PRELIMINARY DESIGN REPORT
LABRANCHE EAST MARSH CREATION PROJECT
(PO-75)

ST. CHARLES PARISH, LOUISIANA
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United States Department of Agriculture

Coastal Protection and
Restoration Authority of Louisiana

COASTAL WETLANDS PLANNING, PROTECTION, AND RESTORATION ACT

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NATURAL RESOURCES CONSERVATION SERVICE

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1.0 INTRODUCTION

The Labranche East Marsh Creation Project PO-75 is located in the Pontchartrain Basin between the south shore of Lake Pontchartrain and Interstate 10 as shown in Figure 1. The Coastal Wetlands Planning, Protection, and Restoration Act (CWPPRA) Task Force approved PO-75 Labranche East Marsh Creation for engineering and design as part of the 19th Priority Project List in January 2010. The United States Department of Agriculture – Natural Resources Conservation Service (NRCS) was designated as the lead federal sponsor for this project with funding approved through CWPPRA by the United States Congress, and the Wetlands Conservation Trust Fund by the State of Louisiana. The State of Louisiana's Coastal Protection and Restoration Authority (CPRA) is serving as the non-federal sponsor. NRCS is the lead agency on engineering and design of the project. NRCS's standards and procedures for design will be used.

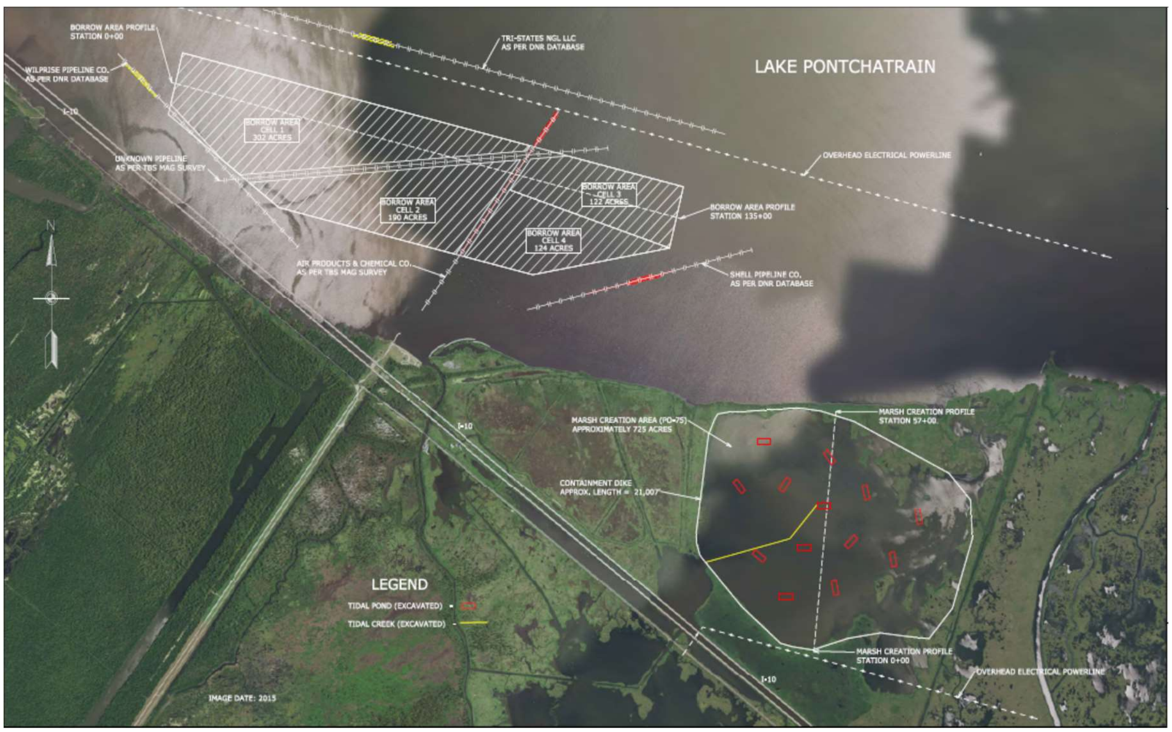

Figure 1. Proposed Project Area and Features

The project team, consisting of members of NRCS and CPRA performed a kick-off meeting on June 6, 2006. Based on that meeting, a plan was developed to identify and address all of the project requirements. The engineering and design, environmental compliance, real estate negotiations, operation/maintenance planning, and cultural resources investigations have been completed to the 30% level as required by the CWPPRA Standard Operating Procedure.

Dredging of access and flotation canals for the construction of Interstate 10 (I-10) resulted in increased salinity and altered hydrology that exacerbated the conversion of wetland vegetation into shallow open water bodies. Without action, these effects will continue to worsen, deepening the area and potentially contributing to shoreline breaching. Creating and nourishing the marsh will aid in prevention of land loss by reducing tidal exchange throughout the area and providing a platform for growth of emergent vegetation. The project would also provide synergistic benefits with several other protection and restoration projects in the immediate vicinity. Directly to the west of the proposed project is the PO-17 project, one of the first CWPPRA projects to successfully build marsh using dredged material. Immediately north of the project is the PO-3b Labranche Shoreline Protection Project. In addition, the U.S. Army Corps of Engineers has several hurricane protection efforts in the area. All the projects will help to protect the vulnerable I-10 corridor and Canadian National (Illinois Central) Railroad just south of I-10.

The restoration strategy for this project is hydraulic dredging for marsh creation and marsh nourishment. The proposed marsh creation/nourishment will be achieved by mining sediment from Lake Pontchartrain to fill open water and mud flat areas. Based on a 2016 USGS aerial photography analysis, approximately 657 acres of open water will be filled and 69 acres of existing marsh will be nourished as part of the project.

Topographic and magnetometer surveys and a geotechnical investigation have been completed for the marsh fill area and for the borrow areas. This information was used to calculate volumes of material required, and to evaluate the immediate and long-term properties of the marsh fill material. Additionally, an analysis has been performed to determine mean high water, mean low water, and mean water elevations in the fill area.

2.0 ENVIROMENTAL CONSIDERATIONS

The goal of Labranche East Marsh Creation Project (PO-75) is to restore the marsh that has been converted to shallow open water. Project implementation would result in an increase of fisheries and wildlife habitat acreage, diversity, and improvement of water quality. The proposed project would provide storm buffer protection to I-10, the region's primary westward hurricane evacuation route, and to a lesser degree, the Canadian National (Illinois Central) Railroad line. The currently proposed project includes a total of 657 acres of area identified for marsh creation, and an additional 69 acres of marsh nourishment for a total of 726 acres.

The project area is primarily shallow open water classified as intermediate salinity. Submerged aquatic vegetation is prevalent throughout. The dominant species is *Ruppoa maritima* (wildgeongrass) with *Myriophyllim spicatum* mixed in (watermilfoil).

Salinity in the project area is based on CRMS 2830 monitoring site located in the southern section of the project area. The site is characterized as intermediate with dominant taxa listed as *Spartina patens* (wiregrass) and a significant presence of *Sagittaria lancifolia* (bulltongue).

All of these environmental parameters were taken into consideration to determine the benefits of creating the marsh creation area. Past projects around the area were analyzed to determine if a marsh creation project would be successful. For more information on the environmental considerations of PO-75 Labranche East Marsh Creation Project see Appendix J.

3.0 TIDES AND WATER LEVELS

Calculations performed during the design of PO-75 Labranche East Marsh Creation include the determination of the mean high, mean low water, and mean water elevations (NAVD 88) for CRMS 2830. All elevations used in the calculations are referenced to Geoid 2003. The water levels from CRMS 2830 were also used to calculate the inundation at 90% and 10%, which is recommended by CPRA's *Marsh Inundation Methodology and Guidance for the Design of Marsh Creation Projects,* for a marsh that is determined to be of intermediate salinity. The relative sea level rise was calculated using CPRA's RSLR spreadsheet. The inundation of the marsh is critical to insure that the project is designed and built to sustain a healthy marsh and allow appropriate tidal exchange. The water level and inundation for PO-75 are shown in Table 1. A more detailed summary of how this was calculated is shown in the Design Calculations located in Appendix F.

Table 1. Summary of Water Level and Inundation

Calculated Values	ELEV. FT NAVD 88
Mean High water from CRMS 2830	1.21
Mean Low Water from CRMS 2830	0.21
Mean Water Level from CRMS 2830	0.68
Mean Range from CRMS 2830	1.00
10% Inundation of marsh at year 1	-0.08
90% Inundation of marsh at year 1	1.50
10% Inundation of marsh at year 20 (includes relative sea level rise)	0.68
90% Inundation of marsh at year 20 (includes relative sea level rise)	1.65

4.0 SURVEYS

Labranche East Marsh Creation Project had topographic, bathymetric, and magnetometer surveys performed within the marsh fill area to facilitate the design of the project. In addition, bathymetric and magnetometer surveys were performed in Lake Pontchartrain to delineate a suitable borrow area.

4.1 Secondary Monument

An existing secondary monument was located near project site and used for vertical and horizontal control for the surveys. The existing secondary monument details are shown below in Table 2. Monument data sheets can be found in Appendix A.

Table 2. Existing Secondary Monuments

Station Name	876 2372 F TIDAL
Northing	565201.14
Easting	3586265.31
Latitude	30° 03’02.36528” N
Longitude	090° 22’04.43598” W
NAVD 88 Elevation	1.71 feet (0.520 meters)
Geoid	2003

4.2 New Secondary Monument

The new monument PO-75-SM-01 was installed in June 2017. This monument will serve as another control for PO-75 Labranche East Marsh Creation for both the marsh creation area and the borrow area during construction. The monument details are shown in Table 3. The monument data sheet can also be found in Appendix A.

Table 3. New Secondary Monuments

Station Name	PO-75-SM-01
Northing	567341.754
Easting	3585346.929
Latitude	30° 03’23.63147” N
Longitude	090° 22’14.68128” W
NAVD 88 Elevation	4.376 feet (1.33 meters)
Geoid	2003

4.3 Fill Area Surveys

NRCS contracted T. Baker Smith to perform all topographic and magnetometer for the proposed project. A Trimble model R7/ R8, and Trimble TSC-2 data logger was used to perform the surveys. When the Trimble equipment was not an option, conventional survey equipment was used, i.e., surveyors tape and level. A Klein Model 3000 side scan sonar and a Marine Magnetics SeaSPY marine magnetometer with a Trimble Model DSM 232 global positioning receiver was used to perform the magnetometer survey. Control for all surveys used for design was monument 876 2372 F TIDAL. This work was completed in September 2010. The survey baseline was established through the proposed marsh creation area in a southwest - northeast orientation. The survey transects for the topographic surveys intersect the baseline at 500 foot intervals. Elevations were recorded at 25 foot intervals or less when topographic features that may have an influence on the project were discovered. Thirty-one additional surveys were taken at various bayous, cuts, and tidal openings connected to the marsh creation area. The survey layout and survey details are shown on the T. Baker Smith survey drawings located in Appendix B.

In December 2017, surveys were conducted by NRCS to check the elevations of the project site to insure that the area hasn't drastically changed. Eight (8) transects within the marsh creation area were taken, which is 20% of the original surveys. The transects are labeled the same as when T. Baker Smith took the surveys and are as follows, smc-37, 31, 26, 22, 19, 14, and sdl-10, and 8. The September 2010 and December 2017 data for the eight transects were compared using statistical analysis, which was a T-test. The T-test showed that there is some significant difference between the original surveys and NRCS surveys for sections smc-37, 31, 26, 22, and 14. However, the difference showed some elevation decrease, meaning some areas are shallower than previously recorded. Therefore using the September 2010 T. Baker Smith surveys will be more conservative when calculating the volume of fill for containment dike and marsh creation platform. Sections smc-19, sdl-10, and 8 had no significate difference between the two sets of data. Appendix F shows the comparison of the surveyed transects.

The magnetometer survey transects of the marsh creation area were spaced at 500' intervals and oriented to provide complete coverage of the area. There was no significant magnetic anomalies within the marsh creation area to show pipelines or other avoidance areas. PVC markers were found; however, they seemed to have been placed by locals to mark boat travel lanes.

Average healthy marsh elevation surveys were conducted at nineteen (19) predetermined locations. These surveys consisted of three surveyed measurements around each location utilizing the same equipment used to acquire the elevations in the marsh creation areas. Shots were taken at the top of the plant's root mass. Average marsh elevations for each location were derived by using the following procedure: (sum of elevations at location number divided by the total number of elevations at same location number = Average Elevation). The average marsh elevation survey are provided in Appendix B. The overall average marsh elevation from the shots was determined to be 0.82' NAVD88.

In December 2017, NRCS conducted additional surveys to determine the elevation at which emergent marsh transitions to mud flat and/ or open water. The survey team looked for areas that provided a gradual slope in order to determine this transition. Fortunately, during the winter month's tides are sometimes lower than normal allowing the team to better locate a gradual slope between emergent marsh and exposed mud flats. That elevation of emergent marsh was determined to be 0.26 ft. NAVD 88, Geoid 03. This elevation is referred to as the lower limit marsh elevation. Appendix F shows the calculations for the lower limit marsh elevation. Table 4 shows the average healthy marsh elevation and lower limit marsh elevation.

Table 4. Average Healthy Marsh Elevation Survey Results

Conducted Surveys	Average Elevation (feet)
Average Healthy Marsh Elevation (19 Sites; 2010 Survey)	0.82
Lower Limit Marsh Elevation (2017 Survey)	0.26

4.4 Borrow Area Surveys

Bathymetric surveys were performed within the Lake Pontchartrain borrow area using a 24-foot survey vessel, and data was collected using Hydrotrac digital echo sounder with HYPACK MAX survey navigation software in conjunction with the Trimble RTK GPS unit. The water bottom elevation data obtained from these surveys were used for determining borrow/dredge operation volumes. The water bottom elevation ranges between -5' to -12'. The track lines were spaced in an east to west configuration at 250' intervals.

Magnetometer surveys were performed in both the borrow area and the marsh creation area. A total of 284 magnetic anomalies were reported in the survey area, with the majority of these anomalies determined to be crab traps placed by local fishermen. The survey confirmed the location of the Shell Pipeline Company pipelines that was reported in the LDNR pipeline data base. The survey located two pipelines not reported in the LDNR data base (Air Products and Chemicals, Inc. and an unknown owner pipeline). The survey did not located the Wilprise Pipeline Company pipeline that was reported in the LDNR data base. Additionally, there is a Tri-States pipeline, NGL pipeline LLC running to the north of the borrow area that is located north of the surveyed area. The construction drawings will identify 100-foot buffer zones on both sides of all reference pipelines within the borrow area, to prevent the dredge from hitting any of the pipelines. Details of these surveys are shown on the T. Baker Smith survey drawings located in Appendix B.

5.0 GEOTECHNICAL EVALUATION

In order to determine the suitability of the soils in the PO-75 Labranche East Marsh Creation Project area for the proposed marsh creation feature, geotechnical subsurface investigations, and analyses were performed by GeoEngineers initially completed on Nov 2010. GeoEngineers collected soil borings for both the marsh creation and the borrow area, and performed laboratory tests to determine soil characteristics on those samples. In addition to standard laboratory testing, settling column tests and self-weight consolidation tests were completed to further analyze material behavior. Following all testing, analyses were completed to determine consolidation of the marsh fill material, stability of the containment dikes, settlement of the containment dikes, and borrow to fill ratios for dredge and fill operations.

Due to concerns regarding constructability raised in the initial geotechnical report, a pilot study was conducted to determine feasibility of the project. The pilot study consisted of 3 small marsh creation cells to compare the constructability and performance of fully-contained earthen containment, semi-contained earthen containment, and the Net Gains Sediment Containment System. The pilot study also allowed for measurement of actual fill height settlement. Upon request, more information can be furnished on the pilot study. After the completion of the pilot study, NRCS tasked GeoEngineers to determine settlement with fill elevations of 3.0 and 3.5 feet and to update the geotechnical report, which was completed in May 2017. A summary of the geotechnical subsurface investigation and analyses is presented below. The geotechnical investigation report prepared by GeoEngineers can be furnished upon request.

5.1 General Geologic Evaluation

The northern part of the Louisiana coastal zone consists of older, elevated sedimentary units to the north that slope seaward further to the south underneath the newer Holocene sediments. Throughout the delta plain of south Louisiana, Pleistocene muds and stiff clays underlie Quaternary (Holocene) deposits and are typically denser than the overlying sediments due to compaction. Labranche is within an area of Delta Plain and Saline Marsh deposits of the Holocene Age. Areas such as this have some variability, but are typically weak and compressible. Shallow sediments are usually made up of peat deposits, soft organic clays, soft clays and loose silts that grade better with depth.

5.2 Soils Investigation

A total of eight (8) subsurface borings were taken by GeoEngineers in the borrow area. The borrow area borings showed a significant amount of clay with some silt mixed for borings BHBA 1-3; while BHBA 4-8 showed interbedded layers of silt, sand, silty sand, sandy silt, and clay. Shells were present in many of the borings at both the mudline and deeper. BHBA-8 was drilled in the area of the borrow area for PO-17. The boring showed more organic clay than was present in the other borings; however borings from PO-17 showed the same stratification as BHBA 4-7 of PO-75 East Labranche Marsh Creation Project.

Seven of the eight borings taken in the marsh creation area and were drilled to depths of thirty (30) feet. BHMC-4 boring was terminated at 80 feet below mudline. All eight (8) borings encountered a peat layer between 5 to 12 feet thick followed by organic clay and clay intermixed with silt and sand seams or layers sometimes several feet thick. The peat and organic clay will be the controlling factor moving forward during design. Figure 2 shows all boring locations taken for the project.

The soil samples were tested in the laboratory for classification, strength, and compressibility. Testing included: field or miniature vane, unconfined compression, unconsolidated undrained triaxial compression, Atterberg limits, grain size distribution, consolidation, settling column, and self-weight consolidation. The boring logs for PO-75 East Labranche Marsh Creation Project can be found in Appendix D.

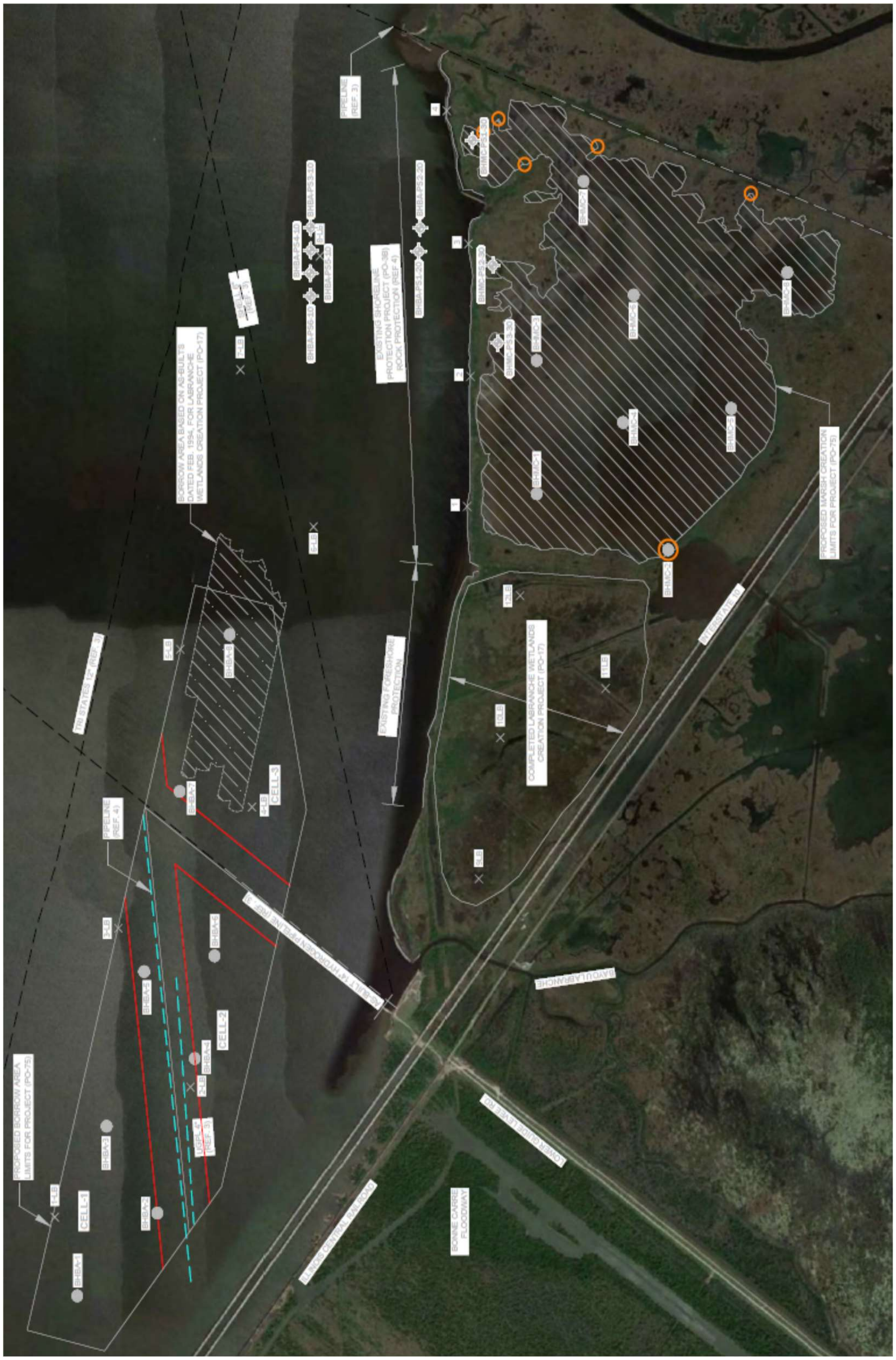

Figure 2. Soil Boring Locations

5.3 Global Slope Stability Analysis for Containment Dikes

GeoEngineers performed slope stability to give NRCS the failure point of the containment dike parameters. The analysis was conducted using an elevation of 0 feet and a factor of safety of 1.3. From the analysis GeoEngineers determined that, at a minimum, the earthen containment dikes should have a slope of 3H: 1V, and a 5 foot crown, and their containment dike typical section (Figure 3) suggest a maximum crown elevation of 5 feet. To prevent losses of dredged material, CPRA recommends one foot of freeboard above the anticipated marsh fill elevation for design of containment dike; therefore, crown height will be determined once a fill elevation is selected. The lower limit of excavation for the borrow area for the containment dike was calculated to be at an elevation of -15 ft.

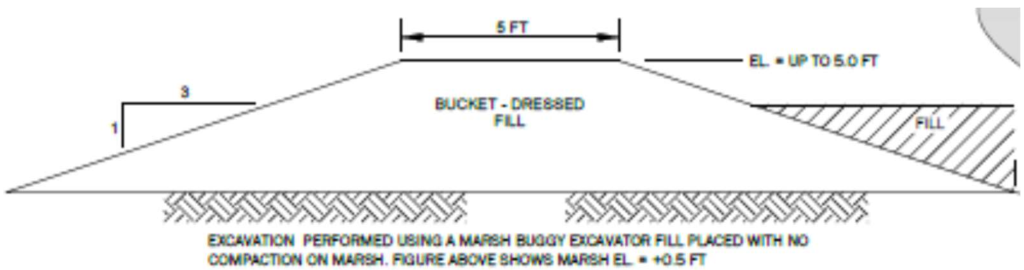

Figure 3. Containment Dike Typical Section

GeoEngineers was also tasked by NRCS to provide alternative containment designs for deep water areas throughout the project site. GeoEngineers provided 2 alternatives that could be used as an alternative to earthen containment. Gabions and Geotubes were the two alternatives provide by GeoEngineers. These will be discussed in greater detail later in this report.

5.4 Marsh Fill Settlement Analysis

NRCS tasked GeoEngineers to conduct a marsh fill settlement analysis to determine the construction fill height required to achieve the design marsh elevation. Settlement and self-weight consolidation tests were performed using samples collected in the marsh fill and borrow area along with the results from the pilot study. In order to accurately quantify cumulative settlement, GeoEngineers used the Army Corps of Engineers (USACE) program, primary consolidation, secondary compression, and desiccation of dredged fill (PSDDF). The program considers settlement of the underlying soils from placement of the fill material above and the self-weight consolidation that occurs within the fill material itself. Properties of the underlying soils were obtained from the laboratory tests conducted on the borings taken by GeoEngineers. Properties of the fill material were obtained from self-weight consolidation testing and index testing on the borings taken. In addition climatic data must be considered and added into PSDDF. Time rate of settlement was first analyzed for fill heights of +2.0’, +2.5’, +4.0’, and +4.5’ NAVD88. As described above, GeoEngineers was later tasked to analyze fill heights of +3.0 and +3.5 NAVD88. The summary of 20 year marsh fill settlement is shown below in Table 5. Figure 4 shows the average high water level, average low water level, 90% inundation, 10% inundation, healthy marsh elevation of 0.82', lower limit marsh elevation of 0.26', and the average settlement curve for each fill height elevation. Water and inundation levels are adjusted for relative sea level rise over the 20-year project life. Settlement curves are located in Appendix (E).

Table 5. Summary of 20 Year Marsh Fill Settlement

Starting Elevation (NAVD88)	Total Settlement at Year 20	Projected 20 Yr. Fill Elevation (NAVD88)
+4.5'	3.3'	+1.2'
+4.0'	3.0'	+1.0'
+3.5'	2.7'	+0.8'
+3.0'	2.3'	+0.7'
+2.5'	2.0'	+0.5'
+2.0'	1.7'	+0.3'

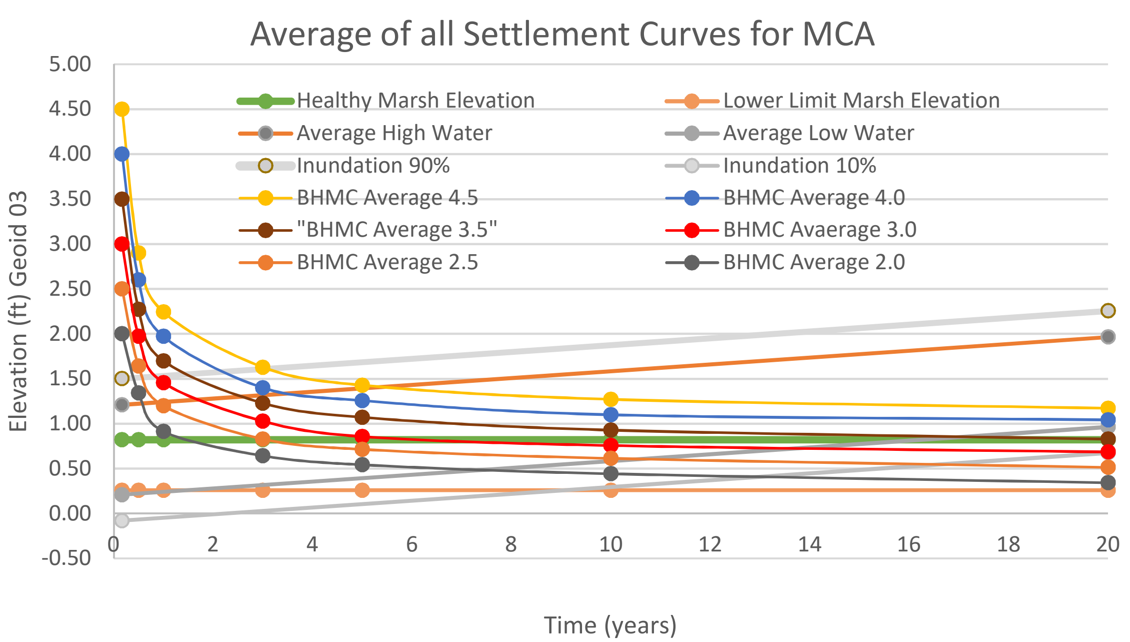

Figure 4. Marsh Fill Settlement Curves

6.0 MARSH CREATION DESIGN

A critical component of the design for PO-75 Labranche East Marsh Creation Project is the calculation of the fill area volume. This volume is governed by several factors including desired marsh elevation, the physical properties of the borrow materials, and the bearing capacity of the foundation soils in the marsh creation area. The elevation of the marsh dictates the type and amount of vegetation that is supported, and ultimately the health of the marsh. To aid in selecting the construction fill elevation, GeoEngineers was tasked to determine settlement of marsh creation fill.

6.1 Borrow Site Design

The borrow site was broken down into 4 areas: Cells 1, 2, 3, & 4 (Figure 1) because of the wide range of depths, -5 feet to -12 feet and to accurately calculate the available material, Cell 3 was broken into two separate cells. The total volume calculated in the borrow site is 16 million cubic yards. The calculations are provided in the Design Calculation Packet located in Appendix (F). The cells will be excavated to a depth of -22 feet in the following order: Cell 1, 2, 4, and 3. The main reason for excavation of material in this order is to avoid using the replenished material in Cell 3, from which PO-17 project material was obtained, unless necessary. The borings within Cell 3 do not show the same properties as the other cells and the material contained more organic clay as compared to a mixture of silt, sand, silty sand, and clay based on GeoEngineers report.

6.2 Preliminary Alternative Analysis

Due to concerns regarding construction costs, NRCS evaluated thirteen alternatives using multiple combinations of fill height, project size (ranging from 279 acres to 749) acres, containment dike alignments, and spill box / spill way options. See Appendix G. Subject to additional evaluations and refinements described below, this analysis confirmed the viability of a large scale project (~639 acres of marsh creation) versus downsizing.

6.3 Constructed Fill Elevation

In selecting the constructed fill elevation, the goal is to provide a marsh platform that stays within the optimal inundation range (between 10% and 90% inundation levels) for the majority of the project life. In order to achieve this, the marsh platform must be constructed above the optimal inundation range, and be allowed to settle or consolidate into that range in the years following construction. For this project, additional information was considered which includes the following:

- Average marsh elevation from the adjacent was determined to be 0.82' NAVD88.
- The lower limit marsh elevation was determined to be 0.26' NAVD 88.
- The PO-75 pilot study fully-contained and partially contained cells were constructed to an elevation of +2.5' NAVD88. Predicted settled elevation at year 3 for those cells was 0.8' NAVD 88. Surveyed elevation for the fully contained cell was 1.2' NAVD at Year 3 and Year 4. Surveyed elevation for the partially contained cell was 1.06' NAVD at Year 3 and Year 4. Appendix F show the calculations for the pilot study. This data indicates that the marsh platform has not settled as much as predicted, and that the elevation seems to have stabilized in the Year 3 – Year 4 timeframe.
- The settlement of the three containment dike heights was calculated and initial settlement shown in Table 6.

Table 6. Calculated Volume for Different Containment Dike Heights

Containment Dike Height including Freeboard	Initial Settlement (foot)	Total Volume Needed for Containment Dike (yds^3)
4.5	1.7	262,751
4.0	1.3	216,855
3.5	1.0	176,697

Using the average of all settlement curves (Figure 4), the design team selected three fill elevations that meet the goal of having a marsh platform that stays within the optimal inundation range (between 10% and 90% inundation levels) for the majority of the project life, as well remaining above the lower limit marsh elevation for the entire project life. The three fill elevations are as follows, 3.5, 3.0, & 2.5 feet NAVD88.

For each of these alternative constructed fill heights, the following sections present and discuss settlement curves for each bore hole for each fill height, provide fill volume estimates, and identify other considerations. AutoCAD Civil 3D 2014 and project site transects were used to determine the average mudline within the project area to calculate the fill volume.

6.3.1 Constructed Fill Elevation of 3.5 (NAVD88)

Figure 5 provides a settlement curve for each borehole for a constructed fill elevation of 3.5 NAVD88. With this fill height, the marsh platform is predicted to remain between the 90% and 10% inundation levels throughout the life of the project (20 years). The settlement curves indicate that the marsh platform will stay above or near the healthy marsh elevation of 0.8' for the majority of the project life as well as staying above the lower limit marsh elevation of 0.26' throughout the project life.

For a constructed fill elevation of 3.5 NAVD88, the volume of fill material needed (including backfill of containment borrow) would be 7,475,755 cubic yards, using a cut to fill ratio of 1.3, and the containment dike elevation would have to be 4.5' NAVD88. Fill volume calculations are located in the Design Calculation Packet located in Appendix (F). The larger volume of fill material needed could increase settlement of the marsh creation area. The containment dike could be susceptible to significant shrinkage due to surface area being exposed to air causing the material to lose moisture. Based on the pilot study more than 2 lifts would be needed to construct the containment dike, and a geotechnical fabric would be needed to stabilize the containment dike for segments constructed in water. Reach for the equipment could be an issue depending the on geometry of containment. Areas that are lower than -2' NAVD88 elevation within the layout of the containment dike could require an alternative containment dike design, i.e. vinyl sheet pile, geotubes, etc. The construction cost estimate with 25% contingency for a fill elevation of 3.5 NAVD88 is $44,742,419.20.

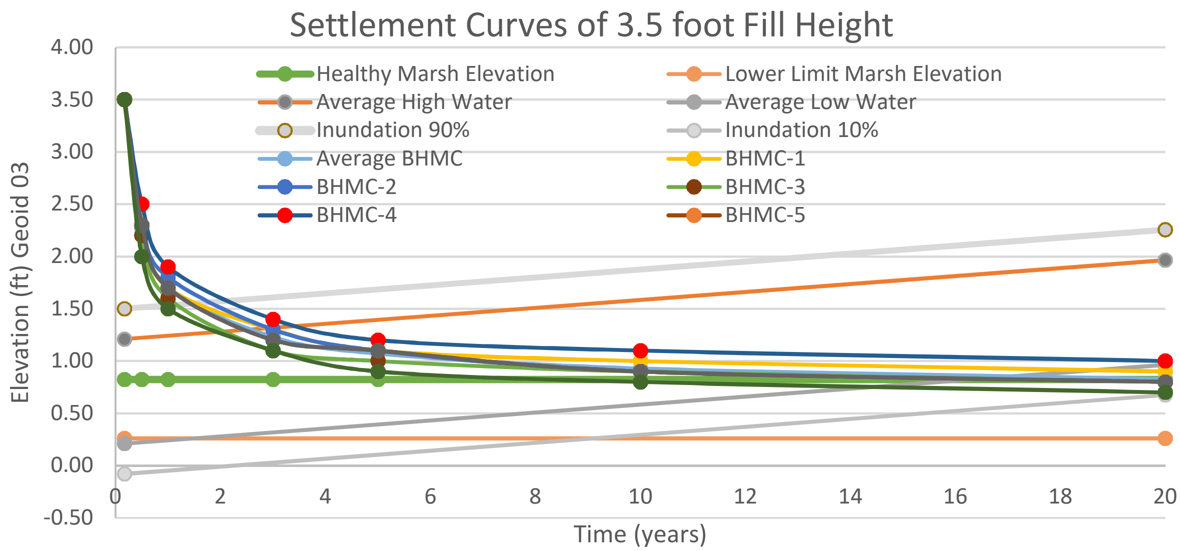

Figure 5. Settlement Curves for 3.5 Foot Fill Height

6.3.2 Constructed Fill Elevation of 3.0' (NAVD88)

Figure 6 provides a settlement curve for each borehole for a constructed fill elevation of 3.0' NAVD. With this fill height, except for one boring, the marsh platform is predicted to remain between the 90% and 10% inundation levels throughout the life of the project (20 years). The settlement curve for individual borings indicate that the marsh platform drop below the healthy marsh elevation of 0.8' between about Years 5 and 18. However, the settlement curve from the individual borings indicate that the marsh platform will stay above the lower limit marsh elevation of 0.26' NAVD for the entire the project life, with Year 20 elevations ranging from about 0.6 to about 0.8 NAVD; these elevations would be capable of supporting emergent marsh vegetation.

For a constructed fill elevation of 3.0 NAVD88, the volume of fill material needed (including backfill of containment borrow) would be 6,682,134 cubic yards, using a cut to fill ratio of 1.3, and the containment dike elevation would have to be 4.0' NAVD88. Fill volume calculations are located in the Design Calculation Packet located in Appendix (F). The containment dike could be susceptible to moderate shrinkage due to surface area being exposed to air causing the material to lose moisture. Based on the pilot study more than 2 lifts would be needed to construct the containment dike, and a geotechnical fabric would be needed to stabilize the containment dike for segments constructed in water instead of relying on alternative containment options. Reach for equipment would not be an issue except in deeper water (bottom elevation less than -2' NAVD88). Areas that are lower than -2' NAVD88 elevation within the layout of the containment dike could require alternative containment dike design, i.e. vinyl sheet pile, geotubes, etc. The construction cost estimate with 25% contingency for a fill height of 3.0 NAVD88 is $40,474,451.00.

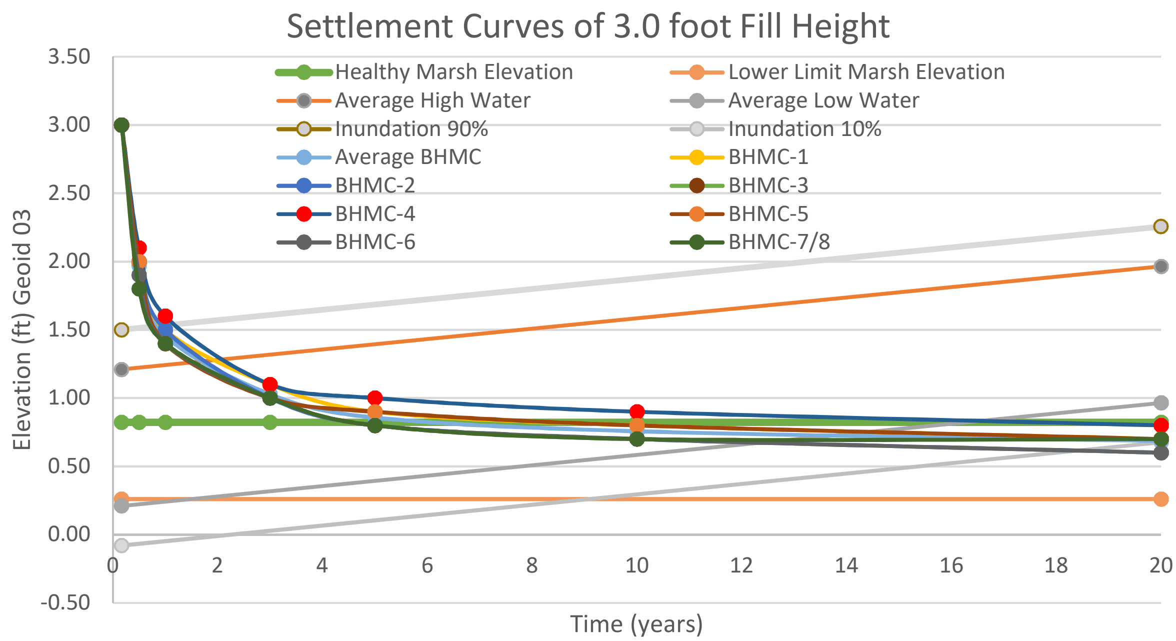

Figure 6. Settlement Curves for 3.0 Foot Fill Height

6.3.3 Constructed Fill Elevation of 2.5’ (NAVD88)

Figure 7 provides a settlement curve for each borehole for a constructed fill elevation of 2.5’ NAVD. With this fill height, the marsh platform is predicted to settle below the 10% inundation level between about Years 14 and 18. The settlement curve for the individual borings indicate that the marsh platform drop below the healthy marsh elevation of 0.8’ between about Year 2 and Year 5. However, all curves indicate that the marsh platform will stay above the lower limit marsh elevation of 0.26’ NAVD for the entire the project life, with Year 20 elevations ranging from about 0.4 to about 0.7 NAVD; these elevations may be capable of supporting some emergent marsh vegetation.

For a constructed fill elevation of 2.5 NAVD88, the volume of fill material needed (including backfill of containment borrow) would be 5,894,280 cubic yards, using a cut to fill ratio of 1.3, and the containment dike elevation would have to be 3.5’ NAVD88. Fill volume calculations are located in the Design Calculation Packet located in Appendix (F). The containment dike shrinkage would be less than for higher fill heights due to a smaller surface area being exposed to air. Based on the pilot study 2 lifts would be needed to construct the containment dike. A geotechnical fabric may sufficiently stabilize the containment dike for segments constructed in the water instead of relying on alternative containment options. Reach for equipment would not be an issue except in deeper water (bottom elevation less than -2’ NAVD88). Areas that are lower than -2’ NAVD88 elevation within the layout of the containment dike could require alternative containment dike design, i.e. vinyl sheet pile, geotubes, etc. The construction cost estimate with 25% contingency for a fill height of 2.5 NAVD88 is $36,219,720.54.

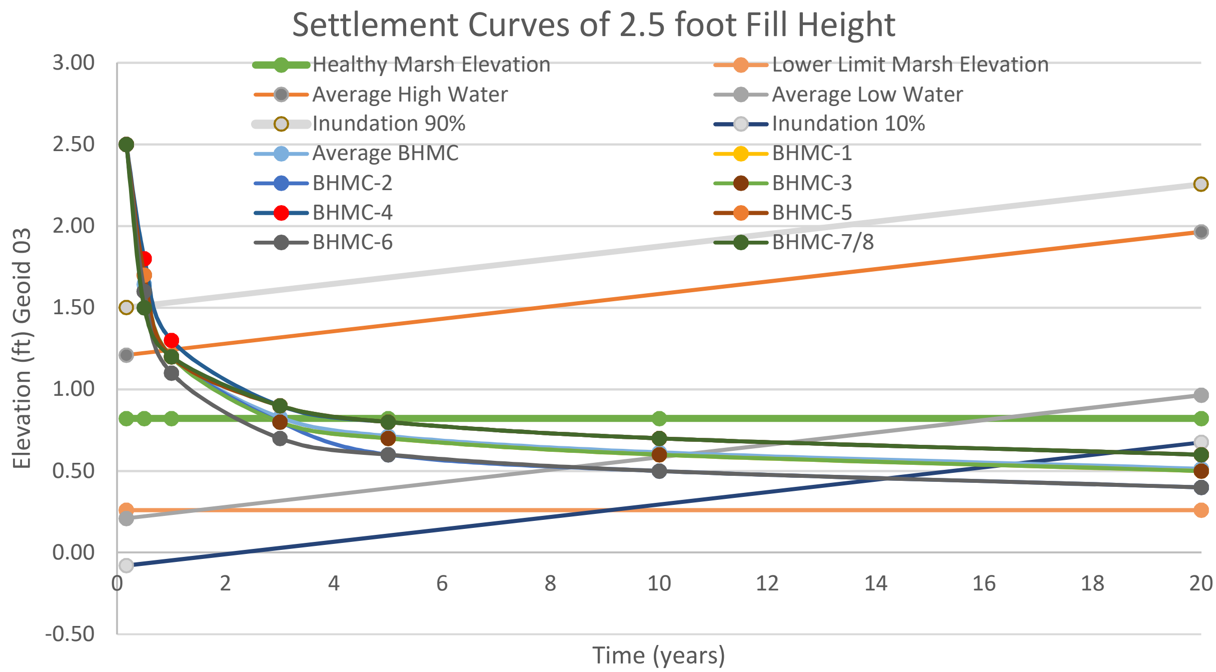

Figure 7. Settlement Curves for 2.5 Foot Fill Height

6.4 Best Constructed Fill Elevation

The constructed fill elevation of 2.5' NAVD does not appear to achieve the goal of having a marsh platform that stays within the optimal inundation range (between 10% and 90% inundation levels) for the majority of the project life, and the marsh platform approaches the lower limit marsh elevation toward the end of the project life. This alternative is eliminated.

The constructed fill elevations of 3.0 and 3.5' NAVD would both achieve the goal of having a marsh platform that stays within the optimal inundation range (between 10% and 90% inundation levels) for the project life, and with either fill height, the marsh platform will stay above the lower limit marsh elevation of 0.26' NAVD for the entire the project life, with Year 20 elevations ranging from about 0.6 to about 0.8 NAVD. These elevations would be capable of supporting emergent marsh vegetation.

Given the results of the pilot study where the observed year 3 elevation was considerably higher than the predicted elevation, the constructed fill elevation of 3.0' NAVD can be expected to yield a marsh platform that would support emergent vegetation throughout the project life. Additionally, containment dikes for a constructed fill elevation of 3.0' NAVD would be easier to construct and maintain compared to those needed for a constructed fill elevation of 3.5' NAVD. Lastly, the construction cost estimate including 25% contingency for a constructed fill elevation of 3.0' NAVD would be $4,267,968.20 less than for a constructed fill elevation of 3.5' NAVD. This reduction in cost is contributed to reducing the amount of material needed to construct the containment dike and fill marsh.

For these reasons, the project team selects a constructed fill elevation of 3.0' NAVD as the best construction fill elevation.

6.5 Containment Dike Design

The primary design parameters associated with the containment dike design includes crown elevation, crown width, side slopes, berm width, and depth of borrow area. NRCS had GeoEngineers determine the limit of these parameters. Slope stability was performed using GeoSlope and hand calculation to verify the program. GeoEngineers recommended the containment dike have a 5 foot crown width with a total height of 5 foot and a 3H: 1V slope. The borrow area for the containment dike was designed with a 15 foot berm, 3H: 1V side slope and a lower limit of excavation of -15 feet. The layout of the containment dike is shown in Figure 8. The project team determined that a containment dike placed on the marsh as much as a practicable would allow for the best constructible containment dike possible. By doing so the project team also minimized multiple deep areas that would require installation of an alternative containment which would increase construction cost.

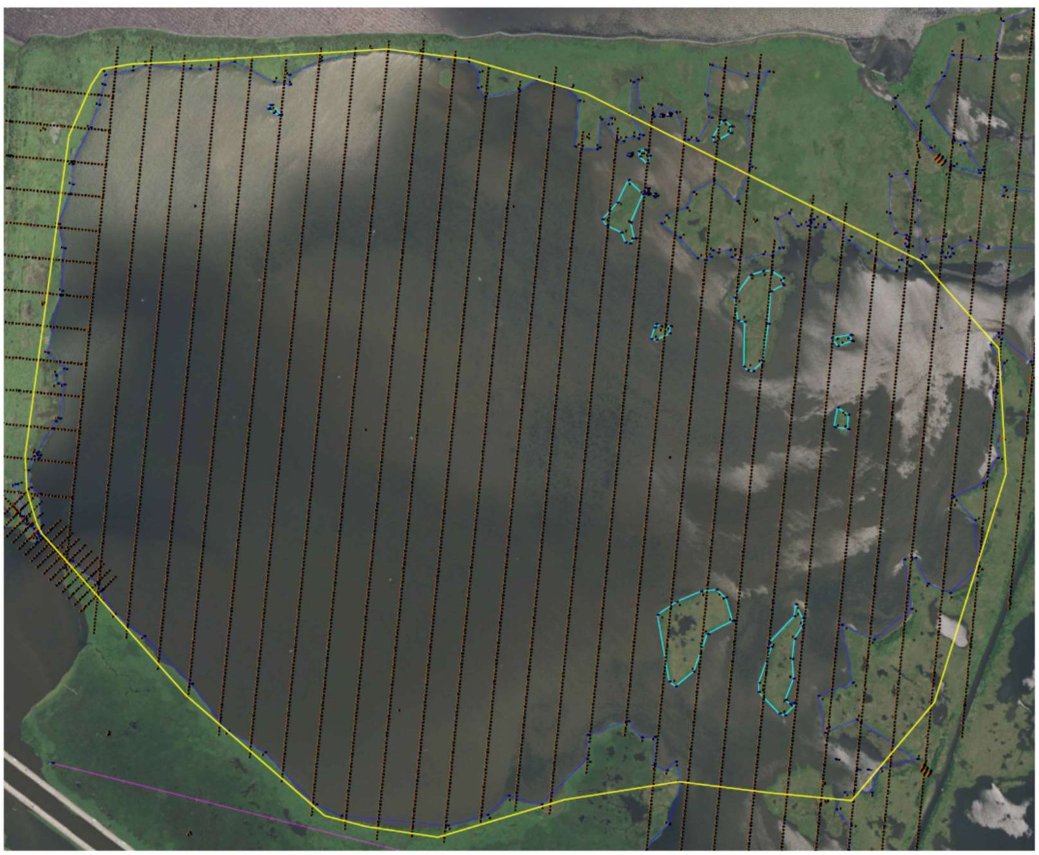

Figure 8. Plan View of Containment Dike

After discussing the proposed containment dike design with CPRA, it was recommended by CPRA to rerun the stability analysis of the containment dike. GeoEngineers ran the stability analysis using 0' mudline elevation and a 5' elevation of the containment dike. Due to the mud line of -2 feet for the open-water sections and a 3.5' foot elevation for fill height that place the containment dike outside the range of slope stability analysis conducted by GeoEngineers. Also NRCS and CPRA wanted to determine if geotechnical fabric would allow for a greater stability of containment dike to be used with a marsh fill of 3.5' and any areas that could require alternative containment dike. CPRA analyzed the containment dike for slope stability at an elevation of 4.5 with 4H: 1V slope and 5 foot crown. Based on the analysis of the containment dike the factor of safety for stability is 1.95 during construction of containment dike and 1.295 once the fill has been pumped into the cell. During construction of the dike using geotextile fabric at an elevation of 0.8'was recommend based on the analysis. From CPRA's Slope Stability analysis the containment dikes would be stable for elevation under 3.5'. The information was use to insure initial stability of containment dike in water sections and more analysis will need to be conducted and finalized prior to 95% design review meeting. See Appendix F for stability runs.

7.0 DEEPWATER ALIGNMENT DESIGN

For areas of deeper water (< -2 foot NAVD), along the containment alignment, there is a need for an alternative to an earthen dike due to the poor soil conditions. Based on GeoEngineers recommendation, previous projects, and historical knowledge, three alternatives were chosen to be analyzed. GeoEngineers recommended the use of gabions or geotubes, while NRCS added a vinyl sheet pile wall as the third alternative. Each alternative was analyzed to determine, which was the most suitable for this project. Using pros, cons, soil characteristics, and constructability as criteria for selecting the best alternative design.

7.1 Gabions

Gabions were considered due to the fact that they can be stacked to achieve desired height and provide light weight alternative due to the poor soil conditions. Gabions also provide flexibility when mudline elevation changes by adding or removing from the configuration of the system. Due to the open area of the wire mesh used to construct the gabion, the soil identified by the geotechnical report would not be held in place in the gabion without using a geomembrane making the construction of the gabion very difficult. Water bottom elevation would require multiple layers to meet the elevation of +3.5 feet. This would cause stability concerns during filling of marsh creation area. The tidal creek starts at the location of the major deep water area so removal of some of the gabions would be necessary to allow water exchange and this would cause instability of the gabions.

7.2 Geotubes

Geotubes was another alternative considered because they allow the flexibility of conforming to the marsh bottom and use either surrounding marsh soil or off site material to fill the tubes. The Geotubes, like the gabions, would possibly not hold the fine material present in the borrow area and would need an offsite borrow source to fill properly. The outside borrow source could increase the bearing pressure from the Geotubes which, would cause large settlement and would need to be imported to the project site. Due to the water bottom elevation, multiple layers of Geotubes would be required, which would cause stability issues during filling of the marsh creation area. The tidal creek starts at the location of the major deep water area so removal of some of the Geotubes would be necessary to allow water exchange. Removing Geotubes to match the width of the tidal creek would not be possible and this would cause the tidal creek to widen over time allowing more water to flow and potentially removing material from the marsh creation area.

7.3 Vinyl Sheetpile Wall

The third alternative is a vinyl sheetpile wall to contain the material in the deep water sections. This design allows for removal or cutting of individual panels to establish the tidal creek without compromising the structural integrity of the sheetpile wall. The sheetpile would not require any extra material from borrow area like the other alternatives. There is no bearing pressure to cause excessive elastic settlement or differential settlement to cause instability, which is the case with the other alternatives. Only the width of the tidal creek could be removed, allowing the tidal creek to stay stable over the life span of the project.

7.4 Best Alternative for Deepwater Alignment Design

The design team carefully considered all pros, cons, and constructability factors of the three alternatives. The design team chose to move forward with having a vinyl sheetpile wall. The main factor was that no extra material from borrow area or imported material would be needed, and the constructability and simplicity of the sheetpile compared to the other alternatives. The linear feet and square footage of the vinyl sheetpile is located in Appendix F design calculations. Preliminary design calculations using CWALSHT are also located in Appendix F. The preliminary design has a sheet pile length of 30 feet with the sheet pile imbedded to and elevation of -25'. Using CWALSHT to determine the design parameters, the preliminary designed sheet pile will need to have a minimum moment of inertia of 186 in^4 and minimum section modulus of 37.2 in^3. These requirement are a starting point and more analysis will be conducted between 30% and 90% Design Review.

8.0 Tidal Ponds and Tidal Creek

During multiple project team meetings, tidal creek and multiple tidal ponds were discussed as project features. The team also discussed the depth of the tidal creek and ponds, as well as the number of ponds needed. During the discussions, 20 ponds were initially selected, with size of ponds being approximately 1 acre in size.

Many ideas were discussed as to how the tidal creek and ponds would be constructed, as well as how the ponds might be connected. Several ideas were discussed which includes the following: 1) digging pre-fill, 2) digging post-fill, 3) using a marsh buggy to create controlled ruts post-fill, and 4) allowing for natural connectivity. The project team decided that the main tidal creek would be excavated to a -7 foot elevation based on GeoEngineers report and settlement calculations of the marsh creation fill. The project team also decided that the connection between ponds would consist of marsh buggy tracks, which would allow water movement once the sheetpile structure is removed in year 3. Any ponds that aren't connected with tracks would remain isolated until natural tidal creeks form in the marsh creation area.

Ultimately, the project team decided to have 13 ponds, approximately one acre in size, and spaced at about 1000 feet apart. The tidal creek connects to the southwest corner of the marsh creation area and connects to 3 centrally located ponds; which is 3,275 linear feet. The three ponds then connect to additional 8 ponds via tracks from the marsh buggy and the remaining 2 ponds are not connected via marsh buggy tracks to the tidal creek. Figure 9 shows the Tidal creek and tidal pond layout within the project area.

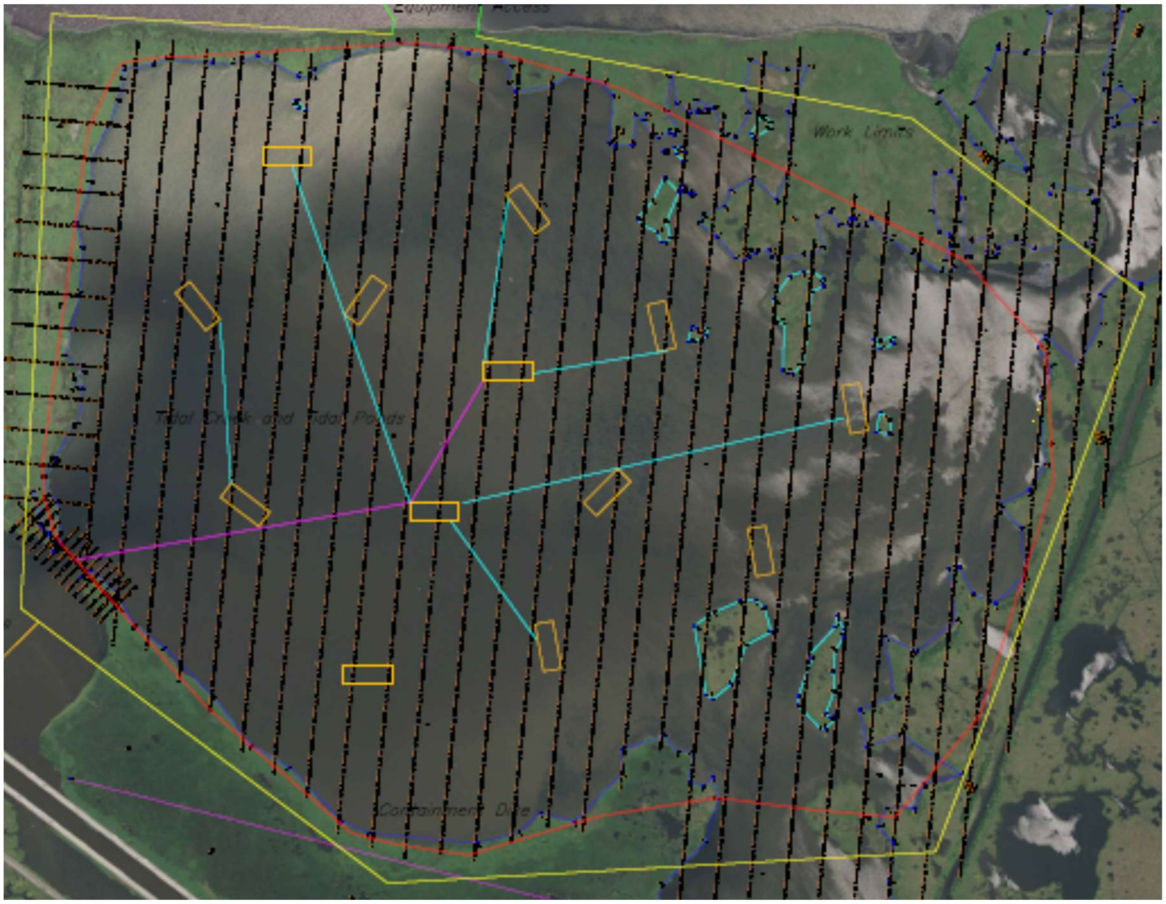

Figure 9. Layout of Tidal Creek and Tidal Ponds

9.0 Vegetative Plantings

Many marsh creation areas will experience natural vegetative colonization and will not require planting. However, the proposed marsh creation area is very large and portions may not colonize naturally due to seed dispersal limitations. To address the possibility that portions may not colonize naturally, the project cost estimate will include funding to install bare root vegetative plugs and/or small pot plants over ¼ of the marsh creation area. The estimate is derived as follows:

(657 acres x 25% x 625 plants per acre x $5 per plant installed) + $12000 for mobilization/ demobilization => $525,281.25.

10.0 CONSTRUCTION DOCUMENTS

10.1 Construction Sequence

Table 7 provided below show the anticipated construction sequence.

Table 7. Construction Sequence

Construction Sequence							
Item No.		Work	Work Days	Can Begin On Day	Can End On Day	Must Begin By Day	Must End By Day
	1a	Mag Survey Borrow Area	14	1	15	1	15
	1b	Hydrographic Survey	14	1	15	1	15
2		Mobilize to Project site	4	14	18	14	18
8		Contractor Quality Control	417	1	417	1	417
1		Construction Surveys	387	14	401	14	401
7		Tidal Creek and Ponds	27	14	41	65	79
5		Containment Dike	55	14	69	24	79
3		Vinyl Sheet Pile	9	14	23	70	79
6		Install Staff Gauges	3	67	70	76	79
	2a	Place Discharge Pipe	5	67	72	74	79
4		Fill Marsh Creation Area	310	79	389	89	399
2		Demobilize from site	4	397	401	399	403
	1c	As-Built	14	352	366	403	417
				Max	417		

10.2 Construction Drawings

See Draft Construction Drawings provided along with Design Report.

10.3 Specifications

Specifications will be drafted between 30% and 95% design review.

10.4 Bid Schedule

Table 8 provide below is the preliminary bid schedule based on the current features of the project.

Table 8. Bid Schedule

Item No.	Work	Spec No.	Quantity	Unit	Unit Price	Amount
1	Mobilization and Demobilization	8	1	Job	L.S.	$
2	Construction Surveys	7	1	Job	L.S.	$
3	Contractors Quality Control	94	1	Job	L.S.	$
4	Excavation, Marsh Creation Dredging	21	6,682,134	CY	$	$

5	Identification Markers or Plaques, Staff Gauges	93	50	EA	$	$
6	Excavation, Tidal Creek and Tidal Pond	21	1	Job	L.S.	$
7	Earthfill, Containment Dike	23	1	Job	L.S.	$
8	Piling, Sheet Pile	13	16,740	SF	$	$

Total Bid $

10 .5 Cost Estimate

Table 9 provided below is the estimated construction cost using a 3.0 foot fill height and 4.0 foot containment dike height.

Table 9. Cost Estimate

Item No.	Work	Spec No.	Quantity	Unit	Unit Price	Amount
1	Mobilization and Demobilization	8	1	Job	L.S.	$ 2,597,000.00
2	Construction Surveys	7	1	Job	L.S.	$ 494,000.00
3	Contractors Quality Control	94	1	Job	L.S.	$ 1,010,000.00
4	Excavation, Marsh Creation Dredging	21	6,682,134	CY	$ 4.00	$ 26,728,536.00
5	Identification Markers or Plaques, Staff Gauges	93	50	EA	$ 580.00	$ 29,000.00
6	Excavation, Tidal Creek and Tidal Pond	21	1	Job	L.S.	$ 376,105.11
7	Earthfill, Containment Dike	23	1	Job	L.S.	$ 455,278.44
8	Piling, Sheet Pile	13	16,740	SF	$ 14.00	$ 234,360.00
9	Vegetative Planting (Separate Contract)		1	Job	L.S.	$ 525,281.25

Total Engineer's Estimate	**$ 32,379,560.80**
Contingency 25%	$ 8,094,890.20
Total Cost	$ 40,474,451.00

11.0 MODIFICATIONS TO APPROVED PHASE 0 PROJECT

Changes from Phase 0 to 30% design review of the project have occurred and are as follows. 1) Marsh Creation and nourishment area changed from 931 acres to 726 acres.
2) The Marsh Creation area is now fully contained compared to semi-contained. 3) Proposed containment dike alignment changed to limit the amount of open water and canals to construct through. 4) Length of the tidal creek was changed from 10,000 linear feet to 3,275 linear feet. 5) The construction cost for Phase 0 was estimated at $24,913,770 which is lower than the estimated cost as of 30% design review of $40,474,451.00. This is due mostly to the increase in quantity of the marsh creation fill. Due to changes in project size and cost, NRCS and CPRA will submit a scope change request to Technical Committee after completion of the 30% Design Review.

12.0 MODIFICATIONS TO PRELIMNARY (30%) DESIGN

13.0 COMMENTS ON PRELIMINARY (30%) DESIGN

14.0 O&M&M

REFERENCES

Basis for Design: A listing of reference documents used in the design, such as handbooks, codes, reports, studies, and criteria.

Cole, George M. *Water Boundaries*. New York, NY: John Wiley & Sons, Inc. p. 24-27., 1997.

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United States Army Corps of Engineers, EM 1110-2-5027. *Confined Disposal of Dredged Material.* Washington, D.C. 1987.