

**Sabine Pass to Galveston Bay, Texas
Coastal Storm Risk Management and Ecosystem
Restoration
Final Integrated Feasibility Report and
Environmental Impact Study**

Appendix P

Monitoring and Adaptive Management Plan

May 2017

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1 MITIGATION PLAN OVERVIEW

This document outlines the feasibility-level monitoring and adaptive management plan for the Sabine Pass to Galveston Bay, Texas (S2G), Recommended Plan. The monitoring and adaptive management plan was developed with assistance from several resource agencies and the Project Delivery Team (PDT). It identifies and describes the monitoring and adaptive management activities, as well as the duration and periodicity of these activities, and estimates their cost and duration. This plan will be further developed in the preconstruction, engineering, and design (PED) phase as specific design details are made available. This document also contains an adaptive management plan for taking corrective actions in case monitoring demonstrates that mitigation measures are not achieving ecological success. The plan was developed by USACE in consultation with the S2G Resource Agency Coordination Team to fully compensate for both the direct and indirect wetland habitats of the Recommended Plan.

1.1 AUTHORIZATION FOR MITIGATION MONITORING/ADAPTIVE MANAGEMENT

Section 2036(a) of Water Resources Development Act (WRDA) 2007 directs the Secretary of the Army to ensure that any project with unavoidable non-negligible adverse impacts to significant ecological resources, that is being recommended for Congressional authorization, a) recommend a specific plan to mitigate fish and wildlife losses; b) ensure that other habitat types are mitigated to not less than in-kind condition, to the extent possible; and c) include the following specific mitigation plan components: 1) monitoring until successful; 2) criteria for determining ecological success; 3) a description of available lands for mitigation and the basis for the determination of availability; 4) the development of an adaptive management plan; 5) identification of the entity responsible for monitoring and 6) establishment of a process for consultation with Federal and state resource agencies to determine the success of mitigation. The implementation guidance for Section 2036(a) was issued in a CECW-PC Memorandum dated 31 August 2009.

The mitigation plan, presented in Appendix O, addresses requirements “a” and “b” described above, and this document addresses requirement “c”. The mitigation monitoring plan identifies the ecological success criteria for the mitigation, describes the cost and duration of the monitoring, and identifies the entities responsible for the monitoring.

1.2 MITIGATION OBJECTIVES

The primary objective of the proposed mitigation plan is to restore approximately 453 acres of emergent marsh, and preserve in perpetuity approximately 559 acres of forested wetlands. Wetland Value Assessment (WVA) models (see Appendix O) were run for the cited impacts to determine the wetland functions and values that would be lost. Such functions/values are expressed in terms

of Average Annual Habitat Units (AAHUs). As indicated in Table 1-1 below, these models predicted that approximately 143 AAHUs would be lost due to direct and indirect impacts to existing fresh, intermediate and brackish marsh habitats combined, while approximately 43 AAHUs would be lost due to direct and indirect impacts to cypress-tupelo swamp and bottomland hardwood forests, over the course of the 50-year period of analysis. The Mitigation Plan would provide a total of 262.9 AAHUs to compensate for total losses of 186.0 AAHUs.

Table 1-1. Mitigation Plan Summary

Wetland Type	Direct Impacts		Indirect Impacts				Total Impacts (acres)	Total AAHUs Lost
	Direct Wetland Impacts (acres)	AAHUs	Indirect Wetland Impacts (acres)	AAHUs	Functional Impacts (affected acres)	AAHUs		
Forested Wetlands								
Swamp	10.6	-7.2	1.9	-0.1	0.0	0.0	12.5	-7.3
Bottomland Hardwood	44.3	-30.3	12.7	-5.1	0.0	0.0	57.0	-35.4
Subtotal	54.9	-37.4	14.6	-5.2	0.0	0.0	69.5	-42.7
Coastal Marsh								
Fresh Marsh	24.3	-11.4	0.0	0.0	785.2	-18.8	809.5	-30.2
Intermediate Marsh	6.8	-4.0	19.2	-8.5	322.5	-4.1	348.5	-16.6
Brackish Marsh	74.2	-33.7	78.5	-35.2	1029.5	-27.6	1182.2	-96.5
Subtotal	105.3	-49.0	97.7	-43.7	2137.2	-50.5	2340.2	-143.3
Total Impacts*	160.2	-86.5	112.3	-48.9	2137.2	-50.5	2409.7	-186.0

* Totals may not add exactly due to rounding.

1.3 MITIGATION WORKPLAN

1.3.1 Acquisition and Preservation of Forested Wetland Features

The mitigation plan for forested wetlands consists of preservation in perpetuity of approximately 447 acres of swamp and bottomland hardwoods (BH) in Mitigation Area 11 in the bottomlands of the Sabine River and about 112.5 acres of BH forest in Mitigation Area 161 on the upland/wetlands margin of the Neches River in the Bessie Heights area (Figures 1-1 and 1-2). No restoration of these areas is included so the work plan is comprised of real property acquisition activities only. These lands would be acquired during the construction phase by the non-Federal sponsor (NFS) for project implementation. Properties would be acquired in accordance with Public Law 91-646, as both properties are privately owned. The NFS would manage the property and grant USACE right of entry for monitoring.

1.3.2 Acquisition, Construction and Planting of Marsh Restoration Features

The mitigation plan would restore approximately 63 acres of fresh marsh and associated shallow ponds and sinuous channels in Mitigation Area 52, 151 acres of intermediate marsh and associated waters in Mitigation Area 31, and 239 acres of brackish marsh and associated waters in Mitigation Areas 28 and 29 (Figures 1-3, 1-4 and 1-5).

Mitigation Areas 28, 29 and 31 are owned by TPWD. Mitigation Area 52 is privately owned; acquisition and preservation of this area would be accomplished as described for Mitigation Areas 11 and 161 (see Section 1.3.1).

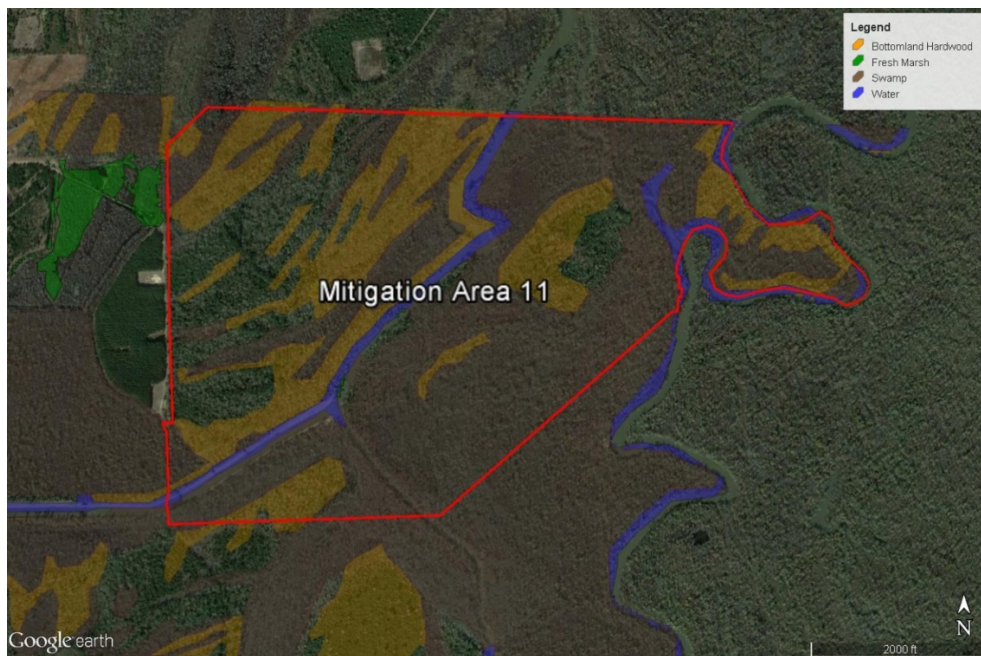


Figure 1-1. Swamp and Bottomland Hardwood Mitigation Area 11



Figure 1-2. Bottomland Hardwood Mitigation Area 161

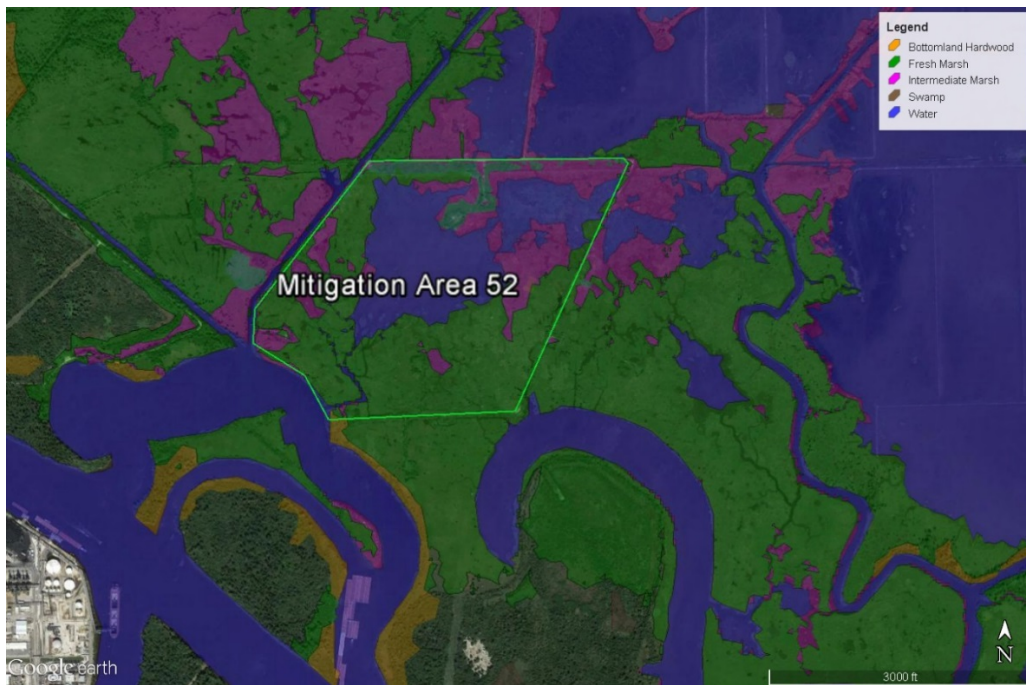


Figure 1-3. Fresh Marsh Mitigation Area 52

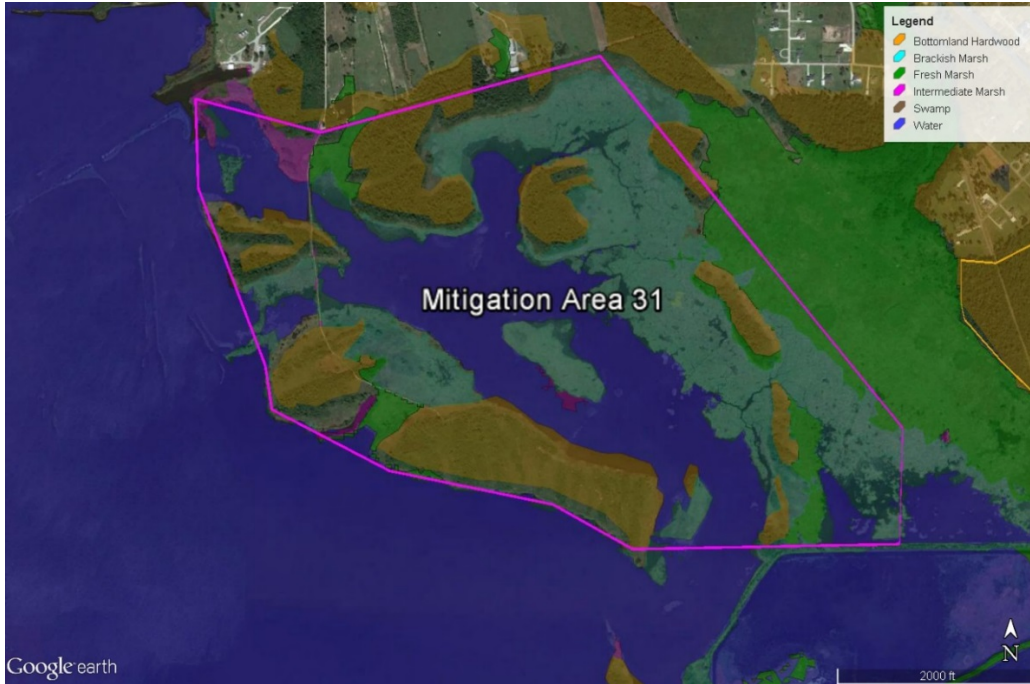


Figure 1-4. Intermediate Marsh Mitigation Area

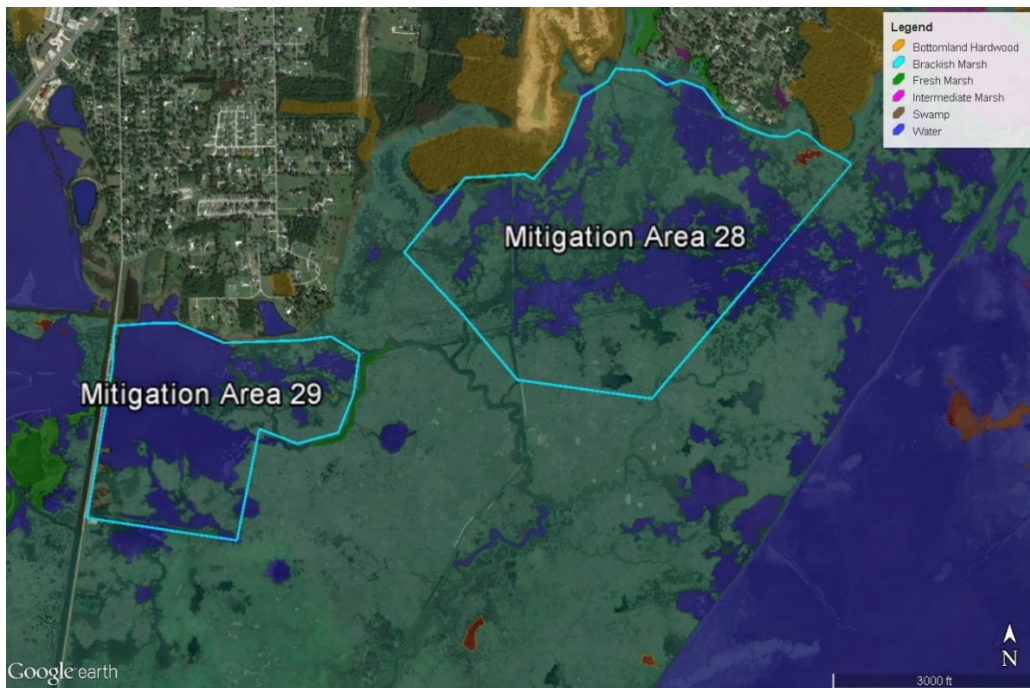


Figure 1-5. Brackish Marsh Mitigation Areas

Shoaled sediments from maintenance dredging of the adjacent deep-draft navigation channels of the Sabine-Neches Waterway (SNWW) would be used to restore marsh in areas of open water within the outlined areas shown on Figures 1-3 through 1-5. Marsh would be constructed to target

elevations determined during the PED phase in coordination with the resource agencies, utilizing comparisons to nearby reference marshes to establish the optimum post-settlement elevation range. At this time, it is projected that a range of elevations between 1.2 and 1.5 feet (NAVD88) would be achieved for emergent marsh and 0 to – 2.0 feet MLLW for restored ponds and channels within the marsh. One permanent staff gage would be established early in the PED phase near each mitigation area to measure water elevations to be used in establishing the optimum marsh elevation range and to monitor the marsh elevations during the O&M phase.

The construction estimate assumes that shoaled material from SNWW's Sabine-Neches Canal B, which extends across the north end of Sabine Lake from the mouth of the Neches River to the mouth of the Sabine River, would be used to construct mitigation areas 28 and 29. This is the closest segment of the SNWW to the Old River mitigation sites. This channel is not regularly dredged, so cost estimates included the full cost of maintenance dredging to hydraulically dredge the material and pump it into targeted open water areas. Maintenance material from the SNWW's Neches River Channel might be used instead of, or in addition to, the Sabine-Neches Canal B material for these areas. Material from regularly scheduled maintenance dredging of nearby reaches of the Neches River Channel is proposed for construction of mitigation areas 31 and 52. Only the incremental cost of additional hydraulic pipeline, pumping and pipe movement needed to create the marsh is included in the cost estimates for these alternatives.

Existing canals provide access routes for floating hydraulic pipelines into all of the mitigation areas. If deepening of the access canals is required in order to facilitate hydraulic pipeline flotation or to transport other necessary construction equipment, that material would be used to restore marsh elevation in the mitigation areas or in adjacent open water areas acceptable to resource agencies. Temporary board roads may be constructed along access corridors and staging areas wherever emergent marsh exists. Board roads would be removed when work is completed. Fill material may be deposited to offset damage to underlying marsh caused by soil compression under the board road. Details of construction/flotation access corridors and staging areas would be developed during the PED phase. Every effort would be made to avoid and minimize environmental impacts to the extent practicable. Any unavoidable wetland impacts would be determined in consultation with resource agencies and the mitigation areas would be enlarged as needed to compensate for impacts which exceed AAHUs provided by the Best Buy Mitigation Plans.

Temporary containment dikes, constructed with in-situ materials excavated from immediately adjacent open water areas, would hold dredged material slurry while it decants and consolidates to form new marsh platforms in open water areas. For all of the marsh mitigation alternatives, it was assumed that marsh would be restored in 65 percent of the open water, and that sinuous channels and ponds would be created in the remaining 35 percent of open water. Dredged material would

be allowed to flow into existing marsh surrounding the open water areas within the containment dikes; marsh vegetation would winnow the fine-grained material and nourish existing marsh. Temporary erosion control measures (such as concrete mats or riprap) for the containment dikes may be installed where needed.

Construction of the mitigation areas would begin as soon as possible after project construction is initiated. Construction would need to proceed on several areas concurrently because it is estimated that the total construction period for each area, from initiation through establishment of marsh vegetation would be 8 years. Initial construction of each area is estimated to take 2 years; settlement and consolidation of the material would take up to 3 years; and channels and ponds would be created in within 4-5 years of beginning construction. Containment dikes or temporary erosion control features would be removed in the sixth year of the construction period to encourage marsh plant growth and to maximize edge for aquatic organisms to utilize exterior and interior marsh areas. *Spartina patens* would be planted on 5-foot centers in the year following completion of pond/channel construction (year 6 of mitigation construction). Based on recent experience in similar marsh restoration areas in the same area, it is assumed that 50 percent of the *Spartina patens* plants would need to be replanted the year following initial planting (year 7 of the construction period). It is also expected that *Spartina alterniflora* and other native wetland vegetation would grow in the mitigation areas within 1-2 years, as nearby seed sources are abundant. Invasive and nuisance vegetation would be removed in year 8 (the last year of the construction period) to facilitate growth of native vegetation over the restored marsh areas. Baseline surveys of the forested wetland mitigation areas would be conducted in the last year of the mitigation implementation period (year 10), and to determine the extent of Chinese tallow cover of selected areas.

1.4 MAINTENANCE MANAGEMENT PLAN

All of the mitigation areas would require periodic inspection as part of normal operations and maintenance (O&M), in accordance with ER 1105-2-100, Section C-3(e)(10) and Section 2(d) of implementation guidance for WRDA 2007 Section 2036(a) (USACE, 2006). None of the mitigation plans include structures intended to last beyond the initial construction period, and therefore no long-term inspection or maintenance activities/costs are needed for the Recommended Plan. Post-construction monitoring to determine the success of mitigation measures is primarily the responsibility of the NFS for project implementation; this plan is presented in Section 2.2. Monitoring reports described in Section 2.3 would be prepared by the NFS, with copies provided to USACE for upward reporting. The monitoring and reporting costs have been included in the O&M cost.

2 MONITORING PLAN

An effective monitoring program is required to determine if the mitigation outcomes are consistent with performance standards. Mitigation success criteria were developed as the basis of determining ecological success and to determine if adaptive management actions are required. Upon completion of the mitigation area acquisition and construction, monitoring for ecological success would be initiated and would continue until ecological success is achieved, as defined by the mitigation success criteria. The following objectives, performance standards and success criteria would be further refined during the PED phase.

USACE would be responsible for monitoring, reporting and resource agency coordination during the Construction Phase. The non-Federal implementation sponsor would be responsible for monitoring, reporting and agency coordination during the O&M Phase. Resource agency coordination would be initiated and documented by the NFS for each monitoring activity; USACE would be notified of each consultation meeting. All monitoring reports prepared by the NFS would be provided to USACE for upward reporting.

If one or more of the monitoring reports detailed in Section 2.3 indicates that mitigation success is threatened, as determined by USACE and the NFS in coordination with the resource agencies, significant corrective actions would be necessary as described in the Adaptive Management Plan (Section 3.0). The need for such actions could trigger the need for additional monitoring not identified below, including the need to extend monitoring beyond the times indicated. The NFS would be responsible for conducting this additional monitoring, preparing monitoring reports, and conducting required corrective actions. Necessary corrective actions would be determined by USACE in coordination with the NFS and the resource agencies.

2.1 CONSTRUCTION PHASE

At this time the construction period for the Recommended Plan is estimated to be 10 years in length. The mitigation implementation period would coincide with, and begin concurrently with, the general construction period as none of the mitigation areas are co-located with Recommended Plan construction areas. Year references in the descriptions below refer to the mitigation implementation period. For example, if a feature is completed by the end of Year 5, it would be finished 5 years from the start of the mitigation implementation period, and 5 years prior to the end of project construction and the beginning of project operation.

2.1.1 Forested Wetland Mitigation Areas

Construction Phase - Forested Wetlands (CFW) Objective 1 - Acquire Real Estate Interests

Performance Standard: All procedures relating to the procurement of title evidence, title clearance, and closing for acquisition of the appropriate real estate interest will be in accordance with ER 405-1-12-5.

Success Criteria CFW1:

- Complete acquisition of forested wetland Mitigation Areas 11 and 161 by the end of Year 7 of the mitigation implementation period.
- Obtain right-of-entry for monitoring activities by end of Year 8.

2.1.2 Emergent Marsh Mitigation Areas

2.1.2.1 Construction Phase – Emergent Wetlands (CEM) Objective 1 – Acquire Real Estate Interests

Mitigation Areas 28, 29 and 31 are owned by TPWD. Mitigation Area 52 is privately owned; acquisition and preservation of this area would be accomplished as described for Mitigation Areas 11 and 161.

Performance Standard: Acquisition of the appropriate real estate interest in accordance with USACE Real Estate guidance and regulation.

Success Criteria CEM 1:

- Complete acquisition of Mitigation Area 52 by the end of Year 1 of the mitigation implementation period
- Obtain right-of-entry for construction and monitoring activities in Mitigation Areas 28, 29 and 31 by the end of Year 1

It is estimated that construction of the marsh mitigation areas and establishment of wetland vegetation therein would take a total of 8 years. Therefore, all necessary real estate interests must be acquired by end of Year 1 of the mitigation implementation period.

2.1.2.2 CEM Objective 2 – Create Emergent Marsh in Mitigation Areas 28, 29, 31 and 52

Performance Standard: Create approximately 452.8 acres of emergent marsh and associated shallow ponds and sinuous channels in Mitigation Areas 28, 29, 31 and 52, as detailed in Table 2-1.

Table 2-1. Mitigation Areas - Acres of Emergent Marsh and Water

Marsh Mitigation Area	Emergent Marsh Created (acres)	Shallow Ponds/Channels Created (acres)	Total Restored Area (acres)
28	86.0	47.2	133.2
29	69.0	37.0	106.0
31	98.0	52.7	150.7
52	40.9	22.0	62.9
Total	293.9	158.9	452.8

Success Criteria CEM2:

- Initial construction activities (construction of containment dikes and drainage structures, hydraulic pumping of shoaled material, and construction of erosion control features, if needed) completed by the end of Year 2. Material for all sites would be obtained from nearby channel segments of the Sabine-Neches Waterway (SNWW) deep draft navigation project.
- Settlement and consolidation of the marsh fill (sized in accordance with acres shown in Table 2-1) completed by the end of Year 5, when initial target marsh elevations would be reached.
- Construction of shallow ponds and sinuous channels in the Mitigation Area (sized in accordance with acres shown in Table 2-1) completed by the end Year 5.
- Containment dikes and temporary erosion control features degraded or removed by the end of Year 6.
- Completion of *Spartina patens* plantings on 5-foot centers over the restored marsh platforms by the end of Year 6, and in Year 7, up to 50 percent of the plants would be replaced if needed. Other marsh plants, and in particular *Spartina alterniflora*, are expected to volunteer in the newly restored marsh areas due to the abundance of seeds in the dredged material and in established adjacent marshes.

2.1.2.3 CEM Objective 3 – Establish Marsh Elevation and Topography

Performance Standard: Attain functional marsh and water elevations determined by comparison with reference marshes and the staff gages installed early in the PED phase. The target elevation range would be determined in coordination with resource agencies.

CEM3 Success Criteria:

- 80 percent of the restored areas in each marsh mitigation area exhibit surface elevations within 0.5 feet of the desired final target elevation ranges by the end of Year 5
- 90 percent of the restored areas in each marsh mitigation area exhibit surface elevations within 0.5 feet of the desired final target elevation ranges by the end of Year 7

Initial planting of wetland vegetation (CEM Objective 4- Year 6) cannot begin until the desired final target elevations are achieved in Year 5. If the CEM3 success criterion for Year 5 has not been achieved, then construction modifications would be implemented by USACE to achieve the appropriate elevations and plants would not be installed until the marsh elevation/topography success criterion is achieved.

2.1.2.4 CEM Objective 4 – Establish Native Wetland Vegetation

Performance Standard: Native wetland vegetation would be established over a majority of the restored marsh acreage.

Success Criteria CEM4:

- Complete initial plantings in each marsh mitigation area by the end of Year 6. Plantings would be accomplished in accordance with contract specifications to be developed during the PED phase, in coordination with the resource agencies.
- By the middle of Year 7, attain at least 50 percent survival of planted *Spartina patens* or achieve a minimum average cover of 65 percent in the restored marsh areas, comprised of planted or volunteer, native, herbaceous wetland species included on the National Wetland Plant List for the Gulf Coastal Plain (USACE, 2016). If neither of these criteria are met, a maximum of 50 percent of the original *Spartina patens* plants would be replaced with new plantings by the end of Year 7.
- By the end of Year 8, achieve a minimum average cover of 75 percent planted or volunteer, native, herbaceous wetland species in the restored marsh areas.

2.1.2.5 CEM Objective 5 – Remove Invasive and Nuisance Vegetation

Performance Standard: Facilitate establishment of native wetland vegetation by removing invasive and nuisance vegetation.

Success Criterion CEM 5: In Year 8, remove a minimum of 90 percent of invasive and nuisance vegetation in the restored marsh of Mitigation Areas 28, 29, 31 and 52.

2.1.3 Cost

First costs for acquisition or other real estate interests for all mitigation areas associated with CFW Objective 1 and CEM Objective 1 are included in the overall project construction cost and are tracked in line item 01 Lands and Damages in the Total Project Cost Summary (TPCS). These are reported in the Cost Section of the Engineering Appendix (Appendix D) and they are described in the Real Estate Plan (Appendix E).

First costs for mitigation construction monitoring and reporting associated with CEM Objectives 2, 3, 4 and 5 have been included in line item 06 Fish and Wildlife Facilities presented in the TPCS (Appendix D).

2.2 O&M PHASE

All mitigation areas must be maintained to provide the ecological functions and values required to fully compensate for project impacts. Year references in the descriptions below refer to the post-construction monitoring period, which begins after the construction and mitigation implementation period is complete.

2.2.1 Forested Wetland Mitigation Areas

2.2.1.1 OMFW Objective 1 - Preservation of Forested Wetland Mitigation Areas

Performance Standard: Preserve 447 acres of swamp and BH in Mitigation Area 11 and 112.5 acres of BH forest in Mitigation Area 161.

Success Criteria OMFW 1:

- Perform visits in Years 2 and 4 to Mitigation Areas 11 and 161 and provide reports to verify that the mitigation areas remain in preservation status. Random surveys may be performed during these visits to record forested wetland species composition and tree size in the swamp areas of Mitigation Area 11 and BH areas of Mitigation Area 161. This information would be collected to inform long-term management; it would not be considered a baseline condition which must be maintained by the non-Federal sponsor.

- If more than 5 acres of swamp or BH in Mitigation Areas 11 and 161, respectively, are sold or otherwise distributed, the lost acres would be replaced as specified in the Adaptive Management Plan.

2.2.1.2 OMFW Objective 2 – Management of Invasive Chinese Tallow

Performance Standard: Maintain forested wetlands in Mitigation Areas 11 and 161 without significant new infestations of Chinese tallow.

Success Criteria OMFW 2:

- In Year 5, satellite photographs would be reviewed and field survey would be conducted as needed to document Chinese tallow growth (dbh growth and cover percentages) within known gaps and to identify new gaps meeting the size and hydrologic criteria. Survey methods would be established in coordination with resource agencies. Chinese tallow prefers mesic conditions and is more likely to invade bottomland hardwood stands than the swamp stands, but it is able to tolerate a wide range of site conditions (Camarillo et al. 2015). Growth can occur within mature forest stands if gaps develop and if the area is only flooded seasonally. However, if acres of tallow infestation (defined as majority of midstory or overstory canopy) exceed 40 percent of existing swamp or BH acreage in the monitored blow-down areas or gaps, a tallow control program would be initiated as specified in the Adaptive Management Plan.

2.2.2 Marsh Mitigation Areas

2.2.2.1 O&M Emergent Marsh (OMEM) Objective 1 – Continuity of Marsh Mitigation Areas 28, 29, 31, and 52

Performance Standard: Continued existence of acres of created marsh and shallow ponds/channels specified in Table 2-1 at functional marsh elevations through the monitoring period.

Success Criterion OMEM1: In Year 5, obtain LIDAR data or conduct field surveys to determine surface elevations of restored marsh areas. At least 90 percent of the restored marsh areas in Mitigation Areas 28, 29, 31 and 52 must maintain a surface elevation that is within the functional marsh elevation range. The targeted functional range would be established by comparison to reference marshes in the vicinity. Reference marshes and specific survey methods would be identified in coordination with resource agencies during the PED phase.

2.2.2.2 OMEM Objective 2: Maintain Native Wetland Vegetation Coverage

Performance Standard: Maintain species composition and percent cover of wetland vegetation in the restored marsh areas with herbaceous wetland species from the Gulf Coastal Plain Regional Wetlands Plant list (USACE, 2016).

Success Criteria OMEM2:

- In Year 5, conduct and report on field surveys of vegetation in the restored marsh areas of Mitigation Areas 28, 29, 31 and 52 using the Braun-Blanquet vegetation survey method.
- Maintain a minimum 80 percent average coverage of native herbaceous species in the restored marsh mitigation areas.

2.2.2.3 OMEM Objective 3: Control of invasive and nuisance plant species.

Performance Standard: Manage Mitigation Areas 28, 29, 31 and 52 to minimize invasive and nuisance plant species.

Success Criteria OMEM3:

- In Years 1 and 3, remove a minimum of 90 percent of invasive and nuisance vegetation from the restored marsh areas.
- For the remainder of the monitoring period, 5 percent or less of the emergent marsh vegetation cover in the restored marsh areas would contain invasive and nuisance vegetation. Invasive/nuisance vegetation coverage would be determined during the vegetation surveys conducted under OMEM Objective 2. The invasives/nuisance vegetation coverage would be determined with satellite image analysis and field verification. Specific survey methodology would be determined in coordination with resource agencies during the PED phase.

2.2.3 Cost

O&M costs of the monitoring and reporting associated with OMFV Objectives 1, 2 and 3, and OMEM Objectives 1, 2 and 3 were calculated using the IWR-Plan Version 2.0 Annualizer developed using October 2016 price levels, a 3.125 percent discount rate, and a 50-year period of analysis. Average annual costs for monitoring and reporting the forested wetland mitigation areas and the marsh mitigation areas are estimated to be \$4,628 and \$35,660, respectively. Total average annual costs for monitoring and reporting (as described in Section 2.3 below) of \$40,288 would be included in the O&M cost of the project, in accordance with USACE Implementation Guidance for Section 2036(a) of WRDA 2007, paragraph 5(c).

2.3 MITIGATION MONITORING REPORTING

2.3.1 Baseline Monitoring Reports

2.3.1.1 Forested Wetland Mitigation Areas

In year 9 of the mitigation implementation period, USACE Galveston District Real Estate Division would provide a report on the status of acquisition actions and agreements governing access for monitoring activities. If acquisition activities are not complete, status reports would be provided biannually until acquisition activities are complete.

2.3.1.2 Emergent Marsh Mitigation Areas

In Year 10 of the mitigation implementation period, after completion of the final mitigation construction activities, the mitigation areas would be monitored in coordination with resource agencies, and a baseline monitoring report prepared. USACE would be responsible for the monitoring and report preparation. Information provided would include the following items:

- A discussion of all completed mitigation construction activities.
- A description of the completed marsh mitigation features, including acres of marsh and acres of ponds/channels that were created within each mitigation area.
- As built planview drawings of the mitigation areas showing their approximate boundaries, finished elevations as well as ponds and channels established within the marshes, permanent photo stations and staff gages.
- An assessment of whether construction success criteria CEM2 (Marsh Creation), CEM3 (Elevation and Topography), CEM4 (Native Vegetation Plantings, and CEM 5 (Invasives Removal) have been satisfied.
- Photos taken at permanent photo stations established within the marsh mitigation areas. At least two photos would be taken at each station with the view of each photo always oriented in the same general direction from one monitoring event to the next. The number of photo stations required as well as the locations of these stations would vary depending on the mitigation feature, to be determined in coordination with the resource agencies and the NFS during the PED phase.
- Mean high and mean low water level elevation readings collected from the permanent staff gages installed near each mitigation area during the PED phase.
- Qualitative observations to assess the status and success of the mitigation areas, including an estimate of the average percent cover by native plant species (planted and volunteer) and invasive/nuisance plant species; general condition of native vegetation; the condition of ponds and channels constructed within the marsh areas; and any other potential problems or concerns that could affect the success of the mitigation program.

- Recommendations for actions needed to meet mitigation and management/maintenance goals and mitigation success criteria and to increase the likelihood of success.

2.3.2 O&M Phase Monitoring Reports

2.3.2.1 Forested Wetland Mitigation Areas

In Years 2 and 4, Mitigation Areas 11 and 161 would be visited and a brief report prepared to verify that the areas remain in preservation status. In Year 5, blow down areas or gaps that have been identified would be visited, and mitigation success would be assessed. Information provided would include the following items:

- An assessment of whether O&M success criteria OMF1 (Forested Wetland Preservation) and OMF2 (Chinese Tallow Management) have been satisfied.
- Verification that the areas remain in preservation status.
- Brief description of the survey methodology and maps of surveyed areas or transects.
- General descriptions of species composition and tree size (dbh) of cypress-tupelo swamp areas in Mitigation Area 11 and BH in Mitigation Area 161
- Identification of blow-down areas or gaps in cypress-tupelo canopy cover on satellite image of each mitigation area, and those selected for field survey
- Within the gaps selected for field survey, the relative percentage of dominant species in the midstory and overstory canopies (with specific consideration given to the presence of Chinese tallow), and qualitative observations of the understory to identify tallow seedlings.
- Qualitative observations of hydrologic flows, general condition of native vegetation, evidence of unauthorized use, or any other observations or concerns that could affect the success of the mitigation program.
- Recommendations for actions needed to meet mitigation and management goals and mitigation success criteria.

Thereafter, it is recommended that the non-Federal sponsor make biennial visits to Mitigation Areas 11 and 161 to ensure that the areas remain in preservation status. It is also recommended that the non-Federal sponsor make site visits every 10 years (Years 15, 25, 35, and 45) and prepare reports with information on species composition and size, blow down areas and tallow growth comparable to that required in Year 5.

2.3.2.2 *Emergent Marsh Mitigation Areas*

In Years 1 and 3, reports would be prepared on the removal of invasive/nuisance vegetation from the restored marsh areas. Information provided in the reports would include:

- A discussion of all completed invasive/nuisance vegetation removal activities.
- An assessment of whether the O&M success criterion OMEM3 (Control of Invasive/Nuisance Vegetation) for Years 1 and 3, respectively, has been satisfied.

In Year 5, the marsh mitigation areas would be monitored and a monitoring report prepared which includes the following bulleted items. It is recommended that the non-Federal sponsor continue to conduct the same monitoring and reporting every 5 years thereafter to ensure continued existence of the mitigation areas.

- An assessment of whether O&M success criteria OMEM1 (Marsh Continuity), OMEM2 (Native Wetland Vegetation, OMEM3 (Invasive/Nuisance Vegetation Control) have been satisfied.
- Photos taken at permanent photo stations established within the marsh mitigation areas for the baseline survey. At least two photos would be taken at each station with the view of each photo always oriented in the same general direction from one monitoring event to the next.
- Mean high and mean low water level elevation readings collected from the permanent staff gages installed near each mitigation area during the PED phase.
- Qualitative observations to assess the status and success of the mitigation areas, including an estimate of the average percent cover by native plant species (planted and volunteer) and invasive/nuisance plant species; general condition of native vegetation; the condition of ponds and channels constructed within the marsh areas, noting excessive scouring and/or siltation; and any other potential problems or concerns that could affect the success of the mitigation program.
- Recommendations for actions needed to meet mitigation and management and maintenance goals and mitigation success criteria, and to improve the likelihood of success.

2.3.3 District Consultation and USACE Civil Works Project Mitigation Database Reports

Section 2036(a) of WRDA 2007 requires the USACE to conduct annual consultation with appropriate Federal and State agencies to assess the success of mitigation plans and to prepare annual reports summarizing the results of the consultations until the mitigation objectives have been achieved. To satisfy these requirements, annual consultation reports (District Consultation Reports) will be prepared by Galveston District and submitted to the USACE Southwestern Division (SWD), or the reports will be submitted as directed by SWD. Information needed to compile these reports would be provided by the NFS. Each report will provide the following information:

- List of the types of mitigation implemented.
- Brief description of the mitigation, including acres implemented and acres remaining to be implemented (if any).
- Description of the steps taken to consult with other Federal agencies and State agencies.
- Discussion of the status of consultation, identifying the agencies involved and the outcome. If consultation is complete, a listing of the outcome as one of the following: no action needed; no response from Federal or state agencies on consultation; on schedule with no adaptive management implemented due to consultation, or on schedule with adaptive management implemented due to consultation; behind schedule with adaptive management implemented due to consultation; or, behind schedule for reasons not related to consultation.
- Discussion of the outcome of consultation (if completed). This discussion would include: an assessment of the likelihood that the mitigation will achieve the success criteria.

In addition to the District Consultation Reports discussed above, data and information concerning the mitigation would be entered by Galveston District into the USACE's Civil Works Project Mitigation Database on an annual basis. The data and information required for entry into this database are specified within the database itself.

2.4 PROJECT CLOSEOUT

Annual monitoring reports would cease when it is determined that the objectives of the marsh and forested wetland mitigation plans have been achieved. USACE and resource agencies would meet to evaluate monitoring reports, and provide a recommendation to the Division Commander in the last scheduled annual report to confirm that mitigation is complete. At this time, it is estimated that monitoring would be conducted for 5 years to ensure the success of the mitigation features.

3 ADAPTIVE MANAGEMENT PLAN

3.1 FORESTED WETLANDS

3.1.1 Objective 1 - Preservation of Forested Wetland Mitigation Areas

3.1.1.1 Performance Standard

Ownership and management of the forested wetland acres specified in Table 2-1 would be maintained by the NFS or state conservation agency in accordance with the terms of the perpetual conservation easement. However, sale or release of up to 5 acres of cypress-tupelo swamp in Mitigation Area 11 or BH in Mitigation Area 161 would be allowed without replacement, if sale or release is approved by the agency owner, determined to be in the public interest, and reported to USACE.

3.1.1.2 Adaptive Management Threshold/Trigger

Mitigation Area 11. If more than 50 acres of swamp are permanently lost due to detrimental changes in hydrologic conditions (flows and duration), severe hurricane damage or fire, actions to encourage reforestation, improve hydrologic conditions to enable reforestation, or acquire additional forested wetland acreage within the watershed would be required to maintain a minimum of 241 acres of swamp in perpetuity.

Mitigation Area 161. If more than 25 acres of BH are permanently lost due to detrimental changes in hydrologic conditions (flows and duration), hurricane damage or fire, actions to encourage reforestation, improve hydrologic conditions to enable reforestation, or acquire additional forested wetland acreage would be required such that a minimum of 87 acres of BH forest are maintained in perpetuity.

The minimum acreage thresholds were established with the Wetlands Value Assessment (WVA) model to determine the minimum number of acres needed to match the mitigation targets and fully compensate for the loss of 7.3 AAHUs due to swamp impacts and 35.4 AAHUs due to BH impacts. Further details of this Adaptive Management Plan would be developed in coordination with resource agencies during the PED phase.

3.1.1.3 Cost

Inasmuch as risks of permanent losses in excess of the thresholds due to a hurricane or fire are considered to be low, no specific adaptive management actions are included in the O&M cost estimate. No significant adverse changes in hydrology are anticipated, and fire risk in this area is generally low due to the humid environment and high rainfall rates. At least one hurricane would

be expected during the period of analysis, but the risk of permanent tree loss in excess of the specified thresholds is considered to be low.

3.1.2 Objective 2 – Management of Invasive Chinese Tallow

3.1.2.1 Threshold/Trigger

If acres of tallow infestation (defined as a majority of midstory or overstory canopy) exceed 40 percent of existing swamp or BH acreage in the monitored blow-down areas or gaps, a tallow control program would be initiated. Management to prevent Chinese tallow from replacing native species in bottomland hardwood forests includes proper density management of stands in areas where Chinese tallow is likely to grow and early detection of gap formation to allow treatment of establishing Chinese tallow before it outcompetes regenerating native species (Camarillo et al. 2015). The tallow removal and control effort would consist of annual aerial applications of a specific herbicide (which has minimal effects on other overstory and understory species) to the infested areas for 3 consecutive years, with up to two follow-up applications within 5 years of the last annual application.

3.1.2.2 Cost

While Chinese tallow infestation of the swamp areas in Mitigation Area 11 are possible, the likelihood of infestation in the swamp areas is considered to be low because of the prevalent hydrologic conditions. Therefore, no cost for tallow control in Mitigation Area 11 are included in the cost estimate.

Contrary to the swamps in Mitigation Area 11, the potential for tallow infestation in the BH of Mitigation Area 161 is considered more likely due to mesic conditions in this area. Costs for a tallow control program as described above are therefore included in the project construction cost line item 06 Fish and Wildlife Facilities in conformance with USACE Implementation Guidance for Section 2036(a) of WRDA 07, paragraph 5.d. The estimated first cost of this tallow removal and control effort is \$166,000.

3.2 EMERGENT MARSH

3.2.1 Optimum Marsh Elevations

3.2.1.1 Threshold/Trigger

There is uncertainty in both future rates of relative sea level change (RSLC) and marsh accretion rates, but based on the best available information at this time, it is possible that the marsh mitigation areas would adapt to sea level changes and remain ecologically successful through the period of analysis. Productive and valuable coastal salt marshes have evolved in response to rising

sea-levels (Pethic, 1981; Delaune et al., 1983). Marsh accretion is a natural process which changes the elevation of marsh. Biomass accumulation could offset much if not all of the RSLC in water surface elevation. “Primary productivity of salt marsh vegetation is regulated by changes in sea level, and the vegetation, in turn, constantly modifies the elevation of its habitat toward an equilibrium with sea level” (Morris et al., 2002:2876). A rise in relative sea level brings an increase in production and biomass density that enhances sediment deposition by increasing the efficiency of sediment trapping. This can lead to an absolute increase in the elevation of the marsh platform and result in a landward migration of the marsh (Gardner et al., 1992; Gardner and Porter, 2001). However, a rapid rise in sea level could lead to the death of marsh vegetation, which in this area generally leads to the loss of organic soils and the replacement of marsh by open water.

A marsh accretion study is currently underway in the McFaddin National Wildlife Refuge (Patrick Walther, 2016 personal communication); however, data is too preliminary to determine rates or trends in this area. A NOAA study of marsh accretion rates for the upper Texas coast (Feagin and Yeager, 2008) found contrasting accretion rates for two different marshes on the Upper Texas Coast. In one case on Galveston Island, in an area with a steeply sloping marsh edge and significant erosion due to its direct exposure to West Bay, an average -3.16 inches (in)/year of vertical loss was documented. On the Matagorda Peninsula, accretion rates appear to be keeping up with relative sea level rise in *Spartina alterniflora* low marshes before faulting (+0.31 in/year). Other average rates cited by this study include +0.4 in/year in the Trinity River Estuary (Williams 2003) and an average of +0.06 in/year in the Trinity River floodplain marsh (Yeager et al. 2007). Thus, rates can be extremely varied in the same general area depending upon the precise conditions in each location.

The intermediate RSL change rate for the project area developed for this study is predicted to be an average of 0.43 in/year through 2080 – slightly higher than the accretion rate recorded in the Matagorda Peninsula marshes and about the same as one accretion rate recorded in the Trinity River estuary. The S2G marsh mitigation areas are all situated in the wide floodplain of the Neches River, between 20 and 30 miles inland from the Gulf of Mexico. They are located in gently sloping marshes inland of the open river channel. All of these areas were affected by subsidence related to mid-20th century oil and gas withdrawal which has waned significantly in recent decades (USACE 2011, Appendix C). Production has either ceased in these fields or has been low and steady over the last 25 years. Subsidence rates are thus much lower than in the past. This is reflected in the extremely low to nonexistent, recent land loss rates measured by USGS for the area (see Appendix O). There is great uncertainty about the rate of future sea level rise and thus the future rate of marsh accretion is also uncertain. If the rate of rise is higher than the intermediate level, it is probable that marsh accretion would not be able to keep up and additional material would be required to maintain functioning marsh systems in the mitigation areas.

3.2.1.2 Cost

Based on the best available information, it is possible that the marsh mitigation areas would adapt to sea level changes and remain ecologically successful through the period of analysis. Therefore, no specific adaptive management actions are included in the mitigation cost estimate. However, if O&M monitoring of the marsh elevations determine a need for physical modifications to maintain the functions and values of the mitigation measures in the future, arrangements would need to be made to pump dredged material to restore functional elevations. All of the mitigation areas are located near SNWW navigation channels, making it feasible to pump and place material in the mitigation areas if determined necessary. It is possible that this corrective action could be undertaken as part of regular maintenance dredging. Funding needed to pay incremental differences in cost above the Federal standard, would be provided by the NFS.

3.2.2 Control of invasive and nuisance plant species

3.2.2.1 Threshold/Trigger

Adaptive management actions to remove invasive/nuisance vegetation would be implemented if they comprise more than 5 percent of marsh cover in the restored marsh of Mitigation Area 28, 29, 31 or 52. USACE, in coordination with resource agencies, would determine if the percentage of invasive/nuisance vegetation is exceeding the specified percentage, based on observations recorded during regular monitoring visits and review of satellite images.

The likelihood of the need for corrective actions is considered to be low, because functional marsh elevations would be attained during construction (as ensured by monitoring during construction) and full coverage by native marsh would be achieved (as ensured by monitoring during construction and implementation of the invasives/nuisance vegetation removal plan following initial planting). The likelihood for the need to control invasive vegetation beyond Year 3 of the O&M phase would generally not become an issue in these marshes as long as the appropriate elevation is attained and native vegetation remains in place.

3.2.2.2 Cost

The likelihood of the need for corrective actions is considered to be low because sufficient elevation would be provided by initial construction, and full coverage by native marsh vegetation would be achieved. Therefore, no specific adaptive management actions are included in the mitigation cost estimate.

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