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Tidal Marsh Mitigation Plan

BSC Improvements PA 15 Mitigation
USACE File SWG-2011-01183

CESI Project Number 32-13

July 2013

Prepared For



The Port of Houston Authority

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Port of Houston Authority, SWG-2011-01183,
Bayport Ship Channel, Chambers & Harris Co., TX.
Attachment 2, Tidal Marsh Mitigation Plan at
Baytown Nature Center, Sheet 1 of 27.

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Tidal Marsh Mitigation

<p>BSC Improvements PA 15 Mitigation USACE File SWG-2011-01183</p> <p>Harris County, Texas</p>	<p>The Port of Houston Authority 111 East Loop North Houston, Texas 77029</p> 
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INTRODUCTION

The Bayport Ship Channel (BSC) Improvements Project is a proposed project located in Upper Galveston Bay to improve the existing navigation channel. The dredged material Placement Area (PA) for materials dredged for construction ("new work material") of the project is PA 15, an extension of Atkinson Island, which is located adjacent to the Houston Ship Channel, near the confluence of Upper Galveston Bay with Trinity Bay, in Chambers County, Texas. The Port of Houston Authority (hereafter "the applicant") proposes permanent impacts to 9.23 acres of saltmarsh adjacent to PA 15 on the east side and up to 4.7 acres of temporary impacts that may occur in the temporary construction corridor during construction activities on PA 15. To compensate for impacts to saltmarsh adjacent to PA 15, the Port of Houston Authority proposes to create 8.25 acres of saltmarsh at the Baytown Nature Center in Harris County, Texas. To compensate for temporary impacts that will occur during construction activities east of PA 15, the applicant proposes to perform on-site mitigation through the restoration of the temporary construction corridor to pre-construction conditions. The applicant has submitted a Department of the Army (DoA) Clean Water Act (CWA) Section 404 permit under USACE File SWG-2011-01183. The mitigation proposed for these impacts is hereafter referred to in this report as the BSC Improvements PA 15 Mitigation.

This Tidal Marsh Mitigation Plan details all actions proposed to compensate for unavoidable impacts to wetlands and waters of the U.S. resulting from construction activities. In accordance with the 2008 Final Mitigation Rule (33 CFR 332) (2008 Final Compensatory Mitigation Rule), this Tidal Marsh Mitigation Plan includes the following 12 required components of a mitigation plan:

1. Objectives
2. Site selection
3. Site protection instrument
4. Baseline information
5. Determination of credits
6. Mitigation work plan
7. Maintenance plan
8. Performance standards
9. Monitoring requirements
10. Long-term management plan
11. Adaptive management plan
12. Financial assurances

OBJECTIVES

This Tidal Marsh Mitigation Plan addresses compensatory mitigation for permanent impacts to 9.23 acres of tidal fringe saltmarsh and temporary impacts to 4.7 acres of tidal fringe saltmarsh at the PA 15 temporary construction corridor. Proposed compensation for permanent impacts consists of permittee-responsible mitigation under a watershed approach. Compensatory mitigation will consist of the creation of 8.25 acres of tidal fringe saltmarsh, dominated by smooth cordgrass (*Spartina alterniflora*) and black mangrove (*Avicennia germinans*).

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Proposed compensation for temporary impacts resulting from construction activities at the PA 15 temporary construction corridor will consist of returning the temporary impact area to pre-construction conditions, including recontouring and revegetation of the site.

The purpose of this Tidal Marsh Mitigation Plan is to describe how unavoidable impacts to jurisdictional waters of the U.S. associated with the BSC Improvements Project will be compensated for.

SITE SELECTION

Project Site Description

Mitigation for Permanent Impacts

The proposed mitigation site is located at the Baytown Nature Center (BNC), in Baytown, Harris County, Texas. The BNC is 450 acres encompassing two connected peninsulas in the western edge of the City of Baytown. It is owned, protected, and managed by the City of Baytown Parks and Recreation Department. The peninsulas are surrounded by three bays: Burnet Bay to the north, Scott Bay to the south and Crystal Bay and the Houston Ship Channel to the west. The BNC was established at the site of the former Brownwood subdivision, which was abandoned after severe subsidence and repeated flooding. Approximately 150-acres of wetland restoration projects have already been constructed within the BNC, and this compensatory mitigation plan has been designed to contribute to previous restoration efforts.

The proposed mitigation site is located in the Buffalo Bayou – San Jacinto River Watershed (Hydrologic Unit Code [HUC] 1204010407), which drains all or part of Harris, Montgomery, Waller, Walker, Grimes, Liberty and San Jacinto Counties, for a total drainage area of approximately 4,500 square miles. In Harris County, the San Jacinto River watershed covers approximately 487 square miles. Additional information concerning the proposed mitigation site is located in the **Baseline Information** section of this Tidal Marsh Mitigation Plan.

Site Selection Process

Mitigation for Permanent Impacts

During the site selection process, the applicant considered several options for providing compensatory mitigation for the unavoidable impacts proposed by the development. The 2008 Final Compensatory Mitigation Rule states that mitigation options should be considered based on the following hierarchy:

- Purchasing credits from an operational mitigation bank
- Purchasing credits from an approved in-lieu fee program
- Permittee-responsible mitigation under a watershed approach
- Permittee-responsible mitigation through on-site, in-kind mitigation
- Permittee-responsible mitigation through off-site and/or out-of-kind mitigation

The impact site is outside of the primary and secondary service areas for any mitigation banks and in-lieu fee programs. Therefore, the applicant proposes to perform permittee-responsible mitigation under a watershed approach.

Permittee-responsible mitigation under a watershed approach ensures that the ecological functional lift provided by an ecological mitigation project is performed within the same watershed as the ecological functional loss that results from unavoidable impacts. This guarantees that there is no net loss of aquatic resources in the watershed. The impact site on Atkinson Island and the BNC are located on the Houston Ship Channel and in the same 4-digit HUC (HUC 1204). Both of these locations contribute to the quality of habitat in the Houston Ship Channel and Galveston Bay. The BNC is located approximately 9 miles upstream of the impact site on Atkinson Island, and improvements to the BNC will enhance the ecological functions of both of these waterbodies. A **Vicinity Map** is located in **Appendix A** and a **2008 Aerial Photograph of the Proposed Mitigation Site** is located in **Appendix B**. A **2012 Aerial Photograph** depicting the **Proposed Mitigation Site with 10-Digit Hydrologic Unit Codes** is located in **Appendix C**.

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Mitigation for Temporary Impacts

Impacts at the PA 15 temporary construction corridor will be confined to the duration of construction activities. Therefore, the applicant proposes to perform permittee-responsible on-site, in-kind mitigation at the temporary impact site. On-site, in-kind mitigation increases the likelihood that compensation for functions and services lost during impacts is achieved.

SITE PROTECTION INSTRUMENT

The proposed wetlands will be constructed at the BNC. Upon achievement of the success criteria outlined in the **Performance Standards** section, the wetland will be protected and managed under the existing BNC management plan. Management and stewardship by the BNC will prohibit all development and other activities except those outlined in this Tidal Marsh Mitigation Plan. The applicant owns the submerged land upon which the proposed mitigation site is located.

BASELINE INFORMATION

The proposed mitigation site is located at the BNC, in Baytown, Harris County, Texas, approximately 20 miles east of Houston. The BNC is located at the site of the former Brownwood subdivision. After the subdivision was built in the 1940s and 1950s, unrestrained withdrawal of groundwater resulted in the Brownwood subdivision sinking approximately 9 feet, leaving the peninsula vulnerable to flooding during storms and hurricanes. In 1983 Hurricane Alicia decimated the subdivision. The City of Baytown discontinued all utilities to the subdivision and forced the residents to evacuate their homes. For over a decade, the neighborhood was dormant as the remaining homes were flooded repeatedly.

In 1993, Crouch Environmental Services, Inc. (CESI) proposed transforming the former neighborhood into a wildlife refuge by constructing 60 acres of saltmarsh and freshwater habitat. That successful endeavor led the City to set aside the 450-acre area as the BNC.

The BNC consists of approximately 300 acres of uplands and 150 acres of wetlands and is home to 275 species of birds, including five endangered species. Alligators, deer, fox, and other native wildlife have also returned. In 1997 the BNC was officially designated part of the Great Coastal Texas Birding Trail, a 500-mile route linking the best bird-watching sites along the coast. It is also used as an outdoor classroom for students. Plans are underway for new walking trails and other wildlife observation areas. With the subdivision now removed, the peninsula is reverting to its original mosaic of forest and wetlands (BNC, 2013).

The proposed mitigation site is a shallow cove located on the south side of the BNC peninsula, adjacent to Scott Bay. The approximate center coordinates for the cove are W 95°02'32.78" longitude, N 29°45'0.73" latitude, (Universal Trans Mercator (Zone 15R) 302498.63 m E, 3292853.58 m N). A review of historical aerial photographs reveals that the location of the proposed compensatory mitigation is historically upland and saltmarsh. In the 1953 historical aerial photograph the proposed mitigation site appears to consist of both upland and saltmarsh habitats. However, by 1978, the proposed mitigation site has been almost completely submerged due to subsidence. The **1953 and 1978 Historical Aerial Photographs** are located in **Appendix D**. Although the area in the vicinity of the mitigation site has subsided more than 9 feet since 1900 (Region H Water Planning Group, 2009), virtually no subsidence is projected for eastern Harris County (Neighbors, 2003) due to the implementation of the 1999 Harris County Subsidence District Regulatory Plan, which regulates groundwater withdrawals. A map of **Elevation Changes Due to Subsidence** is located in **Appendix E**.

Currently, the proposed mitigation site is submerged by the tidal waters of Scott Bay. A site assessment was conducted by biologists from CESI on June 11, 2013. CESI biologists surveyed the entire site by kayak, and determined the entire proposed mitigation site to be open water. No vegetation was observed on the project site. No section 404 wetlands or areas of submerged aquatic vegetation were observed on the project site. Depth measurements taken throughout the proposed mitigation site indicate that the maximum depths on the project site at mean high water (MHW) are approximately 8 feet at the southern portion of the site, becoming shallower in near

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shore areas. Depths taken in near shore areas drop to 4 feet at MHW at 20-30 feet from the shoreline. The uplands surrounding the proposed mitigation site are lined with rip-rap at the upland/shoreline interface. Dead, rooted trees are located on the submerged lands in the central and western portion of the proposed mitigation site. Sediments on the proposed mitigation site were observed to be predominantly sandy, with some areas overlain by several inches of silt.

The general assessment of mitigation site bottom conditions on June 11, 2013 did not result in indications of continuous or extensive subtidal oyster reef within the proposed footprint. A more comprehensive bay bottom condition probing effort conducted by Gahagan and Bryant Associates, Inc. on July 17 and 19, 2013 confirmed the lack of extensive or continuous bottom reef. The probing investigation involved approximately 76 evenly distributed probing locations spaced on 100 foot centers covering the proposed site and the adjacent seaward area surrounding it. Only seven locations within the proposed site indicated areas of remnant shell in mud mainly corresponding to the location of the historical shoreline, visible in the 1953 aerial, that has since subsided, but also areas around where dead tree stumps remain. These areas were probed with a Ponar grab sampler, and only two of the locations were observed to have sporadic live and dead oyster clusters with attached mussels, intermixed with sandy and silt areas. These locations were in areas containing fallen trees, stumps, and/or broken concrete or riprap. Three other sporadic locations of similar growth on debris serving as substrate were observed south and southeast outside of the proposed mitigation footprint. All other probe areas only indicated soft bottom conditions. No indication of any sizable, continuous, consolidated reef growth was apparent, and the live oyster clusters observed are indicative of small, scattered, sporadic growth on submerged debris (e.g. logs, rip-rap). The continuous area of rip-rap proposed as shore protection for the marsh containment levee will provide far more substrate surface area for oyster attachment than would the sporadic areas of live and dead oyster clusters observed within the proposed footprint. Therefore recolonization of the proposed shore protection substrate would result in greater live oyster cluster density than what is present. An aerial photograph with the location of the oysters observed on the project site is located in **Appendix G**. Additional information regarding the marsh containment levee may be found in the **Mitigation Work Plan** section of this Tidal Marsh Mitigation Plan and in the **Cross-section A-A'** located in **Appendix F**. No seagrasses were observed during any of the site visits and bottom probing efforts previously discussed.

The proposed mitigation site is located in the Gulf Coast Prairies and Marshes natural region of Texas, which is approximately 20,312 square miles (Gould, 1975). Gulf Coast prairies are nearly level, with slow surface drainage and elevations ranging from sea level to approximately 250 feet above mean sea level (MSL). In addition to wildlife habitat, the prairies are used for crops, livestock grazing, and urban and industrial centers. It is estimated that as much as 99 percent of the coastal prairies in Texas have been converted to agricultural land (Gould, 1975; McMahan, et. al, 1984).

Gulf Coast marshes are low, wet areas typically inundated with saline water, ranging from sea level to a few feet in elevation above MSL. These marshes support species of sedges, rushes, cordgrasses, reeds, and forbs, which provide beneficial wildlife habitat for numerous birds and marine fisheries. Many areas in the region have been invaded by noxious volunteer species such as honey mesquite (*Prosopis glandulosa*), smut grass (*Sporobolus indicus*), and Chinese tallow (*Triadica sebifera*).

According to *The Vegetation Types of Texas*, the project site is located within the "Marsh/Barrier Island" vegetation type (McMahan et al., 1984). The dominant vegetation in these areas includes water hyacinth (*Eichhornia* sp.), pennywort (*Hydrocotyle* sp.), bulltongue arrowhead (*Sagittaria lancifolia*), and duckweed (*Lemna* sp.). These types of vegetation are associated with hydric lowlands landward of brackish marshes, coastal prairies, and marshes.

One soil type is mapped by the Natural Resources Conservation Service (NRCS) as occurring on the proposed mitigation site, Vamont-Urban land complex. This soil series is classified as non-hydric in Harris County. The following soil series description is taken from the 1976 NRCS *Soil Survey of Harris County* (USDA NRCS, 1976).

Vamont – Urban land complex (Vn) – This nearly level to gently sloping soil is in broad, irregular areas and in long and narrow, gently sloping areas leading to low terraces and flood plains of major streams and drainageways. Vamont soils account for 20 to 75 percent of this complex; Urban covers 10 to 70 percent; and other soils account for 15 percent or less. The surface layer of Vamont soil is firm, medium acid, very

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dark grayish-brown clay about four inches thick. The layer below that is 14 inches thick and consists of firm, strongly acid clay that is predominantly mottled with yellowish-brown and gray. To a depth of 60 inches is a layer of very firm, strongly acid to medium acid, grayish-brown clay that has few yellowish-brown and brownish-yellow mottles. This soil has high shrink-swell potential in the clay layers. Vamont soil is somewhat poorly drained with rapid surface runoff. Internal drainage is slow, and permeability is very slow.

According to the FEMA floodplain data for Harris County (FEMA Panel Nos. 48201C0745L and 4801C0935L, both effective February 18, 2009), the entire project site is situated in the 100-year floodplain.

DETERMINATION OF CREDITS

The proposed compensatory mitigation area at the BNC will compensate for unavoidable impacts to aquatic resources by providing functions and services similar to those provided by the impacted area. The proposed mitigation includes compensation for losses of these functions and services as the mitigation area achieves the success criteria. These functions and services include providing suitable habitat for aquatic flora and fauna in the project vicinity and watershed, providing an area where suspended solids can be trapped and settle, and providing water quality treatment and polishing through the assimilation of non-point source pollutants.

To ensure the function and value of impacted wetlands are being adequately compensated for, interim hydrogeomorphic modeling (iHGM) was used to calculate compensation requirements. The purpose of the iHGM is to provide an easily repeatable and rapid assessment of the current functional condition of a given aquatic resource. The fundamental unit for evaluating impacts within the iHGM is the Functional Capacity Index (FCI). Several iHGM models exist, specific to different classifications of wetlands. The tidal fringe iHGM was used to determine the ecological value of services lost as a result of construction of the improvements at Atkinson Island DMPA and gained by construction of the proposed mitigation site. The tidal fringe iHGM uses the following sub-indices to determine FCI values: biota, botanical, physical, and chemical. The FCI value of each sub-index is calculated by incorporating data obtained from several field variables observed into specific equations. The mean value of these FCIs for each wetland assessment area is multiplied by the acreage of the aquatic system to determine the Functional Capacity Unit (FCU) of the wetland. By calculating the FCI of the tidal fringe saltmarsh to be impacted on Atkinson Island, the area of tidal fringe saltmarsh creation necessary to compensate for losses was calculated. The amount of mitigation required for this project, as determined by the iHGM model, is 8.25 acres. A brief synopsis of the results of the modeling effort is provided in **Table 1**.

Table 1. Summary of FCIs, FCUs, and Calculated Compensation Acreages

	Subindex			
	Biota	Botanical	Physical	Chemical
Impacted Marsh FCI (area weighted average)	0.65	0.81	0.59	0.69
Impacted Marsh FCU	6.00	7.50	5.40	6.35
FCU = FCI * acreage; Required Mitigation Acreage = Impacted FCU/Proposed Marsh FCI				
Proposed Marsh FCI	0.79	1.00	0.67	0.77
Proposed Acreage Required	7.59	7.50	8.06	8.25**
Proposed Marsh FCU	6.00	7.50	5.40	6.35

**To fully compensate for impacts to Functional Capacity Units (FCUs), the proposed mitigation marsh must generate enough FCUs to compensate for the loss of FCUs for each of the four sub-indices (Biota, Botanical, Physical, and Chemical). Therefore, the proposed marsh acreage must equal or exceed the largest area required to compensate for any of the four sub-indices. Here, the Chemical sub-index acreage has been used as the minimum acreage that will fully compensate for the impacted FCUs.

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MITIGATION WORK PLAN

GEOGRAPHIC BOUNDARIES

Mitigation for Permanent Impacts

The applicant proposes to construct all compensatory mitigation for permanent impacts in the cove located on the south side of the BNC, adjacent to Scott Bay. The applicant intends to construct 8.25 acres of tidal fringe saltmarsh dominated by smooth cordgrass and planted with black mangroves at two locations along the existing shoreline, following the approval of this Tidal Marsh Mitigation Plan by the United States Army Corps of Engineers (USACE). Please refer to the **Baseline Information** section of this Tidal Marsh Mitigation Plan for the approximate center coordinates of the proposed mitigation sites. A **Plan View** for the proposed mitigation area is located in **Appendix F**.

Mitigation for Temporary Impacts

Compensation for temporary impacts to the construction corridor will occur at the PA 15 temporary construction corridor. The construction corridor will be bounded by construction and silt fence prior to and during construction to ensure construction activities do not extend beyond the zone specified, and construction mats will be used for equipment access. Upon completion of construction, the construction corridor will be restored to the pre-existing elevation contours if necessary (although no change in elevation contours is anticipated), and replanted as necessary as close to the pre-existing coverage as practicable. An aerial depicting the location of the temporary impact area is located in **Appendix H**.

CONSTRUCTION METHODS

Soil Contouring

Mitigation for Permanent Impacts

Construction activities include creation and planting of 8.25 acres of tidal fringe saltmarsh wetlands at the BNC in a cove adjacent to Scott Bay. To bring the substrate of the proposed mitigation site to suitable elevations to facilitate the success of the tidal fringe saltmarsh, beneficial use of non-contaminated sediments from suitable locations, is proposed, and would be tested for contaminants prior to use to ensure fill material used is environmentally acceptable. The proposed source and testing results will be coordinated with the USACE prior to construction. The soils will be stockpiled in surrounding uplands and mechanically placed in the cove.

The project would result in the net placement of approximately 52,000 to 58,000 cubic yards of fill into Scott Bay. Soils will be contoured so that the proposed grade at the existing upland/shoreline interface will be the MHW elevation (1.66' NAVD88) and the grade at the proposed marsh creation levee will be 6 inches below MHW (1.16' NAVD88). Please refer to the **Plan View** in **Appendix F** for further detail.

A marsh containment levee will be constructed to contain sediments introduced into Scott Bay. The levee will provide a method of reducing wave energy and thereby protecting saltmarsh plantings. The crest of the levee will be constructed to one foot above MHW (2.66' NAVD88). For a visual representation and additional details, please refer to **Cross-section A-A'** in **Appendix F** for further detail.

The 1,355-linear foot marsh containment levee would be constructed as an earthen levee protected by a rip-rap veneer. Soil fill (approximately 7,600 cubic yards) would be used to build the levee to approximately 7.5 feet above the existing bay bottom and an 18-inch layer of rip-rap (approximately 3,200 cubic yards) would be placed on the top and bay-side of the levee. The slope of the levee on the Scott Bay side would be 4:1. The presence of a rip-rap veneer on the upper 1.5 feet of the levee would provide a porous substrate for tidal waters to pass through in the elevations between +1 and -0.5 MHW. This will allow the tidal salt marsh to become inundated during daily high tides, and to drain from the marsh during low tides. The marsh containment levee will yield approximately 0.29 acres of additional potential habitat, yielding a total project area of 8.54 acres.

Saltmarsh creation associated with a separate mitigation project will occur within a 1.38-acre section in the northwest portion of the cove (SWG-2011-00125). These projects will be constructed concurrently. Visual markers will be

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placed around the boundary between the two mitigation areas to ensure that, while there will be no difference in the vegetative community, a clear visual separation between the two areas exists. Please refer to the **Plan View** in **Appendix F** for further detail.

Mitigation for Temporary Impacts

Compensation for temporary impacts in the PA 15 temporary construction corridor will commence after construction activities are complete. The use of construction mats and silt fencing should preclude any substantial change in elevation in the construction corridor to rutting, dredged material spillage etc. In the event activities result in substantial areas in the construction corridor being lowered or filled, soils in the temporary impact area will be graded and restored to pre-construction contours. Target soil elevations and contours will be based on a pre-construction elevation survey. A post-construction elevation survey will be performed following contouring activities to ensure the temporary construction corridor is consistent with pre construction conditions.

Planting Plan

Mitigation for Permanent Impacts

Once the sediments have been contoured to elevations suitable for tidal fringe saltmarsh success, the soils will be allowed to settle for approximately 3 months before planting will commence on the proposed mitigation site. A Texas Parks and Wildlife (TPWD) permit for harvesting wetland plants will be required in order to obtain smooth cordgrass for transplant to the proposed mitigation site at the BNC. This permit will be obtained prior to commencement of harvesting and planting activities. Healthy plugs of smooth cordgrass would be harvested from nearby healthy and dense cordgrass communities at the BNC and transplanted to the proposed mitigation site. Harvested plugs will be kept moist and shaded until they are planted. Planting of harvested plugs will occur within 24 hours of harvesting, to decrease mortality and stress.

Harvested plants will be live, fresh, healthy, and uninjured at the time of planting. Field harvested cordgrass plugs will consist of clumps that contain viable root-rhizome stock. The minimum plug size to be installed at the planting site is four inches by four inches. Although it will be acceptable to divide large root-masses into smaller plugs, excessive manipulation and disturbance of the soil mass will be avoided, to minimize physical damage and desiccation during harvest, transport, and planting.

When smooth cordgrass is harvested from local populations, other species intermingled with the target species will not be excluded from the harvested material prior to planting unless these species are noxious plants that will have a deleterious effect on the wetlands diversity over time. Noxious and invasive species will be excluded from harvest and planting activities to the maximum extent possible. A list of species identified as noxious or invasive by TPWD may be found at www.texasinvasives.org/plant_database/tpwd_results.php.

Natural water depths will be maintained during planting and initial plant establishment to allow optimal rooting conditions. Vegetation will be installed on approximately 5-foot centers, at the appropriate depth for the specific species. Smooth cordgrass will be installed by hand using a shovel, spade, dibble, trowel, or other method. The planting tool will be used to create a shallow hole in the moist substrate for installation. The hole will be of sufficient depth and width to allow the entire root mass to be inserted without breakage or other damage. Excessively deep vegetation placement will not occur.

To supplement vegetative species diversity and the wildlife value of the proposed mitigation marsh, two areas adjacent to existing uplands on the mitigation site will be planted with black mangroves (*Avicennia germinans*). An approximately 10-foot-wide by 374-foot-long (0.09 acres) section of the northern project boundary, and an approximately 10-foot-wide by 289-foot-long (0.06 acres) section of the eastern project boundary will be planted with black mangroves. Mangrove saplings will be transported from a reputable nursery to the proposed project site at the BNC and planted on 5-foot centers. For planting locations, please refer to the **Plan View** and **Cross-section A-A'** in **Appendix F**.

Mangroves and smooth cordgrass will be installed upright so that the junction between the root crown and the stem is at the substrate surface. After installation of the plant in the hole, the hole will be carefully closed around the plant

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roots by filling the hole with excavated soil, and gently applying foot pressure to the edge of the hole. Should it be determined that there is a possibility of newly installed vegetation floating free of its hole, the plant may be weighted down with a non-galvanized iron nail or an equivalent method as appropriate.

Mitigation for Temporary Impacts

A pre-construction survey of existing vegetative cover at the PA 15 temporary construction corridor will determine the vegetative baseline cover values that must be achieved to compensate for losses resulting from construction activities. Based on the results of this survey, native vegetation will be replanted as necessary to achieve as close to the pre-construction cover conditions of wetland vegetation in the 4.7-acre temporary construction corridor as practicable. Planting will commence following construction and the completion of soil contouring activities.

MAINTENANCE PLAN

Mitigation for Permanent Impacts

The applicant will be responsible for all maintenance and management activities. The applicant will consult a regional mitigation specialist and/or the USACE in the event adaptations or revisions to this Tidal Marsh Mitigation Plan are required.

All mitigation areas on the BNC will be inundated daily through normal tidal inflows from Scott Bay to maintain low marsh conditions. Should it be determined by the applicant that appropriate hydrology levels are not being maintained by tidal sources during the course of the mitigation activities, the applicant will implement appropriate corrective action to address the deficiency.

Should it be determined that natural establishment of vegetative communities on is unsuccessful at either the BNC mitigation site replanting options will be evaluated. Invasive species will be monitored and controlled during all phases of construction, establishment, maintenance, and monitoring. This can include selective mowing and selective spraying. The created wetlands will be protected by temporarily installed construction or wire fencing to prevent grazing by species such as nutria, grass carp, or other fauna. No vehicular or other traffic will be allowed to transverse the area, preventing soil compaction, plant mortality, and/or seed dispersal. Replanting will occur if any significant event occurs that prevents coverage of vegetation from meeting the predetermined success criteria.

Mitigation for Temporary Impacts

The PA 15 temporary construction corridor will be monitored six months post replanting to ensure a minimum 75 percent plant survival rate. If success criteria are not met, areas in need of attention will be replanted. If success criteria are met, no further monitoring will be conducted. It should be noted that the USACE plans to fill the Marsh Cells M7/8/9 in 2015. The planned filling will inundate the proposed construction corridor with a thin layer of sediment and water for a period of time. The PHA cannot guarantee the long term survival or propagation of the replanted vegetation after that time.

PERFORMANCE STANDARDS

Mitigation for Permanent Impacts

The success criteria used to evaluate the performance standards for this Tidal Marsh Mitigation Plan are intended to ensure that the chemical, physical, and biological functions of the compensatory mitigation area compensate for the chemical, physical, and biological functions lost due to impacts on the project site. Monitoring and quantification of performance standards will assess the success of the saltmarsh wetland. The tidal fringe iHGM will be used to quantify the performance of the mitigation area. To be considered successful, the mitigation area FCUs for the four tidal fringe iHGM sub-indices (biota, botanical, physical, and chemical) must meet or exceed the FCUs lost to impact for each of these sub-indices.

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The project will be considered successful if the following conditions are met:

- Minimum of 50 percent survival of installed plugs within 60 calendar days of planting
- Nuisance, invasive, noxious, and exotic species should consist of relative cover of 10 percent or less. A list of species identified as noxious or invasive by TPWD may be found at www.texasinvasives.org/plant_database/tpwd_results.php.
- After one calendar year from planting, the following target FCUs must be met:

Biota	6.00
Botanical	7.50
Physical	5.40
Chemical	6.35

These FCU values must be met or exceeded one, two, and three calendar years following planting activities. A transplant survival survey of the planted mitigation area must be performed within 60 calendar days following the initial planting effort. If at least 50 percent survival of transplants is not achieved within 60 calendar days of planting, a second planting effort will be completed within 60 calendar days of completing the initial survival survey. If optimal seasonal requirements for replanting targeted species are not suitable when replanting would be required, the permittee must provide a replanting schedule to the Corps of Engineers, Chief, Compliance Section, Regulatory Branch, Galveston District (Corps) for review and approval. Written reports detailing plant survival must be submitted to the Corps within 30 calendar days of completing the initial survival survey and any subsequent replanting effort.

A thorough review of the iHGM model for the mitigation area indicated that the percent areal coverage of native vegetation is the only variable that has a temporal component. In order to achieve the required number of FCUs to achieve compensation for permanent impacts, areal coverage of native vegetation must be at least 90 percent. An iHGM dataform summarizing the index values needed to achieve the necessary number of FCUs is located in **Appendix I**. If expected conditions are met by the end of year one, the BNC mitigation area is expected to exceed success criteria and achieve the Anticipated Year 1 FCU values detailed in the dataform located in **Appendix I**.

If success criteria for wetland areas are not met at any of the scheduled times, including after initial transplanting activities and during the first three years of monitoring, those areas that are not sufficiently vegetated will be replanted with vegetation and monitored for the remainder of the three years. At the end of the required three-year monitoring period, the mitigation area will be required to achieve the minimum FCUs for the four sub-indices. If this requirement is not satisfied, corrective action will be required to meet the target FCU values. The area will then be monitored on an annual basis until the success criteria is met. This will be repeated until the tidal fringe wetland areas meet the required success rate.

Mitigation for Temporary Impacts

The construction corridor will be resurveyed pre- and post-construction to verify the condition of the wetland vegetation. The PA 15 temporary construction corridor will be monitored six months post replanting to ensure a minimum 75 percent plant survival rate. Nuisance, invasive, noxious, and exotic species should consist of relative cover of 10 percent or less. If this success criterion is not met, areas in need of attention will be replanted. If success criteria are met, no further monitoring will be conducted. It should be noted that the USACE plans to fill Marsh Cell M7/8/9 in 2015. The planned filling will inundate the proposed construction corridor with a thin layer of sediment and water for a period of time. The PHA cannot guarantee the long term survival or propagation of the replanted vegetation after that time.

Tidal Marsh Mitigation

MONITORING REQUIREMENTS

Monitoring Methods

Mitigation for Permanent Impacts

Monitoring requirements for the compensatory mitigation area will adhere to the 2008 Final Compensatory Mitigation Rule and USACE Regulatory Guidance Letter 08-03. Monitoring studies at the BNC will be conducted on an annual basis for up to three years after all mitigation activities are complete. Monitoring studies at the BNC will occur annually past the nominal three year required monitoring period only if the mitigation site does not meet success criteria during that time.

Success criteria of the compensatory mitigation area will be evaluated annually. The assessment of wetland vegetation establishment and the iHGM assessment will be determined by a visual assessment of pre-established sample plots located in the created wetlands. All variables required to complete the iHGM will be assessed and quantified. The location of each of these sample plots will be randomly determined, but will remain fixed for all subsequent monitoring events. This will allow for an accurate determination of the progress of the wetland as it matures, and will limit variation in assessment results due to site-specific differences.

Mitigation for Temporary Impacts

Monitoring studies at the PA 15 temporary impact site will be conducted six months following completion of planting. The assessment of wetland vegetation establishment and quantification of the areal vegetative coverage will be determined by a visual assessment of the planted areas. If success criteria are met, no further monitoring will be conducted.

Monitoring Reports

Mitigation for Permanent Impacts

An as-built mitigation monitoring report, detailing the site conditions immediately after completion of construction, will include a project description, project history, aerial photographs, as-built drawings, and an estimate of the percent survival of installed vegetation. The as-built mitigation monitoring report will be submitted to the USACE within three months after all construction and planting activities are complete. Thereafter, the site will be monitored annually for up to three years, or until the mitigation site meets success criteria.

All subsequent annual monitoring reports will include descriptions of the entire proposed mitigation site. The annual monitoring reports will describe the results of the iHGM analysis, provide photographic documentation of the proposed mitigation sites, discuss results in comparison to performance standards, and if needed, provide recommendations for corrective actions that might be necessary to compensate for deficiencies.

Mitigation for Temporary Impacts

Mitigation for temporary impacts at the PA 15 temporary construction corridor will be monitored six months following revegetation of the impact site. A Mitigation Monitoring Report will be submitted to the USACE describing the results of the monitoring assessment, the areal coverage of installed vegetation, provide photographic documentation of the proposed mitigation sites, discuss results in comparison to performance standards, and if needed, provide recommendations for corrective actions that might be necessary to compensate for deficiencies. The USACE plans to fill the Marsh Cell M7/8/9 in 2015. The planned filling will inundate the proposed construction corridor with a thin layer of sediment and water for a period of time. The PHA cannot guarantee the long term survival or propagation of the replanted vegetation after that time.

Achievement of Success Criteria for Both Mitigation Areas

Once the proposed mitigation sites have been determined to have met the minimum success criteria, the USACE will be notified in writing within 30 days of the last monitoring event that the mitigation plan has met minimum success. If the success criteria are not met at the scheduled times after initial planting activities and during the first three years of monitoring at the BNC, or within six months at the PA 15 temporary construction corridor, areas in need of

Tidal Marsh Mitigation

rehabilitation will be improved via the methods outlined in the Maintenance Plan section of this Tidal Marsh Mitigation Plan.

Should any condition be observed that is indicative of a problem at the proposed mitigation sites, the condition will be evaluated and a solution recommended in the Recommendation Section of the annual monitoring reports. Solutions may include erection of predator barriers, installation of additional vegetation, adjusting site elevations, or other prudent solutions that are dependent on the site and situation. Should undesirable plant species threaten the proposed projects, these species will be eradicated manually or mechanically by industry-approved methods that will not harm wildlife or aquatic resources.

Should corrective action be required during the monitoring and maintenance period, the applicant will implement the appropriate mitigation action in order to assure that project success criteria are achieved.

All monitoring reports will be submitted to:

**United States Army Corps of Engineers
 Galveston District
 2000 Fort Point Road
 Galveston, TX 77550**

The applicant is the responsible party for conducting the monitoring. The applicant may choose to hire a reputable environmental consultant to perform the monitoring, analyze the data collected, and prepare a monitoring report in accordance with this Tidal Marsh Mitigation Plan. The applicant is the responsible party for providing the monitoring reports to the USACE, at the address listed above, unless otherwise directed by the USACE.

LONG-TERM MANAGEMENT

After performance standards have been achieved and the mitigation areas have met all success criteria, long-term management is needed to ensure the sustainability of the resource. The Final Mitigation Monitoring Report for the proposed project will include a description of management needs and the funding mechanism that will be used to meet those needs. Additional details are located in the **Site Protection Instrument** section of this Mitigation Plan.

ADAPTIVE MANAGEMENT

Adaptive management is a strategy to address unforeseen changes in site conditions or other components of the compensatory mitigation project. If the compensatory mitigation project cannot be constructed in accordance with the approved Tidal Marsh Mitigation Plan, or if performance standards are not being met as anticipated, the permittee must notify the USACE, with approval required for any significant modification of the Tidal Marsh Mitigation Plan. Performance standards may be revised in accordance with adaptive management to account for measures taken to address deficiencies in the mitigation project.

For the proposed mitigation areas, adaptive management may include the following measures:

- Plant additional wetland vegetation species in areas where new growth is inadequate
- Adjust site conditions to improve hydrologic conditions
- Improve or enhance erosion control measures
- Provide for additional access restrictions if human disturbance is impacting the site

The Final Mitigation Monitoring Report for the proposed project at the BNC will include additional adaptive management details and guidelines for implementation.

Adaptive management is a key component of this Tidal Marsh Mitigation Plan that provides for on-going evaluation and changes to the mitigation measures, as needed, to satisfy required compensation for impacts to waters of the U.S., including wetlands. The applicant or its successors or assigns will be responsible for implementing adaptive management to achieve mitigation success.

Tidal Marsh Mitigation

FINANCIAL ASSURANCES

The overall success of compensatory mitigation, including creation, restoration, and enhancement of natural ecosystems is subject to many variables. Site-specific factors such as local droughts, catastrophic storm events, fires or floods, pest infestations, herbivory, disease, or illegal entrance by off-road vehicles may negatively affect a compensatory mitigation project before it has achieved the specified performance standards, and thus may require additional effort or remediation to ensure functional success. The District Engineer determines if a project would require financial assurances on a case-by-case basis. Financial assurances may be necessary to ensure the initiation and successful completion of required compensatory mitigation, including but not limited to multiple-year plantings, invasive and/or nuisance species control, hydroperiod establishment, and any corrective actions following the initial physical phases of landscape construction (e.g., grading and planting).

Should the District Engineer determine that financial assurances are required for this project, the permittee will create and implement a USACE-approved performance bond, letter of credit, escrow, or causality insurance for the period of construction, planting, maintenance, and monitoring activities. The amount of the financial assurances will be established based on the size and complexity of the proposed compensatory mitigation project, the estimated amount required to construct and remediate the proposed compensatory mitigation project, and monitoring of the compensatory mitigation site. The financial assurances will also include a reasonable amount to cover contingency costs to meet performance standards or other amount determined to be appropriate to the level of the uncertainty for completion of a successful compensatory mitigation project.

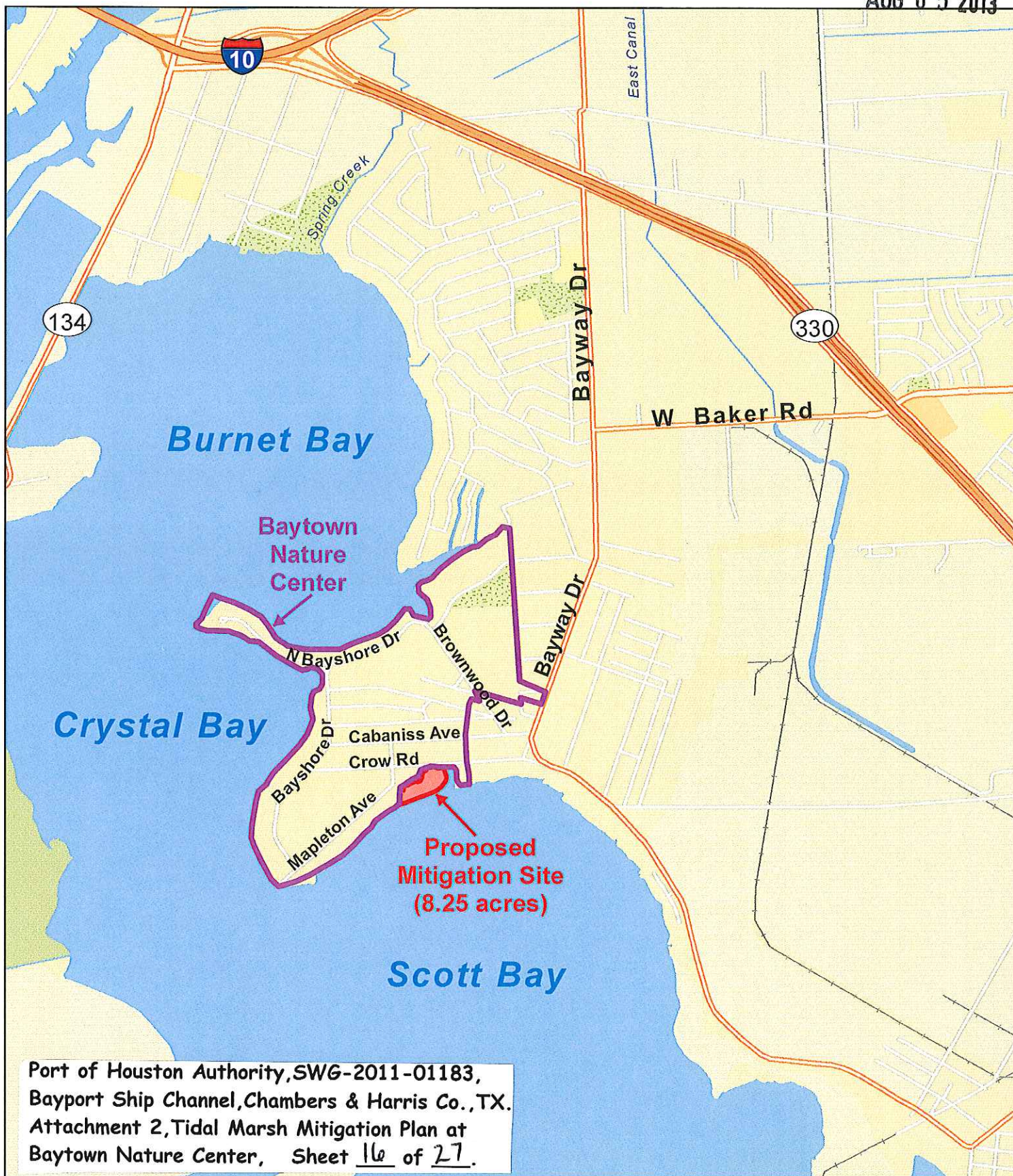
**Port of Houston Authority, SWG-2011-01183,
Bayport Ship Channel, Chambers & Harris Co., TX.
Attachment 2, Tidal Marsh Mitigation Plan at
Baytown Nature Center, Sheet 14 of 27.**

Tidal Marsh Mitigation

REFERENCES

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- Gould, F.W. 1975. *Texas Plants-A Checklist and Ecological Summary*. Texas Agricultural Experiment Station, Publication 585.
- McMahan, C.A., R.G. Frye, and K.L. Brown. 1984. *The Vegetation Types of Texas Including Cropland, an Illustrated Synopsis to Accompany the Map*. Texas Park and Wildlife Department. Austin, Texas.
- Neighbors, R.J., 2003. Subsidence in the Greater Houston Area – Past, Present and Future. Proceedings, CIGMAT-2003 Conference and Exhibition. Harris-Galveston Coastal Subsidence District and the Fort Bend Subsidence District.
- Region H Water Planning Group. 2009. 2011 Regional Water Plan. Chapter 3 – Analysis of Current Water Supplies.
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Port of Houston Authority, SWG-2011-01183,
Bayport Ship Channel, Chambers & Harris Co., TX.
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 Bayport Ship Channel, Chambers & Harris Co., TX.
 Attachment 2, Tidal Marsh Mitigation Plan at
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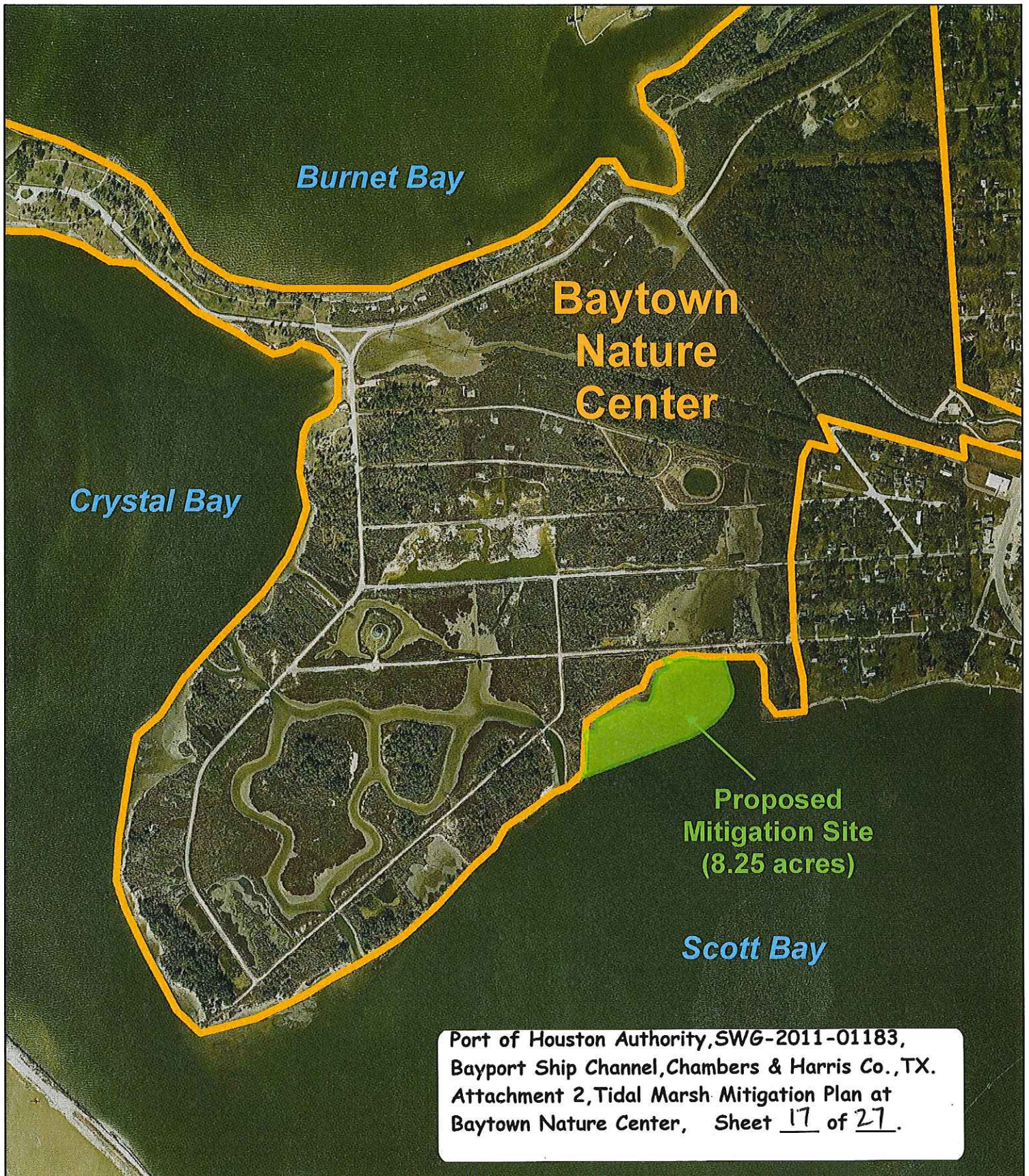


0 1,250 2,500
 Feet



Port of Houston Authority
 BSC Improvements PA 15 Mitigation
APPENDIX A
 VICINITY MAP

Harris County, Texas



N

0 400 800 Feet

CROUCH ENVIRONMENTAL SERVICES, INC.



Port of Houston Authority
 BSC Improvements PA 15 Mitigation
APPENDIX B
 2008 AERIAL PHOTOGRAPH
 WITH PROPOSED MITIGATION SITE

Harris County, Texas

Baytown Nature Center

Proposed Mitigation Site (8.25 acres)

Scott Bay

Buffalo Bayou-San Jacinto River
1204010407

Adlong Ditch-Cedar Bayou
1204020301

Clear Creek-Frontal Galveston Bay
1204020401

Dickinson Bayou
1204020204

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Bayport Ship Channel, Chambers & Harris Co., TX.
Attachment 2, Tidal Marsh Mitigation Plan at
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Atkinson Island

APPENDIX C



0 0.5 1
Miles



Port of Houston Authority
BSC Improvements PA 15 Mitigation
PROPOSED MITIGATION SITE
WITH 10-DIGIT HYDROLOGIC
UNIT CODES
Harris County, Texas

Port of Houston Authority, SWG-2011-01183,
Bayport Ship Channel, Chambers & Harris Co., TX.
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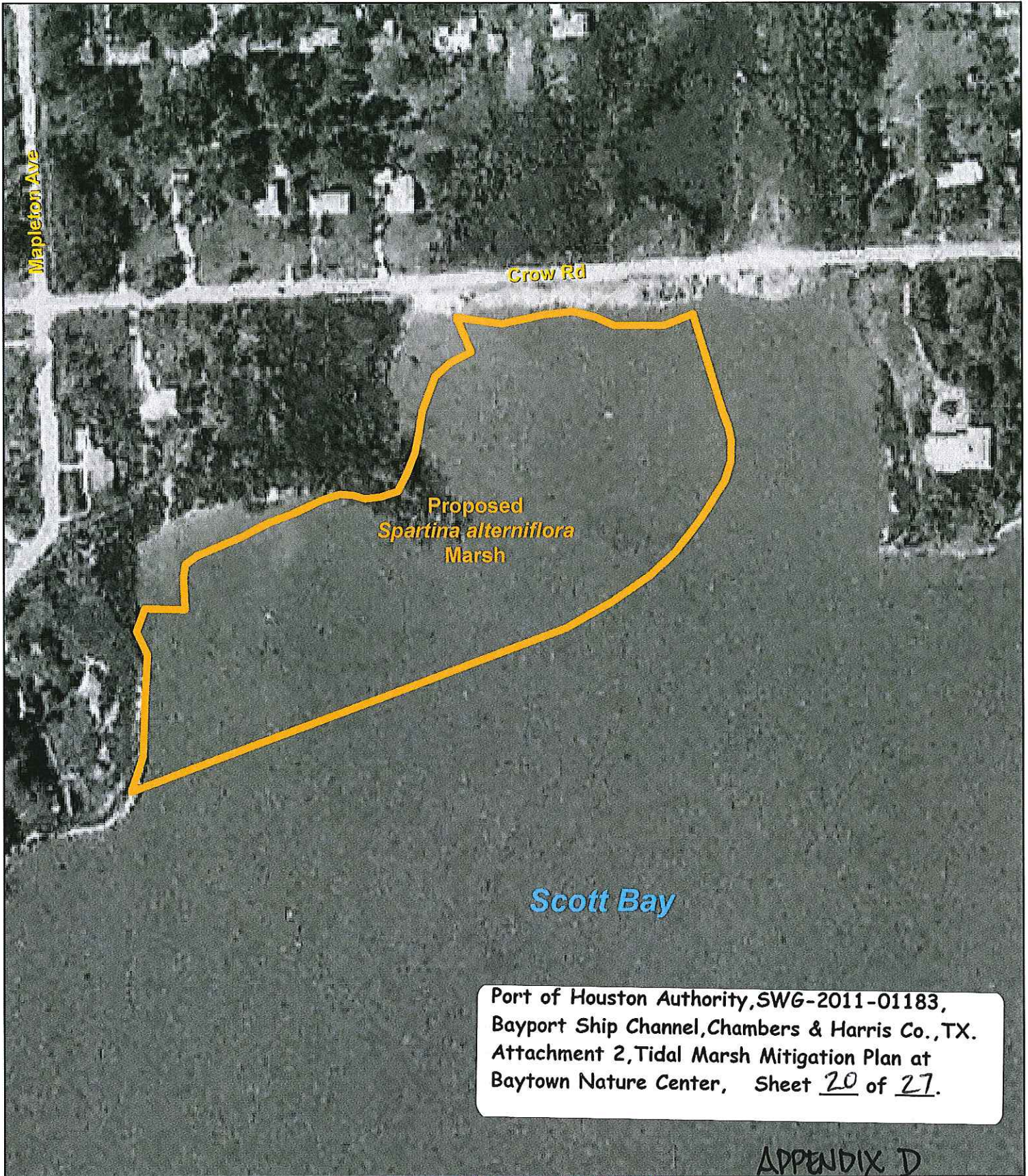


APPENDIX D

N
0 100 200
Feet
CROUCH ENVIRONMENTAL SERVICES, INC.



Port of Houston Authority
BSC Improvements PA 15 Mitigation
1953 HISTORICAL AERIAL
PHOTOGRAPH WITH PROPOSED
MITIGATION SITE OVERLAY
Harris County, Texas



Port of Houston Authority, SWG-2011-01183,
 Bayport Ship Channel, Chambers & Harris Co., TX.
 Attachment 2, Tidal Marsh Mitigation Plan at
 Baytown Nature Center, Sheet 20 of 27.

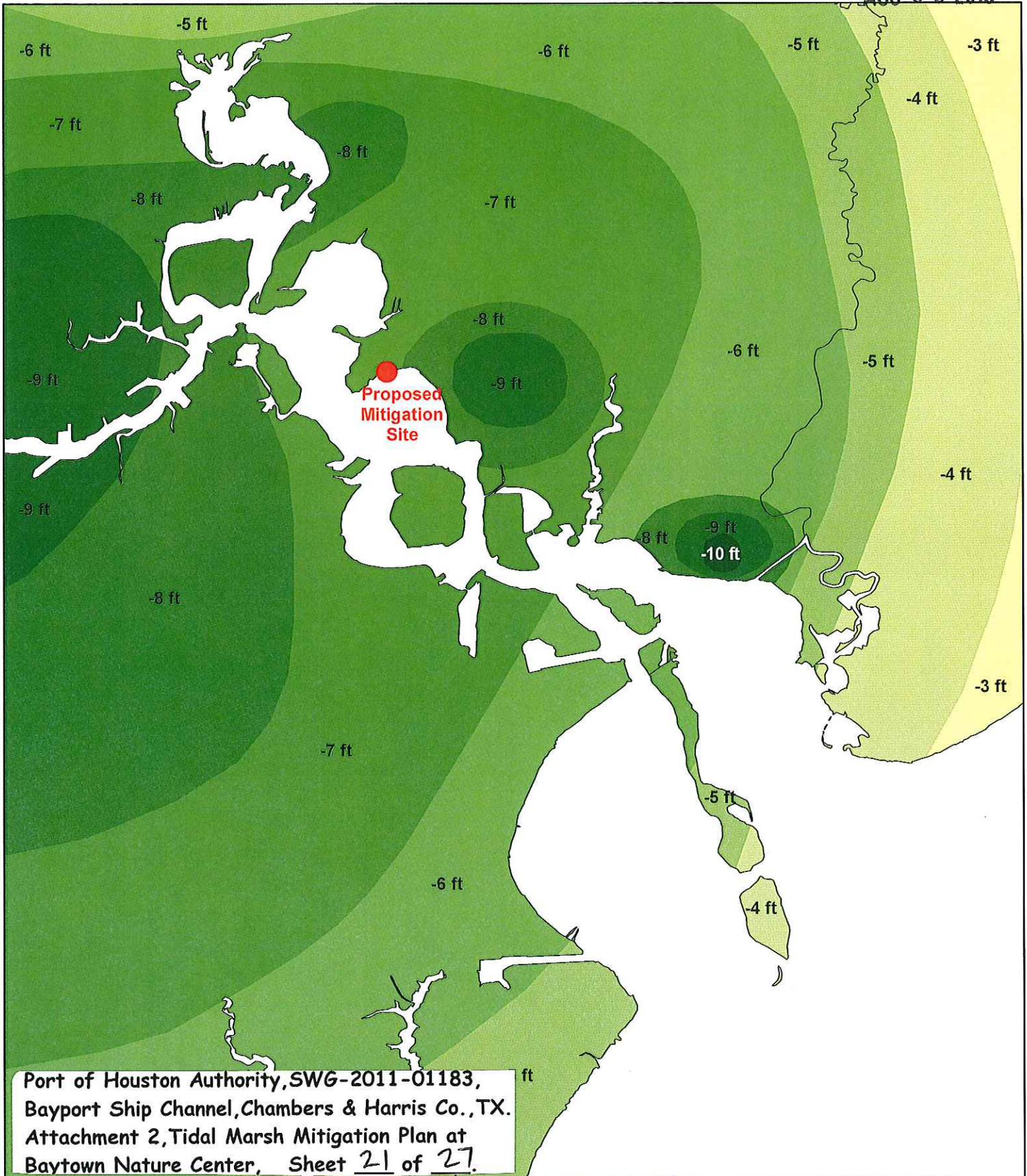
APPENDIX D

0 100 200 Feet

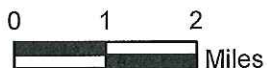
CROUCH ENVIRONMENTAL SERVICES, INC.



Port of Houston Authority
 BSC Improvements PA 15 Mitigation
 1978 HISTORICAL AERIAL
 PHOTOGRAPH WITH PROPOSED
 MITIGATION SITE OVERLAY
 Harris County, Texas



Port of Houston Authority, SWG-2011-01183,
 Bayport Ship Channel, Chambers & Harris Co., TX.
 Attachment 2, Tidal Marsh Mitigation Plan at
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CROUCH  **ENVIRONMENTAL SERVICES, INC.**



Port of Houston Authority
 BSC Improvements PA 15 Mitigation
APPENDIX E
 CHANGE DUE TO SUBSIDENCE 1906 - 2000

Harris County, Texas

Baytown Nature Center



Total Planted Mangroves: 0.15 acres

Total Project Area: 8.54 acres

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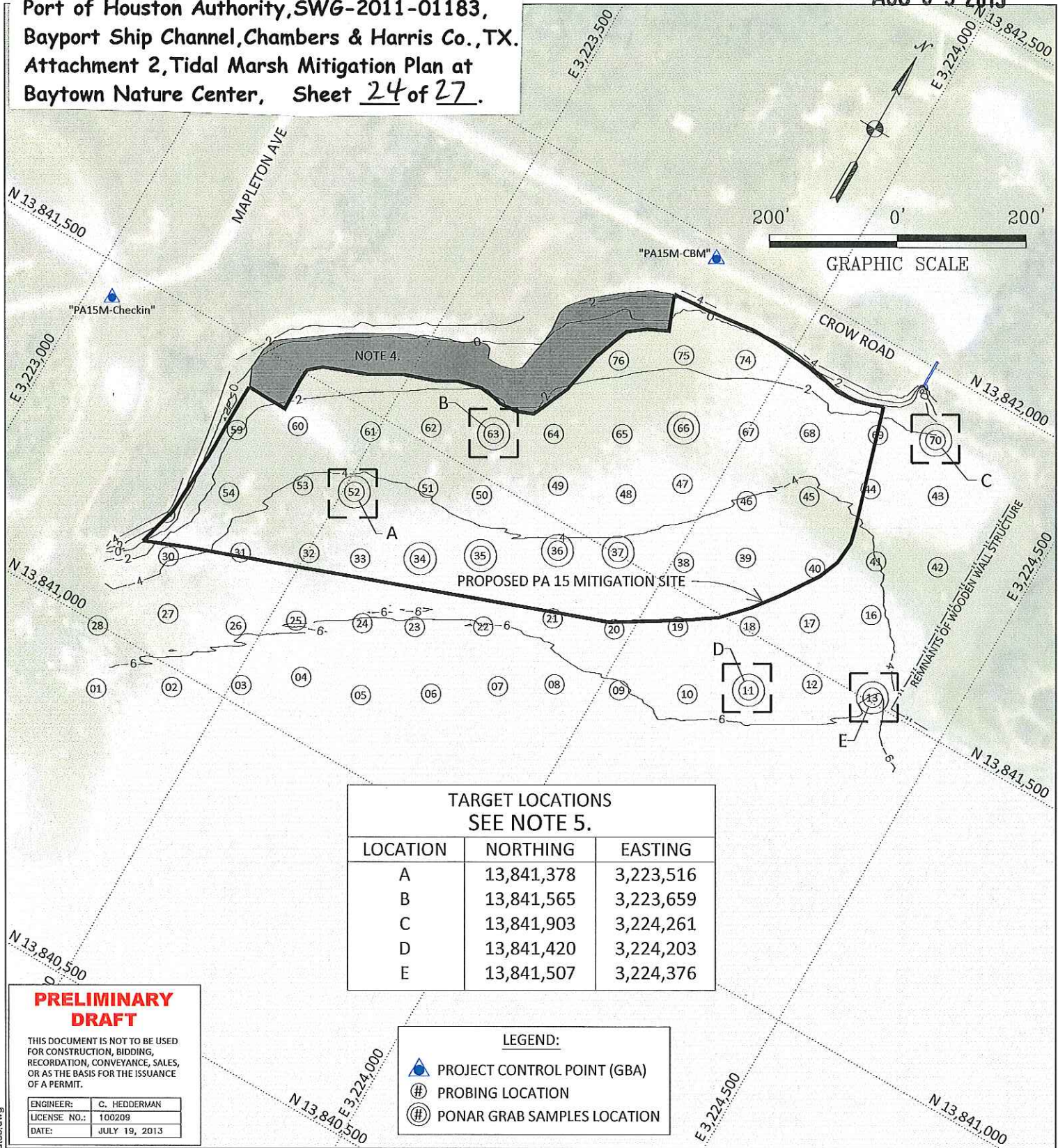
0 75 150
Feet



Port of Houston Authority
BSC Improvements PA 15 Mitigation
APPENDIX F
PROPOSED MITIGATION SITE

Harris County, Texas

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 Bayport Ship Channel, Chambers & Harris Co., TX.
 Attachment 2, Tidal Marsh Mitigation Plan at
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**TARGET LOCATIONS
SEE NOTE 5.**

LOCATION	NORTHING	EASTING
A	13,841,378	3,223,516
B	13,841,565	3,223,659
C	13,841,903	3,224,261
D	13,841,420	3,224,203
E	13,841,507	3,224,376

PRELIMINARY DRAFT

THIS DOCUMENT IS NOT TO BE USED FOR CONSTRUCTION, BIDDING, RECORDATION, CONVEYANCE, SALES, OR AS THE BASIS FOR THE ISSUANCE OF A PERMIT.

ENGINEER:	C. HEDDERMAN
LICENSE NO.:	100209
DATE:	JULY 19, 2013

LEGEND:

- PROJECT CONTROL POINT (GBA)
- PROBING LOCATION
- PONAR GRAB SAMPLES LOCATION

- NOTES:**
- AERIAL IMAGERY WAS OBTAINED FROM THE TNRS WEBSITE AND WAS DATED 2012.
 - PROPOSED MITIGATION SITE WAS TRACED FROM THE DRAFT COMPENSATORY MITIGATION PLAN, BSC IMPROVEMENTS PA 15 MITIGATION, USACE FILE SWG-2011-01183, PREPARED FOR THE PORT OF HOUSTON AUTHORITY, BY CROUCH ENVIRONMENTAL SERVICES, INC.
 - HORIZONTAL COORDINATES SHOWN ARE REFERENCED TO NAD83, TEXAS SOUTH CENTRAL ZONE 4204, VERTICAL ELEVATIONS ARE REFERENCED TO NAVD83, 2001 ADJUSTMENT, IN U.S. SURVEY FEET. ELEVATIONS SHOWN ARE FROM A TOPOGRAPHIC/HYDROGRAPHIC SURVEY BY GBA, JULY 2012.
 - GB BIOSCIENCES CORPORATION MARSH CREATION PROJECT, USACE PERMIT NO. SWG-2011-00125.
 - SPORADIC LIVE & DEAD OYSTER CLUSTERS WITH ATTACHED MUSSELS, INTERMIXED WITH SANDY SILT AREAS. LOCATIONS CONTAIN FALLEN TREES, TREE STUMPS, AND/OR BROKEN CONCRETE RIP RAP FALLEN FROM SHORELINE.

BAYPORT SHIP CHANNEL IMPROVEMENTS
 33 USC 408 Report

APPENDIX G PA 15 MITIGATION SITE
 BAYTOWN NATURE CENTER

TurnerCollie & Braden Inc.
 JOINT VENTURE PORT DEVELOPMENT AND ENVIRONMENTAL SERVICES
GAHAGAN & BRYANT ASSOCIATES

Date	JULY 2013	Job No.	60183643	Plate No. X
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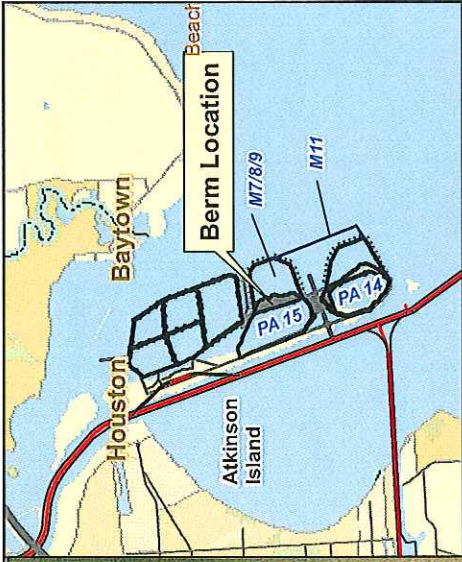
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Port of Houston Authority, SWG-2011-01183,
Bayport Ship Channel, Chambers & Harris Co., TX.
Attachment 2, Tidal Marsh Mitigation Plan at
Baytown Nature Center, Sheet 25 of 27.

M7/8/9

PA 15

50 ft Construction Corridor Extent



Background: HGAC 2012 Aerial

Legend

- 50 ft Construction Corridor Limit
- Toe of Proposed Stability Berm
- Tidal Wetlands within Footprint of Proposed Stability Berm and the 50 ft Construction Corridor
- HGNC PAs Already Built, In-Progress, or Planned

BAYPORT SHIP CHANNEL IMPROVEMENTS
ENVIRONMENTAL ASSESSMENT FOR
SECTION 408 AND SECTION 204 REPORTS

APPENDIX H
Tidal Wetland Delineation
East of PA15 Levee



Turner Collie & Braden, Inc.
GAHAGAN & BRYANT ASSOCIATES

Date: July 2013 Job No. 60183643 Exhibit 3.2.1-1

Appendix I

Select value for each variable by placing an "X" in the appropriate yellow boxes

1 Vedges: The amount of marsh-water meters/hectare

Site Description	Qualitative	Quantitative	Sub Index
Marsh shows deterioration due to subsidence, large amounts of open water	Very High	>800 m ² /ha (>1,062 ft ² /acre)	0.8
Well developed tidal drainage network present	High	350 - 800 m ² /ha (465 - 1,052 ft ² /acre)	1.0
Simple tidal network with isolated ponds & depressions in the marsh interior	Mediocre	200-350 m ² /ha (265 - 465 ft ² /acre)	0.7
Marsh lacks both tidal creeks & isolated ponds & depressions, shoreline is linear or smooth - Marsh area is large relative to shoreline length. On the WAA is a depression that is not affected by the daily tide (i.e. high marsh)	Low	Less than 200 m ² /ha (<266 ft ² /acre)	0.4

2 Veydor: Site hyperperiod or degree of hydrological modifications

Site Description	Sub Index
Site is open, no hydrologic restrictions	1.0
Moderate hydrologic restriction (i.e. levees/seals overtopped frequently by waves, or has marsh breaches or large numerous culverts)	0.6
Severe hydrologic restriction (High elevation berm with infrequent overtop, small culverts, single opening or breach)	0.3
Site receives water only during extreme storm events	0.1
Site is cut off from tidal exchange	0.0

3 Vvchc: Number of nekton habitat types present

Habitat types within 150 ft of the edge of the WAA	Sub Index
Low Marsh	0.2
High Marsh	0.3
Subtidal creeks	0.5
Intertidal creeks	0.7
ponds or depressions	0.8
SAVs	1.0
Oyster Reef	
Unvegetative flats	
Algal flats	
Coarse woody debris	

4 Vvypal: Proportion of the site that is covered by vegetation typical of the regional subclass

(*Spartina subifera*, *Alternanthera philoxeroides*, *Aster spinosus*, *Phragmites drummondii*, *Sesbania drummondii*, *Typha sp*, *Cyperus eriantherus*)

Total % Cover by typical species	Variable Sub Index
10%	0.1
20%	0.1
30%	0.2
40%	0.4
50%	0.5
60%	0.6
70%	0.7
80%	0.9
90%	1.0
100%	1.0

5 Vvlope: Distance to water greater than or equal to 6 feet deep

Distance to navigation channel or water greater than or equal to 6 ft deep	Variable Sub Index
Less than 150 ft	0.10
151-450 ft	0.50
Greater than 450 ft	1.00

Variable	Subindex
V _{edge}	0.40
V _{hydro}	0.60
V _{vchc}	0.80
V _{vypal}	1.00
V _{slope}	0.10
V _{width}	0.85
V _{rough}	1.00
V _{soil}	0.80

Year 1

Biota:	
FCL = [(V _{edge} * 2 V _{hydro} + 0.5 V _{vchc})/3.5] + V _{vypal} /2	
FCL = 0.79	
Botanical	
FCL = V _{vypal}	
FCL = 1.00	
Physical	
FCL = [(V _{slope} + V _{width} + V _{rough} + V _{soil} + V _{hydro})/5]	
FCL = 0.67	
Chemical	
FCL = (V _{vypal} * V _{hydro}) ^{1/2}	
FCL = 0.77	

Sub Index	Criteria	Anticipated Year 1 FCUs
Biota	6.00	6.48
Botanical	7.50	8.25
Physical	5.40	5.53
Chemical	6.35	6.39

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Appendix I

5

Vvwidth: Average marsh width
Mean Width WAA Distance (ft)

Variable Sub Index	0-30 ft	31-75 ft	76-150 ft	151-225 ft	226-300 ft	301-375 ft	376-450 ft	451-525 ft	526-600 ft	Greater than 600 ft
	0.1	0.25	0.5	0.6	0.8	x	0.9	0.95	1.0	1.0

7

Vrough: Manning's roughness coefficient
fBase + fTopo + fveg = manning's end

(fBase) =	0.025	0.030	X
Sediment surface	0.025	0.030	X
(fTopo) =	0.001		
Topographic relief	0.001		
WAA is flat no microtopographic or macrotopographic relief	0.005		X
WAA has 5-25% topographic relief	0.010		
WAA has 26-50% topographic relief	0.20		
WAA has greater than 50% topographic relief			
(fveg) =	0.070		
Vegetation	0.070		
Less 50% cover	0.030		
50-75% cover	0.040		
76-100% cover	0.050		
100% cover	0.060		
0.070	0.100		
		X	

Description of Conditions

Predominantly short flexible stem grass (i.e. Spartina alterniflora, S. patens, Distichlis spicata)			
Predominantly short stiff trailing sedge (i.e. Batis & Salicornia)			
Predominantly tall flexible grass (i.e. tall Spartina alterniflora, S. cynosuroides, Scirpus sp.)			X
Predominantly tall with stiff leaves or mixed with woody shrubs (i.e. Juncus roemerianus, Mangroves, etc.)			

Roughness (rounded down) = 0.09

FCI variable sub index =

Variable Sub Index	"x" Automatically picked
0.04	0.1
0.05	0.2
0.06	0.4
0.07	0.6
0.08	0.8
0.09	1.0
0.10	1.0

LookUp

6
1

8

Vsoil

Soil Texture	Variable Sub Index
Sandy	0.2
Sandy loam	0.40
Loam	0.6
Clay loam	0.8
Clay	1.0

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