# Geotechnical Engineering Report—Revision 1

East Leeville Marsh Creation and Nourishment (BA-194)
Lafourche Parish, Louisiana

*for*
**Coastal Protection and Restoration Authority**

May 8, 2020

GeoEngineers
Earth Science + Technology

## Geotechnical Engineering Report – Revision 1

East Leeville Marsh Creation and Nourishment (BA-194)
Lafourche Parish, Louisiana

*for*
**Coastal Protection and Restoration Authority**

May 8, 2020

GeoEngineers

11955 Lakeland Park Boulevard, Suite 100
Baton Rouge, Louisiana 70809
225.293.2460

# Geotechnical Engineering Report

## East Leeville Marsh Creation and Nourishment (BA-194)
## Lafourche Parish, Louisiana

**File No. 18274-004-02**

**May 8, 2020**

Prepared for:

Coastal Protection and Restoration Authority
150 Terrace Avenue
Baton Rouge, Louisiana 70802

Attention: Jessica Diez

Prepared by:

GeoEngineers, Inc.
11955 Lakeland Park Boulevard, Suite 100
Baton Rouge, Louisiana 70809
225.293.2460

Alicia Sellers

Alicia R. Sellers, PE
Geotechnical Engineer

David S. Eley 5-8-2020

David S. Eley, PE
Principal

STATE OF LOUISIANA
DAVID S. ELEY
REG. No. 26373
REGISTERED
PROFESSIONAL
ENGINEER
IN
CIVIL ENGINEERING

ARS:DSE:kc



GeoEngineers

# Table of Contents



**FIGURES**

**APPENDICES**

## 1.0 INTRODUCTION AND PROJECT UNDERSTANDING

GeoEngineers, Inc. (GeoEngineers) is pleased to present this revised geotechnical engineering report to the Coastal Restoration and Protection Authority (CPRA) and Baird, Inc. (Baird) for geotechnical services in support of the East Leeville Marsh Creation and Nourishment (BA-194) project located in Lafourche Parish, Louisiana (Figure 1).

GeoEngineers has previously submitted a geotechnical engineering report (October 11, 2018) for the East Leeville Marsh Creation Project. Our design analyzed earthen containment dike construction using borrow material from within the marsh creation cells. Subsequent to our report submittal, CPRA requested GeoEngineers analyze a design utilizing borrow material from channels outside the limits of the marsh creation area and earthen containment dikes and complete additional stability and settlement analyses. This report revision incorporates these additional geotechnical analyses for the East Leeville Marsh Creation and Nourishment Project.

Discussions of our geotechnical engineering recommendations are included in this report. Examples of our engineering calculations will be provided separately. A discussion of our geotechnical field investigation and laboratory testing results were presented in our Geotechnical Data Report submitted on October 8, 2018 and our Geotechnical Data Report – Addendum 1 submitted on March 17, 2020.

Our additional services were performed under a Subconsultant Professional Services Agreement between Baird and GeoEngineers dated January 9, 2020 (Reference No. 12992.101.L.1.Rev0) and in general accordance with our proposal dated January 9, 2020.

All elevations described in this report, including figures and appendices, are referenced to the North American Vertical Datum of 1988 (NAVD88), Geoid 12A. Report figures are located at the end of the report text. Appendices are organized as shown in the table of contents.

## 2.0 SITE CONDITIONS

### 2.1. Surface Conditions

#### 2.1.1. Marsh Creation Area

The East Leeville marsh creation area surface is a mix of open water, fragmented marsh, and intact marsh. The marsh creation area is split into six primary containment cells and are labeled Cells 1 through 6, as shown in Figure 2. Based on the survey data provided to us by CPRA, the marsh creation area surface and mudline elevations generally range from about elevation +1 (El. +1) foot to about El. -4 feet. Water depths will vary based on the time of year, the direction of wind, and tidal fluctuations. In addition, multiple pipelines traverse the project area.

#### 2.1.2. Borrow Area

As shown in Figure 1, the potential borrow area is located approximately five miles east of the marsh creation area in Caminada Bay. Borrow area water depths ranged from about four to six feet at the time of field exploration. The borrow area and our field explorations in the area are shown in Figure 3.

## 2.2. Subsurface Conditions

Subsurface conditions discussed below are based on the soil borings completed for this project. No artifacts or material other than that noted on the soil boring logs included in our data report was observed by GeoEngineers during our field investigation or during laboratory testing; however, GeoEngineers personnel are not trained in recognition of such items.

Subsurface profiles based on the soil borings and cone penetration tests (CPTs) for the various marsh creation areas are shown in Figures 4 and 5, and the subsurface profile based on the soil borings for the borrow area is shown in Figure 6. Although undetected anomalies (sand layers, wood debris, etc.) beyond the explorations may exist, the generalized subsurface conditions can be described as given in the following sections.

### 2.2.1. Marsh Creation Area

The subsurface soils within the marsh creation areas generally consist of very soft to soft clay and silty clay interbedded with layers of silt and sand throughout. A predominantly silty sand layer was encountered ranging from approximate El. -20 feet to El. -30 feet across the cells. The soils within Cell 3, however, are less sandy, and the near surface soils consist of more organic clay and peat to approximately El. -6 feet.

The subsurface soils encountered in the channels around the perimeter of the marsh creation areas (soil borings B-50 through B-55) were, in general, similar to what was encountered in borings and CPTs in adjacent cells. A few channel borings around Cell 3, however, did not encounter as much organic clay and peat. This was taken into consideration in our gap closure analyses of Cell 3.

The design soil properties vs. elevation based on the data obtained from the field explorations and laboratory testing are provided in Appendix A.

### 2.2.2. Borrow Area

Near surface soils within the borrow area generally consist of very soft clay and silty clay to approximately El. -23 feet. A silty sand layer was encountered in 6 of the 8 borrow area borings at approximately this elevation which was near the boring termination of about El. -25 feet.

# 3.0 CONCLUSIONS AND RECOMMENDATIONS

GeoEngineers evaluated survey information and various geotechnical data to develop engineering recommendations for the East Leeville Marsh Creation and Nourishment project. Our analyses focused on containment of dredged fill, dredged fill properties, and settlement of the project features. Our results, conclusions, and recommendations are described in the following sections.

## 3.1. Earthen Containment Dikes

Our analyses for the earthen containment dikes included evaluating slope stability, bearing capacity, settlement, and cut-to-fill. Our containment dike analysis results are presented below and discussed further in Appendices B and C.

### 3.1.1. Recommended Dike Sections

#### *3.1.1.1. Cells 1 & 2*

In areas where the mudline elevation is -1.0 feet or higher, unreinforced containment dike construction may proceed in Cells 1 and 2 by building the earthen containment dikes in one lift with a crown elevation of +4.5 feet, crown widths of five and ten feet, and 4H:1V side slopes. The recommended earthen containment dike design section is illustrated in Figure 7a.

In areas where the mudline elevation is -1.0 to -2.0 feet, unreinforced containment dike construction may proceed in Cells 1 and 2 by building the earthen containment dikes in one lift with a crown elevation of +4.5 feet, crown widths of five and ten feet, and 5H:1V side slopes. The recommended earthen containment dike design section is illustrated in Figure 7a.

In sections where the mudline elevation is -2.0 to -3.0 feet, staged construction will be necessary for Cells 1 and 2 to build earthen containment dikes with a crown elevation of +4.5 feet, crown widths of five and ten feet, and 5H:1V side slopes. The recommended earthen containment dike design section is illustrated in Figure 7a.

For lift construction, we recommend building the dike to El. +1.0 feet across the width of the final design section; allow the dike fill and foundation soils to consolidate for two weeks; and then continue filling to El. +4.5 feet. The recommended earthen containment dike design sections are illustrated in Figure 7a.

Slope stability analyses with articulated concrete mattresses (ACMs) were performed for Cells 1 and 2 for all sections. An open-cell, 4-inch thick ACM was modeled on the crest and on the exterior side of the dike with a unit weight of 100 pounds per cubic foot (pcf) and a friction angle of 40°.

For areas supporting ACMs, containment dike construction can proceed as outlined above for the various mudlines. In areas where the mudline elevation is -2.0 feet -3.0, a geotextile reinforcement (1,200 pounds per foot tensile strength – ASTM D4595) will also be required between the two lifts to reinforce the containment dike. The recommended earthen containment dike design sections with ACMs are illustrated in Figure 7b.

#### *3.1.1.2. Cell 3*

In areas where the mudline elevation is -2.0 feet or higher, staged construction with geotextile reinforcement (1,200 pounds per foot tensile strength – ASTM D4595) will be necessary for Cell 3 to build earthen containment dikes with a crown elevation of +4.5 feet, crown widths of five and ten feet, and 5H:1V side slopes. The recommended earthen containment dike design section is illustrated in Figure 7c.

For lift construction, we recommend building the dike to El. +1.0 feet across the width of the final design section and allow the dike fill and foundation soils to consolidate for two weeks; place the geotextile reinforcement at this elevation; and then continue filling to El. +4.5 feet.

#### *3.1.1.3. Cells 4, 5 & 6*

In areas where the mudline elevation is -3.0 feet or higher, staged construction will be necessary for Cells 4, 5, and 6 to build earthen containment dikes with a crown elevation of +4.0 feet, crown widths of five and ten feet, and 5H:1V side slopes. The recommended earthen containment dike design section is illustrated in Figure 7c.

For lift construction, we recommend building the dike to El. +1.0 feet across the width of the final design section; allow the dike fill and foundation soils to consolidate for four weeks; and then continue filling to El. +4.0 feet. Please note the extra consolidation time recommendation compared to Cells 1, 2 and 3. There is less silt present in the subgrade in this area, and we believe settlement (i.e. strength gain) will take longer.

### 3.1.2. Slope Stability and Bearing Capacity

Stability of the containment dikes was evaluated assuming mean low water conditions (El. +0.15 feet). It was assumed the material for the dikes would be dredged from an adjacent borrow channel outside of the marsh creation cells.

Mudwaves are likely to occur during construction of the containment dikes if the material at the mudline is very soft and/or submerged. For our stability analyses, we assumed material with a shear strength less than 50 pounds per square foot (psf) would mudwave. Based on site data, we expect mudwaving to be primarily limited to Cell 3.

The results of our slope stability and bearing capacity analyses for the recommended containment dike sections are summarized below in Tables 3.1 and 3.2, respectively. A discussion of our slope stability and bearing capacity evaluations is provided in Appendix B.

**TABLE 3.1. CONTAINMENT DIKE SLOPE STABILITY**

| Cell | Design Mudline El. (ft) | Crest Width (ft) | Critical Slope Safety Factor[1] | | | |
|---|---|---|---|---|---|---|
| | | | Case 1 | Case 2 | Case 3 | Case 4 |
| 1 & 2 | -1.0 | 5 | 1.28 | 1.55 | 2.13 | 1.28 |
| | -1.0 | 10 | 1.27 | 1.50 | 2.13 | 1.26 |
| | -2.0 | 5 | 1.33 | 1.80 | 2.53 | 1.33 |
| | -2.0 | 10 | 1.32 | 1.73 | 2.53 | 1.32 |
| | -3.0, Lift 1 | 40 | 3.35 | 2.99 | 3.04 | N/A |
| | -3.0, Lift 2 | 5 | 1.24 | 1.85 | 3.04 | 1.24 |
| | -3.0, Lift1 | 45 | 3.35 | 2.99 | 3.04 | N/A |
| | -3.0, Lift 2 | 10 | 1.24 | 1.77 | 3.04 | 1.24 |
| 1 & 2 (with ACMs) | -1.0 | 5 | 1.22 | 1.46 | 2.13 | 1.22 |
| | -2.0 | 5 | 1.26 | 1.72 | 2.51 | 1.26 |
| | -3.0, Lift 1 | 40 | 3.35 | 2.99 | 3.04 | N/A |
| | -3.0, Lift 2 | 5 | 1.62 | 1.83 | 3.04 | 1.62 |
| 3 | -2.0, Lift 1 | 40 | 1.79 | 2.46 | 1.93 | N/A |
| | -2.0, Lift 2 | 5 | 1.23 | 1.56 | 1.93 | 1.22 |
| | -2.0, Lift 1 | 45 | 1.79 | 2.48 | 1.93 | N/A |
| | -2.0, Lift 2 | 10 | 1.21 | 1.52 | 1.93 | 1.21 |

| Cell | Design Mudline El. (ft) | Crest Width (ft) | Critical Slope Safety Factor[1] | | | |
|---|---|---|---|---|---|---|
| | | | Case 1 | Case 2 | Case 3 | Case 4 |
| 4, 5 & 6 | -1.0, Lift 1 | 35 | 3.16 | 2.66 | 1.40 | N/A |
| | -1.0, Lift 2 | 5 | 1.22 | 1.88 | 1.40 | 1.22 |
| | -1.0, Lift 1 | 40 | 3.16 | 2.66 | 1.40 | N/A |
| | -1.0, Lift 2 | 10 | 1.21 | 1.81 | 1.40 | 1.21 |
| | -3.0, Lift 1 | 35 | 2.58 | 2.91 | 2.81 | N/A |
| | -3.0, Lift 2 | 5 | 1.19 | 1.96 | 2.81 | 1.19 |
| | -3.0, Lift 1 | 40 | 2.57 | 2.91 | 2.81 | N/A |
| | -3.0, Lift 2 | 10 | 1.18 | 1.89 | 2.81 | 1.18 |

[1] Case 1 = Internal failure of the containment dike, no marsh fill placed.
Case 2 = Global failure of the containment dike into the borrow channel, no marsh fill placed.
Case 3 = Failure of the borrow channel, no marsh fill placed, construction equipment modeled.
Case 4 = Failure of the containment dike, marsh fill placed.

The critical factors of safety presented in Table 3.1 meet or exceed the acceptable safety factor of 1.2, except for Cells 4, 5 & 6, -3.0, Lift 2 with a 5-foot and 10-foot crown width with a 1.19 and 1.18 safety factor, respectively, which we feel is acceptable in this instance.

The stability of the containment dikes was modeled with an external borrow channel. However, we understand that, in some areas, material for the dikes may also be dredged from a borrow channel within the marsh creation cells. The factors of safety associated with a Case 4 failure with an internal borrow channel are similar to the Case 4 factors of safety presented in Table 3.1.

**TABLE 3.2. CONTAINMENT DIKE BEARING CAPACITY**

| Cell | Mudline El. (ft) | Crest Width (ft) | Factor of Safety |
|---|---|---|---|
| 1 & 2 | -1.0 | 5 | 1.76 |
| | -1.0 | 10 | 1.79 |
| | -2.0 | 5 | 1.91 |
| | -2.0 | 10 | 1.87 |
| | -3.0 | 5 | 1.95 |
| | -3.0 | 10 | 1.89 |
| 3 | -2.0 | 5 | 1.96 |
| | -2.0 | 10 | 1.96 |
| 4, 5 & 6 | -1.0 | 5 | 1.82 |
| | -1.0 | 10 | 1.96 |
| | -3.0 | 5 | 2.33 |
| | -3.0 | 10 | 2.30 |

The computed factors of safety presented in Table 3.2 for bearing exceed the acceptable factor of safety of 1.3.

### 3.1.3. Geotextile Reinforcement

Geotextile reinforcement was incorporated into our stability analyses for Cells 1 and 2 with ACMs and Cell 3 assuming at least 1,200 pounds per foot tensile strength (ASTM D4595). This is within the capabilities of woven geotextile fabrics, including, but not limited to, the five percent strain condition of Mirafi®'s HP 270 woven high-performance polypropylene geotextile fabric. Geotextile fabric should be installed to the manufacturer's recommendations. Geotextile seams parallel to the dike alignment must be sewn or otherwise secured to preserve the strength. Seams perpendicular to the dike alignment may be overlapped so that geotextile is uniformly present under the dike but do not need to be sewn. Measures to weigh or pin the fabric down may be necessary to keep the geotextile in place during construction.

### 3.1.4. Containment Dike Settlement

Containment dike settlement includes two components. One component is foundation soil settlement below the containment dike, which includes consolidation and elastic compression (construction settlement). The other component is settlement within the fill itself, which is a combination of compaction due to the weight of the fill and desiccation-induced shrinkage settlement. These two components will combine with wind, rain and wave erosion to degrade the containment dike. As such, regular maintenance of the containment dikes will likely be required through construction of the marsh fill platform.

#### *3.1.4.1. Consolidation Settlement of Foundation Soils*

Based on the amount of sand/silt layers and seams encountered in our subsurface explorations, consolidation settlement of the foundation soils will occur quickly, particularly in Cells 1 through 3. There is less silt/sand layering in Cells 4 through 6, so we expect settlement to be a bit slower in these cells. Our approach to evaluating consolidation settlement for the containment dikes is discussed in Appendix C. Containment dike crown elevation vs. time plots are also included, along with tabular results, in Appendix C. These plots include consolidation, shrinkage, and self-weight settlement but do not include construction settlement. Construction settlement is addressed in the following section.

#### *3.1.4.2. Construction Settlement*

Based on our experience, GeoEngineers estimates construction settlement in clay and organic soils to be approximately 20 percent of the total foundation consolidation settlement. Construction settlement will occur rapidly as fill is placed and will not manifest appreciably during routine construction surveys of the built containment dikes. Based on consolidation settlement of the foundation soils ranging from 0.5 to 1.0 feet, respectively, we expect construction settlement to be about 1 to 2.5 inches.

#### *3.1.4.3. Shrinkage and Self-Weight Settlement of Fill Soils*

Containment dike settlement will be influenced by desiccation of exposed soil above the average water level and compression of fill after it is placed, especially when fill is excavated from a submerged (buoyant) condition and placed above water (total stress). Research conducted by GeoEngineers indicates peat and inorganic low-plasticity clay experience relatively little shrinkage when the embankment base is submerged (about 5 to 10 percent volume loss for exposed soil); however, peat fill compression may be significant. Inorganic high-plasticity clays experience moderate shrinkage (about 15 to 20 percent exposed soil volume loss) even with the embankment base submerged, and silty sands experience relatively little shrinkage (about 5 percent or less exposed soil volume loss). Because the available containment dike borrow material is generally composed of clays and silty clays, we estimate post-construction shrinkage settlement and self-weight settlement combined will be about 15 percent of the fill height from the containment dike crown to the mudline, in addition to the total foundation settlement. We expect this settlement to occur within six months after construction. Settlement plots in Appendix C have incorporated fill shrinkage and self-weight settlement.

#### 3.1.5. Mechanical Dredging Cut-to-Fill

Earthen containment dike construction commonly involves removing material from a submerged condition within excavator reach of the dike alignment, placing it in the dike footprint, then shaping it to meet containment dike geometry specifications. At the project site, material in the top 10 feet of the in-place borrow soil profile generally consists of clay and silty clay, with Cell 3 having more peat and organic material. Material losses during construction, compaction, and water drainage as the fill is placed and shaped, soil shrinkage, and foundation settlement during construction results in more than one cubic yard of material excavated from the in-place borrow soil for every cubic yard in the fill template. Due to the number of variables involved, calculating the cut-to-fill ratio for the containment dikes is very difficult. To allow for adequate material quantities in project design and cost estimating, GeoEngineers recommends a cut-to-fill ratio of about 2 to 1 to account for material losses, construction settlement, mudwave displacement, and compression settlement and shrinkage.

### 3.2. Gap Closures

Based on a review of the survey information provided by CPRA, GeoEngineers identified five locations around the marsh creation cell perimeters where the existing mudline is lower than the design mudline elevations evaluated, as shown in Figure 2. Based on the mudline elevations at these locations, it will be more difficult to build earthen containment dikes as discussed previously and, as such, modified dike design sections will be required. Due to thicker fill at these locations, there will also be more settlement within the fill and therefore more maintenance should be expected to maintain the design elevation.

#### 3.2.1. Recommended Gap Closure Sections

##### *3.2.1.1. Cell 2 Design*

We identified one gap closure location in Cell 2 (“North Cell 2”) with a mudline elevation as deep as - 4.5 feet. For areas with where the mudline elevation is -3.0 to -4.5 feet, staged construction will be necessary to build an earthen containment dike with a crown elevation of +4.5 feet, crown width of five feet, and 5H:1V side slopes.

For lift construction, we recommend building the dike to El. +1.0 feet across the width of the final design section; allow the dike fill and foundation soils to consolidate for two weeks; place the geotextile reinforcement at this elevation; and then continue filling to El. +4.5 feet. The recommended Cell 2 gap closure design section is illustrated in Figure 8a, and our analyses are provided in Appendix D.

##### *3.2.1.2. Cell 3 Design*

We identified three gap closure locations in Cell 3 (“North Cell 3”, “Northeast Cell 3”, and “South Cell 3”) with mudline elevations as deep as -4.0 feet. For areas with where the mudline elevation is -2.0 to -4.0 feet, staged construction will be necessary to build an earthen containment dike with a crown elevation of +4.5 feet, crown width of five feet, and 5H:1V side slopes.

For lift construction, we recommend building the dike to El. +1.0 feet across the width of the final design section; allow the dike fill and foundation soils to consolidate for two weeks; place the geotextile reinforcement at this elevation; and then continue filling to El. +4.5 feet. The recommended Cell 3 gap closure design section is illustrated in Figure 8b, and our analyses are provided in Appendix D.

While sheet pile gap closures do not appear necessary for this project, we also analyzed a general sheet pile gap closure section for Cell 3 with a mudline elevation of -5.0 feet. We have provided various design options with the earthen containment dike section built at El. +1 feet to El. +2 feet, as shown in Figure 8b. Most steel sheet pile sections can meet the required section modulus. Alternate materials may also be effective given the low modulus requirement but must be evaluated by material. Our analyses are provided in Appendix D.

#### *3.2.1.3. Cell 6 Design*

We identified one gap closure location in Cell 6 ("East Cell 6") with a mudline elevation as deep as -4.0 feet. For areas with where the mudline elevation is -3.0 to -4.0 feet, staged construction will be necessary to build an earthen containment dike with a crown elevation of +4.0 feet, crown width of ten feet, and 5H:1V side slopes.

For lift construction, we recommend building the dike to El. +1.0 feet across the width of the final design section; allow the dike fill and foundation soils to consolidate for four weeks; place the geotextile reinforcement at this elevation; and then continue filling to El. +4.0 feet. The recommended Cell 6 gap closure design section is illustrated in Figure 8c, and our analyses are provided in Appendix D.

### 3.2.2. Slope Stability and Bearing Capacity

Stability of the modified containment dike sections at gap closure locations was evaluated assuming mean low water conditions (El. +0.15 feet). It was assumed the material for the dikes would be dredged from an adjacent borrow channel outside of the marsh creation cells. Mudwaves are also likely to occur in Cell 3 during construction of the containment dikes if the material at the mudline is very soft and/or submerged.

The results of our slope stability and bearing capacity analyses for the modified containment dike sections at gap closure locations are summarized below in Tables 3.3 and 3.4, respectively. A discussion of our gap closure slope stability and bearing capacity evaluations is provided in Appendix D.

**TABLE 3.3. GAP CLOSURE SLOPE STABILITY**

| Gap ID | Design Mudline El. (ft) | Crest Width (ft) | Critical Slope Safety Factor[1] | | | |
|---|---|---|---|---|---|---|
| | | | Case 1 | Case 2 | Case 3 | Case 4 |
| North Cell 2 | -4.5, Lift 1 | 40 | 2.81 | 3.01 | 3.69 | N/A |
| | -4.5, Lift 2 | 5 | 1.48 | 1.91 | 3.71 | 1.49 |
| North Cell 3 | -4.0, Lift 1 | 40 | 2.40 | 2.62 | 2.54 | N/A |
| | -4.0, Lift 2 | 5 | 1.31 | 1.66 | 1.92 | 1.31 |
| NE/S Cell 3 | -4.0, Lift 1 | 40 | 2.42 | 2.62 | 2.54 | N/A |
| | -4.0, Lift 2 | 5 | 1.30 | 1.64 | 2.54 | 1.30 |

| Gap ID | Design Mudline El. (ft) | Crest Width (ft) | Critical Slope Safety Factor[1] | | | |
|---|---|---|---|---|---|---|
| | | | Case 1 | Case 2 | Case 3 | Case 4 |
| Cell 3 (El. +1ft Crown) | -5.0, Pre-Sheet Pile | 40 | 2.50 | 2.69 | 2.74 | N/A |
| | -5.0, Post-Sheet Pile | 40 | 2.50 | N/A | N/A | 1.99 |
| Cell 3 (El. +2ft Crown) | -5.0, Pre-Sheet Pile | 30 | 1.72 | 2.17 | 2.74 | N/A |
| | -5.0, Post-Sheet Pile | 30 | 1.73 | N/A | N/A | 1.47 |
| East Cell 6 | -4.0, Lift 1 | 40 | 2.50 | 3.00 | 3.46 | N/A |
| | -4.0, Lift 2 | 10 | 1.64 | 2.04 | 3.46 | 1.64 |

[1] Case 1 = Internal failure of the containment dike, no marsh fill placed.
Case 2 = Global failure of the containment dike into the borrow channel, no marsh fill placed.
Case 3 = Failure of the berm into the borrow channel.
Case 4 = Failure of the containment dike, marsh fill placed.

The critical factors of safety presented in Table 3.3 meet or exceed the acceptable factor of safety of 1.2.

**TABLE 3.4. GAP CLOSURE BEARING CAPACITY**

| Cell | Mudline El. (ft) | Crown El. (ft) | Crest Width (ft) | Factor of Safety |
|---|---|---|---|---|
| 2 | -4.5 | +4.5 | 5 | 2.21 |
| 3 | -6.0[1] | +4.5 | 5 | 2.05 |
| 3 | -6.0[2] | +1.0 | 40 | 3.96 |
| 3 | -6.0[2] | +2.0 | 30 | 3.05 |
| 6 | -4.0 | +4.0 | 10 | 2.30 |

[1] Mudline at elevation -4.0 feet with mudwave to elevation 6.0 feet

The computed factors of safety presented in Table 3.4 for bearing exceed the acceptable factor of safety of 1.3.

## 3.3. Marsh Creation Areas

Our analyses for the marsh creation areas included evaluating marsh fill settlement, marsh foundation soil settlement, and cut-to-fill. The results of our marsh fill analyses are presented below and discussed further in Appendix E.

### 3.3.1. Marsh Fill Settlement

Freshly created marsh platforms settle over time. Elevation changes in the marsh fill are driven by self-weight consolidation, water draining, evaporating, or being drawn down due to plant growth, along with marsh foundation soil settlement due to the new load introduced by the marsh fill. GeoEngineers evaluated marsh fill and foundation settlement for target end-of-construction elevations ranging from El. +3.5 feet to El. +1.5 feet for the various marsh creation cells. Our evaluation does not include regional subsidence.

Additional elevation loss due to regional subsidence must be subtracted from the curves included in this report.

As GeoEngineers understands, a successful marsh creation project establishes a marsh platform that remains within the intertidal range (between mean high water and mean low water or between the 20 percent and 80 percent inundation levels for saline marsh) for as long as practical during the project life. Based on this and the results of our analyses, GeoEngineers recommends building the marsh platform to El. +3.0 to +3.5 feet. A 30-day fill construction period was modeled for all cells, and for mudline El. -2 feet of Cells 1 through 3, a 60-day fill construction period was also modeled. A summary of our calculation approach and our analyses are provided in Appendix E.

#### 3.3.2. Hydraulic Dredging Cut-to-Fill

Hydraulically dredged material cut-to-fill ratios have been reported between 1.0 (1-yard cut from the borrow for every 1 yard placed in the fill area) and 1.5 for marsh creation projects in Louisiana, depending on material type, containment scheme, and dredge/pipe/containment efficiencies. The material exiting the dredge pipe will initially be less dense than the in-place borrow material but, with time, should return to borrow area densities due to consolidation, desiccation and plant-induced evapotranspiration. GeoEngineers recommends a cut-to-fill ratio of 1.2 based on in-place borrow to long-term in-place fill for this site. The cut-to-fill ratio can change with dredge size. In general, more retention time (i.e. a smaller dredge) results in lower cut-to-fill ratios.

## 4.0 CONSTRUCTION CONSIDERATIONS

### 4.1. General Considerations

Based on the expected site construction activities and evaluations completed for this project, the following construction considerations are offered:

- Our evaluations are based on a limited number of investigations over a wide area. Our evaluations indicate generally similar conditions across the site. However, CPRA should expect localized areas during construction to require location-specific remedies. GeoEngineers offers our services during construction to address issues that may arise.
- Several pipelines are near the marsh creation cells and borrow area. We recommend taking precautions to mitigate impact to pipelines prior to construction. The project design and construction teams should work closely with the companies that have pipelines in the area and conduct a pre-construction geophysical survey to confirm pipeline and other obstruction locations.
- Water depth in the marsh creation areas is variable.
- Soil excavated to build containment dikes, particularly in the areas of Cells 1 through 3, is likely to contain significant amounts of silt and sand. While these soils are good for stability and bearing, they erode easily, and portions of the marsh creation cells are exposed to open water wave action. ACMs are planned to help reduce erosion; however, silt and sand can still wash from beneath the ACM. To help reduce erosion, a class B, C, or D nonwoven geotextile meeting the requirements of the 2016 Version of Louisiana Standard Specifications for Roads and Bridges, Section 1019 may be placed beneath the ACM, particularly in zones exposed to wave energy. Vegetation is probably the best long-

term erosion protection, and the benefits of the geotextile should be weighed against potential negative effects geotextile may have on vegetation growth.

- Peat considerations (primarily in Cell 3):
  - Peat used in constructing containment dikes may compress significantly under loading requiring more fill; however, it can be utilized and should not be wasted.
  - Energy diffusers or other such precautions are recommended to reduce scouring of organic deposits during hydraulic fill placement. We understand scoured floating blocks of peat have blocked discharge weir boxes at sites with similar conditions. At these sites wire mesh fences placed in a wide arc in front of the discharge point were used to screen out floating organic material blocks.
  - Peat is a weak, light-weight material. Mudwaves and lateral displacement should be expected while placing fill in areas with peat.
  - Peat settlement during hydraulic fill placement will result in an initial fill thickness greater than the difference between the target fill elevation and the pre-construction mudline elevation.
- Dewatering structures (weirs, drainage culverts) should be designed to allow retention of as much soil fill as practical. In general, placement of such structures away from the dredge discharge point is preferred.

### 4.2. Construction Sequencing

- The contractor should plan to place fill in low areas first, then move to higher ground, both for the containment dikes and hydraulic marsh fill. Lower areas will require more fill and are expected to settle more. Filling these low areas first will allow some of the additional settlement to be realized and then potentially mitigated by placing additional fill in these areas during construction. After initial construction is complete, containment dikes can be topped off and low areas of the marsh fill surface can be supplemented with additional hydraulically dredged fill.
- There is some silty sand towards the bottom of the borrow area soil borings. If dredge depths incorporate these deeper sands, larger soil particles will fall out of suspension more quickly than smaller soil particles, resulting in mounds of high sand concentration in the immediate vicinity of the dredge pipe discharge location. For sand fill projects, a low-ground-pressure bulldozer would typically be used to spread the sand after discharge; however, this will not likely work at this location due to the amount of fines in the dredged material and the weak underlying soil. Construction planning that includes moving the dredge pipe discharge location frequently may better distribute sand and result in less mounding. Locating discharge points within thicker fill areas, may also offset additional settlement typically associated with greater fill depth. Sand and silt will tend to settle rapidly and have less consolidation after placement than clay.

### 4.3. Containment Dike Construction

- It is prudent to allow time for material stabilization and dewatering for containment dike construction, even if not required for stability. To improve constructability, GeoEngineers recommends consideration be given to building the containment dikes to about one to two feet above mean water level, then letting the dike section rest for at least one week to allow the fill to start draining and foundation soils to start adjusting under the load for all containment dikes. This “best construction practice” will also allow some strength gain of the underlying foundation soils thus reducing the potential for localized failures during construction. Historically, similar approaches have resulted in stable platforms, which can support further dike construction with less complications. Please note that this is separate from areas where lift construction and minimum required wait periods have been specified (2 to 4 weeks depending on location). This practice of building the base of the containment dike, even when it is not necessarily required, may help address locally weak areas that are not identified by the limited and widely spaced soil borings and CPTs completed for the project.

- Where permissible, the contractor should build containment dikes on emergent marsh. This provides a higher base elevation and the marsh vegetation is natural reinforcement, resulting in less fill and generally lower failure potential. From an engineering perspective, the contractor may use the top layer of marsh for dike fill (i.e. it is okay to use marsh grass and roots for containment dike fill).
- When building earthen containment dikes, sound construction practice includes excavating and placing soil as gently as practical in as intact a mass as practical.
- Earthen containment dike fill should be maintained about one foot above the level of the hydraulic marsh fill, plus any free water ponded on top of the marsh fill.
- Containment structure design recommendations are based on hydraulic fill retention during normal weather conditions. Exceptional weather, such as hurricane winds or storm surge, were not considered.
- Containment dike construction must include the construction/stability berm widths shown in Figures 7 and 8 between the dike and the borrow channel. Unless otherwise specified, we recommend the marsh buggy excavators stay at least two feet away from the containment dike toe and as far away from the borrow slope as practical.
- Contractors are likely to excavate deeper for “better” soil to build earthen containment dikes, often plunging through the top few feet of weak soil. This may result in borrow channels that are deeper than necessary. As such, we recommend having contractors adhere to the depth guidelines presented in this report.

## 5.0 LIMITATIONS

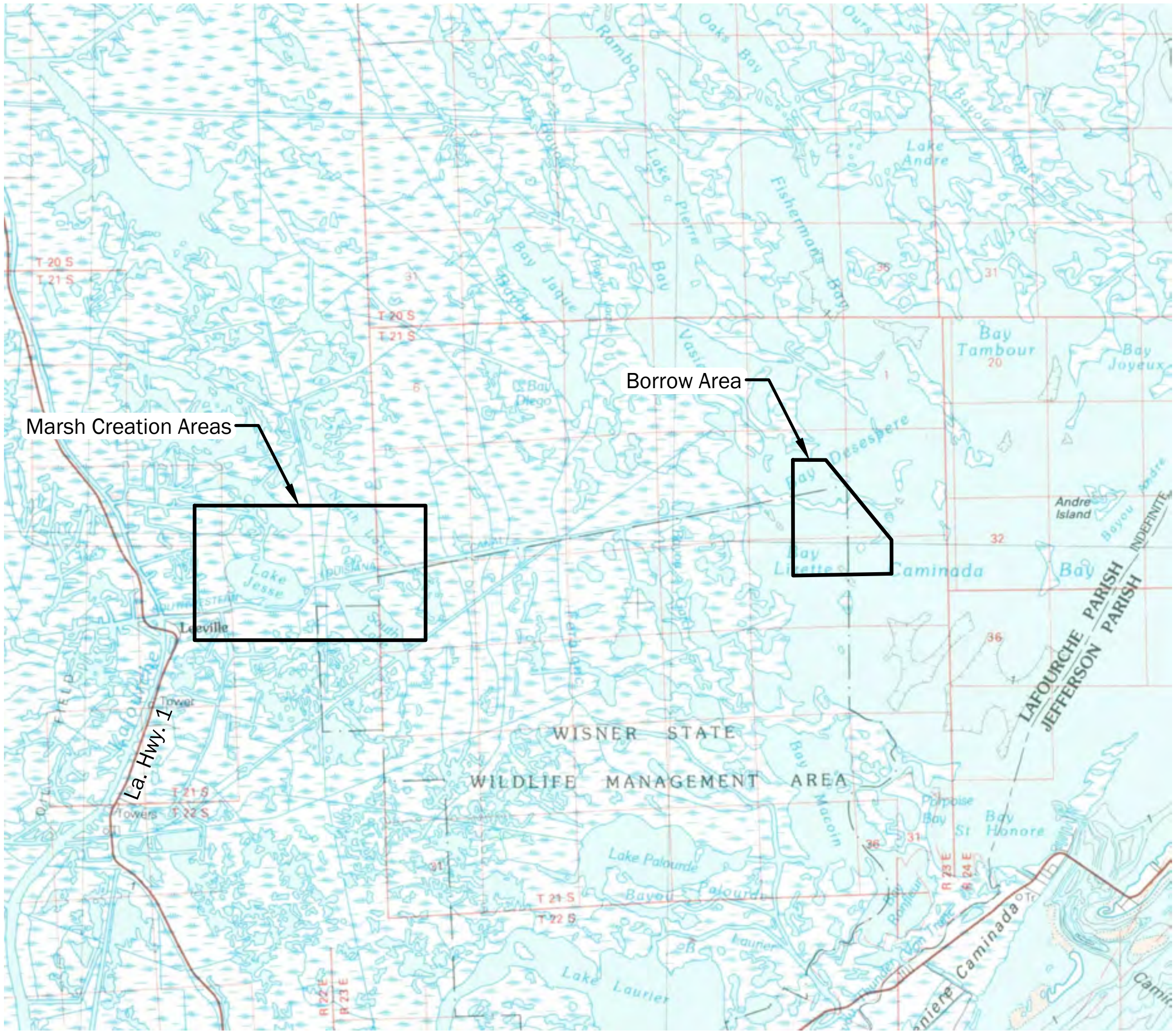
This report has been prepared exclusively for the Coastal Restoration and Protection Authority and Baird, Inc. in support of the East Leeville Marsh Creation and Nourishment Project (BA-194) project located in Lafourche Parish, Louisiana.

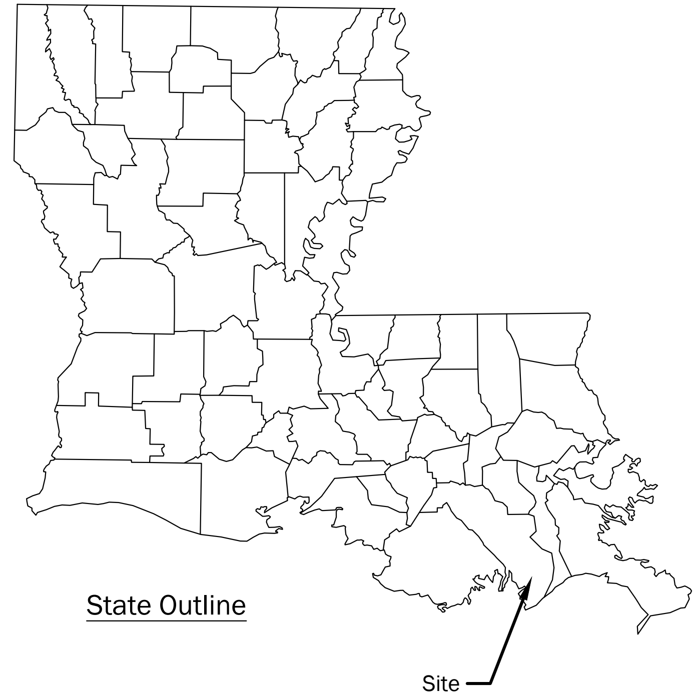
Within the limitations of scope, schedule and budget, our services have been executed in accordance with generally accepted practices in the field of geotechnical engineering in this area at the time this report was prepared. No warranty or other conditions, expressed or implied, should be understood.

Please refer to Appendix F titled “Report Limitations and Guidelines for Use” for additional information pertaining to use of this report.

FIGURES

GeoEngineers




## Notes:

1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. cannot guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.

Data Source: Topographic image was taken from USGS, Quad: Terrebonne, Dated: 1983

Projection: LA State Plane, South Zone, NAD83, US Foot

N
W E
S

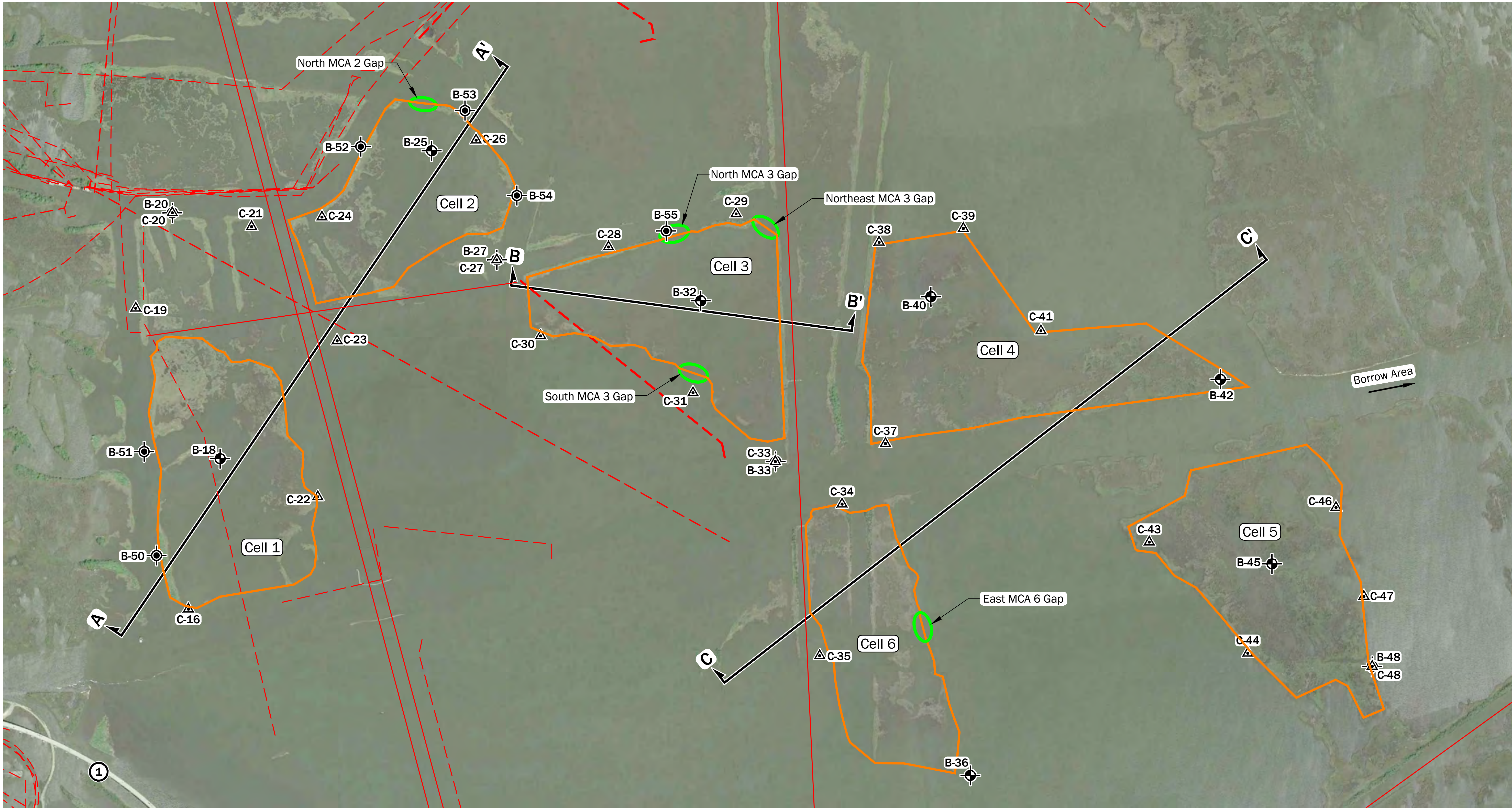
2 0 2
Miles

**Vicinity Map**

East Leeville Marsh Creation and Nourishment (BA-194)
Lafourche Parish, Louisiana

GEOENGINEERS

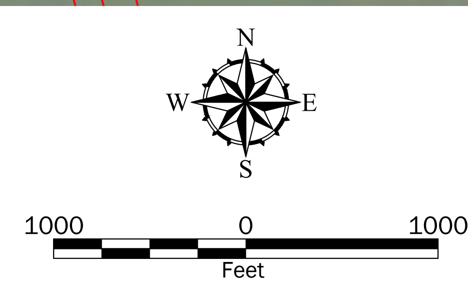
**Figure 1**




Notes:

1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. cannot guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.

Data Source: Aerial was taken from Google Earth, Imagery Dated: 3/20/2019
Pipelines were taken from Sonris (Dated 9/13/2018), and emails from Kinetica (Dated 4/10/2018), Hilcorp (Dated 4/10/2018), LOOP (Dated 4/9/2018), Shell (Dated 4/10/2018)
Projection: LA State Plane, South Zone, NAD83, US Foot




**Legend**

- B-18 Boring by GeoEngineers, 2018
- B-51 Boring by GeoEngineers, 2020
- CPT-16 Cone Penetrometer Test by GeoEngineers, 2018
- A A' Cross Section Location
- Pipelines (from SONRIS)
- Pipelines (Verified by Surveyor & Pipeline entities)
- Marsh Creation Areas
- Gap Closures (Deeper than typical containment dike)

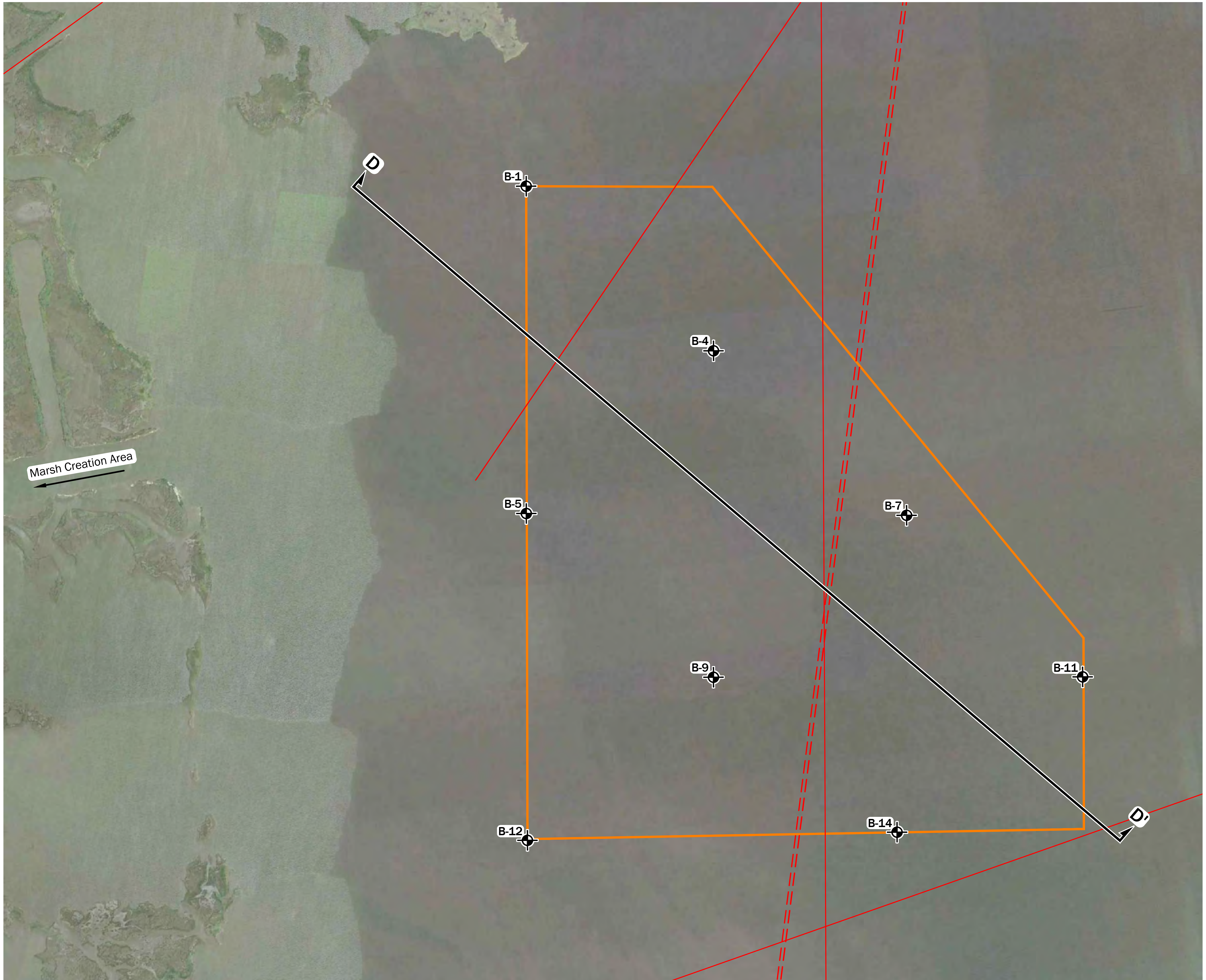
**Marsh Creation Area**
**Site Plan**

East Leeville Marsh Creation and Nourishment
(BA-194)
Lafourche Parish, Louisiana

GEOENGINEERS

**Figure 2**

P:\18\18274004\CAD\02\Geotech - Final\18274004002_F02-06_Boring CPT Plan.dwg TAB:F02 - BLP Date Exported: 04/16/20 - 13:33 by kcook




**Legend**

- Pipelines (from SONRIS)
- Pipelines (Verified by Surveyor & Pipeline entities)
- B-1 Boring by GeoEngineers, 2018
- Borrow Area
- D D' Cross Section Location

Notes:

1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. cannot guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.

Data Source: Aerial was taken from Google Earth, Imagery Dated: 3/20/2019
Pipelines were taken from Sonris (Dated 9/13/2018), and emails from Kinetica (Dated 4/10/2018), Hilcorp (Dated 4/10/2018), LOOP (Dated 4/9/2018), Shell (Dated 4/10/2018)

Projection: LA State Plane, South Zone, NAD83, US Foot

N
W E
S

2000 0 2000
Feet

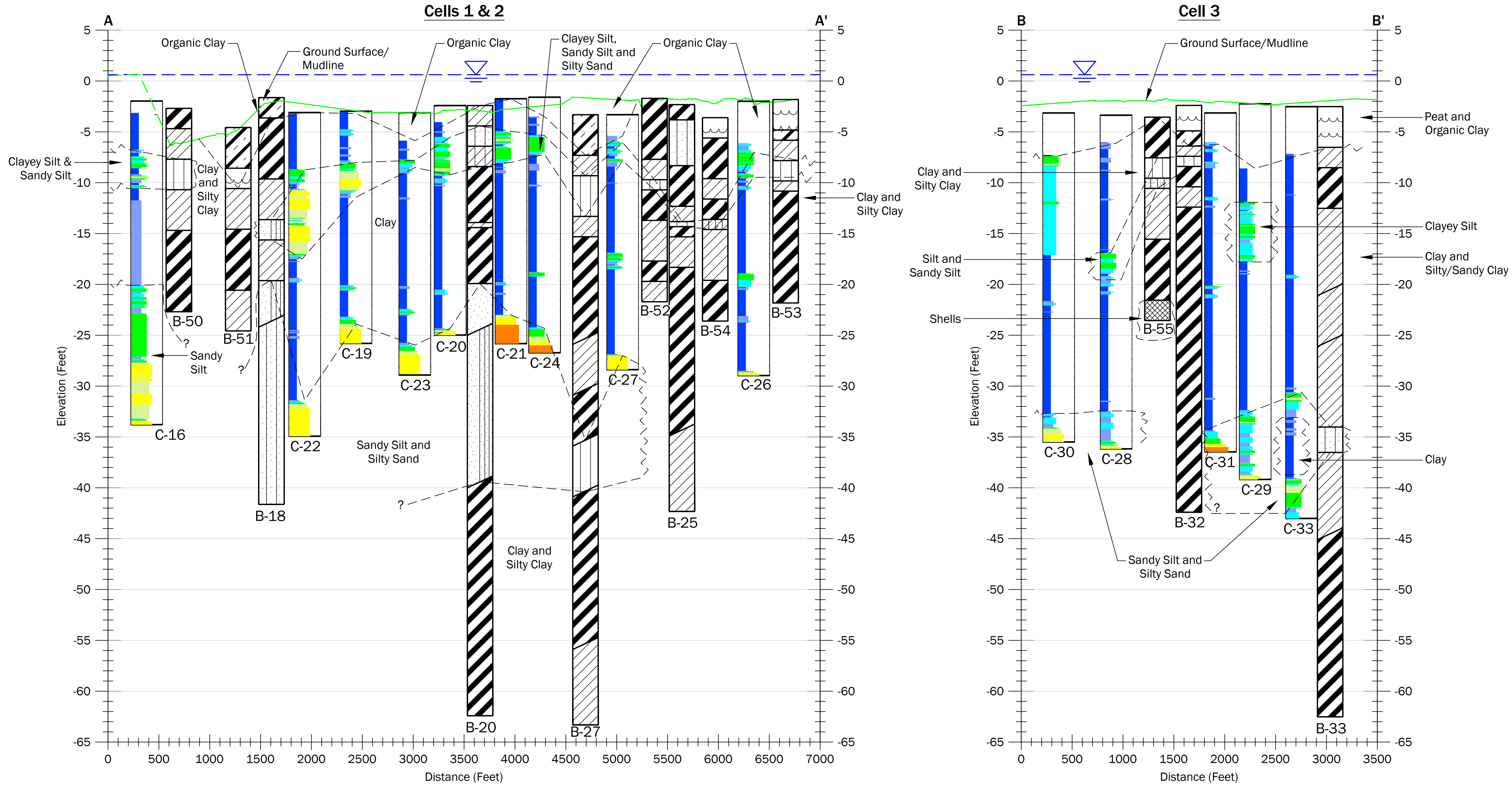
**Borrow Area**
**Site Plan**

East Leeville Marsh Creation and Nourishment
(BA-194)
Lafourche Parish, Louisiana

GeoEngineers

**Figure 3**

P:\18\18274004\CAD\02\Geotech - Final\18274400402_F02-06_Boring CPT Plan.dwg TAB:F03 - BLP Date Exported: 03/25/20 - 17:49 by kcook




Notes:
1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. cannot guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.

Data Source:
1. Boring and CPT mudline elevations were provided by Lonnie G Harper, Drawing: Boring Location Map_Final, Project # 2018-31, Sheet 3, Dated: 4/10/2018
2. Water elevation was provided by CPRA Dated: Sept. 31, 2018
3. Ground surface/mudline obtained from survey provided by CPRA on 7/31/18.

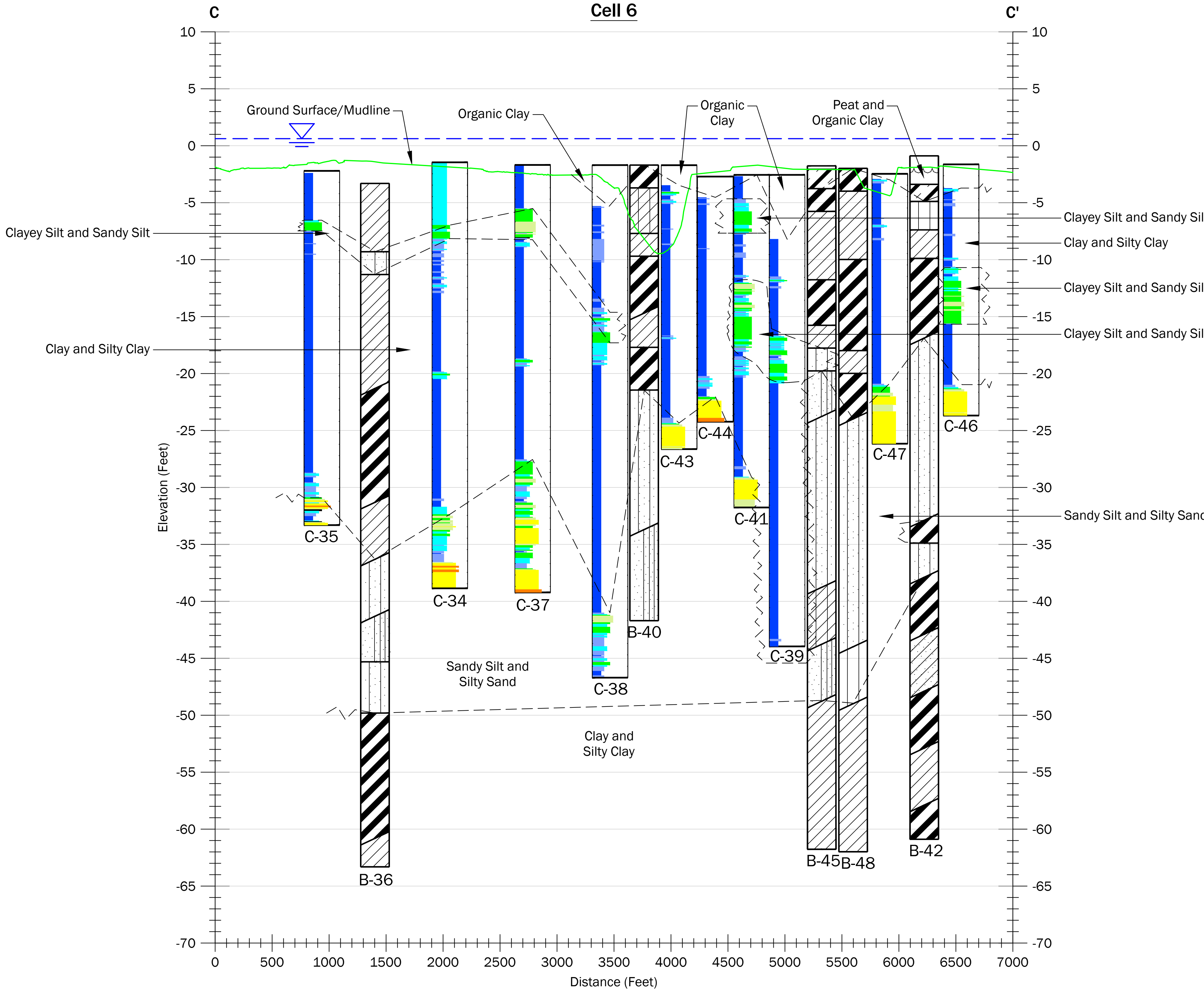
1000 0 1000
Horizontal Scale in Feet
10 0 10
Vertical Scale in Feet
Vertical Exaggeration: 100X

**CPT Legend**
1 - Sensitive, Fine Grained Soils
2 - Organic Soils, Peats
3 - Clay
4 - Clays & Silty Clays
5 - Silty Clays & Clayey Silts
6 - Clayey Silts & Sandy Silts
7 - Sandy Silts & Silty Sands
8 - Silty Sands & Sands
9 - Sands
10 - Sands & Gravelly Sands
11 - Very Stiff Fine Grained Soils*
12 - Sands & Clayey Sands*
*Overconsolidated or Cemented

**Boring Legend**
Peat
Organic Clay
Silty Clay, Sandy Clay
Silt
Clay
Silty Clayey Sand
Sand
Clayey Sand
Silty Sand
Sand with Silt
Clayey Silt

**Subsurface Profiles A-A' and B-B'**
East Leeville Marsh Creation and Nourishment (BA-194)
Lafourche Parish, Louisiana
GeoEngineers
Figure 4

P:\18\18274004\CAD\02\Geotech - Final\18274004402_F02-06_Boring CPT Plan.dwg TAB:Section A-A' and B-B' Date Exported: 03/27/20 - 10:19 by kcook




## CPT Legend

- 1 - Sensitive, Fine Grained Soils
- 2 - Organic Soils, Peats
- 3 - Clay
- 4 - Clays & Silty Clays
- 5 - Silty Clays & Clayey Silts
- 6 - Clayey Silts & Sandy Silts
- 7 - Sandy Silts & Silty Sands
- 8 - Silty Sands & Sands
- 9 - Sands
- 10 - Sands & Gravelly Sands
- 11 - Very Stiff Fine Grained Soils*
- 12 - Sands & Clayey Sands*

*Overconsolidated or Cemented

## Boring Legend

- Peat
- Organic Clay
- Silty Clay, Sandy Clay
- Silt
- Clay
- Silty Clayey Sand
- Sand
- Clayey Sand
- Silty Sand
- Sand with Silt
- Clayey Silt

1000 0 1000
Horizontal Scale in Feet

10 0 10
Vertical Scale in Feet
Vertical Exaggeration: 100X

Notes:

1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. cannot guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.

Data Source:

1. Boring and CPT mudline elevations were provided by Lonnie G Harper, Drawing: Boring Location Map_Final, Project # 2018-31, Sheet 3, Dated: 4/10/2018
2. Water elevation was provided by CPRA Dated: Sept. 31, 2018
3. Ground surface/mudline obtained from survey provided by CPRA on 7/31/18.

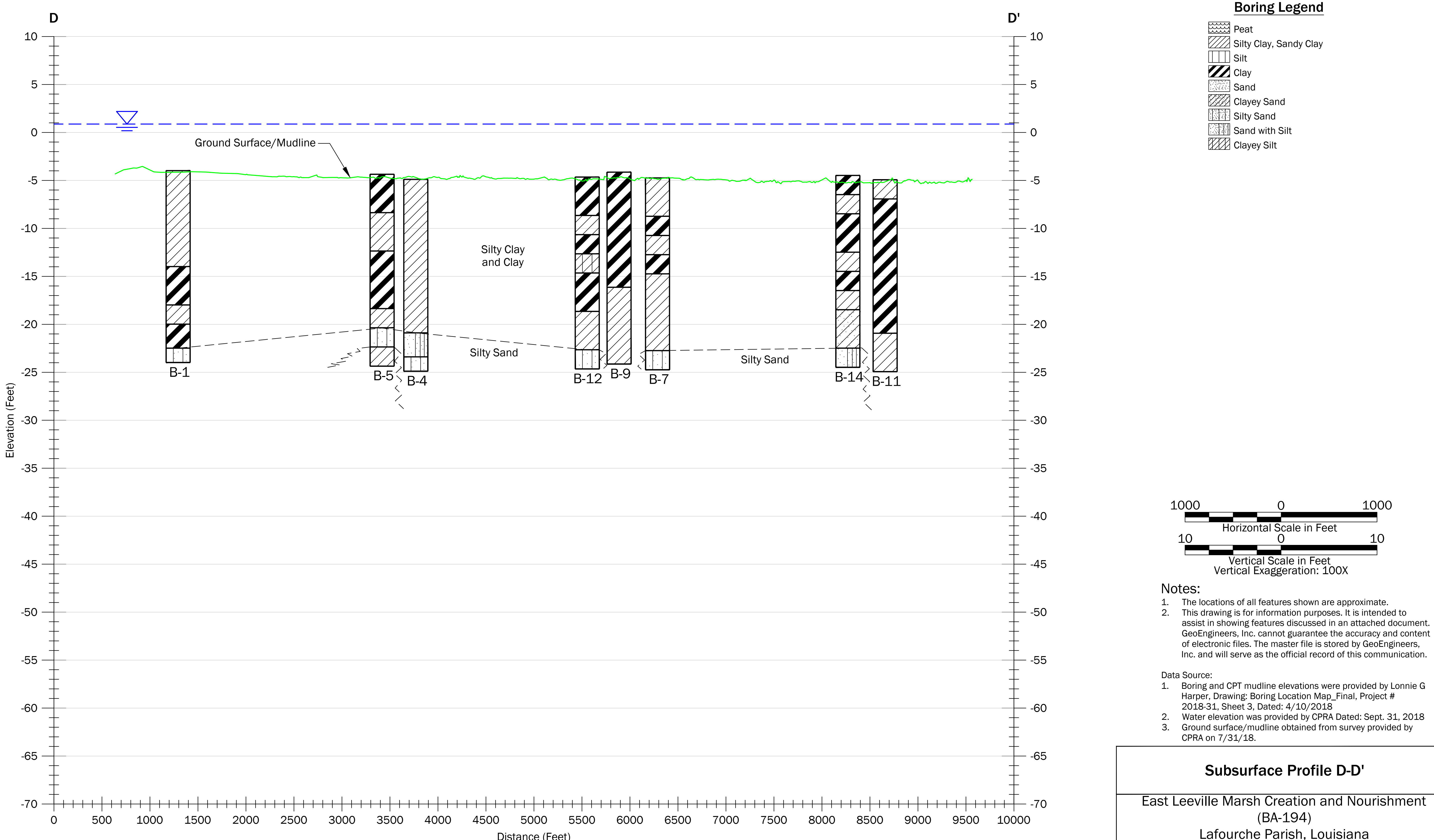
**Subsurface Profile C-C'**

East Leeville Marsh Creation and Nourishment (BA-194)
Lafourche Parish, Louisiana

GEOENGINEERS

**Figure 5**

P:\18\18274004\CAD\02\Geotech - Final\18274004\02_F02-06_Boring CPT Plan.dwg TAB:Section C-C' Date Exported: 03/25/20 - 19:14 by kcook




Notes:

1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. cannot guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.

Data Source:

1. Boring and CPT mudline elevations were provided by Lonnie G Harper, Drawing: Boring Location Map_Final, Project # 2018-31, Sheet 3, Dated: 4/10/2018
2. Water elevation was provided by CPRA Dated: Sept. 31, 2018
3. Ground surface/mudline obtained from survey provided by CPRA on 7/31/18.

**Subsurface Profile D-D'**

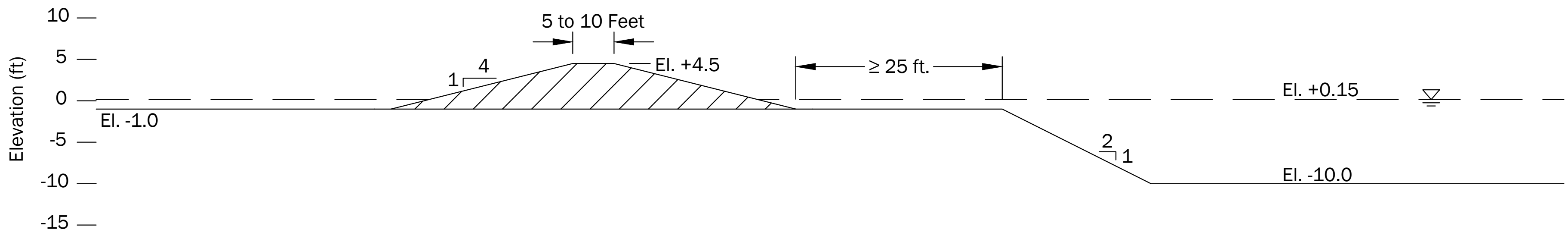
East Leeville Marsh Creation and Nourishment (BA-194)
Lafourche Parish, Louisiana

GeoEngineers

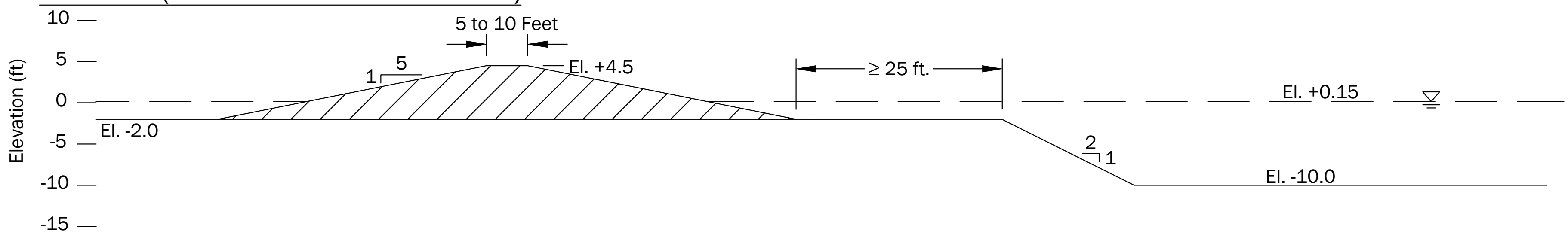
**Figure 6**

P:\18\18274004\CAD\02\Geotech - Final\1827400402_F07a-07b_Design Sections.dwg TAB:F07a ECD Design Date Exported: 03/27/20 - 10:33 by kcook

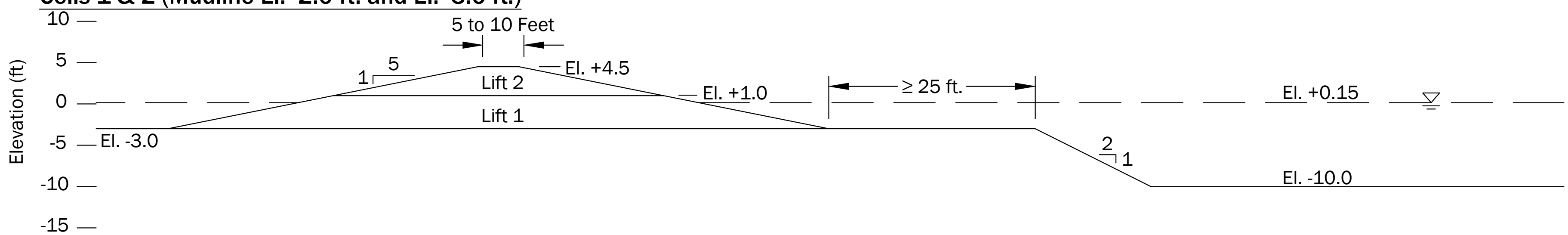
## Cells 1 & 2 (Mudline El. -1.0 ft. and Higher)



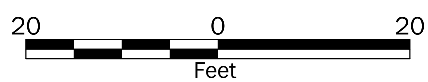

## Cells 1 & 2 (Mudline El. -1.0 ft. and El. -2.0 ft.)




## Cells 1 & 2 (Mudline El. -2.0 ft. and El. -3.0 ft.)




Note:
Allow lift 1 to rest for at least 2 weeks before adding lift 2.




**Cells 1 & 2 Containment Dike Design Sections**

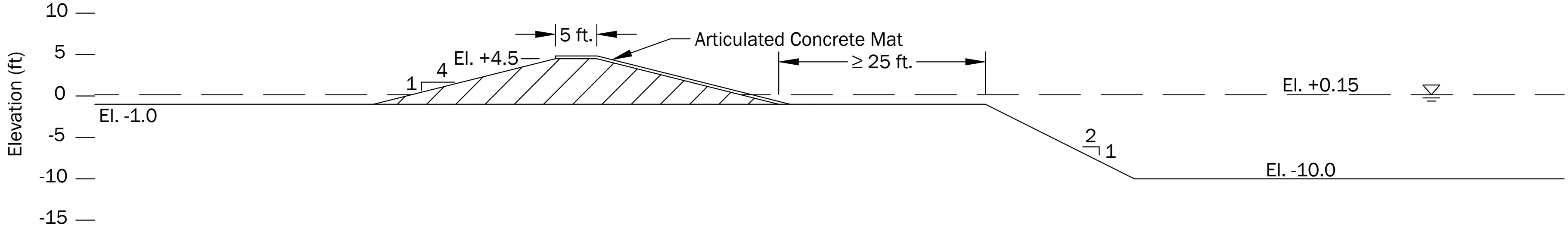
East Leeville Marsh Creation and Nourishment
(BA-194)
Lafourche Parish, Louisiana

GEOENGINEERS

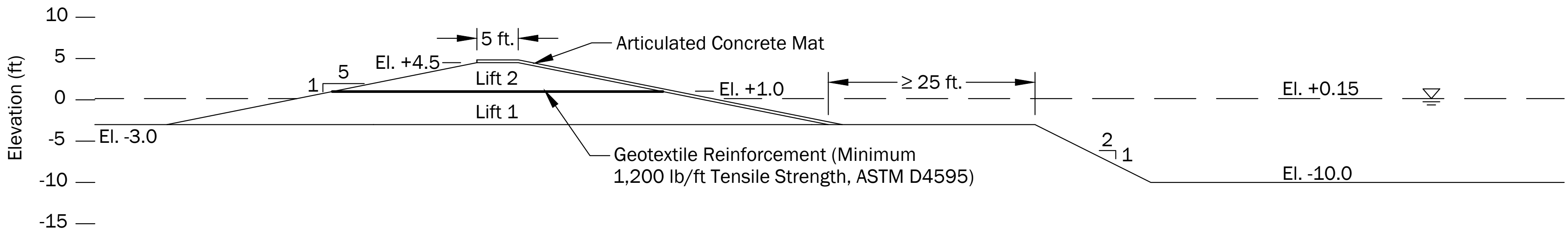
**Figure 7a**

P:\18\18274004\CAD\02\Geotech - Final\1827400402_F07a-07b_Design Sections.dwg TAB:F07b ECD Design Date Exported: 05/08/20 - 10:54 by kcook

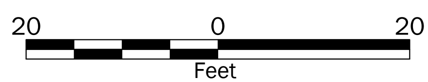
## Cells 1 & 2 (Mudline El. -2.0 ft. and Higher)




## Cells 1 & 2 (Mudline El. -2.0 ft. and El. -3.0 ft.)




Note:
Allow lift 1 to rest for at least 2 weeks before adding lift 2.




**Cells 1 & 2 Containment Dike Design Sections**

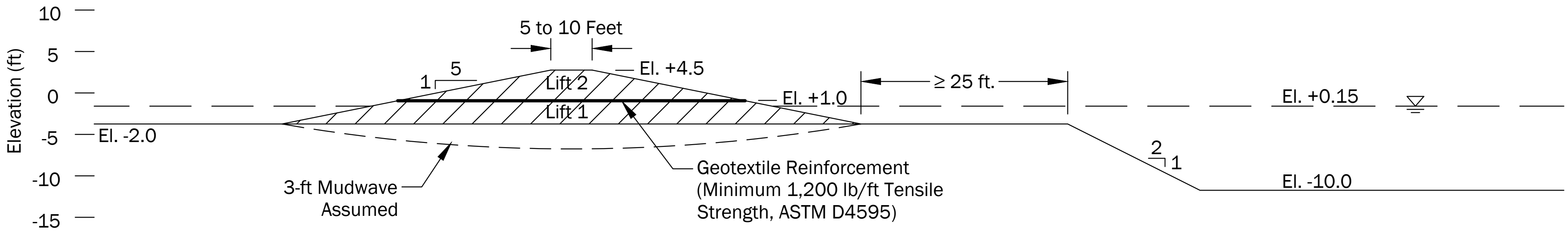
East Leeville Marsh Creation and Nourishment
(BA-194)
Lafourche Parish, Louisiana

GEOENGINEERS

**Figure 7b**

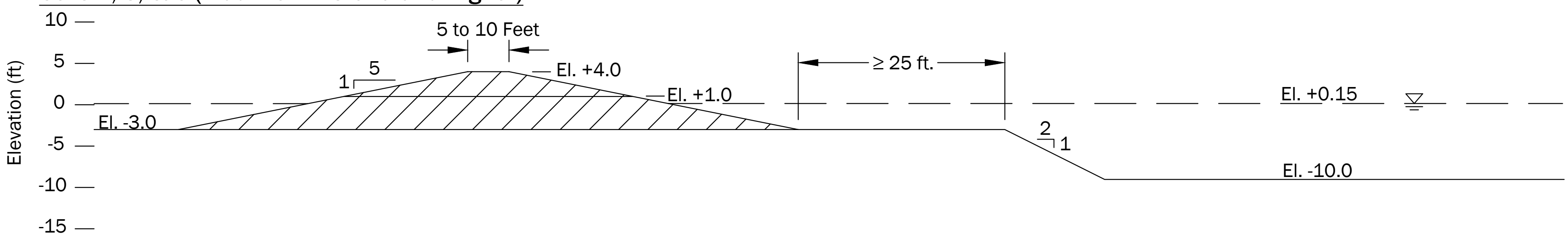
P:\18\18274004\CAD\02\Geotech - Final\1827400402_F07a-07b_Design Sections.dwg TAB:F07c ECD Design Date Exported: 03/27/20 - 10:34 by kcook

## Cell 3 (Mudline El. -2.0 ft. and Higher)

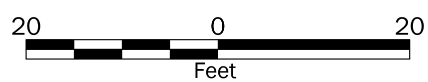



Note:
Allow lift 1 to rest for at least 2 weeks before adding lift 2.

## Cells 4, 5, & 6 (Mudline El. -3.0 ft. and Higher)

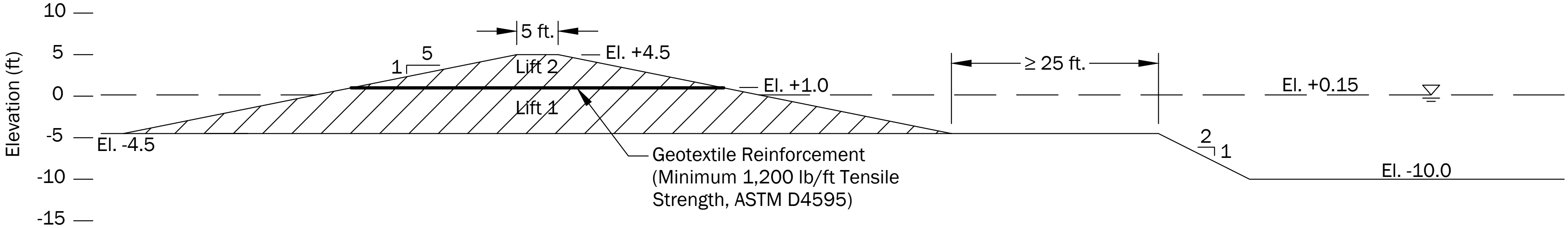



Note:
Allow lift 1 to rest for at least 4 weeks before adding lift 2.




| **Cells 3, 4, 5 & 6 Containment Dike Design Sections** | |
|---|---|
| East Leeville Marsh Creation and Nourishment (BA-194) Lafourche Parish, Louisiana | |
| GeoEngineers | **Figure 7c** |

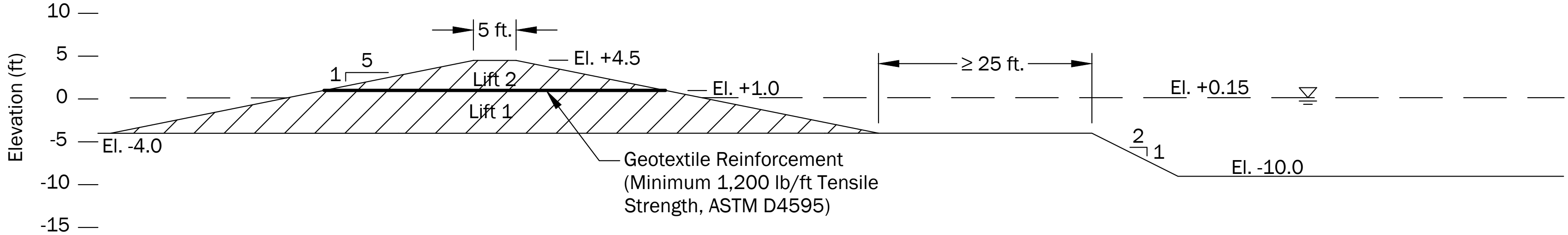
## Cell 2 (Mudline El. -3.0 ft. to El. -4.5 ft.)




**Note:**
**Allow lift 1 to rest for at least 2 weeks before adding lift 2.**

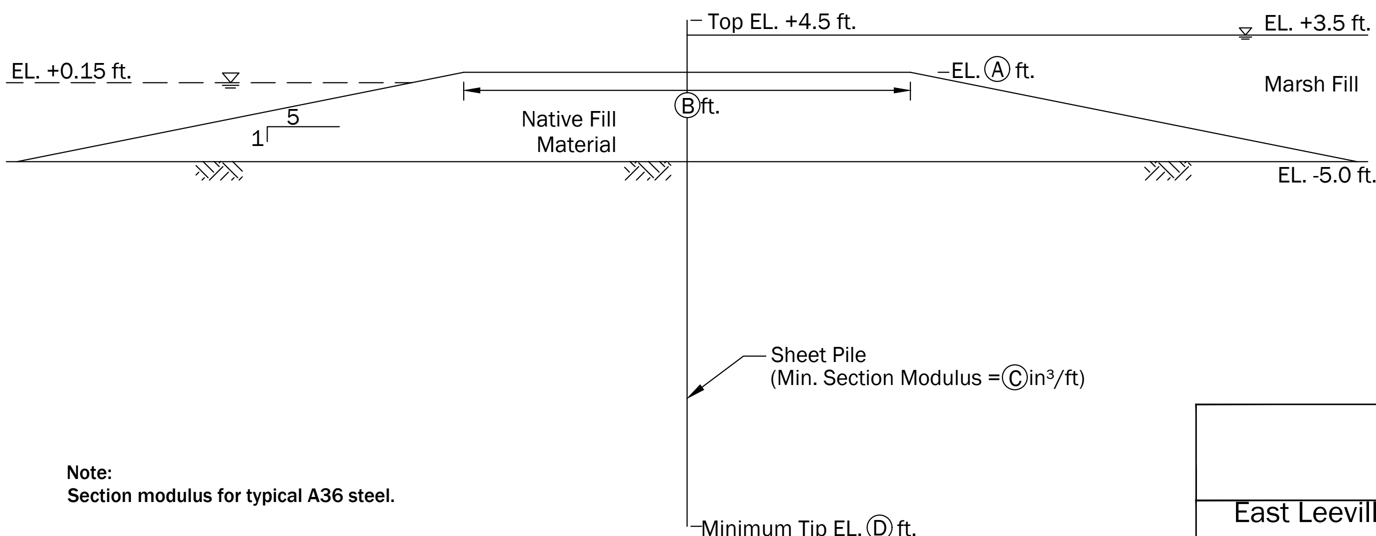
| Cell 2 Gap Closure Design Section | |
|---|---|
| East Leeville Marsh Creation and Nourishment (BA-194) Lafourche Parish, Louisiana | |
| GeoEngineers | Figure 8a |

## Cell 3 (Mudline El. -2.0 ft. to El. -4.0 ft.)

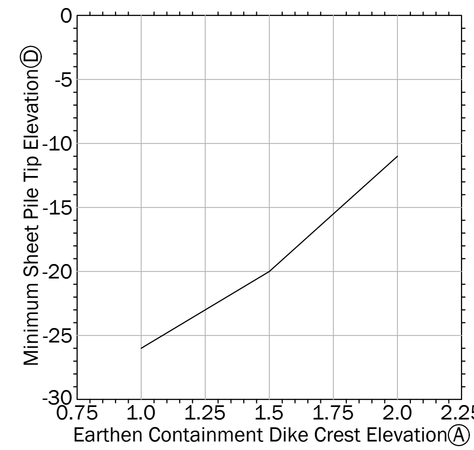



**Note:**
**Allow lift 1 to rest for at least 4 weeks before adding lift 2.**

## Cell 3 (Mudline El. -4.0 ft. to El. -5.0 ft.)




**Note:**
**Section modulus for typical A36 steel.**




| Sheet Pile Gap Closure Options | A | B | C | D |
|---|---|---|---|---|
| Design Option 1 | +1.0 | 40 | 2.3 | -26 |
| Design Option 2 | +1.5 | 35 | 1.1 | -20 |
| Design Option 3 | +2.0 | 30 | 0.5 | -11 |

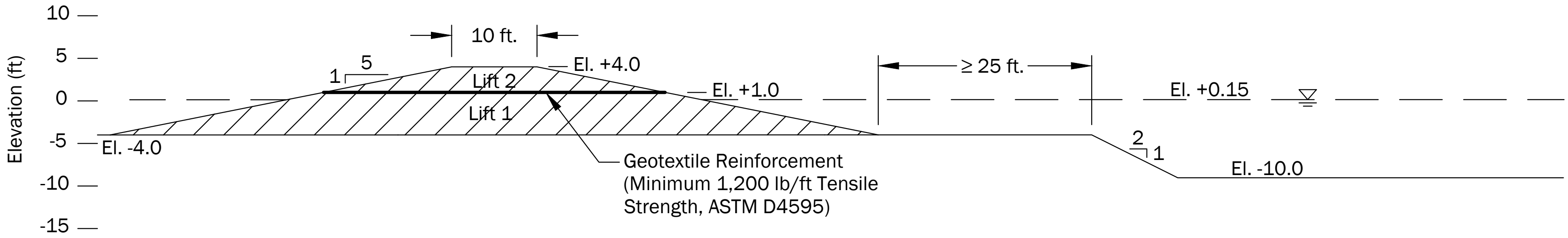
**Cell 3 Gap Closure**
**Design Sections**

East Leeville Marsh Creation and Nourishment
(BA-194)
Lafourche Parish, Louisiana

GEOENGINEERS

**Figure 8b**

## Cell 6 (Mudline El. -3.0 ft. to El. -4.0 ft.)

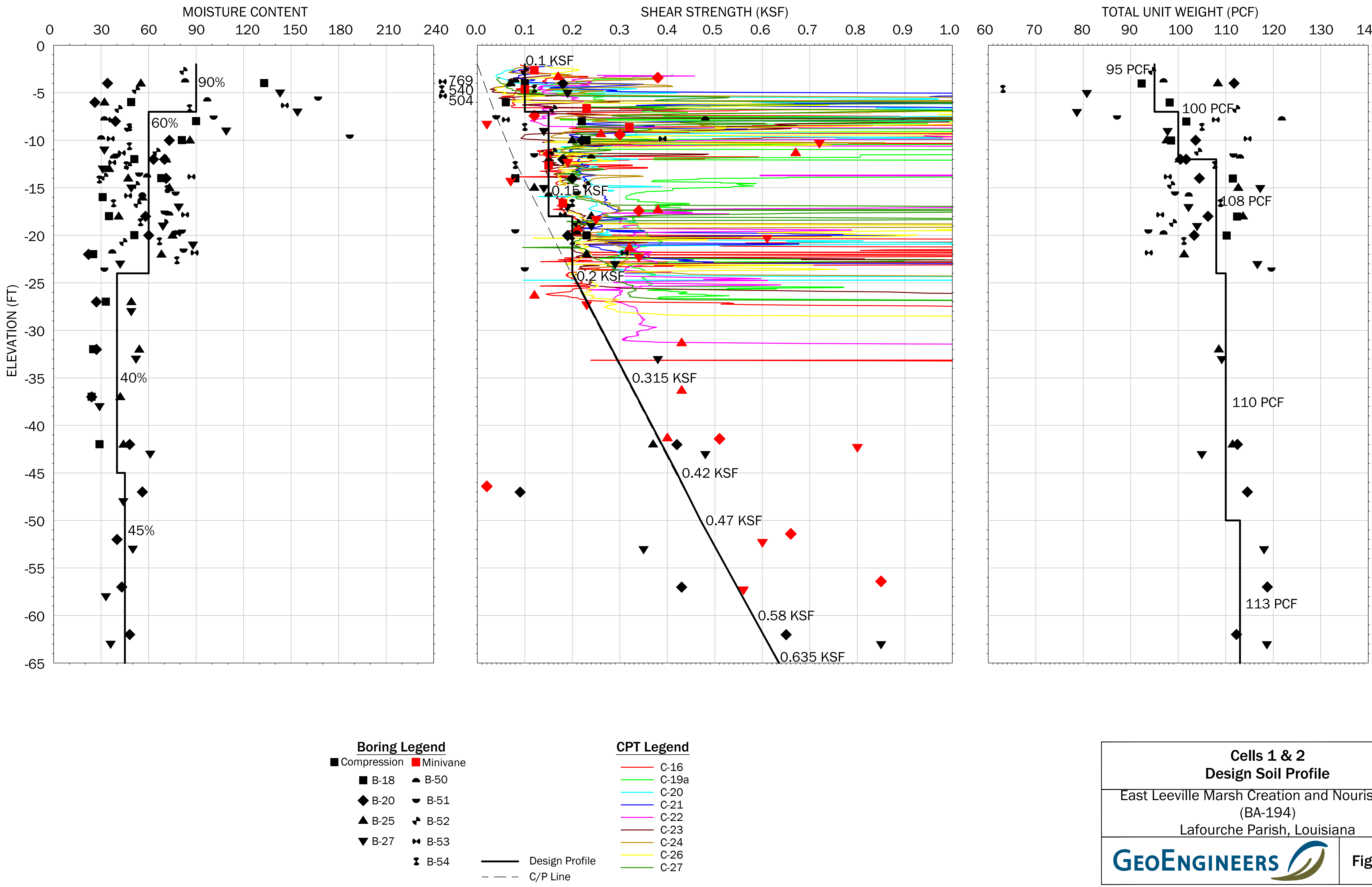



**Note:**
**Allow lift 1 to rest for at least 4 weeks before adding lift 2.**

| | |
|---|---|
| **Cell 6 Gap Closure Design Section** | |
| East Leeville Marsh Creation and Nourishment (BA-194) Lafourche Parish, Louisiana | |
| GeoEngineers | **Figure 8c** |

APPENDICES

# APPENDIX A
## Design Soil Profiles



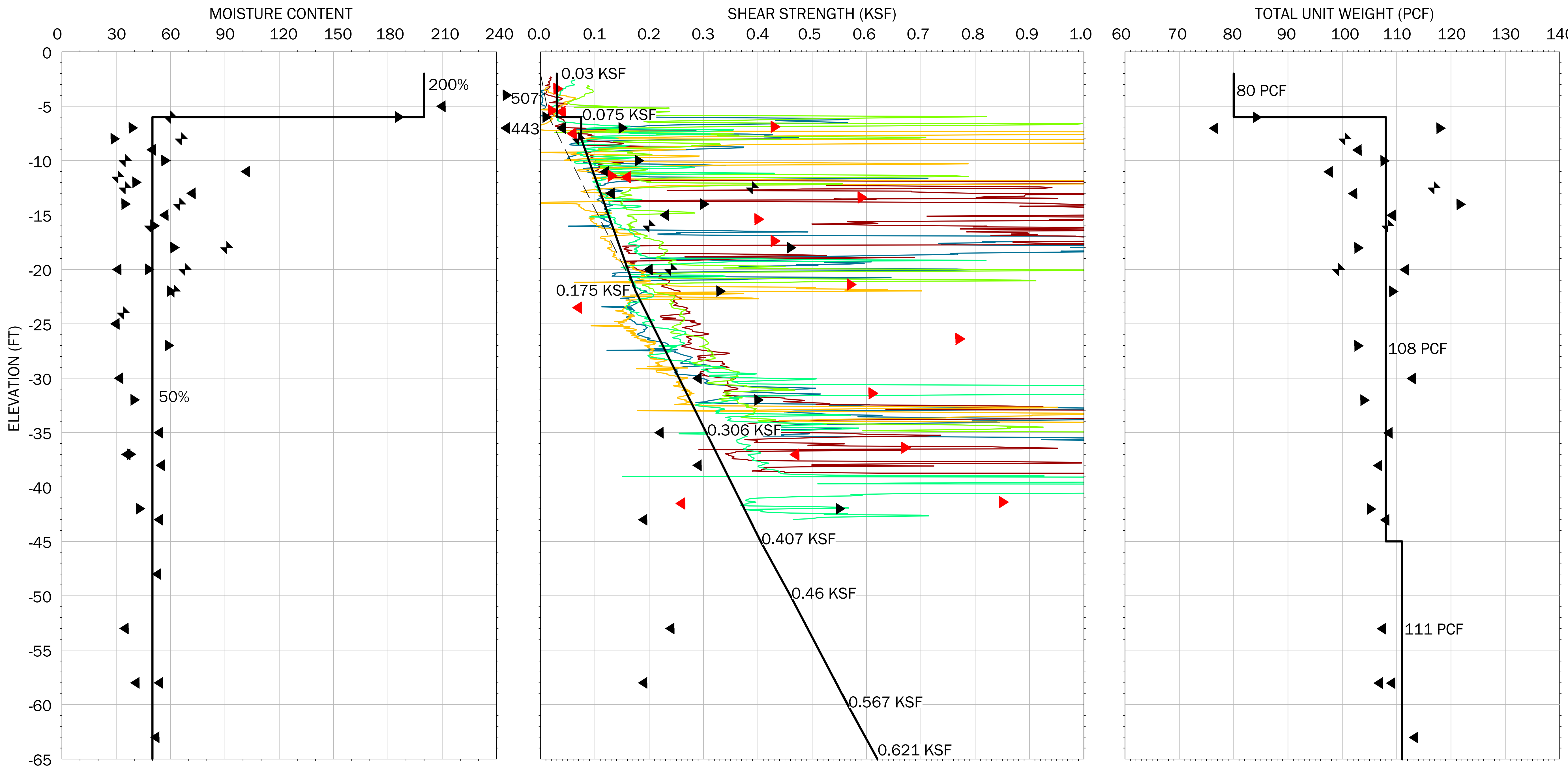

**Cells 1 & 2**
**Design Soil Profile**

East Leeville Marsh Creation and Nourishment
(BA-194)
Lafourche Parish, Louisiana

GeoEngineers

**Figure A-1**

P:\18\18274004\CAD\02\Geotech - Final\18274400402_FA1-A2_Lab Data.dwg TAB:Lab Graphs Cell 1-2 Date Exported: 04/17/20 - 9:15 by kcook




**Boring Legend**

Compression Minivane

B-32

B-33

B-55

Design Profile

C/P Line

**CPT Legend**

C-28

C-29

C-30

C-31b

C-33a

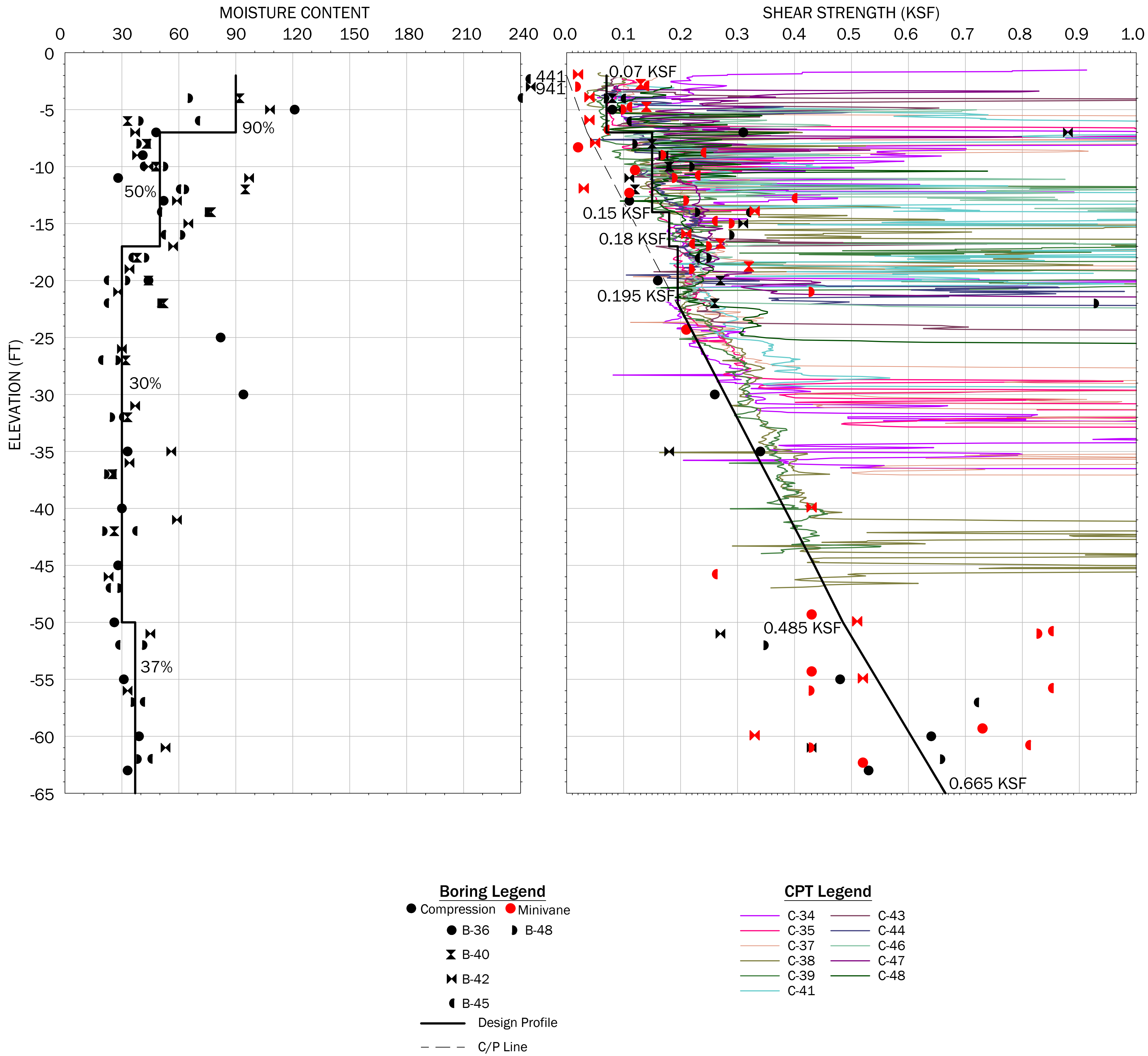
**Cell 3**
**Design Soil Profile**

East Leeville Marsh Creation and Nourishment
(BA-194)
Lafourche Parish, Louisiana

GEOENGINEERS

**Figure A-2**

P:\18\18274004\CAD\02\Geotech - Final\18274004_02_FA1-A2_Lab Data.dwg TAB:Lab Graphs Cell 3 Date Exported: 04/17/20 - 9:19 by kcook




**Cells 4, 5 & 6**
**Design Soil Profile**

East Leeville Marsh Creation and Nourishment
(BA-194)
Lafourche Parish, Louisiana

GEOENGINEERS

**Figure A-3**

P:\18\18274004\CAD\02\Geotech - Final\18274004002_FA1-A2_Lab Data.dwg TAB:Lab Graphs Cell 4-5 Date Exported: 03/26/20 - 8:40 by kcook

**TABLE A-1. SETTLEMENT PARAMETERS – CELLS 1 & 2**

| Elevation (ft) | | Cohesion (ksf) | Moisture Content (%) | Specific Gravity[1] | Wet Unit Weight (pcf) | Initial Void Ratio[2], $e_0$ | Compression Index[3], $C_c$ | Recompression Index[4], $C_r$ | Coefficient of Consolidation, $C_v$ ($ft^2$/day) | Effective Overburden Pressure, $P'_0$ (tsf) | Overconsolidation Ratio, OCR | Preconsolidation Pressure, $P_c$ (tsf) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| -1.5 | -7.0 | 0.100 | 90 | 2.63 | 95 | 2.415 | 1.20 | 0.120 | 0.020 | 0.045 | 7.6 | 0.341 |
| -7.0 | -12.0 | 0.150 | 60 | 2.66 | 100 | 1.617 | 0.87 | 0.060 | 0.040 | 0.137 | 3.1 | 0.428 |
| -12.0 | -18.0 | 0.150 | 60 | 2.66 | 108 | 1.617 | 0.71 | 0.109 | 0.040 | 0.252 | 1.5 | 0.368 |
| -18.0 | -24.0 | 0.200 | 60 | 2.66 | 108 | 1.617 | 0.68 | 0.106 | 0.040 | 0.389 | 1.2 | 0.473 |
| -24.0 | -35.0 | 0.258 | 40 | 2.68 | 110 | 1.085 | 0.43 | 0.043 | 0.200 | 0.588 | 1.0 | 0.588 |
| -35.0 | -45.0 | 0.368 | 40 | 2.68 | 110 | 1.085 | 0.43 | 0.043 | 0.200 | 0.838 | 1.0 | 0.838 |
| -45.0 | -50.0 | 0.445 | 45 | 2.68 | 110 | 1.218 | 0.51 | 0.051 | 0.110 | 1.017 | 1.0 | 1.017 |
| -50.0 | -60.0 | 0.525 | 45 | 2.68 | 113 | 1.218 | 0.51 | 0.051 | 0.110 | 1.203 | 1.0 | 1.203 |
| -60.0 | -70.0 | 0.635 | 45 | 2.68 | 113 | 1.218 | 0.51 | 0.051 | 0.110 | 1.456 | 1.0 | 1.440 |

[1] SG= -0.001*M.C. + 2.7234
[2] $e_0$ = 0.0266*M.C. + 0.0206
[3] $C_c = 7.2701e^{-0.036*\text{dry UW}}$ and $C_c$ = 0.0233*M.C. – 0.5396 (where consolidation data unavailable)
[4] $C_r = 0.1 \times C_c$ (where consolidation data unavailable)

**TABLE A-2. SETTLEMENT PARAMETERS – CELL 3**

| Elevation (ft) | | Cohesion (ksf) | Moisture Content (%) | Specific Gravity[1] | Wet Unit Weight (pcf) | Initial Void Ratio[2], $e_0$ | Compression Index[3], $C_c$ | Recompression Index[4], $C_r$ | Coefficient of Consolidation, $C_v$ ($ft^2$/day) | Effective Overburden Pressure, $P'_0$ (tsf) | Overconsolidation Ratio, OCR | Preconsolidation Pressure, $P_c$ (tsf) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| -2.0 | -6.0 | 0.030 | 200 | 2.52 | 80 | 5.341 | 2.78 | 0.278 | 0.050 | 0.018 | 5.4 | 0.096 |
| -6.0 | -8.0 | 0.075 | 50 | 2.67 | 108 | 1.351 | 0.54 | 0.054 | 0.070 | 0.058 | 3.8 | 0.223 |
| -8.0 | -15.0 | 0.100 | 50 | 2.67 | 108 | 1.351 | 0.54 | 0.054 | 0.070 | 0.161 | 1.5 | 0.248 |
| -15.0 | -22.0 | 0.150 | 50 | 2.67 | 108 | 1.351 | 0.63 | 0.063 | 0.070 | 0.320 | 1.1 | 0.346 |
| -22.0 | -35.0 | 0.240 | 50 | 2.67 | 108 | 1.351 | 0.63 | 0.063 | 0.070 | 0.548 | 1.0 | 0.548 |
| -35.0 | -45.0 | 0.355 | 50 | 2.67 | 108 | 1.351 | 0.63 | 0.063 | 0.070 | 0.810 | 1.0 | 0.810 |
| -45.0 | -50.0 | 0.433 | 50 | 2.67 | 111 | 1.351 | 0.63 | 0.063 | 0.070 | 0.985 | 1.0 | 0.985 |
| -50.0 | -60.0 | 0.513 | 50 | 2.67 | 111 | 1.351 | 0.63 | 0.063 | 0.070 | 1.167 | 1.0 | 1.167 |
| -60.0 | -70.0 | 0.620 | 50 | 2.67 | 111 | 1.351 | 0.63 | 0.063 | 0.070 | 1.410 | 1.0 | 1.409 |

[1] SG= -0.001*M.C. + 2.7234
[2] $e_0$ = 0.0266*M.C. + 0.0206
[3] $C_c = 7.2701e^{-0.036*\text{dry UW}}$ and $C_c$ = 0.0233*M.C. – 0.5396 (where consolidation data unavailable)
[4] $C_r = 0.1 \times C_c$ (where consolidation data unavailable)

**TABLE A-3. SETTLEMENT PARAMETERS – CELLS 4, 5 & 6**

| Elevation (ft) | | Cohesion (ksf) | Moisture Content (%) | Specific Gravity[1] | Wet Unit Weight (pcf) | Initial Void Ratio[2], $e_0$ | Compression Index[3], $C_c$ | Recompression Index[4], $C_r$ | Coefficient of Consolidation, $C_v$ ($ft^2$/day) | Effective Overburden Pressure, $P'_0$ (tsf) | Overconsolidation Ratio, OCR | Preconsolidation Pressure, $P_c$ (tsf) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| -1.0 | -7.0 | 0.070 | 90 | 2.63 | 95 | 2.415 | 1.20 | 0.120 | 0.020 | 0.049 | 4.4 | 0.214 |
| -7.0 | -14.0 | 0.150 | 50 | 2.67 | 110 | 1.351 | 0.52 | 0.052 | 0.070 | 0.181 | 2.2 | 0.399 |
| -14.0 | -17.0 | 0.180 | 50 | 2.67 | 110 | 1.351 | 0.63 | 0.063 | 0.070 | 0.300 | 1.5 | 0.442 |
| -17.0 | -22.0 | 0.195 | 30 | 2.69 | 110 | 0.819 | 0.29 | 0.012 | 1.000 | 0.395 | 1.2 | 0.456 |
| -22.0 | -35.0 | 0.263 | 30 | 2.69 | 110 | 0.819 | 0.29 | 0.012 | 1.000 | 0.610 | 1.0 | 0.610 |
| -35.0 | -45.0 | 0.383 | 30 | 2.69 | 110 | 0.819 | 0.29 | 0.012 | 1.000 | 0.883 | 1.0 | 0.883 |
| -45.0 | -50.0 | 0.460 | 30 | 2.69 | 110 | 0.819 | 0.29 | 0.012 | 1.000 | 1.062 | 1.0 | 1.062 |
| -50.0 | -60.0 | 0.545 | 37 | 2.69 | 116 | 1.005 | 0.34 | 0.034 | 0.300 | 1.255 | 1.0 | 1.255 |
| -60.0 | -70.0 | 0.665 | 37 | 2.69 | 116 | 1.005 | 0.34 | 0.034 | 0.300 | 1.523 | 1.0 | 1.508 |

[1] SG= -0.001*M.C. + 2.7234

[2] $e_0$ = 0.0266*M.C. + 0.0206

[3] $C_c = 7.2701e^{-0.036*dry\ UW}$ and $C_c$ = 0.0233*M.C. – 0.5396 (where consolidation data unavailable)

[4] $C_r$ = 0.1 x $C_c$ (where consolidation data unavailable)

# APPENDIX B
## Containment Dike Slope Stability and Bearing Capacity

## APPENDIX B
## CONTAINMENT DIKE SLOPE STABILITY AND BEARING CAPACITY

### Calculation Approach

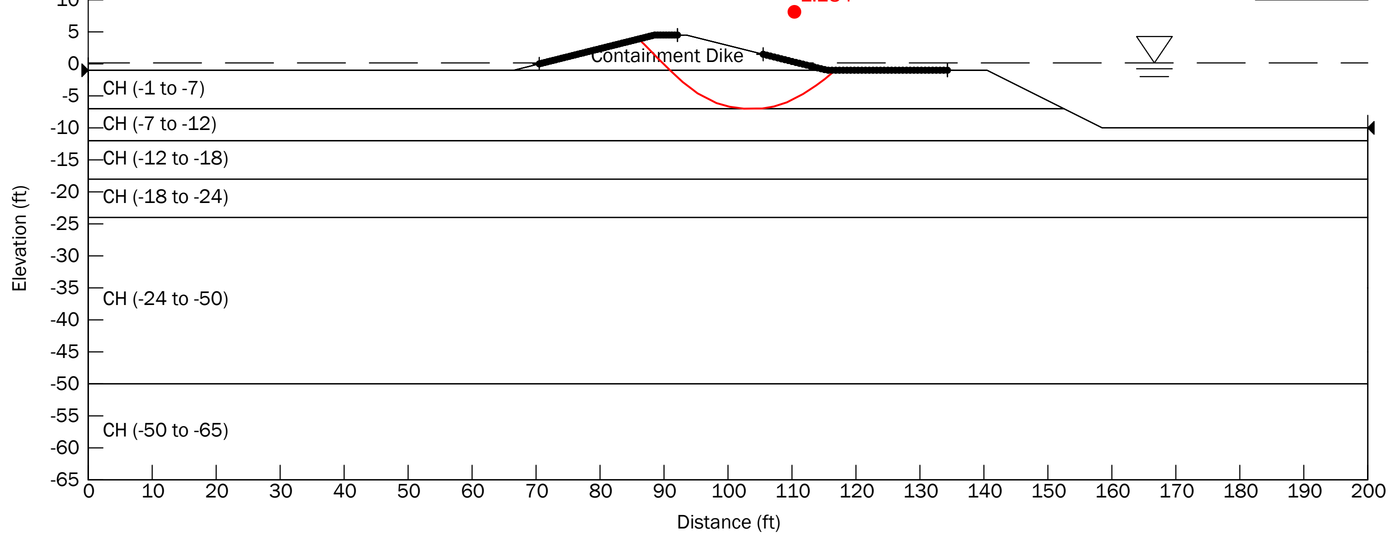
Containment dike slope stability was evaluated using optimized circular search parameters with Spencer's method in the GEO-SLOPE International Limited computer program SLOPE/W (GeoStudio 2016 and 2020). Bearing capacity of the containment dikes was also evaluated using traditional bearing capacity theory. Design considerations for the slope stability and bearing capacity evaluations are described below.

1. Three representative design profiles (Cells 1 & 2; Cell 3; and Cells 4, 5 & 6; Figures A-1 through A-3 of Appendix A) were used in our stability and bearing analyses.
2. A mean low water elevation of +0.15 feet, as provided by CPRA.
3. Governing mudline elevations for each cell, as provided by CPRA:
    a. Cells 1 & 2: El. -1.0 feet, El. -2.0 feet, El. -3.0 feet;
    b. Cell 3: El. -2.0 feet; and
    c. Cells 4, 5 & 6: El. -1.0 feet, El. -3.0 feet
4. A required factor of safety for slope stability for this project of 1.2.
5. A required factor of safety for bearing capacity for this project of 1.3.
6. Slope stability evaluations for the following cases:
    a. Case 1: Internal failure of the containment dike, no marsh fill placed;
    b. Case 2: Global failure of the containment dike into the borrow channel, no marsh fill placed;
    c. Case 3: Failure of the borrow channel, no marsh fill placed, construction equipment modeled; and
    d. Case 4: Failure of the containment dike, marsh fill placed.
7. For Case 3, the load of marsh excavation equipment on the bench between the containment dike toe and the top of the borrow channel was applied to the mudline. A load of 260 psf minus the depth of water (to account for buoyancy) and minus the weight of the mudwave material, as applicable, was applied at the mudline for each track width (4 feet).
8. The stability of the containment dikes was modeled with an external borrow channel. However, we understand that, in some areas, material for the dikes may also be dredged from a borrow channel within the marsh creation cells. The factors of safety associated with a Case 4 failure with an internal borrow channel are similar to a Case 4 failure with an external borrow channel.
9. The bearing capacity of the containment dikes was evaluated using the method for bearing on a two-layer cohesive soil as outlined in Figure 11-5 of the Naval Facilities Engineering Command Design Manual 7.02 *Foundations and Earth Structures*.
10. The values for unit weight within the containment dike material were based on the unit weight of the material within the depth of the proposed borrow channel for each cell. An assumed initial cohesion of 60 psf was used for the containment dike material based on our experience with similar projects. In cases where a second lift was necessary for stability, we included up to 15 percent gain in shear strength of the first lift of the dike and of shallow soil layers directly under the dike first lift.

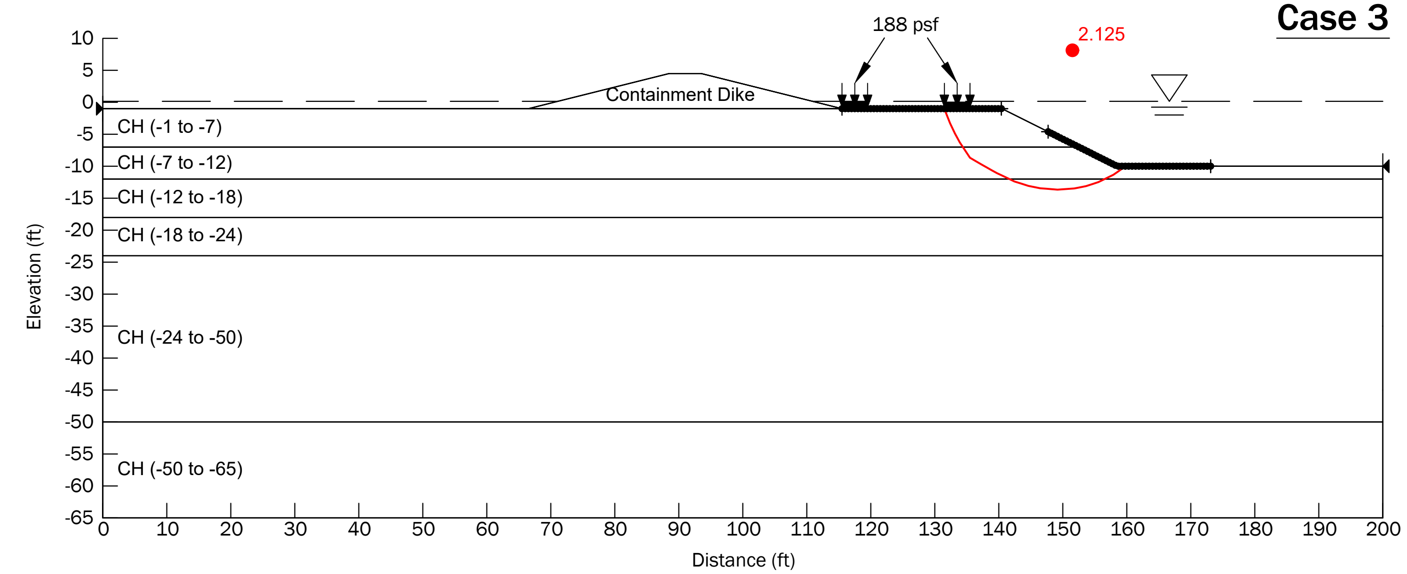
11. Based on the marsh fill settlement analyses, a unit weight of 85 pounds per cubic foot (pcf) was selected for the marsh fill material. Conservatively, a cohesion of 0 psf was assumed for the strength of the material.
12. An open-cell, 4-inch thick ACM was modeled above the crest and on the exterior side of the dike with a unit weight of 100 pcf and a friction angle of 40°.

The results of our analyses are shown in the following figures and calculations.

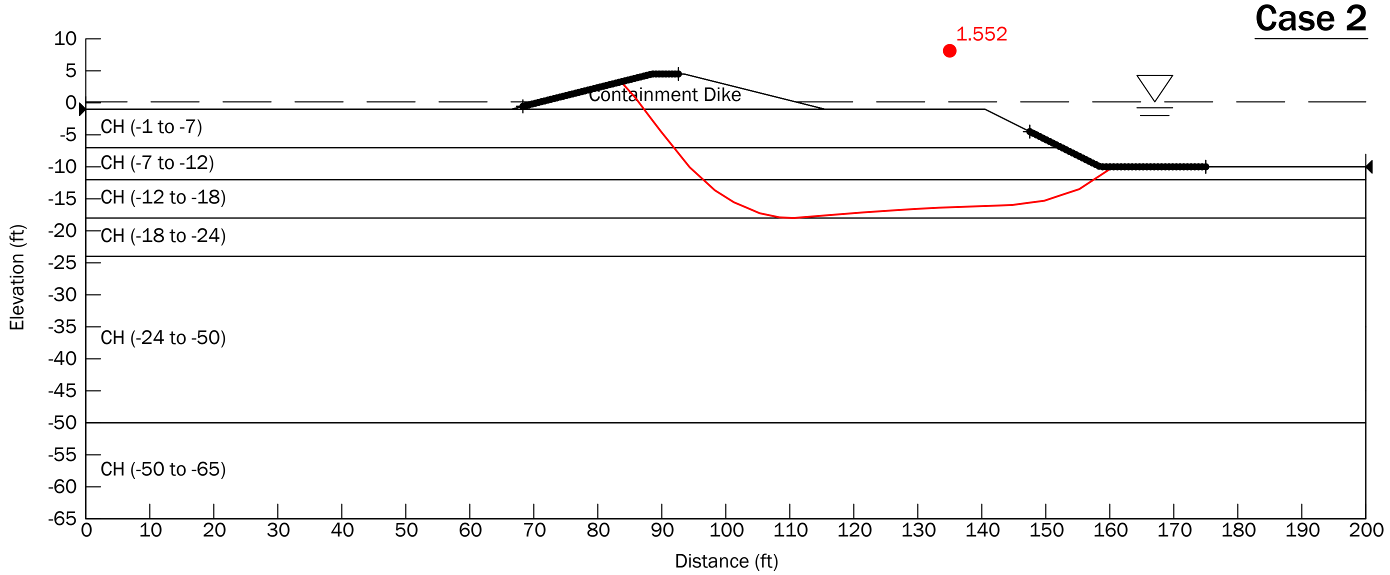
## Case 1



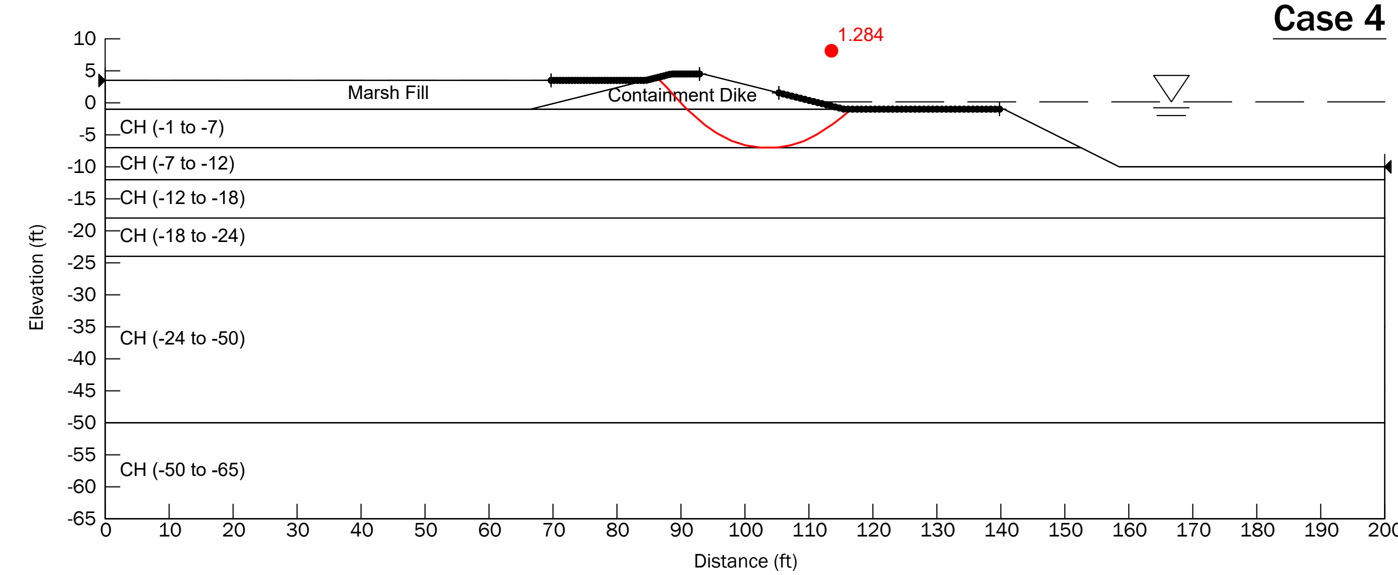

## Case 3




## Case 2




## Case 4



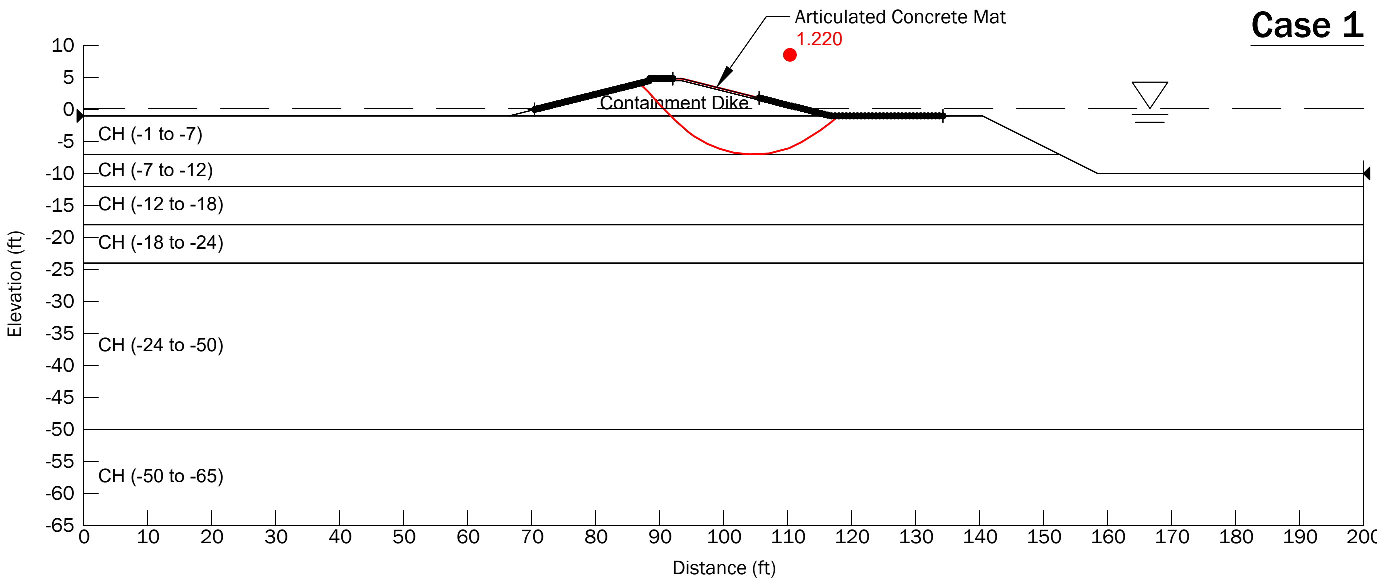

| Name | Model | Unit Weight (pcf) | Cohesion' (psf) | Phi' (°) | Cohesion Fn |
|---|---|---|---|---|---|
| Marsh Fill | Mohr-Coulomb | 85 | 0 | 0 | |
| Containment Dike | Mohr-Coulomb | 95 | 60 | 0 | |
| CH (-1 to -7) | Mohr-Coulomb | 95 | 100 | 0 | |
| CH (-7 to -12) | Mohr-Coulomb | 100 | 150 | 0 | |
| CH (-12 to -18) | Mohr-Coulomb | 108 | 150 | 0 | |
| CH (-18 to -24) | Mohr-Coulomb | 108 | 200 | 0 | |
| CH (-24 to -50) | Spatial Mohr-Coulomb | 110 | | 0 | 200 psf + 10.4 psf/ft |
| CH (-50 to -65) | Spatial Mohr-Coulomb | 113 | | 0 | 470 psf + 11 psf/ft |

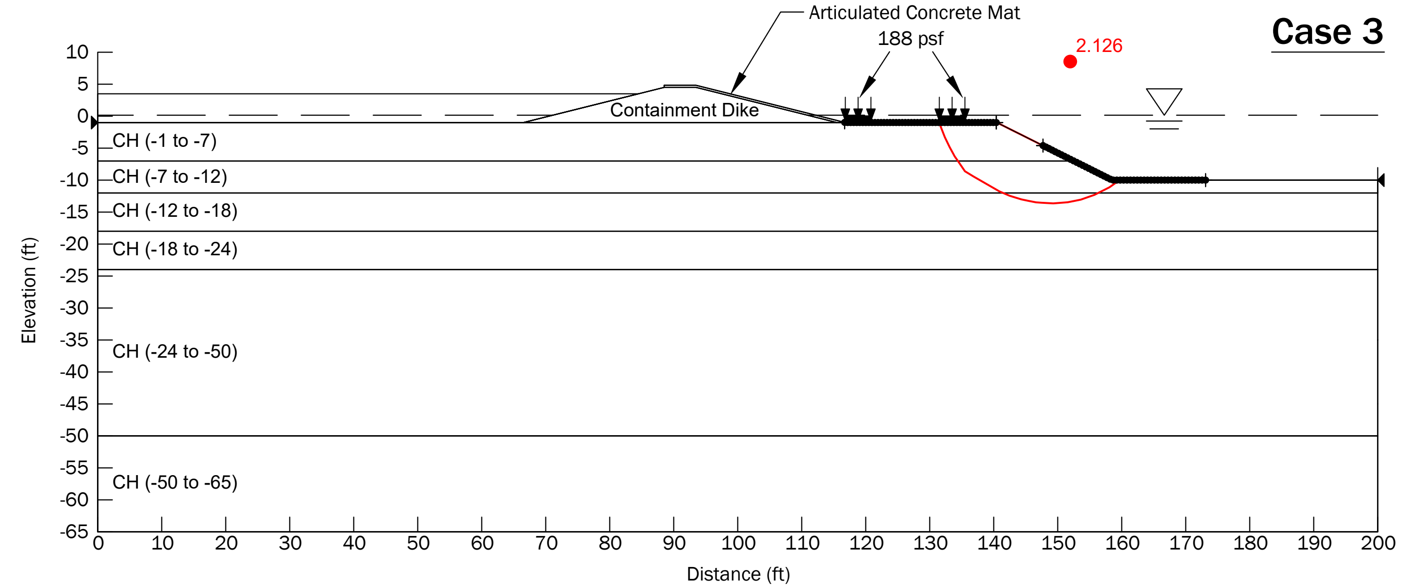
**Containment Dike Slope Stability - Cells 1 & 2, Mudline El. -1.0 ft, 5ft Crest**

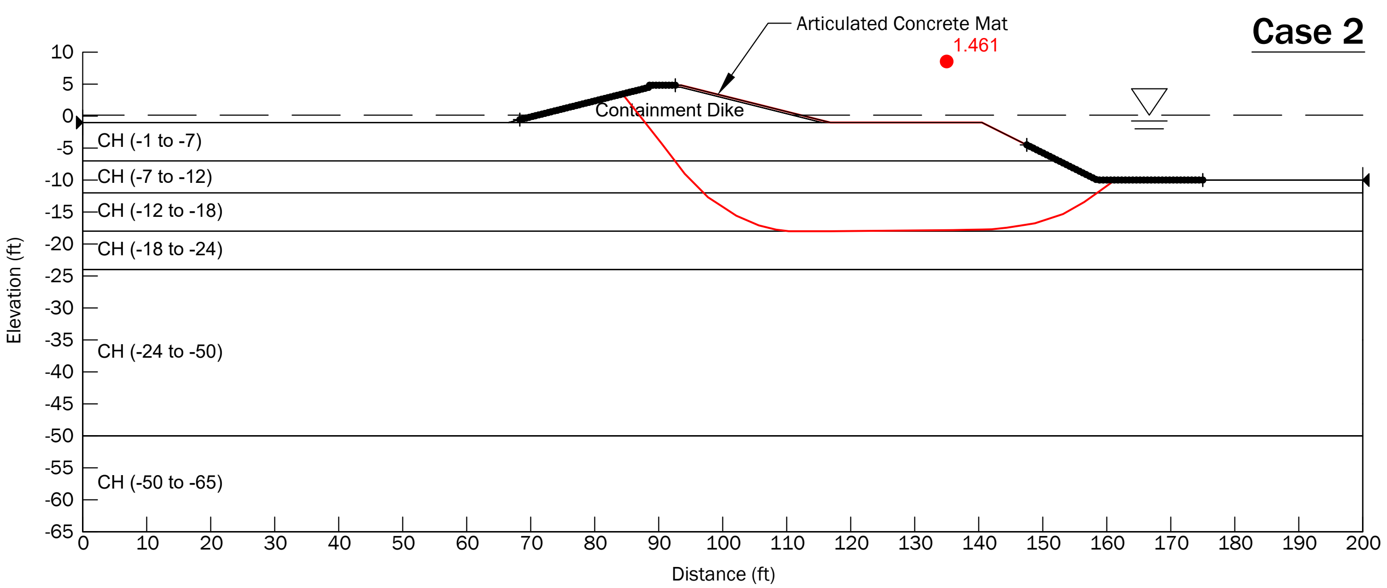
East Leeville Marsh Creation and Nourishment
(BA-194)
Lafourche Parish, Louisiana

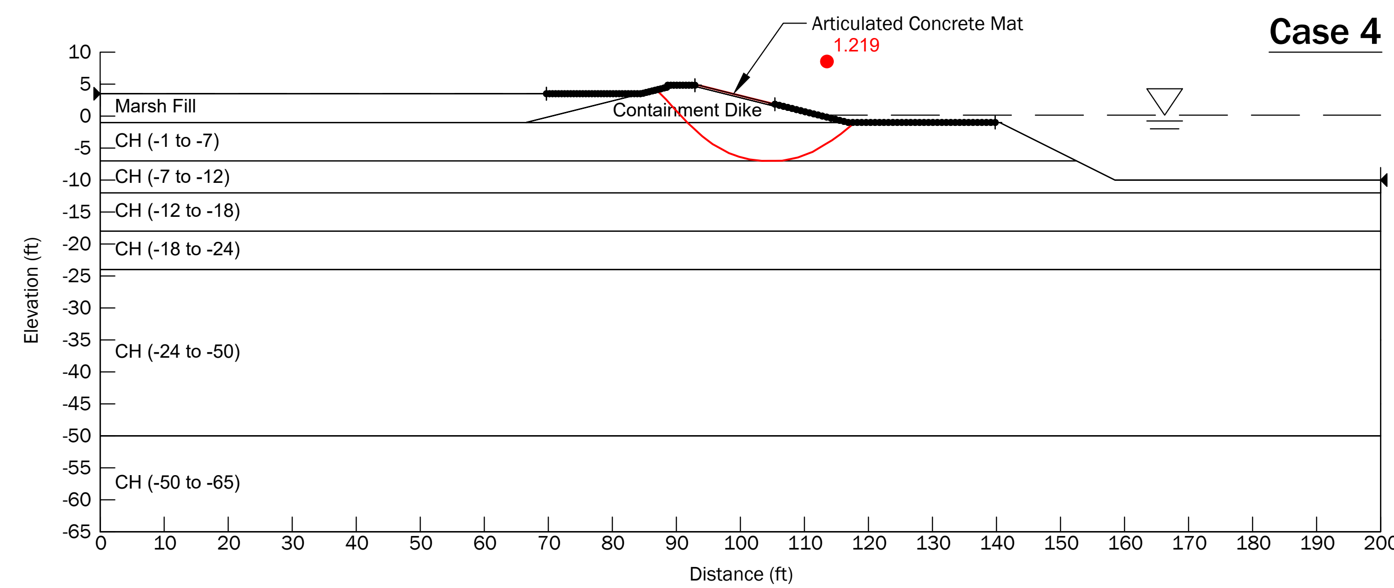
GeoEngineers

**Figure B-1a**



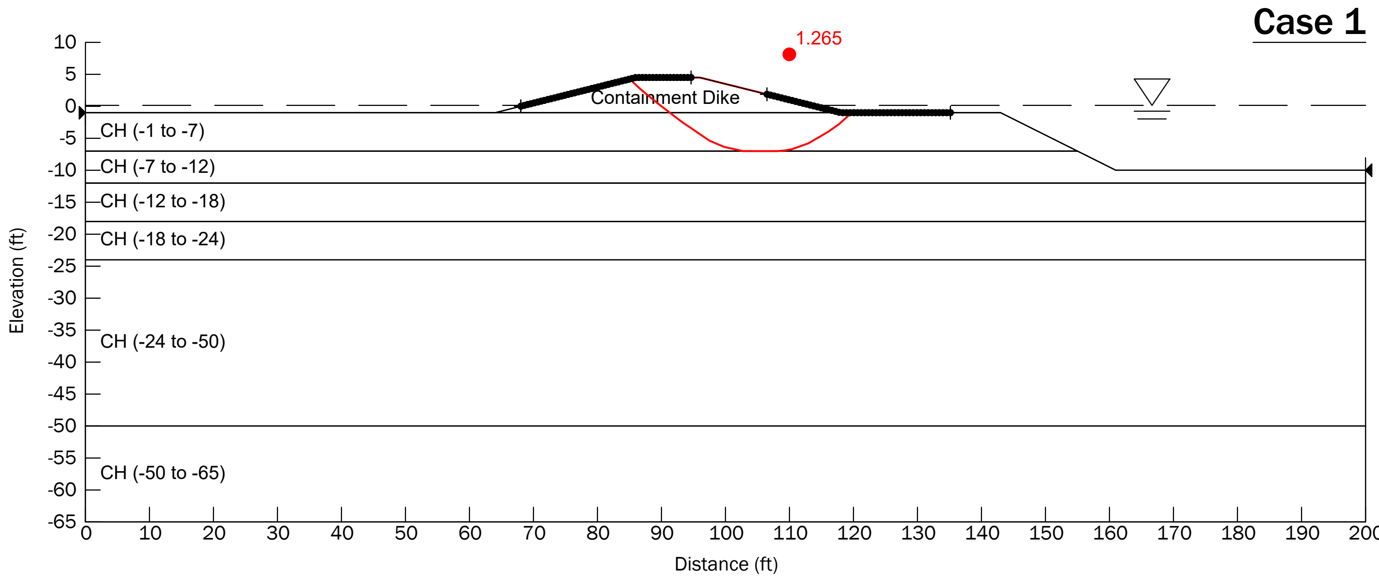

| Name | Model | Unit Weight (pcf) | Cohesion' (psf) | Phi' (°) | Cohesion Fn |
|---|---|---|---|---|---|
| Marsh Fill | Mohr-Coulomb | 85 | 0 | 0 | |
| Articulated Concrete Mat | Mohr-Coulomb | 100 | 0 | 40 | |
| Containment Dike | Mohr-Coulomb | 95 | 60 | 0 | |
| CH (-1 to -7) | Mohr-Coulomb | 95 | 100 | 0 | |
| CH (-7 to -12) | Mohr-Coulomb | 100 | 150 | 0 | |
| CH (-12 to -18) | Mohr-Coulomb | 108 | 150 | 0 | |
| CH (-18 to -24) | Mohr-Coulomb | 108 | 200 | 0 | |
| CH (-24 to -50) | Spatial Mohr-Coulomb | 110 | | 0 | 200 psf + 10.4 psf/ft |
| CH (-50 to -65) | Spatial Mohr-Coulomb | 113 | | 0 | 470 psf + 11 psf/ft |

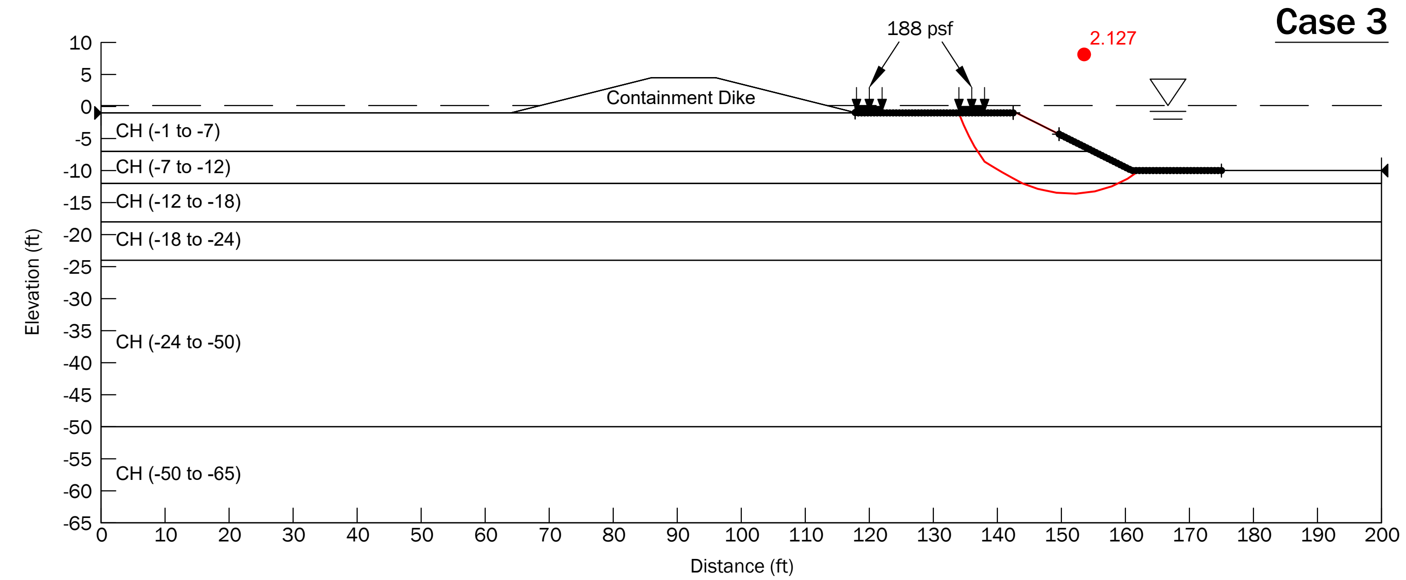
**Containment Dike Slope Stability - Cells 1 & 2, Mudline El. -1.0 ft, 5ft Crest, ACM**

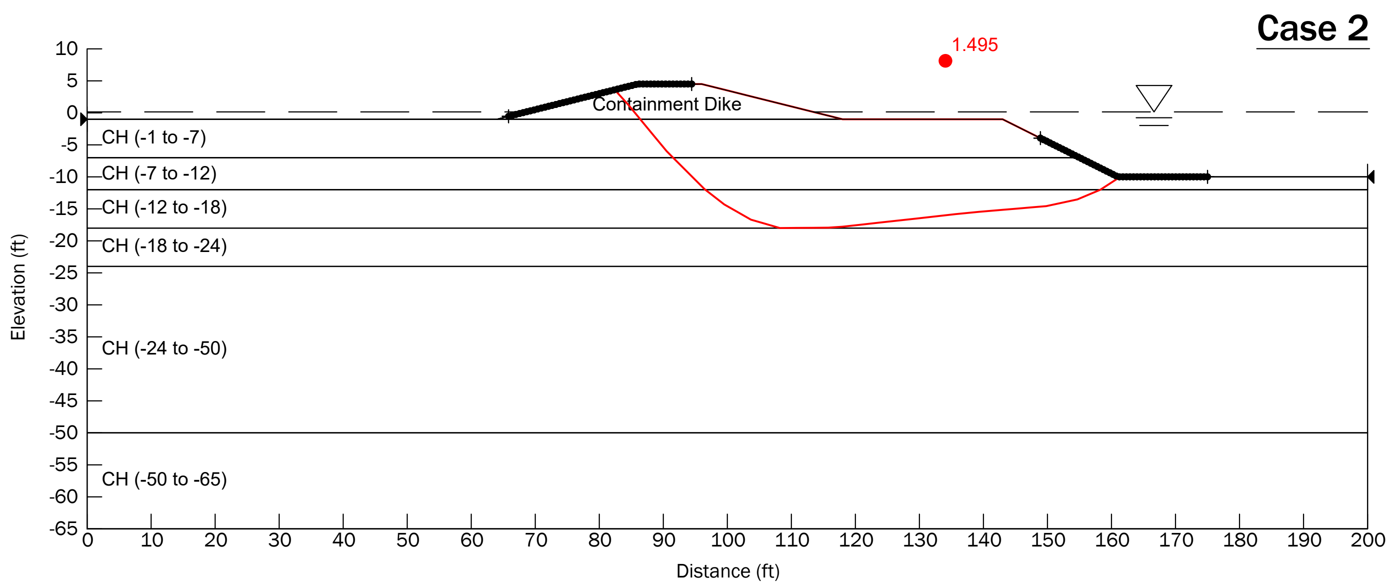
East Leeville Marsh Creation and Nourishment (BA-194)
Lafourche Parish, Louisiana

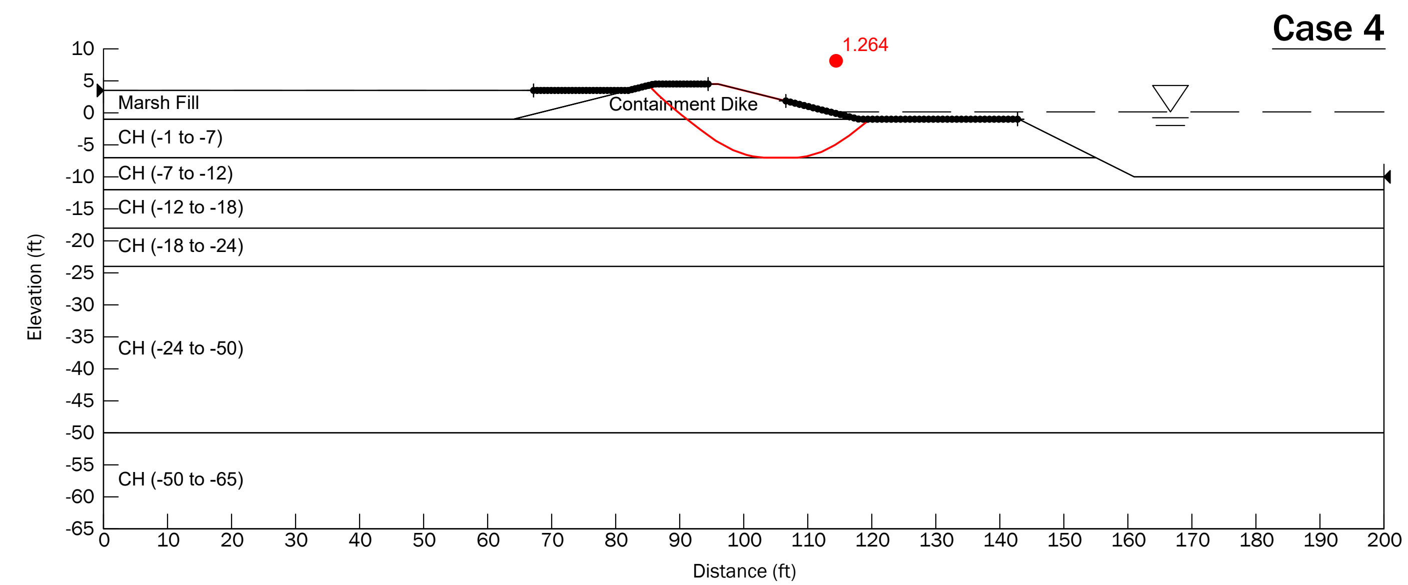
GeoEngineers

Figure B-1b



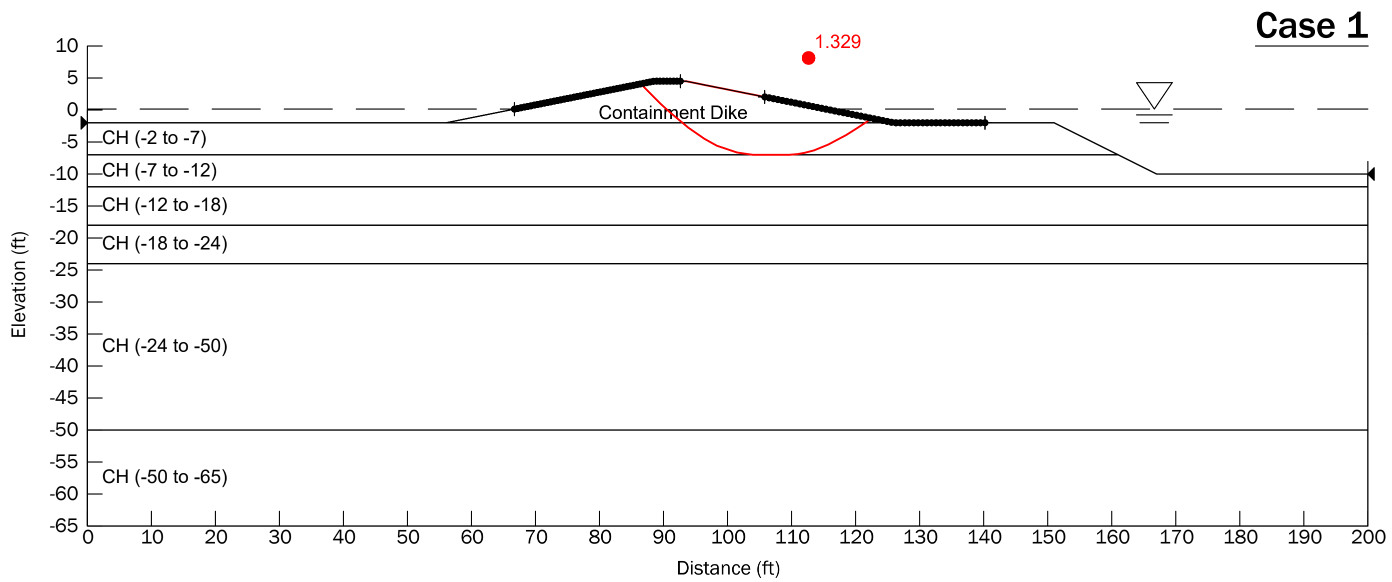

| Name | Model | Unit Weight (pcf) | Cohesion' (psf) | Phi' (°) | Cohesion Fn |
|---|---|---|---|---|---|
| Marsh Fill | Mohr-Coulomb | 85 | 0 | 0 | |
| Containment Dike | Mohr-Coulomb | 95 | 60 | 0 | |
| CH (-1 to -7) | Mohr-Coulomb | 95 | 100 | 0 | |
| CH (-7 to -12) | Mohr-Coulomb | 100 | 150 | 0 | |
| CH (-12 to -18) | Mohr-Coulomb | 108 | 150 | 0 | |
| CH (-18 to -24) | Mohr-Coulomb | 108 | 200 | 0 | |
| CH (-24 to -50) | Spatial Mohr-Coulomb | 110 | | 0 | 200 psf + 10.4 psf/ft |
| CH (-50 to -65) | Spatial Mohr-Coulomb | 113 | | 0 | 470 psf + 11 psf/ft |

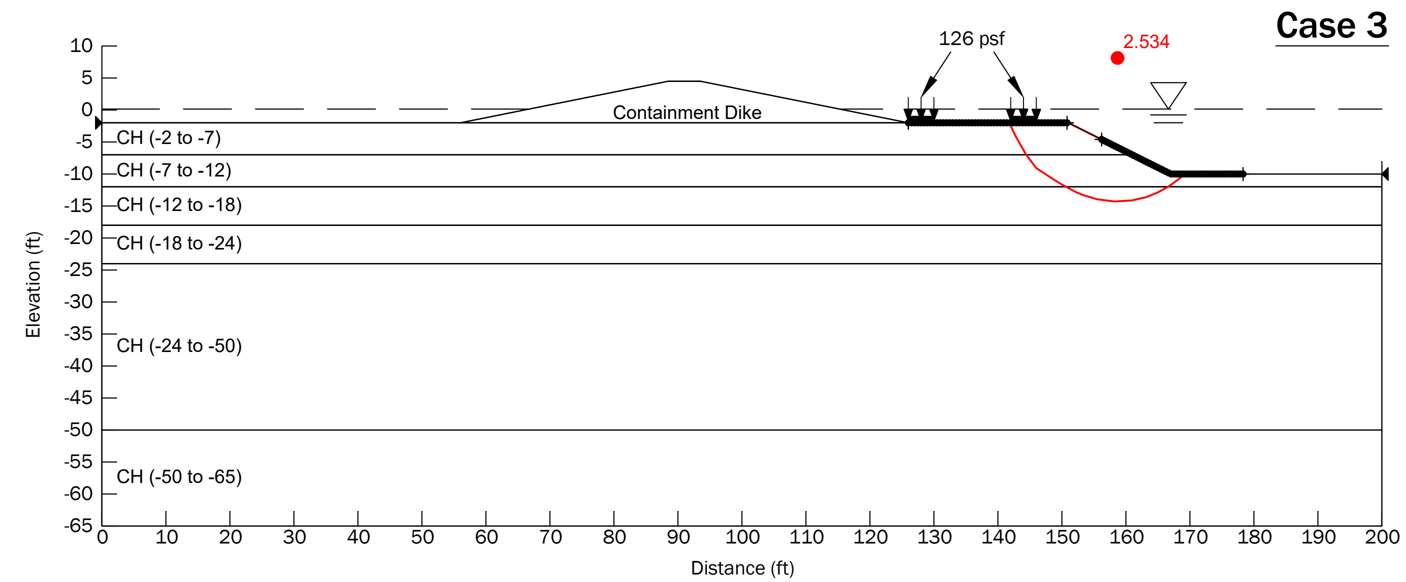
**Containment Dike Slope Stability - Cells 1 & 2, Mudline El. -1.0 ft, 10ft Crest**

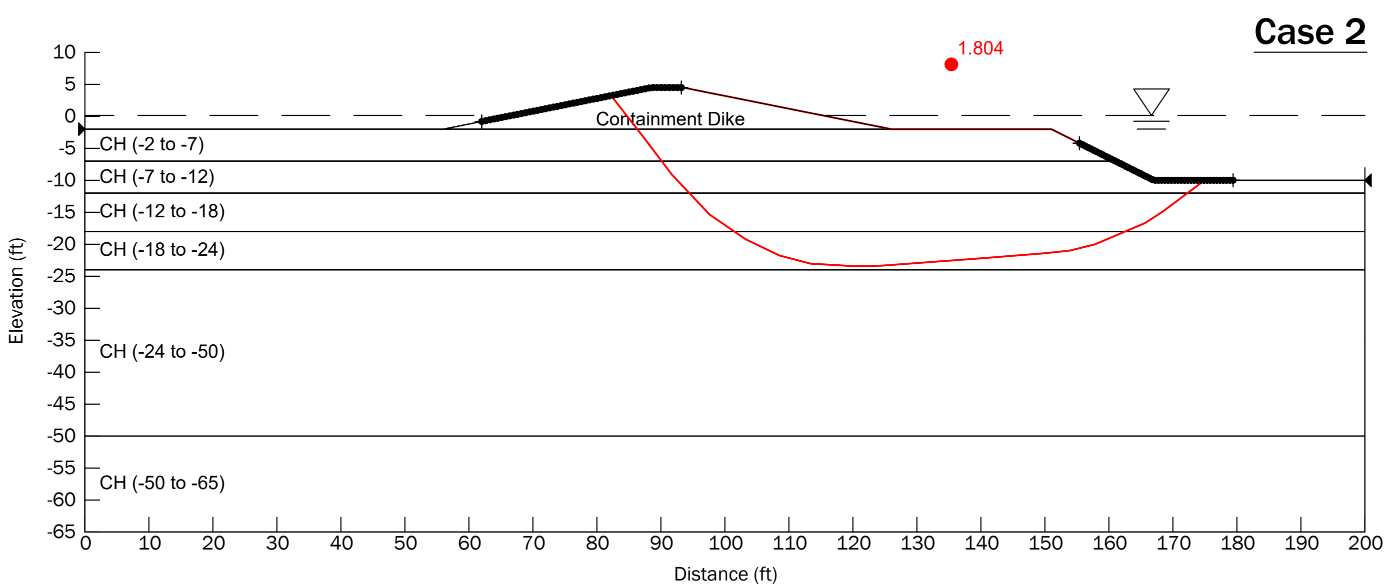
East Leeville Marsh Creation and Nourishment (BA-194)
Lafourche Parish, Louisiana

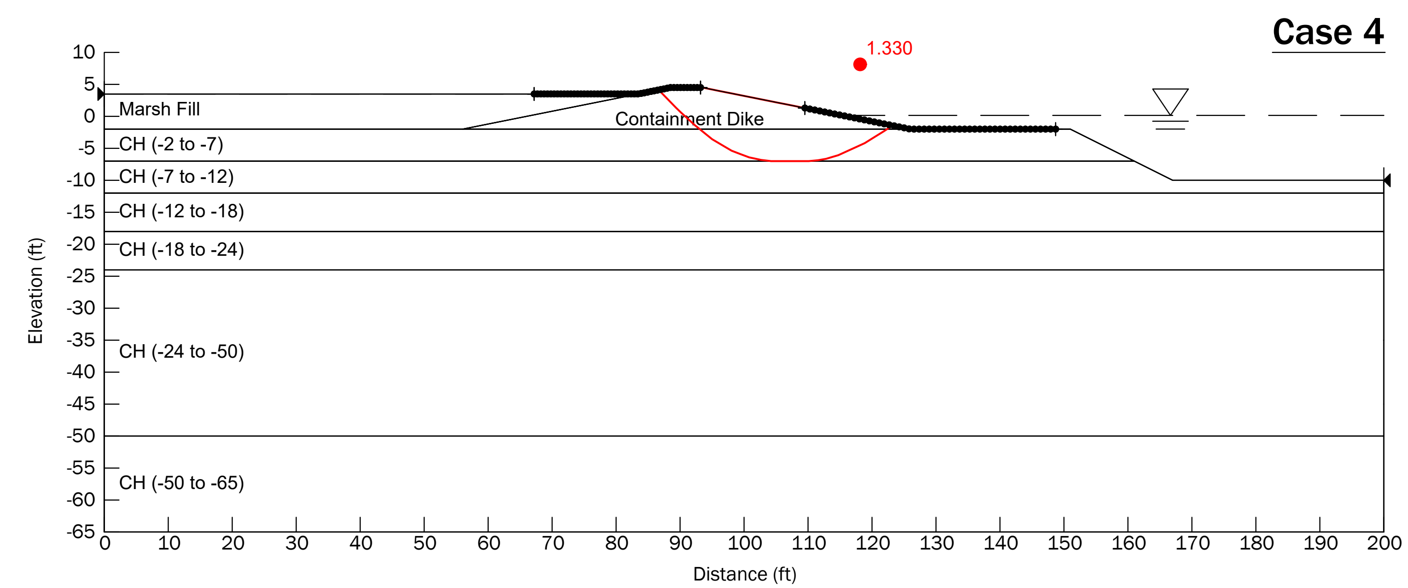
GEOENGINEERS

**Figure B-1c**




| Name | Model | Unit Weight (pcf) | Cohesion' (psf) | Phi' (°) | Cohesion Fn |
|---|---|---|---|---|---|
| Marsh Fill | Mohr-Coulomb | 85 | 0 | 0 | |
| Containment Dike | Mohr-Coulomb | 95 | 60 | 0 | |
| CH (-2 to -7) | Mohr-Coulomb | 95 | 100 | 0 | |
| CH (-7 to -12) | Mohr-Coulomb | 100 | 150 | 0 | |
| CH (-12 to -18) | Mohr-Coulomb | 108 | 150 | 0 | |
| CH (-18 to -24) | Mohr-Coulomb | 108 | 200 | 0 | |
| CH (-24 to -50) | Spatial Mohr-Coulomb | 110 | | 0 | 200 psf + 10.4 psf/ft |
| CH (-50 to -65) | Spatial Mohr-Coulomb | 113 | | 0 | 470 psf + 11 psf/ft |

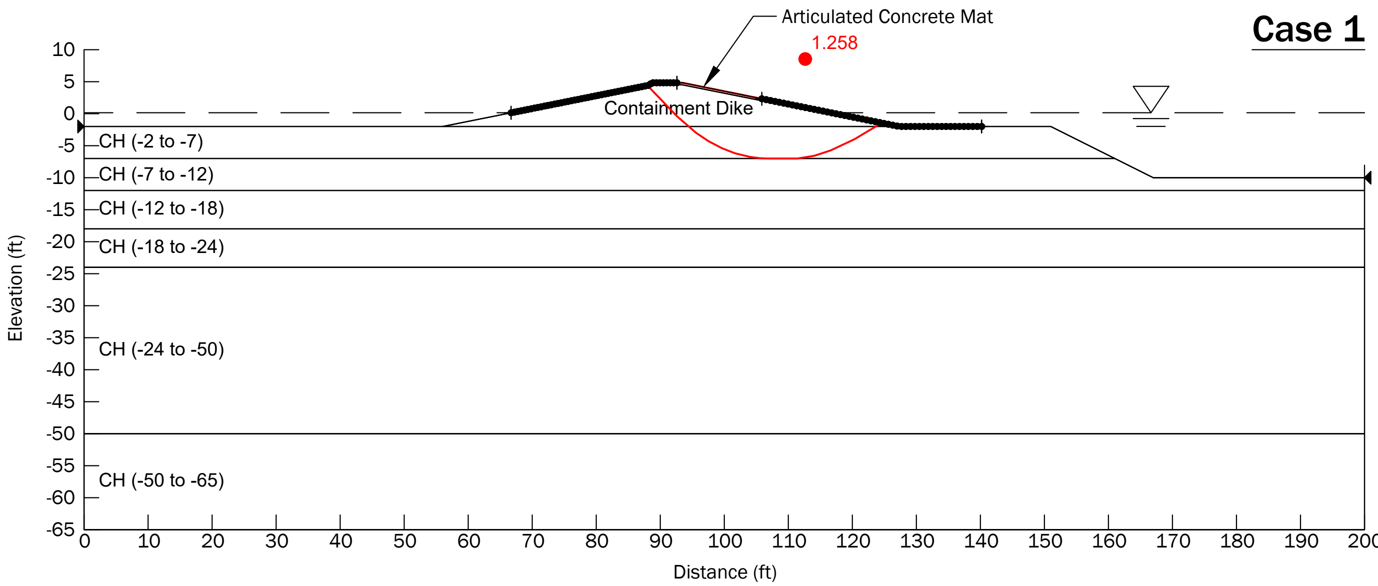
**Containment Dike Slope Stability - Cells 1 & 2, Mudline El. -2.0 ft, 5ft Crest**

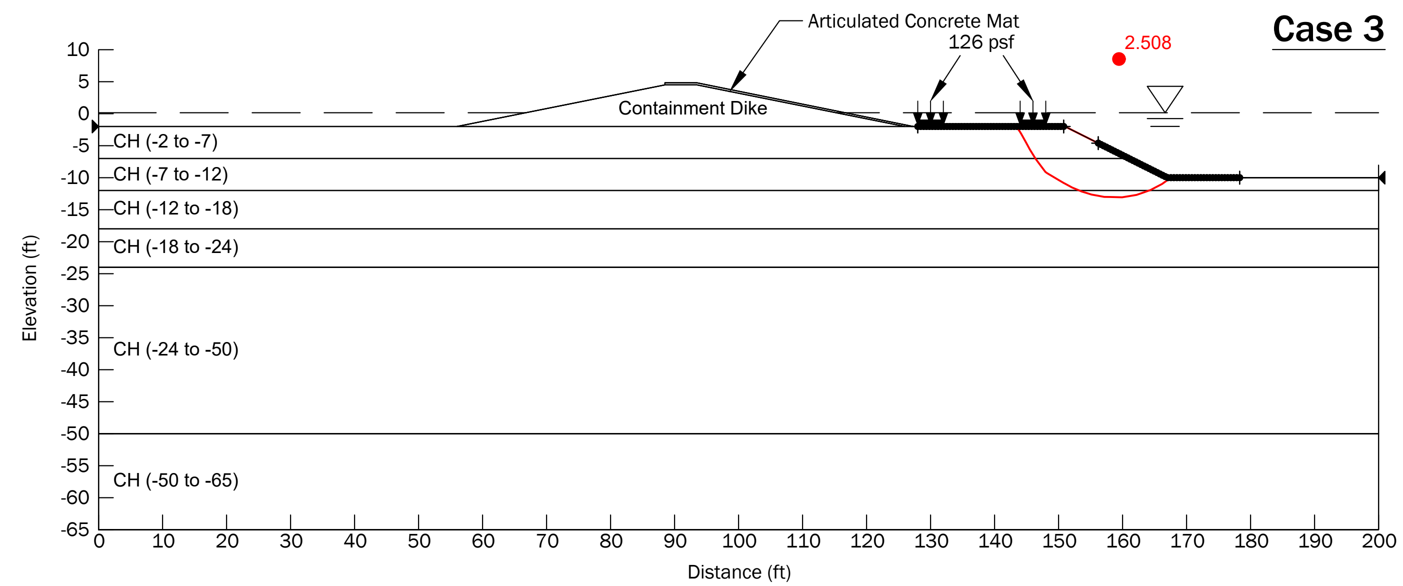
East Leeville Marsh Creation and Nourishment
(BA-194)
Lafourche Parish, Louisiana

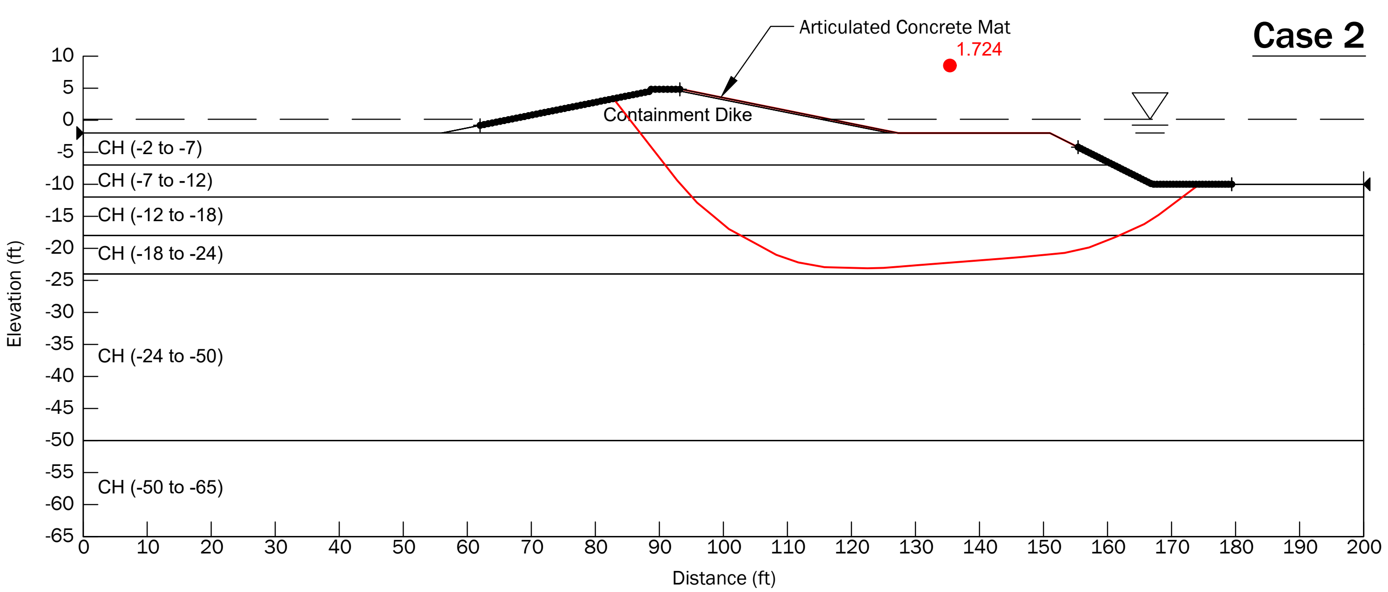
GEOENGINEERS

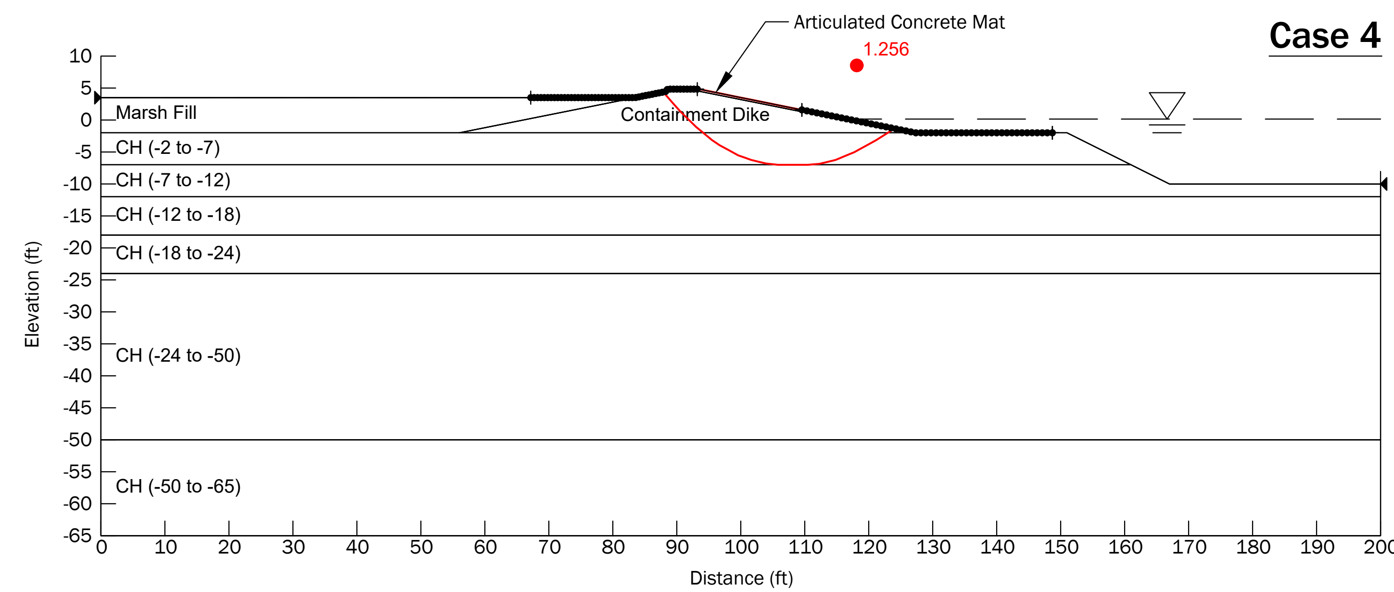
**Figure B-2a**

P:\18\18274004\CAD\02\Geotech - Final\18274400402_FB1a-6b_Slope Stability.dwg TAB:B2a Date Exported: 03/23/20 - 14:36 by kcook



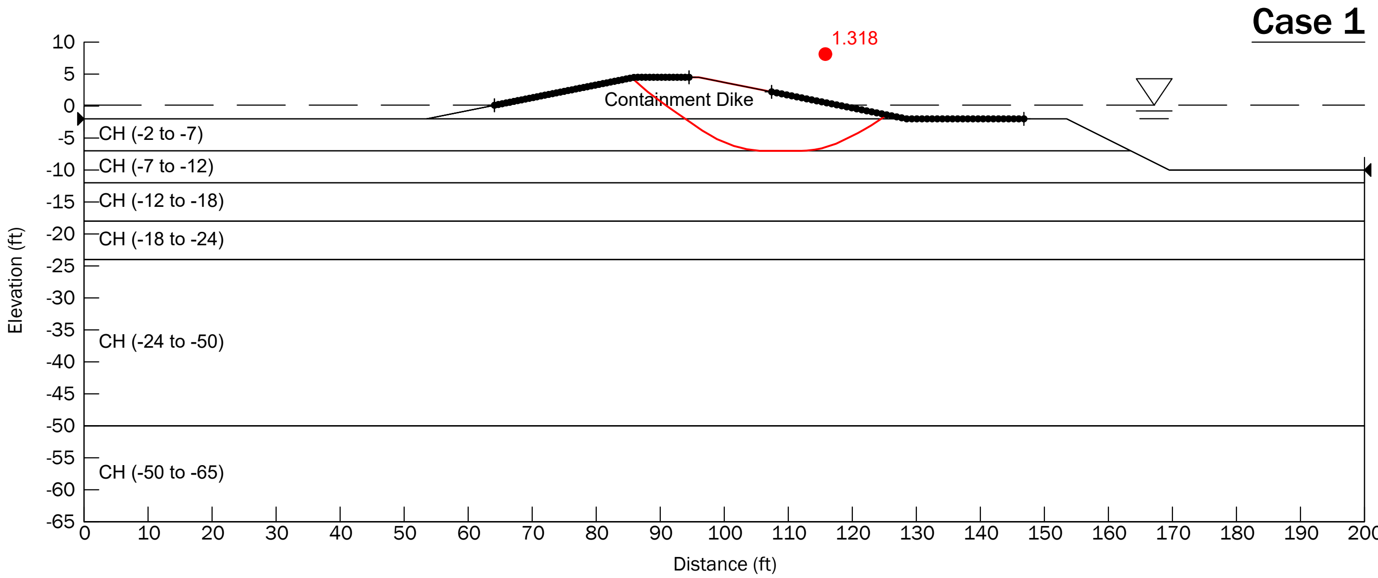

| Name | Model | Unit Weight (pcf) | Cohesion' (psf) | Phi' (°) | Cohesion Fn |
|---|---|---|---|---|---|
| Marsh Fill | Mohr-Coulomb | 85 | 0 | 0 | |
| Articulated Concrete Mat | Mohr-Coulomb | 100 | 0 | 40 | |
| Containment Dike | Mohr-Coulomb | 95 | 60 | 0 | |
| CH (-2 to -7) | Mohr-Coulomb | 95 | 100 | 0 | |
| CH (-7 to -12) | Mohr-Coulomb | 100 | 150 | 0 | |
| CH (-12 to -18) | Mohr-Coulomb | 108 | 150 | 0 | |
| CH (-18 to -24) | Mohr-Coulomb | 108 | 200 | 0 | |
| CH (-24 to -50) | Spatial Mohr-Coulomb | 110 | | 0 | 200 psf + 10.4 psf/ft |
| CH (-50 to -65) | Spatial Mohr-Coulomb | 113 | | 0 | 470 psf + 11 psf/ft |

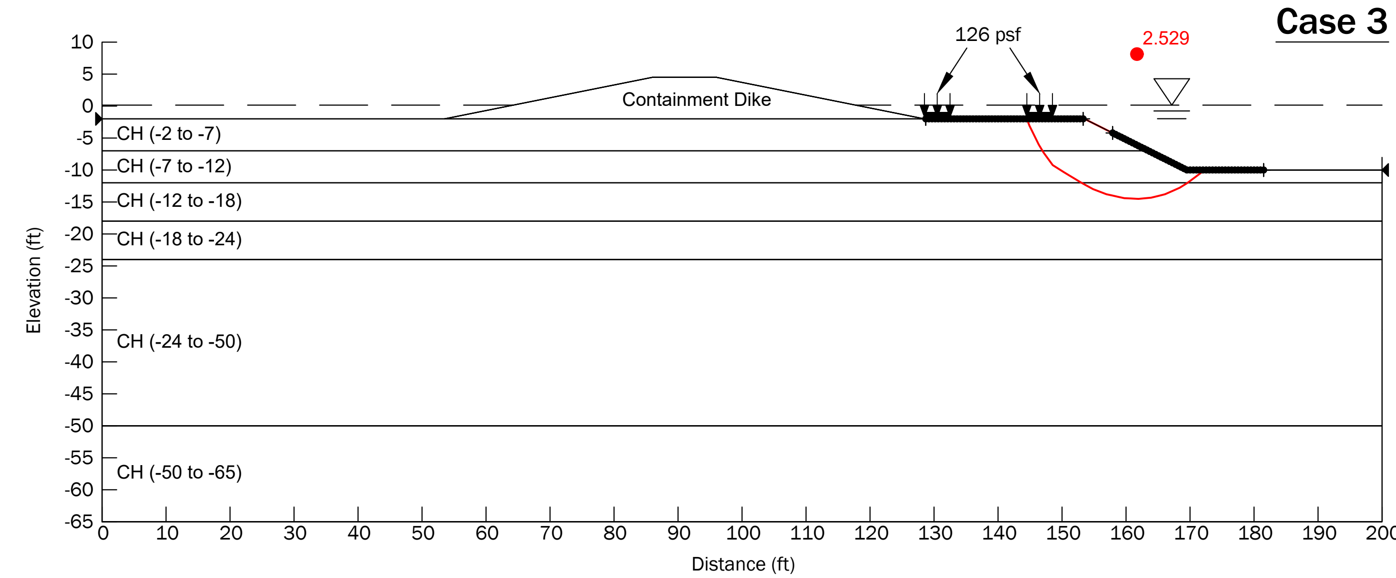
**Containment Dike Slope Stability - Cells 1 & 2, Mudline El. -2.0 ft, 5ft Crest, ACM**

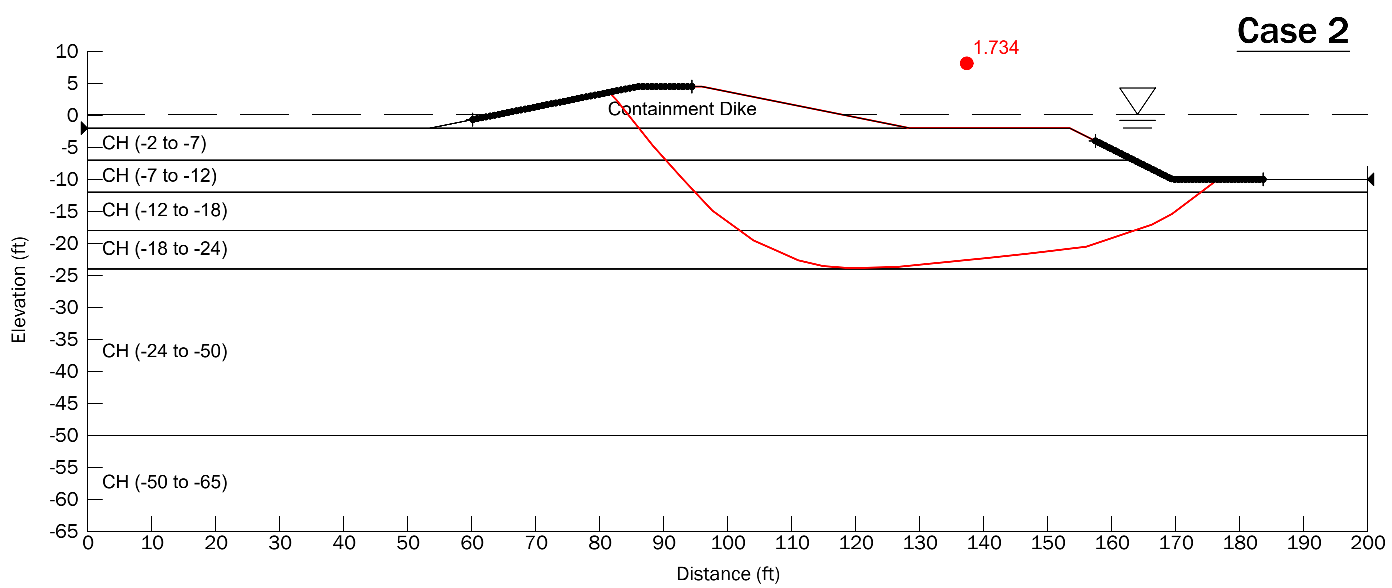
East Leeville Marsh Creation and Nourishment (BA-194)
Lafourche Parish, Louisiana

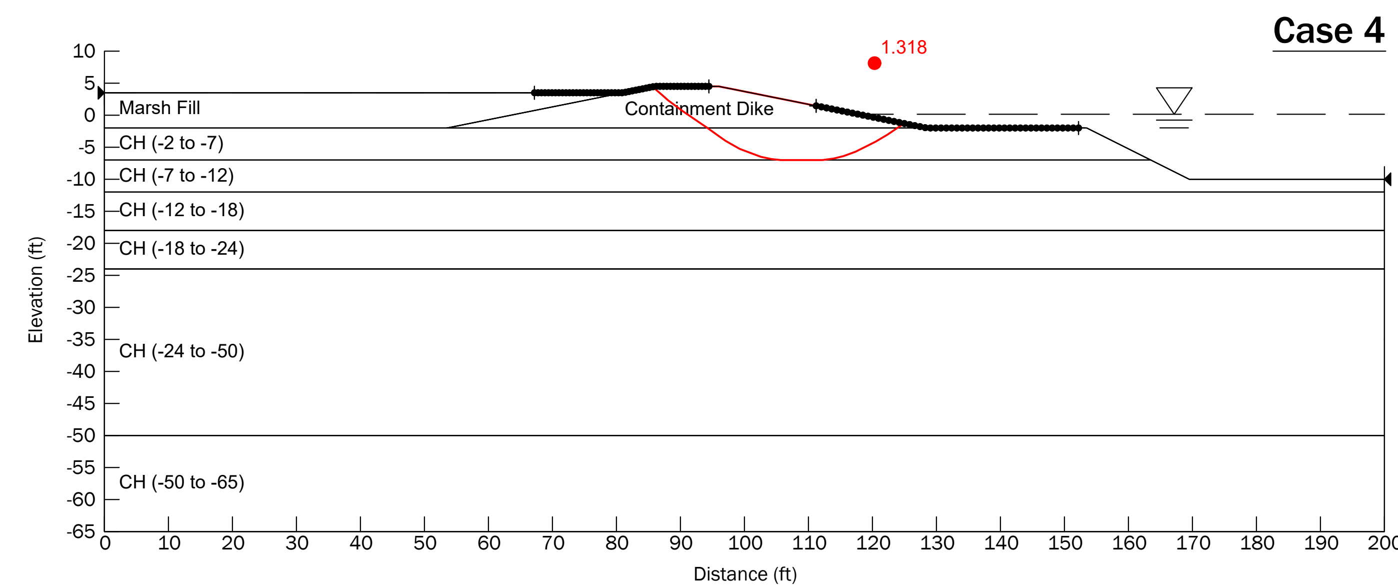
GeoEngineers

**Figure B-2b**




| Name | Model | Unit Weight (pcf) | Cohesion' (psf) | Phi' (°) | Cohesion Fn |
|---|---|---|---|---|---|
| Marsh Fill | Mohr-Coulomb | 85 | 0 | 0 | |
| Containment Dike | Mohr-Coulomb | 95 | 60 | 0 | |
| CH (-2 to -7) | Mohr-Coulomb | 95 | 100 | 0 | |
| CH (-12 to -18) | Mohr-Coulomb | 108 | 150 | 0 | |
| CH (-24 to -50) | Spatial Mohr-Coulomb | 110 | | 0 | 200 psf + 10.4 psf/ft |
| CH (-7 to -12) | Mohr-Coulomb | 100 | 150 | 0 | |
| CH (-18 to -24) | Mohr-Coulomb | 108 | 200 | 0 | |
| CH (-50 to -65) | Spatial Mohr-Coulomb | 113 | | 0 | 470 psf + 11 psf/ft |

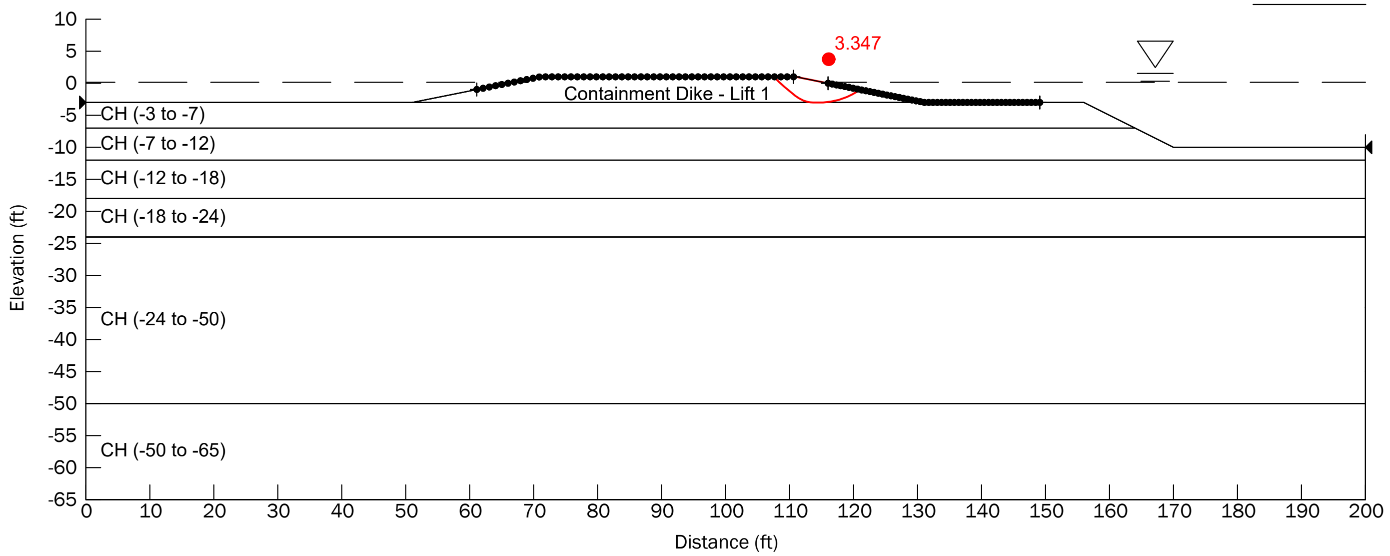
**Containment Dike Slope Stability - Cells 1 & 2, Mudline El. -2.0 ft, 10ft Crest**

East Leeville Marsh Creation and Nourishment
(BA-194)
Lafourche Parish, Louisiana

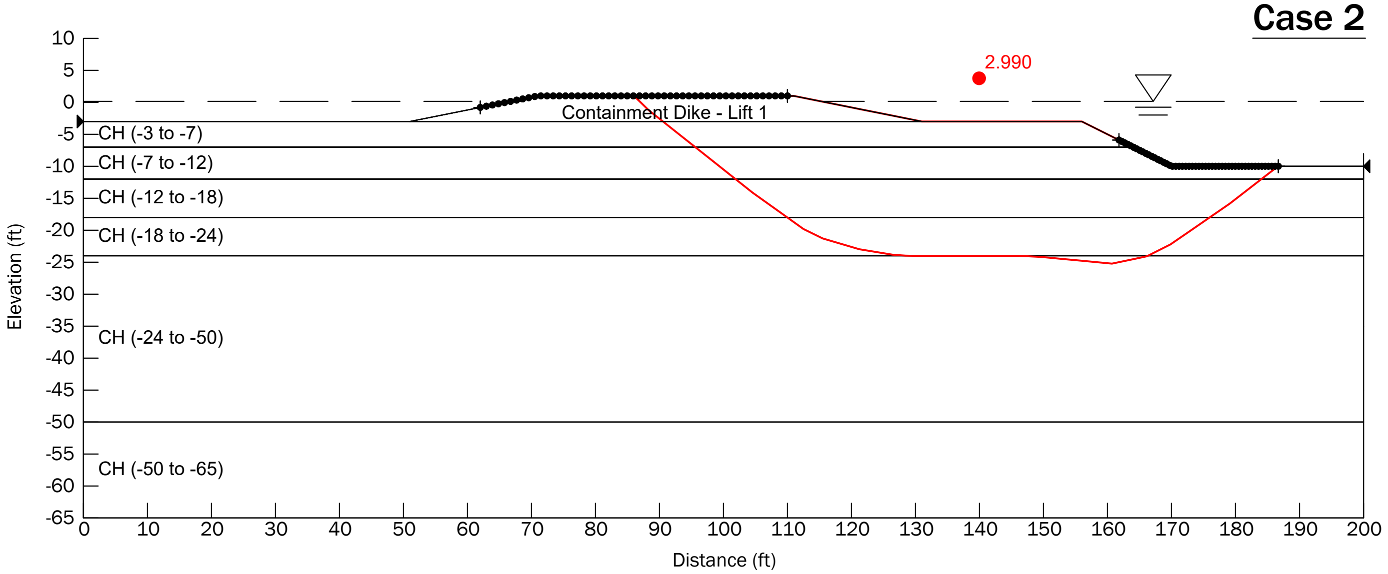
GeoEngineers

**Figure B-2c**

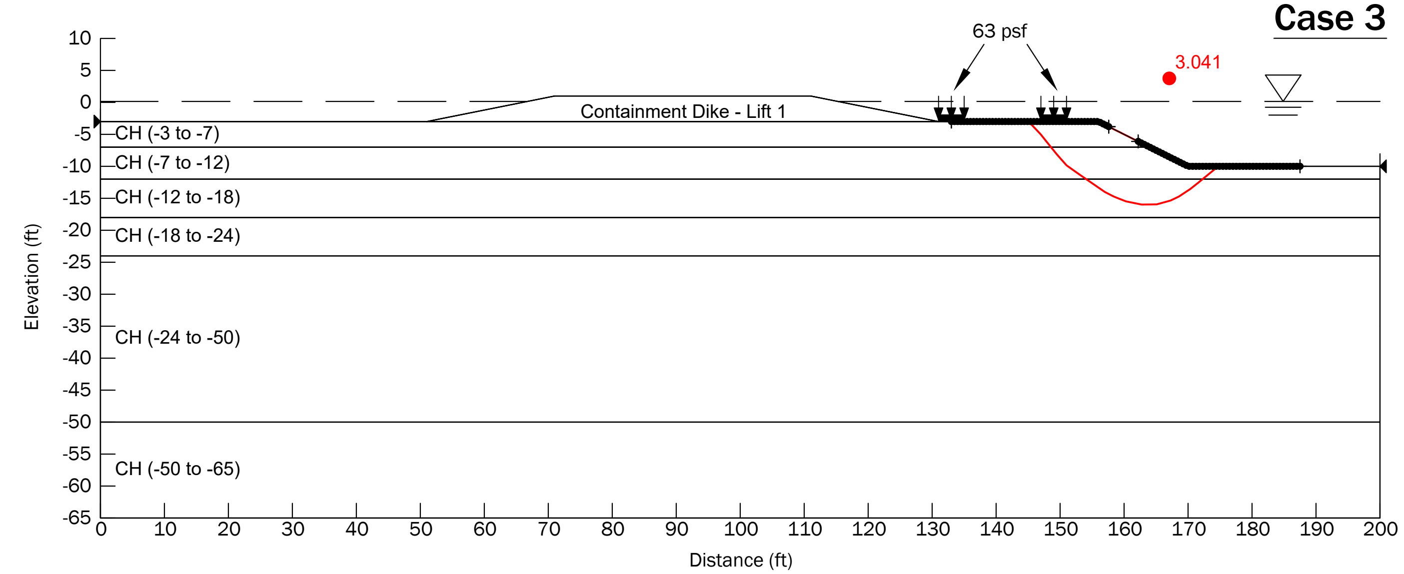
## Case 1




## Case 2




## Case 3



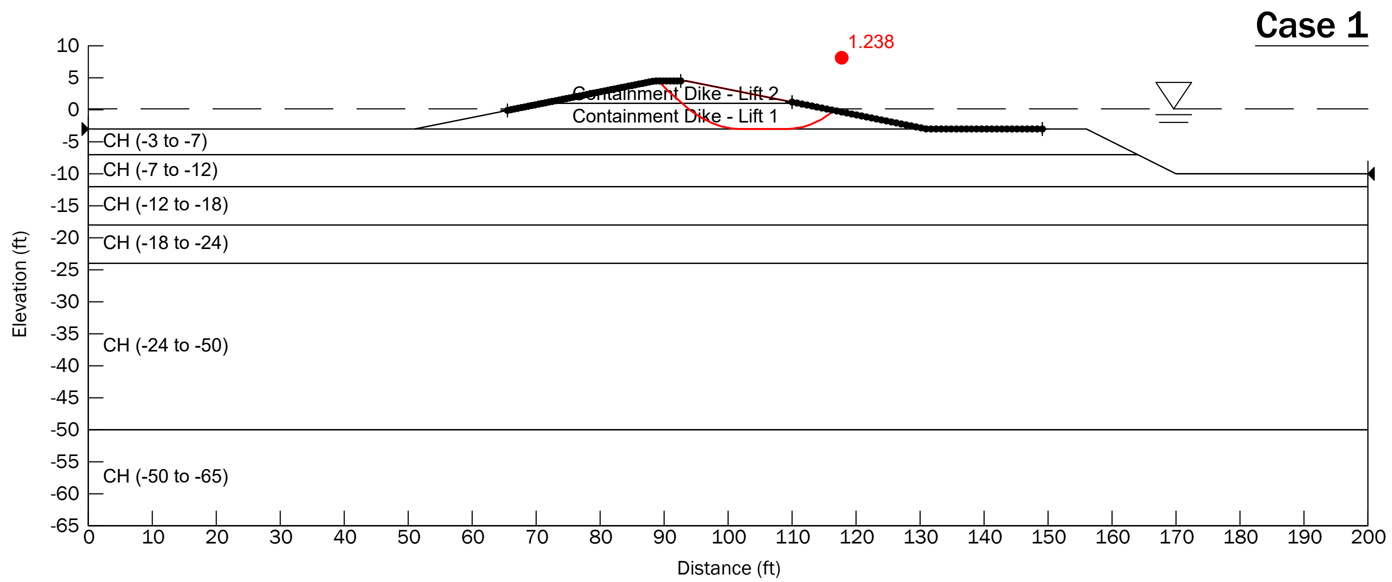

| Name | Model | Unit Weight (pcf) | Cohesion' (psf) | Phi' (°) | Cohesion Fn |
|---|---|---|---|---|---|
| Containment Dike - Lift 1 | Mohr-Coulomb | 95 | 60 | 0 | |
| CH (-3 to -7) | Mohr-Coulomb | 95 | 100 | 0 | |
| CH (-7 to -12) | Mohr-Coulomb | 100 | 150 | 0 | |
| CH (-12 to -18) | Mohr-Coulomb | 108 | 150 | 0 | |
| CH (-18 to -24) | Mohr-Coulomb | 108 | 200 | 0 | |
| CH (-24 to -50) | Spatial Mohr-Coulomb | 110 | | 0 | 200 psf + 10.4 psf/ft |
| CH (-50 to -65) | Spatial Mohr-Coulomb | 113 | | 0 | 470 psf + 11 psf/ft |

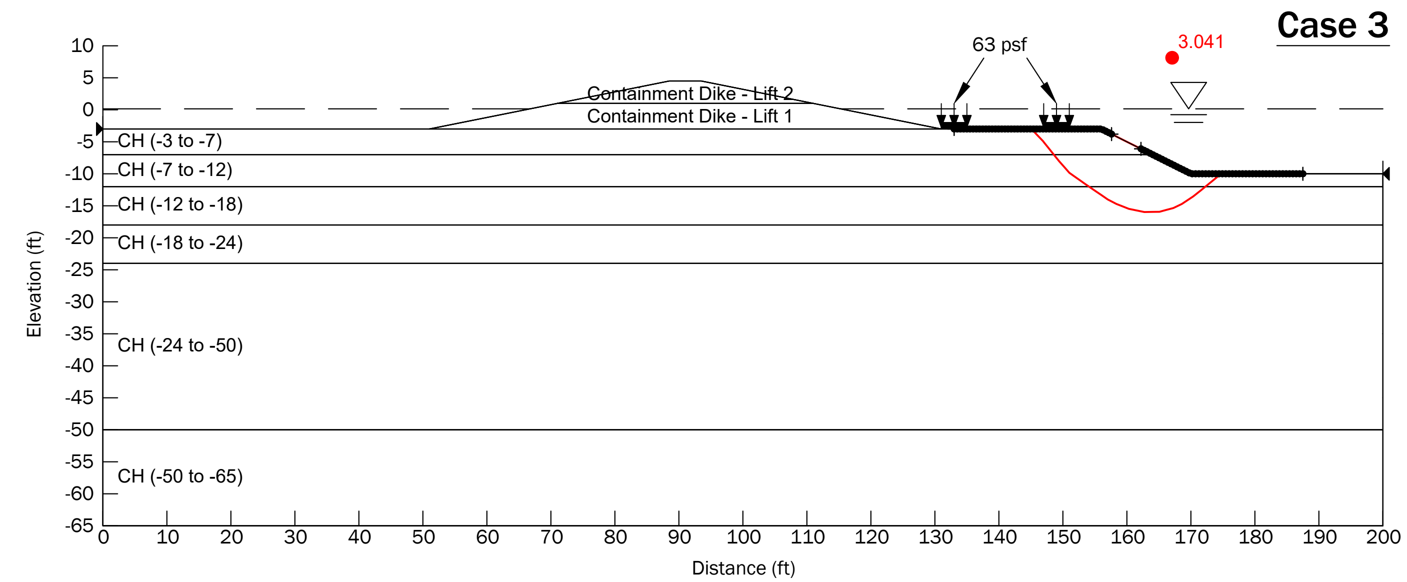
**Containment Dike Slope Stability - Cells 1 & 2, Mudline El. -3.0 ft, 5ft Crest, Lift 1**

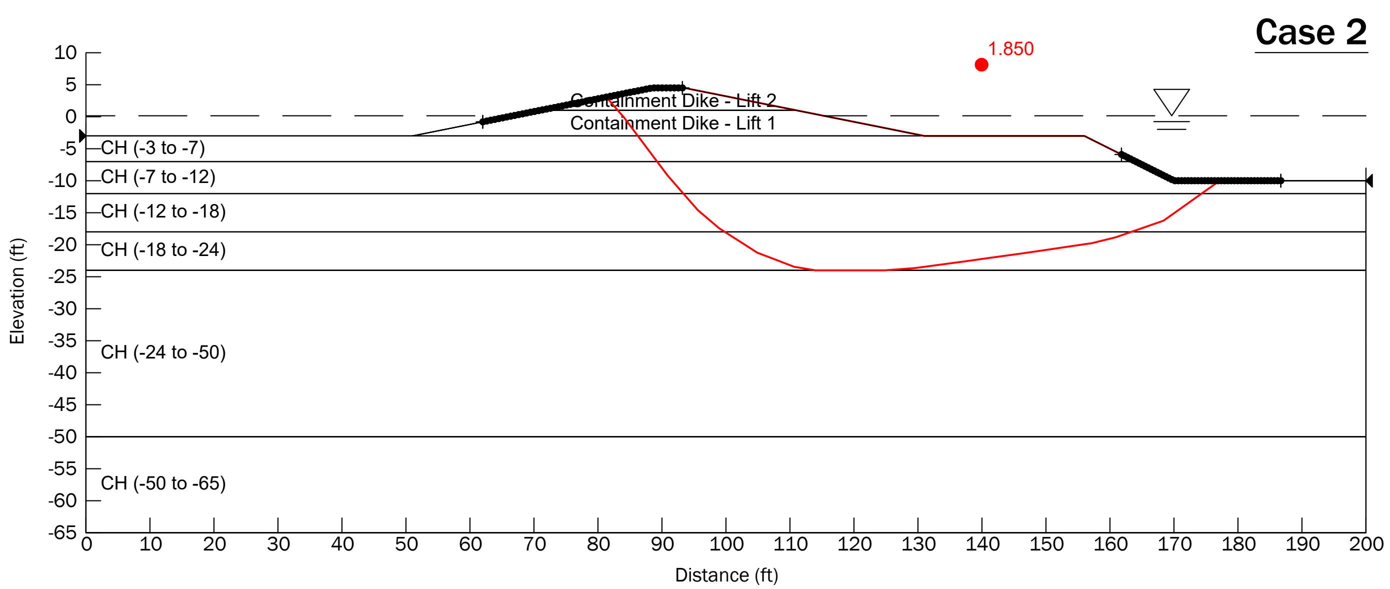
East Leeville Marsh Creation and Nourishment (BA-194)
Lafourche Parish, Louisiana

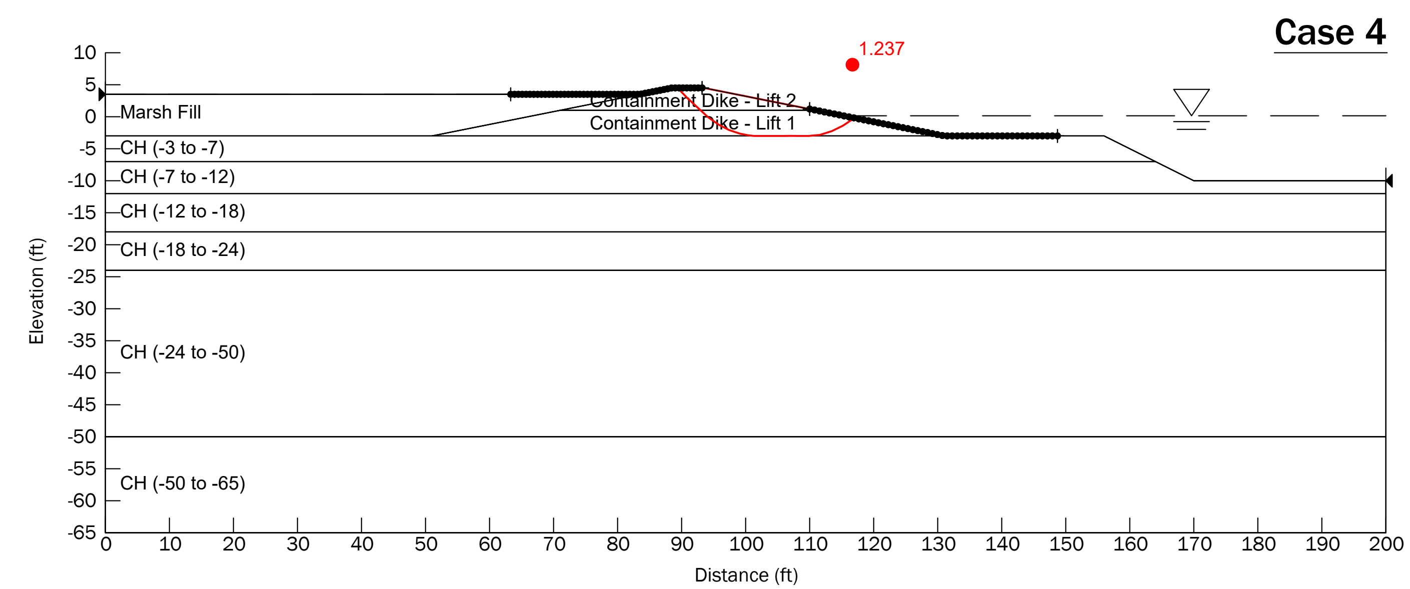
GEOENGINEERS

**Figure B-3a**




| Name | Model | Unit Weight (pcf) | Cohesion' (psf) | Phi' (°) | Cohesion Spatial Fn | Cohesion Fn |
|---|---|---|---|---|---|---|
| Marsh Fill | Mohr-Coulomb | 85 | 0 | 0 | | |
| Containment Dike - Lift 2 | Mohr-Coulomb | 95 | 60 | 0 | | |
| Containment Dike - Lift 1 | Mohr-Coulomb | 95 | 66 | 0 | | |
| CH (-3 to -7) | Spatial Mohr-Coulomb | 95 | | 0 | 100 psf + 15% | |
| CH (-7 to -12) | Spatial Mohr-Coulomb | 100 | | 0 | 150 psf + 15% | |
| CH (-12 to -18) | Mohr-Coulomb | 108 | 150 | 0 | | |
| CH (-18 to -24) | Mohr-Coulomb | 108 | 200 | 0 | | |
| CH (-24 to -50) | Spatial Mohr-Coulomb | 110 | | 0 | | 200 psf + 10.4 psf/ft |
| CH (-50 to -65) | Spatial Mohr-Coulomb | 113 | | 0 | | 470 psf + 11 psf/ft |

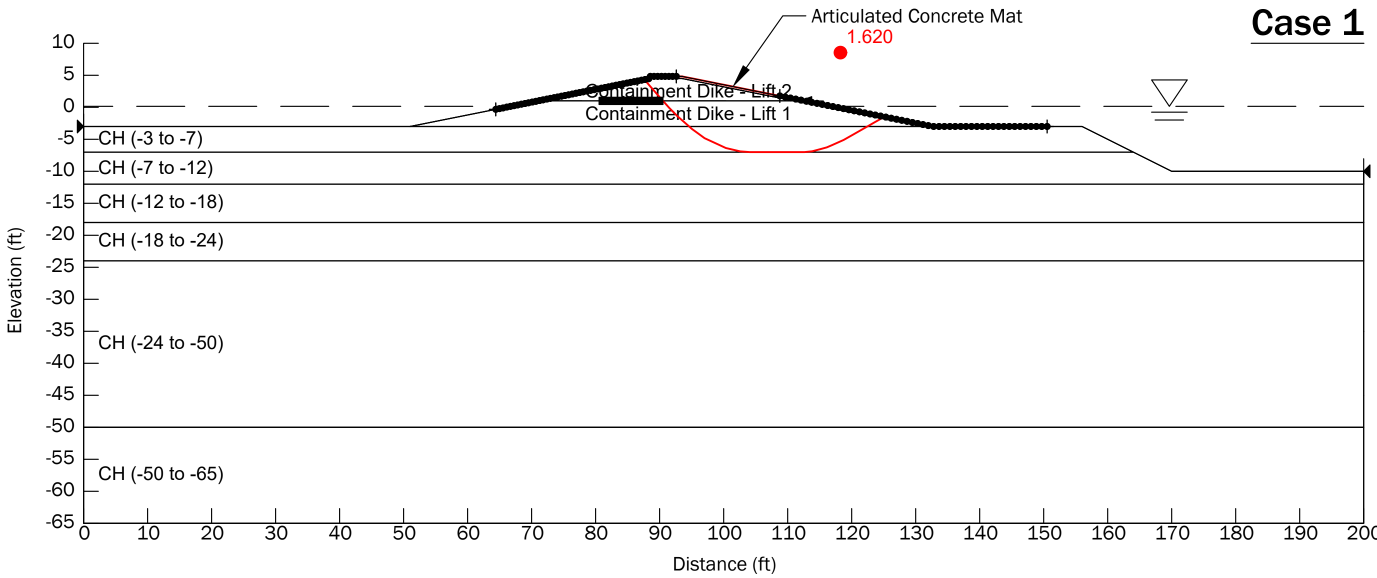
**Containment Dike Slope Stability - Cells 1 & 2, Mudline El. -3.0 ft, 5ft Crest, Lift 2**

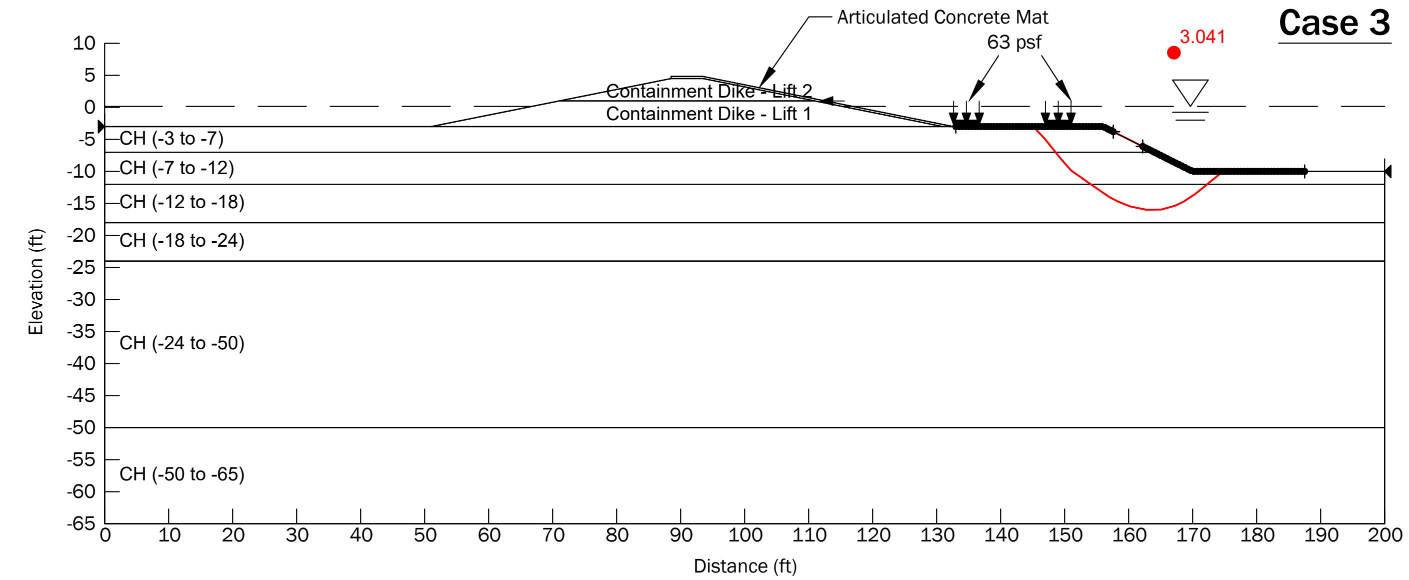
East Leeville Marsh Creation and Nourishment (BA-194)
Lafourche Parish, Louisiana

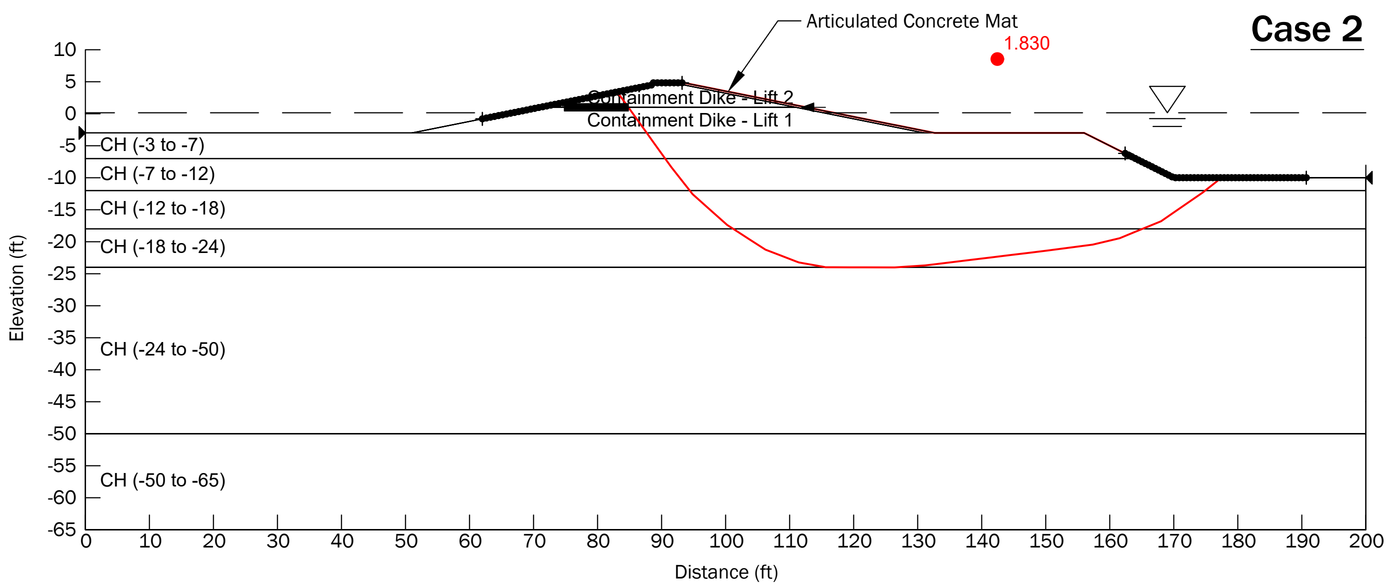
GeoEngineers

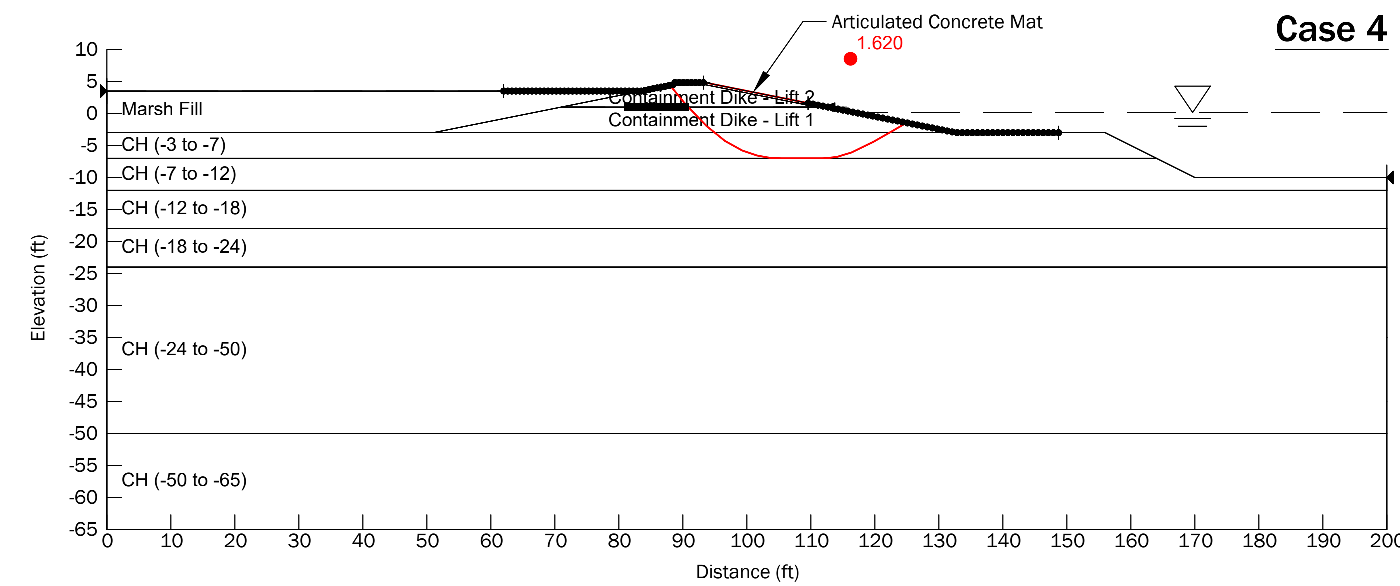
**Figure B-3b**

P:\18\18274004\CAD\02\Geotech - Final\18274004402_FB1a-6b_Slope Stability.dwg TAB:B3b Date Exported: 03/27/20 - 11:27 by kcook




| Name | Model | Unit Weight (pcf) | Cohesion' (psf) | Phi' (°) | Cohesion Spatial Fn | Cohesion Fn |
|---|---|---|---|---|---|---|
| Marsh Fill | Mohr-Coulomb | 85 | 0 | 0 | | |
| Articulated Concrete Mat | Mohr-Coulomb | 100 | 0 | 40 | | |
| Containment Dike - Lift 2 | Mohr-Coulomb | 95 | 60 | 0 | | |
| Containment Dike - Lift 1 | Mohr-Coulomb | 95 | 66 | 0 | | |
| CH (-3 to -7) | Spatial Mohr-Coulomb | 95 | | 0 | 100 + 15% | |
| CH (-7 to -12) | Spatial Mohr-Coulomb | 100 | | 0 | 150 + 15% | |
| CH (-12 to -18) | Mohr-Coulomb | 108 | 150 | 0 | | |
| CH (-18 to -24) | Mohr-Coulomb | 108 | 200 | 0 | | |
| CH (-24 to -50) | Spatial Mohr-Coulomb | 110 | | 0 | | 200 psf + 10.4 psf/ft |
| CH (-50 to -65) | Spatial Mohr-Coulomb | 113 | | 0 | | 470 psf + 11 psf/ft |

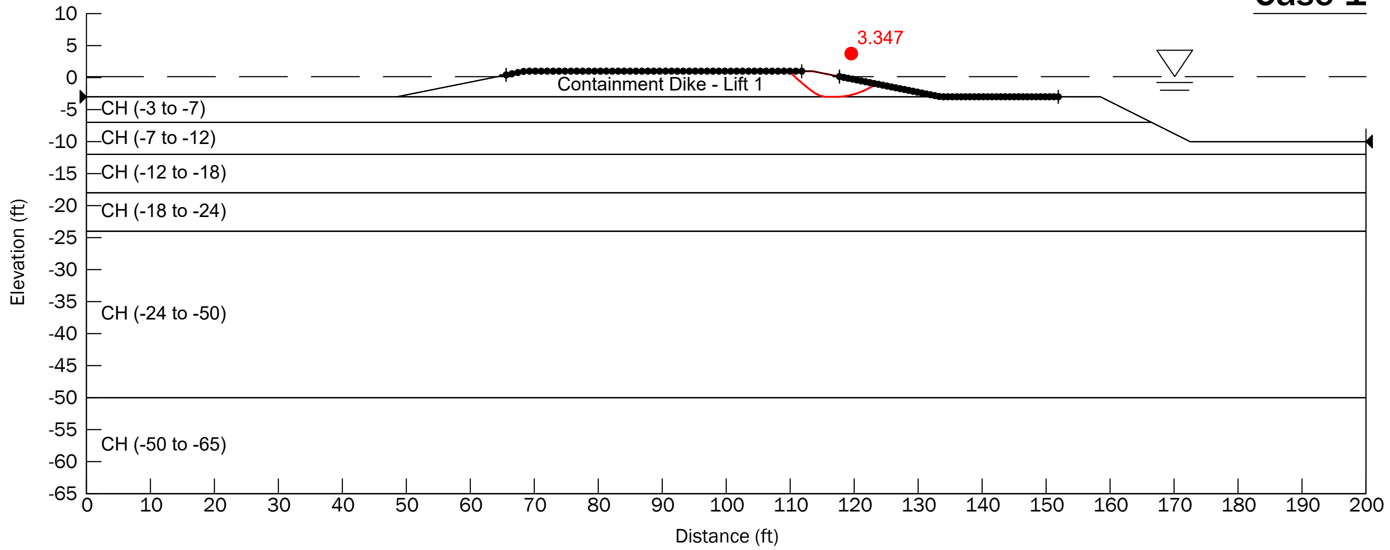
**Containment Dike Slope Stability - Cells 1 & 2, Mudline El. -3.0 ft, 5ft Crest, ACM**

East Leeville Marsh Creation and Nourishment (BA-194)
Lafourche Parish, Louisiana

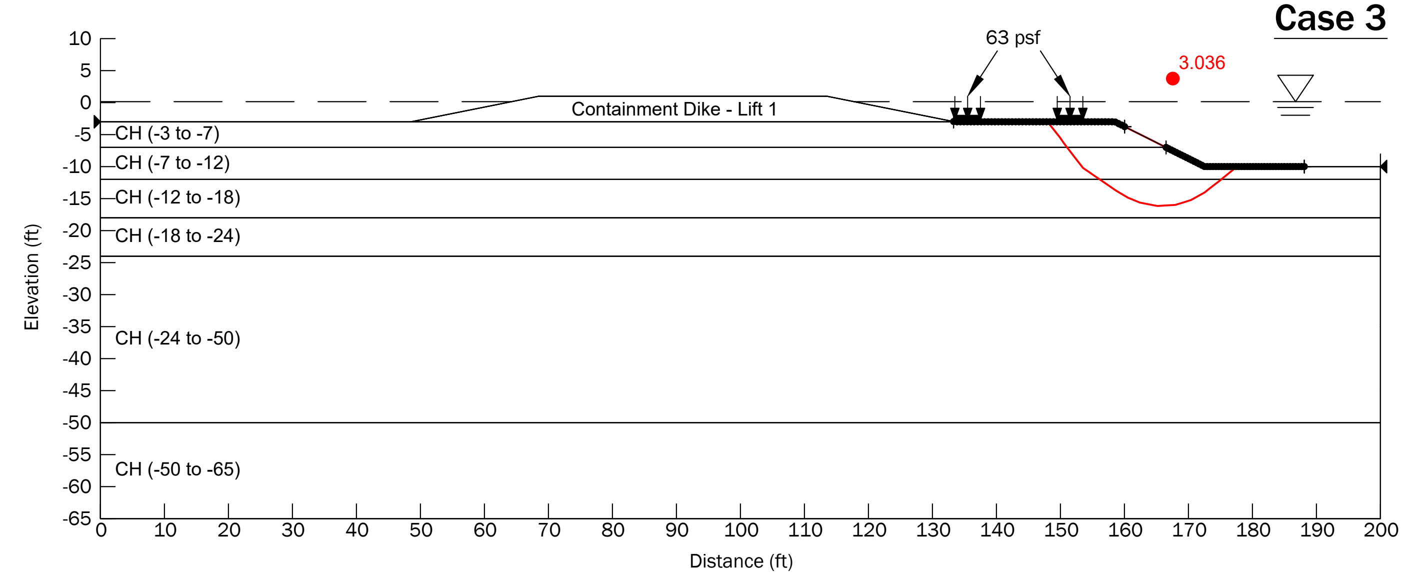
GeoEngineers

**Figure B-3c**

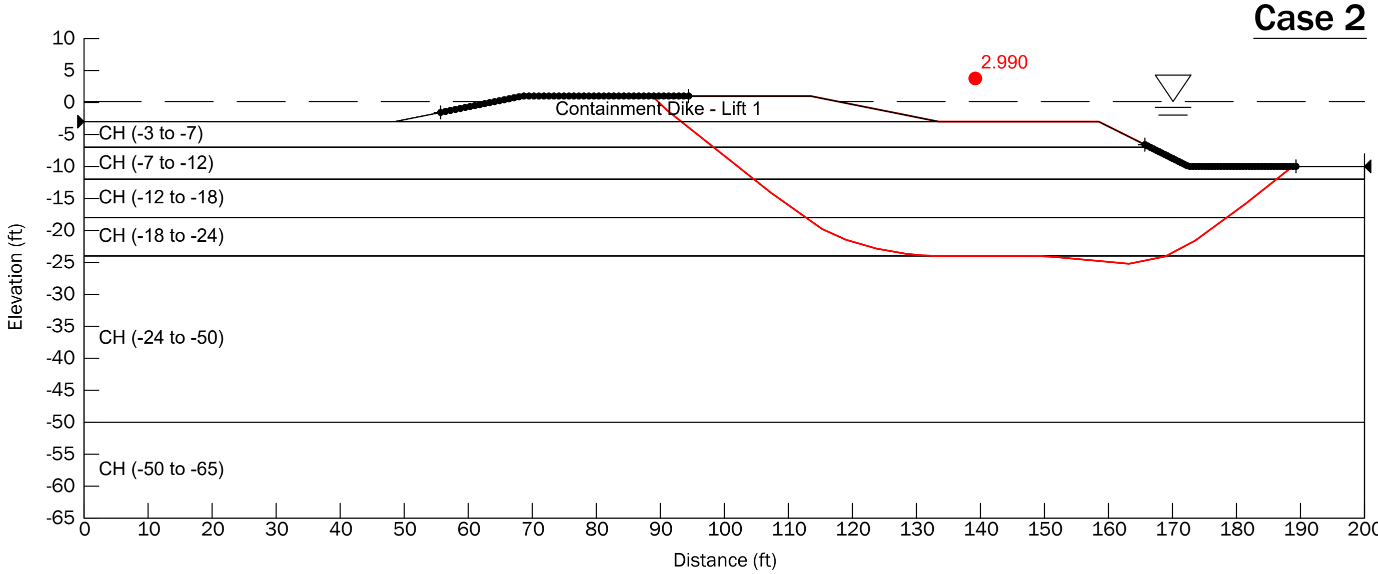
## Case 1




## Case 3




## Case 2



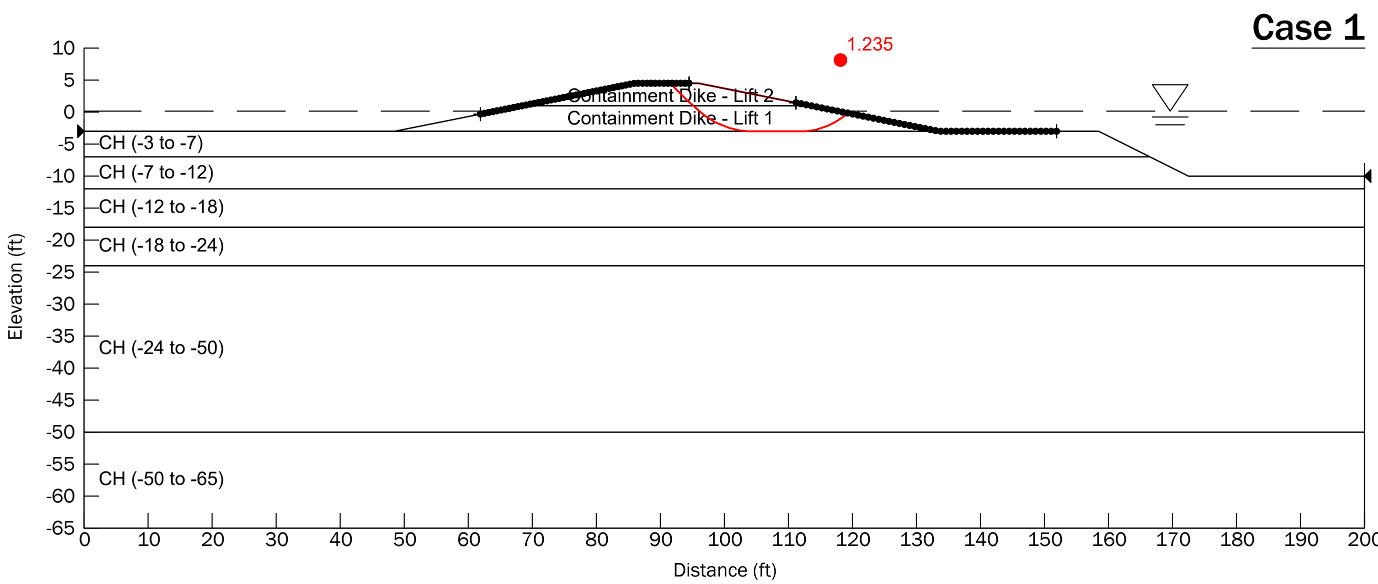

| Name | Model | Unit Weight (pcf) | Cohesion' (psf) | Phi' (°) | Cohesion Fn |
|---|---|---|---|---|---|
| Containment Dike - Lift 1 | Mohr-Coulomb | 95 | 60 | 0 | |
| CH (-3 to -7) | Mohr-Coulomb | 95 | 100 | 0 | |
| CH (-7 to -12) | Mohr-Coulomb | 100 | 150 | 0 | |
| CH (-12 to -18) | Mohr-Coulomb | 108 | 150 | 0 | |
| CH (-18 to -24) | Mohr-Coulomb | 108 | 200 | 0 | |
| CH (-24 to -50) | Spatial Mohr-Coulomb | 110 | | 0 | 200 psf + 10.4 psf/ft |
| CH (-50 to -65) | Spatial Mohr-Coulomb | 113 | | 0 | 470 psf + 11 psf/ft |

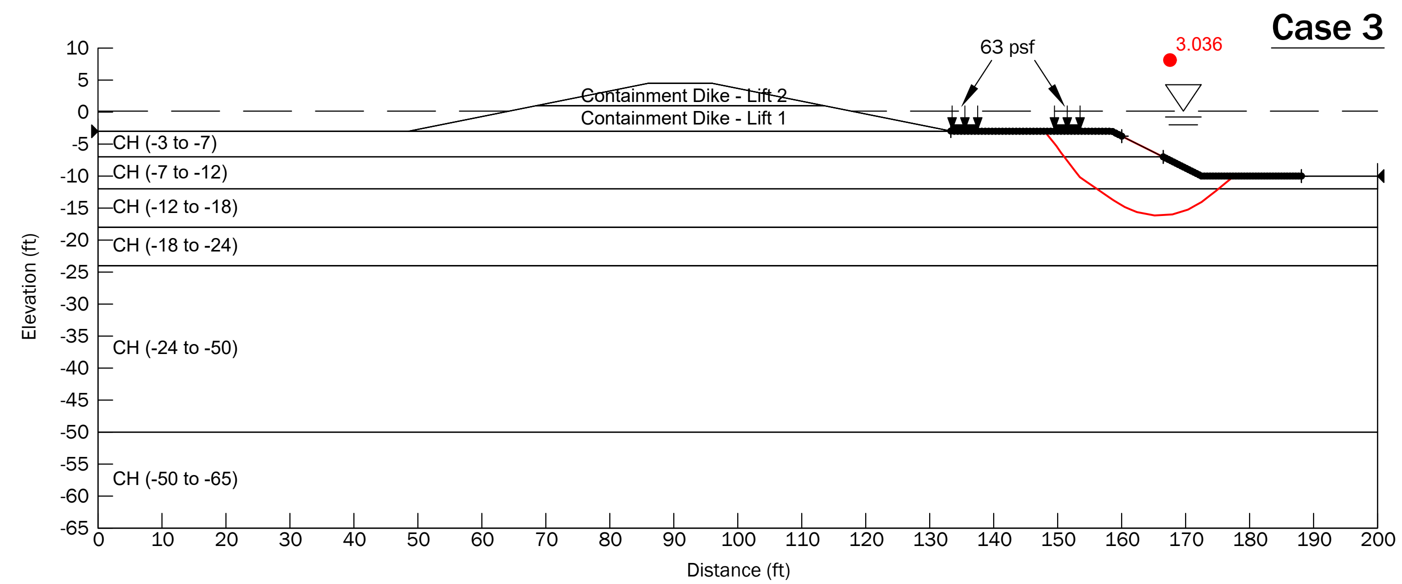
**Containment Dike Slope Stability - Cells 1 & 2, Mudline El. -3.0 ft, 10ft Crest, Lift 1**

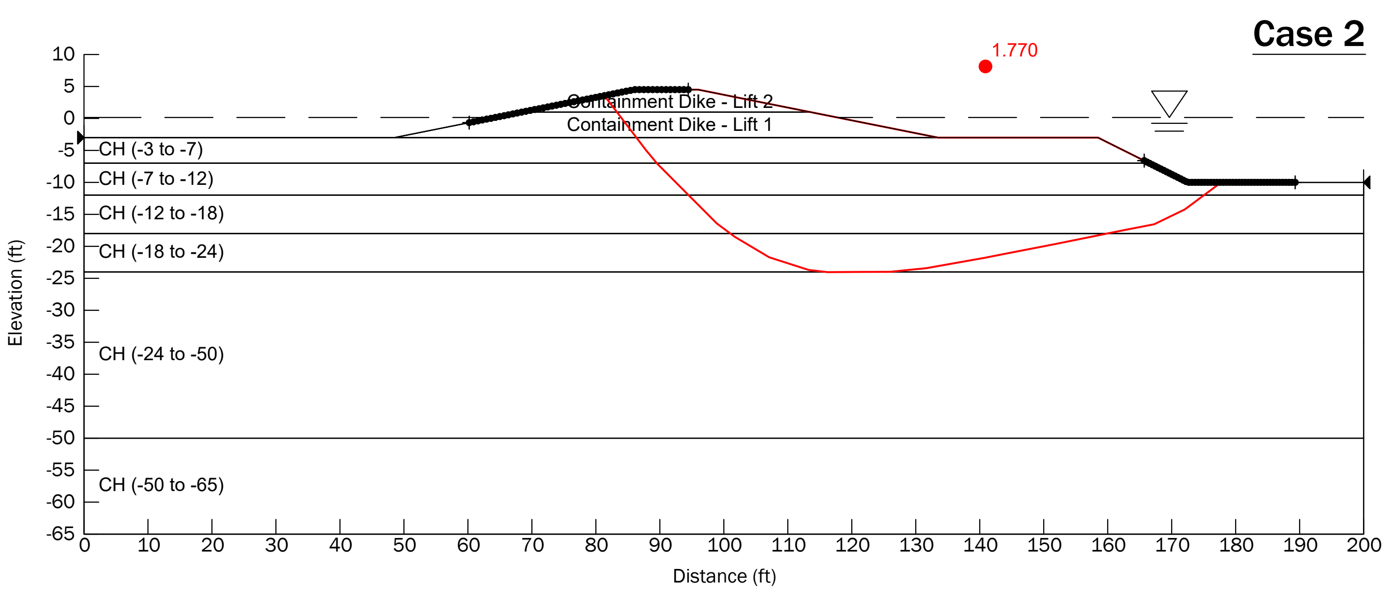
East Leeville Marsh Creation and Nourishment (BA-194)
Lafourche Parish, Louisiana

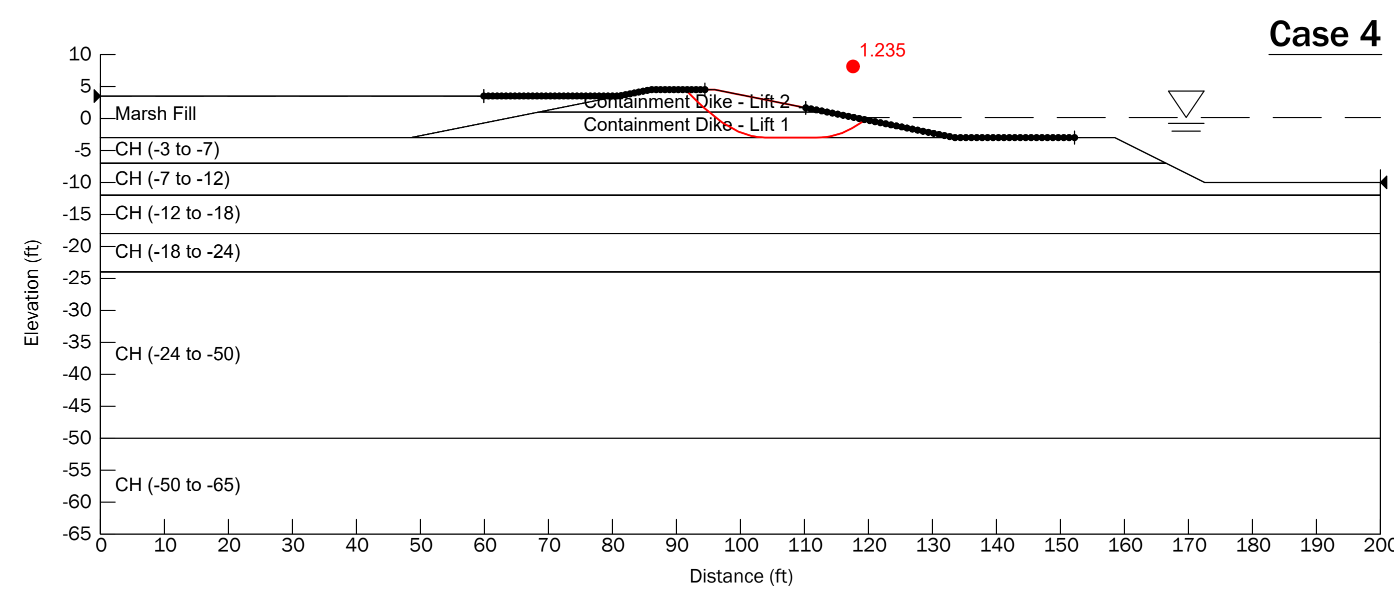
GeoEngineers

**Figure B-3d**




| Name | Model | Unit Weight (pcf) | Cohesion' (psf) | Phi' (°) | Cohesion Spatial Fn | Cohesion Fn |
|---|---|---|---|---|---|---|
| Marsh Fill | Mohr-Coulomb | 85 | 0 | 0 | | |
| Containment Dike - Lift 1 | Mohr-Coulomb | 95 | 66 | 0 | | |
| Containment Dike - Lift 2 | Mohr-Coulomb | 95 | 60 | 0 | | |
| CH (-3 to -7) | Spatial Mohr-Coulomb | 95 | | 0 | 100 psf + 15% | |
| CH (-7 to -12) | Spatial Mohr-Coulomb | 100 | | 0 | 150 psf + 15% | |
| CH (-12 to -18) | Mohr-Coulomb | 108 | 150 | 0 | | |
| CH (-18 to -24) | Mohr-Coulomb | 108 | 200 | 0 | | |
| CH (-24 to -50) | Spatial Mohr-Coulomb | 110 | | 0 | | 200 psf + 10.4 psf/ft |
| CH (-50 to -65) | Spatial Mohr-Coulomb | 113 | | 0 | | 470 psf + 11 psf/ft |

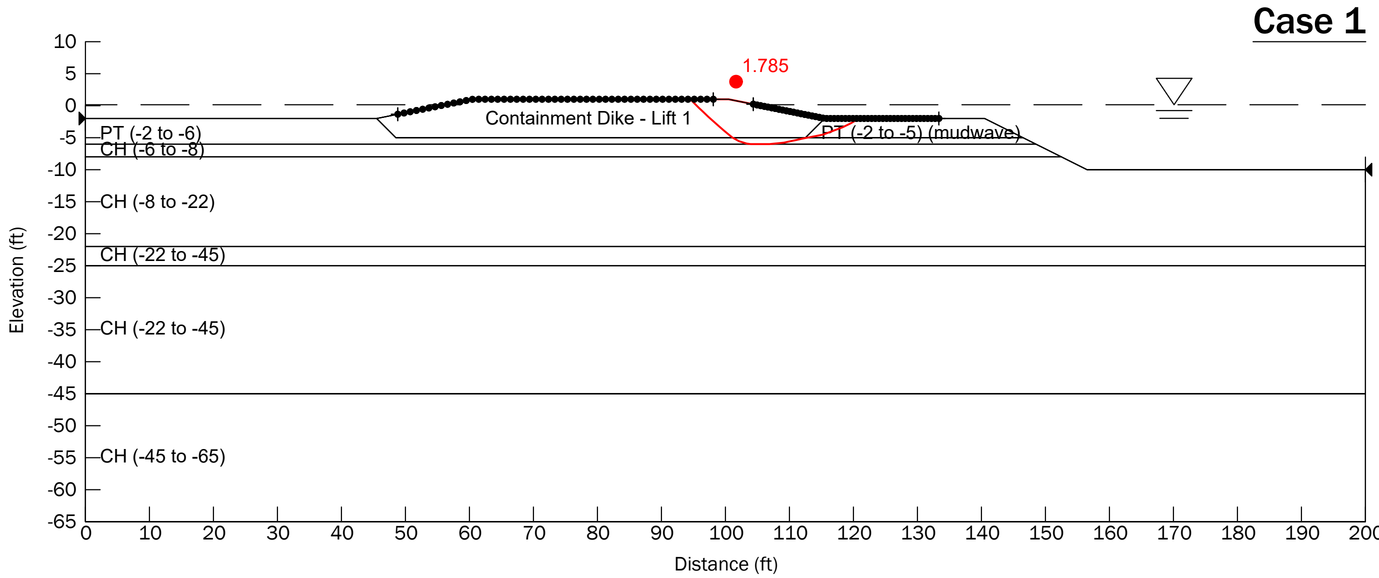
**Containment Dike Slope Stability - Cells 1 & 2, Mudline El. -3.0 ft, 10ft Crest, Lift 2**

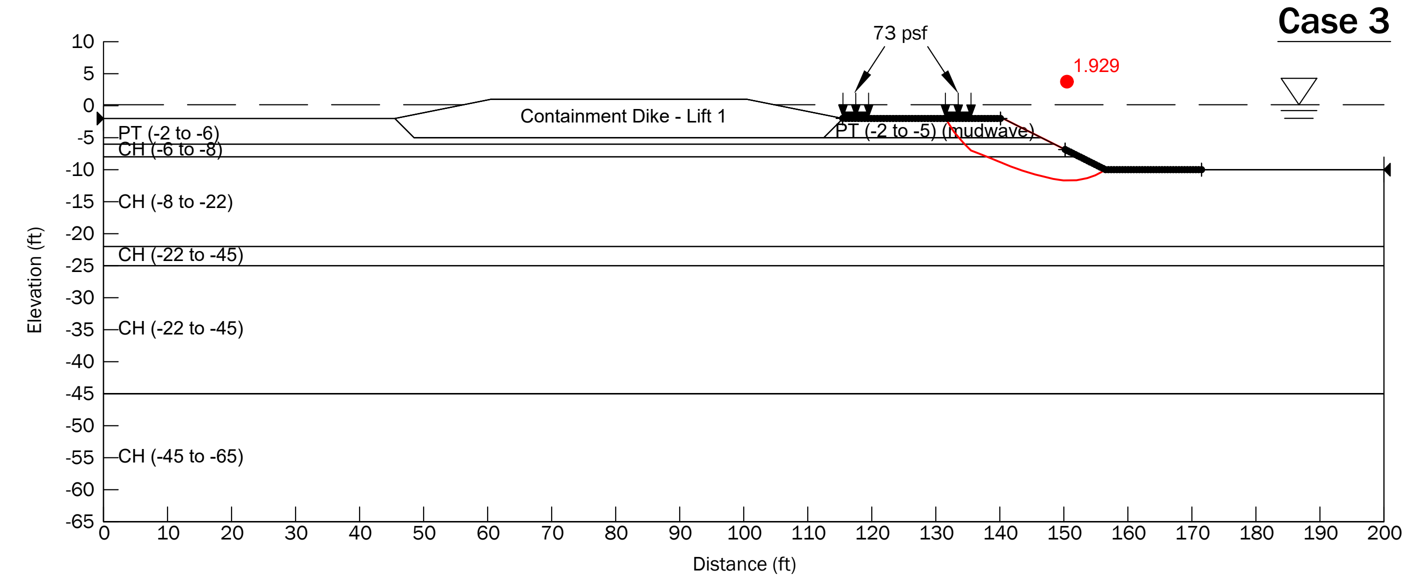
East Leeville Marsh Creation and Nourishment (BA-194)
Lafourche Parish, Louisiana

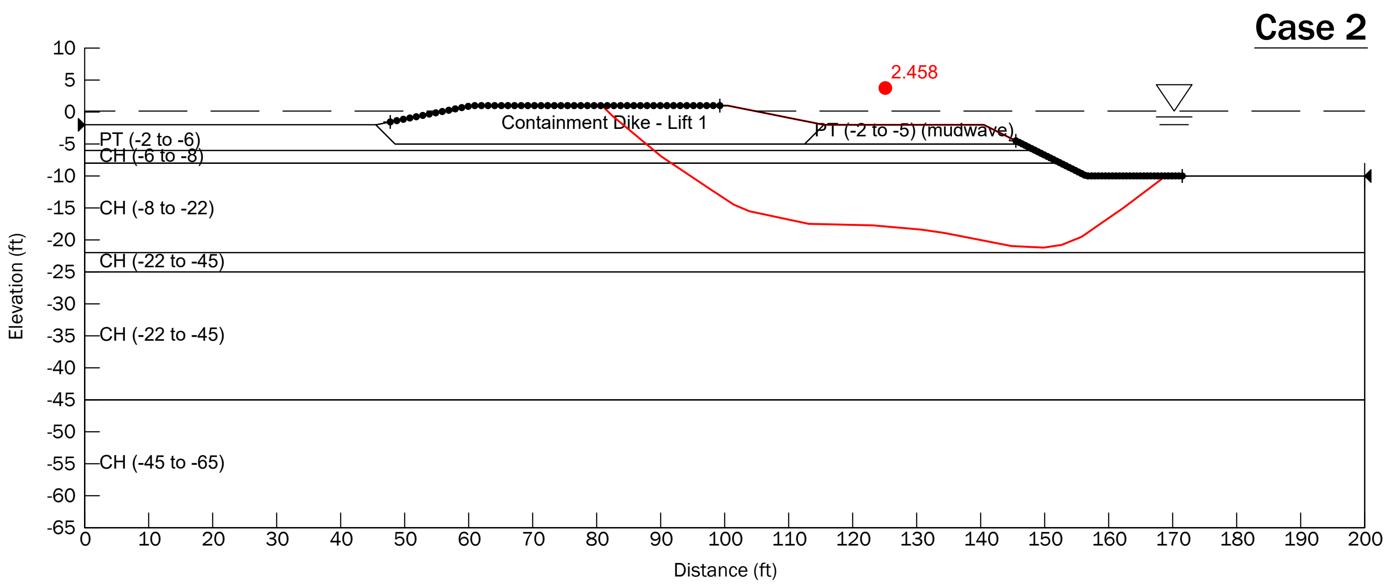
GeoEngineers

Figure B-3e

P:\18\18274004\CAD\02\Geotech - Final\18274004002_FB1a-6b_Slope Stability.dwg TAB:B3e Date Exported: 03/27/20 - 11:30 by kcook




| Name | Model | Unit Weight (pcf) | Cohesion' (psf) | Phi' (°) | Cohesion Fn |
|---|---|---|---|---|---|
| Containment Dike - Lift 1 | Mohr-Coulomb | 90 | 60 | 0 | |
| PT (-2 to -5) (mudwave) | Mohr-Coulomb | 80 | 5 | 0 | |
| PT (-2 to -6) | Mohr-Coulomb | 80 | 30 | 5 | |
| CH (-6 to -8) | Mohr-Coulomb | 108 | 75 | 0 | |
| CH (-8 to -22) | Spatial Mohr-Coulomb | 108 | | 0 | 75 psf + 7.1 psf/ft |
| CH (-22 to -45) | Spatial Mohr-Coulomb | 108 | | 0 | 175 psf + 10 psf/ft |
| CH (-45 to -65) | Spatial Mohr-Coulomb | 111 | | 0 | 405 psf + 10.75 psf/ft |

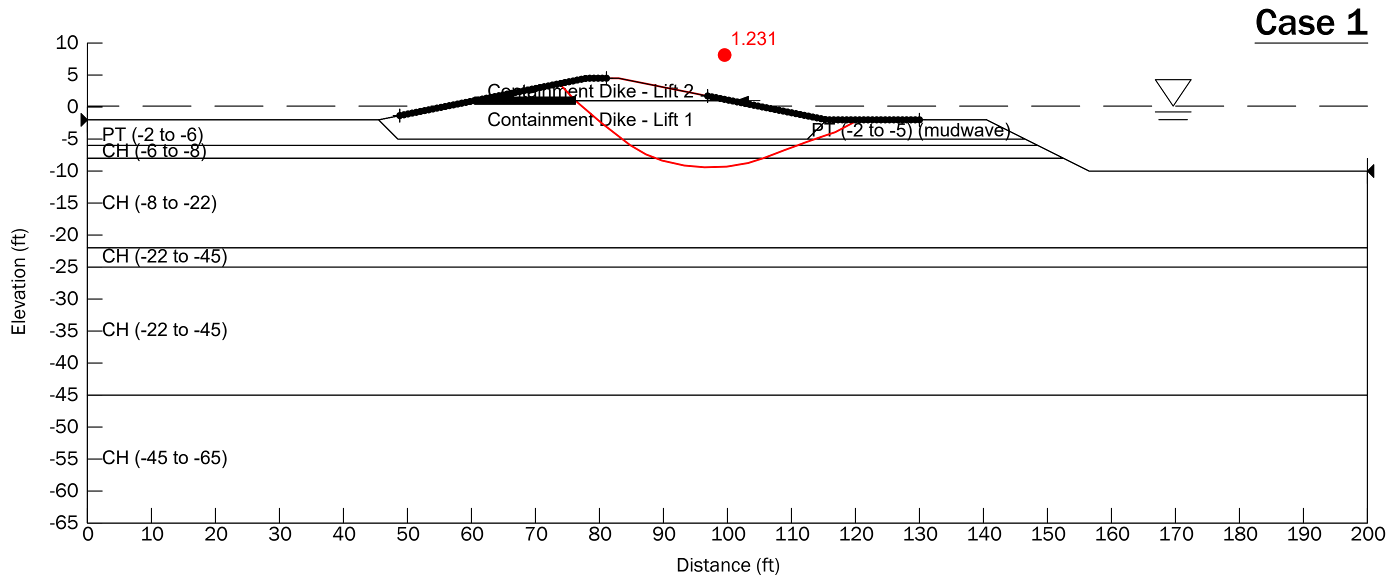
**Containment Dike Slope Stability - Cell 3, Mudline El. -2.0 ft, 5ft Crest, Lift 1**

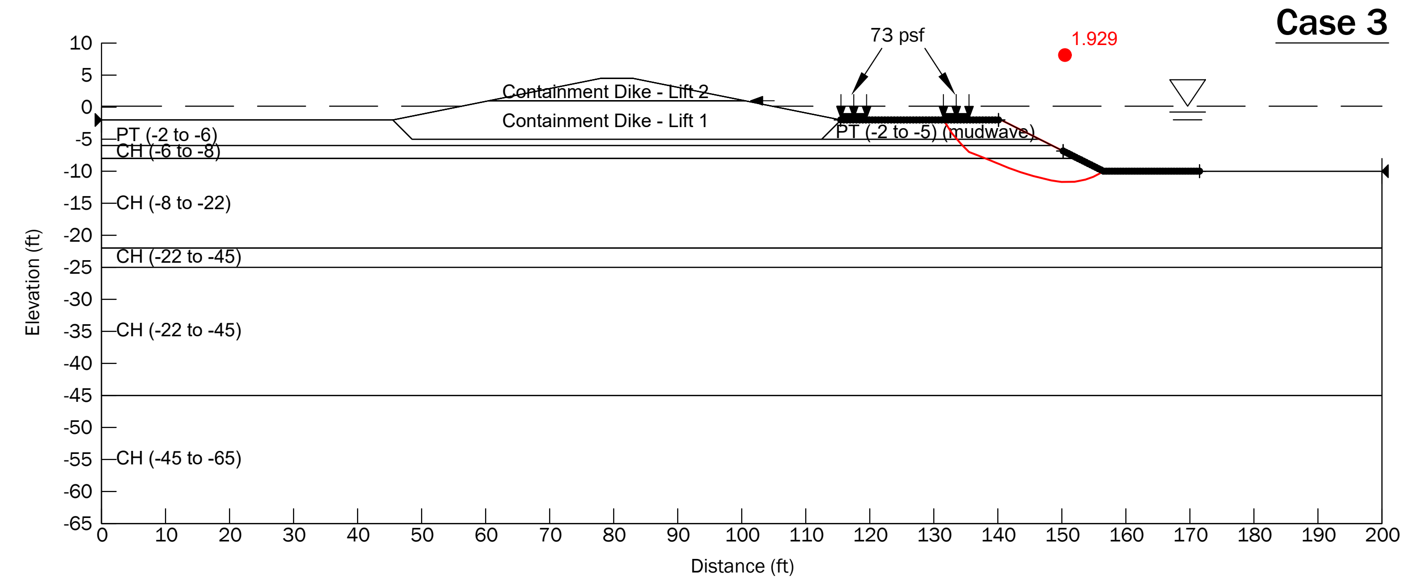
East Leeville Marsh Creation and Nourishment (BA-194)
Lafourche Parish, Louisiana

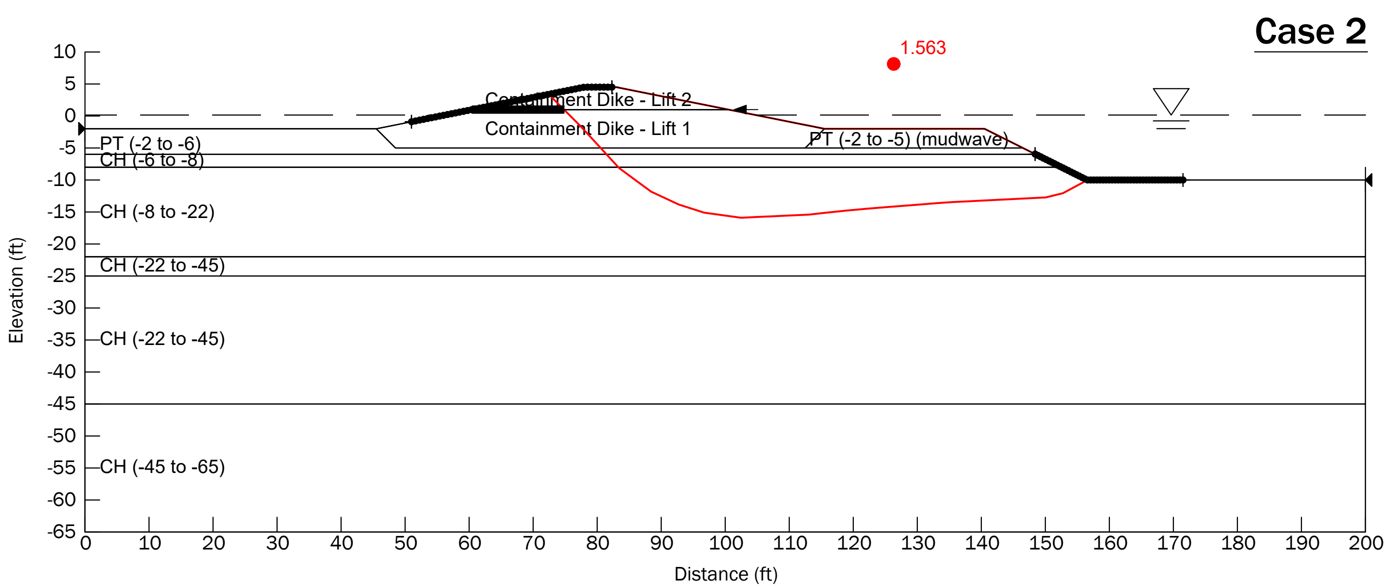
GeoEngineers

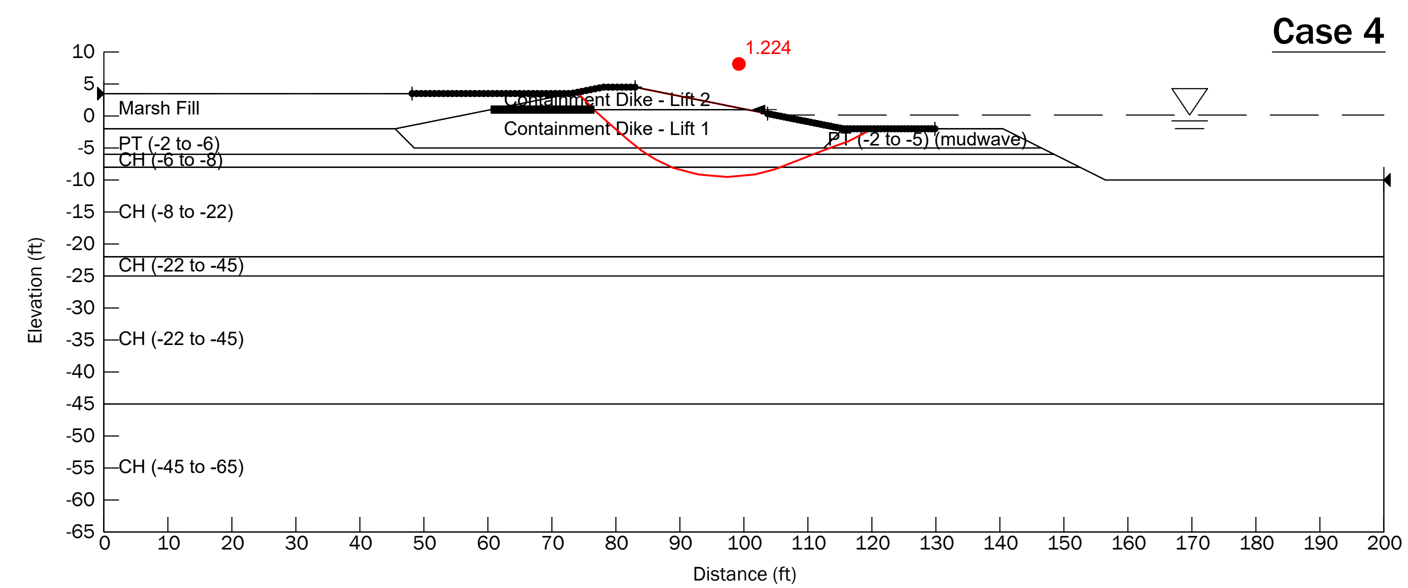
**Figure B-4a**

P:\18\18274004\CAD\02\Geotech - Final\18274400402_FB1a-6b_Slope Stability.dwg TAB:B4a Date Exported: 03/24/20 - 8:36 by kcook




| Name | Model | Unit Weight (pcf) | Cohesion' (psf) | Phi' (°) | Cohesion Spatial Fn | Cohesion Fn |
|---|---|---|---|---|---|---|
| Marsh Fill | Mohr-Coulomb | 85 | 0 | 0 | | |
| Containment Dike - Lift 2 | Mohr-Coulomb | 90 | 60 | 0 | | |
| Containment Dike - Lift 1 | Mohr-Coulomb | 90 | 66 | 0 | | |
| PT (-2 to -5) (mudwave) | Mohr-Coulomb | 80 | 5 | 0 | | |
| PT (-2 to -6) | Spatial Mohr-Coulomb | 80 | | 5 | 30 psf + 15% | |
| CH (-6 to -8) | Spatial Mohr-Coulomb | 108 | | 0 | 75 psf + 15% | |
| CH (-8 to -22) | Spatial Mohr-Coulomb | 108 | | 0 | 75 psf + 7.1 psf/ft + 15% | |
| CH (-22 to -45) | Spatial Mohr-Coulomb | 108 | | 0 | | 175 psf + 10 psf/ft |
| CH (-45 to -65) | Spatial Mohr-Coulomb | 111 | | 0 | | 405 psf + 10.75 psf/ft |

**Containment Dike Slope Stability - Cell 3, Mudline El. -2.0 ft, 5ft Crest, Lift 2**

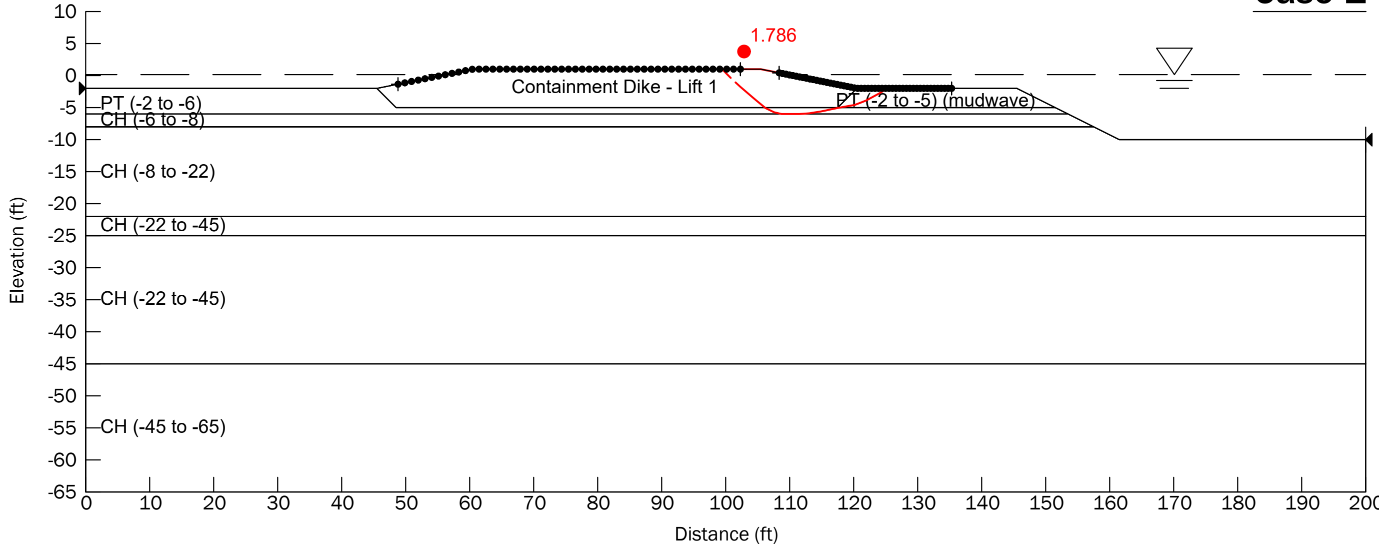
East Leeville Marsh Creation and Nourishment (BA-194)
Lafourche Parish, Louisiana

GeoEngineers

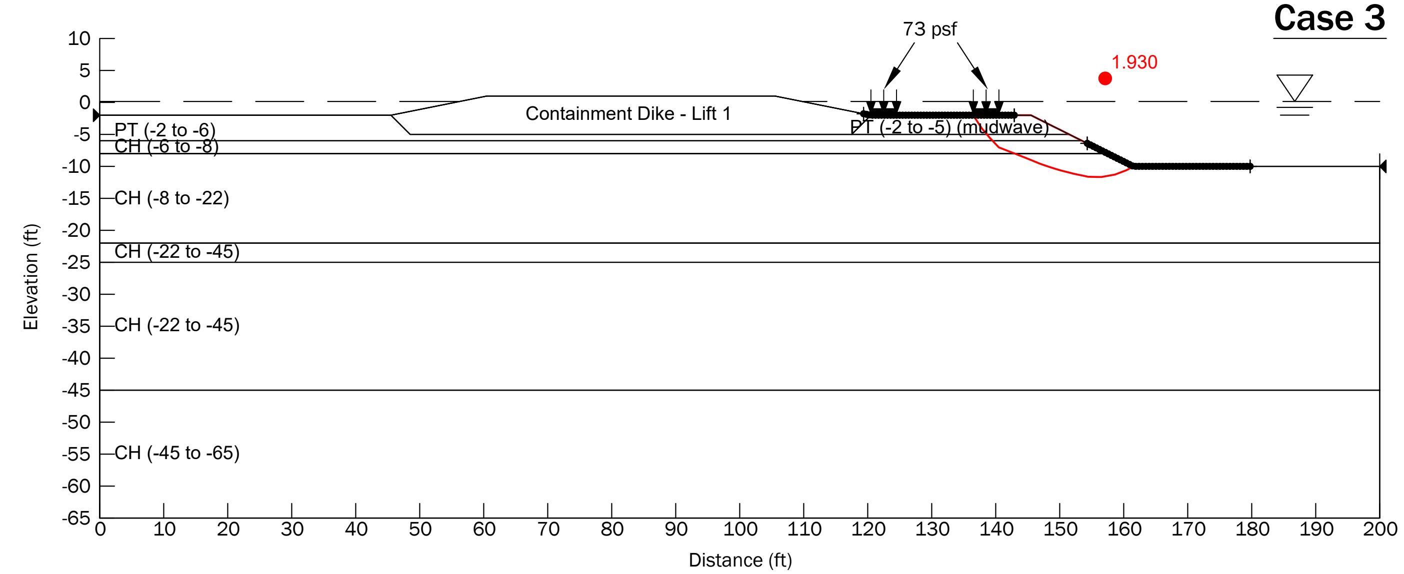
**Figure B-4b**

P:\18\18274004\CAD\02\Geotech - Final\18274004002_FB1a-6b_Slope Stability.dwg TAB:B4b Date Exported: 03/24/20 - 8:39 by kcook

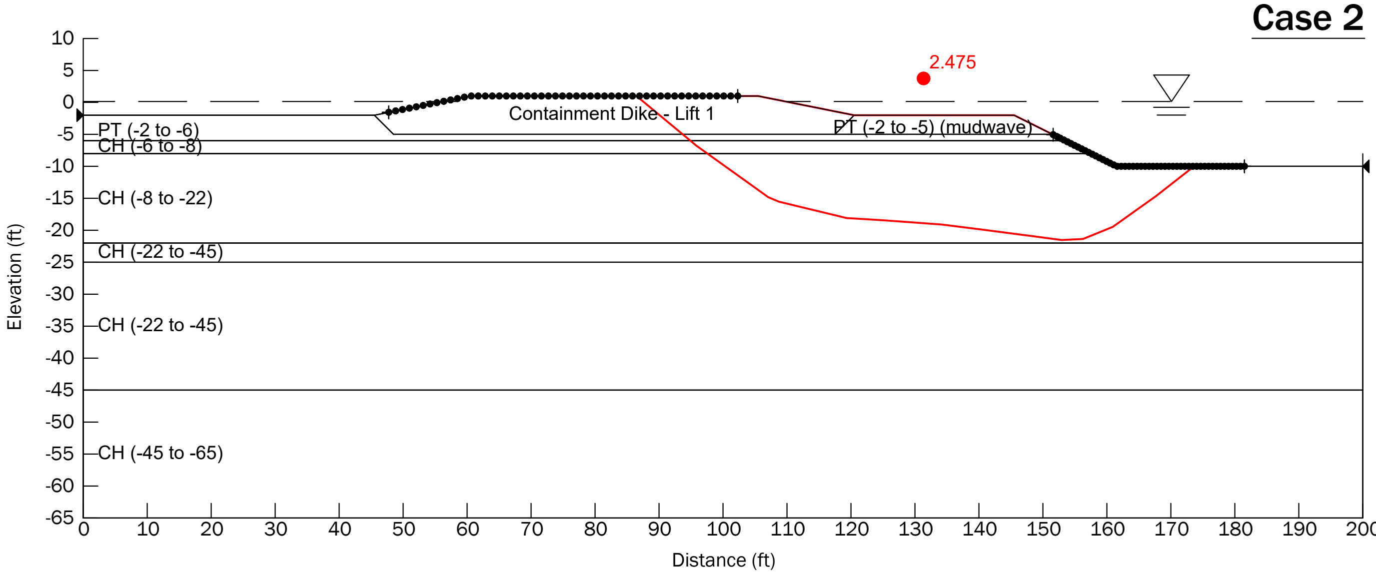
## Case 1




## Case 3




## Case 2



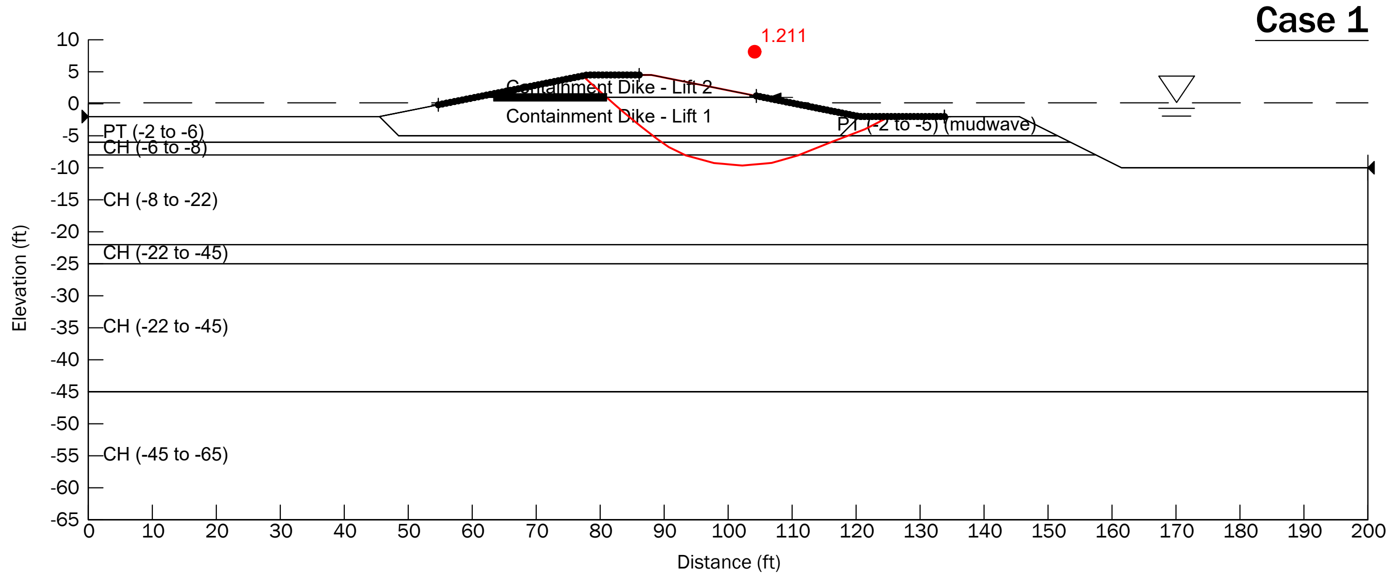

| Name | Model | Unit Weight (pcf) | Cohesion' (psf) | Phi' (°) | Cohesion Fn |
|---|---|---|---|---|---|
| Containment Dike - Lift 1 | Mohr-Coulomb | 90 | 60 | 0 | |
| PT (-2 to -6) | Mohr-Coulomb | 80 | 30 | 5 | |
| CH (-6 to -8) | Mohr-Coulomb | 108 | 75 | 0 | |
| CH (-8 to -22) | Spatial Mohr-Coulomb | 108 | | 0 | 75 psf + 7.1 psf/ft |
| CH (-22 to -45) | Spatial Mohr-Coulomb | 108 | | 0 | 175 psf + 10 psf/ft |
| CH (-45 to -65) | Spatial Mohr-Coulomb | 111 | | 0 | 405 psf + 10.75 psf/ft |
| PT (-2 to -5) (mudwave) | Mohr-Coulomb | 80 | 5 | 0 | |

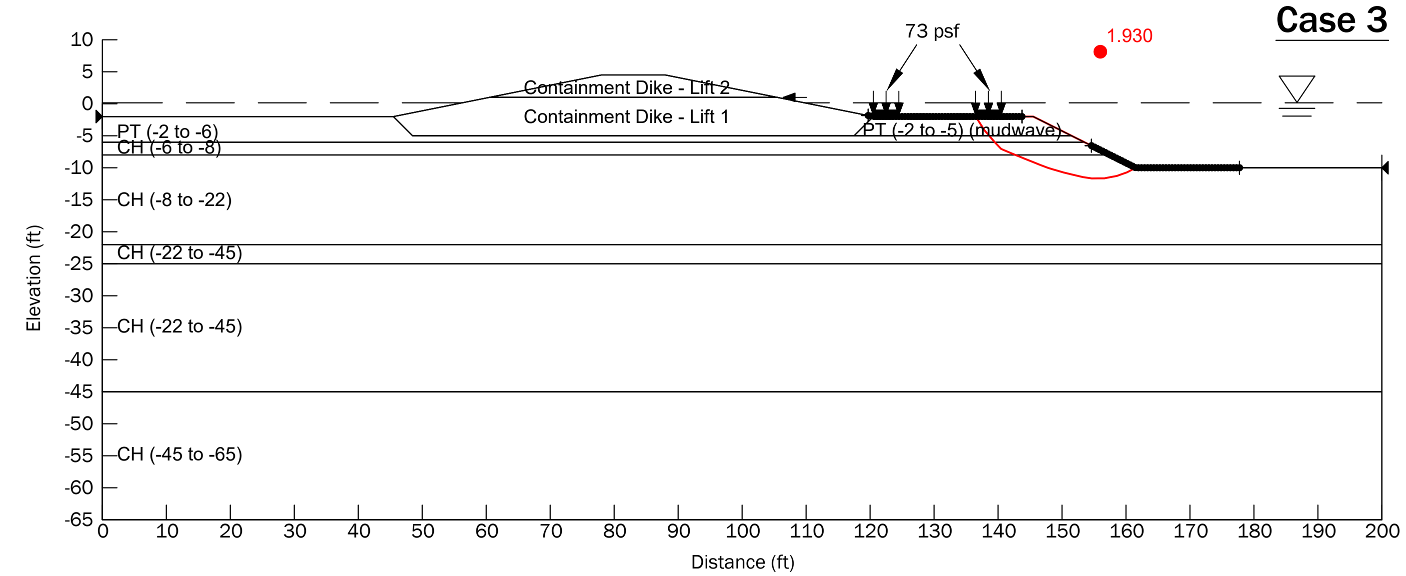
**Containment Dike Slope Stability - Cell 3, Mudline El. -2.0 ft, 10ft Crest, Lift 1**

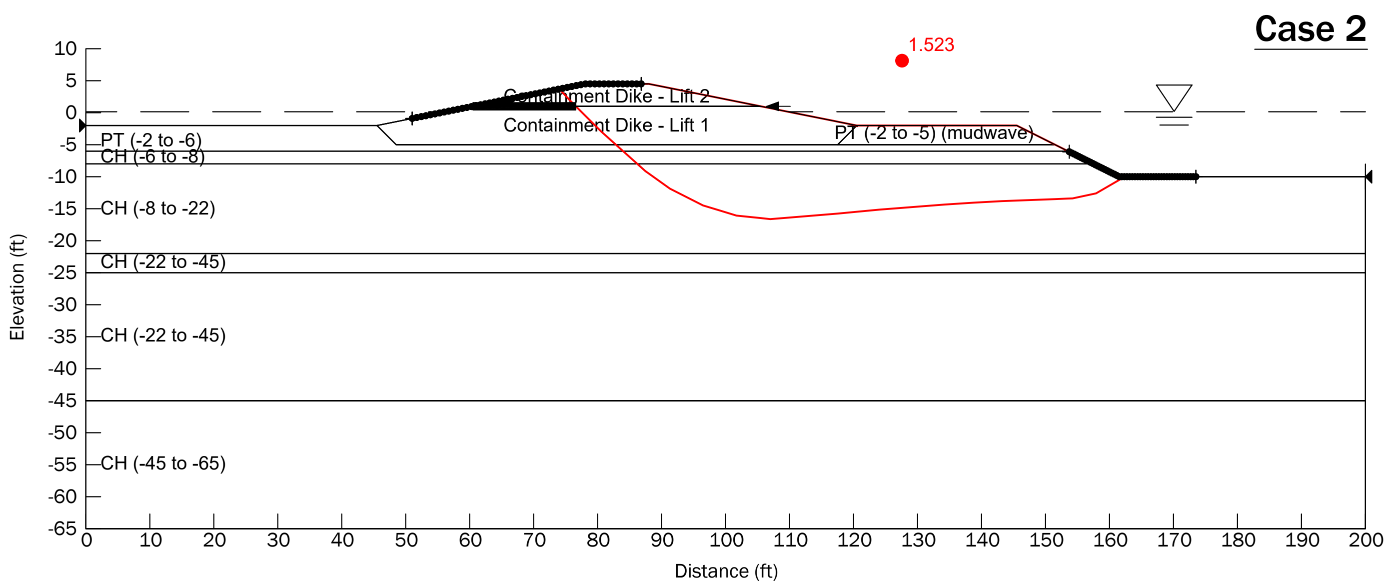
East Leeville Marsh Creation and Nourishment (BA-194)
Lafourche Parish, Louisiana

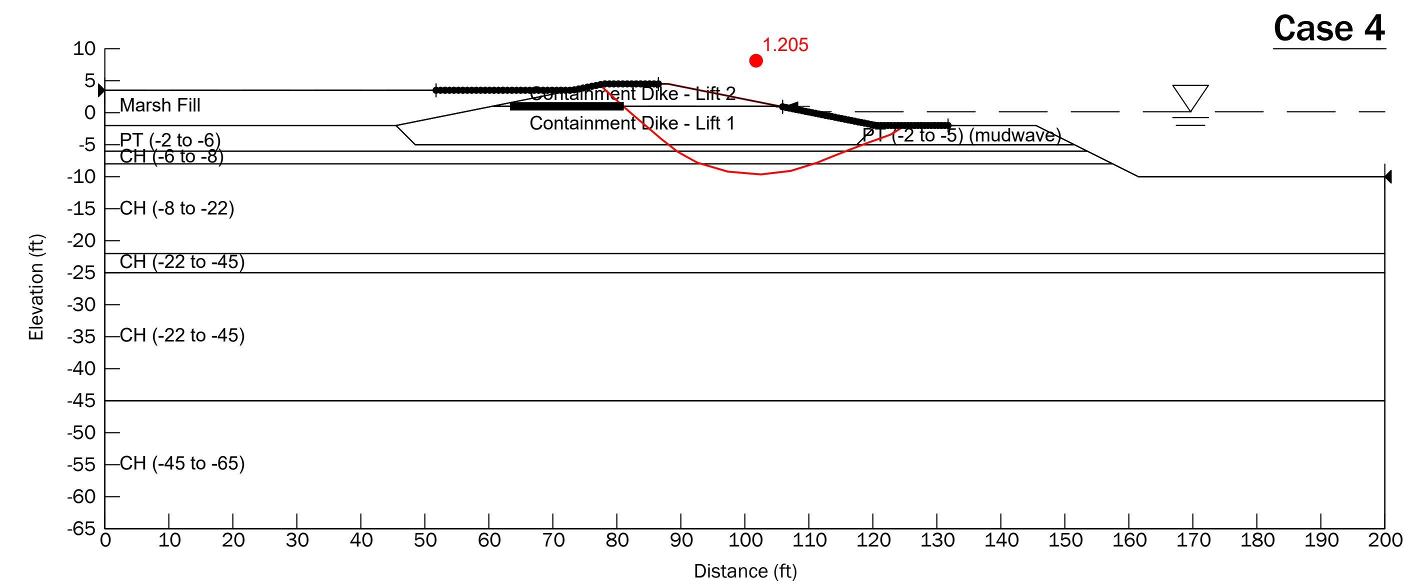
GEOENGINEERS

**Figure B-4c**




| Name | Model | Unit Weight (pcf) | Cohesion' (psf) | Phi' (°) | Cohesion Spatial Fn | Cohesion Fn |
|---|---|---|---|---|---|---|
| Marsh Fill | Mohr-Coulomb | 85 | 0 | 0 | | |
| Containment Dike - Lift 1 | Mohr-Coulomb | 90 | 66 | 0 | | |
| PT (-2 to -6) | Spatial Mohr-Coulomb | 80 | | 5 | 30 psf + 15% | |
| CH (-6 to -8) | Spatial Mohr-Coulomb | 108 | | 0 | 75 psf + 15% | |
| CH (-8 to -22) | Spatial Mohr-Coulomb | 108 | | 0 | 75 psf + 7.1 psf/ft + 15% | |
| CH (-22 to -45) | Spatial Mohr-Coulomb | 108 | | 0 | | 175 psf + 10 psf/ft |
| CH (-45 to -65) | Spatial Mohr-Coulomb | 111 | | 0 | | 405 psf + 10.75 psf/ft |
| PT (-2 to -5) (mudwave) | Mohr-Coulomb | 80 | 5 | 0 | | |
| Containment Dike - Lift 2 | Mohr-Coulomb | 90 | 60 | 0 | | |

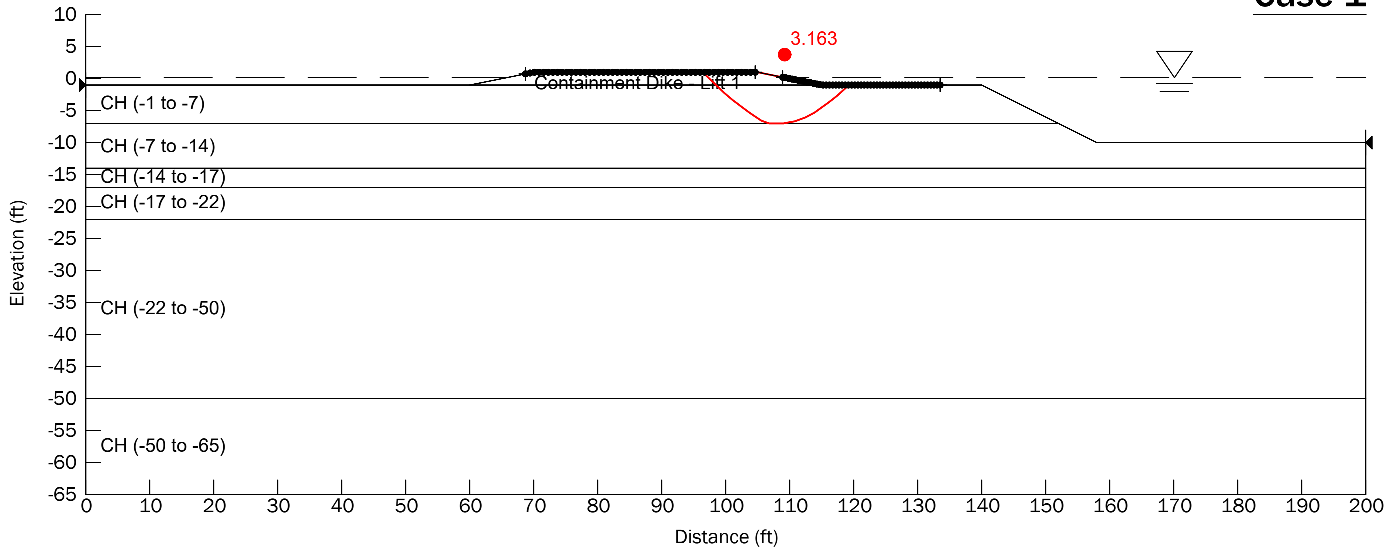
**Containment Dike Slope Stability - Cell 3, Mudline El. -2.0 ft, 10ft Crest, Lift 2**

East Leeville Marsh Creation and Nourishment (BA-194)
Lafourche Parish, Louisiana

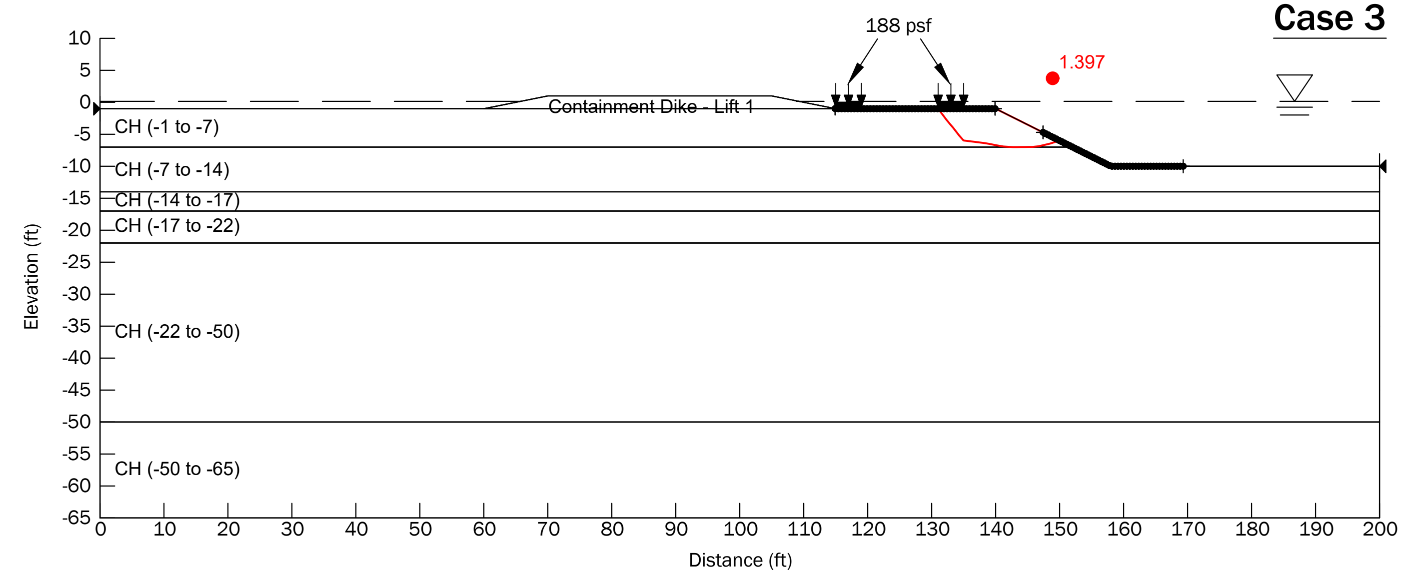
GEOENGINEERS

**Figure B-4d**

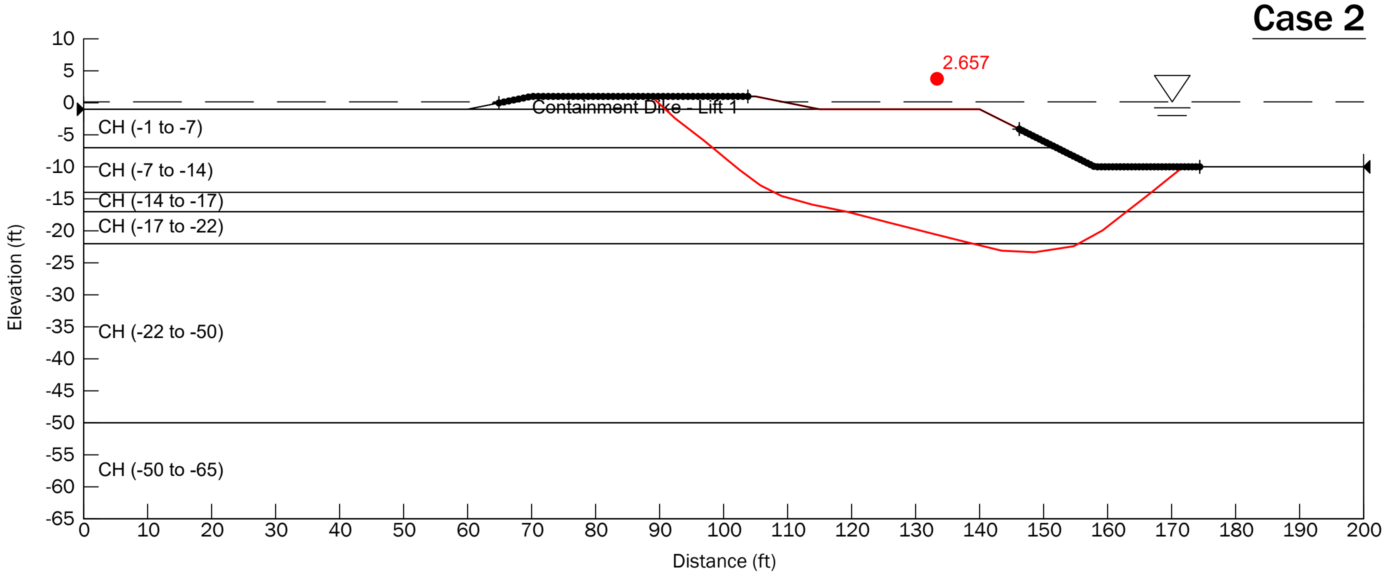
## Case 1




## Case 3




## Case 2



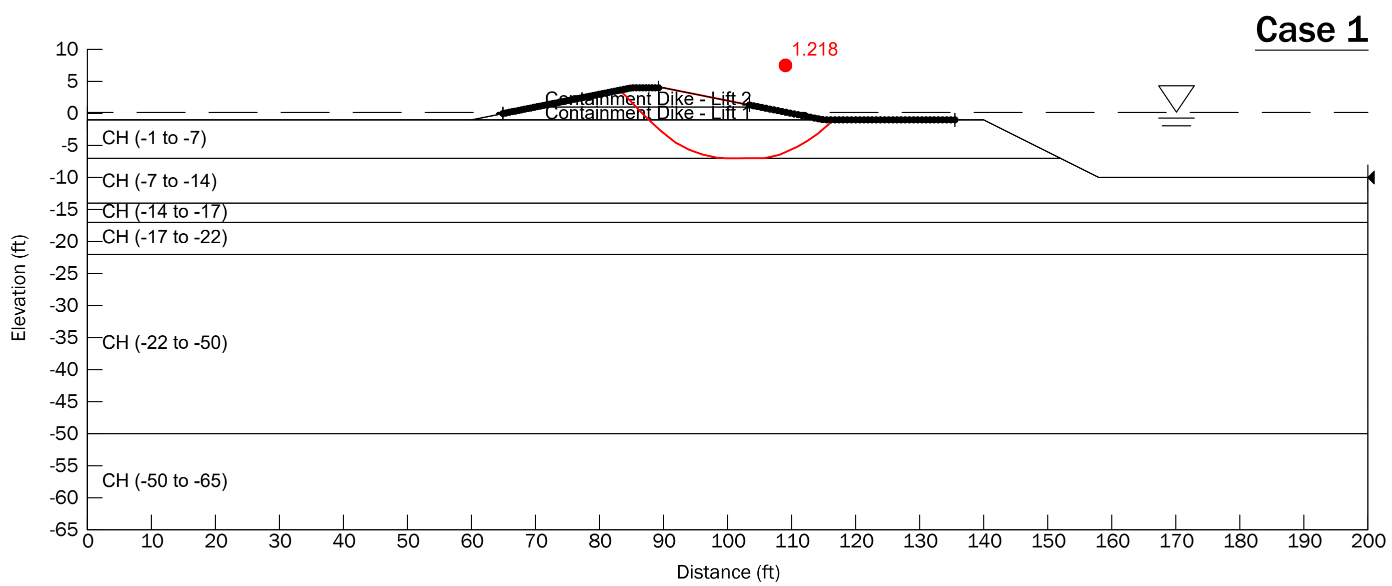

| Name | Model | Unit Weight (pcf) | Cohesion' (psf) | Phi' (°) | Cohesion Fn |
|---|---|---|---|---|---|
| Containment Dike - Lift 1 | Mohr-Coulomb | 95 | 60 | 0 | |
| CH (-1 to -7) | Mohr-Coulomb | 95 | 70 | 0 | |
| CH (-7 to -14) | Mohr-Coulomb | 110 | 150 | 0 | |
| CH (-14 to -17) | Mohr-Coulomb | 110 | 180 | 0 | |
| CH (-17 to -22) | Mohr-Coulomb | 110 | 195 | 0 | |
| CH (-22 to -50) | Spatial Mohr-Coulomb | 110 | | 0 | 195 psf + 10.4 psf/ft |
| CH (-50 to -65) | Spatial Mohr-Coulomb | 116 | | 0 | 485 psf + 12 psf/ft |

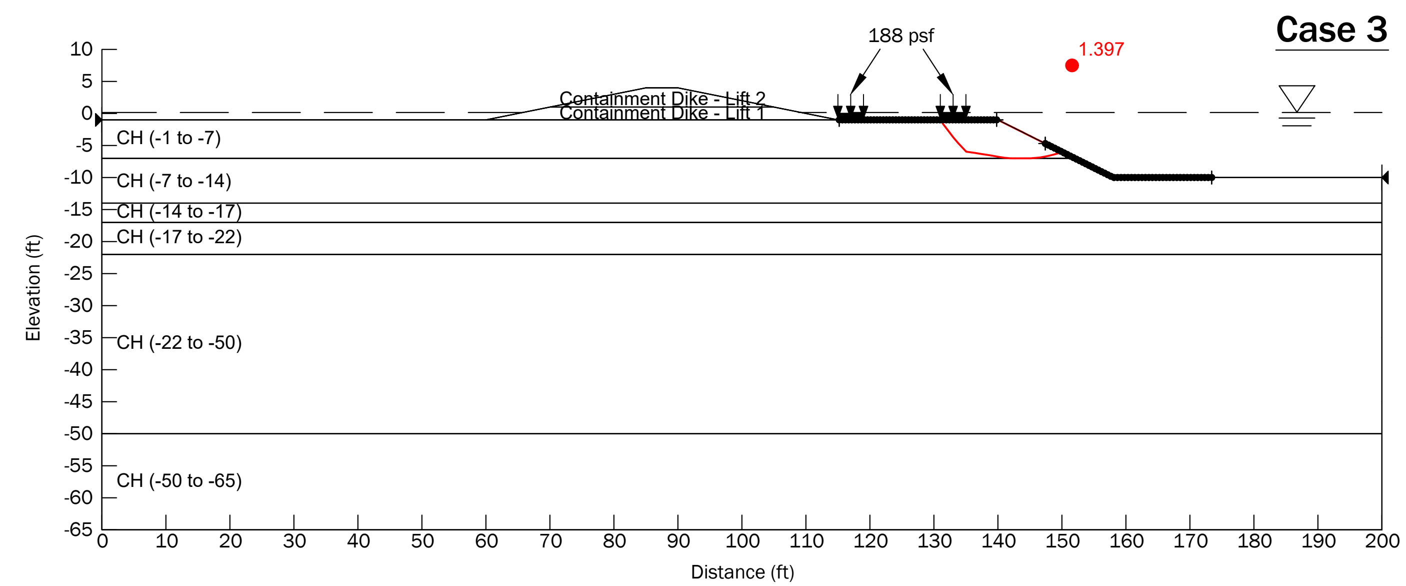
**Containment Dike Slope Stability - Cell 4, 5 & 6, Mudline El. -1.0 ft, 5ft Crest, Lift 1**

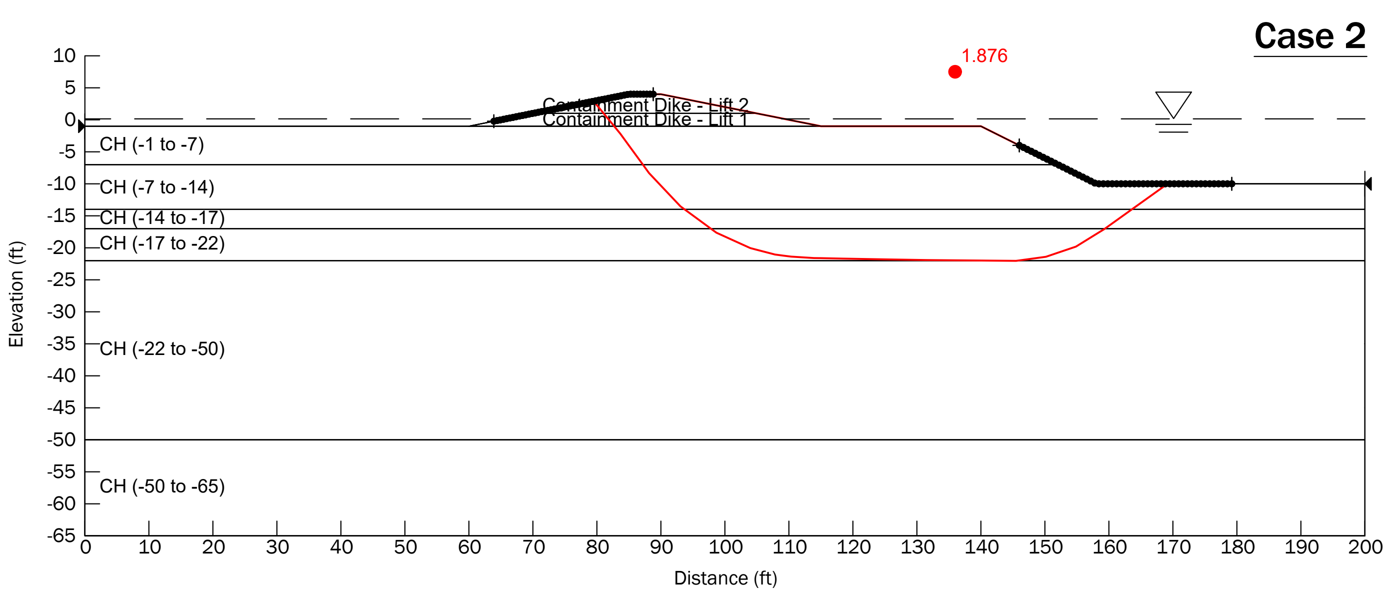
East Leeville Marsh Creation and Nourishment (BA-194)
Lafourche Parish, Louisiana

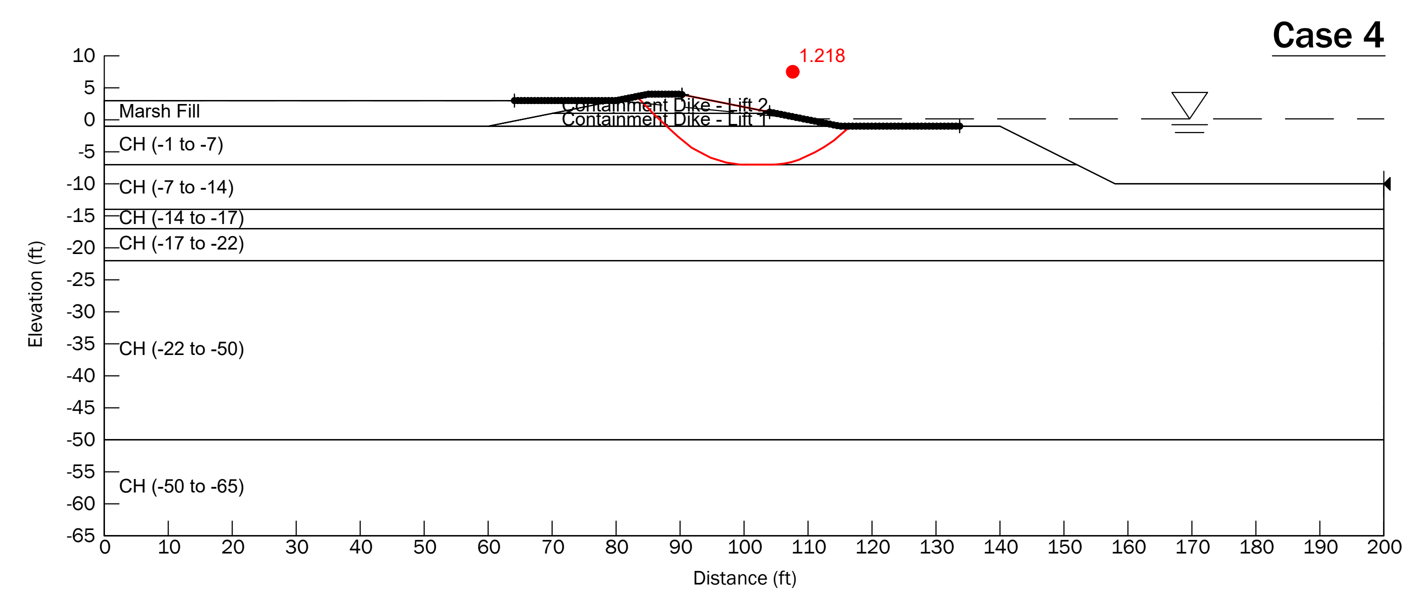
GEOENGINEERS

**Figure B-5a**




| Name | Model | Unit Weight (pcf) | Cohesion' (psf) | Phi' (°) | Cohesion Spatial Fn | Cohesion Fn |
|---|---|---|---|---|---|---|
| Marsh Fill | Mohr-Coulomb | 85 | 0 | 0 | | |
| Containment Dike - Lift 2 | Mohr-Coulomb | 95 | 60 | 0 | | |
| Containment Dike - Lift 1 | Mohr-Coulomb | 95 | 66 | 0 | | |
| CH (-1 to -7) | Spatial Mohr-Coulomb | 95 | | 0 | 70 psf + 15% | |
| CH (-7 to -14) | Spatial Mohr-Coulomb | 110 | | 0 | 150 psf + 15% | |
| CH (-14 to -17) | Mohr-Coulomb | 110 | 180 | 0 | | |
| CH (-17 to -22) | Mohr-Coulomb | 110 | 195 | 0 | | |
| CH (-22 to -50) | Spatial Mohr-Coulomb | 110 | | 0 | | 195 psf + 10.4 psf/ft |
| CH (-50 to -65) | Spatial Mohr-Coulomb | 116 | | 0 | | 485 psf + 12 psf/ft |

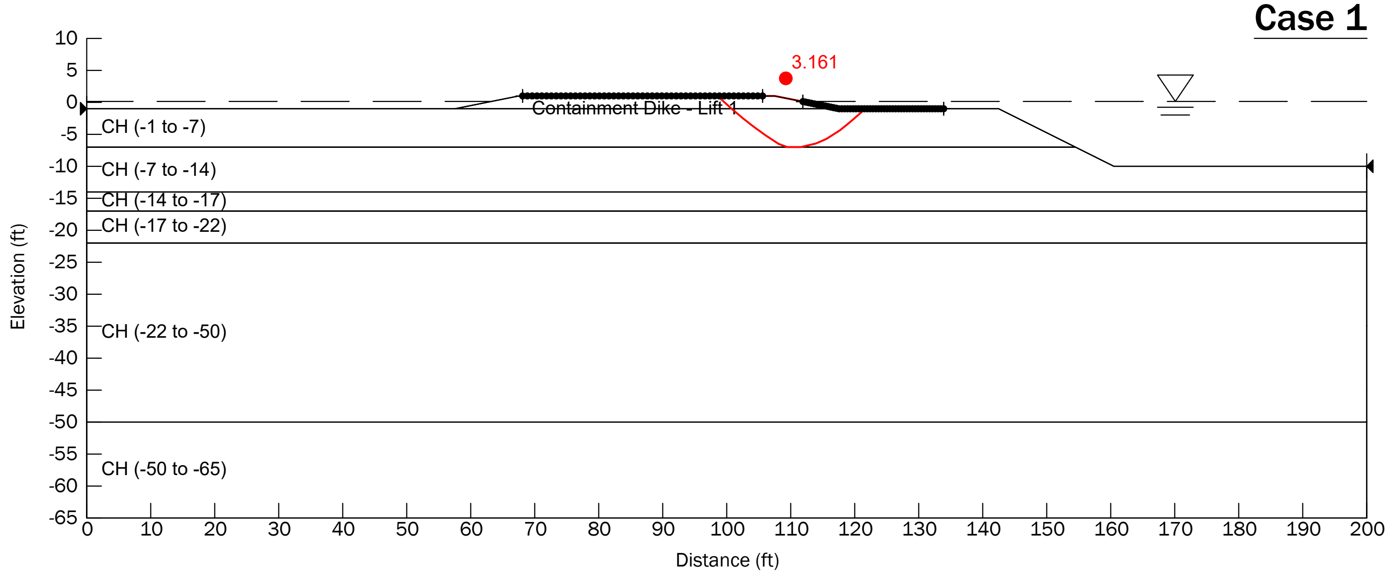
**Containment Dike Slope Stability - Cell 4, 5 & 6, Mudline El. -1.0 ft, 5ft Crest, Lift 2**

East Leeville Marsh Creation and Nourishment
(BA-194)
Lafourche Parish, Louisiana

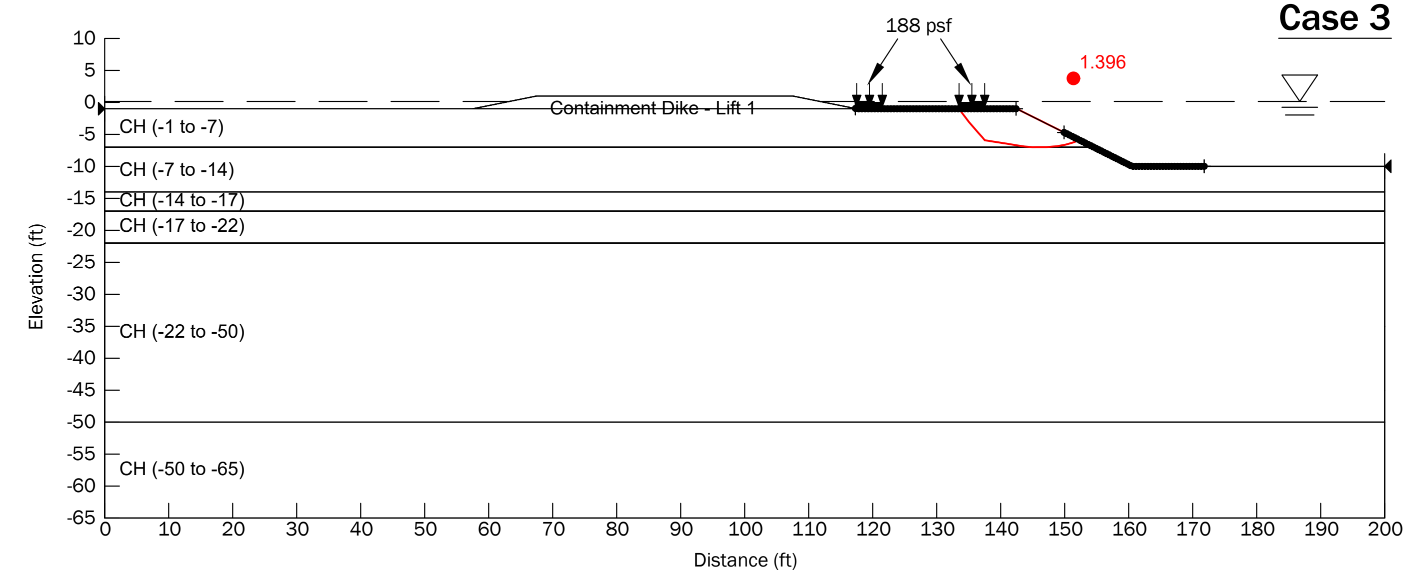
GeoEngineers

**Figure B-5b**

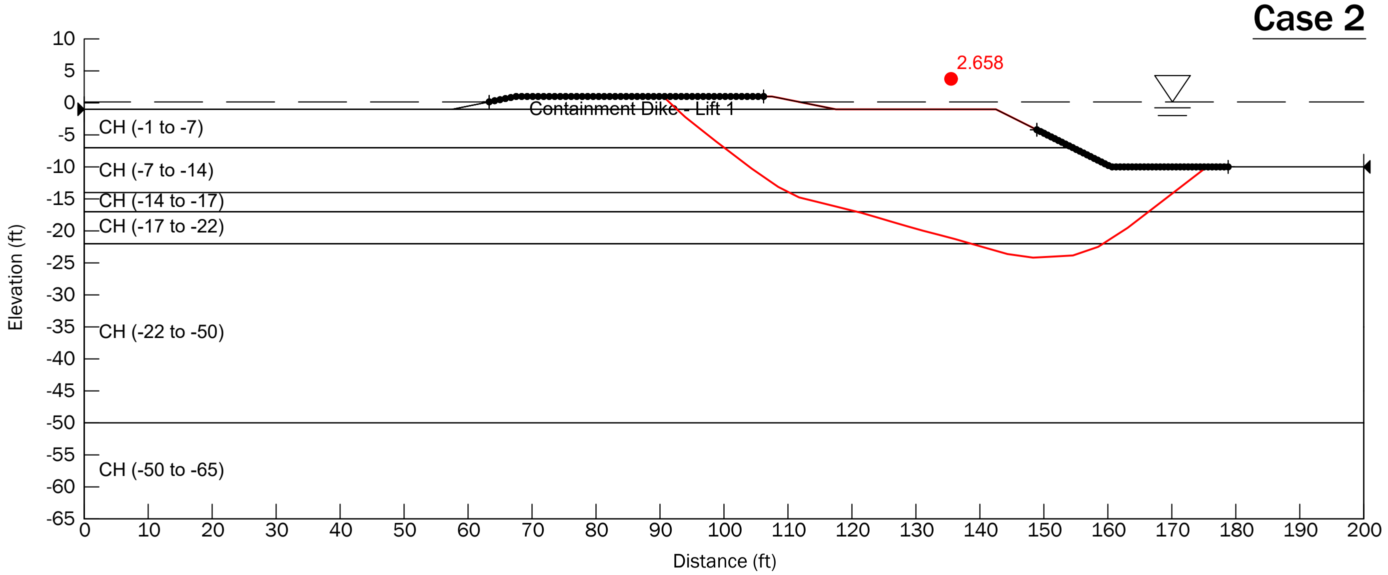
## Case 1




## Case 3




## Case 2



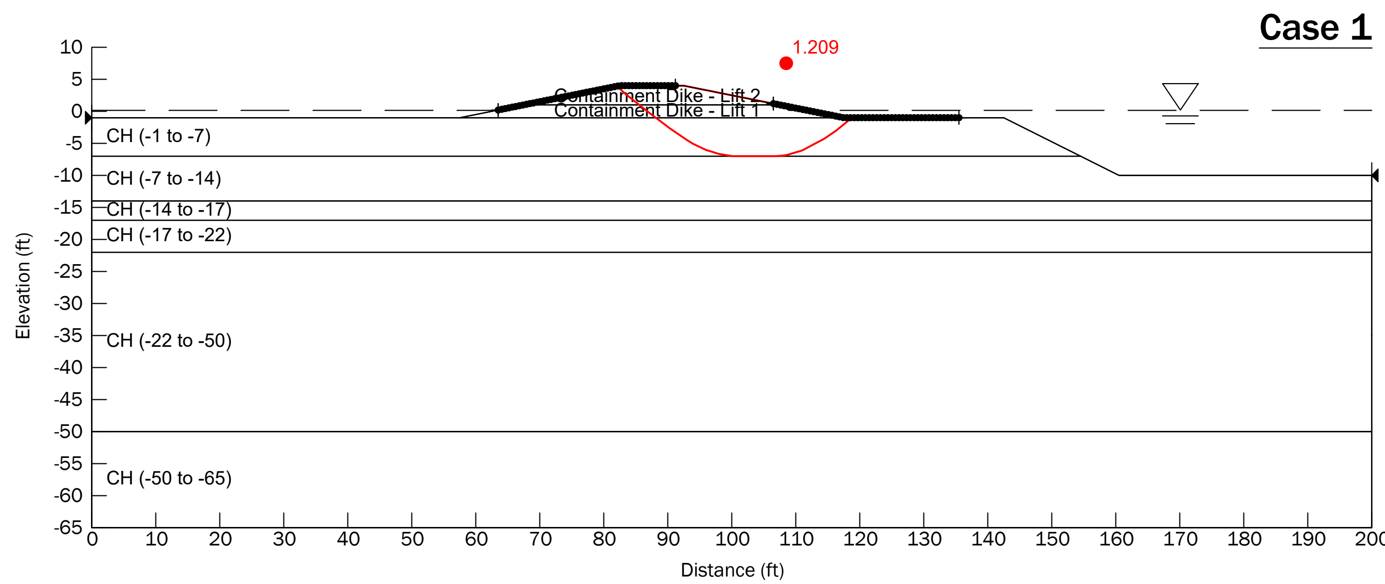

| Name | Model | Unit Weight (pcf) | Cohesion' (psf) | Phi' (°) | Cohesion Fn |
|---|---|---|---|---|---|
| Containment Dike - Lift 1 | Mohr-Coulomb | 95 | 60 | 0 | |
| CH (-1 to -7) | Mohr-Coulomb | 95 | 70 | 0 | |
| CH (-7 to -14) | Mohr-Coulomb | 110 | 150 | 0 | |
| CH (-14 to -17) | Mohr-Coulomb | 110 | 180 | 0 | |
| CH (-17 to -22) | Mohr-Coulomb | 110 | 195 | 0 | |
| CH (-22 to -50) | Spatial Mohr-Coulomb | 110 | | 0 | 195 psf + 10.4 psf/ft |
| CH (-50 to -65) | Spatial Mohr-Coulomb | 116 | | 0 | 485 psf + 12 psf/ft |

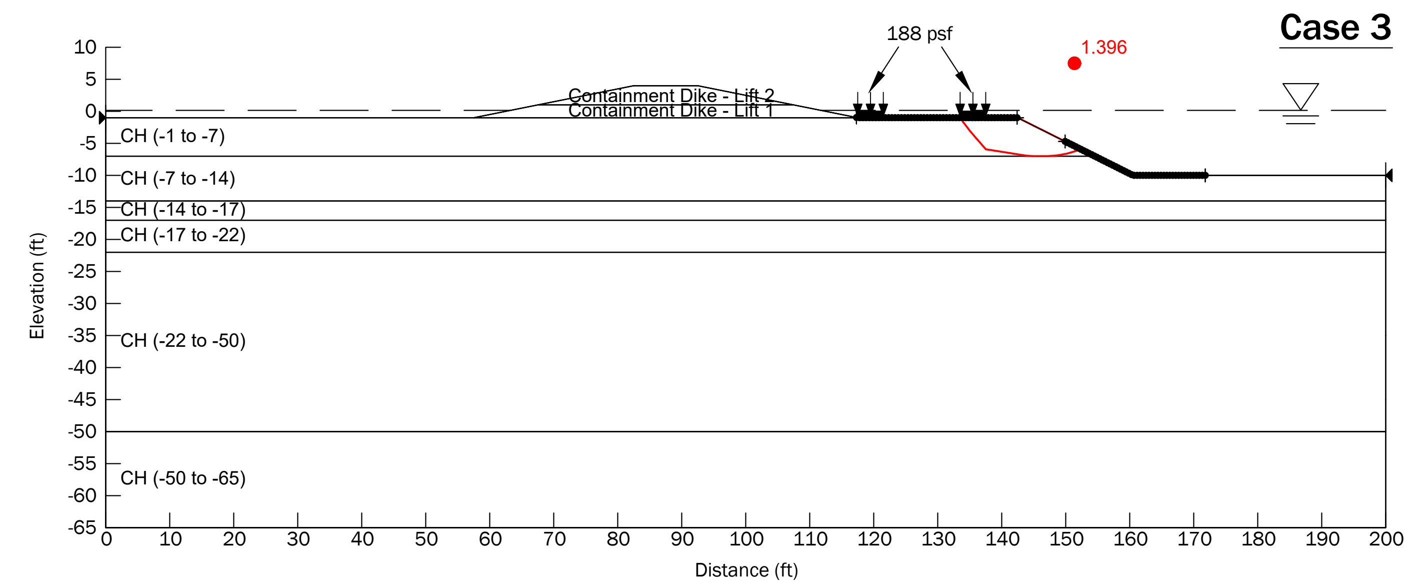
**Containment Dike Slope Stability - Cell 4, 5 & 6, Mudline El. -1.0 ft, 10ft Crest, Lift 1**

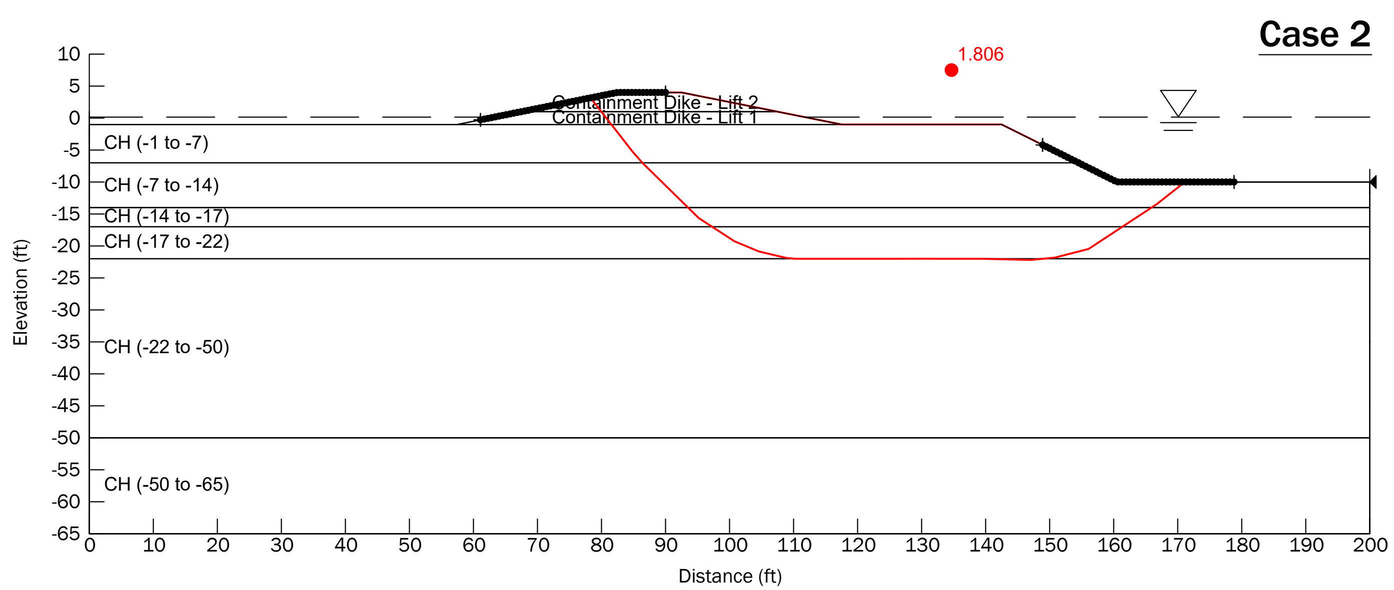
East Leeville Marsh Creation and Nourishment (BA-194)
Lafourche Parish, Louisiana

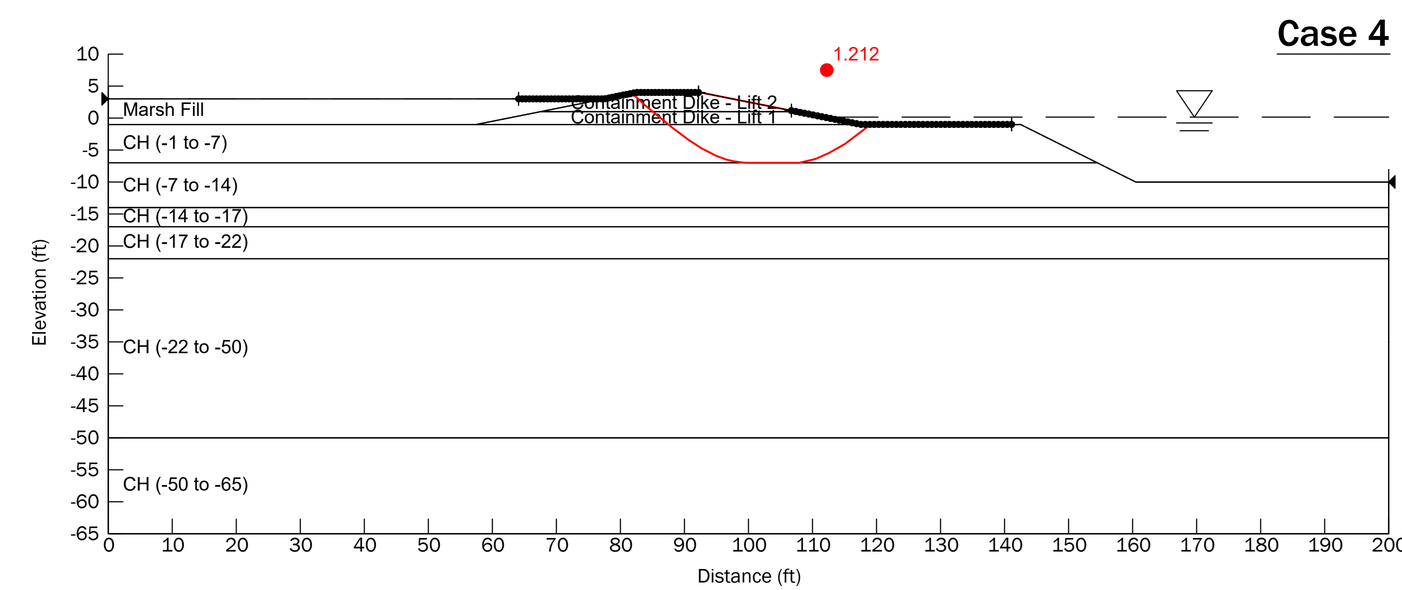
GEOENGINEERS

**Figure B-5c**




| Name | Model | Unit Weight (pcf) | Cohesion' (psf) | Phi' (°) | Cohesion Spatial Fn | Cohesion Fn |
|---|---|---|---|---|---|---|
| Marsh Fill | Mohr-Coulomb | 85 | 0 | 0 | | |
| Containment Dike - Lift 2 | Mohr-Coulomb | 95 | 60 | 0 | | |
| Containment Dike - Lift 1 | Mohr-Coulomb | 95 | 66 | 0 | | |
| CH (-1 to -7) | Spatial Mohr-Coulomb | 95 | | 0 | 70 psf + 15% | |
| CH (-7 to -14) | Spatial Mohr-Coulomb | 110 | | 0 | 150 psf + 15% | |
| CH (-14 to -17) | Mohr-Coulomb | 110 | 180 | 0 | | |
| CH (-17 to -22) | Mohr-Coulomb | 110 | 195 | 0 | | |
| CH (-22 to -50) | Spatial Mohr-Coulomb | 110 | | 0 | | 195 psf + 10.4 psf/ft |
| CH (-50 to -65) | Spatial Mohr-Coulomb | 116 | | 0 | | 485 psf + 12 psf/ft |

**Containment Dike Slope Stability - Cell 4, 5 & 6, Mudline El. -1.0 ft, 10ft Crest, Lift 2**

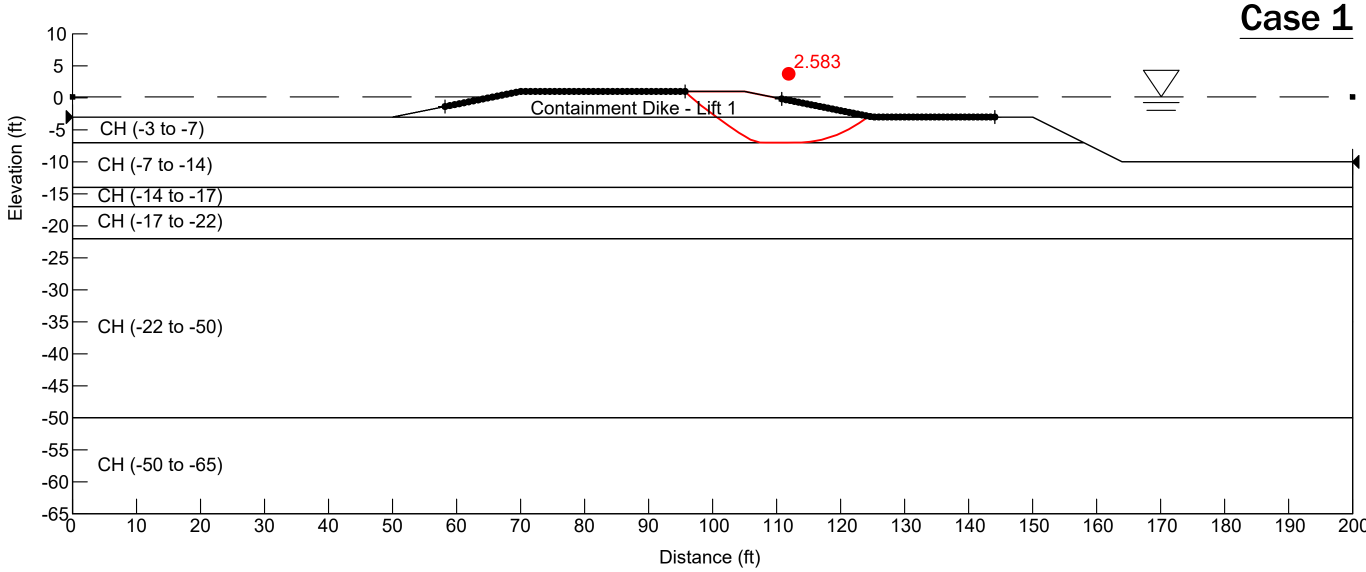
East Leeville Marsh Creation and Nourishment
(BA-194)
Lafourche Parish, Louisiana

GeoEngineers

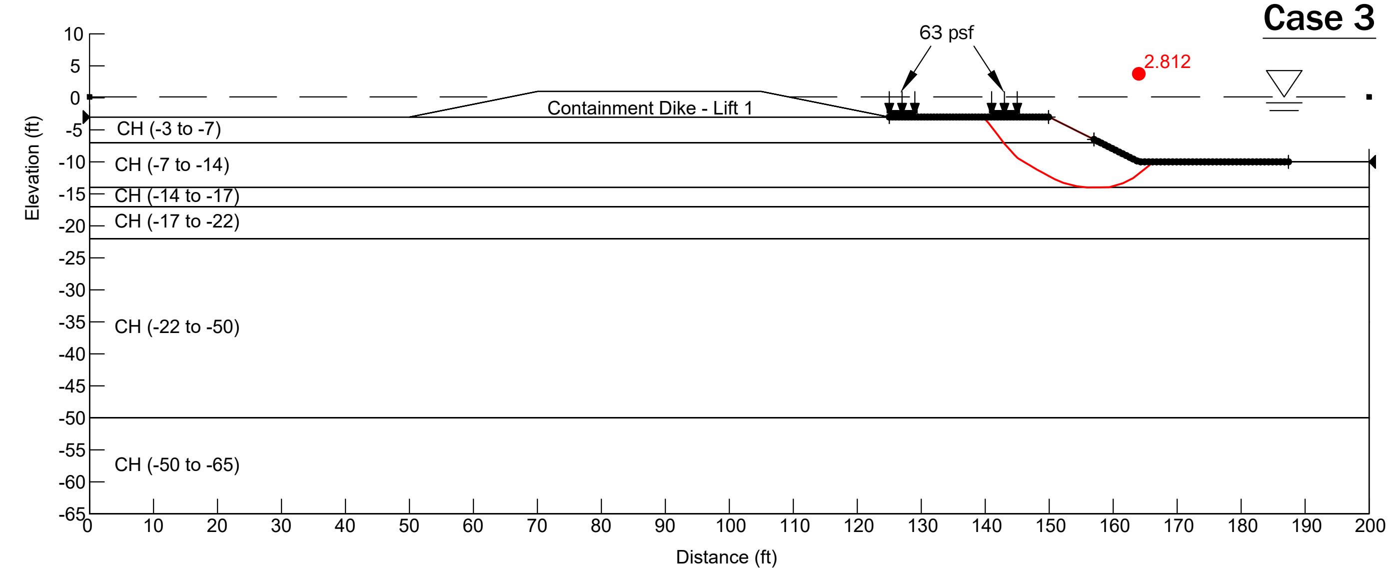
**Figure B-5d**

P:\18\18274004\CAD\02\Geotech - Final\18274004402_FB1a-6b_Slope Stability.dwg TAB:B5d Date Exported: 03/26/20 - 10:13 by kcook

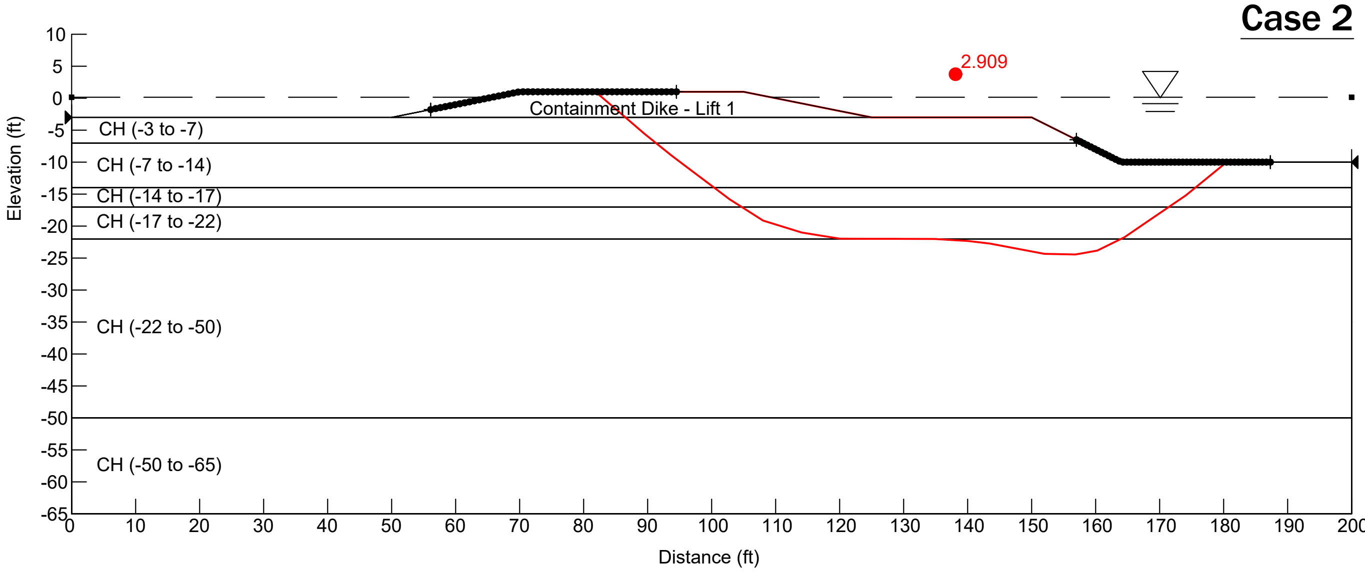
## Case 1




## Case 3




## Case 2



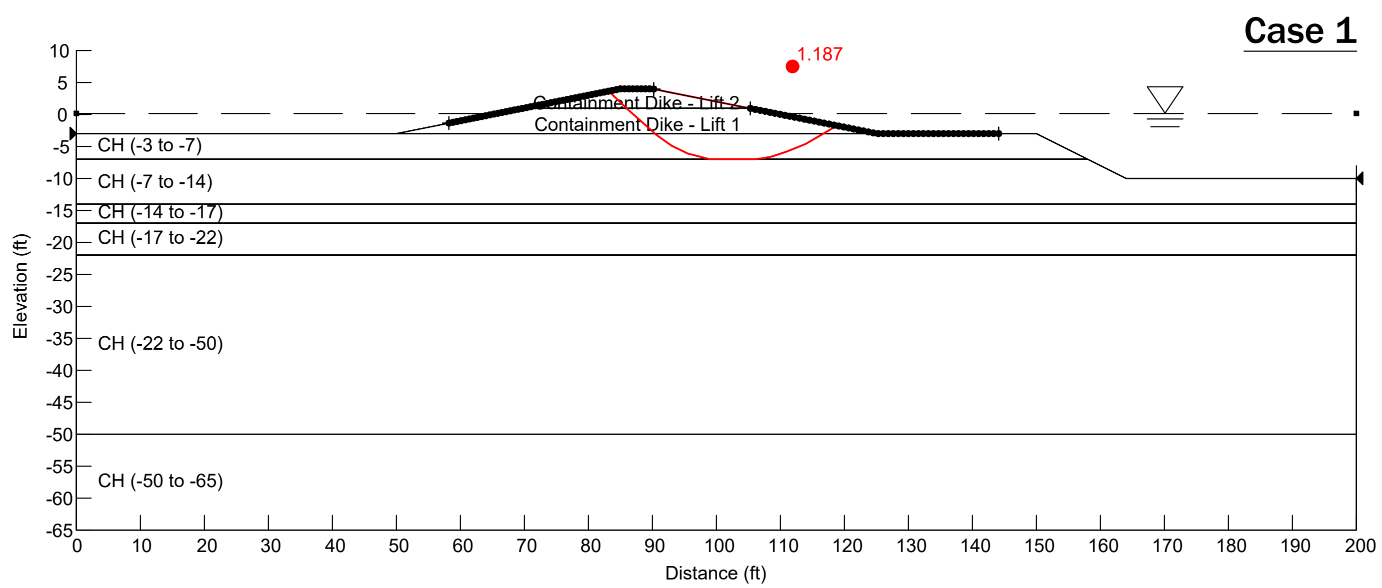

| Name | Model | Unit Weight (pcf) | Cohesion' (psf) | Phi' (°) | Cohesion Fn |
|---|---|---|---|---|---|
| Containment Dike - Lift 1 | Mohr-Coulomb | 95 | 60 | 0 | |
| CH (-3 to -7) | Mohr-Coulomb | 95 | 70 | 0 | |
| CH (-7 to -14) | Mohr-Coulomb | 110 | 150 | 0 | |
| CH (-14 to -17) | Mohr-Coulomb | 110 | 180 | 0 | |
| CH (-17 to -22) | Mohr-Coulomb | 110 | 195 | 0 | |
| CH (-22 to -50) | Spatial Mohr-Coulomb | 110 | | 0 | 195 psf + 10.4 psf/ft |
| CH (-50 to -65) | Spatial Mohr-Coulomb | 116 | | 0 | 485 psf + 12 psf/ft |

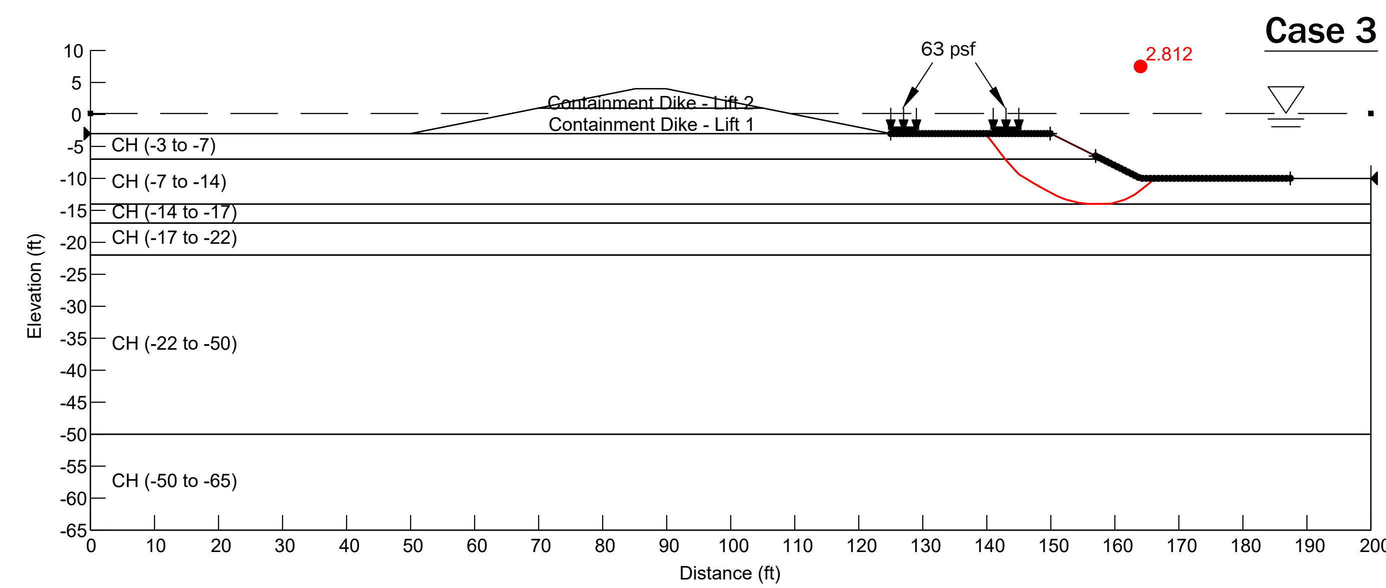
**Containment Dike Slope Stability - Cell 4, 5 & 6, Mudline El. -3.0 ft, 5ft Crest, Lift 1**

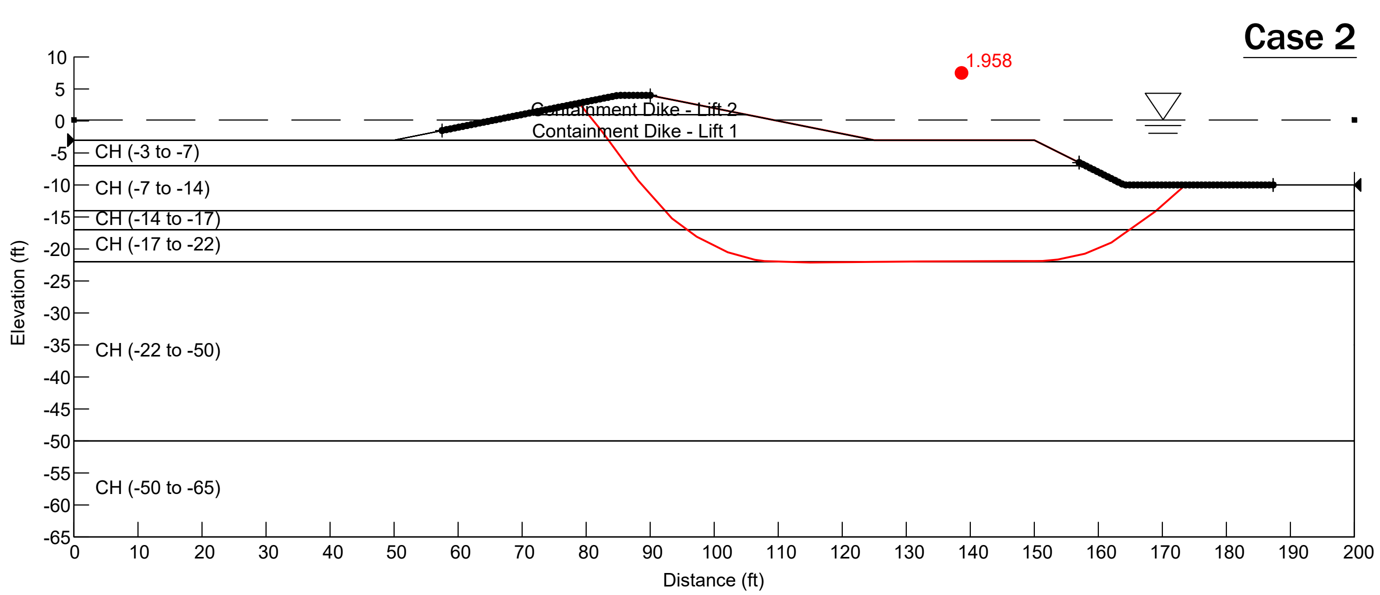
East Leeville Marsh Creation and Nourishment (BA-194)
Lafourche Parish, Louisiana

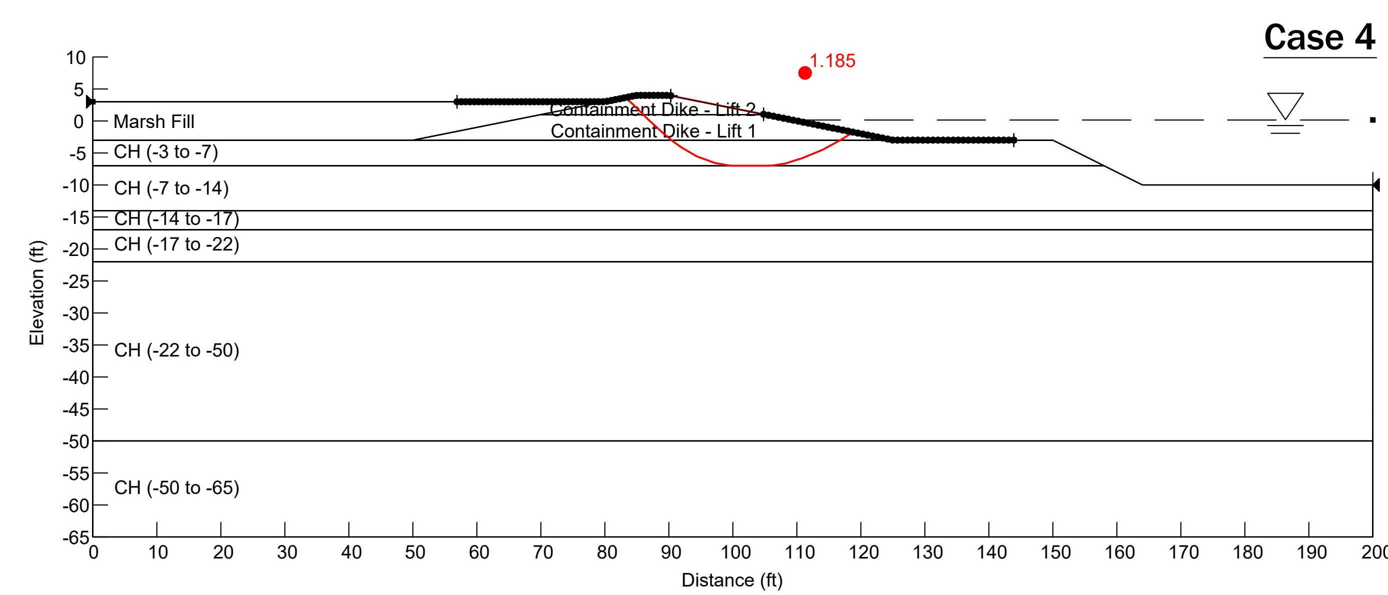
GeoEngineers

**Figure B-6a**



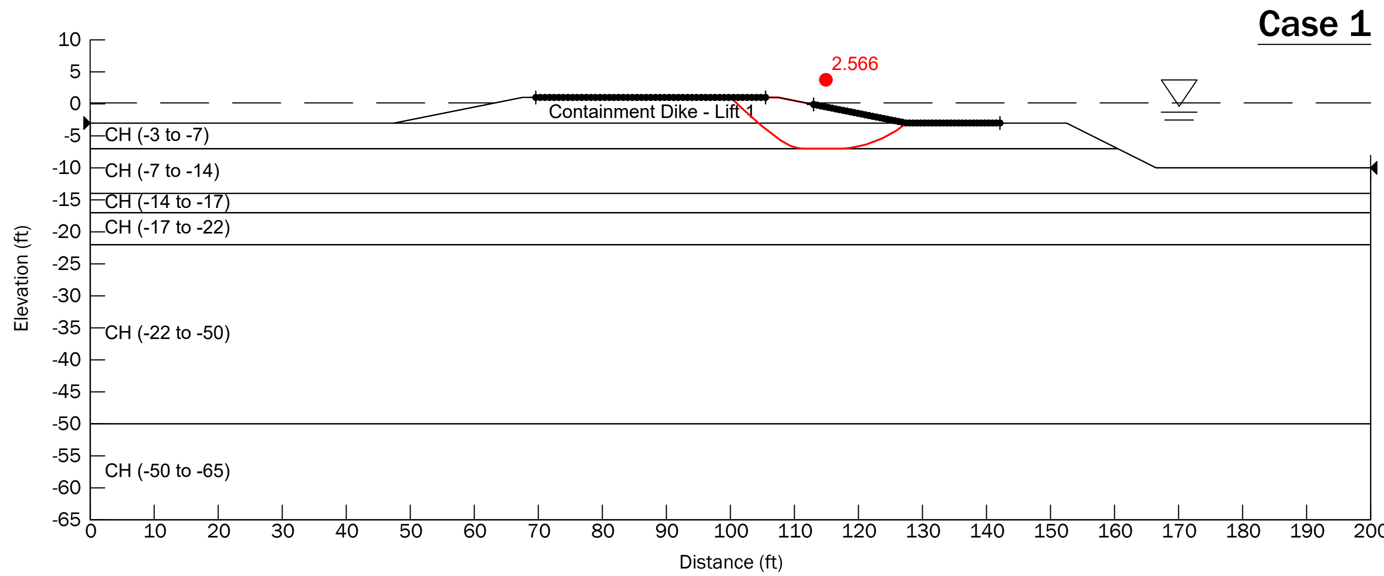

| Name | Model | Unit Weight (pcf) | Cohesion' (psf) | Phi' (°) | Cohesion Spatial Fn | Cohesion Fn |
|---|---|---|---|---|---|---|
| Marsh Fill | Mohr-Coulomb | 85 | 0 | 0 | | |
| Containment Dike - Lift 1 | Mohr-Coulomb | 95 | 66 | 0 | | |
| Containment Dike - Lift 2 | Mohr-Coulomb | 95 | 60 | 0 | | |
| CH (-3 to -7) | Spatial Mohr-Coulomb | 95 | | 0 | 70 psf + 15% | |
| CH (-7 to -14) | Spatial Mohr-Coulomb | 110 | | 0 | 150 psf + 15% | |
| CH (-14 to -17) | Mohr-Coulomb | 110 | 180 | 0 | | |
| CH (-17 to -22) | Mohr-Coulomb | 110 | 195 | 0 | | |
| CH (-22 to -50) | Spatial Mohr-Coulomb | 110 | | 0 | | 195 psf + 10.4 psf/ft |
| CH (-50 to -65) | Spatial Mohr-Coulomb | 116 | | 0 | | 485 psf + 12 psf/ft |

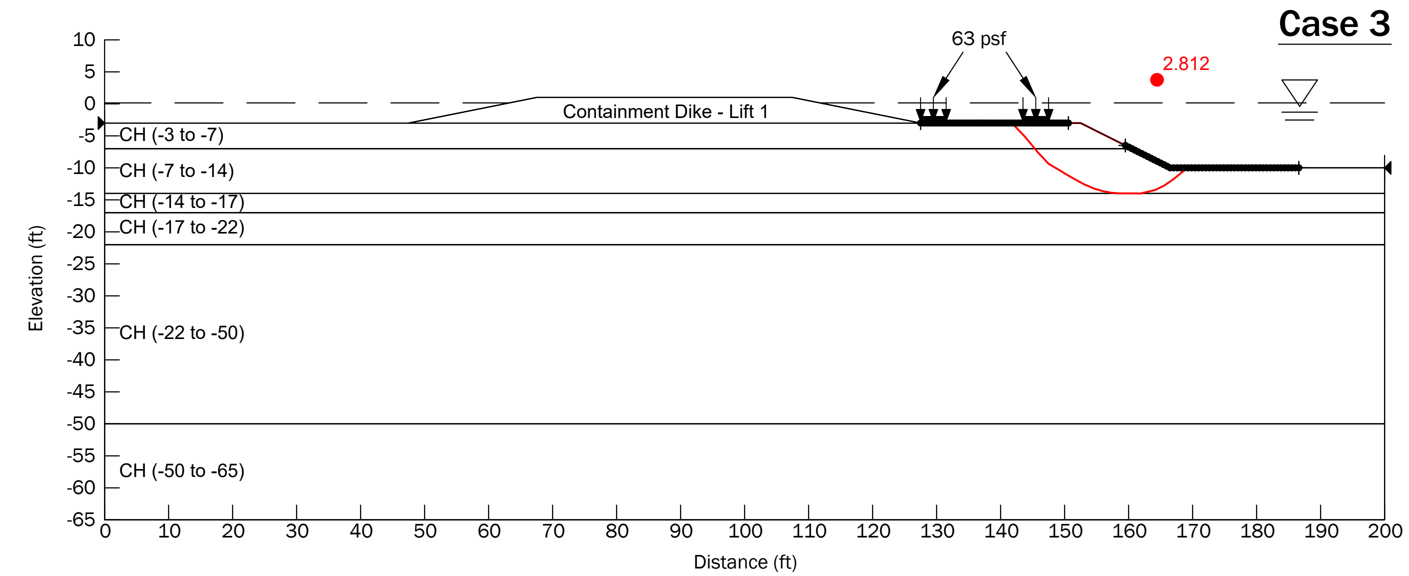
**Containment Dike Slope Stability - Cell 4, 5 & 6, Mudline El. -3.0 ft, 5ft Crest, Lift 2**

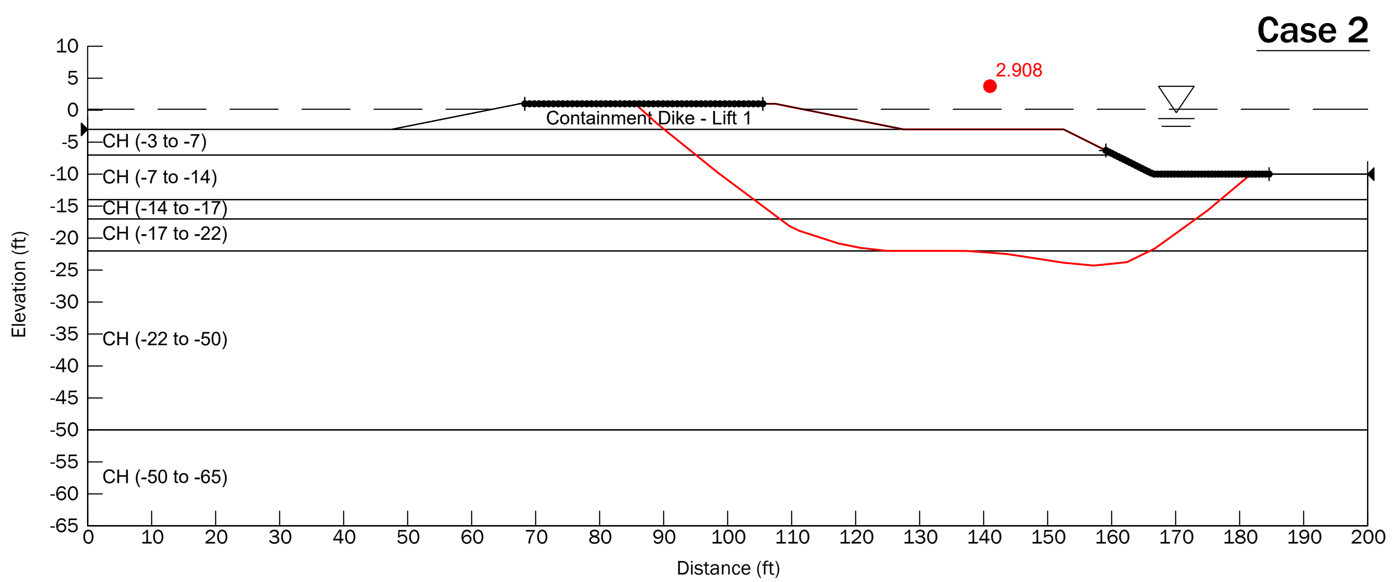
East Leeville Marsh Creation and Nourishment
(BA-194)
Lafourche Parish, Louisiana

GeoEngineers

**Figure B-6b**




| Name | Model | Unit Weight (pcf) | Cohesion' (psf) | Phi' (°) | Cohesion Fn |
|---|---|---|---|---|---|
| Containment Dike - Lift 1 | Mohr-Coulomb | 95 | 60 | 0 | |
| CH (-3 to -7) | Mohr-Coulomb | 95 | 70 | 0 | |
| CH (-7 to -14) | Mohr-Coulomb | 110 | 150 | 0 | |
| CH (-14 to -17) | Mohr-Coulomb | 110 | 180 | 0 | |
| CH (-17 to -22) | Mohr-Coulomb | 110 | 195 | 0 | |
| CH (-22 to -50) | Spatial Mohr-Coulomb | 110 | | 0 | 195 psf + 10.4 psf/ft |
| CH (-50 to -65) | Spatial Mohr-Coulomb | 116 | | 0 | 485 psf + 12 psf/ft |

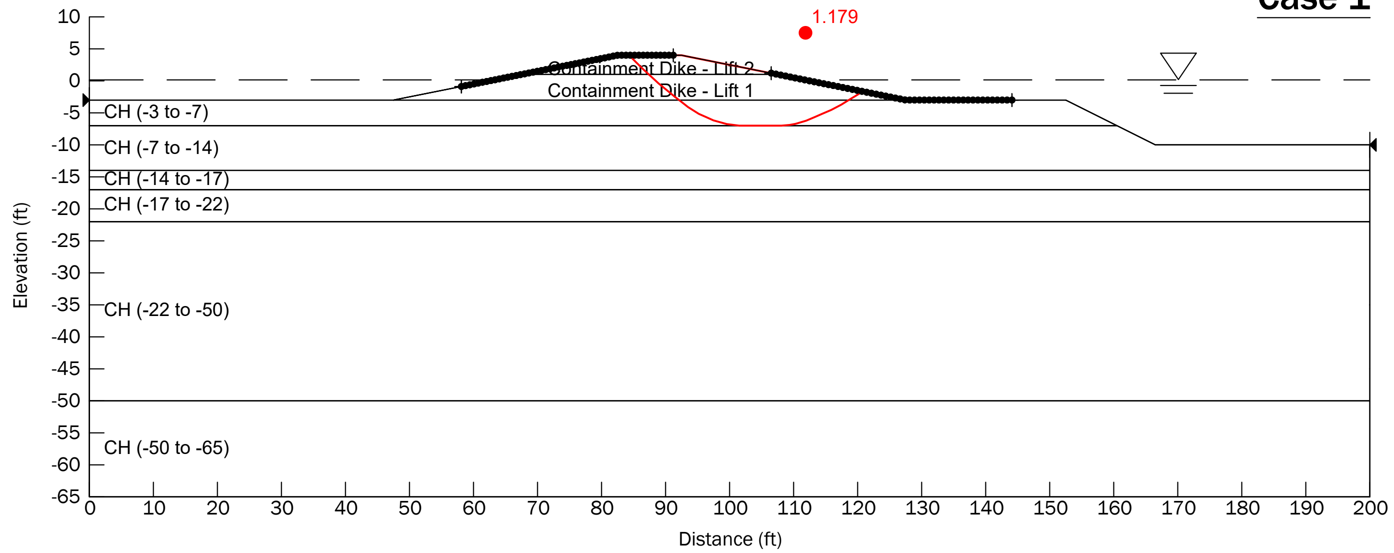
**Containment Dike Slope Stability - Cell 4, 5 & 6, Mudline El. -3.0 ft, 10ft Crest, Lift 1**

East Leeville Marsh Creation and Nourishment
(BA-194)
Lafourche Parish, Louisiana

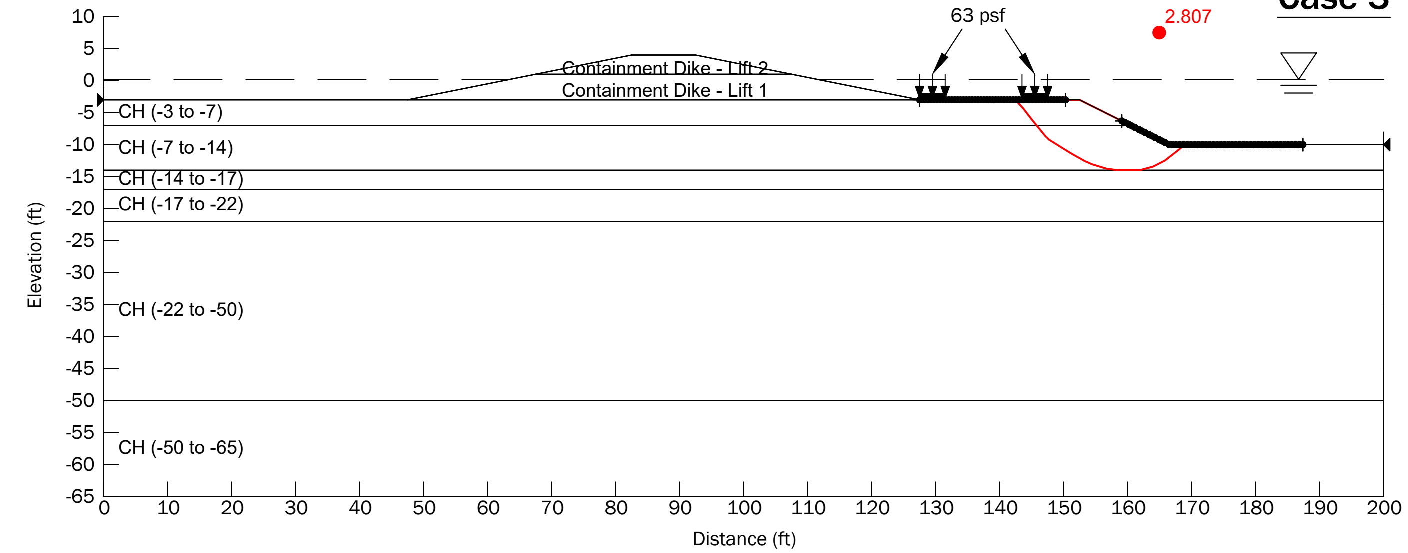
GEOENGINEERS

**Figure B-6c**

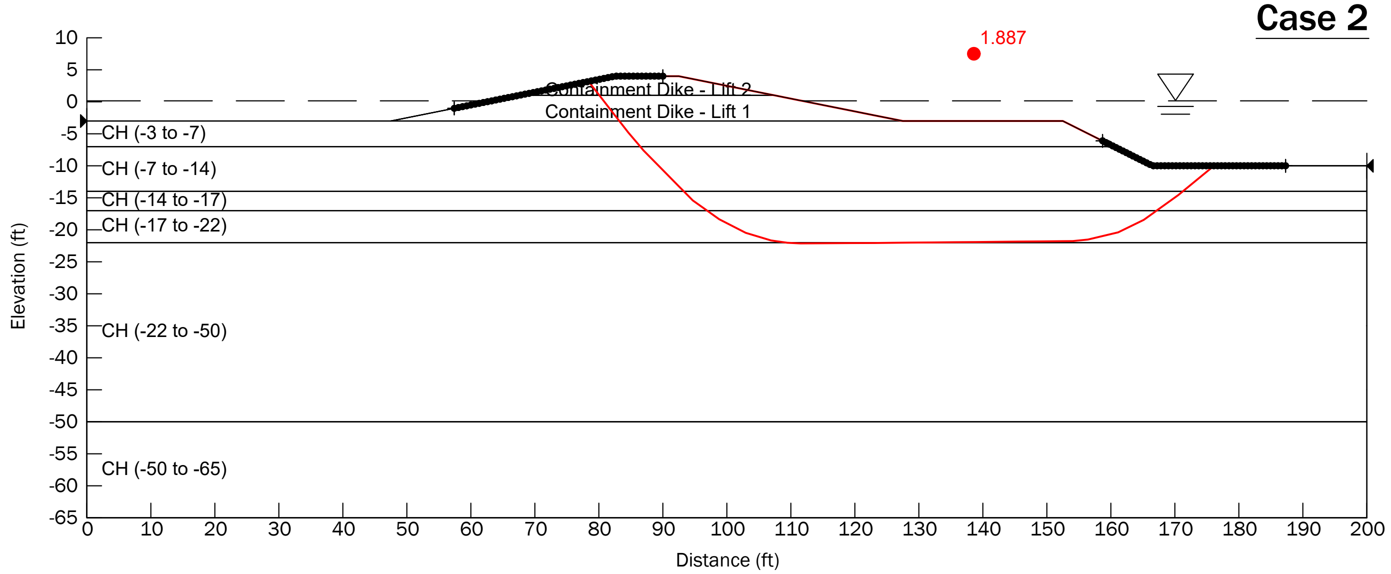
## Case 1



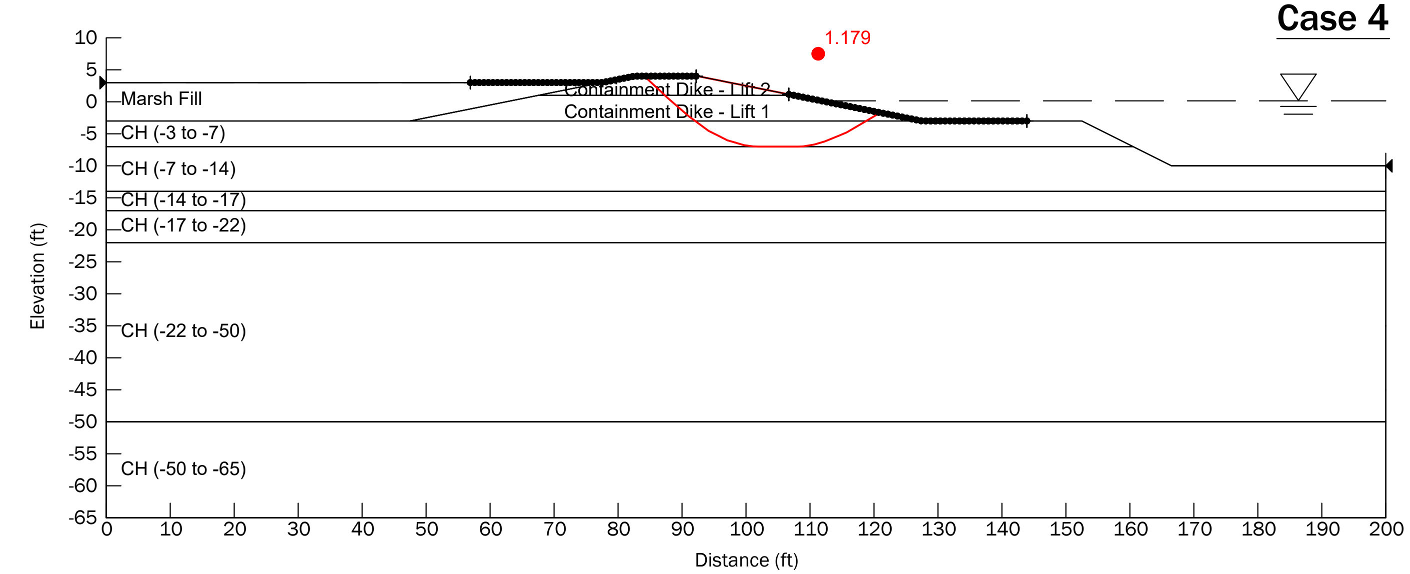

## Case 3




## Case 2




## Case 4




| Name | Model | Unit Weight (pcf) | Cohesion' (psf) | Phi' (°) | Cohesion Spatial Fn | Cohesion Fn |
|---|---|---|---|---|---|---|
| Marsh Fill | Mohr-Coulomb | 85 | 0 | 0 | | |
| Containment Dike - Lift 2 | Mohr-Coulomb | 95 | 60 | 0 | | |
| Containment Dike - Lift 1 | Mohr-Coulomb | 95 | 66 | 0 | | |
| CH (-3 to -7) | Spatial Mohr-Coulomb | 95 | | 0 | 70 psf + 15% | |
| CH (-7 to -14) | Spatial Mohr-Coulomb | 110 | | 0 | 150 psf + 15% | |
| CH (-14 to -17) | Mohr-Coulomb | 110 | 180 | 0 | | |
| CH (-17 to -22) | Mohr-Coulomb | 110 | 195 | 0 | | |
| CH (-22 to -50) | Spatial Mohr-Coulomb | 110 | | 0 | | 195 psf + 10.4 psf/ft |
| CH (-50 to -65) | Spatial Mohr-Coulomb | 116 | | 0 | | 485 psf + 12 psf/ft |

**Containment Dike Slope Stability - Cell 4, 5 & 6, Mudline El. -3.0 ft, 10ft Crest, Lift 2**

East Leeville Marsh Creation and Nourishment (BA-194)
Lafourche Parish, Louisiana

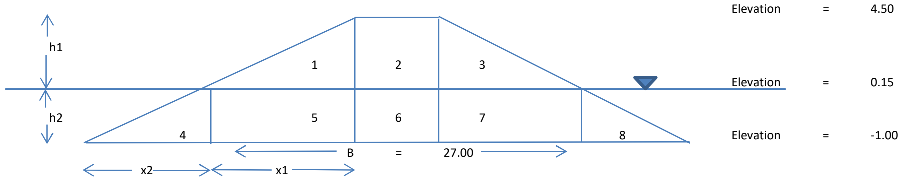
GeoEngineers

**Figure B-6d**

# FACTOR OF SAFETY FOR BEARING CAPACITY
# FOR UNREINFORCED DIKES USING NAVFAC DM 7; FIGURE 11-5, PAGE 7-11-6

## Cells 1 & 2, Mudline El. -1.0 ft, 5ft Crest

| Elevation at Bottom of Dike (ft.) | Elevation at Top of Dike (ft.) | Height of Dike (ft.) | Slope Inclination (H:V) | | Width at Top of Dike (ft.) | Elevation of Water (ft.) | Full Width at Bottom of Dike (ft.) | h1 (ft.) | h2 (ft.) | x1 (ft.) | x2 (ft.) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| -1.00 | 4.50 | 5.50 | 4.00 | 1.00 | 5.00 | 0.15 | 49.00 | 4.35 | 1.15 | 17.40 | 4.60 |




Assumptions:
1. Unit weight of dike = 95 pcf
2. Water at EL. +0.15 feet
3. Mudline at EL -1 feet
4. The effective width of the dike is equal to the width of the crown plus the width of one sloped side.
5. The factor of safety for bearing capacity must be greater or equal to 1.3.

## APPLIED STRESS

| Total Unit Weight of Dike (pcf) | Buoyant Unit Weight of Dike (pcf) | Effective Width of Dike (B) (ft.) | Applied Stress (psf) |
|---|---|---|---|
| 95.00 | 32.60 | 27.00 | 404 |

| Zone | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | Total |
|---|---|---|---|---|---|---|---|---|---|
| Area ($ft^2$) | 38 | 22 | 38 | 3 | 20 | 6 | 20 | 3 | 149 |
| Applied Load (lb./ft.) | 3595 | 2066 | 3595 | 86 | 652 | 187 | 652 | 86 | 10921 |

## SUBSURFACE CONDITIONS

| Soil Description | | Elevation (ft.) | | | | Cohesion (ksf) | Cohesion (psf) | Thickness (ft.) |
|---|---|---|---|---|---|---|---|---|
| CH (-1 to -7) | | -1.00 | - | -7.00 | | 0.100 | 100.00 | 6.00 |
| CH (-7 to -12) | | -7.00 | - | -12.00 | | 0.150 | 150.00 | 5.00 |
| CH (-12 to -18) | | -12.00 | - | -18.00 | | 0.150 | 150.00 | 6.00 |
| CH (-18 to -24) | | -18.00 | - | -24.00 | | 0.200 | 200.00 | 6.00 |
| CH (-24 to -50) | | -24.00 | - | -50.00 | | 0.300 | 300.00 | 26.00 |
| CH (-50 to -65) | | -50.00 | - | -65.00 | | 0.500 | 500.00 | 15.00 |
| | | | | | | | | |
| | | | | | | | | |

| T | B | T/B | C1 | C2 | C2/C1 |
|---|---|---|---|---|---|
| 11.00 | 27.00 | 0.41 | 122.73 | 150.00 | 1.2 |

## BEARING CAPACITY RESULTS

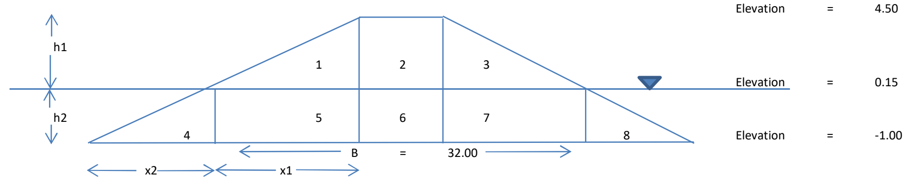
| Effective Width of Dike (B) (ft.) | Nc Factor From NAVFAC DM-7 Figure 11-5 | C1 | Ultimate Bearing Capacity (psf) | Applied Stress (psf) | Factor of Safety |
|---|---|---|---|---|---|
| 27.00 | 5.80 | 123 | 712 | 404 | 1.76 |

Figure B-7a

# FACTOR OF SAFETY FOR BEARING CAPACITY
# FOR UNREINFORCED DIKES USING NAVFAC DM 7; FIGURE 11-5, PAGE 7-11-6

## Cells 1 & 2, Mudline El. -1.0 ft, 10ft Crest

| Elevation at Bottom of Dike (ft.) | Elevation at Top of Dike (ft.) | Height of Dike (ft.) | Slope Inclination (H:V) | | Width at Top of Dike (ft.) | Elevation of Water (ft.) | Full Width at Bottom of Dike (ft.) | h1 (ft.) | h2 (ft.) | x1 (ft.) | x2 (ft.) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| -1.00 | 4.50 | 5.50 | 4.00 | 1.00 | 10.00 | 0.15 | 54.00 | 4.35 | 1.15 | 17.40 | 4.60 |




Assumptions:
1. Unit weight of dike = 95 pcf
2. Water at EL. +0.15 feet
3. Mudline at EL -1 feet
4. The effective width of the dike is equal to the width of the crown plus the width of one sloped side.
5. The factor of safety for bearing capacity must be greater or equal to 1.3.

## APPLIED STRESS

| Total Unit Weight of Dike (pcf) | Buoyant Unit Weight of Dike (pcf) | Effective Width of Dike (B) (ft.) | Applied Stress (psf) |
|---|---|---|---|
| 95.00 | 32.60 | 32.00 | 412 |

| Zone | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | Total |
|---|---|---|---|---|---|---|---|---|---|
| Area ($ft^2$) | 38 | 44 | 38 | 3 | 20 | 12 | 20 | 3 | 176 |
| Applied Load (lb./ft.) | 3595 | 4133 | 3595 | 86 | 652 | 375 | 652 | 86 | 13175 |

## SUBSURFACE CONDITIONS

| Soil Description | | Elevation (ft.) | | | | Cohesion (ksf) | Cohesion (psf) | Thickness (ft.) |
|---|---|---|---|---|---|---|---|---|
| CH (-1 to -7) | | -1.00 | - | -7.00 | | 0.100 | 100.00 | 6.00 |
| CH (-7 to -12) | | -7.00 | - | -12.00 | | 0.150 | 150.00 | 5.00 |
| CH (-12 to -18) | | -12.00 | - | -18.00 | | 0.150 | 150.00 | 6.00 |
| CH (-18 to -24) | | -18.00 | - | -24.00 | | 0.200 | 200.00 | 6.00 |
| CH (-24 to -50) | | -24.00 | - | -50.00 | | 0.300 | 300.00 | 26.00 |
| CH (-50 to -65) | | -50.00 | - | -65.00 | | 0.500 | 500.00 | 15.00 |
| | | | | | | | | |
| | | | | | | | | |

| T | B | T/B | C1 | C2 | C2/C1 |
|---|---|---|---|---|---|
| 11.00 | 32.00 | 0.34 | 122.73 | 150.00 | 1.2 |

## BEARING CAPACITY RESULTS

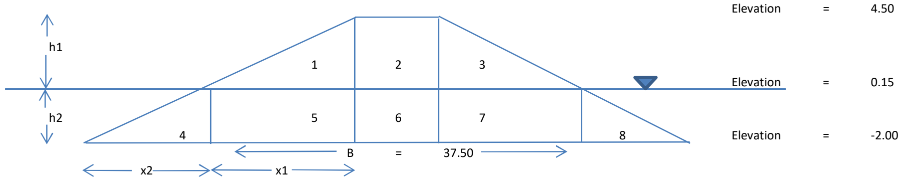
| Effective Width of Dike (B) (ft.) | Nc Factor From NAVFAC DM-7 Figure 11-5 | C1 | Ultimate Bearing Capacity (psf) | Applied Stress (psf) | Factor of Safety |
|---|---|---|---|---|---|
| 32.00 | 6.00 | 123 | 736 | 412 | 1.79 |

Figure B-7b

# FACTOR OF SAFETY FOR BEARING CAPACITY
# FOR UNREINFORCED DIKES USING NAVFAC DM 7; FIGURE 11-5, PAGE 7-11-6

## Cells 1 & 2, Mudline El. -2.0 ft, 5ft Crest

| Elevation at Bottom of Dike (ft.) | Elevation at Top of Dike (ft.) | Height of Dike (ft.) | Slope Inclination (H:V) | | Width at Top of Dike (ft.) | Elevation of Water (ft.) | Full Width at Bottom of Dike (ft.) | h1 (ft.) | h2 (ft.) | x1 (ft.) | x2 (ft.) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| -2.00 | 4.50 | 6.50 | 5.00 | 1.00 | 5.00 | 0.15 | 70.00 | 4.35 | 2.15 | 21.75 | 10.75 |




Assumptions:
1. Unit weight of dike = 95 pcf
2. Water at EL. +0.15 feet
3. Mudline at EL -2 feet
4. The effective width of the dike is equal to the width of the crown plus the width of one sloped side.
5. The factor of safety for bearing capacity must be greater or equal to 1.3.

## APPLIED STRESS

| Total Unit Weight of Dike (pcf) | Buoyant Unit Weight of Dike (pcf) | Effective Width of Dike (B) (ft.) | Applied Stress (psf) |
|---|---|---|---|
| 95.00 | 32.60 | 37.50 | 406 |

| Zone | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | Total |
|---|---|---|---|---|---|---|---|---|---|
| Area (ft$^2$) | 47 | 22 | 47 | 12 | 47 | 11 | 47 | 12 | 244 |
| Applied Load (lb./ft.) | 4494 | 2066 | 4494 | 377 | 1524 | 350 | 1524 | 377 | 15207 |

## SUBSURFACE CONDITIONS

| Soil Description | | Elevation (ft.) | | | | Cohesion (ksf) | Cohesion (psf) | Thickness (ft.) |
|---|---|---|---|---|---|---|---|---|
| CH (-2 to -7) | | -2.00 | - | -7.00 | | 0.100 | 100.00 | 5.00 |
| CH (-7 to -12) | | -7.00 | - | -12.00 | | 0.150 | 150.00 | 5.00 |
| CH (-12 to -18) | | -12.00 | - | -18.00 | | 0.150 | 150.00 | 6.00 |
| CH (-18 to -24) | | -18.00 | - | -24.00 | | 0.200 | 200.00 | 6.00 |
| CH (-24 to -50) | | -24.00 | - | -50.00 | | 0.300 | 300.00 | 26.00 |
| CH (-50 to -65) | | -50.00 | - | -65.00 | | 0.500 | 500.00 | 15.00 |
| | | | | | | | | |
| | | | | | | | | |

| T | B | T/B | C1 | C2 | C2/C1 |
|---|---|---|---|---|---|
| 10.00 | 37.50 | 0.27 | 125.00 | 150.00 | 1.2 |

## BEARING CAPACITY RESULTS

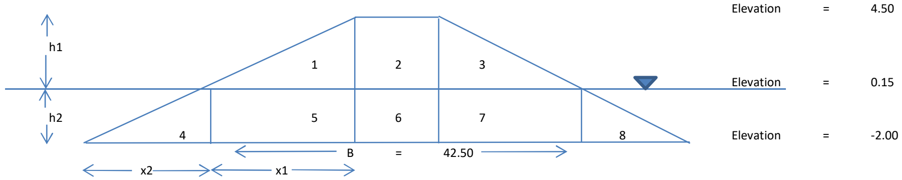
| Effective Width of Dike (B) (ft.) | Nc Factor From NAVFAC DM-7 Figure 11-5 | C1 | Ultimate Bearing Capacity (psf) | Applied Stress (psf) | Factor of Safety |
|---|---|---|---|---|---|
| 37.50 | 6.20 | 125 | 775 | 406 | 1.91 |

Figure B-8a

# FACTOR OF SAFETY FOR BEARING CAPACITY
# FOR UNREINFORCED DIKES USING NAVFAC DM 7; FIGURE 11-5, PAGE 7-11-6

## Cells 1 & 2, Mudline El. -2.0 ft, 10ft Crest

| Elevation at Bottom of Dike (ft.) | Elevation at Top of Dike (ft.) | Height of Dike (ft.) | Slope Inclination (H:V) | | Width at Top of Dike (ft.) | Elevation of Water (ft.) | Full Width at Bottom of Dike (ft.) | h1 (ft.) | h2 (ft.) | x1 (ft.) | x2 (ft.) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| -2.00 | 4.50 | 6.50 | 5.00 | 1.00 | 10.00 | 0.15 | 75.00 | 4.35 | 2.15 | 21.75 | 10.75 |




Assumptions:
1. Unit weight of dike = 95 pcf
2. Water at EL. +0.15 feet
3. Mudline at EL -2 feet
4. The effective width of the dike is equal to the width of the crown plus the width of one sloped side.
5. The factor of safety for bearing capacity must be greater or equal to 1.3.

## APPLIED STRESS

| Total Unit Weight of Dike (pcf) | Buoyant Unit Weight of Dike (pcf) | Effective Width of Dike (B) (ft.) | Applied Stress (psf) |
|---|---|---|---|
| 95.00 | 32.60 | 42.50 | 415 |

| Zone | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | Total |
|---|---|---|---|---|---|---|---|---|---|
| Area (ft$^2$) | 47 | 44 | 47 | 12 | 47 | 22 | 47 | 12 | 276 |
| Applied Load (lb./ft.) | 4494 | 4133 | 4494 | 377 | 1524 | 701 | 1524 | 377 | 17624 |

## SUBSURFACE CONDITIONS

| Soil Description | | Elevation (ft.) | | | | Cohesion (ksf) | Cohesion (psf) | Thickness (ft.) |
|---|---|---|---|---|---|---|---|---|
| CH (-2 to -7) | | -2.00 | - | -7.00 | | 0.100 | 100.00 | 5.00 |
| CH (-7 to -12) | | -7.00 | - | -12.00 | | 0.150 | 150.00 | 5.00 |
| CH (-12 to -18) | | -12.00 | - | -18.00 | | 0.150 | 150.00 | 6.00 |
| CH (-18 to -24) | | -18.00 | - | -24.00 | | 0.200 | 200.00 | 6.00 |
| CH (-24 to -50) | | -24.00 | - | -50.00 | | 0.300 | 300.00 | 26.00 |
| CH (-50 to -65) | | -50.00 | - | -65.00 | | 0.500 | 500.00 | 15.00 |
| | | | | | | | | |
| | | | | | | | | |

| T | B | T/B | C1 | C2 | C2/C1 |
|---|---|---|---|---|---|
| 10.00 | 42.50 | 0.24 | 125.00 | 150.00 | 1.2 |

## BEARING CAPACITY RESULTS

| Effective Width of Dike (B) (ft.) | Nc Factor From NAVFAC DM-7 Figure 11-5 | C1 | Ultimate Bearing Capacity (psf) | Applied Stress (psf) | Factor of Safety |
|---|---|---|---|---|---|
| 42.50 | 6.20 | 125 | 775 | 415 | 1.87 |

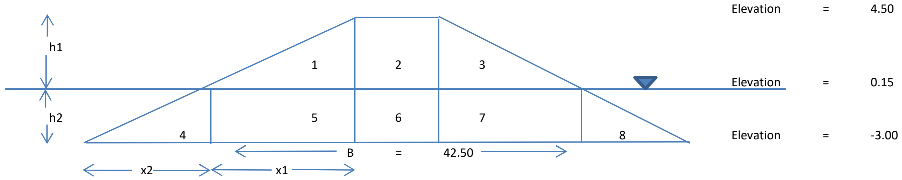
are

Figure B-8b

# FACTOR OF SAFETY FOR BEARING CAPACITY
# FOR UNREINFORCED DIKES USING NAVFAC DM 7; FIGURE 11-5, PAGE 7-11-6

## Cells 1 & 2, Mudline El. -3.0 ft, 5ft Crest

| Elevation at Bottom of Dike (ft.) | Elevation at Top of Dike (ft.) | Height of Dike (ft.) | Slope Inclination (H:V) | | Width at Top of Dike (ft.) | Elevation of Water (ft.) | Full Width at Bottom of Dike (ft.) | h1 (ft.) | h2 (ft.) | x1 (ft.) | x2 (ft.) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| -3.00 | 4.50 | 7.50 | 5.00 | 1.00 | 5.00 | 0.15 | 80.00 | 4.35 | 3.15 | 21.75 | 15.75 |




Assumptions:
1. Unit weight of dike = 95 pcf
2. Water at EL. +0.15 feet
3. Mudline at EL -3 feet
4. The effective width of the dike is equal to the width of the crown plus the width of one sloped side.
5. The factor of safety for bearing capacity must be greater or equal to 1.3.

## APPLIED STRESS

| Total Unit Weight of Dike (pcf) | Buoyant Unit Weight of Dike (pcf) | Effective Width of Dike (B) (ft.) | Applied Stress (psf) |
|---|---|---|---|
| 95.00 | 32.60 | 42.50 | 415 |

| Zone | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | Total |
|---|---|---|---|---|---|---|---|---|---|
| Area ($ft^2$) | 47 | 22 | 47 | 25 | 69 | 16 | 69 | 25 | 319 |
| Applied Load (lb./ft.) | 4494 | 2066 | 4494 | 809 | 2234 | 513 | 2234 | 809 | 17652 |

## SUBSURFACE CONDITIONS

| Soil Description | | Elevation (ft.) | | | | Cohesion (ksf) | Cohesion (psf) | Thickness (ft.) |
|---|---|---|---|---|---|---|---|---|
| CH (-3 to -7) | | -3.00 | - | -7.00 | | 0.100 | 100.00 | 4.00 |
| CH (-7 to -12) | | -7.00 | - | -12.00 | | 0.150 | 150.00 | 5.00 |
| CH (-12 to -18) | | -12.00 | - | -18.00 | | 0.150 | 150.00 | 6.00 |
| CH (-18 to -24) | | -18.00 | - | -24.00 | | 0.200 | 200.00 | 6.00 |
| CH (-24 to -50) | | -24.00 | - | -50.00 | | 0.300 | 300.00 | 26.00 |
| CH (-50 to -65) | | -50.00 | - | -65.00 | | 0.500 | 500.00 | 15.00 |
| | | | | | | | | |
| | | | | | | | | |

| T | B | T/B | C1 | C2 | C2/C1 |
|---|---|---|---|---|---|
| 9.00 | 42.50 | 0.21 | 127.78 | 150.00 | 1.2 |

## BEARING CAPACITY RESULTS

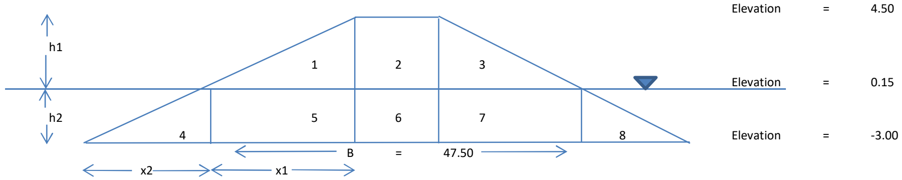
| Effective Width of Dike (B) (ft.) | Nc Factor From NAVFAC DM-7 Figure 11-5 | C1 | Ultimate Bearing Capacity (psf) | Applied Stress (psf) | Factor of Safety |
|---|---|---|---|---|---|
| 42.50 | 6.35 | 128 | 811 | 415 | 1.95 |

Figure B-9a

# FACTOR OF SAFETY FOR BEARING CAPACITY
# FOR UNREINFORCED DIKES USING NAVFAC DM 7; FIGURE 11-5, PAGE 7-11-6

## Cells 1 & 2, Mudline El. -3.0 ft, 10ft Crest

| Elevation at Bottom of Dike (ft.) | Elevation at Top of Dike (ft.) | Height of Dike (ft.) | Slope Inclination (H:V) | | Width at Top of Dike (ft.) | Elevation of Water (ft.) | Full Width at Bottom of Dike (ft.) | h1 (ft.) | h2 (ft.) | x1 (ft.) | x2 (ft.) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| -3.00 | 4.50 | 7.50 | 5.00 | 1.00 | 10.00 | 0.15 | 85.00 | 4.35 | 3.15 | 21.75 | 15.75 |




Assumptions:
1. Unit weight of dike = 95 pcf
2. Water at EL. +0.15 feet
3. Mudline at EL -3 feet
4. The effective width of the dike is equal to the width of the crown plus the width of one sloped side.
5. The factor of safety for bearing capacity must be greater or equal to 1.3.

## APPLIED STRESS

| Total Unit Weight of Dike (pcf) | Buoyant Unit Weight of Dike (pcf) | Effective Width of Dike (B) (ft.) | Applied Stress (psf) |
|---|---|---|---|
| 95.00 | 32.60 | 47.50 | 426 |

| Zone | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | Total |
|---|---|---|---|---|---|---|---|---|---|
| Area ($ft^2$) | 47 | 44 | 47 | 25 | 69 | 32 | 69 | 25 | 356 |
| Applied Load (lb./ft.) | 4494 | 4133 | 4494 | 809 | 2234 | 1027 | 2234 | 809 | 20232 |

## SUBSURFACE CONDITIONS

| Soil Description | | Elevation (ft.) | | | | Cohesion (ksf) | Cohesion (psf) | Thickness (ft.) |
|---|---|---|---|---|---|---|---|---|
| CH (-3 to -7) | | -3.00 | - | -7.00 | | 0.100 | 100.00 | 4.00 |
| CH (-7 to -12) | | -7.00 | - | -12.00 | | 0.150 | 150.00 | 5.00 |
| CH (-12 to -18) | | -12.00 | - | -18.00 | | 0.150 | 150.00 | 6.00 |
| CH (-18 to -24) | | -18.00 | - | -24.00 | | 0.200 | 200.00 | 6.00 |
| CH (-24 to -50) | | -24.00 | - | -50.00 | | 0.300 | 300.00 | 26.00 |
| CH (-50 to -65) | | -50.00 | - | -65.00 | | 0.500 | 500.00 | 15.00 |
| | | | | | | | | |
| | | | | | | | | |

| T | B | T/B | C1 | C2 | C2/C1 |
|---|---|---|---|---|---|
| 9.00 | 47.50 | 0.19 | 127.78 | 150.00 | 1.2 |

## BEARING CAPACITY RESULTS

| Effective Width of Dike (B) (ft.) | Nc Factor From NAVFAC DM-7 Figure 11-5 | C1 | Ultimate Bearing Capacity (psf) | Applied Stress (psf) | Factor of Safety |
|---|---|---|---|---|---|
| 47.50 | 6.30 | 128 | 805 | 426 | 1.89 |

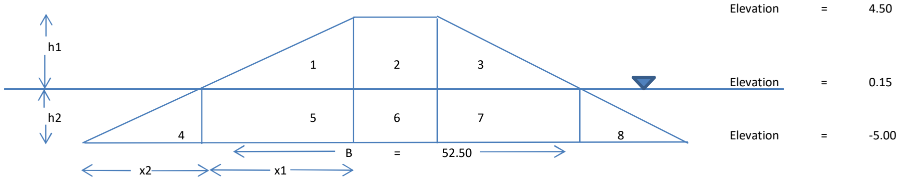
Figure B-9b

# FACTOR OF SAFETY FOR BEARING CAPACITY
# FOR UNREINFORCED DIKES USING NAVFAC DM 7; FIGURE 11-5, PAGE 7-11-6

## Cell 3, Mudline El. -2.0 ft, 5ft Crest

| Elevation at Bottom of Dike (ft.) | Elevation at Top of Dike (ft.) | Height of Dike (ft.) | Slope Inclination (H:V) | | Width at Top of Dike (ft.) | Elevation of Water (ft.) | Full Width at Bottom of Dike (ft.) | h1 (ft.) | h2 (ft.) | x1 (ft.) | x2 (ft.) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| -5.00 | 4.50 | 9.50 | 5.00 | 1.00 | 5.00 | 0.15 | 100.00 | 4.35 | 5.15 | 21.75 | 25.75 |

*3 ft mudwave (surface layer C<50 psf)




Assumptions:
1. Unit weight of dike = 90 pcf
2. Water at EL. +0.15 feet
3. Mudline at EL -5 feet
4. The effective width of the dike is equal to the width of the crown plus the width of one sloped side.
5. The factor of safety for bearing capacity must be greater or equal to 1.3.

## APPLIED STRESS

| Total Unit Weight of Dike (pcf) | Buoyant Unit Weight of Dike (pcf) | Effective Width of Dike (B) (ft.) | Applied Stress (psf) |
|---|---|---|---|
| 90.00 | 27.60 | 52.50 | 401 |

| Zone | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | Total |
|---|---|---|---|---|---|---|---|---|---|
| Area ($ft^2$) | 47 | 22 | 47 | 66 | 112 | 26 | 112 | 66 | 499 |
| Applied Load (lb./ft.) | 4258 | 1958 | 4258 | 1830 | 3092 | 711 | 3092 | 1830 | 21027 |

## SUBSURFACE CONDITIONS

| Soil Description | | Elevation (ft.) | | | | Cohesion (ksf) | Cohesion (psf) | Thickness (ft.) |
|---|---|---|---|---|---|---|---|---|
| PT (-2 to -6) | | -5.00 | - | -6.00 | | 0.030 | 30.00 | 1.00 |
| CH (-6 to -8) | | -6.00 | - | -8.00 | | 0.075 | 75.00 | 2.00 |
| CH (-8 to -22) | | -8.00 | - | -22.00 | | 0.125 | 125.00 | 14.00 |
| CH (-22 to -45) | | -22.00 | - | -45.00 | | 0.200 | 200.00 | 23.00 |
| CH (-45 to -65) | | -45.00 | - | -65.00 | | 0.450 | 450.00 | 20.00 |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |

| T | B | T/B | C1 | C2 | C2/C1 |
|---|---|---|---|---|---|
| 17.00 | 52.50 | 0.32 | 113.53 | 200.00 | 1.8 |

## BEARING CAPACITY RESULTS

| Effective Width of Dike (B) (ft.) | Nc Factor From NAVFAC DM-7 Figure 11-5 | C1 | Ultimate Bearing Capacity (psf) | Applied Stress (psf) | Factor of Safety |
|---|---|---|---|---|---|
| 52.50 | 6.90 | 114 | 783 | 401 | 1.96 |

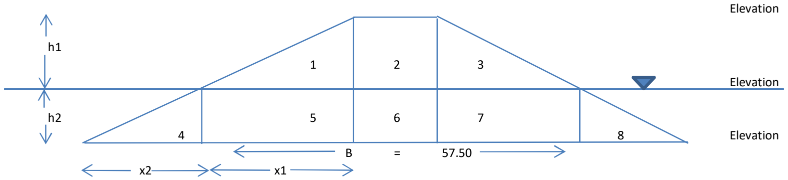
Figure B-10a

# FACTOR OF SAFETY FOR BEARING CAPACITY
# FOR UNREINFORCED DIKES USING NAVFAC DM 7; FIGURE 11-5, PAGE 7-11-6

## Cell 3, Mudline El. -2.0, 10ft Crest

| Elevation at Bottom of Dike (ft.) | Elevation at Top of Dike (ft.) | Height of Dike (ft.) | Slope Inclination (H:V) | | Width at Top of Dike (ft.) | Elevation of Water (ft.) | Full Width at Bottom of Dike (ft.) | h1 (ft.) | h2 (ft.) | x1 (ft.) | x2 (ft.) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| -5.00 | 4.50 | 9.50 | 5.00 | 1.00 | 10.00 | 0.15 | 105.00 | 4.35 | 5.15 | 21.75 | 25.75 |

*3 ft mudwave (surface layer C<50 psf)




Assumptions:
1. Unit weight of dike = 90 pcf
2. Water at EL. +0.15 feet
3. Mudline at EL -5 feet
4. The effective width of the dike is equal to the width of the crown plus the width of one sloped side.
5. The factor of safety for bearing capacity must be greater or equal to 1.3.

## APPLIED STRESS

| Total Unit Weight of Dike (pcf) | Buoyant Unit Weight of Dike (pcf) | Effective Width of Dike (B) (ft.) | Applied Stress (psf) |
|---|---|---|---|
| 90.00 | 27.60 | 57.50 | 412 |

| Zone | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | Total |
|---|---|---|---|---|---|---|---|---|---|
| Area ($ft^2$) | 47 | 44 | 47 | 66 | 112 | 52 | 112 | 66 | 546 |
| Applied Load (lb./ft.) | 4258 | 3915 | 4258 | 1830 | 3092 | 1421 | 3092 | 1830 | 23695 |

## SUBSURFACE CONDITIONS

| Soil Description | | Elevation (ft.) | | | | Cohesion (ksf) | Cohesion (psf) | Thickness (ft.) |
|---|---|---|---|---|---|---|---|---|
| PT (-2 to -6) | | -5.00 | - | -6.00 | | 0.030 | 30.00 | 1.00 |
| CH (-6 to -8) | | -6.00 | - | -8.00 | | 0.075 | 75.00 | 2.00 |
| CH (-8 to -22) | | -8.00 | - | -22.00 | | 0.125 | 125.00 | 14.00 |
| CH (-22 to -45) | | -22.00 | - | -45.00 | | 0.200 | 200.00 | 23.00 |
| CH (-45 to -65) | | -45.00 | - | -65.00 | | 0.450 | 450.00 | 20.00 |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |

| T | B | T/B | C1 | C2 | C2/C1 |
|---|---|---|---|---|---|
| 17.00 | 57.50 | 0.30 | 113.53 | 200.00 | 1.8 |

## BEARING CAPACITY RESULTS

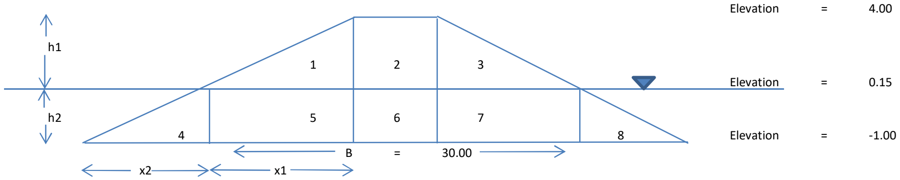
| Effective Width of Dike (B) (ft.) | Nc Factor From NAVFAC DM-7 Figure 11-5 | C1 | Ultimate Bearing Capacity (psf) | Applied Stress (psf) | Factor of Safety |
|---|---|---|---|---|---|
| 57.50 | 7.10 | 114 | 806 | 412 | 1.96 |

Figure B-10b

# FACTOR OF SAFETY FOR BEARING CAPACITY
# FOR UNREINFORCED DIKES USING NAVFAC DM 7; FIGURE 11-5, PAGE 7-11-6

## Cells 4, 5 & 6, Mudline El. -1.0 ft, 5ft Crest

| Elevation at Bottom of Dike (ft.) | Elevation at Top of Dike (ft.) | Height of Dike (ft.) | Slope Inclination (H:V) | | Width at Top of Dike (ft.) | Elevation of Water (ft.) | Full Width at Bottom of Dike (ft.) | h1 (ft.) | h2 (ft.) | x1 (ft.) | x2 (ft.) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| -1.00 | 4.00 | 5.00 | 5.00 | 1.00 | 5.00 | 0.15 | 55.00 | 3.85 | 1.15 | 19.25 | 5.75 |




Assumptions:
1. Unit weight of dike = 95 pcf
2. Water at EL. +0.15 feet
3. Mudline at EL -1 feet
4. The effective width of the dike is equal to the width of the crown plus the width of one sloped side.
5. The factor of safety for bearing capacity must be greater or equal to 1.3.

## APPLIED STRESS

| Total Unit Weight of Dike (pcf) | Buoyant Unit Weight of Dike (pcf) | Effective Width of Dike (B) (ft.) | Applied Stress (psf) |
|---|---|---|---|
| 95.00 | 32.60 | 30.00 | 357 |

| Zone | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | Total |
|---|---|---|---|---|---|---|---|---|---|
| Area ($ft^2$) | 37 | 19 | 37 | 3 | 22 | 6 | 22 | 3 | 150 |
| Applied Load (lb./ft.) | 3520 | 1829 | 3520 | 108 | 722 | 187 | 722 | 108 | 10716 |

## SUBSURFACE CONDITIONS

| Soil Description | | Elevation (ft.) | | | | Cohesion (ksf) | Cohesion (psf) | Thickness (ft.) |
|---|---|---|---|---|---|---|---|---|
| CH (-1 to -7) | | -1.00 | - | -7.00 | | 0.070 | 70.00 | 6.00 |
| CH (-7 to -14) | | -7.00 | - | -14.00 | | 0.150 | 150.00 | 7.00 |
| CH (-14 to -17) | | -14.00 | - | -17.00 | | 0.180 | 180.00 | 3.00 |
| CH (-17 to -22) | | -17.00 | - | -22.00 | | 0.195 | 195.00 | 5.00 |
| CH (-22 to -50) | | -22.00 | - | -50.00 | | 0.200 | 200.00 | 28.00 |
| CH (-50 to -65) | | -50.00 | - | -65.00 | | 0.500 | 500.00 | 15.00 |
| | | | | | | | | |
| | | | | | | | | |

| T | B | T/B | C1 | C2 | C2/C1 |
|---|---|---|---|---|---|
| 13.00 | 30.00 | 0.43 | 113.08 | 180.00 | 1.6 |

## BEARING CAPACITY RESULTS

| Effective Width of Dike (B) (ft.) | Nc Factor From NAVFAC DM-7 Figure 11-5 | C1 | Ultimate Bearing Capacity (psf) | Applied Stress (psf) | Factor of Safety |
|---|---|---|---|---|---|
| 30.00 | 5.75 | 113 | 650 | 357 | 1.82 |

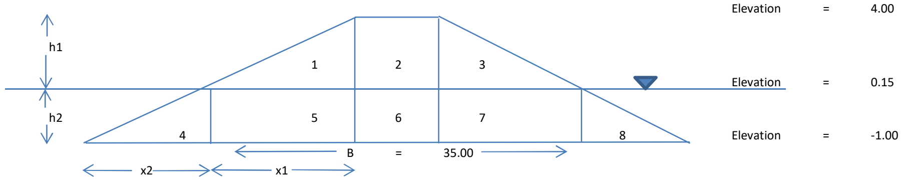
Figure B-11a

# FACTOR OF SAFETY FOR BEARING CAPACITY

# FOR UNREINFORCED DIKES USING NAVFAC DM 7; FIGURE 11-5, PAGE 7-11-6

## Cells 4, 5 & 6, Mudline El. -1.0 ft, 10ft Crest

| Elevation at Bottom of Dike (ft.) | Elevation at Top of Dike (ft.) | Height of Dike (ft.) | Slope Inclination (H:V) | | Width at Top of Dike (ft.) | Elevation of Water (ft.) | Full Width at Bottom of Dike (ft.) | h1 (ft.) | h2 (ft.) | x1 (ft.) | x2 (ft.) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| -1.00 | 4.00 | 5.00 | 5.00 | 1.00 | 10.00 | 0.15 | 60.00 | 3.85 | 1.15 | 19.25 | 5.75 |




Assumptions:
1. Unit weight of dike = 95 pcf
2. Water at EL. +0.15 feet
3. Mudline at EL -1 feet
4. The effective width of the dike is equal to the width of the crown plus the width of one sloped side.
5. The factor of safety for bearing capacity must be greater or equal to 1.3.

## APPLIED STRESS

| Total Unit Weight of Dike (pcf) | Buoyant Unit Weight of Dike (pcf) | Effective Width of Dike (B) (ft.) | Applied Stress (psf) |
|---|---|---|---|
| 95.00 | 32.60 | 35.00 | 364 |

| Zone | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | Total |
|---|---|---|---|---|---|---|---|---|---|
| Area ($ft^2$) | 37 | 39 | 37 | 3 | 22 | 12 | 22 | 3 | 175 |
| Applied Load (lb./ft.) | 3520 | 3658 | 3520 | 108 | 722 | 375 | 722 | 108 | 12732 |

## SUBSURFACE CONDITIONS

| Soil Description | | Elevation (ft.) | | | | Cohesion (ksf) | Cohesion (psf) | Thickness (ft.) |
|---|---|---|---|---|---|---|---|---|
| CH (-1 to -7) | | -1.00 | - | -7.00 | | 0.070 | 70.00 | 6.00 |
| CH (-7 to -14) | | -7.00 | - | -14.00 | | 0.150 | 150.00 | 7.00 |
| CH (-14 to -17) | | -14.00 | - | -17.00 | | 0.180 | 180.00 | 3.00 |
| CH (-17 to -22) | | -17.00 | - | -22.00 | | 0.195 | 195.00 | 5.00 |
| CH (-22 to -50) | | -22.00 | - | -50.00 | | 0.200 | 200.00 | 28.00 |
| CH (-50 to -65) | | -50.00 | - | -65.00 | | 0.500 | 500.00 | 15.00 |
| | | | | | | | | |
| | | | | | | | | |

| T | B | T/B | C1 | C2 | C2/C1 |
|---|---|---|---|---|---|
| 13.00 | 35.00 | 0.37 | 113.08 | 180.00 | 1.6 |

## BEARING CAPACITY RESULTS

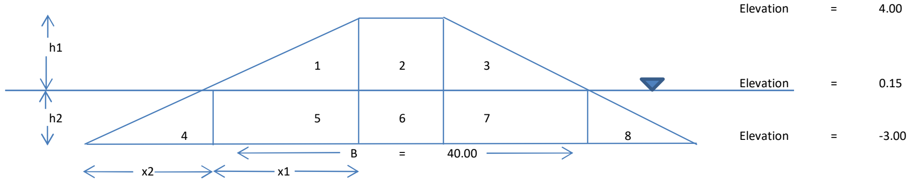
| Effective Width of Dike (B) (ft.) | Nc Factor From NAVFAC DM-7 Figure 11-5 | C1 | Ultimate Bearing Capacity (psf) | Applied Stress (psf) | Factor of Safety |
|---|---|---|---|---|---|
| 35.00 | 6.30 | 113 | 712 | 364 | 1.96 |

Figure B-11b

# FACTOR OF SAFETY FOR BEARING CAPACITY
# FOR UNREINFORCED DIKES USING NAVFAC DM 7; FIGURE 11-5, PAGE 7-11-6

## Cells 4, 5 & 6, Mudline El. -3.0 ft, 5ft Crest

| Elevation at Bottom of Dike (ft.) | Elevation at Top of Dike (ft.) | Height of Dike (ft.) | Slope Inclination (H:V) | | Width at Top of Dike (ft.) | Elevation of Water (ft.) | Full Width at Bottom of Dike (ft.) | h1 (ft.) | h2 (ft.) | x1 (ft.) | x2 (ft.) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| -3.00 | 4.00 | 7.00 | 5.00 | 1.00 | 5.00 | 0.15 | 75.00 | 3.85 | 3.15 | 19.25 | 15.75 |




Assumptions:
1. Unit weight of dike = 95 pcf
2. Water at EL. +0.15 feet
3. Mudline at EL -3 feet
4. The effective width of the dike is equal to the width of the crown plus the width of one sloped side.
5. The factor of safety for bearing capacity must be greater or equal to 1.3.

## APPLIED STRESS

| Total Unit Weight of Dike (pcf) | Buoyant Unit Weight of Dike (pcf) | Effective Width of Dike (B) (ft.) | Applied Stress (psf) |
|---|---|---|---|
| 95.00 | 32.60 | 40.00 | 374 |

| Zone | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | Total |
|---|---|---|---|---|---|---|---|---|---|
| Area ($ft^2$) | 37 | 19 | 37 | 25 | 61 | 16 | 61 | 25 | 280 |
| Applied Load (lb./ft.) | 3520 | 1829 | 3520 | 809 | 1977 | 513 | 1977 | 809 | 14954 |

## SUBSURFACE CONDITIONS

| Soil Description | | Elevation (ft.) | | | | Cohesion (ksf) | Cohesion (psf) | Thickness (ft.) |
|---|---|---|---|---|---|---|---|---|
| CH (-1 to -7) | | -3.00 | - | -7.00 | | 0.070 | 70.00 | 4.00 |
| CH (-7 to -14) | | -7.00 | - | -14.00 | | 0.150 | 150.00 | 7.00 |
| CH (-14 to -17) | | -14.00 | - | -17.00 | | 0.180 | 180.00 | 3.00 |
| CH (-17 to -22) | | -17.00 | - | -22.00 | | 0.195 | 195.00 | 5.00 |
| CH (-22 to -50) | | -22.00 | - | -50.00 | | 0.200 | 200.00 | 28.00 |
| CH (-50 to -65) | | -50.00 | - | -65.00 | | 0.500 | 500.00 | 15.00 |
| | | | | | | | | |
| | | | | | | | | |

| T | B | T/B | C1 | C2 | C2/C1 |
|---|---|---|---|---|---|
| 11.00 | 40.00 | 0.28 | 120.91 | 180.00 | 1.5 |

## BEARING CAPACITY RESULTS

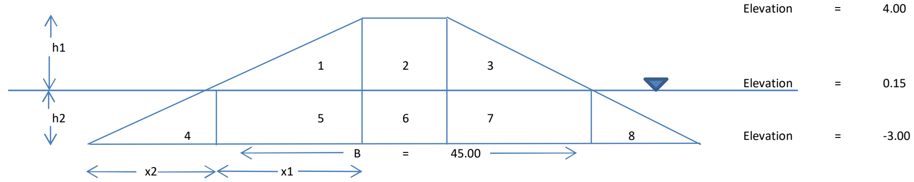
| Effective Width of Dike (B) (ft.) | Nc Factor From NAVFAC DM-7 Figure 11-5 | C1 | Ultimate Bearing Capacity (psf) | Applied Stress (psf) | Factor of Safety |
|---|---|---|---|---|---|
| 40.00 | 7.20 | 121 | 871 | 374 | 2.33 |

Figure B-12a

# FACTOR OF SAFETY FOR BEARING CAPACITY
# FOR UNREINFORCED DIKES USING NAVFAC DM 7; FIGURE 11-5, PAGE 7-11-6

## Cells 4, 5 & 6, Mudline El. -3.0 ft, 10ft Crest

| Elevation at Bottom of Dike (ft.) | Elevation at Top of Dike (ft.) | Height of Dike (ft.) | Slope Inclination (H:V) | | Width at Top of Dike (ft.) | Elevation of Water (ft.) | Full Width at Bottom of Dike (ft.) | h1 (ft.) | h2 (ft.) | x1 (ft.) | x2 (ft.) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| -3.00 | 4.00 | 7.00 | 5.00 | 1.00 | 10.00 | 0.15 | 80.00 | 3.85 | 3.15 | 19.25 | 15.75 |




Assumptions:
1. Unit weight of dike = 95 pcf
2. Water at EL. +0.15 feet
3. Mudline at EL -3 feet
4. The effective width of the dike is equal to the width of the crown plus the width of one sloped side.
5. The factor of safety for bearing capacity must be greater or equal to 1.3.

## APPLIED STRESS

| Total Unit Weight of Dike (pcf) | Buoyant Unit Weight of Dike (pcf) | Effective Width of Dike (B) (ft.) | Applied Stress (psf) |
|---|---|---|---|
| 95.00 | 32.60 | 45.00 | 384 |

| Zone | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | Total |
|---|---|---|---|---|---|---|---|---|---|
| Area (ft$^2$) | 37 | 39 | 37 | 25 | 61 | 32 | 61 | 25 | 315 |
| Applied Load (lb./ft.) | 3520 | 3658 | 3520 | 809 | 1977 | 1027 | 1977 | 809 | 17296 |

## SUBSURFACE CONDITIONS

| Soil Description | | Elevation (ft.) | | | | Cohesion (ksf) | Cohesion (psf) | Thickness (ft.) |
|---|---|---|---|---|---|---|---|---|
| CH (-1 to -7) | | -3.00 | - | -7.00 | | 0.070 | 70.00 | 4.00 |
| CH (-7 to -14) | | -7.00 | - | -14.00 | | 0.150 | 150.00 | 7.00 |
| CH (-14 to -17) | | -14.00 | - | -17.00 | | 0.180 | 180.00 | 3.00 |
| CH (-17 to -22) | | -17.00 | - | -22.00 | | 0.195 | 195.00 | 5.00 |
| CH (-22 to -50) | | -22.00 | - | -50.00 | | 0.200 | 200.00 | 28.00 |
| CH (-50 to -65) | | -50.00 | - | -65.00 | | 0.500 | 500.00 | 15.00 |
| | | | | | | | | |
| | | | | | | | | |

| T | B | T/B | C1 | C2 | C2/C1 |
|---|---|---|---|---|---|
| 11.00 | 45.00 | 0.24 | 120.91 | 180.00 | 1.5 |

## BEARING CAPACITY RESULTS

| Effective Width of Dike (B) (ft.) | Nc Factor From NAVFAC DM-7 Figure 11-5 | C1 | Ultimate Bearing Capacity (psf) | Applied Stress (psf) | Factor of Safety |
|---|---|---|---|---|---|
| 45.00 | 7.30 | 121 | 883 | 384 | 2.30 |

# APPENDIX C
## Containment Dike Settlement

## APPENDIX C
## CONTAINMENT DIKE SETTLEMENT

### Calculation Approach

1. The following descriptions explain how the settlement parameters were developed for the East Leeville Marsh Creation and Nourishment project area.

   a. Three representative settlement profiles (Cells 1 & 2; Cell 3; and Cells 4, 5 & 6; Tables A-1 through A-3 of Appendix A) were used in our settlement analyses.

   b. A total of twelve consolidation tests were completed on soil samples from soil borings within the marsh creation areas to represent various soil layers across the site.

   c. Graphs for each consolidation test were reconstructed to determine compression coefficients ($C_c$), recompression coefficients ($C_r$), vertical consolidation coefficients ($C_v$), initial void ratios ($e_0$), and maximum past pressures ($P_c$).

   d. For soil layers without a representative consolidation test or where test results seemed inconsistent with past experience, $C_c$ values were determined based on correlations developed from the site-specific consolidation test results, $C_r$ values were assumed to be 10 percent of the $C_c$ values, and $C_v$ values were determined based on moisture content and dry density correlations developed by the University of Massachusetts from a study of numerous coastal Louisiana consolidation test results.

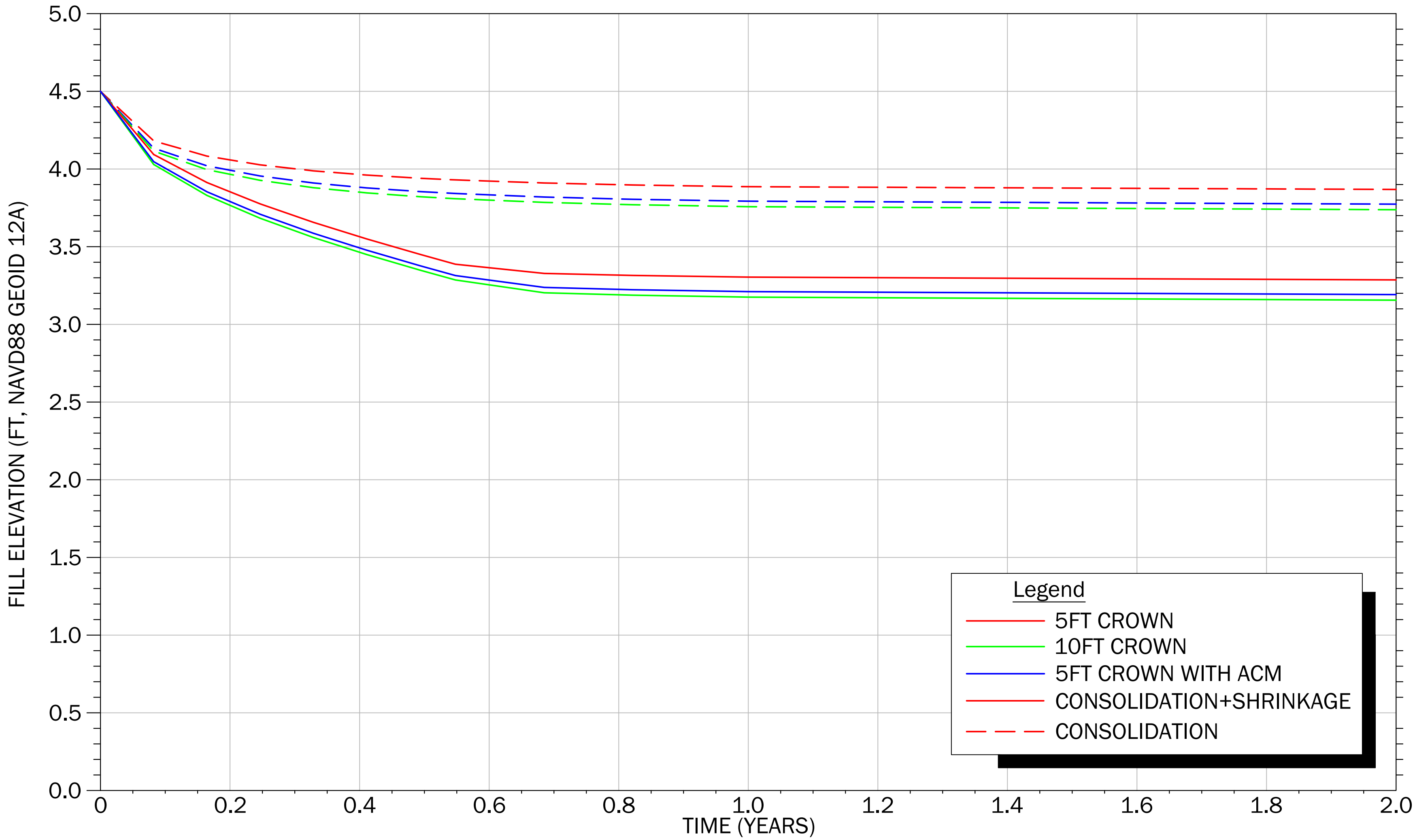
   e. The maximum past pressure ($P_c$) was obtained from the consolidation test curves for the soil layers with a representative consolidation test. $P_c$ values were also back-calculated based on shear strength. The values for $P_c$ were then utilized to determine the over-consolidation ratio (OCR) for soil layers at the site. Based on this evaluation, soils above approximate El. -22 feet are over-consolidated, and soils below approximate El. -22 feet are normally consolidated.

2. In the East Leeville project area, clay shear strength for a normally consolidated soil profile is approximately 22 percent of the effective overburden pressure. This relationship is shown as the C/P line on the shear strength profiles in Figures A-1 through A-3 of Appendix A.

3. Based on our stability analysis for the earthen containment dikes, the recommended design geometries provided in Figures 7a through 7c were used for the settlement analysis. Water was assumed to be at the average water level of El. +0.62 feet, as provided by CPRA.

4. Primary consolidation settlement was calculated using one-dimensional consolidation theory and Boussinesq stress distribution in the SETANL computer program. For foundation settlement purposes, dike fill was assumed to have been placed instantaneously as a single lift or two separate lifts with two to four weeks' time between lifts.

The results of our analyses are shown in the following figures.




| FILL ELEVATION (FEET NAVD88) | | | | | | | |
|---|---|---|---|---|---|---|---|
| CROWN | END OF CONSTRUCTION | 6 MONTHS | 1 YEAR | 3 YEARS | 5 YEARS | 10 YEARS | 20 YEARS |
| 5FT CROWN | 4.5 | 3.9(3.5) | 3.9(3.3) | 3.9(3.3) | 3.9(3.3) | 3.9(3.3) | 3.9(3.3) |
| 10FT CROWN | 4.5 | 3.8(3.3) | 3.8(3.2) | 3.7(3.2) | 3.7(3.2) | 3.7(3.2) | 3.7(3.2) |
| 5FT CROWN ACM | 4.5 | 3.9(3.4) | 3.8(3.2) | 3.8(3.2) | 3.8(3.2) | 3.8(3.2) | 3.8(3.2) |

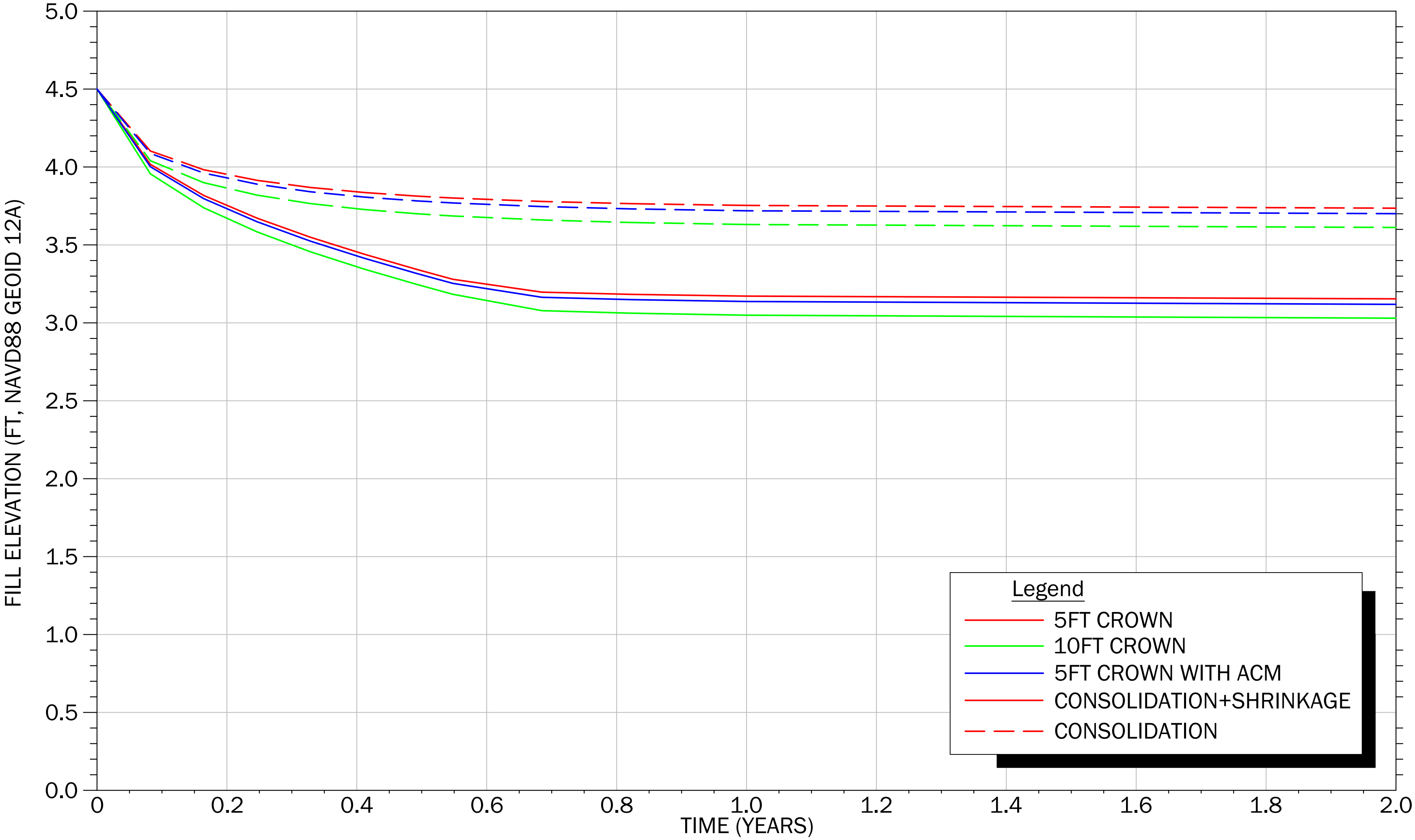
NOTE: CONSOLIDATION + SHRINKAGE VALUES ARE REPRESENTED IN PARENTHESES

**Earthen Containment Dike Crown Elev. vs. Time**
**Cells 1 & 2 - Mudline El. -1 Ft.**

East Leeville Marsh Creation and Nourishment
(BA-194)
Lafourche Parish, Louisiana

GEOENGINEERS

**Figure C-1a**




| FILL ELEVATION (FEET NAVD88) | | | | | | | |
|---|---|---|---|---|---|---|---|
| CROWN | END OF CONSTRUCTION | 6 MONTHS | 1 YEAR | 3 YEARS | 5 YEARS | 10 YEARS | 20 YEARS |
| 5FT CROWN | 4.5 | 3.8(3.3) | 3.8(3.2) | 3.7(3.2) | 3.7(3.2) | 3.7(3.2) | 3.7(3.2) |
| 10FT CROWN | 4.5 | 3.7(3.2) | 3.6(3.0) | 3.6(3.0) | 3.6(3.0) | 3.6(3.0) | 3.6(3.0) |
| 5FT CROWN ACM | 4.5 | 3.8(3.3) | 3.7(3.1) | 3.7(3.1) | 3.7(3.1) | 3.7(3.1) | 3.7(3.1) |

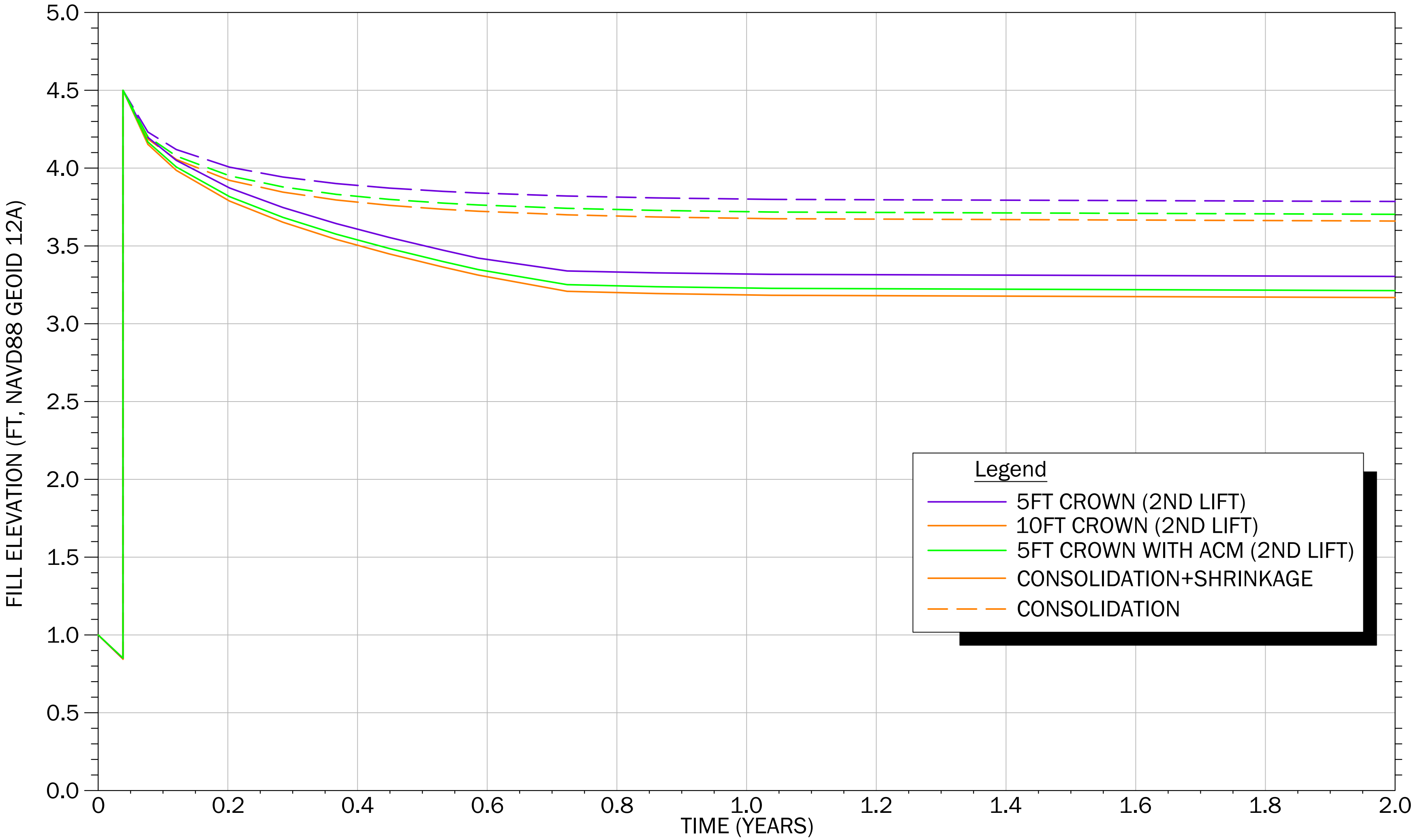
NOTE: CONSOLIDATION + SHRINKAGE VALUES ARE REPRESENTED IN PARENTHESES

**Earthen Containment Dike Crown Elev. vs. Time**
**Cells 1 & 2 - Mudline El. -2 ft.**

East Leeville Marsh Creation and Nourishment
(BA-194)
Lafourche Parish, Louisiana

GeoEngineers

**Figure C-1b**




| FILL ELEVATION (FEET NAVD88) | | | | | | | |
|---|---|---|---|---|---|---|---|
| CROWN | END OF CONSTRUCTION | 6 MONTHS | 1 YEAR | 3 YEARS | 5 YEARS | 10 YEARS | 20 YEARS |
| 5FT CROWN 2ND LIFT | 4.5 | 3.9(3.5) | 3.8(3.3) | 3.8(3.3) | 3.8(3.3) | 3.8(3.3) | 3.8(3.3) |
| 10FT CROWN 2ND LIFT | 4.5 | 3.7(3.4) | 3.7(3.2) | 3.7(3.2) | 3.7(3.2) | 3.7(3.2) | 3.7(3.2) |
| 5FT CROWN ACM 2ND LIFT | 4.5 | 3.8(3.4) | 3.7(3.2) | 3.7(3.2) | 3.7(3.2) | 3.7(3.2) | 3.7(3.2) |

NOTE: CONSOLIDATION + SHRINKAGE VALUES ARE REPRESENTED IN PARENTHESES

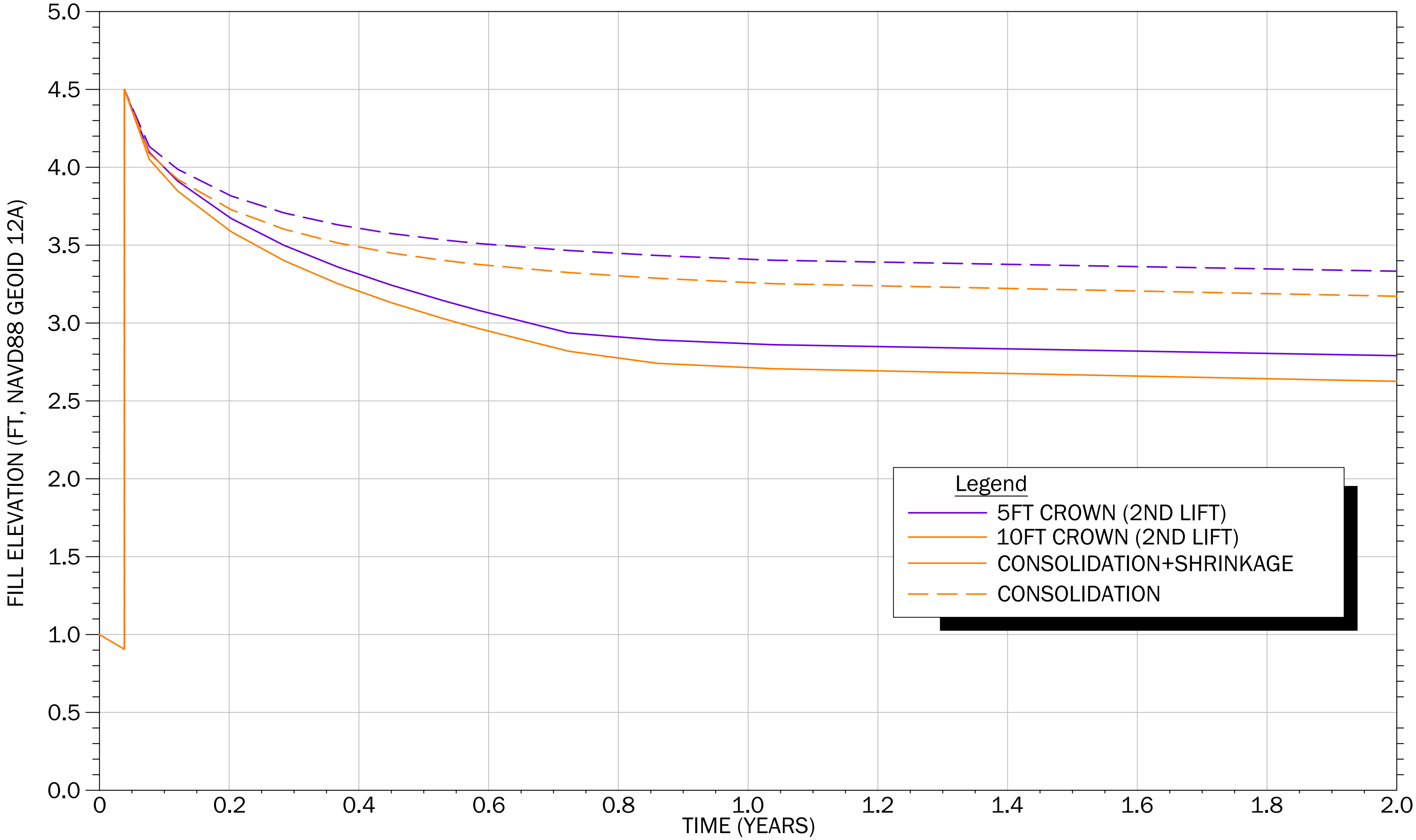
**Earthen Containment Dike Crown Elev. vs. Time**
**Cells 1 & 2 - Mudline El. -3 ft.**

East Leeville Marsh Creation and Nourishment
(BA-194)
Lafourche Parish, Louisiana

GEOENGINEERS

**Figure C-1c**

P:\18\18274004\CAD\02\Geotech - Final\1827400402_FC_ECD vs Time Final.dwg TAB:C2b - Cell 32y Date Exported: 05/08/20 - 11:25 by kcook




| FILL ELEVATION (FEET NAVD88) | | | | | | | |
|---|---|---|---|---|---|---|---|
| CROWN | END OF CONSTRUCTION | 6 MONTHS | 1 YEAR | 3 YEARS | 5 YEARS | 10 YEARS | 20 YEARS |
| 5FT CROWN 2ND LIFT | 4.5 | 3.5(3.1) | 3.4(2.9) | 3.3(2.8) | 3.3(2.8) | 3.3(2.7) | 3.3(2.7) |
| 10FT CROWN 2ND LIFT | 4.5 | 3.4(3.0) | 3.3(2.7) | 3.1(2.6) | 3.1(2.6) | 3.1(2.6) | 3.1(2.6) |

NOTE: CONSOLIDATION + SHRINKAGE VALUES ARE REPRESENTED IN PARENTHESES

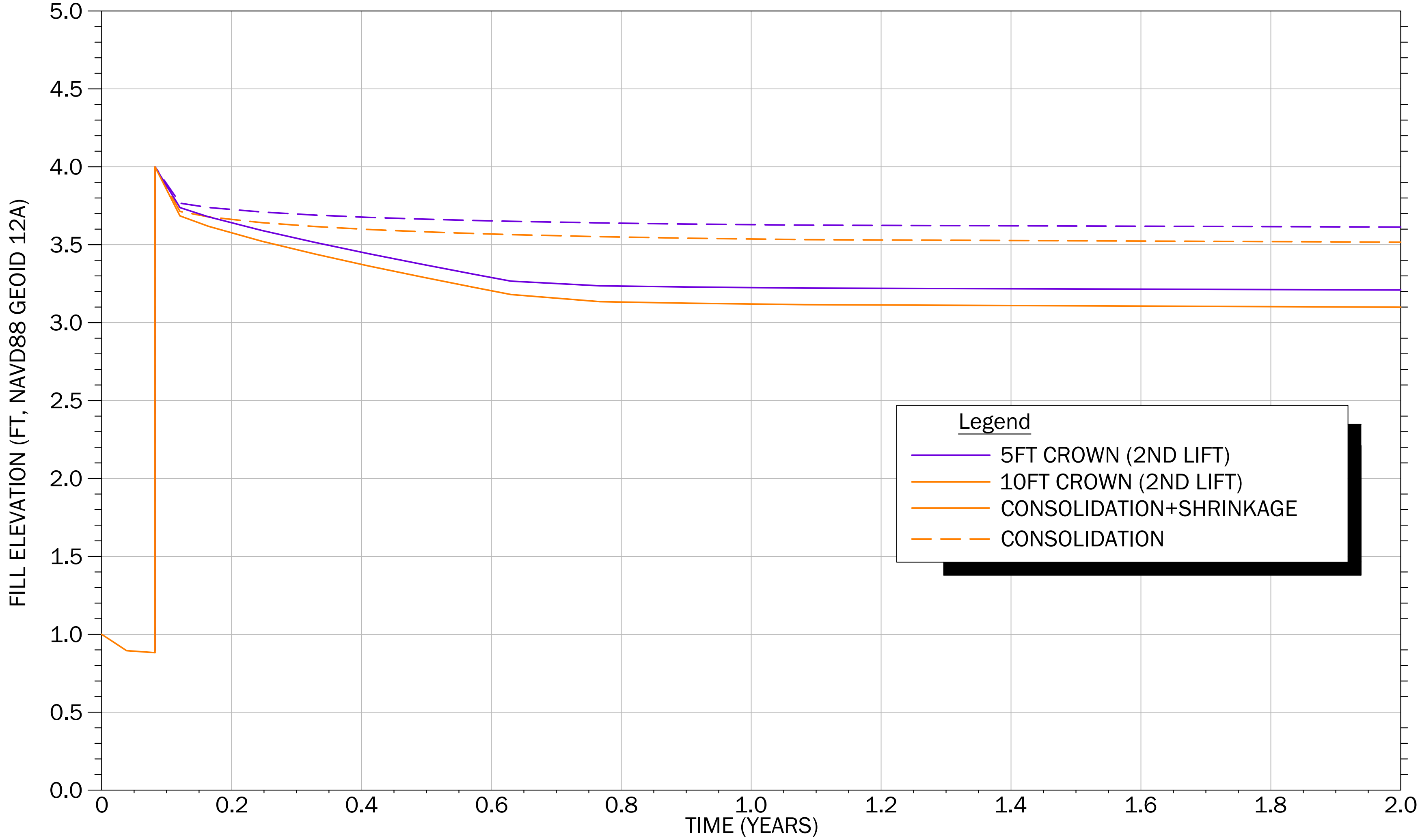
**Earthen Containment Dike Crown Elev. vs. Time**
**Cell 3 - Mudline El. -2 ft.**

East Leeville Marsh Creation and Nourishment
(BA-194)
Lafourche Parish, Louisiana

GEOENGINEERS

**Figure C-2**

P:\18\18274004\CAD\02\Geotech - Final\1827400402_FC_ECD vs Time Final.dwg TAB:C3b - Cells 456 Date Exported: 04/17/20 - 14:26 by kcook




| FILL ELEVATION (FEET NAVD88) | | | | | | | |
|---|---|---|---|---|---|---|---|
| CROWN | END OF CONSTRUCTION | 6 MONTHS | 1 YEAR | 3 YEARS | 5 YEARS | 10 YEARS | 20 YEARS |
| 5FT CROWN 2ND LIFT | 4.0 | 3.7(3.4) | 3.6(3.2) | 3.6(3.2) | 3.6(3.2) | 3.6(3.2) | 3.6(3.2) |
| 10FT CROWN 2ND LIFT | 4.0 | 3.6(3.3) | 3.5(3.1) | 3.5(3.1) | 3.5(3.1) | 3.5(3.1) | 3.5(3.1) |

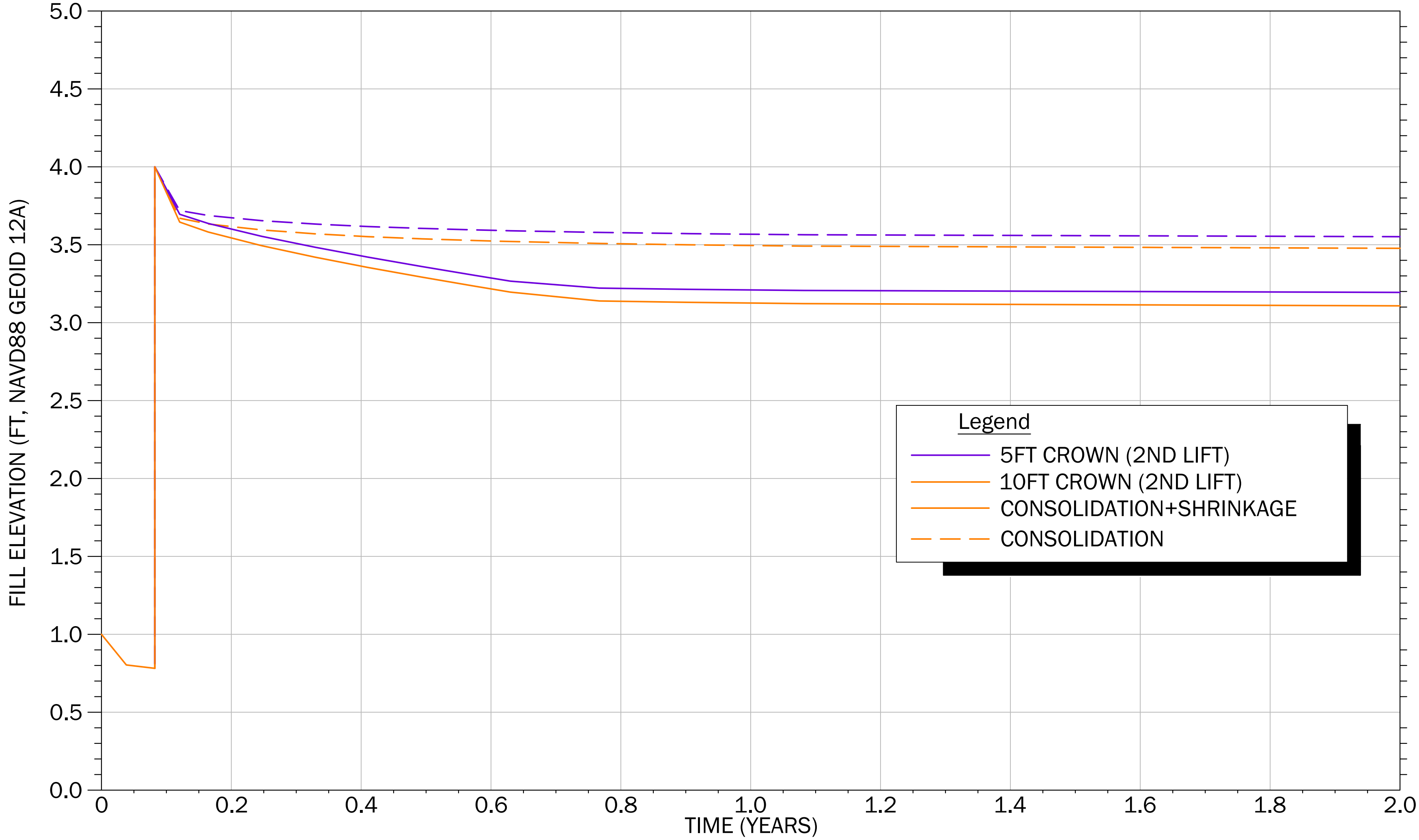
NOTE: CONSOLIDATION + SHRINKAGE VALUES ARE REPRESENTED IN PARENTHESES

**Earthen Containment Dike Crown Elev. vs. Time**
**Cells 4, 5 & 6 - Mudline El. -1 ft.**

East Leeville Marsh Creation and Nourishment
(BA-194)
Lafourche Parish, Louisiana

GEOENGINEERS

**Figure C-3a**




| FILL ELEVATION (FEET NAVD88) | | | | | | | |
|---|---|---|---|---|---|---|---|
| CROWN | END OF CONSTRUCTION | 6 MONTHS | 1 YEAR | 3 YEARS | 5 YEARS | 10 YEARS | 20 YEARS |
| 5FT CROWN 2ND LIFT | 4.0 | 3.6(3.4) | 3.6(3.2) | 3.5(3.2) | 3.5(3.2) | 3.5(3.2) | 3.5(3.2) |
| 10FT CROWN 2ND LIFT | 4.0 | 3.5(3.3) | 3.5(3.1) | 3.4(3.1) | 3.5(3.1) | 3.5(3.1) | 3.5(3.1) |

NOTE: CONSOLIDATION + SHRINKAGE VALUES ARE REPRESENTED IN PARENTHESES

**Earthen Containment Dike Crown Elev. vs. Time**
**Cells 4, 5 & 6 - Mudline El. -3 ft.**

East Leeville Marsh Creation and Nourishment
(BA-194)
Lafourche Parish, Louisiana

GeoEngineers

**Figure C-3b**

# APPENDIX D
## Gap Closures

## APPENDIX D
## GAP CLOSURE ALTERNATIVES

### Calculation Approach

Based on review of survey information provided by CPRA, GeoEngineers identified five locations around the marsh creation cell perimeters where the existing mudline is lower than the design mudline elevations evaluated for containment dikes. These locations are identified in Figure 2. Based on the mudline elevations at these locations, the earthen containment dike design sections discussed previously will not be stable and, as such, modified dike design sections will be required. Recommended gap closure design sections are shown in Figures 8a through 8c. Gap closure structure slope stability was evaluated using optimized circular search parameters with Spencer's method in the GEO-SLOPE International Limited computer program SLOPE/W (GeoStudio 2016 and 2020). Bearing capacity of the sections was evaluated using traditional bearing capacity theory. Parameters were evaluated as described below, and the stability results are included in this appendix.

1. The mudline was assumed to be El. -4.0 feet for the gaps within Cell 3 and Cell 6 and El. -4.5 feet for the Cell 2 gap.
2. The mean low water level of El. +0.15 feet was used.
3. Slope stability was evaluated for the following cases:
    a. Case 1: Internal failure of the containment dike, no marsh fill placed;
    b. Case 2: Global failure of the containment dike into the borrow channel, no marsh fill placed;
    c. Case 3: Failure of the borrow channel, no marsh fill placed; and
    d. Case 4: Failure of the containment dike, marsh fill placed.
5. For water depths greater than four feet, it is assumed the marsh excavation equipment will float; therefore, marsh equipment load was not modeled on the bench for Case 3 of each.
6. The stability of the containment dikes was modeled with an external borrow channel. However, we understand that, in some areas, material for the dikes may also be dredged from a borrow channel within the marsh creation cells. The factors of safety associated with a Case 4 failure with an internal borrow channel are similar to a Case 4 failure with an external borrow channel.
7. The bearing capacity of the containment dikes was evaluated using the method for bearing on a two-layer cohesive soil as outlined in Figure 11-5 of the Naval Facilities Engineering Command Design Manual 7.02 *Foundations and Earth Structures*.
8. The values for unit weight within the containment dike material were based on the unit weight of the material within the depth of the proposed borrow channel for each cell. An assumed initial cohesion of 60 psf was used for the containment dike material based on our experience with similar projects. In cases where a second lift was necessary for stability, we included up to 15 percent gain in shear strength of the first lift of the dike and of shallow soil layers directly under the dike first lift.

While sheet pile gap closures do not appear necessary for this project, we also analyzed a general sheet pile gap closure section for Cell 3 with a mudline elevation of -5.0 feet. Parameters were evaluated as described below, and the stability results are included in this appendix.

1. The containment dike geometry was modeled in SLOPE/W for three design conditions to develop a relationship between crown elevation and sheet pile requirements:

   (1) a crown elevation of +1.0 feet, a crown width of 40 feet, and 5H:1V side slopes;

   (2) a crown elevation of +1.5 feet, a crown width of 35 feet, and 5H:1V side slopes; and

   (3) a crown elevation of +2.0 feet, a crown width of 30 feet, and 5H:1V side slopes.

   a. The sheet pile top was modeled at El. +4.5 feet, and the sheet pile bottom was modeled from El. -26 feet to El. -11 feet for the various design options.

   b. Stability was evaluated for the four typical cases discussed previously with modifications – Cases 1 through 3 were evaluated without the sheet pile installed, and Cases 1 and 4 were modeled with the sheet pile installed.

2. Design strengths and unit weights were input into the United States Army Corps of Engineers (USACE) computer program CWALSHT.

   a. The sheet pile wall top was modeled at El. +4.5 feet with the marsh fill material modeled as a distributed pressure applied to the sheet pile and containment dike.

   b. The water level on the external side was modeled at mean low water (El. +0.15 feet) and on the internal (marsh) side was modeled at the top of the wall (El. +4.5 feet).

   c. Adhesion was assumed to be equal to the cohesion for strengths less than or equal to 100 psf and 0.5 times the cohesion for strengths greater than 100 psf.

   d. The sweep search method was used to complete the analysis.

   e. Design sheet pile length was determined by running the program for a cantilevered pile with a factor of safety of 1.5 for passive pressures and 1.0 for active pressures.

   f. Maximum bending moment and scaled deflection were determined by running the program with equal passive and active safety factors (1.0) for a cantilevered pile with a modulus of elasticity of 2.9 x $10^7$ pounds per square inch (psi) (typical for A36 steel).

   g. The required sheet pile section modulus was calculated using the following equation:

   $$S = \frac{M_{max}(lb \cdot ft) \times 12\frac{in}{ft}}{\sigma_a\left(\frac{lb}{in^2}\right)}$$

   Where S = section modulus ($in^3$ per foot of wall)

   $M_{max}$ = maximum bending moment in wall (program output)

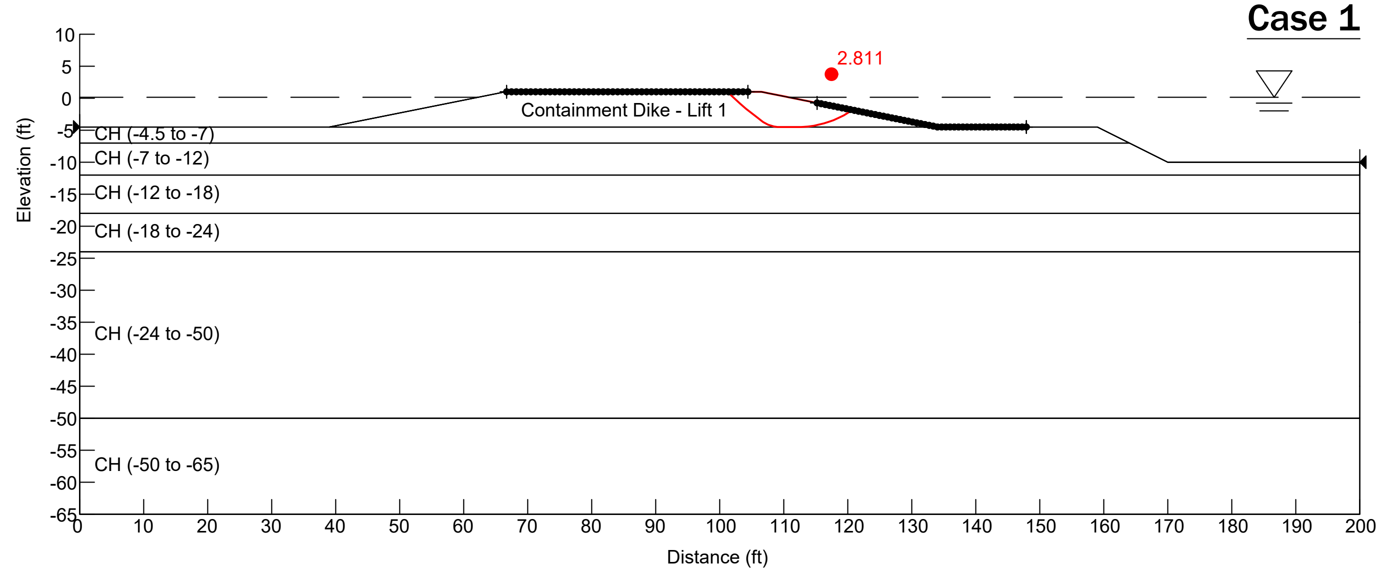
   $\sigma_a$ = allowable steel stress (Assumed 25,000 psi – typical for A36 steel)

   h. The section modulus was used to select a viable sheet pile section from standard U.S. sheet pile sizes (Skyline Steel was used, but the values are fairly consistent among manufacturers).

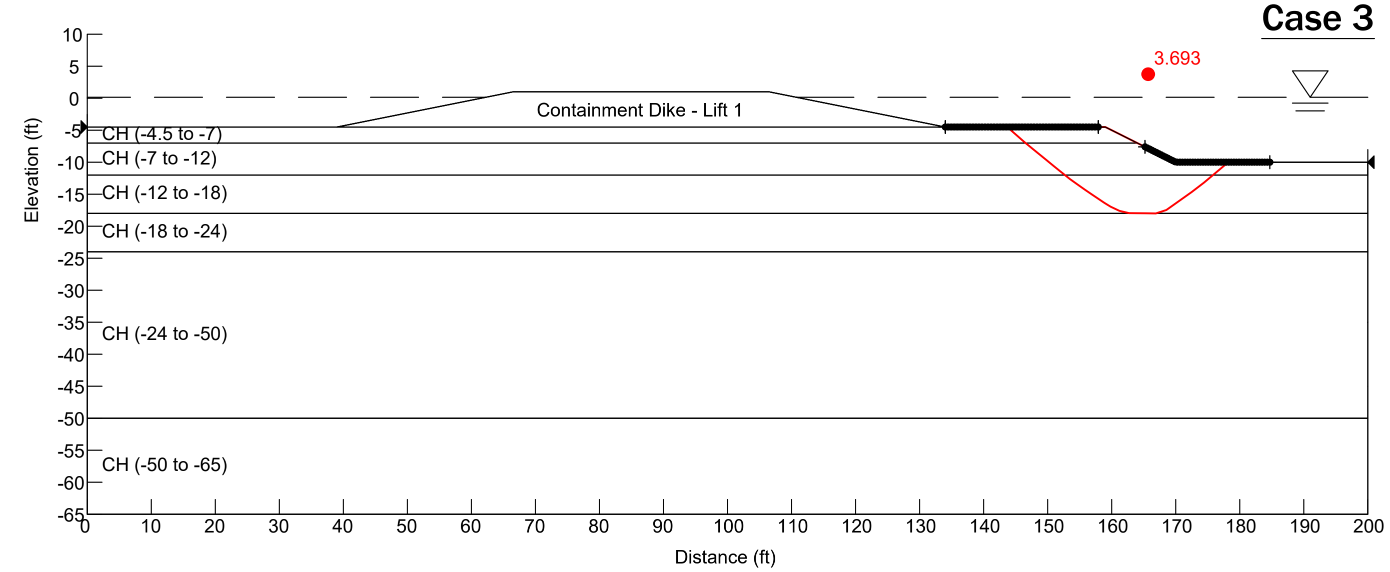
   i. Maximum deflection was computed using the maximum scaled deflection and the moment of inertia from the selected sheet pile section. Deflection was checked to make sure it was not excessive. Generally, we prefer to see less than two inches of deflection at the mudline.

The results of our analyses are shown in the following figures and calculations.

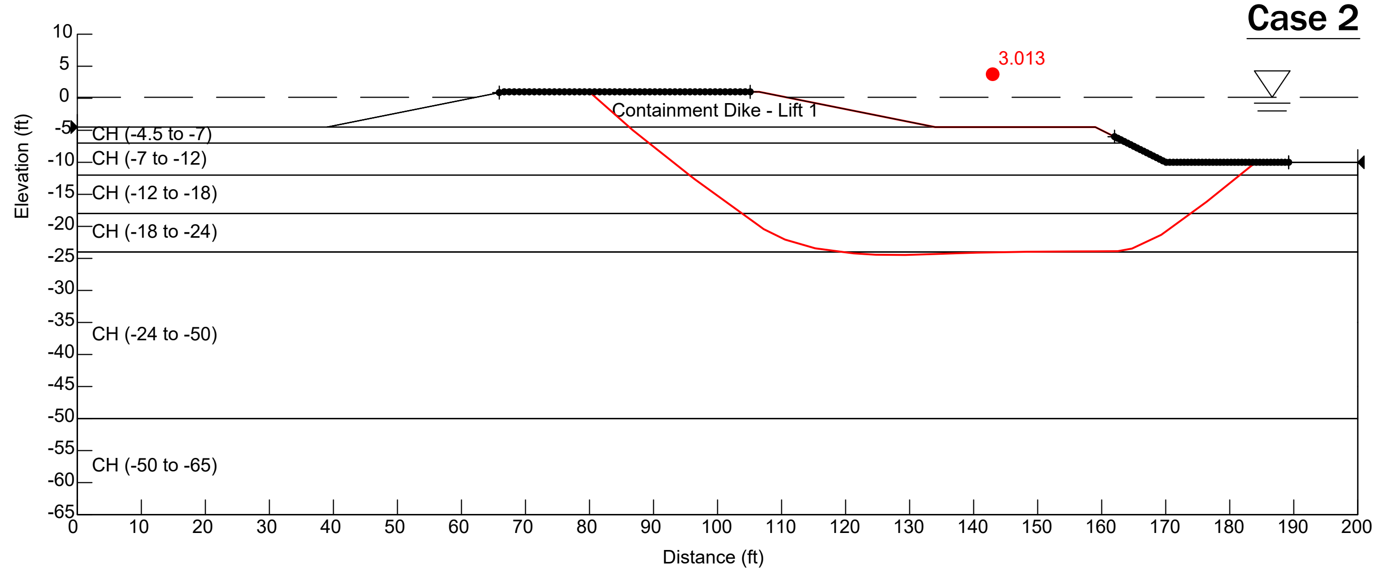
## Case 1




## Case 3




## Case 2



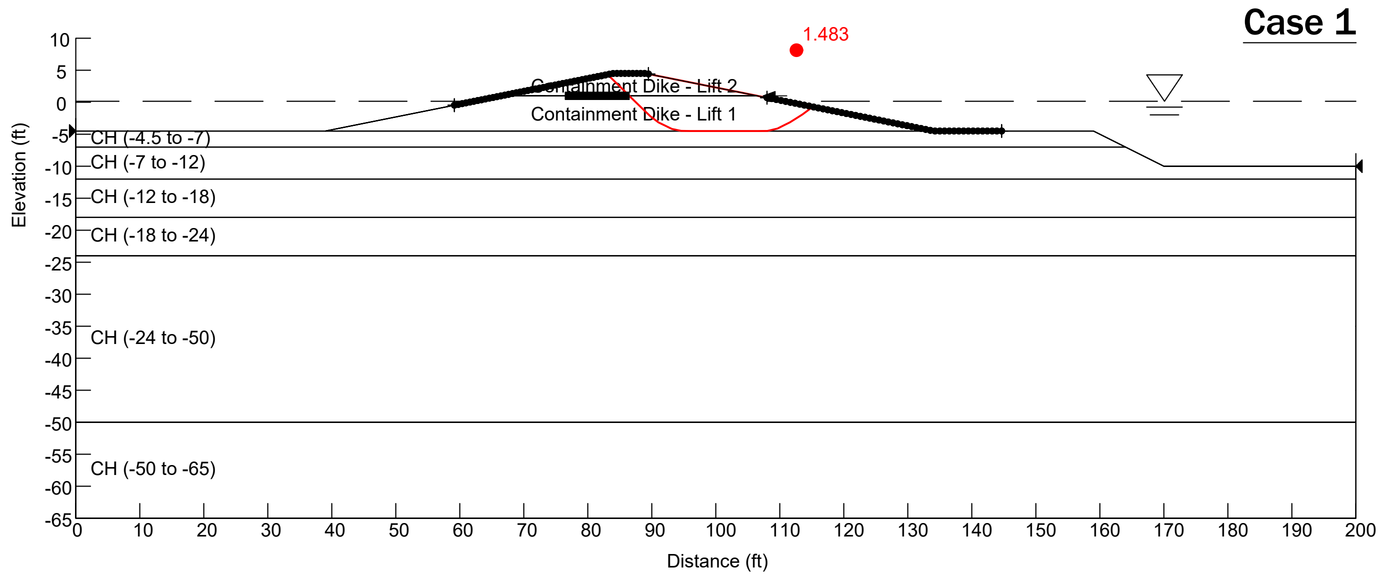

| Name | Model | Unit Weight (pcf) | Cohesion' (psf) | Phi' (°) | Cohesion Fn |
|---|---|---|---|---|---|
| Containment Dike - Lift 1 | Mohr-Coulomb | 95 | 60 | 0 | |
| CH (-4.5 to -7) | Spatial Mohr-Coulomb | 100 | 100 | 0 | |
| CH (-7 to -12) | Mohr-Coulomb | 100 | 150 | 0 | |
| CH (-12 to -18) | Mohr-Coulomb | 108 | 150 | 0 | |
| CH (-18 to -24) | Mohr-Coulomb | 108 | 200 | 0 | |
| CH (-24 to -50) | Spatial Mohr-Coulomb | 110 | | 0 | 200 psf + 10.4 psf/ft |
| CH (-50 to -65) | Spatial Mohr-Coulomb | 113 | | 0 | 470 psf + 11 psf/ft |

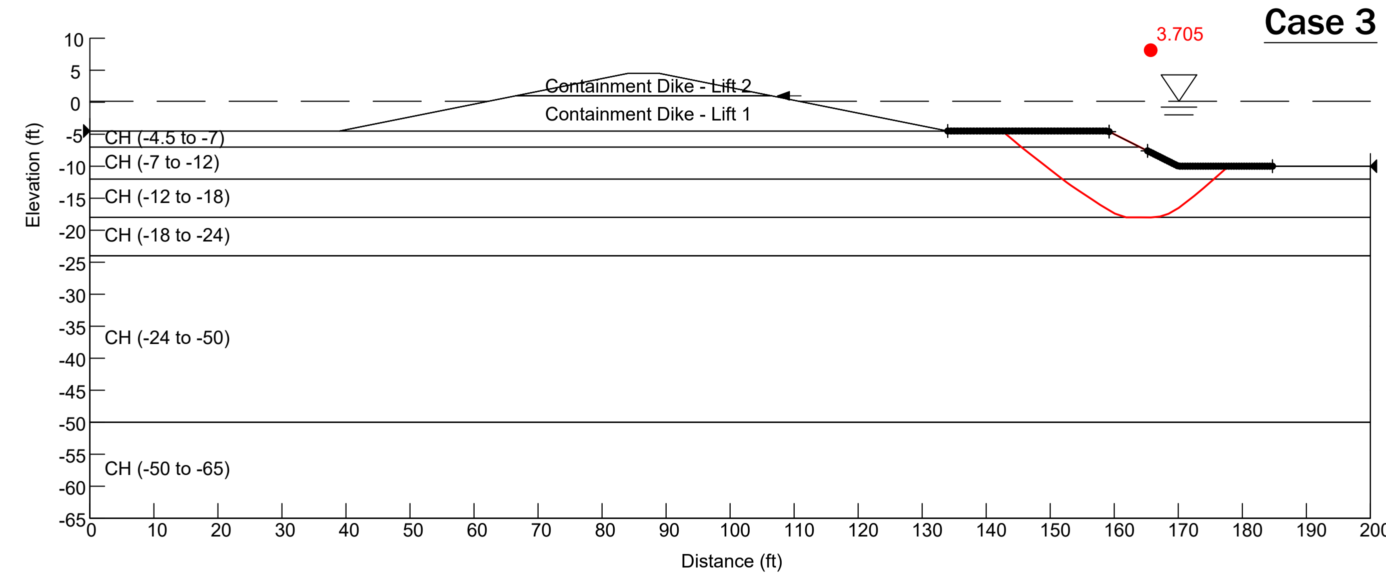
**Gap Closure Slope Stability -**
**North Cell-2, Mudline El. -4.5 Ft, Lift 1**

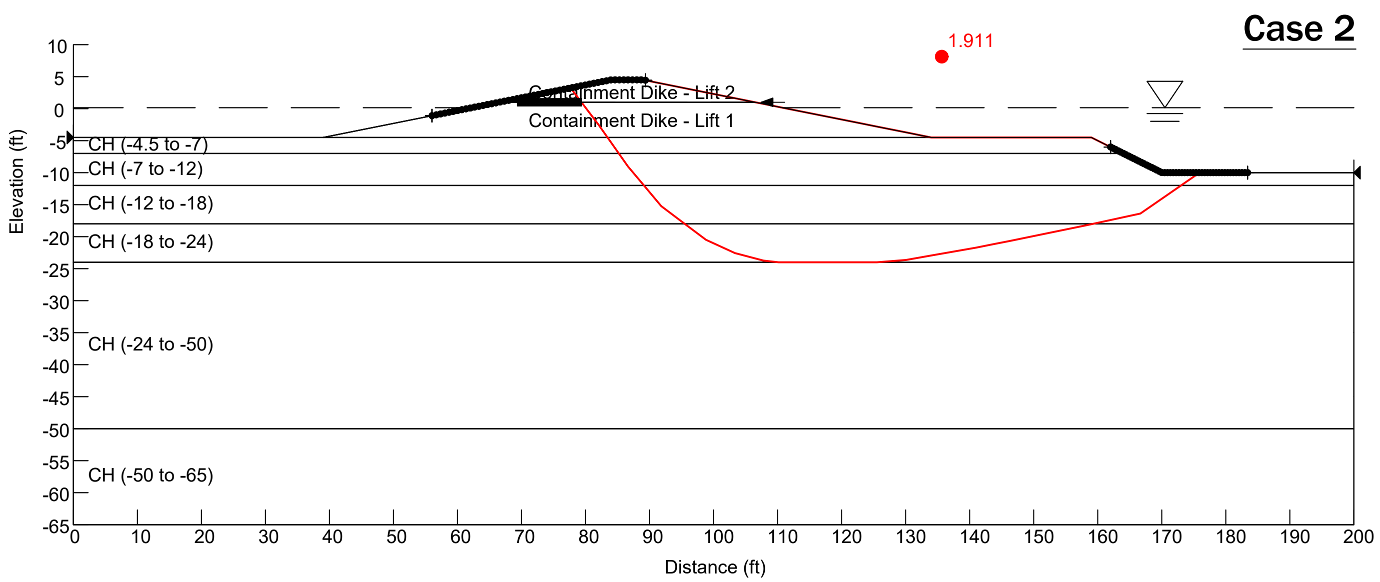
East Leeville Marsh Creation and Nourishment
(BA-194)
Lafourche Parish, Louisiana

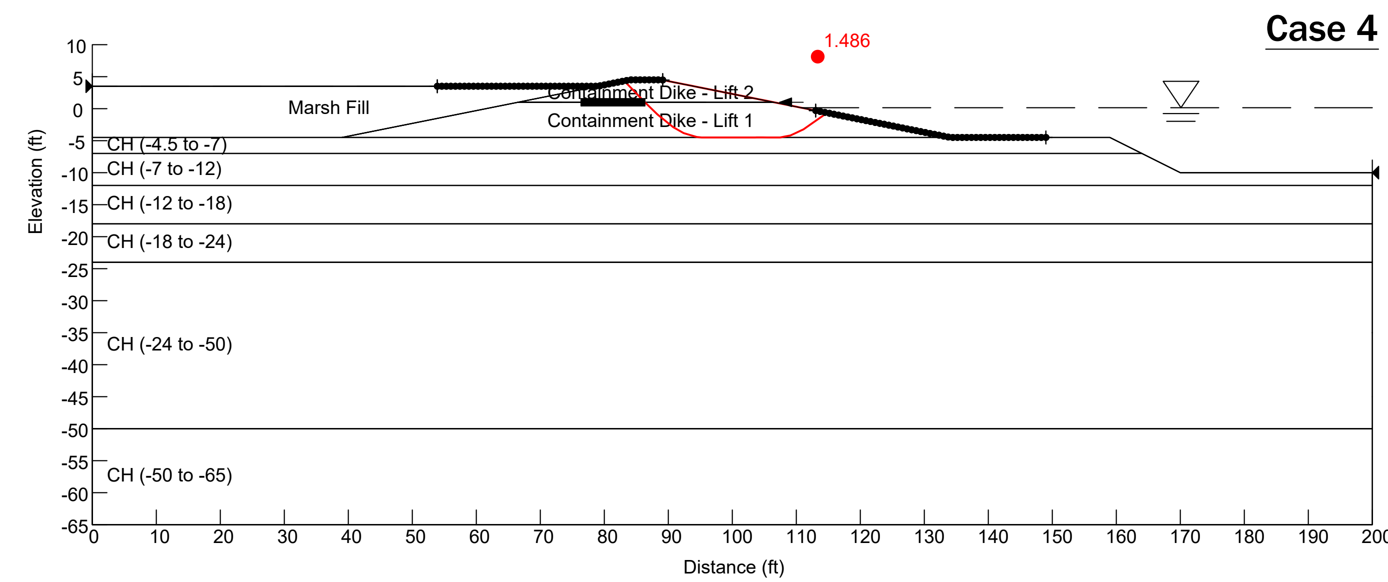
GeoEngineers

**Figure D-1a**



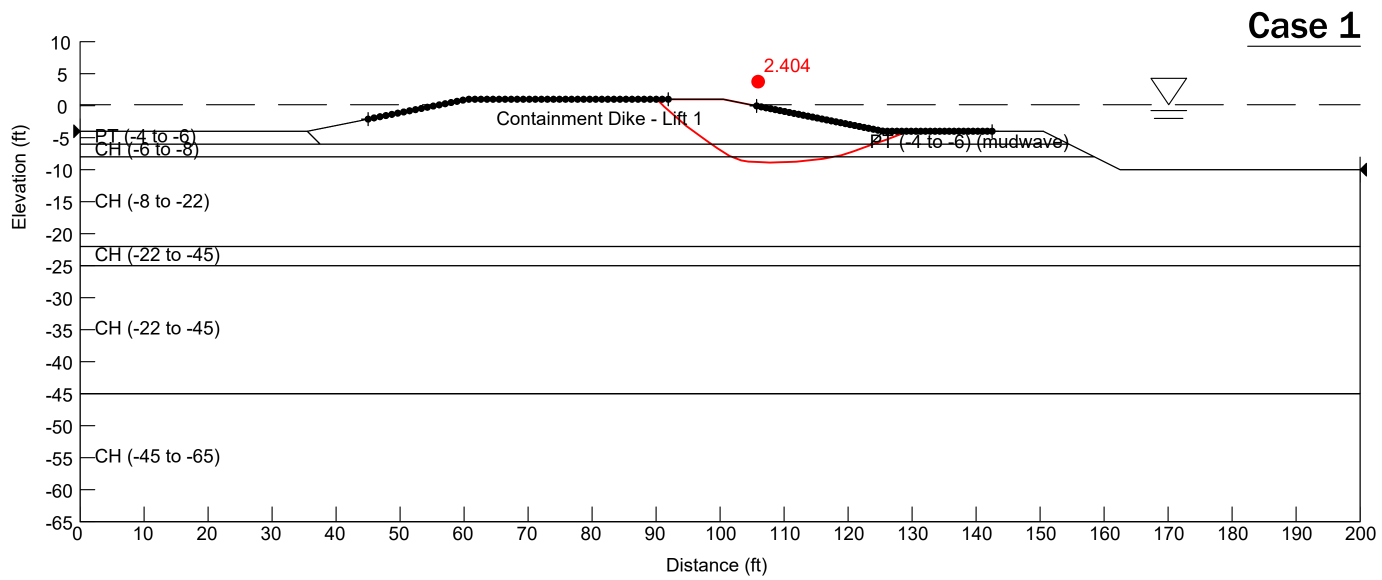

| Name | Model | Unit Weight (pcf) | Cohesion' (psf) | Phi' (°) | Cohesion Spatial Fn | Cohesion Fn |
|---|---|---|---|---|---|---|
| Marsh Fill | Mohr-Coulomb | 85 | 0 | 0 | | |
| Containment Dike - Lift 1 | Mohr-Coulomb | 95 | 66 | 0 | | |
| Containment Dike - Lift 2 | Mohr-Coulomb | 95 | 60 | 0 | | |
| CH (-4.5 to -7) | Spatial Mohr-Coulomb | 100 | | 0 | 100 psf + 15% | |
| CH (-7 to -12) | Spatial Mohr-Coulomb | 100 | | 0 | 150 psf + 15% | |
| CH (-12 to -18) | Mohr-Coulomb | 108 | 150 | 0 | | |
| CH (-18 to -24) | Mohr-Coulomb | 108 | 200 | 0 | | |
| CH (-24 to -50) | Spatial Mohr-Coulomb | 110 | | 0 | | 200 psf + 10.4 psf/ft |
| CH (-50 to -65) | Spatial Mohr-Coulomb | 113 | | 0 | | 470 psf + 11 psf/ft |

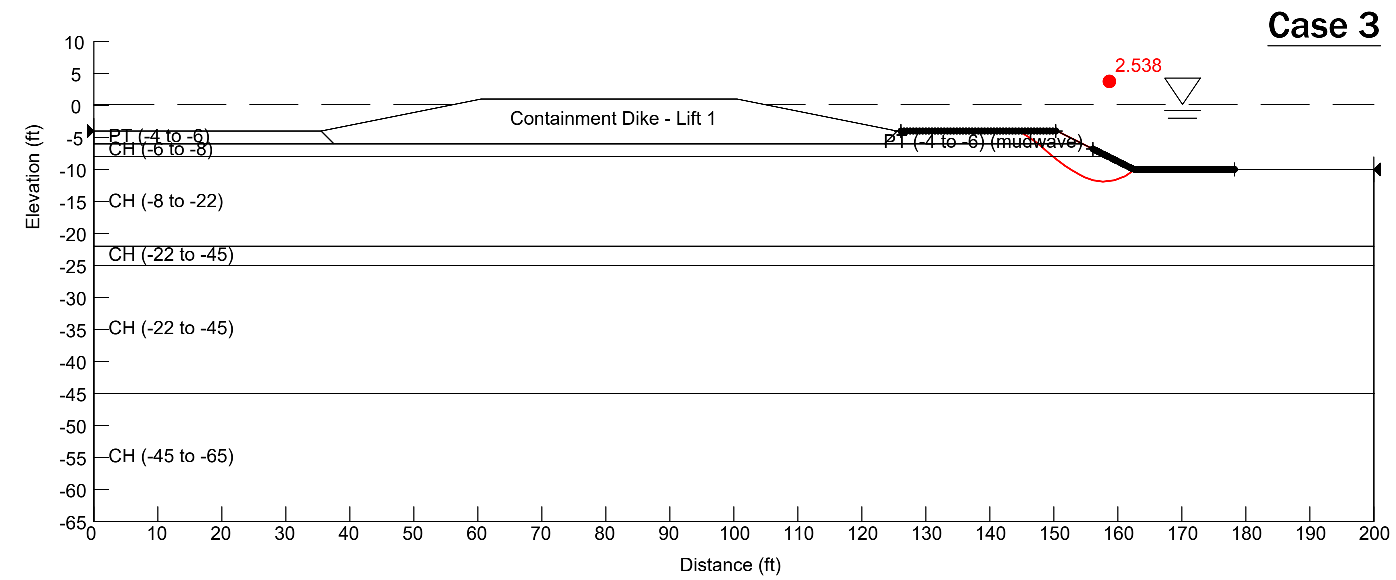
**Gap Closure Slope Stability -**
**North Cell-2, Mudline El. -4.5 Ft, Lift 2**

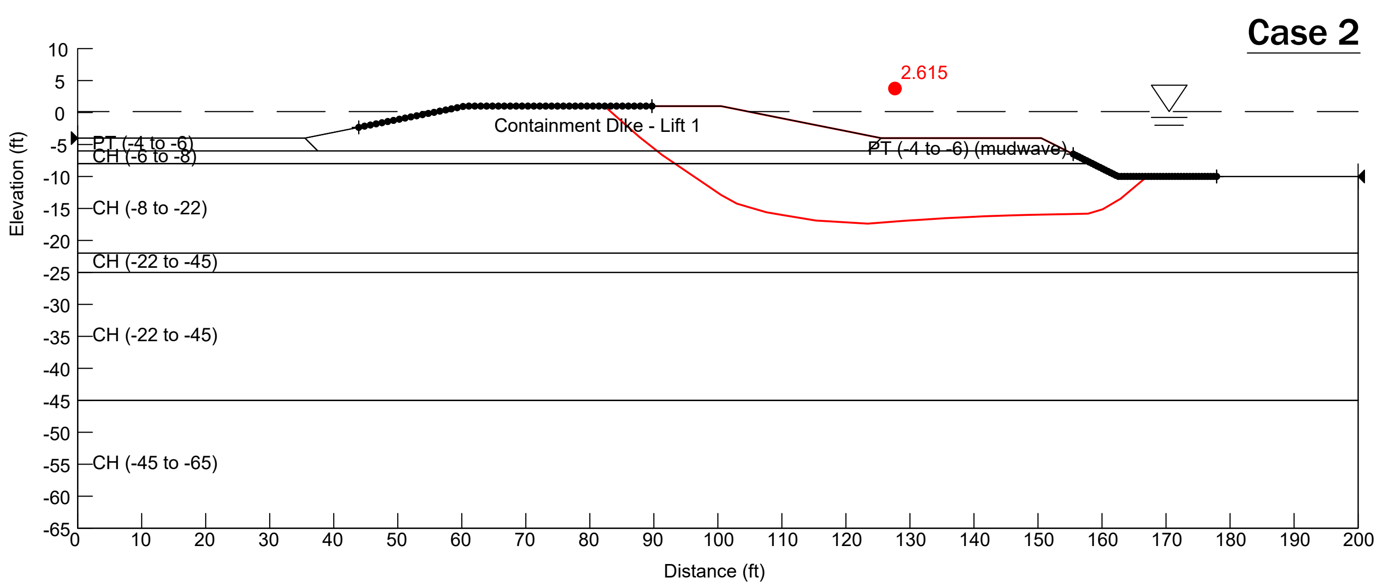
East Leeville Marsh Creation and Nourishment
(BA-194)
Lafourche Parish, Louisiana

GeoEngineers

**Figure D-1b**




| Name | Model | Unit Weight (pcf) | Cohesion' (psf) | Phi' (°) | Cohesion Fn |
|---|---|---|---|---|---|
| Containment Dike - Lift 1 | Mohr-Coulomb | 90 | 60 | 0 | |
| PT (-4 to -6) | Mohr-Coulomb | 108 | 30 | 0 | |
| PT (-4 to -6) (mudwave) | Mohr-Coulomb | 80 | 5 | 0 | |
| CH (-6 to -8) | Spatial Mohr-Coulomb | 108 | 75 | 0 | |
| CH (-8 to -22) | Spatial Mohr-Coulomb | 108 | | 0 | 75 psf + 7.1 psf/ft |
| CH (-22 to -45) | Spatial Mohr-Coulomb | 108 | | 0 | 175 psf + 10 psf/ft |
| CH (-45 to -65) | Spatial Mohr-Coulomb | 111 | | 0 | 405 psf + 10.75 psf/ft |

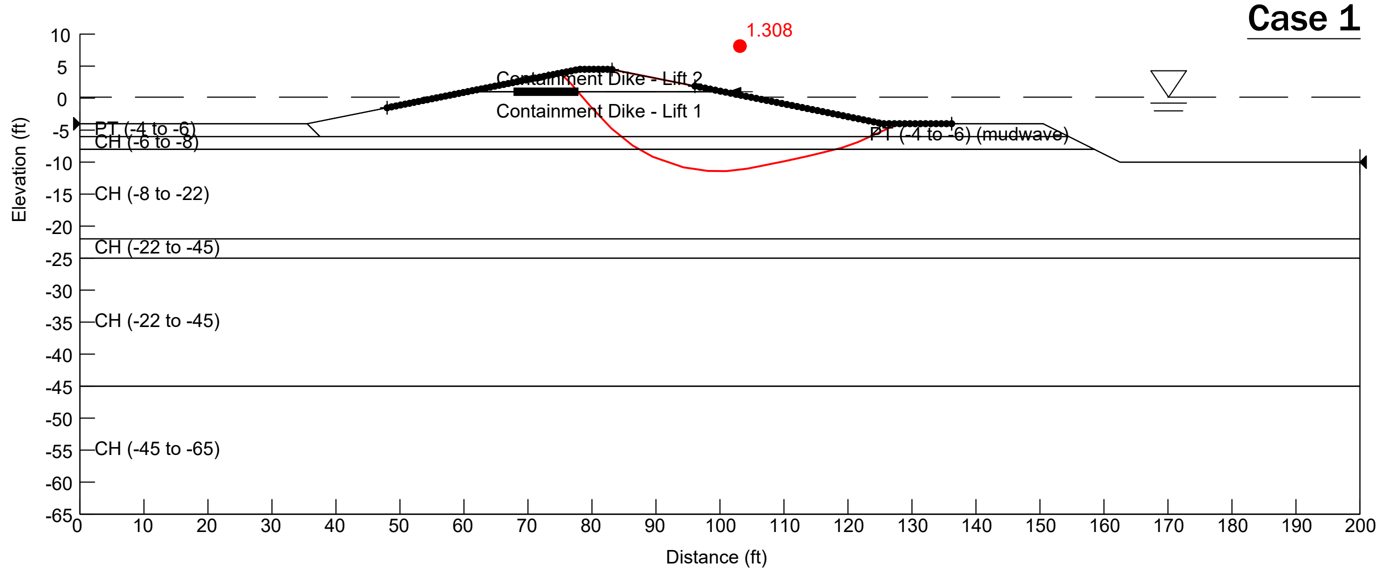
**Gap Closure Slope Stability -**
**Cell 3, Mudline El. -4.0 Ft, Lift 1**

East Leeville Marsh Creation and Nourishment
(BA-194)
Lafourche Parish, Louisiana

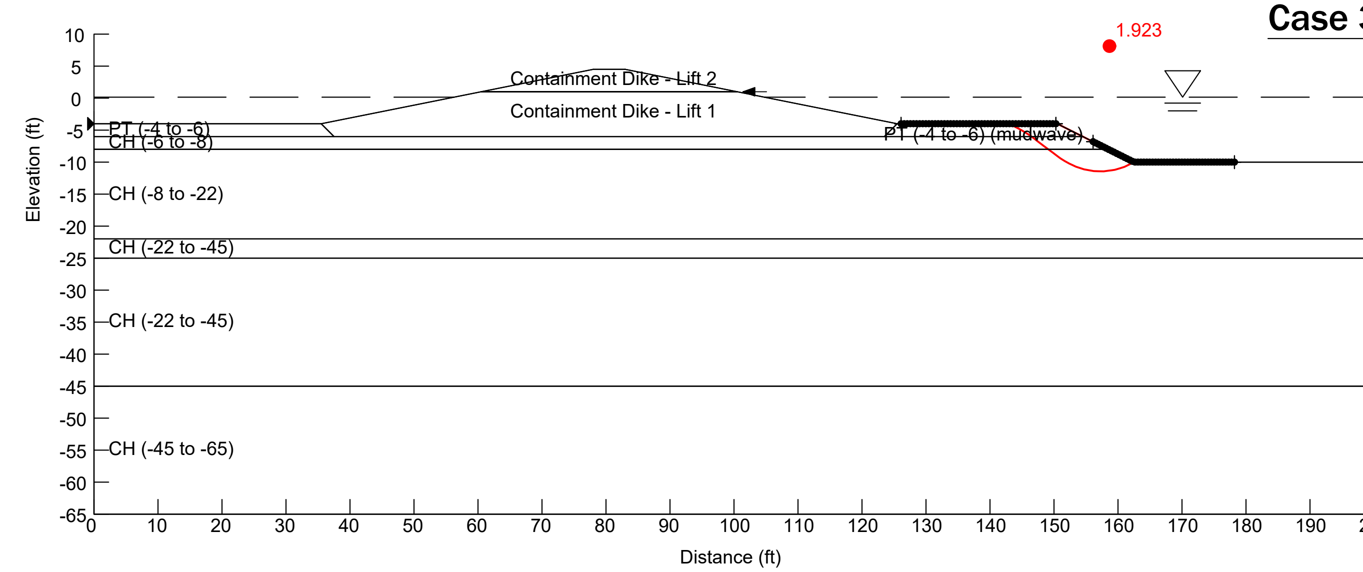
GeoEngineers

**Figure D-2a**

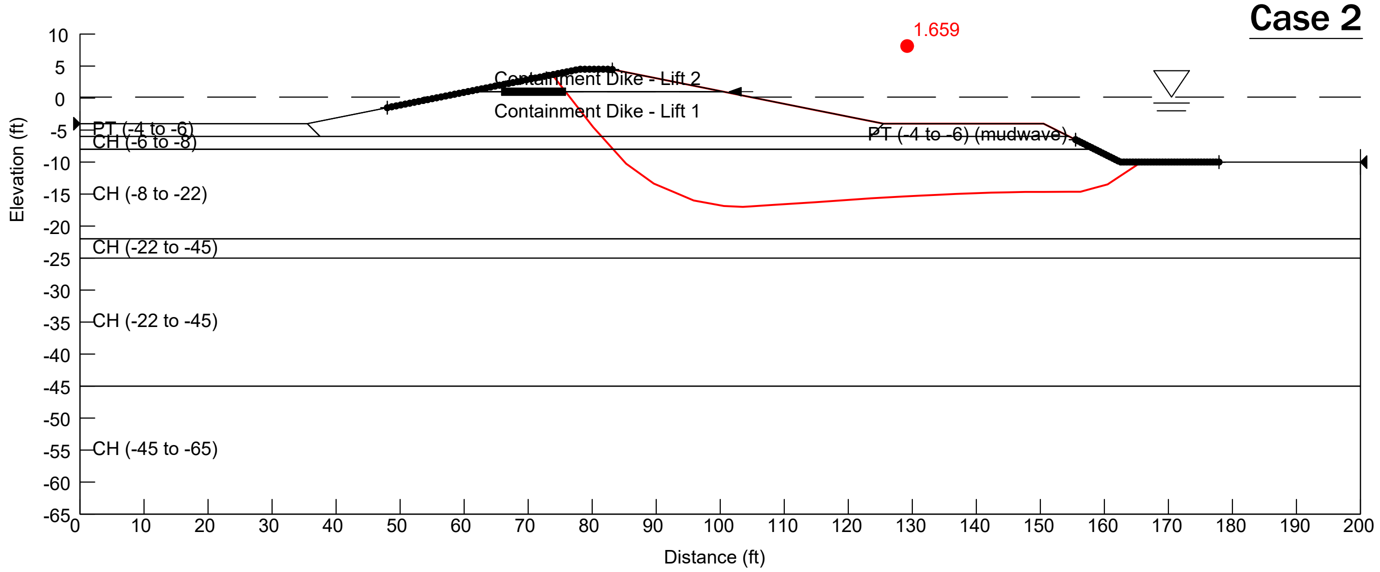
## Case 1



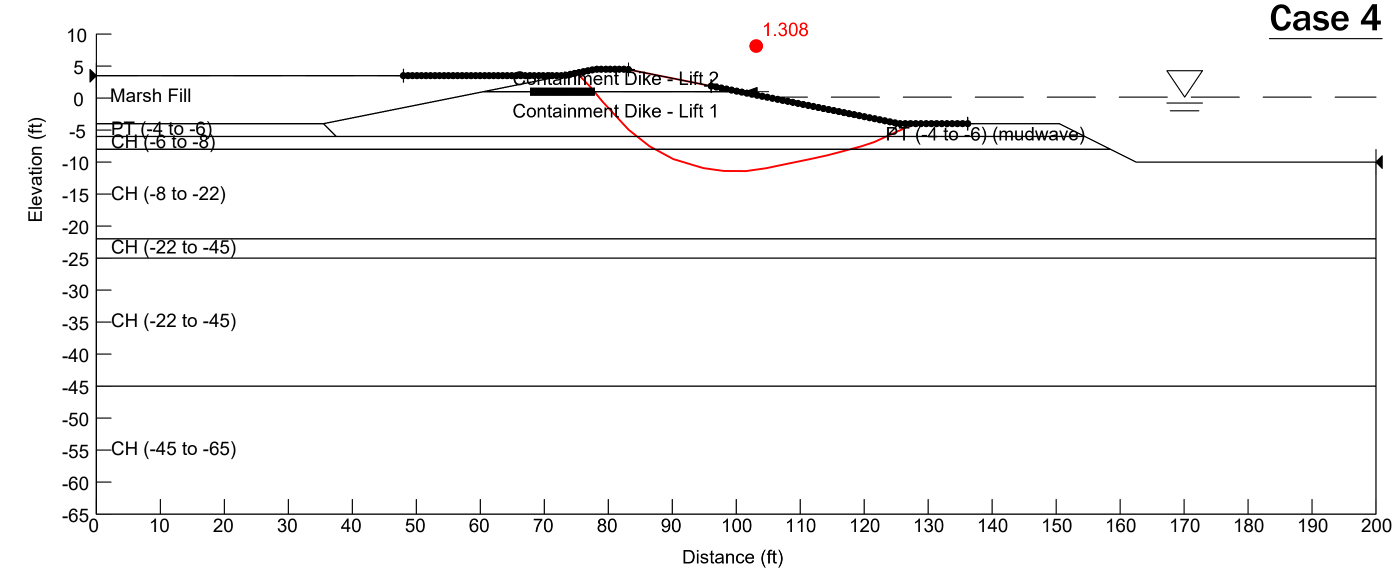

## Case 3




## Case 2




## Case 4




| Name | Model | Unit Weight (pcf) | Cohesion' (psf) | Phi' (°) | Cohesion Spatial Fn | Cohesion Fn |
|---|---|---|---|---|---|---|
| Marsh Fill | Mohr-Coulomb | 85 | 0 | 0 | | |
| Containment Dike - Lift 1 | Mohr-Coulomb | 90 | 66 | 0 | | |
| Containment Dike - Lift 2 | Mohr-Coulomb | 90 | 60 | 0 | | |
| PT (-4 to -6) | Spatial Mohr-Coulomb | 108 | 30 | 0 | | |
| PT (-4 to -6) (mudwave) | Mohr-Coulomb | 108 | 5 | 0 | | |
| CH (-6 to -8) | Spatial Mohr-Coulomb | 108 | | 0 | 75 psf + 15% | |
| CH (-8 to -22) | Spatial Mohr-Coulomb | 108 | | 0 | 75 psf + 7.1 psf/ft + 15% | |
| CH (-22 to -45) | Spatial Mohr-Coulomb | 108 | | 0 | | 175 psf + 10 psf/ft |
| CH (-45 to -65) | Spatial Mohr-Coulomb | 111 | | 0 | | 405 psf + 10.75 psf/ft |

**Gap Closure Slope Stability -**
**North Cell 3, Mudline El. -4.0 Ft, Lift 2**

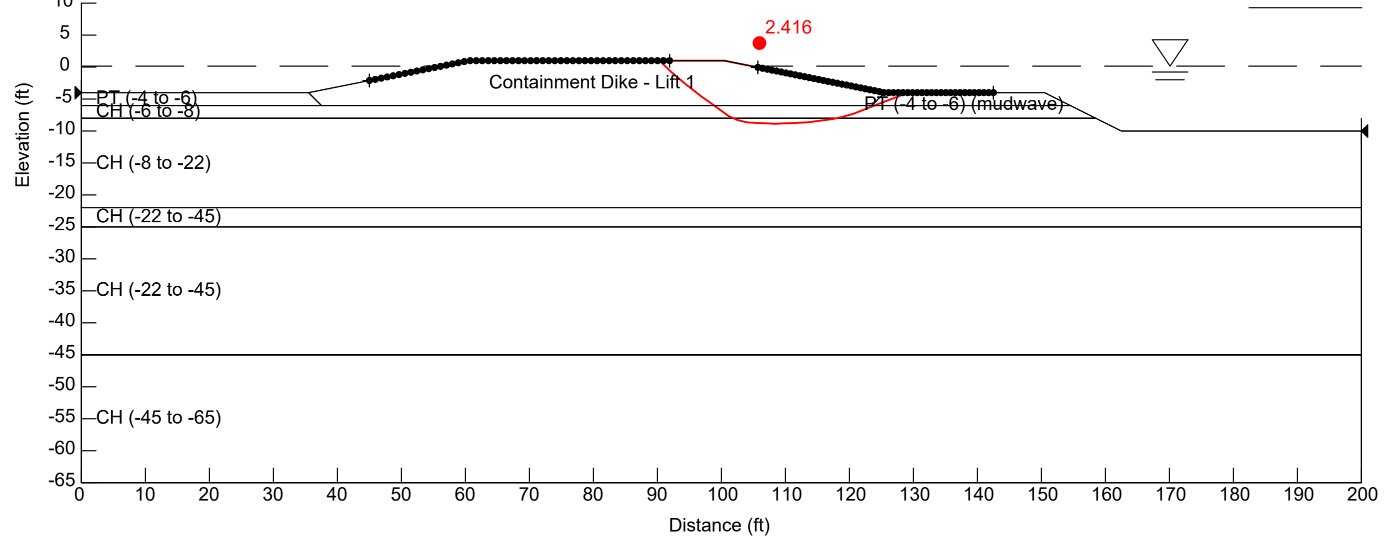
East Leeville Marsh Creation and Nourishment
(BA-194)
Lafourche Parish, Louisiana

GeoEngineers

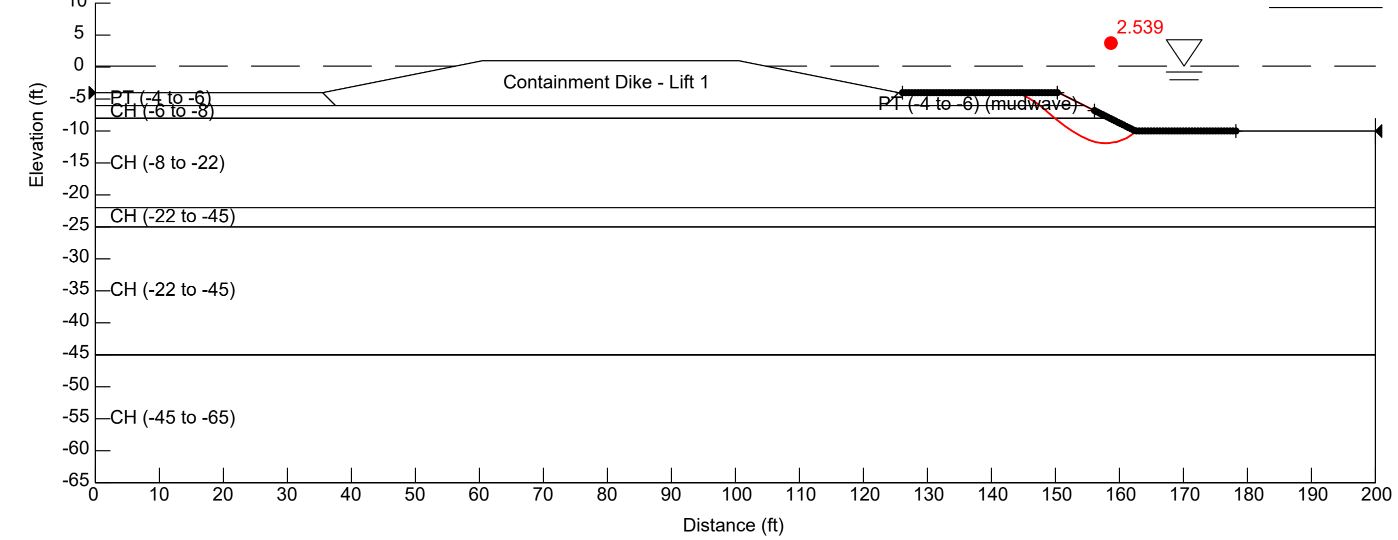
**Figure D-2b**

P:\18\18274004\CAD\02\Geotech - Final\18274004002_FD1-5b_Slope Stability.dwg TAB:D2b- Date Exported: 04/17/20 - 14:33 by kcook

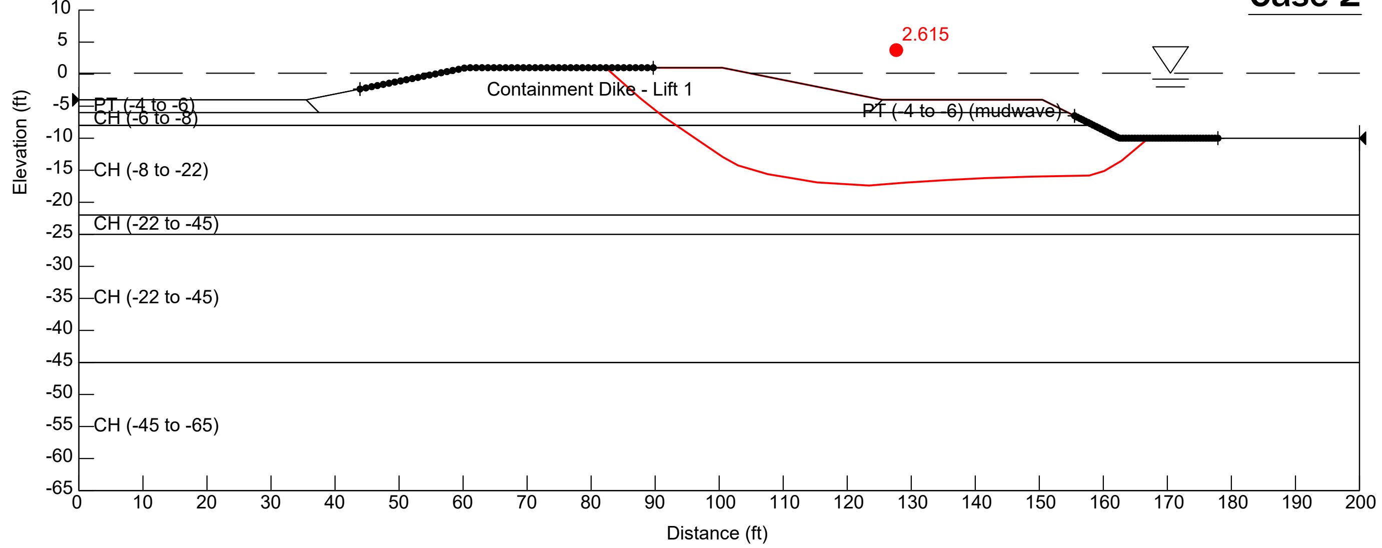
## Case 1




## Case 3




## Case 2




| Name | Model | Unit Weight (pcf) | Cohesion' (psf) | Phi' (°) | Cohesion Fn |
|---|---|---|---|---|---|
| Containment Dike - Lift 1 | Mohr-Coulomb | 90 | 60 | 0 | |
| PT (-4 to -6) | Mohr-Coulomb | 80 | 30 | 5 | |
| CH (-6 to -8) | Spatial Mohr-Coulomb | 108 | 75 | 0 | |
| CH (-8 to -22) | Spatial Mohr-Coulomb | 108 | | 0 | 75 psf + 7.1 psf/ft |
| CH (-22 to -45) | Spatial Mohr-Coulomb | 108 | | 0 | 175 psf + 10 psf/ft |
| CH (-45 to -65) | Spatial Mohr-Coulomb | 111 | | 0 | 405 psf + 10.75 psf/ft |
| PT (-4 to -6) (mudwave) | Mohr-Coulomb | 80 | 5 | 5 | |

**Gap Closure Slope Stability -**
**NE/S Cell 3, Mudline El. -4.0 Ft, Lift 1**

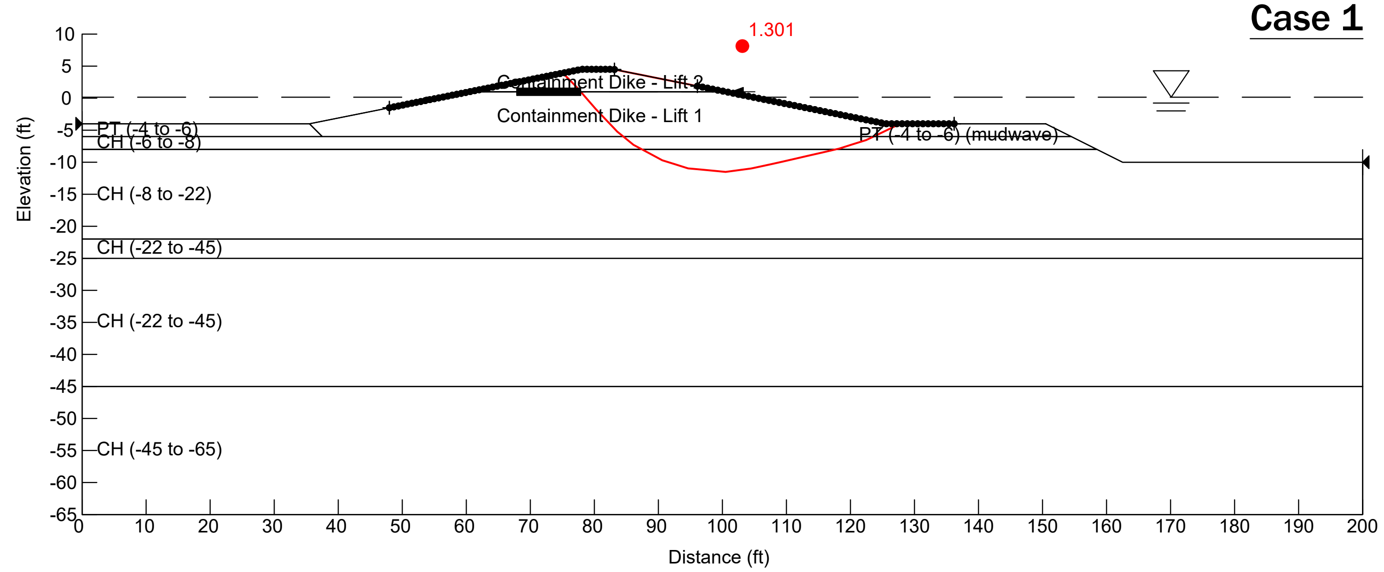
East Leeville Marsh Creation and Nourishment
(BA-194)
Lafourche Parish, Louisiana

GEOENGINEERS

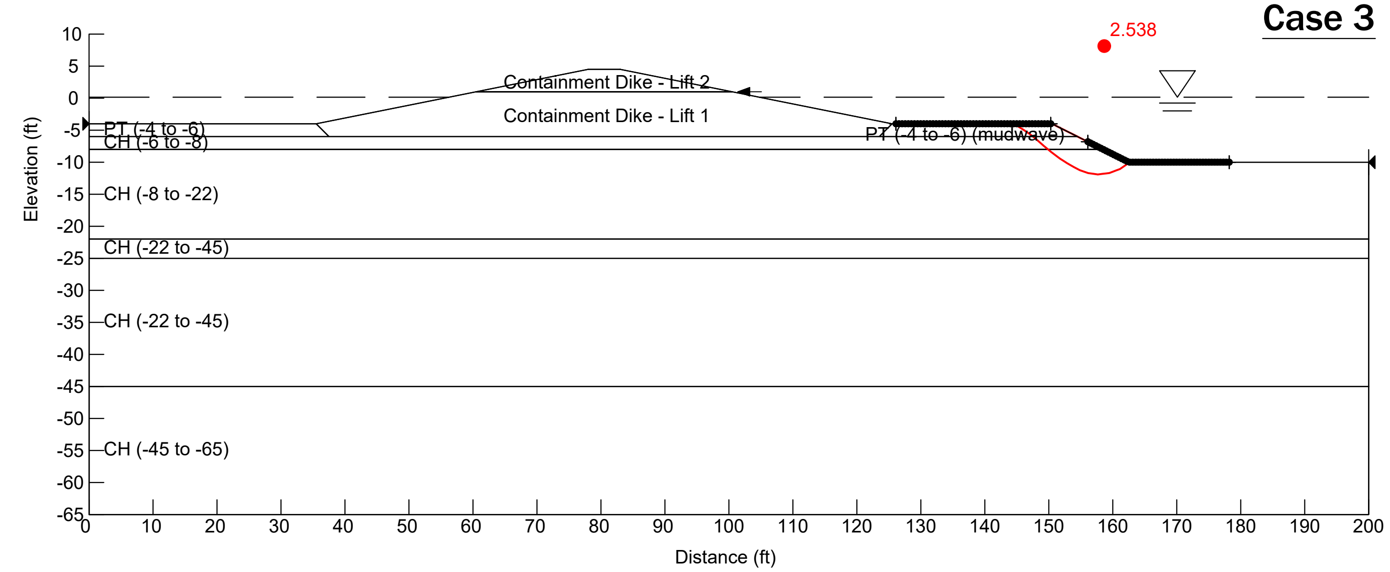
**Figure D-3a**

P:\18\18274004\CAD\02\Geotech - Final\18274004002_FD1-5b_Slope Stability.dwg TAB:D3a Date Exported: 04/17/20 - 14:34 by kcook

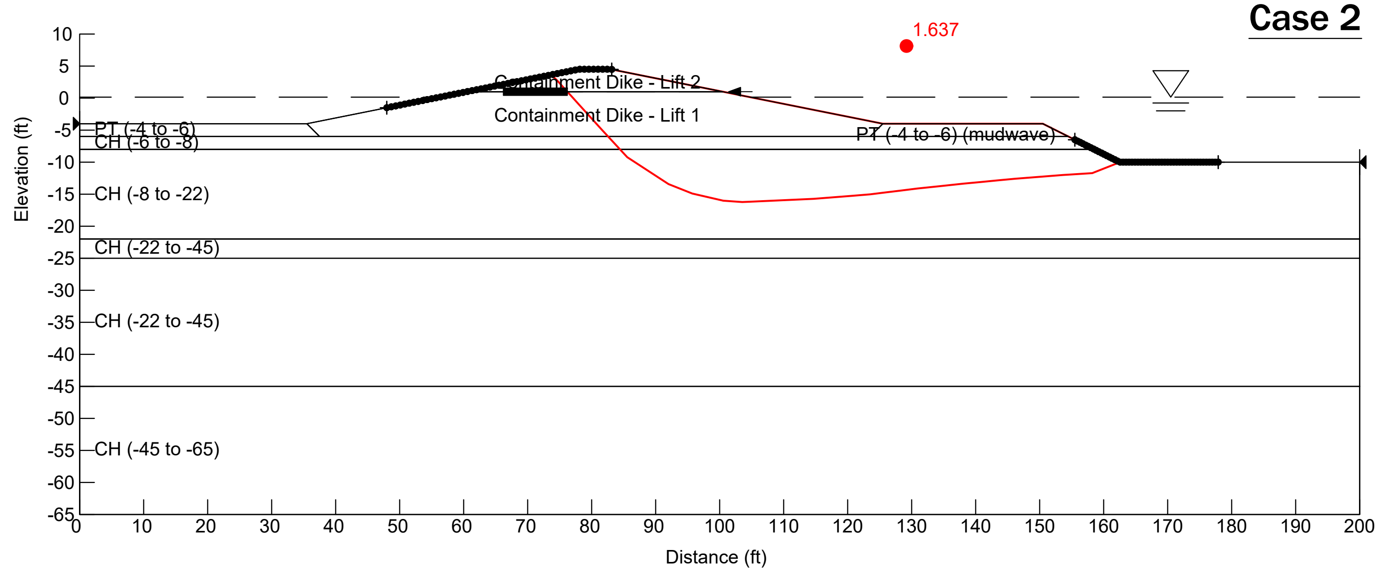
## Case 1



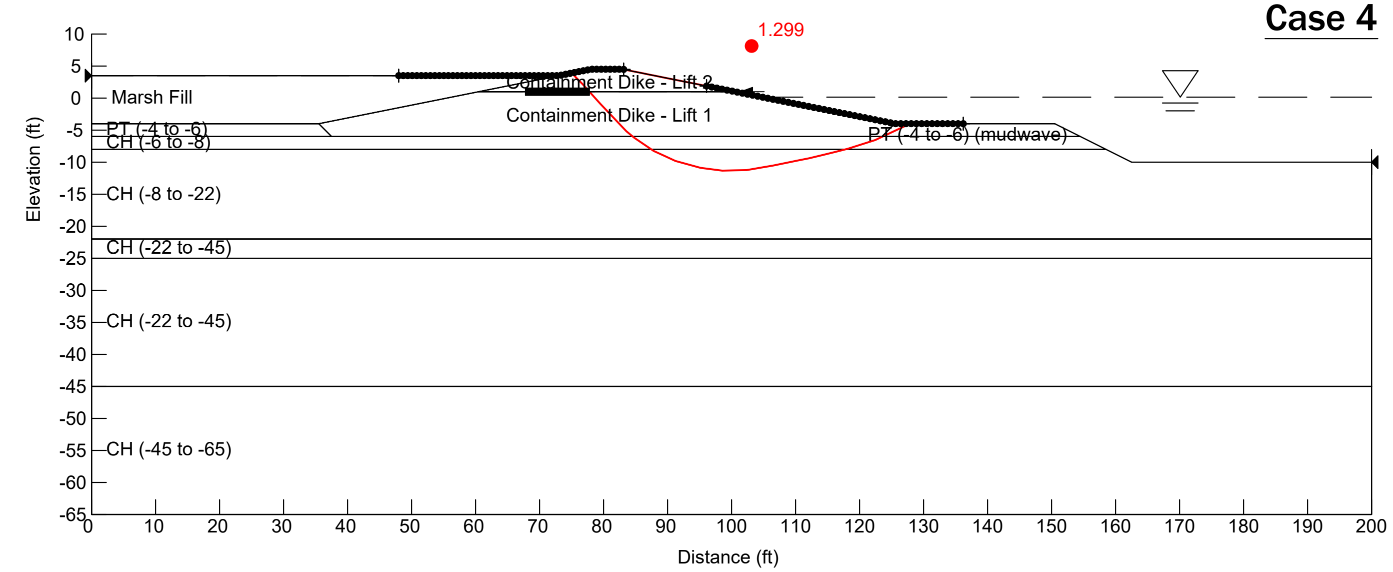

## Case 3




## Case 2




## Case 4




| Name | Model | Unit Weight (pcf) | Cohesion' (psf) | Phi' (°) | Cohesion Spatial Fn | Cohesion Fn |
|---|---|---|---|---|---|---|
| Marsh Fill | Mohr-Coulomb | 85 | 0 | 0 | | |
| Containment Dike - Lift 1 | Mohr-Coulomb | 90 | 66 | 0 | | |
| Containment Dike - Lift 2 | Mohr-Coulomb | 90 | 60 | 0 | | |
| PT (-4 to -6) (mudwave) | Mohr-Coulomb | 80 | 5 | 0 | | |
| PT (-4 to -6) | Spatial Mohr-Coulomb | 80 | 30 | 5 | | |
| CH (-6 to -8) | Spatial Mohr-Coulomb | 108 | | 0 | 75 psf + 15% | |
| CH (-8 to -22) | Spatial Mohr-Coulomb | 108 | | 0 | 75 psf + 7.1 psf/ft + 15% | |
| CH (-22 to -45) | Spatial Mohr-Coulomb | 108 | | 0 | | 175 psf + 10 psf/ft |
| CH (-45 to -65) | Spatial Mohr-Coulomb | 111 | | 0 | | 405 psf + 10.75 psf/ft |

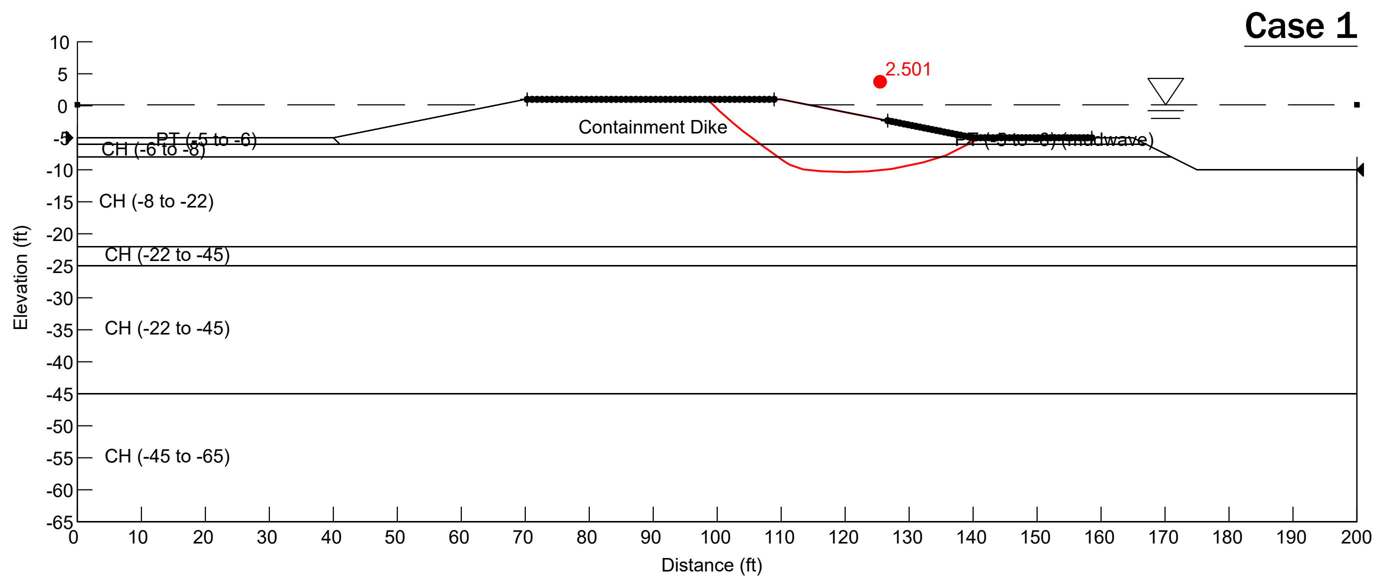
**Gap Closure Slope Stability - NE/S Cell 3, Mudline El. -4.0 Ft, Lift 2**

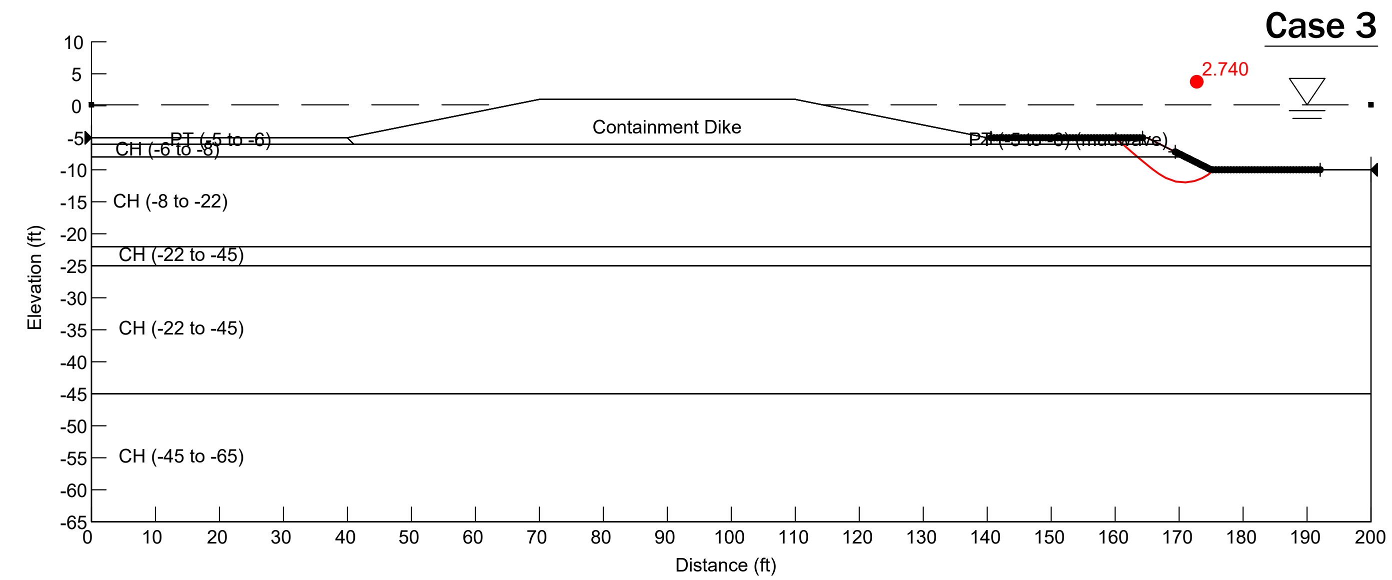
East Leeville Marsh Creation and Nourishment (BA-194)
Lafourche Parish, Louisiana

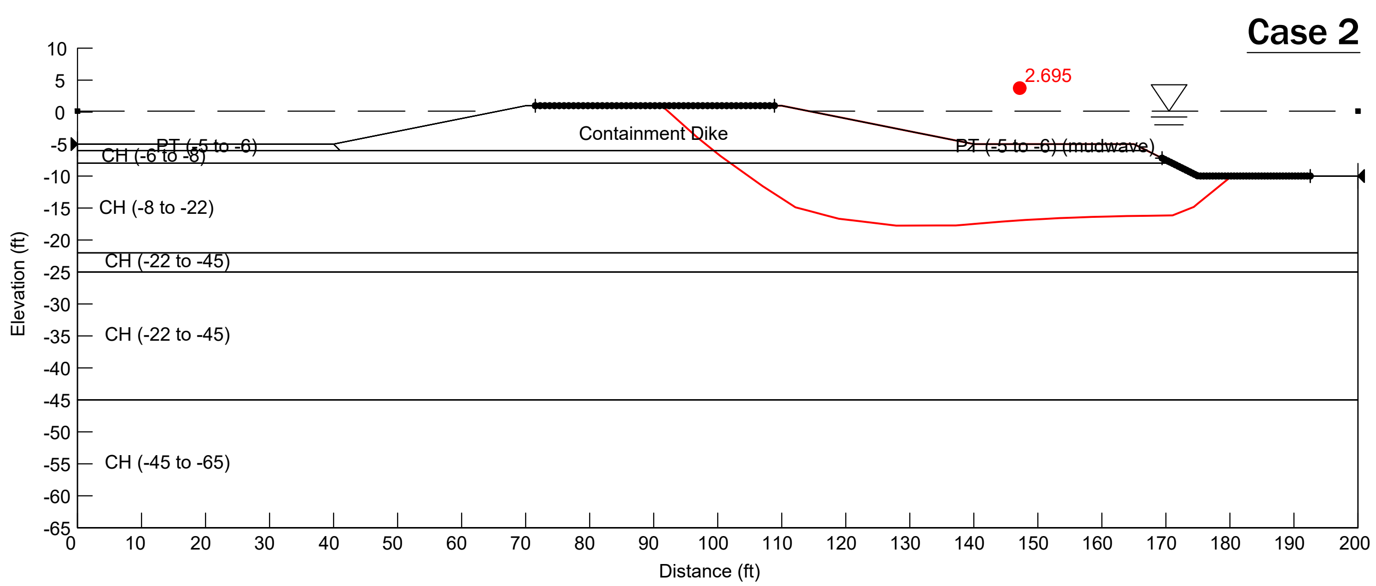
GeoEngineers

**Figure D-3b**

P:\18\18274004\CAD\02\Geotech - Final\18274004002_FD1-5b_Slope Stability.dwg TAB:D3b Date Exported: 04/17/20 - 14:36 by kcook




| Name | Model | Unit Weight (pcf) | Cohesion' (psf) | Phi' (°) | Cohesion Fn |
|---|---|---|---|---|---|
| Containment Dike | Mohr-Coulomb | 90 | 60 | 0 | |
| PT (-5 to -6) | Mohr-Coulomb | 80 | 30 | 5 | |
| PT (-5 to -6) (mudwave) | Mohr-Coulomb | 80 | 5 | 0 | |
| CH (-6 to -8) | Mohr-Coulomb | 108 | 75 | 0 | |
| CH (-8 to -22) | Spatial Mohr-Coulomb | 108 | | 0 | 75 psf + 7.1 psf/ft |
| CH (-22 to -45) | Spatial Mohr-Coulomb | 108 | | 0 | 175 psf + 10 psf/ft |
| CH (-45 to -65) | Spatial Mohr-Coulomb | 111 | | 0 | 405 psf + 10.75 psf/ft |

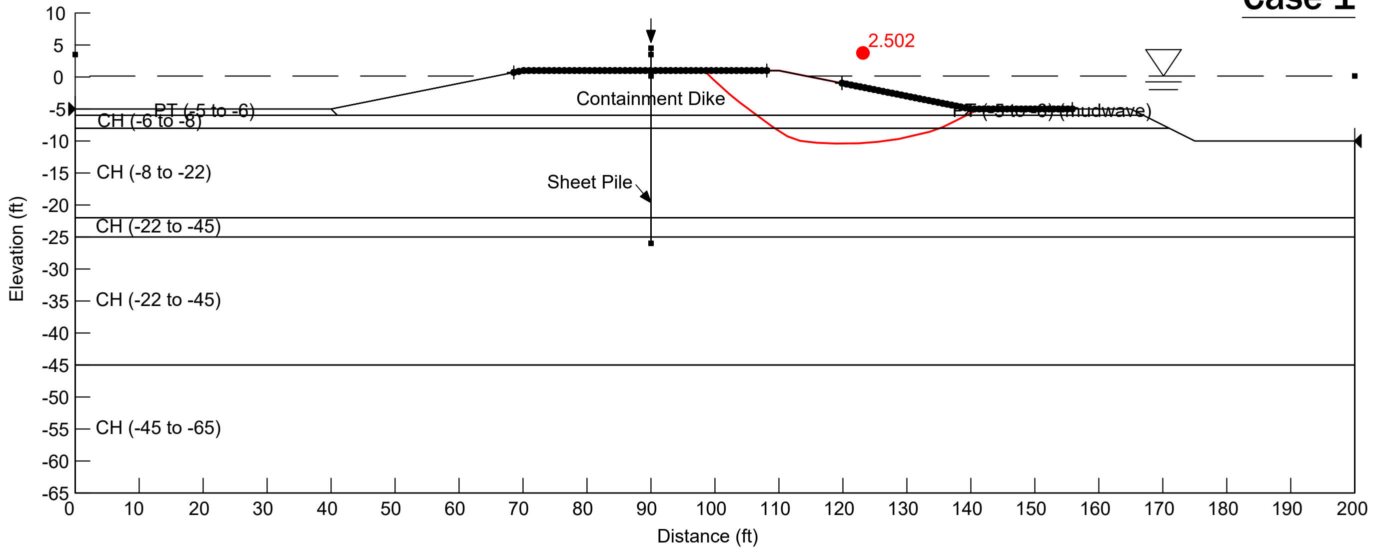
**Gap Closure Slope Stability - Cell 3, Mudline El. -5.0ft, Crown El. +1.0ft., Pre-Sheet Pile Installation**

East Leeville Marsh Creation and Nourishment
(BA-194)
Lafourche Parish, Louisiana

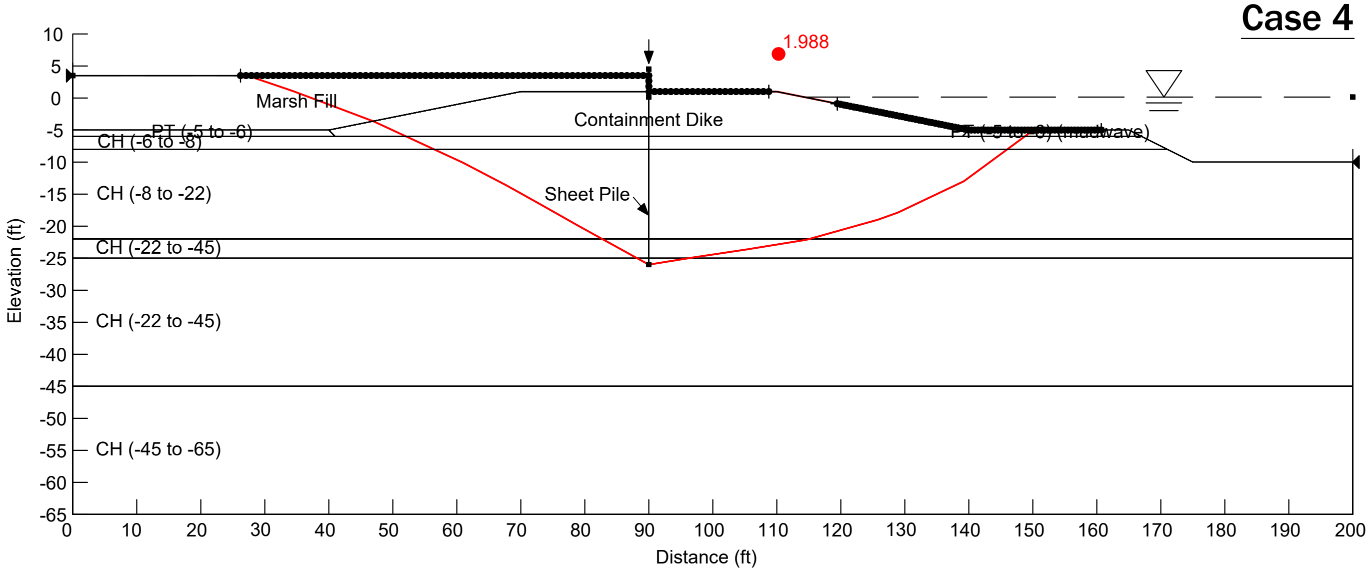
GeoEngineers

**Figure D-4a**

## Case 1




## Case 4



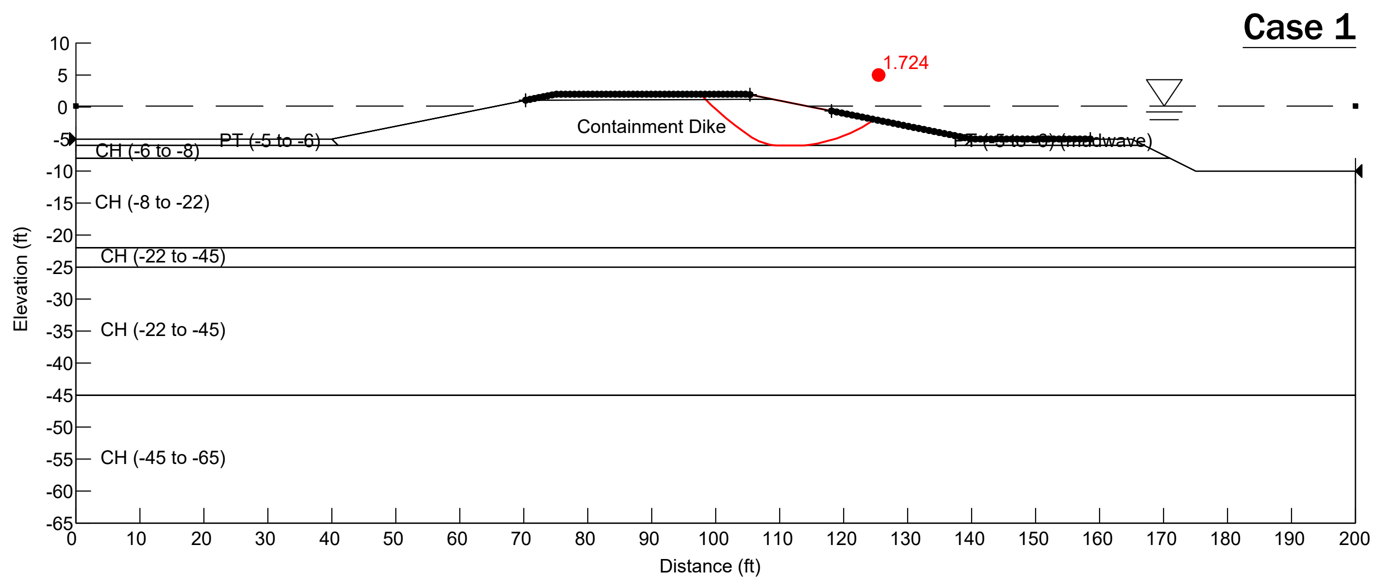

| Name | Model | Unit Weight (pcf) | Cohesion' (psf) | Phi' (°) | Cohesion Fn |
|---|---|---|---|---|---|
| Containment Dike | Mohr-Coulomb | 90 | 60 | 0 | |
| PT (-5 to -6) | Mohr-Coulomb | 80 | 30 | 5 | |
| PT (-5 to -6) (mudwave) | Mohr-Coulomb | 80 | 5 | 0 | |
| CH (-6 to -8) | Mohr-Coulomb | 108 | 75 | 0 | |
| CH (-8 to -22) | Spatial Mohr-Coulomb | 108 | | 0 | 75 psf + 7.1 psf/ft |
| CH (-22 to -45) | Spatial Mohr-Coulomb | 108 | | 0 | 175 psf + 10 psf/ft |
| CH (-45 to -65) | Spatial Mohr-Coulomb | 111 | | 0 | 405 psf + 10.75 psf/ft |

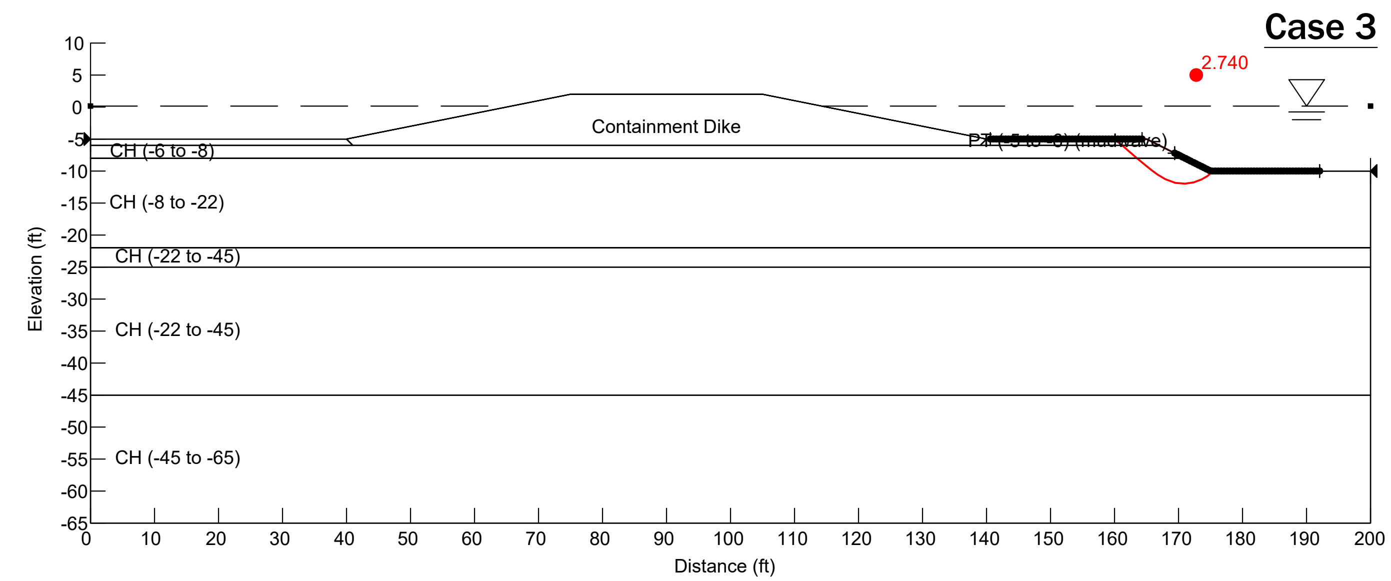
**Gap Closure Slope Stability - Cell 3, Mudline El. -5.0ft, Crown El. +1.0ft., Post-Sheet Pile Installation**

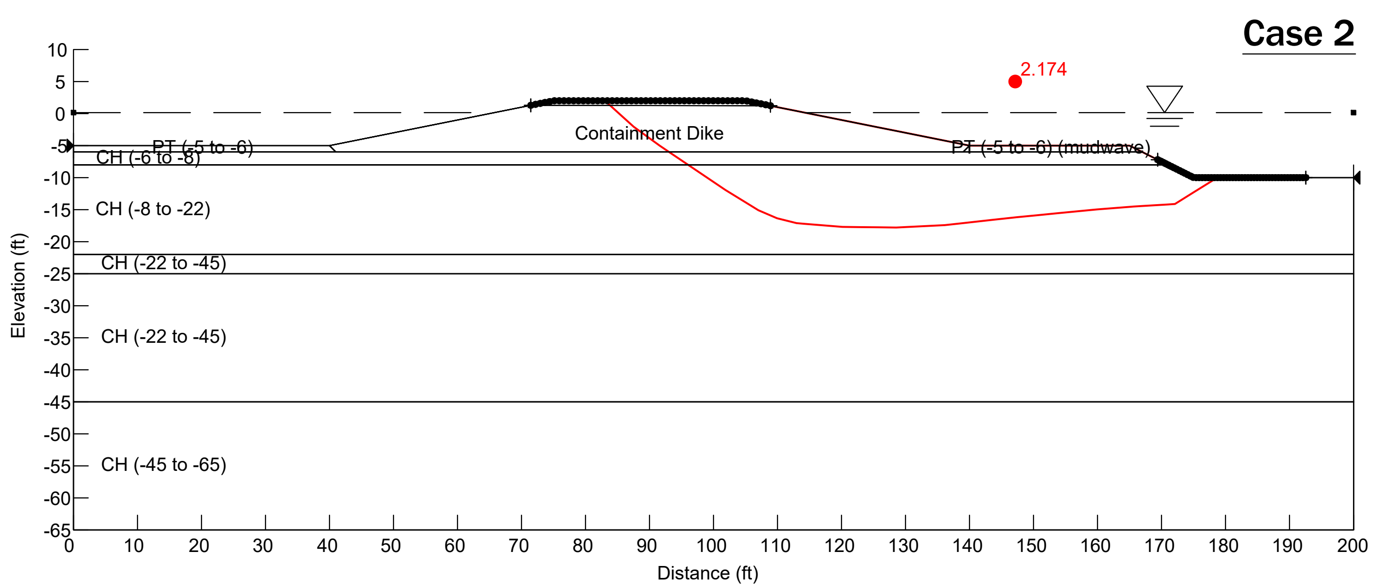
East Leeville Marsh Creation and Nourishment
(BA-194)
Lafourche Parish, Louisiana

GEOENGINEERS

**Figure D-4b**



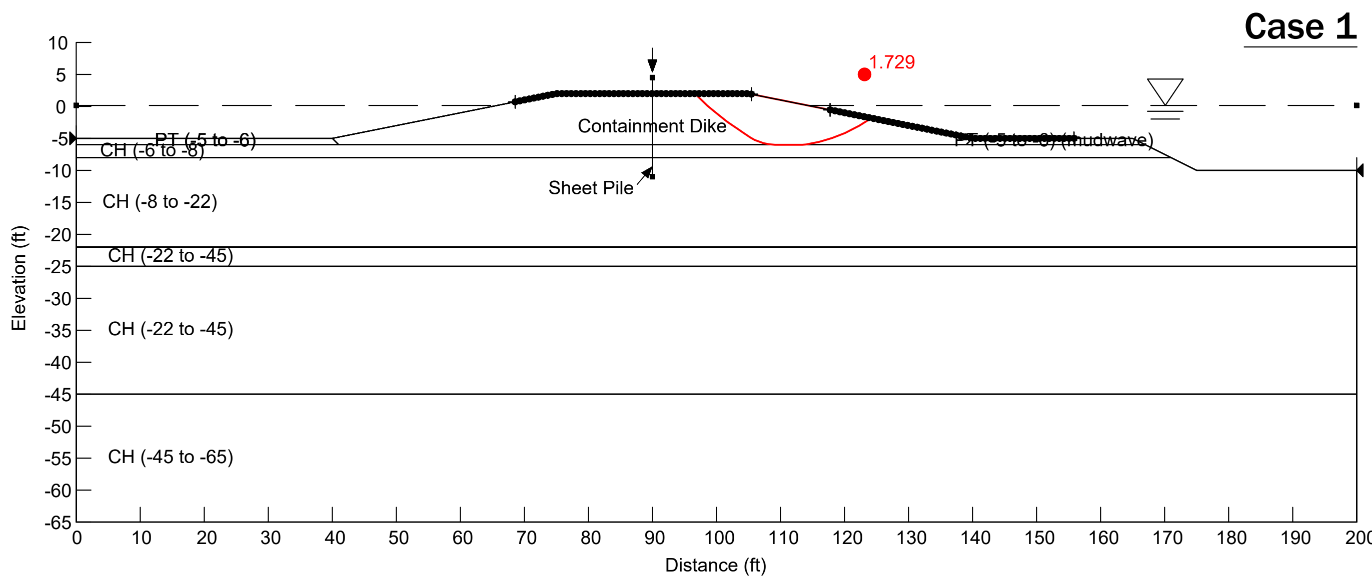

| Name | Model | Unit Weight (pcf) | Cohesion' (psf) | Phi' (°) | Cohesion Fn |
|---|---|---|---|---|---|
| Containment Dike | Mohr-Coulomb | 90 | 60 | 0 | |
| PT (-5 to -6) | Mohr-Coulomb | 80 | 30 | 5 | |
| PT (-5 to -6) (mudwave) | Mohr-Coulomb | 80 | 5 | 0 | |
| CH (-6 to -8) | Mohr-Coulomb | 108 | 75 | 0 | |
| CH (-8 to -22) | Spatial Mohr-Coulomb | 108 | | 0 | 75 psf + 7.1 psf/ft |
| CH (-22 to -45) | Spatial Mohr-Coulomb | 108 | | 0 | 175 psf + 10 psf/ft |
| CH (-45 to -65) | Spatial Mohr-Coulomb | 111 | | 0 | 405 psf + 10.75 psf/ft |

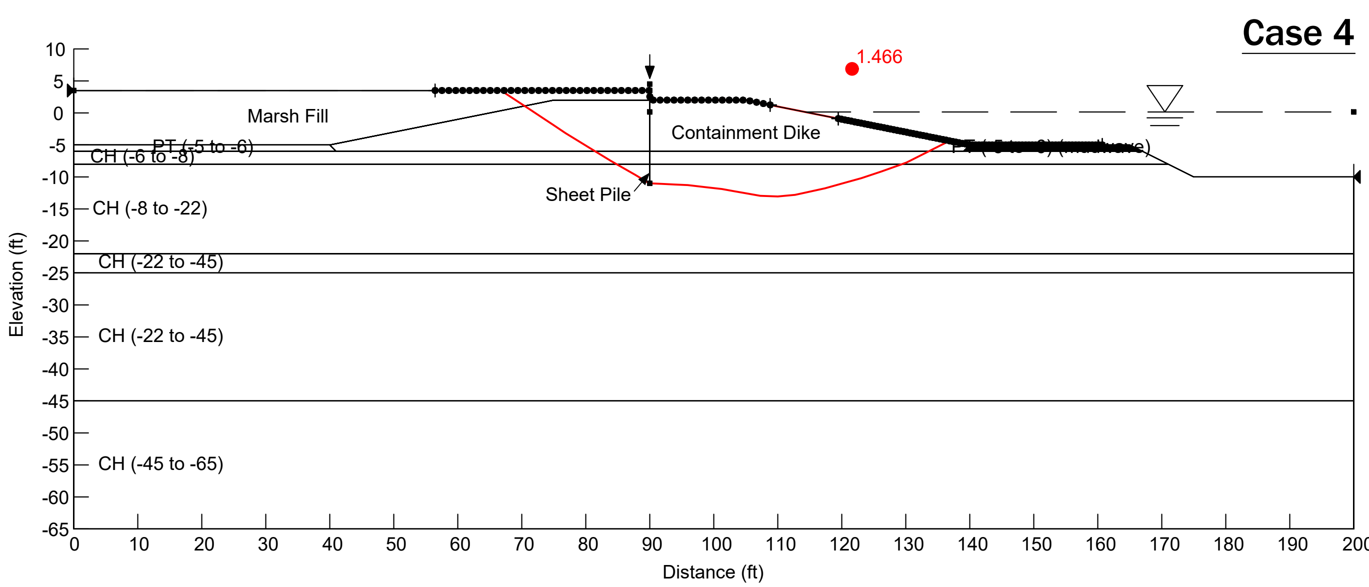
**Gap Closure Slope Stability - Cell 3, Mudline El. -5.0ft, Crown El. +2.0ft., Pre-Sheet Pile Installation**

East Leeville Marsh Creation and Nourishment
(BA-194)
Lafourche Parish, Louisiana

GeoEngineers

**Figure D-4c**




| Name | Model | Unit Weight (pcf) | Cohesion' (psf) | Phi' (°) | Cohesion Fn |
|---|---|---|---|---|---|
| Containment Dike | Mohr-Coulomb | 90 | 60 | 0 | |
| PT (-5 to -6) | Mohr-Coulomb | 80 | 30 | 5 | |
| PT (-5 to -6) (mudwave) | Mohr-Coulomb | 80 | 5 | 0 | |
| CH (-6 to -8) | Mohr-Coulomb | 108 | 75 | 0 | |
| CH (-8 to -22) | Spatial Mohr-Coulomb | 108 | | 0 | 75 psf + 7.1 psf/ft |
| CH (-22 to -45) | Spatial Mohr-Coulomb | 108 | | 0 | 175 psf + 10 psf/ft |
| CH (-45 to -65) | Spatial Mohr-Coulomb | 111 | | 0 | 405 psf + 10.75 psf/ft |

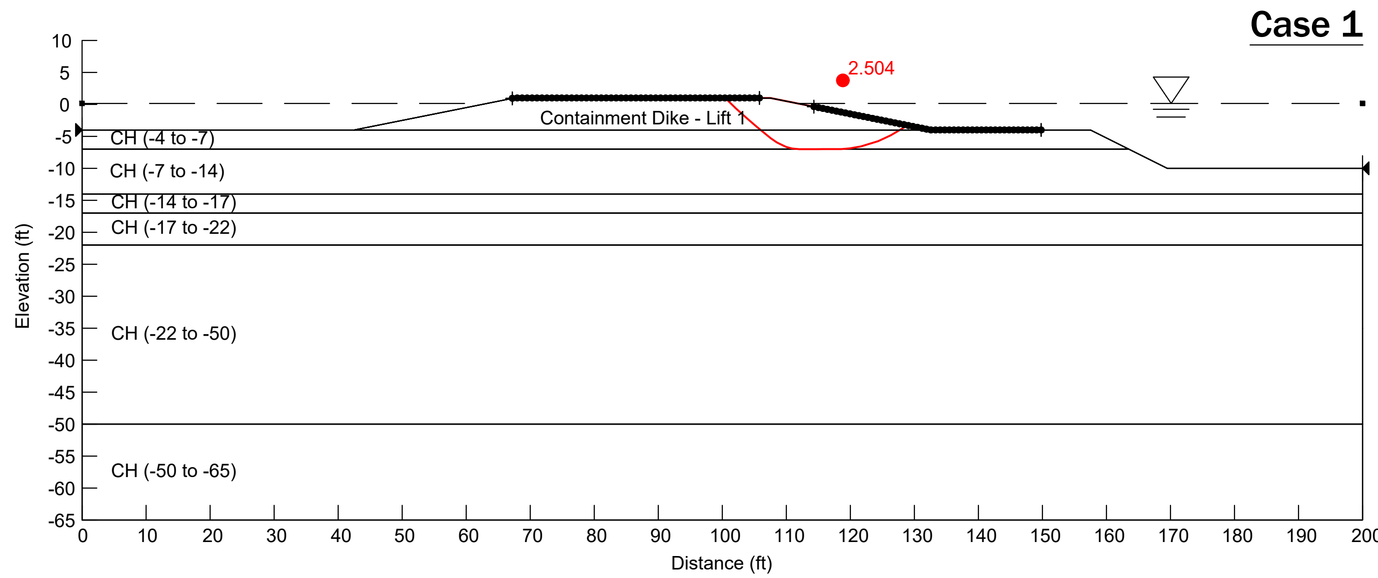
**Gap Closure Slope Stability - Cell 3, Mudline El. -5.0ft, Crown El. +2.0ft., Post-Sheet Pile Installation**

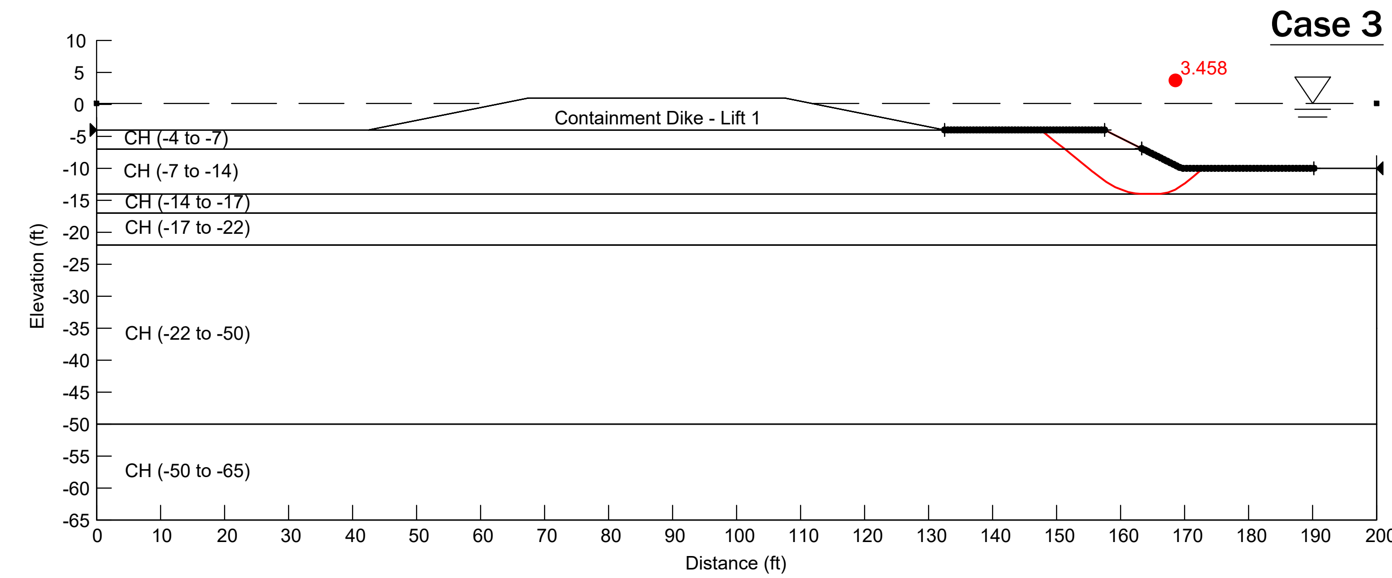
East Leeville Marsh Creation and Nourishment (BA-194)
Lafourche Parish, Louisiana

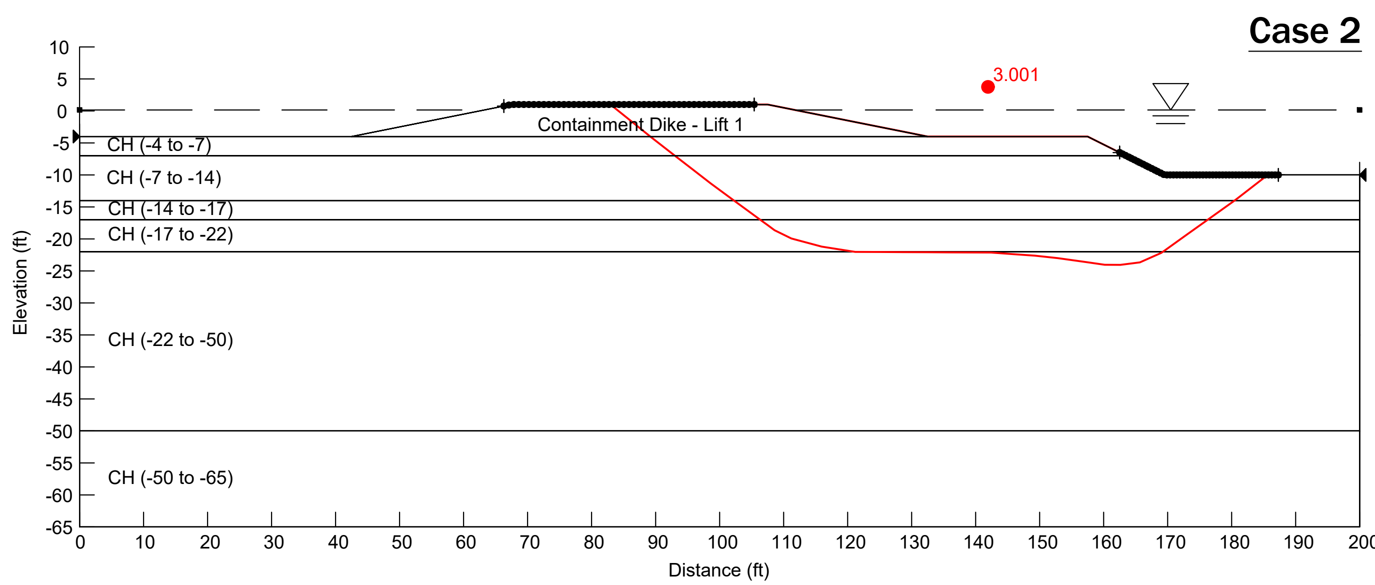
GeoEngineers

**Figure D-4d**

P:\18\18274004\CAD\02\Geotech - Final\18274400402_FD1-5b_Slope Stability.dwg TAB:D4d Date Exported: 04/17/20 - 14:50 by kcook



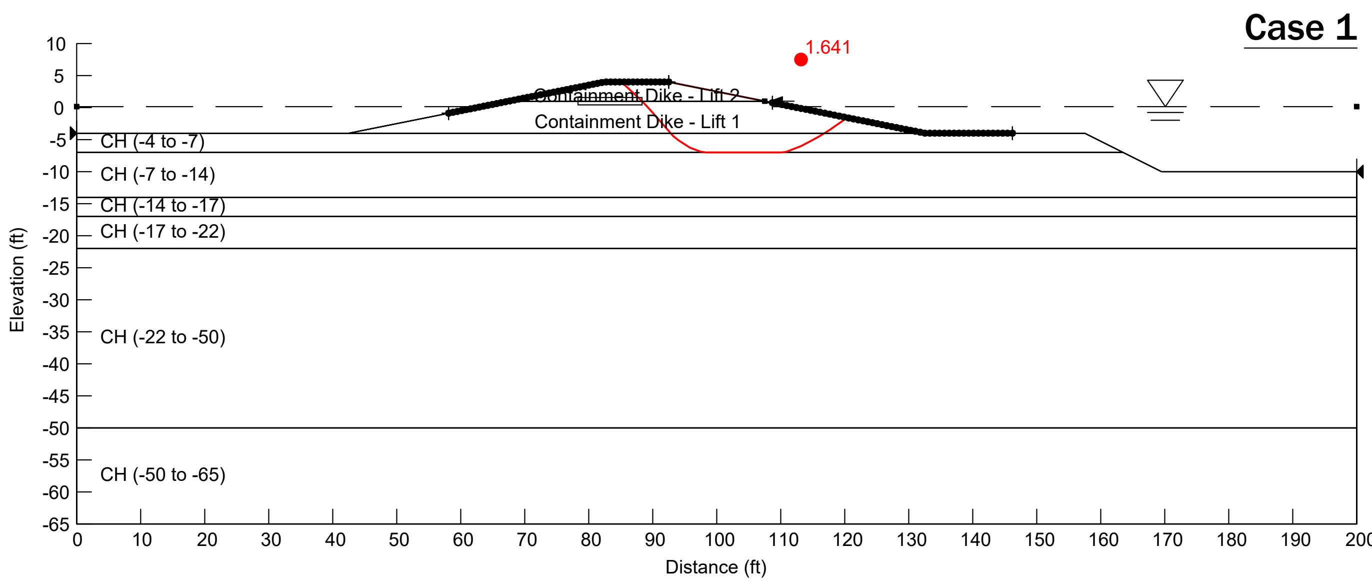

| Name | Model | Unit Weight (pcf) | Cohesion' (psf) | Phi' (°) | Cohesion Fn |
|---|---|---|---|---|---|
| Containment Dike - Lift 1 | Mohr-Coulomb | 95 | 60 | 0 | |
| CH (-4 to -7) | Mohr-Coulomb | 95 | 70 | 0 | |
| CH (-7 to -14) | Mohr-Coulomb | 110 | 150 | 0 | |
| CH (-14 to -17) | Mohr-Coulomb | 110 | 180 | 0 | |
| CH (-17 to -22) | Mohr-Coulomb | 110 | 195 | 0 | |
| CH (-22 to -50) | Spatial Mohr-Coulomb | 110 | | 0 | 195 psf + 10.4 psf/ft |
| CH (-50 to -65) | Spatial Mohr-Coulomb | 116 | | 0 | 485 psf + 12 psf/ft |

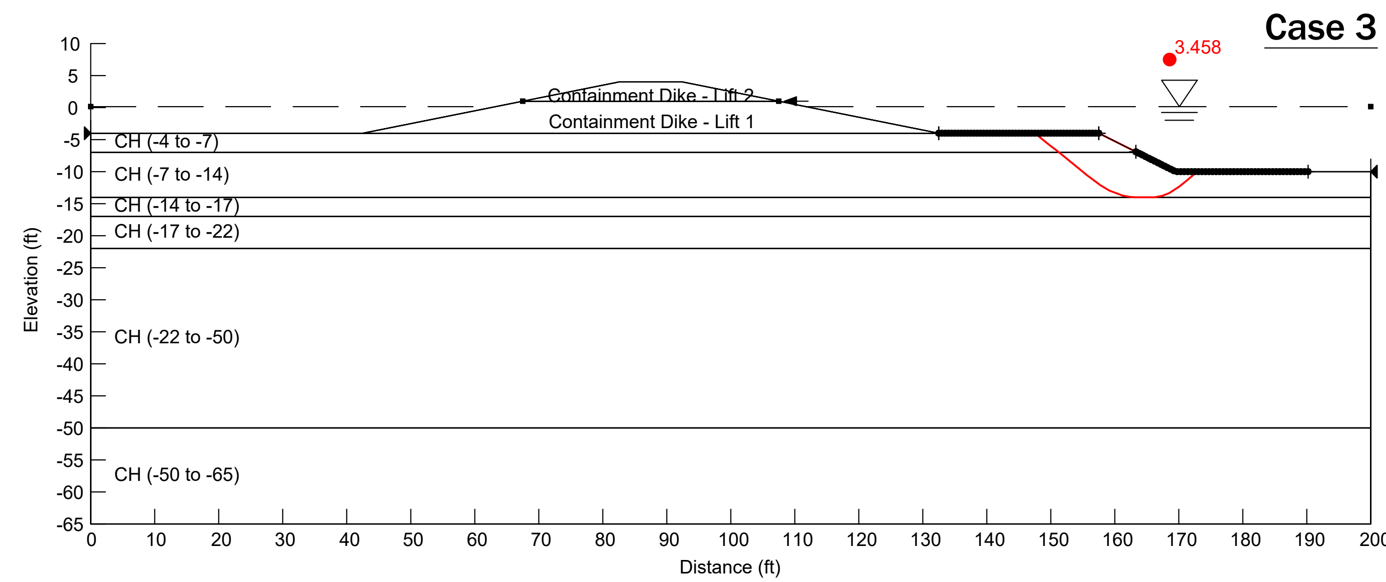
**Gap Closure Slope Stability - East Cell 6, Mudline El. -4.0ft, Lift 1**

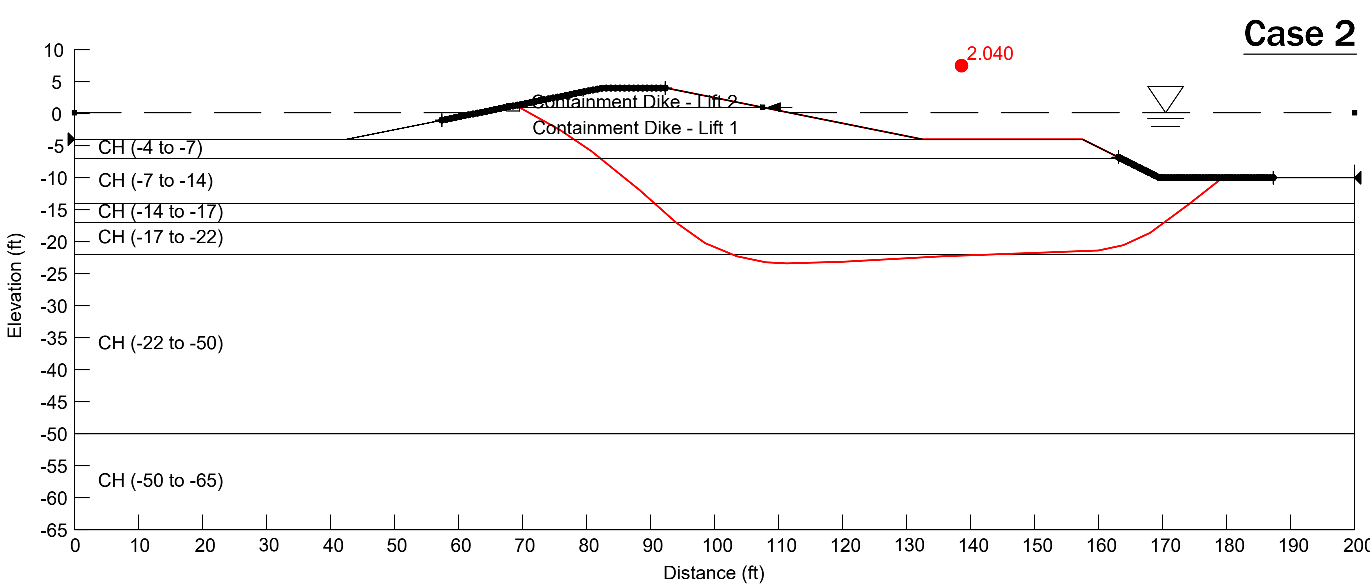
East Leeville Marsh Creation and Nourishment (BA-194)
Lafourche Parish, Louisiana

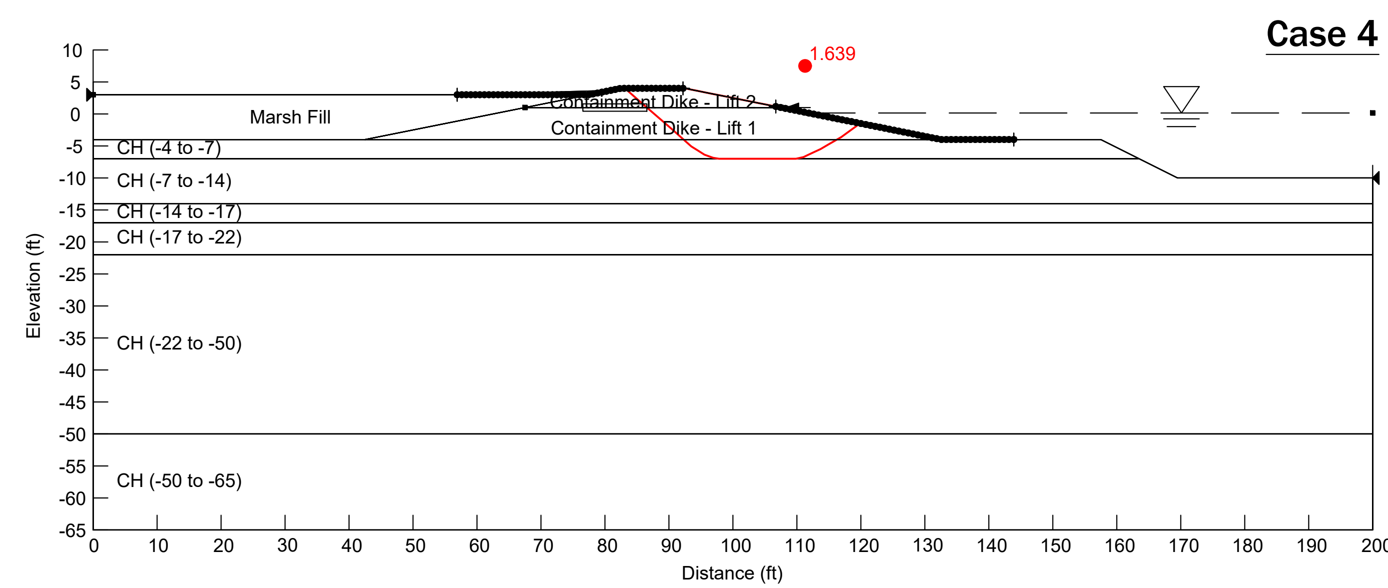
GEOENGINEERS

**Figure D-5a**




| Name | Model | Unit Weight (pcf) | Cohesion' (psf) | Phi' (°) | Cohesion Fn |
|---|---|---|---|---|---|
| Containment Dike - Lift 1 | Mohr-Coulomb | 95 | 60 | 0 | |
| CH (-4 to -7) | Mohr-Coulomb | 95 | 70 | 0 | |
| CH (-7 to -14) | Mohr-Coulomb | 110 | 150 | 0 | |
| CH (-14 to -17) | Mohr-Coulomb | 110 | 180 | 0 | |
| CH (-17 to -22) | Mohr-Coulomb | 110 | 195 | 0 | |
| CH (-22 to -50) | Spatial Mohr-Coulomb | 110 | | 0 | 195 psf + 10.4 psf/ft |
| CH (-50 to -65) | Spatial Mohr-Coulomb | 116 | | 0 | 485 psf + 12 psf/ft |

**Gap Closure Slope Stability - East Cell 6, Mudline El. -4.0ft, Lift 2**

East Leeville Marsh Creation and Nourishment (BA-194)
Lafourche Parish, Louisiana

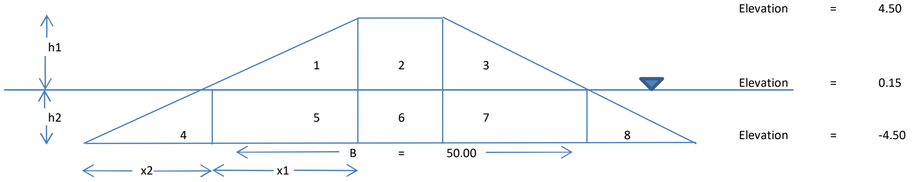
GeoEngineers

**Figure D-5b**

# FACTOR OF SAFETY FOR BEARING CAPACITY
# FOR UNREINFORCED DIKES USING NAVFAC DM 7; FIGURE 11-5, PAGE 7-11-6

## Cell 2 Gap Closure, Mudline -4.5ft

| Elevation at Bottom of Dike (ft.) | Elevation at Top of Dike (ft.) | Height of Dike (ft.) | Slope Inclination (H:V) | | Width at Top of Dike (ft.) | Elevation of Water (ft.) | Full Width at Bottom of Dike (ft.) | h1 (ft.) | h2 (ft.) | x1 (ft.) | x2 (ft.) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| -4.50 | 4.50 | 9.00 | 5.00 | 1.00 | 5.00 | 0.15 | 95.00 | 4.35 | 4.65 | 21.75 | 23.25 |




Assumptions:
1. Unit weight of dike = 95 pcf
2. Water at EL. +0.15 feet
3. Mudline at EL. -4.5 feet.
4. The effective width of the dike is equal to the width of the crown plus the width of one sloped side.
5. The factor of safety for bearing capacity must be greater or equal to 1.3.

## APPLIED STRESS

| Total Unit Weight of Dike (pcf) | Buoyant Unit Weight of Dike (pcf) | Effective Width of Dike (B) (ft.) | Applied Stress (psf) |
|---|---|---|---|
| 95.00 | 32.60 | 50.00 | 439 |

| Zone | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | Total |
|---|---|---|---|---|---|---|---|---|---|
| Area ($ft^2$) | 47 | 22 | 47 | 54 | 101 | 23 | 101 | 54 | 450 |
| Applied Load (lb./ft.) | 4494 | 2066 | 4494 | 1762 | 3297 | 758 | 3297 | 1762 | 21931 |

## SUBSURFACE CONDITIONS

| Soil Description | | Elevation (ft.) | | | | Cohesion (ksf) | Cohesion (psf) | Thickness (ft.) |
|---|---|---|---|---|---|---|---|---|
| CH (-4 to -7) | | -4.50 | - | -7.00 | | 0.100 | 100.00 | 2.50 |
| CH (-7 to -12) | | -7.00 | - | -12.00 | | 0.150 | 150.00 | 5.00 |
| CH (-12 to -18) | | -12.00 | - | -18.00 | | 0.150 | 150.00 | 6.00 |
| CH (-18 to -24) | | -18.00 | - | -24.00 | | 0.200 | 200.00 | 6.00 |
| CH (-24 to -50) | | -24.00 | - | -50.00 | | 0.300 | 300.00 | 26.00 |
| CH (-50 to -65) | | -50.00 | - | -65.00 | | 0.500 | 500.00 | 15.00 |
| | | | | | | | | |
| | | | | | | | | |

| T | B | T/B | C1 | C2 | C2/C1 |
|---|---|---|---|---|---|
| 19.50 | 50.00 | 0.39 | 158.97 | 300.00 | 1.9 |

## BEARING CAPACITY RESULTS

| Effective Width of Dike (B) (ft.) | Nc Factor From NAVFAC DM-7 Figure 11-5 | C1 | Ultimate Bearing Capacity (psf) | Applied Stress (psf) | Factor of Safety |
|---|---|---|---|---|---|
| 50.00 | 6.10 | 159 | 970 | 439 | 2.21 |

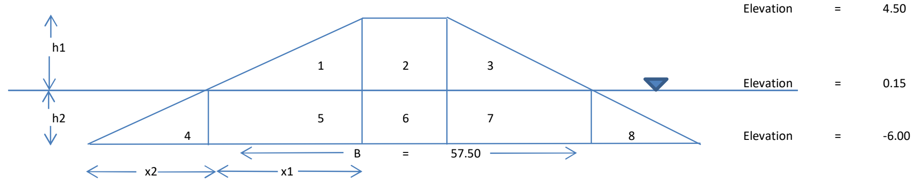
Figure D-6

# FACTOR OF SAFETY FOR BEARING CAPACITY
# FOR UNREINFORCED DIKES USING NAVFAC DM 7; FIGURE 11-5, PAGE 7-11-6

## Cell 3 Gap Closure, Mudline -4.0ft

| Elevation at Bottom of Dike (ft.) | Elevation at Top of Dike (ft.) | Height of Dike (ft.) | Slope Inclination (H:V) | | Width at Top of Dike (ft.) | Elevation of Water (ft.) | Full Width at Bottom of Dike (ft.) | h1 (ft.) | h2 (ft.) | x1 (ft.) | x2 (ft.) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| -6.00 | 4.50 | 10.50 | 5.00 | 1.00 | 5.00 | 0.15 | 110.00 | 4.35 | 6.15 | 21.75 | 30.75 |

*2 ft mudwave (surface layer C<50 psf)




Assumptions:
1. Unit weight of dike = 90 pcf
2. Water at EL. +0.15 feet
3. Mudline at EL. -4.0 feet w/ mudwave to EL. -6 ft
4. The effective width of the dike is equal to the width of the crown plus the width of one sloped side.
5. The factor of safety for bearing capacity must be greater or equal to 1.3.

## APPLIED STRESS

| Total Unit Weight of Dike (pcf) | Buoyant Unit Weight of Dike (pcf) | Effective Width of Dike (B) (ft.) | Applied Stress (psf) |
|---|---|---|---|
| 90.00 | 27.60 | 57.50 | 416 |

| Zone | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | Total |
|---|---|---|---|---|---|---|---|---|---|
| Area ($ft^2$) | 47 | 22 | 47 | 95 | 134 | 31 | 134 | 95 | 604 |
| Applied Load (lb./ft.) | 4258 | 1958 | 4258 | 2610 | 3692 | 849 | 3692 | 2610 | 23925 |

## SUBSURFACE CONDITIONS

| Soil Description | | Elevation (ft.) | | | | Cohesion (ksf) | Cohesion (psf) | Thickness (ft.) |
|---|---|---|---|---|---|---|---|---|
| CH (-6 to -8) | | -6.00 | - | -8.00 | | 0.075 | 75.00 | 2.00 |
| CH (-8 to -22) | | -8.00 | - | -22.00 | | 0.125 | 125.00 | 14.00 |
| CH (-22 to -45) | | -22.00 | - | -45.00 | | 0.200 | 200.00 | 23.00 |
| CH (-45 to -65) | | -45.00 | - | -65.00 | | 0.450 | 450.00 | 20.00 |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |

| T | B | T/B | C1 | C2 | C2/C1 |
|---|---|---|---|---|---|
| 16.00 | 57.50 | 0.28 | 118.75 | 200.00 | 1.7 |

## BEARING CAPACITY RESULTS

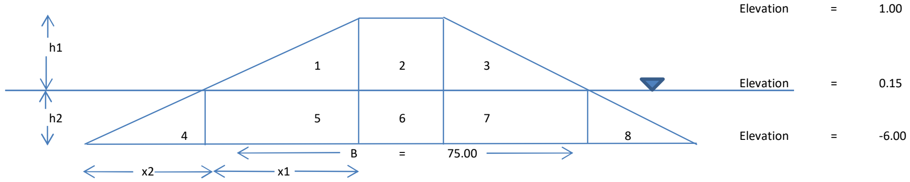
| Effective Width of Dike (B) (ft.) | Nc Factor From NAVFAC DM-7 Figure 11-5 | C1 | Ultimate Bearing Capacity (psf) | Applied Stress (psf) | Factor of Safety |
|---|---|---|---|---|---|
| 57.50 | 7.20 | 119 | 855 | 416 | 2.05 |

# FACTOR OF SAFETY FOR BEARING CAPACITY
# FOR UNREINFORCED DIKES USING NAVFAC DM 7; FIGURE 11-5, PAGE 7-11-6

## Cell 3 Sheet Pile Gap Closure, Mudline -5.0ft, Crown +1ft

| Elevation at Bottom of Dike (ft.) | Elevation at Top of Dike (ft.) | Height of Dike (ft.) | Slope Inclination (H:V) | | Width at Top of Dike (ft.) | Elevation of Water (ft.) | Full Width at Bottom of Dike (ft.) | h1 (ft.) | h2 (ft.) | x1 (ft.) | x2 (ft.) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| -6.00 | 1.00 | 7.00 | 5.00 | 1.00 | 40.00 | 0.15 | 110.00 | 0.85 | 6.15 | 4.25 | 30.75 |

*1 ft mudwave (surface layer C<50 psf)




Assumptions:
1. Unit weight of dike = 90 pcf
2. Water at EL. +0.15 feet
3. Mudline at EL. -5.0 feet w/ mudwave to EL. -6 ft
4. The effective width of the dike is equal to the width of the crown plus the width of one sloped side.
5. The factor of safety for bearing capacity must be greater or equal to 1.3.

## APPLIED STRESS

| Total Unit Weight of Dike (pcf) | Buoyant Unit Weight of Dike (pcf) | Effective Width of Dike (B) (ft.) | Applied Stress (psf) |
|---|---|---|---|
| 90.00 | 27.60 | 75.00 | 224 |

| Zone | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | Total |
|---|---|---|---|---|---|---|---|---|---|
| Area (ft$^2$) | 2 | 34 | 2 | 95 | 26 | 246 | 26 | 95 | 525 |
| Applied Load (lb./ft.) | 163 | 3060 | 163 | 2610 | 721 | 6790 | 721 | 2610 | 16837 |

## SUBSURFACE CONDITIONS

| Soil Description | | Elevation (ft.) | | | | Cohesion (ksf) | Cohesion (psf) | Thickness (ft.) |
|---|---|---|---|---|---|---|---|---|
| CH (-6 to -8) | | -6.00 | - | -8.00 | | 0.075 | 75.00 | 2.00 |
| CH (-8 to -22) | | -8.00 | - | -22.00 | | 0.125 | 125.00 | 14.00 |
| CH (-22 to -40) | | -22.00 | - | -40.00 | | 0.200 | 200.00 | 18.00 |
| CH (-40 to -45) | | -40.00 | - | -45.00 | | 0.200 | 200.00 | 5.00 |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |

| T | B | T/B | C1 | C2 | C2/C1 |
|---|---|---|---|---|---|
| 34.00 | 75.00 | 0.45 | 161.76 | 200.00 | 1.2 |

## BEARING CAPACITY RESULTS

| Effective Width of Dike (B) (ft.) | Nc Factor From NAVFAC DM-7 Figure 11-5 | C1 | Ultimate Bearing Capacity (psf) | Applied Stress (psf) | Factor of Safety |
|---|---|---|---|---|---|
| 75.00 | 5.50 | 162 | 890 | 224 | 3.96 |

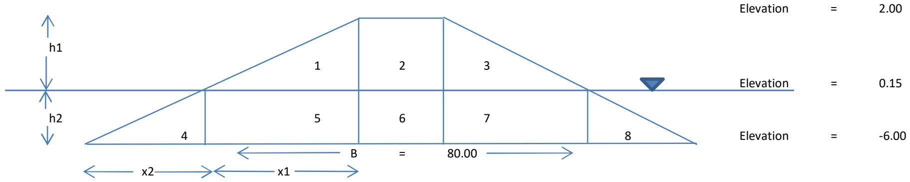
Figure D-8a

# FACTOR OF SAFETY FOR BEARING CAPACITY
# FOR UNREINFORCED DIKES USING NAVFAC DM 7; FIGURE 11-5, PAGE 7-11-6

## Cell 3 Sheet Pile Gap Closure, Mudline -5.0ft, Crown +2ft

| Elevation at Bottom of Dike (ft.) | Elevation at Top of Dike (ft.) | Height of Dike (ft.) | Slope Inclination (H:V) | | Width at Top of Dike (ft.) | Elevation of Water (ft.) | Full Width at Bottom of Dike (ft.) | h1 (ft.) | h2 (ft.) | x1 (ft.) | x2 (ft.) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| -6.00 | 2.00 | 8.00 | 5.00 | 1.00 | 40.00 | 0.15 | 120.00 | 1.85 | 6.15 | 9.25 | 30.75 |

*1 ft mudwave (surface layer C<50 psf)




Assumptions:
1. Unit weight of dike = 90 pcf
2. Water at EL. +0.15 feet
3. Mudline at EL. -5.0 feet w/ mudwave to EL. -6 ft
4. The effective width of the dike is equal to the width of the crown plus the width of one sloped side.
5. The factor of safety for bearing capacity must be greater or equal to 1.3.

## APPLIED STRESS

| Total Unit Weight of Dike (pcf) | Buoyant Unit Weight of Dike (pcf) | Effective Width of Dike (B) (ft.) | Applied Stress (psf) |
|---|---|---|---|
| 90.00 | 27.60 | 80.00 | 292 |

| Zone | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | Total |
|---|---|---|---|---|---|---|---|---|---|
| Area ($ft^2$) | 9 | 74 | 9 | 95 | 57 | 246 | 57 | 95 | 640 |
| Applied Load (lb./ft.) | 770 | 6660 | 770 | 2610 | 1570 | 6790 | 1570 | 2610 | 23349 |

## SUBSURFACE CONDITIONS

| Soil Description | | Elevation (ft.) | | | | Cohesion (ksf) | Cohesion (psf) | Thickness (ft.) |
|---|---|---|---|---|---|---|---|---|
| CH (-6 to -8) | | -6.00 | - | -8.00 | | 0.075 | 75.00 | 2.00 |
| CH (-8 to -22) | | -8.00 | - | -22.00 | | 0.125 | 125.00 | 14.00 |
| CH (-22 to -40) | | -22.00 | - | -40.00 | | 0.200 | 200.00 | 18.00 |
| CH (-40 to -45) | | -40.00 | - | -45.00 | | 0.200 | 200.00 | 5.00 |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |

| T | B | T/B | C1 | C2 | C2/C1 |
|---|---|---|---|---|---|
| 34.00 | 80.00 | 0.43 | 161.76 | 200.00 | 1.2 |

## BEARING CAPACITY RESULTS

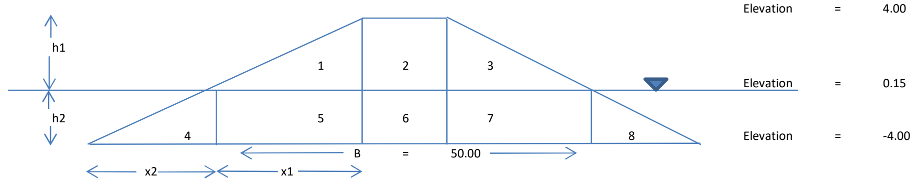
| Effective Width of Dike (B) (ft.) | Nc Factor From NAVFAC DM-7 Figure 11-5 | C1 | Ultimate Bearing Capacity (psf) | Applied Stress (psf) | Factor of Safety |
|---|---|---|---|---|---|
| 80.00 | 5.50 | 162 | 890 | 292 | 3.05 |

Figure D-8b

# FACTOR OF SAFETY FOR BEARING CAPACITY
# FOR UNREINFORCED DIKES USING NAVFAC DM 7; FIGURE 11-5, PAGE 7-11-6

## Cell 6 Gap Closure, Mudline -4.0ft

| Elevation at Bottom of Dike (ft.) | Elevation at Top of Dike (ft.) | Height of Dike (ft.) | Slope Inclination (H:V) | | Width at Top of Dike (ft.) | Elevation of Water (ft.) | Full Width at Bottom of Dike (ft.) | h1 (ft.) | h2 (ft.) | x1 (ft.) | x2 (ft.) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| -4.00 | 4.00 | 8.00 | 5.00 | 1.00 | 10.00 | 0.15 | 90.00 | 3.85 | 4.15 | 19.25 | 20.75 |




Assumptions:
1. Unit weight of dike = 95 pcf
2. Water at EL. +0.15 feet
3. Mudline at EL -4 feet
4. The effective width of the dike is equal to the width of the crown plus the width of one sloped side.
5. The factor of safety for bearing capacity must be greater or equal to 1.3.

## APPLIED STRESS

| Total Unit Weight of Dike (pcf) | Buoyant Unit Weight of Dike (pcf) | Effective Width of Dike (B) (ft.) | Applied Stress (psf) |
|---|---|---|---|
| 95.00 | 32.60 | 50.00 | 401 |

| Zone | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | Total |
|---|---|---|---|---|---|---|---|---|---|
| Area (ft$^2$) | 37 | 39 | 37 | 43 | 80 | 42 | 80 | 43 | 400 |
| Applied Load (lb./ft.) | 3520 | 3658 | 3520 | 1404 | 2604 | 1353 | 2604 | 1404 | 20067 |

## SUBSURFACE CONDITIONS

| Soil Description | | Elevation (ft.) | | | | Cohesion (ksf) | Cohesion (psf) | Thickness (ft.) |
|---|---|---|---|---|---|---|---|---|
| CH (-4 to -7) | | -4.00 | - | -7.00 | | 0.070 | 70.00 | 3.00 |
| CH (-7 to -14) | | -7.00 | - | -14.00 | | 0.150 | 150.00 | 7.00 |
| CH (-14 to -17) | | -14.00 | - | -17.00 | | 0.180 | 180.00 | 3.00 |
| CH (-17 to -22) | | -17.00 | - | -22.00 | | 0.195 | 195.00 | 5.00 |
| CH (-22 to -50) | | -22.00 | - | -50.00 | | 0.200 | 200.00 | 28.00 |
| CH (-50 to -65) | | -50.00 | - | -65.00 | | 0.500 | 500.00 | 15.00 |
| | | | | | | | | |
| | | | | | | | | |

| T | B | T/B | C1 | C2 | C2/C1 |
|---|---|---|---|---|---|
| 18.00 | 50.00 | 0.36 | 154.17 | 200.00 | 1.3 |

## BEARING CAPACITY RESULTS

| Effective Width of Dike (B) (ft.) | Nc Factor From NAVFAC DM-7 Figure 11-5 | C1 | Ultimate Bearing Capacity (psf) | Applied Stress (psf) | Factor of Safety |
|---|---|---|---|---|---|
| 50.00 | 6.00 | 154 | 925 | 401 | 2.30 |

Figure D-9

# Appendix E
## Marsh Creation Fill and Foundation Settlement

## APPENDIX E
## MARSH CREATION FILL AND FOUNDATION SETTLEMENT

### Calculation Approach

Settlement parameters and drainage considerations were developed as described in the calculation approach description for containment dike settlement in Appendix C.

For the marsh fill material, consolidation parameters were obtained from low-stress consolidation test results. Three composite samples from within the proposed borrow area were created and tested. The results of the tests were used to model the marsh fill material for these analyses.

Marsh creation area settlement consists primarily of two separate processes: consolidation of dredged fill and consolidation of the foundation soils. Consolidation of the dredged fill was modeled using PSDDF (Primary Consolidation, Secondary Compression, and Desiccation of Dredged Fill), a program created for the USACE to simulate finite strain consolidation in dredged fill materials. Consolidation of the foundation soils was modeled iteratively using one-dimensional consolidation theory and Boussinesq stress distribution in the SETANL computer program.

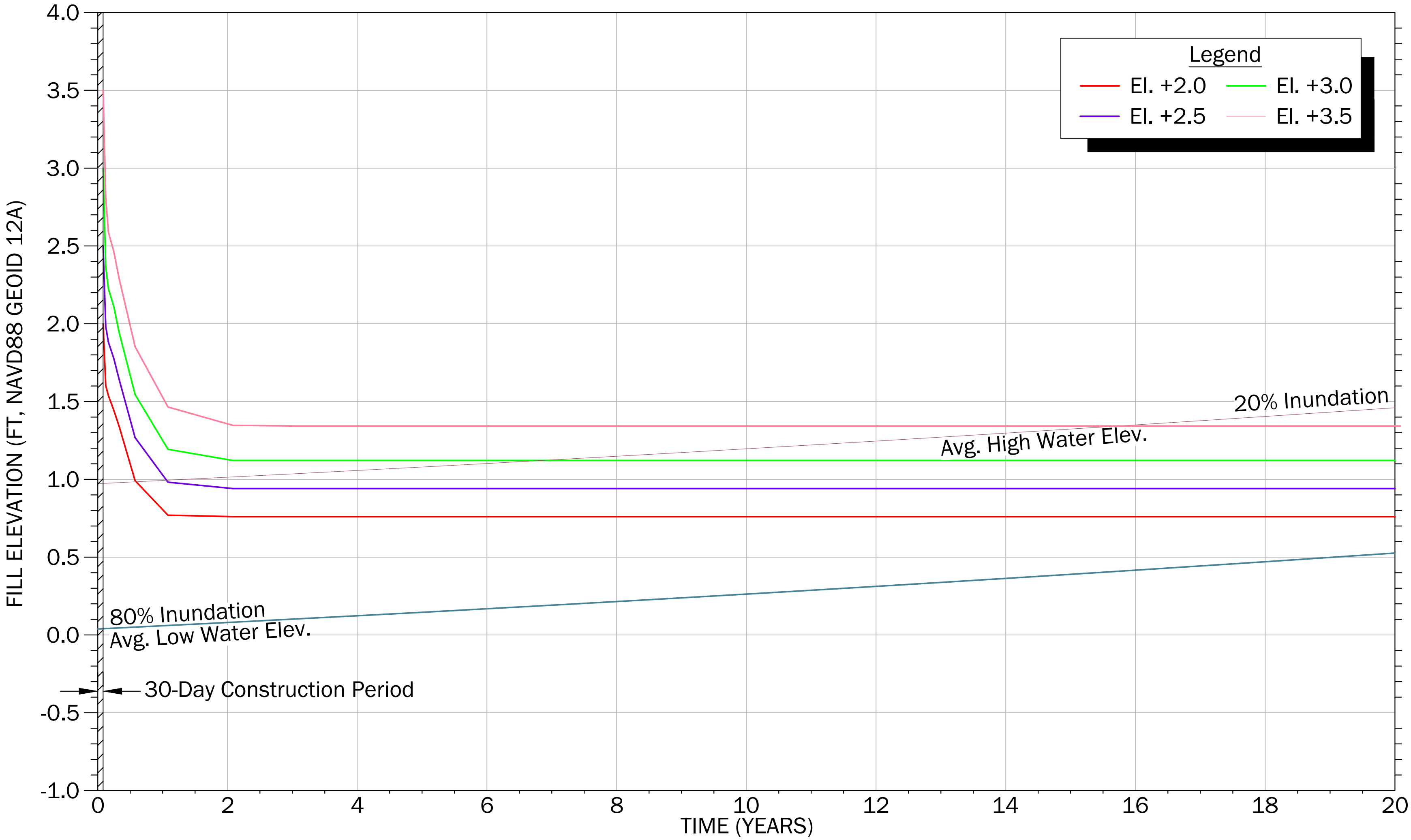
To account for the effects of progressive dredged fill densification and submergence below the waterline caused by fill and foundation soil settlement, we re-computed the effective vertical stress and corresponding settlement at various time intervals after fill placement. The typical steps at each time interval included the following:

1. We calculate settlement for the foundation soil beneath the fill based on the elapsed time and the effective stress calculated for the application of a single lift of dredged fill. The foundation settlement results determine the new mudline elevation.
2. From PSDDF, we determine the change in thickness of the dredged fill to calculate the new fill density and the new fill surface elevation. The new fill surface elevation is influenced by both the foundation settlement and the change in fill thickness computed by PSDDF.
3. We then re-compute the effective vertical stress based on the new fill surface and mudline elevations. The water level was assumed to mound within the marsh fill until the fill surface lowered beneath the mean high-water level of El. +1.08 feet, as provided by CPRA. The water level was assumed to be at the mean high-water level for the remainder of the time increments.
4. We then use the new, lower effective stress to re-compute foundation settlement.

This process is repeated at days 30, 60, 90, 180, 365 (1 year), 730 (2 years), 1095 (3 years), 1825 (5 years), 3650 (10 years), and 7300 (20 years). To model settlement occurring within the hydraulic fill during the construction period (30 to 60 days), we applied multiple lifts to the dredged fill during the construction period. A unit weight was calculated using a specific gravity of 2.71 and using an average void ratio from the combination of each fill lift at the end of construction. This unit weight was used to compute the load from the marsh fill at the end of construction and estimate the time-rate settlement.

The sum of the dredged fill settlement and the underlying foundation soil settlement was used to determine the total settlement at the surface of the dredged fill area after completion of fill placement. Settlement of dredged fill evaluations were performed for scenarios with fill placed to a surface elevation of +1.5 feet to +3.5 feet at the end of construction. The results of our analyses are shown in the following figures.

Our evaluation does not include regional subsidence. Additional elevation loss due to regional subsidence must be subtracted from the curves included in this report.




| FILL ELEVATION (FEET NAVD88) | | | | | | |
|---|---|---|---|---|---|---|
| END OF CONSTRUCTION | 6 MONTHS | 1 YEAR | 3 YEARS | 5 YEARS | 10 YEARS | 20 YEARS |
| 3.5 | 2.0 | 1.5 | 1.3 | 1.3 | 1.3 | 1.3 |
| 3.0 | 1.7 | 1.2 | 1.1 | 1.1 | 1.1 | 1.1 |
| 2.5 | 1.4 | 1.0 | 0.9 | 0.9 | 0.9 | 0.9 |
| 2.0 | 1.0 | 0.7 | 0.7 | 0.7 | 0.7 | 0.7 |

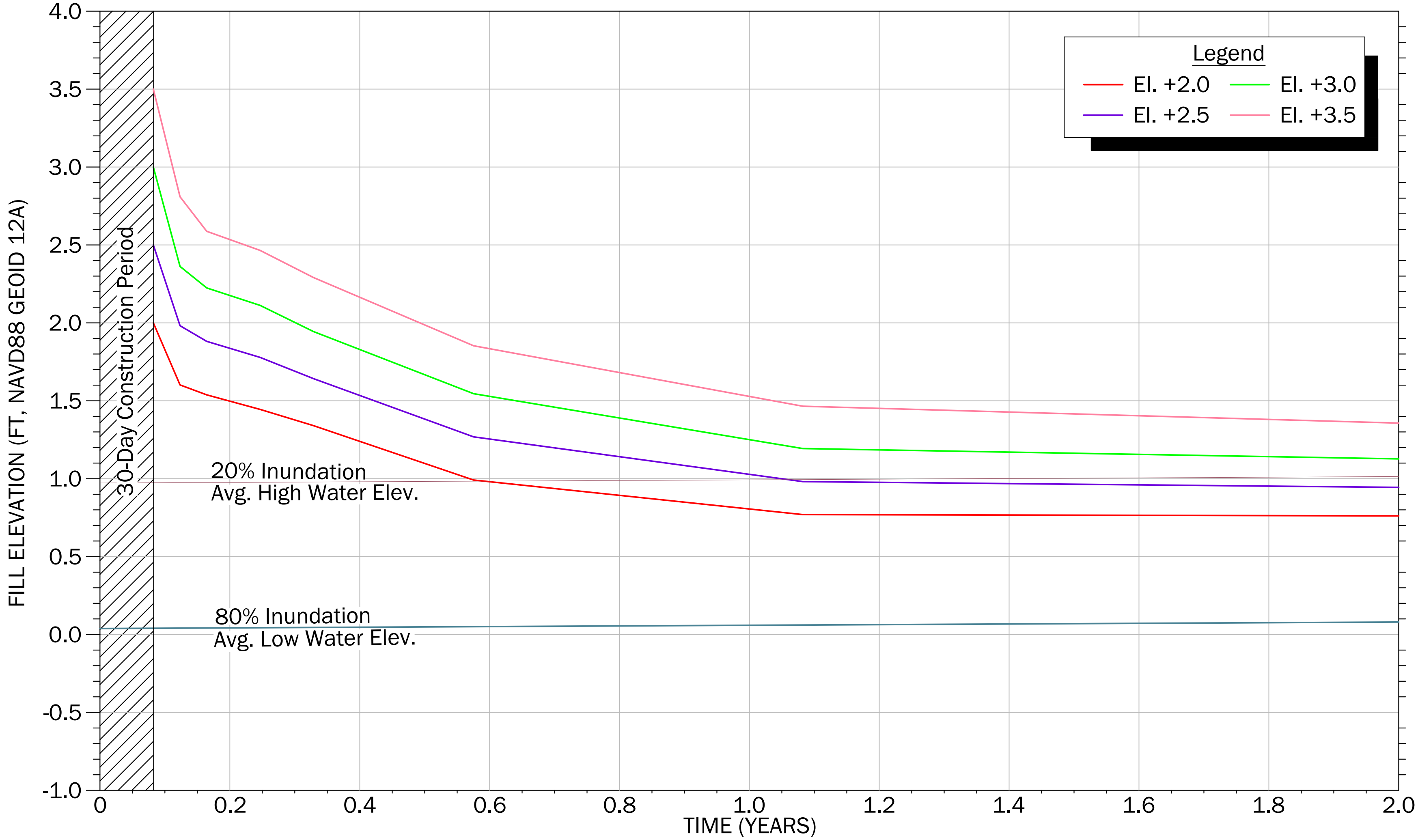
THE CURVES PRESENTED IN THIS FIGURE DO NOT INCLUDE REGIONAL SUBSIDENCE.

**Marsh Fill Elevation vs. Time**
**Cells 1 & 2 Mudline El. -1 ft.**

East Leeville Marsh Creation and Nourishment
(BA-194)
Lafourche Parish, Louisiana

GEOENGINEERS

**Figure E-1a**



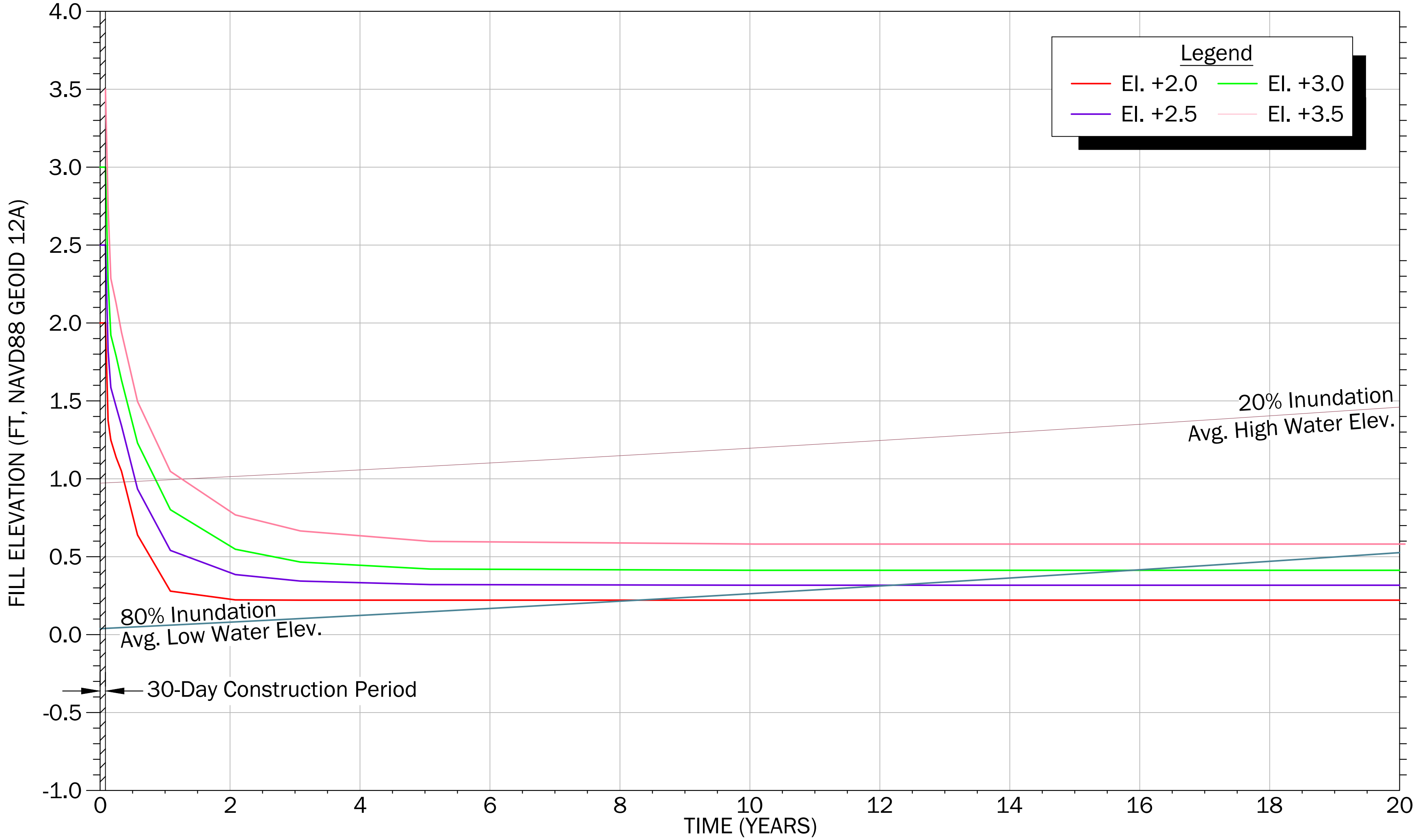

**Marsh Fill Elevation vs. Time (First 2 Years)**
**Cells 1 & 2 Mudline El. -1 ft.**

East Leeville Marsh Creation and Nourishment
(BA-194)
Lafourche Parish, Louisiana

GeoEngineers

**Figure E-1b**

THE CURVES PRESENTED IN THIS FIGURE DO NOT INCLUDE REGIONAL SUBSIDENCE.




| FILL ELEVATION (FEET NAVD88) | | | | | | |
|---|---|---|---|---|---|---|
| END OF CONSTRUCTION | 6 MONTHS | 1 YEAR | 3 YEARS | 5 YEARS | 10 YEARS | 20 YEARS |
| 3.5 | 1.6 | 1.1 | 0.8 | 0.6 | 0.6 | 0.6 |
| 3.0 | 1.4 | 0.8 | 0.5 | 0.4 | 0.4 | 0.4 |
| 2.5 | 1.1 | 0.5 | 0.3 | 0.3 | 0.3 | 0.3 |
| 2.0 | 0.8 | 0.3 | 0.2 | 0.2 | 0.2 | 0.2 |

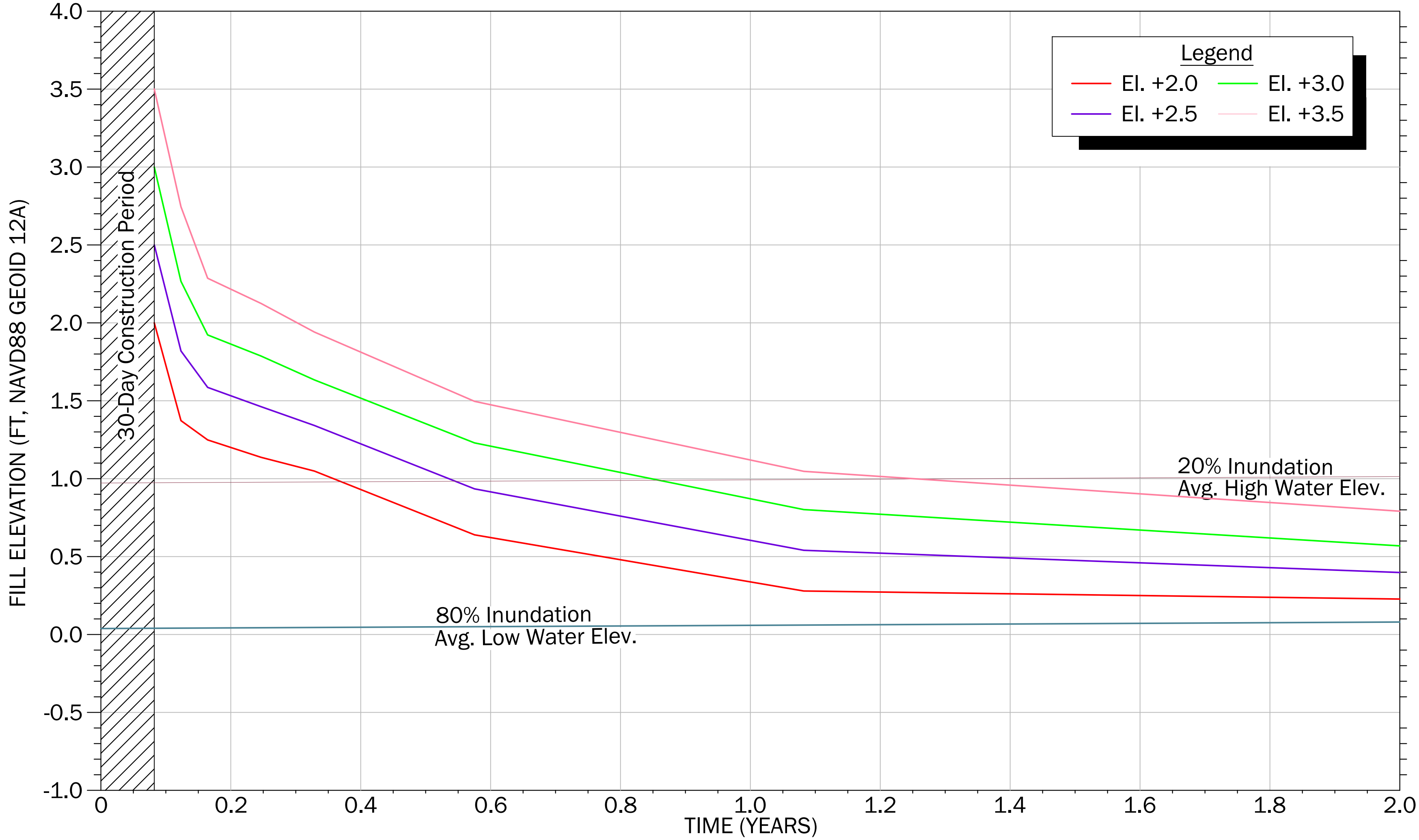
THE CURVES PRESENTED IN THIS FIGURE DO NOT INCLUDE REGIONAL SUBSIDENCE.

**Marsh Fill Elevation vs. Time**
**Cells 1 & 2 Mudline El. -2 ft.**

East Leeville Marsh Creation and Nourishment
(BA-194)
Lafourche Parish, Louisiana

GEOENGINEERS

**Figure E-2a**




**Marsh Fill Elevation vs. Time (First 2 Years)**
**Cells 1 & 2 Mudline El. -2 ft.**

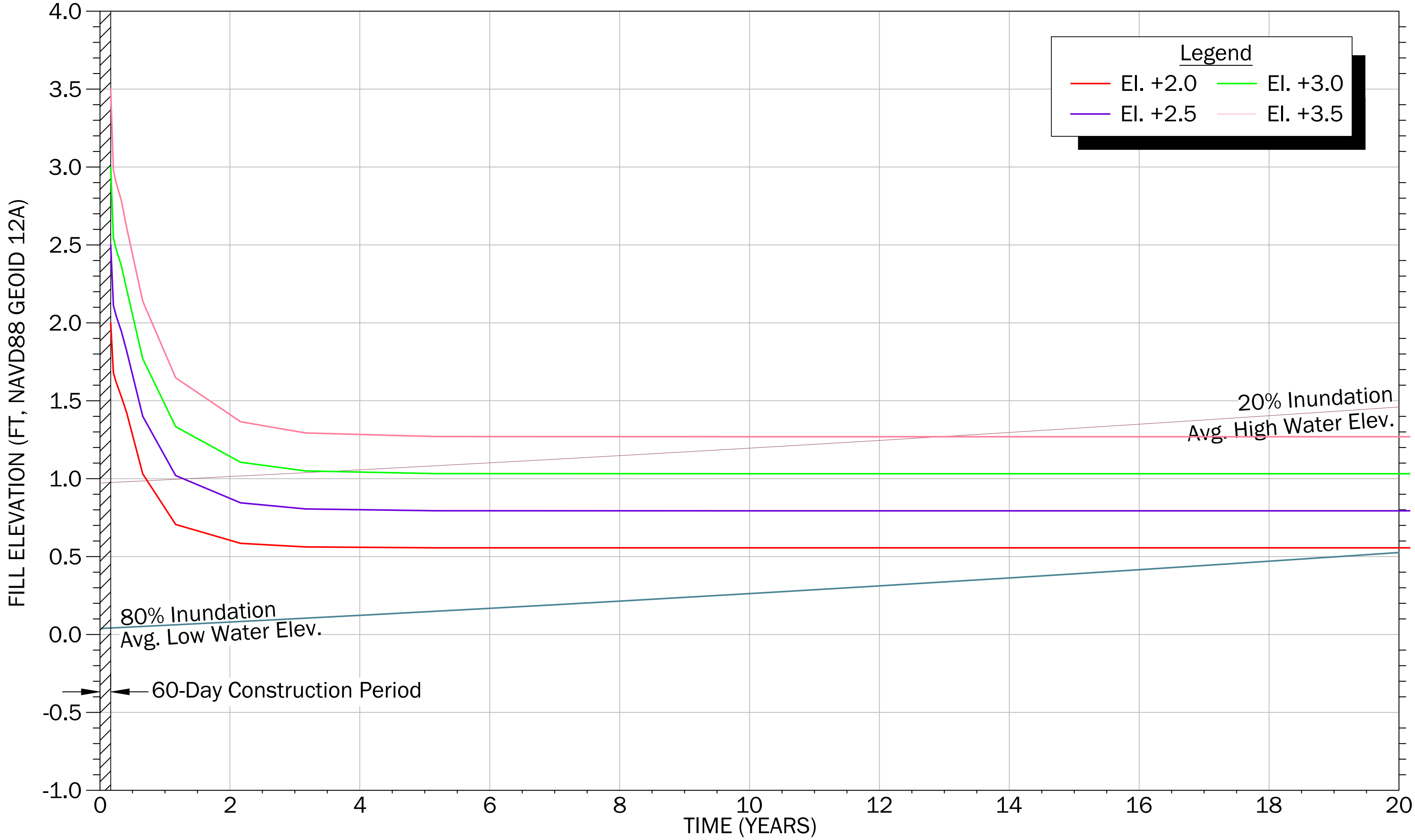
East Leeville Marsh Creation and Nourishment
(BA-194)
Lafourche Parish, Louisiana

GeoEngineers

**Figure E-2b**

THE CURVES PRESENTED IN THIS FIGURE DO NOT INCLUDE REGIONAL SUBSIDENCE.

P:\18\18274004\CAD\02\Geotech - Final\1827400402_FE_Marsh Fill.dwg TAB:E2c - Cells 1 and 2 ml 2  Date Exported: 03/27/20 - 13:45 by kcook




| FILL ELEVATION (FEET NAVD88) | | | | | | |
|---|---|---|---|---|---|---|
| END OF CONSTRUCTION | 6 MONTHS | 1 YEAR | 3 YEARS | 5 YEARS | 10 YEARS | 20 YEARS |
| 3.5 | 2.4 | 1.6 | 1.3 | 1.3 | 1.3 | 1.3 |
| 3.0 | 2.1 | 1.3 | 1.1 | 1.0 | 1.0 | 1.0 |
| 2.5 | 1.7 | 1.0 | 0.8 | 0.8 | 0.8 | 0.8 |
| 2.0 | 1.3 | 0.7 | 0.6 | 0.6 | 0.6 | 0.6 |

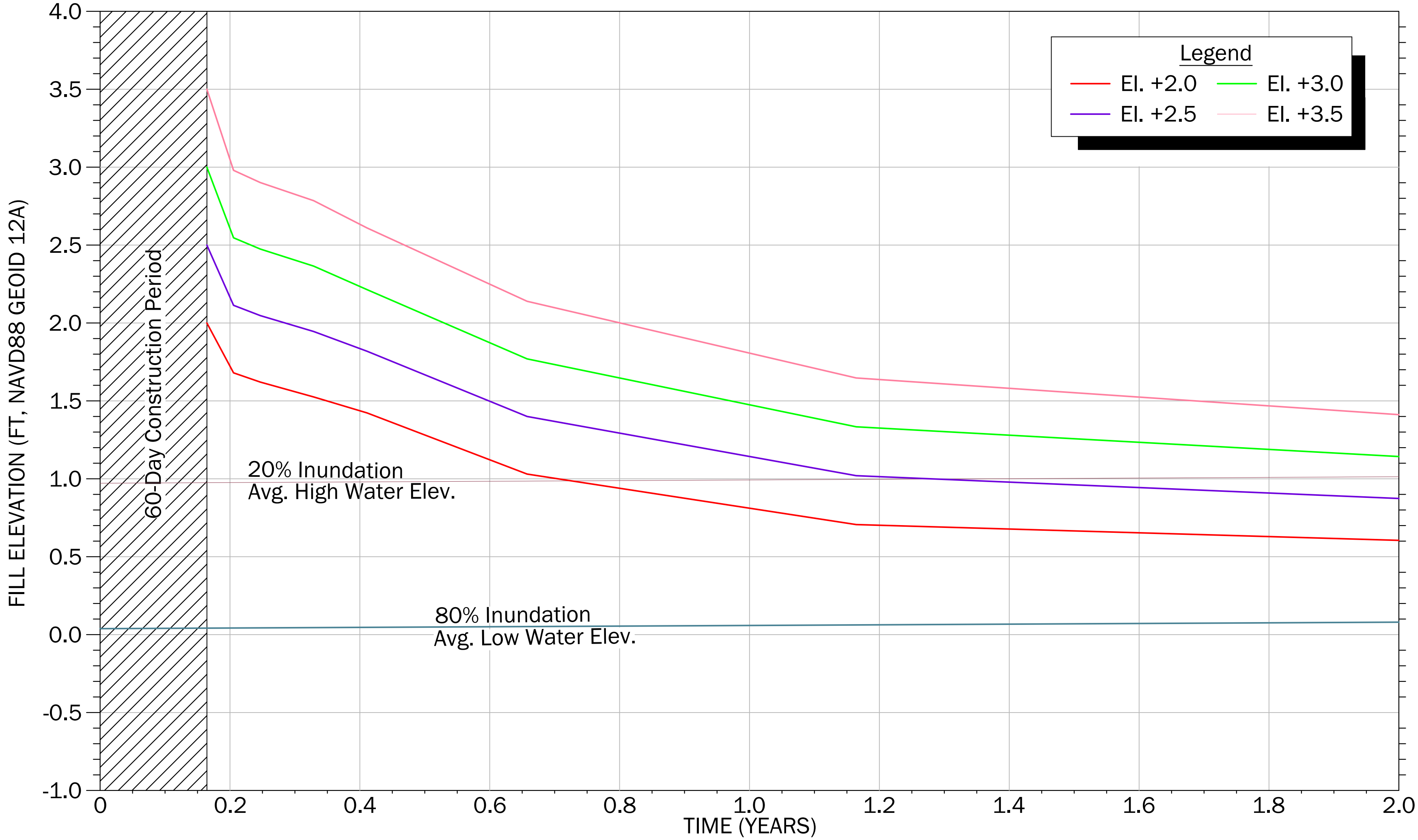
THE CURVES PRESENTED IN THIS FIGURE DO NOT INCLUDE REGIONAL SUBSIDENCE.

**Marsh Fill Elevation vs. Time**
**Cells 1 & 2 (60-Day) Mudline El. -2 ft.**

East Leeville Marsh Creation and Nourishment
(BA-194)
Lafourche Parish, Louisiana

GEOENGINEERS

**Figure E-2c**




**Marsh Fill Elevation vs. Time (First 2 Years)**
**Cells 1 & 2 (60-Day) Mudline El. -2 ft.**

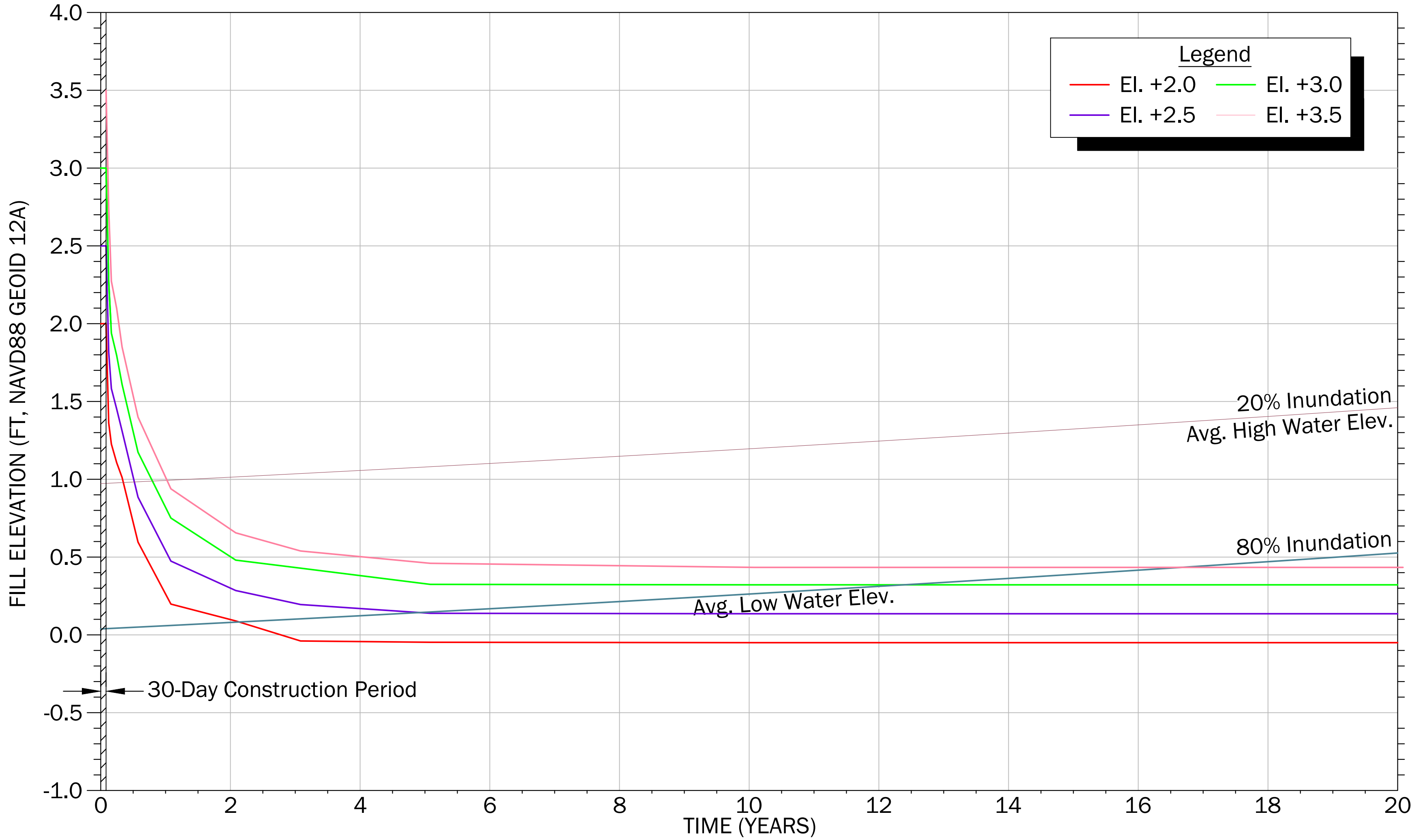
East Leeville Marsh Creation and Nourishment (BA-194)
Lafourche Parish, Louisiana

GeoEngineers

**Figure E-2d**

THE CURVES PRESENTED IN THIS FIGURE DO NOT INCLUDE REGIONAL SUBSIDENCE.

P:\18\18274004\CAD\02\Geotech - Final\1827400402_FE_Marsh Fill.dwg TAB:E3a - Cell 3 Date Exported: 03/27/20 - 13:46 by kcook




| FILL ELEVATION (FEET NAVD88) | | | | | | |
|---|---|---|---|---|---|---|
| END OF CONSTRUCTION | 6 MONTHS | 1 YEAR | 3 YEARS | 5 YEARS | 10 YEARS | 20 YEARS |
| 3.5 | 1.5 | 0.9 | 0.5 | 0.5 | 0.4 | 0.4 |
| 3.0 | 1.3 | 0.8 | 0.4 | 0.3 | 0.3 | 0.3 |
| 2.5 | 1.0 | 0.5 | 0.2 | 0.1 | 0.1 | 0.1 |
| 2.0 | 0.7 | 0.2 | 0.0 | 0.0 | -0.1 | -0.1 |

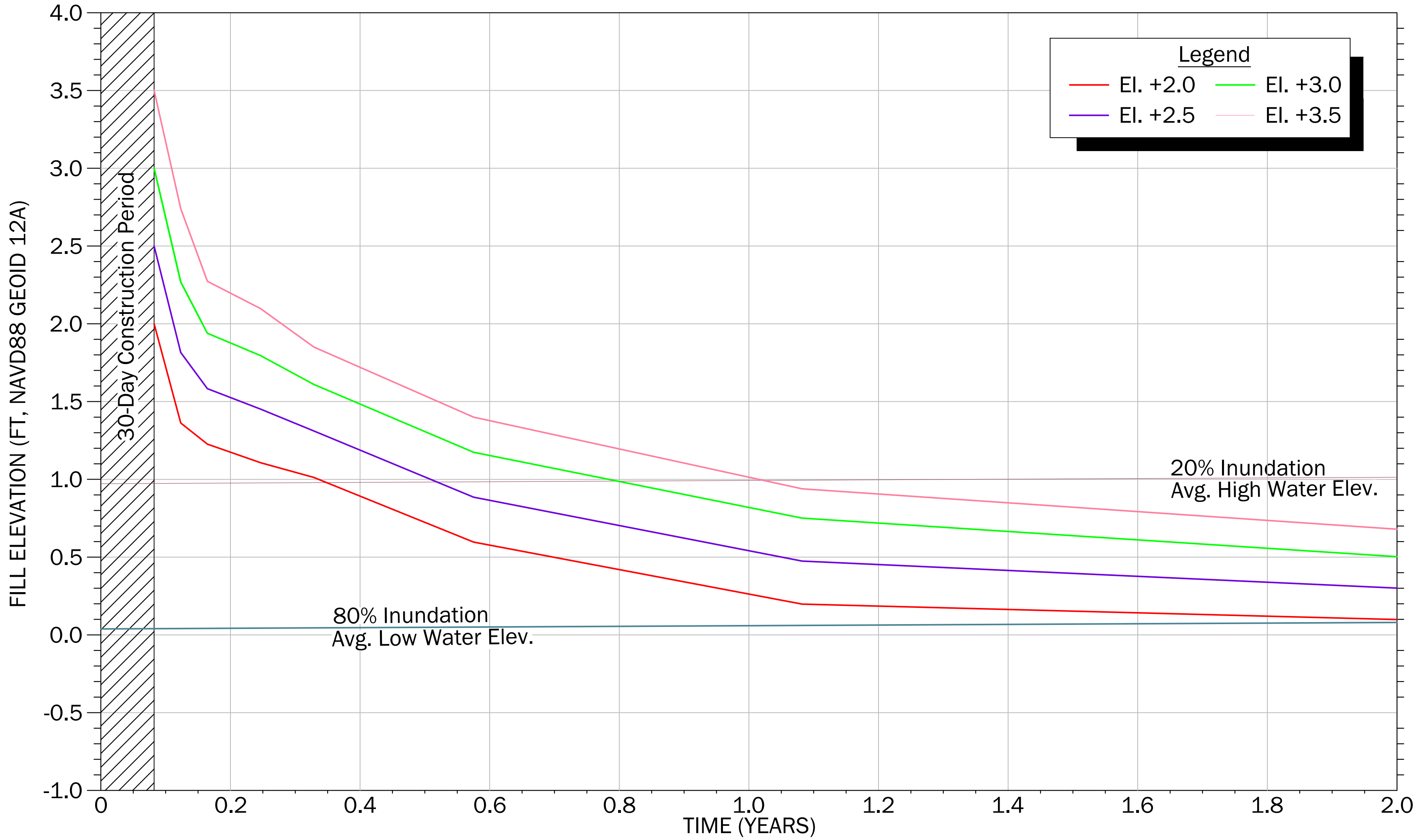
THE CURVES PRESENTED IN THIS FIGURE DO NOT INCLUDE REGIONAL SUBSIDENCE.

**Marsh Fill Elevation vs. Time**
**Cell 3 Mudline El. -2 ft.**

East Leeville Marsh Creation and Nourishment
(BA-194)
Lafourche Parish, Louisiana

GEOENGINEERS

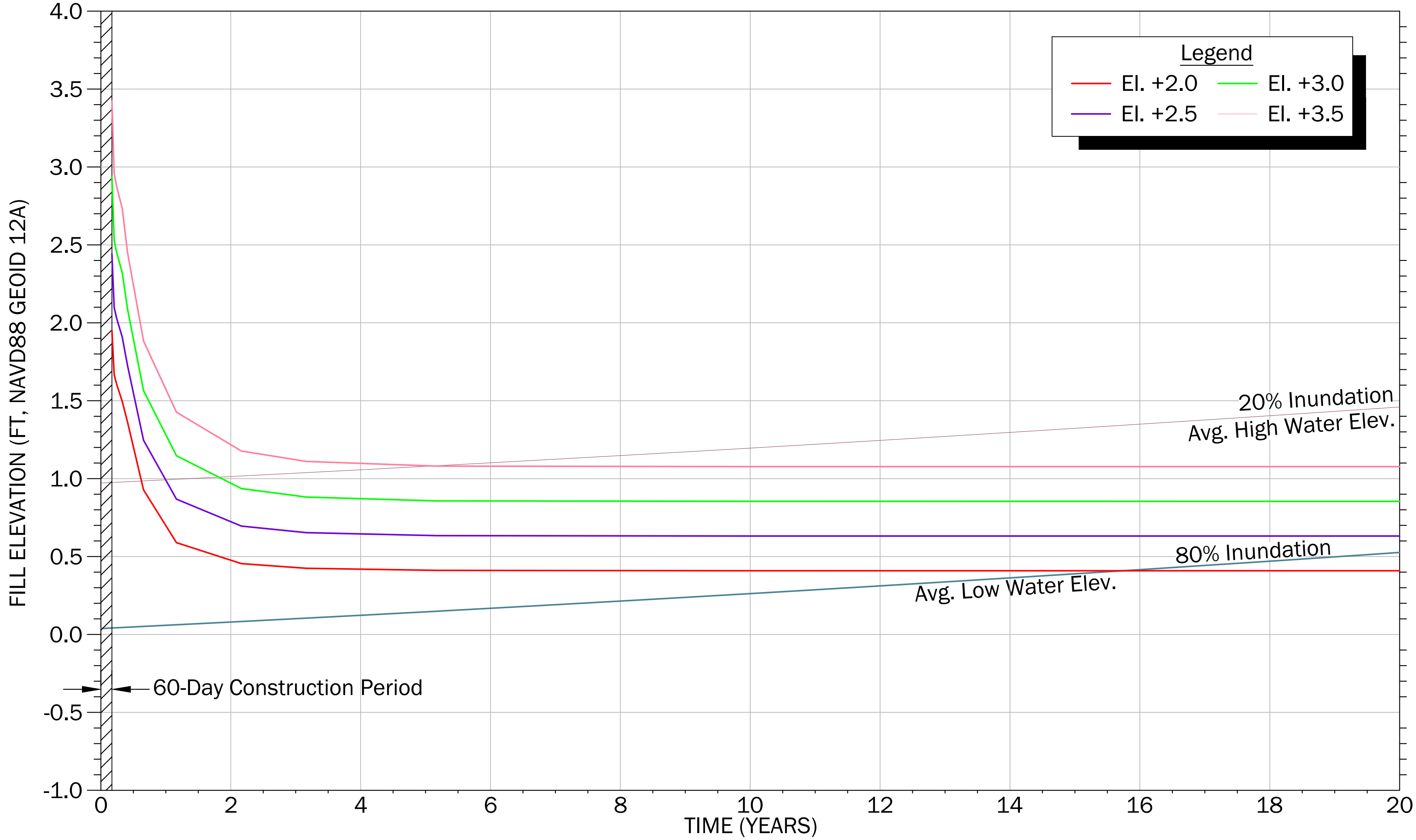
**Figure E-3a**




| **Marsh Fill Elevation vs. Time (First 2 Years)**<br>**Cell 3 Mudline El. -2 ft.** | |
|---|---|
| East Leeville Marsh Creation and Nourishment<br>(BA-194)<br>Lafourche Parish, Louisiana | |
| GeoEngineers | **Figure E-3b** |

THE CURVES PRESENTED IN THIS FIGURE DO NOT INCLUDE REGIONAL SUBSIDENCE.

P:\18\18274004\CAD\02\Geotech - Final\1827400402_FE_Marsh Fill.dwg TAB:E3c - Cell 3 Date Exported: 03/27/20 - 13:47 by kcook




| FILL ELEVATION (FEET NAVD88) | | | | | | |
|---|---|---|---|---|---|---|
| END OF CONSTRUCTION | 6 MONTHS | 1 YEAR | 3 YEARS | 5 YEARS | 10 YEARS | 20 YEARS |
| 3.5 | 2.2 | 1.4 | 1.1 | 1.1 | 1.1 | 1.1 |
| 3.0 | 1.9 | 1.1 | 0.9 | 0.9 | 0.9 | 0.9 |
| 2.5 | 1.6 | 0.9 | 0.7 | 0.6 | 0.6 | 0.6 |
| 2.0 | 1.2 | 0.6 | 0.4 | 0.4 | 0.4 | 0.4 |

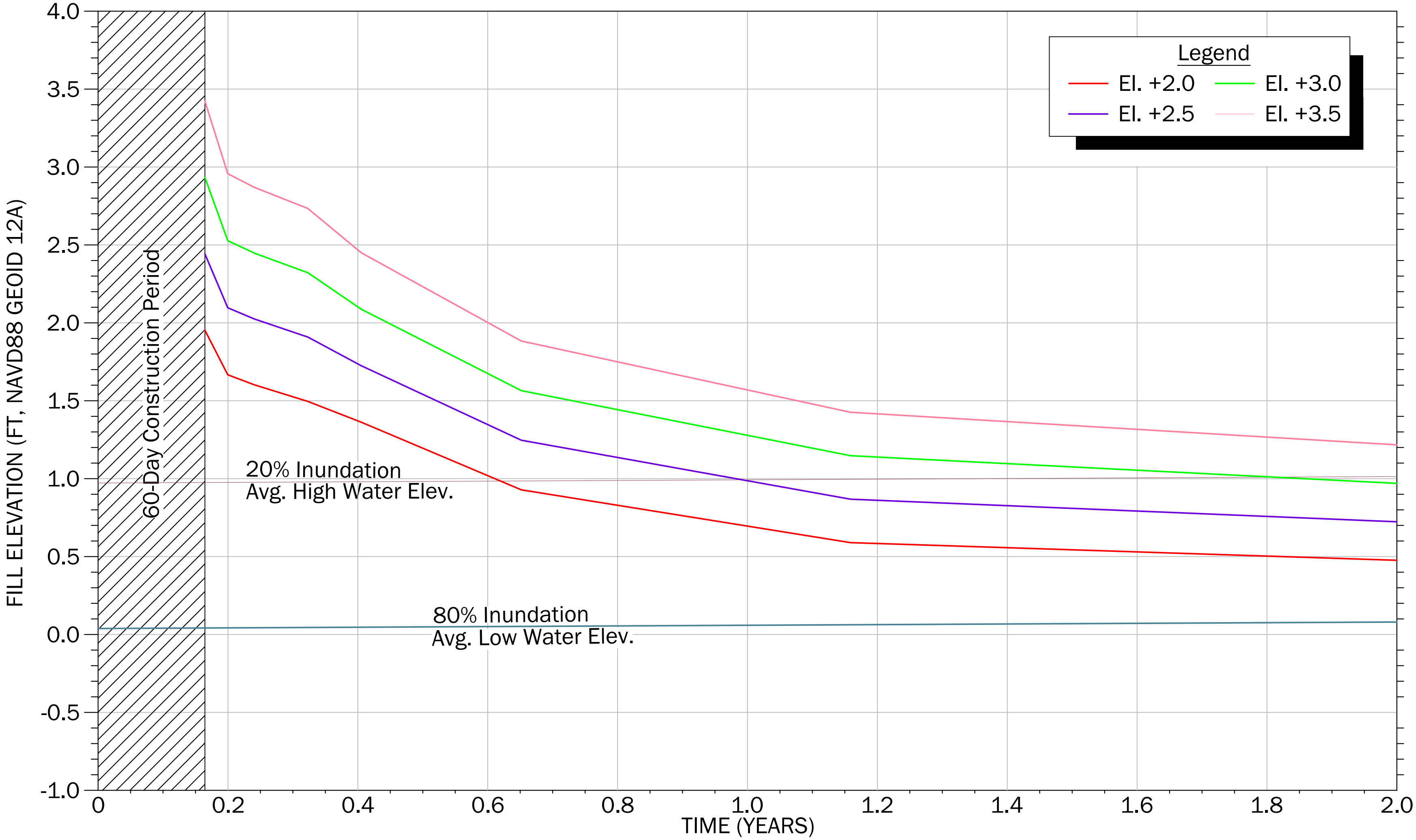
THE CURVES PRESENTED IN THIS FIGURE DO NOT INCLUDE REGIONAL SUBSIDENCE.

**Marsh Fill Elevation vs. Time**
**Cell 3 (60-Day) Mudline El. -2 ft.**

East Leeville Marsh Creation and Nourishment (BA-194)
Lafourche Parish, Louisiana

GeoEngineers

**Figure E-3c**



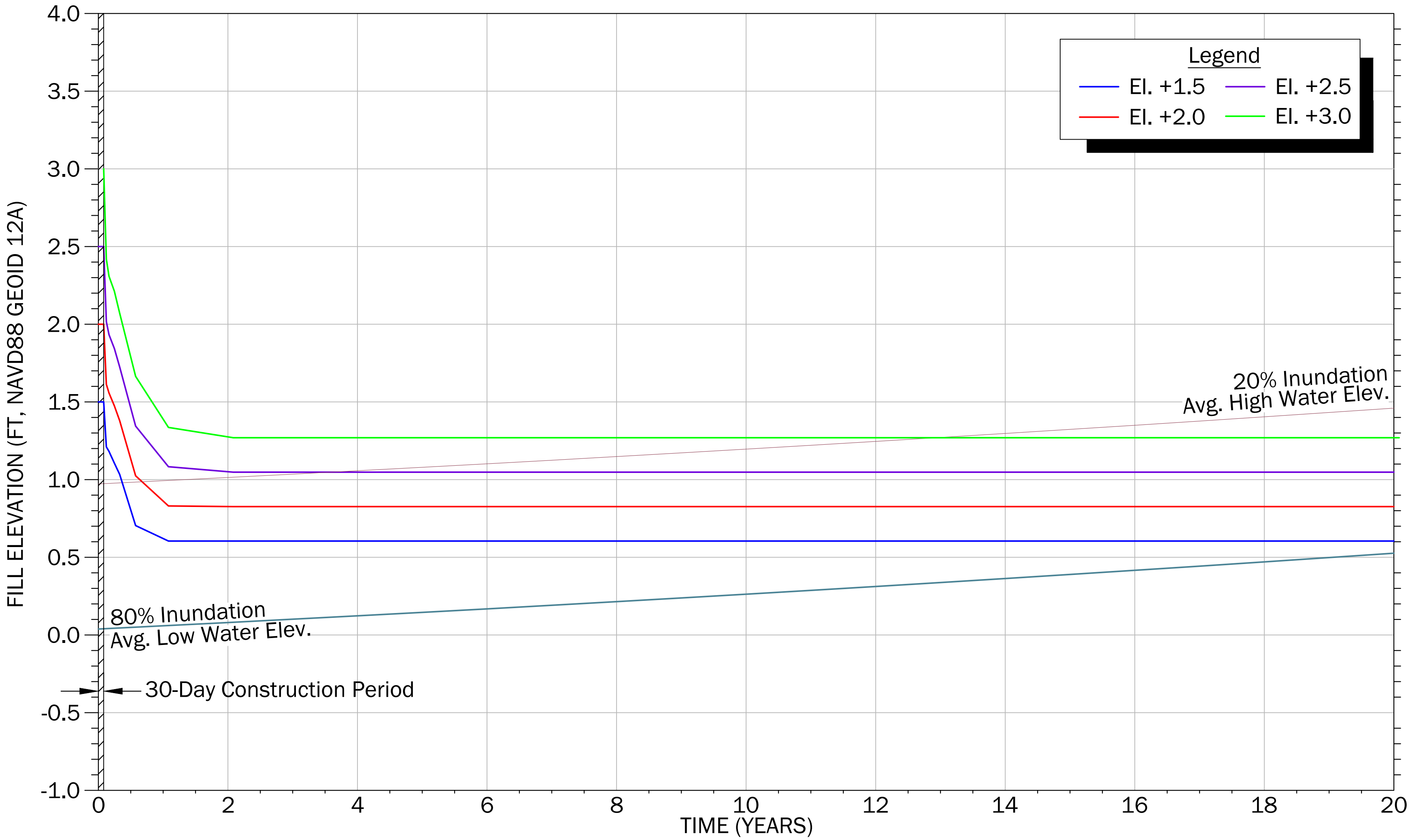

**Marsh Fill Elevation vs. Time (First 2 Years)**
**Cell 3 (60 Day) Mudline El. -2 ft.**

East Leeville Marsh Creation and Nourishment
(BA-194)
Lafourche Parish, Louisiana

GeoEngineers

**Figure E-3d**

THE CURVES PRESENTED IN THIS FIGURE DO NOT INCLUDE REGIONAL SUBSIDENCE.




| FILL ELEVATION (FEET NAVD88) | | | | | | |
|---|---|---|---|---|---|---|
| END OF CONSTRUCTION | 6 MONTHS | 1 YEAR | 3 YEARS | 5 YEARS | 10 YEARS | 20 YEARS |
| 3.0 | 1.8 | 1.3 | 1.3 | 1.3 | 1.3 | 1.3 |
| 2.5 | 1.5 | 1.1 | 1.0 | 1.0 | 1.0 | 1.0 |
| 2.0 | 1.1 | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 |
| 1.5 | 0.8 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 |

THE CURVES PRESENTED IN THIS FIGURE DO NOT INCLUDE REGIONAL SUBSIDENCE.

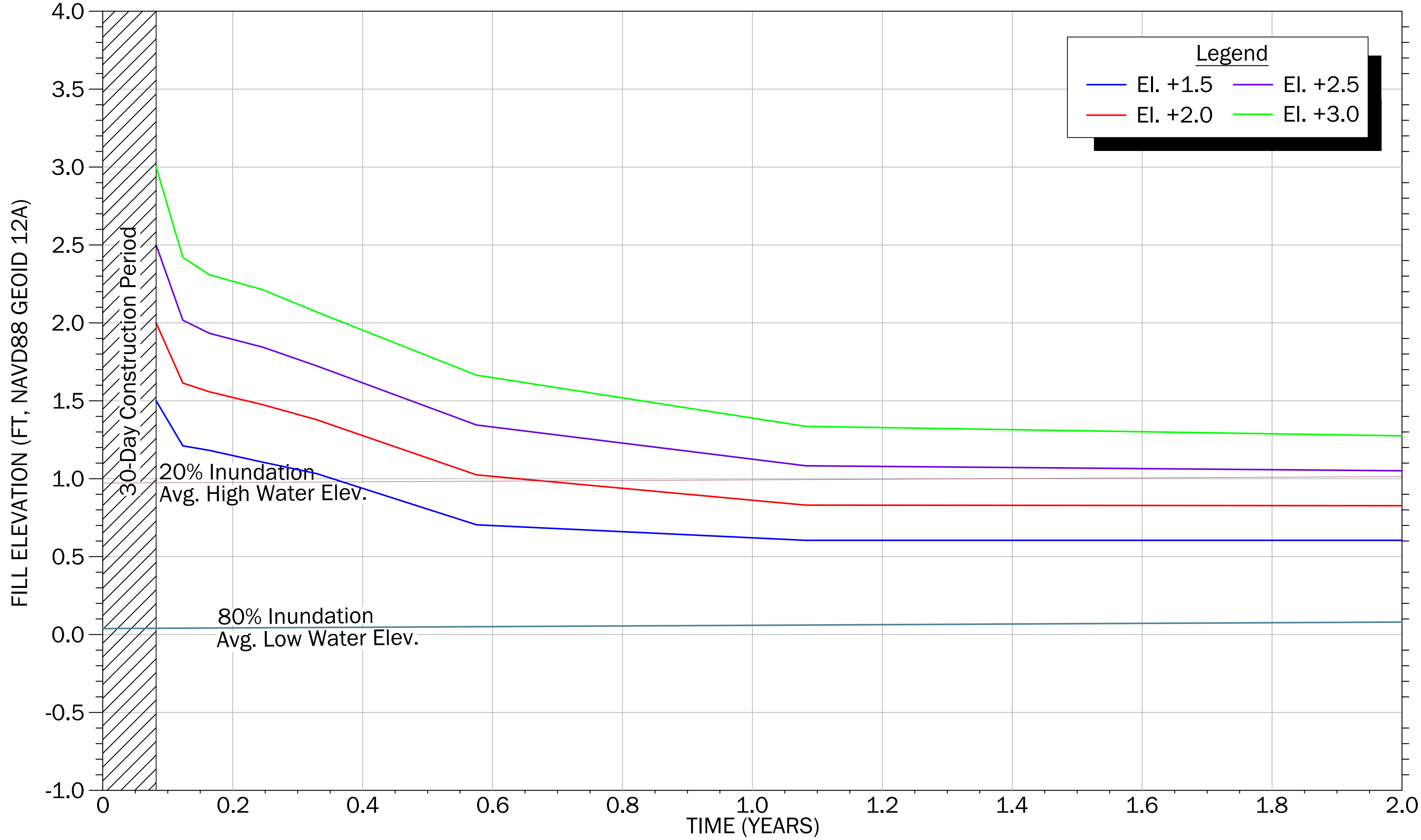
**Marsh Fill Elevation vs. Time**
**Cells 4, 5 & 6 Mudline El. -1 ft.**

East Leeville Marsh Creation and Nourishment
(BA-194)
Lafourche Parish, Louisiana

GEOENGINEERS

**Figure E-4a**

P:\18\18274004\CAD\02\Geotech - Final\1827400402_FE_Marsh Fill.dwg TAB:E4b - Cells 4 5 6 Date Exported: 03/27/20 - 13:48 by kcook




**Marsh Fill Elevation vs. Time (First 2 Years)**
**Cells 4, 5 & 6 Mudline El. -1 ft.**

East Leeville Marsh Creation and Nourishment
(BA-194)
Lafourche Parish, Louisiana

GeoEngineers

**Figure E-4b**

THE CURVES PRESENTED IN THIS FIGURE DO NOT INCLUDE REGIONAL SUBSIDENCE.

# APPENDIX F
## Report Limitations and Guidelines for Use

## APPENDIX F
## REPORT LIMITATIONS AND GUIDELINES FOR USE

This appendix provides information to help you manage your risks with respect to the use of this report.

### Geotechnical Services Are Performed for Specific Purposes, Persons and Projects

This report has been prepared exclusively for the Coastal Restoration and Protection Authority and Baird, Inc. The information contained herein is not applicable to other sites.

GeoEngineers, Inc. (GeoEngineers) structures our services to meet the specific needs of our clients. No party other than the Coastal Protection and Restoration Authority and Baird, Inc. may rely on the product of our services unless we agree to such reliance in advance and in writing. This is to provide our firm with reasonable protection against open-ended liability claims by third parties with whom there would otherwise be no contractual limits to their actions. Within the limitations of scope, schedule and budget, our services have been executed in accordance with our Agreement with the Client and generally accepted geotechnical practices in this area at the time this report was prepared. Use of this report is not recommended for any purpose or project except the one originally contemplated.

### A Geotechnical Engineering or Geologic Report Is Based on a Unique Set of Project-Specific Factors

This report has been prepared for the East Leeville Marsh Creation and Nourishment (BA-194) project located in Lafourche Parish, Louisiana. GeoEngineers considered a number of unique, project-specific factors when establishing the scope of services for this project and report. Unless GeoEngineers specifically indicates otherwise, it is important not to rely on this report if it was:

- not prepared for you,
- not prepared for your project,
- not prepared for the specific site explored, or
- completed before important project changes were made.

For example, changes that can affect the applicability of this report include those that affect:

- the function of the proposed structure;
- elevation, configuration, location, orientation or weight of the proposed structure;
- composition of the design team; or
- project ownership.

If important changes are made after the date of this report, we recommend that GeoEngineers be given the opportunity to review our interpretations and recommendations. Based on that review, we can provide written modifications or confirmation, as appropriate.

### Subsurface Conditions Can Change

This geotechnical or geologic report is based on conditions that existed at the time the study was performed. The findings and conclusions of this report may be affected by the passage of time, by man-made events such as construction on or adjacent to the site, or by natural events such as floods, earthquakes, slope instability or groundwater fluctuations. If more than a few months have passed since issuance of our report or work product, or if any of the described events may have occurred, please contact GeoEngineers before applying this report for its intended purpose so that we may evaluate whether changed conditions affect the continued reliability or applicability of our conclusions and recommendations.

### Most Geotechnical and Geologic Findings Are Professional Opinions

Our interpretations of subsurface conditions are based on field observations from widely spaced sampling locations at the site. Site exploration identifies the specific subsurface conditions only at those points where subsurface tests are conducted or samples are taken. GeoEngineers reviewed field and laboratory data and then applied our professional judgment to render an informed opinion about subsurface conditions throughout the site. Actual subsurface conditions may differ, sometimes significantly, from those indicated in this report. Our report, conclusions and interpretations should not be construed as a warranty of the subsurface conditions.

### Geotechnical Engineering Report Recommendations Are Not Final

The construction recommendations included in this report are preliminary and should not be considered final. GeoEngineers' recommendations can be finalized only by observing actual subsurface conditions revealed during construction. GeoEngineers is unable to assume responsibility for the recommendations in this report without performing construction observation.

We recommend that you allow sufficient monitoring, testing and consultation during construction by GeoEngineers to confirm that the conditions encountered are consistent with those indicated by the explorations, to provide recommendations for design changes if the conditions revealed during the work differ from those anticipated, and to evaluate whether earthwork activities are completed in accordance with our recommendations. Retaining GeoEngineers for construction observation for this project is the most effective method of managing the risks associated with unanticipated conditions.

### A Geotechnical Engineering or Geologic Report Could Be Subject to Misinterpretation

Misinterpretation of this report by members of the design team or by contractors can result in costly problems. GeoEngineers can help reduce the risks of misinterpretation by conferring with appropriate members of the design team after submitting the report, reviewing pertinent elements of the design team's plans and specifications, participating in pre-bid and preconstruction conferences, and providing construction observation.

### Do Not Redraw the Exploration Logs

Geotechnical engineers and geologists prepare final boring and testing logs based upon their interpretation of field logs and laboratory data. The logs included in a geotechnical engineering or geologic report should never be redrawn for inclusion in architectural or other design drawings. Photographic or electronic reproduction is acceptable, but separating logs from the report can create a risk of misinterpretation.

### Give Contractors a Complete Report and Guidance

To help prevent costly problems associated with unanticipated subsurface conditions, we recommend giving contractors the complete geotechnical engineering or geologic report but preface it with a clearly written letter of transmittal. In that letter, advise contractors that the report's accuracy is limited. In addition, encourage them to confer with GeoEngineers and/or to conduct additional study to obtain the specific types of information they need or prefer.

### Contractors Are Responsible for Site Safety on Their Own Construction Projects

Our geotechnical recommendations are not intended to direct the contractor's procedures, methods, schedule or management of the work site. The contractor is solely responsible for job site safety and for managing construction operations to minimize risks to on-site personnel and adjacent properties.

### Read These Provisions Closely

It is important to recognize that the geoscience practices (geotechnical engineering, geology and environmental science) are less exact than other engineering and natural science disciplines. Without this understanding, there may be expectations that could lead to disappointments, claims and disputes. GeoEngineers includes these explanatory "limitations" provisions in our reports to help reduce such risks. Please confer with GeoEngineers if you need to know more how these "Report Limitations and Guidelines for Use" apply to your project or site.

### Biological Pollutants

GeoEngineers' Scope of Work specifically excludes the investigation, detection, prevention or assessment of the presence of Biological Pollutants. Accordingly, this report does not include any interpretations, recommendations, findings or conclusions regarding the detecting, assessing, preventing or abating of Biological Pollutants, and no conclusions or inferences should be drawn regarding Biological Pollutants as they may relate to this project. The term "Biological Pollutants" includes, but is not limited to, molds, fungi, spores, bacteria and viruses, and/or any of their byproducts.

A Client that desires these specialized services is advised to obtain them from a consultant who offers services in this specialized field.