureau Station in West Palm Beach, Florida, during an 8-year period from July 1938 to July 1946. The wind rose in **Figure 3.1-4** is based on data taken at the West Palm Beach International Airport during a 10-year period from 1998 to 2007. These wind roses indicate that the prevailing winds are from the northeast, east, and southeast, with easterly and southeasterly winds occurring most often.

During winter months (December through March), winds are often from the northwest, north, and northeast. Cold fronts, associated with areas of low pressure, generally traverse the continental U.S. from west to east. Severe northeasters can cause extensive beach erosion and shorefront damage. The summer months (June through September) are characterized by tropical weather systems traveling east to west in the lower latitudes. These tropical systems have the potential to develop into tropical storms and hurricanes, which can generate devastating winds. Southeast tradewinds make up the typical summer wind climate.

3.1.4. WAVES

Wave height, period, direction of approach, magnitude, and phasing of storm surge are important dynamic factors influencing beach change in central east Florida (Hammer et al. 2005). The most familiar ocean waves are wind-generated waves, which are formed by the transfer of energy from winds blowing over the water surface. Wind-generated waves can vary in size from ripples to as large as 10 feet or more in height. Their size and frequency of occurrence are important factors in shaping the shoreline on Florida's sandy coasts. Storm waves generated by the wind are the primary cause of beach sand erosion and shoreline damage in the study area. Wind waves that occur in the study area consist of "sea" and "swell" waves. Sea waves are generated by local winds and are observed traveling with the wind. Swell waves are generated from distant storms that enter the study area independent of local wind conditions. The broad continental shelf has the greatest influence on regional-scale wave transformation, and the large sand ridges shown in **Figure 2.2-1** appear to have the greatest influence on smaller-scale wave refraction patterns in the Martin County study area (USACE 2009).

In most cases, buoy data provide the most informative source of wave information because they represent actual measurements rather than hindcast information derived from large-scale models. However, very few sites along the U.S. east coast have wave records from buoy measurements of sufficient length to justify their use as a source of long-term information (Hammer et al. 2005). Sources of measured directional wave data from offshore central east Florida include the Florida Coastal Data Network (CDN) (Wang et al. 1990) and various short-term deployments of individual gauges [e.g., the 1991 University of Florida deployment of a wave gauge offshore Jupiter Island (Harris 1991)]. However, the most comprehensive analysis of nearshore wave climate for central east Florida is by the USACE Coastal and Hydraulics Laboratory through wave hindcast studies (Hubertz et al. 1993).



BASED ON SIX-HOUR READINGS OVER AN EIGHT-YEAR PERIOD FROM 1 JULY 1938 TO 31 JULY 1946 BY THE U.S. WEATHER BUREAU AT WEST PALM BEACH, FLORIDA.

FIGURE 3.1-3.
AVERAGE DIRECTION, DURATION AND VELOCITY
OF WINDS FOR 8-YEAR PERIOD
AT WEST PALM BEACH, FLORIDA
MARTIN COUNTY HURRICANE AND
STORM DAMAGE REDUCTION PROJECT
HUTCHINSON ISLAND, FLORIDA

This map and/or digital data is for planning purposes only and should not be used to determine the precise location of any feature. Data provided as-is.
Q:\GIS PROJECTS\EIS_MARTIN_CO\EIS\Figure updates 030211\figure3.1-3_windrose1946.mxd. Data sources: USACE 1993.

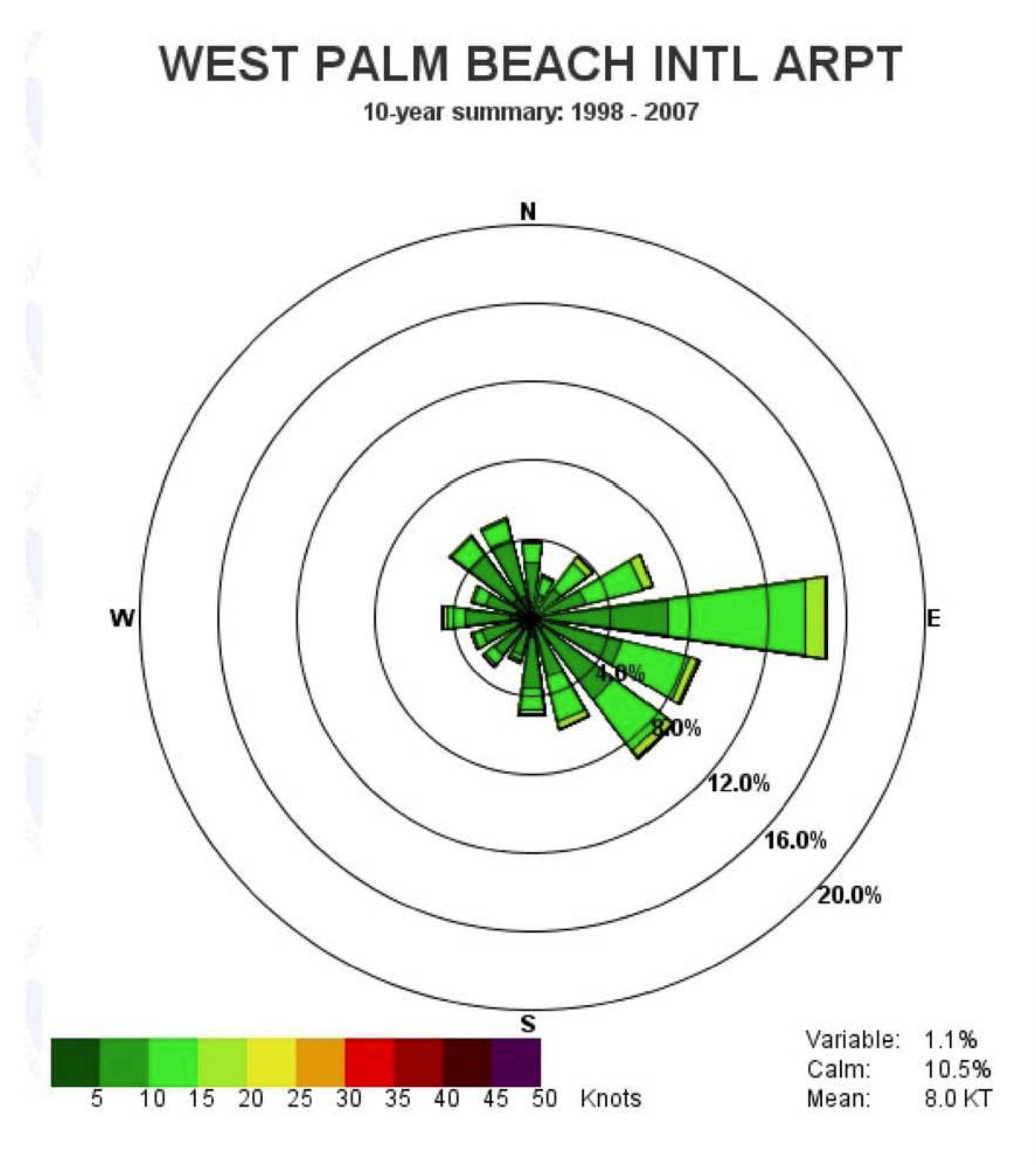


FIGURE 3.1-4
AVERAGE DIRECTION, DURATION AND VELOCITY
OF WINDS FOR 1998-2007 AT WEST PALM BEACH, FLORIDA
MARTIN COUNTY HURRICANE AND
STORM DAMAGE REDUCTION PROJECT
HUTCHINSON ISLAND, FLORIDA

This map and/or digital data is for planning purposes only and should not be used to determine the precise location of any feature. Data provided as-is
Q:\GIS PROJECTS\EIS_MARTIN_CO\EIS\Figure updates 030211\figure3.1-4_windrose2007.mxd Data sources: USACE 1993.

The wave hindcast data used in this report were obtained from station 14 located at a water depth of 180 feet offshore of Hutchinson Island, where the shoreline angle is 24° west of due north. Wave plots for station 14 are shown in **Figure 3.1-5.** Most waves (76%) occur within the 30° and 90° compass sector. Dominant wave direction is between 30° and 60°, from which 39% of waves in the record propagate. Mean height for all waves is 1.2 meters, with a standard deviation of 0.7 meter. Mean height for waves from the dominant direction is 1.3 meters, and the standard deviation is 0.7 meter. A significant number of wave events (40%) have peak periods greater than 9 seconds, and the mean peak period for the entire record is 9.1 seconds (Hammer et al. 2005). A summary of averaged monthly wave heights derived from the 20-year Wave Information Study (WIS) record are provided in **Table 3.1-1**.

Table 3.1-1. Averaged Monthly Wave Conditions from 1980 to 1999

Month	Wave Height (m)	Peak Period (s)	Wave Direction (Deg*)
January	1.31	6.0	28
February	1.32	6.2	25
March	1.29	5.7	23
April	1.11	5.4	22
May	0.96	5.2	16
June	0.72	4.4	11
July	0.56	4.1	3
August	0.68	4.2	4
September	1.07	4.9	17
October	1.45	5.5	22
November	1.49	5.7	27
December	1.35	6.1	31

* Wave directions measured in degrees from shore-normal, counterclockwise

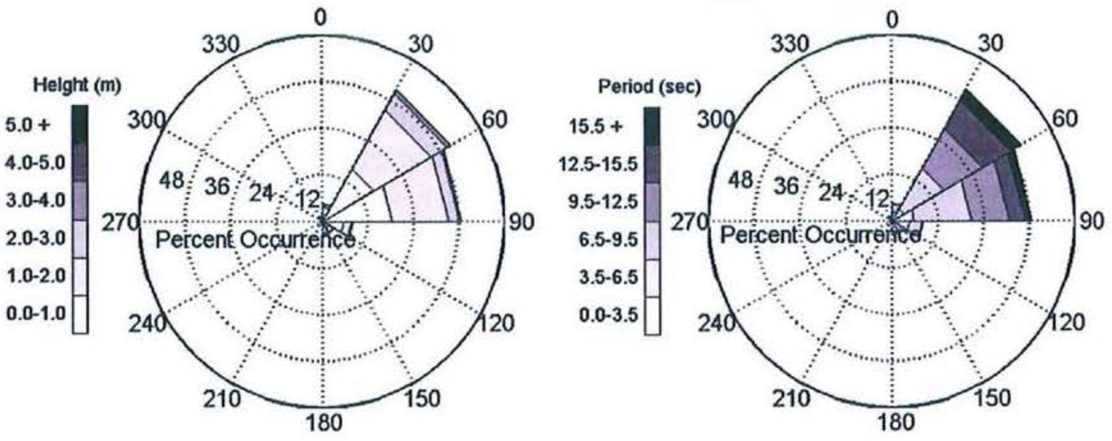
Source: USACE (2009)

3.1.5. TIDES

Tides in the project area are a mixture of semi-diurnal and diurnal types. The mean annual range of tide in the Atlantic Ocean at Hutchinson Island is 2.6 feet, and the higher spring range is 3.1 feet (NOAA 1993). All elevations, depths, and water levels in this report refer to mlw, which is 1.1 feet below the 1929 NGVD 2.9 feet below mhw.

Storms and hurricane winds blowing in from the sea can create abnormally high tides in the coastal area. Tropical storms in this vicinity can occasionally increase the tide range to about 7 feet. The lowest tide to be expected is 2 feet below mlw.

Wind set-up is a local phenomenon that can occur during tropical depressions and severe storm events. It is the tendency for water levels to increase at the downwind shore and decrease at the upwind shore. Wind set-up occurs most dramatically in shallow water and has significantly more effect on seasonal and long-term erosion than astronomical tides. During severe onshore winds, wind set-up of 3 to 4 feet is not uncommon. As developed by the National Oceanic and Atmospheric Administration (NOAA), the storm surge levels with a frequency of occurrence of once in 10 years, 50 years, and 100 years would be 3.7, 5.2, and 6.1 feet above msl, respectively.



Wave height and period for hindcast data from WIS Station AU2014, January 1976 and December 1995. Direction indicates from where waves were traveling relative to true north. Radial length of gray tone segments indicates percent occurrence of each range of wave height and period.

FIGURE 3.1-5.
WAVE HEIGHT AND PERIOD DATA FOR
JANUARY 1976 AND DECEMBER 1995 AT WIS 14m
MARTIN COUNTY HURRICANE AND
STORM DAMAGE REDUCTION PROJECT
HUTCHINSON ISLAND, FLORIDA

This map and/or digital data is for planning purposes only and should not be used to determine the precise location of any feature. Data provided as-is.
Q:\GIS PROJECTS\EIS_MARTIN_CO\EIS\Figure updates 030211\figure3.1-5_waveplots.mxd Data source: Hammer et. al 2005.

3.1.6. CURRENTS

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

The Florida Current is the local manifestation of the Gulf Stream, the intense western boundary current of the North Atlantic that transports heat north from the equator. The system narrows and intensifies between the southeast Florida shore and the Bahamas; this portion of the Gulf Stream is commonly known as the Florida Current. The axis of the Florida Current runs northward, east of the study area. Flow speeds can exceed 2.5 m/sec (Lee et al. 1985). The Florida Current dominates circulation along the central east Florida continental shelf. However, wind-driven currents also play an important role. Unlike other shelf regions where tidal forces contribute substantially to circulation processes, the controlling parameter in the Florida Current area seems to be the lateral position of the frontal zone relative to the shelf—the closer the front, the greater the influence on local circulation.

Circulation processes within the study area include spin-off eddies and meanders of the Florida Current, wind-driven currents, upwelling/downwelling dynamics, and tides. Other contributions may stem from shelf waves, inertial oscillations, and coastal inlet exchange. Shelf currents are aligned principally along isobaths; cross-shelf components are typically much weaker. Despite the presence of multiple forcing mechanisms, most current energy on the shelf can be related to subtidal variability (Lee and Mayer 1977). The position of the Florida Current front is the principal control of subtidal shelf circulation from Miami, Florida, to Cape Hatteras, North Carolina (Zantopp et al. 1987).

3.1.7. STORM SURGE

Storm surge elevation is defined as the rise of the ocean surface above its normal high tide level during a storm. The increased elevation can be attributed to a variety of factors including waves, wind shear stress, and atmospheric pressure. An estimate of storm surge is essential for design of the beach fill crest elevation, as a higher storm surge will allow larger storm waves to attack the shore.

The major threats to the shoreline of Hutchinson Island are storm surge and waves caused by northeasters, subtropical and tropical storms, and hurricanes. Storm surge and wave elevations can be classified and predicted for various storms using historical information and theoretical models. **Figure 3.1-6** shows the storm surge elevations for hurricane surge levels and northeaster surge levels at selected recurrence intervals for the Martin County Atlantic coast. The hurricane surge frequency data were derived from Federal Emergency Management Agency (FEMA) (FEMA 1983) and the northeaster surge frequency data were derived from WIS (Ebersole 1982). The surge curves are based on data points for the 10-, 50-, 100-, and 500-year recurrence intervals.

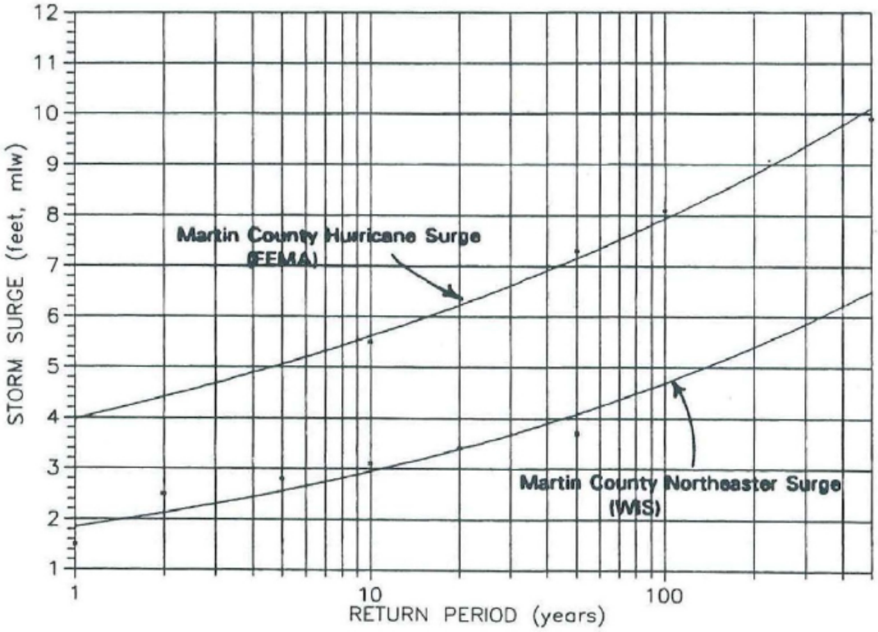


FIGURE 3.1-6.
STORM SURGE FREQUENCY CURVE
MARTIN COUNTY HURRICANE AND
STORM DAMAGE REDUCTION PROJECT
HUTCHINSON ISLAND, FLORIDA

This map and/or digital data is for planning purposes only and should not be used to determine the precise location of any feature. Data provided as-is.
Q:\GIS PROJECTS\EIS_MARTIN_CO\EIS\Figure updates 030211\figure3.1-6_surgefreq.mxd. Data source: USACE 1994.

Higher frequency of storm occurrence and storm surge elevations were obtained from WIS Report 7 for other meteorological-induced water-level anomalies (i.e., northeaster-type storms) (Ebersole 1982). Hindcasting of northeaster storm surges was performed using historical wind and pressure fields. Water levels given in the WIS Report 7 are referenced to the stillwater level. Data for northeaster events for Martin County are based on interpolation between the storm surge data for Mayport and Miami Beach, Florida (**Figure 3.1-6**).

3.1.8. SEA LEVEL RISE

Average sea level is an important factor affecting erosion along the Florida east coast. Sea level along the Atlantic coast is estimated to be rising at a rate of 0.006 feet per year. Changes in sea level have large ramifications in flat coastal regions. A slight increase in the level of the ocean along the flat beaches of the Florida east coast, though very small vertically, would shift the shoreline landward a noticeable distance.

3.1.9. GEOLOGY AND GEOMORPHOLOGY OF STUDY AREA

Beach sediments along the project area are composed primarily of medium- to coarse-grained sand with large quantities of carbonate mixed throughout (Meisburger and Duane 1971). Inundated sediments in the project area generally are classified in the Anastasia Formation, which is regarded as Pleistocene in age, but includes some recently cemented Holocene beach rock (Hammer et al. 2005). The Anastasia underlies all modern beach sediments within the study area (Freedenberg et al. 1995). State geological maps illustrate the general stratigraphy and surficial sediment classification for subaerial deposits within the project area (**Figure 3.1-7**).

Morphology of the continental margin offshore of southeastern Florida reflects the influence of four shaping processes, including, reef building during the Tertiary period, deposition on the shelf in the littoral zones of the Pleistocene era, erosion by the Florida Current, and deposition and shaping by bottom currents (Uchupi 1969). Meisburger and Duane (1971) documented the Eocene and post-Eocene history within the study area as one of repeated invasions and retreats of the sea. Erosional unconformities and hiatuses in the Eocene column point to tectonic instability throughout that period. Analysis of seismic reflection profiles indicated an abrupt steepening of dip of some deep reflections, an apparent effect of a near-coast fault between Cape Canaveral and Fort Pierce (Meisburger and Duane 1971). During the Pleistocene, central east Florida was alternately flooded and exposed to subaerial erosion, leaving a variable and sometimes complex series of sediment and erosional surfaces (Meisburger and Duane 1971). During Pleistocene interglacial periods, marine sands were deposited in submerged areas and transgressive stratigraphic sequences were formed (Stauble and McNeill 1985). The last major event was the advance of the Holocene sea across the upper continental slope and shelf, starting about 12,000 years ago and ending about 4,000 years ago (Curray 1965; Milliman and Emery 1968). Reworking of some marine sands deposited within interglacial periods continued during the Holocene (Stauble and McNeill 1985). Presently, a thick sedimentary section underlies the area, with Pleistocene sediments of the Anastasia Formation comprise much of the offshore subsurface sedimentary environment. The offshore portion of the study area is limited to the Florida Continental Shelf, which is the southern-most part of the East Coast Shelf. It is composed of strata lying at low angles and dipping generally easterly and southeasterly (Field and Duane 1974). The continental shelf narrows dramatically from a maximum width of about 48 km near Cape Canaveral to a minimum of about 16 km in the southern extent of the study area where it merges with the Florida-Hatteras slope (**Figure 3.1-7**). This reduction in width is accompanied by a distinct increase in shelf steepness from north to south (Field and Duane 1974). The Florida Continental Shelf has been classified into several morphologic zones, including an inner smooth zone extending from the shoreline out to a depth of about 16 meters, a ridge zone (known as the Inner Shelf Plain) extending from 40- to 60-meter water depth, and another deep ridge zone between 60 and 80 meters (Uchupi 1969) (**Figure 3.1-8**). The inner ridge zone between 16- and 40-meter water depth occurs in an area blanketed by relict terrigenous sands containing appreciable quantities of shell debris. The proposed borrow area C1-B identified for this project is located within the inner ridge portion of the continental shelf.

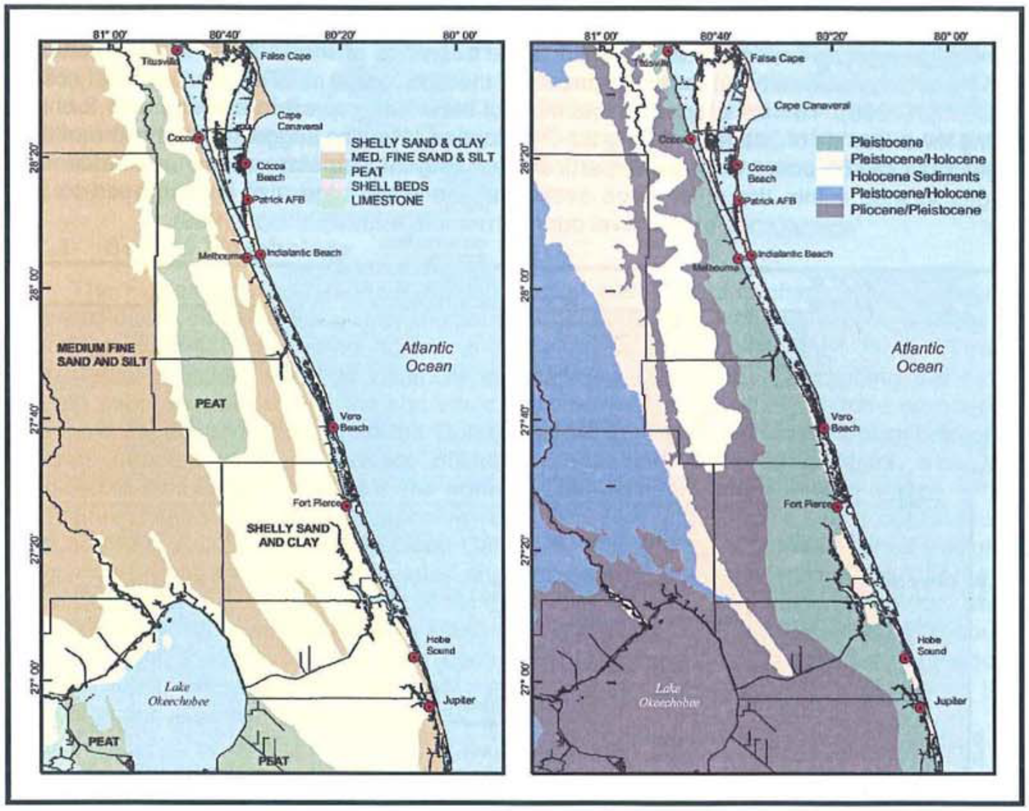


FIGURE 3.1-7.
SURFICIAL SEDIMENTS AND STRATIGRAPHY
OF CENTRAL EAST FLORIDA
MARTIN COUNTY HURRICANE AND
STORM DAMAGE REDUCTION PROJECT
HUTCHINSON ISLAND, FLORIDA

This map and/or digital data is for planning purposes only and should not be used to determine the precise location of any feature. Data provided as-is.
Q:\GIS PROJECTS\EIS_MARTIN_CO\EIS\Figure updates 030211\figure3.1-7_surficialsed.mxd. Data source: Hammer et. al 2005, FGS.

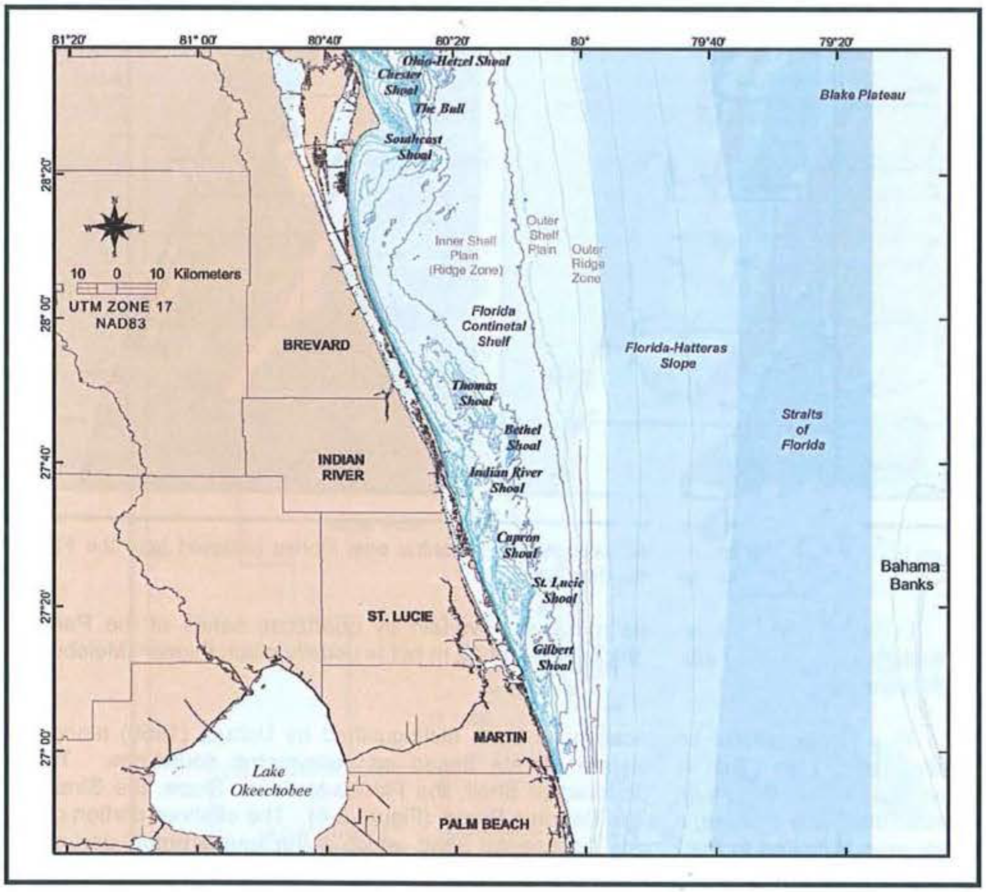


FIGURE 3.1-8.
PHYSIOGRAPHIC PROVINCES OF THE CONTINENTAL MARGIN OFFSHORE CENTRAL EAST FLORIDA
MARTIN COUNTY HURRICANE AND STORM DAMAGE REDUCTION PROJECT
HUTCHINSON ISLAND, FLORIDA

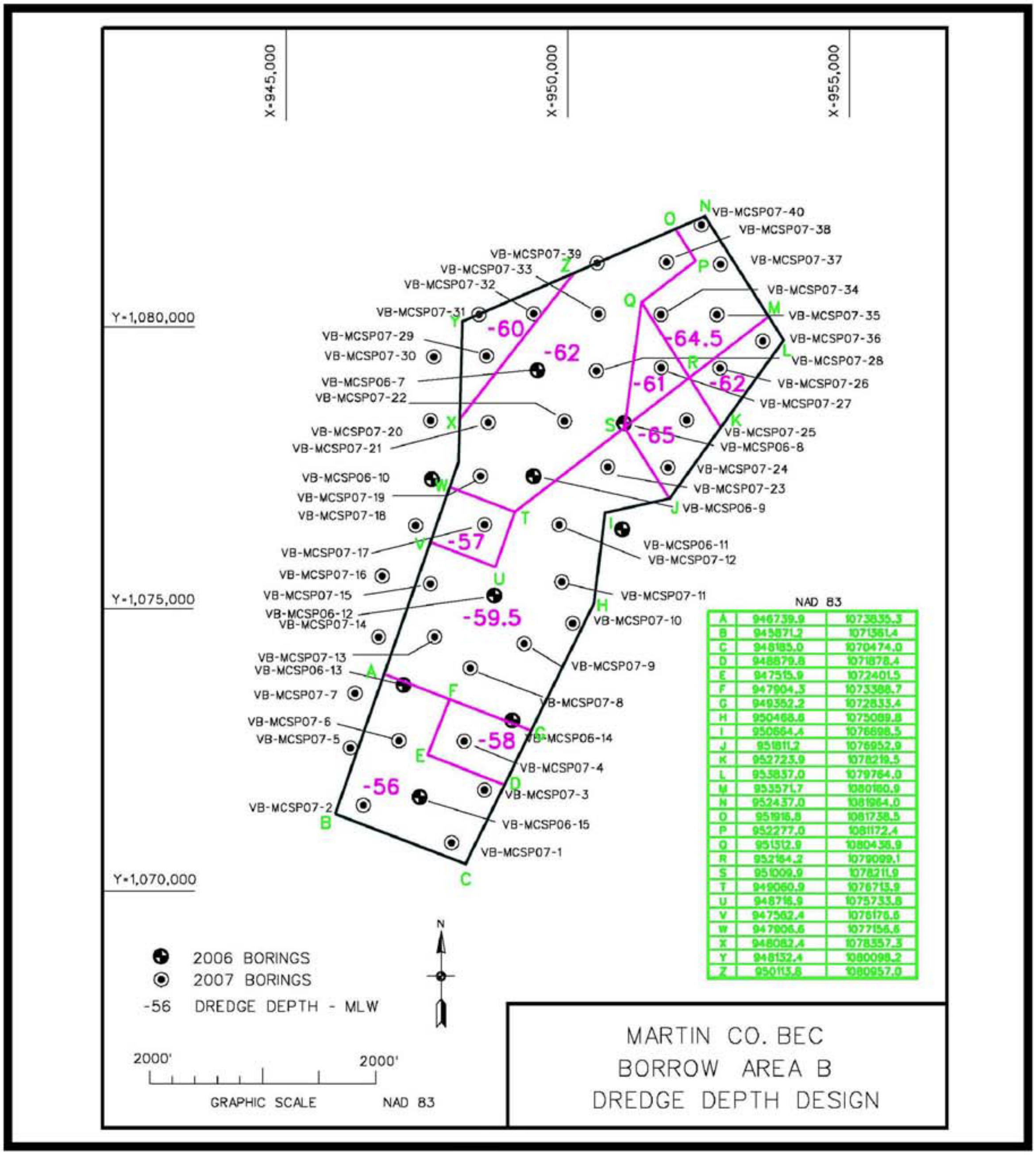
This map and/or digital data is for planning purposes only and should not be used to determine the precise location of any feature. Data provided as-is
Q:\GIS PROJECTS\EIS_MARTIN_CO\EIS\Figure updates 030211\figure3.1-8_physprovs.mxd. Data source: Hammer et. al 2005.

3.1.9.1. C1-B Borrow Area Sediment Characteristics

In August 2007, USACE collected 40 vibracore soil test borings to termination depths of approximately 20 feet below the seafloor to characterize the sediment within the preferred C1-B borrow area (**Figure 2.2-2**). Sieve analysis and carbonate content tests were conducted on all 40 samples. The vibracore borings revealed sands, silty sands, and shelly material throughout the C1-B borrow area, with clays and silts near the termination depths (Challenge Engineering and Testing 2007). The sand is primarily calcareous with a mixture of shell and contains a small (less than 5%) amount of silt. The sediment in C1-B has a mean grain size of 1.37 phi (0.39 mm), a sorting of 1.14 phi, contains 2.47% silt, and 100% of the sand in the borrow area has a moist Munsell value of 5 or higher (Taylor Engineering, Inc. 2009a). The colors of the materials were noted to change significantly from dark to lighter as the split core tubes were left open to air-dry. The complete geotechnical report is provided in Appendix F.

Challenge Engineering and Testing, Inc. (2007) used acid digestion testing to ascertain the carbonate content of 49 representative vibracore samples. The carbonate content ranged from 30% to 90%. Notably, the analysis excluded the estimated percentage of carbonate based on visual shell. These results suggest that the borrow area composite should not exceed the maximum acceptable carbonate content of 93% (Taylor Engineering, Inc. 2009a).

Sand volume estimates within the C1-B borrow area were determined using vibracore data collected by the USACE in 2006 and 2007 and allowable dredging limits (**Figure 3.1-9**). The vibracores collected from the C1-B borrow area measured 4 to 15 feet of suitable sediment in addition to the 2-foot required buffer. The total project requirement for the remainder of the 50-year life of the Martin County HSDR Project is between 2.4 and 4.0 mcy. The surface area of C1-B is approximately 1000 acres. The excavation depth varies from -56 to -65 feet mlw, resulting in approximately 11.5 mcy of sand.



NAD 83

A	946739.9	1073835.3
B	945871.2	1071361.4
C	948185.0	1070474.0
D	948879.8	1071878.4
E	947515.9	1072401.5
F	947904.3	1073388.7
G	949352.2	1072833.4
H	950468.8	1075089.8
I	950664.4	1076698.5
J	951811.2	1076952.9
K	952723.9	1078219.5
L	953837.0	1079764.0
M	953571.7	1080180.9
N	952437.0	1081964.0
O	951916.8	1081738.5
P	952277.0	1081172.4
Q	951512.9	1080436.9
R	952164.2	1079099.1
S	951009.9	1078211.9
T	949060.9	1076713.9
U	948716.9	1075733.8
V	947562.4	1076176.6
W	947806.6	1077156.6
X	948082.4	1078357.3
Y	948132.4	1080098.2
Z	950113.8	1080957.0

FIGURE 3.1-9.
BORROW AREA C1-B - DREDGE DEPTH AND DESIGN
MARTIN COUNTY HURRICANE AND
STORM DAMAGE REDUCTION PROJECT
HUTCHINSON ISLAND, FLORIDA

This map and/or digital data is for planning purposes only and should not be used to determine the precise location of any feature. Data provided as-is.
Q:\GIS PROJECTS\EIS_MARTIN_CO\EIS\Figure updates 030211\figure3.1-9_dredgedepths.mxd Data sources: USACE 1993.

3.1.9.2. Native Beach Sediment Characteristics

In November 2008, Taylor Engineering collected 64 sand samples from the beach in Martin County to determine the color of the native sediment. **Table 3.1-2** contains results of the color analysis of the samples collected. The moist sand colors, based on the Munsell classification system, are predominantly 5Y and 2.5Y 5/1 or higher (Taylor Engineering, Inc. 2009a).

Table 3.1-2 Native Sediment Moist Munsell Color

Station	Moist Munsell Color			
	Toe of Dune	Berm Crest	MHW	MLW
SL R-110	2.5Y 6/2	2.5Y 6/2	2.5Y 6/2	2.5Y 6/2
SL R-112	2.5Y 6/2	2.5Y 6/2	2.5Y 6/2	2.5Y 5/2
SL R-114	5Y 6/2	5Y 6/2	5Y 6/3	5Y 5/2
R-1	5Y 6/2	2.5Y 6/2	2.5Y 7/2	5Y 6/2
R-4	2.5Y 6/2	2.5Y 6/2	5Y 7/2	2.5Y 6/2
R-7	2.5Y 7/2	2.5Y 7/2	2.5Y 7/2	2.5Y 6/2
R-10	5Y 6/1	2.5Y 6/1	2.5Y 6/1	5Y 5/1
R-13	5Y 5/1	5Y 6/1	5Y 6/1	5Y 5/1
R-16	5Y 5/1	5Y 6/1	5Y 6/2	5Y 5/1
R-19	5Y 5/1	5Y 5/1	5Y 5/1	5Y 5/1
R-22	5Y 5/1	5Y 6/1	5Y 5/1	5Y 5/1
R-25	5Y 6/1	5Y 5/1	5Y 5/1	5Y 5/1
R-26	5Y 5/2	5Y 6/2	5Y 6/2	5Y 5/2
R-28	2.5Y 5/2	5Y 6/2	5Y 6/2	n/a
R-31	2.5Y 5/2	2.5Y 6/2	2.5Y 6/2	2.5Y 5/2
R-34	2.5Y 5/3	2.5Y 5/2	2.5Y 6/2	2.5Y 5/2

Source: Taylor Engineering, Inc. (2009a)

Because sediments within a borrow area can vary, the commonly used summary statistics (mean grain size and sorting coefficient) for assessing grain size distributions may not adequately characterize the sediments that ultimately end up on the beach. The extensive handling and mixing of sediments throughout the dredging process often result in substantial changes in grain size distributions compared to those in sediment samples taken from the borrow area.

Data compiled from past sediment surveys established a mean grain size range and material sorting. A beach sampling analysis (Harris 2005, 2007, and 2008) included the collection of sand samples at six cross-shore (at elevations 10, 5, 0, -5, -10, and -15 feet NGVD) and five alongshore locations [at FDEP reference monuments R-112 (in St. Lucie County), R-4, R-15, R-24, and R-30] of the 2005, 2006, and 2007 beach. Beach sampling analysis before 2005 included the collection of sand samples between four and six cross-shore (at elevations 10, 5, 0, -5, -10, and -15 feet NGVD) and eight alongshore locations (at FDEP reference monuments R-1, R-4, R-7, R-11, R-15, R-18, R-20, and R-25). **Table 3.1-3** lists native beach sediment characteristics from six sampling events. The data from these efforts indicate a composite mean grain size of roughly 0.26 to 0.39 mm throughout the project area and a sorting coefficient (standard deviation) of roughly 0.31 to 1.47 phi (Taylor Engineering, Inc. 2009a).

Table 3.1-3. Native Sediment Characteristics

Date	Monuments	Locations	Mean Grain Size*		Silt Content*	Carbonate Content	Sorting	Data Source
		(ft-NGVD)	(phi)	(mm)	(%)	(%)	(phi)	
1990	R-1, R-4, R-7, R-11, R-15, R-18, R-20, R-24	+10, +5, 0, -5, -10, -15	1.772	0.293	0.71		0.31	ATM 1998
1996	R-1, R-4, R-7, R-11, R-15, R-18, R-20, R-25	+10, 0, -10, -15	1.721	0.303	1.36		1.36	Taylor Engineering 2000
1997	R-1, R-4, R-7, R-11, R-15, R-18, R-20, R-26	+10, 0, -10, -15	1.927	0.263	1.60		1.47	Taylor Engineering 2000
2005	R-4, R-15, R-24, R-30, R-112	+10, +5, 0, -5, -10, -15	1.342	0.394	0.39	21 - 93	1.37	Harris 2005
2006	R-4, R-15, R-24, R-30, R-113	+10, +5, 0, -5, -10, -15	1.709	0.306	0.29	8 - 42	1.28	Harris 2007
2007	R-4, R-15, R-24, R-30, R-113	+10, +5, 0, -5, -10, -15	1.571	0.337	0.60	19 - 91	1.29	Harris 2008

*Composite, Moments Method

Source: Taylor Engineering (2009a)

3.1.9.3. Borrow Area Compatibility with Native Sand

Table 3.1-4 summarizes the composite sediment characteristics of both the native beach and borrow area C1-B. The acceptable limits match those found in the Sediment QA/QC Plan which is included as an attachment in the FDEP permit application. Table 3.1-5 indicates that the composite properties of the borrow area closely resemble those of the native beach. Therefore, sediment used as beach fill in Martin County from this borrow area is compatible with the native sand and will preserve the integrity of the beach (Taylor Engineering, Inc. 2009a).

Table 3.1-4. Comparison of Borrow Area and Native Beach Sediment Characteristics

Characteristic	Native Beach Composite	Borrow Area Composite	Beach Fill Acceptable Limits
Mean Grain Size (mm)	0.26 – 0.39	0.39	0.18 – 0.75*
Mean Grain Size (phi)	1.34 – 1.93	1.37	-
Sorting (phi)	0.31 – 1.47	1.14	-
Silt Content (%)	0.6 – 1.60	2.47	0 - 2.5
Carbonate Content (%)	26 – 66	83.45	<93**
Moist Munsell Color	Hues of 2.5Y, 5Y Value 5 or lighter Chroma lighter than 3	Hues of 10YR Value 5 or lighter Chroma lighter than 3	Hues of 2.5Y, 5Y, 10YR Value 5 or lighter Chroma lighter than 3

*Range of the July 2007 data, carbonate removed.
**Based on range of native beach carbonate data.
Source: Taylor Engineering (2009a)

3.2. VEGETATION

Much of the project area is undergoing development, and consequently, the land has been cleared of native vegetation to make room for hotels, condominiums, and private residences. The proximity of this development, as well as foot traffic to the beach, affects the ability of the dune system to experience the natural cycle of erosion and accretion. Native vegetation around these developments has largely been replaced with ornamentals that are of little use to native wildlife.

In June 1994, prior to the initial beach nourishment, an assessment of beach and dune vegetation was conducted (ATM 1994). The entire project reach was surveyed and included the area from mhw landward, through the pioneer zone, over the primary dune, and for a distance of 25 feet into the back dune community. The vegetative community of the dune system varied from areas with well established naturally functioning ecosystems to areas where no natural vegetation existed.

An example of a well-established and high quality beach and dune system is located between survey monuments R-8 and R-12, also known as Bob Graham Beach (**Figure 3.2-1**). This area is characterized by a wide, gently sloping non-vegetated beach; an area of pioneer plants (whose roots stabilize the dune) including seashore saltgrass *(Distichilis spicata),* railroad vine *(Ipomoea pes-caprae),* beach morning glory *Ipomoea imperati),* seashore panicum *(Panicum virgatum,* and sea oats *(Uniola paniculata);* and a densely vegetated back dune including sea purslane *(Sesuvium portulacastrum),* beach elder *(Iva imbricata),* palmetto *(Serenoa repens),* and sea grape *(Coccoloba uvifera).*

Several areas along the project reach were planted with sea oats and have supported the recruitment of pioneer dune species. In these areas, the dune system is in various stages of recruitment and succession (**Figure 3.2-2**). These areas are characterized by a narrow zone of colonizing plants and a back dune vegetated primarily with herbaceous groundcover species with less than 100% areal cover (ATM 1994). During the 1994 survey, five plant species protected by state and/or federal laws were observed in the study area. They include beach creeper *(Ernodea littoralis),* inkberry *(Scaevola plumier),* burrowing four o'clock *(Okenia hypogaea),* sea lavender [*Tornefortia (Mallotonia) gnaphalodes*], and coastal vervain *(Verbena glandularia maritima).* ATM (1994) includes a complete plant list and details regarding specific locations of the threatened and endangered plants.

The existing upland vegetation in the general project area includes shrubs and trees such as sand pine *(Pinus clausa)*, Australian pine *(Causuarina equisetifolia)*, sea grape, and wax myrtle *(Myrica cerifera).* The nearby major water courses are the Indian River and St. Lucie River, and these rivers are bordered primarily with red mangroves *(Rhizophora mangle)*. Other flora along these rivers include cordgrass (*Spartina* sp.), glasswort-salt grass *(Salicornia* sp.), and rush *(Juncus roemerianus)* marshes. The vegetation closer to the ocean and on the dunes, is primarily pioneer species such as saltgrass *(Salicornia* sp.), sand spur *(Cenchrus* sp.), wild bean (*Macroptilium lathyroides*), seaside spurge *(Euphorbia polygonifolia),* and sea oats.

3.3. THREATENED AND ENDANGERED SPECIES

Table 3.3-1 lists the endangered and threatened species that potentially occur within the project area and that are under the jurisdiction of USFWS, NMFS, and FWC. According to the 2003 USFWS Standard Local Operating Procedures for Endangered Species (SLOPES) for the federally threatened southeastern beach mouse (*Peromyscus polionotus niveiventris*): "the beach mouse has been extirpated from Fort Pierce Inlet, St. Lucie County south through Broward County." Therefore, the threatened and endangered species of concern within the project area include the loggerhead, green, hawksbill, Kemp's ridley, and leatherback sea turtles; the West Indian manatee; the humpback whale, the North Atlantic right whale, the finback whale, the sei whale, and the sperm whale; the smalltooth sawfish; and the piping plover. There are no designated or proposed critical habitats vital to the continued existence of any endangered or threatened species in the study area. The Biological Assessment (Appendix J) discusses life history traits of threatened and endangered species in detail, identifies potential project impacts on the species, and provides protection and conservation recommendations.

Figure 3.2-1. Example of a Typical Well-Established Dune System along the Project Reach, Hutchinson Island, Martin County, Florida

Figure 3.2-2. Typical Planted Sea Oats and Early Recruitment Areas along the Project Reach, Hutchinson Island, Martin County, Florida

Table 3.3-1. Federally and State Listed and Candidate Species in Martin County, Florida

Common Name	Scientific Name	Listing Status		
		USFWS	NMFS	FFWCC
FISH				
Smalltooth sawfish	*Pristis pectinata*	-	Endangered	-
REPTILES				
American alligator	*Alligator mississippiensis*	Threatened/SA	-	-
Eastern indigo snake	*Drymarchon corais couperi*	Threatened	-	-
Green sea turtle	*Chelonia mydas*	Endangered*	Endangered*	-
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	-
BIRDS				
Piping plover	*Charadrius melodus*	Threatened	-	-
American Oystercatcher	*Haematopus palliatus*	SSC	-	-
Brown Pelican	*Pelicanus occidentalis*	SSC	-	-
Black Skimmer	*Rynchops niger*	SSC	-	-
Least Tern	*Sterna antillarum*	Endangered	-	Threatened
Roseate Tern	*Sterna dougalii dougalii*	Threatened	-	-
MAMMALS				
Finback whale	*Balaenoptera physalus*	-	Endangered	-
Humpack whale	*Megaptera novaeangliae*	-	Endangered	-
North Atlantic right whale	*Eubalaena glacialis*	-	Endangered	-
Sei whale	*Balaenoptera borealis*	-	Endangered	-
Sperm whale	*Physeter catodon [=macrocephalus]*	-	Endangered	-
West Indian manatee	*Trichechus manatus*	Endangered	-	-

SA = Similarity of Appearance
SSC = Species of Special Concern
* Breeding colonies in Florida are listed as endangered; elsewhere threatened

3.3.1. SEA TURTLES

Martin County is within 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 is listed as a threatened species, while all other sea turtles are listed as endangered under the U.S. Endangered Species Act of 1973. In Martin County, FWC defines March 1 through October 31 as the official nesting season for all species of sea turtles.

In order to eliminate or reduce the risk of impacting nesting sea turtles, project construction will not be conducted during peak sea turtle nesting season. It is estimated that beach construction activities will commence after the sea turtle nesting season ends (November 1) and will be completed prior to the beginning of the main nesting season (April 15). Between 1985 and 1990 (6 years), a cumulative total of only 2 nests were successfully dug in March in Martin County (an average of 0.33 nests/year) and 35 nests in April (an average of 5.8 nests/year) in Martin County. These data indicate that minimal nesting activity occurs in March and April, and that impacts to nesting sea turtles can be minimized if construction is completed before April 15.

3.3.1.1. Nesting Habitat

The east coast of Florida (including Martin County) supports one of the highest nesting densities of loggerhead, green, and leatherback sea turtles within the southeastern United States. Ninety percent of loggerhead nesting in the U.S. occurs in south Florida (Shoop et al. 1985). Hutchinson Island supports the greatest concentration of sea turtle nesting activity in Florida and one of the highest loggerhead sea turtle nesting aggregations in the western Atlantic (Harris et al. 1984; Hopkins and Richardson 1984; Williams-Walls et al. 1983; NMFS and USFWS 1991a).

Historical Nesting Activity (Pre- and Post-Project Construction)

Sea turtle nesting surveys have been conducted annually on Hutchinson Island since 1981. During the 1985 nesting season, 1,071 loggerhead clutches were deposited on the project beach (ABI 1979). In addition, more than 3,000 (27 nests) green sea turtle eggs and 675 (9 nests) leatherback sea turtle eggs were deposited in the project beach during the summer of 1985. Between 1985 and 1990, the project area produced a total of 7,638 loggerhead, 189 green, and 55 leatherback sea turtle nests (ABI 1994).

Beach nourishment first occurred on the Martin County portion of Hutchinson Island during the winter of 1995/1996. During the 1995, 1996, and 1997 sea turtle nesting seasons, a comprehensive study was conducted on the effects of beach nourishment. This study included physical and biological components and addressed all aspects of sea turtle reproduction from the emergence of adult females onto the beach through the emergence of hatchlings from their nests, and it provided a complete year (1995) of pre-construction survey data and 2 years (1996 and 1997) of post-construction data. The results of this comprehensive study have been presented in three reports (EAI 1997a and 1997b; Ernest and Martin 1999). Sea turtle nesting and nest reproductive success were monitored during the subsequent 3 years (1998-2000), and results summarized in three reports (EAI 1998, 2000a, and 2000b).

In the spring of 2001, a 1.4-km-long section of beach along the southern portion of the original 1995/1996 nourishment area was renourished (R-16 to R-22.3). In accordance with permit conditions for this project, a sea turtle nest relocation program was instituted prior to and during construction, and sea turtle nest monitoring was required following project construction. In the spring of 2002, another 0.8-km-long section of beach immediately north of the 2001 project area was renourished (R-13.5 to R-16). Again, a turtle nest relocation/protection program was implemented prior to and during construction, while a program to monitor nesting and nest reproductive success continued after construction was completed. Results of the 2001 and 2002 nest relocation programs, as well as subsequent monitoring of nesting and reproductive success from 2001 through 2004, were reported (EAI 2002, 2003, 2004a, 2004b).

The northernmost 6.8 km of Martin County's coastline underwent beach renourishment (6.6 km) and dune restoration (0.2 km) during the spring of 2005 (R-1 to R-25). These projects restored the county beach after the passage of Hurricanes Frances and Jeanne in September 2004. In conformance with permit conditions for the 2005 beach and dune projects, a construction-phase sea turtle nest relocation program and a post-construction-phase sea turtle nesting and reproductive success monitoring program were implemented (EAI 2005).

Recent Nesting Activity (2004-2009)

During the 2009 nesting season, Martin County accounted for approximately 14.9 percent of the overall nesting along Florida's Atlantic coast. From 2004 to 2009, there was an average of 5,949 loggerhead, 760 green, and 335 leatherback sea turtle nests laid within the county (**Table 3.3-2**).

Table 3.3-2. Summary of Sea Turtle Nesting along 21.9 miles of Coastline in Martin County, Florida, from 2004 to 2009

	Loggerhead		Green Turtle		Leatherback	
Year	Nests	False Crawls	Nests	False Crawls	Nests	False Crawls
2004	5,130	8,430	300	929	144	75
2005	5,822	9,969	584	3,824	230	308
2006	5,532	7,313	579	1,585	205	110
2007	5,210	7,491	1,307	4,129	494	212
2008	7,356	8,463	1,111	2,935	274	120
2009	6,643	7,322	679	1,069	663	177
Mean	**5,949**	**8,165**	**760**	**2,412**	**335**	**167**

Source: USFWS (2010)

Loggerhead Sea Turtle

Of the counties along the east coast of Florida, Martin County supported the third highest nesting of loggerhead sea turtles with 6,643 nests or 303 nests per mile in 2009

(FWC 2009b; **Table 3.3-2**). In 2009, loggerhead sea turtles laid 660 nests along 4 miles of shoreline in the project area (**Table 3.3-3**). In 2009, loggerhead sea turtles made 7,322 false crawls in Martin County (Table 3.3-2). Along 4 miles of shoreline in the project area, loggerhead turtles made 561 false crawls in 2009 (Table 3.3-3).

Green Sea Turtle

Of the counties along the east coast of Florida, Martin County supported the third highest nesting of green sea turtles with 679 nests or 31 nests per mile in 2009 (FWC 2009b; Table 3.3-2). In 2009, 40 green sea turtles nests were laid along 4 miles of shoreline in the project area (Table 3.3-3). In 2009, green sea turtles made 1,069 false crawls in Martin County (Table 3.3-2). Along 4 miles of shoreline in the project area, green sea turtles made 31 false crawls in 2009 (Table 3.3-3).

Leatherback Sea Turtle

Of the counties along the east coast of Florida, Martin County supported the highest nesting of leatherback sea turtles with 663 nests or 30 nests per mile in 2009 (FWC 2009b; Table 3.3-2). In 2009, 224 leatherback sea turtles nests were laid along 4 miles of shoreline in the project area (Table 3.3-3). In 2009, leatherback sea turtles made 177 false crawls in Martin County (Table 3.3-2). Along 4 miles of shoreline in the project area, leatherback sea turtles made 23 false crawls in 2009 (Table 3.3-3).

Hawksbill and Kemp's Ridley Sea Turtle

No occurrences of hawksbill or Kemp's ridley nesting have been documented in the action area or Martin County (USFWS 2010). The majority of nesting surveys conducted in Florida occur during the morning hours and are based on interpretation of the tracks left by the turtles as they ascend and descend the beach; the turtles themselves are rarely observed. Because hawksbill and Kemp's ridley turtle tracks are difficult to discern from loggerhead tracks, it is likely that nesting by both species is underreported (Meylan et al. 1995).

Table 3.3-3. Summary of Sea Turtle Nesting along Approximately 4 Miles (FDEP Reference Monuments R-1 to R-25) of Shoreline in Martin County, Florida, from 2004 to 2009

	Loggerhead		Green Turtle		Leatherback	
Year	Nests	False Crawls	Nests	False Crawls	Nests	False Crawls
2004	505	613	23	22	38	3
2005	996	2143	25	150	76	56
2006	688	950	29	81	59	15
2007	764	707	86	173	162	21
2008	928	665	37	51	82	11
2009	660	561	40	31	224	23
Mean	**757**	**940**	**40**	**85**	**107**	**22**

Source: USFWS (2010)

3.3.1.2. 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, they are the loggerhead, green, hawksbill, Kemp's ridley, and leatherback sea turtles (**Table 3.3-4**) (Hammer et al. 2005). The table orders the species from highest to lowest abundance. The east coast of Florida is an important year-round habitat for juvenile, subadult, and adult loggerhead and green sea turtles on both the inner shelf and mid-shelf (20- to 40-meter isobath). Hawksbill, Kemp's ridley, and leatherback sea turtles also are found year-round, although they primarily use the mid-shelf and (in the case of leatherbacks) the outer shelf and continental slope (Teas 1993).

Table 3.3-4. Sea Turtle Species Potentially Occurring Offshore of East Florida

Common and Scientific Names	Status[a]	Life Stages Present	Seasonal Presence	Nesting Season
Loggerhead sea turtle *(Caretta caretta)*	T	Adults, subadults, juveniles, and hatchlings	Year-round (most abundant during spring and fall migrations)	April-September
Green sea turtle *(Chelonia mydas)*	T/E[b]	Adults, subadults, juveniles, and hatchlings	Year-round	May-November
Hawksbill sea turtle *(Eretmochelys imbricata)*	E	Adults, subadults, juveniles, and hatchlings	Year-round	June-September
Kemp's ridley sea turtle *(Lepidochelys kempi)*	E	Juveniles and subadults	Year-round (most abundant during spring and fall migrations)	(no nesting in area)
Leatherback sea turtle *(Dermochelys coriacea)*	E	Adults, subadults, juveniles, hatchlings	March-October	March-July

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

[b] Green sea turtles are listed as threatened except for Florida, where breeding populations are listed as endangered. Due to inability to distinguish between the two populations away from the nesting beach, green sea turtles are considered endangered wherever they occur in U.S. waters.

Source: Hammer et al. (2005) and USFWS (1999)

The ESA protects all sea turtles in U.S. territorial waters. Currently, USFWS lists leatherbacks as endangered and loggerheads as threatened. Except for the Florida breeding population, listed as endangered, USFWS also lists green turtles as threatened. Due to the inability to distinguish between the breeding and non-breeding populations away from the nesting beach, green sea turtles are considered endangered wherever they occur in U.S. waters (NMFS and USFWS 1991a,b).

Loggerhead Sea Turtle

Loggerhead turtles are present year-round in Florida waters, with peak abundance 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).

Juvenile loggerheads, which researchers believe overwinter along the eastern Florida inner shelf, depart in the spring (March – April) and are replaced by adult males that migrate into the area to mate (Ryder et al. 1994). 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 be 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. It appears the nearshore rock resources in these areas represent a travel corridor (to nesting sites) and not a main foraging or developmental habitat (Ryder et al. 1994). Juvenile loggerhead turtles generally feed on insects and invertebrates from within *Sargassum* mats, while subadult and adult loggerheads primarily feed upon bottom dwelling invertebrates (crabs, mollusks, shrimp), and macroalgae (Ryder et al. 1994).

On the project beach, 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; Turtle Expert Working Group (TEWG) 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 (cm), they leave the pelagic environment and move into nearshore habitats (Carr 1987; Bowen et al. 1993).

Green Sea Turtle

The USFWS considers the green as common within the inner shelf waters off the project area. All life stages of green turtles can be found during different times of the year in and around the project area. 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 2009a, 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 (CSA International, Inc. 2010a).

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, Martin, 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 are feeding 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 for unknown reasons either incidentally or selectively ingest these non-nutritional items. 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 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 only very rarely in the nearshore waters of the project area.

Hawksbill Turtle

Hawksbill turtles 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).

Hatchling hawksbills are pelagic, drifting 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.

Kemp’s Ridley Turtle

The Kemp’s ridley 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 (TEWG 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 cm carapace length, juveniles enter shallow coastal waters (TEWG 2000).

Post-pelagic (juvenile, subadult, and adult) Kemp's ridley turtles feed primarily on portunid crabs, but also occasionally eat mollusks, shrimps, dead fishes, and vegetation (Mortimer 1982; Lutcavage and Musick 1985; Shaver 1991; NMFS and USFWS 1992b; Burke et al. 1993; Werner and Landry 1994). The Kemp's ridley is considered very rare in nearshore waters of the project area.

3.3.2. 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 3.3-5**). The table orders the several species by relative abundance (highest to lowest).

Table 3.3-5. Endangered Marine Mammal Species Potentially Occurring on the Eastern Florida Inner Shelf

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)
Humpback whale (*Megaptera novaeangliae*)	E	Adults, subadults, and juveniles	Rare	December to March
North Atlantic right whale (*Eubalaena glacialis*)	E	Adults, subadults, and juveniles	Rare	December to March

[1] Status: E = endangered.

Source: Wiley et al. 1995; USFWS 2001; http://www.neaq.org

3.3.2.1. Florida Manatee

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 is divided into 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 2001a). Adult Florida manatees average about 3 meters (9.8 feet) 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 2001a).

Manatees are seen mostly as solitary individuals or in groups of up to six individuals. Florida manatees found along the Atlantic U.S. coast are of the Atlantic Region subpopulation (USFWS 2001a), and observers on the Atlantic coast counted 2,148 individuals (FMRI 2009). 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 2001a). As water temperatures rise in spring, individuals disperse from these winter aggregation areas, some migrating as far north as coastal Virginia (USFWS 2001a). 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 2001a). Individual and small groups of manatees are regularly sighted within shallow nearshore waters off St. Lucie and Martin Counties, including the Fort Pierce inlet (pers. comm., Lois Edwards [Coastal Tech, Inc.] and Keith Spring [CSA International, Inc.], August 2010).

In 1976, 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 2001a). However, the project area is not designated as critical habitat.

3.3.2.2. Humpback Whale

The humpback whale (*Megaptera novaeangliae*) is federally listed as endangered. It 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, there are at least five geographically distinct feeding aggregations 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 and abundance. Calving and breeding occurs in the Caribbean from January to March (Tove 2000). The coastal region of Florida is not designated as an area of concentrated occurrence for humpback whales. The habitat in the vicinity of the borrow area is not ideal for foraging or breeding humpback whales, but could potentially serve as a migration corridor to feeding and breeding grounds.

3.3.2.3. North Atlantic Right Whale

The North Atlantic right whale (*Eubalaena glacialis*) is one of the most endangered whales in the world. The New England Aquarium's (NEAQ) Atlantic right whale research and conservation initiative estimates a total world population of about only 400 (NEAQ 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 for feeding, nursery, and mating during summer (Kraus et al. 1988; Schaeff et al. 1993). From June to September, most animals are feeding 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 (Lee and Socci 1989; Krause et al. 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, there is no right whale critical habitat located in the project area. The southern critical habitat area widens near the Georgia-Florida State boundary where the highest concentrations of individual whales are concentrated during their winter calving season (typically December through March, with peak calving in December and January) (**Figure 3.3-1**). 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).

3.3.2.4. Other Whales

During summer, sei whales *(Balaenoptera borealis)* and finback whales *(Balaenoptera physalus)* are found at their higher-latitude breeding areas. During fall, winter, and spring, these species are expected to occur primarily east of the 2,000-meter isobaths. Sperm whales (*Physeter macrocephalus)* are found along the shelf break (approximately 200-m isobaths) and eastward. These species typically occur much farther east and in deeper water than the offshore borrow area. Therefore, none of these species are expected to occur within the action area.

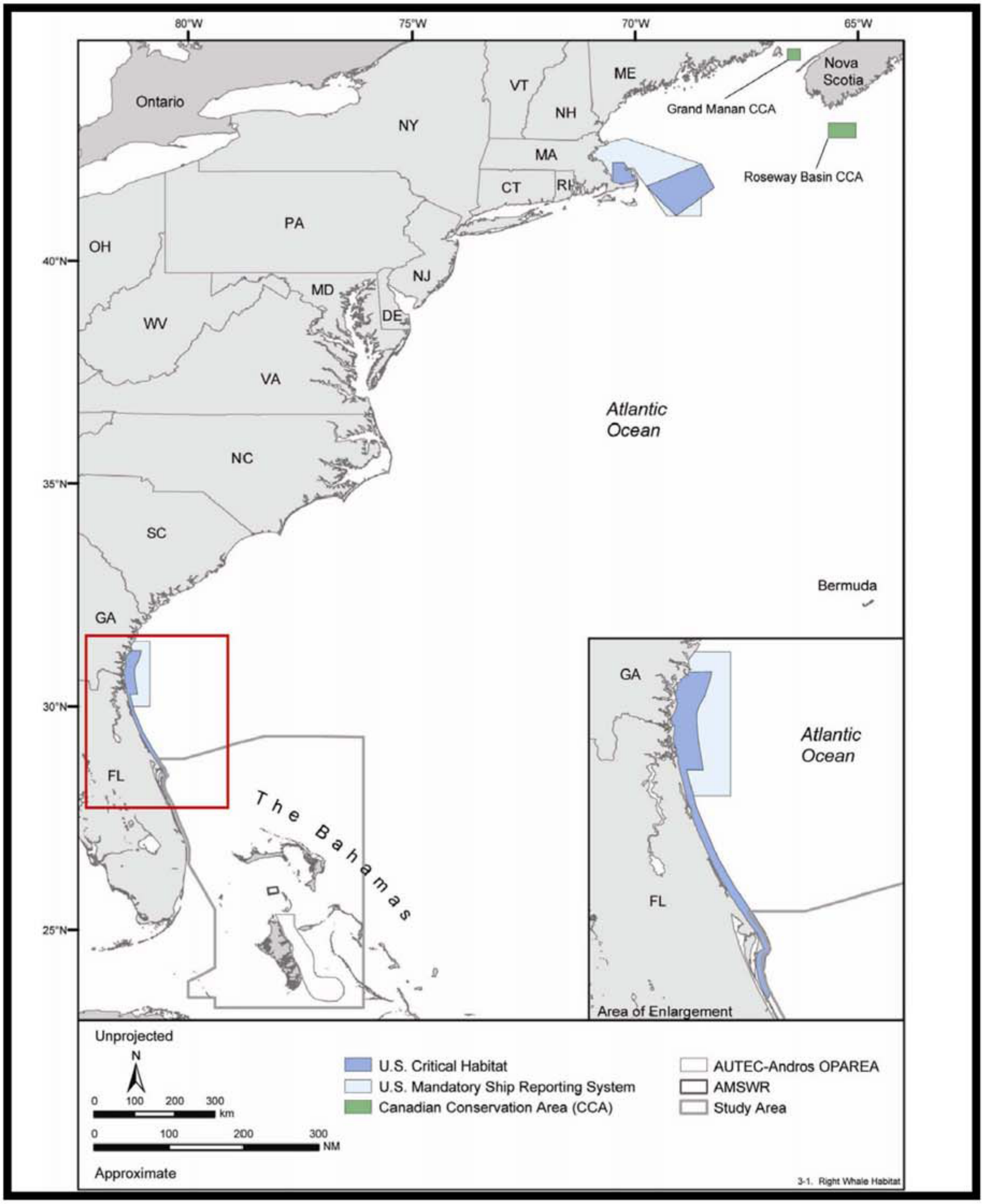


FIGURE 3.3-1.
DESIGNATED CRITICAL HABITATS, CONSERVATION AREAS,
AND MANDATORY SHIP REPORTING ZONES FOR NORTH ATLANTIC RIGHT WHALES
MARTIN COUNTY HURRICANE AND STORM DAMAGE REDUCTION PROJECT
HUTCHINSON ISLAND, FLORIDA

This map and/or digital data is for planning purposes only and should not be used to determine the precise location of any feature. Data provided as-is.
Q:\GIS PROJECTS\EIS_MARTIN_CO\EIS\Figure updates 030211\figure3.3-1_rightwhale.mxd. Data sources: Dept. of Navy 2007

3.3.3. SMALLTOOTH SAWFISH

The smalltooth sawfish (*Pristis pectinata*) is currently listed as endangered by NMFS and 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, and its known primary range is 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.

The smalltooth sawfish is distributed in tropical and subtropical waters worldwide. It normally inhabits shallow waters (10 meters or less), often near river mouths or in estuarine lagoons over sandy or muddy substrates, but may also occur in deeper waters (20 meters) of the continental shelf. Shallow water less than 1 meter deep appears to be an important nursery area for young smalltooth sawfish. Maintenance and protection of habitat is an important component of the 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 2006). Their diet consists of macroinvertebrates and fishes such as herrings and mullets. The saw is reportedly used to rake surficial sediments in search of crustaceans and benthic fishes or to slash through schools of herrings and mullets (NMFS 2006).

3.3.4. PIPING PLOVER

The piping plover *(Charadrius melodus)* is a rare to uncommon winter resident that can be found 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 be found inland but prefers sandy beaches and tidal mudflats where it forages along the waterline or high up the beach along the wrackline. 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 previous winter census stated that approximately 20 to 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]. A piping plover survey was conducted in the vicinity of the project area (St. Lucie Inlet) from January to May 2009 by EAI in support of permitting planned dune restoration project at Bathtub Beach Park on Hutchinson Island. According to Robert Ernest, there was one documented sighting of a piping plover in or near the project area, but their occurrence there is very rare, given the high amount of human use and associated disturbances (Robert Ernest, personal communication, August 7, 2009). Only one solitary bird has been observed on the Atlantic beaches (of Hutchinson Island) considerably distant to the inlet (EAI 2009). Designated critical habitat for wintering piping plovers in the vicinity of the project area is found to the south of the project area on Juniper Island, Martin County, Florida (Florida Unit 33) **(Figure 3.3.2).** No critical habitat is designated within the project area.

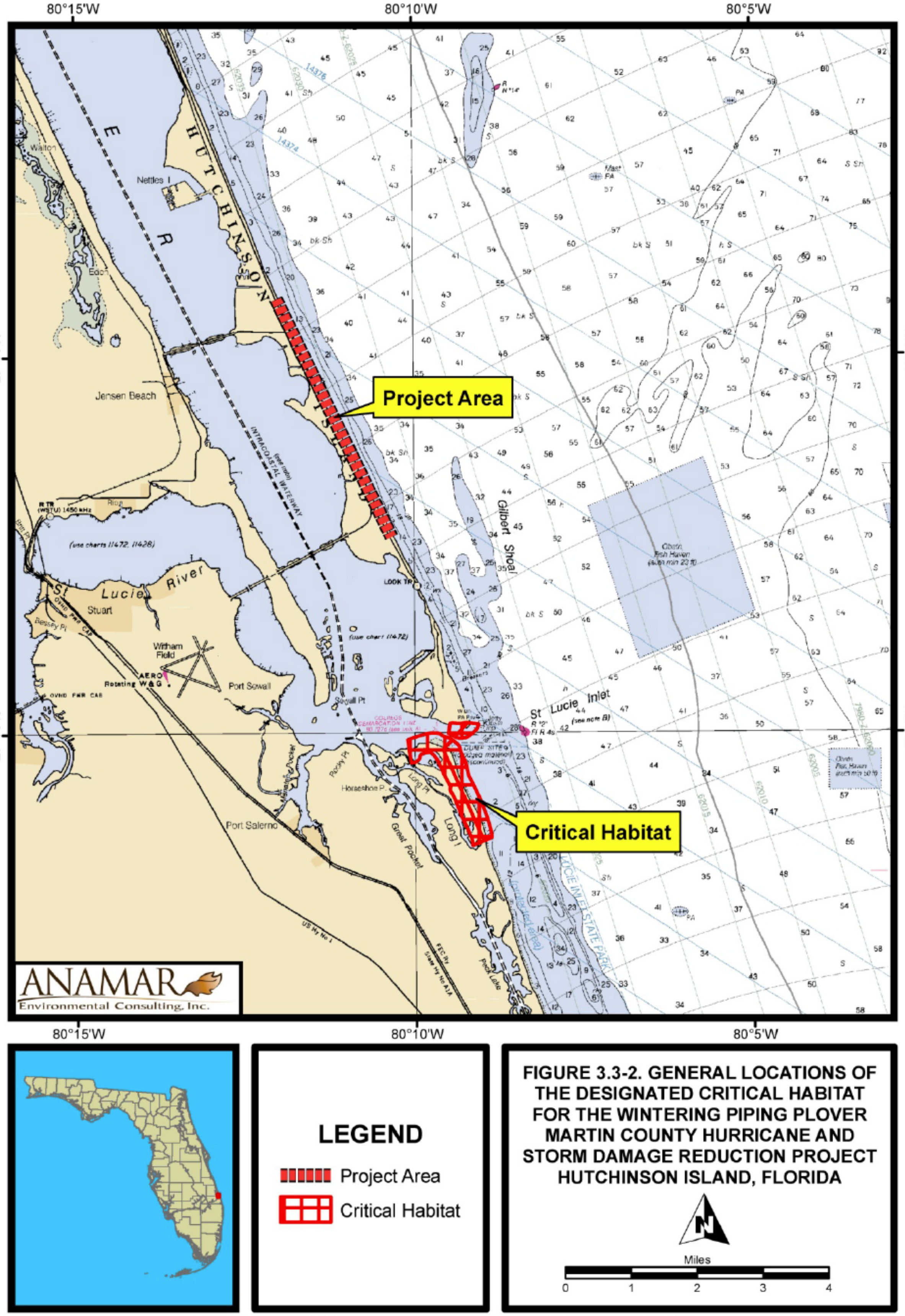


FIGURE 3.3-2. GENERAL LOCATIONS OF THE DESIGNATED CRITICAL HABITAT FOR THE WINTERING PIPING PLOVER MARTIN COUNTY HURRICANE AND STORM DAMAGE REDUCTION PROJECT HUTCHINSON ISLAND, FLORIDA

This map and/or digital data is for planning purposes only and should not be used to determine the precise location of any feature.
Data provided as-is. Q:\GIS PROJECTS\EIS_MARTIN_CO\EIS\Figure updates 030211\figure3.3-2_Piping Plover 020711.mxd. Data sources: NOAA, USACE, USFWS.

3.4. NEARSHORE HARDGROUNDS AND ARTIFICIAL REEFS

Section 3.4.1 describes nearshore hardground resources within and adjacent to the site and results of hardbottom surveys that have been conducted in the project area. Section 3.4.2 provides results of monitoring surveys conducted at the mitigation reefs constructed within the project area.

3.4.1. NEARSHORE HARDGROUNDS

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, extending 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. Generally, these reefs have a low profile, but in some areas along Martin County they rise several feet above the bottom. At some locations, the reefs are frequently covered by a thin layer of sand, leaving only scattered patches of exposed rock.

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 utilizes 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 “wormrock” is somewhat ephemeral, as storm waves and burial by sediments may destroy the structures (CSA International 2009) 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).

These worm reefs provide two very important functions. First, as hardened structures, the reefs tend to help dissipate destructive wave energy. Second, the reefs provide attachment area for livebottom plants and structural habitat for a wide variety of invertebrates and fishes. Although these worm reefs are found from Cape Canaveral to Key Biscayne, they are best developed between St. Lucie and Martin Counties off the Hutchinson Island coast. 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; Inc. [CPE] 2006; CSA 2010a) and is 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 1989; Holloway-Adkins 2001; CSA 2009).

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, and 1974; Multer and Milliman 1967; Kirtley and Tanner 1968; Mehta 1973).

1994 Baseline Survey

Prior to initial project construction in 1995, a nearshore reef and rock survey was conducted by CSA to characterize the reefs and hardbottom communities off northeast Martin County for assessing impacts from, and planning for, beach renourishment (Coastal Science Associates 1994). These investigations revealed hardbottom reef tracts consisting of ephemeral limestone outcrops with the marine bristle worm, *Phragmatopoma lapidosa.* It was estimated that between the St. Lucie/Martin County line and the St. Lucie Inlet there were approximately 150 acres of hardbottom communities, approximately 80% of which were of the sabellariid worm reef type (ATM 1991). Some of these reef tracts were scattered along the project beach between monuments R-1 and R-25, with the western edge beginning approximately 500 feet seaward of the 1992 shoreline (**Figure 2.3-1**). During initial construction, it was estimated that approximately 1.3 acres of hardbottom habitat were located within the project construction template. To offset impacts to nearshore hardbottom habitat, nearshore artificial reef was created three sites totaling approximately 6 acres located approximately 900 feet offshore monuments R-12, R-18, and R-20 (**Figure 2.3-1**). These reefs were constructed during the summer of 2000 using steel and concrete material from the dismantled Evans Crary Bridge within the ETOF.

Two additional nearshore hardbottom surveys were conducted in 2007 and 2010 along the project reach to establish pre-construction baseline conditions. The surveys included a combination of sidescan sonar with ground-truthing, aerial photography, and underwater diver-verified reef characterization studies. Results of the surveys are provided below.

2007 Baseline Survey

As part of the current permitting process, Martin County was required to provide more recent baseline information on hardbottom resources that occur within and downdrift of the proposed project area. Wormrock reefs (hardbottom) in the project area provide an important habitat resource, particularly as a developmental habitat for immature green turtles. Other primary benthic habitats within the area of evaluation include exposed lime rock, sand, and unconsolidated substrate. A long-term study was conducted to evaluate hardbottom exposure in the project area (R-1 to R-25) and downdrift of the project site (R-25 to R-30) (Stites et al. 2007; Taylor Engineering, Inc 2009a). The report is provided in Appendix H.

To meet project goals, the following tasks were performed:

- Mapping of historical hardbottom distribution using available aerial photography;
- Measurement of hardbottom exposure in the project area; and
- Quantification of historic hardbottom distributions and, where possible, linked the results to beach nourishment and storm events.

Aerial photographs from 1996 through 2008 were reviewed to evaluate the distribution of nearshore hardbottom within the Martin County HSDR Project area and to assess their extent in relation to the 1996 predicted equilibrium toe of fill (ETOF) approved under FDEP Permit No. 0169205-001-008. Only the aerial photographs from 1997, 2001, 2004, and 2008 were of sufficient clarity to map exposed hardbottom.

Two zones were established seaward of the FDEP reference monuments so the hardbottom within the project footprint could be differentiated from the hardbottom seaward or downdrift of the project area (beyond the ETOF). These two zones are defined as

- Zone A - the nearshore bottom within the beach design template (R-monument to the predicted 1996 ETOF).
- Zone B - the nearshore bottom from the predicted ETOF seaward an additional 500 feet. FDEP typically requires post-construction transect data within this zone to assess secondary impacts associated with beach nourishment activities.

Preliminary drawings of delineated visible hardbottoms overlayed on aerial photographs from 1997, 2001, 2004, and 2008 are provided in **Figure 3.4-1** (Taylor Engineering, Inc. 2009a). Hardbottom distribution and community composition were characterized along transects within the project area to develop a baseline of biological information. The goal of that evaluation was to identify any trends in the available data with respect to exposure of hardbottom resources.

Table 3.4-1 summarizes the results of total exposed hardbottom acres within project and downdrift areas. Total exposed hardbottom varied in the four evaluation years with the least amount of hardbottom visible within Zone A during 2001 and the greatest amount of visible hardbottom within Zone B during 2004 (Taylor Engineering, Inc. 2009a). The least amount of hardbottom habitat occurred in 2001 in project area Zone A, only a few months after a partial nourishment between R-16 and R-22.

In all 4 evaluation years, the greatest area of exposed hardbottom occurred within the project area Zone B in 2004 (**Table 3.4-1**). Within Zone B, the 2004 aerials (taken roughly 1 year after the last beach nourishment) show 54.7 acres of exposed hardbottom, which is 68% more exposed hardbottom than in 1997, 70% more than in 2001, and 66% more than in 2008. Analysis of the downdrift areas found similar consistency in exposed hardbottom acreage (**Table 3.4-1**), with exposed hardbottom acreage and distribution differing little between 2001, 2004, and 2008. No 1997 aerials exist for the downdrift area, thus no comparative evaluation occurred.

Zone A comprises the nearshore waters, mhw seaward to the ETOF, within both the project and downdrift areas. Within the project area, Zone A exhibited the maximum hardbottom area in 1997 (14.0 acres) and the least (1.2 acres) in 2001 (**Table 3.4-1**). Analysis of the 2004 aerial showed 7.3 acres of hardbottom, 48% less than in 1997 (Stites et al. 2007, Taylor Engineering, Inc. 2009a). In 2008, 11.7 acres of hardbottom became visible, only 17% less than that observed in 1997.

Table 3.4-1. Hardbottom Acres within Project and Downdrift Areas, Martin County, Florida

	Hardbottom Acres			
Location	**1997**	**2001**	**2004**	**2008**
Project Area, Zone A	14.0	1.2	7.3	11.7
Project Area, Zone B	17.5	16.8	54.7	18.5
Downdrift Area, Zone A	No Aerial	7.1	2.3	11.5
Downdrift Area, Zone B	No Aerial	0.2	0.0	0.0
Total Area	31.5	25.3	64.3	41.7

Source: Taylor Engineering, Inc (2009a)

In all 4 evaluation years, the greatest area of exposed hardbottom occurred within the project area Zone B in 2004 (**Table 3.4-1**). Within Zone B, the 2004 aerials (taken roughly 1 year after the last beach nourishment) show 54.7 acres of exposed hardbottom, which is 68% more exposed hardbottom than in 1997, 70% more than in 2001, and 66% more than in 2008. Analysis of the downdrift areas found similar consistency in exposed hardbottom acreage (**Table 3.4-1**), with exposed hardbottom acreage and distribution differing little between 2001, 2004, and 2008. No 1997 aerials exist for the downdrift area, thus no comparative evaluation occurred.

Zone A comprises the nearshore waters, mhw seaward to the ETOF, within both the project and downdrift areas. Within the project area, Zone A exhibited the maximum hardbottom area in 1997 (14.0 acres) and the least (1.2 acres) in 2001 (**Table 3.4-1**). Analysis of the 2004 aerial showed 7.3 acres of hardbottom, 48% less than in 1997 (Stites et al. 2007, Taylor Engineering, Inc. 2009a). In 2008, 11.7 acres of hardbottom became visible, only 17% less than that observed in 1997.

2010 Baseline Survey

In August 2010, CSA conducted a pre-construction hardbottom baseline survey along the project reach extending from range monument R-1 south to R-29 (**Figure 3.4-2**) (CSA International 2010).

The baseline survey objectives were as follows:

- Establish and survey 12 permanent cross-shore transects—10 within the project area and two downdrift of project area (Figure 1 of CSA report);
- Map the nearshore hardbottom edge within the project area;
- Conduct quantitative video transect surveys along two 20-m segments of hardbottom along each transect; and
- Collect qualitative video along the entire length of each transect.

A total of 52 taxa were recorded during the baseline survey, including 36 macroalgal taxa, 15 faunal taxa, and biotic turf. Distribution of hardbottom habitat in the project area was patchy and likely ephemeral in nature. Natural hardbottom occurred from the nearshore hardbottom edge eastward approximately 40 meters (from 30 to 70 meters) along the project area transects, while artificial reefs (comprising concrete pilings) were encountered on the easternmost portions of these transects (approximately from 70 to 150 meters).

Hardbottom in the downdrift area consisted of a relatively continuous stretch of rock from the intertidal zone eastward approximately 30 meters composed of naturally occurring exposed coquina limestone (Anastasia formation) and sabellariid wormrock *(P. lapidosa).* Wormrock abundance was greater in the downdrift area than in the project area, likely due to a more favorable location for wormrock formation in the shallow, intertidal zone.

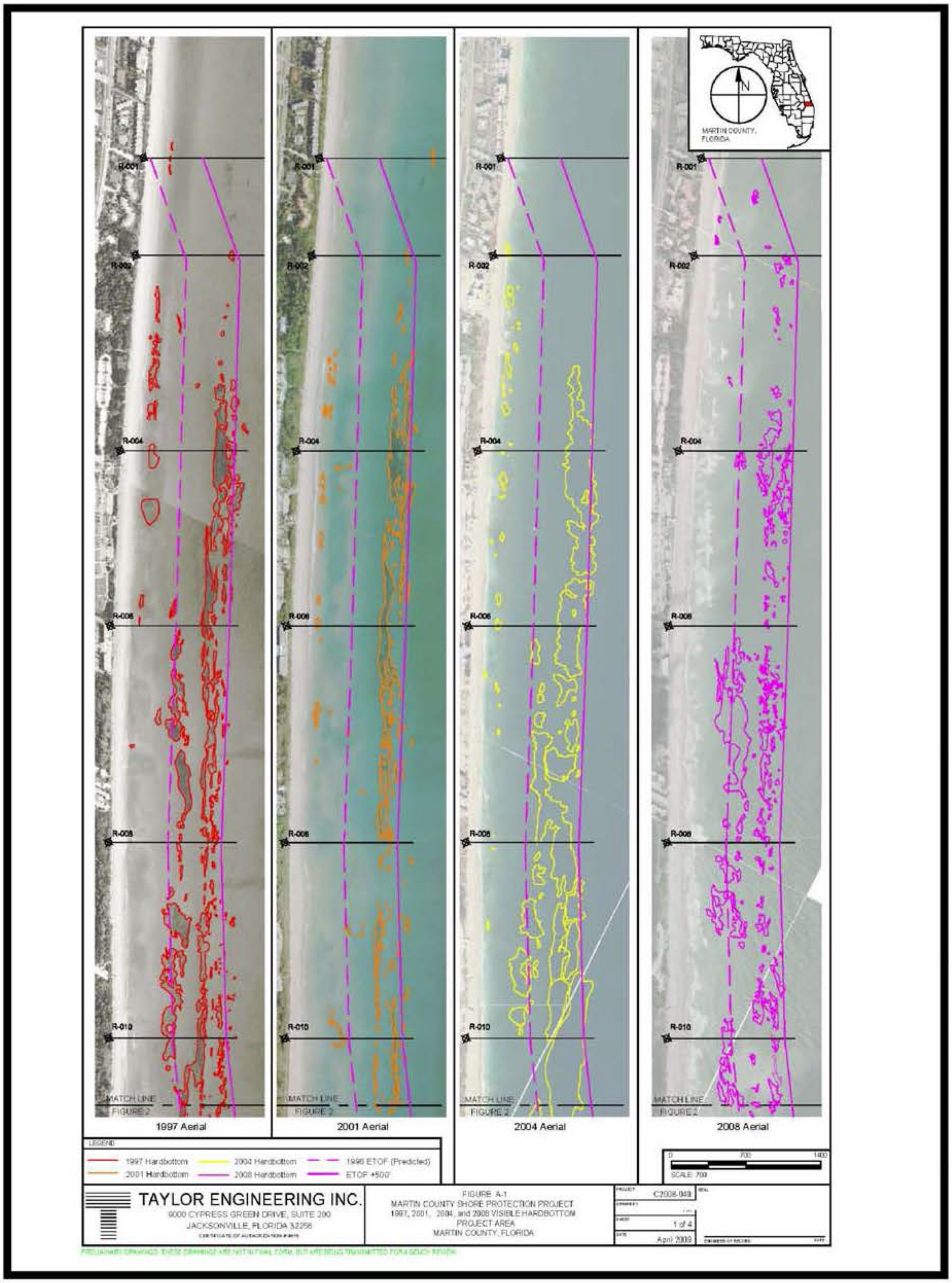


FIGURE 3.4-1a. 1997, 2001, 2004, AND 2008 VISIBLE HARDBOTTOM, MARTIN COUNTY HURRICANE AND STORM DAMAGE REDUCTION PROJECT, HUTCHINSON ISLAND, FLORIDA

This map and/or digital data is for planning purposes only and should not be used to determine the precise location of any feature. Data provided as-is.
Q:\GIS PROJECTS\EIS_MARTIN_CO\EIS\Figure updates 030211\figure3.4-1a_hardbottom.mxd Data source: Taylor Engineering.

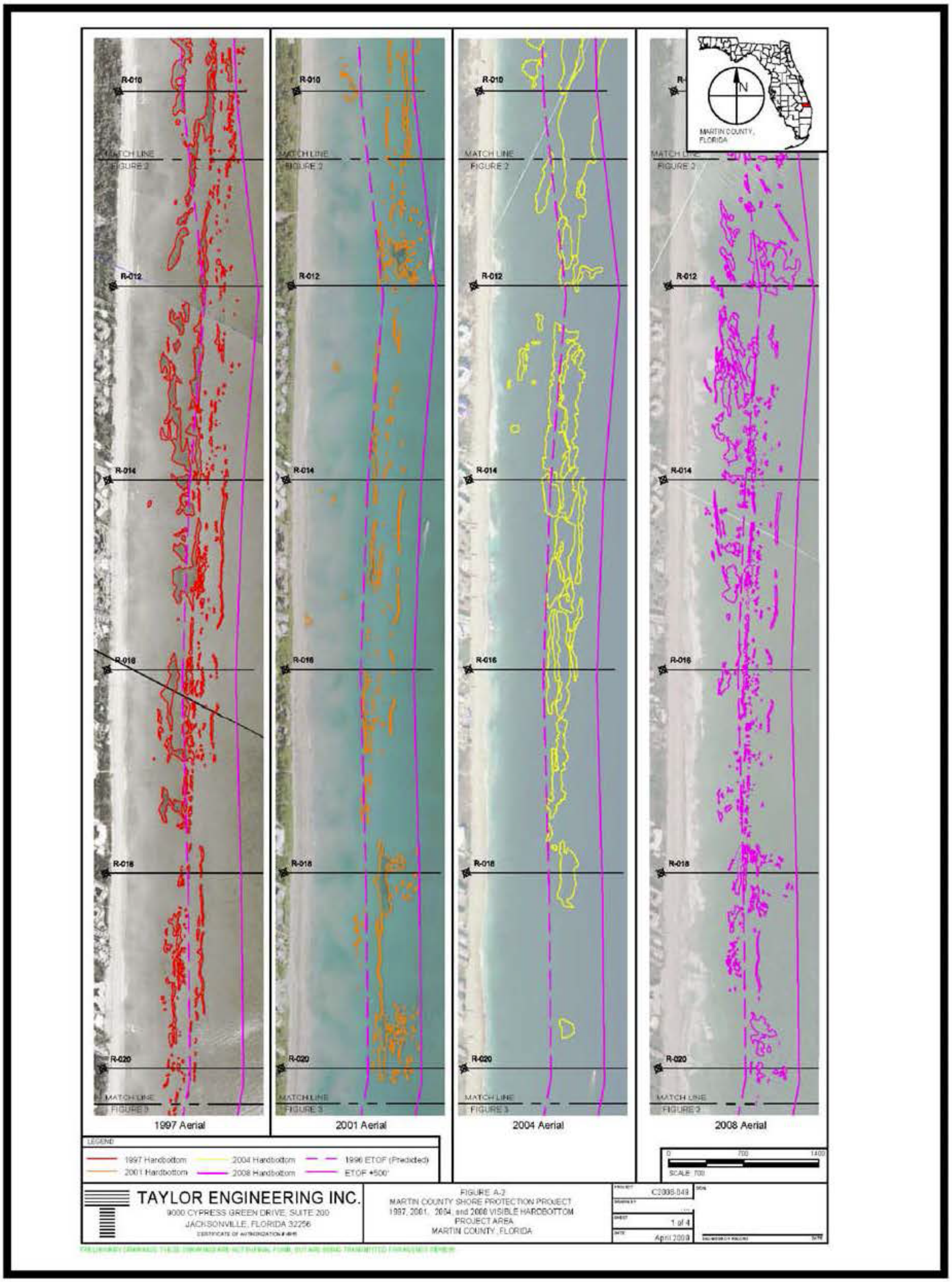


FIGURE 3.4-1b. 1997, 2001, 2004, AND 2008 VISIBLE HARDBOTTOM, MARTIN COUNTY HURRICANE AND STORM DAMAGE REDUCTION PROJECT, HUTCHINSON ISLAND, FLORIDA

This map and/or digital data is for planning purposes only and should not be used to determine the precise location of any feature. Data provided as-is. Q:\GIS PROJECTS\EIS_MARTIN_CO\EIS\Figure updates 030211\figure3.4-1b_hardbottom.mxd Data source: Taylor Engineering.

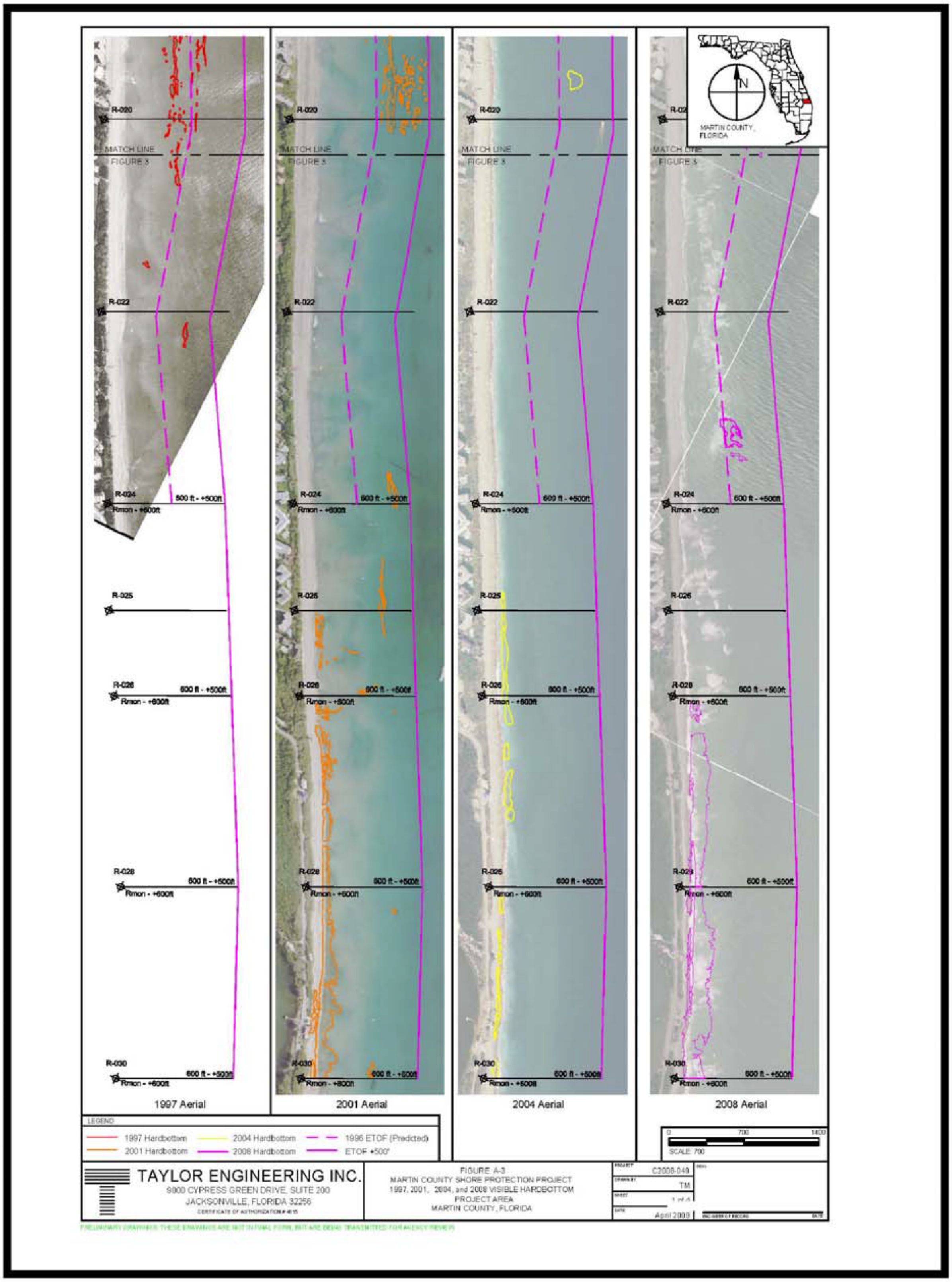


FIGURE 3.4-1c. 1997, 2001, 2004, AND 2008 VISIBLE HARDBOTTOM, MARTIN COUNTY HURRICANE AND STORM DAMAGE REDUCTION PROJECT, HUTCHINSON ISLAND, FLORIDA

This map and/or digital data is for planning purposes only and should not be used to determine the precise location of any feature. Data provided as-is.
Q:\GIS PROJECTS\EIS_MARTIN_CO\EIS\Figure updates 030211\figure3.4-1c_hardbottom.mxd Data source: Taylor Engineering.

Ins

2010 Nearshore Imagery Courtesy of Pickett & Associates. Flight Date: 05/16/2010

2004 Background Imagery Courtesy of LABINS

FIGURE 3.4-2
SURVEY AREA OVERVIEW SHOWING PERMANENT CROSS-SHORE TRANSECTS ESTABLISHED AND SURVEYED DURING THE HUTCHINSON ISLAND SHORE PROTECTION PROJECT 2010 HARD BOTTOM BASELINE SURVEY; MARTIN COUNTY HURRICANE AND STORM DAMAGE REDUCTION PROJECT, HUTCHINSON ISLAND, FLORIDA

3.4.2. ARTIFICIAL REEFS

The loss of nearshore hardbottom habitat between monuments R-22 and R-23 was mitigated by creating three areas of nearshore artificial reefs totaling 6 acres. Results of annual monitoring of fish and benthic species identified at nearshore mitigation reefs A, B, and C are summarized in **Figure 3.4-3** and **Tables 3.4-2 and 3.4-3**. At Site A, a total of 21 fish species were identified in 2006, as compared to 23 in 2004. In 2006, the number of sport fishes identified at Site A was 8, the highest number of species recorded during 6 years of monitoring. Several spiny lobsters were also observed at Site A in 2006. During all spring and summer monitoring events, there appeared to be several well-established colonies of sabellariid wormrock reef at Site A; however, in December 2006, it was noted that wormrock was absent (Harris 2006). At Site B, a total of 17 fish species were identified in 2006, as compared to 20 in 2004. The total benthic coverage increased between 2004 and 2006. The invasive exotic green algae species *Caulerpa brachypus* was observed drifting and attached to the substrates in 2004, but was not observed in 2006. At Site C, a total of 15 fish species were identified in 2006, as compared to 20 in 2004. Spiny lobster was also observed. The most notable observation in 2006 was the continued increase in attached benthic organism's thickness and coverage on the steel and concrete surfaces. The absence of the invasive species *Caulerpa brachypus* was also noted. Since monitoring was initiated in 2002, two federally protected species, the Goliath Grouper and Striped Croaker, have been observed at all three mitigation sites. They are considered species of special concern because of their limited habitat range in Florida. The only known breeding population of Striped Croaker in North America is located in Brevard, Indian River, and St. Lucie Counties (Gilmore 1992). This species is dependent on nearshore rock algae reefs for most of its lifespan (Harris 2006). Overall, the results indicate that these artificial reefs have become an active living artificial reef community utilized by both fish and benthic organisms (Harris 2006). Representative photographs of the current conditions of Sites A, B, and C are provided in **Figures 3.4-4, 3.4-5, and 3.4-6**, respectively.

The monitoring reports also indicate that some burial of the reef structures occurred during the 2004 and 2005 hurricanes. This was most notable in mitigation reef C where a decline in the clusters of reef material was noted. Water depths to the sand bottom were significantly shallower than during the previous monitoring events, so burial of a significant amount of the material was suspected. Some settlement (and/or burial) and scour around the bridge pieces that were located in 2006 was also noted. The scour provides habitat similar to that provided by scour around nearshore natural reefs in the area. Many of the stacked components within the artificial reef appear to be stable, and are continuing to provide many overhangs and crevices, which are an excellent habitat for a variety of marine organisms (Harris 2006).

Characteristics indicative of sand movement after beach nourishments were detected based on a review of aerial photographs taken in 1997, 2001, and 2003, and an evaluation of current biological conditions. Zone A (includes the nearshore bottom within the beach design template hardbottom) fluctuates widely in response to various factors (storms, nourishment, and intertidal sand transport), but the influence of nourishment events may diminish within a year of an event. Zone B (includes the nearshore bottom from the predicted ETOF seaward an additional 500 feet) hardbottom acreage fluctuates but remains relatively stable despite the various factors, suggesting relatively low nourishment-related impacts. Although containing relatively little hardbottom, the downdrift area remains relatively stable despite a variety of factors (Stites et al. 2007).

Figure 3.4-3. Number of Fish Species Identified (not Including Unidentified Fry) at Mitigation Reef Sites A, B, and C from 2002-2006, Martin County, Florida

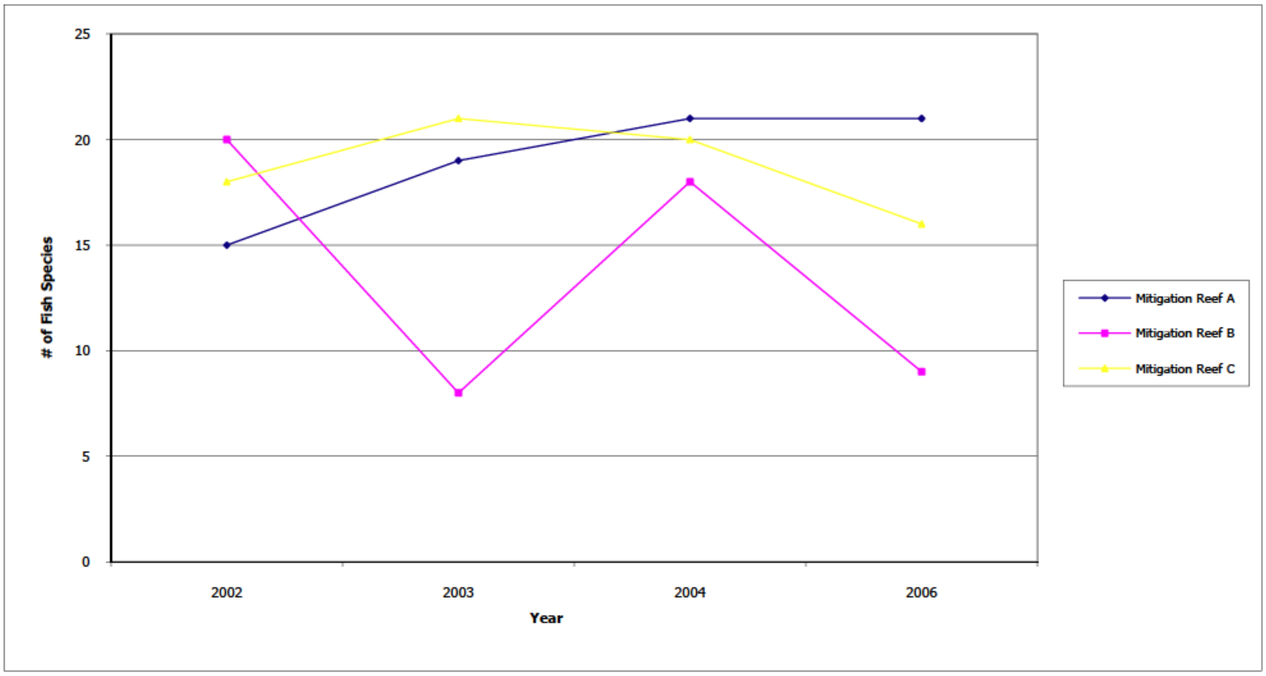


Table 3.4.-2. Fish Species Census from 2002-2006 for Nearshore Mitigation Reefs A, B, and C, Martin County, Florida (page 1 of 3)

	Mitigation Reef A				Mitigation Reef B				Mitigation Reef C			
Species	**2002**	**2003**	**2004**	**2006**	**2002**	**2003**	**2004**	**2006**	**2002**	**2003**	**2004**	**2006**
Atlantic Bumper											10's	1
Atlantic Spadefish	>20	10's	10’s	10’s	>10	>10	2	10's	>20	>10	2	
Barracuda			1	10’s	1		1	1	1	1	1	
Beaugregory	4	4	2	1	4				5	1	2	10's
Bermuda Chub		1							1			
Black Margate			10’s	10’s		4	5			>10	10's	10's
Blue Angelfish			1	2								
Blue Runner	>20	10's	100’s				100's	3		100's	10's	
Cardinalfish			4									
Common Snook	3	10's	8	3	2	1	10's		1	8	2	1
Cubaru				2								10's
Doctorfish	1	7	1		4		10's		2			
Dwarf Goatfish			1									
French Angelfish			2		1							
Fry (unidentified species)			100’s	10’s			100's	100's		10's	100's	
Gag Grouper			2	1						1	1	
Goliath Grouper		2		1			1		1			2
Gray Triggerfish		1					7	1	1	1	1	
Grey Angelfish		1	1							1		
Grey Snapper	>10	>10	10’s	7	>10	3	10's		>10	7	10's	2
Green Moray Eel										1		
Hairy Blenny				2	4				1			4
Highhat	8		1	4	4				7	2	1	3
Hogfish		1										
King Mackerel				1								

Table 3.4.-2. Fish Species Census from 2002-2006 for Nearshore Mitigation Reefs A, B, and C, Martin County, Florida (page 2 of 3)

	Mitigation Reef A				Mitigation Reef B				Mitigation Reef C			
Species	**2002**	**2003**	**2004**	**2006**	**2002**	**2003**	**2004**	**2006**	**2002**	**2003**	**2004**	**2006**
Lane Snapper	8	4	1		3		2	2		10's	1	
Mackeral Scad										10's		
Mutton Snapper										1		
Nurse Shark											2	
Porcupinefish							1				1	
Porkfish	>10	>60	10’s	10’s	>20	>60	10's	10's	>20	100's	100's	>20
Red Porgy		3	3							4	4	
Reef Croaker											10's	
Round Scad (Cigar Minnow)												100's+
Sergeant Major		1			1				4			
Sailors Choice			>10				10's		>50			
Scamp											1	
Schoolmaster									1			
Scorpianfish				2								
Sheepshead	3	>10		3	4	>10	4	5	3	6	7	
Slippery Dick		5				5						
Southern Flounder				2			1					
Spanish Grunt								2				
Spiny Lobster	1			8	1				1			2
Spotted Goatfish					2							
Spotted Moray Eel			1		1		1					
Spottail Pinfish	1	8	10’s	10’s	>10	>14	10's			10	1	3
Spotted Scorpionfish										1		
Stonecrab	1											
Stripped Croaker				5			10's					100's

Table 3.4.-2. Fish Species Census from 2002-2006 for Nearshore Mitigation Reefs A, B, and C, Martin County, Florida (page 3 of 3)

	Mitigation Reef A				Mitigation Reef B				Mitigation Reef C			
Species	**2002**	**2003**	**2004**	**2006**	**2002**	**2003**	**2004**	**2006**	**2002**	**2003**	**2004**	**2006**
Tomtate	100's			10's	100's				>30			10's
Townsend Angelfish												1
Two Spot Cardinalfish					3							
White Margate	>20	10's			1					3		
White Spotted Soapfish								1				

Data compiled by ANAMAR Environmental Consulting, Inc. from several reports (Harris 2002, Harris 2003, and Harris 2006). Copies of reports are provided in Appendix G. No data were collected in 2005 due to lack of visibility. Information on number of adults and juveniles is not included in this table, but can be found in the reports.

Table 3.4-3. 2006 Benthic Species Census and Abundance for Nearshore Mitigation Reefs A, B, and C, Martin County, Florida

Benthic Species Identified	Common Name	Mitigation Reef A	Mitigation Reef B	Mitigation Reef C
Green Algae				
Bryopsis pennata	No common name	Abundant		Abundant
Caulerpa mexicana	Mexican seaweed	Abundant	Abundant	
Codium spp.		Single		
Red Algae				
Botryocladia occidentalis	No common name	Few		
Bryothamnion triquetrum	Red marine alga	Few	Few	Few
Gelidium americanum	No common name	Abundant	Abundant	Abundant
Gracilaria mammillaris	No common name	Many	Many	Many
Brown Algae				
Dictyota spp.	Y-branched alga	Few		
Padina spp.	Scroll alga	Few		
Sponges				
Pseudaxinella lunaecharta	Orange sticky sponge	Abundant	Abundant	Abundant
Encrusting sponges		Abundant	Abundant	Abundant
Unidentified orange sponge		Abundant		
Yellow encrusting sponge		Many	Few	Few
Cnidarians				
Aglaophenia latecarinata	Feather plume hydroid		Abundant	Abundant
Carijoa riisei	White telesto	Many	Many	Many
Leptogorgia hebes	Regal sea fan	Abundant	Abundant	Abundant
Leptogorgia virgulata	Yellow sea whip	Few	Abundant	Abundant
Mat anenome			Single	Single
Oculina difusa	Ivory bush coral	Many		
Phyllangia americana	Hidden cup coral	Few	Few	Few
Solitary anenome			Few	Few
Worms				
Phragmatopoma spp.	Sabellariid wormrock	Many		
Tubeworms		Few	Few	Few
Tunicates				
Ascidia niger	Black solitary tunicate	Many	Many	Many
Eudistoma obscuratum	Black condominium tunicate	Many	Many	Many
Globular tunicates (Styela spp. – like)	Solitary tunicates	Abundant	Abundant	Abundant
White colonial tunicate		Many	Many	Many
Sea Urchins				
Arbacia punctulata	Purple urchin	Few		
Echinometra lucunter	Rock-boring urchin	Few		
Gastropods				
Terebra salleana	Eastern augers		Many	Many
Bryzoans				
Bugula turrita	Fan bryzoan		Single	Single

Data compiled by ANAMAR Environmental Consulting, Inc. from Harris (2006). Complete report is provided in Appendix G.

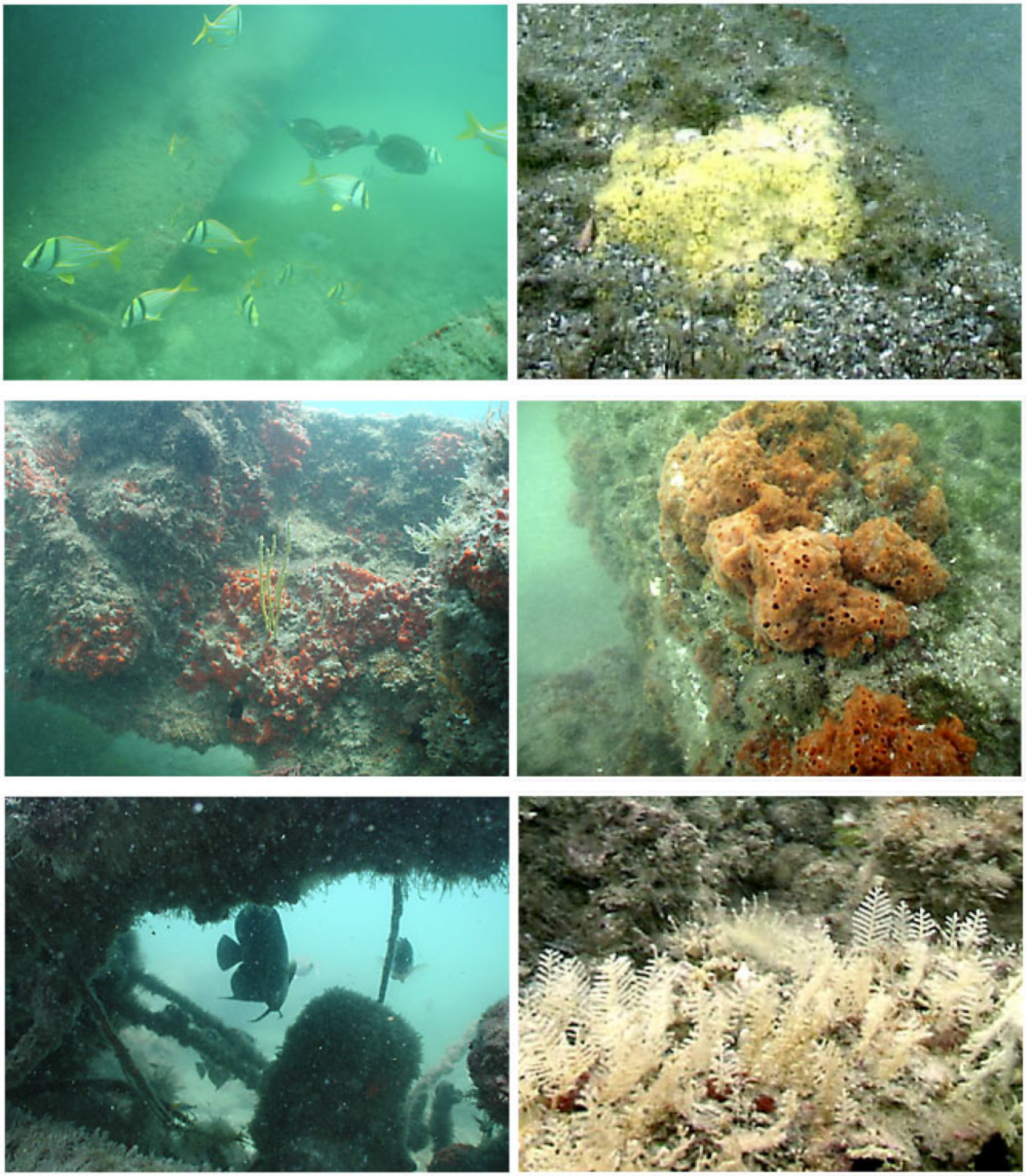
Figure 3.4-4. Photographs of Artificial Mitigation Reef A

Photos Courtesy of Lee Harris and Kerry Dillon, Martin County Artificial Reef Program (www.martinreefs.com)

Figure 3.4-5. Photographs of Artificial Mitigation Reef B

Photos Courtesy of Lee Harris and Kerry Dillon, Martin County Artificial Reef Program
(www.martinreefs.com)

Figure 3.4-6. Photographs of Artificial Mitigation Reef C



Photos Courtesy of Lee Harris and Kerry Dillon, Martin County Artificial Reef Program|
(www.martinreefs.com)

3.5. OFFSHORE HARDBOTTOM

Hardbottom habitats on the continental shelf off eastern Florida consist of rock outcrops colonized by various algae, sponges, hard corals, soft corals, fire corals, tunicates, and other sessile invertebrates that comprise the epibiota (Hammer et al. 2005). Solitary corals found in this area include *Astrangia* and *Phylangia* and colonial corals include members of the following genera: *Diploria, Isophyllia, Mycetophyllia, Montastrea,* and *Solenastrea* (Hammer et al. 2005). Offshore hardbottom areas generally support more dense and more diverse epibiotal assemblages than those found on nearshore hardbottom (Goldberg 1973). Much of the rock substrate underlying these epibiotal assemblages is composed of relict Pleistocene beach ridges that generally parallel the present-day shoreline (Meisburger and Duane 1971). These ridges are generally positioned along a north-south axis and tend to protrude at variable heights above the sedimentary layer in a discontinuous fashion. Exposed rock will vary in relief from a level pavement to ledges as high as 4 meters. In areas where rock substrate is exposed for adequate periods of time, epibiota will assemble through larval settlement from the water column. Such assemblages are thought to take decades to develop into mature communities composed of long-lived organisms (Dayton 1984).

Within the region encompassed by the sand resource areas, hardbottom tracts exist in offshore (shelf) and nearshore (0- to 4-meter depths) waters. Offshore hardbottom features are associated with the shallow shelf, intermediate shelf, and outer shelf (Miller and Richards 1979; Perkins et al. 1997). A single hardbottom trend occurs in nearshore waters of the project area (SAFMC 1998b; Lindeman and Snyder 1999).

Coquina rock outcroppings are not uncommon offshore of Martin County in water depths of 30 to 90 feet. These outcroppings are similar to nearshore reefs, but are more stable and have a greater diversity of attached organisms and associated fish and invertebrate species. Many of these coquina rock outcropping reefs are popular fishing and diving areas.

During the period December 2007 to June 2008, sidescan sonar surveys of offshore borrow ares C1-B were conducted by Southeastern Archaeological Research, Inc. (SEARCH) as a component of the submerged cultural resource study for this project (**Figure 3.5-1** old **Figures 3.4-2**). To determine the presence of hardbottom and assess potential dredging impacts to hardbottom resources within the potential borrow areas, a more detailed analysis of existing sidescan sonar data was performed by ANAMAR Environmental Consulting, Inc (Appendix L). The sidescan mosaics revealed areas of high backscatter in Borrow Area C1-B. Two target areas, B-01 and B-02, were identified within C1-B (**Figures 2.2-3 and 2.2-4).** A geotechnical survey was performed in August 2007 in area C1-B (**Figure 2.2-3**). Cores were collected near Targets B-01 and B-02, indicating mostly sand and shell but no consolidated rock (see core logs in Appendix F).

Further groundtruthing was conducted by the sponsor in July 2009 to characterize these features. The dive survey was designed to investigate the proposed borrow area substrate and the overlying water column for significant resources including hardbottom or reef habitats, aggregations of fishes, protected species such as sea turtles, or other biologically relevant conditions (Hesperides Group, LLC 2009). Teams of two divers collected flora and fauna lists, sediment descriptions, water temperature, depth, and visibility data.

The survey confirmed that the proposed borrow area is located on a relatively deep sand shoal with contains no hardbottom resources and observed few species that are normally associated with natural or artificial reefs (Hesperides Group, LLC 2009). Additionally, an investigation of the two small anomalies identified in the sidescan sonar survey (**Figure 2.2-4**) revealed no significant benthic features, only small, current-induced sand ridges. Green benthic algae was abundant over the entire area surveyed and the water column planktonic biomass was visibly heavy. The most numerous fishes observed were small, schooling members of the herring and jack families. The substrate consisted of sand and shell hash of fine to medium grain size with minimal amounts of silt/clay (fines). Bathymetric contours of the shoal were small and not visibly discernible to the divers during the survey. A complete copy of this report is provided in Appendix O.

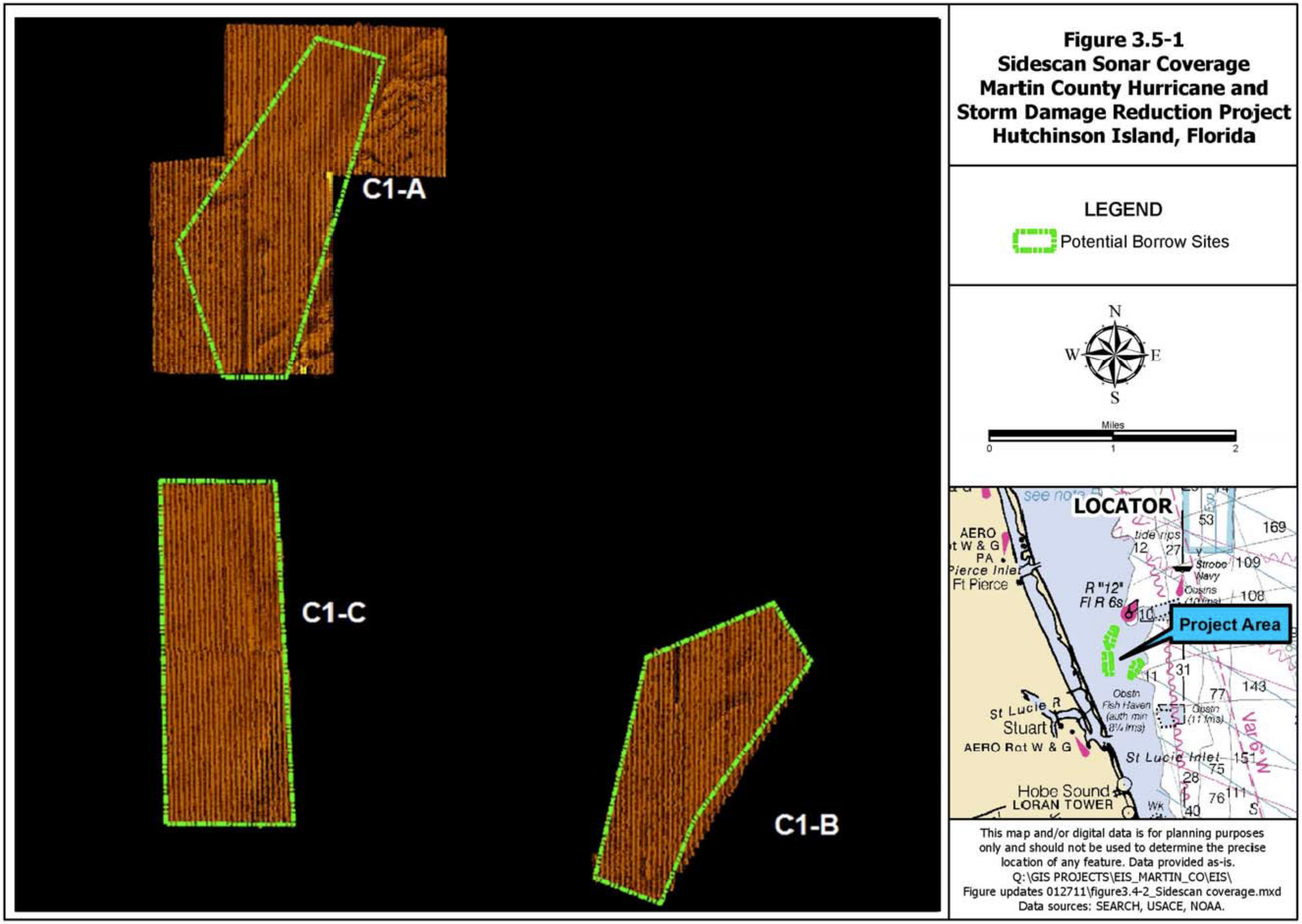


Figure 3.5-1
Sidescan Sonar Coverage
Martin County Hurricane and
Storm Damage Reduction Project
Hutchinson Island, Florida

This map and/or digital data is for planning purposes only and should not be used to determine the precise location of any feature. Data provided as-is.
Q:\GIS PROJECTS\EIS_MARTIN_CO\EIS\
Figure updates 012711\figure3.4-2_Sidescan coverage.mxd
Data sources: SEARCH, USACE, NOAA.

3.6. FISH AND WILDLIFE RESOURCES

The beaches of Martin County are typical of south-central Atlantic coastal areas that are subject to dynamic and often stressful conditions. The biological communities found in the general project area are well adapted to the particular physiochemical and hydrodynamic conditions associated with the supralittoral beach zone, intertidal swash zone, nearshore reefs, offshore reefs and softbottom areas. The most diverse continental shelf fish assemblage within the United States occurs south of Cape Canaveral to Jupiter Inlet. More than 800 fish species have been recorded within a 10-mile radius of the St. Lucie Inlet (Gilmore 2008).

3.6.1. BIRDS

Birds are abundant on the beaches and in estuarine habitats in Martin County, with shore and wading birds comprising the majority of the avifauna. The motility of these species allows these organisms to seek protective refuge and forage for food in the dunes and tree stands that comprise a portion of the project area. Birds that may nest, forage, court, stage, roost, or otherwise use the beach, nearshore, or offshore habitat in the project area include both protected and species that, while are not listed, fall under the consideration of the policies of cooperating State and Federal agencies. These policies and agreements are discussed in this section, along with recent monitoring efforts, resources, and species known to occur in the vicinity of the project area.

3.6.1.1. Migratory Bird Policies

<u>USACE Jacksonville District Migratory Bird Protection Policy</u>

Florida's coastal areas provide habitat to numerous unique species of migratory birds, a large majority of which are shorebirds and colonial nesting birds. These species are protected by state and federal laws. Habitat for these birds can be affected and, in some cases, created during construction and/or dredging along the waterways. The Jacksonville District in conjunction with FWC, the Audubon Society, and USFWS has developed a district-wide policy concerning its activities and migratory bird nesting.

The Migratory Bird Treaty Act of 1918, as amended (16 USC 703) protects most migratory bird species as listed by USFWS. The Florida Endangered and Threatened Species Act of 1977, Title XXVIII, Chapter 372.072, provides for the protection of species listed by the State. The purpose of USACE's Migratory Bird Protection Policy is to provide protection to nesting migratory bird species that commonly use the dredged material disposal sites within Jacksonville District while facilitating disposal of dredged material to meet the Federal standard for navigation channel and harbor maintenance as authorized by Congress. Section 4.35, Environmental Commitments includes information regarding USACE protection specifications for contracts as related to migratory bird protection and a link to the policy.

<u>Memorandum of Understanding – USFWS and BOEMRE</u>

In June 2009, a Memorandum of Understanding (MOU) was entered between BOEMRE and USFWS to meet the requirements under Section 3 of Executive Order 13186 (66 FR 3853, January 17, 2001) concerning the responsibilities of Federal agencies to protect migratory birds. The Executive Order directs executive departments and agencies to take certain actions to further implement the Migratory Bird Treaty Act (MBTA). The purpose of this MOU is to strengthen migratory bird conservation through enhanced collaboration between the BOEMRE and USFWS. This MOU does not waive legal requirements under the MBTA or any other statutes and does not authorize the take of migratory birds. This MOU identifies specific areas in which cooperation between the Parties will substantially contribute to the conservation and management of migratory birds and their habitats.

Birds of Conservation Concern

The 1988 amendment to the Fish and Wildlife Conservation Act mandates USFWS to "identify species, subspecies, and populations of all migratory nongame birds that, without additional conservation actions, are likely to become candidates for listing under the Endangered Species Act (ESA) of 1973." *Birds of Conservation Concern 2008* (USFWS 2008) is the most recent effort to carry out this mandate. The overall goal of this report is to accurately identify the migratory and non-migratory bird species (beyond those already designated as federally threatened or endangered) that represent our highest conservation priorities. The project area is located in Bird Conservation Region 31 (BCR). **Table 3.6-1** identifies birds of conservation concern from BCR 31 (Peninsular Florida) (USFWS 2008). Note that not of all the species on this list occur in the project area.

3.6.1.2. Habitat and Monitoring Results

No critical habitat is designated within the project area. Designated critical habitat for wintering piping plovers in the vicinity of the project area is found to the south of the project area on Jupiter Island, Martin County, Florida (Florida Unit 33) **(Figure 3.3-2).**

In April 2005, daily migratory bird observations were conducted along the project during the 2005 renourishment event. These observations are summarized in **Table 3.6-2.** Ring-billed gulls and sanderlings were the most commonly observed species. Black-bellied plovers, ruddy turnstones, willets, laughing gulls, and royal terns were also frequently observed during the monitoring period. Occasional observations of crows, mottled ducks, brown pelicans, spotted sandpiper, Wilson's plovers, herring gulls, common loon, and killdeer were also recorded.

FWC maintains a database of observations made by individuals, agencies, and conservation organizations that monitor beach-nesting birds in Florida (http://myfwc.com/shorebirds/bnb/data-summary-results.asp, accessed February 25, 2011). Data recorded include bird counts, nesting productivity, courtship behavior, predation, number of chicks and eggs, and life stages. Data from the 2010 monitoring efforts along the beaches in Martin County include least terns, oystercatchers, and black skimmers observed in various courting and nesting stages. Most of the observations were recorded south of the project area in Sailfish Point. However, this data helps characterize local nesting habits of birds in the vicinity of the project area.

Table 3.6-1. BCR 31 (Peninsular Florida) 2008 Birds of Conservation Concern List

Common Name	Species Name
Black-capped Petrel (nb)	*Pterodroma hasitata*
Audubon's Shearwater (nb)	*Puffinus lherminieri*
Brown Booby (nb)	*Sula leucogaster*
Magnificent Frigatebird	*Fregata magnificens*
American Bittern (nb)	*Botaurus lentiginosus*
Least Bittern	*Ixobrychus exilis*
Reddish Egret	*Egretta rufescens*
Roseate Spoonbill	*Ajaja ajaja*
Swallow-tailed Kite	*Elanoides forficatus*
Bald Eagle (b)	*Haliaeetus leucocephalus*
Short-tailed Hawk	*Buteo brachyurus*
American Kestrel (paulus ssp.)	*Falco sparverius*
Peregrine Falcon (b)	*Falco peregrinus*
Yellow Rail (nb)	*Coturnicops noveboracensis*
Black Rail	*Laterallus jamaicensis*
Limpkin	*Aramus guarauna*
Snowy Plover (c)	*Charadrius alexandrinus*
Wilson's Plover	*Charadrius wilsonia*
American Oystercatcher	*Haematopus palliates*
Solitary Sandpiper (nb)	*Tringa solitaria*
Lesser Yellowlegs (nb)	*Tringa flavipes*
Whimbrel (nb)	*Numenius phaeopus*
Long-billed Curlew (nb)	*Numenius americanus*
Marbled Godwit (nb)	*Limosa fedoa*
Red Knot (rufa ssp.) (a) (nb)	*Calidris canutus*
Semipalmated Sandpiper (Eastern) (nb)	*Calidris pusilla*
Buff-breasted Sandpiper (nb)	*Tryngites subruficollis*
Short-billed Dowitcher (nb)	*Limnodromus griseus*
Least Tern (c)	*Sternula antillarum*
Black Skimmer	*Rynchops niger*
White-crowned Pigeon	*Patagioenas leucocephala*
Common Ground Dove	*Columbina passerina*
Mangrove Cuckoo	*Coccyzus minor*
Smooth-billed Ani	*Crotophaga ani*
Chuck-will's-widow	*Caprimulgus carolinensis*
Red-headed Woodpecker	*Melanerpes erythrocephalus*
Loggerhead Shrike	*Lanius ludovicianus*
Black-whiskered Vireo	*Vireo altiloquus*
Brown-headed Nuthatch	*Sitta pusilla*
Yellow Warbler (gundlachi ssp.)	*Dendroica petechia*
Prairie Warbler	*Dendroica discolor*
Prothonotary Warbler	*Protonotaria citrea*
Bachman's Sparrow	*Peucaea aestivalis*
Grasshopper Sparrow	*Ammodramus savannarum*
Henslow's Sparrow (nb)	*Ammodramus henslowii*
Nelson's Sharp-tailed Sparrow (nb)	*Ammodramus nelsoni*
Saltmarsh Sharp-tailed Sparrow (nb)	*Ammodramus caudacutus*
Seaside Sparrow (c)	*Ammodramus maritimus*
Painted Bunting (nb)	*Passerina ciris*

Source: USFWS 2008

Table 3.6-2. Migratory Birds Observed Daily on the Beach during the 2005 Renourishment Event

Date: April 2005	Black-bellied Plover	Crows	Ring-billed Gull	Ruddy Turnstone	Sanderling	Willet	Laughing Gull	Royal Tern	Mottled Duck	Brown Pelican	Spotted Sandpiper	Wilson's Plover	Herring Gull	Common Loon	Killdeer
1	1	2	2	1	18	1									
2			20-30		30-40	2	1	1							
3			15-25		35-45	1	4								
4			6	2	15-20		7	15							
5	2		15	4	32	1									
6	1		6		38		6								
7			3	1	22										
8				4	24	2	1								
9	1		3		23	3	4	1							
10	1		1				7	4	2	3					
11	1		15		49	1									
12			10		22										
13			1		23	3									
14	2		3		29										
15			4		40	1									
16	1		5		19	10									
17			1	2	19						1	1			
18		1	12	5	6	4							2		
19	1	3	5	8	30	2								1	
20	2		4	10	10	5	1	1	2	1					
21	1		4	16	15	4		1							
22	1		6	5	26	1	2	2							
23	4			2	25	1		2							
24	1				28				2						
25	4		5	5	32				2						
26			1		31										
27	1			2	16			1				1			
28			4		20			1				7			
29			1		20			2							
30			1	4	10										1

3.6.2. NEARSHORE FISH AND BENTHIC FAUNA

Inhabitants in the intertidal swash zone must cope with diurnal tides which leave many organisms aerially exposed for up to 6 hours at a time, and subjected to the high energy of the ocean waves. Typically, these habitats have low species diversity because of the harsh environmental conditions. However, animals that are able to adapt to these dynamic conditions are faced with very little competition from other organisms. Hence, the populations that are able to survive in this dynamic zone usually consist of a large number of individuals representing few species.

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

Both nearshore and offshore reefs are found along the entire Atlantic coast of Florida (**Figure 3.6-1**) and contribute significantly to the high biodiversity found in these areas. Limestone depositions, which form ridges and rocky outcrops and contribute to livebottom communities, are found along the entire length of the project area. Livebottom biota are among the most widely distributed benthic communities in Florida waters. Many of the rocky outcrops are carved and shaped by sand scouring and through bioerosion caused by rock-boring organisms such as clionid sponges and clams. From these erosional forces, the overall surface area of the rock structures is increased (an increase in rugosity) and forms important attachment sites for sessile organisms. The first inhabitants of these rocks usually are the attached algae. Herbivory by nearby crustaceans is well documented (Barnes and Hughes 1988) and the attached algae provide the primary food source for a wide variety of invertebrates. Crevices in these limestone outcrops provide important refuge for commercially important crustaceans such as the stone crab *(Menippe mercenaria*), blue crab *(Callinectes sapidus)* and spiny lobster *(Panulirus argus).* The limestone outcrops that form three-dimensional structures provide the only vertical habitat found along vast expanses of sandy substrate. Large carnivores such as great barracuda *(Sphyraena barracuda),* lane snapper *(Lutjanus synagris),* yellowtail snapper *(Ocyurus chrysurus*), grouper *(Epinephelus* sp.*),* and sea bass *(Centropristis* sp.*)* are frequently found around these rocky structures. Smaller reef fish, such as sheepshead *(Archosargus probatocephalus),* porkfish *(Anisotremus virginicus),* hairy blenny *(Labrisoma nuchipinnis),* slippery dick *(Halichoeres bivittata),* and doctorfish *(Acanthurus chirurgus)*, are also commonly seen foraging around the hardbottom habitat. In 1993, prior to project construction, a quantitative fish census was performed by USFWS. The results are summarized in the Coordination Act Report (CAR) (Appendix C of 1994 GDM).

The most recent (2007) nearshore species inventory, showed that relatively more complex and well-developed epibiotal and fish communities were observed in association with substrate that had exposed rock cover than where sand substrate predominated (CSA 2007). Greater numbers of benthic species were observed in areas of higher vertical relief and near distinct ledges (CSA 2007). The epibiotal communities were dominated by various species of algae. In addition to algae, exposed rock areas were colonized by hydroids, small numbers of sponges and tunicates, and rarely by hard and soft corals. The hard corals *Oculina* sp., *Phyllangia americana, Siderastrea sidereal,* and *Siderastrea radians* were observed in exposed rock cover areas. Overall, very low numbers of sponges and corals were observed during the survey. Sabellariid worm rock was present in the study area and appeared to be healthy and in an accretionary or growth stage. Motile invertebrates were observed in very low numbers and were associated with the rock outcrops. A total of 41 epibiota were identified during the *in situ* species inventory **(Table 3.6-3).**

Eight fish species were observed during the CSA 2007 monitoring survey. The most common adult and juvenile fishes observed were porkfish *(Anisotremus virginicus)*, sheepshead *(Archosargus probatocephalus)*, and black margate *(Anisotremus surinamensis).* Individual fish of the following species were also observed: schoolmaster *(Lutjanus apodus),* cocoa damselfish *(Pomacentrus variabilis),* silver porgy *(Diplodus argenteus),* spadefish *(Chaetodipterus faber),* and hairy blenny *(Labrisomus nuchipinnis).* Like the epibiota, fish abundance was greater in areas of high vertical relief and near distinct ledges.

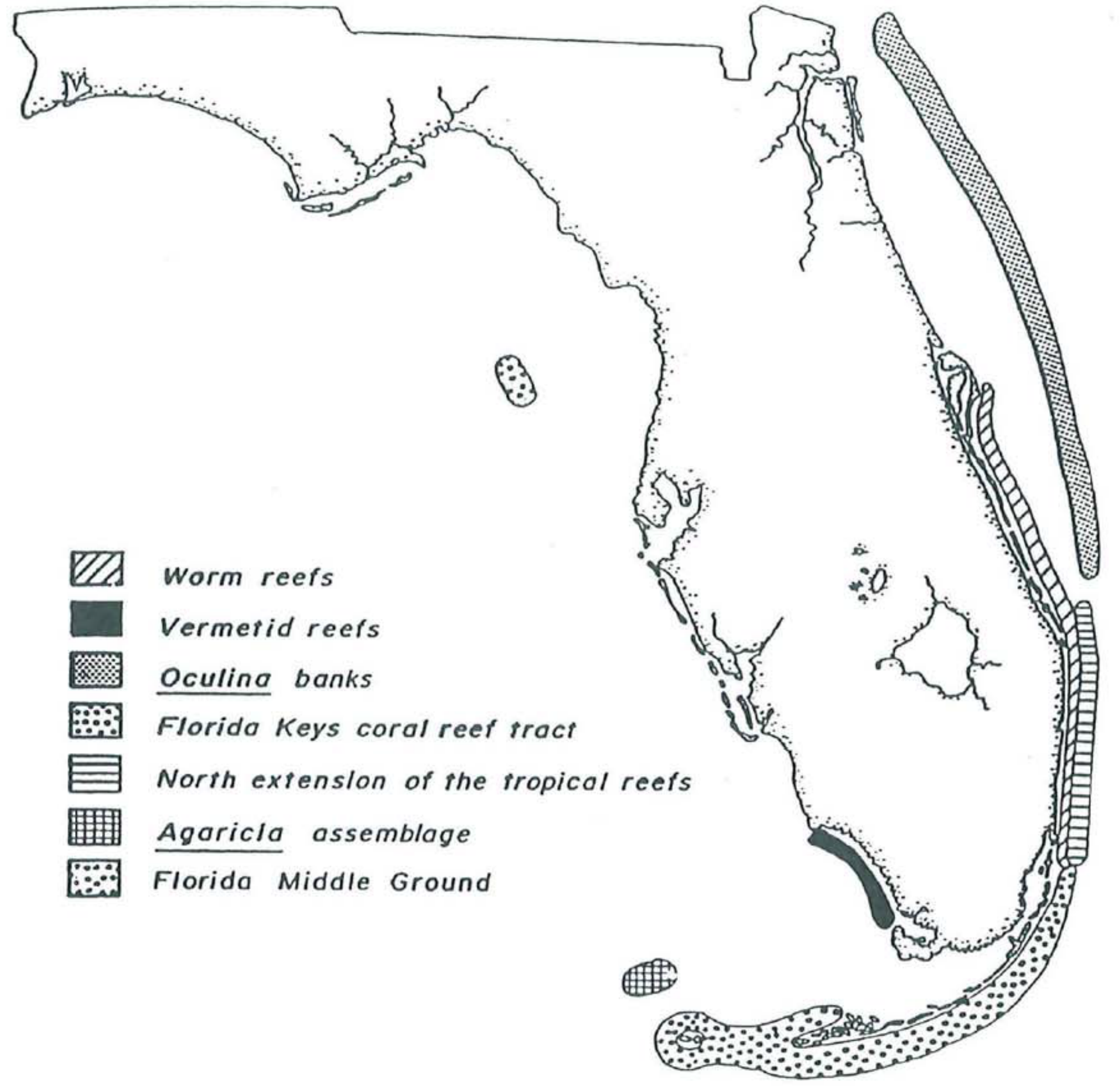


FIGURE 3.6-1.
DISTRIBUTION OF POTENTIAL REEF HABITAT
MARTIN COUNTY HURRICANE AND STORM DAMAGE REDUCTION PROJECT
HUTCHINSON ISLAND, FLORIDA

This map and/or digital data is for planning purposes only and should not be used to determine the precise location of any feature. Data provided as-is.
Q:\GIS PROJECTS\EIS_MARTIN_CO\EIS\Figure updates 030211\figure3.6-1_reefs.mxd Source: Jaap, W.C. and P. Hallock 1990

Table 3.6-3. List of Taxa Identified *In Situ* by Divers along the Entire Length and within 1 Mile to Each Side of the Quantitative Survey Lines on Nearshore Habitat North of the Inlet in Martin County, Florida (page 1 of 2)

Identified Taxa	Survey Lines															
	R-2	R-6	R-8	R-10	R-12	R-14	R-16	R-18	R-20	R-22	R-24	R-26	R-28	R-30	R-35	R-40
Stony Corals																
Siderastrea radians							X									X
Siderastrea sidereal															X	X
Occulina sp.																X
Phyllangia Americana				X												
Octocorals																
Leptogrogia virgulata	X			X												
Leptogorgia sp.				X												
Macroalgae																
Botryocladia sp.			X			X	X									
Bryothamnion sp.			X	X											X	X
Heterosiphonia gibbesii			X													
Liagora sp.		X		X												X
Unidentified red algae		X	X	X			X	X							X	X
Avrainvillea sp.																X
Halimeda sp.		X		X											X	X
Caulerpa mexicana		X	X	X											X	
Caulerpa racemosa																X
Caulerpa prolifera				X		X									X	
Caulerpa sertularioides															X	
Codium sp.		X														X
Penicillus sp.															X	
Unidentified green algae			X	X												
Dictyota sp.	X		X	X	X		X									X
Padina sp.				X											X	X
Unidentified brown algae			X	X												X

Table 3.6-3. **List of Taxa Identified *in situ* by Divers along the Entire Length and within 1 Mile to Each Side of the Quantitative Survey Lines on Nearshore Habitat North of the Inlet in Martin County, Florida** (page 2 of 2)

Identified Taxa	**Survey Lines**															
	R-2	**R-6**	**R-8**	**R-10**	**R-12**	**R-14**	**R-16**	**R-18**	**R-20**	**R-22**	**R-24**	**R-26**	**R-28**	**R-30**	**R-35**	**R-40**
Turf algal complex	X	X	X	X	X	X	X	X	X	X					X	X
Mat cyanobacteria					X	X										X
Unidentified drift algae				X	X											
Unidentified macroalgae		X	X	X	X		X	X							X	X
Fauna																
Unidentified bryozoan																X
Hydroids			X	X	X	X									X	X
Phragmatopoma lapidosa				X			X								X	
Colonial tunicates	X			X												X
Solitary tunicate	X			X		X									X	
Holothuroid																X
Encope sp.	X															
Actiniidae	X			X												
Cirripedia										X						
Gastropoda										X						
Arbacia sp.			X													
Sponges																
Unidentified sponge		X	X												X	
Encrusting sponge			X													
Cliona sp.					X											X

Source: CSA (2007)

3.6.3. OFFSHORE FISH AND BENTHIC FAUNA

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).

During the 2009 dive survey, various invertebrate and vertebrate organisms were observed. Results indicate the benthic community of the C1-B borrow area is composed of taxa typical of soft bottom habitats such as bivalves, gastropods, echinoderms, and crustaceans (Hesperides Group, LLC 2009). Several species of invertebrates found strictly in soft bottom habitats were very common, including razor clams (*Ensis directus),* arrowhead sand dollar, and a portunid crab. Other notable fauna included various small bivalves and gastropods, beaded sea stars *(Astropecten articulates),* sea hare *(Aplysia* sp.), brittle stars *(Ophiarachna* sp.), and box crabs *(Calappa flammea).* Numerous sand dollars were observed on several of the dives along with egg cases of *Neverita duplicate,* and a moon snail in the family *Naticidae.* These taxa are generally characterized by locally dense populations, high fecundity, and short life spans.

Distribution of interstitial bryozoans has recently been studied at shoals located offshore St. Lucie County, including the St. Lucie Shoal. A study for the USACE conducted by Brostoff (2002) identified an average of 19 different species located within the samples from the St. Lucie Shoal, with the exceedingly dominant species collected being *Cupuladria doma.* Previous studies of Capron Shoal (north of St. Lucie Shoal) by Winston and Håkansson (1986) described the interstitial bryozoan population as adapting to interstitial conditions, characterized by 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).

Although there is no hardbottom habitat located within the boundaries of the offshore borrow area, it does occur in the vicinity of the project area; therefore, the resources associated with hardbottom habitats are described. Offshore hardbottom areas support a suite of species similar to that found on nearshore hardbottom, but diversity is generally higher (Hammer et al. 2005). Most of these species are reef fishes of tropical origin, and several examples of the transitional nature of the region are found. Mutton snapper *(Lutjanus analis),* yellowtail snapper, sailors choice *(Haemulon parra),* schoolmaster *(Lutjanus apodus),* and dog snapper *(Lutjanus jocu)* reach northern limits within the area encompassed by the sand resource areas (Gilmore and Hastings 1983). Some cross-shelf segregation of fish species has been noted offshore of the Hutchinson Island area, but this is more evident in the northern portion of the study area where inshore temperature ranges are more variable and tropical elements of the assemblage are displaced offshore. Nevertheless, the most obvious cross-shelf faunal break occurs at the outer shelf. Species common on deeper reefs but not generally found shallower than 30 meters are wrasse bass *(Liopropoma eukrines),* bank butterflyfish *(Chaetodon aya),* tattler *(Serranus phoebe),* and yellowtail reeffish *(Chromis enchrysurus).* Species that typify intermediate reefs are blue angelfish *(Holacanthus bermudensis),* spotfin butterflyfish *(Chaetodon ocellatus),* reef butterflyfish *(Chaetodon sedentarius),* jackknife-fish *(Equetus lanceolatus),* and hogfish *(Lachnolaimus maximus).*

3.6.4. MARINE MAMMALS

The Marine Mammal Protection Act of 1972 protects all marine mammals from harvesting within the borders of the U.S., regardless of status. Therefore, all marine mammals encountered in the offshore region of Hutchinson Island must be given due consideration. This section considers marine mammals not listed under the ESA.

The inner shelf plain and estuaries surrounding the project area support seasonal and permanent populations of marine mammals. Bottlenose dolphins are year-round residents, while the North Atlantic Right Whale and Humpback Whale may pass through the study area during migration. Key biological aspects of selected marine mammal species that could possibly occur in the proposed action areas are summarized in **Table 3.6-4** and sections below.

Table 3.6-4. Marine Mammals Occurring in Project Area

Common Name	Scientific Name	Frequency off Florida
WHALES		
Bryde's whale	*Balaenoptera brydei*	Rare
Minke whale	*Balaenoptera acutorostrata*	Regular
Pygmy sperm whale	*Kogia breviceps*	Regular
Dwarf sperm whale	*Kogia sima*	Regular
Gervais' beaked whale	*Mesoplodon europaeus*	Regular
Cuvier's beaked whale	*Ziphius cavirostris*	Regular
Blainville's beaked whale	*Mesoplodon densirostrus*	Regular
Sowerby's beaked whale	*Mesoplodon bidens*	Rare
True's beaked whale	*Mesoplodon mirus*	Extralimital
DOLPHINS		
Bottlenose dolphin	*Tursiops truncates*	Regular
Atlantic spotted dolphin	*Stenella frontalis*	Regular
Pantropical spotted dolphin	*Stenella attenuate*	Regular
Spinner dolphin	*Stenella longirostris*	Regular
Striped dolphin	*Stenella coeruleoalba*	Regular
Risso's dolphin	*Grampus griseus*	Regular
Pygmy killer whale	*Feresa attenuate*	Regular
False killer whale	*Pseudorca crassidens*	Regular
Short-finned pilot whale	*Globicephala macrorynchus*	Regular
Orca	*Orcinus orca*	Regular
Rough-toothed dolphin	*Steno bredanensis*	Regular
Clymene dolphin	*Stenella clymene*	Regular
Common dolphin	*Delphinus delphis*	Rare
Fraser's dolphin	*Lagenodelphis hosei*	Regular
Melon-headed whale	*Peponocephala electra*	Regular
Harbor porpoise	*Phocoena phocoena*	Extralimital

3.6.4.1. Whales

Bryde's whales (*Balaenoptera brydei)* are found both offshore and near the coast in tropical and subtropical waters, in both deep and shallow waters. They are found in subtropical and tropical waters and generally do not range north of 40° in the northern hemisphere or south of 40° in the southern hemisphere (Jefferson et al. 1993). These whales opportunistically feed on plankton (e.g., krill and copepods), and crustaceans (e.g. pelagic red crabs, shrimp) as well as schooling fish (e.g., anchovies, herring, mackerel, pilchards, and sardines). Bryde's whales use different methods to feed, including skimming the surface, lunging, and creating bubble nets (http://www.nmfs.noaa.gov/pr/species/mammals/cetaceans/brydeswhale.htm, accessed December 22, 2010).

Strandings of Gulf Stream (or Gervais') beaked whale *(Mesoplodon europaeus)*, Cuvier's beaked whale *(Ziphius cavirostris)*, pygmy sperm whale (*Kogia* sp.), and minke whale *(Balaenoptera acutorostrata)* are known to occur in Florida. Beaked whales are believed to primarily inhabit deep water, but could potentially be found in the borrow area vicinity.

3.6.4.2. Dolphins

Bottlenose Dolphin

Bottlenose dolphins *(Tursiops truncatus)* are very sociable and are typically found in groups of two to 15 individuals, although groups of 100 have been reported. They are opportunistic feeders, taking a wide variety of fishes, cephalopods, and shrimp. There are two morphologically and genetically distinct forms of bottlenose dolphins: a nearshore (coastal) and an offshore form (Duffield et al 1983, Duffield 1986). The offshore form is distributed primarily along the outer continental shelf and continental slope in the Northwest Atlantic Ocean; however, the offshore morphotype has been documented to occur relatively close to shore over the continental shelf south of Cape Hatteras, NC

Atlantic Spotted Dolphin

Atlantic spotted dolphins *(Stenella frontalis)* prefer the tropical to warm temperate waters along the continental shelf of the Atlantic Ocean. This species generally occurs in coastal or continental shelf waters 65 to 820 feet (20 to 250 meters) deep, but can be found occasionally in deeper oceanic waters. The population in the western North Atlantic is estimated at 36,000 to 51,000 animals (http://www.nmfs.noaa.gov/pr/species/mammals/cetaceans/spotteddolphin_atlantic.htm, accessed December 22, 2010). Group size for the Atlantic spotted dolphin may range from just a few dolphins to several thousand. They prey on epipelagic (surface dwelling) fish, squid, and crustaceans. Atlantic spotted dolphins are expected to be uncommon within the vicinity of the project area.

Pantropical Spotted Dolphin

Pantropical spotted dolphins *(Stenella attenuata)* often occur in groups of several hundred to 1,000 animals. They are considered quite gregarious, often schooling with other dolphin species, such as spinner dolphins. Although specific migratory patterns haven't been clearly described, they seem to move inshore in the fall and winter months and offshore in the spring. They feed primarily on mesopelagic cephalopods and fishes (http://www.nmfs.noaa.gov/pr/species/mammals/cetaceans/spotteddolphin_pantropical.htm, accessed December 22, 2010). Pantropical spotted dolphins spend the majority of their day in shallower water typically from 300 to 1,000 feet (90 to 300 meters) deep, with nocturnal feeding occurring in deeper waters. Pantropical spotted dolphins are expected to be uncommon within the vicinity of the project area.

Spinner Dolphin

Spinner dolphins *(Stenella longirostris)* are distributed in oceanic and coastal tropical waters (Leatherwood *et al.* 1976). This is presumably an offshore, deep-water species (Schmidly 1981; Perrin and Gilpatrick 1994), and its distribution in the Atlantic is very poorly known. In the western North Atlantic, these dolphins occur in deep water along most of the U.S. coast south to the West Indies and Venezuela, including the Gulf of Mexico. Spinner dolphin sightings have occurred exclusively in deeper (>2,000 m) oceanic waters (CETAP 1982; Waring et al. 1992) off the northeast U.S. coast. Spinner dolphins often occur in groups of several hundred to several thousand animals. They are considered quite gregarious, often schooling in large groups and with other dolphin species, such as spotted dolphins. Spinner dolphins feed primarily at night on mid-water fishes and deep-water squid, while resting for most of the daylight hours. In most places, spinner dolphins are found in the deep ocean where they likely track prey.

Striped Dolphin

Striped dolphins *(Stenella coeruleoalba)* are some of the most abundant and widespread dolphins in the world. This species occurs in the U.S. off the west coast, in the northwestern Atlantic and in the Gulf of Mexico. In general, striped dolphins appear to prefer continental slope waters offshore to the Gulf Stream (Leatherwood *et al.* 1976; Perrin *et al.* 1994; Schmidly 1981). Striped dolphins are usually found in tight, cohesive groups averaging between 25 and 100 individuals, but have been occasionally seen in larger groups of up to several hundred and even thousands of animals. Striped dolphins feed on a diverse diet consisting of various species of relatively small, closely-packed, midwater, "benthopelagic" and/or "pelagic" shoaling/schooling fish (e.g., "myctophids" and cod) and cephalopods (e.g., squid and octopus) throughout the water column. Recent abundance estimates for the Western Atlantic population is between 68,500 and 94,500 (http://www.nmfs.noaa.gov/pr/species/mammals/cetaceans/stripeddolphin.htm, accessed December 22, 2010).

Risso's Dolphin

Risso's dolphins *(Grampus griseus)* are distributed worldwide in tropical and temperate seas, and in the Northwest Atlantic occur from Florida to eastern Newfoundland (Leatherwood *et al.* 1976; Baird and Stacey 1990). Off the northeast U.S. coast, Risso's dolphins are distributed along the continental shelf edge from Cape Hatteras northward to Georges Bank during spring, summer, and autumn (CETAP 1982; Payne *et al.* 1984). In winter, the range is in the mid-Atlantic Bight and extends outward into oceanic waters (Payne *et al.* 1984). In general, the population occupies the mid-Atlantic continental shelf edge year round, and is rarely seen in the Gulf of Maine (Payne et al. 1984). Risso's dolphins are found in groups of 5 to 50 animals, but groups typically average between 10 and 30 animals. They have been reported as solitary individuals, pairs, or in loose aggregations in the hundreds and thousands. Occasionally this species associates with other dolphins and whales. The Western North Atlantic stock is estimated to be 13,000 to 20,500 animals (http://www.nmfs.noaa.gov/pr/species/mammals/cetaceans/rissosdolphin.htm, accessed December 21, 2010).

Pygmy Killer Whale

Pygmy killer whales *(Feresa attenuate)* are small members of the dolphin group and are found primarily in deep waters throughout tropical and subtropical areas of the world. Pygmy killer whales usually occur in groups of 50 or less. They are generally less active than other oceanic dolphins; frequently they are seen "logging"--resting in groups at the surface with all animals oriented the same way. They prefer deeper areas of warmer tropical and subtropical waters where their prey is concentrated. The numbers of pygmy killer whales off the U.S. or Canadian Atlantic coast are unknown, and seasonal abundance estimates are not available for this stock, since it was rarely seen in any surveys. A group of six pygmy killer whales was sighted during a 1992 vessel survey of the western North Atlantic off of Cape Hatteras, North Carolina, in waters >1500 meters deep (Hansen et al. 1994), but this species was not sighted during subsequent surveys (NMFS 1999a; NMFS 2002; Mullin and Fulling 2003). Pygmy killer whales are expected to be uncommon within the vicinity of the nearshore area and proposed borrow area.

False Killer Whale

False killer whales *(Pseudorca crassidens)* are large members of the dolphin family. These whales are gregarious and form strong social bonds. They are usually found in groups of 10 to 20 that belong to much larger groups of up to 40 individuals in Hawaii and 100 individuals elsewhere. False killer whales are also found with other cetaceans, most notably bottlenose dolphins. They feed during the day and at night on fishes and cephalopods. False killer whales occur in the U.S. in Hawaii, along the entire West Coast, and from the Mid-Atlantic coastal states south. They prefer tropical to temperate waters that are deeper than 3,300 feet (1000 meters) (http://www.nmfs.noaa.gov/pr/species/mammals/cetaceans/falsekillerwhale.htm, accessed December 22, 2010). Since false killer whales prefer deeper water, they are expected to be uncommon within the vicinity of the project area.

Short-finned Pilot Whale

Short-finned pilot whales (*Globicephala macrorhynchus*) are found in warm temperate and tropical waters and occur primarily along the Atlantic coast south of Cape Hatteras. Strandings along the east coast of Florida have occurred during fall, winter, and spring. As they occur predominantly in the offshore waters of Florida beyond the continental shelf, pilot whales are not expected to occur nearshore or in the vicinity of the project area.

Orca

Orcas *(Orcinus orca)* normally occur in small groups and feed on bony fishes, sharks, rays, skates, cephalopods, seabirds, sea turtles, and other marine mammals. Orca sightings off the coast of northern Florida have been close to shore. However, just to the north off of North Carolina, there are sightings in deep waters seaward of the continental shelf break. Orcas are expected to be rare throughout the year between the shoreline and the proposed borrow area.

3.7. ESSENTIAL FISH HABITAT

The Magnuson-Stevens Fishery Conservation and Management Act requires identification of habitats needed to create sustainable fisheries and comprehensive fishery management plans (FMPs) with habitat inclusions. The act also requires preparation of an EFH assessment (Appendix E) 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 are used by fish 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 project area falls under the jurisdiction of the South Atlantic Fisheries Management Council (SAFMC), which is responsible for the conservation and management of fish stocks within the federal 200-mile limit of the Atlantic Ocean off the coasts of North Carolina, South Carolina, Georgia, and east Florida to Key West. The SAFMC has produced several Fisheries Management Plans (FMPs) for single and mixed groups of species. All of these FMPs, including those for penaeid shrimps, spiny lobster, red drum, snapper-grouper (reef fishes) and coastal migratory pelagics were amended in a single document (SAFMC 1998b) 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 1999b). The SAFMC recently prepared a Fishery Ecosystem Plan (SAFMC 2009) that expands many of the EFH descriptions provided in the Habitat Plan (SAFMC 1998b). Note that some of the species managed by SAFMC and NMFS also are 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.

Table 3.7-1 summarizes species or species groups managed by the SAFMC and NMFS that may be found within or in the vicinity of the project area. **Figure 3.7-1** depicts EFH in the project area and **Figures 3.4-1a,b,c** depict nearshore hardbottom resources along the project reach. Members of these groups occur in the project area for at least a portion of their life history. The following subsections briefly describe the EFH for these species and their respective life stages.

Table 3.7-1. EFH Designations, Associated Species Complexes, and Locations

EFH Designation	Fishery	Position within the Project Area
Sargassum	Dolphin-Wahoo, Snapper/Grouper, Highly Migratory Species	Borrow Area
Sandy Shoals	Coastal Migratory Pelagics, Sailfish	Borrow Area
Hardbottom	Snapper/Grouper, Spiny Lobster	Fill Area
Artificial Reefs	Red Drum, Snapper/Grouper	Fill Area
Offshore Marine Habitats Used for Spawning and Growth to Maturity	Penaeid Shrimp	Borrow Area
Ocean High-Salinity Surf Zones	Red Drum, Coastal Migratory Pelagics	Fill Area
Nearshore Shelf/Oceanic Waters	Spiny Lobster	Fill Area
Shallow Subtidal Bottom	Spiny Lobster	Fill Area

The continental shelf off South Hutchinson Island is unique in that its climate and oceanographic and topographical setting within tropical and warm temperate aquatic environments has produced an exceptionally complex and uniquely rich fish fauna and EHF setting in a relatively small area (Gilmore 2008). Gilmore (2008) compiled information from the published literature, unpublished literature, unpublished fish survey data, and interviews with local fishermen to provide quantitative information on regional fish distribution, life history, ecology, and EFH in coastal waters adjacent to South Hutchinson Island and the Florida central east coast. This study was conducted to help make informed decisions and predictions of fish and fishery impacts relevant to beach restoration activities, including ocean shoal sand.

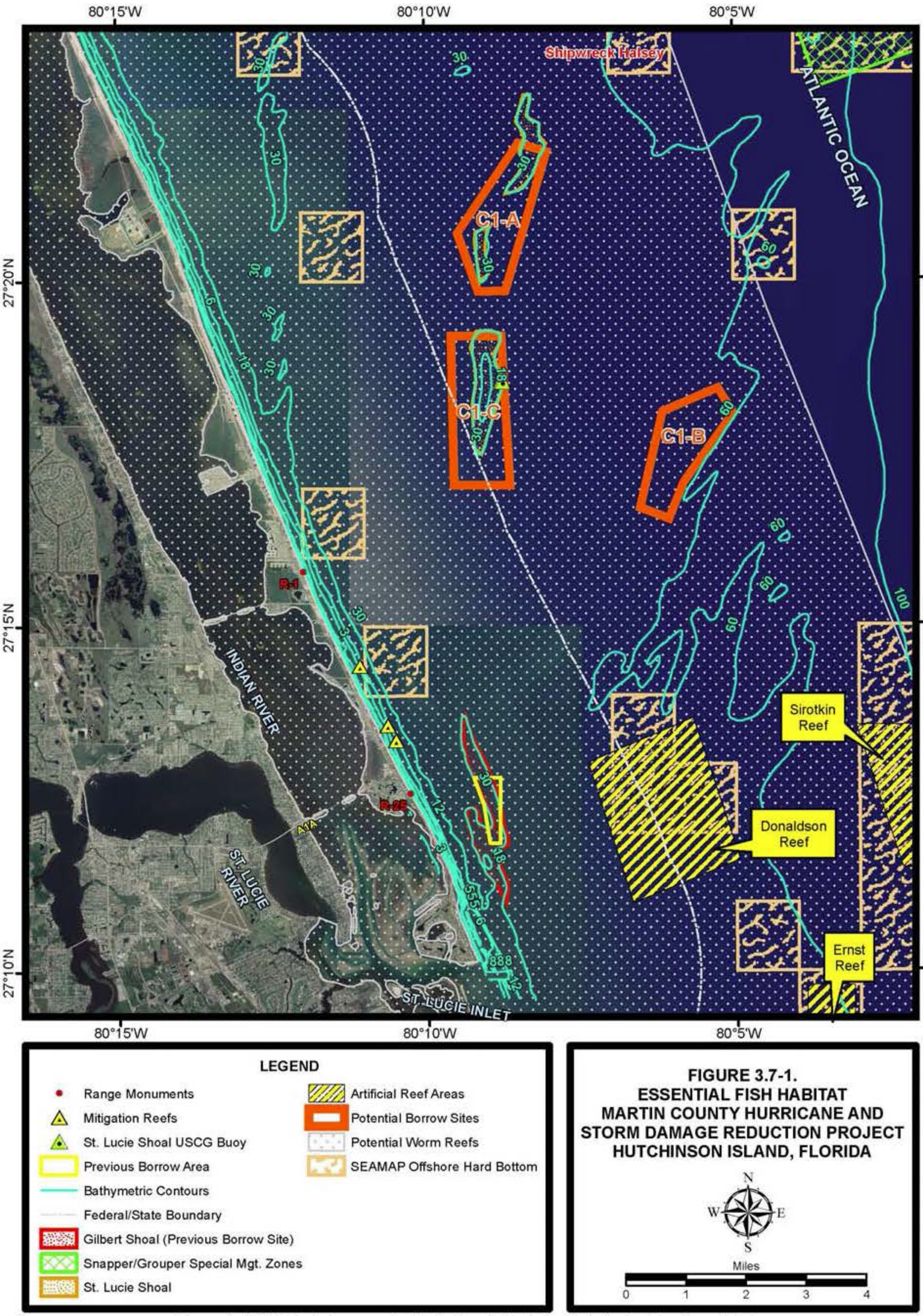


FIGURE 3.7-1.
ESSENTIAL FISH HABITAT
MARTIN COUNTY HURRICANE AND STORM DAMAGE REDUCTION PROJECT
HUTCHINSON ISLAND, FLORIDA

This map and/or digital data is for planning purposes only and should not be used to determine the precise location of any feature. Data provided as-is.
Q:\GIS PROJECTS\EIS_MARTIN_CO\EIS\Figure updates 030211\figure3.7-1_EFH_070810. Data sources: LABINS, FGDL, FDEP, ANAMAR.

3.7.1. ESSENTIAL FISH HABITAT TYPES

3.7.1.1. *Sargassum*

Sargassum, a genus of macroalga 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 cm (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) will 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 Sargassumfish 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, flyingfishes, 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).

The SAFMC has designated *Sargassum* as EFH for species in the snapper-grouper complex and the dolphin-wahoo fishery. Species within the snapper-grouper complex use Sargassum for spawning (SAFMC 2002). Sargassum is considered a Habitat of Particular Concern (HAPC) for dolphin and wahoo (SAFMC 2003a). In addition to SAFMC-managed species, billfish and swordfish utilize Sargassum for various life stages.

3.7.1.2. Sandy Shoals

Coastal migratory pelagic fish use sandy shoals for all lifestages, though spawning most frequently takes place inshore (Collette and Nauen 1983). It is likely that sailfish, though a member of the highly migratory species complex, also use the shoals for spawning. This species tends to frequent nearshore waters more often than other highly migratory species. Interviews conducted with local fishermen indicated that shoals concentrate planktivorous fish, herrings, sardines, and menhaden. The large schools of herrings, sardines, and menhaden attract pelagic carnivores such as barracuda, mackerel, little tunny, and various jacks and sharks to waters adjacent to the shoals (Gilmore 2008).

Gilmore (2008) stated the sand/shoal fish assemblage studies of Walsh et al. (2006) and Vasslides and Able (2008) were of direct value. The Walsh and Vasslides-Able studies provide insight into the value of shoals to both benthic and pelagic species and have relevance in Florida even though they were both based on work done on the continental shelf in other states. Vasslides and Able (2008) found that sand ridges (sand shoals) off New Jersey were “strategic ecological features” increasing the abundance of certain species and providing EFH for economically important species, commercial, and recreational fisheries.

3.7.1.3. Nearshore Hardbottom

Nearshore hardbottom provides EFH for the snapper-grouper species complex and the spiny lobster. This habitat is derived from large accretionary ridges of coquina mollusks, sand, and shell marl, which lithified parallel to ancient shorelines during Pleistocene interglacial periods (Duane and Meisburger 1969). The habitat complexity of nearshore hardbottom is expanded by colonies of tube-building polychaete worms (Kirtley and Tanner 1968) and other invertebrates and macroalgae (Goldberg 1973, Nelson and Demetriades 1992). Generally, nearshore hardbottom is utilized by adult and juvenile fishes, and for spawning by the large and diverse snapper-grouper complex. Juvenile spiny lobsters use nearshore hardbottom before moving to offshore reefs as they mature (FWRI Web article http://research.myfwc.com/features/view_article. asp?id=4128).

Nearshore hardbottom habitat occurring in the project area was described in Section 3.4. On a broad scale, nearshore hardbottom is distributed in patches along the east coast of Florida, providing important ecological functions for plants, invertebrates, marine turtles, and fishes of the region (CSA International, Inc. 2009a) and is considered EFH for coastal pelagic and reef fish management units (SAFMC 1998**a**, 2009). More detailed information on specific fish assemblages can be found in Section 2.1.2 of Appendix E. Structural complexity of nearshore hardbottom is augmented by the reef-building polychaete *Phragmatopoma lapidosa*.

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 meters.

3.7.1.4. Artificial Reefs

Artificial reefs are designated EFH for the snapper-grouper complex and red drum fishery. Mitigation reefs A, B, and C are situated approximately 900 feet offshore of the project area (Appendix G). Man-made reefs are deployed to change habitats from a soft to a hard substrate system or to add vertical profile to low-profile (<1 meter) hard substrate systems. These reefs are generally deployed to provide fisheries habitat in a specific desired location that provides some measurable benefit to humans. Man-made reefs provide new primary hard substrate similar in function to newly exposed hardbottom (Goren 1979). Aside from the often obvious differences in the physical characteristics and materials involved in creating a man-made reef, the development and ecological succession of the epibenthic assemblages occur in a similar fashion on natural hard substrates and man-placed hard substrates (Wendt et al. 1989). Demersal reef-dwelling finfish, pelagic planktivores, and pelagic predators use natural and man-made hard substrates in very similar ways and often interchangeably (Sedberry and Van Dolah 1984). The changes in species composition and local abundance of important species in a specific area are often seen as the primary benefits of reef deployment activities.

3.7.1.5. Offshore Marine Habitats Used for Spawning and Growth to Maturity

Penaeid shrimp utilize offshore habitats for multiple life stages. Shelf waters encompassing the three potential borrow areas provide suitable water depth and substrate for spawning shrimp, which migrate offshore as adults. EFH for penaeid shrimp includes inshore estuarine nursery areas, offshore marine habitats for spawning and growth to maturity, and all interconnecting water bodies (SAFMC 1998a, 1998b). Offshore waters also serve as habitat for larval and post-larval shrimp. These shrimp are planktonic and feed on zooplankton in the water column.

3.7.1.6. Nearshore Shelf/Oceanic Waters and Shallow Subtidal Bottom

Nearshore shelf/oceanic waters and shallow subtidal bottom waters are designated as EFH for spiny lobster and are present in the study area. Post-larvae and juveniles utilize these habitats. Larvae and pueruli are dispersed from the Florida Current to the Gulf Stream, advecting into coastal gyres and countercurrents to ultimately inhabit shelf waters and rocky substrate in the study area.

3.7.1.7. Ocean High-Salinity Surf Zone

This zone is designated EFH for coastal migratory pelagics and red drum. Coastal migratory pelagics may utilize this zone during all life stages. Adult red drums utilize this zone during spring and fall migration.

3.7.1.8. Water Column

The water column is considered EFH for the highly migratory species complex. Sailfish, in particular, are known to spawn nearer to shore than the other billfish in this category; therefore, they are included in this assessment.

3.7.2. MANAGED SPECIES

3.7.2.1. 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.

Five coastal migratory pelagic fish species are managed by SAFMC: cero mackerel (*Scomberomorus regalis*), cobia (*Rachycentron canadum*), king mackerel *(Scomberomorus cavalla),* Spanish mackerel (*Scomberomorus maculates*), and little tunny (*Euthynnus alletteratus*) (SAFMC 1998a). The habitat of adults in the coastal pelagic management unit, excluding dolphin (*Coryphaena hippurus*), is the coastal waters outward to the edge of the continental shelf in the Atlantic Ocean. The larval habitat of all species in the coastal pelagic management unit is the water column. Within the spawning area, eggs and larvae are concentrated in the surface waters (SAFMC 1998a).

Spawning of king and Spanish mackerel takes place from May through September, with peaks in July and August. The cero is thought to spawn year round with peaks in April through October, whereas little tunny spawn from April to November. The diet of these scombrids consists primarily of fishes and, to a lesser extent, penaeid shrimp and cephalopods (Collette and Nauen 1983).

Cobia spawn offshore where external fertilization takes place in large spawning aggregations; however, the pelagic eggs have been collected at both inshore and offshore stations. Based on past collections of gravid females, spawning in South Carolina takes place from mid May through August (Shaffer and Nakamura 1989), and likely earlier off the southeast coast of Florida. Cobia are adaptable to their environment and can utilize a variety of habitats and prey. They are voracious predators that forage primarily near the bottom, but on occasion capture prey near the surface. Their favorite benthic prey are crabs, and to a much lesser extent other benthic invertebrates and fishes (Ditty and Shaw 1992).

EFH for coastal pelagic species includes *Phragmatopoma* reefs (worm reefs) off the central coast of Florida; ocean high-salinity surf zone; and nearshore hardbottom is 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, all coastal inlets and state-designated nursery habitats are included as EFH for coastal migratory pelagic species (SAFMC 1998a).

3.7.2.2. Penaeid Shrimp

Penaeid shrimps managed by the SAFMC and found in the project area are brown shrimp (*Farfantepenaeus aztecus*), pink shrimp (*F. duorarum*), and white shrimp (*Litopenaeus setiferus*). Penaeid shrimp divide their life cycle between offshore and inshore areas. The high-salinity oceanic waters serve as habitat and spawning areas for large mature shrimp, whereas inshore areas are used as nursery areas (SAFMC 1981). Peak spawning occurs in spring, summer, and fall (Florida Fish and Wildlife Conservation Commission's Fish and Wildlife Research Institute [FWRI] http://research.myfwc.com/features/view_article.asp?id=5352).

EFH for penaeid shrimps 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 1998a). 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 shrimps feed on zooplankton in the water column and make their way into inshore waters. For the inshore phase of the life history, post-larval shrimps settle to the bottom and resume a benthic existence in estuaries that provide rich food sources as well as shelter from predation. Young penaeid shrimps prefer shallow water habitats with nearby sources of organic detritus such as estuarine emergent wetlands or mangrove fringe.

As shrimp grow, they begin migrating toward high-salinity oceanic waters. Parker (1970) observed that the size of brown shrimp at the time of emigration is apparently related to density of individuals, but smaller individuals tended to concentrate in shallow peripheral zones. St. Amant et al. (1966) observed that as juveniles increased in size, they migrated into deeper, larger bays, through the lower bays and to offshore waters. Lindner and Anderson (1956) stated that shrimp size increased from inshore to offshore waters. The largest shrimp were in the outside waters where salinity values were highest (SAFMC 1998b).

The relative abundance of pink, white, and brown shrimp in the Atlantic may be related to offshore bottom sediment composition. Kennedy and Barber (1981) suggest that spawning pink shrimp may be most abundant off Cape Canaveral and Cape Lookout because that species has an affinity for the hard, coarse, and particularly calcareous bottom sediments indicative of those areas.

3.7.2.3. Red Drum

Red drum (*Sciaenops ocellata*), a member of the drum family Sciaenidae, occur in the project area. EFH for red drum includes tidal freshwater, estuarine emergent wetlands (e.g., flooded salt marshes, brackish marsh, and tidal creek systems), mangrove shorelines, seagrasses, oyster reefs and shell banks, unconsolidated bottom (e.g., soft sediments), ocean high-salinity surf zones, and artificial reefs (SAFMC 1998a, 2009). Red drum EFH particular to the project area includes ocean high-salinity and surf zone.

Red drum are found from Virginia to the Florida Keys, however distribution is largely determined by life stage and migration pattern. Red drum use a wide reach of the oceanic system, from the beachfront seaward. Large red drum are thought to migrate along the Atlantic coast and are subjected to man's alterations of the natural system. Nearshore and offshore bar and bank areas, such as Gaskins and Joiner Banks in South Carolina, are areas where large concentrations of red drum can be located. Nearshore artificial reefs are also known to attract red drum when they migrate in the spring and fall. Red drum concentrate around inlets, shoals, and capes, and regularly move between the surf zone and deeper water (SAFMC 1998a).

The distribution of red drum between estuarine habitat and oceanic waters is dependent largely on stage of development, temporal, and environmental factors. Red drum are euryhaline, living in both diluted and concentrated seawater. Eggs and newly hatched larvae require salinities above 25 ppt. Spawning occurs in or near passes of inlets (e.g., "Grillage" at the mouth of Charleston Harbor), where larvae are transported into the upper estuarine areas of low salinity. As larvae develop into juveniles and subadults, they utilize progressively higher salinity estuarine and beachfront surf zones. Red drum move out of estuarine areas as adults and occupy the high-salinity surf zone of nearshore and offshore coastal waters. In North Carolina and Virginia, large adults move into estuaries during summer months.

HAPCs for red drum are coastal inlets, state-designated nursery habitats of particular importance to red drum, documented sites of spawning aggregations, and habitats for submerged aquatic vegetation (SAFMC 1998a). In many areas throughout the geographic range of red drum, mature adults migrate from inshore waters to spawn in coastal and offshore areas. Tagging studies conducted in inshore waters of the area have documented that red drum will migrate to ocean inlets such as St. Lucie or Ft. Pierce, presumably to spawn (Stevens and Sulak 2001, Tremain et al. 2004). Adult and subadult red drum occur in the nearshore waters of the region during late summer and fall months.

Other sciaenids found in the project area include kingfish (*Menticirrhus* spp.), sand drum (*Umbrina coroides*), and striped croaker (*Bairdiella sanctaeluciae*). These species are not managed by the SAFMC, but may serve as prey for other managed species in the project area (e.g., reef fishes and coastal pelagic species). Striped croaker is considered a species of special concern by the State of Florida.

3.7.2.4. Snapper-Grouper Complex (Reef Fishes)

The Reef Fish Management Unit consists of 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 1998b, 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 1998b). Appendix E (EFH Assessment) details reef fish species with EFH in the project area.

These hardbottom features extend from nearshore out to at least 200-meter water depths. Juveniles of many species utilize both hardbottom features and inshore habitats, including artificial structures (i.e., docks and bridge pilings), mangrove roots, oyster reefs, and seagrass meadows. Eggs and larvae of reef fishes are pelagic and reside in the upper water column for the first 20 to 50 days of life. HAPCs described for the snapper-grouper management unit include high-relief offshore areas where spawning occurs, localities of known spawning aggregations, and nearshore hardbottom areas.

Phylogenetically, the snapper-grouper complex is diverse and includes representatives of two suborders of perciformes (Percoidei and Labroidei), and the order Tetraodontiformes. However, 68 of these species are within eight percoid families. There is considerable variation in specific life history patterns and habitat use among the snapper-grouper species complex. According to NMFS stock assessments and SAFMC SSC analyses, 17 of the 73 species in the FMP are overfished (<30%). The overfished species include ten groupers, two snappers, two porgies, one grunt, one temperate bass, and one tilefish (SAFMC 1998b).

This EFH Assessment summarizes some of the ecological variations among the more commercially-valuable species. Short biological characterizations are also provided for 18 representative species from seven families. These include the serranid groupers (snowy grouper, yellowedge grouper, warsaw grouper, speckled hind, scamp, and jewfish), percichthyid temperate basses (wreckfish), lutjanid snappers (gray snapper, mutton snapper, blackfin snapper, red snapper, silk snapper, and vermilion snapper), haemulid grunts (white grunt), sparid porgies (red porgy), carangid jacks (greater amberjack), and malacanthid tilefishes (golden tilefish and blueline tilefish). Seven of these species are over-fished (SAFMC 1998b). Information on habitat use, biological attributes, and reproduction is provided for many of these and other species in Table 2 of the EFH Assessment (Appendix E).

3.7.2.5. Spiny Lobster

Spiny lobsters begin their existence in the Florida Keys as larvae that arrive on oceanic currents. As planktonic larvae, they pass through 11 life stages in more than 6 months (SAFMC 1998a). They then metamorphose into a transitional swimming stage (puerulus) (Little and Milano 1980; Lyons 1989) that is found along Florida's southeast coast year-long (Hunt et al. 1991). Pueruli travel through channels between the Florida Keys and enter nursery areas in Florida Bay and the Gulf of Mexico, where they preferentially settle into clumps of red alga *Laurencia* (Herrnkind and Butler 1986). In 7 to 9 days they metamorphose into juveniles and take a solitary residence in the algal clumps for 2 to 3 months (Marx and Herrkind 1986, Hunt et al. 1991).

When juvenile spiny lobster reach a carapace length of 15 to 16 mm, they leave the algal clumps and reside individually within rocky holes, crevices, coral, and sponges. They remain solitary until carapace length reaches approximately 25 to 35 mm, when they begin congregating in rocky dens. They remain in these nurseries from 15 months to 2 years (Hunt et al. 1991).

Adult lobsters move to deeper waters in the coral reef environment, where they occupy dens or holes during daylight hours. They are nocturnal feeders and predominantly prey upon mollusks and crustacea, including hermit crabs and conch. Adults move to offshore reefs to spawn, and larvae are swept to the shallow coastal areas by the

Florida Current, where many are lost during this relatively long process (9 months) (Marx and Herrnkind 1986, Hunt and Lyons 1985; Hunt et al. 1991).

EFH for spiny lobster (*Panulirus argus*) consists of hardbottom, coral reefs, crevices, cracks, and other structured bottom in shelf waters. Juvenile habitat is in nearshore waters and ranges in type from massive sponges, mangrove roots, and seagrass meadows to soft bottom with macroalgal clumps. Spiny lobster has a complex series of planktonic larvae that are transported by small-scale currents as well as the Gulf Stream (SAFMC 1998**a**). At least two life stages (adults and planktonic larvae) occur in the project area. Adult spiny lobster frequently occurs in holes, crevices, and under ledges provided by nearshore and offshore hardbottom habitats in the region. On occasion these adults migrate, walking in groups or single file lines along the open seafloor (e.g, Kanciruk and Herrnkind 1978). Various stages of planktonic spiny lobster larvae are expected to occur in the water column of the project area; mostly in the vicinity of the borrow site where the advective effect of offshore currents would be prevalent. In addition, the Gulf Stream is an EFH because it provides a mechanism to disperse spiny lobster larvae. Areas that meet the criteria for essential fish habitat-habitat areas of particular concern (EFH-HAPCs) for spiny lobster include Florida Bay, Biscayne Bay, Card Sound, and coral/hardbottom habitat from Jupiter Inlet south to the Dry Tortugas, Florida (SAFMC 1998a).

3.7.2.6. Sailfish

Sailfish are distributed worldwide in tropical and temperate waters throughout the western Atlantic from the Gulf of Maine south to Brazil, and including the Caribbean Sea and the Gulf of Mexico. Compared with marlins and swordfish, sailfish are a nearshore species. Sailfish are believed to live up to 10 years and reach a weight of 110 pounds. An important spawning area for sailfish is off the lower east coast of Florida, where fish move inshore to spawn from mid-May through September. Anecdotal evidence suggests that sailfish frequent the St. Lucie shoal area (DoN 2007).

3.7.2.7. Dolphin and Wahoo

Dolphin (*Coryphaena hippurus*) and wahoo (*Acanthocybium solandri*) are oceanic species associated with the western edge of the Gulf Stream, traveling near this edge as they migrate through the project area near the offshore borrow site.

Data suggest that dolphin may be involved in northward migrations during the spring and summer, with occasional movements and migrations controlled by drifting objects in open waters. Spawning, which is poorly documented, is thought to take place in oceanic waters where pairing occurs (Ditty et al. 1994). Based on the occurrence of young dolphin in the Florida Current, spawning may be almost year round (November-July) with peak activity from January through March (Palko et al. 1982). Owing to the oceanic distribution of this species, it is not surprising that both egg and larval stages are pelagic. Upon hatching, this species experiences rapid growth, with both sexes reaching sexual maturity within the first year (Palko et al. 1982). As larvae, they feed primarily on crustaceans, with copepods as the primary prey item. Adult dolphin are opportunistic, top-level predators. They feed upon a variety of fishes (e.g., flyingfish) and crustaceans, especially those species commonly associated with drifting flotsam and *Sargassum* in the Florida Current. As suggested by recreational catches in southern Florida, dolphin are present most frequently from March through August and again from September through February (Palko et al. 1982).

Wahoo occur in tropical and subtropical waters of the Atlantic, Pacific and Indian Oceans including the Caribbean and the Gulf of Mexico. They are short-lived fish and grow rapidly, reaching lengths up to 60.1 inches and weights up to 45 pounds. Both sexes are capable of reproducing during the first year of life, with males maturing at 34 inches and females at 40 inches. Spawning in the United States takes place from June to August. Wahoo are voracious predators that feed primarily on fishes such as frigate mackerel, butterfish, porcupinefish, and round herring.

All life stages (eggs, larvae, juveniles, and adults) of dolphin and wahoo are closely associated with the Gulf Stream and could occur in the project vicinity near the offshore borrow site (Appendix E). 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*.

3.7.2.8. 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 the 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, 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. EFH identified by NMFS (1999, 2009) for coastal shark species is presented in Appendix E.

3.7.2.9. Bluefish

Bluefish are managed by the Mid-Atlantic Fishery Management Council (MAFMC). Due to their wide-ranging nature, bluefish this species is included in this assessment. The following is excerpted from the NMFS website at http://www.nmfs.noaa.gov/habitat/habitatprotection/profile/midatlantic/bluefishhome.htm.

In the Mid-Atlantic Bight, bluefish eggs are found in the open ocean at temperatures 18°C to 22°C and salinities >31.0 ppt. Peak spawning occurs in the evening (Norcross et al. 1974). Eggs in the southern part of the Mid-Atlantic Bight may be advected south and offshore (Norcross et al. 1974).

Larvae in the Mid-Atlantic Bight occur in open oceanic waters, near the edge of the continental shelf in the southern Bight and over mid-shelf depths farther north (Norcross et al. 1974; Kendall and Walford 1979). Larvae spawned in the South Atlantic Bight (spring-spawned cohort) are subject to advection north via the Gulf Stream (Hare and Cowen 1996, Kendall and Walford 1979), but some recruit successfully to estuaries in the South Atlantic Bight (Collins and Stender 1987; McBride et al. 1993).

The transport of pelagic-juveniles was outlined by Kendall and Walford (1979) and elaborated by Hare and Cowen (1996). Many are found in the vicinity of Cape Hatteras as early as April. In May, several have been collected on the shelf in the South Atlantic Bight (Fahay 1975; Kendall and Walford 1979). By June they occur in the Mid-Atlantic Bight between the shore and the shelf/slope front, actively crossing the shelf (Hare and Cowen 1996). In both the South Atlantic Bight and Mid-Atlantic Bight, there is a strong negative correlation between fish size and depth indicating an offshore origin and onshore migration with growth.

Juveniles occur in estuaries, bays, and the coastal ocean of the Mid-Atlantic Bight and South Atlantic Bight, where they are less common. They occur in many habitats, but do not use the marsh surface. Juveniles begin to depart Mid-Atlantic Bight estuaries in October and migrate south to spend the winter months south of Cape Hatteras.

Adult bluefish occur in the open ocean, large embayments, and most estuarine systems within their range. Although they occur in a wide range of hydrographic conditions, they prefer warmer temperatures and are not found in the Mid-Atlantic Bight when temperatures decline below 14-16°C.

3.8. COASTAL BARRIER RESOURCES

The Coastal Barrier Resources Act (CBRA) of 1982 (PL 97-348) discourages development on largely undeveloped coastal barriers along the Atlantic, Gulf, and Great Lakes coasts by prohibiting use of federal expenditures. The CBRA was designed to help conserve important coastal habitats, save federal dollars, and protect human lives. Due to the urbanization and highly developed nature of much of Hutchinson Island, the northern (St. Lucie County) half and southern (Martin County) half of Hutchinson Island is not part of the CBRA.

A portion of the Martin County project lies within “otherwise protected area” (OPA) P11AP which has development protections already (Martin County Bob Graham Beach Park). New construction in OPAs cannot receive Federal flood insurance unless it conforms to the purposes for which the area is protected. No restrictions are placed on other Federal expenditures within an OPA and therefore P11AP is included in the federally authorized project.

3.9. WATER QUALITY

The State of Florida classifies surface waters from I (drinking water quality) to V (industrial water discharge quality). The biological composition of Class V waters is minimal due to the high toxicity of the water. The water quality around the St. Lucie Inlet and Atlantic Ocean has a State of Florida classification of II, which are waters that are acceptable for recreational bathing, fishing, and wildlife management. The predominant issue that affects water quality in offshore waters in south Florida is turbidity, which is 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) and is measured by the intensity of light scattered passing through the water sample.

3.10. HAZARDOUS, TOXIC, AND RADIOACTIVE WASTE

The area along the project shoreline consists primarily of residences and motels and is void of any heavy industry or repair shops. No hazardous or toxic wastes are believed to be in the project area or are knowingly discharged into the waters of the Indian River Lagoon or Atlantic Ocean. However, it is probable that some amount of petroleum byproduct from recreational boats and jet skies is discharged into the coastal waters adjacent to the project beach.

3.11. AIR QUALITY

Martin County lies within the Southeast Florida Intrastate Air Quality Region, as established by 40 CFR Part 81.49. USEPA (40 CFR Part 81.310) designates Martin County as being in attainment with National Ambient Air Quality Standards for ozone, nitrogen dioxide, carbon monoxide; total suspended particulates, and sulfur dioxide that are better than national standards. The EPA has not made a designation for lead in southeastern Florida.

Ambient air quality along coastal Martin County is generally good due to prevalent ocean breezes from the northeast to the southeast. The area consists of single family and multi-family homes, condominium complexes, and large hotels. Coastal development and the popularity of the beaches area all contribute to motorized vehicles and vessels being in the project area at any given time. The project area along the island does not support any heavy industry that could be associated with airborne particulates. Because of the sea breezes that are usually present along the Hutchinson Island shore, airborne pollutants are readily dispersed. This project will not require air quality permits.

3.12. NOISE

Ambient sources of noise within the project area are beach and nearshore recreational activities, breaking surf, boat and vehicular traffic, and noise from adjacent residences. Because Martin 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, which results in more ambient noise along the beach front as well as more boating traffic during the winter tourist season.

During project construction, noise levels in the project area both at the beach fill site and offshore borrow area will temporarily increase. This increase will be associated with construction equipment and vehicles within the beach fill area, pump out equipment in the nearshore area, and hopper dredge operations. Hopper dredge sounds consist of a combination of sounds emitted from two relatively continuous sources: engine and propeller noise similar to that of large commercial vessels, and sounds of dragheads moving in contact with the substrate (Clarke et al. 2003; Thomsen et al. 2009).

3.13. AESTHETIC RESOURCES

Consideration of aesthetic resources within the project study area is required by the National Environmental Policy Act of 1969 (NEPA), as amended and ER 1105-2-100. Aesthetic resources are defined as "those natural and cultural features of the environment that elicit a pleasurable response" in the observer, most notably from the predominantly visual sense. The 4 miles of project area public beaches have been eroded by past high tides and strong winds that have deteriorated the aesthetic character and qualities of the area. The authorized shore protection area is developed commercially and residentially and has been severely eroded. Park seawalls and bulkheads have been exposed due to intense wave action. Residential development appears to be in scale with the existing treeline and blends with it when viewed from a distance. Aesthetic resources of the proposed project area have been degraded annually by shoreline erosion.

3.14. RECREATION RESOURCES

Florida beaches historically have attracted high numbers of visitors and are responsible for a majority of tourism in the state (Pilkey et al. 1984). Martin County beaches are heavily utilized by local residents as well as tourists throughout the year and provide the basis of the tourist industry, which in turn benefits the Martin County economy. To improve public access, Martin County has completed several public access strips with parking along the project area (**Table 3.14-1**) and opened two public beaches, Stuart and Jensen. Recreational activities within the project area include, but are not limited to fishing, snorkeling, scuba diving, surfing, birdwatching, swimming, windsurfing, and boating.

The recreation capacity of the Martin County public beaches have been reduced due to erosion of the barrier island. The eroded beach limits recreational use, especially during high tide when very little dry beach is available for passive and active recreational activities. Public parks have spent a considerable amount of money to enhance and preserve beaches for public use along high energy shorelines.

Martin County's beaches and ocean environment provide many recreational opportunities for residents and visitors (**Table 3.14-1**). The high diversity of fish species in this area supports sport and recreational fishing opportunities, and Martin County is known as the "Sailfish Capital of the World". With the Gulf Stream just offshore, Martin County is considered by many to be a boating and fishing paradise. With more than 20 marinas, a dozen fishing and sightseeing charters, and a variety of bait and tackle shops, Martin County offers an abundance of boating and fishing excursions.

Scuba diving is also a popular recreational activity. Local waterways have many beautiful reefs and colorful marine life. Snorkeling and scuba diving bring out many visitors and residents to the beaches, rivers, and offshore spots. Martin County's Artificial Reef Program now offers over a dozen outstanding sites for fishing and dive exploration, and the number continues to grow.

Table 3.14-1. Public Access Points and Associated Activities along the 4-Mile Project Reach, Hutchinson Island, Martin County, Florida

Public Access	Parking Spaces	Activities/Amenities
Glasscock	40	Fishing, surfing, birdwatching, shelling, dune walkovers
Jensen Beach	316	Fishing, surfing, swimming, birdwatching, shelling, snorkeling, windsurfing, dune walkovers
Bob Graham	70	Diving, fishing, swimming, surfing, snorkeling, birdwatching, shelling, dune walkovers, showers
Alex's Beach	15+	Fishing, swimming, snorkeling, birdwatching, shelling, dune walkovers
Bryn Mawr	27	Fishing, swimming, birdwatching, shelling
Stokes	10	Fishing, swimming, surfing, snorkeling, birdwatching, shelling, dune walkovers
Virginia Forest	26	Fishing, swimming, birdwatching, shelling, dune walkovers
Tiger Shores	31	Fishing, swimming, surfing, birdwatching, shelling, dune walkovers, showers
Stuart Beach	238	Lifeguard, concession, picnic area, restrooms, fishing, surfing, swimming, birdwatching, shelling, snorkeling, windsurfing, dune walkovers, showers, museum

Source: USACE (2005)

3.15. NAVIGATION

Most of the vessel traffic within the Martin County area is associated with recreational boating, fishing, and SCUBA diving. While most of the concentrated vessel traffic is within the Indian River Lagoon and the St. Lucie Inlet, private and chartered fishing boats are common along the nearshore and offshore reefs and shoals.

The proposed borrow areas are located away from commercial shipping routes. Boating in the area is associated mainly with recreational and commercial fishing, including the harvesting of shrimp and scallops.

3.16. CULTURAL RESOURCES

The earliest widely accepted date of occupation by aboriginal inhabitants of Florida dates from around 12,000 years ago. This earliest cultural period, called the Paleo-Indian period, lasted until about 7500 B.C. Sea level was lower and the continental shelves were exposed--an area almost twice the width of the current size of the state. Few Paleo-Indian archeological sites are recorded in Florida, however, two are recorded in the vicinity along the Atlantic coast. These are the Douglass Beach site (8SL17) to the north in St. Lucie County and the Cutler Ridge site in Dade County to the south.

During the Archaic period (ca. 7500 B.C. to ca. 500 B.C.), a wider range of resources was exploited and may have led to a more sedentary existence. Sea level rose to its present position. Few Archaic period archeological sites are recorded in south Florida. Known sites are clustered along the Atlantic and Gulf coasts and inland waterways. Four sites have been recorded in Martin County. Most notable is the Hutchinson Island burial mound (8MT37), a National Register eligible Late Archaic site located to the south of the project area.

The Glades culture sequence (ca. 500 B.C. to A.D. 1513) follows the Archaic in this part of Florida, with the largest number of sites along the coasts. Glades site types recorded by the Florida Master Site File include shell and earth middens and low sand mounds located near the project area.

During the early historic period, beginning with the first Spanish colonial period (1513 to 1763), the Calusa inhabited southern Florida. Other native tribes, the Jaega and the Ais inhabited the Atlantic coast as well. Their population was decimated by European-introduced diseases, warfare, enslavement, and migration out of Florida.

The Miccosukee and the Seminole migrated into Florida in the 18th and 19th centuries from Georgia and Alabama. Throughout the mid 1800s, the U.S. relentlessly pursued a policy of Indian removal in Florida. The Seminole and Miccosukee, resisting removal, eventually established themselves in the Everglades, Big Cypress Swamp, and the Ten Thousand Islands.

American settlement in south Florida began in earnest in the late 19th century and in project area, in the 1880s. The earliest communities in Martin County developed along the west bank of the Indian River where the soils were ideal for pineapple production. In the late nineteenth and early twentieth centuries, the Florida East Coast railway brought new settlers and tourists. Land and agriculture were the economic backbone of South Florida.

In 1926 and 1928, hurricanes demolished the region and recovery from the after effects only began around World War II. By the 1950s, the population of the region had exploded and today Martin County's industry includes cattle, agriculture, commercial and sport fishing and tourism.

The Florida Master Site File at the Division of Historic Resources has recorded three historic properties within the beach renourishment area of the Martin County HSDR project. The Jensen Beach site (8MT2), ineligible for the National Register of Historic Places (NRHP), is a prehistoric shell midden located on the beach. It was initially discovered in the 1950s, was revisited in 1994 (Carr 1995) and was not relocated. It is assumed destroyed and is documented as such in the Florida Master Site Files.

Additionally, two, historic shipwrecks, the *No Name* shipwreck (8MT17) and the *Coszme Calzado* (8MT44), are also recorded along the nearshore of the Martin County HSDR project. They date from the mid-nineteenth and early twentieth centuries, respectively. Both vessels were wooden hulled and remnants, including anchors, ballast, pipes and cables are extant along the nearshore of the project area.

The House of Refuge at Gilberts Bar (8MT27), to the south of the project area, is listed on the National Register of Historic Places (NRHP). This is one of only ten Houses of Refuge built by the U.S. Life Saving Service in 1876 that still exists. Immediately to the south of the House of Refuge, the *Georges Valentine* (8MT21), another twentieth century historic shipwreck, lies just offshore. This shipwreck is also listed on the NRHP.

On February 5, 1980, the State Division of Archives, History, and Records Management and the Heritage Conservation and Recreation Service were notified by letter of the proposed action and their comments requested. Both agencies indicated that the proposed project would not adversely impact any sites listed, or eligible for listing, in the National Register of Historic Places.

For the offshore borrow areas for the Martin County HSDRP, the Division of Historical Resources reviewed the project in accordance with Section 106 of the *National Historic Preservation Act of 1966,* as amended, *36 CFR Part 800: Protection of Historic Properties,* and the *National Environmental Policy Act of 1969,* as amended. In a letter to USACE dated July 20, 2006, it was recommended that the proposed borrow sites, Areas C1-A and C1-B, located offshore of St. Lucie County in the area known as the "St. Lucie Shoal" (DHR No. 2006-3203) be investigated by a professional underwater archeologist to locate known and unidentified shipwreck sites that may be impacted by sand borrowing activities associated with the proposed project. Data from the Florida Master Site Files indicate two documented shipwrecks within close proximity to the proposed borrow areas, the *Halsey* (8SL30) and the *America* (8SL28). The *Halsey*, a shipwreck from 1942, is located approximately 1.5 miles north of area C1-A according to NOAA nautical charts and shipwreck data

Between September 2007 and June 2008, SEARCH conducted an underwater remote sensing survey of four proposed sand borrow areas for shore protection projects in the region. This survey included the borrow area C1-B which is the preferred borrow area for the Martin County HSDRP project. The remote sensing survey used a magnetometer, sidescan sonar, and sub-bottom profiler, integrated with a Differential Global Positioning System (DGPS), to identify any potentially significant submerged cultural resources within these borrow areas.

Results of the survey in the report titled, *Historic Assessment and Submerged Cultural Resources Remote Sensing Survey of Four Borrow Areas for Martin and St. Lucie Counties Shore Protection Projects, Florida* (SEARCH 2008) identified no potentially significant submerged cultural resources with borrow area C1-B. SEARCH also located two previously recorded historic shipwrecks, the *Amazone* (8SL29) and the *Halsey* (8SL30) outside of the project area. SEARCH did not locate the previously recorded *America* Wreck (8SL28) but determined it does not exist in the project area.

3.17. SOCIOECONOMICS

3.17.1. DEMOGRAPHICS

The 2000 census estimated there were 126,731 people residing in Martin County, and the 2007 population estimate was 139,182 people. From April 1, 2000, to July 1, 2007, the population percent change was estimated at 9.8%. Median household income for 2007 was estimated at $55,229. In 2007, approximately 8.5% of the population was living below poverty. In 2006, of the population that was 25 years of age or older, 88.6% had graduated from high school and 29.0% had a bachelor’s degree or higher.

3.17.2. ECONOMICS

3.17.2.1. Tourism

Martin County's economy is largely based on tourism. The tourist dollars brought into Martin County each year account for a large portion of the County's revenue base. Many businesses, particularly along the coast, are tourist-oriented and rely on revenue generated from tourists (http://www.martin.fl.us). Tourist-related taxes collected in Martin County in 2007 were $615,861 (**Table 3.17-1**) (Leigh Goldstein, Marstel-Day, LLC 2008).

Table 3.17-1. Tourism-Related Tax Revenue

Tax Year	Martin County Bed Tax (2%)
2003	$511,465
2004	$629,085
2005	$692,175
2006	$668,563
2007	$615,861

Source: Andreassi (2008)

3.17.2.2. Fishing

East central Florida fisheries are significant in economic (billions of dollars) (Kidlow 2008) and aesthetic value. The commercial fishery landings for St. Lucie and Martin Counties alone were worth $3 to $9 million annually between 1990 and 2007 (Gilmore 2008). In addition to commercial fishing, recreational fisheries, tournaments, and artificial reef programs contribute significantly to the local economy.

Central east Florida coastal counties not only possess significant inshore fisheries (snook, red drum, spotted seatrout, tarpon, sheepshead, gray snapper, stone/blue crab, shrimp, clam/oyster), but also major lucrative coastal and offshore fisheries (sailfish, swordfish, dolphin, king and Spanish mackerel, pompano, grouper and snapper, shrimp, scallop, spiny lobster) (Gilmore 2008). Local fishing tournaments bring competitors from throughout the United States.

The USFWS and U.S. Census Bureau's 2006 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation reported that 2.8 million residents and non-residents age 16 years or older sport-fished in Florida, of which 68 percent were Florida residents. In Florida, anglers 16 years or older spent approximately $4.3 billion on fishing expenses in 2006. Totals include food, lodging, transportation, equipment rental, bait, and cooking fuel. **Table 3.17-2** summarizes total recreation expenditures for fishing in Florida in 2006.

Table 3.17-2. Sport Fishing Expenditures in Florida for State Residents and Non-Residents 16 Years and Older

Expenditure	Cost
Trip-related	$2.0 billion
Equipment	$1.9 billion
Other	$393 million
Total	**$4.3 billion**

Source: USFWS and U.S. Census Bureau 2006

A study was conducted to estimate the net economic value that the natural and artificial reef resources of Martin County provide to the local economy and reef users (Hazen and Sawyer 2004). In 2003, visitors and residents spent 529,000 person-days using artificial and natural reefs in Martin County (person-day = one person participating in an activity for a portion or an entire day). Fishing on the reefs is by far the most prevalent reef-related activity in Martin County, comprising 86% of reef-using person-days. Economic contributions related to the use of artificial and natural reefs in Martin County are summarized in **Table 3.17-3**. In 2003, residents and visitors spent $20 million in reef-related expenditures in Martin County. These expenditures generated $13.1 million in sales in Martin County, which resulted in $5.8 million in income to Martin County residents and provided 182 jobs in the county. Reef expenditures generated indirect business taxes of $856,000.

Table 3.17-3. Economic Contribution of Reef-Related Expenditures to Martin County, Florida, 2003 Residents and Visitors

Type of Economic Contribution	Artificial Reefs	Natural Reefs	All Reefs
Sales, in 2003 dollars (a)	$7,172,000	$5,965,000	$13,137,000
Income, in 2003 dollars (b)	$3,211,000	$2,630,000	$5,841,000
Indirect Business Taxes, in 2003 dollars (c)	$460,000	$396,000	$856,000
Employment (d)	99	84	182

a The sales contribution is defined as the value of the additional output produced in the county due to the reef-related expenditures.

b Total income is the sum of wages, salaries, proprietor's income, profits, rents, royalties, and dividends.

c The indirect business tax contribution is the sum of the additional excise taxes, property taxes, fees, licenses, and sales taxes collected due to the reef-related expenditures. It excludes taxes on profit and income.

d Employment includes the number of full-time and part-time jobs.

Source: Hazen and Sawyer (2004)

To obtain demographic characteristics of the reef users in Martin County, resident and visitor boater surveys were conducted. Results of these surveys are summarized in **Tables 3.17-4 and 3.17-5**. The median age of respondents in Martin County who were resident reef users was 53, and the median age was 53 for visitor reef users. Ninety-six percent of the resident reef users were male and 4% were female. Ninety-two percent of the visitor reef users were male and 8% were female. On average, residents have been boating in south Florida for 22 years, while visitors have been boating only for 5 years. The resident reef user's average boat length is 26 feet. Nearly 20% of the respondents were members of fishing and/or diving clubs. The median household income for resident reef users was $87,500, and $45,000 for visitor reef users.

Table 3.17-4. Residents: Demographic Characteristics and Boater Profile of Resident Reef Users in Martin County, Florida, 2003

Characteristics	Reef-Users	Martin County Population [(a)]
Median age	53	48
Sex:		
Male	96%	49%
Female	4%	51%
Median household income	$87,500	$43,083
Boater profile:		
Average years of residence in Martin County	14	N/A
Average years of boating in South Florida	22	N/A
Average length of boat used for saltwater activities	26 ft.	N/A
Percentage of respondents who belong to fishing and/or diving clubs	19%	N/A
Sample size	272	--

a From the U.S. Bureau of the Census (1999 and 2000)

Source: Hazen and Sawyer (2004)

Table 3.17-5. Visitors: Demographic Characteristics Visitor Reef Users in Martin County, Florida, 2003

Characteristics	Value	Number of Respondents
Median Age of Respondent	53 years	506
Sex of Respondent:		495
Male	92%	--
Female	8%	--
Median Household Income, 2003 Dollars	$45,000	406
Average Years of Boating in Southeast Florida	5	511
Percentage of Respondents Who Own Boat	82%	500
Percentage of Respondents Who Belong to Fishing and/or Diving Clubs	10%	500

Source: Hazen and Sawyer (2004)

4. ENVIRONMENTAL EFFECTS

This chapter is the scientific and analytic basis for comparing and contrasting the alternatives. It includes a discussion of the anticipated changes to the existing environment including direct, indirect, and cumulative effects. **Table 2.2-5** in Section 2 summarizes and compares the effects of the three alternatives considered (Beach Nourishment Using the Offshore Borrow Area C1-B, Beach Nourishment Using an Upland Sand Source, and the No Action Alternative).

4.1. GENERAL ENVIRONMENTAL EFFECTS

4.1.1. BEACH FILL AREA

The beneficial effects of sand renourishment along the proposed project area include establishing a larger buffer area to protect against storms and flooding, and creating additional dry beach for turtle nesting and recreational activities. Beach renourishment will likely increase sea turtle nesting habitat provided the sand is compatible with naturally occurring beach sediments and that compaction and escarpment remediation measures are incorporated into the project.

Potential negative effects to sea turtles include possible destruction of nests deposited within the boundaries of the proposed project during construction, harassment in the form of construction-related disturbance to or interference with female turtles attempting to nest within the construction area or on adjacent beaches, artificial lighting-induced disorientation of hatchlings as they emerge from the nest and crawl to the water, and behavior modification of nesting females from escarpment formation within the project area during the nesting season. Escarpments can cause false crawls or selection of marginal or unsuitable nesting areas to deposit eggs. Additionally, the quality and/or color of the donor sand could affect nesting success as related to the ability of female turtles to excavate a nest, the nest incubation environment, and the ability of hatchlings to emerge from the nest. At the dredging site, the dredge may entrain swimming turtles.

Several protective measures can minimize some of these potential negative impacts. Scheduling renourishment projects outside the sea turtle nesting window provides the most important means of avoiding and minimizing impacts. During construction, daily pre-dawn surveys to locate nests and the relocation of all found nests to a safe hatchery will reduce impacts within the construction area. During 24-hour operations, minimum and shielded construction lighting will reduce turtle avoidance of the beach and false crawl behavior. The use of sand that is similar to the “natural” or “existing” beach considering grain size distribution including a level of “fines” (material passing through a #200 sieve) not exceeding 5% will likely provide a sand suitable for natural nesting, incubation, and hatching behaviors. After construction, beach tilling can reduce sand density to appropriate levels. Likewise, post-construction removal of scarps prior to sea turtle nesting season will allow turtles to crawl up the beach to safe nesting elevations. Annual escarpment and compaction monitoring typically occurs on an annual basis just prior to the sea turtle nesting season for 3 years following construction. A more detailed discussion of reasonable and prudent measures to avoid and mimimize impacts is provided in Section 4.35, Environmental Committments.

The proposed project will likely produce more favorable environmental conditions than exists at present, although construction operations will produce some temporary adverse effects as discussed above. In addition, the presence of construction equipment and personnel will temporarily detract from the aesthetics of the beach. Construction will include best management practices to ensure efficient construction and to minimize the time that equipment and personnel remain on the project area habitats.

Immediately after renourishment, the dredged sand may be darker than the sediments on the existing beach, which may detract from the aesthetics of the beach. However, the natural working of the dredged sediments by sunlight, rain, and wind will lighten the color of the sediments in a relatively short time.

After construction, the beach profile typically undergoes a period of reworking by waves and currents. The beach fill reclines to an “equilibrium profile” within about one year of a renourishment event. Direct burial of shoreline bottom (benthic) habitat would occur within this equilibrium profile. During the first year post-construction there would be a high potential for greater-than-normal erosion of the dry beach along with possible loss of sea turtle nests. Turbidity could be elevated in the nearshore waters during renourishment and as the beach profile equilibrates during the first year post-construction.

Construction activities will result in temporary disturbance to sandy benthic habitats along the nearshore zones in the immediate proximity of construction activities. However, since these sandy beaches and subtidal areas are populated by small, short-lived organisms with great reproductive potential, these communities usually recover quickly from most environmental disturbances such as beach restoration projects (ATM 1991, Taylor Engineering 2009a).

Prior to the initial beach nourishment in 1996, numerous investigations (including sidescan sonar with ground-truthing, aerial photography, and underwater diver-verified reef characterization studies) were conducted along the project reach. These investigations revealed the presence of hardbottom reef tracts consisting of ephemeral limestone outcrops and the marine bristle worm, *Phragmatopoma lapidosa.* These reef tracts were found scattered along the project beach between monuments R-1 and R-25, with the western edge beginning approximately 500 feet seaward of the 1992 shoreline. During initial construction, 1.3 acres of hardbottom habitat located seaward of monument R-22 were directly impacted by the nourished sand sloughing seaward as it sought equilibrium with the ocean bottom. In 2000, construction of 6.0 acres of artificial reefs (A, B, and C) was completed to mitigate for direct impacts to nearshore hardbottom habitat during initial project construction. These 6 acres of artificial reefs are sufficient to offset impacts to any hardbottom reef located between R-1 and R-25, as indicated by USFWS in the Coordination Act Report dated January 24, 1994 (USFWS 1994).

If possible, previously established pipeline corridors will be used to transfer material from the dredge to the beach fill areas (**Figure 2.2-5a, b**). However, because of the ephemeral nature of hardbottom resources in the project area, the exact location of the pipelines will be determined prior to construction to avoid and minimize impacts to hardbottom to the extent possible. Since no hardbottom or archeological resources are located within or adjacent to the borrow area, no impacts are anticipated during dredging operations. A compensatory mitigation plan has been developed to address any additional impacts within the project area.

4.1.2. OFFSHORE BORROW AREA

Dredging at offshore shoals and ridges creates several physical factors that will produce impacts on biological resources associated with these features (CSA International, Inc. et al. 2009). As general categories, these physical factors are:

- Sediment removal;
- Turbidity; and
- Sediment deposition.

Removal of sediments from borrow sites can alter seabed topography, creating pits that may either refill rapidly or potentially cause detrimental impacts for extended periods of time. Immediate losses of infaunal biomass occur and these can affect adjacent areas through food web disturbances at poorly known time scales. If borrow pits are deep, current velocity is reduced at the bottom, which can lead to deposition of fine particulate matter, and in turn, a biological assemblage can be established that is much different in composition than the original. Long-term physical and biological impacts could occur if dredging significantly changes the physiography of the borrow area.

Dredging causes suspension of sediments, which increases turbidity over the bottom. Although turbidity plumes associated with dredging often are short lived and may affect relatively small areas, resuspension and redispersion of dredged sediments by subsequent currents and waves can propagate dredge-related turbidity for extended periods after dredging ends. For sand dredging from offshore shoals for beach nourishment, turbidity plumes are typically minimal, and consequently turbidity effects are expected to be less important in unprotected offshore areas because sand settles more rapidly than clay and silt and offshore shoals tend to be coarser than inshore deposits. In addition, the open ocean environment provides more dynamic physical oceanographic conditions, which minimize settling effects.

Offshore organisms are adapted to sediment transport processes, which create scouring, natural turbidity, and sedimentation under normal conditions. Biological responses to turbidity depend on all of these physical factors, coupled with the type of organism, geographic locations, and the time of year. Turbidity from dredging can affect food availability for benthic organisms. Changes in light penetration and wavelengths due to turbidity can affect visibility and may be detrimental or beneficial, depending in part on whether an organism is predator or prey.

Turbidity can interfere with food gathering processes of filter feeders and organisms that feed by sight as a result of inundation with non-nutritive particles. In addition to altered feeding rates, other biological responses to turbidity include reduced hatching success, slowed growth, abnormal development, tissue abrasion, and increased mortality. Suspension and dispersion processes uncover and displace benthic organisms, temporarily providing extra food for bottom-feeding species.

Suspended sediments settle and are deposited nearby dredged offshore sand borrow sites. The extent of deposition and boundaries of biological impact are dependent on the type and amount of suspended sediments and physical oceanographic characteristics of the area. Deposition of sediments can suffocate and bury benthic biota, although some mobile soft bottom organisms are able to migrate vertically to the new surface.

4.2. VEGETATION

4.2.1. PREFERRED ALTERNATIVE, BEACH NOURISHMENT USING OFFSHORE BORROW AREA C1-B

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

During initial project construction, a vegetation protection plan was developed with specific measures to ensure that unacceptable impacts to the existing vegetation communities would not occur (ATM 1994). These measures should also be followed during subsequent renourishment projects. Specific measures to be undertaken include:

1. No fill will be placed landward of the existing line of woody or scrub vegetation (i.e., sea grapes). The precise landward limit of the fill will depend upon the dune conditions at the time of project construction.
2. A pre-construction consultation with FDEP will be conducted to discuss appropriate measures with respect to protection of the threatened and endangered plants within the beachfill area. Because each plant species is unique, the same approach is not necessarily appropriate for each of the species. Specific measures that may be implemented, upon consultation with FDEP, include field staking of areas containing endangered plants, plant relocation, and buffer zones. In some instances, partial or total burial of certain plants (i.e., burrowing four o'clock) may be the only reasonable construction alternative. On-site consultation with FDEP will determine if such impacts are acceptable.

4.2.2. BEACH NOURISHMENT USING AN UPLAND SAND SOURCE

Effects on vegetation at the beach fill site will be similar to the preferred alternative. Sand from an upland source would be obtained from a commercial quarry. There would likely be some terrestrial vegetation loss at the quarry site in association with the excavation of sand.

4.2.3. NO ACTION ALTERNATIVE (STATUS QUO)

The No Action Alternative would adversely affect vegetation within the project area. Continued erosion of the beach would result in continued loss of vegetated beach and dune habitats. Additionally, continued erosion may cause landowners to implement alternative amoring measures such as seawalls to protect their property. These measures could result in negative impacts to the dune system by altering profile and displacing vegetation.

4.3. THREATENED AND ENDANGERED SPECIES

The mandate of the ESA is to ensure that endangered and threatened species are protected and that government departments and agencies should take all reasonable and prudent precautions to assure that their activities do not jeopardize the continued existence, or destroy or adversely modify the critical habitats, of listed species (Dickerson et al. 2004).

4.3.1. PREFERRED ALTERNATIVE, BEACH NOURISHMENT USING OFFSHORE BORROW AREA C1-B

4.3.1.1. Sea Turtles

4.3.1.1(a). Nesting Habitat

Of the threatened and endangered species found in coastal Martin County, nourishment activities are more likely to impact sea turtles, simply by their ubiquity during nesting season. Martin County lies within the peak nesting range for three species of sea turtles (loggerhead sea turtle, green sea turtle, and leatherback sea turtle) that regularly nest along the beaches of southeast Florida. Hutchinson Island supports one of the highest loggerhead sea turtle nesting aggregations in the western Atlantic (Harris et al. 1984; Hopkins and Richardson 1984; Williams-Walls et al. 1983). 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 2005, 2007). Impacts of a nourishment project on sea turtle nesting habitat are typically short-term because a nourished beach will be reworked by natural processes in subsequent years. Constant wave and current action reworks the beach, reducing sand compaction and the frequency of escarpment formation while the sun bleaches darker sand (USFWS 2005)

<u>Physical Alterations</u>

Physical alterations of the beach due to beach nourishment include changes in sand compaction, density, sheer resistance, color, moisture content, and gas exchange of beach sand (Nelson and Dickerson 1988; Nelson 1991; Ackerman 1991; Ackerman et al.1992). However, the effects of increased sand compaction and scarp formation can be greatly reduced or eliminated through compaction monitoring, mechanical tilling, and beach grading. Compaction monitoring is a state and federal permit that is required immediately following nourishment activities, prior to nesting season commencement, and for 2 years following project completion. Tilling the recently nourished beach is required by state and federal agencies if compaction (using a penetrometer test) exceeds 500 pounds per square inch at any two adjacent sampling stations or depths. Additionally, escarpments greater than 18 inches in height or 100 feet in length must be leveled prior to nesting season commencement.

Effects on Nesting Success

Potential effects of sand renourishment directly related to nesting include destruction of nests deposited within the boundaries of the proposed project, disturbing or interfering with female turtles attempting to nest within the construction area or on adjacent beaches as a result of construction activities, lighting-induced disorientation of hatchling turtles on beaches adjacent to the construction area as they emerge from the nest and crawl to the water, and behavior modification of nesting females from beach escarpment formation during a nesting season that results in false crawls or selection of marginal or unsuitable nesting areas to deposit eggs. The quality of the placed sand could affect the ability of the female turtles to nest, the suitability of the nest incubation environment, and the ability of hatchlings to emerge from the nest.

In general, research has shown that the principal effect of beach nourishment on sea turtle reproduction is a reduction in nesting success during the first year post-nourishment (USFWS 2005). Nesting success is often hindered during this first year following nourishment as a result of escarpments obstructing beach accessibility, altered beach profiles, and increased compaction (USFWS 2007). Research has also shown that the impacts of a nourishment project on sea turtle nesting habitat are typically short-term because a nourished beach will be reworked by natural processes in subsequent years, and beach compaction and the frequency of escarpment formation will decline (USFWS 2005).

The numbers of nests deposited within the study area had generally increased since 1981 (EAI 2005). However, a slight decline in nesting success occurred in 1997, the first year post-construction of the initial 1996 Martin County HSDR Project (Ernest and Martin 1999). After this period, sea turtle reproductive success rebounded to pre-construction levels (Ernest and Martin 2004). Thus, the restoration project effects were limited only to the nesting season immediately following construction.

Loggerhead turtle nesting activity on the renourished beach (Zones Z-EE) was compared to nesting activity on the control beach (Zones K-N) from 1991 through 2005 (EAI 2005). Annual numbers of loggerhead turtle nests and turtle nesting success from 1991 to 2005 are provided in **Figures 4.3-1 and 4.3-2**. Annual nest numbers for 2005 were relatively low on both beaches when compared to the previous 14 years (**Figure 4.3-1**). This is consistent with the overall trend for Florida. Loggerhead nest numbers during 2005 were the second lowest on record for the past 17 years based on Index Nesting Beach Survey data (FWC and FWRI 2006).

During the turtle survey period from 1991 through 2005, the annual number of loggerhead turtle nests and nesting success on both the renourished beach (Zones Z-EE) and control beach (Zones K-N) exhibited similar annual fluctuation patterns (**Figures 4.3-1 and 4.3-2**). This similarity in nest fluctuations between the project and control beach was evident during both the baseline years (1991 to 1995) and following the 1996 initial renourishment event (EAI 2005). Both the project beach and control beach experienced a high number of loggerhead turtle nests in 1995 and 2000, with nests at the project beach exceeding nests at the control beach. A slight decline in nest numbers began in 1996 at the project beach and continued until 1999 (**Figure 4.3-1**). This period of decline may have coincided with the initial beach nourishment in 1996; however, the decline may also be unrelated to the nourishment since the control beach also experienced a very pronounced decline in 1997 (EAI 2005). A decline in nest numbers began in 2001 at both the project beach and control beach, suggesting that factors other than the partial renourishment events in 2001 and 2002 likely affected the number of loggerhead turtle nests (EAI 2005).

USFWS has jurisdiction over sea turtles on the beach (nesting adults, incubating eggs, and hatching young). For projects located from Brevard to Broward Counties, USFWS requires that nourishment activities not be conducted during the peak nesting season from May 1 through October 31 to minimize the impact to nesting sea turtles. In addition, USFWS requires that sea turtle nests be monitored and relocated between March 1 and April 30 if nourishment activities are conducted during that period. The 2010 USFWS Biological Opinion contains specific terms and conditions that must be complied with to minimize impacts to sea turtles during project construction (see Section 4.35, Environmental Commitments). These protective measures and the use of beach-compatible sand sources help ensure the continued existence of suitable nesting habitat for sea turtles without jeopardizing the existence of the species.

Beneficial Effects

USFWS biological opinions for similar projects acknowledge 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 2005).

For the 2012 event, USACE is proposing alternate berm templates designed to allow the beach to equilibrate more rapidly to further minimize sea turtle nesting impacts. In a recent report prepared for FDEP, assessments of alternative construction templates for beach nourishment projects were evaluated to better identify aspects of traditional beach nourishment projects that negatively or positively impact sea turtles and provided recommendations for alternative design criteria that may improve the quality of nesting habitat (PBS&J and EAI 2007). The goal of the experiment is to design an alternative construction template that more closely mimics a natural beach profile, improves the quality of the built beach as sea turtle nesting habitat, and provides an acceptable level of shoreline protection. A conceptual alternative design template is provided in **Figure 2.2-6**.

Summary

Since the proposed project would use sand with characteristics very similar to the native beach sand, sand quality will not likely have negative effects on sea turtle nesting or hatchling emergence. However, beach nourishment along the project reach may still have negative effects on nesting sea turtles (from nesting disturbance, sand compaction, potential for scarp formation, artificial lighting) during the first post-construction year. As natural processes rework the nourishment area and the beach equilibrates, the increase in beach area provided by nourishment will likely have a long-term benefit on sea turtle nesting.

This page intentionally left blank.

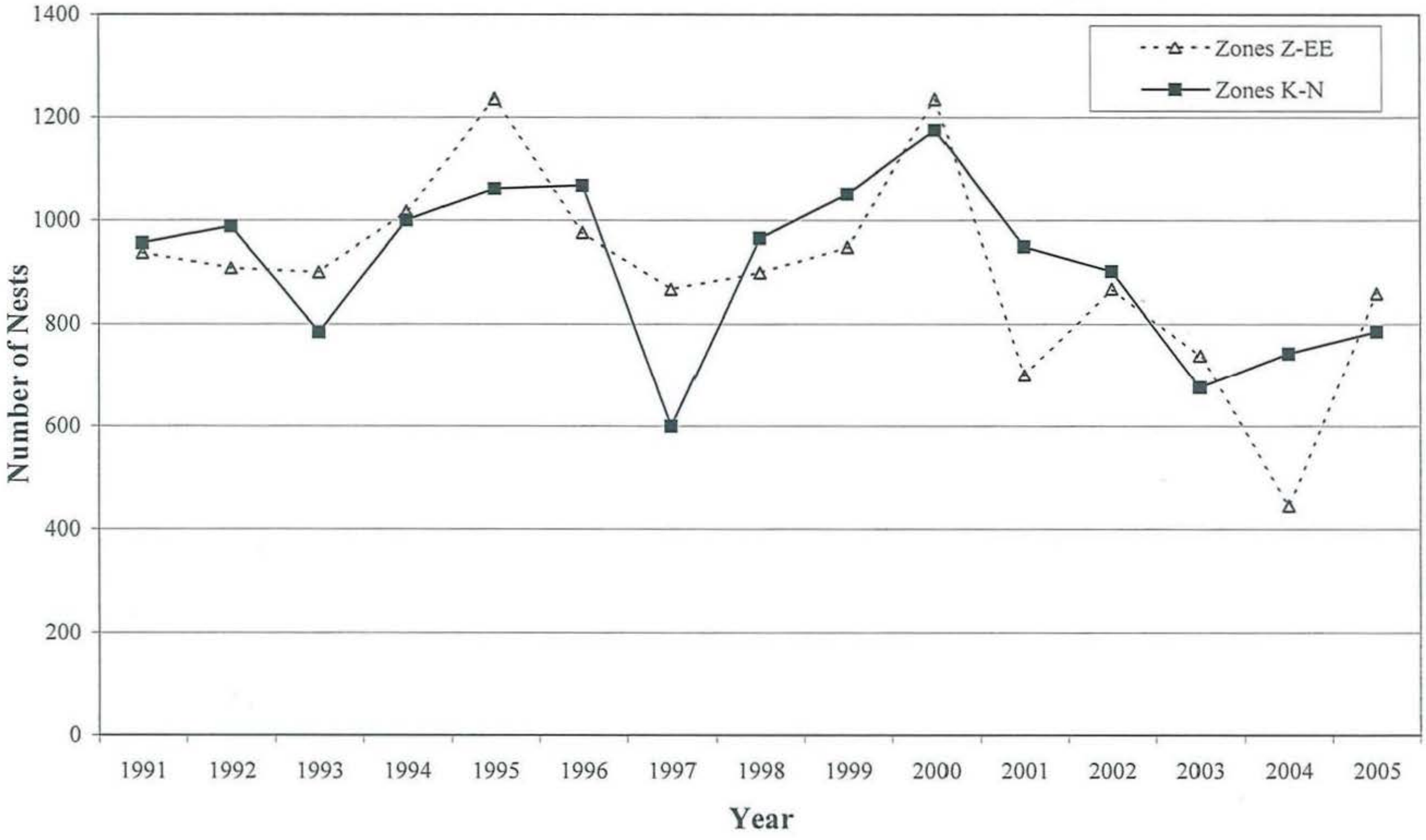


Figure 4.3-1. Annual numbers of loggerhead turtle nests along six kilometers of beach (Zones Z-EE) within the 2005 Martin County Beach Renourishment Project and four kilometers of control/natural beach (Zones K-N). The Martin County Beach Renourishment Project was completed on 30 April 2005 at the beginning of the 2005 loggerhead nesting season. Zones Z-EE were first nourished just prior to the 1996 nesting season so 1991-1995 represent baseline years. Portions of Zones Z-EE were renourished just prior to the 2001 and 2002 nesting seasons.
Data Source: EAI 2005.

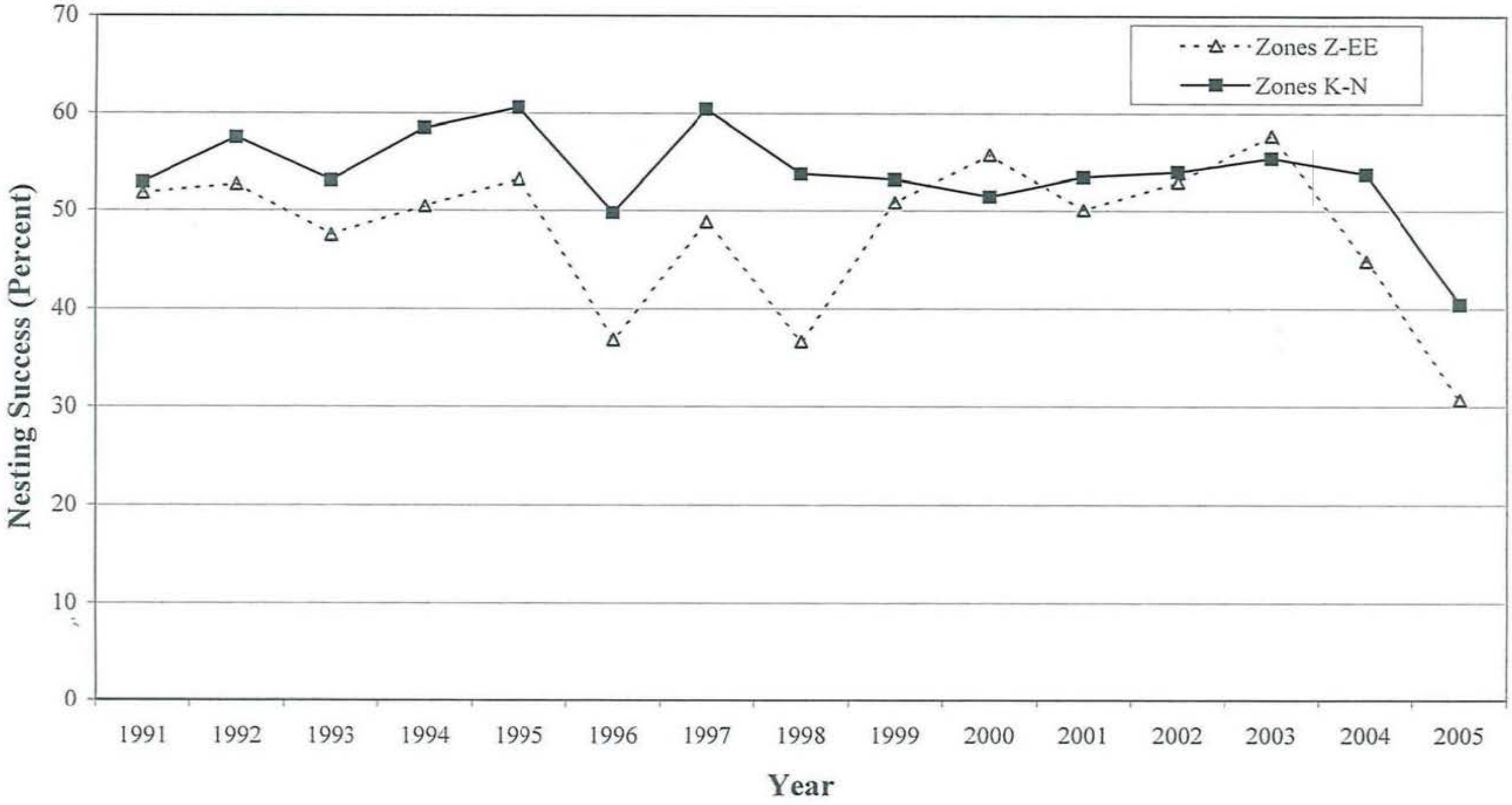


Figure 4.3-2. Annual loggerhead turtle nesting success along six kilometers of beach (Zones Z-EE) within the Martin County Beach Renourishment Project and four kilometers of control/natural beach (Zones K-N). The Martin County Beach Renourishment Project was completed on 30 April 2005 at the beginning of the 2005 loggerhead nesting season. Zones Z-EE were first nourished just prior to the 1996 nesting season so 1991-1995 represent baseline years. Portions of Zones Z-EE were renourished just prior to the 2001 and 2002 nesting seasons.
Data Source: EAI 2005.

4.3.1.1(b) Inner Shelf Habitat

Juvenile and subadult loggerhead, Kemp's ridley, and green turtles use central east Florida inner shelf waters as developmental habitat, foraging on benthic organisms primarily on inner-shelf hardbottom habitats (Hammer et al. 2005). Impact-producing factors (IPFs) associated with the beach nourishment along the project reach using material from borrow area C1-B that may potentially affect sea turtles include:

- Vessel traffic
- Entrainment by hopper dredge dragheads
- Alteration of nearshore hardbottom habitat
- Foraging
- Turbidity
- Underwater noise from dredging equipment

Vessel Traffic

Dredge, dredge support, and construction vessel traffic associated with this project gives rise to a chance of collision between these vessels and sea turtles. The risk would vary depending upon location, vessel speed, and visibility. As discussed in Section 3.3.1.2, all life stages (hatchling, juvenile or subadult, and adult) may occur within the project area. During the hatching season, it is believed that hatchling turtles leave their nesting beaches and swim offshore to areas of water mass convergence. A moving vessel may 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 will comply with the "Sea Turtle and Smalltooth Sawfish Construction Conditions" (NOAA Fisheries 2006) and "Vessel Strike Avoidance Measures and Reporting for Mariners" issued by NOAA Fisheries, Southeast Region. The dredge vessel will be manned with trained and NMFS-approved protected species observers, and dredge support vessel operators and crews will be instructed to maintain a vigilant lookout for turtles during offshore transits and maneuvers. Despite these precautions, turtles may 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. It is assumed, however, that a collision between a sea turtle and moving vessel is unlikely. Adult, subadult, and perhaps juvenile turtles are capable of avoiding moving dredge related vessels, especially when these vessels operate within these limited areas at slow to relatively slow speeds. Impacts from collisions are, consequently, not likely to adversely affect marine turtle populations within the project area.

Entrainment by Hopper Dredge Dragheads

Incidental takes of sea turtles have been documented from hopper dredge operations that use trailing suction dragheads (NMFS 1997). However, numerous methods have been implemented to reduce the number of turtle takes during hopper dredge operations, including special turtle deflecting hopper dredge dragheads, relocation trawling, dredging windows, and the use of trained protected species observers during dredging operations (NMFS 1997). All recommendations of the 1997 NMFS Regional Biological Opinion (RBO) for hopper dredging operations will be implemented to ensure that incidental take is minimized, and the environmental window for hopper dredging within the southeastern United States as recommended by NMFS (December 1 through March 31) will be adhered to. Environmental windows (periods when dredging is allowed) for turtle protection generally involve winter months when sea turtle abundances are known to be low.

The sea turtle deflecting draghead is required year-round for all hopper dredging projects in Southeast Florida. For offshore borrow area dredging projects in southeast Florida, the 1997 RBO also recommends 100% inflow screening and 100% outflow screening. If conditions prevent 100% inflow screening, then inflow screening can be reduced, but 100% outflow screening is required along with a justification for the change noted in the preliminary dredging report. Preliminary dredging reports that summarize the results of the dredging and note any sea turtle takes must be submitted within 30 working days of completion of any given dredging project. Logs will be maintained of any sea turtle injuries or deaths caused by hopper dredging activities, with immediate notification to USACE, Jacksonville District and NMFS.

Relocating sea turtles away from dredging sites is another management practice developed by the USACE Engineer Research and Development Center (ERDC) and recommended by NMFS in the Gulf Regional Biological Opinion (GRBO) as a potential method to reduce incidental takes (NMFS 2003). Modified shrimp trawling equipment is used to sweep bottoms to remove turtles that might be encountered by an approaching dredge and relocate captured sea turtles 3 to 5 miles from the dredging area (Dickerson et al. 2007). However, relocation trawling can severely impact hopper dredging schedules, inflate project costs, and be potentially hazardous for the threatened and endangered species intended for protection due to the rigors and stress of trawling and on-deck handling (Dickerson et al. 2007). This method of sea turtle protection is typically held as a last resort due to the high financial costs, logistical difficulties, and safety risks required to undertake such efforts (Dickerson et al. 2004). Due to these potential impacts, it is important to fully evaluate the pros and cons of this technique as a mitigation tool.

Alteration of Nearshore Hardbottom Habitat

Impacts to juvenile sea turtle species from the proposed project due to the loss of developmental nearshore habitat (hardbottom) will depend on the extent of buried nearshore hardbottom within the project area and the longevity of that burial (before currents disperse the sand). The project will displace juvenile turtles (i.e., prevent them from using these areas) as long as macroalgae and seafloor structure are covered by project sand.

Between the St. Lucie/Martin County line and the St. Lucie Inlet, there are approximately 150 acres of nearshore hardbottom communities, of which, approximately 80% are of the sabellariid worm reef type (ATM 1991). During initial project construction, nearshore hardbottom was impacted and nearshore artificial reef was created within three separate sites totaling 6 acres and located approximately 900 feet offshore monuments R-12, R-18, and R-20 to mitigate for impacts. These reefs were constructed over the summer of 2000 using steel and concrete components of the dismantled Evans Crary bridge. These reefs were monitored annually from 2002 to 2006 and copies of the reports are provided in Appendix G. Overall, the results indicate that these artificial reefs have become an active living artificial reef community and are used by both fish and benthic organisms (Harris 2006). Since the same template will be used for future nourishments, no additional impacts to nearshore hardbottoms within the ETOF are anticipated; therefore, no additional mitigation for these resources is proposed. However, a contingency mitigation plan has been developed by Martin County and details how unanticipated impacts would be compensated.

Foraging

During project construction, foraging activities of juvenile sea turtles may be temporarily impacted in the immediate vicinity of construction activities (i.e., pipeline placement and beach fill deposition). These impacts would be short-term and restricted to the immediate vicinity of the activity. Foraging sea turtles would most likely be displaced to adjacent areas of nearshore hardbottom or farther offshore.

Foraging activities of juvenile sea turtles are also affected by direct burial of hardbottom habitat. Studies by Dr. Llewellyn Ehrhart and his students at the University of Central Florida show that some nearshore reefs provide important developmental and foraging habitat for juvenile turtles (http://www.cccturtle.org). The potential exists for long-term secondary impacts to hardbottom communities adjacent to the ETOF resulting from sedimentation and/or chronic turbidity. Secondary impacts to sea turtle foraging habitat could include reductions in photosynthetic rates of macroalgae and potential burial of macroalgal species. Overall, secondary impacts to the foraging habitat of green sea turtles adjacent to ETOF should be minimal. However, there is concern that the recurrent burying of these nearshore habitats could potentially result in cumulative harmful impacts to sea turtles and numerous fish species.

Dredging activities at the borrow site can reduce food availability both by removing potential food items and altering the benthic habitat (NMFS 1996). These effects would be temporary, as benthic populations within these softbottom habitats would be expected to recover over a period of months to years, depending on the grain size and stability of subsurface sediments exposed after dredging (Hammer et al. 2005). In addition, borrow sites represent only a small portion of this type of benthic habitat available in the study area. Additional information on impacts to benthic resources is discussed in Section 4.5.1.2.

Turbidity

Several activities during construction will affect water quality, including dredging and sand placement on the beach face, producing turbidity at the borrow site and along the shoreline. The limited extent and short duration of the reduced water clarity and implementation of proper design and Best Management Practices (BMPs) are expected to reduce the magnitude and extent of temporary impacts of project activities.

Therefore, any potential impacts on sea turtles are considered negligible and therefore not likely to adversely affect sea turtles within the project area.

Underwater Noise from Dredging Equipment

Little is known of how turtles may respond to noise from offshore activities. In contrast to marine mammals, relatively little is known about sea turtle 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 but rather is structured for 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).

It is likely that sea turtles could 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 be short-term behavioral changes such as evasive maneuvers, disruption of activities, or short-term departure from the area. Impacts are considered negligible and therefore not likely to adversely affect sea turtles within the project area.

4.3.1.2. Marine Mammals

Potential impacts from dredging operations in the borrow area that may affect marine mammals (including endangered, threatened, and non-threatened species) offshore include:

- Vessel traffic
- Turbidity
- Underwater noise from dredging equipment

Vessel Traffic

Dredge, dredge support and construction vessel traffic associated with the project gives rise to a chance of collision between these vessels and listed marine mammals. The risk would vary depending upon location, vessel speed, and visibility. As discussed in Section 3.3.2, North Atlantic right whales may be present 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, it is anticipated that they will 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 not likely to occur within the project area.

Marine mammals are unlikely to be physically injured by dredging *per se* because they generally do not rest on the bottom and most can avoid contact with dredging vessels and equipment (Hammer et al. 2005). However, physical injury from vessel strikes as the dredge and support vessels travel to and from the borrow area is a concern, particularly for the North Atlantic right whale and humpback whale. Right whales are particularly susceptible due to their surface resting and slow swimming habits. Vessel strikes account for the largest number of confirmed right whale deaths (Zani et. al 2008). According to the NMFS Large Whale Ship Strike Database, as of 2004, North Atlantic right whales were the fourth most commonly struck whale species in the world. The region comprised of the southeast United States and Caribbean had the fifth highest number of vessel strikes on all whale species in the world and was the leader in vessel strikes for all of North America. When speed was recorded for individual vessel strike events, the most common vessel speed was 13 to 15 knots. Substantially fewer strikes occurred for vessels traveling at speeds less than 10 knots (Jensen and Silber 2004); however, the project area is outside of the Early Warning System areas between Brunswick, Georgia, and St. Augustine, Florida, and the Cape Cod Bay and Mid-Atlantic 10-knot speed zones. NMFS published regulations in February 1997 restricting vessel approaches of North Atlantic right whales. These regulations prohibit all approaches within 460 meters of any North Atlantic right whale, whether by boat, aircraft, or other means (NMFS 1998). The project study area does not include right whale critical habitat; therefore, the possibility of encounters with right whales is limited.

Impacts to West Indian manatees are not expected at the beach fill site or the borrow area. Sightings of manatees have been restricted to warm freshwater, estuarine, and extremely nearshore coastal waters (Department of the Navy 2007). West Indian manatees rarely occur in offshore waters, where abundant seagrass and vegetation are not available (Reynolds III and Odell 1991). Manatees are uncommon to rare within offshore waters of the inner shelf. However, they are extremely vulnerable to vessel strikes within inshore waters from transiting vessels. Measures to minimize the potential for vessel strikes of endangered whales and manatees are discussed in Section 4.35, Environmental Committments.

Turbidity

Marine mammals in and near the borrow area may encounter turbid water during dredging. This turbidity could temporarily interfere with feeding or other activities, but the animals could easily swim to avoid turbid areas. Proper implementation of the approved design and construction BMPs should prove effective in reducing the magnitude and extent of impact resulting from project activities. Turbidity generation will cease at the completion of construction. Due to the limited extent and short duration of the reduced water clarity, potential impacts on marine mammals are considered negligible.

Noise

Hopper dredge sounds consist of a combination of sounds emitted from two relatively continuous sources: engine and propeller noise similar to that of large commercial vessels, and sounds of dragheads moving in contact with the substrate (Clarke et al. 2003; Thomsen et al. 2009). Noise levels are not sufficient to cause hearing loss or other auditory damage to marine mammals (Richardson et al. 1995). However, some observations in the vicinity of dredging operations and other industrial activities have documented avoidance behavior, while in other cases, animals seem to develop a tolerance for the industrial noise (Malme et al. 1983; Richardson et al. 1995). The main concern would be that dredging noise could cause avoidance of the dredging area during humpback whale and (especially) North Atlantic right whale migrations (Hammer et al. 2005).

4.3.1.3. Smalltooth Sawfish

IPFs associated with the project that may potentially impact smalltooth sawfish include:

- Turbidity
- Underwater noise from dredging equipment
- Entrainment by hopper dredge dragheads

Turbidity

Several activities during construction will affect water quality. The main source of water quality impacts is borrow area dredging and sand placement on the beach face, which will produce turbidity at the borrow site and along shore. Proper implementation of the approved design and construction BMPs should limit the level and extent of construction-related turbidity. Turbidity generation will 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 are considered negligible.

Underwater Noise from Dredging Equipment

In general, the sources and levels of underwater noise generated during the project are expected to be short term and cause only negligible impacts on smalltooth sawfish. Smalltooth sawfish that may visit the project area during the construction period are likely move away from or avoid disturbance caused by construction activities. These temporary avoidance behaviors are expected to incur negligible impacts on smalltooth sawfish.

Entrainment by hopper dredge dragheads

The smalltooth sawfish normally inhabits shallow waters (10 meters or less) 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 2006). There is a small risk of sawfish being entrained in the hopper dredge draghead, as sand is being extracted from the borrow area. To reduce the risk of impacts from dredging and vessel strikes, the project will comply with the "Sea Turtle and Smalltooth Sawfish Construction Conditions" (NOAA Fisheries 2006). Entrainment risks will be minimized through mitigation measures that include the use of sea turtle deflecting draghead deflector which would also assist with deflecting smalltooth sawfish.

These activities may affect, but are not likely to adversely affect, smalltooth sawfish individuals in the project area. Smalltooth sawfish that may visit the project area during the construction period are likely to be displaced by disturbance from ongoing activities. These disturbances may result in temporary movement or avoidance of the area.

4.3.1.4. Piping Plovers

Wintering grounds for piping plovers 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 renourishment construction phase, there may be some displacement of foraging and resting birds including piping plovers. This displacement is expected to be short-term, and habitat exists north and south of the project area with similar characteristics that may be used by displaced species while construction activities are ongoing.

Birds that use the beach for nesting and breeding are more likely to be affected by beach nourishment than those that use the area for feeding and resting during migration (USDOI/MMS 1999). Piping plovers may be displaced by dredges, pipelines, and other equipment along the beach, or may avoid foraging along the shore if they are aurally affected (Peterson et al. 2001). 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 in the sand (Greene 2002). Fine sediment that reduces water clarity can also decrease the feeding efficiency of birds (Peterson et al 2001).

Direct impacts to piping plovers from project construction are expected to be minimal as birds are motile and can avoid construction activities. The disposal of sand on the beach may temporarily interrupt foraging and resting activities of shorebirds that utilize the project beach area. This interruption would be limited to the immediate area of disposal and duration of construction. The prey base for many shorebirds, which includes the benthic organisms mentioned in Section 3.5.1, would be temporarily reduced in the project area. This impact would be short-term as recovery of beach infauna is expected within 1 year after sand placement.

Piping plovers are protected by the Endangered Species Act of 1973, the Florida Threatened and Endangered Species Act of 1977, and the Federal Migratory Bird Treaty Act of 1918. The Atlantic coast population of the piping plover was listed as a threatened species in 1985. To prevent impacts to piping plovers during construction, the project would be constructed in compliance with the USACE-Jacksonville district-wide migratory bird protection policy. Complete migratory bird protection specifications for contracts can be found at the following website: http://www.saj.usace.army.mil/Divisions/Planning/Branches/Environmental/Protection_Environment.htm.

4.3.2. BEACH NOURISHMENT USING AN UPLAND SAND SOURCE

The material obtained from an upland source would be beach-quality sand of similar grain size to the native beach sand. It is not expected that the upland sand itself would be detrimental to nesting sea turtles or emergence success. However, the other potential impacts previously discussed with respect to nesting success and physical alterations of the beach (i.e., sand compaction, potential for scarp formation, artificial lighting effects, etc.) would still apply.

4.3.3. NO ACTION ALTERNATIVE (STATUS QUO)

Under present conditions, the shoreline is expected to continue to erode. Sea turtles would be affected by the No Action Alternative because the eroding beach continues to reduce sea turtle nesting habitat.

4.4. HARDGROUNDS

4.4.1. PREFERRED ALTERNATIVE, BEACH NOURISHMENT USING OFFSHORE BORROW AREA C1-B

IPFs associated with the project 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

Distribution of hardbottom in the project area is patchy and likely ephemeral in nature (CSA 2011). Hardbottom burial and exposure result from a variety of factors, including natural processes such as longshore sediment transport (shore-parallel), cross-shore sediment transport (shore-perpendicular), storms (i.e., northeasters and hurricanes), shifting shoals, and anthropogenic activities such as beach nourishment. Storms erode and deposit sand throughout the intertidal and nearshore areas, perpetually exposing and burying hardbottom in the process. As a variety of forces cause continual transport of sand through the nearshore littoral zone, hardbottom burial, whether direct or secondary, man-made or natural, is often ephemeral (Stites et al. 2007). Regardless of beach nourishment activities, annual differences in storm intensity, duration, and frequency greatly influence the amount of hardbottom exposure. Therefore, re-exposure of nearshore hardbottom may likely occur due to high-energy dynamics of the area and downdrift and cross-shore erosion of fill material after equilibration of beach fill.

The extent of impacts to nearshore hardbottom from this project depends on depth of burial, sand characteristics, and duration of coverage. However, despite numerous beach nourishment projects, little is know about sedimentation effects, especially on coral reef or other hardbottom communities located in immediate proximity (Peterson and Bishop 2005). Ephemeral hardbottom in this area is characterized by high turf, macroalgae, hydroids, bryzoans, sponges, tunicates, and wormrock (CSA 2011). Beach nourishment activities associated with the Martin County HSDR project may directly bury nearshore hardbottom habitat within the beach design template that provide a habitat for fish, juvenile green sea turtles, and invertebrates and may have secondary impacts on adjacent (waterward and downdrift) hardbottom habitat. Burial of nearshore hardbottom would result in a local reduction of macroalgae and invertebrates that could potentially modify the nearshore food web. Sponges seem to survive burial for longer durations and hydroids and bryzoans rapidly colonize exposed substrate

(Lybolt and Tate 2008). Therefore, these organisms will likely re-colonize re-exposed substrates in the same fashion they colonize any previously buried hardbottom. At a beach nourishment project site in Florida, Lindeman and Snyder (1999) observed dramatic decreases in fish species and numerical abundance of individuals following the burial of nearshore hard bottom. The number of species detected 12 months prior to and 15 months after burial decreased by nearly one order of magnitude, from 54 to eight species (Lindeman and Snyder 1999). At several other beach nourishment projects in Florida, added sand was documented to redistribute offshore from the beach via cross-shelf currents, covering hard bottom habitat (Marsh and Turbeville 1981; Continental Shelf Associates 2002b).

Impacts hardbottom resources within the 1996 ETOF have been previously mitigated; therefore, no additional mitigation is proposed for the fill area. There was concern that sand would gradually erode from the project beach and flow south with the longshore current and impact as much as 20.5 acres of hardbottom habitat south of the project area between monuments R-23 and R-42. This southern transport of sand represents a potential secondary impact to these hardbottom structures and associated flora and fauna. However, because of the dynamic physical oceanographic conditions that currently exist in the nearshore environment and the resiliency of the hardbottom habitat along the shoreline, USACE does not anticipate that significant adverse impacts will occur south of the project area from the beach renourishment project. This conclusion is based in part on results from a recent baseline survey conducted on hardbottom resources that occur within and downdrift of the proposed project area. A long-term study was conducted to evaluate hardbottom exposure in the project area (R-1 to R-25) and downdrift of the project site (R-25 to R-30) (Stites et al. 2007; Taylor Engineering, Inc 2009a) (Appendix H). Analysis of the downdrift areas found similar consistency in exposed hardbottom acreage (**Table 3.4-1**), with exposed hardbottom acreage and distribution differing little between 2001, 2004, and 2008. Therefore, USACE does not anticipate that additional mitigation would be required for hardbottom habitat south of the project area. However, post-construction monitoring will occur and a contingency mitigation plan has been developed by the Sponsor that would compensate for any secondary or indirect impacts due to burial that may occur downdrift of the project area or outside of the ETOF that have not been previously mitigated for. The final amount of mitigation for unanticipated impacts, if any, will be evaluated based on the post-construction monitoring report.

Alteration of Exposed Nearshore Hardbottom (Pipeline Placement)

Pipeline placement impacts to nearshore hardbottom resources depend on the placement location, size, and duration of sand delivery pipelines within the project area. If possible, previously established pipeline corridors will be used to transfer material from the dredge to the beach fill areas. However, the exact location of the pipelines will be determined prior to construction to make sure no hardbottom resources are present. The 3-foot-diameter pipelines may be collared to minimize contact with the ocean bottom; therefore, potential impacts to hardbottom would be limited to shading of benthos immediately under the pipeline and crushing of biota beneath the support collars. Shading will have the greatest impact on photosynthetic organisms (e.g., macroalgae).

Potential impacts by shading are considered minor as microalgae recolonizes quickly. Anchors or spuds will be located entirely in sand bottom. Daily monitoring of all pipelines to shore will be performed to check for sand movement and leaks. Continuous leak monitoring will be required of the dredging contractor through fluctuation in pressure through the pipelines. Implementation of proper design and BMPs is expected to reduce the magnitude and extent of impact resulting from project activities; therefore, potential impacts from pipeline placement/removal activities are considered minor and not likely to adversely affect the nearshore hardbottom within the project area.

Turbidity

Several activities during construction will affect water quality. The main source of water quality impacts to nearshore hardbottom is sand placement on the beach face, which will produce turbidity at the beach sand placement site and adjacent waters. Impacts to nearshore hardbottom from turbidity depend on sediment grain size and duration of pumping activities. Finer sediments will have a longer suspension time compared with coarser sediments. Increased turbidity in nearshore waters would result in temporary shading of photosynthetic organisms (e.g., macroalgae), siltation of sessile organisms, and potentially cause interference to suspension feeders. The sabellariid polychaete, *Phragmatopoma lapidosa,* is able to tolerate high levels of turbidity and can survive direct burial for limited periods of time. Because of the resiliency of the hardbottom habitat (being periodically exposed, buried, and re-exposed) in this area, it is likely that these organisms would be able to survive in highly turbid conditions that may be temporarily present during beach renourishment. Since the duration of the construction activity is anticipated to be relatively short, the potential impacts from turbidity are considered minor.

4.4.2. BEACH NOURISHMENT USING AN UPLAND SAND SOURCE

Impacts to nearshore hardbottom habitat from using an upland sand source will be the same as using as an offshore sand source because the design footprint is the same.

4.4.3. NO ACTION ALTERNATIVE (STATUS QUO)

With the No Action Alternative, no excavation, suspension/dispersion, or deposition of sediment will occur as a result of dredging. Therefore, no impacts on the nearshore environment, offshore borrow area, or any of their associated resources are anticipated.

4.5. WILDLIFE RESOURCES

This section discusses potential direct and indirect impacts of each alternative to birds, benthic assemblages, and marine mammals at the beach fill site and offshore borrow area, as applicable. Impacts to fish are discussed in Section 4.6, Fish and Essential Fish Habitat.

4.5.1. PREFERRED ALTERNATIVE, BEACH NOURISHMENT USING OFFSHORE BORROW AREA C1-B

IPFs associated with the beach nourishment along the project reach using material from borrow area C1-B that may potentially affect fish and wildlife resources include:

- Alteration of bird foraging and nesting habitat related to dredging and construction activities
- Disturbance of the sand bottom habitats and associated benthic communities of the borrow area and beach fill site during nourishment activities
- Effects of dredging activities on non-threatened marine mammals

4.5.1.1. Shorebirds and Migratory Birds

Potential Effects

A large number of avian species including, but not limited to, sanderlings, gulls, terns, plovers, and skimmers forage, winter, and/or breed along Hutchinson Island. While coastal development has reduced important beach habitat for a number of avian species, (USACE 1998), beach nourishment can restore beach habitat for many nesting shore birds (Greene 2002). However, during the beach renourishment construction phase, there may be some displacement of foraging and resting birds as well as small mammals and reptiles that use the project area. This displacement is expected to be short-term, and ample areas exist north and south of the project area with similar characteristics that may be used by displaced species while construction activities are ongoing.

Birds that use the beach for nesting and breeding are more likely to be affected by beach nourishment than those that use the area for feeding and resting during migration (USDOI/MMS 1999). Birds may be displaced by dredges, pipelines, and other equipment along the beach, or may avoid foraging along the shore if they are aurally affected (Peterson et al. 2001). Sand placed on the beach has the potential to crush eggs, hatchlings, and adult birds (USDOI/MMS 1999). If the sediment is too coarse or high in shell content, it can inhibit the birds' ability to extract food particles in the sand (Greene 2002). Fine sediment that reduces water clarity can also decrease feeding efficiency of birds (Peterson et al 2001).

Direct impacts to shorebirds from project construction are expected to be minimal as birds are motile and can avoid construction activities. The disposal of sand on the beach may temporarily interrupt foraging and resting activities of shorebirds that use the project beach area. This interruption would be limited to the immediate area of disposal and duration of construction. The prey base for many shorebirds, which includes the benthic organisms mentioned in Section 3.6.2, would be temporarily reduced in the project area. This impact would be short-term as recovery of beach infauna is expected within 1 year after sand placement. In addition, shorebirds usually take advantage of the opportunity to forage on borrow area infauna as the sand from the borrow areas is pumped onto the beach. After the initial construction, re-colonization of dune grasses and other beach vegetation will provide additional refuge and foraging opportunities to birds and other wildlife.

The Martin County nearshore waters are naturally turbid because of the highly dynamic physical conditions present in the area. Organisms inhabiting this shoreline must be readily adapted to these turbid conditions in order to successfully survive. Therefore, elevated turbidity levels from placement of fill material on the beach is not expected to have a significant detrimental impact to such sightfeeders as the brown pelican *(Pelecanus occidentalis)* or other shorebirds, waterfowl, or wading birds.

In general, gulls are likely to be of low sensitivity to the effects of dredging activities as they have a broad diet, are able to use a wide variety of habitats, and are generally less affected by disturbance (Cook and Burton 2010). In fact, dredging activity may attract gulls to an area as bottom sediments are stirred up, releasing benthic organisms into the water column where they can be preyed on by gulls (Tasker et al. 1986; Herron Baird 1990).

Most tern species forage within 10 km of the coast (Becker et al. 1993; Furness and Tasker 2000; Bertolero et al. 2005; Perrow et al. 2006; Rock et al. 2007), hovering several metres above the water's surface, before plunging after prey. Prey species may vary between locations, depending on availability and include fish species such as sandeel and herring (Monaghan et al. 1989; Furness and Tasker 2000; Garthe and Hüppop 2004; King et al. 2009). As they are constrained to a short foraging range, they are highly vulnerable to reduced food availability (Furness and Tasker 2000; Garthe and Hüppop 2004; King et al. 2009). Thus any changes in food availability at a local level could have an impact on populations. As they require clear water for foraging (Essink 1999), terns may thus be particularly sensitive to the turbidity caused by dredging operations and the re-suspension of sediment.

Monitoring Requirments

Bird nesting areas are protected by the Florida Threatened and Endangered Species Act of 1977 and the Federal Migratory Bird Treaty Act in 1918. To prevent impacts to migratory bird species during construction, the project would be constructed in compliance with the Jacksonville District Corps of Engineers district-wide Migratory Bird Protection Policy (USACE 1993). According to USACE policy, should nesting begin within the construction area, a temporary 200-foot buffer will be created around the nests and marked to avoid entry. The area will be left undisturbed until nesting is completed or terminated and the chicks fledge. Complete migratory bird protection specifications for contracts can be found at the following website: http://www.saj.usace.army.mil/Divisions/Planning/Branches/Environmental/Protection_Environment.htm.

In accordance with the JCP permit, monitoring of breeding shorebirds within the project boundaries shall begin on April 1 or 10 days before construction-related activities begin. Nesting surveys shall occur daily throughout the construction period or through August if no shorebird nesting activity is observed. Non-breeding shorebird monitoring within the project boundaries shall begin 2 weeks before construction-related activities begin and occur every 2 weeks for at least 1 year post-construction. Additional information on USACE protection specifications for contracts as related to migratory bird protection is provided in Section 4.35, Environmental Commitments.

4.5.1.2. Benthic Infauna

Brooks et al. (2006) reviewed existing literature on offshore benthic assemblages along the U.S. East and Gulf of Mexico continental shelf. From the few studies available, it appears that general "recovery" from anthropogenic disturbance by offshore benthic assemblages occurs within three months to 2.5 years. However, the authors concluded that presently it is difficult to draw conclusions about approximate recovery benthic faunal times following anthropogenic activities such as sand mining and/or disposal operations because of the paucity of studies.

Impacts within Beach Fill Area

Placement of sand on the beach will result in the burial and subsequent loss of most of the beach infauna. The Hutchinson Island beach area is typical of other sandy beaches that are subject to coastal processes. The biological diversity of the sandy beach is low, but the populations of individual species are often immense. Species found in the project area, such as annelid worms, coquina clams, ghost shrimp, and mole crabs, are highly specialized and adapted to the harsh and dynamic environment. Since these sandy beaches are populated by small, short-lived organisms with great reproductive potential, these communities usually recover quickly from most environmental disturbances such as beach restoration projects (ATM 1991). Several studies have investigated the recolonization of beach infauna following nourishment and found that beach and surf zone populations recover to pre-nourishment levels within 1 year after completion of nourishment (Reilly and Bellis 1983; Gorzelany and Nelson 1987; Hurme and Pullen 1988; Dodge et al. 1991, 1995; Hackney et al. 1996). Hackney et al. (1996) suggest that to help minimize impacts to beach infauna, construction should take place in late fall and winter months to coincide with periods of low recruitment and low biological standing stock, and that sand used should be a close match to native beach sand. However, Lindquist and Manning (2001) have suggested that repeated renourishments in the same project area could continue to reduce the proportion of large adult coquina clams and mole crabs in the population, which could have far-reaching consequences. The sand source for the proposed project is compatible with the existing beach sediments and contains a relatively low silt/clay content (average of 5%), which should promote rapid recovery of beach infauna within 1 year after sand placement. Therefore, impacts to beach infauna are expected to be short-term.

Impacts within Borrow Area

Infaunal invertebrates and any motile macrobenthic invertebrate species will most likely be injured during entrainment as part of the dredging operations. Dredging of offshore borrow areas will result in the loss of benthic organisms, including the arrowhead sand dollar (*Encope emarginata),* which is a common species found throughout the sandy substrate. Sessile and slow-moving invertebrates are at the greatest risk of being removed from the borrow areas, resulting in a reduction in the number of individuals, species, and biomass in the dredged area. These organisms will be impacted by direct removal and burial due to increased turbidity. However, these highly fecund invertebrates are expected to repopulate after dredging activities cease.

Brooks et al. (2006) found in most cases, polychaetes were the first to recolonize dredged or disposal sites, with crustaceans, specifically amphipods, also recolonizing relatively quickly. Some studies notes that carnivores recolonized dredged areas in a short amount of time, speculating that this response may be tied to the food resources available in dredged areas due to dead and injured organisms resulting from the dredging process itself. Measurements of recovery, however, were varied, with some studies looking at general abundance of organisms, and others evaluating community structure. Those evaluating entire communities often indicated that while abundances of organisms may increase to background levels relatively quickly, community structure may remain altered for some time, and, in repetitively mined areas, may have difficulty ever recovering to the original state.

Hammer et al. (2005) identified that potential impacts from dredging within the proposed borrow areas are expected to be localized and short-term because surrounding areas can serve as a primary source for re-colonization of the benthos. Many studies have concluded that the borrow site is fully recovered within 1 year post-dredging, with the taxonomic diversity and density often restored because of the organisms' ability to adapt to their new environment (ATM 1991; Welker 1974; McCauly et al. 1977; Oliver et al. 1977; Goldberg 1988; Deis et al. 1992). Bowen and Marsh (1988) observed recovery to pre-dredging levels of the macroinfaunal communities in a borrow area offshore of Delray Beach, Florida within 1 year of construction. Burlas et al. (2001) monitored borrow sites with bathymetric high points off northern New Jersey and found essentially all infaunal assemblage patterns recovered within 1 year after dredging disturbance except recovery of average sand dollar weight and biomass composition, which required 2.5 years. Based on previous studies, Byrnes et al. (2004) concluded that levels of infaunal abundance and diversity may recover within 1 to 3 years, but recovery of species composition may take longer. Benthic infauna monitoring performed during previous beach nourishment projects in Broward County indicated that, although the borrow areas were rapidly colonized following dredging, individual species recovered at different rates based upon their regeneration time, ability to disperse, and reproductive strategies (Dodge et al. 1995).

Based on the results of these studies, it is anticipated that recolonization of the borrow areas by benthic macroinfaunal species will occur within 1 to 2 years after dredging is completed. Changes in infaunal community structure are anticipated based upon differences in generation time and reproductive strategies of infaunal organisms and these changes may persist for 2 to more than 3 years. Grazers and detritivores that feed upon the macroinvertebrate communities within the proposed borrow areas will be temporarily displaced during dredging activities. If infaunal community structure changes persist for a period of years, short-term impacts to selective bottom feeders may also occur due to loss of specific prey species within the dredged borrow sites. Van Dolah et al. (1984) suggest that the recovery time for the benthic species may be dependent upon the extent and intensity of active dredging. Infauna recovery is not only dependent upon dredging activities but is reliant on natural variability and temporal changes (Byrnes et al. 2004). Adjacent sandy areas and shoals would provide alternative feeding habitat for grazers and detritivores during infaunal recolonization of the borrow areas. These undisturbed areas that surround the borrow sites would also serve as a primary source of recolonizing fauna for the excavated borrow sites (Van Dolah et al. 1984).

Mining sand from an offshore borrow area can also modify the texture of the sediment or cause the site to become a reservoir of fine sediments and organic material (NRC 1995) while increasing the bottom depth of the borrow site. This can lead to heavily anoxic sediments and to colonization by a community which differs considerably from that in the original deposits (Dickson and Lee 1972; Shelton and Rolfe 1972; Kaplan et al. 1975; Bonsdorff 1983; Hily 1983; van der Veer et al 1985; Hall 1994).

To minimize impacts and promote recolonization of mined areas the total removal of substrate should be avoided (Diaz et al. 2004). Small areas within the borrow site should be left to serve as refuge patches that would promote recolonization and serve as habitat for mobile species. Facilitating rapid recolonization of a mined site by established community members would minimize alteration of community structure and function and reduce potential effects upon trophically dependent fishes (Diaz et al. 2004).

Given that only a relatively small area (125 acres) within the 1000-acre C1-B borrow area will be disturbed per dredging event (interval is estimated to be 13 years) and that the expected recovery time of the affected benthic community after sand removal is anticipated to be less than the dredging interval, the potential for significant cumulative benthic impacts is possible but unlikely. In light of recent studies showing the recovery of benthic communities and the ability of benthic organisms to recolonize, the project is not expected to result in a significant long-term adverse impact on benthic communities at the borrow site.

4.5.1.3. Non-Threatened Marine Mammals

Marine mammals species may alter passage routes to avoid noise from ship traffic or from increased water turbidity during or following disposal activities (Thomsen et al. 2009). Vessel noise and plume impacts to marine mammals are temporary and localized to the immediate vicinity of the borrow area, and are not expected to affect breeding, nursery, or feeding areas for adults or juveniles. Therefore, dredging activities at the borrow area are not likely to adversely affect the marine mammals within the project area.

4.5.2. BEACH NOURISHMENT USING AN UPLAND SAND SOURCE

Impacts to the beach and nearshore habitat associated with placing fill from an upland sand source will be similar to those discussed above. However, there would be no impacts to offshore fish and wildlife habitats if an upland sand source was used. There is potential; however, for impacts to terrestrial wildlife habitat associated with mining the quarry site.

4.5.3. NO ACTION ALTERNATIVE (STATUS QUO)

No adverse impacts to fish are expected under the No Action Alternative. It is probable that maintenance of status quo conditions would result in increased exposure of nearshore rock outcrops as the shoreline continues to erode at its present rate. This could provide increased habitat for surf zone fishes. Continued shoreline erosion would jeopardize the remaining dune habitat along the Martin County shoreline, potentially decreasing the available habitat for migratory birds and dune species.

4.6. FISH AND ESSENTIAL FISH HABITAT ASSESSMENT

The following subsections summarize the direct and indirect impacts of the proposed action and other alternatives on EFH within the beach fill area and the proposed borrow area, federally managed fisheries, and associate species such as major prey species, including affected life history stages. An EFH Assessment has been prepared for this project and is provided in Appendix E.

The Atlantic States Marine Fisheries Commission (ASMFC) is concerned that some fish species may suffer direct mortality, sub-lethal impairment, or degraded habitat (Greene 2002). In March 2003, SAFMC established policies regarding protection of the EFHs and HAPCs impacted by beach dredge and fill activities and large-scale coastal engineering projects. In general, SAFMC found that the array of large-scale and long-term beach dredging projects and related disposal activities constitute a real and significant threat to EFHs under their jurisdiction, and the cumulative effects of these projects have not been adequately assessed (SAFMC 2003b).

Nourishment activities for the original beach nourishment project and future renourishment activities have the potential to directly and indirectly harm fish and wildlife resources. Potential direct impacts of sand dredging to fisheries are virtually unknown, but may include effects from loss of essential habitat and alteration in trophic energy transfer from the benthos to fish populations (Coastal Tech 2007).

4.6.1. PREFERRED ALTERNATIVE, BEACH NOURISHMENT USING OFFSHORE BORROW AREA C1-B

IPFs associated with the project that may potentially affect EFH include:

- Alteration (burial) of exposed nearshore hardbottom and associated epibenthos during and subsequent to nourishment activities
- Disturbance of the sand bottom habitats and modification of the shoal feature at the offshore borrow area
- Turbidity
- Impacts to managed fisheries

4.6.1.1. Nearshore Hardbottom Habitat

Nearshore hardbottom and worm reefs are identified by SAFMC as EFH and HAPC. These reefs help reduce wave energy, stabilize shorelines (Kirtley 1966; Kirtley and Tanner 1968), and provide structural habitat for fish (Gore et al. 1978; Nelson 1989; Lindeman and Snyder 1999). The loss (burial) of nearshore hardbottom habitat will result in impacts to the young stages of several reef fish species that use the nearshore hardbottom habitat including species within the SAFMC Reef Fishes and Spiny Lobster Management Units. Nearshore hardbottom is an important component of the cross-shelf developmental pathways used by many reef fishes (Lindeman et al. 2000). It is expected that juvenile fishes will be displaced (i.e., prevented from using these impacted areas) as long as the associated epiflora, epifauna, and seafloor structure are covered. Re-colonization of re-exposed hard substrates by wormrock and turf and macroalgae is probable as these organisms have high recruitment capability and coverage and re-exposure of hardbottom substrate is a common occurrence in the project area.

Increased turbidity due to suspended sediments in the water column may physically stress fish by clogging their gills and reducing the absorption of dissolved oxygen. Adults can avoid the suspended material by moving out of the area, but juvenile fish may be more vulnerable and susceptible to stress (SAIC 1986).

Hardbottom impacts within the ETOF during initial project construction have been previously mitigated and no additional impacts are anticipated during subsequent nourishment events because the fill template is the same. Since the impacted area a minor portion of the total habitat available for use along the coast of Martin County, the impact to EFH within the beach fill area is considered minor. Therefore, reef fish assemblages are not expected to be signifcanlty adversely impacted within the beach fill area.

4.6.1.2. Nearshore Sand Bottom Habitat

Members of the penaeid shrimps and red drum 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 that are contiguous with the nearshore hardbottom as foraging areas. Since the temporal duration of the nourishment activities associated with the Martin County HSDR project is short (3 to 4 months) and the soft bottom infaunal invertebrate assemblages recover relatively rapidly (forage habitat), impacts to the EFH within the nearshore beach fill site is expected to be relatively minor, and therefore not likely to significantly adversely affect the soft bottom EFH within the project area.

4.6.1.3. Offshore Shoal Habitat

The next renourishment is scheduled for 2012 and requires removal of approximately 787,000 cy of sand from borrow area C1-B. Each nourishment event is expected to impact approximately 125 acres within the 1,000-acre site approximately every 13 years. Borrow area C1-B has relatively less vertical relief than those shoals located within the St. Lucie Shoal complex.

Sand shoals have been identified as 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 and pelagic fish species and motile macrobenthic invertebrates that include categories of spawning, shelter, or foraging (CSA International, Inc. et al. 2009). Recent local studies (Gilmore 2008) have determined that 200 fish species use the sand shoal habitats along southeast Florida. Gilmore (2008) 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, which are important prey for the coastal pelagic fish, dolphin and wahoo, and highly migratory species groups. SAFMC identifies sandy shoals as EFH for migratory pelagic fish, including king mackerel, Spanish mackerel, cobia, and dolphin. Further, anecdotal evidence suggests that this shoal area is biologically unique and diverse, supporting fisheries that are economically and recreationally important, such as the migratory species listed above, sailfish, and prey species consumed by these fishery species. Michel et al. (2001) note that the geomorphology of offshore shoals provide a unique assembly of micro-habitats that facilitate high biological productivity. Removal or modification of the borrow area C1-B shoal feature could impact EFH for multiple SAFMC-managed species groups that use this feature. In addition, multiple SAFMC-managed species groups, both fish and invertebrates, may be impacted during dredging activities withn the borrow area by entrainment including penaeid shrimps, spiny lobster, and red drum species group.

Environmental impact assessments for Outer Continental Shelf mining have predicted that effects from dredging on fish assemblages will be minimal based on the assumption that resident fish are wide-foraging or migratory and spend only a portion of their life cycle at the borrow site (Hammer et al. 1993; Louis Berger Group 1999). Hobbs (2002) proposes that the habitat impacted by dredging will have minimal effects on transitory fish, given the small percentage of the overall geographic range the dredge site represents. However, contrasting opinion suggests that fish (and other secondary production) may be dependent on the areal extent of required habitat(s), and that every unit of loss of habitat function results in a decrease in production (Peterson et al. 2001).

Fish that prey on exclusively non-motile organisms, and fish that are less motile themselves, are anticipated to suffer the greatest effects from dredging (Greene 2002). The degree to which fish that prey on benthic invertebrates are affected depends on the recovery rate of the benthic communities. With the loss of autotrophic and heterotrophic invertebrates, small fish would lose a valuable food source. If full recovery of benthic communities is measured in terms of years and not months as some researchers have asserted, then recovery of predator species would require a similar or greater amount of time (Peterson et al. 2001).

Secondary impacts to fish species may occur as a result of sedimentation/siltation adjacent to borrow areas. Suspension of sediment can cause mortality of eggs and larvae of marine and estuarine fish (Newcombe and Jensen 1996) and feeding reduction in juvenile and adult fish. These impacts would be short-term and limited to the vicinity of the borrow areas and duration of the project.

Numerous benthic organisms and fishes inhabit offshore shoal areas, but specifics regarding species, assemblages, and ecological interrelationships between the topographic features and associated biota are not well known. A 2-year study was conducted on the inner continental shelf of the Middle Atlantic Bight, USA, to compare finfish and invertebrate assemblages at sand shoal and nearby flat-bottom habitats (Slacum, Jr. et al. 2010). Results from this study indicate there was a trend toward greater abundance, species richness, and species diversity in flat-bottom habitats than in shoal habitats, and all of these community measures were generally lower during the winter than in spring, summer, or fall. In addition, among shoals, a trend toward greater abundance at shoals with a steeper grade was evident. Since this study indicated that winter was the period of lowest finfish and invertebrate use of shoal habitat, winter months would be the best time of year for dredging sand to minimize acute impacts.

Potential long-term physical and biological impacts could occur if dredging significantly changes the physiography of shoals (Hammer et al. 2005). The magnitude of such effects is expected to be correlated with the timing, duration, and scale of sand mining activities (Pickett and White 1985). Since only a relatively small area (125 acres) within the borrow area will be disturbed per dredging event (at an estimated interval of 13 years) and the close proximity of similar, relatively undisturbed, adjacent habitat, effects on fish and EFH within the borrow area are expected to be short-term and localized.

4.6.1.4. Managed Fisheries

This section describes more specific details regarding potential effects to specific managed fisheries as a result of beach nourishment using the offshore borrow area C1-B.

Coastal Migratory Pelagics

Coastal migratory pelagic species are migratory water column dwellers; however, most of these species have some affinity for man-made or natural structures. Hardbottom features, sandy bottoms, and shoal areas occurring from the surf zone to the shelf break encompass EFHs for coastal pelagic fishes. EFHs could be affected by turbidity that could alter migratory routes or temporarily disrupt feeding activity in shelf or nearshore waters. Coastal pelagic species such as cobia, jacks, king and Spanish mackerels, round scad, and Spanish sardine could be attracted to a dredge and its attendant structures (Hammer et al. 2005). Loss of shoal habitat is a substantial and long-term effect. The temporal scale of shoal morphology precludes quick recovery for species that are dependent on these types of relief features, including prey of the coastal migratory pelagic complex (Hammer et al. 2005).

Snapper-Grouper Complex

Snapper-grouper EFH/HAPC exists on all hardbottom areas throughout the study area; therefore, effects of attraction, entrainment, and turbidity are possible. Negative effects could be substantial and measures should be taken to protect hardbottom areas and avoid effects to snapper-grouper (Hammer et al. 2005).

Red Drum

Oceanic high-salinity surf zones and artificial reefs are considered EFH/HAPC for adult red drum. However, threats to the red drum's adult habitat are not as numerous as those faced by post-larvae, juveniles, and sub-adults in the estuarine and coastal waters. Threats to the nearshore and offshore habitats that adult red drum utilize include dumping of dredged material and mining for sand. Associated threats with mining sand for beach nourishment projects include burial of bottoms near disposal sites, release of contaminants directly or indirectly associated with mining (i.e., mining equipment and materials), increase in turbidity to harmful levels, and hydrologic alterations that could result in diminished desirable habitat (ASMFC 2002).

Spiny Lobster

Spiny lobster EFH exists in all hardbottom areas throughout the study region. Hardbottom areas meeting spiny lobster HAPC criteria are not found north of Jupiter Inlet. Measures should be taken to protect hardbottom areas and avoid dredging impacts to spiny lobster EFH (Hammer et al. 2005).

Penaeid Shrimp

Effects of entrainment on EFH for penaeid shrimp are expected to be minimal. Van Dolah et al. (1992) estimated the mortality of postlarval shrimp from entrainment to be no more than 1,883 shrimp per day during dredging. Given that one female white shrimp produces 500,000 to 1 million eggs per spawn (Anderson et al. 1949) and natural post-larval penaeid shrimp mortality is estimated at greater than 60% (Minello et al. 1989), the number entrained was considered inconsequential.

Highly Migratory Species

As with coastal pelagic fishes, highly migratory species could be affected by turbidity generated during a dredging project. Turbidity plumes could alter normal migratory and feeding patterns, but these effects would be of short duration. Some highly migratory species could be attracted to a dredge or related structures (Hammer et al. 2005). Effects of dredging are expected to be minimal; however, utilization by sailfish could decrease as a result of shoal removal.

EFH exists throughout the study area for several species and species groups. Effects to the water column, such as turbidity, are expected to be temporary. In addition, BMPs would be employed to monitor and control turbidity in order to minimize unavoidable impacts. Direct effects of entrainment are not expected to be substantial due to the motility of the majority of species involved. Non-motile organisms that serve as prey could be affected.

Díaz-Delgado et al. (2004) predicted that mobile species would be displaced with shoal removal and have to search for replacement habitat. Gilmore (2008) states that removal of a portion of EFH will proportionally reduce fish species that are dependent on EFH, particularly if they are species that typically saturate the habitat. If local shoals constitute EFH for sardines, menhaden, and herring, it must be assumed that their removal will result in reduction of forage fish populations (Gilmore 2008), which in turn could result in a reduction in the various commercial and recreational species, such as mackerel, that depend on shoal forage as a food source. This was a prediction also made by Vasslides and Able (2008). Although there was nothing in the literature surveyed that presented hard comparative data on planktivorous fish on shoals versus artificial reef formations, it is possible that artificial reefs may offer schooling planktivorous fishes an alternative habitat if their natural shoal habitat is removed (Gilmore 2008).

Gilmore (2008) concluded that without some additional *in situ* studies of local sand shoals, it would be difficult to make accurate predictions of the effects of sand-shoal mining on regional fisheries. It is recommended that the targeted shoals off South Hutchinson Island be examined for potential fishery impacts.

4.6.2. BEACH NOURISHMENT USING AN UPLAND SAND SOURCE

Impacts to nearshore EFH (i.e., nearshore hardbottom) will be the same from using an upland sand source as an offshore sand source because the design template is the same. However, there would be no impacts to offshore EFH associated with using an upland sand source.

4.6.3. NO ACTION ALTERNATIVE (STATUS QUO)

No adverse impacts to EFH are expected under the No Action Alternative. It is probable that maintenance of status-quo conditions would result in increased exposure of nearshore rock outcrops as the shoreline continues to erode at its present rate. This could provide increased EFH habitat for surf zone fishes.

4.7. CURRENTS AND CIRCULATION

4.7.1. PREFERRED ALTERNATIVE, BEACH NOURISHMENT USING OFFSHORE BORROW AREA C1-B

The preferred borrow area for this project, C1-B, is a relatively low relief shoal located approximately 6 miles offshore. It lies approximately 3 miles south-southeast of the St. Lucie Shoal complex and has less vertical relief than C1-A and C1-C, which are located directly on the St. Lucie Shoal.

Nearshore Wave Environment

Mining shoals for sand may alter the local wave climate and cause erosion within or in the vicinity of the project area. Hayes and Nairn (2004) conducted an evaluation of the potential impacts from dredging linear shoals in the U.S. Gulf and Atlantic continental shelves and concluded that the deflation of a shoal feature could change wave patterns between the shoal and the shoreline. In turn, such dredging could change sand-transport patterns, both along the shore and across the shore, and change erosion and accretion rates along the shore. Kelley et al. (2004) verified this conclusion in their examination of a borrow site offshore of Martin County (depths were approximately 8 to 10 m) and recommended using wave transformation numerical modeling tools that recognize the random nature of incident waves as they propagate onshore when examining incremental and cumulative changes from sand dredging on the continental shelf. The excavation of a borrow area sufficiently close to shore can focus incident waves on specific regions of the shoreline, increasing the potential for beach erosion in those areas (USACE 2009).

USACE performed a similar analysis that expanded on the study conducted by Kelley et al. (2004) to address the potential impacts and determine if excavating portions of the C1-B borrow area could potentially influence wave refraction patterns across the region, possibly resulting in wave energy focusing and increased erosion along the adjacent shoreline (USACE 2009). The same numerical wave refraction model (STWAVE) was used to simulate the nearshore wave environment landward of the proposed borrow area. A new high-resolution survey was acquired of this region which provided more detailed coverage over a larger geographic area than the previous study. Existing wave refraction conditions were simulated using STWAVE and comparative runs were made using various borrow-area dredging configurations. The goal of this modeling study was to develop designs for borrow-area dredging that would have no significant impacts on wave refraction patterns and littoral processes along the adjacent shorelines. The study concluded that no significant changes to the nearshore wave environment are expected as a result of dredging borrow area C1-B to the maximum limits of excavation as shown in **Figure 3.1-9**.

Offshore Borrow Area

Excavation within the borrow area alters the seabed topography, creating pits that that may refill rapidly or may be very slow to fill. Studies show pits are likely to be persistent features of the sea bed topography for several years except where sands are mobile due to high current velocities (Eden 1975, van Der Veer et al. 1985, Newell et al. 1998). 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 (Wright 1977). 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 (PM) and potentially create a biological assemblage much different in composition than the original (Hammer et al. 2005). This action could alter this shoal structure permanently and locally affect the seabed topography within the borrow site. Even though BMPs will be implemented in the design of the dredging profile of the shoal to help minimize the impacts to the shoal, the potential impacts from the modification to the shoal are considered significant; and therefore, could cause detrimental impacts to the benthic community for extended periods of time. However, not all impacts from dredge pits are detrimental. Borrow pits are known to attract numerous fishes and have also been known to provide resting places for sea turtles (Spring and Snyder 1991).

4.7.2. BEACH NOURISHMENT USING AN UPLAND SAND SOURCE

Since the offshore wave climate would not be affected if an upland sand source is used, no adverse impacts to the nearshore wave environment are expected.

4.7.3. NO ACTION ALTERNATIVE (STATUS QUO)

No adverse impacts to the nearshore wave environment are expected under the No Action Alternative.

4.8. CULTURAL RESOURCES

4.8.1. PREFERRED ALTERNATIVE, BEACH NOURISHMENT USING OFFSHORE BORROW AREA C1-B

The Florida SHPO recommended that the proposed borrow sites, Areas C1-A and C1-B, located offshore of St. Lucie County in the vicinity known as the “St. Lucie Shoal” be investigated by a professional underwater archeologist to locate known and unidentified cultural resources, including shipwrecks and submerged prehistoric landforms that might contain prehistoric sites that may be impacted by sand borrowing activities associated with the proposed project. Data from the Florida Master Site Files indicate two documented shipwrecks within close proximity to the proposed borrow areas, the *Halsey* (8SL30) and the *America* (8SL28). No submerged prehistoric sites are recorded.

An underwater remote sensing survey was conducted of the four proposed sand borrow areas for shore protection projects in the region, including relocation of the recorded shipwrecks the *America*, the *Halsey* and the *Amazone*. The *Amazone* (8SL29) and the *Halsey* (8SL30) were relocated outside of the project areas. The previously recorded *America* Wreck (8SL28) was not relocated but it was determined that it does not exist in the project area. C1-A contained a magnetic anomaly indicative of a potentially significant cultural resource, specifically a shipwreck. C 1-B did not contain any significant anomalies indicative of cultural resources. Anomalies indicative of submerged landforms and prehistoric sites were not identified in either borrow area. The submerged cultural resources survey cleared the borrow area C1-B, which is the preferred borrow area for the Martin County HSDR project.

Onshore Cultural Resources

The Jensen Beach Site (8MT2), a prehistoric midden recorded within the beach renourishment area of the Martin County HSDR project, is documented as destroyed in the Florida Master Site Files. Therefore, placement of dredged material on the beach will not affect any known terrestrial archeological resources. In a letter dated December 21, 1992, the SHPO concurred with USACE no-effect determination for beach renourishment.

To the south and outside of the project area, the House of Refuge at Gilbert’s Bar is listed on the National Register of Historic Places. The House of Refuge is the only one of 10 houses of refuge erected by the U.S. Life Saving Service in 1876 that still exists. The House of Refuge is situated in back of a rock outcropping that acts as a semi-permanent barrier for natural shore protection.

Coordination with interested agencies has indicated that no detrimental effects are anticipated with implementation of the proposed plan. In 1980, the State Division of Archives, History, and Records Management and the Heritage Conservation and Recreation Service indicated that the proposed project would not adversely impact any sites listed, or eligible for listing, in the National Register of Historic Places.

Nearshore Cultural Resources

There are two, recorded submerged archaeological resources in the nearshore beach renourishment area of the Martin County HSDR project. Two, historic shipwrecks from the mid-nineteenth and early twentieth centuries, the *No Name* shipwreck (8MT17) and the *Coszme Calzado* (8MT44), are located along the nearshore, approximately 250 feet seaward of the shoreline. The condition of these shipwrecks is currently unknown and whether they are covered by sand or exposed. Despite the fact that the project area has been re-nourished several times since 1996, a 300 foot (100 meter) buffer zone will be placed around the location of the wrecks. Pipeline corridors will be surveyed prior to project construction, and vessel anchoring will be prohibited within these buffers so impacts to these submerged cultural resources will not occur due to activities associated with the placement of pipelines or pump-out operations. Coordination with the SHPO and the appropriate federally recognized Native American tribes is ongoing.

Offshore Resources

Between September 2007 and June 2008, SEARCH conducted an underwater remote sensing survey of four proposed sand borrow areas for shore protection projects in the region. This survey included the borrow area C1-B which is the preferred borrow area for the Martin County HSDR project. The remote sensing survey used a magnetometer, sidescan sonar, and sub-bottom profiler, integrated with a Differential Global Positioning System (DGPS), to identify any potentially significant submerged cultural resources within these borrow areas.

Results of the survey in the report titled, *Historic Assessment and Submerged Cultural Resources Remote Sensing Survey of Four Borrow Areas for Martin and St. Lucie Counties Shore Protection Projects, Florida* (SEARCH 2008) identified no potentially significant submerged cultural resources with borrow area C1-B. SEARCH also located two previously recorded historic shipwrecks, the *Amazone* (8SL29) and the *Halsey* (8SL30) outside of the project area. SEARCH did not locate the previously recorded *America* Wreck (8SL28) but determined it does not exist in the project area.

The USACE has determined that no historic properties will be affected by the proposed dredging project in the C1-B borrow area. The SHPO concurred with this determination on April 4, 2008 (DHR Project File No. 2008-05091) and found the submitted report complete and sufficient in accordance with Chapter 1A-46, F.A.C. The letters regarding these findings is provided in Appendix C.

In summary, the USACE has determined that the current Martin County HSDR project will not pose any adverse effect to significant historic resources. This includes the beach renourishment and nearshore project areas, and the offshore preferred alternative borrow area C1-B. Coordination with the SHPO and the appropriate federally recognized Native American tribes is ongoing.

4.8.2. BEACH NOURISHMENT USING AN UPLAND SAND SOURCE

Impacts to cultural resources are not anticipated with the placement of upland sand within the beach renourishment area. Impacts to the submerged cultural resources nearshore will be eliminated by buffering the recorded shipwrecks to avoid placement of pipelines, anchors, or pump-out operations within the recorded site boundaries.

4.8.3. NO ACTION ALTERNATIVE (STATUS QUO)

For beach renourishment of the Martin County HSDR project, the No-Action Alternative would have no adverse impact to historic properties. Within the nearshore, the impacts of continued erosion and deflation of the sand surrounding the recorded shipwrecks could have the potential for adverse effect. There are no adverse effects to submerged cultural resources within the proposed borrow areas under the no-action alternative.

4.8.4. NATIONAL HISTORIC PRESERVATION ACT OF 1966 (INTER ALIA)

Federal undertakings will comply with the Archeological and Historical Preservation Act of 1974 (16 USC 469-469c); Executive Order 11593, the Abandoned Shipwreck Act of 1987 (PL 100-298; 43 U.S.C. 2101-2106); the National Historic Preservation Act of 1966, as amended (16 USC 470); and the Advisory Council on Historic Preservation's implementing regulations under 36CFR800 (*Protection of Historic Properties*). Section 106 of the National Historic Preservation Act requires federal agencies to provide the SHPO (as agent to the Advisory Council on Historic Preservation) reasonable opportunity to evaluate and comment on any federal undertaking. The act requires the agency to coordinate with SHPO whether or not the agency believes there would be impacts to significant historic resources. The project is in compliance with each of these federal laws.

4.9. SOCIOECONOMIC

Martin County's economy is largely based on tourism. The tourist dollars brought into Martin County each year account for a large portion of the County's revenue base. Many businesses, particularly along the coast, are tourist-oriented and rely on revenue generated from tourists (http://www.martin.fl.us). Short-term economic impacts to beach-associated tourism revenues will likely occur during project construction. No permanent impacts on commercial or recreational fishing are expected. There was some concern from surf and bait/tackle shop owners that the project could have an economic impact on their businesses due to degradation of surfing conditions as a result of fill placement in the nearshore environment (Appendix C, Pertinent Correspondence). However, local businesses could potentially benefit from increased tourism revenues after project construction.

A social-effects assessment was conducted after the 2004 hurricane season to explore how the shore protection project in Martin County affected social conditions compared to St. Lucie County, which had no shore protection project in place (Leigh Goldstein, Marstel-Day, LLC 2008). The study concluded that the presence of a shore protection project likely affected socioeconomic conditions. Regarding economic indicators, Martin County appeared to be slightly less vulnerable. The most significant of these indicators appeared to be social stressors and economic hardship, represented by domestic violence filings and bankruptcy rates. St. Lucie County exhibited significant increases in both of these categories following the hurricanes, while Martin County did not.

The shore protection project appears to have reduced damages and permitted a faster recovery. Martin County residents appear to have returned to their homes sooner and in higher numbers than residents of St. Lucie County. This may be attributed, at least in part, to having a shore protection project in place which allowed a quick response to the hurricanes with little bureaucracy and allowed Martin County personnel to focus on other needs.

Insurance rates will likely continue to increase as development in coastal areas increases and damage from storms becomes more costly. With increased evidence of the infrastructure protection provided by a shore protection project, such protection may be included in the methodology for determining approved rate changes. Ultimately, this could mean that the presence of a shore protection project would reduce insurance costs. These lowered costs, in addition to the reduced stressors resulting from the shore protection project, would protect lower-income residents. A shore protection project may have greater impact in more economically disadvantaged areas because of these suggested advantages.

4.9.1. PREFERRED ALTERNATIVE, BEACH NOURISHMENT USING OFFSHORE BORROW AREA C1-B

The 2012 cost of placing 787,800 cy of material from the proposed offshore borrow area is estimated at $9.09/cy. The cost estimate including mobilization/demobilization, dredging and beach fill, tilling, construction/vibration controls and monitoring, endangered species observers, sea turtle trawling, and sea turtle relocation trawling is $9,700,297.

4.9.2. BEACH NOURISHMENT USING AN UPLAND SAND SOURCE

The price per cy for most of the suppliers of upland sand exceeds the 2012 estimated total unit cost of $9.09/cy for sand from the offshore borrow areas (**Table 2.2-4**). The 2007 total unit cost of upland sand material delivered to project area ranges from $9.00/cy (note: this price does not include delivery) to $32.00/cy. Therefore the cost of 787,800 cy yards of sand from an upland source ranges from $7,090,200 to $25,209,600. It is important to consider that this estimate does not include equipment needed to move the sand to the desired grade and template design, and these unit prices are likely to increase by 2012.

Transportation of the sand from the inland borrow site to the project area is also expected to be an issue of concern among local residents since the project area, which is located on Hutchinson Island, is not easily accessible by highway and can only be reached by driving through the city of Stuart. Nourishing the beach by a trucking operation can have substantial secondary impacts associated with traffic congestion, road damage, spilled sand along roadways, noise, and numerous safety and aesthetic concerns at the beach fill site where dump trucks must drive along the beach (NRC 1995). Because of these potential drawbacks and the large number of truck loads involved, upland sand sources may be rejected as logistically and economically unpractical as a borrow source for large-scale nourishment projects such as this.

4.9.3. NO ACTION ALTERNATIVE (STATUS QUO)

In general, socioeconomic losses result from storm damages to buildings and land along the Atlantic coastline, as well as losses in revenue to Martin County. Shoreline recession can potentially undermine the oceanfront structures and recreational amenities that have been developed in the public parks along the project area. Continued erosion of the existing beach would result in increased potential for storm damage; increased energy requirements associated with post-storm clean-up activities; and a likely reduction in beach-associated tourism revenues, property tax, and jobs.

4.10. AESTHETICS

IPFs associated with the Martin County HSDR project that could potentially impact aesthetic resources include:

- Presence of construction equipment
- Noise
- Turbidity

4.10.1. PREFERRED ALTERNATIVE, BEACH NOURISHMENT USING OFFSHORE BORROW AREA C1-B

The pipeline coming out of the water and along the beach, earthmoving equipment spreading sand along the beach, and associated construction activities will temporarily affect the aesthetics in the project area. Earth moving equipment used to distribute the sand will temporarily create visual disturbance as well as noise and exhaust fumes, which will decrease the overall aesthetic value in the immediate vicinity of the project activities. Earth moving equipment will be operating from along the beach front to effectively distribute the sand 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 will correspond closely with the existing sand. With restoration of the currently eroded beaches the overall aesthetic value within the project beach area will increase.

Noise and viewshed impacts caused by dredging activities at the preferred borrow area would be short-term and negligible since the site is located approximately 6 miles offshore. Therefore, the overall impacts are not likely to adversely affect aesthetics within the project area.

4.10.2. BEACH NOURISHMENT USING AN UPLAND SAND SOURCE

Nourishing the beach by a trucking operation can have substantial aesthetic impacts associated with traffic congestion, road damage, spilled sand along roadways, and noise at the beach fill site where dump trucks must drive along the beach (NRC 1995). A typical street-legal dump truck carries about 9 to 16 cy of material; therefore approximately 34,088 to 60,600 truck-loads must be hauled to the site to meet the renourishment requirement of 787,800 cy. It is estimated that approximately 189 to 337 dump trucks per day for 6 months would have to arrive at the site to meet project requirements.

4.10.3. NO ACTION ALTERNATIVE (STATUS QUO)

With the No Action alternative, the aesthetic value of the beach will continue to diminish as the beachfront continues to erode and narrow. In addition, the potential for the construction of numerous emergency shoreline armoring structures and other stopgap measures that would very likely continue to narrow the beach would increase, diminishing the aesthetic value of the area and resulting in long-term, permanent impacts to the aesthetics of the area.

4.11. RECREATION

IPFs associated with the Martin County HSDR project potentially impacting recreational resources include:

- Limited and/or restricted access
- Turbidity

4.11.1. PREFERRED ALTERNATIVE, BEACH NOURISHMENT USING OFFSHORE BORROW AREA C1-B

Recreational activities on the public beaches such as swimming, snorkeling, diving, birdwatching, surfing, and fishing would be temporarily interrupted during project construction. However, the resulting advantages gained by a wider and more stable public beach surface area would enhance the quality and opportunities for recreational experiences enjoyed by the public along Hutchinson Island while providing for conservation of the shorefront as a natural resource. Increases in water column sedimentation and burial of hardbottom areas may affect diving, snorkeling, and surfing in the area. However, increases in turbidity and sedimentation are expected to be temporary in nature.

The sand color of the post-construction beach may be different from that of the current beach, and may detract from the aesthetic quality of the project beach. This impact would be short-term as natural working of the dredged sediments by sunlight, rain, and wind will lighten the sediments with time. Increased beach area and restoration of the natural shoreline would result in an overall improved aesthetic quality.

Offshore boating, fishing, and diving at the borrow site would be temporarily interrupted during dredging activities. However, there are ample opportunities for fishing and boating in other locations nearby.

4.11.2. BEACH NOURISHMENT USING AN UPLAND SAND SOURCE

Impacts to swimming, snorkeling, diving, fishing, and surfing in the nearshore, beach fill area would be similar to the Preferred Alternative, as described above. Offshore recreational opportunities (e.g., fishing, snorkeling, or scuba diving) would not incur impacts.

4.11.3. NO ACTION ALTERNATIVE (STATUS QUO)

With the No Action Alternative, the shoreline would continue to erode, resulting in the loss of existing shoreline and reduction in both the visual aesthetics and recreational opportunities. Offshore recreational opportunities (e.g. fishing, snorkeling, or scuba diving) would not incur impacts.

4.12. COASTAL BARRIER RESOURCES

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

4.13. WATER QUALITY

4.13.1. PREFERRED ALTERNATIVE, BEACH NOURISHMENT USING OFFSHORE BORROW AREA C1-B

Dredged material will be obtained from the offshore borrow areas using a hopper dredge. Material would be discharged directly onto the beach via pipeline following pre-established pipeline corridors (if possible) to avoid hardbottom areas. The initial discharge of material would be formed into a shore-parallel dike that would advance alongshore ahead of the construction template backfill. The dike would help to contain the discharge effluent, allowing time for sediments to drop from the flow. Construction would generally commence at the south end of the project and work toward the north. The material will be graded and shaped by earthmoving equipment in order to achieve the desired beach profile.

Implementation of the beach fill plan will likely temporarily elevate turbidity levels during the dredging and nourishment phases. The quality and general characteristics of the material used to nourish the beach will determine if the beach fill material will be environmentally acceptable to the nearshore area. The identified borrow area material has an acceptable silt content (5%) and is coarse enough to stabilize the beach without rapidly eroding down slope.

There would be temporary adverse effects caused by turbidity during dredging operations and nourishment of the beaches. The potential effects of dredging include sedimentation during dredging and an increase in turbidity, which reduces penetration of light required by photosynthetic organisms. This short-term, localized increase may have an adverse impact on non-motile autotrophs and heterotrophs such as periphyton, drifting phytoplankton, sponges, soft corals, and mollusks. These highly fecund organisms usually repopulate the project shoreline within a matter of weeks to months. The elevated turbidity level will be temporary in nature and is not expected to be significant as state standards for turbidity will not be exceeded [less than 29 nephelometric turbidity units (NTUs) above background levels]. The substrate has minimal silt content, therefore, turbidity and/or oxygen depletion associated with dredging is reasonably predicted to be minimal and of no significant impact.

The oceanographic conditions in this area are very dynamic, and beach material is constantly eroded and resuspended by wave energy. Therefore, short-term elevated turbidity levels during the construction phase are not expected to significantly alter background water clarity seaward of the project area.

The composition of the nearshore hardbottom habitat (ephemeral limestone, worm rock) will likely determine the extent to which these areas may be impacted from the placement of sand onto the eroded project beach. Ephemeral low relief coquina limestone rock may be buried during sedimentation, but will likely be re-exposed during future sand scouring, therefore, the overall impact on these ephemeral reef areas is considered negligible. Worm rock *(P. lapidosa)* may actually benefit from a temporary increase in turbidity if the increase is not exceedingly large or long in duration. *P. lapidosa* are capable of using the resuspended sand grains to further build and enlarge their rock tubes. As has been discussed throughout this SEIS, the beach nourishment project is expected to directly impact 1.3 acres of hardbottom habitat within the project area. Although eroded sand from the renourished beach is expected to flow south, this sand is not expected to significantly adversely impact any hardbottom areas south of the project beach. However, the overall short-term and long-term impact of increased turbidity and sedimentation will be quantitatively assessed during an extensive monitoring plan at both the borrow site and the beach fill area. In any instance, state water quality standards for turbidity will not be exceeded (within 29 NTUs of background conditions).

Although remote, accidental spills and releases of waste and/or fuel could potentially impact water quality. As part of the USACE standard contractual requirements, a marine pollution control plan will be followed in the event of a spill to contain the spill and minimize impacts to water quality.

4.13.2. BEACH NOURISHMENT USING AN UPLAND SAND SOURCE

Impacts to the water quality within the beach fill area would be similar to the Preferred Alternative. There would be no impacts to water quality at the borrow area if an upland sand source is used.

4.13.3. NO ACTION ALTERNATIVE (STATUS QUO)

There would be no adverse impacts to the water quality within the beach fill or borrow area with the No Action Alternative.

4.14. HAZARDOUS, TOXIC, AND RADIOACTIVE WASTE

The offshore dredge areas, onshore staging area, and the vehicles and earth-moving equipment all represent potential sources of pollution due to the possibility of accidental spillage. However, accident and spill prevention plans delineated in the contract specifications should prevent most spills. All motorized vehicles will be maintained and appropriate precautions taken to ensure that no hazardous or toxic wastes are dumped either on the beach or into the nearshore waters. The No Action Alternative would not create situations to cause these potential impacts.

4.15. AIR QUALITY

4.15.1. PREFERRED ALTERNATIVE, BEACH NOURISHMENT USING OFFSHORE BORROW AREA C1-B

Some airborne pollutants can be expected to originate from project vehicles and machinery during the beach fill construction phase. These vehicles and machines will be well maintained to reduce the unnecessary release of airborne pollutants into the atmosphere. Any toxicant released into the atmosphere would likely be rapidly dispersed away from the project area by ocean-generated breezes.

BOEMRE prepared an air quality analysis using project-specific parameters to estimate emissions for the preferred alternative. Criteria air pollutant emissions were estimated for the preferred action using estimates of power requirements, duration of operations, and emission factors for the various equipment types. Multiplying horsepower (hp) rating, activity rating factor (percent of total power), and operating time yields the energy used. The energy used multiplied by an engine-specific emission factor yields the emission estimate. Operational data from the 2001-2002 nourishment cycles were used to estimate power requirements and duration for each phase of the proposed hopper dredging activity. The horsepower (hp) rating of the dredge plant was assumed for each activity as follows: 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 estimated duration of dredging was approximately 127 days. The estimated time to each complete dredge cycle, including idle time, was approximately 8.27 hours per load. It was assumed that about 2,353 cy of material would be moved in each cycle, requiring about 367 loads to excavate enough material to place 0.6 million cy of sand on the beach. The placement and relocation of the nearshore mooring buoys used during pump-out may involve up to two tender tugboats, a derrick barge, two work barges, and pipeline hauler/crane. It was assumed that the buoy would need to be moved at most five times during the project, with each move taking approximately 12 hours. It was assumed that a crew/supply vessel would operate daily for 4 hours as well.

All dredging was assumed to occur on the OCS, whereas 55% of hopper transport and crew/supply vessel activities were assumed to occur over state waters or 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 were obtained from EPA's *Compilation of Air Pollutant Emissions Factors, AP-42, Volume 1* (2002). Emission factors for tiered equipment used in beach construction were derived from NONROAD model (5a) estimates. Total project emissions of nitrates (NO_x), sulfur dioxide (SO_2), carbon monoxide (CO), volatile organic compounds (VOCs), and particulate matter are presented in **Table 4.15-1**.

The proposed action may result in small, localized, temporary increases in concentrations of nitrogen dioxide (NO_2), SO_2, CO, VOCs, and PM. Since the project is located in an attainment area, there is no requirement to prepare a conformity determination. Nonetheless, estimates were tallied to determine the portion of total emissions that would occur within state limits. Since the federal OCS waters attainment status is unclassified, there is no provision for any classification in the Clean Air Act for waters outside of the boundaries of state waters. Calculating the increase in emissions that may occur within the state limits was done by subtracting out the dredging-related and 45% of transport emissions, since those activities would take place entirely over federal waters.

Emissions associated with the dredge plant would be the largest contribution to the inventory. However, the total increases are relatively minor in context of the existing point and nonpoint and mobile source emissions in Martin County (**Table 4.15-1**). Any pollutant released into the atmosphere would quickly disperse from the project area by prevailing winds.

Table 4.15-1 Estimated Emissions for the Preferred Alternative (tons per year)

Activity	Emissions (tons)					
	NOx	**SO2**	**CO**	**VOC**	**$PM_{2.5}$**	**PM_{10}**
Dredge Plant (Hopper)						
Dredging/Operation	12.5	0.2	2.9	0.3	0.2	0.2
Turning/Sail	59.7	1.0	13.7	1.6	1.0	1.0
Pump-out	13.7	0.2	3.1	0.4	0.2	0.2
Idle/Connect-Disconnect	3.9	0.1	0.9	0.1	0.1	0.1
Supporting Offshore Activities	11.2	0.2	2.6	0.2	0.3	0.08
Beach Fill	9.6	1.8	4.5	0.7	0.8	0.8
Total Emissions	**110.6**	**3.5**	**27.7**	**3.3**	**2.5**	**2.4**
Total Emissions within State	69.1	2.8	18.2	2.2	1.8	1.7
Total Emissions within OCS	41.5	0.7	9.5	1.1	0.7	0.7
2002 Countywide Emissions Nonpoint + Mobile (Point and Nonpoint + Mobile)	10,077 (19,296)	2,271 (19,313)	73,578 (85,599)	13,006 (14,004)	1,426 (3,188)	3,893 (5,857)
Martin County 2002 emissions from EPA National Emission Inventory http://www.epa.gov/air/data/						

4.15.2. BEACH NOURISHMENT USING AN UPLAND SAND SOURCE

The short-term impacts from emissions by dump trucks and other construction equipment associated with the project could be significant given the number of dump trucks required to transport the sand from the upland mine area. Because the period of construction activity is brief, exhaust emissions from vehicles and construction equipment associated with the project would have a temporary effect on air quality.

However, this impact would not just be within the local project area, it would have short-term impacts along the entire route that the dump trucks would make on a daily basis from the mine to the beach fill area.

4.15.3. NO ACTION ALTERNATIVE (STATUS QUO)

The No Action alternative would have no impact on air quality.

4.16. NOISE

4.16.1. PREFERRED ALTERNATIVE, BEACH NOURISHMENT USING OFFSHORE BORROW AREA C1-B

The project construction activities would result in short-term minor adverse effects to the noise environment in the vicinity of both the beach fill and borrow area sites. Construction will include temporary sources of noise. This noise has the potential to adversely impact biological resources such as fishes, sea turtles, marine mammals, and seabirds as discussed above in Sections 4.3 and 4.5. Any such impacts, however, are expected to be minor and temporary. Noise generated from activities at the borrow area site would not be expected to affect noise-sensitive receptors onshore due to the distance from shore.

Proper maintenance of construction and dredging equipment would minimize the noise impacts and construction activities would occur for a short period. Construction noise would have a short-term, minor effect on sound levels in the vicinity of the construction activities.

4.16.2. BEACH NOURISHMENT USING AN UPLAND SAND SOURCE

The project construction activities would result in short-term minor adverse effects to the noise environment in the vicinity of both the beach fill area and along the dump truck travel routes. The noise has potential to impact shorebirds and other wildlife on the beach. Construction noise would have a short-term, minor effect on sound levels in the vicinity of the construction activities.

4.16.3. NO ACTION ALTERNATIVE (STATUS QUO)

The No Action alternative would not result in noise impacts.

4.17. PUBLIC SAFETY

As a public safety measure, beach- and water-related recreation in the immediate vicinity of the discharge pipe will be prohibited during project construction. Likewise, water-related activities near the dredge site will also be prohibited during borrow excavation. Recreational access to these areas will return to pre-construction conditions following completion of the project. Long-term effects are not anticipated.

The No Action alternative would assume continued erosion, allowing the surf zone to advance landward, with the potential of negative impacts to public safety due to storm damage.

4.18. ENERGY REQUIREMENTS AND CONSERVATION

Energy requirements for the proposed alternative would be limited to fuel for the dredging equipment, fuel for trucks during transportation, and fuel for other construction equipment. The use of sand from the proposed offshore borrow areas would require less energy expenditure than obtaining sand from an inland source and transporting the sand to the project site.

The No Action alternative would allow erosion to continue and would require a greater energy expenditure of on-site preventative measures and post-storm clean-up in the event of a storm (USACE 1996).

4.19. NATURAL OR DEPLETABLE RESOURCES

No natural energy resources occur within the project area. The borrow area proposed as a source for beach-quality sand is considered a depletable resource. Project dredging will reduced the quantity of sand in the borrow area. Shoals provide important physical habitat for fish that rely on shoals to optimize feeding along an otherwise featureless substrate (Caruso 2002; Tinsman 2002). There is concern among coastal managers and commercial and recreational fishermen that a decline in the sandy shoal habitat would lead to a decline in local fisheries and possibly a loss of local productivity (Caruso 2002; Tinsman 2002).

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 cause detrimental impacts to the benthic community for extended periods of time. 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 (Newell et al. 1998). 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). Therefore, the impacts are considered minor and not likely to adversely affect the soft bottom infaunal invertebrate assemblages within the sand bottom areas of borrow site. However, this action could alter this shoal structure permanently and locally affect the seabed topography within the borrow site. Even though BMPs will be implemented in the design of the dredging profile of the shoal to help minimize the impacts to the shoal, the potential impacts from the modification to the shoal are considered significant; and therefore, could cause detrimental impacts to the benthic community for extended periods of time.

However, not all impacts from dredge pits are detrimental. Borrow pits are known to attract numerous fishes and have also been known to provide resting places for sea turtles (Spring and Snyder, personal observations off Hobe Sound, FL).

The No Action alternative would allow the sand in the borrow areas to remain relatively intact, although some redistribution would likely occur with natural cycles and storm events.

4.20. SCIENTIFIC RESOURCES

There are no known impacts to scientific resources associated with the proposed project or the No Action Alternative.

4.21. NATIVE AMERICANS

None of the proposed project activities occur on land belonging to Native Americans; therefore, the implementation of the proposed project would not result in any impacts to Native Americans or land belonging to Native Americans.

4.22. RE-USE AND CONSERVATION POTENTIAL

There is no potential for re-use associated with the proposed project activities; therefore, this is not applicable to the proposed renourishment project. Energy requirements for the proposed alternatives would be confined to fuel for the dredge, labor transportation, and other construction equipment.

4.23. URBAN QUALITY

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 presence of construction equipment would temporarily detract from the aesthetics of the environment, thereby possibly temporarily affecting the localized visual aesthetics associated with urban quality in Martin County.

The commercial businesses and residential properties along the project beach would benefit from the storm protection afforded by the project and incur less risk of property damage. After the 2004 hurricane season, an assessment was conducted to evaluate the performance and damages prevented by the shore protection project in Martin County. Results indicate that in the absence of the federal project, about $9.5 million would have been spent by landowners and/or local and state governments prior to the 2004 tropical season to protect private property and to slow erosion and mitigate storm damages (Lent et al. 2007). The difference in damages between “with” and “without” project conditions is estimated at more than $11.3 million (Lent et al. 2007).

The No Action alternative would assume continued shoreline erosion, reduction of storm protection, and continued loss of recreational beach area with repercussions to tax revenues and tourism commerce.

4.24. SOLID WASTE

No impacts related to solid waste are expected as a result of this project. Precautionary measures will be included in the contract specifications for proper disposal of solid wastes. These 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 will not be permitted.

4.25. DRINKING WATER

No municipal or private water supplies are located in or near the project site; therefore, drinking water supplies will not be impacted by implementation of the proposed project.

4.26. CUMULATIVE IMPACTS

Cumulative impact is the "impact on the environment which results 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" (40CFR1508.7). The proposed action, in addition to past projects and any future actions, would primarily impact the beach, nearshore hardbottom resources, and offshore sand borrow areas and adjacent habitats. Significant issues to be addressed include potential long-term and cumulative effects on protected species, water quality, EFH and HAPC, fish and wildlife resources, benthic communities, sediment transport, wave modification from dredging offshore, cultural and socioeconomic resources, and aesthetics and recreation.

Until this project expires in 2046, the beach will continue to be maintained as an area suitable for shoreline protection, recreation, and wildlife habitat. The proposed C1-B offshore borrow area will likely last the life of the project. Cumulative impacts will be assessed over the life of the project with continued monitoring and comparison to existing baseline data. Monitoring requirements are discussed in detail in Section 2.3.2 and Environmental Commitments are summarized in Section 4.35.

Table 4.26-1 summarizes the impacts of such cumulative actions by identifying the past, present, and reasonably foreseeable future conditions of the various resources that are directly or indirectly impacted by the proposed action and its alternatives. The table also illustrates the with-project and without-project conditions (the difference being the incremental impact of the project). Also illustrated is the future condition with any reasonable alternatives (or range of alternatives). Appendix D contains more detailed information of how the cumulative impacts were examined using the 11 steps identified by the Council on Environmental Quality (CEQ 1997).

The No Action alternative would result in continued erosion of beaches, increased potential for storm-related property damage, and decreased property values. No adverse environmental impacts to nearshore and offshore hardbottom habitats and fish communities are anticipated due to the No Action alternative. An increased exposure of nearshore hardbottom due to continued beach erosion is probable which, in turn, could provide increased habitat for surf zone fishes. Continued erosion of the beach could threaten the existing dune habitat along the project area, potentially decreasing habitat for birds and dune species. Continued shoreline recession would also reduce the amount of dry beach available for sea turtle nesting and may result in poor site selection by nesting females.

Table 4.26-1. Summary of Cumulative Impacts (Page 1 of 3)

Resource	Past and Present (Baseline/Existing Condition)	Future Without Project	Future With Proposed Action
Threatened and Endangered Species: Sea Turtles	Hutchinson Island supports the greatest concentration of sea turtle nesting activity in Florida. 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. The entire project reach has been previously renourished using an offshore sand source (Gilbert Shoal). The most recent renourishment was in 2005. Sea turtle nesting surveys have been conducted in a consistent manner on Hutchinson Island every year since 1981. Nesting activity is summarized in Section 3.3.1.	Sea turtle nesting and nearshore habitat use will continue in the area. Project-specific impacts will be avoided, but ongoing threats to sea turtle populations will continue. In the absence of the project, property owners may construct seawalls or other armoring 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 resulted in loss of 1.3 acres of juvenile developmental habitat (nearshore hardbottom) which has bee mitigated for. 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 will be minimized through vessel-strike avoidance and dredge-related impact mitigation measures. Negative effects on nesting and hatching success would be most pronounced during the first nesting season following nourishment. However, there would be an increase in suitable nesting habitat after the beach reaches equilibrium. Due to the small spatial extent and short duration of project impacts, no significant cumulative impacts are expected.
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, but the manatee is not expected to be present in offshore borrow area. Past and current threats to marine mammal populations include vessel strikes, fishing gear entanglement, ingestion of marine debris, pollution, and underwater noise.	Marine mammals will continue to occur in the area. Project-specific impacts will be avoided, but ongoing threats to marine mammal populations will 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 will 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 will continue to inhabit the area. Project-specific impacts will be avoided, but ongoing threats to sawfish populations will 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 will be minimized through mitigation measures. Due to the small spatial extent and short duration of project impacts, no significant cumulative impacts are expected.

Table 4.26-1. Summary of Cumulative Impacts (Page 2 of 3)

Resource	Past and Present (Baseline/Existing Condition)	Future Without Project	Future With Proposed Action
Nearshore Hardbottom	Prior to initial project construction, numerous investigations including sidescan sonar with ground-truthing, aerial photography, and underwater diver-verified reef characterization studies were conducted along the project reach. These investigations revealed the presence of hardbottom reef tracts consisting of ephemeral limestone outcrops and the marine bristle worm, *P. lapidosa*. It was estimated that between the St. Lucie/Martin County line and the St. Lucie Inlet there was approximately 150 acres of hardbottom communities, approximately 80 percent of which are of the sabellariid worm reef type (ATM 1991). These communities have historically been subjected to the dynamics of the nearshore environment including sand movement, scouring, and alternating burial/exposure.	Nearshore hardbottom areas will continue to exist in the area, subject to the natural dynamics of the nearshore environment including sand movement, scouring, and alternating burial/exposure. Natural physical stresses would continue to limit biodiversity. In the absence of the project, the potential for secondary and cumulative impacts of chronic sedimentation to nearshore hardbottom communities would be eliminated, however, property owners may construct seawalls or other armoring to protect their property, which may result in impacts to nearshore hardbottom.	During initial project construction, 1.3 acres of nearshore hardbottom was impacted and represents a small percentage of the similar habitat in the area. Impacts were mitigated through the construction of artificial reef habitat. Renourishment of the project area should result in minimal cumulative impacts on nearshore hardbottom provided appropriate monitoring and mitigation is conducted.
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. Terrestrial wildlife in the project area consists of small mammals such as raccoon, opossum, rabbit, and rodents; multiple species of coastal shorebirds, amphibians, and reptiles. Birds are abundant on the beaches and in estuarine habitats, with shore and wading birds comprising the majority of the avifauna.	Project-specific impacts will be avoided, but soft bottom communities would continue to be affected by natural sand movement. Nearshore hardbottom edge 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 seawalls or other armoring 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 will 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. . Species could be impacted in a number of different ways, including direct mortality, sublethal impairment, and degraded habitat. Effects are not likely to be significant 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 site. No significant cumulative impacts are expected.

Table 4.26-1. Summary of Cumulative Impacts (Page 3 of 3)

Resource	Past and Present (Baseline/Existing Condition)	Future Without Project	Future With Proposed Action
Essential Fish Habitat	Managed species and species groups in the project area include *Sargassum*; live/hardbottom habitats; penaeid shrimps; spiny lobster; red drum; coastal pelagic fishes; reef fishes; dolphin and wahoo; and highly migratory pelagic species. Habitats of Particular Concern (HAPCs) for and live/hardbottom habitats of the eastern Florida area include the *Phragmatopoma* worm reefs found in nearshore waters.	Project-specific impacts will 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 seawalls or other armoring to protect their property; which may result in impacts to nearshore EFH.	In addition to ongoing processes affecting nearshore EFH, the project will resulted in the burial of 1.3 acres of nearshore hardbottom habitat resulting in an incremental loss of EFH for reef fishes. However, the impact represents a small percentage of the similar habitat in the area. Unavoidable impacts were mitigated through the construction of artificial reef habitat consisting of low to medium-relief to mimic the structure of the affected areas. Dredging will affect EFH by temporarily altering the sand shoal habitat (e.g., reducing shoal height, creating pits). However, the impact is reversible and represents a small percentage of the similar habitat in the area.
Water Quality	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 due to stormwater and effluent runoff resulting in increased nutrients and freshwater inputs to the nearshore coastal areas. .	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 will 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 significant cumulative impacts are expected.

4.26.1. CUMULATIVE ACTIVITIES SCENARIO

The geographic scope of this analysis includes the shoreline of Martin County with the Indian River Lagoon to the west, St. Lucie Inlet to the south, and St. Lucie County to the north and borrow area C1-B located in the Atlantic Ocean approximately 6 miles offshore of Martin and St. Lucie Counties, Florida. The project impact area extends from R-1 to R-25 (4–mile project fill area) and R-26 to R-29 which includes an area south of the project fill area that may be susceptible to 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 may, together with the proposed project, result in cumulative impacts. In addition to the coastline, the project area includes the offshore borrow area located in a sand ridge approximately 6 miles offshore. Cumulatively, this project and other similar projects may impact sand shoals 3 to 6 miles offshore.

4.26.1.1. Past Conditions and Activities

The coastline of Martin County is low-lying and vulnerable to storm surge and other storm event damages. The problem along the project area is one of sand erosion and lowering of the beach profile with subsequent recession of the shoreline and dunes. From 1996 to 2005, the project area was nourished four times (1996, 2001, 2002, and 2005) to address the damage sustained from a series of significant storms, including a strong “northeaster” during project construction in 1996, three hurricanes in 1999, two hurricanes in 2004, and three hurricanes in 2005. The initial 1996 nourishment placed a much greater volume of sand on the beach (advanced nourishment) than the subsequent three nourishment events (**Table 1.2-1**).

North of the project area, the federal Ft. Pierce Shore Protection Project area (about 1.3 miles) has received nourishment sand since 1971. The federal project began in 1980. Since that time, 14 nourishments have placed sand on various portions of the project beach. Most recently, Martin County nourished Bathtub Beach, about 1,000 feet of shoreline, in the Spring of 2010. SailFish Point Beach, just to the south and about 1,500 feet in length, received sand in 2005 and 2009.

4.26.1.2. Present/Ongoing Activities

There are no ongoing beach restoration activities in the project area. The proposed borrow area C1-B 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.

4.26.1.3. Reasonably Foreseeable Future Activities

The Martin County HSDR project authorizes construction of a protective and recreational beach along 4 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 renourishment interval of 11 years, now estimated at a 13 year interval. Federal participation (cost-sharing) is authorized for 50 years from date of initial construction and expires in 2046. The previously approved borrow area has been depleted. Therefore, borrow area C1-B is proposed as a potential source of beach-compatible sand. The total sand needed for the remainder of the 50-year life of the project is estimated to be between 2.4 and 4.0 million cubic yards. The next renourishment phase is scheduled for 2012 and will involve the placement of approximately 787,000 cubic yards of material along the 4-mile project area.

Regionally, beach nourishment is expected to continue in the coming years, compounding opportunities for recurring impacts. In southeast Florida alone, approximately 100 dredging events are projected to occur between 1969 and 2050 using at least 100,000,000 cubic yards of sediment in an area that is 4 miles wide by 120 miles long (from Dade County to Martin County) (USACE 1996). **Table 4.25-2** summarizes beach nourishment projects in Martin and St. Lucie Counties which are in the immediate vicinity (north and south) of the Martin County HSDR project. A complete summary of beach nourishment projects funded from 1995-2010 along the Atlantic coast of Florida (including sand bypassing) and total miles of beach nourished is provided in Table 2 of Appendix D.

Immediately north of the project area, St. Lucie County has initiated a beach renourishment project to address the deteriorated shoreline and emergency conditions as soon as possible with parallel development of a future federal Shore Protection Project to provide for future re-nourishment of south County beaches. More than a decade ago, the USACE recommended a “feasibility study” for a study area extending from just south of Blind Creek (R-77) to the Martin County Line. However, due to limited funding, the USACE only partially advanced that Feasibility Study, which until recently remained substantially incomplete and without sufficient federal funding to substantially advance any USACE project. USACE is currently completing the feasibility study but will not likely complete their project feasibility study and implementation process prior to 2012. The renourishment interval and volume are 10 years and 200,161 cubic yards, respectively. The proposed borrow area for Project re-nourishment are offshore St. Lucie County in reasonable proximity to the project fill-area; they can also likely yield the 50-year total estimated volume of beach compatible sand.

Table 4.26-2. Summary of Martin and St. Lucie Counties Beach Nourishment Projects

		Initial Nourishment				Re-nourishment			
County	**Project**	**Year**	**Estimated Quantity (cy)**	**Location/Segment**	**Re-nourishment Interval (Years)**	**Re-Nourishment Year**	**Estimated Quantity (cy)**	**Location/ Segment**	**Comments**
St. Lucie	*Fort Pierce SPP Beach Nourishment*	1971	1970 - initial construction (718,000)	South jetty at Ft. Pierce Inlet to Surfside Park (R-34 to R-46) 2.3 miles	4	1980; 1999; 2003; 2005	1980 - 346,000; 1999 - 830,000; 2003 - 336,000; 2005 - 517,000	1999 - R34-R41 & R41-R46; 2003 - R34-R41; 2005 - R34-R41	A 2-year renourishment interval may be more realistic here below the inlet. This area acts as a feeder beach to downdrift beaches to the south.
						March 1999	830,000	Ft. Pierce Inlet to R-41	Fill source: Capron Shoal
						April 2003	336,000	Ft. Pierce Inlet to T-36	
						April 2004	406,000	Ft. Pierce Inlet to T-36.5	
						May 2005	616,000	Ft. Pierce Inlet to R-41	
						April 2007	503,800	Ft. Pierce Inlet to R-41	
						May 2009	189,600	Ft. Pierce Inlet to R-35	
	St. Lucie County South Beach Emergency Dune Restoration	2005	162,000	R-98.4 to R-101.5; R-103.3 to R-115 + 1000 ft.	n/a	n/a	n/a	n/a	Upland truck haul
	St. Lucie County Beaches - Reconnaissance Study	--	--	St. Lucie County Beaches	--	--	--	--	--
Martin	*Martin County HSDR - Hutchinson Island*	Dec. 1995 - April 1996	1,340,000	St. Lucie/Martin county line to Stuart Beach Park (R-1 to R-25)	13	Winter 2001 - Spring 2002	304,000	R-1 to R-25	Fill source: Gilbert Shoal
						2005	885,000	R-1 to R-25	
	Jupiter Island Beach Restoration Project	1973-1974		Town of Jupiter Island; R-75 to R-117	3-4 (through 1996)	1996; 1999	1996 - 1,740,000	1996 - R77-R106; 1999 - R78-R84; R92-R100	--
	Bathtub Beach Nourishment	Spring 2010	35,000	R-34.5 to R-35.5	n/a	Spring 2010	n/a	n/a	Fill source: St. Lucie Inlet Flood Shoal
	Sailfish Point Nourishment	Winter/ spring 2005	25,000	R-36 to R-37.5	n/a	Winter/spring 2009	50,000	R-36 to R-37.5	Fill source: St. Lucie Inlet North Channel

4.26.2. CUMULATIVE IMPACTS BY RESOURCE

In accordance with the approach recommended by the Council on Environmental Quality (1997), this analysis focuses on the potential impacts that are most important or meaningful. The marine resources of most interest for the cumulative analysis are threatened and endangered species, hardbottom, fish and wildlife resources, EFH, and water quality.

4.26.2.1. Threatened and Endangered Species

Sea Turtles

As discussed in Section 3.3.1, five endangered or threatened 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 ledges for feeding (macroalgae), resting, and shelter from predators.

Species recovery plans indicate that 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 marine debris (NMFS and USFWS, 1991a, 1992a,b, 1993, 2008). These impacts are widespread, diffuse, and ongoing, and will continue in the future regardless of whether this project is conducted.

The proposed project will affect only 4 miles of the approximately 1,400 miles of available sea turtle nesting habitat in the southeastern U.S. Research has shown that the principal effect of beach nourishment on sea turtle reproduction is a temporary reduction in nesting success during the first year following project construction. Research has also shown that the impacts of a nourishment project on sea turtle nesting habitat are typically short-term because a nourished beach will be reworked by natural processes in subsequent years, and beach compaction and the frequency of escarpment formation will decline.

Many of the direct effects of beach nourishment may persist over time and become indirect impacts. These indirect effects include increased susceptibility of relocated nests to catastrophic events, consequences associated with potential increased beachfront development, changes in the physical characteristics of the beach, the formation of escarpments, and future sand migration.

Approximately 1.3 acres of nearshore hardbottom foraging habitat for juvenile sea turtles will was directly impacted by beach construction and gradual beach fill equilibration, which represents an incremental loss of developmental habitat for juvenile sea turtles. The animals will be prevented from using the buried hardbottom habitat as long as macroalgae and seafloor structures are covered. However, the area impacted is a small percentage of the total habitat area available in the region. Therefore, the impact to sea turtle developmental habitat is considered minor. Suitable replacement habitat was created in 2000 to mitigate for direct impacts to nearshore hardbottom habitat.

In addition to the habitat loss, sea turtles may be disturbed by turbidity and noise during construction, and there is a small risk of a sea turtle being struck by a construction vessel or entrained in the hopper dredge draghead. However, measures can be implemented to minimize impacts to sea turtles. The 2010 USFWS Biological Opinion contains terms and conditions that implement the reasonable and prudent measures that USACE must comply with during project construction and post-construction monitoring. In addition, to reduce the risk of impacts from dredging and vessel strikes, the project will comply with the "Sea Turtle and Smalltooth Sawfish Construction Conditions" (NOAA Fisheries 2006) and "Vessel Strike Avoidance Measures and Reporting for Mariners" issued by NOAA Fisheries, Southeast Region. Trained and NMFS-approved protected species observers will be used on board the dredge vessel during all dredging operations, and dredge support vessel operators and crews will be instructed to maintain a constant lookout for sea turtles during transits and maneuvers. With mitigation measures in place, the potential for sea turtle "takes" due to dredging and vessel strikes is expected to be significantly reduced.

Although there is a risk of a small number of sea turtle "takes" due to dredging and vessel strikes, the impacts would not likely be detectable cumulatively, based on the other known sources of impact to sea turtles. In a 1990 study, the National Academy of Sciences estimated that between 5,000 and 50,000 loggerheads were killed annually by the shrimping fleet in the southeastern Atlantic and Gulf of Mexico (National Research Council 1990). Mortality associated with shrimp trawls was estimated to be 10 times greater than that of all other human-related factors combined. Most of these turtles were neritic juveniles, the life stages most critical to the stability and recovery of sea turtle populations (NMFS and USFWS 2008).

The FPL nuclear power plant just north of the project area regularly entrains marine turtles in their cooling water intake system, and FPL holds an incidental take permit for this impact. The plant has an ongoing program that captures almost all turtles before they enter the plant, where they would die. Some turtles are killed each year and hatchlings and juveniles may pass through the net and die without the notice of the plant personnel. Mortality at the plant represents the most significant ongoing impact to marine turtles along the Hutchinson Island shoreline

In the 2010 Biological Opinion, USFWS determined that the anticipated level of take associated with a beach nourishment project, as proposed, is not likely to jeopardize the continued existence of sea turtles. Critical habitat has not been designated in the project area; therefore, the project will not result in destruction or adverse modification of critical habitat. However, if future projects in southern St. Lucie County are conducted concurrently with Martin County, cumulative of minor local habitat loss due to burial of hardbottom areas in multiple areas may elevate the level of the impacts. Also, the range of influence from noise, vessel traffic, and turbidity could overlap. However, projects impacting hardbottom resources will require mitigation for their permanent impacts.

Future federal actions unrelated to the proposed action require separate consultation pursuant to Section 7 of the ESA.

Marine Mammals

As discussed in Section 3.3.2, three endangered marine mammal species may occur in the area: the Florida manatee, humpback whale, and North Atlantic right whale. Of these, only the manatee is common regionally. The two endangered whales are rare and may be present seasonally (December to March). Manatees are usually found in quiescent inshore waters and are unlikely to be present along the beach or in borrow areas.

Historically, the most significant threat presently faced by Florida manatees is death or serious injury from boat strikes (USFWS 2001a). Other known causes of manatee deaths include entrapment or crushing in water control structures and navigational locks, poaching and vandalism, entanglement in shrimp nets, monofilament line (and other fishing gear), entrapment in culverts and pipes, and ingestion of debris. Natural causes of death include disease, parasitism, reproductive complications, and other non-human-related injuries, as well as occasional exposure to cold and red tide. Vessel strikes will continue to be a significant threat to the Florida manatee population regardless of whether this project is conducted.

For humpback whales and right whales, ship collisions and fishing gear entanglements are the most common anthropogenic causes of mortality (NMFS 1991a, 1991b, 2005). Other potential threats are habitat degradation, noise, contaminants, underwater explosive activities, climate and ecosystem change, and commercial exploitation. These impacts are widespread, diffuse, and ongoing, and will continue in the future regardless of whether this project occurs.

Vessel strikes comprise the most important potential impact on marine mammals. Because the existing manatee and Northern Right Whale populations are so small any vessel striking a manatee or North Atlantic right whale during the project would represent a significant cumulative impact. To reduce the risk of vessel strikes, the project will comply with the “Vessel Strike Avoidance Measures and Reporting for Mariners” issued by NOAA Fisheries, Southeast Region. Trained and NMFS-approved protected species observers will be used on board the dredge vessel during all dredging operations, and dredge support vessel operators and crews will be instructed to maintain a constant lookout for marine mammals during transits and maneuvers. With these mitigation measures in place, the potential for marine mammal “takes” due to vessel strikes is expected to be significantly reduced.

Due to the small spatial extent and short duration of activities, a single nourishment event will not likely produce significant impacts on endangered or threatened marine mammals. However, the project may result in temporary disturbance of marine mammals due to turbidity and noise during construction. These are minor impacts that are not likely to be significant cumulatively in context with existing stresses on marine mammal populations. The proposed 13-year nourishment interval through 2046, will help keep the potential for significant cumulative impacts from repeated individual nourishment projects low. The timing of beach nourishment project(s) in St. Lucie County, may increase concurrent, project-related impacts on local marine mammals. If future projects in southern St. Lucie and northern Martin County are conducted concurrently, the range of influence from turbidity, noise, and vessel traffic will extend spatially, if not temporally.

Smalltooth Sawfish

As discussed in Section 3.3.3, the smalltooth sawfish is an endangered demersal fish species inhabiting shallow, nearshore waters. Historically, its population has declined and its range has contracted, mainly due to fisheries bycatch (NMFS 2009). Other past and current threats are habitat loss and degradation, entanglement in marine debris, pollution, and anthropogenic disturbance (NMFS 2009). These widespread ongoing impacts are expected to continue in the future regardless of whether this project is conducted.

Construction-related turbidity and noise may disturb the smalltooth sawfish. To reduce the risk of impacts, the project will comply with the “Sea Turtle and Smalltooth Sawfish Construction Conditions” (NOAA Fisheries 2006). These measures are intended to reducethe potential for “takes” of smalltooth sawfish during construction. Consultation was initiated on April 30, 2007 with the NMFS regarding a new South Atlantic Division Regional Biological Opinion (SADRBO) to update the 1997 SADRBO for “the continued dredging of channels and borrow areas in the Southeastern Unites States”. Per October 24, 2007 NMFS guidance letter (NMFS, 2007), until the new SADRBO is issued the Corps will follow the reasonable and prudent measures, and implementing terms and conditions outlined in the 1997 SADRBO. These include NOAA’s updated construction conditions described above.

The small spatial extent and short duration of construction activities suggest that any single nourishment event is not very likely to impact smalltooth sawfish. Project construction may result in temporary disturbance or dislocation of these animals from dredging, turbidity and noise. These are minor impacts not likely to produce significant cumulative impacts in context with existing stresses on the population. Until 2046, assuming a 13-year renourishment interval, the potential for significant cumulative impacts from repeated individual nourishment projects in the same area is low. The timing of beach nourishment project(s) in St. Lucie County, may result in concurrent, overlapping impacts on smalltooth sawfish from the construction of two projects at the same time. If future projects in southern St. Lucie and northern Martin County are conducted concurrently, the range of influence from noise, vessel traffic, and turbidity could overlap. Also, if the projects use the same sand shoal(s), dredging-related impacts could overlap.

4.26.2.2. Nearshore Hardbottom

Beach nourishment activities may directly bury hardbottom habitat within the beach design template and may have secondary impacts on adjacent (waterward and downdrift) hardbottom habitat south of the project area. Numerous investigations including sidescan sonar with ground-truthing, aerial photography, and underwater diver-verified reef characterization studies were conducted along the project reach. These investigations revealed the presence of hardbottom reef tracts consisting of ephemeral limestone outcrops and the marine bristle worm, *P. lapidosa*. These hardbottom areas are considered unique natural habitat for fish, juvenile green sea turtles, and invertebrates. During initial construction, it was estimated that 1.3 acres of hardbottom habitat was be directly impacted by the nourished sand sloughing seaward as it seeks equilibrium with the ocean bottom.

Dredging and nourishment will likely cause no significant ecological impacts to those reefs that are permanent and subjected to fewer scouring events. Computer models predicted and USACE coastal engineers concurred that it is likely that no reef tracts outside the project's influence (other than the 1.3 acres previously mentioned) or south of the project area will be directly impacted by the beach nourishment project.

Secondary impacts, such as scouring of encrusting sponges and sessile algae from rock surfaces due to the increase in water column turbidity, may occur. Holes, crevices, and hanging rock ledges may be partially or fully filled in from the increase in sand sloughing along the bottom. Increases in water column sedimentation and burial of hardbottom areas may result; however, increases in turbidity and sedimentation are expected to be temporary in nature. Because background turbidity and sedimentation levels are naturally high in this area, no significant, long-term changes attributable to the beach nourishment project are expected.

4.26.2.3. Fish and Wildlife Resources

As discussed in Sections 3.6 and 3.7, 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.

The project will result in 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. Significant effects are unlikely 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 site. No significant cumulative impacts are expected.

Until 2046, assuming a 13-year renourishment interval, the potential for significant cumulative impacts on fish and wildlife resources from repeated individual nourishment projects in the same area is low. However, if the interval is reduced due damage caused by storm events, the potential for significant cumulative impacts will increase. In addition, beach restoration projects in St Lucie County use nearby sand shoals for beach sand and create the potential for concurrent and overlapping impacts on benthic communities in the borrow area. The potential for significant cumulative impacts will be reduced by leaving portions of the existing shoals undisturbed as “refuge patches” and will help reduce the potential for significant cumulative impacts by providing a nearby source of plant and animal re-colonization propagules for the disturbed borrow area.

4.26.2.4. Essential Fish Habitat

As discussed in Section 3.7, managed species and species groups with EFH in the project area include *Sargassum*; live/hardbottom habitats; penaeid shrimps; spiny lobster; red drum; coastal pelagic fishes; reef fishes; dolphin and wahoo; and highly migratory pelagic species. HAPCs for live/hardbottom habitats of the eastern Florida area include the *Phragmatopoma* worm reefs found in nearshore waters.

The project will resulted in the burial of 1.3 acres of nearshore hardbottom habitat which resulted in an incremental loss of EFH for hardbottom as well as reef fishes. However, the area buried is a small percentage of the total habitat area available in the region. Due to the small spatial extent and short duration of project impacts, no significant cumulative impacts on EFH are expected. Assuming a 13-year renourishment interval, the potential for significant cumulative impacts from repeated individual nourishment projects in the same area is low. However, if the renourishment interval decreases due to unanticipated damages from storms, the potential for significant cumulative impacts on EFH will increase.

4.26.2.5. Water Quality

Beach nourishment projects, as well as local inlet management activities along the central east coast of Florida, could result in several localized, short-term turbidity plumes and sedimentation adjacent to the beach fill sites and offshore borrow areas during project construction. Currently, the general consensus is that the cumulative impacts of localized turbidity plumes generated from these projects is expected to minimally impact the adjacent hardbottom epibenthic communities, provided appropriate protective and mitigative measures and monitoring are applied during these projects. Wave and current action should also help dissipate elevated sediment levels and assist in removing accumulated sediment from hardbottom resources adjacent to fill and borrow areas.

Previous studies conducted by Van Dolah et al. (1992, 1994) found that dredging appeared to have little impact on bottom turbidities at various borrow sites. However, potential long-term chronic effects of sedimentation and turbidity from these concurrent nourishment and dredging actions are unknown. There is some concern that the added effect of recurrent localized, short-term turbidity and sedimentation upon hardbottom resources adjacent to the borrow site and nourishment area may cumulatively impact these resources. Chronic perturbations could cause long-term reductions in primary and secondary productivity of hardbottom epibenthic communities by reducing the amount of light available for photosynthesis. However, the suitability of the proposed sediment source should minimize these impacts. Construction sedimentation and long-term monitoring for the proposed project will provide the data to accurately judge the effectiveness of the sediment rate value and predict the future impacts of turbidity and sedimentation related to authorized renourishments.

Continued urbanization and population growth in Martin and St. Lucie Counties also contributes to coastal water quality degradation. Water quality may deteriorate due to unrelated anthropogenic sources, such as stormwater and effluent runoff, resulting in increased nutrients and freshwater inputs to the nearshore coastal areas. In 2000, the U.S. Census Bureau estimated the population of Martin County at 126,731. In 2006, the population was 139,393, an increase of approximately 10%. In 2000, the population in St. Lucie County was approximately 192,695. In 2006, the population was 252,724, an increase of approximately 31.2% (http://quickfacts.census.gov/qfd/states.html).

4.26.2.6. Currents and Circulation

According to Hammer et al. (2005), the analysis of current patterns resulting from this study suggests that proposed sand mining will have negligible impacts on large-scale circulation along the shelf. The proposed sand mining locations are small relative to the entire shelf area, and it is anticipated that project-related dredging will not remove enough material to significantly alter major bathymetric features in the region. Therefore, the forces and/or geometric features that principally affect circulation patterns will remain relatively unchanged. In some cases, sand extraction from the OCS may prove environmentally preferable to nearshore borrow areas because potential changes to waves and currents resulting from dredging large quantities of sand from the seafloor may be more pronounced in shallow water (Byrnes et al. 2004).

4.27. IRREVERSIBLE AND IRRETRIEVABLE COMMITMENT OF RESOURCES

4.27.1. IRREVERSIBLE

An irreversible commitment of resources is one in which the ability to use and/or enjoy the 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 is estimated to contain a sufficient amount of sand to last the life the project which expires in 2046.

Use of sand from offshore borrow areas would also irreversibly preclude its current use as habitat for benthic organisms. However, remaining sand reserves within and adjacent to the borrow area will provide for re-colonization of benthic organisms. Due to the dynamic nature of nearshore benthic environments, sand used to nourish the beach will eventually disperse in the nearshore areas and create habitat for shallow water benthic communities. Impacts of beach restoration on nearshore hardbottom communities are reversible. These nearshore hardbottom areas are cyclically covered and exposed due to seasonal and other temporal changes in beach profiles.

4.27.2. IRRETRIEVABLE

An irretrievable commitment of resources is one in which, due to decisions to manage the resource for another purpose, opportunities to use or enjoy the resource as they presently exist are lost for a period of time. Benthic organisms within the borrow area and beach fill area that would be eliminated during construction would be irretrievably lost for a period of time. However, the high rate of repopulation expected from these organisms reduces the significance of the loss.

4.28. UNAVOIDABLE ADVERSE ENVIRONMENTAL EFFECTS

Species of relatively non-motile infaunal invertebrates that inhabit the borrow area will unavoidably be lost during dredging. Those species that are not able to escape the construction area are expected to recolonize after project completion. There would be an unavoidable reduction in water clarity and increased turbidity and sedimentation that would be limited to the immediate areas of dredging and beach fill operations. This impact will be temporary and should disappear shortly after construction activities cease. There would also be unavoidable impacts to 1.3 acres of nearshore hardbottom. These impacts have been mitigated for by the construction of 6.0 acres of artificial reef. The borrow area is approximately 1,000 acres, and approximately 125 acres of softbottom habitat at the borrow area would be disturbed per event every 13 years to meet the nourishment requirements.

4.29. LOCAL SHORT-TERM USES AND MAINTENANCE/ENHANCEMENT OF LONG-TERM PRODUCTIVITY

The Martin County HSDR Project will result in several localized, short-term turbidity plumes and sedimentation adjacent to the beach fill sites and offshore borrow areas during project construction. Shoreline protection using beach fill with periodic renourishment is an ongoing effort. Beach renourishment projects have a temporary and short-term impact on local offshore and nearshore biological resources. Research has shown that the impacts of a nourishment project on sea turtle nesting habitats are typically short-term because a nourished beach will be reworked by natural processes in subsequent years, and beach compaction and the frequency of escarpment formation will decline (USFWS 2005). Hammer et al. (2005) identified that potential impacts on benthos from dredging are expected to be localized and short-term due to the surrounding areas that could serve as a primary source for re-colonization. Short-term reductions in primary productivity and reproductive and feeding success of invertebrate species and fish are expected. The sustainability of these populations should not be negatively affected provided appropriate monitoring and mitigation measures are taken.

4.30. INDIRECT EFFECTS

Many of the direct effects of beach nourishment may persist over time and become indirect impacts. These indirect effects include the consequences associated with potential increased beachfront development, changes in the physical characteristics of the beach, formation of escarpments, and future sand migration (USFWS 2005). Indirect biological impacts of beach nourishment activities include diminished reproductive success, reduction in biomass of prey food items, and long-term changes to substrate composition at dredging sites (Jutte and Van Dolah 1999; Peterson and Manning 2001).

Pilkey and Dixon (1996) state that beach replenishment frequently leads to more development in greater density within shorefront communities that are then left with a future of further replenishment or more drastic stabilization measures. Dean (1999) also notes that the very existence of a beach nourishment project can encourage more development in coastal areas. Increased shoreline development may adversely affect sea turtle nesting success. Greater development may support larger populations of mammalian predators, such as foxes and raccoons, than undeveloped areas (NRC 1990), and can also result in greater adverse effects due to artificial lighting.

4.31. COMPATIBILITY WITH FEDERAL, STATE, AND LOCAL OBJECTIVES

The federal objective is to contribute to national economic development consistent with protecting the nation's environment, pursuant to national environmental statutes, applicable executive orders, and other federal planning requirements.

Specific federal and county objectives are as follows:

1. Reduce expected storm damages through beach nourishment and other project alternatives;
2. Re-establish beaches as suitable recreation areas;
3. Maintain suitable habitat for nesting sea turtles, invertebrate species, and shorebirds;
4. Maintain commerce associated with beach recreation in Martin County.

The proposed Martin County HSDR Project is consistent with Federal and local objectives and with the State of Florida's Coastal Zone Management Plan.

4.32. CONFLICTS AND CONTROVERSY

Conflicts and controversy are discussed in Section 1.6 and have been addressed through the coordination with agencies and through the public comments.

4.33. UNCERTAIN, UNIQUE, OR UNKNOWN RISKS

The proposed Martin County HSDR Project does not involve any activities that have not been previously utilized during past nourishment activities performed in Martin County or along the east central Florida coast. Precautionary measures will be included in the contract specifications to ensure there are no impacts related to hazardous, toxic, or solid waste, and necessary corrective measures will be undertaken as required by the permits and laws in the unlikely event that any unacceptable impacts occur.

4.34. PRECEDENT AND PRINCIPLE FOR FUTURE ACTIONS

Initial construction of the Martin County HSDR Project was completed in 1996. Subsequent renourishments of the entire project area or portions of the project area were conducted in 2001, 2002, and 2005. The project area is scheduled for renourishment in 2012. The project is authorized until 2046 and the renourishment interval is estimated at 13 years.

4.35. ENVIRONMENTAL COMMITMENTS

USACE and Martin County as well as its contractors are committed to avoiding, minimizing, or mitigating for adverse effects during and after construction activities by including the following environmental commitments in the project contract plans and specifications.

4.35.1. SEA TURTLES

Considering that hopper dredging will be used for this project, compliance with all recommendations of the 1997 NMFS Biological Opinion regarding hopper dredging will be required to assure that incidental take of sea turtles are minimized during hopper dredging operations. The sea turtle deflecting draghead is required for all hopper dredging projects during the months that turtles may be present, unless a waiver is granted by the USACE in consultation with NMFS. The 1997 amended Biological Opinion mandates that year round, one-hundred percent observer coverage is necessary for beach nourishment project in southeast Florida. One hundred percent inflow screening is required, and 100 percent overflow screening is recommended when observers are required on hopper dredges. If conditions prevent 100 percent inflow screening, inflow screening can be reduced, but 100 percent outflow screening is required, and an explanation must be included in the preliminary dredging report. Preliminary dredging reports which summarize the results of the dredging and any sea turtle take must be submitted within 30 working days of completion of any given dredging project. Logs of any sea turtle injuries or deaths due to hopper dredging activities will be maintained, with immediate notification to USACE-Jacksonville District, USFWS and NMFS as appropriate, and FWC.

To minimize the potential for collisions, vessels transporting dredged materials to the project site are expected to implement protective measures, where feasible, to avoid interactions with sea turtles, including maneuvering away from the animal or slowing the vessel particularly during poor sighting conditions (i.e. fog, high sea state, darkness). During transport of dredged material to the project site and when returning to the dredge site, vessels would use extreme caution and proceed at a safe speed such that the vessel can take proper and effective action to avoid a potential collision with a sea turtle; this preventative action would significantly reduce the potential for a vessel strike with a sea turtle. Any collision with and/or injury to a sea turtle shall be reported immediately to the NMFS's Protected Resources Division and the local authorized sea turtle stranding/rescue organization.

Reasonable and Prudent Measures

The Corps and Martin County agree to comply with the reasonable and prudent measures and non-discretionary terms and conditions stated in the USFWS Biological Opinion for the proposed Martin County HSDR Project. The USFWS believes the following reasonable and prudent measures are necessary and appropriate to minimize take of loggerhead, green, leatherback, hawksbill, and Kemp's ridley sea turtles in the proposed action area.

1. Beach quality sand suitable for sea turtle nesting, successful incubation, and hatchling emergence shall be used on the project site.
2. Sand placement activities shall not occur from May 1 through October 31, the period of peak sea turtle egg laying and egg hatching, to reduce the possibility of sea turtle nest burial, crushing of eggs, or nest excavation.
3. If sand placement activities are conducted during the period from March 1 through April 30, or November 1 through November 30, surveys for early and

late nesting sea turtles shall be conducted, respectively, if nests are constructed in the area of sand placement, the eggs shall be relocated.

4. Immediately after completion of the project and prior to the next three nesting seasons, beach compaction shall be monitored and tilling shall be conducted as required by March 1 to reduce the likelihood of impacting sea turtle nesting and hatching activities. The March 1 deadline is required to reduce impacts to leatherbacks that nest in greater frequency along the south Atlantic coast of Florida than elsewhere in the continental U.S.
5. Immediately after completion of the project and prior to the next three nesting seasons starting March 1, monitoring shall be conducted to determine if escarpments are present and escarpments shall be leveled as required to reduce the likelihood of impacting sea turtle nesting and hatching activities.
6. USACE shall ensure that contractors performing the sand placement work fully understand the sea turtle protection measures detailed in this incidental take statement.
7. During the early (March 1 through April 30) and late (November 1 through November 30) portions of the nesting season, construction equipment and supplies shall be stored in a manner that will minimize impacts to sea turtles to the maximum extent practicable.
8. During the early (March 1 through April 30) and late (November 1 through November 30) sea turtle nesting season, lighting associated with the project shall be minimized to reduce the possibility of disrupting and disorienting nesting or hatchling sea turtles.
9. Sand placement activities using an offshore sand source will be restricted to within 500 feet unless nighttime monitoring is conducted.
10. Permanent exterior lighting is prohibited.
11. Pre- and post-construction lighting surveys shall be conducted.
12. The sea turtle permit holder shall be notified if a sea turtle nest is excavated.
13. All reports shall be submitted to FWC and USFWS.
14. State and federal agencies shall be notified immediately upon locating a dead, injured, or sick sea turtle.

4.35.2. RIGHT WHALES AND MARINE MAMMALS

To minimize project impacts on right whales and other marine mammals related to transporting dredged material to the project site, the following protective measures will be implemented:

- During transport of dredged material from the borrow area to the project site and when returning to the dredge site, vessels would use extreme caution and proceed at a safe speed such that the vessel can take proper and effective action to avoid a collision with a right whales or other marine mammals and can be stopped within a distance appropriate to the prevailing circumstances and conditions. This preventive action would significantly reduce the potential for a vessel strike with a listed species.

- Dredge contractors would participate in the right whale Early Warning System (EWS), where ships are alerted to the presence of right whales in the project area during the calving season with the aid of aerial surveys. To the extent practicable, vessel operations in right whales critical habitat during the calving season would be minimized and transit course altered immediately upon notification of a right whale sighting through the EWS.
- When whales have been sighted in the area, vessels would increase vigilance and take reasonable and practicable actions to avoid collisions and activities that might result in close interaction of vessels and marine mammals. Actions may include changing speed and/or direction and are dictated by environmental and other conditions (e.g., safety, weather).
- From November 15 through April 15, barges or dredges moving through right whale critical habitat shall take the following precautions: During evening hours or when there is limited visibility due to fog or sea states greater than Beaufort 3, the tug/barge or dredge operator shall slow down to 5 knots or slowest safe navigable speed when traversing between areas if whales have been spotted within 15 nmi of the vessel's path within the previous 24 hours.
- From December 1 through 30 March, daily aerial surveys of the EWS area will be conducted by others (i.e., EWS) to monitor for the presence of right whales. Right whale sightings will be immediately communicated to the dredging contractor's dredge. In addition, the tug/barge or dredge operator shall maintain a 500-yard buffer between the vessel and any sighted whale.
- A NMFS-approved observer would be present on hopper dredges 24 hours a day year-round during the transport of dredged materials. Observers would monitor for the presence of marine mammals from the bridge during daylight hours while transiting to and from the disposal area.
- Floating weeds, algal mats, *Sargassum* rafts, clusters of seabirds, and jellyfish are good indicators of the possible presence of sea turtles and marine mammals. Therefore, increased vigilance in watching for sea turtles and marine mammals will be taken where these are present.

4.35.3. MANATEES

Although manatees are not likely to occur in the project area, the following protection measures will be implemented to minimize potential impacts to manatees:

1. The contractor shall instruct all personnel associated with the project of the potential presence of manatees, the need to avoid collisions with these animals and the need to be on constant lookout for manatees during all phases of operation.
2. All construction personnel shall be advised that there are civil and criminal penalties for harming, harassing, or killing manatees and right whales which are protected under the Marine Mammal Protection Act of 1972, the Endangered Species Act of 1973, and the Florida Manatee Sanctuary Act. The Contractor

shall be held responsible for any manatee harmed, harassed, or killed as a result of construction activities.

3. If siltation barriers are used, they shall be made of material in which manatees cannot become entangled, are properly secured, and are regularly monitored to avoid manatee entrapment. Barriers must not block manatee entry to or exit from essential habitat.
4. All vessels associated with the project shall operate at "no wake/idle" speeds at all times while in waters where the draft of the vessel provides less than a four foot clearance from the bottom and vessels shall follow routes of deep water whenever possible. Boats used to transport personnel shall be shallow-draft vessels, preferably of the light-displacement category where navigational safety permits.
5. If a manatee(s) is sighted within 100 yards of the project area, all appropriate precautions shall be implemented by the contractor to ensure protection of the manatee. These precautions shall include the operation of all moving equipment no closer than 50 feet of a manatee. If a manatee is closer than 50 feet to moving equipment or the project area, the equipment shall be shut down and all construction activities shall cease to ensure protection of the manatee. Construction activities shall not resume until the manatee has departed the project area.
6. Prior to commencement of construction, each vessel involved in construction activities shall display at the vessel control station or in a prominent location, visible to all employees operating the vessel, a temporary sign at least 8 1/2" x 11" reading, "Caution: Manatee Habitat/Idle Speed is Required in Construction Area." In the absence of a vessel, a temporary 3' x 4' sign reading "Caution: Manatee Area" will be posted adjacent to the issued construction permit. A second temporary sign measuring 8½" X 11" reading "Caution: Manatee Habitat. Equipment Must Be Shutdown Immediately If A Manatee Comes Within 50 Feet Of Operation" will be posted at the dredge operator control station and at a location prominently adjacent to the displayed issued construction permit. The contractor shall remove the placards upon completion of construction.
7. Any collisions with a manatee or sighting of any injured or incapacitated manatee shall be reported immediately to USACE.
8. The contractor shall maintain a daily log detailing sightings, collisions, or injuries to manatees occurring during the contract period. The data shall be recorded on forms provided by the Contracting Officer (sample form is appended to the end of this section). All data in original form shall be forwarded directly to the Chief of Environmental Resources Branch, P. O. Box 4970, Jacksonville, Florida, 32232-0019, within 10 days of collection, and copies of the data will be supplied to the Contracting Officer. Within 15 days following project completion, a report summarizing the above incidents and sightings, including a list of names and addresses for all observers used during the construction will be submitted to the proper personnel.

9. Furthermore, during hopper dredge operations, NMFS observers will be on board 24 hours a day and will serve as a lookout to alert the vessel pilot of the occurrence of manatees in the project areas. If a manatee is observed, collisions shall be avoided either through reduced vessel speed, course alteration, or both.

4.35.4. SHOREBIRDS AND MIGRATORY BIRDS

Throughout the Jacksonville District there are numerous unique species of migratory birds. These birds are protected by state and federal laws. A large majority of these birds species are shorebirds and colonial nesting birds. During construction and/or dredging along the waterways, habitat for these birds can potentially be affected or created. The Jacksonville District, in conjunction with the State of Florida Fish and Wildlife Conservation Commission (FWC), the Audubon Society, and USFWS, has developed a district-wide policy concerning its activities and migratory bird nesting. A copy of the Migratory Bird Protection Policy can be downloaded from:
www.saj.usace.army.mil/Divisions/Planning/Branches/Environmental/Protection_Environment.htm.

The USACE protection specifications for contracts as related to migratory bird protection are provided below.

1. The Contractor shall keep construction activities under surveillance, management, and control to prevent impacts to migratory birds and their nests. All construction personnel shall be advised that migratory birds are protected by the Florida Endangered and Threatened Species Act of 1977, Title XXVIII, Chapter 372.072, and the U.S. Fish and Wildlife Service pursuant to the Migratory Bird Treaty Act of 1918 and the Endangered and Threatened Species Act of 1982, as amended. The Contractor may be held responsible for harming or harassing the birds, their eggs or their nests as a result of the construction.
2. In order to meet these responsibilities, the Contractor shall conduct monitoring of the construction area beginning 1 April through 31 August, if construction activities occur during that period. Daily monitoring using the attached forms will be conducted during the dawn or dusk time frames by a bird monitor approved by the Contracting Officer or the Contracting Officer's Representative. (Caution will be taken by the monitor to avoid disturbance to the nesting birds.) The Contractor shall maintain a daily log detailing monitoring and nesting activity. Within 30 days after completion of construction, a summary of monitoring shall be submitted to the Corps detailing nesting and nesting success/failure including species, number of nests created, location, number of eggs, number of offspring generated during the project and reasons for nesting success or failure, if known.
3. Any nesting activity observed by the Contractor will be reported immediately to the Contracting Officer or the Contracting Officer's Representative who shall have sole authority for any work stoppages, creation of the buffer area, or restart of construction activities.
4. Should nesting begin within the construction area, a temporary, 200-foot buffer will be created around the nests and marked to avoid entry (the Contracting Officer will provide signs). The area will be left undisturbed until nesting is

completed or terminated, and the chicks fledge. The decision to allow construction in a former nesting site will be determined by the Contracting Officer in consultation with the U.S. Fish and Wildlife Service and the Florida Game and Fresh Water Fish Commission. Access to the nesting sites by humans (except limited access when accompanied by the bird monitor or Contracting Officer), equipment or pets under control of the Contractor is prohibited.

5. If nesting occurs within the construction area, a bulletin board will be placed and maintained by the Contractor in the contracting shed with the location map of the construction site showing the bird nesting areas and a warning, clearly visible, stating that "BIRD NESTING AREAS ARE PROTECTED BY THE FLORIDA THREATENED AND ENDANGERED SPECIES ACT AND THE FEDERAL MIGRATORY BIRD TREATY ACT".
6. NOTE: Birds will find the top of the dike or the flat interior desirable nesting habitat. If construction activity ceases for any period of time, nesting may occur before work can resume. Any stoppage of activity could induce nesting, subsequently, construction could be altered or stopped to avoid impacting the birds unless the State of Florida and the U.S. Fish and Wildlife Service authorizes the interruption of nesting and/or destruction of the eggs. (NOTE: This authorization is highly unlikely.) Areas which are potentially suitable for nesting can be altered to make the area undesirable. One approved method is the placement of stakes at 10- to 15-foot intervals and tie flagging between the stakes in a web fashion. This may dissuade bird nesting until construction can be resumed. In addition, the disposal area basin can be flooded prior to the beginning of nesting season to the elevation required for displacement from the disposal of dredged material in order to make the basin undesirable for bird nesting.
7. The Contractor's Environmental Protection Plan shall contain the qualifications of the bird monitor and the steps to be taken to construct the project in such a manner as not to impact migratory birds or induce their nesting. The qualifications of the bird monitor are a demonstrated ability to identify bird species, general and nesting behavior characteristics, nests and eggs, and a knowledge of habitat requirements. In addition, references must be provided to verify non-educational experience.
8. Delays in work due to the fault of negligence of the Contractor or the Contractor's failure to comply with this specification shall not be compensable. Any adjustments to the contract performance period or price that are required as a result of compliance with this section shall be made in accordance with the Contract Clause entitled "SUSPENSION OF WORK".

4.35.5. NEARSHORE HARDGROUNDS

All practical measures will be taken by the construction crew to avoid adverse impacts to hardground habitat and associated communities. These measures will include pre-dredging surveys to locate all hardground areas. Anchoring of any dredge barge will be permitted in sandy areas only.

4.35.6. QUALITY ASSURANCE FOR BEACH FILL SEDIMENT AND DREDGING ACTIVITIES

Attachment D of the FDEP Joint Coastal Permit Application includes a Sand Quality Control (QC) and Quality Assurance (QA) Plan. The purpose of the Sand QC and QA Plan, required by paragraph 62B-41.008 (1) (k) (4b) FAC, is to ensure that the sediment from the permitted borrow area will meet the standards outlined in the permit. In-depth geotechnical investigations for the project have verified that the sediment located within the spatial limits of the permitted borrow area meets the requirements stated in paragraph 62B-41.007 (2) (j). The QC Plan for the project will outline requirements placed on the Contractor to ensure that all work occurs within the horizontal and vertical limits of the permitted borrow area and that the Contractor takes appropriate remedial actions for unsuitable material, if necessary. The QA Plan outlines the steps taken by the Owner (Martin County) to observe, samples, and test the placed sediments to assure compliance with the permit.

4.36. COMPLIANCE WITH ENVIRONMENTAL REQUIREMENTS

4.36.1. NATIONAL ENVIRONMENTAL POLICY ACT OF 1969

Environmental information on the project has been compiled and the Draft SEIS was prepared and circulated to appropriate local, state, and federal agencies, as well as interested academic institutions and citizens, prior to finalization in accordance with NEPA. Comments received from these sources have been addressed in the Final SEIS and in **Appendix C, Pertinent Correspondence**.

4.36.2. ENDANGERED SPECIES ACT OF 1973

Consultation was reinitiated with NMFS on April 30, 2007 requesting an updated South Atlantic Division Regional Biological Opinion (SADRBO) for “The Continued Dredging of Channels and Borrow Areas in the Southeastern United States,” original dated September 25, 1997. By letter dated October 25, 2007, NMFS acknowledged receipt of our reinitiation package and provided the following guidance: “So long as the COE follows the reasonable and prudent measures, and implementing terms and conditions outlined in the SARBO, and continues to ensure that its actions will not jeopardize the continued existence of any listed species or result in the destruction or adverse modification of designated critical habitat, the protective coverage of the biological opinion and the Endangered Species Act (ESA) will not lapse.” Consultation was initiated with USFWS on January 14, 2009, and USACE received a request for additional information (RAI) from USFWS on July 20, 2009. Response to that RAI dated August 7, 2009 is included in Appendix C, Pertinent Correspondence. USFWS issued an updated biological opinion in June 2010. This project has been fully coordinated under the Endangered Species Act and is in full compliance with ESA.

4.36.3. FISH AND WILDLIFE COORDINATION ACT OF 1958

This project has been coordinated with USFWS. A Final Coordination Act Report (CAR) dated January 24, 1994 was submitted by USFWS. This project was re-coordinated with USFWS via letter dated November 25, 2009 and a draft response letter concurring with the Corps determination that the 1994 CAR covers the proposed action was received via email on December 10, 2009. This project will be in full compliance with the Fish and Wildlife Coordination Act of 1958.

4.36.4. NATIONAL HISTORIC PRESERVATION ACT OF 1966 (INTER ALIA)

Federal undertakings will comply with the Archeological and Historical Preservation Act of 1974 (16 USC 469-469c); Executive Order 11593, the Abandoned Shipwreck Act of 1987 (PL 100-298; 43 U.S.C. 2101-2106); the National Historic Preservation Act of 1966, as amended (16 USC 470); and the Advisory Council on Historic Preservation's implementing regulations under 36CFR800 (*Protection of Historic Properties*). Section 106 of the National Historic Preservation Act requires federal agencies to provide the SHPO (as agent to the Advisory Council on Historic Preservation) reasonable opportunity to evaluate and comment on any federal undertaking. The act requires the agency to coordinate with SHPO whether or not the agency believes there would be impacts to significant historic resources. The project is in compliance with each of these federal laws.

4.36.5. CLEAN WATER ACT OF 1972 (CWA)

The project will be in compliance with the CWA. A Joint Coastal Application permit was submitted by the sponsor on April 17, 2009. A Section 401 water quality certification will be issued by FDEP. All State water quality standards would be met. A Section 404(b) evaluation is included in this report as Appendix A. A public notice was issued in a manner that satisfies the requirements of Section 404 of the CWA.

4.36.6. CLEAN AIR ACT OF 1972

No air quality permits would be required for this project. An air quality emissions analysis was completed by the cooperating agency for this NEPA document, BOEMRE, and is included in Appendix N. The project is expected to be in attainment with EPA air quality standards.

4.36.7. COASTAL ZONE MANAGEMENT ACT OF 1972

A federal consistency determination in accordance with 15CFR930 Subpart C is included in this report as Appendix B. Preliminary state consistency review was performed during the coordination of the NOI and the state has determined that, at this stage, the project is consistent with the Florida Coastal Zone Management Program (see letter dated July 26, 2007, from the Florida State Clearinghouse concurring with our consistency determination in Appendix C).

4.36.8. FARMLAND PROTECTION POLICY ACT OF 1981

No prime or unique farmland would be impacted by implementation of this project. This act is not applicable.

4.36.9. WILD AND SCENIC RIVER ACT OF 1968

No designated Wild and Scenic River reaches would be affected by project-related activities. This act is not applicable.

4.36.10. MARINE MAMMAL PROTECTION ACT OF 1972

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

4.36.11. ESTUARY PROTECTION ACT OF 1968

No designated estuary would be affected by project activities. This act is not applicable.

4.36.12. FEDERAL WATER PROJECT RECREATION ACT

The principles of the Federal Water Project Recreation Act (Public Law 89-72), as amended, have been fulfilled by complying with the recreation cost-sharing criteria as outlined in Section 2 (a), paragraph (2). Another area of compliance includes the public beach access requirement on which the renourishment project hinges [Section 1, (b)].

4.36.13. FISHERY CONSERVATION AND MANAGEMENT ACT OF 1976

The project has been coordinated with NMFS and will be in compliance with the Fishery Conservation and Management Act. USACE received a preliminary letter dated June 28, 2007 from NMFS. Comments on the SEIS were received from NMFS on January 7, 2011. USACE prepared a response package and submitted it to NMFS on February 22, 2011. All correspondence is provided in **Appendix C, Pertinent Correspondence**.

4.36.14. SUBMERGED LANDS ACT OF 1953

The project would occur on submerged lands within of the state of Florida. The project has been coordinated with the State and is in compliance with the Submerged Lands Act of 1953.

4.36.15. COASTAL BARRIER RESOURCES ACT AND COASTAL BARRIER IMPROVEMENT ACT OF 1990

There are no designated coastal barrier resources in the project area that would be affected by this project. These acts are not applicable.

4.36.16. RIVERS AND HARBORS ACT OF 1899

The proposed work would not obstruct navigable waters of the United States. The proposed action has been subject to public notice, public hearing, and other evaluations normally conducted for activities subject to the Rivers and Harbors Act of 1899. The project is in full compliance.

4.36.17. ANADROMOUS FISH CONSERVATION ACT

Anadromous fish species would not be affected. The project has been coordinated with NMFS and is in compliance with the Anadromous Fish Conservation Act.

4.36.18. MIGRATORY BIRD TREATY ACT AND MIGRATORY BIRD CONSERVATION ACT

Impacts to migratory birds will be mitigated by implementation of conservation measures required by the Migratory Bird Treaty Act and the Migratory Bird Conservation Act; thus the project will be in compliance with both acts.

4.36.19. MARINE PROTECTION, RESEARCH AND SANCTUARIES ACT

The term "dumping" as defined in the Marine Protection, Research and Sanctuaries Act {3[33 U.S.C. 1402](f)} 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 SEIS have been evaluated under Section 404 of the Clean Water Act.

4.36.20. MAGNUSON-STEVENS FISHERY CONSERVATION AND MANAGEMENT ACT

This act requires preparation of an EFH assessment and coordination with NMFS. An independent EFH assessment is provided in **Appendix E**. USACE provided this EFH assessment to NMFS during the EFH coordination process. NMFS responded with their EFH conservation recommendations via letter dated January 7, 2011. The Corps formally responded to the EFH recommendations via letter dated February 22, 2011. Therefore this project is in compliance with this Act and EFH coordination is complete.

4.36.21. EXECUTIVE ORDER 11990, PROTECTION OF WETLANDS

No wetlands would be affected by project activities. This project is in compliance with the goals of this Executive Order 11990.

4.36.22. EXECUTIVE ORDER 11988, FLOOD PLAIN MANAGEMENT

The project is in the base flood plain (100-year flood) and is being evaluated in accordance with this Executive Order. The project will be in compliance.

4.36.23. EXECUTIVE ORDER 12898, ENVIRONMENTAL JUSTICE

The proposed project would not result in adverse human health or environmental effects, nor would the activity impact subsistence consumption of fish or wildlife. The project is in compliance with Executive Order 12898.

4.36.24. EXECUTIVE ORDER 13089, CORAL REEF PROTECTION

The proposed project may affect U.S. coral reef ecosystems as defined in Executive Order 13089. The offshore borrow areas will be designed to avoid impacts to hardbottom resources by establishing a 500-foot buffer around any identified resources. Additional protective measures will be implemented to minimize impacts to adjacent hardbottom resources, including turbidity monitoring with cessation of construction activities if turbidity exceeds the State limit of 29 NTUs above background, real-time sedimentation monitoring during project construction, and post-construction monitoring of nearshore hardbottom resources adjacent to the beach fill areas to evaluate potential long-term impacts of turbidity and sedimentation. A mitigation plan was developed in coordination with federal, state, and county agencies to fully compensate for unavoidable impacts to nearshore hardbottom resources. The nearshore hardbottom epibenthic communities landward of the ETOF do not represent irreplaceable resources. With proper placement of artificial reefs, suitable replacement habitat has been created for nearshore epibenthic species. The proposed project will be in compliance with Executive Order 13089.

4.36.25. OUTER CONTINENTAL SHELF LANDS ACT

The federal government administers the submerged lands, subsoil, and seabed, lying between the states' seaward jurisdiction and the seaward extent of federal jurisdiction. The Outer Continental Shelf Lands Act (OCSLA) and subsequent amendments, in later years, outlines the federal responsibility over the submerged lands of the OCS. Additionally, it authorizes the Secretary of the Interior to lease those lands for mineral development. The project has been coordinated with the U.S. Minerals Management Service, which is a cooperating agency for this NEPA document, and is in compliance with the OCSLA.

5. LIST OF PREPARERS

5.1. PREPARERS

A list of preparers, with their qualifications, experience, and corresponding roles in the preparation of this Draft SEIS is provided in **Table 5.1-1**.

Table 5.1-1. List of Preparers

Name	Discipline	Role in SEIS Preparation	Experience
Paul DeMarco, M.S. USACE, Jacksonville District	Biologist	USACE Project Manager	18 Years, Natural Resources Management and Ecology
Michelle Rau, M.S. ANAMAR Environmental Consulting, Inc.	Ecologist	ANAMAR Project Manager, Principle Writer	14 Years, Natural Resources Management and Ecology
Christine Smith, B.A. ANAMAR Environmental Consulting, Inc.	GIS Specialist	Developed Figures and Maps, EFH Assessment	6 Years, Environmental Geography and ArcGIS
Terence Cake, P.E. ANAMAR Environmental Consulting, Inc.	Water Resources Engineer	404(b) Evaluation Report	16 Years, Water Resources and Environmental Engineering
Constance Steen ANAMAR Environmental Consulting, Inc.	Editor	Technical Editing and Document Formatting	>25 Years Working with Environmental Documents
Debra Segal, M.S. Wetland Solutions, Inc.	Senior Scientist	Document Reviewer	18 Years, Natural Resources Management and Ecology

5.2. REVIEWERS

A list of reviewers, their discipline, and corresponding roles in the review of the Draft SEIS is provided in **Table 5.2-1**.

Table 5.2-1. List of Reviewers

Name	Discipline	Role in SEIS Preparation
Geoffrey Wikel, BOEMRE Environmental Division	Oceanographer	Technical Reviewer
Dr. James R. Woehr, BOEMRE Environmental Division	Avian Biologist	Technical Reviewer
Dr. Sally Valdes, BOEMRE Environmental Division	Ecologist	Technical Reviewer
Dr. Brian Jordan, BOEMRE Environmental Division	Marine Archaeologist	Technical Reviewer
Kimberly Skrupky, BOEMRE Environmental Division	Marine Biologist	Technical Reviewer
Melissa Meeker, Hesperides Group	Coastal Engineer	Technical Reviewer
Kathy Fitzpatrick, Martin County	Coastal Engineer	Project Sponsor
Grady Caulk, USACE, Jacksonville District	Archaeologist	Technical Reviewer

6. PUBLIC INVOLVEMENT

6.1. SCOPING AND DRAFT SEIS

An NOI to prepare a Draft SEIS appeared in the Federal Register on June 1, 2007. In addition, the NOI was mailed to interested and affected parties by letter dated June 1, 2007. A copy of the scoping letter, NOI, letters of comment/response are provided in **Appendix C**.

A Notice of Availability (NOA) of the Draft SEIS appeared in the Federal Register on November 5, 2010. In addition, the NOA was mailed to interested and affected parties by letter dated November 1, 2010. Comments and responses to those comments have been incorporated into the Final SEIS and are located in Appendix C.

6.2. AGENCY COORDINATION

The proposed project was coordinated with the following agencies: USFWS, NMFS, USEPA, Florida State Clearinghouse, FFWCC, FDEP, Florida SHPO, BOEMRE and other interested parties. Issues of concern raised by state and federal agencies relevant to the proposed nourishment project are incorporated into this Draft SEIS for detailed evaluation. The proposed action will involve evaluation for compliance with guidelines pursuant to Section 404(b) of the Clean Water Act; application (to the State of Florida) for Water Quality Certification pursuant to Section 401 of the Clean Water Act; certification of state lands, easements, and rights of way; and determination of Coastal Zone Management Act consistency. Agency coordination letters are in **Appendix C**.

As a federal agency with jurisdiction to manage resources available on the OCS, BOEMRE was invited by USACE to participate as a partner on the Martin County HSDR Project in April 2007. This partnership was developed to fulfill BOEMRE's mandatory statutory environmental and leasing requirements for the issuance of a negotiated noncompetitive agreement for the use of OCS sand resources. As a cooperating agency, with respect to NEPA, BOEMRE:

- Participated in the NEPA process;
- Participated in the scoping process;
- Assumed, on the request of USACE, responsibility for developing information and preparing environmental analyses for which BOEMRE has special expertise; and
- Made available staff support at the lead agency's request to enhance the interdisciplinary capability of USACE.

BOEMRE also agreed to participate in the required ESA Section 7 consultation, the Magnuson-Stevens Fishery and Conservation Management Act Essential Fish Habitat consultation (Section 305), the NHPA Section 106 process, and the Coastal Zone Management Act Section 307 consistency determination. As the lead federal agency for ESA Section 7 and the Essential Fish Habitat consultations, USACE notified USFWS and NMFS of its lead role and BOEMRE's cooperating status. Through this partnership USACE jointly submitted, with BOEMRE, the ESA Section 7 and Essential Fish Habitat assessments to USFWS and NMFS. USACE also acted as the lead federal agency for Section 106 compliance in accordance with 36 CFR Part 800.2(2) while BOEMRE acted as a cooperating agency for Section 106 compliance, offering input and consultation as needed.

6.3. LIST OF STATEMENT RECIPIENTS (DRAFT SEIS)

A complete mailing list for the NOI and NOA is in **Appendix C**. The final SEIS is posted on USACE ftp site: ftp://ftp.saj.usace.army.mil/pub/Public_Dissemination/Martin%20County%20BEC%20New%20Borrow%20Area/.

6.4. COMMENTS RECEIVED AND RESPONSE

Comments received during the scoping process and DSEIS public comment process are summarized in Section 1.6. Complete letters of comment and response are provided in **Appendix C.**

7. REFERENCES

Ackerman, R.A. 1991. *Physical factors affecting the water exchange of buried eggs.* Pages 193-211. In: Deeming, C. and M. Gerguson (eds.). Egg Incubation—Its Effect on Embryonic Development in Birds and Reptiles. Cambridge University Press, Cambridge, England.

Ackerman, R.A., R. Rimkus, and R. Horton. 1992. *Hydric structure and climate of natural and renourished sea turtle nesting beaches along the coast of Florida.* Florida Department of Natural Resources, Tallahassee, Florida.

Adams, J.A. 1960. *A contribution to the biology and postlarval development of the sargassum fish,* Histrio histrio *(Linnaeus), with a discussion of the Sargassum complex.* Bulletin of Marine Science of the Gulf and Caribbean. 10(1):55-82.

ANAMAR Environmental Consulting, Inc. 2009. *Biological analysis and review of sidescan sonar data collected in potential sand borrow areas, Martin County Shore Protection Project, Hutchingosn, Island, Martin County, Florida.* Prepared for the U.S. Army Corps of Engineers Jacksonville District, Jacksonville, FL. January 2009.

Anderson, W.W., J.E. King, and M.J. Lindner. 1949. *Early life stages in the life history of the common marine shrimp,* Penaeus setiferus *(Linneaus). Biol. Bull*. (Woods Hole). 96:168-172.

Andreassi, G. *Martin County doubles bed tax to 4%.* TC Palm. January 8, 2008. http://tcpalm.com/new/2008/jan08/martin-doubles-bed-tax-4.

Applied Biology, Inc. (ABI). 1979. *Biological studies concerning dredging and beach nourishment at Duval County, Florida with a review of pertinent literature.* U.S. Army Corps of Engineers District, Jacksonville, Florida. Unpublished report, September 1979.

Applied Biology, Inc. (ABI). 1994. *Florida Power & Light Company, St. Lucie Unit 2 annual environmental operating report 1993.* Volume 1. AB-631. Prepared by Applied Biology, Inc. for Florida Power & Light Co., Juno Beach.

Applied Technology and Management, Inc. (ATM). 1991. *Summary report: 4-mile beach restoration project, Martin County, Florida.* Prepared for Martin County Board of County Commissioners. September 9, 1991.

Applied Technology and Management, Inc. (ATM). 1994. *Assessment of terrestrial habitats.* Martin County Beach Restoration. Prepared for Florida Department of Environmental Protection. Bureau of Beaches Coastal Systems. December 2, 1994.

Applied Technology and Management, Inc. (ATM). 1998. *Martin County Beach nourishment project, project performance report.* Gainesville, Florida.

Atlantic States Marine Fisheries Commission (ASMFC). 2002. *Beach nourishment: a review of the biological and physical impacts.* November 2002.

Baird, R.W. and P.J. Stacey. 1990. *Status of Risso's dolphin, Grampus griseus, in Canada*. Can. Field-Nat. 105: 233-242.

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.

Barnes, R.D. 1974. *Invertebrate Zoology.* Third Edition. W.B. Saunders Company, Philadelphia.

Barnes, R.S. and R.N. Hughes. 1988. *Introduction to Marine Ecology.* Second Edition. Blackwell Science Inc., Malden, MA.

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.

Becker, P.H., D. Frank, and S.R. Sudmann. 1993. *Temporal and spatial pattern of common tern (*Sterna hirundo*) foraging in the Wadden Sea*. Oecologia, **93**, 389-393

Békésy, G. 1948. *Vibration of the head in a sound field, and its role in hearing by bone conduction.* Journal of the Acoustical Society of America. 20:749-760.

Bertolero, A., D. Oro, A. Martinez Vilalta, and M. Angel Lopez. 2005. *Selection of foraging habitats by Little Terns* Sterna albifrons *at the Ebro Delta (NE Spain).* Revista Catalana d'Ornitologia*,* 21, 37-42.

Blair, S.M. and B.S. Flynn. 1988. *Sunny Isles beach restoration project: mechanical damage to the reefs adjacent to the borrow area.* Metropolitan Dade County Department of Environmental Resources Management Technical Report 88-14. 33 pp.

Blair, S.M., B.S. Flynn, and S. Markley. 1990. *Characteristics and assessment of dredge related mechanical impact to hard-bottom reef areas of northern Dade County, FL.* Pages 5-20. In: Jaap, W.C. (ed.). Proceedings of the American Academy of Underwater Sciences Tenth Annual Scientific Diving Symposium, Diving for Science 1990, Costa Mesa, CA.

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.

Bonsdorff, E. 1983. *Recovery potential of macrozoobenthos from dredging in shallow brackish waters; Fluctuation and succession in marine ecosystems.* Proceedings of the 17th European Marine Biology Symposium, Brest : France, *Oceanologica Acta, 27-32.*

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.

Bowen, P.R. and G.A. Marsh. 1988. *Benthic faunal colonization of an offshore borrow pit in southeastern Florida.* Miscellaneous Paper D-88-5, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

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. NMFS-SEFSC-477, Orlando, FL.

Britt & Associates, Inc. 1979. *Reef damage survey for the Broward County Erosion Prevention Division, Broward County, FL.* 166 pp.

Brooks, R.A., C.N. Purdy, S.S. Bel, and K.J. Sulak. 2006. *The benthic community of the eastern U.S. continental shelf: a literature synopsis of the benthic faunal resources.* Continental Shelf Research. 26:804-818.

Brostoff, W. N. 2002. *Interstitial bryozoan fauna from Capron Shoal, Florida and adjacent areas: final report.* U.S. Army Corps of Engineers Research & Development Center, Vicksburg, MS. Prepared for USACE Jacksonville District.

Browder, A.E., R. Dean, and R. Chen. 1996. *Performance of a submerged breakwater for shore protection.* 25th International Conference on Coastal Engineering, American Society of Civil Engineers September 2-6, 1996, New York, New York.

Burlas, M., G.L. Ray, and 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 Corps of Engineers, New York District, Engineer Research and Development Center and Waterways Experiment Station.

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. 1993(1):176-180.

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.* Pages 140-142. In:: Salmon, M. and J. Wyneken (eds.). Proceedings of the Eleventh Annual Workshop on Sea Turtle Biology and Conservation. NOAA Technical Memorandum NMFS-SEFC-302.

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, T.D. Thibaut, and D.B. Snyder. 2004. *Physical and biological effects of sand mining offshore Alabama, USA.* Journal of Coastal Research. 20(1):6-24.

Carr, A.F. 1986. *Rips, FADS, and little loggerheads.* Bioscience 36(2):92-100.

Carr, A. 1987. *New perspectives on the pelagic stage of sea turtle development.* Conservation Biology. 1:103-121.

Carr, R.S., L. Jester, J. Pepe, Jim, and W.S. Steele. 1995. *An archaeological survey of Martin County*. The Archaeological and Historical Conservancy, Inc.

Caruso, P. (Paul.Caruso@state.ma.us) (24 April 2002): *Beach nourishment.* Karen Greene (kngreene@erols.com).

CETAP. 1982. *A characterization of marine mammals and turtles in the mid- and north Atlantic areas of the U.S. outer continental shelf, final report*. Washington, DC, Bureau of Land Management. #AA551-CT8-48 538 pp.

Challenge Engineering and Testing, Inc. 2007. *Final report: vibracore sampling and laboratory testing. Martin County Offshore Investigations Project*. Prepared for U.S. Army Corps of Engineers, Jacksonville District. Geotechnical Branch. November 2007.

Clarke, D., C. Dickerson, K. Reine. 2003. *Characterization of underwater sounds produced by dredges.* U.S. Army Engineer Research and Development Center, Vicksburg, MS and DynCorp Corporation, Vicksburg, MS

Coastal Planning and Engineering, Inc. (CP&E). 1997. *Survey and project information report (PL-84-99) Martin County, Florida Shore Protection Project.* Prepared for U.S. Army Corps of Engineers, Jacksonville District.

Coastal Planning and Engineering, Inc. (CP&E). 2006. *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 Science Associates, Inc. 1994. *Martin County nearshore rock and reef survey: final report.* Prepared for Applied Technology and Management, Inc. November 1994.

Coastal Tech. 2007. *St. Lucie County, Florida South Beach: Geotechnical Investigation Reconnaissance Level Investigation Plan.* Prepared for St. Lucie County. July 2007.

Collette, B.B. and C.E. Nauen. 1983. FAO Species Catalogue. Vol. 2. *Scombrids of the World.* An Annotated and Illustrated Catalogue of Tunas, Mackerels, Bonitos, and Related Species Known to Date. FAO Fish Snynop. 125(2)137 pp.

Collins, M.R. and B.W. Stender. 1987. *Larval king mackerel (Scomberomorus cavalla), Spanish mackerel (S. maculatus), and bluefish (Pomatomus saltatrix) off the southeast coast of the United States, 1973-1980.* Bulletin of Marine Science. 41:822-834.

Comyns, Bruce H., N. M. Crochet, J.S. Franks, J. R. Hendon, and R. S. Waller. 2002. *Preliminary assessment of the association of larval fishes with pelagic sargassum habitat and convergence zones in the northcentral* Gulf of Mexico. Univ. of So. Mississippi Institute of Marine Sciences.

Continental Shelf Associates, Inc. (CSA). 2002a. *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, SC. 47pp + app.

Continental Shelf Associates, Inc. (CSA). 2002b. *Second post-nourishment monitoring survey of nearshore hard bottom habitats south of Fort Pierce Inlet Fort Pierce, Florida.* Unpublished report. 29pp.

Continental Shelf Associates, Inc. (CSA). 2007. *Baseline survey of nearshore hardbottom habitats in Martin County, Florida.* CSA International, Jupiter, Florida.

Continental Shelf Associates, Inc. (CSA). 2011. *Hutchinson Island Shore Protection Project 2010 hard bottom baseline survey.* CSA International, Jupiter, Florida. January.

CSA International, Inc. 2009. *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. 2010. *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., Applied Coastal Research and Engineering, Inc., Barry A. Vittor & Associates, Inc., C.F. Bean, L.L.C., and Florida Institute of Technology. 2009. *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.

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 northcentral Gulf of Mexico.* Proceedings of the Fifty-Third Annual Gulf and Caribbean Fisheries Institute. No. 53. 636-645 pp.

Cook, A.S.C.P. & Burton, N.H.K. 2010. *A review of the potential impacts of marine aggregate extraction on seabirds.* Marine Environment Protection Fund (MEPF) Project 09/P130. ISBN 978 0 907545 35 4.

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.

Council on Environmental Quality (CEQ). 1997. *Considering cumulative effects under the National Environmental Policy Act.* January 1997.

Courtenay, W.R., Jr., D.J. Herrema, M.J. Thompson, W.P. Azzinaro, and J. van Montfrans. 1972. *Ecological monitoring of two beach nourishment projects in Broward County, Florida.* Shore and Beach. 40(2): 8-13.

Courtenay, W.R., Jr., D.J. Herrema, M.J. Thompson, W.D. Azzinaro, and J. van Montfrans. 1974. *Ecological monitoring of beach erosion control projects, Broward County, Florida, and adjacent areas.* U.S. Army, Corps of Engineers, Coastal Engineering Research Center Technical Memorandum 41. 88 pp.

Curray, J.R. 1965. *Late quaternary history, continental shelves of the United States.* Pages 723-735 In: The Quaternary of the United States. Princeton University Press.

Dayton, P. 1984. *Processes structuring some marine communities: are they general?* Pages 181-200. In: Strong, D.R., D. Simberloff, L.G. Abele, and A.B. Thistle (eds.). Ecological Communities, Conceptual Issues and the Evidence. Princeton University Press.

Dean, C. 1999. *Against the Tide: The Battle for America's Beaches.* Columbia University Press. New York, New York.

Deis, D.R., K.W. Spring, and A.D. Hart. 1992. *Captiva Beach Restoration Project – Biological Monitoring Program*. Pages 227-241 In: New Directions in Beach Management: Proceedings of the 5th Annual National Conference on Beach Preservation Technology. Tallahassee, FL. Florida Shore and Beach Preservation Association.

Department of the Navy (DoN). 2007. *Marine Resources Assessment for Southeastern Florida and the AUTEC-Andros Operating Areas, Final Report*. Naval Facilities Engineering Command (NAVFAC), Norfolk, Virginia. Contract #N62470-02-D-9997, CTO 0034. Prepared by Geo-Marine, Inc., Hampton, Virginia for U.S. Fleet Forces Command.

Diaz, R.J., G.R. Cutter, Jr., C.H. Hobbs, III. 2004. *Potential Impacts of Sand Mining Offshore of Maryland and Delaware: Part 2 – Biological Considerations.* Journal of Coastal Research. 20(1):61-69.

Díaz-Delgado, R, J. Seoane, and J. Bustamante. 2004. *Competing roles for landscape, vegetation, topography and climate in predictive models of bird distribution.* Ecological Modeling. 171:209-222.

Dickerson, D.D., M.S. Wolters, C.T. Theriot, and C. Slay. 2004. *Dredging Impacts on Sea Turtles in the southeastern USA: a historical review of protection.* In: Proceedings of World Dredging Congress XVII, Dredging in a Sensitive Environment. 27 September-1 October 2004. Central Dredging Association, ISBN 90-9018244-6, CD-ROM.

Dickerson, D.D., C. Theriot, M. Wolters, C. Slay, T. Bargo, and W. Parks. 2007. *Effectiveness of relocation trawling during hopper dredging for reducing incidental take of sea turtles.* Engineer Research and Development Center, Waterways Experiment Station, Vicksburg, MS.

Dickson, R. and A. Lee. 1972. *Study of the effects of marine gravel extraction on the topography of the sea bed. ICES, C.M. 1972*/E: 25.

Ditty, J.G. and R.F. Shaw. 1992. *Larval development, distribution, and ecology of cobia* Rachycentron canadum *(Family: Rachycentridae) in the Northern Gulf of Mexico.* Fishery Bulletin. 90:668-677.

Ditty, J.G., C.B. Grimes, and J.S. Cope. 1994. *Larval development, distribution, and abundance of common dolphin,* Coryphaena hippurus*, and pompano dolphin,* C. equiselis *(Family:* Coryphaenidae*), in the northern Gulf of Mexico.* Fishery Bulletin. 92:275-291.

Dodd, C.K., Jr. 1988. *Synopsis of the biological data on the loggerhead sea turtle* Caretta caretta *(Linnaeus 1758).* U.S. Fish and Wildlife Service, Biological Report, 88(14).

Dodge, R.E., S. Hess, and C. Messing. January 1991. *Final Report: Biological monitoring of the John U. Lloyd Beach renourishment: 1989.* Prepared for Broward County Board of County Commissioners Erosion Prevention District of the Office of Natural Resource Protection. NOVA University Oceanographic Center: Dania, Florida. 62 pp. plus appendices.

Dodge, R.E., W. Goldberg, C. Messing, and S. Hess. 1995. *Final Report: Biological monitoring of the Hollywood-Hallandale Beach nourishment project.* Prepared for Broward County Board of County Commissioners, Department of Natural Resources Protection, Biological Resources Division. September 1995.

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. Contrib. Mar. Sci. 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.

Duane, D.B. and E.P. Meisburger. 1969. *Geomorphology and sediments of the nearshore continental shelf: Miami to Palm Beach, Florida.* U.S. Army Corps of Engineers, CERC Technical Memorandum No. 29, vp.

Duffield, D. A. 1986. *Investigation of genetic variability in stocks of the bottlenose dolphin (*Tursiops truncatus*).* Final report to the NMFS/SEFSC, Contract No. NA83-GA-00036, 53 pp.

Duffield, D. A., S. H. Ridgway and L. H. Cornell. 1983. *Hematology distinguishes coastal and offshore forms of dolphins (Tursiops).* Can. J. Zool. 61: 930-933.

Ebersole, B.A. 1982. *Atlantic coast water-level climate.* WIS Report 7. April 1982.

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.

Eckert, K.L. 1995. *Leatherback Sea Turtle,* Dermochelys coriacea. In: Plotkin, P.T. (ed.). National Marine Fisheries Service and U.S. Fish and Wildlife Service Status Reviews for Sea Turtles Listed under the Endangered Species Act of 1973. Silver Spring, MD.

Eckert, S.A., D.W. Nellis, K.L. Eckert, and G.L. Kooyman. 1986. *Diving patterns of two leatherback sea turtles (*Dermochelys coriacea*) during internesting intervals at Sandy Point, St. Croix, U.S. Virgin Islands.* Herpetologica. 42(3):381-388.

Ecological Associates, Inc. (EAI). 1997a. *Martin County Beach Nourishment Project, Sea Turtle Monitoring and Studies, 1995 Annual Report.* Ecological Associates, Inc., Jensen Beach, Florida. 39 pp. + tables, figures, and appendices.

Ecological Associates, Inc. (EAI). 1997b. *Martin County Beach Nourishment Project, Sea Turtle Monitoring and Studies, 1996 Annual Report.* Ecological Associates, Inc., Jensen Beach, Florida. 61 pp. + tables, figures, and appendices.

Ecological Associates, Inc. (EAI). 1998. *Martin County Beach Nourishment Project: Results of 1998 Sea Turtle Monitoring, Hutchinson Island, Florida.* Ecological Associates, Inc., Jensen Beach, Florida. 12 pp. + tables and figures.

Ecological Associates, Inc. (EAI). 2000a. *Martin County Beach Nourishment Project: Results of 1999 Sea Turtle Monitoring, Hutchinson Island, Florida.* Ecological Associates, Inc., Jensen Beach, Florida. 11 pp. + tables and figures.

Ecological Associates, Inc. (EAI). 2000b. *Martin County Beach Nourishment Project: Results of 2000 Sea Turtle Monitoring, Hutchinson Island, Florida.* Ecological Associates, Inc., Jensen Beach, Florida. 12 pp. + tables and figures.

Ecological Associates, Inc. (EAI). 2002. *Martin County Beach Renourishment Project: Results of 2001 Sea Turtle Monitoring, Hutchinson Island, Florida.* Ecological Associates, Inc., Jensen Beach, Florida. 12 pp. + tables and figures.

Ecological Associates, Inc. (EAI). 2003. *Martin County Beach Renourishment Project: Results of 2002 Sea Turtle Monitoring, Hutchinson Island, Florida.* Ecological Associates, Inc., Jensen Beach, Florida. 12 pp. + tables and figures.

Ecological Associates, Inc. (EAI). 2004a. *Martin County Beach Renourishment Project: Results of 2003 Sea Turtle Monitoring, Hutchinson Island, Florida.* Ecological Associates, Inc., Jensen Beach, Florida. 16 pp. + tables and figures.

Ecological Associates, Inc. (EAI). 2004b. *Martin County Beach Renourishment Project: Results of 2004 Sea Turtle Monitoring, Hutchinson Island, Florida.* Ecological Associates, Inc., Jensen Beach, Florida. 16 pp. + tables and figures.

Ecological Associates, Inc. (EAI). 2005. *Martin County Beach Nourishment and Dune Restoration Projects, Results of 2005 Sea Turtle Monitoring.* Ecological Associates, Inc., Jensen Beach, Florida. 11 pp. + tables, figures, and appendices.

Ecological Associates, Inc. (EAI). 2006. *Martin County Monitoring Area, Hutchinson Island, Florida; Results of 2005 Sea Turtle Monitoring.* Ecological Associates, Inc., Jensen Beach, Florida. 15 pp. of figures and tables.

Ecological Associates, Inc. (EAI). 2009. Piping Plover Surveys – St. Lucie Inlet Area. Prepared for Martin County, Florida. Ecological Associates, Inc., Jensen Beach, Florida.

Eden, R. A. 1975. North Sea environmental geology in relation to pipelines and structures. *Oceanology International 75, 302-9.*

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.

Environmental Defense. 2000. *70 Ph.D. scientists urge higher environmental standards in beach and dredge fill projects.* Letter to Colonel Joe R. Miller. Dated June 27, 2000. (http://www.environmentaldefense.org/documents/457_BeachDredgingLetter2000.pdf)

Ernest, R.G. and R.E. Martin. 1999. *Martin County Beach Nourishment Project: Sea Turtle Monitoring and Studies.* 1997 Annual Report and Final Assessment. Unpublished report prepared for the Florida Department of Environmental Protection.

Ernest, R.G. and R.E. Martin. 2004. *Martin County Beach Nourishment Project: Results of 2004 Sea Turtle Monitoring, Hutchinson Island, Florida.* Prepared for Martin County.

Ernst, C.J., J. Lovich, and R. Barbour. 1994. *Turtles of the United States and Canada.* Smithsonian Institute Press, Washington, D.C., 578 pp.

Essink, K. 1999. *Ecological effects of dumping of dredged sediments; options for management.* Journal of Coastal Conservation, 5, 69-80.

Fahay, M.P. 1975. An annotated list of larval and juvenile fishes captured with surface-towed meter net in the South Atlantic Bight during four R/V Dolphin cruises between May 1967 and February 1968. *NOAA Tech. Rep.* NMFS SSRF-685. 39 p.

Federal Emergency Management Agency (FEMA). 1983. *Flood Insurance Study, Martin County, Florida Unincorporated Areas.* December 1980.

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 Coastal Management Program (FCMP). 1996. *Florida State of the Coast Report.* Prepared by the Florida Center for Public Management at Florida State University.

Florida Department of Environmental Protection (FDEP). 2007. Critically eroded beaches in Florida. Bureau of Beaches and Coastal Systems. Division of Water Resource Management.

Florida Department of Environmental Protection (FDEP). 2009. *Joint Application for Joint Coastal Permit / Authorization to Use Sovereignty Submerged Lands / Federal Dredge and Fill Permit*. Tallahassee, FL.

Florida Fish and Wildlife Conservation Commission (FWC). 2009a. Standard manatee conditions for in-water work. Tallahassee, Florida [Internet]. [cited July 23, 2009]. Available from http://myfwc.comldocslWildlifeHabitatsJManatee_StdCondln_waterWork.pdf.

Florida Fish and Wildlife Conservation Commission (FWC). 2009b. Florida statewide nesting beach survey data—2008 season [Internet]. [Cited July 23, 2009.] Available from http://www.floridamarine.org/features/view_article.asp?id=11812.

Florida Fish and Wildlife Conservation Commission (FWC) and Fish and Wildlife Research Institute (FWRI). 2006. *Annual trends in Florida's sea turtle nesting.* http://research.myfwc.com/featues/view_article.asp?id=10690. Accessed March 17, 2006.

Florida Marine Research Institute (FMRI). 2009. *Manatee synoptic surveys.* http://research.myfwc.com/features/print_article.asp?id=15246. Accessed April 7, 2009.

Florida Natural Areas Inventory (FNAI). 2001. Online Field Guide to Rare Animals of Florida. http://www.fnai.org/fieldguide/search_002.cfm.

Freedenberg, H., R. Hoenstine, Z. Chen, and H. Williams. 1995. *A geological investigation of the offshore area along Florida's central east coast, year 1.* U.S. Department of the Interior, Minerals Management Service by the State of Florida, Department of Environmental Protection, Florida Geological Survey, Tallahassee, FL. Open File Report Number 69, 97 pp.

Furness, R.W. and M.L. Tasker. 2000. *Seabird-fishery interactions: quantifying the sensitivity of seabirds to reductions in sandeel abundance, and identification of key areas for sensitive seabirds in the North Sea.* Marine Ecology Progress Series. 202, 253-264.

Garthe, S. O. Hüppop. 2004. *Scaling the possible adverse effects of marine wind farms on seabirds: developing and applying a vulnerability index*. Journal of Applied Ecology, 41, 724-734.

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, R.G., Jr. 1992. *Striped croaker,* Bairdiella sanctaeluciae. Pages 218-222. In: Gilbert, C.R. (ed). *Rare and Endangered Biota of Florida*. University Press of Florida.

Gilmore, R.G., Jr. 2008. *Regional Fishery Resource Survey and Synthesis in Support of Martin County's Comprehensive Beach and Offshore Monitoring Program. Final Report.* Prepared for Martin County Engineering Department, Stuart, Florida. December 2008.

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 P.A. Hastings. 1983. *Observations on the ecology and distribution of certain peripheral fishes in Florida.* Florida Scientist. 46:31-51.

Goldberg, W.M. 1973. *The ecology of the octocoral communities off the southeast Florida coast; geomorphology, species composition, and zonation.* Bulletin of Marine Science. 23(3):465-488.

Goldberg, W.M. 1988. *Biological effects of beach nourishment in south florida: the good, the bad and the ugly.* Proceedings of Beach Preservation Technology 1988 Tallahassee, Florida. Florida Shore and Beach Preservation Association.

Gore, R.H., L.E. Scotto, and L.J. Becker. 1978. *Community composition, stability, and trophic partitioning in decapod crustaceans inhabiting some subtropical sabellarid worm reefs. studies on the decapod crustacea of the Indian River region of Florida.* Bulletin of Marine Science. 28(2):221-248.

Goren M. 1979. *Succession of benthic community on artificial substratum at elat (Red Sea).* J. Expt. Mar. Biol. Ecol. 38:1949.

Gorzelany, J.F. and W.G. Nelson. 1987. *The effects of beach nourishment on the benthos of a subtropical Florida beach.* Marine Environmental Research. 21:75-94.

Gram, R. 1965. *A Florida Sabellariidae reef and its effect on sediment distribution*. Journal of Sedimentary Petrology 38:863-868.

Grant, G., H. Malpass, and J. Beasley. 1996. *Correlation of leatherback turtle and jellyfish occurrence*. Herpetological Review. 27(3):123-125.

Greene, K. 2002. *Beach nourishment: a review of the biological and physical impacts.* ASMFC Habitat Management Series #7. Atlantic States Marine Fisheries Commission, Washington, DC. 174 pp.

Gulf Regional Biological Opinion (GRBO). 2003. *Dredging of Gulf of Mexico navigation channels and sand mining (borrow) areas using hopper dredges by COE Galveston, New Orleans, Mobile, and Jacksonville Districts.* Gulf Area Regional Biological Opinion issued to USACE South Atlantic, Mississippi Valley, and Southwest Divisions by National Marine Fisheries Service, St. Petersburg, Florida.

Hackney, C. T., M.H. Posey, S.W. Ross, and A.R. Norris. 1996. *A review and synthesis of data on surf zone fishes and invertebrates in the south atlantic bight and the potential impacts from beach renourishment.* Prepared for U.S. Army Corps of Engineers, Wilmington District, North Carolina. 111 pp.

Haig, S. M. 1992. *Piping plover* (Charadrius melodus). In: A. Poole, P.Stettenheim, and F. Gill (Eds.) The Birds of North America, No.2 Philadelphia. The Academy of Natural Sciences; Washington, DC. The American Ornithologists' Union.

Hall, S.J. 1994. *Physical disturbance and marine communities: life in unconsolidated sediments.* Oceanography and Marine Biology: An Annual Review 32, 179 -239.

Hammer, R.M., B.J. Balcom, M.J. Cruickshank, and C.L. Morgan. 1993. *Synthesis and analysis of existing information regarding environmental effects of marine mining.* Continental Shelf Associates, Inc. for the U.S. Department of the Interior, Minerals Management Service, Office of International Activities and Marine Minerals, Herndon, VA. Final Report, OCS Study MMS 93-0006. 392 pp.

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.

Hansen, L. J., K. D. Mullin, and C. L. Roden. 1994. *Preliminary estimates of cetacean abundance in the northern Gulf of Mexico from vessel surveys, and of selected cetacean species in the U.S. Atlantic Exclusive Economic Zone from vessel surveys.* Southeast Fisheries Science Center, Miami Laboratory, Contribution No. MIA-93/94-58. Available from: NMFS, Southeast Fisheries Science Center, 75 Virginia Beach Dr., Miami, FL, 33149.

Hare, J. A., and R. K. Cowen. 1996. *Transport mechanisms of larval and pelagic juvenile bluefish (Pomatomus saltatrix) from South Atlantic Bight spawning grounds to Middle Atlantic Bight nursery habitats.* Limnol. Oceanogr. 41(6):1264−1280.

Harris, B.A., W.J. Conley, and J.A. Huff. 1984. *The status of Florida's nesting sea turtle populations from 1979 through 1983.* Florida Department of Natural Resources, Bureau of Marine Research.

Harris, L.E. 2002. *2002 Monitoring of Martin County nearshore mitigation reefs.* Performed for Martin County Engineering Department. Stuart, Florida.

Harris, L.E. 2003. *2003 monitoring of Martin County nearshore mitigation reefs.* Performed for Martin County Engineering Department. Stuart, Florida.

Harris, L.E. 2005. *Sand sample grain size distribution (GSD) analysis for the Martin County, Florida Beach Nourishment Project.* Sand Sample Collection Date: July 21, 2005. Indialantic, FL.

Harris, L.E. 2006. *2006 Monitoring of Martin County nearshore mitigation reefs.* Performed for Martin County Engineering Department. Stuart, Florida.

Harris, L.E. 2007. *Sand sample grain size distribution (GSD) analysis for the Martin County, Florida Beach Nourishment Project.* Sand Sample Collection Date: August 18, 2006. Indialantic, FL.

Harris, L.E. 2008. *Sand sample grain size distribution (GSD) analysis for the Martin County, Florida Beach Nourishment Project.* Sand Sample Collection Date: July 11, 2007. Indialantic, FL.

Harris, L.E. and K.L. Dillon. 2006. *2005 Monitoring Report. Martin County's Artificial Reefs Deployed 2000 to 2005.* Performed for Martin County Engineering Department. Stuart, Florida. March 2006.

Harris, P.S. 1991. *The influence of seasonal variation in longshore sediment transport with applications to the erosion of the downdrift beach at Jupiter Inlet, Florida.* M.S. Thesis, University of Florida, Gainesville, FL.

Hayes, M.D. and R.B. Nairn. 2004. *Characteristics of OCS sand ridges and shoals.* Journal of Coastal Research. 20(1):138-148.

Hazen and Sawyer. 2004. *Socioeconomic study of reefs in Martin County, Florida.* Prepared by Hazen and Sawyer for Martin County, Florida. Final Report. July 21, 2004.

Henwood, T.A. 1987. *Movements and seasonal changes in loggerhead turtle* Caretta caretta *aggregations in the vicinity of Cape Canaveral, Florida (1978-1984).* Biological Conservation, 40:191-202.

Herrnkind, W.F. and M.J. Butler IV. 1986. *Factors regulating settlement and microhabitat use by juvenile spiny lobsters,* Panulirus argus. Marine Ecology Progress Series 34. 8 pp.

Herrnkind, W.F., M.J. Butler IV, and R.A. Tankersley. 1988. *The Effects of Siltation on Recruitment of Spiny Lobsters, Panulirus argus.* Fishery Bulletin. 86(2):331-338.

Herron Baird, P. 1990. *Concentrations of seabirds at oil-drilling rigs.* Condor, 92, 768-771.

Hesperides Group, LLC. 2009. *Martin County Beach Erosion Control Project dive survey of proposed borrow area C1-B.* Prepared for Martin County Engineering Department, Stuart, Florida. September 28, 2009.

Hily, C. 1983. Macrozoobenthic recolonisation after dredging in a sandy mud area of the Bay of Brest enriched by organic matter. In Fluctuation and Succession in Marine Ecosystems. Proceedings of the 17th European Marine Biology Symposium, Brest. France. *Oceanologica Acta* 113-20.

Hirsch, ND, LH Disalvo, and R. Peddicord. 1978. *Effects of dredging and disposal on aquatic organisms.* Technical Report DS-78-5. Reprint 1987. U.S. Army Corps of Engineers, Waterways Experiment Station, Environmental Laboratory. Vicksburg, MS.

Hirth, H.F. 1997. *Synopsis of* the Biological Data on the Green Turtle C*helonia mydas (Linnaeus, 1758)*. U.S. Fish and Wildlife Service Biological Report. 97(1) 120 pp.

Hobbs, C.H., III. 2002. *An Investigation of Potential Consequences of Marine Mining in Shallow Water: An Example from the Mid-Atlantic Coast of the United States.* Journal of Coastal Research. 18(1):94-101.

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.

Hopkins, S.R. and J.I. Richardson (eds.). 1984. *Recovery Plan for Marine Turtles.* Prepared by Marine Turtle Recovery Team for National Marine Fisheries Service. 355 pp.

Hubertz, J.M., R.M. Brooks, W.A. Brandon, and B.A. Tracy. 1993. *Hindcast Wave Information for the U.S. Atlantic Coast.* WIS Report 30 (AD A356 321), U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Hunt, J.H. and W.G. Lyons. 1985. *Comparisons of Catch Rate and Size Frequency of Spiny Lobsters,* Panulirus argus, *captured in standard traps and traps with escape gaps.* Unpublished Manuscript. FDNR, MRL.

Hunt, J.H., T.R. Matthews, D. Forcucci, B.S. Hedin, and R. Bertelsen. 1991. *Management implications of trends in the population dynamics of the Caribbean spiny lobster,* Panulirus argus*, at Looe Key National Marine Sanctuary.* NOAA Technical Memorandum.

Hurme, A.K. and E.J. Pullen. 1988. *Biological effects of marine sand mining and fill placement for beach replenishment: lessons for other uses.* Marine Mining. 7:123-136.

Japp, W.C. and P. Hallock. 1991. *Coral reefs*. Pages 574-616. In: Myers, R.L. and J.J. Ewel (eds.). Ecosystems of Florida. Univ. of Central Florida Press, Orlando.

Jefferson, T.A., S. Leatherwood, and M.A. Webber. 1993. *Marine mammals of the world. FAO Species Identification Guide.* Rome, Italy: Food and Agriculture Organization of the United Nations.

Jensen, A.S. and G.K. 2004. Large whale ship strike database. NOAA Technical Memorandum NMFS-OPR-25. 37 p.

Jordan, R.R. 1999. Letter from Robert R. Jordan, Director and State Geologist (State of Delaware, Delaware Geological Survey, University of Delaware, Newark, Delaware 19716-7501) to Thomas R. Kitsos, Acting Director (U.S. Department of the Interior, Minerals Management Service, 1849 C Street NW, Washington, DC 20240) dated April 23, 1999. 2 pp.

Jutte, P.C. and R.F. VanDolah. 1999. *An assessment of benthic infaunal assemblages and sediments in the Joiner Bank and Gaskin Banks borrow areas for the Hilton Head Beach Renourishment Project. Final Report – Year 1.* Prepared by the Marine Resources Division, South Carolina Department of Natural Resources for Olsen Associates, Inc. and the Town of Hilton Head Island.

Kanciruk, P. and W. Herrnkind. 1978. *Mass migration of spiny lobster* Panulirus argus (Crustacea: Palinuridae*) behavior and environmental correlates.* Search Results. Bulletin of Marine Science 28 (4):601-623.

Kaplan, E. H., Welker, J. R., Kraus, M. G. & McCourt, S. 1975. Some factors affecting the colonisation of a dredged channel. *Marine Biology 32,* 193-204.

Kelley, S.W., J.S. Ramsey, and M.R. Byrnes. 2004. *Evaluating shoreline response to offshore sand mining for beach nourishment.* Journal of Coastal Research. 20(1):89-100.

Kendall, A. and L. Walford. 1979. *Sources and distribution of bluefish, Pomatomus saltatrix, larvae and juveniles off the east coast of the United States*. Fish. Bull. 77(1):213-227.

Kennedy, Jr., Frank S. and Barber, G. 1981. *Spawning and recruitment of pink shrimp,* Penaeus duorarum*, off eastern Florida.* Journal of Crustacean Biology. 1(4):474-485 (Nov. 1981).

Kidlow, J. 2008. *Phase II: Florida's Ocean and Coastal Economies Report*. National Economics Program. Report to the Florida Oceans and Coastal Council. 205 pp + 65 pp appendices.

King, S., I.M.D. Maclean, T. Norman, and A. Prior. 2009. *Developing guidance on ornithological cumulative impact assessment for offshore wind farm developers.* COWRIE.

Kirtley, D.W. 1966. *Intertidal Reefs of Sabellariidae (Annelida, Polychaeta) along the Coast of Florida.* Master's Thesis, Florida State University, Tallahassee.

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. 1974. *Geological significance of polychaetous annelid family Sabellariidae.* Ph.D. Thesis, Florida State University, Tallahassee.

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. *Sabellarid worms: builders of 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.* Pages 83-85. In: Eckert, S.A., 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.* In: W.J. Chandler (ed.) Audobon Wildlife Report 1988/89. p. 685-698. Academic Press, Inc., San Diego, CA.

Kraus, S.D., R.D. Kenney, A.R. Knowlton, and J.N. Ciano. 1983. *Endangered right whales of the southwestern North Atlantic.* U.S. Department of the Interior, Minerals Management Service, Atlantic OCS Region, Herndon, VA, 69 pp.

Kraus, S.D., R.D. Kenney, A.R. Knowlton, J.H. Prescott, and H.E. Winn. 1990. *Engangered right whales of the southern North Atlantic, Voluume I.* Edgerton Research Laboratory, New England Aquarium, Central Wharf, Boston, MA 0211. Prepared for Minerals Management Service, Hendon, VA. Contract No. 14-35-0001-30486. OCS Study MMS 90-(J7=I). http://www.gomr.boemre.gov/PI/PDFImages/ESPIS/0/878.pdf

Leatherwood, S., D.K. Caldwell, and H.E. Winn. 1976. *Whales, dolphins, and porpoises of the western North Atlantic: a guide to their identification.* NOAA Tech. Rep. NMFS Circ. 396. 176 pp.

Lee, T.N. and D.A. Mayer. 1977. *Low-frequency current variability and spin-off eddies along the shelf off southeast Florida.* Journal of Marine Research. 35:193-220.

Lee, D.s. and M.C. Socci. 1989. *Potential effects of oil spills on seabirds and selected other oceanic vertebrates off the North Carolina coast*. North Carolina Biological Survey and the North Carolina State Museum of Natural Sciences. Occasional Papers of the NC Biological Survey. 1989-1. Raleigh, NC. 64p.

Lee, T.F., F.A. Schrott, and R. Zanotopp. 1985. *Florida Current*: low-frequency variability as observed with moored current meters dur*ing April 1982 to June 1983.* Science. 227:298-302.

Leigh Goldstein, Marstel-Day, LLC. 2008. *Martin County, Florida, Social Effects Assessment Case Study Part I.* March 3, 2008.

Lenhardt, M.L. 1982. *Bone conduction hearing in turtles.* Journal of Auditory Research 22:153-160.

Lenhardt M.L. and S.W. Harkins. 1983. *Turtle shell as an auditory receptor.* Journal of Auditory Research 23:251-260.

Lent, L.K., B.K. Harper, and M.B. Graves. 2007. *Shore protection assessment: damages prevented by the Martin County, FL, project in 2004.* Shore and Beach. 75(1):6-11.

Levin, J. 1970. *A literature review of the effects of sand removal on a coral reef community.* University of Hawaii Sea Grant Program, UNIHI-SEA GRANT-TR-71-01, 78 pp.

Lindeman, K.L. 1997. *Development of grunts and snappers on southeast Florida: cross-shelf distributions and effects of beach management alternatives.* Ph.D. diss., Univ. Miami, Coral Gables, FL. 419 pp.

Lindeman, K.C. and D.B. Snyder. 1999. *Nearshore hardbottom fishes of southeast Florida and effects of habitat burial caused by dredging.* Fish. Bull. 97:508-525.

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.

Lindner, M. J. and W. W. Anderson . 1956. *Growth, migrations, spawning and size distribution of shrimp* Penaeus setiferus. Fishery Bulletin (U.S.). 56:555–645.

Lindquist, N. and L. Manning. 2001. *Impacts of beach nourishment and beach scraping on critical habitat and productivity of surf fishes, final report.*

Little, E.J., and G.R. Milano. 1980. *Techniques to monitor recruitment of postlarval spiny lobsters,* Panulirus argus, *to the Florida Keys.* Fla. Mar. Res. Publ. No. 37. 16 pp.

Louis Berger Group Inc. 1999. *Use of federal offshore sand resources for beach and coastal restoration in New Jersey, Maryland, Delaware, and Virginia.* Contract No. 1435-01-98-RC-30820. Department of the Interior, Minerals Management Service, Office of International Activities and Marine Minerals, Herndon, VA. 244 pp.

Lutcavage, M. and J.A. Musick. 1985. *Aspects of the biology of sea turtles in Virginia.* Copeia. 1985(2):449-456.

Lybolt, M. and S. Tate. 2008. *Rapid changes in nearshore habitat: Is resource burial an appropriate measure of project impact?* In: Shore & Beach, Vol. 76, No. 1, Winter 2008.

Lyons, W.G. 1989. *Nearshore marine ecology at Hutchinson Island, Florida: 1971-1974. XI. Mollusks.* Florida Marine Research Publication 47. 131 pp.

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.

Malme, C.I., Miles, P.R., Clark, C.W., Tyak, P. and Bird, J.E.. (1983) *Investigations of the potential effects of underwater noise from petroleum industry activities on migrating gray whale behavior.* BBN Report 5366, Report from Bolt Beranek & Newman Inc., Cambridge, MA, for U.S. Minerals Management Service, Anchorage, AK. NTIS PB86-174174.

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.

Marquez, R.M. 1990. *Sea turtles of the world.* FAO Species Catalogue, Volume 11. RAO, Rome. 81 pp.

Marsh, G. A. and D.B. Turbeville. 1981. *The environmental impact of beach nourishment: Two studies in southeastern Florida.* Shore and Beach, July 1981, 40-44.

Marszalek, D.S. 1981. *Impact of dredging on a subtropical reef community, southeast Florida, U.S.A.* Proceedings of the 4th International Coral Reef Symposium Manila. 1:147-153.

Marx, J.M., and W.F. Herrnkind. 1986. *Species profiles: life histories and environmental requirements of coastal fishes and invertebrates (South Florida)--spiny lobster.* U.S. Fish Wildl. Serv. Biol. Rep. 82(11.61). U.S. Army Corps of Engineers, TR EL-82-4. 21 pp.

McBride, R.A. 1987. *Tidal inlet history, morphology, and stability, eastern coast of Florida, USA.* Pages 1592-1607. In: Kraus, N.C. (ed.). Coastal Sediments '87, American Society of Civil Engineers, New York, NY.

McBride, R. J. Ross, and D. Conover. 1993. *Recruitment of bluefish* Pomatomus saltatrix *to estuaries of the U.S. South Atlantic Bight.* Fish. Bul*l.* 91:389-395.

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.

McCauly, J.E., R.A. Parr, and D.R. Hancock. 1977. *Benthic infauna and maintenance dredging. a case study.* Water Research. XI:233-242.

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, Fort Pierce, FL.* Coastal Oceanography Engineering Laboratory, Engineering Industrial Experiment Station., University of Florida, Gainesville, FL. 67 pp.

Meisburger, E.P. and D.B. Duane. 1971. *Geomorphology and sediments of the inner continental shelf Palm Beach to Cape Kennedy, Florida.* Technical Memorandum No. 34, U.S. Army Corps of Engineers, Coastal Engineering Research Center, Vicksburg, MS. 91 pp.

Meylan, A. 1988. *Spongivory in hawksbill turtles: a diet of glass.* Science. 239:393-395.

Meylan, A. 1992. *Hawksbill turtle* Eretmochelys imbricate. Pages 95-99. In: Moler, P. (ed.). Rare and Endangered Biota of Florida. University Presses of Florida, Gainesville, Florida.

Meylan, A. 1995. Facsimile dated April 5, 1995, to Sandy MacPherson, National Sea Turtle Coordinator, U.S. Fish and Wildlife Service, Jacksonville, Florida. Florida Department of Environmental Protection, St. Petersburg, Florida.

Meylan, A.B. and K.A. Bjorndal. 1983. *Sea turtles nesting at Melbourne Beach, Florida; II. Post-nesting movements of* Caretta caretta. Biological Conservation 26:79-90.

Meylan, A., B. Schroeder, and A. Mosier. 1995. *Sea turtle nesting activity in the state of Florida 1979-1992.* Florida Marine Research Publications, Number 52. State of Florida Department of Environmental Protection, Florida Marine Research Institute. St. Petersburg, Florida. 51 pp.

Michel, J. 2004. *Regional management strategies for federal offshore borrow areas, U.S. east coast and Gulf of Mexico coasts.* Journal of Coastal Research. 20(1):149-154.

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: Herndon, Virginia.* U.S. Department of the Interior, Minerals Management Service. OCS Report MMS 2001-089. 116 pp.

Miller, G.C. and W.J. Richards. 1979. *Reef fish habitat, faunal assemblages, and factors determining distributions in the South Atlantic Bight.* Pages 114-130 In: Proceedings of the Gulf and Caribbean Fisheries Institute, 33**rd** Annual Session. November 1979.

Milliman, J.D. and K.O. Emery. 1968. *Sea levels of the past 35,000 years.* Science. 162(1):121-123.

Minello, T.J., R.J. Zimmerman, and E.X. Martinez. 1989. *Mortality of young brown shrimp,* Penaeus aztecus *in estuarine nurseries. Trans. Am. Fish. Soc.* 118(6):693-708.

Monaghan, P., J.D. Uttley, M.D. Burns, C. Thaine, and J. Blackwood. 1989. *The relationship between food supply, reproductive effort and breeding success in arctic terns* Sterna paradisaea. Journal of Animal Ecology, 58, 261-274.

Mortimer, J.A. 1982. *Feeding ecology of sea turtles.* Pages 103-109 In: Bjorndal, K.A. (ed.). Biology and Conservation of Sea Turtles. Smithsonian Institution Press, Washington, D.C.

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.

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.

Mullin, K.D. and G.L. Fulling. 2003. *Abundance of cetaceans in the southern U.S. North Atlantic Ocean during summer 1998.* Fish. Bull. 10:603-613.

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). 1991a. *Recovery plan for the northern right whale* (Eubalaena glacialis). Prepared by the Right Whale Recovery Team for the National Marine Fisheries Service. Silver Spring, M.D.

National Marine Fisheries Service (NMFS). 1991b. *Recovery plan for the humpback whale (*Megaptera novaeangliae*).* Prepared by the Humpback Whale Recovery Team for the National Marine Fisheries Service, Silver Spring, M.D.

National Marine Fisheries Service (NMFS). 1994. *Designated critical habitat; northern right whale.* Federal Register. 59(106):28793-28808.

National Marine Fisheries Service (NMFS). 1996. *Biological opinion. the continued hopper dredging of channels and borrow areas in the southeastern United States.* November 1996.

National Marine Fisheries Service (NMFS). 1997. *Biological opinion. the continued hopper dredging of channels and borrow areas in the southeastern United States.* Office of Protected Resources, Silver Spring, MD and Southeast Regional Office, St. Petersburg, FL. 25 September.

National Marine Fisheries Service (NMFS). 1998. *Marine Mammal Protection Act of 1972 Annual Report, January 1, 1997 to December 31, 1997.* National Marine Fisheries Service, Office of Protected Resources, Silver Spring, MD.

National Marine Fisheries Service (NMFS). 1999a. *Cruise results. summer Atlantic Ocean marine mammal survey.* NOAA Ship Oregon II cruise 236 (99- 05), 4 August to 30 September 1999. Available from: SEFSC, 3209 Frederic Street, Pascagoula, MS, 39567.

National Marine Fisheries Service (NMFS). 1999b. *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). 2002. *Cruise results. Mid-Atlantic cetacean survey. NOAA ship Gordon Gunter cruise GU-02-01, 6 February - 8 April 2002.* Available from: SEFSC, 3209 Frederic Street, Pascagoula, MS 39567.

National Marine Fisheries Service (NMFS). 2005. *Recovery plan for the North Atlantic right whale (*Eubalaena glacialis*).* Silver Spring, Maryland. National Marine Fisheries Service.

National Marine Fisheries Service (NMFS). 2006. *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). 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 and U.S. Fish and Wildlife Service (NMFS/USFWS). 1991a. *Recovery plan for U.S. population of loggerhead turtle*. National Marine Fisheries Service, Washington, D.C. 64 pp.

National Marine Fisheries Service and U.S. Fish and Wildlife Service (NMFS/USFWS). 1991b. *Recovery plan for U.S. population of Atlantic green turtle.* National Marine Fisheries Service; Washington, D.C.

National Marine Fisheries Service and U.S. Fish and Wildlife Service (NMFS/USFWS). 1992a. *Recovery plan for leatherback turtles (*Dermochelys coriacea*) in U.S. Caribbean, Atlantic, and Gulf of Mexico.* National Marine Fisheries Service, Washington, D.C.

National Marine Fisheries Service and U.S. Fish and Wildlife Service (NMFS/USFWS). 1992b. *Recovery plan for the Kemp's ridley sea turtle (*Lepidochelys kempii). National Marine Fisheries Service, St. Petersburg, Florida.

National Marine Fisheries Service and U.S. Fish and Wildlife Service (NMFS/USFWS). 1993. *Recovery plan for hawksbill turtle* (Eretmochelys imbricata) *in the U.S. Caribbean, Atlantic, and Gulf of Mexico.* National Marine Fisheries Service, St. Petersburg, Florida. 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 Oceanic and Atmospheric Administration (NOAA). 1993. *East coast of North and South America, including Greenland, tide tables 1993 high and low water predictions.* Issued 1992.

National Oceanic and Atmospheric Administration (NOAA). 2008a. *Beach nourishment: a guide for local government officials. geologic characteristics of borrow areas and sediments.* http://www.csc.noaa.gov/beachnourishment/html/geo/borrow.htm. Accessed January 7, 2008.

National Oceanic and Atmospheric Administration (NOAA). 2008b. *A guide for local government officials. methods of investigation to identify sources of suitable sand for nourishment.* http://www.csc.noaa.gov/beachnourishment/html/geo/sand.htm Accessed January 7, 2008.

National Oceanic and Atmospheric Administration (NOAA) Fisheries. 2006. *Sea turtle and smalltooth sawfish construction conditions.* National Marine Fisheries Service (NMFS) SE Regional Office, St. Petersburg, FL. http://sero.nmfs.noaa.gov/pr/endangered%20species/Sea%20Turtle%20and%20Smalltooth%20Sawfish%20Construction%20Conditions%203-23-06.pdf .

National Research Council (NRC). 1990. *Decline of the sea turtles: causes and prevention.* National Academy Press, Washington, D.C. 259 pp.

National Research Council (NRC). 1995. *Beach nourishment and protection.* National Academy Press, Washington, D.C. 334 pp.

Nairn, R., J.A. Johnson, D. Hardin, and J. Michel. 2004. *A biological and physical monitoring program to evaluate long-term impacts from sand dredging operations in the United States outer continental shelf.* Journal of Coastal Research. 20(1):126-137.

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 Technaical Report EL-86-2(Rev.). 34. pp.

Nelson, D.A. 1991. *Methods of biological monitoring of beach restoration projects: problems and solutions in the real world.* Pages 263-276 In: Presenting and Enhancing Our Beach Environment: Proceedings of the 1991 National Conference on Beach Presentation Technology. Florida Shore and Beach Preservation Association, Tallahassee, Florida.

Nelson, D.A. and D.D. Dickerson. 1988. *Hardiness of nourished and natural sea turtle nesting beaches on the east coast of Florida.* Unpublished report, U.S. Army Corps of Engineers Waterways Experiment Station, Vicksburg, Mississippi.

Nelson, W.G. 1989. *Beach nourishment and hard bottom habitats: the case for caution.* In: Tait, S. (ed.). Proc. 1989 National Conference on Beach Preservation Technology, Tallahassee. Florida Shore and Beach Preservation Association.

Nelson, W.G. and L. Demetriades. 1992. *Peracarids associated with Sabellariid worm rock (*Phragmatopoma lapidosa Kinberg*) at Sebastian Inlet, Florida, U.S.* J. Crust. Bio. 12(4):647-654.

New England Aquarium (NEAQ). 2010. *North atlantic right whale* (accessed July 2010) http://www.neaq.org/animals_and_exhibits/animals/northern_right_whale/index.php

Newcombe, C.P. and J.O. Jensen. 1996. *Channel suspended sediment and fisheries: a synthesis for quantitative assessment of risk and impact.* N. Amer. J. Fish. Manag. 16:693-727.

Newell, R.C., L. J. Seiderer, and D.R. Hitchcock. 1998. *The impact of dredging works in coastal waters: A review of the sensitivity to disturbance and subsequent recovery of biological resources on the sea bed.* Oceanography and Marine Biology: An Annual Review. 36,127-78.

Norcross, J.J., S.L. Richardson, W.H. Massmann, and E.B. Joseph. 1974. *Development of young bluefish* (Pomatomus saltatrix) *and distribution of eggs and young in Virginia coastal waters. Trans. Am. Fish. Soc.* 103(3):477-497.

Oliver, J., Slattery, P., Hulberg, L. and J. Nybakken. 1977. *Patterns of succession in benthic infaunal communities following dredging and dredged material disposal in Monterey Bay.* Technical Report D-77-27, October 1977. U.S. Army Corps of Engineers Waterways Experiment Station.

Palko, B.J., G.L. Beardsley and W. Richards. 1982. *Synopsis of the biological data on dolphin-fishes,* Coryphaena hippurus Linnaeus *and* Coryphaena equiselis Linnaeus. FAO Fisheries Synopsis (130) and NOAA Technical Report NMFS Circular (443).

Palm Beach County Department of Environmental Resources Management. 2001. *Sea turtle nesting activity at Ocean Ridge, Palm Beach County, Florida, 2001 nesting season.*

Parker, G.A. 1970. *Sperm competition and its evolutionary consequences in the insects.* Biological Review. 45:525-567.

Payne, P.M., L.A. Selzer, and A.R. Knowlton. 1984. *Distribution and density of cetaceans, marine turtles, and seabirds in the shelf waters of the northeastern United States, June 1980-December 1983, based on shipboard observations.* 245 p. NOAA/NMFS Contract No. NA-81-FA-C-00023.

PBS&J and EAI. 2007. *Assessment of alternative construction template for beach nourishment projects phase i. final report.* Prepared for Florida Department of Environmental Protection Bureau of Beaches and Coastal Systems. January 2007.

Perkins, T.H., H.A. Norris, D.T. Wilder, S.D. Kaiser, D.K. Camp, R.E. Matheson, Jr., R.G. Gilmore, Jr., J.D. Reed, G.A. Zarillo, K. Connell, M. Fillingfin, and F.M. Idris. 1997. *Distribution of hard-bottom habitats on the continental shelf off the northern and central east coast of Florida, final report.* Southeast Area Monitoring and Assessment Program Bottom Mapping Workgroup and the National Marine and Fisheries Service.

Perrin, W. F. and J. W. Gilpatrick, Jr. 1994a. Spinner dolphin. *pp. 99-128 In:* S. H. Ridgway and R. Harrison (eds.) Handbook of marine mammals, Volume 5: The first book of dolphins. Academic Press, San Diego, California. 418 pp.

Perrin W.F., C.E. Wilson CE, .F.I. Archer II. 1994b. *Striped dolphin* - Stenella coeruleoalba (Meyen, 1833). In: Handbook of Marine Mammals (Ridgway SH, Harrison SR. eds.) Vol. 5: The First Book of Dolphins. Academic Press, London. pp. 129-160.

Perrow, M., E.R. Skeate, R. Lines, and D. Brown. 2006. *Radio telemetry as a tool for impact assessment of wind farms: the case of Little Terns* Sterna albifrons at Scroby Sands, Norfolk, UK. Ibis, 148, s57-s75.

Peters, D.J. and W.G. Nelson. 1987. *The seasonality and spatial patterns of juvenile surf zone fishes of the Florida east coas .* Florida Scientist 50(2):85-99.

Peterson, C.H. and M.J. Bishop. 2005. *Assessing the environmental impacts of beach nourishment.* In: BioScience, October 2005 . Vol. 55 No. 10.

Peterson, C.H. and L. Manning. 2001. *How beach nourishment affects the habitat value of intertidal beach prey for surf fish and shorebirds and why uncertainty still exists.* Proceedings of the Coastal Ecosystems & Federal Activities Technical Training Symposium, August 20-22, 2001. Gulf Shores, Alabama.

Peterson, C.H., W. Laney, and T. Rice. 2001. *Biological impacts of beach nourishment.* Workshop on the Science of Beach Renourishment, May 7-8, 2001. Pine Knoll Shores. North Carolina.

Pickett, S.T.A. and P.S. White. 1985. *The ecology of natural disturbance and patch dynamics.* Academic Press, London.

Pilkey, O.H. and K.L. Dixon. 1996. *The crops and the shore.* Island Press. Washington, D.C.

Pilkey, O.H., Jr., D.C. Sharma, H.R. Wanless, L.J. Doyle, O.H. Pilkey, Sr., W.J. Neal, and B.L. Gruver. 1984. *Living with the East Florida shore.* Duke University Press, Durham, NC, 259 pp.

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

Reilly, F.J. and V.J. Bellis. 1983. *The ecological impact of beach nourishment with dredged materials on the intertidal zone at Bogue Banks, North Carolina.* U.S. Army Corps of Engineers Coastal Engineering Research Center. Misc. Report No. 80-1, 32 pp.

Reynolds III, J.E. and D.K. Odell (eds). 1991. *Marine mammal strandings in the United States.* Proceedings of the Second Marine Mammal Stranding Workshop, Miami, Florida, December 3-5, 1987. NOAA Technical Report NMFS 98:1-157.

Richardson, W.J., C.R. Greene, C.I. Malme, and D.H. Thomson. 1995. *Marine mammals and noise.* Academic Press, San Diego, CA. 576 pp.

Ridgeway, S.H., E.G. Wever, J.G. McCormick, J. Palin, and J.H. Anderson. 1969. *Hearing in the giant sea turtle,* Chelonia mydas. Proceedings of the National Academy of Sciences 64:884-890.

Rock, J.C., M.L. Leonard, and A.W. Boyne. 2007. *Foraging habitat and chick diets of roseate tern, Sterna dougallii, breeding on Country Island, Nova Scotia.* Avian Conservation and Ecology, 2, 4.

Ross, J.P. and M.A. Barwani. 1982. Review of sea turtles in the Arabian area. Pages 373-383 In Bjorndal, K.A. (ed). *Biology and Conservation of Sea Turtles.* Smithsonian Institution Press, Washington, D.C.

Ryder, T.S., E. Standora, M. Eberle, J. Edbauer, K. Williams, S. Morreale, and A. Bolten. 1994. *Daily movements of adult male and juveline 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.

Schaeff, C.M, S.D. Kraus, M.W. Brown, and B.N. White. 1993. *Assessment of the population structure of western North Atlantic right whales* (Eubalaena glacialis) *based on sighting and mtDNA data.* Can. J.Zool. 71: 339-445.

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.

Schmid, J.R. and L.H. Ogren. 1992. *Subadult Kemp's ridley sea turtles in the southeastern U.S.: results of long-term tagging studies.* Pages 102-103 In: Salmon, M. and J. Wyneken (comps.). Proceedings of the Eleventh Annual Workshop on Sea Turtle Biology and Conservation. NOAA Technical Memorandum NMFS-SEFSC-302.

Schmidly, D. J. 1981. *Marine mammals of the southeastern United States coast and the Gulf of Mexico.* Pub. No. FWS/OBS-80/41, U.S. Fish and Wildlife Service, Office of Biological Services, Washington, DC, 163 pp.

Schroeder, B.A. and N.B. Thompson. 1987. *Distribution of the loggerhead turtle,* Caretta caretta, *and the leatherback turtle,* Dermochelys coriacea, *in the Cape Canaveral, Florida area: Results of Aerial Surveys.* Pages 45-53 In: Witzell, W.N. (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.

Science Applications International Corporation (SAIC). 1986. *Ocean dumping site designation delegation handbook for dredged material.* Prepared for U.S. Environmental Protection Agency, Washington, D.C.

Sedberry, G.R. and R.F. Van Dolah. 1984. *Demersal Fish Assemblages Associated with Hardbottom Habitat in the South Atlantic Bight of the U.S.A.* Environ. Biol. Fishes. 11(4):241-258.

Shaffer, R.V. and E.L. Nakamura. 1989. *Synopsis of biological data on the cobia* Rachycentron canadum (Pisces: Rachycentridae). NOAA Technical Report NMFS Circular 82. 32 pp.

Shaver, D.J. 1991. *Feeding ecology of wild and headstarted Kemp's ridley sea turtles in South Texas Waters.* Journal of Herpetology. 25(3):327-334.

Shelton, R. G. and Rolfe, M. S. 1972. *The biological implications of aggregate extraction: recent studies in the English Channel. ICES C.M.* 1972/E: 26.

Shoop, C.R., C.A. Ruckdeschel, and N.B. Thompson. 1985. *Sea turtles in the southeast United States: nesting activity as derived from aerial and ground surveys, 1982.* Herpetologica. 41(3):252-259.

Slacum, H.W. Jr., W.H. Burton, E.T. Methratta, E.D. Weber, R.J.Llanso, and 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 2:277-298.

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.

Silber, G.K. and P.J. Clapham. 2001. *Draft updated recovery plan for the western North Atlantic right whale, Eubalaena glacialis.* Silver Spring, Maryland: National Marine Fisheries Service.

Simpfendorfer, C.A. 2006. *Movement and habitat use of smalltooth sawfish.* Mote Marine Laboratory Technical Report 1070. Sarasota, FL.

South Atlantic Fishery Management Council (SAFMC). 1981. *Profile of penaeid shrimp fishery in the South Atlantic.* South Atlantic Fishery Management Council, Charleston, SC. 321 pp.

South Atlantic Fishery Management Council (SAFMC). 1983a. *Fishery management plan, regulatory impact review and final environmental impact statement for the snapper grouper fishery of the South Atlantic region.* South Atlantic Fishery Management Council, Charleston, SC. 237 pp.

South Atlantic Fishery Management Council (SAFMC). 1983b. *Source document for the snapper grouper fishery of the South Atlantic region.* South Atlantic Fishery Management Council, Charleston, SC.

South Atlantic Fishery Management Council (SAFMC). 1998a. *Comprehensive amendment addressing essential fish habitat in fishery management plans of the South Atlantic region:* South Atlantic Fishery Management Council, Charleston, S.C.

South Atlantic Fishery Management Council (SAFMC). 1998b. Habitat plan for the South Atlantic region: Essential Fish Habitat Requirements for Fishery Management Plans of the South Atlantic Fishery Management Council. Charleston, S.C. 457 pp.

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). 2003a. *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). 2003b. *Policies for the protection and restoration of essential fish habitats from beach dredging and filling and large-scale coastal engineering.* March 2003. Memorandum. Charleston, SC.

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.

Southeast Archeological Research, Inc. (SEARCH). 2008. *Historic assessment and submerged cultural resources remote sensing survey of four borrow areas for Martin and St. Lucie counties shore protection projects, Florida.* Prepared for USACE, Jacksonville District. October 2008.

Spring, K.D. and D.B. Snyder. 1991. *Personal observations of sea turtles utilizing borrow pits off Hobe Sound, FL.*

St. Amant, L.S., J.G. Broom, and T.B. Ford. 1966. *Studies of brown shrimp,* Panaeus aztectus*, in Barataria Bay, Louisiana, 1962-1965.* Proc. Gulf Carib. Fish. Inst., 18th Annual Session, Nov. 1965. pp 1-17.

Stauble, D.S. and D.F. McNeill. 1985. *Coastal geology and occurrence of beachrock: Central Florida Atlantic Coast.* Guidebook for Field Trip #4. Geological Society of America Annual Convention, Orlando, FL. 68 pp.

Stevens, P.W. and K.J. Sulak. 2001. *Egress of adult sportfish from an estuarine reserve within Merritt Island National Wildlife Refuge, Florida*. Gulf of Mexico Science 2:77-89.

Stites, D., A.J. Maguire, and S. Schropp. 2007. *Martin County Shore Protection Project Hardbottom Evaluation.* Prepared for Martin County by Taylor Engineering, Inc. Jacksonville, Florida. October 2007.

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.

Tasker, M. L., P. Hope-Jones, T. Dixon, and A. Wallis. 1986. *Seabirds associated with oil production platforms in the North Sea*. Ringing and Migration, 7, 7-14.

Taylor Engineering. 2000. *Martin County, Florida Shore Protection Project 1996 initial construction beach performance.* June 2000. Jacksonville, Florida.

Taylor Engineering, Inc. 2007. *Martin County upland sand source reconnaissance.* Prepared for Martin County, Florida.

Taylor Engineering. 2009a. *Coastal engineering narrative, Martin County Beach Restoration Project. Attachment B.* Prepared for: Florida Department of Environmental Protection Joint Coastal Permit Application. April 2009.

Taylor Engineering. 2009b. *Martin County Shore Protection Project Hardbottom Evaluation 1997, 2001, 2004, and 2008 Martin County Beach Restoration Project. Attachment E.* Prepared for: Florida Department of Environmental Protection Joint Coastal Permit Application. April 2009.

Taylor Engineering, Inc. 2009c. *Literature review of effects of beach nourishment on benthic habitat Martin County Shore Protection Project. Attachment J.* Prepared for: Florida Department of Environmental Protection Joint Coastal Permit Application. April 2009.

Teas, W.G. 1993. *Species composition and size class distribution of marine turtle strandings on the Gulf of Mexico and southeast United States Coasts, 1985-1991.* NOAA Technical Memoradum NMFS-SEFSC-315, 43 pp.

Thomsen, F., S.R. McCully, D. Wood, P. White, and F. Page. 2009. *A generic investigation into noise profiles of marine dredging in relation to the acoustic sensitivity of the marine fauna in UK waters: PHASE 1 Scoping and review of key issues*, Aggregates Levy Sustainability Fund / Marine Environmental Protection Fund (ALSF/MEPF), Lowestoft, UK. 61pp. Available from http://www.alsf-mepf.org.uk/projects/2008/08p21/final-report.aspx.

Thompson, N.B. and H. Huang. 1993. *Leatherback turtles in southeast U.S. waters.* National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Southeast Fisheries Science Center, Miami, FL. NOAA Technical Memorandum NMFS-SEFSC-318. 11 pp.

Tinsman, Jeffrey. 2002. Senior Fisheries Biologist, Delaware Department of Natural Resources, Division of Fish and Wildlife: Telephone interview with Karen Greene, April 26.

Tove, Michael H. 2000. *Guide to the offshore wildlife of the Northern Atlantic.* University of Texas Press, Austin. 250 pp.

Tremain, D.M., C.W. Harnden, and D.H. Adams. 2004. *Multidirectional movements of sportfish species between a no-take zone and surrounding waters of the Indian River Lagoon, Florida*. Fishery Bulletin 102:533-544.

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.* NOAA Technical Memorandum NMFS-SEFSC-444.

Uchupi, E. 1969. *Morphology of the continental margin off southeastern Florida.* Southeastern Geology. 11(2):129-134.

U.S. Army Corps of Engineers (USACE). 1986. *Feasibility report with environmental impact statement: beach erosion control study, Martin County, Florida. September 1985.* Jacksonville District, South Atlantic Division.

U.S. Army Corps of Engineers (USACE). 1993. Migratory Bird Protection Policy. USACE Jacksonville District, Planning Division, Jacksonville, FL.

U.S. Army Corps of Engineers (USACE). 1994. *Martin County, Florida, Shore Protection Project General Design Memorandum with Environmental Assessment.* June 1994. Jacksonville District, South Atlantic Division.

U.S. Army Corps of Engineers (USACE). 1996. *Coast of Florida erosion and storm effects study: Region III with Final Environmental Impact Statement.* USACE Tech Rep., Jacksonville District. Three volumes and Appendices A-1.

U.S. Army Corps of Engineers (USACE). July 1998. *Beach Erosion Control and Hurricane Protection Project Dade County, Florida, Modifications at Sunny Isles,* Final Environmental Impact Statement.

U.S. Army Corps of Engineers (USACE). 2000. *PL 84-99 Rehabilitation Evaluation Report for the Martin County, Florida Shore Protection Project.* Prepared in February 2000 for USACE Jacksonville District by Coastal Systems International, Inc.

U.S. Army Corps of Engineers (USACE). 2005. *Project Information Report: Rehabilitation Effort for the Martin County Hurricane/Shore Protection Project.* Prepared for Public Sponsor, Martin County Board of County Commissioners, Stuart, Florida. 2/24/2005.

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, 18 September 2006.

U.S. Army Corps of Engineers (USACE). 2009. *Wave refraction analysis, Martin County Borrow Area "B". USACE*-Jacksonville District, Jacksonville, Florida.

U.S. Department of the Interior/Minerals Management Service (USDOI/MMS). 1999. *Environmental Report: Use of federal offshore sand sources for beach and coastal restoration in New Jersey, Maryland, Delaware, and Virginia.* Office of International Activities and Marine Minerals. OCS Study. MMS 99-0036.

U.S. Environmental Protection Agency (USEPA). 2010. *Environmental Impact Statements, Notice of Availability*. Federal Register 75: 68355-68356. 5 November.

U.S. Fish and Wildlife Service (USFWS). 1994. *Hutchinson Island Martin County, Florida Beach Nourishment Project.* Fish and Wildlife Coordination Act Report. January 1994.

U.S. Fish and Wildlife Service (USFWS). 1999. *South Florida Multi-species Recovery Plan.* Southeast Region, Atlanta, Georgia. May 18, 1999.

U.S. Fish and Wildlife Service (USFWS). 2001a. *Florida Manatee Recovery Plan, (*Trichechus manatus latirostris*), Third Revision.* Atlanta, Georgia: U.S. Fish and Wildlife Service.

U.S. Fish and Wildlife Service (USFWS). 2001b. *Critical habitat for piping plover* (Charadrius melodus). http://www.fws.gov/plover#maps. Accessed on April 7, 2009.

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). 2008. *Birds of conservation concern 2008.* U.S. Department of Interior, Fish and Wildlife Service, Division of Migratory Bird Management, Arlington, Virginia. 85 pp. http://www.fws.gov/migratorybirds/]

U.S. Fish and Wildlife Service (USFWS). 2010. Biological opinion based on review of proposed sand placement project along shoreline in Martin County, Florida. S. Florida Ecological Services Office, Vero Beach, FL. June 8. 53 pp.

USFWS and U.S. Census Bureau. 2008. *2006 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation Hunting and Fishing Activities.*

van der Veer, H.W., Bergman, M J.N and Beukema, J.J. 1985. *Dredging activities in the Dutch Waddensea: effects on macrobenthic infauna.* Netherlands Journal of Sea Research 19, 183-90.

Van Dolah, R.F., D.R. Calder and D.M. Knott. 1984. *Effects of dredging and open-water disposal on benthic macroinvertebrates in a South Carolina estuary.* Estuaries. Springer Publishing, New York. 7:28-37.

Van Dolah, R.F., P.H. Wendt, R.M. Martore, M.V. Levisen, and W.A. Roumillat. 1992. *A physical and biological monitoring study of the Hilton Head Beach Nourishment Project.* South Carolina Wildlife and Marine Resources Department, Marine Resource Research Institute for the Town of Hilton Head Island and South Carolina Coastal Council. 159 pp.

Van Dolah, R.F., R.M. Martore, A.E. Lynch, M.V. Levisen, P.H. Wendt, D.J. Whitaker, and W.D. Anderson. 1994. *Final report: environmental evaluation of the Folly Beach Nourishment Project.* U.S. Army Corps of Engineers, Charleston District, Charleston, SC.

Vasslides, J.M. and K.W. Able. 2008. *Importance of shoreface sand ridges as habitat for fishes off the northeast coast of the United States.* Fishery Bulletin 106. 15 pp.

Walsh, Harvey 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. 22 pp.

Wang, H., S.L. Schofield, L.H. Lin, and S.B. Malakar. 1990. *Wave Statistics along the Florida Coast: A Comparison of Data, 1984-1989.* Florida Coastal Data Network, Coastal and Oceanographic Engineering Department, University of Florida, Gainesville, FL.

Waring, G.T., C.P. Fairfield, C.M. Ruhsam, and M.Sano. 1992. *Cetaceans associated with Gulf Stream features off the northeastern USA shelf.* ICES Marine Mammals Comm. CM 1992/N:12, 29 pp.

Weber, M. 1995. *Kemp's ridley sea turtle,* Lepidochelys kempii. Pages 109-122 In: Plotkin, P.T. (Ed.). National Marine Fisheries Services and U.S. Fish and Wildlife Service Status Reviews for Sea Turtles Listed Under the Endangered Species Act of 1973. National Marine Fisheries Service, Silver Spring, Maryland.

Welker, J.R. 1974. *Some effects of dredging on populations of macrobenthic organisms.* Fishery Bulletin. LXXII (April 1974) 445-480.

Wendt et al. 1989 – from SAFMC 1998. *Habitat plan for the South Atlantic Region: essential fish habitat requirements for fishery management plans of the South Atlantic Fishery Management Council.* p. 108.

Werner, S.A. and A.M. Landry, Jr. 1994. *Feeding ecology of wild and head started Kemp's ridley sea turtles* (Lepidochelys kempii). Page 163 In: Bjorndal, K.A., A.B. Bolten, D.A..Johnson, and P.J. Eliazar (compilers). Proceedings of the Fourteenth Annual Symposium on Sea Turtle Biology and Conservation, NOAA Technical Memoradum 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, D.H. and D.G. Clarke. 2007. A *review of suspended sediment impacts on salmonids, estuarine fish, and shellfish with relation to dredging activities*. Draft Manuscript.

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.

Williams-Walls, N., J. O'Hara, R.M. Gallagher, D.F. Worth, B.D. Perry, and J.R. Wilcox. 1983. *Spatial and temporal trends of sea turtles nesting on Hutchinson Island, Florida, 1971-1979.* Bulletin of Marine Science. 33(1):55-66.

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.

Witherington, B.E.. 2002. *Ecology of neonate loggerhead turtles inhabiting lines of downwelling near a Gulf Stream front.* Marine Biology 140:843-853.

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.

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.

Zani, Monica A.; Taylor, Jessica K.D.; Kraus, Scott D. 2008. *Observation of a right whale (*Eubalaena glacialis*) birth in the coastal waters of the southeast United States*. In: Aquatic Mammals, Volume 34, Number 1, January 2008, pp. 21-24(4).

Zantopp, R.J., K.D. Leaman, and T.N. Lee. 1987. *Florida current meanders: A close look in June-July 1984.* Journal of Physical Oceanography. 17:584-595.