Potential Sites for Wetland Restoration, Enhancement, and Creation: Corpus Christi/Nueces Bay Area

WATER QUALITY

ECOTOURISM

HABITAT & LIVING RESOURCES

A Joint Project of the
Corpus Christi Bay National Estuary Program
and the Texas General Land Office

In conjunction with the
Center for Coastal Studies, TAMU-CC

Corpus Christi Bay National Estuary Program

CCBNEP-15 July 1997

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POTENTIAL SITES FOR WETLAND RESTORATION, ENHANCEMENT, AND CREATION: CORPUS CHRISTI/NUECES BAY AREA

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CORPUS CHRISTI BAY NATIONAL ESTUARY PROGRAM

The Corpus Christi Bay National Estuary Program (CCBNEP) is a four-year, community based effort to identify the problems facing the bays and estuaries of the Coastal Bend, and to develop a long-range, Comprehensive Conservation and Management Plan. The Program's fundamental purpose is to protect, restore, or enhance the quality of water, sediments, and living resources found within the 600 square mile estuarine portion of the study area.

The Coastal Bend bay system is one of 28 estuaries that have been designated as an **Estuary of National Significance** under a program established by the United States Congress through the Water Quality Act of 1987. This bay system was so designated in 1992 because of its benefits to Texas and the nation. For example:

- Corpus Christi Bay is the gateway to the nation's sixth largest port, and home to the third largest refinery and petrochemical complex. The Port generates over $1 billion of revenue for related businesses, more than $60 million in state and local taxes, and more than 31,000 jobs for Coastal Bend residents.
- The bays and estuaries are famous for their recreational and commercial fisheries production. A study by Texas Agricultural Experiment Station in 1987 found that these industries, along with other recreational activities, contributed nearly $760 million to the local economy, with a statewide impact of $1.3 billion, that year.
- Of the approximately 100 estuaries around the nation, the Coastal Bend ranks fourth in agricultural acreage. Row crops -- cotton, sorghum, and corn -- and livestock generated $480 million in 1994 with a statewide economic impact of $1.6 billion.
- There are over 2600 documented species of plants and animals in the Coastal Bend, including several species that are classified as endangered or threatened. Over 400 bird species live in or pass through the region every year, making the Coastal Bend one of the premier bird watching spots in the world.

The CCBNEP is gathering new and historical data to understand environmental status and trends in the bay ecosystem, determine sources of pollution, causes of habitat declines and risks to human health, and to identify specific management actions to be implemented over the course of several years. The 'priority issues' under investigation include:

- altered freshwater inflow
- declines in living resources
- loss of wetlands and other habitats
- bay debris
- degradation of water quality
- altered estuarine circulation
- selected public health issues

The **COASTAL BEND BAYS PLAN** that will result from these efforts will be the beginning of a well-coordinated and goal-directed future for this regional resource.

STUDY AREA DESCRIPTION

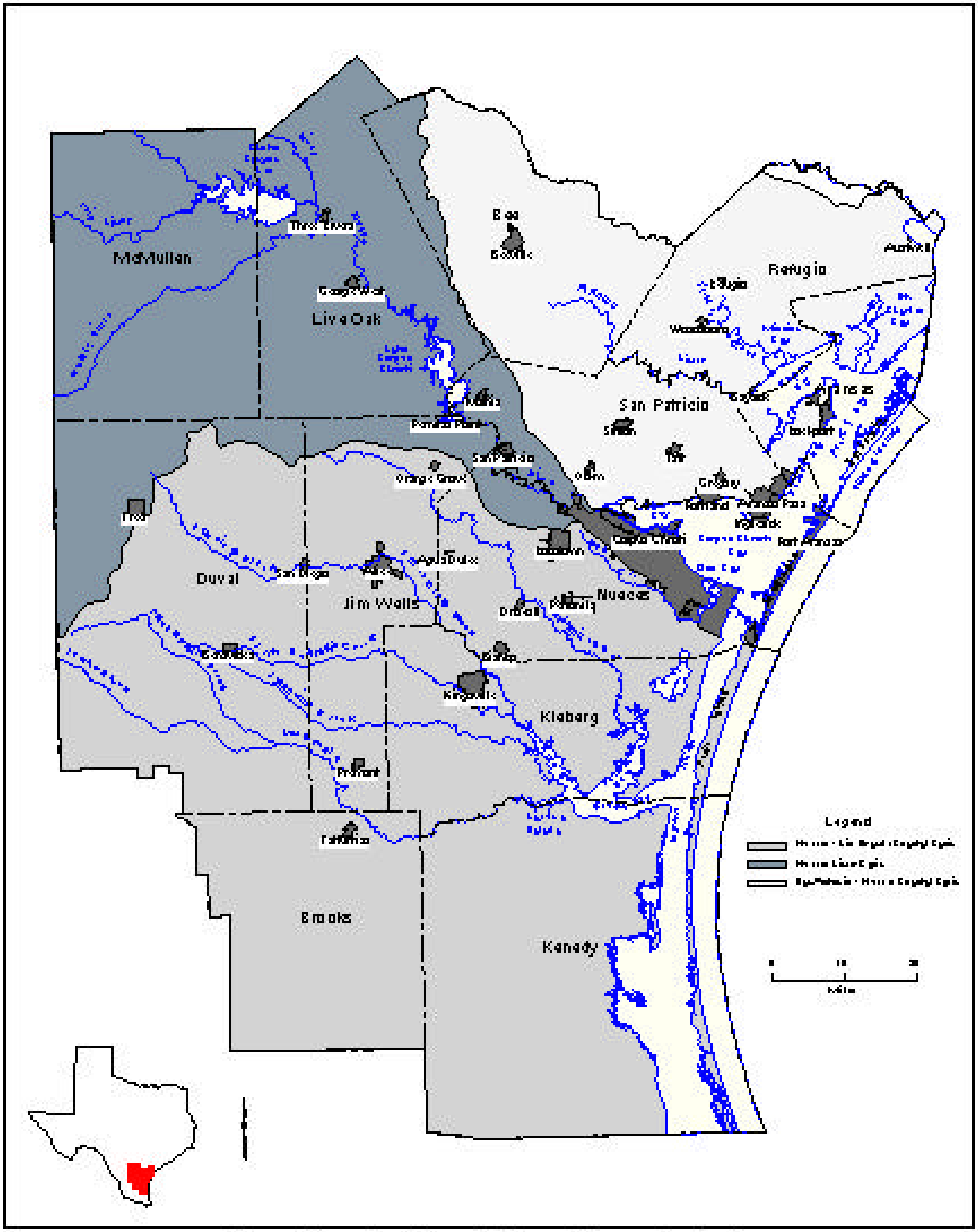
The CCBNEP study area includes three of the seven major estuary systems of the Texas Gulf Coast. These estuaries, the Aransas, Corpus Christi, and Upper Laguna Madre are shallow and biologically productive. Although connected, the estuaries are biogeographically distinct and increase in salinity from north to south. The Laguna Madre is unusual in being only one of three hypersaline lagoon systems in the world. The study area is bounded on its eastern edge by a series of barrier islands, including the world's longest -- Padre Island.

Recognizing that successful management of coastal waters requires an ecosystems approach and careful consideration of all sources of pollutants, the CCBNEP study area includes the 12 counties of the Coastal Bend: Refugio, Aransas, Nueces, San Patricio, Kleberg, Kenedy, Bee, Live Oak, McMullen, Duval, Jim Wells, and Brooks.

This region is part of the Gulf Coast and South Texas Plain, which are characterized by gently sloping plains. Soils are generally clay to sandy loams. There are three major rivers (Aransas, Mission, and Nueces), few natural lakes, and two reservoirs (Lake Corpus Christi and Choke Canyon Reservoir) in the region. The natural vegetation is a mixture of coastal prairie and mesquite chaparral savanna. Land use is largely devoted to rangeland (61%), with cropland and pastureland (27%) and other mixed uses (12%).

The region is semi-arid with a subtropical climate (average annual rainfall varies from 25 to 38 inches, and is highly variable from year to year). Summers are hot and humid, while winters are generally mild with occasional freezes. Hurricanes and tropical storms periodically affect the region.

On the following page is a regional map showing the three bay systems that comprise the CCBNEP study area.



Corpus Christi Bay National Estuary Program Study Area

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POTENTIAL SITES FOR WETLAND RESTORATION, ENHANCEMENT, AND CREATION: CORPUS CHRISTI/NUECES BAY AREA

EXECUTIVE SUMMARY

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Coastal wetlands provide numerous biological, physical, and chemical functions, including groundwater discharge/recharge, flood storage and desynchronization, shoreline erosion control, sediment trapping, water quality improvement, food chain support/nutrient export, fisheries and wildlife habitat, and recreation/education/culture. Despite their value, coastal wetlands are disappearing. Recent estimates of wetland loss, coastwide, show that estuarine emergent wetlands decreased by 9.5% between the mid-1950s and the early 1990s; palustrine emergent wetlands declined by about 29 %; forested wetlands or bottomland hardwoods declined by 10.9%; and palustrine scrub-shrubs increased by 58.7%. As a consequence of the importance of coastal wetlands and the losses and degradation of both marine resources and wetland habitats, restoration, enhancement, and habitat creation are receiving greater attention.

This report is the result of the cooperative efforts between Environmental Protection Agency (EPA), Texas General Land Office (GLO), Center for Coastal Studies (CCS), and the Corpus Christi Bay National Estuary Program (CCBNEP). Funding was provided by EPA, Region 6, through a State Wetlands Grant to the Coastal Division, GLO. Both GLO and CCS staff produced the document, and CCBNEP provided technical assistance and published the final report.

The purpose of this report is to help state and federal agencies, conservation organizations, and other resource managers restore, enhance, or create wetlands on a watershed scale using grants or other financial sources for project planning, implementation, and monitoring. The report is intended to serve as a reference for agencies and organizations interested in restoration, enhancement, or creation of wetlands in the Corpus Christi/Nueces Bay area. It does not represent a consensus view of priority activities, nor identify all areas potentially suited for wetlands restoration, enhancement, or creation. A site-specific evaluation will be necessary at these and other potential sites to determine their feasibility and cost effectiveness. In addition, efforts to satisfy broader system-wide needs will be contingent upon status and trend results of wetlands in the study area. These wetland restoration, enhancement and creation efforts

Some areas identified in the report are contained within or adjacent to private lands. Efforts were made to contact property owners where possible, but some owners were not identified or contacted during document preparation. No lands were entered without landowner permission. All assessments of sites whose landowners were not contacted were made from adjoining publicly accessible areas. Identification of such lands within this document does not constitute consent by the landowner to include their property in restoration or enhancement projects. This report simply identifies potential restoration sites and presents conceptual plans for those sites. Organizations interested in implementing restoration projects should identify property owners and contact them regarding their interest in the project before moving forward.

The Corpus Christi/Nueces Bay study area is on the south central Texas coast and includes all of Nueces County and approximately the southeast one-fourth of San Patricio County. The study area of this report is only part of the overall study area for the Corpus Christi Bay National Estuary Program (CCBNEP). Wetlands in the study area have been variously described and mapped; however, little has been published about their current status and trends.

Field investigations of potential sites for wetland restoration, enhancement, and creation were conducted from October 1995 through May 1996 within each of the following ecological areas: Nueces River and delta, Oso Creek and Bay, Encinal and Live Oak peninsulas, North Nueces/Corpus Christi Bay drainage, Indian Point/Corpus Christi Beach, upper Laguna Madre, and Mustang Island. Field visits, historical photographs, and correspondence with advisory group members were used to evaluate the sites for causes of wetland degradation or loss. Sites on private lands were assessed from adjacent public property, aerial photographs, and descriptions in published literature, or accessed with permission of the landowner.

Based on all available information for each site, a conceptual restoration, enhancement, or creation plan was developed incorporating all appropriate components: construction, modification of water regime, and restoration and protection of wetland vegetation and/or wetland fauna. The importance of establishing goals at the development stage of a project and defining and implementing an appropriate monitoring strategy was addressed, particularly in regard to functional assessments. Sites were evaluated for existing functions and values and potential restoration, enhancement, or creation of functions and values. Discussions of site and functional design criteria, monitoring, and functional assessments were included to assist in achieving project goals and objectives.

Four broad categories were used for estimating implementation costs for each project: low (projects less than $10,000); medium (projects ranging from $10,000 to $50,000); and high (projects greater than $50,000 but less than $1,000,000) and very high (projects greater than $1,000,000). Potential partnerships were suggested for planning, implementation, and/or monitoring for each site and descriptively by programs, with principal contacts included for each program.

Thirty-nine sites were identified and evaluated for potential wetland restoration, enhancement, or creation. Six sites are located within the Nueces River delta, eight sites along the Nueces/Corpus Christi Bay shorelines, two sites within Corpus Christi Beach area, three sites on Indian Point, four sites within the Oso Creek and Bay complex, three sites on Encinal Peninsula, three sites on Live Oak Peninsula, eight sites on Mustang Island, and two sites within upper Laguna Madre. Four classes of wetland systems, Estuarine, Palustrine, Riverine, and Lacustrine, were represented in the final sites. Some sites were representative of a single system; other sites represented three of the four systems.

Most of the sites currently would exhibit between four and six potential functions and values. Four sites provide eight potential functions and values, four sites have nine, and three sites could provide ten functions and values. All restoration, enhancement, or creation projects, when implemented, could potentially improve food chain support/nutrient export, and fisheries and wildlife habitat functions. Implementation of twenty-five projects could potentially enhance recreational values, twenty-one sites could improve water quality, nineteen sites could improve sediment trapping functions, and nineteen sites could be used as educational sites. Eleven sites could assist in flood storage and desynchronization, seven sites could be used as illustrating cultural values in the study area, and six sites as performing potential groundwater discharge or recharge.

The sites represent a wide distribution of estimated costs for implementation, with 9 designated as low cost, 10 as medium cost, one as medium to high cost, fifteen as high cost, two as high to very high cost, and two sites as very high cost. Eleven federal and five state and private programs are available to assist state and local governments, private landowners, and others in funding and providing technical assistance for implementing wetland restoration, enhancement, and creation projects.

Future studies should include expanding the geographic scope of this research on Nueces and part of San Patricio counties to include identifying potential sites for wetland restoration, enhancement, and creation in the remainder of the CCBNEP study area, or the remainder of San Patricio County, and Refugio, Aransas, Kleberg, Kenedy, Bee, Live Oak, McMullen, Duval, Jim Wells, and Brooks counties. Results of the ongoing research on current status and historical trends of wetlands in the CCBNEP study area (White *et al.,* 1996) can be used to focus on restoring, enhancing, or creating those wetland types within the Corpus Christi/Nueces Bay study area that are most threatened, scarce, and/or vulnerable. In addition, efforts should be made to incorporate wetland restoration, enhancement, and creation projects in relation to landscape-level conservation goals for long-term sustainability of natural resources in the Corpus Christi Bay management area.

INTRODUCTION

WHY COASTAL WETLANDS ARE IMPORTANT

Coastal wetlands, an integral part of estuarine ecosystems, have tremendous biologic and economic values. Texas coastal wetlands serve as nursery grounds for over 95 percent of the recreational and commercial fish species found in the Gulf of Mexico. They provide breeding, nesting, and feeding grounds for more than a third of all threatened and endangered animal species and support many threatened plant species. In addition, Texas coastal wetlands support permanent and seasonal habitat for a great variety of wildlife, including 75 percent of North America's bird species.

Coastal wetlands also perform many chemical and physical functions. Wetlands retain pollutants such as suspended material, excess nutrients, toxic chemicals, and disease-causing microorganisms. Marshes filter nitrates and phosphates from rivers and streams that receive wastewater effluents. Pollutants associated with the trapped material in wetlands may be converted by biochemical processes to less harmful forms, or they may remain buried and be absorbed by the wetland plants themselves and either recycled or transported from the area. Studies indicate that restoring just one percent of a watershed's area to appropriately located wetlands has the potential to reduce polluted runoff of nitrates and herbicides by up to 50 percent (Robinson, 1995). Wetlands help reduce erosion by absorbing and dissipating wave energy, binding and stabilizing sediments, and increasing sediment deposition. Wetlands also reduce the hazards of hurricanes and other coastal storms by protecting coastal and inland properties from wind damage and flooding (Whittington *et al*., 1994). Primarily because of their topography or position in the landscape, wetlands can reduce, capture, and retain surface-water runoff, thus providing storage capacity and overall protection during periods of flooding. Wetlands which are located in the mid or lower reaches of a watershed contribute more to flood attenuation, since they are in the path of more water than their upstream counterparts. These values can provide economic benefits to downstream property owners. Wetlands also promote groundwater recharge by diverting, slowing, and storing surface water, thus allowing infiltration and percolation of water into the saturated zone.

THE NEED TO RESTORE, ENHANCE, AND CREATE WETLANDS

Coastal wetland loss from both natural and human-induced causes is significant in Texas and is a continuing concern because of the essential roles that wetlands perform. The Texas Parks and Wildlife Department (TPWD) estimates that 35 percent of the state's coastal marshes were lost between 1950 and 1979 (TPWD, 1995). Recent estimates of wetland loss for the entire coast show that estuarine emergent wetlands decreased by 9.5% between the mid-1950s and the early 1990s; palustrine emergent wetlands declined by about 29 %; forested wetlands or bottomland hardwoods declined by 10.9%; and Palustrine scrub-shrubs increased by 58.7% (Moulton *et al*., 1997).

The decline in coastal wetlands and other habitats, along with overharvesting and climate change, is one of the principal reasons for the decline in a number of living marine resources. Thayer (1992) states that "the increasing loss of fish habitat due to unwise development, pollution and other human activities is the single largest long-term threat to the future viability of marine fisheries in the United States." Habitat loss is the most widely cited probable cause of declining trends in certain species or groups in the CCBNEP study area (Tunnell *et al.*, 1996).

As a consequence of the recognized importance of coastal wetlands and the losses and degradation of both marine resources and wetland habitats, restoration, enhancement, and habitat creation are receiving greater attention. For example, the statute requiring the development of a State-owned Wetlands Conservation Plan (PARKS & WILDLIFE CODE §14.002) contains a goal of no overall net loss of state-owned coastal wetlands and includes provisions for sites for compensatory mitigation, enhancement, and restoration. The Corpus Christi Bay National Estuary Program (CCBNEP) identified wetland loss as one of the seven priority issues for the Corpus Christi Bay system (CCBNEP, 1996). Restoration, enhancement, and creation of wetland functions and values offer a unique opportunity to improve water and sediment quality, as well as provide additional wetland functions to the Corpus Christi/Nueces Bay area. Failure to restore wetlands and other aquatic ecosystems may result in sharply increased environmental costs later and permanent ecological damage.

USING THIS REPORT

The information in this report is designed to help state and federal agencies, conservation organizations, and other resource managers to restore, enhance, or create wetlands on a watershed scale using grant funds or other financial sources for project planning, implementation, and monitoring. A glossary has been included in Appendix A to aid the reader in the use of terms in this report. Natural resource trustee agencies and parties responsible for oil or chemical spills can use the information to develop and carry out plans to restore or enhance wetlands to remedy natural resource injuries from those spills. Applicants for permits from the U.S. Army Corps of Engineers may be able to develop and carry out mitigation plans to fulfill permit requirements for compensating for wetlands damaged from dredging or filling. However, potential sites included in this plan do not necessarily mean they are approved or suitable for use as compensatory mitigation sites for a Section 404 permit. Compensatory mitigation is only appropriate after wetland impacts have been avoided and minimized. In addition, each potential site selected for restoration, enhancement, or creation will need to be evaluated for endangered species, rookery concerns, etc., prior to developing site specific plans. Owners of sites identified in the report can also use the report to develop proposals for mitigation banks or to participate in the several financial incentive programs for wetlands conservation, restoration, or enhancement listed in the report.

This report is intended to serve as a technical reference to agencies and organizations involved or interested in restoration, enhancement, or creation of wetlands in the Corpus Christi/Nueces Bay area. It does not represent a consensus view of priority activities, but simply identifies areas technically suited to wetland restoration, enhancement, or creation and presents primarily conceptual plans for project implementation.

Some areas identified in the document are contained within or adjacent to private lands. Efforts were made to contact property owners where possible, but some area owners were not identified or contacted during the document preparation. Identification of such lands within this document does not constitute consent by the landowner to include their property in restoration or enhancement projects. This report simply identifies potential restoration sites and presents conceptual plans for those sites. Organizations interested in implementing restoration projects should identify property owners and contact them regarding their interest in the project before moving forward.

Wetland restoration is best approached in the holistic context of what the system has lost, or what cumulative functions and values have been degraded over time. The causes of degradation or loss may be more regional (i.e., reduction of freshwater inflow) than site-specific (i.e., road or channel construction through the wetland), or both, resulting in cumulative impacts to the wetland. Remediation of site-specific problems may not result in restoration of wetland functions if regional problems are not resolved. Therefore, the goal of a wetland restoration plan should be to provide information across the watershed scale that would ultimately restore structural and functional integrity of the estuarine system.

Ecosystem-wide restoration plans have suggested the following elements: establish long-term restoration goals, determine steps of a restoration plan, and develop an implementation strategy (Tanner, 1991). The second element is synthesized within this report by determining where sites have been lost or degraded and their position in the landscape with respect to adjacent habitats. The first element will be accomplished through the efforts of the Corpus Christi Bay National Estuary Program after evaluating results of status and trends of wetlands for the study area (White *et al*., 1996). The third element should incorporate results of the first and second to accomplish restoration goals through a cost-effective and successful restoration plan that has public acceptance and is governed by a combined philosophy of achieving sustainable use and sustainable development without degrading the wetland systems in the Texas Coastal Bend.

STUDY AREA

GENERAL SETTING

The Corpus Christi/Nueces Bay study area is on the south central Texas coast and includes all of Nueces County and approximately the southeast one-fourth of San Patricio County (Fig. 1). The study area includes all or part of 25 USGS 7.5-minute quadrangles. Also, Corpus Christi, Nueces, and Oso bays and part of upper Laguna Madre and Redfish Bay lie within the study area boundary. Rivers and creeks included in the area are the Nueces River and Oso, Petronila, and Gum Hollow creeks. The study area of this report is only part of the overall study area for the Corpus Christi Bay National Estuary Program.

The Corpus Christi/Nueces Bay estuary is the sixth largest in surface area among the ten bay-estuary-lagoon systems in Texas (Diener, 1975). The estuarine system has historically received wide variations of freshwater inflows, and these extreme inflows have made the estuary a highly diverse and dynamic system (Texas Natural Resource Conservation Commission [TNRCC], 1991).

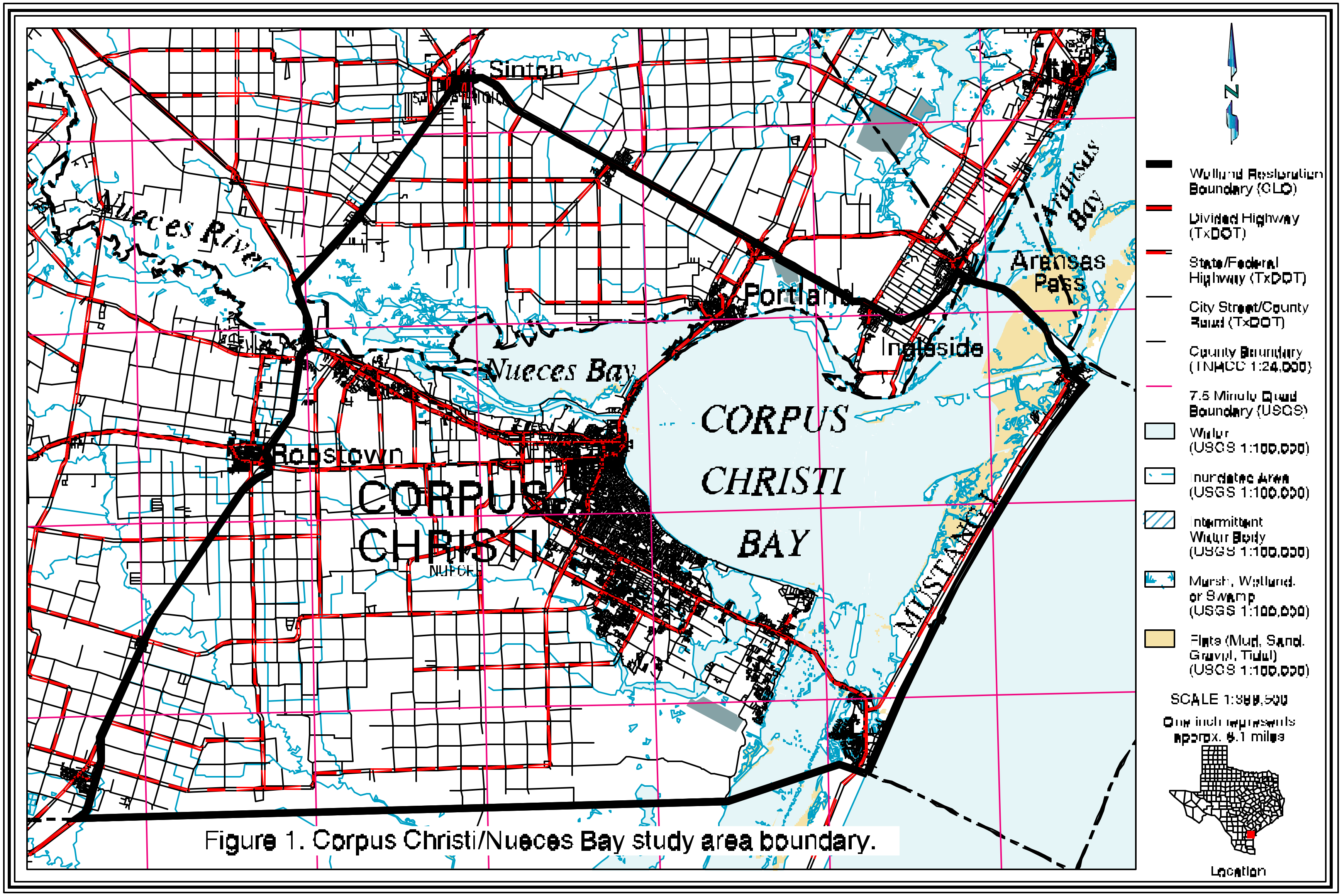

Figure 1. Corpus Christi/Nueces Bay study area boundary.

Several inlets from the bay-estuary-lagoon system to the Gulf of Mexico occur in the study area. There were two natural tidal inlets in the Corpus Christi map area until the early 1900's: Aransas Pass and Corpus Christi Pass (Packery Channel). The old Corpus Christi Pass was closed in 1929 as a consequence of human activities in upper Laguna Madre and Corpus Christi Bay. Aransas Pass, the only major tidal pass in the Corpus Christi map area, lies between St. Joseph and Mustang islands. Aransas Pass has been stabilized in its present position by jetty placement since the late 1800's. Fish Pass, also known as the Corpus Christi Water Exchange Pass, was dredged through Mustang Island in 1972 (Behrens and Watson, 1973). Fish Pass cuts through Mustang Island approximately 13 miles southwest of Aransas Pass. Packery Channel separates Mustang and Padre islands. Newport, Corpus Christi (new), and North passes are also shown on the map; these are ephemeral channels across the barrier islands which are active only following severe storms or hurricanes (Brown *et al*., 1976).

Geology

The present Texas coastline was formed principally by large-scale sea-level fluctuations (on the order of a few hundred feet) that occurred during the Quaternary Period in conjunction with repeated advance and retreat of continental ice sheets (Morton and Paine, 1984). The Quaternary Period (Pleistocene and Holocene epochs) began 2 to 3 million years ago with the onset of continental glaciation (sea-level fall). Subsequent melting of the ice sheets released the stored water and sea levels rose (Morton and Paine, 1984). Pleistocene fluvial and deltaic muddy and sandy sediments (Beaumont Formation) deposited in both marine and nonmarine environments surround the Corpus Christi/Nueces Bay area (Brown *et al.*, 1976). Pleistocene fluvial and deltaic deposits form the bluffs common in Corpus Christi, Oso, and Nueces bays. These deposits are found at elevations greater than 10 to 15 ft (3.0 to 4.5 m) above current sea level and are composed mostly of interdistributary mud (Brown *et al*., 1976). The Ingleside barrier-strandplain system is another extensive Pleistocene unit composed of sand approximately 3.0 mi (4.8 km) in width paralleling the coast along Encinal Peninsula and Live Oak Ridge.

After deposition of the Beaumont Formation, sea level lowered during Wisconsonian glaciation (approximately 18,000 to 120,000 years before present), and entrenchment of coastal rivers and streams occurred in response to the decline (Morton and Paine, 1984). Glacial retreat released stored water, causing sea level to rise. About 5,000 years ago, the rate of sea-level rise decreased. Estimates of rates of rise during the last 3,000 years range from 2.5 to 12.5 cm per century. During the Holocene, or the last 10,000 years, deposition of sediments partly-filled stream valleys (Morton and Paine, 1984). Several processes, including erosion of valley walls and oyster-reef growth, contributed to estuarine sedimentation, as the rate of sea-level rise diminished.

Active geologic processes in the Corpus Christi/Nueces Bay area include shoreline erosion/accretion and relative sea-level rise. Shoreline erosion rates, calculated for the period between the late 1800's and 1982 for Corpus Christi, Nueces, and Oso bays, indicate that Nueces Bay is shallower than Corpus Christi Bay, has a shorter wave fetch, and receives more fluvial sediment-factors that can promote shoreline accretion and reduce erosion (Morton and Paine, 1984). In southern Nueces Bay, 93 percent of the shoreline occupied a 1982 position bayward of its 1882 position; however, in northern Nueces Bay, about 45 percent of the 1982 shoreline held a position bayward of its late 1800's position (Morton and Paine, 1984). This disparity is a result of spoil disposal and rapid marsh progradation.

Corpus Christi Bay can be divided into eastern, northern, and southern sections (Morton and Paine, 1984). Eastern Corpus Christi Bay or the bay margin of Mustang Island encompasses an area of widespread shoreline retreat. In 1982, about 61 percent of the shoreline was located landward of its 1867 position. Approximately 28 percent of the southern Corpus Christi Bay shoreline was eroding, whereas more than 50 percent of the shoreline exhibited net accretion during the period between the late 1800's and 1982. Along the northern shoreline, nearly 40 percent of the 1982 shoreline occupied a position landward of that in 1867, whereas 33 percent of the shoreline held a position seaward of its 1867 position.

Changes in shoreline position in Oso Bay over the 100-year period between 1881-82 and 1982 generally reflect major changes that have occurred since 1934 (Morton and Paine, 1984). More of the shoreline was accreting over the 100-year period than during the 1934-to-1982 period. Only about 10 percent of the Oso Bay shoreline, a value significantly less than that for the 1881-82 to 1934 period, occupied a position in 1982 landward of its position in 1881-82. Relative sea-level rise, or a rise in sea level with respect to the surface of the land, has also impacted the area. Relative sea-level rise consists of two components, actual sea-level rise and subsidence. Eustatic or global sea-level rise is estimated to be about 2.3 mm/yr in the Gulf of Mexico (White and Calnan, 1990a). Subsidence may be caused by natural compaction of sediments or by withdrawal of underground fluids (Paine, 1993). Subsidence associated with fluid extraction in the Corpus Christi area appears to be minor and is primarily centered near Clarkwood and southern Nueces Bay (Morton and Paine, 1984). Subsidence in the Nueces fluvial-deltaic area is reported to be on the order of 0.2 to 1.0 ft (6 to 30 cm) for the period 1942-1951 (Brown and others, 1976). These amounts of subsidence translate into annual rates of about 0.28 to 1.2 in (0.7 to 3 cm) (White and Calnan, 1990a).

Surficial sediments in Nueces Bay are predominantly muddy sands (Mannino and Montagna, 1996). Sediments with the highest sand content occur at the river mouth and along the northern and southern shorelines. HDR Engineering, Inc. and Naismith Engineering, Inc. (1993) report that large reefs of live oysters were once found on the southeast side of Nueces Bay and extended west of the Nueces Bay Causeway. Historical records show that significant commercial harvests of the eastern oyster occurred in the bay through 1962 (TNRCC, 1991). However, large-scale dredging operations occurred in the bay from 1959 until 1974, and an estimated 13 million cubic yards of oyster shell was removed. Also, increased salinities from reduction or alteration of freshwater inflows may have contributed to the demise of the reefs (TNRCC, 1991).

Muddy sands are dominant in Corpus Christi Bay, with sandy sediments occurring along the shallow bay margins (White *et al.*, 1983). Sandy sediments are most abundant in upper Laguna Madre and in southern Redfish Bay (White *et al.*, 1983).

Soils

Detailed hydric soil information has been published by the United States Department of Agriculture's (USDA) Natural Resource Conservation Service (NRCS) on both Nueces and San Patricio counties (Appendices B and C). Properties of soils in the study area can have a significant impact on storm runoff depending on their permeability, erodability, and the hydrologic cover condition associated with land use or cover. The physical characteristics of soils change dramatically from the eastern or coastal counties toward the western counties of the study area. Generally clays, clay loams and fine sandy loams are predominant on the east while loamy sands, sands, and deep sands predominate on the west.

The major soil associations occurring in Nueces and San Patricio counties include the Victoria, Orelia-Banquete, Miguel-Willacy, Lomalta, Trinity-Frio-Zavala, Willacy-Clareville-Orelia, Clareville-Orelia, Aransas-Sinton-Odom, Pettus-Pharr, Galveston-Mustang, and Papalote-Delfina-Leming associations (Guckian and Garcia, 1979; Franke *et al.*, 1992). These series represent the largest extent of areal coverage in the study area. Information on soil series within the study area is located in published county soil survey reports or at the local NRCS office (Guckian and Garcia, 1979; Franke *et al.*, 1992; Baird *et al.*, 1996).

Wetland soil is both the medium in which many of the wetland chemical transformations take place and the primary storage of available chemicals for most wetland plants. Hydric soil is defined by the U.S. Soil Conservation Service (1987) as "a soil that is saturated, flooded, or ponded long enough during the growing season to develop anaerobic conditions in the upper part." There are two types of wetland soils: (1) mineral soils, and (2) organic soils (also called *Histosols*) (Mitch and Gosselink, 1993). Most soils have some organic material; however, when a soil has less than 20 to 35 percent organic matter (on a dry weight basis), it is considered a mineral soil. The U. S. Soil Conservation Service (1975) defined organic soils and organic soil materials under two conditions of saturation:

> 1. saturated with water for long periods or are artificially drained and, excluding live roots, (a) have 18 percent or more organic carbon if the mineral fraction is 60 percent or more clay, (b) have 12 percent or more organic carbon if the mineral fraction has no clay, or (c) have a proportional content of organic carbon between 12 and 18 percent if the clay content of the mineral fraction is between zero and 60 percent; or
>
> 2. never saturated with water for more than a few days and have 20 percent or more organic carbon.

Organic matter tends to accumulate in wetlands because of the imbalance between primary production and decomposition. All organic soils are defined as hydric (except for Folists, an uncommon soil type derived from decomposed leaves), regardless of water table depth. Any soil that is frequently ponded or flooded during the growing season is defined as hydric. All other soils are defined as hydric on the basis of a combination of soil taxonomy and water table depth. Hydric soils criteria , therefore, combine both soil and hydrologic features (National Research Council, 1995).

Bathymetry

The deepest areas in the bay-estuary-lagoon system occur in the dredged ship channels where dredged depths are near 45 ft (13.6 m). Scour depths in the Corpus Christi Ship Channel near Port Aransas are greater than 50 ft (15 m). Corpus Christi Bay is the deepest bay in the system, measuring 14 to 16 ft (4.2 to 4.8 m) deep over most of the bay area; bay margins typically have relatively steep, narrow slopes (White *et al.* 1983). Depths in Aransas and Copano bays (bays just north of the study area) are less than in Corpus Christi Bay; bay centers are approximately 10 ft (3 m) and 8 to 10 ft (2.4 to 3.0 m) deep, respectively. Laguna Madre, Nueces, Redfish, and Oso bays are relatively shallow, with depths of generally less than 2 to 4 ft (0.6 to 1.2 m). Exceptions to these generally shallow depths occur in Redfish Bay and Laguna Madre. Redfish Bay is 8 to 10 ft (2.4 to 3 m) deep in the area near Corpus Christi Ship Channel. Some areas of upper Laguna Madre near Demit Island and Encinal Peninsula are approximately 6 ft (1.8 m) deep.

Nueces Bay is relatively shallow with an average depth of 4.8 ft (1.5 m) (Mannino and Montagna, 1996). The mid-section of the bay and the area near the causeway have the greatest depth, ranging from 3.2 to 4.8 ft (1 to 1.5 m), but are predominantly 3.2 to 4.0 ft (1.0 to 1.25 m). Shallow areas are located along the shore and next to the Nueces delta and the Nueces River mouth. All bay depths are influenced by meteorological factors such as floods, droughts, spring tides, wind stress, etc., which can elevate or depress the water level.

Climate

Climate in the Corpus Christi/Nueces Bay study area is characterized as dry subhumid. Average annual precipitation in the area decreases from north to south, ranging from 34 to 28 inches (86 to 72 cm). Corpus Christi averages 28.5 inches (72.4 cm) annually. High evapotranspiration rates during a normal year produce precipitation deficits (White *et al.*, 1983). Henley and Rauschuber (1981) reported that the Nueces Bay area receives 70 cm/yr precipitation with an evaporation rate of 152 cm/yr. Temperatures vary across the area but generally range from average winter lows in the mid 40's (°F) (7° to 9°C) to average summer highs in the low to mid 90's (33° to 35°C) (White *et al.*, 1983). Winds are perhaps the most important influence on developing the coastal environments (Tunnell, *et al.*, 1996). Winds are predominantly southeasterly, but north and northeast winds prevail in the winter.

Tides

Tidal cycles are a primary component of hydrologic dynamics in coastal marsh systems. Varying degrees of inundation in relation to marsh elevation differentially affect vegetation dynamics. Tides can be stressful to plants (e.g., submergence, anaerobic soil conditions, deposition of salts in the soil), but they also are beneficial, periodically flushing salts out of the marsh and moving nutrients into the marsh (Mitsch and Gosselink, 1986). Seasonal cycles superimposed on diurnal tide patterns have a significant impact on plant zonation patterns (Bleakney, 1972; Armstrong *et al*., 1985; Wood, 1986).

Tidal exchange in Texas estuaries is due to astronomical tides, meteorological conditions (winds, barometric pressure), and density stratification (Armstrong, 1987). Astronomical tides within the study area are predominantly diurnal, but also have a semidiurnal component. Mean tidal range along the Gulf beach is about 45 cm (1.5 ft) (Morton and McGowen, 1980), whereas astronomical tidal range within bays, especially in upper bays, is generally 0.5 ft (<15 cm). The greatest influence by astronomical tides on the bay system is at the tidal inlet. Seasonal high tides occur during the spring (highest in late May) and fall (October), and seasonal lows occur during winter (February) and summer (July). Due to shallow bay depths and a relatively small tidal prism (Smith 1974, 1977, 1978), wind exerts a much greater influence on bay circulation than astronomical tides (Morton and McGowen, 1980). Substantial exchange of water between the Gulf of Mexico and Texas estuaries occurs from wind-generated tides (Ward *et al.*, 1982).

Salinity

Water salinities in the bay-estuary-lagoon system in the Corpus Christi area vary across the entire system, in part because of the regional variations in freshwater inflows from rivers and streams and in saltwater interchange from tidal passes. Seasonal and cyclic climatic variations compound the complexity of the system by producing salinities substantially higher than normal during dry periods and lower than normal during wet periods (White *et al.* 1983).

Average salinities in mid-Corpus Christi Bay range from 35 ppt in winter (February) to a low of 15.6 ppt in the fall (October) (Holland *et al.*, 1975). Salinities fluctuate over a wider range in shallow bay margins than in mid-bay areas, but average salinities are generally lower in the bay margins (Brown *et al.*, 1976).

The salinity distribution throughout Nueces Bay provides evidence of the circulation pattern and physical structure of the bay (Mannino and Montagna, 1996). The influences of freshwater inflow from the river and saline water from Corpus Christi Bay are quite evident from the isohalines. A plume of highly saline water is discernible along the central southern shore. This is caused by the daily discharge of approximately 1.4×10^6 m^3 day^{-1} of cooling water from the CPL power plant located on the southern shore (Whitledge, 1993).

WETLANDS

Wetlands in the study area have been variously described and mapped (Brown *et al.*, 1976; Benton *et al.*, 1977; Espey, Huston and Associates, Inc., 1977; White *et al.*, 1983; White and Calnan, 1990b; Pulich, 1991; Bureau of Reclamation, 1993). In addition, the U. S. Fish and Wildlife Service has published National Wetlands Inventory maps of the study area based on 1956, 1979, and 1992 aerial photography. The Texas Parks and Wildlife Department has mapped land use/land cover, including wetlands, based on Landsat Thematic Mapper imagery (digital data available through the Internet at http://www.nri.state.tx.us/nri/data.html or http://www.nri.state.tx.us/wetnet/data.html).

Little is known about the current status and trends of wetlands in the study area. White *et al.* (1983) compared changes in wetland distribution in the approximately 20 years between 1958 and 1959, and 1979. On Mustang and North Padre island, the following changes were noted: (1) marine grasses were spreading over the flats; (2) vegetation was spreading over previously barren sand flats and dunes; and, (3) there was an increase in man-modified areas partly from the numerous dredged channels in the area. White *et al.* (1983) also noted the disconnection of Shamrock Island from Mustang Island during the 20-year period. Palustrine emergent marshes appeared to be increasing in the central part of Mustang Island. Along the bay margins, estuarine emergent marshes showed slight to moderate increases. In the Nueces River delta, White and Calnan (1990b) compared historical photographs taken in 1930 with those taken in 1959 and 1979. Vegetated wetlands showed a slight decrease of 133 acres (54 ha) between 1930 and 1959 and a decrease of 185 acres (75 ha) between 1959 and 1979. The decrease in vegetated area over the 49-yr period was 318 acres (129 ha).

Nueces River and Delta

Wetlands along the Nueces River and delta are primarily estuarine emergent marshes from the bay to near the western edge of the study area boundary where U.S. Highway 37 crosses the Nueces River (Fig. 2). Palustrine emergent marshes and forested wetlands occur near and along the river, just east of this study area boundary. Estuarine vegetation associated with the lower delta includes *Batis maritima* (saltwort), *Salicornia virginica* (perennial glasswort), *Borrichia frutescens* (sea oxeye daisy), *Spartina alterniflora*, (smooth cordgrass) (along the intertidal margins), *Monanthochloe littoralis* (saltflat grass), *Iva* sp., *Spartina spartinae* (Gulf cordgrass), *Distichlis spicata* (saltgrass), and some *Scirpus maritimus* (salt marsh bullrush) (Pulich, 1991). Freshwater marshes and wooded vegetation may include *Phragmites australis* (common reed), *Typha* spp. (cattail), *Baccharis halimifolia* (Seepwillow), *Fraxinus* sp. (Mexican ash), *Parkinsonia aculeata* (Retama), *Acacia farnesiana* (Huisache), *Prosopis glandulosa* (honey mesquite), and *Salix nigra* (black willow). Seagrass beds of *Halodule wrightii* (shoalgrass) and *Ruppia maritima* (widgeon grass) occur in Nueces Bay.

Oso Creek and Bay

Estuarine emergent marshes, including both high and low marsh species, occur along the margins of Oso Bay (Fig. 3). Inland along Oso Creek, estuarine emergent marshes occur along the wind tidal flats at elevations above the channels but within the narrow Oso valley (White *et al.*, 1983). Palustrine freshwater marshes occur in association with some ponds near the creek. Woodlands mapped along the upper reaches of Oso Creek include *Parkinsonia aculeata, Acacia farnesiana, Baccharis halimifolia, Salix nigra* (black willow), *Celtis* sp. (Hackberry), *Fraxinus* sp., and *Tamarix* sp. (saltcedar) (White *et al.*, 1983).

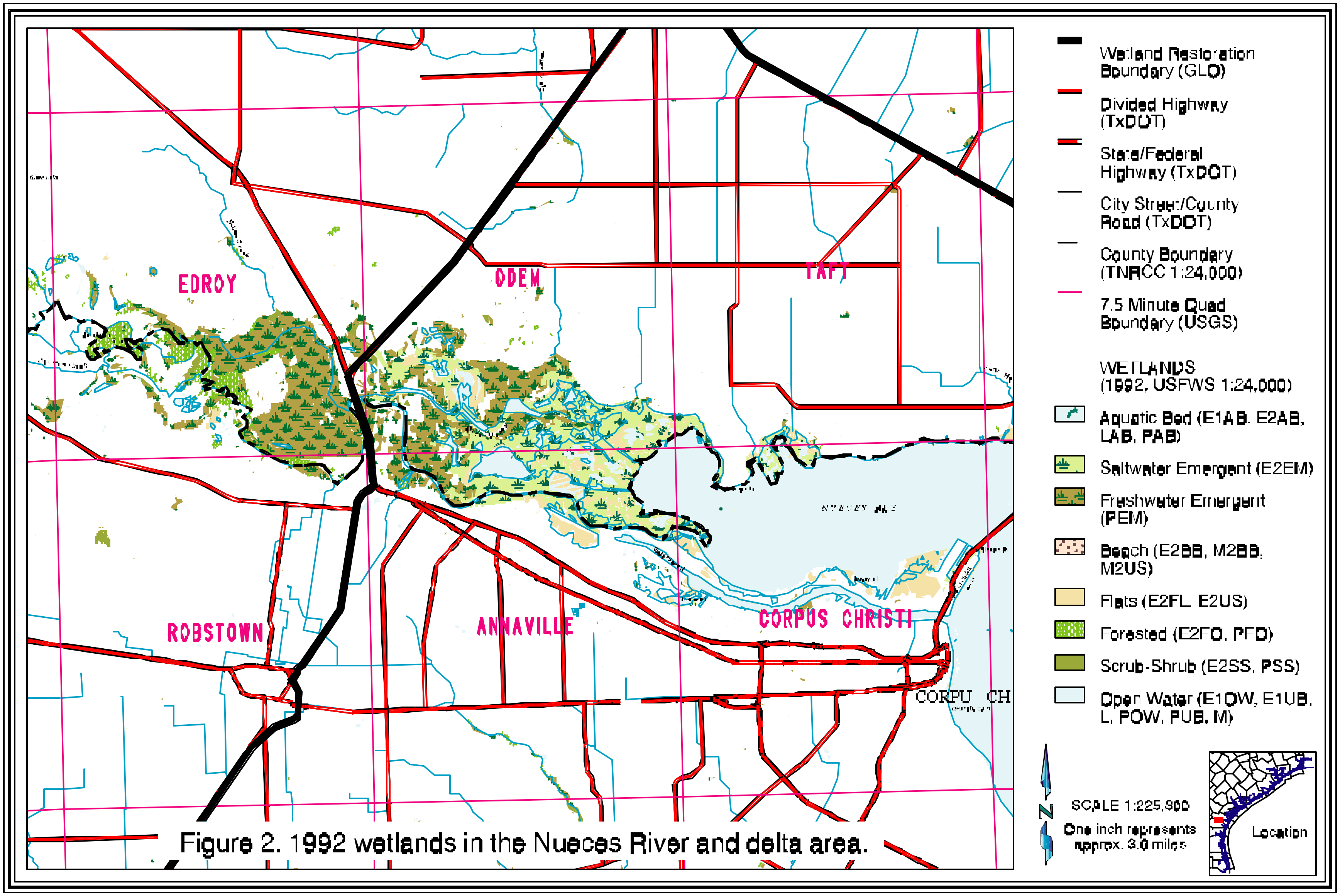

Figure 2. 1992 wetlands in the Nueces River and delta area.

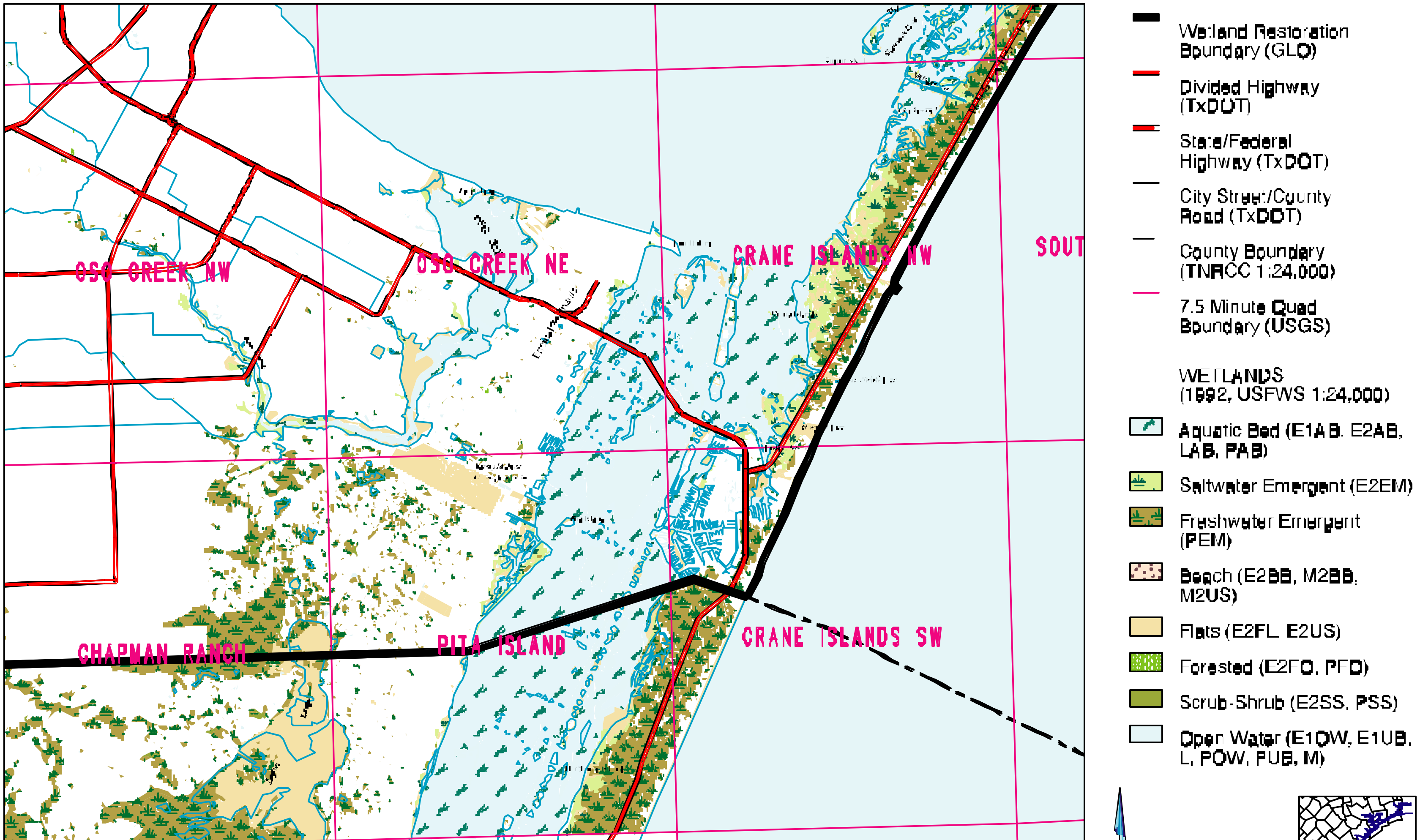

Figure 3. 1992 wetlands in the Oso Bay/Creek, Encinal Peninsula, upper Laguna Madre, and South Mustang Island areas.

Encinal and Live Oak Peninsulas

Wetlands in the Flour Bluff and Live Oak ridge areas of the Ingleside barrier strandplain are primarily numerous ponds with palustrine emergent marsh vegetation (Fig. 3). These areas are often surrounded by live oak mottes. Palustrine freshwater marshes contain a variety of species, including *Typha* spp., *Sesbania* sp., *Scirpus* spp., *Juncus* spp., *Paspalum lividum* (Longtom), *Sagittaria* spp. (arrowhead), *Nelumbo* sp. (lotus), *Ludwigia* sp. (primrose), *Bacopa monnieri* (water hyssop), *Cephalanthus occidentalis* (common buttonbush), *Salix nigra*, *Phragmites australis*, and others.

Upper Laguna Madre

Grassflats in upper Laguna Madre are composed primarily of *Halodule wrightii*, *Ruppia maritima*, and *Halophila engelmannii* (Fig. 3). Estuarine emergent marshes include *Spartina alterniflora* in patches along intertidal areas and topographically higher marshes of *Batis*/*Salicornia*/*Monanthochloe*.

Mustang Island

Wetlands associated with Mustang Island include a fairly broad expanse of marine grasses extending from the wind-tidal flats to the edge of deeper water in Corpus Christi Bay (White *et al.*, 1983) (Fig. 3). Estuarine emergent marshes along the margin of Corpus Christi Bay may include *Spartina alterniflora*, *Batis maritima*, *Salicornia* spp., *Distichlis spicata*, *Borrichia frutescens*, *Monanthochloe littoralis*, and *Avicennia germinans* (black mangrove). Palustrine emergent wetlands occur primarily gulfward of Park Road 53. Freshwater vegetation includes *Typha* sp., *Scirpus americanus*, *Spartina spartinae*, *Eleocharis* spp., *Cyperus* spp., *Fimbristylis* sp., *Juncus* spp., and others (White *et al.*, 1983). Freshwater marshes occur primarily in deflation troughs and depressions.

North Nueces/Corpus Christi Bays

Estuarine emergent marshes of *Spartina alterniflora* occur in some areas of the intertidal north shoreline of Nueces (Fig. 3) and Corpus Christi bays (Fig. 4). The seagrasses, *Halodule wrightii* (shoalgrass) and *Ruppia maritima*, (widgeongrass) occur in relatively narrow bands along much of the north Corpus Christi Bay shoreline and some of the north Nueces Bay shoreline.

Indian Point/Corpus Christi Beach

In the Indian Point area, some *Spartina alterniflora* fringes the western shoreline in Nueces Bay and grades into a *Batis*/*Salicornia*/*Monanthochloe* marsh towards the Highway 35 causeway (Fig. 4). Some *Borrichia frutescens* also occurs west of the highway. Wetland vegetation on the east side of the causeway is an estuarine marsh of *Batis maritima*. The North Beach area wetlands are composed primarily of estuarine emergent marsh with *Batis*/*Salicornia*/*Monanthochloe* species assemblage.

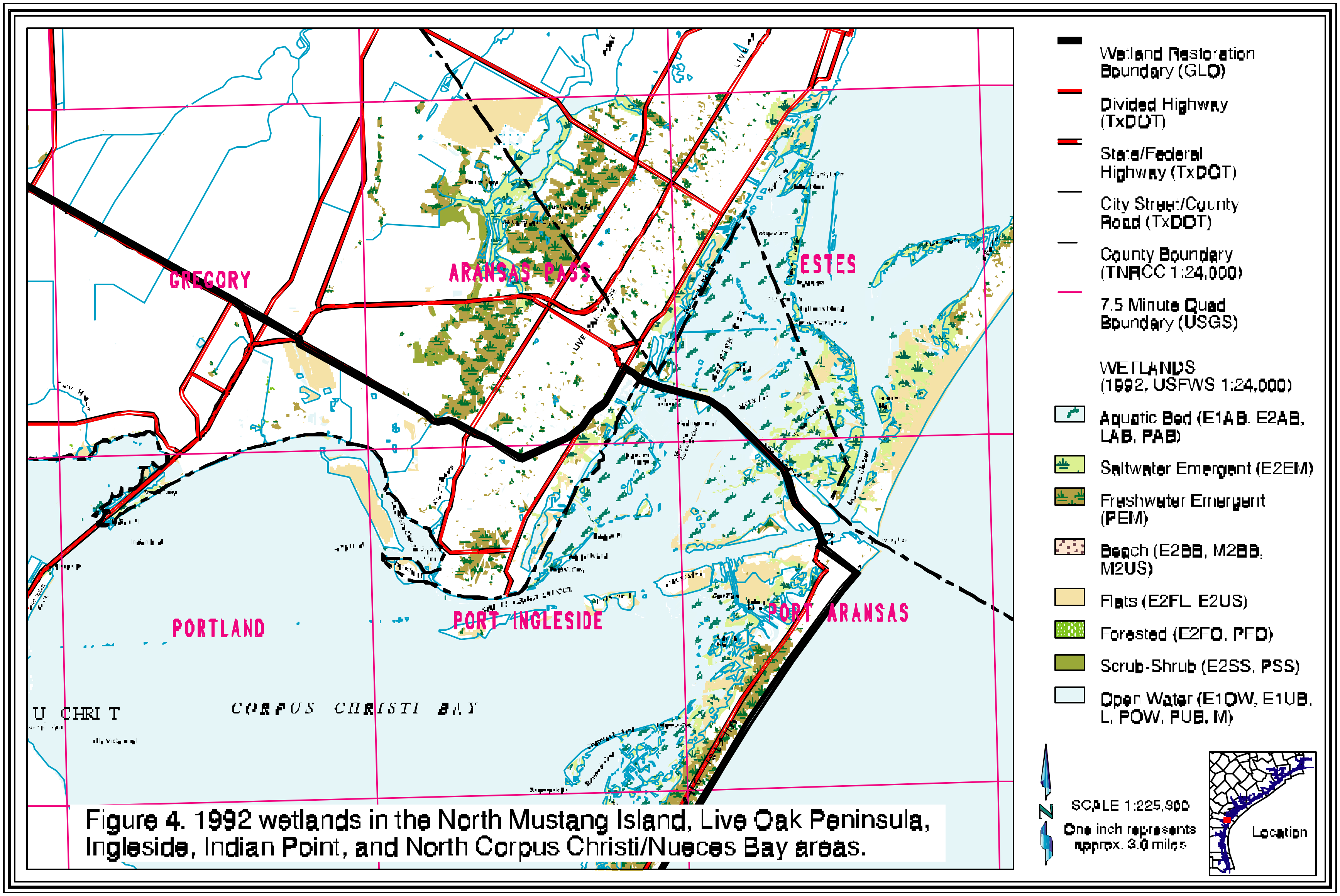

Figure 4. 1992 wetlands in the North Mustang Island, Live Oak Peninsula, Ingleside, Indian Point, and North Corpus Christi/Nueces Bay areas.

LIVING RESOURCES

Fish and Wildlife

The study area is a complex and diverse ecosystem, offering several biological habitats and broad ranges of abiotic components to its inhabitants. Shallow bay grassflat areas are often densely populated with fishes seeking the protection of submerged and emergent aquatic vegetation.

Fishes and invertebrates that use estuaries have been split into six ecological classifications (McHugh, 1967). Examples from the study area for each category are given below:

1. Freshwater fishes that occasionally enter brackish waters [*Ictalurus punctatus* (channel catfish), *Lepomis macrochirus* (bluegill)]
2. Truly estuarine species which spend their entire lives in the estuary *[Gobiesox strumosus* (skilletfish)]
3. Anadramous and catadromous species [*Dorsoma cepedianum* (gizzard shad), *Anguilla rotrata* (American eel)]
4. Marine species which pay regular, seasonal visits to the estuary, usually as adults (sharks, bluefish)
5. Marine species which use the estuary primarily as a nursery ground, i.e., spawning and spending much of their adult life at sea but often returning seasonally to the estuary (*Sciaenops ocellatus*, *Peneaus* spp.)
6. Adventitious visitors which appear irregularly and have no apparent estuarine requirements [*Lutjanus campechanus* (red snapper), *Rachycentron canadum* (cobia)]

Of the species which use these areas, those found in the greatest abundance include *Menidia beryllina* (tidewater silverside), *Cyprinodon variegatus* (sheepshead minnow), *Anchoa mitchilli* (bay anchovy), *Mugil cephalus* (striped mullet), and *Fundulus similis* (longnose killifish) (Gunter, 1967). Larger fishes, including *Cynoscion nebulosus* (spotted seatrout), *Sciaenops ocellatus* (red drum), and *Paralichthys lethostigma* (southern flounder) are also frequently found in shallow bay flat areas.

Many of the most economically important species harvested in the study area, including penaeid shrimp and *S. ocellatus* (red drum) are classified above as No. 5, which is the most common of these life history strategies. High primary productivity relative to that of the marine systems ensures a vast and varied food supply for larval and juvenile stages of such species. Structurally complex habitats offered by seagrass beds and coastal marshes provide cover, thereby reducing predation potential (Orth *et al.*, 1984; Heck and Crowder, 1988). The salinity gradient between the head of the estuaries and the gulf passes provides optimal habitat for species which require ontogenetic shifts in salinity throughout their life cycle such as *Anchoa mitchilli* (bay anchovy) and penaeid shrimp (Monaco *et al.*, 1989).

The fish community using seagrass meadows in Redfish Bay is very distinctive (Hoese and Jones, 1963), characterized by the presence of *Lucania parva* (rainwater killifish), *Gerres cinereus* (yellowfin mojarra), *Lagodon rhomboides* (pinfish), *Gobiosoma robustum* (code gobie), *Penaeus* *duorarum* (pink shrimp), *Neopanope texana* (Say's mud crab), and *Palaemonetes pugio* (grass shrimp), with *Micropogonias undulatus* (Atlantic croaker) notably absent. Other studies on fish relating to the use of seagrass beds included work by Zimmerman (1969) on macrofauna in *Thalassia testudinum* (turtlegrass) beds; Holt and Arnold (1982) and Holt *et al.* (1983) on *S. ocellatus* eggs, larvae and juveniles; and Gourley (1989) on nekton use of adjacent *T. testudinum* and *Halodule wrightii* beds.

The most robust database for determining trends in fish abundance in the study area has been collected by the Texas Parks and Wildlife Department's Coastal Fisheries Division (Dailey *et al.*, 1992). Fishery-independent data have been collected with standardized methodology (bag seines, gill nets and trawls) since 1975, and multiple-year trend reports are produced annually (McEachron and Green, 1985; Crowe *et al.*, 1986; Hammerschmidt *et al.*, 1988; Rice *et al.*, 1988; Meador *et al.*, 1988; Dailey *et al.*, 1988; Maddux *et al.*, 1989; Mambretti *et al.*, 1990; Dailey *et al.*, 1991; Kana *et al.*, 1993).

An average of 8.4 million pounds of marine species was commercially harvested in the study area from 1972-1992, with landings ranging from a low of 5.2 million pounds in 1989 to a high of 12.0 million pounds in 1991. Marine organisms landed in the commercial fishery were partitioned into five categories: (1) finfish, (2) shrimp, (3) blue crab, (4) oysters, and (5) other.

Few species of reptiles and no amphibians are permanent inhabitants of coastal marshes, mainly due to salinity pressure. *Malaclemys terrapin littoralis* (diamondback terrapin) is a notable exception, inhabiting brackish marshes along the eastern U.S. and Gulf Coast (Carr, 1952). Alligator populations are typically associated with brackish marshes of the Aransas, Mission, and tributary creeks (northeast of the study area) flowing into the bay systems; alligators crossing shallow bays have been reported by local fisherman (McAlister and McAlister, 1993).

Many species of waterfowl feed on submergent plants in ponds and tidal creeks of coastal marshes. *Ruppia maritima* (widgeongrass) occurs extensively in coastal marshes when areas are inundated for prolonged periods and is of primary importance to waterfowl. Thousands of wintering redheads (*Aythya americana*) and northern pintails (*Anas acuta*) feed on submerged aquatic vegetation in Laguna Madre. Mottled Ducks (*Anas fulvigula*) are one of the few waterfowl species that use Texas coastal marshes year-round (Stutzenbaker, 1988). Several fish and shellfish-feeding birds used a natural marsh site in the Nueces River delta from June 1989 to June 1990 including the Great Blue Heron (*Ardea herodias*), Tricolored Heron (*Egretta tricolor*), Black-Crowned Night Heron (*Nycticorax nycticorax*), Great Egret (*Casmerodius albus*), and Snowy Egret (*Egretta caerulea*) (Ruth, 1990). Several species of wading and aquatic shorebirds fed on benthic organisms in shallow intertidal areas in the Nueces River delta. Species that capitalized on migration of prey in and out of marshes via tidal creeks included Lesser Scaup (*Aythya affinis*), Bufflehead (*Bucephala albeola*), White Pelican (*Pelecanus erythrorhynchos*), and cormorants (*Phalacrocorax* spp.). Sixty-six species of birds were observed feeding and roosting in the same natural marsh in the Nueces River delta from September 1992 to August 1993 (Nicolau, 1993).

The range of an exotic herbivore, *Myocaster coypu* (nutria), is currently expanding into the study area (T. Stehn, ANWR, and J. Holt, UTMSI, pers. comm.) and may significantly alter coastal marshes.

Nutria are almost exclusively vegetarians and prefer the succulent parts of the plant base, especially coarse plants like cattail, reeds, smooth cordgrass, and other species. Nutria can consume between 2.5 to 3.5 pounds of vegetation a day (Nailon and Sanderson, 1994). Other rodents residing within the coastal marsh include *Oryzomys palustris* (rice rat), *Sigmodon hispidus* (cotton rat), *Reithrodonomys fulvescens* (fulvous harvest mouse), and *Mus musculus* (house mouse) (Martin *et al.*, 1991). *Procyon lotor* (racoon) is an opportunistic feeder in coastal marshes preying on fish, crabs, and bird eggs (Linscombe and Kinler, 1985).

Endangered/Threatened Species

Several listed species that directly depend on estuarine and adjacent marine habitats have been included in Table 1. Their importance to the study area should be noted, as any actions taken to protect or enhance habitat within the area watershed may affect the downstream estuarine-dependent flora and fauna.

Table 1. Listed endangered, threatened and candidate species within the CCBNEP study area. USFWS[1] = U.S. Fish and Wildlife Service; TPWD[2]=Texas Parks and Wildlife Department; TNHP[3]=Texas Natural Heritage Program; TOES[4]=Texas Organization of Endangered Species.

Scientific Name	Common Name	USFWS	TPWD	TNHP	TOES
FISH					
Oostethus brachyurus	Opossum Pipe Fish		T	G5S1	
Syngnathus affinis	Texas Pipe Fish			G5S1	
AMPHIBIANS					
Hypopachus variolosus	Sheep Frog		T		
Notophthalmus meridionalis	Black-spotted Newt	C2	E		
Siren sp.	South Texas Siren	C2	E		
REPTILES					
Lepidochelys kempii	Kemp's Ridley Sea Turtle	E	E	G1S1	E
Caretta caretta	Loggerhead Sea Turtle	T	E	G3S2	T
Chelonia mydas	Green Sea Turtle	T	T	G3S1	T
Dermochelys coriacea	Leatherback Sea Turtle	E	E	G3S1	E
Eretmochelys imbricata	Hawksbill Sea Turtle	E/CH		G3S1	E
Alligator mississippiensis	American Alligator	T/SA			WL
Nerodia clarki	Gulf Saltmarsh Snake	C2		G4QS4	
BIRDS					
Pelecanus occidentalis	Brown Pelican	E	E	G5S1	E
Laterallus jamaicensis	Black Rail	C2	W		
Egretta rufescens	Reddish Egret	C2	T	G4S22	T
Plegadis chihi	White-faced Ibis	C2	T	G5S2	T
Mycteria americana	Wood Stork		T	G5S3N	T

Dendrocygna bicolor	Fulvous Whistling Duck	C2		G5S4	T
Oxyura dominica	Masked Duck			G5S4	WL
Haliaeetus leucocephalus	Bald Eagle	T	E		
Falco peregrinus anatum	American Peregrine Falcon	E	E	G3T2S1	E
Falco peregrinus tundrius	Arctic Peregrine Falcon	T/SA	T	G3T1S1	T
Charadrius melodus	Piping Plover	T	T	G2S2	T
Charadrius montanus	Mountain Plover	C2		G3S2	
Charadrius alexandrinus nivosus	Western Snowy Plover	C2		G4TU	
Numenius borealis	Eskimo Curlew	E	E	G1S1	E
Numenius americanus	Long-billed Curlew	C2		G5S5	
Sterna antillarum antillarum	Coastal Least Tern				T
Sterna antillarum athalassos	Interior Least Tern	E	E	G4T2S1	E
Sterna fuscata	Sooty Tern		T	G5S2	WL
Chilidonias niger	Black Tern	C2	W		
Rhynchops niger	Black Skimmer				T
Elanoides forficatus	American Swallow-tailed Kite		C3	T	

MAMMALS

Lasiurus ega	Southern Yellow Bat		T		
Tursiops truncatus	Bottle-nosed Dolphin			G?S2	

1 U.S. Fish and Wildlife Service: E-Endangered; T-Threatened; T/SA- Threatened due to similarity of appearance. USFWS, 12 October 1983. Fed. Reg. 48 (198):46332-46337. C1 - Candidate, category 1. USFWS has substantial information on biological vulnerability threats to support proposing to list as endangered or threatened. Data are being gathered on habitat needs and for critical designations. C2 - Candidate, category 2. Information indicates that proposing to list as endangered or threatened is possibly appropriate; substantial data on biological vulnerability and threats are not currently known to support the immediate preparation of rules. Further biological research field study will be necessary to ascertain the status and/or taxonomic validity of the taxa in category 2. 3A - Former Candidate, rejected because presumed extinct and/or habitats destroyed. 3B - Former Candidate, rejected because not a recognized taxon; i.e., synonym or hybrid. 3C - Former Candidate, rejected because more common, widespread, or adequately protected.

2 Texas Parks and Wildlife Department, Endangered/Threatened Species Data File: (TNHP, 1994). E - Endangered; T - Threatened.

3 Texas Natural Heritage Program, Special Species and Natural Community Status (1994). G1 - Critically imperiled globally, extremely rare, 5 or fewer occurrences. G2 - Imperiled globally, very rare, 6 to 20 occurrences. G3 - Very rare and local throughout range or found locally in restricted range, 21 to 100 occurrences. G4 - Apparently secure globally. G5 - Demonstrably secure, globally S1-5 state ranking of the same categories as those listed globally. GX - Believed to be extinct throughout range. U - denotes uncertain rank (G2?), or range (G1G2). Q - designates questionable rank or taxonomic assignment. H - denotes historical occurrence. T- subrank of subspecies or variety.

4 Texas Organization for Endangered Species; Endangered, Threatened and watch lists of Plants and Vertebrates of Texas (March, 1987 - plants and January, 1988 - vertebrates). E - State endangered species - any species which is in danger of extinction in Texas or in addition to list federal status. T - State threatened species - any species which is likely to become a state endangered species within the foreseeable future. WL - TOES Watch List - any species which at present has either low population or restricted range in Texas and is not declining or being restricted in its range but requires attention to insure that the species does not become endangered or threatened (State of Texas).

Historic Land Use and Population

The importance of wetlands to historic cultures should also be identified when discussing various functions and values in the study area. Since early civilization, many cultures have learned to live in harmony with wetlands, and the southern region of the central Texas Gulf Coast provides excellent evidence of these relationships. Abundant evidence has been uncovered of historic people existing in the Texas Coastal Bend. These societies depended on wetlands for population development and sustenance.

The Karankawa are among the most interesting Indian groups of Texas and have been the subject of a considerable number of archaeological studies describing their presence on the Gulf Coast. The Karankawa were actually a series of Indian groups who lived on the coastal strip from Galveston Bay south to the vicinity of Corpus Christi (Hester, 1980). These people subsisted as hunters and gatherers (Newcomb, 1961). They caught fish and collected oysters and other shellfish from the waters of the bays and Gulf, at times leaving extensive shell middens along the upland shores (Campbell, 1960; Newcomb, 1961). Some groups moved between the offshore barrier islands and the mainland on a seasonal basis (Smith, 1983; Ricklis, 1990). Both the Karankawa and Archaic populations that preceded them used marine shells for constructing tools and ornaments, in addition to their procurement as a food resource.

Shell tool artifacts play a major role in the cultural assessment of prehistoric sites. Shell tools are typically abundant in many of the sites located on the central Texas coast (which includes bays of Nueces and San Patricio counties). The use of shell as material for tools is typical of aboriginal inhabitants along the entire Gulf of Mexico, usually where there are few readily available lithic sources (Steele and Mokry, 1984). Ricklis and Cox (1993) assert that the substitution of the shell tool for lithic tools is related to a critical distance from the lithic procurement area. At this point, marine shell, predominantly sunray venus (*Macrocallista nimbosa*) and whelk (*Busycon* sp.) began to be substituted for flint as viable tool material. The numerous shell tools reported from the central Texas coast have long been presumed to represent the use of surrogate material in an environment characterized by limited lithic availability.

Radiocarbon dates of 7500-7000 BP have been secured from the basal shell strata at various sites from White's Point located on the northwest side of Nueces Bay (Ricklis, 1993). These represent the earliest evidence of human exploitation of marine resources on the Texas coast and are among the earliest on the eastern seaboard of the United States. Perforated oyster shells have been recovered from numerous sites, including those at White's Point. Johnson (1981) made the assumption that the perforated oyster shell is a significant part of the cultural trait of certain aboriginal organization in that these shells may be used as a marker to ascertain the limits of the area occupied by the representative culture. Among the shell artifacts recovered from a site at Oso Bay, were 89 projectile points, 88 manufactured from sunray venus clams and one manufactured from southern quahog (*Mercenaria campechiensis*) (Headrick, 1993).

The shoreline of Oso Bay and the banks of Oso Creek have long been recognized as highly productive archaeological sites. A survey carried out during the spring of 1994 involved examination of the southwestern shoreline along Oso Bay. The overall goal of the survey was to identify and assess the number, extent, and condition of archaeological sites along the western shoreline of Oso Bay, in an area that has been subjected to increasing residential development with the recent westward expansion of the city of Corpus Christi. Sites were documented as early as the 1920s and 1930s (Martin, 1930), and the abundant aboriginal materials from the area formed the baseline information of the first defined archaeological cultures on the Texas coast (Ricklis, 1994). A large prehistoric cemetery on the northwestern shoreline of Oso Bay was one of a number of sites on the central Texas coast investigated by teams from the University of Texas in the 1930s and early 1940s (Hester, 1980; Jackson *et al.*, 1986). A full-scale archaeological investigation, with published results, has never been carried out at any site on either Oso Creek or Oso Bay. Even a small project such as the presently reported survey constitutes a worthwhile contribution to the local archaeological record, much of which has been lost to development resulting from the growth of Corpus Christi (Ricklis, 1994).

Overall, many of the cultural sites are linked with coastal wetlands, especially those areas included in this study, and probably hold archaeological significance. Future resource management plans must consider the significance of any such sites and include appropriate measures to preserve their historical and prehistorical significance.

Current Land Use and Population

A number of factors in and around the study area contribute to current diversified and extensive land and water use (Brown *et al.*, 1976). The Corpus Christi area supports a high population concentration which extends to the upper coastal zone. The population of the study area was approximately 500,000 in 1990, with about 250,000 people living in the Corpus Christi area (the major urban center in the study area). Other towns in the coastal counties of the study area include Portland, Ingleside, and Aransas Pass (Table 2).

Table 2. Population of Major Cities in the Study Area (U. S. Census Bureau, 1990) (after Baird *et al.*, 1996).

City or Town	County	Population
Corpus Christi	Nueces	257,453
Portland	San Patricio	12,224
Aransas Pass	San Patricio	7,180
Ingleside	San Patricio	5,696

The area has extensive mineral resources, notably oil, gas, and chemical raw materials (sulfur, salt and lime) - supporting major petroleum-refining and petrochemical centers. In addition, the area has fertile and productive lands that support extensive agriculture with only minor amounts of irrigated crops. Grain sorghum, corn, small grains, and cotton are dryland crops produced in the region. Percentages of land use by counties within the study area are listed in Table 3. The percentages were derived from the Geographic Information Service (GIS) land use data base compiled by the USGS around 1980. The key difference between counties is the percentage of agricultural land (which includes both cropland and pastureland) versus rangeland. Several counties have substantial percentages of water or wetlands. The category of "all other" land use includes transportation, marinas, and undeveloped/open.

Table 3. Percent Land Use by Counties in the Study Area (USGS, 1980) (after Baird *et al*., 1996).

County	Urban	Agricultural	Range	Water	Wetland	All other
Nueces	7	57	11	21	4	1
San Patricio	2	67	20	3	4	1

Corpus Christi is the third leading port in Texas with respect to tonnage handled annually. The extensive Gulf Intracoastal Waterway and ship channels have led to a high-volume flow of imports and exports. Human influences within the study site area are greatest along the moderately populated and industrialized shores of the Nueces estuary and to a lesser extent around the other two estuarine systems. In general, the local economy is based upon row-crop agriculture, ranching, oil and gas, sport and commercial fishing, and tourism (Diener, 1975; Brown *et al.*, 1976, 1977; McGowen *et al.*, 1976).

Previously identified human influences (Diener, 1975) affecting living natural resources were incorporated into the Corpus Christi Bay National Estuary Program priority issues (CCBNEP, 1994) and include:

1. reduced freshwater flow
2. degradation of water quality
3. destruction or loss of wetlands and other critical habitats
4. altered estuarine circulation from channelization and disposal of dredged material
5. point-source and nonpoint-source pollution
6. bay debris
7. persistent brown tide and periodic red tides

METHODS

Field investigations of potential sites for wetland restoration, enhancement, and creation were conducted from October 1995 through May 1996 within each of the following ecological areas: Nueces River and delta, Oso Creek and Bay, Encinal and Live Oak Peninsulas, North Nueces/Corpus Christi Bay drainage, Indian Point/Corpus Christi Beach, upper Laguna Madre, and Mustang Island. The U.S. Geological Survey (USGS) 7.5-minute quadrangle maps (scale 1:24,000), and color infra-red and black-and-white aerial photographs (1956, 1979, 1988, 1992, and 1995) at various scales were used in the surveys to identify hydrologic sources and adjacent land uses.

Wetland sites were located in U.S. Fish and Wildlife Service (USFWS) GIS data files from the National Wetlands Inventory (NWI) for system, subsystem, class, subclass, water regime, and special modifiers in accordance with the Cowardin *et al.* (1979) classification. Current functions and values were determined for each site using the following categories: groundwater discharge/recharge, flood storage and desynchronization, sediment trapping, water quality improvement, food chain support/nutrient export, fisheries habitat, wildlife habitat, and recreation/education/culture. Field visits, historical photographs, and correspondence with advisory group members were used to evaluate the sites for causes of wetland degradation or loss.

Sites on private lands were assessed from adjacent public property, aerial photographs, and descriptions in published literature, or accessed with permission of the landowner. Names of private landowners were not included in the report information. Before developing a restoration, enhancement, or creation project for any site identified in this report, ownership of the site should be conclusively determined by examining county real property records. All persons owning an interest in either the surface estate or the mineral estate underlying the site should be contacted and permission for the project obtained.

Evaluations were conducted with special consideration given to the following concerns: species which have decreased in abundance, habitats which have decreased in spatial extent, functions or values which have been degraded or lost, development pressures, and anticipated future losses. Factors critical to designing restoration plans were synthesized from the literature to address issues of goal determination, success criteria, and functions which have been determined as priority enhancement/restoration issues (shoreline erosion control, water quality improvement, and fish and wildlife habitat). The importance of establishing goals at the development stage of a project, and defining and implementing an appropriate monitoring strategy was addressed, particularly in regard to functional assessments.

Based on all available information for each site, a potential restoration, enhancement, or creation plan was developed incorporating all appropriate components: construction activity, modification of water regime, and wetland vegetation and/or wetland fauna. Potential functions and values which would increase or become established in each site were suggested, as well as potential economic benefits. Management options were included to facilitate the generation of a list of potential partners and their involvement in the restoration/enhancement/creation plan. The estimated cost of each conceptual plan was indicated with one to three dollar signs ($) denoting a relatively inexpensive to relatively expensive plan. Estimated costs for plans with one dollar sign ($) would be less than $10,000; projects with two dollar signs ($$) would range from $10,000 to $50,000; projects with three dollar signs ($$$) would cost greater than $50,000 to $99,000 and those project with the potential to exceed $1,000,000 are designated as four dollar signs ($$$$).

Finally, potential funding sources, including federal, state and private programs, were identified for wetland projects on private and publicly owned lands. A brief overview of each program was provided, along with primary contacts for additional information.

RESULTS

OVERVIEW

Thirty-nine sites were identified and evaluated for potential wetland restoration, enhancement, or creation (Figure 5). Six sites are located within the Nueces River delta, eight sites along the Nueces/Corpus Christi bay shorelines, two sites within Corpus Christi Beach area, three sites on Indian Point, four sites within the Oso Creek and Bay complex, three sites on Encinal Peninsula, three sites on Live Oak Peninsula, eight sites on Mustang Island, and two sites within the upper Laguna Madre (Table 4).

Four classes of wetland systems, Estuarine, Palustrine, Riverine, and Lacustrine, were represented in the final sites. Some sites were representative of a single system; Sites 6, 14, 20, 26, 27, 29, 30, 31, 34, 35, 36, and 37 were classified as Estuarine, and Site 2 was Palustrine. Other sites represented three of the four systems; Sites 8, 9, and 13 contained Estuarine, Palustrine, and Riverine, while Site 15 encompassed Estuarine, Palustrine, Riverine, and Lacustrine (Table 4).

Sites were evaluated for existing functions and values and potential restoration, enhancement, or creation of these functions and values (Table 5). Sites 35 and 36 were designated as enhancing the least number of functions, food chain support/nutrient export, and wildlife and fisheries habitat. The two sites are located within the upper Laguna Madre estuarine system, are isolated from adjacent systems, and encompass little direct recreational, educational, or cultural values. Most of the sites ranged between four and six potential functions and values. Four sites (15, 24, 27, and 29) were evaluated as providing eight, four sites (19, 21, 22, and 23) with nine, and three sites (7, 11, and 12) with ten potential functions and values. All restoration, enhancement, or creation projects could potentially improve food chain support/nutrient export, and fisheries and wildlife habitat functions. Implementation of projects on twenty five of the sites could potentially enhance recreational values, twenty-one sites could improve water quality, nineteen sites could improve sediment trapping functions, and nineteen sites could be used as educational sites. Eleven sites could assist in flood storage and desynchronization, seven sites may illustrate cultural values in the study area, and six sites would perform potential groundwater discharge or recharge.

The sites represented a wide range of estimated costs to finance the potential restoration, enhancement, or creation plans. Nine sites were designated a low cost, ten as medium cost, one as medium to high cost, fifteen as high cost, and two as high to very high cost, and two sites as very high cost (see Table 5). These general estimates, however, may change depending upon the actual size of the restoration site and time of implementation. Potential partnerships were also

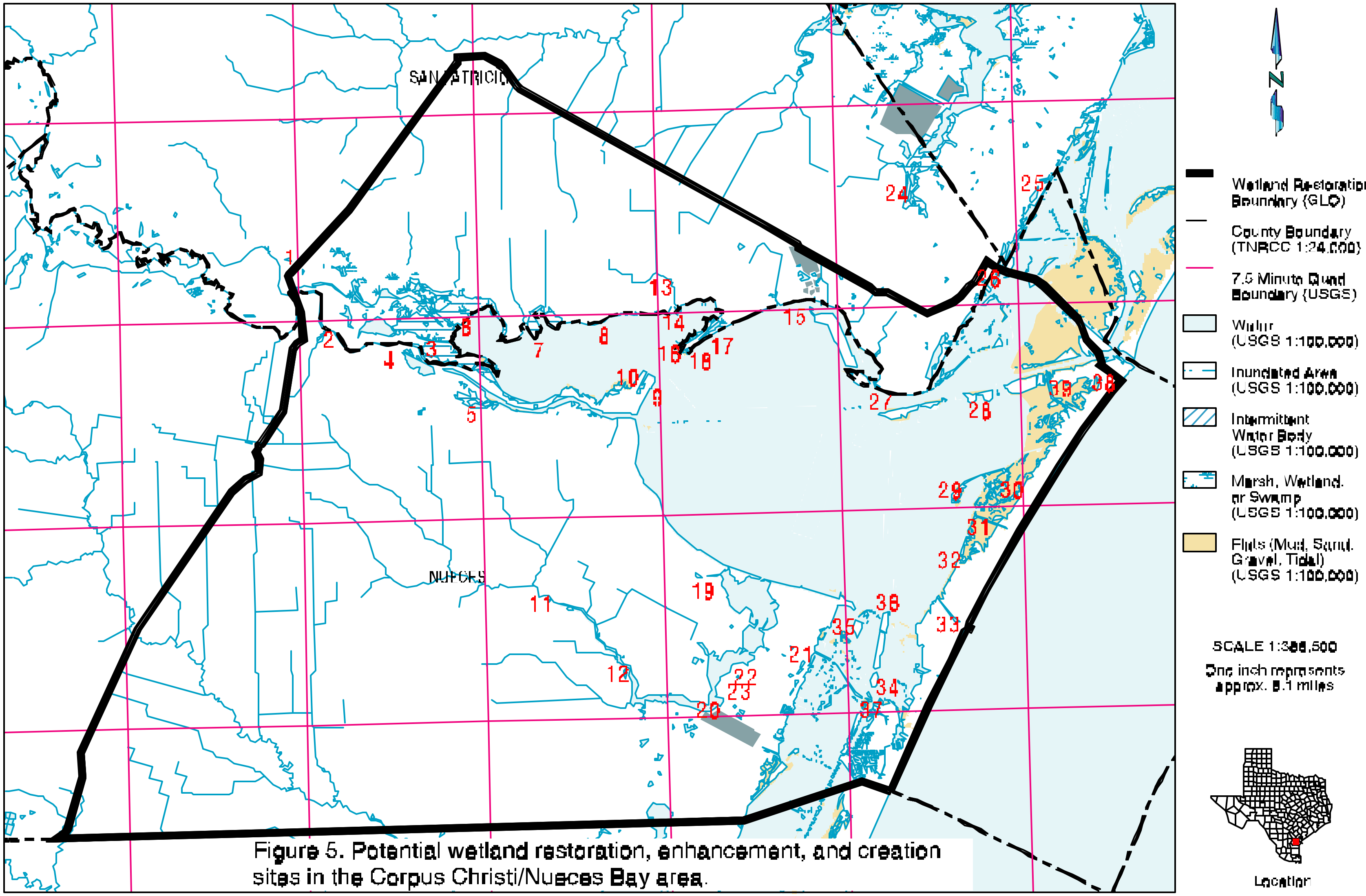

Figure 5. Potential wetland restoration, enhancement, and creation sites in the Corpus Christi/Nueces Bay area.

Table 4. Potential sites and associated wetland systems in Nueces River Delta (NRD), Nueces/Corpus Christi Shoreline (NCC), Corpus Christi Beach (CCB), Indian Point (IP), Oso Creek and Bay (OSO), Encinal (ENC) and Live Oak (LO) peninsulas, Mustang Island (MI), and upper Laguna Madre (ULM).

Site No.	Site Name	Water-shed	Estuarine	Palustrine	Riverine	Lacustrine
1	Hwy 77 Park	NRD	X	X		
2	Hwy 77 and 37 Junction Tertiary Treatment Ponds	NRD		X		
3	COE Mitigation Site	NRD	X		X	
4	Allison Treatment Plant Water Diversion	NRD	X		X	
5	Tule Lake	NRD	X	X		
6	Nueces Delta Front	NRD	X			
7	White’s Point	NCC	X	X	X	
8	Nueces Bay North Shoreline	NCC	X	X	X	
9	Corpus Christi Beach Wetland	CCB	X	X		
10	Rincon Channel	CCB	X	X		
11	Landfill/Oso Creek	OSO		X	X	
12	Corpus Chrisit Botanical Gardens	OSO	X	X		
13	Gum Hollow Creek	NCC	X	X	X	
14	Gum Hollow Delta	NCC	X			
15	Green Lake, Corpus Christi Bay Drainage, and North Shoreline	NCC	X	X	X	X
16	Indian Point Western Shoreline	IP	X			
17	Sunset Lake	IP	X	X		
18	Indian Point Park	IP	X	X		
19	Hans Suter Park/Stormwater Drainage	OSO	X	X		X
20	Mud Bridge	OSO	X			
21	Graham/Laguna Shores Ponds	ENC	X	X	X	
22	Ramfield Road Wetland	ENC		X		
23	Caribbean Road Wetland	ENC		X		
24	McCampbell Slough	LO	X	X		X
25	Hwy 35 Wetland	LO	X	X		
26	Pelican Cove Mangroves	LO	X			
27	Ingleside Cove Shore	NCC	X			
28	Pelican Island	NCC	X	X		
29	Shamrock Island	MI	X			

30	Shamrock Cove	MI	X			
31	Wilson's Cut	MI	X			
32	Mid-Mustang Island Site	MI	X	X		
33	Fish Pass	MI	X	X		
34	GLO State Tracts 59,60	MI	X			
35	Coyote Island	ULM	X			
36	Gulf Intracoastal Waterway No. Island	ULM	X			
37	Snoopy's Flats	ULM	X			
38	City of Port Aransas Intertidal Flat	MI	X	X		
39	Piper Channel	MI	X	X		

Table 5. Potential functions and values and associated estimated costs for sites.

Site No.	Groundwater Discharge/ Recharge	Shoreline Erosion Control	Sediment Trapping	Flood Storage and Desynchro-nization	Water Quality Improve-ment	Food Chain Support/Nutrient Export	Fisheries Habitat	Wildlife Habitat	Recreation/ Education/ Culture	Estimated Cost[a]
1					X	X	X	X	r e	$$
2				X	X	X	X	X		$$$
3			X		X	X	X	X		$$$$
4					X	X	X	X		$$$
5					X	X	X	X	e	$$$
6		X	X			X	X	X		$$$
7		X	X	X	X	X	X	X	r e c	$$$
8		X	X			X	X	X		$$
9					X	X	X	X	r e	$$
10					X	X	X	X	r e	$$
11		X	X	X	X	X	X	X	r e c	$$$$
12		X	X	X	X	X	X	X	r e c	$$
13	X	X	X	X	X	X	X	X		$$$
14			X		X	X	X	X		$$$
15	X	X	X	X	X	X	X	X		$$$
16		X				X	X	X		$$$
17						X	X	X		$$
18						X	X	X	r e c	$
19			X	X	X	X	X	X	r e c	$$$-$$$$
20					X	X	X	X	r e	$
21	X		X	X	X	X	X	X	r e	$$
22	X		X	X	X	X	X	X	r e	$
23	X		X	X	X	X	X	X	r e	$
24	X		X	X	X	X	X	X	r	$
25						X	X	X	r	$$$
26					X	X	X	X	r e	$
27		X	X			X	X	X	r e c	$$$-$$$$

Table 5. continued

Site No.	Groundwater Discharge/ Recharge	Shoreline Erosion Control	Sediment Trapping	Flood Storage and Desynchro-nization	Water Quality Improve-ment	Food Chain Support/Nutrient Export	Fisheries Habitat	Wildlife Habitat	Recreation/ Education/ Culture	Estimated Cost[a]
28		X	X			X	X	X		$$-$$$
29		X	X			X	X	X	r e c	$$
30		X	X			X	X	X	r	$$$
31						X	X	X	r	$
32						X	X	X	r	$
33						X	X	X	r	$$
34						X	X	X	r e	$
35						X	X	X		$$$
36						X	X	X		$$$
37						X	X	X	r	$$
38						X	X	X	r e	$$
39						X	X	X	r e	$$$

[a] See methods for ranking categories

suggested for implementation and/or monitoring and are listed individually for each site and descriptively by programs in the final section of this report.

SITE DESCRIPTIONS AND PLANS

SITE 1: Hwy 77 Park

Location: Northwest corner of IH 37 and Hwy 77; public access along road easement only

Ownership and Management: Roadside park allows public access to view wetland; all other parts of site are under private ownership.

General Description: This site supports primarily freshwater wetlands, although the extensive drainage northeast of the roadside park has tidal influence through the bridge culverts connecting upper reaches of the Nueces River Basin. Wetland enhancement probably occurred inadvertently when the present Hwy 77 and IH 37 were completed. These two major highways effectively serve as a dam retaining freshwater runoff at their point of intersection.

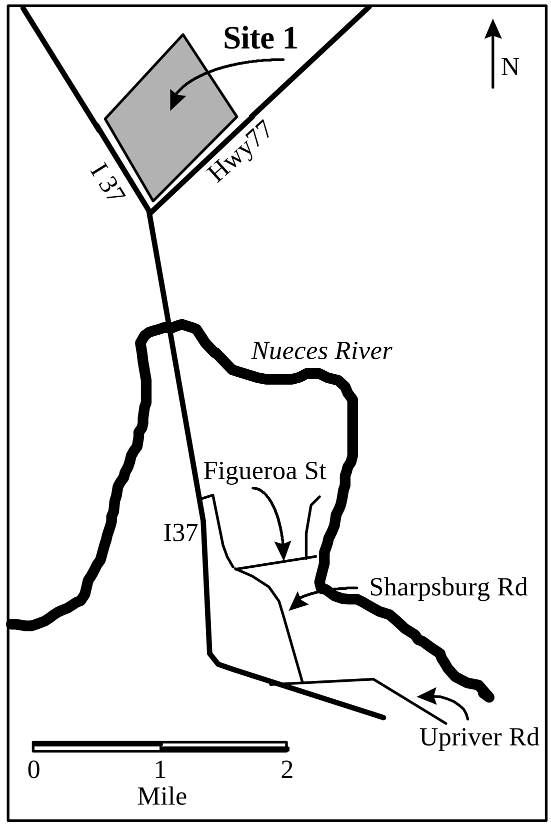

Figure 6. Location of Site 1 for potential wetland enhancement.

Current Wetland Classification:

- Estuarine Intertidal Emergent Persistent
  Irregularly Flooded
- Palustrine Aquatic Bed Floating Vascular
  Permanently Flooded/Excavated
- Palustrine Emergent Persistent
  Temporarily Flooded
  Seasonally Flooded
- Palustrine Scrub-Shrub Broad-Leaved Deciduous
  Temporarily Flooded
  Semipermanently Flooded
  Permanently Flooded
- Upland

Water Regime: Hydrology of the site is primarily from upland runoff from the north. The site may be influenced by tidal waters via the highway bridge. The topography of the site varies extensively; some areas are permanently flooded, while others are seasonally or temporarily flooded.

Wetland Vegetation: Much of the emergent vegetation seen from the highway consists of cattail (*Typha* spp.). An extensive stand of scrub-shrub vegetation is delineated on the 1992 NWI maps, but is not publicly accessible; therefore, identification of scrub-shrub was not determined.

Wetland Fauna: This site supports a diversity of waterbirds, particularly when wetlands are drying up and concentrating an apparently abundant food source. Most likely, these wetlands additionally support an abundant population of frogs during periods of high rainfall.

Adjacent Land Use: Two major highways border the site, while adjacent upland is primarily rangeland.

Current Functions and Values:

- Water Quality Improvement
- Food Chain Support/Nutrient Export
- Fisheries Habitat
- Wildlife Habitat
- Recreation/Education

Causes of Degradation/Loss: No known losses or degradation can be determined. Because of the diversity of wetlands due to topographic relief of the site, the water retained by the highways may have increased the amount of permanently flooded wetlands.

Potential REC Plan:

Modification of Water Regime: Two diversion swales could be constructed to divert highway runoff into the wetland during and following rainfall events. Surface waters can be retained by constructing a low levee just upstream of the bridge culvert. Increasing the retention time of highway runoff would improve water quality. The site would be an excellent location for a water-quality monitoring station, which could be operated by students in the surrounding school districts.

Wetland Construction: The upland area adjacent to the existing scrub-shrub wetland could be excavated to an elevation which would support scrub-shrub vegetation.

Modification of Wetland Vegetation: Scrub-shrub habitat is not an extensive wetland type in the study area. Existing scrub-shrub in this site could be expanded and maintained by the upland island excavation and increased water regime. Planting wetland vegetation in the diversion swale and on the levee would minimize erosion and increase habitat.

Modification of Wetland Fauna: Nesting waterbirds and other bird fauna that use scrub-shrub habitat could potentially increase in abundance. In addition, the increased water regime would enhance food resources.

Additional Construction: Interpretive signs could be located onsite for visitors at the roadside park that would increase public education about palustrine wetlands in the Texas Coastal Bend.

Potential Functions and Values:

- Water Quality Improvement
- Food Chain Support/Nutrient Export
- Fisheries Habitat
- Wildlife Habitat
- Recreation/Education

Potential Economic Benefits:

- Ecotourism

Management Options: Once enhancement of the site is completed, low maintenance would be required to ensure levee integrity.

Estimated Cost of Plan: $$

Potential Partnerships: Texas Prairie Wetland Program, U.S. Fish and Wildlife Service; Texas Department of Transportation; Texas Watch and Urban Watch Program, Texas Natural Resource Conservation Commission; Adopt-A-Wetland Program, Center for Coastal Studies-TAMUCC

SITE 2: Hwy 77 and 37 Junction Tertiary Treatment Ponds

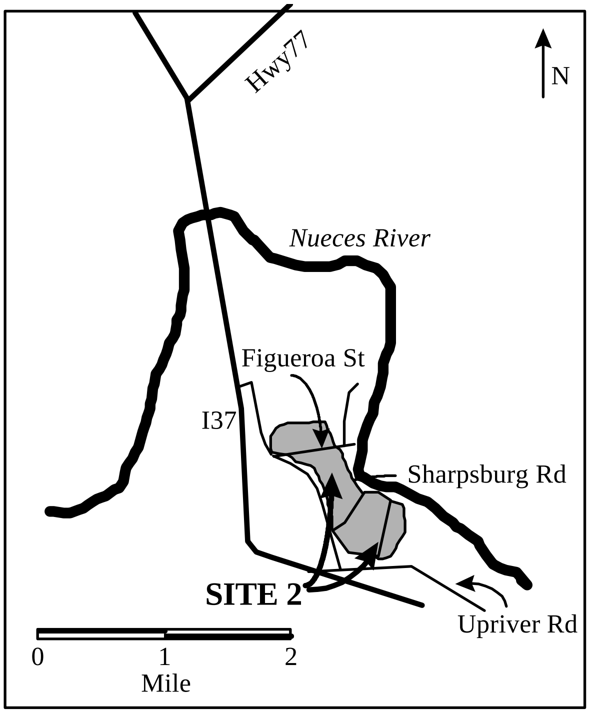

Figure 7. Location of Site 2 for potential wetland enhancement.

Location: Junction of Upriver Road and frontage road for IH 37N; no public access to site

Ownership and Management: City of Corpus Christi and private ownership

General Description: The created forested wetlands in the center of this site were constructed as settling ponds to allow settling of sediments from an adjacent drinking water facility prior to release into the Nueces River. The forested wetlands are a unique wetland type in the study area and are utilized by a diversity of birds. The surrounding area is seasonally flooded and supports typical wet-prairie grassland vegetation.

Current Wetland Classification:

- Palustrine Emergent Persistent
  - Temporarily Flooded
  - Seasonally Flooded
  - Semipermanently Flooded
- Palustrine Forested Broad-leaved Deciduous
  - Temporarily Flooded
- Palustrine Unconsolidated Bottom
  - Semipermanently Flooded
- Palustrine Unconsolidated Shore
  - Temporarily Flooded\Excavated
- Upland

Water Regime: Water enters the forested wetlands from the treatment facility. Urban drainage enters the prairies via ditches. The surrounding prairie is occasionally flooded during the high-water stage of the Nueces River.

Wetland Vegetation: Tree species that comprise the forested wetland category are unknown at this time. The prairie species range from Gulf Cordgrass (*Spartina spartinae*) at high marsh elevations to saltgrass (*Distichlis spicata*) and sedges around ephemeral ponds.

Wetland Fauna: No studies have been conducted onsite.

Adjacent Land Use: Highway 37 is adjacent to the wetlands; a small residential community is located along the Nueces River.

Current Functions and Values:

- Flood Storage and Desynchronization
- Water Quality Improvement
- Food Chain Support/Nutrient Export
- Fisheries Habitat
- Wildlife Habitat

Causes of Degradation/Loss:

The two-lane road servicing the residential community on the river bisects the prairie, thus limiting water exchange and isolating the wetlands to the north of the road.

Potential REC Plan:

Modification of Water Regime: Water could be diverted from the constructed wetland to the adjacent prairie to increase the hydroperiod in the ephemeral ponds. In addition, the prairie east of the constructed wetlands could support scrub-shrub vegetation with the increased water regime. Meandering swales could be constructed to partially connect the ephemeral ponds and increase water retention time in the wetland site. Water quality would be enhanced as a result. The site could be used as a part of the Texas Urban Watch water quality monitoring program for area schools. Culverts through the road would reconnect the wetlands on either side.

Modification of Wetland Vegetation: Scrub-shrub vegetation, primarily Buttonbush (*Cephalanthus occidentalis*), could be planted to create an additional wetland type and an ecotonal connection between the forested wetlands and wet prairies.

Modification of Wetland Fauna: The created scrub-shrub wetland would provide nesting and roosting habitat for wading birds and other bird species. Food resources would be increased in the wet prairies within both the vegetated swales and ephemeral ponds.

Other Construction: The constructed wetland is designated as a wildlife conservation area and could be minimally developed for educational and recreational use. Trails within the forested wetlands and boardwalks on the edges of the wet prairie would provide important wetland education.

Potential Functions and Values:

- Flood Storage and Desynchronization
- Water Quality Improvement
- Food Chain Support/Nutrient Export

- Fisheries Habitat
- Wildlife Habitat
- Recreation/Education

Potential Economic Benefits:

- Education
- Recreation
- Increased water quality
- Increased property values adjacent to the wetlands

Management Options: The City of Corpus Christi already manages the constructed wetlands. The land in private ownership could be purchased or incentives provided to the landowners for enhancement of their property. Local birding organizations could provide volunteers for tours and educational field trips. A long-term monitoring research project could be established for several graduate research projects at area universities.

Estimated Cost of Plan: $$$

Potential Partnerships: Texas Prairie Wetland Program, U.S. Fish and Wildlife Service; Texas Department of Transportation; Texas Watch and Urban Watch Program, Texas Natural Resource Conservation Commission; U.S. Fish and Wildlife Service, Partners for Wildlife Program; USFWS Coastal Ecosystem Program; Adopt-A-Wetland Program, Center for Coastal Studies-TAMUCC; University of Texas Marine Science Institute;Audubon Outdoor Club

SITE 3: Nueces Delta/Corps of Engineers Mitigation Site

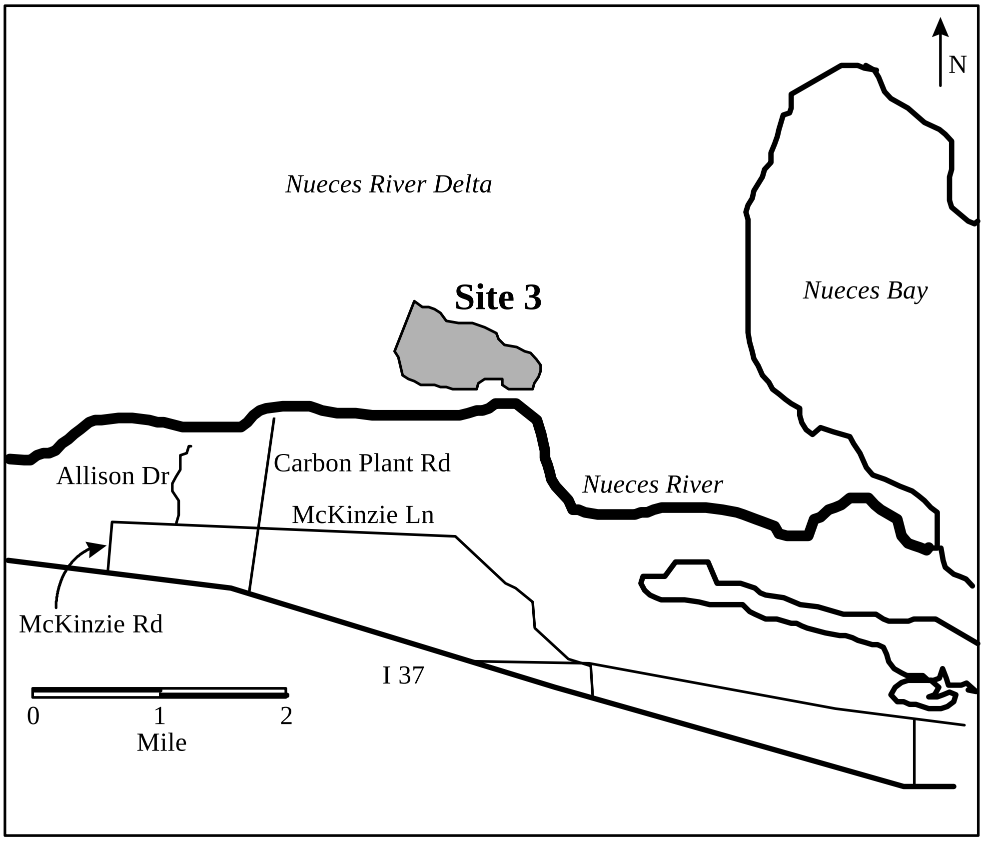

Figure 8. Location of Site 3 for potentialwetland enhancement.

Location: Within Nueces River delta, north of Nueces River and adjacent to Valero Refineries; limited access by boat only

Ownership and Management: Private ownership, leased to U.S. Army Corps of Engineers

General Description: In 1987, the U.S. Army Corps of Engineers intitated a mitigation project in relation to the Corpus Christi Ship Channel 45-foot project. This mitigation site has had limited success in establishing emergent, intertidal vegetaton as a result of initial improper elevations. Some remediated areas in which elevations were increased and smooth cordgrass (*Spartina alterniflora*) was planted in 1995 and have become well established.

Current Wetland Classification:

- Estuarine Subtidal Unconsolidated Bottom
- Estuarine Subtidal Unconsolidated Bottom/Excavated
- Estuarine Intertidal Emergent Persistent
  - Regularly Flooded
  - Regularly Flooded/Spoil

Irregularly Flooded
- Estuarine Intertidal Unconsolidated Shore
  Regularly Flooded
  Regularly Flooded/Excavated
  Irregularly Flooded
  Irregularly Flooded/Excavated
- Riverine Tidal Unconsolidated Bottom (listed as E1UBL)
- Upland

Water Regime: The marsh is tidally influenced via connections to tidal creeks within the Nueces River delta. Salinities are affected by upland runoff into the delta and limited water diversion via the Rincon Bayou project downstream of the IH 37 Nueces River Bridge. Floodwaters occasionally enter the site over a narrow berm when the Nueces River is high.

Wetland Vegetation: Vegetation within the site is limited; however, an established stand of smooth cordgrass is located at the west end.

Wetland Fauna: A six-year study has been conducted onsite to evaluate colonization and establishment of benthic (organisms living in the substrate), nektonic (those free-swimming organisms utilizing the water column), and avian fauna. The mitigated sites were not similar in species composition or abundances to reference marshes, primarily as a result of increased inundation, lack of vegetation, and turbid water conditions. However, an increase in species richness and similarity of the remediated sites and reference sites did occur following changes in elevation and establishment of smooth cordgrass (*Spartina alterniflora*) (Nicolau and Tunnell, 1996).

Adjacent Land Use: The site is located within the Nueces River delta and adjacent to the Nueces River.

Current Functions and Values:

- Sediment Trapping
- Water Quality Improvement
- Food Chain Support/Nutrient Export
- Fisheries Habitat
- Wildlife Habitat

Causes of Degradation/Loss: The created site was originally constructed with improper elevations (too much substrate was excavated) which resulted in a subtidal water regime that could not support emergent vegetation. Salinities within the site become quite high (>50 ppt) in the summer and during drought years due to low river flow into the delta.

Potential REC Plan:

Modification of Water Regime: The site would become primarily intertidal if elevations were raised by refilling selected areas to the correct elevation. In addition, diversion of wastewater effluent from the Allison Treatment Facility into the site would decrease salinities within the site.

Modification of Wetland Vegetation: Once elevations were corrected, salt marsh plant species appropriate to local water regime could be planted to stabilize sediment. In addition, submergent vegetation, such as wigeongrass (*Ruppia maritima*) could be planted at the southeast corner of the site, where wind fetch is low and turbidity levels would not affect establishment.

Modification of Wetland Fauna: The current subtidal community would be replaced with emergent marsh species at remediated wetlands.

Potential Functions and Values:

- Sediment Trapping
- Water Quality Improvement
- Food Chain Support/Nutrient Export
- Fisheries Habitat
- Wildlife Habitat

Potential Economic Benefits:

- Increase of habitat for commercially- and recreationally-important species (i.e., penaeid shrimp, red drum, speckled trout)
- Improvement of effluent quality from water treatment facility prior to entering natural habitats and Nueces Bay

Management Options: Once elevations are corrected and vegetation established, little management will be necessary.

Estimated Cost of Plan: $$$

Potential Partnerships: Army Corps of Engineers; City of Corpus Christi

SITE 4: Allison Treatment Plant Discharge Diversion Site

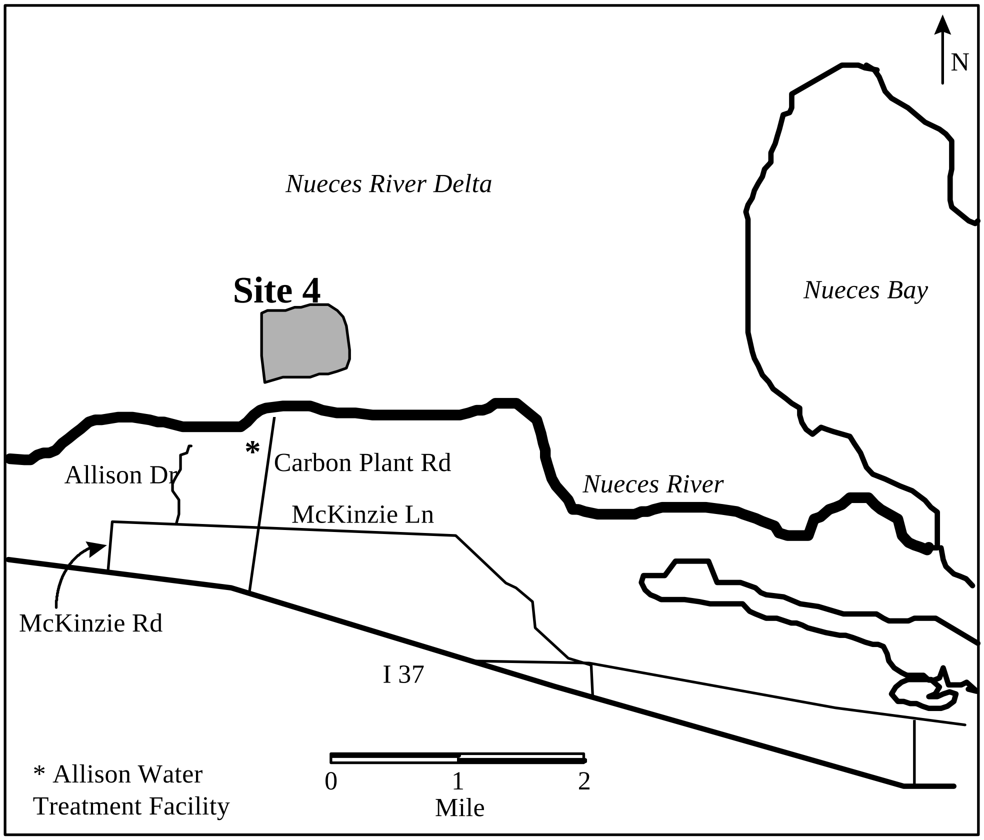

Figure 9. Location of Site 4 for potentialwetland enhancement.

Location: Within Nueces River delta, north of Nueces River; limited boat access

Ownership and Management: City of Corpus Christi

General Description: The current site being considered by the Texas Natural Resource Conservation Commission for release of treated municipal wastewater is composed of estuarine intertidal and subtidal wetlands within the Nueces River delta. The Nueces River delta has been impacted by the lower inflows from the Nueces River after completion of the dam at Lake Corpus Christi and more recently Choke Canyon Dam. The delta exhibits high salinities during the summer and drought years.

Current Wetland Classification:

- Estuarine Subtidal Unconsolidated Bottom
- Estuarine Subtidal Aquatic Bed
- Estuarine Intertidal Emergent Persistent
  Regularly Flooded

Irregularly Flooded

- Estuarine Intertidal Scrub-Shrub Broad-leaved Evergreen
  Irregularly Flooded
- Estuarine Intertidal Unconsolidated Shore
  Regularly Flooded
- Estuarine Subtidal Unconsolidated Bottom

Water Regime: The site is primarily tidally influenced. Floodwaters may enter the site during high water events in the Nueces River.

Wetland Vegetation: Wigeon grass (*Ruppia maritima*) is the primary submergent species in shallow, subtidal areas. Glasswort/saltwort species occur along the intertidal flats in isolated patches, as well as camphor daisy (*Machaeranthera phyllocephala*) and camphorweed (*Heterotheca subaxillaris*) . High marsh species include sea ox-eye daisy (*Borrichia frutescens*), saltgrass (*Distichlis spicata*) and shoregrass (*Monanthochloe littoralis*) with discrete patches of Gulf cordgrass (*Spartina spartinae*).

Wetland Fauna: No studies have been conducted onsite.

Adjacent Land Use: The Nueces River delta is not developed, although cattle grazing does occur in the northern sections. The Army Corps of Engineers mitigation site (Site 3) is downstream and east of this potential site.

Current Functions and Values:

- Food Chain Support/Nutrient Export
- Fisheries Habitat
- Wildlife Habitat

Causes of Degradation/Loss: Water storage in Lake Corpus Christi and Choke Canyon has severely restricted freshwater flow within the Nueces River delta, particularly after Rincon Bayou was hydrologically disconnected from the Nueces River. The Bureau of Reclamation reestablished the connection in 1995. No data exists to evaluate what this change did to the delta system, although more intermediate marsh vegetation probably occurred prior to the hydrologic alterations.

Potential REC Plan:

Modification of Water Regime: The City of Corpus Christi plans to construct a pipeline to the site for wastewater discharge from the Allison Treatment Facility. These discharges will increase the amount of water flowing through the delta and locally reduce estuarine salinities. Nutrients from the discharge may affect water quality prior to their uptake by plants and animals.

Modification of Wetland Vegetation: Freshwater vegetation could be planted at the immediate location of the discharge, which would enhance the vegetative diversity of the site. In addition, naturally occurring vegetation will probably increase in areas affected by the wastewater discharge.

Modification of Wetland Fauna: Local populations of salt marsh animals may decrease as salinity levels decrease. Increases in prey abundance may occur due to more water in the marsh and ameliorated salinities.

Potential Functions and Values:

- Water Quality Improvement
- Food Chain Support/Nutrient Export
- Fisheries Habitat
- Wildlife Habitat

Potential Economic Benefits:

- Increased fisheries productivity in the estuarine system

Management Options: Effects of wastewater discharge should be evaluated within the scope of a long-term monitoring plan.

Estimated Cost of Plan: $$$

Potential Partnerships: City of Corpus Christi

SITE 5: Tule Lake

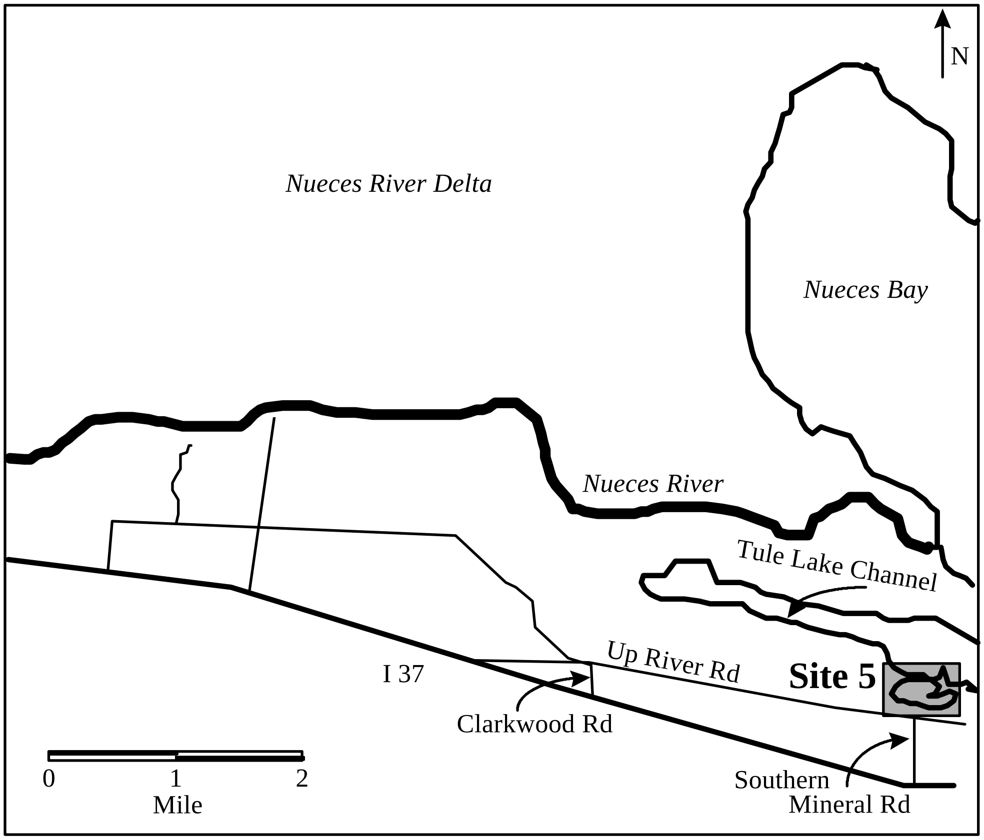

Figure10. Location of Site 5 for potential wetland enhancement.

Location: Intersection of Up River Road and Southern Minerals Road; access only along road easement

Ownership and Management: Port of Corpus Christi Authority

General Description: Tule Lake was connected to Nueces Bay prior to development of the Corpus Christi Harbor Ship Channel and the railroad line. Episodic freshwater inflows occurred primarily from upland runoff. Currently, treated industrial effluent provides a salinity gradient within Tule Lake and has increased floral and faunal diversity. The site is used extensively by resident and migratory bird species as a roosting, feeding, and nesting habitat.

Current Wetland Classification:

- Estuarine Subtidal Unconsolidated Bottom
- Estuarine Intertidal Emergent Persistent
  Irregularly Flooded
- Estuarine Intertidal Unconsolidated Shore
  Regularly Flooded
  Irregularly Flooded

Irregularly Flooded/Excavated

- Palustrine Emergent Persistent
  - Temporarily Flooded
  - Seasonally Flooded
  - Seasonally Flooded/Excavated
- Palustrine Unconsolidated Shore
  - Seasonally Flooded
  - Seasonally Flooded/Excavated
- Palustrine Unconsolidated Bottom
  - Semipermanently Flooded
- Upland

Water Regime: Tule Lake is tidally influenced by water from the Corpus Christi Ship Channel and by treated industrial process waters.

Wetland Vegetation: Glasswort/saltwort species occur along the intertidal flats in isolated patches, as well as camphor daisy (*Machaeranthera phyllocephala*) and camphorweed (*Heterotheca subaxillaris*). High marsh species include sea ox-eye daisy, saltgrass and shoregrass with discrete patches of Gulf cordgrass (*Spartina spartinae*). Smooth cordgrass (*Spartina alterniflora*) was planted in Tule Lake as a result of a mitigation project and has become well established.

Wetland Fauna: Tule Lake supports some of the highest bird species richness values and abundance in the Texas Coastal Bend; bird counts are recorded annually during the Corpus Christi Christmas bird count. Over 300 species have been documented, including such species of concern as the Brown Pelican, Reddish Egret, Osprey, Peregrine Falcon, and Snowy and Piping Plovers. Documentation of Snowy Plovers nesting at Tule Lake exemplifies the ecological importance of this site (G. Blacklock and H. Fetter, personal communication).

Adjacent Land Use: Industrial activities predominate the lands around Tule Lake with a tidal connection to the Corpus Christi Ship Channel.

Current Functions and Values:

- Water Quality Improvement
- Food Chain Support/Nutrient Export
- Fisheries Habitat
- Wildlife Habitat
- Education

Causes of Degradation/Loss: Contaminants have been introduced into Tule Lake by brine discharge from oil and gas activities in the 1950s as well as unrestricted industrial discharge. Erosion from adjacent agricultural lands increased the sediment load with associated chemical contaminants into Tule Lake. Levees surrounding the dredged material cells have eroded into Tule Lake and increased the amount of tidal mud flats, decreasing water depths and emergent marsh habitats. Nonpoint-source runoff from adjacent uplands can degrade water quality. Currently, no additional development is occurring around Tule Lake.

Potential REC Plan:

Continuation of Water Regime: The tidal connection of Tule Lake with the ship channel should be maintained to ensure adequate circulation of waters within the lake system. Industrial effluent discharge has increased the habitat diversity and has provided a freshwater site, a wetland type which is uncommon in the port area.

Modification of Sediment Load: The levee erosion occurring on the west side of Tule Lake should be controlled to minimize further loss of intertidal emergent marsh habitat.

Modification of Wetland Vegetation: No enhancement of vegetation is needed in Tule Lake.

Modification of Wetland Fauna: No modifications should be made to Tule Lake to enhance wetland faunal diversity, as the area is used extensively by numerous bird species.

Construction Activities: An observation tower could be constructed for a wildlife viewing platform and educational facility. Interpretive signs could aid in bird identification, explain functions and values of wetlands, and publicize the cooperative relationships between industry and wildlife habitat. (The Port Authority of Corpus Christi is evaluating potential options to increase wetland acreage, an activity that would require extensive dirt work. Implementation of their plan would place the "Potential Cost of Plan" as $$$.)

Potential Functions and Values:

- Water Quality Improvement
- Food Chain Support/Nutrient Export
- Fisheries Habitat
- Wildlife Habitat
- Education

Potential Economic Benefits:

- Education
- Ecotourism
- Water Quality Enhancement
- Facilitated Permitting of Port Projects

Management Options: The Port of Corpus Christi Authority has initiated an comprehensive evaluation of Tule Lake area restoration options. The site has experienced cumulative impacts from a variety of complex issues that must be addressed prior to any restoration efforts. In addition, the port staff believes there is potential to increase wetland acreage in the Tule Lake area; however, this potential goal is in relation to Port of Corpus Christi interests, and would be planned by their staff. On-site, societal benefits would occur if their plan is implemented. The conceptual plan within this report is interested in ensuring that Tule Lake does not receive any additional fill activities. Limiting future access to Tule Lake is essential to preserve the ecological integrity of the site (i.e., minimal disturbance to birds, plants, soils). The boardwalk could be used for educational field trips and decrease the potential dangers of visitors using road easements. Local birding and nature groups could organize field days at the site to increase educational and recreational opportunities at Tule Lake.

Estimated Cost of Plan: $$$ (see *Construction Activities* above)

Potential Partnerships: Port of Corpus Christi Authority; industry; local Audubon Society groups

SITE 6: Nueces Delta Shoreline

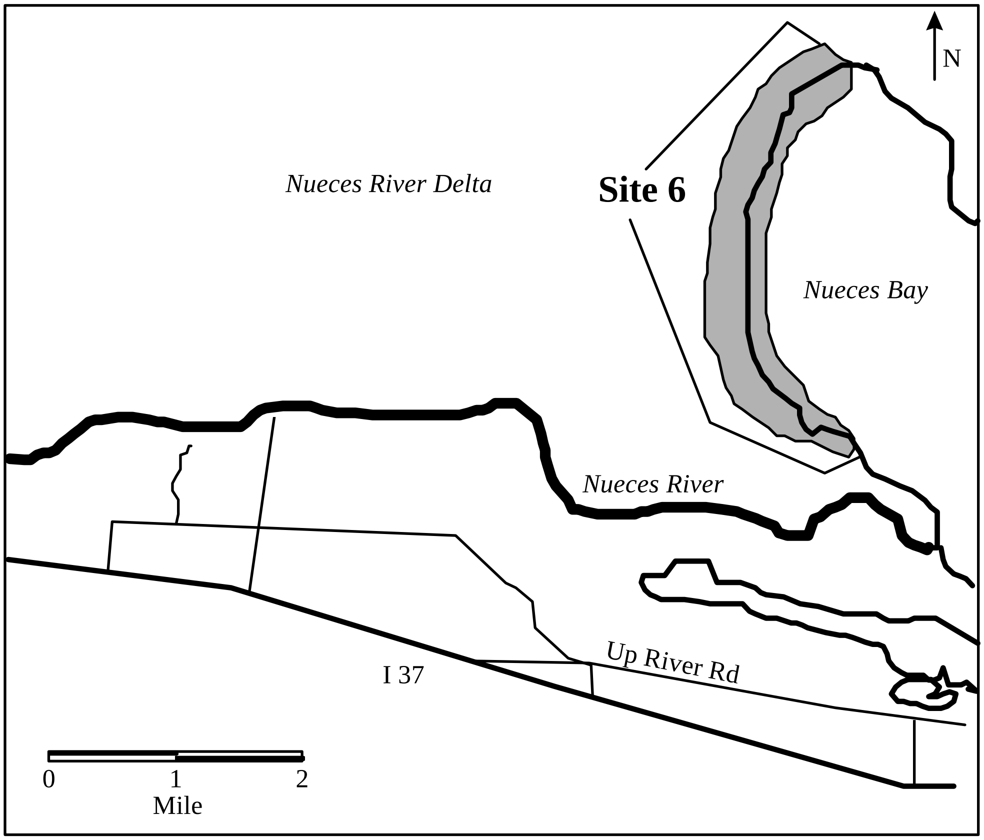

Figure 11. Location of Site 6 for potential wetland enhancement.

Location: East of Rincon Bayou drainage into Nueces Bay; access by boat only

Ownership and Management: Privately owned

General Description: Substantial erosion has occurred along the Nueces River delta due to prevailing southeast wind-driven waves, and emergent marsh has decreased as a result.

Current Wetland Classification:

- Estuarine Subtidal Unconsolidated Bottom
- Estuarine Intertidal Emergent Persistent Regularly Flooded
- Estuarine Intertidal Unconsolidated Shore Regularly Flooded

Water Regime: The site is tidally influenced

Wetland Vegetation: The emergent vegetation is predominately smooth cordgrass (*Spartina alterniflora*).

Wetland Fauna: The fringe marsh is important as a nursery habitat for several fish and crustaceans.

Adjacent Land Use: Agriculture in the uplands to the north; industry to the south

Current Functions and Values: No wetland functions are present in the eroded areas.

Causes of Degradation/Loss: Intertidal and subtidal salt marsh habitat has been lost for a diversity of fishery species through shoreline erosion. In addition, nutrient export from the marsh is decreased as marsh losses continue. Marsh accretion is not occurring due to the lack of sediment-laden water flowing through the Nueces River delta.

Potential REC Plan:

Construction Plan: Sediment is needed from available sources (e.g., dredged material) to reverse shoreline erosion. In addition, a wave barrier must be constructed to ensure marsh restoration success.

Modification of Wetland Vegetation: Smooth cordgrass should be planted immediately following soil placement to begin rhizome growth.

Potential Functions and Values:
- Shoreline Erosion Control
- Sediment Trapping
- Food Chain Support/Nutrient Export
- Fisheries Habitat
- Wildlife Habitat

Potential Economic Benefits:
- Beneficial use of dredged material

Management Options: Monitoring is essential to remediate any problems.

Estimated Cost of Plan: $$$

Potential Partnerships: Corps of Engineers; Bureau of Reclamation; Port of Corpus Christi Authority; State of Texas; Private Landowners

SITE 7: White's Point

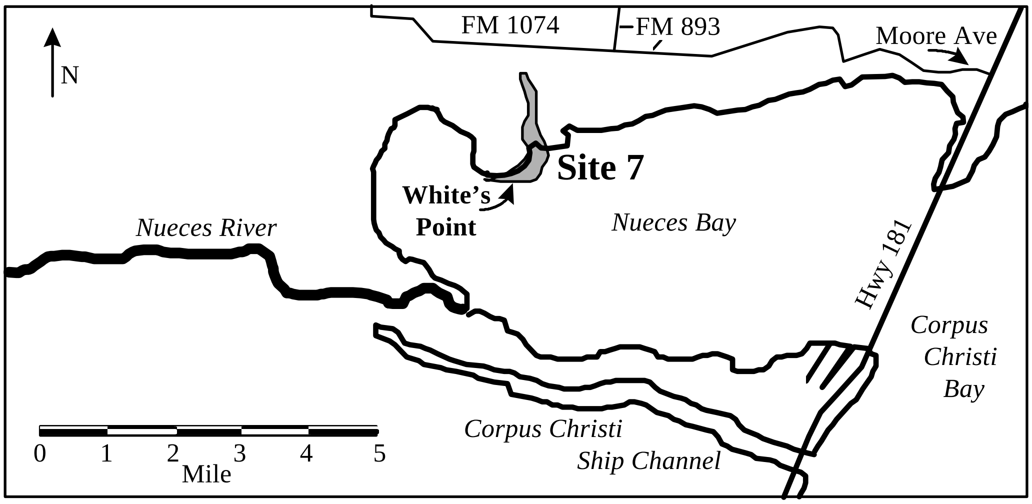

Figure 12. Location of Site 7 for potential wetland enhancement.

Location: Northern shore and adjacent creek of Nueces Bay; limited access by boat and no land access

Ownership and Management: : Oil and Gas Exploration Leases

General Description:

Current Wetland Classification:

- Estuarine Subtidal Aquatic Bed Rooted Vascular
- Estuarine Subtidal Unconsolidated Bottom
- Estuarine Intertidal Emergent Persistent
  - Regularly Flooded
  - Irregularly Flooded
- Estuarine Intertidal Unconsolidated Shore
  - Regularly Flooded
  - Irregularly Flooded
- Palustrine Unconsolidated Bottom
  - Semipermanently Flooded/Impounded/Diked
  - Semipermanently Flooded/Excavated
- Palustrine Emergent Persistent
  - Semipermanently Flooded
  - Semipermanently Flooded/Diked/Impounded
  - Seasonally Flooded
  - Seasonally Flooded/Impounded-Diked
  - Temporarily Flooded
  - Temporarily Flooded/Excavated
  - Temporarily Flooded/Impounded-Diked

- Palustrine Scrub-Shrub Broad-leaved Deciduous
  - Temporarily Flooded
  - Temporarily Flooded/Impounded-Diked
- Palustrine Forested Broad-leaved Deciduous
  - Temporarily Flooded
- Palustrine Unconsolidated Shore
  - Seasonally Flooded
  - Seasonally Flooded/Excavated
- Riverine Intermittent Streambed
  - Seasonally Flooded
  - Seasonally Flooded/Excavated
- Upland

Water Regime: Primarily tidal influence, occasionally influenced by upland stream runoff and infrequently influenced by Nueces River flooding

Wetland Vegetation: Smooth cordgrass in intertidal, regularly flooded areas; Saltwort/Glasswort/Saltgrass associations in intertidal, irregularly flooded areas; subtidal aquatic bed vegetation is unknown; no onsite evaluations were conducted to determine palustrine vegetation composition

Wetland Fauna: No studies have been conducted onsite.

Adjacent Land Use: Oil and gas exploration; agriculture in upland

Current Functions and Values:

- Shoreline Erosion Control
- Flood Storage and Desynchronization
- Water Quality Improvement
- Food Chain Support/Nutrient Export
- Fisheries Habitat
- Wildlife Habitat
- Recreation/Education/Culture

Causes of Degradation/Loss: Oil and gas exploration at White's Point has historically impacted the site by construction of well pads and roads through the wetlands, the discharge of brine via mainland creek drainage and associated sediment discharge from creek erosion, channel dredging, and offshore by oyster shell removal. These cumulative impacts have altered the natural wetland functions and values.

Potential REC Plan:

Modification of Water Regime: By recontouring upland freshwater stream drainage and utilizing excavated and diked/impounded wetlands in the upland area, floodwater desynchronization and sediment retention/water quality improvement would occur prior to entering estuarine wetlands and Nueces Bay. Increased tidal exchange to estuarine wetlands could occur via properly placed culverts through oil and gas roads leading to active well pads. Abandoned pads and access roads could be scraped down and contaminated soil removed from the site. Previously isolated wetlands would be reconnected to bay waters and water quality enhanced.

Modification of Wetland Vegetation: Removal of low-value emergents (e.g., cattails) in palustrine wetlands and vegetation plantings of species with important nutrient retention qualities and wildlife food values would enhance palustrine habitats. Through improved water retention time in palustrine wetlands adjacent to creeks, restoration of riparian vegetation and scrub-shrub habitats could be implemented. Revegetation of intertidal and subtidal wetlands in previously degraded areas would increase fisheries and wildlife habitats.

Modification of Wetland Fauna: Increased quality of palustrine vegetation would enhance wildlife habitat for nesting and foraging species. Restored estuarine habitats would improve fisheries and wildlife functions and associated nutrient export to adjacent bay habitats.

Potential Functions and Values:

- Shoreline Erosion Control
- Flood Storage and Desynchronization
- Sediment Trapping
- Water Quality Improvement
- Food Chain Support/Nutrient Export
- Fisheries Habitat
- Wildlife Habitat
- Recreation/Education/Culture

Potential Economic Benefits:

- Water quality enhancement for recreationally- and commercially-important species and associated prey.

Management Options: Cooperative efforts of partners would monitor establishment of wetland functions and values and identify any necessary modifications.

Estimated Cost of Plan: $$$

Potential Partnerships: Texas Prairie Wetland Program, U.S. Fish and Wildlife Service; Texas and Urban Watch Program, Texas Natural Resource Conservation Commission; Coastal Management Program; Oil and Gas Corporations; Private Landowners

SITE 8: Nueces Bay North Shoreline

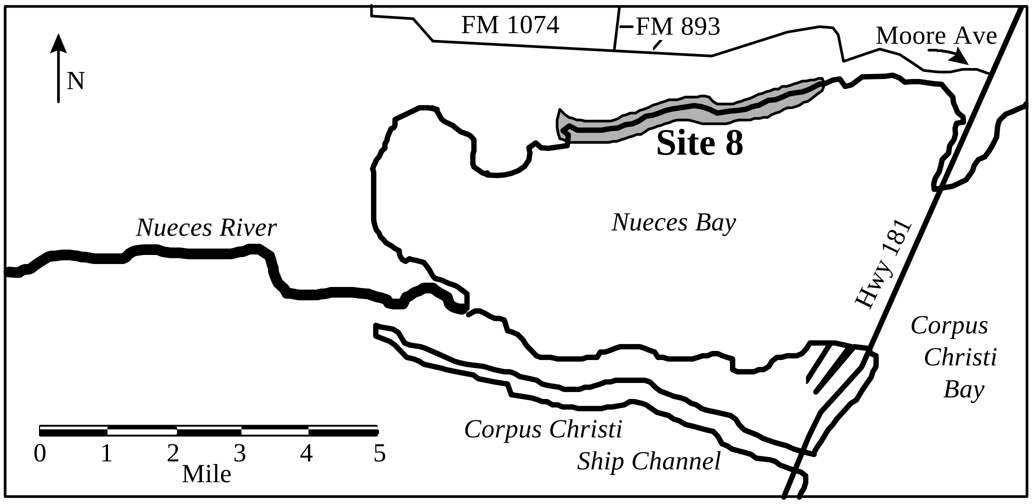

Figure 13. Location of Site 8 for potential wetland enhancement.

Location: North shoreline in San Patricio County; access by boat only and no land access

Ownership and Management: Shoreline is under private ownership; submerged lands areunder state ownership.

General Description: The northern shoreline of Nueces Bay has experienced continuous erosion primarily due to prevailing southeasterly winds and high wave energy.

Current Wetland Classification:

- Estuarine Subtidal Aquatic Bed Rooted Vascular
- Estuarine Intertidal Emergent Persistent
  Irregularly Flooded
- Palustrine Emergent Persistent
  Temporarily Flooded
  Semipermanently Flooded/Diked/Impounded
  Semipermanently Flooded/Excavated
- Palustrine Unconsolidated Shore
  Seasonally Flooded
- Riverine Intermittent Streambed
  Seasonally Flooded
- Upland

Water Regime: Tidally influenced, minor influence from freshwater stream runoff

Wetland Vegetation: Estuarine wetlands along high tide line of shoreline are primarily vegetated with saltgrass (*Distichlis spicata*), and mixture of salt-tolerant forbs (Sea ox-eye daisy, camphor

daisy, etc.). Palustrine vegetation was not determined, as these wetlands are under private ownership.
Wetland Fauna: No faunal studies have been undertaken at this site

Adjacent Land Use: Agricultural upland use

Current Functions and Values:

- Shoreline Erosion Control
- Sediment Trapping
- Food Chain Support/Nutrient Export
- Fisheries Habitat
- Wildlife Habitat

Causes of Degradation/Loss: Prevailing onshore southeast winds continue to erode shoreline reducing intertidal and subtidal habitats.

Potential REC Plan:

Proposed Construction: Creating a wave barrier offshore to reduce erosion. A barrier could be constructed at mean water level using concrete-linked materials.

Modification of Wetland Vegetation: Plant intertidal vegetation, such as smooth cordgrass (*Spartina alterniflora*) within erosion barrier and along unconsolidated shoreline; plant subtidal vegetation, such as shoalgrass (*Halodule wrightii*) between wave barrier and shoreline.

Modification of Wetland Fauna: Restored habitat would increase wetland faunal communities.

Potential Functions and Values:

- Shoreline Erosion Control
- Sediment Trapping
- Food Chain Support/Nutrient Export
- Fisheries Habitat
- Wildlife Habitat

Potential Economic Benefits:

- Reduce losses of land value
- Increase commercial and recreational fisheries and wildlife habitat
- Increase nutrient export to adjacent habitats

Management Options: Maintenance of wave barrier would be necessary throughout life of project or until shoreline restored. Monitor development of habitats to remediate potential problems with design.

Estimated Cost of Plan: $$ (dependent upon length of shoreline habitat restored)

Potential Partnerships: Natural Resource Conservation Service; Soil and Water Conservation District; Coastal Management Program; U.S. Fish and Wildlife Service, Coastal Ecosystem Program; Private Landowners

SITE 9: Corpus Christi Beach Wetland

Location: Northbound frontage road of Hwy 181 on Corpus Christi Beach; road easement access only

Ownership and Management: The site is owned by the City of Corpus Christi

General Description: A mosaic of vegetated wetlands surrounding unvegetated, frequently flooded tidal ponds are tidally connected via a culvert underneath Hwy 181 to Rincon Channel.

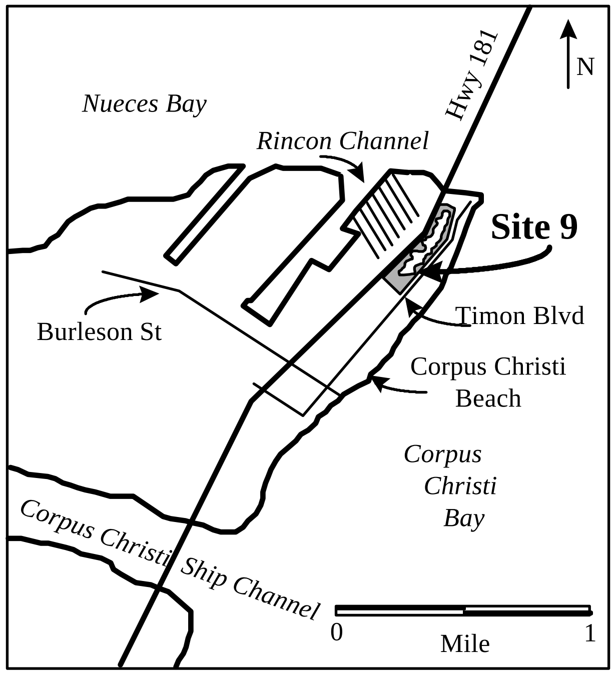

Figure 14. Location of Site 9 for potential wetland enhancement.

Current Wetland Classification:

- Estuarine Subtidal Unconsolidated Bottom
- Estuarine Intertidal Emergent Persistent Irregularly Flooded
- Estuarine Intertidal Unconsolidated Shore Regularly Flooded
- Palustrine Unconsolidated Bottom Semipermanently Flooded/Excavated
- Upland

Water Regime: The wetlands are driven hydrologically by limited tidal exchange with Rincon Channel via culverts which are located beneath Hwy 181. Extreme high tides in the bays will flood this wetland and adjacent lands within Corpus Christi Beach residential/commercial areas. Freshwater input to the wetlands occurs during high rainfall events when adjacent urban runoff enters the wetlands. The wetland is additionally affected by prolonged low tides and drought periods.

Wetland Vegetation: Persistent emergent vegetation surrounding the intertidal mudflat ponds is predominantly a *Borrichia/Lycium* association. Patches of *Prosopis glandulosa* surround the wetland along the upland fringe.

Wetland Fauna: Several wading bird species utilize the wetlands during periods of standing water in the wetland ponds. The vegetated marsh is utilized by willets and rails for protection and nesting during wetter years.

Adjacent Land Use: The frontage road of Hwy 181 borders the wetland on the west, a two-lane road on the east and an RV Park on the North, a convenience store on the south.

Current Functions and Values:

- Water Quality Improvement
- Food Chain Support/Nutrient Export
- Fisheries Habitat
- Wildlife Habitat
- Recreation

Causes of Degradation/Loss: This relict wetland is one of two remaining wetlands on Corpus Christi Beach, due to port, residential, and commercial development. The wetland is limited in providing essential functions and values due to the poor tidal circulation to the wetlands. Concerns for the future survival of the wetlands should be assessed in any City of Corpus Christi development plans.

Potential REC Plan:

Modification of Water Regime: The culverts connecting the wetlands to Rincon Channel should be evaluated to determine if maintenance is needed for maximum water interchange. Additional culverts may be necessary to increase water exchange at the north end of the site.

Construction: Boardwalks and interpretive signs could be placed along edge of the wetland parellel to the road easement, with elevated viewing blinds constructed at key areas to maximize passive interaction with wetland wildlife.

Potential Functions and Values:

- Water Quality Improvement
- Food Chain Support/Nutrient Export
- Fisheries Habitat
- Wildlife Habitat
- Recreation/Education

Potential Economic Benefits:

- Tourism - wildlife viewing area
- Education - values of wetlands in an urban setting for water quality improvement and fisheries and wildlife habitat, field site for Texas State Aquarium Education Program
- Adjacent Property Value - increased due to open-space preservation of natural wetlands setting

Management Options: Continued protection of this relict wetland on Corpus Christi Beach is essential. In addition, the Corpus Christi Beach Wetland Site would be an ideal location for the Urban Watch Water Quality Monitoring Program, particularly through the involvement of young residents of Corpus Christi Beach.

Estimated Cost of Plan: **$$**

Potential Partnerships: Texas Department of Transportation; Texas and Urban Watch Program,Texas Natural Resources Conservation Commission; Adopt-A-Wetland Program, Center for Coastal Studies-TAMUCC; Texas State Aquarium; Great Texas Coastal Birding Trail Program, Texas Parks and Wildlife Department

SITE 10: Rincon Channel Wetlands

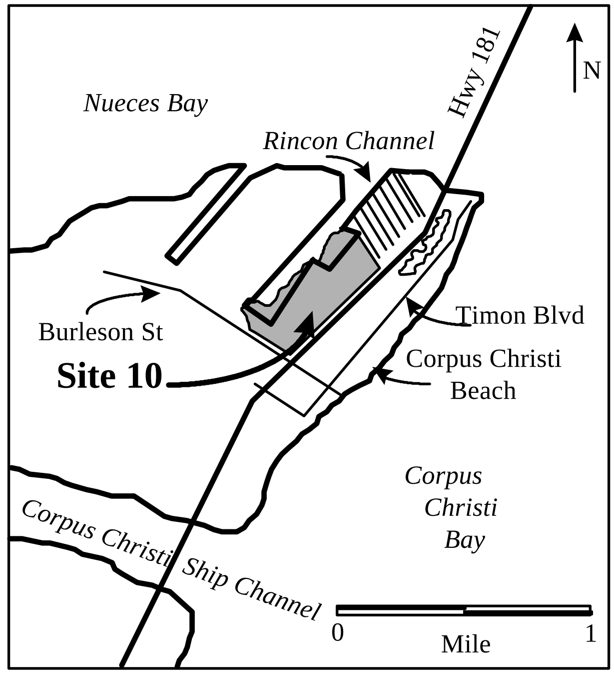

Figure 15. Location of Site 10 for potential wetland enhancement.

Location: Southbound frontage road by Hwy 181 on Corpus Christi Beach; road easement access only

Ownership and Management: The wetlands adjacent to Rincon Channel are under private ownership; the Port of Corpus Christi Authority is an adjacent property owner.

General Description: Extensive intertidal marshes occurred along the southern shore of Nueces Bay prior to the development of the Port of Corpus Christi. Several thousand acres of wetlands were destroyed from placement of dredged material. The relict wetlands along the Rincon Channel have been altered recently by the maintenance of Rincon Channel and through stormwater runoff from adjacent Highway 181 and stormwater drainage from residential and commercial properties along Corpus Christi Beach.

Current Wetland Classification:

- Estuarine Intertidal Emergent Persistent
  - Regularly Flooded
  - Irregularly Flooded
- Estuarine Intertidal Unconsolidated Shore
  - Irregularly Flooded (not on 1992 NWI map)
- Palustrine Emergent Persistent
  - Semipermanently Flooded
- Upland

Water Regime: Most of the hydrology in this wetland is driven by estuarine tides entering Rincon Channel from Nueces Bay which are regionally affected by lunar and wind-driven tides. Freshwater enters the wetlands via stormwater drainages.

Wetland Vegetation: Predominant emergent vegetation includes *Batis maritima, Salicornia* spp., in regularly flooded areas, and *Borrichia frutescens/Lycium carolinianum* in the higher, irregularly flooded wetlands. The species composition of freshwater vegetation in the Palustrine Emergent habitats is unknown.

Wetland Fauna: Currently, a diverse assemblage of waterbirds utilize the Rincon Channel wetlands throughout the year. Wading birds search the emergent marsh fringe for food during high tide and unvegetated mudflats during low tide. A elongate spit along the Rincon Channel is commonly used as a roosting place by cormorants and White and Brown Pelicans during low tides.

Adjacent Land Use: An excavated, subtidal channel bordering the tidal flat on the west side separates the wetlands from the seawall-reinforced commercial district. A canal-home development lies north of the site, while the frontage road of Hwy 181 borders the wetlands to the east. No development has occurred south of the site, where a two-lane road bisects the main wetlands from the adjacent freshwater site.

Current Functions and Values:

- Water Quality Improvement
- Food Chain Support/Nutrient Export
- Fisheries Habitat
- Wildlife Habitat

Causes of Degradation/Loss: Losses of wetlands along southern Nueces Bay resulted from Port of Corpus Christi development. These existing wetlands have developed on an old landfill that was operated by the City of Corpus Christi and/or replaced a primarily unvegetated intertidal wetland. The wetlands are limited in areal extent, but do support a substantial amount of wildlife relative to their size. The wetlands improve water quality, as stormwater runoff enters the emergent wetlands at several points. However, transport of waters across the wetlands is limited. The wetlands support intertidal vegetated and unvegetated areas, but perimeter-to-area ratio is low, limiting the amount of fringe marsh available for prey protection and predator foraging. Future development of this area may occur. Only two wetland sites remain on Corpus Christi Beach (see also Site 11); therefore, loss of these wetlands would severely affect the natural resources remaining in this area.

Potential REC Plan:

Modification of Water Regime: The existing water quality improvement function could be further enhanced by minor excavation of meandering tidal creeks leading from the stormwater drains into the vegetated intertidal wetlands. This enhancement would allow more surface contact of urban waters with both vegetation and sediment for pollution uptake. The extensive *Batis-Salicornia* wetland in the southern part of the site could be recontoured to increase perimeter-to-area ratio by shallow excavation of tidal channels through the vegetated emergent marsh. This enhancement would increase fisheries and wildlife habitat fringe wetlands and increase tidal flow throughout the wetland to facilitate food chain support and nutrient export from decaying vegetation within the marsh interior. The tidal channels should mimic meandering "finger" channels and small isolated vegetation islands in natural marshes, yet not to the extent of fragmenting the vegetated portions of the marsh. The intertidal mud flat functions quite well at present and should not be considered for any revegetation plans. The proximity of the wetlands to Hwy 181 provides an excellent opportunity to increase public awareness about the natural resources of the Texas Coastal Bend. The frontage road would allow visitors access to view the wildlife within the Rincon Channel wetland and understand the benefits of wetlands in an urban landscape.

Construction: Boardwalks and interpretative signs could be installed on the edge of the wetland along the road easement with elevated viewing blinds constructed at critical areas maximizing positive interactions of people and wetland wildlife with minimum impact.

Potential Functions and Values:

- Water Quality Improvement
- Food Chain Support/Nutrient Export
- Fisheries Habitat
- Wildlife Habitat
- Recreation/Education

Potential Economic Benefits:

- Tourism - wildlife viewing area
- Education - values of wetlands in an urban setting for water quality improvement and fisheries and wildlife habitat; field site for Texas State Aquarium Education Program
- Adjacent Property Value - increased due to preservation of open space and a natural wetlands setting

Management Options: Continued protection of this relict wetland on Corpus Christi Beach is essential. In addition, the Rincon Channel Wetlands Site would be an ideal location for the Urban Watch Water Quality Monitoring Program, particularly through the involvement of residents and Winter Texans living at Corpus Christi Beach.

Estimated Cost of Plan: $$

Potential Partnerships: State of Texas; Private Landowners; City of Corpus Christi; Texas Department of Transportation; Texas Natural Resources Conservation Commission; U.S. Fish and Wildlife Coasal Ecosystem Program; Adopt-A-Wetland Program, Center for Coastal Studies-TAMUCC; Corpus Christi Independent School District; Texas State Aquarium

SITE 11: City of Corpus Christi Future Park/Oso Creek Complex

Location: Junction of Chapman Ranch Road and Oso Creek Bridge; no access to potential creation site

Ownership and Management: City of Corpus Christi

General Description: The site is adjacent to Oso Creek and was purchased to remove topsoil to cap an adjacent landfill. The site includes upland areas used for row crop farming and Oso Creek wetlands.

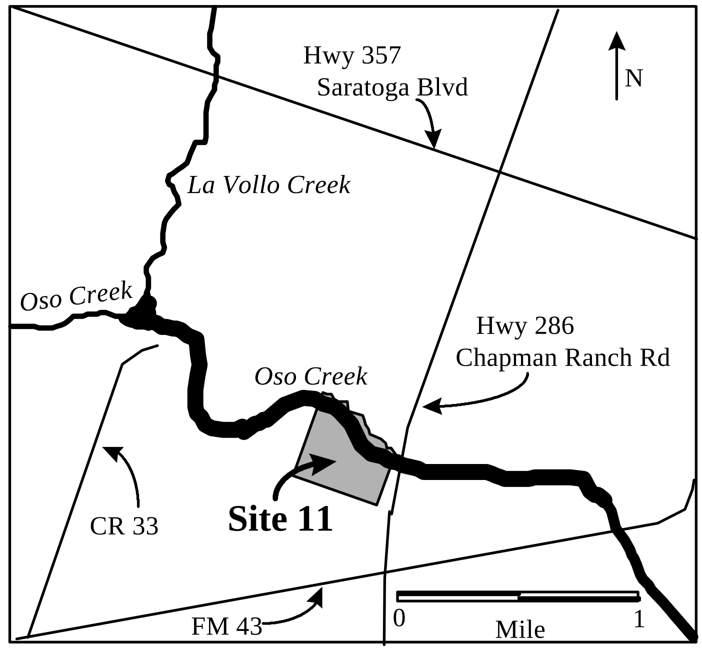

Figure 16. Location of Site 11 for potential wetland enhancement.

Current Wetland Classification:

- Palustrine Emergent Persistent
  Temporarily Flooded
- Palustrine Emergent Persistent
  Seasonally Flooded
- Palustrine Emergent Persistent
  Seasonally Flooded
- Palustrine Forested Broad-leaved Deciduous
  Temporarily Flooded
- Palustrine Unconsolidated Bottom
  Permanently Flooded
- Riverine Intermittent Streambed
  Seasonally Flooded
- Upland

Water Regime: The created wetland will receive water from the Oso Creek watershed. Additional water is discharged from wastewater treatment facilities upstream from the site.

Wetland Vegetation: Vegetation along the uplands consists primarily of mesquite (*Prosopis glandulosa*) and scrub understory bordering agricultural lands. Many of the slopes of the creek are scoured and fairly steep, limiting any vegetation establishment; however, riparian vegetation and ephemeral wetlands are located along portions of a natural terrace between upland and creek.

Wetland Fauna: Unknown

Adjacent Land Use: Current land use on the west side of Oso Creek is primarily agriculture, while the Greenwood Landfill is located on the east side.

Current Functions and Values:

- Food Chain Support/Nutrient Export
- Fisheries Habitat
- Wildlife Habitat

Causes of Degradation/Loss: The upper reaches of Oso Creek have been used for brine discharge which eliminated native vegetation and resulted in erosion of creek slope and streambed in some areas of Oso Creek.

Potential REC Plan:

Construction Actions: The City of Corpus Christi purchased the site primarily to excavate topsoil from the upland agricultural lands and cover the Greenwood Landfill. The excavated area will be converted to a wetland with appropriate slope to enhance wetland vegetation establishment and diversity. A detailed plan is being developed by a private consulting firm and is currently not available.

Potential Functions and Values:

- Shoreline Erosion Control
- Flood Storage and Desynchronization
- Sediment Trapping
- Water Quality Improvement
- Food Chain Support/Nutrient Export
- Fisheries Habitat
- Wildlife Habitat
- Recreation/Education/Culture

Potential Economic Benefits:

- Habitat Diversity
- Education Site
- Improved Water Quality

Management Options: This project is currently being developed by the City of Corpus Christi and other partnerships including funding from the Coastal Management Program. A comprehensive management plan is being developed at this time.

Estimated Cost of Plan: $$$$

Potential Partnerships: City of Corpus Christi; Texas Watch and Urban Watch Program, Texas Natural Resource Conservation Commission; local birding and nature groups

SITE 12: Corpus Christi Botanical Gardens

Location: Southwest corner of Staples Street and Oso Creek bridge; access within Corpus Christi Botanical Gardens

Ownership and Management: The Corpus Christi Botanical Gardens are operated by the Corpus Christi Botanical Society under a 60-yr lease from the City of Corpus Christi.

General Description: The wetlands are part of property leased by the Corpus Christi Botanical Society. The upland areas within the gardens are being landscaped with native vegetation and educational displays of xeriscape landscaping. The wetlands are located along Oso Creek and include both freshwater and estuarine-influenced wetlands.

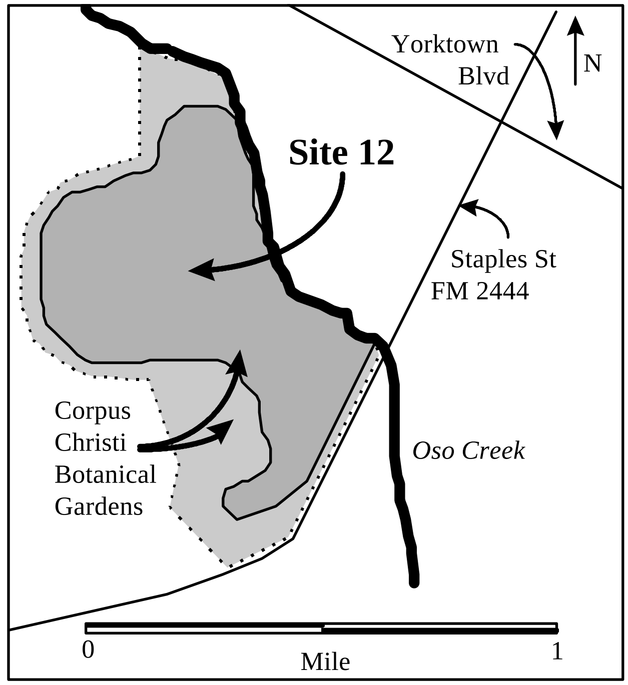

Figure 17. Location of Site 12 for potential wetland enhancement.

Current Wetland Classification:

- Estuarine Emergent Persistent
  - Irregularly Flooded
- Estuarine Intertidal Flat
  - Irregularly Flooded
  - Regularly Flooded
- Estuarine Subtidal Open Water
- Palustrine Emergent Persistent
  - Semipermanently Flooded
- Palustrine Open Water
  - Permanent/Excavated
- Upland

Water Regime: Water levels within the freshwater wetlands fluctuate both seasonally within a year and among years, depending on rainfall and runoff events. An extensive amount of upland runoff is directed into the wetlands from drainage ditches along Staples Street. Currently, the estuarine flats do not pond water long after rainfall and runoff. Under high water conditions following any substantial rainfall events, overflow from the wetlands runs into Oso Creek.

Wetland Vegetation: The freshwater wetlands are predominantly composed of California bulrush (*Scirpus californicus*) and cattails (*Typha* sp.) along the fringe and submergent vegetation in the center of the wetland during wet years. The estuarine wetlands range from Gulf Cordgrass (*Spartina spartinae*) to Saltgrass (*Distichlis* spicata) and glasswort (*Salicornia* sp.) along the interface between wetlands and uplands.

Wetland Fauna: A wide range of waterbirds and passerines are attracted to the wetlands and upland vegetation.

Adjacent Land Use: Sorghum and cotton agricultural fields surround the wetlands, with the exception of a recent residential community which directly borders the wetland on the west side.

Current Functions and Values:

- Shoreline Erosion Control
- Flood Storage and Desynchronization
- Sediment Trapping
- Water Quality Improvement
- Food Chain Support/Nutrient Export
- Fisheries Habitat
- Wildlife Habitat
- Recreation/Education/Culture

Causes of potential degradation/loss: Expansion of development of the City of Corpus Christi westward will affect Oso Creek and associated wetlands within the Corpus Christi Botanical Society properties through localized increases of stormwater discharge. Current development easements for drainage ditches do not allow sufficient slope ratios (at least 3:1) and meandering design for flood desynchronization and establishment of wetland vegetation to restore water quality.

Potential REC Plan:

Modification of Water Regime: The drainage system could be redesigned to allow for continued development yet minimize damage to wetlands and creek system. The water regime could be controlled to enhance habitat for fisheries and wildlife and improve water quality prior to entering the estuarine system. A low levee designed to retain water at shallow depths in the estuarine flats area could be constructed in an area between two upland peninsulas prior to entering Oso Creek. A water-control structure (stop-log) within the levee would enhance water-level management to maintain plant diversity and seasonal drawdowns. The levee would not retain floodwaters greater than wetland capacity.

Modification of Wetland Vegetation: Seasonal retention of fresh water would allow the establishment of freshwater, intermediate, and brackish vegetation at appropriate elevations and inundation periods. Removal of noxious vegetation (e.g., salt cedar [*Tamarix* sp.]) and replacement plantings of native vegetation (e.g., sedges, rushes, arrowhead, etc.) would enhance wetland diversity and provide additional food sources for waterbirds.

Modification of Wetland Fauna: Enhancement of existing habitats and improvement of water quality would increase populations of both resident and migratory animals. Floating islands constructed of native vegetation could be anchored in the open areas of the wetland to increase nesting substrate. Nest boxes could be placed around the wetland perimeter to increase cavity-nesting species.

Potential Functions and Values:

- Shoreline Erosion Control
- Flood Storage and Desynchronization
- Sediment Trapping
- Water Quality Improvement
- Food Chain Support/Nutrient Export
- Fisheries Habitat
- Wildlife Habitat
- Recreation/Education/Culture

Potential Economic Benefits:

- Improved water quality for recreationally- and commercially-important estuarine species and associated prey
- Reduction of downstream flooding due to increased flood desynchronization
- Excellent educational facility for citizen awareness of importance of urban wetlands

Management Options: The Corpus Christi Botanical Society with the cooperative effort of partners would manage the wetlands for optimum wetland diversity and functions.

Estimated Cost of Plan: $$

Potential Partnerships: City of Corpus Christi; Corpus Christi Botanical Gardens; Texas Prairie Wetland Program, U.S. Fish and Wildlife Service; Coastal Management Program; Texas Watch and Urban Watch Program, Texas Natural Resource Conservation Commission; Adopt-a-Wetland Program, Center for Coastal Studies,TAMU-CC

SITE 13: Gum Hollow Creek

Location: North of Nueces Bay in San Patricio County; limited visual access at County Road and no access to creek

Ownership and Management: Private Ownership

General Description: The Gum Hollow Creek system drains a major upland area west of Portland and has been channelized in the upper areas to increase upland runoff. Recurrent brine discharge destroyed freshwater vegetation and increased stream erosion within the creek drainage. The displaced sediment formed a fluvial delta fan at the mouth of the creek into Nueces Bay. In addition, oil spills in the Gum Hollow Creek area have further impacted the native flora and fauna. At present, the creek can be categorized as degraded habitat.

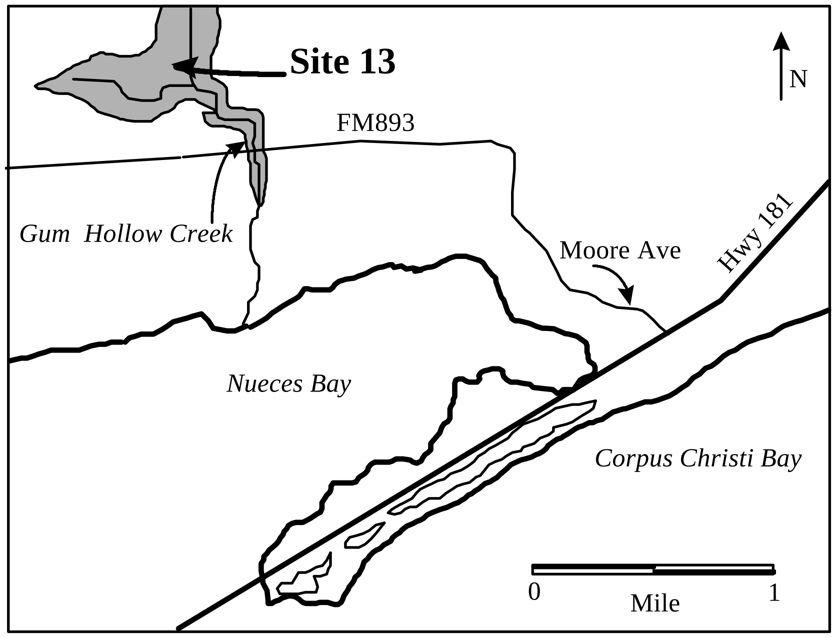

Figure 18. Location of Site 13 for potential wetland enhancement.

Current Wetland Classification:

- Estuarine Subtidal Unconsolidated Bottom
- Palustrine Emergent Persistent
  - Temporarily Flooded
  - Temporarily Flooded/Excavated
- Palustrine Emergent Persistent
  - Seasonally Flooded/Diked-Impounded
  - Semipermanently Flooded/Excavated
- Palustrine Unconsolidated Bottom
  - Semipermanently Flooded/Diked-Impounded
  - Permanently Flooded/Diked-Impounded
- Palustrine Unconsolidated Shore
  - Temporarily Flooded/Diked-Impounded
  - Seasonally Flooded/Diked-Impounded
- Riverine Lower Perennial Unconsolidated Bottom/Diked-Impounded
- Riverine Lower Perennial Unconsolidated Bottom/Excavated/Diked-Impounded

- Riverine Intermittent Streambed
  Seasonally Flooded
- Upland

Water Regime: Waters enter the creek system from upland runoff. Two dams are located at the lower end of the creek. The upper dam impounds most of the fresh water that floods the creek; the lower dam eliminates saltwater intrusion.

Wetland Vegetation: Cattail (*Typha* spp.) is the predominant emergent marsh vegetation along the creek with an extensive stand of California bulrush (*Scirpus californicus*) at the confluence of the western arm of the creek and the channelized portion flowing from the north. Little submergent vegetation occurs within the creek with the exception of coontail upstream of the upper dam. The creek banks are fairly steep, eliminating any significant amount of riparian vegetation along the watercourse.

Wetland Fauna: No studies have been conducted onsite.

Adjacent Land Use: Agricultural land use, oil and gas exploration

Current Functions and Values:

- Groundwater Discharge/Recharge
- Shoreline Erosion Control
- Flood Storage and Desynchronization
- Sediment Trapping
- Water Quality Improvement
- Food Chain Support/Nutrient Export
- Fisheries Habitat
- Wildlife Habitat

Causes of Degradation/Loss: Habitat degradation has historically occurred as a result of brine discharge through the creek system. Channelization of the upper areas and erosion have eliminated most fringe wetland areas along the creek edge. Numerous fish kills have been reported in the creek, probably due to nonpoint-source pollution, slow flow in summer leading to oxygen depletion, and oil spills.

Potential REC Plan:

Modification of Water Regime: The channelized portion of the creek can be recontoured to enhance flood desynchronization and water quality. Low-water dams would remain in place to retain water along certain portions of the creek system.

Modification of Wetland Vegetation: Other wetland plants, such as arrowhead (*Sagitarria* sp.), sedges or shrubs (*Cephalanthus occidentalis*) can be planted in place of cattail along the creek edges. Riparian vegetation can be restored along the watercourse to increase water quality from agricultural land runoff.

Modification of Wetland Fauna: Increased wetland plant diversity of vegetation which will serve as food for wildlife and enhance animal diversity at Gum Hollow Creek. Riparian vegetation will function as protection and habitat for resident and migratory neotropicals.

Potential Functions and Values:

- Groundwater Discharge/Recharge
- Shoreline Erosion Control
- Flood Storage and Desynchronization
- Sediment Trapping
- Water Quality Improvement
- Food Chain Support/Nutrient Export
- Fisheries Habitat
- Wildlife Habitat

Potential Economic Benefits: Water quality will be enhanced as it drains into Nueces Bay, thus increasing habitat quality for recreational and commercial fisheries and associated species in the estuarine food web.

Management Options: No extensive maintenance is necessary once vegetation has become established.

Estimated Cost of Plan: $$$

Potential Partnerships: Soil and Water Conservation District; Texas Natural Resource Conservation Commission; Partners for Wildlife, U.S. Fish and Wildlife Service; Oil and Gas Corporations; Private Landowners

SITE 14: Gum Hollow Delta

Location: North shoreline of Nueces Bay west of Portland; limited boat access

Ownership and Management: Private ownership

General Description: The delta was formed by Gum Hollow Creek and increased in size when brine discharge eliminated native creek vegetation and the creek slopes eroded. The delta is largely unvegetated and has no tidal channels-meandering through the delta, with the exception of the main Gum Hollow Creek channel.

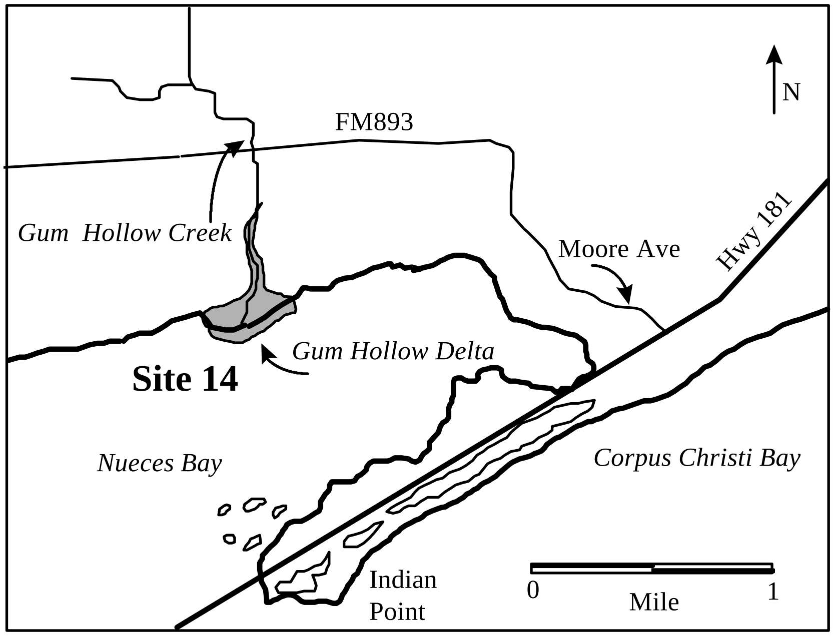

Figure 19. Location of Site 14 for potential wetland enhancement.

Current Wetland Classification:

- Estuarine Subtidal Unconsolidated Bottom
- Estuarine Intertidal Emergent Persistent Irregularly Flooded
- Estuarine Intertidal Unconsolidated Shore Regularly Flooded
- Estuarine Intertidal Unconsolidated Shore Irregularly Flooded
- Upland

Water Regime: The wetlands on Gum Hollow Delta are driven primarily by tidal influence, as the fresh waters drain from Gum Hollow Creek through a central channel into Nueces Bay.

Wetland Vegetation: Smooth cordgrass (*Spartina alterniflora*) lines the creek channel and occurs on the edge of the delta. Sparse saltwort (*Batis maritima*) occurs in patches on the delta.

Wetland Fauna: No studies have been conducted onsite.

Adjacent Land Use: The uplands immediately adjacent to the delta are primarily rangeland, although the creek primarily bisects agricultural lands.

Current Functions and Values:

- Shoreline Erosion Control
- Sediment Trapping
- Water Quality Improvement
- Food Chain Support/Nutrient Export
- Fisheries Habitat
- Wildlife Habitat

Potential Causes of Degradation/Loss: Wave activity may reduce the size of the delta as little vegetation exists to anchor sediments from erosional forces of prevailing southeasterly winds. Reduced water quality from upland runoff may limit use by estuarine organisms of subtidal sediments and the water column.

Potential REC Plan:

Modification of Water Regime: Smaller finger tidal channels can be created to increase perimeter -to-area ratio of wetlands. If the adjacent areas were excavated to a lower elevation, the site could support high marsh vegetation subject to extreme high tides.

Modification of Wetland Vegetation: Smooth cordgrass can be planted along the finger tidal channels and saltwort on high marsh areas.

Modification of Wetland Fauna: Increased wetland diversity will enhance fisheries and wildlife populations.

Potential Functions and Values:

- Shoreline Erosion Control
- Sediment Trapping
- Water Quality Improvement
- Food Chain Support/Nutrient Export
- Fisheries Habitat
- Wildlife Habitat

Potential Economic Benefits:

- Improved water quality for recreationally- and commercially-important estuarine species and associated prey

Management Options: An evaluation of contaminants present would be helpful in determining remediation strategies. Minimal maintenance would be required once recontouring of tidal creeks and high marsh areas and establishment of vegetation was achieved.

Estimated Cost of Plan: $$$-$$$$

Potential Partnerships: Coastal Management Program; Texas and Urban Watch Program, Natural Resource Conservation Service; Private landowners; industry

SITE 15: Green Lake, Corpus Christi Bay Drainage, and North Shoreline

Location: Drainage from the Town of Gregory to Corpus Christi Bay and north shoreline of Corpus Christi Bay; limited boat access and no land access

Ownership and Management: Uplands and shoreline are under private ownership; submerged lands are patent lands (No. 106) that are owned and managed by Port of Corpus Christi Authority.

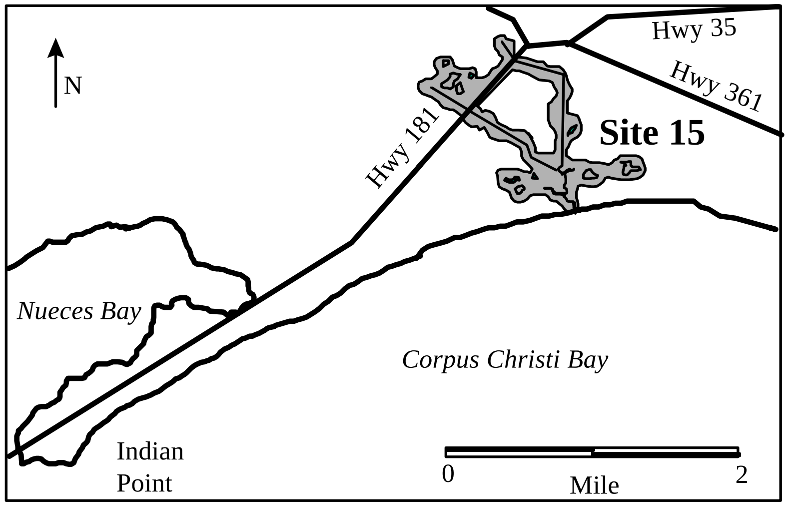

Figure 20. Location of Site 15 for potential wetland enhancement.

General Description: The wetlands associated with the drainage system through agricultural lands are primarily restricted to the streambed and in excavated and/or diked impounded ponds. The drainage system has a linear design to increase water drainage through the uplands and into Corpus Christi Bay.The northern shoreline of Corpus Christi Bay continues to be impacted by erosion. The intertidal areas have decreased and slope has increased between upland and subtidal areas of the bay.

Current Wetland Classification:

- Lacustrine Limnetic Aquatic Bed Rooted Vascular
  Permanently Flooded/Diked/Impounded
- Lacustrine Limnetic Aquatic Bed Floating Vascular
  Permanently Flooded/Diked/Impounded
- Palustrine Aquatic Bed Floating Vascular
  Permanently Flooded Excavated
- Palustrine Emergent Persistent
  Temporarily Flooded
  Seasonally Flooded
- Palustrine Emergent Persistent
  Seasonally Flooded/Diked/Impounded
- Palustrine Forested Broad-leaved Deciduous
  Temporarily Flooded/Diked/Impounded
- Palustrine Scrub-Shrub Broad-Leaved Deciduous
  Temporarily Flooded
- Palustrine Unconsolidated Bottom
  Temporarily Flooded (Tidal)
  Seasonally Flooded (Nontidal) Diked/Impounded

- Palustrine Unconsolidated Bottom
  Semipermanently Flooded
- Riverine Intermittent Streambed
  Seasonally Flooded/Excavated
- Riverine Lower Perennial Unconsolidated Bottom Diked/Impounded
- Estuarine Subtidal Unconsolidated Bottom
- Estuarine Intertidal Unconsolidated Shore
  Regularly Flooded
- Upland

Water Regime: Hydrology is primarily driven by upland runoff into the ponds and drainage ditch. The shoreline is influenced primarily by tidal waters in Corpus Christi Bay. Limited freshwater inflow from upland drainage system is immediately mixed and does not significantly change salinities along the shoreline.

Wetland Vegetation: No studies have been conducted onsite. No extensive vegetation was mapped for the National Wetland Inventory 1992.

Wetland Fauna: No studies have been conducted onsite.

Adjacent Land Use: Uplands are used for agriculture; urban and highway stormwaters discharge; adjacent industrial activities

Current Functions and Values:

- Groundwater Discharge/Recharge
- Shoreline Erosion Control
- Flood Storage and Desynchronization
- Sediment Trapping
- Water Quality Improvement
- Food Chain Support/Nutrient Export
- Fisheries Habitat
- Wildlife Habitat

Causes of Degradation/Loss: Surface waters are probably not retained in the linear ditch system long enough to improve water quality or provide adequate available water for wetland vegetation establishment. The riparian vegetation associated with the drainage ditch is reduced by adjacent agricultural practices, thus limiting the potential for the vegetation to filter contaminants from runoff. The northern shoreline has eroded from the high wave energy generated by prevailing southeasterly winds and the long fetch across Corpus Christi Bay. Functional losses of shoreline habitat may have been partially replaced as the shoreline receded, unless the erosion rate has exceeded the recolonization rate of plants and animals. No studies have been conducted to quantify habitat degradation.

Potential REC Plan:

Modification of Water Regime: The drainage ditch is adjacent to several excavated,diked, or impounded freshwater ponds. Excavation of shallow channels to these ponds would create an oxbow lake system. These oxbow lakes would aid in desynchronizing flood flow and retaining water for longer periods. This would promote establishment of wetland vegetation and improve water quality prior to flowing into Corpus Christi Bay. Decreased slope and resulting increased area of intertidal habitat could be achieved by depositing sediment (potentially as beneficial use of dredged material) in the impacted areas. High wave energy will need to be reduced by constructing temporary wave barriers offshore until vegetation has become established. Evaluation of necessity of permanent wave barriers would be essential to ensure long-term success of the plan.

Modification of Wetland Vegetation: The buffer between the drainage system and agricultural lands would be increased by the planting of native grasses and/or riparian vegetation to remove potential contaminants before they could enter the creek system. Each oxbow lake wetland could be replanted with high-value wetland vegetation for both water quality improvement and food resources for wildlife. Smooth cordgrass (*Spartina alterniflora*) can be planted in the lower intertidal areas, saltgrass (*Distichlis spicata*) and saltmeadow cordgrass (*S. patens*) can establish in higher intertidal areas.

Modification of Wetland Fauna: Natural colonization and establishment of wetland fauna could occur as the site developed. Fish restocking may be necessary if this essential component of the food chain did not colonize naturally

Potential Functions and Values:

- Groundwater Discharge/Recharge
- Shoreline Erosion Control
- Flood Storage and Desynchronization
- Sediment Trapping
- Water Quality Improvement
- Food Chain Support/Nutrient Export
- Fisheries Habitat
- Wildlife Habitat

Potential Economic Benefits:

- Increase in estuarine fisheries production
- Improved water quality for waters entering estuarine system
- Continued beneficial use of dredged material from ship channel maintenance

Management Options: Maintenance of wave barriers will be necessary until vegetation is established. A long-term monitoring program with an ecosystem approach would be necessary to ensure success and improvement of the project.

Estimated Cost of Plan: $$$

Potential Partnerships: Texas Prairie Wetlands Program, U.S. Fish and Wildlife Service; USFWS Partners for Wildlife Program; Section 319 Program; Texas and Urban Watch Program, Texas Natural Resource Conservation Commission; USDA Natural Resource Conservation Service; San Patricio County Soil and Water Conservation District; Port of Corpus Christi Authority; Army Corps of Engineers; Coastal Management Program; adjacent industry, private landowners

SITE 16: Nueces Bay East Shoreline

Location: Nueces Bay eastern shoreline west of Hwy 181 between Nueces Bay Causeway and City of Portland; land and boat access

Ownership and Management: Shoreline is under private ownership; submerged lands are under state ownership.

General Description: Indian Point encompasses a diverse assemblage of estuarine wetlands. The site has been extensively modified by construction of a railroad bed, a two-lane road, and a four-lane highway. The highway bed was constructed from adjacent sediment, which resulted in the creation of Sunset Lake (see Site 17). The wetlands along the Nueces Bay shoreline have been largely reduced over the past 50 years.

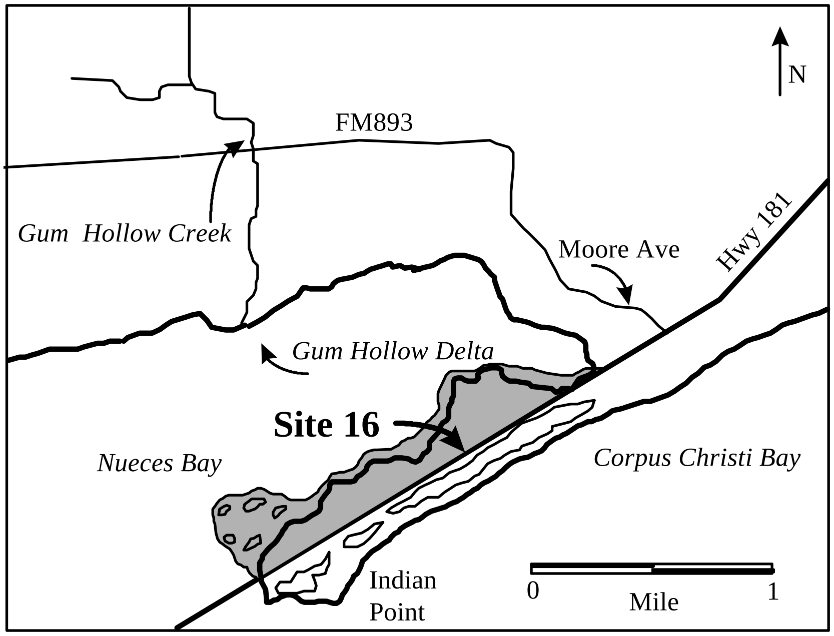

Figure 21. Location of Site 16 for potential wetland enhancement.

Current Wetland Classification:

- Estuarine Subtidal Unconsolidated Bottom
- Estuarine Subtidal Aquatic Bed Rooted Vascular
- Estuarine Intertidal Emergent Persistent
  - Regularly Flooded
  - Irregularly Flooded
- Estuarine Intertidal Unconsolidated Shore
  - Regularly Flooded
  - Irregularly Flooded
- Upland

Water Regime: The hydrology of the wetlands at this site is driven primarily by tidal influence. The elevation gradient produces irregularly and regularly flooded areas and supports subtidal and intertidal vegetated and unvegetated wetlands.

Wetland Vegetation: Subtidal vegetation is composed primarily of shoalgrass (*Halodule wrightii*); regularly flooded, intertidal wetlands support fringe stands of smooth cordgrass

(*Spartina alterniflora*), while the irregularly flooded vegetated flats consist of saltwort (*Batis maritima*) and glasswort species (*Salicornia* spp.).

Wetland Fauna: No site-specific evaluations have been conducted in the seagrass meadows, although the areas support large rafts of Redheads during the fall and winter. The intertidal vegetated and unvegetated wetlands are utilized by both migratory and resident shorebirds and wading birds Although not mapped on NWI classification, some small patches of oyster reefs are located in this site.

Adjacent Land Use: The site is bordered by the unconsolidated deep water habitat of Nueces Bay to the west and Highway 181 to the east. In addition, an unmaintained channel is located along the length of the shoreline.

Current Functions and Values:

- Shoreline Erosion Control
- Food Chain Support/Nutrient Export
- Fisheries Habitat
- Wildlife Habitat

Causes of Degradation/Loss: Extensive losses of intertidal vegetated and unvegetated wetlands have occurred over the past 60 years. There is no one reason for these losses. Construction of commercial facilities along the shoreline has added to the losses of wetlands and wetland degradation. The result has been the loss of habitat for wetland-dependent species. No known development plans are underway, although the proposed raising of Hwy 181 as a hurricane evacuation route could facilitate adequate water exchange between the wetlands on the west shoreline and those on the east side of the highway (Sites 17 and 18).

Potential REC Plan:

Modification of Water Regime: Channelized areas could be partially filled with dredged material from other channel maintenance projects and restored to subtidal, vegetated wetlands. Additional dredged material could be used to restore intertidal wetlands to 1930's acreage with a mosaic design which would enhance wetland diversity.

Modification of Wetland Vegetation: Modified elevations throughout the site could be planted with appropriate species at the appropriate elevation gradient.

Modification of Wetland Fauna: Natural recolonization of faunal species would occur from existing wetland habitats within the site.

Potential Functions and Values:

- Shoreline Erosion Control
- Food Chain Support/Nutrient Export
- Fisheries Habitat
- Wildlife Habitat

Potential Economic Benefits:

- Beneficial use of dredged material
- Ecotourism potential to an accessible site and high-profile location for residents and visitors

Management Options: A detailed restoration plan would need to allow for restoration of wetland diversity which existed prior to losses and degradation of existing habitats. The rookery islands at the perimeter of the site would remain isolated to ensure that no predation routes would be established. The area could be designated as a wetland preserve and have minimal activities within it, dependent upon the goals of the plan. The proximity of Hwy 181 to the wetlands may necessitate periodic trash cleanups.

Estimated Cost of Plan: $$$

Potential Partnerships: Texas General Land Office; Coastal Management Program; Army Corps of Engineers; Texas Natural Resource Conservation Commission

SITE 17: Sunset Lake

Location: East shoreline of Hwy 181 between Nueces Bay Causeway and City of Portland; visual access by road easement

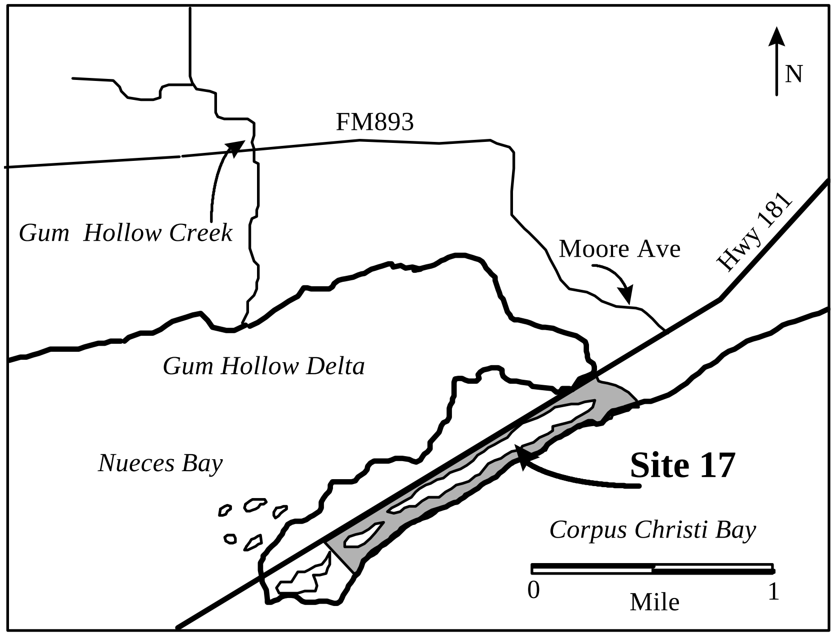

Figure 22. Location of Site 17 for potential wetland enhancement.

Ownership and Management: Private ownership

General Description: Sunset Lake is located on the east side of Hwy 181 on a peninsula extending southeast from the City of Portland, between Nueces and Corpus Christi bays. The lake was created by sediment removal to obtain roadbed material for the highway. The area was historically an intertidal irregularly flooded estuarine wetland.

Current Wetland Classification:

- Estuarine Subtidal Unconsolidated Bottom
- Estuarine Intertidal Emergent Persistent
  Irregularly Flooded
- Estuarine Intertidal Unconsolidated Shore
  Regularly Flooded
- Palustrine Emergent Persistent
  Temporarily Flooded
  Seasonally Flooded/Excavated
- Upland

Water Regime: Sunset Lake is connected to Nueces Bay by one culvert underneath Hwy 181. This culvert often becomes plugged, thus restricting or eliminating water exchange. This estuarine water source also varies considerably in salinity range, and the limited exchange of the lake with the bay often results in higher salinities from high evaporation rates in the shallow lake. Two small freshwater wetlands are located in the northwest corner of the site.

Wetland Vegetation: Most of the intertidal wetlands in the site are unvegetated, although some discrete patches of salt marsh vegetation occur along the fringe.

Wetland Fauna: The periodic drought conditions in the Texas Coastal Bend result in high salinities in wetlands with restricted tidal exchange. High salinities may cause estuarine faunal dieoffs in Sunset Lake. The margins are used as roosting areas for gulls and terns, and Black Skimmers have historically nested along the northwest shoreline. The listed Piping Plover forages around the perimeter of Sunset Lake.

Adjacent Land Use: Upland residential areas located north of the site are within the Portland city limits. An abandoned railroad bed is located to the east of the lake and Highway 181 is located to the west.

Current Functions and Values:

- Food Chain Support/Nutrient Export
- Fisheries Habitat
- Wildlife Habitat

Causes of Degradation/Loss: A recent blockage in the culvert leading from the lake to the bay resulted in lowered water levels and an increase in emergent flats. Extreme high tides during the Fall 1996 flooded the lake from the Corpus Christi Bay side, and waters were trapped in the lake. Subsequent evaporation increased lake salinities higher than adjacent water bodies. The culvert has been cleaned out, but low rainfall and typical low tides in the summer have limited tidal exchange and kept water from returning to previous levels. Even under regular tidal flow condition, a single culvert limits the amount of tidal exchange for a wetland this size. Highway improvements are underway that may include more water exchange culverts.

Potential REC Plan:

Modification of Water Regime: Additional culverts are needed to improve water circulation in and out of Sunset Lake. The size of the culverts will determine the amount and size of estuarine organisms entering and exiting the site.

Modification of Wetland Vegetation: Increased tidal circulation will improve existing vegetation along the lake fringe. Salinities may be too high for establishment of vegetation that requires regular tidal flushing. Moreover, the functions associated with the unvegetated tidal flats will be enhanced by a more regular flushing regime.

Modification of Wetland Fauna: The increase of tidal circulation will naturally result in a higher diversity of estuarine organisms that serve as prey items for other estuarine fauna and wetland animals.

Potential Functions and Values:

- Water Quality Improvement
- Food Chain Support/Nutrient Export
- Fisheries Habitat
- Wildlife Habitat

Potential Economic Benefits:

- Ecotourism
- Water quality enhancement for recreationally- and commercially-important species and associated prey species

Management Options: The high profile location of Sunset Lake will provide educational and passive recreational opportunities for citizens and visitors. Water quality monitoring could be conducted by area schools to increase the understanding of unvegetated wetlands and their importance to wetland species.

Estimated Cost of Plan: $$

Potential Partnerships: Coastal Management Program; Texas Department of Transportation; Texas and Urban Watch Program, Texas Natural Resources Conservation Commission; Adopt-A-Wetland Program, Center for Coastal Studies-TAMU

SITE 18: Indian Point Park

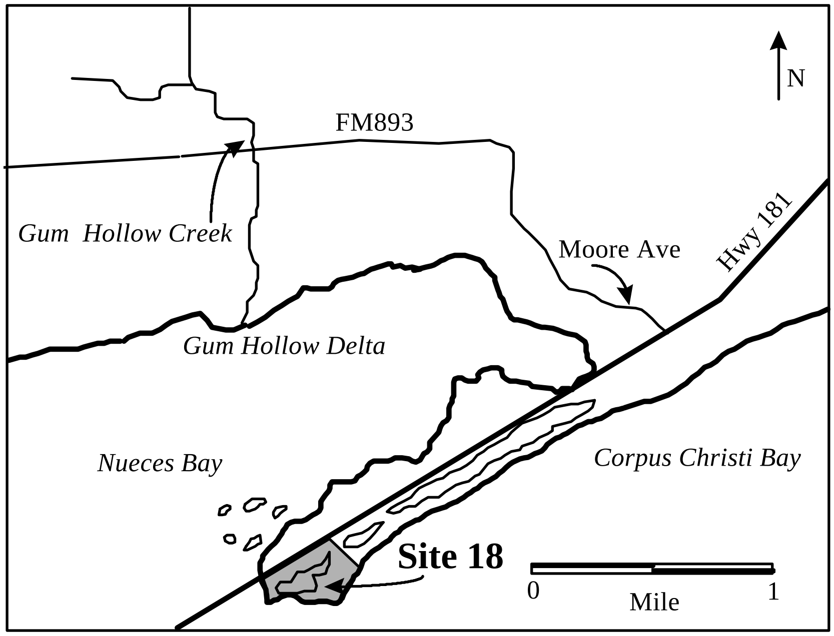

Figure 23. Location of Site 18 for potential wetland enhancement.

Location: East shoreline of Hwy 181 between Nueces Bay Causeway and City of Portland; limited land access only

Ownership and Management: Shoreline owned by City of Portland; submerged lands are patent lands (No. 106) owned and managed by Port of Corpus Christi Authority

General Description: Indian Point Park is located on the southeast corner of the peninsula extending from the City of Portland between Corpus Christi and Nueces Bay. The shell beach ridge along the Corpus Christi Bay protects complex mosaic of saltwort and an intertidal pond system.

Current Wetland Classification:

- Estuarine Subtidal Aquatic Bed Rooted Vascular
- Estuarine Subtidal Unconsolidated Bottom
- Estuarine Intertidal Emergent Persistent
  - Regularly Flooded
  - Irregularly Flooded
- Estuarine Intertidal Unconsolidated Shore
  - Regularly Flooded
- Palustrine Emergent Persistent
  - Seasonally Flooded
- Upland

Water Regime: The wetlands within the park are governed by tidal exchange with Corpus Christi Bay. Palustrine wetlands are present only after significant rainfall.

Wetland Vegetation: The emergent vegetation consists primarily of saltwort (*Batis maritima*).

Wetland Fauna: The wetlands and associated intertidal ponds are used extensively by wading birds for feeding and roosting. The shellbanks and bay shoreline are utilized by shorebirds, terns, and gulls.

Adjacent Land Use: The park is situated along Corpus Christi Bay and is separated from ponds associated with Sunset Lake (Site 17) by an abandoned railroad bed.

Current Functions and Values:

- Food Chain Support/Nutrient Export
- Fisheries Habitat
- Wildlife Habitat
- Recreation/Education

Causes of Degradation/Loss: Historical photographs from the 1930s show that the wetlands within the current park site were more densely vegetated with fewer ponds. Although no causes of wetland loss have been documented, the low elevation of the site and its' location along the northwest portion of Corpus Christi Bay would subject the site to erosion caused by high wave energy and high storm tides.

Potential REC Plan:

Modification of Water Regime: Tidal exchange through the park wetlands could be connected to adjacent wetlands via culverts or passes through the abandoned railroad bed.

Modification of Wetland Vegetation: Existing vegetation would naturally increase as a result of increased tidal circulation.

Modification of Wetland Fauna: Faunal diversity would increase as a result of the enhancement.

Potential Functions and Values:

- Food Chain Support/Nutrient Export
- Fisheries Habitat
- Wildlife Habitat
- Recreation/Education/Culture

Potential Economic Benefits:

- Ecotourism
- Improved nursery habitat for recreationally- and commercially-important estuarine species

Management Options: The current management plan for the park could be expanded to include the adjacent wetlands and increase protection from adverse activities. Educational opportunities and public awareness of Indian Point Park wetlands would be enhanced as the sites are located in a high profile position adjacent to Highway 181.

Estimated Cost of Plan: $

Potential Partnerships: City of Portland; Texas Department of Transportation; Texas Natural Resource Conservation Commission; Partners for Wildlife, U.S. Fish and Wildlife Service; Coastal Ecosystem Program, USFWS

SITE 19: Oso Golf Course Drainage Creek and Hans Suter Park

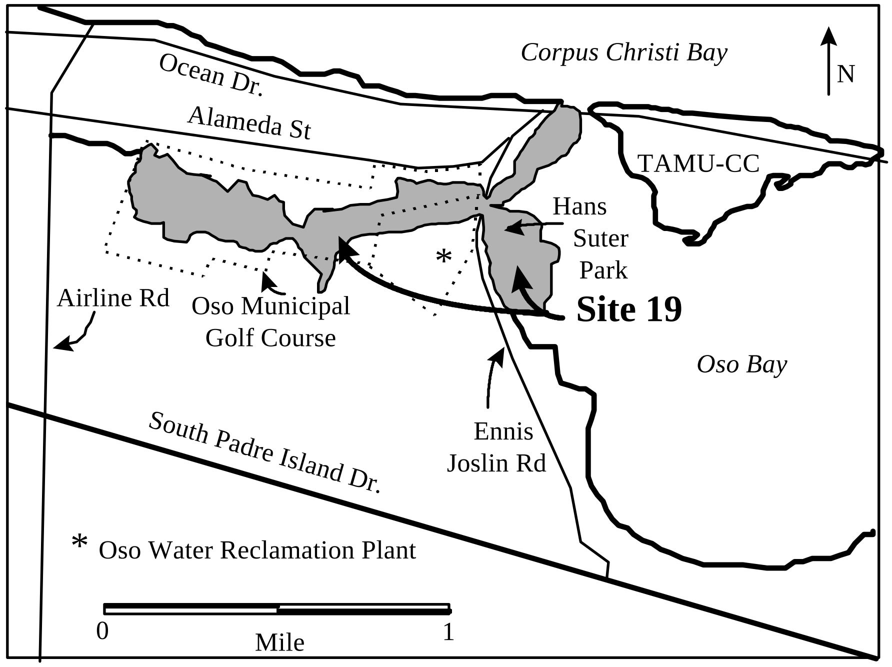

Figure 24. Location of Site 19 for potential wetland enhancement.

Location: The site is located along the stormwater drainage adjacent to Alameda Street through the Oso Public Golf Course, by a City of Corpus Christi sewage treatment facility and into Oso Bay in the vicinity of Ennis Joslin Road and Nile Road; limited park access only

Ownership and Management: City of Corpus Christi

General Description: Part of the site has historically served as stormwater drainage receiving point for the southern part of Corpus Christi from an area generally bordered by Ocean Drive, Airline Street, and a neighborhood subdivision in the Pharoah Valley area. Palustrine and Lacustrine wetlands occur along the drainage and have been diked/impounded throughout the golf course. Intermittent flow downstream passes through seasonally and temporarily flooded scrub-shrub wetlands and into Oso Bay. The other part of the site is located downstream of the sewage treatment facility receives treated effluent from the facility as it flows into Oso Bay. A city park has enhanced the educational and recreational opportunities with interpretive signs and a boardwalk occurring in the wetland.

Current Wetland Classification:

- Estuarine Subtidal Unconsolidated Bottom
- Estuarine Intertidal Emergent Persistent
  Irregularly Flooded
- Estuarine Intertidal Unconsolidated Shore
  Irregularly Flooded
- Estuarine Intertidal Broad-leaved Deciduous
  Temporarily Flooded
- Lacustrine Limnetic Unconsolidated Bottom
  Permanently Flooded/Diked/Impounded
- Palustrine Emergent Persistent
  Temporarily Flooded

- Palustrine Scrub-Shrub Broad-Leaved Deciduous
  Temporarily Flooded
- Palustrine Scrub-Shrub Broad-leaved Deciduous
  Seasonally Flooded
- Palustrine Unconsolidated Bottom
  Artificially Flooded/Excavated
- Upland

Water Regime: The waters in the wetlands of the urban part of the site are fed by stormwater runoff, while water flowing through Hans Suter Park is discharged from the sewage treatment facility across Ennis Joslin Road. Tidal exchange with Corpus Christi Bay occurs via culverts beneath Ocean Drive to the north of the site, and under bridge to east by Corpus Christi Naval Air Station. Freshwater enters the Oso Bay via streamflow from Oso Creek.

Wetland Vegetation: A variety of emergent freshwater plants are located along the stormwater drainage. Lacustrine and palustrine wetlands are fringed by cattail (*Typha* spp.). Scrub-shrub species are unknown, although *Baccharis* sp. and salt cedar (*Tamarix* sp.) probably occur. Estuarine emergent vegetation in Oso Bay adjacent to stormwater ditch is composed primarily of glasswort (*Salicornia* sp.) and saltgrass (*Distichlis spicata*) and a variety of high marsh forbs. The vegetation alongside and adjacent to the treatment waters grades rapidly from freshwater species to brackish and salt marsh vegetation.

Wetland Fauna: The fauna associated with the urban stormwater drainage is unknown. A diverse assemblage of waterbirds utilize the wetland habitats of the water treatment discharge areas.

Adjacent Land Use: All upland areas are urbanized with residential, recreational, and commercial uses. The site is a subtidal and emergent wetland complex partially vegetated with submergent aquatic vegetation and emergent vegetation at the northwestern end of Oso Bay, which is connected to Corpus Christi Bay.

Current Functions and Values:

- Flood Storage and Desynchronization
- Sediment Trapping
- Water Quality Improvement
- Food Chain Support/Nutrient Export
- Fisheries Habitat
- Wildlife Habitat
- Recreation/Education

Causes of Degradation/Loss: The complexity of the site makes determination of wetland change over time difficult. The urbanization of the area, with concomitant paving and building construction, in association with channelized, concrete-lined ditch systems has resulted in stormwaters entering Oso Bay at high rates and velocities. The effects of elevated nutrient concentrations of sewage effluent into Oso Bay have not been evaluated, but increases in submerged aquatic vegetation are visible.

Potential REC Plan:

Modification of Water Regime: Stormwater drainage into Oso Bay could be modified by creating several finger channels and diverting waters through wetland vegetation. The current discharge channel for the sewage effluent also could be modified to enter several smaller channels to increase contact of nutrient-rich waters with wetland vegetation.

Modification of Wetland Vegetation: By diverting fresh water into more finger channels, the amount of fresh and intermediate vegetation would increase in the Hans Suter Park/Stormwater Drainage wetlands. The vegetation would improve water quality prior to entering Oso Bay, and serve as food and protection for wetland wildlife. The stormwater drainage within the Oso Public Golf Course could be enhanced by removing existing cattail and salt cedar and replacing with sedges, tuberous perennials, and buttonbush.

Modification of Wetland Fauna: Vegetation enhancement along the stormwater drainage would increase the wetland areas for wildlife. The increase in fresh and intermediate wetlands at Hans Suter Park would support higher numbers of wetland birds.

Potential Functions and Values:
- Flood Storage and Desynchronization
- Sediment Trapping
- Water Quality Improvement
- Food Chain Support/Nutrient Export
- Fisheries Habitat
- Wildlife Habitat
- Recreation/Education/Culture

Potential Economic Benefits:
- Increased water quality for Oso Bay and recreationally- and commercially-important estuarine species and their associated prey
- Ecotourism

Management Options: The site is currently used by area schools as a learning facility and by citizens and visitors as a wildlife viewing area. More interpretive signs could be located along the boardwalk emphasizing the wetland vegetation zones and importance of wetlands in an urban landscape. A water quality monitoring platform with safety rails could be constructed adjacent to one of the channels to facilitate use as an Texas/Urban Watch site.

Estimated Cost of Plan: $$$

Potential Partnerships: Coastal Management Program; Texas General Land Office; Texas Watch and Urban Watch Program, Texas Natural Resource Conservation Commission; Adopt-

A-Wetland Program, Center for Coastal Studies-TAMUCC, City of Corpus Christi; area nature groups

SITE 20: Mud Bridge

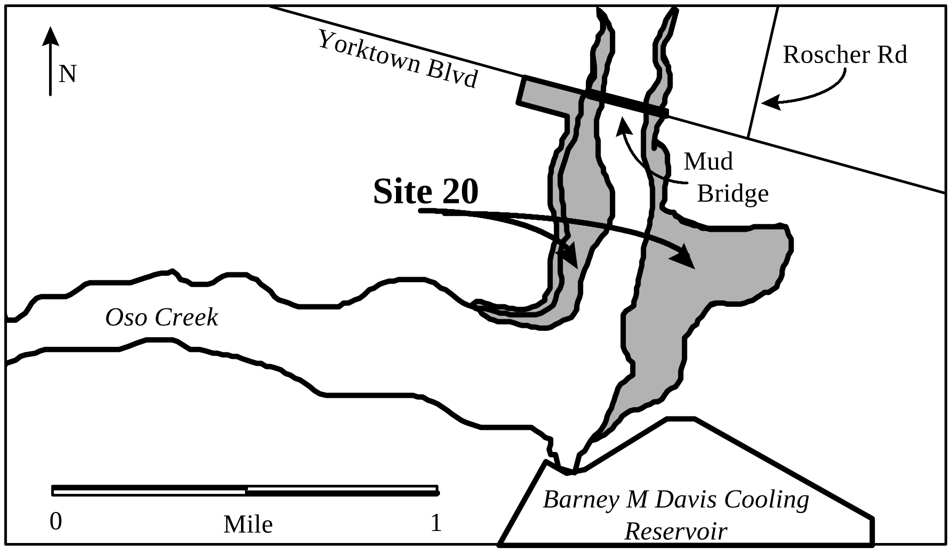

Figure 25. Location of Site 20 for potential wetland enhancement.

Location: Adjacent to Yorktown Boulevard bridge over Oso Bay; road easement access only

Ownership and Management: Uplands are under private ownership; adjacent submerged lands are under state ownership.

General Description: Extensive intertidal wetlands along Oso Creek adjacent to Mud Bridge (Yorktown Blvd) are important feeding and roosting sites for migratory and resident shorebirds. Due to the proximity of warm waters discharging from the Barney Davis Power Plant Facility upstream, fishermen drive onto the flats to reach prime fishing areas.

Current Wetland Classification:

- Estuarine Subtidal Aquatic Bed Rooted Vascular
- Estuarine Intertidal Emergent Persistent
  - Irregularly Flooded
- Estuarine Intertidal Unconsolidated Shore
  - Regularly Flooded
  - Irregularly Flooded
- Upland

Water Regime: The site is hydrologically driven by daily and seasonal tides, stream flow from Oso Creek, and warm water discharge from the Barney Davis Power Plant.

Wetland Vegetation: Discontinuous bands of Glasswort/Saltwort association occur along the fringe of irregularly flooded elevations.

Wetland Fauna: Migratory and resident shorebirds use the area for feeding and resting.

Adjacent Land Use: Upland areas are primarily rangeland; cooling ponds of the power plant are located to the southeast. Yorktown Boulevard crosses Oso Creek at the site.

Current Functions and Values:

- Food Chain Support/Nutrient Export
- Fisheries Habitat
- Wildlife Habitat

Causes of Degradation/Loss: The vehicular traffic across the intertidal flats has decreased vegetation cover and caused surface erosion. Birds are typically driven away by the activity. In addition, the site is often used as an area to dump trash.

Potential REC Plan:

Construction Activity: A heavy cable fence should be constructed as a vehicular barrier to eliminate vehicular traffic on the intertidal flats. A path could be constructed of permeable material (for surface water flowthrough) along the upland area to allow pedestrian traffic access to fishing locations.

Modification of Wetland Vegetation: With elimination of vehicles on the flats, natural recovery of wetland vegetation could occur.

Modification of Wetland Fauna: Potential shorebird use could increase as a result of reducing disturbance on the site.

Potential Functions and Values:

- Water Quality Improvement
- Food Chain Support/Nutrient Export
- Fisheries Habitat
- Wildlife Habitat
- Recreation, Education

Potential Economic Benefits:

- Ecotourism

Management Options: Enforcement of no vehicle access on the site would be necessary to ensure recovery of the site. A beach cleanup effort could be undertaken by area school groups.

Estimated Cost of Plan: $

Potential Partnerships: Coastal Management Program; Texas Department of Transportation; City of Corpus Christi

SITE 21: Graham/Laguna Shores Ponds

Location: Corner of Graham and Laguna Shores Roads; limited road easement access only.

Ownership and Management: Private ownership

General Description: The isolated freshwater ponds and tidally-connected estuarine ponds are located adjacent to Laguna Madre and are largely unvegetated. An excavated freshwater pond is connected to adjacent wetlands by an excavated, concrete-lined drainage ditch through which stormwater runoff fills the wetlands following significant rainfall.

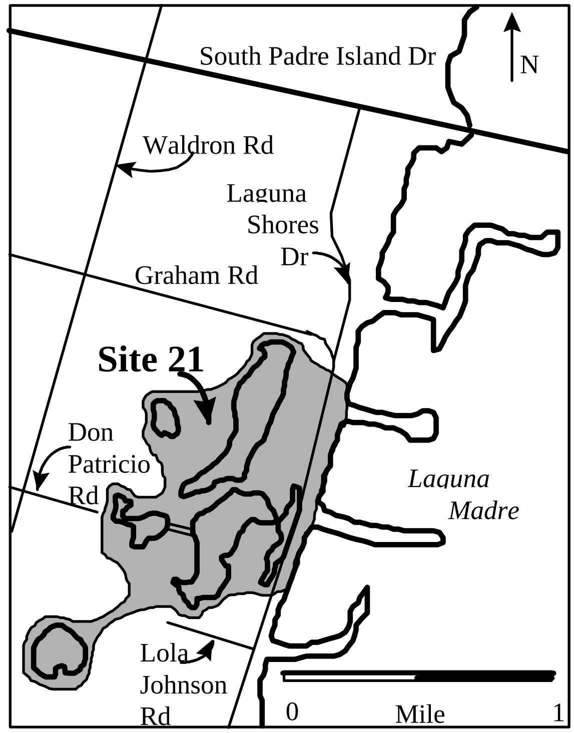

Figure 26. Location of Site 21 for wetland enhancement.

Current Wetland Classification:

- Estuarine Subtidal Unconsolidated Bottom
- Estuarine Intertidal Emergent Persistent
  Irregularly Flooded
- Estuarine Intertidal Unconsolidated Shore
  Regularly Flooded
  Irregularly Flooded
- Palustrine Emergent Persistent
  Seasonally Flooded
  Temporarily Flooded
  Temporarily Flooded/Excavated
- Palustrine Scrub-Shrub Broad-leaved Deciduous
  Seasonally Flooded
- Palustrine Unconsolidated Bottom
  Semipermanently Flooded
  Semipermanently Flooded/Excavated
- Riverine Lower Perennial Unconsolidated Bottom
  Excavated/Diked/Impounded
- Upland

Water Regime: Freshwater runoff enters the wetlands from the urban areas of Flour Bluff. A limited tidal connection is located through a culvert under Laguna Shores Road.

Wetland Vegetation: Cattail (*Typha* spp.) is present in the smaller freshwater wetlands that are temporarily flooded. A small stand of scrub-shrub vegetation (species unknown) is located at the southwest corner of the largest freshwater pond. Limited tidal exchange probably results in salinity conditions that are not conducive to establishment of wetland vegetation.

Wetland Fauna: No studies have been conducted onsite.

Adjacent Land Use: The upland areas surrounding the wetlands are not developed, with the exception of some residential neighborhoods to the west.

Current Functions and Values:

- Groundwater Discharge/Recharge
- Flood Storage and Desynchronization
- Sediment Trapping
- Wildlife Habitat
- Recreation

Causes of Degradation/Loss: The construction of Laguna Shores Road severely limits tidal exchange with the estuarine wetlands under seasonal high tide conditions. In addition, water that remains following a storm tide event is retained in the ponds, and salinity increases as evaporation occurs.

Potential REC Plan:

Modification of Water Regime: Larger culverts are needed to increase tidal circulation to the estuarine ponds. Diversion of stormwater runoff from adjacent ditches that drain directly into the Laguna Madre into the freshwater wetlands would increase hydroperiod.

Construction Activity: A sampling deck could be constructed onsite and used as a water-quality monitoring site by Flour Bluff Independent School District students.

Modification of Wetland Vegetation: Even with increased tidal circulation, the higher salinities of the Laguna Madre would probably preclude establishment of smooth cordgrass. However, lowered salinities with increased flushing would allow establishment of a glasswort/saltwort association. Subtidal areas which are currently unvegetated could become colonized by shoalgrass (*Halodule wrightii*).

Modification of Wetland Fauna: Establishment and increased abundance of benthic organisms would increase prey availability for migrating and resident shorebirds.

Potential Functions and Values:

- Groundwater Discharge/Recharge

- Flood Storage and Desynchronization
- Sediment Trapping
- Water Quality Improvement
- Food Chain Support/Nutrient Export
- Fisheries Habitat
- Wildlife Habitat
- Recreation/Education

Potential Economic Benefits: Increased property value adjacent to enhanced wetlands

Management Options: Maintenance of culverts is necessary to ensure proper circulation.

Estimated Cost of Plan: $$

Potential Partnerships: City of Corpus Christi; Texas Department of Transportation; Coastal Management Program; Texas Watch and Urban Watch Program, Texas Natural Resource Conservation Commission; Partners for Wildlife, U.S. Fish and Wildlife Program; Adopt-A-Wetland Program, Center for Coastal Studies-TAMUCC

SITE 22: Ramfield Road Wetland and SITE 23: Caribbean Road Wetland

Location: Site 22 is located 0.3 miles East of Roscher Road on Ramfield Road, while Site 23 is 0.3 miles east of Roscher Road on Caribbean Road; limited road easement access only

Ownership and Management: Private ownership

General Description: Historical information is currently unavailable; however, road construction across the low swale probably backed water into the sites. The sites were existing wetlands in the 1992 NWI classification and a favorite spot for area bird watchers. The wetlands have now been drained and are under rangeland use. The low areas drain into the lower reaches of Oso Creek and Bay.

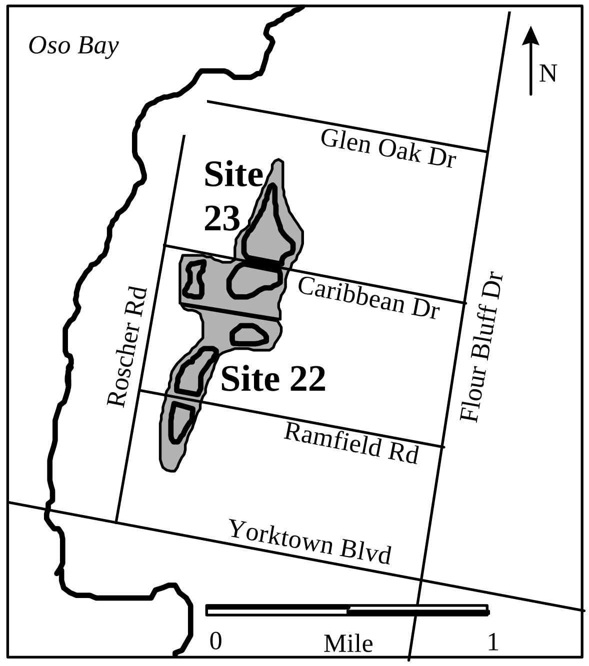

Figure 27. Location of Site 22 and 23 for potential wetland enhancement.

Current Wetland Classification:

- Estuarine Intertidal Emergent Persistent
  - Irregularly Flooded
  - Regularly Flooded
- Palustrine Aquatic Bed Floating Vascular
  - Semipermanently Flooded
  - Semipermanently Flooded/Excavated
- Palustrine Emergent Persistent
  - Semipermanently Flooded
- Palustrine Scrub-Shrub Broad-Leaved Deciduous
  - Temporarily Flooded
- Palustrine Unconsolidated Bottom
  - Permanently Flooded
  - Permanently Flooded/Excavated
- Upland

Water Regime: The wetlands historically ponded water from upland runoff. The wetlands are now drained, but may have been filled with an auxiliary water source in the past.

Wetland Vegetation: The emergent marsh to the north of the road in Site 22 supported tuberous perennials (i.e., arrowhead, burhead) and sedges (*Cyperus* spp., *Scirpus* spp.). The wetland south of the road was designated as a scrub-shrub wetland, although the area is currently under hay meadow production. At site 23, the wetland supported aquatic bed vegetation to the north of the road and, while permanently flooded, the pond to the south was unvegetated.

Wetland Fauna: The wetlands historically supported a diversity of migratory waterfowl, shorebirds, wading birds and migratory neotropical species.

Adjacent Land Use: The rural area is not heavily developed, most tracts are used for grazing land and horse stables.

Current Functions and Values:
- Shoreline Erosion Control
- Sediment Trapping
- Wildlife Habitat

Causes of Degradation/Loss: It could not be determined why wetlands were drained, although it is possible that auxiliary water into the wetland was eliminated. The result has been loss of emergent marsh, and submergent aquatic vegetation habitat and related animal use. The sites still function to slow down floodwaters and trap sediment.

Potential REC Plan:

Modification of Water Regime: A water-control structure could be placed through the roadbeds to facilitate water management for either seasonally ponded or moist soil wetlands. The sandy soils in Flour Bluff enhance groundwater recharge values for adjacent coastal woodlands. A shallow well could be drilled onsite as an auxiliary water source.

Modification of Wetland Vegetation: A seed bank may still be available which would allow wetland vegetation to become reestablished.

Modification of Wetland Fauna: Bird use would increase following restoration of wetland functions.

Potential Functions and Values:
- Groundwater Discharge/Recharge
- Flood Storage and Desynchronization
- Sediment Trapping
- Water Quality Improvement
- Food Chain Support/Nutrient Export
- Fisheries Habitat
- Wildlife Habitat
- Recreation/Education

Potential Economic Benefits:
- Ecotourism

Management Options: A detailed management plan could be developed depending upon private owners' goals.

Estimated Cost of Plan: $

Potential Partnerships: Texas Prairie Wetland Program, U.S. Fish and Wildlife Service; Partners for Wildlife, USFWS

SITE 24: McCampbell Slough

Location: Upstream of Port Bay in San Patricio County; limited boat access only, no land access

Ownership and Management: Private ownership

General Description: This wetland complex exhibits a high diversity of wetland types and habitats with extensive freshwater habitats intergrading into intertidal and subtidal wetlands.

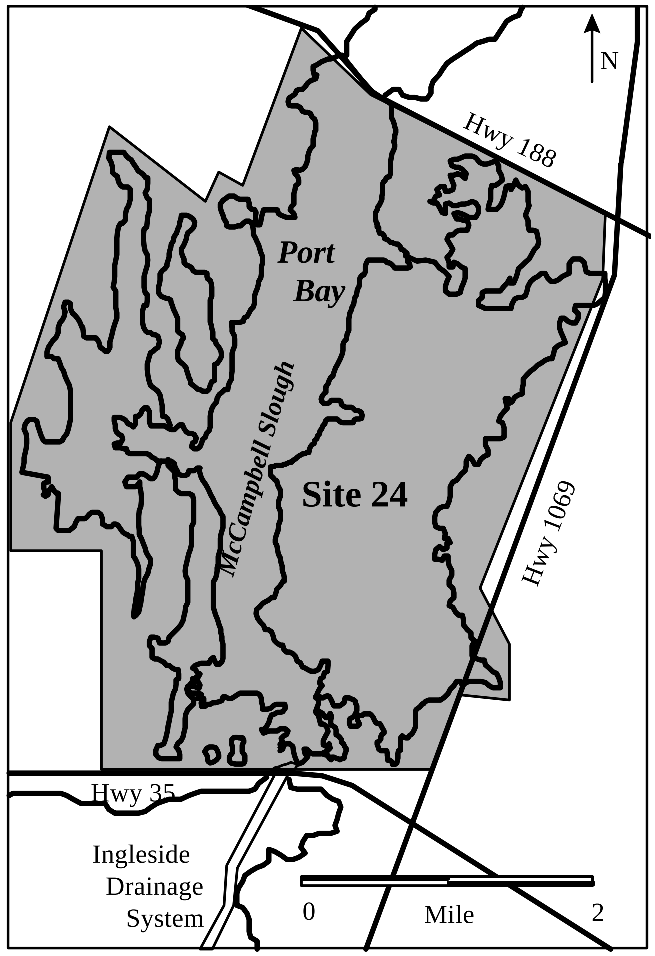

Figure 28. Location of Site 24 for potential wetland enhancement.

Current Wetland Classification:

- Estuarine Subtidal Aquatic Bed Rooted Vascular
- Estuarine Subtidal Aquatic Bed Rooted Vascular/Excavated
- Estuarine Subtidal Unconsolidated Bottom
- Estuarine Intertidal Emergent Persistent
  - Regularly Flooded
  - Irregularly Flooded
- Estuarine Intertidal Unconsolidated Shore
  - Regularly Flooded/Excavated
  - Irregularly Flooded
- Lacustrine Limnetic Unconsolidated Bottom
  - Permanently Flooded Diked/Impounded
- Palustrine Emergent Persistent
  - Temporarily Flooded
  - Seasonally Flooded/Diked/Impounded
- Palustrine Emergent Persistent
  - Semipermanently Flooded
  - Semipermanently Flooded/Excavated
- Palustrine Scrub-Shrub Broad-Leaved Deciduous
  - Temporarily Flooded
- Palustrine Scrub-Shrub Broad-leaved Evergreen
  - Temporarily Flooded
- Palustrine Unconsolidated Bottom

Semipermanently Flooded
Permanently Flooded

- Palustrine Unconsolidated Shore
  Temporarily Flooded/Excavated
  Seasonally Flooded
- Upland

Water Regime: McCampbell Slough receives upland drainage from throughout the southern portion of Live Oak Peninsula and tidal influence from Port Bay.

Wetland Vegetation: No studies have been conducted onsite.

Wetland Fauna: No studies have been conducted onsite.

Adjacent Land Use: The Reynolds Metal, Inc., settling ponds are located to the west of the site, rural areas areas are located on the east side, extensive oil and gas operations are located throughout the site.

Current Functions and Values:

- Groundwater Discharge/Recharge
- Flood Storage and Desynchronization
- Sediment Trapping
- Water Quality Improvement
- Food Chain Support/Nutrient Export
- Fisheries Habitat
- Wildlife Habitat
- Recreation

Causes of Degradation/Loss: The site encompasses a wide diversity of wetland types, although alteration has occurred. Oil and gas exploration roads and well pads have restricted water exchange in some areas, and borrow pits were excavated for road material. Channels have been excavated through some of the wetland areas as well.

Potential REC Plan:

Modification of Water Regime: Culverts could be installed through oil and gas roads to increase tidal circulation.

Modification of Wetland Vegetation: No vegetation modifications are necessary in tidal areas; the palustrine wetlands are predominantly choked with cattail (*Typha* spp.). The freshwater wetlands could increase in wildlife value if cattails were removed and a diversity of plant species important to wildlife planted in conjunction with open water areas.

Modification of Wetland Fauna: Enhancement of freshwater wetlands would increase use of these areas by waterfowl and wading birds for feeding, nesting and roosting.

Potential Functions and Values:

- Groundwater Discharge/Recharge
- Flood Storage and Desynchronization
- Sediment Trapping
- Water Quality Improvement
- Food Chain Support/Nutrient Export
- Fisheries Habitat
- Wildlife Habitat
- Recreation

Potential Economic Benefits:

- Recreational Hunting
- Ecotourism

Management Options: This wetland system is under private ownership and could serve as a reference wetland for other enhancement and restoration projects, although no quantitative evaluation has been undertaken onsite. A stewardship program with the landowner and state and federal agencies would ensure the continued functioning of this site.

Estimated Cost of Plan: $

Potential Partnerships: Texas Prairie Wetland Program, U.S. Fish and Wildlife Service; Partners for Wildlife Program, USFWS; Coastal Management Program; Texas Coastal Preserve Program, Texas General Land Office

SITE 25: Hwy 35 Wetland Project

Location: East of Hwy 35 between Rockport and Aransas Pass, immediately south of City by the Sea Residential Development; limited boat access

Ownership and Management: Private ownership; the Texas General Land Office has a conservation easement on the property (D. Rocha, TGLO Corpus Christi Field Office, pers.comm.).

General Description: A protected embayment has been created by placement of dredged material adjacent to the Gulf Intracoastal Waterway and the natural shoreline. This area is influenced by normal tides, but has restricted flow characteristics.

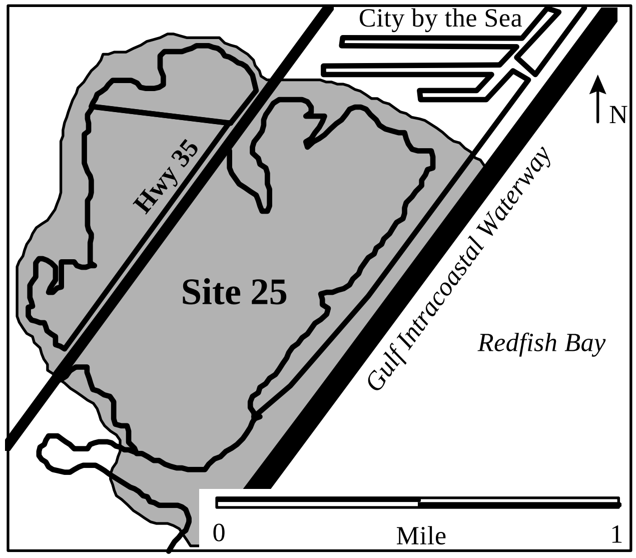

Figure 29. Location of Site 25 for potential wetland enhancement.

Current Wetland Classification:

- Palustrine Aquatic Bed Floating Vascular
- Permanently Flooded/Excavated
- Palustrine Emergent Persistent
  - Temporarily Flooded
  - Seasonally Flooded
- Estuarine Subtidal Unconsolidated Bottom
- Estuarine Intertidal Emergent Persistent
  - Regularly Flooded
  - Irregularly Flooded
- Estuarine Intertidal Unconsolidated Shore
  - Regularly Flooded
  - Irregularly Flooded
- Upland

Water Regime: The site is tidally influenced, with freshwater runoff from Highway 35 and adjacent uplands.

Wetland Vegetation: The wetlands contain a mixture of salt marsh species, including *Batis maritima*, *Salicornia bigelovii*, *Monanthochloe littoralis*, *Suaeda linearis*, *Sporobolus virginicus*, *Limonium nashii*, *Scirpus maritimus*, *Borrichia frutescens*, *Spartina spartinae*, and *S. patens.*

The palustrine emergent wetlands are primarily dominated by cattail (*Typha* sp.), and no floating species were observed.

Wetland Fauna: No studies have been conducted onsite.

Adjacent Land Use: Housing development to the north, Highway 35 to the west, and the GIWW to the east.

Current Functions and Values:
- Food Chain Support/Nutrient Export
- Fisheries Habitat
- Wildlife Habitat

Causes of Degradation/Loss: Potential degradation from highway runoff into the wetland could degrade water quality. Limited tidal exchange with Redfish Bay may result in increased salinities during low tidal regimes and reduce benthic organism populations.

Potential REC Plan:

Construction Plan: This site is being considered as a compensatory mitigation site for seagrasses impacted by a pipeline in upper Laguna Madre. If the project is implemented, a total of 6.7 acres will be excavated, 5 acres of which will be planted with *Halodule wrightii*. In addition, four, 40-ft wide circulation channels will be constructed around the perimeter. The site will be excavated to a depth of +0.5 ft MLT, the same elevation as dense seagrass beds adjacent to the site. In the event that this project is not undertaken, it would be advisable to consider the construction plan as designed if seagrass creation is the goal of another project.

Modification of Water Regime: Tidal circulation will increase in the site and improve water quality by reducing evaporation potential and diluting highway runoff waters.

Modification of Wetland Vegetation: Following a sediment conditioning time of at least 90 days, the 5-acre excavated area will be planted with *Halodule wrightii*. Each planting unit will be placed on a 3-ft center. A planting unit will consist of live seagrass material contained in a 3-in-diameter plug. Each planting unit will be securely embedded in the planting surface. A slow-release phosphorus fertilizer may be added at the time of planting. No more than one 6-in plug of source material per square yard will be obtained from the borrow areas.

Potential Functions and Values:
- Food Chain Support/Nutrient Export
- Fisheries Habitat
- Wildlife Habitat
- Recreation

Potential Economic Benefits: Increased habitat for commercially- and recreationally-important fish species.

Management Options: Monitoring of the project will need to occur for at least three years following planting.

Estimated Cost of Plan: $$$

Potential Partnerships: Texas General Land Office

SITE 26: Pelican Cove Mangroves

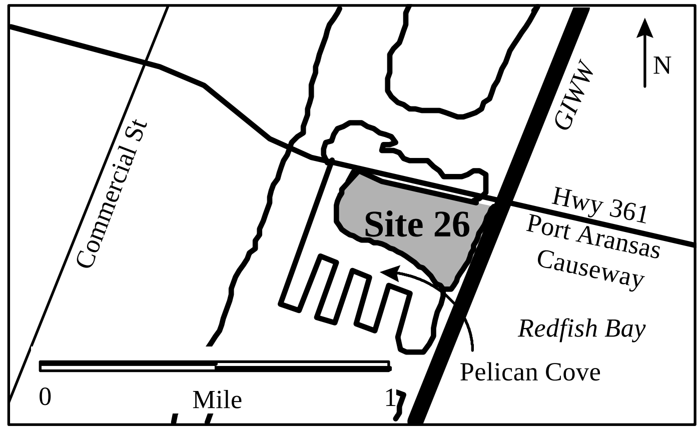

Figure 30. Location of Site 26 for potential wetland enhancement.

Location: Below Gulf Intracoastal Waterway bridge in Aransas Pass adjacent to Pelican Cove-subdivision; limited visual access by road easement only

Ownership and Management:
Private ownership

General Description: This site represents an extensive, monotypic stand of black mangroves (*Avicennia germinans* within the Redfish Bay/Harbor Island area; however, this site is not delineated on the 1992 NWI maps as estuarine scrub-shrub vegetation. Freezes typically kill back aboveground plant parts or stunt these tropical shrubs; however, this mangrove stand has withstood impacts from low temperatures due to the protection of the Gulf Intracoastal Waterway bridge overhead and bluff adjacent to the site. The site belongs to Pelican Cove subdivision and is adjacent to one of the main roads leading to residential canal lots.

Current Wetland Classification:

- Estuarine Intertidal Emergent Persistent (actually Scrub-Shrub)
  Irregularly Flooded
- Upland

Water Regime: Tidal exchange with the Gulf Intracoastal Waterway is limited and occurs only during extreme high tides.

Wetland Vegetation: The vegetation is primarily black mangroves (*Avicennia germinans*) with fringe high marsh of saltwort/glasswort association.

Wetland Fauna: No studies have been conducted onsite.

Adjacent Land Use: Residential subdivision is located to the south, Gulf Intracoastal Waterway to the east, and a shipyard to the north.

Current Functions and Values:

- Water Quality Improvement
- Food Chain Support/Nutrient Export
- Fisheries Habitat
- Wildlife Habitat

- Recreation

Causes of Degradation/Loss: No known degradation processes or losses of this habitat are known, as black mangroves are typically limited by the environmental conditions of the Texas Coastal Bend. Limited tidal exchange may be impacting potential fisheries use of the site, which, in turn, could be limiting use by foraging wading birds.

Potential REC Plan:

Modification of Water Regime: Small tidal channels could be excavated to improve tidal exchange and lower salinities in the site.

Modification of Wetland Vegetation: No modification is necessary.

Modification of Wetland Fauna: Enhancement of the site through improved water circulation may result in higher use by fisheries and wildlife. Mangroves are highly utilized by nesting and foraging wading birds, and by migratory neotropicals as resting sites in other areas which support large stands of mangroves.

Construction Activity: A boardwalk, interpretive displays, and water quality monitoring deck could be constructed for wildlife viewing, and to help area school children, visitors and residents understand mangrove wetlands and how they function. The local school district could utilize the site as a Texas/Urban Watch Program site and monitor water quality in this unique wetland.

Potential Functions and Values:
- Water Quality Improvement
- Food Chain Support/Nutrient Export
- Fisheries Habitat
- Wildlife Habitat
- Recreation/Education

Potential Economic Benefits:
- Ecotourism
- Educational Site for Rare Wetland Type
- Increased water quality for recreationally- and commercially-important estuarine species and associated prey

Management Options: The developer, residents, schoolchildren, local birding groups, area universities, and state agencies could cooperatively manage the activities at the site.

Estimated Cost of Plan: $

Potential Partnerships: Pelican Cove developers; Pelican Cove residents; Texas Watch and Urban Watch Program, Texas Natural Resource Conservation Commission; Adopt-A-Wetland

Program, Center for Coastal Studies-TAMUCC; local birding groups; Texas A&M University-Corpus Christi, University of Texas Marine Science Institute

SITE 27: Ingleside Cove Shore

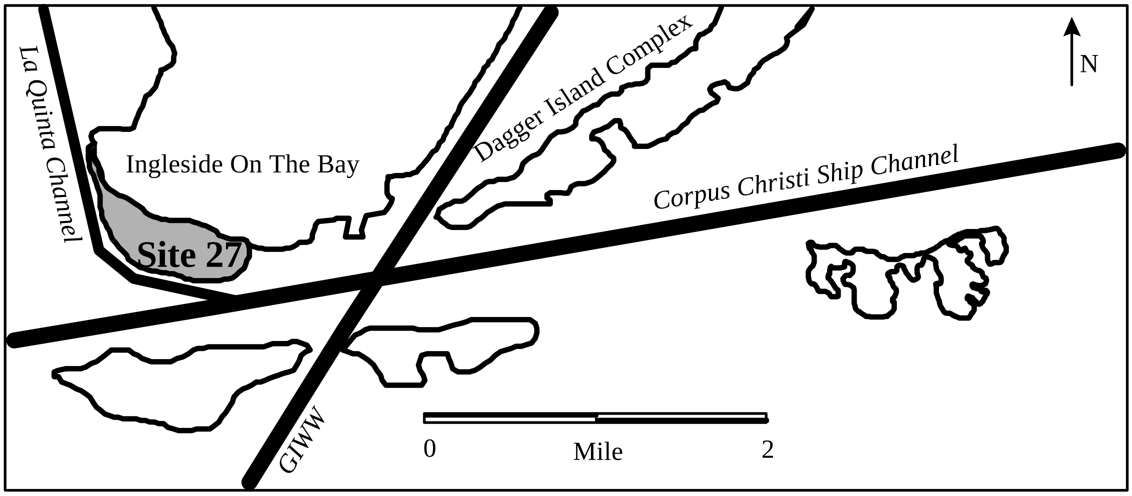

Figure 31. Location of Site 27 for potential wetland enhancement.

Location: Shoreline adjacent to Corpus Christi Ship channel in Ingleside Cove; limited visual access by road easement only

Ownership and Management: Uplands are under private ownership and submerged lands are owned by Port of Corpus Christi Authority.

General Description: This site is located at the southern point of Live Oak Peninsula. The upland/wetland interface occurs at the base of McGloin Bluff and the Corpus Christi Bay shoreline. Currently, the shoreline is protected from wave energy from Corpus Christi Bay by a dredged material island on the southern side of the La Quinta Ship Channel. The intertidal areas along the shoreline are greatly diminished along the Corpus Christi Bay shoreline east of Ingleside Cove due to high wave energy from ship traffic in the navigation channel.

Current Wetland Classification:

- Estuarine Subtidal Aquatic Bed Rooted Vascular
- Estuarine Intertidal Unconsolidated Shore
  Regularly Flooded
- Upland

Water Regime: Tidal waters from Corpus Christi Bay drive the primary hydrology of the site. Excessive waves from ship traffic have eroded shorelines along residential areas.

Wetland Vegetation: No intertidal vegetation is present at the site. Submerged aquatic vegetation is located along the southern edge of the site.

Wetland Fauna: Unknown

Adjacent Land Use: The Corpus Christi Ship Channel is located south of the site, and La Quinta Ship Channel crosses the site to the northwest. A large dredged material island is located south of the site in Corpus Christi Bay. The residential area borders the shoreline to the north.

Current Functions and Values:

- Shoreline Erosion Control
- Sediment Trapping
- Food Chain Support/Nutrient Export
- Fisheries Habitat
- Wildlife Habitat/Culture

Causes of Degradation/Loss: Increased wave activity has produced high-energy water circulation across the site, reducing the potential for establishment of emergent marsh vegetation which would reduce shoreline erosion and increase sediment trapping. Currently, the site does not support diverse wetland types. The wave energy from passing ships will continue, a fact which must be considered in a restoration plan.

Potential REC Plan:

Construction Activity: A wave barrier must be constructed to reduce wave energy prior to reaching the shoreline. Placement of geotextile tubes filled with dredged material approximately 200 ft (61 m) bayward of the shoreline would create a sheltered area adequate for establishment of emergent/submergent vegetation.

Modification of Water Regime: Water levels would not fluctuate as drastically following attenuation of wave energy from ship wakes. Water quality would improve as sediments would not be continually resuspended into the water column.

Modification of Wetland Vegetation: Depending upon water depth, submergent vegetation could recolonize throughout the site, and intertidal vegetation such as smooth cordgrass could be planted at strategic locations to enhance establishment.

Modification of Wetland Fauna: The increase in wetland diversity and improvement of water quality will potentially increase use of the site by fish and wildlife and will enhance food chain support and nutrient export into adjacent wetland and estuarine systems.

Potential Functions and Values:

- Shoreline Erosion Control
- Sediment Trapping
- Food Chain Support/Nutrient Export
- Fisheries Habitat
- Wildlife Habitat
- Recreation/Education/Culture

Potential Economic Benefits:

- Increase wetland habitats to support recreationally- and commercially- important species and associated prey
- Increase adjacent land values
- Beneficial use of dredged material

Management Options: The site should be monitored to ensure achievement of project goals and remediation of any problems.

Estimated Cost of Plan: $$$-$$$$

Potential Partnerships: Port of Corpus Christi Authority; U.S. Army Corps of Engineers; Coastal Management Program, USDA Natural Resource Conservation Service; residential landowners

SITE 28: Pelican Island

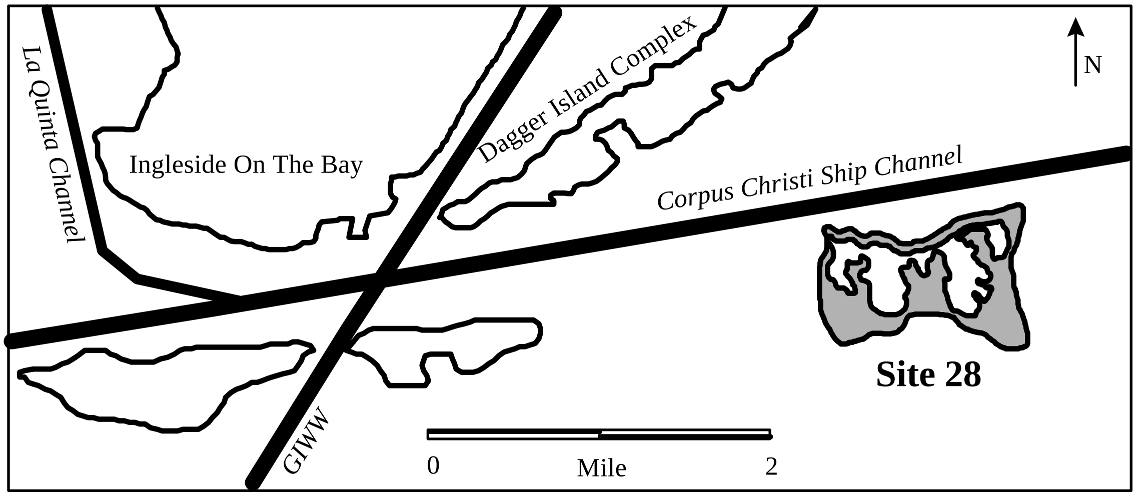

Figure 32. Location of Site 28 for potential wetland enhancement.

Location: Dredged material island located south of Corpus Christi Ship Channel immediately south of Ingleside and west Mustang Island; limited boat access only (except during nesting season when no access is allowed)

Ownership and Management: Owned by Port of Corpus Christi Authority (Nueces County Navigation District), leased and managed by National Audubon Society and monitored by the Texas Coastal Sanctuaries Program of the Texas Colonial Waterbird Group

General Description: Pelican Island is a dredged material island that supports one of the two largest nesting populations of Brown Pelicans on the Texas Coast The island is protected throughout the nesting season by volunteers and Audubon wardens to ensure nesting success of this species. Natural resource agencies, Audubon Society, Port Authority of Corpus Christi, and the U.S. Army Corps of Engineers coordinate the renourishment of parts of Pelican Island using dredged material.

Current Wetland Classification:

- Estuarine Subtidal Aquatic Bed Rooted Vascular
- Estuarine Intertidal Emergent Persistent
  Regularly Flooded
- Estuarine Intertidal Emergent Persistent
  Irregularly Flooded/Spoil
- Estuarine Intertidal Unconsolidated Shore
  - Irregularly Flooded/Spoil
- Estuarine Intertidal Unconsolidated Shore
  Regularly Flooded/Spoil

- Palustrine Emergent Persistent
  Semipermanently Flooded/Excavated
- Palustrine Unconsolidated Shore
  Temporarily Flooded/Excavated
- Upland

Water Regime: Tidal waters influence the wetlands along the shoreline of Pelican Island.

Wetland Vegetation: The island provides a mosaic of nesting habitats ranging from sandy clay, sand, and shell beaches to upland vegetation of grasses, prickly pears, shrubs, and scattered trees.

Wetland Fauna: The island is one of two nesting sites in the study area for Brown Pelicans and is used by other colonial nesting species.

Adjacent Land Use: The Corpus Christi Ship Channel is located to the north of the island.

Current Functions and Values:
- Shoreline Erosion Control
- Sediment Trapping
- Food Chain Support/Nutrient Export
- Fisheries Habitat
- Wildlife Habitat

Causes of Degradation/Loss: Waves driven by predominant southeasterly winds are eroding the shoreline on the southern side of the island.

Potential REC Plan: The status and trends of this island will be evaluated in a Corpus Christi Bay National Estuary Program FY97 project to determine changes in rookeries in relation to vegetation dynamics over time and natural erosion and accretion processes. Protection of the southern shore could be achieved by constructing a wave barrier offshore of the island and would additionally create a protected lagoon adjacent to the island.

Modification of Water Regime: Protection from onshore winds would increase water clarity and promote establishment of submergent vegetation.

Modification of Wetland Vegetation: Natural establishment of submergent vegetation, primarily shoalgrass (*Halodule wrightii*), would occur once conditions improved in the sheltered lagoon.

Modification of Wetland Fauna: Increase in use of the enhanced wetland areas by both fish and wildlife would naturally occur over time.

Potential Functions and Values:
- Shoreline Erosion Control
- Sediment Trapping
- Food Chain Support/Nutrient Export

- Fisheries Habitat
- Wildlife Habitat

Potential Economic Benefits:

- Ecotourism both locally and along the Texas coast (indirect by increasing Brown Pelican populations)
- Cooperative effort between industry and conservation

Management Options: The Texas Coastal Sanctuaries Program of the Texas Colonial Waterbird Group monitors the success of the nesting population of Brown Pelicans.

Estimated Cost of Plan: $$-$$$

Potential Partnerships: Port of Corpus Christi Authority; U.S. Army Corps of Engineers; Coastal Management Program; Coastal Wetland Conservation Grant, U.S. Fish and Wildlife Service; Coastal Bend Audubon Society; local nature groups

SITE 29: Shamrock Island

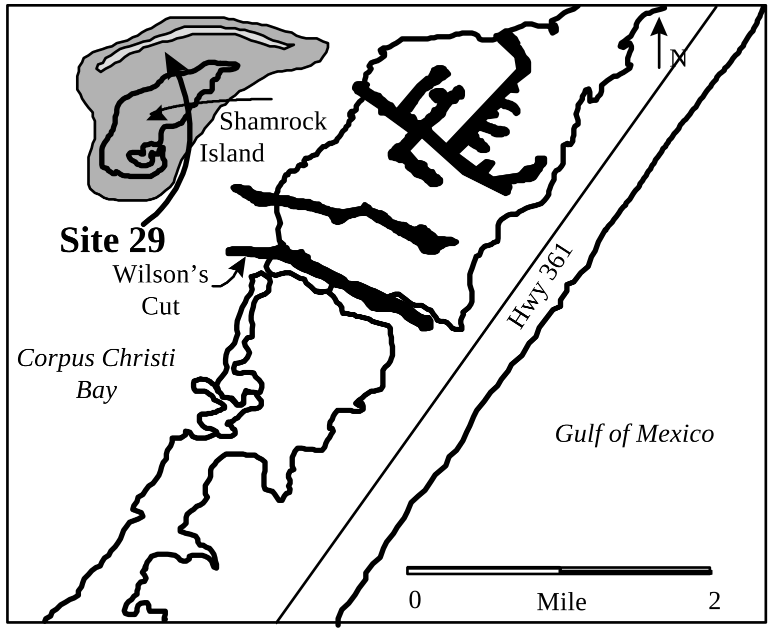

Figure 33. Location of Site 29 for potential wetland enhancement.

Location: West of Mustang Island in Corpus Christi Bay; limited boat access only (except during nesting season when access is not permitted)

Ownership and Management: The Nature Conservancy of Texas; The Texas General Land Office has a conservation easement to the island

General Description: Shamrock Island is a natural island located bayward of the western shoreline of Mustang Island in Corpus Christi Bay. Extense shorelines occur around and within the interior of the island, due to interior lagoons that are linked to the bay system. The island is one of the most productive colonial waterbird rookeries in the Texas Coastal Bend and has been monitored for many years during the Texas Colonial Waterbird Count.

Current Wetland Classification:

- Estuarine Subtidal Aquatic Bed Rooted Vascular
- Estuarine Subtidal Unconsolidated Bottom
- Estuarine Intertidal Emergent Persistent
  Regularly Flooded
- Estuarine Intertidal Emergent Persistent
  Irregularly Flooded
- Estuarine Intertidal Scrub-Shrub Broad-leaved Evergreen
  Irregularly Flooded
- Estuarine Intertidal Unconsolidated Shore
  Regularly Flooded
  Irregularly Flooded
- Upland

Water Regime: The island shoreline and adjacent wetlands are hydrologically driven by tides.

Wetland Vegetation: The island supports a diversity of nesting habitats including sandy and shell beaches and ridges, upland grasses, shrubs (0.5-1m), and saltcedar (*Tamarix* spp.) to 3 m.

Wetland Fauna: Colonial waterbird nesting data is available for many years and illustrates the diversity of wading birds, gulls and terns which utilize the island.

Adjacent Land Use: The island is surrounded by Corpus Christi Bay which has unvegetated bottom on the west side and vegetated seagrass meadows along and within wetlands of Mustang Island to the east.

Current Functions and Values:

- Shoreline Erosion Control
- Sediment Trapping
- Food Chain Support/Nutrient Export
- Fisheries Habitat
- Wildlife Habitat
- Recreation/Education/Culture

Causes of Degradation/Loss: Circulation patterns in Corpus Christi Bay have been altered by the dredging of Aransas Pass for the Corpus Christi Ship Channel and the construction and maintenance of the Gulf Intracoastal Waterway. The island has decreased in size through erosion of the northern peninsula, which once partially connected Shamrock Island to the bay wetlands of Mustang Island. Oil and gas activities on the island have degraded water and sediment quality, although remediation efforts have been undertaken to restore habitats on the interior of the island. Bulkheads constructed to offset erosion have altered natural shoreline contours over time. Changes in vegetation in relation to island topographic changes have not been evaluated.

Potential REC Plan:

Construction Activities: An offshore reef could be constructed to reduce wave energy from the north on the northern shoreline. Conceptual plans have been drawn up in other studies which suggest a hard substrate approach (i.e., oyster reef construction). The reef should be long enough to protect most of the island shoreline.

Modification of Wetland Vegetation: Submergent vegetation could be planted between the reef and the island to increase fisheries habitat. The shallow, intertidal areas along the shoreline could be planted with smooth cordgrass or allowed to remain unvegetated. Exotic species such as saltcedar are present on the island. Because their structure increases nesting habitat diversity for colonial waterbirds they will not be removed. Upland vegetation has been replanted as mitigation for degraded habitats from oil and gas activities.

Modification of Wetland Fauna: The increase in subtidal vegetated habitats would enhance foraging area for some of the nesting species. Those species which nest along the shell and sand beaches will be protected from wave energy on the northern shore.

Potential Functions and Values:

- Shoreline Erosion Control

- Sediment Trapping
- Food Chain Support/Nutrient Export
- Fisheries Habitat
- Wildlife Habitat
- Recreation/Education/Culture

Potential Economic Benefits:

- Increased habitat for recreationally- and commercially-important estuarine species and associated prey
- Ecotourism

Management Options: A comprehensive management plan is being developed under the direction of The Nature Conservancy of Texas.

Estimated Cost of Plan: $$$

Potential Partnerships: The Nature Conservancy of Texas; Texas General Land Office; Coastal Management Program; Audubon's Coastal Sanctuaries Program; Coastal Ecosystem Program, U.S. Fish and Wildlife Service

SITE 30: Shamrock Cove

Location: West side of Mustang Island north of Wilson's Cut; limited road and boat access

Ownership and Management: Private ownership

General Description: Shamrock Cove encompasses both subtidal areas of Corpus Christi east of Shamrock Island and intertidal/subtidal wetlands along the bayside of Mustang Island.

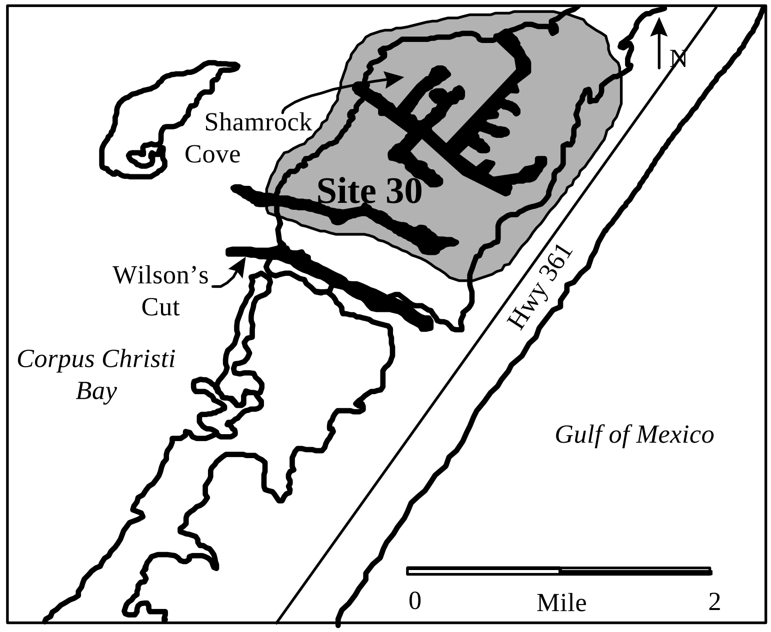

Figure 34. Location of Site 30 for potential wetland enhancement.

Current Wetland Classification:

- Estuarine Subtidal Aquatic Bed Rooted Vascular
- Estuarine Subtidal Unconsolidated Bottom
- Estuarine Subtidal Unconsolidated Bottom/Excavated
- Estuarine Intertidal Emergent Persistent
  Regularly Flooded
- Estuarine Intertidal Emergent Persistent
  Irregularly Flooded
- Estuarine Intertidal Unconsolidated Shore
  Regularly Flooded
  Irregularly Flooded
- Upland

Water Regime: The wetlands of Shamrock Cove are tidally influenced.

Wetland Vegetation: Subtidal wetlands are dominated by shoalgrass (*Halodule wrightii*). The emergent marsh vegetation in intertidal areas is composed primarily of smooth cordgrass (*Spartina alterniflora*), although black mangroves (*Avicennia germinans*) have recently increased. High marsh areas are vegetated by patches of glasswort/saltwort associations.

Wetland Fauna: The wetlands in this site are very productive and are a prime recreational fishing area. The excavated channel provides protection to fishery species during the warmest summer months and probably during infrequent freezes in the Texas Coastal Bend. Wintering waterfowl heavily utilize Shamrock Cove area from fall through early spring. Wading birds are commonly observed foraging along the marsh fringe.

Adjacent Land Use: Mustang Island is largely undeveloped adjacent to the Shamrock Cove site.

Current Functions and Values:

- Shoreline Erosion Control
- Sediment Trapping
- Food Chain Support/Nutrient Export
- Fisheries Habitat
- Wildlife Habitat
- Recreation

Causes of Degradation/Loss: Historical photographs show more extensive emergent marsh vegetation on this site in the 1950's. Channelization and deposition of dredged material has changed the bottom profile and altered water circulation throughout the wetlands. Fragmentation of emergent marshes has occurred in conjunction with an apparent increase in submerged aquatic vegetation. Although the excavated channels have increased water circulation in some areas of the wetland, the dredged material placement has altered circulation patterns. Concern has been raised that continued development of Mustang Island and any residential/marina development that may be planned for the bayside of the island will result in losses of wetland habitats.

Potential REC Plan:

Modification of Water Regime: Finger channels off main excavated channels within the interior of the island could be filled using dredged material for seagrass habitat enhancement.

Modification of Wetland Vegetation: Colonization of submerged aquatic vegetation would occur naturally in the filled channels resulting in an increase this wetland type and decreasing fragmented patterns within the seagrass meadow.

Modification of Wetland Fauna: The increase of subtidal habitat could increase populations of fish using the site.

Potential Functions and Values:

- Shoreline Erosion Control
- Sediment Trapping
- Food Chain Support/Nutrient Export
- Fisheries Habitat
- Wildlife Habitat
- Recreation

Potential Economic Benefits:

- Beneficial use of dredged material

- Ecotourism

Management Options: All efforts should be made to preserve these essential barrier island wetlands. The site could be managed in conjunction with Shamrock Island under a single conservation plan with The Nature Conservancy of Texas.

Estimated Cost of Plan: $$$

Potential Partnerships: Texas General Land Office; Coastal Management Program; The Nature Conservancy of Texas; Coastal Ecosystem Program, U.S. Fish and Wildlife Service

SITE 31: Wilson's Cut

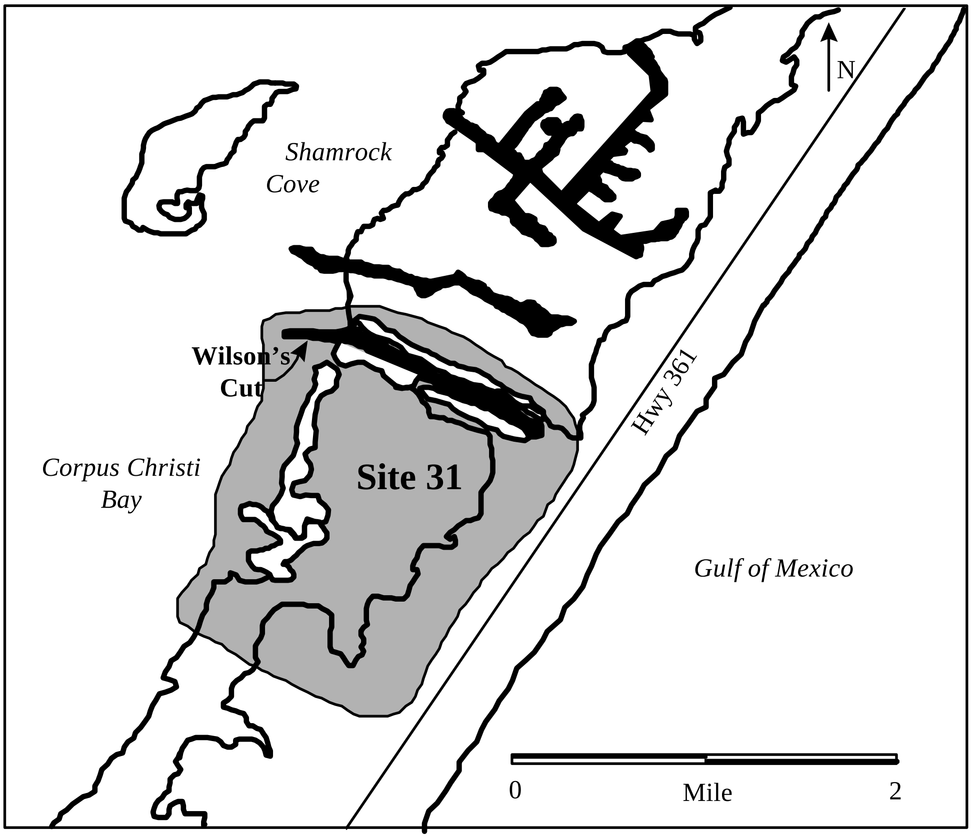

Figure 35. Location of Site 31 for potential wetland enhancement.

Location: West side of Mustang Island, north of Mustang Island State Park, south of Wilson Cut; limited road and boat access

Ownership and Management: Private ownership

General Description: The site is predominantly a subtidal, submergent vegetated wetland with an intertidal unconsolidated shoreline along the perimeter.

Current Wetland Classification:

- Estuarine Subtidal Aquatic Bed Rooted Vascular
- Estuarine Subtidal Unconsolidated Bottom
- Estuarine Subtidal Unconsolidated Bottom
- Estuarine Intertidal Emergent Persistent
  - Regularly Flooded
  - Irregularly Flooded
- Estuarine Intertidal Unconsolidated Shore
  - Regularly Flooded

Irregularly Flooded

- Upland

Water Regime: Tidal influence governs the hydrology at this site.

Wetland Vegetation: The submergent vegetation is composed primarily of shoalgrass (*Halodule wrightii*). Emergent vegetation identification was not determined, as no onsite evaluation has been conducted.

Wetland Fauna: No studies have been conducted onsite, although wading birds and waterfowl have been observed seasonally from offsite foraging in shallow subtidal and intertidal wetlands.
Adjacent Land Use: Upland areas of Mustang Island are not extensively developed.

Current Functions and Values:

- Food Chain Support/Nutrient Export
- Fisheries Habitat
- Wildlife Habitat
- Recreation

Causes of Degradation/Loss: Limited tidal exchange with Corpus Christi Bay has resulted from dredged material placement.

Potential REC Plan:

Modification of Water Regime: Placement of small tidal channels along Wilson's Cut and the bay shoreline into the interior wetland would increase water circulation into the site.

Modification of Wetland Fauna: Estuarine organisms which may be currently limited in this site due to high salinities would colonize the site after increasing tidal circulation.

Potential Functions and Values:

- Food Chain Support/Nutrient Export
- Fisheries Habitat
- Wildlife Habitat
- Recreation

Potential Economic Benefits:

- Habitat enhancement for recreationally- and commercially-important species and associated prey
- Ecotourism

Management Options: Limited management will be necessary once tidal channels have stabilized. The site could be preserved in conjunction with The Nature Conservancy of Texas management plan for Shamrock Island.

Estimated Cost of Plan: $

Potential Partnerships: Coastal Management Program; Texas General Land Office, The Nature Conservancy of Texas

SITE 32: Mid-Mustang Island Site

Location: West side of Mustang Island, North of Mustang Island State Park, South of site 31; no public access

Ownership and Management: Private ownership

General Description: This site is located along the bayside of Mustang Island and has an extensive mosaic of estuarine and palustrine wetland types. The site is largely unimpacted, with one exception of a road construction actvities and could serve as an excellent reference wetland for Mustang Island.

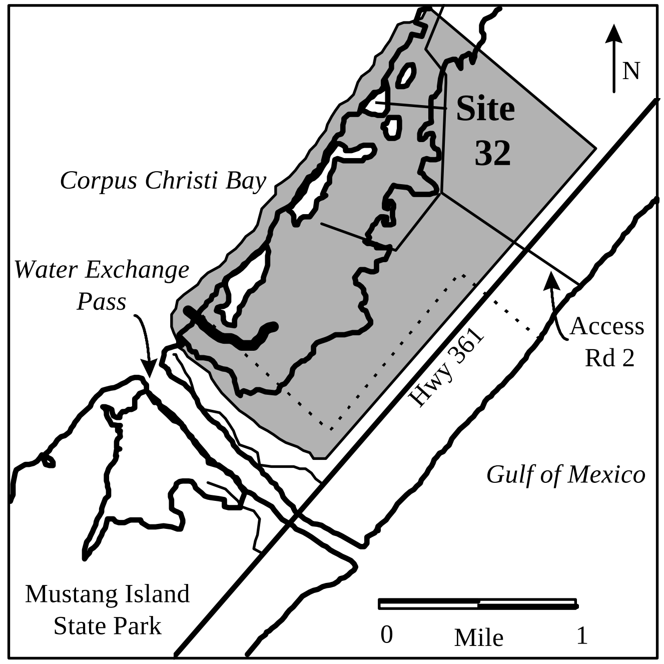

Figure 36. Location of Site 32 for potential wetland enhancement.

Current Wetland Classification:

- Estuarine Subtidal Aquatic Bed Rooted Vascular
- Estuarine Subtidal Unconsolidated Bottom
- Estuarine Subtidal Unconsolidated Bottom
- Estuarine Intertidal Emergent Persistent
  - Regularly Flooded
  - Irregularly Flooded
- Estuarine Intertidal Unconsolidated Shore
  - Regularly Flooded
  - Irregularly Flooded
- Palustrine Emergent Persistent
  - Temporarily Flooded
  - Seasonally Flooded
  - Semipermanently Flooded
  - Semipermanently Flooded/Excavated
- Palustrine Unconsolidated Bottom
  - Semipermanently Flooded
- Upland

Water Regime: The estuarine wetlands are hydrologically driven by tidal exchange with Corpus Christi Bay. A mitigation project adjacent to the site increased tidal flow at the southern area of the estuarine wetland. The palustrine wetlands within the vegetated flats of Mustang Island are depressional and retain rainwater seasonally depending upon their depths.

Wetland Vegetation: This site supports diverse wetland vegetation, ranging from submerged aquatic vegetation in subtidal estuarine waters, narrow, intertidal fringes of *Spartina alterniflora* along tidal creeks, high marsh vegetation of *Batis maritima* and *Salicornia* spp, to freshwater species of *Typha* sp. and sedges.

Wetland Fauna: Migrating waterfowl utilize the seagrass meadows during spring and fall, migrating and resident shorebirds forage in the intertidal flats, and various waterbirds utilize the nearshore and freshwater wetlands.

Adjacent Land Use: The island is relatively undeveloped near this site, although condominiums are located within two miles. Mustang Island State Park shares the southern boundary.

Current Functions and Values:

- Food Chain Support/Nutrient Export
- Fisheries Habitat
- Wildlife Habitat

Causes of Degradation/Loss: Roads and well pads from oil and gas exploration are located within the site, and tidal exchange with Corpus Christi Bay is restricted. Development pressures are likely as barrier island properties become difficult to obtain.

Potential REC Plan:

Modification of Water Regime: A culvert could be placed underneath the oil and gas roads which bisect wetlands and bay waters to increase water circulation and improve water quality.

Modification of Wetland Fauna: The estuarine wetlands would increase in value of nursery habitat for several species of fish, crabs, and shrimp.

Potential Functions and Values:

- Food Chain Support/Nutrient Export
- Fisheries Habitat
- Wildlife Habitat
- Recreation

Potential Economic Benefits: The site would provide essential habitat for recreationally- and commercially-important species.

Management Options: Maintenance of culverts would be necessary to maintain hydrologic flows in and out of the site.

Estimated Cost of Plan: $

Potential Partnerships: Coastal Management Program; The Nature Conservancy of Texas; Partner's for Wildlife Program, U.S. Fish and Wildlife Service; Texas Prairie Wetland Program, USFWS

SITE 33: Mustang Island State Park-Water Exchange Pass

Location: Southwest side of Fish Pass within Mustang Island State Park; no road access and limited pedestrian access

Ownership and Management: Texas Parks and Wildlife Department

General Description: The site is predominantly composed of estuarine intertidal flats that have been modified by dredged material from the construction of the Water Exchange Pass. The freshwater wetlands are ephemeral in nature, filling primarily with rainfall.

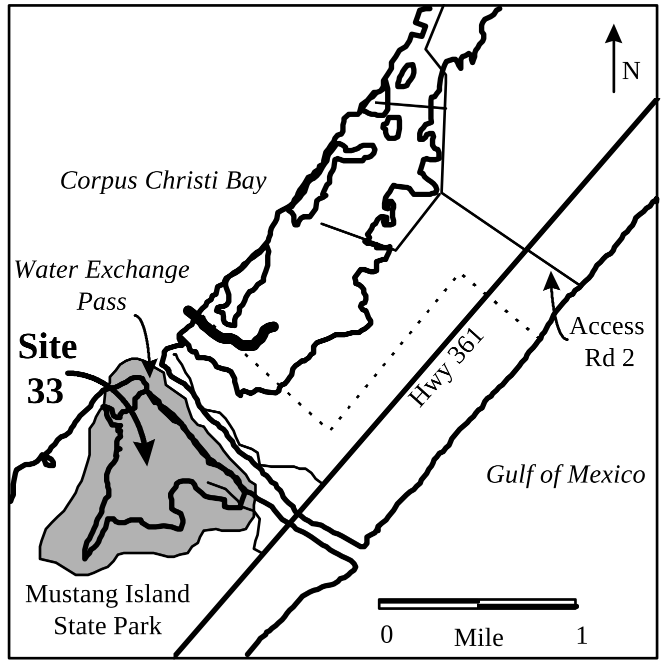

Figure 37. Location of Site 33 for potential wetland enhancement.

Current Wetland Classification:

- Estuarine Intertidal Emergent Persistent
  - Regularly Flooded
  - Irregularly Flooded
- Estuarine Intertidal Unconsolidated Shore
  - Irregularly Flooded
- Palustrine Emergent Persistent
  - Temporarily Flooded
  - Seasonally Flooded
- Upland

Water Regime: The intertidal flats are irregularly inundated with tidal waters from the Water Exchange Pass. The ephemeral freshwater wetlands are shallow and remain dry except during high rainfall periods.

Wetland Vegetation: Most of the site is unvegetated intertidal flats, although high marsh areas support *Spartina spartinae* and sparse *Salicornia* spp. meadows. The freshwater vegetation is composed primarily of *Typha* sp.

Wetland Fauna: Migratory and resident shorebirds utilize the flats in the fall and spring, while wading birds forage in narrow fringes of vegation along the Water Exchange Pass.

Adjacent Land Use: State-owned and operated parklands

Current Functions and Values:

- Food Chain Support/Nutrient Export
- Fisheries Habitat
- Wildlife Habitat
- Recreation

Causes of Degradation/Loss: Direct placement of dredged material during the construction of the Water Exchange Pass and materials subsequently transported into the site by wind may have altered and reduced tidal circulation.

Potential REC Plan:

Modification of Water Regime: The extension of tidal channels into the irregularly flooded unconsolidated shore and bottom estuarine wetland types would increase edge habitat for wetland vegetation. A similar project was successfully completed north of this site to increase water circulation into estuarine wetlands. Diversion of waters from the roadside ditches into some of the freshwater, ephemeral ponds would increase hydroperiod for these Palustrine wetland types.

Modification of Wetland Vegetation: Vegetation, such as *Spartina alterniflora* or *Distichlis spicata* could be established along tidal channels to increase habitat for fishery species and for foraging wading birds.

Potential Functions and Values:

- Food Chain Support/Nutrient Export
- Fisheries Habitat
- Wildlife Habitat
- Recreation

Potential Economic Benefits: The enhancement of estuarine wetlands would increase habitat for recreationally- and commercially-important fish, crabs, and shrimp.

Management Options: Tidal circulaton through the intertidal creeks would maintain estuarine connection in enhanced wetlands.

Estimated Cost of Plan: $$

Potential Partnerships: Texas Parks and Wildlife Department; Texas Prairie Wetland Program, U.S. Fish and Wildlife Service; Coastal Ecosystem Program, USFWS

SITE 34: Corpus Christi/Newport Pass

Location: South end of Mustang Island on west side of State Road 361 between Corpus Christi Pass and Packery Channel; limited road and boat access

Ownership and Management: State- and county-owned lands, as well as private land ownership

General Description: This area contains uplands, marshes, algal/tidal flats, seagrasses, and oysters.

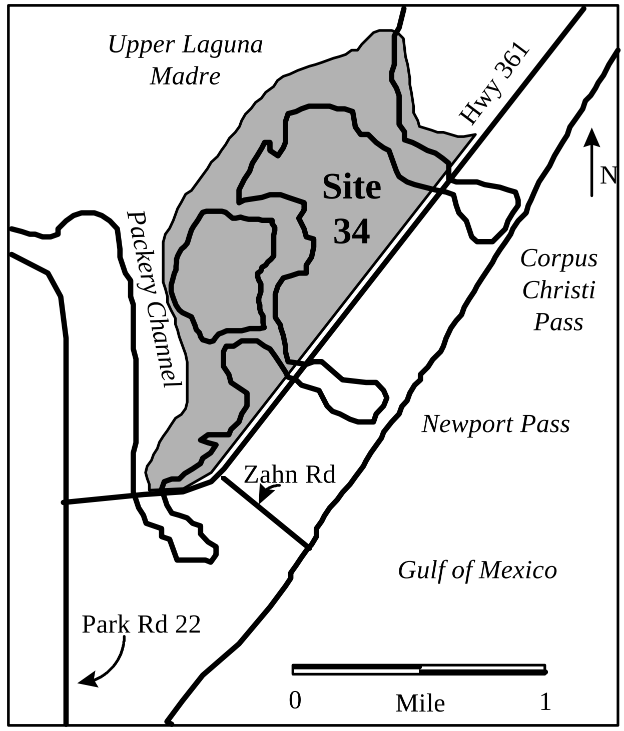

Figure 38. Location of Site 34 for potential wetland enhancement.

Current Wetland Classification:

- Estuarine Subtidal Unconsolidated Bottom
- Estuarine Intertidal Emergent Persistent
  - Irregularly Flooded
  - Regularly Flooded
- Estuarine Intertidal Unconsolidated Shore
  - Regularly Flooded
  - Irregularly Flooded
- Upland

Water Regime: The site is tidally influenced.

Wetland Vegetation: The intertidal areas are mainly unvegetated. High marsh elevations are sparsely covered with *Borrichia frutescens, Salicornia virginica,* and *Distichlis spicata*.

Wetland Fauna: The intertidal edge is heavily used by migratory shorebirds during fall and spring, in particular, the Snowy and Piping Plover. The adjacent deeper waters are used by pelicans, cormorants, and other waterfowl.

Adjacent Land Use: Highway 361 is located to the east of the tracts, Packery Channel and a residential subdivision are located to the west and south. Recreation, including hunting, fishing, birding, and boating are predominant within the site and vicinity. Portions of the site have historically been used for oil and gas production.

Current Functions and Values:

- Food Chain Support/Nutrient Export
- Fisheries Habitat
- Wildlife Habitat
- Recreation

Causes of Degradation/Loss: Oil and gas development has impacted the site, and a well pad and access road still exists. Current impacts include runoff from State Highway 361, uncontrolled vehicular traffic, and trash.

Potential REC Plan:

Construction Plan: A management plan to promote the protection and conservation of the federally listed piping plover, other key species, and their habitats is being developed for this parts of this area by the USFWS, GLO, and TPWD. The goals and objectives of the plan are focused primarily on preservation and education. Preservation goals are designed to avoid habitat degradation, enhance habitat value, and prohibit surface impacts from oil and gas development and other potentially degrading activities. Education goals focus on data gathering compatible with other goals and objectives, education of schoolchildren, and public outreach. Birdwatching and nature appreciation will be enhanced through the use of this area as well.

Potential management actions planned for portions of the site include the erection of a vehicular barrier and gates along State Highway 361, paved parking and trash receptacles along the highway, removal of the oil and gas structures, and refurbishing of the access road and well pads for parking. In addition, an observation tower and walkways will be constructed, along with interpretive and informational signage. Education materials and programs designed to promote the importance of preserving wetland and tidal flat habitats and species dependent on those habitats will be available to the public and special interest groups. Although only portions of the site are presently included in the management plan under development, the entire site could be incorporated into a holistic management plan approach between the state, county and private land owners.

Potential Functions and Values:

- Food Chain Support/Nutrient Export
- Fisheries Habitat
- Wildlife Habitat
- Recreation/Education

Potential Economic Benefits:

- Ecotourism

Management Options: Minimal maintenance, such as trash pickups, will be required.

Estimated Cost of Plan: $

Potential Partnerships: Texas Department of Transportation; Texas Parks and Wildlife Department; Coastal Ecosystem Program, U.S. Fish and Wildlife Service; Nueces County Commissioners Court; local environmental groups and other nongovernmental organizations; public schools; local industries; private landowners along Packery Channel

SITE 35: Coyote Island

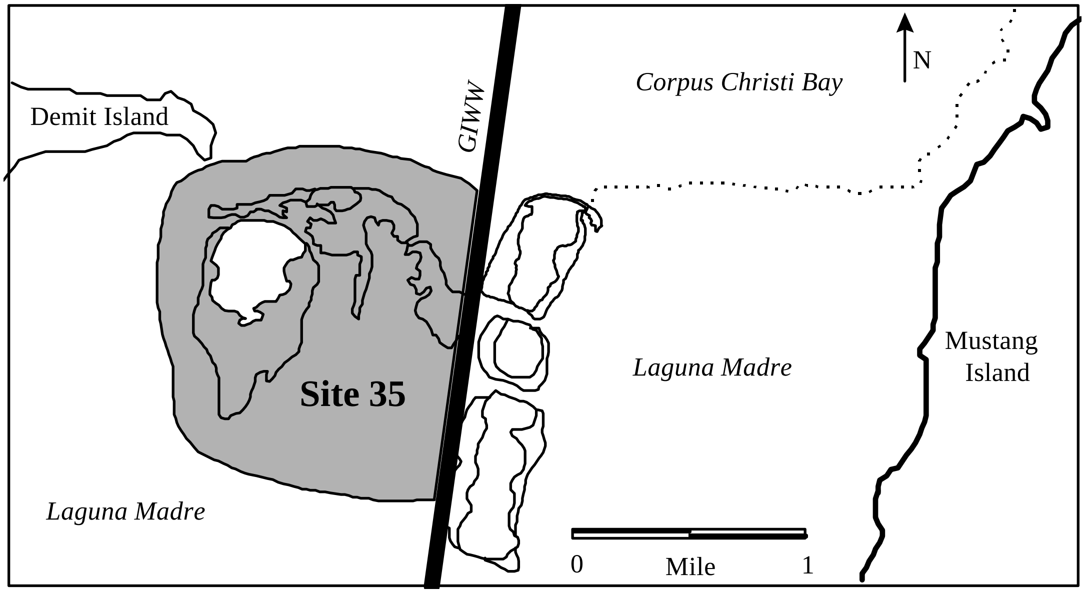

Figure 39. Location of Site 35 for potential wetland enhancement.

Location: Northern upper Laguna Madre east of Corpus Christi Naval Air Station, west of Gulf Intracoastal Waterway; limited boat access

Ownership and Management: Texas General Land Office

General Description: Coyote Island was created approximately 45 to 50 years ago from dredged material from the Boat Hole. The island contains approximately 70 acres of uplands and 50 acres of wetlands, with the highest elevations mostly on the north end of the island. An earthen levee is located on the north end of the island.

Current Wetland Classification:

- Estuarine Subtidal Unconsolidated Bottom
- Estuarine Subtidal Aquatic Bed Rooted Vascular (as found in rectangle)
- Estuarine Intertidal Unconsolidated Shore
  - Regularly Flooded
  - Regularly Flooded/Spoil
  - Irregularly Flooded
- Upland

Water Regime: The site is tidally influenced.

Wetland Vegetation: Submerged aquatic vegetation (SAV) of primarily *Halodule wrightii* surrounds the island.

Wetland Fauna: The SAV is important as habitat for numerous recreational and commercial fishery organisms, as well as their prey.

Adjacent Land Use: Recreational fishing and boating, commercial boat traffic on Gulf Intracoastal Waterway

Current Functions and Values:

- Food Chain Support/Nutrient Export
- Fisheries Habitat
- Wildlife Habitat

Causes of Degradation/Loss: Placement of dredged material used to create the island probably destroyed seagrass habitat.

Potential REC Plan:

Construction Plan: Portions of the uplands on the northern part of the island could be excavated to elevations between 0.0 and +1.0 mean low tide (MLT). In addition, at least two circulation channels on the western side of the island should be constructed for water exchange and equipment access. The dredged material could be deposited and contained on uplands above mean high tide on the extreme northern end of the island. Construction should occur between May 15 and August 1, because the threatened Piping Plover may use the sandflats during the rest of the year.

Modification of Wetland Vegetation: The excavated area should be planted with *Halodule wrightii*.

Potential Functions and Values:

- Food Chain Support/Nutrient Export
- Fisheries Habitat
- Wildlife Habitat
- Beneficial Use of Dredged Material

Potential Economic Benefits: Increased habitat for commercially- and recreationally-important fish species.

Management Options: Monitoring of the project will need to occur for at least three years following planting. Evaluation of this site would be useful to assess similar projects on other dredged material islands in the study area.

Estimated Cost of Plan: $$$

Potential Partnerships: Army Corps of Engineers; City of Corpus Christi; Texas General Land Office

SITE 36: Gulf Intracoastal Waterway North Island

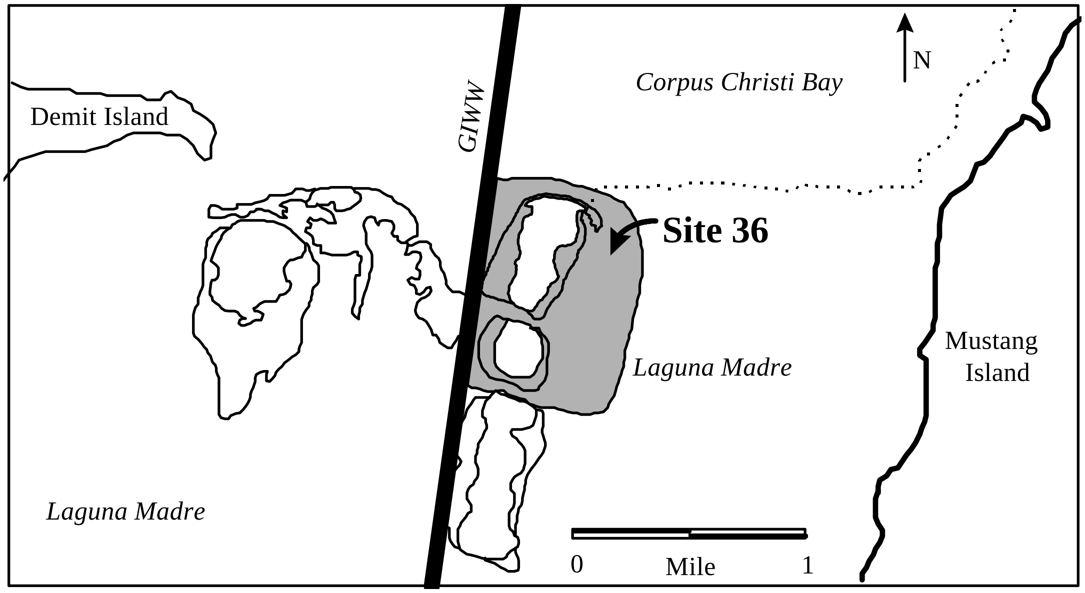

Figure 40. Location of Site 36 for potential wetland enhancement.

Location: Northernmost dredged material island at junction of Corpus Christi Bay and upper Laguna Madre, west of Gulf Intracoastal Waterway; boat access

Ownership and Management: Texas General Land Office

General Description: The island was created from dredged material when the GIWW was dredged more than 45 years ago. The island consists of approximately 55 acres of upland, 27 acres of marsh**,** and 25 acres of tidal flat.

Current Wetland Classification:

- Estuarine Subtidal Aquatic Bed Rooted Vascular (as found in rectangle)
- Estuarine Intertidal Emergent Persistent
  Seasonal Tidal/Spoil
- Estuarine Intertidal Emergent Persistent
  Irregularly Flooded/spoil
- Estuarine Intertidal Unconsolidated Shore
  Regularly Flooded
  Irregularly Flooded
- Upland

Water Regime: The site is tidally influenced.

Wetland Vegetation: The estuarine emergent marshes include the high marsh species, *Batis maritima*, *Salicornia* spp., *Borrichia frutescens*, and others. The seagrass, *Halodule wrightii*, occurs near the island.

Wetland Fauna: The seagrass meadows are important as habitat for numerous recreational and commercial fishery organisms, as well as their prey. Shorebirds and wading birds utilize the tidal flats. The island has been surveyed for colonial waterbird activity for many years, but data are combined with all islands north of the Kenedy Causeway.

Adjacent Land Use: Boating and fishing; the adjacent GIWW is used for commercial shipping and recreational boating.

Current Functions and Values:

- Food Chain Support/Nutrient Export
- Fisheries Habitat
- Wildlife Habitat

Causes of Degradation/Loss: Placement of dredged material used to create the island probably destroyed seagrass habitat.

Potential REC Plan:

Construction Plan: Various portions of uplands on the northern part of the island should be excavated to elevations between 0.0 and +1.0 mean low tide (MLT). At least one circulation channel on the western side of the island should be constructed for water exchange and equipment access. The dredged material would be deposited and contained on uplands above mean high tide. Construction should occur between May 15 and August 1, because the threatened Piping Plover may use the tidal sandflats during the rest of the year.

Modification of Wetland Vegetation: The excavated area would be planted with *Halodule wrightii*.

Potential Functions and Values:

- Food Chain Support/Nutrient Export
- Fisheries Habitat
- Wildlife Habitat
- Beneficial Use of Dredged Material

Potential Economic Benefits: Increased habitat for commercially- and recreationally-important fish species.

Management Options: Monitoring of the project will need to occur for at least three years following planting. Evaluation of this site would be useful to assess similar projects on other dredged material islands in the study area.

Estimated Cost of Plan: $$$

Potential Partnerships: Army Corps of Engineers; City of Corpus Christi; Texas General Land Office

SITE 37: Snoopy's Flats

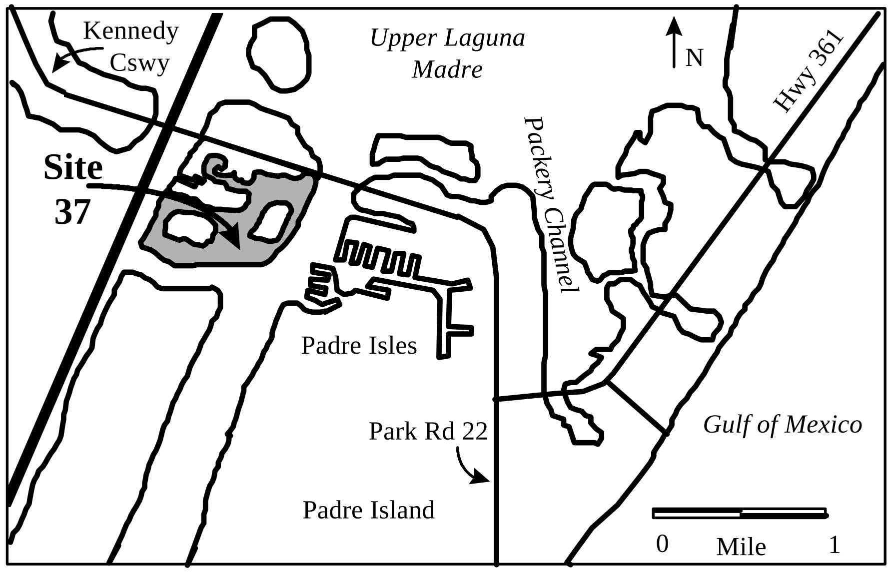

Figure 41. Location of Site 37 for potential wetland enhancement.

Location: Southeast side of Kennedy Causeway, adjacent to Snoopy's and Marker 37; limited road access

Ownership and Management: Uplands are under privatel ownership, or leased from the Texas General Land Office; submerged lands are under state ownership.

General Description: The intertidal area between Hwy 358 and the slightly elevated road to Snoopy's Restaurant and Marker 37 Marina has limited tidal exchange and sparse high marsh vegetation lining a small tidal creek.

Current Wetland Classification:

- Estuarine Intertidal Unconsolidated Shore
  - Regularly Flooded
  - Irregularly Flooded
- Upland

Water Regime: The site is tidally influenced via a culvert from the tidal creek to the marina and from seasonal high tide events.

Wetland Vegetation: Fringe high marsh is dominated by saltwort (*Batis maritima*) and minor components of high marsh forbs (i.e., sea ox-eye daisy [*Borrichia frutescens*]) on slightly higher elevations. The uplands are vegetated by prairie grasses typical of vegetated flats on the barrier islands.

Wetland Fauna: A diversity of wading birds and shorebirds utilize the site for both feeding and roosting.

Adjacent Land Use: The Gulf Intracoastal Waterway is located to the west and an excavated channel connects channels of Padre Isles residential subdivision and the lagoon north of the highway. Commercial businesses are located on adjacent uplands.

Current Functions and Values:

- Food Chain Support/Nutrient Export
- Fisheries Habitat
- Wildlife Habitat

Causes of Degradation/Loss: Limited tidal exchange prevents flushing of accumulated salts in the intertidal sediments. In addition, the wetlands are frequently driven upon by recreational vehicles during low tide, which destroys existing vegetation and increases erosion on the wetland surface.

Potential REC Plan:

Modification of Water Regime: Dredging of tidal creeks from the adjacent channel east of the site would increase tidal exchange.

Modification of Wetland Vegetation: Natural colonization of salt-tolerant species would occur along the created tidal creeks, although plantings in key locations could facilitate colonization rates.

Modification of Wetland Fauna: The decrease in sediment salinities and increased tidal circulation could enhance productivity of benthic prey organisms for shorebirds. The created tidal creeks would increase mobile prey items for wading birds.

Construction Activities: A vehicle barrier fence would need to be constructed bordering the wetland along both roadways to eliminate disturbance of sediments, plants, and animals.

Potential Functions and Values:

- Food Chain Support/Nutrient Export
- Fisheries Habitat
- Wildlife Habitat
- Recreation

Potential Economic Benefits:

- Ecotourism
- Habitat for recreationally- and commercially-important estuarine species and associated prey species

Management Options: Enforcement of no vehicle access is necessary to ensure success of wetland creation and enhancement.

Estimated Cost of Plan: $$

Potential Partnerships: Texas General Land Office, commercial leasees; Coastal Management Program; City of Corpus Christi

SITE 38: City of Port Aransas Intertidal Flat

Location: Southwest corner of Hwy 361 and G Street in Port Aransas; limited road easement access only

Ownership and Management: City of Port Aransas, Texas Department of Transportation, and Texas Parks and Wildlife

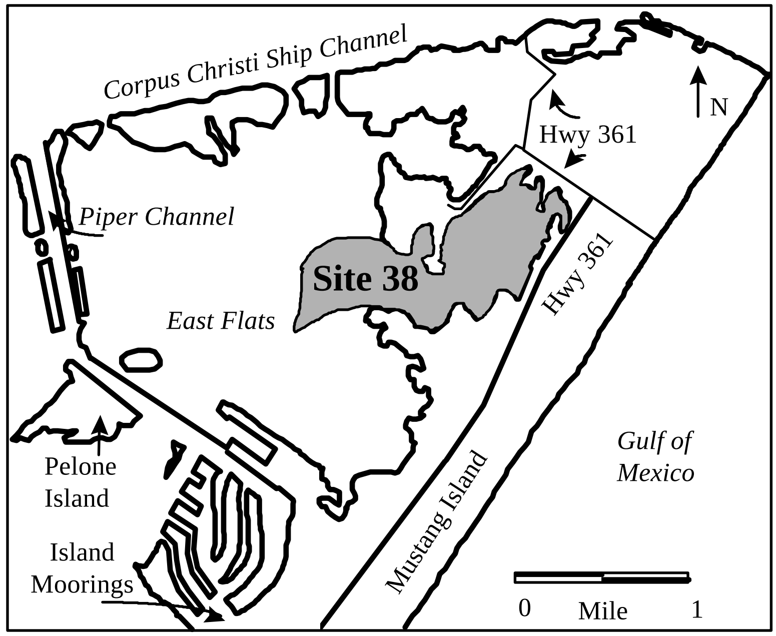

Figure 42. Location of Site 38 for potential wetland enhancement.

General Description: This wetland complex is influenced hydrologically by urban runoff from the west side of Port Aransas and tidal waters from Piper Channel to the south. Historically, this area was tidally connected to a natural pass between Corpus Christi Bay and the Gulf of Mexico as part of the tidal delta of Harbor Island. Placement of dredged material from the Corpus Christi Ship Channel and, to a lesser extent, Piper Channel has reduced tidal exchange into this site.

Current Wetland Classification:

- Estuarine Subtidal Aquatic Bed Rooted Vascular
- Estuarine Subtidal Unconsolidated Bottom
- Estuarine Intertidal Emergent Persistent
  - Regularly Flooded
  - Irregularly Flooded
- Estuarine Intertidal Unconsolidated Shore
  - Irregularly Flooded
- Palustrine Emergent Persistent
  - Temporarily Flooded
- Palustrine Unconsolidated Bottom
  - Permanently Flooded
  - Artificially Flooded/Excavated
- Upland

Water Regime: Freshwater runoff from urban drainage system and tidally influenced through Piper Channel.

Wetland Vegetation: Most of the wetlands are unvegetated, in part due to limited tidal exchange. A dense stand of *Typha* sp. is located at the urban drain outfall.

Wetland Fauna: The wetlands are used extensively by wading birds and shorebirds when the wetland is unundated. During substrate exposure periods, gulls and terns use the site for roosting.

Adjacent Land Use: City of Port Aransas residential and business districts.

Current Functions and Values:
- Food Chain Support/Nutrient Export
- Fisheries Habitat
- Wildlife Habitat
- Recreation

Causes of Degradation/Loss: Placement of dredged material from channel creation and maintenance has altered tidal circulation.

Potential REC Plan:

Modification of Water Regime: Dredging of tidal channels from Piper Channel into upper reaches of site would increase tidal circulation. The dredged material could be used to recontour the flow of fresh water into the wetland and possibly to construct nature trails along the adjacent uplands.

Modification of Wetland Vegetation: A more even distribution of fresh and tidal water would probably increase the amount of natural colonization of emergent and submergent vegetation.

Construction Plan: The site could be connected with the Port Aransas wastewater treatment birding trail to the west with nature trails and walkways around the perimeter of this site. A water-quality monitoring platform could be constructed to establish a station for the Texas Watch and Urban Watch programs.

Potential Functions and Values:
- Food Chain Support/Nutrient Export
- Fisheries Habitat
- Wildlife Habitat
- Recreation/Education

Potential Economic Benefits:
- Ecotourism

Management Options: Maintenance of nature trails would be necessary.

Estimated Cost of Plan: $$

Potential Partnerships: Coastal Management Program; local birding and garden clubs; Texas and Urban Watch Programs, Texas Natural Resource Conservation Commission; Coastal Ecosystem Program, U.S. Fish and Wildlife Service; Adopt-A-Wetland Program, Center for Coastal Studies-TAMUCC; University of Texas Marine Science Institute

SITE 39: Piper Channel

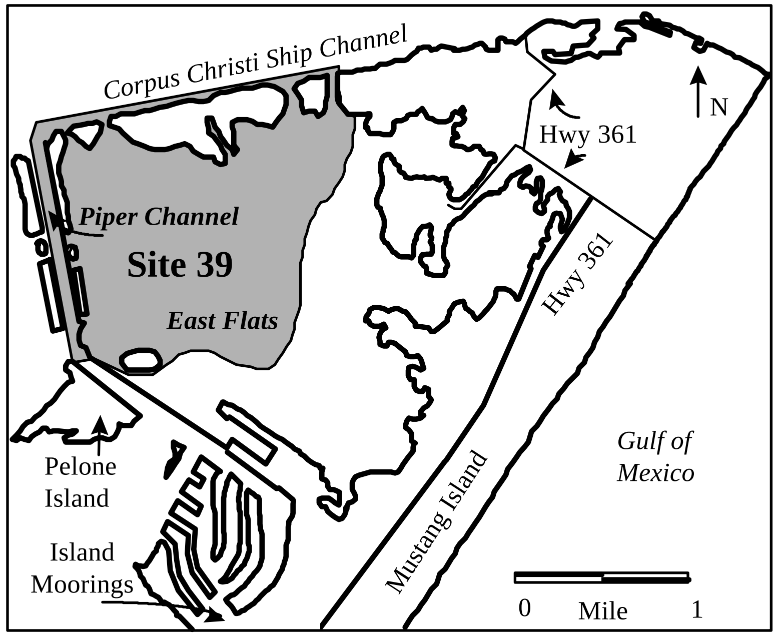

Figure 43. Location of Site 39 for potential wetland enhancement.

Location: North and south side of Piper Channel in East Flats area on northern end of Mustang Island; boat access only

Ownership and Management: Channel privately maintained, dredged material storage areas leased from Texas General Land Office, submerged lands state-owned

General Description: The wetlands adjacent to the channel were altered by the placement of dredged material in early 1920's during excavation of the Corpus Christi Ship Channel. Dredged material containment cells are located along the channel from the ship channel to Island Moorings residential area. Wetlands range from limited estuarine intertidal vegetation to unvegetated tidal areas.

Current Wetland Classification:

- Estuarine Subtidal Unconsolidated Bottom
- Estuarine Intertidal Aquatic Bed Algal
  Regularly Flooded
- Estuarine Intertidal Unconsolidated Shore
  Regularly Flooded
  Irregularly Flooded
- Palustrine Emergent Persistent
  Seasonal-Tidal
- Upland

Water Regime: Tidal energy is moderately high to the site and water exchange is facilitated through Piper Channel, the Corpus Christi ship channel and Aransas Pass.

Wetland Vegetation: The wetlands exhibit very low relief with slight changes in elevation, except for areas adjacent to channels. Limited areas of smooth cordgrass (*Spartina alterniflora*) are located adjacent to Piper Channel and immediately behind dredged material deposits. Small areas of black mangroves are present along eroded tidal channels within the dredged material cells. Neither of these species covers enough areal extent to be designated on the 1992 National Wetlands Inventory maps.

Wetland Fauna: A wide diversity of wading and shorebirds utilize the intertidal flats during low tides. The lower intertidal areas have scattered oyster beds, although many clumps are dead. The wetlands have historically been used for commercial crabbing.

Adjacent Land Use: Dredged material cells are located within the site adjacent to excavated navigation channels. A residential area, Island Moorings, is located to the east on Mustang Island, and the City of Port Aransas is located to the north.

Current Functions and Values:

- Food Chain Support/Nutrient Export
- Fisheries Habitat
- Wildlife Habitat
- Recreation

Causes of Degradation/Loss: The general area around the northern end of Mustang Island has changed dramatically due to the excavation and maintenance of the Corpus Christi Ship Channel. This site has limited tidal exchange due to the placement of dredged material [cells]. These activities have probably resulted in a decrease of productivity of fisheries and wildlife in many of the intertidal flats, although no quantitative evidence is available. Little emergent marsh vegetation currently occurs in the site, probably due to high(er) salinities and current elevation. Development plans are always under consideration as these intertidal flats have typically been destroyed to build canal subdivisions and marinas on intertidal flats on the barrier islands.

Potential REC Plan:

Modification of Water Regime: Tidal circulation could be increased by excavating tidal channels through low dredged material deposits to areas with limited exchange.

Modification of Wetland Vegetation: Emergent vegetation would probably expand into these enhanced areas, although strategic plantings of smooth cordgrass may facilitate rates of establishment. Certain areas of extensive tidal flat should remain unvegetated for Piping Plover use.

Modification of Wetland Fauna: Increased marsh access for fisheries through the excavated tidal channels would enhance available habitat for estuarine and wetland species.

Potential Functions and Values:

- Food Chain Support/Nutrient Export
- Fisheries Habitat
- Wildlife Habitat
- Recreation/Education

Potential Economic Benefits:

- Increased fisheries productivity
- Ecotourism

Management Options: The site could be used as a pilot project to increase public awareness about the value of East Flats.

Estimated Cost of Plan: $$$

Potential Partnerships: Port of Corpus Christi Authority; Army Corps of Engineers; Coastal Management Program; Texas General Land Office; Coastal Ecosystem Program, U.S. Fish and Wildlife Service; The Nature Conservancy of Texas; Private Landowners

DISCUSSION

SITE SELECTION CONSIDERATIONS

Site Design Criteria

Design and analysis of restoration, enhancement, and creation (REC) projects is very site-specific (Cobb, 1987), although there are general guidelines for all habitat types. For example, guidelines for estuarine marsh restoration have clear and well-tested criteria for design and implementation (see Zedler, 1984 and 1990; Minello *et al.*, 1986; Cobb, 1987; Broome *et al.*, 1988; Ruth, 1990; Kusler and Kentula, 1990; Kentula *et al.*, 1993; National Research Council, 1992; Thayer, 1992; Nicolau, 1993; Belaire and Templet, 1993; Matthews and Minello, 1994; Turner *et al.*, 1994; Rozas *et al.*, 1994). On the other hand, seagrass restoration is still considered to be somewhat in the research and testing stage (see Cobb, 1987; Carangelo, 1988; Fonseca *et al.*, 1990; Fonseca, 1993; Montagna, 1993). Cobb's report (1987) on marsh and seagrass mitigation projects for South Texas, including this study area, is an excellent evaluation of both successful and unsuccessful compensatory mitigation and general siting, design, and monitoring information. For projects requiring a Section 10/404 permit and compensatory wetland mitigation in the Corps of Engineers (COE), Galveston District, the COE, USFWS, and other state and federal resource agencies have developed guidelines for salt marsh, bottomland hardwood, and seagrass restoration and creation. These guidelines were developed to facilitate consistent interagency recommendations for compensatory mitigation and can be used for other REC projects. The USFWS field office in Clear Lake can be contacted (281-286-8282) for a copy of the guidelines.

Achieving success (success is achieving the project's goals and objectives) in wetland restoration, enhancement, and creation projects, requires consideration of four key technical factors: (1) correct hydrology and elevation (stable and suitable water supply); (2) suitable soil/substrate for biotic success; (3) protection from wind, wave, and wake energies (energy systems); and (4) correct plant species and propagule selection and installation (Landin, 1992). Matthews and Minello (1994) outline nine key factors for successfully establishing *Spartina alterniflora*.

Goals need to be developed for each project. Where it is possible, the goals should take into consideration wetland functions, the place of the wetland in the overall landscape/ watershed/ ecosystem, and whether the goals are cost-effective (Landin, 1992). Goals that are not cost-effective or sustainable should not be undertaken.

Functional Design Criteria

Wetland functions are the physical, chemical, and biological processes or attributes of a wetland (Adamus *et al.*, 1987). Functions exist in the absence of society and are normally part of the self-sustaining properties of an ecosystem (Brinson, 1993). Important wetland characteristics that determine wetland functions at each site are geomorphic setting or position in the landscape, water source, and hydrodynamics (Smith, 1993; Brinson, 1993). Values are the wetland processes or attributes that are valuable or beneficial to society. An example of the difference between functions and values is the removal of nitrate from surface and groundwater by wetlands. Nonpoint sources of nitrate are intercepted from agricultural and urban landscapes by wetlands (Brinson, 1993). The societal service is improved water quality because of lower nitrate concentrations. The removal of nitrogen by denitrification is the ecosystem function. Denitrification is the mechanism that allows this removal to occur.

Wetlands at the 39 sites in the Corpus Christi/Nueces Bay study area perform many functions and values, including groundwater discharge/recharge, flood storage and desynchronization, shoreline erosion control, sediment trapping, water quality improvement, food chain support/nutrient export, fisheries and wildlife habitat, and recreation/education/culture. Wetland functions at each of the REC sites and in the watersheds or landscape have been degraded or lost from direct and indirect adverse impacts; therefore, the goals are to either restore lost functions, enhance those degraded functions that currently occur at each site, or, in some cases, create wetland functions that would benefit the watershed. The wetland functions of shoreline erosion control and sediment trapping, water quality improvement, and fish and wildlife habitat are discussed in more detail, along with some basic design considerations for each function, as plans to restore, enhance, or create these functions are being developed for many of the sites.

Monitoring

The success of salt marsh restoration can be evaluated in both the short-term or the immediate response of the hydrological and biological features, and over the longterm to determine the development of the ecosystem (Zedler, 1984). Success in the short-term may not assure success in the longterm, and failure in the short-term does not necessarily preclude long-term success. Typically, vegetation canopy of the planted vegetation is often used as the only measure of success. For example, resource agencies often consider a successful REC project as one that has achieved at least a 70% canopy coverage of *Spartina alterniflora* within one to three years of planting. Cobb (1987) recommends that marsh creation projects achieve 90% to 100% cover of a nearby natural control marsh within two years.

Ideally, monitoring will include not only canopy cover but also those features that ecologists find to be important indicators of ecosystem function and those features the public considers to be important (Zedler, 1984). Three- to five-years of monitoring study are essential, using, if available, a nearly natural marsh as a control site for comparison. Cobb (1987) recommended monitoring of compensation sites and control marshes in early spring, summer, and fall for two years, and then once during the growing season for three additional years. Characteristics to be sampled on permanent transects or test plots are elevation, soil salinity, algal cover, plant species composition, cover, height, and above- and below-ground biomass, invertebrate species composition, and bird and fish usage. Aerial photos taken of the site immediately following construction and at yearly intervals can be used to determine overall plant density and coverage.

For seagrass transplants, Montagna (1993) recommends long-term monitoring, with annual sampling over four years. Transplant sites should be compared to natural, undisturbed habitats. Benthic macrofauna and biomass can be used to determine community structure changes (Montagna, 1993). Also, Montagna (1993) suggests that total organic matter or Eh profiles are good, cost-effective monitoring tools for seagrass ecosystem function. Fonseca (1994) also suggests monitoring survival of the seagrass planting units, their areal coverage, and number of shoots per planting unit.

FUNCTIONAL ASSESSMENTS

Available Techniques

A number of methods have been developed over the last 20 years to assess the functions of wetlands. Functional assessments should occur both before and after implementation of a REC project to determine increases in functional values. Lonard and Clairain (1986) summarize many of the early wetland assessment methods prior to 1981 and present an update of methodologies since 1981. Many newer methods, including the Wetland Evaluation Technique (WET) (Adamus *et al.*, 1987), have been developed since 1986. Many of the newer approaches are summarized by the World Wildlife Fund (1992). The WET was designed to rapidly assess a broad range of functions throughout the U.S., and, with the probable exception of the Habitat Evaluation Procedures (USFWS, 1980), this method has received more use than others. However, despite the variety of methods that have been developed, none have received widespread use for the following reasons: (1) extensive time and resource requirements for implementation; (2) subjectivity in implementation; (3) limited number of wetland functions considered; (4) applicability of method results; (5) concerns over technical validity; and (6) limited geographic scope (Smith, 1993).

A promising new wetland functional assessment technique currently being developed on a regional scale in many areas of the U.S. is the Hydrogeomorphic (HGM) Approach. The HGM Approach takes the extensive amount of information and professional judgement already available and utilizes that knowledge base to make rapid assessments (Brinson, 1996). The HGM Approach is based on three factors that influence how wetlands function: position in the landscape (geomorphic setting), water source (hydrology), and the flow and fluctuation of the water once in the wetland (hydrodynamics). With the HGM Approach, wetlands are classified on the basis of differences in function. The classification recognizes, for example, that depressional wetlands and river floodplains occupy different parts of the landscape, and therefore differ in both the number of functions that they perform and the relative intensity at which they perform them. In addition, the approach maintains a clear policy-science separation. Societal issues are dealt with only after changes in function are determined. The HGM Approach uses reference wetlands, which are sites that encompass the known variation in the functioning of subclasses of wetlands (Brinson, 1996). Hopefully, the HGM classification, HGM models, and reference wetlands will soon be developed and determined for Texas coastal wetlands.

Shoreline Erosion Control

Erosion is a serious threat to waterfront property and habitats along many areas of the Corpus Christi/Nueces Bay shoreline (see the "geology section" on p. 5 for a general discussion of bay shoreline erosion). Shoreline erosion is a natural process caused by a rise in sea level, prevailing winds, current conditions, and sediment deficiency (Seidensticker and Nailon, 1990). Erosion can be prevented by structural measures, such as riprap, bulkheads, groins, and revetments; however, shoreline structures are often expensive and may have adverse environmental impacts. Vegetation establishment along the shoreline is usually much cheaper than structural methods and can provide both fish and wildlife habitat and shoreline stabilization.

Shoreline erosion control or shoreline stabilization with hydrophytic or wetland vegetation, primarily *Spartina alterniflora*, is the binding of soil at the shoreline by wetland plants, and the physical dissipation of erosive energy caused by waves, currents, or tides in a basin or channel (Marble, 1992). Mud and sand transported by water are trapped in the marsh, raising the elevation of the intertidal zone and eventually preventing waves from breaking on the shoreline.

Wetland vegetation becomes established and functions best in controlling shoreline erosion in areas where wave energy and shoreline slope are low to moderate. In areas where fetch is greater than 1.2 mi (1.9 km) (Marble, 1992), temporary or permanent breakwaters and other devices may be needed to protect the marsh. Temporary breakwaters may include fences of used cargo parachutes, plastic snow fence, or used Christmas trees (Seidensticker and Nailon, 1990), or more permanent breakwater structures of fabricated geotextile tubes, and artificial reefs of oyster shell or coal combustion by products. Also, three-dimensional woven geotextile mats can be anchored on erosional shorelines and in areas with relatively steep slopes. The mats, along with rooted vegetation, resist damage from wave energy and help retain sediment.

Restoration/creation sites 6, 7, 8, 11, 12, 13, 14, 15, 16, 27, 28, 29, and 30 will function in helping to control shoreline erosion (Table 5). Sites along the north shore of Nueces and Corpus Christi bays, where fetch and the resulting erosional forces are great, will require temporary breakwaters and/or geotextile mats to protect the developing marsh. Sites along the south shore of Nueces Bay are exposed to north winds and will also need breakwater protection. In addition, the eroding northeast shoreline of Shamrock Island will require a more permanent breakwater of coal combustion byproducts or oyster shell.

Water Quality Improvement

Wetlands are important in maintaining water quality because they function as filters to remove pollutants, nutrients, and sediments from waters. Without the pollution removal ability of wetlands, the estuary could be adversely affected by high levels of nutrients being transported from upstream areas to the estuary, resulting in algal blooms which reduce oxygen levels and cause massive fish kills. In addition, pollutants such as pathogens and toxics could impact the estuary unless upstream wetland areas trap and absorb these substances. Vegetated buffers, in general, and riparian corridors, in particular, are effective in filtering sediment, nutrients, pesticides, particulate organic matter, and bacteria from farm and feedlot runoff (Phillips, 1989). As uplands become more intensively managed and the area of wetlands is reduced, nutrient processing and retention become impaired (National Research Council, 1995). In addition, increased amounts of sediment, nutrients, and pesticides from watersheds undergoing development can alter the biological makeup of wetlands and overburden their ability to purge pollutants if they are added beyond the wetland's capacity to assimilate them (Kusler *et al.*, 1994).

A wetland that functions to retain and transform nutrients must be capable of physically retaining the nutrients (Marble, 1992). This is accomplished when the water velocity is slowed by the stems and leaves of emergent and woody plants so that sediments and the absorbed nutrients settle to the bottom. Both emergent and submerged aquatic vegetation are particularly useful in nutrient retention and uptake, although woody vegetation can store nutrients for a longer period in woody tissues. In general, the more dense the vegetation, the greater the wetland's ability to remove and take up nutrients and retain sediment and toxicants. (Marble, 1992). Other factors that determine a wetland's ability to retain water, thus trapping sediment and the toxicants which may be bound to the substrate, are: (1) constricted outlets or no outlets, which will slow water and hold it in the basin; (2) gentle gradients in the wetland basin will slow water velocity; (3) long duration and extent of seasonal flooding allow for a longer water retention time; and (4) shallow water depth increases frictional resistance and slows water velocity (Marble, 1992). Vegetation that persists throughout the year is optimal for this function. Marble (1992) also mentions that it is important that the water source of the wetland be principally from surface runoff for the wetland to function in water quality improvement.

Wetlands at sites 1, 2, 3, 4, 5, 7, 9, 10, 11, 12, 13, 14, 15, 19, 20, 21, 22, 23, 24, and 26 currently provide water quality improvement. Many of these wetlands receive or will receive highway, urban, or agricultural runoff, or effluent from wastewater discharges. Plans for these sites include restoring, enhancing, or creating the water quality improvement function and value. The sediment trapping function at other sites may be enhanced or restored, and this may also provide some water quality improvement.

Fish and Wildlife Habitat

Wetlands, including estuarine emergent marshes and submerged aquatic vegetation, are important habitats in the Corpus Christi/Nueces Bay study area, serving as nursery and feeding areas and providing protection from predators for a variety of invertebrates and fish. The fish and invertebrates are, in turn, eaten by a variety of shorebirds in the marshes and ducks in the seagrasses. Montagna *et al.* (1996) describe the intertidal salt marsh and seagrass habitats of the estuarine ecosystem in the study area (see also the introductory section on fish and wildlife, p. 15) and discuss how habitats are related to other biotic and abiotic components in the ecosystem.

Wetlands at all 39 sites in the study area currently serve as fish and wildlife habitats. Many of these wetlands are degraded and have minimal habitat values. Plans to restore or enhance hydrology and/or plant wetland vegetation will facilitate achieving increased wildlife and fisheries abundance and diversity, along with restoring, enhancing, or creating other wetland functions.

Major factors that interact and are important in determining habitat use of restored, enhanced, or created wetlands are elevation, salinities, hydrology, and hydroperiod or the hydrologic signature of a wetland. For example, incorrect elevations and slope, along with higher than optimum salinities, were primary factors in the failure of *Spartina alterniflora* to become established at a compensatory mitigation site in the Nueces River delta (Nicolau, 1993). As a result, the habitat functions of the mitigation site differ from an adjacent natural marsh, although, with time, the natural marsh and mitigation site are becoming more similar in terms of benthic, nekton, and avian species usage.

Hydrology and hyrdoperiod are extremely important for the maintenance of wetland structure and function (Mitsch and Gosselink, 1993). Hydrologic conditions affect abiotic factors, including salinity, which, in turn, determine the flora and fauna of a wetland. Obviously, marsh hydroperiod controls habitat use by nekton, because they can occupy the marsh surface only when it is flooded (Rozas, 1995). Hydroperiod may also indirectly determine habitat use through its influence on vegetation and the prey of nektonic predators (Rozas, 1995).

Cultural Values

Many significant prehistoric and historic cultural episodes have occurred along the central Texas coast adjacent to or directly on many of the sites listed in this report. The migratory nature of coastal groups is documented historically and inferred archaeologically from both site formation and location and the variety seen in artifact assemblages from the coast. Coastal groups may have stayed for only a short period of time at any one site (Campbell, 1958a) but returned repeatedly over generations or centuries to favored sites or to sites with seasonally stable resources. The size of coastal sites in terms of group dynamics (base camps and seasonal camps) suggests that the size of a site may be a function of repetitious usage rather than the size of the group.

Coastal exploitation of shellfish, fish, and small mammals is evident with emphasis on estuarine ecological niches as population densities increased (Black, 1989). It has been suggested that a trade network may have been established during the periods of occupation with inland groups exchanging shells (both raw material and ornaments) for chert tools and raw materials (Hester, 1970). Excavations of these sites is the key to determining the long sequence of prehistoric and historic human occupation on the central Texas coast. Over the last ten years, much new information has been gathered which begins to shed light on the absolute time frame involved in prehistoric occupation of the central Texas coast (Ricklis, 1995).

The culture integrity of utilitarian and functional remains is imperative in determining the human chronology of hunter and gatherer societies occupying several of the potential sites in the study area. Restoration sites 7, 11, 12, 18, 19, 27, and 29 have been identified as possessing current cultural significance in both archaic and prehistoric chronological occupation. In addition, each of the above-mentioned sites possesses educational functions and values to be utilized by current and future generations. Prospective resource management plans should take into consideration the significance of any cultural implications that may exist on each site and take appropriate measures to preserve the historical and prehistorical significance which is impacted by artificial land-modification.

POTENTIAL FUNDING PROGRAMS FOR WETLAND RESTORATION, ENHANCMENT, AND CREATION

Many federal, state, and private programs are available to state and local governments, private landowners, and others to fund and/or provide technical assistance for wetland restoration, enhancement, or creation.

FEDERAL PROGRAMS

National Coastal Wetlands Conservation Grant Program

The National Coastal Wetlands Conservation Grant Program is authorized by section 305 of the Coastal Wetlands Planning, Protection and Restoration Act (CWPPRA) of 1991. Funds are administered by the U.S. Fish and Wildlife Service (USFWS) and are intended for coastal states to acquire, restore, enhance, or manage coastal lands or waters, including wetlands. Grants are available to coastal and Great Lakes states on a competitive basis and require a 50/50 federal/state match, or 75/25 if the state has a land trust for acquisition of wetlands or open space. Texas has a dedicated land trust for acquisition. In Texas, the TPWD has received CWPPRA monies for coastal wetland acquisition and restoration.

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Coastal Zone Management Program

The National Oceanic and Atmospheric Administration (NOAA) administers The Coastal Zone Management Programs under the Coastal Zone Management Act (CZMA) of 1972. Texas Coastal Zone Management Programs Grants Program is administered by the Texas General Land Office. Projects selected for the grants program are funded under 306/306a of the CZMA. Resource Management Improvement Grants afford coastal states that have a federally approved Coastal Zone Management Programs with 50/50 matching grants for projects that enhance coastal natural resources. Texas received federal approval of the Coastal Zone Management Program on January 10, 1997.

Entities eligible for funding under the Coastal Zone Management Programs Grants Program are: incorporated city and county governments in the coastal zone; state agencies; public universities; subdivisions of the state with jurisdiction in the coastal zone; councils of governments and other regional governmental entities in the coastal zone; the Galveston Bay Estuary Program; the Corpus Christi Bay National Estuary Program; and nonprofit organizations that are nominated by eligible entities in other categories. Among the funding priorities is critical areas enhancement.

Critical areas are coastal wetlands, submerged aquatic vegetation, oyster reefs, hard substrate reefs, and tidal sand and mud flats.

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Wetlands Reserve Program (WRP)

The WRP is a voluntary program authorized by the Food Security Act of 1985 that provides owners of eligible land an opportunity to offer an easement for purchase by the Secretary of Agriculture and to receive cost-share assistance to restore cropland to natural wetlands. Recent revisions of the WRP have included a broader definition of land type than just cropland. Eligible land includes those wetlands farmed under natural conditions, substantially altered lands as determined by the Natural Resource Conservation Service (NRCS), or prior converted croplands (converted prior to December 23, 1985), with those adjacent lands deemed necessary to protect the restored areas. Land must be capable of being restored, taking into account the cost of the restoration to a condition that will provide long-term significant wetland functions and values. The WRP offers farmers a unique opportunity to retire marginal agricultural lands and convert them to wetlands. It is also the only available program that offers cash compensation to the landowner. Landowners maintain ownership and the easement, and are responsible for minimal taxes on easement lands. Farmers can apply through county NRCS offices during specified sign-up periods. The NRCS and the USFWS will specify in a Wetlands Reserve Plan of Operation the method in which the wetlands and adjacent uplands (if any) must be restored and maintained.

Under the 1996 Farm Bill, the WRP will have an enrollment cap of 975,000 acres nationwide. Beginning October 1, 1996, one-third of the total program acres will be enrolled in permanent easements, one-third in 30-year easements, and one-third in restoration only cost-share agreements. Individuals may choose the category for their eligible land. Also, the WRP provides landowners with 75% to 100% cost-sharing for permanent easements, 50% to 75% for 30-year easements, and 50% to 75% for restoration cost-share agreements. Cost-sharing will help pay for restoration. The revised WRP stipulates that effective October 1, 1996, no new permanent easements may be enrolled until at least 75,000 acres of temporary easements have entered the program.

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Partners for Wildlife Program (PWP)

The PWP is administered by the USFWS and is designed to involve landowners, conservation groups, businesses, state and local governments, and other entities in preserving and restoring fish and wildlife habitat. Through alliances with landowners and others, the USFWS hopes to improve important fish and wildlife habitat while also promoting compatible land uses. In 1994, the PWP was involved in the restoration or enhancement of over 14,000 acres in Texas at an average cost to the public of only $19/acre. Projects were designed to improve water quality, reduce soil erosion, and improve vegetative cover.

The PWP can provide landowners with both financial and/or technical assistance. Participants can enter into agreements of 10 years or longer. Cost-shared assistance up to 100% is given as reimbursement for habitat improvements participants have completed. Cooperators may be asked to share costs on projects by providing supplies, equipment use, or their own labor.

To promote even greater participation in the program, the USFWS has developed a "safe harbor" policy for landowners who attempt conservation actions on behalf of threatened and endangered species. Under this policy, landowners are given assurance that restored habitats may returned to pre-restoration conditions when agreements end, even if listed species become established on their lands.

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Challenge Cost Share Program

The Challenge Cost Share Program is administered by the USFWS. The program is designed to promote the management and enhancement of fish and wildlife resources and natural habitats on public and private lands in partnership with nonfederal entities. The USFWS provides matching funds for up to 50% of the total project cost. Funds provided by the USFWS cannot be matched with other federal funds.

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North American Wetlands Conservation Act (NAWCA)

The NAWCA provides funding for wetlands conservation projects involving acquisition, restoration, and enhancement. The NAWCA is administered by the USFWS. It encourages partnerships among public agencies and other interests. Federal funding must be matched one-to-one with a nonfederal source. Demonstration projects require a minimum [of a] five-year agreement.

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North American Waterfowl Management Plan (NAWMP) Joint Venture Projects

The NAWMP is jointly administered by the USFWS, TPWD, Ducks Unlimited, NRCS, and the Wetland Habitat Alliance of Texas. The NAWMP's purpose is to protect, restore, and enhance wetlands important to waterfowl and other wetland-dependent bird species. The plan is implemented at the grassroots level by federal-state-private partnerships called joint ventures. The three joint ventures in Texas are the Gulf Coast, Playa Lakes, and Lower Mississippi Valley.

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Texas Prairie Wetlands Project

The Texas Prairie Wetlands Project is jointly administered by the USFWS, TPWD, Ducks Unlimited, and the NRCS. The project is a partnership to restore, create, or enhance waterfowl and wildlife habitat and is designed to accomplish the goals and objectives of the Gulf Coast Joint Venture in Texas' 28 Gulf Coast counties. Landowners must develop a management plan, which may include water management or wetland creation, enhancement, or restoration, in exchange for financial and technical incentives. Landowners interested in financial assistance may receive cost-sharing of construction costs of up to 75%, or 100% where supplemental water is provided, in exchange for a commitment to maintain their wetland for 10 years or more. Landowner contributions will be an important consideration for project funding. Project agreements will be for a period of not less than 10 years, with longer agreement periods a funding consideration. Projects must also involve a minimum of five acres of surface water and upland habitat buffers. During average years, shallow surface water should be present for at least four months between September and April.

Contact:
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Gulf Coast Joint Venture
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Natural Resources Conservation Service Technical Assistance Program

This program provides technical assistance to landowners who sign agreements with local soil and water conservation districts. Services include assistance for managing, using, enhancing, creating, and restoring wetlands. Technical assistance and information are provided according to local priorities and available resources.

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Agricultural Conservation Program

The Agricultural Conservation Program (ACP) is administered by the Consolidated Farm Service Agency. The ACP provides cost-shared funds of up to 75% for activities that provide long-term and community-wide benefits, including establishing permanent vegetative cover, erosion control, wildlife enhancement, and restoring or creating shallow water areas for wildlife. Activities should be those that the landowner would not or could not undertake without financial and technical assistance. Applicants must own between 10 and 1,000 acres to be eligible for participation in ACP. (The ACP was terminated by the passage of the 1996 Farm Bill)

Contact:
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409-260-9381

Clean Water Act Section 319 Nonpoint Source Pollution Program

Congress enacted section 319 of the Clean Water Act in 1987, establishing a national program to control nonpoint sources (NPS) of water pollution. Section 319 provides for EPA to award grants to states to help them implement NPS management programs. In Texas, the TNRCC manages the section 319 program for urban areas and activities. The Texas State Soil and Water Conservation Board is the lead agency for management of agricultural/silvicultural NPS abatement programs. The EPA uses an allocation formula to determine the amount to be awarded to each state. In order to give greater emphasis to funding specific watershed resource restoration activities at the local level, at least 10 percent of each State's overall work program should be devoted to watershed resource restoration activities. Watershed resource restoration activities include, for example, projects that restore wetlands, lakes, rivers, streams, coastal zones and estuaries, shorelines, riparian areas, seagrass beds, coral reefs, and other aquatic habitats. States should identify such watershed resource restoration activities in their work plan.

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Texas State Soil and Water Conservation Board
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STATE AND PRIVATE PROGRAMS

Matching Aid to Restore States Habitat Program (MARSH)

MARSH is administered by Ducks Unlimited. Projects receiving first consideration are those that lead to the protection or restoration of NAWMP sites or those that protect and enhance other important waterfowl habitats. MARSH provides cost-shared assistance of up to 50% to public agencies and private conservation groups that are: (1) able to execute long-term habitat agreements; (2) capable of delivering and managing the proposed projects; and (3) willing to assume all liability associated with the project.

Contact:
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Jackson, MS 39211
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Wetland Habitat Alliance of Texas (WHAT)

WHAT provides up to 100% financial assistance to landowners with projects such as management of water on cropped wetlands or wetland restoration, enhancement, or creation. Habitat agreements are for a 10-year minimum. The landowner maintains ownership of the land.

Contact:
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WHAT
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Private Lands Initiative (PLI)

The PLI is a voluntary program in which landowners enhance wildlife habitat through a partnership with the TPWD. Funding is cost-shared by the landowner and National Fish and Wildlife Foundation. The landowner maintains the improvements, which may include moist soil management, pumping agreements, and fencing.

Contact:
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Private Lands Enhancement Program (Technical Guidance Program)

Landowners interested in conserving and managing wildlife habitats may receive technical assistance from the TPWD in the conservation of wildlife populations that utilize habitat on the landowner's property. This is an advisory service provided without charge to landowners.

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Texas Parks and Wildlife Department Landowner Incentive Program

The goal of the Landowner Incentive Program it to provide financial encouragement to conserve rare species. Most rare species inhabit privately owned and managed lands in Texas. Recent analyses of the effectiveness of the Endangered Species Act have almost unanimously called for improved incentives for the participation of private landowners in species conservation and recovery. The program awards one-time grants averaging $6,000 (maximum of $10,000) to landowners who agree to enhance their properties for rare species. The landowner should contribute at least 20% of the total cost of the project, but this cost share can include labor and materials. The TPWD wants to encourage creative projects for conserving rare species. Some funding ideas may include offsetting the cost of management activities such as habitat improvements (restoring native vegetation, prescribed burns, selective brush management, grazing management systems, fire ant control, establishing nest boxes) or habitat protection (such as constructing exclosure fences to protect sensitive habitats). Interested landowners can apply to have their project funded and their application will be reviewed and ranked by a committee consisting of landowners and agency representatives. Projects will be funded until annual funding ($100,000 for 1997) has been allotted.

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Appendix A: Glossary

Attributes: characteristics that are correlated with and can serve as indicators of ecosystem structure and function (Aronson *et al.*, 1993)

Biological Integrity: the ability of an ecosystem to support and maintain a balanced, integrated, adaptive community of organisms having a species composition, diversity, and functional organization comparable to that of natural habitat of the region (Karr, 1991)

Bottomland: lowlands along streams and rivers, usually on alluvial floodplains that are periodically flooded. These are usually forested and in the Southeast are often called Bottomland hardwood forests (Mitsch and Gosselink, 1993)

Brackish: marine and estuarine waters with mixohaline salinity

Broad-leaved deciduous: woody angiosperms (trees or shrubs) with relatively wide, flat leaves that are shed during the cold or dry season (Cowardin *et al.*, 1979)

Broad-leaved evergreen: woody angiosperms (trees or shrubs) with relatively wide, flat leaves that generally remain green and are usually persistent for a year or more (Cowardin *et al.*, 1979)

Channel: an open conduit either naturally or artificially created which periodically or continuously contains moving water, or which forms a connecting link between two bodies of standing water (Langbein and Iseri, 1960)

Channel Bank: the sloping land bordering a channel. The bank has steeper slope than the bottom of the channel and is usually steeper than the land surrounding the channel (Cowardin *et al.*, 1979)

Codominant: two or more species providing about equal areal cover which in combination control the environment (Cowardin *et al.*, 1979)

Creation: bringing into being a new ecosystem that previously did not exist on the site (National Research Council, 1992)

Deciduous stand: a plant community where deciduous trees or shrubs represent more than 50% of the total areal coverage of trees or shrubs (Cowardin *et al.*, 1979)

Disturbance: any relatively discrete event in time that disrupts the ecosystem, community, or population structure, and changes resources, substrate availability, or the physical environment (Pickett and White, 1985)

Dominant: The species controlling the environment

Ecosystem: all of the biotic elements (i.e., species, populations, and communities) and abiotic elements (i.e., land, air, water, and energy) interacting in a given geographic area, such that a flow of energy leads to a clearly defined trophic structure, biotic diversity, and materials cycle (Odum, 1971)

Emergent Hydrophytes: erect, rooted, herbaceous angiosperms that may be temporarily to permanently flooded at the base but do not tolerate prolonged inundation of the entire plant; e.g., bulrushes (*Scirpus* spp.), salt marsh cordgrass (Cowardin *et al.*, 1979)

Enhancement: any improvement of a structural or functional attribute (National Research Council, 1992)

Estuarine: deepwater tidal habitats and adjacent tidal wetlands what are usually semi-enclosed by land but have open, partially obstructed, or sporadic access the ocean and in which ocean water is at least occasionally diluted by freshwater runoff from the land

Estuary: an ecosystem defined seaward by the measurable dilution of seawater, usually between headlands enclosing a embayment, upstream by the limit of tidal influence, and landward by mean higher high water, but including transition riparian and upland habitat margins (Simenstad *et al.*, 1991)

Extreme High Water of Spring Tides: the highest tide occurring during a lunar month, usually near the new or full moon; the is equivalent to extreme higher high water of mixed semidiurnal tides (Cowardin *et al.*, 1979)

Extreme Low Water of Spring Tides: the lowest tide occurring during a lunar month, usually near the new or full moon. This is equivalent to extreme lower low water of mixed semidiurnal tides (Cowardin *et al.*, 1979)

Flat: a level landform composed of unconsolidated sediments- usually mud or sand. Flats may be irregularly shaped or elongate and continuous with the shore, whereas bars are generally elongate, parallel to the sore, and separated from the shore by water (Cowardin *et al.*, 1979)

Floating Plant: a non-anchored plant that floats freely in the water or on the surface; e.g., water hyacinth (*Eichhornia crassipes*) or common duckweed (*Lemna minor*) (Cowardin *et al.*, 1979)

Floating-leaved Plant: a rooted, herbaceous hydrophyte with some leaves floating on the water surface; e.g., white water lily (*Nymphaea odorata*), floating-leaved pondweed (*Potamogeton natans*). Plants such as yellow water lily (*Nuphar luteum*) which sometimes have leaves raised above the surface are considered floating-leaved plants or emergents, depending on their growth habit at a particular site (Cowardin *et al.*, 1979)

Floodplain: a flat expanse of land bordering an old river (Reid and Wood, 1976)

Fresh: term applied to water with salinity less than 0.5 ppt dissolved salts (Cowardin *et al.*, 1979)

Function: any performance, attribute, or rate function at some level of biological organization (e.g., energy flow, detritus processing, nutrient spiraling) (National Research Council, 1992)

Functional replacement: replacement of the functions of a particular ecosystem or habitat (Shreffler and Thom, 1993)

Growing Season: The frost-free period of the year (Cowardin *et al.*, 1979)

Habitat: the environment occupied by individuals of a particular species, population, or community (Kusler and Kentula, 1990)

Habitat fragmentation: the result of human activities that fragment natural ecosystems into fewer and smaller pieces (Wiens, 1985)

Herbaceous: with the characteristics of an herb; a plant with no persistent woody stem above ground (Cowardin *et al.*, 1979)

Historic condition: a condition known to have previously existed in the estuary from historic or recent paleoecological evidence; this definition assumes prior human disturbance in the ecosystem (Shreffler and Thom, 1993)

Histosols: organic soils (Cowardin *et al.*, 1979)

Hydric Soil: soil that is wet enough to periodically produce anaerobic conditions, thereby influencing the growth of plants (Cowardin *et al.*, 1979)

Hypersaline: term to characterize waters with salinity greater than 40 ppt

Intermittently Exposed: surface water present throughout year except in years of extreme drought (Cowardin *et al.*, 1979)

Intermittently Flooded: substrate is usually exposed but surface water is presnet for variable periods with no seasonal periodicity (Cowardin *et al.*, 1979)

Intertidal: the substrate is exposed and flooded by tides; this includes the splash zone (Cowardin *et al.*, 1979)

Irregularly Exposed: land surface exposed by tides less often than daily (Cowardin *et al.*, 1979)

Irregularly Flooded: land surface flooded less often than daily (Cowardin *et al.*, 1979)

Lacustrine: wetlands and deepwater habitats with all of the following characteristis: (1) situated in a topographic depression or a dammed river channel; (2) lacking trees, shrubs, persistent emergetns, emergent mosses, or lichens with greater than 30 percent areal coverage; and (3) total area exceeds 8 hectare (20 acres) (Cowardin *et al.*, 1979)

Landscape: a heterogeneous land area composed of a cluster of interacting ecosystem that is repeated in similar form throughout (Forman and Godron, 1986)

Limnetic: all deepwater habitats in lakes (Cowardin *et al.*, 1979)

Littoral: wetland habitats of a lacustrine system that extens from shore to a depth of 2 m below low water or to the maximum extent of nonpersistent emergent plants (Cowardin *et al.*, 1979)

Long-Term: ten years or longer (Shreffler and Thom, 1993)

Lower Perennial: Riverine System with continuous flow, low gradient, and no tidal influence (Cowardin *et al.*, 1979)

Marine: open ocean overlying the continental shelf and its associated high-energy coastal line (Cowardin *et al.*, 1979)

Marsh: a frequently or continually inundated wetland characterized by emergent herbaceous vegetation adapted to saturated soil condition (Mitsch and Gosselink, 1993)

Mean High Water: the average height of the high water over 19 years (Cowardin *et al.*, 1979)

Mean Higher High Tide: the average height of the higher of two unequal daily high tides over 19 years (Cowardin *et al.*, 1979)

Mean Low Water: the average height of the low water over 19 years (Cowardin *et al.*, 1979)

Mean Lower Low Water: the average height of the lower of two unequal daily low tides over 19 years (Cowardin *et al.*, 1979)

Mean Tide Level: a plane midway between mean high water and mean low water (Cowardin *et al.*, 1979)

Mesohaline: term to characterize waters with salinity of 5 to 18 ppt, due to ocean-derived salts (Cowardin *et al.*, 1979)

Mineral Soil: soil composed of predominately mineral rather than organic materials (Cowardin *et al.*, 1979)

Mitigation: actions taken to avoid, reduce, or compensate for the effects of environmental damage. Among the broad spectrum of possible actions are those that restore, enhance, create, or replace damaged ecosystem (National Research Council, 1992)

Mixohaline: term to characterize waters with salinity of 5 to 18 ppt, due to ocean-derived salts (Cowardin *et al.*, 1979)

Monitoring: periodic evaluation of a restoration, creation, or enhancement site to determine success in attaining goals (Shreffler and Thom, 1993)

Mud: wet, soft earth composed predominantly of clay and silt-fine mineral sediments less than 0.074 mm in diameter (Black, 1968; Liu, 1970)

Natural: dominated by native biota and occurring within a physical system that has developed through natural processes (without human intervention), in which natural processes continue to take place (Kusler and Kentula, 1992)

Nonpersistent Emergents: emergent hydrophytes whose leaves and stems break down at the end of the growing season so that most above-ground portions of the plants are easily transported by currents, waves, or ice; the breakdown may result form normal decay or the physical force of strong waves or ice; at certain seasons of the year there are no visible traces of the plants above the surface of the water (Cowardin *et al.*, 1979)

Obligate Hydrophytes: species that are found only in wetlands - e.g., cattail (*Typha latifolilia*) as opposed to ubiquitous species that grow either in wetland or on upland - e.g., maple (*Acer rubrum*) (Cowardin *et al.*, 1979)

Oligohaline: term to characterize water with salinity of 0.5 to 5.0 ppt, due to ocean-derived salts (Cowardin *et al.*, 1979)

Organic Soil: soil composed of predominately organic rather than mineral material. Equivalent to Histosol (Cowardin *et al.*, 1979)

Palustrine: all nontidal wetlands dominated by trees, shrubs, persistent emergents, emergent mosses or lichens, and all such wetlands that occur in tidal areas where salinity stemming from ocean-derived salts is below 0.5 ppt. It also includes wetlands lacking such vegetation but with all of the following characteristics: (1) area less than 8 hectares; (2) lack of active wave-formed or bedrock shoreline features; (3) water depth in the deepest part of the basin of less than 2 m at low water; (4) salinity stemming from ocean-derived salts of less than 0.5 ppt (Cowardin *et al.*, 1979)

Permanently Flooded: water covers land surface throughout year in all years (Cowardin *et al.*, 1979)

Persistence: the time period during which a certain attribute of the landscape continues to be present (Shreffler and Thom, 1993)

Persistent Emergent: emergent hydrophytes that normally remain standing at least until the beginning of the next growing season; e.g., cattails (*Typha* spp.) or bulrushes (*Scirpus* spp.) (Cowardin *et al.*, 1979)

Photic Zone: the upper water layer down to the depth of effective light penetration where photosynthesis balances respiration. This level (the compensation level) usually occurs at the depth of 1% light penetration and forms the lower boundary of the zone of net metabolic production (Cowardin *et al.*, 1979)

Pioneer Plants: herbaceous annual and seedling perennial plants that colonize bare areas as a first stage in secondary succession (Cowardin *et al.*, 1979)

Polyhaline: term to characterize water with salinity of 18 to 30 ppt, due to ocean salts

Predisturbance condition: the condition thought to have previously existed in the estuary prior to the onset of human disturbance (Shreffler and Thom, 1993)

Reclamation: a process designed to adapt a wild or natural resource to serve a utilitarian human purpose. Often used to refer to processes that destroy native ecosystems and convert them to agricultural or urban uses (National Research Council, 1992)

Reference ecosystem: an existing, indigenous ecosystem that is used as an ecological yardstick for the purposes of project design and evaluation (Shreffler and Thom, 1993)

Regularly Flooded: alternately floods and exposes land surfaces at least daily (Cowardin *et al.*, 1979)

Rehabilitation: used primarily to indicate improvement of a visual nature to a natural resource; putting back into good condition or working order (National Research Council, 1992)

Resilience: the ability of an ecosystem to return to a former successional trajectory after being degraded or deflected by some outside disturbances (Shreffler and Thom, 1993)

Resistance: an ecosystem’s inertia in the face of change (Shreffler and Thom, 1993)

Restoration: return of an ecosystem to a close approximation of its previously existing condition (modified from National Research Council, 1992)

Restoration Ecology: the discipline that provides the theoretical foundation for the practice of ecological restoration (Shreffler and Thom, 1993)

Riverine: wetland and deepwater habitats contained within a channel with two exceptions: (1) wetland dominated by trees, shrubs, persistent emergents, emergent mosses, or lichens, and (2) habitats with water containing ocean-derived salts in excess of 0.5 ppt (Cowardin *et al.*, 1979)

Salinity: the total amount of solid material in grams contained in 1 kg of water when all the carbonate has been converted to oxide, the bromine and iodine replaced by chlorine, and all the organic matter completely oxidized (Cowardin *et al.*, 1979)

Sand: composed predomiantly of coarse-grained mineral sediments with diameters larger than 0.074 mm (Black 1968) and smaller than 2 mm (Liu 1970; Weber 1973)

Saturated: substrate is saturated for extended periods during growing season but surface water is seldom present (Cowardin *et al.*, 1979)

Seasonally Flooded: surface water is present for extended periods, expecially in early growing season but is absent by the end of the season (Cowardin *et al.*, 1979)

Self-maintaining system: an ecosystem that can perform all of its natural functions without human intervention or dependence on engineered structures (National Research Council, 1992)

Semi-permanently Flooded: surface water persists throughout growing season in most years. When surface water is absent, water table is at or near surface (Cowardin *et al.*, 1979)

Shrub: a woody plant which at maturity is usually less than 6 m (20 ft) tall and generally exhibits several erect, spreading, or prostrate stems and has a bushy appearance; e.g., buttonbush (*Cephalanthus occidentalis*) (Cowardin *et al.*, 1979)

Spring Tide: the highest high and lowest low tides during the lunar month (Cowardin *et al.*, 1979)

Stability: the general concept embracing both resistance and resilience (Shreffler and Thom, 1993)

Structure: the physiognomy of an ecosystem, which is generally expressed in terms of life forms, vertical stratification, and size of the dominant plants (Shreffler and Thom, 1993)

Submergent Plant: a vascular or nonvascular hydrophyte, either rooted or nonrooted, which lies entirely beneath the water surface, except for flowering parts in some species; e.g., stoneworts (*Chara* spp.) (Cowardin *et al.*, 1979)

Subtidal: the substrate is continuously submerged with tidal water (Cowardin *et al.*, 1979)

Success: achieving established goals. Success in wetland restoration, creation, and enhancement ideally requires criteria, preferably measurable as quantitative values, be established prior to commencement of these activities (Kusler and Kentula, 1990)

Terrigeneous: derived from or originating on the land (usually referring to sediments) as opposed to material or sediments produced in the ocean (marine) or as a result of biologic activity (biogenous) (Cowardin *et al.*, 1979)

Tidal: for riverine systems, the gradient is low and the water velocity fluctuates under tidal influence (Cowardin *et al.*, 1979)

Tree: a woody plant which at maturity is usually 6 m (20 ft) or more in height and generally has a single trunk, unbranched for 1 m or more above the ground, and a more or less definite crown (Cowardin *et al.*, 1979)

Vernal Pool: shallow, intermittently flooded wet meadow, generally dry for most of the summer and fall (Mitsch and Gosselink, 1993)

Watershed: the entire surface drainage area that contributes water to a lake or river (Shreffler and Thom, 1993)

Water Table: the upper surface of a zone of saturation. No water table exists where that surface is formed by an impermeable body (Langbein and Iseri, 1960)

Wet Meadow: grassland with waterlogged soil near the surface but without standing water for most of the year (Mitsch and Gosselink, 1993)

Wet Prairie: similar to a marsh but with water levels usually intermediate between a marsh and a wet meadow (Mitsch and Gosselink, 1993)

Appendix B. Hydric soils list for Nueces County, Texas.

MAPUNIT NAME (NEW NAME)	COMPONENT (C) INCLUSION (I)	LOCAL LANDFORM	HYDRIC CRITERIA	ACRES
Banquete Clay (Edroy)	(Edroy) (C)	Marine Terrace	Saturation Ponding	11,526
Banquete Clay Low (Edroy)	(Edroy) (C)	Depression	Saturation Ponding	3,695
Clayey Alluvial Land (Aransas)	Clayey Alluvial Land (C)	Flood Plain	Flooding	1,741
Frio Clay Loam (Sinton)	Aransas (I)	Flood Plain	Flooding	---
Galveston and Mustang Fine Sands	Mustang (C)	Salt Marsh	Saturation	8,914
	Inclusions (I)	Marine Ter.	Sat. Pond	---
Lomalta Clay (Aransas, Saline)	(Aransas) (C)	Flood Plain	Sat.Fld.Pond	2,725
	Inclusions (I)	Depression	Sat.Pond	---
Made Land (Ijam)	Made Lane (C)	Marine Ter.	Saturation	3,705
	Inclusions (I)	Tidal Flat	Sat.Pond	---
Mustang Fine Sand	Mustang (C)	Salt Marsh	Saturation	7,028
	Inclusions (I)	Marine Ter.	Sat.Pond	---
Orelia Clay Loam	Edroy (I)	Depression	Sat.Pond	---
Orelia Fine Sandy Loam	Edroy (I)	Depression	Sat.Pond	---
Orelia-Slickspot Cmplx (Orelia Williamar)	Edroy (I)	Depression	Sat.Pond	---
Spoil Banks	Spoil Banks (C)	Marine Ter.	Saturation	2,485
	Inclusions (I)	Tidal Flat	Sat.Pond.	
Tidal Flats	Tidal Flats	Tidal Flat	Sat.Pond	18,345
	Inclusions (I)	Tidal Flat	Sat.Pond	---
Trinity Clay, Occas.	Aransas (I)	Flood Plain	Flooding	---

Flooded (Aransas)				
Trinity Clay, Freq. Flooded (Aransas)	(Aransas) (C)	Flood Plain	Flooding	3,985
Victoria Clay, o to 1 Percent Slopes	Edroy (I)	Depression	Sat.Pond	---
Victoria Clay, Low	Edroy (I)	Depression	Sat. Pond	---

Appendix C. Hydric soils list for San Patricio County, Texas.

Sat = meets saturation criteria **Fld** = meets flooding criteria **Pd** = meets ponding criteria

MAPUNIT NAME	COMPONENT (C)	LOCAL LANDFORM	HYDRIC CRITERIA
Aransas Clay	Aransas (I)	Depression	Fld
Aransas Clay Freq. Flooded	Aransas (C)	Flood Plain	Fld
Aransas Clay Saline	Aransas (C)	Flood Plain	Fld, Sat,Pd
	Barrada (I)	Tidal Flat	Sat,Pd
	Dianola (I)	Flood Plain	Fld
	Mustang (I)	Salt Marsh	Sat,Fld
	Tatton (I)	Tidal Flat	Sat,Pd
Barrada-Tatton Association	Barrada (C)	Tidal Flat	Sat,Pd
	Tatton (C)	Tidal Flat	Sat,Pd
	Aransas (I)	Flood Plain	Fld
	Mustang (I)	Salt Marsh	Sat,Fld
Beaches	Barrada (I)	Tidal Flat	Sat,Pd
	Mustang (I)	Salt Marsh	Sat,Fld
	Tatton (I)	Tidal Flat	Sat,Pd
Dianola Soils	Dianola (C)	Tidal Flat	Fld
	Aransas (I)	Flood Plain	Sat,Fld,Pd
	Barrada (I)	Tidal Flat	Sat,Pd
	Dietrich (I)	Tidal Flat	Sat,Pd
	Mustang (I)	Salt Marsh	Sat,Fld
	Tatton (I)	Tidal Flat	Sat,Pd
Dietrich Fine Sand	Dianola (I)	Flood Plain	Fld
	Mustang (I)	Salt Marsh	Sat,Fld
Edroy Clay	Edroy (C)	Marine	Sat,Pd
Edroy Clay, Depressional	Edroy (C)	Depression	Sat,Pd
Falfurrias Association	Dietrich (I)	Tidal Flat	Sat,Pd
	Mustang (I)	Salt Marsh	Sat,Fld

Galveston Association	Dianola (I) Tatton (I)	Flood Plain Tidal Flat	Fld Sat,Pd
Galveston-Mustang Association	Mustang (C) Barrada (I) Dianola (I)	Salt Marsh Tidal Flat Flood Plain	Sat,Fld Sat,Pd Fld
Ijam Soils	Tjam (C) Barrada (I) Dianola (I) Tatton (I)	Tidal Flat Tidal Flat Flood Plain Tidal Flat	Sat Sat,Pd Fld Sat,Pd
Mustang Fine Sand	Mustang (C) Barrada (I) Dianola (I) Dietrich (I)	Salt Marsh Tidal Flat Flood Plain Tidal Flat	Sat,Fld Sat,Pd Fld Sat,Pd
Narta Fine Sandy Loam	Narta (C)	Marine	Sat
Odem Find Sandy Loam	Aransas (I)	Flood Plain	Fld
Orelia Fine Sandy Loam	Edroy (I)	Depression	Sat,Pd
Psamments	Dianola (I) Mustang (I) Tatton (I)	Flood Plain Salt Marsh Tidal Flat	Fld Sat,Fld Sat,Pd
Papalote Fine Sandy Loam, 0 to 1 percent slopes	Edroy (I)	Depression	Sat,Pd
Raymondville Clay Loam, 1 to 3 percent slopes	Edroy (I)	Depression	Sat,Pd
Sarita-Nueces Complex	Edroy (I)	Depression	Sat,Pd
Sinton Loam	Aransas (I)	Flood Plain	Fld
Tatton Complex	Tatton (C) Barrada (I)	Tidal Flat Tidal Flat	Sat,Pd Sat,Pd

	Dianola (I) Mustang (I)	Flood Plain Salt Marsh	Fld Sat,Fld
Victoria Clay, 0 to 1 percent slopes	Edroy (I)	Depression	Sat,Pd
Victoria Clay, 1 to 3 percent slopes	Edroy (I)	Depression	Sat,Pd
Victoria Clay, Depressional	Edroy (I)	Depression	Sat,Pd