Rockefeller Refuge Gulf Shoreline Stabilization (ME-18)

Final Design Report

Prepared for:

State of Louisiana

Coastal Protection and Restoration Authority

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EXECUTIVE SUMMARY

Through the Coastal Wetlands Planning, Protection and Restoration Act (CWPPRA), the State of Louisiana's Coastal Protection and Restoration Authority (CPRA) and the National Marine Fisheries Service (NMFS) have been combating the 25 to 35 square miles of coastal erosion that occurs in Louisiana each year. The severity of erosion and associated impacts vary with location, and the overall causes are both man-induced and natural. One location that has been targeted for protection is the Gulf shoreline along the Rockefeller Wildlife Refuge in southwest Louisiana.

Recent estimates indicate erosion along the western portion of the Refuge's Gulf of Mexico shoreline are as high as 46 feet per year (USGS 2013), which is equivalent to approximately 17 acres of wetlands lost per year over the current 3-mile project length. Without stabilizing the Refuge coast, the shoreline may retreat over 900 feet within a 20 year timespan. This is equivalent to over 300 acres of Louisiana's coastal wetlands lost to erosion within the project area. To help mitigate the erosion experienced by the Refuge, CPRA has teamed with NMFS to implement the Rockefeller Refuge Gulf Shoreline Stabilization Project (ME-18).

Due to several design challenges, many of which are related to the extremely soft soils in the area, a demonstration project was implemented in 2009 to compare several shoreline protection alternatives. During post-construction monitoring, additional insight was gained on important design elements such as foundation integrity and settlement, erosion trends, and metocean conditions. The reef breakwater with a lightweight aggregate core (LWAC) alternative was subsequently recommended for implementation of the full project.

The current project includes a reef breakwater with LWAC design that is intended to protect up to 3 miles of shoreline along the Gulf of Mexico. Because of the high erosion rates at the mouth of Joseph Harbor Bayou, the project will extend slightly into the mouth of the inlet. Although the LWAC allows for a higher crest elevation and improved wave attenuation, soil consolidation will result in settlement over time. Based on an initial elevation of +3.25 ft, the anticipated post-settlement crest elevation over the 20 year design life of the breakwater is approximately +1.9 ft. Settlement should continue to be monitored after project construction.

Gaps in the breakwater will be included to maintain circulation of water and marine life. Spacing and geometry of the breakwater gaps were compared in terms of cost, constructability, wave attenuation, and required material quantities. Based on the analysis, a recommended alternative has been developed that appears to offer the most functional, cost-effective design.

Based on preliminary design, approximately $27,496,560 is anticipated to be required to construct of a reef breakwater with LWAC as protection along approximately 3 miles of shoreline. This cost equates to approximately $1,900/LF of breakwater construction. During final design, refinements to the breakwater cross-section and incorporation of the previously-constructed (existing) breakwaters will continue to be explored to help reduce required material quantities (and associated cost) and support constructability.

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ACRONYMS

ASCE American Society of Civil Engineers
CEM Coastal Engineering Manual
CIAP Coastal Impact Assistance Program
CIRIA Construction Industry Research and Information Association
CPRA Coastal Protection and Restoration Authority
CWPPRA Coastal Wetlands Planning, Protection and Restoration Act
DCP Data Collection Platforms
D_{n50} Median Stone Size
DNR Louisiana Department of Natural Resources
H_{mo} Spectral Significant Wave Height
H_s Significant Wave Height
H_{st} Transmitted Wave Height
H_{10} Average of highest 10 percent of all wave heights
JCLS John Chance Land Surveys, Inc.
K_t Wave Transmission Coefficient
LADOTD Louisiana Department of Transportation and Development
LWA Lightweight Aggregate
LWAC Lightweight Aggregate Core
MHHW Mean Higher High Water
MLLW Mean Lower Low Water
NAVD North American Vertical Datum of 1988
NMFS National Marine Fisheries Service
NOAA National Oceanic and Atmospheric Administration
OCPR Office of Coastal Protection and Restoration
RSLR Relative Sea Level Rise
T_p Peak Wave Period
USACE United States Army Corps of Engineers
USGS United States Geological Survey

1.0 INTRODUCTION

1.1 Purpose

Louisiana's coastline is a dynamic, ever changing environment facing erosional losses of 25 to 35 square miles each year, adversely impacting the state's wetlands and other coastal resources. There are many causes for this erosion, such as the effects of man, subsidence, and severe coastal storms, which are complex and vary by region and location. At the Rockefeller Wildlife Refuge (Refuge) in southwest Louisiana's Cameron Parish, recent studies estimate that erosion claims an average of 46 ft of marsh each year, which is equivalent to a loss of approximately 17 acres per year over the proposed 3-mile project area (USGS 2013).

To help mitigate erosion at the Refuge, the State of Louisiana's Coastal Protection and Restoration Authority (CPRA) teamed with the National Marine Fisheries Service (NMFS) to implement the Rockefeller Refuge Gulf Shoreline Stabilization Project through the Coastal Wetlands Planning, Protection and Restoration Act (CWPPRA). The overall stabilization project is intended to protect the 9.2-mile portion of the Refuge west of Joseph Harbor Bayou (Figure 1-1); however, the current funding will only provide protection for up to 3 miles of the most critically eroded shoreline west of Joseph Harbor Bayou, as pictured in Figure 1-2.

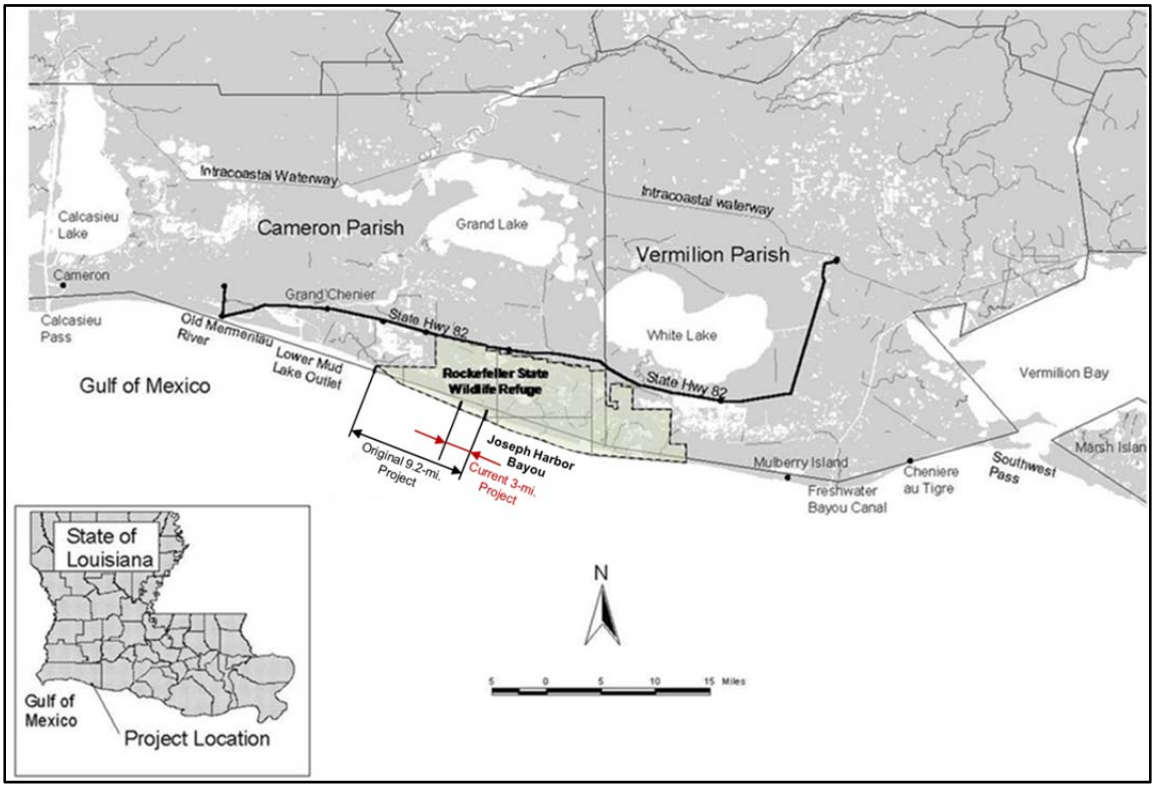

Figure 1-1 Project location

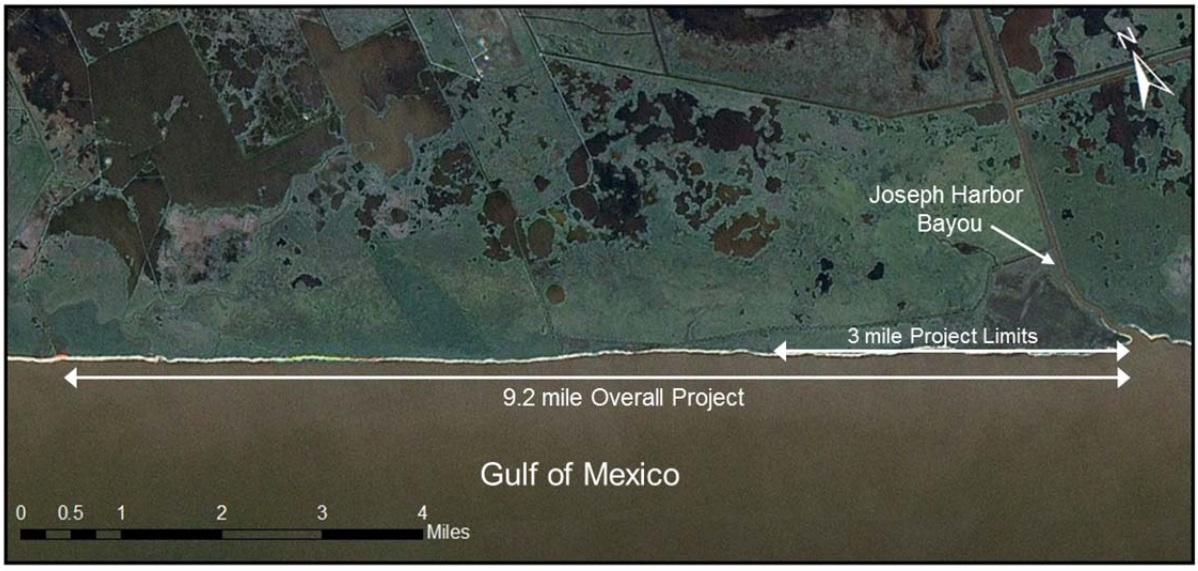

Figure 1-2 Project extent along Gulf shoreline.

Previously, several alternatives were analyzed for shoreline protection along the Refuge coastline. Considerations included cost, constructability, design life, level of shoreline protection, and other parameters that would ultimately help decide which projects were most suitable for construction. Of the various alternatives considered, three were implemented as part of a demonstration project: a reef breakwater, a gravel beach fill, and a reef breakwater with lightweight aggregate core (LWAC). All three proceeded through final design phases, construction (in 2009), and post construction monitoring to help determine a preferred alternative for the full project. Construction of the demonstration phase and post-construction monitoring was funded through the Coastal Impact Assistance Program (CIAP).

Important aspects, such as settlement, wave transmission, and erosion reduction, played a role in selecting the preferred alternative, the reef breakwater with LWAC. The current phase of the project is planned to consist of construction of this alternative as part of the Rockefeller Refuge Gulf Shoreline Stabilization Project (ME-18). This report documents the 95% engineering and design for the current phase, which will construct up to 3 miles of shoreline protection along the Refuge's Gulf coast.

1.2 Authorization

HDR was given authorization for this work through a contract with CPRA. The project was initially funded and authorized in accordance with the CWPPRA (16 U.S.C.A., Section 3951-3956) as project ME-18, Priority Project List 10. The demonstration portion was funded with qualified outer continental shelf oil and gas revenues by CIAP. The current project includes design of up to 3 miles of shoreline protection, starting at Joseph Harbor Bayou.

1.3 Demonstration Project

The demonstration project, which was completed in 2009, encompassed design and construction of various shore protection alternatives. Initial data collection and reporting were described in the Data Collection Report (Shiner Moseley 2002) and the 20% preliminary design was documented in the Feasibility Study Report (Shiner Moseley 2003). These initial efforts resulted in selection of several alternatives for possible inclusion in a demonstration program, including the reef breakwater with LWAC option (Figure 1-3). Subsequent design for the demonstration program was documented by Shiner Moseley (2004, 2005, 2006).

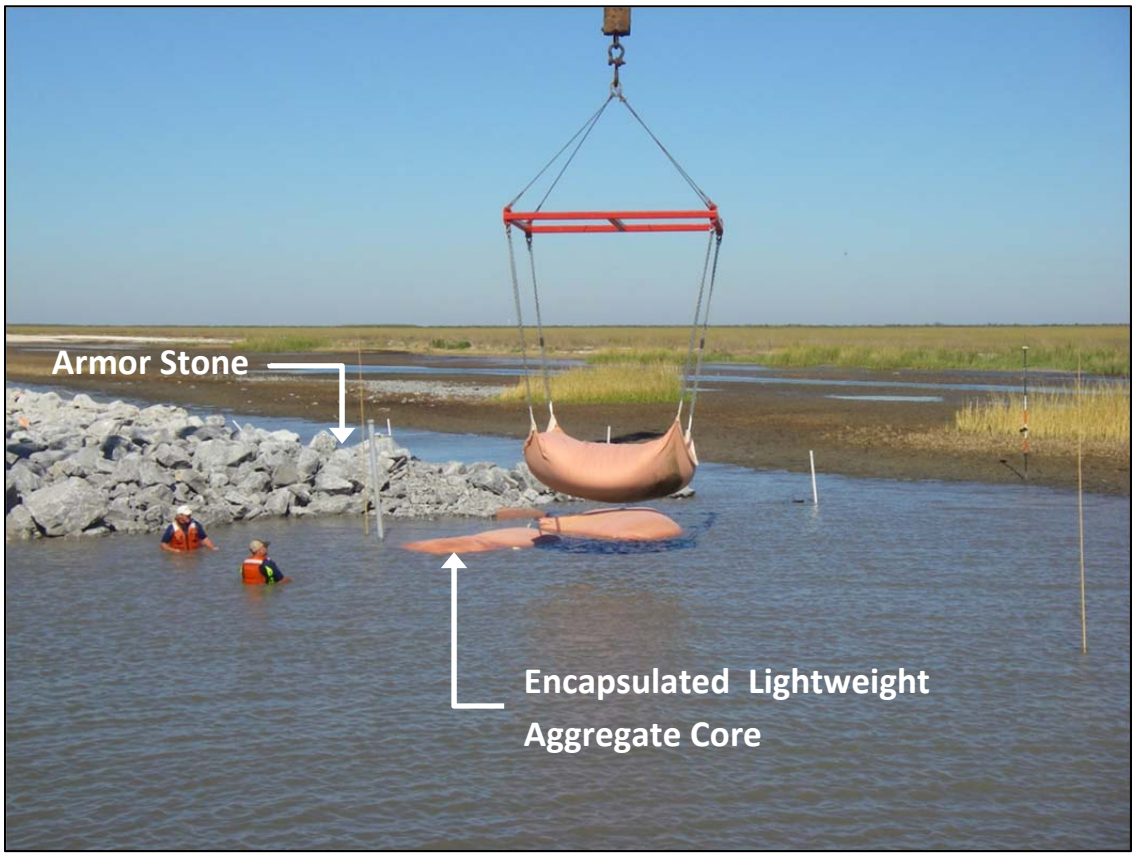

Figure 1-3 Construction progress of breakwater with LWAC.

The demonstration project was subsequently constructed from April 9 to December 4, 2009 at a cost of $5,622,000, as detailed in the Project Completion Report (HDR 2010). Post construction monitoring of the project was performed to compare and analyze the alternatives for settlement, hydraulic stability, wave attenuation, and shoreline response. Location of the demonstration project features and post construction monitoring are shown in Figure 1-4 and Figure 1-5, respectively. Data collected during the post construction monitoring included topographic/bathymetric surveys and aerial photography, and measurements of water levels, wave conditions seaward and landward of the structures, and meteorological conditions (e.g. wind speed/direction, barometric pressure, and rainfall).

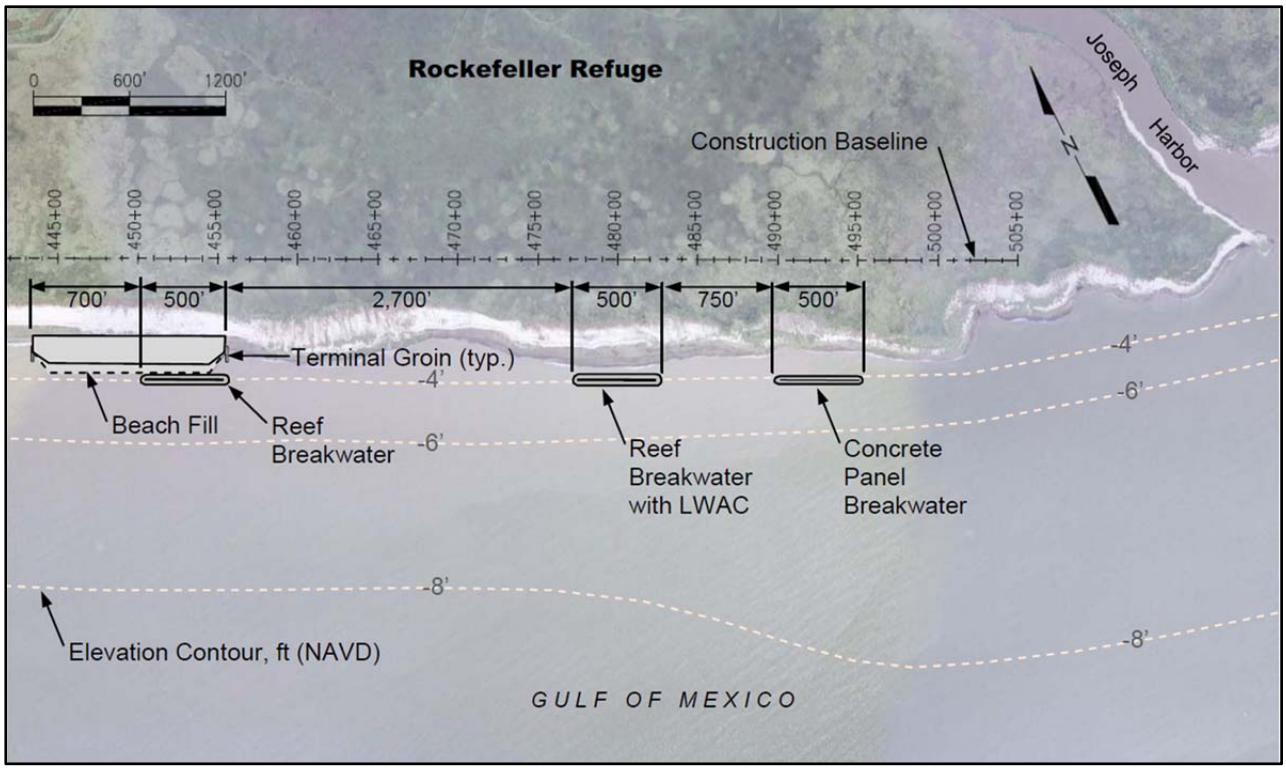

Figure 1-4 Original design layout for demonstration project.

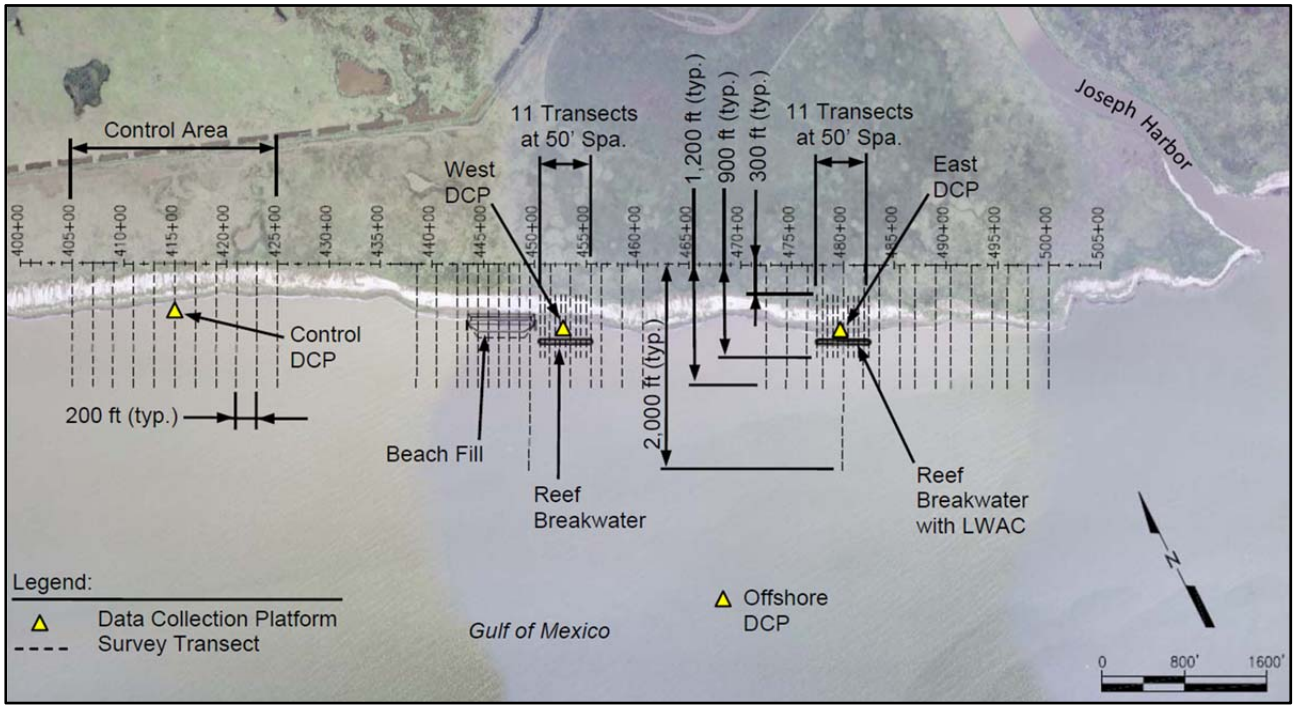

Figure 1-5 Post construction monitoring layout.

Post-construction monitoring provided additional insight on several aspects of the project as follows (HDR 2011):

- Because of the extremely soft foundation soils along the Refuge shoreline, the potential for excessive settlements during and subsequent to construction were a significant concern. Actual settlements of the reef breakwater with LWAC were less than anticipated, which may allow minor dimensional or construction modifications that help reduce unit cost of the full project.

- Review of measured shoreline recession rates along the demonstration project area revealed that, as expected, the reduction of shoreline recession was the greatest in the center of each breakwater, with recession increasing towards the breakwater ends. It was therefore recommended to construct the full project to be as continuous as feasible with minimal gaps.

- A comparison of tide data collected at the demonstration project site to nearby long-term tide records indicated that water levels recorded at the U.S. Geological Survey (USGS) Calcasieu Pass gage are most similar to those at the Refuge. Long-term data from the Calcasieu Pass gage are therefore recommended for application during design of the full project. The NOAA Calcasieu Pass site is recommended for long-term records of wind. This information helps verify and improve confidence in assumptions applied during previous design.

- The reef breakwater with LWAC is recommended for construction along the full project shoreline, primarily due to this method's better ability to attenuate waves and reduce shoreline recession. This alternative also performed well in accommodating the soft foundation soils and displayed adequate hydraulic stability despite the potential destabilizing effects of the LWAC.

2.0 SITE CONDITIONS

Characterizing existing site conditions is essential for developing a successful design, particularly in this area with extremely soft soils and direct exposure to waves from the open gulf. For the current phase of the project, an updated site characterization was performed including a review of topographic and bathymetric surveying, geotechnical investigations, aerial photography, prior reports and historical information, a wave and water level assessment, and a morphological evaluation. The details and supporting historical information carried forward from previous efforts are documented in Shiner Moseley (2003) and HDR (2011). Additional topographic and bathymetric data were collected in 2013 and 2014 to supplement the current design effort. LDWF is in the process of updating maps of potential locations of pipelines within the Refuge, including in the project area. Should the LDWF map updates identify any pipelines within the project vicinity, they will be addressed in final design. Key findings of the overall data collection and site characterizations are summarized below.

2.1 Topography and Bathymetry

Multiple topographic and bathymetric surveys have been performed to provide quantitative information about the shape of the beach profile, both before and after structures were constructed, to help determine local wave conditions, the structures' effects on shoreline change, and changes to the structure shapes (due to settlement, scour, etc.) after they have been constructed. In addition, knowledge of the beach profile shape can aid in the prediction of future depths at a given location across the profile, which is important when developing future shoreline protection structures. Table 2.1 summarizes the surveys conducted throughout the project, including the design, construction and monitoring phases. Topographic/bathymetric surveys were collected by John Chance Land Surveys, Inc. in September 2013 and between April and May 2014 to assist the current design. The spatial coverage of the most recent surveys is shown in Figure 2-1. Location of the existing breakwaters constructed for the demonstration project (i.e., the reef breakwater and reef breakwater with LWAC), as well as a set of existing breakwaters constructed for a related oyster ring breakwater demonstration project (Bio-Engineered Oyster Reef Demonstration Project LA-08), are also shown in Figure 2-1.

Table 2.1 Topographic and bathymetric survey collection summary.		
Date	**Description**	**Entity that Collected or Provided Data**
June-July 2002	Design (DEMO)	John Chance Land Surveys, Inc.
April 2009-April 2010	Construction	J. Bordelon and Assoc. LLC
July-August 2010	Monitoring	John Chance Land Surveys, Inc.
November 2010	Monitoring	John Chance Land Surveys, Inc.
March 2011	Monitoring	John Chance Land Surveys, Inc.
September- October 2013	3 Mile Design and Monitoring of the LWAC Test Section	John Chance Land Surveys, Inc.
April-May 2014	Joseph Harbor Bayou	John Chance Land Surveys, Inc.

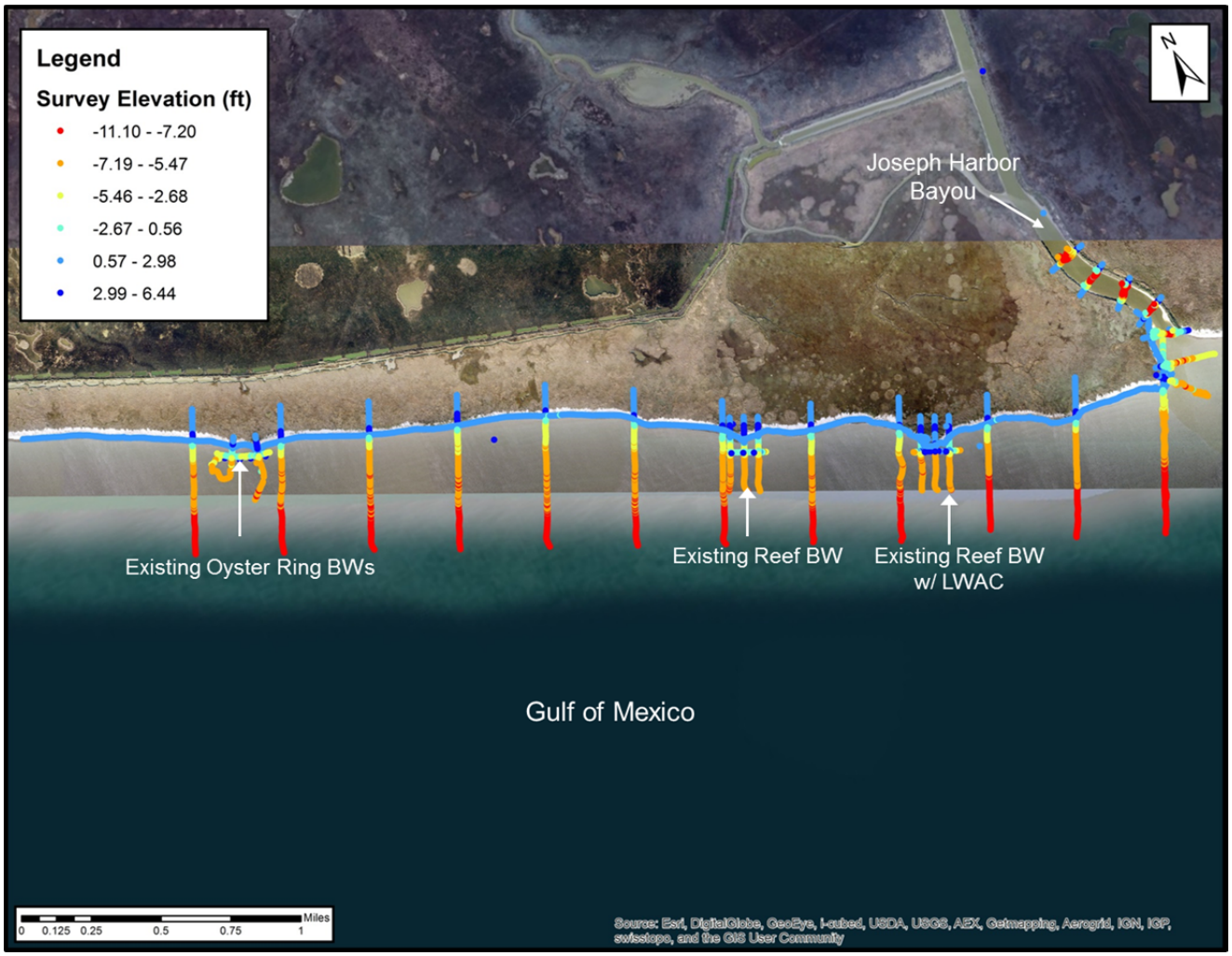

Figure 2-1 Topographic/bathymetric survey transects along 3 mile project location.

2.2 Geotechnical Conditions

Two geotechnical investigations were performed by Fugro Consultants, LP (Fugro) to support the proposed design alternatives. The first phase of investigations was completed in July 2002 to support the original feasibility study. The associated geotechnical report was divided into two parts, with the first report (Fugro 2002) focusing on bearing capacity and the second report (Fugro 2003) focusing on settlement. The second phase of investigations, documented in Fugro (2004), was completed in August 2004 to support the 30% design and to better define soil parameters. Key geotechnical engineering considerations at the site included allowable soil bearing capacity of the predominantly soft upper soils, consolidation and elastic (near-instantaneous) settlement of the structures, global stability of the structures, and construction considerations. The following section provides a summary of the previous geotechnical investigations carried out to support the project.

Borings

A total of 20 borings were drilled and sampled during the first phase of investigations; boring depths ranged from 25 to 100 ft. For the second phase of investigations, nine borings, each 45 ft deep, and six field vanes, each 20 ft deep were drilled. The borings were generally located on a line approximately parallel to the shoreline. Because of the predominantly soft clayey soils, thin-walled Shelby tube sampling was performed using the wet-rotary technique. Budget constraints restricted field investigations to land and shallow water only – no borings or probes were performed from floating plant. However, 100 grab samples were obtained from the seafloor within about 2,000 ft of the shoreline.

Subsurface Conditions

The subsurface conditions appeared to be relatively uniform along-shore and across-shore, with predominantly clayey soils. Table 2.2 describes the subsurface soil conditions with estimated shear strengths.

Table 2.2 Subsurface conditions along the ME-18 site.

Estimated Shear Strength, psf	Depth, ft	Soil Description
20-200	0-20	Very soft Clay
50-300	20-40	Very soft to soft Clay
1000-2000	40-60	Stiff Clay and Sandy Clay
500-1500	60-100	Firm to Stiff Clay and Sandy Clay

Laboratory Testing

In order to characterize the subsurface soils at the site, in addition to visual classification, geotechnical laboratory testing was performed that included index tests (Atterberg Limits), moisture content, unit weight, consolidation, and shear strength tests.

Analyses

Settlement

Because the upper soil strata along the Refuge shoreline are composed of very soft soils, a significant design challenge presented itself and warranted considerable attention during development of the demonstration program. In addition to analysis of bearing capacity and slope stability, structure settlement was assessed in detail. For alternatives predicted to have significant settlement, increased wave transmission was a concern due to potential for greater erosion of the marsh. Settlement data collected during monitoring of the demonstration project will assist in design requirements for the current project.

Figure 2-2 presents measurements of settlement and crest elevation for the reef breakwater with LWAC (from the demonstration project) with S10, S11, and S12 representing the locations for three settlement plates along the breakwater with LWAC. The horizontal axis on these plots represents time after final rock placement, excluding elastic (short-term or initial) settlements that occurred as the rock was being placed. Also shown (in Figure 2-2) is the elevation associated with the predicted and/or maximum acceptable level of settlement developed during design. Note that the 20-yr extrapolations of settlement remain at or above the minimum desired crest elevation of +1.9 ft.

Measured elastic settlements, or near-instantaneous settlements caused by lateral soil displacement during placement of the stone, are plotted in Figure 2-3. As summarized in Table 2.3, the measured values were generally less than the predicted values. For design, elastic settlement is commonly estimated to be on the order of 20% of the (calculated) total consolidation settlement and/or initial structure height. The lesser values of elastic settlement shown in Figure 2-3 are a beneficial result of the monitoring program, which will help refine the design of the structure.

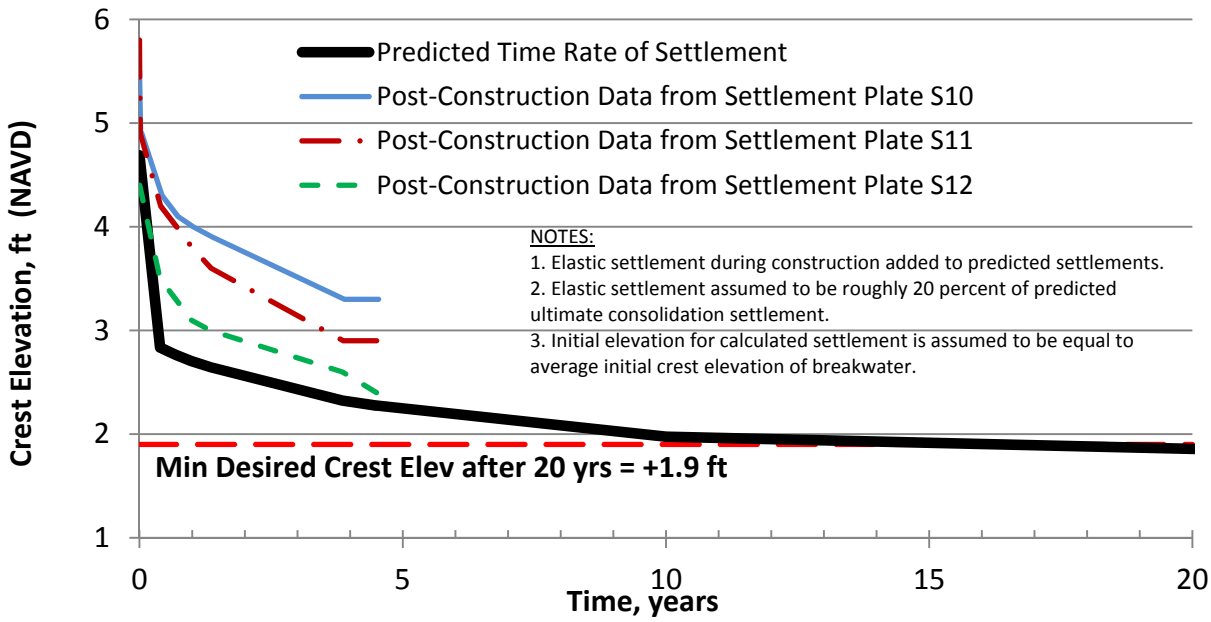

Figure 2-2 Measured and predicted crest elevation of Reef Breakwater with LWAC.

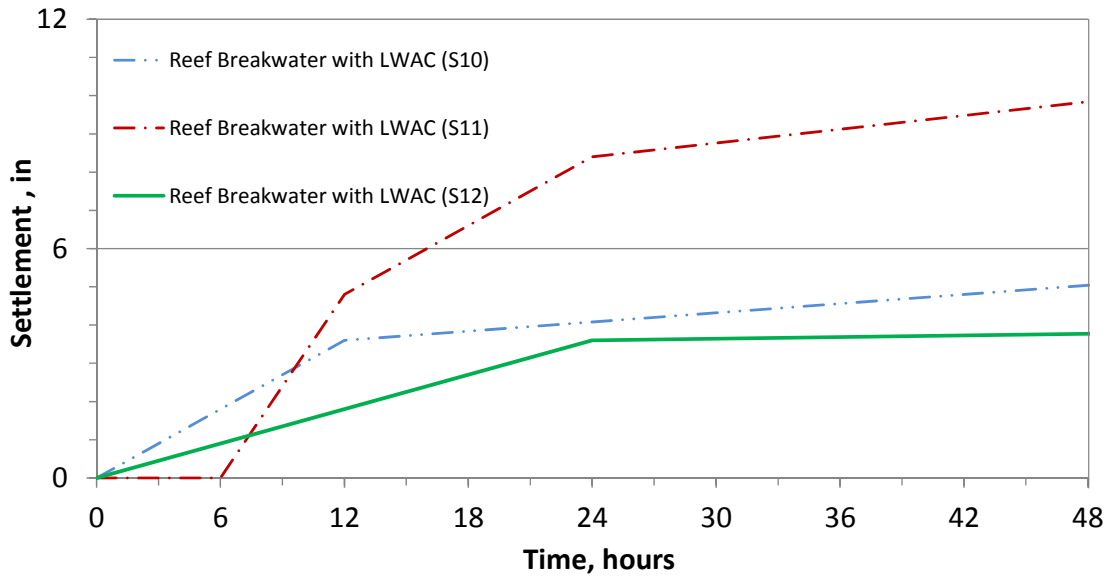

Figure 2-3 Elastic settlements measured at Reef Breakwater with LWAC.

Table 2.3 Elastic settlement of reef breakwater with LWAC.		
Structure	**Approximate Elastic Settlement, in**	
	Predicted	**Measured**
Reef Breakwater with LWAC	6 to 24	S10 = 5
		S11 = 9
		S12 = 4
		Average = 6

At the time of the first phase of geotechnical investigations, the project team considered a reef breakwater option to have potential for success, and a generalized cross-section was provided to Fugro for analysis. However, the specific construction material for the breakwater had not yet been determined. Settlement analysis was based on various loads from 100 psf to 250 psf. Estimated centerline settlement was between 1.1 and 2.2 ft.

During the second phase of investigations, more specific centerline and edge settlements were computed for all design options. The reef breakwater and reef breakwater with LWAC had total estimated centerline settlements of 1.3 and 1.5 ft, respectively. Edge settlements were predicted to be generally less than centerline settlements. It was expected that about 40 to 50 percent of total settlement would occur over a period of about 8 to 12 years; the remaining settlement was predicted to occur over a period of 40 to 45 years.

Bearing Capacity

An allowable bearing capacity of 220 psf was previously recommended for the structures using a factor of safety of 2, and 290 psf with a factor of safety of 1.5. After close coordination with CPRA staff, the latter value was suggested to be acceptable for design considering that localized failure may not be catastrophic for continued functional performance of the breakwaters.

Global Stability

Short- and long-term stability analyses were previously performed for the design options. For the site, a global stability factor of safety of 1.3 was considered acceptable. The results indicated that the reef breakwaters were expected to be stable against a potential slope failure, with a minimum computed factor of safety of 1.63.

Updated Geotechnical Analysis

Additional geotechnical analyses were performed in 2014 to determine current soil conditions at the site, including percent consolidation, soil strength gain, and bearing capacity. The results indicated the reef breakwater and reef breakwater with LWAC settlements are 1.5 ft and 2.7 ft, resulting in current average crest elevations of +0.4 ft and +2.9 ft, respectively. The oyster ring breakwater has an average current crest elevation of approximately -0.1 ft. The ultimate

consolidation for the reef breakwater with LWAC was estimated to be between 2.0 and 2.7 feet. Figure 2-2 includes the most recent settlement and crest elevation results for the LWAC breakwater.

Because the current crest elevation of the reef breakwater with LWAC is approximately one foot above the desired +1.9 ft 20-year elevation and is not expected to settle below this minimum desired elevation, no additional fill is necessary. The reef breakwater is approximately 1.6 ft below the minimum desired elevation of the reef breakwater with LWAC, while the oyster ring breakwater is approximately 2 ft below the minimum desired elevation of the reef breakwater with LWAC; therefore, additional three and four-foot fills were considered for the respective breakwaters. However, the foundation soils have not gained sufficient additional bearing capacity for a single three or four-foot fill. Staged construction was suggested to raise the reef breakwater at one foot per year for three years and the oyster breakwater at one foot per year for four years. Due to the large gradation of the armor stone, it may be difficult to accurately place one-foot fills each year. In addition, performing these fills would not be cost-effective considering economy-of-scale issues (i.e., the relatively small scale and limited nature of work that would be required in such a harsh and remote construction environment).

2.3 Wind

The collection of wind data was important to determine if winds measured during the monitoring phase of the demonstration project were representative or similar to winds measured nearby at Calcasieu Pass (NOAA Station 8768094) that were previously applied during detailed design. Comparison of the wind data measured at the project site with the NOAA data would thereby provide confidence in the use of long-term data and associated seasonal trends previously applied for project design. A wind rose was developed to provide a graphical representation of the wind conditions at Calcasieu Pass, which, based on comparison to data measured for the demonstration project, is representative of the wind conditions at the project site. The prevailing winds at Calcasieu Pass and the project site are from the southeast.

2.4 Water Level

Water level data were recorded during post construction monitoring of the demonstration project and referenced to NAVD ’88 based on surveys performed by John Chance Land Surveys, Inc. (2011). A comparison of data from the demonstration project and the Calcasieu Pass USGS station indicates that the USGS data provide a good representation of conditions at the project site. As a result, it is recommended that the USGS data set, which has a longer data record and minimal data gaps, be applied for long-term water level evaluations.

Water level exceedance curves were developed for the recently collected demonstration project monitoring data as well as the USGS Calcasieu Pass data from January 2006 to March 2011. As shown in Figure 2-4, water levels did not reach the current breakwater crest elevation during the monitoring period. It should also be noted that the proposed elevation for the breakwater crest after 20 years of settlement, +1.9 ft, was exceeded less than 20% of the time during both data periods.

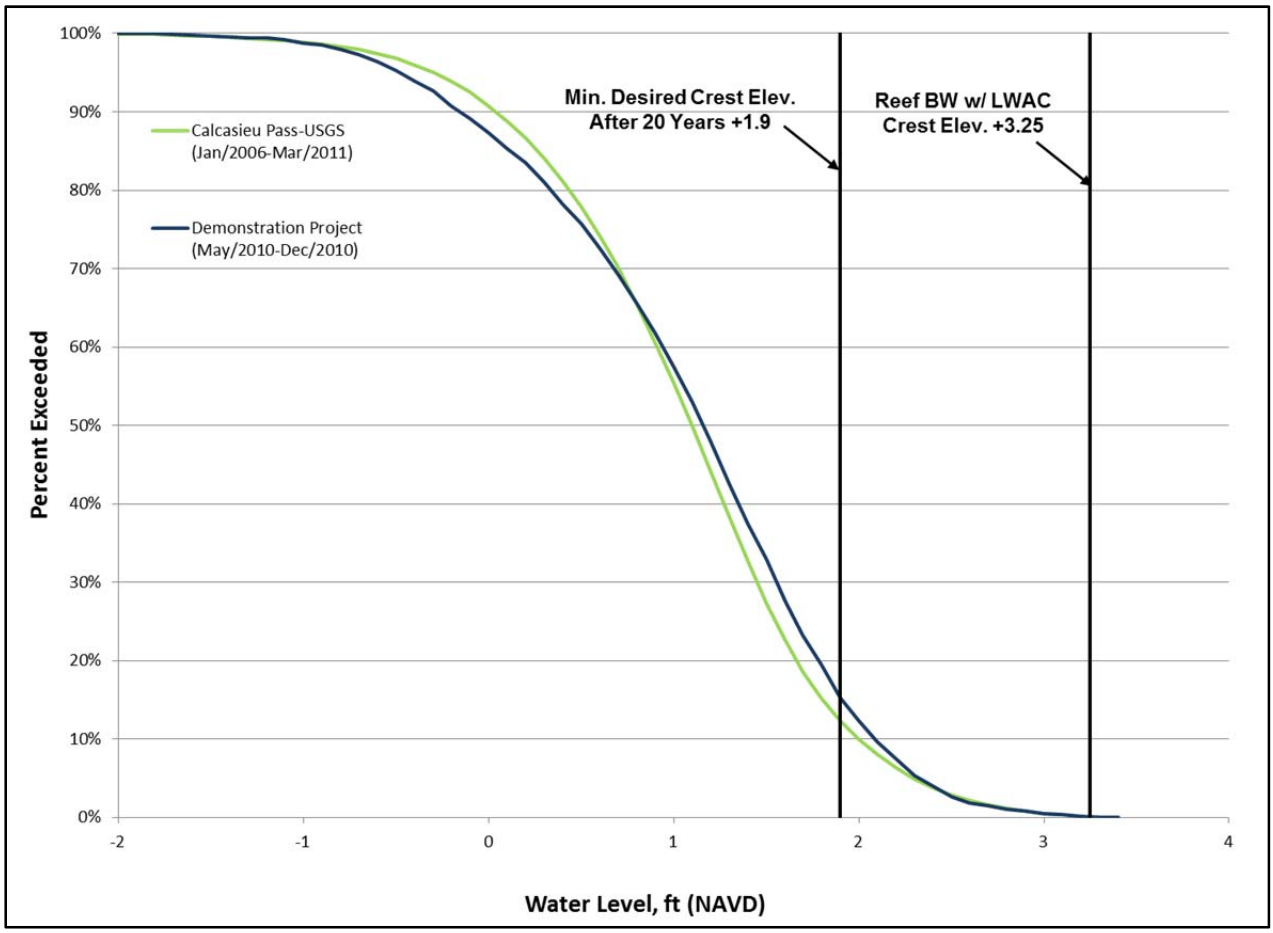

Figure 2-4 Water level exceedance.

2.5 Waves

During the monitoring period (May-November 2010) of the demonstration project, wave data were collected landward and seaward of the breakwaters. The predominant direction of wave propagation during this period was from the south, as depicted in Figure 2-5. The significant wave height (H_s) was less than 1.5 ft approximately 93 percent of the time with an average peak wave period of 5.7 sec. The maximum recorded H_s was 3.2 ft with a peak period of 13.4 sec on July 1, 2010.

For wave data collected during monitoring of the demonstration project, significant wave height tended to increase in May and June and decrease from July to October. Overall, the largest waves were recorded in June, July, and September compared to the other months. Average wave heights recorded landward of the reef breakwater with LWAC were typically 96 percent smaller than those recorded at the control site.

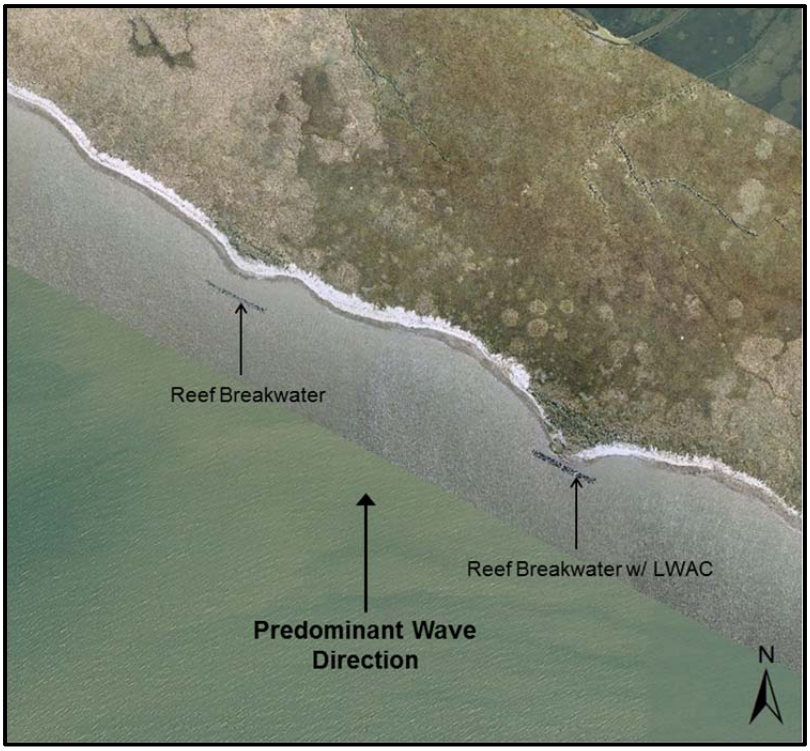

Figure 2-5 Predominant wave direction.

The ability of the breakwaters to attenuate wave energy is of particular interest because wave action is the primary cause of shoreline recession along the Refuge. Reducing this wave energy will effectively reduce the shoreline recession. The wave transmission coefficient, K_t, which is the ratio of wave heights landward and seaward of the breakwater, is commonly used to express a breakwater's ability to attenuate waves. Wave transmission coefficients were calculated using data obtained during the monitoring effort. The wave transmission for the reef breakwater with LWAC, averaged over the entire post construction monitoring period, was calculated to be 0.03. The reef breakwater with LWAC's ability to dissipate wave energy was greater than other alternatives constructed because of its higher crest.

The 30% Design Report for the demonstration project (Shiner Moseley 2004) lists design values estimated for wave transmission for typical daily conditions, a 1-year return period storm, and a Category 1 hurricane. During the post construction monitoring period, for waves meeting the typical daily values, the transmission coefficients, transmitted wave heights, and energy reduction percentages were calculated and averaged as summarized in Table 2.4. The comparison of design and measured values shows that the reef breakwater with LWAC met, or performed better than, the design thresholds, which was largely attributable to the lesser settlements and higher crest elevation than were assumed during design.

Table 2.4 Comparison of design and measured wave transmission for typical daily conditions.		
	Reef Breakwater with LWAC	
	Design	Actual
Transmission Coefficient, K_t	0.13	0.04
Wave height seaward of structure, H_s (ft)	1.6	1.6
Transmitted wave height (landward of structure), H_{st} (ft)	0.2	0.1
Energy Reduction (%)	98	99.7

Additionally, the transmission coefficients were compared based on the water level, seaward wave height at the breakwater, and wave period. A summary of these results is provided in the Post Construction Monitoring Report (HDR 2011). For these metrics, the reef breakwater with LWAC was consistently the most effective option with less than 10% wave height transmission for all cases when water level was less than +3 ft. Based on these results, the design of the reef breakwater with LWAC, as previously developed for the demonstration project, appears to adequately reduce wave energy transmitted to the project shoreline.

3.0 SHORELINE CHANGE

3.1 Relative Sea-Level Rise

Relative sea level rise (RSLR) is the combination of eustatic (global) sea level rise and local land subsidence, and can exacerbate shoreline retreat by allowing water and waves to penetrate further landward. Unless designed to encourage sediment deposition, shoreline protection structures generally help offset adverse effects of RSLR by reducing wave penetration rather than reducing landward submergence/drowning.

Long-term estimates of subsidence rates along the Gulf shoreline of the Chenier Plain generally range from 0 to 1 ft per century (Gagliano 1998). However, short-term subsidence rates can be much greater, ranging from 0.4 to 0.6 inches per year for areas within the vicinity of the Refuge (Shinkle and Dokka 2004). In general, subsidence rates along the Gulf coast appear to decrease with distance west from the Mississippi River.

Considering that eustatic sea-level rise has been estimated to be on the order of only 0.05 inches per year (Shinkle and Dokka 2004), the estimates of subsidence mentioned above provide reasonable approximations of relative sea-level rise. In addition, rates of relative sea-level rise along the coasts of the United States have been estimated by NOAA from water level trends at tide stations having long-term (decadal) records (Zervas 2001). Data collected from 1958 to 1999 at Sabine Pass and from 1939 to 1974 at Eugene Island suggest rates of relative sea-level rise of 2.2 ft per century and 3.2 ft per century, respectively.

Based on these trends, relative sea-level rise at Rockefeller Wildlife Refuge may be anywhere from five to ten inches over the desired 20-year design life of the project. Future increases in relative sea-level rise could gradually decrease the ability of the shoreline protection structure(s) to attenuate waves, although effects are expected to be minimal during the 20-year design life of the project. Considering the extremely soft soils that limit the foundation loads and associated height of the breakwater, no additional height allowance has been included specifically for sea-level rise.

3.2 Shoreline Change

Byrnes *et al.* (1995) concluded that rates of shoreline recession within Louisiana's Chenier plain are generally increasing with time, and that the long-term average rate along the Refuge is about 35 ft per year. More recently, USGS estimated the average shoreline erosion rate along the project shoreline to be approximately 46 ft per year (USGS 2013) based on shoreline change from 1998 to 2010 (Figure 3-1).

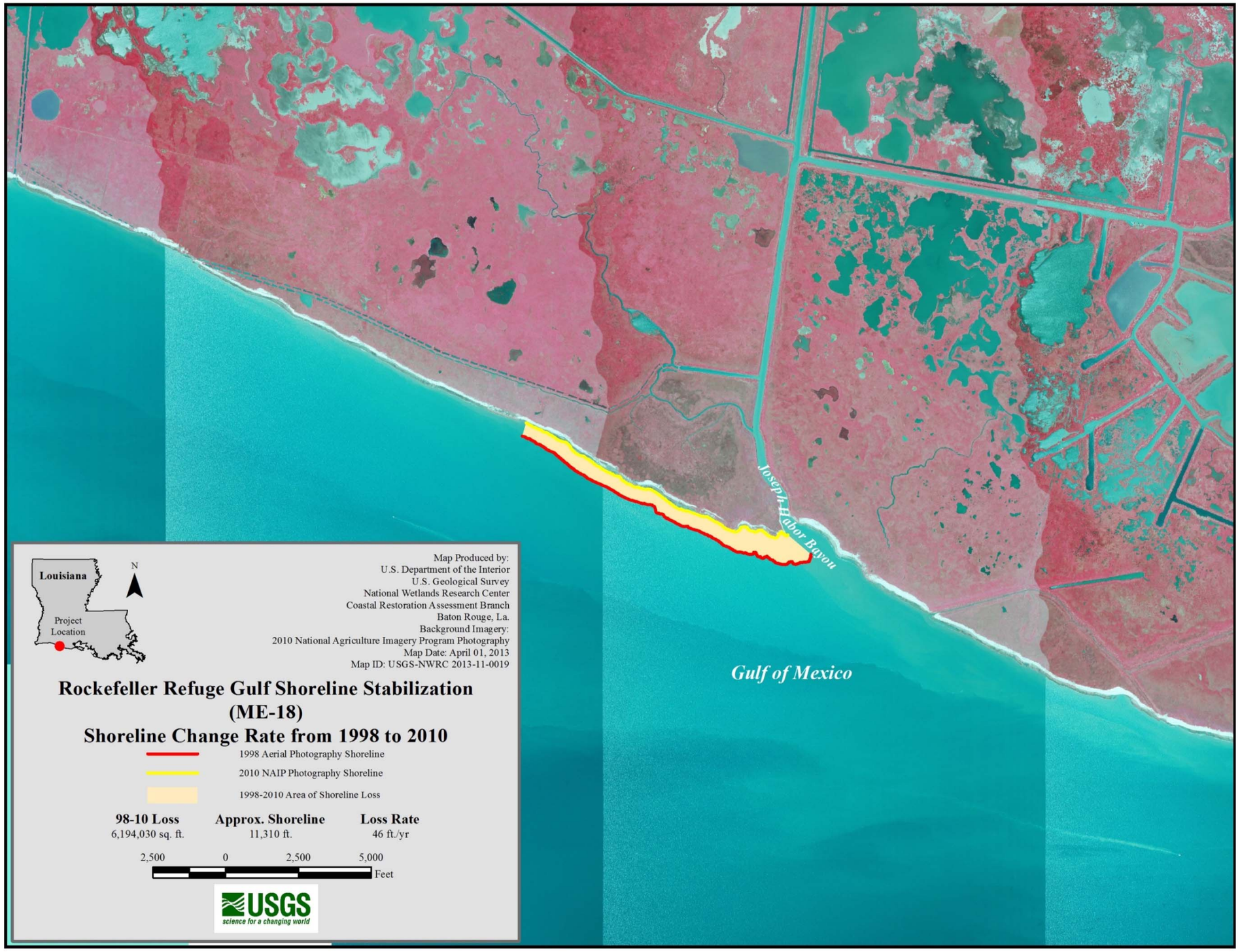

Figure 3-1 Shoreline change rate from 1998 to 2010 (USGS 2013).

It is well recognized that tropical cyclones can make a significant contribution to the erosion along the Louisiana coast. During storms, deposits of shell that are perched atop the beach along the Refuge shoreline can be transported landward by waves as washover deposits onto the marsh, which forms the back beach and upper beach. This process results in an exposed zone of marsh seaward of the beach, referred to here as the lower berm (Figure 3-2), to be reworked by waves during and/or after the storm.

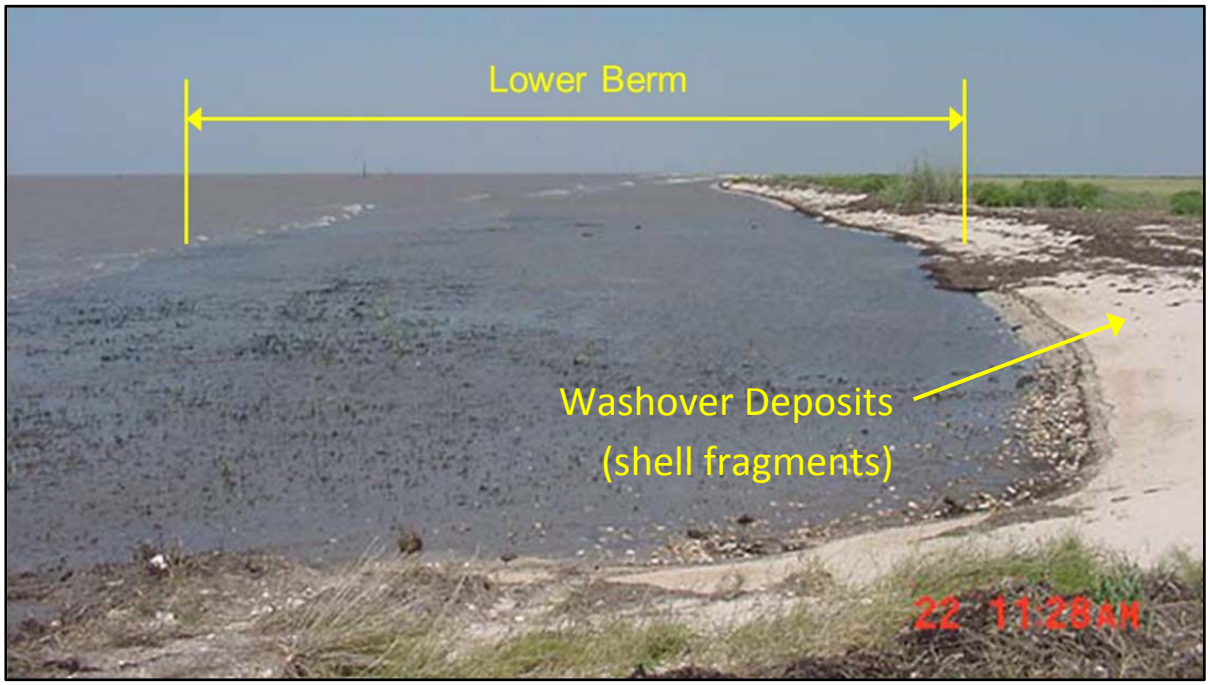

Figure 3-2 Typical lower berm.

Note that, depending on storm duration, the stronger storms that generate a large surge do not necessarily produce the most severe erosion at the Refuge because the beachface and marsh become submerged and, as a result, are somewhat protected by a cushion of water as waves pass overtop.

To help evaluate the alternatives constructed during the demonstration project, shoreline change was analyzed from surveys performed at the completion of construction in February 2010 and at three subsequent dates: August 2010, November 2010, and March 2011. To be consistent, the "shoreline" was defined as the +1.0 ft contour, except at Stations 454+00, 454+50, and 455+00 which were landward of the reef breakwater. The +0.5 ft contour was applied at these locations due to the formation of a distinct scarp at an elevation below +1.0 ft. Shoreline change measured from the survey data was compared with aerial photography obtained throughout the monitoring period for qualitative verification. Aerial photography collected during the monitoring program is provided in HDR (2011).

Erosion landward of the reef breakwater with LWAC was found to be minimal during the monitoring period, with an average shoreline recession of approximately 3 ft from February 2010

to March 2011. This lesser shoreline recession is due in part to less wave energy transmitted across the reef breakwater with LWAC. Shoreline rates as surveyed during the post construction monitoring phase of the demonstration project are provided in Table 3.1 for the reef breakwater with LWAC as well as within the control area, which was unprotected. It should be noted that during the monitoring period, the control area experienced a shoreline erosion rate of over 40 ft per year.

Table 3.1 Average shoreline change.

	Average Shoreline Change, ft		
	February to August 2010 (6 months)	February to November 2010 (9 months)	February 2010 to March 2011 (13 months)
Control Area (Unprotected)	-26.9	-37.7	-45.3
Reef Breakwater with LWAC	-1.5	+0.5	-3.0

4.0 FUTURE WITHOUT PROJECT

Each year, the Refuge loses approximately 46 ft of marsh along the Gulf of Mexico to erosion (USGS 2013), equating to approximately 17 acres per year over the 3-mile project area. Left to face this erosion without any protection, the Refuge shoreline will continue to retreat landward, leaving less marsh complex, which could have substantial impacts on the Refuge as well as the surrounding area. Figure 4-1 provides a projection of continued 46 ft/yr loss at the Refuge for the next 10, 20, and 50 years. Based on linear extrapolation, in 10 years the shoreline will retreat 460 ft, in 20 years 920 ft, and in 50 years 2,300 ft. The associated acreage lost for each of these periods is approximately 170 acres, 340 acres, and 840 acres, respectively over the 3-mile project area. The shorelines projected in Figure 4-1 are not intended as precise, quantitative depictions of the manner in which the Refuge will erode, but are meant to be general estimates for the scale of erosion. They do not include the potential limiting effects of the existing structures.

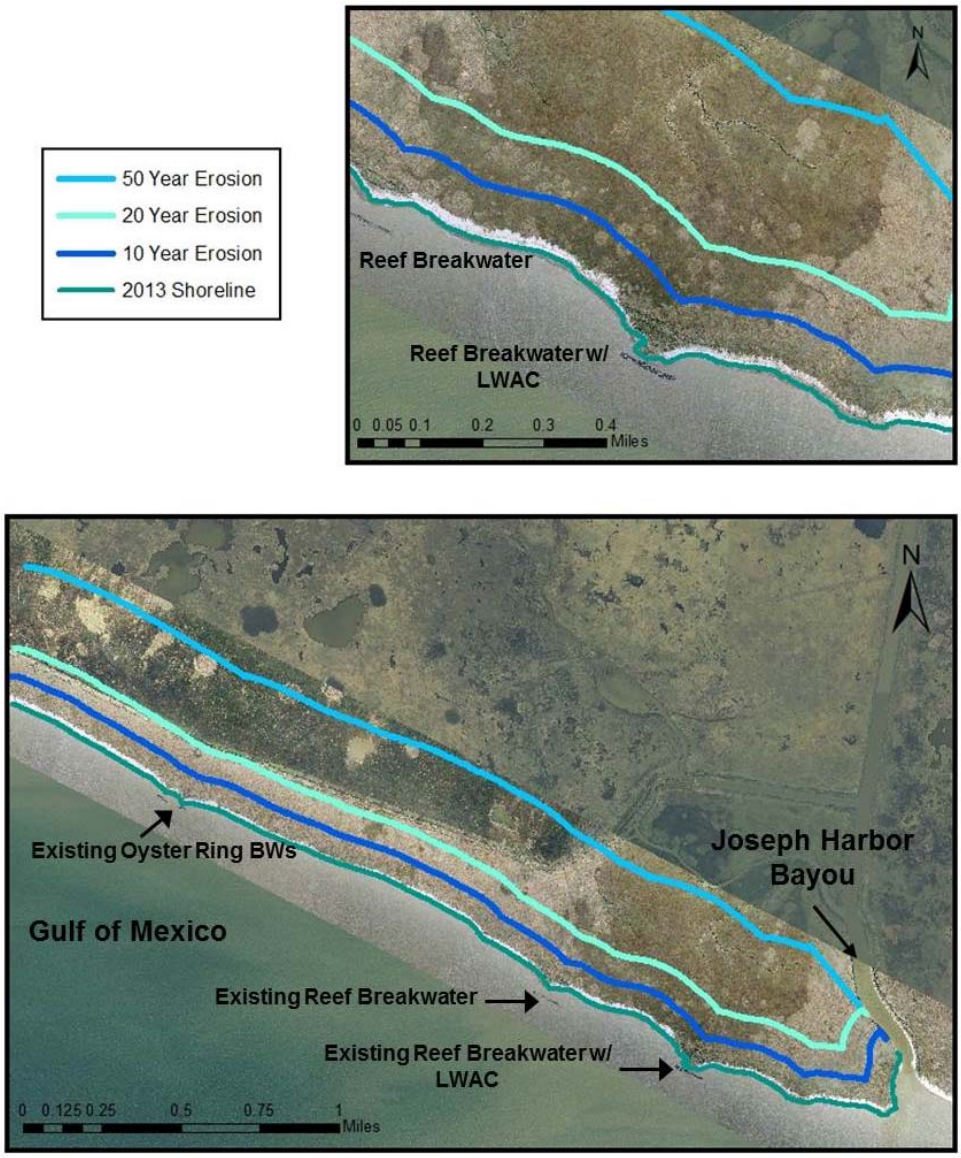

Figure 4-1 Future projections of shoreline erosion.

5.0 DESIGN

5.1 Design Objectives

The primary challenge for the Rockefeller Refuge Gulf Shoreline Stabilization Project is to design and construct a cost-feasible structure that will be both hydraulically stable under open-coast wave conditions and geotechnically stable despite very soft foundation soils. Based on criteria stated by CPRA, the reef breakwater with LWAC must meet several key requirements:

- Prevent beach erosion for up to Category 1 hurricane conditions, which were estimated to have a return interval of about 10 years at the project site.
- Be designed, constructed, monitored, and maintained over a 20-year design life.
- Where practicable, the protection should remain stable for more severe storm conditions up to an event having a 100-year return period. Note that a 100-year storm has an 18.2% probability of occurring within any given 20-year period.

Estimates of soil consolidation and settlement by Fugro (2004) were applied to evaluate functional performance under the lower crest elevations that are expected to exist at completion of a 20-year project life.

5.2 Breakwater Design and Layout

Breakwater Layout

The breakwater is planned to be constructed along the approximate -3.5 ft (NAVD ’88) contour, approximately 150 ft offshore, and will generally follow the shape of the shoreline as shown in Figure 5-1. Because the shoreline is continually eroding, it is anticipated the breakwater alignment will be updated throughout construction. Reviews will be necessary as construction continues to ensure the breakwater follows the -3.5 ft (NAVD ’88) contour. Placing the breakwater as close to the shoreline as possible is intended to help reduce cost by decreasing the amount of material needed for construction through a smaller cross-section. However, locating the breakwaters too close to shore may pose draft limitations during construction[1]. The previously constructed reef breakwater and the reef breakwater with LWAC from the demonstration project as well as the existing oyster ring breakwaters will be incorporated in the proposed breakwater layout.

[1] Note that, during the demonstration project, the breakwaters were constructed without excavation of a flotation channel.

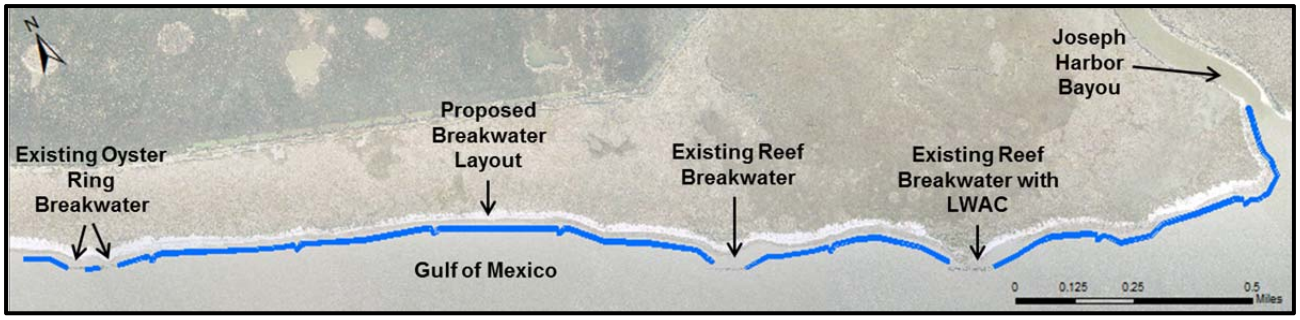

Figure 5-1 Breakwater layout.

Due to the higher rates of erosion experienced near the mouth of Joseph Harbor Bayou, the breakwater will extend from the inner mouth of Joseph Harbor Bayou to approximately three miles west. Locating the east end of the breakwater within the inner mouth of Joseph Harbor Bayou will help reduce erosion and flanking of the breakwater, and help maintain the current location and configuration of the mouth of the inlet.

Breakwater Design

Figure 5-2 provides a typical cross-section of the proposed breakwater. The material used for the core is a lightweight shale or clay aggregate that is nearly neutrally buoyant. The lightweight material will be encapsulated in high-strength geotextile containers to provide a lighter core for the structure than if rock is used. Figure 5-3 shows an example of geotextile containers as they are being filled with the lightweight material. By decreasing the bearing pressure, the LWAC allows greater crest elevation and increased wave attenuation.

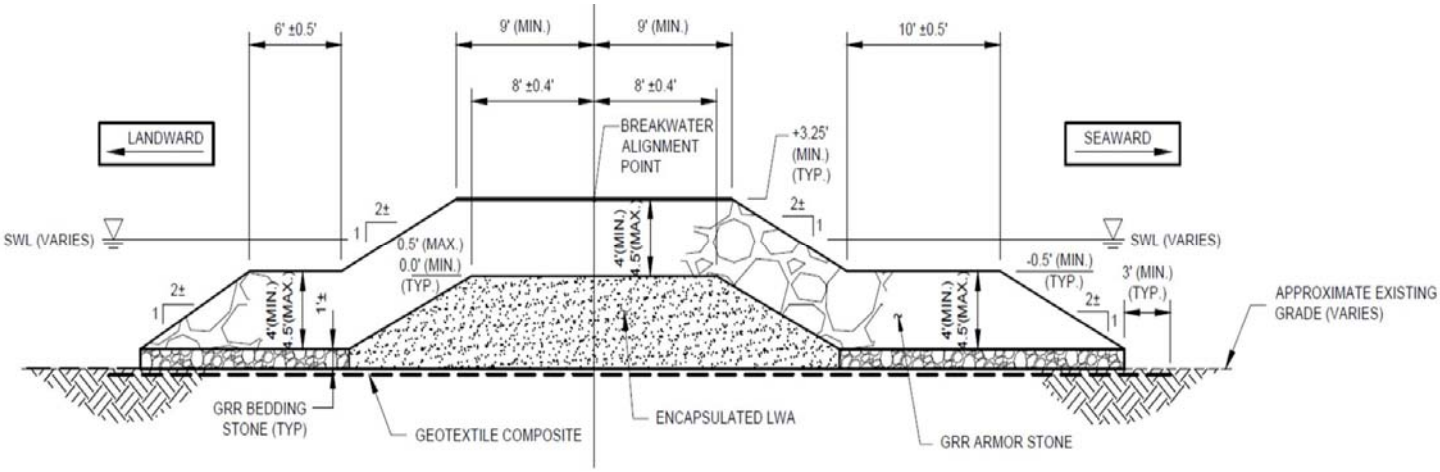

Figure 5-2 Typical section - Reef Breakwater with LWAC.

During the demonstration phase, a layer of bedding stone was placed on top of the LWAC to act as a barrier, protecting the geotextile containers within the core from potential damage by the

larger armor stones. During construction of the demonstration phase, the bedding stone shifted between the geotextile containers, resulting in a larger volume of bedding stone being utilized than anticipated. In an effort to reduce the volume of stone imported to the site, as well as reduce the corresponding cost, the bedding layer on the LWAC was omitted from the current design. Alternative methods (e.g. utilizing stronger geotextile fabric containers, adding protective shroud, etc.) for reducing damage to the geotextile containers continue to be assessed and will be determined prior to final design.

Figure 5-3 Geotextile containers being filled with Lightweight Aggregate.

The LWAC will be capped with armor stone conforming to a standard 1,000 lb Riprap Class gradation in accordance with the Louisiana Department of Transportation and Development's Standard Specifications for Roads and Bridges (2006). The armor stone was sized using the methodology of van der Meer for statically-stable submerged breakwaters as described in CUR Report 169 (Centre for Civil Engineering Research and Codes 1995). The stone stability analysis resulted in a required median stone weight of approximately 1,040 lbs. The stability calculations were based on a stone unit weight (based on apparent density) of 155 lb/ft^3, which is the minimum anticipated for most commercial sources that commonly provide limestone to the Gulf coast. The 1,000 lb Riprap Class allows a median stone size ranging from 1,000 lbs to approximately 2,000 lbs and a maximum stone size of 5,000 lbs as shown in Table 5.1 .

Table 5.1 Recommended riprap gradation: 1,000 LB Riprap Class.	
Stone Size, lb	**Percent of Stone Smaller Than**
5,000	100
2,000	45-100
1,000	10-50
300	0-15

A 12-in thick bedding layer will be included to help prevent damage to the underlying geotextile layer during placement of the stone as well as help further distribute the loads of the individual armor stones. The bedding layer will not be included under the LWAC. A toe has been included in the breakwater section to help combat scour at the base of the breakwater. A geotextile composite, including a geotextile fabric and geogrid, will be placed beneath the entire section of the structure to further help evenly distribute the load of the structure on the underlying soft soils.

As with all structures that reflect some wave energy rather than completely dissipating it, localized scour on the seaward side of the structure may occur. The scour potential on mud seafloors is particularly high, but accurate scour prediction methods for cohesive soils do not exist. Lowering the wave reflection and minimizing the down-rushing water jet, which occurs as a wave trough approaches the structure, from impacting the foundation sediments are practical methods to help reduce the potential for scour. The toe of the breakwater has been configured to help reduce scour during most conditions; however, severe storms such as hurricanes may cause some scour damage.

5.3 Numerical Modeling

As discussed in Section 1.3, a recommendation from the demonstration project was to construct a relatively continuous structure to help reduce the magnitude of differential settlement and end scour. To prevent the breakwater from becoming an impediment to the ingress and egress of marine organisms between the shoreline and the Gulf, small breakwater gaps will be constructed. In addition to providing a passage for marine organisms, the gaps will also allow more direct seaward flow of ground (surface) water runoff from inland areas, and help to maintain tidal conveyance. A key consideration in the design of the breakwater gaps is potential wave transmission that could continue to erode the Refuge shoreline. The MIKE21 Spectral Wave (MIKE21 SW) software (DHI 2008) was used to model three alternative breakwater gap configurations. The effects of the alternative configurations on the wave field and overall wave attenuation were compared and a preferred alternative was chosen. The MIKE21 Flow Model Hydrodynamic Module Flexible Mesh (MIKE21 HD) software was then applied to model the entire length of the project to determine the hydrodynamic effects at these gaps.

MIKE21 Spectral Wave Analysis

For analysis of wave propagation through the breakwater gaps, a numerical model was developed with the MIKE21 SW (DHI 2008) software. The model was applied for relative comparison of wave attenuation for the three breakwater gap alternatives, one of which was chosen as preferred and is shown in Figure 5-4.

Input

Table 5.2 lists four cases having different wave conditions and breakwater crest elevations that were modeled for each alternative. Both the anticipated breakwater elevations at construction and the elevations after the breakwater settled for 20 years were modeled. Two wave conditions were modeled. The first condition was run with a representative daily wave height of 0.8 ft determined by averaging the monthly average wave heights during the post-construction monitoring period from the demonstration project. The second wave condition represents a larger wave of 3.2 ft that may be experienced at the site, modeled as the maximum wave height recorded during the monitoring period. Each of these wave heights was applied in the model at various angles of approach in 5 degree increments from parallel to the shoreline from the west to parallel to the shoreline from the east.

Table 5.2 Conditions modeled in MIKE21 SW

Case	Breakwater Elevation[1]	Wave Conditions			Wave Direction
		Wave Height, H_{mo}	Wave Period, T_p	Description	
Case 1	Initial Crest Elevation	0.8 ft (0.24 m)	5.7 sec	Day-to-Day	160° to 250°, increments of 5°
Case 2	Initial Crest Elevation	3.2 ft (0.98 m)	13.4 sec	Maximum	
Case 3	Approx. Crest Elevation After 20 years	0.8 ft (0.24 m)	5.7 sec	Day-to-Day	
Case 4	Approx. Crest Elevation After 20 years	3.2 ft (0.98 m)	13.4 sec	Maximum	

Notes:
1. Wave conditions were obtained from the Offshore DCP during post-construction monitoring. The Offshore DCP was installed in a water depth of approximately 14-ft, located approx. 3,350 ft offshore.

Output

Figure 5-5 shows the results from the wave model for Case 4 with waves approaching perpendicular to the shoreline. The preferred alternative tends to transmit the least amount of wave energy of the three alternatives and is the preferred alternative after comparing the quantities of construction material necessary, as well as the corresponding costs.

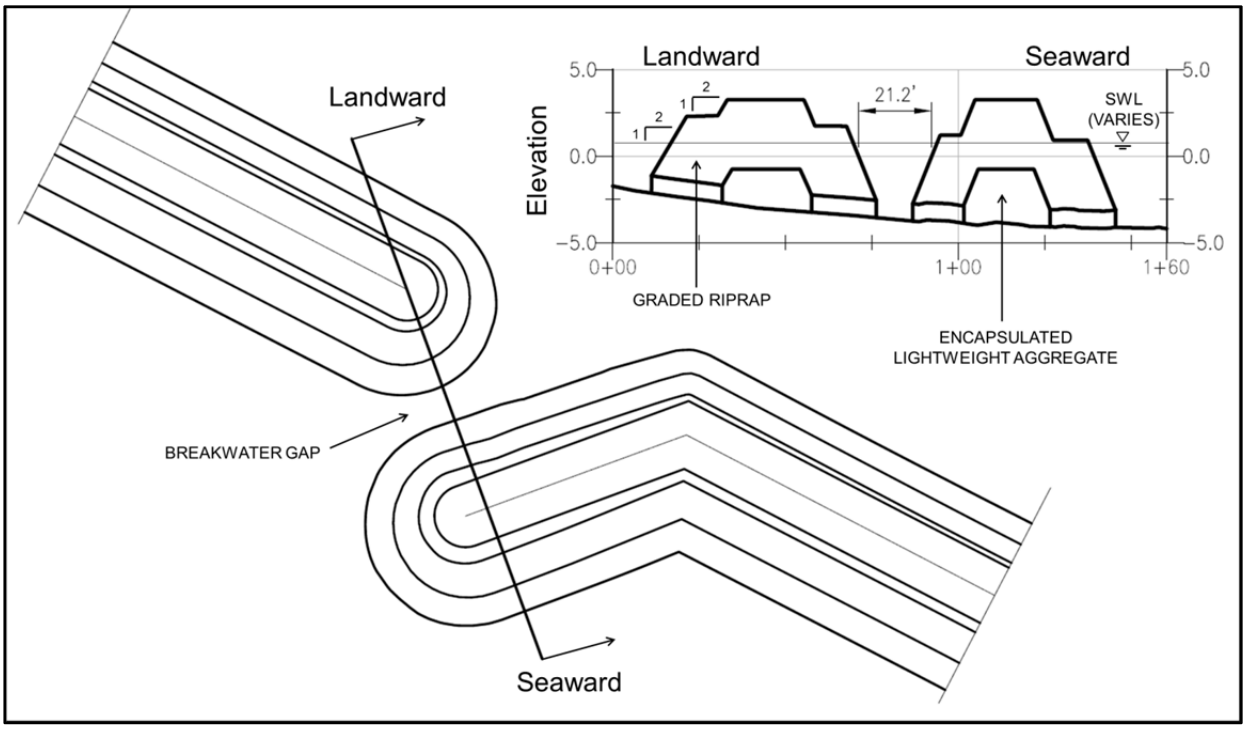

Figure 5-4 Breakwater gap schematic.

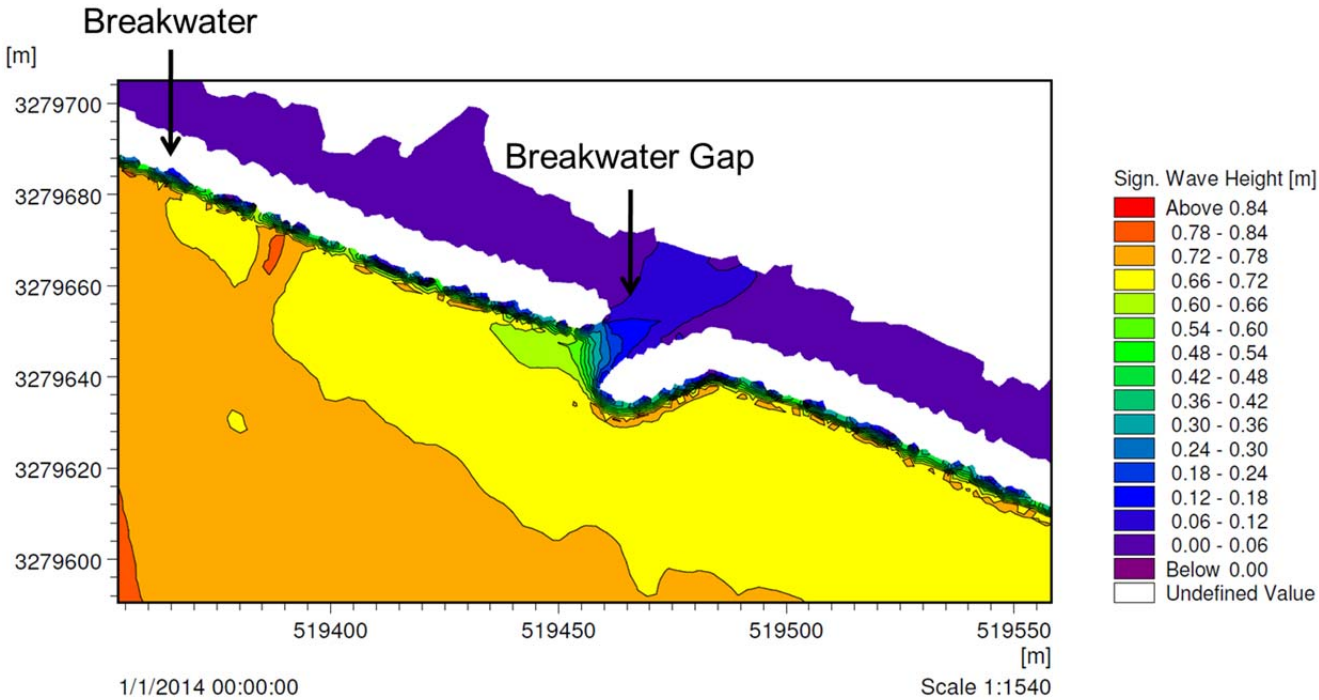

Figure 5-5 Wave model example output for preferred breakwater gap alternative analysis.

MIKE21 Flow Model Hydrodynamic Module Analysis

A numerical model was developed using the MIKE21 HD (DHI 2008) software to determine tidal variations and current velocities within and surrounding the breakwater gaps, both landward and seaward. These results were applied to determine stone stability for scour protection around the toes. The bedding stone layer beneath the breakwater will be continued across the bottom of the breakwater gaps to provide additional protection to these areas using a median stone size, D_{n50}, calculated for optimum stone stability.

Input

Typical daily tides measured during the post construction monitoring were applied to the model and are shown in Figure 5-6. The time series covered one week of data at 30-minute increments beginning August 1, 2010 and ending August 8, 2010. Water levels ranged from approximately -1.20 feet to 1.95 feet. The tide along the Louisiana coast is mixed, meaning that both semi-diurnal and diurnal signals are present, but the diurnal component is typically dominant.

The calculated current speeds and water depths were then applied to several stone stability analysis methods to determine a suitable bedding stone size within the breakwater gaps to help prevent scouring around the breakwater toes.

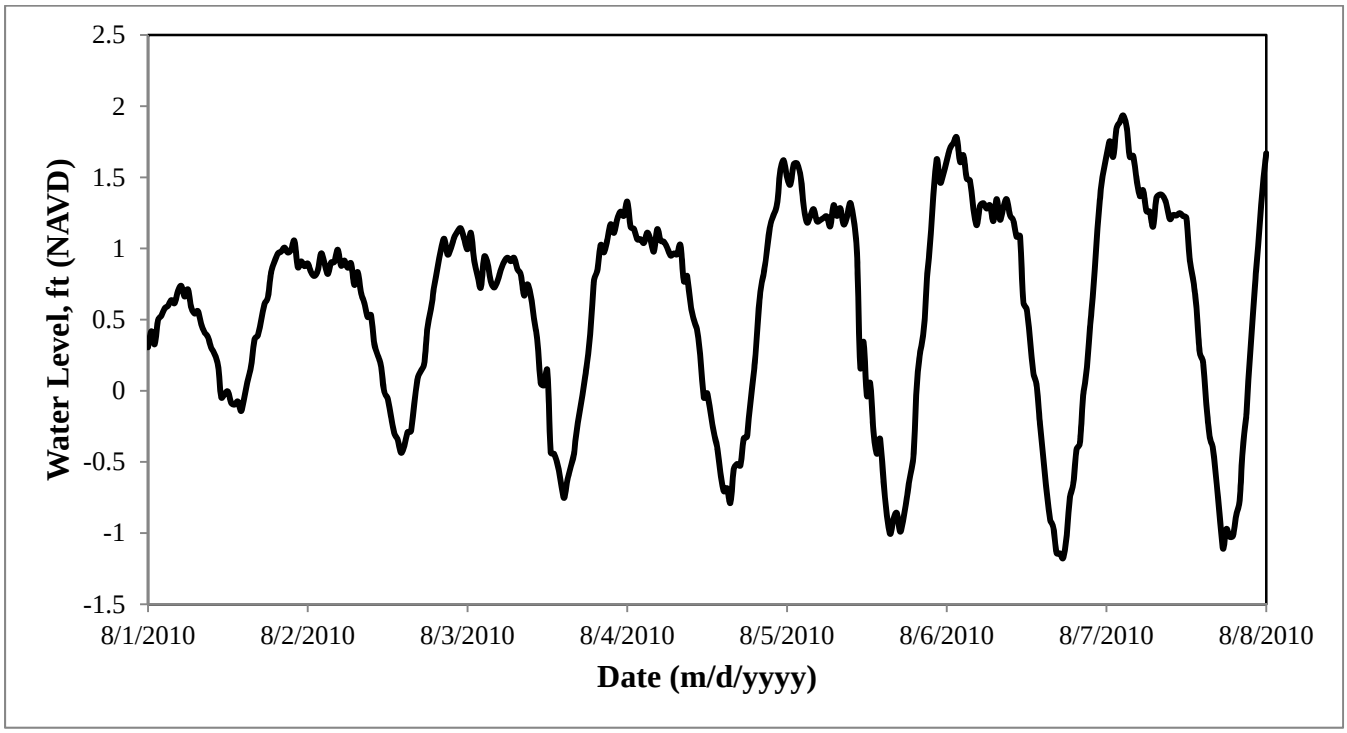

Figure 5-6 Typical water levels collected during post construction monitoring.

Output

Figure 5-8 shows the predicted percent exceedance of current speeds found at points surrounding a representative breakwater gap, as depicted in Figure 5-7. As shown in Figure 5-8, the current speeds are not expected to surpass approximately 1.8 feet/second with 90% of the average current speed values below approximately 0.3 ft/s. Figure 5-9 shows an example of the hydrodynamic model results, including velocity vectors to display the circulation allowed through the breakwater gaps.

For conservatism, the largest isolated current speed and water depth found, 4.1 ft/s and 3.9 ft, were applied to analyze stone stability and determine a median stone size, D_{n50}, for scour protection. Several methods were analyzed for calculating an appropriate D_{n50}, but CEM VI-5 equation VI-5-131 yielded the most realistic results. A minimum D_{n50} of 0.1 feet was calculated as a stable stone layer within the breakwater gaps. Because this value is less than the 0.4 feet D_{n50} of the design bedding stone for the entire breakwater, the design bedding stone is expected to protect the toes from anticipated scouring and will be continued into the breakwater gaps.

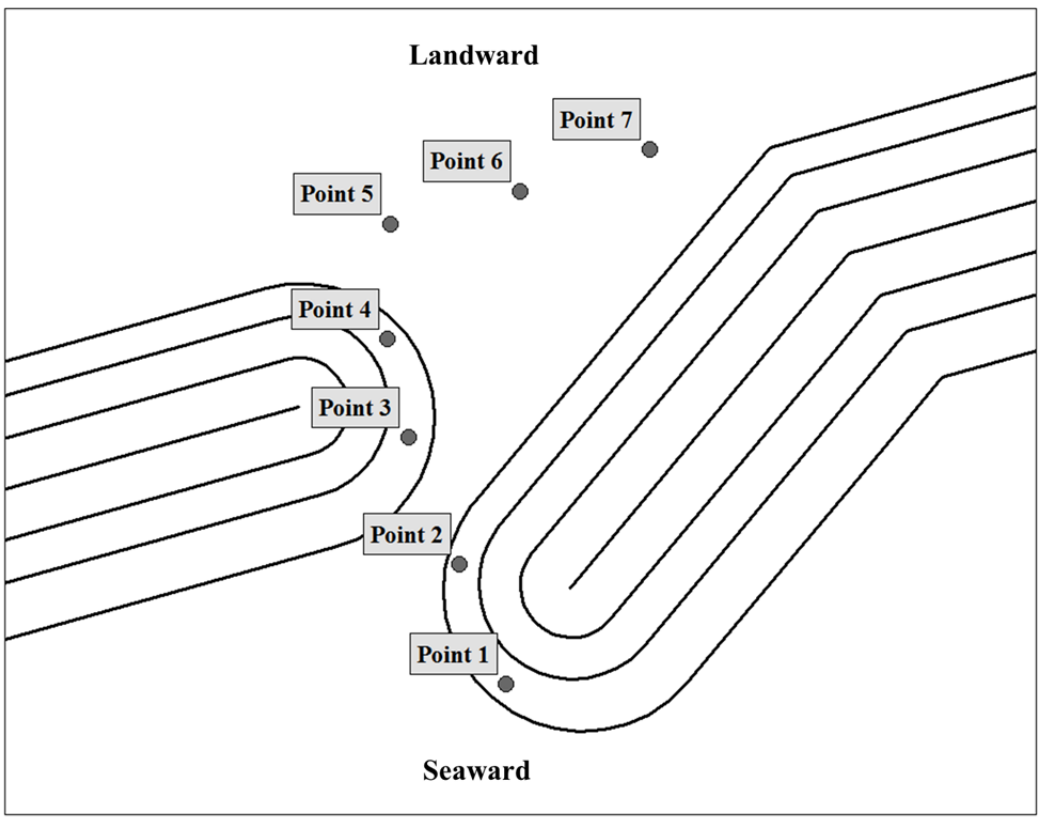

Figure 5-7 Schematic of analyzed breakwater gap points.

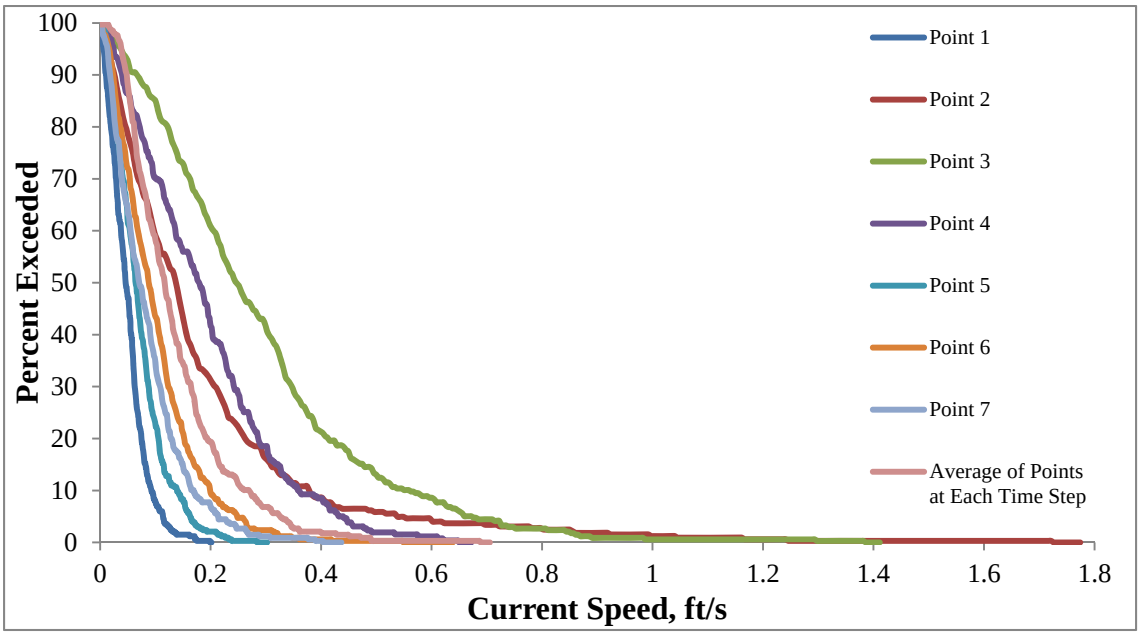

Figure 5-8 Percent exceedance curve of current speed at analyzed breakwater gap points.

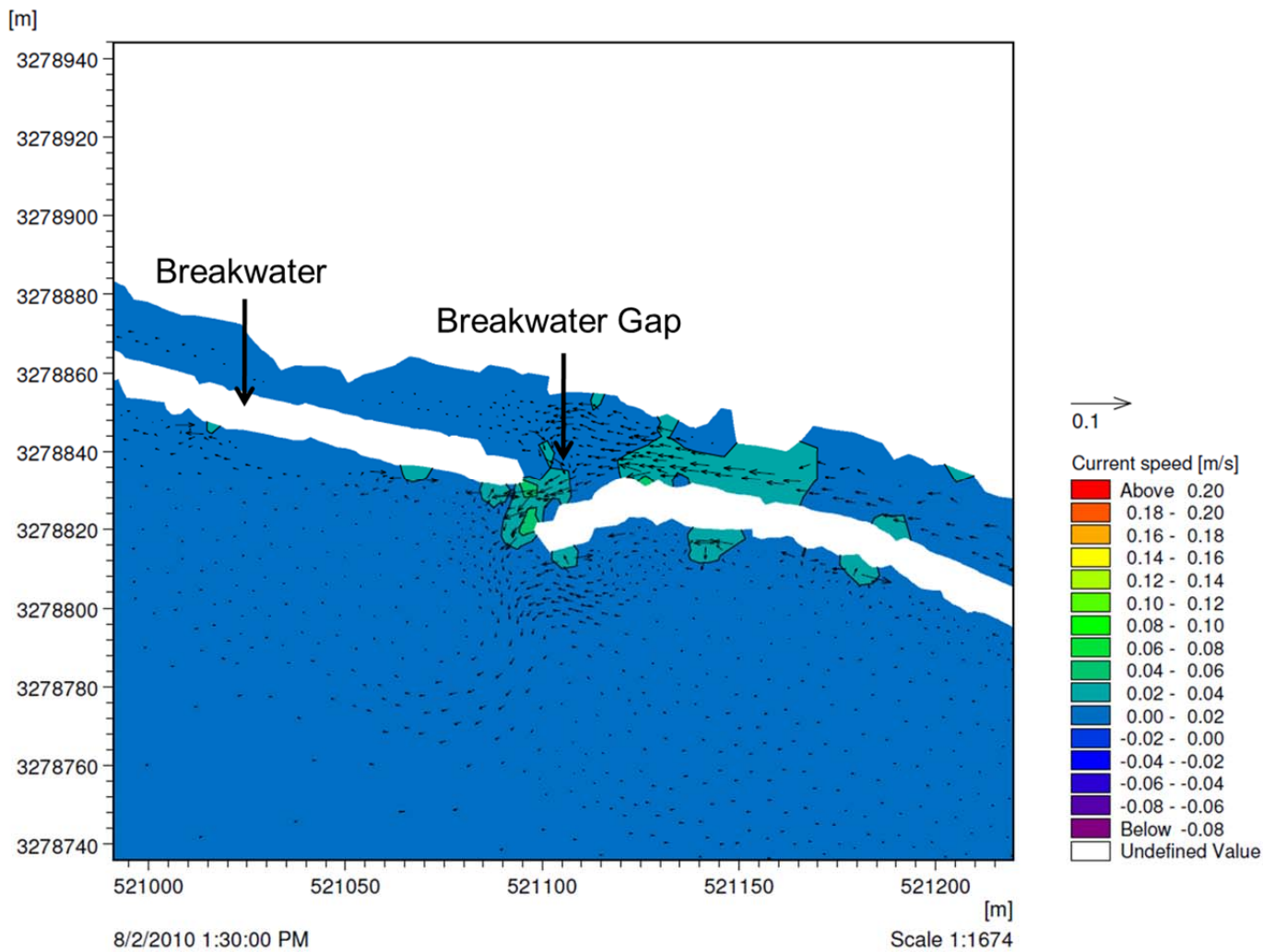

Figure 5-9 Hydrodynamic model example output for preferred breakwater gap alternative analysis.

5.4 Constructability

Lessons learned from construction of the demonstration project and other similar breakwater projects will be applied to the current design. Due to the very soft soils at the site, during construction it will be important for the drop height of the stone be minimized, to the extent practicable, during placement on prepared subgrades to help reduce lateral soil displacements and any potential mud waving. In addition, it is recommended that the entire breakwater be constructed in relatively uniform lifts; differences in height of more than about 0.5 to 1 foot during construction should be avoided to reduce the likelihood of slope or base failures.

The cross-section of the reef breakwater with LWAC is relatively complex and will require prefabrication of the containers for the LWAC. Based on previous projects, after the contractor becomes familiar and adept with these extra steps (typically within a few weeks), the rate of construction significantly improves. Figure 5-10 shows construction of the Biloxi Marsh Shoreline Protection (PO-72) in Lake Borgne where the construction contractor utilized multiple equipment barges to place the various layers of materials in the required sequence. The anticipated time of completion for the proposed project layout is approximately 600 days based on these previous similar projects.

Figure 5-10 Construction of Biloxi Marsh Shoreline Protection (PO-72).

As with any marine project, delays may occur due to inclement weather, which may impact the project schedule. Weather will not only have direct impacts on the times the construction contractor can perform the work, but also on the transportation of materials to the site. Depending on the location of the rock quarry, a combination of rail, trucking, and/or barge transport may be used to deliver the quarrystone to the project region, although it is anticipated that the majority of materials will be delivered to the project site via barge. Barges carrying material and equipment will likely access Joseph Harbor Bayou from Mermentau River, a distance of approximately 14 miles, or from Freshwater Bayou, a distance of approximately 30 miles. The construction contractor should be given enough flexibility with the schedule to allow for the potentially long delays due to working and transporting equipment and materials in the open Gulf.

Because it will not be feasible (or permitted) for the construction contractor to access the project site by land, or work from land, construction of the project will be performed entirely from floating equipment. To accommodate the draft of work vessels and barges, an optional flotation channel will be included in the project layout parallel to the breakwater. It is recommended that the flotation channel be at least 80 ft wide and approximately 7 ft deep to accommodate the dimensions of expected equipment and material barges. The flotation channel should be close enough to the breakwater so that construction equipment can reach the entire breakwater footprint; however, if the flotation channel is too close, it may cause the breakwater foundation to become unstable. Material excavated from the flotation channel should be side-cast into a temporarily stockpile seaward of the flotation channel as shown in Figure 5-11. To allow safe and proper navigation through the channel at Joseph Harbor, the temporary stockpile will end before entering the channel, and a separate stockpile will be located to the east of Joseph Harbor. This is expected to prevent conflicts with navigation that may occur if the stockpile is allowed to enter the channel. Upon project completion, the material will be backfilled into the flotation channel, although it is anticipated that some of the material will be displaced from wave action.

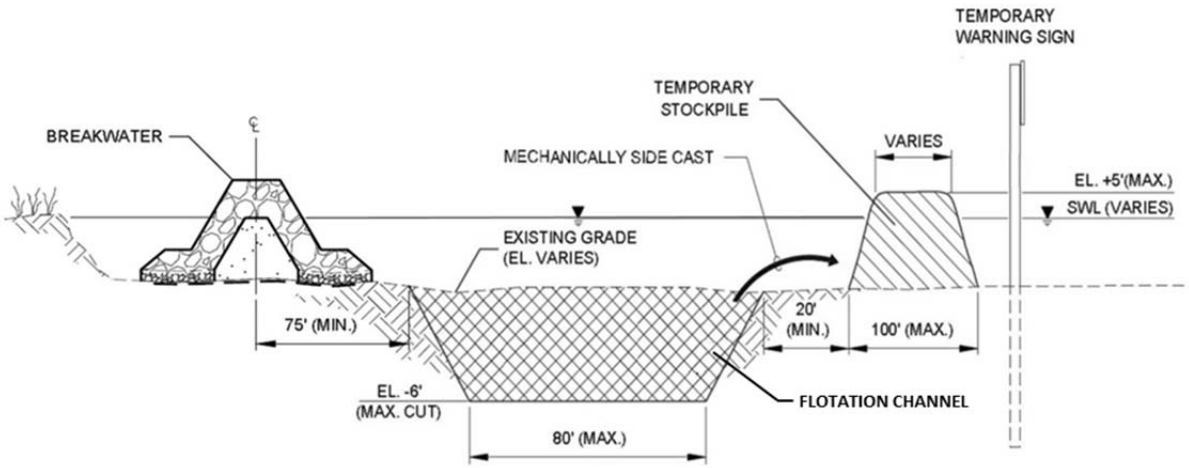

Figure 5-11 Typical section – Temporary flotation channel and stockpile.

5.5 Opinion of Probable Construction Cost

An opinion of probable construction cost was developed for the reef breakwater with LWAC design. Costs of materials such as quarrystone, lightweight aggregate encapsulated in geotextile materials, geotextiles, etc. were discussed with a number of construction contractors who have performed similar work along the Gulf coast, particularly in Louisiana. In addition, bids for previous similar projects, such as the Biloxi Marsh Shoreline Protection (PO-72), were reviewed.

Significant differences of the ME-18 project compared to other similar projects that will likely increase cost include (1) exposure to open Gulf conditions, (2) a larger gradation requirement which is more difficult to produce and handle, and (3) long travel distances, including travel within the open Gulf, to import materials. These factors, among others, may contribute to

increases in rock costs by up to $20-$30/ton as compared to similar projects. For the proposed alignment and cross-sections shown in the attached 95% drawings, the breakwater is expected to average approximately $1,900/LF.

Based on the current preliminary design, the total cost of the project is estimated to be approximately $27,496,560. A detailed breakdown of the opinion of probable cost is shown in Appendix A.

6.0 SUMMARY AND RECOMMENDATIONS

The Rockefeller Wildlife Refuge in Cameron Parish, LA is currently experiencing erosion rates in excess of 40 ft per year along the Gulf of Mexico shoreline. The State of Louisiana's CPRA along with NMFS are currently implementing the Rockefeller Refuge Gulf Shoreline Stabilization Project (ME-18) to assist in the protection of 3 miles of shoreline along the Refuge.

The 95% preliminary design carries forward work performed as part of a prior demonstration project and monitoring effort, and involves the engineering and design for construction of up to 3 miles of the original 9.2-mile project area. Additional insights obtained as a result of the monitoring effort were applied for updated analyses of geotechnical and wave conditions, shoreline change, breakwater spacing and alignment, constructability, and cost.

Without shoreline protection, the 3-mile project length could experience approximately 340 acres of erosion over the anticipated 20-year lifespan of the project. The selected method of shoreline stabilization is a reef breakwater with LWAC. The LWAC is expected to allow for construction of a higher crest elevation, thereby improving wave attenuation. The breakwater will be constructed continuously (with small gaps) from the mouth of Joseph Harbor Bayou to the west approximately 3 miles. Anticipated pre- and post-settlement crest elevations over the 20 year design life of the reef breakwater are +3.25 ft (NAVD '88) and approximately +1.9 ft, respectively.

As the project is constructed the shoreline is expected to continue to erode, changing its shape and location. Staged review of the alignment will be necessary to ensure that the breakwater continues to follow the -3.5 ft contour, approximately 150 ft offshore. A breakwater gap design has been developed and evaluated for improved circulation of water and marine life around the breakwater segments.

After performing a geotechnical analysis, staged construction was suggested to raise the rock breakwater at one foot per year for three years and the oyster breakwater at one foot per year for four years to meet minimum desired crest elevations. However, this would not be cost-effective, and due to the large gradation of the armor stone, it may be difficult to accurately place one-foot fills each year. Incorporating the existing structures without additional fill into the current design is expected to provide adequate shoreline protection.

An opinion of probable construction cost was developed for the recommended reef breakwater with LWAC design. Based on review of previous projects and on the current preliminary design, it is estimated the project can extend from the mouth of Joseph Harbor Bayou to approximately three miles west for a construction cost of $27,496,560.

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APPENDIX A

Preliminary Opinion of Probable Construction Cost

STATE OF LOUISIANA
COASTAL PROTECTION AND RESTORATION AUTHORITY
ROCKEFELLER REFUGE GULF SHORELINE STABILIZATION (ME-18)
PRELIMINARY (95%) OPINION OF PROBABLE CONSTRUCTION COST

BASE BID[1]

	ITEM	QUANTITY	UNIT	UNIT PRICE	EXTENSION	CUMULATIVE TOTAL
1.1	Mobilization/Demobilization[3]	1	LS	$ 620,000	$ 620,000	
1.2	Topographic and Bathymetric Surveying	1	LS	$ 178,100	$ 178,100	
1.3	Pre-Construction Hazard Survey	1	LS	$ 21,400	$ 21,400	
1.4	Acceptance Aerial Photograph	1	LS	$ 10,700	$ 10,700	
1.5	Geotextile Composite	90,000	SY	$ 12	$ 1,080,000	
1.6	Bedding Layer Stone	18,700	TONS	$ 65	$ 1,215,500	
1.7	Armor Stone[4]	122,500	TONS	$ 75	$ 9,187,500	
1.8	Encapsulated Lightweight Aggregate[4]	27,700	CY	$ 155	$ 4,293,500	
1.9	Settlement Plates	12	EA	$ 3,500	$ 42,000	
1.10	Lighted Daybeacons	8	EA	$ 5,600	$ 44,800	
			CONTINGENCIES (15%):		$ 2,504,030	
					$ 19,197,530	**$ 19,197,530**

ADD. ALT #1[2]

	ITEM	QUANTITY	UNIT	UNIT PRICE	EXTENSION	CUMULATIVE TOTAL
2.1	Topographic and Bathymetric Surveying	1	LS	$ 44,500	$ 44,500	
2.2	Pre-Construction Hazard Survey	1	LS	$ 5,300	$ 5,300	
2.3	Acceptance Aerial Photograph	1	LS	$ 2,700	$ 2,700	
2.4	Geotextile Composite	22,300	SY	$ 12	$ 267,600	
2.5	Bedding Layer Stone	5,300	TONS	$ 65	$ 344,500	
2.6	Armor Stone[4]	34,000	TONS	$ 75	$ 2,550,000	
2.7	Encapsulated Lightweight Aggregate[4]	7,000	CY	$ 155	$ 1,085,000	
2.8	Settlement Plates	2	EA	$ 3,500	$ 7,000	
2.9	Lighted Daybeacons	2	EA	$ 5,600	$ 11,200	
			CONTINGENCIES (15%):		$ 647,670	
					$ 4,965,470	**$ 24,163,000**

ADD ALT. #2[2]

	ITEM	QUANTITY	UNIT	UNIT PRICE	EXTENSION	CUMULATIVE TOTAL
3.1	Topographic and Bathymetric Surveying	1	LS	$ 27,350	$ 27,350	
3.2	Pre-Construction Hazard Survey	1	LS	$ 3,300	$ 3,300	
3.3	Acceptance Aerial Photograph	1	LS	$ 1,600	$ 1,600	
3.4	Geotextile Composite	13,700	SY	$ 12	$ 164,400	
3.5	Bedding Layer Stone	3,400	TONS	$ 65	$ 221,000	
3.6	Armor Stone[4]	22,300	TONS	$ 75	$ 1,672,500	
3.7	Encapsulated Lightweight Aggregate[4]	3,200	CY	$ 155	$ 496,000	
3.8	Settlement Plates	2	EA	$ 3,500	$ 7,000	
3.9	Lighted Daybeacons	1	EA	$ 5,600	$ 5,600	
			CONTINGENCIES (15%):		$ 389,810	
					$ 2,988,560	**$ 27,151,560**

ITEM	QUANTITY	UNIT	UNIT PRICE	EXTENSION	CUMULATIVE TOTAL
Allowance for Additional Material at Existing Structures[9]	1	LS	$ 300,000	$ 300,000	
		CONTINGENCIES (15%):		$ 45,000	
				$ 345,000	**$ 27,496,560**

Notes:

1. Base Bid consists of 9830 LF of breakwater for a total project length of approximately 2.0 mi (including breakwater gaps).
2. Additive Alternate No. 1 breakwater consists of 2720 LF of breakwater for a total additional project length of approximately 0.5 mi (including breakwater gaps). Additive Alternate 2 breakwater consists of 1790 LF of breakwater for a total additional project length of approximately 0.3 mi (including breakwater gaps).
3. Costs for excavation and backfilling of Access and Flotation Channels (approx. 30,000 cy) are included within Modibilization/Demobilization bid item. Temporary warning signs are considered subsidiary to Access and Flotation Channels cost. It is assumed that temporary warning signs will be reused as work progresses.
4. The quantities of armor stone and LWA represent maximum GRR thickness and maximum LWA elevations.
5. This opinion of probable construction cost is based on data available at the date of publication and is not necessarily all inclusive. Actual construction costs may vary based on market conditions at time of bidding.
6. Quantities and unit prices are based on approximate in-place dimensions.
7. Costs associated with land acquisition, if required, are not included.
8. Allowance for additional material at existing structures is for an approximately 1 foot layer of armor stone on the existing oyster ring breakwaters and rubble mound breakwater.

APPENDIX B

Land Ownership Investigation

(Provided by CPRA)

Exhibit A

Rockefeller Refuge Gulf Shoreline Stabilization
ME-18
Cameron Parish, La

Legend

- Breakwater
- Temporary Flotation Channel
- Temporary Dredge Spoil Placement
- Pipelines
- Township/Range
- Section Lines

Owner

- Cameron Parish School Board
- Rockefeller Wildlife Refuge
- State-claimed Waterbottoms

All project features are graphical representations only, are subject to change, and may not reflect true location or dimension

1:22,000

Kilometers: 0 0.125 0.25 0.5

Miles: 0 0.125 0.25 0.5

N

Source:
Coastal Protection and Restoration Authority of Louisiana
Imagery: 2013 NAIP DOQQ
Map Date: April 23, 2014
//2014040178

APPENDIX C

Preliminary Cultural Resources Assessment

(Provided by NMFS)

Preliminary Cultural Resources Review for Rockefeller Refuge Shoreline Protection ME-18, 2014

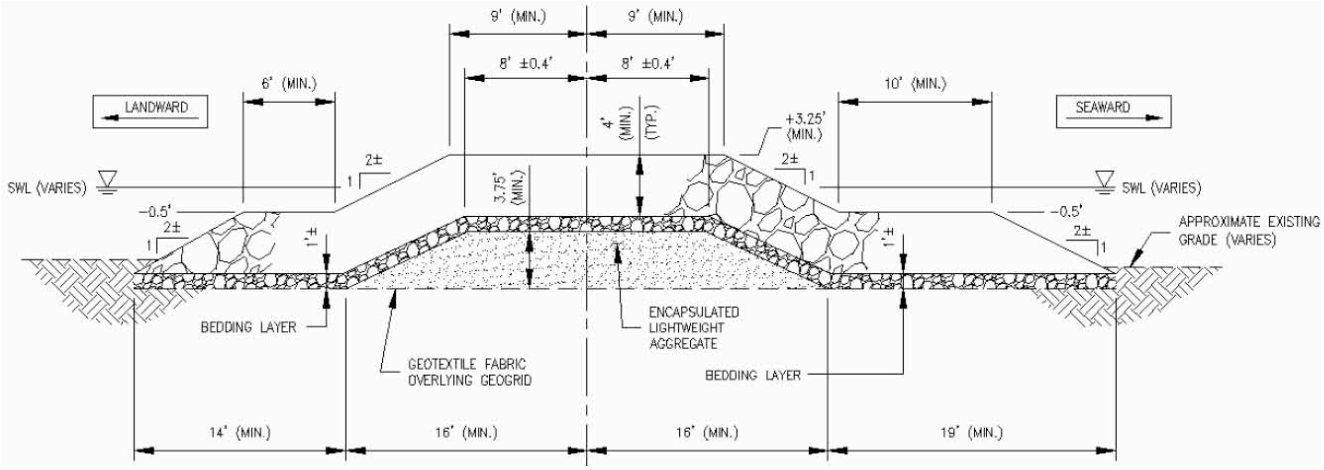
The NOAA Fisheries Service in partnership with the State of Louisiana through the Coastal Wetland Planning and Protection Act (CWPPRA) propose continuation of shoreline protection at Rockefeller Refuge, Cameron Parish, Louisiana. The proposed action is the continuation of the Rockefeller Refuge Shoreline Protection Project initiated by the CWPPRA, and considered in a 2006 environmental assessment (EA) prepared by Fenstermaker. The 2006 EA analysis of these resources is provided below. The determination remains the same. Changes that have occurred since the EA involve the continued erosion of the shoreline into the previously existing marsh.

…Archeological features consist of several known shell middens on or near the refuge and a shipwreck site. The Nuevo Constante, a Spanish merchant ship, foundered in 19 ft of water some 1,600 ft off the coast near what is now the Rockefeller Refuge in 1766 (http://www.crt.state.la.us/archaeology/nuevo/hist). Archaeologists, under contract to the State of Louisiana, mapped and catalogued the wreck in 1981. They also searched the shore for the shipwreck survivors' camp, which had been extensively documented. They found a few historic artifacts. It appeared, however, that waves had washed it on shore. No other evidence of the survivors' camp was found. Maps show that the shoreline in this area has eroded about 4,600 ft since 1766 and it is assumed that erosion destroyed the site of the camp (Fenstermaker 2006).

In the 2006 EA, the preferred alternative was the construction of test sections of the build alternatives for assessment in the challenging environmental conditions at the location. The State of Louisiana, through the Coastal Impact Assistance Program, funded construction of the test sections, including a test of the proposed action, and measured results of shoreline erosion abatement in 2012 as shown on Figure 1.

The original goals were to halt gulf shoreline retreat and direct marsh loss from Beach Prong to Joseph Harbor (9.2 miles). Of the original 80 considered alternatives, the reef breakwater with lightweight aggregate (LWA) was most promising for erosion abatement, and thus has been selected for continuation. The reduction in shoreline retreat and a view of the reef breakwater is viewable on 2013 photography (Figure 1). This option was analyzed as Alternative 4 in the 2006 EA, quoted below.

Alternative 4 [below] would consist of constructing a reef breakwater with a LWA core replacing the rock core of the structure. The LWA is an encapsulated lightweight expanded shale or clay product that is almost neutrally buoyant, decreasing the bearing pressure and allowing greater crest elevations and increased wave attenuation. The greater crest elevation is intended to eliminate the need for secondary protection via beach fill as provided in the previous reef breakwater alternative (Alternative 3). A secondary benefit of the LWA core is lower permeability and less wave transmission through the structure, although armor stone stability may decrease with decreased permeability. This alternative would also be installed along the entire 9.2 miles of the project (Fentermaker 2006).



Source: Fentermaker 2006

The currently proposed activity is similar in intent and location to the original proposal. Construction of the proposed breakwater is expected to benefit 198 acres of marsh during the 20-year project life. The proposed action would enable near-shore waters to shallow, and natural vegetation to colonize landward of the proposed structure. The structures will be staggered to maintain material and organism linkages.

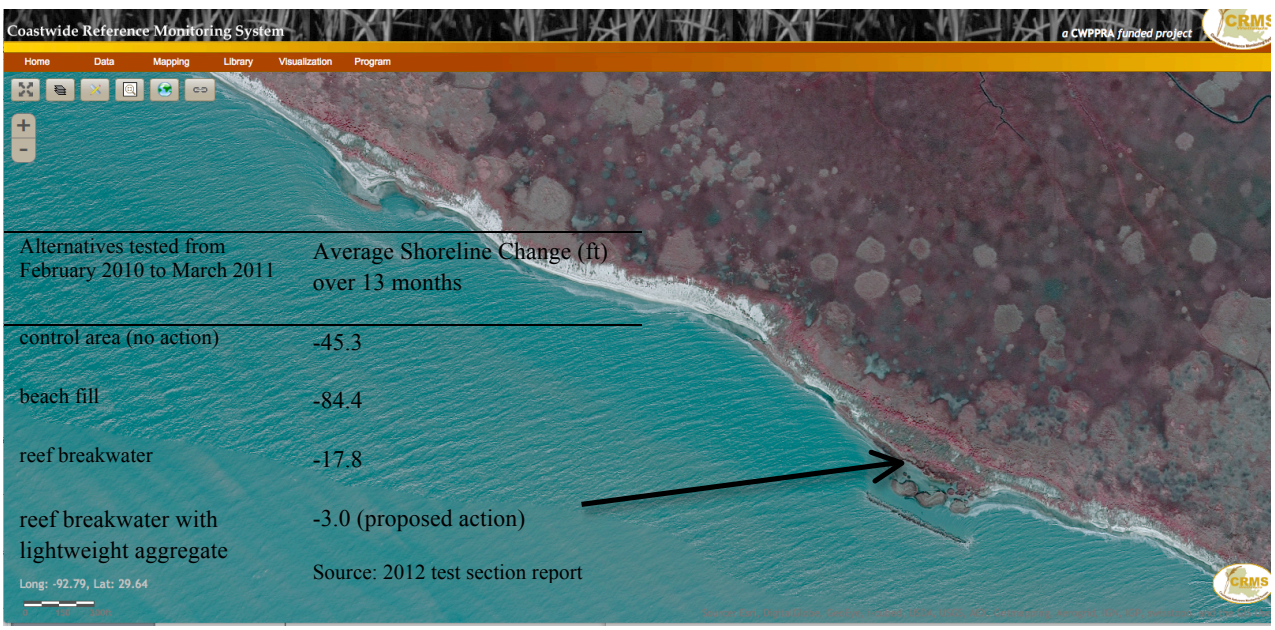


Figure 1. Existing structure and proposed extension of shoreline protection in Cameron Parish, Louisiana

The State of Louisiana Division of Archaeology records were reviewed April 23, 2014 for historic cultural resources. The proposed project is located within the Big Constance Quadrange along the shoreline of Rockefeller State Wildlife Refuge. Records indicate four sites along the shore of the refuge east of the proposed activity, as shown in Figure 2. The sites are listed as16CM114, 16CM150, 16CM151, and 16CM152. Shoreline erosion in 2004, ten years ago, had reached the sites. The record for 16CM114 indicates it is not eligible for the State or national register because "no insitu deposits remain" in response to the shoreline erosion that has occurred. The reference for this site is #22-2696, the 2004 Southwest Region annual report, and # 22-0972, the 1984 Cultural Resource Survey of a Proposed Boathouse and Bulkhead on Prien Lake, in Lake Charles, Louisiana.

Sites 16CM150, 16CM151, and 16CM152 are also referenced in the #22-2696. Sites 16CM150 and 16CM152 have a determination for historical register database as "ineligible."

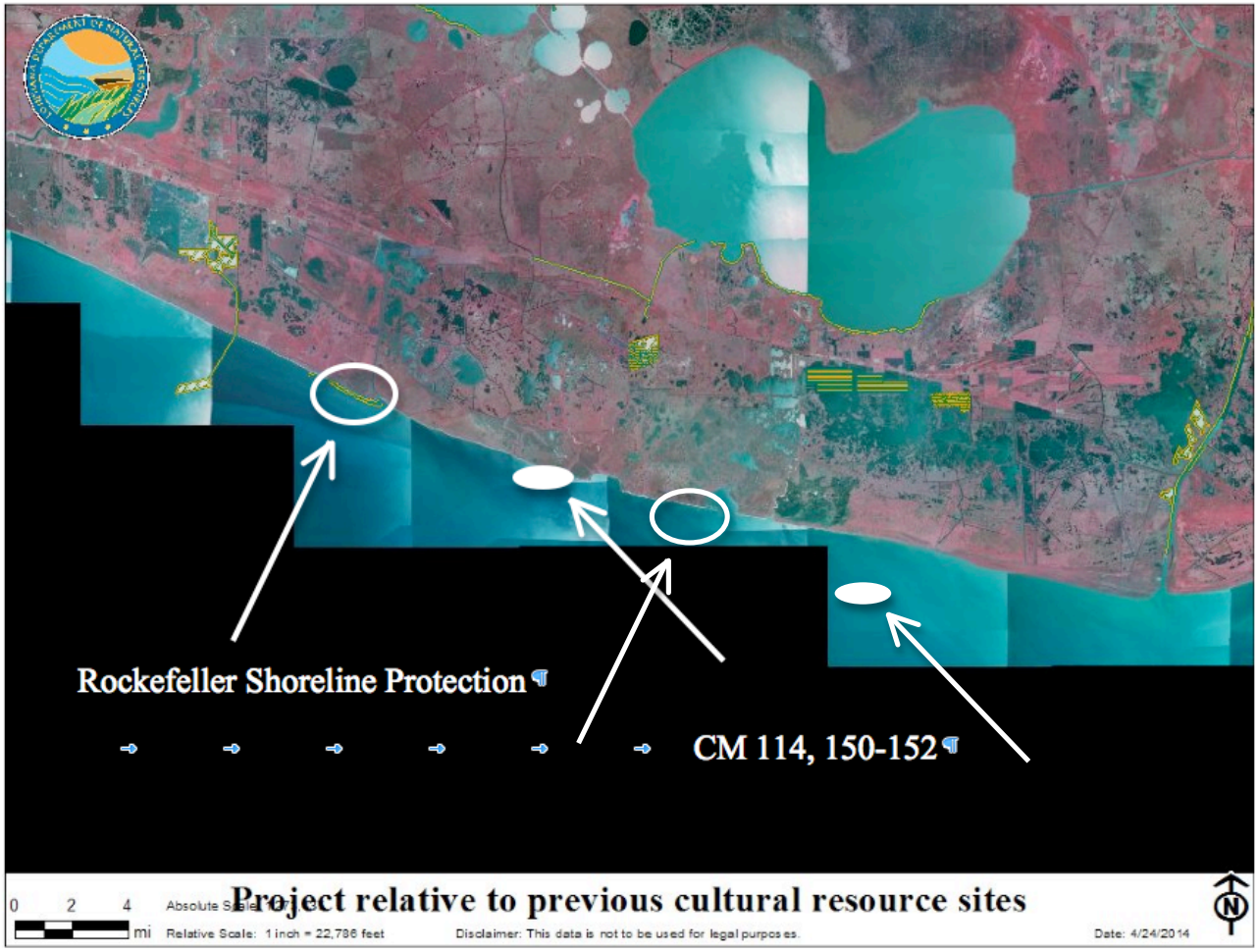


Figure 2. Current shoreline test sections and proposed extension for Rockefeller Shoreline Protection (ME-18) and archeology sites in Cameron Parish, Louisiana.

As covered in the Report # 22-2696, *the Southwest Regional Archaeology Program at the University of Louisiana at Lafayette undertook programs in public outreach, survey and planning during the 2003/2004 grant year. As a result of these activities, 37 acres were surveyed, 18 new sites recorded, and 12 sites updated. Significant site evaluation this year was concentrated on the analysis and reporting of the Gold Mine site (16RI13). This site was excavated in 1978-1980 by a vocational and professional archaeologists but a complete report on the excavation was never completed. This site represents a mortuary ossuary dating to 1123BP (AD 825) and is a significant site for understaing Troyville - Coles Creek period culture history in Louisiana. This project was undertaken as part of an effort to update and refine the Louisiana Comprehensive Archaeological Plan. The site is recommended eligible for nomination to the National Register of Historic Places under Criterion Nine. Public outreach efforts resulted in contacts with three landowners and 37 other individuals. Twenty-eight presentations and site tours were given to a total audience of 733 people. One article was published in a peer-reviewed journal (Southeastern Archaeology) and three articles were published in the Louisiana Archaeological Society Newsletter. Consultation and*

technical assistance was provided to one federal agency, one federally recognized Indian tribe, five city/state agencies, and nine private firms and organizations.

Report # 22-0972 states, *A cultural resource survey of a proposed boathouse and bulkhead on Prien Lake in Lake Charles was conducted by Joseph Frank* [in 1984]. *Pedestrian survey, with subsurface testing, of the area in and around proposed boathouse was done. An auguring program used in three locations encountered a shell midden approximately 5cm beneath the surface (16CM114). Considering no cultural resources were discovered at the proposed boat house, there is no basis for determinations of significance, there will be to impact with construction.*

Determination

Due to the location of the proposed project in the nearshore waters of the eroding coast, construction in shallow water, and expected shoreline protection, it is unlikely that cultural resources would be adversely affected. Materials that have been collected from this location are "redeposited beach deposits." Burial of any existing or future deposits is possible from the placement of lightweight aggregate and any accumulated sediments.

APPENDIX D

Revised Cost Information

(Provided by CPRA)

Project:	Rockefeller Refuge Gulf Shoreline Stabilization ME-18	Date:	6-Aug-14	Revised:	9-Sep-14
Computed by:	Julia Wall	*Project Priority List 10*	*(ver.072414)*		
Item No.	**Work or Material**	**Quantity**	**Unit**	**Unit Cost**	**Amount**
1	Mobilization/Demobilization	1	LS	$620,400	$620,400
2	Shoreline Protection (Armor Stone)	178,800	ton	$75.00	$13,410,000
3	Lighted Daybeacons	11	each	$5,600.00	$61,600
4	Settlement Plates	16	each	$3,500.00	$56,000
5	Geotextile Composite	126,000	SY	$12.00	$1,512,000
6	Bedding Layer Stone	27,400	ton	$65.00	$1,781,000
7	Encapsulated Lightweight Aggregate	37,900	CY	$155.00	$5,874,500
8	Allowance for Addional Materials at Existing Structures				$300,000
9	Construction Surveys	1	LS	$294,950.00	$294,950

*Cost inludes Base Bid, Alt 1, and Alt 2

ESTIMATED CONSTRUCTION COST **$23,910,450**

ESTIMATED CONSTRUCTION + 15% CONTINGENCY **$27,497,018**

TOTAL ESTIMATED PROJECT COSTS

PHASE I

Federal Costs

Engineering and Design:

Engineering	$300,000			
Geotechnical Investigation				
Hydrologic Modeling				
Data Collection (incl ….)	$100,000			
Cultural Resources	$20,000			
			SubTotal:	$420,000

			SELECT	USE
Supervision and Administration (includes NEPA Compliance)			NMFS	$45,000
Corps Administration				$3,300

State Costs

Supervision and Administration (including PM, ecological review and engineering review - ADD $$$ if modeling review required)				$25,000
Easements and Land Rights				
Oyster **Seed** Ground in Project area/Borrow area (Yes/No) (No - if have Lease)	No	Assessment	$0	
Oyster **Lease** in Project area/Borrow area (Yes/No)	No	Survey	$0	
		Appraisal	$0	
Land Rights		$3,000		
			SubTotal:	$3,000

Monitoring				
Monitoring Plan Development	$5,000			
			SubTotal:	$5,000

* *Monitoring is now done through CRMS except on projects that an agency requests project specific monitoring and projects such as Barrier Island projects and Demo projects.*

Total Phase I Cost Estimate: **$501,300**

PHASE II

Federal Costs

Estimated Construction Cost +25% Contingency		$27,497,018		
Oyster Issues (# of **Impacted** Acres)	0 ACR	$0		
			SubTotal:	$27,497,018
Supervision and Inspection	712 days @	$1,952.00	per day (10 hrs)	$1,389,824
Supervision and Administration				$45,000
Corps Administration - reconcile Project First Costs				$816
Engineering update for shelved Projects:				$0

State Costs

Supervision and Administration	$25,000
Total Phase II Cost Estimate:	**$28,957,658**

TOTAL ESTIMATED PROJECT FIRST COST **$29,458,958**

Rockefeller Refuge Gulf Shoreline Stabilization ME-18
Operation & Maintenance and Monitoring
Project Priority List 10 (ver.072414)

O&M Cost Considerations:

Annual Costs:

	Federal	State	TOTAL
Annual Inspections	$3,400	$7,400	**$10,800**
Annual Cost for Operations	$0	$0	**$0**
Preventive Maintenance	$0	$0	**$0**

Specific Intermittent Costs:

Construction Items	Unit	Quantity	Unit Cost	Year 1	Year 3	Year 6	Year 8	Year 9	Year 10	Year 13	Year 15	Year 16	Year 20	Total
Contractor Mob/Demob	each	1	$10,000.00				$10,000			$10,000				
Lighted Daybeacons Maintenance	each	1	$15,000.00				$15,000			$15,000				
		Subtotal		$0	$0	$0	$25,000	$0	$0	$25,000	$0	$0	$0	
		Subtotal w/ 25% contingency		***$0***	***$0***	***$0***	***$31,250***	***$0***	***$0***	***$31,250***	***$0***	***$0***	***$0***	$ 62,500.00
Monitoring Items (State costs placed in separate "monitoring" acct)														
Monitoring Management	each	1	$6,400	$6,400	$6,400	$6,400	$6,400	$6,400	$6,400	$6,400	$6,400	$6,400	$6,400	64000
Data Analysis and Report	each	1	$15,000		$15,000	$15,000		$15,000				$15,000	$15,000	
Aerial Photography	each	1	$7,500											
		Subtotal	***$22,500***	***$6,400***	***$21,400***	***$21,400***	***$6,400***	***$21,400***	***$6,400***	***$6,400***	***$6,400***	***$21,400***	***$21,400***	$139,000
State Costs														
Engineering Monitoring							$10,000			$10,000				
Engineering and Design Cost				$719	$2,113	$2,113	$2,972	$2,113	$719	$2,972	$719	$2,113	$2,113	
Administrative Cost				$384	$1,284	$1,284	$2,859	$1,284	$384	$2,859	$384	$1,284	$1,284	$ 13,290.00
Topo/Bathy Elevation Survey														
11 days @ $3,755 per day				$41,305	$41,305		$41,305				$41,305		$41,305	
Shoreline Mapping				$5,600	$5,600		$5,600				$5,600		$5,600	$28,000
		Subtotal		***$48,008***	***$50,302***	***$3,397***	***$62,736***	***$3,397***	***$1,103***	***$15,831***	***$48,008***	***$3,397***	***$50,302***	$ 286,481
		Subtotal with 25% contingency		***$60,010***	***$62,878***	***$4,246***	***$78,420***	***$4,246***	***$1,379***	***$19,789***	***$60,010***	***$4,246***	***$62,878***	$ 358,101
Federal Costs														
Administrative Cost				$3,264	$4,302	$1,488	$9,015	$1,488	$450	$8,209	$3,264	$1,488	$4,302	
			Total	***$69,674***	***$88,580***	***$27,134***	***$125,085***	***$27,134***	***$8,229***	***$65,648***	***$69,674***	***$27,134***	***$88,580***	$596,871

Annual / General Project Costs:

Corps Administration	**$1,225**	**annually,**	**PLUS add**	**$1,020**	**in year 20**
YR20 Close Out Report	**$20,000**	**in year 20**			
Monitoring *	**$0**				

*CRMS is not applicable for monitoring in shoreline protection projects

Construction Schedule:

Planning & Design Start	**June-13**
Planning & Design End	**December-14**
Const. Start	**April-16**
Const. End	**March-18**

*(Minimum of two years to complete this phase, **unless** modeling is required)*

(Constr Funding approval in Jan., requires 6 months for contracting and advertising plus 2 months for cost share agreement)

Rockefeller Refuge Gulf Shoreline Stabilization ME-18

Project Priority List 10 (ver.072414) **9-Sep-14**

Performance Time

Task Name	Duration	Start	Finish	Predecessors
Construction NTP	0 days	4/1/2016	4/1/2016	
Mobilization	30 days	4/11/2016	5/10/2016	1FS+10 days
Initial Surveys/Hazard Surveys	7 days	4/15/2016	4/21/2016	1FS+14 days
Flotation Channel Dredging	14 days	5/11/2016	5/24/2016	2
Breakwater Construction	600 days	5/25/2016	1/14/2018	4
Backfill Flotation Channel	14 days	1/15/2018	1/28/2018	5
Final Surveys	14 days	1/15/2018	1/28/2018	5
Demobilization	30 days	2/12/2018	3/13/2018	7FS+14 days
			Total Days:	**712**

APPENDIX E

Description of Changes from Phase 0 Approval

(Provided by NMFS)

Description of changes from Phase 0 Approval

Project Background

- Project funded originally through CWPPRA on PPL 10
- 84 different shoreline protection designs were evaluated
- Project surveys and geotechnical sampling was conducted over entire 9.2 mile project
- Due to challenging soil conditions at site, a demonstration project was implemented
- Construction and monitoring of demonstration project funded through CIAP

Demonstration Design

- Design criteria
  - Prevent erosion for up to Category 1 hurricane conditions (estimated return period of about 10 years)
  - Where practicable, the shore protection alternative should remain stable for more severe storm conditions up to a 100-year event.
- Alternatives analysis
  - Selected 3 of the most promising design alternatives of the 84 reviewed
  - Most alternatives did not meet design criteria or were too expensive
- Decided to construct a demonstration project first to assess preferred alternatives

Project Scope Change

- Beginning at the west bank of Joseph's Harbor Canal, construct 10,560 LF of near shore breakwater along the -4' contour westward.

- Plan view would reflect an offset configuration; i.e. every 1,500 LF the breakwater section would end, and the next section would begin at the same station, but offset by 30'.

- Construction Cost + 15% = $24.71M TY20 Gross Acres = 223 TY20 Net Acres = 198

Current Design

- Beginning at the west bank of Joseph's Harbor Canal, construct up to 15,840 LF of near shore breakwater along the -3.5' contour westward to incorporate test sections and LA-08 project features.

- Plan view reflects an offset configuration every 1,500 LF.

- Construction Cost + 15% = $28.15M TY20 Gross Acres = 334 TY20 Net Acres = 297

APPENDIX F

Potential Oyster Lease Impacts

(Provided by CPRA)

Rooney, Erin

From: Jennifer Shortess <Jennifer.Shortess@la.gov>
Sent: Tuesday, April 29, 2014 3:19 PM
To: Rooney, Erin; Geesey, Brett
Cc: Julia Wall; John D. Foret - NOAA/NMFS/SEFSC/EHCFC (john.foret@noaa.gov); Garvin Pittman; Brian Boeneke
Subject: FW: Rockefeller - ME-18
Attachments: Rockefeller Shoreline.pdf

Erin,
Please see the information below and attachment for item no. 11 – oyster lease information.

Thanks,
Jennifer R. Shortess
CPRA – Engineering Division

From: Brian Boeneke
Sent: Tuesday, April 29, 2014 1:40 PM
To: john.foret@noaa.gov
Cc: Jennifer Shortess; Garvin Pittman
Subject: FW: Rockefeller

See below and attached to support the oyster lease requirement for the 30% design for ME-18.

Thanks.

B. Keith Boeneke, PMP
CPRA – Contractor
CWPPRA Project Manager
Office: 225-987-7471
Cell: 225-931-8212 (preferred)
Brian.boeneke@la.gov

From: James Wray
Sent: Wednesday, April 16, 2014 10:45 AM
To: Garvin Pittman
Subject: Rockefeller

There are no oyster leases in the vicinity of the project.

James Wray
Land Specialist III
O.L.A.C.P.
Real Estate and Land Division
Coastal Protection and Restoration Authority
P.O. Box 44027
450 Laurel Street, 12th Floor
Baton Rouge, LA 70804-4027

Telephone: (225) 342-7329
Fax: (225) 242-3311
email: james.wray@la.gov

Confidentiality Notice and Request

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Flotation Channel
Breakwater
Stockpile
Rockefeller Shoreline Stabilization

APPENDIX G

Response to 30% Design Meeting Comments

APPENDIX G

Response to 30% Design Meeting Comments

This appendix provides responses to comments on the Rockefeller Refuge Gulf Shoreline Stabilization Project (ME-18) 30% Design presented in April 2014.

Information Needed to Prepare Wetland Value Assessment (WVA)

1. *The area of project effect needs to be determined. This may include only the area immediately adjacent to the proposed breakwater although indirect effects should be addressed (will there be up-drift accretion or increased down drift erosion?).*

   Response:
   The surrounding shoreline is expected to continue to erode at average rates. Based on the demonstration project, no measurable increase or decrease in erosion is expected to occur outside of the project area when compared to the current average erosion rate.

2. *Provide information regarding anticipated benefits. Changes in shoreline erosion rates should be estimated for anticipated FWP conditions. The following questions are likely to emerge as the project moves forward through re-evaluation by the WGs:*
   a. *What is the basis for the proposed reduction in erosion rate?*
   b. *How are storm/synoptic events considered in projected FWP shoreline erosion rates?*
   c. *Is the rate anticipated to be steady state over the 20 year period, or are changes anticipated?*
   d. *How will structure settlement from 3.25 ft to 1.9 ft affect erosion rates?*
   e. *Is RSLR incorporated into water level exceedance estimates? If so, what rates are used?*
   f. *Is the estimated exceedance interval of <20% still water only?*
   g. *How will overtopping change over time as the structure settles and SLR occurs?*
   h. *Verify if the settlement and water level exceedance of <20% of the time at TY20 incorporated RSLR.*
   i. *If we are to add in storm events to the analysis, we would need to figure how many and what target years to include. Although it has been brought up that erosion rates are not higher on storm years than non-storm years so that would need to be also looked at someway.*

   Response:
   a. The reduction in erosion rate was measured during the post-construction monitoring phase of the ME-18 demonstration project.
   b. According to Rockefeller Wildlife Refuge manager, major storm events do not cause significant shoreline erosion in the project area because the elevated water levels due to storm surge dampen the wave effects. More typical storms with high wave energy and low storm surge cause the preponderance of the erosion forces.

c. Without shoreline protection, the average erosion rate is anticipated to continue at approximately 46 ft/yr.
d. The project is designed to protect the shoreline with a breakwater crest elevation of +1.9 ft. Therefore, erosion rates are not expected to change after settlement.
e. Water level exceedance rates presented in the design report are based directly off water level data collected and do not incorporate RSLR.
f. The estimated water level exceedance of <20% factors is still water only.
g. The project is designed to protect the shoreline with a breakwater crest elevation of +1.9 ft. Therefore, although overtopping rates may increase due to settling, they are not expected to exceed the threshold for erosion. In addition, the wide crest of the breakwater is designed to dissipate overtopping energy as it transmits across the crest, decreasing the potential for erosion.
h. Consideration for RSLR was incorporated in design of the demonstration project, which has now become part of the proposed design.
i. Because major storm events do not cause significant shoreline erosion in the project area, adding storm events to the analysis would not be necessary. In addition, these storms are viewed as relatively random with low probabilities, so estimating how many and specifying target years may prove difficult.

3. *Project area survey data is of course important for V4 variable. Coordination and completion of this information is important to allow for adequate to time review data for shallow and deep open water evaluation.*

   Response:
   Additional survey data has been received and included in the 95% design report.

Engineering/Performance Comments

1. *Request an Engineering opinion on long term performance given synoptic storm events, annual background rates, and RSLR.*

   Response:
   A wind rose and wave rose for the project site were created to determine site conditions. These site conditions were incorporated into the design and modeling of the breakwater.

2. *Note the proposed structure elevation differs from the demonstration project; is it anticipated the performance would also differ?*

   Response:
   The results from the demonstration project were considered and included in the design of the proposed project.

3. *If cross section of the breakwater is changed from 30 to 95%, suggest an updated performance projection or an engineering opinion on effect on performance be provided.*

Response:
The cross-section of the breakwater has not been changed from 30 to 95%.

4. *The potential value of stair step on the back of the breakwater to address toe trenching with water returning seaward during routine overtopping was briefly mentioned and discussed. Toe trenching and ultimate undermining/slump failure non-CWPPRA rock at ETI (admitting it is an unlike comparison) was also discussed. Attached is a picture of the CWPPRA ETI revetment rock. The same occurred with the non-CWPPRA ETI breakwater rock.*

   Response:
   Modeling results suggest velocities seaward of the breakwater and within the gaps are relatively small and are not expected to cause compromising trenching or scour. These results can be viewed in the 95% design report.

5. *To prepare for questions anticipated during 95% and WG review: was a slope analysis was done to determine the offset of the borrow from the breakwater assuming none of the borrow is backfilled? Did the performance projections assume the slope of the flotation canal (without backfilling) is translated onto the breakwater during the project life.*

   Response:
   A geotechnical slope stability analysis was performed to analyze the potential influence of the flotation channel on the breakwater. The flotation channel is outside the area of effect of the breakwater; therefore impacts to the breakwater stability are not anticipated if the channel is not backfilled.

6. *If reach constraints allow, disposal of flotation material behind the breakwater is an option.*

   Response:
   This has been noted. As the project progresses, the possibility of depositing material behind the breakwater will be considered.

7. *How will flotation, access and dredge disposal/reach be addressed for the gaps?*

   Response:
   The updated alignment of the flotation channels and temporary stockpiles follows the breakwater shape, including the breakwater gaps. This alignment can be viewed in the 95% design plans.

8. *Depth of cut for flotation was minimal (i.e., skimming) in some reaches and less than what a bucket may grab. Insight might be gained from Raccoon or Holly Beach on need to make flotation a pay item.*

   Response:
   Flotation dredging has been added as a part of mobilization/demobilization costs.

Cost Estimate Comments

1. *Rock quantity should cover the maximum breakwater height plus any construction vertical tolerance needed to include cost for signage.*

   Response:
   Rock quantity covers the maximum breakwater height plus construction vertical tolerances.

APPENDIX H

NRCS Overgrazing Determination

(Provided by NMFS)

USDA
United States Department of Agriculture

August 19, 2014

Mr. John D. Foret
National Oceanic and Atmospheric Administration
Estuarine Habitats & Coastal Fisheries Center
646 Cajundome Boulevard
Lafayette, Louisiana 70508

Dear Mr. Foret:

RE: Rockefeller Refuge Gulf Shoreline Stabilization Project (ME-18)

I am in receipt of your request for an overgrazing determination for the Rockefeller Refuge Gulf Shoreline Stabilization Project (ME-18). I contacted our local district conservationist and our state grazing land specialist to discuss the grazing in the project area. Currently, livestock are not grazing in the area, nor do we see a potential for grazing once the project is installed. Therefore, it is our opinion, overgrazing is not a problem in this project area. If you have any questions please let me know.

Sincerely,

W. Britt Paul
Assistant State Conservationist/Water Resources

Cc: (electronic distribution only)
Randolph Joseph, Assistant State Conservationist/Field Operations, Lafayette, Louisiana
Frank Chapman, District Conservationist, Lake Charles, Louisiana
John Jurgensen, Civil Engineer, Alexandria, Louisiana
Johanna Pate, State Grazing Land Specialist, Alexandria, Louisiana

Natural Resources Conservation Service
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APPENDIX I

Response to 95% Design Meeting Comments

APPENDIX I

Response to 95% Design Meeting Comments

This appendix provides responses to comments on the Rockefeller Refuge Gulf Shoreline Stabilization Project (ME-18) 95% Design presented in October 2014.

Engineering/Performance Comments

1. *The second to last sentence on page 6, Section 2.0 implies that the magnetometer survey may have not been completed because the locations of pipelines are not known.*

   Response: The sentence on page 6 is referring to additional pipelines that may be identified by LDWF through anticipated LDWF map updates. A magnetometer survey was performed during design.

2. *The second bullet on page 21, Section 5.1 states that one key design requirement is that the project be "maintained" over a 20-year design life. Because maintenance does not appear to be in the cost estimate, we assume that the bullet refers to maintaining a target elevation for the project life without maintenance.*

   Response: The assumption mentioned is correct. The bullet refers to maintaining a target elevation for the project life without placement of additional riprap as maintenance.

3. *The first sentence on page 21, Section 5.2 states that the breakwater is planned to be constructed along the -3.5 ft depth contour. The reason stated further in the paragraph is to avoid draft limitations. Cost saving may result in placing the breakwater closer to shore (i.e., at the -2.5 ft depth contour), unless an access channel would be needed.*

   Response: The approximate location of the breakwater centerline along the -3.5 ft NAVD '88 contour was determined through consideration of construction equipment draft limitations as well as avoiding impacts to the current marsh shoreline.

4. *Breakwater gap velocity modeling predicts low water velocities would likely occur in the "gaps", likely not leading to shore erosion. We (U.S. Fish and Wildlife Service) support the placement of breakwater gaps for hydrology and aquatic organism access between the shoreline and the Gulf.*

   Response: This has been noted.

5. *Sentence 5, Page 31 of the design report states that access channel dredged material is to be temporarily stockpiled seaward should the channel be needed. It is recommended that since the breakwaters may be 100 to 150 feet Gulfward of the shoreline, that consideration be given to placing access channel material between the breakwater and the existing shoreline.*

Response: Placing material dredged from the access/flotation channels landward of the breakwater has been considered. Reach limitations of the anticipated dredging equipment likely prevents efficient placement of the dredged material and was not included in design.

6. *The O&M costs indicated in Appendix A are moderate primarily including the maintenance of lighted day beacons. We assume that the fully funded costs will include this level of O&M and not additional future rock maintenance. At a construction cost of $1,900 per linear foot or $9.2 million per miles, additional rock maintenance may increase the total cost significantly.*

   Response: The item "Allowance for Additional Material at Existing Structures" is not part of O&M costs. This item is intended as a contingency to place additional riprap material on top of the currently in-place demonstration segments (e.g. reef breakwater, reef breakwater with LWAC, and/or oyster ring breakwaters) if geotechnical conditions under these structures improve prior to construction. Placing additional riprap material as part of O&M for rock maintenance is currently not included in the design.

7. *The Monitoring Plan includes surveys at post-construction years 1, 3, 8, and 15 on page 5. Associated mapping is proposed in post-construction years 3, 6, 9, and 16. It is unclear what the year 6 report will be based on.*

   Response: Years 3, 6, and 9 follow the typical 3 year schedule for OM&M reports. Year 3 will include data from the As-built survey and year 1 data collection; the year 6 report will incorporate data from the year 3 data collection; and the year 9 report will incorporate data from year 8 data collection. The year 12 report was skipped because no new data will available. The year 16 report will incorporate data from year 15 data collection.

8. *In the, "Updated Geotechnical Analysis" section on page 11 of the design report it is stated that the, "reef breakwater and reef breakwater with LWAC settlements are 1.5 ft and 2.7 ft, resulting in the current average crest elevations of +-.4 ft and +2.9 ft, respectively". Apparently different design templates and crown heights were compared to derive that "breakwater with LWAC" was the selected design. It is unclear why the same tiered structure template was not used for both. Both appear to have a cross-sectional area of approximately 280 square feet, but the LWAC has a wider base grid to disperse the weight. With the long contract duration, the first rock tier to elevation 0.0 ft could be constructed over the entire length and capped to a higher elevation on a second pass; if that would provide any additional soil strengths. While not contesting the results, the more simplistic breakwater (if viable) would certainly be cheaper.*

   Response: Constructing the structure in lifts was considered in previous alternatives analyses, although the time required to consolidate the underlying soils to gain strength adequate to hold the additional material required to raise the breakwater to a sufficient elevation was deemed too long of a period (outside the anticipated construction period). The updated geotechnical analyses discussed in this section also considered placing

additional material onto existing structures, but the geotechnical results showed additional material placement would be infeasible as the underlying soils have still not gained adequate strength.

9. *The plan drawings mandate a geotextile shroud, which did not appear to make it to the bid sheet or specification requirements.*

   Response: The geotextile shroud is subsidiary to the Encapsulated Lightweight Aggregate bid items. The shroud is discussed in Specification TS-8 and noted on Sheet 11 of the Plans.

10. *Was a segmented breakwater system considered?*

    Response: Segmented breakwaters were considered. A segmented configuration typically performs well in sandy environments where a sand source is present as it replenishes the loss of sand between the structures. At Rockefeller Refuge, there is not a direct source of sand and the existing material is easily eroded. Gaps in the structure could cause increased erosion between the structures.

11. *What will the settlement be?*

    Response: After the 20 year lifespan, the crest elevation is expected to be approximately +1.9 ft NAVD '88.

12. *Is there an O&M plan?*

    Response: The current O&M plan includes maintenance of daybeacons and periodic monitoring surveys. Placement of additional riprap material is not included in the O&M plan.

13. *Would it be possible to add more material onto the existing structures?*

    Response: The current geotechnical conditions do not allow for placement of additional material, but eventually the soils may strengthen enough to allow placement of additional material on the existing structures.

14. *Is material being added to the oyster reef breakwaters?*

    Response: Adding or moving the oyster reefs was considered, although, due to the complexities and unknowns associated with the constructed features, it was decided to incorporate the structures into the current design.

15. *Would it be possible to receive a cheaper bid if the project were to be presented and/or constructed during the springtime where wave conditions and weather may be calmer?*

Response: Since the overall construction time will span approximately two years, during which inclement weather is a possibility as construction time will occur over multiple seasons, timing of the bid will not likely impact the project costs.

16. *Was an extension of the bedding material considered in the wave analysis?*

    Response: An extension in the bedding material was not considered. The numerical model results indicated minimal velocities within and around the breakwater gap. Based on those results, it does not seem necessary to extend the bedding material.

17. *Did waves coming from different directions result in higher velocities in the wave models?*

    Response: The wave direction within the numerical model was varied 180 degrees to review effects from multiple directions. A single location with higher velocity was recorded, although it is not expected to be a typical velocity. In addition, when the waves were angled directly into the breakwater gap, no significant velocities were recorded.

18. *What are the options if the bid comes in too high?*

    Response: The construction documents are set up with a base bid and two additive alternate bids. Should bids on the overall project come in higher than the budget; a reduced project can be awarded.