BA-171 Caminada Headland Back Barrier Marsh Creation Project

Coastal Wetland Planning, Protection, and Restoration Act PPL 23

95% Design Report

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1.0 INTRODUCTION

1.1 Authority

The Caminada Headland Back Barrier Marsh Creation Project (herein referred to as BA-171) is located in the Barataria Basin in the vicinity of Port Fourchon and Bay Champagne as shown in Figure 1. The Louisiana Coastal Wetlands Planning, Protection and Restoration Task Force designated BA-171 as part of the 23rd Priority Project List. The Environmental Protection Agency (EPA) was designated as the lead federal sponsor with funding approved through the Coastal Wetlands Planning, Protection and Restoration Act (CWPPRA) of 1990 by the United States Congress and the Wetlands Conservation Trust Fund by the State of Louisiana. The Louisiana Coastal Protection and Restoration Authority (CPRA) is serving as the local sponsor and will also be providing engineering and design services. The Project's Technical Consultant is Coastal Engineering Consultants, Inc. (CEC), Baton Rouge and Naples, Florida.

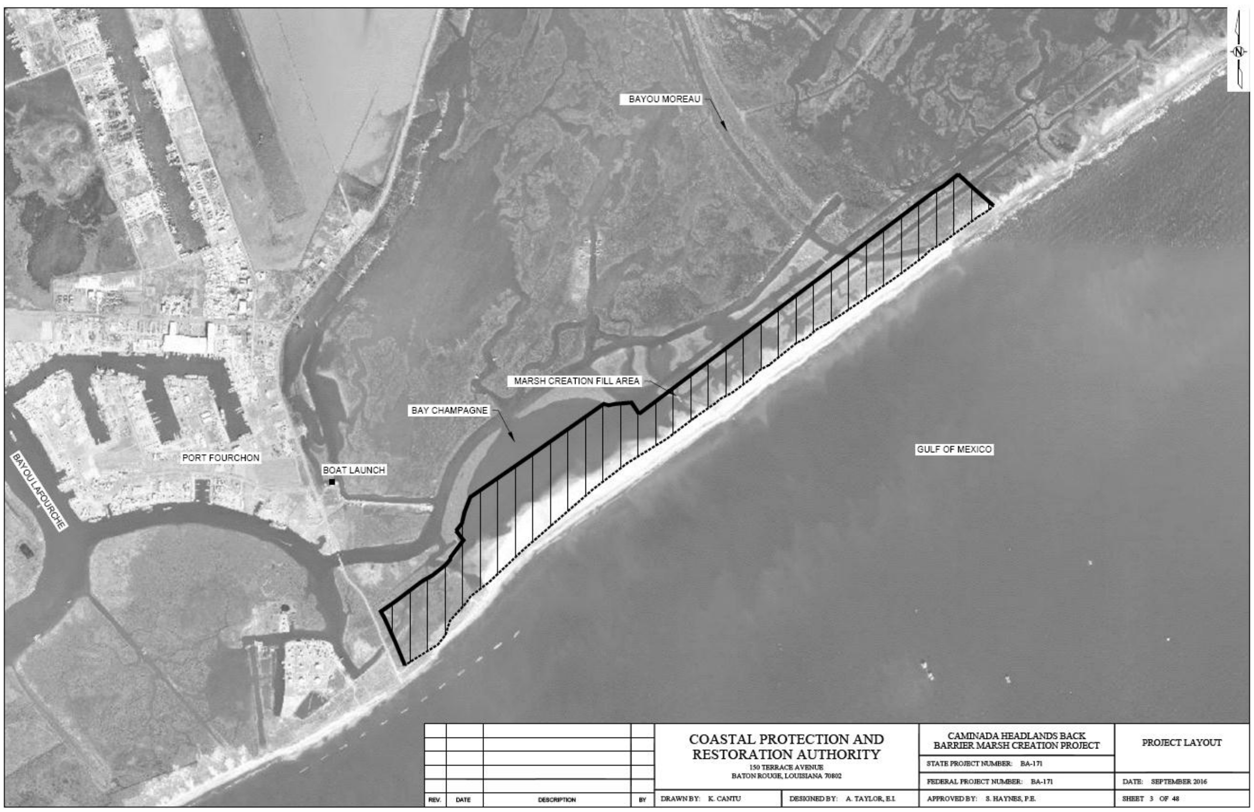

Figure 1: BA-171 Vicinity Map

1.2 Caminada Headland Regional History

The Caminada Headland is a barrier headland that has evolved through years of deltaic evolution, reforming a coastal feature created by deposition of Mississippi River sediment carried to the Gulf of Mexico by several distributaries, primarily Bayou Moreau, that meandered across the Lafourche Delta Lobe prior to its abandonment about 1,000 years ago. Behind one section of the western beach is the remnant of an interior fresh water lake, now called Bay Champagne. Landward of the beach, east of Bay Champagne, there is a series of marshes and chenier ridges intersected by oil and gas pipelines and well-access canals. Much of the marsh is now under saline stress as is the vegetation of the cheniers (CEC 2012).

The Caminada Headland has also been impacted by tropical storms and hurricanes to the extent that numerous overwash features are evident along the length of the Caminada Headland. Storm breaching is also documented in post storm photography. Much of the emergent marsh that lies between Louisiana Highway 1 and the beach is interrupted by large areas of open water resulting from breaches (storm-created channel openings) across the beach, as well as subsidence and eustatic sea level rise. As the beach and dune continue to migrate landward, overwashed sediments are lost into newly formed open water and land loss rates are exacerbated. The continued deterioration of the Caminada Headland threatens thousands of acres of wetland habitat as well as critical infrastructure, including Port Fourchon, LA Highway 1, and the lower Lafourche levee system (CEC 2012).

1.3 Barataria Basin Barrier Shoreline (BBBS) Restoration Study

The Barataria Basin Barrier Shoreline (BBBS) Restoration Study (SJB, USACE 2011) was completed in 2011 to evaluate restoration alternatives for the Barataria Basin Shoreline, including the Caminada Headland. These alternatives propose shoreline and marsh restoration to address severe erosion and land loss and to ensure the Headland's continuing geomorphic and ecological form and function. Due to the Caminada Headland's transgressive system, the BBBS study developed and analyzed multiple beach and dune templates, as well as evaluated the marsh platform for overwash. The BA-171 project, along with a few subsequent back barrier marsh creation projects and the Caminada Headland Beach and Dune Increments I and II Projects (BA-45 and BA-143), will aim to achieve the goals for the Caminada Headland set forth by the BBBS study.

1.4 Project Goals

The primary goal of BA-171 is to create and nourish approximately 430 acres of back barrier marsh with sediment dredged from an offshore borrow site that will create a marsh platform upon which the beach and dune can migrate, reducing the likelihood of breaching, improving the longevity of the barrier shoreline, and protecting wetlands and infrastructure to the north and west.

The engineering and design, environmental compliance, real estate negotiations, operation/maintenance planning, and cultural resources investigation have been completed to the final (95%) design level as required by the CWPPRA Standard Operating Procedures Version 22, and utilized the CPRA Draft Basis of Design Memorandum ED.BODM.01.V1.0 Marsh Creation Design Criteria for design. Responses to the 30% design comments can be found in Appendix I.

2.0 EXISTING CONDITIONS

2.1 Land Ownership

The majority of the project area is situated on land owned by the Edward Wisner Donation. However, the westernmost portion of the project area and the equipment access area from Highway 3090 is owned by the Caillouet Land Corporation as shown in Figure 2. Numerous oil and gas infrastructure can be found in the project area vicinity including the Louisiana Offshore Oil Pipeline (LOOP), the Chevron Pipeline, and the Arrowhead/Harvest Pipeline.

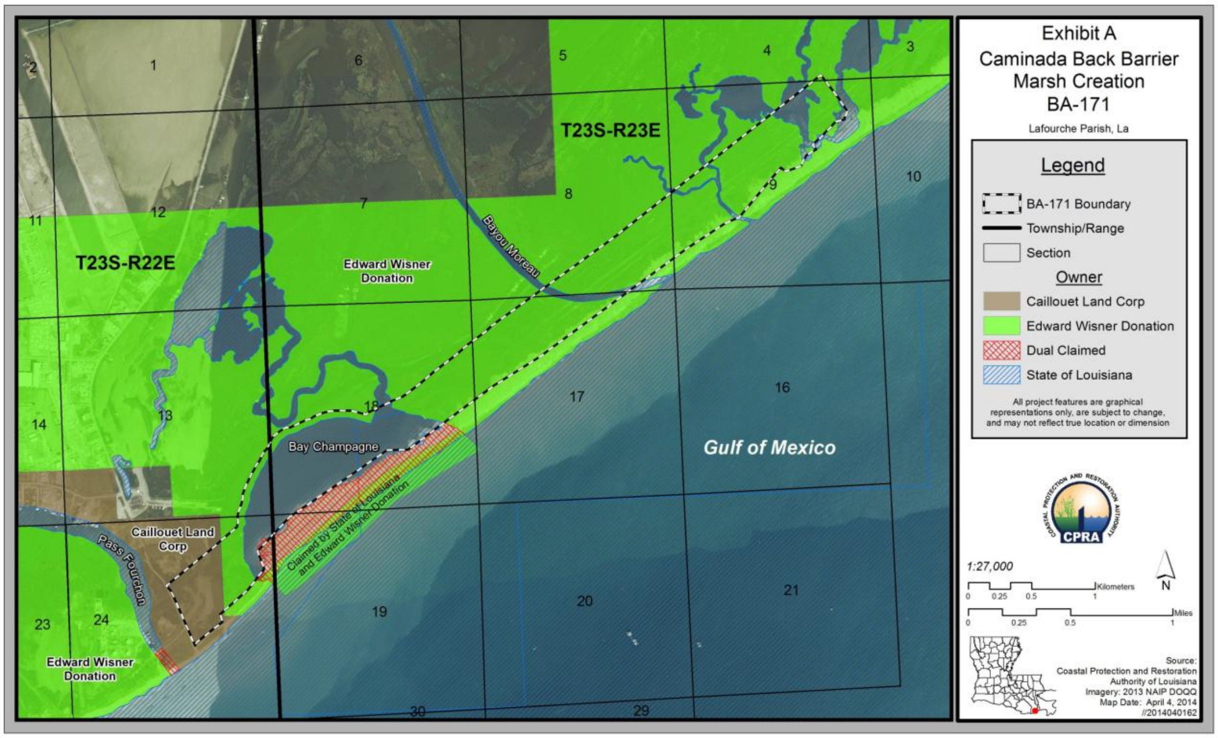

Figure 2: Tax Ownership map.

2.2 Cultural Resources Assessment

As a part of the BBBS study and the Caminada Headland Beach and Dune Increment I Project (BA-45), Goodwin & Associates performed a Cultural Resources Survey on the Caminada Headland and offshore borrow area. The EPA contacted the State Historic Preservation Office (SHPO) regarding the BA-171 project requesting a determination of effect for any Area of Potential Effects that might be recorded within the project area and proposed borrow area. After a review of the provided survey, the EPA was issued a letter stating that no known culturally significant sites would be disturbed through the creation of the BA-171 project. Copies of the letters can be found in Appendix D.

In addition to the cultural resources survey performed on the Headland and borrow area, CPRA tasked Morris P. Hebert (MPH) to perform a cultural resource survey on the dredge pipeline alignments from the proposed borrow area to the marsh fill area. The central dredge pipeline alignment was found to have potentially culturally significant areas and therefore would need additional investigation to make that pipeline alignment viable.

2.3 Oyster Lease Assessment

One oyster lease has been identified within the marsh fill area. The CPRA Landrights Division will begin the process of procurement of the oyster lease once Phase II funding has been approved.

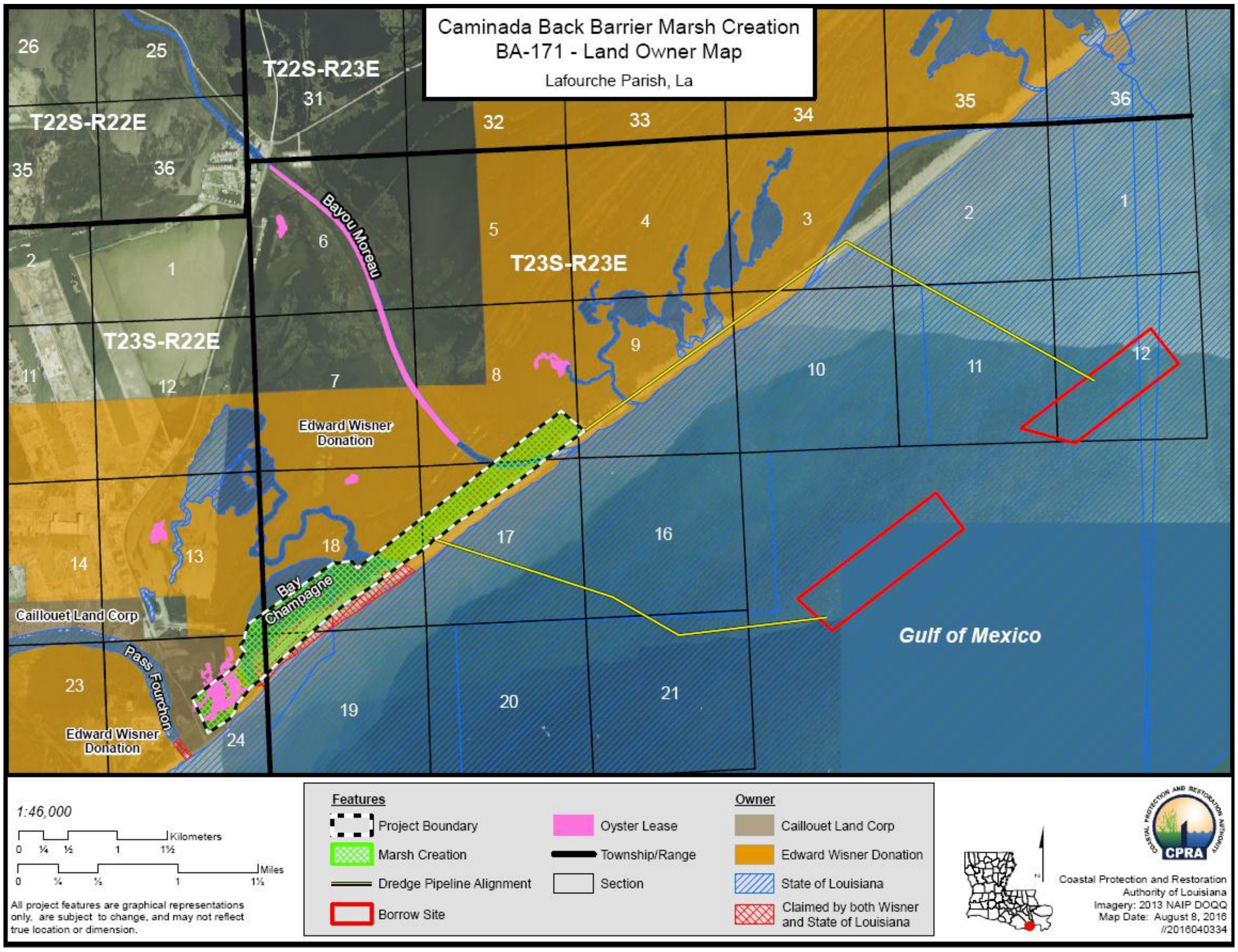

Figure 3: Active oyster leases in the BA-171 project area

2.4 Relative Sea Level Rise

In order to properly design the BA-171 project and ensure it is built and performs according to the objectives for the 20-year project life, certain natural processes such as relative sea level rise (RSLR) must be assessed. Relative sea level rise consists of two components: eustatic (or global) sea level rise (ESLR) and subsidence.

Eustatic sea level rise refers to a global average of increasing water levels that takes into account a number of variables such as thermal expansion, loss of glaciers and ice caps, and deposition of sediment on the ocean floor, to name a few. CPRA Planning and

Research Division recommended a historic rate of ESLR of 0.0079 feet/year. This is based on an examination of regionally-stable tide gauges and satellite altimetry data for the northern Gulf Coast (DeMarco et al., 2012).

Subsidence is defined as the local change (sinking) in land elevation relative to a fixed vertical datum. Accretion is defined as the process of growth or increasing in land elevation relative to a fixed vertical datum. These two processes work against one another, and in some cases, one process influences the area more than the other. Eight and a half years of elevation data from nearby CRMS stations (CRMS0164: +0.77 cm/yr; CRMS0292: +0.94 cm/yr) as well as basin-wide trends (Terrebonne: +0.65 ± 0.09 cm/yr; Barataria: +0.70 ± 0.26 cm/year) indicate that existing marsh in the project area has the ability to keep up with RSLR. While the mechanisms necessary for this positive elevation change may not be all present in the created marsh, particularly early in the project life,we propose that accretion will be sufficient to offset subsidence over the project life. Therefore, ESLR will be the only component applied to future conditions.

The rate of ESLR was used to determine the annual incremental RSLR for the BA-171 project area over the 20-year project life (Table 1). RSLR is calculated using the following equation using 1992 as a start data:

$$E(t) = at + bt^2 + St$$

Where E is the change in relative sea level at a time, *t*
a is the rate of ESLR
b is an acceleration factor, and
S is the rate of subsidence

Table 1: BA-171 Annual Incremental RSLR (feet NAVD88 Geoid12A)

Year	Annual Incremental Subsidence (*St*) (feet)	Annual Incremental ESLR ($at + bt^2$) (feet)	Annual Incremental RSLR ($at + bt^2 + St$) (feet)
2017	0.000	0.000	0.000
2018	0.000	0.019	0.019
2019	0.000	0.037	0.037
2020	0.000	0.057	0.057
2021	0.000	0.077	0.077
2022	0.000	0.097	0.097
2023	0.000	0.117	0.117
2024	0.000	0.138	0.138
2025	0.000	0.160	0.160
2026	0.000	0.182	0.182
2027	0.000	0.204	0.204
2028	0.000	0.226	0.226
2029	0.000	0.250	0.250
2030	0.000	0.273	0.273
2031	0.000	0.297	0.297
2032	0.000	0.321	0.321
2033	0.000	0.346	0.346
2034	0.000	0.371	0.371
2035	0.000	0.397	0.397
2036	0.000	0.423	0.423
2037	0.000	0.449	0.449

2.5 Tidal Datum

Establishment of the tidal datum for BA-171 occurred in the early stages of preliminary engineering since it pertains to many aspects of the project design including surveys, geotechnical analysis, and constructability. The tidal datum is a standard elevation defined by a certain phase of the tide and issued to measure local water levels and establish design criteria. Typically, the primary objective for computing the tidal datum is to establish the target construction marsh fill elevation that maximizes the duration that the restored marsh will be at intertidal elevation throughout the 20 year project life.

A tidal datum is referenced to a fixed point known as a benchmark and is typically expressed in terms of mean high water (MHW), mean low water (MLW), and mean tidal levels (MTL) over the observed period of time. MHW is the average of all the high water heights observed over one tidal epoch. MLW is the average of all the low water elevations observed over one tidal epoch. MTL is the mean of the MHW and MLW for that time period. A normal tidal epoch lasts approximately 19 years; however, since this project is located near the Gulf of Mexico and has anomalous sea level changes, a modified tidal epoch of 5 years was used (NOAA 2013).

The Coastwide Reference Monitoring System (CRMS) monitoring station CRMS0292 located at 29°23’0.12”N, 90°38’0.03”W, which is about 3.5 miles from the project area, was selected as the control station because of its proximity to the project area and similar hydrologic conditions. The period of record used was July 17, 2008 to January 17, 2014. A detailed summary of the tidal datum calculations is shown in the Design Calculations Packet located in Appendix F. The results of the tidal datum determination for the BA-171 project area are as follows:

- MHW = 0.84 feet, NAVD88
- MLW = -0.59 feet, NAVD88
- MTL = 0.12 feet, NAVD88

Historically, the tidal range has been the accepted range for healthy marsh. However, this method neglects non-tidal water level influences such as precipitation and management regimes. In order to account for tidal and non-tidal influences, an additional water level determination method, the Percent Inundation Method, was used to determine the optimal marsh elevation range.

2.6 Percent Inundation Determination

The vertical positioning of marsh platforms and the frequency with which the marsh floods strongly influences plant communities and marsh health (Visser 2003, Mitsch 1986). Historically, the tidal range between mean high water (MHW) and mean low water (MLW) has been the accepted range for healthy marsh. This approach only takes into account the tidal influences on the water levels, whereas in many areas, non-tidal influences such as meteorological events, river discharges, and management regimes often have a large impact on the water levels found in that region. Therefore, using percent inundation rather than tidal range as a proxy for marsh health can give a more accurate representation of the water levels found in the area. Percent inundation refers to the percentage of the year a certain elevation of land would be flooded. To illustrate the two approaches, Figure 4 shows both MHW and MLW and 20% and 80% inundation levels. For BA-171 the tidal range and the optimal inundation range are very similar, so either method would be yield similar results.

To determine percent inundation the percentiles were calculated based on data gathered from the CRMS0292 station. A detailed summary of the percent inundation calculations is shown in the Design Calculations Packet located in Appendix F. The result of the percent inundation determination for BA-171 at TY0 is shown in Table 2.

Table 2: Percent inundation elevations for TY0

TY0	Elevation (ft NAVD88)
10%	1.03
20%	0.74
30%	0.53
40%	0.35
50%	0.17
60%	-0.03
70%	-0.17
80%	-0.47
90%	-0.77

Saline marshes, like those in the BA-171 project area, are most productive when flooded between 20% and 80% of the time (Snedden 2012). The project team utilized best professional judgment to identify target constructed marsh elevations that would maximize short term and long-term marsh function while taking into account eustatic sea-level rise (ESLR) (Figure 4).

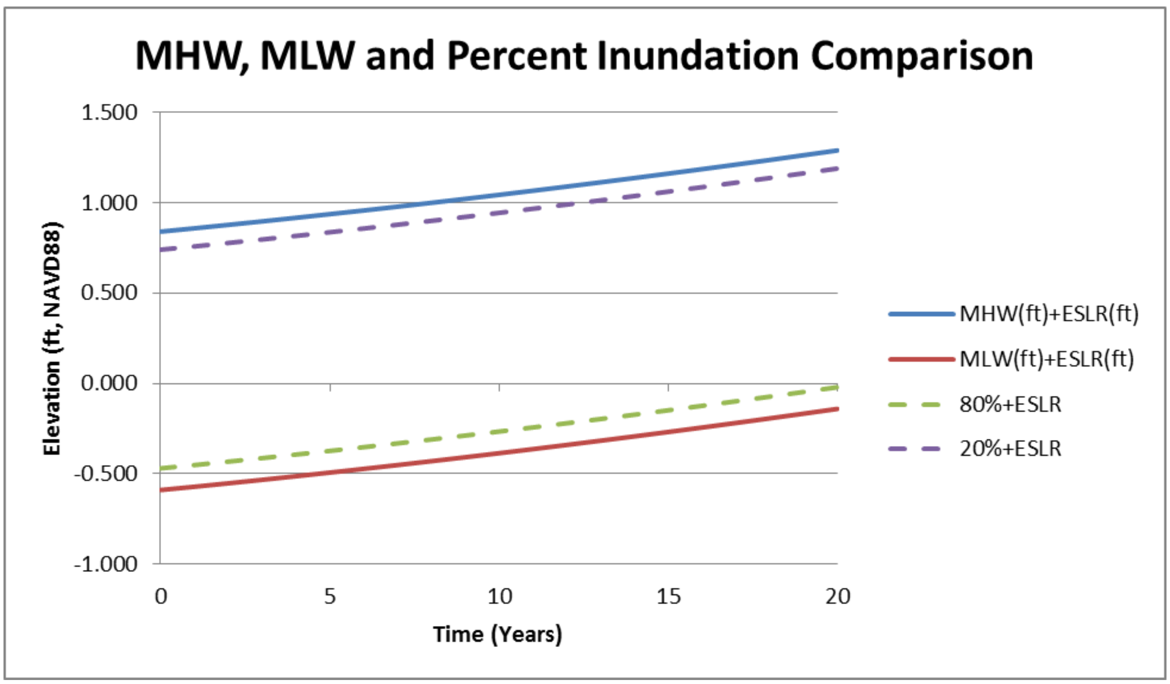

Figure 4: Percent inundation and MHW, MLW comparison

3.0 SURVEYS

3.1 Topographic, Bathymetric, Magnetometer, and Geophysical Surveys

Topographic, bathymetric, magnetometer, and geophysical survey data was collected within the project area, proposed borrow area, equipment access corridor, and dredge pipeline alignments in order to facilitate the design of the marsh creation fill area and the borrow areas utilizing CPRA survey standards. The design survey effort was performed from May 2015 to July 2015 by Morris P. Hebert (MPH). All horizontal coordinates are referenced to Louisiana State Plane Coordinate System, North American Datum of 1983 (NAD83). All elevations are referenced to North American Vertical Datum of 1988 (NAVD88) GEOID12A (MPH 2015).

3.2 Horizontal and Vertical Control

One National Geodetic Survey (NGS) primary monument (TE23-SM-01) exists in the vicinity of the project area. NGS monument "TE23-SM-01" is located southeast of Port Fourchon, 40 feet east of the centerline of LA Hwy 3090 and 65 feet northeast of the bridge approach near Pass Fourchon, Louisiana. The field survey was accomplished utilizing RTK surveying procedures and checked using Gulfnet Virtual Real-Time Network. The data sheet for the survey monument can be found in Appendix A.

3.3 Marsh Creation Fill Area Surveys

Survey transects were taken approximately every 250 feet and were a continuation of the survey transects performed along the beach and dune as shown in Appendix B. Transects were taken over open water areas, broken marsh, and across pipeline canals. Position, elevation, and water depths were recorded every 25 feet along each transect or where elevation changes were greater than 0.5 feet. Topographic and bathymetric survey methods were used as applicable to obtain all transects and were consistent with CPRA survey standards. The topographic portions were merged with the bathymetric portions at the land/water interface and were separated by no more than 50 feet. Side shots were taken as necessary to pick up variations in topographic features (highs and lows) such as trenasses, meandering channels, broken marsh areas, or any other existing features such as pipelines, well heads, wooden gates, and warning signs which may affect project design implementation. The use of a fixed height aluminum rod (8 feet or 10 feet in length) with a 6 inch diameter metal plate as the base of the rod was used to prevent the rod from sinking when topographic data was collected.

A magnetometer survey was taken in the fill area pipeline canals, the northern canal adjacent to the marsh creation fill area, and within Bayou Moreau as shown in Appendix B in order to locate any pipelines or obstructions in the fill area. A Geometrics G882 cesium magnetometer was utilized and correlated to a position with RTK GPS using the Hypack Navigation Software package. For each magnetic finding, a closed loop path was run with the magnetometer. The path completely enclosed the original finding location, while maintaining a distance of approximately 25 feet from that location.

The magnetometer survey verified the existence of three pipeline corridors within the project area. The first housed a 20 inch Chevron Pipeline positioned in the southern pipeline canal running parallel to the shoreline. This pipeline has an average depth of cover of approximately 8 feet along the pipeline canal. Two other pipelines running parallel to the shoreline in the northern pipeline corridor are 12 inch Arrowhead/Harvest Pipelines positioned in the northern pipeline canal. These pipelines have depths of cover that varied greatly across the length of the canal. At their deepest, the pipelines have depths of cover of approximately 5 feet; however, areas of the pipelines in the vicinity of Bay Champagne were exposed. Since the magnetometer survey was taken, Arrowhead/Harvest has buried their pipeline further in order to maintain a depth of cover of at least 4 feet. The final pipelines in the vicinity are the LOOP, which is a combination of a 4 inch diesel, a 48 inch crude, and a 30 inch brine pipeline. These pipelines run north to south and serve as the eastern boundary of the fill area. These pipelines had an approximate depth of cover of 7 feet. The magnetometer survey lines and locations of anomalies and intensities are shown on the MPH magnetometer survey drawings in Appendix B. This magnetometer data was utilized to evaluate project features, evaluate Contractor risk, and construction logistics. Further analysis will be required to reduce risk to the Owner, Engineer of Record, and Contractor prior to Construction.

3.4 Healthy Marsh Elevation Survey

Elevations from points shown in Appendix B that appeared to have healthy marsh were utilized to determine an average elevation of healthy marsh. Table 3 shows the results of the average healthy marsh survey. According to this survey, healthy marsh elevation is +0.34 ft, NAVD88.

Table 3: Average healthy marsh elevation survey results

Location	Elevation (ft NAVD88)
M-1	0.71
M-2	0.21
M-3	0.14
Average	**0.34**

3.5 Borrow Area Survey

Survey transects were taken every 200 feet in the proposed borrow area. Position, elevation, and water depth were recorded every 50 feet along each transect. Bathymetric survey methods consistent with CPRA standards were used to obtain all transects (CPRA 2013).

In addition to a bathymetric survey, a magnetometer survey was performed along the same transects as the bathymetric survey. This survey identified any pipelines, well heads, or any other obstructions within the borrow area. Similar equipment that was used on the marsh fill area magnetometer survey was utilized in the proposed borrow area.

The magnetometer survey verified the existence of multiple pipelines and significant magnetometer anomalies. Found within the proposed borrow area were the LOOP and two other potential pipelines. Since the water depth in this area of the Gulf of Mexico is approximately 30 feet, probing for depth of cover was not possible without additional equipment, so a 500 foot buffer between the magnetometer anomaly and the top of cut was implemented. These buffers separated the borrow area into two separate borrow areas each approximately 190 acres. The locations of these magnetometer anomalies can be found in the drawings located in Appendix B.

3.6 Dredge Pipeline Alignment Surveys

A bathymetric, magnetometer, and geophysical survey was performed on the proposed alignments from the offshore borrow area to the marsh fill area. The purpose of this survey was to identify any potential access issues for the dredge pipeline including existing pipelines or wellheads and any potentially culturally significant areas.

Transects were spaced every 98 feet (30 meters) so as to comply with the SHPO requirements for geophysical surveys. Position, elevation, and water depths were recorded every 25 feet along each transect. Bathymetric and topographic survey methods were used where applicable to obtain all transects along the dredge pipeline alignment and were merged at the land/water interface with less than 50 feet of separation. A magnetometer survey was taken along the alignments and utilized similar methods seen in the borrow area magnetometer survey. The survey verified the existence of LOOP in the westernmost dredge pipeline alignment. The results of the magnetometer survey can be found in Appendix B.

Since there was previous work done in this area along the beach and dune, some portions of the dredge pipeline alignments were previously surveyed and cleared of any potential culturally significant areas. The middle of the three dredge pipeline alignments investigated showed the existence of a potentially culturally sensitive area, and in order to utilize this alignment, additional field work would need to be performed per SHPO's request. The geophysical report and drawings can be found in Appendix B.

4.0 GEOTECHNICAL ENGINEERING ANALYSIS

In order to determine the suitability and physical characteristics of the soils in the BA-171 project area, a geotechnical subsurface investigation and geotechnical engineering analysis was conducted by both Eustis Engineering and GeoEngineers. Eustis Engineering was tasked to collect vibracores in the offshore borrow area, perform laboratory tests to determine soil characteristics, and perform consolidation tests in order to aid in the settlement determination in the marsh creation fill area. GeoEngineers was tasked to collect soil borings on the Caminada Headland, perform laboratory tests to determine soil characteristics, perform global slope stability analysis of the proposed earthen containment dikes, estimate the total settlement of the proposed earthen containment dikes and marsh creation fill areas, determine an adequate cut-to-fill ratio for the dredge and fill operations, and evaluate soil strength parameters at multiple locations along the proposed earthen containment dike alignment.

4.1 Marsh Fill Area Geotechnical Subsurface Investigation

Soil conditions were evaluated in the marsh creation fill area by advancing eight (8) soil borings to depths ranging from approximately 30 to 80 feet below the existing mudline. The approximate soil boring locations are shown in Figure 5.

The soil borings were performed in 0 to 5 feet of water. Samples were collected continuously in the upper 20-feet of the soil and on 5-foot centers thereafter to boring completion depths. The soil borings were completed in May 2015 using a marsh buggy mounted rotary-drill rig. Soil strength, unit weight, and index properties observed during drilling and laboratory test results are located on the soil boring logs in Appendix C.

Shelby tube samples were tested for miniature vane shear strength and removed from their tubes. Laboratory tests included soil compressive strength, moisture content, organic content, grain size analysis, specific gravity, consolidation with rebound, and Atterberg limits.

Those samples unable to be collected using Shelby tubes were collected using the Standard Penetration Test (SPT) Method with split-barrel sampling spoons. These samples were then classified, stored, and transported to the laboratory.

Figure 5: Soil Boring and CPT Locations

Cone Penetrometer Tests (CPTs) were also performed in the marsh fill area along the proposed earthen containment dike alignment as shown in Figure 5. The results of the CPT data helped to verify soil conditions between soil borings and aided in the geotechnical engineering analyses for earthen containment dike settlement and stability. The CPT locations and data can be found in Appendix C.

4.2 Borrow Area Subsurface Investigation

Soil conditions were evaluated in the proposed borrow area by advancing ten (10) vibracores to 30 feet below the existing mudline. The approximate vibracore locations are shown in Figure 6.

The vibracores were performed in approximately 30 feet of water. Samples were collected to a depth of approximately 30 feet below the mudline; in some cases, recovery was less than 25 feet and a second vibracore had to be taken in that location. The vibracores were completed in January 2015 by Ocean Surveys, Inc. using a pneumatic vibratory corer onboard a 33-ft by 55-ft lift boat. Index properties observed during drilling and laboratory test results are located on the vibracore logs in Appendix C.

Settling column tests and self-weight consolidation tests were performed on a bulk composite sample of the borrow area material from all of the vibracores and used in the marsh fill settlement analyses.

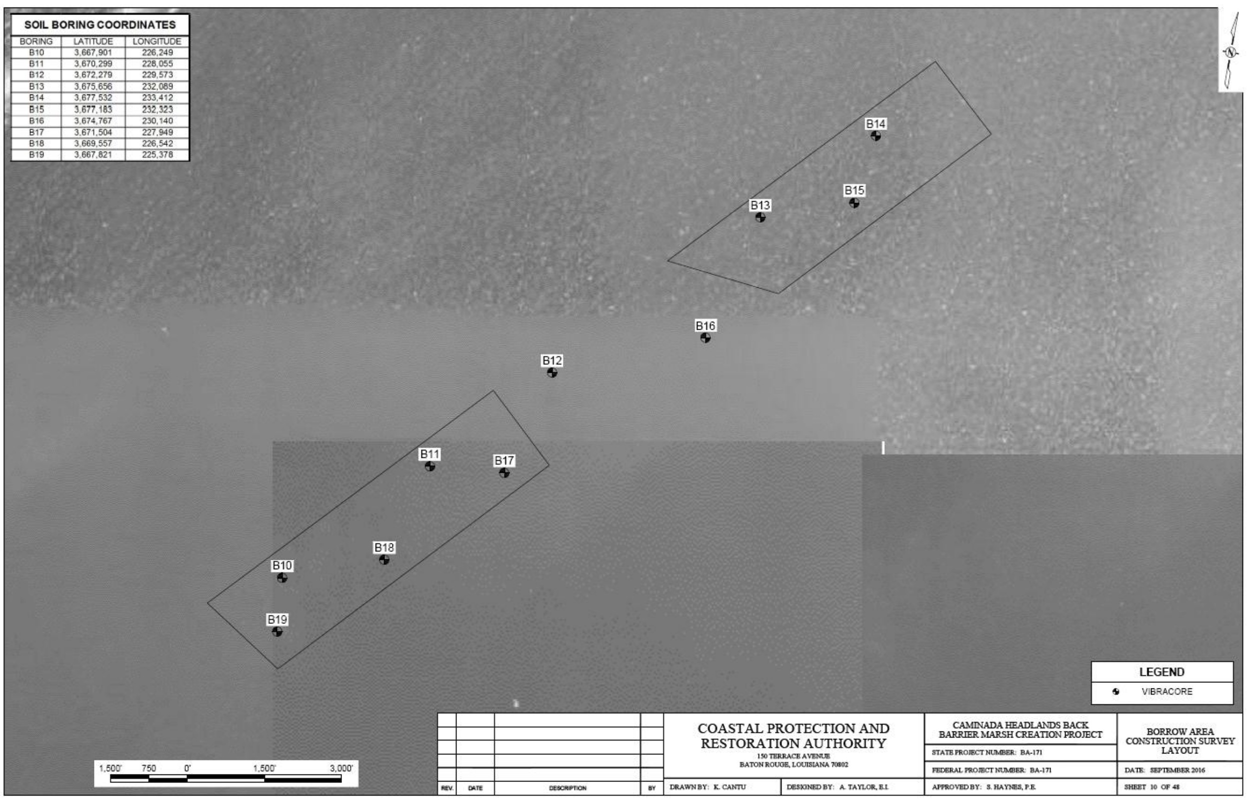

Figure 6: Vibracore locations in proposed borrow area

4.3 General Geologic Evaluation

Subsurface conditions vary greatly across the project area due to years of Gulf swells redistributing sediment loads from Bayou Lafourche. Small interdistributary ridges consisting of sand and finer-grained fluvial sediments are found throughout the back barrier marshes contributing to the variability of the geology. Generally the first 15-20 feet below the mudline in the marshes furthest from the Headland and in Bay Champagne is soft to medium clay with stiffer clays below the soft to medium clays. In those areas were the interdistributary ridges can be found, the first 2-3 feet is generally very soft to soft clay; below that to a depth that ranges from approximately 15 feet to 40 feet, soft clay can be found and dense granular deposits to medium/stiff clay can be found. Those areas nearest to the beach and dune generally have clayey sand to sand deposits in the first 4-8 feet below the mudline and soft clays are found below those deposits (GeoEngineers 2016).

4.4 Earthen Containment Dike Global Slope Stability Analysis

Global slope stability analyses were performed on the proposed earthen containment dikes (ECDs) at different elevations and geometries. The slope stability of the earthen containment dike has two types of driving forces: (1) the forces induced by the soil weight, and (2) any seepage forces which tend to cause the soil to slide. In response to these driving forces, the subsurface soils have a resistant force in the form of shear strength, which attempts to keep the slope from sliding. Both the driving forces and the resisting forces are dependent on the geometry of the situation: the “Failure Surface”. GeoEngineers performed a stability analysis that computes factors of safety, against potential failure based on limit equilibrium theory. Stability runs included evaluating the earthen containment dike with respect to a borrow channel excavated to -10 ft NAVD88 on one side, a borrow channel on both sides of containment both being excavated to -10 ft NAVD88, and placement of marsh fill. Table 4 shows the results of the slope stability analyses for the earthen containment dikes at an elevation that would allow at least one foot of freeboard during the filling of the marsh creation fill area. A factor of safety of 1.2 was determined by CPRA in consultation with GeoEngineers to be acceptable for ECD slope stability analyses, based on experience, risk, similar projects and the CPRA Draft Marsh Creation Design Criteria ED.BODM.01.V1.0.

Table 4: Earthen Containment Dike Slope Stability Results.

Condition	Estimated Berm Crest El. (ft. NAVD88)	Borrow Excavation Offset (ft)	Berm Side Slope	Factor of Safety
Failure from Dike to Excavation(s)	+3.0	25	5H:1V	1.55
Failure from Dike to Marsh	+3.0	25	5H:1V	1.43

4.5 Earthen Containment Dike Settlement Analysis

Due to the load from the ECD on the existing soils, a consolidation settlement analyses of the foundation soils beneath the earthen containment dikes were computed based on the ECD geometries/templates determined from the slope stability analyses and the consolidation soil properties of the underlying soils. See Figure 11 as an example of an

ECD used for estimating the consolidation settlement. Reducing the crown elevation and width will decrease the load and thus reduce the magnitude of settlement under the earthen containment dikes. Total settlement factors include regional subsidence, self-weight consolidation, and elastic settlement of the in situ soils. The settlement time is influenced by the drainage paths, soil properties, and the coefficient of consolidation, Cv. Self-weight consolidation is dependent on several factors, including organic content, natural moisture content, and construction methodology. Elastic settlement of the in situ soils will occur quickly and will likely result in an increase in the quantity of fill required to reach the design construction elevation.

Settlement for the containment dike was performed using elevations ranging from +2.5 to +4.0 feet NAVD 88. The design elevation was +3.0 feet NAVD88 and is shown in Figure 13 in Section 7.2 Earthen Containment Dike Design.

4.6 Marsh Creation Settlement Analysis

A marsh creation settlement analysis was performed to determine the constructed marsh fill elevation of the marsh creation fill areas and the total volume of fill material. The final elevation of the marsh creation area (at year twenty) is governed by two forms of settlement: (1) the settlement of the underlying soils in the marsh creation areas caused by the loading exerted by the placement of the dredged fill material, and (2) the self-weight consolidation of the dredged material (See Figure 7). Data from low pressure consolidation tests were used to estimate the magnitude and time-rate of settlement of the underlying soils of the marsh creation fill areas. Self-weight consolidation tests were also performed on a composite sample from the borrow area material to estimate the self-weight consolidation magnitude and time-rate of settlement of the dredged fill material.

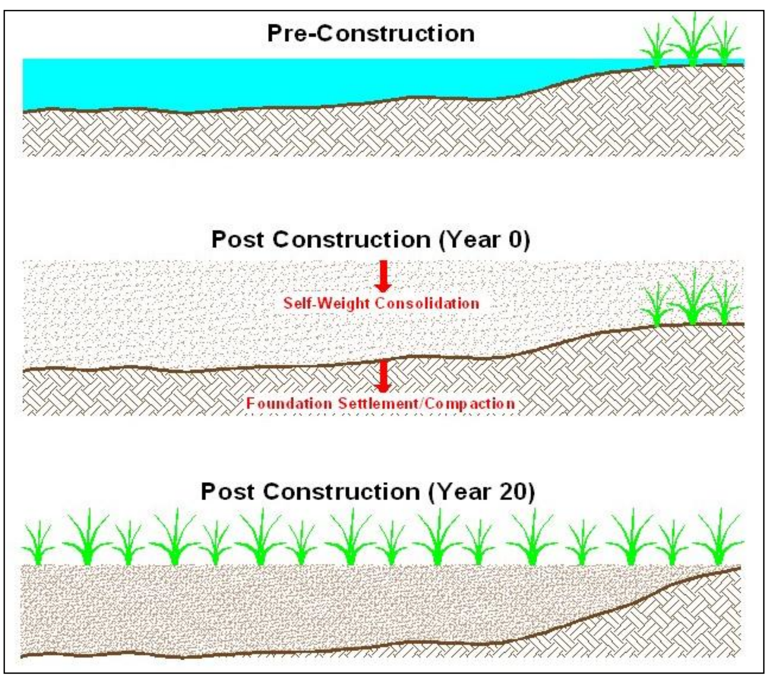

Figure 7: Marsh Creation Settlement

Settlement curves were developed for a two-lift marsh fill in 0.5 ft increments for proposed construction marsh fill elevations ranging from 2.0 feet to 4.0 feet NAVD 88. These settlement curves show the changes in elevation over the 20-year design life of the project and were used to compare different construction marsh fill elevations.

The estimated total settlement is shown in Figure 8. The project area experiences rapid settlement within the first few months after construction. Therefore, a two-lift approach was evaluated in order to achieve the final constructed marsh fill elevation.

To determine the final constructed marsh fill elevation that would yield the most productive marsh at the end of the 20-year project life, water levels in the vicinity of the project area and eustatic sea level rise were taken into account.

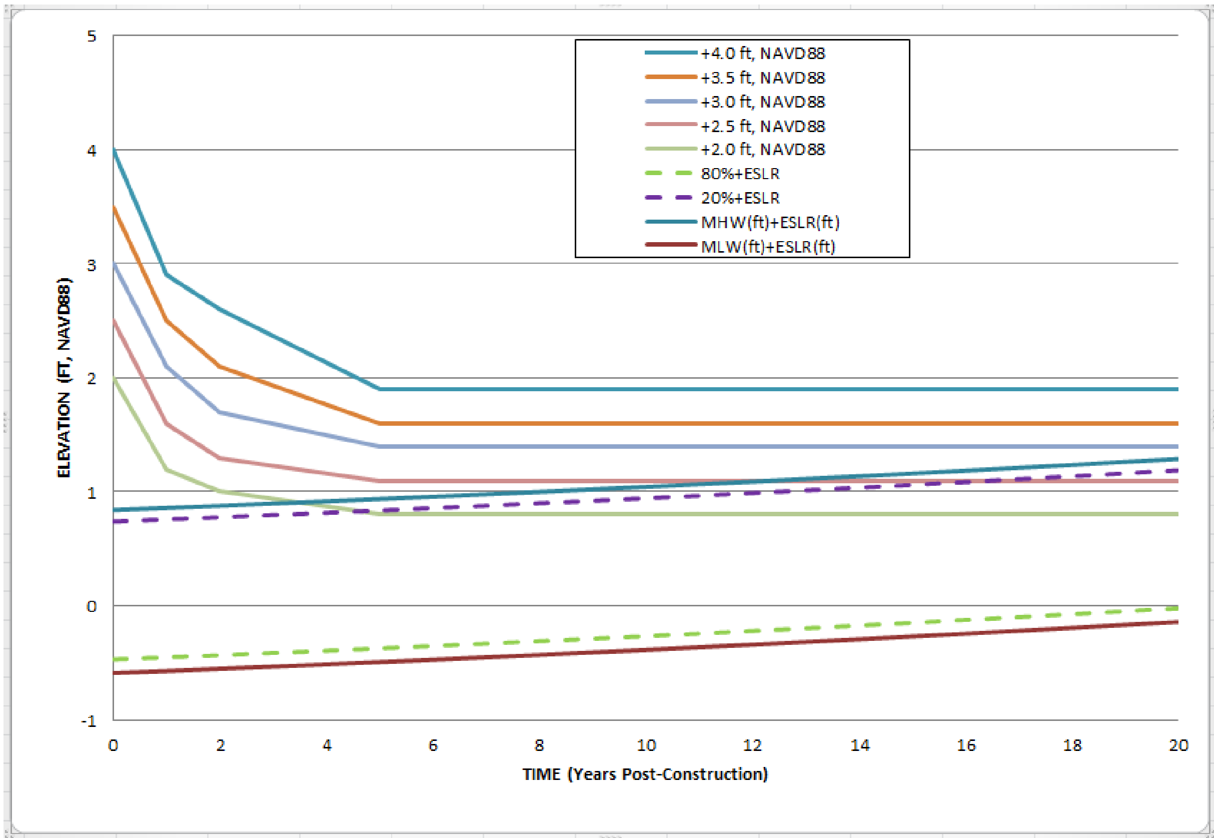

Figure 8: Estimated Total Settlement Curves overlaid on the 20% inundated, 80% inundated, MHW, and MLW lines, including ESLR

The ideal final marsh platform would settle into the optimal saline marsh range (20%-80% inundated) shortly after construction and would remain there for the duration of the 20 year project life. The final marsh fill area would also serve as a stable platform on which the newly created beach and dune can roll back upon. This data was utilized to design the marsh creation fill area as specified in Section 7.1.

4.7 Cut-to-Fill Ratio Recommendations

A cut to fill ratio was determined by GeoEngineers in order to account for losses due to dredging, containment, and dewatering. A cut to fill ratio of 1.5 will be applied for all hydraulically dredged marsh fill sediment. Mechanical dredging of the containment dikes has generally yielded a cut to fill ratio approximately between 1.2 and 1.6. For this project a cut to fill of 1.5 will be used for mechanical dredging of the containment dikes.

5.0 BORROW AREA MODELING

5.1 Model Setup

Coastal Engineering Consultants (CEC) was tasked to analyze the potential effects to the shoreline from mining the proposed offshore borrow area. The Delft3D model was selected in order to predict effects that the borrow area excavation may have on wave refraction, sediment transport patterns, and morphological changes along the Caminada Headland.

CEC utilized bathymetric/topographic data, water elevations, wave height, wave period and direction, wind speed and direction and sediment characteristics from the proposed project area and offshore borrow area to calibrate the model.

5.2 Model Scenarios

Five scenarios were analyzed for potential impacts to the shoreline. Scenarios 1 through 3 evaluated the effect dredging the offshore borrow would have under average wind and wave conditions, Scenario 4 evaluated the case in which significant morphologic effects would occur, and Scenario 5 evaluated the effects of a 20-year storm event. Each of the five scenarios were simulated twice; once with existing bathymetry and again with the dredged proposed borrow area. Effects were measured by comparing the existing conditions run to the dredge borrow area scenario (CEC 2016).

5.2.1 **Scenarios 1 through 3: Average Wind and Wave Conditions**

Scenarios 1 through 3 were statistically analyzed to derive three general conditions that most commonly occur. Each Scenario had slightly different inputs for the different conditions. Table 5 summarizes the parameters analyzed for each Scenario.

Table 5: Scenario 1 through 3 model inputs

Parameter	Scenario 1	Scenario 2	Scenario 3
Percent Occurrence	16.6%	9.2%	9.0%
Wave Height	0.92 ft	2.36 ft	2.30 ft
Wave Period	5.1 s	5.5 s	5.8 s
Wave Direction	135°	156°	135°
Wind Speed	13.78 ft/s	18.70 ft/s	19.03 ft/s
Wind Direction	170°	167°	137°

Scenario 1 results showed very little changes between existing conditions and dredging the borrow area. Wave heights differed by less than 0.16 feet, and differences in wave periods did not exceed 1 second over the vast majority of the project area. Sediment transport magnitude difference indicated there were no changes exceeding 0.03 feet.

Scenario 2 and 3 results were similar to Scenario 1 results.

5.2.2 **Scenario 4: Significant Morphological Impacts**

Scenario 4 aimed to define a wave/wind condition responsible for the majority of morphologic changes. The parameters evaluated are outlined in Table 6.

Table 6: Scenario 4 model inputs

Parameter	Scenario 4
Wave Height	6.0 ft
Wave Period	7.2 s
Wave Direction	157°
Wind Speed	31.17 ft/s
Wind Direction	167°

Simulations were performed with normal wave conditions at the beginning through approximately hour 14, then growing to reach maximum wave height of 6.0 feet around hour 19 and eventually dropping back to normal conditions at the end of the simulation. Similarly as with Scenarios 1 through 3, the difference in wave period did not exceed 1 second, and the sediment transport magnitude differed by less than 0.03 feet. The wave height along the shoreline differed by -0.16 ft to 0.39 ft, which is insignificant compared to the offshore wave height of around 6.0 ft.

5.2.3. **Scenario 5: 20-Year Storm Impacts**

Scenario 5 aimed to simulate the effects associated with a 20-year storm such as Hurricane Katrina. The parameters evaluated are outlined in Table 7.

Table 7: Scenario 5 model inputs

Parameter	Scenario 5
Wave Height	26.38 ft
Wave Period	13.0 s
Wave Direction	145°
Wind Speed	105.64 ft/s
Wind Direction	145°

Simulations were performed with normal wave conditions at the beginning and growing to reach the maximum wave height of 26.38 feet around hour 8 and dropping back to normal conditions around hour 18 for the remaining simulation period. Similar to Scenario 4, the wave conditions offshore were much more significant than those found near the shoreline.

The difference in wave period was less than 2 seconds, which is not significant. Sediment transport magnitude differences indicated that the majority of changes occurred in the borrow area with a couple of isolated spots along the shoreline being overtopped. However, even at the end of the 24 hour period, differences were only about 0.16 feet mostly in the borrow area.

5.3 Model Summary

Based on the results of these five scenarios, it can be concluded that the excavation of the proposed borrow area will not have an adverse effect on wave refraction patterns and resultant sediment transport rates along the Caminada Headland. A copy of the results of the modeling effort can be found in Appendix H.

6.0 HAZARDOUS, TOXIC AND RADIOACTIVE WASTE INVESTIGATION (HTRW)

Due to the location of the proposed borrow area, it was determined that it was necessary to assess the condition of the existing sediment in the borrow area prior to initiation of the project. Gulf Engineers & Consultants (GEC) was contracted to perform a Hazardous, Toxic, and Radioactive Waste (HTRW) assessment of the proposed borrow area soils. This included collecting three ten-foot core samples. Analysis performed on the three core samples included water quality tests, visual analysis of the cores, and laboratory analysis for a select number of constituents of concerns (GEC 2015).

The findings the constituents of concern within the proposed borrow area were within acceptable limits and would not have any adverse effects on plants, aquatic life, and human exposure. Results of the analysis can be found in Appendix G.

7.0 MARSH CREATION DESIGN

The project proposes to create marsh by hydraulically dredging material from a borrow site located approximately 1.5 miles offshore in the Gulf of Mexico for placement into the designated marsh creation fill area shown in Figure 9 and the Preliminary Design Drawings located in Appendix E. The marsh creation design was broken into four (4) components: the marsh creation fill area, the earthen containment dikes, the dredge borrow area, and the dredge pipeline alignments. The design of each component is discussed in the sections below.

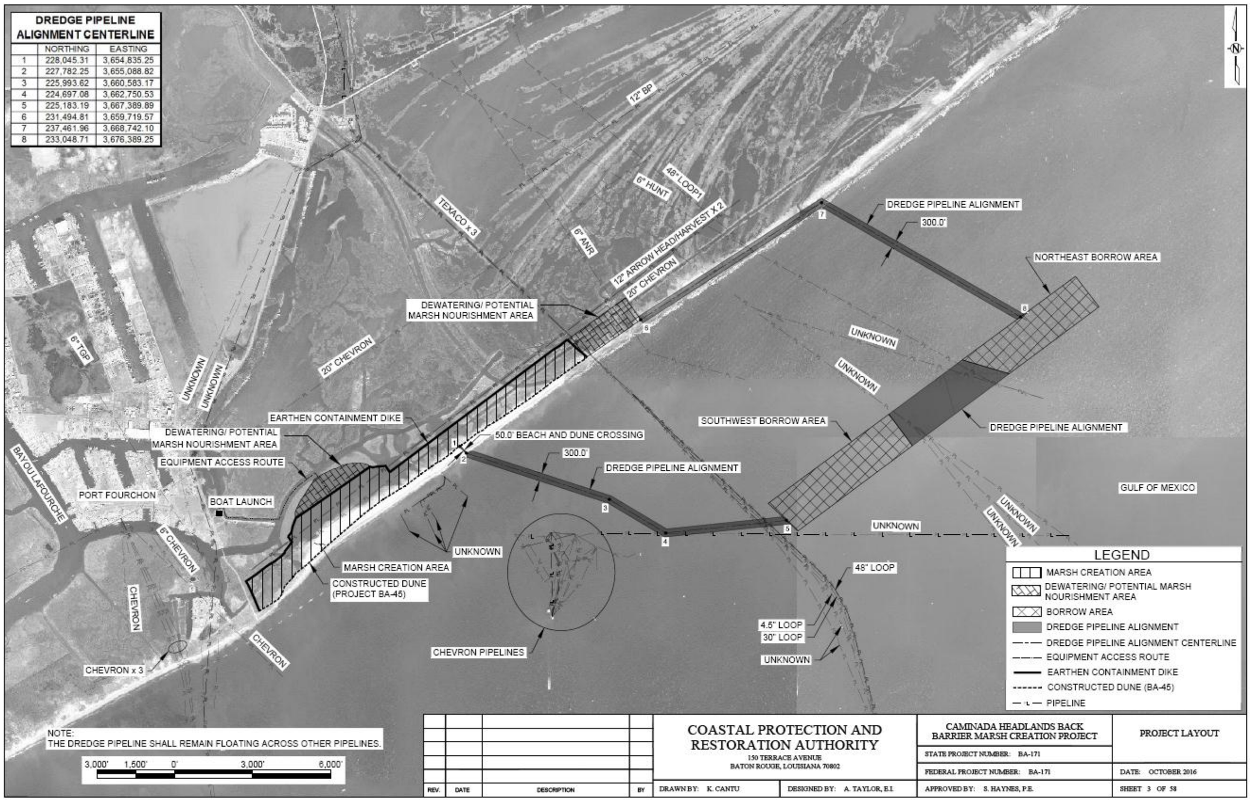

Figure 9: Plan view of the project design features

7.1 Marsh Creation Fill Area Design

The primary goal of the marsh creation fill area feature is to address the land loss in this area while also providing an over wash platform for the newly-created beach and dune (BA-45). These goals governed the configuration of the marsh creation fill area. The alignment of the fill area went through many changes from the original Phase 0 configuration before finalizing the alignment shown in Figure 10. The Phase 0 plan was to create two marsh fill areas leaving the area around Bayou Moreau open since that area appeared to be healthy marsh. However, the results of the healthy marsh elevation surveys showed that area being lower than what the constructed marsh fill elevation would be at the end of the 20 year project life. In order to create a continuous marsh platform for the beach and dune to roll back onto, the two fill areas were combined into one fill area. The alignment was further constrained by the presence of deep water areas within the vicinity of the Arrowhead/Harvest pipeline corridor.

The next step in the marsh creation design involved determining an appropriate constructed marsh fill elevation (CMFE). This elevation was governed by several factors including the tidal range, percent inundation, the healthy marsh elevation, the physical properties of the borrow material, and the bearing capacity of the foundation soils in the marsh creation fill area. Determination of the constructed marsh fill elevation was based on consideration of the average marsh elevation over the life of the project with respect to intended functioning of the marsh from both a habitat perspective and meeting the project goals and objectives. One element of the design is to maximize the time period that the marsh platform has an elevation within the functional saline marsh inundation range (20%-80% inundated) and maximize the time period spent in the range that most closely correlates to the tidal range (20%-80% inundated). Over the 20-year project life, including eustatic sea level rise as discussed in Section 4.4, the preferred inundation range is expected to rise from -0.47 ft NAVD88 and 0.74 ft NAVD88 (80%-20% inundated) to -0.021 ft NAVD88 and 1.189 ft NAVD88.

To achieve the project goals, the marsh platform will initially have to be pumped to a constructed marsh fill elevation outside of the functional saline marsh range and settle into the range over the design life. To satisfy these conditions, the marsh creation fill area will be pumped to an initial fill elevation of +2.0 ft NAVD88, be allowed to settle for 60 days, and then will again be pumped to a final constructed fill elevation of +2.0 ft NAVD88.

After determining the constructed marsh fill elevations, the total volume of the marsh creation fill area was calculated using AutoCAD Civil software. The software creates a 3-Dimensional surface based on XYZ coordinate data from the survey cross-sections. This surface is known as the Triangulated Irregular Network (TIN). The TIN model represents a surface as a set of contiguous, non-overlapping triangles. Both a TIN surface containing the 2015 survey data from MPH and a flat TIN surface at the creation construction elevation was created by AutoCAD. AutoCAD then uses the XYZ differences of each surface to calculate the volume of the marsh creation fill area. Since the containment borrow must be refilled, the volume to build the containment dikes plus a cut-to-fill ratio of 1.5 for the dikes is then added to the volume required to fill the marsh creation fill areas. The cut-to-fill ratio of 1.5 is then applied, resulting in a final estimate of volumes for the marsh creation fill area. Table 8 summarizes the fill volumes for the BA-171 project.

Table 8: Summary of Creation Acreage and Volume

Fill Area	Constructed Marsh Fill Elevation (ft NAVD88)	Area (Acres)	Cut to Fill	Volume of Fill (yd^3)	Volume of Cut (yd^3)
1	2.0	385	1.5	1,325,405	1,988,108

Though the final constructed fill elevation of the marsh fill area will be +2.0 ft, NAVD88, volume calculations were determined at a slurry height elevation lower than the final constructed marsh fill elevation to allow for primary consolidation settlement of the fill to occur. As shown in the settlement curve in Figure 12, the fill elevation decreases at a much quicker rate within the first few years after construction as compared to the mid to later years due to the draining of excess pore water. Midway between onset and completion of primary consolidation settlement, the material has a chance to mostly dewater giving a more accurate estimate of the actual volume of dredged material needed to achieve the target marsh elevation.

Dewatering/marsh nourishment areas are located within Bay Champagne and extending along the eastern side of the marsh creation fill area. While these areas will be primarily used for decanting supernatant water, there is a potential for sediment fines to be present in this water resulting in potential nourishment for the surrounding marshes. Therefore, these areas will also be permitted for potential marsh nourishment/marsh creation areas to account for any sediment that may escape through the dewatering structures.

7.2 Earthen Containment Dike Design

The primary design parameters associated with the earthen containment dike (ECD) template design include crown elevation, crown width, and side slopes. A minimum of one foot of freeboard is needed to contain the dredge slurry within the proposed marsh creation fill area. Therefore, the earthen containment dikes will be constructed to an elevation of +3.0 ft NAVD88 based on the initial constructed marsh fill elevation (CMFE) of +2.0 and will be maintained throughout the duration of dredging operations. Three ECD template alternatives were evaluated based on the soil boring data, marsh creation criteria, water level criteria, and constructability concerns, utilizing the SLOPE/W global stability geotechnical engineering software. The three ECD template alternatives consisted of Alternative 1-multiple lift construction, Alternative 2-woven geotextile reinforcement, and Alternative 3-sand base.

7.2.1 Alternative 1-Multiple Lift Construction

Due to the variability in the project area, some reaches along the earthen containment dike alignment have high to moderate strength soils while other areas have very weak strength soils. In those areas where the soils have high or moderate strength, the global slope stability analyses results indicated that the entire earthen containment dike template can be built using two construction lifts while still achieving a minimum factor of safety of at least 1.2. However, in those areas with weaker soils, three or more lifts may be necessary to construct the full template, and a prescribed wait time of 30-45 days between lifts will be necessary to allow for the soils to gain strength. The utilization of a multi-lift methodology for construction of the ECD will result in increased construction duration and constructability risk.

The estimated 30-45 day waiting period between lifts is much longer than the allowable idle period for marsh excavators; therefore, the excavators will need to be demobilized and remobilized between lifts potentially increasing the cost and construction duration. Delaying the completion of the earthen containment dikes also delays the pumping of material into the marsh fill area resulting in a much longer overall construction time potentially spanning multiple hurricane and bird nesting seasons.

The multi-lift process will also require more borrow material and could require double handling of the very soft material, which will result in a further strength reduction of the soft in-situ soil.

Based on the factors stated above, the ECD weak soil areas propose high risk for ECD failure, which will result in the inability to construct the project and an increase in risk to the Engineer of Record, the Owner, and the Contractor. Therefore, the multi-lift methodology in the soft soils is not recommended and additional ECD alternatives were evaluated.

7.2.2 Alternative 2-Dike Reinforced with Woven Geotextile Fabric

This second alternative evaluated includes placing a woven geotextile as soil reinforcement with a tensile strength at 5% strain of 1,500 pounds per foot (125 pounds per inch) within the earthen containment dike along those reaches with weak soils. Slope stability analyses were performed in various locations along the proposed alignment, and those scenarios with a mudline elevation of -2.0 ft NAVD88 and geotextile fabric resulted in factors of safety above 1.2 To achieve the minimum factor of safety of 1.2, in-situ soil will be placed to an elevation of -2.0 ft NAVD88 in those areas deeper than -2.0 ft NAVD88, the woven geotextile fabric will be placed, and then in-situ soil will be placed to the design elevation of +3.0 ft NAVD88. In those areas where geotextile fabric is needed and the existing ground elevation is above -2.0 ft NAVD88, the geotextile fabric will be placed on the existing ground. The geotextile fabric will be placed with the machine direction perpendicular to the containment dike with a 3 foot overlap of the fabric so as to provide a stable platform to construct the containment dike section.

This method of construction eliminates the need for the multi-lift construction approach, therefore eliminating the need for the 30-45 day wait periods as described in Alternative 1 and reducing the risk of increased construction duration. While construction with geotextile fabric will be more expensive than constructing simply with in-situ material, the likelihood of failure in construction of the earthen containment dike greatly decreases therefore increasing the likelihood of constructing a successful project.

7.2.3 Alternative 3-Sand Base

The final alternative evaluated involves placing sand, mined from the sand flat in Bay Champagne, along the length of the entire containment dike alignment to provide a stable base upon which to construct the earthen containment dikes. Sand is a favorable material to use as a base because of its ability to consolidate immediately. With this alternative, the sand base would be placed to just above the water surface and capped with in-situ soil to the design elevation of +3.0 ft NAVD88.

The biggest concern with this alternative is constructability. Though the sand is located within the marsh fill area, it is not easily accessible to the containment dike alignment. Due to the oil and gas infrastructure and the shallow depths present within the marsh fill area, equipment access would be limited making the process of moving the sand from the sand flat to the containment dike alignment very slow. Along with equipment limitations, this alternative risks not having a sufficient quantity of sand to complete the entire section of sand needed along the containment dike. Current sand quantities were derived using a boring taken along the outer edge of the sand flat, so in order to confirm the quantity of available sand additional data collection will be necessary. If the quantity was found to be insufficient, it would result in the need to find an alternative source of sand, which will incur additional time and money for the project.

7.2.4 Preferred Alternative

The preferred alternative was determined based on constructability and evaluating which alternative posed the least risk to the Engineer of Record, the Owner, and the Contractor. Alternative 2, Dike Reinforced with Geotextile Fabric, was chosen as the preferred alternative. This option allowed for the full earthen containment dike template to be constructed in two lifts while maintaining a minimum factor of safety of 1.2. The dikes will be constructed with a crown width of 5 feet and a side slope of 5H:1V. The material to build the containment dikes will be mechanically dredged from borrow areas on either side of the alignment where allowed and will have a maximum bottom elevation of -10 ft NAVD88. Side slopes within the borrow area will be 2H:1V, and the borrow will be located a minimum of 25 feet from the toe of the containment for stability purposes. Figure 10 shows the length of the alignment that will need geotextile fabric reinforcement, and Figure 11 shows a typical section of the earthen containment dikes with geotextile fabric in place.

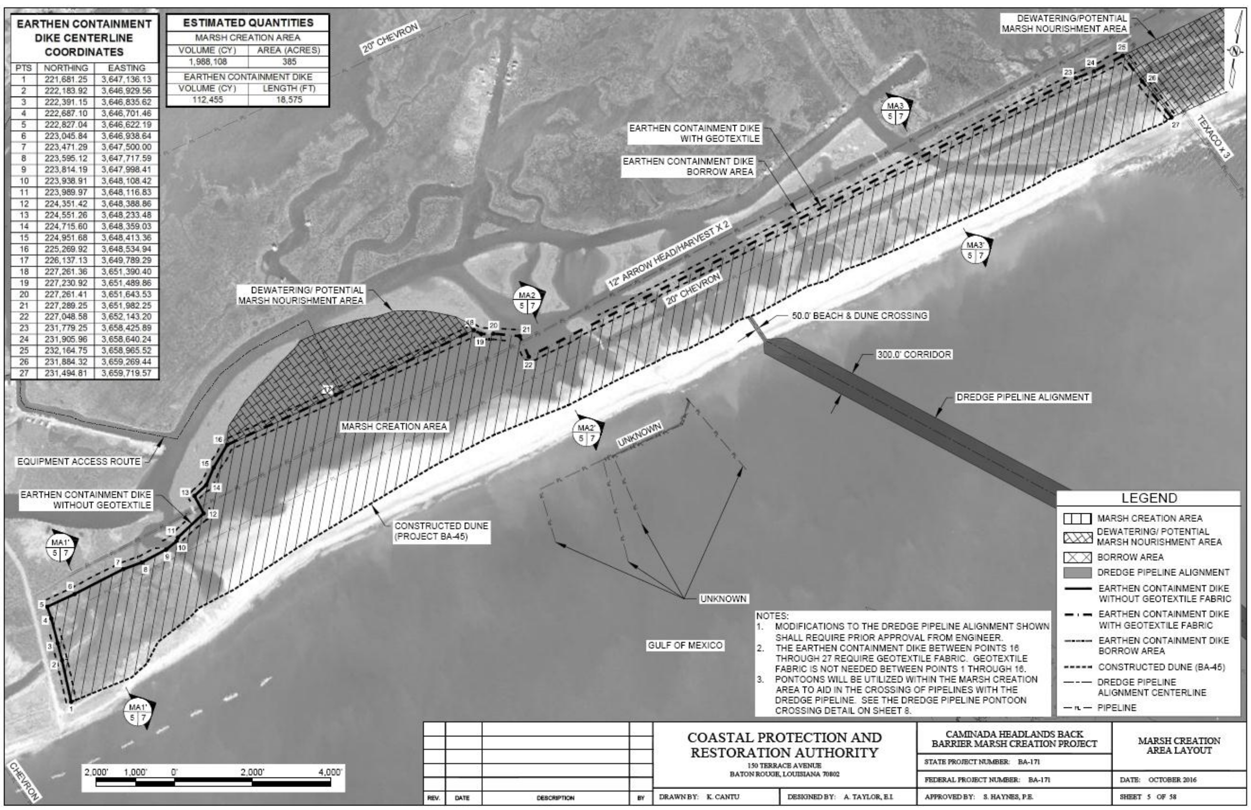

Figure 10: Plan view showing location of ECD with and without geotextile fabric

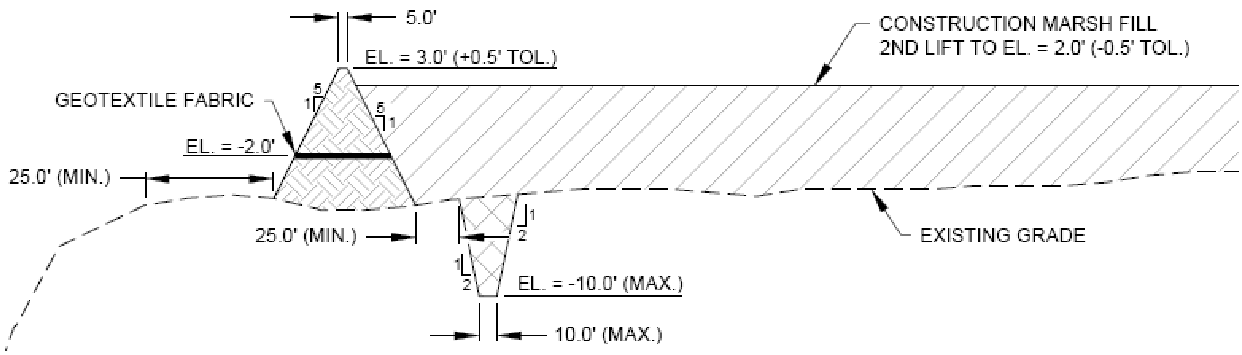

Figure 11: Typical earthen containment dike section with geotextile fabric placed

As discussed in Section 6.5, settlement of the soils beneath the earthen containment dikes was computed based on the dike geometries. The settlement curve for the final dike geometry and elevation is shown in Figure 12. The results show that a minimum of one (1) foot of freeboard will be present at all times during construction and throughout the 20 year project design life.

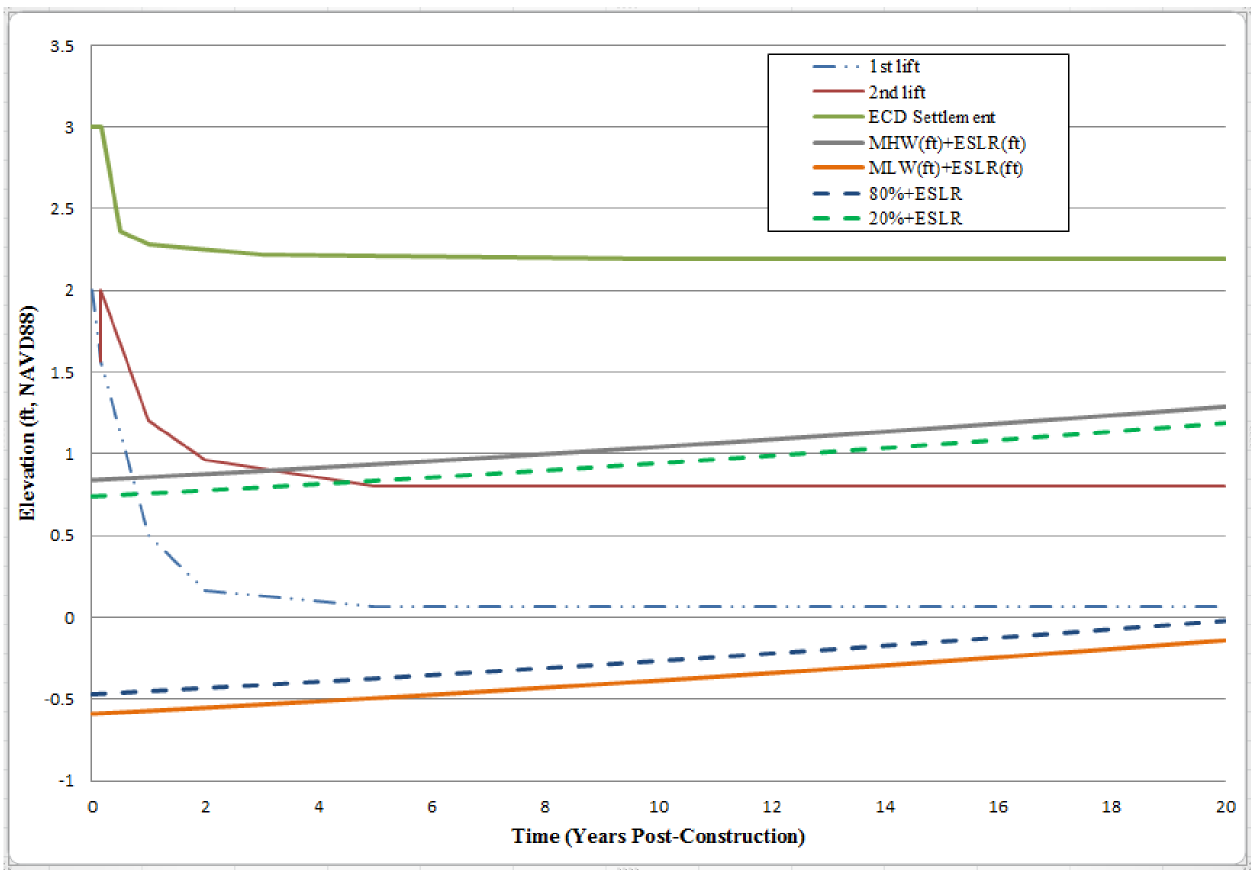

Figure 12: Earthen containment dike and two-lift marsh fill estimated settlement curve

Table 9 details the design aspects of the earthen containment dikes.

Table 9: Summary of Earthen Containment Dike Design

Marsh Creation Area	Design Elevation (ft NAVD88)	Side Slopes	Crown Width (ft)	Factor of Safety	Minimum Borrow Offset (ft)	Cut to Fill	Volume of Fill (yd^3)	Volume of Cut (yd^3)
1	3.0	5H : 1V	5	1.2	25	1.5	74,970	112,455

Long reach excavators are envisioned to construct the earthen containment dikes. Equipment access and pipeline crossings will not be finalized until pipeline agreements are in place prior to construction and all pipeline locations have been verified.

7.3 Borrow Area Design

The typical controlling factors in the borrow area design are the location, size, and available material. It is preferred that the borrow area be located in close proximity to the marsh creation fill area in order to minimize the pumping distance of the dredged material. The borrow area should be free of any existing oyster leases, culturally significant sites, and oil and gas infrastructure if possible.

By the LCA BBBS study, a large potential borrow area was identified approximately 1.5 miles from the shoreline in the Gulf of Mexico. Over 500 acres of the Gulf of Mexico water bottom was investigated for identifying a borrow area for use in the marsh creation fill area. These investigations cleared the entire borrow area of any potentially culturally significant area and helped to identify the presence of multiple pipelines found in the area. Based on bathymetric and magnetometer surveys for the design of this project, the borrow area was then delineated into two borrow areas shown in Figure 13.

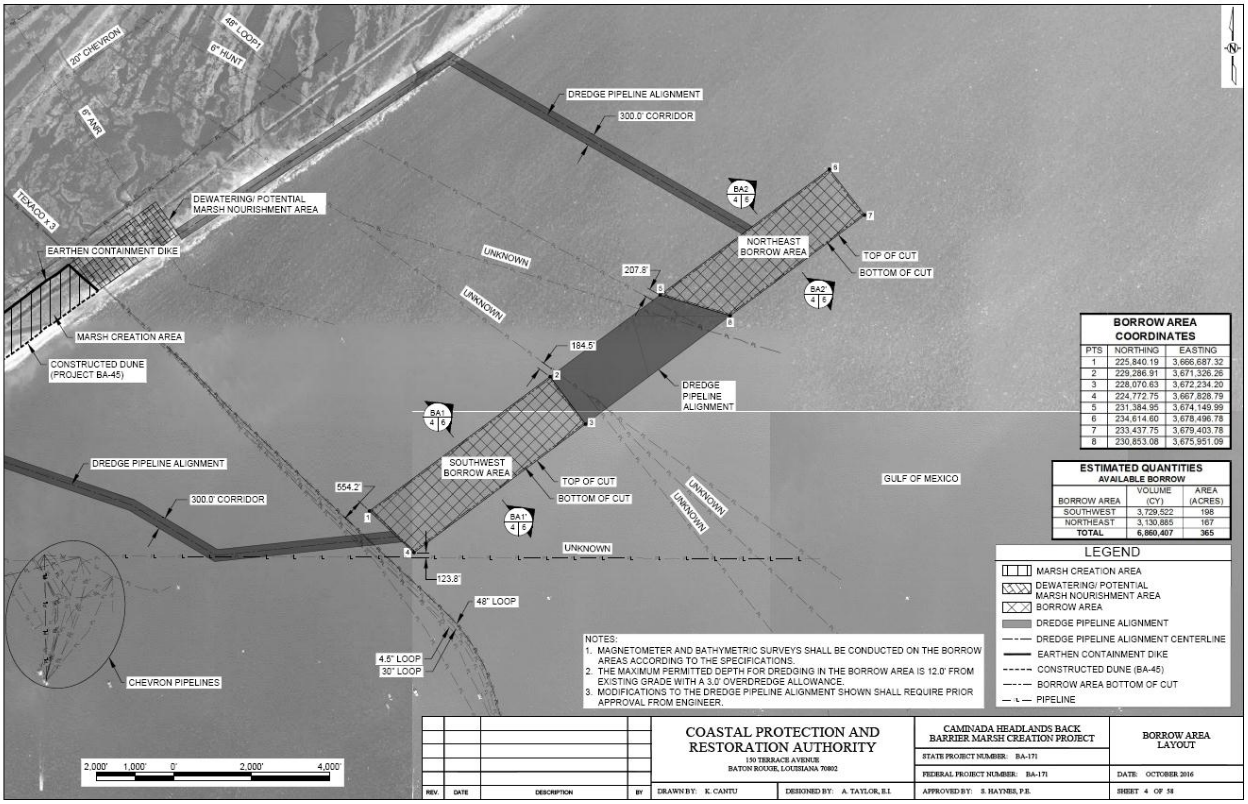

Figure 13: Plan view of proposed borrow areas

A cut-to-fill ratio should be applied when placing hydraulically dredged material to account for any lost material during the dredging and dewatering processes. Typically, it takes approximately 1.3 to 1.5 cubic yards of hydraulically removed material to fill 1.0 cubic yards in the placement area. A cut to fill ratio of 1.5 was applied to determine the needed cut volume for the borrow area. A summary of in-place fill and cut volumes is found in Table 8 in Section 7.1.

A maximum cut depth of 12 feet was determined to be sufficient to ensure adequate volume would be available while also ensuring there would be no impact on the existing shoreline as discussed in Section 5.0. Cross-sectional areas of each transect in the borrow area were calculated using the data collected in the borrow area survey to compute average end area. The available volume of material, without the 3 foot overdredge volume, within each of the two potential borrow areas was then calculated using these areas and the results of those calculations can be found in Table 10. For additional information refer to the detailed soil boring logs in Appendix C.

Table 10: Proposed borrow area acreages and volumes

Borrow Area	Area (Acres)	Available Volume (CY)
Southwest	198	3,729,522
Northeast	167	3,130,885
Total	**365**	**6,860,407**

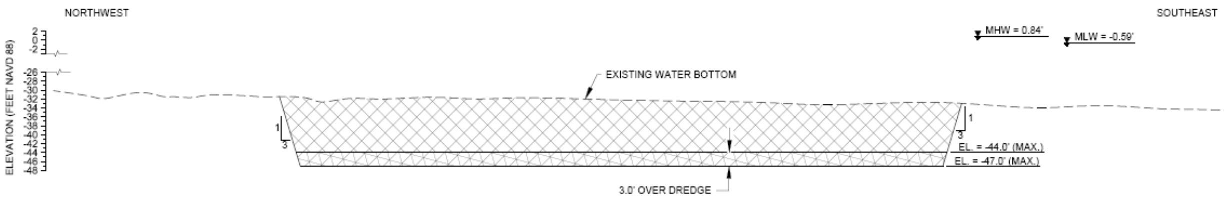

Figure 14: Borrow Area typical section

7.4 Dredge Pipeline Alignment Design

As with the proposed borrow area, dredge pipeline alignments were investigated prior to the BA-171 project's inception. During the Caminada Headland Beach and Dune Restoration Increments I and II projects, dredge pump out areas were surveyed to offer the construction contractor the option to anchor hopper dredge or scow barges for offload to the Caminada Headland via sediment delivery pipeline. Two of these pump out areas were in close proximity to the borrow area and offered an alignment onto the Headland. Just as with the borrow area, these locations were free of any culturally significant areas.

Along with the two pump out locations and the corresponding dredge pipeline alignments, a third dredge pipeline alignment was investigated in order to provide options for the Contractor. During the geophysical survey, an area within the alignment was determined to potentially have a culturally sensitive area and without further investigation, that alignment would not be available for use. An alignment connecting the two borrow areas is available for use in order to give the Contractor flexibility to utilize material in either borrow area without having to move the dredge pipe. Due to the presence of pipelines within this area, the dredge pipeline will have to remain floating at all times between the two borrow areas.

7.4.1 Caminada Beach and Dune Crossing

Dredge pipeline access to the back barrier marshes from the borrow area can only be accomplished by crossing the newly constructed Caminada Beach and Dune Increment 1 (BA-45) Project. Through coordination with the BA-45 project team, a 50 ft wide corridor location was determined to allow the dredge pipeline crossing. This 50 ft wide corridor will be returned to existing conditions upon the completion of the BA-171 project.

7.4.2 Arrowhead/Harvest and Chevron Pipeline Crossings

Due to the presence of the Arrowhead/Harvest pipelines and the Chevron pipeline in the marsh fill area, the dredge pipeline will be required to remain floating over those pipelines so as not to disturb the soils above the pipelines. To accomplish this, pontoons will be used to float the dredge pipeline above the oil and gas pipelines. The pontoons are easily moveable allowing the Contractor to move the dredge pipeline as needed throughout construction. Figure 15 shows a detail of the proposed pipeline crossing.

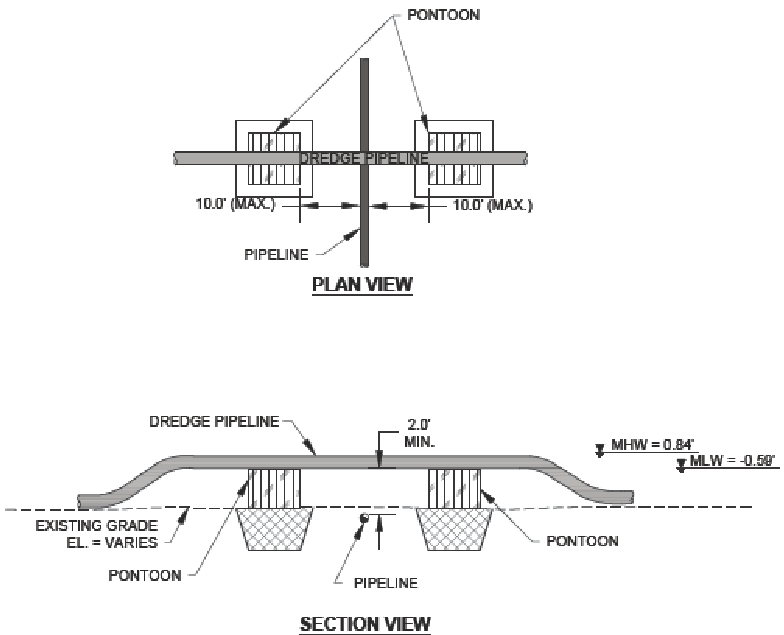

Figure 15: Dredge pipeline crossing

8.0 CONSTRUCTION

8.1 Duration

An approximate construction duration was developed using the CDS Dredge Production and Cost Estimation Software (Texas A&M 2015) and Microsoft Project. Assuming the construction of the containment dikes will be completed prior to dredging, the time to fill the marsh creation fill area would take approximately 6 months to complete using a 30 inch hydraulic cutter head dredge and incorporating weather days. The estimated total construction time from mobilization to demobilization is approximately 1 year.

8.2 Final Opinion of Probable Construction Costs

A Final Opinion of Probable Construction Cost was prepared for this project using the CWPPRA PPL 26 spreadsheet. The estimated construction cost including a 25% contingency is $25,080,070.

8.3 Risk

Engineering Design Documents, Plans, and Specifications, were prepared by or under the direct supervision of a licensed professional engineer and registered in the state of Louisiana following professional engineering standards as per La. R.S. Title 37, and Louisiana Administrative Code Title 46, Part LXI, Professional and Occupational Standards, as governed by the Louisiana Professional Engineering and Land Surveying Board. The engineering analyses effort completed for this final design report provides guidance and insight pertaining to the construction of the proposed project features based on the data acquired to date, and shall not be used for bidding. These documents are not to be used for construction, bidding, recordation, conveyance, sales, or as the basis for the issuance of a permit.

9.0 MODIFICATIONS TO APPROVED PHASE 0 PROJECT

As a result of Phase 1 activities, the features originally approved in Phase 0 have been modified to present a more constructible and competitive project for consideration of Phase II funding. Specific modifications include the merging of two marsh creation fill areas into one continuous fill area immediately adjacent to and landward of the newly-constructed Caminada Headland Beach and Dune Increment I project (BA-45). Creating a continuous marsh platform behind the beach and dune allows for the migration of the beach and dune to the north while still protecting the infrastructure and cities to the north. After maneuvering around constraints such as oil and gas infrastructure and deep water areas, the marsh fill area acreage decreased from 430 acres to 385 acres. Based on the acquisition of data and the engineering analysis as specified in this preliminary design report, the current project configuration of features provides a more constructible project.

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Appendix A:
Secondary Monument Data Sheets and CRMS Survey Reports

Appendix B:
MPH Survey Drawings and Geophysical Report

Appendix C:
GeoEngineers Soil Boring and CPT Logs, Eustis Vibracore Logs

Appendix D:
Preliminary Cultural Resources Determination

Appendix E:
Preliminary Design Drawings

Appendix F:
Calculations Package

Appendix G:
Hazardous, Toxic, and Radioactive Waste Report

Appendix H:
CEC Borrow Area Wave Modeling Report

Appendix I:
Responses to 30% Design Comments