



DRAFT Post-Construction Monitoring Report: Year 4

Galveston Island State Park Marsh Restoration
and Protection Phase III

CEPRA 1637

Galveston, TX
April 1, 2026

HDR Engineering, Inc.
TBPELS Firm
Registration No. F-754

Contents

1	Introduction	1
1.1	Background	1
1.2	Purpose and Scope	3
2	Data Collection	4
2.1	Ground Digital Photography	4
2.2	Aerial Photography	6
2.3	Topographic Surveying	7
2.3.1	Breakwaters	7
2.3.2	Marsh	8
3	Monitoring Analysis and Reports.....	9
3.1	Breakwater Geometry	9
3.2	Establishment of Hard Substrate Habitat	13
3.3	Protection of Estuarine Habitat	15
3.3.1	Estuarine Emergent Marsh – Low Marsh	16
3.3.2	Estuarine Emergent Marsh - High Marsh	19
3.3.3	Shallow Open Water Habitat	21
3.4	Marsh Edge Position	22
3.4.1	Area A	27
3.4.2	Area B	28
3.4.3	Area C	29
3.4.4	Area D and E	30
3.4.5	Areas F, G, and H	31
3.4.6	Area I	33
3.4.7	Area J and K.....	34
3.4.8	Areas L and M	36
3.4.9	Marsh Edge Position Summary	38
4	Summary and Conclusions	40
5	References	41
	Appendix A: Digital Photographs	42
	Appendix B: Aerial Photograph	93
	Appendix C: Surveys.....	99

Tables

Table 1. Breakwater design criteria	9
Table 2. Summary of breakwater crest elevation measurements.....	10
Table 3. Relative percentages of shoreline change calculated in each monitoring area.	38
Table 4. Averaged percentages of shoreline change from Year 3 to Year 4.....	38
Table 5. Marsh edge recession rate of selected monitoring areas.	39

Figures

Figure 1. Project location.	2
Figure 2. Phase III project features (Aerial imagery represents Year 4 taken on March 03, 2026).	2
Figure 3. Typical ground digital photograph of the base of the Oak Bayou Breakwater.	5
Figure 4. Typical ground digital photograph of the crest of the Oak Bayou Breakwater.	5
Figure 5. Typical ground digital photo of marsh edge.....	6
Figure 6. RTK GPS measurement of the Oak Bayou breakwater crest elevation.....	7
Figure 7. Topographic survey of marsh edge position.....	8
Figure 8. Oak Bayou and Butterowe Bayou breakwater elevations measured using RTK GPS.....	10
Figure 9. Dana Cove breakwater elevations measured using RTK GPS	11
Figure 10. Eastern point near Sta. 38+00 cross-section of the Dana Cove Breakwater	12
Figure 11. Western point near Sta. 17+00 cross-section of the Dana Cove Breakwater	12
Figure 12. Sta. 17+50 cross-section of the Oak Bayou Breakwater.....	12
Figure 13. Oysters and barnacles on Oak Bayou Breakwater.....	13
Figure 14. Oysters and barnacles on Butterowe Bayou breakwater.	14
Figure 15. Oyster and algae on Dana Cove breakwater.	14
Figure 16. Marsh monitoring areas.	15
Figure 17. Vertical scarp along marsh shoreline at Area A.	16
Figure 18. Vertical scarp along marsh shoreline at Area B.	17
Figure 19. Exposed shallow bay bottom sloping gently up to marsh edge at Area E.	17
Figure 20. Previously submerged marsh edge at Area I.	18
Figure 21. Exposed shallow depths surround Area J near the sand bar.	18
Figure 22. Black mangrove [<i>Avicennia germanins</i>] in red] on northwestern side of Area K.	19
Figure 23. Black mangrove and salt wort (<i>Batis Maritima</i>) observed in Area I.....	20
Figure 24. Black mangrove (indicated in red) and other high marsh plants within Area A.	20
Figure 25. Sand/Mud flat northeast of Area A.....	21
Figure 26. Sand/Mud flat northeast of Area I.	22
Figure 27. Marsh shoreline: Area A.	23
Figure 28. Marsh shoreline: Area A and Area B.	23
Figure 29. Marsh shoreline: Area C.	24
Figure 30. Marsh shoreline: Area D and Area E.	24
Figure 31. Marsh shoreline: Area F, Area G, and Area H.....	25
Figure 32. Marsh shoreline: Area I, Area J, and Area K.	25
Figure 33. Marsh shoreline: Area L and Area M.	26
Figure 34. Marsh edge position change for Area A.	28

Figure 35. Marsh edge position change for Area B.	29
Figure 36. Marsh edge position change for Area C.	30
Figure 37. Marsh edge change for Area D and E.	31
Figure 38. Area F footprint	32
Figure 39. Area G footprint.....	32
Figure 40. Marsh edge change for Area I.	33
Figure 41. Shoreline change for Area K.....	35
Figure 42. Vulnerable marsh shoreline in Area K.	35
Figure 43. Shoreline change for Area L and M.	37
Figure 44. Area L looking north.....	37

This page is intentionally left blank.

1 Introduction

This report documents post-construction (Year 4) performance monitoring of Phase III of the Galveston Island State Park Marsh Restoration and Protection project (CEPRA Project No. 1637). Year 4 Monitoring measurements and observations were compared with the baseline conditions (Year 0) established after construction of the Phase III improvements, and with assessments after Year 1, Year 2, and Year 3. A summary of the Phase III project elements and monitoring initiatives is provided below.

1.1 Background

The construction contract for CEPRA Project No. 1637 was executed between the Texas General Land Office (TGLO) and Luhr Bros., Inc. on May 28, 2021. Construction began in July 2021 and finished in October 2021. Phase III improvements consisted of three rock breakwaters totaling 7,550 linear feet (LF) - 825 LF at Butterowe Bayou, 2,500 LF at Oak Bayou, and 4,225 LF at Dana Cove. The breakwaters were designed to have a 25-year project life with the goal of providing shelter from waves to approximately 311 acres of shallow open water, seagrass beds and approximately 100 acres of existing estuarine marsh complex (estuarine emergent marsh and shallow open water habitat). Additionally, the breakwaters are expected to provide hard substrate habitat that functions similarly to oyster reefs. A project location map is provided in Figure 1 and Phase III project features are labeled in Figure 2.

The project was funded through the National Fish and Wildlife Foundation (NFWF) for the restoration and protection of estuarine marsh within West Bay in Galveston Island State Park. Five years of post-construction monitoring will be performed in accordance with the Monitoring and Adaptive Management Plan (MAMP) for the Galveston Island State Park Marsh Restoration and Protection Project. The MAMP was originally developed in 2016 to meet NFWF Gulf Environmental Benefit Fund (GEBF) requirements for Phases I and II of the Project and was amended in 2020 to include Phase III of the Project (HDR 2020). The monitoring is intended to determine if the project has met or is expected to meet the intended conservation objectives and, if not, whether adaptive management actions may be warranted. The current performance monitoring effort was conducted in accordance with the MAMP.

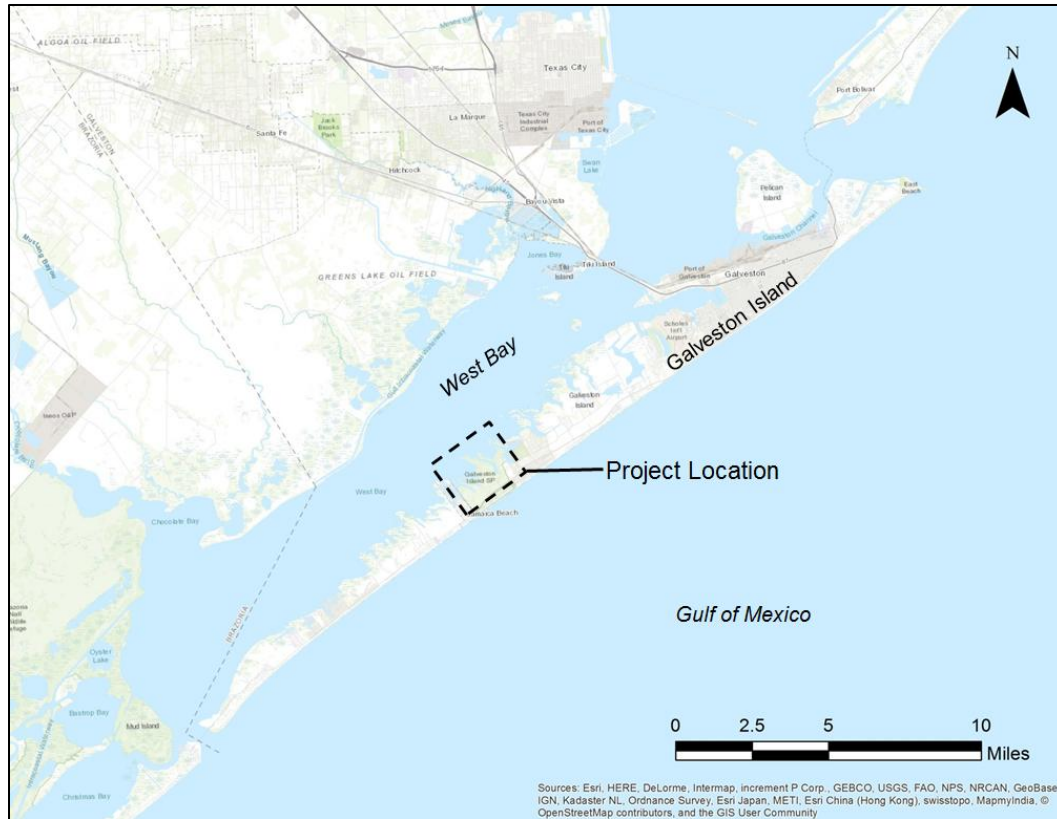


Figure 1. Project location.



Figure 2. Phase III project features (Aerial imagery represents Year 4 taken on March 03, 2026).

1.2 Purpose and Scope

Baseline (Year 0) conditions of the Phase III breakwaters and marsh edge were established through topographic and bathymetric surveys and aerial photography performed during breakwater construction; and through field observations, field photographs, and Real Time Kinematic (RTK) GPS measurements collected approximately 2 months after construction on December 16, 2021.

Annual monitoring includes site visits performed by HDR to assess the general condition of the breakwaters and marsh. The monitoring effort includes surveying the breakwaters and marsh shoreline position with RTK GPS and aerial photography. Annual monitoring results are then compared to initial baseline conditions and objectives established by the MAMP to assess the performance of the Phase III improvements in the following areas:

- Breakwater geometry
- Establishment of hard substrate habitat
- Protection of estuarine habitats
- Stability of existing marsh edge position

This report documents the Year 4 Monitoring effort and aerial photography that were conducted in February 2026. The data collection methods discussed in the following section closely replicate Year 1, Year 2, and Year 3 Monitoring.

2 Data Collection

Baseline conditions of the breakwater were assessed during site visits performed by HDR throughout construction between July and October 2021. Additional data, including breakwater surveys and aerial photography, were provided by the construction contractor. A site visit was performed by HDR and the Texas Parks and Wildlife Department (TPWD) on December 16, 2021, to assess general, post-construction conditions within the marsh protection site and to establish baseline measurements within the marsh.

Year 1 Monitoring was performed over the course of two days on January 26, 2023, and February 9, 2023. Breakwater conditions were assessed during the first site visit and marsh edge position was measured during both visits.

Year 2 Monitoring was performed over the course of two days on May 2, 2024, and June 27, 2024, to assess both the breakwater conditions and marsh edge position.

Year 3 Monitoring was performed over the course of two days, starting on February 1, 2025, and ending on February 2, 2025. Day one was used to assess breakwater conditions and marsh edge position near the Butterowe Bayou and Oak Bayou breakwaters. Day two assessed breakwater conditions and marsh edge positions near the Dana Cove breakwater.

Year 4 Monitoring was performed over the course of two days, starting on February 6, 2026, and ending on February 7, 2026. Day one was spent surveying the crest of the three breakwaters and the marsh edges of Areas A to E. Day two focused on surveying the marsh edges of Area I to Area M. The water levels during these two days dropped to -0.85 feet NAVD on day one and -1.25 feet NAVD on day 2.

2.1 Ground Digital Photography

Digital photographs were taken at the base and crest along various sections of the Phase III breakwaters to document field conditions observed during the February 6th and February 7th, 2026, site visits. Representative breakwater conditions observed during the Year 4 Monitoring are shown in Figure 3 and Figure 4.



Figure 3. Typical ground digital photograph of the base of the Oak Bayou Breakwater (facing west).



Figure 4. Typical ground digital photograph of the crest of the Oak Bayou Breakwater (facing west).

Digital photographs of the protected estuarine habitat features were also taken to document conditions observed during the February 2026 site visits. See Figure 5 for a representative photograph of the marsh edge.



Figure 5. Typical ground digital photo of marsh edge.

The locations where the photos were taken were documented to capture photos of the same area in future monitoring site visits. Year 4 photographs of each marsh area and breakwater are provided in Appendix A. Field conditions of the breakwaters and estuarine marsh complex are discussed in Section 3.

2.2 Aerial Photography

Aerial photography was performed by Terra Flight Aerial Imaging, Inc. on February 23, 2026. The aerial photography captured approximately 2,000 acres, covering the entire project site and surrounding areas, including a portion of breakwater at Carancahua Cove constructed for a previous project phase. Aerial photographs were provided in true color. A high-resolution aerial photograph is included in Appendix B, and georeferenced digital files have been provided to TGLO.

2.3 Topographic Surveying

During Year 4 Monitoring site visits, HDR conducted RTK surveying using a Virtual Reference Station (VRS). VRS eliminates the need to set up a base station at the project site by connecting to a network of permanent GPS base stations. The base station used for this project is on the southwestern end of Galveston Island near the intersection of San Luis Pass Road and Baywater Drive and on the northeast of Galveston Island near the intersection of 27th Street and Postoffice St. RTK GPS equipment was applied to measure crest elevation along each breakwater and to measure the position of the marsh edge.

2.3.1 Breakwaters

The crest elevations of the Phase III breakwaters were measured as part of Year 4 Monitoring on February 6th and 7th, 2026. Surveying of Dana Cove breakwater during Year 4 Monitoring is shown in Figure 6.



Figure 6. RTK GPS measurement of the Oak Bayou breakwater crest elevation. Photo facing northeast.

2.3.2 Marsh

During Year 4 Monitoring site visit, HDR performed the RTK surveying of the marsh edge location at the same selected areas that were measured during the previous four monitoring events. For this monitoring effort, edge position is defined as the most bayward limit of vegetation. Comparisons of the marsh edge location between the post-construction surveying, Year 1, Year 2, Year 3 and Year 4 Monitoring are discussed in Section 3.4. Marsh surveying on Area A during the Year 4 Monitoring is shown in Figure 7.



Figure 7. Topographic survey of marsh edge position.

3 Monitoring Analysis and Reports

3.1 Breakwater Geometry

According to the MAMP, breakwater geometry should be similar to the original design specifications (crest elevation, side slopes, and length) at the end of the five-year monitoring period. The crest elevation should be relatively uniform with minimal settlement; scour should not pose a risk for structural failure; and the breakwater should be performing as designed. The performance criteria for the Phase III breakwaters stated in the MAMP are summarized below:

- Maintain design breakwater lengths (total of approximately 7,750 LF)
- Breakwater cross-sections should be relatively stable
- Target average settlement of less than 6 inches (total, not per year)

The baseline conditions of the breakwater geometry were assessed by field observations, photographs, and RTK GPS measurements of the crest elevation, cross section, length, location, and gradation of riprap. Stone condition was evaluated for loose, displaced, cracked, or deteriorating stone by field observations and field photographs. Nearly all stones observed appeared stable and in good condition without cracks. The post-construction survey indicated all three breakwaters met the design specifications and showed minimal scour. The baseline conditions of the Phase III breakwaters are listed in Table 1.

Table 1. Breakwater design criteria

Design Criteria		Value
Breakwater Cross-Section	Minimum Crest Elevation (feet, NAVD88)	3.5
	Crest Width (feet)	5
	Side Slope	1V:2H
Breakwater Length (LF)	Butterowe Bayou	825
	Oak Bayou	2,500
	Dana Cove	4,225

During Year 4 Monitoring, the lengths and cross-sectional stability of the Phase III breakwaters were confirmed to meet the design criteria stated in Table 1 through field observations, digital and aerial photography, and GPS surveying. Field engineers walked the entire length of the breakwaters and found the stone to be stable and in good condition. The side slopes of 2H:1V were observed intact. No segments of the breakwaters were seen in deteriorating condition with respect to stone stability.

The Year 4 survey data showed a decrease in the average crest elevation of the breakwaters from +3.75 feet NAVD to +3.73 feet NAVD. Table 2 provides the distribution of elevations along the crest of the three breakwaters. Generally, the crest elevation was evenly distributed from +3.25 feet NAVD to +4.0 feet NAVD, with less than 5% of the survey points falling below +3.25

feet NAVD. The average settlement throughout the entire monitoring phase of the project has not exceeded the 6-inch limit, meeting the target set by the MAMP.

Table 2. Summary of breakwater crest elevation measurements

Phase III Breakwater	Measured Crest Elevation (feet NAVD88)				
	Less than +3.25	+3.25 to +3.5	+3.5 to +3.75	+3.75 to +4.0	Greater than +4.0
Dana Cove	3% (-2%)	15% (-5%)	31% (+1%)	31% (+1%)	19% (+4%)
Oak Bayou	3%	24% (+7%)	28% (+1%)	24% (-9%)	21% (+1%)
Butterowe Bayou	0%	18% (+5 %)	50% (+33%)	27% (-34%)	5% (-4%)

Numbers in parenthesis show the difference between the Year 3 and Year 4 monitoring periods. Positive values indicate an increase in percentage from the Year 3 monitoring. Negative values indicate a decrease in percentage from the Year 3 monitoring.

Figure 9 and Figure 8 show three points along the Oak Bayou and Dana Cove breakwaters where elevations fell between +3 feet NAVD and +3.25 feet NAVD. The Oak Bayou low point, shown in Figure 8, had an elevation of +3.2 feet NAVD. No scour or significant settlement was observed in proximity to this low point during the site visit. This low point is likely a localized variation in the crest elevation as opposed to an indicator of settlement or structural instability of the breakwater.

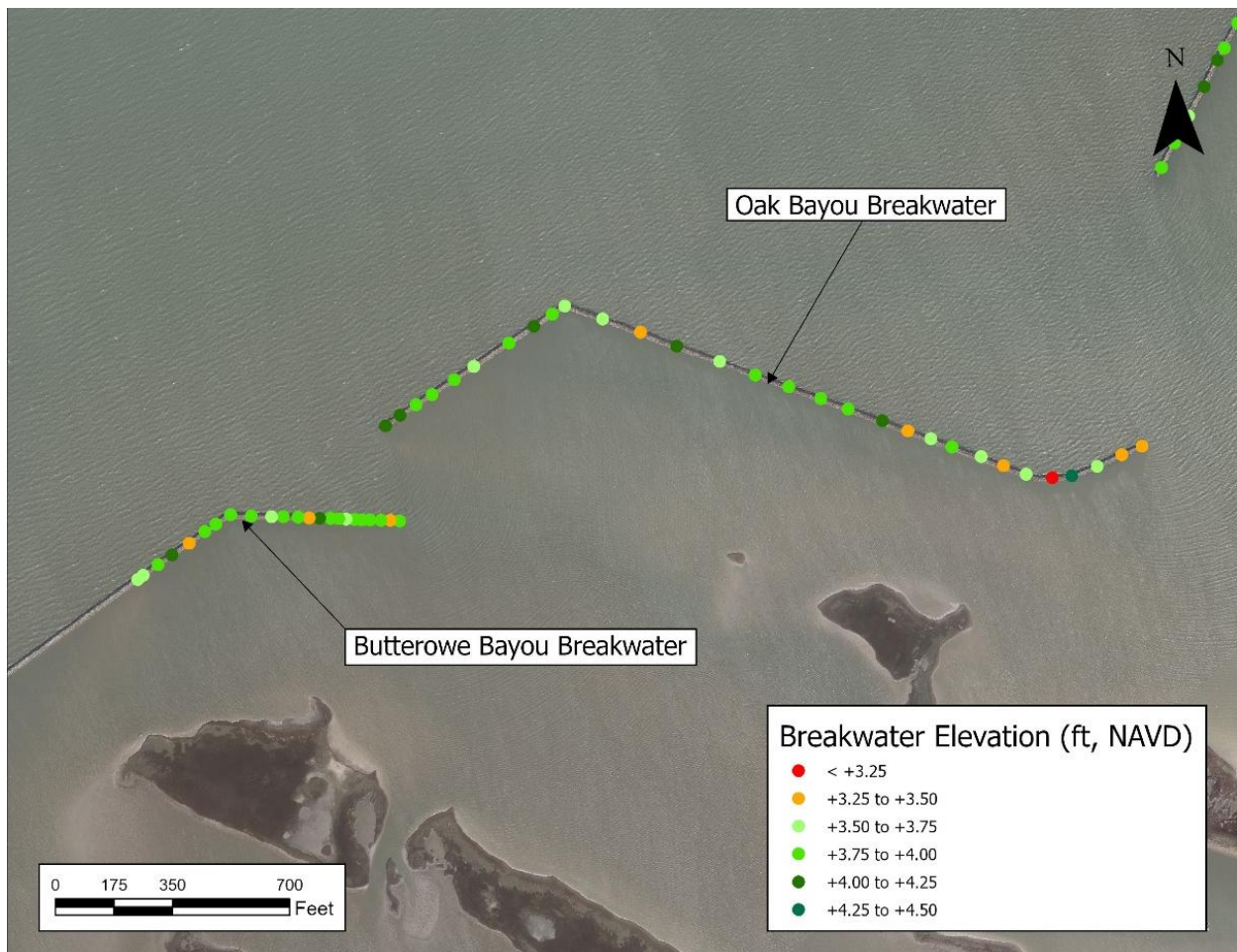


Figure 8. Oak Bayou and Butterowe Bayou breakwater elevations measured using RTK GPS

The Dana Cove low points had elevations of +3.1 feet NAVD and +3.2 feet NAVD. These points were located at the western corner and eastern segment of the breakwater, respectively. The western corner of the Oak Bayou breakwater has been a consistent low area throughout the past monitoring periods, with the crest elevations ranging from +3.25 feet NAVD and +3.5 feet NAVD. Although the crest elevation is comparatively lower along this segment of the breakwater, the elevation has remained consistent throughout the past monitoring periods, indicating that the segment is stable. The low point along the eastern segment of the Dana Cove breakwater was in an area where elevations range between +3.5 ft NAVD and +4.0 ft NAVD. During the visit, there were no noticeable indications of settlement along this segment of the breakwater. Similar to the Oak Bayou Breakwater, the low points along the Dana Cove breakwaters are likely localized variations in crest elevation due to the lack of uniformity of placement across the cross-sections.

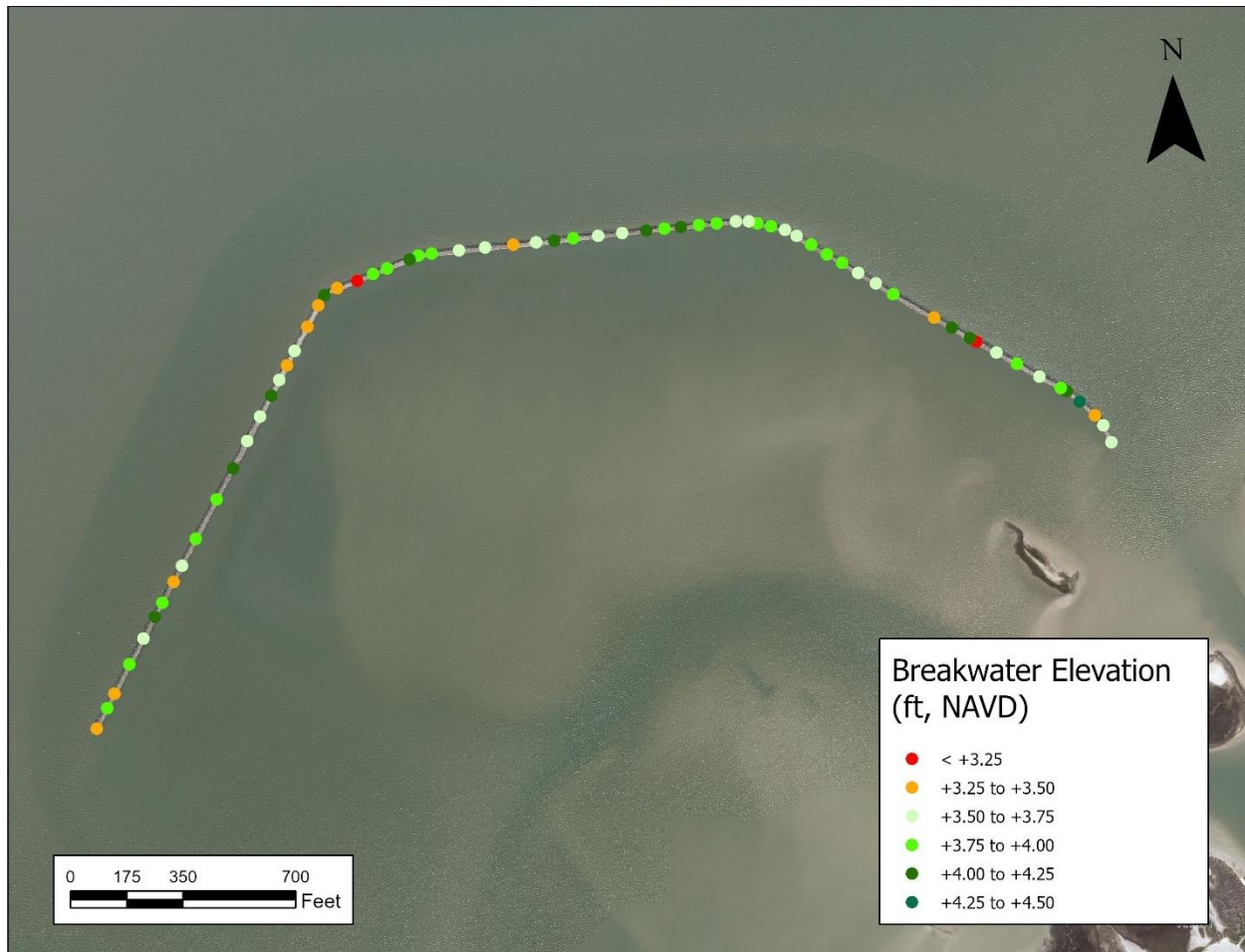


Figure 9. Dana Cove breakwater elevations measured using RTK GPS

In areas where low points were identified, the corresponding cross-sections from the breakwater as-builts (Appendix C) were reviewed to check the baseline crest elevations. It was found that most of the corresponding cross-sections were constructed slightly below +3.5 feet NAVD88, and/or had side slopes that were slightly steeper in some segments than the 2H:1V design criteria but were within acceptable construction tolerance limits. These post-construction conditions could account for some of the Year 4 crest elevation measurements being below the design elevation, rather than being entirely due to settlement. Three cross-sections from the as-builts for the Dana Cove and Oak Bayou breakwaters are included in Figure 10 to Figure 12 to illustrate this point.

Note that breakwater cross-sections were surveyed after construction was completed and served as the Year 0 baseline conditions. Annual monitoring for Year 1 to Year 5 does not include cross-section surveys.

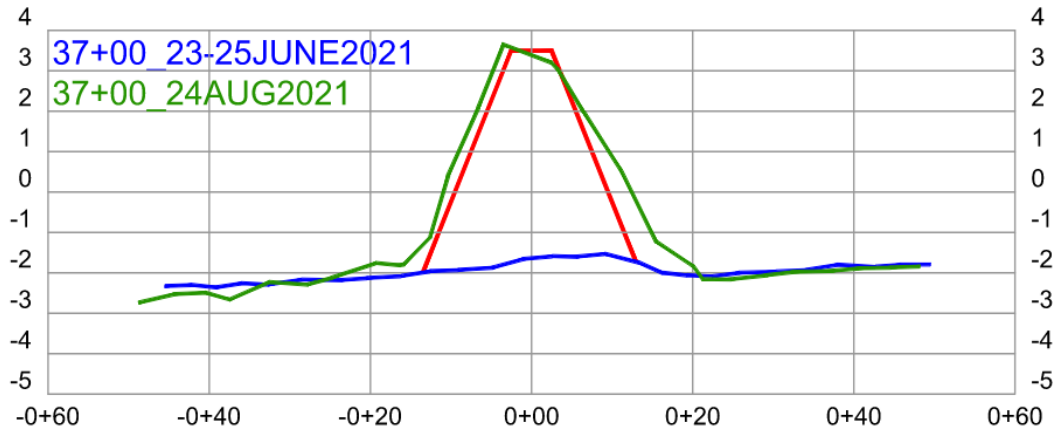


Figure 10. Eastern point near Sta. 38+00 cross-section of the Dana Cove Breakwater (red line showing design template)

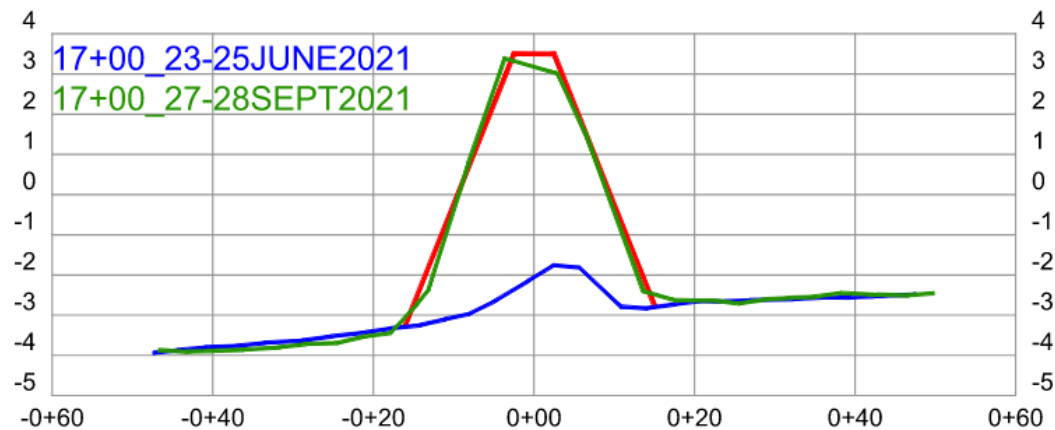


Figure 11. Western point near Sta. 17+00 cross-section of the Dana Cove Breakwater (red line showing design template)

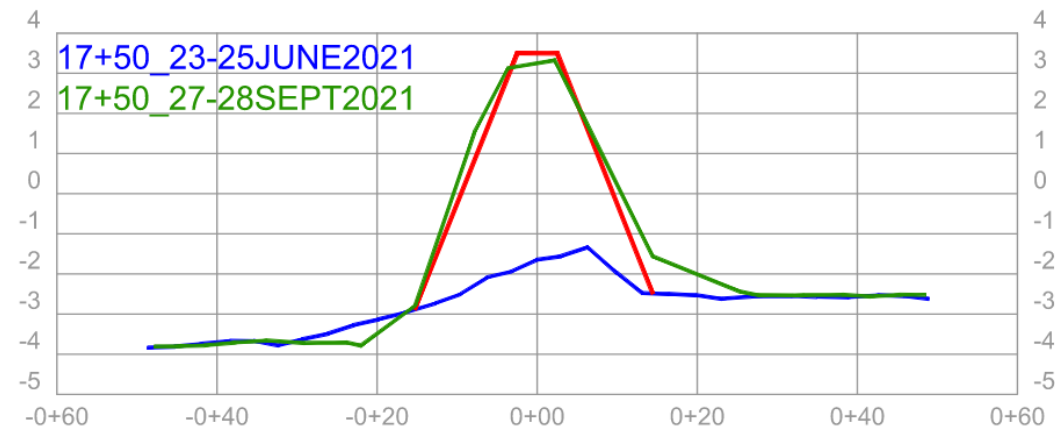


Figure 12. Sta. 17+50 cross-section of the Oak Bayou Breakwater (red line showing design template)

3.2 Establishment of Hard Substrate Habitat

Both sides of the Phase III breakwaters were designed to provide hard substrate habitat. The corresponding performance criteria stated in the MAMP for hard substrate habitat on the Phase III breakwaters is summarized below:

- Create approximately 15,500 linear-feet (i.e., 7,750 feet along each side of the breakwater) of hard substrate habitat that will be similar to oyster reef habitat.

For Year 4 Monitoring, field observations and field photography were used to document the presence of encrusting species and algae attached to the breakwater. The low water level during the Year 4 Monitoring allowed for the observations of the full extent of oyster beds along a total of 15,500 LF of breakwater (i.e., 7,550 LF on each side of the breakwaters at the water's edge). Green algae species, Eastern oysters (*Crassostrea virginica*), and barnacle species were observed along the entirety of the three breakwaters. Hard substrate habitat on both sides of the Phase III breakwaters is shown in Figure 13 through Figure 15. Crustacean species were present on the breakwaters and throughout the marsh areas.



Figure 13. Oysters and barnacles on Oak Bayou Breakwater.



Figure 14. Oysters and barnacles on Butterowe Bayou breakwater.



Figure 15. Oyster and algae on Dana Cove breakwater.

3.3 Protection of Estuarine Habitat

The Phase III breakwaters protect several types of estuarine habitats from wave action. Approximately 311 acres of shallow open water and seagrass beds, and approximately 100 acres of existing estuarine marsh complex (estuarine emergent marsh and shallow open water habitat) are protected by the breakwaters. The performance criteria stated in the MAMP for evaluating project benefits to the protected targeted estuarine habitats are summarized below.

- Protect estuarine marsh complex from increased wave action,
- Protect and create calm shallow estuarine subtidal/open water habitat, and
- Reduce erosion to estuarine marsh complex shoreline compared to historical conditions.

After construction of the breakwaters, baseline conditions of the estuarine marsh habitat were assessed at 13 sections of marsh shoreline (Areas A through M), including nine islands (Area D and Areas F through M), seven of which are small islets (Area D, Area F, Area G, Area H, Area L, Area J, and Area M). The locations of the marsh areas selected for monitoring are shown in Figure 16. These locations were chosen based on their proximity to the newly constructed breakwaters and the potential protection they will receive from them. Particularly vulnerable marsh areas, such as small islets and narrow spits, were also selected for monitoring.



Figure 16. Marsh monitoring areas.

Estuarine emergent marsh and shallow open water habitats were present during the initial post-construction site visit. HDR and TPWD made observations of plant type and erosional scarping along exposed edges of existing marsh. Small scarps were observed along many bay-facing shorelines, indicating erosion from wave action. High marsh plant species were seen at higher elevations along the shoreline in several monitoring areas. These features have remained present over the past four monitoring periods.

3.3.1 Estuarine Emergent Marsh – Low Marsh

Low elevation areas within the estuarine emergent marsh complex, referred to as low marsh, were dominated by smooth cordgrass (*Spartina alterniflora*) and were consistent with observations from the post-construction site visit. The low marsh edge varied between a small (approximately 0.5 to 1 foot) vertical scarp (Figure 17 and Figure 18) to mild sloping shorelines with no scarp (Figure 19) and was dependent on surrounding features. Due to low water levels during the site visit, partially submerged vegetation noted during the Year 3 Monitoring was fully emergent during the Year 4 Monitoring. The vegetation edge of these areas, shown in Figure 20 and Figure 21) were more easily identifiable.



Figure 17. Vertical scarp along marsh shoreline at Area A.



Figure 18. Vertical scarp along marsh shoreline at Area B.



Figure 19. Exposed shallow bay bottom sloping gently up to marsh edge at Area E.



Figure 20. Previously submerged marsh edge at Area I.



Figure 21. Exposed shallow depths surround Area J near the sand bar.

3.3.2 Estuarine Emergent Marsh - High Marsh

Plant species representative of higher elevation areas within the estuarine marsh complex, referred to as high marsh, were observed along a few sections of shoreline predominantly in Areas A, I, and K. These outcroppings of high marsh plants were identified during the post-construction site visit and were confirmed to still be present at the time of Year 4 Monitoring. Photos of high marsh species seen during Year 4 Monitoring are shown below in Figure 22 through Figure 24.



Figure 22. Black mangrove [*Avicennia germanins*] in red] on northwestern side of Area K.



Figure 23. Black mangrove and salt wort (*Batis Maritima*) observed in Area I.



Figure 24. Black mangrove (indicated in red) and other high marsh plants within Area A.

3.3.3 Shallow Open Water Habitat

Shallow open water habitats were observed during the Year 0 Monitoring across the entire marsh complex. These habitats included spits and sand bars found near or along the shorelines of the monitoring areas. These habitats are typically adjacent to the gently sloping shorelines and mud flats. During the Year 4 Monitoring, low water levels exposed much of the existing shallow water habitats, some of which are shown in Figure 25 and Figure 26.



Figure 25. Sand/Mud flat northeast of Area A.



Figure 26. Sand/Mud flat northeast of Area I.

3.4 Marsh Edge Position

The baseline estuarine emergent marsh edge shoreline (referred to herein as the marsh edge position) for 13 selected monitoring areas were documented by measuring the horizontal location of the bay-facing extent of emergent marsh vegetation with RTK GPS.

Year 4 Monitoring measured marsh edge position with GPS surveying methods (Section 2.3.2). A shoreline for each area was created based on these measurements and a comparison with the aerial photography. Figure 27 through Figure 33 show enlarged views of Year 0, Year 1, Year 2, Year 3 and Year 4 marsh edge position.

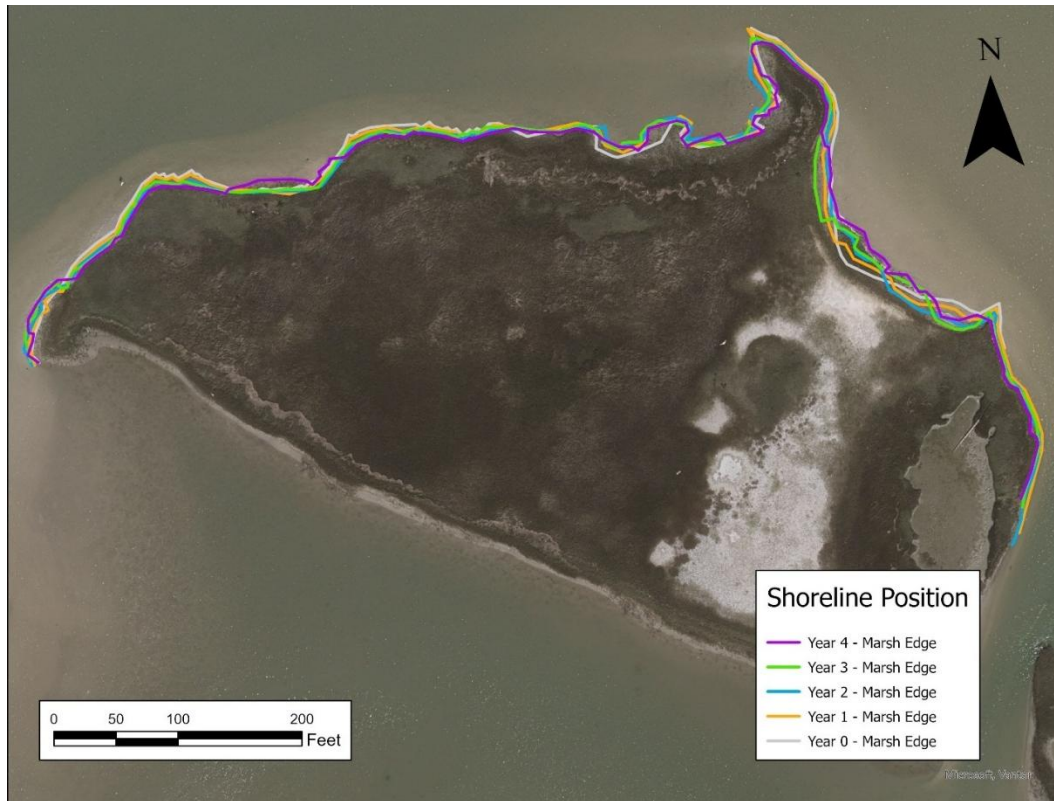


Figure 27. Marsh shoreline: Area A.



Figure 28. Marsh shoreline: Area A and Area B.



Figure 29. Marsh shoreline: Area C.



Figure 30. Marsh shoreline: Area D and Area E.

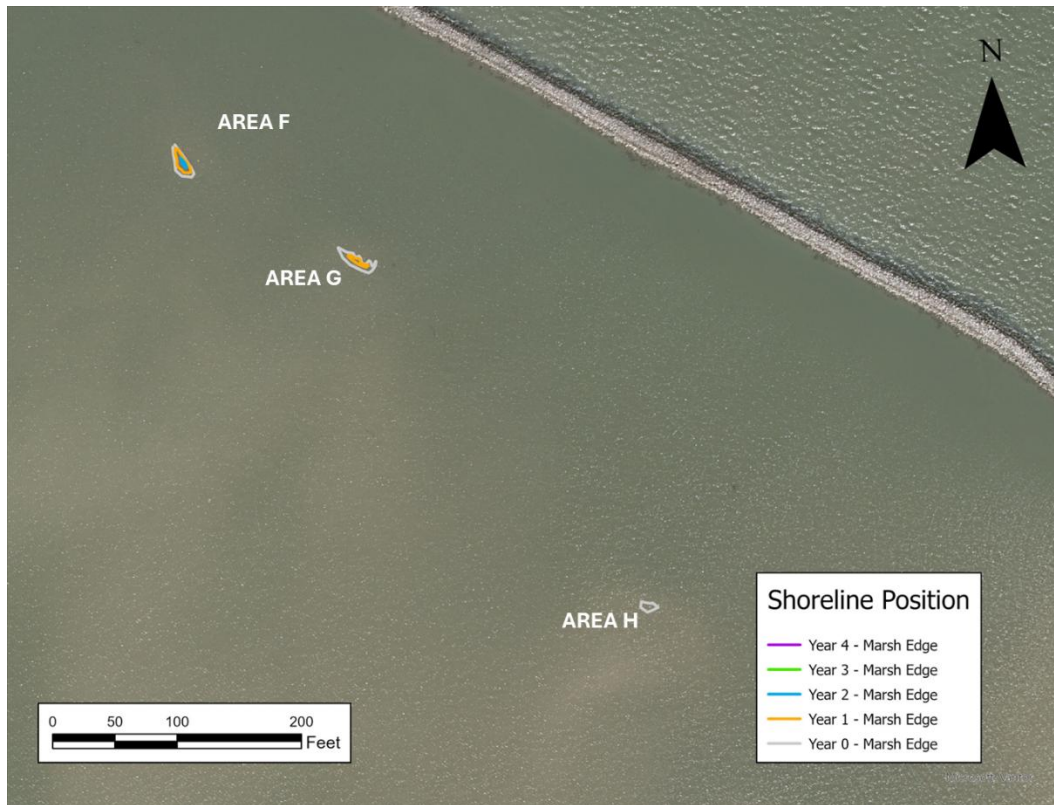


Figure 31. Marsh shoreline: Area F, Area G, and Area H.

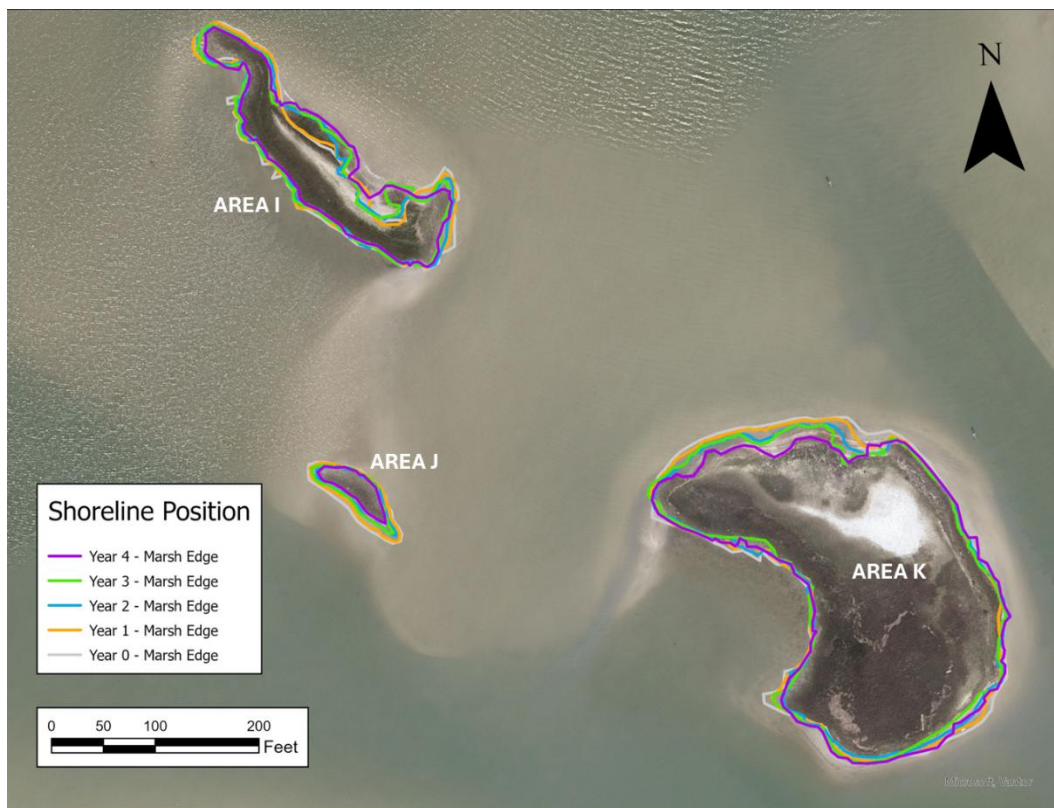


Figure 32. Marsh shoreline: Area I, Area J, and Area K.

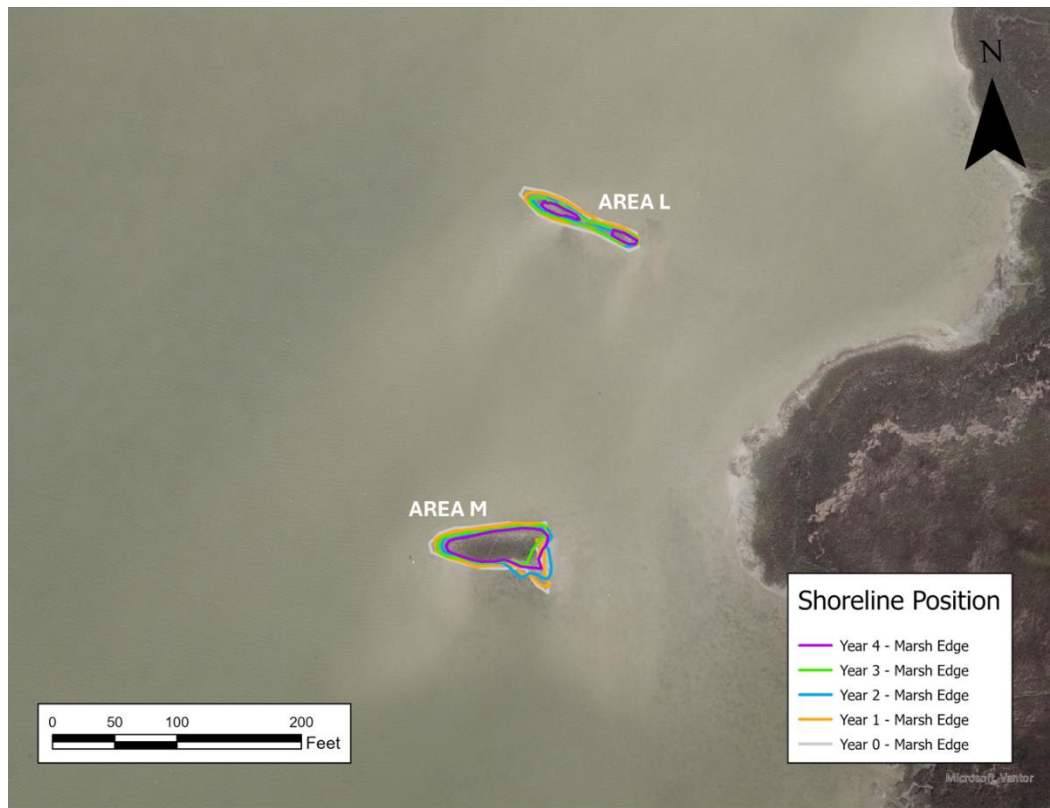


Figure 33. Marsh shoreline: Area L and Area M.

The marsh edge surveyed during the Year 4 Monitoring was compared with the Year 3 marsh edge position to determine the magnitude of advancement or retreat that occurred from Year 3 to Year 4. The data showed an average marsh edge position change of -1.3 ft during Year 4 Monitoring. This marked an increase in shoreline retreat that more closely resembled the Year 1 and Year 2 Monitoring values. The advancement observed during the Year 3 Monitoring period appears to have been atypical and was likely the result of unique forcing conditions (e.g. Hurricane Beryl) impacting short-term morphodynamic trends in the region. Apart from Area M, the remaining small marsh islets (e.g. Area D, J, and L) all experienced a retreat of the marsh edge higher than 2 ft. As previously observed, scarps, and protruding land masses experienced retreat, with the largest occurring along the northern marsh edge of Area K. Advancement was typically observed along partially submerged vegetated shorelines whose growth tends to vary more from year to year.

The color-coding system shown in the shoreline change figures (see Figure 34 to Figure 43) represents the approximated horizontal difference between Year 3 and Year 4 marsh edge position. Marsh edge retreat relative to Year 3 conditions are shown by warm colors ranging from -1.0 foot to -18.0 feet. Marsh edge advancement relative to the Year 3 conditions are shown by cool colors ranging from +1.0 foot to +15.0 feet. A neutral color was assigned for areas where the horizontal differences between marsh edge positions were between -1.0 foot and +1.0 foot. This neutral range communicates the uncertainty in the precision of measured shoreline change in these areas due to small fluctuations in vegetation extents between monitoring events and incidental differences in measurement techniques.

3.4.1 Area A

Area A is the furthest west monitoring area, located at the northern end of a strip of land just south of the Butterowe Bayou breakwater. To the west of Area A is a spit that transitions into a gently sloping shoreline with a partially submerged vegetated marsh edge along the west/northwest shorelines. The northern marsh edge fluctuates between scarps with emergent low marsh vegetation and gently sloping shorelines with partially submerged marsh edge of low marsh vegetation. This stretch of shoreline also contains a land protrusion that extends north towards the breakwater creating a small cove covered in mudflats and partially submerged vegetation. To the east of Area A is a stretch of shallow sand bars that gently slope up to the northeastern shoreline into mudflats covered by partially submerged low marsh vegetation and high marsh vegetation (see Figure 24 and Figure 25).

Historically, the northern marsh edge has been receding with some advancement occurring near areas containing partially submerged vegetation. This trend continued during the Year 4 Monitoring period. The land protrusion has historically experienced some advancement along its western marsh edges and erosion along its northern and eastern marsh edges. During the Year 4 Monitoring period the western and northern marsh edges receded from their previous position, forming a scarp along the northern end of the land protrusion. The eastern side of the land protrusion has advanced from its previous position during the Year 4 Monitoring period. The northeastern marsh edge of Area A transitions to a scarp bordering a channel separating Area A and Area B (see Figure 34). This stretch of marsh has receded during past monitoring periods and continued to recede during the Year 4 Monitoring period.

According to the Year 4 Monitoring data, Area A has experienced -0.2 feet of average change of marsh edge position from Year 3 to Year 4, indicating an overall retreat of the Area A marsh edge. The largest amount of recession and advancement occurred on the east and west side of the land protrusion where -12.0 feet and +13.0 feet of change in the marsh edge position occurred respectively. Generally, scarps retreated -1.0 foot to -5.0 feet throughout the Area A marsh edge. Partially submerged vegetation, along the northeastern marsh edge and portions of the northern marsh edge experienced up to +10.0 feet of advancement.

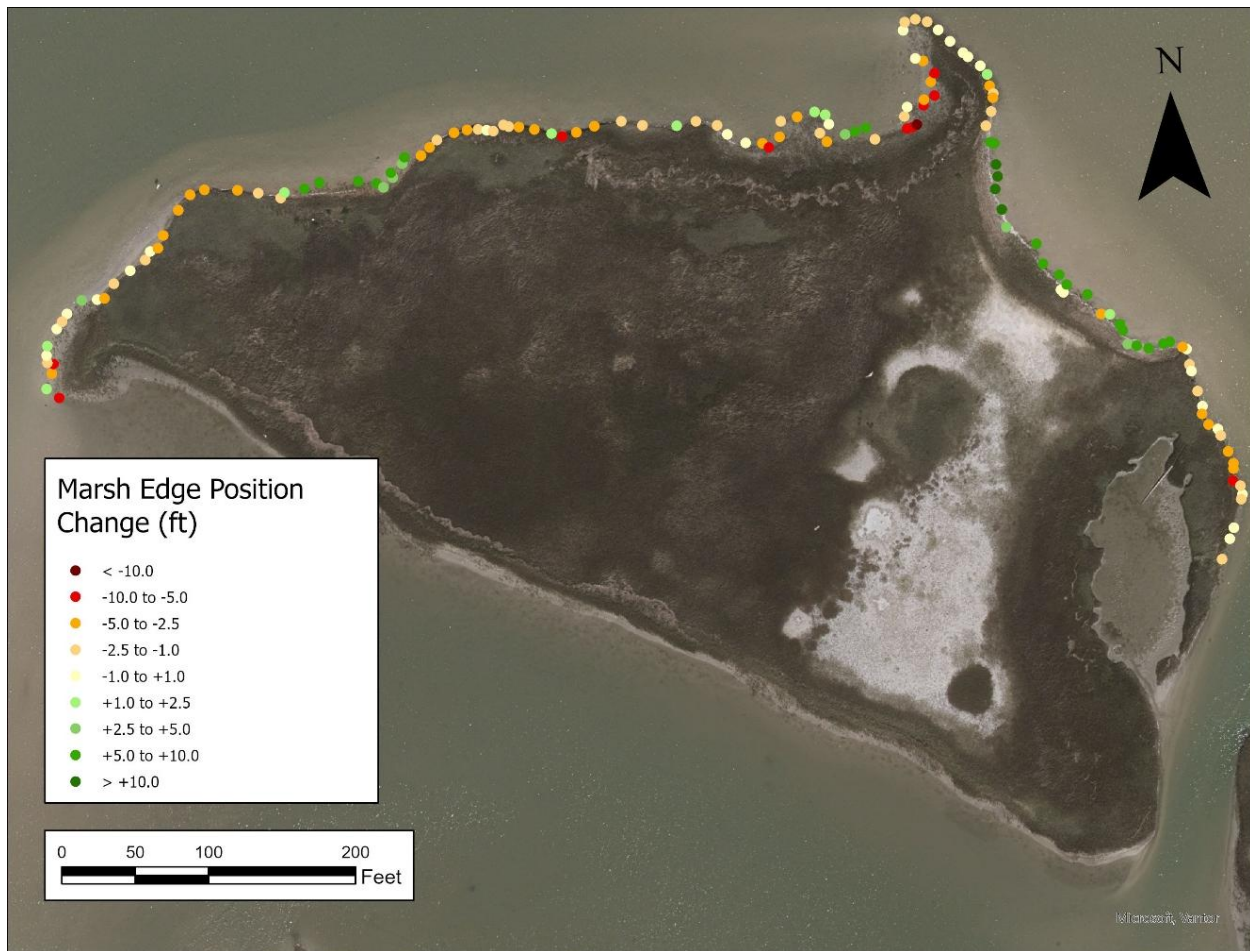


Figure 34. Marsh edge position change for Area A.

3.4.2 Area B

Area B is located southeast of Area A along a channel separating the two monitoring areas. Area B is covered in emergent low marsh vegetation and consists of a western and northeastern shoreline covered with scarps and partially submerged low marsh vegetation. Historically, the western marsh edge has fluctuated between periods of advancement and recession but retreated during the Year 4 Monitoring period, when compared to previous monitoring periods (see Figure 28). The northeastern marsh edge has retreated over the past few monitoring periods and continued to do so during the Year 4 Monitoring. The shorelines are scarped with shallow water sand bars along the northeastern shoreline.

Per Year 4 Monitoring data, Area B has experienced an average of -1.9 feet of retreat of the marsh edge. The average recession during Year 4 reflects the trend observed during the Year 1 and Year 2 Monitoring periods. The average recession rate along the Area B marsh edge ranged from -1.0 foot to -5.0 feet (see Figure 35).

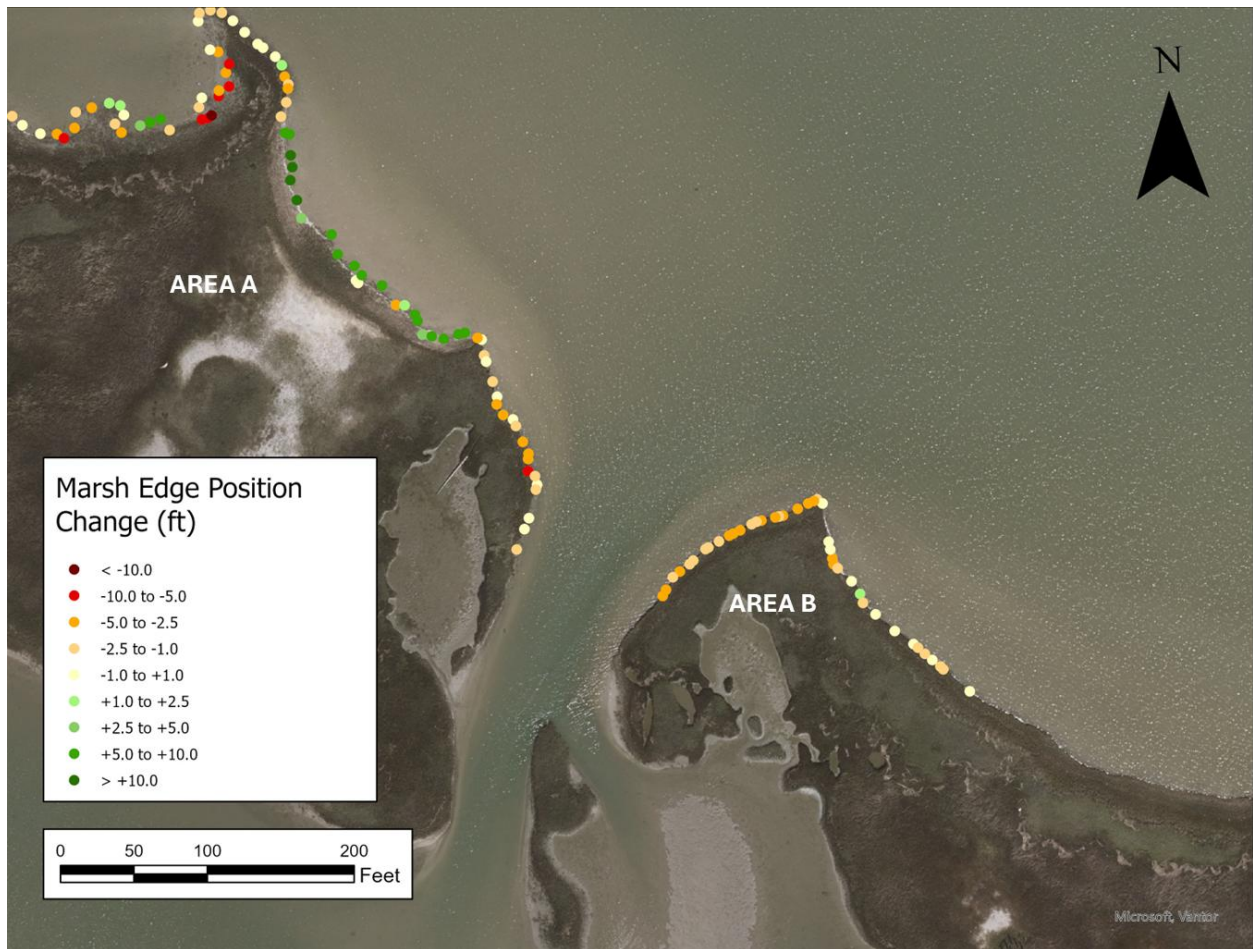


Figure 35. Marsh edge position change for Area B.

3.4.3 Area C

Area C is the northern end of a large island between Area A and Area E. To the west of Area C is a large stretch of shallow water leading to a gently sloping western shoreline that contains partially submerged marsh edge of low marsh vegetation. To the east of the island is a channel leading up to a scarped eastern shoreline with fully emergent low marsh vegetation.

According to the Year 4 Monitoring data, Area C has experienced an average of -1.5 feet of marsh edge retreat. This recession rate follows trends present during the Year 1 and Year 2 Monitoring periods. Both eastern and western marsh edges have experienced up to -5.0 feet of recession. The northern tip of Area C receded about -10.0 feet south from its Year 3 position. This was the most significant shoreline change that occurred in the area (see Figure 36).



Figure 36. Marsh edge position change for Area C.

3.4.4 Areas D and E

Area D is a small islet located near the Oak Bayou Breakwater, northwest of Area E. The shoreline of Area D is scarped and is covered by low lying marsh vegetation. During previous monitoring periods, this island experienced retreat. This trend continued during the Year 4 Monitoring period. During the Year 4 Monitoring period, Area D has experienced an average of -2.1 feet of marsh edge recession. The largest recession of -5.5 feet occurred along the western side of the islet which is exposed to the largest fetch (see Figure 37).

Area E is located south of the Oak Bayou breakwater, to the east of Area D. Water depths around Area E are relatively shallow, resulting in gently sloping shorelines covered in low marsh vegetation. At the terminus of Area E's northern shoreline, there is a land protrusion extending northeast towards the Oak Bayou breakwater. Along the western face of the land protrusion is a mudflat that is partially covered by low marsh vegetation. The northern and eastern shorelines of the land protrusion were scarped but transitioned back into gently sloping shorelines along the eastern side of Area E. Historically this monitoring area has experienced recession along all of its marsh edges except for regions adjacent to mudflats and partially submerged low marsh vegetation.

During the Year 4 Monitoring period, Area E experienced an average of -1.4 feet of marsh edge recession. The largest of which occurred along the scarps observed during the site visit and ranged from -2.5 feet to -5.0 feet of recession. The damaged vegetation along these scarps had their roots exposed and stalks snapped. Some advancement did occur within the cove west of the land protrusion that ranges from +1.0 foot to +2.5 feet. From Year 3 to Year 4 there was noticeably more marsh edge recession (see Figure 37). However, the marsh edge recession rates did not exceed levels observed in Year 2.

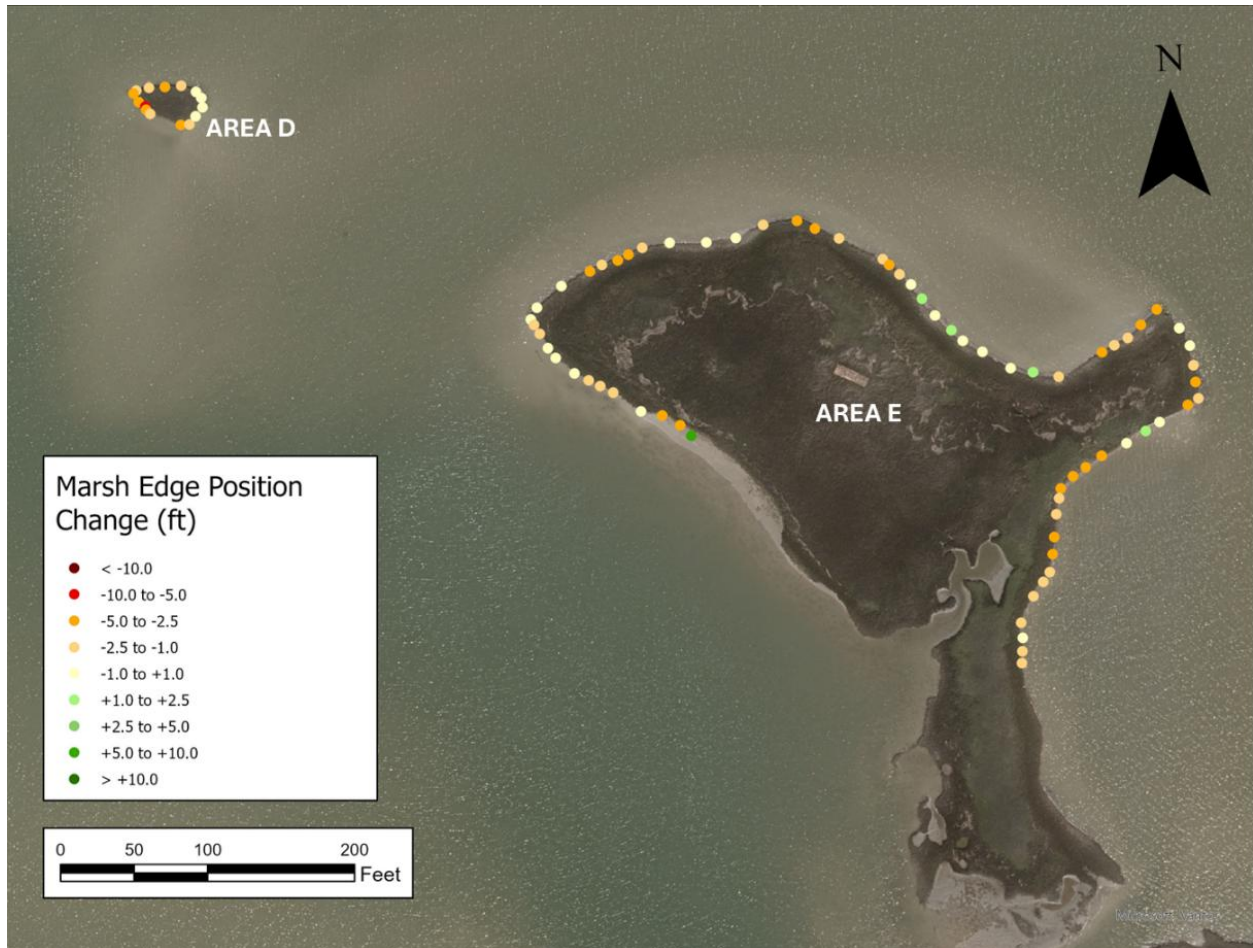


Figure 37. Marsh edge change for Area D and E.

3.4.5 Areas F, G, and H

Areas F, G, and H were small islets positioned directly behind the Dana Cove breakwater. These islands were typically partially visible during low tide but have been eroding away since Year 1 Monitoring as shown in Figure 38 and Figure 39.

During the Year 4 site visits the low water levels provided an opportunity to photograph the footprints of Areas F and G (e.g. Figure 38 and Figure 39). The photographs confirm that these islands have been eroded to the elevation of the surrounding bathymetry. Area H also experienced similar erosion but was not photographed during the site visit.



Figure 38. Area F footprint



Figure 39. Area G footprint

3.4.6 Area I

Area I is one of three larger islands directly southeast of the Dana Cove breakwater. This island is located in a large stretch of shallow water habitat with a spit at its southwestern end and a sand bar along its eastern shoreline. The western and northwestern shorelines of Area I are gently sloping, connected to mudflats, and covered in partially submerged low marsh vegetation (see Figure 20). The eastern and southeastern shorelines of Area I transition from scarped shorelines to the north to patches of partially submerged vegetation on a gently sloping sand bars to the south. These shorelines also contain some high marsh vegetation along the higher elevations.

Historically, Area I has experienced fluctuations of accretion and recession along the western marsh edges. The northwestern and southeastern marsh edges have receded in the past and are more dynamic due to the presence of partially submerged vegetation. The eastern marsh edge advanced from Year 1 to Year 3 due to the growth of partially submerged low marsh vegetation which persisted during the Year 4 Monitoring period.

During the Year 4 Monitoring period, the Area I marsh edges experienced an average marsh edge position change of -0.31 feet. The western and northwestern marsh edges experienced -1.0 feet to -5.0 feet of recession with some points along the northwest experiencing -7.0 feet of recession. The eastern and southeastern marsh edges advanced between +1.0 foot and +5.0 feet, with the partially submerged vegetation advancing about +11.0 feet to the southwest.



Figure 40. Marsh edge change for Area I.

3.4.7 Areas J and K

Area J is an islet located to the west of Area I and Area K. This monitoring area is connected to Area I by a spit present during low tide. The shoreline of Area J is scarped with some sections along the northern end being more gently sloping. The islet is dominated by low marsh vegetation that can become partially submerged during high tide events.

Historically, the Area J marsh edge has receded on all sides. During the Year 3 Monitoring period, the southwestern marsh edges experienced some advancements. During the Year 4 Monitoring period, the Area J marsh edge receded an average of -2.48 feet from its Year 3 position, continuing a trend observed during Year 1 and Year 2. The western marsh edges experienced -2.5 feet to -5.0 feet of recession. The eastern marsh edge experienced -1.0 feet to -2.5 feet of recession. The largest recession occurred at the southern tip of the islet where the marsh edge receded -11.7 feet from its Year 3 position (see Figure 41).

Area K is the largest of the three large islands south of the Dana Cove Breakwater. The island has a heavily trafficked navigational channel present to its east, a spit coming off its western tip and a shallow water habitat to its north. In addition, there is a sand bar along the eastern shoreline, and a mudflat along its western shoreline. Though the island is partially protected by the Dana Cove Breakwater, its northern shoreline is still exposed to a relatively long northern fetch.

Historically, the Area K marsh edges have fluctuated between advancement and recession throughout the past four monitoring periods with the exception of the northern marsh edge. The northern marsh edge has been steadily receding over the last 4 years. The northern marsh edge is scarped, with small coves present where low and high marsh vegetation has retreated. The remaining shorelines are gently sloping shorelines covered by partially submerged low marsh vegetation and fully emergent high marsh vegetation.

During the Year 4 Monitoring period, Area K experienced an average change in marsh edge position of +0.35 feet. The south, east, and west marsh edge advanced up to +10 feet with the largest advancement of +12.6 feet occurring along the southern marsh edge. The northern shoreline continued to recede up to -15.8 feet in some locations (see Figure 41). Similar to Year 3, vegetation along the northern marsh edge showed signs of significant damage (see Figure 42).

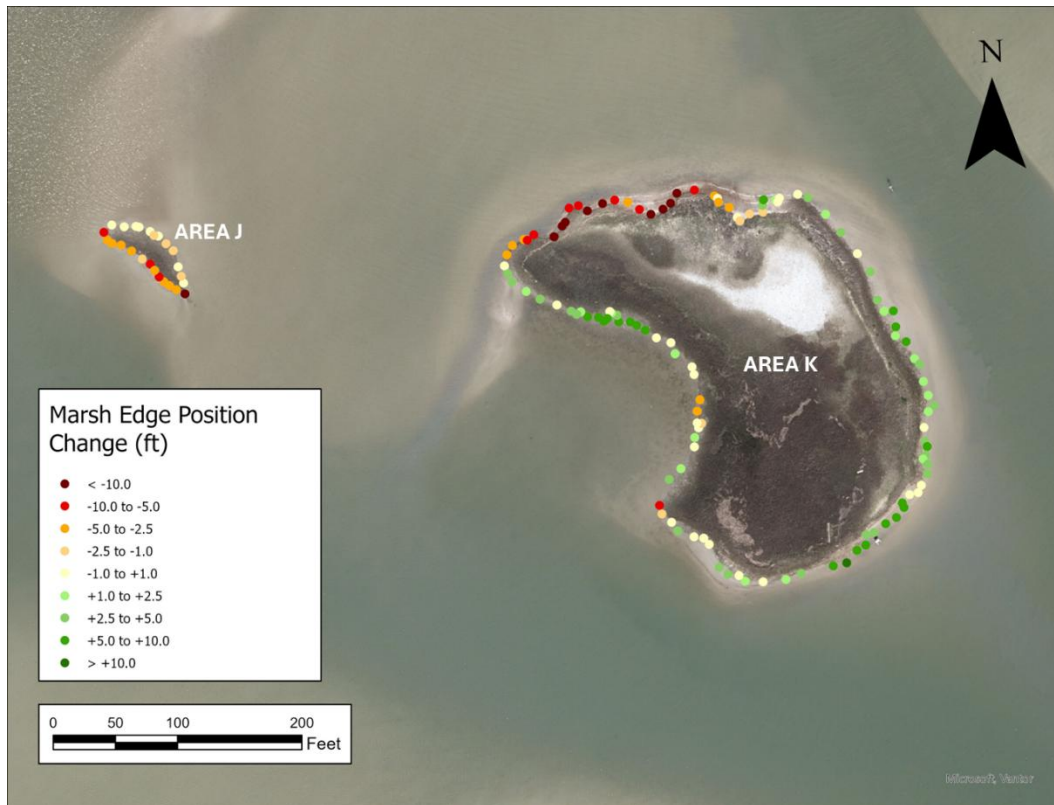


Figure 41. Shoreline change for Area K.



Figure 42. Vulnerable marsh shoreline in Area K.

3.4.8 Areas L and M

Areas L and M are islets southwest of Area K near the GISP bayside camping site. These islets are located within a shallow water region exposed long fetch lengths from the north/northwest. Historically, Areas L and M have experienced shoreline retreat throughout the past monitoring periods.

During the Year 4 Monitoring, Area L experienced an average of -2.5 feet of change in marsh edge position. The islet was separated into an eastern and western segment due to the loss of vegetation within the center of the islet (see Figure 44). Due to the damaged vegetation and the elevation relative to the surrounding land, the eastern segment of Area L is likely submerged during high tide. This segment experienced up to -5.0 feet of marsh edge recession from its Year 3 position. The western segment is still covered by some partially submerged low marsh vegetation. The shoreline along this segment are scarped and experienced up to -5.0 feet of recession from its Year 3 marsh edge position. The most significant recession occurred at its northwest tip where the marsh edges receded -10.5 feet.

During the Year 4 Monitoring, Area M experienced -0.2 feet of change in marsh edge position with a peak of -6.8 feet of recession occurring at its western end. The southeast end of the island accreted up to +12.6 feet due to a patch of submerged vegetation not present during Year 3 returned during Year 4. The western marsh edge of Area M is scarped but transitions into a gently sloping shoreline along its eastern end. The low marsh vegetation previously present on the islet was still present during the Year 4 Monitoring.

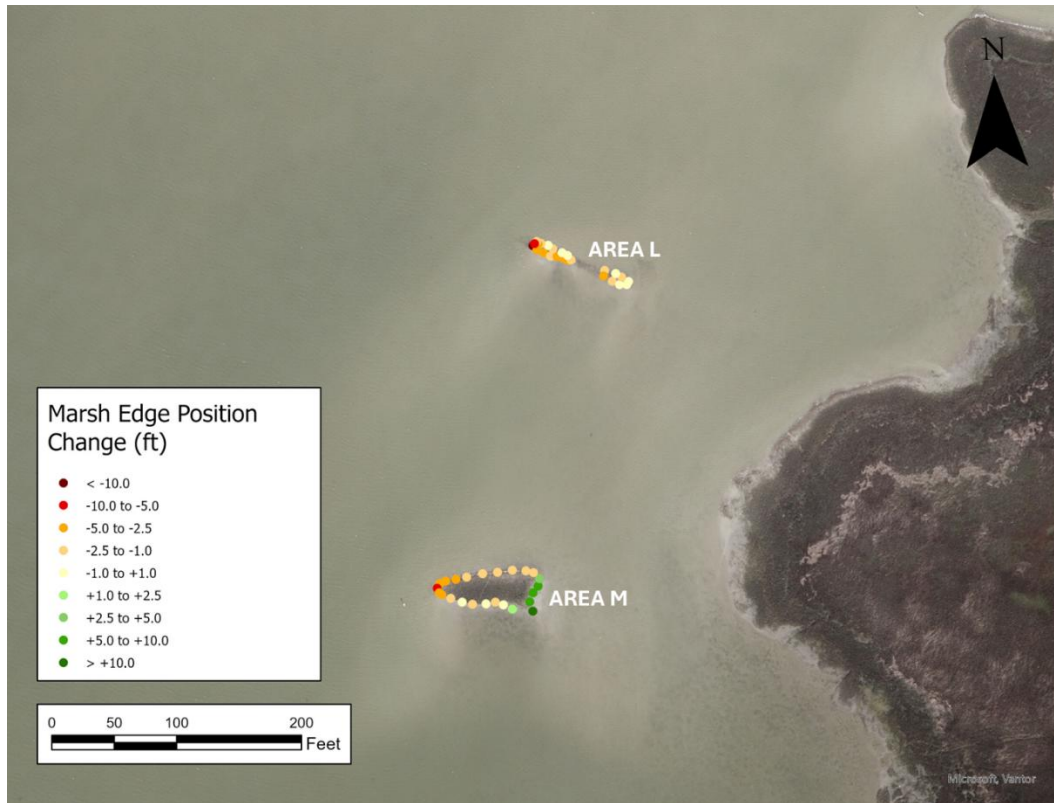


Figure 43. Shoreline change for Area L and M.



Figure 44. Area L looking north.

3.4.9 Marsh Edge Position Summary

The results of the marsh edge position change analysis are summarized in Table 3 as percentages relative to the number of survey points (marsh edge position measurements) taken at each individual monitoring area. These percentages represent shoreline change trends within each monitoring area. Marsh edge retreat greater than 5.0 feet was measured in all monitoring Areas besides Area B and Area E (varying from 1% to 12% of the respective survey measurements taken in these areas). Marsh expansion greater than 2.5 feet made up 4% to 20% of the measurements taken in Areas A, E, I, K, and M. When compared to Year 3 Monitoring, an increase in the amount of erosion occurred (see Table 3 and Table 4). These marsh edge position change percentages were averaged over the entire project site to more clearly illustrate project wide trends. Areas F, G, and H are shown with 0% erosion or accretion because these areas were completely eroded by Year 3.

Table 3. Relative percentages of shoreline change calculated in each monitoring area from Year 3 to Year 4.

Area ID	Marsh Edge Position Change (feet)								
	Erosion / Marsh Retreat				Neutral	Accretion / Marsh Expansion			
	-15.0 to -10.0	-10.0 to -5.0	-5.0 to -2.5	-2.5 to -1.0		+1.0 to +2.5	+2.5 to +5.0	+5.0 to +10.0	+10.0 to +20.0
Area A	1%	7%	22%	22%	19%	6%	5%	15%	3%
Area B	0%	0%	35%	40%	23%	3%	0%	0%	0%
Area C	0%	3%	13%	47%	23%	13%	0%	0%	0%
Area D	0%	7%	33%	33%	27%	0%	0%	0%	0%
Area E	0%	0%	28%	35%	29%	6%	0%	1%	0%
Area F	0%	0%	0%	0%	0%	0%	0%	0%	0%
Area G	0%	0%	0%	0%	0%	0%	0%	0%	0%
Area H	0%	0%	0%	0%	0%	0%	0%	0%	0%
Area I	0%	3%	24%	24%	17%	18%	8%	4%	2%
Area J	4%	12%	32%	20%	32%	0%	0%	0%	0%
Area K	8%	7%	8%	4%	22%	14%	20%	17%	1%
Area L	4%	4%	29%	33%	29%	0%	0%	0%	0%
Area M	0%	4%	21%	38%	13%	4%	4%	13%	4%

A summary table of the average change marsh edge position across the entire project area is presented in Table 4. The distribution of marsh edge position change during the Year 4 Monitoring period has skewed towards erosion. The table shows an increase in the number of shorelines experiencing -1.0 feet to -5.0 feet of erosion and a decrease in the number of shorelines experiencing +1.0 feet to 5.0 feet of accretion.

Table 4. Averaged percentages of shoreline change from Year 3 to Year 4.

Area ID	Marsh Edge Position Change (feet)								
	Erosion / Marsh Retreat				Neutral	Accretion / Marsh Expansion			
	-15.0 to -10.0	-10.0 to -5.0	-5.0 to -2.5	-2.5 to -1.0		+1.0 to +2.5	+2.5 to +5.0	+5.0 to +10.0	+10.0 to +20.0
Percent of Total Project	2%	5%	22%	24%	22%	9%	7%	8%	1%

To compare the average amount of marsh edge recession during this monitoring project, Table 5 was created to summarize the amount of shoreline loss per year for each monitoring area. The increase in erosion is reflected in the higher average recession rates for each monitoring area in Table 5. Area F, G, and H completely eroded by Year 1, Year 2, and Year 3 so these areas were marked as 'No Return' in Table 5 to indicate that this location didn't experience change after total loss.

Table 5. Marsh edge recession rate of selected monitoring areas.

Area ID	Approximate Shoreline Recession Rate (feet/year)				
	Year 0 to Year 1	Year 1 to Year 2	Year 2 to Year 3	Year 3 to Year 4	Year 0 to Year 4
Area A	-0.5	-0.8	0.0	-0.17	-0.4
Area B	-1.2	-2.3	-0.2	-1.92	-1.4
Area C	-1.5	-2.8	-0.3	-1.53	-1.6
Area D	-2.9	-2.8	0.6	-2.08	-1.8
Area E	0.6	-2.1	-0.2	-1.43	-0.8
Area F	-1.9	-3.5	-1.0	No Return	N/A
Area G	-2.8	-5.0	No Return	N/A	N/A
Area H	-6.0	No Return	N/A	N/A	N/A
Area I	-1.0	-0.8	1.3	-0.31	-0.2
Area J	-1.8	-3.7	0.7	-2.82	-1.9
Area K	-2.7	-2.6	-0.9	0.35	-1.5
Area L	-1.5	-2.6	0.5	-2.48	-1.5
Area M	-0.6	-0.9	-0.3	-0.20	-0.5
Average ft/yr:	-1.8	-2.5	0.0	-1.3	-1.4
Median ft/yr:	-1.5	-2.6	-0.2	-1.5	-1.5

4 Summary and Conclusions

This report documents Year 4 performance monitoring of Phase III of the CEPRA Project No. 1637. Monitoring efforts assessed the conditions of the Phase III breakwaters and estuarine marsh complex in the project area. GPS measurements, digital and aerial photography, and field observations were used to determine if Year 4 performance objectives of the MAMP had been met. The criteria established by the MAMP for each objective were evaluated based on how Year 4 Monitoring results compared with the Year 0 baseline, Year 1, Year 2, and Year 3 results. The performance objectives focused on:

- Breakwater geometry
- Establishment of hard substrate habitat
- Protection of estuarine habitats
- Stability of existing marsh edge position

All Phase III breakwaters appeared to meet the breakwater geometry and hard substrate habitat objectives. Based on GPS elevation measurements and field observations, the breakwaters appear stable, and scour does not appear to be affecting breakwater stability. Hard substrate habitat was observed on both sides of the breakwaters. Measured crest elevation in Year 4 was slightly lower than Year 3 but still met the settlement criteria in the MAMP. About 3% of crest elevation measurements are below +3.25 feet. The average elevation of all three breakwaters is above the specified construction elevation of +3.5 feet.

Based on Year 4 Monitoring, the monitoring objectives for protection of estuarine habitat are met. Since Year 0, the overall average rate of change in marsh edge position was -1.4 feet/year, which is less than the historical shoreline change rate of -2.9 feet/year for adjacent marshes as reported by HDR (2013). The plant species and estuarine marsh complex habitats identified during Year 0 site visit were observed during the most recent site visit. High marsh vegetation that was observed during Year 3 was also observed during Year 4. However, indications of damage to marsh vegetation, such as exposed root systems and broken blades of cordgrass, were observed along the northern shorelines of Area A, Area E, Area K, and Area L. Most notably, areas of historically submerged low marsh vegetation have advanced over the entire monitoring site. Other features, such as sand bars/shoals and shallow open-water habitats, appeared similar to baseline conditions.

Marsh edge position at the 13 areas selected prior to Year 0 Monitoring were measured during Year 4 Monitoring. Areas F, G and H were visible during Year 4 Monitoring due to low water levels and appeared to have been eroded down to the elevation of the surrounding bathymetry, confirming their loss. The survey data showed an increase in the percentage of shorelines experiencing erosion. The number of shorelines that remained relatively stable with positions fluctuating ± 1.0 feet decreased from 31% in Year 3 to 22% in Year 4.

5 References

HDR Engineering, Inc (HDR) 2013. Recovery Act: Restoring Estuarine Habitat in West Galveston Bay, Technical Memorandum – Post-Construction Monitoring of CEPRA Project No. 1483. Report prepared for the Texas General Land Office, National Oceanic and Atmospheric Administration, and Texas Parks and Wildlife Department.

HDR Engineering, Inc. (HDR) 2020. Monitoring and Adaptive Management Plan for Galveston Island State Park Marsh Restoration and Protection – Revised for Project Phase III. CEPRA Project No. 1637. Report Prepared for National Fish and Wildlife Foundation, Texas General Land Office, & Texas Parks and Wildlife Department.

HDR Engineering, Inc (HDR) 2021. Galveston Island State Park Marsh Restoration and Protection Phase III (CEPRA Project No. 1637) Closeout Documents. Prepared for Texas General Land Office with Letter of Transmittal dated November 11, 2021.

HDR Engineering, Inc (HDR) 2022. Galveston Island State Park Marsh Restoration and Protection Phase III (CEPRA Project No. 1637) Post-Construction Monitoring Report: Year 0. Report prepared for Texas General Land Office.

HDR Engineering, Inc (HDR) 2023. Galveston Island State Park Marsh Restoration and Protection Phase III (CEPRA Project No. 1637) Post-Construction Monitoring Report: Year 1. Report prepared for Texas General Land Office.

HDR Engineering, Inc (HDR) 2024. Galveston Island State Park Marsh Restoration and Protection Phase III (CEPRA Project No. 1637) Post-Construction Monitoring Report: Year 2. Report prepared for Texas General Land Office.

HDR Engineering, Inc (HDR) 2024. Galveston Island State Park Marsh Restoration and Protection Phase III (CEPRA Project No. 1637) Post-Construction Monitoring Report: Year 3. Report prepared for Texas General Land Office.

Appendix A: Digital Photographs



Figure A1. Area A – Year 4



Figure A2. Area A – Year 4



Figure A3. Area A – Year 4



Figure A4. Area A – Year 4



Figure A5. Area A – Year 4



Figure A6. Area A – Year 4



Figure A7. Area A – Year 4



Figure A8. Area B – Year 4



Figure A9. Area B – Year 4



Figure A10. Area B – Year 4



Figure A11. Area C – Year 4



Figure A12. Area C – Year 4



Figure A13. Area C – Year 4



Figure A14. Area C – Year 4



Figure A15. Area D – Year 4



Figure A16. Area D – Year 4



Figure A17. Area D – Year 4



Figure A18. Area E – Year 4



Figure A19. Area E – Year 4



Figure A20. Area E – Year 4



Figure A21. Area E – Year 4



Figure A22. Area E – Year 4



Figure A23. Area E – Year 4



Figure A24. Area E – Year 4



Figure A25. Area I – Year 4



Figure A26. Area I – Year 4



Figure A27. Area I – Year 4



Figure A28. Area I – Year 4



Figure A29. Area I – Year 4



Figure A30. Area I – Year 4



Figure A31. Area I – Year 4



Figure A32. Area I – Year 4



Figure A33. Area I – Year 4



Figure A34. Area I – Year 4



Figure A35. Area J – Year 4



Figure A36. Area J – Year 4



Figure A37. Area J – Year 4



Figure A38. Area J – Year 4



Figure A39. Area K – Year 4



Figure A40. Area K – Year 4



Figure A41. Area K – Year 4



Figure A42. Area K – Year 4



Figure A43. Area K – Year 4



Figure A44. Area K – Year 4



Figure A45. Area L – Year 4



Figure A46. Area L – Year 4



Figure A47. Area M – Year 4



Figure A48. Area M – Year 4



Figure A49. Area M – Year 4



Figure A50. Area M – Year 4

Appendix B: Aerial Photographs



Figure B1. Year 0 Aerial Photography



Figure B2. Year 1 Aerial Photography



Figure B3. Year 2 Aerial Photography



Figure B4. Year 3 Aerial Photography



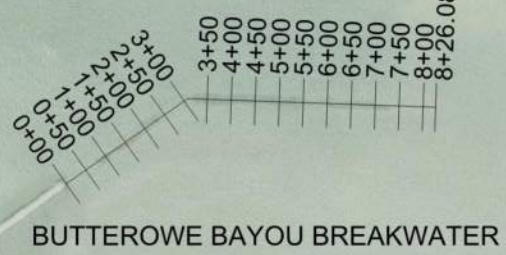
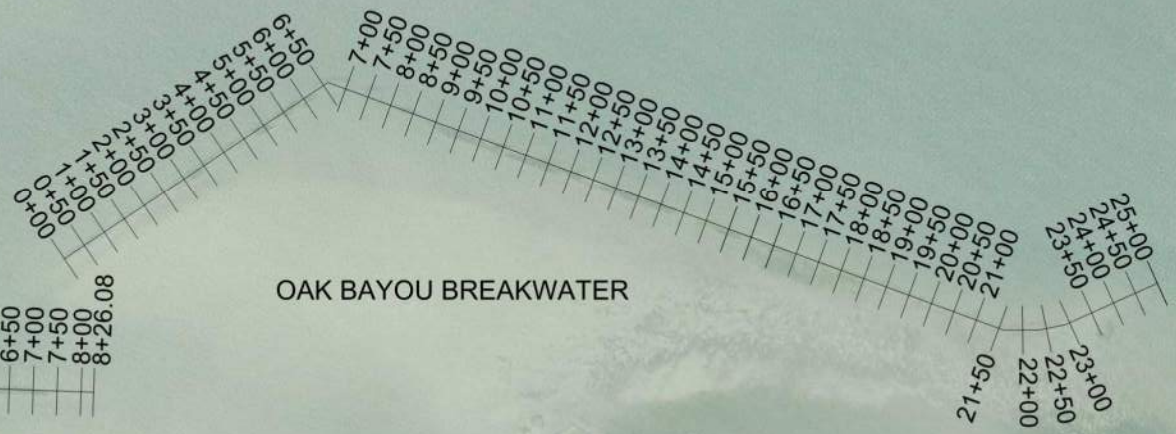
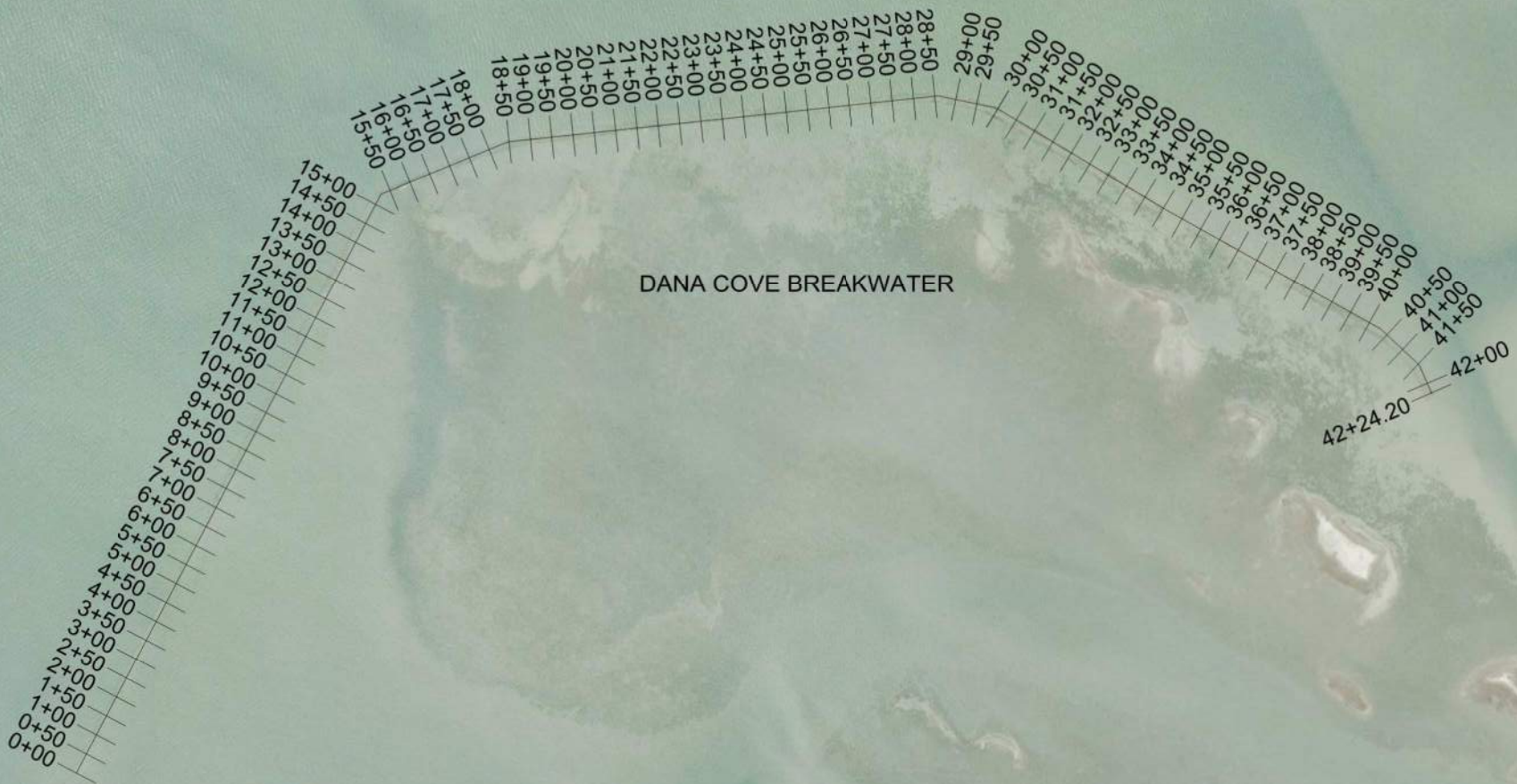
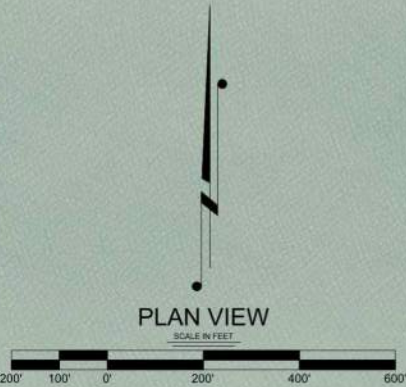
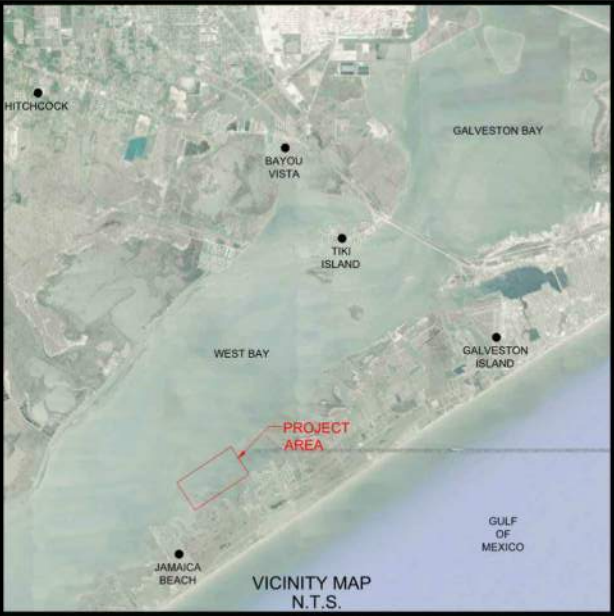
YEAR 4 MONITORING

APPENDIX B

PHOTO TAKEN BY TERRA FLIGHT IMAGING (03/04/2026)

Figure B5. Year 4 Aerial Photography

Appendix C: Surveys



NOTES:
1) SOUNDINGS DATA WERE RECORDED BY T. BAKER SMITH ON 2, 4, 24 AUGUST, 27-28 SEPTEMBER, 5-6 OCTOBER, 2021. SEA FLOOR AND TOPOGRAPHIC CONDITIONS ARE SUBJECT TO CHANGE.
2) A SINGLE-BEAM ECHOSOUNDER OPERATING AT 200KHZ WAS UTILIZED FOR THE BATHYMETRIC PORTION OF THE SURVEY.
3) HORIZONTAL DATUM: NAD83, TEXAS SOUTH CENTRAL ZONE, US FEET.
4) VERTICAL DATUM: NAVD 88 REFERENCE MONUMENT "HOCSD 62"
"HOCSD 62"
N: 13,843,727.04
E: 3,264,124.31
ELEV: 6.3' NAVD88

CEPRA 1637, GLO CONTRACT NO. 21-141-000-C818, GLO PROJECT NUMBER 318003



T. BAKER SMITH
A CENTURY OF SOLUTIONS
3854 FM 1069
Anahuac, TX 78336
(361) 334-5710 • tbasmith.com
TBSPL# 810194575

NO.	DATE	REVISION



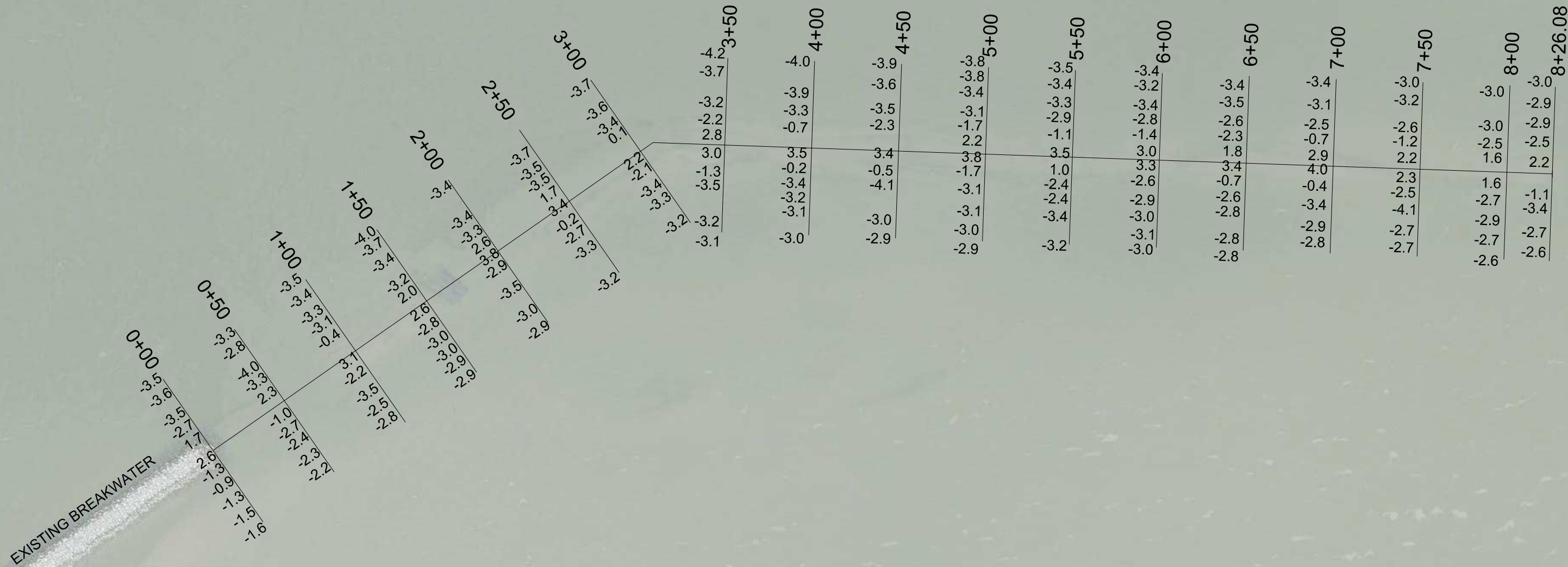
10/11/2021

LUHR BROS., INC.
GISP MARSH RESTORATION AND PROTECTION PHASE III
BUTTEROWE BAYOU, OAK BAYOU AND DANA COVE
BATHYMETRIC SURVEY
GALVESTON COUNTY, TEXAS

SCALE	DATE	SHEET	OF	DATE
1"=200'	CDW	1	11	OCT. 2021



WEST BAY



NOTES:
1) SOUNDINGS DATA WERE RECORDED BY T. BAKER SMITH ON 2, 4, 24 AUGUST, 27-28 SEPTEMBER, 2-6 OCTOBER, 2021. SEA FLOOR AND TOPOGRAPHIC CONDITIONS ARE SUBJECT TO CHANGE.
2) A SINGLE-BEAM ECHOSOUNDER OPERATING AT 200KHZ WAS UTILIZED FOR THE BATHYMETRIC PORTION OF THE SURVEY.
3) HORIZONTAL DATUM: NAD83, TEXAS SOUTH CENTRAL ZONE, US FEET.

NOTES:
4) VERTICAL DATUM: NAVD 88 REFERENCE MONUMENT "HGCSO 62"
"HGCSO 62"
N: 13,845,727.04
E: 3,264,124.31
ELEV: 6.3' NAVD88



CEPRA 1637, GLO CONTRACT NO. 21-141-000-C818, GLO PROJECT NUMBER 318003



T. BAKER SMITH
A CENTURY OF SOLUTIONS
3044 FM 1080
P.O. Box 1080
Baytown, TX 77520
409.671.0710 - bsmith@tbs.com
TBSPLS #10194575

NO.	DATE	REVISION

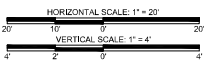
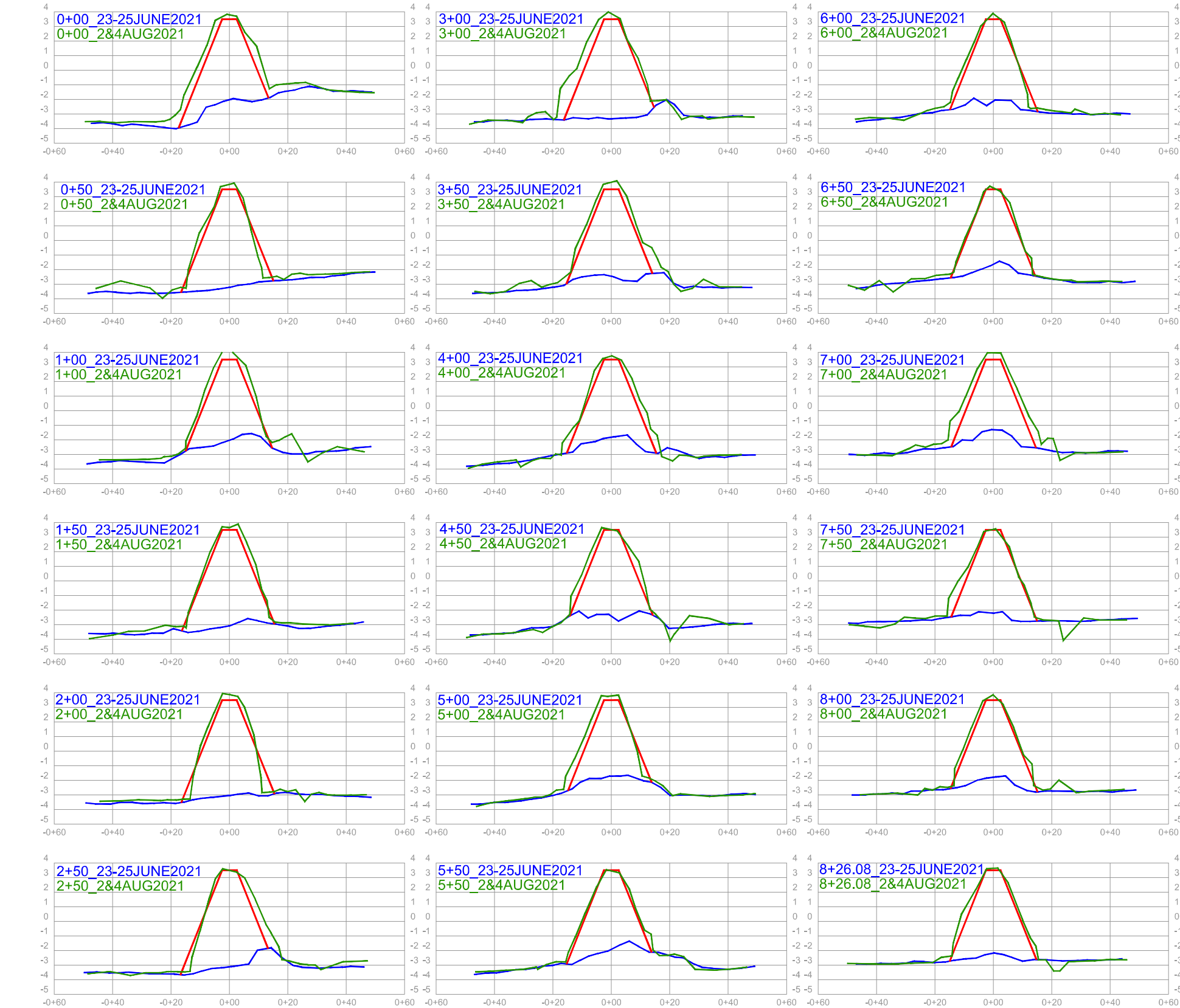
LUHR BROS., INC.
GISP MARSH RESTORATION AND PROTECTION PHASE III
BUTTEROWE BAYOU BREAKWATER
BATHYMETRIC SURVEY
GALVESTON COUNTY, TEXAS

SCALE: 1"=30'
DRAWN BY: CDW

SHEET 2 OF 11
OCT. 2021



10/11/2021



NOTES:
1) SOUNDINGS DATA WERE RECORDED BY T. BAKER SMITH ON 2, 4, 24 AUGUST, 27-28 SEPTEMBER, 3-6 OCTOBER, 2021. SEA FLOOR AND TOPOGRAPHIC CONDITIONS ARE SUBJECT TO CHANGE.
2) A SINGLE-BEAM ECHOSOUNDER OPERATING AT 200KHZ WAS UTILIZED FOR THE BATHYMETRIC PORTION OF THE SURVEY.
3) HORIZONTAL DATUM: NAD83, TEXAS SOUTH CENTRAL ZONE, US FEET.
NOTES:
4) VERTICAL DATUM: NAVD 88 REFERENCE MONUMENT "HGCSD 62"
"HGCSD 62"
N: 13,845,727.04
E: 5,264,124.51
ELEV: 6.3' NAVD88

CEPRA 1637, GLO CONTRACT NO. 21-141-000-C818, GLO PROJECT NUMBER 318003



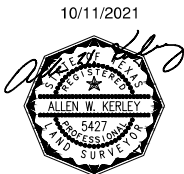
T. BAKER SMITH
A HISTORY OF SOLUTIONS
3804 FM 1080
Pineburg, TX 78869
807.794-0710 • tbsmith.com
TBPLS #10194575

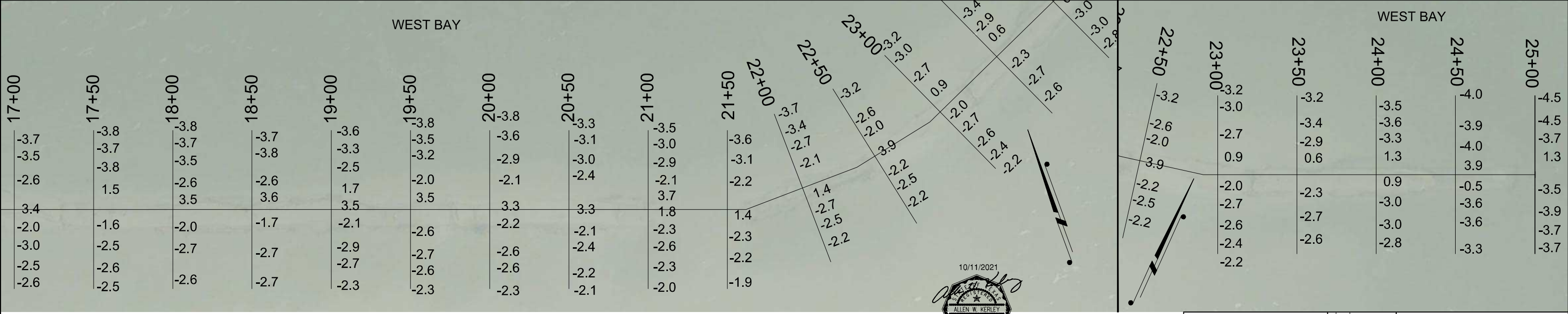
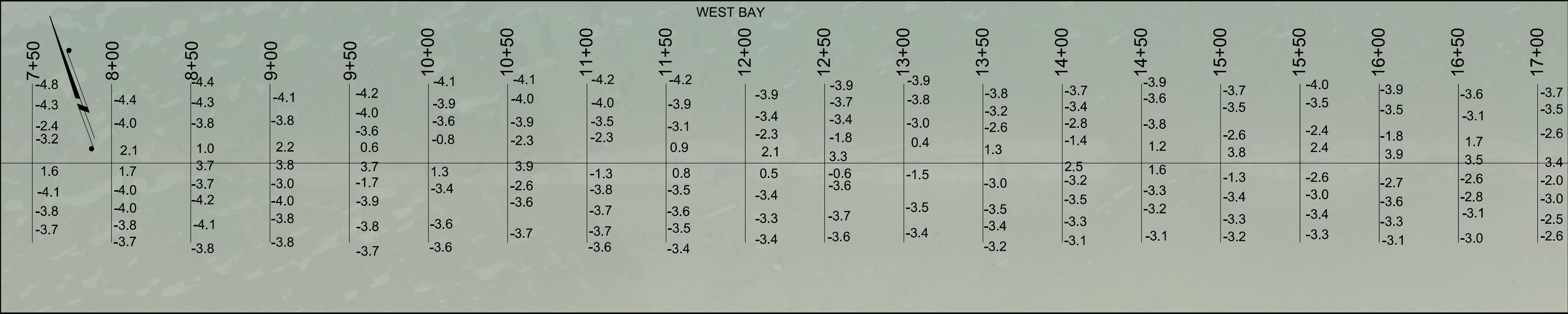
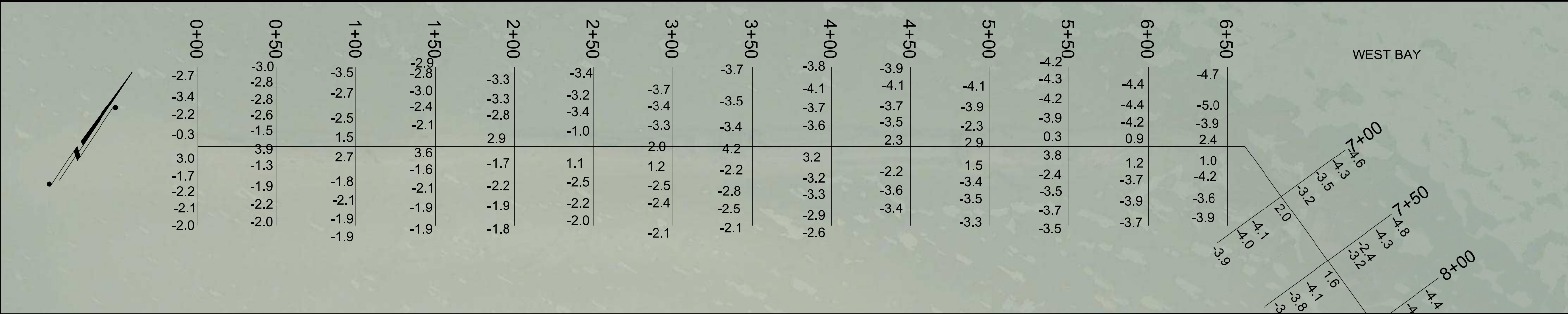
NO.	DATE	REVISION

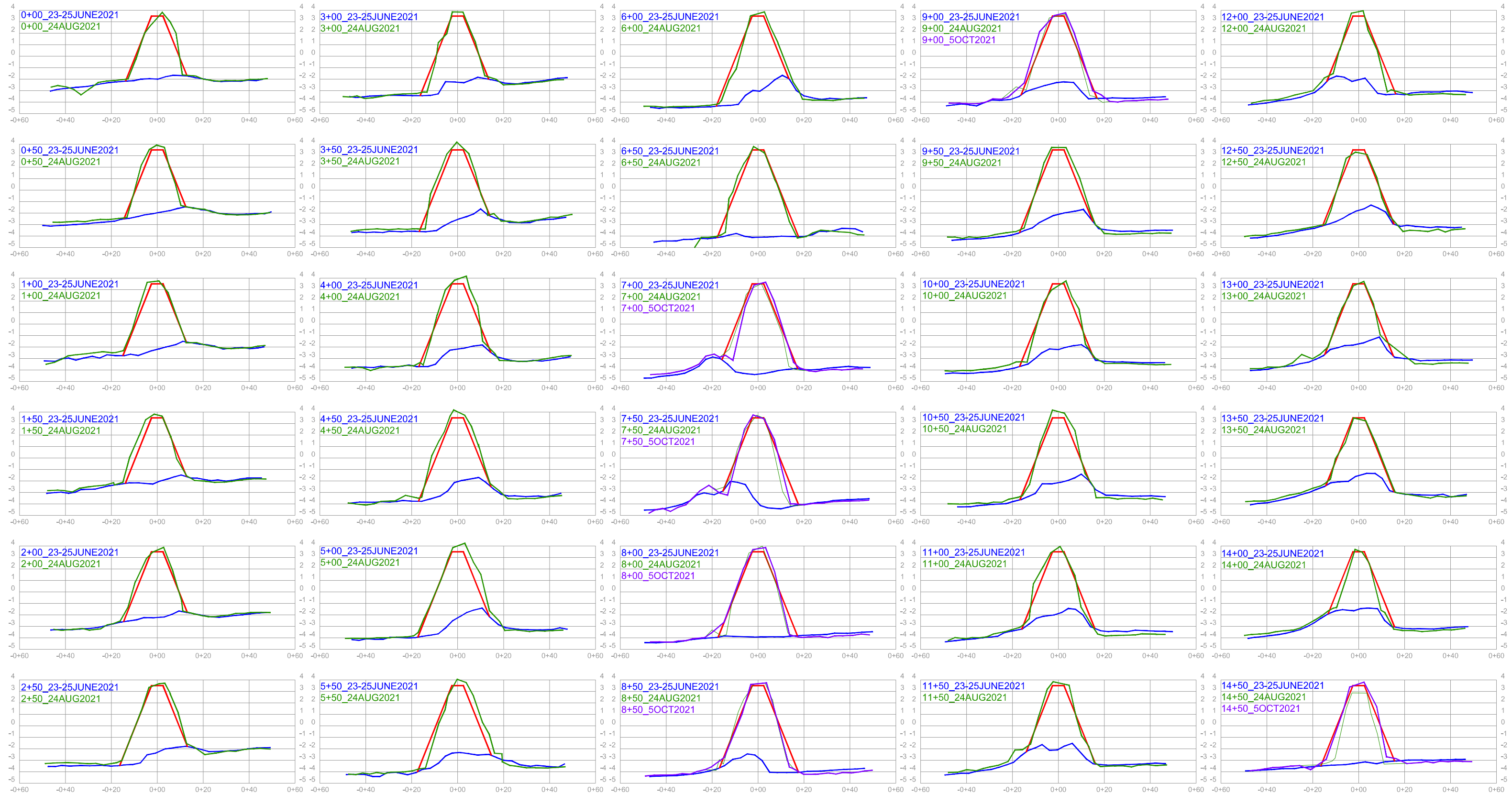
LUHR BROS., INC.
GISP MARSH RESTORATION AND PROTECTION PHASE III
BUTTEROWE BAYOU BREAKWATER
BATHYMETRIC SURVEY
GALVESTON COUNTY, TEXAS

SCALE: 1"=20'
DRAWN BY: CDW

SHEET 3 OF 11
OCT. 2021



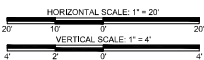
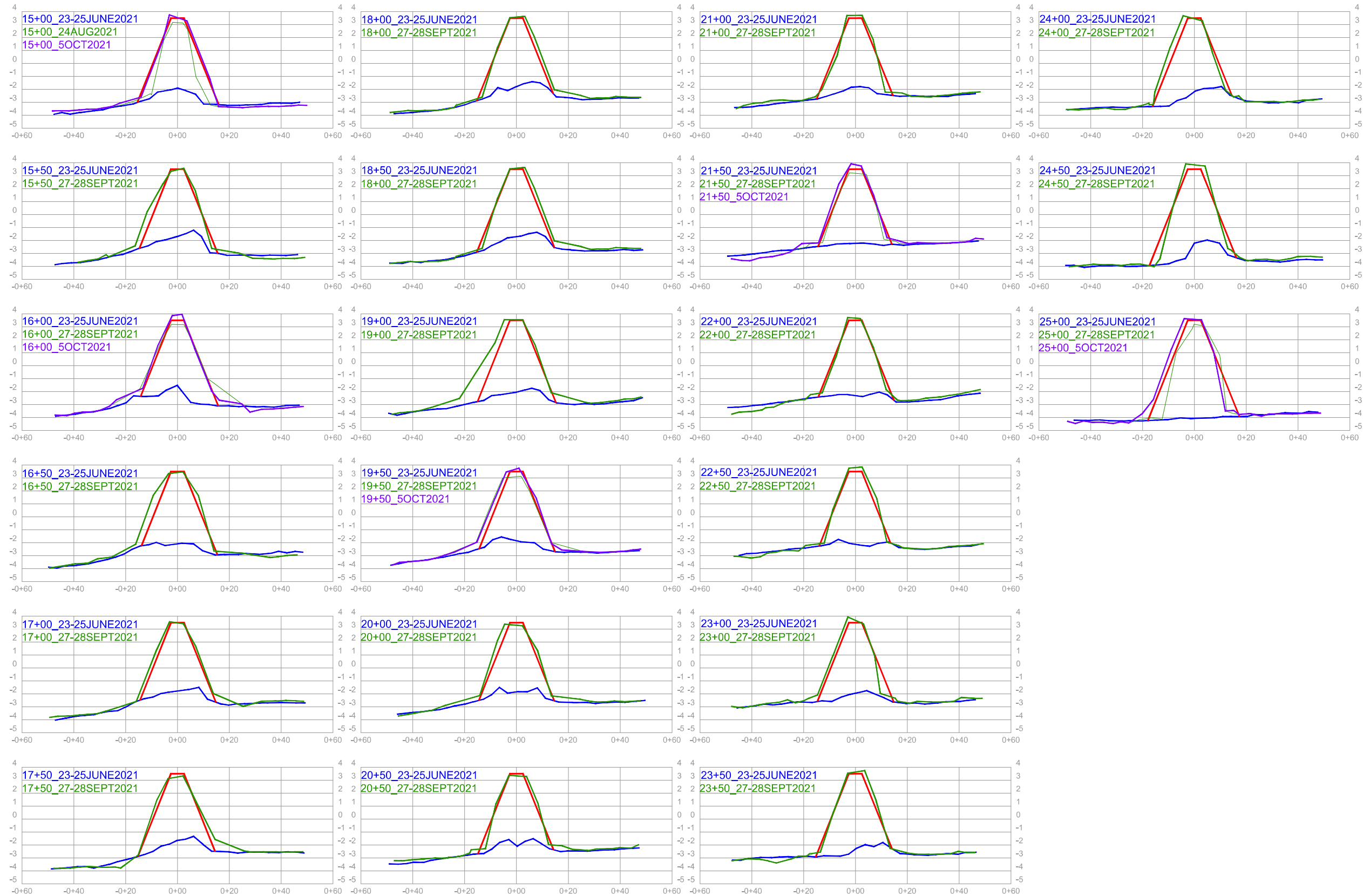




HORIZONTAL SCALE: 1" = 20'
VERTICAL SCALE: 1" = 4'

NOTES:
1) SOUNDINGS DATA WERE RECORDED BY T. BAKER SMITH ON 2, 4, 24 AUGUST, 27-28 SEPTEMBER, 5-6 OCTOBER, 2021. SEA FLOOR AND TOPOGRAPHIC CONDITIONS ARE SUBJECT TO CHANGE.
2) A SINGLE-BEAM ECHOSOUNDER OPERATING AT 200KHZ WAS UTILIZED FOR THE BATHYMETRIC PORTION OF THE SURVEY.
3) HORIZONTAL DATUM: NAD83, TEXAS SOUTH CENTRAL ZONE, US FEET.
4) VERTICAL DATUM: NAVD 88 REFERENCE MONUMENT "HGCSD 62"

"HGCSD 62"
N: 13,845,727.04
E: 5,264,124.51
ELEV: 6.3' NAVD88



NOTES:
1) SOUNDINGS DATA WERE RECORDED BY T. BAKER SMITH ON 2, 4, 24 AUGUST, 27-28 SEPTEMBER, 5-6 OCTOBER, 2021. SEA FLOOR AND TOPOGRAPHIC CONDITIONS ARE SUBJECT TO CHANGE.
2) A SINGLE-BEAM ECHOSOUNDER OPERATING AT 200KHZ WAS UTILIZED FOR THE BATHYMETRIC PORTION OF THE SURVEY.
3) HORIZONTAL DATUM: NAD83, TEXAS SOUTH CENTRAL ZONE, US FEET.
NOTES:
4) VERTICAL DATUM: NAVD 88 REFERENCE MONUMENT "HGCSO 62"
"HGCSO 62"
N: 13,845,727.04
E: 5,264,124.31
ELEV: 6.3' NAVD88

CEPRA 1637, GLO CONTRACT NO. 21-141-000-C818, GLO PROJECT NUMBER 318003

**T. BAKER SMITH**
A BENTLEY SYSTEMS COMPANY
3004 FIVE 1000
FARMERS ROAD, TX 77069
832.795.4770 • www.tbbs.com
TBPLS #10194575

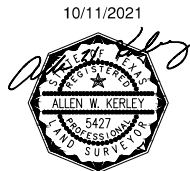
NO.	DATE	REVISION

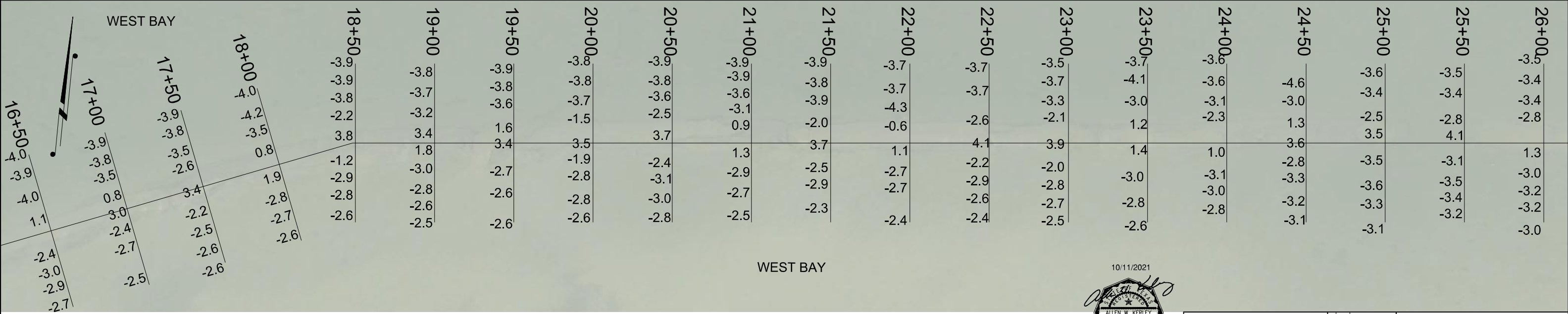
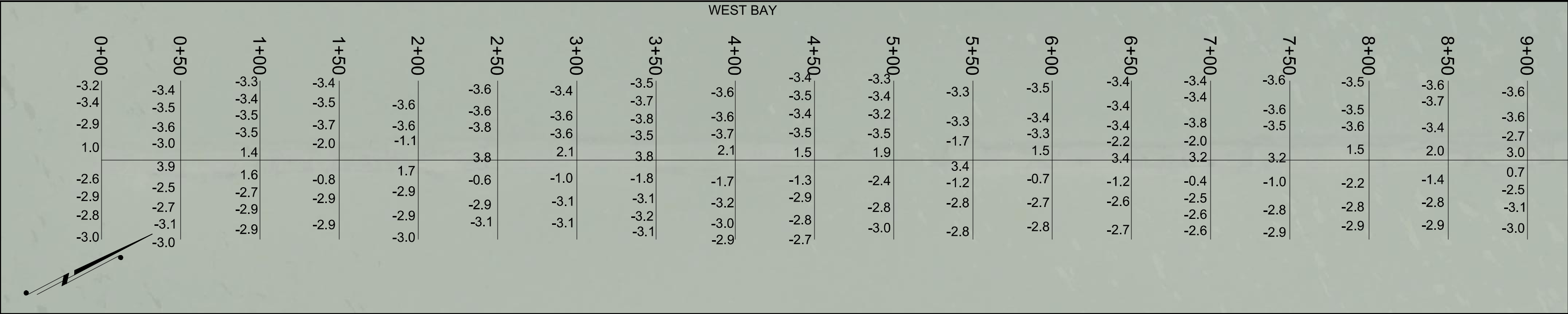
LUHR BROS., INC.
GISP MARSH RESTORATION AND PROTECTION PHASE III
OAK BAYOU BREAKWATER
BATHYMETRIC SURVEY
GALVESTON COUNTY, TEXAS

SCALE	1"=20'
DRAWN BY	CDW

SHEET 6 OF 11

OCT. 2021





NOTES:
1) SOUNDINGS DATA WERE RECORDED BY T. BAKER SMITH ON 2, 4, 24 AUGUST, 27-28 SEPTEMBER, 5-6 OCTOBER, 2021. SEA FLOOR AND TOPOGRAPHIC CONDITIONS ARE SUBJECT TO CHANGE.
2) A SINGLE-BEAM ECHOSOUNDER OPERATING AT 200KHZ WAS UTILIZED FOR THE BATHYMETRIC PORTION OF THE SURVEY.
3) HORIZONTAL DATUM: NAD83, TEXAS SOUTH CENTRAL ZONE, US FEET.

NOTES:
4) VERTICAL DATUM: NAVD 88 REFERENCE MONUMENT "HGCSO 62"
"HGCSO 62"
N: 13,845,727.04
E: 5,264,124.31
ELEV: 6.3' NAVD88



CEPRA 1637, GLO CONTRACT NO. 21-141-000-C818, GLO PROJECT NUMBER 318003



10/11/2021



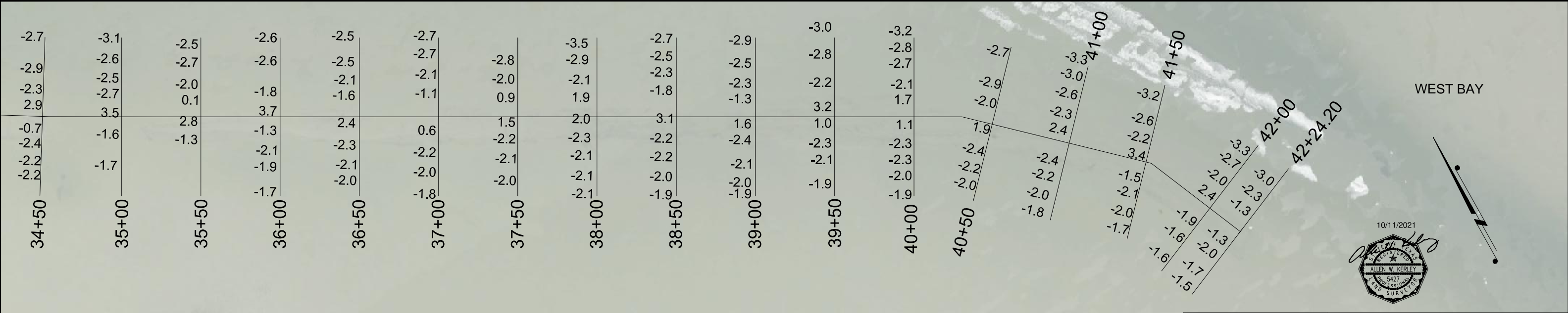
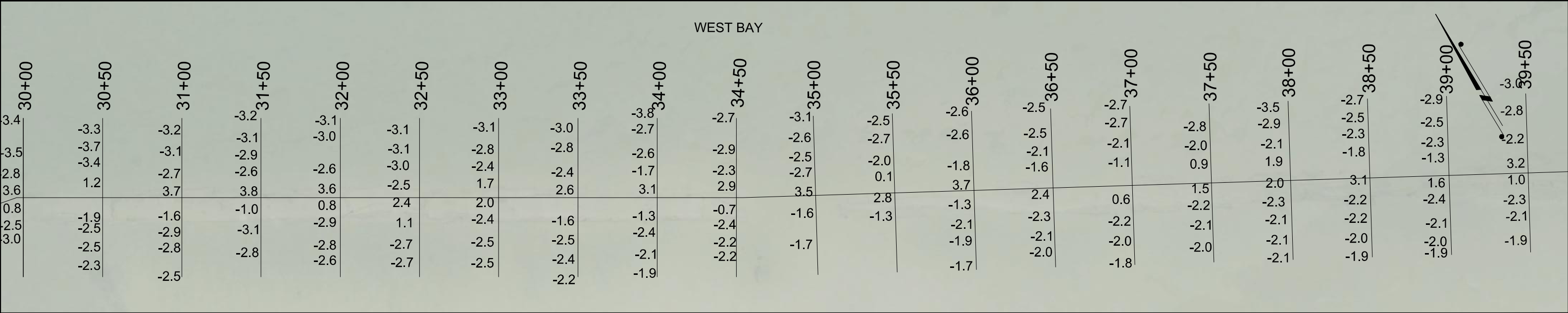
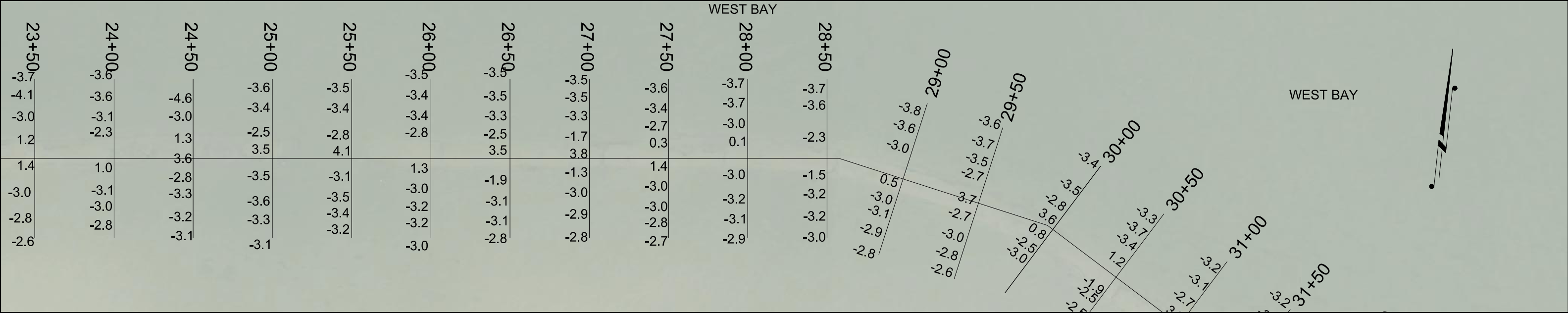
NO.	DATE	REVISION

LUHR BROS., INC.
GISP MARSH RESTORATION AND PROTECTION PHASE III
DANA COVE BREAKWATER
BATHYMETRIC SURVEY
GALVESTON COUNTY, TEXAS

SCALE: 1"=30'
DRAWN BY: CDW

SHEET 7 OF 11

OCT. 2021



NOTES:
1) SOUNDINGS DATA WERE RECORDED BY T. BAKER SMITH ON 2, 4, 24 AUGUST, 27-28 SEPTEMBER, 2-6 OCTOBER, 2021. SEA FLOOR AND TOPOGRAPHIC CONDITIONS ARE SUBJECT TO CHANGE.
2) A SINGLE-BEAM ECHOSOUNDER OPERATING AT 200KHZ WAS UTILIZED FOR THE BATHYMETRIC PORTION OF THE SURVEY.
3) HORIZONTAL DATUM: NAD83, TEXAS SOUTH CENTRAL ZONE, US FEET.

NOTES:
4) VERTICAL DATUM: NAVD 88 REFERENCE MONUMENT "HGCSD 62"
"HGCSD 62"
N: 13,845,727.04
E: 5,264,124.31
ELEV: 6.3' NAVD88



CEPRA 1637, GLO CONTRACT NO. 21-141-000-C818, GLO PROJECT NUMBER 318003

T. BAKER SMITH
A CENTURY OF SOLUTIONS
3044 FM 1688
P.O. Box 1000
Galveston, TX 77550
409.745.4770 - tbsmith.com
TBSL# 10104575

NO.	DATE	REVISION

10/11/2021

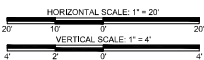
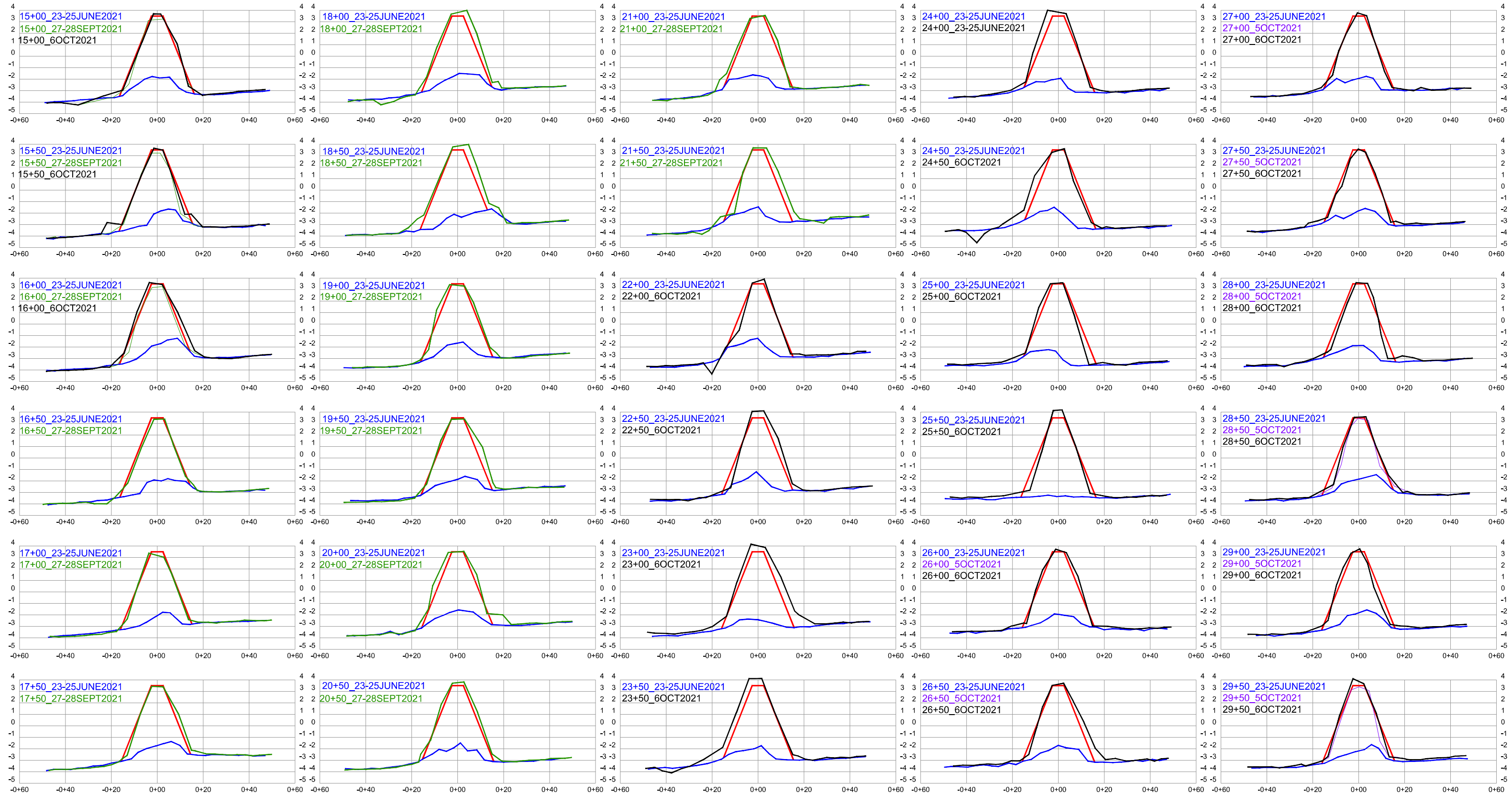
ALLEN W. KERLEY
5427
PROFESSIONAL SURVEYOR
STATE OF TEXAS

LUHR BROS., INC.
GISP MARSH RESTORATION AND PROTECTION PHASE III
DANA COVE BREAKWATER
BATHYMETRIC SURVEY
GALVESTON COUNTY, TEXAS

SCALE: 1"=30'
DRAWN BY: CDW

SHEET 8 OF 11

OCT. 2021



NOTES:
1) SOUNDINGS DATA WERE RECORDED BY T. BAKER SMITH ON 2, 4, 24 AUGUST, 27-28 SEPTEMBER, 5-6 OCTOBER, 2021. SEA FLOOR AND TOPOGRAPHIC CONDITIONS ARE SUBJECT TO CHANGE.
2) A SINGLE-BEAM ECHOSOUNDER OPERATING AT 200KHZ WAS UTILIZED FOR THE BATHYMETRIC PORTION OF THE SURVEY.
3) HORIZONTAL DATUM: NAD83, TEXAS SOUTH CENTRAL ZONE, US FEET.
4) VERTICAL DATUM: NAVD 88 REFERENCE MONUMENT "HGCSD 62"

"HGCSD 62"
N: 13,845,727.04
E: 5,264,124.31
ELEV: 6.3' NAVD88

10/11/2021



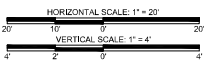
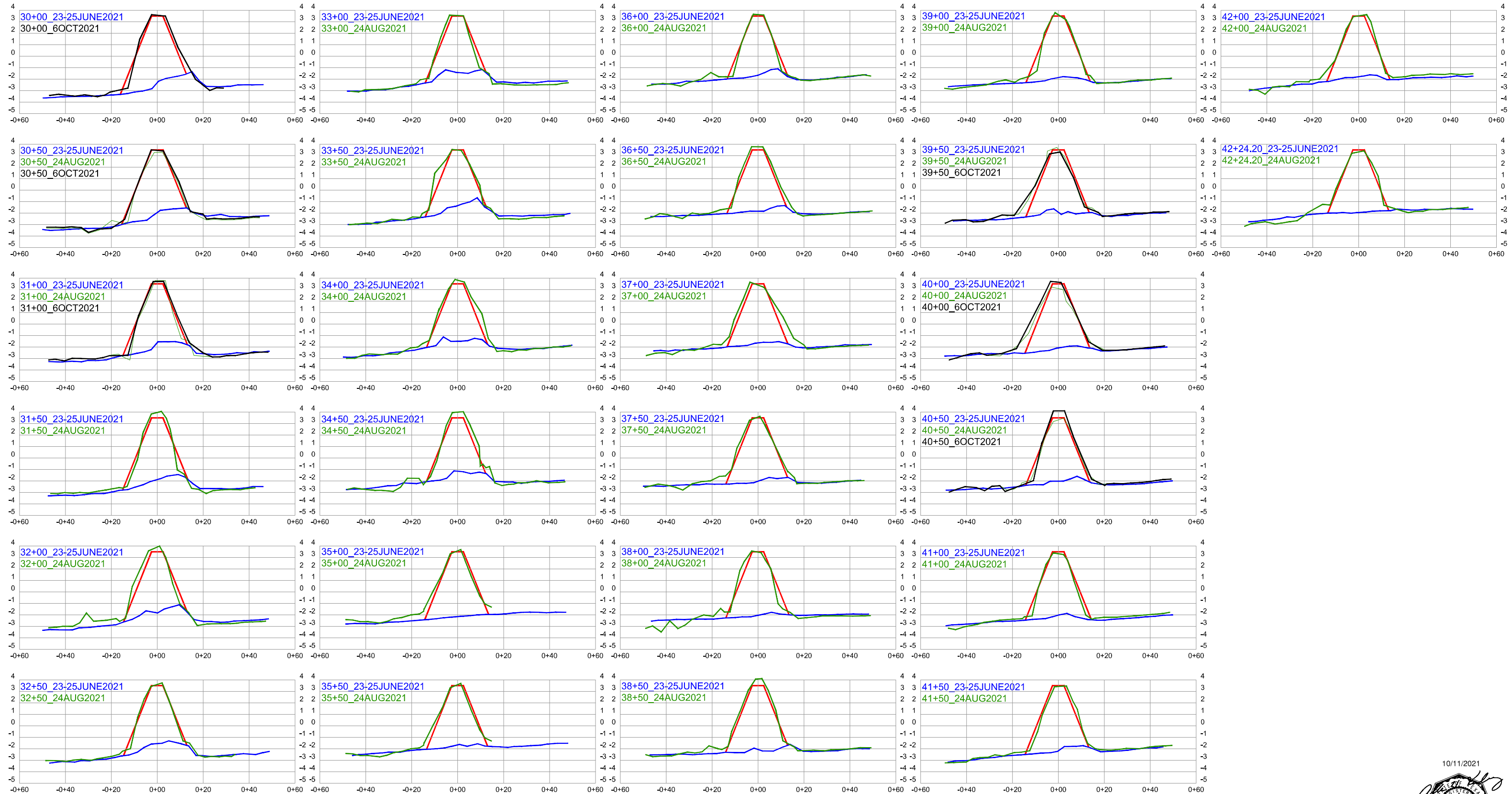
NO.		DATE	REVISION

LUHR BROS., INC.
GISP MARSH RESTORATION AND PROTECTION PHASE III
DANA COVE BREAKWATER
BATHYMETRIC SURVEY
GALVESTON COUNTY, TEXAS

SCALE: 1"=20'
DRAWN BY: CDW

SHEET 10 OF 11
OCT. 2021

CEPRA 1637, GLO CONTRACT NO. 21-141-000-C818, GLO PROJECT NUMBER 318003



NOTES:
1) SOUNDINGS DATA WERE RECORDED BY T. BAKER SMITH ON 2, 4, 24 AUGUST, 27-28 SEPTEMBER, 5-6 OCTOBER, 2021. SEA FLOOR AND TOPOGRAPHIC CONDITIONS ARE SUBJECT TO CHANGE.
2) A SINGLE-BEAM ECHOSOUNDER OPERATING AT 200KHZ WAS UTILIZED FOR THE BATHYMETRIC PORTION OF THE SURVEY.
3) HORIZONTAL DATUM: NAD83, TEXAS SOUTH CENTRAL ZONE, US FEET.
4) VERTICAL DATUM: NAVD 88 REFERENCE MONUMENT "HGCSD 62"
"HGCSD 62"
N: 13,845,727.04
E: 5,264,124.31
ELEV: 6.3' NAVD88

CEPRA 1637, GLO CONTRACT NO. 21-141-000-C818, GLO PROJECT NUMBER 318003

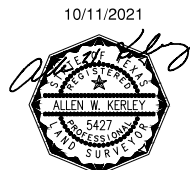
T. BAKER SMITH
A DIVISION OF SOLUTIONS
3004 FM 1080
P.O. Box 1000
Galveston, TX 77550
409.745-0710
TBSLPS #10194575

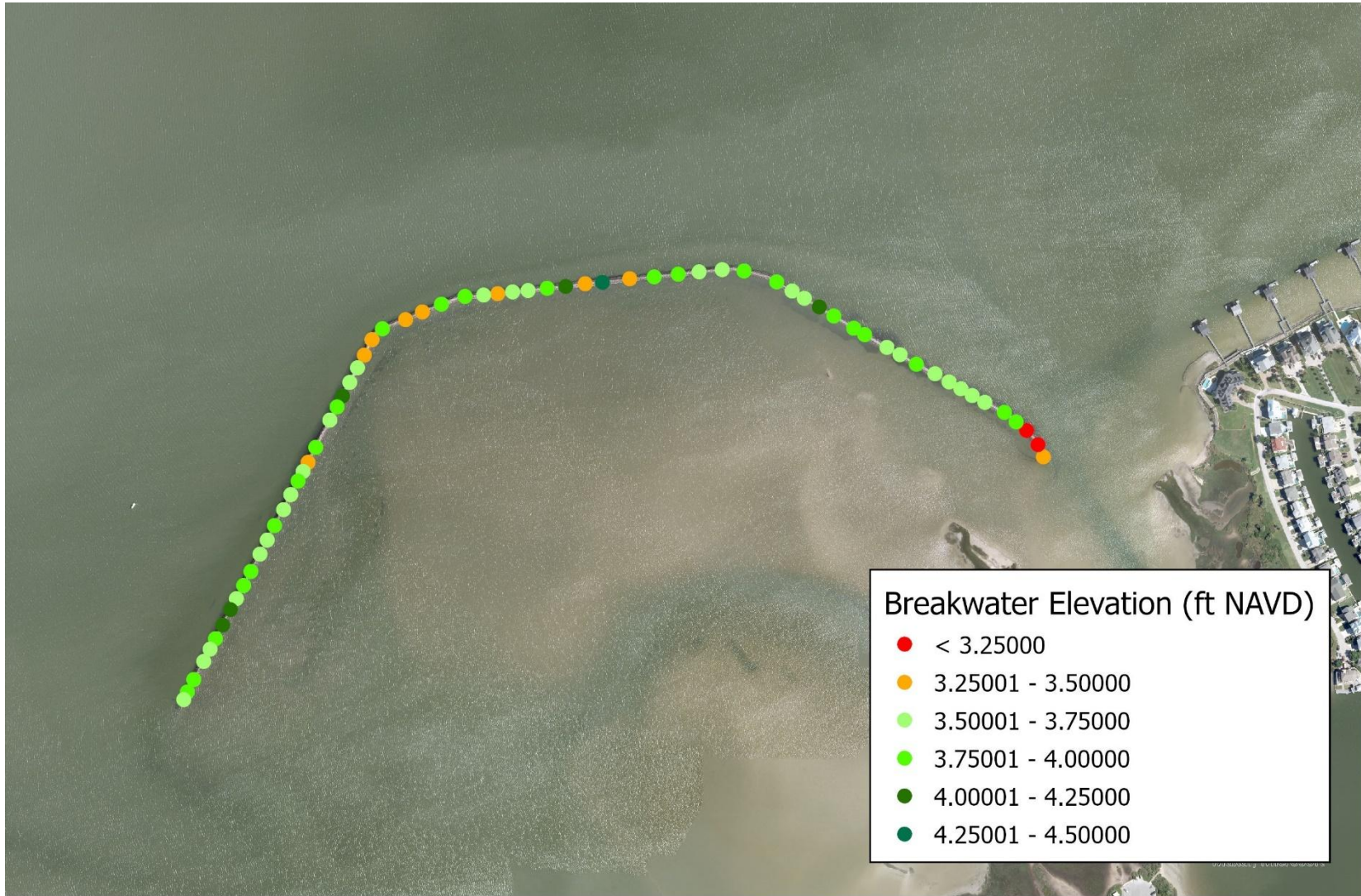
NO.	DATE	REVISION

LUHR BROS., INC.
GISP MARSH RESTORATION AND PROTECTION PHASE III
DANA COVE BREAKWATER
BATHYMETRIC SURVEY
GALVESTON COUNTY, TEXAS

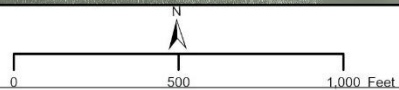
SCALE: 1"=20'
DRAWN BY: CDW

SHEET 11 OF 11
OCT. 2021





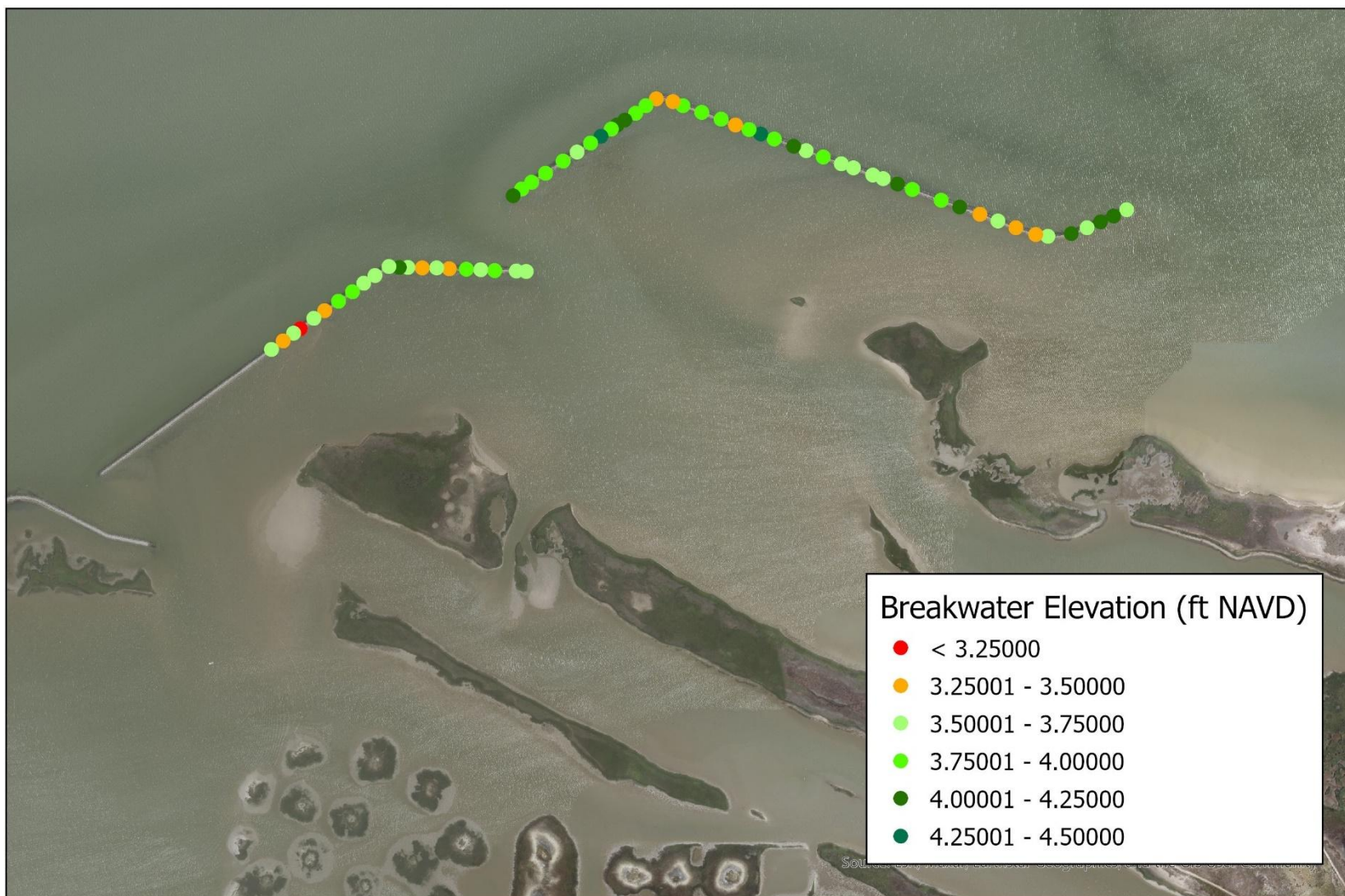
CLIENT
LOGO



YEAR 1 MONITORING - BREAKWATER ELEVATION SURVEY

APPENDIX C

DATA COLLECTED BY HDR DURING YEAR 1 MONITORING (01/2023)



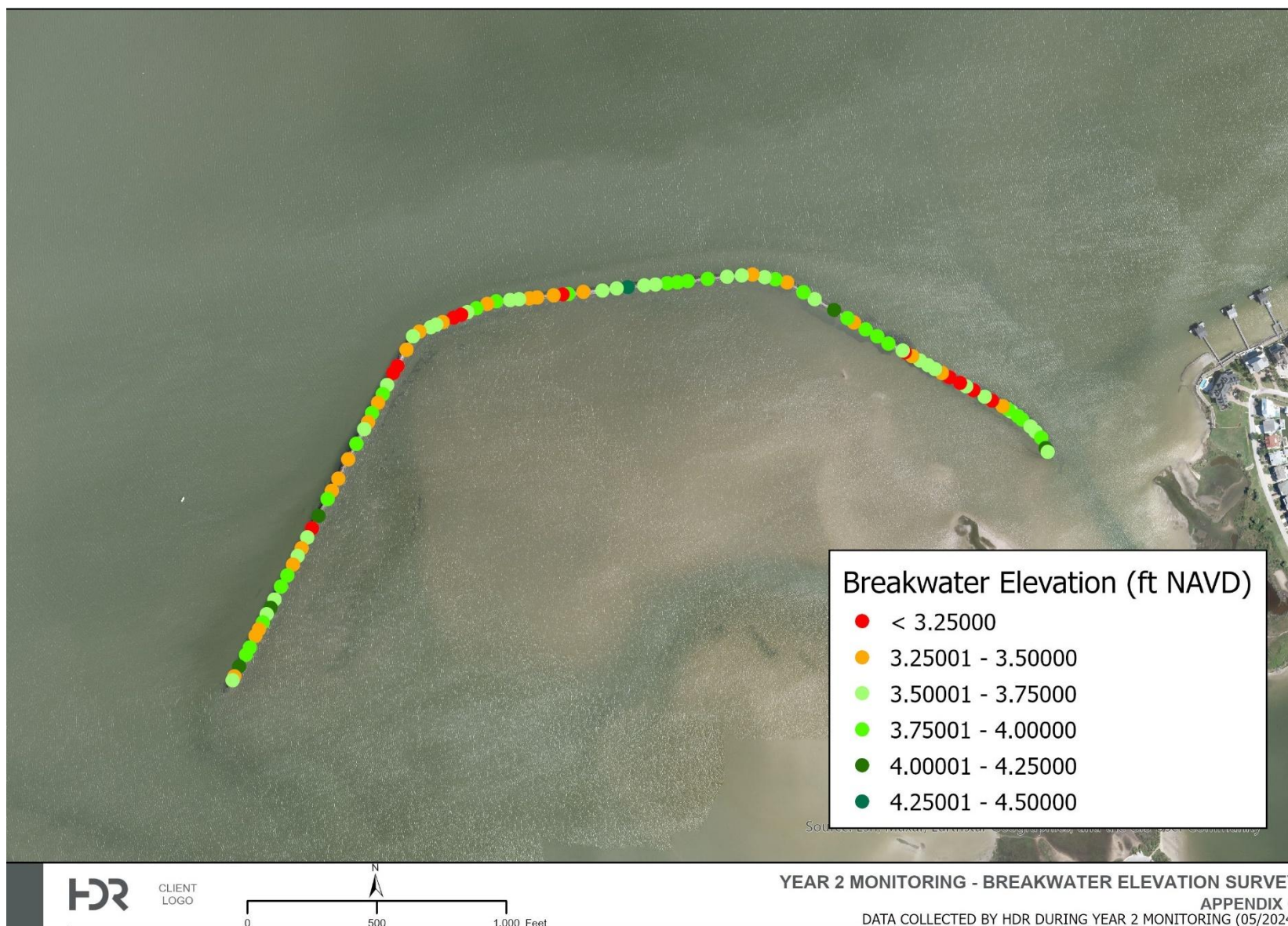
CLIENT
LOGO

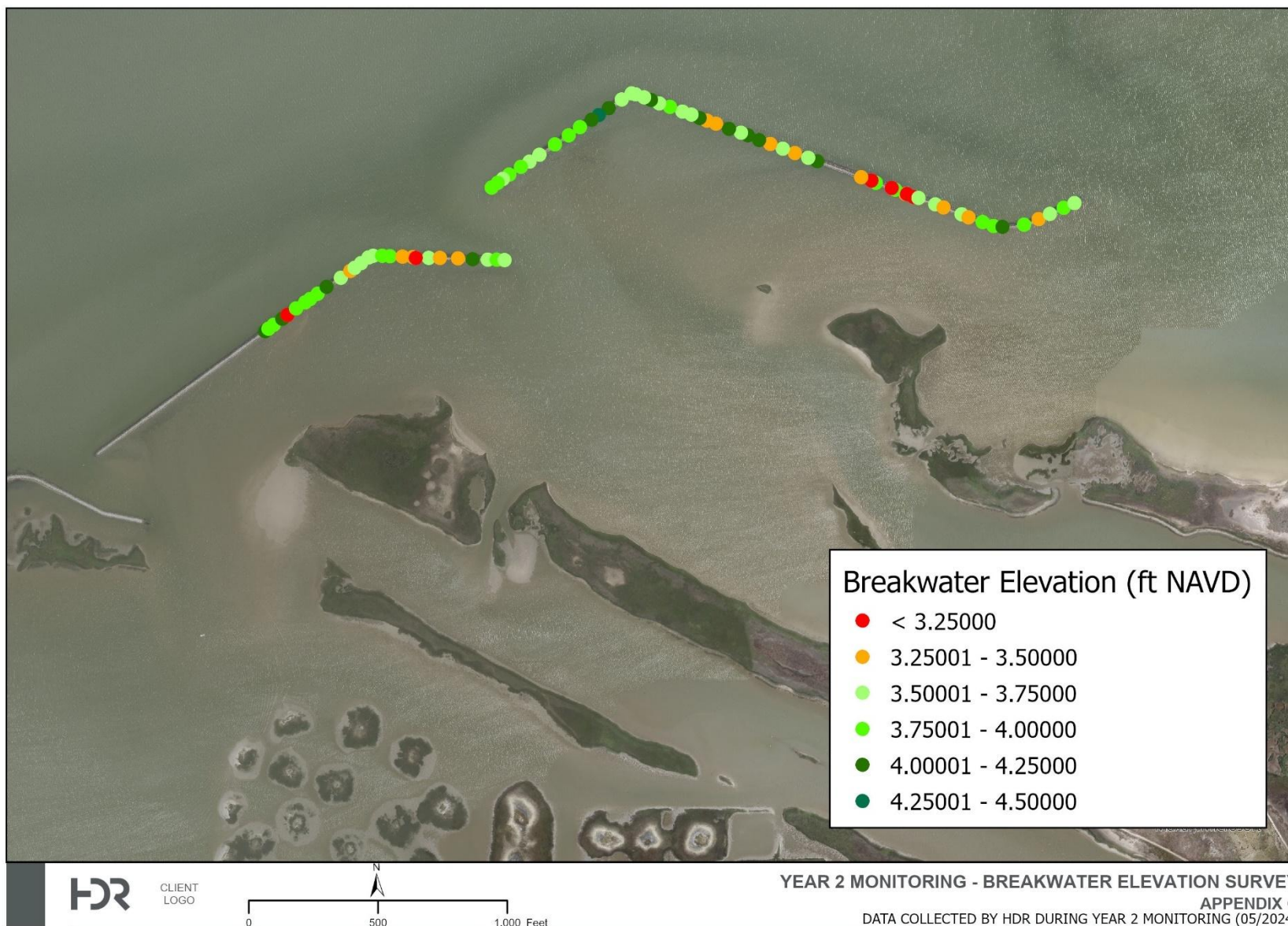


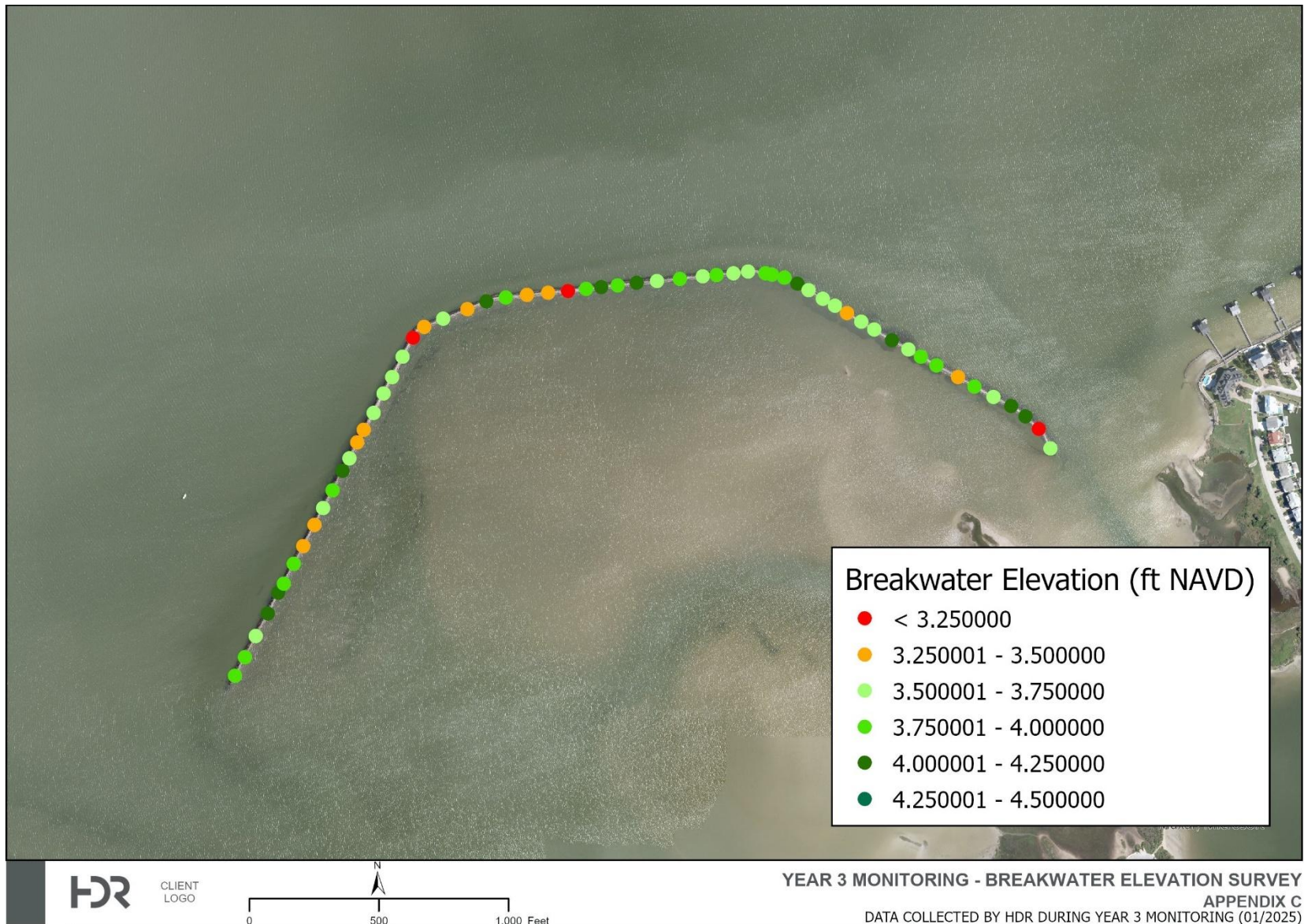
YEAR 1 MONITORING - BREAKWATER ELEVATION SURVEY

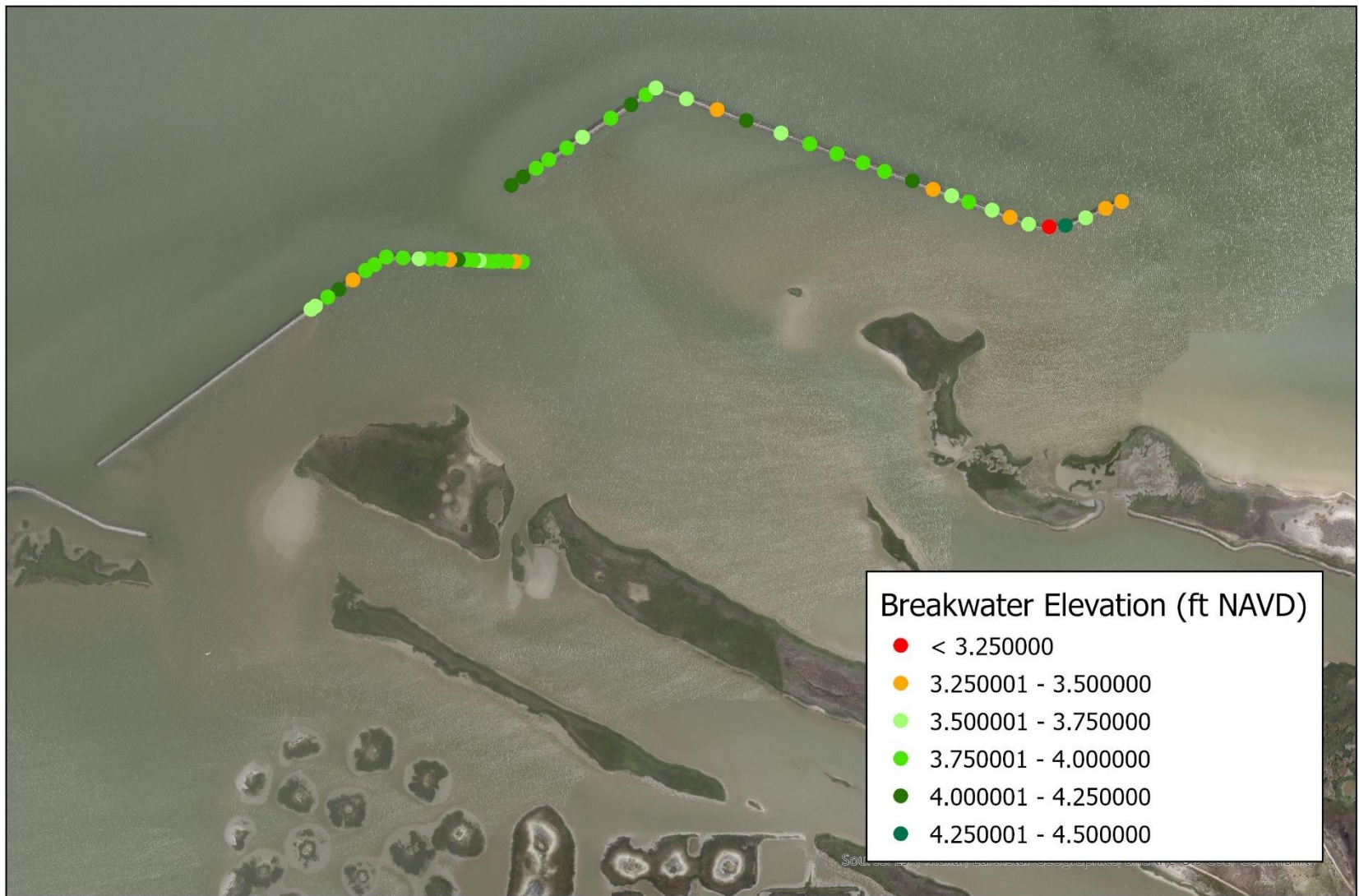
APPENDIX C

DATA COLLECTED BY HDR DURING YEAR 1 MONITORING (01/2023)









CLIENT
LOGO



YEAR 3 MONITORING - BREAKWATER ELEVATION SURVEY

APPENDIX C

DATA COLLECTED BY HDR DURING YEAR 3 MONITORING (01/2025)

