U.S. Army Corps of Engineers

Galveston District
Southwestern Division

Sabine Pass to Galveston Bay, Texas Coastal Storm Risk Management and Ecosystem Restoration

Draft Integrated Feasibility Report – Environmental Impact Statement

September 2015

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DEPARTMENT OF THE ARMY
GALVESTON DISTRICT, CORPS OF ENGINEERS
P. O. BOX 1229
GALVESTON, TEXAS 77553-1229

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Coastal Storm Risk Management
and Ecosystem Restoration

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Environmental Impact Statement

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EXECUTIVE SUMMARY*

STUDY DESCRIPTION

This is a Draft Integrated Feasibility Report and Environmental Impact Statement (DIFR-EIS) examining coastal storm risk management (CSRM) and ecosystem restoration (ER) problems and opportunities within six counties of the upper Texas coast (Orange, Jefferson, Chambers, Harris, Galveston, and Brazoria Counties). Currently the study has identified and screened alternatives to address CSRM and ER, and is presenting a tentatively selected plan (TSP). This DIFR-EIS will undergo public review, policy review, Agency Technical Review (ATR), and Independent External Peer Review (IEPR). The U.S. Army Corps of Engineers (USACE) study team will respond to review comments, then present a recommended plan and develop a Final Integrated Feasibility Report and Environmental Impact Statement (FIFR-EIS).

STUDY PURPOSE AND SCOPE

The purpose of this report is to present the findings of the feasibility investigations and analyses conducted to determine if there is a Federal interest in potential CSRM and ER projects within the coastal areas of the six-county study area. The scope of the study was the subject of multiple vertical team meetings with Headquarters USACE (HQUSACE) in the early stages of formulation. This study is recognized as a critical effort that encompasses six counties (Orange, Jefferson, Chambers, Harris, Galveston, and Brazoria) along 120 miles of the upper Texas coast (Figure ES-1). Multiple options for study scope were considered for this extensive geographic area. It became apparent as the study team identified alternatives, that a feasibility-level evaluation of all the potential alternatives in the entire six-county study area would be difficult to accomplish and maintain compliance with the 3x3x3 Rule. This rule applies to feasibility studies and requires completion within 3 years and under $3 million, unless an exemption is approved by HQUSACE. Feasibility-level evaluation of all the potential alternatives in the six-county study in three years introduced risk that was too high and not acceptable for decision making. An exemption request was approved in a CECW-SWD memorandum dated February 25, 2014. The approval was granted to pursue a scope for this study that would take 3.8 years and cost $4.4 million, and address only feasibility-level evaluation of CSRM projects in two of the three regions originally identified for the study (Sabine, Galveston, and Brazoria). The exemption approved evaluation of the Sabine region, focusing on Orange and Jefferson Counties, and the Brazoria region, focusing on the Freeport area in Brazoria County. Because of cost and complexity, the decision was made to include only a programmatic assessment of potential CSRM projects in the Galveston region (Galveston, Harris, and Chambers Counties) and potential ER projects throughout the entire six-county study area. The programmatic assessment is a listing of future interim studies that have high potential for recommending CSRM and ER

projects with Federal interest. These studies could leverage previous and ongoing studies by others.

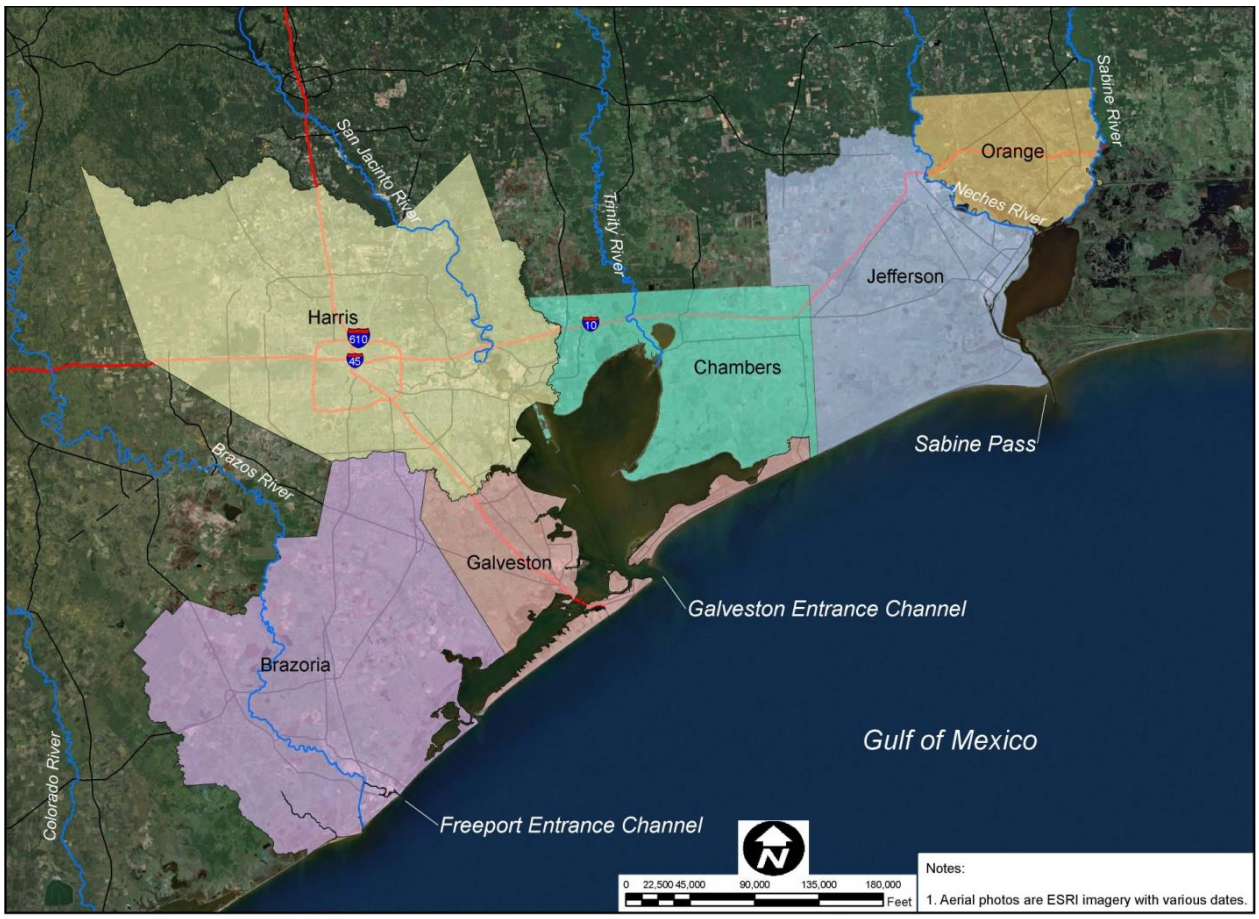

Figure ES-1: Sabine Pass to Galveston Bay Study Area

PROBLEMS AND OPPORTUNITIES

The study area has seen several major historical surge events in the past 120 years. The most notable is the 1900 Storm, which inundated most of the island city of Galveston, Texas, and adjacent areas on the mainland. The storm was responsible for over 8,000 deaths and up to $30 million in property damage. Most recently, Hurricane Rita in 2005 resulted in storm surge of 9.24 feet in Port Arthur, Texas, and just over eight feet in Sabine Pass. Hurricane Ike in 2008 produced storm surges from 14 feet near Sabine Pass with 11 to 12 feet across Sabine Lake. Port Arthur was spared the storm surge thanks to its 14- to 17-foot seawall. However, the remaining southern half of Jefferson County was inundated, with estimated high water marks reaching 18 to 19 feet to the south and east of High Island.

Both hurricanes resulted in significant impacts on coastal shorelines, marsh, and forested wetlands. Shorelines eroded in some areas, while others were covered with several feet of sediment. Thousands of acres of coastal marsh were inundated with high salinity Gulf waters, scouring and killing marsh types that were not tolerant of the higher salinity. In addition to inundating marshes near the coast, tidal surges resulted in significantly increased salinities in large areas of swamp and freshwater marsh in the Sabine region for months after the storms.

Specific Problem and Opportunity statements are described in the main body of this DIFR-EIS, in Chapter 4. This study identifies a TSP for implementation to address the storm surge flooding in the study area. Considering the recent damages from Hurricane Ike, the population and infrastructure of the region, and the national significance of the economic and environmental resources within the region, there is a Federal interest for implementing a project. A variety of alternatives were analyzed in the study, including the "No Action Alternative." The alternatives were measured against planning criteria developed for the study that align with USACE policies.

PLANNING OBJECTIVES

The objectives listed below were developed from problem and opportunity statements and used to guide the plan formulation for the TSP. The alternatives were measured throughout the study using the measuring criteria and in greater detail as the alternative screening progressed. The planning objectives were developed to align with the "four accounts" listed in the Economic and Environmental Principles for Water and Related Land Resources Implementation Studies. These "principles" were established pursuant to P.L. 89-80, as amended. The four accounts are established to facilitate evaluation and display of effects of alternative plans. The four accounts are: 1) National Economic Development (NED); 2) Environmental Quality (EQ); 3) Regional Economic Development (RED); and 4) Other Social Effects (OSE).

- Objective 1: Reduce economic damages to business, residents, and infrastructure for the Sabine and Brazoria region for the 50-year period of analysis.
- Objective 2: Reduce risk to human life from storm surge impacts for the Sabine and Brazoria region for the 50-year period of analysis.
- Objective 3: Maintain and/or restore coastal habitat that contributes to storm surge attenuation where feasible for the 50-year period of analysis.
- Objective 4: Enhance energy security and reduce economic impacts of petrochemical supply-related interruption for the Sabine and Brazoria regions for the 50-year period of analysis.

- Objective 5: Reduce risk to critical infrastructure (e.g., medical centers, ship channels, schools, transportation) for the Sabine and Brazoria regions for the 50-year period of analysis.
- Objective 6: Identify opportunities to enhance functionality of existing hurricane protection systems including evaluation of impacts due to sea level rise for the 50-year period of analysis.

Environmental policies require that fish and wildlife resource conservation be given equal consideration with other study purposes in the formulation and evaluation of alternative plans. In the evaluation process, care was given to preserve and protect significant ecological, aesthetic, and cultural values, and to conserve natural resources. Alternative plans were formulated to reduce the risk of damages from coastal storms, as well as avoid environmentally significant resources. Where impacts could not be avoided, impacts were quantified and a mitigation plan was formulated. A mitigation estimate was developed and included as a project cost.

The following constraint was developed from the problem and opportunity statements and used to guide the plan formulation for this study. Reducing life-safety risk is a primary objective of the study; however, careful evaluation of alternatives is required to ensure that structural plans do not increase risk. As such, features that increase risk to human life from storm surge impacts in the Sabine and Brazoria regions for the 50-year period of analysis will not be considered in the TSP.

FORMULATION OF ALTERNATIVE PLANS

Nonstructural and structural measures were considered as part of the study analysis and were developed to address study objectives. The nonstructural measures considered include buyouts or relocations, as well as identification of conservation areas. Floodplain management and emergency planning were also considered. The structural measures include new coastal and inland structural barriers, reconstruction of existing and construction of new regional hurricane protection systems, local surge protection systems, raising roads as surge or overwash protection barriers, Gulf shoreline protection (beach and dune restoration, nearshore breakwaters, chenier ridge restoration), Gulf Intracoastal Waterway (GIWW) erosion protection, marsh restoration, and salinity/water control structures.

Through the initial scoping, and performance of a SMART Planning Charette (Charette), the full Vertical Team (USACE District, Division, Headquarters, and Office of Water Project Review) worked through an abbreviated version of the six-step planning process, considering a full array of measures and alternatives, and then formulated comprehensive (regional) plans to include in the "Initial Alternative Plans Array." This resulted in a list of about 75 initial measures that

served as the building blocks of alternative plans. These nonstructural and structural measures were considered as part of the study analysis and were developed to address study objectives.

The initial measures were screened to determine if they adequately addressed the problems and objectives of this study. The remaining measures were then formed into arrays of alternatives plans, which were screened in three distinct iterations (increasing in level of detail as the screening progressed) to determine the most effective alternatives including:

- Initial Array of Alternatives;
- Evaluation Array of Alternatives; and
- Final Array of Alternatives.

In the Initial Array of Alternatives phase, comprehensive alternative plans were formulated for each of the three regions in the six-county study area. The Initial Array of Alternatives included eleven alternatives for the Sabine Region, nine alternatives for the Galveston Region and five alternatives for the Brazoria Region, for a total of 25 alternatives considered in the Initial Array of Alternatives. The Initial Array of Alternatives were screened using three quantitative criteria (economic benefits, environmental benefits, and implementation costs) and one qualitative criterion (environmental impacts). The screening process led to the identification of the Evaluation Array of Alternative Plans, which is comprised of ten alternatives (three from Sabine Region, four from Galveston Region, and three from Brazoria Region) to be evaluated in more detail.

The Evaluation of Alternatives was used as a decision point to determine whether the data collected and utilized for this analysis are sufficient to make the determination of which alternative "Gate" or "No-Gate" in the Sabine Region to carry forward for detailed analysis. It was estimated the plans would provide roughly the same amount of benefits. Consideration was given to a variety of factors including engineering, economics, costs, and environmental impacts for the Gate and No-Gate Alternatives; however, cost of the Gate Alternative is approximately $865 million more expensive than the No-Gate Alternative. Therefore, the Gate Alternative was dropped from further consideration in the study.

Recent USACE planning modernization has resulted in the 3x3x3 guidelines under which this study was developed. Therefore, a scope was developed for completion of the study that would evaluate a final array of structural and non-structural alternatives in the six-county study area and that would be completed in 3 years for $3 million. The USACE Galveston District (SWG) developed an option for completing the study in a manner that was low to moderate risk and requested an exemption from the 3x3x3 guidelines to complete this study. The recommendation was to pursue a $4.4 million programmatic assessment of the six-county study area and focused

evaluation on two sub-regions, Sabine and Brazoria, within the study area as the first interim study for CSRM project implementation. This first interim feasibility study would be followed by future studies recommending CSRM projects in the Galveston region, as well as ER opportunities throughout the entire six-county region. Future feasibilities will leverage studies, data, and models currently under development by others in the Galveston region. The exemption request was approved by HQUSACE and the recommended focus of the study in the Sabine and Brazoria regions continued into the Final Array of Alternatives evaluation.

In accordance with the exemption request approval, the Sabine and Brazoria CSRM alternatives were carried forward into detailed feasibility analysis. The Final Array of Alternatives is presented in Table ES-1. This list presents the project area for the final array. The "Optimization Alternatives" embedded in the project areas listed in Table ES-1 are the actual final array evaluated and compared to determine the TSP.

Table ES-1: Tentatively Selected Plan (TSP) Separable Elements

Initial Array Alternative Name	TSP Separable Elements / Description
No Action	No Action or Future Without Project (FWOP)
S5	Orange-Jefferson CSRM
S5	Port Arthur and Vicinity CSRM
B2	Freeport and Vicinity CSRM
S11 & B5	Brazoria and Sabine Nonstructural

This DIFR-EIS presents the results of the alternatives analysis and selection of the TSP through an iterative process based on economic, engineering, social, and environmental factors. From evaluation of 59 Optimization Alternatives within 20 Alternative Reaches, the performance of Final Array of Alternatives was measured, then evaluated and compared against each other to determine a TSP. The evaluation included a comparison of the future without-project condition (FWOP) and the with-project condition.

FUTURE WITHOUT-PROJECT CONDITION

Before the Final Array of Alternatives were evaluated, additional details of the future without-project conditions were gathered for the project areas. Based on the evaluation of the FWOP conditions, there is the potential for significant economic damages in the Orange-Jefferson CSRM, Port Arhur and Vicinity CSRM, and Freeport and Vicinity CSRM project areas. There are also concerns for life-safety, damages to critical infrastructure, sea level changes, and impacts on significant environmental resources. Opportunities to provide life-safety benefits, and other non-traditional secondary or ancillary economic benefits were identified, including

preventing disruptions in business and increases in reducing disruption to significant industrial and manufacturing facilities located in the project area.

FINAL ARRAY EVALUATION RESULTS

The Optimization Alternatives were evaluated in detail, then compared against each other to identify which plan contributes most to the objectives. The Optimization Alternatives were evaluated for the NED objectives. Life-safey, critical infrastructure, and consideration of RSLC were evaluated qualitatively. The decision criteria for selecting a TSP at this point in the study was based on building a plan for each project area that reasonably maximized net benefits (Objective 1 for the study) from the Final Array of Alternatives. The current TSP is the NED plan for each project area and only considers economics as the decision criteria. The TSP includes the following features:

Orange-Jefferson CSRM

- Orange 3 New Levee (11-foot)
- Beaumont A New Levee (12-foot)
- Jefferson Main New Levee (11-foot)

Port Arthur and Vicinity CSRM

- 8-10 ft I-Wall Raise (1-foot)
- Closure Structure Raise (1-foot)
- I-Wall Raise Near Valero (1-foot)
- I-Wall Raise Near Tank Farm (1-foot)

Freeport and Vicinity CSRM

- Dow Barge Canal Gate Structure
- Oyster Creek Levee Raise (1-foot)
- East Storm Levee Raise (1-foot)
- Freeport Dock Floodwall Raise (1-foot)
- Old River Levee Raise at Dow Thumb (1-foot)
- Tide Gate I-Wall Raise (1-foot)

RECOMMENDED PLAN

Based on the planning objectives and USACE policy, the TSP is likely to be considered the Recommended Plan as listed above. This does not preclude a decision to refine or alter the TSP

at the Agency Decision Milestone (ADM) based on responses from public, policy, and technical reviews of this DIFR-EIS, specifically for the Orange-Jefferson CSRM. Compelling factors exist to support a decision to select a plan at least one foot higher than the NED Plan based on economics (the higher plans provides more net benefits), life-safety (the lower the probability of flood event damaging property generally results in lower risk to loss of life), critical infrastructure (major oil refineries that could produce significant impacts to local, regional, and the national economy), and RSLC (a resilient project would be cheaper to build it now rather than retro-fit it later). A final decision will be made at the ADM following the reviews and higher-level coordination within USACE to select a plan for feasibility-level design and recommendation for implementation. The decision made, ie., NED versus one foot higher, will be documented in the FIFR-EIS. A supplemental DIFR-EIS would not likely be produced unless there are substantial design changes that significantly alter environmental impacts. Coordination with the natural resource agencies will continue throughout the study process as required by the Fish and Wildlife Coordination Act.

ENVIRONMENAL COMPLIANCE

The TSP would have significant environmental impacts and, therefore, an EIS is being prepared and integrated with the feasibility report. The Notice of Intent to file the EIS was published in the Federal Register on November 24, 2014. The U.S. Fish and Wildlife Service (USFWS) actively participated the impacts evaluation and environmental modeling, and is preparing a draft Fish and Wildlife Coordination Act Report; their preliminary recommendations have been incorporated into the draft report. USACE prepared a Draft Biological Assessment (BA) that will be submitted to USFWS and National Marine Fisheries Service (NMFS) for review. The BA determined that the TSP would have no effect on listed species that may occur in the project area. USACE is proposing to execute a Programmatic Agreement among USACE, the Texas State Historic Preservation Officer (SHPO), and any non-Federal sponsors to address the identification and discovery of cultural resources that may occur during the construction and maintenance of proposed or existing facilities. There is a potential for new construction and improvements to existing structures to cause effects on historic properties; however, the numbers of properties that may be affected are not extensive. Intensive cultural resources investigations to identify and evaluate any historic properties within proposed construction areas will be conducted prior to construction. The DIFR-EIS will be complete for release to the public following a successful TSP meeting with the vertical team.

PUBLIC COORDINATION

Extensive public scoping, stakeholder communication, and resource agency coordination have been maintained throughout development of the TSP. Four scoping meetings were held in early

2012, which assisted identifying CSRM problems and ER opportunities in the original six-county study area. Two stakeholder briefings were held in the spring of 2014 that focused primarily on communicating the goals and progress of the study with local governments and agencies. Resource agency meetings were held in 2013 and 2014 to update them on the progress of the study, and intensive WVA modeling meetings were held through the first half of 2015 to model impacts of the Orange-Jefferson CSRM Plan. Continuous contact has been maintained with outside organizations that have been working to address the same problems as those addressed by this study. In particular, close communication has been maintained with the team at Texas A&M Galveston, which has been working to develop the Ike Dike proposal, the Severe Storm Prediction, Education and Evacuation from Disasters (SSPEED) Center (a consortium of several universities headquartered at Rice University in Houston) which has been assessing a number of other CSRM, ER and recreation initiatives for the Galveston Bay region, and the Gulf Coast Community Protection and Restoration District (GCCPRD) which is preparing a report evaluating CSRM opportunities in the six-county study area.

The majority of the public and agency comments pertained to the Galveston Bay Region and to ecosystem restoration opportunities in general, and are summarized in the report. In the Sabine region, the majority of comments pertained to the need for storm surge protection in Orange County. Industrial interests and the general public emphasized the need to protect petro-chemical facilities in the area. The general public was also concerned about maintaining or improving evacuation routes during storm emergencies. County governments, non-governmental organizations (NGOs), and the public were interested in maintaining and restoring marsh systems in the area. In the Brazoria region, the majority of comments related to the need to address hydrologic/erosion impacts of existing navigation projects, and the need for restraint in the construction of structural systems that would encourage more development. Resource agencies and NGOs urged restoration of natural coastal shoreline features and working with nature and natural processes, as well as protecting shoreline features that provide natural erosion protection.

NON-FEDERAL SPONSOR SUPPORT

The existing Port Arthur and the Freeport HFPPs local sponsors have expressed interest in cost sharing for the TSP identified for the Port Arthur and Vicinity CSRM and the Freeport and Vicinity CSRM. The local sponsors responsible for operation and maintenance are the Jefferson Country Drainage District No. 7 and the Velasco Drainage District (VDD), respectively. The local sponsor for Orange-Jefferson CSRM would be Orange County and Jefferson County. They have also expressed interest in cost share for construction.

AREAS OF CONTROVERSY AND UNRESOLVED ISSUES

There are risks that the TSP will require refinements and change because of technical, policy, and public comments on the DIFR-EIS. If significant changes to the TSP are needed, environmental impacts will be reevaluated, and additional NEPA review may be needed. There no other known controversies or unresolved issues with the study results at this time.

MAJOR FINDINGS AND CONCLUSIONS

A diligent effort was made to coordinate and collaborate with resource agencies, local industry, and environmental interests throughout the study process and public meetings. Environmental resource concerns were addressed early in the study process to ensure that adverse impacts are avoided to the maximum extent practicable. The recommendations contained herein reflect the information available at this time. To ensure that all applicable laws and policies are addressed for the TSP, this DIFR-EIS will undergo public, policy, and technical reviews. The study team will address any outstanding issues raised during the review and confirm the analysis in this DIFR-EIS and recommendations to move forward with development of the feasibility-level design and completion of a FIFR-EIS.

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List of Acronyms

AAHU	Average Annualized Habitat Units
ACE	Annual Chance Exceedence
ADCIRC	Advanced Circulation
ADM	Agency Decision Milestone
APE	Area of Potential Effects
AQCR	Air Quality Control Region
BA	Biological Assessment
BCR	Benefit-to-cost ratio
BiOp	Biological Opinion
BPA	Beaumont-Port Arthur
BUDM	Beneficial Use of Dredged Material
CAA	Clean Air Act
CAR	Coordination Act Report
CBBEP	Coastal Bend and Bays Estuary Program
CBRA	Coastal Barrier Resources Act
CEQ	Council on Environmental Quality
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
cfs	Cubic feet per second
CO2	Carbon dioxide-equivalent
CO2e	Carbon dioxide-equivalent
CSRM	Coastal Storm Risk Management
CWA	Clean Water Act
CY	Cubic yards
CY/YRr	Cubic yards per year
dBA	Logarithmic A-weighted decibel
DIFR-EIS	Draft Integrated Feasibility Report and Environmental Impact Statement
EC	Engineer Circular
EFH	Essential fish habitat
EIS	Environmental Impact Statement
EJ	Environmental Justice
ETN	Emergency Tracking Network
EOP	Environmental Operating Principles
EO	Executive Order
EPA	U.S. Environmental Protection Agency
EQ	Environmental quality
ER	Ecosystem Restoration
ERDC	Engineer Research and Design Center

ºF	Degrees Fahrenheit
FCSA	Feasibility Cost Sharing Agreement
FEMA	Federal Emergency Management Agency
FIFR-EA	Final Integrated Feasibility Report and Environmental Impact Statement
FPPA	Farmland Protection Policy Act
FM	Farm to Market Road
FWOP	Future Without-Project
FY	Fiscal year
GHG	Greenhouse Gases
GIWW	Gulf Intracoastal Waterway
GLO	General Land Office
H&H	Hydraulics and Hydrology
HFPP	Hurricane Flood Protection Project
HGB	Houston, Galveston and Brazoria Airshed
HPTRM	High performance turf reinforcemente mattress
HSC	Houston Ship Channel
HTRW	Hazardous, Toxic and Radioactive Waste
HQUSACE	Headquarters U.S. Army Corps of Engineers
IDC	Interest during construction
IPCC	Intergovernmental Panel on Climate Change
LERRs	Lands, easements, rights-of-way, and relocations
LF	Linear Feet or Foot
LNG	Liquid Natural Gas
MBTA	Migratory Bird Treaty Act
MCACES	Micro Computer Aided Cost Engineering System
MCY	Million cubic yards
MLLW	Mean lower low water
MLT	Mean low tide
MOVES	Motor Vehicle Emissions Simulator
MPRSA	Marine Protection, Research, and Sanctuaries Act
MSA	Metropolitan Statistical Area
MSL	Mean Seal Level
NAAQS	National Ambient Air Quality Standards
NAICS	North American Industry Classification System
NAVD	North American Vertical Datum
NED	National Economic Development
NEPA	National Environmental Policy Act
NFS	Non-Federal Sponsor
NGO	Non-Governmental Organizations

NMFS	National Marine Fisheries Service
NRHP	National Register of Historic Places
NOAA	National Oceanic and Atmospheric Administration
NOx	Nitrous oxides
NNBF	Natural and nature-based features
NRC	National Research Council
NRCS	Natural Resource Conservation Service
NSI	National Structure Inventory
NWR	National Wildlife Refuge
O&M	Operations and maintenance
OSE	Other social effects
P&G	Principles and Guidelines
PA	Placement area
PCB	Polychlorinated biphenyl
PDT	Project Delivery Team
PED	Preconstruction Engineering and Design
PGL	Planning Guidance Letter
P.L.	Public Law
PMP	Project Management Plan
PSD	Prevention of Significant Deterioration
RCRA	Resource Conservation and Recovery Act
RED	Regional economic development
RSLC	Relative sea level change
RSM	Regional Sediment Managment
SIP	State Implementation Plan
SAV	Submerged aquatic vegetation
SHPO	State Historic Preservation Officer
SOC	Species of Concern
SPR	Strategic Petroleum Reserve
SNWW	Sabine-Neches Waterway
SWL	Still Water Level
TCEQ	Texas Commission on Environmental Quality
TCMP	Texas Coastal Management Program
TEEX	Texas Engineering Extension Service
TPWD	Texas Parks and Wildlife Department
TWDB	Texas Water Development Board
TxDOT	Texas Department of Transportation
US	United States
USACE	United States Army Corps of Engineers

USCG	U.S. Coast Guard
USDA	U.S. Department of Agriculture
USEPA	U.S. Environmental Protection Agency
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
VDD	Velasco Drainage District
VE	Value Engineering
VOC	Volatile organic compounds or
WMA	Wildlife management areas
WRRDA	Water Resources and Reform Development Act

1 STUDY INFORMATION

1.1 INTRODUCTION

This is a Draft Integrated Feasibility Report and Environmental Impact Statement (DIFR-EIS) examining coastal storm risk management (CSRM) and ecosystem restoration (ER) opportunities within six counties of the upper Texas coast (Orange, Jefferson, Chambers, Harris, Galveston, and Brazoria Counties). Report sections required for compliance with the National Environmental Policy Act (NEPA) are indicated with an asterisk following the section heading. The Feasibility Cost Sharing Agreement (FCSA) for this study was signed on January 10, 2013, with the non-Federal sponsor, the Texas General Land Office (GLO). Currently, the study has identified and screened alternatives to address CSRM and ER, and is presenting a tentatively selected plan (TSP). This DIFR-EIS will undergo public review, policy review, Agency Technical Review (ATR), and Independent External Peer Review (IEPR). The U.S. Army Corps of Engineers (USACE) study team will respond to review comments, then present a recommended plan and develop a Final Integrated Feasibility Report and Environmental Impact Statement (FIFR-EIS).

1.2 STUDY AUTHORITY

1.2.1 General Authority

Authorization for the study is derived from a resolution from the Committee on Environmental and Public Works dated June 23, 2004, entitled "Coastal Texas Protection and Restoration Study".

> *By resolution dated June 23, 2004 entitled "Coastal Texas Protection and Restoration Study", the Committee on Environment and Public Works, U.S. Senate has requested that in accordance with Section 110 of the Rivers and Harbors Act of 1962 the Secretary of the Army develop a comprehensive plan for severe erosion along coastal Texas for the purposes of shoreline erosion and coastal storm damages, providing for environmental restoration and protection, increasing natural sediment supply to coast, restoring and preserving marshes and wetlands, improving water quality, and other related purposes to the interrelated ecosystem along the coastal Texas area.*

The study fits into the overall concept of the authorization to conduct an integrated and coordinated approach to locating and implementing opportunities for CSRM and ER. The purpose of the study is to recommend for Congressional approval a regional CSRM and ER project that encompasses the six coastal counties of the upper Texas coast between Sabine Pass and Galveston Bay. Pursuant to NEPA, an EIS will be integrated into the report.

1.2.2 Additional Study Guidelines

The request for re-scoping the Sabine Pass to Galveston Bay Shoreline Erosion Feasibility Study was granted November 21, 2011. A Planning Charette was performed in August 2012. Memorandums were prepared for In-Progress Reviews (IPR) throughout the study to document discussions with the vertical team and for input into the decision log and decision management plan. The documents provided guidance to the study team as the study progressed. Most importantly, an exemption approval to the 3x3x3 Rule was provided in a CECW-SWD memorandum, dated February 25, 2014. The memorandum provided guidance on the scope of the study. This is discussed further in the next section, "Study Purpose and Scope."

1.3 STUDY PURPOSE AND SCOPE*

The purpose of this report is to present the findings of the feasibility investigations and analyses conducted to determine if there is a Federal interest in potential CSRM and ER projects within the coastal areas of the six-county study area. This study is an interim response to the "Coastal Texas Protection and Restoration Study," authority. Originally, the study was intended to develop recommendations for regional CSRM and ER projects for Congressional approval across a study area encompassing six counties along the upper Texas coast between Sabine Pass and Galveston Bay. Because of a 3x3x3 Rule exemption approved February 25, 2014, the study scope was revised to focus full feasibility planning efforts on CSMR projects in the northern (Orange and Jefferson) and southern (Brazoria County) parts of the study area. Accordingly, the feasibility study effort described here has focused on CSRM recommendations for the Sabine Region (Orange and Jefferson Counties) and the Brazoria Region (the Freeport metropolitan area in southern Brazoria County). An FCSA amendment was executed on March 9, 2015, to modify the scope of the study.

In the exemption approval, it was agreed that this report would present a programmatic overview of CSRM problems and opportunities in the central Galveston region (Galveston, Harris, and Chambers Counties) and a programmatic assessment of ER opportunities for the entire six-county study area. Using work already accomplished to date, the programmatic assessment is a listing and screening of alternatives identified as having high potential to demonstrate Federal interest and result in successful CSRM and ER projects. Potential CSRM and ER measures are

described and illustrated in individual measure sheets presented in Appendix A. The measures were evaluated, combined into potential alternatives, and screened as explained in Appendix B. The alternatives evaluated include an extensive list of CSRM alternatives for Galveston Bay and ER alternatives for the entire six-county area. Future feasibility studies could leverage this work and ongoing work by others to develop and recommend future CSRM or ER projects. In addition, these alternatives could be used to develop projects that could be completed under other existing authorities. This EIS could also serve as a vehicle from which future Environmental Assessments of the evaluated alternatives could be tiered.

1.4 NON-FEDERAL SPONSOR

The USACE Galveston District was responsible for the overall management of the study and the report preparation. As the non-Federal sponsor of the study, the GLO was actively involved throughout the study process. The GLO would not be the implementation sponsor. The existing Port Arthur and the Freeport HFPPs local sponsors have expressed interest in cost sharing for the TSP identified for the Port Arthur and Vicinity CSRM and the Freeport and Vicinity CSRM. The local sponsors responsible for operation and maintenance are the Jefferson Country Drainage District No. 7 and the Velasco Drainage District (VDD), respectively. The local sponsor for Orange-Jefferson CSRM would be Orange and Jefferson Counties. They have also expressed interest in cost share for construction.

1.5 STUDY AREA

The study area encompasses six coastal counties of the upper Texas coast (Figure 1-1). Over five million people reside in the six counties, which includes the fourth largest U.S. city (Houston), and three other metropolitan areas (Beaumont/Port Arthur/Orange, Galveston/Texas City, and Freeport/Surfside). The population of the counties is projected to increase to over nine million within the next 50 years. In addition to the population at risk, three of the nine largest oil refineries in the world, 40 percent of the nation's petrochemical industry, 25 percent of the nation's petroleum-refining capacity, and three major U.S. seaports based on tonnage (Port of Houston, Port of Beaumont, and Port Freeport) are also located in the study area. The growing population, communities, and nationally significant industries are severely vulnerable to risks from coastal storm events. Approximately 2.26 million people across the study area live within storm-surge inundation zones, and estimates for a one-month closure of the Houston Ship Channel (HSC) alone are upwards of $60 billion in damages to the national economy. All of these characteristics of the study area are important to note from a planning and environmental setting perspective; however, the six-county study area was refined in the study process, which ultimately focused on direct damages to structures in an economic evaluation.

The study area was broken down into regions. The Sabine region includes the Sabine Lake system and Gulf shoreline from Sabine Pass to High Island and the Sabine-Neches Waterway, serving the Ports of Beaumont, Port Arthur, and Orange. The Galveston region includes all of the Galveston Bay system including the Gulf shoreline from High Island to San Luis Pass and Bolivar Peninsula. The Houston-Galveston Navigation System provides access to the Ports of Galveston, Texas City, and Houston. The Brazoria region includes the Brazos River system and the Gulf shoreline in Brazoria County, as well as the Freeport Harbor Channel (FHC), serving Port Freeport. The major landmarks listed above are noted in Figure 1-1 to show general locations of the regions. All three regions include heavily industrialized areas of strategic importance to the nation, as well as navigation channels, including the Gulf Intracoastal Waterway (GIWW), that are critical infrastructure.

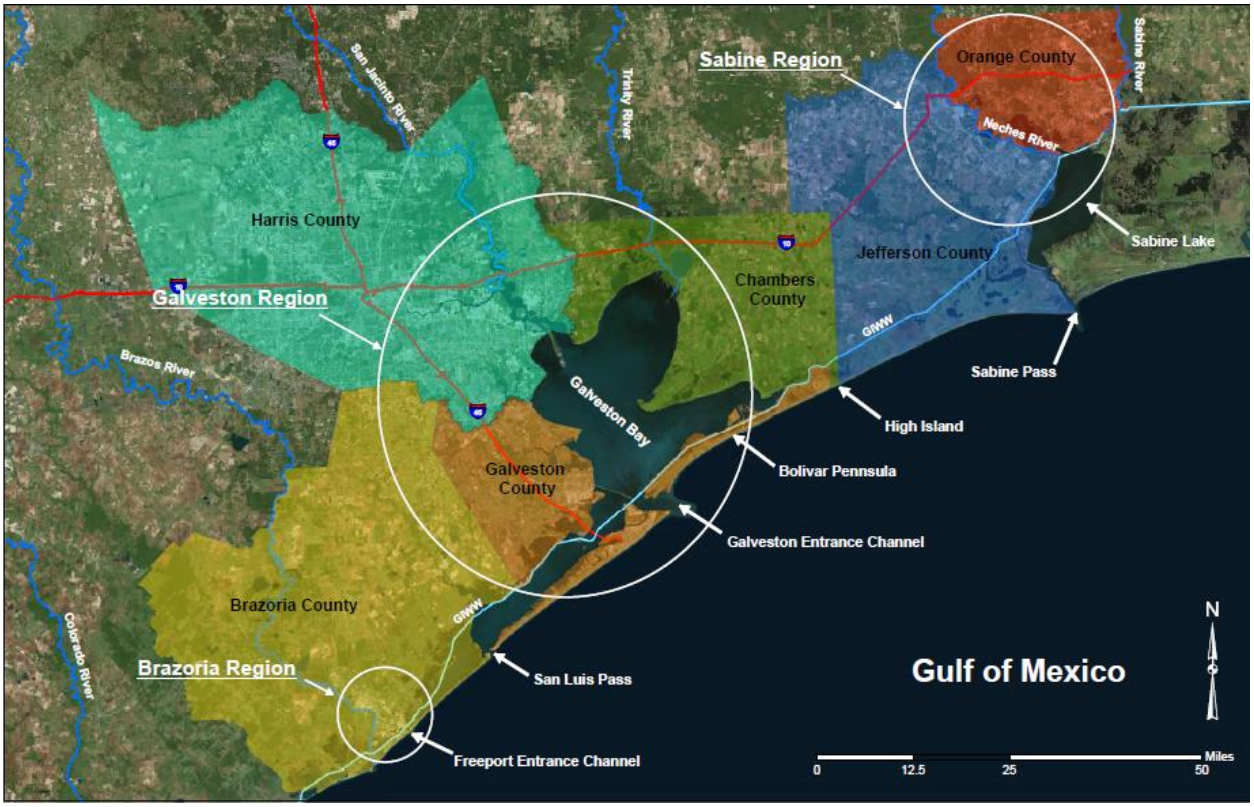

Figure 1-1: Sabine Pass to Galveston Bay, Texas Study Area

1.6 PROJECT AREA

The regions were refined in the study within the Sabine and Brazoria regions located in Orange, Jefferson, and Brazoria Counties into project areas. These project areas are focal points where the study team identified alternatives. The geographical extent of the study was large at the beginning of the study. The project areas were not defined until the "Final Array of

Alternatives" was developed; therefore, the project areas are defined in the future without-project (FWOP) section where important details of resources were investigated to define the FWOP. The following represent the project areas: Senators John Cornyn and Ted Cruz, and Representatives Randy Weber (District 14), Sheila Jackson Lee (District 18), Pete Olson (District 22), Gene Green (District 29), and Brian Babin (District 36).

1.7 PROJECT DATUMS

All elevations referred to in this report, unless specifically noted otherwise, are based on the North American Vertical Datum of 1988 (NAVD 88). All depths used in this report are at Mean Lower Low Water (MLLW) datum unless otherwise specified.

1.8 MAJOR HISTORICAL SURGE EVENTS IN THE STUDY AREA

The study area has seen several major historical surge events in the past 120 years. The storm surge levels in this section are presented in Mean Sea Level (msl). The most notable is perhaps the 1900 Storm, which inundated most of the island city of Galveston, Texas, and adjacent areas on the mainland. The storm was responsible for over 8,000 deaths and up to $30 million in property damage. Storm surge values for Jefferson and Orange Counties are not available (Weems).

Other major events include the 1915 Storm, which made landfall across western Galveston Island and, due to its large size, resulted in storm surge of 16 feet in Galveston, partially ameliorated by the newly built 17-foot Galveston Seawall, and a surge of 9 to 11 feet across coastal areas of Jefferson and Orange Counties. Hurricane Audrey made landfall from Sabine Pass to Cameron in June 1957. Storm surge heights exceeded 6 feet in coastal areas north of Galveston, with storm surge of 8 to 10 feet recorded across eastern Jefferson and Orange Counties. Hurricane Carla (1961) made landfall across the Central Texas coast and caused 7- to 8-foot storm surge across coastal Jefferson and Orange Counties.

In 1983 during Hurricane Alicia, Baytown, Texas, had 10- to 12-foot tides, with Morgan City, Texas, seeing the highest tides at 12.1 feet. Hurricane Bonnie (1986) was a very small Category 1 hurricane that made landfall between High Island and Sea Rim State Park in Jefferson County. Storm surge was 6 to 7 feet across Jefferson County. Hurricanes Chantal and Jerry (1989) were very small Category 1 hurricanes that made landfall at High Island and Galveston, respectively, and caused storm surge values of 4 to 5 feet across Jefferson County.

Tropical Storm Frances in 1998 made landfall across the central Texas coast. Nearly every road in Sabine Pass was underwater. Highway 87 flooded south of Port Arthur to Sabine Pass, and

north of Port Arthur to Bridge City. Many locations further inland across western Jefferson County were also underwater. The extensive flooding was due to tides running 3.5 to 5 feet for 2.5 days.

Hurricane Rita in 2005 resulted in storm surge of 9.24 feet in Port Arthur, Texas, and just over 8 feet in Sabine Pass. Hurricane Ike in 2008 produced storm surges from 14 feet near Sabine Pass with 11 to 12 feet across Sabine Lake. Port Arthur was spared the storm surge thanks to its 14- to 17-foot seawall. However, the remaining southern half of Jefferson County was inundated, with estimated high water marks reaching 18 to 19 feet to the south and east of High Island (Southeast 2013).

Hurricane Ike struck the upper Texas coast in 2008 and was the third-costliest storm in U.S. history, causing an estimated $29 billion in property damage. Impacts on an eight-county region's economy have been estimated at $142 billion over the four yearly quarters following the storm.

1.9 HISTORY OF THE INVESTIGATION

Investigation of surge damage impacts in the Galveston and Jefferson County region began in 2004 after the initiation of a Feasibility Study with the intent of evaluating plans to develop CSRM and ER features. The team had completed development of the expected condition of the area if no action were taken over a 50-year period. Almost immediately after completion of that effort, the region was impacted by Hurricane Ike. The study was put on hold at that time and the determination was made in late 2011 to rescope the study to include surge reduction measures for a six-county region to include Orange, Jefferson, Chambers, Galveston, Harris, and Brazoria Counties.

This study began under the 3x3x3 guidelines developed under the recent USACE planning modernization. Under these guidelines, planning studies are limited to a duration of 3 years and cost of $3 million dollars, and are managed through a 3-tier vertical team (VT). These planning guidelines were revised to emphasize risk-based decision-making and early vertical team engagement while further developing and enhancing our planning capability.

The team held four scoping meetings in early 2012. A total of 285 distinct ideas were collected and these were collated and screened by the team to a detailed list of measures. These measures were considered during the SMART (Specific, Measurable, Attainable, Risk Informed, and Timely) Planning Charette held August 6 through 10, 2012.

At the Charette, the full Vertical Team (USACE District, Division, Headquarters, and Office of Water Project Review) worked through an abbreviated version of the six-step planning process, considering a full array of measures and alternatives, and then formulated comprehensive (regional) plans to include in the Initial Alternative Plans Array. After the Charette, a Project Management Plan was developed and a FCSA with the GLO (non-Federal sponsor) was executed on January 10, 2013.

In February 2014, an exemption request to allow the study to continue outside of the 3x3x3 guidelines was approved by HQUSACE, resulting in a $4.4 million study, which focused on the Brazoria and Sabine area CSRM problems and opportunities. The Notice of Intent to prepare an EIS was published in the Federal Register on November 24, 2014.

1.10 PRIOR STUDIES, REPORTS, AND EXISTING USACE WATER PROJECTS

1.10.1 Existing Coastal Storm Risk Management Projects

The following studies and projects were reviewed as part of feasibility study investigations. These reports provide information on previous Federal and local evaluation of CSRM problems in the study area.

1.10.1.1 Port Arthur HFPP, Texas

The existing Port Arthur and Vicinity, Texas Hurricane Flood Protection Project (HFPP) was authorized by the Flood Control Act of 1962, Public Law 87-874. Construction began in March 1966, and was completed in April 1982. The system protects the Port Arthur region from coastal storm surge events coming from the Gulf of Mexico. It also protects from flooding from the Sabine River. The levee system consists of 27.8 miles of earthen embankment and 6.6 miles of floodwall. This includes 3.5 miles of coastal cantilever I-wall. There is also a wave barrier on Pleasure Island. The system was designed and constructed for a 1% ACE storm event. It is operated by Jefferson County Drainage District No. 7.

1.10.1.2 Texas City HFPP, Texas

The Texas City and Vicinity, Texas HFPP was authorized by the Flood Control Act of July 3, 1958, Public Law 85-500, substantially in accordance with recommendations of the Chief of Engineers in the House Document No. 347, 85th Congress, 2nd Session. Construction began in 1962. Authorized modifications to the project were approved in the Flood Control Act of 1968, House Document No. 187, 90th Congress, 1st Session. Authorized modifications included an extension of the levee protection system to protect the City of Hitchcock and La Marque. Construction was completed in April 1987. The Texas City, Texas HFPP is located on the

southwest shore of Galveston Bay about nine miles northwest of Galveston, Texas. The system was designed and constructed for a 1% Annual Chance Exceedance (ACE) event. The levee system consists of earthen embankment and floodwalls protecting an area of approximately 36 square miles. The levee consists of 21.85 miles of earthen embankment and floodwall. There are approximately 1.32 miles of floodwall on the system, consisting of nearly 0.92 mile of I-wall (0.64 mile of Braced Cantilever I-wall and 0.28 mile of Cantilever I-wall) and 0.4 mile of T-wall. One section of earthen embankment was constructed in 1930 and enlarged in the authorized project. There is a section of levee on the northwest side of the system which was constructed by local interests in 1947 and is included as part of the system.

1.10.1.3 Freeport HFPP, Texas

The overall project for hurricane flood protection for Freeport and Vicinity, Texas, was authorized by the Flood Control Act of 23 October 1962, Public Law 87-874, substantially in accordance with House Document No. 495, 87th Congress, 2nd Session. The authorization provides for construction of improvements at Freeport and Vicinity, Texas, for protection against storm tides caused by tropical cyclones along the Gulf Coast of magnitudes up to and including the standard project hurricane. The Freeport and Vicinity HFPP is located in the coastal planes in southern Brazoria County, about 48 miles southwest of Galveston, Texas. The system was designed and constructed for a 1% ACE event. The VDD, a subdivision of the State of Texas, is the local sponsor of the Freeport and Vicinity HFPP. The system consists of approximately 43 miles of levees and wave barriers, seven pump stations and multiple gates, culverts and related appurtenances. Additionally, the line of protection includes multiple structures that also serve as control structures and docks for the DOW Chemical Co., BASF, Conoco Philips, Exxon and Port Freeport. As a part of this Project, the USACE upgraded and incorporated existing levees into the HFPP in addition to extending and constructing a new levee reach northward along Oyster Creek to the high bank of Oyster Creek just east of the City of Clute, Texas. This created a coherent HFPP extending from the 7-mile "river system", which connects to the HFPP at Brazos River mile 11, and extends to the high bank on Oyster Creek just east of the City of Clute, Texas.

1.10.2 Navigation Projects in the Study Area

There are multiple deep-draft navigation channels in the study area including: the Sabine-Neches Waterway (SNWW), the Houston Ship Channel (HSC), and the Freeport Ship Channel. Additionally there are shallow-draft channels in the area including the Gulf Intracoastal Waterway (GIWW), Chocolate, Cow, and Adams Bayou.

The SNWW is an approximately 64-mile Federally authorized and maintained waterway located in Jefferson and Orange Counties in southeast Texas and Cameron Parish, Louisiana. The deep-draft portion of the authorized Federal project generally provides for a channel 42 feet deep and

800 feet wide at the entrance to the Gulf of Mexico, a channel 40 feet deep and 500 feet wide to Port Arthur, and a channel depth of 40 feet MLLW and 400 feet wide to Beaumont by way of the Neches River. Authorization for deepening the SNWW to 48 feet MLLW was included in the Water Resources and Reform Development Act (WRRDA) of 2014.

Freeport Harbor provides deepwater access from the Gulf of Mexico to Port Freeport. The waterway extends from deep water in the Gulf through a 0.83-mile jettied channel to the Lower Turning Basin, then westerly approximately 1.5 miles to and including the Brazosport Turning Basin, then westerly approximately 2.2 miles through the Upper Turning Basin to and including a turning basin at Brazos Harbor. The Stauffer Channel extends 1.15 miles from the Upper Turning Basin to the Stauffer Turning Basin. Authorized project widths of the channel range from 400 feet from the Gulf to the Brazosport Turning Basin to 200 feet for the Brazos Harbor Channel. The majority of the Freeport channel has been constructed of a depth of 46 feet MLLW. Brazos Harbor Channel and Turning Basin are 37 feet MLLW. The deauthorized Stauffer Channel measures 200 feet wide with a depth of approximately 19 feet MLLW. In 1929, the Brazos River was diverted to control excessive dredging requirements in Port Freeport, resulting in the jettied channel entrance being separated from the river mouth. Authorization for deepening Freeport Channel varying depths of 56 feet, 51 feet, and 26 feet MLLW was included in the WRRDA of 2014.

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2 EXISTING CONDITIONS*

2.1 GENERAL

The six-county study area is a large and complex region that includes approximately 6,865 square miles and two environmentally sensitive and economically important bay systems (Sabine Lake, Galveston Bay), and several large watersheds (Sabine, Neches, Trinity, San Jacinto and Brazos Rivers). It covers about 120 miles of the Texas coast. The following description provides a brief overview of existing conditions for the entire six-county area. However, since the study scope was revised to focus full feasibility planning efforts on CSMR projects in the northern (Orange and Jefferson Counties) and southern (Brazoria County) parts of the study area only, geopolitical maps are provided for the general project areas in each county as Figures 2-1, 2-2, and 2-3 respectively.

2.2 PHYSICAL DESCRIPTION OF THE EXISTING AREA

2.2.1 Tides

NOAA's Center for Operational Oceanographic Products and Services also provides tide data for the Texas coastline. The datum for these tide levels is MLLW.

Table 2-1: Diurnal tide ranges within the StudyArea

Station	Diurnal Range (feet)
Texas Point NWR, Sabine Pass, Texas	1.98
Galveston Pleasure Pier, Texas	2.04
Pier 21, Galveston, Texas	1.41
Morgan's Point, Texas	1.31
U.S. Coast Guard (USCG) Freeport, Texas	1.80

Wind has a significant impact on tides. When strong winds blow onshore, the tidal level is enhanced. When winds blow more strongly offshore, the tidal level is reduced. For example, the station located at the Texas Point National Wildlife Refuge (NWR) at Sabine Pass, Texas, tends to have higher tides, as well as a wider diurnal range, because it is directly on the coastline and very open to the changing winds. In contrast, the station at Port Arthur, Texas, located on the western side of Sabine Lake, is much more protected from wind, and therefore the tidal range is significantly smaller; low tides range from -0.8 to 1.2 feet, and high tides range from 0.5 to 1.5 feet. The same comparison can be made between the Galveston Pleasure Pier and Pier 21. These daily variations in tide due to wind are actually wind-induced surge but not necessarily

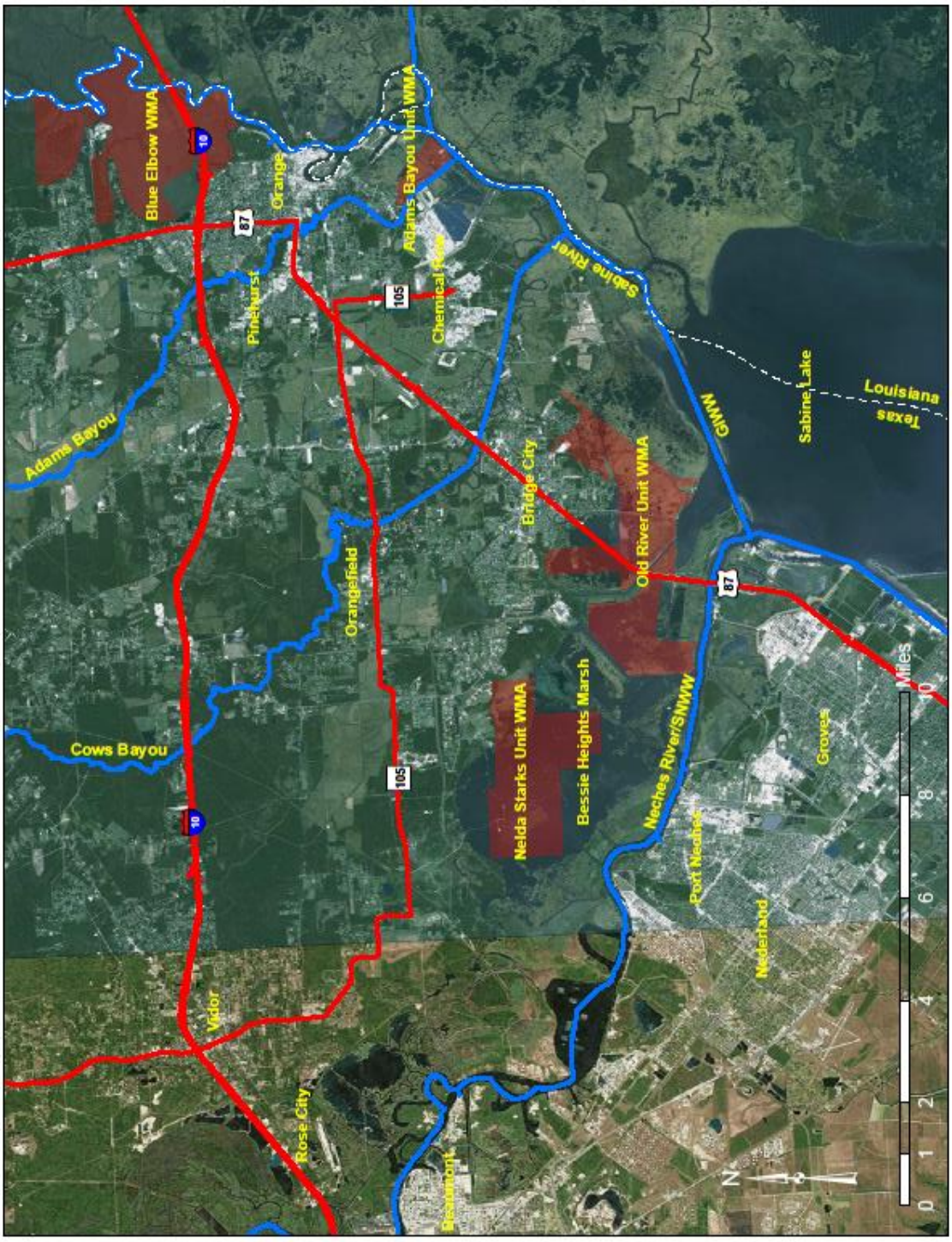

Figure 2-1: Geopolitical Map of Sabine Region (Orange County)

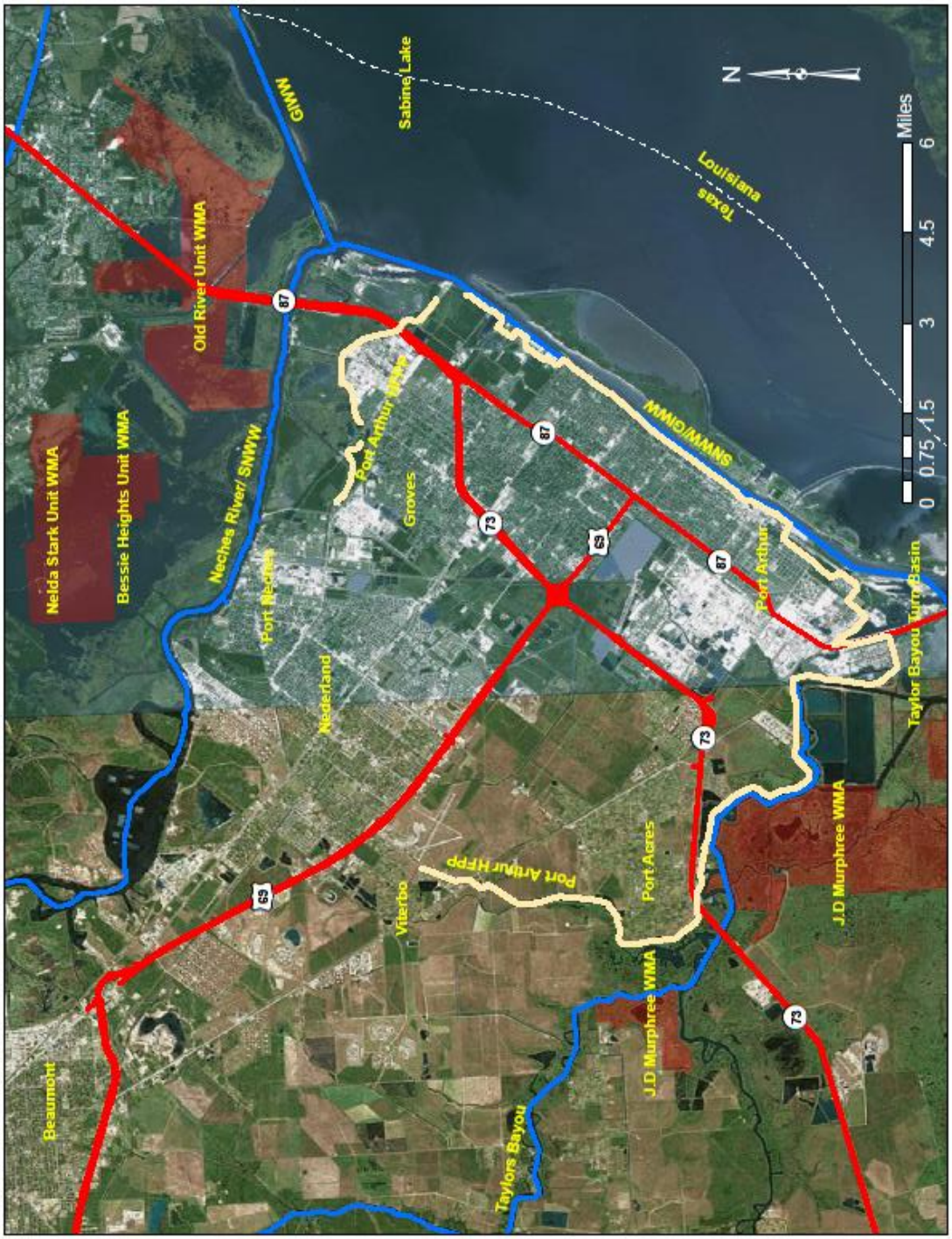

Figure 2-2: Geopolitical Map of Sabine Region (Jefferson County)

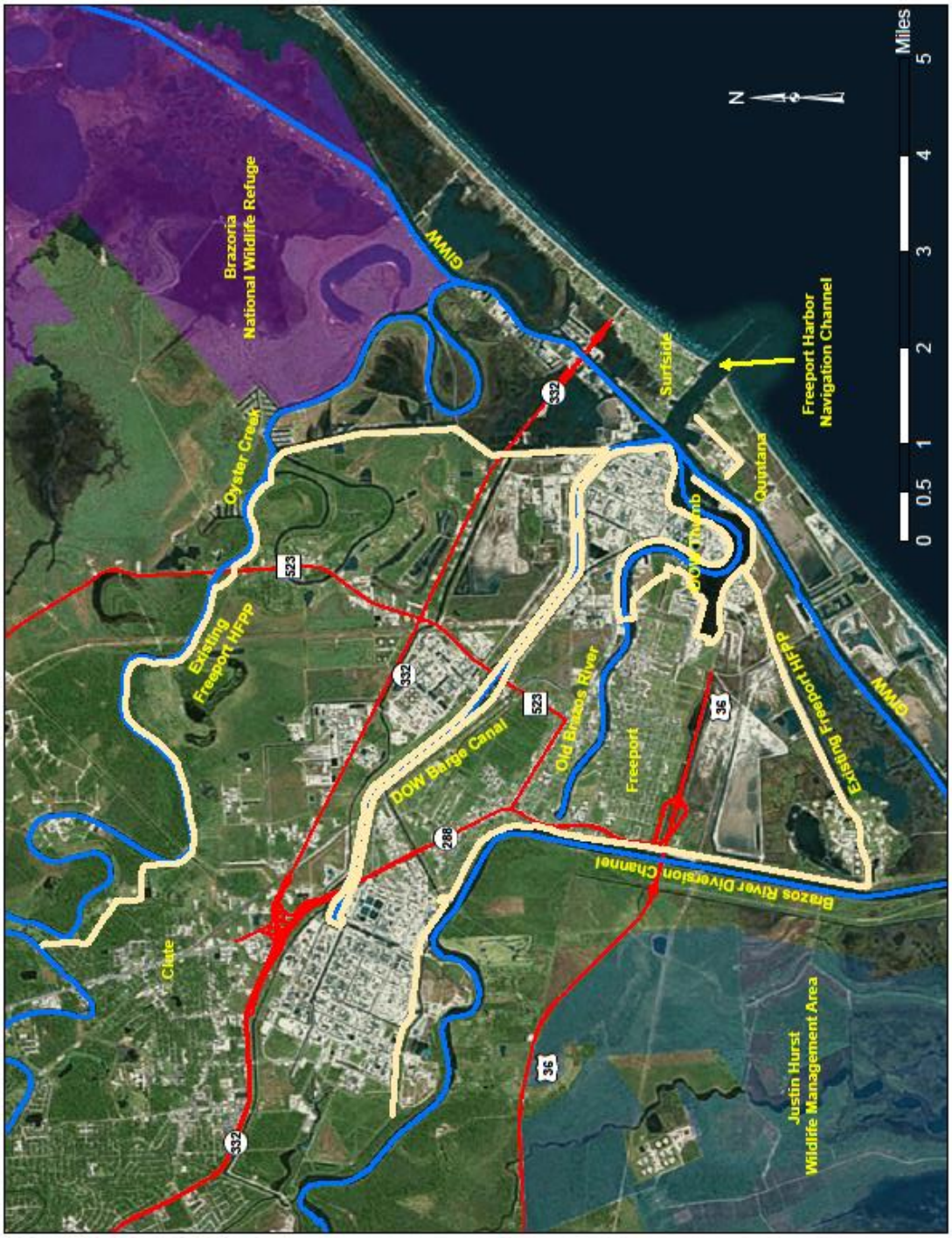

Figure 2-3: Geopolitical Map of Brazoria Region (Freeport)

related to storms. They can be separated from the measurements for most locations by subtracting the predicted astronomical tide from the measured water level.

2.2.2 Currents and Circulation

There are three major river and bay systems within the study area: the Sabine Lake system, the Galveston Bay system, and the Brazos River system. Additionally, the GIWW passes through the entire study area adding additional complexity to the movement of water. Each of these systems, along with other waterways in the study area, is discussed in detail below.

2.2.2.1 Sabine Lake System

The Sabine region's circulation and salinity patterns are complex. Fresh water enters the system through several tributaries, including the Sabine and Neches Rivers. The Sabine and Neches Rivers flow into Sabine Lake and into the Gulf of Mexico through Sabine Pass.

The Sabine-Neches Waterway (SNWW) Navigation Channel system serves as a pathway for both freshwater from the inflowing rivers and the saltwater wedge coming up the deep draft channel through Sabine Pass. This combination results in highly stratified conditions in the navigation channel, bringing saltwater up the SNWW and into the northwest corner of Sabine Lake and the lower reaches of the Neches River. As a result, the observed salinity in Sabine Lake is highest at both the southern end, where the lake connects to Sabine Pass, and the northern end, where the lake connects to the SNWW. The lowest salinities are observed in the central and eastern portions of the lake, which are furthest from sources of salt water (USACE 2009).

2.2.2.2 Galveston Bay System

The San Jacinto River runs from Lake Houston in Harris County, Texas, to Galveston Bay. Continuing southward, the river merges with Buffalo Bayou before the mouth of the bayou at Galveston Bay. The San Jacinto River drains an area of 3,976 square miles with almost 2 million acre-feet of runoff. Discharges into Galveston Bay vary considerably due to reservoirs, water supply constraints, and the complexity of the watershed.

The Trinity River is a 710-mile-long river that is the longest river flowing entirely within Texas. It rises in extreme north Texas, a few miles south of the Red River, and flows onward to the south, discharging into Trinity Bay, an arm of Galveston Bay, near the town of Anahuac east of Houston.

The Buffalo Bayou watershed is a 102-square-mile watershed primarily located in west-central Harris County with a small portion crossing into Fort Bend County. Near downtown Houston, White Oak Bayou flows into Buffalo Bayou. Just east of downtown Houston near the Turning Basin, Buffalo Bayou becomes the HSC. Buffalo Bayou and the HSC receive discharged water from several major tributaries, such as White Oak, Brays, Greens, Halls, Sims, and Vince Bayous. Buffalo Bayou mean discharge varies considerably, and is estimated to be 20,000 cubic feet per second (cfs) at its outfall into the HSC.

The HSC, built in 1914 to link the Port of Houston with Galveston Bay and the Gulf of Mexico, runs through Buffalo Bayou and the lower course of the San Jacinto River into Galveston Bay. The San Jacinto River proper is navigable for about 20 miles above its mouth. Commercial shipping traffic in the HSC main channel renders it unsuitable for recreational purposes.

2.2.2.3 Brazos River System

The Brazos River watershed begins in the State of New Mexico and then runs approximately 840 miles across Texas to its mouth at the Gulf of Mexico, two miles south of Freeport in Brazoria County. It is the longest river in Texas and the one with the greatest discharge. Discharges at the mouth have been recorded as high as 120,000 cfs (USGS).

2.2.2.4 GIWW

The GIWW spans the entire study area from Sabine Lake to Freeport (and beyond). The salinity of the water varies dramatically from reach to reach. Spans that are open to the Gulf of Mexico and to large bays like Galveston Bay tend to have a higher salinity. Spans of the GIWW more closed off and protected, like in Jefferson County and near Freeport, tend to have better access to freshwater sources, and therefore, a lower salinity.

2.2.2.5 Additional Waterways

In addition to the major waterways mentioned previously in this section, several other waterways exist within the study area. These include (but are not limited to) Oyster Creek, Taylors Bayou, Chocolate Bayou, Cedar Bayou, Cow Bayou, Adams Bayou, Little Cypress Bayou, Dickinson Bayou, Halls Bayou, Austin Bayou, and Bastrop Bayou.

2.2.3 Relative Sea Level Change

Relative Sea Level Change (RSLC) was calculated following USACE guidance provided in ER 1100-2-8162 "Incorporating Sea Level Change" dated 31 December 2013, and ETL 1110-2-1 "Procedure to Evaluated Sea Level Change Impacts, Responses and Adaptation" dated 30 June 2014. For the study area, all of the sea level rise is due to a combination of a eustatic component

of ocean water rising and subsidence along the Gulf Coast. Projections of low, moderate, and high levels of RSLC at the end of the 50-year period of analysis are estimated to range from 0.71 foot to 2.90 feet within the study area. Detailed discussion on RSLC is included in Section 3.6.

2.3 ENVIRONMENTAL AND HISTORIC RESOURCES

2.3.1 Description of the Ecological Region

The study area lies within the Gulf Prairie and Marsh ecological region, which extends along the Texas Gulf Coast from the Sabine River south to the Rio Grande (Gould et al. 1960). The prominent features of this coastal ecosystem include tidal, micro-tidal, and freshwater coastal marshes; bays and lagoons that support extensive seagrass beds, tidal flats, and reef complexes; barrier islands; tallgrass prairie with small depresssional wetlands, forest riparian corridors, oak mottes and coastal woodlots, and dense brush habitats. Wetland habitats provide important wintering and migration stopover habitat for migratory birds, including Central Flyway waterfowl, shorebirds, wading birds, and marsh and waterbirds. A string of refuges and wildlife management areas (WMAs) along the coast serve as critical staging areas for waterfowl migrating to and from Mexico (TPWD 2013; USFWS 2013).

Natural forces, which shape the system, include dominant south to southeast winds, tropical weather systems, and a substantial rainfall of over 60 inches per year. Flooding and freshwater inflows are key systemic processes, which buffer salinity and provide nutrients and sediments to extensive estuaries in the Sabine and Galveston regions. In contrast to these regions, the Brazos River discharges directly into the Gulf of Mexico, but deltaic and barrier island processes have formed extensive coastal wetlands along the coast in Brazoria County. While highly impacted by human activities, this ecosystem remains very productive for a wide variety of fish and wildlife.

The Sabine and greater Galveston Bay estuaries and extensive coastal wetlands in the Brazos delta region are a vital habitat for 75 percent of the fish and shellfish species found in the Gulf of Mexico. The marshes and rice prairies over the entire study area are a major wintering area for waterfowl of the central flyway. On average, 1.3 to 4.5 million ducks, or 30 to 71 percent of the total flyway population, winter annually on the Texas Gulf coast (Stutzenbaker and Weller 1989). This area also winters 90 percent of the snow, Canada, and greater white-fronted geese in the Central Flyway (Buller 1964). On average, 180,000 pairs of colonial-nesting waterbirds nest annually in Texas coastal habitats. Near coastal forests are critically important for the nation's songbird resources, as the vast majority utilize this habitat during their trans- and circum-Gulf migrations (USFWS 2008).

2.3.2 Storm Surge Effects on the Study Area

Storm surge has had both long-term positive and negative effects on the ecosystem of the region. Storm overwash deposits help shape and maintain coastal environments affected by RSLR. In some areas, storm surges cause shoreline accretion by depositing sediment on beaches and within marshes behind the shore. Hurricane Rita's surge resulted in shoreline accretion along some sections of Bolivar Peninsula of up to 170 feet (Andrews et al. 2006). Sediment carried on and over barrier islands such as Follets Island helps to maintain the natural trangressive development of this barrier island. In other areas, storm surges had erosive effects. Far more of the Gulf shoreline in southeast Texas suffered erosion as a result of Rita's surge than experienced accretion. In the Chenier Plain, Hurricane Ike caused the complete loss of a sand veneer between the low tide line and the slight dune ridge that bordered the shore from Sabine Pass to High Island, and even more importantly, removed much of this ridge which once protected the freshwater wetland and coastal prairie complex in the Texas Point NWR, J.D.Murphree WMA, and McFaddin NWR (Williams et al. 2009). On Bolivar Peninsula, Hurricane Ike removed nearly all traces of sand dunes, which had stood 1.2 to 1.5 meters in height, and exposed underlying Pleistocene mud deposits. Bolivar Peninsula is too wide at most locations for sand overwash to be deposited in marshes along the backside of the barrier island; most was deposited mid-island. On Galveston Island, marshes are rapidly shrinking due to RSLR and wave erosion. Hurricane Ike did not provide supplementary material to fill this accretion deficit. Instead, erosion rates 1.5 times greater than normal were recorded (Williams et al. 2009).

Coastal marshes and swamps in some parts of the study area were flooded with storm surge for weeks after Hurricanes Rita and Ike, while coastal marshes in the Galveston Bay area drained quickly, reducing the potential for long term-impacts (FEMA 2009). Coastal marshes around Galveston Bay contain salt-tolerant vegetation, are formed on mineral soils and are sloped toward the bay. However, it is expected that the Chenier Plain marshes surrounding Sabine Lake will experience significant, long-term impacts. These marshes are concave in shape, and under normal conditions, do not drain as rapidly as tidal fringe marshes. The normal drainage of these marshes is also impaired by numerous human-caused hydrologic modifications within and adjacent to these marshes, such as the GIWW, the Sabine-Neches Waterway, numerous roads, and other infrastructure (FEMA 2009). In addition to inundating salt marshes near the coast, these surges resulted in significantly increased salinities in large areas of swamp and freshwater marsh in the Sabine system for months after the storms (Steyer et al. 2007; FEMA 2009). The marshes of Sabine Lake are composed of generally brackish and intermediate vegetation communities, which were not tolerant of the higher salinity of Ike's storm surge. Therefore, the high salinity water was either lethal to these plants or had sub-lethal effects ranging from reduced seed production, vegetative stress, and increased vulnerability to disease (Smart and

Barko 1980; Linthurst and Seneca 1981; Howard and Mendelssohn 1999). Further compounding the problem are the organic soils that are typical of these marshes, and when exposed to saline waters, can produce high amounts of hydrogen sulfide, which can lead to sulfide toxicity and death in marsh plants. 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 2009).

In addition to significant marsh loss from shoreline erosion and saltwater stress, other direct impacts on coastal wetlands include scouring and compression, as well as downed trees from surge and winds (FEMA 2009). Oyster beds and fishing grounds were covered by sediment from the retreating storm surge in Galveston Bay, Trinity Bay, Sabine Lake, and the Chenier Plain. The loss of oyster reefs not only impacts the oyster fishery, but also can result in bay-wide ecological impacts.

2.3.3 Attenuation of Storm Surge Impacts by Coastal Wetlands

It is generally believed that coastal wetlands provide critical protection against incoming hurricane storm surges, and that restoration of lost wetlands should be a key component of any strategy to protect vulnerable regions such as the Sabine Pass to Galveston Bay study area. However, few studies have evaluated the value of wetlands in protecting against storm surge in this area. Furthermore, studies of the attenuation effects of coastal marshes and forests in Louisiana and Mississippi have yielded mixed results (Fitzpatrick 2008, Resio and Westerink 2008, Wamsley et al. 2007).

Historically, many studies have relied upon a USACE estimate of the degree to which marshes and coastal forests slow inland surge penetration (USACE 1963). This report analyzed seven storms occurring between 1909 and 1957 throughout southern Louisiana, producing a widely cited rule of thumb that each 2.7 miles of marsh knocks down the storm surge by 1 foot (1-meter reduction per 14.5 km of marsh). However, the data from this study varied by about a factor of three; attenuation rates as high as 1 foot per 1.3 miles of marsh was seen in one storm, and as low as 1 foot per 3.8 miles of marsh in another (Masters n.d.).

More recent storm surge studies have found that the inland penetration of the storm surge is an extremely complicated function of storm track, speed, duration, size, and associated waves; the regional topography, geometry of the shore, presence of barrier islands, and slope of the ocean bottom; plus the type and thickness of vegetation, and presence or absence of levees. Wetlands will slow down the inland penetration of a storm surge, so the surge will not be able to advance very far inland before the winds die down if a region is exposed to strong winds for a short

period of time. One example of this was in western Louisiana during Hurricane Rita of 2005 (Resio and Westerink 2008). As the hurricane rapidly approached western Louisiana, Rita blew water away from the coast and then plunged water onto land as the eye of the storm passed rapidly. Maximum inland attenuation rates ranged from 1 foot per 2.1 miles to 1 foot per 3.6 miles of inland penetration, under conditions in which the coast was only subject to onshore winds for a few hours.

Hurricane Rita also provides an example of an opposite effect. For slow moving storms, or for portions of the coast subjected to strong winds for many hours, the wetlands may completely flood, and there would be no reduction of storm surge. During Rita, strong winds blew along the east side of the Mississippi for almost a full day, completely flooding the 25 miles of wetlands fronting the Mississippi River levee at English Turn. In fact, the model results show that the surge probably increased in height, by 1 foot per 8.7 miles of inland penetration because the surge piled up against the levee (Resio and Westerink 2008).

Another storm surge simulation investigates what would happen if Louisiana wetlands were allowed to continue to deteriorate with no restorative efforts over the next 50 years (Wamsley 2007). Results suggest that storm surge heights would increase by 10 to 15 percent along Louisiana coastal areas to the east of New Orleans. These results held for both a severe Katrina-like hurricane, and a more modest hurricane. However, the authors cautioned that additional research is required because "the impact of landscape features on surge propagation is a relatively new application for surge models."

This summary indicates that the effect of wetlands in attenuating storm surge is situationally dependent. Wetlands can attenuate surge in many situations but may also be largely irrelevant in others. The effect of specific marsh restoration or preservation measures cannot be determined without studies and modeling based on fundamental underlying physics, forcing and dissipation mechanisms, adequate specification of the system geometry, and the evaluation of a wide array of storms, varying in direction, speed, and size (Resio and Westerink 2008).

2.3.4 Protected Lands in the Study Area

2.3.4.1 Sabine Region

McFaddin NWR covers about 58,861 acres in Jefferson and Chambers Counties (USFWS 2012 and 2013). Along with the J.D. Murphree WMA, 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/beach systems exist along the coastline, although much has been lost through erosion and shoreline retreat, leaving only a low-lying washover terrace (TPWD 2013).

J.D. Murphree WMA is 24,498 acres of fresh, intermediate and brackish marsh on the Chenier plain in Jefferson County (TPWD 2013). Extending north and south of the GIWW west of the Sabine-Neches Waterway, the WMA is highly diverse in coastal wetland communities.

Texas Point NWR in Jefferson County encompasses 8,952 acres of fresh to saline marshes and some wooded uplands and prairie ridges (USFWS 2012 and 2013). The Refuge's southern boundary consists of over 6 miles of Gulf of Mexico shoreline. The Chenier plain is characterized by relict beachfronts that form ridges paralleling the Gulf shore. The term derives from the French name for live oak trees (*chenier*), which typically are found growing atop these ridges.

Lower Neches River WMA has 7,998 acres located near Bridge City in Orange County (TPWD 2013). The WMA is composed of three separate units. The Nelda Stark and Old River units are located adjacent to the lower Neches River. The Nelda Stark Unit is primarily shallow open water, which resulted from the degradation of a former marsh system by saltwater intrusion and subsidence. The Old River Unit, near the mouth of the Neches River, is a mixture of intermediate marsh and open water. The Adams Bayou Unit is located on Adams Bayou, a tributary of the lower Sabine River. Formerly a meandering coastal stream and forested bottomland, it was channelized to allow oil field access but still contains a remnant of the Sabine River forested wetlands.

Tony Houseman WMA, managed as a cooperative effort between the Texas Department of Transportation (TxDOT) and TPWD, is located on the Sabine River at Interstate 10 (I-10) (TPWD 2013). A 600-foot boardwalk leads from the center into the swamp. Outdoor recreation includes public hunting opportunities, fishing, wildlife viewing, hiking, and canoeing. The WMA extends from the western bank of the Sabine River just north of the community of Echo down to the confluence of Little Cypress Bayou and the Sabine River south of I-10 at Orange. More than 80 percent is cypress-tupelo swamp.

Two USACE-approved mitigation banks are located on the Neches and Sabine rivers. The Neches River Cypress Swamp Preserve is located north of Interstate 10 below the Neches River Saltwater Barrier (USACE 2005a). Located north of Interstate 10 and west of the Sabine River, the 2,737-acre Blue Elbow Swamp Mitigation Bank is owned by the Texas Department of Transportation (TxDOT) and used to mitigate impacts of state highway projects.

2.3.4.2 Galveston Region

Anahuac NWR is located in Chambers County along the north shore of East Bay, within the Chenier plain region of southwestern Louisiana and southeastern Texas (USFWS 2013). The Refuge's southern boundary consists of nearly 7 miles of Galveston Bay shoreline (TPWD 2013). Comprising 34,400 acres, it contains brackish and saline marshes, coastal prairie, and coastal woodlands (USFWS 2012).

Armand Bayou Nature Center and Preserve covers a total of 2,800 acres along Armand Bayou in southeastern Harris County (TPWD 2013). Armand Bayou, a tributary of Clear Lake, is a tidally influenced component of the Galveston Bay system. The Preserve is unique in that it is a remnant natural system still existing within a heavily developed, densely populated region. The brackish water bayou bounded by riparian hardwood forest is surrounded by 900 acres of remnant coastal prairie currently under restoration. The Armand Bayou Coastal Preserve is leased from the GLO by the TPWD.

Atkinson Island WMA is the southern portion of Atkinson Island, a long, narrow island in the very northern tip of Galveston Bay, on the edge of Harris and Chambers Counties (TPWD 2013). The island was used as a case study for the construction of a wetland restoration project using dredged materials. Habitats on the island include a 40-acre woodlot and 90 acres of brackish marsh.

Candy Abshier WMA is located in Chambers County south of the community of Smith Point. This 209-acre WMA consists primarily of coastal prairie habitat with important coastal woodlot or oak mottes. Approximately 60 acres of the area are in this oak motte habitat with the remaining acreage in coastal prairie vegetation. It is owned and managed by TPWD.

Moody NWR is located on the north shore of East Bay (USFWS 2012). The refuge has approximately of 2 miles of bay shoreline and covers 3,517 acres. It took a direct hit and suffered extensive damages from Hurricane Ike. The USFWS holds a perpetual non-development conservation easement on the Moody NWR, which is otherwise entirely privately owned and managed.

North Deer Island Sanctuary is a 10-plus acre island in West Galveston Bay, one of the few natural islands left in this system. It is one of the most important colonial waterbird nesting islands on the upper Texas coast, used by 10,000 to 30,000 pairs of birds each year (TPWD 2013). Dredged material has been placed over approximately one-third of the island. Natural uplands are covered by a plant community unique on the upper Texas coast, composed of lime

prickly ash, mesquite, paloverde, and mulberry trees, as well as lantana and cactus. High-quality salt marshes border the uplands on the southeast side of the island. The island is owned by three equal undivided interests - the National Audubon Society, the Houston Audubon Society, and a private individual. It is a Houston Audubon/National Audubon Bird sanctuary.

The Scenic Galveston Preserve contains a wetland corridor gateway to Galveston Island and a mainland coastal prairie component at Virginia Point. The O-Quinn estuarine portion runs along both sides of Interstate Highway 45 (I-45) as it passes from the mainland to Galveston Island. This 900-acre area is composed of natural, undisturbed tidal marsh and about 70 acres that have been restored to historical marsh conditions. The 1,500-acre Virginia Point tract is predominantly coastal prairie with interspersed freshwater sloughs and ponds. Together, these tracts of land form a contiguous coastal preserve across the southern tip of the mainland from Jones Bay to the west, where the wetlands are adjacent to property across Highland Bayou managed by The Nature Conservancy and Galveston Bay Foundation, to Galveston Bay to the east. The preserve encompasses approximately 5 linear miles of Bay shoreline. The O'Quinn I-45 Estuarial Corridor is owned by SCENIC GALVESTON. The Virginia Point Peninsula Preserve is owned by the GLO.

2.3.4.3 Brazoria Region

The Brazoria NWR is a 44,414-acre wildlife conservation area along the coast in Brazoria County (USFWS 2012). It borders the GIWW, behind Follets Island in Brazoria County. Refuge habitats are made up of salt water, fresh water, and brackish wetlands. In addition, there are prairies, woody thickets, salt and mud flats, and lakes and streams. The refuge also contains 5,000 acres of rare, native bluestem prairie, representing one of the last coastal prairies in Texas. Brazoria NWR has a key location on the Texas Gulf, which helps Freeport draw one of the highest Audubon Christmas bird counts in the nation - more than 200 species.

Christmas Bay Coastal Preserve, in Brazoria County, encompasses a shallow 4,173-acre embayment in the southwestern portion of the Galveston Bay system (TPWD 2013). The preserve is one of the most ecologically productive bays of the Galveston complex and has not yet been greatly altered by human activity. The preserve totals approximately 5,700 acres in area. Nearly level prairies are contiguous to extensive fresh and saline marshes. Christmas Bay benefits from Brazoria NWR, a 42,000-acre protected wetland, which contributes to the preserve's productivity and helps protect its water quality. Owned by the GLO, the preserve is leased to TPWD and designated by the TPW Commission as a State Scientific Area.

Justin Hurst WMA (Bryan Beach Unit) is located on the Gulf shoreline on the eastern shore of the Brazos River Diversion Channel. The unit is 440 acres dominated by a 90-acre embayment,

which is flooded by Gulf waters during high tides and storms. Large vegetated coastal dunes surround the embayment and separate it from the Gulf.

The Nannie M. Stringfellow WMA is comprised of approximately 3,664 acres in Brazoria County (TPWD 2013). Located in the floodplain of the San Bernard River, the dominant vegetation is coastal bottomland hardwood forest, which is subject to frequent flooding.

San Bernard NWR in Brazoria County serves as the end point of the Central Flyway for waterfowl in winter, and an entry point for neotropical migratory songbirds tired from a 600-mile Gulf crossing from the Yucatan Peninsula (USFWS 2012). The 57,698-acre refuge contains salt and freshwater marshes, sloughs, ponds, coastal prairies, and bottomland forest. Refuge bottomland forests and willow trees attract high numbers of warblers migrating north. Several remote islands in a sheltered bay between the GIWW and the Gulf come alive every nesting season with herons, egrets, terns, and gulls.

2.3.5 Physical and Hydrological Characteristics of the Study Area

The study area, situated in the west Gulf Coastal Plain Physiographic Province, can be divided into two distinct physiographic areas. The surface topography of the project area is mainly flat to gently rolling and slopes to the southeast toward the Gulf. The coastal areas of the eastern- and westernmost sections (Jefferson, Chambers and western Brazoria counties) are barrier headlands consisting of beach or eroding marsh shores, dune and supratidal habitats that naturally decrease in elevation toward fringing intertidal marshes, lakes, and ponds. On the east, Sabine Lake formed in the elongated drowned river valley of the Sabine River; it empties into the Gulf through a narrow constriction at Sabine Pass. The Sabine and Neches Rivers flow into Sabine Lake. On the west, the Brazos River flows directly into the Gulf through a diversion channel constructed by the USACE in 1929 (USACE 2012). A diversion dam about 7.5 miles above the original Brazos River mouth was constructed as part of this navigation improvement project, and the diversion channel rerouted the Brazos River from the dam to an outlet in the Gulf about 6.5 miles southwest of the original mouth. The San Bernard River, the westernmost river in the study area, meanders through a landscape of coastal marshes and lakes on its way to the Gulf (USACE 2008). Its mouth is now frequently closed due to sand accretion from the Diversion Channel delta.

In between, the coastal areas of Galveston, Harris, and eastern Brazoria counties are characterized by a nearly continuous series of marginal marine embayments separated from the Gulf by a system of barrier islands and peninsulas (Lankford and Rehkemper 1969). Coastline features are typically the result of several active, geologic processes including longshore drift,

beach wash, wind deflation and deposition, tidal currents and waves, delta outbuilding, and river point bar and flood deposits. The Trinity and San Jacinto rivers, Clear Creek, and Chocolate Bayou are the largest inflows to the Galveston Bay system. Important tributaries in these watersheds include Buffalo, Cedar and Dickinson Bayous.

The coastal zone is underlain by sedimentary deposits that originated in ancient but similar coastal systems - Recent and Holocene-age alluvium containing thick deposits of clay, silt, sand, and gravel, overlying the Pleistocene Beaumont Formation (Barnes 1982, 1987; McGowen et al. 1976). These formations consist mainly of stream channel, point bar, natural levee, and backswamp deposits associated with former and current river channels and bayous.

Probably of most significance in relation to potential storm surge impacts, the widest part of the intercontinental shelf in the northern Gulf of Mexico lies offshore of the study area. At its widest point, offshore of Sabine Pass, the bottom slope averages 6 feet per mile until roughly 1 mile offshore, after which it steadily decreases to an average of 1 foot per mile through roughly 10 miles offshore (White et al. 1987). Thus, for most of its extent the shelf is gently sloping and (with the exception of a few topographically high features such as the Sabine, Heald, and Shepard banks, and relict Sabine, Trinity, and Brazos river valleys) is relatively featureless. Sandy muds and clay muds predominate the surface inner shelf region; however, the surface of virtually the entire area is covered by a sheet of sand approximately 2 feet thick (Anderson and Wellner 2002; PBS&J 2004; White et al. 1988). Storm surges are strongly influenced by the geometry of the basin and continental shelf leading up to the coastal floodplain, especially the depth of water and shelf width. Shelves with a larger shallow-water area will produce larger surges than those with steep offshore slopes (Resio and Westerink 2008).

2.3.6 Biological Communities in the Study Area

2.3.6.1 Coastal prairies

Remnant tracts of tall grass and salty prairies are present in the study area, often interspersed within coastal marshes. Slightly higher in elevation, the grass and prairie tracts offer a different type of habitat (USFWS 2008). Wooly rosemallow, bushy bluestem, and gulf cordgrass thrive there and provide important nesting habitat for mottled ducks, dickcissels, and other species. Black rails, short-eared owls, and LeConte's sparrow find shelter and feed within these prairie habitats. Almost all of the region's historic native coastal tall grass prairie and its associated prairie wetlands have been lost through conversion to agricultural uses and urban development (USFWS 2008). This community is considered critically imperiled by the Texas Natural Heritage Program (USGS 2000).

2.3.6.2 Coastal marshes

Salt marsh is located along the Gulf shoreline and higher salinity areas of the estuarine systems. Subjected to regular tidal inundation, low saline marsh is dominated by smooth cordgrass/oystergrass (*Spartina alterniflora*) and often accompanied by seashore saltgrass (*Distichlis spicata*), blackrush (*Juncus romerianus*), saline marsh aster (*Aster tenuifolius*), and marshhay cordgrass/wiregrass (*S. patens*). The dominant species in high salt marsh, which is subject to less-frequent tidal inundation, is glasswort (*Salicornia* spp.). Brackish marshes grade inland from salt marsh. The dominant species in low brackish marsh is saltmarsh bulrush (*Scirpus robustus*); 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 marshes and dominate interior marshes of the Sabine and Galveston Bay systems. The diversity and density of plant species are relatively high with marshhay cordgrass the most dominant species in high marsh. Co-dominant species in low marsh are seashore paspalum (*Paspalum vaginatum*), Olney bulrush (*S. americanus*), California bulrush/giant bulrush (*S. californicus*), and common reedgrass/roseau cane (*Phragmites australis*); bulltongue (*Sagittari lancifolia*) and sand spikerush (*E. montevidensis*) are also frequent. Freshwater marshes dominate in upstream reaches of the Sabine, Neches, Trinity, San Jacinto, and Brazos Rivers. They are heterogeneous, with local species composition governed by frequency and duration of flooding, topography, substrate, hydrology, and salinity. Co-dominant species in low marsh are maidencane (*P. hemitomen*), giant cutgrass (*Zizaniopsis milacea*), and bulltongue. Co-dominant species in high marsh are squarestem spikerush (*E. quadrangulata*) and marshhay cordgrass. Other characteristic species include American lotus (*Nelumbo lutea*), watershield (*Brasenia screben*), duckweed *(Lemna* spp.), and fanwort (*Cabomba caroliniana*). Salinity rarely increases above 2 ppt, with a year-round average of approximately 0.5 to 1 ppt. Tidal fresh marshes support extremely high densities of wildlife, such as migratory waterfowl. Marsh serves as nursery areas for many important commercial and recreational fish and shellfish species including white and brown shrimp, blue crab, red drum, flounder, and speckled sea trout. 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 (USFWS 2008).

2.3.6.3 Forested Wetlands

Upstream of the coastal marshes in Sabine, Neches, and Trinity estuaries, the study area is dominated by dense bottomland hardwood forests and cypress-tupelo swamps. These wetland forests cover an intricate network of sloughs and sandy ridges formed within the rivers' relict

meander belts. Bald cypress (*Taxodium distichum*) – tupelo-gum (*Nyssa aquatica*) swamps grow in the inundated areas between the ridges, and floodplain hardwood forest of oaks (*Quercus nigra, Q. phellos, Q. alba, Q. lyrata*), sweetgum (*Liquidambar styraciflua*), hickories (*Carya* spp.), American elm (*Ulmus americanus*), maple (*Acer rubrum*), green ash (*Fraxinus pennsylvanica*), American holly (*Ilex opaca*), and loblolly pine (*Pinus taeda*) grow atop the sandier ridges and on the Pleistocene terrace uplands that border the floodplains. In general, these are healthy, stable habitats. The hardwoods, and especially the cypress trees, have been logged repeatedly since the turn of the century and as recently, perhaps, as the 1950s (USACE 1998). Though much of the forest is secondary growth, the swamp and bottomland hardwood habitats have medium to high value for food and cover to resident and migratory fish and wildlife. Forested wetlands in the San Jacinto and Brazos River system are dominated by bottomland hardwood communities.

Oak woodlot habitats (also known as oak mottes) can be found on higher ridges and mounds scattered across coastal marshlands. They are vital for resident and migrant species of wildlife, especially neotropical migrant passerine species.

2.3.6.4 Aquatic Habitats

Extensive freshwater aquatic habitats are present in the upstream reaches of rivers and bayous in the study area. Large estuarine aquatic habitats are present in the Sabine Lake area, the greater Galveston Bay area, Chocolate Bayou, and the San Bernard River delta area. Approximately 36,000 acres of oyster reefs are present in the Sabine and Galveston Bay systems. The Texas oyster fishery is the second largest in the country, with Galveston Bay accounting for approximately 18 percent of total oyster landings. The average annual catch value of Galveston Bay oysters for the period between 2005 and 2007 was in excess of $10.4 million (FEMA 2009). Sabine Lake is currently closed to commercial oyster harvesting (USACE 2011). In addition to supporting a large commercial fishery, oyster reefs provide important habitats for numerous commercially and recreationally important fishery species, such as red drum and brown shrimp. Oysters are also vital to maintaining the water quality of estuarine systems. Through their filter-feeding activities, oysters remove nutrients, pollutants, and algae from the water column. The shallow Gulf of Mexico waters, tidal flats, and beaches provide important shallow water feeding, breeding and nesting habitat utilized by killdeer, black-necked stilt, and willet (USFWS 2008). This transition from land to sea contains a combination of salt-tolerant marsh and beach plants, which are adapted to shifting sands, high winds, and rising waters and help protect the dunes from erosion.

2.3.7 Essential Fish Habitat

Essential fish habitat (EFH) consists of those habitats necessary for spawning, breeding, feeding, or growth to maturity of species managed by Regional Fishery Management Councils, as described in a series of Fishery Management Plans, pursuant to the Magnuson-Stevens Fishery Conservation and Management Act. The study area contains EFH for larval, juvenile, and adult brown and white shrimp (*Penaeus aztecus* and *Penaeus setiferus*); juvenile king mackerel (*Scomberomorus cavalla*), vermilion snapper (*Rhomboplites aurorubens*), Warsaw grouper (*Epinephelus nigritus*), and Wenchman snapper (*Pristipomoides aquilonaris*); juvenile and adult red drum (*Sciaenops ocellatus*), Almaco jack (*Seriola rivoliana*), and gray triggerfish (*Balistes capriscus*); adult gag grouper (*Mycteroperca microlepis*) and gray snapper (*Lutjanus griseus*); larval, juvenile and adult red snapper (*Lutjanus campechanus*), lane snapper (*Lutjanus synagris*), greater amberjack (*Seriola dumerili*), and cobia (*Rachycentron canadum*). The categories of EFH that occur within the study area include estuarine emergent marsh, estuarine submerged aquatic vegetation, estuarine hard bottom, and estuarine mud/soft bottoms.

2.3.8 Threatened and Endangered Species

Federally-listed species potentially occurring within the vicinity of the six county study area include wintering populations of the piping plover (*Charadrius melodus*), Atwater's prairie chicken (*Tympanuchus cupido attwateri*), Eskimo curlew (*Numenius borealis*), whooping crane (*Grus americana*), several species of whales (blue [*Balaenoptera musculus*], fin [*Balaenoptera physalus*], humpback [*Megaptera novaeangliae*], sei [*Balaenoptera borealis*], and sperm [*Physeter macrocephalus*]), swimming green, hawksbill, Kemp's ridley, leatherback, and loggerhead sea turtles (*Chelonia mydas, Eretmochelys imbricata, Lepidochelys kempii, Dermochelys coriacea, and Caretta caretta*), and Texas prairie dawn-flower (*Hymenoxys texana*) (USFWS 2013; NOAA 2013). National Marine Fisheries Service has also designated the following four species of corals as endangered for this area – lobed star (*Orbicella annularis),* mountainous star *(Orbicella faveolata),* boulder star *(Orbicella franksi),* and elkhorn (*Acropora palmata).* Descriptions of these species and their habitats are provided in the Biological Assessment (Appendix J).

Critical habitat for wintering populations of the piping plover is present in Galveston and Brazoria Counties. In Galveston County, shoreline areas around Rollover Pass, near Fort Travis at the Galveston East Jetty, Big Reef at the Galveston West Jetty, and on the east side of San Luis Pass have been designated. In Brazoria County, critical habitat has been designated for the western Brazoria County shoreline, beginning at Bryan Beach State Park and extending west to beyond the county line.

2.3.9 Water and Sediment Quality

Water and sediment quality in the study area are generally of good quality, as evidenced by testing of water and sediments in conjunction with maintenance dredging of existing navigation channels and proposed modifications for the Sabine-Neches Waterway (USACE 2011), the GIWW from High Island to Brazos River (USACE 2003), the Houston-Galveston Navigation Channels and associated projects (USACE 2003, 2010, 2013), the Texas City Channel (USACE 2008), the Freeport Harbor Channel (USACE 2012), and the mouth of the San Bernard River (USACE 2008). In the Sabine region, freshwater stream segments are generally of good quality, but tidal segments of several streams have depressed levels of dissolved oxygen and undesirable levels of bacteria, due in large part to low tidal flows (TCEQ 2014). Contaminated sediments and edible fish tissues have been reported for a few segments in and near the Neches and Sabine Rivers. In the Brazoria region, only one stream has been classified as non-supporting for recreation use due to undesirable levels of bacteria. Additional information is provided for the No Action Alternative description in section 7.7.1.

2.3.10 Air Quality

The Galveston and Brazoria regions are located within the Houston-Galveston-Brazoria (HGB) Air Quality Control Region (AQCR), consisting of Harris, Montgomery, Liberty, Chambers, Galveston, Brazoria, Fort Bend, and Waller Counties. This AQCR meets all of the U.S. Environmental Protection Agency (EPA) National Ambient Air Quality Standards (NAAQS), except for ozone. Exposure to ground level ozone in high concentrations can result in adverse effects on humans, plants, and animals. Urban areas typically have high levels of ground level ozone. The HGB AQCR is classified as marginal nonattainment for the 2008 ozone NAAQS, and severe nonattainment for the 1997 ozone NAAQS.

Jefferson and Orange counties are located in the Beaumont-Port Arthur (BPA) AQCR. On October 20, 2010, the EPA published a final rule in the *Federal Register* (75 FR 64675), effective November 19, 2010, approving a redesignation request and finalizing a determination that the BPA area is in attainment for the revoked one-hour ozone standard. The EPA's determination to redesignate signifies that the BPA area has met all of the applicable Federal Clean Air Act requirements for the purpose of redesignation to attainment.

2.3.11 Hazardous, Toxic, and Radioactive Waste Concerns

Hundreds of petrochemical plants, oil storage facilities, hazardous waste facilities, aboveground tanks, and underground storage tanks are located in storm surge-vulnerable regions of the numerous industrial centers in the study area (Orange, Beaumont, Port Arthur, Texas City,

Pasadena/Deer Park, Houston, Baytown, Chocolate Bayou, and Freeport). In the Houston Ship Channel area alone, about 20,000 acres along lower Buffalo Bayou contain industrial facilities with potential for toxic environmental releases as a result of storm surge (Rifai and Burleson 2012). Hurricane Ike caused hundreds of localized oil and other toxic spills that threaten fish and wildlife throughout the affected area (FEMA 2008). As of Oct. 1, 2008, the multi-agency task force for spill response had assessed more than 200 pollution reports, which include more than 180 sites in the Houston-Galveston area and 47 in the area from Port Arthur to Lake Charles, Louisiana. The type and amount of pollution included oil and diesel from vessels, as well as industrial chemicals.

2.3.12 Cultural Resources

Numerous cultural resource surveys in the area have documented over 1,000 cultural resource sites in the study area, ranging from prehistoric shell middens to numerous historic sites including houses, buildings, bridges, tunnels, and lighthouses. The area includes several National Historic Landmarks, including the San Jacinto Battlefield, the Battleship Texas, the Tall Ship Elissa, and the Spindletop Oil Field, as well as National Historic Landmark Districts, such as the Galveston Strand Historic District and the Galveston East End Historic District. The Galveston Strand District contains many Victorian-era National Register structures from the city's historic heyday when Galveston's national prominence resulted in it being called "the Wall Street of the Southwest". There are over 100 National Register Properties within the study area. Sixty of the historic properties are located in the city of Galveston, and are primarily historic houses, commercial and government buildings. Other National Register sites and districts located throughout the area include the Apollo Mission Control Center, the Space Environment Simulation Laboratory, the Saturn V Launch Vehicle, the Point Bolivar and Sabine Pass Lighthouses, the Beaumont Commercial District, the Jefferson Historic District, the Port Arthur-Orange Bridge, the W. H. Stark House, the Old Wallisville Townsite, Fort Anahuac, and the Chambers and Jefferson County Courthouses. The majority of these cultural resources are vulnerable to damage or destruction from hurricane storm surge.

2.3.13 Energy and Mineral Resources

Hundreds of pipelines cross the waterways and marshes of the study area. Pipelines crossing beneath the navigation channels are generally buried deeply enough that they would not be affected by storm surge scouring. However, it is likely that pipelines are present in many areas where storm surge barriers or ER measures such as marsh restoration or breakwaters have been proposed. In-depth research and surveys would be needed to identify pipelines for detailed pre-construction planning and design.

2.3.14 Socioeconomic Considerations

The Sabine Pass to Galveston Bay study area encompasses six coastal counties of the upper Texas coast. Over five million people reside in the six counties, which include the 4th largest U.S. city (Houston) and three other large metropolitan areas (Beaumont/Port Arthur/Orange, Galveston/Texas City and Freeport/Surfside). The population of these counties is projected to increase to over nine million within the next 50 years. In addition to the at risk population, three of the nine largest oil refineries in the world, 40 percent of the nation's petrochemical industry, 25 percent of the nation's petroleum-refining capacity, and three of the ten largest US seaports are also located in the study area. The growing population, communities and nationally significant industries are severely vulnerable to risks from coastal storm events. Approximately 2.26 million people across the study area live within a storm-surge inundation zone, and estimates for a one-month closure of the Houston Ship Channel alone are upwards of $60 billion in damages to the national economy.

Hurricane Ike is an example of the types of socioeconomic disruptions that could be expected when another major hurricane strikes the area. Numerous industries, including the petrochemical, health care, agriculture and forestry, fishing, tourism, nonprofit, and small business sectors would be adversely affected, both during and after the storm. Shipping would be disrupted and port facilities damaged in three of the four primary Texas ports (Kraus and Lin 2009). According to USACE records, in 2006 these four port areas cumulatively accounted for nearly 500 million short tons (454 million metric tons) of waterborne tonnage and handled 25 percent of all foreign (imports and exports) tonnage traveling on U.S. waterways. Crude petroleum tonnage was 35 percent of the national total. Other significant commodity totals include gasoline (19.8 percent of national coastwise total), distillate fuel oil (24.3 percent of national coastwise total), wheat (22.4 percent of national coastwise total), and benzene and toluene (72 percent of national coastwise total). Clearly, recovery of the coastal navigation channels and associated waterways was of national urgency after Hurricane Ike (Tirpak 2009). During Hurricane Ike, hundreds of thousands of homes along the upper Texas coast were severely damaged or destroyed as a surge of up to 20 feet hit in conjunction with the high tide (FEMA 2008). It has been estimated that 75 percent of the 24,000 structures on Galveston Island flooded during Ike to a maximum height of 10 to 12 feet (Tirpak 2009). Entire cities were inundated with the mud and debris that accompanied the surge. In the small town of Bridge City, only 14 of its 3,400 homes were habitable after the storm. In Gilchrist, located on the Bolivar Peninsula, only one home was left standing when the winds stopped. Months after the storm, thousands of families across the region continued to struggle with finding places to live near their jobs and children's schools in an effort to restore some normalcy to their lives (FEMA 2008). Hurricane Ike also placed immediate and long-term strains on the ability of impacted

communities to provide access to health care and specialty health services, and basic services, like childcare, public education, and public utilities.

3 FUTURE WITHOUT-PROJECT CONDITIONS*

The USACE is required to consider the FWOP alternative (called the "No Action" alternative) during the planning process and assessment of impacts to comply with USACE regulation and guidance for planning as well as NEPA. With the FWOP, it is assumed that no project would be implemented by the Federal Government or by local interests to achieve the planning objective. The FWOP forms the basis against which all other alternative plans are measured.

The FWOP condition assumes the continuation of existing conditions for the resources listed above; no improvement of existing HFPPs at Port Arthur, Texas City, and Freeport; no intervention to reduce the impacts of storm surge on the vulnerable populations and infrastructure of the study area; and no large-scale ER efforts to improve the sustainability of fragile coastal systems and attenuate storm surge.

3.1 PROJECT AREA

The regions described in Section 1.5 were refined in the study within the Sabine and Brazoria regions located in Orange, Jefferson, and Brazoria counties into project areas. These project areas were defined to show more detail on the FWOP conditions storm surge flood risk. The project areas generally align with the 0.2% Annual Chance Exceedence (500-year floodplain) and locations of economic damages analyzed in the study. Figures 3-1 and 3-2 show the project areas. The Orange-Jefferson CSRM and Port Arthur and Vicinity CSRM projects areas are in the same general vicinity. In Figure 3-1, the highlighted areas shown in red are located on the Orange County side and structures in yellow on the Jefferson County side. The Orange-Jefferson CSRM focus on inundation of structure on the Orange and Jefferson County side, while the Port Arthur and vicinity focus on the Jefferson County side.

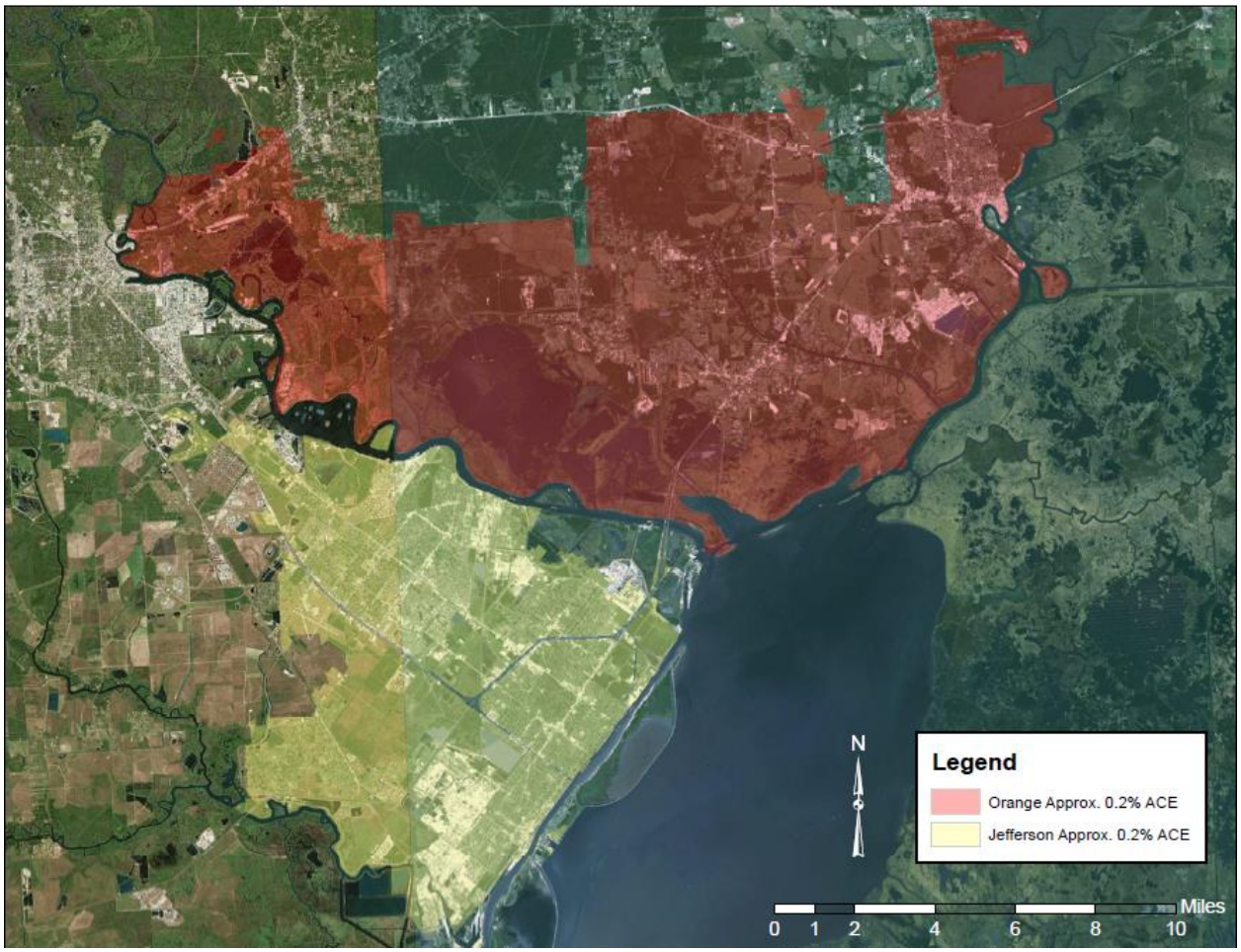

Figure 3-1: Orange-Jefferson CSRM and Port Arthur and Vicinity CSRM Project Areas

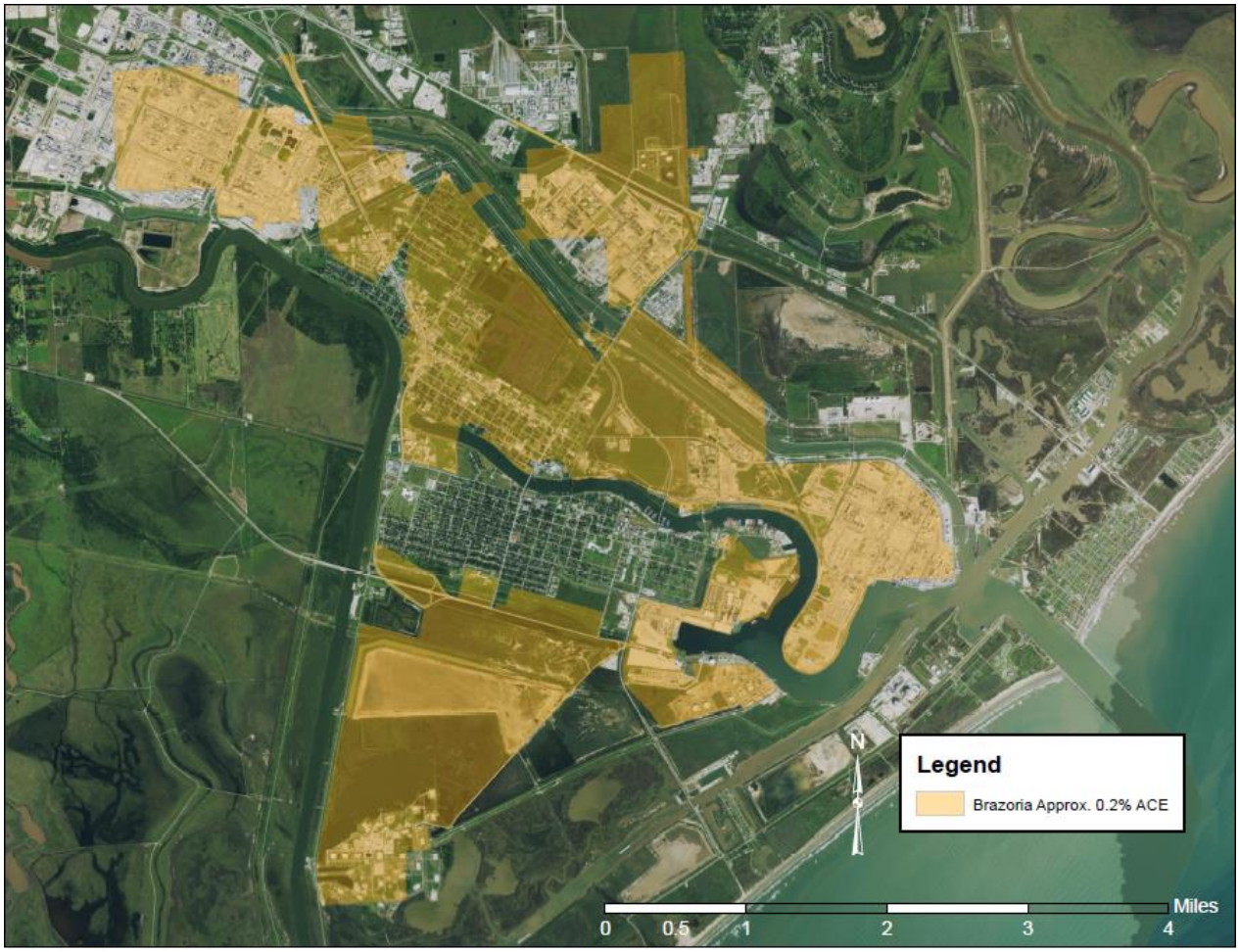

Figure 3-2: Freeport and Vicinity CSRM Project Areas

In order to define the the FWOP for life-safety, economic damages, and critical infrastructure under the FWOP, a description of the existing HFPPs is required. This includes a description of the existing facilities in place and the known vulnerabilities in those systems. The following is a brief description of the existing projects in place, including two Federal projects (Freeport HFPP and Port Arthur HFPP). Other projects in the vicinity are noted, but were not originally built by USACE. Additional detail of the existing projects is included in the engineering appendix (Appendix D).

As noted in Section 1.9 of this report, the Port Arthur and the Freeport HFPPs were constructed by USACE. The local sponsors responsible for operation and maintenance are the Jefferson Country Drainage District No. 7 and the Velasco Drainage District (VDD), respectively. There is no existing USACE HFPP in the Orange-Jefferson CSRM project area. The following describes the existing projects in place for each project area.

Orange-Jefferson CSRM Project Area

A known existing flood protection facility located in the Orange-Jefferson CSRM project area is a wall surrounding the Exxon Mobil industrial facilities as indicated in Figure 3-3. This facility was constructed by local industry around the Exxon Mobil plant.

Figure 3-3: Existing Floodwall in the Orange-Jefferson CSRM Project Areas

Port Arthur and Vicinity CSRM Project Area

The existing HFPP protects the Port Arthur region from coastal storm surge events coming from the Gulf of Mexico. It also protects from flooding from the Sabine River. The levee system consists of 27.8 miles of earthen embankment and 6.6 miles of floodwall. This includes 3.5 miles of coastal cantilever I-wall (Texas Coastal I-Wall study). There is also a wave barrier on Pleasure Island. The system was designed and constructed for a 1% ACE.

The Port Arthur and Vicinity CSRM project area has an existing USACE HFPP with a preliminary Levee Safety Action Classification (LSAC) that has resulted in the RMC initiating a Semi-Quantitative Risk Assessment (SQRA) to better define the systems risk. This classification was primarily driven by three main risk factors (probability of load, probability of failure, and

nature of the consequences). The following lists the major engineering concerns for the Port Arthur and Vicinity CSRM:

- Potential failure due to I-wall stability (locations of concern shown in Figure 3-4); and
- Currently the system would suffer a catastrophic failure during a future hydraulic loading roughly equivalent to 0.6% ACE (150-year event).

The existing system at Port Arthur is considered "minimally acceptable" under the USACE's P.L. 84-99 program. A Periodic Inspection was completed for the Port Arthur system in 2012, and the sponsor was provided a list of items to correct. The sponsor is in the process of correcting these items. The potential failure issues addressed in this study are not considered an O&M responsibility. The existing Port Arthur HFPP is certifiable for FEMA accreditation under CFR 65.10, so the local sponsor has no current plans to address the risk drivers for the engineering concerns in the FWOP condition. It is assumed in the FWOP condition that no other actions to reduce the risk will take place by others.

Figure 3-4: Port Arthur and Vicinity CSRM Failure Locations

Freeport and Vicinity CSRM Project Area

The existing HFPP at Freeport consists of approximately 43 miles of levees and wave barriers, seven pump stations and multiple gates, culverts, and related appurtenances, generally depicted in Figure 3-5. Additionally, the line of protection includes multiple structures that also serve as control structures and docks for the DOW Chemical Co., BASF, Conoco Philips, Exxon, and Port Freeport.

Figure 3-5: Existing HFPP in Freeport and Vicinity CSRM

The Freeport and vicinity system has a preliminarily LSAC that has resulted in the RMC conducting an SQRA to define the systems risk. This classification was driven by numerous factors. The primary structural factors that would have Federal interest are seepage/slope stability of "sandy" levees, I-wall stability, and a "low" level of protection (i.e., high probability of overtopping).

- Steady state seepage analysis for the levees and foundation areas that have a high sand content show high potential for levee failure at top of levee loading;
- Potential failure of the I-wall at the tide gate due to stability; and

- System capacity corresponds to around a 0.7% ACE (130-year event) with significant consequences.

Currently the system is "unacceptable" in the PL 84-99 program and not certifiable for FEMA accreditation under CFR 65.10; therefore, the local sponsor has a System-Wide Improvement Framework (SWIF) plan in place to address the deferred maintenance issues and issues impeding CFR 65.10 accreditation. The sponsor has no current plans to address the structural risk drivers for the LSAC rating due to the performance concerns coming at a more significant hydraulic loading event than the requirements under CFR 65.10. The FWOP would result in no action being undertaken to reduce the risk that the system would suffer a catastrophic failure during a future hydraulic loading roughly equivalent to 0.7% ACE event.

3.2 ECONOMIC CONDITIONS

The FWOP economic conditions were evaluated throughout plan formulation in greater levels of detail to screen measures and alternatives as the study progressed. It is important to note some level of detail regarding the plan formulation process used in this study to introduce how the FWOP economic conditions were estimated. First, management measures to address flood risk and ecosystem restoration were developed and screened. Then remaining measures were evaluated as stand-alone alternatives or in combination with each other and screened in an interative process referred to as the Initial Array, Evaluation Array, and the Final Array of Alternatives. The economic screening performed during each iteration is described in detail in Appendix B (Plan Formulation) and summarized here for the all screening leading up to Final Array of Alternatives. More detail for the FWOP economic conditions for the Final Array Alternatives is described in this section.

3.2.1 Initial and Evaluation Array of Alternatives

For the Initial and Evaluation Array Alternatives, FWOP economic damages and benefits were estimated using the Hydrologic Engineer Center Flood Impact Analysis model (HEC-FIA) for the 1% ACE event (or 100-year). HEC-FIA is a software package developed by USACE that analyzes the consequences of flood events. The economic damage estimates are roughly equivalent to insured losses, and do not include damages to the economy as a whole. Economic and cost criteria were applied to screen the alternatives.

3.2.2 Final Array of Alternatives

This is a summary of the FWOP economic conditions for the Final Array of Alternatives. Structure files for the project areas were developed to determine the potential flood damages to properties based on estimated storm surge events. Estimated Annual Damages (EAD) under the

FWOP conditions were calculated using the risk and uncertainty within HEC-FDA version 1.2.5, through integration of frequency-damage data. Based on the characteristics of the floodplain, the project areas were split into damage reaches based on hydraulic, geotechnical, and environmental considerations. The EADs for the FWOP conditions are presented in detail in Appendix B for each alternative reach along with the engineering inputs and assumptions into the model. The results are summarized here. Tables displaying structure and content values by reach, detailed tables of the EAD calculations, and additional detail regarding development of the structure file is provided in Appendix C.

The effort for estimating EAD estimates for each damage reach used a different methodology than what was employed for the Initial Array and Evaluation Array Alternatives. This screening used HEC-FIA with 1% ACE depth grids in conjunction with HAZUS-MH data to determine FWOP economic damages as described previously in Section 3.1.1. This analysis incorporated a risk-based analysis in compliance with ER-1105-2-101.

Still water levels were used to determine the overall economic efficiency of the final array alternatives since low-probability wave run-up and/or overtopping do not incorporate a reliable means of determining high-level overall economic efficiency. Design considerations for wave run-up and overtopping will be analyzed later and applied to specific locations where it is applicable. This includes along the levee/floodwall system and necessary interior drainage analysis on the final feasibility-level design of the recommended plan. Fragility curves were developed for use in the HEC-FDA model for specific locations along the Port Arthur and Freeport HFPP in order to account for the anticipated system performance at those locations, and were used to scope the reconstruction and resiliency features for the existing system. Additional detail of the fragility curve development for the economic evaluation for the FWOP condition is included in Appendix D, Geotechnical Section.

Orange-Jefferson CSRM

To estimate EADs, the system was set up with three major components based on their location. This was primarily due to initial configurations of new levees based on alignments from the Orange County Flood Protection Planning Study (Orange Report), completed in 2012. The following lists the Alternative Reaches.

- Orange 1, Orange 2 and Orange 3
- Jefferson Main
- Beaumont A, Beaumont B, Beaumont C

The Orange component runs along the north side of the Neches River and was divided into three sections: Orange 1 on the western end that primarily protects Rose City, Orange 2 that begins just east of Rose City and ends roughly halfway between Rose City and Bridge City, and Orange 3, which encompasses the remainder of the Orange County component. Figure 3-6 presents the Orange-Jefferson damage reaches. The "with-project" levee and floodwall alignments are included in this figure although this discussion is only supposed to present the FWOP Alternative Reaches.

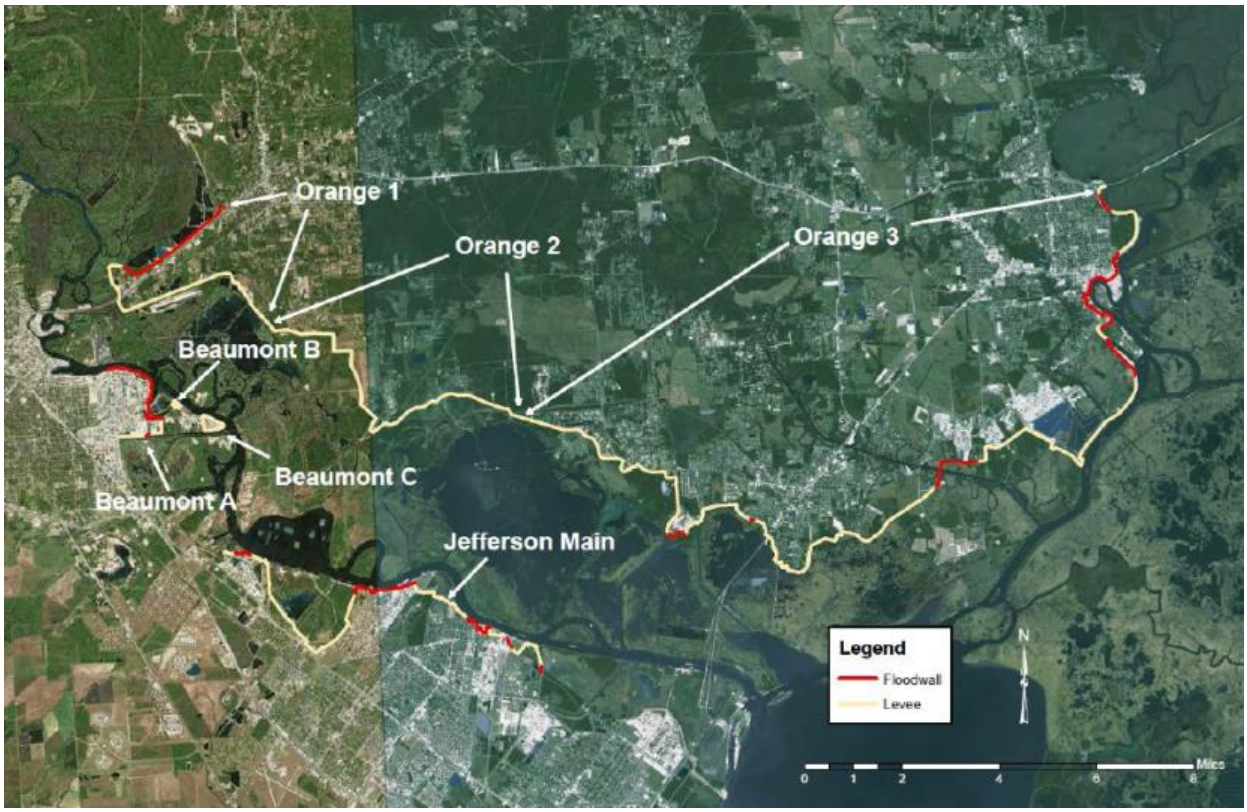

Figure 3-6: Orange-Jefferson CSRM Alternative Reaches

For the Orange 1, Orange 2, and Orange 3 alternative reaches, significant damages start at approximately the 1% ACE; the depth of flooding at the 1% ACE is approximately 8 feet. In the Jefferson Main alternative reach, significant damages start between the 2% and 1% ACE; the depth of flooding between the 2% and 1% ACE is approximately 6.5 feet and 7.5 feet. For the Beaumont A, Beaumont B, and Beaumont C reaches, the significant damages start at the 1% ACE; the depth of flooding is approximately 7.5 feet.

The total number of structures in the Orange-Jefferson CSRM is 27,125 (Orange County) and 26,605 (Jefferson Country). The total structure and content values of inventoried structures (2015 price and levels of development) for the Orange-Jefferson CSRM, in Orange County is

$6,147,511,000 ($3,170,490,000 structure value and $2,977,021,000 in content value). Total structure and content values of inventoried structures (2015 price and levels of development) for the Orange-Jefferson CSRM project area, in Jefferson County, is $8,120,438,000 ($3,998,788,000 structure value and $4,121,650,000 in content value).

Table 3-1 estimates the FWOP EADs for the damage reaches in the Orange-Jefferson CSRM. Damage categories such as commercial or industrial are provided in Appendix C, Economics.

Table 3-1: Expected Annual Damages
FWOP for the Orange-Jefferson CSRM Project Area by Alternative Reaches
(2015 price level)

Orange-Jefferson CSRM Alternative Reaches	Total
Orange 1	$312,000
Orange 2	$68,000
Orange 3	$29,987,000
Beaumont A	$6,937,000
Beaumont B	$23,000
Beaumont C	$262,000
Jefferson Main	$28,231,000

Port Arthur and Vicinity CSRM

The draft findings of the SQRA for the Freeport system were applied to the plan formulation for the Port Arthur because one has not yet been done for this system. For the Port Arthur HFPP, the detailed description of the needs is similar to what will be presented in the Freeport HFPP section. However, the Port Arthur system is different because there are no known deferred maintenance issues for the Port Arthur system at this time.

The FWOP conditions for the Port Arthur and Vicinity CSRM began with defining reaches for the system. These were based on the failure locations identified by the levee safety program in the absence of a SQRA. Figure 3-7 displays the Port Arthur HFPP failure locations. These locations were included in the plan formulation where improvements would positively impact the system's capacity for protection. The following lists the Alternative Reaches at Port Arthur.

- 8-foot to 10-foot I-Wall Raise
- Closure Structure Raise
- I-Wall Raise Near Valero
- Raise Near Tank Farm

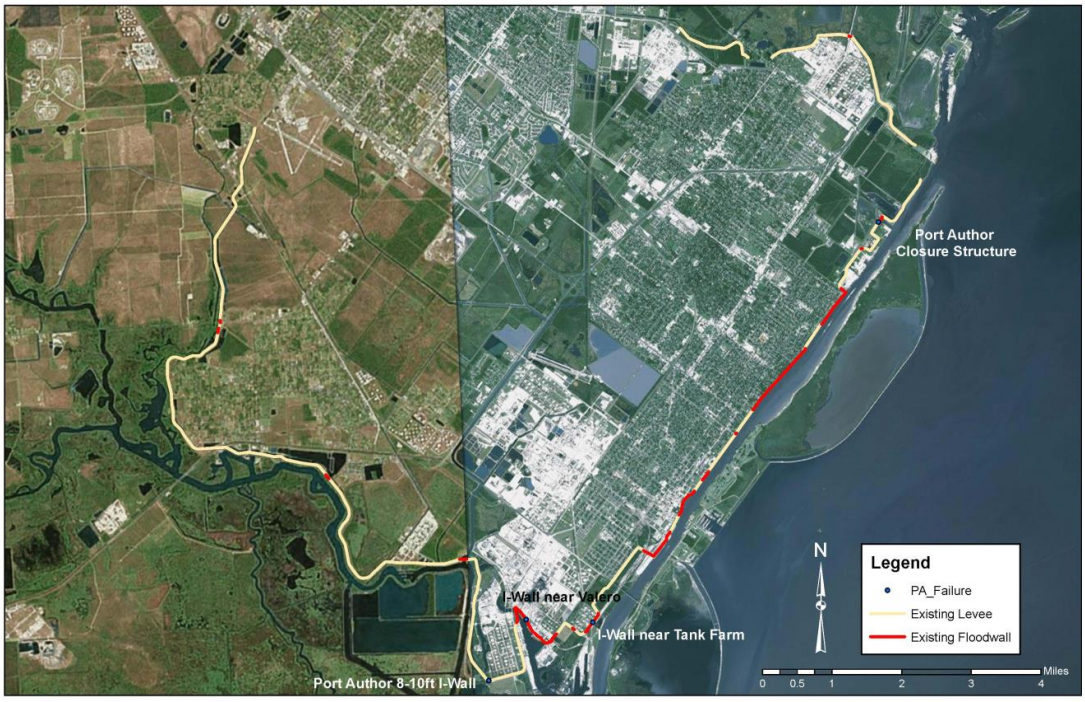

Figure 3-7: Port Arthur and Vicinity Failure Locations

The estimated start of damages for the Port Arthur and Vicinity alternative reaches is approximately 15 feet, which correlates to estimated high probability of failure of the existing HFPP based on the fragility curves. Flooding depths approximate the stage on the exterior side of the existing HFPP, which goes up to approximately 14 feet for the 0.1% ACE.

There are 43,968 structures included in the structure file for the Port Arthur and Vicinity CSRM. The total structure and content values of inventoried structures (2015 price and levels of development) for the Port Arthur and Vicinity CSRM is $19,195,051,000 (7,869,963,000 structure value and $11,625,088,000 in content value). Table 3-2 estimates the FWOP EADs for the damage reaches in the Port Arthur and Vicinity CSRM project area. Damage categories are defined in Appendix C, Economics.

Table 3-2: Expected Annual Damages
FWOP for the Port Arthur and Vicinity Project Area by Alternative Reaches
(2015 price level)

Port Arthur and Vicinity CSRM Alternative Reaches	Total
8-foot to 10-foot I-Wall Raise	$23,413,000
Closure Structure Raise	$3,784,000
I-Wall Raise Near Valero	$61,867,000
Raise Near Tank Farm	$38,009,000

Freeport and Vicinity CSRM

The draft findings of the SQRA for the Freeport system show vulnerabilities primarily associated with steady state seepage issues, and floodwall and levee overtopping. Other performance issues identified during the SQRA were the result of deferred local sponsor maintenance or alterations that local industrial stakeholders have constructed over time. Floodwall performance issues, at locations where the originally constructed floodwall is still in place and has been operated and maintained in an acceptable manner, are being evaluated to include stability and resiliency. Levee reaches that are non-uniform in height or otherwise susceptible to concentrated overtopping erosion during an event are being evaluated for raising or armoring to reduce the likelihood of breach.

The formulation of alternatives for the Freeport and Vicinity CSRM project area began with defining reaches for the system. These were based on the failure locations identified in the SQRA (Figure 3-8). These locations were then narrowed during formulation to those locations where improvements would positively impact the system's capacity for protection and to reduce any redundancies. For example, improvements to the DOW Barge Canal would negate any failures at the DOW Turning Basin.

Figure 3-8: Freeport and Vicinity CSRM Failure Locations

The following is the resulting list of Alternative Reaches at the Freeport and Vicinity CSRM.

- DOW Barge Canal
- Oyster Creek Levee
- East Storm Levee
- South Storm Levee
- Freeport Dock Floodwall
- Old River Levee at DOW Thumb
- Tide Gate I-Wall

The estimated start of damages for the Freeport and Vicinity alternative reaches is approximately 15 feet, which correlates to estimated high probability of failure of the existing HFPP based on the fragility curves. Flooding depths approximate the stage on the exterior side of the existing HFPP, which goes up to approximately 19 feet for the 0.1% ACE.

There are 23,326 structures included in the structure file for the Freeport and Vicinity CSRM. The total structure and content values of inventoried structures (2015 price and levels of development) is approximately $16,700,000,000. Estimates could be higher based on additional structures in the lower reaches outside the DOW Barge Canal structure file inventory.
Table 3-3estimates the FWOP EADs for the damage reaches in the Freeport and Vicinity CSRM. Damage categories are defined in Appendix C, Economics.

Table 3-3: Expected Annual Damages
FWOP for the Freeport and Vicinity Project Area by Alternative Reaches
(2015 price level)

Freeport and Vicinity CSRM Alternative Reaches	Total
DOW Barge Canal	$166,660,000
Oyster Creek Levee	$3,800,000
East Storm Levee	$1,701,000
South Storm Levee	$254,000
Freeport Dock Floodwall	$3,960,000
Old River Levee at DOW Thumb	$2,517,000
Tide Gate I-Wall	$2,785,000

3.3 ENVIRONMENTAL CONDITIONS

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 fresh water 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 RSLC (IPCC 2014).

The effects of hydrological alterations that have decreased freshwater and sediment inflows and increased saltwater intrusion into coastal marshes are expected to continue. These alterations have resulted in the loss of coastal freshwater wetlands and the conversion of remaining fresh marsh systems to more brackish regimes, reducing native biological diversity and productivity. Increased marsh loss could alter the entire food chain in these areas, resulting in wide-reaching and long-term impacts on coastal habitats and fisheries production in terms of species like red drum, white shrimp, and blue crab.

The loss of 1.2 million acres of historic wetlands in Texas makes the remaining areas especially important for wildlife (USFWS 2013). Marsh losses like those on the Neches River, where approximately 9,500 acres of open-water areas have been created by marsh loss at Rose City, Bessie Heights, and Old River Cove, would continue. Subsidence associated with extraction of ground water, oil, and gas would continue, although possibly at a slower rate (Kennish 2001). Marshes along the Gulf shoreline are breaking and converting to open water as a result of subsidence and sea level rise, ultimately resulting in total loss of marsh. Hurricane Ike removed most of the natural beach berm on McFaddin NWR, creating a situation where salt water from the beach now washes regularly into freshwater marshes. Restricting saltwater intrusion into the Upper Salt Bayou system is critical to maintaining the Chenier Plain's continuum of fresh, intermediate, and brackish saline marshes. In addition to their significant ecological value, these marshes also serve to attenuate storm surge and provide a natural defense to shorelines.

3.4 LIFE SAFETY

The population at risk broken down by project area is included in Table 3-4. The populations at risk were developed based on the 2010 census blocks that intersect the damageable properties in the project areas. This population reflects the residential population that could be exposed to flood risk. This does not include transportation routes for population evacuating or those at work in commercial or industrial areas. Defining the population at risk and the depth of flooding is

evaluated in a risk assessment, which was not performed in this study. What is known about the project areas is the residential population that could be exposed to flood risk listed in Table 3-4. Other considerations include high-risk areas that have populations/residents with special needs, such as elderly populations over 65, hospitals, nursing homes, and schools. These types of populations were not fully defined in this study; however, the existing structures (hospitals, nursing homes, and schools) were inventoried in the project area. These structures are listed in Section 3.5 below. Additional information on the location of these structures is included in Appendix C, Economics. Flooding depths are also a consideration. Flooding depths are significant concern at approximately 15 feet where residents have limited ability to vertically evacuate. Approximate flooding depths for each project area were not developed outside of the economic analysis for the FWOP condition. The still-water level estimates for depth of flooding are included in Section 3.2.2 for the project areas.

Table 3-4: Population at Risk by Project Area and Alternative Reach

Population at Risk	
Orange-Jefferson CSRM	
Orange 1	17,014
Orange 2	13,952
Orange 3	60,044
Beaumont A	2,078
Beaumont B	2,078
Beaumont C	2,078
Jefferson Main	116,762
Port Arthur and Vicinity CSRM	116,762
Freeport and Vicinity CSRM	16,559

It is important to note the type of warning systems for the project areas in the FWOP condition. Broad warnings as storm systems develop are coordinated through various agencies such as the National Weather Service, which provides reports to the essential print and electronic media outlets. The National Weather Service generally releases tropical storm watches 48 hours in advance of any anticipated onset of tropical storm force winds. Since outside preparedness activities become difficult once winds reach tropical storm force, warnings are issued 36 hours in advance of any anticipated onset of tropical storm force winds. The Texas Department of Public Safety's Division of Emergency Management coordinates the state emergency management program, as well as implementing the Texas Emergency Tracking Network (ETN), part of a comprehensive data-management system that provides real-time information before, during, and after a disaster. Orange and Jefferson Counties are members of the Southeast Texas Altering Network, which can alert users of emergencies, plant operations, traffic, and weather information or other outreach from emergency management. Orange and Jefferson Counties, as well as

Brazoria County, have emergency management departments that engage their respective cities, including specific evacuation plans and processes.

3.5 CRITICAL INFRASTRUCTURE

The following is a description of the existing critical infrastructure in each project area. Critical infrastructure listed here includes industrial and manufacturing facilities, as well as public facilities. This is a qualitative discussion of the FWOP condition focused on the impacts associated with potential storm surge flooding. The inventory of critical infrastructure was developed from information derived from the Homeland Security Infrastructure Program (HSIP), which is an infrastructure geospatial data inventory. The critical infrastructure is reported for the project areas by type (school, chemical manufacturing, etc.). A North American Industry Classification System (NAICS) code is included in the full listing of the inventory included in Appendix C, Economics. The project areas are discussed by county; Orange-Jefferson CSRM includes Orange and Jefferson County; Port Arthur and Vicinity CSRM includes Jefferson County; Freeport includes Brazoria County. There is overlap in this discussion between the Orange-Jefferson CSRM and Port Arthur and Vicinity project areas since the Jefferson Main Alternative Reach (within the Orange-Jefferson CSRM project area) has overlapping structures located in the Port Arthur and Vicinity project area.

Orange – Jefferson CSRM (Orange and Jefferson County)

Public Facilities – Orange County

- 20 schools
- 14 law enforcement
- 2 hospitals/6 nursing homes
- 11 fire stations

Industrial and Manufacturing – Orange County

- 20 chemical manufacturing
- 5 electric generation
- 0 petroleum refining
- 1 airport

Public Facilities – Jefferson County

- 42 schools
- 19 law enforcement

- 13 hospitals/7 nursing homes
- 26 fire stations

Industrial and Manufacturing – Jefferson County

- 54 chemical manufacturing
- 1 electric generation
- 5 petroleum refining
- 1 airport

Some of the significant industrial and manufacturing facilities located in Orange-Jefferson CSRM include Exxon Mobil, DuPont, Honeywell, Firestone, Petrochemical, Chevron, Phillips, Laxness, Solvay Solexis, and Entergy. A detailed description of each critical facility is not provided here; however, to explain one in some detail, Exxon Mobil is located near downtown Beaumont, Texas, on the Neches River. The refinery processes 345,000 barrels of crude oil per day and produces 2.5 billion gallons of gasoline annually (Exxon Mobil, 2015).

Port Arthur and Vicinity CSRM (Jefferson County)

Public Facilities – Jefferson County

- 42 schools
- 19 law enforcement
- 13 hospitals/7 nursing homes
- 26 fire stations

Industrial and Manufacturing – Jefferson County

- 54 chemical manufacturing
- 1 electric generation
- 5 petroluem refining
- 1 airport

Significant industrial and manufacturing facilities located in the Port Arthur and Vicinity CSRM include Valero, Premcor, Total, Motiva Enterprises, and Huntsman Petrochemical. Jack Brooks Regional Airport is also in the project area. A detailed description of each critical facility is not provided here; however, to explain one in some detail, Motiva is the largest petroleum refinery in the United States, with a daily capacity of approximately 600,000 barrels of crude oil. (Beaumont Enterprise, 2014).

Freeport and Vicinity CSRM (Brazoria County)

Public Facilities – Brazoria County

- 6 schools
- 3 law enforcement
- 0 hospitals/0 nursing homes
- 2 fire stations

Industrial and Manufacturing – Brazoria County

- 24 chemical manufacturing
- 0 electric generation
- 0 petroleum refining

Significant industrial and manufacturing facilities located in the Freeport and Vicinity CSRM include Petroleum Reserve, DOW Chemical, Freeport LNG, Huntsman Gulf Chemicals, Phillips 66 Liquefied Petroleum Gas (LPG) Terminal, SI Group, and NALCO. A detailed description of each critical facility is not provided here; however, to explain one in some detail, DOW Chemical is the largest integrated chemical manufacturing complex in the western hemisphere. The Freeport site produces 44 percent of DOW's products sold in the U.S. and 20 percent of the company's products sold globally (DOW, 2015).

In summary, the critical infrastructure located in the project areas could be impacted during a flood in the FWOP. Of note, if the refineries were closed down due to flood events, there could be significant impacts on gas supplies and multiplier effects on the economy, e.g. increase in transportation costs. Local roadways and major thoroughfares in the project areas were not evaluated in detail for the FWOP condition. Although it is included in the objectives for this study, they are considered ancillary benefits, so they are only covered in this context in the report.

3.6 RELATIVE SEA LEVEL CHANGE

USACE expectations of climate change and relative sea level change, and their impact is an important component of the FWOP condition. The planning horizon of 50 years is used in this study; however, RSLC is estimated beyond that to 100 years. Some key requirements for RSLC in a feasibility study include:

- At a minimum 20-, 50-, and 100-year planning horizons should be considered in the analysis.

- A thorough physical understanding of the project area and purpose is required to effectively assess the project's sensitivity to RSLC.
- Sea level changes should be incorporated into models at the mean and extreme events.
- Identification of thresholds by the project delivery team and "tipping points" (points where the functionality of a project is impaired or a no longer functions as intended) within the impacted project area. This will inform both the selection of anticipatory, adaptive, and reactive options selected and the decision/timing strategies.

Tables 3-5 through 3-6 present the estimated RSLC in the project areas for the 20-, 50- and 100-year for the Low, Intermediate, and High scenarios. Additional information on how the estimates were developed are included in Appendix D. The Sabine Pass, Texas, row corresponds to the sea level rise estimates for the Orange-Jefferson CSRM and Port Arthur and Vicinity CSRM project areas; and the Freeport, Texas, row corresponds to the Freeport and Vicinity CSRM project areas.

The EAD tables presented for the FWOP condition for the final array did not include estimates for the 20-, 50- and 100-year sea level rise scenarios.

Table 3-5: Estimated RSLC over the first 20 years of the project life (2030-2050)

Tidal Gage	Measured Relative SLR Rate (NOAA)	Low (ft)	Intermediate (ft)	High (ft)
Sabine Pass, TX	5.66 mm/yr	0.37	0.54	1.08
Freeport, TX	4.35 mm/yr	0.29	0.46	1.00

Table 3-6: Estimated RSLC over the first 50 years of the project life (2030-2080)

Tidal Gage	Measured Relative SLR Rate (NOAA)	Low (ft)	Intermediate (ft)	High (ft)
Sabine Pass, TX	5.66 mm/yr	0.93	1.49	3.26
Freeport, TX	4.35 mm/yr	0.72	1.27	3.05

Table 3-7: Estimated RSLC over the first 100 years of the project life (2030-2130)

Tidal Gage	Measured Relative SLR Rate (NOAA)	Low (ft)	Intermediate (ft)	High (ft)
Sabine Pass, TX	5.66 mm/yr	1.86	3.42	8.38
Freeport, TX	4.35 mm/yr	1.43	2.99	7.95

3.7 FUTURE WITHOUT-PROJECT CONDITIONS SUMMARY

Based on the evaluation of the FWOP conditions, there is the potential for significant economic damages in the Orange-Jefferson CSRM, Port Arhur and Vicinity CSRM, and Freeport and Vicinity CSRM project areas. There are also concerns for life-safety, damages to critical infrastructure, sea level changes, and impacts on significant environmental resources. These can be further characterized as problems and opportunities for the Federal Government or local interests to implement projects. The FWOP forms the basis against which all potential projects are measured. Before a recommendation to implement a project can be identified, a plan formulation process in accordance with USACE policies needs to be followed. Definition of the FWOP is an important step in this process. The next sections describe the problems and opportunities, objectives and constraints, and the plan formulation process followed to identify a TSP that meets USACE policies for implementation.

4 PROBLEMS AND OPPORTUNITIES

4.1 PROBLEMS AND OPPORTUNITIES

Problem and opportunity statements for the Sabine Pass to Galveston Bay study were initially developed in collaboration with Federal, state, and local agencies, private groups, and the affected public. Four regional public scoping meetings were held across the study area during February to March 2012 jointly by USACE and the GLO. The problems and opportunities were also visited in the Planning Charette in August 2012, and were refined as the study progressed. Problems and opportunities were used to develop the planning objectives for the study and guide in selection of the TSP as described in Section 5. The problems and opportunities listed here are the same developed in the early planning stages.

It is important to explain how a problem or opportunity led to a planning objective/constraint or whether it feeds into the programmatic assessment of potential CSRM projects in the Galveston region (Galveston, Harris, and Chambers Counties) and potential ER projects in the entire six-county study area. For these reasons, a problem or opportunity is provided a reference code to track a problem or opportunity to an objective/constraint or to a programmatic assessment project discussed in subsequent sections.

Due to stipulations of the 3x3x3 Rule exemption, the feasibility study effort described here has focused on CSRM recommendations for the Sabine Region (Orange and Jefferson Counties) and the Brazoria Region (the Freeport metropolitan area in southern Brazoria County). The following in-depth alternative analyses and recommendations do not include CSRM projects in the Galveston Region or ER projects throughout the six-county study area. The latter are handled programmatically as described in Section 1.3 of this report.

4.1.1 Problem Statements

- (P1) Population at risk – Over six million people in six counties on the upper Texas coast, which include the fourth largest U.S. city (Houston), and three other metropolitan areas (Beaumont/Port Arthur/Orange, Galveston/Texas City, and Freeport/Surfside) are severely vulnerable to life safety and economic risks from coastal storm events. Approximately 2.26 million people reside within an identified storm-surge inundation zone. The population of the six-county region is expected to grow to over nine million by 2050.
- (P2) Three of the nine largest oil refineries in the world, 40 percent of the nation's petrochemical industry, 25 percent of the nation's petroleum-refining capacity, and their

associated infrastructure (pipelines, transportation networks, and utilities) will continue to be at risk without a comprehensive plan aimed at reducing susceptibility to flood and hurricane risk. Two of the nation's petroleum strategic reserves are within the surge zone.

- (P3) Three major U.S. seaports, approximately 150 miles of the GIWW (nation's 3rd busiest waterway), and associated infrastructure will continue to be susceptible to flood and hurricane storm damages. A 30-day closure of the HSC has been estimated to result in an economic loss of $60 billion to the nation.
- (P4) Storm-induced erosion is degrading nationally significant migratory waterfowl and fisheries habitats within the study area. The chenier ridges and marshes along the entire coastline of Jefferson County serve as a storm surge buffer to the GIWW, the city of Port Arthur, and several petrochemical facilities, including the largest oil refinery in the U.S. If the ridges and marshes disappear, saltwater inundation will result in the death of marsh vegetation and the conversion of marsh to open water, eliminating the protective buffer.
- (P5) Three existing hurricane protection systems at Port Arthur, Texas City, and Freeport were nearly overtopped during Hurricane Ike. These systems do not meet current design standards for resiliency and redundancy and will be increasingly at risk from storm damages due to relative sea level change and climate change. Critical infrastructure throughout the region, including hurricane evacuation routes, nationally significant medical centers, government facilities, universities, and schools were extensively damaged by recent storm events.
- (P6) This is a geologically sand-starved system; sediment removed from the system is not replenished. This results in continued shoreline retreat and accelerated shoreline erosion during storm events.
- (P7) The study area is located in an area with a high frequency of storm impacts and economic damages (second highest area of occurrence on Gulf coast). Environmental impacts on refineries are likely from storm damages (e.g., release of toxic substances).
- (P8) Potential damages of $100 billion could have resulted if the storm track of Hurricane Ike had been slightly to the south.
- (P9) The value of infrastructure associated with petrochemical/oil/gas refineries that could be impacted by storms is very high.

4.1.2 Opportunity Statements

- (Op1) Provide shoreline protection to reduce risks to commercial and residential property, real estate, and infrastructure within the six-county study area;
- (Op2) Enhance ecotourism and recreation opportunities;
- (Op3) Enhance public education related to coastal storm risk;

- (Op4) Reduce environmental damage associated with storm damage to refinery infrastructure;
- (Op5) Enhance or restore endangered species habitat;
- (Op6) Reduce risk for evacuation routes so they remain clear longer;
- (Op7) Manage regional sediment management for beneficial uses to navigation and other operations;
- (Op8) Increase reliability of the nation's energy supply;
- (Op9) Avoid or mitigate adverse natural resource impacts;
- (Op10) Leverage resources from multiple stakeholders for effective solutions; and
- (Op11) Establish more resilient communities.

4.2 PLANNING GOALS AND OBJECTIVES

4.2.1 Planning Goals

The main goals of this project are to reduce the risk to lives and property associated with coastal storms within the Orange-Jefferson, Port Arthur and Vicinity, and Freeport and Vicinity CSRM project areas. In-depth alternative analyses for the Galveston region or ER were not performed beyond the Evaluation Array Alternatives; thus, there are no recommendations to construct ER or projects in the Galveston region as part of the TSP.

4.2.2 Public Concerns

Public input was solicited at four public scoping meetings held in January and February 2012 in Beaumont, Seabrook, Galveston, and Freeport, Texas. During the scoping process, concerns raised included erosion of the GIWW shoreline, nonstructural solutions to storm surge damages should be considered above all else, and keeping the mouth of the San Bernard River open for recreational navigation.

4.2.3 Planning Objectives

The objectives listed in Table 4-1 were developed from the problem and opportunity statements and used to guide the plan formulation for the TSP. It also ties the problem or opportunity to an objective as indicated by the reference codes. If a problem or opportunity is addressed in the programmatic assessment, those fall within that respective column in the table. Some problems and opportunities cross over in the objectives. For example, the opportunity Op10 crosses over all objectives. The intent of this opportunity is to capture data, reports, outputs from SSPEED, Texas A&M Galveston, Surge District studies, etc. that have already been performed in the study area. The row highlighted in green in Table 4-1 is the previous ER objective developed for this study, but is not included in development of the TSP.

Table 4-1 is organized to align the study planning objectives to the "four accounts" listed in the Economic and Environmental Principles for Water and Related Land Resources Implementation Studies. These "principles" were established pursuant to P.L. 89-80, and amended. The four accounts are established to facilitate evaluation and display of effects of alternative plans. The four accounts are: 1) National Economic Development (NED); 2) Environmental Quality (EQ); 3) Regional Economic Development (RED); and 4) Other Social Effects (OSE).

- NED: account displays changes in the economic value of the national output of goods and services.
- EQ: account displays non-monetary effects on significant natural and cultural resources.
- RED: account registers changes in the distribution of regional economic activity that result from each alternative plan. Evaluations of regional effects are to be carried out using nationally consistent projections of income, employment, output, and population.
- OSE: account registers plan effects from perspectives that are relevant to the planning process, but are not reflected in the other three accounts.

Environmental policies require that fish and wildlife resource conservation be given equal consideration with other study purposes in the formulation and evaluation of alternative plans. In the evaluation process, care was given to preserve and protect significant ecological, aesthetic, and cultural values, and to conserve natural resources. Alternative plans were formulated to reduce the risk of damages from coastal storms, as well as to avoid environmentally significant resources. The location of potential ER projects relative to new levee system alternatives were considered during plan formulation. ER opportunities identified by this study are described and mapped in Appendix A. They are located outside of the new levee alternatives, in the floodplain of the Neches River and on the coastal plain south of the Orange-Jefferson CSRM project area. The location of the new levee alignment and the design of the culvert system minimized impacts on wetlands and floodplains, both inside and outside of the system, to the greatest extent practicable. The potential for marshes to migrate landward due to RSLC is low because of the abrupt 8- to 10-foot elevation change between the floodplain and the upland in most of project area. Therefore, there would be no impacts on potential future ER projects. Where impacts of this TSP could not be avoided, impacts were quantified and a mitigation plan was formulated. A mitigation estimate was developed and included as a project cost.

4.2.4 Planning Constraints

The following constraint was developed from the problem and opportunity statements and used to guide the plan formulation for this study. Reducing life-safety risk is a planning objective of the study; however, careful consideration is required to ensure structural plans do not increase

Table 4-1: Sabine Pass to Galveston Bay, Texas Planning Objectives and Measurements

Planning Objectives	NED*		OSE*	RED*	EQ*	Programmatic Assessment
	Coastal Storm Surge Damage Benefits	Costs	Population at Risk	Critical Infrastructure Impacts	Ecosystem Functionality	
1. Reduce economic damage to business, residents and infrastructure for the Sabine and Brazoria region for the 50-year period of analysis. Problem/Opportunity Code: P7, P8, Op1, Op2, Op9, Op10, Op11	Benefits for coastal storm damages averted (ADCIRC floodplain and water elevation; CAD values)	First Cost of Construction; O&M Life Cycle Cost**; Mitigation & Monitoring Cost				Problem/Opportunity Code: P4, P6, Op5, Op7
2. Reduce risk to human life from storm surge impacts for the Sabine and Brazoria region for the 50-year period of analysis. Problem/Opportunity Code: P1, P8, Op3, Op10, Op11			Number of people for which risk is reduced (2010 census)			
3. Maintain and/or restore coastal habitat that contributes to storm surge attenuation where feasible for the 50-year period of analysis.					Average Annual Habitat Units (AAHUs)	
4. Enhance energy security and reduce economic impacts of petrochemical supply-related interruption for the Sabine and Brazoria region for the 50-year period of analysis. Problem/Opportunity Code: P2, P8, Op5, Op10, Op8	CAD value of facilities			Effect of transportation disruptions after storms		
5. Reduce risks to critical infrastructure (e.g., medical centers, ship channels, schools, transportation, etc.) for the Sabine and Brazoria region for the 50-year period of analysis. Problem/Opportunity Code: P3, P8, Op4, Op9, Op10, Op11				Number of critical facilities and evacuation routes for which risk is reduced		
6. Identify opportunities to enhance functionality of existing hurricane protection system including evaluation of impacts due to sea level rise for the 50-year period of analysis. Problem/Opportunity Code: P5, P8, Op10	Benefits for coastal storm damages averted (ADCIRC floodplain and water elevation; CAD values)					

*These columns correspond to the Principle and Guidelines four accounts: National Economic Development (NED), Other Social Effects (OSE), Regional Economic Development (RED) and Environmental Quality (EQ)

** Operation, Maintenance, Repair, Replacement and Rehabilitation (OMRR&R) costs were not included and are not expected to impact plan formulation since they would impact the alternatives proportionally

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risk. As such, any features that increase risk to human life from storm surge impacts in the Sabine and Brazoria regions for the 50-year period of analysis will not be considered in the TSP.

4.3 RELATED PROJECT DOCUMENTS

Related project documents include the following:

- 1975 Final Environmental Impact Statement: Maintenance Dredging Gulf Intracoastal Waterway Texas Section, Main Channel and Tributary Channels. Volumes 1, 2, and 3. Galveston, Texas
- 2003 Final Environmental Assessment, Houston-Galveston Navigation Channels, Texas – Upper Barge Lanes. Galveston District, Galveston, Texas
- 2003 Final Feasibility Report and Environmental Assessment, Gulf Intracoastal Waterway, High Island to Brazos River, Texas, Section 216 Study. Galveston District, Galveston, Texas
- 2005 Draft Feasibility Report, Freeport and Vicinity, Texas Hurricane Flood ProtectionProject. Galveston District, Galveston, Texas
- 2008 Final General Reevaluation Report and Environmental Assessment, Texas City Channel Deepening Project. Galveston District, Galveston, Texas
- 2010 Final Environmental Assessment, Houston-Galveston Navigation Channels, Texas – Expansion of Placement Areas 14 and 15. Galveston District, Galveston, Texas
- 2011 Final Environmental Impact Statement, Sabine-Neches Waterway Channel Improvement Project, Southeast Texas and Southwest Louisiana. Galveston District, Galveston, Texas
- 2012 Final Environmental Impact Statement, Freeport Harbor Channel Improvement Project, Brazoria County, Texas. Galveston District, Galveston, Texas
- 2013 Draft Environmental Assessment, Galveston Harbor Channel Extension Post-Authorization Change Report, Galveston County, Texas (March 2013). Galveston District, Galveston, Texas

4.4 DECISIONS TO BE MADE

The decision to be made is to select a plan as the TSP from a final array to meet the objectives of the study. The planning objectives align with the Federal objective and the four accounts. The plan that best meets the objectives is identified as the TSP. This does not preclude a decision to refine or alter the TSP based on inputs for public, policy, and technical reviews of this DIFR-EIS.

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5 FORMULATION AND EVALUATION OF ALTERNATIVE PLANS*

5.1 PLAN FORMULATION RATIONALE

Plan formulation is the process of building alternative plans that meet planning objectives and develop alternatives within the planning constraints. Alternative plans are a set of one or more management measures functioning together to address one or more planning objectives. A management measure is a feature or activity that can be implemented at a specific geographic site to address one or more planning objectives.

The planning process for this feasibility study is driven by the overall objective of developing a comprehensive plan that will help manage risks associated with coastal storms within the study counties while avoiding and minimizing impacts on the area's environmental resources.

Preliminary plans were formulated by combining management measures. Each plan was formulated in consideration of the following four criteria described in the Principles and Guidelines (P&G):

- Completeness: Extent to which the plan provides and accounts for all necessary investments or actions to ensure realization of the planning objectives.
- Effectiveness: Extent to which the plan contributes to achieving the planning objectives.
- Efficiency: Extent to which the plan is the most cost-effective means of addressing the specified problems and realizing the specified opportunities, consistent with protecting the nation's environment.
- Acceptability: Workability and viability of the alternative plan with respect to acceptance by Federal and non-Federal entities and the public, and compatibility with existing laws, regulations, and public policies.

Initial study efforts involved a determination of the magnitude and extent of the problems within the study area in order to develop and evaluate an array of alternative solutions that meet the existing and long-range future needs of the non-Federal sponsor and the public. At the initiation of the feasibility phase of the project, lines of communication were opened with Federal, state, and local agencies, private groups, and the affected public. Four regional public scoping meetings were held across the study area during February to March 2012.

5.2 MANAGEMENT MEASURES

The initial array of measures was developed with public, local government, and agency input gathered during the four scoping meetings. During the scoping process, the measures were grouped geographically into the three major regions (Sabine, Galveston, and Brazoria).
Potential structural and nonstructural measures considered were:

- Structural (raising roadways, levees, flood walls, flood gates, breakwaters, marsh/dune/shoreline restoration, hardening of infrastructure, etc.)
- Nonstructural (buyouts, raising structures, flood warning systems, floodplain management, regional sediment management, etc.)

Potential projects for the Sabine area include Gulf shoreline protection and restoration measures such as beach nourishment, dune restoration, chenier ridge restoration, sediment management, shoreline armoring, and submerged near-shore breakwaters. Potential projects for the Galveston area include various Gulf shoreline protection and restoration measures such as beach nourishment, dune restoration, beach ridge restoration, sediment management, shoreline armoring, and submerged near-shore segmented breakwaters. Specific targets include, but are not limited to, the shoreline west of Rollover Pass and near Fort Travis. Projects may include development of a comprehensive regional sediment management plan for the Galveston Bay system and Gulf shoreline. Viability of Gulf shoreline projects is dependent on the GLO's ability to acquire easements. Potential projects for the Brazoria area include various Gulf shoreline protection and restoration measures such as beach nourishment, dune restoration, sediment management, shoreline armoring and submerged near-shore breakwaters. Specific targets include Quintana/Bryan Beach, Surfside Beach, and Follets Island. At the SMART Planning Charette (Charette), the full Vertical Team (USACE District, Division, Headquarters, and Office of Water Project Review) worked through an abbreviated version of the six-step planning process, considered a full array of measures and alternatives, and then formulated comprehensive (regional) plans to include in the "Initial Alternative Plans Array." Information gathered during the public scoping process, combined with work conducted at the Charette, resulted in identification of approximately 39 individual implementable measures and five comprehensive regional alternative plans addressing the entire six-county area. Each plan included structural and nonstructural measures that would address CSRM and ER objectives.

During the Charette, the team identified three criteria that would be utilized to evaluate the initial array of alternatives. The three criteria are 1) Implementation Costs; 2) Damages Reduced; and 3) Environmental Benefits. It was envisioned at the Charette that these criteria would be used to evaluate the five alternatives that were developed from the measures during the Charette. After

the Feasibility Cost Share Agreement (FCSA) for the study was signed and efforts began on data collection, the study team determined that many of the components of the different alternatives were redundant and that information on the measures was incomplete. The Project Delivery Team (PDT) decided to deconstruct the alternatives, collect available targeted information, and refine/reformulate the measures for completeness and to eliminate redundancies.

This resulted in a list of about 75 reformulated initial measures that served as the building blocks of alternative plans. These nonstructural and structural measures were considered as part of the study analysis and were developed to address study objectives previously presented in Section 4. These measures were combined with other measures, nonstructural or structural, to form alternatives to be evaluated in the study process. These alternatives are screened in the Plan Formulation Phase, as discussed in the next section. The majority of the measures developed were structural; however, it should be noted that nonstructural measures were carried forward to the Final Array of Alternatives. The structural measures included new coastal and inland structural barriers, reconstruction of existing and construction of new regional hurricane protection systems, local surge protection systems, raising roads as surge or overwash protection barriers, Gulf shoreline protection (beach and dune restoration, nearshore breakwaters, chenier ridge restoration), GIWW erosion protection, marsh restoration, and salinity/water control structures. Measure Information Sheets with descriptions and maps of each measure are presented in Appendix A. Table 2-1 of Appendix B includes the list of the 75 initial measures.

After the reformulation of the intial 75 measures, each measure was evaluated to determine whether it would address the planning objectives. If they did not, they were removed from further consideration. This screening process removed 15 measures from the study. Table 5-1 summarizes this process and the criteria used. Section 3.1.2 of Appendix B describes the reasons for elimination.

Table 5-1: Summary of Management Measures and Initial Screening of Measures

	Number of Measures	**Screening Criteria**
Management Measures	75 Measures in Sabine, Galveston, and Brazoria Regions	None, this was the initial array of management measures
Initial Screening of Measures	Resulted in elimination of 15 measures from the 75 measures	Economic Damages Reduces based on water surface elevations; Acres of habitat protected/restored by the plan; and order of magnitude parametric costs (Class 5 cost estimate)

5.3 SUMMARY OF ALTERNATIVES ANALYSES

The initial measures were screened to determine if they adequately addressed the problems and objectives of this study. The remaining measures were then formed into arrays of alternatives plans, which were screened to determine the most effective alternatives. The screening produced three iterations of alternatives including:

- Initial Array of Alternatives;
- Evaluation Array of Alternatives; and
- Final Array of Alternatives.

5.3.1 Initial Array of Alternatives

In this phase, comprehensive alternative plans were formulated for each of the three regions in the six-county study area. This was done to make the task of formulating alternatives for such a large and diverse area more manageable. The alternatives were meant to be stand-alone plans that can be compared directly to one another. Alternatives have been included that are anchored to existing or proposed structural projects (or "hard" structures), as well as "soft" structural alternatives that could reduce impacts with ER or protection measures and improve the resiliency of the system. Some alternatives were intended to provide all-inclusive plans and others were drafted to focus more closely on traditional structural or ER measures. The Initial Array of Alternatives included eleven alternatives for the Sabine Region, nine alternatives for the Galveston Region and five alternatives for the Brazoria Region, for a total of 25 alternatives considered in the Initial Array of Alternatives. A detailed description of the alternatives is included in Section 5.2 of Appendix B (note that each alternative was provided an Alternative Number). A summary of the alternatives is provided below.

For the Sabine Region, the eleven alternatives included evaluation of existing HFPPs in the region, construction of additional levees to protect Orange County, the use of gated surge barrier structures in combination with the new levees, as well as environmental restoration measures such as beach and dune restoration, marsh and barrier island restoration, shoreline protection along the Gulf and the GIWW, nearshore breakwaters, and hydrologic restoration. Nonstructural alternatives were also considered.

Nine alternatives were developed for the Galveston region, including alternatives which addressed CSRM and ER in combination and individually. These alternatives included evaluation of the existing HFPP in the region, a coastal barrier, ring levees, gated surge barrier structures, as well as environmental restoration measures such as beach and dune restoration,

marsh and barrier island restoration, shoreline protection along the Gulf and the GIWW, and nearshore breakwaters. Nonstructural alternatives were also considered.

For the Brazoria Region, the five alternatives included plans for evaluating the existing HFPP, as well as environmental restoration measures such as beach and dune restoration, shoreline protection along the GIWW, and a groin. Nonstructural alternatives were also considered.

The Initial Array of Alternatives was screened using three quantitative criteria (economic benefits, environmental benefits and implementation costs) and one qualitative criterion (environmental impacts) (Table 5-2) to develop the Evaluation Array of Alternatives.

Table 5-2: Criteria for Screening Initial Array of Alternatives

Criteria	Metric
Damages reduced	Economic damages reduced based on water surface elevation
Environmental benefits	Acres habitat protected/restored by the plan
Implementation costs	Order of magnitude parametric (Class 5 cost estimates)
Environmental Impacts	Qualitative Analysis using: construction impacts to wetlands and sensitive habitat; system-wide hydrologic impacts' and endangered species impacts

This screening process removed eight alternatives from the Sabine Region, five from the Galveston Region and two from the Brazoria Region. Section 5.5 of Appendix B summarizes the reasons for eliminating alternatives.

5.3.2 Evaluation Array of Alternatives

The screening process described in the previous section led to the identification of the Evaluation Array of Alternative Plans, which is composed of ten alternatives (three from Sabine Region, four from Galveston Region, and three from Brazoria Region) to be evaluated in more detail. The Evaluation Array of Alternatives are listed and described in Table 5-3.

The Evaluation Screening of Alternatives was used as a decision point to determine whether the data collected and utilized for this analysis is sufficient to make the determination of which alternative (S5-"Gate"/S8-"No-Gate") to carry forward for detailed analysis. It was estimated the plans would provide roughly the same amount of benefits. Therefore, since the benefits are roughly the same, the primary determining factor was cost, allowing the alternative with the lowest cost to be the alternative to be carried forward into more detailed evaluation. If the two alternative costs were not significantly different, both alternatives would require additional detailed evaluation before either could be ruled out.

Table 5-3: Evaluation Array of Alternatives

Alternative Number	Alternative Name	Description
S5	Sabine Inland Barrier CSRM Focus(Neches Gate/Sabine Levees/HFP)	Neches River Navigation Gate, Sabine Levees, Port Arthur HFP
S8	Sabine ER (with surge barrier on upper Sabine River)	Beach and dune restoration, restore beach ridge, nearshore breakwaters, GIWW shoreline protection, marsh restoration on Neches River and at Keith Lake and Texas Point, Salt Bayou hydrologic restoration, Sabine River levees and gate
S11	Sabine Nonstructural Alternative	Buyouts and Lone Star-type conservation plan
G2	Galveston Coastal Barrier CSRM Focus	Coastal barrier and gates, and buyouts/relocations within a 500 ft buffer
G5	South Galveston Bay Inland Barriers CSRM Focus	Surge barrier and gates near Hartman Bridge, Tx City HFP, Galveston Ring Levee, Chocolate Bayou ring levee, Raise Hwy 146 and buyouts/relocations within a 500 ft buffer
G7	Galveston Bay ER	Beach and dune restoration, GIWW shoreline protection, marsh restoration, East Bay shoreline protection, closing Rollover Pass
G9	Galveston Bay Nonstructural Alternative	Buyouts and Lone Star-like conservation plan
B2	Brazoria Coastal Barrier CSRM Focus (revised)	Freeport HFP
B3	Brazoria ER	Beach and dune restoration, groin, and GIWW shoreline protection
B5	Brazoria Nonstructural Alternative	Buyouts and Lone Star-like conservation plan

Consideration was given to a variety of factors including engineering, economics, costs, and environmental impacts for the Gate and No-Gate Alternatives; however, the cost of the Gate Alternative is approximately $865 million more expensive than the No-Gate Alternative. This cost difference is significant and further refinement and detailed analyses would not be expected to reduce this difference. Therefore, the Gate Alternative (S8) was dropped from further consideration in the study.

5.3.3 Scoping of Study under 3x3x3 Guidelines

Recent USACE planning modernization has resulted in the 3x3x3 guidelines under which this study was developed. Therefore, a scope was developed for completion of the study that would evaluate a final array of structural and non-structural alternatives in the six-county study area and that would be completed in 3 years for $3 million.

The USACE Galveston District (SWG) developed an option for completing the study in a manner that was low to moderate risk and requested an exemption from the 3x3x3 guidelines to complete this study. The recommendation was to pursue a $4.4 million programmatic assessment of the six-county study area and focused evaluation on two sub-regions, Sabine and Brazoria, within the study area as the first interim study for CSRM project implementation. This first interim feasibility study would be followed by future studies recommending CSRM projects in the Galveston region, as well as ER opportunities throughout the entire six-county region. Future feasibilities will leverage studies, data, and models currently under development by others in the Galveston region. The exemption request was approved by USACE Headquarters and the recommended focus of the study in the Sabine and Brazoria regions continued into the final array of alternative plans.

5.3.4 Final Array of Alternatives

In accordance with the exemption request approval, the Sabine and Brazoria CSRM alternatives were carried forward into detailed feasibility analysis. The Final Array of Alternatives is presented in Table 5-4. These alternatives were evaluated in detail in the final evaluation to determine the TSP.

In the final evaluation, it became necessary to redefine the names for the Final Array of Alternatives. For example, the S5 Alternative was split into two individual alternatives: 1) Orange-Jefferson CSRM; and 2) Port Arthur and Vicinity CSRM. The project areas are listed by their name in Table 5-4.

Table 5-4: Final Array of Alternatives

Alternative Number	Description
No Action	No Action or Future Without Project (FWOP)
S5	Orange-Jefferson CSRM
S5	Port Arthur and Vicinity CSRM
B2	Freeport and Vicinity CSRM
S11 & B5	Brazoria and Sabine Nonstructural

5.4 COMPARISON OF FINAL ARRAY OF ALTERNATIVE PLANS AND DECISION CRITERIA

The Final Array of Alterantives are generally listed in Table 5-4. This list is considered a project area for the remainder of the discussion of the evaluation and comparison of the final array. The "Optimization Alternatives" embedded in the project areas listed in Table 5-4 are the actual final array evaluated and compared to determine the TSP. The Optimization Alternatives are defined in Table 5-5. The Optimization Alternatives were defined by Alternative Reaches discussed in

the economic conditions FWOP described in Section 3.2.2. The Alternative Reaches are included in the Table for reference. The No Action Alterantive is not listed in the table since it is the FWOP condition for each of the project areas. Brazoria and Sabine Nonstructural are also not listed because Alternative Reaches were not required for the nonstructural evaluation.

Table 5-5: Relationship with Project Area, Alternative Reaches and Optimization Alternatives

Project Area	Alternative Reaches	Optimization Alternatives
Orange-Jefferson CSRM	Orange 1	11-, 12-, 13- and 14-foot New Levee
	Orange 2	11-, 12-, 13- and 14-foot New Levee
	Orange 3	11-, 12-, 13- and 14-foot New Levee
	Jefferson Main	11-, 12-, 13- and 14-foot New Levee
	Beaumont A	11-, 12-, 13- and 14-foot New Levee
	Beaumont B	11-, 12-, 13- and 14-foot New Levee
	Beaumont C	11-, 12-, 13- and 14-foot New Levee
Port Arthur and Vicinity CSRM	8-10 ft I-Wall	No Fail, 1-foot Raise, 2-foot Raise
	Closure Structure	No Fail, 1-foot Raise, 2-foot Raise
	I-Wall Near Valero	No Fail, 1-foot Raise, 2-foot Raise
	I-Wall Near Tank Farm	No Fail, 1-foot Raise, 2-foot Raise
Freeport and Vicinity CSRM	DOW Barge Canal	Levee Rehabilitation; Gate Structure
	Oyster Creek Levee	No Fail, 1-foot Raise, 2-foot Raise
	East Storm Levee	No Fail, 1-foot Raise, 2-foot Raise
	South Storm Levee	1-foot Raise, 2-foot Raise
	Freeport Dock Floodwall	Partial Fail, No Fail, 1-foot Raise
	Old River Levee at DOW Thumb	No Fail, 1-foot Raise, 2-foot Raise
	Tide Gate I-Wall	No Fail, 1-foot Raise, 2-foot Raise

5.4.1 Final Screening Criteria

In order to select a plan from the final array, screening criteria were developed that align with the objectives of the study (See Table 4-1, Section 4.2.3) and listed below.

- Objective 1: Reduce economic damages to business, residents, and infrastructure for the Sabine and Brazoria region for the 50-year period of analysis.
- Objective 2: Reduce risk to human life from storm surge impacts for the Sabine and Brazoria region for the 50-year period of analysis.
- Objective 3: Maintain and/or restore coastal habitat that contributes to storm surge attenuation where feasible for the 50-year period of analysis.

- Objective 4: Enhance energy security and reduce economic impacts of petrochemical supply-related interruption for the Sabine and Brazoria region for the 50-year period of analysis.
- Objective 5: Reduce risk to critical infrastructure (e.g., medical centers, ship channels, schools, transportation) for the Sabine and Brazoria region for the 50-year period of analysis.
- Objective 6: Identify opportunities to enhance functionality of existing hurricane protection systems including evaluation of impacts due to sea level rise for the 50-year period of analysis.

The planning objectives were aligned with the four accounts: NED, EQ, RED, and OSE. The Optimization Alternatives were evaluated in detail, then compared against each other to identify which plan contributes most to the objectives. This screening criteria is different than the screening process used in the Initial and Evaluation Array of Alternatives. The Optimization Alternatives were evaluated first for the NED objectives (Objectives 1, 4 and 6) using the HEC-FDA model. The EADs presented in this report use storm surge levels without considering sea level rise scenarios for the 20-, 50- and 100-year sea level rise scenarios. Alternative Reaches were defined in the FWOP; this condition is the baseline to show reductions in EAD and to identify which plan reasonably maximizes net economic benefits, i.e., the NED plan. The compilations of each NED plan from the project areas are considered for the TSP. The screening criteria for RED and OSE objectives are qualitative (Objectives 4 and 2, respectively). For RED, critical infrastructure impacts are discussed qualitatively with focus on the effect of transportation disruptions after storms and the number of critical facilities and evacuation routes for which risk is reduced. For OSE, alternative performance is measured based on the number of people for which risk is reduced. This is discussed qualitatively for the final array. Another means to measure reduction in life-safety risk is to utilize a quantitative model. The HEC-FIA model has not been used to evaluate the final array. The final array evaluation results are described first in terms of economic performance, i.e. the net benefits are displayed for each Optimization Alternative. The net benefits were developed by comparing the Optimization Alternatives to the FWOP EADs. The qualitative discussion of life-safey, critical infrastructure, and consideration of RSLC is provided in Section 5.4.4.

5.4.2 Final Array Evaluation Results

The following sections present the results of the evaluation of the final array. This section focuses on a description of the Optimization Alternatives and the economic evaluation results. Additional description of the Optimization Alternatives is provided in Appendix D, Section 1.9, and the detailed economic evaluation results is provided in Appendix C, Economics.

5.4.2.1 No Action/Future Without-Project Condition

The FWOP is define in Section 3 of this report; this condition is the baseline EADs to show how well an alternative performs against the NED planning objective and to identify which plan reasonably maximizes net economic benefits, i.e., the NED plan.

5.4.2.2 Orange-Jefferson CSRM Project Area

The following section describes the proposed Orange-Jefferson CSRM Optimatization Alternatives. The plans in this project area include a combination of new levees and floodwalls at varying heights to address the storm surge flood risk. The Optimization Alterantives run along the north side of the Neches River and the west bank of the Sabine River. Figure 5-1 shows the location of the Optimization Alternatives listed below.

- Orange 1 consists of approximately 27,000 linear feet (LF) of levee and 16,500 LF of floodwall (total of 8.2 miles); levee heights evaluated include 11-foot, 12-foot, 13-foot, and 14-foot;
- Orange 2 consists of approximately 34,600 LF of levee (6.6 miles); levee heights evaluated include 11-foot, 12-foot, 13-foot, and 14-foot;
- Orange 3 consists of a combination of 113,600 LF of levee and 29,800 LF of floodwall (total of 27 miles); levee heights evaluated include 11-foot, 12-foot, 13-foot, and 14-foot;
- Jefferson Main runs along the south side of the Neches River and consists of approximately 41,700 LF of levee and 16,200 LF of floodwall (11 miles); levee heights evaluated include 11-foot, 12-foot, 13-foot, and 14-foot;
- Beaumont A is combination of 3,100 LF of levee and 200 LF of floodwall (0.6 mile); levee heights evaluated include 11-foot, 12-foot, 13-foot, and 14-foot;
- Beaumont B is 2,500 LF of levee (0.5 mile); levee heights evaluated include 11-foot, 12-foot, 13-foot, and 14-foot; and
- Beaumont C is 6,800 LF of levee (1.3 mile); levee heights evaluated include 11-foot, 12-foot, 13-foot, and 14-foot.

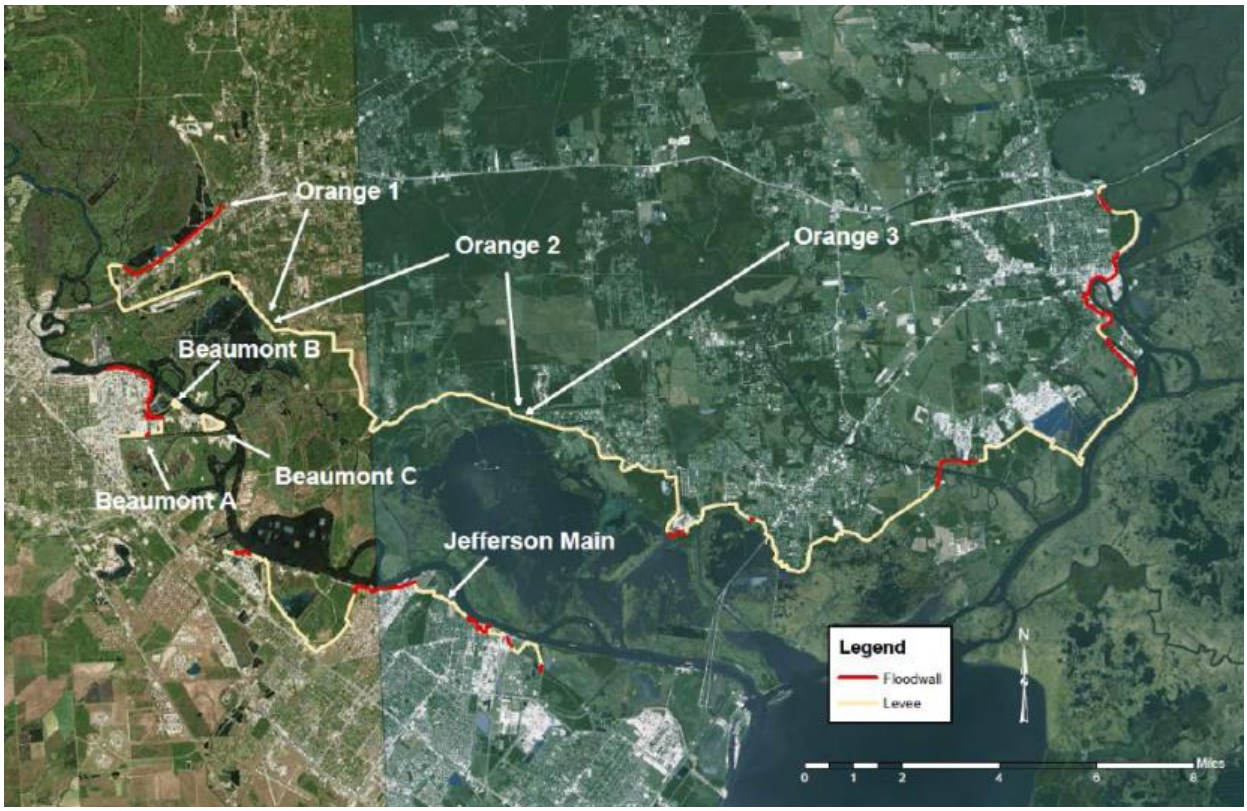

Figure 5-1: Location of Optimization Alternatives in the Orange-Jefferson CSRM Project Area

Economic Evaluation

The net benefits of Optimization Alternatives for the Orange-Jefferson CSRM project area are presented in Table 5-6. Negative net benefits are shown in red text. Fish and wildlife mitigation costs were included in the economic evaluation. The approved WVA was used to quantify habitat impacts for a conservatively wide footprint of the alignment's construction right-of-way. Estimated mitigation costs (first costs and monitoring/adaptive management costs) were developed based upon conceptual mitigation plans. The same mitigation cost was applied to all height alternatives in each segment, as the impacts and mitigation would be similar for all heights and the cost variation among them would be small. When compared to other cost elements, estimated fish and wildlife mitigations costs were not large enough to affect plan selection.

Table 5-6: Net benefits of Optimization Alternatives for the Orange-Jefferson CSRM project area

Alternative Reach	Optimization Alternatives	Net Benefits
Orange 1	11-foot New Levee	**($1,769,000)**
	12-foot New Levee	**($2,380,000)**
	13-foot New Levee	**($2,996,000)**
	14-foot New Levee	**($3,617,000)**
Orange 2	11-foot New Levee	**($1,757,000)**
	12-foot New Levee	**($2,112,000)**
	13-foot New Levee	**($2,467,000)**
	14-foot New Levee	**($2,822,000)**
Orange 3	11-foot New Levee	$9,851,000
	12-foot New Levee	$10,232,000
	13-foot New Levee	$9,804,000
	14-foot New Levee	$8,810,000
Jefferson Main	11-foot New Levee	$22,461,000
	12-foot New Levee	$22,580,000
	13-foot New Levee	$22,496,000
	14-foot New Levee	$22,123,000
Beaumont A	11-foot New Levee	$2,743,000
	12-foot New Levee	$2,992,000
	13-foot New Levee	$3,037,000
	14-foot New Levee	$2,942,000
Beaumont B	11-foot New Levee	**($58,000)**
	12-foot New Levee	**($82,000)**
	13-foot New Levee	**($106,000)**
	14-foot New Levee	**($131,000)**
Beaumont C	11-foot New Levee	**($442,000)**
	12-foot New Levee	**($449,000)**
	13-foot New Levee	**($574,000)**

5.4.2.3 Port Arthur and Vicinity CSRM

The following section describes the proposed Port Arthur and Vicinity CSRM Optimization Alternatives. The plans include modifications to the existing HFPP at Port Arthur. Figure 5-2 shows the location of the Optimization Alternatives listed below.

- 8- to 10-foot I-Wall
  - No fail: 3,500 LF of 15-foot- wide 6-inch scour pad
  - 1-foot raise: 7,500 LF of 15-foot-wide 6-inch scour pad. This option would include adding capacity to the system in this reach by addressing low areas of the levee

system, raising 2,000 LF of levee 1 foot and providing overtopping erosion protection.

- 2-foot raise: 7,500 LF of 15-foot-wide 6-inch scour pad; and 60,000 LF of levee raising 2 feet along with raising the Highway 87 and Highway 73 levee crossings. Floodwalls at two pump stations would be added along with 1,000 LF of floodwall reconstruction at the Taylors Bayou closure. This option would also require the replacement of one gravity drainage structure and one vehicle closure structure.

- *Closure Structure*
  - No fail: Construction of two, 300 LF of 100-foot-wide 6-inch scour pads, one on each side of the structure to provide erosion protection to reduce the likelihood of a brittle failure if the systems' capacity is exceeded.
  - 1-foot raise: This includes replacement of a vehicle closure structure that is 12 feet high by 30 feet wide. It also includes 300 LF of 100-foot-wide 6-inch scour pad, one on each side of the structure to provide erosion protection to reduce the likelihood of a brittle failure if the systems' capacity is exceeded. This option also included raising 12,000 LF of levee 1 foot.
  - 2-foot raise: Replace two vehicle closure structures/gate structures that are 12 feet high by 30 feet wide, including two 300 LF of 100-foot-wide 6-inch scour pad along both sides of each closure structure. This plan includes raising 12,000 LF of levee 2 feet and adding floodwalls at two pump stations, 500 LF total (7 feet tall) along with reinforcing pump station walls at four existing pump stations.

- I-Wall Near Valero
  - No fail: Construction of 5,000 LF of 15-foot-wide 6-inch scour pad to provide additional structural integrity to the I-Wall and erosion protection to reduce the likelihood of failure.
  - 1-foot raise: Construction of 5,000 LF of 15-foot-wide 6-inch scour pad with a 1-foot levee raise over 3,000 LF to provide additional system capacity, increase structural integrity of the I-wall, and provide erosion protection to reduce the likelihood of system overtopping.
  - 2-foot raise: This option will require significant reconstruction of the HFPP in the evaluated area including 5,000 LF of flood wall (15 feet tall), 10 closure structures 15 feet high and 20 feet wide, 3,000 LF of levee raised 2 feet along with the work specified in the I-wall near Tank Farm (2-foot raise) and 8- to 10-foot I-Wall (2-foot raise) required work.

- *I-Wall Near Tank Farm*
  - No fail: Construction of 1,800 LF of 15-foot-wide 6-inch scour pad to provide erosion protection to reduce the likelihood of a brittle failure if the systems' capacity is exceeded. Struvturally reinforce the I-Wall to protect against wall failure.
  - 1-foot raise: Construction of 1,800 LF of 15-foot-wide 6-inch scour pad and batter piling and wailer system with 1-foot rise will provide additional system capacity, increase structural integrity of the I-wall and provide erosion protection to reduce the likelihood of a brittle failure if the systems' capacity is exceeded. Additionally, 7,000 LF of levee will need to be raised 1 foot.
  - 2-foot raise: Construction of 2,000 LF of floodwall (15 feet tall) along with 19,400 LF of levee raised 2 feet. There would be construction of a floodwall at one pump station (200 LF at 7 feet tall), replacing an additional 12,000 LF of floodwall (15 feet tall). There would be rebuilding of four existing pump stations at 1,100 cubic feet per second (cfs).

Figure 5-2: Optimization Alternatives - Port Arthur and Vicinity CSRM Project Area

Economic Evaluation

The net benefits of Optimization Alternatives for the Port Arthur and Vicinity CSRM project area are presented in Table 5-7. Environmental impacts and associated mitigation costs were not needed in the comparison.

Table 5-7: Net Benefits of Optimization Alternatives for the Port Arthur and Vicinity CSRM Project Area

Alternative Reach	Optimization Alternatives	Net Benefits
8- to 10-foot I-Wall	No Fail	$13,305,000
	1-Foot Raise	$17,292,000
	2-Foot Raise	$17,215,000
Closure Structure	No Fail	$2,622,000
	1-Foot Raise	$2,908,000
	2-Foot Raise	$2,628,000
I-Wall Near Valero	No Fail	$45,153,000
	1-Foot Raise	$50,662,000
	2-Foot Raise	$41,076,000
I-Wall Near Tank Farm	No Fail	$12,758,000
	1-Foot Raise	$20,932,000
	2-Foot Raise	$18,843,000

5.4.2.4 Freeport and Vicinity CSRM

The following section describes the proposed Freeport and Vicinity CSRM Optimization Alternatives. The plans include modifications to the existing HFPP at Freeport. Figure 5-3 shows the location of the Optimization Alternatives listed below.

- *Dow Barge Canal Protection*

The Dow Barge Canal levees are approximately eight miles long and represent a significant risk to the HFPP performance at and above the design event. This risk is primarily from seepage and instability caused by seepage through the "sandy" levee and foundation material. Significant risk also exists with numerous pipeline penetrations, I-wall instability, and non-uniform levee heights. The study team utilized a closure structure and pump station constructed at the junction of the North Barge Canal and East Storm Levee. This structure would allow barge traffic to pass during routine operations and will have a pumping capacity of 2,000,000 gallons per min (gpm). The structure length would be approximately 500 feet long with two sector gates totaling approximately 80 feet wide for vessel traffic. Additional tidal circulation would be provided by two sluice gates approximately 15 feet wide each. The final configuration of this structure would match the proposed level of protection for the system.

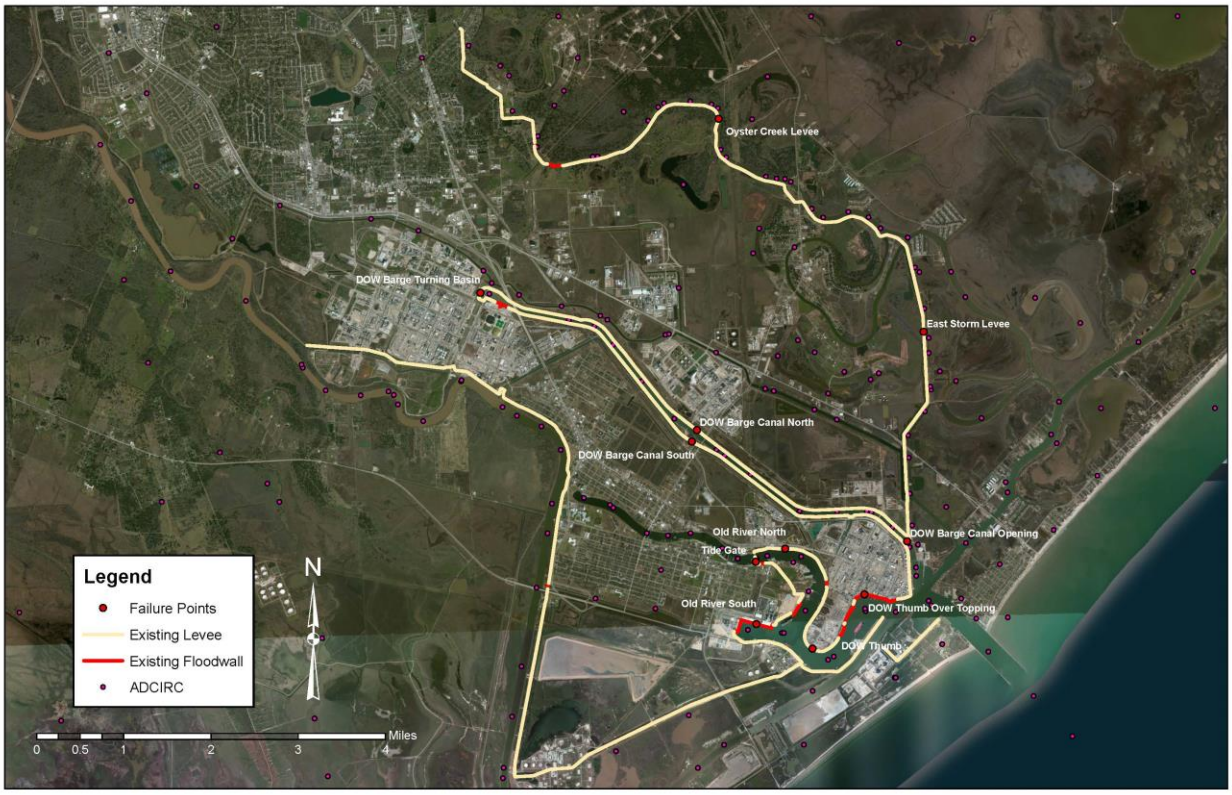

Figure 5-3: Location of Optimization Alternatives in the Freeport and Vicinity CSRM Project Area

- *Oyster Creek Levee*

Oyster Creek Levee was constructed at varying elevations to account for the changes in flood elevation as noted in the hydraulic modeling. Updated hydraulic modeling showed a height deficiency over 3,500 LF.

- No fail: The Oyster Creek levee would be raised 2 feet over 3,500 LF in order to correct the noted height deficiency. The construction procedure would include stripping topsoil, removal of a 12-foot-wide asphalt road, placement of fill, replacement of a 12-foot-wide road and turfing.
- 1-Foot Raise: Construction would include 3,500 LF of 3-foot levee raise and 10,000 LF of 1-foot levee raise for a total distance of 13,500 LF. The construction procedure would include stripping topsoil, removal of a 12-foot-wide asphalt road, placement of fill, replacement of a 12-foot-wide road and turfing.
- 2-Foot Raise: Construction would include 3,500 LF of a 4-foot levee raise and 33,000 LF of a 2-foot levee raise, replacing 1,000 feet of floodwall reconstruction at 8 feet

high, raising 2,300 LF of Highway 523 at the levee crossing, construction of one pump station with 1,100 cfs capacity, and replacement of six gravity structures would be required.

- *East Storm Levee*

East Storm Levee is a large earth embankment that faces the Gulf of Mexico and has direct wave and surge impacts from the Gulf. The proposed construction procedure will include stripping topsoil, removal of a two-lane asphalt road, placement of fill, and replacement of a two-lane road and turfing.

- No Fail: Construction of 13,115 LF of High Performance Turf Reinforcing Mat (HPTRM)
- 1-foot raise: Construction would include 13,115 LF of levee raised 1 foot with HPTRM
- 2-foot raise: Construction would include 19,115 LF of levee raised 2 feet with HPTRM, 800 LF of new floodwall at one pump station, reinforcing pump station walls and raising 2,500 LF of Highway 332 at the levee crossing.

- *South Storm Levee*

The south storm levee is a frontal levee that has potential for direct wave impact from the Gulf of Mexico during storm loading. When this levee was originally constructed, the area south of the levee was very low in elevation. Over the last 40 years, USACE constructed dredge disposal areas for the deep draft navigation channel in this low area. Continued use of the disposal areas has increased the elevation of the low area to a point that it is now higher than the South Storm Levee.

- 1-foot raise: Construction would include earth placement on top of the existing earth embankment for a 1-foot raise.
- 2-foot raise: Construction would include earth placement on top of the existing earth embankment for a 2-foot raise.

- *Freeport Dock Floodwall*

The Freeport Dock floodwall is a 3-foot floodwall that was added to the dock face at the Port Freeport docks after Hurricane Ike under PL 84-99. This floodwall has drop-in panels that are removable to allow for "roll on, roll off" cargo loading. During evaluation of the HFPP for CFR

65.10, the local sponsor noted that the wall/panels were structurally deficient. This deficiency was confirmed during the Freeport SQRA.

- Partial Fail: Construction would include replacing the drop-in panels and anchor system.
- No Fail: Reinforcement of 3,000 lf of floodwall to meet all USACE requirements for a wall/drop-in panel system located at a port facility.
- 1-Foot Raise: Construction of the 1-foot raise would require complete reconstruction of 3,000 LF of dock and flood wall assembly.

- *Old River Levee at Dow Thumb*

This reach of levee is an earth embankment that would be susceptible to erosion during an overtopping event. Updated modeling shows an area of this reach that has significant risk to large wave attack and overtopping from wave propagation along the adjacent deep draft navigation channel.

- No Fail: Construction of 14,500 LF of HPTRM and 4,000 LF of 15-foot-wide 6-inch scour pad to provide erosion protection to reduce the likelihood of failure.
- 1-Foot Raise: Construction of 4,000 LF of 15-foot-wide 6-inch scour pad along with 3,000 LF of levee raised 1 foot and 14,500 LF of HPTRM to "level up" the low spots and provide erosion protection to reduce the likelihood of a brittle failure if the system's capacity is exceeded.
- 2-Foot Raise: Due to extremely low Factors of Safety (FOS) for global stability, raising the levee over existing heights by adding additional earth fill is not an option; therefore, under this scenario, the existing embankment would be removed and 12,000 LF of 10-foot-tall floodwall would be constructed. In areas that do not have stability issues 6,500 LF of levee would be raised 2 feet, one drainage structure would be replaced, and the saltwater intake at DOW A801 would be replaced.

- *Tide Gate I-Wall*

The I-wall located at the Tide Gate was constructed as part of the original HFPP construction when the earth embankment section could not reach design elevation. The very soft foundation materials that were present in the old river channel would not support the additional weight of the embankment section. The proposed construction would be to reconstruct the I-wall as a pile-founded T-wall. The overall length of the T-wall is approximately 362 feet.

- No Fail: Construction of 362 LF of floodwall 10 feet tall.
- 1-Foot Raise: Construction of 700 LF of floodwall (11 feet tall) along with 2,000 LF of levee raised 1 foot.
- 2-Foot Raise: Construction of 700 LF of floodwall (12 feet tall) and 3,500 LF of levee raised 2 feet along with adding a floodwall at one pump station (200 LF at 7 feet tall). The tide gate structure adjacent to the I-wall will require significant modification or complete reconstruction to accommodate a 2-foot raise.

Economic Evaluation

The net benefits of Optimization Alternatives for the Freeport and Vicinity CSRM project area are presented in Table 5-8. Environmental impacts and associated mitigation costs were not needed in the comparison.

Table 5-8: Net Benefits of Optimization Alternatives for the Freeport and Vicinity CSRM Project Area

Alternative Reach	Optimization Alternatives	Net Benefits
DOW Barge Canal	Levee Rehabilitation; Gate Structure	$113,914,000
Oyster Creek Levee	No Fail	$2,010,000
	1-Foot Raise	$2,314,000
	2-Foot Raise	$490,000
East Storm Levee	No Fail	$796,000
	1-Foot Raise	$835,000
	2-Foot Raise	$120,000
South Storm Levee	1-Foot Raise	**($74,000)**
	2-Foot Raise	**($164,000)**
Freeport Dock Floodwall	Partial Fail	$123,000
	No Fail	$2,093,000
	1-Foot Raise	**($3,944,000)**
Old River Levee at DOW Thumb	No Fail	$969,000
	1-Foot Raise	$1,241,000
	2-Foot Raise	**($2,196,000)**
Tide Gate I-Wall	No Fail	$1,526,000
	1-Foot Raise	$1,721,000
	2-Foot Raise	$549,000

5.4.2.5 Brazoria and Sabine Nonstructural

Surveys of aerial imagery for the three counties were performed to look for the potential for nonstructural buyouts. Buyouts would be ancillary to the implementation of new levees/floodwalls in Orange and Jefferson Counties and to the enhancement of features in the Port Arthur and Freeport CSRM project areas. Buyout opportunities in Brazoria are virtually

non-existent and very limited in both Orange and Jefferson Counties. Several structures in Jefferson have the potential for being bought out; however, these structures are commercial and buying out these structures is very unlikely to be the economic viable. Figure 11 of Appenidx C shows the potential for buyouts in Orange County. There are approximately 20 residential structures that could be potentially economically viable and are currently being evaluated. While some of the parcels appeared to have no structures located on them, inspection of county appraisal records in many cases showed improvements on a lot of these parcels. Visual inspections of aerial photos and further inspection of the appraisal records showed that many of these were agricultural improvements and would, therefore, not be subject to any permanent evacuation analysis. A quantitative analysis was conducted to determine the viability of any proposed nonstructural buyout. The analysis showed the nonstructural buyouts had negative net benefits and any potential buyouts were screened from the analysis. The economic evaluation results are included in Table 13 of the Economic Appendix.

5.4.3 Comparison of Alternative Plans

This section provides a summary of the results of the Final Array of Alternatives evaluation and a comparison of plans. The screening criteria are applied to select a TSP. Table 5-17 presents the final array plans and a summary of the contributions to the planning objectives. Plans were evaluated first to identify an NED plan.

Objectives 1, 4, and 6 are described first since they were the objectives related to NED. The following is a summary and comparison of the plans for these objectives. For Objective 1, the net benefits were calculated for each Optimization Alternative. The plan that reasonably maximizes net benefits is the NED plan. Objective 4 is embedded within the NED and RED accounts. Specifically for the NED, the values of the critical infrastructure were included in the economic analysis, and measured when the economic evaluation of the Optimization Alternatives was performed and an NED plan was identified.

In the Orange-Jefferson CSRM project area, Optimization Alternatives within the Orange 1, Orange 2, Beaumont B, and Beaumont C Alternative Reaches did not have positive net benefits; therefore, the new levees considered at the various heights for those reaches were screened from further consideration. In the Port Arthur and Vicinity CSRM project area, all Alternative Reaches had positive net benefits. In the Freeport and Vicinity CSRM project area, all Alternative Reaches had positive net benefits except the South Storm Levee. The raises considered for that reach was screened from further consideration. The nonstructural buyouts for the Sabine and Brazoria Regions were not economically viable and were screened from further

consideration. The plans that reasonably maximized NED from each project area are highlighted in green in Table 5-9 and listed below:

Table 5-9: Average Recommended Relative Sea Level Change (RSLC), Feet NAVD

Location	Without RSLC	Low RSLC	Int.* RSLC	High RSLC	TSP Height	Surplus/ Deficit (Without)	Surplus/ Deficit (Low)	Surplus /Deficit (Int.)	Surplus/ Deficit (High)
Dow Barge Canal	15.85	16.58	17.15	18.93	26.00	10.15	9.43	8.85	7.08
Sabine Floodwall	12.50	13.43	13.98	15.77	11.00	-1.50	-2.43	-2.98	-4.77
Sabine Levee	12.33	13.24	13.83	15.59	11.00	-1.33	-2.24	-2.83	-4.59
Freeport Levee	16.42	17.13	17.66	19.45	20.75	4.33	3.63	3.09	1.30
Oyster Creek	16.41	16.41	16.41	16.41	19.00	2.59	2.59	2.59	2.59
Port Arthur Floodwall	13.25	16.10	16.72	18.25	19.00	5.75	2.90	2.28	0.75
Port Arthur Levee	12.94	13.86	14.43	16.20	18.00	5.06	4.14	3.58	1.80

*Note Int. - Intermediate

The NED plan for the Orange-Jefferson CSRM is:

- Orange 3 New Levee (11-foot)
- Jefferson Main New Levee (11-foot)
- Beaumont A New Levee (12-foot)

The NED plan for the Port Arthur Vicinity CSRM is:

- 8- to 10-foot I-Wall Raise (1-foot)
- Closure Structure Raise (1-foot)
- I-Wall Raise Near Valero (1-foot)
- I-Wall Raise Near Tank Farm (1-foot)

The NED plan for the Freeport and Vicinity CSRM is:

- DOW Barge Canal Gate Structure
- Oyster Creek Levee Raise (1-foot)
- East Storm Levee Raise (1-foot)
- Freeport Dock Floodwall Raise (1-foot)
- Old River Levee Raise at Dow Thumb (1-foot)
- Tide Gate I-Wall Raise (1-foot)

Regarding Objective 6, the EADs presented in this report use storm surge levels without considering sea level rise scenarios for the 20-, 50- and 100-year sea level change scenarios; however, a performance of the NED plans against RSLC is provided. Table 5-9 shows the performance of the NED plans against the 50-year RSLC estimated for the project areas. This table was developed by averaging levee heights specified by engineering criteria for the 50-year RSLC and comparing them to the elevation of the index points used in the HEC-FDA model for the NED Plans. The column highlighted yellow is the height of the NED plans in the economic analysis. The comparison shows the NED Plans perform well with the RSLC scenario for the 50-year period, except for areas in the "Sabine Region." The rows highlighted light blue show the Orange-Jefferson CSRM (NED plan) is deficient in height at the 50-year project life. Table 5-10 summarizes the range in RSLC deficits for the Orange-Jefferson CSRM project area. As the height of the plan decreases, the range in the deficit increases among the Optimization Alternatives. The locations listed in Table 5-9 correspond to locations included in the H&H analysis.

The expectation for each project area would be that all plans would positively impact life-safety risk and reduce the likelihood of secondary impacts on critical infrastructure to meet Objectives 2 and 4. This is shown in Table 5-10 as an expected positive impact. Additional qualitative discussion of Objectives 2 and 4 is provided in the next section. Objective 3 was removed from consideration in this planning study from an ER implementation standpoint. Opportunities to meet these objectives could be pursued under different study authorizations. The ER objective achieved in this study through avoiding, minimizing, and mitigating impacts on existing habitats.

5.4.4 Identifying a Tentatively Selective Plan (TSP)

The decision criteria for selecting a TSP at this point in the study was based on building a plan for each project area that reasonably maximized net benefits (Objective 1 for the study) from the Final Array of Alternatives. The current TSP is the NED plan for each project area and only considers economics as the decision criteria. The TSP includes the following features:

Orange-Jefferson CSRM

- Orange 3 New Levee (11-foot)
- Beaumont A New Levee (12-foot)
- Jefferson Main New Levee (11-foot)

Table 5-10: Comparison of Final Array of Alternative by Planning Objectives

	NED			OSE		RED
	Objective 1		Objective 6	Objective 2		Objective 4 and 5
	Net Benefits	Screening Status	Sea Level Rise	Population at Risk		Critical Infrastructure Impacts
Orange-Jefferson CSRM						
Orange 1			Surplus/Deficit Range (Approx. Feet NAVD)	PAR FWOP/Expected Impact		Number of Facilities by County
11-foot Raise	($1,769,000)	Screened Out		17,014	Expected Positive Impact	Reduces likelihood of secondary impacts on: • 20 schools • 14 law enforcement • 2 hospitals/6 nursing homes • 11 fire stations • 20 chemical manufacturing • 5 electric generation • 0 petroleum refining
12-foot Raise	($2,380,000)	Screened Out				
13-foot Raise	($2,996,000)	Screened Out				
14-foot Raise	($3,617,000)	Screened Out				
Orange 2						
11-foot Raise	($1,757,000)	Screened Out		13,952	Expected Positive Impact	
12-foot Raise	($2,112,000)	Screened Out				
13-foot Raise	($2,467,000)	Screened Out				
14-foot Raise	($2,822,000)	Screened Out				
Orange 3						
11-foot Raise	$9,851,000	$9,851,000	-1.3 – 4.8 feet deficit	60,044	Expected Positive Impact	
12-foot Raise	$10,232,000	$10,232,000	-0.5 – 3.8 feet deficit			
13-foot Raise	$9,804,000	Screened Out	0.5 surplus - 2.8 feet deficit			
14-foot Raise	$8,810,000	Screened Out				
Beaumont A						
11-foot Raise	$2,743,000	Screened Out	-1.3 – 4.8 feet deficit	2,078	Expected Positive Impact	Reduces likelihood of secondary impacts on: • 42 schools • 19 law enforcement • 13 hospitals/7 nursing homes • 26 fire stations • 54 chemical manufacturing • 1 electric generation • 0 petroleum refining • 1 airport
12-foot Raise	$2,992,000	$2,992,000	-0.5 – 3.8 feet deficit			
13-foot Raise	$3,037,000	$3,037,000	0.5 surplus - 2.8 feet deficit			
-foot Raise	$2,942,000	Screened Out				
Beaumont B						
11-foot Raise	($58,000)	Screened Out		2,078	Expected Positive Impact	
12-foot Raise	($82,000)	Screened Out				
13-foot Raise	($106,000)	Screened Out				
14-foot Raise	($131,000)	Screened Out				
Beaumont C						
11-foot Raise	($442,000)	Screened Out		2,078	Expected Positive Impact	
12-foot Raise	($449,000)	Screened Out				
13-foot Raise	($574,000)	Screened Out				
Jefferson Main						
11-foot Raise	$22,461,000	$22,461,000	-1.3 – 4.8 feet deficit	116,762	Expected Positive Impact	
12-foot Raise	$22,580,000	$22,580,000	-0.5 – 3.8 feet deficit			
13-foot Raise	$22,496,000	Screened Out	0.5 surplus - 2.8 feet deficit			
14-foot Raise	$22,123,000	Screened Out				
Port Arthur and Vicinity CSRM*						
8-10ft I-Wall						
No Fail	$13,305,000	Screened Out		116,762	Expected Positive Impact	Reduces likelihood of secondary impactson: • 42 schools • 19 law enforcement • 13 hospitals/7 nursing homes • 26 fire stations • 54 chemical manufacturing • 1 electric generation • 0 petroleum refining • 1 airport
1-foot Raise	$17,292,000	$17,292,000				
2-foot Raise	$17,215,000	Screened Out				
Closure Structure						
No Fail	$2,622,000	Screened Out				
1-foot Raise	$2,908,000	$2,908,000				
2-foot Raise	$2,628,000	Screened Out				
I-Wall Near Valero						
No Fail	$45,153,000	Screened Out				
1-foot Raise	$50,662,000	$50,662,000				
2-foot Raise	$41,076,000	Screened Out				
I-Wall Near Tank Farm						
No Fail	$12,758,000	Screened Out				
1-foot Raise	$20,932,000	$20,932,000				
2-foot Raise	$18,843,000	Screened Out				
Freeport and Vicinity CSRM*						
Dow Barge Canal				16,559	Expected Positive Impact	Reduces likelihood of secondary impacts on: • 6 schools • 3 law enforcement • 0 hospitals/0 nursing homes • 2 fire stations • 24 chemical manufacturing • 0 electric generation • 0 petroleum refining
No Fail	$113,914,000	$113,914,000				
Oyster Creek Levee						
No Fail	$2,010,000	Screened Out				
1-foot Raise	$2,314,000	$2,314,000				
2-foot Raise	$490,000	Screened Out				
East Storm Levee						
No Fail	$769,000	Screened Out				
1-foot Raise	$835,000	$835,000				
2-foot Raise	$120,000	Screened Out				
Freeport Dock						
Partial Fail	$123,000	Screened Out				
No Fail	$2,093,000	$2,093,000				
1-foot Raise	($3,944,000)	Screened Out				
Old River at Dow Thumb						
No Fail	$969,000	Screened Out				
1-foot Raise	$1,241,000	$1,241,000				
2-foot Raise	($2,196,000)	Screened Out				
South Storm Levee						
1-foot Raise	($74,000)	Screened Out				
2-foot Raise	($164,000)	Screened Out				
Tide Gates						
No Fail	$1,526,000	Screened Out				
1-foot Raise	$1,721,000	$1,721,000				
2-foot Raise	$549,000	Screened Out				
Sabine Nonstructural Buyout		Screened Out				
Brazoria Nonstructural Buyout		Screened Out				

* The comparison shows the economic analysis performs well with the RSLC scenario for the 50-year period for Port Arthur and Vicinity and the Freeport and Vicinity CSRM; therefore, the surplus is not reported in this tabl

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Port Arthur and Vicinity CSRM

- 8- to 10-foot I-Wall Raise (1-foot)
- Closure Structure Raise (1-foot)
- I-Wall Raise Near Valero (1-foot)
  I-Wall Raise Near Tank Farm (1-foot)

Freeport and Vicinity CSRM

- Dow Barge Canal Gate Structure
- Oyster Creek Levee Raise (1-foot)
- East Storm Levee Raise (1-foot)
- Freeport Dock Floodwall Raise (1-foot)
- Old River Levee Raise at Dow Thumb (1-foot)
- Tide Gate I-Wall Raise (1-foot)

5.4.5 Selection of the Recommended Plan

USACE guidance requires selection of the TSP as the Recommended Plan unless there are other Federal, state, local, or international concerns that make another alternative viable to recommend at full cost sharing. In addition, there is an opportunity for the local sponsor to request implementation of a locally preferred plan (LPP) in which they would fully fund the cost above the NED plan if it were higher, or the plan would be reduced in cost if they preferred a smaller plan. Any plan other than the NED Plan would require a waiver from the Assistant Secretary of the Army for Civil Works. It is unlikely there will be a locally preferred plan for this study. However, it may make sense to recommend a plan that provides a higher level of performance because it fulfills other, non-economic objectives of the study including considerations of life-safety, critical infrastructure, and RSLC.

This draft report will undergo public, policy, Agency Technical Review (ATR), and Independent External Peer Review (IEPR), and the study team will address all comments from these reviews. Based particularly on input from public and agency reviews concerning public safety and infrastructure concerns, it may be appropriate for USACE to consider recommending a more robust plan for the Orange-Jefferson CSRM after the Agency Decision Milestone (ADM) is conducted. The ADM is the decision point where a Senior Leader Panel confirms the TSP and makes the decision on the Recommended Plan to carry forward for detailed feasibility-level design based on policy, public, ATR, and IEPR reviews of the draft report.

The decision to select a plan other than the TSP is not based on quantitative economic analysis alone, but rather takes into consideration other factors that could justify higher project cost and

more robust construction than could be otherwise justified. The following discussion identifies other compelling factors that might support a plan larger than the TSP for the Orange-Jefferson CSRM for consideration by the Senior Leader Panel. If approved, a TSP providing greater protection for the Orange-Jefferson CSRM would be further refined in the next study phase.

For example, Table 5-11 is a summary of comparable Optimization of Alternatives in terms of net benefits, percent change in net benefits, annual costs, and total project cost differences within the Orange-Jefferson CSRM project area. An increase in 1 foot among the Optimization Alternatives would cost about $72 million more but would only provide about $545,000 more in net annual benefits. Based on economics alone, even though the 11-foot levee is incrementally justified, it does not make sense to recommend a plan that costs that much more for such minimal benefits.

Table 5-11: Cost Analyses Comparison for Optimization Alternatives in the Orange-Jefferson Project Area

Objective 1						
	Net Benefits	**Net Benefits % Change**	**Annual Cost**	**Annual Cost % Change**	**Total Project Cost**	**Incremental Change in Total Project Cost**
Orange-Jefferson CSRM						
Orange 3						
11-foot Raise	$9,851,000	N/A	$14,895,000	N/A	$246,811,000	N/A
12-foot Raise	$10,232,000	3.9%	$16,711,000	12.2%	$288,284,000	$41,473,000
Beaumont A						
12-foot Raise	$2,992,000	N/A	$3,075,000	N/A	$70,202,000	N/A
13-foot Raise	$3,037,000	1.5%	$3,405,000	10.7%	$77,743,000	$7,541,000
Jefferson Main						
11-foot Raise	$22,461,000	N/A	$3,250,000	N/A	$64,726,000	N/A
12-foot Raise	$22,580,000	0.5%	$4,212,000	29.6%	$87,674,000	$22,948,000

However, based on the qualitative evaluation performed, each alternative reach is expected to have a positive impact on life-safety, because reductions in economic damages are generally considered highly correlated to reductions in risk in terms of life-safety. For the Orange-Jefferson CSRM project area, the population at risk is estimated as follows:

- Orange 3 Alternative Reach – 60,044 residents
- Beaumont A Alternative Reach – 2,078 residents
- Jefferson Main Alternative Reach – 116,762 residents

The risk assessment for the Orange-Jefferson CSRM is largely qualitative. Defining the population at risk, above, and the depth of flooding is evaluated in a risk assessment. Other considerations include populations in high risk areas with special needs, such as elderly populations over 65, and care and shelter facilities including hospitals, nursing homes and schools. Figures 5-4 and 5-5 depict the locations of hospitals, nursing homes, and schools in the areas of Orange and Jefferson Counties that would be protected by the TSP. Flooding depths for the Orange 3, Beaumont A, and Jefferson Main Alternative Reaches are approximately 6-8 feet (estimated depths of flooding at the 1% ACE from the economic analysis). Disabled residents are a high risk population that would be particularly vulnerable in 6 to 8 feet of flooding if there were not sufficient lead time for evacuations or if evacuation procedures are not implemented appropriately. Approximately 19 percent of the 178,884 people at risk in the Orange-Jefferson CSRM project area, or 33,000 people, would be considered disabled (2015 U.S. Census). Of the approximately 500,000 people in New Orleans during Hurricane Katrina, 100,000 were too elderly, disabled, or lacked transportation and resources to evacuate, with disastrous results. (2015 datacenterresearch.org), and it is assumed that the Orange-Jefferson CSRM project area could experience similar outcomes. In addition, given the critical infrastructure and refining capacity also located in the project area, a compelling argument can be made to provide a higher level of storm surge risk reduction by building a foot higher than the current TSP.

In addition to increased life-safety benefits, there are other non-traditional secondary or ancillary economic benefits not included in the NED Plan that should be considered, including preventing disruptions in business such as loss of revenue, wages, and sales tax, and their multiplier effects. The cost of emergency response and cleanup would also be avoided. Most importantly, increased protection would also avoid disruption of significant industrial and manufacturing facilities located in the project area; notably, the Motiva and Exxon Mobil refineries that have the capacity to refine 945,000 barrels of crude oil per day and can produce 6.7 billion gallons of gasoline annually. In 2014, the U.S. Energy Information Administration reports that the U.S. consumed 136.78 billion gallons of gasoline. These two refineries alone can produce about 5 percent of that demand. If they were running at full production with gas prices at $2.50/gallon and were to go out of production for even a month, this could be up to a $1.4 billion hit to the national economy and would be even more significant to the regional and local economies. Spending $72 million to provide an additional foot of performance and lower the probability of being impacted would seem to be a small investment to protect such significant infrastructure and would be worth the investment.

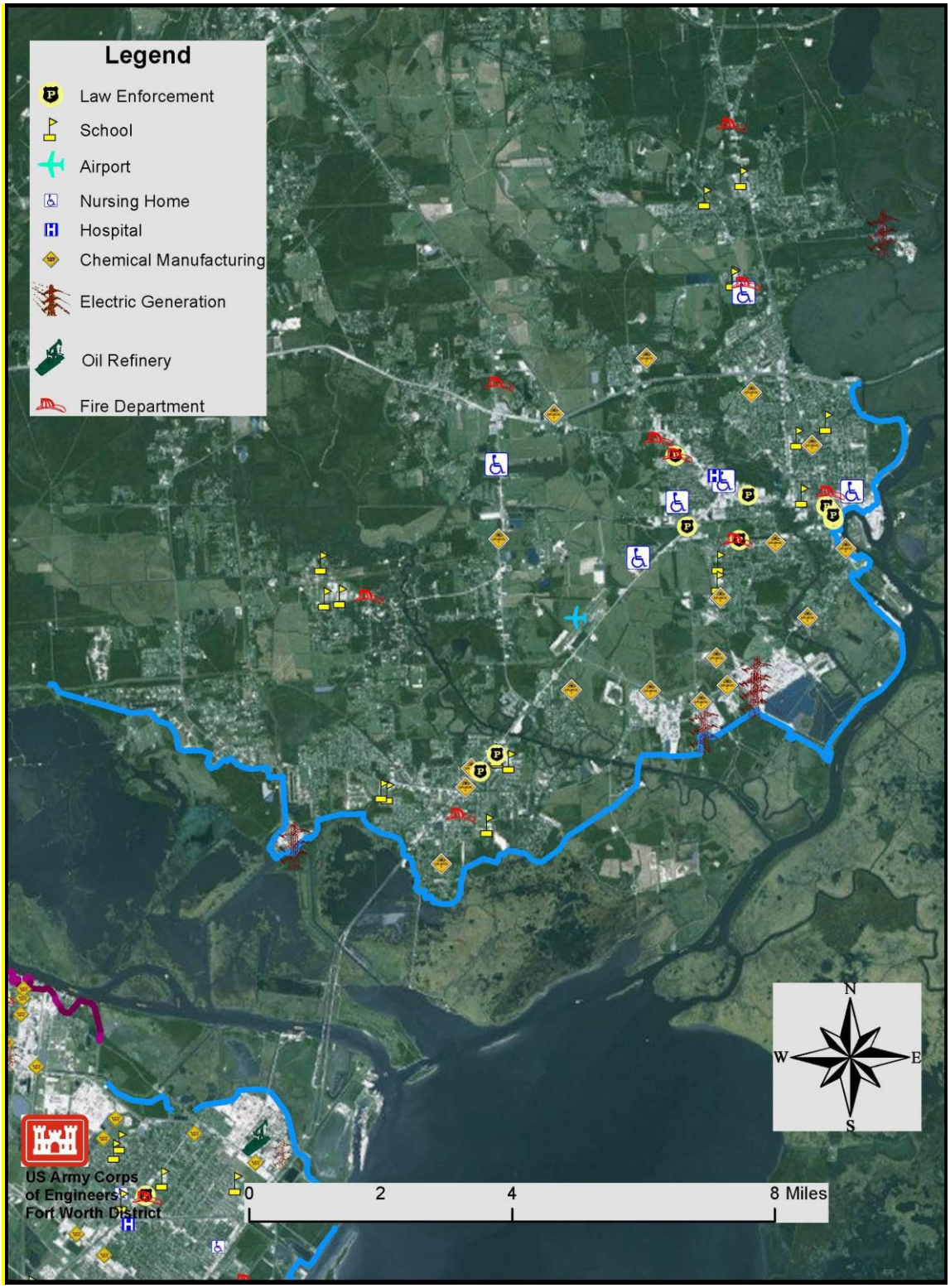

Figure 5-4: Orange County Critical Infrastructure

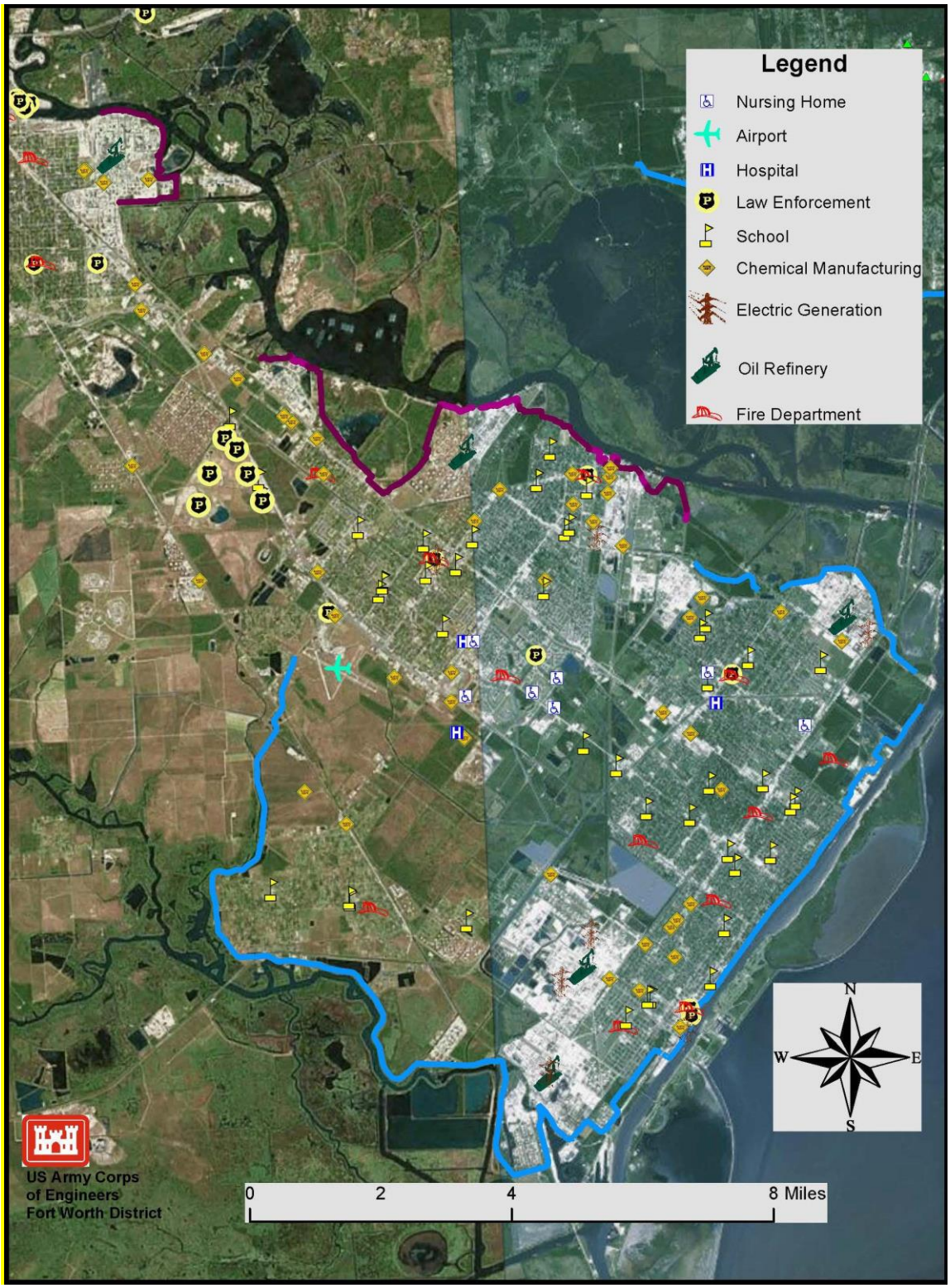

Figure 5-5: Jefferson County Critical Infrastructure

In addition, the current TSP could result in larger future project modifications to account for RSLC in the Orange-Jefferson CSRM project area. Efficiencies would be gained by spending an additional $72 million now to account for projected RSLC. Table 5-12 displays the ranges for RSLC for each of the alternative reaches. The deficit is already a concern for feasibility-level design and would need to be taken into further consideration in the study to ensure the recommended plan would meet USACE design criteria for RSLC. With this in mind, the 12-foot levees would perform better than the NED Plan when considering RSLC scenarios and would be worth the additional Federal investment. If the NED plan remains the final recommendation from the Senior Leader Panel at the ADM, then it may still be appropriate for USACE to consider cost sharing in the design and construction of any recommended floodwall or I-wall to accommodate future construction for RSLC adaptation. This expense would be minimal compared to the significant expense of project replacement in the future. Additional discussion of design criteria for RSLC is provided in Section 6.2.2.

Table 5-12: Ranges for RSLC for the Orange-Jefferson CSRM Project Area

Orange 3	Range of RSLR Projected
11-foot Raise	-1.3 – 4.8 feet deficit
12-foot Raise	-0.5 – 3.8 feet deficit
13-foot Raise	0.5 surplus - 2.8 feet deficit
Beaumont A	
11-foot Raise	-1.3 – 4.8 feet deficit
12-foot Raise	-0.5 – 3.8 feet deficit
13-foot Raise	0.5 surplus - 2.8 feet deficit
Jefferson Main	
11-foot Raise	-1.3 – 4.8 feet deficit
12-foot Raise	-0.5 – 3.8 feet deficit
13-foot Raise	0.5 surplus - 2.8 feet deficit

5.4.5.1 Selection of the Recommended Plan Summary

Based on the planning objectives and USACE policy, the TSP is likely to be considered the Recommended Plan as listed in Section 5.4.6 and described in detail in Section 6 of this report. This does not preclude a decision to refine or alter the TSP at the ADM based on responses from public, policy, and technical reviews of this DIFR-EIS, specifically for the Orange-Jefferson CSRM. Compelling factors exist to support a decision to select a plan at least 1 foot higher than the NED Plan based on economics (the higher plans provides more net benefits), life safety (the lower the probability of flood event damaging property generally results in lower risk to loss of life), critical infrastructure (major oil refineries that could produce significant impacts on local, regional, and the national economy), and RSLR (a resilient project would be cheaper to build it now rather than retro-fit it later). A final decision will be made at the ADM following the

reviews and higher-level coordination within USACE to select a plan for feasibility-level design and recommendation for implementation. The decision made, ie. NED versus a foot higher, will be documented in the FIFR-EIS. A supplemental DIFR-EIS would not likely be produced unless there are substantial design changes that significantly alter environmental impacts. Coordination with the natural resource agencies will continue throughout the study process as required by the Fish and Wildlife Coordination Act.

5.4.6 Comparison of Environmental Impacts for Final Array of Alternatives

5.4.6.1 WVA Modeling of Alternatives

WVA modeling was utilized to quantify impacts of the Final Array of CSRM Alternatives on marsh and forested wetlands. This modeling was conducted only for the Orange-Jefferson CSRM project area, as no wetland impacts were identified in the Port Arthur and Freeport and Vicinities CSRM project areas. The WVA Marsh Model was approved for use by HQUSACE memo dated May 6, 2014; WVA Swamp and Bottomland Hardwood models are certified. The approval memo, a description of the WVA model and a detailed description of the WVA application to this study, are presented in Appendix O. The WVA is a suite of habitat-based models originally developed by the USFWS that utilizes a community approach to quantify changes to fish and wildlife habitat quality and quantity, measured in AAHUs.

Direct impacts as quantified by the model reflect the assumed loss of all marsh and forested wetlands within the construction right-of-way of the Orange 1 ,2, and 3 Alternative Reaches, Jefferson Main, and Beaumont Alternative Reaches A, B, and C in the first year of construction. Staging areas would be situated to avoid impacts on wetlands or other significant environmental resources; numerous suitable areas are available. In previously disturbed areas, impacts were assessed for a conservatively-wide alignment right-of-way, which would accommodate construction of any of the four height alternatives and adjustments to account for RSLC. Construction rights-of-way for floodwalls and related direct impacts would be roughly the same for all height alternatives. Construction rights-of-ways for the 11, 12, and 13 feet levee height alternatives for all of the reaches would be proportionately lower than the 14 feet Alternative, as levee footprints would be slightly narrower. Differences would be small when compared to the overall width of the right-of-way assessed for impacts. The width of the construction right-of-way varies based on existing ground elevation and the type of structure proposed. In general, impacts were captured for earthen levee right-of-way segments from 200 to 325 feet in width; impacts for floodwall segments were captured for right-of-way segments ranging from 150 to 200 feet in width.

Given the small differences in right-of-way widths among the height alternatives, as well as uncertainties inherent in the preliminary engineering alignment and the future rate of RSLC, direct impacts were modeled using only the oversized width and applied to all RSLC scenarios. RSLC was considered in determining indirect impact areas for the 50-year period of analysis. The alignment width will be reevaluated for the final feasibility report to determine if adjustments are needed. If it is determined that the recommended plan would result in impacts significantly higher than those quantified for the draft report, the impact assessment will be revised and additional public review may be necessary.

The general area of the levee alignment was carefully evaluated to identify areas into which wetlands would have migrated under the three RSLC scenarios in the FWOP condition. The NOAA Sea-Level Rise Viewer (NOAA 2015) was used to identify new tidally-influenced areas, and the NOAA marsh impacts/migration viewer was used to map changes in marsh type and extent for a 50-year sea-level rise approximating the low, intermediate, and high rates in this area.

The NOAA method for mapping marsh migration due to RSLC assumes that specific wetland types exist within an established tidal elevation range, based on an accepted understanding of what types of vegetation can exist given varying frequency and time of inundation, as well as salinity impacts from such inundation (NOAA 2012). The viewer maps changes associated with sea-level rise in 1-foot increments. The potential changes associated with projected 50-year low, intermediate, and high RSLC in the Sabine region (+0.93 feet, +1.49 feet, and +3.26 feet, respectively) were evaluated using the 1-, 2- and 4-foot Sea Level Rise and Marsh Impacts views.

No FWP impacts were identified for most of the areas identified as vulnerable to RSLC in the FWOP condition. Increasing sea levels would be expected to increase the extent of tidal flow into the smaller bayous and streams, which cut from the upland to the floodplain. The higher water levels would flood low-lying bayou and stream bottoms, creating new wetlands in several areas shown in Appendix O. In general, however, relatively high valley walls along the upland terraces of the Sabine and Neches Rivers would prevent large-scale overland flooding over the period of analysis. Indirect impacts associated with installation of the levee system would be minimized by maintaining flows in tidal bayous and streams equivalent to the FWOP condition. Culverts would be sized and modified as needed to provide for increased tidal flows expected with RSLC. With tidal access maintained at FWOP flows, RSLC-related landscape and wetland changes to areas both inside and outside of the levee system would occur with the project in place, as they would have occurred in the FWOP condition.

Indirect impacts identified for the Orange 1 and 3 Reach Alternatives are related to two primary effects – those associated with fisheries access impacts on the extensive marshes in the lower Adams Bayou and Cow Bayou floodplains (a functional impact), and indirect impacts related to changes in hydrologic connectivity caused by the new levee system and the Cow Bayou structure, which would result in the loss of wetland acreage. Indirect impacts that would result in the loss of wetland acreage in Orange 1 and 3 were modeled separately for the three RSLC scenarios. Indirect fisheries impacts on marsh function associated with the surge gate impacts on fisheries access were modeled for the low RSLC scenario, and these impacts were applied to the intermediate and high scenarios for the Orange 3 reach only. Higher tidal inundation would improve fisheries access even with the structures in place; the low RSLC condition thus provides a conservatively high impact assessment.

5.4.6.2 Orange-Jefferson CSRM Project Area

The three reaches in Orange County (Orange 1, 2, and 3) and the four reaches in Jefferson County (Jefferson Main, Beaumont A, B, and C) were each evaluated with four separate height alternatives – 11, 12, 13, and 14 feet Alternatives. Direct and indirect impacts on marsh and forested wetlands, as quantified using the WVA model, for all of the Jefferson Main and Beaumont Alternatives are presented in Table 5-2, and impacts on Orange 1, 2, and 3 Alternatives are presented in Table 5-13. No impacts were identified for Beaumont B, and no indirect impacts were identified for the Jefferson Main or Beaumont A and C; impacts for each reach are limited to direct impacts which apply to all levee height alternatives and all RSLC scenarios. The impacts are minimal, reflecting the developed and industrialized nature of these project areas.

Table 5-13: Total Wetland Impacts of Jefferson Main and Beaumont Alternatives (All RSLC Scenarios)

Wetland Type	Jefferson Main		Beaumont A		Beaumont C	
	All Height Alternatives and All RSLC Scenarios					
	Acres	AAHU	Acres	AAHU	Acres	AAHU
Swamp	0.9	-0.4				
Bottomland Hardwood	13.9	-6.4	0.3	-0.2		
Forested Wetland Subtotal	14.8	-6.8	0.3	-0.2		
Fresh Marsh	13.4	-6.1	2.6	-1.6		
Intermediate Marsh	0.4	-0.2	0.6	-0.3	1.0	-0.6
Brackish Marsh	9.9	-4.9				
Marsh Subtotal	23.7	-11.2	3.2	-1.9	1.0	-0.6
Total Impacts	**38.5**	**-18.0**	**3.5**	**-2.1**	**1.0**	**-0.6**

Impacts for Orange 3 are much higher than for Orange 1 and 2 (Table 5-14). Orange 3 is about twice as long as Orange 1 and 2 combined, and this size difference is reflected in the higher direct impacts. In addition, direct and indirect wetland impacts related to construction of the Adams and Cow tidal surge gates are associated with Orange 3; surge gates are not required for Orange 1 and 2.

Table 5-14: Direct and Indirect Wetland Impacts of Orange 1, 2, and 3 Alternatives (All RSLC Scenarios)

DIRECT IMPACTS																		
	Orange 1 (All Height Alternatives)						Orange 2 (All Height Alternatives)						Orange 3 (All Height Alternatives)					
	Low RSLR		Intmd RSLR		High RSLR		Low RSLR		Intmd RSLR		High RSLR		Low RSLR		Intmd RSLR		High RSLR	
Wetland Type	**Acres**	**AAHU**	**Acres**	**AAHU**	**Acres**	**AAHU**	**Acres**	**AAHU**	**Acres**	**AAHU**	**Acres**	**AAHU**	**Acres**	**AAHU**	**Acres**	**AAHU**	**Acres**	**AAHU**
Forested Wetlands																		
Swamp	18.9	-7.7	18.9	-7.7	18.9	-7.7	0.7	-0.4	0.7	-0.4	0.7	-0.4	18.0	-10.6	18.0	-10.6	18.0	-10.6
Bottomland Hardwood	13.4	-5.7	13.4	-5.7	13.4	-5.7	18.0	-10.1	18.0	-10.1	18.0	-10.1	94.1	-57.3	94.1	-57.3	94.1	-57.3
Subtotal	32.3	-13.4	32.3	-13.4	32.3	-13.4	18.7	-10.5	18.7	-10.5	18.7	-10.5	112.1	-67.9	112.1	-67.9	112.1	-67.9
Coastal Marsh																		
Fresh Marsh	25.0	-14.7	25.0	-14.7	25.0	-14.7	6.0	-3.4	6.0	-3.4	6.0	-3.4	34.4	-18.8	34.4	-18.8	34.4	-18.8
Intermediate Marsh													10.9	-6.2	10.9	-6.2	10.9	-6.2
Brackish Marsh													101.1	-48.8	101.1	-48.8	101.1	-48.8
Subtotal	25.0	-14.7	25.0	-14.7	25.0	-14.7	6.0	-3.4	6.0	-3.4	6.0	-3.4	146.4	-73.8	146.4	-73.8	146.4	-73.8
Total Direct Impacts*	**57.3**	**-28.1**	**57.3**	**-28.1**	**57.3**	**-28.1**	**24.7**	**-13.9**	**24.7**	**-13.9**	**24.7**	**-13.9**	**258.5**	**-141.7**	**258.5**	**-141.7**	**258.5**	**-141.7**

INDIRECT IMPACTS																		
Forested Wetlands																		
Swamp	4.4	-0.8	4.4	-0.8	4.4	-0.8							1.9	-0.8	0	-0.1	0.0	-0.1
Bottomland Hardwood	0.7	-0.3	0.7	-0.3	0.7	-0.3							12.7	-5.1	12.7	-5.1	12.7	-5.1
Subtotal	5.1	-1.1	5.1	-1.1	5.1	-1.1							14.6	-5.9	12.7	-5.2	12.7	-5.2
Coastal Marsh																		
Fresh Marsh	1.4	-0.7	1.4	-0.7	1.4	-0.7							785.2	-18.8	785.2	-18.8	785.2	-18.8
Intermediate Marsh													342.1	-14.2	322.5	-12.6	322.5	-13.8
Brackish Marsh													1075	-50.4	1130.4	-63.4	1092.6	-60.7
Saline Marsh																	49.7	-9.7
Subtotal	1.4	-0.7	1.4	-0.7	1.4	-0.7							2202.2	-83.4	2238.1	-94.8	2250.0	-103.0
Total Indirect Impacts*	**6.5**	**-1.8**	**6.5**	**-1.8**	**6.5**	**-1.8**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**2216.8**	**-89.3**	**2250.8**	**-100.0**	**2262.7**	**-108.2**

TOTAL IMPACTS BY REACH																		
Total Forested Wetlands	37.4	-14.5	37.4	-14.5	37.4	-14.5	18.7	-10.5	18.7	-10.5	18.7	-10.5	126.7	-73.8	124.8	-73.1	124.8	-73.1
Total Coastal Marsh	26.4	-15.4	26.4	-15.4	26.4	-15.4	6.0	-3.4	6.0	-3.4	6.0	-3.4	2348.6	-157.2	2384.5	-168.6	2396.4	-176.8
Total Impacts by Reach*	**63.8**	**-29.9**	**63.8**	**-29.9**	**63.8**	**-29.9**	**24.7**	**-13.9**	**24.7**	**-13.9**	**24.7**	**-13.9**	**2475.3**	**-231.0**	**2509.3**	**-241.7**	**2521.2**	**-249.9**

* Totals may not add exactly due to rounding.

Orange 1 impacts (direct and indirect) would be the same for all RSLC scenarios (63.8 acres; -29.9 AAHUs). Indirect impacts in this reach are associated with wetland loss caused by the permanent alteration of tidal access, and thus the effects would be the same across all RSLR scenarios. Orange 2 impacts would also be the same for all RSLC scenarios (24.7 acres; -13.9 AAHUs); no indirect impacts were identified in this reach. Orange 3 impacts increase slightly with each higher RSLC scenario because wetland losses due to hydrologic modifications related to the location of the levee alignment increase with RSLC. For example, it was assumed that some swamp would convert to brackish marsh under intermediate and high RSLR because of changes to the salinity regime and higher water elevations. Likewise, some marsh areas would

switch from intermediate to brackish or brackish to saline due to the changing salinity regime. At other locations, former uplands were assumed to convert to marsh as tides pushed into new areas due to intermediate and high RSLR.

The great majority of Orange 3 acreage impacts are due to indirect functional impacts related to reductions in fisheries access in the Adams and Cow Bayou floodplains. Under low RSLC, a total of 2,475.3 acres would be impacted, resulting in the loss of -236.0 AAHUs; under intermediate RSLC, 2,509.3 acres would be impacted, resulting in the loss of -241.7 AAHUs; and under high RSLC, 2,521.2 acres would be impacted, resulting in the loss of -249.9 AAHUs. Of these totals, functional impacts would affect roughly 2,137 acres and result in the loss of about -50.5 AAHUs for all RSLC scenarios.

The Orange-Jefferson CSRM Alternatives would result in the loss of EFH. Impacts on estuarine emergent marsh by Orange 1, 2, and 3, Jefferson Main, and Beaumont A and C are shown in Tables 5-2 and 5-3 above. Orange 1, 2, and 3 direct impacts would result in the loss of about 25.0, 6.0, and 146.4 acres of estuarine emergent marsh, respectively. Jefferson Main and Beaumont A and C would impact 23.7, 3.2, and 1.0 acre, respectively. Beaumont B would result in no EFH impacts. Orange 3 would also result in the loss of approximately 11 acres of estuarine soft bottom EFH. This is the area estimated for the footings of the Adams and Cow Bayou surge gate structures. The structures themselves would provide artificial hard bottom habitat in the same area, increasing the diversity of EFH bottom types in the area. The net long-term loss of EFH bottom habitat from the Cow and Adams gate structures would therefore be negligible. Functional impacts on about 2,137 acres of estuarine emergent marsh along Adams and Cow Bayous in Orange 3 would result in the loss of about 50.5 AAHUs.

The potential HTRW impacts for all alternatives in the Orange-Jefferson CSRM project area have been determined to be low, as no unresolved current or recent hazardous materials releases were identified within 0.25 mile of the alternative alignments by the HTRW Assessment presented in Appendix N. Numerous facilities that produce or store hazardous materials were identified adjacent to Orange 3, Jefferson Main, and Beaumont A, B and C; none were identified adjacent to the Orange 1 and 2 reaches. Therefore, risks that currently unidentified HTRW sites may be impacted are higher for all height alternatives of the Orange 3, Jefferson Main, and Beaumont reaches than they are for Orange 1 and 2.

No other significant environmental impacts have been identified for the any of the Orange-Jefferson CSRM project area alternatives. Air emissions modeling (presented in Appendix I) was developed for a conservatively high estimate of construction equipment needs and durations. The modeling determined that total emissions for construction of all reaches would be below *de*

minimis thresholds; and thus, construction would have no significant impacts on ambient air quality in the area. Emissions would be proportionately higher for each height alternative, assuming that the time needed to construct levee segments would be proportionately longer as the height increases. Impacts on prime farmlands were roughly similar across all reaches and would be differ proportionately by the height of each alternative. No ESA impacts have been identified for any of the project area reaches. Water and sediment quality impacts would be similar for all reaches/height alternatives with the exception of Orange 3. Fill material needed to construct earthen levees would be obtained commercially for all reaches and tested as needed to ensure suitability for use. Temporary sediment load and turbidity impacts would be minimized using best management practices (BMPs) as the levees are constructed. Orange 3 would have additional temporary turbidity and bottom sediment impacts during construction of the Adams and Cow Bayou surge gates. The potential for temporary noise impacts on sensitive receptors is greatest in Orange 3 since it passes through several communities; Orange 1 would create temporary noise impacts for the Rose City area; few sensitive receptors are located adjacent to the Orange 2 right-of-way. The potential for historic properties impacts on historic structures or cemeteries is greatest for Orange 3, since it passes through residential and business centers in the city of Orange and Bridge City; potential for impacts on prehistoric archeological sites may be higher in Orange 1 and 2, since much of those alignments remain undeveloped. Potential for historic properties impacts in all of the Jefferson County reaches is low because of the extensive industrial and residential development in the vicinity of those alignments.

5.4.6.3 Port Arthur and Vicinity CSRM Project Area

No direct or indirect impacts on wetlands would be expected with construction of any of the alternatives, as construction activities would be generally be undertaken within the existing Port Arthur HFPP right-of-way. Additional temporary and permanent rights-of-way would be needed for construction of modifications in the Taylor Bayou Turning Basin area; all of this additional area is previously disturbed by industrial development. Staging areas would be situated to avoid impacts on wetlands or other significant environmental resources; numerous suitable areas are available. The TSP 1-foot raise alternative for the four alternatives would require the raising of about 4.5 miles of levee, construction of about 2.8 miles of scour pads, the replacement of one vehicle closure structure and the reinforcement of the I-Walls near Valero and near the Tank Farm. Raising levees and floodwalls by 2 feet over all of the four alternative project areas, rather than 1 foot as described for the TSP, would require the raising of approximately 18 miles of levee, construction of about 1.5 miles of scour pads, replacement of about 3.8 miles of I-Walls, construction of about 0.25 mile of new floodwalls at pump stations, replacement of drainage structures, reconstruction of about 13 vehicle closure structures, elevation of about 1.5 miles of highways, and the rebuilding of four pump stations at higher elevations. While this is significantly more construction than that required for the 1-foot raise, most construction activity

would be confined to the existing right-of-way; areas where additional right-of-way would be needed are previously distrubed. Additional staging areas would be situated to avoid environmental impacts.

No other significant environmental impacts have been identified for the any of the Port Arthur and Vicinity CSRM project area alternatives. Air emissions modeling (presented in Appendix I) was developed for a conservatively high estimate of construction equipment needs and durations, including the 2-foot raise described above. The modeling determined that total emissions for construction of all reaches would be below *de minimis* thresholds; and thus, construction would have no significant impacts on ambient air quality in the area. Emissions would be proportionately higher for each height alternative, assuming that the time needed to construct levee segments would be proportionately longer as the height increases. No ESA or prime farmland impacts were identified. Water and sediment quality impacts would be similar for all reaches/height alternatives. Fill material needed to construct earthen levees would be obtained commercially for all reaches and tested as needed to ensure suitability for use. Temporary sediment load and turbidity impacts would be minimized using BMPs as the levees are constructed. The potential for historic properties impacts on historic structures or cemeteries is greatest for the I-Wall Raise near Tank Farm (all height alternatives) because it passes adjacent to 43 residential structures in Port Arthur. There is a potential for temporary noise impacts on residents in the homes near the same reach. Potential historic properties and temporary noise impacts would be greater for the 2-foot raise because much longer reaches of the levee/floodwall system, passing adjacent to about 180 residential structures, would be reconstructed.

The greatest potential impact is associated with the HTRW sites located in the vicinity of the I-Wall Raise Near Tank Farm, I-Wall Raise Near Valero, and 8-10 ft I-Wall Raise Alternatives. While no unresolved current or recent hazardous materials releases were identified within 0.25 mile of these reaches alignments (see Appendix N), industrial facilities that produce or store hazardous materials were identified adjacent to these reaches. Therefore, risks that currently unidentified HTRW sites may be impacted are higher for all height alternatives of the three reaches listed above.

5.4.6.4 Freeport and Vicinity CSRM Project Area

The TSP 1-foot raise for all of the alternative project areas would require the raising of about 6 miles of levee, reinforcement of about 2.75 miles of existing levee and 0.6 mile of floodwall, replacement of 700 LF of I-Wall, construction of about 0.75 mile of scour pads, and construction of the new surge gate on the DOW barge canal. A 2-foot raise for all of the alternative project areas would require the raising of about 11.2 miles of levee, reinforcement of about 0.6 mile of floodwall, replacement of 1.5 miles of floodwall, construction of 0.2 mile of new floodwalls,

construction of the new surge gate on the DOW barge canal, reconstruction of the Tide Gate, construction of a new pump station, and the replacement of numerous gravity drains. No direct or indirect impacts on wetlands would be expected with construction of any of the alternatives, as construction activities would be generally be undertaken within the existing Freeport HFPP right-of-way. However, some additional temporary and permanent rights-of-way would be needed for construction of all alternative heights in the Oyster Creek Levee Raise, Tide Gate I-Wall Raise, Old River North at DOW Thumb Levee Raise, and Freeport Dock Floodwall Raise reaches. All but one of these reaches are previously disturbed by industrial development. The approximately 3-mile-long Oyster Creek Levee Raise may require a minor amount of additional right-of-way, estimated at this time to be about 10 feet wide. The area that would be disturbed is upland scrub-shrub and forest; no wetlands would be impacted. The DOW Barge Canal Gate Structure would be constructed within the existing project right-of-way and in areas already impacted by previous construction. No significant water quality or benthic impacts are anticipated with installation of a gate in this artificial canal. Staging areas would be situated to avoid impacts on wetlands or other significant environmental resources; numerous suitable areas are available.

No other significant environmental impacts have been identified for the any of the Freeport and Vicinity CSRM alternatives. Air emissions modeling (presented in Appendix I) was developed for a conservatively high estimate of construction equipment needs and durations, including the 2-foot raise described above. The modeling determined that total emissions for construction of all reaches would be below *de minimis* thresholds; and thus, construction would have no significant impacts on ambient air quality in the area. A consistency determination would not be required. Emissions would be proportionately higher for each height alternative, assuming that the time needed to construct levee segments would be proportionately longer as the height increases. No ESA or prime farmland impacts were identified. Water and sediment quality impacts would be similar for all reaches/height alternatives. Fill material needed to construct earthen levees would be obtained commercially for all reaches and tested as needed to ensure suitability for use. Temporary sediment load and turbidity impacts would be minimized using BMPs as the levees are constructed. There is little potential for historic properties impacts for most of the reaches; however, three archeological sites near the Oyster Creek Levee Raise would need to be avoided by project construction. Construction of any of the height alternatives of the Tide Gate I-Wall Raise and the Oyster Creek Levee Raise would result in temporary noise impacts on approximately five residences each; the East Storm Levee Raise would result in temporary noise impacts on approximately 13 residences. The remainder of the reaches pass adjacent to industrialized areas where historic property and noise impacts are not likely.

The greatest potential impact is associated with the HTRW sites located in the vicinity of the Old River North at DOW Thumb, the Freeport Dock Floodwall Raise, and the Tide Gate I-Wall Raise Alternatives. While no unresolved current or recent hazardous materials releases were identified within 0.25 mile of these reaches alignments (see Appendix N), industrial facilities that produce or store hazardous materials were identified adjacent to these reaches. Therefore, risks that currently unidentified HTRW sites may be impacted are higher for all height alternatives of the three reaches listed above.

5.4.6.5 Environmentally Preferable Alternatives

Environmentally preferable alternatives will be identified after alternatives are refined and presented in the Record of Decision for the Final IFR-EIS.

5.4.6.6 Comparison of Socioeconomic Impacts of Final Array Alternatives

The Orange-Jefferson CSRM would impact roughly 31 acres of land currently classified as residential and 36 acres of commercial and industrial land in Orange County. In Jefferson County, about 3 acres of residentially zoned land would be impacted, but approximately 100 acres of commercial and industrial land would be impacted, as well as 63 acres of vacant land. Up to approximately 100 structures in Orange and Jefferson Counties, including private residences, could be impacted by the construction of the Orange-Jefferson CSRM Plan. Efforts will be made during final feasibility planning to reduce impacts on existing structures. The proposed Orange-Jefferson CSRM would provide protection to a number of residential and commercial properties in the two counties. Improvements to the Freeport CSRM would further protect a large portion of Port Freeport where, as noted, a number of petrochemical facilities exist, as well as the importation of commodities such as crude, paper goods, and liquid natural gas. Freeport is also the location of a Strategic Petroleum Reserve site. Enhancements at the Port Arthur and Vicinity CSRM would provide additional protection to key refineries in the area, including faculties operated by Valero, Premcor, Total, and Motiva Enterprises. The proposed TSP would also have beneficial impacts on a diverse population in the three counties. Jefferson, the more racially diverse of the three counties, has a population that is over 50 percent non-white according to the most recent Census Bureau data. Brazoria also has a substantial minority population, while Orange County is less diverse.

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6 TENTATIVELY SELECTED PLAN

6.1 PLAN COMPONENTS

The components of the TSP are listed below by project area and illustrated in Figures 6-1 through 6-3. Section 6.1.1 describes the TSP in detail; additional detail of the TSP description is provided in the Engineering Appendix. An economic summary of the TSP is provided in Tables 17, 18, and 19 of Appendix C, Economics. This section would be renamed the "Recommended Plan" for the FIFR-EIS following responses from public, policy, and technical reviews of this DIFR-EIS and the ADM.

Orange-Jefferson CSRM

- Orange 3 New Levee (11-foot)
- Beaumont A New Levee (12-foot)
- Jefferson Main New Levee (11-foot)

Port Arthur and Vicinity CSRM

- 8-10 ft I-Wall Raise (1-foot)
- Closure Structure Raise (1-foot)
- I-Wall Raise Near Valero (1-foot)
- I-Wall Raise Near Tank Farm (1-foot)

Freeport and Vicinity CSRM

- DOW Barge Canal Gate Structure
- Oyster Creek Levee Raise (1-foot)
- East Storm Levee Raise (1-foot)
- Freeport Dock Floodwall Raise (1-foot)
- Old River Levee Raise at DOW Thumb (1-foot)
- Tide Gate I-Wall Raise (1-foot)

6.1.1 Description of the TSP

6.1.1.1 Orange-Jefferson CSRM Project Area

Orange 3 New Levee (11-Foot)

The Orange 3 New Levee is a levee/floodwall flood protection system that would serve to reduce the flood-damage potential from storm surge for much of the southern half of Orange County along the Sabine River and Bessie Heights Marsh. As conceived, the structures

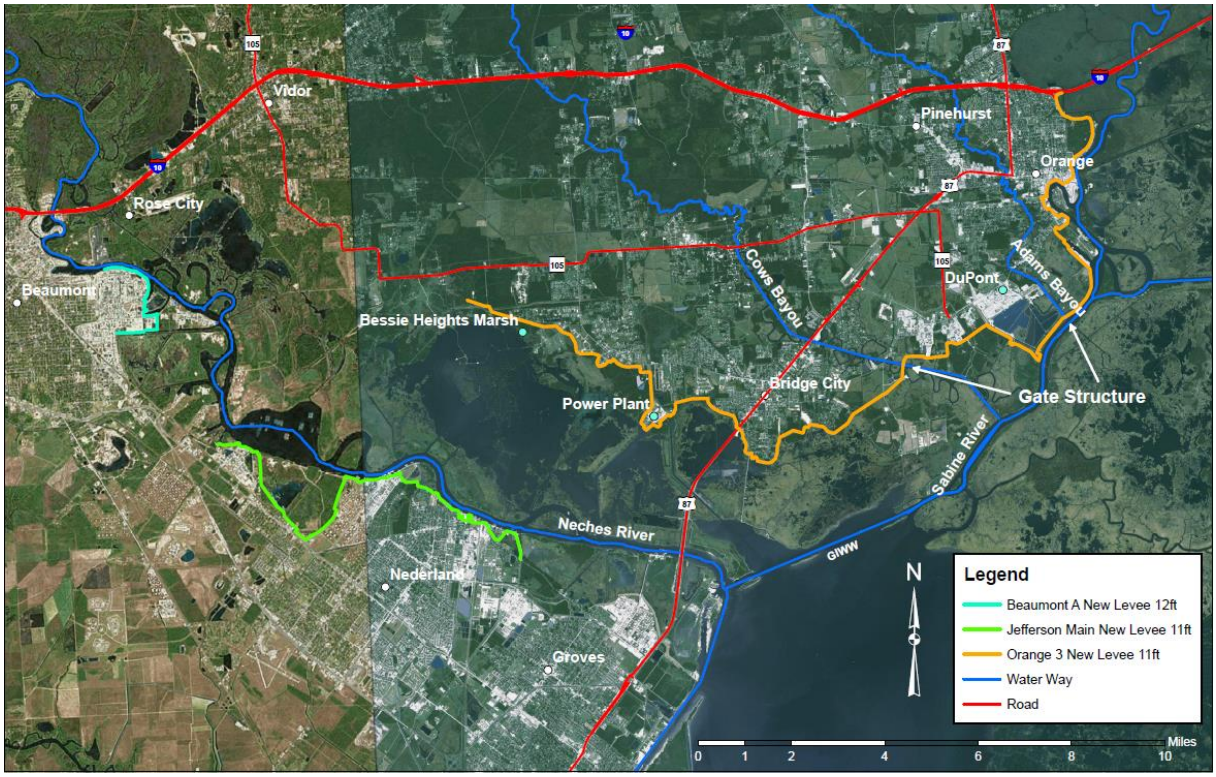

Figure 6-1: Orange-Jefferson CSRM Plan

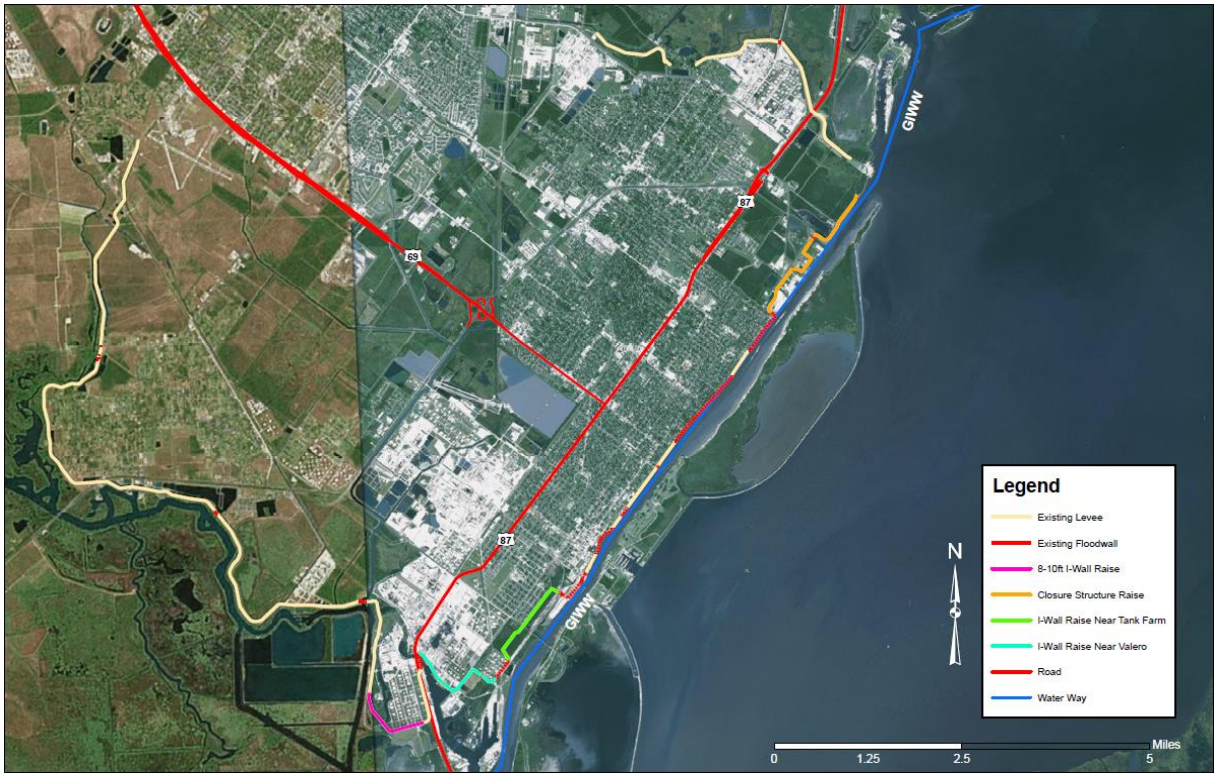

Figure 6-2: Port Arthur and Vicinity CSRM Plan

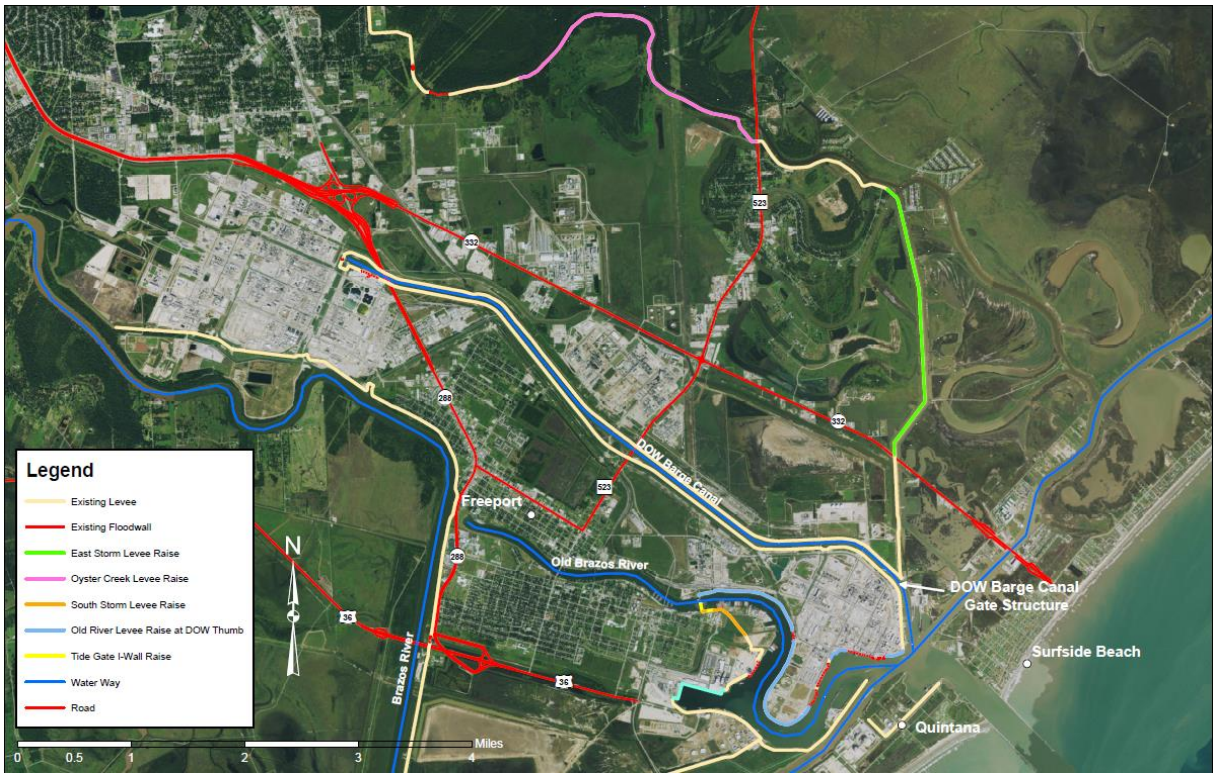

Figure 6-3: Freeport and Vicinity CSRM Plan

composing the system would be built to an elevation capable of handling an 11-foot storm surge. At this time, there is no provision for future relative sea level rise, waves on top of the surge level, and additional minimum freeboard for wave overtopping in project design or cost. Therefore, the structure heights to accommodate this surge would likely end up being designed several feet higher than the heights assumed for the optimization analysis. For the optimization analysis, it was assumed that sea-level rise, wave run-up, and overtopping could be uniformly applied across the system without affecting the TSP outcome.

The Orange 3 New Levee begins at Interstate-10 at its northeast end, about 1.75 miles west of where the highway crosses the Sabine River. From there, the alignment roughly parallels the Sabine River to the south and then to the southwest to an industrial canal 1.65 miles northeast of the mouth of Cow Bayou. Along this reach, the alignment crosses Adams Bayou, which is used for navigation. There, the alignment turns sharply to the northwest, going up to a point near the south corner of the DuPont Sabine River Works plant. From this point, the alignment runs southwesterly to Bridge City, crossing Cow Bayou along the way, which is also used for navigation. The alignment then wraps around Bridge City to the south, turning northwesterly along the north side of the Bessie Heights Marsh to an end point less than a mile southwest of Farm to Market Road (FM) 1135, where it intersects FM 105 (Orangefield Road). Along this

reach, the system will protect an electrical power-generating plant. In total, the length of the system will be approximately 27.2 miles, 21.1 miles of which will consist of earthen levee and 6.1 miles of concrete floodwall. The crossing of both Adams Bayou and Cow Bayou will require navigable gate structures incorporated into the levee alignment. The structures include a sector gate for navigation and adjacent vertical lift floodgates for allowing normal channel flow. The proposed alignment crosses several secondary roads, State Highway 87, Adams and Cow Bayous, an industrial canal, a power plant intake canal, and floodplains where the foundation conditions are poor. It also crosses numerous pipelines and utilities, industrial facilities, commercial properties, residential areas, and sensitive environmental habitats. Consequently, there are going to be several challenges in implementing this reach of the project that will add considerably to its construction cost.

The Orange 3 New Levee reduces the flood-damage potential from storm surge within the cities of Orange, West Orange, Pinehurst, Bridge City, and Orangefield. It also protects petrochemical plants and Entergy Texas Inc.'s Sabine (Power) Plant in Bridge City.

Beaumont A New Levee (12-Foot)

The proposed Beaumont A New Levee is an earthen levee/concrete floodwall protection system that would protect ExxonMobil's Beaumont Chemical Plant. This 3.6-mile-long system, consisting of 1.1 miles of levee and 2.5 miles of floodwall, was envisioned to supplant the existing flood protection system surrounding the plant to provide a level of protection that will protect against a 12-foot surge. It has been learned, however, that a recent industry improvement has resulted in consruction of a barrier that is approximately 3 to 4 feet higher than currently proposed in the TSP. The existing industry barrier alignment generally follows the TSP alignment, with the industry barrier more robust and providing a higher level of protection than the TSP.

Jefferson Main New Levee (11-Foot)

The proposed Jefferson Main New Levee (11-foot) is an earthen levee/concrete floodwall protection system that would serve to reduce the flood-damage potential from storm surge along the northeastern boundary of Jefferson County defined by the Neches River. As conceived, the structures comprising the system would be built to an elevation capable of handling an 11-foot storm surge. At this time, there is no provision in the concept features assumed in developing the TSP project costs that accounts for future RSLC, waves on top of the surge level, and additional minimum freeboard for wave overtopping. Therefore, the structure heights to accommodate this surge likely would end up being designed several feet higher that the heights assumed for the optimization analysis.

The alignment begins near the northeastern terminus of the existing Port Arthur and Vicinity HFPP, where it would tie into high ground. It runs west-northwest generally along the west bank of the Neches River, nearly 11.0 miles, to a point on the north side of the DuPont Beaumont Works Industrial Park in Nederland. Because industrial facilities to be protected front the river, approximately 3.1 miles of the system would consist of floodwall. The alignment crosses industrial plants and must provide access to several docking facilities along the river. It circumvents a large upland wetland area, thereby avoiding adverse impacts on the wetland.

6.1.1.2 Port Arthur and Vicinity CSRM Project Area

8- to 10-foot I-Wall Raise (1-Foot)

The TSP includes modifications to the existing HFPP with a 1-foot raise. The 1-foot raise would require 7,500 LF of 15.5-foot scour pad along with removing the excess stick-up height from the existing I-wall and adding erosion protection to reduce the likelihood of a brittle failure if the systems' capacity is exceeded. This plan would also include adding capacity to the system in this reach by addressing low areas of the levee system, raising 2,000 LF of levee 1 foot, and providing overtopping erosion protection at areas subject to excessive erosion.

Closure Structure Raise (1-foot)

The TSP for the existing Port Arthur HFPP includes a 1-foot raise for the closure structure. This includes replacement of the closure structure gate that is 12 feet high by 30 feet wide. It also includes 2,300 LF of 100-foot-wide 6-inch scour pad, one on each side of the structure to provide erosion protection to reduce the likelihood of a brittle failure if the systems' capacity is exceeded. This alternative also includes raising 12,000 LF of levee 1 foot.

I-Wall Raise Near Valero (1-foot)

The TSP for the existing Port Arthur HFPP at the I-Wall near the Tank Farm would be an additional structural support and a 1-foot raise. Construction of 5,000 LF of 15.5-foot-wide scour pad and structural support system with a 1-foot rise would provide additional system capacity and provide resiliancy if the systems' capacity were exceeded. An additional 3,000 LF of adjacent levee would need to be raised 1 foot for this alternative.

I-Wall Raise Near Tank Farm (1-foot)

The TSP for the existing Port Arthur HFPP at the I-Wall near the Tank Farm would be an additional structural support and a 1-foot raise. Construction of 1,800 LF of 15.5-foot-wide scour pad and structural support system with a 1-foot rise would provide additional system

capacity and provide resiliancy if the systems' capacity were exceeded. An additional 7,000 LF of adjacent levee would need to be raised 1 foot for this alternative.

6.1.1.3 Freeport and Vicinity CSRM Project Area

DOW Barge Canal Protection

The TSP for reconstruction and resiliency features for the existing Freeport HFPP at the DOW Barge Canal levee would consist of a surge gate structure and pump station constructed at the junction of the North Barge Canal and East Storm Levee. This structure would allow barge traffic to pass during routine operations and would have a pumping capacity of 2,000,000 gpm. The surge gate length would be approximately 500 feet long, with the two sector gates totaling approximately 80 feet in width for vessel traffic. Additional tidal circulation would be provided by two sluice gates approximately 15 feet wide each. The final configuration of this structure would match the proposed level of protection for the system.

Oyster Creek Levee Raise (1-Foot)

The TSP for reconstruction and resiliency features for the existing Freeport HFPP at the Oyster Creek Levee reach is a proposed 1-foot raise in system capacity along with extending an elevation to account for changes in surge loading. Construction would include 3,500 LF of 3-foot levee raise and 10,000 LF of 1-foot levee raise for a total distance of 13,500 LF. The construction procedure would include stripping topsoil, removal and replacement of a 12-foot-wide asphalt road, placement of fill, and turfing.

East Storm Levee Raise (1-Foot)

The TSP for reconstruction and resiliency features for the existing Freeport HFPP at the East Storm Levee is a 1-foot raise in system capacity. Construction would include 13,115 LF of levee raised one foot along with HPTRM installation for erosion protection.

Freeport Dock Floodwall Raise (1-Foot)

The TSP for reconstruction and resiliency features for the existing Freeport HFPP at the Freeport Dock Floodwall is a reconstruction of the existing wall/drop-in panel system. The construction would include 3,000 LF of floodwall to meet all USACE requirements for a wall/drop-in panel system located at a port facility.

Old River Levee Raise at DOW Thumb (1-Foot)

The TSP for reconstruction and resiliency features for the existing Freeport HFPP along the DOW thumb levee reach is a 1-foot raise in system capacity. Construction would include 4,000

LF of a 15.5-foot-wide scour pad along with 3,000 LF of levee raised 1 foot and 14,500 LF of HPTRM. Additional material would be added in order to "level up" the low spots of this reach of levee, which in conjunction erosion protection, would reduce the likelihood of a brittle failure if the systems' capacity is exceeded.

In this location, the study interfaces with the Freeport Harbor Channel Improvement Project General Reevaluation Report (GRR) underway for the deep-draft channel project authorized by WRRDA 2014. The feasibility-level design of this feature will be configured so it does not change the FOS of the DOW Thumb Levee, which would impact the assumptions made in the GRR.

Tide Gate I-Wall Raise (1-Foot)

The TSP for reconstruction and resiliency features for the existing Freeport HFPP at the I-wall located at the Tide Gate is a complete reconstruction of the I-wall and extension of the reconstructed floodwall to replace two additional sections of floodwall at a 1-foot raise in system capacity. Construction would consist of 700 LF of floodwall 11 feet tall along with 2,000 LF of levee raised 1 foot.

6.1.2 Separable Elements

A separable element is any part of a project which has separately assigned benefits and costs, and which can be implemented as a separate action (at a later date or as a separate project). Orange-Jefferson, Port Arthur, and Freeport CSRM Plans function individually and are separable. Each piece of Port Arthur and Freeport are not separable elements but need to be constructed together in order to function as a system. For Orange-Jefferson CSRM Plans on the other hand, the Alternative Reaches could potentially be separated out.

6.1.3 Fish and Wildlife Mitigation

6.1.3.1 Summary of Environmental Impacts

Environmental impacts on specific resources are described in Section 7. No significant environmental impacts have been identified for the Port Arthur and Freeport and Vicinities CSRM Plans. All environmental impacts identified for the TSP are associated with the Orange-Jefferson CSRM Plan, and these are limited to wetland impacts (Table 6-1). Direct impacts, affecting approximately 300.5 acres, would result from construction of the new levee-floodwall system, and indirect impacts on about 2,551.3 acres would be associated with functional fisheries access impacts on the extensive marshes in the lower Cow and Adams Bayous floodplains and

Table 6-1: Direct and Indirect Impact (Intermediate RSLC)- Orange-Jefferson CSRM Plan

DIRECT IMPACTS								
	Orange Reach 3		Beaumont Reach A		Jefferson Reach		Totals	
Wetland Type	Acres	AAHUs	Acres	AAHUs	Acres	AAHUs	Acres	AAHUs
Forested Wetlands								
Swamp	18.0	-10.6			0.9	-0.4	18.9	-11.0
Bottomland Hardwood	94.1	-57.3	0.3	-0.2	13.9	-6.4	108.3	-63.9
Subtotal	112.1	-67.9	0.3	-0.2	14.8	-6.8	127.2	-74.9
Coastal Marsh								
Fresh Marsh	34.4	-18.8	2.6	-1.6	13.4	-6.1	50.4	-26.5
Intermediate Marsh	10.9	-6.2	0.6	-0.3	0.4	-0.2	11.9	-6.7
Brackish Marsh	101.1	-48.8			9.9	-4.9	111.0	-53.7
Subtotal	146.4	-73.8	3.2	-1.9	23.7	-11.2	173.3	-86.9
Total Direct Impacts*	**258.5**	**-141.7**	**3.5**	**-2.1**	**38.5**	**-18.0**	**300.5**	**-161.8**
INDIRECT IMPACTS								
Forested Wetlands								
Swamp	0.0	-0.1					0.0	-0.1
Bottomland Hardwood	12.7	-5.1					12.7	-5.1
Subtotal	12.7	-5.2					12.7	-5.2
Coastal Marsh								
Fresh Marsh	785.2	-18.8					785.2	-18.8
Intermediate Marsh	322.5	-12.6					322.5	-12.6
Brackish Marsh	1130.4	-63.4					1130.4	-63.4
Subtotal	2238.1	-94.8					2238.1	-94.8
Total Indirect Impacts*	**2250.8**	**-100.0**					**2250.8**	**-100.0**
TOTAL IMPACTS BY REACH								
Total Forested Wetlands	124.8	-73.1	0.3	-0.2	14.8	-6.8	139.9	-80.1
Total Coastal Marsh	2384.5	-168.6	3.2	-1.9	23.7	-11.2	2411.4	-181.7
Total Impacts by Reach*	**2509.3**	**-241.7**	**3.5**	**-2.1**	**38.5**	**-18.0**	**2551.3**	**-261.8**
* Totals may not add exactly due to rounding.								

limited impacts from construction of the levee and surge gates in a few locations. In total, approximately 139.9 acres of forested wetland and 2,411.4 acres of coastal marsh would be impacted. Mitigation would be needed to compensate for a loss of 80.1 AAHUs from forested wetlands and 181.7 AAHUs from coastal wetlands. However, potential exists for impacts on buried hazardous and toxic materials during construction of improvements. Additional investigation would be required during PED to identify areas of concern and strategies for minimizing impacts.

6.1.3.2 Summary of Conceptual Fish and Wildlife Mitigation Plan

In accordance with the mitigation framework established by Section 906 of the Water Resources Development Act (WRDA) of 1986 (33 USC 2283), as amended by Section 2036 of WRDA 2007 and Section 1040 of the Water Resources Reform and Development Act (WRRDA) of 2014, the Council on Environmental Quality (CEQ)'s National Environmental Policy Act (NEPA) regulations (40 CFR Sections 1502.14(f), 1502.16(h), and 1508.20), and Section C-3 of Engineer Regulation (ER) 1105-2-100, USACE will ensure that project-caused adverse impacts to ecological resources are avoided or minimized to the extent practicable, and that remaining, unavoidable impacts are compensated to the extent justified.

Mitigation would be needed to compensate for a loss of 80.1 AAHUs from forested wetlands and 181.7 AAHUs from coastal wetlands. Impacts were avoided and minimized to the greatest extent practicable in the selection of the proposed new levee system alignment. The levee was located as close to the upland-wetland margin as possible to minimize wetland impacts, while also minimizing social effects and maximizing economic benefits. Engineering design incorporated NMFS recommendations that would reduce EFH impacts. Opportunities to further avoid and minimize environmental impacts will be evaluated during final feasibility planning. Since the alignment may change as a result of public, technical and policy review, conceptual mitigation plans and estimates have been developed for the DIFR-EIS. Remaining unavoidable impacts will be fully compensated with in-kind mitigation. Conceptual mitigation measures, described more fully in Appendix O, consist of coastal marsh restoration, the acquisition and long-term conservation of bottomland hardwoods and/or swamps, and possible improvements to the forested wetland areas targeted for conservation. WVA modeling will be conducted to quantify benefits (AAHUs) of mitigation measures. Selection of potential mitigation sites and modeling of benefits will be conducted in coordination with resource agencies. Feasibility-level costs of selected mitigation measures will be developed, and the costs and benefits will be used to identify a best buy mitigation plan using Cost Effectiveness-Incremental Cost Analysis that will fully compensate for all impacts.

Mitigation banks will be investigated to determine if sufficient and appropriate mitigation is available; none are known at this time. If mitigation banks are not available to compensate for all or a portion of project impacts, areas in the floodplains of the Neches and Sabine Rivers within and adjacent to the study area will be reviewed to identify potential in-kind mitigation sites. Additional sites may be suggested by resource agencies. Areas targeted for evaluation exclude areas already identified for beneficial use or mitigation in conjunction with other projects. Specifically, authorized improvements to the SNWW navigation project include the restoration of large areas within both Bessie Heights and Old River Cove marshes with the beneficial use of dredged material. In addition, areas targeted for restoration by TPWD have also been excluded. Any mitigation sites selected for this project would augment, not replace, these other proposals.

During final feasibility planning, an appendix to the FIFR-EIS will be prepared that presents sensitivity analyses of the WVA marsh models using a sensitivity spreadsheet prepared by the ERDC Environmental Lab. These sensitivity analyses will provide additional information to assist in the investigation of several unresolved issues related to the suitability graphs for Variables 1, 2, and 3 and the aggregation methods used to combine the marsh habitat units and open water habitat units for each sub-model. These analyses will be coordinated with the ECO-PCX and reported in a separate appendix to the FIFR-EIS.

6.1.4 Historic Properties Mitigation

Development of a mitigation plan will be deferred to Pre-construction Engineering and Design (PED) when surveys and site assessments will be completed. The mitigation of historic properties may be necessary following an evaluation of impacts to determine if any of the four currently listed historic properties would be indirectly impacted. The eight archeological sites within the study area also would need to be evaluated as to their horizontal and vertical extent and eligibility for inclusion in the National Register of Historic Places (NRHP). The two cemeteries within the study may also be directly impacted and would need to be delineated and evaluated. There is also the potential for identifying cultural resources during survey investigations of high probability areas. Based on the current level of data, the mitigation of impacted historic properties might involve the construction of measures to reduce impacts on the setting of historic buildings or districts, as well as Historic American Building Survey documentation. If impacts are identified, archeological historic properties would require data recovery excavations or avoidance and cemeteries would need disinterment and interment of burials to a new location. The relocation of burials from impacted cemeteries might also involve purchasing land if other arrangements cannot be made.

6.1.5 Cost Estimate

A Class 4 parametric cost, using historical and unit costs, was applied to develop the cost estimate for screening the final array within the alternative reaches in the project areas. A cost estimate using Microcomputer Aided Cost Estimating System (MCACES) will be developed for the plan carried forward for feasibility-level design following the concurrent public, policy, Agency Technical Review (ATR), and Independent External Peer Review (IEPR).

6.1.6 Project Schedule and Interest During Construction

A project schedule and interest during construction plan will be developed for the plan carried forward for feasibility-level design following the concurrent public, policy, ATR, and IEPR review.

6.2 DESIGN AND CONSTRUCTION CONSIDERATIONS

A feasibility-level design for the TSP is not complete at this time; however, the following design considerations are known. Significant consideration was given to the existing infrastructure that is in extremely close prominently to the work areas. Construction activities would be closely monitored to ensure that there is not any damage to industrial facilities or the existing project. Coordination with numerous different stakeholders along with the project local sponsors will be required.

6.2.1 Value Engineering

A Value Engineering Study will be performed on the plan carried forward for feasibility-level design following the concurrent public, policy, ATR, and IEPR.

6.2.2 Sea Level Change

Design and construction considerations for future feasibility-level design for the Port Arthur and Freeport and Vicinity CSRMs will focus on addressing the potential impacts of relative rise of sea level change in the study area. Constraints within the existing HFPPs create problems accommodating a design for the higher RSLC scenarios. At lower levels of RSLC, the adaptability of the existing project features is minor in scope; however, at the higher levels, it becomes more challenging. The eventual design of the recommended plan would be tied to existing project features, and the designers must consider this. This applies to numerous locations within both of the existing systems.

6.2.3 Storm Surge

Regarding storm surge for future feasibility-level design at the Port Arthur and Freeport and Vicinities CSRM Plans, design will be focused on developing a design for the system as a whole. Given the specific work noted in the TSP, the designers will have to apply current engineering design requirements to these two complex systems.

6.3 REAL ESTATE CONSIDERATIONS

The Non-Federal Sponsors will be responsible for acquiring and furnishing all lands, easements, rights-of-way, relocations (i.e., P.L. 91-646 relocations and utility/facility relocations), borrow material, and dredged or excavated material disposal areas (LERRD) for the project areas, as required. All lands needed for this project will be acquired in fee, with the exception of the land needed for the flood protection levee easements, staging areas, perpetual road easements, and borrow area easements. A Real Estate Plan was developed to present the Real Estate requirements for the TSP. It is estimated that up to 100 residential properties could be impacted by the TSP; approximately 64 in Orange County and 35 in Jefferson County. During feasibility-level design, the residential properties will be avoided to the extent possible.

6.3.1 Lands, Easements, and Rights-of-Way

The following lists the Lands, Easements, and Rights-of-Way requirements for the TSP. Descriptions of the Orange 3, Jefferson Main, and Beaumont A alternative reaches assumed levee heights at 11-foot, 12-foot, and 13-foot, respectively. The TSP includes a lower levee height design of 1-foot in these reaches. The Real Estate Plan will be revised to reflect this in future phases of this study.

The following is a list of the TSP from the Orange-Jefferson CSRM Plan:

- Orange 3 New Levee (11-foot)
- Beaumont A New Levee (12-foot)
- Jefferson Main New Levee (11-foot)

For the Orange 3 New Levee, current plans indicate 21.51 miles of new levee (200 feet wide) and 5.65 miles of new floodwall (60 feet wide) would be constructed. In general, the alignment for the levee and/or floodwall starts near Rose City (I-10) and meanders in a southeast direction, turning north near Bridge City, to the termini near the City of Orange and adjacent to I-10. In support of the construction activities, the following estimates were used:

- 96 acres of borrow material would be required for the construction of new levee and floodwall;
- 27.16 miles of perpetual road easement (40 feet wide) for operations and maintenance; and
- temporary work area easement (20 feet wide by 27.16 miles in length) for three years, seven staging areas (2 acres each) for 3 years.

For the Jefferson Main and Beaumont A alternatives, current plans indicate 8.82 miles of levee (200 feet wide) and 5.49 miles of floodwall (60 feet wide) would be constructed. In general, the alignment starts on the west bank of the Neches River, immediately north of the DuPont facility, and meanders in a southeastern direction to Port Neches Atlantic Road. In support of the construction activities, the following estimates were used:

- 28 acres of borrow material would be required for the construction of new levee and floodwall;
- 14.31 miles of perpetual road easement (40 feet wide) for operations and maintenance;
- temporary work area easement (20 feet wide by 14.31 miles in length) for 3 years; and
- 3 staging areas (2 acres each) for 3 years, and 1 staging area (3 acres - Beaumont) for 3 years.

For the Port Arthur and Vicinity CSRM, certain portions of the existing 29.04-mile system of levees and floodwalls and/or closure system would be improved or replaced. All work would be achieved within the existing rights-of-way. In support, the following estimates were used:

- temporary work area easement (20 feet wide by 29.04 miles in length) for 3 years; and
- Five staging areas (2 acres each) for 3 years.

For the Freeport and Vicinity CSRM, certain portions of the existing 43.12-mile system of levees and floodwalls and/or closure system would be improved or replaced. All work would be achieved within the existing rights-of-way. In support, the following estimates were used:

- temporary work area easement (20 feet wide by 43.12 miles in length) for 3 years; and
- 10 staging areas (2 acres each) for 3 years.

6.3.2 Facility Removals/Utility Relocations

Multiple pipelines would be impacted by this project; however, relocation and modification costs were not included in the plan formulation costs because the relocations and modifications that

would be necessary largely depend on the feasibility-level design, and what the actual field conditions are when more thoroughly investigated. The Real Estate Plan will be revised to reflect this in future phases of this study.

6.4 OPERATIONS AND MAINTENANCE CONSIDERATIONS

Operation and maintenance (O&M) of these facilities would be extensive. The TSP will be a complex system constructed in a marine environment. O&M requirements would include, but not be limited to, biannual exercising of the systems gates and closure structures, grass mowing, painting, pump station O&M, drainage and navigation structure operation, and maintenance and alteration approvals under Section 408. Under 33 U.S. Code 408 (commonly referred to as Section 408), the Secretary of the Army, on the recommendation of the Chief of Engineers, may grant permission for the alteration of a USACE civil works project if it is determined that the alteration will not be injurious to the public interest and will not impair the usefulness of the project. The local sponsors would also be required to coordinate with stakeholders for operation and maintenance concerns and evacuation/emergency action planning. Additional O&M detail on the plan carried forward for feasibility-level design will be provided.

6.5 ECONOMIC ANALYSIS FOR RECOMMENDED PLAN

6.5.1 Economic Optimization

The proposed TSP includes the compilation of the NED plans from the project areas. Refer to Tables 10 through 12 in Appendix C, Economics, for the bracketing of the economic evaluation

6.5.2 Economic Sensitivities

Economic sensitivities are discussed in Section 6.7.2 of this report, under risk and uncertainty.

6.6 SUMMARY OF ACCOUNTS

6.6.1 National Economic Development (NED)

Estimated net benefits for the TSP Separable Elements are listed below by project area. Overall, the estimated net benefits of the TSP is $71,809,000.

- Orange-Jefferson CSRM - $35,304,000
- Port Arthur and Vicinity CSRM - $21,860,000
- Freeport and Vicinity CSRM - $14,646,000

6.6.2 Environmental Quality (EQ)

Potential impacts of the TSP on human and environmental resources have been identified and presented in this document. All factors that may be relevant to the TSP were considered, including direct and indirect impacts on wetlands, effects on essential fish habitat and listed species, air quality, water and sediment quality, hazardous materials, historic properties, socioeconomic, and environmental justice impacts. Environmental impacts on wetlands are the primary environmental effect. All potential effects are evaluated in Section 7.0.

6.6.3 Regional Economic Development Benefits (RED)

The proposed TSP reduces probabilities of direct damages, but also decreases the occurrence of secondary impacts, such as potential disruptions to refining capacities, which could lead to higher fuel prices. It is expected that a quantitative (input/output) model will not be used to estimate these secondary impacts (benefits other than direct damages); however, this will be confirmed following the concurrent public, policy, and technical reviews. This information would be used to support a decision to increase the levee height in any of the project areas in support for RED.

6.6.4 Other Social Effects (OSE)

Based on the qualitative evaluation performed on the Orange-Jefferson CSRM, Port Arthur and Vicinity CSRM, and the Freeport and Vicinity CSRM, the expectation for each project area would be that all plans would positively impact life-safety risk. A quantitative model was not used to determine performance of plans against life-safety risk reduction. It is expected that the TSP would have a positive impact and no increase in risk. This will be confirmed following the concurrent public, policy, and technical reviews.

6.7 RISK AND UNCERTAINTY

6.7.1 Engineering Data and Models

This section summarizes risk and uncertainty included in some key models and methods applied in this study and documented in the report appendices in more detail.

6.7.1.1 Hydrology and Hydraulics

The hydrologic, hydraulic, and coastal information presented in this report relied heavily on available data gathered from many local, state, and national sources. Some of the information was preliminary, such as the HEC-RAS models for the Neches River, Cow Bayou, and Adams Bayou. The models had been through quality control and assessment by the entities they were

acquired from, and additional Quality Assurance/Quality Control was performed by USACE. These models have relatively low risk and uncertainty but should be reevaluated again during PED. Additionally, the watersheds and waterways may change by the time PED begins and this should be addressed at that time.

For most interior drainage areas, hydrologic calculations were performed using the rational and regression methods. These are common methods of estimating rainfall runoff and discharges at outfalls, and their use is permitted by USACE. Detailed models would have been preferred, such as HEC-HMS and HEC-RAS models, but time and budget constraints prevented a higher level of analysis. To reduce uncertainty, two separate rational method calculation formulations and two separate regression formulations were used. The results produced very similar results; typically, the difference was in the 5-10 percent range. It is recommended that more detailed modeling be performed before PED.

Relative Sea Level Change

The project must consider possible trends that affect the area. One trend that would likely impact the area is RSLC. The degree of uncertainty and values vary considerably amongst the worldwide scientific community, and this issue will likely be debated and methods will likely be improved over time. This study uses current USACE sea level change guidance as required for USACE studies. To account for the unknowns in sea level change, USACE requires evaluation of high, medium, and low scenarios of sea level change projections.

Recommendations to address RSLC scenarios are described in detail in the engineering appendix and summarized here. The entrance channel jetties at both Freeport and Sabine Neches Waterway are high enough that there is no concern of being impacted by RSLC estimates. Levees should be constructed in an adaptable or anticipatory manner for estimated sea level rise if possible. Outfall calculations account for the predicted rise in sea level by increasing size and capacity.

This project utilizes the highest estimated sea level change value following required USACE guidance. Using the “high” estimates in the guidance reduces the risk that sea level change is underestimated or that future estimates may impact the project. Uncertainty is considered by evaluating a range of possible sea level change possibilities from “low” to “high.” It is recommended that RSLC be reevaluated during PED because the understanding of sea level change and USACE guidance may change between the completion of this report and initiation of PED.

Hydrodynamics and Storm Surge

Typical Conditions. Typical conditions were assessed using previous modeling efforts, analysis of existing data, and limited salinity transport modeling. Uncertainties in collected data are transferred to the analyses presented here. ERDC-CHL utilized a Desktop Off-Channel Wetland Salinity Mitigation Model (DOWSMM) to perform an analysis to quantitatively assess the impacts of the proposed gates. DOWSMM modeling is based on previous modeling efforts without site-specific calibration or validation data.

Storm Conditions. Baseline storm surges used for the analysis were composed of the suite of storm surges produced from the Federal Emergency Management Agency (FEMA) Texas Joint Storm Surge Study (JSS). The FEMA Texas JSS used the Advanced Circulation (ADCIRC) model together with the ERDC Steady State Wave model (STWAVE) to perform storm surge and wave simulations. Statistics based on the JSS model runs were updated using the most recent Joint Probability Method-Optimal Sampling (JPM-OS) code.

In the Freeport region, without project storm model results were applied for both with- and without-project conditions. This approach includes uncertainty associated with still water level overtopping and potential adjacent impacts.

Storms at Orange County and Port Arthur were modeled for without-project conditions in the same manner as Freeport. One new with project alignment was modeled as a vertical wall in this region. This approach provides information about adjacent impacts but does not include calculation of still water level overtopping. It also does not include detailed analysis of the separable elements, since all elements were included in the sole with-project model run.

6.7.1.2 Other Engineering Risk and Uncertainty

Risk and uncertainty for the existing systems stems from the use of existing information for the initial assumptions of what the feasibility-design will entail. This risk varies from small for I-wall reconstruction/resiliency features in areas where significant information is available, to large risk in areas of levee raising where minimal existing information is available. Additional risk will need to be addressed with the design of the TSP regarding how it will be designed as an entire system to perform at a uniform level.

Other risks and uncertainties associated with the engineering data and modeling are in the assumptions that were made based on the following:

- The accuracy of available information and data collected.
- Assessment of existing physical conditions based primarily on photo imagery and LiDAR data, no on-the-ground physical survey data.
- The preliminary levee system alignments assumed for the Orange-Jefferson CSRM projects. Alignments might adjust during feasibility-level design.
- Assessment of the foundation conditions/soil properties for the Orange-Jefferson CSRM project areas based on very limited geotechnical investigations.
- Assumed structure heights based on the still-water elevation only. Decisions are yet to made regarding how high the structures will be raised after factoring in relative sea-level rise, wave run-up, and wave overtopping, and evaluating an LPP could result in a substantial increase in hydraulic loading on the structures and will increase the seepage potential, either of which could significantly change the designs of the levee embankments and floodwall as conceived in developing the TSP.
- Generic conceptual design templates for the levee embankment and floodwall uniformly applied across the new Orange-Jefferson CSRM alignments. Future designs will be tailored to the local conditions and will therefore vary.
- The closure structures with navigable opening and pump stations are conceptual in nature based on similar structures and pump stations that were constructed for the New Orleans Hurricane and Storm Damage Risk Reduction System. These have not been conceptually designed for the CSRM projects.

6.7.2 Economic Data and Models Analysis

Uncertainty related to economics can come from several sources. One source is the structure elevation, which has two components: the topographic ground elevation that a structure sits on, and the structure's estimated first floor elevation. Another source is the value of the structure and its contents. The final source of uncertainty is in the inundation depth/percent damage relationship (usually known as depth damage functions) used to estimate damages to a structure for a given level of flooding. Parameter settings in HEC-FDA account for these uncertainties. Additional information on the uncertainties is contained in Appendix C, Economic Analysis, in the Risk Performance of Proposed Action section.

6.7.3 Project Cost and Schedule Risk Analysis

A Cost and Schedule Risk Analysis will be performed on the plan carried forward for feasibility-level design following the concurrent public, policy, ATR, and IEPR review.

6.7.4 Environmental Data and Analyses

The most current available data were used for environmental analyses of the study area, augmented by brief field visits to the study areas and reviews of habitat classification using the most recent aerial photographs. Ecological modeling was required to quantify impacts or mitigation. The sensitivity of the WVA model application to comparative valuations of marsh and open water is presented in Appendix Q. Uncertainty is inherent in ecosystems, and therefore unavoidable when evaluating ecological processes and impacts. There is often a lack of extensive data sets for all parameters under study, and many of the physical and biological processes are not completely understood. Ecological analyses for the study utilized input from several engineering models referenced in the table above.

Impact assessments for the Orange-Jefferson CSRM Plan are based in part on assumptions regarding the operating plans that will be developed during PED. Resource agencies have requested to participate in the preparation of this plan to ensure that the system is operated to maintain tidal access to wetlands inside and outside of the levee system. Because of uncertainty associated with project performance, the monitoring and adaptive management plan should include evaluation of the performance of the culvert system in maintaining tidal flows. Impact assessments are also based upon assumptions regarding the amount of constriction (and thus fisheries access impacts) to Adams and Cow Bayous created by placement of the surge gate structures within the bayou floodways. Impact assumptions should be reviewed when engineering design is sufficiently complete to determine if impacts have been captured appropriately.

There is risk that the location of the alignment will change because of technical, policy, and public comments on the draft report and those changes to the alignment may be needed to address unexpected HTRW discoveries during construction. Although no unresolved current or recent hazardous material releases were found near any of the CSRM Plan alignments, most of the refineries and chemical plants have had violations in the past. The HTRW facilities along the construction right-of-way should be more thoroughly investigated with visual inspections and interviews with facility managers to confirm the potential HTRW risks along the levee alignment prior to construction or more detailed design. If significant changes in the alignment are needed, environmental impacts will be reevaluated, and additional NEPA review may be needed.

6.8 CONSISTENCY WITH OTHER STATE AND FEDERAL LAWS

This DEIS has been prepared to satisfy the requirements of all applicable environmental laws and regulations and has been prepared using the Council on Environmental Quality (CEQ) NEPA regulations (40 CFR Part 1500–1508) and the USACE's regulation ER 200-2-2 -

Environmental Quality: Policy and Procedures for Implementing NEPA, 33 CFR 230. In implementing the Recommended Plan, USACE would follow provisions of all applicable laws, regulations, and policies related to the proposed actions. The following sections present brief summaries of Federal environmental laws, regulations, and coordination requirements applicable to this DEIS.

6.8.1 Clean Air Act

Temporary air emission impacts resulting from construction of the TSP in the Sabine and Brazoria Regions have been calculated; the analysis is presented in Appendix I. The Sabine Region is currently designated as in attainment or unclassifiable with National Ambient Air Quality Standards (NAAQS); therefore, a General Conformity Determination is not required. Brazoria County is contained within the Houston-Galveston-Brazoria (HGB) Air Quality Control Region (AQCR); this region meets all of the NAAQS, except for ozone. The HGB area is currently classified as being in severe nonattainment for the 8-Hr ozone (1997) standard and marginal nonattainment for the 8-Hr ozone (2008) standard. Direct and indirect emissions would result from temporary construction activities. Construction of the TSP in this area would result in emissions below the *de minimis* threshold for nonattainment pollutants and thus a conformity determination is not required.

Air emissions from the operation of internal combustion engines that produce exhaust result in Greenhouse Gas (GHG) emissions that could contribute to global climate change. The CEQ published “Draft NEPA Guidance on Consideration of the Effects of Climate Change and Greenhouse Gas Emissions", December 18, 2014. The Draft Guidance suggests that the impacts of projects directly emitting GHG in excess of 25,000 metric tons or more of carbon dioxide (CO2)-equivalent (CO2e) GHG emissions per year be considered in a qualitative and quantitative manner in NEPA reporting; however, there are no implementing regulations to direct development of these analyses for Federal projects. On December 19, 2014, EPA delegated authority for GHG Prevention of Significant Deterioration (PSD) permitting in Texas to the state air regulatory agency, Texas Commission on Environmental Quality (TCEQ) (TCEQ, 2015). As implemented by TCEQ, GHG permits are required only for stationary sources or facilities already required to obtain PSD permits for other criteria pollutants. GHG are not listed as NAAQS pollutants subject to regulation under the Texas State Implementation Plan (SIP). No listed pollutants are generated above *de minimis* levels, and the TSP would not result in any new stationary emission sources. Under the state program, non-stationary sources of emissions like construction equipment/construction projects are not required to obtain permits. Therefore, GHG emissions were not calculated for the Sabine or Brazoria region.

Clean Water Act Section 404 of the CWA regulates dredge-and/or-fill activities in waters of the U.S. In Texas, Section 401 of the CWA (State Water Quality Certification Program) is regulated by the TCEQ. Compliance will be achieved through coordination of the draft report with TCEQ to obtain water quality certification for the project. Coordination includes an evaluation of the project based on the Section 404(b)(1) Guidelines as presented in Appendix H. USACE has requested that TCEQ issue 401 State Water Quality Certification for the TSP.

6.8.2 Clean Water Act

USACE has requested Section 401 State Water Quality Certification for the TSP. USACE has determined that construction of the TSP will not violate water quality standards. The proposed alignment for the Orange-Jefferson CSRM Plan has been located to minimize, to the greatest extent practicable, impacts on the Neches and Sabine River floodplains and to avoid and minimize impacts on the aquatic ecosystem. Unavoidable, significant impacts would be fully mitigated. Construction of the Port Arthur and Vicinity and Freeport and Vicinity CSRM Plans would have negligible impacts. The TSP is the least environmentally damaging practicable alternative. A CWA Section 404(b)(1) evaluation is presented in Appendix H.

6.8.3 Endangered Species Act

A draft Biological Assessment (BA) was prepared describing the study area, Federally listed threatened and endangered species of potential occurrence in the study area as identified by the NMFS and USFWS, and potential impacts of the TSP on these protected species (Appendix J). The Draft BA has been submitted to NMFS and USFWS for their review. USACE has determined that the TSP would have no effect on the following listed animal species: piping plover, red knot, whooping crane, West Indian manatee, four whale species (fin, humpback, sei, and sperm), four sea turtle species (green, Kemp's ridley, loggerhead and hawksbill), and four coral species (lobed star, mountainous star, boulder star and elkhorn). The TSP would also have no effect on the following candidate species: Sprague's pipit, and two freshwater mussel species (smooth pimpleback and Texas fawnsfoot). There is no designated critical habitat in the project areas.

6.8.4 Magnuson-Stevens Fishery Conservation and Management Act

The Magnuson-Stevens Fishery Conservation and Management Act (PL 94-265), as amended, establishes procedures for identifying EFH and required interagency coordination to further the conservation of Federally managed fisheries. Its implementing regulations 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 Act and identifies consultation requirements. EFH consists of those habitats necessary for

spawning, breeding, feeding, or growth to maturity of species managed by Regional Fishery Management Councils in a series of Fishery Management Plans.

Submittal of this DIFR-EIS to NMFS initiates EFH consultation. It contains an assessment of impacts on EFH in Section 7.6.2 Essential Fish Habitat Impacts. Direct and indirect impacts associated with construction of the Orange-Jefferson CSRM Plan would result in the loss of about 275.9 acres of estuarine emergent marsh over the period of analysis. Marsh acres include water within the marsh and small drainages; some SAV in the estuarine marsh areas would also be lost. The Cow and Adam Bayous surge gate structures would constrict flows in these bayous while in their normal open condition, resulting in fisheries access impacts on a total of about 2,137 acres of estuarine emergent marsh in the bayou floodplains upstream of the gated structures. Direct and indirect impacts would be fully compensated with the restoration of estuarine emergent marsh and shallow water in the amount determined using the WVA model and the CE/ICA incremental analysis. Conservation measures identified by the NMFS will be considered during this process.

6.8.5 Coastal Zone Management Act

Under the Texas Coastal Management Program (TCMP), enacted under the Coastal Zone Management Act in 1972, the GLO reviews Federal activities to determine whether they are consistent with the policies of the TCMP. USACE has prepared a Consistency Determination that evaluates the TSP for consistency with the TCMP and has concluded that it is fully consistent to the maximum extent practicable with the enforceable policies of the Texas program (Appendix M).

6.8.6 Fish and Wildlife Coordination Act

The Fish and Wildlife Coordination Act provides for consultation with the USFWS and, in Texas, with TPWD whenever the waters or channel of a body of water are modified by a department or agency of the U.S. A Draft Coordination Act Report (CAR) is being prepared by the USFWS; it will be included in the Final IFR-EIS (Appendix K). USFWS and TPWD have participated in numerous impact review meetings and in the WVA modeling. USFWS has provided draft conservation recommendations which have been incorporated into the DIFR-EIS impact evaluations and implementation recommendations discussed in Section 7.0.

6.8.7 Marine Mammal Protection Act of 1972

The Marine Mammal Protection Act was passed in 1972 and amended through 1997. It is intended to conserve and protect marine mammals and establish the Marine Mammal

Commission, the International Dolphin Conservation Program, and a Marine Mammal Health and Stranding Response Program. The TSP would have no effect on marine mammals.

6.8.8 National Historic Preservation Act

Compliance with the National Historic Preservation Act of 1966, as amended (54 U.S.C. § 306108), requires the consideration of effects of the undertaking on all historic properties in the project area and development of mitigation measures for those adversely affected properties in coordination with the SHPO and the Advisory Council on Historic Preservation. It has been determined that there is a potential for new construction, improvements to existing facilities, and maintenance of existing facilities to cause effects on historic properties. Therefore, in accordance with 36 CFR 800.14, USACE will execute a Programmatic Agreement among USACE, the Texas SHPO, and non-Federal implementation sponsors to address the identification and discovery of cultural resources that may occur during the construction and maintenance of proposed or existing facilities. USACE will also invite the ACHP and Native American tribes to participate as signatories to the Programmatic Agreement. A draft of the Programmatic Agreement is provided in Appendix L.

6.8.9 Federal Water Project Recreation Act

This 1995 Act requires consideration of opportunities for outdoor recreation and fish and wildlife enhancement in planning water-resource projects. The TSP is not expected to have any long-term effects on outdoor recreation opportunities in the area.

6.8.10 Farmland Protection Policy Act of 1981 and the CEQ Memorandum Prime and Unique Farmlands

In 1980, the CEQ issued an Environmental Statement Memorandum "Prime and Unique Agricultural Lands" as a supplement to the NEPA procedures. Additionally, the Farmland Protection Policy Act, passed in 1981, requires Federal agencies to evaluate the impacts of Federally funded projects that may convert farmlands to nonagricultural uses and to consider alternative actions that would reduce adverse effects of the conversion. The Orange-Jefferson CSRM Plan would directly impact approximately 178 acres of prime or otherwise important farmlands; no indirect impacts have been identified. Impacts on prime and important farmlands have been minimized to the greatest extent possible. The proposed alignment has been designed to follow the upland/wetland margin to the greatest extent possible. Existing drainage patterns would be maintained, and surrounding land uses would remain compatible with agriculture in so much as they are today. Minor impacts (less than 1 acre) on lands classified as prime farmland would occur with construction of the Freeport and Vicinity CSRM Plan. No practicable alternatives to these impacts exist since the improvements are being made to an existing levee

system. No prime and unique farmlands would be impacted by construction of the Port Arthur CSRM Plan. Based upon the USACE scoring of the relative value of the farmland in these corridor-type sites, no further consideration for protection will be required. This will be confirmed by coordination with NRCS.

6.8.11 Executive Order 11988, Floodplain Management

This Executive Order (EO) directs Federal agencies to evaluate the potential effects of proposed actions on floodplains. Such actions should not be undertaken that directly or indirectly induce growth in the floodplain unless there is no practicable alternative. The Water Resources Council Floodplain Management Guidelines for implementation of EO 11988, as referenced in USACE ER 1165-2-26, require an eight-step process that agencies should carry out as part of their decision making on projects that have potential impacts on or within the floodplain. The eight step assessment, presented later in this report, concludes that all practicable alernatives have been considered in developing the TSP, and that the main Federal objective of reducing coastal flood risk cannot be achieved by alternatives outside the floodplain. The TSP does not support direct or indirect floodplain development within the base floodplain. USACE and the study's NFS have lead public outreach efforts to local communities starting with the NEPA scoping meeting, and will continue throughout the study process.

6.8.12 Executive Order 11990, Protection of Wetlands

This EO directs Federal agencies to avoid undertaking or assisting in new construction located in wetlands, unless no practicable alternative is available. Construction of the Orange-Jefferson CSRM Plan would result in the conversion of about 400 acres of wetlands to a levee system. All practicable measures have been taken to minimize the loss of wetlands. Alternatives to avoid the loss of wetlands were evaluated, and the levee alignment was carefully located to minimize the loss. The alignment will be reviewed to determine if impacts may be minimized further, and these will be presented in the FIFR-EIS. This DIFR-EIS affords the public an opportunity for review prior to completion of the FIFR-EIS and the selection of a TSP. Based on these actions and considerations, it has been determined that the TSP is the only practicable alternative. These impacts will be fully compensated by the mitigation plan so that there will be no net loss of wetlands.

6.8.13 Coastal Barrier Improvement Act of 1990

This act is intended to protect fish and wildlife resources and habitat, prevent loss of human life, and preclude the expenditure of Federal funds that may induce development on coastal barrier islands and adjacent nearshore areas. The Coastal Barrier Improvement Act of 1990 was enacted to reauthorize the Coastal Barrier Resources Act (CBRA) of 1982. The Gulf shoreline area south and west of existing Freeport is designated as unit T05. Improvements to the existing levee

system would be made within the existing levee right-of-way, which is not included in the CBRA unit. CBRA units in the Sabine Region are more than 10 miles south of the project area. No construction would occur within any of the CBRA zone units in the general area of the Sabine and Brazoria TSPs.

6.8.14 Executive Order 12898, Environmental Justice

This EO directs Federal agencies to determine whether the Preferred Alternative would have a disproportionate adverse impact on minority or low-income population groups within the project area. Based on a demographic analysis of of the study area presented in Appendix R and findings of an environmental justice review, the TSP would not have a disproportionately high and adverse impact on any low-income or minority population.

6.8.15 Executive Order 13186, Responsibilities of Federal Agencies to Protect Migratory Birds and the Migratory Bird Treaty Act

The Migratory Birds and the Migratory Bird Treaty Act (MBTA) of 1918 (as amended) extends Federal protection to migratory bird species. Among other activities, nonregulated "take" of migratory birds is prohibited under this Act in a manner similar to the ESA prohibition of "take" of threatened and endangered species. Additionally, EO 13186 "Responsibilities of Federal Agencies to Protect Migratory Birds" requires Federal agencies to assess and consider potential effects of their actions on migratory birds (including, but not limited to, cranes, ducks, geese, shorebirds, hawks, and songbirds). The effect of the TSP on migratory bird species has been assessed, and no impacts are expected on migratory birds or their habitat in the project area. Construction contracts would include instructions to avoid impacts on migratory birds and their nests from construction-related activities.

6.8.16 Executive Order 13045, Protection of Children from Environmental and Safety Risks

This EO requires Federal agencies to make it a high priority to identify and assess environmental health and safety risks that may disproportionately affect children and to ensure that policies, programs, activities, and standards address these risks. This report has evaluated the potential for the TSP to increase these risks to children, and it has been determined that children in the project areas would not likely experience any adverse effects from the proposed project.

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7 ENVIRONMENTAL CONSEQUENCES*

Environmental consequences of the No Action and TSP plans are compared below. Impacts described below apply to all of the optimization heights of the alternatives in the Final Array. The right-of-way was sized to include lands needed to construct a levee or floodwall suitable for at least the Intermediate RSLC scenario plus additional lands needed for construction. A comparison of all factors compared in evaluating the Final Array of Alternatives, including environmental effects, is presented in Section 5.4 of this report.

7.1 PROTECTED LANDS

7.1.1 Orange-Jefferson CSRM Plan

No Action Alternative. State-managed lands in the vicinity would continue to be conserved and managed for the benefit of fish of wildlife resources through the period of analysis. The Tony Houseman WMA is located at northeast end of the Orange-Jefferson CSRM Plan, north and south of Interstate 10. The Lower Neches River WMA includes three separate properties along the central section of the CSRM Plan in Orange County.

FWP Alternative. Construction of the Orange-Jefferson CSRM Plan TSP would impact approximately 4.4 and 43.1 acres, respectively, of TPWD property in the Tony Houseman and Lower Neches River WMAs. Details of these impacts are shown in Table 7-1. In the Tony Houseman WVA, approximately 2.1 of the impacted acres are forested wetlands. In the Lower Neches WMA, approximately 38.7 acres are wetlands, with the majority of impacts occurring on coastal marsh. The wetland impacts have been evaluated and quantified with the WVA model along with the other direct impacts of this plan. Efforts were made to minimize impacts on TPWD property when laying out the alignment for the new levee system. It is possible that the impacts may change as a result of public, technical, and policy review of the proposed alignment. The plan would not impact any TPWD structures. No indirect impacts on TPWD property have been identified.

Table 7-1: Impacts on TPWD Property

	Acres of Impacts				
Property Name	BH	Swamp	Marsh	Other	Total
Tony Houseman WMA	1.0	1.1	0.0	2.3	4.4
Lower Neches River WMA					
Adams Bayou Unit	0.0	3.0	10.6	5.0	
Old River Unit	0.0	0.0	15.7	0.0	
Nelda Stark Unit	6.6	0.0	0.7	1.5	
Subtotal	6.6	3.0	27.0	6.5	43.1
Total	7.6	4.1	27.0	8.8	47.5

7.1.2 Port Arthur and Vicinity CSRM Plan

No Action Alternative. State-managed lands in the vicinity would continue to be conserved and managed for the benefit of fish and wildlife resources through the period of analysis. The Big Hill Unit of the J.D. Murphree WMA is located on the west bank of Taylor Bayou, adjacent to the southwest levee of the existing Port Arthur HFP system.

FWP Condition. No direct or indirect impacts on TPWD property or other protected lands are expected in conjunction with improvements to the Port Arthur TSP.

7.1.3 Freeport and Vicinity CSRM Plan

No Action Alternative. State-managed lands in the vicinity of the Freeport HFP system would continue to be conserved and managed for the benefit of fish and wildlife resources through the period of analysis. The Brazoria NWR and Justin Hurst WMA are located near the east and west boundaries, respectively, of the existing Freeport HFP system. These lands would continue to be managed for conservation and the benefit of fish of wildlife resources through the period of analysis.

FWP Alternative. No direct or indirect impacts on USFWS or TPWD property are expected in conjunction with improvements to the Port Arthur TSP.

7.2 PHYSICAL AND HYDROLOGICAL CHARACTERISTICS

7.2.1 Orange-Jefferson CSRM Plan

No Action Alternative. The existing Sabine-Neches Waterway (SNWW) 40-foot deep-draft navigation channel passes through the study area, following the Orange-Jefferson County line.

Deepening of the existing channel to -48 feet MLLW was authorized by the Water Resources Reform and Development Act (WRRDA) of 2014. Deepening the channel would allow the saltwater wedge in the deep draft navigation channel to reach further inland and increase salinity in the lower Neches and Sabine River channels, as well as Sabine Lake (USACE 2011). Since construction of the deeper channel is likely in the foreseeable future, projected FWP salinities from the SNWW feasibility study have been utilized as the FWOP salinities for impact evaluation in this study.

Future rates of freshwater inflow and RSLC are likely to result in significant changes in the FWOP condition for the study area (National Research Council [NRC], 1987; Intergovernmental Panel on Climate Change [IPCC], 2013; Milliken et al., 2008a). FWOP forecasts of salinity, marsh loss, and related impacts on plant and animal communities in the study area are important in establishing the baseline condition against which FWP impacts are measured. Project impacts and costs have been assessed against 50-year projections of the three potential rates of RSLC calculated for Sabine Pass, TX (Low – 0.93 foot; Intermediate – 1.49 feet; and High – 3.26 feet).

The high, generally flat terrace between the Sabine and Neches Rivers is on average 10 feet higher than the surrounding floodplains of the two rivers. Similarly, on the west bank of the Neches River, the flat coastal plain averages 10 to 15 feet higher than the floodplain. Extensive marshes line the Neches River floodplain on both sides of the river; however, the majority occur on the east side in Orange County. On the Sabine River, extensive marshes extend east from the river into Louisiana. In Texas, the narrow floodplains of Cow and Adams Bayous are lined with narrow fringes of forested wetlands, which give way to large marshes where they reach the Sabine River. These are the largest drainages in the Orange County area and are nearly the only drainages flowing east into the Sabine River. The western edge of the Orange County upland is drained by numerous, evenly spaced, small drainages, which cut from the upland to the large marshes in the Neches River floodplain. A few even smaller drainages flow into the Neches floodplain from the Jefferson County side. A map of the Sabine regions drainages and sub-basins is shown in Figure 7-1.

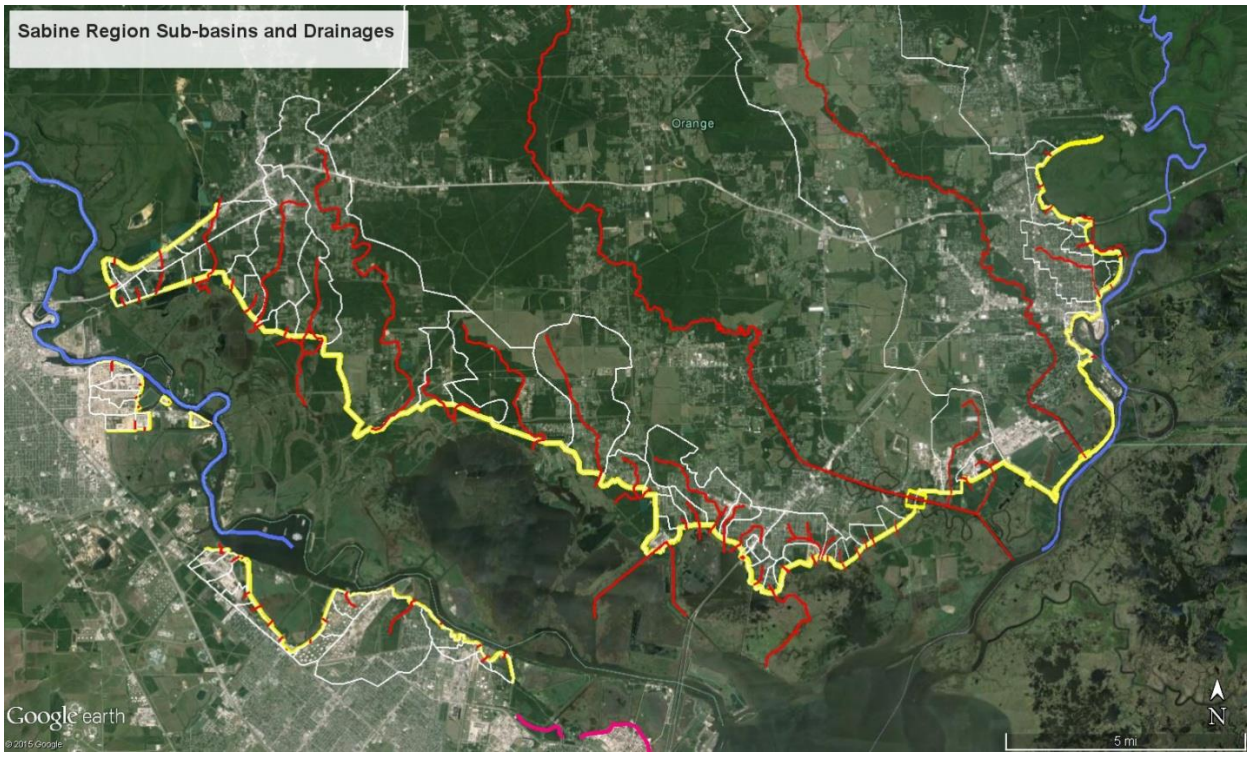

Figure 7-1: Sabine Regions Sub-basins and Drainages

In the existing condition, freshwater inflows from the upland areas to marshes and forested wetlands in the floodplain are being conveyed primarily though existing stream channels. The majority of the time, flows are directed toward channels and ditches that discharge into the floodplain through existing drainages. Water flows into the Sabine and Neches Rivers through channels with incised beds, and in some cases flows spread out directly into wetland areas. Overland sheet flow is generally temporary, occurring during intense or long duration rain events. The degree to which shallow groundwater aquifers may contribute flows to the floodplain is unknown, but groundwater flows are assumed to be a minor contributor. It is believed that marshes in the floodplain rely primarily on rainfall and tidal push for inundation.

The relatively high difference in elevation between the floodplain and the uplands will protect most of the developed upland areas from the effects of RSLC for the period of analysis. However, the larger tidal prism and higher water elevations will result in higher water levels in the large and small drainages, which cut from the uplands to the river valleys. Marshes may migrate further inland along these drainages as a result of the higher RSLC conditions.

FWP Alternative. Construction of the Orange-Jefferson CSRM Plan TSP would result in a new levee system around the southern upland floodplain margin of Orange County, and a similar system along lower-lying sections of the upland floodplain margin along the southern bank of the

Neches River in Jefferson County. Such a system could potentially affect freshwater inflows to the floodplain downstream of the levee system by blocking or redirecting flows, and by inhibiting tidal flows into marshes located upstream of the levee system. The design of the levee system would minimize these impacts to the greatest extent possible through the inclusion of an extensive culvert system that would allow flows through the levee at essentially FWOP conditions.

7.2.1.1 Design Accommodations to Minimize Impacts

Gated culverts would be placed everywhere the red drainage lines intersect the yellow levee alignment shown in Figure 7-1. Sluice gate culverts are planned for use everywhere there are tidal flows; flap gate culverts may be utilized in upstream areas above tidal influence. The levee alignment, drainage basins and proposed culvert locations were evaluated in detail using aerial images to check for smaller, secondary drainages where culverts would also be needed to maintain flows to adjacent wetlands. Approximately 13 new culverts, recommended as a result of this analysis, have been incorporated into the project design where additional connectivity appeared to be needed.

Culverts have been designed to maintain existing flows for a 100-year rainfall event, with an additional 10 percent to account for the predicted increase in rainfall due to climate change over the period of analysis. The sluice gates would remain open except when surge protection is needed; they would be closed temporarily for a short period before and after a storm occurs. Flap gate culverts would provide for one-way flow downstream from the levee system. Both culvert types will be designed with longer spans and lower heights than would typically be used in an attempt to replicate the natural drainage profile.

In the existing condition, freshwater inflows from the upland areas to marshes and forested wetlands in the floodplain are being conveyed primarily though existing stream channels. The majority of the time, flows are directed toward channels and ditches that discharge into the floodplain through existing drainages. A channel would be constructed along the inside of the levee system to collect flows and direct them into the existing stream channels, replicating the flow pattern of the majority of flows entering the floodplain. Impacts from overland flows are expected to be minimal because these flows are minor and temporary.

During a surge event, the sluice gates would be closed; pumps would be used to pump rainfall runoff from the interior to the exterior. The pumps are being conservatively sized to avoid floodplain impacts on the interior of the levee system, and to allow overbank flooding in the streams in the floodplain outside of the levee during high flow events. Hydrologic flows in the

FWP condition would thus be very similar to FWOP flows in location, duration, and magnitude, both inside and outside of the levee system.

Based on these assumptions, it was determined that the levee would have negligible impacts on the general hydrology of the floodplain both inside and outside of the levee system. Because this determination rests heavily on these assumptions, resource agencies have requested to be involved in the development of Operating Manuals during the PED Phase and during subsequent periodic reviews when operating plans are reevaluated to determine project performance under future conditions, including potentially higher than anticipated rates of RSLC. In addition, the monitoring and adaptive management plan for this project must include periodic monitoring of the extent and quality of wetlands in the floodplain to determine if the assumptions regarding freshwater flows appear valid.

The potential for hydrologic impacts of proposed surge gates on Adams and Cow Bayous was evaluated using ERDC's DOWSMM desktop hydrologic model. This modeling indicates negligible impacts on the water surface elevation and salinity within Adams and Cow Bayous from potential constrictions to the channel cross-section with the proposed surge gates in their normal open condition. This was determined by a sensitivity analysis conducted on the inlet size for each bayou, based on the assumption that construction of the gates would result in some reduction of the cross-section while open to daily flows. In the analysis, bayou cross-sections were reduced by a wide range of estimated parameters, up to a maximum 75 percent constriction. It was determined that the limited tidal prism associated with the bayous results in minimal energy loss across the connection between the bayous and the Sabine River, and therefore, constriction of this access point results in little change in the tidal energy passing into the bayou. The insensitivity of the water surface elevation and the salinity impacts gives high confidence that the general conclusion associated with this study is robust; constriction of the inlet, even significant constriction, results in minimal impacts on water surface elevation and salinity within the bayous.

The extent to which these constrictions would impound stormwater within the bayous was also examined by evaluating the effects of a significant rainfall event (Tropical Storm Allison) that had been captured in the median flow simulation. Once again, this analysis applies to the normal, open condition of the gate and evaluated the impacts of rainfall not associated with a significant storm surge event. Given the type of structures currently being evaluated (sector gates on the navigation channels with one or more flanking vertical lift gates to maintain flows on one or both sides of the navigation gates), it is estimated that existing flows may be reduced by a maximum of 50 percent. The DOWSMM analysis showed that, even for a 50 percent constriction, the volume of water resulting from such a storm could still pass through the

constriction with little impact on upstream stage. There was no attempt made to determine if this storm event represented a project flood, and hence a larger storm could have a more significant impact.

Impacts related to the temporary closure of the gates were also considered to determine whether fisheries migration would be impacted with short-term surge-related gate closures. The degree of impact would be influenced by the timing and duration of a structure closure relative to peak migration seasons. However, given the predicted return interval of 10 to 15 years for storm surges high enough to threaten the areas targeted for protection by this study (which are generally 7 to 10 feet higher than the structure locations), interruption of fishery migrations would be rare. In addition, it is not anticipated that the gates, once closed, would remain closed for an extended period. The operating plan for the gates has not yet been developed, but even a worst-case estimate of closure time (5 to 7 days every 10 to 15 years) would result in only minor and temporary impacts on fisheries access. The project design includes a pump system that would significantly reduce the flood duration upstream of the structures after the gates have been closed to protect against storm surge impacts. It must be noted, however, that should the final structure design reduce the cross section by more than 50 percent, additional modeling and environmental analysis would be needed to more thoroughly characterize potential hydrologic impacts of the gate structures.

7.2.1.2 Unavoidable Indirect Impacts

Despite all efforts to minimize impacts, some indirect impacts of the Orange-Jefferson CSRM Plan remain. These are related to fisheries access impacts on the extensive marshes in the lower Cow and Adams Bayous floodplains from the Cow and Adams Bayou surge gate structures, and to localized hydrologic impacts caused by location and construction of the parts of the system.

Based on all of the above analyses and assumptions, it appears that the only significant impact of the Cow and Adam Bayous surge gate structures would be fisheries access impacts associated with the day-to-day operation in the open condition. The fisheries impacts are discussed in detail in the section on fish and wildlife impacts below. For the historic RSLC scenario, indirect impacts on swamps and bottomland forests upstream of the gated structures are expected to be negligible because changes in water surface elevation and salinity are expected to be negligible (USACE 2015). Therefore, no WVA impact modeling was needed for the Adams and Cow Bayous forested wetlands.

A few localized indirect hydrologic impacts remaining after minimization efforts were also identified. An analysis of the location of the levee system alignment identified small areas that would be impounded between the new levee and terrace bluff. These impoundments would

result in the loss of small stands of swamp and bottomland hardwood. Construction of the Cow Bayou gate structure and levee system would indirectly affect a few areas both inside and outside the levee system by permanently disrupting tidal connections. Tidal access to one bottomland hardwood area outside of the levee would also be permanently disrupted by levee construction activities. Indirect impacts in the vicinity of the Cow Bayou structure could be higher under the Intermediate and High RSLC, as wetlands could have persisted and migrated further inland in without the hydrologic disruptions caused by gate construction. Modifications to reduce these impacts will be explored during final feasibility planning. Specific information on these losses is provided in the Coastal Marsh and Forested Wetland impact sections below.

The indirect wetland impacts described above have been captured and quantified with WVA modeling that is described in detail in Appendix O. Impacts calculated for the Intermediate RSLC condition will be utilized to determine compensatory mitigation.

7.2.2 Port Arthur and Vicinity CSRM Plan

No Action Alternative. The area protected by the Port Arthur HFP System TSP is densely covered with residential, commercial, and industrial development with a few isolated wetland areas. Drainages flow primarily in the Neches River to the north, the Sabine-Neches Canal to the east, and Taylor Bayou to the west. The configuration of the HFP would continue to be maintained at the existing dimensions. Higher water levels associated with Intermediate and High RSLC could result in overtopping during future storm surges.

FWP Alternative. The Port Arthur CSRM Plan improvements would not result in physical impacts on the floodplain or hydrology; no changes in the general layout of the right-of-way are planned. Interior drainage will be managed in the same manner as the Orange-Jefferson CSRM Plan, such that improvements would have negligible impacts on the general hydrology of the floodplain both inside and outside of the levee system. No impacts on the large marsh systems west of the existing Port Arthur HFP system are expected.

7.2.3 Freeport and Vicinity CSRM Plan

No Action Alternative. The existing Freeport Harbor Project (FHP) 45-foot deep-draft navigation channel extends from deep water in the Gulf of Mexico into the south-central area of the existing Freeport HFP system. Freeport Harbor is located on the Old Brazos River Channel, which dead-ends near State Highway 288. The waterway is heavily developed with industrial and commercial properties, including petrochemical manufacturing and storage terminals, warehousing, and related businesses. Deepening of the existing channel to 56 feet MLLW was authorized by the Water Resources Reform and Development Act (WRRDA) of 2014.

Deepening the channel is not expected to have significant effects on salinity or circulation since proximity to the Gulf and lack of freshwater inflows make salinities in the channel very high.

Future rates of freshwater inflow and RSLC are likely to result in significant changes in the FWOP condition for the study area (National Research Council [NRC], 1987; Intergovernmental Panel on Climate Change [IPCC], 2013; Milliken et al., 2008a). FWOP forecasts of salinity, marsh loss, and related impacts on plant and animal communities in the study area are important in establishing the baseline condition against which FWP impacts are measured. Project impacts and costs have been assessed against 50-year projections of the three potential rates of RSLC calculated for Sabine Pass, TX (Low – 0.71 feet; Intermediate – 1.11 feet; and High – 2.4 feet).

The area within the Freeport HFP system is dense industrial and commercial development, with small residential areas. No natural wetlands are present in the majority of this area; however, marsh and forested wetlands are present in areas adjacent to Oyster Creek on the northeastern side of the system. Existing interior drainage systems have maintained sufficient flows to allow these areas to persist despite their location within the levee system.

FWP Alternative. The Freeport CSRM Plan would replace floodwalls, raise levees, and install resiliency features. With the exception of about 3,500 feet in the upper Oyster Creek area, these improvements would be made within the existing project right-of-way and thus will have little impact on physical characteristics of the system. Additional right-of-way required in the Oyster Creek area would be less than 1 acre and would not extend into nearby waterways. A surge gate structure, similar to those proposed for Cow and Adams Bayous in the Sabine region, is proposed for the DOW Barge Canal. This is a man-made, dead-end, industrial canal lying in the center of the existing Freeport HFP system; no wetlands lie along the canal. The gate would normally remain open, being closed for short periods before and after expected storm surges. Construction of the gate would result in some degree of flow constriction, but effects on salinity and water surface elevation would be low because of the limited tidal prism associated with the canal.

7.3 COASTAL PRAIRIE

7.3.1 Sabine Region CSRM Plans

The Orange-Jefferson and Port Arthur and Vicinity CSRM Plans are combined for this impact evaluation.

No Action Alternative. No remnant tracts of native tall grass or salty prairies have been identified in the Sabine region project areas.

FWP Alternative. TSP improvements would be contained within the existing right-of-way; no impacts on coastal prairie are anticipated.

7.3.2 Freeport and Vicinity CSRM Plan

No Action Alternative. Coastal prairie would continue to be critically imperiled in the Brazoria region. No remnant tracts of native tall grass or salty prairies have been identified in the study area. The nearest known prairie restoration sites are located in the Brazoria and San Bernard NWRs, located east and west of the Brazoria study area.

FWP Alternative. TSP improvements would be contained within the existing right-of-way with the exception of one small area near Oyster Creek. No coastal prairie is present in the minor right-of-way expansion.

7.4 COASTAL MARSH

7.4.1 Orange-Jefferson CSRM Plan

No Action Alternative. Tens of thousands of acres of coastal marsh are present in the study area, located primarily in the floodplains of the Sabine and Neches River, as well as Cow and Adams Bayous. These marshes would be expected to persist, with some areas undergoing slow wetland loss and conversion to open water over the period of analysis. In the lower Neches River Valley, this conversion is caused by subsidence and faulting (sometimes related to oil and gas production), dredged canals, alteration of hydrologic regime (due to channelization and placement of dredged material), decreased input of fluvial sediment (due to upstream dams), and construction of artificial levees (White and Tremblay 1995). Similar factors are responsible for marsh loss in the Sabine River Basin. Recent wetland loss rates (1984-2014) have been calculated by USGS for 12 subunits of the study area by analyzing multiple dates of cloud-free Landsat imagery from 1984-2014 (USGS 2014). The loss rates range from a low of 0.0052 percent per year in the Bessie Heights area on the Neches River, to a high of 0.0982 percent per year in the Old River Cove area along the north shore of Sabine Lake. These rates would be expected to increase under the Intermediate and High RSLC scenarios. This expectation is based on the negative relationship between RSLC and wetland loss rates that has been observed in coastwide non-fresh marshes outside of active deltaic influences in Louisiana (USACE 2013).

FWP Alternative. Direct impacts from construction the approximately 39-mile-long TSP levee system in Orange and Jefferson Counties would result in the loss of about 173.3 acres of coastal marsh (fresh – 50.4 acres; intermediate – 11.9 acres; brackish – 111.0 acres) and 86.9 AAHUs. The right-of-way was sized to include lands needed to construct a levee or floodwall suitable for

the Intermediate RSLC scenario plus additional lands needed for construction, and it was assumed that all wetlands within the right-of-way would be permanently lost due to construction. The plan currently calls for all earthen material for the levee system to be obtained from commercial borrow sources. If new borrow areas are identified during final feasibility planning or prior to construction, these areas will be evaluated for impacts in coordination with the resource agencies and the appropriate NEPA document will be prepared. Staging areas needed to support construction would be located in previously disturbed or non-wetland upland areas.

Construction of the new levee system would also result in some indirect impacts resulting in the loss of marsh. A careful examination of the proposed alignment identified several areas where marsh would be impounded between the levee or floodwall and the upland bluff, or where hydrologic connections would be permanently disrupted by levee system construction. These indirect impacts would result in the loss of about 100.9 acres of brackish marsh and 44.3 AAHUs. During final feasibility planning, the plan will be reevaluated to determine if these impacts can be reduced.

The direct and indirect coastal marsh impacts described above have been illustrated, captured, and quantified with WVA modeling that is described in detail in Appendix O. Impacts calculated for the Intermediate RSLC condition will be utilized to determine compensatory mitigation.

7.4.2 Port Arthur and Vicinity CSRM Plan

No Action Alternative. Fresh and intermediate wetlands are located within the existing levee system, with the majority clustered in a low-lying central area. Some wetlands are located along the exterior perimeter of the levee system, along the Neches River and Taylor Bayou. The floodplain marshes are experiencing wetland loss rates similar to marshes in Orange County, but would be expected to persist through the period of analysis.

FWP Alternative. TSP improvements from the Port Arthur CSRM Plan would result in no impacts on coastal marsh. All construction activities would be confined to the existing right-of-way or immediately adjacent industrial areas.

7.4.3 Freeport and Vicinity CSRM Plan

No Action Alternative. No natural wetlands are present in the majority of the area protected by the existing Freeport HFP system; however, marsh and forested wetlands are present in areas adjacent to Oyster Creek on the northeastern side of the system. These areas would be expected to persist through the period of analysis.

FWP Alternative. No coastal marsh would be impacted by construction of the Freeport CSRM Plan. About 1 acre outside of the existing right-of-way adjacent to 3,500 feet of the Oyster Creek levee reconstruction area would be affected; no wetlands are present in this area. Other TSP improvements would be made within the existing project right-of-way and thus will have no impact on coastal marsh. BMPs would be utilized to ensure no inadvertent filling of adjacent marsh areas during construction.

7.5 FORESTED WETLANDS

7.5.1 Orange-Jefferson CSRM Plan

No Action Alternative. Thousands of acres of forested wetlands are present in the study area, located primarily in the upper floodplains of the Sabine and Neches River, and along Cow and Adams Bayous. Isolated stands of bottomland hardwoods are also scattered across the undeveloped interior of Orange County. Swamps would be subject to increasing stress due to salinity increases associated with RSLC. It is expected that some of the forested wetlands would be lost to development over the period of analysis. Generally, development activities are regulated under Section 404 of the Clean Water Act, and these losses would likely be replaced by required compensatory mitigation. Other unregulated losses would also be expected, especially in relation to silviculture and borrow area activities that are expected to continue in the study area. Depending upon specific circumstances, these activities may not be regulated and forested wetland losses would not be replaced.

FWP Alternative. Direct impacts during construction of the new levee system would result in the loss of about 127.2 acres of forested wetland (swamp –18.9 acres; bottomland hardwood – 108.3 acres), resulting in the loss of 74.9 AAHUs. The right-of-way was sized to include lands need to construct a levee or floodwall suitable for the Intermediate RSLC scenario plus additional lands needed for construction, and it was assumed that all wetlands within the right-of-way would be permanently lost due to construction.

Construction of the new levee system would also result in some indirect forested wetland impacts. Approximately 12.7 acres of swamp and bottomland hardwoods would be impounded between the levee or floodwall and the upland bluff, or would be adversely affected by disrupted tidal access. These impacts are expected to result in the eventual loss of the forested wetlands, represented by a loss of 5.2 AAHUs. During final feasibility planning, the plan will be reevaluated to determine if these impacts can be reduced.

The direct and indirect coastal marsh impacts described above have been captured and quantified with WVA modeling that is described in detail in Appendix O. Impacts calculated for the Intermediate RSLC condition will be utilized to determine compensatory mitigation.

7.5.2 Port Arthur and Vicinity CSRM Plan

No Action Alternative. Small pockets of forested wetlands (primarily bottomland hardwoods) are scattered through the less densely developed areas within the levee system. A few small bottomland hardwood areas are located adjacent to the levees along the Neches River. It is expected that some of the forested wetlands would be lost to development over the period of analysis. Generally, development activities are regulated under Section 404 of the Clean Water Act, and these losses would likely be replaced by required compensatory mitigation.

FWP Alternative. TSP improvements would result in no impacts on forested wetlands. All construction activities would be confined to the existing right-of-way or immediately adjacent industrial areas.

7.5.3 Freeport and Vicinity CSRM Plan

No Action Alternative. Small pockets of forested wetlands (primarily bottomland hardwoods) are scattered through the less densely developed areas within the levee system. The greatest concentration is scattered along the levees adjacent to Oyster Creek. It is expected that some of the forested wetlands would be lost to development over the period of analysis. Generally, development activities are regulated under Section 404 of the Clean Water Act, and these losses would likely be replaced by required compensatory mitigation.

FWP Alternative. Construction of the Freeport CSRM plan may result in the removal of a few trees and scrub/shrub along the inside of about 3 miles of the existing levee system right-of-way on Oyster Creek as shown in Figure 7-2. Only a small amount of additional right-of-way, about 10 feet, is expected to be required. The impact area is not identified as a wetland in the National Wetland Inventory. This impact is considered negligible since it does not affect forested wetland habitat, the amount of trees affected would be small, and thousands of acres of similar natural habitat would remain in the general area. Other TSP improvements would be made within the existing project right-of-way and thus will have no impact on forested wetlands. Best management practices would be utilized to ensure no inadvertent impacts on adjacent wetland forests during construction.

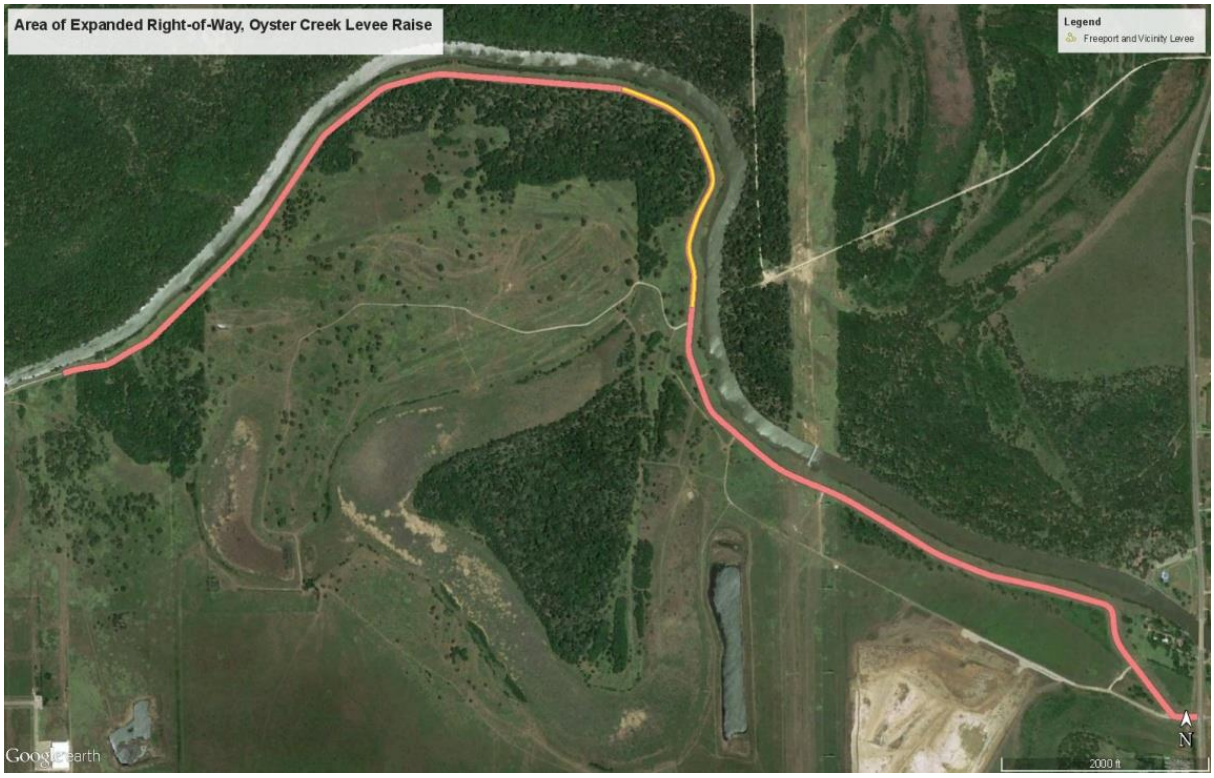

Figure 7-2: Area of Expanded Right-of-Way, Oyster Creek

7.6 IMPACTS TO FISH AND WILDLIFE AND THEIR HABITATS

7.6.1 Fish and Wildlife Impacts

7.6.1.1 Sabine Region CSRM Plans

The Orange-Jefferson and Port Arthur and Vicinity CSRM Plans are combined for this impact evaluation.

No Action Alternative. Natural habitats within the Orange-Jefferson CSRM Plan construction right-of-way would continue to provide cover, roosting, foraging, and nesting habitat for fish and wildlife during the period of analysis. Some marsh may convert to open water in the Sabine and Neches River floodplains, but most of the wetland habitats would persist even under the High RSLC Scenario. In Orange County on the Sabine River and in the vicinity of Bridge City, the majority of the upland/floodplain transition in the area considered for the new levee alignment is lined by development or placement areas. Between Bridge City and Rose City, most of the upland/floodplain transition is undeveloped.

In Jefferson County, the transition from the uplands to the Neches floodplain in the area affected by the CSRM plan is lined with continuous urban or industrial development. Wildlife accesses

the floodplain using narrow corridors through development or crossing over leveed placement areas, in addition to passing through natural areas. Fishery access is unobstructed in most streams and bayous. Fish and wildlife access is unobstructed across the levees of the existing Port Arthur HFP levee system, on the northeast and southwest sides of the system. The right-of-way of the existing system is maintained as cleared, grassy levee with sideslopes, and as floodwall systems. Existing culverts are open in their normal, operating condition; they are closed for short periods before and after storm surge events.

FWP Alternative. Direct impacts of construction of the Orange-Jefferson CSRM Plan would result in the destruction of approximately 300.5 acres of natural fish and wildlife habitat; indirect impacts described above would result in the loss of appeoximately 128.5 acres of forested wetlands and marsh. No direct or indirect impacts on fish and wildlife habitat would be expected from construction of the Port Arthur and Vicinity CSRM Plan. This is a small fraction of the tens of thousands of acres of fish and wildlife habitat present in the study. During construction, fish and wildlife would be able to move out of construction corridors into adjacent habitat and avoid harm. BMPs would be enforced to prevent fill material from entering nearby wetlands or waters. Forest clearing during construction would be conducted during the fall or winter to minimize impacts on nesting migratory birds, when practicable. Forested areas in the construction right-of-way would be surveyed prior to construction to avoid impacting nesting bald eagles. Terrestrial wildlife would be able to cross-earthen levee segments to access remaining habitat on either side, as it does now across the levees of the Port Arthur HFP. Floodwall segments would generally be located in developed areas and limited in length; wildlife would be able to utilize nearby levee segments for access as needed. Fisheries access would be maintained at FWOP levels as described in the physical and hydrological impacts section.

The Cow and Adam Bayous surge gate structures would result in fisheries access impacts on extensive marshes in the bayou floodplains upstream of the gated structures (Figures 7-3 and 7-4) from day-to-day operation in the open condition. These impacts could be expected to affect approximately 1,300 and 900 acres of coastal marsh in the Cow and Adams Bayou floodplains, respectively, resulting in the loss of 50.5 AAHUs over the period of analysis. The upstream limit of the affected areas, defined to include all upstream marshes in the bayou floodplains, is approximately 7.7 stream miles upstream of the Cow Bayou structure and 4.4 stream miles upstream of the Adams Bayou structure.

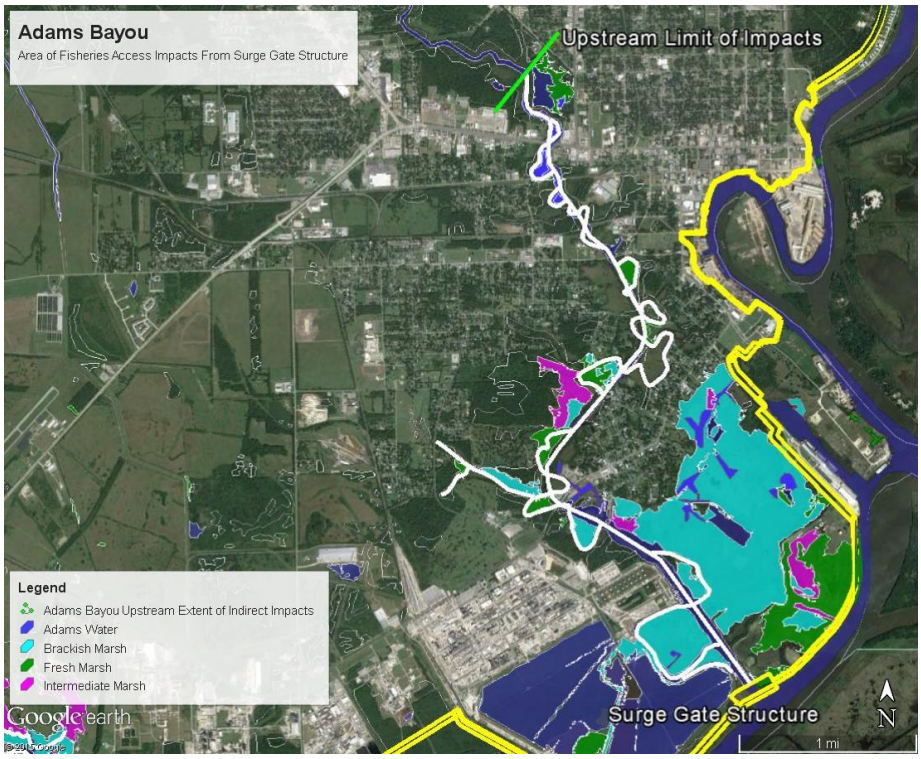

Figure 7-3: Adams Bayou Indirect Fisheries Impact of Surge Gate Structure

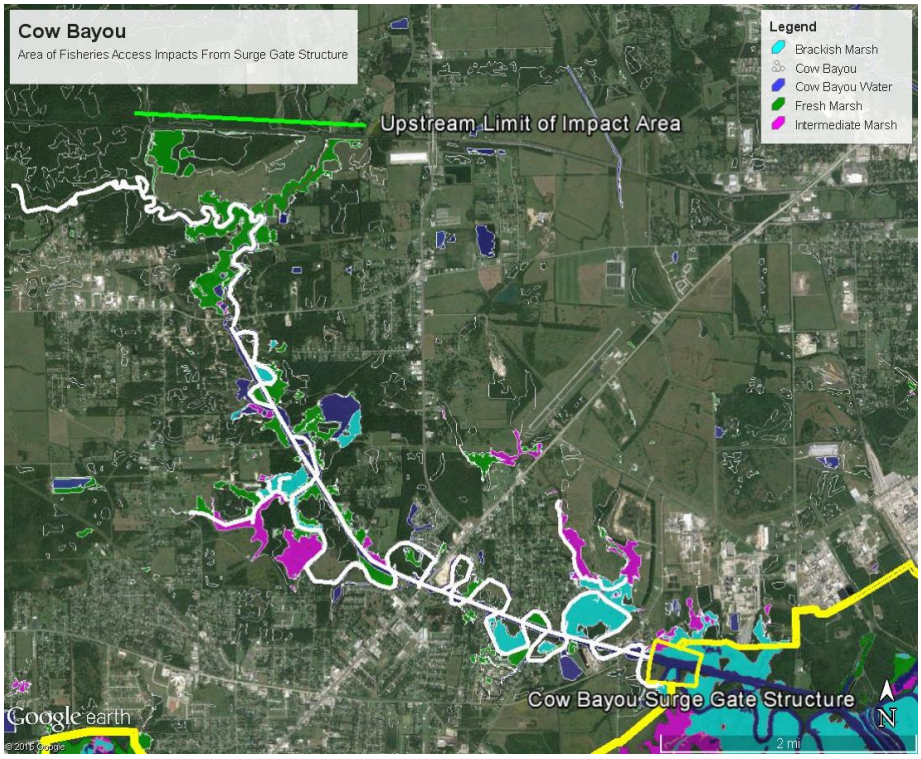

Figure 7-4: Cow Bayou Indirect Fisheries Impact of Surge Gate Structure

According to the NMFS (2008), the ability of estuarine dependent marine fishery organisms to migrate to and from coastal habitats decreases as structural restrictions increase, thereby reducing fishery production (Hartman et al. 1987; Rogers et al. 1992; Rozas and Minello 1999). The physical ability (i.e., swimming speed) to navigate through a structure is not the only factor influencing fish passage. Both behavioral and physical responses govern migration and affect passage of fishery organisms through structures. These responses may vary by species and life stage. In addition, most marine fishery species are relatively planktonic in early life stages and are dependent on tidal movement to access coastal marsh nursery areas. For this reason, in general, the greater the flow through a structure into a hydrologically affected wetland area, the greater the marine fishery production functions provided by that area. It should not be assumed that structures that have been determined to provide sufficient drainage capacity also optimize or provide adequate fishery passage. More investigation is warranted to refine and adaptively manage water control structure design and operations to minimize adverse impacts on fishery passage. Structures constructed along the sides of Cow and Adams Bayou would interfere with organism movement into and out of the bayou, but this impact could be minimized by following specific NMFS design recommendations.

Since only preliminary information on the Cow and Adams gate structures is available at this time, the WVA indirect impacts analysis assumed that the structures would reduce the cross-sectional area of the inlets by 50 percent. Final structural designs will incorporate fisheries-friendly considerations recommended by NOAA (2008) to the greatest extent possible. If it is determined that the final feasibility design would reduce the cross-sectional area of the bayou inlets by more than 50 percent, impacts will be reevaluated and reported in the FIFR-EIS.
The direct and indirect coastal marsh impacts described above have been captured and quantified with WVA modeling that is described in detail in Appendix O.

7.6.1.2 Freeport and Vicinity CSRM Plan

No Action Alternative. The right-of-way of the existing Freeport HFP system is maintained as cleared, grassy levee and sideslope areas, and as floodwall systems. Natural habitats adjacent to the construction right-of-way would continue to provide to provide cover, roosting, foraging, and nesting habitat for fish and wildlife during the period of analysis. The exterior levees follow Oyster Creek on the east and the Brazos River Diversion Channel on the west. Wildlife access is unobstructed across the levees along these levee segments.

FWP Alternative. With the exception of the less than 1 acre of right-of-way expansion on Oyster Creek, Freeport and Vicinity CSRM Plan improvements would be accomplished within the existing right-of-way. During construction, fish and wildlife would be able to move out of construction corridors into adjacent habitat and avoid harm. BMPs would be enforced to prevent

fill material from entering nearby wetlands or waters. Forest clearing during construction would be conducted during the fall or winter to minimize impacts on nesting migratory birds, when practicable. Terrestrial wildlife would be able to cross-earthen levee segments to access remaining habitat on either side. Floodwall segments would generally be located in developed areas and limited in length; wildlife would be able to utilize nearby levee segments for access as needed. There is little potential for bald eagle nests in the vicinity of the levee system because of the low quality and size of forested wetlands in the area.

7.6.2 Essential Fish Habitat Impacts

7.6.2.1 Sabine Region CSRM Plans

The Orange-Jefferson and Port Arthur and Vicinity CSRM Plans are combined for this impact evaluation because EFH conditions and impacts are similar.

No Action Alternative. Estuarine habitats in the study area (estuarine emergent marsh, estuarine submerged aquatic vegetation, estuarine hard bottom, and estuarine mud/soft bottoms) would continue to be open and available for use by fish and shellfish through the period of analysis. Shallow open water estuarine areas are likely to increase and estuarine emergent marsh is likely to decrease as a result of RSLC.

FWP Alternatives. This DIFR-EIS initiates EFH consultation for the TSP under the Magnuson-Stevens Fishery Conservation and Management Act. Direct and indirect impacts associated with construction of the Orange-Jefferson CSRM Plan would result in the loss of about 275.9 acres of estuarine emergent marsh over the period of analysis. Marsh acres include water within the marsh and small drainages; some SAV in the estuarine marsh areas would also be lost. These acres would be replaced by in-kind mitigation in the amount determined using the WVA model and the CE/ICA incremental analysis; all impacts would be fully compensated with the restoration of estuarine emergent marsh and shallow water.

Construction of the Cow and Adams Bayous surge gates would result in the loss of approximately 11 acres of estuarine soft bottom EFH. This is the area estimated for the footings of the gate structures. The structures themselves would provide artificial hardbottom habitat in the same area, increasing the diversity of EFH bottom types in the area. The net long-term loss to EFH bottom habitat from the Cow and Adams gate structures would therefore be negligible.

Construction would result in the temporary burial of benthic organisms and temporary increases in water column turbidity in the vicinity of the Cow and Adams Bayous gates. Recovery of benthic macroinvertebrates following burial is typically rapid (recovering within months rather

than years) (VanDerWal et al., 2011; Wilber et al., 2006; Wilber and Clarke, 2001), and consequently no long-term effects are expected. The displacement of finfish and shrimp species (including estuarine dependent organisms that serve as prey for Federally managed species) during levee system construction would be temporary and individuals should move back into these specific areas once the project is completed.

The Cow and Adam Bayous surge gate structures would constrict flows in these bayous while in their normal open condition, resulting in fisheries access impacts on a total of about 2,137 acres of estuarine emergent marsh in the bayou floodplains upstream of the gated structures. These impacts could be expected to affect approximately 1,235 and 902 acres of coastal marsh in the Cow and Adams Bayou floodplains, respectively, resulting in the loss of 50.5 AAHUs over the period of analysis. The functional loss to these marsh systems would be replaced by marsh restoration in the amount determined using the WVA model and the CE/ICA incremental analysis; all impacts would be fully compensated with the restoration of estuarine emergent marsh and shallow water.

No impacts on EFH are expected from the Port Arthur CSRM Plan. In most areas, construction would take place within the existing right-of-way and from barges in adjacent waterways. No improvements are proposed in the vicinity of the two gates along Taylor Bayou on the southwest side of the system.

7.6.2.2 Freeport and Vicinity CSRM Plan

No Action Alternative. Estuarine habitats in the study area (estuarine emergent marsh, estuarine submerged aquatic vegetation, estuarine hardbottom, and estuarine mud/soft bottoms) would continue to be open and available for use by fish and shellfish through the period of analysis. Shallow open water estuarine areas are likely to increase and estuarine emergent marsh is likely to decrease as a result of RSLC.

FWP Alternative. EFH would not be significantly affected by construction of the Freeport CSRM Plan. Construction of a surge gate at the mouth of the DOW Barge Canal would permanently affect up to 3 acres of soft bottom. However, there is no estuarine emergent marsh or other natural habitat lining the canal, tidal energy and flushing is low, water quality is poor, and the canal provides little benefit to shell or finfish that may enter it. Therefore, impacts on EFH would be negligible. The displacement of finfish and shrimp species (including estuarine dependent organisms that serve as prey for Federally managed species) during gate construction would likely be temporary and individuals should move back into these specific areas once the project is completed. The potential harm to some individual finfish and shellfish from temporary

turbidity-related impacts would be minimal and would not reduce any populations of Federally managed species or their prey.

7.6.3 Threatened and Endangered Species Impacts

This evaluation was combined for the Sabine and Brazoria regions, as listed species are generally the same for both.

No Action Alternative. Hopper dredging at the SNWW and Freeport Entrance Channels would continue with potential for takes of threatened and endangered green, Kemp's ridley, loggerhead, and hawksbill sea turtles. These potential impacts are addressed in the November 19, 2003, Gulf Regional Biological Opinion (GRBO) to USACE on Hopper Dredging of Navigation Channels and Borrow Areas in the U.S. Gulf of Mexico, and Revision 2 to the GRBO, issued January 9, 2007, for USACE dredging projects on the Gulf Coast. Existing threats to the twelve remaining listed and three candidate species described below would be expected to be minor, as most of the species rarely occur, and some do not occur, in the project areas.

FWP Alternative. The Orange-Jefferson CSRM Plan and the Port Arthur and Freeport and Vicinities CSRM Plans would have no effect on the following listed animal species: piping plover, red knot, whooping crane, the West Indian manatee, four whale species (fin, humpback, sei, and sperm), four sea turtle species (green, Kemp's ridley, loggerhead, and hawksbill), and four coral species (lobed star, mountainous star, boulder star, and elkhorn). The CSRM plans would also have no effect on the following Candidate species: Sprague's pipit, and two freshwater mussel species (smooth pimpleback and Texas fawnsfoot). No critical habitat is located in the project areas. The details of this assessment may be found in the USACE Biological Assessment (Appendix J).

7.7 WATER AND SEDIMENT QUALITY IMPACTS

7.7.1 No Action Alternative for All CSRM Plans

This evaluation was combined for the Sabine and Brazoria project areas, as water quality conditions and impairments are similar in both areas.

Several stream segments in the Sabine region have been classified by TCEQ (2014) as non-supporting for aquatic life, recreation, fish consumption, and general uses. In the Brazoria region, only one stream has been classified as impaired; Oyster Creek (ID # 1109) is identified as non-supporting for recreation use due to undesirable levels of bacteria. Sampling of tidal segments of the Sabine and Neches Rivers and the GIWW (ID # 501, 702) has identified

undesirable levels of bacteria (Enterococcus and E-coli) and PCB's in edible fish tissues. Tidal segments of small streams such as Little Cypress, Adams Bayou, Gum Gully, Cow Bayou, Coon Bayou, and Cole Creek (ID #'s 501B, 508, 508B, 511, 511B, and 511C) have low flows, little tidal energy, high dissolved solids, and high turbidity due to a heavy clay substrate and forest detritus; they generally report depressed levels of dissolved oxygen and undesirable levels of bacteria and certain nutrients. Little Cypress Bayou also exhibits water toxicity, as do the lower segments of the Neches River and Star Lake Canal, near the confluence of the Neches River and Sabine Lake. Freshwater stream segments in the Sabine region generally have higher water quality than do tidal segments, with a few, such as Adams Bayou, Gum Gully, Cow Bayou, Taylor Bayou/North Fork, and Alligator Bayou (ID # 508A, 508B, 511A, 701, and 702A, reporting depressed levels of dissolved oxygen and high bacteria levels.

An implementation plan has been developed to improve water quality for support of recreational and aquatic life uses for the Cow and Adams Bayou watersheds (Orange County Stakeholder Advisory Group 2015). The plan addresses nonpoint discharges from failing onsite sewage facilities, pastures, forests, and urban runoff, as well as primary point sources such as wastewater treatment facilities and illicit discharges. Water quality will improve marginally over the period of analysis if the stakeholders are successful in reducing existing discharges. Circulation and tidal flows may increase as RSLC increases tidal flows into the region.

Surface sediments in the Sabine and Brazoria regions are generally of good quality, as evidenced by testing of water and sediments in conjunction with maintenance dredging of existing navigation channels and proposed modifications for the Sabine-Neches Waterway (USACE 2011), the Freeport Harbor Channel (USACE 2012), and the mouth of the San Bernard River (USACE 2008). Major industrial facilities that handle and generate hazardous materials and waste are located in both the Sabine and Brazoria regions. In the Sabine region, facilities are concentrated in southern Orange County and along the south bank of the Neches River. Several are located within the levees of the existing Port Arthur HFP along the west bank of the Sabine-Neches Canal in Jefferson County. In the Brazoria region, numerous facilities are located within the boundaries of the existing Freeport HFP system in southern Brazoria County. More detailed information on these facilities can be found in the Appendix N. The general risk of encountering contaminated surface sediments is low since no unresolved current recent hazardous material releases were identified in either region, and no significant RCRA or CWA violations were found. These industries are expected to continue operating in the project area over the period of analysis because of their needs to access existing port and pipeline infrastructure.

7.7.2 FWP Alternatives for Sabine Region CSRM Plans

It is assumed that approximately 15 million cubic yards (mcy) of fill material required to construct the Orange-Jefferson and Port Arthur CSRM Plans would be obtained from commercial borrow sources. The material would be primarily clays and sands. Testing to ensure that the material is free of contaminants would be conducted prior to use if the commercial borrow source has not already been tested. USFWS has indicated that this will be a requirement of the USFWS CAR (in preparation; expected in 2015). The majority of the material would be placed in upland areas; however, approximately 300.5 acres of marsh and forested wetlands would be directly impacted by the placement of fill material by bulldozers and possibly drag-line cranes. The proposed alignment has been located to minimize, to the greatest extent practicable, impacts on the Neches and Sabine River floodplains and to avoid and minimize impacts on the aquatic ecosystem. Unavoidable, significant impacts would be fully mitigated. A detailed description of these impacts is provided in Appendix O.

Construction of the Cow and Adams Bayou surge gates would result temporary increases in water column turbidity in the vicinity of the Cow and Adams Bayou gates. These bayous are normally turbid due to the high clay content of bayou sediments. No long-term effects from temporary turbidity increases are expected.

Discharges of fill material into wetlands and waterways adjacent to the upland fill areas would be minimized by the use of silt curtains to minimize turbidity impacts; forestry BMPs, such as water bars and diversion ditches, would be utilized if needed to stabilize disturbed forest floors and prevent erosion. Potential impacts on flows and interior flooding were described above in the section on impacts on physical and hydrological characteristics of the Sabine Region. The potential for hydrologic impacts on Adams and Cow Bayous was evaluated, and modeling indicates negligible impacts on the water surface elevation and salinity within Adams and Cow Bayous from potential constrictions to the channel cross-section with the proposed surge gates in their normal open condition. Hydrologic flows in the FWP condition would be very similar to FWOP flows in location, duration, and magnitude, both inside and outside of the levee system. Culverts have been designed to maintain existing flows for a 100-year rainfall event, with an additional 10 percent to account for the predicted increase in rainfall due to climate change over the period of analysis. The negligible indirect impacts would not be expected to exceed established Total Daily Maximum Loads (TMDLs) for Adams and Cow Bayous and their tributaries.

Construction of improvements to the Port Arthur CSRM Plan would have minimal impacts on water quality. No changes would occur to the existing alignment and pump facilities would be

improved or maintained to provide for future daily flows and flood waters. At this time, it is assumed that fill material for the levee improvements would be obtained from commercial borrow sources. Discharges of fill material into adjacent wetlands and waterways would be minimized by the use of silt curtains and other BMPs.

7.7.3 FWP Alternative for Brazoria Region

It is assumed that approximately 450,000 cubic yards of fill material required to construct the Freeport and Vicinity CSRM Plan would be obtained from commercial borrow sources. Testing to ensure that the material is free of contaminants will be conducted prior to use if the commercial facility has not already done so. Construction would have minimal impacts on water quality. No changes would occur to the existing alignment and pump facilities would be improved or maintained to provide for future daily flows and flood waters. Effects of the proposed surge gate on the DOW Barge Canal are expected to minimal, based on analysis of the Cow and Adams surge gates. Discharges of fill material into adjacent wetlands and waterways will be minimized by the use of silt curtains and other BMPs.

7.8 AIR QUALITY IMPACTS

7.8.1 No Action Alternative - All CSRM Plans

The Sabine Region is located in the BPA AQCR. According to EPA Region 6, this region has been re-designated as in attainment for the 1997 8-hour Ozone NAAQS (EPA 2015). Further, the Sabine region is designated as in attainment for all other criteria pollutants.

Brazoria County is located within the HGB AQCR as defined in the Texas State Implementation Plan (SIP), adopted in 1972 and revisions thereafter. The area is currently designated as severe nonattainment for the 8-hour ozone (1997) standard and marginal nonattainment for the 8-hour ozone (2008) standard. The HGB AQCR is in attainment for all other criteria pollutants.

7.8.2 FWP Alternative –All CSRM Plans

7.8.2.1 Air Emission Impacts

Air emissions of the Orange-Jefferson, Port Arthur and Vicinity, and Freeport and Vicinity CSRM plans were modeled and the results are presented in Appendix I. The air emission impacts assessed in this report are based on preliminary construction estimates and schedules for evaluated alternatives. The impact assessments utilized conservatively-high duration and quantity estimates to ensure that all potential impacts are identified and disclosed for review. The EPA software package Motor Vehicle Emissions Simulator (MOVES) 2014 was utilized to

generate emission factors based on the types of construction equipment and vehicles anticipated. Air quality impacts are expected to be temporary and confined to the duration of the construction events. Sources of air quality changes from the TSP are expected to result from direct emissions from construction and demolition equipment, such as cranes, excavators, bulldozers, concrete pumps, saws, and generators, and indirect emissions from commuting workers and delivery vehicles such as cars, pickup trucks, flatbed trucks, dump trucks, and concrete trucks. The equipment lists, along with their proposed operations, are quite lengthy; they have not been included in the appendix but are available upon request.

Total modeled emissions (tons/year) for each CSRM Plan in the BPA AQCR are provided in Table 7-2, and the total modeled emissions for the Freeport and Vicinity CSRM Plan in the HGB ACQR are provided in Table 7-3. Per 40 CFR Part 93, Chapter 153, a conformity determination would be required for each criteria pollutant or precursor where the total of direct and indirect emissions of the criteria pollutant or precursor in a nonattainment or maintenance area caused by a Federal action would equal or exceed minimum thresholds defined in the regulation. These General Conformity thresholds are presented in Appendix I.

Table 7-2: Air Quality Impacts in the BPA AQCR

Year	Alternatives	Airshed	Pollutant (tons/year)						
			CO	NOx	PM-10	PM-2.5	SO_2	VOC	Lead
2020	Orange	Sabine	21.0	25.7	2.1	2.0	0.1	5.8	0.0
2021	Orange	Sabine	21.0	25.7	2.1	2.0	0.1	5.8	0.0
2022	Orange	Sabine	21.0	25.7	2.1	2.0	0.1	5.8	0.0
2023	Beaumont	Sabine	30.6	37.4	2.9	2.8	0.1	9.0	0.0
2023	Orange	Sabine	21.0	25.7	2.1	2.0	0.1	5.8	0.0
2024	Port Arthur	Sabine	17.9	44.4	2.8	2.7	0.1	6.6	0.0
2024	Orange	Sabine	21.0	25.7	2.1	2.0	0.1	5.8	0.0
2025	Port Arthur	Sabine	17.9	44.4	2.8	2.7	0.1	6.6	0.0
2025	Orange	Sabine	21.0	25.7	2.1	2.0	0.1	5.8	0.0
2026	Port Arthur	Sabine	17.9	44.4	2.8	2.7	0.1	6.6	0.0
2026	Orange	Sabine	21.0	25.7	2.1	2.0	0.1	5.8	0.0
2027	Port Arthur	Sabine	17.9	44.4	2.8	2.7	0.1	6.6	0.0
2027	Orange	Sabine	21.0	25.7	2.1	2.0	0.1	5.8	0.0
2028	Jefferson	Sabine	16.9	26.3	1.8	1.8	0.1	4.9	0.0
2029	Jefferson	Sabine	16.9	26.3	1.8	1.8	0.1	4.9	0.0

CO=carbon monoxide, NOx=nitrous oxides, PM-10=particulate matter less than 10 microns, PM-2.5=particulate matter less than 2.5 microns, SO_2=Sulphur dioxide, VOC=volatile organic carbons

Table 7-3: Air Quality Impacts in the HGB AQCR

Year	Alternative	Airshed	Pollutant (tons/year)						
			CO	NOx	PM-10	PM-2.5	SO_2	VOC	Lead
2020	Freeport	HGB	12.2	3.0	0.5	0.4	0.0	2.3	0.0
2021	Freeport	HGB	12.1	3.0	0.5	0.4	0.0	2.3	0.0
2022	Freeport	HGB	12.1	3.0	0.5	0.4	0.0	2.3	0.0

CO=carbon monoxide, NOx=nitrous oxides, PM-10=particulate matter less than 10 microns, PM-2.5=particulate matter less than 2.5 microns, SO_2=Sulphur dioxide, VOC=volatile organic carbons

The BPA ACQR is classified as in attainment for all NAAQS pollutants and, therefore, the General Conformity Rule does not apply. The single greatest increase of any criteria pollutant from all projects within the region is 70.1 tons/year of nitrous oxides (NOx) (2024 – 2027). Since the General Conformity Rule *de minimis* thresholds do not apply and the total emissions from all activities are demonstrated to be below the significance thresholds, the TSP would not have significant impacts on ambient air quality within the region.

The HGB AQCR is classified as marginal nonattainment for the 2008 ozone NAAQS, and severe Nonattainment for the 1997 ozone NAAQS. Therefore, the General Conformity Rule applies to the precursors of ozone (NOx and volatile organic compounds or VOC) resulting from the TSP. The *de minimis* thresholds are 25 tons/year for NOx and VOC. Emissions of NOx and VOC are estimated to increase by 3.0 tons/year and 2.3 tons/year, respectively, for years 2020 to 2022; therefore, the *de minimis* thresholds are not exceeded and a conformity determination is not required. Emissions from the other criteria pollutants are demonstrated to be below the significance thresholds identified above. Because the TSP levels fall below the *de minimis* thresholds for non-attainment pollutants and are below significance levels for attainment pollutants, the TSP would not have significant impacts on ambient air quality within the HGB region.

7.8.2.2 Greenhouse Gas Impacts

Air emissions from the operation of internal combustion engines that produce exhaust result in GHG emissions that could contribute to global climate change. The CEQ published "Draft NEPA Guidance on Consideration of the Effects of Climate Change and Greenhouse Gas Emissions", December 18, 2014 (CEQ 2014). The Draft Guidance suggests that the impacts of projects directly emitting GHG in excess of 25,000 metric tons or more of carbon dioxide (CO2)-equivalent (CO2e) GHG emissions per year be considered in a qualitative and quantitative manner in NEPA reporting; however, there are no implementing regulations to direct development of these analyses for Federal projects. On December 19, 2014, EPA delegated authority for GHG Prevention of Significant Deterioration (PSD) permitting in Texas to TCEQ

as part of the approval of the SIP (EPA 2014). As implemented by TCEQ, GHG permits are required only for stationary sources or facilities already required to obtain PSD permits for other criteria pollutants. Under the state program, non-stationary sources of emissions like construction equipment/construction projects are not required to obtain permits. Since no PSD permitting is required for any of the TSP projects in Texas, detailed GHG analysis was not performed. All emissions would come from individual mobile internal combustion engines in on-road and non-road equipment, and it is likely that the total GHG emissions from mobile sources for the five projects would exceed 25,000 metric tons per year of CO2e per year when considered cumulatively.

However, except for the NAAQS pollutants emitted by these mobile sources as indicated above, the same GHG emissions would occur for every mobile vehicle and piece of equipment regardless of whether the TSP is implemented. The vehicles and equipment would be used elsewhere by the project contractors on other construction projects, but not necessarily in the two airsheds affected by the TSP. Since GHG are not listed as NAAQS pollutants subject to regulation under the Texas SIP, and no listed pollutants are generated above *de minimis* levels, and the TSP would not result in any new stationary emission sources, detailed analysis of GHG emissions was not performed.

7.9 NOISE IMPACTS

The No Action Alternative will be discussed separately for each of the CSRM Plans, but the FWP condition discussion has been combined for all the Sabine and Brazoria region plans since the impacts will be similar for all.

7.9.1 No Action Alternative for all CSRM Plans

7.9.1.1 Orange-Jefferson CSRM Plan

Ambient noise levels in the vicinity of the proposed Orange-Jefferson CSRM Plan would vary from natural noise levels found in undeveloped, rural areas of southwest Orange County to noise levels associated with urban areas and industrial sites in south Orange and northeast Jefferson Counties. Each of the three Orange-Jefferson CSRM Plan distinct construction areas is described separately below.

- About 190 residences are located adjacent to the proposed Orange 3 right-of-way in Orange County. About 25 residences are located 30-40 feet from the right-of-way; 80 are located from 100-600 feet away, and the remainder are located between 50 and 100 feet from the proposed right-of-way. Numerous schools are located in the general area in

southern Orange County; the closest is located one-third of a mile from the right-of-way and the rest are more than 0.5 mile away. Only one hospital is located in Orange and it is more than 2 miles from the proposed right-of-way.

- About 40 residences are located adjacent to the proposed Jefferson Main right-of-way in northeast Jefferson County. About four residences are located very close, within 10 to 50 feet, and another 25 are located between 50 and 75 feet of the proposed right-of-way. The remainder are located more than 200 feet away.
- No residences are located adjacent to the proposed right-of-way in Beaumont A.

Construction of the surge gates in Adams and Cow Bayous would result in temporary and minor noise impacts on aquatic life. It is anticipated that coffer dams would be constructed to facilitate gate construction and thus noise impacts on aquatic life from construction of the gates themselves would be minimal. Pile drivers and draglines could be used to construct the coffer dam and an open channel around the coffer dam would be maintained at all times. Fish and other aquatic life would be able to move away from the area of noise impacts, thus minimizing the temporary effects.

7.9.1.2 Port Arthur and Vicinity CSRM Plan

In the vicinity of the existing Port Arthur HFP project, ambient noises would be associated with dense urban and industrial development, and barge and ship traffic on the deep draft navigation channels. Residents along the ship channels would also be exposed to temporary noise levels associated with occasional maintenance dredging of these channels.

Approximately 180 residences are located adjacent to the existing HFP system; of these, approximately 43 are located adjacent to the I-Wall Reach Near the Tank Farm where a levee raise modification is proposed. Most of these are located about 100 feet from the levee centerline. Numerous schools are located in the general area, with the closest four are located at least one-half mile away. None of the area hospitals are located closer than 1 mile from the project, and three are located 2 or more miles distant.

No noise impacts on aquatic life are anticipated, as proposed modifications to the existing project do not entail construction activities in adjacent waterbodies.

7.9.1.3 Freeport and Vicinity CSRM Plan

In the vicinity of the existing Freeport HFP project, ambient noises would be associated with industrial development and minor residential urban development, in addition to noises associated with ship traffic on the deep- and shallow-draft navigation channels. Residents near the ship

channels would also be exposed to temporary noise levels associated with occasional maintenance dredging of these channels.

Approximately 105 residences are located adjacent to the existing Freeport HFP system, divided roughly equally between Freeport and Oyster Creek. The existing right-of-way passes immediately adjacent to the Freeport Public Library, Brazosport High School, Freeport Intermediate, and one large apartment complex. None of these are located near the levee system segments to be reconstructed by the CSRM Plan. Numerous other schools in the area are located at least one-half mile away. There are no major hospitals located in the area protected by the existing HFP system. Construction of any of the height alternatives of the Tide Gate I-Wall Raise and the Oyster Creek Levee Raise would result in temporary noise impacts on approximately five residences each; the East Storm Levee Raise would result in temporary noise impacts on approximately 13 residences. The majority of the structures are located over 200 feet away; however the structures in the Tide Gate I-Wall Raise area could be located within 100 feet of a potential temporary work area.

Construction of the surge gate in the mouth of the DOW barge canal would result in temporary and minor noise impacts on aquatic life. It is anticipated that coffer dams would be constructed to facilitate gate construction and thus noise impacts on aquatic life from construction of the gates themselves would be minimal. Pile drivers and draglines could be used to construct the coffer dam and an open channel around the coffer dam would be maintained at all times. Fish and other aquatic life would be able to move away from the area of noise impacts, thus minimizing the temporary effects.

7.9.2 FWP Alternatives –All CSRM Plans

None of the CSRM Plans are expected to result in significant long-term noise impacts. No new permanent noise sources would be installed as part of the TSP; noise impacts would be temporary, occurring during construction only. The Plans would, however, create short-term noise level increases for noise-sensitive receivers located close to the construction zone. Construction activities near sensitive receptors such as residences, schools, hospitals, etc, would be conducted solely during normal daylight working hours; no construction activities would occur during evening or night hours.

EPA identifies a 24-hour exposure level of 70 logarithmic A-weighted decibels (dBA) as the maximum level of environmental noise, which will prevent any measurable hearing loss over a lifetime (U.S. EPA 2015). This is an average over a 24-hour period. Occasional higher noise

levels can be consistent with a 24-hour average of 70 dBA if a sufficient amount of relative quiet is experienced for the remaining period of time.

Noise levels related to construction would be based upon the actual number/type of equipment operating in one location at a specific time, and would also fluctuate as equipment is maneuvered throughout the construction right-of-way. Some of the temporary construction activities associated with levee system improvements are expected to generate noise above the 70-dBA level at times during each day. Typical temporary noise levels that could be associated with construction include 73 dBA for large front end loaders from a distance of 100 feet, 86 dBA for off-road haul trucks at 50 feet, 88 dBA for unloading crane at 50 feet, and 90 dBA for vibratory sheet piling at 100 feet (Epsilon Associates 2006). For comparison, typical interior home noise levels are about 50 dBA. Construction activities would be limited to daylight hours to reduce average daily impacts to nearby residents. Contractors would be required to comply with local noise ordinances during construction. There is potential for vibrations associated with construction of some floodwall improvements to affect nearby structures. These effects will be evaluated during detailed design.

7.10 HAZARDOUS, TOXIC, AND RADIOACTIVE WASTE IMPACTS

The construction rights-of-way for the three CSRM plans have been investigated for the presence of hazardous materials, hazardous waste, and the potential for contamination by current or past industrial or other activities. A detailed report of this investigation is provided as Appendix N. The locations of HTRW areas of concern were identified by latitude and longitude along the alignment. For the purposes of this investigation, a risk to the proposed levee and floodwall alignments is defined as the presence of an HTRW contamination site or HTRW generation site on or adjacent to an alignment, the presence of an activity with the potential for contamination adjacent to or within 0.25 mile of an alignment, or the presence of a past HTRW contamination site or activity adjacent to or within 0.25 mile of an alignment. Except for large oil refining and chemical plants, small HTRW sites such as commercial gas stations in excess of 0.25 mile from the alignment corridor do not pose an environmental risk to the project.

HTRW concerns were investigated through a review of state and Federal databases maintained to monitor permits and activities regulated by state and Federal agencies, such as the TCEQ and the EPA. Envirosite Corporation was contracted to search relevant environmental databases for sites and activities on or near the levee and floodwall alignments. The EPA's Enforcement and Compliance History Online (website was visited to identify past HTRW incidents or permit noncompliance violations for sites identified in the Envirosite Corporation database reviews, primarily violations of the Clean Air Act (CAA), CWA, and RCRA. In addition, historical

USGS topographic maps and historical aerial photographs were obtained along the levee and floodwall alignments to identify former industrial or other activities that may have contributed to HTRW contamination in the project areas. The volume of material examined for this report is too large to include in the appendix (over 28,500 pages of reports and maps), but the data are available in electronic format from USACE for further review.

7.10.1 Orange-Jefferson CSRM Plan

7.10.1.1 No Action Alternative

Facilities which store or produce hazardous materials are described separately for each of the three Orange-Jefferson CSRM Plan's distinct construction areas. In addition to these facilities, numerous pipelines transporting hazardous materials for shipment or further processing cross the proposed alignments. The locations of all identified HTRW sites and pipeline crossings discussed here are shown on maps in Appendix N.

The proposed construction right-of-way for Orange 3 runs near numerous chemical manufacturing and other industrial facilities, including the Port of Orange and several ship-building yards. Research identified seven major HTRW sites and facilities near or adjacent to the proposed alignment. All are currently operating industrial facilities and listed in databases identifying the generation, handling, or release of hazardous materials and waste. The largest of these, DuPont-Invista (Sabine River Works), maintains several large wastewater treatment and cooling ponds along the proposed alignment. The other operating HTRW facilities are Signal International (Front Street Yard), Conrad Orange Shipbuilding, Lanxess, Honeywell, Chevron Phillips Chemical Company, and Firestone Polymers (Firestone Synthetic Rubber and Latex Company). One former industrial hazardous waste disposal site, owned by WMW Holding Company, has been closed by TCEQ and classified as clean.

The Jefferson Main alignment runs near six operating industrial facilities that generate or store hazardous materials and waste: DuPont Beaumont Works, the Motiva Port Neches Terminal Dock, ChemTreat, OilTanking Port Neches, Trans-Global Solutions (Erickson Refining), and Huntsman Refinery. A former Exxon Tank Farm is also located in this reach. One National Priority List Superfund area is located adjacent to this alignment on Star Canal. EPA is currently preparing an agreement to implement remediation, which will involve removal of sediment from Star Bayou (EPA 2015).

Beaumont A runs adjacent to the eastern and southern boundaries of the large Exxon-Mobil Refinery, including an Exxon-Mobil hazardous waste storage area at the southeast corner of the facility, and Arkema, a chemical manufacturing plant. Another facility in the general area,

Chemical Storage and Loading, stores hazardous materials but is not protected by the Beaumont A levee system.

The Orange-Jefferson CSRM project area would continue to be subject to future risks of storm surge impacts, and related potential impacts of petrochemical spills from the facilities identified in this report. These industries have emergency operating plans, which help reduce the risks of spills caused by tropical storm impacts, but impacts can occur with storms of great magnitude or when storms spin up quickly and come ashore with little advance warning.

7.10.1.2 FWP Alternative

The general HTRW risk associated with construction of the levee alignment in Orange County is classified as low, since no unresolved current or recent hazardous material releases were found, and no significant recent RCRA or CWA permit violations were identified in the proposed construction right-of-way. Most of the refineries and chemical plants had numerous CAA violations in the past or currently in effect due to stack emissions, but these do not raise the risk of ground-based HTRW contamination. One facility which stores hazardous materials (Chemical Storage and Loading) is not protected by the Orange-Jefferson CSRM Plan; it would need to continue to provide its own protection from surge impacts. The other facilities, which store crude oil, or manufacture gasoline and other petrochemicals such as industrial polymers, synthetic rubber, and other chemicals would experience lower risks of spills associated with storm surge impacts if the CSRM Plan is implemented. The HTRW facilities along the construction right-of-way should be more thoroughly investigated with visual inspections and interviews with facility managers to confirm the potential HTRW risks along the levee alignment prior to construction or more detailed design.

7.10.2 Port Arthur and Vicinity CSRM Plan

7.10.2.1 No Action Alternative

The Port Arthur CSRM alignment lies adjacent to three large petroleum and petrochemical facilities – Texaco Chemical Company (Neches Plant), Total Refinery-BASF Chemicals, and the Valero Port Arthur Refinery. A smaller chemical facility, Calabrian Corporation, is located about 900 feet away. Motiva Enterprises - Port Arthur Refinery, currently with the largest refining capacity in the U.S., is located in Port Arthur, but is over 1 mile away from the construction right-of-way. The project area would continue to be subject to future risks of I-wall overtopping due to storm surge, and related potential impacts of petrochemical spills. These industries have emergency operating plans, which help reduce the risks of spills caused by tropical storm impacts, but impacts can occur with storms of great magnitude or when storms spin up quickly and come ashore with little advance warning.

7.10.2.2 FWP Alternative

Total Refinery-BASF Chemicals and Valero have numerous CAA violations in the past or currently in effect due to stack emissions, but these do not raise the risk of ground-based HTRW contamination. No currently active spills or land/water releases of hazardous materials were found for these facilities or others in the area. Therefore, the Port Arthur project area is classified as a generally low risk for HTRW impacts associated with reconstruction of portions of the levee system. The facilities in the Port Arthur area, which store crude oil, or manufacture gasoline, petrochemicals, and liquid sulphur dioxide, would experience lower risks of spills associated with storm surge impacts if the CSRM Plan is implemented. The HTRW facilities indicated should be more thoroughly investigated with visual inspections and interviews with facility managers to confirm the potential HTRW risks along the alignment corridor prior to construction or more detailed design.

7.10.3 Freeport and Vicinity CSRM Plan

7.10.3.1 No Action Alternative

The Freeport and Vicinity CSRM Plan alignment lies adjacent to six operating chemical and petroleum industrial facilities: Nalco Freeport Plant, Chemical Specialties, Air Liquide Freeport HYCO Plant, and three separate sites associated with DOW Chemical Company (the Texas Operations Plant, the Oyster Creek plant, and DOW Chemical Shipping). Other chemical and refining facilities are located in close proximity to the alignment, including numerous shipping points along the Port of Freeport and Intracoastal Waterway shipping corridors. The alignment lies adjacent to petroleum bulk stations, storage tanks, and pipelines. It passes adjacent to Freeport Liquid Natural Gas (LNG) Receiving Storage and the Tejas Power natural gas transmission pipeline and a natural gas gathering system (Galveston Island Gathering System). The proposed alignment corridor also crosses the Bryan Mound Strategic Petroleum Reserve facility located on the Brazos River. There is a large, 48-inch buried pipeline connecting the Bryan Mound facility to the refineries at Texas City to the northeast, but the exact location of this pipeline is not known. There are numerous pipeline crossings along the proposed levee and floodwall alignments. Many of the pipeline crossings transport hazardous materials between processing facilities, and others transport finished products to shipping terminals. The project area would continue to be subject to future risks of levee system overtopping impacts, and related potential impacts of petrochemical spills. These industries have emergency operating plans, which help reduce the risks of spills caused by tropical storm impacts, but impacts can occur with storms of great magnitude or when storms spin-up quickly and come ashore with little advance warning.

7.10.3.2 FWP Alternative

The general risk level for the Freeport area is indicated as low, since no current or recent unresolved RCRA or CWA releases were identified for any of the industrial facilities in the Freeport area. Many of the facilities have ongoing CAA violations due to stack emissions. The facilities in the Freeport area, which store crude oil, or manufacture petrochemicals, industrial gases, and other chemicals, would experience lower risks of spills associated with storm surge impacts if the CSRM Plan is implemented. The HTRW facilities along the construction alignment should be more thoroughly investigated with visual inspections and interviews with facility managers to confirm the potential HTRW risks along the alignment corridor prior to construction or more detailed design. Pipeline crossings are identified as points of concern along the proposed alignments where special caution should be exercised during construction to avoid damage to the pipelines and release of hazardous materials into the environment.

7.11 CULTURAL RESOURCES IMPACTS

7.11.1 No Action Alternative – All CSRM Plans

The proposed project area for the Sabine to Galveston Bay, Texas, Coastal Storm Risk Management and Ecosystem Restoration Study is located along the upper Texas coast and has been occupied by humans since the Paleoindian period dating to around 11,500 BP. The study area is characterized by upland coastal prairies dissected by streams and rivers and extensive bay and estuarine systems along the coast. The study area is primarily drained by the Trinity River, the San Jacinto River, Buffalo Bayou, and the Brazos River. Sediments in the region are generally fluvial sandy and silty clays overlying Pleistocene-aged clay. Prehistoric sites are commonly found within these upper sediments along streams and rivers and along the shorelines of the bays and gulf coast, close to prime areas for resource exploitation. These sites include campsites, dense shell middens, and cemeteries containing projectile points, stone, bone, and shell tools, aquatic and terrestrial faunal remains, hearth features, ceramics, and in some cases human remains and associated funerary objects. Historic-age resources in the region consist of farmsteads and ranches, houses, buildings, bridges, tunnels, oil industry structures, cemeteries, lighthouses, shipwrecks, and the ruins of these buildings and structures. Although historic-age resources can occur anywhere, these sites tend to be concentrated in small towns and urban areas, along roads, and within current and historic navigation paths. Shipwrecks may also occur in numerous locales due to the dynamic nature of the sea floor and bay bottoms and the lack of navigation improvements until the latter part of the nineteenth century. These dynamic conditions can result in shifting shoals and reefs that endanger ships, as well as bury their wrecks as shorelines and bars migrate through time.

A preliminary assessment of the cultural resources within the region was conducted using a desktop review of the databases maintained by the Texas Historical Commission and the Texas Archeological Research Laboratory for terrestrial and marine cultural resources, as well as the shipwreck and obstruction databases of the National Oceanic and Atmospheric Administration and the Bureau of Ocean Energy Management. There are over 3,600 cultural resources located within this region of the upper Texas Coast. These cultural resources include National Historic Landmarks, NRHP listed properties, archeological sites, cemeteries, historical markers, and shipwrecks and submerged resources. The National Historic Landmarks in the six-county study area are all located in the Galveston Region. These are the San Jacinto Battlefield, the Battleship Texas, and the Tall Ship Elissa, as well as National Historic Landmark Districts, the Galveston Strand Historic District and the Galveston East End Historic District. The NRHP Properties are generally located in urban areas and consist of historic houses, commercial and government buildings, and structures. NRHP Properties in the Sabine Region include the Navy Park Historic District, W.H. Stark House, Sims House, and Woodmen of the World Lodge. These are all located in the area that would be protected by the Port Arthur and Vicinity CSRM Plan. NRHP Properties in the Galveston Region include the Main Street/Market Square Historic District, Pomeroy Homestead, Ross S. Sterling House, Ashbel Smith Building, Fort Travis, Washburn Tunnel, and others. NRHP Properties in Brazoria are generally located in more inland areas of the county, with the southernmost property located in Lake Jackson, just inland of the Freeport and Vicinity CSRM project area.

Within the areas of the proposed Orange-Jefferson CSRM Plan, the study area was examined within 200 feet of the proposed work for archeological resources and cemeteries and 1,500 feet for historic structures and buildings. There are a total of eight archeological sites (41OR15, OR39, OR59, OR60, OR70, BO4, BO119, and BO121, four NRHP Properties (Navy Park Historic District, W.H. Stark House, Sims House, and the Woodmen of the World Lodge), and three cemeteries (Evergreen, Thomas, and an unknown cemetery) within this study area. There are also 25 historical markers within the study area; however, only one of these, the Niblett's Bluff marker in Orange, is more than 50 years old, having been erected in 1964.

7.11.2 FWP Alternatives – All CSRM Plans

The primary considerations concerning cultural resources are threats from direct impacts on intact terrestrial archeological sites and indirect impacts on historic structures and buildings from new construction and improvements. A large portion of the study area has been altered for industrial and commercial use, especially in the cities of Orange, Port Arthur, and Freeport. As such, these urban areas have a low probability for intact prehistoric archeological sites to occur. However, there is a moderate to high potential for encountering historic-age archeological sites

and cemeteries, as well as historic-age structures and buildings. In those areas outside of the urban centers, the potential for encountering prehistoric archeological sites is moderate to high. There are no proposed actions within marine environments and therefore no potential to impact submerged cultural resources.

The Area of Potential Effect (APE) for this project will be the footprint of the TSP for direct impacts on archeological resources plus a 1,500-foot buffer for indirect impacts on standing structures or buildings. The Orange-Jefferson CSRM Plan construction right-of-way overlaps with five archeological sites and two cemeteries. Additionally, there are four National Register Properties within 1,500 feet of the proposed levee system (Navy Park Historic District, W.H. Stark House, Sims House, and the Woodmen of the World Lodge), all of which would experience reduced risk of storm surge damages with construction of the new levee system. The five archeological sites in Orange County (41OR15, OR39, OR59, OR60, and OR70) are all prehistoric sites that have poorly delineated boundaries, insufficient documentation, and have not been evaluated for NRHP eligibility. All of these sites have the potential to be directly impacted by construction activities. The two cemeteries also have a potential to be directly affected by levee construction as their recorded boundaries overlap with the proposed project area. These cemeteries, the Thomas cemetery and an unknown cemetery, are not well documented and their locations may not be accurate within the existing state databases.

There are numerous cultural resources that occur near the APE for the Port Arthur and Freeport CSRM Plans; however, most of these resources occur outside of the areas proposed for improvements. In Port Arthur, there are no cultural resources that overlap with the areas for proposed improvements along the existing hurricane protection system. However, there are three archeological sites (41BO4, BO119, and BO121) that are within proximity to the proposed improvement areas along the Freeport hurricane protection system. These three sites all occur along Oyster Creek, are poorly delineated, lack sufficient documentation, and have not been evaluated for NRHP eligibility.

Based on the current information for the proposed levee construction and improvements, there is a potential to affect historic properties and cemeteries. These effects consist of direct impacts from earth moving and excavation activities related to construction and potential indirect effects on historic structures such as diminished viewshed from the raising of levees and floodwalls. The USACE recommends intensive cultural resources investigations to identify and evaluate any historic properties within proposed construction areas. The scope of these investigations will be determined in concert with the Texas SHPO and Native American Tribes and in accordance with the Programmatic Agreement for this project (Appendix L).

7.12 PRIME AND UNIQUE FARMLANDS

Prime and other unique farmlands in the CSRM plan areas were mapped using the NRCS Web Soil Survey website (USDA 2015). Custom Soil Reports and soil maps were downloaded for each area and area available upon request. Soils were clipped from the USDA database to calculate prime farmland impacts of CSRM Plan construction right-of-ways.

7.12.1 Orange-Jefferson CSRM Plan

7.12.1.1 No Action Alternative

Mapped soil units identified as prime, unique, statewide, or locally important farmlands (hereafter referred to as prime or otherwise important farmland) under the Farmland Protection Policy Act (FPPA) occur within the proposed construction rights-of-way in Orange and Jefferson County. Units identified by the NRCS in the construction area are, in descending order of prevalence, Ijam clay, Orcadia-Urban land complex, Orcadia-Anahuac complex, Aris-Spindletop complex, Orcadia-Aris complex, Neches coarse sand, Leton loam, Neel-Urban Land Complex, Orcadia silt loam, and Franeau clay (U.S. Department of Agriculture [USDA] 2015). Impacts on prime farmland during the FWOP condition would occur primarily from industrial, commercial and/or residential development, and continue according to expected trends of population growth and development in each area.

7.12.1.2 FWP Alternative

Impacts are described separately for the three distinct construction areas of the Orange-Jefferson CSRM Plan. Alternatives to the proposed alignments were evaluated as described in Chapter 5.

Orange 3 would convert approximately 160 acres of prime farmland, as defined by the NRCS Web Soil Survey (USDA 2015), into a CSRM levee system. About 60 percent of the area to be impacted by construction (about 380 acres) is classified as prime farmland. Recent aerial photographs were reviewed to determine the current status of mapped units located within the right-of-way, and approximately half (160 acres) were found to be developed or in use as pipeline right-of-ways or placement areas. Therefore, about 160 acres of prime or otherwise important farmland would be converted to a non-agricultural use. This represents about 0.3 percent of the total "land in farms" reported by the Orange County 2012 agriculture census (USDA 2012). The undeveloped prime farmland areas that will be impacted are fragmented, surrounded by development, and not currently used for agriculture. The proposed alignment has been designed to follow the upland/wetland margin to the greatest extent possible. Almost all of the lands north of the alignment are developed urban, suburban, and industrial areas. Almost all of the lands south of the alignment are bottomland wetlands, which are not farmed; other areas

are industrial cooling ponds or placement areas. The westernmost 2.3 miles of the alignment extends inland away from the upland/wetland margin, with a few tracts south of the alignment which appear to be used for pasture. Only one small area of the construction right-of-way itself (about 6 acres in size) appears to have been farmed recently; levees for rice farming are present in the area.

Jefferson Main would convert approximately 18 acres of prime farmland, as mapped and defined by the NRCS Web Soil Survey (USDA 2015), into the new levee system. About 45 percent of the area to be impacted by construction is identified as prime farmland. Although 113 acres of the alignment are mapped as prime or important farmland, all but about 18 acres is currently developed and thus should be exempt from consideration. This represents about 0.005 percent of the total "land in farms" reported by the Jefferson County 2012 agriculture census (USDA 2012). The proposed alignment has been designed to follow the upland/wetland margin to the greatest extent possible. On the north, the alignment would be bordered primarily by the Neches River, but industrial ponds or placement areas occur in some areas. The vast majority of the area south of the levee system is dense urban and industrial development. None of the area within or adjacent to the alignment appears to be used for crop agriculture; use as pasture is possible in a few small areas.

Beaumont A would not adversely affect prime farmland. Although approximately 3 acres of the alignment is mapped as prime farmland, as defined by the NRCS Web Soil Survey (USDA 2015), the entire proposed alignment is currently developed and part of an industrial facility. The proposed alignment has been designed to follow the upland/wetland margin around a large petro-chemical complex to the greatest extent possible. Outside of the levee, on the north, lies the Neches River. To the east and south lie industrial development and a placement areas. None of the area within or adjacent to the alignment is used for crop agriculture or pasture.

Construction of the Orange-Jefferson CSRM Plan would not make areas outside of the alignment unfarmable; interior drainage patterns would be maintained at FWOP conditions and access across the levee system would be possible. Any areas compatible with agricultural use that occur in the vicinity of the proposed alignment would remain fully compatible with agricultural use after project construction. Impacts on prime and otherwise important farmlands have been minimized to the greatest extent practicable.

7.12.2 Port Arthur and Vicinity CSRM Plan

7.12.2.1 No Action Alternative

No prime or otherwise important farmlands are located within the proposed construction right-of-way of the existing HFP project in Jefferson County, Texas.

7.12.2.2 FWP Alternative

The Port Arthur and Vicinity CSRM Plan would have no impacts on prime and unique farmlands. Construction activities would be restricted to the existing levee system right-of-way, with the exception of a few small areas within existing industrial complexes.

7.12.3 Freeport and Vicinity CSRM Plan

7.12.3.1 No Action Alternative

No prime or otherwise important farmlands are located within the right-of-way of the existing HFP project in Brazoria County, Texas. Mapped soil units identified as prime or otherwise important farmland are present in one small area on Oyster Creek proposed for right-of-way expansion under the Freeport and Vicinity CSRM Plan. These soils are Asa silt loam and Asa silty loam (USDA 2015).

7.12.3.2 FWP Alternative

Minor impacts (less than 1 acre) on lands classified as prime farmland would occur with expansion of the right-of-way along Oyster Creek in conjunction with construction of the Freeport and Vicinity CSRM Plan. Impacts on prime and otherwise important farmlands have minimized to the greatest extent practicable.

7.13 FLOODPLAIN IMPACTS

7.13.1 EO 11988

EO 11988 (Floodplain Management) requires Federal agencies to avoid "to the extent possible the long and short-term adverse impacts associated with the occupancy and modification of floodplains and 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" for:

- Acquiring, managing, and disposing of Federal lands and facilities;
- Providing Federally undertaken, financed, or assisted construction and improvements; and
- Conducting Federal activities and programs affecting land use, including but not limited to water and related land resources planning, regulation, and licensing activities.

USACE ER 1165-2-26 contains the USACE's policy and guidance for implementing EO 11988. Per ER 1165-2-26, the USACE must first determine whether there are practicable alternatives to placing a proposed project in a floodplain. In addition, ER 1165-2-26 specifies that all reasonable factors should be taken into consideration when determining practicability. These factors are conservation, economics, visual elements, natural and beneficial values served by floodplains, impact of floods on human safety, locational advantage, the functional need for locating the development in the floodplain, historic values, fish and wildlife habitat values, endangered and threatened species, Federal and state designations of wild and scenic rivers, refuges, etc., and, in general, the needs and welfare of the people.

7.13.2 EO 11988 Eight-Step Analysis

To assist in complying with EO 11988, the USACE has issued guidance (USACE ER 1165-2-26), as it pertains to planning, design, and construction of USACE projects. The Water Resources Council Floodplain Management Guidelines for implementation of EO 11988, as referenced in USACE ER 1165-2-26, requires an eight-step process that agencies should carry out as part of their decision-making on projects that have potential impacts on, or are sited within, the floodplain. The eight steps reflect the decision-making process required in Section 2(a) of EO 11988. In order to demonstrate the Proposed Action complies with EO 11988 and to address related public safety concerns, the following documentation is provided. The existing floodplain management activities, including National Flood Insurance Program related actions and requirements are described. This is followed by a response to the eight-step process.

1. *Determine if the proposed action is in the base floodplain.*

Yes, the Proposed Action lies within the base floodplain. The proposed action includes three separate project areas. Two of the areas currently have existing hurricane flood protection systems that lie in the base floodplain. The proposed action for the third project area includes the construction of new levee and floodwalls, which will also lie in the base floodplain.

2. *If the action is in the base floodplain, identify and evaluate practicable alternatives to the action or to location of the action in base floodplain.*

Alternatives have been evaluated and not carried forward, as they were either not practicable or did not meet the goals of the Proposed Action. Coastal storm flood risks are addressed by the Proposed Action. The proposed coastal flood risk management plan is located within the base floodplain and includes modifications to two existing hurricane flood protection systems. A coastal flood risk analysis followed the "Principles and Guidelines for Water and Related Land Resources," dated March 1983, including evaluation of contributions to NED and reducing potential life-safety risk. Plan formulation and screening of plans described in this Feasibility Report, Chapter 5, is the basis for concluding there are no practicable alternatives to locating the proposed flood risk management plan in the base floodplain. The main Federal objective of reducing coastal flood risk cannot be achieved by alternatives outside the floodplain. All structural alternatives considered were located in the base floodplain.

Practicable nonstructural alternatives like flood proofing, structure relocation, permanent evacuation, and instrumentation were considered. Flood proofing, structure relocation and permanent evacuation were removed from consideration because they were not viable for broad application across the three project areas and were not economically viable.

3. State whether the proposed action would induce development in the base floodplain.

The Proposed Action would not induce development in the base floodplain. The Proposed Action would occur in areas that are highly urbanized among the three counties, all of which have substantial industrial investment. Urban development would remain on the protected side of the existing hurricane flood protection systems and on the protected sides of the proposed new levees and floodwalls. The cities of Beaumont, Port Arthur, and Freeport all participate in the National Flood Insurance Program (NFIP) which specifies how cities that participate should manage floodplain development, particularly through zoning ordinances and building codes. No indication exists that these cities have any intention of opting out of the NFIP at any point in the future.

4. Identify the impacts in the base floodplain of the proposed action and any induced development.

Impacts within the base floodplain are presented in Chapter 4. Potential impacts on the base floodplain are described for the Proposed Action. Impacts on fish and wildlife, cultural resources, recreation, and other floodplain resources are considered in the Feasibility Report. Avoidance and minimization of impacts on existing floodplain resources has been considered in the development of the Proposed Action. Most of the expected losses or impacts on existing

floodplain resources are expected to be compensated by the benefits provided by the Proposed Action. Mitigation requirements for the Proposed Action are described in Section 6.1.2.

5. Describe measures available to minimize adverse impacts on the natural and beneficial floodplain values.

Avoidance and minimization efforts for all resources are described in Section 6.1.2. A summary of the potential environmental impacts of the Proposed Action are described in Section 6.1.2. Direct impacts of the Proposed Action would affect approximately 301 acres from construction of the new levee-floodwall system, and indirect impacts of 2,551 acres of functional fisheries access to the extensive marshes in the lower Cow and Adams Bayous floodplains and to limited impacts from construction of the levee and surge gates in a few locations. In total, 140 acres of forested wetland and 2,411 acres of coastal marsh would be impacted. Mitigation would be needed to compensate for a loss of 80 AAHUs from forested wetlands and 181.7 AAHUs from coastal wetlands.

6. Describe the effect of the above topics on any reevaluation of alternatives and on the final plan selection

A re-evaluation of alternatives was not required because of considering the topics listed above. There are no remaining unmitigated adverse effects on natural and beneficial floodplain due to implementation of the Proposed Action.

7. Finding and Explanation

EO 11988 requires Federal agencies to avoid, to the extent possible, the long- and short-term adverse impacts associated with the occupancy and modification of flood plains and to avoid direct and indirect support of floodplain development wherever there is a practicable alternative. The Proposed Action does not support direct or indirect floodplain development within the base floodplain. USACE and the study's NFS have lead public outreach efforts to local communities starting with the NEPA scoping meeting, and will continue throughout the study process. These scoping meetings are described in Section 9.1. A public and agency review of the Draft Feasibility Report and EIS will be conducted and relevant public and agency comments will be considered.

8. Critical Actions

The Proposed Action is the most responsive to the planning objectives established in the Feasibility Report and is consistent with the requirements of this Executive Order. The Proposed Action is the most practicable alternative to minimize both short- and long-term adverse impacts associated with modification and occupancy of the base floodplain while maintaining the avoidance of direct and indirect development in the floodplain. The Proposed Action also seeks to minimize impacts on health and human safety and, where possible, to preserve the natural and beneficial uses of the floodplain.

7.14 SOCIOECONOMIC IMPACTS (ENVIRONMENTAL JUSTICE)

EO 12898 directs Federal agencies to determine whether the Preferred Alternative would have a disproportionate adverse impact on minority or low-income population groups within the project area. Based on the findings of an environmental justice review, presented earlier in this report, the Sabine and Brazoria TSPs would not significantly disproportionately affect low-income or minority populations.

7.14.1 No Action Alternative – All CSRM Plans

The population in Orange County within the Orange-Jefferson CSRM project area has been identified as being approximately 79 percent white in the aggregate, but with at least seven Census blocks showing populations in which minorities make up more than 50 percent. Jefferson County, for both the Orange-Jefferson CSRM project area and Port Arthur CSRM project area, by contrast has an aggregate white population of 45 percent and 20 census blocks showing minority populations over 50 percent. The population in Brazoria County for the Freeport CSRM has an aggregate racial makeup of 61 percent white and 39 percent minority. Ten Census blocks have populations that have minority populations that are over 50 percent. No evidence exists showing concentrations of low-income populations that could potentially be disproportionately impacted by a Federal action in any of the project areas for the three counties.

7.14.2 FWP Alternatives – All CSRM Plans

The proposed action for this CSRM involves the construction of new levees and floodwalls, thereby potentially impacting the population in Orange County. Based on the proposed footprint, one Census block with over 50 percent minority population would be impacted with the construction of the levee/floodwall at the Orange 3 reach. Public involvement will need to continue to ensure no disproportionate impacts occur for these residents. The other two project areas consist of existing hurricane flood protection systems where impacts from construction

activities would be less intrusive; therefore, the potential for disproportionate adverse impacts is considered to be negligible.

7.15 PROTECTION OF CHILDREN FROM ENVIRONMENTAL AND SAFETY RISKS

EO 13045 requires that Federal agencies evaluate their programs or activities to determine if they would result in disproportionate environmental health and safety risks to children. Children may be more or less sensitive than adults to equivalent levels of exposure to environmental pollutants. In addition, there may be age-related differences in types and levels of exposure.

7.15.1 No Action Alternative – All CSRM Plans

All of the CSRM project areas (Orange-Jefferson, Port Arthur and Freeport) would continue to be subject to existing and increasing future risks of storm surge impacts, and related potential impacts of petrochemical spills. These industries have emergency operating plans, which help reduce the risks of spills caused by tropical storm impacts, but impacts can occur with storms of great magnitude or when storms spin up quickly and come ashore with little advance warning. Given the high density of petrochemical industries in these areas, FWOP risks of storm surge impacts would continue to place children living in the project areas at risk to environmental pollutant exposures.

7.15.2 FWP Alternatives – All CSRM Plans

All three of the CSRM Plans would reduce potential risks to children's health and safety associated with contaminant spills resulting from storm surge impacts on industrial facilities in the project area. Children residing in Orange County and in the Port Neches and Nederland areas of Jefferson County would receive protection that does not exist at this time, and risks to residents residing within the existing Port Arthur and Freeport CSRM project areas would be reduced. Construction of the CSRM plans are not expected to increase risks to children’s health and safety.

7.16 CUMULATIVE IMPACTS

Cumulative impacts are defined in 40 CFR 1508.7 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.” Cumulative impacts for the TSP were assessed in accordance with CEQ guidance.

7.16.1 Sabine Region

7.16.1.1 Sabine Region Past or Present Actions

Past, present, and reasonably foreseeable projects/activities within the study area were compared to the TSP to determine whether the TSP, when combined with the impacts of other actions, could have cumulatively significant impacts on the environment.

Sabine-Neches Waterway 40-foot Channel. Channel and port improvements began in 1885 when Army Engineers completed construction of the east and west jetties (Alperin, 1977). Relying on an artificial channel dredged from Sabine Pass and following the western shore of Sabine Lake, the Port Arthur International Public Port was established in 1899. A 9-foot-deep canal was later dug in the Neches River from the Port Arthur Ship Channel to Beaumont in 1908. Multiple subsequent channel improvement projects have resulted in the current 40-foot mean low tide (MLT) authorized depth and a 77-mile-long channel from Port Arthur to Beaumont. In 1912, a 25-foot MLT navigation channel was constructed from the mouth of the Neches River, across the northern edge of Sabine Lake, and up the Sabine River to near the City of Orange, Texas. Also part of the SNWW, the Sabine River Channel was deepened to 30 feet MLT in 1922 and remains at that depth today.

GIWW – Texas Section, Main Channel and Tributaries. Construction of the GIWW between the Sabine River and Galveston Bay began in 1925. Originally, 9 feet MLT by 100 feet wide, it was later enlarged to its current authorized dimensions of 12 feet MLT by 125 feet. As it leaves Louisiana, the GIWW follows the Sabine River and connects with the SNWW approximately 3 miles below Orange, Texas. The GIWW then follows the Sabine River Channel and the Sabine-Neches Canal to the head of the Port Arthur Canal, where it exits the SNWW and continues westward to Galveston Bay.

Port Arthur and Vicinity HFPP. Hurricane-flood protection projects at Freeport and Port Arthur were authorized in 1962 (USACE 2005). The Port Arthur HFFP includes approximately 34.4 miles of protective works, including about 27.8 miles of earthen levees and 6.6 miles of concrete and steel sheet pile floodwalls. The system includes 12 pump stations, which remove accumulated rainfall from the protected area. The system surrounds a 60-square-mile area around Port Arthur and nearby smaller cities such as Groves, Lakeview, and Port Acres.

Port of Beaumont Intermodal Improvement Projects. Extensive capital improvements to the Port of Beaumont have recently been completed on both sides of the Neches River (Port of Beaumont 2015). A new 250-acre petroleum terminal has been constructed north of the Neches River in Orange County; intermodal connections include new roadways, ship, and barge docks. Rail lines

and storage have been expanded on both sides of the river. More than 80 acres of all-weather, open storage has been constructed south of the Port. Other Port improvements include a general cargo wharf, repairs of bulkheads and upgrades of lots, a new double layberth for military vessels and a new 90,000-square-foot transit shed in Orange County, and an extension of the main Harbor Island east wharf on the Beaumont side. A new office-building complex has been erected to house the U.S. Surface Deployment and Distribution Command's 842nd Transportation Battalion.

Various Neches River Marsh Restoration Projects. TWPD has restored large areas of marsh in the Old River and Nelda Stark units of the Lower Neches WMA with the beneficial use of dredged material (BUDM) from the SNWW. Marsh has also been created in the Rose City and Old River areas as part of mitigation for private projects or National Resource Damage Assessments. In addition, the Sabine-Neches Navigation District and USACE restored marsh in the Bessie Heights area under a Section 204 Continuing Authorities Program project. In all, hundreds of acres of marsh have been restored along the north shore of Neches River south of Interstate 10.

7.16.1.2 Sabine Region Reasonably Foreseeable Future Actions

SNWW Channel Improvement Project (48-Foot MLLW). The 48-Foot SNWW Channel Improvement Project was authorized by the 2014 Water Resources Reform and Development Act (WRRDA). The SNWW to Beaumont would be deepened to 48 feet MLLW and the Sabine Bank Channel would be extended an additional 13.2 miles into the Gulf. In addition, the Taylor Bayou channels and turning basins would be deepened and widened, and three new anchorage/turning basins would be constructed on the Neches River. Beneficial use features and mitigation measures have been developed that effectively avoid or mitigate all environmental impacts. Extensive BUDM features would be constructed with new work and maintenance material along the lower Neches River as part of this project.

Port Arthur LNG and Pipeline. Sempra LNG, through its affiliate Port Arthur LNG, L.L.C., has amended a previous proposal for a liquified natural gas (LNG) import facility to propose construction of a new natural gas liquefaction and export terminal and pipeline system in Jefferson County, Texas (Port Arthur LNG 2015). Located southwest of the junction of the GIWW and SNWW south of Port Arthur, the facility would include two liquefaction trains, a natural gas liquids (NGL) loading/unloading facility and storage area, marine berths, and three storage tanks. The project would interconnect with intra- and interstate pipelines lying north and south of this area. The project anticipates filing a final Federal Energy Regulatory Commission application in the fourth quarter of 2015. If approved, construction could begin in 2017 with the possible commencement of commercial operations in 2021.

7.16.1.3 Sabine Region Resource Impact Evaluation

Land use and cumulative environmental impacts in the Sabine Region are related historically to the development of three major industries in East Texas: commercial lumbering, shipbuilding and crude oil/petrochemical production/refining. The spread of railroads into the forests of east Texas in the last quarter of the nineteenth century spurred the growth of the commercial timber industry throughout the region, which experienced such rapid growth that by the turn of the twentieth century, logging was the primary economic activity in the Sabine Region (Texas Beyond History 2015). This changed quickly with the advent of the twentieth century. In 1901, the discovery of the Spindletop oilfield south of Beaumont stimulated the explosive growth of the oil industry, which remains a primary economic driver in the region to this day (Texas State Historical Association 2015). Storage facilities, pipelines, and major refining units were built in Beaumont, Port Arthur, and Orange; these facilities have grown and spread, generally located close to navigation channels and highways throughout the area. By 1920, most of the forests on lands acquired by the big lumber mills had been harvested, and tangled thickets of second growth hardwoods began to grow in their place. Although the majority of forested wetlands in the study area are secondary growth, many stands are mature enough that they provide medium to high habitat values. The commercial lumber industry's dominance has declined but the commercial lumber industry remains active; managed timber stands are prevalent in the area today. Construction of deep-draft navigation channels into the area by 1908 and the accessibility of timber stimulated the growth of ship building industries in Orange, which were expanded rapidly to meet demands during both world wars. This industry was a primary driver in the growth of the City of Orange and remnants remain along the Sabine River Channel.

Agricultural production, recreation and conservation areas have also influenced this area's land use history. One part of the extensive J.D. Murphree WMA is located southwest of the Port Arthur HFPP, and several units (Nelda Stark, Old River and Adams Bayou) of the Lower Neches WMA are scattered along the Neches and Sabine River bottomland areas. The Blue Elbow WMA is located in the bottomlands west of the Sabine River in the City of Orange, near Interstate 10. These state-owned lands will be protected and managed to provide fish and wildlife habitat for the foreseeable future. Agriculture, dominated by cattle grazing and rice production, is not a major economic driver in the area.

The existing SNWW 40-foot navigation project has increased salinity intrusion by providing an avenue for the salt-water wedge to travel further inland than it would have otherwise (USACE 2011). Subsidence, exacerbated by oil/gas/water withdrawal, has also led to permanent inundation and loss of forested wetlands, and smaller access canals for oil/gas exploration have opened interior marsh areas to salinity intrusion and marsh loss. Construction of PAs lining the

banks of the SNWW and construction of the GIWW have altered natural channel and overland flows, affecting freshwater recharge of large areas of interior marsh. All of these factors collectively have resulted in the widespread conversion of fresh marshes to brackish marshes, and the loss of thousands of acres of marsh in the lower reach of the Neches River.

Significant environmental impacts of public and private projects constructed after passage of NEPA have been addressed by compensation plans that mitigated impacts on the environment. Implementation of the SNWW 48-foot project would result in extensive BUDM marsh restoration in the Neches River floodplain, as will continued marsh restoration efforts by TPWD in the Lower Neches WMA.

Impacts of the TSP in the Sabine Region would not be sufficient, when combined with past, present, and reasonably foreseeable future impacts, to lead to significant degradation of the region's environment. Construction of the Port Arthur and Vicinity CSRM Plan would result in negligible environmental impacts. Direct and indirect impacts of the TSP on wetlands from construction of the Orange-Jefferson CSRM Plan would be fully mitigated with a plan that compensates for impacts on forested wetlands and marshes. Levee and culvert design would maintain future tidal connectivity, resulting in negligible impacts on floodplains both inside and outside of the levee system. Marsh mitigation efforts would complement current and future marsh restoration efforts by TPWD and USACE. The new system would have no impacts on threatened and endangered species. With the exception of fisheries access impacts on Adams and Cow Bayous, existing circulation, salinity, and sediment transport patterns would not be affected; water quality would be expected to remain generally the same. The indirect functional fisheries access impacts would be mitigated by restoration of marsh systems in the Neches bottomland outside of the levee system.

7.16.2 Brazoria Region

7.16.2.1 Brazoria Region Past or Present Actions

Freeport Harbor Jetties. The Rivers and Harbors Act (RHA) of June 14, 1880, provided for construction of jetties for controlling and improving the channel over the bar at the mouth of the Brazos River (Alperin, 1977). Currently, the jetties extend approximately 7,700 feet and 8,640 feet on the north and south sides of the channel, respectively.

GIWW Texas Section, Main Channel and Tributaries. Construction of the Federally authorized GIWW between Galveston Bay and the Brazos River began in the 1907 with a 5-foot-deep by 40-foot-wide channel (Alperin 1977). Subsequent improvements have resulted in its current

authorized dimensions of 12 feet by 125 feet. The GIWW crosses the existing Freeport Harbor Channel near Mile 1.5.

Brazos River Diversion Channel. Due to excessive siltation and flooding problems at Freeport, this project was authorized by Congress on March 3, 1925, and USACE completed the project in 1929 (Alperin, 1977). A diversion dam was constructed about 7.0 miles above the original mouth of the Brazos River and a diversion channel was excavated to reroute the Brazos River from the new dam to an outlet in the Gulf about 6.5 miles southwest of the original mouth.

Freeport Harbor Channel 45-Foot Project. Originally authorized by the Rivers and Harbors Act of 1935, the navigation channel was deepened to its existing authorized 45-foot depth in 1978. The Freeport Harbor Channel Jetty and Outer Bar channels are currently maintained by USACE to a depth of 48 feet MLT at a width of 400 feet. These existing channels are approximately 6.3 miles long. The North Jetty was relocated north of its original location as part of these improvements; approximately 3,500 feet were added onshore to protect against flanking, and it was lengthened seaward by 500 feet. The South Jetty was also rehabilitated concurrent with the North Jetty improvements.

Freeport and Vicinity HFPP. The Freeport HFPP is a Federal project authorized in 1962 (USACE 2005). Approximately 42 square miles (including areas of Freeport, Velasco, Lake Jackson, Clute, Lake Barbara, and Oyster Creek) were protected by approximately 56 miles of levees, wave barriers, floodwalls, drainage structures, pumping plants, and a vertical-lift tide gate on the navigation channel.

Bryan Mound Strategic Petroleum Reserve (SPR). Constructed in 1979, the Bryan SPR storage facility occupies 500 acres at the southeast corner of the Freeport and Vicinity HFPP, close to port and terminal facilities at Freeport and the ConocoPhillips tank farm. The site has a total DOE-authorized storage capacity of approximately 232 million barrels as part of the United States' emergency oil supply (DOE, 2004). Two principal crude oil pipelines extend from the Bryan Mound salt dome: a 4-mile, 30-inch-diameter line to the ConocoPhillips terminal and docks; and a 46-inch line to the ARCO Pipeline Company terminal in Texas City, Texas.

Freeport LNG Phase I. Freeport LNG Development, LP was permitted to construct the new Freeport LNG Import Terminal Project on Quintana Island, across the GIWW from Freeport (FERC, 2004). The project included LNG ship docking and unloading facilities with a protected single berth equipped with mooring and breasting dolphins, unloading and return arms, reconfiguration of a storm protection levee and a permanent access road, two 26-inch-diameter LNG transfer lines, one 16-inch-diameter vapor return line, and service lines, two double-walled

LNG storage tanks, ancillary utilities, buildings, and service facilities at the LNG terminal, and 9.6 miles of 36-inch-diameter natural gas pipeline extending from the LNG import terminal to a proposed Stratton Ridge Meter Station (FERC, 2004). This first phase of the Freeport LNG Project was completed in April 2008 and is currently operational.

Port Freeport - Velasco Terminal. The Velasco Terminal is a large cargo terminal improvement project under construction at Port Freeport. With a total 2,400 linear feet of new berths planned, 800 feet have been built thus far (Port Freeport, 2012). The facility is designed to handle new-generation gantry cranes and vessels up to 48-foot draft. It will handle containerized and break-bulk cargo, with 90 acres of developable land with rail access. The new 800-foot-long Berth 7 with 20 acres for containerized and/or break-bulk cargo activity has been completed.

7.16.2.2 Brazoria Region Reasonably Foreseeable Future Actions

Freeport Harbor Channel Widening Project (Widening Project). Port Freeport has obtained USACE Section 404/Section 10 permits for dredge and fill activities related to the widening of the Freeport Harbor Entrance Channel. The project site is located along the northern edge of the Freeport Harbor Jetty and Outer Bar channels. These are currently maintained by the USACE to a depth of 48 feet MLT and approximate length of 6.3 miles. The project would widen, but not deepen, the Jetty and Outer Bar Channels an additional 150 to 200 feet. The length of channel that is proposed for widening is 6.1 miles, of which 5.7 miles will be widened by 200 feet. Approximately 300,000 CY of silty/sand construction material will be used beneficially to nourish Quintana Beach.

Freeport Harbor Channel Improvement Project (Deepening Project) and General Reevaluation Report. Authorized by WRRDA 2014, the Freeport Harbor CIP would deepen the Outer Bar Channel from the Gulf of Mexico to 58 feet MLLW; deepen the Jetty Channel through the Lower Turning Basin to 56 MLLW; deepen the Main Channel from the Lower Turning Basin to the Brazosport Turning Basin to 56 feet MLLW; deepen through the Upper Turning Basin to 51 feet MLLW; deepen and widen the lower 3,700 feet of the Stauffer Channel at a depth of 51 feet MLLW and width of 300 feet; and dredge the remainder of the Stauffer Channel to a depth of 26 feet MLLW. Mitigation measures have been developed to compensate for all unavoidable environmental impacts. A General Reevaluation Report is currently underway to reanalyze the completed study in response to changed conditions and assumptions. Completion of the Director's Report is currently scheduled for October 2016.

Freeport LNG Phase II. In July 2014, FERC authorized Freeport LNG Development, L.P. to site, construct and operate facilities to liquefy and export domestic natural gas from its existing LNG import terminal near Freeport, Texas (FERC 2014). In addition, FERC authorized Freeport

LNG's Phase II Modification Project that will revamp the previously authorized but unconstructed Phase II Project. The Phase II Modification Project comprises three major components: reorientation of the Phase II dock, modification of the transfer facilities, and modification of access roads to the terminal.

7.16.2.3 Brazoria Region Resource Impact Evaluation

Historical land use and cumulative environmental impacts in the study area are dominated by the growth of petro-chemical, LNG, and other industrial facilities. This growth has been facilitated by the growth of the deep-draft port and shallow-draft navigation channels in the study area. Significant environmental impacts of public and private projects constructed after passage of NEPA have been addressed by compensation plans that mitigated impacts on the environment. The petro-chemical and other shipping-dependent industries, as well as recreation and conservation areas (NWRs, State Parks, State Historic Sites, and WMAs), have influenced this area's land use history, navigation channel development and maintenance, coastal transportation trends, and regional economic significance. Older projects and, in particular, the Brazos River Diversion Channel and the GIWW have modified the natural hydrology, changing tidal circulation, freshwater flows, and sedimentation patterns in significant ways.

Construction of the Brazos River Diversion Channel left the existing Freeport Harbor Channel navigation channel as a dead-end channel in the bed of the Old Brazos River channel, extending from the Gulf to a dam near State Highway 288. This segment of the Freeport Harbor Channel is relatively low in biological productivity and largely devoid of natural habitats. Existing vegetation is sparsely distributed, and no significant or sensitive terrestrial or aquatic habitats exist within or along the project area. The navigation channel is heavily developed with industrial and commercial properties, including petrochemical manufacturing, storage terminals, warehousing, and related businesses. The extensive levee system of the Freeport and Vicinities HFPP lines most of the waterways in this system and prevents sheetflow from the entering the channel. Despite these modifications, water quality in the navigation channel system is generally good, although salinities approach Gulf levels because of proximity to the Gulf and lack of freshwater inflows.

The heavy sediment load of the Brazos River, which once nourished the Old Brazos River delta, is now being diverted through the Brazos River Diversion Channel to a point about 6 miles southwest of the old delta. Without this sediment source, the Old Brazos River delta is collapsing and is no longer serving as a nearshore sand source for nearby beaches, contributing to Gulf shoreline erosion in the area (Watson 2003). The Freeport Jetties and the offshore portion of the Freeport Harbor Navigation Channel also contribute to shoreline erosion by blocking or traping longshore sediment transport along the Gulf shoreline.

The landlocked GIWW was constructed generally parallel to and inland of the Gulf shoreline to provide a protected channel for coastwide shallow draft navigation. It intersects the Freeport Harbor Navigation Channel (the Old Brazos River Channel) and the Brazos River Diversion Channel, as well as many other natural rivers near their debouchment into the Gulf. Freshwater flows from the river systems and tidal inflows divert into the GIWW, disrupting normal circulation and salinity patterns in the area near the GIWW and the Gulf shoreline.

Recreation and conservation areas (NWRs, State Parks, and WMAs), have influenced this area's land use history as well. The Brazoria and San Bernard NWR's border the Brazoria study area to the northeast and southwest of the project area. The Justin Hurst WMA and Quintanna State Park are located along the Gulf shore, outside of the project area. These Federally and state-owned lands will be protected and managed to provide fish and wildlife habitat for the foreseeable future.

Impacts of the TSP in the Brazoria Region would not be sufficient, when combined with past, present and reasonably foreseeable future impacts, to lead to significant degradation of the region's environment. TSP modifications to the existing Freeport HFPP proposed as part of the Freeport and Vicinity CSRM Plan would have negligible environmental impacts. Modifications to the levee system would occur primarily within the existing, disturbed right-of-way. Minor impacts on an upland forested area along Oyster Creek, where a small increase in right-of-way is needed, would be negligible. No impacts on wetlands are anticipated. Existing circulation, salinity, and sediment transport patterns would not be affected; water quality would be expected to remain generally the same. No impacts on fish and wildlife, threatened or endangered species, or essential fish habitat are anticipated.

7.17 ANY ADVERSE ENVIRONMENTAL IMPACTS THAT CANNOT BE AVOIDED SHOULD THE TSP BE IMPLEMENTED

The TSP would result in minor direct adverse impacts on benthos from construction of surge gates in Cow and Adams Bayous, but these impacts will be temporary. The same gate structures would also result in minor functional impacts on fisheries access in these bayous. Construction of the new Orange-Jefferson CSRM Plan would result in the loss of about 359 acres of marshes and forested wetlands. In addition, approximately 178 acres of soil units mapped as prime farmland would no longer be available for agricultural use. No other long-term environmental impacts are expected to occur as a result of the TSP.

7.18 ANY IRREVERSIBLE OR IRRETRIEVABLE COMMITMENTS OF RESOURCES INVOLVED IN THE IMPLEMENTATION OF THE TSP

The labor, capital, and material resources expended in the planning and construction of this project are irreversible and irretrievable commitments of human, economic, and natural resources. Approximately 359 acres of marsh and forested wetlands would be lost from construction proposed improvements, but these losses would be fully compensated with in-kind mitigation. Another resource that would be irretrievably committed to construct the proposed project is the approximate 178 acres of prime farmland that would no longer be available for agricultural use following construction of the new Orange-Jefferson CSRM Plan.

7.19 RELATIONSHIP BETWEEN LOCAL SHORT-TERM USES OF MAN'S ENVIRONMENT AND THE MAINTENANCE AND ENHANCEMENT OF LONG-TERM PRODUCTIVITY

The construction of the TSP would result in the loss of 359 acres of wetlands. These impacts would be fully mitigated in the same general area, resulting in no net loss of wetlands and preservation of the areas long-term productivity. New levee system construction would permanently impact approximately 178 acres, which are categorized as prime farmland, from potential future agricultural use. However, it is unlikely that the area would be used for agriculture because it is located along the margin of developed uplands.

7.20 ENERGY AND NATURAL OR DEPLETABLE RESOURCE REQUIREMENTS AND CONSERVATION POTENTIAL OF VARIOUS ALTERNATIVES AND MITIGATION MEASURES

NEPA regulations in 40 CFR 1502.16 (e) and (f) require a discussion of project energy requirements and natural or depletable resource requirements, along with conservation potential of alternatives and mitigation measures in an EIS. Energy (fuel) will be required to construct the new levee system and reconstruct existing systems, but this is a short-term impact. Construction of the TSP would not result in a significant depletion of depletable energy or natural resources. They would, however, reduce the risk of serious disruptions in the Nation's energy and petrochemical supplies by reducing storm surge impacts on areas with a high density of large petrochemical facilities

8 IMPLEMENTATION REQUIREMENTS

This chapter provides a summary of the implementation requirements for the project in a preliminary format. The Final Integrated Feasibility Report and Environmental Impact Statement (FIFR-EIS) will provide additional implementation requirements.

8.1 DIVISION OF PLAN RESPONSIBILITIES AND COST-SHARING REQUIREMENTS

The Project Partnership Agreement (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 sponsors must agree to meet the requirements for non-Federal responsibilities, which will be identified in future legal documents. Some of the likely responsibilities are:

- Provide a minimum of 35 percent, but not to exceed 50 percent, of total flood risk management costs attributable to the structural alternative as further specified below:
  1. Pay, during design, 35 percent of design costs in accordance with the terms of a design agreement entered into prior to commencement of design work for the project;
  2. Pay, during construction, 5 percent of total flood risk management costs attributable to the structural alternative;
  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 LERRDs 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 project; and

- Pay, during construction, any additional funds necessary to make its total contribution equal to at least 35 percent of total flood risk management costs. Shall not use funds from other Federal programs, including any non-Federal contribution required as a matching share, to meet any of the non-Federal obligations for the project unless the Federal agency providing the Federal portion of such funds verifies in writing that expenditure of such funds for such purpose is authorized;
- Not less than once each year, inform affected interests of the extent of protection afforded by the project;

- Agree to participate in and comply with applicable Federal floodplain management and flood insurance programs;
- Comply with Section 402 of the WRDA of 1986, as amended (33 U.S.C. 701b-12), which requires a non-Federal interest to prepare a floodplain management plan within one year after the date of signing a project cooperation agreement, and to implement such plan not later than one year after completion of construction of the project;
- Publicize floodplain information in the area concerned and provide this information to zoning and other regulatory agencies for their use in adopting regulations, or taking other actions, to prevent unwise future development and to ensure compatibility with protection levels provided by the project;
- 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 level of protection the project affords, hinder operation and maintenance of the project, or interfere with the project's proper function;
- 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;
- For so long as the project remains authorized, operate, maintain, repair, rehabilitate, and replace the project, or functional portions of the project, including any mitigation features, 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;
- 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;
- Hold and save the U.S. 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 U.S. or its contractors;

- 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 CFR Section 33.20;
- 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.);
- 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;
- 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;
- 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

- 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 WRDA 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.

8.2 COST FOR THE RECOMMENDED PLAN

The cost estimate included here is intended to provide an estimate of total costs of the TSP. An MCACES cost estimate will be provided for the plan selected for feasibility-level design. The TSP cost is included in Table 8-1.

Table 8-1: Estimate of Total Costs of the TSP

Recommended Plan Feature	Cost Estimate
Orange-Jefferson CSRM Plan	
Orange 3 New Levee (11-foot)	$246,811,000
Jefferson Main New Levee (11-foot)	$65,726,000
Beaumont A New Levee (12-foot)	$70,202,000
Subtotal	$382,739,000
Port Arthur and Vicinity CSRM Plan	
8-10 ft I-Wall Raise (1-Foot)	$8,915,000
Closure Structure Raise (1-Foot)	$10,654,000
I-Wall Near Valero (1-Foot)	$8,948,000
I-Wall Near Tank Farm (1-Foot)	$4,627,000
Subtotal	$33,144,000
Freeport and Vicinity CSRM Plan	
DOW Barge Canal Gate Structure	$130,000,000
Oyster Creek Levee Raise (1-Foot)	$4,869,000
East Storm Levee Raise (1-Foot)	$6,530,000
Freeport Dock Floodwall Raise (1-Foot)	$2,850,000
Old River Levee Raise at DOW Thumb (1-Foot)	$8,294,000
Tide Gate I-Wall Raise (1-Foot)	$3,800,000
Subtotal	$156,343,000
Total	$572,226,000

8.3 COST-SHARING APPORTIONMENT

Once an MCACES cost estimate is developed for the plan carried forward for feasibility-level design, a cost-sharing apportionment table will be developed.

8.4 VIEWS OF NON-FEDERAL SPONSOR AND OTHERS

The existing Port Arthur and the Freeport HFPPs local sponsors have expressed interest in cost sharing for the TSP identified for the Port Arthur and Vicinity CSRM and the Freeport and Vicinity CSRM. The local sponsors responsible for operation and maintenance are the Jefferson County Drainage District No. 7 and the Velasco Drainage District (VDD), respectively. The local sponsor for Orange-Jefferson CSRM would be Orange County and Jefferson County. They have also expressed interest in cost sharing for construction.

8.5 TSP AND RECENT USACE INITIATIVES

8.5.1 USACE Campaign Plan

The TSP addresses the Chief of Engineers Campaign Plan Goal 2: Deliver enduring and essential water resource solutions using effective transformation strategies.

Objective 2a: Modernize the Civil Works project planning program and process. This DIFR-EIS contributes to the objective defined within Goal 2. This report recommends specific solutions to water resource problems and opportunities based on risk-informed decisions. It was developed in close collaboration with stakeholders and partners. The SMART planning principles and risk-informed decision-making were applied in this study and the study complies with the 3x3x3 Rule, which establishes the timeframe and costs required to complete the study.

Objective 2c: Deliver quality solutions and services. This objective is measured by successfully meeting or exceeding established commitments for schedule, cost, and quality to ensure consistent, high-quality performance. The cost estimate for the TSP has not been developed at this point in the study. When the cost estimate is developed, a Cost and Schedule Risk Analysis and a Risk Management Plan will be performed/developed to ensure the authorized cost limits are set and cost risks are managed.

8.5.2 Environmental Operating Principles

Environmental consequences of construction and operation of the TSP have been considered in avoiding and minimizing impacts; remaining unavoidable impacts would be fully mitigated. Sustainability was an integral consideration in the development of flood risk reduction

recommendations. A risk management and systems approach was developed with input from the USACE Risk Management Center and the Flood Risk Management Planning Center of Expertise; operation of the projects will also employ a risk management approach. Coordination with stakeholders and the general public began with four public scoping meetings, continued with stakeholder updates, and extensive resource agency input during impact modeling. Resource agency knowledge and evaluation methods developed for similar projects were applied in the impact analysis. A thorough NEPA and engineering analysis has ensured that we will meet our corporate responsibility and accountability for actions that may impact human and natural environments in the Sabine and Brazoria regions. This analysis will be transparent and communicated to all individuals and groups interested in USACE activities.

9 PUBLIC INVOLVEMENT

9.1 PUBLIC INVOLVEMENT ACTIVITIES

Extensive public scoping, stakeholder communication, and resource agency coordination were maintained throughout development of the TSP. Four scoping meetings were held in early 2012, which resulted in the identification of over 250 ideas addressing CSRM problems and ER opportunities in the six-county study area. The February 6, 2012, invitation to participate in meetings held in Beaumont, Seabrook, Galveston and Freeport, Texas, was published in local newspapers and on the USACE-Galveston District website, in addition to an extensive public mailing.

Two stakeholder briefings were held in the spring of 2014 that focused primarily on communicating the goals and progress of the study with local governments and agencies. Continuous contact has been maintained with outside organizations that have been working to address the same problems as those addressed by this study. In particular, close communication has been maintained with the team at Texas A&M Galveston, which has been working to develop the Ike Dike proposal, the Severe Storm Prediction, Education and Evacuation from Disasters Center (a consortium of several universities headquartered at Rice University in Houston), which has been assessing a number of other CSRM, ER, and recreation initiatives for the Galveston Bay region, and the Gulf Coast Community Protection and Restoration District, which is preparing a report evaluating CSRM opportunities in the six-county study area.

USACE published the Notice of Intent (NOI) to prepare an EIS in the Federal Register on November 24, 2014. Written comments were accepted for a 30-day period following that notice. In total, about 20 written comments were received following the public meetings and NOI. The NOI and comments are presented in Appendix F. Comments made at the public meetings and in the written comments are summarized below.

The majority of the original public and agency comments received pertained to the Galveston Bay Region and to ER opportunities in general. The Audubon Society expressed concerns regarding Colonial Waterbird rookeries and piping plover critical habitat areas. Several rookery and critical habitat areas are within the project area, which provide nesting and feeding habitat, and are currently subject to erosion from storm damage, ship traffic and sand mining activities. The Port of Houston Authority (PHA) advised that solutions will need to reflect industry participation or sponsorship of projects, considering that public and private interests coexist along the coast. The feasibility of structural solutions on the Houston Ship Channel (HSC) need to be considered prior to implementation, as most of the current transportation systems that serve

the HSC cannot appropriately accommodate proposed flood control structures without causing a disruption in the transportation of commerce. The City of Galveston and the general public also expressed interest in public and private partnerships, which can reduce the financial burden on taxpayers. The City of Galveston recommended that a sediment management plan be considered that encourages beneficial use of dredge materials for public and private projects such as beach preservation, beach nourishment, and establishment of a natural sand dune defense system. Local citizens and municipalities would also like to see conservation and enhancement of wetlands, in combination with responsible development, to prevent and mitigate impacts from severe weather and flood damage, specifically on Bolivar Peninsula and west end of Galveston Island. Multiple comments referenced flood control projects, greenspace, and conservation areas as practicable and effective examples.

In the Sabine region, Orange County expressed strong support for an evaluation of surge protection for that county, including protection for Chemical Row and the Entergy Power Plant. USACE was urged to evaluate levee and surge gate alternatives, and to utilize the Orange County Study, which evaluated several potential alternatives. Industrial facilities and the general public emphasized the need to protect petro-chemical facilities in the area, one of which is the largest refinery in the U.S. The general public was also concerned about maintaining or improving evacuation routes during storm emergencies. Jefferson County and Ducks Unlimited supported shoreline erosion control for the GIWW; this would prevent the loss of interior marshes that serve as storm buffers for inland communities. Comments from resource agencies focused on the need for marsh restoration on the lower Neches River and marshes near Sabine Pass, and dune and shoreline restoration of the Jefferson county shoreline, again as a means for buffering surge impacts. GIWW erosion, marsh, dune, and shoreline restoration will be addressed as part of the new Jefferson County ER study.

In the Brazoria region, the local sponsor of the Freeport Hurricane Flood Protection Project (HFPP) supported evaluation of storm surge impacts on the existing system. This would strengthen existing protection of the dense petrochemical and residential development within the Freeport HFPP. Maintaining or improving evacuation routes were important to local citizens. Local interest groups and the general public expressed concern with maintaining a tidal connection with the Gulf at the San Bernard River, and the effect of altered circulation created by the GIWW intersection with the Brazos River Diversion Channel. Local citizens also expressed concern regarding the effect of the Brazos River Diversion Channel on sediment delivery to the Surfside area. Beach restoration in the Surfside area would protect nearby residences and help attenuate storm surge. Resource agencies recommended restoration of Follets Island, a barrier peninsula, as a means of buffering storm surge impacts on the Freeport

mainland. Tidal circulation, sediment supply, and beach and marsh restoration will be addressed as part of the upcoming Coastal Texas study.

The Sierra Club provided comprehensive comments, which applied to the six-county study area. In general, they urged restoring natural coastal shoreline system features and urged restraint in the construction of structural systems that would encourage more development. They supported structural measures that are limited in size and focused on vulnerable, developed areas, and recommended targeted buyouts rather than structural alternatives in areas such as Surfside in the Brazoria Region. They urged working with nature and natural processes, as well as protecting shoreline features that provide natural erosion protection.

The DIFR-EIS will be released for public review and comment. All comments received and USACE responses will be included in the Final IFR-EIS.

9.2 DISTRIBUTION LIST*

A list of all Federal and state legislative representatives, agencies, organizations, and persons to whom the notice of availability will be sent is presented as Appendix T. Names shown in all caps are owners of properties that are in or adjacent to the Orange-Jefferson CSRM Plan right-of way or adjacent to the existing Port Arthur and Freeport and Vicinities CSRM Plan alignments.

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10 RECOMMENDATIONS

10.1 OVERVIEW

A diligent effort was made to coordinate and collaborate with resource agencies, local industry, and environmental interests throughout the study process and public meetings. Environmental resource concerns were addressed early in the study process to assure that adverse impacts were avoided to the maximum extent practicable. The recommendations contained herein reflect the information available at this time. To ensure the TSP complies with all applicable laws and policies and is acceptable to the public, this DIFR-EIS will undergo public, policy, and technical review. The study team will address any outstanding issues raised during the review and confirm the analysis in this DIFR-EIS and recommendations to move forward with development of the feasibility-level design and completion of a FIFR-EIS.

10.2 RECOMMENDATION

The recommendations contained herein reflect the information available at this time and current Departmental policies governing formulation of individual projects. They do not reflect program and budgeting priorities inherent in the formulation of a national Civil Works construction program nor the perspective of higher review levels with the Executive Branch. Consequently, the recommendations may be modified before they are transmitted to the Congress as proposals for authorizations and implementation funding. However, prior to transmittal to the Congress, the non-Federal sponsor, the state, interested Federal agencies, and other parties will be advised of any modifications and will be afforded an opportunity to comment further.

_____ _____

Date

Richard P. Pannell
Colonel, Corps of Engineers
District Engineer

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