State of Louisiana

Coastal Protection and Restoration Authority of Louisiana (CPRA)

2024 Operations, Maintenance, and Monitoring Report

for

Rockefeller Refuge Gulf Shoreline Stabilization

State Project Number ME-0018
Priority Project List 10

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Cameron Parish

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Preface

The Rockefeller Refuge Gulf Shoreline Stabilization (ME-0018) project was funded through the Coastal Wetlands Planning, Protection, and Restoration Act (CWPPRA) on the 10th Priority Project List with the National Oceanic and Atmospheric Administration (NOAA)/National Marine Fisheries Service (NMFS) as the federal sponsor and the Coastal Protection and Restoration Authority (CPRA). This report includes monitoring data collected through April 2024.

This report is the 1st report in a series of OM&M reports on the ME-0018 project. Relevant documents and data can be found in CIMS (cims.coastal.la.gov).

I. Introduction

The Rockefeller Gulf Shoreline Stabilization Project is composed of 3.85 miles of a semi-continuous reef breakwater in the Mermentau Basin of Cameron Parish, Louisiana. The breakwater structure is comprised of light weight aggregate core (LWAC) armored with limestone on the Louisiana Gulf Coast shoreline along Rockefeller Wildlife Refuge in Cameron Parish, Louisiana west of Joseph's Harbor (Figure 1). A small section of the LWAC breakwater was tested as successful for attenuating waves in this location (HDR Engineering, Inc., 2011). Fisheries and water exchange gaps in the breakwater were designed to stop prevailing waves from easily passing through to the shoreline. The previously constructed ME-0018 CIAP test sections and the LA-0008 Bioengineered Oyster Reef Demonstration project (McGinnis, 2017) were incorporated into the alignment; the western ME-0018 test section (rock rip-rap) was removed and used to cover the ME-0018 LWAC (Figure 2 and 3). Structure construction was conducted from April 2018 through May 2020.

Figure 1. Rockefeller Refuge Gulf Shoreline Stabilization Project (ME-0018) location map

II. Maintenance Activity

a. Project Feature Inspection Procedures

No project feature inspections were planned or conducted for this project.

b. Inspection Results

No project feature inspections were planned or conducted for this project.

c. Maintenance Recommendations

i. Immediate/ Emergency Repairs

None

ii. Programmatic/ Routine Repairs

None

d. Maintenance History

General Maintenance:

None

III. Operation Activity

Structure Operations:

There are no active operations associated with this project.

IV. Monitoring Activity

a. Monitoring Goals

The goal of ME-0018 is to halt shoreline retreat and direct marsh loss to protect marsh habitat for wildlife and fisheries habitat and provide storm surge protection. To achieve this, the project was designed with the following objectives:

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

b. Monitoring Elements

Post-Hurricane Survey

Starting less than a month after ME-0018 construction ended, Louisiana had an extreme 2020 hurricane season as five named tropical systems made landfall from June 7 – October 29, and four additional storms made landfall elsewhere along the Gulf Coast. The ME-0018 project area was

heavily impacted by Hurricane Laura (Category 4; the strongest storm to strike southwest Louisiana in recorded history) on August 27 and Hurricane Delta (Category 2) on October 9 which both made landfall in western Cameron Parish (NOAA, 2020). The rock breakwater withstood the hurricanes very well and did not require repair after the storms. In order to re-establish baseline conditions, a Post-Hurricane survey (HDR Engineering Inc., 2021) was conducted at the ME-0018 project location which included repeating the As-built topographic/bathymetric elevation survey (January – March 2021) and a shoreline position assessment from NOAA post storm imagery was taken on October 10, 2020 (HDR Engineering, Inc. 2021). The Post-Hurricane elevation survey transects extended further into the protected marsh than the as-built survey transects and included a reference area on the east side of Joseph's Harbor Bayou. Because the hurricane damages occurred soon after construction, the Post-Hurricane elevation survey was considered a Construction phase activity and was used to establish a new baseline and as a reference to isolate hurricane impacts to the project for future monitoring efforts.

Analysis Groups

The shoreline protected by the project was divided into five analysis groups for a geospatially explicit analysis of hurricane impacts across the project area (Figure 3). These groups were carried over from the Post-Hurricane Report to provide a greater level of detail for shoreline movement since the hurricane impacts were incurred. The analysis groups are described below:

Group 1 (Mouth of Joseph Harbor Bayou) is the easternmost portion of the study area. It is located west of the mouth of Joseph Harbor Bayou (Joseph Harbor) and includes 2,700 ft of shoreline. This area was selected to capture the influence of Joseph Harbor on shoreline movement within the project area. This analysis group also includes 350 ft of shoreline north of the breakwater structures with open exposure to Joseph Harbor.

Group 2 (ME-0018 Demonstration Sections) spans 5,700 ft of shoreline which includes the area of the two demonstration sections completed in December 2009 and the more recently constructed breakwater structures in the vicinity. The demonstration areas differ from other construction locations in the study area in two ways: 1) the pre-construction shoreline extended into the Gulf relative to the remainder of the study area that had a relatively flat or linear shoreline geomorphology and 2) the breakwater alignment was updated during construction to accommodate the change in shoreline and bathymetry due to the demonstration features and to incorporate the demonstration features into the overall system.

Group 3 (Middle Typical) is the center-most analysis group and includes 4,400 ft of shoreline. This analysis group is generally characterized by the typical linear shoreline geomorphology and breakwater construction technique.

Group 4 (LA-0008) spans 3,500 ft of shoreline and includes the LA-0008 demonstration project which was constructed in April 2012 and was incorporated into the ME-0018 project in 2022. This analysis group is functionally similar to Group 2 in that the shoreline had been influenced by another structure before construction of ME-0018.

Group 5 (Western Typical) is the westernmost analysis group and includes 5,300 ft of shoreline. Like Group 3, this analysis group is generally characterized by the typical linear shoreline geomorphology and breakwater construction technique.

Control - a control area was established prior to the Post-Hurricane Survey 3,650 ft east of Joseph Harbor along 2,950 ft of shoreline without a breakwater system. This shoreline is directly exposed to waves and currents from the open Gulf of Mexico including high tides, storms, and hurricane events. The control area has a similar pre-construction shoreline geomorphology as the typical shoreline segments. The beaches are composed of similar soft marine clays and crushed shell and are both backed by similarly vegetated marshland. Although the Control was not included in the As-built survey, it will be used through the project's 20-year design life to measure project performance.

The following monitoring elements will provide the information necessary to evaluate the project goals.

Shoreline Change

To document shoreline movement, differential GPS is used to map the shoreline in both the project (behind the project features) and reference (control) areas (Steyer et al. 1995). Contiguous, emergent vegetation is used to delineate the shoreline. Shoreline is mapped along the project area and along the reference area southeast of Joseph Harbor Canal in conjunction with the elevation surveys. Aerial imagery can also be used for shoreline change analyses. The gulfward edge of continuous vegetation is mapped with a differential Global Positioning System (dGPS). Shoreline movement is analyzed using ESRI ArcMap 10.7.1 and the Digital Shoreline Analysis System (DSAS) version 5.0 (Himmelstoss et al. 2018). Net shoreline movement (NSM) was calculated between the As-Built and Post-Hurricane and Monitoring surveys to determine the shoreline movement. The end point rate (EPR) for shoreline movement is calculated by subtracting the difference in shoreline position between two survey years and dividing it by the time between surveys to give a rate in feet per year. Future shoreline change analyses are planned for 2028 and 2035.

Elevation

Topographic and bathymetric surveys intersecting the shoreline are used to track elevation changes of the LWAC breakwater, marsh, and water bottoms both landward and gulfward of the structure. Elevation data with minimum horizontal spacing of 10 ft for topography and 25 ft for bathymetry, or closer if necessary, is used to define distinct morphologic features such as the end of continuous vegetation, steep changes in slope, shoreline face, sand bars, scour holes, and distinct changes in structure profile (shoreward toe, shoreward crest, center crest, gulfward crest, and gulfward toe). Survey transect endpoints are approximately 200 ft landward from the structure (at least 25 feet into the continuous marsh vegetation) and extend 200 ft into the Gulf of Mexico from the centerline of the breakwater. Survey transects bisect the project area; transects are located at the ends of the structure, near the ends and in the middle of fish gaps, between gaps on about 500 ft spacing and collocated with the settlement plates (spaced approximately 1000' apart), and crossing each

existing structure from the remaining CIAP test section (1 structure = 3 transects) and LA-0008 (1 at each structure and the gap = 3 transects).

Construction surveys conducted by Patriot captured the settlement plate elevation at the time of installation, periodically throughout construction, and for the As-Built survey. The Post-Hurricane and 3-year monitoring surveys were conducted by Hydroterra following previously stated monitoring procedures. In addition to elevation collected from each settlement plate, the distance from the top of the settlement plate pole to the rocks is being measured to interpret differences between structure and subsurface settlement as long as the settlement plate poles are viable. Complimenting elevation surveys were conducted during planning, construction (As-built), Post-Hurricane, and the Year 3 survey (2024). Future monitoring surveys are planned at intervals of 8 and 15 years following construction. The same transect locations from the Post-Hurricane survey were used to collect elevation data for the Year 3 elevation monitoring in 2024 and will be used for future surveys (2028 and 2035 planned) as well.

During the elevation surveys, substrate was characterized for each survey point collected using seven classifications:

- Marsh – Typically herbaceous vegetation (grasses, sedges, rushes, whips)
- Marsh Pond – Enclosed water body within the marsh
- Shrub – Shrub or bushes typically occurs between Marsh and Sand/Shell Hash.
- Sand/Shell Hash – Sand or shell hash between the Marsh and Old Marsh Platform. May contain a dune, berms, and beach face.
- Old Marsh Platform – Typically intertidal and unvegetated but may be supratidal. Old Marsh Platform may have some isolated vegetation from old rhizomes and typically ends with a sharp drop-off at subtidal end.
- Water Bottom/Bathy – Area between Old Marsh Platform and Structure, and seaward of Structure, which typically remains underwater.
- Structure – In addition to 10-ft sampling interval, points were collected for shoreward toe, shoreward crest, gulfward crest, and gulfward toe of structure.

c. Monitoring Results and Discussion

Results from the Post-Hurricane Report (HDR Engineering, Inc., 2011) show that the breakwater performed as intended, withstanding two major hurricanes within two months and suffering no structural damage. Further, shoreline data analysis demonstrated a significant difference in hurricane impacts from the area protected by the breakwater and an adjacent control area, with the project area experiencing much less erosion than the control. This suggests that hurricane impacts from the 2020 season to the Rockefeller Refuge coastline would have been much more drastic in the absence of these breakwater structures. By comparing the most recent monitoring survey data to the as-built and Post-Hurricane Report survey data, this report provides current project analyses and interim conclusions for the effectiveness of the project to storm impact mitigation by limiting energy transfer to the protected shoreline area and thus promoting a resilient coastal landscape at

the Rockefeller Refuge. Based on data collected up to this point, the project has withstood numerous hurricane events beyond the design objectives, mitigated shoreline loss, maintained its structural integrity, and therefore met all three design objectives thus far.

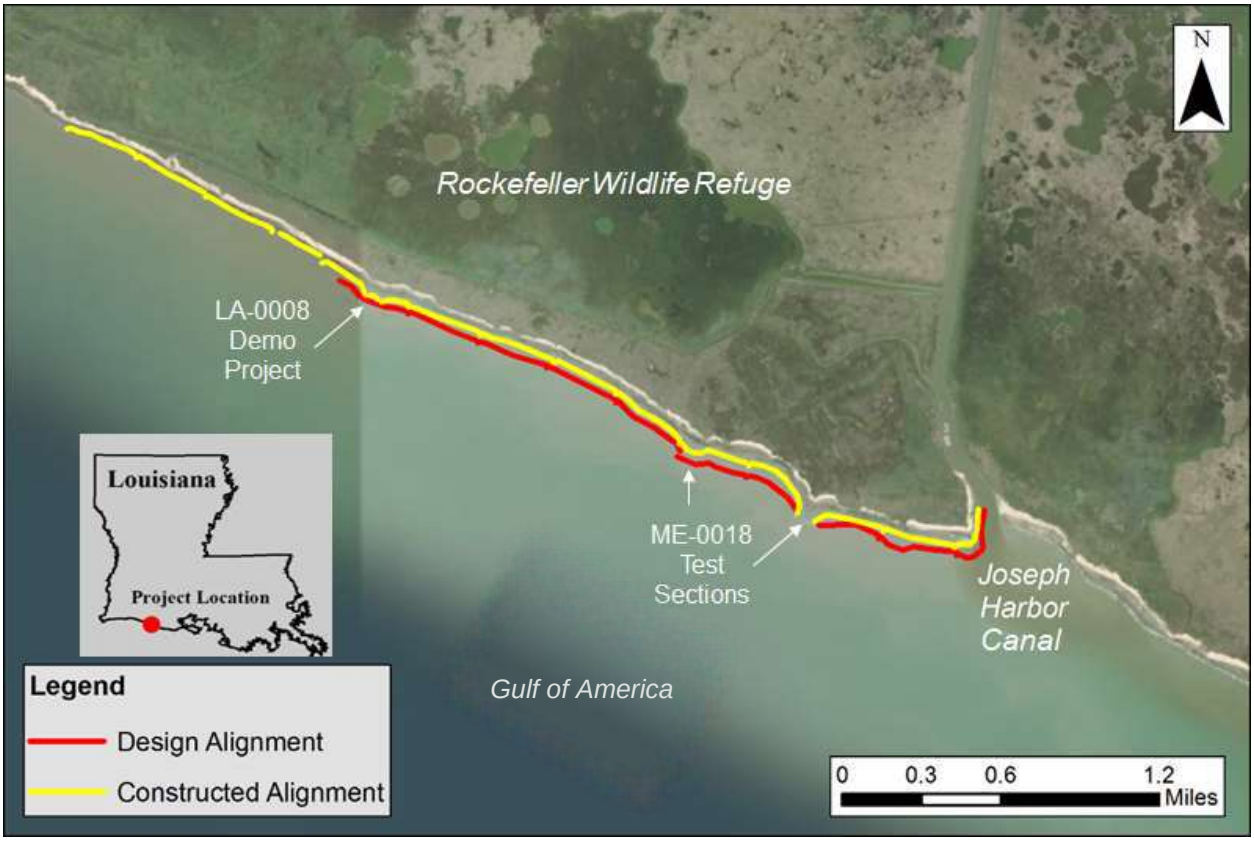

Figure 2. Location of designed and constructed Rockefeller Gulf Shoreline Stabilization project (ME-0018) alignment along the Gulf of America shoreline for Rockefeller Wildlife Refuge in Cameron Parish, Louisiana. The alignment was adjusted northward because of erosion between the time of planning and construction; the structure alignment was also extended northwest for about a mile from what was originally planned.

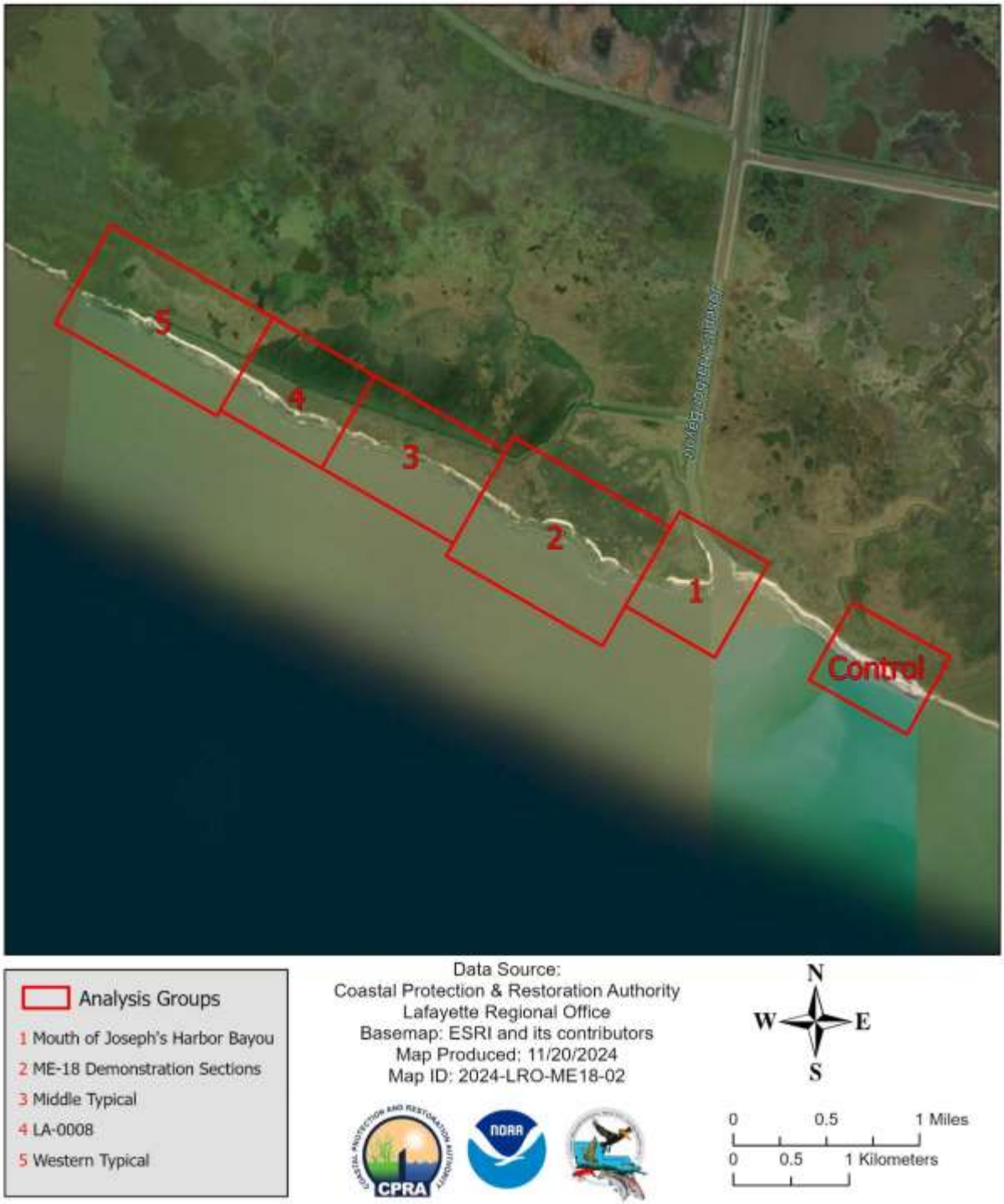

Figure 3. ME-0018 Analysis Group locations and descriptions including Control area east of Joseph's Harbor Bayou

Shoreline Change

In between the As-Built survey in May 2020 and the Year 3 monitoring survey in 2024, the protected portion of the Rockefeller Refuge shoreline pro-graded into the Gulf of Mexico while the Control continued to erode. This timeframe includes damage and recovery from 2020 Hurricanes Laura and Delta. Net shoreline movement (NSM) values along the protected shoreline ranged from -39.5 ft to 96.4 ft, (average 5.8 ft) while the unprotected Control area lost 223.3 ft on average (Table 1; Figure 3). This relatively neutral shoreline movement is indicative of the ability of the breakwater to not only mitigate storm impacts, but also to foster recovery in protected areas.

Hurricane impacts in the project area were drastically reduced (55% lower; Table 4) compared to that of the Control. Net shoreline movement between the As-built survey (February/May 2020) and the Post Hurricane survey (October 2020) was -74.6 ft along the protected shoreline and -165.2 ft in the Control area (HDR Engineering Inc, 2021). Further, the Year 3 monitoring data shows a continued pattern of divergence between the project and control shorelines, with the project area gaining 61.3 ft since the Post Hurricane survey and the control losing 52.9 ft in the same time frame.

The erosion rate (EPR) along the Control shoreline (-53.5 ft/yr) was fairly consistent with the projections of future loss at the Rockefeller Refuge used in the final design report (-46 ft/yr; USGS 2013). Also, when compared to the erosion rate for the project area (1.5 ft/yr), these results demonstrate that the projections used for project design have accurately captured project effectiveness thus far and further establishes that the breakwater structure is enhancing shoreline stabilization at the Rockefeller Refuge project area. Further, a recent shoreline analysis across the Louisiana Gulf Coast identifies the geomorphic region of this project (Eastern Chenier Plain) as having the second worst average shoreline change in Louisiana from 1998-2021 after the Chandeleur Islands (Berlinghoff et al 2025). The shoreline change rates identified for the Rockefeller Refuge reach of the Eastern Chenier Plain region match those of the control area, at -59.1ft/year and -53.5ft/year, respectively.

All five analysis groups in the project area experienced an average net positive shoreline movement from the Post-Hurricane survey to the most recent 2024 survey (Table 2; Figure 4). When taken in contrast to the ubiquitous negative shoreline movement associated with the Post-Hurricane data, this shows that the loss/recovery pattern following the 2020 hurricane season is consistent across the project area. At a more detailed level, the degree of shoreline gain were not as consistent across analysis groups. Group 3 appears to be the best performer across all monitoring events, showing the lowest amount of shoreline loss associated with the 2020 hurricane season (-48.4 ft; HDR Engineering Inc, 2021), and the highest shoreline gain from Post-Hurricane to the 2024 survey (146.5 ft; Table 2). This area is located in the center of the ME-0018 structure and is the most insulated, with the most contiguous/linear breakwater reach of all analysis groups. From As-Built to the Post-Hurricane survey, Group 5 had the greatest shoreline movement variability and had the greatest negative value for average shoreline movement of all analysis groups (Table 1, Figure 4). When compared to the more recent trend following hurricane recovery to the 2024 survey, in which Group 5 showed the second highest positive shoreline movement (51.0 ft; Table 2), this area is of

particular interest. A significant portion of the negative shoreline movement in Groups 4 and 5 appears to be connected to the presence of gaps in the breakwater structure that are especially wide (150-200 feet wide as opposed to the typical gap width of around 60 feet; Appendix A). These wider gaps are a result of a 50 ft buffer around two pipelines that cross the project area. The stark contrast in shoreline stability between these wider openings and standard design gap widths highlights a threshold for breakwater spacing that supports shoreline protection and validates the current structural design. Since methodology for shoreline data collection reflects vegetated shoreline and therefore does not include sand/shell hash (unvegetated) area, it is likely that areas of sand/shell deposition during the 2020 hurricane season in Group 5 experienced positive shoreline movement in the period after the Post-Hurricane Report as these areas were colonized by marsh vegetation (Figure 5 and 6). This pattern may indicate the capacity of the breakwater structure to build marsh by trapping sediment and providing a relatively low-energy environment to facilitate vegetative expansion, which in turn creates sustainable land gain. Further, timing for positive shoreline movement on the western side of Group 5 after the Post-Hurricane survey correlates with the construction of the ME-37 breakwater structure in 2020. It appears likely that the added protection of the breakwater structure extension reduced energy transfer behind the structure on the western terminus of ME-0018 in Group 5, facilitated marsh expansion and therefore illuminated the cumulative value of additional shoreline stabilization projects in the area. A polygon of shoreline movement from the As-Built (2020) to Year 3 (2004) surveys was created to calculate acreages for shoreline change across the project/control areas (Figure 6). Over this time period, the control area lost 12.7 acres, which equates to 31.7 acres/linear mile. Spatial patterns for acreage of shoreline movement were generally the same as the DSAS. Based on the shoreline data analyzed, the project met design objectives. The breakwater protected the shoreline behind it, mitigated the effect of multiple hurricane events, and facilitated shoreline expansion.

Shoreline Movement – As-Built (2020) to Year 3 (2024)				
Analysis Group	**Mean NSM (ft)**	**Minimum NSM (ft)**	**Maximum NSM (ft)**	**Mean EPR (ft/yr)**
1 - Joseph's Harbor	-29.2	-140.1	58.0	-7.6
2 - ME-0018 Demo	-12.1	-190.1	149.7	-3.1
3 - Middle Typical	96.4	25.6	172.7	25.0
4 - LA-0008	-39.5	-148.2	134.7	-10.2
5 - Western Typical	-14.1	-153.5	202.4	-3.7
Project Overall	5.8	-190.1	202.4	1.5
Control	-223.3	-317.0	-158.3	-53.5

Table 1. DSAS Analysis for total Net Shoreline Movement (NSM) and End Point Rate (EPR) in ME-0018 Project Area from the As-Built survey (May 2020) to the 3-year Monitoring survey (April 2024).

Shoreline Movement – Post-Hurricane (2020) to Year 3 (2024)				
Analysis Group	**Mean NSM (ft)**	**Minimum NSM (ft)**	**Maximum NSM (ft)**	**Mean EPR (ft/yr)**
1 - Joseph's Harbor	39.6	-24.3	147.5	11.4
2 - ME-0018 Demo	34.7	-162.1	189.3	10.0
3 - Middle Typical	146.5	25.6	234.4	42.1
4 - LA-0008	14.1	-94.3	134.7	4.0
5 - Western Typical	51.0	-32.7	202.4	14.6
Project Overall	61.3	-162.1	234.4	17.6
Control	-52.9	-92.1	-20.8	-15.2

Table 2. DSAS Analysis for total Net Shoreline Movement (NSM) and End Point Rate (EPR) in ME-0018 Project Area from the Post-Hurricane survey (October 2020) to the Year 3 Monitoring survey (April 2024).

Shoreline Movement – As-Built (5/2020) to Post-Hurricane (10/2020)			
Analysis Group	**Mean NSM (ft)**	**Minimum NSM (ft)**	**Maximum NSM (ft)**
1 - Joseph's Harbor	-83.3	-187.7	N/A
2 - ME-0018 Demo	-71.7	-189.8	0
3 - Middle Typical	-48.4	-108.1	0
4 - LA-0008	-64.7	-142.1	0.2
5 - Western Typical	-98.1	-227.2	N/A
Project Overall	-74.6	-227.2	0.2
Control	-165.2	-319.0	-N/A

Table 3. DSAS Analysis for total Net Shoreline Movement (NSM) in ME-0018 Project Area from the As-Built survey (May 2020) to the Post-Hurricane survey (October 2020). Data taken directly from the Post-Hurricane Report (HDR Engineering, Inc., 2011), which did not include End Point Rate analysis.

Net Shoreline Movement (ft)			
Analysis Group	**Hurricane Abatement As-Built (2020) to Post-Hurricane (2020)**	**Hurricane Recovery Post-Hurricane (2020) to Year 3 (2024)**	**Total As-Built (2020) to Year 3 (2024)**
1 - Joseph's Harbor	-83.3	39.6	-29.2
2 - ME-18 Demo	-71.7	34.7	-12.1
3 - Middle Typical	-48.4	146.5	96.4
4 - LA-0008	-64.7	14.1	-39.5
5 - Western Typical	-98.1	51.0	-14.1
Project Overall	-74.6	61.3	5.8
Control	-165.2	-52.9	-223.3

Table 4. DSAS Analysis for total Net Shoreline Movement (NSM) across three survey events. Time intervals have been characterized as a proxy for hurricane abatement, hurricane recovery, and total shoreline stabilization difference between Project Area and Control.

ME-0018 DSAS Analysis – As-Built (February/May 2020) to Year 3 Survey (April 2024)

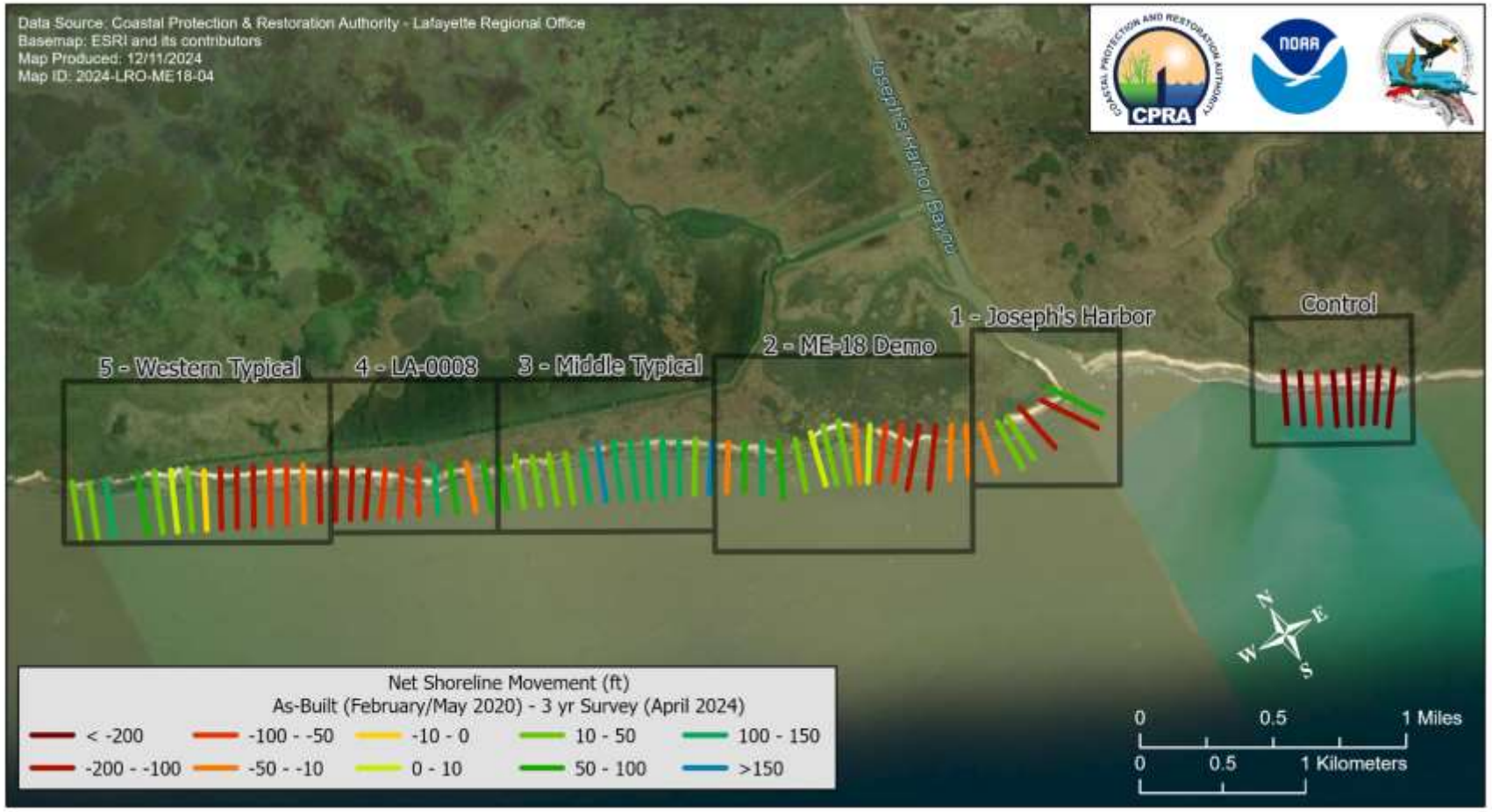

Figure 4. DSAS Analysis for total Net Shoreline Movement in ME-0018 Project Area from the As-Built survey (May 2020) to the Year 3 Monitoring survey (April 2024)

ME-0018 DSAS Analysis – Post-Hurricane (October 2020) to Year 3 Survey (April 2024)

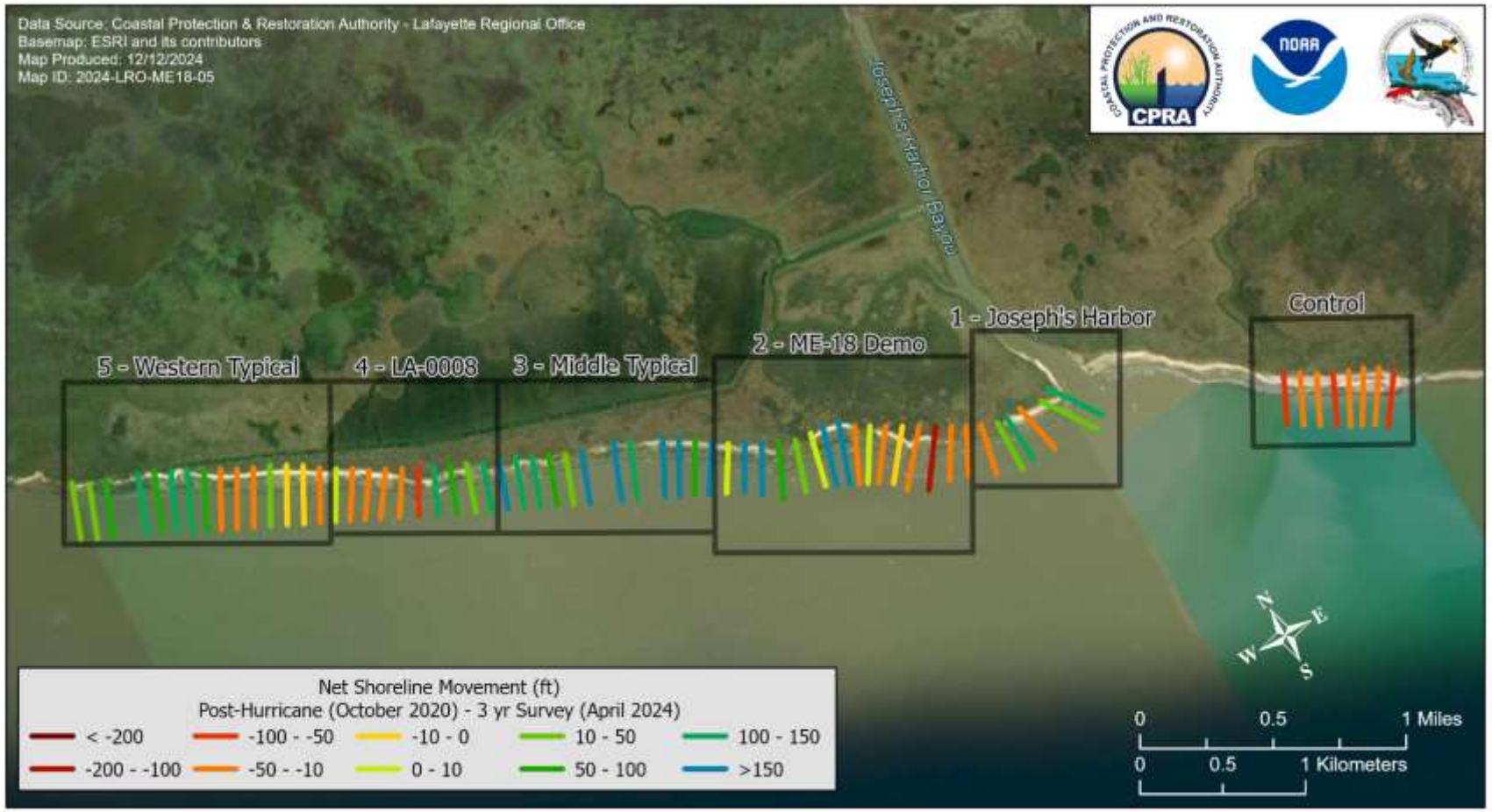

Figure 5. DSAS Analysis for Net Shoreline Movement in ME-0018 Project Area from the Post-Hurricane survey (October 2020) to the Year 3 Monitoring survey (April 2024).

ME-0018 DSAS Land Change Analysis – As-Built (February/May 2020) to Year 3 Survey (April 2024)

Figure 6. Shoreline land change acreages calculated from DSAS analysis of As-Built (May 2020) and Year 3 (April 2024) survey data.

Elevation Survey

An elevation change assessment was conducted to understand the impacts and recovery of Hurricanes Laura and Delta by comparing data from the Year 3 monitoring survey to the Post-Hurricane Report survey, and the As-Built survey. As-built data does not extend as far inland as the Post-Hurricane and Year 3 monitoring data and also does not include the control. However, the Post-Hurricane survey was used as the baseline for the Year 3 monitoring survey, and this survey extent will continue to be used for future analyses.

Ecotones

Substrate classifications from elevation data and geomorphic location were used to identify geospatially explicit ecotone classifications within the coastal landscape (Figure 7). These ecotones were used to isolate and analyze changes in ecological zones along the cross-section of the project and control areas. The ecotone classes identified are described below:

The **Behind Shoreline** ecotone is located inland of the as-built shoreline for both the project and control areas. This area serves as a reference point for elevation dynamics in existing marsh and adds detail to sedimentation/vegetation patterns observed.

The **Between Shoreline and Structure** ecotone only exists within the project area where the structure is present. This area is seaward of the as-built shoreline and shoreward of the breakwater structure. This area accounts for how the relatively lower-energy conditions behind structure are affecting sediment and vegetative colonization dynamics.

The **Front of Structure/Shoreline** ecotone is the area seaward of the structure in the project area and seaward of the as-built shoreline at the control. This area is exposed to the highest energy of the areas surveyed and thus, has the lowest elevations present in the survey. By comparing the front of the structure to the front of the control shoreline, a comparison can be drawn for how the sediment dynamics differ between areas with a rigid breakwater structure to the natural shoreline. This area also offers insight into the unmitigated processes dictating shoreline change in the control area.

The **Behind Structure Gaps** ecotone was isolated from that of the Between Shoreline and Structure due to the increased energy environment from gaps in the breakwater structure. Gaps were placed along the structure to allow water exchange behind the structure and facilitate fisheries habitat.

The survey data was classified according to Analysis Group and Ecotone. To analyze the data, elevations from the Post-Hurricane and Year 3 monitoring survey were interpolated to make a surface using the Natural Neighbor tool within ArcGIS. The resulting mosaic was then blended to create one continuous surface. Using the "Extract by Point" tool, elevations from the Monitoring survey surface were subsampled using the locations of As-Built point data to retrieve elevation values at the same coordinate for each surveying event.

ME-0018 Ecotones

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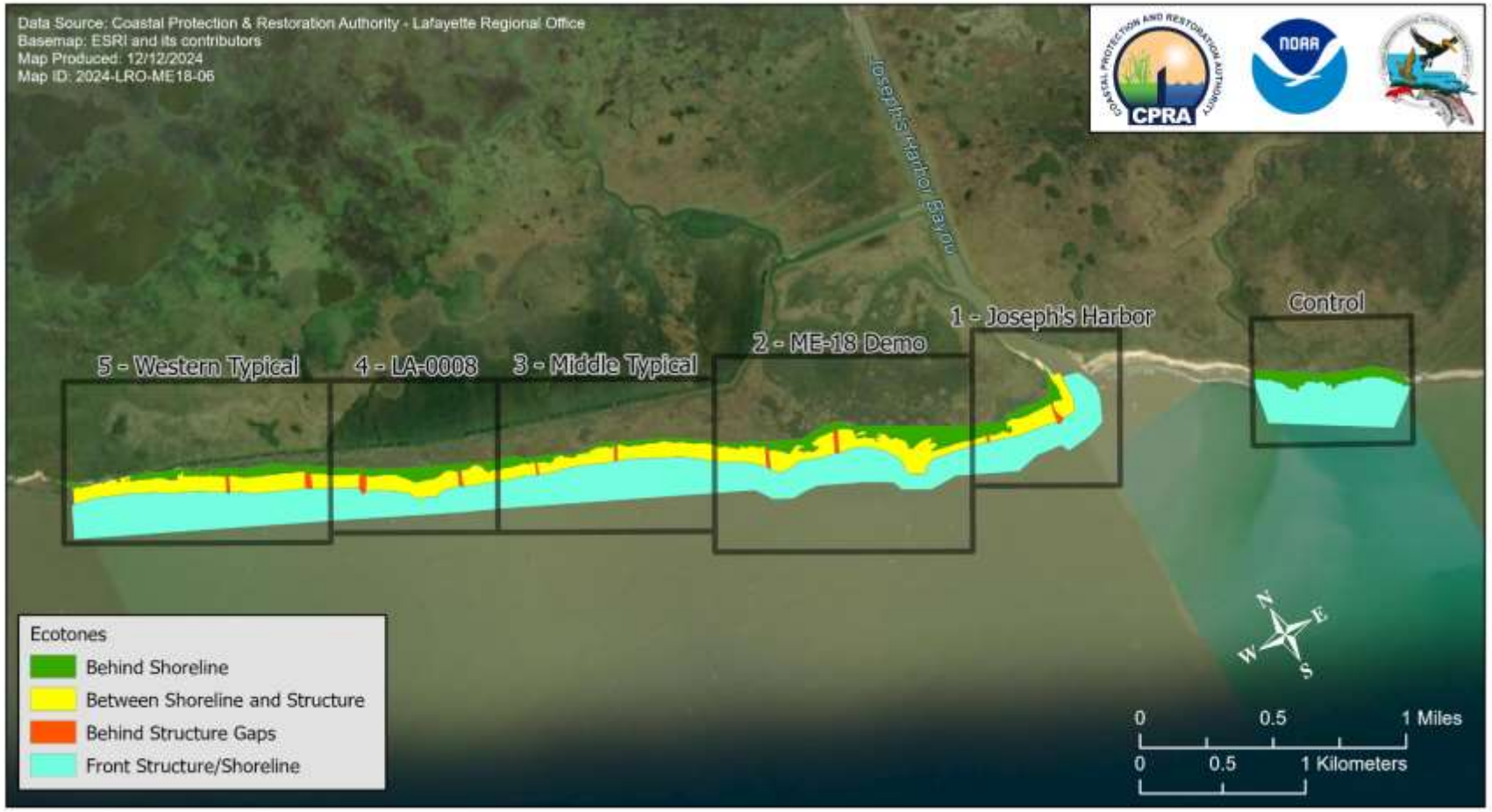

Figure 7. ME-0018 Ecotone locations across Project and Control areas used for elevation data analysis

Elevation survey data across ecotones is shown in Figure 8. No As-Built elevation survey was performed for the Control, so the elevation data for the Control begins with the Post-Hurricane survey. Behind Shoreline data was also not collected for the As-Built surveyof the Project Area. Elevations from the Year 3 survey were generally higher behind the shoreline in the Project area than the Control. Elevation in the Between Shoreline and Structure ecotone of the Project area appears to be stable across all survey events. Although the Front of Structure elevations are lower in the Project Area than the Front of Shoreline in the Control, the relative trend of elevation change across surveys appears to be consistent for the Project Area and the Control.

Hurricane impacts in the Project Area were consistently negative across Analysis Groups, with the most severe impacts observed in the unprotected, Front of Structure ecotone (Figure 9). The least elevation loss was observed in the Between Shoreline and Structure ecotone (Figure 8) which demonstrates project effectiveness and the ability of the breakwater to trap sediment on egress. The highest elevation loss in the Behind Structure Gap ecotone was observed at the two end groups, Group 1 and Group 5. Group 1 had the highest loss within this ecotone of the two worst groups, presumably due in part to proximity to Joseph's Harbor Bayou. This suggests that there is some effect of wave energy entering the area behind the structure from the open ends of the breakwater, which is exacerbated by the energy input from the mouth of the Bayou. Groups 4 and 5 appeared to have a higher exposure to erosional force in general, illustrated by the front of structure ecotone losses shown in Figure 8. This indicates that the relative shoreline location has an effect on soil volume change dynamics, which is consistent with the findings of the DSAS analyses (Table 1, Figure 3, and Figure 4). The soil volume loss in Groups 4 and 5 is especially visible within the two gaps west of the LA-0008 structure (Figures 9 and 10; Appendix A). As seen in the DSAS analyses, these wider gaps appear to allow more free energy transfer from the Gulf and enhancing erosional force behind the structure relative to other locations within the Project Area. This discrepancy in erosional mitigation behind the structure in the presence of wider gaps bolsters the success of the gap design used for the rest of the project area, and highlights the threshold for gapping in gulf shoreline stabilization projects.

Table 5 and Figure 10 give insight into hurricane recovery across Project Analysis Groups as well as the control. Although Hurricane impacts are not calculable for the Control, using the Post-Hurricane survey as a baseline allows for inferences for the elevation dynamics in this area to be compared to the project as both locations progress from the 2020 hurricane season event. Behind Shoreline elevation change was positive across all Analysis Groups in the Project Area and negative within the Control (Figure 10). This may be due to biogeomorphic dynamics as the relatively protected vegetated ecosystem behind the breakwater is able to trap sediment, build belowground biomass, and thus gain elevation. Continued loss was observed in the Behind Shoreline Gap ecotone, although not as severe as what was documented during the 2020 Hurricane season (Figure 9 and Figure 10). After elevation loss across all groups from the 2020 hurricane season (Figure 9), the Between Shoreline and Structure ecotone was stable, showing nearly no change from the Post-Hurricane Survey to the Year 3 monitoring survey (Figure 8 and 10). Though the elevation outside of the breakwater (Front of Structure ecotone) in the Project Area is generally

lower than the Front of Shoreline ecotone in the Control (Figure 8), the soil elevation loss between surveys is much higher in the Control than in any of the Project locations (Figure 8, 9, and 10).

Based on the elevation data collected, the project met its goals. The breakwater protected the shoreline behind it and retained sediment to allow land building and vegetative expansion to occur within the Project Area that was not observed in the Control. Overall, the Project Area significantly outperformed the control in soil volume. The soil volume change between surveys was calculated using survey DEMs and the cut/fill tool in ESRI ArcPro. In the three years following the 2020 Hurricane season (using data from the 2021 Post-Hurricane Survey and the 2024 Year 3 Survey), the ME-0018 project has retained 311,423 cubic yards of sediment per linear mile when compared to the Control (Table 5). Extrapolated over the full 3.85 breakwater miles of the Project Area, that is a net benefit of 1,198,285 cy of Gulf sediment retained on the shoreline. The rate of unit volume change was calculated to demonstrate how much sediment is trapped per linear mile annually. The results show that almost 100,000 cubic yards of sediment was retained per linear breakwater mile between the Post- Hurricane and Year 3 surveys (Table 5). The difference in soil volume change highlights the capacity for the breakwater structure to facilitate post-hurricane recovery and therefore enhance ecosystem resilience to storm events. Further, the continued trend of this discrepancy in soil accumulation between the Project Area and the Control, may lead to compound effects as more stable land is built and vegetated, which will in turn enhance inland habitat protection from ambient and acute erosional forces from the Gulf.

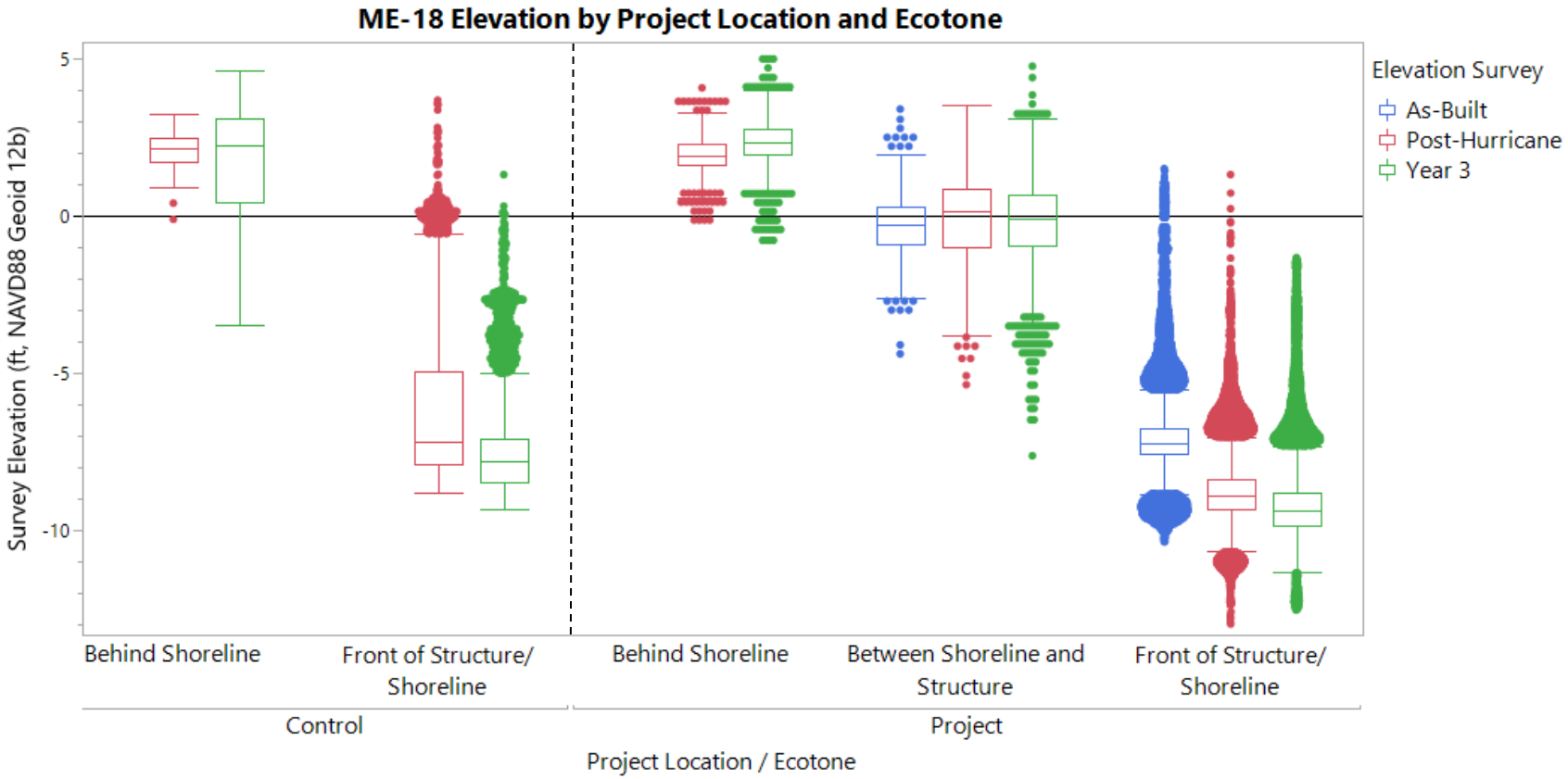

Figure 8. Survey Elevation data from the As-Built (2020), Post- Hurricane (2021), and Year 3 (2024) surveys by Ecotone and Project Location (Project/Control). There is no As-Built elevation data for the Behind Shoreline ecotone and for the entire Control. Also, no structure related ecotones are present in the Control.

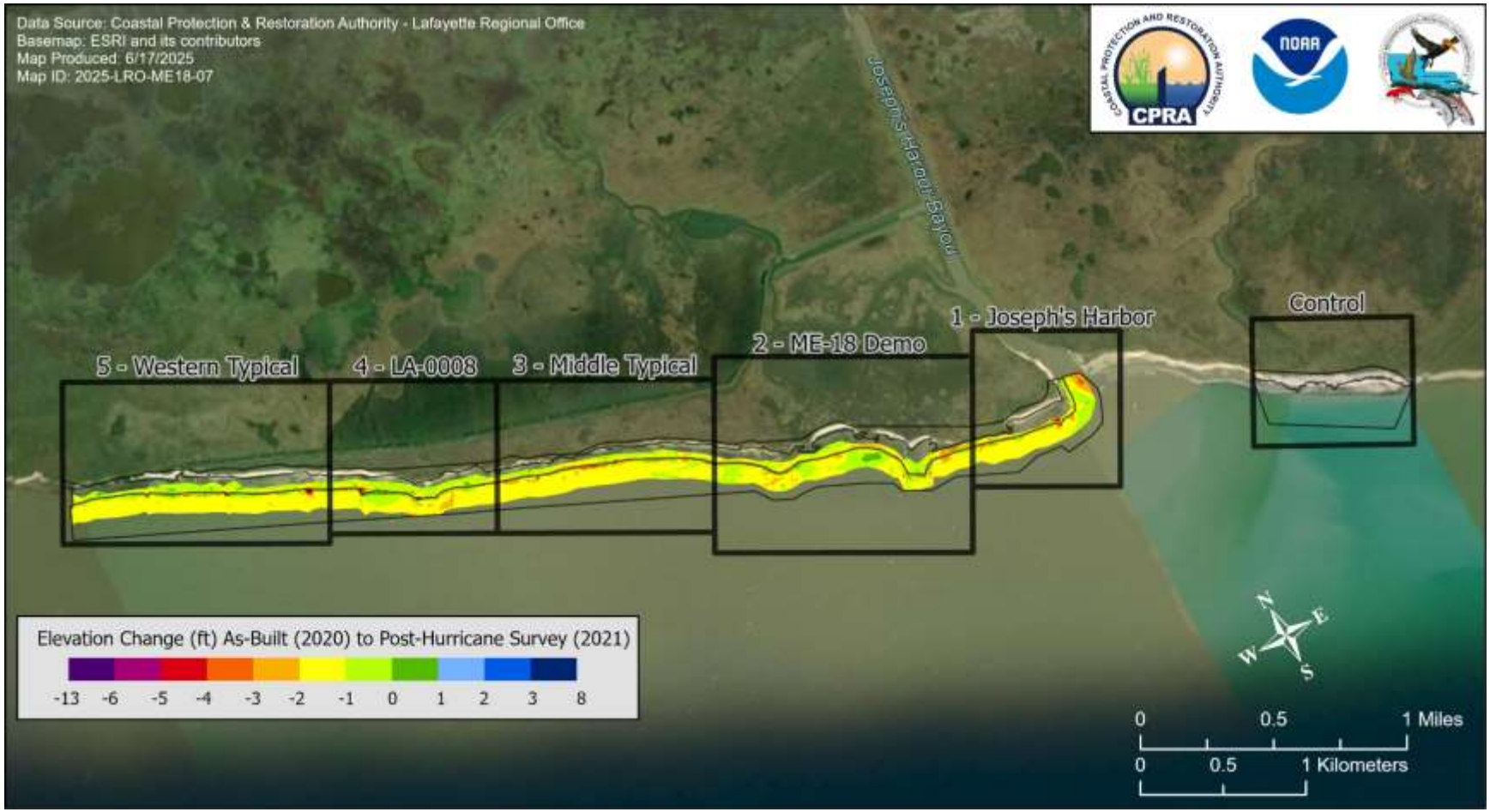

Figure 9. Survey Elevation change data taken from the As-Built (2020) to Post- Hurricane (2021) surveys. Ecotone and Analysis group should outlined in black. There is no As-Built elevation data for the Behind Shoreline ecotone and for the entire Control.

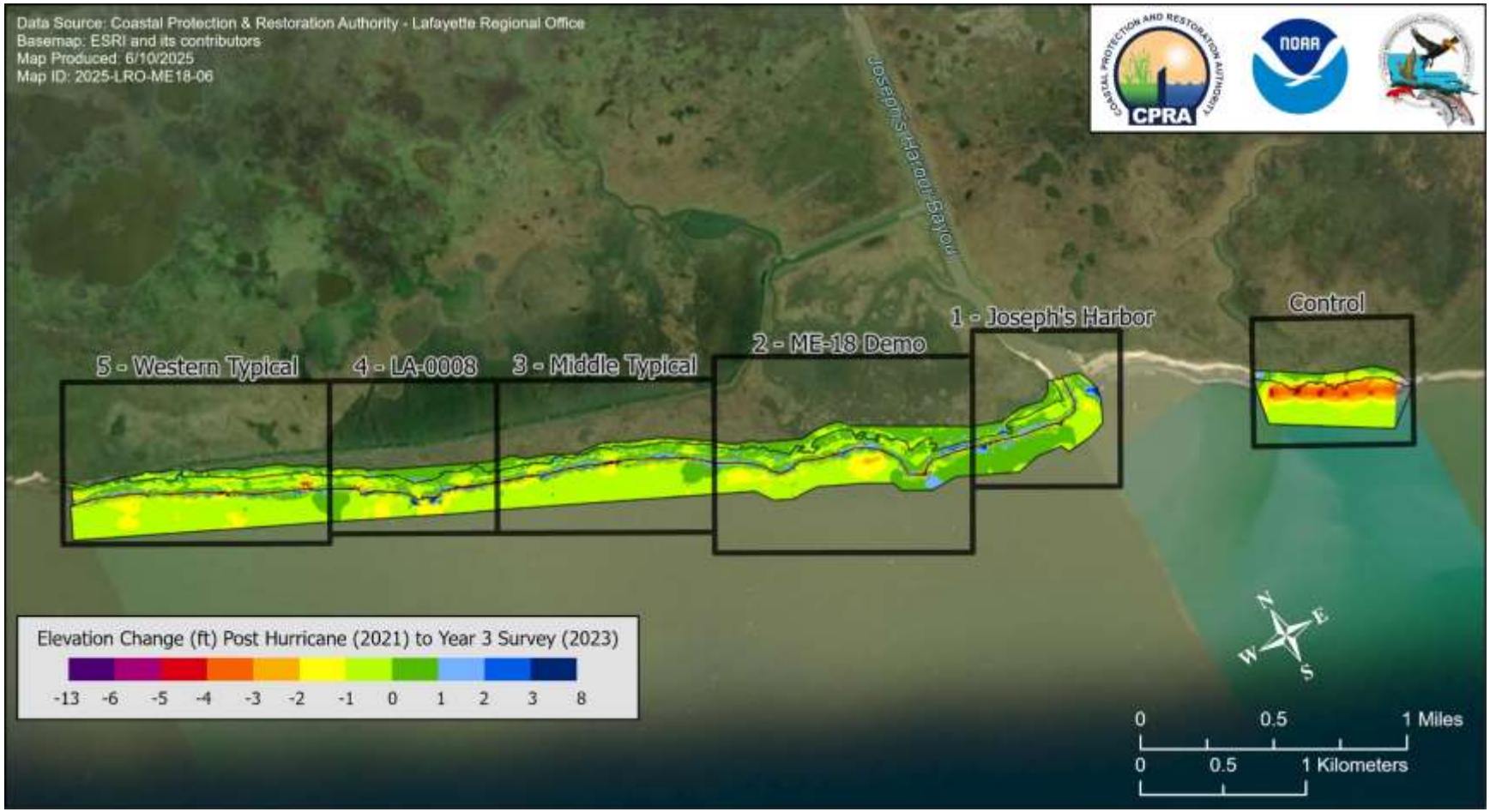

Figure 10. Survey Elevation change data taken from the Post- Hurricane (2021) to Year 3 (2024) surveys. Ecotone and Analysis group should outlined in black.

Soil Volume Change Comparison (Post Hurricane to Year 3)				
	Length (linear miles)	Total Volume Change (cy)	Unit Volume Change (cy/ lm)	Rate of Unit Volume Change (cy/lm/yr)
Project	3.85	-226,088	-58,724	-18,544
Control	0.4	-147,987	-369,967	-116,832
Difference			311,243	98,287

Table 5. Soil Volume change comparison between Project and Control areas. Total volume change was taken from the Post-Hurricane survey (2021) to the Year 3 survey (2024). The As-Built data was not included due to spatial limitations of that dataset. Total volume was divided by the total length of the respective study area to create for a common unit for comparison. Time was then accounted for to give a standardize rate volume change for comparison.

Project Benefits Analysis

Despite the enhanced vulnerability of this geomorphic region to shoreline loss (Berlinghoff et al 2025), gulf shoreline stabilization has demonstrated success in reversing the degradation of shoreline and building new land via energy abatement and enhanced sediment trapping behind breakwater structure(s). Apart from data analyses, this effect is clearly visual through aerial imagery of the area (Figure 10). Further, the study area for ME-0018 represents the area that was projected to have eroded into the Gulf of Mexico over the 20-year project life if left unprotected. It does not extend inland to include the marsh that is protected and nourished by the project between the shoreline and Hwy 82. Sediments that had been trapped prior to the 2020 hurricanes were washed inland and nourished marshes outside of the project area. Also, it is likely that the presence of the structure during the 2020 hurricanes prevented landloss between the Gulf and Hwy 82. Those benefits are not captured here but could be the subject of a targeted study.

Cost benefit analyses were conducted for the purpose of characterizing a monetary benefit for land (DSAS) and soil volume (elevation) retained by the breakwater structure when compared to the control area. These analyses are not intended to be comprehensive, but are meant to highlight a beneficial component of gulf shoreline stabilization that is currently under-explored, and stimulate further investigation of similar projects in the area for the future.

The total acres of land lost in the Control Area from the As-Built survey (May 2020) to the Year 3 survey (April 2024), was 12.7 acres (Table 6). Unlike the elevation data, the DSAS calculations include the impacts from Hurricanes Laura and Delta immediately following construction. Although the Project area actually gained land during the same time period (4.6 acres), it was counted as a neutral/ stable value. This was done for the sake of conservative calculations as well as the limitation of land building up to the breakwater structure. A total of 31.7 acres were retained per linear breakwater mile, which is 122.2 acres total project benefit over the entire project area. A conservative estimate for comparable construction costs (excluding Engineering, Design, Permitting, etc.) for marsh creation projects was used ($80k/acre) to calculate a value for this land

area retained. Using this value, the project benefit of the land retention from May 2020 to April 2024 was $9.7 million ($2.5 million per linear mile). When this value is integrated with the construction costs at ME-0018, an annual return on investment of $2.5 million (9%) with a break even period of 11.5 years.

Land Retention Benefit Analysis (As-Built to Year 3)			
	Total Acres of Land Loss/Land Gain	Land Retained per Linear mile (ac/mile)	
Project	4.6	31.7	
Control	-12.7		
Project Benefit (Total Area)		**122.2 ac**	
ME-18 (2020-2024) Project Benefit	Land Retained in Project Area (ac)	Land Retained Cost Benefit ($80k/acre)	Land Retained Cost Benefit per Breakwater mile
	122.2	**$9.7 million**	**$2.5 million**
	Total Construction Cost	Land Retention Annual Return on Investment	Break Even Period (years)
	$28.6 million	**$2.5 million**	**11.5**

Table 6. Project Benefit Analysis of land retention (acres) calculated from DSAS net shoreline movement across all survey events. Land gain in the project area (4.6 ac) was counted as stable and not included in land retention calculations.

Soil Volume Benefit Analysis (Post-Hurricane to Year 3)			
	Total Soil Volume Change per linear mile (cy/mile)	Difference in Soil Volume Change per linear mile (cy/mile)	
Project	-58,724	311,243	
Control	-369,967		
Project Benefit (Total Volume)		**1,198,285 cy**	
ME-18 (2021-2024) Project Benefit	Total Soil Volume Retained in Project Area	Soil Cost Benefit ($18/cy)	Soil Cost Benefit per Breakwater mile
	1.2 mcy	$21.6 million	$5.6 million
	Total Construction Cost	Soil Volume Annual Return on Investment	Break Even Period (years)
	$28.6 million	**$6.8 million**	**4.2**

Table 7. Cost Benefit Analysis of Soil Volume change behind the breakwater structure using unit volume change (cubic yards/linear mile/year) to illustrate project effect on soil volume change from the Post-Hurricane to the Year 3 Survey. As-Built elevation data is not available for the Control, so no analysis was done for the As-Built to Post-Hurricane Surveys.

The same sediments trapped and retained by the breakwater structure are used for marsh creation in the region, therefore a value was ascribed to determine the approximate cost benefit of the sediment retained by ME-0018 in marsh creation dollars (Table 7). Using nearby, recently constructed project construction costs (CS-59, ME-20, CS-66) and the 2023 Louisiana Master Plan as guidance, a cost per cubic yard of $18/cubic yard for this area was used. Through year three, ME-0018 has trapped and retained $21.6 million of sediment for an annual return on investment of $6.8 million. That equates to $5.6 million of sediment stored per project mile. At this rate, the project pays for its construction costs with comparable gulf sediment in 4.2 years. Since Louisiana Gulf Coast shoreline erosion is continuous and ongoing and given the fact that the ME-0018 project continuously traps sediments, the value of the project will increase through time. Although the soil volume cost benefit trend may slow based on the sustainable elevation threshold in survey area, given that the analysis only is extrapolated from three years of benefit it is a reasonable assumption that pattern of soil retention will continue well into the remaining project lifespan and provide significantly more cost benefit to the area impacted by the project. The total cost benefit over the 20 year project lifespan is $50-136 million. Further, although DSAS and elevation surveys are two independent datasets, they demonstrate a similar message when comparing the cost benefit of the breakwater structure's capacity for shoreline stabilization and sediment trapping.

Beyond land building and inland protection, the reef component of the project also provides significant ecological benefits to the region. The breakwater structure has effectively created an artificial reef which supports an abundance of new oyster cultures, and provides extensive edge habitat on both sides of the reef. Observations by the refuge manager (Figure 12; personal communication, Philip Trosclair May 5 2025) include enhancing water quality via lower water turbidity behind the breakwater structure, shoreline surveys which identify onshore protection of nesting birds, and vastly improved fisheries habitat. In fact, the breakwater has created a previously absent inshore recreational fishery with red drum, speckled trout, and southern flounder. The project area has become a popular fishing spot with both locals and travelers.

Figure 10. Photograph provided by Philip Trosclair, Rockefeller Refuge Manager taken on 11/16/2023 facing west at the western end of ME-37, which is a continuation from the western extent of ME-0018. This photograph demonstrates the sediment stabilization behind the structure.

Figure 11. Photograph provided by Philip Trosclair, Rockefeller Refuge Manager taken on 4/20/2020 demonstrating the enhance edge habitat behind the structure and utilization by recreational fishing boat.

Settlement Plates

Settlement plate elevation data obtained during the construction surveys, As-Built surveys, Post-Hurricane surveys, and the Year 3 Monitoring surveys were compared. Four settlement values were calculated at each settlement plate location:

1) Settlement between the construction (varies between July 2018 and May 2020) and the Post-Hurricane survey (January 2021)
2) Settlement between the As-Built survey (May 2020) and the Post-Hurricane survey (January 2021)
3) Settlement between the Post-Hurricane survey (January 2021) and Year 3 monitoring survey (March 2024)
4) Total Settlement measured from construction (varies between July 2018 and May 2020) to the Year 3 monitoring survey (March 2024)

Table 8 shows settlement plate elevation change measured across all survey events. Total change from construction to the 3-year monitoring survey was -2.1 ft. The general trend for the higher average settlement was observed in the eastern reach of the project area, however the highest values of settlement were observed in two settlement plates on the west side of the project (SPAE 6: -3.35, SPAE 1: -3.23; Table 8 and Figure 13). The settlement value from the as-built to the hurricane survey was isolated from the total elevation change to identify how much of total settlement can be attributed to the 2020 hurricane season. An average of 29% of all settlement from construction to the Year 3 survey can be attributed to the 7 month period between the as-built survey and the hurricane survey. With the exception of one settlement plate (SPAE 5), all settlement values for the 3 years from the hurricane survey and the Year 3 survey are comparable or less than the settlement experienced in the relatively brief period between the as-built and hurricane survey.

Figure 13. Settlement Plate Locations across Project Area taken from HDR Engineering Inc, 2021.

Settlement Plate	Settlement Construction to Hurricane (ft)	Settlement As-Built to Hurricane (ft)	Settlement Hurricane to 3-yr (ft)	Total Settlement Construction to 3-year (ft)	Percent Hurricane Settlement
SPAE6	-1.26	-0.86	-2.09	-3.35	26%
SPAE5	-1.3	-0.69	*	**-0.69**	53%*
SPAE3	-1.38	-0.72	-0.43	-1.81	40%
SPAE4	-1.65	-0.85	-0.55	-2.2	39%
SPAE2	-1.05	-0.75	-0.62	-1.67	45%
SPAE1	-2.66	*	-0.57	**-3.23**	*
SP1	-1.53	-1.09	-0.35	-1.88	58%
SP2	0.11	0.52	-0.28	-0.17	*
SP3	-1.81	-0.53	-0.25	-2.06	26%
SP4	-1.75	-0.41	-0.38	-2.13	19%
SP5	-1.38	-0.51	-0.26	-1.64	31%
SP6	-1.42	-0.42	-0.41	-1.83	23%
SP7	-1.8	-0.49	-0.38	-2.18	22%
SP8	-1.33	-0.39	-0.58	-1.91	20%
SP9	-1.12	-0.51	-0.33	-1.45	35%
SP10	-1.78	-0.74	-0.39	-2.17	34%
SP11	-2.27	-0.42	-0.35	-2.62	16%
SP12	-2.46	-0.29	-0.38	-2.84	10%
SP13	-2.22	-0.54	-0.45	-2.67	20%
SP15	-1.61	-0.41	-0.45	-2.06	20%
SP16	-2.03	-0.48	-0.52	-2.55	19%
Average	**-1.60**	**-0.53**	**-0.50**	**-2.05**	**29%**

Table 8. Settlement Plate Elevation Change across all elevation surveys (Construction, As-built, Hurricane, Year 3)

V. Conclusions

a. Project Effectiveness

The Rockefeller Refuge Gulf Shoreline Stabilization project (ME-0018) has demonstrated success in achieving the main objective to mitigate erosional storm impacts within the project area during the first three years of the 20-year project life (2020-2040). The unique circumstances surrounding the quick succession of events following construction completion and the 2020 hurricane season allowed for project goals to be tested more abruptly than anticipated. The project performed at or beyond expectations towards the specific project goals. It was designed to survive a Category 1 storm and it stood up to direct strikes from a Category 4 storm and a Category 2 storm back to back in the same season without requiring maintenance. It quickly trapped sediments lost to the storm and returned to land building without human intervention.

Negative shoreline movement was drastically less in areas with protected shoreline. Further, the value of material trapped and retained by the ME-0018 project over just three years is equivalent to the budgets used in marsh creation projects in the region ($5.6 million of sediment stored per mile of Gulf shoreline) with a reasonable total cost benefit over the 20 year project lifespan of $50-136 million. Given the additional benefit that shoreline protection projects provide in the form of infrastructure protection and reef and fisheries habitat, the value and effectiveness of the ME-0018 project is among the highest in the region.

b. Recommended Improvements

Expansion of the Project Area to the west would enhance existing shoreline protection (as demonstrated by the effect of the ME-37 project on the western end of ME-0018) and stabilize more coastal land area within Rockefeller Refuge. With some of the highest rates of shoreline loss anywhere on the Louisiana Gulf Coast, time is of the essence for shoreline stabilization in this area.

c. Lessons Learned

The breakwater structure was successful at mitigating storm impacts and facilitating shoreline stability. This analysis supports the ability of shoreline stabilization projects in this region to provide protection from storm surge energy along the vulnerable vegetated shoreline, to stimulate recovery after storms, and to build relatively high elevation land at the coast. This capacity for shoreline recovery and vegetative colonization provides a significant lesson for project monitoring/design as the period between extreme storm events is key to long-term landscape resilience. Shoreline geometry and relative location also appeared to have an effect on relative shoreline movement and volume change, with the western portion of the project area being generally exposed to higher energy than the east and especially more so than the more insulated and central section of the Project Area. The presence of wider gaps (150–200 feet) in the breakwater structure, which were necessary to buffer existing pipelines, showed increased shoreline erosion compared to areas with standard 60-foot gaps. This contrast underscores the

importance of optimal gap spacing for effective shoreline protection and validates the current design approach used in future Gulf shoreline stabilization projects in the area.

The lack of As-Built elevation survey data for the Control was a clear and apparent gap when assessing project effectiveness for ME-0018. As-built data for the control would have been invaluable to more accurately measure hurricane impact mitigation to the ME-0018 Project Area. In future projects, efforts between project construction and monitoring staff should be coordinated prior to construction close out to identify a control area so that as-built survey elevation can be conducted to include the project control prior to construction close out. The enhanced storm resilience and facilitated shoreline expansion will allow this and future shoreline stabilization projects to persist through and thrive between extreme storm events, creating a long-term pattern of enhanced shoreline stability. This leads to the conclusion that inland impacts of such shoreline stabilization breakwater structure may be underrepresented with current metrics. Further analysis should be conducted on the dynamics of land change inland of protected shoreline structures beyond the current project area to determine the total area protected by this project. It is likely that the prevention of landloss and protection of inland infrastructure is occurring well inland of current project boundaries that only include the area that would have eroded over the project timeframe. Further, the project has proven to be a vital habitat by fostering the expansion of local oyster cultures along the structure, and sustaining a dynamic edge-effect, which is of vital importance to support healthy fisheries. Fishermen are catching trout in this part of the coast for the first time. When all of the benefits of this Gulf shoreline protection project are weighed together, it emerges as the best approach to prevent ongoing landloss and enhance coastal ecosystems in the region.

VI. Literature Cited

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Appendix A
Breakwater Gap Imagery

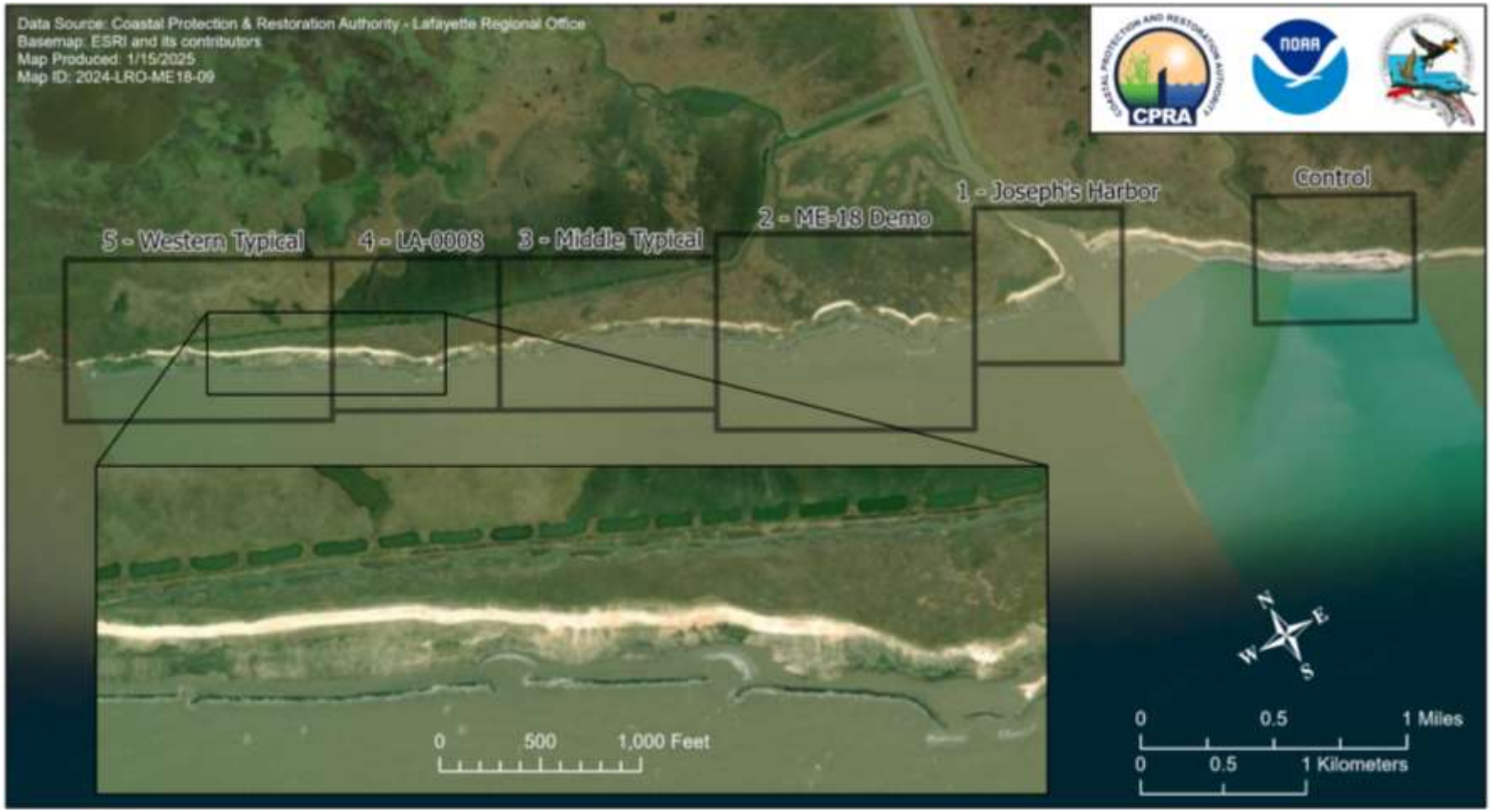

Figure A1- Area view of project area highlighting erosional effect of expanded gaps in breakwater structure due to buffer for existing pipeline.

Photo A2: Taken January 29, 2025 facing southeast towards wider fish gaps west of LA-0008. The enhanced erosion is apparent by the concave shoreline and fragmented, degrading vegetation.

Photo A3: Taken January 29, 2025 facing northwest towards westernmost of the two location with wider fish gaps west of LA-0008.

Photo A4: Taken January 29, 2025 facing southeast towards easternmost of the two location with wider fish gaps west of LA-0008.

Appendix B
Three Year Budget Projection

Rockefeller Refuge Gulf Shoreline Stabilization/ ME-0018 / C.150018.8/PPL 10

Three-Year Operations & Maintenance Budgets 07/01/2024 - 06/30/2027

Project Manager	O & M Manager	Federal Sponsor	Prepared By
Dion Broussard	*Dion Broussard*	*NOAA NMFS*	*Dion Broussard*

	2024/2025 (-5)	2025/2026 (-6)	2026/2027 (-7)
Maint. Insp. (Nav Aid Contrac	$10,000.00	$14,600.00	$14,600.00
Structure Operation	$0.00	$0.00	$0.00
State Administration	$4,600.00	$4,600.00	$4,600.00
Federal Administration	$3,400.00	$3,400.00	$5,397.00
Maintenance/Rehabilitation	$15,000.00	$0.00	$0.00

24/25 Description: Timber Pile, Signage, and Lighted Day Beacon Replacement (one)

E&D	$0.00	
Construction	$15,000.00	
Construction Oversight	$0	
Sub Total - Maint. And Rehab.	$ 15,000.00	

25/26 Description: No Maintenance Activity

E&D		$0.00
Construction		$0.00
on Oversight (CPRA Admin)		$0.00
Sub Total - Maint. And Rehab.		$0.00

26/27 Description: No Maintenance Activity

E&D			$0.00
Construction			$0.00
Construction Oversight			$0.00
		Sub Total - Maint. And Rehab.	$0.00

	2024/2025 (-5)	2025/2026 (-6)	2026/2027 (-7)
Total O&M Budgets	$ 48,000.00	$ 22,600.00	$ 24,597.00

O &M Budget (3 yr Total)	**$ 95,197.00**
Unexpended O & M Budget	**$ 777,528.00**
Remaining O & M Budget (Projected)	**$ 682,331.00**

OPERATION AND MAINTENANCE BUDGET WORKSHEET

Rockefeller Refuge Gulf Shoreline Stabilization/ ME-0018 / C.150018.8/PPL 10/ 2024-2025

DESCRIPTION	UNIT	EST. QTY.	UNIT PRICE	ESTIMATED TOTAL
O&M Inspection and Report	EACH	2	$5,000.00	**$10,000.00**
General Structure Maintenance	LUMP	0	$0.00	**$0.00**
Engineering and Design	LUMP	0	$0.00	**$0.00**
Operations Contract	LUMP	0	$0.00	**$0.00**
Construction Oversight	LUMP	0	$0.00	**$0.00**
ADMINISTRATION				
STATE Admin.	LUMP	1	$4,600.00	$4,600.00
FEDERAL SPONSOR Admin.	LUMP	1	$3,400.00	$3,400.00
SURVEY Admin.	LUMP	0	$0.00	$0.00
OTHER				$0.00
			TOTAL ADMINISTRATION COSTS:	**$8,000.00**
MAINTENANCE / CONSTRUCTION				
SURVEY				
SURVEY DESCRIPTION:				
Secondary Monument	EACH	0	$0.00	$0.00
Staff Gauge / Recorders	EACH	0	$0.00	$0.00
Marsh Elevation / Topography	LUMP	0	$0.00	$0.00
TBM Installation	EACH	0	$0.00	$0.00
OTHER				$0.00
			TOTAL SURVEY COSTS:	**$0.00**
GEOTECHNICAL				
GEOTECH DESCRIPTION:				
Borings	EACH	0	$0.00	$0.00
OTHER				$0.00
			TOTAL GEOTECHNICAL COSTS:	**$0.00**
CONSTRUCTION				
CONSTRUCTION DESCRIPTION:				

Rip Rap	LIN FT	TON / FT	TONS	UNIT PRICE	
Rock Dike	0	0.0	0	$0.00	$0.00
Bank Paving	0	0.0	0	$0.00	$0.00
	0	0.0	0	$0.00	$0.00
Filter Cloth / Geogrid Fabric		SQ YD	0	$0.00	$0.00
Navigation Aid		EACH	1	$1,500.00	$1,500.00
Signage		EACH	1	$1,500.00	$1,500.00
General Excavation / Fill		CU YD	0	$0.00	$0.00
Dredging		CU YD	0	$0.00	$0.00
Sheet Piles (Lin Ft or Sq Yds)			0	$0.00	$0.00
Timber Piles (each or lump sum)			1	$7,000.00	$7,000.00
Timber Members (each or lump sum)			0	$0.00	$0.00
Hardware		LUMP	0	$0.00	$0.00
Materials		LUMP	0	$0.00	$0.00
Mob / Demob		LUMP	1	$5,000.00	$5,000.00
Contingency		LUMP	0	$0.00	$0.00
General Structure Maintenance (25%)		LUMP	0	$0.00	$0.00
Vegetative Plantings		LUMP	0	$0.00	$0.00
OTHER		LUMP	0	$0.00	$0.00
OTHER				$0.00	$0.00
				TOTAL CONSTRUCTION COSTS:	**$15,000.00**
				TOTAL OPERATIONS AND MAINTENANCE BUDGET:	**$33,000.00**

OPERATION AND MAINTENANCE BUDGET WORKSHEET

Rockefeller Refuge Gulf Shoreline Stabilization/ ME-0018 / C.150018.8/PPL 10/ 2025-2026

DESCRIPTION	UNIT	EST. QTY.	UNIT PRICE	ESTIMATED TOTAL
O&M Inspection and Report	EACH	2	$5,000.00	**$10,000.00**
General Structure Maintenance	LUMP	0	$0.00	**$0.00**
Engineering and Design	LUMP	0	$0.00	**$0.00**
Operations Contract	LUMP	0	$0.00	**$0.00**
Construction Oversight	LUMP	0	$0.00	**$0.00**
ADMINISTRATION				
STATE Admin.	LUMP	1	$4,600.00	$4,600.00
FEDERAL SPONSOR Admin.	LUMP	1	$3,400.00	$3,400.00
SURVEY Admin.	LUMP	0	$0.00	$0.00
OTHER				$0.00
			TOTAL ADMINISTRATION COSTS:	**$8,000.00**
			TOTAL ADMINISTRATION COSTS:	**$8,000.00**
MAINTENANCE / CONSTRUCTION				
SURVEY-				
SURVEY DESCRIPTION: Inspection of pipeline for integrity , identification of repair needs, if any				
Secondary Monument	EACH	0	$0.00	$0.00
Staff Gauge / Recorders	EACH	0	$0.00	$0.00
Marsh Elevation / Topography	LUMP	0	$0.00	$0.00
TBM Installation	EACH	0	$0.00	$0.00
Other		0	$0.00	$0.00
			TOTAL SURVEY COSTS:	**$0.00**
GEOTECHNICAL				
GEOTECH DESCRIPTION:				
Borings	EACH	0	$0.00	$0.00
OTHER				$0.00
			TOTAL GEOTECHNICAL COSTS:	**$0.00**
CONSTRUCTION				
CONSTRUCTION DESCRIPTION: Repairs to pipeline as revealed by results of inspection for integrity, if any				
Rip Rap	LIN FT	TON / FT	QTY	UNIT PRICE
Rock Dike	0	0.0	0	$0.00 $0.00
Bank Paving	0	0.0	0	$0.00 $0.00
	0	0.0	0	$0.00 $0.00
Filter Cloth / Geogrid Fabric		SQ YD	0	$0.00 $0.00
Navigation Aid		EACH	0	$0.00 $0.00
Signage		EACH	0	$0.00 $0.00
General Excavation / Fill		CU YD	0	$0.00 $0.00
Dredging		CU YD	0	$0.00 $0.00
Sheet Piles (Lin Ft or Sq Yds)			0	$0.00 $0.00
Timber Piles (each or lump sum)			0	$0.00 $0.00
Timber Members (each or lump sum)			0	$0.00 $0.00
Hardware		LUMP	0	$0.00 $0.00
Materials		LUMP	0	$0.00 $0.00
Mob / Demob		LUMP	0	$0.00 $0.00
Contingency		LUMP	0	$0.00 $0.00
General Structure Maintenance (25%)		LUMP	0	$0.00 $0.00
Vegetative Plantings		LUMP	0	$0.00 $0.00
OTHER		LUMP	0	$0.00 $0.00
Other		LUMP	0	$0.00 $0.00
			TOTAL CONSTRUCTION COSTS:	**$0.00**
			TOTAL OPERATIONS AND MAINTENANCE BUDGET:	**$18,000.00**

OPERATION AND MAINTENANCE BUDGET WORKSHEET

Rockefeller Refuge Gulf Shoreline Stabilization/ ME-0018 / C.150018.8/PPL 10/ 2026-2027

DESCRIPTION	UNIT	EST. QTY.	UNIT PRICE	ESTIMATED TOTAL
O&M Inspection and Report	EACH	2	$5,000.00	**$10,000.00**
General Structure Maintenance	LUMP	0	$0.00	**$0.00**
Engineering and Design	LUMP	0	$0.00	**$0.00**
Operations Contract	LUMP	0	$0.00	**$0.00**
Construction Oversight	LUMP	0	$0.00	**$0.00**
ADMINISTRATION				
CPRA Admin.	LUMP	1	$4,600.00	$4,600.00
FEDERAL SPONSOR Admin.	LUMP	1	$5,397.00	$5,397.00
SURVEY Admin.	LUMP	0	$0.00	$0.00
OTHER				$0.00
			TOTAL ADMINISTRATION COSTS:	**$9,997.00**
MAINTENANCE / CONSTRUCTION				
SURVEY				
SURVEY DESCRIPTION: Pipeline Inspection & Testing				
Secondary Monument	EACH	0	$0.00	$0.00
Staff Gauge / Recorders	EACH	0	$0.00	$0.00
Marsh Elevation / Topography	LUMP	0	$0.00	$0.00
TBM Installation	EACH	0	$0.00	$0.00
OTHER				$0.00
			TOTAL SURVEY COSTS:	**$0.00**
GEOTECHNICAL				
GEOTECH DESCRIPTION:				
Borings	EACH	0	$0.00	$0.00
OTHER				$0.00
			TOTAL GEOTECHNICAL COSTS:	**$0.00**
CONSTRUCTION				
CONSTRUCTION DESCRIPTION:				
Rip Rap	LIN FT	TON / FT	TONS	UNIT PRICE
Rock Dike	0	0.0	0	$0.00	$0.00
Bank Paving	0	0.0	0	$0.00	$0.00
	0	0.0	0	$0.00	$0.00
Filter Cloth / Geogrid Fabric		SQ YD	0	$0.00	$0.00
Navigation Aid		EACH	0	$0.00	$0.00
Signage		EACH	0	$0.00	$0.00
General Excavation / Fill		CU YD	0	$0.00	$0.00
Dredging		CU YD	0	$0.00	$0.00
Sheet Piles (Lin Ft or Sq Yds)			0	$0.00	$0.00
Timber Piles (each or lump sum)			0	$0.00	$0.00
Timber Members (each or lump sum)			0	$0.00	$0.00
Hardware		LUMP	0	$0.00	$0.00
Materials		LUMP	0	$0.00	$0.00
Mob / Demob		LUMP	0	$0.00	$0.00
Contingency		LUMP	0	$0.00	$0.00
General Structure Maintenance (25%)		LUMP	0	$0.00	$0.00
Vegetative Plantings		LUMP	0	$0.00	$0.00
OTHER		LUMP	0	$0.00	$0.00
OTHER				$0.00	$0.00
				TOTAL CONSTRUCTION COSTS:	**$0.00**
			TOTAL OPERATIONS AND MAINTENANCE BUDGET:	**$19,997.00**