US Army Corps of Engineers ®
Galveston District

# Appendix K

## Monitoring and Adaptive Management Plan

**for**

## Coastal Texas Protection and Restoration Study

**October 2020**

# Coastal Texas Protection and Restoration Feasibility Study

## Final Feasibility Report

## Monitoring and Adaptive Management Plan

## October 2020

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Texas General Land Office

United States Army Corps of Engineers
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# 1.0 INTRODUCTION

This document provides a feasibility-level monitoring and adaptive management plan for the Coastal Texas Final Feasibility Report (FR) for the Coastal Texas Study, which proposes Coastal Storm Risk Management (CSRM) and Ecosystem Restoration (ER) opportunities within 18 coastal counties in Texas along the entire Texas Gulf coast. The FR presents the investigation of comprehensive water resources management for the Texas coast to ensure public safety and benefit to the Nation, while balancing the primary missions of navigation, flood and hurricane storm damage reduction, and environmental stewardship. This FR will be used to inform decision makers, stakeholders, and the public of the tradeoffs that should be considered in future decisions in order to maintain existing coastal storm risk levels and/or reduce coastal storm risk along the Texas coast.

This plan identifies potential and necessary monitoring activities for ER features, outlines how results from the monitoring would be used to assess ER and mitigation feature success and, if needed, adaptively manage the project features to achieve the desired objectives. The plan specifies who would be responsible for monitoring and adaptive management activities, as well as provides estimated costs.

This Monitoring and Adaptive Management Plan (MAMP) was prepared by members of the Coastal Texas project delivery team (PDT) in consultation with resource agencies, which included Texas Parks and Wildlife Department, US Fish and Wildlife Service, Texas Commission on Environmental Quality, National Marine Fisheries Service, US Environmental Protection Agency, National Park Service, Bureau of Ocean Energy Management, and the Natural Resources Conservation Service. The level of detail in this plan is based on currently available data and information developed during plan formulation as part of the feasibility study. Uncertainties remain concerning the exact project features, monitoring elements, and adaptive management opportunities because of the variability of natural systems and the scale of the ER and CSRM features. Components of the MAMP, including costs, were similarly estimated using available information. Uncertainties will be addressed in the preconstruction, engineering and design (PED) phase; this plan will be revised during that phase to incorporate more detailed monitoring, adaptive management plans, and cost breakdowns.

## 1.1 Authorization for Monitoring and Adaptive Management

In accordance with the Water Resources Development Act of 2007 Section 2036, Section 2039 and subsequent implementation guidance (CECW-PB Memorandum dated August 31, 2009), MAMP are required for both National Ecosystem Restoration (NER) project components and for any Mitigation Plan required for the National Economic Development (NED) component.

Section 2039 specifically directs the Secretary of the Army to ensure that when conducting a feasibility study for an ecological restoration project (or component of a project), the recommended project must include a plan for monitoring the success of the project. The implementation guidance for Section 2039 specifies that ER projects include plans to track and improve restoration success through monitoring and adaptive management. Guidance stipulates that the monitoring plan includes a description of the monitoring activities, the criteria for success, and the estimated cost and duration of the monitoring. It also specifies that monitoring will be performed until restoration success is achieved.

This MAMP includes all elements required by the WRDA 2007 implementation guidance for section 2039.

## 1.2 Introduction to Monitoring and Adaptive Management

Monitoring and adaptive management provides a directed iterative approach to achieve restoration project goals and objectives by focusing on strategies promoting flexible decision making that can be adjusted as outcomes from restoration management actions and other events become better understood. Initiating a formal MAMP early in the study process enables the study team to identify and resolve key uncertainties and other potential issues that can positively or negatively influence project outcomes during every stage of the planning and project implementation process. Therefore, early implementation of monitoring and adaptive management will result in a project that can better succeed under a wide range of uncertain conditions and can be adjusted as necessary. Furthermore, careful monitoring of project outcomes both advances scientific understanding and helps adjust policies and/or operations as part of an iterative learning process.

Adaptive management acknowledges the uncertainty about how ecological systems function and how they may respond to management actions. Monitoring and assessment that analyzes responses is essential to implementation of the project as restoration progresses. The MAMP was developed in order to:

- Allow scientists and managers to collaboratively design plans for managing complex and incompletely understood ecological systems.
- Reduce uncertainty over time.
- Implement systematic monitoring of outcomes and impacts.
- Incorporate an iterative approach to decision-making.
- Provide a basis for identifying options for improvements in the design, construction and operation of restoration through adaptive management.
- Ensure interagency collaboration and productive stakeholder participation as they are key elements to success.

### 1.2.1 Monitoring and Adaptive Management Process

The monitoring and adaptive management program and process is complimentary to the USACE Project Life Cycle (planning, design, construction, and operation and maintenance). The process is not elaborate or duplicative and enhances activities already taking place. The basic process was adapted from a technical note published by the Engineering Research and Development Center (ERDC)[1].

Elements of the program include an iterative process that involve:

1. Planning a program or project;
2. Designing the project;
3. Building the project;
4. Operating and maintaining the project;
5. Monitoring and assessing project performance;
6. Continuing, adjusting, or terminating a project if the goals and objectives are not being achieved.

### 1.2.2 Adaptive Management Team

As part of the monitoring and adaptive management process, a team is set up to implement the process. The MAMP provides the framework and guidance for an Adaptive Management Team (AMT) to review and assess monitoring results. In addition, the AMT will recommend adaptive management actions when ecological success is not achieved and decision criteria are triggered. The AMT members shall work together to make recommendations relevant to implementing the MAMP. The AMT is composed of USACE staff, the non-Federal sponsor (NFS), interested resource agencies, and other stakeholders. Although the USACE has coordinated with the entities that will comprise the AMT in development of the Feasibility Report and Environmental Impact Statement (FR-EIS), the AMT will not be officially established until the PED phase of the project.

The AMT focuses on maintaining the ecological function of coastal habitats through management actions within the project area. The AMT shall review the monitoring results and advise on recommended actions that are consistent with the project goals. These goals should reflect the current and future needs of the habitat and the species they support within the project area. The NFS and USACE shall have final determination on all adaptive management actions recommended.

The NFS and USACE are responsible for ensuring that monitoring data and assessments are properly used in the adaptive management decision-making process. If the NFS and USACE determine that adaptive management actions are needed, they will coordinate with the AMT for implementation of those actions. The NFS and USACE are also responsible for project documentation, reporting, and external communication.

[1] Fischnecich, C., et al. 2012. The Application of Adaptive Management to Ecosystem Restoration Projects. EBA Technical Notes Collection. ERDC TN-EMRRP-EBA-10. Vicksburg, MS: US Army Engineering Research and Development Center. www.wes.army.mil/el/emrrp.

The AMT shall meet a minimum of once per year, as scheduled by the NFS and USACE during the monitoring period, to review the results of monitoring and assess whether project objectives are being met. If objectives are not being met, the AMT may recommend that adaptive management actions be taken in response to monitoring results and decision-making triggers.

The AMT may also consider other related projects in the hydrologic basin in determining the appropriate adaptive management actions and may consult with other recognized experts or stakeholders as appropriate, to achieve project goals.

Recommendations for adaptive management should be based on:

- Monitoring data from previous years,
- Consideration of current habitat conditions,
- Consideration of current and potential threats to habitat establishment success, and
- Past and predicted responses to threats by target species and habitats.

#### **1.2.2.1 Team Structure**

The AMT shall include representatives from USACE, Galveston District and the Regional Planning and Environmental Center (RPEC), and the NFS. The USACE may be represented by the Project Biologist(s), as well as the Project Hydrology and Hydraulics (H&H) representative and the Project Geotechnical representative as needed. Other USACE attendees may include the Project Manager, Project Real Estate Specialists, and/or Operations and Maintenance designees, as needed.

The Texas General Land Office (GLO) is the NFS for the Feasibility Study portion of this project. Following the execution of a feasibility cost share agreement in November 2015, the GLO actively participated in the scoping of the study and contributed a non-Federal cost share, which includes work-in-kind and contracting with GLO professional service providers. The GLO has worked alongside the USACE on the Feasibility Report (FR) in the formulation and screening process and will continue to provide assistance throughout the entire Coastal Texas Study process.

A NFS for the construction phase will be identified by the Texas Legislature. The GLO is also working to identify construction sponsors on the local level. Local construction sponsors could include local governments, such as counties, cities, levee improvement districts, drainage districts, municipal utility districts, or other special taxing entities that could be created for this project.

The AMT should also include representatives from resource agencies who would serve in an advisory capacity, to assist in evaluation of monitoring data and assessment of adaptive management needs. The agencies may include, but not limited to:

- U.S. Fish and Wildlife Service
- Texas Parks and Wildlife Department
- Texas General Land Office, Coastal Resources
- Texas Commission on Environmental Quality
- National Marine Fisheries Service
- U.S. Environmental Protection Agency
- National Park Service
- Natural Resources Conservation Service

## 1.3 Recommended Plan

The Recommended Plan includes a combination of ER and CSRM features that function as a system to reduce the risk of coastal storm damages to natural and built infrastructure and to restore degraded coastal ecosystems through a comprehensive approach employing multiple lines of defense. Focused on redundancy and robustness, the proposed system provides increased resiliency along the Bay and is adaptable to future conditions, including relative sea level change. The Recommended Plan can be broken into three groupings: a Coastwide ER plan, a lower Texas coast CSRM plan, and an upper Texas coast CSRM plan.

***Coastwide ER Plan:*** A Coastwide ER plan was formulated to restore degraded ecosystems that buffer communities and industry on the Texas coast from erosion, subsidence, and storm losses. A variety of measures have been developed for the study area, including construction of breakwaters, marsh restoration, island restoration, oyster reef restoration and creation, dune and beach restoration, and hydrologic reconnections. Figure 1 shows the location of the ER measures and the following describes what each measure includes:

- Bolivar Peninsula and West Bay Gulf Intracoastal Waterway (GIWW) Shoreline and Island Protection (G-28):
    - Shoreline protection and restoration through the nourishment of 664 acres of eroding and degrading marshes and construction of 40.4 miles of breakwaters along unprotected segments of the GIWW on Bolivar Peninsula and along the north shore of West Bay,
    - Restoration of 326 acres (approximately 5 miles) of an island that protected the GIWW and mainland in West Bay, and
    - Addition of oyster cultch to encourage creation of 18.0 acres (26,280 linear feet) oyster reef on the bayside of the restored island in West Bay.
- Follets Island Gulf Beach and Dune Restoration (B-2)
    - Restoration of 10.1 miles (1,113.8 acres) of beach and dune complex on Gulf shorelines of Follets Island in Brazoria County.

- West Bay and Brazoria GIWW Shoreline Protection (B-12)
  - Shoreline protection and restoration through nourishment of 551 acres of eroding and degrading marshes and construction of about 40 miles breakwaters along unprotected segments of the GIWW in Brazoria County,
  - Construction of about 3.2 miles of rock breakwaters along western shorelines of West Bay and Cow Trap lakes, and
  - Addition of oyster cultch to encourage creation of 3,708 linear feet of oyster reef along the eastern shorelines of Oyster Lake.
- East Matagorda Bay Shoreline Protection (M-8)
  - Shoreline protection and restoration through the nourishment 236.5 acres of eroding and degrading marshes and construction of 12.4 miles of breakwaters along unprotected segments of the GIWW near Big Boggy National Wildlife Refuge (NWR) and eastward to the end of East Matagorda Bay,
  - Restoration of 96 acres (3.5 miles) of island that protects shorelines directly in front of Big Boggy NWR, and
  - Addition of oyster cultch to encourage creation of 3.7 miles of oyster reef along the bayside shorelines of the restored island.
- Keller Bay Restoration (CA-5)
  - Construction of 3.8 miles of rock breakwaters along the shorelines of Keller Bay in order to protect submerged aquatic vegetation (SAV), and
  - Construction of 2.3 miles of oyster reef along the western shorelines of Sand Point in Lavaca Bay by installation of reef balls in nearshore waters.
- Powderhorn Shoreline Protection and Wetland Restoration (CA-6)
  - Shoreline protection and restoration through the nourishment of 529 acres of eroding and degrading marshes and construction of 5.0 miles of breakwaters along shorelines fronting portions of Indianola, the Powderhorn Lake estuary, and Texas Parks and Wildlife Department (TPWD) Powderhorn Ranch.
- Redfish Bay Protection and Enhancement (SP-1)
  - Construction of 7.4 miles of rock breakwaters along the unprotected segments of the GIWW along the backside of Redfish Bay and on the bayside of the restored islands
  - Restoration of 391.4 acres of islands including Dagger, Ransom, and Stedman islands in Redfish Bay, and

  - Addition of oyster cultch to encourage creation of 1.4 miles of oyster reef between the breakwaters and island complex to allow for additional protection of the Redfish Bay Complex and SAV.

- W-3 – Port Mansfield Channel, Island Rookery, and Hydrologic Restoration
  - Restoration of the hydrologic connection between Brazos Santiago Pass and the Port Mansfield Channel by dredging 6.9 miles of the Port Mansfield Channel, providing 112,864.1 acres of hydrologic restoration in the Lower Laguna Madre,
  - 9.5 miles of beach nourishment along the Gulf shoreline north of the Port Mansfield Channel using beach quality sand from the dredging of Port Mansfield Channel, and
  - Protection and restoration of Mansfield Island with construction of a 0.7 mile rock breakwater and placement of sediment from the Port Mansfield Channel to create 27.8 acres of island surface at an elevation of 7.5 feet (NAVD 88).

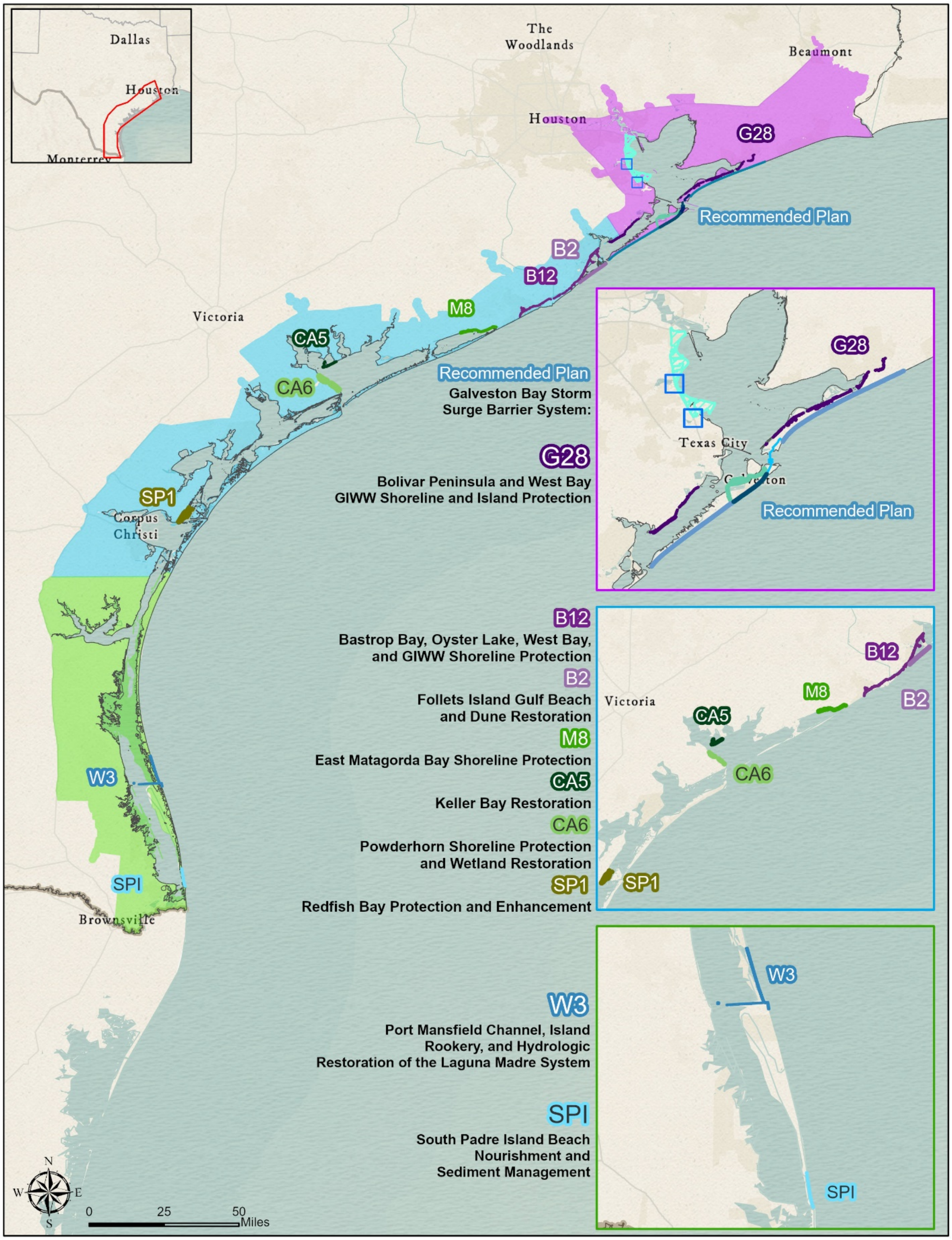


*Figure 1. Coastwide ER Measures of the Recommended Plan*

***Lower Texas Coast Plan:*** The lower Texas coast component of the recommended plan includes 2.9 miles of beach nourishment at South Padre Island to be completed on a 10-year cycle for the authorized project life of 50 years (Figure 2).

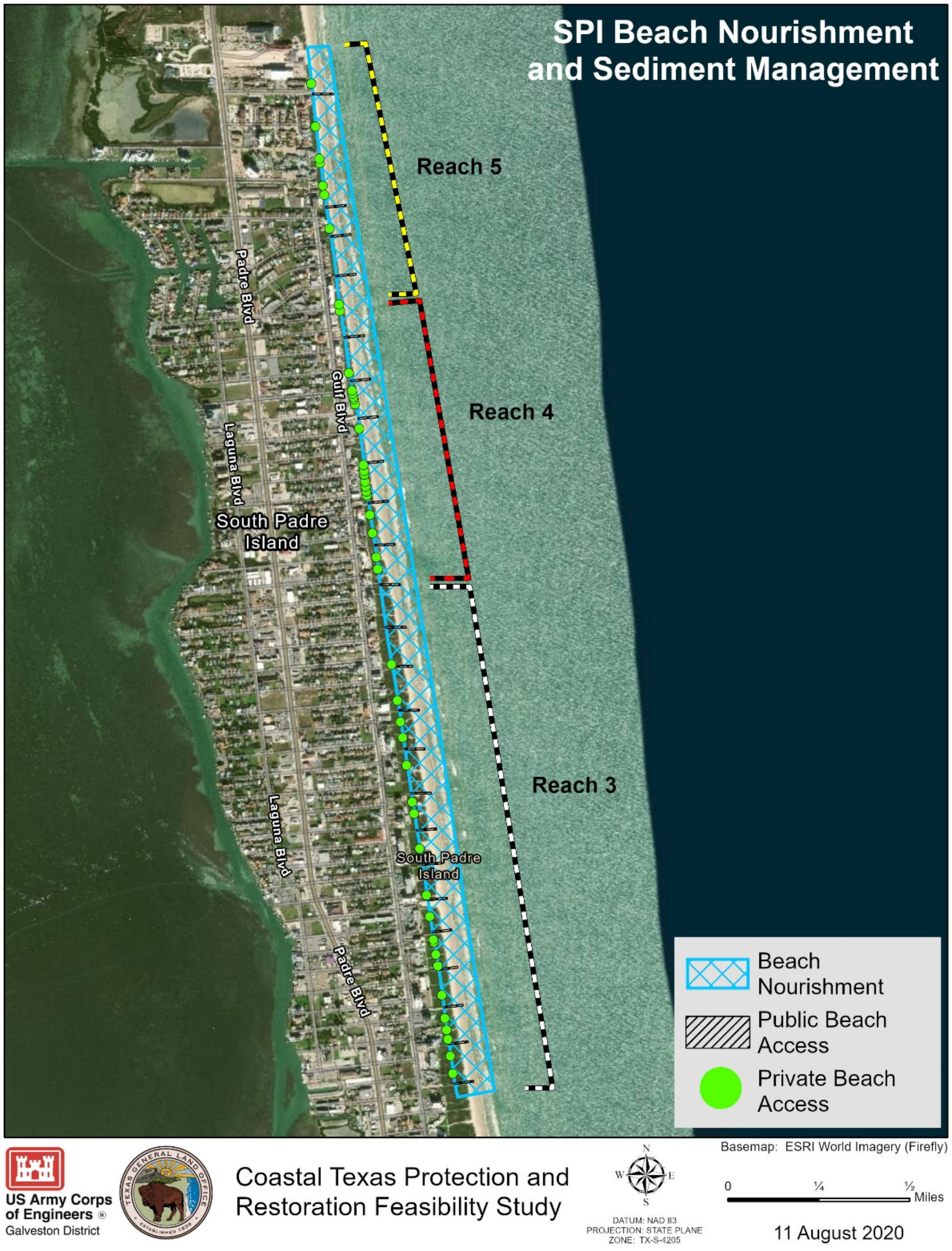


*Figure 2. South Padre Island CSRM*

***Upper Texas Coast Plan:*** The upper Texas coast component of the recommended plan includes a multiple-lines-of-defense system known as the Galveston Bay Storm Surge Barrier System. The system is designed to provide a resilient, redundant, and robust solution to reduce risks to communities, industry, and natural ecosystems from coastal storm surge. The system includes a Gulf line of defense which separates the Galveston Bay system from the Gulf of Mexico to reduce storm surge volumes entering the Bay system. It also includes Bay defenses which enable the system to manage residual risk from waters already in Galveston Bay. Figure 3 shows the spatial relationship between the Gulf and Bay lines of defense. Measures which make up the system include:

- The Bolivar Roads Gate System, across the entrance to the Houston Ship Channel, between Bolivar Peninsula and Galveston Island (Figure 4);
- 43 miles of beach and dune improvements on Bolivar Peninsula and West Galveston Island that work with the Bolivar Roads Gate System to form a continuous line of defense against Gulf of Mexico surge, preventing or reducing storm surge volumes that would enter the Bay system (Figure 4);
- Improvements to the existing 10-mile Seawall on Galveston Island to complete the continuous line of defense against Gulf surge (Figure 4);
- An 15.8-mile Galveston Ring Barrier System (GRBS) that impedes Bay waters from flooding neighborhoods, businesses, and critical health facilities within the City of Galveston;
- 2 surge gates on the west perimeter of Galveston Bay (at Clear Lake and Dickinson Bay) that reduce surge volumes that push into neighborhoods around the critical industrial facilities that line Galveston Bay; and
- Complementary nonstructural measures, such as home elevations or floodproofing, to further reduce Bay-surge risks along the western perimeter of Galveston Bay.

Within the recommended plan, it has been determined that several features, identified as "actionable" measures, have a sufficient level of site-specific detail to fully understand the context and intensity of the anticipated impacts of the feature. Therefore, the EIS has incorporated a site-specific Tier Two analysis for some features for which the measures would be fully compliant with NEPA and all environmental laws and regulations, including MSFCMA. Feature identified as "Tier One" measures will require separate independent NEPA analysis at which time additional EFH consultation would occur to ensure full compliance with MSFCMA once the impacts are fully understood. Table 1 shows which measures are actionable and which are not.

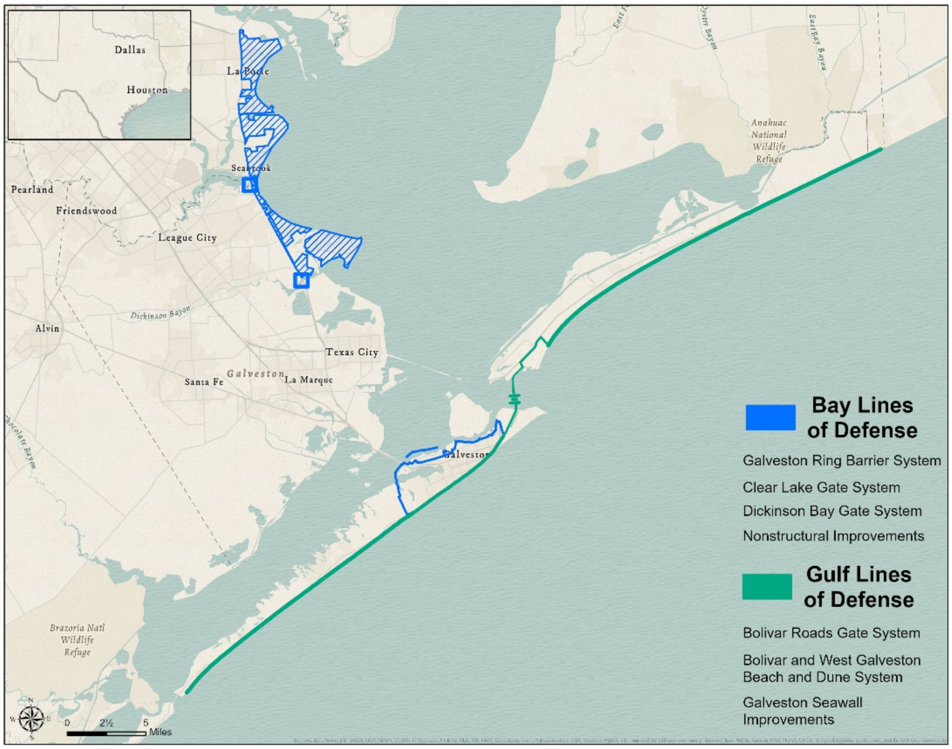


*Figure 3. Galveston Bay Storm Surge Barrier System*

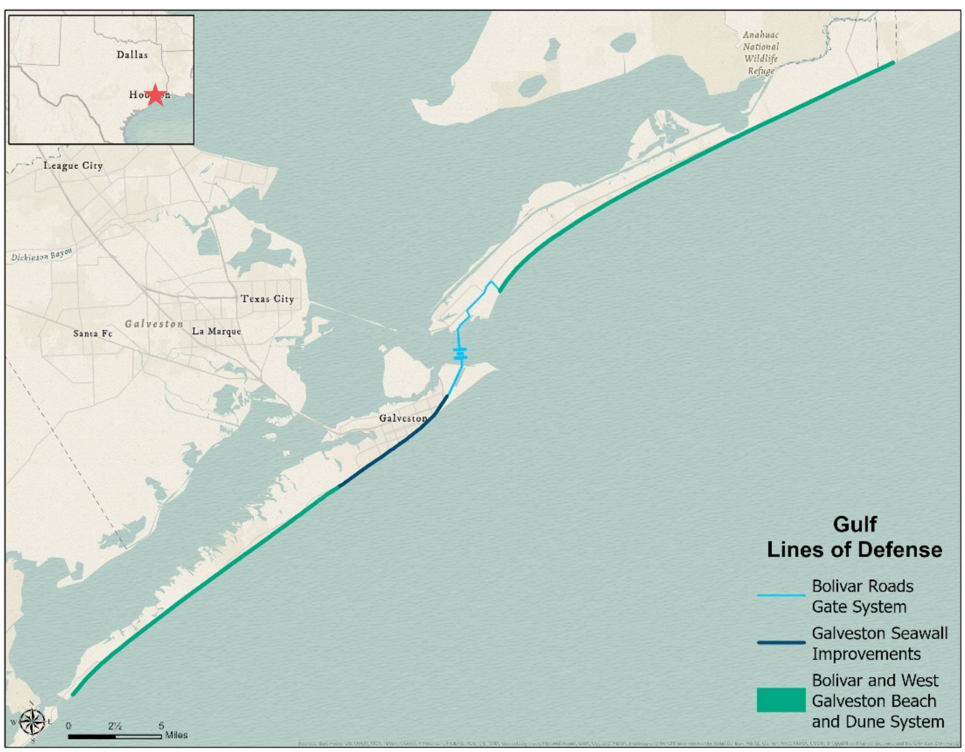


*Figure 4. Gulf Lines of Defense of the Galveston Bay Storm Surge Barrier System*

*Table 1. Actionable and Tier One Measures of the Recommended Plan*

| **Recommended Plan Component** | **Actionable*** | **Tier One+** |
|---|---|---|
| G-28 – Bolivar Peninsula and West Bay GIWW Shoreline and Island Protection | X | |
| B-2 – Follets Island Gulf Beach and Dune Restoration | | X |
| B-12 – West Bay and Brazoria GIWW Shoreline Protection | X | |
| CA-5 – Keller Bay Restoration | X | |
| CA-6 – Powderhorn Shoreline Protection and Wetland Restoration | X | |
| M-8 – East Matagorda Bay Shoreline Protection | X | |
| SP-1 – Redfish Bay Protection and Enhancement | X | |
| W-3 – Port Mansfield Channel, Island Rookery, and Hydrologic Restoration | X | |
| South Padre Island Beach Nourishment | X | |
| Bolivar Roads Gate System | | X |
| Bolivar and West Galveston Beach and Dune System | | X |
| Galveston Seawall Improvements | | X |
| Galveston Ring Barrier System | | X |
| Clear Lake Surge Gate | | X |
| Dickinson Surge Gate | | X |
| Non-structural Measures | | X |

* Tier 2 NEPA, no additional EFH consultation anticipated

+ Tier 1 NEPA, Requires additional NEPA

- 

Monitoring and adaptive management are applicable to ER features because of the variability and uncertainty that are associated with these systems. For instance, coastal marshes are highly complex transition zones between terrestrial and aquatic ecosystems and restored marshes require time to develop the ecological functions and services of natural marshes. The sediments used to create the substrate in marsh restoration projects do not possess the biogeochemical properties and functions of natural wetland soils. These processes are not well understood and there is considerable variation in ecosystem trajectories and outcomes. Therefore, monitoring these sites is essential to identifying the sources of uncertainty in order to provide the data that are necessary to guide decision making and adaptive management. Similarly, monitoring is crucial for other types of projects such as beach and dune restoration and island creation. Dune and beach restoration projects can increase the amount of habitat for threatened and endangered species. Effective monitoring is a risk reduction strategy that can mitigate adverse impacts to these listed species.

### 1.3.1 Project Goals and Objectives

The main objective of the Coastal Texas Study is to recommend an alternative that will reduce the risk to lives and property associated with coastal storms in addition to providing ecological benefits, including enhancing shoreline stability and restoring coastal ecosystems.

The following planning objectives for the 50-year period of analysis were developed from problem and opportunity statements used in formulation and evaluation of the ER alternatives:

1. Restore fish and wildlife habitat such as coastal wetlands, oyster reefs, beaches, and dunes;
2. Reduce saltwater intrusion into sensitive estuarine systems;
3. Reduce erosion to barrier island, mainland, and interior bay and channel shorelines;
4. Improve water quality in coastal bays and estuaries with restoration of marshes and oyster reefs.

Environmental policies require that fish and wildlife resource conservation be given equal consideration with other study purposes in the formulation and evaluation of alternative plans. In the evaluation process, care was given to preserve and protect significant ecological, aesthetic, and cultural values, along with conserving natural resources.

# 2.0 MONITORING

An effective monitoring program will be required to determine if the project outcomes are consistent with original project goals and objectives. The power of a monitoring program developed to support adaptive management lies in the establishment of feedback between continued project monitoring and corresponding project management. A carefully designed monitoring program is the central component of the adaptive management plan as it supplies the information to assess whether the project is functioning as planned.

Monitoring must be closely integrated with the adaptive management components because it is the key to the evaluation of adaptive management needs. Objectives must be considered to determine appropriate indicators to monitor. In order to be effective, monitoring must be able to distinguish between ecosystem responses that result from project implementation (i.e. management actions) and natural ecosystem variability.

## 2.1 Monitoring Plan

According to the USACE implementation guidance memo for WRDA Section 2039, “Monitoring includes the systematic collection and analysis of data that provides information useful for assessing project performance, determining whether ecological success has been achieved, or whether adaptive management may be needed to attain project benefits.”

The following discussion outlines a monitoring plan that will support the Coastal Texas Study Adaptive Management Plan. The plan identifies performance measures along with desired outcomes and monitoring design in relation to specific objectives. A performance measure includes specific feature(s) to be monitored to determine project performance. Additional monitoring may be identified to help further understand interrelationships of restoration features, external environmental variability, and to corroborate project effects.

Ecological success criteria, or decision-making triggers, are related to each performance measure and desired outcome in order to identify the need for potential implementation of adaptive management actions with the AMT. These criteria/triggers are identified in Section 3.2.1.

Overall, monitoring results will be used to evaluate habitat restoration project objectives and to inform the need for adaptive management actions to ensure successful restoration is achieved.

### 2.1.1 Monitoring Period

Pre-construction/baseline data, during construction, and post-construction monitoring will be utilized to determine restoration success. Baseline monitoring will begin during PED prior to project construction and continue during construction when possible. Monitoring will continue until the trajectory of ecological change and/or other measures of project success are determined as defined by project- specific objectives. Section 2039 of WRDA 2007 allows ecological success monitoring to be cost-shared for up to ten years post-construction. Once ecological success has been achieved, which may occur in less than ten years post-construction, no further monitoring would be performed. If ecological success cannot be determined within the ten-year post construction period of monitoring, any additional required monitoring would be the responsibility of the NFS.

There may be issues related to sustainability of the project that would require some monitoring and adaptive management beyond achieving the project objectives. For example, bird islands may be susceptible to colonization by invasive species. Invasive plants such as salt cedar (*Tamarix ramosissima*) and Chinese tallow (*Triadica sebifera*) can become established on higher elevation areas with lower salinity, which would degrade the nesting habitat of some avian guilds. Invasive animals, such as coyotes and fire ants can have negative impacts on nesting colonial waterbirds. Due to the variable nature of the coastal environment, the monitoring baseline may change during the period of analysis. Consequently, it may be appropriate to consider extending project-specific monitoring and adaptive management beyond 10 years.

Per USACE policy, cost-shared monitoring would cease if additional monitoring would result in monitoring costs exceeding 1 percent of the total project cost minus the costs of adaptive monitoring and adaptive management of the restoration features.

### 2.1.2 Monitoring Elements

Defining and assessing progress towards project objectives are crucial components of the MAMP. The following section outlines the proposed performance measure criteria, desired outcomes and monitoring design needed to measure restoration progress, determine ecological success and support the adaptive management program should changes need to be made to improve project performance.

The elements described in this section are based on the available project information from the monitoring and adaptive management plans for the Jefferson County Ecosystem Restoration (JCER) study, the Sabine-Neches Waterway Channel Improvement project, and the Sabine Pass to Galveston Bay CSRM / ER study. The project objectives, performance measures, ecological success criteria, and timetables for the Coastal Texas study are consistent with these previous projects. In addition, the majority of the monitoring techniques in this study will utilize remote sensing and GIS in manner that is similar to the methods of the aforementioned projects. However, the monitoring and adaptive management plan for this study will be updated and refined during PED.

**1. Marsh Restoration**

**Project Objective: Restore coastal marshes to similar ecological processes and functions of natural marshes to the maximum extent practicable in order maintain or provide valuable ecosystem services and functions.**

**Performance Measure 1:** Reduce post-construction shoreline erosion rates compared to pre-construction by 50% by Year 6.

**Ecological Success Criterion 1:** Reinforcement measures are expected to reduce shoreline erosion rates by approximately 50% based on previous experiences with this type of structure along the GIWW shorelines in Jefferson County and other areas.

**Monitoring Design and Rationale:** Historic erosion rates for each shoreline protection site can be established from historic aerial photography. Photography and remote sensing surveys will be used to determine post-construction erosion rates at each shoreline protection site at Years 1, 3, and 6.

**Performance Measure 2:** Establish marsh elevation post-construction sufficient for healthy marsh.

**Ecological Success Criterion 2:** Based on local conditions and future rates of projected RSLR, marsh elevation in restored marsh restoration units (following de-watering and settlement) sufficient to support vegetation and marsh establishment is between +1.2 MSL and +2.2 MSL (local datum) at Year 3.

**Monitoring Design and Rationale:** To measure elevation (including accretion and subsidence) at each restoration site, one rod-surface elevation table (RSET), replicate feldspar stations and settlement plates will be established within the constructed marsh footprint to measure changes in elevation. Elevation will be sampled bi-annually for a period of 10 years post-project or until desired ecological success is achieved, whichever comes first. Elevation, accretion and subsidence measured at existing stations located near each marsh restoration site will also be utilized, as appropriate. One Light Detection and Ranging (LiDAR) survey will be collected pre- construction and three times post-construction at Year 1, 3, and 6 to determine overall elevation throughout the entire restoration unit.

**Performance Measure 3:** Average cover of 80% desirable vegetation on marsh restoration sites at Year 5 compared to pre-construction.

**Ecological Success Criterion 3.1:** One year following completion of final construction activities achieve a minimum average cover of 25%, comprised of native herbaceous species. Three years following construction, achieve a minimum average cover of 75% native species. For the period beginning 5 years post-construction and continuing through project success, maintain a minimum average cover of 80%, comprised of native herbaceous species.

**Ecological Success Criterion 3.2:** Invasive, noxious, and/or exotic plant species comprise less than 5% of cover of the marsh restoration unit at Year 2 and is maintained at or less than 5% thereafter.

**Monitoring Design and Rationale:** Vegetation will be sampled annually, at each restoration site and in marshes protected by breakwaters. Permanent vegetation monitoring stations and/or transects will be established for assessing the vegetation community at each site. In addition to community composition, these stations will be sampled for water level, above- and below-ground biomass, and soil parameters such as pH, temperature, salinity, and redox potential. The ratio of marsh to open water should be 80:20. Marsh edge, which is the interface that quantifies the physical limit between the vegetation and open water, should range between 1.2 and 1.4. Sites will be sampled annually post- construction until success is determined.

## 2. Island Restoration/Creation

**Project Objective: Restore and/or create coastal islands to prevent shoreline erosion, inundation of inland areas from relative sea level rise, and maintain valuable ecosystem services and functions**.

**Performance Measure 1:** Reduce post-construction shoreline erosion rates compared to pre-construction by 50% by Year 6.

**Ecological Success Criterion 1:** Reinforcement measures are expected to reduce shoreline erosion rates by approximately 50% based on previous experiences with this type of structure throughout along the GIWW shorelines in Jefferson County and other areas.

**Monitoring Design and Rationale:** Historic erosion rates for each shoreline protection site can be established from historic aerial photography. Photography and remote sensing surveys will be used to determine post-construction erosion rates at each shoreline protection site at Years 1, 3, and 6.

**Performance Measure 2:** Establish island surface elevation that increases the sedimentation process of capture, settlement, dewatering of fill materials and the promotion of microtopographical features, the resistance to erosion, and accretion to keep pace with relative sea level rise.

**Ecological Success Criterion 2:** Restored island with marsh elevations at +1.5 to 2.0 NAVD88 (or the local datum) that are sufficient to support low and high marsh by Year 3 as well as unconsolidated shores for wading birds, native shrubs for rookeries, submerged aquatic vegetation habitat, and upland elevations +9.0 MSL to accommodate relative sea level rise throughout out the life of the project

**Monitoring Design and Rationale:** The natural processes of settlement, dewatering, and compaction of sediments should create microtopographical features on the island surface. Island elevation status will be evaluated by remote sensing and LiDAR data. Low and high marsh elevation levels can also be indicated by the presence of marsh species such as *Spartina alterniflora* and *S. patens*, respectively. Higher elevations above the intertidal zone will be delineated by the presence of non-halophytic herbaceous species and native shrubs.

**Performance Measure 3:** Evaluate the growth of island vegetation annually by assessing plant species richness, diversity, health, abundance, distribution, and the presence of invasive / exotic species

**Ecological Success Criterion 3:** For the period beginning 5 years post-construction and continuing through project success, maintain a minimum average cover of 80% (50% native shrubs and 30% herbaceous species). Presence of invasive species is less than 5% percent cover. Plant species richness, diversity, health, abundance, and distribution in the restored marsh are comparable to reference sites.

**Monitoring Design and Rationale:** Average percent cover of vegetation will be obtained by establishing transects. Species richness and diversity of plants is indicative of low and high marsh communities and comparable to reference sites. Plant health is consistently documented as 'Healthy' and 'Reproductive Evidence' with little to no instances of 'Disease' or excessive 'Predation' (herbivory). Plant abundance (e.g., stems per $m^2$) is comparable to respective plant communities at the reference sites. Plant distribution adheres to zonation based on environmental filters, i.e. elevation, tidal prism, and salinity, which should result in low and high marsh plant communities. Field personnel should note the presence of avian species and guilds as well as the condition of any adjacent seagrass meadows and record their observations in qualitative terms.

**3. Dune and Beach Restoration**

Project Objective 1: **Restore and/or enhance beaches and dunes along the Gulf of Mexico shoreline to prevent breaches and erosion caused by storm surge and relative sea level rise and to protect coastal wetlands.**

**Performance Measure 1:** Monitor beach and dune erosion and erosion rates annually using remote sensing to determine if beaches and dunes maintain acceptable height, slope, elevation, and area as determined by the ranges of natural dunes in county management beach plans

**Ecological Success Criterion 1.** The shoreline and dunes exhibit ≤ 5% losses in height, slope, elevation, and area compared to the historical ranges of the reference areas and county management beach plans

**Monitoring Design and Rationale:** Elevation will be sampled annually by LiDAR for a period of 10 years post-project or until desired ecological success is achieved, whichever comes first. One Light Detection and Ranging (LiDAR) survey will be collected pre-construction and three times post-construction at Year 1, 3, and 6 to determine overall elevation and geomorphology throughout the entire restoration unit. Other sources of geospatial data may be used to monitor the resistance and resilience of beach and dune restoration to erosive forces.

**Performance Measure 2:** Immediately after construction (Year 1), plant native herbaceous vegetation on 3-foot centers to stabilize the dune system.

- *Spartina patens*
- *Panicum amarum*
- *Uniola paniculata*

**Ecological Success Criterion 2:** >50% of plants survive one year after planting

**Monitoring Design and Rationale:** Examples of three salt-tolerant species of grass that are appropriate for dune vegetation projects on the Texas coast are: bitter panicum (*Panicum amarum*), sea oats (*Uniola paniculata*), and marsh hay cordgrass (*Spartina patens*). One thousand plants should stabilize a 50- by 100-foot strip within a year. Plant abundance should be measured by stems per 0.25 $m^2$ rather than percent cover

**Performance Measure 3:** After Year 1, monitor and measure the following vegetation assessment parameters annually along transects for comparison with reference sites:

- Plant community (diversity)
- Species richness
- Plant type
- Density (stems per $m^2$)
- Percent cover
- Condition
- Invasive species (presence / absence)

**Ecological Success Criterion 3:** Vegetation assessment parameters are within two standard deviations of the mean vegetation assessment parameters at the reference sites.

**Monitoring Design and Rationale:** Plants provide critical biophysical reinforcement to erosive forces for beaches and dunes. The fibrous root systems of emergent macrophytes can act in manner similar to reinforcement bars in concrete. The dune /beach plant community should be diverse because of varying levels of salt tolerance. Vegetation parameters will be obtained by establishing transects from the beach backshore to the back dunes. Plant density should be carefully monitored to avoid adverse impacts on nesting endangered sea turtles. The plant type (emergent vs. trailing vine) and condition (qualitative indicators) are factors in determining the amount of structural reinforcement for the shoreline. The presence of invasive plant species should not be tolerated at any level.

**Performance Measure 4:** Conduct field sampling of infaunal invertebrates quarterly at one mile intervals on the shoreline to determine if the restored beaches and dunes maintain the same invertebrate communities as the reference sites

**Ecological Success Criterion 4.** The abundance of infaunal invertebrates of the shoreline and dunes are within 80% of the mean infaunal invertebrate population density at the reference sites. In addition, the survey contains specimens of invertebrate families that provide essential sustenance for listed species.

**Monitoring Design and Rationale:** Sampling should be conducted by deploying three transects at each one mile interval sampling station. Replicate box core samples will be obtained along transects, which should be established parallel to the shoreline. However, the sampling design may need to be adjusted in accordance with local conditions. Ideally, sampling stations should be located in areas within the critical habitat of listed species or in areas where they have been observed.

## 4. Oyster Reef Restoration/Creation

Project Objective: **Restore and/or create oyster reefs to prevent shoreline erosion, improve water quality, create estuarine habitat, and maintain valuable ecosystem services and functions.**

**Performance Measure:** Determine oyster density, size class distribution, and recruitment semiannually by performing random sampling with divers.

**Ecological Success Criterion:** After Year 3 (post-construction), oyster density, including recruitment, is ≥ 25 $m^{-2}$ and/or 50% of the mean density of the reference reefs.

**Monitoring Design and Rationale:** Within 30 days after construction, the bathymetry of the reef should be determined with side scan sonar and geospatial coordinates should be recorded. The pre- and post-construction side scan sonar data will be imported into ArcGIS and converted into layers or shapefiles, which will determine the area of reef available for oyster recruitment and colonization. During semiannual monitoring, divers will collect four random 0.25 $m^{-2}$ quadrat samples on each reef or every 1000 linear feet. Reference reefs should be located within 1000 feet of the project site or adjacent to it in same bay system. All live and dead oysters will be counted and measured for length. Observations about the quality and condition of the oysters will also be made and recorded. Sampling personnel will also note and count mud crabs, oyster drills, sponges, other mollusks, tunicates, and boring clams collected in the sample in order evaluate the level of predation and competition on the reef.

**5. Hydrologic Restoration**

**Project Objective: Reduce the hypersaline conditions and improve the water quality of 112,864.1 acres of the Lower Laguna Madre by dredging the Mansfield Channel to increase tidal inflows into the lagoon.**

**Performance Measure:** One month after dredging, begin measuring salinity, water temperature, and tidal flow on a monthly basis at permanent sampling stations.

**Ecological Success Criterion:** After Year 1, water quality parameters are one standard deviation away from the desired mean water quality parameters

**Monitoring Design and Rationale:** Salinity, water temperature, and tidal flow will be measured on a monthly basis at permanent Texas Coastal Ocean Observation Network (TCOON) sampling stations. Environmental factors of the estuary and its terrestrial watershed, such as freshwater inflows, precipitation, ambient temperatures, flood events, and anthropogenic stressors (i.e. pollution, eutrophication) should be monitored by acquiring existing data from other state and federal agencies.

### 2.1.3 Monitoring Procedures

The following monitoring procedures will provide the information necessary to evaluate the previously identified project objectives for the Coastwide ER Plan features within the Coastal Texas Study. The monitoring procedures are described in enough detail to make the approach clear, but do not fully describe the monitoring regime. A monitoring plan with detailed methods, protocols, timing, and responsible parties will be developed in coordination with resource agencies prior to the start of monitoring. During development of the detailed MAMP, it is expected that if new, cost effective methodologies exist they would be employed. Likewise, it is expected that at that time, monitoring specifications, such as timing of the surveys (i.e. high tide, growing season, etc.), specific equipment needs, monitoring locations, etc. will be identified.

**Area Change:** To determine changes of vegetated and non-vegetated areas within the project area, near-vertical color-infrared digital aerial imagery will be acquired during pre-construction and used as a pre-construction standard for future changes in marsh changes and shoreline position. Three additional satellite and/or aerial photographic acquisitions will be conducted at Year 1, 3, and 6. These data will be collected in conjunction with LiDAR missions and under separate acquisition in non-LiDAR years, if needed. The photography will be georeferenced, classified, and analyzed using standard operating procedures developed during PED. Opportunities should be sought to utilize existing aerial imagery (e.g. Google Earth, county/state contracted flights, etc.) if the data are comparable to previous surveys (i.e. timing is similar).

**Vegetation:** Vegetation sampling will occur annually within all restoration units (2 sites per marsh restoration unit with less than 1,000 acres restored; 2 sites per 1,000 acres rounded to the nearest thousand for sites over 1,000 acres) and at 2 reference sites for the duration of the monitoring period. A restoration unit is defined as the individual parcels within the project area that have been selected for restoration activities. Sampling will occur during spring months, at the peak of the growing season. Permanent 100 m field monitoring transects will be located randomly within each marsh restoration units. The distance between transects will be dependent on the project site area and variability. Monitoring will measure percent cover of native and non-native plant species and structural diversity. Photographs stations will also be established along the transect to document vegetation conditions. All transects and photograph stations will be documented via Global Positioning System (GPS) coordinates in order to reacquire their positions in each year of sampling.

General observations, such as fitness and health of plantings, native plant species recruitment, and signs of drought stress should be noted during the surveys. Additionally, potential soil erosion, flood damage, vandalism and intrusion, trampling, and pest problems would be qualitatively identified.

A general inventory of all wildlife species observed and detected using the project area would be documented. Nesting sites, roosting sites, animal burrows, and other signs of wildlife use of the newly created habitat would be recorded. The notes would be important for early identification of species colonization patterns. In addition, monitoring will note the presence, absence, and / or activity of any listed species that may occur in the area.

**Marsh Elevation:** One LiDAR topographic survey covering all restoration units will be collected prior to construction (completed as a PED task for engineering and not included as part of the monitoring costs here) and recollected three times post-construction in Year 1, 3, and 6. LiDAR data will be used to assess overall marsh elevation throughout the restoration unit. The resulting data will provide a density of approximately 1 elevation point per square meter accurate to approximately +/-15 cm (root-mean square-error [RMSE]) vertical elevation and +/-1.5 m (RMSE) horizontal position. The data would be used to identify low lying areas by surface elevation.

LiDAR is necessary to provide accurate elevation data and is significantly more accurate than photogrammetry methods with minimal post-data collection corrections. It is acknowledged that LiDAR has flaws when collecting data in marsh areas, particularly if flights are performed during high tide; however, there are currently no other methodologies available besides physical on the ground measurements, which would have a substantial cost increase over LiDAR.

Surface elevation will be measured from a RSET benchmark established within or adjacent to the vegetation survey plots using the RSET technique developed by Cahoon et al[2]. This technique provides a non-destructive process that precisely measures the sediment elevation of wetlands over long periods of time relative to a fixed subsurface datum. Marker horizons, indicated with white feldspar clay, would be used in conjunction with the RSET to measure vertical accretion. When used simultaneously, the RSET and marker horizon techniques can provide information on above and below ground processes that influence elevation change. The data will also be used to determine rates of elevation change, particularly relative to sea level change, to ground-truth LiDAR data and assess significant changes in advance of the more intensive LiDAR surveys. This methodology is a relatively inexpensive way to annually measure elevation changes in a subset of the restoration units and indicate whether areas are in need of additional monitoring or adaptive management actions. Surface elevation will be sampled one time preceding construction and up to 10 years post-construction, or until the ecological success is achieved, whichever comes first.

**Shoreline Change:** To determine shoreline position changes within the project area, aerial or satellite imagery can be used as a pre-construction condition to determine the rate of change observed in the past and serve as a pre-construction standard for future changes in shoreline position. Additional aerial or satellite imagery acquisitions post-construction should be used to supplement shoreline surveys to determine the overall rate of erosion. Opportunities should be sought to utilize existing aerial imagery (e.g. Google Earth, county/state contracted flights, etc.) if the data are comparable to previous surveys (i.e. timing is similar). This imagery would be collected in conjunction with the area change survey, resulting in only one aerial imagery data collection per survey year.

### 2.1.4 Use of Monitoring Results and Analysis

Results of monitoring will be assessed in comparison to project objectives and decision-making triggers to evaluate whether the project is functioning as planned and whether adaptive management actions are needed to achieve project objectives. The results of the monitoring will be provided to the AMT who will evaluate and compare data to project objectives and decision making triggers. The AMT will use the monitoring results to assess habitat responses to management, evaluate overall project performance, and make recommendations for adaptive management actions as appropriate. If monitoring results, as compared to desired outcomes and decision making triggers show that project objectives are not being met, the AMT will evaluate causes of failure and recommend adaptive management actions to remedy the underlying problems.

As data is gathered through monitoring, more information will also be available to address uncertainties and fill information gaps. Uncertainties such as effective operational regimes, restoration design needs, benefits generated by restored features, and accuracy of models can be evaluated to inform adaptive management actions and future restoration needs.

# 3.0 ADAPTIVE MANAGEMENT

The primary incentive for implementing an adaptive management program is to increase the likelihood of achieving desired project outcomes given project uncertainties. All ecosystem restoration and mitigation projects face uncertainty due to incomplete understanding of relevant ecosystem structure and function, resulting in imprecise relationships between project actions and corresponding outcomes. Principal sources of uncertainty include:

1. Incomplete description and understanding of relevant ecosystem structure and function,
2. Imprecise relationships between project management actions and corresponding outcomes,
3. Engineering challenges in implementing project alternatives, and
4. Ambiguous management and decision-making processes.

It is important to determine the type of risk each uncertainty comprises and to discern what constitutes sufficient knowledge to proceed considering those risks. There is significant institutional knowledge regarding the construction of the restoration measures; therefore, there is minimal uncertainty from a construction standpoint. Uncertainties relating to measure design and performance are mainly centered on site specific, design-level details (e.g. exact sediment quantities, invasive species removal needs, extent of erosion control needs, construction staging area locations, pipeline pathways, timing and duration of construction, engineering challenges, etc.), which would be addressed during the pre-engineering and design (PED) phase.

Identified uncertainties with the Coastal Texas Recommended Plan include:

- **Relative Sea Level Rise (RSLR)** including whether sea level rise will be greater than assumed in the design;
- **Climate Change**, such as drought conditions and variability of significant storm frequency, intensity, and timing;
- **Natural Variability** in ecological and physical processes;
- **Sediment Dynamics**, including subsidence and accretion rates;
- **Marsh Restoration Challenges** such as fluctuating water budgets due to alterations in the hydroperiod, wetland soil development, biogeochemistry, and microbial communities;
- **Invasive and Nuisance Species**;

- **Project Feature Implementation Timing**, including schedule and timeline, availability of construction funds. Also, challenges exist with the ability (or lack thereof) to build entire ER measures at one time or building portions of a measure incrementally and constructing specific features before moving to the next feature.

Issues such as climate change, relative sea level rise, and regional subsidence are significant scientific uncertainties for most Gulf Coast restoration projects. These uncertainties were incorporated in the plan formulation process and will be monitored by gathering data on water levels, salinities, and land elevation. Specifically, for RSLC, USACE EC-11165-2-21 provides an 18-step process for developing a "low", "intermediate" and "high" future RSLR scenario and provides guidance to incorporate these potential effects into project management, planning, engineering, design, construction, operation and maintenance. The study team evaluated and designed the TSP and ultimately the Recommended Plan under the "intermediate" scenario in accordance with the EC-1165 (See Engineering Appendix). This information will be assessed and will inform adaptive management actions. In addition, procedures to evaluate sea level change impacts, response and adaptation will continue to be examined under USACE ETL 1100-2-1 which provides guidance for understanding the direct and indirect physical and ecological effects of projected future RSLR on USACE projects and systems of projects and considerations for adapting to those effects.

Many factors such as ecosystem dynamics, engineering applications, institutional requirements, and many other key uncertainties can change or evolve over a project's life. The MAMP will be regularly updated to reflect data acquired during as well as resolution and progress on resolving existing key uncertainties or identification of any new uncertainties that may emerge. Specifically, the MAMP will be revised in the PED phase as more detailed project designs are developed and uncertainties are better understood. The MAMP would then be used during and after project construction to adjust the project as necessary to better achieve goals, objectives, and restoration results.

## 3.1 Assessment

Assessment of the adaptive management framework describes the process by which the results of the monitoring efforts will be compared to the project performance measures, which reflect the objectives of the restoration actions.

The results of the monitoring program will be assessed annually through the AMT. Monitoring results will be compared to the desired project outcomes and decision-making triggers as set forth by the project performance measures.

This assessment process will measure the progress of the project in relation to the stated project objectives, evaluate project effectiveness and consider if adaptive management actions are needed. Assessments will also inform the AMT if other factors are influencing the response that may warrant further research.

USACE will document and report the monitoring results, assessments, and the results of the AMT deliberations to the managers and decision-makers designated for the Coastal Texas project. USACE, with assistance from the monitoring team, will also produce annual reports that show progress towards meeting project objectives as characterized by the performance measures. Results of the assessments will be used to evaluate adaptive management needs and inform decision-making.

### 3.1.1 Database Management

Database management is an important component of the monitoring plan and the overall adaptive management program. Data collected as part of the monitoring and adaptive management plans will be archived as prescribed in the refined monitoring and adaptive management plan developed during PED. The database manager will be responsible for storing final monitoring reports and other study documentation (decisions, agendas, reports) and making them available when requested. Monitoring reports and associated data will be searchable by a variety of fields determined by the project sponsors and AMT.

Data standards, quality assurance and quality control procedures and metadata standards will also be prescribed in the refined monitoring and adaptive management plan. The database will be designed to store and archive the monitoring and adaptive management data. The format of each data set will vary as appropriate to the type of monitoring. Therefore, data are expected to be archived separately, rather than collated in one master database. Each dataset will include: data and metadata transfer and input policies and standards; data validation procedures, and mechanisms to ensure data security and integrity.

## 3.2 Decision-Making

Decisions on the implementation of adaptive management actions are informed by the assessment of monitoring results. The information generated by the monitoring plan will be used by USACE and the NFS in consultation with other AMT members to guide decisions on adaptive management that may be needed to ensure that the ecosystem restoration and mitigation projects achieve success. Final decisions on implementation of adaptive management actions are made by USACE.

If monitoring determines that a management threshold has been crossed (i.e., a ‘trigger’ has been “activated”) then there are three possible response pathways:

1. Determine that more data is required and continue (or modify) monitoring;
2. Select and implement a remedial action;

3. Revisit project goals and objectives if the data indicates they were inadequate and/or inaccurate (this option would only be considered as a last resort and upon careful consideration by and consensus of the PDT and AMT).

### 3.2.1 Decision Criteria

Decision criteria, also referred to as adaptive management thresholds or 'triggers', are used to determine if and when adaptive management opportunities should be implemented. They can be qualitative or quantitative based on the nature of the performance measure and the level of information necessary to make a decision. Desired outcomes can be based on reference sites, predicted values, or comparison to historic conditions. Several potential decision criteria are identified below, based on the project objectives and performance measures.

More specific decision criteria, possibly based on other parameters such as hydrology, geomorphology, and vegetation dynamics, may be developed during PED. If assessments show that any of these triggers are met, USACE would consult with the AMT to discuss whether an adaptive management action is warranted, and if so, what that action should be. Investigations may be required to determine the cause of failure in order to inform the type of adaptive management actions that should be implemented, if needed. Additionally, prior to enacting any adaptive management measures, USACE would assess whether supplemental environmental analyses are required.

**<u>Project Objective 1:</u> Restore coastal wetlands with similar ecological processes and functions of natural marshes to the maximum extent practicable in order to maintain or provide valuable ecosystem services and functions.**

> **Performance Measure 1.1:** Reduce post-construction shoreline erosion rates compared to pre-construction by 50% by Year 6.
>
> **Ecological Success Criterion 1.1:** Reinforcement measures are expected to reduce shoreline erosion rates by approximately 50% based on previous experiences with this type of structure along the GIWW shorelines in Jefferson County and other areas.
>
> **Management Threshold:** The erosion rate has not been reduced by at least 50% when compared to the non-protected areas and the erosion rate is not in line with the erosion rate defined at sites which already have armoring.
>
> **Possible Causes of Failure:** The most likely cause to not meeting the desired outcome is a deficiency in the breakwater structures. Structural deficiencies could include: the structure height or width is insufficient to attenuate wave energies due to higher wave energies (both natural and manmade), higher rate of subsidence at the placement site, or higher rate of RSLR than anticipated; loss of or insufficient size of rock; need for smaller/larger openings within and between structures; misalignment of the structure

(i.e. too close/far from the shoreline); etc. If structural deficiency is not identified as the cause then other causes such as erosion coming from the marsh toward the GIWW should be investigated, although this is not anticipated.

**Potential Adaptive Management Measures:** A range of potential adaptive management measures may be needed from repairing the structure to increasing the height and/or width of the structure to a complete redesign of the structure, which includes a new alignment.

**Performance Measure 1.2:** Establish marsh elevation post-construction sufficient for healthy marsh.

**Ecological Success Criterion 1.2:** Based on local conditions and future rates of projected RSLR, marsh elevation in restored marsh restoration units (following de-watering, compaction, and settlement) sufficient to support vegetation and marsh establishment is between +1.2 MSL and +2.2 MSL (local datum) at Year 3.

**Management Threshold:** The target elevation is not met and maintained by the target year and for a period of 6 years post-construction in any given area of the restoration unit.

**Possible Causes of Failure:** Some potential causes for not meeting and maintaining the target elevation include: loss of sediment through erosion or scour or higher than expected subsidence or RSLR rate.

**Potential Adaptive Management Measures:**

The product delivery team considered the potential impacts of RSLR on this objective and had previously recommended outyear renourishment to help formulate measures adaptable to RSLR over the project life. Despite the exclusion of outyear renourishment as an authorized project component, the viability of ER features will be maintained through monitoring and adaptive management. If it is determined that adaptive management is needed to maintain viability, additional authorization may be sought to cover the costs of adaptively managing the measure to ensure success.

For example, if overall elevations throughout the restoration unit are not being achieved, renourishment using dredged material could be pursued to obtain the target elevation. If RSLR or subsidence are identified as the root cause, reevaluation of target elevations may be conducted, and a new target elevation established to ensure resiliency and sustainability over the 50-year performance period.

Erosion control may be needed to control loss of sediment in specific areas during tidal exchanges or significant weather events. Adaptive management measures could include installation of straw wattles, erosion mats, or vegetative plantings to increase root mass and cover in areas showing the greatest sediment losses. Re-grading to support the geomorphic conditions of the marsh may be required if some areas showing excessive rates of sedimentation, erosion or scour. Additional monitoring or studies should be completed to identify the cause of soil loss/increase at the site and addressed as appropriate.

**Performance Measure 1.3:** Average cover of 80% desirable vegetation on marsh restoration sites at Year 5 compared to pre-construction.

**Ecological Success Criterion 1.3.1:** One year following completion of final construction activities achieve a minimum average cover of 25%, comprised of native herbaceous species. Three years following construction, achieve a minimum average cover of 75% native species. For the period beginning 5 years post-construction and continuing through project success, maintain a minimum average cover of 80%, comprised of native herbaceous species.

**Ecological Success Criterion 1.3.2:** Invasive, noxious, and/or exotic plant species comprise less than 5% of cover of the marsh restoration unit at year 2 and is maintained at or less than 5% thereafter.

**Management Threshold:** The desired minimum average cover of desirable species within each marsh restoration unit is not achieved within the prescribed timeframe.

**Possible Causes of Failure:** Marsh vegetation may not achieve the target percent cover or structural conditions due to improper geomorphic, hydrologic, or biogeochemical conditions (e.g. erosion/scour, sedimentation, high redox potential, poor water quality including salinity, tidal influences), or natural events (e.g. loss during storm events or drought, herbivory or trampling).

**Potential Adaptive Management Measures:** Replanting may be needed if triggers for vegetative cover are activated. Monitoring results should be used to assess the underlying cause of inadequate cover, which may require that additional adaptive management actions be implemented to support successful replanting. For example, scouring and higher average salinity levels may prevent successful establishment of vegetative communities. Actions would be required to address scouring and the tidal influence in the area to reduce saline levels to promote desirable conditions for native species.

Plant protection may also be required if monitoring indicates that failure is due to herbivory or trampling by wildlife or recreationists.

**Project Objective 2:** **Restore and/or create coastal islands to provide habitat for colonial nesting birds and prevent shoreline erosion, inundation of inland areas from relative sea level rise, and maintain valuable ecosystem services and functions**.

**Performance Measure 2.1:** Reduce post-construction shoreline erosion rates compared to pre-construction by 50% by Year 6.

**Ecological Success Criterion 2.1:** Reinforcement measures are expected to reduce shoreline erosion rates by approximately 50% based on previous experiences with this type of structure throughout along the GIWW shorelines in Jefferson County and other areas.

**Management Threshold:** The erosion rate has not been reduced by at least 50% when compared to the non-protected areas and the erosion rate is not in line with the erosion rate defined at sites which already have armoring.

**Possible Causes of Failure:** The most likely cause to not meeting the desired outcome is a deficiency in the breakwater structures. Structural deficiencies could include: the structure height or width is insufficient to attenuate wave energies due to higher wave energies (both natural and manmade), higher rate of subsidence at the placement site, or higher rate of RSLR than anticipated; loss of or insufficient size of rock; need for smaller/larger openings within and between structures; misalignment of the structure (i.e. too close/far from the shoreline); etc. If structural deficiency is not identified as the cause then other causes such as erosion coming from the marsh toward the GIWW should be investigated, although this is not anticipated.

**Potential Adaptive Management Measures:** A range of potential adaptive management measures may be needed from repairing the structure to increasing the height and/or width of the structure to a complete redesign of the structure, which includes a new alignment.

**Performance Measure 2.2:** Establish island surface elevation that increases the sedimentation process of capture, settlement, dewatering of fill materials and the promotion of microtopographical features, the resistance to erosion, and accretion to keep pace with relative sea level rise.

**Ecological Success Criterion 2.2:** Restored island with marsh elevations at +1.5 to 2.0 NAVD88 (or the local datum) that are sufficient to support low and high marsh by Year 3 as well as unconsolidated shores for wading birds, native shrubs for rookeries, submerged aquatic vegetation habitat, and upland elevations +9.0 MSL to accommodate relative sea level rise throughout out the life of the project

**Management Threshold:** A restored island with marsh elevations below +1.5 NAVD88 (or the local datum) that do not support low and high marsh by Year 3

**Possible Causes of Failure:** Island surface elevation may be decreased by greater than expected settlement and / or compaction of sediments. Storm surge and wave action can decrease surface area and elevation. Failure of vegetation to establish could also result in an increase in erosion and erosion rates.

**Potential Adaptive Management Measures:** Erosion control may be needed to control loss of sediment in specific areas during tidal exchanges or significant weather events. Adaptive management measures could include installation of straw wattles, erosion mats, or vegetative plantings to increase root mass and cover in areas showing the greatest sediment losses.

**Performance Measure 2.3:** Evaluate the growth of island vegetation annually by assessing plant species richness, diversity, health, abundance, distribution, and the presence of invasive / exotic species

**Ecological Success Criterion 2.3:** For the period beginning 5 years post-construction and continuing through project success, maintain a minimum average cover of 80% (50% native shrubs and 30% herbaceous species). Presence of invasive species is less than 5% percent cover. Plant species richness, diversity, health, abundance, and distribution in the restored marsh are comparable to reference sites.

**Management Threshold:** Plant species richness, diversity, health, abundance, and distribution in the restored island are greater than two standard deviations from the means of the reference sites. Presence of invasive species is greater than 5% percent cover.

**Possible Causes of Failure:** Island vegetation may not achieve the target percent cover or structural conditions due to improper geomorphic, hydrologic, or biogeochemical conditions (e.g. erosion/scour, sedimentation, low redox potential, poor water quality including salinity, tidal influences), or natural events (e.g. loss during storm events or drought, herbivory or trampling).

**Potential Adaptive Management Measures:** Adaptive management measures could include vegetative plantings to increase root mass and cover in areas of low production and / or erosion. Re-grading the surface to support the geomorphic conditions of the low and high marsh zones may be required if some areas showing excessive rates of sedimentation, erosion or scour.

**Project Objective 3: Restore and/or enhance beaches and dunes along the Gulf of Mexico shoreline to prevent breaches caused by storm surge and relative sea level rise and to protect coastal wetlands.**

**Performance Measure 3.1:** Monitor beach and dune erosion and erosion rates annually using remote sensing to determine if beaches and dunes maintain acceptable height, slope, elevation, and area as determined by the ranges of natural dunes in county management beach plans

**Ecological Success Criterion 3.1.** The shoreline and dunes exhibit ≤ 5% losses in height, slope, elevation, and area compared to the historical ranges of the reference areas and county management beach plans

**Management Threshold:** The shoreline and dunes exhibit > 10% losses in height, slope, width, and shape compared to the historical trends of the reference areas

**Possible Causes of Failure:** Sand losses due to entrainment and Aeolian transport or excess erosion due to storm surge, wave action, or accelerated relative sea level rise.

**Potential Adaptive Management Measures:** Replant vegetation if necessary, to increase plant density and structural integrity of the dunes. Curtail human traffic in the area by imposing driving restrictions and / or erecting additional barriers.

**Performance Measure 3.2:** Immediately after construction (Year 1), plant native herbaceous vegetation on 3-foot centers to stabilize the dune system

- *Spartina patens*
- *Panicum amarum*
- *Uniola paniculata*

After Year 1, monitor and measure the following vegetation assessment parameters annually along transects for comparison with reference sites:

- Plant community (diversity)
- Species richness
- Plant type
- Density (stems per $m^2$)
- Percent cover
- Condition
- Invasive species (presence / absence)

**Ecological Success Criterion 3.2:** >50% of plants survive one year after planting. Vegetation assessment parameters are within two standard deviations of the mean vegetation assessment parameters at the reference sites.

**Management Threshold:** <50% of plants survive one year after planting.

**Possible Causes of Failure:** Vegetation may not achieve the target percent cover or structural conditions due to improper geomorphic, hydrologic, or biogeochemical conditions (e.g. erosion/scour, sedimentation, poor water quality including salinity, tidal influences), or natural events (e.g. loss during storm events or drought, herbivory or trampling).

**Potential Adaptive Management Measures:** Replant 50% of plants after the management ‘trigger’ has been activated. Investigate the site and conduct testing of the sediments if necessary, to identify any impediments to plant growth such as lack of nutrients or phytotoxins.

**Performance Measure 3.3:** Conduct field sampling of infaunal invertebrates quarterly at one mile intervals on the shoreline to determine if the restored beaches and dunes maintain the same invertebrate communities as the reference sites

**Ecological Success Criterion 3.3.** The abundance of infaunal invertebrates of the shoreline and dunes are within 80% of the mean infaunal invertebrate population density at the reference sites. In addition, the survey contains specimens of invertebrate families that provide essential sustenance for listed species.

**Management Threshold:** The abundance of infaunal invertebrates of the shoreline and dunes exhibit are less than 80% of the mean infaunal invertebrate population density at the reference sites. In addition, the survey does not contain specimens of invertebrate families that provide essential forage for listed species

**Possible Causes of Failure:** Sediment deposited during beach nourishment may be too deep and prone to compaction. The overlying substratum may prevent invertebrates from migrating into the deposited sediments. As a result, there may be a reduction in forage for listed species and adverse impacts on their population.

**Potential Adaptive Management Measures:** Tilling and/or grading the sediments may reduce compaction and bulk density.

<u>Project Objective 4:</u> **Restore and/or create oyster reefs to prevent shoreline erosion, improve water quality, create estuarine habitat, and maintain valuable ecosystem services and functions.**

**Performance Measure:** Determine oyster density, size class distribution, and recruitment semiannually by performing random sampling with divers.

**Ecological Success Criterion:** After Year 3 (post-construction), oyster density, including recruitment, is ≥ 25 $m^{-2}$ and/or 50% of the mean density of the reference reefs.

**Management Threshold:** After Year 3 (post-construction), oyster density, including recruitment, is ≤ 25 $m^{-2}$ and size class distribution is less than 50% of the mean density of the reference reefs.

**Possible Causes of Failure:** Water quality parameters may be adversely affected by climatic and environmental factors such as flood events, drought, and anthropogenic factors such as pollution (e.g. oil spills), non-point source pollution, and development activities in the coastal watershed.

**Potential Adaptive Management Measures:** Establish the reef in a highly suitable location and deploy cultch at the right time of year. Use or refer to the elevation of a reference reef. If oyster recruitment is still below the target mean density, deposit fine cultch on the reef to increase the amount surface area available for larvae attachment.

**<u>Project Objective 5:</u> Reduce the hypersaline conditions and improve the water quality of 112,864.1 acres of the Lower Laguna Madre by dredging the Mansfield Channel to increase tidal inflows into the lagoon.**

**Performance Measure:** One month after dredging, begin measuring salinity, water temperature, and tidal flow on a monthly basis at permanent sampling stations.

**Ecological Success Criterion:** After Year 3, water quality parameters are one standard deviation away from the desired mean water quality parameters

**Management Threshold:** Water quality parameters are greater than two standard deviations of the desired mean water quality parameters

**Possible Causes of Failure:** Sedimentary processes may infill the channel over time and decrease tidal inflows. Environmental disturbances of the lagoon and its terrestrial watershed, such as the lack of freshwater inflows, decreased precipitation, high ambient temperatures, flood events, and anthropogenic stressors (i.e. pollution, eutrophication) may inhibit success.

**Potential Adaptive Management Measures:** Dredge one half-mile segments at the entrance and exit of the channel. Alternatively, dredging may be conducted in other areas of excessive sedimentation to reduce obstructions to tidal flow.

Under this project, potential adaptive management actions will continue to be developed in consideration of the guidance provided in the USACE ETL 1100-2-1 titled "Procedures to Evaluate Sea Level Change Impacts, Response, and Adaption." The technical letter provides guidance for understanding the direct and indirect physical and ecological effects of projected future sea level change on USACE projects and considerations for adapting to those actions including consideration of a longer planning horizon and incorporating more robust management actions.

## 3.3 Project Close-Out

Once ecological success has been documented by the District Engineer in consultation with the Federal and State resource agencies, and a determination has been made by the Division Commander that ecological success has been achieved, no further monitoring or adaptive management will be required and the project can be closed-out. Ecological success will be documented through an evaluation of the predicted outcomes as measured against the actual results. Success would be considered to have been achieved when project objectives have been met or when it is clear they will be met based upon the trend of site conditions and processes.

The project could also be closed out when the maximum 10-year monitoring period has been reached. If that should occur prior to ecological success being achieved, the NFS would be responsible for monitoring and adaptive management beyond the 10 years.

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