Jefferson County Ecosystem Restoration Feasibility Study

Integrated Feasibility Report
and Environmental Assessment

U.S. Army Corps of Engineers
Southwestern Division
Galveston District
May 2019

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List of Acronyms

AAHU	Average annual habitat units
AMM	Alternatives Milestone Meeting
APE	Area of potential effect
AQCR	Air Quality Control Region
BMP	Best management practices
BSO	Building-Structure-Object
CAP	Climate Action Plan
CAR	Coordination Act Report
CBRA	Coastal Barrier Resource Act
CBRS	Coastal Barrier Resource System
CCP	Comprehensive Conservation Plan
CE/ICA	Cost estimate/incremental cost analysis
CEQ	Council on Environmental Quality
CFR	Code of Federal Regulations
CIP	Channel Improvement Project
CMP	Coastal Management Plan
CNRA	Coastal natural resource area
CZMA	Coastal Zone Management Act
CZMP	Coastal Zone Management Program
CWA	Clean Water Act
EA	Environmental Assessment
EIS	Environmental Impact Statement
ER	Engineering Regulation
EFH	Essential fish habitat
EO	Executive Order
EOP	Environmental Operating Principles
EPA	U.S. Environmental Protection Agency
ESA	Endangered Species Act
EQ	Environmental Quality
FWOP	Future without project condition
FWB	Future with project
GDP	Gross domestic product
GHG	Greenhouse Gas
GIWW	Gulf Intracoastal Waterway
GPLNG	Golden Pass Liquefied Natural Gas
HQUSACE	Headquarters, U.S. Army Corps of Engineers
HIS	Habitat Suitability Index
HTRW	Hazardous, Toxic, and Radioactive Waste
IDC	Interest during construction
IFB	Invitation for bid

JCER	Jefferson County Ecosystem Restoration Draft Integrated Feasibility Study and Environmental Assessment
LERDDS	Lands, easements, rights-of-way, relocation, and disposal areas
MBCA	Migratory Bird Conservation Act
MBTA	Migratory Bird Treaty Act
MCY	Million cubic yards
MMPA	Marine Mammal Protection Act
MSA	Metropolitan statistical area
MSL	Mean sea level
MSFCMA	Magnuson-Stevens Fishery Conservation and Management Act
NAAQS	National Ambient Air Quality Standards
NAVD 88	North American Vertical Datum of 1988
NED	National Economic Development
NEPA	National Environmental Policy Act
NER	National Ecosystem Restoration
NHPA	National Historic Preservation Act
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NOI	Notice of Intent
NRCS	Natural Resources Conservation Service
NRHP	National Register of Historic Places
NWR	National Wildlife Refuge
OMRR&R	Operation and maintenance, repair, replacement and rehabilitation
OPA	Otherwise Protected Area
OSE	Other Social Effects
PA	Placement Area
P&G	USACE Planning Guidance Notebook (ER1105-2-100)
PCPI	per capita personal income
PDT	Project development team
PED	Pre-construction engineering and design
RED	Regional Economic Development
REP	Real Estate Plan
RFP	Request for proposal
RHA	Rivers and Harbors Act of 1899
RSLC	Relative Sea Level Change
RPEC	Regional Planning and Environmental Center
RRC	Railroad Commission of Texas
SHPO	State Historic Preservation Office/Officer
SNWW	Sabine-Neches Waterway
SWD	Southwestern Division
SWG	Galveston District
TB	Turning Basins

TCEQ	Texas Council on Environmental Quality
THPO	Tribal Historic Preservation Office/Officer
TPWD	Texas Parks &Wildlife Department
TSP	Tentatively selected plan
TXNDD	Texas Natural Diversity Database
USACE	U.S. Army Corps of Engineers
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
WIK	Work in kind
WMA	Wildlife Management Area
WRRDA	Water Resources Reform and Development Act
WVA	Wetland Valuation Assessment

EXECUTIVE SUMMARY

1. Background and Study Authority

The U.S. Army Corps of Engineers, Galveston District (USACE), in partnership with Jefferson County and the Sabine Neches Navigation District, is reviewing ecosystem restoration opportunities in the study area. The study will help contribute to larger ongoing efforts to improve, preserve, and sustain ecological resources along the Texas coast by non-governmental organizations and government agencies at the local, state, and federal level.

Texas contains one of the largest expanses of coastal wetlands in the contiguous United States and accounts for a significant percentage of the total coastal marsh loss occurring in the Nation. The study area described in this report is an essential ecosystem which includes wetland habitats, is adjacent to essential fish habitat, and has high fish and wildlife values. The shoreline protects the interior coastal wetlands, which also have high fish and wildlife value as well as great economic value as commercial and recreational fisheries. These ecosystems provide habitat for migratory birds, wildlife, finfish, shellfish, and other aquatic organisms including threatened or endangered species. The restoration of the shoreline and marsh habitat would protect these national assets from further degradation.

Study authorization derives from Section 110 of the Rivers and Harbors Act of 1962 and Resolution – Docket 2620 from the House of Representatives Committee on Transportation and Infrastructure adopted February 16, 2000 and entitled "Sabine Pass to Galveston Bay, Texas".

2. Study Area

The study area encompasses Jefferson County. The focused study area has been narrowed to target areas experiencing significant marsh and shoreline degradation. This area encompasses 184,100 acres including waters up to 1.0 mile offshore. This area is outlined in red in Figure 1. The focused study area is made up of two national wildlife refuges (NWR), one wildlife management area (WMA), one state park, one historic site, two navigation channels, and private lands:

- US Fish and Wildlife Service—Texas Chenier Plain Refuge Complex: McFaddin NWR (58,861 acres of marsh and 15.0 miles of Gulf shoreline) and Texas Point NWR (8,972 acres of marsh and 6.0 miles Gulf shoreline);
- Texas Parks and Wildlife Department: J.D. Murphree WMA (24,498 acres of marsh) and Sea Rim State Park (4,141 acres of marsh and 5.2 miles of Gulf shoreline);
- Texas Historical Commission: Sabine Pass Battleground State Historic Site (58 acres of developed land);
- USACE: Gulf Intracoastal Waterway (GIWW), approximately 125 feet wide for 27 miles from Sabine Pass to the southern Jefferson County border (about 410 acres of open water);
- Sabine-Neches Navigation District: Sabine-Neches Waterway (SNWW), approximately 1,056 feet wide for 17.5 miles from the focused study area offshore boundary to Port Arthur (approximately 2,110 acres of open water);
- Texas General Land Office: beach/nearshore/offshore waters (approximately 450 acres of beach and 21,200 acres of open water); and
- Private Lands: approximately 65,570 acres.

3. Problems and Opportunities

The natural processes of subsidence, erosion of wetlands, and habitat switching, combined with widespread human alterations, have caused significant adverse impacts to the Texas coastal region. The ecological functions of the study area have been significantly altered over time.

Natural processes such as erosion, movement of sediments, storms, and relative sea level change (RSLC) have also accelerated land loss and conversion of habitat to open water.

The specific study problems and contributing factors in Jefferson County include:

1. Land loss due to erosion, subsidence, and RSLC threatens the geomorphic structure and hydrologic function of the coastal shoreline, inland marsh systems, and critical infrastructure (GIWW, SNWW);
2. Altered hydrologic conditions are contributing to the conversion of low salinity coastal habitats (e.g. freshwater and intermediate marsh) to those that survive under more saline conditions (e.g. brackish and saline marshes) or open water; and
3. Longshore sediment transport is significantly reduced, limiting the sustainability of the coastal ecosystem.

The opportunities in the study are:

1. Improve longshore sediment transport within the Texas coastal shoreline system;
2. Marsh restoration that complements existing restoration efforts in the study area;
3. Improve current sediment management practices to maximize the quantity and effective use of dredged material;
4. Modify the connection between the GIWW and adjacent freshwater marshes to retain freshwater supplies within the marsh and limit exchange of saltwater from the GIWW into the freshwater marsh areas;
5. Augment the natural wetland building process through placement of beneficial use material to enhance marsh sediment dynamics and micro-hydrology within the marsh; and
6. Improve recreation opportunities in the wildlife management areas (i.e. bird watching, recreation/commercial fishing, etc.).

4. Plan Formulation

Plan formulation took a fully formed plan approach to develop the initial array of alternatives. The formulation process began with identification of management measures that could address the problems and/or opportunities, which were screened out based on technical feasibility and ability to address the problems, opportunities, objectives, and constraints. A comprehensive list of 23 management measures were identified by the PDT in close coordination with the NFS, United States Fish and Wildlife Service (USFWS), Texas Parks and Wildlife Department (TPWD).

After the comprehensive list of measures was established but before alternative development, the PDT identified several plan formulation strategies to help assemble measures into a reasonable and logical array of fully-formed alternative plans. The formulation strategies were primarily driven by our planning objectives and represent different ways of achieving the objectives to varying degrees. This approach was in lieu of relying on IWR Planning Suite to generate all possible combinations of measures and permutations of alternatives. This allowed the PDT to use their project area knowledge and the input of experts to strategically formulate plans to meet objectives using a logical and reasoned approach. The measures were then linked to the strategies and used to develop the initial array of 12 alternatives, which included four plans which were scales of each other. The initial array was presented at the Alternatives Milestone Meeting held March 9, 2017.

The initial array went through a qualitative screening based on study objectives, constraints, resiliency and sustainability of the alternative, and ability to address RSLC over the 50 year period of analysis. This resulted in a focused array of six alternatives. The focused array was presented to the VT at a post-AMM IPR held July 27, 2017.

The USACE Institute of Water Resources (IWR) Planning Suite Software was used to perform a cost-effective, incremental cost analysis (CE/ICA). A total of four plans were identified as cost-effective and a best-buy including: 4Abu, 6A, 1Abu, and 2Abu. These were presented at the Tentatively Selected Plan milestone meeting held April 30, 2018. At that meeting alternative 4Abu was identified as the tentatively selected plan (TSP).

5. Recommended Plan

Alternative 4Abu (Keith Lake Restoration) is the recommended plan and includes construction of 5,170 linear feet of armoring along the southern bank of the GIWW, restores 6,048 acres of brackish marsh habitat in 6 restoration units, includes planting of native species and removal of invasive species within those restoration units and utilizes borrow material primarily from SNWW or identified upland disposal sites. Alternative 4Abu generates 2,695 net AAHUs of marsh habitat at a project first cost of $62.3 million. This includes $2.6 million for monitoring and adaptive management over the 10 year monitoring period. This plan addresses all problems and objectives to varying degrees, within the project footprint, through implementation of the marsh restoration and shoreline protection measures. However, outside of the project footprint, no problems or objectives are addressed.

FINDING OF NO SIGNIFICANT IMPACT

JEFFERSON COUNTY ECOCYSTEM RESTORATION FEASIBILITY STUDY JEFFERSON COUNTY, TEXAS

The U.S. Army Corps of Engineers, Galveston District (Corps) has conducted an environmental analysis in accordance with the National Environmental Policy Act of 1969, as amended. The final Integrated Feasibility Report and Environmental Assessment (IFR/EA) dated **DATE OF IFR/EA**, for the Jefferson County Ecosystem Restoration Feasibility Study addresses ecosystem restoration opportunities and feasibility in Jefferson County, Texas. The final recommendation is contained in the report of the Chief of Engineers, dated **DATE OF CHIEF'S REPORT**.

The Final IFR/EA, incorporated herein by reference, evaluated various alternatives that would improve and restore the overall habitat quality and quantity of marsh and shoreline systems in the study area. The recommended plan is the National Ecosystem Restoration (NER) Plan and includes:

- Restoration of 6,048 acres of technically significant marsh habitat surrounding Keith Lake. Material dredged from the Sabine-Neches Waterway would be hydraulically pumped into open water and low lying areas of five marsh restoration units to achieve a post-construction settlement target elevation of 1.2 feet mean sea level (msl).

- Construction of 5,170 linear feet (0.98 miles) of offset rock breakwaters built in shallow water (<3 feet deep) along the southern shoreline of the Gulf Intracoastal Waterway, at varying distances from the shoreline. The trapezoidal structure would be constructed to a height of +3.0 feet msl, which would require approximately 672,384 cubic feet of material.

- No environmental compensatory mitigation is required; however, consistent with policy a monitoring and adaptive management plan has been developed and will be implemented. Monitoring will continue until the ecological success is determined based on the identified criteria within the Jefferson County Ecosystem Restoration Feasibility Study Monitoring and Adaptive Management Plan included in Appendix A-9. Monitoring is expected to last no more than 10 years.

In addition to a "no action" plan, four alternatives were evaluated.[1] The alternatives included plans which incorporated varying levels of ecosystem restoration within the study area using a variety of methods to implement the measures. Like the recommended plan, all alternatives made use of dredged material to nourish the marsh. Alternative 1Abu applied marsh restoration in a passive manner, while Alternatives 4Abu, 6A, and 2Abu used an active approach in which more intense engineering, design and construction would be completed rather than letting nature rework the material as in 1Abu. Alternatives

[1] 40 CFR 1505.2(b) requires a summary of the alternatives considered.

4Abu and 2Abu incorporated hardened structures along the GIWW, while 1Abu and 6A did not because use of hardened structures would not have met the strategy used to develop the alternatives. Alternative 4Abu is the smallest of the four plans and is the first cost-effective, best-buy plan. Alternative 6A, followed by 1Abu and 2Abu is the next largest plan and also the next more expensive plan. All but Alternative 6A were considered best-buy plans. A complete discussion of alternative formulation is available in Chapter 3 of the main report.

For all alternatives, the potential effects to the following resources were evaluated:

CHECK BOXES AS APPROPRIATE

	In-depth evaluation conducted	Brief evaluation due to minor effects	Resource unaffected by action
Aesthetics	☐	☒	☐
Air quality	☐	☒	☐
Aquatic resources/wetlands	☒	☐	☐
Invasive species	☐	☒	☐
Fish and wildlife habitat	☒	☐	☐
Threatened/Endangered species	☒	☐	☐
Historic properties	☐	☒	☐
Other cultural resources	☐	☒	☐
Floodplains	☐	☒	☐
Hazardous, toxic & radioactive waste	☐	☒	☐
Hydrology	☒	☐	☐
Land use	☐	☒	☐
Navigation	☐	☒	☐
Noise levels	☐	☒	☐
Public infrastructure	☐	☒	☐
Socio-economics	☐	☒	☐
Environmental justice	☐	☒	☐
Soils	☐	☒	☐
Tribal trust resources	☐	☐	☒
Water quality	☐	☒	☐
Climate change	☐	☒	☐

All practical means to avoid or minimize adverse environmental effects were analyzed and incorporated into the recommended plan. Best management practices (BMPs) as detailed in the IFR/EA will be implemented to minimize impacts. [2] BMPs and conservation measures included in the project design are seasonal timing restrictions, biological monitors with stop-work authority, utilizing existing access roads and channels to the greatest extent practicable, employing construction BMPs, siting pumps and pipes in areas that would have the least disturbance on the overall system, and utilizing the smallest construction footprint possible. The project is intended to restore the natural form and function of the coastal system; therefore, all long-term impacts are expected to be beneficial to the overall ecosystem and increase resiliency and sustainability.

No compensatory mitigation is required.

Pursuant to section 7 of the Endangered Species Act of 1973, as amended, the U.S. Army Corps of Engineers determined that the recommended plan may affect but is not likely to adversely affect the following federally listed species or their designated critical habitat: whooping crane and West Indian manatee. The U.S. Fish and Wildlife Service (FWS) concurred with the Corps' determination on **26 April 2019.**

Pursuant to section 106 of the National Historic Preservation Act of 1966, as amended, the U.S. Army Corps of Engineers determined that historic properties may be adversely affected by the recommended plan. The Corps and the Texas State Historic Preservation Office entered into a Programmatic Agreement (PA), dated **DATE OF AGREEMENT.** All terms and conditions resulting from the agreement shall be implemented in order to minimize adverse impacts to historic properties.[3]

Pursuant to the Clean Water Act of 1972, as amended, the discharge of dredged or fill material associated with the recommended plan has been found to be compliant with section 404(b)(1) Guidelines (40 CFR 230). The Clean Water Act Section 404(b)(1) Guidelines evaluation is found in Section 4.5.4 and Appendix A-5 of the IFR/EA.

401 WQC OBTAINED: A water quality certification pursuant to section 401 of the Clean Water Act was obtained from the Texas Commission on Environmental Quality. All conditions of the water quality certification shall be implemented in order to minimize adverse impacts to water quality.

CZMA CONSISTENCY ISSUED: A determination of consistency with the Texas Coastal Zone Management program pursuant to the Coastal Zone Management Act of 1972 was obtained from the Texas General Land Office. All conditions of the consistency determination shall be implemented in order to minimize adverse impacts to the coastal zone.

[2] 40 CFR 1505.2(C) all practicable means to avoid and minimize environmental harm are adopted.

[3] 36 CFR 800.14(b)(1)(ii) meeting the terms and conditions of the PA

In accordance with the Coastal Barrier Resources Act (CBRA), the Corps has determined that the recommended plan is compliant and permissible with the CBRA.

Public review of the draft IFR/EA was completed on 27 July 2018. All comments submitted during the public comment period were responded to in the Final IFR/EA. A 30-day state and agency review of the Final IFR/EA was completed on **DATE SAR PERIOD ENDED**. **PICK OPTION BASED ON RESULTS OF STATE AND AGENCY REVIEW**.

Technical, environmental, and cost effectiveness criteria used in the formulation of alternative plans were those specified in the Water Resources Council's 1983 Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies. All applicable laws, executive orders, regulations, and local government plans were considered in evaluation of alternatives.[4] Based on these report, the reviews by other Federal, State and local agencies, Tribes, input of the public, and the review by my staff, it is my determination that the recommended plan would not significantly affect the human environment; therefore, preparation of an Environmental Impact Statement is not required.[5]

Date	Lars N. Zetterstrom Colonel, Corps of Engineers District Commander

[4] 40 CFR 1505.2(B) requires identification of relevant factors including any essential to national policy which were balanced in the agency decision.
[5] 40 CFR 1508.13 stated the FONSI shall include an EA or a summary of it and shall note any other environmental documents related to it. If an assessment is included, the FONSI need not repeat any of the discussion in the assessment but may incorporate by reference.

1 INTRODUCTION

The U.S. Army Corps of Engineers, Galveston District (USACE), in partnership with Jefferson County and the Sabine Neches Navigation District, is reviewing ecosystem restoration opportunities in the study area. The study will help contribute to larger ongoing efforts to improve, preserve, and sustain ecological resources along the Texas coast by non-governmental organizations and government agencies at the local, state, and federal level.

Jefferson County contains the largest contiguous estuarine marsh complex in Texas. The Chenier Plain landscape sustains a very high level of productivity within the freshwater to salt marshes, coastal prairie grasslands, tidal flats, creeks and basins of the system. This diversity of communities supports an extremely productive complex array of fish and wildlife resources, outdoor recreation opportunities, and storm protection. The area is extremely important for commercial and recreational fisheries productivity and for migratory bird wintering and breeding habitat.

The vast resources found in the coastal system are rapidly degrading due to a variety of changes in the system induced by anthropogenic development and natural processes. The Jefferson County coastal system is in need of aquatic habitat restoration due to several identified problems contributing to degradation of habitat for fish and wildlife using beaches, dunes, and marshes. The key factors identified as having a negative effect on the aquatic habitat include: excessive erosion, decreased sediment supplies, decreased drainage, decreased freshwater inflows, tidal influences, and increasing salinities.

The Jefferson County Ecosystem Restoration Final Integrated Feasibility Study and Environmental Assessment (JCER) is an interim feasibility study that focuses solely on environmental restoration and beneficial use of dredged material in Jefferson County. The goal of this study was to evaluate ecosystem restoration along the eastern Gulf Coast in Texas within Jefferson County, and recommend measures to restore regional ecosystems.

Under the direction and execution of the U.S. Army Corps of Engineers (USACE), a larger Sabine to Galveston (S2G) study commenced in 2012, and USACE held a planning charrette in August of 2012 where participants identified measures to restore ecosystems and address coastal storm risk management in the six county area. Given the scope and complexity of the S2G study area, in 2015 leadership at USACE Southwestern Division (SWD) and USACE Headquarters (HQUSACE) agreed to break the larger S2G study into four smaller, non-interdependent, interim studies, including the JCER study. The JCER study focuses solely on environmental restoration and beneficial use of dredged material in Jefferson County, which is adjacent to the Sabine-Neches Estuary.

1.1 Study Authority

Study authorization derives from Section 110 of the Rivers and Harbors Act of 1962 and Resolution 2620 from the House of Representatives Committee on Transportation and Infrastructure adopted February 16, 2000, and entitled "Sabine Pass to Galveston Bay, Texas" which states:

> *"Resolved by the Committee on Transportation and Infrastructure of the United States House of Representatives, That in accordance with Section 110 of the Rivers and Harbors Act of 1962 the Secretary of the Army is requested to review the feasibility of providing shore protection and related improvements between Sabine Pass and the entrance to Galveston Bay, Texas, in the interest of protecting and restoring environmental resources on and behind the beach, to include the 77,000 acres of freshwater wetlands and the maritime resources of east Galveston Bay and Rollover Bay, and including the feasibility of providing shoreline erosion protection and related improvements to the Galveston Island Beach, Texas, with consideration of the need to develop a comprehensive body of knowledge, information, and data on coastal area changes and processes to include impacts from federally constructed projects in the vicinity of Galveston Island."*

1.2 Study Purpose and Need

The low elevation and proximity of the study area to the Gulf of Mexico puts the unique environment of southeast coastal Texas at risk of damages from significant weather events, such as hurricanes and tropical storms, and coastal erosion. Land subsidence and rising sea levels are expected to increase the potential for coastal flooding, shore erosion, saltwater intrusion, and loss of wetland and shoreline habitats into the future. Congress authorized the investigation of alternatives that provide shore protection and related improvements that protect and restore environmental resources on and behind the beach including freshwater wetlands. The purpose of the study is to identify and recommend solutions that restore ecosystem structure and function, which are sustainable and resilient under current and future conditions.

The scope of the study is to identify potential restoration measures and alternatives that restore the coastal habitats in Jefferson County; identify a National Ecosystem Restoration (NER) plan in the Federal interest; and evaluate the environmental impacts of the proposed restoration.

1.3 Sponsors

The federal sponsor is USACE, represented by the Galveston District (CESWG). The two non-Federal sponsors on this study are Jefferson County and Sabine-Neches Navigation District. The three parties signed a Feasibility Cost Sharing Agreement for this study on July 8, 2016.

1.4 Study Area

The study area encompasses all of Jefferson County, Texas. The focused study area was identified and bounded by where coastal marshes occur within the County under the existing condition. The focused study area includes approximately 184,100 acres of land, Gulf of Mexico Waters up to one-mile offshore, and 26 miles of barrier beach system which is made up of beaches, dunes, and ridges. Behind the barrier beach system, the study area contains a highly diverse coastal wetland community. Vegetative communities found within the area are indicative of saline, brackish, intermediate, and freshwater wetlands/marshes.

The focused study area overlaps Federal, state, and private land ownerships including lands owned and managed by:

- U.S. Fish and Wildlife Service – Texas Chenier Plain Refuge Complex: two national wildlife refuges found in the study area including McFaddin National Wildlife Refuge (NWR) (58,861 acres of marsh and 15 miles of Gulf shoreline), and Texas Point NWR (8,972 acres of marsh and 6 miles Gulf shoreline);

- Texas Parks and Wildlife Department – J.D. Murphree Wildlife Management Area (WMA) (24,498 acres of marsh) and Sea Rim State Park (4,141 acres of marsh and 5.2 miles of Gulf shoreline);

- Texas Historical Commission – Sabine Pass Battleground State Historic Site (58 acres of developed land);

- USACE – Gulf Intracoastal Waterway (GIWW), which includes approximately 27 miles of a 125-foot wide shallow-draft channel from Sabine Pass to the southern Jefferson County border;

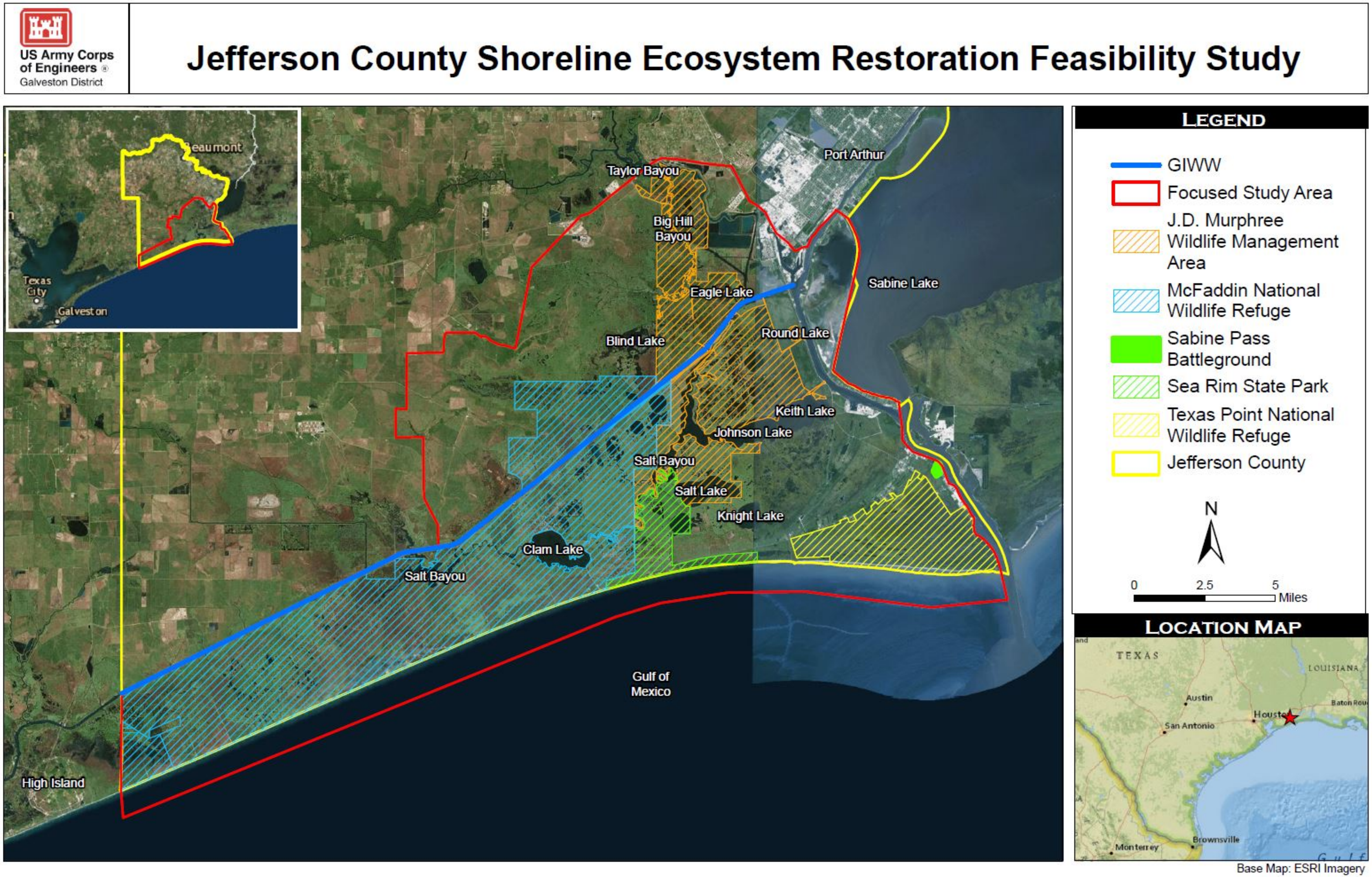
- Sabine Neches Navigation District – Sabine-Neches Waterway (SNWW), which includes approximately 17.5 miles of a 1,056-foot wide deep-draft channel from the focused study area offshore boundary to Port Arthur;

- Texas General Land Office – all beach and nearshore areas (27 miles), and offshore waters (21,200 acres of open water); and lastly,

- Privately owned lands comprising 65,570 acres (Figure 1-1).

U.S. congressional representatives who serve the study area constituents are Senator John Cornyn, Senator Ted Cruz, and Representative Randy Weber (District 14).

Figure 1-1: Jefferson County Study Area



1.5 Significance of the Study Area and Its Resources

Resource significance is determined by the importance and non-monetary value of the resource. The criteria for determining the significance of resources are provided in the federal Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies (United States Water Resources Council 1983) and in USACE planning guidance such as the Planning Guidance Notebook (Engineering Regulation [ER] 1105-2-100). The consideration of significant resources and significant effects is central to plan formulation and evaluation for any type of water resources development project. Significance of resources and effects are derived from institutional, public, and technical recognition of the ecological, cultural, and aesthetic attributes of resources within the study area.

- ***Institutional significance:*** importance of an environmental resource as acknowledged by laws, executive orders (EO), rules, regulations, treaties, policy statements or adopted plans of public agencies or private groups.

- ***Public significance:*** importance of an environmental resource based on public recognition that may take the form of controversy, support, conflict, or opposition.

- ***Technical significance:*** importance of an environmental resource as based on scientific and technical knowledge or professional judgment of critical resource characteristics including: scarcity, representativeness, status and trends, connectivity, limiting habitat, and bio-diversity.

In ecosystem restoration planning, the concept of significance of outputs plays an especially important role because of the challenge of dealing with non-monetary outputs. The three sources of significance – institutional, public and technical – and documentation on the relative scarcity of the resources helps determine the significance of the resources to be restored and helps to establish federal interest in the project.

1.5.1 Institutional Significance

Numerous federal laws and executive orders establish National policy for and federal interest in the protection, restoration, conservation, and management of environmental resources. These provisions include compliance requirements with an emphasis on protecting environmental quality. They also endorse federal efforts to advance environmental goals, and a number of these general statements declare it national policy that full consideration is given to the opportunities which projects afford to ecological resources. Water resource development authorizations have enhanced opportunities for USACE involvement in studies and projects to specifically address objectives related to the restoration of ecological resources and ecosystem management, including the authorization for this study. Several resources in the study area are institutionally recognized as significant.

Essential Fish Habitat (EFH): EFH is designated by NOAA's National Marine Fisheries Service (NMFS) under the Magnuson-Stevens Fishery Conservation and Management Act of 1996. All estuarine and marine waters in the focused study area are identified as EFH, which provides aquatic features necessary for the survival of 18 species of fish managed by the Regional Fishery Management Council.

Migratory Birds and their Habitat: The Migratory Bird Treaty Act of 1918 (16 USC 703-712), Migratory Bird Conservation Act of 1929, as amended (16 USC 715-715d, 715e, 715f-715r) and Executive Order 13186 (Responsibilities of Federal Agencies to Protect Migratory Birds) (January 10, 2001), require federal entities to evaluate how a project would affect migratory birds and to implement measures that encourage conservation of migratory birds. The study area is a convergence zone between the Central and Mississippi Flyways and is the first/last stopover for numerous species migrating to/from the Caribbean, Mexico, Central America, and South America. The study area provides habitat for a number of species of concern including:

- 37 of 48 avian species listed by USFWS as a Species of Conservation Concern in the Gulf Prairies Bird Conservation Region;

- 39 shorebird species including 17 considered as a "Species of Concern", 13 considered as "Species of High Concern", and 3 considered "Highly Imperiled" as identified by the US Shorebird Conservation Plan (USSCP) for the Gulf Coast Prairie Region;

- 14 species in which the study area is considered to have "extremely high importance" to the species and 21 species that have "considerable importance" for the study area as identified by the USSCP;

- 16 species of wetland-associated birds, 10 species of grassland birds, and 13 species utilizing woodland habitats which are listed as rare or declining within the Texas Coastal Prairies as identified in the Partners in Flight Conservation Plan;

- 14 colonial or semi-colonial water bird species deemed at "Moderate Risk," and 6 species deemed at "High Risk" as identified in the North American Waterbird Conservation Plan (2004);

- Conservation and management of Mottled Duck is a major goal of the North American Waterfowl Management Plan (NAWMP) Gulf Coast Joint Venture Chenier Plain Initiative Plan; and

- 3 species with conservation and continental population goals as identified in the NAWMP.

Endangered and Threatened Species and their Habitat: The Endangered Species Act of 1973 (16 USC 1531 et seq.) is Federal legislation that aims to conserve and protect endangered and threatened species and their habitats. US Fish and Wildlife Service (USFWS) and National Marine Fisheries Service (NMFS), identify a total of 19 species with having the potential to occur in the study area, of which three (red knot [*Calidris canutus rufa]*, the piping plover [*Charadrius melodus*], and the whooping crane [*Grus americana*]) regularly use the study area and an additional six species have the potential to use the study area but have not been documented on a consistent basis. Additionally, Texas Administrative Code (TAC 31 §65.171-65.176 and TAC 31§69.01-69.9) identifies a total of 27 species as potentially occurring within Jefferson County, of which eight are also listed by Federal legislation and five regularly occur within the focused study area.

Wetlands: The Clean Water Act, as amended (33 USC 1251-1376), Executive Order 11990 (Protection of Wetlands) (May 24, 1977), and ER 1105-2-100 identify wetlands as a significant resource requiring protection and preservation to the greatest extent practicable. Over 75 percent of the study area is mapped as fresh, intermediate, brackish, or saline marsh. Additionally, the Salt Bayou, the largest remaining contiguous block of freshwater estuarine marsh found in Texas, makes up a portion of the study area and accounts for 3.6 percent of all the estuarine wetlands remaining on the Texas coast and 2.5 percent of all wetlands in the entire state. All wetlands across the entire focused study area make up about four percent of all estuarine wetlands remaining on the Texas coast.

Wildlife Management Areas: USFWS has designated nearly 68,000 acres of the focused study area as important habitat for fish and wildlife. These lands were set aside pursuant to the Migratory Bird Conservation Act and have been actively managed for fish and wildlife purposes. Texas Parks and Wildlife has also purchased nearly 25,000 acres of land in the focused study area in order to protect and manage the vulnerable wetland habitats found within the boundaries for the purposes of fish and wildlife conservation.

Coastal Zone: The study area lies within the delineated coastal zone which was codified as important by the Coastal Zone Management Act, as amended (16 USC 1451 et seq.). The Act provides a basis for protecting, restoring, and responsibly developing coastal resources.

Coastal Barrier Resources: The study area lies within system units and otherwise protected areas as defined by the Coastal Barrier Resources Act (16 USC 55). In total, there are five units comprising 18,798 acres of system units and 60,390 acres of OPAs along the southern boundary of the focused study area. The Act identifies the importance of protecting coastal barrier resources from development and not removing coastal ecological systems.

Conservation Plans: The Salt Bayou Work Group, which is made up of a number of federal, state and local resource agencies and non-governmental organizations, has developed the Salt Bayou Watershed Restoration Plan, which describes the importance of the ecological function of the Salt Bayou system and proposes restoration actions to improve ecological conditions. The Gulf Coast Joint Venture Chenier Plain Initiative Area Plan (Esslinger and Wilson 2001) is a bird habitat conservation plan developed to advance conservation of important bird habitats through biological planning, implementation of habitat conservation activities, and monitoring and research. The Chenier Plain Initiative Area Plan has identified the study area as a priority location.

1.5.2 Public Significance

In Texas, the public strongly supports ecosystem restoration efforts including those developed during this study. Beaches, bays, estuaries and marshes are not only reservoirs of ecological diversity, but they are also the lynchpin of important economic engines for Jefferson County and southeast Texas as a whole. The bays, marshes and estuaries provide game for recreational and commercial fishing, both of which are cultural icons of coastal Texas. Wetlands protected by beaches, dune, and ridge structures are nurseries for many fish species. Wetlands and wildlife in the study area also attract birders, hunters, boaters and other outdoor enthusiasts, including members of the National Audubon Society and National Wildlife Federation.

1.5.3 Technical Significance

Technical significance refers to the importance of an environmental resource as based on scientific and technical knowledge or professional judgment regarding the characteristics of critical resource characteristics.

- *Scarcity*: Measure of a resource's relative abundance within a specified geographic range. Generally, scientists consider a habitat or ecosystem to be rare if it occupies a narrow geographic range or occurs in small groupings. Unique resources, unlike others found within a specified range, may also be considered significant, as well as resources that are threatened by interference from both human and natural causes.

- *Representativeness*: This is a measure of a resource's ability to exemplify the natural habitat or ecosystems within a specified range. The presence of a large number and percentage of native species, and the absence of exotic species, implies representativeness, as does the presence of undisturbed habitat.

- *Status and Trends*: This concept involves evaluating the occurrence and extent of the resource over time, how it has changed and why. The trends associated with the degradation of the resource should indicate whether the resource is declining, recovering, or maintaining a steady status, as well as how quickly the resource is changing.

- *Connectivity*: This is a measure of the potential for movement and dispersal of species throughout a given area or ecosystem, and should be considered in the context of an entire landscape or watershed.

- *Limiting Habitat*: This is habitat that is essential for the conservation, survival, or recovery of one or more species.

- *Bio-diversity*: Most simply defined, biodiversity is a measure of the variety of distinct species and genetic variability within them. It can be measured at the individual level (genetic variation), population level (species variation), and the community level (variation of biological communities and interaction of ecosystem functions).

Scarcity: The study area contains the last remaining Chenier Plain in Texas. The Chenier Plains are a unique and rare landform that stretch nearly 125 miles from southwest Louisiana to southeast Texas and run parallel to the coastline. The Chenier Plains is a system of sandy or shelly beach ridge that is part of a strand plain consisting of cheniers separated by intervening mud-flat deposits with marsh and swamp vegetation that has formed over the last 2,500 years with each westward migration of the Mississippi River.

Representativeness: Development within the study area is limited to navigation channels and oil and gas extraction infrastructure (e.g. wellheads, well pads, tanks, etc.), which make up less than 1 percent of the total land use in the study area. Transportation through the study area is limited to a few roads (<10 miles) maintained by the USFWS on McFaddin National Wildlife Refuge and about eight miles of State Highway 87, which enters the study area at a bridge that crosses over the GIWW just south of Port Arthur and parallels the SNWW to Sabine Pass. Access to the study area is typically by small watercraft following the extensive network of natural watercourses, or by foot. Approximately 52 percent of the study area has been set aside for conservation and management of fish and wildlife species; therefore, future development is unlikely despite extensive urbanization and industrial growth immediately adjacent to the study area.

The study area encompasses the Salt Bayou, which is the largest remaining contiguous coastal marsh in Texas. The Salt Bayou has not received pressure from urbanization; however, development has altered the ability of the marshes to naturally receive freshwater inflows. Despite this, the Salt Bayou continues to be one of the exemplary examples of coastal marsh systems in Texas.

Status and Trends: Wetlands as a whole across the nation are being lost at a significant rate. Texas' wetlands account for six percent of the national total and 12 percent for the Gulf of Mexico total, while wetlands in the study area account for 2.5 percent of all wetlands in the State of Texas and four percent of all coastal marshes in the state. Marshes in the Chenier Plains of Texas declined 16 percent between 1964 through 1966 and 1989 through 1990. The largest degradation of wetland habitat consisted of interior losses of coastal emergent marsh and rice field wetlands (Tacha et al. 1992). Continued altered hydrologic regimes, lack of sediment input, subsidence, and salt water intrusion will continue the trend of marsh conversion to less productive, saline habitats or open water. Under future RSLC conditions, rising sea levels will exacerbate the existing trend and lead to an increase in marsh loss.

Areas in Louisiana have already experienced Chenier Plain loss and the trend will continue at a faster rate than in Texas due to excessive subsidence and altered hydrologic regimes.

Jefferson County has a long history of coastal erosion from natural processes (e.g. wind and wave energies; hurricanes and tropical storms; storm surge; etc.) and human-induced changes (e.g. dredging; construction of shoreline protection features and navigation structures; alteration of tidal inlets and riverine systems; etc.). The erosion rate of the Jefferson County shoreline has averaged about 10.95 feet, or 43 acres, per year. Shoreline erosion, and accompanying land loss, have been more intense since the turn of the century with an average rate of 17 feet, or 67 acres, per year. This declining trend is expected to continue through the planning horizon.

Connectivity: Unique landforms and geographic features found along the upper Texas coast concentrate, or funnel, bird species through the study area, especially migrants. The study area is the first or last stopover for a significant number of migrating birds before they cross the Gulf of Mexico and fly to their breeding or wintering grounds in Mexico, the Caribbean, Central America, or South America.

The freshwater riverine and Gulf waters mix within the marshes and open water areas of the study area. This unique zone provides critical habitat for diadromous species. Marshes provide spawning and nursery habitat for many economically and recreationally important species. After their life stage in the marshes is complete, they move out to Gulf water until they return to spawn.

Limiting Habitat: The study area is the largest remaining block of coastal system that has not had pressure from development. As the trend of urban sprawl and industrial development continues, the study area will become a refuge for species displaced by the actions.

Biodiversity: The study area has a unique assemblage of habitats ranging from chenier, beach and dune ridges to expanses of freshwater, intermediate, brackish and saline marshes. These habitats each support different species that are adapted to the conditions found in the habitats and leading to extreme biodiversity in the study area. Couple the diverse habitats with the hydrologic interconnectedness of the Gulf and freshwater riverine systems and the migratory routes of birds, fish, and other species and the study area becomes an exceptionally productive ecosystem and important natural asset. Jefferson County, including the study area, also supports millions of breeding, migrating, and wintering birds, some of which rely on local habitat for survival.

Millions of birds migrate through the area each spring, including neotropical migrants, shorebirds, water birds, and waterfowl. Radar studies have estimated that more than 50,000 birds occupy the area daily during the spring migration (Gauthreaux et al. 2006). Several million of these birds, comprised of about 75 species, make trans-gulf migrations through Jefferson County, which provides critical in-transit habitat for the birds to rest and replenish fat reserves. For many birds, coastal marshes in Jefferson County are their first or last stop before or after crossing the Gulf during migration to and from Mexico, and Central and South America. If marshes in the study area are lost completely or retreat miles inland, migrating birds may not survive the additional distances needed to find resting places and or forage. Cumulatively, with significant marsh loss occurring in Louisiana and other parts of Texas, even a minor amount of marsh loss at this point is significant.

Coastal marshes of the Chenier Plains also support one of the largest concentrations of breeding colonial water birds in the world and are one of the most important waterfowl areas in North America. Management areas in the study area provide wintering and migration habitat for a significant number of continental duck and goose populations, and they winter more than half of the Central Flyway waterfowl population. The areas also support year-round habitat for over 90 percent of the continental population of mottled ducks (*Anas fulvigula*) and serve as key breeding areas for whistling ducks (*Dendrocygna*) and purple gallinule (*Porphyrio martinicus*). Without action to prevent further deterioration of shoreline areas and marshes, species diversity in the area will decline dramatically, and result in a monoculture of habitat generalist species and an increase in federally protected species as more species become endangered.

1.6 Prior Reports and Existing Water Projects and Restoration Efforts

There have been a number of other federal and state investigations, reports, projects and studies undertaken to reduce shoreline erosion and marsh degradation in the region. A list of ongoing, existing, and completed projects as they relate to the study area follows and the most relevant are:

- Salt Bayou Watershed Restoration Plan, Texas Parks and Wildlife, 2013
- USFWS Chenier Plains Management Plans, Texas Parks and Wildlife
- McFadden NWR Shoreline Restoration, USFWS and the Texas General Land Office, April 2017
- Inverted Siphon Study
- Keith Lake Restoration, Texas Parks and Wildlife
- Coastal Texas Ecosystem Restoration Study (Ongoing), USACE.

1.6.1 Existing Restoration Efforts

The Salt Bayou Workgroup, a multi-agency technical stakeholder group focused on the Salt Bayou ecosystem, has met annually since 2000 to identify ecological issues and opportunities in the watershed, and recently published the Salt Bayou Watershed Restoration Plan (TPWD 2013). Their plan describes the ecological importance of the Salt Bayou system, discusses natural and anthropogenic causes of marsh decline, and proposes a path forward to improve ecological function of the system. The workgroup identified two main categories of alterations with the greatest effect on marshes in the Salt Bayou: 1) human induced and natural changes to hydrology, and 2) subsurface subsidence from loss of organic soils or fluid extraction.

As summarized below, federal, state and local governments have also undertaken several restoration efforts in Jefferson County. Each of these are included in the future without project condition (FWOP) in this analysis, which assumes that each project continues functioning as designed over the period of analysis.

Despite what appears to be a significant restoration effort in the focused study area, landscape scale restoration has not been addressed. To date, all restoration actions target a very specific source of degradation and only minimally, at best, contribute to restoration of the more difficult systemic issues such as drainage concerns, lack of sediment and nutrient input, modification of hydrology, future conditions, etc. Additional restoration, even if it is of a similar nature (e.g. increasing GIWW armoring or acreage of marsh restoration areas), will synergistically contribute to a landscape scale restoration effort by filling in where restoration is not economically feasible or where state or federal agencies do not have authority to implement restoration projects, such as on private land. While existing restoration efforts have localized benefits, a need for action still exists.

Most existing projects have been designed to address the immediate issue and may provide benefits for at most 20 years. When conditions change and warrant modifications to the restoration sites (e.g. increasing the dune heights, adding more rock material, or increasing sediment needs to achieve a higher target elevation), the funding or source material, especially dredged material, may not be available. Any plan developed during this study and authorized by Congress would have an adaptive management plan design that takes into account future conditions, and would set aside an amount of source material, specifically dredging, that would secure a path for funding and source material in the future, providing at least 50 years of benefits, and provide resiliency and sustainability in the face of sea level change.

1.6.1.1 J.D. Murphree WMA Beneficial Use of Dredge Material

The Salt Bayou Unit of the J.D. Murphree WMA, managed by the Texas Parks and Wildlife Department (TPWD), is the site of a 1,500-acre restoration project. The project came to fruition through cooperative efforts of four major players: National Ocean and Atmospheric Administration (NOAA) Fisheries, TPWD, Golden Pass Liquefied Natural Gas (GPLNG), and Ducks Unlimited. It is one of the largest beneficial use of dredged material projects of its kind in Texas. However, it is not the first on JD Murphree. In 2008, a smaller wetland mitigation project completed and served as a template for the 1,500-acre restoration project.

Over the years, saltwater intrusion and subsidence has degraded the Salt Bayou Unit, and reduced the amount of emergent vegetation that provides the foundation for fisheries, birds, amphibians, reptiles, and mammals inhabiting the marsh. Scouring storm surges and other impacts from hurricanes have further degraded the marsh complex. Once areas lose vegetation, they lose their beneficial value to fish and wildlife.

In an attempt to reverse this loss, TPWD worked with GPLNG and Ducks Unlimited to place as much as 24 inches of dredged material in subsided marsh to raise elevations to desirable levels. Dredged material had been filling in GPLNG's shipping berth on SNWW. Project partners saw an opportunity to use more than two million cubic yards of dredge material from the berth that would have otherwise gone to upland disposal sites. This was an opportunity to help restore marsh, while providing a cost savings to GPLNG. TPWD was able to contract with Ducks Unlimited to plan, engineer, survey, and oversee the project through grant funding from NOAA (Rezutek, M, 05 December 2016, personal communication).

Out-year renourishment efforts are planned on an as-needed basis. GPLNG has committed future dredged material that comes from maintaining depths at their berth to continuing the project. To date, the effort has reestablished productivity and growth of native wetland vegetation while maintaining ponds and other surface water features important to a properly functioning ecosystem.

1.6.1.2 Keith Lake Baffle Project

The Keith Lake Baffle project involved constructing baffles beneath the surface of the man-made Keith Lake Fish Pass to remedy increasing saltwater flow through the pass attributable to historic erosion of its banks and bed (Figure 1-2) (Commissioners' Court 2013). This area protects 66,000 acres of marsh south of the GIWW from increasing salinity caused by construction of navigation channels. Since 2015, the project has functioned as designed, and there has been a decrease in salinity in interior marshes near Keith Lake, Johnson Lake and Shell Lake (Rezutek, M. TPWD—JD Murphree WMA. 18 May 2017, personal communication).

Figure 1-2: Completed Keith Lake Fish Pass Baffle Project

1.6.1.3 GIWW Shoreline Armoring

Managers of McFaddin NWR and JD Murphree WMA have successfully constructed over 16 miles of rock breakwater structures to protect shorelines and interior marshes from wave energies created by commercial vessel traffic on the GIWW. The structures dissipate wave energy before it reaches the shoreline, stabilize the shoreline and reestablish emergent vegetation in a protected area between breakwaters and the shore. By slowly trapping sediment, the breakwater structure allows wetland vegetation to reestablish. Lower rates of erosion also prevent damage to sensitive marsh habitats from rapid variations in salinity (Figure 1-3).

The breakwaters are constructed within the GIWW, parallel to the shoreline. They are built in shallow water (<3 feet deep) along the edge of the GIWW, at varying distances from the shoreline and where soils are conducive to supporting without subsidence. In some places the structure may be placed on the edge of the shoreline, while in others it could be up to 60 feet out in the shallow water of the GIWW, but not within the right-of-way. The typical design is a trapezoidal rock berm up to a height of 3.0-3.5 NAVD88, which yields approximately 1-1.5 feet of rock exposed above the mean high tide level. The breakwater design includes a 3- to 4-foot wide crown, a 1-1.5:1 slope, and a base no more than 25 feet wide.

Figure 1-3: Breakwaters along the GIWW in Jefferson County

1.6.1.4 McFaddin NWR Shoreline Restoration

USFWS partnered with Jefferson County and the Texas General Land Office to restore up to a 20 mile stretch of degraded dune ridges at the southern boundary of McFaddin NWR. The goal was to restore the longevity of the Chenier beach ridge to delay shoreline retreat and prevent breaching of the beach ridge during storms. By restoring dune ridges, the frequency and extent of saltwater inundation of interior freshwater marshes declines, shoreline retreat slows, and native beach habitat can return to historic levels. Restoration efforts were completed under two separate projects: 1) construction of an over-wash protection berm, and 2) beach ridge restoration.

Over-wash Protection Berm (Clay Core Berm)

In 2015, McFaddin NWR successfully constructed an over-wash protection berm. The project consists of a 36-foot wide trapezoidal berm configuration with a crest elevation of +6.0 feet NAVD88 and +2.0 feet NAVD88 foundation elevation. Side slopes are 1V:3H with a berm crest about 12 feet wide. On average, the berm is 600 feet inland (varies from 500 to 700 feet) and parallels the current beach. The total length of the approved berm is 14.43 miles (76,207 feet). Engineers built the structure from material excavated from 89 acres of onsite borrow areas. Clay material was excavated from borrow areas parallel and approximately 60 feet landward of berm segments. The borrow pits consist of shallow, alternating areas that were approximately 4 feet deep, 1,000 feet long, and 75 feet wide.

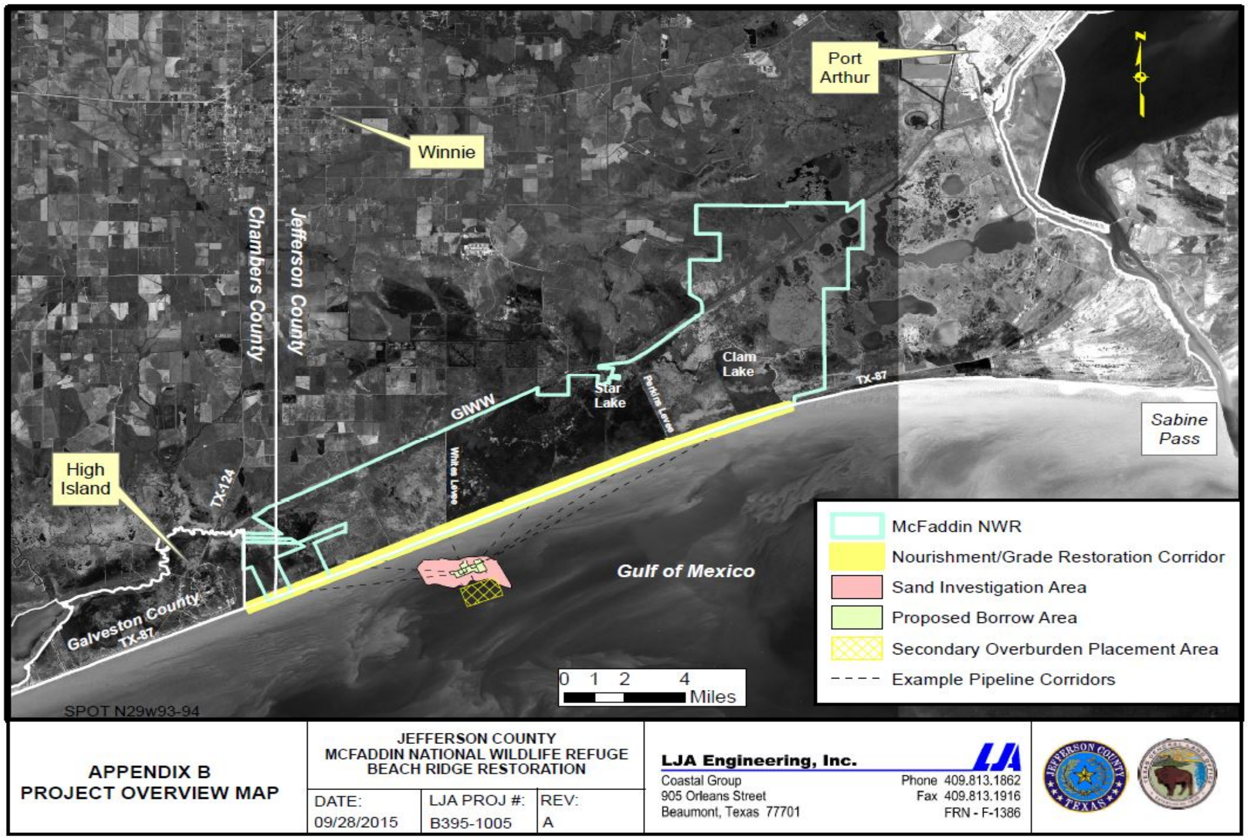
The berm is augmented with about one foot of imported sand as well as sand and organics previously stripped from the berm footprint, which optimizes establishment of vegetation and reduces erosion during storms. The sand covered, clay core berm was vegetated as necessary. By itself, the berm does not protect the shore, and its longevity depends on the health of the shoreline located seaward of the berm. Design engineers assumed a typical shoreline retreat of -30 feet per year suggesting a 10-year functional lifespan without further maintenance of the berm. Since construction, the berm has been instrumental in reducing overtopping events, reducing salinities in adjacent marsh areas, and promoting more favorable freshwater vegetation (USFWS 2013).

Beach Ridge Restoration

The beach ridge restoration project involved placing sand on 20 miles of shoreline by dredging sand from an offshore sediment source and hydraulically pumping the sediment to shore as a sediment-water slurry through a temporary submerged pipeline. Once onshore, the material was pumped along the shoreline to the local construction areas and graded to the required construction template with heavy equipment. The project area expands from the eastern boundary of McFaddin at Sea Rim State Park to the Jefferson and Chambers county lines.

Sediment came from the Target Area 15 borrow source located approximately 1.5 miles offshore (Figure 1-4). This site has a minimum of four million cubic yards of suitable sediment available for use. Dredged slopes at the borrow site were not greater than 5H:1V along the dredged boundaries to ensure integrity of the surrounding seabed.

Figure 1-4: Project Overview Map from the Environmental Assessment Prepared for the McFaddin Beach Ridge Restoration



Design criteria for dune elevation and beach height and width was intended to reduce inundation events into the marshes, slow recent increases in shoreline retreat, and return a portion of sediment to the littoral system. Based on water levels associated with a 5-year storm return interval, wave run-up, and a 2-foot rise in sea level over 100 years, a dune crest of 8 to 9 feet was identified as being sufficiently adequate to provide against saltwater inundation into the wetlands, except under extreme conditions. Dune alignment parallels the 4 foot contour. In locations where alignment was not possible, the alignment shifted landward or seaward while maintaining a continuous dune line. Dune plantings occurred where necessary to increase dune stability.

Renourishing the beach face from about +5.0 feet NAVD88 along a mild slope (2 percent) to the existing mean high waterline, and then increasing the slope to about 5 percent was identified as the optimal design to allow 200 to 300 feet of dry beach berm and sufficient sand quantities to slow recent advances in local erosion. Lastly, fine-grained sediment from the borrow source known as "overburden" will be placed in a grade restoration area between the dune line and existing clay core berms. Deposition of fine sediments helps direct water back towards the Gulf of Mexico (USFWS 2016).

In April 2017, USFWS and the Texas General Land Office constructed roughly three of the 20 miles of beach ridge restoration (Figure 1-5). The remaining 17 miles will be completed as soon as funding becomes available. For purposes of the JCER study, the project is assumed to already be in place and accruing benefits under the existing condition, as it is likely the additional 17 miles will be fully constructed by the time this study goes to Congress for construction funding, if authorized.

In June of 2017, Tropical Storm Cindy put the 3 miles of completed project to test, as did Hurricane Harvey in August of 2017. The new dune system performed and remained resilient to storm surges, torrential flooding rains exceeding 44 inches, and high winds that pounded the Gulf beach. During both storms, very little seawater flowed into interior marshes (D. Head, personal comm. 15 Nov. 2017).

Figure 1-5: Constructed clay berm and beach nourishment at McFaddin National Wildlife Refuge

(Taken 11 Dec 2017, M. Stravato for Texas Tribune)

1.6.1.5 Terracing

Marsh terracing is an effective tool for wetland restoration by converting shallow subtidal bottom to marsh, enhancing deposition and retention of suspended sediments, reducing turbidity, increasing marsh edge habitat, increasing overall primary and secondary productivity, and maximizing access to marine organisms. Terrace fields are arranged into a series of ridges forming a pattern intended to minimize fetch and maximize edge. Terraces are constructed of stackable sediment to a predesigned height, with crown and slopes that tolerate sloughing and shifting of material. Intertidal and subtidal areas are planted with appropriate marsh vegetation to minimize erosion.

In 2013, McFaddin NWR successfully constructed 25,000 linear feet of terrace fields in Willow Lake Blowout. The project directly benefited more than 150 acres of emergent marsh habitat, protected more than 3,600 acres of existing coastal marsh from further degradation, and protected 6,000 linear feet from shoreline erosion, saltwater intrusion, and further marsh loss while restoring and enhancing intertidal submerged aquatic vegetation habitat (USFWS 2017).

1.7 USACE Civil Works Guidance and Initiatives

USACE planning is grounded in the 1983 Economic and Environmental Principles and Guidelines for Water and Related Land Implementation Studies (Principles and Guidelines). The Principles and Guidelines outline general processes and goals for formulating reasonable plans in response to national, state and local concerns. Based on the Principles and Guidelines, USACE tries to balance economic development and environmental needs as it addresses water resources problems. The federal objective of water and related land resources planning is to contribute to National Environmental Restoration (NER) consistent with protecting the nation's environment, in accordance with environmental laws, executive orders and other federal planning requirements. USACE Planning Guidance Notebook (ER 1105-2-100) provides overall direction to formulate, evaluate and select projects for implementation.

The JCER conforms to USACE campaign plan goals, and USACE environmental operating principles by undertaking a proactive public and stakeholder involvement campaign, including a project website, regular stakeholder meetings, and targeted industry meetings. Active and responsive public and resource agency involvement has informed the development of solutions to problems this study seeks to address, and has facilitated sharing and distributing data and knowledge between USACE and other agencies. Relationships that the JCER study team developed with stakeholders, local officials, and other special interest groups and agency partners has facilitated the consensus-building process to create a mutually supportable and environmentally suitable solution for the region. The study was conducted under USACE’s Civil Works Planning modernization process by using SMART planning principles to effectively execute and deliver the study in a timely manner.

HQUSACE approved the JCER’s tentatively selected plan (TSP) in accordance with provisions and requirements of the Planning Guidance Notebook and of Section 1001 of the Water Resources Reform and Development Act of 2014 (WRRDA 2014), as well as the implementation guidance for Section 1001 of WRRDA 2014, as set forth in a memorandum from the Chief, Planning and Policy Directorate of Civil Works, dated 09 April 2015: SUBJECT: "Implementation Guidance for Section 1001 of the Water Resources Reform and Development Act of 2014 (WRRDA 2014) – Vertical Integration and Acceleration of Studies.”

1.8 National Environmental Policy Act Compliance Requirements

The National Environmental Policy Act (NEPA), 43 U.S.C. 4321 et seq., is the national charter legislation for environmental protection. The intent of NEPA is to ensure that information is made available to the public regarding major actions taken by federal agencies that significantly affect the quality of the human environment, and to identify and consider concerns and issues raised by the public. NEPA provides for an early and open process, called scoping, to determine the scope of issues to be addressed and identify significant issues related to a proposed action.

This report documents USACE compliance with NEPA requirements as they relate to ecosystem restoration efforts in Jefferson County, and employs concepts to establish the Council on Environmental Quality (CEQ) NEPA regulations (integration, and tiering) that are appropriate to the planning and design process for the study. CEQ allows agencies to integrate any environmental document in compliance with NEPA with any other agency document to reduce duplication and paperwork (40 CFR 1506.4). Further, CEQ established tiering to provide: "coverage of general matters in broader environmental impact statements (such as national program or policy statements) with subsequent narrower statements or environmental analyses (such as regional or basin-wide program statements or ultimately site-specific statements) … Agencies are encouraged to tier their environmental impact statements to eliminate repetitive discussions of the same issues and to focus on the actual issues ripe for decision at each level of environmental review" (40 CFR 1508.28 and 1502.20). This report is an integrated Feasibility Report and Environmental Assessment and tiers to the SNWW Channel Improvement Project (CIP) EIS for some of the FWOP conditions and impacts from dredging.

2 AFFECTED ENVIRONMENT

Chapter 2 describes historic and existing conditions of significant environmental resources including:

- Land Use
- Air Quality
- Climate,
- Water Resources (e.g. floodplains, hydrology, surface water, groundwater, and water quality),
- Geologic Resources (e.g. geology, soils, and mineral resources),
- Biological Resources (e.g. vegetation and habitats, wildlife, fisheries, protected species, etc.),
- Cultural Resources ,
- Socioeconomic and human resources (e.g. population, employment and income, education and environmental justice),
- Transportation,
- Recreation and aesthetics (visual resources); and lastly,
- Hazardous, toxic and radioactive wastes.

A resource is considered important if it is recognized by statutory authorities including laws, regulations, executive orders, policies, rules, or guidance. In addition, a resource is important if some segment of the general public believes it is or if technical or scientific criteria demonstrate its importance.

Existing conditions in this chapter are discussed as appropriate. While all NEPA resources are significant to various institutions, this section discusses only those resources that proposed alternatives would directly impact. Environmental appendices to this report contain additional detail.

This chapter ends with discussion of the Future Without Project Condition.

2.1 General Environmental Setting and Location of the Study Area

2.1.1 Location

As mentioned in the introduction, the study area includes all of Jefferson County, Texas, while the focused study area is bounded by coastal marshes in the county that encompasses approximately 184,115 acres. The focused area overlaps several prominent ownerships including the McFaddin NWR (58,861 marsh and coastal acres) and Texas Point NWR (8,972 marsh acres), both of which are operated by the U.S. Fish and Wildlife Service. The focused area also intersects the J.D. Murphree Wildlife Management Area (24,498 marsh acres) and Sea Rim State Park (4,141 acres of marsh and coastal areas), all of which are owned and operated by Texas Parks and Wildlife Division. The area contains roughly 27 miles of Texas shoreline. The Texas General Land Office manages most of this.

Two navigation channels are in the focused study area: the GIWW, which extends for 27 miles from Sabine Pass to the Jefferson County border; and the SNWW that runs 79 miles from the Gulf of Mexico to Port Arthur and Beaumont via the Neches River Channel and to Cameron and Calcasieu parishes, Louisiana via Sabine Lake and the Sabine River Channel. The study area also includes 26 miles of barrier beaches made up of beaches, dunes, and ridges. Highly diverse coastal wetland communities thrive behind the barrier beach system. Vegetative communities in the area are indicative of saline, brackish, intermediate, and freshwater wetlands and marshes.

2.1.2 Land Use and Land Ownership

In addition to urban and industrial areas, major land uses in Jefferson County but outside of the focused study area are farming and ranching on higher elevation marshes or marshes that have been filled and converted to agriculture. In the focused study area, land use is predominately devoted to wildlife and outdoor-recreation related activities, and federal and state ownership limits alternate uses such as residential or commercial development. Lands are managed specific to the purpose of the land owner's mission and each land owner has a specific set of rules that permit or restrict activities within their boundaries. Even on private property, land use is generally devoted to fish and wildlife, with agriculture and ranching activities extremely limited.

2.2 Protected and Managed Lands

Special land management areas make up the majority of the focused study area. Special management areas for purposes of this study are lands governed by specific legislation that specifies how to manage the lands.

2.2.1 Federal Ownership

As noted previously, Jefferson County hosts the McFaddin NWR and Texas Point NWR, which are part of the Texas Chenier Plain Refuge Complex. The two refuges contribute to the conservation of wildlife and their habitats and provides important feeding and resting habitats for migrating and wintering populations of waterfowl.

McFaddin NWR covers about 58,861 acres in Jefferson and Chambers Counties. Along with the J.D. Murphree Wildlife Management Area, it protects the largest expanse of remaining freshwater marsh on the Texas coast and thousands of acres of intermediate marsh. The Refuge's southern boundary consists of over 15 miles of Gulf of Mexico shoreline. Remnant dune and beach systems occupy the coastline, although much has been lost through erosion and shoreline retreat, leaving only a low-lying washover terrace (TPWD 2013).

Texas Point NWR encompasses approximately 8,972 acres of saline to brackish marsh contained wholly in Jefferson County. Interspersed in the refuge's marshes are slightly elevated fan-shaped salty chenier prairies and shallow freshwater lakes and ponds. The Refuge's southern boundary consists of over six miles of Gulf shoreline.

2.2.2 State Ownership

State agencies own and operate three properties in the area. Texas Parks and Wildlife Department (TPWD) owns two properties (J.D. Murphree Wildlife Management Area and Sea Rim State Park), and the Texas Historical Commission own one (Sabine Pass Battleground State Historic Site).

The J.D. Murphree WMA is a 24,498 acre tract of fresh, intermediate, and brackish water coastal marsh, and extends north and south of the GIWW and west of the SNWW to the McFaddin NWR boundary. Long-term management of the WMA focuses primarily on winter waterfowl habitat. Additional management activities include providing breeding, nesting, and brood-rearing habitat for mottled ducks via water level manipulation and vegetation management; and restoring wetlands to improve marsh habitats and reestablishing marsh habitat in areas where it was lost through erosion.

Sea Rim State Park is 4,141 acres of remote coastal land consisting of sandy beach with low sand dunes and extensive brackish and intermediate marshes, tidal drainages, lakes and lagoons further inland. The park's southern boundary consists of 5.2 miles of Gulf of Mexico shoreline. The Sabine Pass Battleground State Historic Site tells the story of Confederate Lt. Richard "Dick" Dowling and his 46 soldiers who thwarted an attempted Union attack on Sabine Pass, a primary Texas port for Confederate shipments of supplies and vital to the war effort. The historic site offers self-guided site tours of memorial features and interpretative displays through a 58-acre manicured park-like setting.

2.2.3 Coastal Zone Management Act of 1972

In 1972, Congress passed the Coastal Zone Management Act (CZMA), which established the federal Coastal Zone Management Program (CZMP; Public Law 92-583, 86 Stat. 1280, 16 USC §§ 1451-1464, Chapter 33). The CZMP is a federal-state partnership that provides a basis for protecting, restoring, and responsibly developing coastal resources. The CZMA defines coastal zones wherein development must be managed to protect areas of natural resources unique to coastal regions. Texas has developed and enacted the Coastal Management Plan (CMP), in which any federal and local actions must be consistent with management plans. The Texas General Land Office enforces consistency of the plan for Texas. States must define areas that comprise their coastal zone and develop management plans and protect these unique resources through enforceable policies of state CZMP. Texas defines its coastal zone as the area seaward of the Texas coastal facility designation line, up to three marine leagues into the Gulf. Most of Jefferson County and all of the focused study area lies within the Texas Coastal Zone.

CMP goals and policies focus management efforts on five primary issues of concern to coastal communities: coastal erosion, wetland protection, water supply and water quality, dune protection, and shoreline access. The CMP identifies 16 coastal natural resource areas (CNRAs), of which 10 are in the study area:

- Waters under tidal influence,
- Submerged land,
- Submerged aquatic vegetation,

- Coastal barriers,
- Coastal shore areas,
- Gulf beaches,
- Critical dune areas,
- Special hazard areas,
- Critical erosion areas,
- Coastal preserves.

The remaining six CNRAs, as defined by 31 Texas Administrative Code (TAC) §501.3 - Waters of the open Gulf of Mexico, coastal wetlands, tidal sand or mud flats, oyster reefs, hard substrate surfaces, and coastal historic areas - are not in the focused project area.

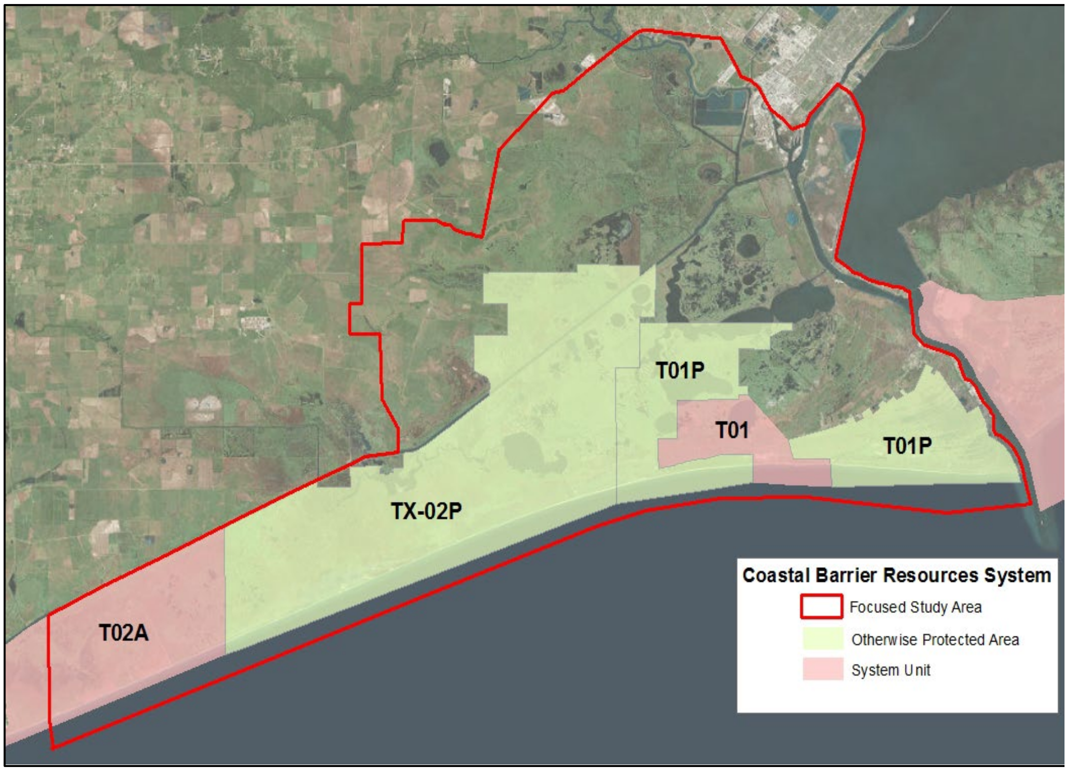
2.2.4 Coastal Barrier Resources Act of 1982

Congress enacted the Coastal Barrier Improvement Act of 1990 to reauthorize the Coastal Barrier Resource Act (CBRA) of 1982 to address problems caused by coastal barrier development. The three main goals of CBRA are to:

- Minimize loss of human life by discouraging development in high risk areas;
- Reduce wasteful expenditure of federal resources; and
- Protect the natural resources associated with coastal barriers.

CBRA applies to areas that are in the John H. Chafee Coastal Barrier Resource System (CBRS), which is a defined set of geographic units along the Atlantic, Gulf of Mexico, Great Lakes, U.S. Virgin Islands, and Puerto Rico. The CBRS includes two types of units, System Units and Otherwise Protected Areas (OPAs). In total, there are five units comprising 18,798 acres of system units and 60,390 acres of OPAs along the southern boundary of the focused study area, of which two extend from the GIWW to the nearshore and three extend from the center of the barrier headland or further south to the nearshore (Figure 2-1).

Figure 2-1: Coastal Barrier Resources System Units in the Focused Study Area



2.2.5 Fish and Wildlife Management Areas

Fish and wildlife management areas are designated habitat for fish and wildlife, or habitat for propagation of such species and where wildlife habitat maintenance or improvement is appropriate. Private or exclusive group use of these lands is not permitted. Vehicles are typically not permitted, unless they are for a wildlife-dependent recreational activity. Fish and wildlife management lands are generally available for selected low-density recreation such as hiking, hunting, fishing, nature study, nature photography, wildlife observation, and other related activities. Public access is restricted during certain critical periods for wildlife such as breeding, nesting, and spawning.

The USFWS and the State of Texas own and operate a significant portion of lands in Jefferson County. Professional staff such as biologists, foresters and conservation officers conduct surveys, prepare management plans, and enforce game and natural resource laws and regulations to ensure sound and integrated management of the lands.

McFaddin and Texas Point NWRs are a part of the larger Texas Chenier Plain Refuge Complex, which was created as part of the Migratory Bird Conservation Act. The focus of these refuges is to retain and intensively manage a significant block of coastal marsh for migrating, wintering and breeding waterfowl, shorebirds and waterbirds, and provide crucial resting areas for Neotropical songbirds migrating across the Gulf. Comprehensive Conservation Plans (CCPs) guide management of NWRs over a 15-year period, and specify goals, objectives, and strategies for refuge managers to carry out their mission. CCPs focus on managing waterfowl, resource values, wetlands loss, and native coastal prairies. Long-term management of the J.D. Murphree WMA is primarily geared toward winter waterfowl habitat. Mottled duck habitat is regularly managed to provide quality breeding, nesting, and brood-rearing habitat through water level manipulation and vegetation management. Additionally, wetland restoration is regularly conducted to improve and reestablish marshes.

2.3 Air Quality

The U.S. Environmental Protection Agency (EPA) has the primary responsibility for regulating air quality nationwide. The Clean Air Act (42 U.S.C. 7401 et seq.), as amended, requires the EPA to set National Ambient Air Quality Standards (NAAQS) for wide-spread pollutants from numerous and diverse sources considered harmful to public health and the environment. The Clean Air Act established two types of national air quality standards classified as either “primary” or “secondary.” Primary standards set limits to protect public health, including the health of at-risk populations such as people with pre-existing heart or lung diseases (such as asthma), children, and older adults. Secondary standards set limits to protect public welfare, including protection against visibility impairment, damage to animals, crops, vegetation, and buildings.

EPA has set NAAQS for six principal pollutants, which are called “criteria” pollutants. These criteria pollutants include carbon monoxide (CO), nitrogen dioxide (NO_2), ozone (O_3), particulate matter less than 10 microns (PM_{10}), particulate matter less than 2.5 microns ($PM_{2.5}$), sulfur dioxide (SO_2) and lead (Pb). If the concentration of one or more criteria pollutant in a geographic area is found to exceed the regulated “threshold” level for one or more of the NAAQS, the area may be classified as a non-attainment area. Areas with concentrations of criteria pollutants that are below the levels established by the NAAQS are considered either attainment or unclassifiable areas.

Jefferson County is in the Beaumont-Port Arthur (BPA) Air Quality Control Region (AQCR). BPA area counties are currently attaining all National Ambient Air Quality Standards (NAAQS) and are currently in compliance with the Clean Air Act. Previously, the area was designated nonattainment for the 2008 ozone standard, but was later designated unclassifiable/attainment effective July 20, 2012 (77 FR 30088). The BPA area was also at one time in nonattainment for the 1997 8-hour ozone standard, but after additional monitoring in 2005 and 2007, it was determined that the area was attaining the standard and was redesignated as unclassifiable/attainment effective November 19, 2010 (75 FR 64675).

Air pollutants within the study area are measured by numerous air monitoring stations. Most of the stations in the region measure the concentrations of criteria air pollutants, as well as temperature, wind, velocity, wind direction, and other meteorological parameters. The monitors operate continuously and are routinely calibrated and maintained to assure quality data. The major sources of air population in the study area are petroleum production, chemical production, shipping, and agriculture.

2.4 Climate

The region has a subtropical climate. Summers are hot and humid with prevailing southerly winds from offshore, while winters are cool and wet. The average annual high temperature is 78.3°F with an average annual low of 58.9°F. In winter, the average temperature is 55°F and the average daily minimum temperature is 44°F. In summer, the average temperature is 82°F and the average daily maximum temperature is 91°F. The average relative humidity in mid-afternoon is about 72 percent.

The average annual total precipitation is about 60 inches. Of this about 49 inches (82%), usually falls in February through November. The average seasonal snowfall is 0.2 inches. Thunderstorms occur on about 67 days each year, and most occur in July and August.

The region's climate is highly variable and exerts both short-term and long-term influences. The dynamic nature of precipitation, temperature, and wind are the climatic factors influencing water and sediment movement and subsequently the development of the Chenier Plain region.

Tropical depressions, tropical storms, and hurricanes are relatively common in the Gulf of Mexico. Hurricane season runs from June through September and, historically, the frequency of hurricanes making landfall along any 50-mile segment of the Texas coast is one in about every six years with annual probabilities of a strike in the study area being approximately 31 percent in any given year (Roth 2010). Typically, the study area will see three tropical storms and/or hurricanes over a four year period. During these events, flooding is the most serious threat. In general, the weaker the system, the more efficient it is at producing heavy rains and catastrophic flooding. Most storms enter from the southeast, and curve north and northeast through eastern and central portions of Texas.

2.5 Water Resources

2.5.1 Floodplains and Flood Risk Management

Average annual precipitation in the study area is approximately 60 inches per year and this includes many intense storm events, which is problematic given that in the focused study area is susceptible to coastal flooding from tropical storms, hurricanes, and during periods of heavy precipitation. As a result, flooding is common. Lands directly along the Gulf Coast are most susceptible to flooding from tidal surges. Alterations of natural topography, primarily to drain inland areas of the watershed, have exacerbated flooding in downstream portions of the watershed.

All areas in the focused study area are in the 100-year coastal floodplain with designation based on high velocity coastal flooding from wave actions, base flood elevation and flood hazard factors. Another important consideration is that there are 60,390 acres of OPAs, as described previously, in which flood insurance is not available for structures that are newly built or substantially improved on or after October 1, 1983.

2.5.2 Hydrology

Historically, hydrology in the Chenier Plain region was critical to processes that created and maintained diversity in coastal wetlands. Frequent flooding over low bayou banks and large volumes of rainwater flowing slowly across coastal prairies and marshes provided nutrients, sediments, and freshwater to marsh systems. Natural drainage allowed a cyclic pattern of drying and flooding under which wetland plants evolved and adapted. Over the past 5,000 years, the Chenier Plain region was predominately a freshwater coastal marsh system, but contained a continuum of coastal marsh types associated with a natural salinity gradient. This continuum of freshwater, intermediate, brackish, and saline wetlands supported a diversity of species specific to the marsh conditions and tidal influences.

Modifications to regional hydrology have affected ecological and geological processes critical to the long-term integrity of coastal ecosystems in the Chenier Plain region. In general, the primary human induced activities that have affected coastal wetlands include construction of the GIWW and smaller navigation canals, oil, gas, and groundwater extraction, and channelization and deepening of natural waterways for navigation and inland drainage. Consequences have resulted in various ecological responses, some of which are directly responsible for the onset of others.

- Saltwater now reaches farther inland into historically freshwater marshes and alters plant species composition and plant productivity.

- New channels and modifications of natural waterways introduced tidal energies into historically non-tidal or micro-tidal marshes, resulting in decreased plant productivity, plant mortality, peat collapse and erosive loss of organic marsh soils. All have contributed to the conversion of the vegetated emergent marsh to open water. Introduction of tidal influence also altered marsh hydroperiods or wetting and drying cycles. Non-tidal and micro-tidal marshes where soil surfaces were exposed only seasonally or during periods of drought became subject to daily tides.

- Alterations to natural drainage systems rapidly transport freshwater and sediments from inland areas directly to the GIWW, bays and the Gulf, and have generally eliminated the slower historic sheet flow of freshwater from prairies to marshes. Historic hydroperiods in marshes have been altered as rapid drainage of inland flood waters has increased the frequency and depth of flood events in downstream marshes. Conversely, drainage improvements in and adjacent to the marshes have promoted more rapid drainage and drying during normal or low precipitation cycles.

- Natural and human-caused subsidence has resulted in submergence or “drowning” of emergent wetlands and conversion to deeper, open water.

2.5.3 Surface Water and Navigation Channels

Based on aerial photography and field reconnaissance, 60 percent of groundcover in the study area consists of surface and groundwater, and floodplains, including the GIWW, SNWW, and adjacent marshes.

Several rivers and lakes cross the Chenier Plain from north to south and divide it into six fairly distinct drainage basins. The southeastern Gulf Coast of Texas is in the East Bay Basin of Galveston Bay and the Sabine Basin (Gosselink et al. 1979). The focused study area is within the Sabine Basin. Salt Bayou drains most of the focused study area from west to east through Star Lake, Clam Lake and on to the GIWW or the SNWW via Keith Lake Fish Pass. Before the construction of the GIWW, Keith Lake Fish Pass and the SNWW, Salt Bayou was a tributary of Taylors Bayou, which flowed eastward from their confluence to its outlet in Sabine Lake. The southeast portion of the focused study area drains west to east by the Texas Bayou and several man-made canals and ditches to the SNWW.

Major streams in Jefferson County include the Neches River, which drains the eastern part of the county and flows into Sabine Lake; Pine Island Bayou, which forms the northern boundary of the county and flows into the Neches River; Taylor Bayou and its principal tributaries, Hillebrandt and Bill Hill Bayous, which drain the western part of the county and flow into Sabine Lake south of Port Arthur; and Spindletop and Salt Bayous, which drain the southern part of the county and flow into the GIWW.

The focused study area is in and near the Sabine-Neches Estuary. The estuary includes Sabine Lake, the Sabine-Neches and Port Arthur Canals, and Sabine Pass, and covers about 100 square miles. In the estuary, freshwater from the Sabine and the Neches Rivers meets saltwater from the Gulf of Mexico. Although it is influenced by tide, the inland location of the estuary protects it from the full force of Gulf waves and storms. The estuary is important for fish, shellfish, and wildlife habitat and sport and commercial fishing.

Sabine Lake is a natural water body on the Texas and Louisiana border about seven miles from the Gulf. According to the Sabine River Authority, the surface area of the lake is roughly 54,300 acres, making it one of the smallest estuaries on the Texas Coast. The lake supports extensive coastal wetlands around much of its perimeter including the focused study area. Its small volume coupled with large freshwater inflows from the Sabine and Neches Rivers cause it to turnover around 50 times per year.

Sabine Lake connects to the Gulf of Mexico via Sabine Pass, a seven-mile long tidal inlet between the Gulf and the southern end of the lake. Historically, Sabine Pass was a narrow, shallow waterway; however, in the latter part of the 19th century, engineers constructed a ship channel (the SNWW) through the pass and lake that enables deep draft navigation to inland terminals on Sabine Lake. Since then, the SNWW has been expanded in length, depth, and width, and extended into the Neches and Sabine Rivers. Today, Sabine Pass connects Gulf mariners to several of the busiest ports in the U.S. – the Port of Beaumont and Port of Port Arthur along with numerous private dedicated terminals.

The focused study area also includes all areas from the shoreline to 1.0 mile into the Gulf, which is part of the territorial seas of Texas.

2.5.3.1 Wetlands

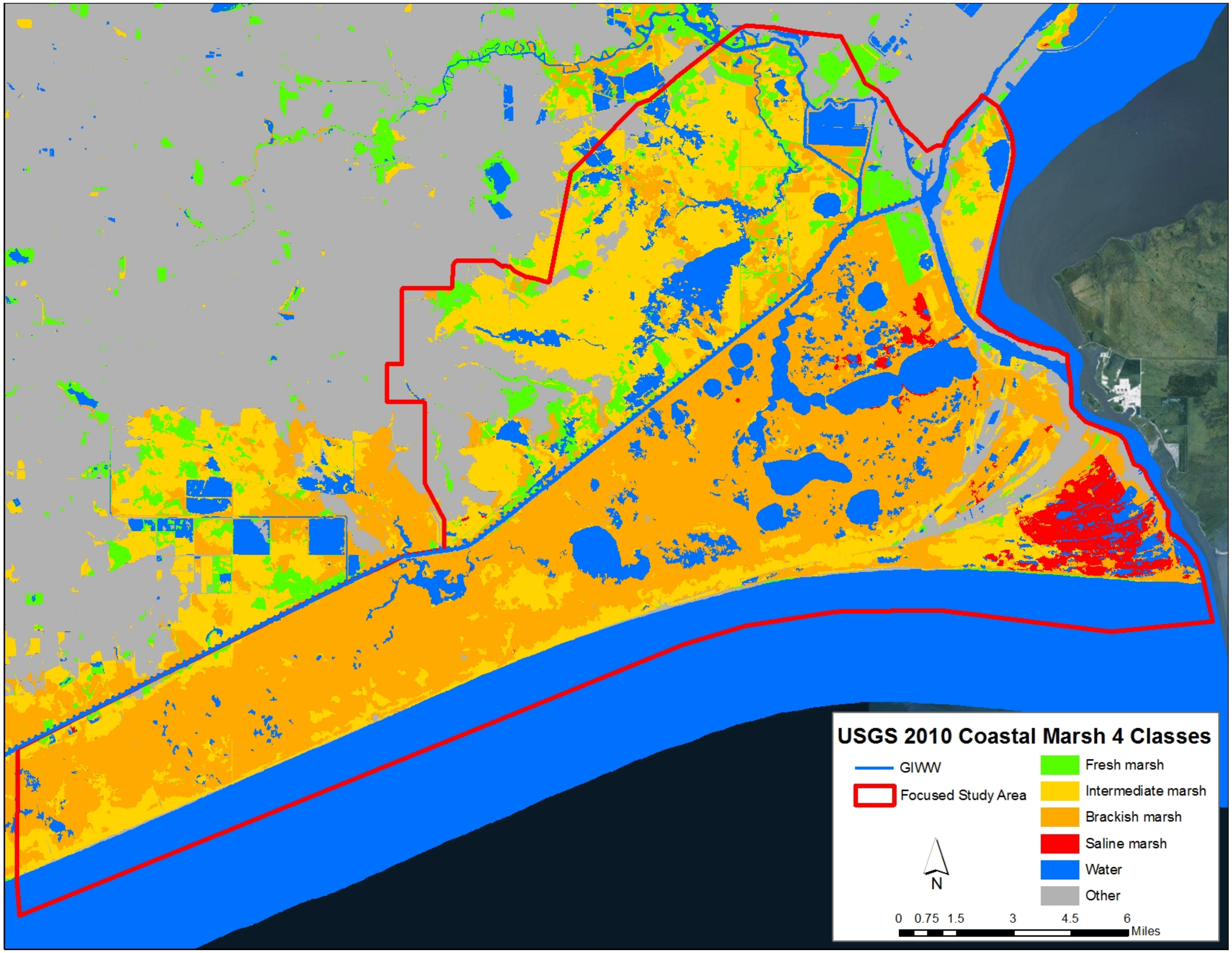
Wetlands are often defined as areas where the frequent and prolonged presence of water at or near the soil surface drives the natural system including the type of soils (i.e. hydric soils) that form, the plants that grow and the fish and/or wildlife that use the habitat. Most of the focused study area is tidally influenced, which creates situations in which the soil surface is frequently inundated and contributes to the hydric soils and vegetation found throughout. Vegetation composition consists of wetland species, such as cordgrasses, saltgrasses, rushes, and submerged and floating-leafed plants such as American lotus (*Nelumbo lutea*), duckweed, and fanwort, that are compatible to the salinity levels found in that area. Species composition is further described in Section 2.7.1.

Numerous agencies have mapped the wetlands in the study area but the following three are usually the most widely accepted: US Fish and Wildlife Service (USFWS) National Wetland Inventory (NWI) (USFWS 2014); TPWD Ecological Mapping System—Western Gulf Coastal Plains (TPWD 2009); and US Geological Survey (USGS) Delineation of Marsh Types from Corpus Christi Bay, Texas to Perdido Bay, Alabama, in 2010 (Enwright 2015). In this particular portion of eastern Texas, the USFWS has identified several errors in the NWI wetland maps and have recommended that the maps not be used until they can be corrected. A similar issue exists for the study area with the TPWD land cover mapping and has therefore not been used in analyzing wetlands. The resource agencies recommended that the PDT utilize the USGS data as the baseline for the most current wetland types and locations in the study area.

Based on the USGS data, there are four wetland types in the study area (Figure 2-2) including:

- Salt marsh: restricted to a narrow zone immediately adjacent to the shoreline of the Gulf of Mexico and associated bays; has the greatest daily tidal fluctuation of the four marsh types and has a well-developed drainage system; water salinity averages 18 parts per thousand (ppt), which leads to a marsh type that supports the least diverse vegetation; vegetation typically consists of cordgrass and saltgrass species
- Brackish marshes: grade inland from salt marsh and are found at the fringes of large water bodies and behind the beach barriers; also subjected to daily tidal action, but also receives some freshwater influence, and its water depths normally exceed that of salt marsh; water salinity ranges from 5.0 to 18.0 ppt with an average of about 8.0 ppt; plant diversity is greater than that of salt marsh
- Intermediate marshes: grade inland from brackish marsh and dominate interior marshes; subjected to periodic pulses of salt water; maintain a year-round salinity in the range of 3 to 4 ppt; the diversity and density of plant species are relatively high
- Freshwater marshes: lie between the intermediate marsh and the coastal prairies and dominate in upstream reaches of the Neches River; normally free of tidal influence with relatively slow drainage; maintains a year-round average water salinity of 0.5 to 1.0, and rarely increases above 2.0 ppt; supports the greatest diversity of plants, with local species composition governed by frequency and duration of flooding, topography, substrate, hydrology, and salinity.

Figure 2-2 USGS Four Marsh Types Vegetation Mapping in the Study Area



2.5.3.2 Waters of the US

The Clean Water Act (33 U.S.C. § 1251 et seq.) requires Federal agencies to protect waters of the U.S. The regulation implementing the Act disallows the placement of dredged or fill material into water unless it can be demonstrated that there are no practical alternatives that are less environmentally damaging. The sections of the Clean Water Act that apply to this study include Section 401 regarding discharges to waterways and 404 regarding fill material in waters and wetlands.

A formal wetland delineation following the 2010 Regional Supplement to the Corps of Engineers Wetland Delineation Manual: Atlantic and Gulf Coastal Plain Region was not completed. Based on the characteristics of jurisdictional wetlands in the guidance, the available information (e.g. USGS, TPWD, and NWI Mapping, proximity to navigable rivers, interstate waters, territorial seas, hydrology, and soil types) is sufficient to make are considered jurisdictional WOTUS.

A more detailed description of each jurisdictional water type can be found in:

- Navigable Waters: section 2.10
- Interstate Waters and Territorial Seas: 2.5.3
- Wetlands: sections 2.5.3.1 and 2.7.1
- Floodplains: section 2.5.1

2.5.4 Groundwater

Jefferson County overlies the Gulf Coast Aquifer. In Texas, the aquifer parallels the Gulf coastline from Louisiana to the border of Mexico, and contains various interconnected layers, some of which are aquicludes (impervious clay or rock layers). From bottom to top, the four main water-producing layers are the Catahoula, Jasper, Evangeline, and Chicot with the Evangeline and Chicot being main sources of fresh groundwater in the region. The maximum total sand thickness of the Gulf Coast Aquifer ranges from 700 feet in the south to 1,300 feet in the north. Freshwater saturated thickness averages about 1,000 feet.

The principal source of fresh groundwater in Jefferson County is precipitation. Most precipitation runs off and becomes streamflow or evaporates immediately. Only a small fraction of rainfall infiltrates to the aquifer's zone of saturation. A large percentage of the water that reaches the zone of saturation rapidly returns to the surface as spring water, which supports the base flow of area streams.

The availability of groundwater sources for domestic supply or recreational use throughout a majority of the study area is limited due to saltwater intrusion, which is a significant source of natural contamination, especially in the deeper Gulf Coast aquifer layers, because of the proximity to the Gulf. Under normal conditions, a layer of salt water underlies the lighter freshwater layer with a well-defined interface between the two layers. At any point, especially near the coast, deeper aquifers may be filled with salt water, very shallow aquifers may contain all freshwater, and an intermediate aquifer may be contained in the interface between the two.

2.5.5 Water Quality

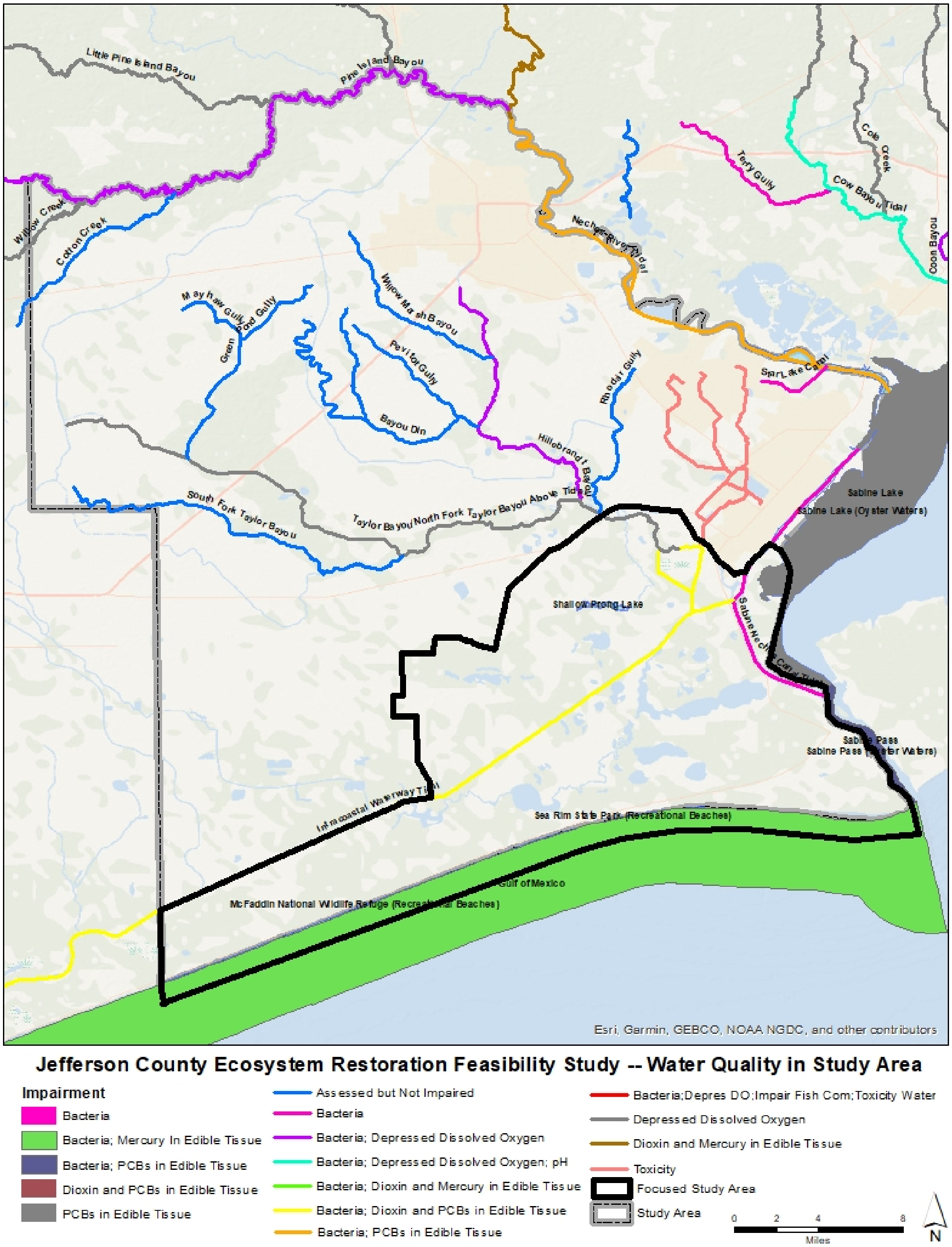
Section 305(b) of the Clean Water Act (CWA) requires states to assess surface and ground water quality and prepare comprehensive reports documenting water quality, which states submit to the USEPA biannually. In addition, Section 303(d) of the CWA requires states to prepare a list of impaired waters based on Total Maximum Daily Loads of pollutants and specify corrective actions. The Texas Commission of Environmental Quality enforces state water quality standards and prepares the state's comprehensive report for submittal to USEPA.

Surface water quality in Jefferson County is influenced by industrial and agricultural practices and saltwater intrusion. Movement of saltwater from the Gulf and bays inland through bayous and marsh systems varies depending upon tides, storms and storm runoff. Channel construction including the GIWW and channelization of natural waterways have facilitated saltwater moving further inland than what has occurred historically or what would occur under natural conditions. Levels and impacts of saltwater intrusion vary by area.

Based on the 303(d) list, seven areas are impaired in Jefferson County. There are high levels of depressed dissolved oxygen concentrations in Taylor Bayou east of the J.D. Murphree WMA along the eastern study area boundary, and in Hillebrandt Bayou north of J.D. Murphree. Taylor Bayou is a natural body of water sensitive to pollutant loading because of hydrological modifications in the form of channelization and construction of a saltwater barrier. Extremely sluggish flow conditions, low atmospheric reaeration capabilities, and point source discharges from Beaumont and Port Arthur compound the problem. Other problem areas include Hillebrandt Bayou (elevated ammonia nitrogen) and Alligator Bayou (toxicity in sediment). Star Lake Canal, the GIWW, Sabine-Neches Canal Tidal and the Gulf of Mexico have been classified as impaired due to high levels of *Enterococcus bacteria* (TCEQ 2015), an indicator of possible presence of pathogenic (disease-causing) bacteria, viruses, and protozoans that could present a health risk during recreational activities or consumption of shellfish (Figure 2-3).

Oil spills, leaks, and contamination from oil production and transport (active wells, pipelines, petrochemical shipping in the GIWW), aerial deposits of airborne contaminants from area refineries, point source pollution from upstream facilities such as landfills, and non-point source pollution from storm water run-off from municipal and industrial developments have intermittently contributed to temporary degraded surface water quality. When identified point-source contaminations occur, the responsible party has cleaned up the site per TCEQ and EPA standards. For non-point source pollution, such as rice cultivation, the level of pollution is such that dilution through precipitation and tidal exchanges does not cause the contamination to rise to a level of concern warranting clean-up. Cumulatively, these incidents, along with natural and other human-influenced causes of poor water quality, contribute to impaired waters. For 303(d) listed waters, TCEQ has assigned them to one of five categories which indicate the status of water quality in the assessment area. All impaired waters in the study area have been assigned a 5b or 5c rating. 5b indicates that an evaluation of the water quality standards is necessary, while 5c indicates additional data collection and/or evaluation to better characterize the impairment is necessary before a management strategy can be selected.

Figure 2-3: Water Quality in the Jefferson County Ecosystem Restoration Study Area



2.6 Geologic Resources

Geological resources are defined as the topography, geology, soils, and mining of a given area. Topography describes the physical characteristics of the land such as slope, elevation, and general surface features. The geology of an area includes bedrock materials and mineral deposits. Mining refers to the extraction of resources (e.g. gravel). The principal geologic factors influencing the stability of structures are soil stability, depth to bedrock, and seismic properties. Soil refers to unconsolidated earthen materials overlying bedrock or other parent material.

The existing physiography, soils, and geomorphology of the region are a result of complex interactions of hydrological, meteorological, and geological processes that occurred during two epochs of the Quaternary period. River, Gulf and subsurface aquatic systems are the primary medium for transporting and mixing sediments and nutrients. Rivers transport sediments and nutrients from inland catchment basins to the mixing and receiving basins of the estuaries, marshlands, and the Gulf of Mexico. The main source of sediment for the Chenier Plan region was reworked former delta sediments of the Mississippi River, combined with sediments of adjacent active distributaries (channels) of the Mississippi. In the focused study area, sediments were also supplied by the Sabine, Neches, and Trinity rivers. Depositional and erosional processes have resulted in land gain or loss through time.

2.6.1 Topography

The landscape is basically flat, with marsh elevations throughout the study area presently hovering just above sea level (about 0.0 to 1 foot mean sea level). Topographic highs of a few inches to a few feet are generally limited to spoil mounds along dredged channels, or in abandoned placement areas, elevated roads and cattle trails, and impoundment or barrier levees.

2.6.2 Geology

During the last Ice Age, the coastal shoreline moved seaward and then retreated inland depending on the erosional and depositional forces and shifting sea levels. During the onset of the Ice Age, the sea was dramatically lower, approximately 440 feet below its present level (Gould 1970). The shoreline was approximately 124 miles seaward of its present position which exposed Pleistocene surface sediments to erosion and weathering. Coastal streams cut valleys into the Pleistocene sediment. As glaciers retreated and sea levels rose, sand, silt and clay sediments were deposited along the coast. The shoreline gradually migrated landward of its present location as evidenced by the inland locations of former beach ridges of the Recent age. The ridges represent paleo shorelines that evolved during the highstand (interval where sea level lies above the continental shelf edge) in sea level. Because sediment supply was abundant as sea levels reached its present level 3,000 to 4,000 years ago, the shoreline advanced seaward of its present location. As sediment supply decreased, the shoreline began retreating and is still eroding today.

The coastal water bodies such as Sabine Lake resulted from the submergence of relic Pleistocene entrenched valleys (Fish 1944). Marsh ponds enlarged when salinity changed or other stresses interrupted the marsh building process and gradually evolved into small lakes. Many irregular shaped lakes represent old river or tidal stream courses that were abandoned.

The geologic formations in the focused study area are divided into three groups according to age: 1) Recent, 2) late Pleistocene or early Recent, and 3) Pleistocene. The geologic substrate of the Chenier Plain region is primarily composed of sediments deposited during the late Recent epoch with some subsurface Pleistocene outcroppings. These deposits are overlain at the coast by a geologically recent series of inland ridges representing stranded beaches that align parallel with the coast. Accumulation of fine-grained sediment deposited between these multiple beach ridges formed marshes and mudflats. Tidal channels lie between successive ridges. The shore of the coast is formed by a narrow beach or washover terrace developed over time through the deposition of sand and shell. The coastline is breached by inlets that connect estuaries extending inland up river valleys.

The Chenier Plain Region is part of the recent geologic plain that is unique to the focused study area. It is characterized by ridges composed of sand and shell fragments aligned parallel to the Gulf shoreline. These ridges originated from accumulations of sand sized particles deposited near river mouths that were reworked by waves and currents into multiple bars or ridges that formed concave seaward. The chenier ridges at the historic mouth of the Sabin River are an example of this process. Away from the river mouth, cheniers represent ancient beach ridges that were formed through erosion processes along sections of the coast undergoing coastal retreat. Storm surges and wave action eroded existing beachfronts and nearshore deposits and deposited them inland over marsh and bay deposits forming the cheniers (Gosselink et al. 1979). Given the region's significant annual rainfall, wetlands isolated from the Gulf by the cheniers developed into highly productive freshwater coastal marsh habitats.

2.6.3 Soils

Most soils within the focused study area are remnants of ancient floodplains and Gulf beaches and consist of old alluvium and marine sediment deposited by ancient streams and the Gulf. These deposits are mostly clayey and sandy soils and exhibit a wide range in textural differences due to their origin within historic floodplain systems. The soils types, both acidic and alkaline, are poorly drained with slow permeability, moderate to high salinity, and a high shrink-swell potential (NRCS 2006).

Three principal soil associations are found throughout the focused study area including: Morey-Crowely-Hockley Association consisting of silty soils of the coastal prairie; Harris-Made Land Association comprised of clay soils of the coastal marsh and spoil from dredging and similar operations; and the Sabine-Coastal Land Association consisting of mixed soils of the coastal prairies and coastal marshes. Within the marsh areas, the most prevalent soil association is the saline Harris-Made land association found within intermediate, brackish, and saline marsh habitats. These areas consist of broad flats covered with salt tolerant vegetation. The flats are occupied mostly by Harris soils. Other wetland soils located in pockets consist of the Crowley-Waller complex. Both Crowley and Waller soils series are level, deep, poorly drained, loamy soils which have mottled lower layers and moderately high available water capacity. Salt prairie habitats are underlain with both natural soils which are deep moderately saline clays, and the Made land soils, which are stratified clay and loamy materials that have been excavated from canals, ditches, and bayous. These soils are affected by salt spray, storm tides, and salty high water tables restricting the kind and density of plants present.

Coastal land soils are found on the lower slopes of sandy ridges and along the Gulf. These soil types form the Sabine-Coastal land association. The shoreline is made up of Sabine-Coastal land association and Saltwater marsh-Tidal association. Coastal soils generally consist of deep, dark colored and slightly acidic sands. As remains of ancient Gulf of Mexico beaches, they are relatively low in nutrients. Specifically, the coastal soils differ dramatically in pH, color, texture, available water capacity, and drainage.
The Gulf beaches are composed primarily of tidal marsh and Galveston fine sand which have virtually no organic matter, are excessively drained, and have a low available water capacity. The Gulf beach has a high percentage of shell material, reflecting a recent scarcity of sand. Clay outcroppings from the underlying strata are exposed along large areas following erosive events such as hurricanes, tropical storms, and winter frontal passages.

Upland habitats (prairies and coastal ridges) are composed of the well-drained Sabine soils (predominantly acid Moray silt loam, Anahuac silt loam, and saline Veston loam).

2.6.3.1 Prime or Unique Farmlands

There are no prime or unique farmlands within the focused study area.

2.6.4 Coastal Erosion

Jefferson County has a long history of coastal erosion from natural processes (e.g. wind and wave energies; hurricanes and tropical storms; storm surge; natural river migration that alters sediment flows; natural transport gradients due to wave conditions, coastline curvature or bathymetric features; etc.) and human-induced changes (e.g. dredging; construction of shoreline protection features and navigation structures; alteration of tidal inlets and riverine systems; etc.). Figure 2-4 and Figure 2-5 show long-term and more recent shoreline change rates along the county's coast. Averaged spatially and temporally, the erosion rate between about 1930 and 2012 in Jefferson County is 3.34 meters per year (10.95 feet per year), which corresponds to an aerial loss rate of 43 acres per year. Shoreline erosion, and accompanying land loss, have been more intense when the temporal average is restricted to a more recent period. In 2000 through 2012, it was 5.18 meters per year (17 feet) and 67 acres respectively (Paine et al. 2014). In both scenarios, accretion has occurred in the middle of the county along the Sea Rim State Park shoreline primarily due to wave diffraction and associated littoral processes attempting to straighten the shoreline which has been altered due to the presence of the Sabine Pass Jetties. The Sabine Pass Jetties interrupt the longshore transport through the eastern half of the study area causing a sediment trap at the east side fillet of the jetty.

Figure 2-4: Long-term shoreline change rate through Jefferson County, Texas (1930 through 2012)

Figure 2-5 Shoreline Change in Jefferson County, Texas (2000 through 2012)

2.6.5 Mineral Resources

Oil and gas exploration and development has occurred within Jefferson County for over 100 years. The famous Spindletop Oilfield, discovered on a salt dome formation south of Beaumont in the eastern part of the study area, marked the birth of the modern petroleum industry.

In Jefferson County, the Railroad Commission of Texas reports 762 oil and gas wells in Jefferson County, as of September 2016 (RRC 2016). Of these 502 were related to oil production and 260 were related to natural gas production. There are approximately 15 active oil, gas, and oil/gas wells located off the Gulf coast within the three nautical mile line. The closest well is approximately 0.2 miles from the coast of Texas Point NWR, while the majority of the wells are located between 1.5 and 2.0 miles offshore. South of the GIWW, there are two main development areas, one north of Clam Lake on McFaddin NWR and a second north of Mud Lake within the J.D. Murphree WMA. It does not appear that there are any exclusive gas wells south of the GIWW.

North of the GIWW, oil and gas wells are mainly located north of the marshes and confined to the Big Hill Oil Field north of Fisher Reservoir, Spindletop south of Beaumont, and unnamed fields east of Beaumont and south of the Lower Neches Valley Authority Canal, and from east of the Town of Hamshire to just west of the Town of Winnie; however, there are numerous active, abandoned and plugged wells scattered throughout the entire county.

Each active well typically has an associated well pad that ranges in size from less than 0.1 acres to over 5 acres in size and may be sparsely vegetated to completely cleared and dressed in soil cement or gravel. Each well also has an associated access road used to develop and monitor the well and remove produced liquids from the site. When hydrocarbons are not trucked from the site, they are moved through one of the thousands of miles of pipelines that have been constructed and buried on the landscape throughout the study area, including under navigation channels, rivers, and lakes and through marshes.

2.7 Biological Resources

Biological communities include plants and animals and the habitats in which they occur. They are important because: (1) they influence ecosystem functions and values; (2) they have intrinsic value and contribute to the human environment; and (3) they are the subject of a variety of statutory and regulatory requirements.

2.7.1 Habitats

Jefferson County is in the Gulf Coast Prairies and Marshes ecoregion characterized as a nearly level, slowly drained plain in area less than 150 feet in elevation, and dissected by streams and rivers flowing into the Gulf. Other defining characteristics include:

- Barrier islands along the coast;
- Tidal, micro-tidal and freshwater marshes surrounding bays and estuaries;
- Tidal flats and reef complexes;
- Remnant tallgrass prairies including small depressional wetlands;
- Oak parklands and oak mottes scattered along the coast; and,
- Tall woodlands in the river bottomlands.

Native vegetation consists of tallgrass prairies and live oak woodlands. Brush species such as mesquite and acacias are more common now than in the past. Although much of the native habitat has been lost to agriculture and urbanization, the region still provides important habitat for migratory birds and spawning areas for fish and shrimp.

On a finer scale, Jefferson County lies in the Chenier Plain. Geographically, the Chenier Plain region extends from Vermillion Bay in southwestern Louisiana to East Galveston Bay in southeast Texas. Chenier plains were once shoreline that ran parallel to the Gulf or as alluvial deposits at the mouths of rivers. The Chenier Plain is characterized by a prograding coastline replenished by sediments carried to the Gulf initially by the Mississippi River and subsequently by the Atchafalaya and other rivers. Cheniers formed when coastal processes accreted and eroded along the shore over time creating alternating ridges separated by marshlands. Higher cheniers support woody vegetation, while mudflats isolated from Gulf waters support diverse freshwater coastal habitats. Jefferson County has the largest remaining cheniers in Texas.

There are seven main biological communities found in the focused study area including: dunes and beaches; coastal marshes, coastal prairies, agricultural lands, inland open waters, oyster reefs, and offshore habitats. Additional information on each of these communities can be found in the Fish and Wildlife Coordination Act Planning Aid Letter in Appendix A-1.

Outside of the focused study area, but within the study area two additional biological communities exist including forested wetlands and upland forests and coastal woodlots. Upstream of the coastal marshes, the study area is dominated by dense bottomland hardwood forests and cypress-tupelo swamps. These wetland forests cover an intricate networks of sloughs and sandy ridges formed within the rivers' relict meander belts that provide medium to high value for food and cover to resident and migratory fish and wildlife. Upland forests and coastal woodlots generally occur on higher elevation uplands that contain acidic soil conditions and are composed of mixed hardwood species, primarily loblolly (*Pinus taeda*) and slash pine (*P. elliottii*).

2.7.1.1 Beach and Dune Vegetation

Beaches are the transition from land to sea. In the lower portion of the beach where sediments are covered frequently by water, aquatic organisms thrive. However, in areas at and just above the high tide zone, conditions are particularly harsh. The lack of water makes life difficult for aquatic or terrestrial species, and the dry sand is easy to heat and cool, resulting in strong swings in temperature. In oceanfront dunes, this high beach area also experiences strong swings in salinity, from highly saline conditions during dry weather caused by salt spray being concentrated by evaporation, to being diluted of salt during intense rains. As a consequence, except in specialized habitats (such as the wrack line, where rotting organic material forms both food and a mechanism for water storage), very few animals and no true plants can live in this zone.

In the wrack zone (base of supratidal zone), a small oasis of life in the otherwise dry and barren sand forms. Here, the debris (e.g. seashells, animal remains, decomposing seaweed and sea grasses, and other materials) left by the high tide forms a narrow band along the shore. The rich organic content of this area provides a reservoir of water and food for the animals found in this area. Species present are usually cryptic species that emerge from the sand at night or when the tide is high, but only in the small number of areas where a significant sand veneer is present over the clay ridges. Some of the species include: crabs, sand hoppers/beach fleas, worms, beetles, spiders, and flies.

Because of the abundance of arthropods and worms, the wrack zone is prime foraging habitat for shorebirds. Shorebird counts are conducted along the Texas Coast between March 22 and May 17 during two week intervals. The most abundant species observed are typically American avocet (*Recurvirostra americana*), western sandpiper (*Calidris mauri*), long-billed and short-billed dowitchers (*Limnodromus scolopaceus* and *L. griseus*, respectively), semipalmated sandpiper (*C. pusilla*), pectoral sandpiper (*C. melanotos*), black-bellied plover (*Pluvialis squatarola*), dunlin (*C. alpine*), sanderling (*C. alba*), willet (*Catoptrophorus semipalmatus*), semi-palmated plover (*Charadrius semipalmatus*), least sandpiper (*C. minutilla*), and snowy plover (*Charadrius alexandrines*). Common nesting shorebird species include the willet, killdeer (*Charadrius vociferous*) and black-necked stilt (*Himantopus mexicanus*). Colonies of nesting birds including least terns (Sterna antillarum) and black skimmers (*Rynchops niger*) occur on beaches and washover terraces. Nesting Kemp's ridley sea turtles historically nested on beaches in Jefferson County, but have not been documented recently presumably due to the lack of beach and dune habitat.

Texas beaches change shape regularly and move landward (retreat) or seaward (advance) in response to wind, waves, currents, the short and long-term relativel sea level rise, and the supply of sand. However, in the focused study area, short-term changes can be variable and long-term changes, combined with a well-documented lack of coarse-grained sand supply, and long-term sea level rise generally creates a long-term retreat scenario. Shoreline retreat has accelerated from historic rates of -20 feet per year to as much as -40 feet per year in some parts of the focused study area.

The backbeach and dune is a more productive habitat than other areas in the shoreline system from a vegetative standpoint. Both contain a mosaic of salt-tolerant plants, which are adapted to shifting sands, high winds, and rising waters. These plants help form dunes by trapping wind-blown sand, while their roots help stabilize the dunes and protect the dune from erosion. Species found growing here include seapurslane (*Sesuvium portulacastrum*), saltmeadow cordgrass/ marshhay cordgrass, (*Spartina patens*), bitter panicum (*Panicum amarum*), Virginia dropseed (*Sporobolus virginicus*), white morninglory (*Ipomoea stolonifera*), camphor daisy (*Rayjacksonia phyllocephala*) goat-foot morninglory (*I. pes-caprae*), glassworts (*Salicornia spp.*), sea-lavender (*Limonium carolinianum*), and busy sea-ox-eye (*Borrichia frutescens*).

The beach ridge that separates the Gulf from interior marshes historically was sufficiently high enough to prevent sea water inundation from the Gulf of Mexico with the exception of significant storm surge episodes associated with tropical storms and hurricanes. The frequency of such inundation was on the order of years to a decade or more. However, the frequency of storms producing significant wave energies has increased exacerbating the eroded shoreface and exposed clay pan. Because this area is sand starved, normal non-storm wave energies meant to nourish the beach continues to erode the shoreface.

The historic dune system has been removed over the years by ongoing annual erosion, unseasonably high tides, and large-scale storm events and hurricanes, which has resulted in the loss of approximately 54% of the dune system leaving approximately 12 miles dunes. In 2008, Hurricane Ike flattened much of the remaining beach ridge and moved a significant amount of sand outside the active profile reducing the dune crest to an elevation that now routinely allows sea water inundation into the formerly fresh and brackish marsh.

2.7.1.2 Inland Open Water Habitats

Inland open water includes all water bodies inland of beaches and passes including estuaries, rivers, drainage ditches, navigation channels, tidal creeks, bayous, reservoirs, lakes, and ponds collectively. Inland open water habitats occur along a salinity gradient that ranges from below 0.5 parts per thousand (fresh) to over 25.0 parts per thousand (saline). Saline open water habitat is generally shallow and turbid and not likely to support any rooted vascular plants. Phytoplankton are the most likely plant or animal species to occur in this habitat. As salinity decreases, the potential for, and diversity of, vascular plants increases. Common vascular species include a number of rooted and floating aquatics such as wigeon grass (*Ruppia maritima*), several pondweeds (Potamogeton spp.), banana waterlily *(Nymphaea mexicana*), and American lotus (*Nelumbo lutea*). Salinity in inland open water habitats have a significant influence on plant and animal community composition. The salinity gradient supports high floral and faunal species.

The region's coastal fishery is a warm water fishery with moderate to high numbers of salt and brackish water species in the Gulf and large estuarine bay systems. Over 95 percent of marine organisms found in the Gulf depend on estuarine habitats (salt, brackish, and intermediate marshes) for survival, and estuaries are often referred to as "food pantries" for the ocean. Estuaries are the cornerstone of a very important commercial and sport fishing industry based on the harvest and sale of seafood. Millions of tons of penaid shrimp, crabs, finfish, oysters, clams, and other marine life depend on the biological richness afforded by estuaries. Segments of the estuarine habitats are also important nursery habitats for a variety of species, especially in their early life stages.

2.7.1.3 Coastal Wetlands (Marshes)

Jefferson County has a highly diverse coastal wetland community. Vegetative communities found in the area are indicative of saline, brackish, intermediate, and freshwater wetlands and marshes. Coastal marsh habitats provide important functions of improving water quality in the estuarine ecosystem, providing flood control benefits, and buffering inland habitats from tropical storm-generated tidal surges. In addition, marshes are extremely biologically productive and diverse and provide detrital input, which is the basis for the estuarine food chain.

Salt marsh in the study area is restricted to a narrow zone immediately adjacent to the Gulf and associated bays. Salt marshes experience the greatest daily tidal fluctuation of the four marsh types and have well-developed drainage systems. Water salinity averages 18 parts per thousand, which leads to a marsh type with the least diverse vegetation. Smooth cordgrass/oystergrass (*Spartina alterniflora*) typically dominate salt marshes, and are often accompanied by seashore saltgrass (*Distichlis spicata*), blackrush (*Juncus roemerianus*), saline marsh aster (*Symphiotrichum tenuifolium*) and marshhay cordgrass. Glasswort dominates high salt marshes where tidal inundation is less frequent.

Brackish marshes (salinity range of 5.0 to 18.0 ppt with an average of about 8.0 ppt) grade inland from salt marsh and are found at the fringes of large water bodies and behind the beach barriers. This marsh type is also subjected to daily tidal action, but also receives some freshwater influence, and its water depths normally exceed that of salt marsh. Water salinity ranges from 5.0 to 18.0 ppt with an average of about 8.0 ppt. Plant diversity is greater than that of salt marsh. The dominant species in low brackish marsh is saltmarsh bulrush (*Bolboschoenus robustus*), while seashore saltgrass and marshhay cordgrass are co-dominant species in high brackish marsh.

Intermediate marshes are subjected to periodic pulses of salt water and maintain a year-round salinity in the range of 3 to 4 ppt. They grade inland from brackish marsh and dominate interior marshes. The diversity and density of plant species are relatively high with marshhay cordgrass the most dominant species in high marshes. Co-dominant species in low marsh are seashore paspalum (*Paspalum vaginatum*), Olney bulrush (*Schoenoplectus americanus*), California bulrush/giant bulrush (*S. californicus*), and common reedgrass/Roseau cane (*Phragmites australis*); bulltongue (*Sagittaria lancifolia*) and sand spikerush (*Eleocharis montevidensis*) are also frequent. Submerged aquatics such as pondweeds and southern waternymph (*Najas guadalupensis*) are abundant in intermediate marsh.

Freshwater marshes lie between the intermediate marsh and the coastal prairies and dominate in upstream reaches of the Neches River. This marsh type is normally free of tidal influence and has year-round average water salinity of 0.5 to 1.0, and rarely increases above 2.0 ppt, with slow drainage. The greatest diversity of plants is supported by fresh marsh, with local species composition governed by frequency and duration of flooding, topography, substrate, hydrology, and salinity. Co-dominant species in low marsh are maidencane (*Panicum hemitomon*), giant cutgrass (*Zizaniopsis miliacea*), and bulltongue. Co-dominant species in high marsh are squarestem spikerush (*Eleocharis quadrangulata*) and marshhay cordgrass. Many submerged and floating-leafed plants are present in this marsh type. Other characteristic species include American lotus, watershield (*Brasenia schreberi*), duckweed (*Lemna spp.*), and fanwort (*Cabomba caroliniana*).

The full continuum of marsh types supports highly diverse and productive biological communities, and conservation of biological diversity in the study area is dependent on maintaining this continuum of wetland habitats. Plant and animal diversity is greater in the fresh and intermediate marshes than in the brackish and saline types. Intermediate marsh receives the highest use of any of the marsh types by wintering and migrating waterfowl and many wading bird species. Fresh, intermediate, and brackish marshes are extremely important to migratory waterfowl. The study area has been recognized as an important waterfowl habitat in the North American Waterfowl Management Plan for supporting hundreds of thousands of individuals of most species within the Central Flyway during the winter months. Brackish and saline marshes provide important year-round habitat for many shorebird and colonial-nesting waterbird species, and are the primary nursery habitat for larval and post-larval stages of many commercially and recreationally-important fish and shellfish species, including white and brown shrimp (*Litopenaeus setiferus and Farfantepenaeus aztecus*), blue crab (*Callinectes sapidus*), red drum (*Sciaenops ocellatus*), flounder (*Paralichthys ssp.*), and speckled sea trout (*Cynoscion nebulosus*).

Some of the more common mammals using coastal marshes include raccoon (*Procyon lotor*), river otter (*Lutra canadensis*), bobcat (*Lynx rufus*), nine-banded armadillo (*Dasypus novemcinctus*), swamp cottontail rabbit (*Sylvilagus aquaticus*), Virginia opossum (*Didelphis virginiana*), muskrat (*Ondatra zibethicus*), nutria (*Myocaster coypus*), coyote (*Canis latrans*), striped skunk (*Mephitis mephitis*), and feral hog (*Sus scrofa*).

Common reptiles include American alligator (*Alligator mississippiensis*), western cottonmouth (*Agkistrodon piscivorus*), speckled kingsnake (*Lampropeltis getula*), red-eared slider (*Trachemys scripta*), and snapping turtle (*Chelydra serpentina*). Amphibians are absent in the areas south of the GIWW within the focused study area due to impacts from tidal salinity exacerbation in former fresh and intermediate marshes. Common amphibians north of the GIWW include the pig frog (*Rana grylio*), southern leopard frog (*R. sphenocephala*), Gulf Coast toad (*Bufo valliceps*), and bullfrog (R. catesbeiana). The lesser siren (*Siren intermedia*) and three-toed amphiuma (*Amphiuma tridactylum*) are probably common though seldom-seen amphibians found in freshwater marshes.

Invertebrate populations are an essential food resource for migratory birds and estuarine fishery species. Various amphipods, midges, mysid shrimp, grass shrimp, crayfish, and numerous crabs are present within all marsh habitats in the focused study area. Some of these invertebrates occur in tremendous quantities. Mosquitoes, biting flies, chiggers, and imported fire ants (*Solenopsis invicta*) are also common. Common butterfly species include monarch (*Danaus plexippus*), little yellow (*Pyristitia lisa*), and Gulf fritillary (*Agraulis vanilla*e) butterflies. Common dragonfly species include the common green darner (*Anax junius*) and seaside dragonlet (*Erythrodiplax berenice*).

Native rangia clams (*Rangia cuneata*) historically occurred throughout the focused study area, thriving in intermediate and brackish marshes, but have been reduced in numbers by saltwater intrusion throughout the system. Periwinkle snails (*Littoraria irrorata*) are found in the salt marshes and in the brackish marsh with the higher salinity levels where smooth cordgrass has become established. Fiddler crabs (*Uca sp.*) are found from the high tide line in high marshes to the intertidal zone across portions of the project area.

2.7.1.4 Coastal Prairies

Coastal Prairies in the study area are located along the gulf coast just inland from the coastal marsh, typically north of the GIWW. The coastal prairie is similar in many ways to the tallgrass prairie of the Midwestern United States. It is estimated that, in pre-settlement times, there were nine million acres of Coastal Prairie, with over 6.5 million in Texas. Today, substantially less than one percent of the Coastal

Prairie remains with remnants totaling less than 65,000 acres in Texas. While much of the former prairie has been converted to pasture for cattle grazing, the majority has been altered for growing rice, sugarcane, forage, and grain crops. Fragmented remnants of the historic native tallgrass Coastal Prairie occur in the study area; however, most tracts are less than 100 acres in size and are privately owned, and are in danger of development or conversion to other kinds of agriculture.

Native salty prairie habitats are found on low-lying coastal ridges and flats which are slightly higher in elevation than the adjacent marshes. Plant communities typical of native salty prairie can also be found on elevated man-made features including dredged material disposal sites and levees. The dominant plant species is Gulf cordgrass (*Spartina spartinae*), while knotroot bristlegrass (*Setaria parviflora*), bushy bluestem (*Andropogon glomeratus*), seaside goldenrod (*Solidago sempervirens*), western ragweed (*Ambrosia psilostachya*), saltmarsh aster (*Symphyotrichum tenuifolium*), seepweed (*Suaeda spp.*), and bigleaf sumpweed (*Iva frutescens*) are common. Remnant native prairie species can be found on slightly drier, non-saline, upland sites. They occur on non-saline soils. Typical native prairie remnants in the study area are mid- and tallgrass species such as little bluestem (*Schizachyrium scoparium*), big bluestem (*Andropogon gerardii*), Indiangrass (*Sorghastrum nutans*), switchgrass (*Panicum virgatum*), brownseed paspalum (*Paspalum plicatulum*), Eastern gammagrass (*Tripsacum dactyloides*), and Gulf Coast muhly (*Muhlenbergia capillaris*). Numerous forbs, legumes, and one native shrub, southern wax myrtle, are also present.

Remnant tracts of tallgrass and salty prairie can still be found along the northern fringes of the focused study area and in other more northern parts of Jefferson County. These areas, just slightly higher in elevation than nearby marsh, provide important nesting, foraging, and migration habitat for waterfowl and thousands of other wildlife. Even in its altered state, the biological community routinely hosts red-tailed hawks (*Buteo jamaicensis*), red-shouldered hawk (*Buteo lineatus*), turkey vulture (*Cathartes aura*), American kestrel (*Falco sparverius*), white-tailed kite (*Elanus leucurus*), northern harrier (*Circus cyaneus*), short-eared owl (*Asio flammeus*), LeConte's sparrow (*Ammadramus leconteii*), seaside sparrows (*A. maritimus*), dickcissel (*Spiza americana*), and eastern meadowlark (*Sturnella magna*). Waterfowl, sandpipers, and other shorebirds are abundant during the fall, winter, and spring months, paralleling and often surpassing other regions with longstanding traditions as crucial stopover areas for these species.

2.7.1.5 Agriculture

Agricultural lands account for 353,971 acres in Jefferson County, with rice fields and pastureland as the primary upland habitat in the study area (USDA 2012). Conversion of native habitats to agricultural uses has occurred on most lands that were capable of supporting these uses.

Rice production requires seasonal flooding that creates emergent wetland habitat used by many avian species and other wildlife during spring and summer. During fall and winter, flooded rice stubble and rice fallow, plowed fields, water leveled fields, weedy fields, ryegrass fields, and pastureland provide habitat for wintering and migrating waterfowl, shorebirds, and wading birds.

Disturbed agricultural and pasturelands, particularly abandoned fields, are extremely susceptible to invasion by exotic plants including Chinese tallowtree (*Triadica sebifera*) and deep-rooted sedge (*Cyperus entrerianus*), which outcompete native plants and decrease habitat value for most native wildlife species.

2.7.1.6 Oyster Reefs

Eastern oyster reefs are present in several areas of the southern portion of Sabine Lake and Keith Lake, and provide ecologically important functions. Oyster reefs are formed where a hard substrate and adequate currents are plentiful. Currents carry nutrients to the oysters and take away sediment and waste filtered by oyster. Most oyster reefs are subtidal or intertidal and found near passes and cuts, and along the edges of marshes. Oysters can filter water 1,500 times the volume of their body per hour which, in turn, influences water clarity and phytoplankton abundance. Due to their lack of mobility and their tendency to bioaccumulate pollutants, oysters are an important indicator species for determining contamination in the bay.

Many organisms, including mollusks, plychaetes, barnacles, crabs, gastropods, amphipods, and isopods, can be found living on the oyster reef, forming a very dense community. Oyster reefs are dependent upon food resources from the open bay and marshes. Many organisms feed on oysters including fish, such as black drum (*Pogonias cromis*), crabs (*Callinectes spp.*), and gastropods such as the oyster drill (*Thais haemastoma*). When oyster reefs are exposed during low tides, shore birds use the reef areas as resting places.

Oysters are not commercially harvested from inland waters of the study area. The Texas Department of State Health Services has not designated any areas in the study area as Restricted, Conditionally Approved, or Approved; therefore, all waters in the study area are prohibited or closed for harvesting mollusks.

2.7.1.7 Offshore Habitats

The southern boundary of the focused study area includes offshore habitats found in the Gulf of Mexico. The nearshore is predominantly composed of coarse sediments, while fine sediments are found in the deeper areas beyond the 260-foot contour (GMFMC 2004). Sediment type plays an important role in determining community structure. Each species has optimal habitat and tolerance limits regarding sediment particle size and chemical composition that influences the distribution of fauna in nearshore waters (Britton and Morton 1989).

There are few seagrasses or attached algae found in the offshore sands due to the strong currents and unstable sediments. Most of the bottom surface is populated with macroinfauna such as an occasional hermit crab (Paguroidea), portunid crab (Portunidae), or ray (Batoidea). Even though there is little life on the sand surface itself, the overlaying waters are highly productive. Phytoplankton are abundant, including microscopic diatoms, dinoflagellates, and other algae. Several species of crustaceans, bivalves and gastropods are found in offshore sands. One of the most common species occurring in shallow offshore sands is the sand dollar (*Mellita quinquiesperforata*) and several species of brittle stars (Ophiuroidea). The most abundant infaunal organism, with respect to the number of individuals, are the polycaetes (Capitellidae, Orbiniidae, Magelonidae, and Paraonidae).

Two types of artificial reefs exist in the Gulf, those structures placed to serve as oil and gas production platforms and those intentionally placed to serve as artificial reefs. Artificial reefs are not believed to exist in the study area, but both types are found just south of the study area boundary. Artificial reefs are colonized by a diverse array of microorganisms, algae, and sessile invertebrates including shelled forms (barnacles, oysters, and mussels), as well as soft corals (bryozoans, hydroids, sponges, and octocorals) and hard corals (encrusting, colonial forms). These organisms provided habitat and food for many motile invertebrates and fishes.

Five species of sea turtles are found in the Gulf of Mexico waters south of the focused study area: leatherback (*Dermochelys coriacea*), hawksbill (*Eretmochelys imbricata*), loggerhead (*Caretta caretta*), green (*Chelonia mydas*), and Kemp's ridley (*Lepidechelys kempii*). Offshore waters are important feeding, resting, and migratory corridors for each of the species.

2.7.2 Protected and Important Habitats

2.7.2.1 Essential Fish Habitat

Congress enacted amendments to the Magnuson-Stevens Fishery Conservation and Management Act (MSFCMA) in 1996 that established procedures for identifying Essential Fish Habitat (EFH) and required interagency coordination to further the conservation of federally managed fisheries. Rules published by the National Marine Fisheries Service (50 CFR Sections 600.805 - 600.930) specify that any federal agency that authorizes, funds or undertakes, or proposes to authorize, fund, or undertake an activity that could adversely affect EFH is subject to the consultation provisions of the above mentioned act and identifies consultation requirements. This environmental assessment was prepared to serve as the EFH assessment.

EFH are habitats necessary for spawning, breeding, feeding, or growth for maturity of species managed by Regional Fishery Management Councils, as described in a series of fishery management plans, pursuant to the Act. The focused study area provides EFH for:

- Larval, juvenile, and adult: Brown Shrimp (*Penaeus aztecus*), white shrimp (*P. setiferus*), red snapper (*Lutjanus campechanus*), lane snapper (*L. synagris*), greater amberjack (*Seriola dumerili*) and cobia (*Rachycentron canadum*);
- Juvenile: vermillion snapper (*Rhomboplites aurorubens*), Warsaw grouper (*Epinephelus nigritus*), and Wenchman snapper (*Pristipomoides aquilonaris*);

- Juvenile and adult: red drum (*Sciaenops ocellatus*), Almaco jack (*Seriola rivolana*), gray triggerfish (*Balistes capriscus*), king mackerel (*Scomberomorus cavalla*), Spanish mackerel (*S. maculatus*), gulf stone crab (*Menippe adina*), gag grouper (*Mycteroperca microlepis*) and scamp (*Mycteroperca phenax*); and,
- Adult: gray snapper (*L. griseus*).

Categories of EFH in the study area include:

- Estuarine Areas: estuarine emergent marsh, submerged aquatic vegetation, hard bottom, and mud and soft bottoms; and,
- Marine Areas: water column, vegetated bottoms and non-vegetated bottoms.

2.7.2.2 Rare, Unique, and Imperiled Vegetation Communities and Wildlife Habitats

The Texas Conservation Action Plan identified several rare, unique, and imperiled plant communities in the state (TPWD 2012). Lists were developed using a conservation status system established by NatureServe. Each plant community possess a global (range-wide) and state rank based on rarity. Conservation status of the community is designated by a number from one to five, preceded by a letter reflecting the appropriate geographic scale (G=Global, S=State). Numbers indicate: 1) critically imperiled, 2) imperiled, 3) vulnerable, 4) apparently secure, and 5) secure. The Action Plan lists nine plant communities that potentially exist in Jefferson County (Table 2-1).

Table 2-1: Rare, Unique, or Imperiled Plant Communities in the Study Area

Common Name	G Rank	S Rank	Habitat Type	Found in Focused Study Area
Black Mangrove Shrubland	G4	S2S3	Aquatic	No
Coastal Louisiana Chenier Forest	G2	S1	Terrestrial	Yes
Eastern Upland Coastal Prairie	G1	S1Q	Terrestrial	Potentially
Gulf Coast Salt Dome Hardwood Forest	G1	S1	Terrestrial	No
Huisache-Spiny Florida Prickly-pear – Gulf Coast Wolfberry/Saltmeadow Cordgrass Shrubland	G2G3	S1	Terrestrial	Potentially
Seashore Crowngrass Saltmeadow cordgrass oligohaline Herbaceous Vegetation	G2?	S1	Wetland	Potential
Texas Gulf Coast Live Oak – Sugarberry Forest	G2G3	S2S3	Terrestrial	No
Vertisol Coastal Prairie	G2	S2	Terrestrial	Yes
West Gulf Coastal Plain Cordgrass Dune Grassland	G2	S1	Terrestrial	Potentially

2.7.3 Protected Species

2.7.3.1 Threatened and Endangered Species

Wildlife species may be classified as threatened or endangered under the Endangered Species Act (ESA) of 1973 (16 USC § 1531 et seq.) and USFWS oversees protection of the non-marine species and National Marine Fisheries Service (NMFS) protect marine species. The ESA ensures that federal agencies and departments use their authorities to protect and conserve endangered and threatened species. Section 7 of ESA requires that federal agencies prevent or modify any projects authorized, funded, or carried out by the agencies that are "likely to jeopardize the continued existence of any endangered species or threatened species, or result in the destruction or adverse modification of critical habitat of such species."

A total of 19 ESA-listed species have been identified in the 2017 Planning Aid Letter (PAL), in the USFWS Official Species List dated March 30, 2018, and or on the NOAA Texas' Threatened and Endangered Species List (Table 2-2). There is no critical habitat designated in the focused study area. For a more detailed discussion on the habitat requirements, historic and current occurrence, and threats to each species, refer to the Biological Evaluation (BE) prepared for this study (Appendix A-2).

Table 2-2: Federally Listed and Candidate Species with Potential to Occur in Jefferson County

Species	Status	FWS	NMFS	Habitat	Occurrence in the Study Area
Birds					
Piping plover *Charadrius melodus*	T	X		Use wide, flat, open, sandy beaches with very little grass or other vegetation. Nesting territories often include small creeks or wetlands. Breed in northern US and Canada in the spring and summer and migrate south in the fall, wintering along the coast of the Gulf of Mexico or other southern locations. Approximately 35% of known population winters along the TX coast.	They are observed in small numbers during winter feeding on invertebrates along exposed mudflats of the bayous. During migration, they occur in very small numbers along the beaches of Jefferson County; large concentrations unlikely due to erosive and narrow shoreline. The species has potential to occur in the focused study area.
Rufa red knot *Calidris canutus rufa*	T	X		Found primarily in intertidal, marine habitats, especially near coastal inlets, estuaries, and bays outside of breeding season. Stopover habitat includes river shorelines with muddy/sandy substrates.	There have been no confirmed records of red knots in the focused study area or Jefferson County. Suitable habitat exists, albeit not high quality. The species has the potential to occur in the focused study area.
Whooping crane *Grus americana*	T	X		Winters along the Gulf Coast and breeds in Canada. On wintering grounds in Texas, they use estuarine marshes, shallow bays, and tidal flats, sometimes using nearby farms. Salt grass, saltwort, smooth cordgrass, glasswort, and sea oxeye dominate marshes, with Gulf cordgrass on the margins.	Members of the experimental population in Louisiana frequently forage in the marshes of the focused study area
Corals					
Elkhorn coral *Acropora palmata*	T		X	Found at depths to 295 feet throughout the wider-Caribbean, specifically Puerto Rico, Belize, the Florida Keys, and the US Virgin Islands.	Focused study area outside the species known range. Species would not occur in the focused study area.
Lobed star coral *Orbicella annularis*	T		X	Found at depths to 295 feet throughout the wider-Caribbean, specifically Puerto Rico, Belize, the Florida Keys, and the US Virgin Islands.	Focused study area outside the species known range. Species would not occur in the focused study area.
Mountainous star coral *O. faveolata*	T		X	Found at depths to 295 feet throughout the wider-Caribbean, specifically Puerto Rico, Belize, the Florida Keys, and the US Virgin Islands.	Focused study area outside the species known range. Species would not occur in the focused study area.

Species	Status	FWS	NMFS	Habitat	Occurrence in the Study Area
Boulder star coral *O. franski*	T		X	Found at depths to 295 feet throughout the wider-Caribbean, specifically Puerto Rico, Belize, the Florida Keys, and the US Virgin Islands.	Focused study area outside the species known range. Species would not occur in the focused study area.
Fish					
Dwarf seahorse *Hippocampus zosterae*	C		X	Found in sub-tropical northwest Atlantic occurring in insular locations including Bermuda, the Bahamas, and Cuba; along Atlantic continental shorelines from northeast Florida through the Florida Keys; and in the Gulf of Mexico south to the Gulf Campeche. Habitat restricted almost completely to seagrass canopies.	Texas has been identified within the species range, but seagrass canopies do not occur in sufficient capacity within the focused study area. Species is highly unlikely to occur in the focused study area.
Mammals					
Sei whale *Balaenoptera borealis*	E		X	Found in warmer waters of the Gulf of Mexico on the continental shelf edge and slope. Prefer deeper waters of oceanic areas far from the coastline.	Preferred habitat does not exist in the focused study area. No potential for occurrence in the study area.
Byrde's whale *B. edeni*	PE		X	Found in warmer waters of the Gulf of Mexico on the continental shelf edge and slope. Prefer deeper waters of oceanic areas far from the coastline.	Preferred habitat does not exist in the focused study area. No potential for occurrence in the study area.
Fin whale *B. physalus*	E		X	Found in warmer waters of the Gulf of Mexico on the continental shelf edge and slope. Prefer deeper waters of oceanic areas far from the coastline.	Preferred habitat does not exist in the focused study area. No potential for occurrence in the study area.
Humpback whale *Megaptera novaeangliae*	E		X	Found in warmer waters of the Gulf of Mexico on the continental shelf edge and slope. Prefer deeper waters of oceanic areas far from the coastline.	Preferred habitat does not exist in the focused study area. No potential for occurrence in the study area.
Sperm whale *Physeter macrocephalus*	E		X	Found in warmer waters of the Gulf of Mexico on the continental shelf edge and slope. Prefer deeper waters of oceanic areas far from the coastline.	Preferred habitat does not exist in the focused study area. No potential for occurrence in the study area.

Species	Status	FWS	NMFS	Habitat	Occurrence in the Study Area
West Indian manatee *Trichechus manatus*	T	X		Found in a variety of water environments, including marine, estuarine, and freshwater. In winter, seek out warm water sites such as springs, deep water areas, areas thermally influenced by the Gulf Stream, and utility plant discharge sites. During spring and summer, leave warm water sites and travel great distances. No known resident populations in Texas.	Historical records of occurrence in the focused study area. Species is considered extremely rare in Texas and its presence is highly unlikely; however, with historic records from the area, it cannot be ruled out with certainty that the species could not occur in the area.
Reptiles					
Loggerhead sea turtle *Caretta caretta*	T	X	X	Occur throughout the temperate and tropical regions of the Atlantic from Nova Scotia to Argentina, Gulf of Mexico, Pacific and Indian Oceans, and the Mediterranean. May be found hundreds of miles off the coast or in inshore areas such as bays, lagoons, salt marshes, creeds, and mouths of large rivers.	Documented records of the species exists in Jefferson County, but no record of nesting or nesting attempts. There is potential for the species to occur in the study area.
Green sea turtle *Chelonia mydas*	T	X	X	Found in inshore and near shore waters from Texas to Massachusetts, the US Virgin Islands, and Puerto Rico. Primarily use shallow habitats such as lagoons, bays, inlets, shoals, estuaries, and other areas with abundant marine algae and seagrasses. Coral reefs and rocky outcrops are often used as resting areas.	The species has been documented foraging in Jefferson County, but no records of nesting or nesting attempts. There is potential for the species to occur in the study area.
Leatherback sea turtle *Dermochelys coriacea*	E	X	X	Mainly pelagic, inhabiting the open ocean and seldom approaches land except for nesting. Found in coastal waters only when nesting or following concentrations of jellyfish. Nest primarily in tropical regions with major nesting beaches in Malaysia, Mexico, French Guiana, Surinam, Costa Rica, and Trinidad. In Atlantic and Caribbean, nesting occurs in US Virgin Islands, Puerto Rico, and Florida.	No records of foraging or nesting in Jefferson County. Focused study area does not support deep marine waters; therefore, it is unlikely that the species would occur in the area.

Species	Status	FWS	NMFS	Habitat	Occurrence in the Study Area
Hawksbill sea turtle *Eretmochelys imbricata*	E	X	X	Generally inhabit coastal reefs, bays, rocky areas, passes, estuaries, and lagoons, where they occur at depths of less than 70 feet. Nesting occurs in undisturbed, deep-sand beaches of high-energy ocean beaches to tiny pocket beaches about 10 feet wide bound by cliff walls. Regularly sighted in Texas, with nesting at Padre Island National Seashore.	No record of nesting or foraging in Jefferson County. Occasional juveniles could be present with the Gulf of Mexico from April through August. Marginal nesting habitat exists in the focused study area. The species has potential to occur in the focused study area although it is not expected to be common.
Kemp's Ridley sea turtle *Lepidochelys kempii*	E	X	X	Adults often found near the coastline in habitats that typically contain muddy or sandy bottoms where prey can be found. Models indicate the most suitable habitats are less than 32 ft in bottom depth with sea surface temperatures between 71.6° and 89.6°F. Utilize seagrass beds, mud bottom and live bottom substrates as important developmental habitats. Post-nesting turtles travel along corridors that are generally shallower than 164 ft in bottom depth.	Has the highest potential for occurrence based on habitat requirements and research. The upper Texas and Louisiana coasts are important foraging and inter-nesting habitats for the species. The number of seasonal nest sites on the upper Texas coast varies each year. Historic nesting is documented in Jefferson County, but recent nesting has not occurred, most likely due to lack of sediment on the shoreline. The species is likely to occur in the action area.

E = Listed Endangered **T** = Listed Threatened **C**= Candidate **PE**= Proposed Endangered

2.7.3.2 Texas State Listed Species

In Texas, animal or plant species of conservation concern may be listed as threatened or endangered under the authority of state law and or under the ESA. Species may be listed as state threatened or endangered and not federally listed. The state list only addresses the status of a species in Texas. The state has listed 27 species as threatened or endangered in Jefferson County.

Eight of the 27 species have also been listed as threatened or endangered under ESA including: piping plover, smalltooth sawfish (*Pristis pectinata*), red wolf (*Canis rufus*), hawksbill sea turtle, green sea turtle, Kemp's ridley sea turtle, leatherback sea turtle, and loggerhead sea turtle. Smalltooth sawfish and red wolf were not identified as occurring in the focused study area and were not considered in the BE. The project area is outside the species known range and/or suitable habitat does not exist in the focused study area. The status of the remaining six species also federally listed are discussed in Table 2-3 and in the BE (Appendix A-2).

After reviewing a description of each species provided by the TPWD and occurrence data on NatureServe and Texas Natural Diversity Database (TXNDD 2018), and consulting with resource agencies, the JCER study team concluded that the focused study area is outside the known range or does not provide suitable habitat for 14 of the 27 species including:

- American peregrine falcon (*Falco peregrinus anatum*)
- Swallow-tailed kite (*Elanoides forficatus*),
- Black bear (*Ursus americanus*),
- Louisiana black bear (*U. americanus luteolus*),
- Rafinesque's big-eared bat (*Corynorhinus rafinesquii*),
- Louisiana pigtoe (*Pleurobema riddellii*),
- Sandbank pocketbook (*Lampsilis satura*),
- Southern hickorynut (*Obovaria jacksoniana*),
- Texas heelsplitter (*Potamilus amphichaenus*),
- Texas pigtoe (*Fusconaia askewi*),
- Triangle pigtoe (*F. lananensis*),
- Northern scarlet snake (*Cemophora coccinea copei*),
- Texas horned lizard (*Phyrnosoma cornutum*), and
- Timber rattlesnake (*Crotalus horridus*).

The following five species have been identified as occurring in the focused study area and for which suitable habitat is available.

1) Bald eagle (*Haliaeetus leucocephalus*): See Section 2.7.3.5 below.

2) Reddish egret (*Egretta rufescens*): Texas considers the reddish egret threatened. Reddish egrets are often seen on brackish and intermediate marshes of the focused study area. Preferred habitats include shores, lagoons, saltmarshes, and salt flats where they primarily forage on fish. Breeding activity generally occurs on coastal islands where they nest in colonies. The species is likely to occur in the focused study area, but nesting is unlikely.

3) White-faced ibis (*Plegadis chihi*): The white-faced ibis is state-listed as threatened. The species is a colonial nester commonly observed throughout the year. It has been documented nesting on the McFaddin NWR. Preferred habitats includes freshwater marshes, sloughs, and ponds with emergent vegetation. The species is likely to occur, including nesting, in the focused study area.

4) Wood stork (*Mycteria americana*): Texas lists the wood stork as threatened. There are historical records of nesting wood storks in Jefferson County, but recent nesting has not been documented. Within the focused study area, wood storks typically frequent brackish marsh habitats during late summer. It is believe these birds are dispersing post-breeding from Mexico, where nesting populations occur. The species is likely to occur in the focused study area, but nesting is unlikely.

5) Alligator snapping turtle (*Macrochelys temminckii*): The alligator snapping turtle has been documented in areas of the focused study area; however, their abundance and distribution is unknown. The turtles frequent bottoms of freshwater rivers, lakes, sloughs, swamps, and bayous, but occasionally are seen in brackish marshes. The species is likely to occur in the focused study area and there is potential for the species to nest here as well.

2.7.3.3 Listed Rare Species in Texas

Rare species are those native Texas species considered imperiled throughout a significant portion of the range. Rare species are not protected by state or federal law; however, Texas Parks and Wildlife tracks rare species and actively promotes their conservation to prevent future endangerment and listing as threatened or endangered. Sixteen species are on the rare species list for Jefferson County.

After reviewing the state's description of each species, reviewing occurrence data on NatureServe and Texas Natural Diversity Database, and consulting with resource agencies, the JCER study team determined that the focused study area is outside the known range or does not provide suitable habitat for 8 of the 16 species including:

- Southern crawfish frog (*Lithobates areolatus areolatus*),
- Sprague's pipit (*Anthus spragueii*),
- Bay skipper (*Euphyes bayensis*),
- Plains spotted skunk (*Spilogale putorius interrupta*),
- Southeastern myotis bat (*Myotis austroriparius*),
- Awnless bluestem (*Bothriochloa exaristata*),

- Chapman's orchid (*Platanthera chapmanii*), and
- Large beakrush (*Rhynchospora macra*).

Eight rare species may occur in the focused study area.

1) Artic peregrine falcon (*Falco peregrinus tundrius*): The wintering range of the arctic peregrine falcon includes all of the Texas Gulf Coast. The southern coast of Texas is a major spring migration staging area. Within the focused study area, most falcons are observed during fall and spring migrations along the Gulf of Mexico shoreline. The sub-species is likely to occur in the focused study area during the winter and migration, but not during the nesting season.

2) Black rail (*Laterallus jamaicensis*): Black rails are seen year-round in the focused study area; however, it is unclear as to whether they nest here. Black rails prefer shallow high salt marsh habitat dominated by Spartina spp.

3) Brown pelican (*Pelecanus occidentalis*): Brown pelicans typically congregate in small to medium flocks on open water and along Gulf shorelines, Sabine Lake, and the GIWW. They can be frequently observed flying throughout the focused study area.

4) Henslow's sparrow (*Ammodramus henslowii*): Henslow's sparrow has been recorded in the focused study area, but is a rare migrant species seen only in November through March. The species frequents fields and marshlands during migration.

5) Snowy plover (*Charadrius alexandrinus*): Snowy plovers and a sub-species, western snowy plover (C. a. nivosus), are both regularly observed during shorebird counts on wildlife refuges in the focused study area between March and May, primarily along the Gulf shoreline.

6) American eel (*Anguilla rostrata*): After 1960, there are no records confirming the presence of American eels in or near the focused study area; however, there are records from the 1970s and 1980s recording the species as inhabiting the Sabine and Neches Rivers (Hendrickson and Cohen 2015). Because their breeding grounds are near Cuba, the only way the species could have made it to these rivers was through Sabine Pass, which is in the focused study area. American eels may occur as a rare species in the SNWW, Sabine Pass, Keith Lake, and Sabine Lake, but is not likely in marsh areas and would not inhabit Gulf shorelines. The American eel can live in saltwater of the Gulf, brackish coastal marshes, or in freshwater rivers and streams of the study area.

7) Texas diamondback terrapin *(Malaclemys terrapin littoralis)*: Terrapin have been recorded during field surveys in the focused study area primarily in the Texas Point NWR area (Guillen et al. 2015). The species inhabits estuarine systems and have been found in a range of habitats including brackish to intertidal salt marshes and tidal flats.

8) Red knots: see Section 2.7.3.1 and Appendix A-2.

2.7.3.4 Marine Mammals

In 1972, Congress passed the Marine Mammal Protection Act of 1972 (MMPA) and amended it periodically through 2007. The MMPA aims to protect and conserve all species of marine mammals such as whales, dolphins, porpoises, sea lions, seals, and manatees. The MMPA also established the Marine Mammal Commission, the International Dolphin Conservation Program and a Marine Mammal Health and Stranding Response Program.

Scientists have documented 28 marine mammals living in the Gulf of Mexico including whales, dolphins and one species of coastal sirenian (West Indian manatee). No seals, sea lions or sea-going otters are present in the Gulf. Twenty-one species of cetaceans regularly occur in the Gulf and are identified in the NMFS Gulf of Mexico Stock Assessment Reports (BOEM 2012, Waring et al. 2014)). The West Indian manatee (*Trichechus manatus*), is also listed in the stock reports as a rare species in the Texas region (Davis et al. 2000). In the northern Gulf, 18 species of marine mammals (listed below in order of abundance) are common:

- Pantropical spotted dolphins (*Stenella attenuata*),
- Spinner dolphins (*Stenella longirostris*),
- Clymene dolphins (*Stenella clymene*),
- Bottlenose dolphins (*Tursiops truncatus*),
- Striped dolphins (*Stenella coeruleoalba*),
- Melon-headed whales (*Peponocephala electra*),
- Atlantic spotted dolphins (*Stenella frontalis*),
- Risso’s dolphins (*Grampus griseus*),
- Short-finned pilot whales (*Globicephala macrorhynchus*),
- Rough-toothed dolphins (*Steno bredanensis*),
- False killer whales (*Pseudorca crassidens*),
- Pygmy sperm whales (*Kogia siga/breviceps*),
- Sperm whales (*Physeter macrocephalus*),
- Pygmy killer whales (*Peponocephala electra*),
- Killer whales (*Orcinus orca*),
- Cuvier beaked whales (*Ziphius cavirostris*),
- Fraser dolphins (*Lagenodelphis hosei*), and
- Bryde’s whales (*Balaenoptera brydei*). (Davis et al. 2000)

Note that pantropical spotted dolphins and striped dolphins, while abundant in the northern Gulf of Mexico, are not common to the northwestern Gulf of Mexico region (Waring et al. 2014).

Common bottlenose dolphins are frequently seen in open waters of the SNWW or in shallow waters along the coastline. In general, dolphins are quite common in estuarine waters and nearshore coastal habitats.

Other species of dolphins and whales prefer deeper offshore waters; therefore, it is unlikely that any of these species would occur in the study area.

Historical records indicate that West Indian manatees inhabited Cow Bayou (Würsig 2017); however, there are no recent records documenting the species, and they are considered extremely rare in Texas. Manatees can live in shallow coastal waters, estuaries, bays, rivers, and lakes, but prefer rivers and estuaries to marine habitats. The occurrence of the West Indian manatee in the study area is possible but unlikely.

2.7.3.5 Bald and Golden Eagles

The Bald and Golden Eagle Protection Act protects the two eagle species. USFWS has outlined sites on McFaddin NWR and nearby Anahuac Lake that serve as concentration areas for Bald Eagles (*Haliaeetus leucocephalus*). Breeding occurs in nearby wooded areas, including areas near restoration units, but is not likely immediately in restoration units due to a lack of large old-growth trees or snags. Because of the species relatively large home range and the abundance of suitable foraging habitat in the focused study area and in restoration units, it is reasonable to expect that they will continue to use the area. The study area is located outside the range of the golden eagle.

2.7.3.6 Migratory Birds

Birds are protected under the Migratory Bird Treaty Act which prohibits activities that take of migratory birds or eagles unless authorized by USFWS; however unlike the Endangered Species Act, they do prohibit taking migratory birds that are unintentionally killed or injured.

Migratory bird species listed below are species of particular conservation concern that potentially occur in the study area. The USFWS published the Birds of Conservation Concern (BCC) 2008 in December 2008 with the goal of identifying migratory and non-migratory birds beyond those already protected under Endangered Species Act with the highest conservation priorities.

Birds on the BCC lists include nongame birds; gamebirds without hunting seasons; candidates for listing per the Endangered Species Act, proposed endangered or threatened species; and recently delisted species. Jefferson County is in Bird Conservation Region (BCR) 37—Gulf Coastal Prairie and the terminus of the Central Flyway. The USFWS IPaC website also lists migratory bird species that may be present in the county.

BCR 37 and the focused study area have one of the greatest concentrations of colonial waterbirds in the world such as breeding Reddish egret (*Egretta rufescens*), roseate spoonbill (*Platalea ajaja*), brown pelican (*Pelecanus occidentalis*), and large numbers of herons and egrets (Ardeidae), ibis (Threskiornithinae), terns (Sternidae), and skimmers (Rynchopidae). The region provides critical in-transit habitat for migrating shorebirds including buffbreasted sandpiper (*Tryngites subruficollis*), Hudsonian godwit (*Limosa haemastica*), and for most neotropical migrant forest birds of eastern North America.

The region is one of the most important waterfowl areas in North America with both wintering and migration habitat for significant numbers of continental duck and goose populations using the Central and Mississippi Flyways. Coastal wetlands are primary wintering sites for dabbling ducks, including northern pintail (*Anas acuta*), gadwall (*Anas strepera*), readhead (*Aythya americana*), lesser scaup (*Aythya affinis*), and white-fronted geese (*Anser albifrons*). These crucial wetlands winter more than half of the Central Flyway waterfowl population. The region also supports year-round habitat for over 90 percent of the continental population of mottled ducks (*Anas fulvigula*), and serves as a key breeding area for whistling ducks (*Dendrocygna* spp.) and purple gallinule (*Porphyrio martinicus*). In addition, hundreds of thousands of waterfowl use the region as stopover habitat while migrating to and from Mexico and Central and South America. The most important waterfowl habitats in the area are coastal marsh, shallow estuarine bays and lagoons, and wetlands on agricultural lands on rice prairies.

There are a total of 43 Birds of Conservation Concern in Bird Conservation Region 37, of which all but five have been documented in the focused study area (Table 2-3).

Table 2-3: Birds of Conservation Concern listed for Bird Conservation Region 37

Wetland Dependent Species		
American bittern	**Short-billed dowitcher (nb)**	**Reddish egret**
Yellow rail (nb)	**Least tern (c)**	**Bald eagle (b)**
Black rail	**Sprague's pipit (nb)**	**Peregrine falcon (b)(nb)**
Long-billed curlew	**Nelson's sharp-tailed sparrow (nb)**	**Snowy plover**
Hudsonian godwit (nb)	**Seaside sparrow**	**Wilson's plover**
Whimbrel (nb)	**American oystercatcher**	**Black skimmer**
Gull-billed tern	**Sandwich tern**	**Least bittern**
Red knot (*roselaari* ssp.) (nb)	Band-rumped storm-petrel (nb)	**Solitary sandpiper (nb)**
Red knot (rufa ssp.) (nb)	Lesser yellowlegs (nb)	Marbled godwit (nb)
Prairie Grasslands		
LeConte's sparrow (nb)	**Henslow's sparrow (nb)**	**Buff-breasted sandpiper (nb)**
Sedge wren (nb)	**Loggerhead shrike**	**White-tailed hawk**
Short-eared owl (nb)	**Grasshopper sparrow**	**Dickcissel**
Botteri's sparrow	Mountain plover (nb)	**Upland sandpiper (nb)**
Woodland or Shrub		
Swainson's warbler	**Prothonotary warbler**	**Swallow-tailed kite**
Painted bunting		

Bold text indicates that species has been documented in study area.
nb = non breeding
b = breeding

2.7.4 Invasive and Noxious Plant and Animal Species

Invasive species are non-native species whose populations tend to grow and spread, and cause harm to native biodiversity, the economy, or health. Invasive species are one of the most pervasive, widespread threats to indigenous biota. The introduction and establishment of invasive species can have substantial impacts on native species and ecosystems. Invasive species capable of spreading and invading into new areas are typically generalists that can easily adapt to new environments and are highly prolific and superior competitors and/or predators. Some are very specialized and more efficient and effective than their native competitors at filling a particular niche. They compete for resources, alter community structure, displace native species, and may cause extirpations or extinctions. Invasive species often benefit from altered and declining natural ecosystems by filling niches of more specialized and displaced species with limited adaptability to changing environments. Noxious species similarly deteriorate habitats and cause damage, except that the species are native. These species tend to spread after disturbance to the soil surface, such as agriculture plantings, landscaping, wildfires, erosion, etc. Several non-native animal and plant invasive species have spread in the study area including:

- Chinese tallowtree,
- Deep-rooted sedge,

- Water hyacinth (*Eichhornia crassipes*),
- Alligator weed (*Alternathera ohiloceroides*),
- Water lettuce (*Pistia stratiotes*),
- McCartney rose (*Rosa bracteata*),
- Vasey grass (*Paspalum urvillei*),
- Johnsongrass (*Sorghum halepense*),
- Eurasian water milfoil (*Myriophyllum spicatum*),
- Hydrilla (*Hydrilla verticillata*),
- Common salvinia (*Salvinia minima*),
- Giant salvinia (*S. molesta*),
- Japanese honeysuckle (*Lonicera japonica*), and
- Red imported fire ants, nutria, and feral hogs.

Invasive native (noxious) plant species include eastern baccharis (*Baccharis halimifolia*), big-leaf sumpweed (*Iva frutescens*), rattlebox (*Sesbania drummondii*), common reed (*Phragmities communis*) and cattail (Typha spp.).

2.8 Cultural Resources

A review of the Texas Historical Commission's Atlas database revealed several prior terrestrial cultural resource surveys and marine surveys within the study area. Although the review identified previous surveys in or transecting Jefferson County, it is important to note that most of the study area has not been surveyed for cultural resources. Currently, 27 known terrestrial archaeological sites, two cemeteries, Sabine Pass Battleground, 13 identified shipwreck sites, seven historical markers, and one historic structure (the GIWW) have been identified. Eighteen of the identified terrestrial archaeological sites have been evaluated for eligibility to the National Register of Historic Places (NRHP), 17 of which were determined to be eligible with only one of these sites (41JF50) deemed ineligible in 2008. Nine of the known terrestrial sites, the 13 identified shipwreck sites, and the GIWW are all unevaluated for NRHP eligibility.

2.9 Economic, Socioeconomic, and Human Resources

Socioeconomics is defined as the basic attributes and resources associated with the human environment, particularly population, demographics, and economic status and development. Demographics entail population characteristics and include data pertaining to race, gender, income, housing, poverty status, and educational attainment. Economic development or activity typically includes employment, wages, business patterns, an area's industrial base, and its economic growth.

Jefferson County has a compact and cohesive social and economic structure. The population lives primarily in urbanized areas (Beaumont and Port Arthur) and the base economy of the county is oriented to petroleum refining and petrochemical processing. There are no natural barriers to interchange between cities and other areas, and to some extent natural geographic features have benefited economic growth through access to the Sabine River and the port facilities in Beaumont and Port Arthur.

Jefferson County, along with the counties of Hardin, Newton, and Orange, make up the Beaumont-Port Arthur Metropolitan Statistical Area (MSA). The smallest census designation that contains the study area is census block group 116.1. Based on aerial imagery, the residential structures, hence concentration of population, is in the northwest corner and northeast corner of the census block group.

All data for this section comes from the US Department of Commerce, Bureau of Economic Analysis website and the United States Census Bureau QuickFacts and County Business Patterns website.

2.9.1 Population, Housing, and Community Cohesion

Jefferson County has an estimated population of 252,993, just less than 1 percent of the state's population and 57 percent of the Beaumont-Port Arthur MSA. Approximately 51 percent of the population is male and 49 percent is female, which is similar to the state, MSA and cities of Beaumont and Port Arthur, as shown in Table 2-4.

Table 2-4: Population by Gender

Gender	Texas	Beaumont-Port Arthur Metropolitan Statistical Area	Jefferson County	Beaumont	Port Arthur	Census Block Group 116.1
Total	26,956,435	406,506	252,993	117,729	54,913	1,114
Male	49.6%	50.5%	51.1%	48.0%	49.2%	50.9%
Female	50.4%	49.5%	48.9%	52.0%	50.8%	49.1%

Source: U.S. Census Bureau, 2012-2016 American Community Survey 5-Year Estimates

As shown in Table 2-5 most of the geographic areas have the greatest population in the 25-34, 35-44 and 45-54 year old age groups. The study area is slightly older with the largest populations in the 35-44, 45-54, 55-50 and 60-64 year old age groups. The median age for the state of Texas is 34 years, 36.8 for the MSA, 36 for Jefferson County and 44 for census block group 116.1.

Table 2-5: Percent of Population by Age Group

Age Group	Texas	Beaumont-Port Arthur Metropolitan Statistical Area	Jefferson County	Beaumont	Port Arthur	Census Block Group 116.1
Total	26,956,435	406,506	252,993	117,729	54,913	1,114
<5	7.3%	6.7%	6.9%	7.6%	8.3%	7.5%
5-9	7.5%	6.8%	6.8%	7.0%	8.5%	5.4%
10-14	7.4%	6.5%	6.2%	6.5%	7.1%	6.6%
15-19	7.1%	6.7%	6.6%	7.0%	6.6%	5.7%
20-24	7.3%	7.0%	7.5%	8.8%	6.8%	4.8%
25-34	14.5%	13.7%	14.6%	14.5%	14.7%	6.8%
35-44	13.5%	12.4%	12.5%	11.5%	11.5%	16.0%
45-54	12.9%	13.3%	13.3%	12.1%	12.5%	17.4%
55-59	5.9%	6.8%	6.7%	6.1%	6.7%	8.8%
60-64	5.0%	5.9%	5.7%	5.5%	5.3%	9.2%
65-74	6.8%	7.9%	7.2%	7.4%	6.3%	8.3%
75-84	3.4%	4.5%	4.3%	4.1%	4.0%	1.7%
85+	1.3%	1.8%	1.8%	1.8%	1.6%	1.9%

Source: U.S. Census Bureau, 2012-2016 American Community Survey 5-Year Estimates

Table 2-6 provides a summary of the race and Hispanic ethnicity distribution of the populations. For the state, the largest group are those identifying as white with 43%, followed by Hispanic at 37%, and Black/African American at 12%. For Jefferson County, there is a higher percentage of Black/African Americans (34%) than the state, while the percentage of white is similar. In the census block that contains the project area, the population is considerably more white (88%), followed by Hispanic (7%) and Black/African American (5%).

Table 2-6: Percent Population by Race/Hispanic Ethnicity

Race and Hispanic Ethnicity	Texas	Beaumont-Port Arthur Metropolitan Statistical Area	Jefferson County	Beaumont	Port Arthur	Census Bock Group 116.1
Total	26,956,435	406,506	252,993	117,729	54,913	1,114
White alone	43.4%	57.7%	42.3%	33.1%	22.0%	87.8%
Black or African American alone	11.6%	24.1%	33.6%	48.0%	38.0%	5.2%
American Indian and Alaska Native alone	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%
Asian alone	4.3%	2.5%	3.5%	3.1%	6.4%	0.0%
Native Hawaiian or Other Pacific Islander alone	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%
Some Other Race alone	0.1%	0.1%	0.0%	0.0%	0.0%	0.0%
Two or more Races	1.6%	1.4%	1.3%	1.1%	1.6%	0.1%
Hispanic or Latino	38.6%	14.0%	19.0%	14.4%	31.8%	6.7%

Source: U.S. Census Bureau, 2012-2016 American Community Survey 5-Year Estimates

2.9.2 Education, Employment and Income

Jefferson County has four school districts: Beaumont Independent School District (ISD), Nederland ISD, Port Arthur ISD, and Port Neches-Groves ISD. There is also a university (Lamar University) in Beaumont and Port Arthur. There is one private school, Monsignor Kelly Catholic High School, in Beaumont.

In 2016, Jefferson County had a per capita personal income (PCPI) of $41,813. This PCPI ranked 87th in the state and was 90% of the state average and 90% of the national average of $49,246. 2016 PCPI reflected an increase of 0.5% from 2015. From 2015 through 2016, PCPI in Texas declined by 1.2%, while PCPI grew by 1.6%. In 2006, the PCPI of Jefferson County was $30,580 and ranked 79th in the state. From 2006 through 2016 compound annual growth rate of PCPI was 3.2%. The compound annual growth rate for the state was 2.8% and for the nation it was 2.6%.

In 2006, personal income in Jefferson County totaled $7,521,488 (personal income estimates are in thousands of dollars, not adjusted for inflation), and ranked 19th in the state. In 2016, Jefferson County had a personal income of $10,648,984 which ranked 21st in the state and accounted for 0.8% of the state total. Personal income for purposes of this data include net earnings by place of residence; dividends, interest, and rent; and personal current transfer receipts received by county residents. Median household income in 2016 was $44,965, which is less than state and U.S. median household income of $$54,727 and $55,322, respectively (Table 2-7).

The economy of Jefferson County specializes in petroleum refining, petrochemical processing, construction, and manufacturing; employing 1.83, 1.76, and 1.36 times more people than what would be expected in a county of similar size. The largest industries by the number of jobs in Jefferson County are Healthcare & Social Assistance (16.8%), manufacturing (14.6%), retail trade (13.7%), and construction (12.3%). The highest paying industries are management of companies and enterprises ($81,071), utilities ($70,908), and petrochemical extraction and refining ($56,136). In the small community of Sabine Pass, most residents work at one of two liquefied natural gas plants in the area, in oil rig servicing, in the small commercial shrimp fleet, or in public sector jobs at the wildlife refuges, school, or post office. They also commute to Port Arthur for industrial and service sector employment.

Table 2-7: Existing Employment and Income near the Study Area

County	Per Capita Income	Median Household Income	Unemployment Rate (percent)
United States	$29,829	$55,322	4.9
State of Texas	$27,828	$54,727	4.6
Jefferson County	$24,738	$44,965	7.0
Sabine Pass	$18,519	$32,003	7.1

Source: U.S. Census Bureau

2.9.3 Environmental Justice

Executive Order 12898 directs federal agencies to identify and address any disproportionately high and adverse human health or environmental effects of their actions on minority and low-income populations, to the greatest extent practicable and permitted by law. CEQ guidance states that minority populations should be identified where either: a) the minority population of the affected area exceeds 50% or b) the minority population percentage of the affected area is meaningfully greater than the minority population percentage in the general population or other appropriate unit of geographic analysis. Low-income populations should be identified with the annual statistical poverty thresholds from the Bureau of the Census' data. In identifying minority and low-income communities, agencies may consider as a community either a group of individuals living in geographic proximity to one another, or a geographically dispersed/transient set of individuals (such as migrant workers or Native American), where either type of group experiences common conditions of environmental exposure or effect (CEQ 1997).

The Environmental Protection Agency (EPA) maintains an environmental justice mapping and screening tool (EJSCREEN) that provides users with a nationally consistent dataset and approach for combining environmental and demographic indicators. EJSCREEN can be used as a first-level screening tool to help determine the level of analysis needed (EPA Glossary of EJSCREEN Terms, https://www.epa.gov/ejscreen/glossary-ejscreen-terms). This analysis uses two of the tool's six demographic indicators:

- Percent Low-Income: Percent of individuals whose ratio of household income to poverty level in the past 12 months was less than 2.

- Percent Minority: Percent minority as a fraction of population, where minority is defined as all but Non-Hispanic White Alone.

Additionally, the tool estimates a Demographic Index, based on the average of two demographic indicators: Percent Low-Income and Percent Minority.

Census block group 116.1 is the smallest geographical census boundary that includes the entire study area. The census block group has an estimated population of 957. Based on aerial imagery, the majority of the population lives in the northwest and northeast extremes of the census block, which places them outside the study area and project footprint. The output of the EJ Screen tool, with the census block group outlined in blue and the focused study area outline in red, is shown in Figure 2-6 with tabular presentation of the information in Table 2-8.

Figure 2-6 shows that the demographic index of the census block group relative to the U.S. is less than the 50^{th} percentile. Anything greater than the 50^{th} percentile would indicate potential concern for environmental justice consideration and warrant additional evaluation. Less than 50% would indicate the concentration of minority and low-income populations were small compared to the region and would therefore not be adversely impacted to a greater degree than the general population.

Table 2-8 shows 11% of the census block's population is minority, compared to 56% for the state and 24% for the nation. Looking at the percentiles, the data show that that compared to the state, the census block is in the 5th percentile, which means that the census block's minority population of 11% is equal to or less than 5% of the state's population. For there to be environmental justice concerns, the census block would need to be in the 50th or greater percentile. Comparing the U.S., the census block is in the 24th percentile, again lower than the 50th percentile where there would be environmental concerns.

Low income percentiles show similar results. For the census block, 26% of the population is low income, compared to 38% for the state and 34% for the U.S (Table 2-8). While the low income indicator is in higher percentiles than the minority population indicator (35th percentile compared to Texas and 40th percentile compared to the U.S.), they are below the 50th percentile

Figure 2-6. Output of the EJ Screen tool, with the census block group outlined in blue and the focused study area outlined in red.

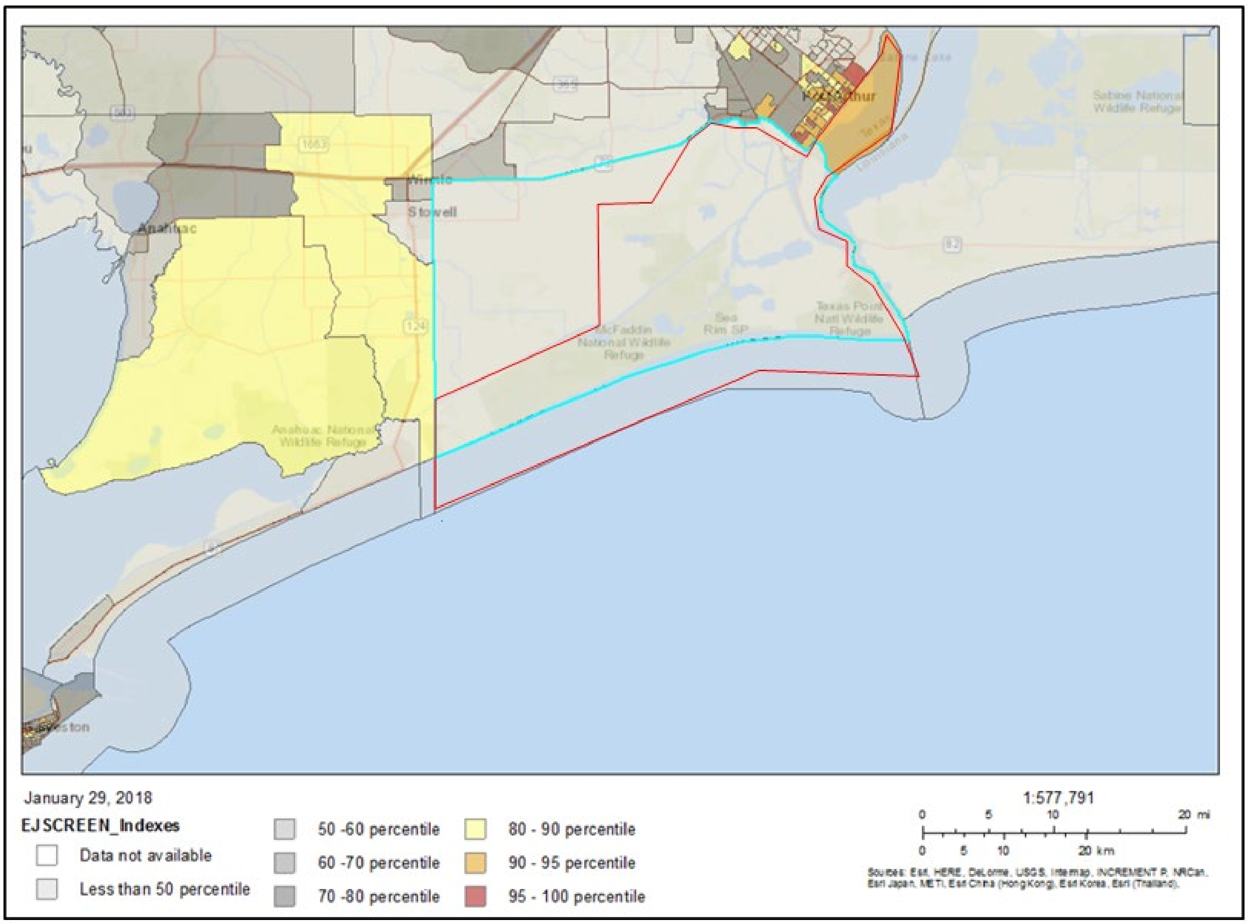


Table 2-8: EJ Screen Data for Demographic Indicator for Census Block 116.1, Texas, and the United States

Indicator	Census Block 116.1	Texas		United States	
		State Average	Percentile	State Average	Percentile
Minority Population	11%	56%	5	38%	24
Low Income	26%	38%	35	34%	40
Demographic Index	18%	47%	12	36%	26

Source: EJ Screen Tool, U.S. Environmental Protection Agency, https://ejscreen.epa.gov/

Given that a relatively small population near the study area and some distant from the project area, and that both the minority and low income populations are below 50% of the population and below the 50th percentile compared to both the state and national populations, there is no indication that the impacts of the project are likely to fall disproportionately on minority and/or low-income members of the community.

2.10 Transportation

Transportation refers to the movement of people, goods, and/or equipment on a surface transportation network that can include many different types of facilities serving a variety of transportation modes, such as vehicular traffic, public transit, and non-motorized travel (e.g., pedestrians and bicycles). The relative importance of various transportation modes is influenced by development patterns and the characteristics of transportation facilities. In general, urban areas tend to encourage greater use of public transit and/or non-motorized modes of transportation, especially if pedestrian, bicycle, and transit facilities provide desired connections and are well operated and well maintained. More dispersed and rural areas tend to encourage greater use of passenger cars and other vehicles, particularly if extensive parking is provided and/or transit systems are unavailable.

2.10.1 Highways and Roads

Highway access into the study area is provided by SH 87, which crosses a bridge over the GIWW just south of Port Arthur and parallels the SNWW through the study area to Sabine Pass. From Sabine Pass, Highway 87 parallels the coast to High Island; however, this stretch of highway has been permanently closed since the late 1980s because of its susceptibility to high tides and erosion. Off-road vehicles still use this stretch of highway to access beaches, but anyone attempting in a sedan, coups, or SUV with four-wheel drive will typically be forced to turn around or get stuck. Jefferson County and others have undertaken feasibility studies to reconstruct or relocate the stretch of highway but none have been implemented and none are expected in the near future. Other surface transportation in the study area is provided by a very small network of NWR system roads, WMA roads, or private roads. Access is limited due to the amount of bayous, lakes, and marshes in the focused study area.

2.10.2 Railways and Canals

In the late 1800s and early 1900s, a system of railways and canals was initiated in the area to facilitate production. A series of railroad towns, including Winnie and Stowell, was created as a result. The Texas and New Orleans Railroad (now the Southern Pacific Transportation Company) built the Gulf and Interstate Railway from Beaumont to Bolivar Peninsula. The Eastern Texas Railroad served from Sabine Pass to Beaumont. The Lone Star Company, the Port Arthur Rice and Irrigation Company, McFaddin Canal Company, Jefferson County Irrigation Company (later renamed Beaumont Irrigation Company), and the Treadaway Canal Company (later renamed Neches Canal Company) developed a series of canals to foster rice farming. Today, there are no active railways in the focused study area. All active railways depart out of Beaumont and include operations by four different railway companies. The legacy railways and canals still remain on the landscape and continue to contribute to a fragmented system. Legacy canals are still used periodically for recreational purposes and infrequently by non-recreation related vessels.

2.10.3 Navigation

Sabine Pass, at the natural opening between Sabine Lake and the Gulf of Mexico, served as an important seaport connection that fostered the growth of Port Arthur. Federal efforts to improve navigation across the bar that once blocked the entrance of deepwater vessels to the Sabine River began during the 1970s.

2.10.3.1 Sabine-Neches Waterway and Sabine Pass Ship Channel

The SNWW is a 64-mile, federally authorized and maintained waterway in Jefferson and Orange Counties in southeast Texas and Cameron Parish, Louisiana. The SNWW links together the Ports of Beaumont, Port Arthur and the Port of Orange. The waterway is the leading bulk liquid cargo waterway and is the largest exporter of liquefied natural gas in the U.S. (TxDOT 2016). The area surrounding the waterway is generally referred to as the “Golden Triangle” and is delineated by the three major Texas seaports of Port Arthur, Beaumont, and Orange. Sabine Pass, Sabine Lake, and Sabine River together form part of the boundary between the states of Texas and Louisiana.

The SNWW is a system of navigation channels that have been superimposed upon the Sabine-Neches estuary in Texas and Louisiana. The estuary includes Sabine Lake, tidal portions of the Sabine and Neches rivers, and a number of tidally influenced bayous and shallow coastal lakes. The only connection with the Gulf of Mexico is a long narrow pass called Sabine Pass through which all tidal interchange occurs. Sabine pass is stabilized by jetties that extend 4.1 miles into the Gulf of Mexico. The jetties were initially constructed for navigational purposes in the late 1880s.

The SNWW has seven reaches, beginning with the Sabine Bank Channel in the Gulf of Mexico and working upstream to the Neches River Channel (Table 2-9). The waterway enters from deep water in the Gulf through the Entrance Channel, which is divided into the Sabine Bank Channel and the Sabine Pass Outer Bar Channel. It enters into Sabine Pass through the Sabine Pass Jetty and Sabine Pass channels, and follows the west bank of Sabine Lake to Port Arthur in the Port Arthur Canal.

The project includes Taylor Bayou Channels and Turning Basins at the confluence of the Port Arthur Junction Area. On the west side of Sabine Lake, the Sabine-Neches Canal is separated from the lake by an artificially created bank of land called Pleasure Island that extends to near the mouth of the Neches River. From the northwestern to the northeastern corner of Sabine Lake, another section of the Sabine-Neches Canal connects the mouths of two rivers, the Neches River (to Beaumont, Texas) and the Sabine River to the east (to Orange, Texas). The Neches River Channel ends at the Beaumont turning basin just south of the Interstate 10 Bridge. The waterway was authorized by the River and Harbor Act of 1962, House Document No. 553, 87th Congress, 2nd Session, and along with the Sabine Pass Ship channel serves the ports of Port Arthur, Beaumont, and Orange in the movement of commodities, particularly crude petroleum.

Table 2-9: Existing Sabine-Neches Waterway Channel Dimensions

Channel Reach	Authorized Depth (feet)	Bottom Width (feet)	Length (miles)
Sabine Bank Channel	42	800	14.7
Sabine Pass Outer Bar Channel	42	800	3.4
Sabine Pass Jetty Channel	40	800-500	4.0
Sabine Pass Channel	40	500-1,133	5.6
Port Arthur Canal (including Taylor Bayou)	40	500-1,788	6.2
Sabine-Neches Canal	40	400-1,060	11.3
Neches River Channel	40	400	18.6

2.10.3.2 Gulf Intracoastal Waterway

The Gulf Intracoastal Waterway (GIWW) passes through the focused study area and forms a portion of the northern boundary. The GIWW is a coastal canal from Brownsville, Texas to the Okeechobee waterway in Fort Myers, Florida. The Texas portion of the canal system extends 379 miles, from Sabine Pass to the mouth of the Brownsville Ship Channel at Port Isabel. The GIWW is the nation’s third busiest inland waterway. The Texas portion of the GIWW handles 67 percent of the entire GIWW’s traffic (TxDOT 2016).

Shallow and deep draft vessels use the same channel where the routes of the GIWW and SNWW overlap. The GIWW coincides with parts of the Sabine Neches, entering from the west just south of Port Arthur, extending through the confined channel reach at Pleasure Island, crossing the more exposed northern edge of Sabine Lake, and following the Sabine River Channel north to just south of the Orange, where the GIWW turns eastward and continues into Louisiana. The GIWW is federally authorized at 125 feet wide and 12 feet deep.

2.10.3.3 Ports

The Port of Beaumont, within the larger study area and just outside the focused study area, ranks fourth in the nation in overall tonnage of cargo processed. The port recently completed construction of a new state of the art petroleum terminal that can handle 120-car unit trains. When fully developed the terminal will have the capacity to offload more than 210,000 barrels of crude oil a day. The US Maritime Administration has designated the Port of Beaumont and Port of Port Arthur as strategic ports in its national Port Readiness Network, which supports deployment of U.S. military forces during defense emergencies. Beaumont handles military equipment shipped to and from Fort Hood and the Red River Army Depot and is recognized as the world's busiest port of military embarkation (TxDOT 2016).

2.11 Recreation and Aesthetics

The J.D Murphree WMA, Sea Rim State Park, McFaddin NWR, and Texas Point NWR contain lands and parks designated for low-density recreational activities such as hunting, fishing, hiking, wildlife observation, photography, environmental education, and interpretation. On private lands, recreational activities are at the discretion of the land owner and are typically managed through an ownership agreement. Public access to and through much of the area is restricted to boats due to the expanse of lakes, bayous and marshes. There are a minimal number of roads and trails available for public use.

Recreational fishing is probably the most common recreational opportunity that people take advantage of in the focused study area. The large variety of fresh and saltwater species make fishing the most popular recreational activity within the marshes. Saltwater fishing opportunities can be found along anywhere along the beaches of the Gulf of Mexico, in 10 Mile Cut and 5 Mile Cut of Salt Bayou, in Star Lake, Clam Lake, Willow Lake, Barnett Lake, Keith Lake, Sabine Lake, Sabine Pass, GIWW, and SNWW. Marsh habitats provide freshwater and saltwater fishing opportunities depending on the area. A small area on the south shore of Keith Lake, just off of State Highway 87 has been filled and graded to support parking for fisherman taking advantage of Keith Lake. In 2016, Jefferson County constructed a new park and boat ramp on the north shore of Keith Lake that provides access to the chain of lakes and bayous in the interior of the focused study area.

Each fall, duck and alligator hunting in the study area is a popular recreational activity. The J.D. Murphree WMA traditionally conducts half-day public waterfowl hunts three days a week on a first come/first-served basis during the regular waterfowl season and each day of the September teal season. Public hunts for alligators are conducted by special permit during the September alligator season. On McFaddin NWR, waterfowl hunting programs are offered ranging from free, first-come/first-served programs to more formal fee permit reservation system. Different hunt units on the refuge open on different days of the week to provide hunting opportunities throughout the week, as well as periods of rest for waterfowl.

Direct access to the beach has been limited to extant portions of State Highway 87 (officially closed in 1989) near High Island on the west and the refuge entrance at Clam Lake Road in the east. Coastal processes including ongoing shoreline retreat and a severe coarse sediment (sand) deficiency often restrict or preclude travel and beach use activities, especially in areas where high erosion rates are seen. Beaches at the western ends of McFaddin and most of Sea Rim State Park remain in the best condition and provide the best recreational beach use opportunities.

From an aesthetic perspective, the landscape is basically flat, with marsh elevations throughout the study area presently hovering just above sea level (about 0.0 to 1 foot mean sea level). Topographic highs of a few inches to a few feet are generally limited to spoil mounds along dredged channels, or in abandoned placement areas, elevated roads and cattle trails, and impoundment or barrier levees. Man-made features within the study area are limited to oil and gas development (i.e., well heads, tank farms, access roads, etc.) and recreational facilities, or visual acuities to marine shipping or recreational boat traffic, otherwise the area is largely undeveloped and provides a serene environment.

2.12 Hazardous, Toxic, and Radioactive Waste

To complete a feasibility level Hazardous, Toxic, and Radioactive Waste (HTRW) evaluation for the JCER, a records search was conducted following the rules and guidance of ER 1165-2-132: HTRW Guidance for Civil Works Projects, and ASTM E1527-13: Standard Practice for Environmental Site Assessment: Phase 1 Environmental Site Assessment Process. In the records review, files, maps and other documents that provide environmental information about the project area are obtained and reviewed. To complete the records review, USACE reviewed publicly available databases and sources, using the proposed footprint of the project, along with an approximate one mile search distance for each of the sources.

Jefferson County has several potential HTRW sites in relative proximity (one mile) to the proposed project footprint, including 8 Resource Conservation and Recovery Act (RCRA) generator sites, 4 registered petroleum storage tanks, and one leaking petroleum storage tank. This is a relatively low concentration of sites given the large oil and gas presence in the county, and all development, whether oil and gas related or not, is generally confined to the large population centers of Port Arthur and Beaumont. Sabine Pass, which is actually part of Port Arthur, is the closest town to the proposed project, and most potential HTRW sites are located in or around this settlement. The proposed project primarily takes place on Federal lands where oil and gas activities are limited, and the identified sites within one mile of the proposed project have an extremely low potential to impact the proposed project.

Although not classified as HTRW, pipelines and oil wells play an important role in the HTRW existing condition in Jefferson County, and in the proposed project area. Numerous plugged oil and gas wells are located offshore within 1.5 miles of the shoreline, and within the Texas Point marsh restoration area. A Railroad Commission of Texas (RRC) database also shows numerous operating oil, gas, and injection wells north of Johnson and Keith Lake. Several pipelines are shown immediately offshore, and several make landfall east of High Island and within Sea Rim State Park. Several pipelines can also be found in the Texas Point restoration area. Refer to the HTRW Appendix for maps of known pipelines in Jefferson County.

2.13 Future Without- Project Condition

The future without-project condition (FWOP), also known as the "No Action Alternative," is the most likely condition expected to occur over the 50-year planning horizon (2027-2077) in the absence of the proposed action or action alternatives. In this case, the No Action Alternative means that no ecosystem restoration activities would be undertaken in the future, beyond those already being implemented or likely to receive funding in the near future (next 5 years). It is assumed that all current or authorized for construction flood control, navigation, and oil and gas projects would be implemented consistent with existing conditions described in the existing conditions section or as described in the decision document and accompanying NEPA compliance document for each Federal project. Future projects that were included in the FWOP condition include:

McFaddin NWR Nourishment (USFWS, GLO): As described in section 1.6.1.4, the FWOP condition assumes that USFWS and GLO will construct the full 20-mile beach ridge restoration project. For purposes of determining the FWOP condition, implementation of the project was assumed to provide benefits for 10 years to the barrier headland for that restoration unit beginning at year 0 of the planning horizon. Thereafter, it was assumed that the restoration work would not be maintained and that the condition of the unit would continue to degrade over time as erosion and RSLC occurred.

Inverted Siphons (USFWS, TPWD, Jefferson County, GLO): This project involves the installation of two inverted siphon systems under the GIWW. One siphon is planned on and would benefit McFaddin NWR and the other would be constructed on and benefit JD Murphree WMA. The purpose of the siphons is to strategically reintroduce freshwater inflows to the project area south of the GIWW on the NWR and WMA to reduce saltwater intrusion and help manage seasonal salinity within the system. A second purpose is to manage seasonal water level targets on the north side of the GIWW to reduce water logged conditions and duration from storm surge and excess runoff in order to improve marsh habitat conditions north of the GIWW. The potential to restore freshwater inflows has been part of a multifaceted program to meet the objectives of the NWR, WMA, and Salt Bayou Restoration Plan management goals. Modeling completed by the Texas Water Development Board (TWDB) in 2009 indicates that the siphons are expected to decrease salinity levels from intermediate/brackish levels to fresh levels in approximately 500 acres of open water habitat and 1,700 acres of emergent marsh. Fringe wetland areas impacted would also experience lower salinity peaks within much of the project area. Specific areas where salinities would be reduced include Willow/Barnett Lake Complex and Shell Lake/Salt Bayou throughout the growing season. This expected decrease in salinities below the present levels was assumed to be a net benefit to the overall health of the marsh and species utilizing the habitats when determining FWOP condition for the focused study area for the Brackish Marsh WVA community model.

The siphons have not been constructed; however, funding is available and NEPA documentation has been completed. Currently, the project is proceeding through the Clean Water Act, Section 404 process, in which USFWS and TPWD must secure a Section 404 regulatory permit from USACE Galveston Regulatory Program prior to construction. It was assumed that the permit could be secured, construction could be completed, and benefits could begin being realized by year 0 of the planning horizon for this study.

Sabine Pass to Galveston Bay, Texas Coastal Storm Risk Management and Ecosystem Restoration (USACE): The Chief of Engineers signed the Sabine Pass to Galveston Bay, Texas Coastal Storm Risk Management and Ecosystem Restoration (S2G) Chief's Report on December 7, 2017. The Report includes recommendation of a plan that would address Coastal Storm Risk Management (CSRM) and Ecosystem Restoration (ER) problems within six counties of the upper Texas coast (Orange, Jefferson, Chambers, Harris, Galveston, and Brazoria Counties). The plan includes:

- Orange 3 CSRM project would consist of a 26.7-mile long levee/floodwall system along the edge of the Sabine and Neches River floodplains from Orange to the vicinity of Orangefield, Texas.
- Port Arthur and Freeport CSRM Projects would raise or reconstruct 11.6 miles and 18.2 miles of existing levees/floodwalls for each system respectively, replace vehicular closure structures, construct navigable surge gate structures, and increase resiliency by installing erosion protection.

The impacts and benefits of the plan were identified in the Final Integrated Feasibility Report and Environmental Impact Statement (FIFR-EIS) and were incorporated into the WVA analysis and other FWOP analysis which contribute to FWP analyses. The FIFR-EIS indicates the Orange 3 CSRM project would result in the loss of 69.5 acres of forested wetlands and 203.0 acres of estuarine marsh, as well as functional impacts to 2,137.2 acres of estuarine marsh resulting in a loss of 43 average annual habitat units (AAHUs) for forested wetlands and 143 AAHUs for estuarine marsh. No direct or indirect impacts on wetlands were anticipated with construction of the Port Arthur and Freeport CSRM Projects. A mitigation plan was incorporated and proposes restoration of 453 acres of estuarine marsh and preservation 559.5 acres of forested wetlands in perpetuity, providing 263 AAHUs to fully compensate for these impacts.

The total first cost of the project is estimated to be $3,248,607,000. This project was funded under the Bipartisan Budget Act of 2018 (PL 115-123), which provided supplemental funding for the USACE in the Flood Control and Coastal Emergencies appropriation. Funding for S2G was made available in 2018 for the pre-engineering design (PED) and construction phases.

Sabine-Neches Waterway Widening and Deepening (USACE): The Chief of Engineers signed the Sabine-Neches Waterway Channel Improvement Project, Southeast Texas and Southwest Louisiana on July 22, 2011. The Report includes a recommendation of the locally preferred plan which includes the following improvements:

- Deepen the SNWW from 40 to 48 feet and the offshore channel from 42 to 50 feet in depth from offshore to the Port of Beaumont Turning Basin;
- Extend the 50-foot deep offshore channel by 13.2 miles to deep water in the Gulf, by increasing the total length of the channel from 64 to 77 miles;
- Taper and mark the Sabine Bank Channel from 800 feet wide to 700 feet wide;
- Deepen and widen Taylor bayou channels and turning basins;
- Ease selected bends on the Sabine-Neches Canal and Neches River Channel; and

- Construct and enlarge/deepen existing turning and anchorage basins on the Neches River Channel.

To implement the plan, a 50-year Dredged Material Management Plan (DMMP) with beneficial use (BU) areas, upland placement areas (PAs) and ocean dredged material disposal sites (ODMDS) was developed. Two of the BU features of the DMMP would offset all direct and indirect marsh impacts in Texas by creating 2,853 acres of emergent marsh vegetation, improving 871 acres of open water habitat, and nourishing 1,234 acres of existing marsh in Texas. One of the BU sites also offsets the impact of conversion of 86 acres of fresh marsh to a confined PA and the indirect impacts of the increase in salinity over approximately 39,000 wetland acres in Texas. Minor erosion impacts would be offset by periodically nourishing 6 miles of Texas and Louisiana Gulf shorelines. The primary impacts of the plan is an indirect impact associated with a small increase in salinity and an associated reduction in biological productivity over approximately 182,000 acres of intertidal marsh in Louisiana, and the potential loss of 691 acres of marsh in Louisiana as some marsh converts to open water. The mitigation plan compensates for all impacts by restoring 2,783 acres of emergent marsh, improving 957 acres of shallow-water habitat, and stabilizing and nourishing 4,355 acres of existing marsh in the Willow and Black Bayou areas, Louisiana.

This project is currently in PED. Funding for construction is expected shortly after the PED phase is complete.

JD Murphree WMA Beneficial Use of Dredged Material (TPWD): For purposes of the FWOP condition, there is a reliable source of dredged material and partnerships in place between the WMA and LNG to assume marsh nourishments (as described in section 1.6.1.1) would continue indefinitely. These units were assumed to being fully functioning and would not realize any loss in the future or potential for additional gains.

2.13.1 Resources Not Analyzed under the FWOP

The following resources will not be analyzed in detail in this section because there is no anticipated change from the existing condition in the future.

- Land Use
- Air Quality
- Recreation and Aesthetics
- Lands with Special Management
- Transportation
- Cultural Resources

The following sections further describe the anticipated FWOP condition if no restoration measures are implemented.

2.13.2 Climate

Future projections of freshwater inflows for the study area are highly uncertain. These flows would be influenced by changes in the timing and amount of precipitation, temperature, water demand, and water supply strategies. The Texas State Climatologist concluded that it is impossible to predict with confidence what precipitation trends will be in Texas over the next half century (Nielsen-Gammon 2009). Unlike precipitation, there is more consensus for a predicted temperature increase in Texas of close to 4 degrees Fahrenheit (°F) by 2060. Patterns of precipitation change are affecting coastal areas in complex ways. The Texas coast saw a 10-15% percent increase in annual precipitation for 1991-2012 compared to the 1901-1960 average. Texas coastal areas are expected to see heavier runoff from inland areas, with the already observed trend toward more intense rainfall events continuing to increase the risk of extreme runoff and flooding.

Texas' entire Gulf Coast historically averages three tropical storms or hurricanes every four years, generating coastal storm surges and sometimes bringing heavy rainfall and damaging winds hundreds of miles inland. The expected rise in sea level is anticipated to result in the potential for greater damage from storm surge along the Gulf Coast. Tropical storms have increased in intensity in the last few decades. Future projections suggest increases in hurricane rainfall and intensity, with a greater number of the strongest hurricanes (Categories 4 and 5) (Melillo et al. 2014).

2.13.2.1 Relative Sea-Level Change (RSLC)

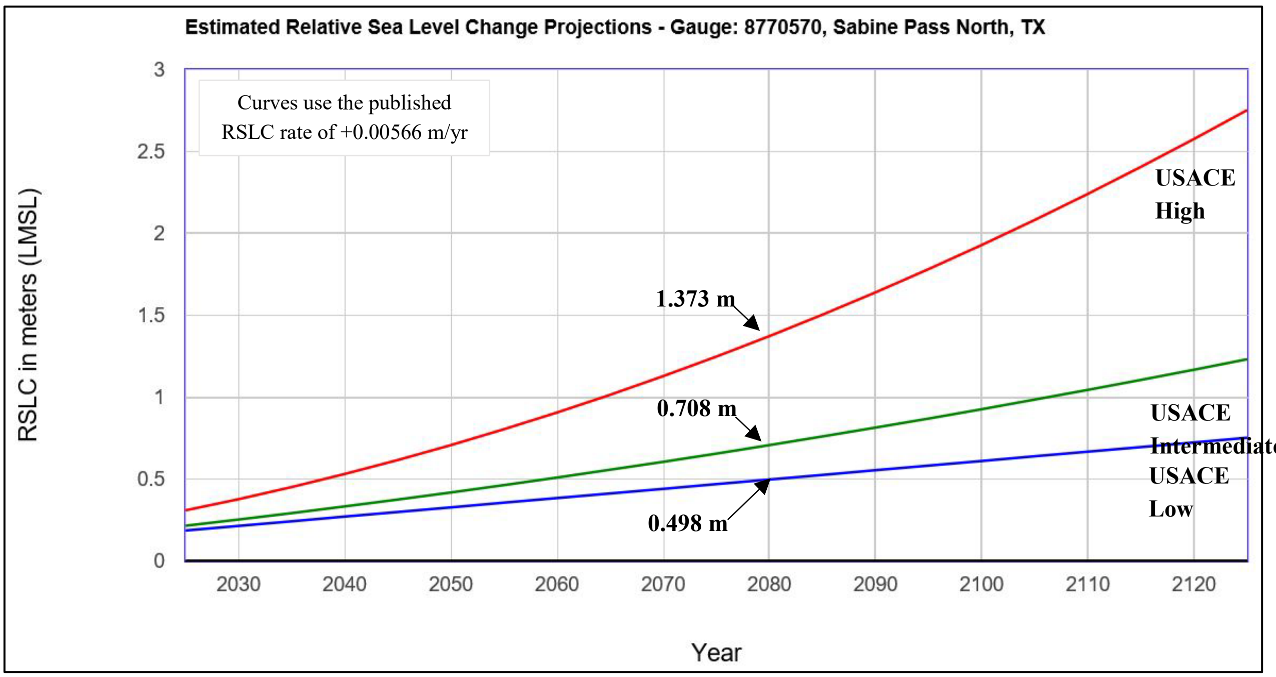
Scientific research indicates that the Global Mean Sea Level has been increasing since the 1990s, which has seen a sea level rise (SLR) rate of around 3 millimeters (0.14 inches) per year, roughly twice the rate seen during the past 100 years. Rise in sea levels is linked to several primary climate-related factors, all induced by the ongoing global change including water thermal expansion and melting of glaciers and polar ice caps. Another factor which is not directly climate related but intensifies sea-level change is the subsidence of coastal lands. Land subsidence, which is the sinking of a land mass, when combined with SLR can have significant impacts on land loss.

Most RSLC models generated for the study area were run using scenario A1B from the 2000 Intergovernmental Panel on Climate Change's (IPCC) Special Report on Emissions Scenarios (SRES) mean and maximum estimates, which are based on global SLR. The A1 family of scenarios assumes that the future world includes rapid economic growth, global population that peaks in mid-century and declines thereafter, and the rapid introduction of new and more efficient technologies. In particular, the A1B scenario assumes that energy sources will be balanced across all sources. Under the A1B scenario, the 2007 IPCC WGI Fourth Assessment Report suggests a likely range of 0.21 to 0.48 meters of SLR by 2090-2099 "excluding future rapid dynamical changes in ice flow."

Although the global SLR predictions are valuable, USACE policy requires incorporation of projected changes to Local Mean Sea Level (LMSL) into the design of Civil Works projects. To attain these values, the USACE Sea Level Change Curve Calculator (available at: http://corpsmapu.usace.army.mil/rccinfo/slc/slcc_calc.html) was used to attain these values and compare the USACE scenarios to the NOAA 2012 Technical Report OAR CPO-1, "Global Sea Level Rise Scenarios for the United States National Climate Assessment." The calculator provides three rates of RSLC including the "low," "intermediate," and "high." The "low" rate of RSLC in based on an extrapolation of historical tide gauge readings. The "intermediate" and "high" rates represent a future acceleration in sea-level change with trajectories based on modified National Resource Council curves (NRC 1987) I and III respectively and adjusted for local vertical land movement.

The output of the calculator is dependent on using adequate historical water level data. The closest NOAA tide gage with more than 40 years of water level data is Sabine Pass North, TX (NOAA Gage 8770570), which has a published RSLC rate of 0.00566 meters/year (0.22 inches/year). Figure 2-7 shows the three scenario curves which represents the temporal trends in water-level above LMSL. The curves indicate that by 2080, just three years after the 50-year planning horizon for the study, the "low" (blue) scenario could realize a 0.498-meter (1.60-foot) rise above LMSL, while the "intermediate" (green) would be 0.708 meters (2.3 feet) in SLR above LMSL, and the "high" (red) 1.373 meters (4.5 feet) above LMSL. The intermediate curve is the assumed rate of RSLC for purposes of this study.

Figure 2-7: RSLC scenarios at NOAA gage 8770570, Sabine Pass North, TX



2.13.3 Water Resources

Water resources would be predominately affected by implementation of the SNWW CIP project. The Final Feasibility Report and EIS documented the impacts of deepening the channel to 48 feet. Concerns that a deeper navigation channel would increase salinity in the Sabine Lake estuarine system were addressed with a 3-D HS model that predicts changes in water elevation, circulation, and salinity due to improvements. Those results are summarized here and were incorporated into the Wetland Valuation Assessment (WVA) analysis completed to determine benefits of implementing ecosystem restoration.

2.13.3.1 Hydrology

The effects of the proposed 48-foot deepening on water surface elevation were investigated by running the model with both the existing channel dimensions (future without project condition) and the 48-foot channel dimensions. Both runs were with the "most likely" relative sea level change of 1.1 feet at the ocean boundary. The model results indicate that the average water surface elevation through most of the study area was largely unaffected by the addition of the 48-foot channel. However, both the amplitude and the average elevation of the tide on the upper Neches River (near the saltwater barrier and outside the JCER focused study area) exhibited a measurable increase. This change in the tidal signal results in an average increase in water surface elevation of 0.067 feet, or 0.8 inches. Specifically within the Jefferson County ER focused study area, observation points 7, 15 and 17 are most relevant and indicate a negligible change of less than 0.01 feet at low and median flows.

Freshwater inflows into the system would remain largely unchanged in the FWOP condition. With construction of the SNWW CIP, the amount of tidal exchange would be increased slightly which would be conveyed to the Gulf marginally faster than in the existing condition.

2.13.3.2 Surface Water

Under RSLC, the amount of surface water in the project area is expected to significantly increase over time. Using the NOAA Sea Level Rise data, it is estimated that 48 percent of the existing marsh would convert to open water or unconsolidated shoreline. Most of this change would occur along the eastern half of the focused study area and south of the GIWW (Figure 2-8).

Figure 2-8: Land Cover change from 2010 to 2077.

Although Jefferson County is expected to see an increase in population and demand for water, expected changes in supply strategies and demands that are part of the 2016 Water Plan East Texas Region (TWDB 2015) would be expected to have only negligible impacts to surface water flows into and out of the focused study area.

2.13.3.3 Wetlands and Jurisdictional Waters of the US

See wetland FWOP condition discussion in section 2.13.5.1. Under the FWOP condition, there is no anticipated change in the extent of Jurisdictional Waters of the US; however, the composition of jurisdictional waters could change as open water increase and wetlands decrease.

2.13.3.4 Groundwater

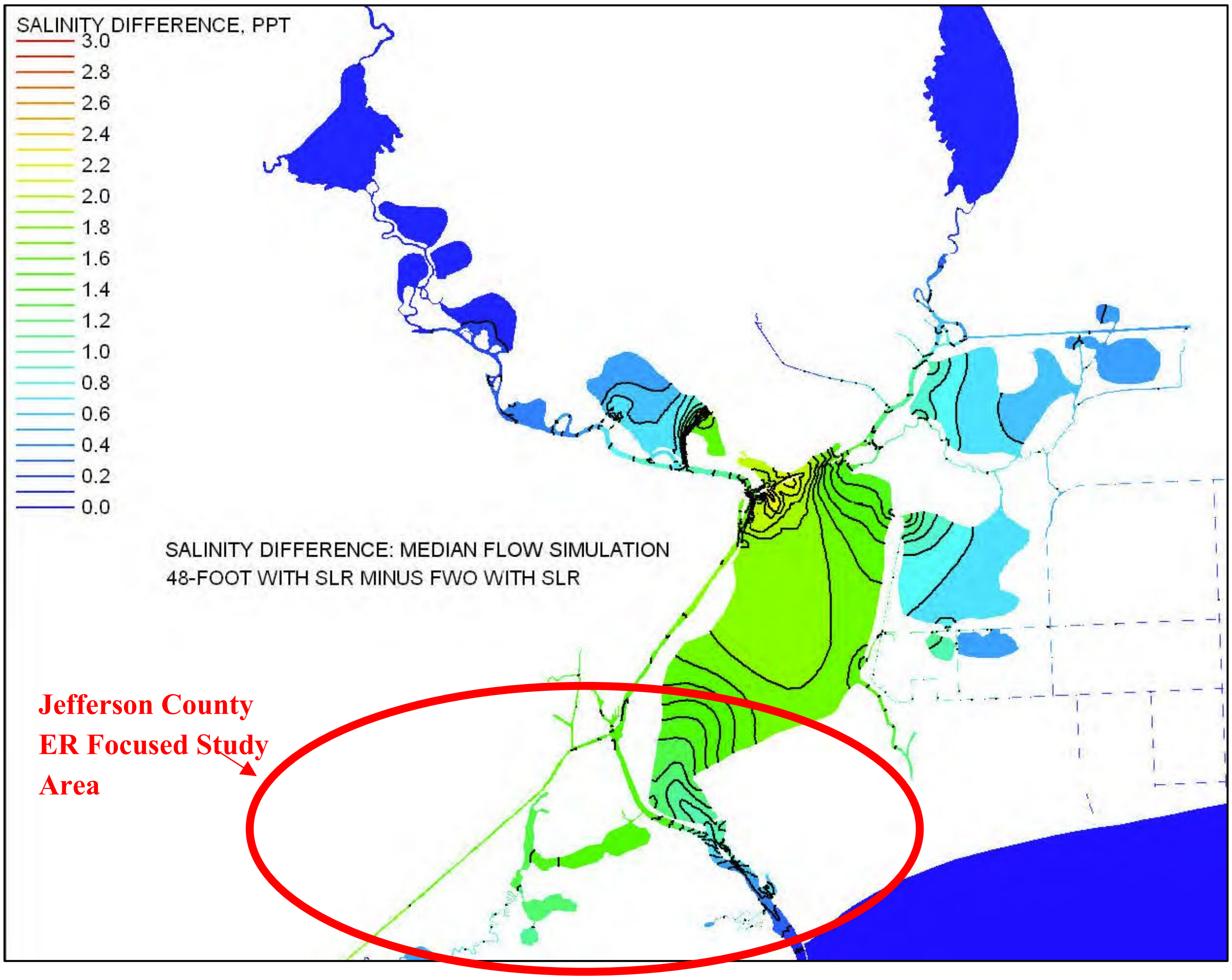
With projected future effects of climate change, there is a potential for saltwater intrusion into shallow groundwater aquifers at or near the focused study area due to a rise in sea levels. A USACE SWG study was completed to assess the impacts of sea level rise on groundwater aquifers (USACE 2009). The study indicates that if sea level rises 0.5 inches (0.04 feet), the freshwater/saltwater interface could potentially rise as much as 1.67 feet, which would not have a significant impact on a freshwater aquifer. However, for a 50-year assessment, sea level rise of 2.3 feet would cause the interface to rise up to 92 feet. For every foot the saltwater level rises, the height of free ground surface water is reduced by one foot. As a result, the interface between saltwater and freshwater underground rises approximately 40 feet for every foot the sea level rises. This could have significant effect on the amount of fresh water in deep aquifers in the study area with or without the project.

2.13.3.5 Water Quality

The effects of the proposed 48-foot deepening would have adverse effects on salinity in the Jefferson County ER focused study area. The salinity differences with deepening range between 0 and 2 ppt over the SNWW CIP study area with the largest differences coinciding with the largest horizontal gradients of salinity. For the low flow case, these transition zones are outside the Jefferson County ER focused study area; however, for the median flow, the transition zones shift further downstream to Bessie Height on the Neches River, at the GIWW and Keith Lake in the Sabine-Neches canal, and along the eastern shore of Sabine Lake, of which all but the eastern edge of Sabine Lake are within the focused study area. Specifically within the focused study area, at low flow there would be 0.0 to 0.4 ppt difference throughout most of the area with the highest difference occurring at Keith and Johnson lakes. Under median flow simulations, there is a 0.0 to 0.4 gradient through Sabine Pass to just south of Keith Lake where salinities begin to increase. Throughout the GIWW and Keith Lake and its associated lakes, salinities increase ranging from 1.0 to 1.62 ppt (Figure 2-9).

These specific statistics were input into the Jefferson County ER WVA community model for the FWOP condition. The WVA requires input of “mean salinity” during the growing season for the assessment of impacts to brackish and saline habitats. These statistics were provided to the PDT and resource agencies for use in predicting the future with project conditions.

Figure 2-9: Salinity Changes for the FWOP Condition for the Jefferson County ER Feasibility Study.



Under the FWOP condition, it was assumed that USFWS and TPWD would construct the two siphons that would restore freshwater flows into a portion of the brackish marshes south of the GIWW. Models developed by the TWDB in 2009 indicate that siphons are expected to decrease salinity levels from intermediate/brackish levels to fresh levels (less than 8 ppt) in approximately 500 acres of open water habitat and 1,700 acres of emergent marsh (Pothina and Guthrie 2009). Fringe wetland areas impacts will also experience lower salinity peaks within much of the benefit area of the siphons. Additional testing indicated that the general chemistry of samples showed there would be no significant impact to water quality south of the GIWW (i.e. samples did not contain significant suspended solids, nutrients, metals, organics or bacteria that would be moved south).

2.13.4 Geologic Resources

Under the FWOP condition, the geology of the study area would not be expected to change. Alterations to bathymetry from maintenance dredging and SNWW CIP, in addition to topographic changes from the placement of dredged material at PAs and in restoration units would continue in the future within and outside the focused study area.

2.13.4.1 Sediment Transport

There are two main types of sediment transport in the system—sediment carried into the channels by heavy rains in the watershed and conveyed through the navigation channels, and sediment transport along the coast.

Under the FWOP condition, a deeper channel will require more dredging than under the existing condition. The low velocities near the bottom of the navigation channel offer conditions favorable for sediment deposition, despite no change in the amount of sediment-laden runoff. As well, the deeper channel will have a larger volume below the existing seabed, making it function as a larger sediment trap. The assumption is that under the FWOP there would be less sediment entering the Gulf and contributing to longshore sediment transport than under the existing condition.

Gravens and King (2003) investigated the shoreline impact of deepening the channel in relation to wave climate produced by the deeper offshore channel and the changes in longshore sediment transport. Under the FWOP, a deeper and longer entrance channel would be expected to have some effect on waves moving from the Gulf to the shore, and that would in turn exert an effect on the rate of longshore sediment transport. Channel deepening would reduce the westward transport on the Texas side and increase the eastern transport on the Louisiana side.

2.13.4.2 Shoreline Erosion

Under the FWOP condition, shorelines will continue to retreat due to RSLC and interrupted longshore sediment transport along the Gulf coast. The Bureau of Economic Geology (BEG) has analyzed historical rates of change and projected shoreline retreat along the Texas Coast (BEG 2017). Erosion rates are predicted to continue following the historical trend and rate of erosion as described in the existing condition (Figure 2-10 and Figure 2-11). The FWOP shoreline consists of widespread erosion except for at two locations: 1) near Sea Rim State Park which is a location of longshore transport convergence and 2) at the fillet against the west side of the SNWW jetties which has historically accreted due to an interruption in the prevailing longshore sediment transport.

Figure 2-10: Predicted shoreline change at year 2056 for the eastern half of the focused study area

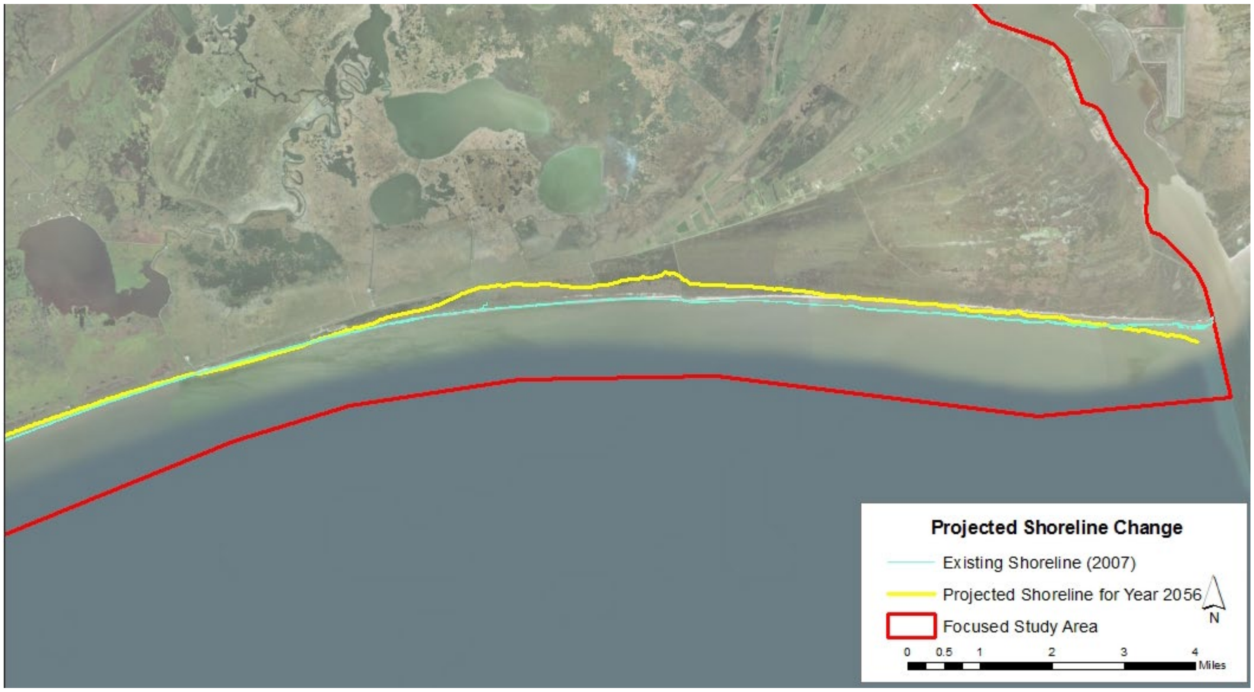
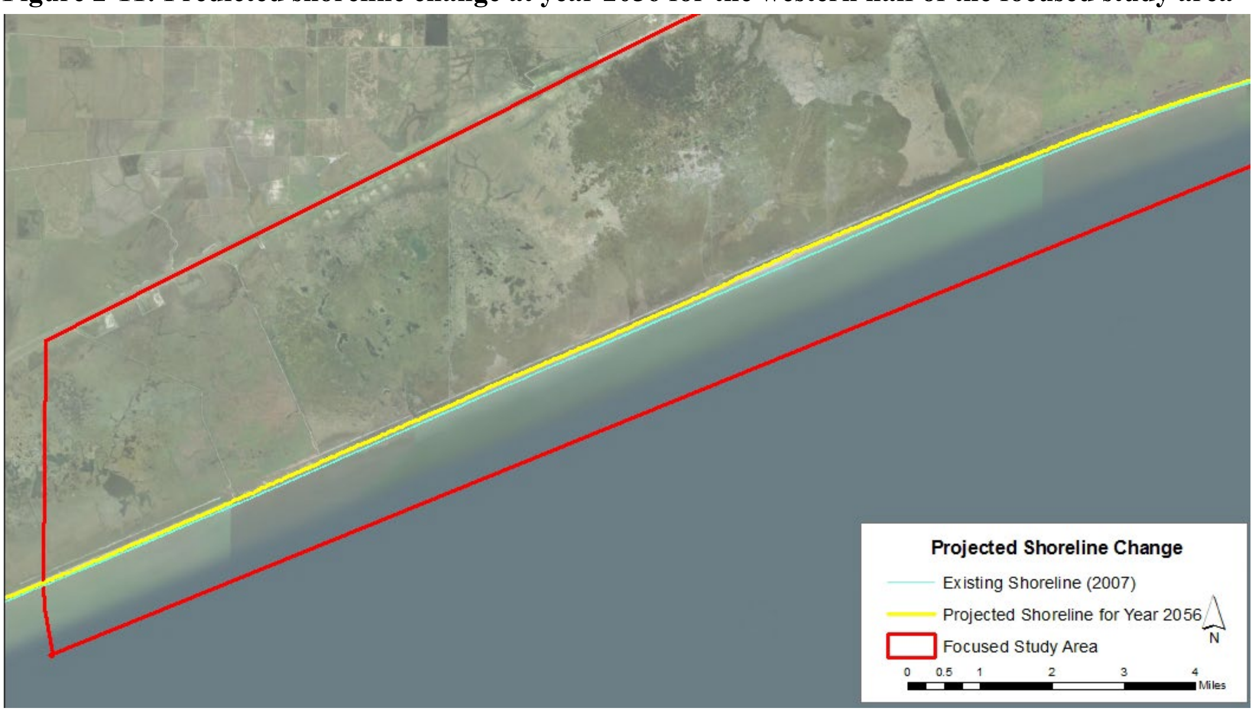


Figure 2-11: Predicted shoreline change at year 2056 for the western half of the focused study area



Along the GIWW, it was assumed that vessel- and wind-generated waves and surges would continue to erode the shoreline at the historical rate of approximately four feet per year, as determined by resource agencies and land managers affected by the loss, where breakwaters do not currently exist. This could result in a land loss of up to 260 acres along the GIWW in Jefferson County. Where GIWW armoring exists now, it is assumed that the structures would continue to function as designed and there would be no significant/measurable erosion to the shoreline behind the structure.

2.13.5 Biological Communities and Special Status Species

The repetition of tropical storm events, hurricanes, and human modification of hydrology and coastal features has increased ecosystem vulnerability on the upper Texas coast. Successive disturbance and salt stress from interference with freshwater flows has put in jeopardy the process by which marsh sediment accretion and land accumulation occurs. "Without a healthy plant community, sedimentary deposition decreases due to the loss of plants in the water column, biogenic accretion ceases due to the lack of plant detritus, and the substrate becomes exposed, leading to rapid erosion. As a result, a tipping point may have been reached, or is about to be reached, where these wetlands will be unable to keep pace with rising sea level." (Williams et al. 2009) As a result, the extensive marshes along the upper Texas coast have reduced resiliency to storm surge impact, complicating their post-storm recovery. All of this is also occurring within the context of climate change, which is likely to result in an increase in the intensity of tropical storms, rising average annual temperatures, and an increase in the rate of relative sea level change.

2.13.5.1 FWOP Impacts on Habitat

Without action, marine influences and other natural and human factors, such as subsidence, sea level change, navigation channels, oil and gas development, industry growth, and population increases would result in continued coastal habitat loss in the study area. Without action, the coastal vegetation resources would continue to decline through bankline erosion, sloughing of the shoreline, and continued fragmentation and conversion of existing brackish and saline marsh to shallow open water habitats.

RSLC is the most likely factor to result in significant changes to biological communities. Future RSLR threatens existing vegetated marshes with submergence and conversion to open water. Increased saltwater intrusion and introduction of tidal energies to historically non-tidal or micro-tidal freshwater marshes is expected to continue causing plant mortality, peat collapse and erosional loss of organic marsh soils, leading to habitat switching and conversion of vegetated marshes to open water. It is likely that these impacts have been and will be the most severe in areas subject to saltwater intrusion from the navigation channels and seawater overwash and in areas with rapid subsidence.

Significant reductions of the brackish and saline marshes under the FWOP condition is anticipated because of the accelerated rate of land loss and the narrowing of zones based on differing salinity regimes. Land loss, saltwater intrusion, and marine influences, conditions that would exacerbate the loss of barrier beach system, would result in the narrowing of the broadly delineated zones of coastal habitat types that exist today. As the zones narrow into smaller bands of coastal habitat types, the acreage associated with each coastal habitat type, particularly brackish marsh and saline marsh, would also diminish.

The barrier beach system, which includes the beach and dune, would continue to erode under normal conditions and would likely be breached during significant storm events. The only location where this would not be as catastrophic is on McFaddin NWR where beach nourishment restoration efforts are underway and renourishment is expected to continue into the future. Without the protective buffer provided by the beach and dune system, interior wetlands would be at an increased risk to severe damage from tropical storm events. Development of the barrier beach is not anticipated since the State and Federal government own all areas along the shoreline and sale of this area is highly unlikely.

It is possible there would be a long-term reduction in freshwater inflow to the estuary since the human population of the state is expected to double during the life of the project. The doubling of the population is expected to increase demand for water, which in turn is anticipated to lower freshwater inflows into marshes and inland freshwater habitats. As well, population growth is anticipated to reduce the acreage of coastal habitats as additional land is converted for development.

In marine and freshwater open water habitats, salinity changes from increased rainfall or tidal influences, increase in water temperatures, extreme weather events, and increased absorption of CO_2 is contributing to a reduction or redistribution of habitat forming organisms. This is resulting in a decrease in nursery habitat for commercially significant fish species and a reduction in suitable habitat for rare or imperiled species. This trend is very likely to continue into the future.

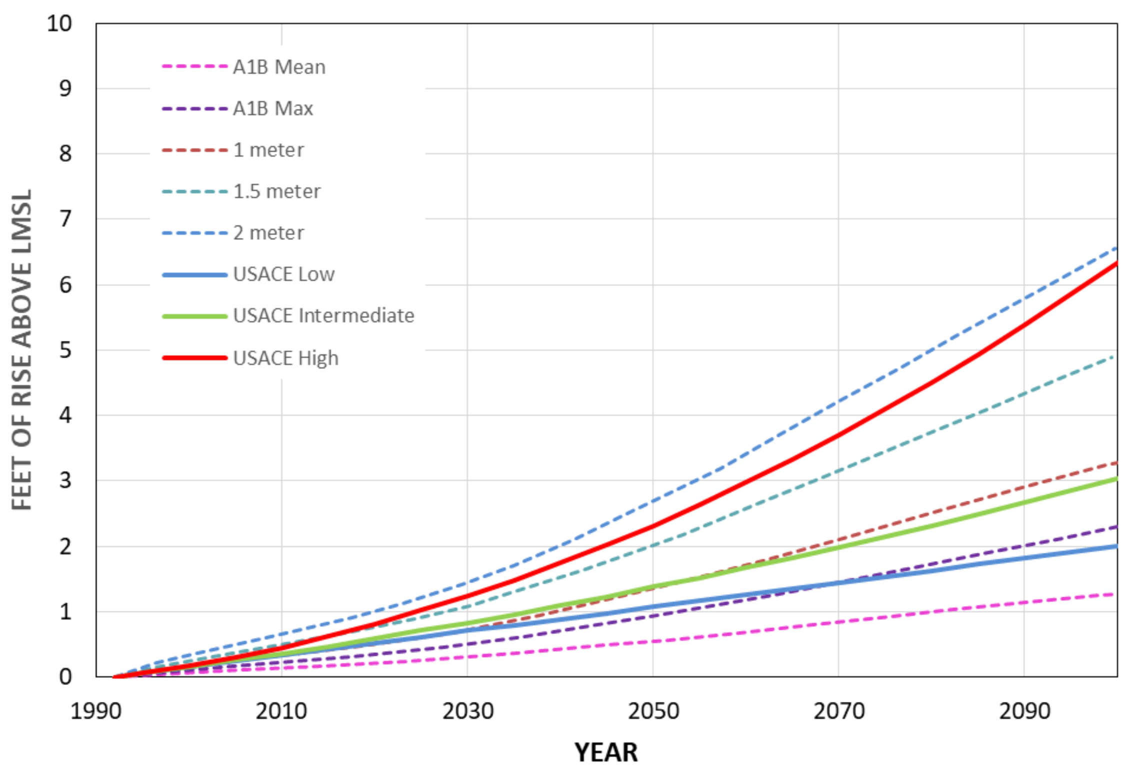
Existing dredging, dredge placement, and offshore oil and gas development is expected to continue into the future similar to the existing conditions.

2.13.6 Sea Level Affecting Marshes Model (SLAMM 6)

In 2009, funding for an application of the SLAMM model to coastal sites in eastern Texas and eastern Mississippi was provided to Warren Pinnacle Consulting, Inc. by NOAA's Coastal Services Center (CSC) in support for the Gulf of Mexico Alliance's Habitat Conservation and Restoration Priority Issue Team (HCRT) and the Gulf Coastal Resiliency Priority Issue Team (PIT). This effort is part of a larger effort that the HCRT is undertaking with the Florida and Texas chapters of The Nature Conservancy (TNC) to understand the Gulf-wide vulnerability of coastal natural communities to SLR in order to help develop appropriate conservation and restoration strategies and actions. The SLAMM model was run for all of Jefferson County south of the GIWW, which incorporates most of the focused study area of this ecosystem restoration study. The report produced from this effort is being incorporated into this study to help identify climate change impacts on marshes in Jefferson County if no action is taken (FWOP condition) (Warren Pinnacle, ,Inc. 2011).

Changes in tidal marsh area and habitat type were modeled using the SLAMM 6 model that accounts for the dominant processes involved in wetland conversion and shoreline modifications during long-term sea level rise. Within SLAMM, there are five primary processes that affect wetland fate under different scenarios of sea-level rise: inundation, erosion, overwash, saturation, and accretion. The NOAA marsh migration viewer only incorporates passive inundation rather than the multiple processes, though it can still be informative. For Jefferson County, the SLAMM model was run using scenario A1B mean and maximum scenarios and 1, 1.5, and 2 meter(s) eustatic SLR rates by year 2100 (Figure 2-12). The 1 meter SLAMM scenario approximately tracks the USACE intermediate curve with A1B maximum approximately equal to USACE low and the USACE high between the 1.5-meter and 2-meter scenarios (Figure 2-12).

Figure 2-12: SLAMM and USACE Sea-Level Rise Curves (SLR assumed to be 0.00125 m/yr)



The study area consists mostly of irregularly-flooded marsh (5%), with dry land (5%) and regularly-flooded marsh (5%) the second and third most common land categories. Depending on the scenario, the site is expected to lose between 4% and 99% of its irregularly-flooded marsh, mainly through conversion to regularly-flooded marsh and tidal flat (Table 2-10, Table 2-11, and Figure 2-13, Figure 2-14). Jefferson County is predicted to lose roughly one quarter of its dry land (both developed and undeveloped) in the most conservative sea level rise scenario (AB1-Mean, below the USACE Low Curve).

The report concludes that model results for the study site (south of GIWW) is vulnerable to sea level rise under more extreme scenarios. Land subsidence, low land elevations relative to mean tide levels (MTL) and low tide ranges cause this system to lose extensive high marsh under SLR scenarios of over 0.6 meters by 2100. Measured accretion rates at the site (and regionally) are relatively high, helping to offset such vulnerabilities under lower scenarios of SLR. However, the vulnerability through 2100 is exacerbated under higher SLR scenarios where SLR rate exceeds the accretion rate of the marsh and much of the study area is projected to transition to tidal flat or open water (Figure 2-15).

Table 2-10: SLAMM6 Model Results—Predicted Percent of Land Covers by 2100
(negative loss rate indicates a gain)

SLR by 2100 (m)	AB1-Mean (0.39)	AB1-Max (0.69)	1.0 (USACE Intermediate)	1.5	2.0
Irregularly-flooded marsh	4%	20%	60%	96%	99%
Undeveloped dry land	22%	38%	52%	65%	71%
Regularly-flooded marsh	-44%	-214%	-415%	-190%	38%
Inland fresh marsh	-6%	-1%	20%	37%	46%
Developed dry land	29%	53%	69%	84%	89%
Ocean beach	96%	86%	85%	92%	97%
Inland Shore	28%	39%	45%	47%	47%
Estuarine Beach	75%	34%	-11%	-14%	63%
Swamp	30%	38%	40%	49%	58%

Table 2-11: SLAMM6 Model Results—Land Cover in Acres for the 1.0 Meter Eustatic SLR Scenario
(USACE Intermediate Curve Equivalent) * Project planning horizon ends at 2077.

	Initial	2050	2075*	2100
Irregularly-flooded Marsh	76532.2	69991.9	55636.4	30847.7
Open Ocean	23828.9	24428.8	24548.2	24892.2
Estuarine Open Water	16936.1	18395.9	19961.1	24472.2
Undeveloped Dry Land	7275.6	6451.4	4977.0	3508.1
Regularly-flooded Marsh	6709.7	11361.2	22752.5	34570.1
Inland Open Water	1262.5	1094.1	1072.3	1061.4
Inland Fresh Marsh	1254.5	1286.5	1220.0	1009.8
Developed Dry Land	990.4	849.9	570.6	307.2
Ocean Beach	567.6	10.9	48.6	84.1
Inland Shore	58.6	48.9	37.7	32.2
Estuarine Beach	42.9	17.4	17.9	47.7
Swamp	7.7	6.1	5.0	4.6
Tidal Flats	0	922.3	2926.1	13014.6
Transitional Salt Marsh	0.0	601.6	1693.2	1614.9
Total (including water)	135466.7	135466.7	135466.7	135466.7

Figure 2-13: SLAMM6 Model Results—Land Cover Change under the A1B maximum scenario

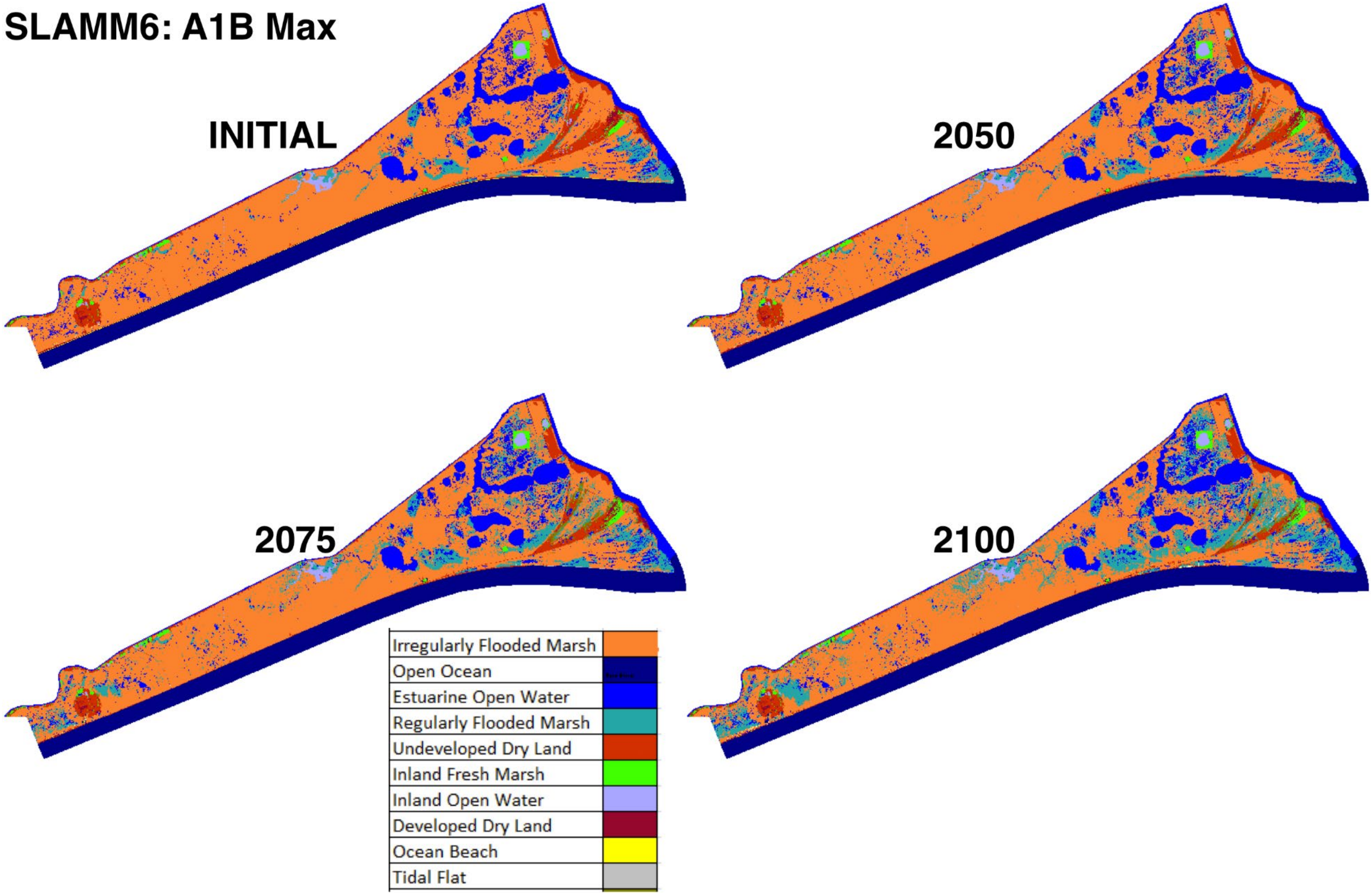


Figure 2-14: SLAMM6 Model Results—Land Cover Change under the 1-meter scenario

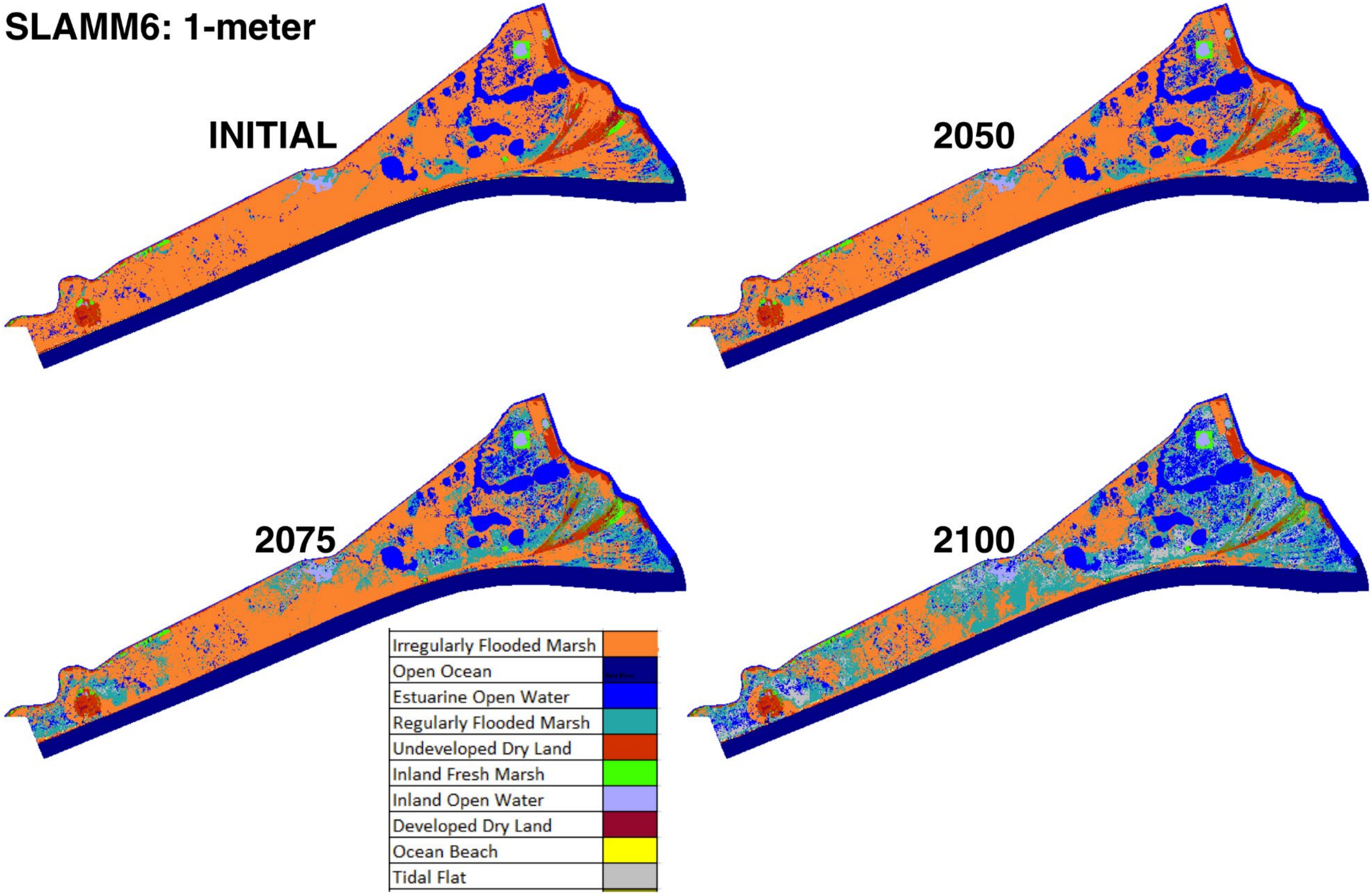
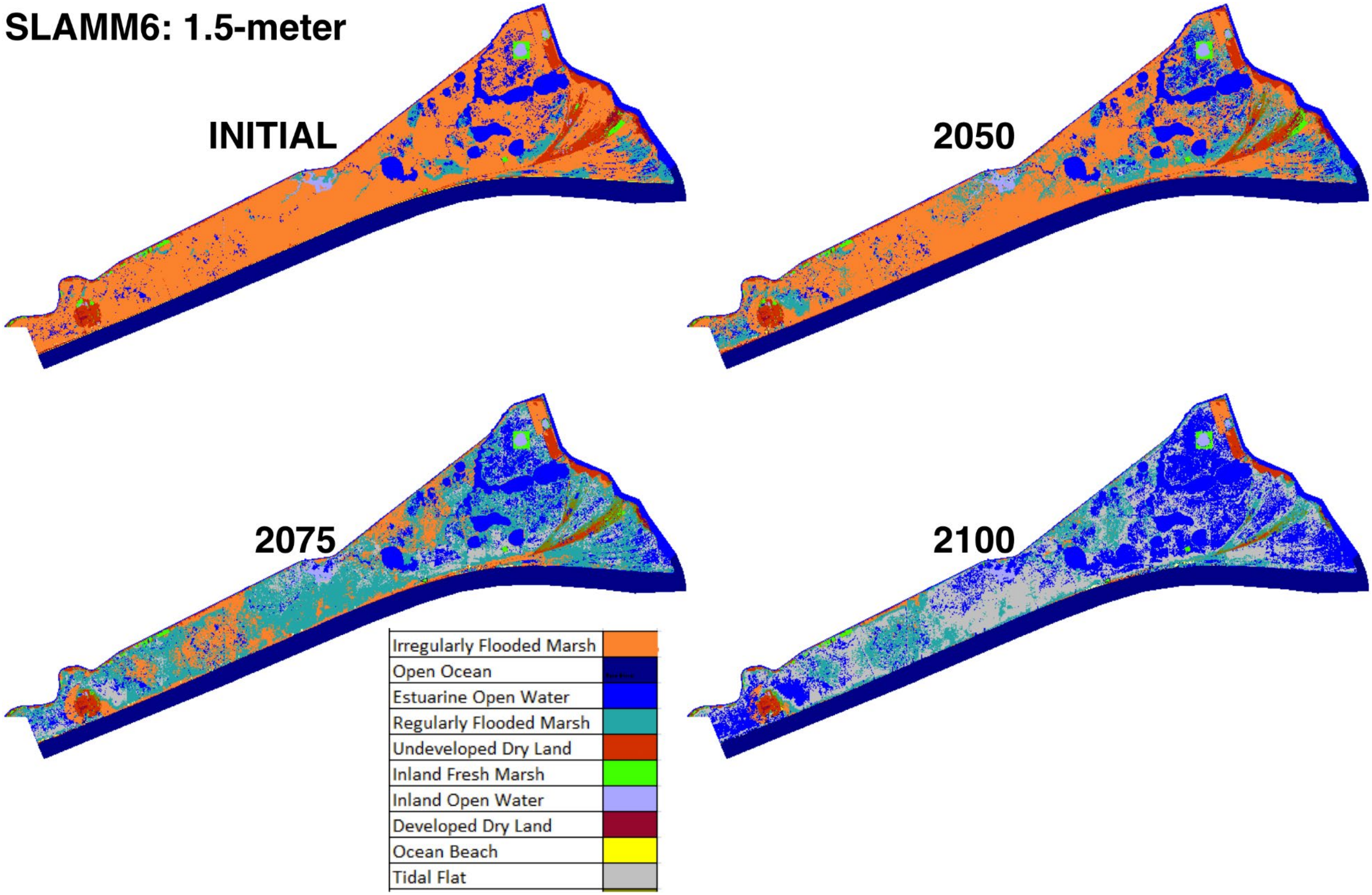


Figure 2-15: SLAMM6 Model Results—Land Cover Change under the 1.5-meter scenario



Model Uncertainty
The purpose of SLAMM is to predict changes based on sea level rise; however, not all the changes observed in the study area are due to the rise in sea level. Therefore, the SLAMM model cannot be expected to fully predict all the changes observed between the historic and contemporary landcover data. As with all environmental models, uncertainty within input data and model processes limit model precision. The model outputs have some error that is likely caused by the relative simplicity of the SLAMM model, limitations in LiDAR accuracy, collection of input data at different time-periods (not temporally synoptic), and lack of precise tidal data or other spatial coverage.

The report notes that the model results under lower rates of SLR may be somewhat conservative (i.e. additional marsh loss may actually occur). First, the SLAMM model has a very simple model of barrier island overwash to primarily effects detached barrier islands. For this reason, the model likely underestimates the effects of large storm events, sand transport, and the resulting conversion and breakup of marsh. Additionally, model inputs predate Hurricane Ike in 2008 which had significant effects on habitat in Jefferson County. Secondly, the model does not account for peat collapse. When salt water penetrates high marsh in this region, death and breakup of the root mat can occur and marsh elevations can fall as a result. This process has been observed at McFaddin NWR.

2.13.7 FWOP Impacts on Fish and Wildlife

Effects of climate change on ecosystems are difficult to predict, due to both uncertainty in climate change scenarios (direction and magnitude of temperature and precipitation) and uncertainty in understanding how species will respond to those changes. Changes in extreme weather events, precipitation, temperature, and sea-level rise are expected to alter coastal marshes resulting in loss of intertidal wetlands and their component wildlife species. In particular, impacts to the four types of marsh found in the focused study area and the associated wildlife and fisheries is expected to vary both temporally and spatially and may be irreversible and severe, particularly for listed species, species of concern, and rare, unique, or imperiled communities. The added impacts of climate change on coastal marshes may greatly increase the threats to already vulnerable populations and species likely resulting in reduced biodiversity (Ohlemuller et al. 2008). It is likely that there will be an increase in species warranting conservation and protection and even extirpation from the area.

In the future, it is reasonable to expect some native marsh-dependent species will move out of their current distribution to seek habitat which meets their life requisites. Within the focused study area, conversion of fresh, intermediate, and brackish marsh to more saline conditions or open water will likely result in a decrease in abundance of existing species due to loss of suitable habitat. However, such range shifts are only feasible with adequate habitat, good dispersal and colonization ability, availability of food resources, and absence of physical barrier which might preclude movement. Displaced species may suffer from increased competition or predation, be susceptible to disease or be maladapted to their new environment. Range shifts would be expected in avian species and larger mammals; however, small mammals, herpetofauna and species with limited range mobility are expected adapt to their new conditions or become extirpated in that portion of their range. During the adjustment period, wildlife demographic responses may include alterations in social groups, reproductive success, and age or sex ratios. Whether a species seeks new habitat or remains in place, all species will react independently and be affected at different rates according to their ecological and physiological constraints (Root and Schneider 2006).

With range shifts, it is probable that different species will move into the now ecologically free space and increase in abundance, which can lead to establishment of monocultures or invasive species. An increase in the extent, frequency, and severity of invasive species and a shift toward invasion in species that have not historically been invasive is also expected.

In marine habitats, altered habitat structure and quality affects species at the population level. As described for marsh-dependent species, changes in distribution, abundance and diversity of communities and species is anticipated. The reduction and/or modification in habitat may reduce overall yield from fisheries through a shrinking of the number, size, and distribution of species.

At the individual level, climate change can have a direct effect on growth and reproduction, changes in spawning periods and duration, lower recruitment, weakening of exoskeletons, and increased stress through changes in metabolism and oxygen consumptions. However, it is possible that some aquatic species may benefit from habitat shifts. For example, coral cover is being reduced due to increased sea temperatures and ocean acidity; however, macroalgal cover is increasing where coral was lost (Bell and Coauthors 2013). Fish species that benefit from algal rich habitat may be able to exploit this change and thrive, while those that rely on coral habitats are expected to suffer (Pearson and Connolly 2016).

2.13.8 Socioeconomics

To identify the FWOP condition for the socioeconomics of the study area, the 2016 Water Plan East Texas Region (TWDB 2015) was relied on to describe the future growth in the study area. Jefferson County is one of 20 counties that are covered in the Region I Water Planning Region boundaries. In the water plan, population projections were developed to determine water needs in the future. For Jefferson County, the population is projected to increase by almost 50% over 2010 numbers. By 2070, Jefferson County is projected to have 373,041 residents. This increase is expected to occur outside the focused study area and mainly occur in the metropolitan areas of Port Arthur and Beaumont. The water plan does not project any new industries starting in its planning region and does not project any major increases in any particular sector of industry. It is expected that the petroleum refining and petrochemical processing industry would continue to be a primary driver of the economy. It would also be expected that the current demographics of the area (e.g. race, age) proportions would be similar to the existing condition.

2.13.9 Hazardous, Toxic, and Radioactive Waste

The HTRW situation in Jefferson County will most likely stay the same in the future without project condition. Jefferson County is a relatively lightly developed area, but contains a high concentration of oil and gas infrastructure, both onshore and offshore. Port Arthur in particular can be expected to grow in size, and the petroleum industry can be reasonably expected to grow in conjunction. The manufacture and use of petroleum, chemicals, and other hazardous materials will continue in the project vicinity with or without the implementation of the proposed project. The extent to which HTRW sites continue to be created and discovered is impossible to predict, although currently existing HTRW sites can be expected to be remediated over time.

3 PLAN FORMULATION

Plan formulation supports USACE's water resources development mission. Planners use a systematic and standard approach to ensure that USACE makes sound investment decisions with federal funds. USACE plan formulation and evaluation of alternatives for this study were conducted in accordance with the Corps Planning Guidance Notebook (Engineer Regulation 1105-2-100). USACE planning guidance emanated from the Economic and Environmental Principles and Guidelines for Water and Related Land Resources Planning Act (P.L. 89-80) and Executive Order 11747, which were approved by the U.S. Water Resources Council in 1982, and by the President in 1983.

Based on guidance and policy, USACE has a defined six-step process to identify and respond to problems and opportunities associated with federal water resources planning objectives, and specific state and local concerns:

1) Identify problems and opportunities,
2) Inventory and forecast conditions,
3) Formulate alternative plans,
4) Evaluate alternative plans,
5) Compare alternative plans; and,
6) Select recommended plan.

Chapter 3 summarizes the JCER plan formulation process used to identify the selected plan to resolve the identified water resources problems and meet the study objectives. After the public, agency technical, and policy review of the draft JCER report, the study team refined the design of the selected plan with additional engineering and environmental investigations.

The planning horizon for this study is 2027-2077.

3.1 Significant Causes of Environmental Change in the Study Area

Over half of the coastal wetlands for the contiguous U.S. are in the Gulf of Mexico region. Texas accounts for six percent of the national total and 12 percent of the regional total. The aerial extent of coastal wetlands in Texas declined at an estimated rate of 8.9 square miles per year between the mid-1950s and the early 1990s. Wetlands in the Chenier Plains of Texas declined 16 percent between 1964 through 1966 and 1989 through 1990. The largest degradation of wetland habitat consisted of interior losses of coastal emergent marsh and rice field wetlands (Tacha et al. 1992). Most losses of emergent wetlands were attributed to conversion to open water which is a much less productive habitat.

Wetland loss in the Chenier Plains can be divided by location into two broad categories: shore and bank erosion and interior loss. Shore and bank erosion is the breakdown of the shorelines of the Gulf Coast and interior lakes and the banks of navigation channels and petroleum access canals. This breakdown is caused by the actions of forces such as natural wave energy, tides, currents, boat wakes, and water surges associated with the passage of large vessels and storms. Erosional forces are exacerbated by relative sea level rise and hydrologic alterations affecting coarse sediment distribution. Continued effects of these forces gradually wear down the shoreline and bank soils and eventually blows or washes them away. Erosion can be particularly rapid and can cause direct loss of significant acreage. Shoreline and bank erosion can also dramatically affect wetland loss when it causes hydrologic connections between relatively isolated marsh systems and dynamic water bodies such as navigation channels and large bays.

Various factors erode interior marshes. Subsidence and sea level rise are natural processes that contribute to marsh deterioration and loss, but in some cases human intervention exacerbates the problem. Part of the decrease of emergent wetlands has been due to conversion to scrub-shrub habitats due to the invasive Chinese tallow tree. Reservoir construction within the watershed has also contributed to loss of interior marsh by altering downstream freshwater flows and sediment transport, and increasing saltwater encroachment.

3.1.1 Anthropogenic Influences

Ecological functions of the study area have been significantly altered as a result of a long history of land development that started in the mid-1800s. Individually, many of the land alterations were minor; however, cumulatively the effects have been significant to ecological and geological processes critical to the long-term integrity of coastal ecosystems.

Historically, much of Jefferson County was predominantly a freshwater to intermediate marsh system, with no regular connections to salt water. However, by 1900, development of a rail line connecting Beaumont to Sabine Pass and the dredging of a six-foot deep channel from Sabine Pass to Taylor Bayou resulted in farmers noticing salinity in their irrigated fields. The railroad berm also caused flooding west of Sabine Pass by inhibiting sheetflow and increased the duration of flooding to the detriment of the marsh community (TPWD 2013).

Manmade navigation channels, while vital for the day-to-day business operations of Texas ports, are large drivers of ecosystem instability along the coast. By the 1930s, the GIWW, a key navigation channel that runs along the entire coastline, and the SNWW had been constructed. As time passed, additional smaller navigation channels and access canals had been constructed across the coastal marshlands and the main navigation channels have been widened and/or deepened several times since construction. The dredged navigation channels and access canals contributed to the loss of interior marshes because of their disruption to the natural hydrology of the area and loss of shoreline.

The effects of the disruptions vary, but generally they have created artificial barriers between wetlands and wetland building and maintenance processes, or they have removed natural barriers between wetlands and wetland deterioration processes. The GIWW, in particular, divided the once-contiguous marshes in the study area and severed the natural freshwater inflows of the bayou systems to downstream marshes. Overland freshwater flows that drained from the northern to the southern portion of the watersheds were cutoff, thereby eliminating the lower portion of the watersheds. The construction of straight canals in areas previously drained by natural channels has increased the speed by which the limited amount of freshwater provided by local rainfall drains seaward and has increased erosion of marshland substrates.

New channels and modifications of natural waterways has introduced tidal energies into historically non-tidal or micro-tidal marshes, resulting in decreased plant productivity, plant mortality, peat collapse and erosive loss of organic marsh soils. All have contributed to the conversion of the vegetated emergent marsh to open water. The introduction of tidal influence also altered marsh hydroperiods or wetting and drying cycles. Non-tidal and microtidal marshes whose soil surfaces were exposed only seasonally or during periods of drought have become subject to daily tidal fluctuations.

Additionally, navigation channels and access canals provide a conduit for saltwater travel inland into previously fresh marshes which rarely experienced any tidal flux. Over the years, water control structures were built to prevent saltwater intrusion, but many have since fallen into disrepair and are no longer functional. Extended exposure to saltwater has killed many salt intolerant plants and has altered the plant species composition and plant productivity of interior marshes. Overall, biological diversity is decreasing through conversion of fresh and intermediate marshes to more brackish regimes and salt-tolerant plant and animal communities. In some locations marshes are converting to open water.

Constructed waterways have been subject to erosive forces eroding the banks of these channels, leading to loss of emergent marsh along the banks. Vessel traffic in particular is causing constant erosion for long stretches of mainland areas and barrier islands. For example, a series of barrier islands separated the GIWW from adjacent bays, lakes and the Gulf of Mexico. Barrier islands shielded these ecosystems from erosive vessel wakes and turbidity during channel usage and maintenance activities. Over time, the barrier islands eroded due to ongoing use, meaning that inland marshes, wetlands, lakes and their habitats are no longer protected from GIWW navigation activities or long stretches of fetch (generating more powerful and erosive waves) from the bay systems. An increased susceptibility to breaching for the lakes and peninsulas that neighbor the waterways are expected to lead to further degradation of these important systems (TGLO 2016).

Oil and gas production has been prominent in the study area since 1902 when the famous Spindletop Oilfield was discovered on a salt dome formation south of Beaumont. Subsequent withdrawal of subsurface fluids and natural pressure decreases within the subsurface strata have reactivated formerly inactive faults. As well, compaction of the strata and downward displacement along faults have caused land-surface subsidence. Where subsidence and fault reactivation occur in wetland areas, the wetlands are typically submerged and converted to open water. Induced subsidence cannot be sustained indefinitely. In the study area, wetland losses were rapid initially, but have since slowed or possibly stopped, and can be correlated to the rapid decline in hydrocarbon production (USGS 2001).

As the coastal region became settled, wetlands were modified to meet the demand for farmland and later for industry. Vast tracts of marshland were drained to create rice fields and cultivated for pastureland. As more industry flourished in the Galveston-Houston-Beaumont metropolitan area, the economic expansion created a demand for more land to accommodate continued growth. Coastal marshes have been filled to provide sites for oil and gas development, factories, refineries, roads, and commercial and residential areas. When wetlands are filled in, deepened or drained, they become significantly less productive habitats, less functional storm surge defenses, and provide less ecological value to their surrounding ecosystems.

As urban, residential, and industry development occurred, the duration and intensity of flooding increased over time. Flood control projects were constructed to attempt to limit the impacts. Flood control levees and seawalls have disrupted the natural cycle of Chenier Plain marsh building and erosion by permanently directing the sediments and nutrients of bayous and rivers to the deep water of the Gulf of Mexico. Levees, as well as navigation channels and canals, have banks that are built up higher than the surrounding elevations, which restrict the drainage of water from the marsh resulting in excessive ponding. Under flood conditions (fresh or salt water), this results in a longer residence time and increased waterlogging stresses, conditions which can lead to plant death and land loss.

In addition to development of land, settlement also brought an introduction of nonnative species. Monocultures of invasive plants reduce natural biological diversity, increase erosion, alter nutrient cycling and displace macro- and micro-fauna that depend on native plants for habitat and food. Already degraded systems are more susceptible to nonnative species invasion. Once a species is established it can be extremely difficult to control the spread and even more difficult to eradicate the species.

3.1.2 Naturogenic Influences

Growth and deterioration of coastal wetlands has been naturally occurring in the Gulf of Mexico region for thousands of years. As wetlands degraded their loss was balanced by natural wetland building processes. Coastal wetlands of the Chenier Plain were created by 5,000 years of sediment deposition and erosion. Sediments were supplied by the Mississippi River and its tributaries and, to some extent, by the Gulf. During the early formation of the Chenier Plain, the river flowed in a westerly channel, depositing sediments which accumulated as vast mud flats to the west as a result of longshore currents. When the river shifted to an easterly course, sediment supply decreased and erosive forces exceeded sediment deposition due to littoral draft. As a result, the shoreline converted to a more typical beach-like nature and gradually retreated. Repetitive pulses of sediment due to changes in the course of the Mississippi River helped to build the systems of cheniers in the region. Inshore mudflats, cut off from wave action and saline Gulf water by the cheniers, developed into highly productive lakes and wetlands.

Changes in the location of the Mississippi River have influenced the areal extent and geography of the coastal areas. Sediment-loss and renourishment of beaches are inherently temporal and cyclic processes. While sand loss is a necessary process in the physical beach systems, the historic barrier and beach dune system in the study area is severely degraded and currently suffering from substantial shoreline erosion and retreat, which has resulted in land loss comparable to that of coastal Louisiana. On average, the shoreline in Jefferson County has been retreating 9.2 feet per year and land loss rates have averaged 35.7 acres per year since 2007 (Paine et al. 2011). A scarcity of coarse sediments in the littoral system contributes to the relative scarcity of well-developed offshore bars and onshore beaches and dunes, which can counterbalance or minimize shoreline retreat.

Beach erosion adversely impacts the resilience of the ecological system. Natural coastal barriers, like beaches and dunes, provide storm surge and flood defense without altering tidal flow conditions. As well, degraded beach and dune systems permit saltwater intrusion into inland coastal habitats, degrading and further reducing the vegetative buffers that would otherwise function as wave dissipaters during tropical events.

Although shoreline retreat has occurred through geologic time with fluctuations in sea level and sediment supply, global climate change due to release of greenhouse gasses appears to be impacting current rates of sea level rise. Land subsidence occurs naturally as recent geologic sediments compact and can occur locally during periods of drought through surface dehydration, oxidation and shrinkage in the region's highly organic soils. Marsh fires during these conditions can also result in loss of surface elevation.

Storms also contribute to the erosion and transport of sediment from the beach into the active zone of storm waves. Once suspended, the sediment is transported along the shore and redeposited farther down the beach, or is carried offshore and stored temporarily in submerged sand bars. Hurricanes and coastal storms can change the width and elevation of beaches and accelerate erosion. Longer lasting storms result in more erosion and sediment transport than fast-moving storms. Very intense storms create higher winds and larger waves, inducing more erosion than less intense storms. Sediment is usually returned from the sand bars to the beach, which is restored gradually to its natural shape. Sometimes, however, sediment moving along the shore leaves the beach system entirely, being swept into inlets or taken far offshore into deepwater where waves cannot return it to the beach. Over time, the process, when combined with sea level rise, produces larger waves that break farther inland.

Relative sea level change (RSLC) is the combination of land subsidence and eustatic sea level rise. Recently, the combination of rising sea levels and land subsidence and altered hydrological regimes have impacted many coastal processes, including geological processes such as erosion, sedimentation and soil formation. Accelerated coastal land loss is occurring, both from the periphery as Gulf and bay shorelines are eroded and retreat and in interior vegetated marshes which are converting to open water. Relative sea level rise threatens further loss of vegetated marsh due to submergence (i.e. loss of elevation). To survive, remaining marshes must accrete or gain elevation at a rate that keeps up with relative sea level rise.

In addition to loss of beach and dune habitat, this loss of elevation along the Gulf shoreline has increased saltwater intrusion from the Gulf, as tidal overwash of the beach ridge, is occurring much more frequently than historically. This increased saltwater intrusion is negatively impacting plant productivity and diversity of many fish and wildlife species in the study area's marshes. Loss of plant productivity may decrease the ability of these marshes to accrete vertically at a rate which keeps up with relative sea level rise, which may lead to submergence and a rapid loss of vegetated marshes as they convert to open water.

Jefferson County has seen several major historical surge events in the past 120 years. The most recent storms include Hurricane Harvey in 2017, Hurricane Ike in 2008 and Hurricane Rita in 2005 and resulted in storm surges ranging from 2 to 4 feet mean sea level (msl), 11 to over 19 feet msl, and 8 to 9.4 feet msl, respectively across the study area (Blake and Zelinsky 2018) (USACE 2015). The three hurricanes resulted in significant impacts on coastal shorelines, marsh and forested wetlands. Storm surges eroded marsh and wetlands in some areas, while other areas were covered with several feet of sediment. Thousands of acres of coastal marsh were inundated with high salinity Gulf waters, scouring and killing marsh species that were not tolerant of the higher salinity. Marshes in the study area are concave in shape, and under normal conditions do not drain as rapidly as tidal fringe marshes, so when these marshes are inundated by storm surge there is a significant increase in salinities in large areas of freshwater marsh for months after the storms.

Further compounding the problem are the organic soils typical of these marshes. When the soils are exposed to saline water, sulphates are introduced to the system, which under conditions of high water temperatures during summer months are reduced to hydrogen sulphide. Sulphide toxicity can cause plant die-offs. Organic soils are also dependent on plant roots for cohesion; therefore, upon plant death, these soils are subject to rapid erosion and dissolution in normal marsh conditions (FEMA 2008).

3.1.3 Conceptual Ecological Model

A conceptual ecological model (CEM) is a tentative description of a system or sub-system that serves as a basis for intellectual organization and represents the modeler's current understanding of the relevant system processes and characteristics (Fischenich 2008). These models, as applied to ecosystems are simple, qualitative models, represented by a diagram which describes general functional relationships among the essential components of an ecosystem.

A CEM was developed by the PDT and resource agencies to depict the condition of the existing environment described in sections 2.1.2 and 2.1.3, arranged in a conceptual diagram (Figure 3-1). It provides assistance with ecosystem characterization, communication, plan formulation, and science, monitoring, and adaptive management. The CEM format utilized here follows a top-down hierarchy of information using the format established by Ogden and Davis (1999). This CEM does not attempt to explain all possible relationships or include all possible factors influencing the performance measure targets within natural systems in the study area. Rather the model attempts to simplify ecosystem function by containing only information deemed most relevant to ecosystem restoration and monitoring goals. The CEM includes the following components:

- ***Drivers:*** This component includes major external driving forces that have large-scale influences on natural systems. Drivers may be natural (e.g. eustatic sea level rise) or anthropogenic (e.g. hydrologic alteration) in nature. Anthropogenic drivers provide opportunities for finding relevant solutions to problems. Natural drivers, however, cannot be influenced directly (i.e. we cannot change the frequency or intensity of tropical storms or change how high or fast sea level rises). Some drivers are both anthropogenic and natural in nature. For example, on a large, historical scale, sediment deposition has been deposited by geologic forces. But on a local scale, sediments can be brought into or removed from the system by man-made changes (e.g. channelization, barriers to movement, etc.) in the system.

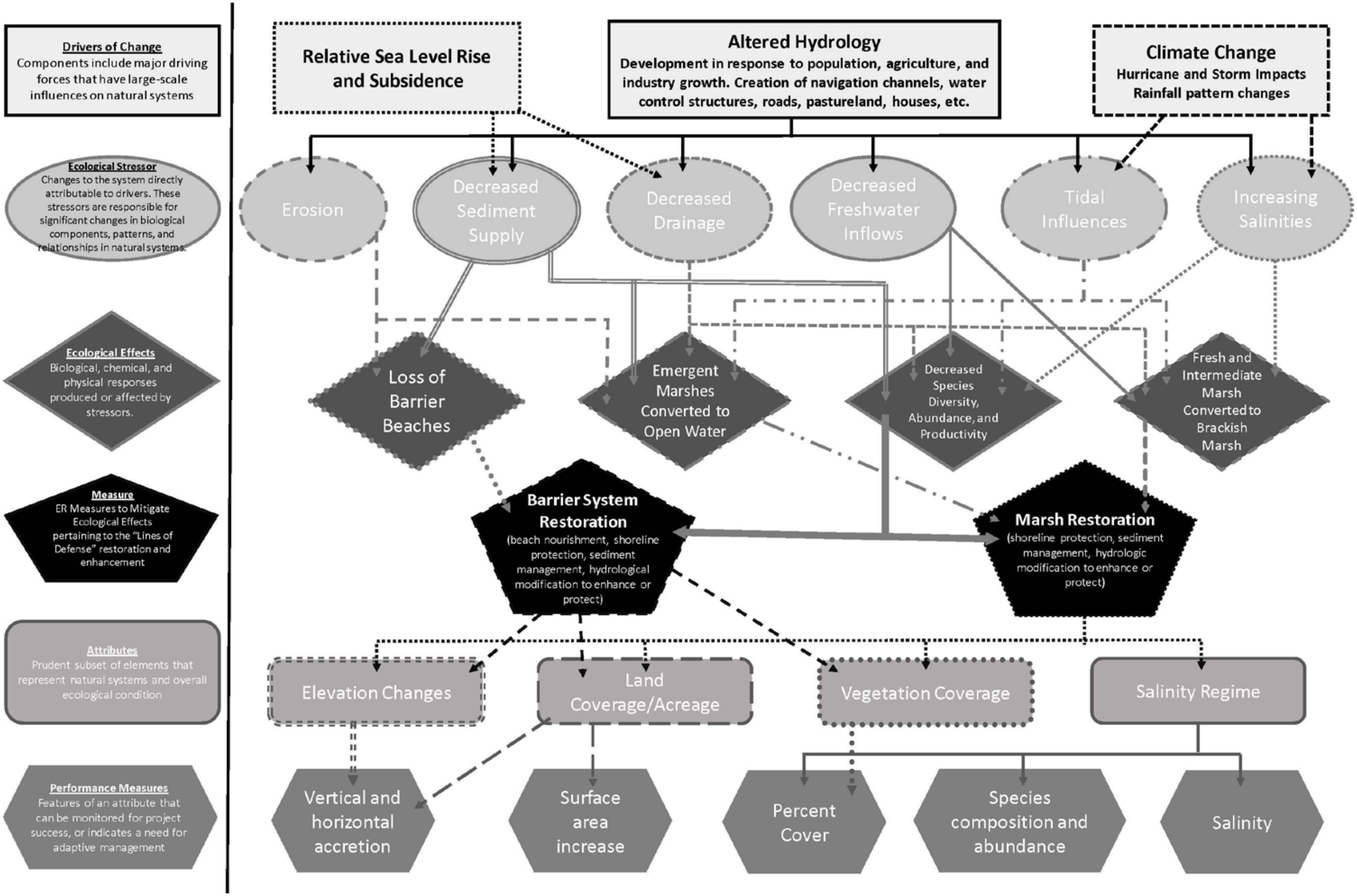
- ***Ecological Stressors:*** This component includes physical or chemical changes that occur within the natural systems, which are produced or affected by drivers and are directly responsible for significant changes in biological components, patterns, and relationships in natural systems.

- ***Ecological Effects:*** This component includes biological, physical, or chemical responses within the natural system that are produced or affected by stressors. CEMs propose linkages between one or more ecological stressors and ecological effects and attributes to explain changes that have occurred in ecosystems.

- ***Attributes:*** This component (also known as indicators or end points) is a prudent subset of all potential elements or components of natural systems representative of overall ecological conditions. Attributes may include populations, species, communities, or chemical processes. Performance measures and restoration objectives are established for each attribute. Post-project status and trends among attributes are measures by an appropriately scaled monitoring and assessment program as a means of determining success of a project or program in reducing or eliminating adverse effects of stressors.

- ***Performance measures:*** This component includes specific features of each attribute to be monitored to determine the degree to which attribute is responding to projects designed to correct adverse effects of stressors (i.e. to determine success of the project).

Figure 3-1 Jefferson County Ecosystem Restoration Feasibility Study Conceptual Ecological Model (CEM)



Natural processes of subsidence, wetland erosion, and habitat switching, combined with widespread human alternations, have significantly damaged the Texas coastal region from an environmental perspective. Ecological functions in the study area have significantly changed over time due to a long history of land development including:

- Wetland conversion to agricultural fields;
- Construction of navigation channels, canals, roads, and flood control structures;
- Oil and gas development; and,
- Urbanization.

Cumulatively, each of the above has changed hydrologic (freshwater flow and drainage restrictions) and geologic (sediment transport restrictions and subsidence from mineral extraction) processes critical to the long-term integrity of the coastal system. Coastal marshes in the Chenier Plains are declining at a rate of about 5.5 square miles per year with a trending increase in loss with projected relative sea level change scenarios.

3.2 Problems and Opportunities

Specific study problems and contributing factors in Jefferson County include:

1) Land loss due to erosion, subsidence, and relative sea level change threatens the geomorphic structure and hydrologic function of the coastal shoreline, inland marsh systems;

2) Altered hydrologic conditions are contributing to the conversion of low salinity coastal habitats such as freshwater and intermediate marshes to those that survive under more saline conditions such as brackish and saline marshes or open water; and,

3) Longshore sediment transport is significantly reduced, limiting the sustainability of the coastal ecosystem.

Opportunities exist in the study area to:

1) Improve longshore sediment transport in the Texas coastal shoreline system;

2) Restore marshes in a manner that complements existing restoration efforts in the study area;

3) Improve current sediment management practices to maximize the quantity and effective use of dredged material;

4) Modify the connection between the GIWW and adjacent freshwater marshes to retain freshwater supplies within the marsh and limit exchange of saltwater from the GIWW into the freshwater marsh areas;

5) Augment the natural wetland building process through placement of beneficial use material to enhance marsh sediment dynamics and micro-hydrology within the marsh; and,

6) Improve recreation opportunities in the wildlife management areas such as bird watching, and recreational and commercial fishing.

3.3 Goals, Objectives and Constraints

The goal of the JCER is to:

- Determine the feasibility of providing shore protection and related improvements in Jefferson County, Texas, to protect and restore the environmental resources and coastal areas to include impacts from federally constructed projects in the vicinity of Galveston Island.

Study objectives are to:

1) Improve freshwater, sediment, and nutrient inputs into the project area such that sustainable areas of fresh, intermediate, brackish and saline marsh are present in the system;

2) Restore the acreage of shoreline, dune, and interior marsh habitat for fish, water fowl, and wildlife species, mimicking, to the extent practicable, conditions which would occur in the area in the absence of human changes; and,

3) Restore a sustainable shoreline system to protect marshes from future degradation in areas located between the Gulf and the GIWW.

Constraints consist of:

1) Complying with guidelines of the Coastal Barrier Resources System Act;

2) Avoiding impacts to navigation on the GIWW and SNWW;

3) Avoiding impacts to J.D. Murphree WMA, McFadden and Texas Point NWRs;

4) Recognizing that natural sediment resources, such as those that may provide suitable sediment material for beach or marsh nourishment or renourishment are limited;

5) Not exceeding the financial capabilities of the non-federal sponsors.

3.4 Identification of Ecosystem Restoration Measures

After identifying the problems in the study area, it was apparent that there were two distinct locations, or restoration zones, in which the problems were occurring: along the shoreline and in the interior marsh. The shoreline was defined as all areas seaward of the dune, which included the dune and ridge features, beach, intertidal zone, and nearshore. Interior marsh was defined as any area landward of the dune. Once these two locations were identified, the PDT worked closely with the non-federal sponsor, USFWS, TPWD, GLO, NOAA and other resource managers to develop a comprehensive list of management measures that could address the problems in the two restoration zones. Each measure was assessed for its ability to address the problems and meet the objectives, technical feasibility, and acceptability.

Other rare habitat types were briefly considered including Chenier Ridges; however, it was determined that if the two dominant habitat types could be restored, the rarer habitat types could recover or at a minimum maintain their existing condition.

3.4.1 Measures Identified by Other Studies

The identification of ecosystem restoration (ER) measures by other studies for Jefferson County were the first measures that were considered. The S2G study and Salt Bayou Watershed Restoration Plan were unified in measure identification. Both identified the following eight restoration measures for Jefferson County:

- Dune restoration and beach nourishment,
- Restore beach ridge,
- Segmented nearshore breakwaters,
- GIWW breakwaters,
- Marsh restoration, improvement, maintenance,
- Salt water control structure,
- Keith Lake Fish Pass, and
- Inverted Siphons under GIWW.

The GLO Texas Coastal Resiliency Master Plan was also consulted. The plan identifies priority restoration strategies for Region 1 including restoration of beach and dunes along the entire Jefferson County Gulf Coast, stabilizing the Texas GIWW near Willow Lake on McFaddin NWR, and freshwater wetland and coastal uplands conservation in the Salt Bayou through construction of inverted siphons. Seven of the eight measures were carried forward for further review. The Keith Lake Fish Pass was not carried forward, because it has already been constructed and is functioning as designed and accruing benefits.

3.4.2 Shoreline Restoration

Naturally retreating beaches and eroding dunes can be counterbalanced by creating a source for sand nourishment. Outside sources, such as beneficial use of dredged material (BUDM) or offshore borrow sites, can be used to nourish a beach by constructing or improving existing dunes and creating a higher and wider beach berm to dissipate wave energy and reduce storm surge, wave runup, and overtopping. Additionally, outside sources could be placed in a feeder beach in shallow water or in an offshore underwater berm so waves can move it gradually toward the beach for accretion.

A living shoreline approach could be taken to provide shoreline protection by intercepting incoming waves and creating stable pocket beaches. This approach uses large, gapped stone structures strategically placed offshore, as a breakwater system. Offshore breakwater designs would require significant knowledge of the coastal processes at the site and likely require additional surveying and modeling. Beach nourishment is an inherent component of any breakwater project.

Specific measures for shoreline restoration that were in the initial array included:

- Measures that address nearshore and beach problems - Abbreviated using S:
    - S-1 Beach nourishment
    - S-2 Feeder beach/Sand Engine and sand fencing
    - S-3 Nearshore feeder berms
    - S-4 Offshore breakwaters
    - S-5 Jetty Modification
- Measures to address dune/ridge problems - Abbreviated using D:
    - D-1 Raise dune, fencing, no plantings
    - D-2 Raise dune, fencing with plantings
    - D-3 Raise ridge elevation with planting
    - D-4 Raise ridge elevation without plantings

The list of shoreline measures was refined and screened out in the following manner:

- D-1 and D-4 were screened out because other measures were optimal (i.e. incorporating plantings would minimally increase the overall cost of the measure but would provide greater benefits and lead to an overall more successful measure)
- S-5 was screened out because of the high cost associated with modifications and adverse impacts to SNWW from increased O&M

3.4.3 Marsh/Wetland Restoration

Restoring interior fresh and intermediate marshes will require effective restoration of the soil accretion process. Measures need to address waterlogging by saltwater as well as restoring the physical conditions (e.g. elevation, flow patterns, wet/dry cycles, etc.) that promote vigorous growth of vegetation and accumulation of organic material. This will require consideration of the rates of surface subsidence in relation to marsh soil accretion such that the design will promote accretion at a rate sufficient to keep up with subsidence and relative sea-level changes (RSLC). Stabilizing degrading marshes and restoring elevations sufficient to support emergent marsh vegetation is most effectively achieved by reintroducing sediments to the system. Sediment inputs could come from outside sources, such as from BUDM or by mining existing placement areas or new borrow sites.

Fresh and intermediate wetlands would benefit from projects that restore local hydrologic conditions by restricting saltwater intrusion and tidal energies, increasing freshwater inflows, and increase mineral sediment supply. Strategies to restore hydrologic condition include: utilizing water control structures (managed or passive), saltwater barriers, levees and water delivery and drainage infrastructure, and channel modifications/reconfigurations to maintain a continuum of brackish to fresh conditions and desirable hydroperiods.

Additionally, reinforcing/stabilizing the shorelines of the GIWW, through the use of hardened structures (e.g. rock breakwaters, shoreline armoring) and/or in conjunction with the living shorelines strategy (e.g. emergent marsh plantings), would reduce the rate of erosion caused by vessel traffic and tidal energies, as well as, preventing a breach of the navigation channel and subsequent intrusion of saltwater into historically freshwater marshes.

Specific measures that were in the initial array included:

- Measures that address marsh soil accretion – Abbreviated using M:
    - M-1 Marsh elevation modification alone
    - M-2 Marsh elevation modification with plantings
    - M-3 Marsh elevation modification, removal of invasive species and plantings
    - M-4 Marsh elevation modification with removal of invasive species no plantings
    - M-5 Sediment control with clay berms to keep sediment from washing away
    - M-6 Training berms
- Measures that address saltwater intrusion (SA):
    - SA-1 Water Control Structures

    - SA-2 Improve drainage (create channel, channel modifications, culvert removal/widening)
    - SA-3 GIWW Armoring
- Measures that address hydrologic connectivity (H):
    - H-1 Inverted Siphons
    - H-2 Water control structure (channel modification to increase freshwater input)
    - H-3 Fish ladders/terraces

The list of marsh measures was refined and screened out in the following manner:

- M-1 was identified as only optimal for the passive strategy.
- M-2 and M-4 were screened out because other measures were optimal (i.e. incorporating plantings would minimally increase the overall cost of the measure but would provide greater benefits and lead to an overall more successful measure).
- M5 was screened out because there were no suitable locations within the priority restoration locations that could benefit from the measure.
- SA-1 was screened out because there were no identified locations or designs that would benefit from measure implementation. One location/design of a water control structure was identified for Wild Cow Bayou. This location currently has a water control structure that is failing and requires significant annual maintenance. In order to achieve the results needed, the PDT determined that even with an enhanced design and/or different location further downstream of the existing structure, significant annual maintenance would be needed, including manually opening and closing gates, cleaning out the structure, etc. Also, it was identified that a redesign and/or relocation of the existing structure would not gain a significant amount of benefits above the FWOP. Additionally, USFWS is exploring options through their funding source to address the current structure problems.
- SA-2 was screened out because no designs or locations were identified where the measure could be implemented. The greatest problem for drainage in the study area is the GIWW. Other areas have drainage problems but most are related to construction of levees. If modification to the levees were implemented to improve drainage, the levee would not function as intended and would induce flooding in areas that were meant to be protected. Within the study area there are numerous existing channels, so adding channels would be environmentally unacceptable and modification/widening existing channels would not improve drainage because of their existing location and purpose, and would result in additional marsh loss from construction.
- H-1 was screened out because this measure has been identified as a reasonably foreseeable action that is expected to be implemented by several partners including the NFS, USFWS, and TPWD. In the initial phases of the study, resource agencies recommended adding this measure because the status of implementation by others was uncertain; however, funding and

authorization/approvals have been secured and implementation of this measure is extremely likely; therefore, resource agencies and the PDT were agreeable to screening the measure out. *NOTE: This measure was presented at the Alternatives Milestone Meeting and incorporated into many of the plans in the initial array, but is not presented or discussed further in this report for clarity purposes since the measure was ultimately screened out.*

- H-2 was screened out because the team agreed that it was a duplicate of SA-2.
- H-3 was screened out because it did not address the problems nor did it meet the objectives of the study.

For marsh measures, brackish marsh was identified as the target habitat type, despite there being a range of fresh, intermediate, and saline marshes within the focused study area. According to USGS 2010 marsh mapping (Figure 2-2), most areas south of the GIWW are considered brackish marsh, while most freshwater marshes occur north of the GIWW. Historically, there were more fresh and intermediate marsh closer to the Gulf, however after the GIWW was constructed, freshwater surface inflows could not reach these areas. These areas changed to brackish marsh due to daily tidal influence bringing in saline waters and the lack of freshwater inflow to dilute the system to fresh or intermediate salinity levels. Through coordination with the resource agencies, it was determined that realistically restoration would likely only be able to maintain what currently exists – brackish marsh. It was also determined that through RSLC and the NOAA marsh migration projections that freshwater marsh is likely to migrate further inland and existing freshwater marsh would convert to brackish conditions; therefore, for areas north of the GIWW, brackish marsh was identified as the target habitat type. It is possible that restoration could function better than anticipated. If that occurs, fresh and intermediate marshes could be restored within the restoration unit; however, we have no certainty this could happen so we accounted for the most likely outcome—brackish marsh.

3.4.4 Initial Ecosystem Restoration Measures Carried Forward

The ER measures carried forward to develop the initial array are described in Table 3-1

Table 3-1: Measures carried forward to develop the initial array.

Measure	Strategy	Assumptions
Beach nourishment (S-1)	Increase the width of the beach profile through sand placement	• Renourishment interval = 10 years • Beach width= 164’
Feeder Beach (Sand Engine) (S-2)	Large-scale mega-nourishment in a laterally restricted area in the swath zone that passively nourishes the shoreline through advection and diffusion	• Volume based on expected sediment lost over the period of analysis
Nearshore feeder berm (S-3)	Construct a sacrificial berm in the nearshore to reduce wave energy and passively nourish the littoral system	• Placed at -15’ MSL up to elevation -10’ MSL • Berm top width= 100’ • 50:1 side slopes

Measure	Strategy	Assumptions
Offshore breakwaters (S-4)	Retain beach fill using hardened structures to dissipate wave energy	• Emergent, segmented, nearshore breakwaters • 150' structure + 300' gap= 1 breakwater • Placed at -5' MSL
Dune and ridge restoration including fencing and plantings (D-2, D-3)	Increase the height and width of the dune/ridge profile through sand placement	• Crest elevation = 10.5' MSL • Width = 6' • 3:1 side slopes
Marsh Elevation Modification Alone (M-1) and Marsh Elevation Modification, removal of invasive species and plantings (M-3)	Reinforce marsh edges/shorelines and increase marsh surface elevation through sediment placement	• Increase marsh elevation from -0.6' MSL to +1.2' MSL at Year 0 and to +2.2' at Year 30 in order to keep up with RSLC • 50% of initial restoration unit is at marsh elevation • 65% of constructed marsh within the restoration unit will be at the appropriate elevation • 5 years for construction, plantings, and establishment
Training Berms (M-6)	Sacrificial berms meant to introduce sediment into the system	• Placement within the restoration cells • Minimal cost • Incorporated as needed during PED
GIWW Armoring (SA-3)	Reduce erosional forces on the GIWW embankment, while decreasing saltwater intrusion into adjacent fresh and intermediate marshes.	• Design will be same as existing breakwaters in Jefferson County • Height = +3.0' MSL yielding 1-1.5' of breakwater exposure • Crest Width = 5'

3.5 Formulation of Initial Array

The PDT developed fully formed plans using a strategies approach. This approach was in lieu of relying on the IWR Planning Suite (version 1.0) software to generate all possible combinations of measures and permutations of alternatives. This allowed the PDT to use their project area knowledge and the input of experts to strategically formulate plans to meet the objectives using a logical and reasoned approach.

3.5.1 Formulation Strategies

After the comprehensive list of measures was established but before alternative development, the PDT identified several plan formulation strategies to help assemble measures into a reasonable and logical array of fully-formed alternative plans. A total of 12 formulation strategies were identified. The formulation strategies were primarily driven by planning objectives and represent different ways of achieving the objectives.

1) **Wildlife and Fisheries (eliminated):** Plans would implement restoration actions that target species-specific habitat requirements that contribute to the recovery of priority species.
2) **Passive (Indirect) Restoration:** Plans would implement a passive restoration approach in which restoration depends on nature reworking the system with minimal human intervention beyond increasing sediment inputs. Any developed plans can be implemented relatively quickly at a relatively low cost; however, benefits accrue at a much slower rate. Measures would typically consist of nature-based or "soft" measures. The minimum amount of work necessary to put the system on a trajectory toward self-sustainment is the premise of the strategy.
3) **Engineered (Direct) Restoration:** Plans would implement an active restoration approach that relies on engineered solutions and human intervention to manipulate the system. Plans that meet this strategy rely on significant design specifications that are labor and time intensive and usually expensive, but benefits begin accruing nearly immediately post-construction. Measures would typically incorporate a combination of structural ("hard") and "soft" measures.
4) **Existing Ecosystem Restoration Plans (Complimentary):** Plans would incorporate measures that complement what has already been implemented or included in the FWS comprehensive conservation plan, WMA plans, TX Coastal Resiliency Plan, and Salt Bayou plans to create a contiguous restored area.
5) **Keith Lake:** This strategy is location specific. Plans would focus on restoration in and around Keith Lake, by mitigating negative impacts of hydrologic modifications through marsh restoration and shoreline work to reduce saltwater intrusion from the SNWW through Keith Lake Fish Pass and the GIWW.
6) **Improve Hydrologic Connectivity:** Plans would improve hydrologic flows into and out of interior marshes by increasing freshwater, sediment, and nutrient inputs and decreasing saltwater intrusion.
7) **Beneficial Use of Dredge Material:** This strategy is measure/source material and location specific. Plans would incorporate measures that can be implemented through use of dredged material from the SNWW. Measures would be nature-based type measures and not include any hardened structures which cannot be constructed from dredged material. This strategy would also be location specific in that it is assumed that dredged material cannot be reasonably transported greater than six miles from the SNWW.
8) **Coastal Shoreline Only:** This strategy is location specific in that plans would focus on restoration of the shoreline only.
9) **North GIWW:** This strategy is location specific in that plans would focus on restoration within areas north of the GIWW.
10) **South GIWW:** This strategy is location specific in that plans would focus on restoration south of the GIWW.

11) **Marsh Accretion:** This strategy is problem specific. Plans would focus on restoration of marsh areas by incorporating measures that promote accretion at a rate sufficient to keep up with subsidence and RSLC.

12) **Comprehensive Strategy:** Plans would incorporate all reasonable measures to maximize achievement of planning objectives.

Eleven of the 12 strategies were carried forward for use in developing alternatives. Strategy 1 was removed from further consideration because any plans that would be developed to target a species-specific habitat requirement would be a duplicate of one of the strategies already identified. For example, increasing foraging, wintering, or stop-over habitat for migratory birds would involve improving the overall condition of marsh habitat, which would be achieved by nearly all of the other strategies listed.

3.5.2 Alternative Development

After the strategies were identified, the team linked the ER measures carried forward to the strategies. At this point as long as the measure would meet the intent of the strategy, it was included. Measures that did not meet the intent of the strategy were not recorded for that strategy (e.g. GIWW armoring cannot be constructed out of dredged material, therefore, it is not included in strategy 7). Table 3-2 shows how each measure correlates to each strategy. During this exercise it was determined that no measures carried forward could meet the intent of Strategy 6 and it was, therefore, removed from further consideration and not developed further.

Table 3-2: Management Measures Linked to the Strategies

Measures	Strategy										
	2 – Passive	3 – Engineered	4 – Complimentary	5 – Keith Lake	6 – Improve Hydro Connect	7 -- Beneficial Use	8 – Shoreline Only	9 – North GIWW	10 – South GIWW	11 – Marsh Accretion	12 -- Comprehensive
S-1: Beach Nourishment	--	Y	Y	Y	--	Y	Y	--	Y	--	Y
S-2: Feeder Beach/Sand Engine	Y	--	--	--	--	Y	Y	--	*	--	Y
S-3: Nearshore Feeder Berm	Y	--	--	--	--	--	Y	--	*	--	*
S-4: Offshore Breakwaters	--	Y	--	--	--	--	Y	--	Y	--	Y
D-2: Raise Dune, Fencing with Plantings	--	Y	Y	--	--	Y	Y	--	Y	--	Y
D-3: Raise Ridge, Fencing, Plantings	--	Y	Y	--	--	Y	Y	--	Y	--	Y
M-1: Marsh Elevation Modification, alone	Y	--	--	*	--	*	--	*	*	*	*
M-3: Marsh Elevation Modification, removal of invasive species and plantings	--	Y	Y	Y	--	Y	--	Y	Y	Y	Y
M-6: Training Berms	Y	Y	--	--	--	--	--	Y	--	Y	Y
SA-3: GIWW Armoring	--	Y	Y	Y	--		--	Y	Y	--	Y

* Could apply to the strategy, but was not considered optimal and another measure was identified as providing for greater success.

3.5.3 Initial Array of Alternatives

A total of 14 alternatives, including the No Action, were included in the initial array of alternatives (Table 3-3). Five alternatives included two scaled plans each, for a total of 19 plans in the initial array.

At the Alternatives Milestone Meeting (AMM), held March 9, 2017, 13 alternatives and a total of 15 plans, including the No Action, were presented along with generalized measure location information and very broad conceptualizations. After the AMM, more detailed conceptualizations were developed for each of the alternatives resulting in three additional scaled plans and one new alternative being identified as able to address the problems and meet the objectives (asterisked in Table 3-3).

Alternative 13 (Hybrid Alternative) was formulated to address a feasibility risk. Geotechnical data indicates that the sediments at the breakwater locations south of Texas Point National Wildlife Refuge (NWR) are soft and could result in excessive subsidence over the project life; therefore, the breakwaters and beach nourishment measures were removed at this location and replaced with the feeder/beach sand engine measure. The risk was not identified at the McFaddin NWR location, so that location still has the beach nourishment and breakwater combination.

Table 3-3: Initial Array of Alternatives

Alternatives	Description	Strategy	Problem Addressed	Objective Achieved
No Action				
	No ecosystem restoration actions would be undertaken in the future beyond those already being implemented or those that have been authorized through other means.	--	--	--
Alternative 1: Passive Restoration Alternative				
Alt. 1a	S-3: Feeder Berm M-1: Marsh elevation modification alone M-6: Training berms	2	1, 2, 3	1, 2, 3
Alt. 1b	S-2: Feeder Beach/Sand Engine M-1: Marsh elevation modification alone M-6: Training berms	2	1, 2, 3	1, 2, 3
Alternative 2: Engineered Restoration Alternative				
Alt 2a	S-1: Beach nourishment S-4: Offshore breakwaters D-2: Raise dune, fencing with plantings D-3: Raise ridge elevation with planting M-3: Marsh elevation modification, removal of invasive species and plantings M-6: Training berms SA-3: GIWW armoring	3	1, 2, 3	1, 2, 3
*Alt 2b**	S-1: Beach nourishment D-2: Raise dune, fencing with plantings D-3: Raise ridge elevation with planting SA-3: GIWW Armoring	3, 8	1, 2, 3	1, 2, 3
Alternative 3: Complimentary Restoration Alternatives				
	S-1: Beach nourishment D-2: Raise dune, fencing with plantings D-3: Raise ridge elevation with planting M-3: Marsh elevation modification, removal of invasive species and plantings SA-3: GIWW Armoring	4	1, 2, 3	1, 2, 3
Alternative 4: Keith Lake Restoration Alternative				
Alt 4a	M-3: Marsh elevation modification, removal of invasive species and plantings SA-3: GIWW Armoring	5	1, 2	1, 2, 3

Alternatives	Description	Strategy	Problem Addressed	Objective Achieved
*Alt 4b**	S-1: Beach nourishment SA-3: GIWW Armoring	5, 8	2, 3	2, 3
Alternative 5: Improve Hydrologic/Hydraulic Connectivity Alternative				
	(no measures met this strategy)	6	2	1
Alternative 6: Beneficial Use of Dredged Material Alternative				
6a	S-1: Beach nourishment D-2: Raise dune, fencing with plantings D-3: Raise ridge elevation with planting M-3: Marsh elevation modification, removal of invasive species and plantings	7	1, 2, 3	1, 2, 3
6b*	S-2: Feeder beach/Sand Engine and sand fencing M-3: Marsh elevation modification, removal of invasive species and plantings	7	1, 2, 3	1, 2, 3
Alternative 7: Coastal Shoreline Alternative				
7a	S-1: Beach nourishment S-4: Breakwaters D-2: Raise dune, fencing with plantings D-3: Raise ridge elevation with planting	8	1, 3	2, 3
7b	S-3: Feeder Berm D-2: Raise dune, fencing with plantings D-3: Raise ridge elevation with planting	8	1, 3	2, 3
Alternative 8: Sea Rim State Park Alternative				
	S-2: Feeder beach/Sand Engine and sand fencing	8	3	2, 3
Alternative 9: North of GIWW Restoration Alternative				
	M-3: Marsh elevation modification, removal of invasive species and plantings M-6: Training berms SA-3: GIWW Armoring	9	1, 2	1, 2
Alternative 10: South of GIWW Restoration Alternative				
	S-1: Beach nourishment S-4: Breakwaters D-2: Raise dune, fencing with plantings D-3: Raise ridge elevation with planting M-3: Marsh elevation modification, removal of invasive species and plantings SA-3: GIWW Armoring	10	1, 2, 3	1, 2, 3
Alternative 11: Marsh Accretion Alternative				
	M-3: Elevation modification, removal of invasive species and plantings M-6: Training berms	11	1, 2	1, 2
Alternative 12: Comprehensive Restoration Alternative				

Alternatives	Description	Strategy	Problem Addressed	Objective Achieved
	S-1: Beach nourishment S-4: Offshore breakwaters D-2: Raise dune, fencing with plantings D-3: Raise ridge elevation with planting M-3: Marsh elevation modification, removal of invasive species and plantings M-6: Training berms SA-3: GIWW armoring	12	1, 2, 3	1, 2, 3
Alternative 13: Hybrid Restoration*				
	S-1: Beach nourishment S-2: Feeder beach/Sand Engine and sand fencing S-4: Offshore breakwaters D-2: Raise dune, fencing with plantings D-3: Raise ridge elevation with planting M-3: Marsh elevation modification, removal of invasive species and plantings M-6: Training berms SA-3: GIWW armoring	3, 12	1, 2, 3	1, 2, 3

* Added after presentation at the AMM milestone meeting.

3.6 Screening of Initial Array of Alternatives

The initial array went through two screening processes. The first screening was a qualitative assessment that assessed each alternative and plan based on its ability to perform in light of future conditions (resiliency, sustainability, effectiveness, and efficiency); synergy with other work being performed and priorities of USACE and resource agencies (acceptability); and overall completeness. The second screening was a quantitative screening in which the array outcome of the qualitative screening was assessed based on a cost-effective, incremental cost analysis (CE/ICA). All cost-effective plans identified during the CE/ICA were carried forward as the final array.

3.6.1 Qualitative Screening

A total of 8 alternatives and all of the associated plans, including the No Action, were carried forward for quantitative screening. Alternative 5, 7, 8, 9, 11, and 12 were not carried forward for further consideration based on the following rationale:

> ***Alternative 5:*** No measures were identified that could meet the intent of the strategy for which the alternative was initially considered. This alternative was initially presented at the AMM with inverted siphon measures as the only means of restoration; however, the inverted siphons were removed from consideration since funding has come available to implement the measure and it is assumed that the siphons will be implemented prior to project implementation.

Alternative 7: While this alternative would provide protection to a large area of inland marsh from storm surge and improves overall beach and dune habitat, it does not address erosion and subsidence of the degraded marshes. The inland marsh areas being protected by the beach and dune are susceptible to RSLC tidal energies entering from the SNWW which would also contribute to degradation of the landward side of the dune. This alternative was screened out because the benefits over the life of the project would be minimal, but the costs would be very high and the plan would not be resilient or sustainable in future conditions.

Alternative 8: Resource agencies and further review of existing data indicate that Sea Rim State Park is currently the only shoreline location in which accretion is being observed; therefore, shoreline ER measures would at best minimally increase the overall benefit over the existing condition.

Alternative 9: After further review of existing data and future without project conditions, in conjunction with resource agencies' knowledge of the proposed restoration areas, areas north of the GIWW are not experiencing the level of subsidence and erosion that areas south of the GIWW are realizing. The PDT and the resource agencies determined that restoration efforts should focus on critically vulnerable areas that would provide more benefit over time. It is recommended that plans be developed to address these areas through a dredged management plan modification or under USACE or non-USACE authorities.

Alternative 11: This alternative was considered to have low resiliency and sustainability in light of future climate conditions. Marsh restoration was identified in locations which would not be protected by a dune or the Chenier Ridge, so these areas would most likely be inundated if the intermediate or high rate of RSLC were to occur. Additionally, existing dune features are susceptible to beach during significant weather events, which would inundate restored marsh and potentially negate ER efforts.

Alternative 12: The developed plan was identical to Alternative 2a.

3.6.2 Quantitative Screening

After the qualitative screening was complete more detailed design was developed so that costs and benefits could be assigned to each plan. During more detailed conceptualization one risk was identified. It was related to an initial voluntary distance limit of BUDM transport that was imposed on the alternatives in the array being assessed. The concern was that imposing the distance limit may result in plans that are more expensive because the source of material may need to come from offshore sources or mined from placement areas. As a result, every alternative that required sediment input (marsh nourishment, dune construction, beach nourishment, etc.) had two scaled plans identified. Plans without the 'bu' ending utilized the original distance limits, while plans ending in 'bu' had all sediment provided through BUDM sources. The incorporation of these risks resulted in a total of the same 8 alternatives, including the No Action, but after the 'bu' scale of plans were added there were a total of 19 plans quantitatively assessed. Table 3-4 describes each plan that made the initial array used for the quantitative analysis.

Table 3-4: Description of the Initial Array Used for the Quantitative Analysis.

Plan	Description
No Action	
No-action	• No ecosystem restoration activities would be undertaken in the future, beyond those already being implemented or those that have been authorized through other means
Alternative 1: Passive Restoration	
Both	• Restoration occurring on USFWS, State owned, and Private lands • Restore 15,009 acres of marsh in 14 restoration units using a passive approach, with nourishment at year 30 to increase platform elevation to increase resiliency to RSLC • No invasive species removal or native plantings would occur • 1A and 1B: Sediment needs would utilize borrow from SNWW, Upland PAs, and offshore sources • 1Abu and 1Bbu: Sediment needs would use borrow material from SNWW
1A/1Abu	• 71,818 linear feet (13.6 miles) of nearshore berm would be constructed south of McFaddin and Texas Point NWRs, with renourishment every 10 years
1B/1Bbu	• Construct sand engine in swash zone south of McFaddin and Texas Point NWRs
Alternative 2: Engineered Restoration	
Both	• Construct 71,818 linear feet (13.6 miles) of beach and dune at McFaddin and Texas Point NWRs, with renourishment every 10 years • Construct 56,455 linear feet (10.7 miles) of shoreline armoring and segmented breakwaters along the north and south shorelines of the GIWW, with OMRRR at year 15 and 25
2A/2Abu	<u>Both</u> • Restoration would occur on USFWS, State owned, and Private Lands • Focuses on all areas within the focused study area • Restore 15,009 acres of marsh habitat in 14 restoration units including invasive species removal, and native species plantings, with nourishment at year 30 to increase platform elevation to increase resiliency to RSLC • Construct 71,818 linear feet (13.6 miles) of offshore segmented breakwaters with a 1 (length):3 (spacing) design ratio, with OMRRR at year 15 and 25
	• 2A: Sediment needs would use borrow from SNWW, Upland PAs, and offshore sources
	• 2Abu: Sediment needs would use borrow material from SNWW.
2B	• Restoration would occur on USFWS and GLO

Plan	Description
Alternative 3: Complementary Restoration	
3/3bu	• Restoration would occur on USFWS, State owned, and Private Lands • Focuses on measures that are already being implemented or have been planned at locations that are contiguous to existing or future restoration efforts. • Restore 12,915 acres of marsh habitat in 12 restoration units including invasive species removal, and native species plantings, with nourishment at year 30 to increase platform elevation to increase resiliency to RSLC • Construct 55,413 linear feet (10.5 miles) of beach and dune at McFaddin NWR, with renourishment every 10 years • Construct 56,455 linear feet (10.7 miles) of armoring and segmented breakwaters along the north and south shorelines of the GIWW, with OMRRR at year 15 and 25
	• 3: Sediment needs would use borrow from SNWW, Upland PAs, and offshore sources
	• 3bu: Sediment needs would use borrow material from SNWW.
Alternative 4: Keith Lake Area Focused Restoration	
Both	• Focuses on the areas in and around Keith Lake • Construct 6,592 linear feet (1.25 miles) of armoring and segmented breakwaters along the southern bankline of the GIWW would be constructed, with OMRRR at year 15 and 25
4A/4Abu	Both • Restoration would occur on USFWS, State owned, USACE, and Private Lands • Restore 8,421 acres of marsh habitat in 6 restoration units including invasive species removal and native species plantings, with nourishment at year 30 to increase platform elevation to increase resiliency to RSLC
	• 4A: Sediment needs would utilize borrow material primarily from the SNWW and upland disposal sites
	• 4Abu: Sediment needs would use borrow material from SNWW.
4B	• Restoration would occur on USFWS and State owned land • Construct 16,400 linear feet (3.1 miles) of beach and dune at Texas Point NWR, with renourishment every 10 years
Alternative 6: Beneficial Use of Dredge Material Alternative	

Plan	Description
Both	• Restoration would occur on USFWS, State owned, and Private Lands • Focuses on the eastern half of the focused study area • Restore 11,596 acres of marsh habitat in 9 restoration units including invasive species removal and native species plantings, with nourishment at year 30 to increase platform elevation to increase resiliency to RSLC • Sediment needs would use borrow material from the SNWW
6A	• Construct 16,400 linear feet (3.1 miles) of beach and dune at Texas Point NWR, with renourishment every 10 years
6B	• Construct sand engine in swash zone south of Texas Point NWR
Alternative 10: South GIWW Restoration	
10/10bu	Both • Restoration would occur on USFWS, USACE, State owned, and Private Lands • Focuses on areas south of the GIWW within the focused study area • Restore 12,560 acres of marsh habitat in 11 restoration units including invasive species removal, and native species plantings, with nourishment at year 30 to increase platform elevation to increase resiliency to RSLC • Construct 71,818 linear feet (13.6 miles) of beach and dune at McFaddin and Texas Point NWRs, with renourishment every 10 years • Construct 38,237 linear feet (7.24 miles) of armoring and segmented breakwaters along south shorelines of the GIWW, with OMRRR at year 15 and 25 • Construct 71,818 linear feet (13.6 miles) of offshore segmented breakwaters with a 1 (length):3 (spacing) design ratio, with OMRRR at year 15 and 25
	• 10: Sediment needs would use borrow from SNWW, Upland PAs, and offshore sources
	• 10bu: Sediment needs would use borrow material from SNWW.
Alternative 13: Hybrid Restoration	

Plan	Description
13/13bu	Both • Restoration would occur on USFWS, USACE, State owned, and Private Lands • Focuses on all areas within the focused study area • Restore 15,009 acres of marsh habitat in 14 restoration units including invasive species removal, and native species plantings, with nourishment at year 30 to increase platform elevation to increase resiliency to RSLC • Construct 55,413 linear feet (10.5 miles) of beach and dune at McFaddin NWR, with renourishment every 10 years • Construct 56,455 linear feet (10.7 miles) of armoring and segmented breakwaters along the north and south shorelines of the GIWW, with OMRRR at year 15 and 25 • Construct 55,413 linear feet (10.5 miles) of offshore segmented breakwaters with a 1 (length):3 (spacing) design ratio, with OMRRR at year 15 and 25 • Construct sand engine in swash zone south of Texas Point NWR
	• 13: Sediment needs would use borrow from SNWW, Upland PAs, and offshore sources
	• 13bu: Sediment needs would use borrow material from SNWW.

3.6.2.1 RSLC Design Considerations

USACE policy states that "restoration is to partially or fully establish the attributes of a naturalistic, functioning, and self-regulating system" (ER 165-2-501), so each plan was designed to the greatest extent practicable, to be a self-regulating system. The first step in determining whether a measure or plan can be self-regulating in the Jefferson County coastal ecosystem is to identify the limiting factor causing the problem. For the coastal marsh and shoreline systems, accretion through sediment inputs is the key to a resilient and sustainable system throughout the planning horizon.

In marsh systems, if sediment inputs are not sufficient to replace lost sediments from tidal erosion and to accrete overall ground elevation, daily tidal flows won't drain properly, which can result in vegetation drowning and/or burning and subsequent conversion of fresh, brackish, and intermediate marsh areas to less productive saline marsh or open water areas. As RSLC increases, low-lying marsh areas further inland will be subjected to increased tidal influences. In the shoreline system, if sediment inputs are not sufficient to maintain or increase the beach and dune size, width, slope, shape, and sand volume, the ongoing maintenance of the system is interrupted or suspended decreasing the size and shape of the coastline and reducing the ability of the system to provide protection to areas landward during significant weather events or under RSLC conditions.

There are three pathways for sediment introduction into the study area: overland through surface flows (marsh areas), through daily tidal cycles (marsh and shoreline areas), and through littoral transport (shoreline areas). Overland surface flows from the north have been significantly altered over time due to numerous constructed barriers (e.g. GIWW, SNWW, land clearing for agricultural practices, transportation corridors, urbanization, etc.) to the point that the constructed barriers severely limit the sediment input into the system. Sediment input through daily tidal cycles in the project area are influenced by fluvial flows. The riverine systems through the project area are sediment starved from actions such as damming upstream, channelization, dredging, and jetty construction, so the system can only minimally at best contribute sediment through this manner. Much of the sediment transported by the major rivers is lost to Sabine Lake or the SNWW. Other river basins outside of the study area are also affected by sediment reducing actions, which has decreased the available sediments that can enter the surf zone and contribute to longshore sediment transport. Additionally, throughout the Gulf, longshore sediment transport has been interrupted by the construction of jetties and breakwaters and in some locations has been captured by inlets. All of these sediment reducing actions contribute to an overall decrease in available beach sediments throughout the study area. The lack of beach sediments has subsequently affected the dune building processes.

Nourishment is the primary means to address the sediment input limiting factor. Each of the plans identified in Table 3-4 were conceptualized based on incorporating measures that would increase the initial sediment volume in the marsh, beach, dune, and/or nearshore. The target elevations, dimensions, and methods for the various measures were based on input from the resource agencies, constructed projects, and future RSLC scenarios. The measures were further refined based on the three RSLC scenarios and incorporated adaptive responses to changed conditions in the future since a self-regulating system is unlikely in light of the significant, irreversible modifications to hydrologic flows and the sediment budget.

For marsh restoration, it is assumed that at the target elevation (+1.2 feet MSL, post-construction settlement) established vegetation could trap the minimal amount of sediments introduced to the system through overland flows or tidal exchange and accrete at a steady rate that will promote a self-sustaining system under the low scenario, or the existing trajectory, over the 50 year planning horizon (i.e. no additional nourishment would be required). However, under the intermediate or high scenarios, the rate of RSLC change is greater than the expected rate of accretion given the low sediment availability. Year 30 was assumed to be the threshold at which the measure could perform under the intermediate scenario, based on the RSLC curve and a daily tidal range of ±1.0-foot, before the marsh steadily degrades and converts to open water, resulting in a loss of marsh function and reversal of benefits gained in the first 30 years of the project life. After year 30, it is assumed that the rate of accretion and previous marsh nourishment actions would not perform as a self-regulating system and would require an adaptive response. Therefore, an adaptive response—a second lift at year 30 that raises the overall marsh platform by +1.0-foot—was incorporated into each of the plans that include marsh restoration. *Note: Year 30 is an assumption; the observed rate of RSLC and monitoring would largely dictate when the future lift would be needed. This could be prior to year 30 or several years after year 30.*

Though not included in the recommended plan, marsh projections were revisited during final feasibility analysis (section 6.6 in the Engineering Appendix). The year 30 lift was based on static inundation without consideration of the additional accretion and for planning purposes. Along the intermediate curve with accretion incorporated the marsh platform would remain approximately 0.7 feet above MTL at year 30. This could still potentially be an appropriate time for an additional lift, though it would likely be a lesser thickness. Along the low curve with accretion included the marsh platform would remain approximately 0.5 feet above MTL at the end of the 50 years which would support a degree of ecological function. Along the high RSLC curve with accretion included the marsh platform projection would be 0.7 feet above MTL in year 23 after initial placement. This could still be an appropriate time for additional nourishment, but an additional lift could be required within the 50 years to preserve ecological function given the acceleration in RSLC rate along the high curve. Absent additional nourishment along the high curve the RSLC rate will outpace accretion and the platform elevation would equal MTL around year 41. *Note: as with the assumption of year 30 during plan evaluation the scenarios for additional nourishment were not rigorously interrogated given the exclusion of continuing construction from the recommended plan.*

For shoreline measures, the significant modification of longshore sediment transport is hindering beach accretion and dune building processes under the existing condition and will be reduced further under the intermediate and high rates of RSLC. In order to increase littoral sediment supply to a rate at which the beach system is self-sustaining would require modification of a number of constructed features within and outside the study area. Doing this would be extremely expensive and ultimately result in lost benefits (e.g. navigation channel closures or reduction in type of vessels that can call on certain ports; increased dredging costs; increased wave energies and subsequent shoreline erosion; flood induced damages, etc.), as well as adverse impacts to other projects. In order to benefit the shoreline, in the absence of constructed features, nourishment is incorporated into some of the plans. The sand engine measure would be the only measure that does not require future outyear nourishments because the design can be overbuilt to provide sufficient material, assuming the intermediate rate of RSLC. The beach nourishment, dune restoration, and nearshore berm measures include renourishment every 10 years given that the system would still be erosive. *Note: The 10 year renourishment interval is also an assumed rate for the planning process; however, the actual timing of the renourishment would be based on monitoring and the observed rate of RSLC.*

3.6.2.2 Benefits

This study used the Wetland Value Assessment (WVA) Coastal Marsh (Version [v] 2.0) and Barrier Headland (v1.0) models to calculate the future without-project (FWOP) and future with-project (FWP) habitat conditions. The WVA models were initially developed by a suite of resource agencies as the primary means of measuring benefits of candidate projects proposed in Louisiana that were eligible for funding under the Coastal Wetlands Planning, Protection and Restoration Act (CWPPRA). Since the initial development, the WVA Marsh Models have undergone several revisions including the omission of certain variables, modifications to the Suitability Index (SI) Graphs, and modifications to the Habitat Suitability Index (HSI) formulas. The WVA suite of marsh models v2.0 was approved for Regional Use in specified EPA Level IV Ecoregions within the Galveston and New Orleans Districts on October 31, 2017. The barrier headland model v1.0 was approved for regional use in coastal Louisiana and eastern Texas on November 9, 2011.

The WVA methodology is similar to the USFWS Habitat Evaluation Procedures (HEP), in that habitat quality and quantity are measured for baseline conditions and predicted for FWOP and FWP conditions. Instead of the species-based approach of HEP, the WVA models use an assemblage of variables considered important to the suitability of a given habitat type for supporting a diversity of fish and wildlife species.

WVA models operate under the assumption that optimal conditions for fish and wildlife habitat within a given coastal wetland type can be characterized, and that existing or predicted conditions can be compared to that optimum to provide an index of habitat quality. Habitat quality is estimated and expressed through the use of a mathematical model developed specifically for each habitat type. To determine the FWOP and FWP habitat function, the variables in each model were projected to reflect anticipated future conditions based on historic monitoring, data results and best professional judgment. The model then determines the assumed relationship between habitat qualities (Suitability Indices) based on a specified Suitability Index graph for each variable. The model then uses a mathematical formula that combines the Suitability Indices for each variable into a single value for wetland habitat quality, termed the Habitat Suitability Index (HSI).

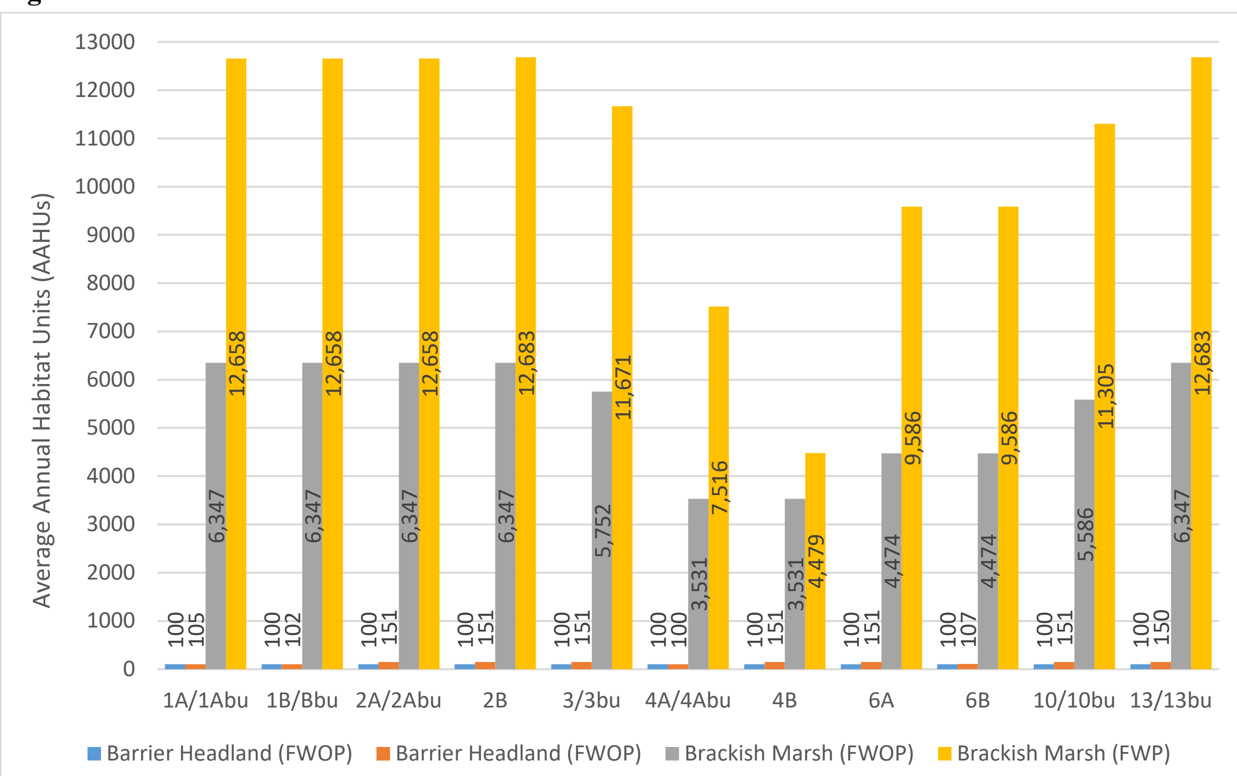
Data for the model runs primarily came from GIS exercises analyzing land cover change over time, vegetative cover, width/length/area, etc.; from existing monitoring such as salinity and shoreline change; and existing data collected during the S2G study or SNWW-CIP. The marsh model was run in 10 year increments, while the barrier headland model was run in 25 year increments. All variables for the FWOP and FWP were determined by an interagency team made up of USACE, USFWS, NMFS, TPWD, and GLO. For a detailed description of how the models were run, including the raw data, and the calculations for determining the habitat units (HUs) and average annual habitat units (AAHUs) see Appendix A-6 (Wetland Value Assessment).

AAHUs for the FWOP and FWP project condition are summarized in Table 3-5 and Figure 3-2. The difference between the two conditions represent the benefit or environmental lift possible with restoration actions. As expected, the larger and more involved restoration plans provide greater lift over smaller, less intensive plans. Alternative 2A/2Abu provides the greatest benefit or net change over the FWOP increasing the overall AAHU by 6,387. Alternative 4b provides the least benefit by providing only 999 AAHUs. Marsh restoration provides the greatest environmental lift when compared to any shoreline work. During this assessment, it was assumed that the benefits would not change with the change sediment source; therefore, the benefits for plans with- and without-‘bu’ ending are the same.

Table 3-5: Future Without and With Project Average Annual Habitat Units and Benefits

Plan	Future Without Project (AAHUs)			Future With Project (AAHUs)			Benefits (AAHUs)		
	Barrier Headland	Brackish Marsh	Total	Barrier Headland	Brackish Marsh	Total	Barrier Headland	Brackish Marsh	Total
1A/1Abu	100	6,347	6,447	105	12,658	12,763	5	6,312	6,316
1B/1Bbu	100	6,347	6,447	102	12,658	12,760	2	6,312	6,313
2A/2Abu	100	6,347	6,447	151	12,658	12,809	51	6,337	6,389
2B	100	6,347	6,447	151	12,683	12,834	51	1,741	1,791
3/3bu	100	5,752	5,852	151	11,671	11,822	51	5,919	5,970
4A/4Abu	100	3,531	3,631	100	7,516	7,616	0	3,985	3,985
4B	100	3,531	3,631	151	4,479	4,630	51	948	999
6A	100	4,474	4,574	151	9,586	9,737	51	5,112	5,163
6B	100	4,474	4,574	107	9,586	9,693	7	5,112	5,119
10/10bu	100	5,586	5,686	151	11,305	11,456	51	5,719	5,770
13/13bu	100	6,347	6,447	150	12,683	12,833	51	6,337	6,388

Figure 3-2: Wetland Value Assessment Results



The PDT recognized a deficiency in how the model values the barrier headland community. The model limits the impact area to a very specific portion of the beach and dune, which is why the total AAHUs for the barrier headland is very small yet involves a lot of restoration activity (i.e. very intensive restoration for minimal lift over a large project area). This represents the value of the barrier headland as a community to fish and wildlife that use the community, but does not account for the benefits barrier headlands provide to ecological communities behind the dune. Dune construction is the first line of defense against coastal storms and beach erosion. They absorb the impact of storm surge and high waves, preventing or delaying flooding of inland marsh areas, saltwater intrusion, and subsequent habitat conversions. Additionally, the dune provides sediment to mitigate beach erosion, which also provides a greater buffer to coastal storms and RSLC.

In order to capture the under-valuation of the barrier headland, the area behind the dune was calculated to determine indirect benefits. The PDT assumed that uncaptured benefits only apply if the dune height and/or width is increased by either mechanical or natural means in order to provide resiliency during coastal storms or under RSLC. Alternative 4A was the only plan that did not involve any shoreline work, so no uncaptured benefits were identified. For alternative 1/1Abu, 1/1Bbu, and 6b, shoreline restoration occurs; however, these alternatives do not benefit an improvement in the dune over the FWOP. The feeder beach and sand engine measures only contribute to the beach profile and would not provide any measurable sediment input to modify the dune.

The indirect benefit acreage is a qualitative estimate of marsh that would be protected from storm surge and sea level rise coming from the Gulf side. Acres were calculated by using the assumption that the area behind the dune is a hemisphere and that areas within the hemisphere would be protected. No quantitative functional value of the habitat from protection was completed due to the lack of certified habitat models that would account for dune benefits (i.e. no WVA analysis was run within the hemisphere, therefore there was no account of FWOP and FWP conditions or annualization of habitat value).

Table 3-6 shows the indirect benefits of each alternative. These benefits were not used within the CE/ICA analysis and were only intended to be a qualitative analysis that could provide additional justification during the "is it worth it analysis." The PDT recognizes that the qualitative estimates are likely overestimated because RSLC was not taken into account. The indirect effects were calculated to make the argument for unmeasured benefits if it came down to selecting between two cost-effective plans. In the end, it turned out that the indirect benefits were not required to aid in selection of the recommended plan.

Table 3-6: Uncaptured benefits of each alternative in terms of acres benefited.

Plan	Direct (acres)	Indirect (acres)
1A/1Abu	1	0
1B/Bbu	13,925	0
2A/2Abu	13,925	26,015
2B	13,925	26,015
3/3bu	12,695	22,127
4A/4Abu	8,369	0
4B	8,369	3,888
6A	10,638	3,888
6B	10,638	0
10/10bu	12,347	26,015
13/13bu	13,925	22,127

3.6.2.3 Costs

The development of average annual costs are presented in Table 3-7 which summarizes values from the initial and continuing construction cost to generate a combined average annual cost for construction. These average annual costs are the inputs for the CE/ICA analysis. Cost Engineering provided construction and real estate costs (including economic costs of USFW lands), a schedule of operation, maintenance, repair, replacement and rehabilitation (OMRRR) costs, and construction durations for each of the fully formed plans. There were no annual O&M costs identified, and the periodic RRR costs were divided into two categories—costs treated as continuing construction costs and costs treated as RRR costs (e.g. addition of material to hardened structures). Continuing construction costs were costs that were associated with out-year nourishments that would be required for the measure to continue functioning and providing benefits through year 50, assuming an intermediate rate of RSCL (e.g. periodic nourishment/renourishment of marsh, beach, or dune). The RRR costs were specifically associated with measures in which hardened structures were constructed and would require periodic repair or rehabilitation over the 50-year planning horizon. (e.g. replacing stone on breakwaters as a result of subsidence or erosion). For RRR costs, net present values were calculated for the costs in out years and brought back to the base year to derive an annual average cost.

Additionally, monitoring and adaptive management costs were estimated for each plan. Monitoring and adaptive management costs for passive plans were estimated at 3% of the first cost of initial construction and at 1% of first cost of initial construction for engineered plans. Economic costs (inclusive of monitoring and adaptive management costs) were annualized using a 50-year period of analysis at a 2.75% discount rate and included interest during construction (IDC). These annualized investment costs were added to annualized RRR costs to derive the average annual initial construction costs. *NOTE: Costs were updated to October 2018 price levels during the feasibility level of design phase for the recommended plan and shown in Chapter 6.*

3.6.3 Cost-Effective, Incremental Cost Analysis (CE/ICA)

The first step in the CE/ICA analysis is to identify those plans that are cost effective. Plans are considered cost effective if no other plan provides the same level of benefits at a lower cost. Of the 19 plans evaluated, five plans, including the no action, were identified as cost effective (Table 3-8 and Figure 3-3).

Table 3-7: Project Cost Summary (Initial and Continuing Construction [$1,000])

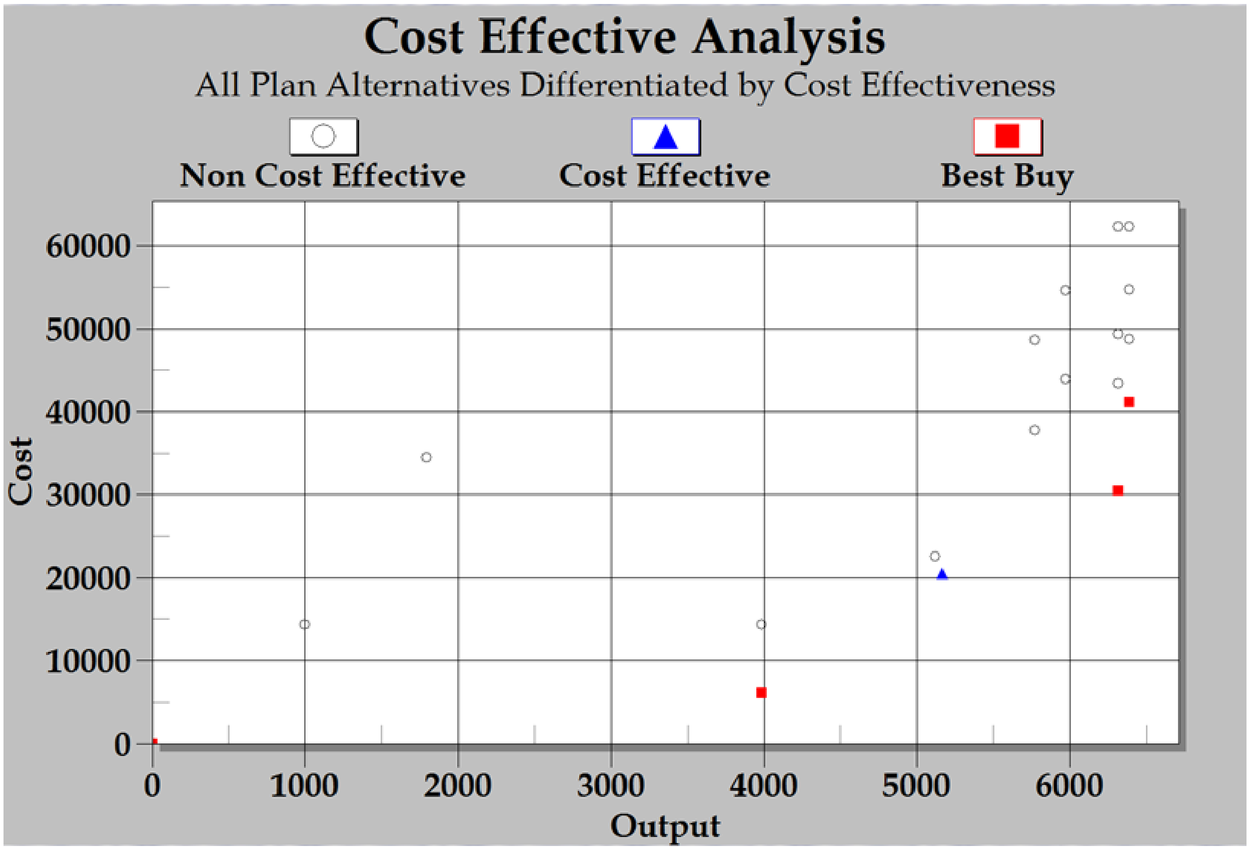
October 2017 Price Levels @ 2.75% Discount Rate over a 50-year Period of Analysis

Plan	Construction and Real Estate Cost and Economic Cost for USFWS Lands	Monitoring and Adaptive Management	Economic Costs (less OMRRR)	Construction Time (Months)	Interest During Construction	Investment Cost	Average Annual Investment Cost	Annualized Out Year Nourishment	Annualized Repair, Replacement and Rehabilitation	Average Annual Costs
1A	$587,878	$17,636	$605,514	120	$90,094	$90,094	$25,766	$17,662	$0	$43,428
1B	922,380	27,671	$950,051	120	141,357	1,091,408	40,427	21,877	0	62,304
2A	803,231	8,032	$811,263	180	189,930	1,001,193	37,085	16,198	1,357	54,640
2B	139,465	1,395	$140,860	120	20,958	161,818	5,994	28,066	446	34,506
3	524,451	5,245	$529,696	120	78,813	608,509	22,540	31,588	446	54,574
4A	295,017	8,851	$303,868	60	21,573	325,441	12,055	2,236	52	14,343
4B	95,375	954	$96,329	60	6,839	103,168	3,821	10,414	52	14,287
6A	222,829	2,228	$225,057	60	15,978	241,035	8,928	11,512	0	20,440
6B	524,549	15,736	$540,285	60	38,358	578,643	21,433	1,099	0	22,532
10	692,960	6,930	$699,890	180	163,856	863,746	31,994	15,542	1,093	48,629
13	1,071,698	10,717	$1,082,415	180	253,412	1,335,827	49,480	11,694	1,093	62,267
1Abu	341,022	10,231	$351,253	120	52,263	403,516	14,947	15,513	0	30,460
1Bbu	675,525	20,266	$695,791	120	103,526	799,317	29,607	19,728	0	49,335
2Abu	556,375	5,564	$561,939	180	131,559	693,498	25,688	14,049	1,357	41,094
3bu	318,300	3,183	$321,483	120	47,833	369,316	13,680	29,794	446	43,920
4Abu	129,571	3,887	$133,458	60	9,475	142,933	5,294	796	52	6,142
10bu	494,688	4,947	$499,635	180	116,973	616,608	22,840	13,816	1,093	37,749
13bu	824,843	8,248	$833,091	180	195,041	1,028,132	38,083	9,545	1,093	48,721

Table 3-8: Preliminary Results of the Cost Effective Analysis

Plan	Annual Cost ($1000)	Annual Benefit (AAHU)	Cost Effective
No Action	$ 0	0	**Best Buy**
1A	$ 43,428	6,318	No
1B	$62,304	6,315	No
2A	$54,640	6,389	No
2B	$34,506	1,793	No
3	$54,574	5,971	No
4A	$14,343	3,985	No
4B	$14,287	1,000	No
6A	$20,440	5,164	**Yes**
6B	$22,532	5,120	No
10	$48,629	5,771	No
13	$62,267	6,388	No
1Abu	$30,460	6,318	**Best Buy**
1Bbu	$49,335	6,315	No
2Abu	$41,094	6,389	**Best Buy**
3bu	$43,920	5,971	No
4Abu	$6,142	3,985	**Best Buy**
10bu	$37,749	5,771	No
13bu	$48,721	6,388	No

Figure 3-3: Cost Effective Analysis Results



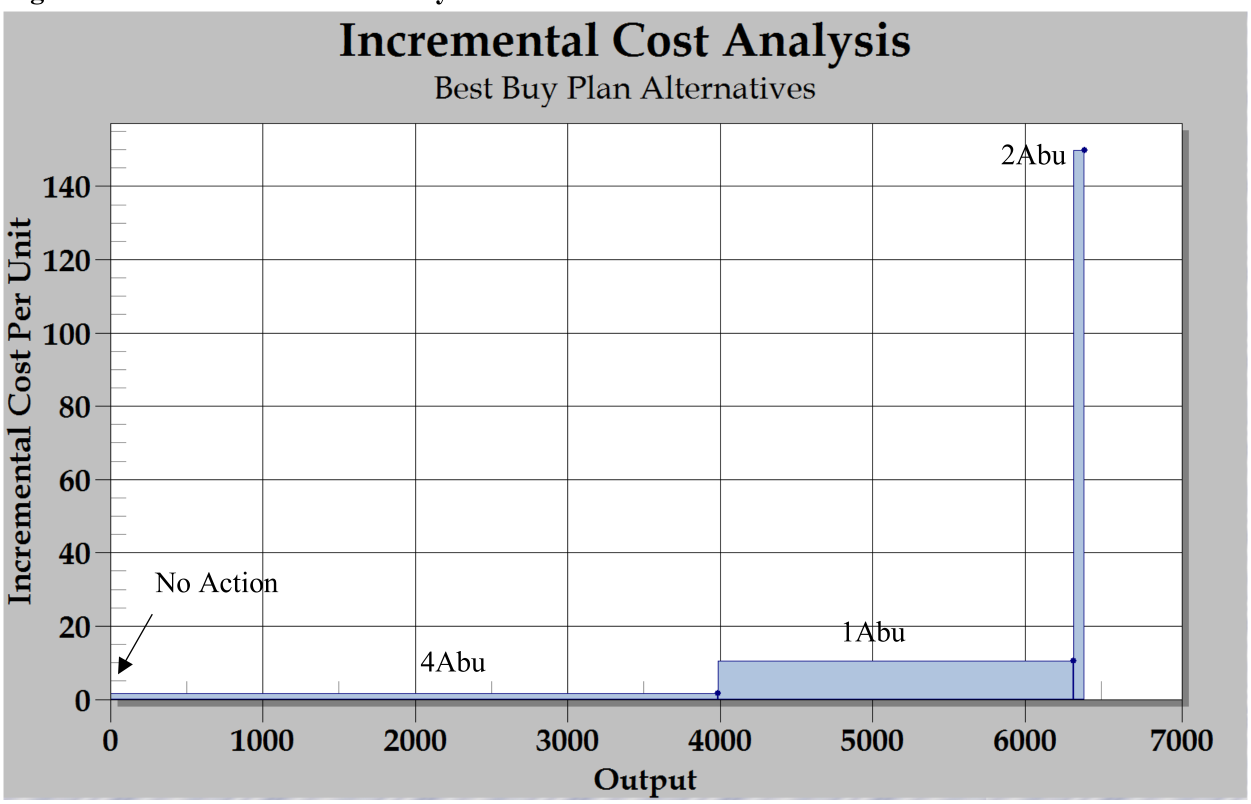
Once the cost effective plans are identified, the next step in the analysis is to identify the best buy array. This process steps through each of the cost effective plans to identify the plan with the lowest incremental cost per incremental benefit (Table 3-9 and Figure 3-4). The first best buy plan, or the plan with the least incremental cost per incremental benefit over the no action plan was 4Abu. This plan has an incremental cost per incremental output of $1,500. It provides 3,985 AAHU over the no action plan. The project economic cost (including initial construction and continued construction) is $182 million.

The second best buy plan, or the plan with the lowest incremental cost per incremental benefit, from 4Abu is 1Abu. The incremental cost per incremental benefit is $10,400. It provides 6,318 AAHUs, an increase of 2,331 from 4Abu. The project economic cost is $680 million. The final best buy plan is 2Abu. It has an incremental cost per incremental benefit over 1Abu of $150,000. It provides 6,389 AAHU of benefit, an increase of 71 AAHU over 1Abu. The economic cost is $1.4 billion.

Table 3-9: Incremental Cost Analysis Results of Best Buy and Cost Effective Plans

Plan	Output (AAHU)	Annual Cost ($1,000)	Average Cost ($1000/AAHU)	Incremental Cost ($1,000)	Incremental Output (AAHU)	Incremental Cost/Incremental Output ($1,000)
No Action	0	$0	$0	--	--	--
4Abu	3,985	$6,142	$1.54	$6,142	3,985	$1.54
1Abu	6,318	$30,460	$4.82	$24,318	2,333	$10.42
2Abu	6,389	$41,094	$6.43	$10,364	71	$149.77

Figure 3-4: Incremental Cost Analysis Results



3.7 Comparison of the Final Array of Alternatives

The final array of alternatives includes a total of 5 plans (No Action, 4Abu, 6A, 1Abu, and 2Abu), which includes all cost effective plans identified during the CE/ICA. The PDT assessed all cost-effective plans against each other, with the cost-effective, best-buy plans (No Action, 4Abu, 1Abu, and 2Abu) being considered first over the cost-effective plan (6A). The cost-effective plan was considered to ensure that it did not provide a better option than one of the best-buy plans given that it could provide ancillary and indirect benefits that some of the best-buys could not provide.

When comparing plans, the following considerations were used to help identify the National Ecosystem Restoration (NER) Plan and the Selected Plan:

- Principles and Guidelines (P&G) Accounts,
- Four formulation criteria suggested by the Principles and Guidelines (P&G) (completeness, effectiveness, efficiency, and acceptability),
- Resiliency and sustainability in light of RSLC,
- Benefit maximization, and
- Risks.

3.7.1 Principles and Guidelines (P&G) Accounts Comparison

The 1983 Principles and Guidelines (P&G) establishes four accounts to facilitate evaluation and display of effects of alternative plans. The national economic development (NED) account displays changes in the economic value of the national output of goods and services. The environmental quality (EQ) account displays non-monetary effects on ecological, cultural, and aesthetic resources including the positive and adverse effects of ER plans. The regional economic development (RED) account displays changes in distribution of regional economic activity (e.g. income and employment). The other social effects (OSE) account displays plan effects from perspectives that are relevant to the planning process, but are not reflected in the other three accounts (e.g. community impacts, health and safety, displacement, and energy conservation). Table 3-10 compares the P&G accounts of the 5 alternative plans.

Table 3-10: P&G Accounts Comparison of Alternative Plans

<table>
<tr><th>Alternative</th><th>NED
(annual cost)</th><th colspan="2">EQ</th><th>RED</th><th>OSE</th></tr>
<tr><td>No Action</td><td>No Change</td><td colspan="2">No Change</td><td>No Change</td><td>No Change</td></tr>
<tr><td>Alt 4Abu</td><td>$6,142</td><td>8,421 acres marsh and 0.6 acres GIWW shoreline restored</td><td rowspan="4">The following impacts are proportional to the scale of each alternative:
• Increased suitable fish and wildlife habitat
• Improved aesthetics
• Temporary adverse impacts to: air quality, soils, water bottoms, hydrology, water quality, fish and wildlife individuals, and recreation
• Permanent beneficial impacts to wetlands and Waters of the US</td><td rowspan="4">The following impacts are proportional to the scale of each alternative:
• temporary increase in employment and economic activity
• Improved nursery habitat for economically important fish species.</td><td rowspan="4">The following impacts are proportional to the scale of each alternative:
• Improved outdoor recreation opportunities such as fishing, hunting, and wildlife watching.</td></tr>
<tr><td>Alt 1Abu</td><td>$30,460</td><td>15,009 acres of marsh restored and 270 acres of Gulf shoreline maintained</td></tr>
<tr><td>Alt 2Abu</td><td>$41,094</td><td>15,009 acres of marsh, 5.2 acres GIWW shoreline, 143 acres of dune, and 270 acres of beach restored</td></tr>
<tr><td>Alt 6A</td><td>$20,440</td><td>11,596 acres of marsh, 33 acres of dune, and 62 acres of beach restored</td></tr>
</table>

3.7.2 Risk Analysis

One risk to implementation was identified as High. There is significant uncertainty whether or not USFWS would be able to implement their share of the various plans.

During formulation, plans were developed at the landscape scale, therefore, ownership boundaries were not considered so that plans would not be artificially biased by man's boundaries. Because of the large expanse of USFWS ownership within the study area, many of the measures would need to be constructed on or benefit USFWS-owned lands. USACE policy discourages recommending projects using Civil Works appropriations on other Federal entities' lands, especially an ecosystem restoration project on USFWS lands for which ecosystem management is within their mission. Deviations from this policy for this study could not be justified. Therefore, all measures that would be constructed on or solely benefit USFWS lands could not be cost-shared and would need to be fully funded and constructed by USFWS.

USFWS was involved throughout the study process, including the identification and formulation of plans. After the cost-sharing responsibilities were provided, USFWS informed the PDT that the agency would be legally unable to commit to implementing any of the plans (i.e. obligating the Federal government to expenses for which funding has not been appropriated) and cannot provide any guarantee that the projects would be set as a priority if funding became available. Additionally, there is significant uncertainty regarding if and when the agency would receive sufficient funding to implement these measures in light of future budget constraints and other budget needs of the Refuge. Language will be incorporated in the recommendation to Congress to provide USFWS special funding for this project; however, it is highly uncertain if Congress will follow this recommendation. In light of this high risk to overall plan performance, the benefit that USFWS lands contribute to the overall plan was a consideration in identifying the NER/Recommended Plan. Table 3-11 provides a summary of the contribution of USFWS lands to each of the alternatives.

Table 3-11: Contribution of USFWS to the Final Array of Alternatives

	Marsh Acres (Overall Contribution to Plan)	Shoreline (LF) (Overall Contribution to Plan)	Total Benefits (AAHUs)	Total Construction Cost ($1,000s)	Probability of Implementation	Effect
No Action	--	--	--	--	--	--
4Abu	683 (8%)	0 (0%)	325 (8%)	$11,391	High	Minimal. If benefits are not realized the overall plan would not suffer.
1Abu	5,398 (36%)	71,818 (100%)	2,277 (36%)	$878,098	Low	Significant. If benefits are not realized the overall plan would not function as designed and resiliency and sustainability would be reduced over the life of the project.
2Abu	5,398 (36%)	71,818 (100%)	2,332 (37%)	$1,133,702	Very Low	
6A	1,987 (17%)	16,400 (100%)	921 (18%)	479,825	Low	

3.7.3 No Action Plan (Cost-effective and Best-buy Plan)

The future without-project condition (FWOP), also known as the “No Action Plan,” is the most likely condition expected to occur in the future in the absence of the proposed action or action plans. In this case, the No Action Plan means that no ecosystem restoration activities would be undertaken in the future, beyond those already being implemented or those that have been authorized through other means. It is assumed that all current or authorized (if not already constructed) flood control, navigation, oil and gas, and ecosystem restoration projects would be implemented consistent with the original document which was approved for implementation, if an action subject to NEPA or 404 permitting, and/or as described in the design plans. Under the No Action, it is assumed that the following actions would be implemented in the future:

- Inverted siphons: This action facilitates freshwater flow movement from marshes north of the GIWW to marshes south of the GIWW. The action is funded by a series of grants and implemented by Jefferson County and other interested parties. Construction is pending receipt of the necessary permits.
- McFaddin Beach Restoration Project: USFWS has authorization to restore 104,150 linear feet (about 20 miles) of beach/dune complex within the McFaddin National Wildlife Refuge in Chambers and Jefferson County. The project includes using approximately 4.1 million cubic yards of sand that is hydraulically dredged from a 241- acre borrow site located 1.5 miles offshore of the project area.
- Sabine to Galveston, Texas Coastal Storm Risk Management (CSRM) and Ecosystem Restoration: A Chief's Report was signed for this study on August 31, 2017. The recommended plan includes construction of several coastal storm risk reduction measures throughout Orange and Jefferson Counties, and the Cities of Port Arthur and Freeport. CSRM measures include: construction of new levees, modification to existing levees, I-Wall raises, floodwall raises, closure structures raises, and a canal gate structure. The recommended plan did not include ecosystem restoration actions in Jefferson County, although mitigation in the form of forested wetland preservation and marsh restoration is part of the recommended mitigation plan.
- Sabine-Neches Waterway (SNWW) Deepening: Authorization for deepening the SNNW from 42 to 48 feet MLLW was included in the Water Resources and Reform Development Act (WRRDA) of 2014. The project is currently in the Pre-Construction Engineering and Design (PED) phase.

3.7.3.1 Is It Worth It? (No Action Plan (Cost-effective and Best-buy Plan))

This plan does not address any of the study objectives. The No Action would not address historic, existing or future problems to mitigate the degraded/degrading ecosystem. This plan is not considered acceptable to the PDT, NFS, or resource agencies.

Pros:

- There would be no surface disturbance and therefore no impacts to any natural resources or the human environment.

Cons:

- 0 acres of improved habitat
- Coastal marshes would be converted to unconsolidated shore or open water habitats.
- Loss of the Chenier Ridge and associated rare/unique vegetative community.
- Coastal beaches and dunes would continue to erode and retreat, eventually leading to a complete loss of the coastal system's primary defense.
- Loss of suitable habitat for migratory birds, T&E species, waterfowl, and other species of concern, which will lead to additional loss of the overall habitat available to the species throughout their range. This would likely lead to additional species being listed under ESA.
- No ancillary/unquantified protection to the GIWW or Port Arthur.

3.7.4 Alternative 4Abu: Keith Lake Restoration

Under this plan, all restoration would occur within the area surrounding Keith Lake and benefit the Keith Lake area. A total of 8,421 acres of marsh would be maintained or restored utilizing borrow material from the SNWW. Restoration would include invasive species removal and native plantings in areas experiencing or having the potential to experience high erosion rates. In addition to marsh restoration, approximately 6,592 linear feet of GIWW armoring/segmented breakwaters would be constructed along the south shoreline of the GIWW. This plan produces 3,985 average annual habitat units (AAHUs). All habitat benefits were able to be accounted for under the WVA analysis.

As expected, the smaller the footprint the less the alternative can address the objectives over the entire focused study area when compared to the larger plans. So 4Abu will inherently provide the smallest amount of lift and overall benefit when compared to the larger, more inclusive cost-effective plans.

3.7.4.1 Objective Performance

Alternative 4Abu addresses to some degree all planning objectives within the project area; however, it does not meet the objectives outside of the project areas. This was intentional based on the strategies approach taken during plan formulation, which was to address the Keith Lake area. Therefore, no measures or restoration areas that did not specifically benefit Keith Lake were included in this plan.

Objective 1 is fully achieved within the identified footprint of alternative 4Abu. By adding dredged material to the system during construction, the system can begin to function and trap sediments and nutrients after a period of settlement and revegetation. As more vegetation is established, sediments and nutrients that flow into the system from tidal energies or other methods hold sediment in place thereby allowing natural accretion over time rather than loss and conversion to deeper, open water areas as would be the case under the FWOP. As the sediment is trapped additional nutrients are also introduced to the system, which can then further sustain the vegetation into the future. By initially increasing the marsh platform, tidal influences from the SNWW and Gulf are minimized by allowing saltwater to drain more quickly thereby reducing the potential for ponding of saltwater and subsequent die off vegetation and burning of the soil.

Objective 1 also focuses on introducing freshwater flows. Unfortunately, not much can be done to restore freshwater flows into the Keith Lake area that is not already in place to be constructed. Under the FWOP, freshwater inflows would be restored through construction of the inverted siphons, which will be constructed in the next couple of years. Funding for this project is available and is only waiting on permits before construction can begin. By increasing marsh elevations, the freshwater inflows will be able to flow throughout the project area and provide additional nutrients to the system and lower overall saline levels conducive to brackish marsh conditions. Additionally, ponding will be reduced which limits the amount of time saline waters will sit on soils and surround vegetation, resulting in a reduction in burning and overall increase in productivity.

Objective 2 partially meets the planning objective through restoration of 8,421 acres of marsh and sustainment of 1.25 miles of shoreline along the GIWW, but does not meet the part of the objective related to dune or Gulf shoreline restoration. Gulf shoreline measures were not included in alternative 4Abu because incorporating dune construction or beach nourishment/sand engine/nearshore berm/etc. would not be within the scope of the strategy used to develop the alternative.

Objective 3 is only partially addressed by Alternative 4Abu. A sustainable shoreline system is achieved along the GIWW through construction of the GIWW armoring. The armoring will reduce future land loss and saltwater intrusion into brackish marsh areas, allowing marsh areas south of the armoring to function without the added pressure from GIWW presence. The design of the armoring, including subsequent crest height elevations in the future, also reduces the impact marshes south of the GIWW would experience due to RSLC. Alternative 4Abu does not restore a sustainable Gulf shoreline system. Marshes that would be protected by a Gulf shoreline system are outside the focused area for the Keith Lake strategy.

3.7.4.2 Resiliency and Sustainability

A significant concern and problem identified for the study area is the loss of the beach and dune and its impacts on the system from RSLC. Gulf shoreline measures would very minimally, at best, protect the Keith Lake area because the Keith Lake area is being affect by RSLC by way of the SNWW through

Keith Lake rather than overland from the Gulf. The existing Chenier Ridge is an upland ridge that forms the northern boundary of Texas Point NWR and parallels the Gulf shoreline starting from the SNWW moving east across the focused study area to about Sea Rim State Park. The Chenier Ridge is sufficient in elevation that it can protect the future marsh restoration sites around Keith Lake from a breach of the Gulf shoreline dune and beach. There is also a second ridge that is not as wide or tall between the Chenier Ridge and the 4Abu project area, which helps protect the project area from some RSLC intrusion from the SNWW that is occurring south of the project area and also provides a secondary buffer to the Chenier Ridge. Therefore, adding Gulf shoreline measures to the plan would not significantly increase resiliency or sustainability of Alternative 4Abu in the future.

Since RSLC is intruding through and affecting Keith Lake, the marsh restoration sites are also susceptible to RSLC. To mitigate this, a future outyear nourishment has been proposed for year 30 at which time the marsh platform elevation will be raised +1-foot MSL. This would allow the marsh to continue functioning and accruing benefits through the 50 year planning horizon. In the absence of the outyear nourishment, the marsh function would steadily degrade as RSLC outpaces the accretion rate.

All areas outside of the 4Abu footprint would remain susceptible to RSLC resulting in degradation of the shoreline system and marsh areas outside of Keith Lake. It is acknowledged that focusing on the Keith Lake area alone may create an "island" of functioning marsh habitat towards the end of the 50-year period of analysis, as other marsh areas outside of the plan's footprint degrade. This is by no means ideal, but the "island" would provide much needed refuge for fish and wildlife species that depend on marshes. It should also be acknowledged that USFWS owns and manages a significant amount of land south of the GIWW and outside of the Keith Lake area, so it is assumed that the agency will seek and implement actions which would prevent an "island effect" from occurring, to the greatest extent practicable.

3.7.4.3 Is It Worth It? (Alternative 4Abu: Keith Lake Restoration)

This plan is an improvement over the no action plan for the marshes in and around Keith Lake, but there would be no change over the No Action outside of the Keith Lake area. The plan reasonably maximizes the benefits and meets all four planning criteria. Additionally, there is only 638 acres of marsh on USFWS land which contributes to about 8 percent of the total AAHUs expected to be realized by this plan. If this location is not restored it would not be detrimental to the overall completeness or effectiveness of the plan.

The additional federal investment of spending at least $1,500 to realize the last added habitat unit ***is worth it.*** By investing the additional money, there would be a net increase in marsh value over the No Action, which can provide a refuge for marsh-dependent species that have been displaced from marshes outside the Keith Lake area.

Pros:

- Net increase in marsh AAHUs over No Action= 3,985
- 8,421 acres of improved habitat over the No Action
  - Increase in suitable habitat for migratory birds, T&E species specifically Whooping Crane, waterfowl, fish, and other species of concern, which will lead to an increase in overall habitat available to the species throughout their range.
  - Restored areas could be eligible for critical habitat designation contributing to additional recovery of T&E species.
- Minimizes the increase in open water and conversion to unconsolidated shore at Keith Lake and maintains the amount of open water consistent with historic and existing conditions.
- Sediment and nutrient inputs are increased contributing to a more sustainable and productive system
- Addresses 2 of 3 problems (Problems 1 and 2) and all objectives to some degree.
- ER is synergistic with TPWD existing and future restoration efforts.
- Smallest footprint for ground disturbing activities, resulting in the least amount of natural resource and human environment impacts, particularly to cultural resources.
- CBRA zones avoided
- Ancillary/unquantified benefits include:
  - Very slight increase in protection to communities north of the restored area, including Port Arthur, because coastal marshes and their vegetation can reduce storm surge levels and attenuate wave energies thereby reducing property damage.
  - A very small reduction in GIWW shoaling can be expected through the minimization

Cons:

- 0 indirect benefits
- 0 net increase in barrier headland AAHUs
- Shoreline retreat and dune loss is not addressed with this plan, which will eventually lead to a complete loss of the coastal system's primary defense.
- The plan does not propose actions that improve longshore sediment transport, so it does not address Problem 3.
- Measures would not protect or improve the Chenier Ridge.
- Utilizes the smallest amount of BUDM when compared to the other cost effective plans, leaving material that would still need to be placed in the PAs.

of erosion along the GIWW shoreline after breakwaters are constructed, thus slightly decreasing the amount of dredging required and minimally increasing the safety of the navigation channel.

- Prevents illegal mooring on the shoreline where breakwaters would be installed, thus protecting existing marsh shoreline and prevents navigation obstacles from unexpected stopped vessels.

3.7.5 Alternative 1Abu: Passive Restoration (Cost-effective and Best-buy Plan)

Under this plan, a passive strategy is used to restore 15,009 acres of marsh in 14 restoration units. Additionally, dredged material placed in the nearshore to create 71,818 linear feet of feeder berm that would increase beach sediment and contribute to restoring the beach. The intent of this plan is to introduce sediments into the system and let nature do the work of re-establishing the marsh and beach system. Minimal mechanical placement of sediments would be completed. This plan produces 6,318 AAHUs. All habitat benefits were able to be accounted for under the WVA analysis.

3.7.5.1 Objective Performance

Objective 1 and 2 are met in the same manner as Alternative 4Abu in regards to marshes, except that more marsh areas under 1Abu are improved providing greater benefit to the overall system.

Objective 2 is further addressed by incorporating shoreline measures. The feeder berms would provide an immediate benefit to increasing the beach width and improving the profile closer to historic conditions, while also attenuating wave energies and reducing erosion forces contributing to loss. As the sediment is removed out of the littoral system through dredging, placement in the nearshore reintroduces the sediments to an adjacent littoral region which preserves valuable sediment resources that would have been lost otherwise to upland placement areas or offshore placement sites. Thus, increasing beach sediments which can be worked to form a natural beach. The plan, however, is not expected to substantially increase the dune profile despite the addition of beach sediments.

Objective 3 is partially achieved by Alternative 1Abu. As discussed for objective 2, the shoreline position is on a trajectory to being restored to historic condition; however, the plan does not include measures that would substantially contribute to dune building, a critical component of a sustainable shoreline system. Under the existing condition, the dune is severely degraded to the point that even with an increase in beach sediments, the primary contributor to dune building in an unaltered system, it is unlikely that the amount of sediment available would not build functioning or stable dunes. The dunes that would form would marginally protect marshes. As well, Alternative 1Abu, does not address the GIWW shoreline. The lack of dune construction and GIWW shoreline armoring was by design of the plan. The strategy for developing 1Abu was to only include passive measures, which is not applicable to dune restoration or GIWW armoring because both require a significant amount of engineered construction actions and do not rely on nature to correct the problem after sediment input.

3.7.5.2 Resiliency and Sustainability

Incorporation of the feeder berm increases the resiliency and sustainability of the shoreline over the FWOP condition. The measure would target erosional hot spots along the Jefferson County coastline. This will provide two methods for combating future conditions and increasing project performance over the life of the study. The material placed in the nearshore will mitigate intensive erosional forces along portions of the beach through wave attenuation and sediment supply. The feeder beach is an intentional sacrificial berm that will slow wave energies that continually erode the beach. The wave attenuation should decrease the rate of erosion and allow the beach to form, which would then provide additional barrier land against storm surge over time. The outyear nourishments included in the plan would supplement sediments moved on shore or out of the system.

As stated earlier, the plan does not include dune construction. This will admittedly affect all marsh areas, inside and outside the restoration units. Without a dune, there is a greater chance that under future climate conditions more intense storms will occur which will in effect cause greater storm surge. The storm surge would be slowed some by the increase in beach width and the wave attenuation from the feeder berm, but will most likely not stop a breach into the marsh areas. Within the restoration units, increasing the marsh platforms should allow the areas to recover quickly because there will not be low lying areas which would hold sea water for extended periods of time.

The anticipated sediment need to sustain the projected outyear nourishment cycles would be provided through O&M dredging of the SNWW or SNWW CIP channel dredging sites. It has been determined that there is sufficient material at these sites to sustain the outyear nourishment actions as proposed. If the rate of erosion increases or the rate of RSLC is greater than the intermediate, sufficient quantities of sediment may not be available and other sources would need to be sought from offshore disposal sites, offshore borrow sites identified by other agencies, or upland PAs.

3.7.5.3 Is It Worth It? (Alternative 1Abu: Passive Restoration (Cost-effective and Best-buy Plan))

The greatest benefit to choosing this plan over 4Abu, is that additional marsh would be restored throughout the focused study area, rather than in just one small region, also resulting in a net increase in AAHUs and additional acreage of suitable habitat for marsh dependent species. Additionally, shoreline retreat would be minimized, although it would not build dune, so impacts from storm surge to marsh behind the dune would not be addressed. By incorporating beach improvement measures, species, such as the ESA-listed red knot and piping plover, that depend on the beach for foraging or nesting benefit, unlike in 4Abu in which only marsh-dependent species benefit.

This plan is more resilient and sustainable under future sea level changes than 4Abu. However, there is an inherent risk with taking a more passive approach to restoration and allowing nature to rework the system, particularly if the surrounding conditions are not ideal (e.g. presence of barriers, undesirable species, etc.). This plan includes restoration actions on USFWS lands that contribute to nearly 36 percent of the total AAHUs expected to be realized with this plan. This plan increases synergy with ongoing restoration and management plans over 4Abu. However, if these actions are not implemented the completeness and effectiveness of the plan would be lowered. If the measures were not implemented, the work that would be completed by USACE and the NFS would look very similar to 4Abu, except that no GIWW armoring would be constructed and a couple of additional marsh sites would be restored north of the GIWW. It was determined by the PDT, with resource agency input, that GIWW armoring was more critical to a successful restoration plan than attempting to restore additional marsh areas.

If the plan were implemented as designed and USFWS were able to carry out measures on their lands, the plan would be more effective, complete, and acceptable than 4Abu. Additionally, more problems can be addressed and biodiversity can be at a minimum sustained if not increased over a larger area. However, given the reasonableness of cost, extreme uncertainty in funding/implementation ability and the risk associated with implementing a passive strategy plan, the PDT determined that this plan ***is not worth*** expending the additional $10,400 of federal investment to achieve the last habitat unit.

Pros:

- Net increase in marsh AAHUs over No Action= 6,312 (+2,327 AAHUs over 4Abu)
- Net increase in barrier headland AAHUs over the No Action = 6 (+6 AAHUs over 4Abu)
- 15,009 acres of marsh improved habitat over the No Action (+6,588 acres over 4Abu)
    - Increase in suitable habitat for migratory birds, T&E species (specifically Whooping Crane, Red Knot and Piping Plover), waterfowl, fish, and other species of concern, which will lead to an increase in overall habitat available to the species throughout their range.
    - Restored areas could be eligible for critical habitat designation contributing to additional recovery of T&E species.

Cons:

- **0 indirect benefits**
- Invasive species would not be removed and no plantings would occur, leaving the restored areas susceptible to invasion of invasive/non-native species and/or monoculture vegetative community.
    - Lowers habitat quality and contributes to less productive system, particularly for species dependent on a diverse marsh system.
- A passive strategy in this marsh system may not be sufficient to completely restore full function of the system leading to a less sustainable and resilient system in the future.
- Lack of dune creation through the passive strategy limits the protection of marsh from storm surge and resulting salt water intrusion.

- Minimizes the increase in open water and conversion to unconsolidated shore throughout the 14 restoration units.
- Shoreline erosion is slowed.
- Sediment and nutrient inputs are increased contributing to a more sustainable and productive system.
- Addresses all problems and objectives throughout the study area.
- Passive approaches include a high degree of certainty that the resulting marsh will be compatible with the surrounding landscape.
- Plan synergistic with TPWD and USFWS Refuge management plans.
- Marsh restoration at TX Point and to a lesser degree the TX Point feeder berm provides some level of protection to the Chenier ridge, a rare geomorphic area.
- Resiliency under this plan is greater than under 4Abu
- Ancillary benefits would be limited to an unquantified, limited amount of storm protection.
- 36% of the expected AAHUs comes from measures on USFWS land.
- Construction would occur in CBRA zones, which will require a determination that a statutory exception applies.
- Erosion and subsequent salinity intrusion through the GIWW is not addressed resulting in no protection to marshes immediately north and south of the GIWW.
- Greater construction footprint resulting in greater adverse impacts to natural and cultural resources than 4Abu.

3.7.6 Alternative 2Abu: Engineered Restoration (Cost-effective and Best-buy Plan)

Under this plan, an active restoration approach would be implemented throughout the focused study area. A total of 15,009 acres of marsh would be maintained or restored in 14 restoration units. GIWW armoring would protect 56,455 linear feet (10.5 miles) of shoreline. The plan also incorporates restoration of the beach and dune through beach nourishment along 71,818 linear feet (13.6 miles) at McFaddin and TX Point NWRs. Offshore breakwaters, parallel to the beach nourishment actions, would be constructed to attenuate wave energies and decrease the rate of shoreline erosion. This plan produces a net increase of 6,389 AAHUs over the No Action plan and indirectly benefits 26,015 acres.

3.7.6.1 Objective Performance

This plan is the most comprehensive and fully addresses all objectives.

3.7.6.2 Resiliency and Sustainability

Marsh resiliency and sustainability is similar to that described for Alternative 1Abu, except that Alternative 2Abu also incorporates restoration of the dune and ridge. By increasing the dune height and width, the dune can act as a barrier to wind and seawater for interior marshes. This will provide a significant increase in protection of interior marshes particularly from daily tidal energies, most storm surge, and future RSLC conditions. Under climate change, more intense storms are likely, so a potential still exists that under extreme events the dune could be breached and seawater could enter the marshes. In this case, the marshes are expected to perform and recover from such an event because the marsh platform would have been increased and vegetation would be established as a result of restoration actions. Seawater, and subsequent loss of vegetation and soils, would not be expected to persist on the landscape for extended periods of time as would be expected under the FWOP condition.

Beach nourishment and dune restoration is a flexible and relatively fast coastal management option when compared to hard construction, and is adaptable to changing conditions. However, nourishment does not end erosion; it only provides additional sediments on which erosion will continue. Therefore, outyear nourishment has been incorporated into the plan in which nourishment will be repeated on a regular basis as sand stock is depleted either by erosion or storm surge. Every outyear nourishment interval would include a significant amount of sacrificial sand that is intended to "re-nourish" the beach and dune. Using the predicted annual rate of sea-level rise over the next 100 years, it is clear that sea-level rise will not overwhelm any particular nourishment project before its next scheduled infusion of sand. Even if the rate of RSLC is significantly higher than planned for, the design of the outyear nourishment (e.g. the height, width, and length of beach and dune) can be modified to account for the change in water elevation. This would likely affect the volume of sediment needed and the cost to place that sand.

To create an even more sustainable shoreline, offshore breakwaters would be placed in shallow waters in the nearshore. This will attenuate wave energies and reduce the rate of erosion on the newly restored shoreline and increase the duration between outyear nourishment cycles and promote a more self-regulating system than the other plans.

As with Alternative 1Abu, the sediment availability anticipated through O&M and SNWW CIP channel dredging sites is sufficient to sustain the outyear nourishment actions as proposed. If the rate of erosion increases or the rate of RSLC is greater than the intermediate scenario, sufficient quantities of sediment may not be available and other sources would need to be sought from offshore disposal sites, offshore borrow sites identified by other agencies, or upland PAs.

3.7.6.3 Is It Worth It? (Alternative 2Abu: Engineered Restoration (Cost-effective and Best-buy Plan))

Alternative 2Abu is the most ecologically sound plan from a systems approach, but also the most expensive. This plan includes strategically designed marsh, beach, and dune restoration measures that complement each other to provide the most resilient and sustainable plan that benefits not only the project footprint, but also provides significant indirect benefits to marshes outside the restoration units. This plan realizes the greatest benefits (both direct and indirect) over the most area in the shortest amount of time. By incorporating dune construction, this plan provides the greatest benefit to the full suite of coastal species and now provides additional habitat for nesting sea turtles and other species that rely on the dune environment for nesting, foraging or protection.

The full array of ancillary benefits could be realized including: decreased O&M dredging in the GIWW and SNWW, safer navigation conditions, and attenuation of storm surge impacts. This plan is also the most synergistic plan with all existing and future restoration management plans in the focused study area. This plan is the most effective and complete plan to address all of the planning objectives, restore ecological function, increase biodiversity and improve resiliency and sustainability under future conditions.

Like Alternative 1Abu, Alternative 2Abu realizes nearly 37 percent of the overall AAHUs as a result of actions required by USFWS. This is a substantial percentage of the overall plan benefits that would greatly affect the overall completeness, effectiveness, and acceptability, especially since this plan relies on shoreline measures to provide the greatest resiliency and sustainability to the overall plan.
Despite the additional direct, indirect, and ancillary benefits realized with this plan, the substantial increase in cost and the high risk that the complete plan is not implemented ***is not worth*** the additional investment and is not in the Federal interest. The ecological premise behind the plan is solid and if this plan were less expensive and if measures benefiting USFWS could be funded and constructed, the plan would be well worth it. The team encourages other local, state, and Federal resource agencies, as well as other interested parties to pursue the separable elements as funding becomes available. Any of the measures and/or locations identified in this plan would incrementally contribute to the recommended plan identified for this study and other restoration actions currently in place or planned for the future.

Pros:

- Net increase in marsh AAHUs over No Action= 6,337 (+2,352 AAHUs over 4Abu, +25 AAHUs over 1Abu)
- Net increase in barrier headland AAHUs over No Action = 52 (+52 AAHUs over 4Abu, +46 AAHUs over 1Abu)
- 15,009 acres of improved habitat (+6,588 acres over 4Abu, +0 acres of 1Abu)
  - Increase in suitable habitat for migratory birds, T&E species (specifically Red Knot, Piping Plover, and sea turtles), waterfowl, fish, and other species of concern, which will lead to an increase in

Cons:

- 37% of the expected AAHUs comes from measures on USFWS land.
- Construction would occur in CBRA zones, which will require a determination that a statutory exception applies.
- Greatest construction footprint resulting in greatest temporary adverse impacts to natural and cultural resources.
- Encountering submerged cultural resources could occur.
- Cost Prohibitive

overall habitat available to the species throughout their range.
    - Restored areas could be eligible for critical habitat designation contributing to additional recovery of T&E species.
- 26,015 acres of indirect benefits in the form of marsh preservation/protection behind the newly created beach/dune system
- Minimizes the increase in open water and conversion to unconsolidated shore throughout the 14 restoration units and in marsh behind the dune.
- Sediment and nutrient inputs are increased contributing to a more sustainable and productive system.
- Synergistic with TPWD and USFWS Refuge management plans.
- Chenier ridge is protected.
- Breakwaters (offshore and GIWW) complement marsh and shoreline restoration to increase resiliency of the overall plan.
- Most resilient and sustainable plan.
- Most, if not all, dredging material would go toward ER and not into upland PAs. Additional sediment may need to be mined from existing PAs which would free up space.
- Ancillary benefits include: same as 4Abu but extending to all restoration sites not just the Keith Lake area.

3.7.7 Alternative 6A: Beneficial Use of Dredge Material (Cost-effective Plan)

Under this plan, all restoration would occur on the eastern half of the focused study area. A total of 11,596 acres of marsh would be maintained or restored utilizing borrow material from the SNWW. Restoration would include invasive species removal and native plantings in areas experiencing or have the potential to experience high erosion rates. Additionally, 16,400 linear feet (5 miles) of beach and dune would be constructed at TX Point NWR. This plan produces a net increase of 5,164 AAHUs over the No Action. An additional 3,388 acres of marsh would be indirectly benefited by shoreline measures.

This plan and 4Abu are very similar in that they both use an active restoration approach, except that three additional restoration sites are added. However, this plan does not include construction of GIWW armoring, like 4Abu.

3.7.7.1 Objective Performance

This plan fully meets all objectives within the project footprint, but would not address any of the objectives in the western half of the study area.

3.7.7.2 Resiliency and Sustainability

By implementing this plan, a “barrier” of sorts would be formed along the eastern edge of the study area beginning at the SNWW, which combats RSLC coming in from the eastern direction and moving west across the study area. This would protect marsh conversions until RSLC rose to a level where the dune could be breached. The areas that would be restored under this plan are currently owned and managed by TPWD or is private land; therefore, these lands are less likely to receive restoration planning and execution in the absence of USACE assistance.

Resiliency and sustainability discussions for marsh restoration, beach nourishment and dune construction in Alternative 2Abu would be also be applicable to this plan, except that the area of restoration is limited to the eastern half of the study area and would not address any problems to the west.

3.7.7.3 Is it Worth It? (Alternative 6A: Beneficial Use of Dredge Material (Cost-effective Plan))

For the additional investment to select this plan, there would be a net increase in marsh and barrier headland maintained or restored over Alternative 4Abu, but less than Alternative 2Abu for marsh and barrier headland and less than Alternative 1Abu for marsh but a greater net increase in barrier headland. The plan maximizes the use of dredge material, which would free up space in upland PAs and minimize the environmental impacts of placing dredged material into the PAs. As well, additional investment would result in increased resiliency and sustainability of the overall study area and not just within the project areas.

Like the previous plans, 6A also incorporates measures which would be carried out by USFWS. These measures contribute to approximately 18 percent of the overall AAHU expectations for this plan. By not implementing the measures, not only would 18 percent of the overall AAHUs not be realized, the resiliency and sustainability features built into the plan (beach nourishment and dune construction) would not be constructed lowering the overall completeness and effectiveness of the plan. If the USFWS measures were not implemented, the actual constructed features would look very similar to 4Abu, expect that there would be no armoring and more marsh sites north of the GIWW. As was the case with Alternative 1Abu, the PDT and resource agencies regard GIWW armoring as a better use of funds over restoring marsh acreage north of the GIWW (i.e. 4Abu is preferred over 6A in the absence of the complete plan being constructed).

If this plan could be fully funded and constructed by all parties, this plan would be worth the investment. However, given the percentage of AAHUs that may not be realized and the lowered resiliency and sustainability, coupled with the preference for GIWW armoring, this plan is not worth the additional Federal investment. Like 2Abu, the PDT encourages the other agencies and interested stakeholders to pursue funding for the separable elements of this plan, as each could incrementally contribute to the overall restoration goal of the study area.

Pros:

- Net increase in marsh AAHUs over No Action= 5,112 AAHUs (+1,127 AAHU over 4Abu, -1,200 AAHU less than 1Abu)
- Net increase in barrier headland AAHUs over No Action= 52 (+52 AAHUs over 4Abu, +46 AAHUs over 1Abu)
- 11,596 acres of improved habitat over the No Action (+3,175 acres over 4Abu, and -3,413 acres less than 1Abu)
    - Increase in suitable habitat for migratory birds, T&E species (specifically Red Knot, Piping Plover, and sea turtles), waterfowl, fish, and other species of concern, which will lead to an increase in overall habitat available to the species throughout their range.
    - Restored areas could be eligible for critical habitat designation contributing to additional recovery of T&E species.
- 3,388 acres of indirect benefits in the form of marsh preservation/protection behind the newly created beach/dune system
- Minimizes the increase in open water and conversion to unconsolidated shore throughout the 9 restoration units and in marsh behind the dune.
- Sediment and nutrient inputs are increased contributing to a more sustainable and productive system.

Cons:

- Salinity intrusion and erosion at the GIWW shoreline would not be addressed, leaving the marshes within 204 feet of the shoreline (4'/year erosion rate) susceptible to habitat conversion.
- 18% of the expected AAHUs comes from measures on USFWS land.
- Construction footprint greater than 4Abu, resulting in greater impacts to natural and cultural resources.

- Synergistic with TPWD and USFWS Refuge management plans.
- Chenier ridge is protected.
- All problems and objectives are addressed in the eastern half of the study area.
- A significant amount of dredged material would go toward ER and not into upland PAs.
- CBRA Zones that require exemptions are avoided.
- Ancillary benefits would be limited to an unquantified, limited amount of storm protection.

3.8 National Ecosystem Restoration Plan and Selection of the Recommended Plan

Federal Planning for water resources development was conducted in accordance with the P&G adopted by the U.S. Water Resources Council.

> "For ecosystem restoration projects, a plan that reasonably maximized ecosystem restoration benefits compared to costs, consistent with the Federal objective, shall be selected. The selected plan must be shown to be cost effective and justified to achieve the desired level of output." This plan shall be identified as the National Ecosystem Restoration (NER) Plan."

Alternative 4Abu was identified as the National Ecosystem Restoration (NER) Plan. This plan reasonably maximizes benefits and is both cost-effective and a best-buy plan, meaning that the plan has the lowest incremental cost per incremental benefit. This plan meets all four planning criteria. Although this plan is not the preferred plan by the resource agencies, they acknowledge reasonableness of cost, and the risk and uncertainties associated with the other plans and accept 4Abu as the NER and the Recommended Plan.

3.9 Plan Modifications

Following the Agency Technical Review and Agency Decision Milestone, two changes occurred that could potentially alter plan formulation and selection. The first modification was a result of removing continuing construction as part of the NER/TSP and the second was removal of marsh restoration on all private lands.

The NER/TSP, as formulated for the Draft Report, includes additional marsh nourishment in year 30 of the project life to sustain the restored marshes as RSLC accelerates. Section 3.6.2.1 – RSLC Design Considerations, above, discusses the rationale for including the outyear nourishment at year 30, which was assumed to be the threshold in which marsh restoration could perform under the 50-year intermediate scenario before the marsh steadily degrades and converts to open water. The future nourishment was recommended as a continuing construction action, to be cost-shared in accordance with initial project construction costs. However, USACE policy does not clearly identify this type of adaptive response to sea level rise as a construction action eligible for inclusion in the project authorization or within the adaptive management plan. Therefore, the outyear nourishment actions should not be included in the recommendation to Congress. As a result, the NER/TSP was modified to remove the outyear nourishment element, which resulted in the recommended plan including only actions that would be constructed during initial construction (i.e. one nourishment for each marsh restoration area and construction of breakwaters). The team acknowledges removing the outyear nourishment will affect plan performance over the 50-year planning horizon and recommends the outyear renourishment be evaluated 25-30 years after implementation.

The second change was the result of determining that the NFS would not pursue acquisition of private lands for marsh restoration and only state or federal owned lands would be considered for marsh restoration. Private lands will be acquired for GIWW armoring only.

These two changes would not only reduce costs, but also reduce the benefits associated with each of the alternatives. In response to the various changes, the PDT performed a CE/ICA validation of the new numbers to make sure the best buy array and recommended plan would not change. After running CE/ICA with the costs and benefits adjusted for exclusion of continuing construction and marsh restoration of private lands, it was determined that the final array remained the same as prior to the removal of these plan elements. The reduction in costs and benefits did not affect the "Is it worth it?" rationale described in Section 3.7. The PDT determined that Alternative 4Abu is still the NER plan and is the recommended plan being put forth for the Chief's Report. The tables and graphs in Appendix C provide the inputs and results of this analysis. It should be noted that the new runs used October 2018 prices and a 2.875% federal interest rate.

Table 3-12: Effect of removing outyear nourishment from the Recommended Plan

	TSP- with continuing construction and private lands	Recommended Plan – without continuing construction and private lands	Change	% Change
Benefits (AAHUs)	3,985	2,695	-1,290	-32%
Total Economic Costs ($1,000s)	$133 mil	$84 mil	-$49 mil	-27%

4 Environmental Consequences

This chapter describes the probable effects or impacts of implementing any of the action alternatives (i.e., the Future with Project condition or FWP). Effects can be either beneficial or adverse, and are considered over a 50-year period of analysis (2027-2077). *Note: Chapter 4 analyses are based on the alternatives as originally formulated, which included continuing construction and private lands. The Recommended Plan is a smaller Alternative 4Abu which has been modified by removing out-year nourishment and marsh restoration of lands that are privately owned. The impacts of the Recommended Plan are expected to be less than that described in this chapter given the reduction in the Alternative 4Abu overall footprint and the decrease in the duration of ground disturbance.*

Four action alternatives, as described in the plan formulation section, were considered when analyzing impacts from implementation of any Ecosystem Restoration (ER) measures. Generally speaking all alternatives are going to have very similar impacts. The main differences between the alternatives with respect to impacts is associated with the temporal and spatial scale of alternatives. Each alternative gets progressively larger in scale by increasing the number of restoration units and measures included in the alternative (Table 4-1). The impacts described throughout this chapter are associated to each alternative, unless specifically called out, and are expected to be proportional to each of the alternatives in intensity (e.g. alternative 4Abu has the smallest footprint and construction period and would be expected to have the least impact for each of the resources when compared to the other three alternatives; while Alternative 2Abu has the largest footprint and longest duration for construction and would therefore have the greatest impacts for each of the resources when compared to the other three alternatives.)

All sediment needs for implementation of any of the action alternatives would come from material dredged from the SNWW. All sediment needs can be met with existing operations and maintenance dredging. This impact analysis will not analyze the impacts of dredging. The analysis will analyze the transportation and placement of dredged material and any other measures which do not require dredged material (e.g. breakwaters, GIWW armoring). Existing NEPA documentation for dredging activities can be found in the Final Feasibility Report for Sabine-Neches Waterway Channel Improvement Project Southeast Texas and Southwest Louisiana and is incorporated by reference (USACE 2011).

When considering impacts, it was assumed that at a minimum best management practices (BMPs) identified throughout this chapter would apply during project construction. Assumed BMPs are based primarily on widely accepted industry, state and federal standards for construction activities. Examples include but are not limited to:

- Use of silt fencing to limit soil migration and water quality degradation;
- Refueling and maintenance of vehicles and equipment in designated areas to prevent accidental spills and potential contamination of water sources and the surrounding soils; and,
- Limiting idling of vehicles and equipment to reduce emissions.

If, for some reason, the BMPs are not implemented, the impacts of any of the action alternatives would only minimally increase from those described in this chapter. The increase impacts would not be substantial enough to cause an adverse insignificant impact to become significant.

Table 4-1: Alternative Comparison by Area

		4Abu (Pre-ADM)	4Abu (Post-ADM) Recommended Plan	6A	1Abu	2Abu
Marsh	Number of Restoration Units	6	6	9	14	14
	Acres Restored	8,421	6,048	11,596	15,009	15,009
	Initial Construction Dredged Material (MCY)	6.7	5.1	9.3	12	12
	Renourishment Cycles	1	0	1	1	1
	Total Renourishment Dredged Material (MCY)	3.7	0	5.1	6.5	6.5
Beach Nourishment	Length (Linear feet)	0	0	16,400	0	71,818
	Acres Restored	0	0	62	0	270
	Initial Construction Dredged Material (MCY)	0	0	1.8	0	5.9
	Renourishment Cycles	0	0	4	4	4
	Total Renourishment Dredged Material (MCY)	0	0	17.3	0	8.2
Dune Construction	Length (Linear feet)	0	0	16,400	0	71,818
	Acres Restored	0	0	33	0	143
	Indirect Benefits (acres)	0	0	3,888	0	26,015
	Initial Construction Dredged Material (MCY)	0	0	0.23	0	0.23
	Renourishment Cycles	0	0	1	0	1
	Total Renourishment Dredged Material (MCY)	0	0	0.1	0	0.5
GIWW Armoring	Length (Linear feet)	6,592	5,170	0	0	56,455
	Footprint (acres)	4.5	3.6	0	0	38
	Initial Construction Stone Volume (ft3)	672,384	651,420	0	0	5,758,410
	Outyear Stone Volume (ft3)	168,096	97,710	0	0	1,439,603
Breakwater	Length (Linear feet)	0	0	0	0	71,818
	Footprint (acres)	0	0	0	0	10.1
	Initial Construction Stone Volume (ft3)	0	0	0	0	330,545
	Outyear Stone Volume (ft3)	0	0	0	0	66,497
Feeder Berm	Length (Linear feet)	0	0	0	71,818	0
	Footprint (acres)	0	0	0	1,331	0
	Initial Construction Dredged Material (MCY)	0	0	0	1.1	0

	Renourishment Cycles	0	0	0	4	0
	Total Renourishment Dredged Material (MCY)	0	0	0	15.6	0
Total	Acres Restored	8,421	6,048	11,691	15,009	15,422
	Footprint (acres)	4.5	3.5	0	1,331	48.1
	Indirect Benefits (acres)	0	0	3,888	0	26,015
	Initial Construction Dredged Material (MCY)	6.7	5.1	11.33	13.1	18.13
	Renourishment Dredged Material (MCY)	3.7	0	22.5	22.1	15.2
	Initial Construction Stone Volume (ft^3)	672,384	651,420	0	0	6,088,955
	Outyear Stone Volume (ft^3)	168,096	97,710	0	0	1,506,100
	Construction Duration (months)	84	60	192	360	360

Conservation measures were incorporated into the impact analysis for ESA-listed species and marine mammals. These measures must be implemented in order to maintain the insignificant impact rating. If they are not implemented, the impact would become significant if impacts are realized. Examples of conservation measures include but are not limited to:

- Seasonal timing restrictions
- Requirement for biological monitors during construction
- Monitoring pre-, during and post-construction for some species

The following 10 resources areas were analyzed in detail for all five action alternatives: land use; lands with special management; air quality; climate; water resources including hydrology, floodplains, surface water, wetlands, waters of the US, groundwater, and water quality; geologic resources including geology, soils, and minerals; biological communities; special status species including Federal and state listed species, species of concern, migratory birds, invasive species, essential fish habitat, and rare, unique and imperiled communities; recreation and aesthetics; transportation; and socioeconomics including environmental justice.

4.1 Land Use

No ER would occur within existing agricultural or developed lands. ER measures would restore historic land cover in areas that have been converted to open water, but this would not change existing or future land use of the restored areas. Therefore, implementation of any of the action alternatives would have no effect on land use.

4.2 Protected and Managed Lands

4.2.1 Federal/State Ownership

Temporary impacts during construction may affect when and where visitors to the land may be able to go or how management is conducted within the restoration units, but access and management would return to normal once construction is complete. Alternative 4Abu would have the least impact to visitors and short-term management of the state and Federal lands, followed by Alternative 6A. Alternative 1Abu and 2Abu would have the same impact and be the greatest when compared to the four alternatives. Implementation of any of the alternatives would not interfere with long-term management of USFWS and TPWD lands. All ER measures are consistent with existing agency management actions. Significant coordination was conducted with each agency during alternative development to ensure their concerns were addressed and that they could support action on their land.

Sea Rim State Park and the Sabine Pass Battleground would not be impacted by any of the proposed alternatives because no restoration activities would occur within their boundaries. The two sites were not identified within any of the priority restoration units during initial plan formulation.

Table 4-2 shows the footprint of marsh restoration within each land ownership. Alternatives 6A and 1Abu/2Abu have been grouped together because there is no variation in the acreage of marsh between those alternatives.

Table 4-2: Marsh ER Occurring (Acreage) within the Various Land Ownerships

Land Owner	4Abu	6A	1Abu/2Abu
USFWS—McFaddin NWR	683	683	1,603.2
USFWS—Texas Point NWR	0	1,304	1,304
TPWD—JD Murphree	5,365	5,719	5,719
TPWD—Sea Rim State Park	0	0	0
THC—Sabine Pass Historic Battleground	0	0	0
Private	2,374	3,890	3,901

Beach nourishment and dune construction in alternative 6A and 2Abu would impact approximately 16,400 linear feet of Texas point NWR, while approximately 71,815 linear feet on McFaddin NWR would be constructed under 2Abu. Shoreline measures in alternative 1Abu would be constructed on GLO land in the swash zone and nearshore, respectively. No shoreline measures are proposed for alternative 4Abu.

Implementation of any of the action alternatives, would have only temporary, minor adverse impacts to Federal- and State-owned lands as a result of construction activities. Long-term beneficial impacts, such as increased recreation opportunities and an increase in suitable habitat for species of concern, can be expected from any of the alternatives.

4.2.2 Coastal Zone Management Act

Under the Coastal Zone Management Act, the Texas General Land Office (GLO) is responsible for implementing the Texas Coastal Management Plan (TCMP) that was developed for Texas. Within this plan there are 20 enforceable policies (Table 4-3) and 16 critical natural resource areas (CNRAs). Any Federal undertaking within the CZMA boundary must be consistent with the enforceable policies and must not adversely affect CNRAs. Adverse effect for the purposes of the TCMP are "Effects that result in the physical destruction or detrimental alteration of a CNRA." Due to the nature of ecosystem restoration measures incorporated into each of the four plans, no adverse effects to any of the CNRAs are anticipated. Direct or indirect adverse impacts would be localized and temporary and not result in any long-term physical destruction or detrimental alterations of a CNRA. Anticipated impacts to CNRAs from implementation of the Recommended Plan have been analyzed in the consistency determination in Appendix A-3.

The 20 policies were reviewed and it was determined that six policies are applicable alternative 2Abu and 6A, while only five policies are applicable to alternatives 4Abu and 1Abu. Each alternative is compliant with the enforceable policies. As well, there would be no adverse effects to CNRAs because of the restoration nature of all action alternatives. TCMP compliance documentation has been completed for the Recommended Plan and transmitted to GLO for a consistency determination (Appendix A-3).

Table 4-3: Enforceable Policies of the Texas CMP (31 TAC 501, Subchapter B)

Policy	Applicability
§ 501.15 Policy for Major Actions	N/A
§ 501.16 Policies for Construction of Electric Generating and Transmission Facilities	N/A
§ 501.17 Policies for Construction, Operation, and Maintenance of Oil and Gas Exploration and Production Facilities	N/A
§ 501.18 Policies for discharges of Wastewater and Disposal of Waste from Oil and Gas Exploration and Production Activities	N/A
§ 501.19 Policies for Construction and Operation of Solid Waste Treatment, Storage, and Disposal Facilities	N/A
§ 501.20 Policies for Prevention, Response and Remediation of Oil Spills	N/A
§ 501.21 Policies for Discharge of Municipal and Industrial Wastewater to Coastal Waters	N/A
§ 501.22 Policies for Nonpoint Source (NPS) Water Pollution	N/A

§ 501.23 Policies for Development in Critical Areas	4Abu, 6A, 1Abu, 2Abu
§ 501.24 Policies for Construction of Waterfront Facilities and Other Structures on Submerged Lands	N/A
§ 501.25 Policies for Dredging and Dredged Material Disposal and Placement	4Abu, 6A, 1Abu, 2Abu
§ 501.26 Policies for Construction in the Beach/Dune System	6A, 2Abu
§ 501.27 Policies for Development in Coastal Hazard Areas	
§ 501.28 Policies for Development Within Coastal Barrier Resource System Units and Otherwise Protected Areas on Coastal Barriers	4Abu, 6A, 1Abu, 2Abu
§ 501.29 Policies for Development in State Parks, Wildlife Management Areas or Preserves	4Abu, 6A, 1Abu, 2Abu
§ 501.30 Policies for Alteration of Coastal Historic Areas	
§ 501.31 Policies for Transportation Projects	N/A
§ 501.32 Policies for Emission of Air Pollutants	4Abu, 6A, 1Abu, 2Abu
§ 501.33 Policies for Appropriations of Water	N/A
§ 501.34 Policies for Levee and Flood Control Projects	N/A

4.2.3 Coastal Barrier Resources Act

The stated purpose of Coastal Barrier Resources Act (CBRA) is to “minimize the loss of human life, wasteful expenditure of Federal revenues, and the damage to fish, wildlife, and other natural resources associated with the coastal barriers…... by restricting future Federal expenditures and financial assistance which have the effect of encouraging development of coastal barriers….”. 16 U.S.C. § 3501(b).

CBRA prohibits new federal projects that encourage development or modifications to costal barrier units unless the project qualifies for a specific exception under 16 USC §3505.

The CBRA contains two categories of exceptions to the general prohibition found in 16 U.S.C. §3504. The first category allows federal expenditures if the requirements of the specific exception are met (16 U.S.C. §3505(a)(1-5). The §3505(a)(1-5) exceptions refer to Federal involvement in projects related to energy resources, existing Federal navigation channels, existing public roads and transportation, national security, and Coast Guard facilities. The second category of exceptions allow federal expenditures if they meet the requirements of the specific exception and also meet the three purposes of CBRA as stated herein (16 U.S.C. §3505 (a)(6)(A-G). The §3505(a)(6)(A-G) exceptions include projects to benefit fish and wildlife habitats, air, and water navigation projects under the Land And Water Conservation Fund Act of 1965 and the Coastal Zone Management Act of 1972. Scientific research, emergency actions under Federal major disaster assistance programs (42 U.S.C.S. §5170, and 42 U.S.C.S §5192), road maintenance, and nonstructural projects for shoreline stabilization are also considered to be a §3505(a)(6)(A-G) exception.

Amendments to CBRA in 1992 created Otherwise Protected Areas (OPAs), which are areas such as parks, sanctuaries and preserves that are not typically threatened with development that may still receive federal assistance.

Alternative 4Abu and 6A propose marsh nourishment projects in two OPAs (Figure 4-1 and Figure 4-2). Alternative 6A also proposes shoreline work in an OPA. The marsh restoration in Alternative 1Abu and the beach nourishment/dune construction in 2Abu would need to qualify for an exception or receive express exemption in order to be constructed (Figure 4-3 and Figure 4-4).

Figure 4-1: Coastal Barrier Resource System in Relation to Alternative 4Abu

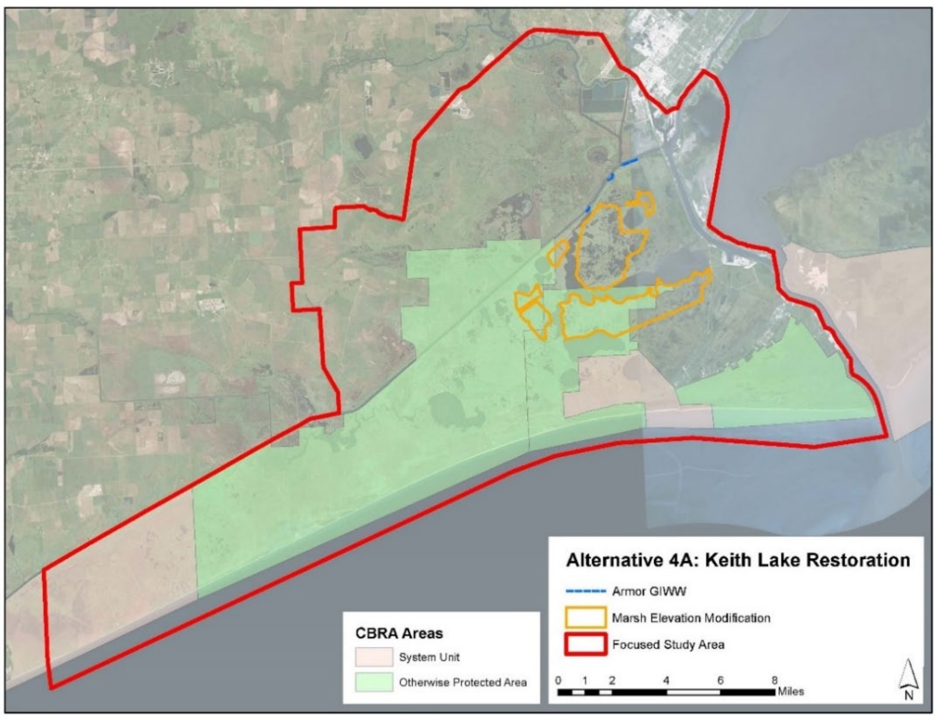
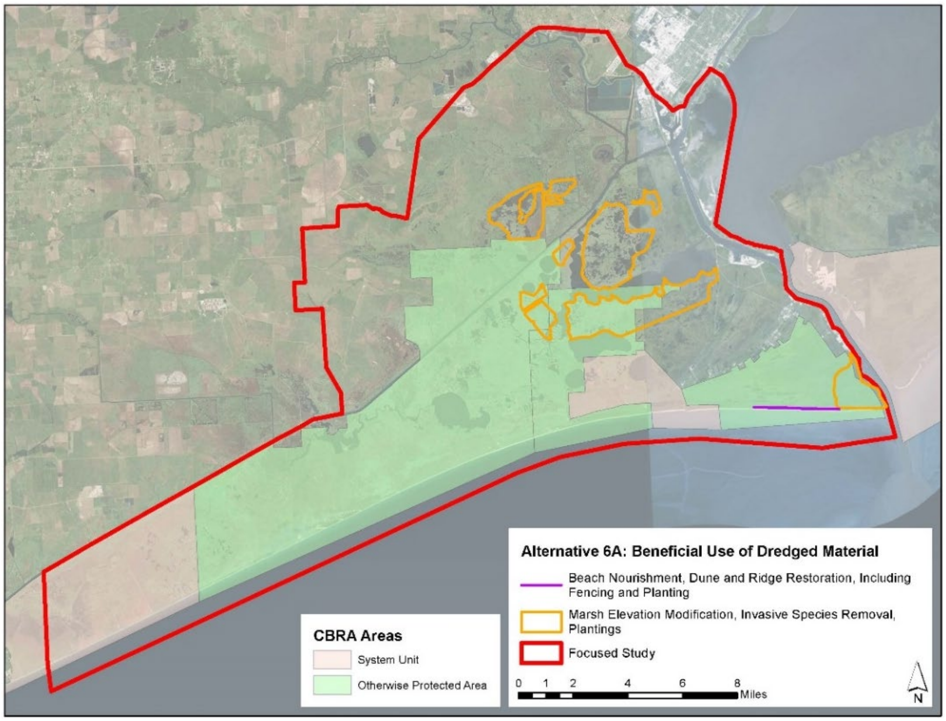


Figure 4-2: Coastal Barrier Resource System in Relation to Alternative 6A



Alternatives 1Abu and 2Abu have measures that would be completed within a System Unit, in which Federal expenditures are prohibited except under certain conditions (Figure 4-3and 4-4) and OPAs. The portions of the alternatives that are within the OPAs would be permissible because they do not implicate the prohibition on Federal flood insurance. However, for the marsh restoration in alternative 1Abu and the marsh restoration and beach nourishment/dune construction in alternative 2Abu to be permissible and compliant with CBRA several criteria must be met: meeting one of the General Exceptions (16 U.S.C. 3505(a)(1)-(5)) or meeting one of the Specific Exceptions (16 U.S.C. 3505(a)(6)(A)-(G)) AND be consistent with all three purposes of the CBRA, which are to minimize (1) the loss of human life; (2) wasteful expenditure of Federal revenues; and (3) damage to fish, wildlife, and other natural resources.

None of the General Exceptions likely apply to either action alternative. However, the Specific Exception 16 U.S.C. 3505(a)(6)(A) potentially applies to both alternatives. This excepts "*Projects for the study, management, protection, and enhancement of fish and wildlife resources and habitat, including acquisition of fish and wildlife habitats, and related lands, stabilization projects for fish and wildlife habitats, and recreational projects.*" The Specific Exception at 16 U.S.C 3505(a)(6)(G) also is potentially applicable to alternative 2Abu. This excepts "*Nonstructural projects for shoreline stabilization that are designed to mimic, enhance, or restore a natural stabilization system.*" Implementation of either alternative would also comply with the three purposes of the CBRA by minimizing:

(1) Loss of human life: Although the project does not specifically reduce loss of human life, the barrier beach, dune, and wetlands have been shown to reduce wind and wave energies from significant weather events on coastal communities. It is anticipated that the restoration efforts would reduce some level of storm surge on coastal communities, although this has not been specifically modeled or calculated because the study purpose is not for coastal storm risk management. Additionally, the action does not promote development and would prevent future development within the sites due to the restrictions placed on the land after an ER project is completed.

(2) Wasteful expenditure of Federal revenues: Ecological benefits have been monetized and each of the alternatives have been identified as being cost-effective and "worth it" to invest federal resources into the project.

(3) Damage to fish, wildlife, and other natural resources associated with the coastal barriers: The study purpose is to improve the ecological conditions of the focused study area through restoration actions. Through implementation the form and function of the coastal system would be improved over the existing and future-without project condition in which there would be a net gain in wetland and barrier beach habitat benefiting fish and wildlife species. Implementation of either alternative would result in temporary impacts to fish, wildlife, and other resources during construction, but would for most resources result in improved conditions over the long-term, realizing net benefits.

Figure 4-3: Coastal Barrier Resource System in Relation to Alternative 1Abu

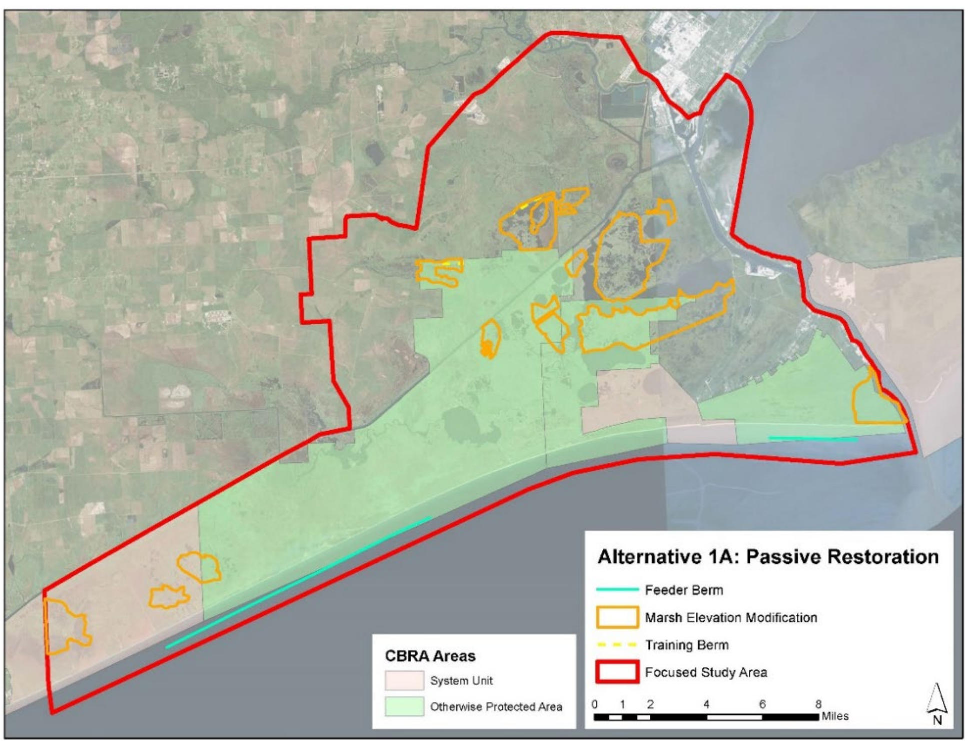
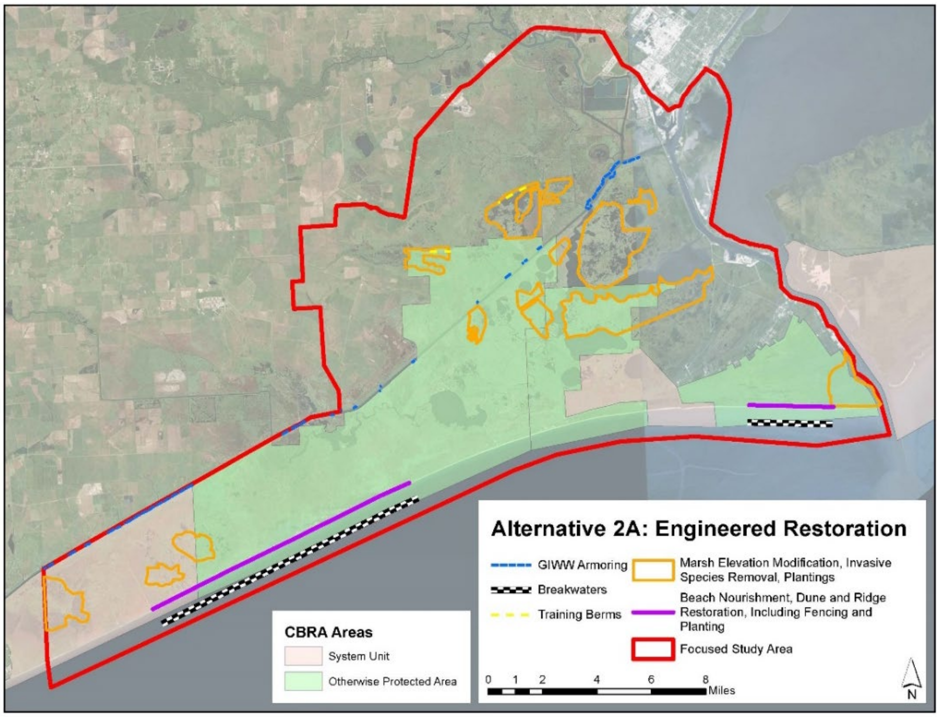


Figure 4-4: Coastal Barrier Resource System in Relation to Alternative 2Abu



4.2.3.1 USFWS Guidance

Additionally, Federal agencies are required to consult with the United States Fish and Wildlife Service (USFWS) on planned expenditures for an action, which will take place in a CBRA System Unit, The responsible federal agency is to consult with USFWS on the work to be performed and to advise on whether any of the Act's exceptions apply.

As Alternative 4Abu does not involve any work within any CBRA System Unit, no consultation is required with the USFWS. A Memorandum for Record (MFR) has been prepared to document that the implementation of Alternative 4Abu would result in a Federal Undertaking in an OPA which is compliant and permissible under CBRA (Appendix A-4).

4.2.4 Fish and Wildlife Management Areas

Implementation of any of the alternatives would not interfere with long-term management of USFWS and TPWD lands. All ER measures are consistent with existing agency management actions. Significant coordination was conducted with each agency during alternative development to ensure their concerns were addressed and that they could support action on their land. Implementation of any of the action alternatives would result in a net increase in fresh, intermediate, and brackish marsh and a decrease in open water. This overall net increase in coastal marshes significantly benefits all species that both the NWRs and WMA manage.

There would be only temporary, minor adverse impacts to the management areas during construction from noise disturbance and construction equipment and personnel presence, but all negative impacts would cease after construction is complete. Alternative 4Abu would have the fewest temporary impacts because it has the shortest duration for construction and smallest ground disturbance footprint, followed by Alternative 6A, 1Abu, and 2Abu sequentially. After construction is complete and vegetation has established, long-term, beneficial impacts would be realized. From a long-term benefits perspective, Alternative 2A would have the greatest beneficial impacts because of the significantly increased resiliency and sustainability of the restoration units, while 4Abu would have the least. These benefits are described in section 4.7.1.

4.3 Air Quality

Air quality impacts from implementation of any of the action alternatives would be similar in scope, but varying in scale and duration, with 4Abu having the least impacts and 2Abu having the greatest impacts. In general, each action alternative would have direct impacts to ambient air quality from construction activities. Air emissions would be mobile in nature, temporary, and localized to the restoration unit(s) being worked at that time. Operation of heavy equipment, support vehicles, and other motorized machinery for construction would result in combustion of fossil fuels and the release of volatile organic compounds (VOCs), nitrogen oxides (NOx), carbon monoxide (CO), ozone (O3), sulfur dioxide (SO2), and particulates(PM10 and PM2.5). Additionally, fugitive dust emitted to the atmosphere by heavy equipment and support vehicles moving across unpaved, non-vegetated roadways or staging areas and wind blowing dust from disturbed areas and storage piles into the atmosphere could create a haze over the project area and increase ambient concentrations of particulate matter.

Construction emissions, including fugitive dust, would be short-term lasting only as long as it takes to complete each measure within each restoration unit. Implementation of the following BMPs would further reduce air quality impacts and should be incorporated when developing contract specifications.

Mobile and Stationary Source Controls:

- The use of heavy machinery should be fitted with approved muffling devices that reduce emissions;
- Plan construction scheduling to minimize vehicle trips;
- Limit idling of heavy equipment;
- Maintain and tune engines per manufacture’s specifications to perform at EPA certification levels, prevent tampering, and conduct inspections to ensure these measures are followed; and
- Consider alternative fuel and energy sources (e.g. natural gas, electricity, etc.) when and where appropriate.

Fugitive Dust Source Controls:

- Stabilize open storage piles and disturbed areas by covering and/or applying water or chemical/organic dust palliative where appropriate at active and inactive sites; and
- Install wind fencing and phase grading operations where appropriate, and operate water trucks for stabilization of surfaces under windy conditions.

Implementation of any of the four action alternatives is expected to have minor adverse impacts on air quality, but is not expected to impact or contribute to any areas not meeting NAAQS. Because action alternatives would be implemented in an area currently designated as in attainment for all NAAQS, TCEQ is not required by the Clean Air Act and Texas Administrative Code to grant a general conformity determination. All action alternatives are, therefore, in compliance with the Clean Air Act.

4.4 Climate

Climate impacts are analyzed from two perspectives: impact of implementing any of the action alternatives on climate and climate change and the impact of climate change on the performance of any of the action alternatives.

NEPA does not specify significance thresholds that may be used to evaluate the effects of a proposed action on global climate. The appropriate approach to evaluating a project's impact on global climate under NEPA is still under development. In August of 2016, the Council on Environmental Quality (CEQ) released NEPA guidance for consideration of the effects of GHG emission and climate change in NEPA documents. The guidance recommends 25,000 metric tons CO_2 equivalent ($MTCO_2e$) of direct emissions per year as a presumptive threshold for analysis and disclosure within NEPA documents. The guidance suggests that if a proposed action would result in direct emissions below this threshold, the emissions would not be relevant to and would not need to be discussed within a NEPA analysis. In April 2017, CEQ withdrew its final guidance for federal agencies on how to consider GHG emission and the effects of climate change in NEPA reviews, and therefore, the USACE may approach the evaluation of GHG impacts using a methodology that it finds appropriate.

At the state level, GHGs are a regulated pollutant under the PSD program when emissions exceed the thresholds set in 30 TAC 116.164(a)(1) or (a)(2). The threshold for new source emissions is: the project emissions are above the major source threshold for a regulated pollutant that is not GHGs, and will emit or have the potential to emit 75,000 tons per year (tpy) or more CO_2e. Emissions of GHGs are regulated and require authorization only when the project emission increases are above this thresholds. None of the alternatives would exceed any non-GHG thresholds and would emit far fewer tpy CO_2e that the regulated amount.

4.4.1 Construction Activities

Under each of the action alternatives, construction activities would generate GHG emissions as a result of combustion of fossil fuels while operating on- and off-road mobile sources. The primary GHGs generated during construction are CO2, CH4, and N2O. The other GHGs such as hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride are typically associated with specific industrial sources and processes and would not be emitted during construction. After construction is complete, all GHG emissions would cease and the area would return to baseline conditions. There are no apparent carbon sequestration impacts that would result from implementation, thus the total direct and indirect impacts would be constrained to very small increases in GHG emissions to the atmosphere from operation of on- and off-road mobile sources. In years in which construction activities are implemented, emissions would incrementally contribute to global emissions, but would not be of such magnitude as to make any direct correlation with climate change.

CO_2 emissions are highly correlated to fuel use. Approximately 99 percent of the carbon in diesel fuel is emitted in the form of CO_2 (EPA 2005). EPA published a CO_2 emission factor of 10,084 grams per gallon (g/gal) or 10 kilograms per gallon (kg/gal) which provides the CO_2e value. To determine the gallons of fuel used to implement the project, it was assumed that 10 percent of the construction costs are associated with fuel consumption. Based on the 10 year average, Walla Walla has determined that the average cost of diesel is $3 per gallon. Using these assumptions, Alternative 4Abu is expected to spend approximately $40 million on construction which translates into 1,333,333 gallons of fuel used, 13,333,333 kg of CO_2e, and 14,697 tons CO_2e (13,333 $MTCO_2e$) for the entire construction period (67 months), which translates into about 219 tons per month (199 $MTCO_2e$ per month) or 2,628 tpy CO_2e (2,388 $MTCO_2e$ per year). Alternative 2Abu is approximately 4 times more expensive than Alternative 4Abu, therefore the emissions would be expected to be approximately 4 times greater over the total construction duration and equal about 53,332 $MTCO_2e$ or 3,555 $MTCO_2e$ per year. The yearly emission of CO_2e for any of the alternatives would be far below the thresholds initially identified by CEQ or as regulated by the state as significant.

The actions considered for GHG analysis do not include emissions emitted by the dredge. It is acknowledged that dredging operations would contribute to GHG emissions; however, this source of emission is to be accounted for under the O&M or SNWW CIP because dredging will occur whether this project is implemented or not.

4.4.2 Alternative Performance

Each action alternative has been designed to be effective and sustainable under future climate conditions. ER measures were developed using the intermediate rate of sea level change and incorporate future nourishment cycles to ensure that each measure is sustainable under rising sea level conditions for the full

50 year planning horizon. An assessment of RSLC was included in the design of each of the alternatives. The evaluation of RSLC is documented in the Engineering Appendix (Appendix B).

However, there is uncertainty about how much sea level change would occur in the project area. RSLC could impact the benefits achieved by any of the action alternatives. If future sea level change is less than the intermediate rate of change, each action alternative would provide more benefits than anticipated. If higher rates of sea level change are experienced, each alternative would provide less benefits than anticipated. With the a higher rate of change, marsh and shoreline restoration features would be less effective because they could be overwhelmed by water levels which would increase their vulnerability. This is a risk to the effectiveness of any of the action alternatives but this situation would also imply that landscape-level inundation would be so great that engineered or designed features could no longer control how, when, or where water moves throughout the restoration unit(s). This could ultimately lead to a shift in project strategy from maintaining elevations to relocations if future sea levels are higher than anticipated.

Additional uncertainties relate to possible extreme weather events. Uncertainty about the size and frequency of storms and climate events, such as El Niño, cannot be predicted over a set period of time. Storm events can cause significant damage to the shoreline and marsh areas. Intact habitats are more resilient against the effects of hurricane storm surge and associated flooding, salinity spikes, and tidal scour, though some hurricane storm surge damage may be unavoidable.

During PED, prior to initial construction (if conditions changed since PED), and prior to renourishment cycles, local conditions will be assessed. If the rate of change is higher than expected under the intermediate scenario, the target elevations for marsh and construction elevations and widths for the beach berm and dune would be modified to increase effectiveness, resiliency, and sustainability in the face of climate change. If the observed rate of change is more aggressive, approaching or exceeding the high rate, reevaluation of the NER may be required.

After construction, monitoring would help evaluate the progress toward meeting project goals, objectives, and desired outcomes for each ER measure and restoration units. If minimal success or obvious failure is occurring, adaptive management techniques would be employed to increase the likelihood of achieving desired project outcomes given the uncertainties with ecosystem restoration. For example, the timing of renourishment cycles may need to be adjusted either sooner or later based on actual loss rates after construction. Also, the dune height or berm width may need to be increased to keep up with RSLC or to combat higher wave and wind energies associated with more significant weather events.

4.5 Water Resources

4.5.1 Hydrology

During marsh restoration, existing fragmented marsh and shallow open water areas would be restored to marsh habitat. Temporary earthen containment/exclusion dikes, if constructed, would temporarily prevent local flows from coming into and over the marsh restoration site during construction activities. However, the dikes would be expected to naturally degrade or would be mechanically breached to provide hydrologic exchange following dewatering and consolidation of dredge sediment slurry. The temporary change in hydrologic flows through the restoration units would not be expected to modify water levels in adjacent areas or permanently alter flows or water levels. Post-construction, marsh platforms would be elevated from their existing condition to aid in the resiliency and sustainability under future conditions. The higher elevations may slightly reduce and modify local throughput (current patterns and flow) of water over the footprint immediately following construction and until the area compacts and sea levels rise. However, overall basin current patterns and flows would be similar to that which existing prior to the fragmentation, degradation and loss under the existing condition. Marsh elevation increases would also reduce the amount of ponding and allow flows to move throughout the area and drain to the lakes, bayous, and ocean, which under the existing condition aided in the conversion of marsh to open water. Marsh restoration would be expected to have an overall beneficial impact in the restoration units by inducing flow conditions more suited to functional wetlands.

Shoreline protection measures would alter the hydrologic flow from the existing condition. Under the existing condition, storm surge and wave energies regularly run up and over the beach and dune causing tidal influences on habitat that was not historically tidally influenced, except during extreme weather events. Under Alternative 6A or 2Abu, beach nourishment and construction of the dune, by design, would reduce tidal influence on marshes behind the dune to a more historic condition prior to the significant hydrologic modifications within and outside the study area. A wider beach would reduce wave energies and slow erosion rates of the beach and dune, while increasing the dune height would prevent storm surge from flowing into marshes behind the dune causing erosion, subsidence, and marsh conversions from less saline habitat to more saline habitat or open water. Storm surge over the dune would still occur during extreme weather events, such as tropical storms and hurricanes, as would have occurred historically. Shoreline restoration provides an overall increase in quality and beneficially impacts all habitats for the long-term.

Under 1Abu, placing dredged material into the nearshore over a large area would not be expected to change the hydrology, currents, circulation patterns, or tides due to the relatively minimal change in bathyemetry (~2% slopes and less than a 5-foot max elevation increase). The nearshore berm would be expected to erode over time which would naturally nourish the beach creating a wider beach to reduce wave energies. The wider beach would likely reduce some wave run-up reducing the frequency of inundation into marshes behind the dune, but not to the extent as under Alternative 6A or 2Abu.

Under Alternative 4Abu and 2Abu, GIWW armoring is not expected to alter flows into and out of the area nor would it alter water levels behind the structures. The structures would by design reduce velocities and protect marsh from wave induced erosion. The proposed design of the GIWW armoring are identical to those used throughout Jefferson County and along other parts of the GIWW. To date, no adverse hydrological influences have been identified. Rather, these structures have provided overall beneficial impacts by reducing erosion caused by waves, slowing land loss, and reducing saltwater intrusion into adjacent marshes.

Under Alternative 2Abu, segmented breakwaters would be constructed in the Gulf of Mexico. These structures would allow flows through the gaps between structures and slow flows over the structures thereby dissipating high energy Gulf waters (i.e. reduce water velocities) and reducing overall wave heights. The structures would not be expected to change water levels or influence the tides. Construction of the breakwaters could induce currents or alter long-shore sediment transport. Because this alternative was not a recommended plan, further modeling to identify impacts of the structures on hydrology were not completed.

4.5.2 Flooding and Floodplains (EO 11998)

EO 11988 requires federal agencies to avoid, to the extent possible, the short- and long-term adverse impacts associated with occupancy and modification of floodplains. Federal agencies are to avoid direct and indirect support of floodplain development wherever there is a practicable alternative. In accomplishing this objective, "each agency shall provide leadership and shall take action to reduce the risk of flood loss, to minimize the impact of floods on human safety, health, and welfare, and to restore and preserve the natural and beneficial values served by floodplains in carrying out its responsibilities."

The objective of the study is to restore coastal ecological functions. Each of the measures are expected to exclusively have beneficial impacts to natural floodplain values. No losses of natural and beneficial floodplain values are anticipated. The nature and extent of flooding within the base floodplain is unaffected by any of the proposed measures.

The risk of inducement of development within the floodplain is normally associated with structural projects such as levees and floodwalls where vacant parcels are no longer subject to frequent flooding, lowering the cost of potential development and providing economic incentive for the addition of inventory to the floodplain. None of the alternatives include measures that would induce development. Implementation of any of the plans may ease the impacts of flooding under RSLC, but it would not otherwise lower the cost of developing in the floodplain as a prerequisite to providing economic incentive that could induce development.

4.5.3 Surface Water/Wetlands

Under all of the action alternatives, placement of dredged material into wetlands would realize a temporary net decrease, but a long-term net increase in the functional value of the wetlands in the restoration units (Table 4-4) when compared to the existing condition or FWOP condition.

During construction, open water and low lying marsh habitat within the restoration units would be filled in during placement of dredged material (approximately 65 percent of each of the restoration units). This would result in the smothering of all existing vegetation in the placement areas resulting in a temporary loss in function as a wetland. As well, construction of a temporary exclusion/containment dike around the marsh restoration units would limit the extent of hydrologic flow into and out of the unit. The dike would be removed either by natural degradation or through breaching when monitoring indicates it is no longer needed. Soils composition is not expected to change with adding dredged material because borrow material is very similar to the existing soil within the restoration units and there are no known contaminants in the dredged material that could leach into the surrounding soils or affect plant growth.

Marsh restoration would convert open water habitat to brackish marsh and any saline marsh in the restoration units would be converted to brackish or marsh resulting in an overall functional value increase over the 50 year planning horizon. The functional value increase would be realized within three years post-construction.

Table 4-4: Net change of brackish marsh with implementation of the action alternatives

Plan	Future Without Project (AAHUs)			Future With Project (AAHUs)			Benefits (AAHUs)*		
	Barrier Headland	Brackish Marsh	Total	Barrier Headland	Brackish Marsh	Total	Barrier Headland	Brackish Marsh	Total
4A/4Abu	100	3,531	3,631	100	7,516	7,616	0	3,985	3,985
6A	100	4,474	4,574	151	9,586	9,737	52	5,112	5,164
1A/1Abu	100	6,347	6,447	105	12,658	12,763	6	6,312	6,318
2A/2Abu	100	6,347	6,447	151	12,683	12,809	52	6,337	6,389

Coastal marsh habitat (wetlands) would be temporarily impacted from construction of dredge pipeline access and flotation channels. These would be restored to pre-construction conditions following completion of the restoration activities.

EO 11990 directs Federal agencies to take action to avoid adversely impacting wetlands wherever possible, to minimize wetlands destruction, to preserve the values of wetlands, and to prescribe procedures to implement the policies and procedures of the Executive Order. Implementation of any of the action alternatives would be fully compliant with this EO since the overall goal of the study is to restore form and function within the study area which includes restoring form and function to wetlands in the restoration units. None of the alternatives would result in a net loss of wetlands, instead they all result in a significant net gain.

Implementation of any of the action alternatives would not affect municipal or private surface water supplies.

4.5.4 Waters of the U.S. (Clean Water Act)

4.5.4.1 Section 404(b)(1)

Section 404(b)(1) of the Clean Water Act regulates the discharge of dredged and fill material into waters of the US, including wetlands. Implementation of any of the action alternatives and all measures would involve discharge of dredged materials and filling of Waters of the US.

<u>Evaluation of Dredged or Fill Material and Disposal Method</u>
Implementation of the marsh restoration measures, beach nourishment, dune construction, and/or feeder berm would all utilize borrow material that would be dredged from the SNWW. The dredged material has been characterized as silt and clay, with varying amounts of organic material and sands. Material would be excavated by either hydraulic or hopper dredge and then pumped through a series of booster pumps to the disposal site (i.e. marsh restoration, shoreline, and nearshore berm location) via a submerged sediment pipeline. Heavy equipment would then be used to achieve the desired +1.2 feet MSL elevation in the marsh, +2.9 feet MSL for the dune and/or the 164-foot beach width. The feeder berm would be pumped into place to achieve the desired width, length, and height.

USACE has collected and archived a significant amount of water and sediment chemistry data as well as elutriate data that provide information on the constituents that are dissolved into the water column contained during dredging and placement. Historical water and elutriate data for detected compounds from 1987, 1990, 1992, and 1998 are presented in PBS&J (2004). Lead and zinc were the only metals found above detection limits in 1987 at all stations in water and elutriate samples. One water sample from station S-SP-87-06 contained 98.0 μg/L of zinc that slightly exceeds the state water quality standards (92.7 μg/L). However, the elutriate value was low indicating no release of zinc to the water column during dredging or placement. Metals were not detected in 1990, and in 1992 the only metal found above detection limits was cadmium (in water) at station S-SP-92-06. In 1998, barium and zinc concentrations were found above detection limits for water and elutriate and were consistently higher in the elutriate samples. This contrasts to the 1987 samples, in which elutriate values were normally lower than water concentrations. Arsenic was detected at most stations in water and two stations for elutriate; cadmium and nickel were found in water only. All values, except the zinc value noted above, were below the water quality criteria (WQC) and state water quality standards.

Oil and grease were detected in 1987 in water and elutriate samples. Ammonia, which was not measured until 1996 was found above detection limits in all elutriate samples for 1998. For the organics, in 1987 fluoranthene was above detection limits at one station. TOC was detected in all water and elutriate samples during 1992, and elutriate concentrations were consistently higher than water concentrations.

Based on available water and elutriate data, there is no indication of current water or elutriate contaminant problems along the SNWW.

For GIWW armoring and offshore breakwater measures material would be rock and geotextile fabric. Depending on the alternative, anywhere from 10.4 MCY to 35.2 MCY of dredged material and 840,480 to 7,595,055 cubic feet of stone would be placed into Waters of the US. Stone would come from an upland quarry and would be transported to the fill site by barge. Cranes and other heavy equipment would be used to place the stone to construct the breakwaters.

See the Engineering Appendix for conceptual designs, the quantity of material required and the footprint of filled areas.

Description of Discharge Site(s)

Between 6 and 14 restoration units would receive dredged material and would result in filling in of wetland or Waters of the US sites. Proposed marsh restoration measures would be located in interior fragmented marshlands throughout the focused study area. Beach nourishment and dune construction measures would be located along the Gulf of Mexico seaward of marshlands. GIWW armoring would be located along the north and/or south shorelines of the GIWW throughout the focused study area. Offshore breakwaters and the feeder berm would be located in the nearshore of the Gulf of Mexico. Salinity within the disposal areas is variable due to tidal fluctuation. The sites are used by a variety of marine and freshwater fauna and also function as critical nursery for some marine species. Interior marsh is necessary for the successful completion of the life cycles of several species, and provides detritus that forms the basis of the food chain for organisms utilizing the area.

Construction of access corridors may be required. Material dredged via mechanical dredge for access would be temporarily side-cast onto water bottoms immediately adjacent to the temporary access corridor. Following construction, the side-cast material would be returned to the temporary access corridor.

Impacts of Dredged/Fill Material

Little or no movement of dredged or fill material is anticipated to occur following dewatering and consolidation of sediments used for the marsh restoration units. This is due to the typically low velocities of water flow across the marsh areas, construction of temporary containment dikes around the restoration units, and the use of the best available techniques and BMPs during construction. Material placed on the dune would not be expected to move significantly post-construction. Erosion mitigating features, such as sand fencing and plantings, would be incorporated during construction to limit the loss of the dune. In contrast, the beach and feeder berm would have significant loss over time. This is anticipated and an intended consequence of placing fill material on the shoreline or in the nearshore. This material is placed in these areas to act as sacrificial land in which natural erosion processes remove the fill material and disperse it elsewhere by longshore transport. This introduces sediments back into the system which have been lost due to hydrologic modifications in the littoral and marine system. Additional fill material would be placed in these restoration units at a specified time based a demonstrated need as determined by monitoring and adaptive management.

During dredging and construction activities, localized effects to water quality is expected, including increased turbidity and total suspended sediments, organic enrichment, reduced dissolved oxygen, elevated carbon dioxide levels, and decreased light penetration, among others. Potential adverse effects on biota, including primary production photosynthesis, suspension/filter feeders, and sight feeders, could be primarily associated with increased turbidity and total suspended sediments, water temperature changes, and lower dissolved oxygen during dredging and construction activities. Any such direct adverse effects to water quality and indirect adverse effects to biota would generally be temporary and localized. Following dredging, placement, and construction activities, overall water quality in the localized impact area would return to conditions which existed prior to activities.

Dredging and placement of dredged material would smother and destroy immobile benthic organisms and force mobile benthos to move from the borrow and discharge areas. It is expected that benthic organisms would re-colonize the borrow sites and the dredged material fill/discharge sites within 1-3 years due to its similarity with the existing substrate in the disposal areas (Wilber et al. 2008). The conversion of shallow open-water and fragmented marsh to restored contiguous marsh would temporarily preclude larger aquatic organisms from initially re-entering the disposal area. Smaller organisms would, however, be able to access the newly restored marsh during high tides. Temporary containment/exclusion dikes would naturally degrade or would be breached in multiple places following construction, if necessary, to restore aquatic organism and fish access if natural degradation is not sufficient. Following construction, dredged sediments would consolidate and differentially settle to different elevations thereby resulting in development of lower-lying areas that would develop into small ponds and streams further enabling aquatic organism access from surrounding waters. Coastal marshes in the focused study area have been fragmenting, degrading, and converting to less productive marshes or open water at a significant rate. Therefore, restoring marsh is considered to have a higher ecological value that shallow open-water because of its benefits to terrestrial and aquatic organisms in an areas with decreasing wetland habitats.

For alternative 4Abu and 2Abu, rock placed for the breakwater structures is expected to settle initially following construction due to the overburden pressure that the rock would create on underlying unconsolidated substrate. However, placement of geotextile fabric between rock and substrate would help to prevent the complete sinking of the rock over time. Additional placement of rocks during OMRR&R is anticipated (on the existing footprint) but rocks are not expected to move laterally following placement.

Placement of rock into the GIWW or nearshore would have localized effects to water quality, including increased turbidity and total suspended sediments. These impacts would be expected to cease following placement. During construction of the GIWW armoring or offshore breakwaters, the placement of geotextile fabric and rock would smother sessile and slow moving benthic organisms and force mobile organisms to move from the placement site. The rock and geotextile fabric, by design, covers benthic subtidal sediments; hence infauna would likely be absent. However, rock would provide substrate for epifaunal colonization (Bilkovic and Mitchell 2013).

Actions Taken to Minimize Impacts

During construction of marsh restoration sites, effluent from dewatering would be discharged into adjacent wetlands via spill box weirs. Movement of sediment during and immediately post-construction would be contained by constructing earthen containment/exclusion dikes around the marsh restoration site. The dike would be constructed from in-situ material located within the marsh restoration/nourishment area using a mechanical (clamshell or bucket) dredge. Borrow areas used for construction of earthen containment/exclusion dikes would be refilled during the placement of dredged material for marsh restoration. The containment dike would be able to maintain one foot of freeboard at all times during dredge discharge operations. Following construction, the dikes would be breached in multiple places to restore fish access if natural degradation has not sufficiently occurred.

Movement of heavy equipment and support vehicles within the marsh or beach nourishment areas would utilize the placement pipeline corridors as much as possible to reduce the potential for additional impacts to marsh and shoreline areas.

Construction of the GIWW armoring and offshore breakwaters would involve placement of rock and geotextile fabric within the identified restoration unit. Geotextile fabric would be placed to reduce subsidence of placed rock over time. Rock would be placed with a barge-mounted crane to increase precision of placement and reduce overall impacts.

Under all action alternatives, the best available practical techniques and BMPs would be utilized during dredging and construction activities to avoid and minimize potential temporary and long-term adverse impacts. Although there are identified temporary adverse impacts with implementation of any of the action alternatives, it has been determined that the benefits of restoring marsh and coastal habitats would far outweigh any impacts.

During plan formulation, resource agencies including USFWS, NOAA, TPWD, and TxGLO were involved in identification of measures, development of alternatives, and benefits and impacts identification. This led to the development of plans that were ecologically sound and complete with the least impacts to the environment. The final four plans analyzed here were identified as the plans that were best-buy plans in which there were no other plans that provided that same level of benefit for that cost.

4.5.4.2 Section 401 and 402

Any project that involves placing dredged or fill material in waters of the U.S. or wetlands, or mechanized clearing of wetlands requires a water quality certification from the state agency as delegated by EPA. A water quality certification was requested from Texas Commission on Environmental Quality (TCEQ). A letter of compliance is provided in Appendix E.

The discharge and placement of dredging material is not expected to exceed Texas Water Quality Standards.

Compliance Determination

Implementation of any of the action alternatives would be in compliance with the Clean Water Act and its implementing regulations. All alternatives would be compliant with the restrictions on discharge including compliance with applicable state water quality standards, applicable toxic effluent standard or prohibition under Section 307, the Endangered Species Act, and Marine Protection, Research and Sanctuaries Act. None of the alternatives would have significant adverse effects on human health and welfare, recreational or commercial fisheries, plankton, fish, shellfish, wildlife, or aquatic sites. Additionally appropriate and practicable steps have been taken to minimize the potential adverse impacts of the discharges on the aquatic ecosystem.

A 404(b)(1) determination has been prepared for the Recommended Plan and included in Appendix A-5.

4.5.5 Groundwater

Implementation of any of the action alternatives would not be expected to cause any measurable beneficial or adverse impacts to groundwater resources. Marsh restoration would increase the overall surface elevation which would increase the height of free ground surface water at the immediate site of restoration. If elevation increases were uniformly performed across the study area, it is conceivable that the increase could reduce the effect of RSLC on the amount of fresh water in deep aquifers when compared to the FWOP condition. However, since the surface elevation increase is performed in a fragmented manner, it is unlikely that the increased height of free ground surface water would beneficially contribute to any change from the FWOP condition.

Implementation of any of the action alternatives would not affect municipal or private groundwater supplies.

4.5.6 Water Quality

Construction activities, hydraulic dredging and placement of dredged material and other fill materials could result in the following localized and temporary impacts to water quality including: reduction of water clarity; change in color; reduction in the pH of receiving area waters toward more acidic conditions; emission of reduced sulphur compounds including hydrogen sulfide often characterized as an objectionable rotten-egg smell; release of organic material with varying quantities of ammonia, nitrogen, and phosphorous, which could stimulate growth of algae and other aquatic plants. The factors responsible include increased turbidity, increased suspended sediments, and organic enrichment, chemical leaching, reduced dissolved oxygen, and elevated carbon dioxide levels, among others. Tidal currents present in the measure areas would serve to disperse and thereby dilute localized changes. Any such impacts would be minimized and controlled by the use of the best available practical techniques and BMPs. Following construction, degraded water quality conditions would be expected to return to baseline conditions prior to construction.

A specific concern raised was the potential for hydraulically pumped saline waters to have a long-term impact on marsh areas adjacent to the placement sites given that SNWW water is significantly higher in salinity than the target marsh restoration salinity or the surrounding marsh salinities. Utilizing dredged material for marsh restoration is a common practice throughout the Gulf of Mexico, with no reported concerns of chloride contamination that were not corrected naturally. Based on monitoring of current restoration units at JD Murphree WMA in the study area and at other sites in Orange County, Texas and in Louisiana that all utilized dredged material from the SNWW/Sabine lake region, placement of dredged material into the restoration units should not have any measurable impact on the short- or long-term success of the project. The amount of saline water that is transported through the dredged pipes and ultimately released into the restoration unit is negligible when compared to the daily tidal influences the unit receives. By increasing marsh elevation and ensuring drainage throughout the restoration units, saline waters introduced through dredged material placement would be drained out in the same manner as daily tidal flows. Rainfall would then further reduce salinity levels to restore equilibrium and achieve the target marsh salinity.

None of the action alternatives would have significant long-term adverse impacts to water chemistry. During marsh restoration and shoreline nourishment, effluent from the dredge discharge pipe would be directed to adjacent fragmented marsh or shoreline for nourishment. Dredged material is expected to be free of contaminants and would be suitable for placement in the aquatic habitat in accordance with the CWA Section 404(b)(1) and is not expected to result in adverse effects to aquatic organisms. Dredging would occur during regularly scheduled maintenance events or during implementation of the SNWW CIP; therefore, water quality and salinity impacts during dredging would be the same as those described under the FWOP.

Indirect impacts of marsh and shoreline restoration include water quality improvements. Restored and nourished areas would increase the surface area in which sediments and excess nutrients can be trapped. This can in turn reduce total suspended solids in the water column and reduce phosphorus and nitrogen levels while increasing dissolved oxygen, all of which help maintain or improve local water quality. Shoreline nourishment would provide a first-line of defense against storm surge and daily tidal influences to marshes behind the dune. By reducing the frequency of salt water inundation into fresh/intermediate and brackish marshes, the natural salinity regime associated with the marsh type can be maintained, unlike in the FWOP condition in which less saline marshes are becoming more saline or converting to open water.

Implementation of any of the action alternatives would result in temporary, minor adverse impacts to water quality, but would realize long-term, direct and indirect benefits over the planning horizon once construction is complete and each of the measures are functioning as designed. Implementation of the action alternatives would have no impact on groundwater quality.

4.6 Geologic Resources

Implementation of any of the action alternatives would have no impact on geology. The restoration measures are not expected to impact geologic hazards such as faulting and subsidence.

Introduction of the dredged materials would change the topography and bathymetry of the restoration units. Marsh units would be increased to +1.2 feet MSL at year 0 and then to +2.2 feet MSL at roughly year 30. The dune would increase to a peak height of +2.9 feet. For these surface changes, the existing elevations are at or below +0.0 MSL, which does not benefit the system. With the increase in elevation and change in topography, the system will be able to more closely function as nature designed allowing surface flows to enter and pass rather than being trapped and create a more resilient and sustainable system under RSLC conditions.

The nearshore berm would also change the bathymetry of the water bottom to a trapezoidal shape which would gradually increase to a max of 1.5 feet over 1,331 acres. The GIWW armoring and offshore breakwaters would also alter topography and bathymetry of the surface water and under water. None of these changes are expected to be significant and all are expected to have an overall benefit by reducing erosion and enabling a resilient and sustainable system under RSLC conditions.

4.6.1 Soils and Water Bottoms

Implementation of any of the action alternatives would reintroduce sediments into the system through placement of dredged material during marsh nourishment, dune construction, and beach nourishment. Between 10.4 million cubic yards (MCY) and 35.2 MCY of dredged material would be placed over the 50 year planning horizon. This increase in sediment is expected to result in long-term beneficial impacts by increasing the amount of hydric soils in the system and creating stability. For marsh sites, the increase in sediment is expected to increase productivity, support wetland building functions, and reintroduce and distribute sediment and nutrients throughout the ecosystem, not just within the restoration unit. For the shoreline (6A, 1Abu, and 2Ab alternatives), increased sediment would increase the available sacrificial land which would allow for wave attenuation and a reduction in erosion of the dune and subsequently marshes behind the dune.

All soils in the marsh restoration units are hydric soils. During construction, hydric soils in the project area would be minimally compacted from heavy equipment moving and placing dredged material within the restoration unit. Compaction would be temporary and would be expected to have a compaction rate similar to other marsh areas near the restoration unit shortly after construction ceases and the marshes are under normal surface flow influence. Placed material would be of very similar quality as the existing soil, which would reduce any compositional or structural changes associated with placing an outside source into the marsh.

Under alternative 4Abu and 2Abu, construction of GIWW armoring would convert soils/water bottoms under the structures to a hardened surface in which the productivity of those soils and water bottoms would be lost. The adverse impact of this conversion is far outweighed by the reduction in shoreline erosion. Existing structures on the GIWW have not resulted in alteration of sediment patterns and therefore impacts are not expected if the structures proposed under this alternative were constructed.

Under alternative 1Abu, placement of dredged material to construct a nearshore berm would result in the direct conversion of water bottom habitats. This conversion is not expected to be significant since the sediment would slowly erode away and reduce down to the original water bottom. As well, the nearshore berm would be expected to stabilize and recolonize as the "new" water bottom until it is eroded away. Under alternative 2Abu, construction of offshore breakwaters would also result in the conversion of soil and water bottoms to a hardened surface, but would also reduce the rate of shoreline erosion over time. However, this measure has the potential for unintended adverse consequences, such as alteration of sedimentation patterns or creation of erosional problems outside the breakwater benefit area or even outside the focused study area. These potential adverse impacts were not modeled as this alternative is not being recommended as the selected plan.

There are no prime or unique farmlands in the focused study area; therefore, implementation of any of the action alternatives would have no impact on farmlands.

4.6.2 Mineral Resources

Within the marsh restoration units around Keith Lake, predominately on JD Murphree WMA, there are a total of 7 producing oil wells and a number of plugged or dry hole wells. All producing wells are located on one of three well pads. An additional four wells pads still exist on the landscape but are not routinely maintained or used due to the lack of well productivity. No other areas within other marsh restoration units, beach or dune, GIWW armoring locations, offshore breakwater locations, or nearshore have existing, producing wells. Marsh restoration efforts would not place dredged material on any existing well pads.

Coordination with current well owners, TPWD and the RRC would be required during PED to identify whether the abandoned well pads should be incorporated into the restoration plan or reclaimed by the well head owner or through other RRC avenues. In general, marsh restoration would protect existing wellheads and production equipment and reduce the future expenses associated with mitigating and/or remediating future conditions. Restoration would reduce the potential for the well pad to become surrounded by open water, resulting in lost access, lost production, and an expenditure of funds and resources to maintain the well pad under the changing conditions with sea level rise. Additionally, if the well pad were breached, tank and tank batteries could leak fluids into the open water areas and surrounding marshes, creating a contaminated site which would affect fish and wildlife species, recreation, water quality, and TPWD JD Murphree WMA management activities.

4.7 Biological Communities

4.7.1 Habitat

During construction activities, it is anticipated that there would be a temporary decrease in aquatic habitat quality due to increased sedimentation from work being done in and near open water. Under each of the action alternatives there would be an immediate loss of shallow open water and a gain of land.

Within the marsh areas, placement and reworking of dredged material by construction equipment would cover and trample marsh vegetation throughout the construction footprint. Minimal emergent vegetation would be present immediately after construction as most of the project area would be unvegetated dredged material. Areas which were already marsh would likely revegetate more rapidly than large, open-water areas which are filled. Marsh vegetation nourished with 6 to 12 inches of material has been shown to respond favorably and revegetate quickly. Large, open-water areas which are filled with dredged material would likely revegetate at a slower rate than nourished marsh. Areas of significant concern for erosion or formation of monoculture communities would be planted post-construction. Areas that are not planted would be expected to fully revegetate to densities, heights, and compositions similar to adjacent marshes within 1 to 2 years after construction.

Earthen retention dikes would be constructed from borrow taken from within each marsh creation site. The dike features would be mechanically breached or degraded within three years of construction if natural degradation has not sufficiently removed the earthen material. Impacts from the construction of retention dikes would be considered temporary and would be mitigated by natural or induced recruitment of native vegetation.

Floatation access channels may be excavated, as needed, in shallow water areas to allow construction equipment access to marsh restoration units. The materials would be temporarily stockpiled on water bottoms adjacent to the excavated channel. Floatation access channel material would be used to backfill floatation access channels following completion of the work. Increased turbidity would be the most immediate impact from the excavation and construction activities. Once the activities have been completed and the dredged material is returned to the previously excavated areas, natural recruitment and rehabilitation of the disturbed areas should occur.

Post-construction, marsh restoration activities would restore shallow open water habitat to brackish marsh, while shoreline restoration would improve the overall beach and dune habitat and protect marshes behind the dune from storm surge and saltwater intrusion. Using the WVA brackish marsh and barrier headland models, the net increase of average annual habitat units (AAHUs) was calculated and is displayed in Table 4-5. Placement of dredged material into marshes and along the beach would increase marsh elevations and widen the beach as sacrificial land to compensate for ongoing land subsidence and future sea level rise.

Table 4-5: Net Change in Barrier Headland and Brackish Marsh with Implementation of the Action Alternatives

Alternative	Barrier Headland				Brackish Marsh				
	FWOP	FWP	Net Change	Acres Restored	FWOP	FWP	Net Change	Acres Restored	
								Direct	Indirect
4Abu	100	100	0	0	3,531	7,516	3,985	8,421	0
6A	100	152	+52	95	4,474	9,586	5,112	11,596	3,888
1Abu	100	106	+6	270	6,347	12,658	6,312	15,009	0
2Abu	100	152	+52	413	6,347	12,683	6,337	15,009	26,015

Under 4Abu, a total of 4.4 acres of submerged bottomlands and inland open water habitat would be modified through construction of the GIWW armoring. Under 2Abu, a total of 48.1 acres of submerged bottomlands, inland open water habitat, and offshore habitat would be modified through construction of the GIWW armoring and the segmented offshore breakwaters. Construction of both stone/rock structures would permanently convert a narrow (<6 feet) but long (length of the breakwater is dependent on the location) portion of the habitat in which it is being placed to a hardened structure. GIWW armoring is currently being used in other places along the GIWW in Jefferson County and to date no unintended adverse consequences, such as alteration of sedimentation or hydrologic flow patterns have been realized. The consequences of offshore segmented breakwaters could include adverse impacts such as alteration of longshore sediment transport. Because 2Abu was not the selected plan, no modeling was done to show potential impacts. Both types of structures, however, would benefit wetlands and the beach/dune system over the long-term by reducing wave energies and slowing the rate of land loss and reducing saltwater intrusion.

Under 1Abu, the feeder berm would only slightly modify the bathymetry of the nearshore. This change would not result in any measurable change in habitat quality or function.

None of the action alternatives would be implemented in coastal prairies or agricultural lands; therefore there would be no impact to these two biological communities. Oyster reefs in Keith Lake are not expected to be affected by construction activities and no placement of dredged material or stone is proposed within Keith Lake.

4.7.2 Individuals

Construction-related activities are anticipated to impact individuals of fish and wildlife, if they occur as a resident, migrant or incidental, within or near the project area. Impacts include habitat removal and/or fragmentation during construction activities and habitat avoidance because of increased noise, dust generation, vibrations, and overall lower quality habitat. Losses of slow moving and less mobile species (small mammals, aquatic invertebrates, benthic species, mussels, smaller/younger fish, and herpetofauna) are anticipated along the access roads and within the construction footprint, particularly during placement of dredged material causing burial of individuals and/or increased turbidity. Faster moving species are expected to be able to avoid injury or death while crossing access roads and by avoiding the construction area. In general, most wildlife, fish, and benthic species would become habituated to the on-going work including adapting to the habitat changes; however, species with a low tolerance to activities are anticipated to be displaced for the duration of activities. The level and duration of the impacts is dependent on the final design of each restoration measure, type of equipment used, and duration of construction activities. However, it is anticipated that once construction is complete, construction-related impacts to individuals would cease.

Benthic, plankton, suspension/filter-feeding species, visual predators and other fishery and aquatic organisms could have short-term localized adverse indirect impacts caused by increased turbidity, total suspended sediments, and water temperatures and lower dissolved oxygen levels from dredging and construction. Benthic organisms could be smothered. Suspension/filter feeding organisms could be impacted due to clogging of the gills and feeding mechanisms which could either cause death or reduce growth and reproduction. Visual predators would have a reduced success rate at catching prey due to lower visibility levels. Following dredging and construction activities, turbidity and suspended sediment levels, water temperature, and dissolved oxygen levels are expected to return to pre-construction conditions. These temporary and localized impacts would be minimized and controlled by implementing the best available practical techniques and BMPs during construction.

From a long-term perspective, implementation of any of the action alternatives would result in improved habitat conditions for all wetland-dependent and shoreline species. A greater diversity and increased abundance of emergent and submerged vegetative species would result in a greater food supply for herbivores, which then results in a greater abundance of herbivores to feed predators. Intertidal marsh and marsh edge would also provide increased foraging opportunities for shorebirds and wading birds using shoreline habitats. Nesting habitat would improve as the marsh platform and wide beach and dune would provide more desirable nesting habitat. The increase in vegetative structure would also provide more cover for prey species.

Although marsh restoration would result in the loss of approximately 65 percent of the open water in the restoration units, wildlife species currently utilizing this habitat would not be expected to be adversely affected. Wildlife species currently utilizing the shallow open water and vegetated shoreline habitat in the restoration units are highly mobile allowing them to relocate into adjacent open water habitats outside the restoration units. The conversion of open water to marsh habitat is generally considered a benefit to aquatic species.

Under alternative 4Abu and 2Abu, GIWW armoring and segmented breakwaters would convert inland open water and offshore habitat to a hardened structure thereby reducing available habitat for aquatic species and resulting in the loss of immobile species. However, these impacts would have an overall minimal impact to fisheries and aquatic populations in the area and would in the long-term protect adjacent habitat that aquatic species depend on for survival that would be lost in the future if the measures were not implemented. As well, the structures would be designed in such a way as to not hinder movement of aquatic species and where practicable, materials would be used that would facilitate formation of a reef to support a greater abundance and diversity of aquatic species. Rock substrate is expected to also provide benefits to some aquatic species by providing them a refuge from predation.

4.7.3 Conclusion

Implementation of any of the action alternatives would have temporary, localized adverse impacts during construction, with some loss of less mobile species and up to 48 acres of habitat conversion due to construction of hardened structures. However, the overall benefits of implementing the action alternatives far outweigh any temporary or permanent loss realized during construction. Restoration of marsh and shoreline areas would have a long-term, beneficial impact to most aquatic and terrestrial habitats and their associated species because of an overall net increase in habitats.

4.8 Special Status Species and Habitats

4.8.1 Threatened and Endangered Species Act

The impacts described in Section 4.7 would also apply to ESA-listed species.

A Biological Evaluation was prepared to document the impacts of implementing the selected plan on listed species (Appendix A-2). Based upon the findings of the BE, USACE has made the following effects determinations for species that were identified as occurring or potentially occurring in the action area:

- Piping plover (*Charadrius melodus*) and Rufa red knot (*Calidris canutus rufa*): No restoration work would be completed in or near suitable habitat. It is highly unlikely that individuals would be affected by restoration actions due to the distance between the restoration site and their observed locations along the Gulf of Mexico Therefore, implementation of the Recommended Plan would have ***no effect*** on the piping plover or red knot.

- Whooping crane (*Grus americana*): ***may affect, but not likely to adversely affect*** - Restoration work could potentially disrupt individual birds during foraging activities. Conservation measures include a seasonal restriction on construction in marshes (Oct 1 – April 15). If the operating windows cannot be achieved, a biological monitor to be on site to stop work if a bird is spotted within 1,000 feet of the active site and require laying down tall (>15') equipment at night.

- Corals: The project area is outside the known range of Elkhorn coral (*Acropora palmata*), lobed star coral (*Orbicella annularis*), mountainous star coral (*O. faveolata*), and boulder star coral (*O. franksi*); therefore, implementation of the Recommended Plan would have ***no effect*** on each of the four coral species.

- Dwarf Seahorse (*Hippocampus zosterae*): The project area is outside the known range of the species; therefore, implementation of the Recommended Plan would have ***no effect*** on dwarf seahorse.

- Whales: The sei whale (*Balaenoptera borealis*), Bryde's whale (*B. edeni*), fin whale (*B. physalus*), humpback whale (*Megaptera novaeangliae*) and sperm whale (*Physeter macrocephalus*) all prefer deep marine water habitat, which is not available in the project area; therefore, implementation of the Recommended Plan would have ***no effect*** on any of the five whale species.

- West Indian Manatee (*Trichechus manatus*): Due to the rarity of the manatee in the action area and the conservation measures that would be implemented, implementation of the action ***may affect, but not adversely affect*** the West Indian manatee.

- Sea Turtles: The leatherback sea turtle (*Dermochelys coriacea*) prefers deep marine water habitat, which is not available in the project area, and the project area is outside the species known nesting range; therefore, implementation of the Recommended Plan would have ***no effect*** on leatherback sea turtles.

  For the remaining four sea turtle species, dredging operations have been analyzed under two separate projects (regular maintenance dredging and SNWW CIP) and have been issued Biological Opinions for each of those actions (NMFS 2003 and 2007). In each BO, NMFS determined that the proposed action of each of the projects were ***likely to adversely affect, but were not likely to jeopardize*** the continued existence of hawksbill, loggerhead, Kemp's ridley or green sea turtle and would have no effect on leatherback sea turtles due to lack of suitable habitat or regular occurrence within the action areas. Conservation measures and an incidental take statement were issued for the four turtle species with each BO. Any dredging operations that would occur for ecosystem restoration would be subject to those identified in the two BOs, which will be dependent on which authority and the purpose of dredging (i.e. regular maintenance or widening/deepening).

> Implementation of the Recommended Plan would have ***no effect*** on nesting loggerhead (*Caretta caretta*), green (*Chelonia mydas*), hawksbill (*Eretmochelys imbricata*), and Kemp's ridley (*Lepidochelys kempii*) sea turtles because no work is proposed along the Gulf of Mexico shoreline.

If 6A, 1Abu, or 2Abu were implemented, a ***may affect, not likely to adversely affect determination*** would be made for piping plover, red knot, and loggerhead, green, hawksbill, and Kemp's ridley sea turtles. This is due to restoration work that would be implemented along the Gulf shoreline, in which each of the species has the potential to inhabit but no confirmed reporting in the project areas. In order to arrive at a may affect, not likely to adversely affect determination numerous conservation measures, such as biological monitoring before, during and after construction, presence/absence surveys prior to and after construction, operating restrictions if presence/absence surveys are positive for species presence, etc would be recommended. If these conservation measures were not acceptable to USFWS, a may affect, likely to adversely affect determination may be warranted, which would involve entering formal consultation and issuance of a Biological Opinion.

4.8.2 Species of Concern

4.8.2.1 Texas State-Listed Species and Texas Listed Rare Species

Impacts to state-listed and rare species would be the same as described for Biological Communities for both habitat and individuals. In general, all species identified as occurring or potentially occurring in the focused study area are highly mobile and would be able to avoid construction related impacts, except for the Alligator snapping turtle and Texas diamondback terrapin. These two species are slower moving and do not have as large of a home range to which they can escape. Impacts to these two species could be adverse resulting in loss of individuals. However, for all species, including the two turtle species, the benefits of ecosystem restoration measures far outweigh any adverse impacts associated with construction.

4.8.2.2 Bald and Golden Eagle Protection Act of 1940

Nesting within the restoration units is not likely due to the lack of suitable nesting sites; however, if construction would occur during the nesting season (late-October to early May), nest surveys would be completed prior to construction. If a nest is documented within the restoration unit, a buffer of at least 330 feet should be maintained between project activities and the nest. Clearing of vegetation should be restricted within 660 feet of the nest site year-round. Assuming these guidelines are followed, impacts to breeding eagles during construction would be insignificant and discountable (USFWS 2007).

Impacts to the species foraging in or near the project area during construction would include temporary habitat avoidance. The level of impact is expected to be insignificant and discountable considering the large home range of the species and considerable extent for suitable foraging habitat available nearby in which the species could use.

After construction is complete, the noise and disturbance of the restoration units is expected to return to baseline conditions and have no impact to breeding and non-breeding birds. Restoration is expected to have long-term beneficial impacts for the species by increasing the availability of suitable habitat for prey species including fish, waterfowl, shorebirds, colonial water birds, and turtles.

4.8.3 Migratory Birds

Many important habitats in the focused study area provide migratory bird shelter, nesting, feeding, and roosting habitat. All adverse impacts to migratory birds would occur during construction and cease post-construction. Significant beneficial impacts to migratory birds would be expected from ecosystem restoration measures. Restoration of marsh, beach, and dunes would result in an overall net increase in functional value and ultimately support larger populations of species and potentially increase species diversity.

During construction, there is a potential for harm and/or harassment of nesting migratory birds. Attempts would be made to conduct all restoration activities outside of the nesting season; however, this may not be possible, due to the timing of dredge availability and the extended length of the nesting season for some species. Prior to construction commencing, if during the nesting season, nest surveys should be completed. If nests are identified, all construction activities should observe a 1,000-foot buffer of any colonial-nesting waterbird colonies (e.g. egrets, herons, ibis, pelicans, etc.); a 1,300-foot buffer for any shorebird nesting colonies (e.g. terns, gulls, plovers, skimmers, etc.); and a 2,000-foot buffer for any brown pelican nesting colonies near the restoration measure implementation locations. Coordination with USFWS should be completed prior to construction if nesting has been identified and USFWS guidelines should be followed to avoid adverse impacts to these species. By implementing these conservation measures, there should be no adverse effects to migratory birds.

Implementation of any of the action alternatives would be in compliance with the Migratory Bird Treaty Act and Executive Order 13186, Responsibility of Federal Agencies to Protect Migratory Birds.

4.8.4 Invasive Species

As with any ground-disturbance activity, the probability of introducing, spreading, and/or establishing new populations of invasive, non-native species, particularly plant species, exists. Contractors would be required to clean all equipment prior to entering the construction area to avoid the spread of invasive species into the project area.

After dredged material has been placed, individual restoration units would be assessed to determine the need for plantings. Areas that are expected to have high rates of erosion, are susceptible to invasive species establishment, or where recruitment of a monoculture is anticipated, would be vegetated with native species. Post-construction and plantings, if needed, each restoration unit would be monitored for invasive species and action taken to prevent establishment of any species.

Executive Order (EO) 13751, dated December 5, 2016, which amends EO 13112 (1999), directs federal agencies to expand and coordinate their efforts to combat the introduction and spread of invasive species (i.e., noxious plants and animals not native to the U.S.). Implementation of BMPs such as cleaning equipment prior to entering restoration units and monitoring post construction for invasive species would prevent further spread of invasive species. Implementation of any of the action alternatives would be in compliance with EO 13751.

4.8.5 Marine Mammals

Impacts to marine mammals from implementation of any of the action alternatives could occur during in-water activities such as set-up/take-down of dredged material transport pipes, operations of watercraft and heavy equipment, etc. Alternative 1Abu and 2Abu would have a higher potential for impacting marine mammals during construction of the nearshore berm (1Abu) or the breakwaters (2Abu), as well as the need to seek offshore borrow sources for marsh and shoreline measures within the furthest west restoration units on McFaddin NWR. Impacts could include temporary habitat avoidance, exposure to underwater sound, and visual disturbances, which would all cease after construction is complete. The most extreme impact could include entrapment and/or collision with pipes, silt barriers, pumps, placement equipment, or other construction equipment. Although this is unlikely due to the relatively low occurrence rate of bottlenose dolphins and extremely rare occurrence of West Indian manatee in the project area, additional measures are being incorporated into the plan to avoid potential incidental harassment and "take" of marine mammals.

The following mitigation measures would be implemented:

- Qualified biologists would monitor the presence of marine mammals during phases which involve open water areas capable of supporting marine mammals.
- Before activities occur in open water areas, a 50-foot radius of the work area should be delineated. If any marine mammal is observed within the 50-foot radius, the biological monitor shall halt construction activities, including shutting down any running equipment until the animal has moved beyond the radius, either through sighting or by waiting until enough time has elapsed (approximately 15 minutes) to assume that the animal has moved beyond the buffer.
- If siltation barriers are used, they will be made of material in which marine mammals cannot become entangled, should be properly secured, and regularly monitored to avoid mammal entrapment.

Implementation of any of the action alternatives could have minor, temporary adverse impacts on marine mammals, but impacts are not anticipated to result in takes. None of the action alternatives would result in long-term adverse impacts to marine mammals. None of the alternatives would reduce the food base, block or limit passage to or from biologically important areas, or permanently destroy habitat.

The anticipated impacts are not expected to rise to the level of significant or result in the need for NOAA to issue an Incidental Take Authorization, especially with the incorporation of the mitigation measures listed above. Typical actions which require permits from NOAA include actions that involve: military sonar and training exercise; oil and gas development, exploration, and production activities; geophysical surveys for renewable energy and scientific research; and pile driving associated with construction projects. None of these activities are proposed under any of the action alternatives.

4.8.6 Essential Fish Habitat

Any of the action alternatives would convert open water and degraded marsh (combination of estuarine marsh and estuarine mud bottoms EFH) to estuarine marsh (marsh edge, submerged aquatic vegetation, marsh ponds, and inner marsh EFHs). Construction activities using earthen materials to create marsh would bury existing EFH substrates and temporarily change environmental conditions, including: increased turbidity, total suspended sediments, and water temperatures and lower dissolved oxygen levels in the water column. However, the effects would be short-term and localized and the area would be expected to return to baseline conditions following completion of dredging and construction activities, except for in the marsh restoration units, in which a different EFH type would form.

Estuarine emergent wetland would be the primary type of EFH that would increase significantly under any of the action alternatives. This type of habitat would be created in shallow-open water areas and deteriorated marsh. Depending on the action alternative, anywhere from 8,421 to 15,009 acres of emergent marsh habitat would be restored, with additional indirect impacts of 3,888 and 26,015 acres indirectly improved with implementation of 6A and 2Abu, respectively. Submerged aquatic vegetation is also expected to increase in parts of the restoration units; however, increased submerged aquatic vegetation would be limited by depth and turbidity, not seed source. Increase in those habitat types would benefit postlarval/juvenile and subadult brown shrimp; postlarval/juvenile and subadult white shrimp; and postlarval/juvenile red drum.

The creation of estuarine emergent wetlands would result in the loss of mud bottoms and estuarine water column as emergent marsh would replace those habitat types. Loss of mud bottom EFH could result in negative impacts to subadult brown shrimp and postlarval/juvenile red drum. Although adverse impacts would occur to some types of EFH, more productive types of EFH (i.e. estuarine emergent wetlands) would be created.

Under Alternative 4Abu and 2Abu, construction of GIWW armoring and segmented breakwaters would convert open water (combination of estuarine mud bottoms, Gulf waters, marsh edge, offshore, beach, coastal, and sand EFH) to rock which is not considered EFH. However, the loss of EFH would be offset by the increase in the quality of EFH due to a decrease in long-term turbidity and suspended sediments from continual erosion and land loss.

As part of MSFCMA, any Federal agency that authorizes, funds or undertakes, or proposes to authorize, fund, or undertake an activity which could adversely affect EFH is subject to the consultation provisions of the Act and identifies consultation requirements (50 CFR Sections 600.805 - 600.930). This integrated feasibility report and environmental assessment was prepared to serve as the EFH assessment. Further consultation with NMFS is not required because USACE has determined that implementation of any of the action alternatives would not adversely affect EFH.

4.8.7 Rare, Unique, and Imperiled Communities

There are a total of six plant communities that occur or have the potential to occur within the focused study area, of which five communities are considered terrestrial/upland communities. These five communities would not be impacted by any of the action alternatives because all work would occur in aquatic or wetland habitats.

The Seashore Crowngrass – Saltmeadow Cordgrass Oligohaline Herbaceous Vegetation community has the potential occur in the project areas, particularly where dune construction would occur, but would only be found in small isolated patches due to the lack of existing dune. Alternative 6A and 2Abu are the only two alternatives that could potentially impact the plant community. Impacts would include covering up existing vegetation and a temporary loss of the community. It would be expected that dune construction would improve the conditions for this plant community to establish and after construction is complete it is possible that the community would reestablish.

4.9 Cultural Resources

The USACE conducted a desktop review of the four alternatives using the Texas Historical Commission's (Atlas) online database. For 6A, four known terrestrial archeological sites (41JF13, 41JF21, 41JF42, and 41JF49) and 23 shipwrecks have the potential to be directly affected by this plan (Table 4-6). For the 1Abu footprint, the same sites could potentially be directly affected as in 6A, except that an additional 3 shipwrecks could also be affected. If alternative 2Abu were implemented, five known terrestrial archeological sites (41JF13, 41JF21, 41JF25, 41JF42, and 41JF49), 26 shipwreck's and portions of the GIWW have the potential to be directly affected by this plan. Unfortunately, the full effect on marine archeological sites cannot fully be determined with this plan, as not all dredge locations to support beneficial use were identified.

Table 4-6. Potentially Affected Cultural Resources.

Resource	Type	Component	Description	NRHP Status
41JF13	Archeological	Prehistoric	Mound/Associated potsherds and fragments of arrowpoints	Eligible-1983
41JF21	Archeological	Prehistoric	Shell midden	Eligible-1983
41JF25	Archeological	Prehistoric	Rangia shell midden	Eligible-1983
41JF42	Archeological	Prehistoric	Shell midden	Eligible-1983
41JF49	Archeological	Prehistoric	Shell midden	Eligible-1983
41JF65	Archeological	Historic	USS Clifton Shipwreck	Eligible-1994
-----	Archeological	Historic	Gillum (Sting Ray) Shipwreck	Undetermined
-----	Archeological	Historic	Pearl Plant Shipwreck	Undetermined
-----	Archeological	Historic	USS Sachem Shipwreck	Undetermined
-----	Archeological	Historic	Julius Caesar Shipwreck	Undetermined
-----	Archeological	Historic	Catherine Shipwreck	Undetermined
-----	Archeological	Historic	Clarke Oil Tank No. 1 Shipwreck	Undetermined
-----	Archeological	Historic	Ella Shipwreck	Undetermined
-----	Archeological	Historic	Unknown Shipwreck	Undetermined
-----	Archeological	Historic	Unknown Shipwreck	Undetermined
41CH267	Archeological	Historic	Stonewall Shipwreck	Undetermined
-----	Archeological	Historic	Annie Taylor (Anna Taylor) (Soledad Cos) Shipwreck	Undetermined
-----	Archeological	Historic	John Sealy Shipwreck	Undetermined
-----	Archeological	Historic	Revenge (Morning Light) Shipwreck	Undetermined
-----	Archeological	Historic	Delaware Sun Shipwreck	Undetermined
-----	Archeological	Historic	Dan Shipwreck	Undetermined
-----	Archeological	Historic	Unknown Shipwreck	Undetermined
-----	Archeological	Historic	Unknown Shipwreck	Undetermined
-----	Archeological	Historic	Unknown Shipwreck	Undetermined
-----	Archeological	Historic	Unknown Shipwreck	Undetermined
-----	Archeological	Historic	Unknown Shipwreck	Undetermined
-----	Archeological	Historic	Unknown Shipwreck	Undetermined
-----	Archeological	Historic	Unknown Shipwreck	Undetermined
-----	Archeological	Historic	Unknown Shipwreck	Undetermined

-----	Archeological	Historic	Terry Walker Shipwreck	Undetermined
-----	Archeological	Historic	John P. Smith Shipwreck	Undetermined
Structure	Architectural	Historic	Gulf Intracoastal Waterway (GIWW)	Undetermined

4.9.1 Recommended Plan (Alternative 4Abu-Keith Lake Restoration)

Alternative 4Abu-Keith Lake Restoration is the Recommended Plan. The USACE conducted a desktop review of the proposed plan's preliminary footprint using the Texas Historical Commission's Atlas online database. Five known terrestrial archeological sites (41JF13, 41JF21, 41JF25, 41JF42, and 41JF49), stand to be directly affected by the recommended plan. Known marine archaeological sites that have the potential to be directly and indirectly affected by the recommended plan consist of 24 reported, undiscovered shipwrecks, in addition to archaeological sites *Clifton* (41JF65) and *Dan* (16CM144). In addition to the archaeological sites, significant remote-sensing targets OS2.4, OS2.5, OS1.1, OS1.2, OS1.3, IS1.4, IS1.5, IS1.6, IS1.10s, IS11s, IS2.1, and IS2.14s, discovered during the an archaeological remote-sensing survey in 2005 (Enright et al. 2005, TAC Permit No. 3061) stand to be directly and/or indirectly affected if not avoided. If these targets cannot be avoided then additional archeological investigations, in the form of ground-truthing, will be necessary. The GIWW is older than 50 years in age, and as such is considered an historical architectural resource; the GIWW (within the preliminary footprint) has not been evaluated for NRHP eligibility. Prior to any armoring, this historical architectural resource will require Section 106 NRHP evaluation.

Unfortunately, the full effect on marine archeological sites cannot fully be determined with this plan, as not all dredge locations to support beneficial use were identified.

The preliminary Area of Potential Effect (APE) for this study is the horizontal and vertical footprint for all actions associated with Alternative 4Abu. In all likelihood, the entirety of the preliminary APE, and possibly additional locations, will be subjected to intensive cultural resource investigations in assessing potential effects; however, the final APE used to identify historic properties will be developed in coordination with the Texas State Historic Preservation Office and all appropriate Native American Tribal Nations (see Appendix A-7). Section 106 cultural resource surveys have not been performed for much of the surrounding region and only approximately 1/3 of the preliminary APE has been previously surveyed with known terrestrial and underwater cultural resources identified as a result. The Recommended Plan overlaps known eligible and unevaluated archeological sites based on background research.

Based on the current information for the proposed actions, Alternative 4Abu, has a potential to affect historic properties. These effects consist of direct and indirect impacts from dredging, marsh elevation modification through the placement of beneficial use of dredged material, armoring portions of the

GIWW, and all terrestrial and marine horizontal and vertical disturbance activities that will occur as a result of this undertaking. The USACE recommends intensive cultural resource investigations to identify and evaluate any historic properties within the final developed APE, and assess effects on these historic properties prior to construction. The scope of these investigations will be determined in consultation with the Texas State Historic Preservation Office and appropriate Native American Tribal Nations.

Texas SHPO and Tribal Nation consultation has been occurring throughout the planning process for this study, with all comments received addressed appropriately, and as a result, in accordance with Section 106 of the NHPA, USACE, the Texas State Historic Preservation Office and all appropriate Native American Tribal Nations will enter into a Programmatic Agreement (PA) that outlines the survey requirements and other terms and conditions that would be completed during PED and prior to any ground disturbing activities. A copy of the Draft PA, plus all SHPO and Tribal Nation correspondence for this study, is included in Appendix A-7.

4.9.2 Environmental Compliance (National Historic Preservation Act of 1966)

Cultural resources affected by federally funded or federally-permitted projects are subject to the requirements of the National Historic Preservation Act of 1966, as amended (NHPA) (54 U.S.C. § 306108) and its implementing regulations (36 CFR 800). Section 106 of the NHPA and its implementing regulations require federal agencies to take into account the impact of their undertakings on historic properties. Historic properties are cultural resources that have been determined eligible for the National Register of Historic Places (NRHP). The Section 106 process is carried out by the federal agency in consultation with the State Historic Preservation Officer (SHPO) and appropriate Tribal Historic Preservation Officer's (THPO). The Section 106 process consists of identifying cultural resources through records searches and field surveys, evaluating cultural resources to determine if they are historic properties using National Register criteria for evaluation (36 CFR 60.4), assessing whether the effects of the undertaking on historic properties will be adverse, and consulting with the SHPO/THPO regarding these effects and any actions that might be taken to treat or mitigate them.

4.10 Economics, Socioeconomics, and Human Resources

Socioeconomic impacts are assessed in terms of direct effects on the local economy and population, and related indirect effects on other socioeconomic resources within the study area or adjacent to the study area, in this case Jefferson County. Socioeconomic impacts would be considered significant if the alternative resulted in a substantial shift in population trends or notably affected regional employment, earnings, or community resources such as schools.

Construction activities would be expected to directly beneficially affect the local economy through a temporary increase in economic activity in the construction sector. Temporary increases in employment, income, business activity, and local tax revenues would be anticipated in years in which construction would occur. No permanent change in population or demand on local public services would be expected as a result of implementing any of the action alternatives

Many in the local communities value recreation and depend on recreation activities as a source of income. No negative impacts associated with reduced recreation, in particular hunting and fishing opportunities, are anticipated as public access to the McFaddin and Texas Point NWRs and the JD Murphree WMA would be maintained. Private land owners affected by recreation decreases would be appropriately compensated when lands are purchased to implement the action.

Implementation of any of the action alternatives would not result in any long-term or permanent, significant adverse or beneficial impacts to socioeconomics. All impacts would be temporary in duration and localized result in beneficial non-significant impacts.

4.10.1 Protection of Children from Environmental Health Risks and Safety Risks

Because children may suffer disproportionately from environmental health and safety risks, Executive Order 13045, Protection of Children from Environmental Health Risks and Safety Risks, was issued on April 21, 1997 to help ensure that federal agencies' policies, programs, activities, and standards address environmental health and safety risks to children.

Implementing any of the action alternatives is not expected to disproportionally affect children due to the remoteness of the project areas relative to the nearest schools and residences (>2 miles away) and the overall benefit of ecosystem restoration to the environment and the communities nearby.

4.10.2 Environmental Justice

Executive Order 12898, Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations, addresses concerns over disproportionate environmental and human health impacts on minority and low-income populations. The impetus behind environmental justice is to ensure that all communities, including minority, low-income or federally recognized tribes, live in a safe and healthful environment and that no group of people including racial, ethnic, or socioeconomic, should bear a disproportionate share of the negative consequences resulting from the execution of federal, state, local, and tribal programs and policies. The goal of fair treatment is not to shift risks among populations, but to identify potential disproportionately high and adverse effects and identify alternatives that may mitigate these effects.

No populations or communities in the study area or at the county level meet the criteria for identification of minority or low-income populations under the CEQ Environmental Justice Guidance. Coupled with the overall benefits of ecosystem restoration to the environment and the communities nearby, implementation of any of the action alternatives would not result in a disproportionately high or adverse impact on minority or low-income populations.

4.11 Transportation

Implementation of any of the action alternatives would have no direct impact on transportation or transportation corridors. Dredging and placement operations would be conducted in a manner that would avoid impacts to navigation. Local use of roadways and highways would be minimal since most access to the restoration site would be via waterways. Insignificant indirect impacts on local roadways and Highway 87 could include the additional wear and tear, caused by support vehicles entering the restoration units. The level of indirect impacts would be expected to be minimal and not cause a noticeable increase or hardship on local maintenance programs.

Section 9 and 10 of the Rivers and Harbors Act of 1899 (RHA), prohibits the construction of any obstruction (e.g. bridge, dam, dike, causeway, wharfs, piers, jetties, breakwaters, bulkheads or other structures) in any port, roadstead, haven, harbor, canal, navigable river, or other water of the United States outside established harbor lines, or where no harbor lines have been established without Congressional approval. Section 10 also prohibits excavation or fill, or in any manner alter or modify the course, location, condition, or capacity of, any port, roadstead, haven, harbor, canal, lake, harbor of refuge, or enclosure within the limits of any breakwater, or of the channel of any navigable water of the United States, unless authorized by the Chief of Engineers and the Secretary of War.

Under alternative 6A and 1Abu, no structures would be built in or near any navigable waters of the US. Under alternative 4Abu and 2Abu, GIWW armoring would be built within the GIWW; however, the structures would be placed outside of the right-of-way and would not interfere with navigation or cause navigational hazards. Dredging operations would involve modification of a navigable river, but placement activities would not be within any location as identified in the RHA. The dredging operations for which borrow material would be used to implement any of the action alternatives have already been authorized by Congress for construction, operation, and maintenance. Therefore, the all action alternatives are compliant with the RHA.

4.12 Recreation and Aesthetics

With implementation of any of the action alternatives, recreation opportunities would be temporarily lost in the immediate vicinity of the construction footprint while construction-related activities are underway. During this period of construction, recreationists may experience an increase in noise from operation of equipment that could impact their ability to seek solitude or may reduce the success of wildlife-dependent recreation activities. During the temporary reduction, similar recreation opportunities would remain available on adjacent lands. Public access to McFaddin and Texas Point NWRs and WMA would be maintained during construction. Recreation would resume in a manner similar to the existing condition after construction is complete.

The aesthetic value of the area suffers each time there is any intrusion in the natural environment by man. The primary issue associated with visual resources is the degree of visible change that may occur in characteristic landscapes, viewsheds, and areas with high scenic value. Construction activities can introduce differing elements of form, line, color, and texture into the landscape through construction or placement of constructed features such as roads, structures, equipment, or manipulation of vegetation. Effects can also result when actions change scenic integrity or result in conditions that produce unattractive landscapes.

Impacts associated with any of the action alternatives on aesthetics include visibility of construction disturbances, constructed structures, and temporary roads. Vegetation clearing and/or placement of dredged material over existing vegetation would present an obvious contrast in color with the surrounding vegetation. As well constructed features such as the dune, breakwaters, nearshore berm, and GIWW shoreline armoring may be visually prominent at foreground and middleground distance zones. Constructed structures and placement areas would be most obvious immediately after construction. For marsh restoration areas, beach nourishment and dune construction, obvious aesthetic changes from the surrounding environment would remain until vegetation has established and the system has begun to function as designed. Temporary placement of staging areas, access roads and floating docks would be visually obvious until use of these is discontinued and the area naturally restores or the structure is removed. Natural restoration would be expected to occur over a period of a couple of years. As restoration, as a measure or naturally from access roads, takes over, aesthetic degradation would decrease as the disturbed surface begins to blend in color, form, and texture. In general, restoration measures would be beneficial to the aesthetic value of the area and pleasing to recreationists.

Short-term impacts may occur where construction-related equipment, activities, and dust could be visible to observers. Impacts would be anticipated in years in which construction is implemented. Alternatives that do not include construction of structures, would realize only temporary aesthetic degradation until the disturbed area blends in with the surrounding environment, at which time, it would be anticipated that the aesthetic value of the area would be improved over the existing condition.

Breakwaters and GIWW armoring would have the greatest potential to permanently alter visual conditions due to use of stone material and placement in open waters. The structures would be only visible while they are being passed in vessels using the GIWW or in the nearshore. The structures would be only slightly above the water surface elevation and would not be expected to affect the overall aesthetics of the environment or decrease the value of the area to the viewer.

Temporary adverse impacts on the aesthetic value of the area from construction and ground disturbance is certain under each of the action alternatives; however, the level of impact, by nature, is subjective and difficult to quantify.

4.13 Hazardous, Toxic and Radioactive Waste

The records search revealed several potential HTRW sites in Jefferson County, although none of these sites have the potential to affect the proposed project. All but one of the identified sites are either RCRA generators or sites of registered petroleum storage tanks, which by itself is not sufficient to expect an HTRW impact. A single leaking petroleum storage tank was identified, but due to its distance (over 0.5 miles) from proposed project features, no effect can be expected from this site.

Although not classified as HTRW, pipelines and oil wells play an important role in determining the acceptability of project alternatives. Most of the project alternatives have the potential to interact in some way with some type of oil and gas infrastructure, and relocations may be required as part of the proposed project.

4.14 Cumulative Impacts

This section presents the cumulative impacts of the Recommended Plan. NEPA regulations require that cumulative impacts of a proposed action be assessed and disclosed in an EIS or EA. The Council on Environmental Quality (CEQ) regulations define a cumulative impact as “the impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (federal or non-federal) or person undertakes such other actions. Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time.” (40 CFR 1508.7)

USACE used NEPA guidance to identify resource topics that would be considered in the cumulative impact analysis (40 CFR 1508.25). From a review of the likely environmental impacts analyzed in Chapter 2 Affected Environment and Future Without Project Condition and this chapter (Future With-Project Condition), USACE determined that the analysis of cumulative impacts would be limited to the following resource topics: lands with special management, air quality, water resources, soils, biological communities, special status species, recreation and aesthetics, and socioeconomics (Table 4-7).

With respect to the remaining topics (e.g. land use, climate, geology, transportation, environmental justice, and HTRW) the future with-project condition shows that the Recommended Plan would either not result in any direct or indirect impacts and therefore would not contribute to a cumulative impact (e.g. there would be no impact related to environmental justice); or that the nature of the resource is such that impacts do not have the potential to cumulate (e.g. impacts related to geology are site specific and do not cumulate), or that the future with- or future-without project condition analysis is in essence a cumulative analysis and no further evaluation is required. For example, because climate change is global in nature, the future without-project condition and future with-project condition analysis is inherently a cumulative impact assessment.

For each resource topic that was carried forward for cumulative impact analysis, the timeframe for cumulative analysis is approximately 100 years in the past (1915), from the beginning of the study, and 50 years in the future (2077), from construction completion. This timeframe accounts for the period of time when significant hydrologic modifications occurred within the focused study area. This period of analysis also captures the period of time when a significant number of environmental laws were enacted in which resource protection became a priority. The future timeframe aligns with the planning and economic period of analysis.

The discussion of baseline conditions and future without project conditions as discussed in Chapter 2 presents conditions in the study area resulting from past, present, and reasonably foreseeable future actions. The following activities were considered during the cumulative impacts analysis.

- Past, present, and reasonably foreseeable future actions are diverse and too numerous to list each individual activity but can be categorized by the following types of activities: development and improvement of navigation; exploration, extraction, development, and export of mineral resources; urbanization; coastal flood risk management; regional planning efforts; ecosystem restoration;

- USACE operation and maintenance (OMRR&R) activities such as dredging and flood control structure (e.g. levees) construction;

- USACE Regulatory (i.e. Section 404 permitting);

- Fish and Wildlife management activities conducted by USFWS, TPWD, non-government entities, and private landowners;

- Land use on federal and private lands; and

- Point and non-point source pollutant activities by the public and industrial sectors.

Cumulative impacts from past, present, and reasonably foreseeable projects, along with implementation of the Recommended Plan, would not be expected to have significant adverse effects within the study area. Adverse impacts associated with the Recommended Plan have been avoided or minimized and are largely temporary in duration and limited to the immediate project area. Overall, implementation of the Recommended Plan would result in beneficial long-term impacts to most resources. See Table 4-7for a brief description of the impacts of the Recommended Plan, past, present, reasonably foreseeable future actions, and cumulative effects.

Table 4-7: Cumulative Impacts

Resource Area	Recommended Plan	Past Actions	Present Actions	Reasonably Foreseeable Future Actions	Cumulative Impacts
Lands With Special Management	Minor temporary direct and indirect impacts, but an overall beneficial improvement in lands that contribute to the overall goal of each mission of the land owner	Most past and present actions have resulted in loss of some lands; however, all losses have been compliant with the overall goal or mission of the land owner OR was mitigated, thereby resulting in no net loss		Future actions could encroach on lands with special management; however, all would be required to comply with the various regulatory laws and policies applicable to that land resulting in minimal adverse impacts	Cumulative the impacts from the Recommended Plan would have no adverse effects on lands with special management, but would have an overall cumulative beneficial impact to other restoration actions that are being implemented in the focused study area increasing the overall value of the lands and further meeting the regulatory features of those lands.
Air Quality	Minor construction related air emissions in the form of fugitive dust and fossil fuel emissions during construction only.	Emission sources from petroleum production, chemical production, shipping, agriculture, and construction contributed to the area not meeting NAAQS and the area being classified as in non-attainment. Regulatory actions were implemented which reduced point and non-point source emissions, bringing the area into attainment.	Construction related air emission in the form of fugitive dust and fossil fuel emission during construction only. Long-term point source emissions from petroleum production, chemical production, shipping, and agriculture will remain a concern in the air quality region. All present and future actions must adhere to existing emission related standards and comply with the Clean Air Act; therefore, all present and future actions should not cause the area to exceed NAAQS and cause the area to be classified as in non-attainment.		Cumulatively the impacts from the Recommended Plan wouldn't cause the area to exceed NAAQS. No cumulative impacts anticipated.

Resource Area	Recommended Plan	Past Actions	Present Actions	Reasonably Foreseeable Future Actions	Cumulative Impacts
Geologic Resources	No geology or minerals impacts. Restoration measures would only realize temporary, localized direct and indirect impact, but would have an overall beneficial long-term impact by reducing erosion and land loss and introducing sediments into the system in an effort to offset hydrologic induced loss and create a more resilient and sustainable system in light of RSLC.	No geology or minerals impacts. Altered hydrology has resulted in sediment starved systems, alternations in how and where sediments move, and eustatic and anthropogenic caused erosion.	No geology or minerals impacts. Continued sedimentation and erosion associated with agriculture, human development, industrialization, storms, navigation channels, flood risk reduction, water supply and oil and gas. Ongoing maintenance and operation of navigation channels and agricultural lands is contributing to additional soil and water bottom impacts.	No geology or minerals impacts. Some future actions would contribute to additional sedimentation and/or erosion and result in impacts to soils and water bottoms. Where feasible, impacts would be mitigated. Ecosystem restoration actions would attempt to offset existing erosion and sediment loss throughout the study area.	No cumulative impacts to geologic resources. Cumulatively, restoration measures would contribute to the betterment of the overall coastal system including reducing land loss through erosion control measures and introduction of sediments into the system over the 50-year period of analysis.

Water Resources	Restoring fragmented marsh and shallow open water areas would result in a net increase in wetland function and value. Increasing the marsh platform would beneficially contribute to the restoration of marshes by reducing salinity and allowing surface flows to move freely into and out of the project area. The overall extent of open water would be reduced in the restoration unit, but marsh provides an overall more productive system.	Significant hydrologic modification into and out of the study area have been completed since the late-1800s. Freshwater flows have been cutoff south of the GIWW; increased flows and water levels (open water) associated with increased runoff due to urbanization and marsh loss; construction of water control structures (e.g. levees, weirs, and a variety of gated structures) to passively and actively control salinity and minimize tidal fluctuations into the area, have created barriers to movement of surface flows out of the area.	Present actions are maintaining the conditions created by past actions and are continuing to contribute to the degradation of water resources.	Future projects involve construction of additional water control structures to reduce tidal surge impacts during tropical storms and hurricanes which would significantly alter hydrologic patterns and fill in or modify wetlands. Future navigation projects would contribute to additional water resource impacts by altering salinity patterns, flows, patterns, and wetland loss. Wetland losses would be mitigated, but would most likely be in a different location, potentially even out of the study area. RSLC is expected to significantly alter the existing open water and marsh ratio. However, restoration and mitigation actions are expected to beneficially contribute to altering some loss of surface flow connectivity through siphon construction and marsh and beach nourishment, all of which minimize saltwater intrusion impacts. Nourishment actions would reduce the overall open water areas and promote surface flows into and out of the area.	Past activities have permanently modified the water resources in the study area. Adverse direct and indirect impacts from the Recommended Plan are insubstantial compared to the changes experienced in the past. However, the direct and indirect beneficial impacts of the Recommended Plan and other ecosystem restoration activities in the study area are substantial in an effort to restore and offset some of the past hydrologic modifications and loss of wetlands. Cumulatively, the Recommended Plan would contribute to the betterment of the coastal ecosystem and be the additive to the synergistic effects of restoring and nourishing sites over the 50-year period of analysis.

Resource Area	Recommended Plan	Past Actions	Present Actions	Reasonably Foreseeable Future Actions	Cumulative Impacts
Biological Resources/ Threatened and Endangered Species/ Migratory Birds/Aquatic Resources	Restoration actions would result in temporary direct and indirect adverse impacts; but would realize an overall net increase in habitat value.	Loss of habitat and degradation of overall habitat value and productivity has been lost over time as a result of hydrologic alternation changes contributing to the loss of historic function of the wetlands. Loss has been at about 8.9 mi2 per year, with approximately 16% lost in the focused study area. The habitat loss or degradation results in less productive systems that cannot provide the same value to plant, animal, or aquatic species as the habitat did under historic conditions.	The ongoing use of the GIWW is resulting in approximately 4 feet of marsh loss per year. While shoreline erosion from normal tidal energies and a reduction in long-shore sediment transport to the Gulf of Mexico shoreline is resulting in a loss of between 20 and 40 feet of shoreline per year. Less than 1% of historic dune system still exists and continues to be degraded under existing conditions. Existing ecosystem restoration actions have attempted to mitigate some loss but not to a level that could reverse or possibly even change any downward trends over the entire focused study area.	Future construction projects would adversely impact biological communities, T&E species, migratory birds, aquatic resources, etc. To the greatest extent practicable, impacts would be avoided or minimized. Where they cannot be avoided or minimized, mitigation would implemented to offset any adverse impacts. RSLC would result in even greater loss, where marshes south of the GIWW would convert to open water and existing dune and beach would be lost. It is expected that marshes and the shoreline would retreat further inland. Future restoration activities would partially offset impacts from past and present actions, but would not result in a reversal of past impacts or nor would it fully mitigate any losses realized under RSLC.	Cumulative impacts would be the synergistic effect with the additive combination of impacts and benefits for overall net acres created, nourished, and protected by other reasonably foreseeable future Federal, state, local, and private restoration efforts. Incremental beneficial impacts would combine with the work implemented under the Salt Bayou Restoration Plan, TX Coastal Resiliency Plan, and NWR/TPWD management plans. Overall, there would be an anticipated increase in wildlife and fisheries diversity and contribution to the sustainment and recovery of species of concern, including T&E.

Resource Area	Recommended Plan	Past Actions	Present Actions	Reasonably Foreseeable Future Actions	Cumulative Impacts
Essential Fish Habitat	There would be a net loss of open water and some alteration to water bottoms and water columns; however, the overall net increase in marsh would lead to more productive EFH for larval and juvenile species, in particular, than open water provides.	Loss and alternation of EFH from construction activities, dredging, oil and gas development, flood risk management structures, etc.	Ongoing EFH degradation would occur under operations and maintenance of navigation channels, flood risk structures, and urbanization. However, ecosystem restoration by other entities have slightly offset these impacts.	Future construction projects would adversely impact EFH by resulting in wetland loss and conversion of water bottoms. EFH impacts would be partially offset through the benefits of restoration and mitigation activities in or near the study area.	Cumulatively impacts to EFH would be the synergistic effect with the additive combination of impacts and benefits for overall net increase in functional value and acreage, while providing more productive habitat than what currently exists.
Cultural Resources	Monitoring during construction would be conducted and if any cultural resources are discovered work would cease until A determination of eligibility for the National Register of Historic Places could be made. For resources determined eligible, appropriate mitigation would be performed to reduce impacts to the resource before construction could continue.	Historic actions have probably resulted in the loss of cultural resources especially prior to enacting legislation to protect such resources. These actions are irreversible. However, many of the constructed features that are now on the landscape that were built decades or even a century ago are qualifying as historic properties themselves and have contributed to the cultural understanding of the past.	Ground disturbing activities are regularly monitored for cultural resources. If found, proper notification to the SHPO is completed and investigations/mitigation is conducted if warranted.	Any future new ground disturbing activities would be monitored for the presence of cultural resources. Proper investigations would be conducted if significant resources are uncovered.	No significant cumulative impacts are anticipated.

Resource Area	Recommended Plan	Past Actions	Present Actions	Reasonably Foreseeable Future Actions	Cumulative Impacts
Recreational and Aesthetic Resources	Recreation impacts would be temporary and localized and result in the loss of use of the restoration unit during construction. Recreation would resume similar to pre-construction levels following construction and after monitoring indicates the restoration has stabilized. Restoration would convert existing viewsheds of open water into marsh wetlands and use the basic design elements of form, line, texture, color, and repetition to create an aesthetically pleasing viewshed. Where marsh is protected through construction of GIWW armoring, the existing viewshed would be maintained, except for in the immediate vicinity of the placed rock.	Some recreation has been impacted by the construction of past actions; however, additional/different recreation has replaced the past recreational activities (e.g. marsh loss has led to less land based recreation opportunities; however, creation of navigation channels and open water areas has resulted in a net increase in aquatic recreation opportunities.) Construction projects have altered the overall aesthetic value of the environment by introducing elements of line, form, color, and texture that is drastically different than the surrounding environment.	General operations and maintenance of constructed features, navigation channels, urbanization/ industrialization, and oil and gas developments have not altered the recreational opportunities or aesthetic value beyond what was created during/post-construction of past actions. Existing restoration efforts have contributed to improving the recreational and aesthetic value of the landscape.	Future construction actions would have similar impacts to the past and present action; however, it is anticipated that there will be an increase in ecosystem restoration in the future which would partially offset past and present actions.	Cumulatively, the project would not result in any adverse impact on recreation. Improved marsh habitat at JD Murphree would incrementally contribute to the betterment of the overall habitat which most recreation opportunities are dependent upon. The Recommended Plan would be a positive increase to the visual resources, especially the viewscape, in the form of providing additional acres of marsh wetlands in an areas that is otherwise being degraded, fragmented, and lost throughout the study area, state and Nation. These beneficial impacts would be in addition to, and in many instances synergistic to, the impacts and benefits from marsh acres restored, nourished, and protected by other Federal, state, local, and private restoration efforts in the study area, county, state, and the Nation.

Resource Area	Recommended Plan	Past Actions	Present Actions	Reasonably Foreseeable Future Actions	Cumulative Impacts
Socioeconomics	Minor beneficial impacts were/would be realized due to temporary increase in employment and local revenue during construction.	Minor beneficial impacts were realized due to temporary increase in employment and local revenue during construction. Navigation development and improvements have led to an overall beneficial increase in local, state, and national economies by being able to import and export commodities that would not have been able to prior to the improvements.	Petroleum refining and petrochemical processing; construction; and manufacturing production provides employment opportunities to the local economy. Recreation provides local revenue, particularly during hunting season.	Minor beneficial impacts would be realized due to temporary increase in employment and local revenue during construction. Long-term beneficial impacts could be realized if future construction activities contribute to additional import/export opportunities, which would result in an overall net benefit to the local, state, and national economies.	Temporary beneficial cumulative impacts are anticipated.

4.15 Irreversible and Irretrievable Commitments of Resources

NEPA 40 CFR 1502.16 requires that environmental analysis include identification of "any irreversible and irretrievable commitments of resources which would be involved in the Recommended Plan should it be implemented." Irreversible and irretrievable resource commitments are related to the use of nonrenewable resources and the effects that the use of these resources have on future generations. Irreversible effects primarily result from use or destruction of a specific resource (e.g. energy and minerals) that cannot be replaced within a reasonable time frame. Irretrievable resource commitments involve the loss in value of an affected resource that cannot be restored as a result of the action (e.g. extinction of a threatened or endangered species).

The Recommended Plan would result in the direct and indirect commitments of resources. These would be related mainly to construction components. Energy typically associated with construction activities would be expended and irretrievably lost under all of the alternatives excluding the no action alternative. Fuels used during the construction and operation of dredging equipment, barges, placement equipment (e.g. bulldozers, backhoes, marsh buggies, etc.) and support vehicles would constitute an irretrievable commitment of fuel resources. Capital and labor resources, as well as, stone material would also be considered an irretrievable and irreversible commitment of resources. The use of such resources would not adversely impact the availability of such resources for other project both now and in the future.

For the Recommended Plan, most resource commitments are neither irreversible nor irretrievable. The dredging of borrow material is considered reversible although it is anticipated that the natural infilling of the borrow pits may take several years. Benthic communities would be removed and lost along with sediment during dredging and placement operations. Benthic communities would also take several years to recover. Slow moving or non-motile fish, wildlife, invertebrates, and plant (aquatic and terrestrial) species would be entrained in the dredge during the dredging of borrow material or smothered during placement of dredged material. These losses would be irretrievable as well. However, most impacts to the species' population as a whole would be insignificant. As well, these impacts would only occur during construction.

No other impacts, such as water resources, existing land uses, or visual resources, have been identified which could result in irreversible or irretrievable commitments of resources which would preclude implementation of any of the action alternatives.

4.16 Mitigation

Due to the lack of long-term and/or permanent adverse impacts to any resource, no mitigation is required to implement any of the action alternatives. In general, there is an overall net increase in aquatic habitat which is compliant with the "no-net loss" policies of various laws, regulations, and policies.

4.17 Environmental Compliance

Federal projects must comply with Federal and State environmental laws, regulations, policies, rules, and guidance. Significant coordination with local, state, and federal resource agencies has occurred from the beginning of the feasibility study. The status of compliance with environmental laws is presented below (Table 4-8).

Table 4-8: Environmental Compliance Status of the Recommended Plan

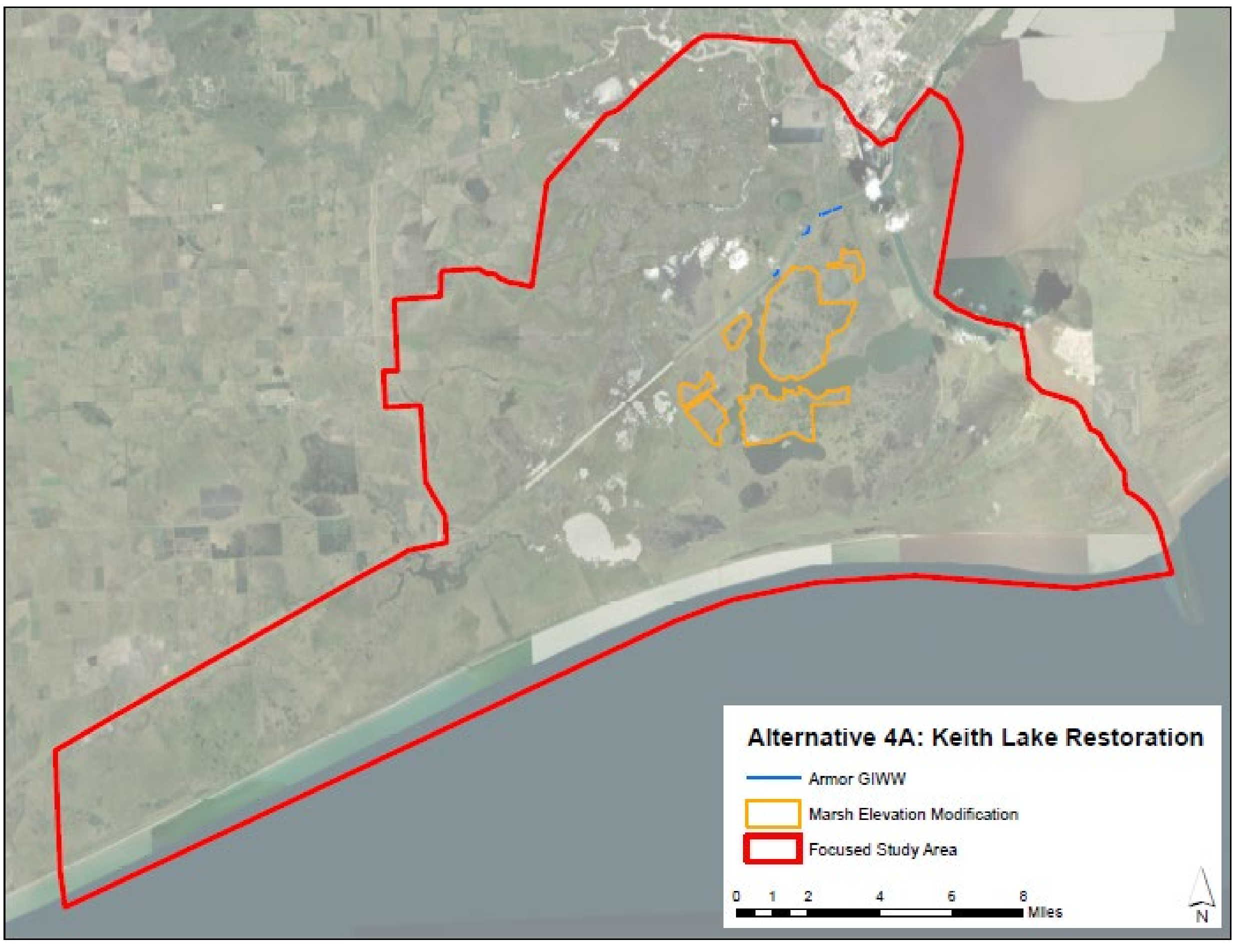
Policies	Compliance Status	Notes
Public Laws		
Abandoned Shipwreck Act of 1988, as amended	Not Applicable	
Archeological and Historic Preservation Act of 1974, as amended	In Progress	
Bald and Golden Eagle Protection Act of 1940, as amended	Compliant	Section 4.8.2.2
Clean Air Act of 1970, as amended	Compliant	Section 4.3; no consultation required
Clean Water Act of 1972, as amended	Compliant	Section 4.5.4, Appendix A-5; Water Quality Certification received from TCEQ on 05Nov18; 404(b)(1) signed 26Jun2018
Coastal Barrier Resources Act of 1982, as amended	Compliant	Section 4.2.3, Appendix A-4; no consultation required
Coastal Zone Management Act of 1972, as amended	Compliant	Section 4.2.2, Appendix A-3; consistency determination received from GLO on 19Sept2018
Endangered Species Act of 1973, as amended	In Progress	Section 4.8.1, Appendix A-2
Farmland Protection Policy Act of 1981	Not Applicable	2.6.3.1
Fish and Wildlife Coordination Act of 1934, as amended	Compliant	Appendix A-1
Magnuson-Stevens Fisheries Conservation and Management Act of 1976, as amended	Compliant	Section 4.8.6; concurrence received 12Jul2018

Policies	Compliance Status	Notes
Marine Mammal Protection Act of 1972, as amended	Compliant	Section 4.8.5; no consultation required
Marine Protection, Research, and Sanctuaries Act of 1972, as amended	Not Applicable	
Migratory Bird Treaty Act of 1918, as amended	Compliant	Section 4.8.3
National Environmental Policy Act of 1970, as amended	In Progress	
National Historic Preservation Act of 1966, as amended	In Progress	
Native American Graves Protection and Repatriation Act of 1990	Not Applicable	
Rivers and Harbors Act of 1899, as amended	Compliant	
Wild and Scenic Rivers Act, as amended	Not Applicable	
Executive Orders		
Environmental Justice (E.O. 12898)	Compliant	Section 4.10.2
Flood Plain Management (E.O. 11988)	Compliant	Section 4.5.2
Protection of Wetlands (E.O. 11990)	Compliant	Section 4.5.3
Protection of Children from Environmental Health Risks (E.O. 13045)	Compliant	Section 4.10.2
Invasive Species (E.O. 13112)	Compliant	Section 4.8.4
Migratory Birds (E.O. 13186)	Compliant	Section 4.8.3

5 RECOMMENDED PLAN

Alternative 4Abu (Keith Lake Restoration) is the recommended plan and includes construction of 5,170 linear feet of armoring along the southern bank of the GIWW, restores 6,048 acres of freshwater, intermediate and brackish marsh habitat in 6 restoration units, includes planting of native species and removal of invasive species within those restoration units and utilizes borrow material primarily from SNWW or identified upland disposal sites. After plan selection, the recommended plan costs and schedules were subjected to a cost and schedule risk analysis. This resulted in a reduction in overall project first costs, primarily driven by a reduction in contingency costs, and is described in detail in the cost engineering appendix. Alternative 4Abu generates 2,695 net AAHUs of marsh habitat at a project first cost of $62.3 million. This includes $2.6 million for monitoring and adaptive management over the 10 year monitoring period.

Figure 5-1: National Ecosystem Restoration Plan Alternative 4Abu (Keith Lake Restoration)



The Recommended Plan would use dredged material from the SNWW, and thus preserve capacity and use of existing upland disposal sites. The team chose Alternative 4Abu as the Recommended Plan based on preliminary analyses because it meets study objectives, reasonably maximizes benefits relative to associated costs, and includes key restoration features to restore and sustain the form and function of the coastal system in part of the study area. It also meets USACE's four planning criteria of effectiveness, efficiency, completeness, acceptability; and addresses three of the four accounts specified by the Principles and Guidelines for Water Resource Development:

1) National Economic Development (NED),
2) Regional Economic Development (RED),
3) Environmental Quality (EQ), and
4) Other Social Effects (OSE).

The Recommended Plan would restore marsh and GIWW shoreline features that stabilize and sustain critical marsh resources today and in the future. Marsh measures consist of marsh restoration and or nourishment to increase land coverage and improve terrestrial wildlife habitat, hydrology, and water quality and fish nurseries. Shoreline measures include constructing rock breakwater features that would mitigate some effects of erosion along the GIWW caused by ship wake. Breakwater structures dissipate wave energies, stabilize shorelines, reduce land loss, reduce saltwater intrusion, and support reestablishment of emergent marsh along the GIWW shoreline via sediment retention. The Recommended Plan would be constructed on public lands management by TPWD (J.D. Murphree Wildlife Management Area), the USFWS (McFaddin National Wildlife Refuge) (Table 5-1).

Table 5-1: Scale and Scope of Selected Plan Measures in Comparison to Land Ownership

Land Ownership	Marsh Measures (acres)	Shoreline Measures (linear feet)
J.D. Murphree Wildlife Management Area	5,365	5,170
McFaddin National Wildlife Refuge	683	0

Planning level design marsh restoration features of the Recommended Plan include:

- 6,048 acres of restored marsh,
- Marsh elevation increases from 0.6 feet to 1.2 feet (mean sea level),
- Sediment from the SNWW,
- 5.1 million cubic yards of material for initial construction, and

Planning level design GIWW armoring features of the Recommended Plan include:

- 5,170 linear feet (0.98 miles) of offset rock breakwater,
- A base width of 41 feet,
- A depth of approximately 3 feet,
- 651,420 cubic feet of stone to start construction, and
- 97,710 cubic feet of stone in year 15.

The design is identical to existing armoring in Jefferson County.

5.1.1 Recommended Plan Assumptions, Risks and Uncertainties

As is the case with Alternative 6A, there is an implementation risk since 683 acres of the project would be on USFWS land and their participation would be required for construction. Significant uncertainty remains regarding if and when USFWS would receive funding to implement measures on the refuge in light of future budget constraints and over refuge budget needs. Key assumptions for project success include:

1) Historical erosion rates are inputs for engineering models; and thus, planning designs assume that the erosion rate is constant and that constructing the Recommended Plan would not change the erosion rate;

2) Net effects of local subsidence and sea level change would not deviate significantly from numbers estimated for this study; and,

3) Volumes of dredged material and timing of maintenance dredging in the SNWW will follow existing plans for expanding the waterway, and funds to maintain dredging in the navigation channel will continue at current levels.

A monitoring and adaptive management plan for the Recommended Plan has been developed to address uncertainties surrounding ecosystem functions, and how ecosystem components respond to restoration projects in light of changing conditions such as changes in sea level change or as new information become available (Appendix A-9).

Risk and uncertainties related to formulation, selection and implementation of the Recommended Plan have been considered in this study. Uncertainties regarding alternatives stem from the precision of the information on ecosystem processes and the methods used to assess performance. In other words, unlike projects such as locks and dams, ecosystems have a much higher degree of random variation, or variation that is not possible to define. Like climate and weather, physical processes related to the evolution of coastal landforms are very complex. While the underlying principles controlling these processes are well understood, reliable simulation of such processes and their interactions (wind and wave processes, ocean currents, tides, sediment transport, storms) require massive amounts of data. As a result, modeling in this study relied on parameters with midpoint values in most cases; however, value assignments may have been selected that are not at or near the midpoint of a range of estimates if justified based on professional judgment of team members, or a rationale supports a selected value such as the need for a conservative safety factor in selection of an estimate.

Lastly, the most critical risk to the implementation of the Recommended Plan is if the USFWS cannot obtain partnership funding for the portion of the plan on their managed lands. The team may reduce this risk by helping the NFS and USFWS develop a memorandum of understanding and where practicable; assist the NFS in identifying alternate sources of funding or partners.

5.1.2 Environmental Impacts

Direct and indirect adverse impacts associated with implementing the recommended plan are temporary in nature (on average less than one year for each restoration unit) and limited in scope (approximately 6,052 acres of total disturbance). Construction activities would contribute the greatest impacts to the environment and could include: localized effects to water quality, including increased turbidity and total suspended sediments, organic enrichment, reduced dissolved oxygen, elevated carbon dioxide levels, and decreased light penetration, among others; habitat removal and/or fragmentation; temporary habitat avoidance because of increased noise, dust generation, vibrations, and overall lower quality habitat; losses of slow moving and less mobile species (small mammals, aquatic invertebrates, benthic species, mussels, smaller/younger fish, and herpetofauna); temporary changes in hydrologic flow; and temporary loss of recreation opportunities.

Implementation of the recommended plan is expected to take approximately 60 months; however, the duration in each marsh restoration unit and at the GIWW breakwaters would be significantly less and last less than one year. Once construction is complete in that disturbance area, temporary impacts related to construction activities would cease. Physical ground disturbance would not occur all at once, but would occur over the 60 month period, allowing previously disturbed areas to recover and begin providing high quality habitat for fish and wildlife species. With restoration, the long-term benefits expected include an overall net increase of 2,695 AAHU and an overall improvement in the quality of marsh habitat for all wildlife and fishery species at all life stages.

Although marsh restoration would result in the loss of approximately 65 percent of the open water in the six restoration units and over 6,048 acres of land, wildlife species currently utilizing this habitat would not be expected to be adversely affected. Wildlife species currently utilizing the shallow open water and vegetated shoreline habitat in the restoration units are highly mobile allowing them to relocate into adjacent open water habitats outside the restoration units. The conversion of open water to marsh habitat is generally considered a benefit to aquatic species.

For the recommended plan, breakwaters would convert approximately 3.5 acres of inland open water habitat to a hardened structure thereby reducing available habitat for aquatic species and resulting in the loss of immobile species. However, these impacts would have an overall minimal impact to fisheries and aquatic populations in the area and would in the long-term protect adjacent habitat that aquatic species depend on for survival that would be lost in the future if the measures were not implemented. As well, the structures would be designed in such a way as to not hinder movement of aquatic species.

Implementation of the recommended plan would have temporary, localized adverse impacts during construction, with some loss of less mobile species and 3.5 acres of habitat conversion due to construction of the breakwater structures. However, the overall benefits of implementing the plan far outweigh any temporary or permanent loss realized during construction. Restoration of marsh and GIWW shoreline areas would have a long-term, beneficial impact to most aquatic and terrestrial habitats and their associated species because of an overall net increase in habitat value.

5.2 Planning and Guidance Criteria

Alternate plans, including the Recommended Plan, should be formulated in terms of four criteria: completeness; effectiveness; efficiency; and acceptability. Recommended Plan satisfies each criteria:

- ***Acceptable -*** USACE can implement the plan from a technical, environmental, economic, political, institutional, and social perspective. Agencies such as USFWS, NOAA, TPWD and GLO support actions that are NEPA compliant, and the NFS supports beneficially using dredge material where most needed.

- ***Effective*** – The recommended plan significantly contributes to addressing restoration problems. Increasing sediment in the coastal system would improve the sustainability of the system. The plan would mitigate coastal erosion and lift to marsh platform elevations thereby reducing land loss and providing essential wildlife habitat.

- ***Efficient*** – The Recommended Plan is cost effective, and it uses dredge material from the SNWW, reduces dredge material in upland disposal sites allowing for reuse in future dredge maintenance activities in federal waterways.

Complete – The plan is a system restoration approach to meeting study goals and objectives to restore and maintain geomorphic shoreline structures such as beaches and dunes and marsh habitat via constructing higher elevation platforms. It provides and accounts for investments and actions to ensure realization of planned restoration outputs specific in the Recommended Plan, and reduces shoreline erosion by introducing suitable sediments and reduces subsidence and habitat switching in marsh areas. It maintains or restores 6,048 acres of marsh, constructs 5,170 linear feet (0.98 miles) of GIWW armoring, which reduces erosion rates of the shoreline.

5.3 National Accounts Addressed

- *National Economic Development*: Ecosystem restoration projects are not formulated based on national economic development, but rather national ecosystem restoration.

- *Regional Economic Development:* Construction activities would likely increase income and business sales in Jefferson County. Potential preservation of ecosystems may sustain or increase spending in local economies from recreational uses of the area.

- *Environmental Quality:* The Recommended Plan would improve marsh elevation in critical low-lying areas.

- *Other Social Account:* Recreation opportunities would increase in value, particularly for wildlife observation and photography, hunting and fishing because habitat value increases bring in greater diversity and larger populations of fish and wildlife. Increased recreation would benefit local economies in Jefferson County assuming the increase consisted of people from outside of the county. There may also be ancillary benefits in terms of preserving and restoring shorelines and marshes to other industries such as navigation and oil and gas, but these benefits were not quantified. There are no anticipated environmental justice or other adverse social impacts.

5.4 Real Estate Requirements

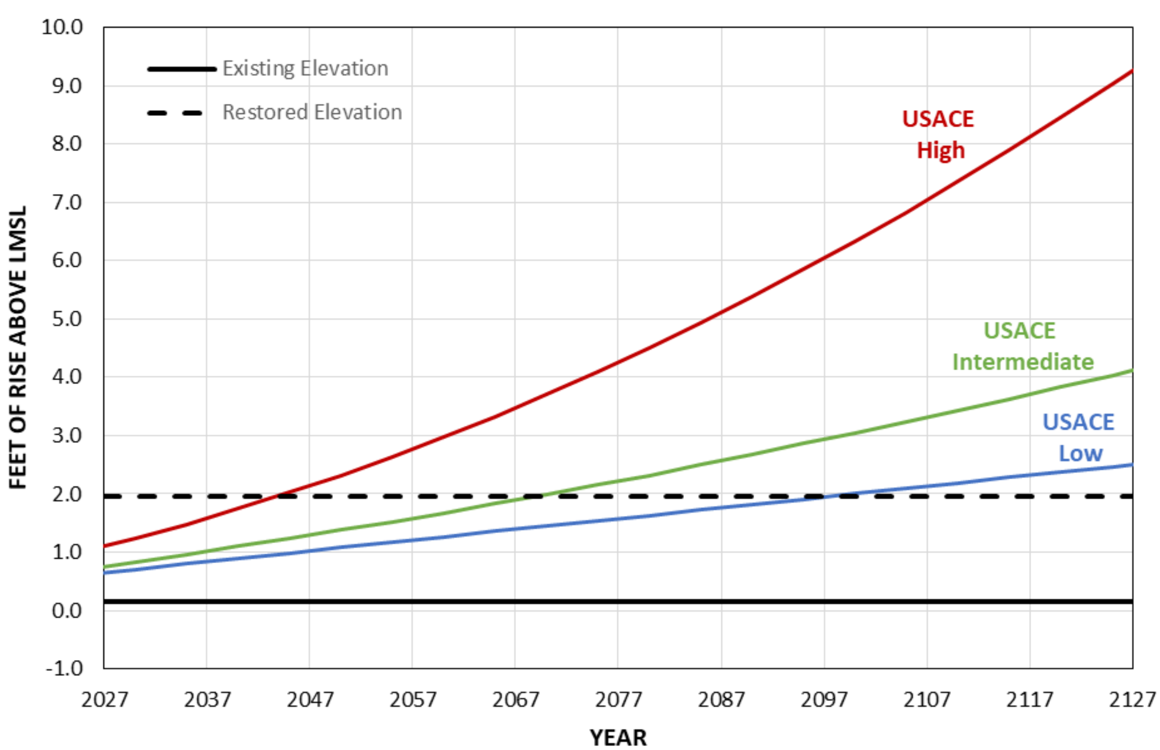
Appendix D contains the real estate plan describing real estate requirements and costs. The real estate plan describes lands, easements, and rights-of-way, relocation and disposal areas (LERRDs) for the construction, operation and maintenance of the proposed project. USACE Galveston District has many perpetual easements in the vicinity; however, the district holds no real estate in the project footprint. Non-federal sponsors would acquire all real estate required for the project.

Six restoration units and the GIWW armoring areas affect real estate tracts consisting of four privately owned tracts, 25 state owned tracts, and six federally owned tracts totaling 6,347 acres of ecosystem restoration lands, including 2.54 acres for armoring. The 25 state owned tracts consists of 5,644 acres within the J.D. Murphree Wildlife Management Area. For the use of this property, the State of Texas and the NFS will enter into an inter-local cooperative agreement, resulting in a non-standard estate acceptable to the Federal government. As stated previously, the privately owned tracts were removed from the recommended plan.

5.5 Sea Level Change

Jefferson County is vulnerable to relative sea level change (Thieler et al., 2000) that threatens coastal communities along with wetlands and habitats further inland. Widespread inundation may occur throughout the county at mean higher-high water from +2 ft. of sea level change relative to 2010 water levels (NOAA/OCM, 2017c). Plan formulation and feature design is based on USACE "intermediate" relative sea level change curve which projects that this +2 ft. is expected to occur in 2081 (Figure 5-2). High and low scenarios were considered in terms of plan sensitivity, essentially a "what-if" exercise regarding a more or less aggressive sea level change condition. Appendix B discusses this in detail.

Figure 5-2: Projected Sea Level Rise



5.6 Cost Estimates

Table 5-2 summarizes estimated Recommended Plan costs. The total estimated borrow required for the Recommended Plan is 10,367,280 cubic yards (cy).

Table 5-2: Equivalent Annual Cost and Benefits of the Recommended Plan
($1,000, October 2018 Prices, 2.875% Interest Rate, 50 Year Period of Analysis)

Item	Costs ($1,000)
Investment Costs	
First Cost of Initial Construction *	$62,252
Interest During Construction (72 months)	$5,607
Total Investment Cost	$67,859
Annual Costs	
Interest	$1,951
Amortization	$624
Annual OMRR&R	$66
Total Average Annual Cost	$2,641
Annual Benefits	
Ecosystem Restoration	2,695 habitat units
*This does not include the economic costs for USFWS lands used for plan formulation and evaluation	

5.7 Operations, Maintenance, Rehabilitation, Restoration and Repair Costs

The non-Federal sponsor is responsible for the OMRRR of the completed project. OMRRR of the proposed restoration project is comprised of future placement of stone, which would be 25% of the original GIWW armoring quantity (blanket stone, rip-rap, and geotextile) in year 15 on the breakwaters in response to RSLC. OMRRR costs are estimated at $2,672,000.

During plan comparison there were future construction actions that were considered OMRR&R and some that were consider continuing construction. Future work associated with hardened structures, i.e., breakwaters in the alternatives, was considered OMRR&R while the addition of sediment to constructed measures, e.g., beach and marsh nourishment, was considered continuing construction. The assumptions and quantities for OMRR&R and continuing construction were identified for each measure in the feature design section in the Engineering Appendix B.

As noted previously, the continuing construction associated with the marsh nourishment in the selected plan has been removed from the final recommended plan. As for the breakwaters in the recommended plan, slight changes were made to the cross-section to accommodate future stone placement as a response to RSLC and allow an additional 2 feet raise in the crest elevation without increasing the base width. The revised section is shown in the engineering drawings. Additionally, one of the three segments contained in the selected plan was removed from the feasibility design; more recent aerials indicated that the particular location already had shoreline armoring. The feasibility design and breakdown of construction is shown in Appendix B: Attachment 1: Plate C-501. The system of breakwaters through Jefferson

County, including those currently in place and those to be constructed through this project, is shown in Figure 5-2.

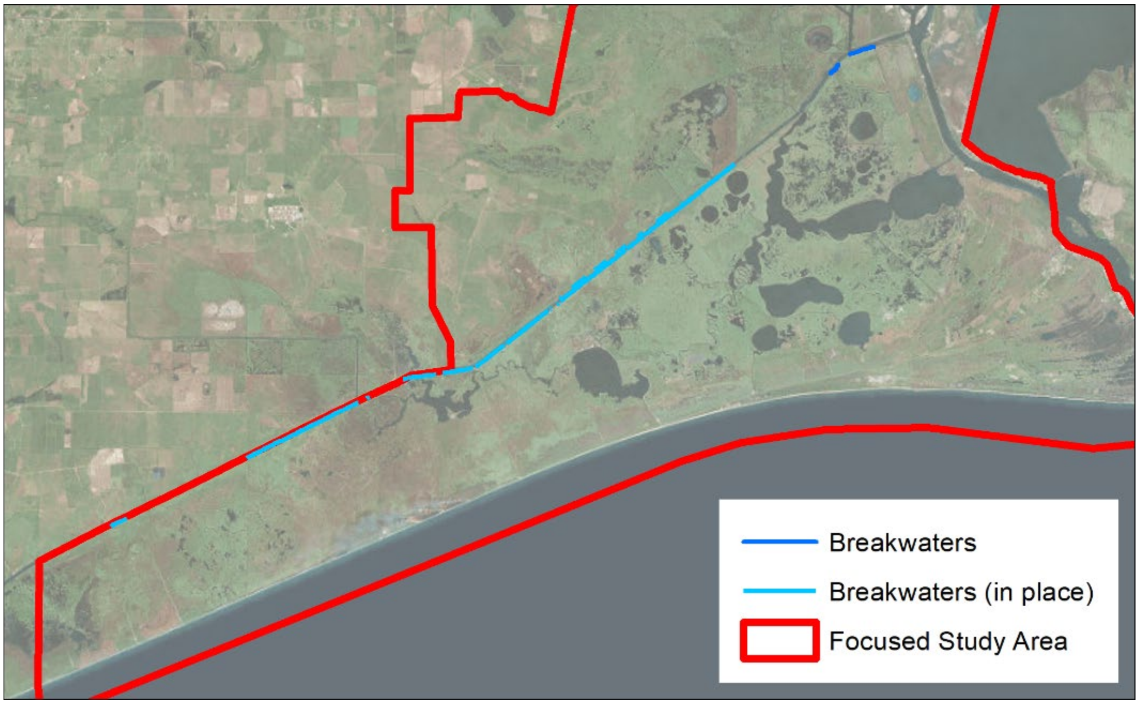


Figure 5-3: System of breakwaters (in place and part of recommended plan)

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5.8 Implementation Requirements

Non-federal study sponsors are the SNWW District and Jefferson County. Both fully support the Recommended Plan, which allows for beneficial use of dredged material to maintain the SNWW and rebuilding of eroded land areas.

Timing of initial construction of this project is dependent on a number of factors including: timing of authorization, duration of pre-engineering and design phase, identification of a cost-share sponsor, and Federal- and non-federal funding cycles. It was assumed that construction would take 60 months to complete all restoration actions, in which it was assumed that only one restoration unit would be undertaken at a time. For purposes of the feasibility study, construction ended in 2026 and benefits began accruing between 2027 and 2077.

Implementation of the marsh restoration measures is highly dependent on dredging cycles. Currently, seasonal timing restrictions related to Endangered Species Act compliance include a seasonal dredging window for hopper dredge use between December 1 and March 31, unless work outside this window cannot be completed, in which NMFS would need to approve the deviation. Hopper dredges would be used for dredging offshore areas of the entrance channel to just inside the jetties. Non-hopper dredges (e.g. cutterhead pipeline dredges) may be used from April to November. This type of dredge would be used anywhere else within the SNWW.

5.8.1 Project Implementation

Project implementation for ecosystem restoration projects is comprised of three phases – Preconstruction Engineering and Design (PED), construction, and monitoring and adaptive management. Implementation of the project is within the existing authorization for construction, and would not require further Congressional approval, except for appropriation of funds.

5.8.2 Pre-Construction Engineering and Design

The PED phase is cost shared 65% Federal, 35% non-Federal for the ecosystem restoration component. Prior to initiating the PED phase, the design team must develop a Project Management Plan (PMP) which defines the scope, work breakdown structure, schedule, and budget to complete PED. Additional items in the PMP are related to value management and engineering, quality control, communication, change management, and acquisition strategy. The draft PMP must be developed, negotiated, and agreed upon by all parties of the PED phase prior to initiation of the PED phase.

A number of activities are expected to take place during PED. These include the completion of a Design Documentation Report (DDR), plans and specifications (P&S), execution of the Project Partnership Agreement (PPA), and contract award activities.
The development of the DDR includes completing the final design of project features. As part of the DDR, the team will complete any ground surveys, utility surveys, and drilling and testing for subsurface (geotechnical) conditions as necessary to complete the final design. Design parameters for all project features will be defined for development of the plans and specifications. Continued coordination with SHPO will ensure requirements for archeological resource investigations and mitigation continue to be met with an archeologist on site during construction for monitoring, identification, and proper documentation/preservation of any cultural resources that might be uncovered during construction.
P&S includes the development of project construction drawings and specifications, estimation of final quantities, and completion of the government cost estimate. Drawings and specifications are made available to contractors interested in bidding on the construction of the proposed project. If required, arrangements for onsite archeological monitoring during construction should be finalized prior to the conclusion of P&S so they may be documented in the PPA.

A PMP for the construction phase must be developed, negotiated, and agreed upon by all parties of the construction phase prior to initiation of the construction phase. The PPA is a binding agreement between the Federal government and the non-Federal sponsor which must be approved and executed prior to the start of construction. The PPA sets forth the obligations of each party. The non-Federal sponsor must agree to meet the requirements for non- Federal responsibilities which will be identified in future legal documents. Some of the likely responsibilities are:

a. Provide 35 percent of total ecosystem restoration costs as further specified below:

1. Provide the non-Federal share of design costs allocated by the Government to ecosystem restoration in accordance with the terms of a design agreement entered into prior to commencement of design work for the ecosystem restoration features;
2. Provide, during the first year of construction, any additional funds necessary to pay the full non-Federal share of design costs allocated by the Government to ecosystem restoration;
3. Provide all lands, easements, and rights-of-way, including those required for relocations, the borrowing of material, and the disposal of dredged or excavated material; perform or ensure the performance of all relocations; and construct all improvements required on lands, easements, and rights-of-way to enable the disposal of dredged or excavated material all as determined by the Government to be required or to be necessary for the construction, operation, and maintenance of the ecosystem restoration features;
4. Provide, during construction, any additional funds necessary to make its total contribution for ecosystem restoration equal to 35 percent of total ecosystem restoration costs;

b. Shall not use funds from other Federal programs, including any non-Federal contribution required as a matching share therefor, to meet any of the non-Federal obligations for the project unless the Federal agency providing the funds are authorized to be used to carry out the project;

c. Prevent obstructions or encroachments on the project (including prescribing and enforcing regulations to prevent such obstructions or encroachments) such as any new developments on project lands, easements, and rights-of-way or the addition of facilities which might reduce the outputs produced by the ecosystem restoration features, hinder operation and maintenance of the project, or interfere with the project's proper function;

d. Shall not use the ecosystem restoration features or lands, easements, and rights-of-way required for such features as a wetlands bank or mitigation credit for any other project;

f. Comply with all applicable provisions of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, Public Law 91-646, as amended (42 U.S.C. 4601-4655), and the Uniform Regulations contained in 49 CFR Part 24, in acquiring lands, easements, and rights-of-way required for construction, operation, and maintenance of the project, including those necessary for relocations, the borrowing of materials, or the disposal of dredged or excavated material; and inform all affected persons of applicable benefits, policies, and procedures in connection with said Act;

g. For so long as the project remains authorized, operate, maintain, repair, rehabilitate, and replace the project, or functional portions of the project at no cost to the Federal Government, in a manner compatible with the project's authorized purposes and in accordance with applicable Federal and State laws and regulations and any specific directions prescribed by the Federal Government;

h. Give the Federal Government a right to enter, at reasonable times and in a reasonable manner, upon property that the non-Federal sponsor owns or controls for access to the project for the purpose of completing, inspecting, operating, maintaining, repairing, rehabilitating, or replacing the project;

i. Hold and save the United States free from all damages arising from the construction, operation, maintenance, repair, rehabilitation, and replacement of the project and any betterments, except for damages due to the fault or negligence of the United States or its contractors;

j. Keep and maintain books, records, documents, or other evidence pertaining to costs and expenses incurred pursuant to the project, for a minimum of 3 years after completion of the accounting for which such books, records, documents, or other evidence are required, to the extent and in such detail as will properly reflect total project costs, and in accordance with the standards for financial management systems set forth in the Uniform Administrative Requirements for Grants and Cooperative Agreements to State and Local Governments at 32 Code of Federal Regulations (CFR) Section 33.20;

k. Comply with all applicable Federal and State laws and regulations, including, but not limited to: Section 601 of the Civil Rights Act of 1964, Public Law 88-352 (42 U.S.C. 2000d) and Department of Defense Directive 5500.11 issued pursuant thereto; Army Regulation 600-7, entitled "Nondiscrimination on the Basis of Handicap in Programs and Activities Assisted or Conducted by the Department of the Army"; and all applicable Federal labor standards requirements including, but not limited to, 40 U.S.C. 3141- 3148 and 40 U.S.C. 3701 – 3708 (revising, codifying and enacting without substantial change the provisions of the Davis-Bacon Act (formerly 40 U.S.C. 276a *et seq.*), the Contract Work Hours and Safety Standards Act (formerly 40 U.S.C. 327 *et seq.*), and the Copeland Anti-Kickback Act (formerly 40 U.S.C. 276c *et seq.*);

l. Perform, or ensure performance of, any investigations for hazardous substances that are determined necessary to identify the existence and extent of any hazardous substances regulated under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), Public Law 96-510, as amended (42 U.S.C. 9601-9675), that may exist in, on, or under lands, easements, or rights-of-way that the Federal Government determines to be required for construction, operation, and maintenance of the project. However, for lands that the Federal Government determines to be subject to the navigation servitude, only the Federal Government shall perform such investigations unless the Federal Government provides the non-Federal sponsor with prior specific written direction, in which case the non-Federal sponsor shall perform such investigations in accordance with such written direction;

m. Assume, as between the Federal Government and the non-Federal sponsor, complete financial responsibility for all necessary cleanup and response costs of any hazardous substances regulated under

CERCLA that are located in, on, or under lands, easements, or rights-of-way that the Federal Government determines to be required for construction, operation, and maintenance of the project;

n. Agree, as between the Federal Government and the non-Federal sponsor, that the non-Federal sponsor shall be considered the operator of the project for the purpose of CERCLA liability, and to the maximum extent practicable, operate, maintain, repair, rehabilitate, and replace the project in a manner that will not cause liability to arise under CERCLA; and

o. Comply with Section 221 of Public Law 91-611, Flood Control Act of 1970, as amended (42 U.S.C. 1962d-5b), and Section 103(j) of the Water Resources Development Act of 1986, Public Law 99-662, as amended (33 U.S.C. 2213(j)), which provides that the Secretary of the Army shall not commence the construction of any water resources project or separable element thereof, until each non-Federal interest has entered into a written agreement to furnish its required cooperation for the project or separable element.

5.8.3 Federal and Non-Federal Cost-Sharing

The federal government will be responsible for 65 percent of the initial construction. Non-federal sponsors will be responsible for 35 percent of the initial construction and 100 percent of the OMRR&R costs. Detailed design of the Recommended Plan will be shared between non-federal Sponsors and USACE contingent upon the execution of a design agreement in accordance with the provisions of ER 1165-2-208. Detailed design will comply with USACE's regulations and standards. Sponsor cost contribution to implement the Recommended Plan are broken down in Table 5-3 and Table 5-4.

Table 5-3: Cost Sharing Obligations for the Recommended Plan (October 2018 Price Levels)

Item	Federal (USACE)	Non-Federal	Subtotal Cost Share	Other (USFWS)	Project First Cost
Initial Construction	$33,164,000	$17,858,000	$51,022,000	$5,461,000	$56,483,000
Lands, Easements, Right of Way and Relocations		3,190,000	3,190,000		3,190,000
Monitoring and Adaptive Management	1,497,000	806,000	2,303,000	276,000	2,579,000
Subtotal	34,661,000	21,854,000	56,515,000	5,737,000	62,252,000
Adjustments to achieve 65/35	2,074,000	(2,074,000)			
First Costs by Entity[1]	$36,735,000	$19,780,000	$56,515,000	$5,737,000	$62,252,000
OMRR&R		$2,672,000			

[1]Non-Federal sponsors' share is based solely on the cost of the Corps plan.

Table 5-4 Breakdown of Costs per Contract per Entity (Costs in $1000)

O&M Schedule	Marsh Cell	Volume for Marsh Construction [CY]	LERRD[1]	Non-Federal Sponsor	USACE	USFWS	Total First Cost
PED				$650	$948		$1,598
FY22- Contract 1	Break Water		$1,374	$1,782	$15,015		$18,171
	1	165,040					
	2A	1,334,960					
FY23 -Contract 2	6A	700,000	$830	$3,318	$4,857		$9,005
FY24 - Contract 3	2B	690,750	$665	$3,714	$5,437	$5,461	$15,277
	3	186,340					
	4	196,990					
	5	425,920					
FY27- Contract 4	2C	588,370	$321	$5,648	$8,267		$14,236
	6B	774,700					
FY36 - MAMP				$1,479	$2,210	$276	$3,965
Totals			$3,190	$16,590	$36,735	$5,737	$62,252

[1] LERRD costs are shown associated with each contract. The Non-Federal Sponsor will obtain all LERRDs required for project construction prior to award of the associated contract.

5.9 Key Social and Environmental Factors

There are currently no direct social or environmental factors that would prevent this project from being constructed as the project areas are uninhabited. The wildlife management areas and parks in Jefferson County are used by local residents and visitors for recreational purposes which would be improved by the construction of this project. The project would also provide additional protection for oil and gas infrastructure in the area and potentially protect that infrastructure from being exposed and vulnerable to damage in storms. The construction of this area of shoreline would provide storm surge protection for the interior marshes which would decrease erosion rates. During construction, habitats within the borrow areas and the construction sites would be temporarily impacted, but would return to a natural state after construction is completed. The project would avoid nesting season during construction to reduce disturbances to migratory birds and wildlife and implement other best management practices during construction.

5.10 Resource Agency Perspectives and Differences

TPWD, NOAA, and EPA have provided letters of support for the recommended plan. USFWS intends to provide a Final CAR that is expected to also show support for restoration in the study area. However, the PDT anticipates the CAR will state that more restoration needs to be done and strongly encourage incorporation of shoreline work. This concern is also shared by the other agencies to some degree.

From the beginning of the study, formulation focused on a number of measures and locations that could benefit from shoreline restoration. Three of the best-buy plans included shoreline work. However, all of these measures and locations are located on or solely benefit USFWS lands. USACE policy would generally be opposed to recommend spending Civil Works appropriations on other Federal entities' lands and if part of the recommended plan, it must be implemented and paid for by USFWS. After several meetings, USFWS expressed concerns about being able to implement their portions of the best-buy plans. Therefore, the PDT felt the risk of USFWS not implementing was very high. If they do not implement, the calculated benefits would not be realized and the overall resiliency to other restoration areas outside USFWS lands would be reduced. Alternative 4Abu is the plan with the least amount of USFWS lands and the plan with the lowest risk.

5.11 Environmental Compliance

Environmental consultation and coordination are ongoing for this study. A Coordination Act Report was received on 26 April 2019, and will be included in the Environmental Appendix. Significant coordination with local, state, and federal resource agencies has occurred from the beginning of this feasibility study. The status of compliance with environmental laws was presented in Table 4-8.

Due to the lack of long-term and/or permanent adverse impacts to any resource, no compensatory mitigation is required to implement the recommended plan. In general, there is an overall net increase in aquatic habitat which is compliant with the "no-net loss" policies of various laws, regulations, and policies.

The recommended plan incorporates conservation measures that when implemented would "avoid" or "minimize" impacts to certain protected species during ground-disturbing activities. Implementation of the conservation measures would nominally increase the cost of construction. Most of these measures are standard practice or must be followed per USACE policies or existing Biological Opinions. The following describes the conservation measures for each:

General Conservation Measures:

1. All personnel (contractors, workers, etc.) will attend training sessions prior to the initiation of, or their participation in, project work activities. Training will include: 1) recognition of piping plovers, rufa red knot, West Indian manatee, and sea turtles, their habitat, and sign; 2) impact

avoidance measures; 3) reporting criteria; 4) contact information for rescue agencies in the area; and 5) penalties of violating the ESA.

2. Project equipment and vehicles transiting between the staging area and restoration site will be minimized to the extent practicable, including but not limited to using designated routes and confining vehicle access to the immediate needs of the project.
3. The contractor will coordinate and sequence work to minimize the frequency and density of vehicular traffic within and near the restoration unit(s) and limit driving to the greatest extent practicable.
4. Use of construction lighting at night shall be minimized, directed toward the construction activity area, and shielded from view outside of the project area to the maximum extent practicable.
5. A designated monitor(s) will be identified who will act as the single point of contact responsible for communicating and reporting endangered species issues throughout the construction period.

Marine Mammals, including West Indian Manatee:

1. Qualified biologists will monitor for the presence of manatee during phases which involve open water areas capable of supporting manatees.
2. Before activities occur in open water areas, a 50-foot radius of the work area should be delineated. If a manatee is observed within the 50-foot radius, the biological monitor shall halt construction activities, including shutting down any running equipment until the animal has moved beyond the radius, either through sighting or by waiting until enough time has elapsed (approximately 15 minutes) to assume that the animal has moved beyond the buffer.
3. If a manatee is sighted within 100 yards of the active work zone, vessels will operate at no wake/idle speeds.
4. If siltation barriers are used, they will be made of material in which manatees cannot become entangled, should be properly secured, and regularly monitored to avoid entrapment. Barrier should not impede manatee movement.
5. Any manatee sightings will be immediately reported to the U.S. Fish and Wildlife Service Houston Ecological Services Office.

Whooping Crane:

1. Seasonal timing restriction between October 1 and April 15 in which construction should be avoided if at all possible.
2. If construction cannot be avoided, a biological monitor with stop-work authority must be present during activities. If a crane is observed within 1,000 feet of the activity area, construction activities must be halted until the bird has vacated the radius. Additionally, if equipment is over 15 feet tall, the equipment must be laid down at dusk.

Sea Turtles: these are described in the Reasonable and Prudent measures/terms and conditions that were included and explicitly described in the final Biological Opinion for dredging operations

1. Seasonal timing restrictions for hopper use between December 1 and March 31, unless work outside this window cannot be completed, in which NMFS would need to approve the deviation;
2. Non-hopper dredges (e.g. cutterhead pipeline dredges) may be used from April to November;
3. Intake and overflow screening;
4. Use of sea turtle deflector dragheads;
5. Observer reporting requirements; and
6. Sea turtle relocation/abundance trawling.

5.11.1 USFWS Coordination Act Report

The USFWS provided a Coordination Act Report (CAR) for the Jefferson County Ecosystem Restoration Feasibility Report on 26 April 2019. The CAR was based on an earlier version of the Feasibility Report, prior to the post-ADM changes documented in Section 1483.9 Plan Modifications. Table 5-4 below shows the general recommendations by the USFWS in the CAR along with the USACE response.

Table 5-5 USFWS Coordination Act Report Recommendations

General Recommendations
1. The No Action Alternative assumes the Service will restore 20 miles of heavily degraded beach shoreline along the McFaddin NWR (Corps 2018). The Service is actively working with partner agencies to complete permitting requirements, final engineering designs, and solidify funding sources for this one time project. The Corps states (Corps 2018) "A systems approach is useful given that marsh restoration alone does not address all study problems, does not meet study objectives, and does not provide inland habitats with sustainable restoration or protection against coastal processes. Shoreline restoration alone would provide a buffer for the adjacent marsh areas, but it does not address stagnation, accretion, and subsidence experienced in the area. Therefore, shoreline restoration in conjunction with marsh restoration is necessary for optimal shoreline protection and sustainable ecosystem restoration." The Service continues to question the Corps TSP selection knowing the plan will accomplish little to restore landscape level degradation of marsh and beach habitat. The Corps own economic and environmental analysis demonstrate minimal benefits from the TSP. The Service appreciates the Corps' acknowledgment of the continued anthropogenic landscape level changes that plague Jefferson County caused by the Corps' own permitted projects. We recommend the Corps fund a more comprehensive alternative in the JCER plan aimed at restoring additional habitats affected by these permitted projects. A future study aimed at evaluating effects from the Corps' permitted projects along the Texas coast is warranted given the economic and environmental resources affected. We continue to recommend the Corps seek additional funding opportunities for a comprehensive restoration plan that will accomplish the objectives of the Study.

	While the alternative chosen does not provide the highest environmental benefit, it does address all three of the objectives of the study. This plan was identified as the National Ecosystem Restoration (NER) Plan, meaning it has the lowest incremental cost per incremental benefit. This plan also meets all four planning criteria. USACE would be happy to work with the Service, TPWD, and Jefferson County to pursue further opportunities for more Ecosystem Restoration projects in the future.
2.	Under the Environmental Consequences section of the DEIS, the Corps states, "If, for some reason, the BMPs, are not implemented, the impacts of any of the action alternatives would only minimally increase from those described in this chapter. The increased impacts would not be substantial enough to cause an adverse insignificant impact to become significant." The Service disagrees with this assumption since wetland impacts scar the landscape and can typically take years to recover. "The die off of wetland vegetation caused by impaction can change the tidal flow patterns through wetlands affecting valuable wetland functions such as shoreline erosion, attenuation of storm surges, and sedimentation in response to sea level" (Stijn, Moonen, P., Schoelynck, Govers, & Bouma, 2012). We request the Corps fully compensate for all impacts to wetlands resulting from construction of any measures associated with the TSP or NER on state, federal, or private lands. The Service and other natural resource agencies are willing to work with the Corps to provide suitable compensation recommendations.
	This project is intended to create/restore habitat. USACE typically does not provide mitigation for Ecosystem Restoration projects. The amount of habitat (and AAHUs) created by this project should far outweigh any temporary impacts due to construction activity.
3.	The TSP should include out-year nourishments of dredge material or sand to combat the effects of sea level rise, shoreline retreat, and wetland fragmentation. We recommend additional nourishment be conducted at a minimum of 10 year intervals (or at intervals determined by the ADT) during the 50-year life of the project for marsh and beach measures.
	The plan originally included out-year nourishment as continuing construction. A white paper was written to justify this approach, however, USACE policy does not clearly identify this type of adaptive response to sea level rise as a construction action eligible for inclusion in the project authorization or within the adaptive management plan. The original placement of material is intended to be at a level sufficient to keep up with a moderate level of sea level rise. Future nourishment events can be investigated as needed.
4.	When enhancing and protecting interior marsh habitat within the Study area, we recommend the TSP include some type of Gulf shoreline protection (beach nourishment, berms, breakwaters etc.) as a first line of defense against storm surge events and sea level rise. Any beach features will need to be closely coordinated with Service and TPWD staff during the PED phase of the Study.
	Beach nourishment, berms, and breakwaters were considered as part of the project alternatives. The benefits of this work based on the Barrier Headland WVA model did not provide enough AAHUs relative to the costs of the material placement to make it a viable alternative at this time. USACE does understand the importance of these features and

	would support working with the Service in the future to find other suitable means of providing the funding for such work.
5.	TSP features should complement existing Refuge and State restoration plans and management objectives and should be closely coordinated with NWR and TPWD managers.
	The PDT would be more than willing to work with Service and TPWD staff during the PED phase to make sure that the design and implementation of the project coordinates with the management objectives of the NWR and TPWD managers.
6.	Evaluate the cumulative effects from past Corps funded construction projects as related to this project such as upstream river damming, SNWW and GIWW navigation, and the Sabine Jetties that contribute to the decreased sediment availability and the ecological degradation experienced in Jefferson County. Additionally, we request the Corps identify a funding mechanism to support restoration on federal, state and private lands for the good of Jefferson County.
	USACE is willing to work the Service, TPWD, and Jefferson County to help identify future funding sources and mechanisms to support additional ecological restoration for the good of Jefferson County.
7.	The TSP should aim to restore historic hydrologic connections, improve wetland salinities, restore historic wet prairies, and remove invasive species across the landscape to enhance habitats for wetland dependent species.
	USACE is committed to restoring habitats to a natural state that mimics the historic properties to the highest degree possible within the confines of the project's allowable budget. This includes working to restoring hydrological connectivity and reduction of invasive species.
8.	Identification of federal and state boundaries with regard to GOM and GIWW shorelines should be identified during the planning phases. The Service remains concerned that the Corps may ignore restoration measures due to internal guidelines restricting funding on federal lands. The Service reminds the Corps of the extensive erosion and degradation to the GOM shorelines within the Study area, the keen interest of the Study's sponsor, potential implications to human and commercial interests including transportation (rail, road, and navigation), and the significant natural resources at risk. As such, the Service is willing to work with the Corps at both the local and national levels to address possible restoration opportunities on federal lands.
	USACE will work with the appropriate state and federal agencies to ensure that the surveyed boundary lines depict the legal boundaries with regards to the GOM and GIWW shorelines.
9.	Actively engage the Texas General Land Office (GLO) in the JCER coordination process. The GLO has responsibility for coastal shorelines seaward of the mean high tide line and state, federal and private landholders landward of this line. This distinction can provide for federal funding opportunities to the GLO and others not normally available to the Service; however, the GLO has not been engaged during any of the planning processes or discussions to define measures or funding opportunities that may be available.

GLO has participated in this project from early on in the planning process. A GLO representative was present at multiple Resource Agency meetings. USACE would be happy to continue to include GLO in the process during PED where appropriate.
10. Dredged material can combat changes in water levels, erosion, and subsidence in most marsh habitats found in Jefferson County through thin layer deposition, open pipe placement, terrace features, and training berms. Pumping distance should not be a limitation and we urge the Corps to evaluate transporting material (new work and maintenance material) to areas outside of the typical 6-mile pump distance to areas along the shoreline and along the GIWW if necessary. All new work (should it become available for use) and maintenance material should be thoroughly tested for contaminants using the standards outlined in the EPA's Inland Testing and Ocean Dumping Manuals prior to being used in any beneficial use projects. Should data suggest toxic levels of contaminants are present, the Service recommends disposal of the material in accordance with EPA guidelines and within an approved landfill site.
Materials dredged from the SNWW are tested for contaminants prior to maintenance operations to verify their suitability for placement in open water. If any of the dredged material tests indicate that the sediments are unsuitable for placement, that material will not be used in the JCER project and will be treated in accordance with Policy Guidance Letter No. 34, Non-CERCLA Regulated Contaminated Materials at Civil Works Projects (5May92).
11. The Service supports the use of Corps' disposal areas to obtain material for beneficial use as long as the material is appropriately tested for contaminants. This material must meet certain criteria (to include but not limited to grain size, silt and clay contents, and contaminants) with respect to the receiving habitats on NWR lands. Specific requirements for BU placement on NWR lands will be determined and coordinated with the Service during the PED phases of the project.
USACE is willing to coordinate with the Service during the PED phase regarding the specific requirements for BU placement on NWR lands.
12. Hard structures (if incorporated as design features) such as reef domes, revetments, breakwaters, riprap, and concrete matting shall be constructed to maximize aquatic access. Design and engineering of hard structures should be coordinated with NWR and TPWD staff if constructed on Service or State lands.
USACE is willing to coordinate with the NWR and TPWD staff during the PED phase regarding the design and engineering of hard structures to be used on the JCER project.
13. The protection and restoration of prairie habitat remains a high-level priority for the Service. Therefore, we recommend the sponsor work with local, state, and federal partners to develop a strategy focused on the preservation of prairie habitat throughout Jefferson County. This is achieved through the recovery of historic pothole and mound complexes, the re-introduction of native prairie species on former agricultural (rice) lands to support pollinators, grassland and wetland dependent species like the mottled duck, bobwhite quail, wintering waterfowl, waterbirds, and shorebirds, and the permanent preservation of prairie habitat through conservation easements.

This project was only focused on the restoration of wetlands and shoreline habitat, but would be open to working with the Service, TPWD, Jefferson County, and any other agency to develop restoration plans to help preserve this important habitat in the future.
14. Incorporate success criteria, monitoring, and adaptive management into all selected features to ensure project success.
Success criteria are features of the monitoring and adaptive management plan (Appendix A9 of the Integrated Feasibility Report - Environmental Assessment)
15. Invasive native and non-native terrestrial and aquatic plants continues to spread across the Study Area. To combat this growing issue, any alternative moving forward should include treatment/removal and monitoring of invasive species.
Monitoring and removal of invasive species are features of the monitoring and adaptive management plan (Appendix A9 of the Integrated Feasibility Report - Environmental Assessment)
16. Initiate modeling of future vessel impacts along the GIWW, Sabine Neches Waterway, and the GOM shorelines. This would include, sediment transport, future sediment deposition along Jefferson County shorelines, sea level rise, sand source identification, beach dune restoration and profiling as part of the ongoing study to scientifically identify, select, and support restoration measures.
This project would not lead to a foreseeable change in vessel traffic along the GIWW or the Sabine-Neches Waterway. Therefore it would not be within the purview of this study to conduct a modeling effort to investigate future impacts of vessel traffic along these waterways.
17. Manage non-native species, reintroduce native plants, restore natural drainage features and use frequent prescribed fire to restore grasslands and prairie habitat.
The ecological restoration features of this project include wetland restoration, but do not include restoration of grasslands and/or prairie habitat. Therefore the recommended steps would not be directed at maintaining the habitat measures of this project.
18. The Corps should obtain a right-of-way from the Service prior to conducting any work on McFaddin or Texas Point National Wildlife Refuges, in conformance with Section 29.21-1, Title 50, Right-of-Way Regulations. Issuance of a right-of-way will be contingent on a determination that the proposed work will be compatible with the purposes for which the Refuge was established.
USACE will work with McFaddin and/or Texas Point NWR to obtain the issuance of a right-of-way prior to commencing any work on said properties.
19. Whooping cranes are known to frequent marsh habitat in Jefferson County. We have the following general recommendations with respect to whooping cranes: project equipment that may be a collision hazard (guy wires that support dredging equipment, telecommunication towers on dredges, antenna or similar items located on dredges) will be marked using red plastic balls or other suitable marking devices sized and spaced, and lighted during inclement weather conditions when low light and/or fog is present and implemented from October 1 through April 30. These recommendations are consistent with the Avian Protection Plan Guidelines used in conjunction

	with the Avian Power Line Interaction Committee. An Avian Protection Plan will be prepared, submitted to the Service for review and comment prior to the onset of construction activities. These actions do not alleviate the Corps responsibility of evaluating project actions and initiating formal Section 7 consultation and should not be construed as such.
	USACE will include the Service's conditions for protection of the Whooping crane in their work plans and contract specifications.
20.	The Service requests that the Corps initiate coordination with the Service during the design phases of the project and prior to the commencement of any restoration activities so site-specific best management practices (BMPs) can be developed for construction activities. Measures should be implemented to avoid or minimize the adverse effects of pollution, sedimentation, and erosion by limiting soil disturbances, scheduling work when the fewest number of fish are likely to be present, managing likely pollutants, and limiting the harm that may be caused by accidental discharges of pollutants and sediments. BMPs attempt to minimize impacts to fish and wildlife species within the immediate construction and nearby areas and may consist of floating turbidity curtains, limiting certain construction activities to daylight hours, limiting the use of or shielding lights at night, no vegetation removal or soil disturbance should be allowed outside of the project area, removal of mature trees providing soil or bank stabilization should be coordinated with the Service and TPWD, erosive banks should be stabilized using bioengineering solutions minimizing the use of riprap, and using monitors in open water areas to identify sensitive species.
	USACE is willing to with the Service and TPWD to include appropriate BMPs in their work plans and contract specifications.
21.	Construction of any study features shall occur at least 1,000 feet away from a colonial waterbird rookery site during the breeding season of February 1 through September 1.
	USACE will include the Service's conditions for protection of the colonial bird rookery sites in their work plans and contract specifications.
22.	Plant restoration sites within the next growing season after project completion to minimize erosion. Plant species and planting schedules should be fully vetted and coordinated with the Service and the ICT. In some instances, the Service may recommend delayed plantings to allow for natural vegetative recruitment and threatened and endangered species utilization when possible.
	USACE is willing to work with the Service and TPWD to determine the best window for planting based on the expert judgement of the staff and the conditions post-construction.
23.	If sand mounding proves to be a viable alternative, we recommend mound projects be placed in low energy wave environments, include wave protection measures (e.g. temporary erodible berms), and be constructed to mitigate wave fetch.
	Sand mounding was investigated as an alternative in the process and not found to be a viable alternative economically.
24.	Restoration efforts may negatively affect marsh habitat i.e. moving equipment necessary for restoration activities. If these impacts are deemed unavoidable and of a permanent nature, the Service recommends mitigation for any direct or indirect wetland impacts with full compensation.

USACE will work with TPWD and the Service to implement BMPs to minimize or avoid impacts during the construction process.
25. The Corps shall initiate coordination with NMFS regarding Essential Fish Habitat (EFH), sea turtle impacts, and mitigation issues within the project area.
USACE has coordinated with NMFS throughout the planning process of this project.
26. Cumulative effects from this and the Texas Coastal Study project must be considered when developing project features and mitigation plans. We recommend the sponsor along with the Corps work with the Texas Coastal Study to develop complimentary project features and geographically consistent mitigation and monitoring plans.
As part of the NEPA process the cumulative effects of projects in the foreseeable future are considered to the best of the analyst's ability. The plans of the Coastal Texas Study are still in flux to a certain degree at this point. During the PED phase USACE can work with the Coastal Texas project team to ensure our measures are complimentary to the greatest degree possible.
27. The Service supports acquisition, restoration and preservation of natural resources within the project area and is willing to assist the Corps in identifying suitable areas in need.
USACE would appreciate the support of the Service in this endeavor.
28. Should this project move to the design and construction phases, we recommend the Corps evaluate the project's effects on threatened and endangered species and other natural resources. We also recommend that the Corps utilize the IPaC system at http://ecos.fws.gov/ipac/and initiate any necessary consultation procedures pursuant to Section 7 of the Act.
This list has been generated and is included at the end of the Biological Assessment in Appendix A2 of the Integrated Feasibility Report – Environmental Assessment.
29. The Service understands that inclusion of restoration features on the Service lands in the proposed Study report does not obligate the Service to actively pursue construction or finance of those features. We also understand that the Corps is not seeking authorization or funding to construct those features because of policy constraints regarding construction of restoration features on Federal land not owned by the Corps. The marsh and beach features located on Service lands are projected to cost more than what is typically provided to the National Wildlife Refuge System for restoration. Therefore, we look forward to partnering with the Corps to find a solution that would allow the most comprehensive measures to be completed, including those on Service lands.
USACE understands the importance of these restoration features to the Service and would be happy to continue to work the Service to find ways to help them come to fruition.
30. All planning, design, or other construction-related activities (e.g., surveys, geotechnical borings, etc.) conducted on National Wildlife Refuges (NWRs) will require the Corps to obtain a Special Use Permit from the Refuge Managers of the McFaddin and Texas Point National Wildlife Refuges. Please contact the Refuge Managers Doug Head and Ernie Crenwelge at 409/971-2909 or by email at douglas_head@fws.gov and ernie_crenwelge@fws.gov.

The obtainment of Special Use Permits for work on the NWRs will be listed as a requirement in the USACE work plans and contract specifications for this project.
31. Work directly with TPWD managers for any restoration measures located within TPWD state parks or WMAs. For Sea Rim State Park, contact Nathan Londenberg, Park Superintendent at 409-971-2559 and for JD Murphree WMA, contact Michael Rezsutek, Project Leader, at 409-736-2551.
USACE will work with the listed personnel, or their replacements, during the PED phase for design and development of measures on TPWD property.
32. We recommend the Corps evaluate TSP measures with respect to the Coastal Barrier Resource Act of 1982 and coordinate as necessary.
The project footprint was overlain on the CBRS Mapper and the project is not within any System Units. While there are Otherwise Protected Areas within the project area, according to CBRA, no further coordination is needed.
33. We continue to encourage the Corps to pursue funding of restoration projects on NWR lands due to the extreme importance of protecting the beach and marsh habitats of Jefferson County.
USACE would be happy to continue to work with the Service to pursue funding opportunities for the restoration work, as we are in agreement as to the importance of this habitat.
34. Borrow pits for construction of wetland creation measures should be located to avoid and minimize direct and indirect impacts to vegetated wetlands. Borrow pit construction should also avoid the following: • avoid inducing wave refraction/diffraction erosion of existing shorelines • avoid inducing slope failure of existing shorelines • avoid submerged aquatic vegetation • avoid increased saltwater intrusion • avoid excessive disturbance to area water bottoms • avoid inducing hypoxia • avoid effects to threatened and endangered species and their habitats
USACE is willing to with the Service, TPWD, and other resource agencies to include appropriate BMPs in their work plans and contract specifications.
35. Wetland creation measures should avoid areas of dense submerged aquatic vegetation.
USACE is willing to include the Service and TPWD to determine locations of dense SAVs that should be avoided during the design phase.
36. The Corps should monitor ecosystem restoration features to document the degree of success achieved. We recommend the Service and other interested natural resource agencies be included in developing those monitoring criteria and in the review of subsequent monitoring information and reports.
USACE has developed a Monitoring and Adaptive Management Plan to determine the success of the restoration features (Appendix A9 of the Integrated Feasibility Report –

	Environmental Assessment). USACE is willing to include the resource agencies in further developing this plan during the PED phase.
37.	We recommend the Corps coordinate with the Service, TPWD, and other interested natural resource agencies during the PED and construction phases to evaluate and minimize impacts associated with construction traffic ingress and egress, and staging areas, spill plan etc.
	USACE is willing to with the Service, TPWD, and other resource agencies to include appropriate BMPs in their work plans and contract specifications.
38.	Conduct sediment pumping during the non-growing season periods to reduce possible salinity impacts on adjoining vegetation.
	As the economic benefits of this project are partially derived from coordinating the construction with the dredging cycle of the Sabine-Neches Waterway, scheduling of the sediment pumping to coincide with the non-growing season may not be feasible. USACE can work with the dredging contractors to schedule this work for that time period, but cannot guarantee it.
	Ecosystem Restoration Specific Recommendations
1.	To avoid saltwater entrapment impacts, the engineers are encouraged to design channels to provide drainage/water exchange, and avoid ponding of Gulf water effluent within or adjacent to the fill areas. Similarly, we recommend any ponds or enclosed non-fill areas have drainage channels (existing or man-made) to carry away Gulf water effluent and avoid concentration of salts.
	USACE is willing to with the Service and TPWD to design the channels appropriately so that excess ponding does not occur.
2.	To pump into eastern and western extremes of the designated fill area, the pipeline route should depart from that designated route only within the proposed fill area, and routed through unvegetated open water areas, to avoid affecting existing wetlands.
	USACE is willing to with the Service and TPWD to design the pipeline route to ensure that it doesn't impact existing wetlands.
3.	If funding is provided to the Service to construct restoration measures (marsh, beach, or breakwater) located on NWR lands outlined in the Study, the funding should be sufficient to cover the necessary administration, engineering, and design work for each restoration measure.
	USACE will work with its contractors, public or private, to ensure that sufficient funding is provided to cover all costs needed for project completion.

5.12 Monitoring and Adaptive Management

A Monitoring and Adaptive Management Plan (MAMP) has also been developed for 4Abu which provides a coherent process for making decisions in the face of uncertainty and increases the likelihood of achieving desired project outcomes based on the identified monitoring program.

The monitoring plan involves pre-construction/baseline data collection, during construction, and post-construction monitoring for five performance measures. Baseline monitoring will begin during PED prior to project construction and continue during construction when possible. Monitoring will continue until the trajectory of ecological change and/or other measures of project success are determined as defined by project-specific objectives. Once ecological success has been achieved, which may occur in less than ten years post-construction, no further monitoring would be performed. If ecological success cannot be determined within the ten-year post construction period of monitoring, any additional required monitoring would be the responsibility of the NFS. The estimated cost for implementing the monitoring plan is $552,000.

The Adaptive Management Plan addresses uncertainties associated with ecosystem function and how the ecosystem components of interest will respond to the restoration efforts in light of changing conditions (e.g. sea-level change is different than anticipated) or new information (e.g. surveys indicate the design needs modification in order to function properly). The MAMP establishes a feedback mechanism whereby monitored conditions will be used to adjust or refine construction or maintenance actions to better achieve project goals and objectives. The plan contains trigger values that informs the iterative process of implementing specified adaptive management measures to help achieve ecological success.

Costs for the adaptive management program were based on estimated level of effort and potential frequency of need. Only those actions which are most likely to be needed have associated costs. Measures included in the recommended plan have been successfully implemented with very similar designs within Jefferson County and throughout the coastal zone in Northern Texas and Western Louisiana; therefore, the desired outcomes are expected and reasonable based on experience. Some examples of management measures include: re-planting vegetation, invasive and nuisance plant control, erosion control, and re-grading. The likelihood that extreme measures, such as relocation of the breakwater structures, is very low. Other adaptive management measures that could help achieve ecological success may require significantly more modeling, design, and feasibility analysis than permitted with adaptive management. These include construction or modification of tidal exchange barriers (e.g. levees, dunes, or breakwaters) and introduction of freshwater flows. If this situation were to occur, additional studies, funding authorizations, or non-USACE endeavors may be required to address the deficiency. The current total estimate for implementing the adaptive management program is $2,027,000.

5.13 Construction and LERRD

Construction would be in accordance with USACE's regulations and standards. LERRD would be the responsibility of the non-Federal Sponsors. There is no anticipated Work in Kind associated with the construction of this project. Any other cost sharing requirements or agreements between USACE and the sponsors would be negotiated and contingent upon approval at the Assistant Secretary of the Army for Civil Works or appropriate level in accordance with applicable guidance and regulations.

5.14 Acquisition Strategy

The construction of the draft recommended plan involves a variety of work including dredging, pipeline construction for dredging and placement activities. This project will not impede navigation traffic on the GIWW or SNWW and will work in concert with regularly scheduled dredging activities in the region. Because of the infrequency of these activities, the project supports a phased initial nourishment and renourishment activities over a 50 year period. This variety supports dividing the construction into small parts that are achievable by specialty contractors like those that dredge. This approach should be considered during the PED phase.

It is assumed that the contracts would be fully funded allowing for such contractor acquisition. The request for proposal (RFP) will provide the government with the opportunity to generate key criteria upon which to select highly qualified contractors. Alternatively, a best-value approach could be utilized if the design team decides that particular aspects of the project foster innovative solutions by the contractor and allows the government to pay for any added value. Another option for an RFP is technically acceptable low price which blends some of the characteristics of the aforementioned acquisition methods. It allows acceptable (measured against established criteria) contractors to offer bids where the low bid is chosen among the pool of acceptable contractors.

5.15 Funding

Construction of the project is dependent on funds made available by Congress and non-Federal Sponsor funding capabilities. To conclude, Treasury funds are appropriated via the Congressional appropriations process.

District Recommendation

I propose the structural features designed to improve, preserve, and sustain ecological resources along the Texas coast identified as the Recommended Plan in the Jefferson County Ecosystem Restoration Feasibility Report and Integrated Environmental Assessment, proceed with implementation in accordance with the cost sharing provisions set forth in this report.

The recommendations contained herein reflect the information available at this time, and current Department of the Army, and U.S. Army Corps of Engineers policies governing formulation of individual studies and projects. The recommendations do not reflect the program and budget priorities inherent to the formulation of a national Civil Works construction program, nor the perspective of higher review levels within the Executive Branch of the U.S. Government. Consequently, the recommendations may be modified before they are transmitted to Congress as proposals for implementation funding. However, prior to transmittal to Congress, the sponsor, the State, interested federal agencies, and other interested parties will be advised of any modifications, and be afforded the opportunity to comment further.

Lars N. Zetterstrom
Colonel, U.S. Army
Commanding

Date 6 JUN 19

6 PUBLIC INVOLVEMENT, AGENCY CONSULTATION AND PUBLIC REVIEW

6.1 Public Involvement

A public notice was published to the SWG website and provided to a number of new media outlets on April 18, 2017 (Appendix E-1). The public notice informed the public of the initiation of a feasibility study and requested input on the study. A dedicated e-mail address for the study was set up and regularly monitored.

The DIFR/EA was released for a 30-day public review period beginning on June 27, 2018. The complete draft report was published to the SWG website. Public comments were accepted through July 27, 2018 by e-mail or mail. Two public comments were received during the comment period, neither of which were considered to impact the recommendation. The first comment was related to expanding ports, which is outside the scope of the study. The second comment was related to a concern that beach nourishment and other Gulf shoreline measures were not incorporated into the Recommended Plan. Shoreline measures were considered as part of other plans but were not selected based on discussions in Chapter 3.

6.2 Resource Agency Coordination

Significant resource agency coordination has been completed throughout the study process. Early in the study staff from USFWS (McFaddin National Wildlife Refuge and the Houston Ecological Services Office), GLO (Upper Coast Field Office), and TPWD (JD Murphree WMA) attended a workshop held in Galveston on January 31, 2017 in which the conceptual ecological model, objectives, opportunities, and constraints statements were refined and measures were developed or modified and screened where possible. Additional communication, via e-mail and telephone, with individuals identified as having significant knowledge of the study area and restoration needs continued throughout the study process.

A broader scope of resource agency involvement was sought through several webinars and an in-person workshop held in Galveston. A total of 14 agencies/divisions and 5 tribes received an invitation, dated April 3, 2017, to participate in the study and provide scoping comments (Appendix E-2). Two webinars were held on May 2, 2017 and May 30, 2017. A total of 28 individuals attended both webinars, with representation of 14 agencies/divisions. An in-person workshop was held June 5 and 6, 2017 in which 18 individuals, representing 8 agencies/divisions, attended in person or via webinar. A second in-person workshop was held on October 26 and 27, 2017 in which 6 agencies/divisions were represented. During each of the webinars/workshops, the cadre of resource agencies provided input into the study tasks done thus far and provided input, feedback and buy-in on assumptions, modeling methods, impacts, and benefits analyses.

All resource agencies that received the initial scoping meeting invite were provided a copy of the complete DIFR/EA on compact disc (CD) and informed of the availability of the report on the SWG website. A total of six agencies provided comments including from EPA Water Division—Wetlands Section, NMFS Habitat Conservation Division, TCEQ Intergovernmental Relations, Kickapoo Tribe of Oklahoma, EPA Compliance Assurance and Enforcement Division, and TPWD Coastal Fisheries Division. In general, comments received fell into two categories: (1) agreed with analysis in report and did not have any comment and/or (2) provided support for the study. Comments are provided in Appendix E-4.

6.3 Environmental Compliance Coordination

Coordination with the appropriate regulatory agency has been ongoing to ensure that each is in agreement with our effects determinations and that they have been made fully aware of the study, the potential impacts, and how the recommended plan is in compliance with the law. Official correspondence requesting information, providing compliance documentation, and response from the regulatory agency is available in Appendix A-1-5 and A-7. Additional correspondence was received from TPWD, which has been included in Appendix E-3.

6.4 USACE Project Delivery Team Members

Name	Position	Organization
Shakhar Misir	Project Manager	CE-SWG-PM-J
Natalie Garrett	Planner	CE-SWF-PER-P
Norman Lewis	Economist	CE-SWF-PEC-PE
Melinda Fisher	Biologist	CE-SWF-PEC-CC
Cris Michalsky	Engineer - Geotech	CE-SWG-ECE-S
Adam Tallman	Engineer – Cost	CE-SWG-EC-PS
Paul Hamilton	Engineer – Coastal Hydrologic	CE-SWG-EC-HB
David Clark	Environmental Protection Specialist	CE-SWF-PEC-TM
Seth Jones	Operations Manager	CE-SWG-OD-N
Nichole Schlund	Real Estate	CE-SWG-RES
James Purcell	Office of Council	CE-SWG-OC
Seth Sampson	Cultural Resources	CE-SWF-PEC
Kristin Shivers	GIS Analyst	CE-SWG-RD-C

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