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

APPENDIX K

FISH AND WILDLIFE COORDINATION ACT
FINAL COORDINATION ACTION REPORT

May 2017

United States Department of the Interior

FISH AND WILDLIFE SERVICE

Texas Coastal Ecological Services Field Office
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Houston, Texas 77058
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In Reply Refer To:
FWS/R2/02ETT
X00-2015-B-
0004

August 18, 2016

Colonel Lars Zetterstrom
US Army Corps of Engineers
Attention: Ms. Janelle Stokes
Environmental Compliance Branch, Coastal Section
PO Box 1229
Galveston, TX 77553-1229

Dear Colonel Zetterstrom:

Based on input from your review of the Service's draft report dated August 9, 2016, please find attached the final Fish and Wildlife Coordination Act Report for the Sabine Pass to Galveston Coastal Storm Risk Management and Ecosystem Restoration Study located in Orange, Jefferson, Chambers, Galveston, Harris, and Brazoria counties, Texas. This project was initiated by the Galveston District Corps of Engineers (Corps) to address storm risk problems in the Galveston Region and ecological restoration opportunities for the entire six county study areas. The purposes of this report are to identify and describe existing fish and wildlife resources within the proposed project areas; evaluate and compare currently proposed alternatives; identify modifications or additional alternatives needed to address fish and wildlife related problems, opportunities, and planning objectives; and to recommend preliminary measures for resource protection during early project planning.

The proposed protection was authorized by a resolution from the Committee on Environmental and Public Works, dated June 23, 2004, entitled "Coastal Texas Protection and Restoration Study". The U.S. Senate directed the Army to 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 and transport along the Texas coast, restoring and preserving marsh and wetlands, improving water quality, and other related purposes to the interrelated coastal ecosystem along Texas. As a result of this resolution, the Corps expects this study to culminate in a detailed report outlining several alternatives for hurricane flood protection. Procedurally, project construction is not authorized, however; attached is the report from the Secretary of the Interior as required by Section 2(b) of the Fish and Wildlife Coordination Act (FWCA) (48 Stat. 401, as amended; 16 U.S.C. 661 et. seq.). The FWCA requires that the Section 2 (b) report be made an integral part of any report regarding further project authorization or administrative approval.

Additional Service involvement for subsequent detailed planning, engineering, design, and construction phases of each planning effort, is required to fulfill our responsibilities under the

FWCA. The Service recommends the Corps reinitiate coordination when project funding is made available.

We appreciate the opportunity to participate in the planning of this project. If you have any questions or comments concerning this report, please contact staff biologist Donna L. Anderson at (281) 286-8282.

Sincerely,

For.

Chuck Ardizzone
Project Leader
Texas Coastal Ecological Services Office

SABINE PASS TO GALVESTON COASTAL STORM RISK MANAGEMENT AND ECOSYSTEM RESTORATION STUDY IN ORANGE, JEFFERSON, CHAMBERS, GALVESTON, HARRIS, AND BRAZORIA COUNTIES, TEXAS

Submitted to:
Galveston District
U.S. Army Corps of Engineers

Prepared by:
Texas Coastal Ecological Services Field Office
Houston, Texas

Reviewed by:
Chuck Ardizzone
Project Leader

U.S. Fish and Wildlife Service
Region 2
Albuquerque, New Mexico
August 18, 2016

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Executive Summary

This report provides planning assistance on the proposed Sabine Pass to Galveston Coastal Storm Risk Management and Ecosystem Restoration Study located in Orange, Jefferson, Chambers, Galveston, Harris, and Brazoria counties. This project was initiated by the Galveston District Corps of Engineers (Corps) to address storm risk problems in the Galveston Region and ecological restoration opportunities for the entire six county study area. The study focuses on the non-structural and structural alternatives: 1) reevaluation of the existing Hurricane Flood Protection (HFP) project at Freeport 2) reevaluation of existing HFP at Port Arthur; and 3) evaluation of a new levee system along the lower Neches and Sabine Rivers in the vicinity of Beaumont and Orange, Texas. The Corps assumes that construction activities needed to provide improvements to the existing Freeport and Port Arthur Hurricane Flood Protection systems will occur within existing right-of-ways with no wetland impacts expected. To construct the full project as proposed under the intermediate Relative Sea Level Rise scenario (most likely the alternative to be proposed by the Corp), the Corps estimates the TSP would indirectly impact an estimated 2,137.2 acres of fresh, intermediate, and brackish marsh, 12.7 acres of bottomland hardwoods, and 1.9 acres of forested swamplands. Direct impacts total 44.3 acres of bottomland hardwoods, 10.6 acres of swamplands, and 105.3 acres of fresh, intermediate, and brackish marsh. Both impact acreage amounts are estimated and are considered worst case scenario.

The proposed protection was authorized by a resolution from the Committee on Environmental and Public Works, dated June 23, 2004, entitled "Coastal Texas Protection and Restoration Study". The U.S. Senate directed the Corps to develop a comprehensive plan along coastal Texas for the purposes of shoreline erosion and coastal storm damages, providing for environmental restoration and protection, increasing natural sediment supply to coastal shorelines, restoring and preserving marshes and wetlands, improving water quality, and other related purposes to the interrelated ecosystem along the coastal Texas area. As a result of this resolution, the Corps expects this study to culminate in a detailed report outlining several alternatives for hurricane flood protection. Procedurally, project construction is not authorized, however attached is the report of the Secretary of the Interior required by Section 2(b) of the Fish and Wildlife Coordination Act (FWCA) (48 Stat. 401, as amended; 16 U.S.C. 661 et. seq.). The FWCA requires that Section 2 (b) report be made an integral part of any report supporting further project authorization or administrative approval.

The Service understands the study, TSP, and Recommend Plans are subject to future Congressional approval and funding. We anticipate additional Service involvement for subsequent detailed planning, engineering, design, and construction phases of each planning effort and are required to fulfill our responsibilities under the FWCA. The Service recommends the Corps reinitiate coordination under a separate FWCA agreement when project funding is made available where a thorough review of the project footprint and impacts will be conducted.

This report was not reviewed by the Texas Parks and Wildlife Department (TPWD), National Marine Fisheries Service (NMFS), National Resource Conservation Service (NRCS); however, their comments on this report will be provided under separate cover.

The Service does not object to providing greater flood reduction and improved hurricane protection to a six county area provided the following fish and wildlife recommendations are incorporated into future project planning and implementation:

1. Situate flood protection features so that destruction of wetlands and non-wet bottomland hardwood forests are avoided or minimized to the maximum extent practicable. The Corps shall fully compensate for any unavoidable losses of wetland habitat or non-wet bottomland hardwoods caused by project features.

2. Minimize enclosure of wetlands with levee alignments. When enclosing wetlands is unavoidable, establish non-development easements directly adjacent to those wetlands, or maintain hydrologic connections with adjacent, un-enclosed wetlands to minimize secondary impacts from development and hydrologic alteration.

3. Avoid adverse impacts to bald eagle nesting locations and wading bird colonies through careful design protection features and timing of construction. The National Bald and Golden Eagle Management Guidelines are included.

4. Forest clearing associated with project features should be conducted during the fall or winter to minimize impacts to nesting migratory birds, when practicable. The Migratory Bird Treaty Act (MBTA) protects all native migratory birds and prohibits the taking, killing, possession, and transportation (among other actions) of migratory birds, their eggs, and parts, except when specifically permitted by regulations of specific intentional uses. A list of birds protected under the MBTA can be found in 50 CFR 10 of the MBTA and at http://www.fws.gov/migratorybirds/regulationspolicies/mbta/mbtandtx.html.

5. A complete mitigation plan to compensate for direct and indirect habitat impacts should be developed in consultation with the Service and other state and federal natural resource agencies during final feasibility planning and presented in the Final IFR-EIS. The Final IFR-EIS should specify the mitigation plan that will be implemented concurrently with project construction. The Service understands the scale of the mitigation and levee construction features of this project and the time required for beneficial use projects to be completed. The Corp should complete initial construction of mitigation features at any given mitigation use site within two years and additional features (channel and pond construction) to be completed as soon as possible.

6. The project's first Project Cooperation Agreement (or similar document) should include language that includes the responsibility of the local-cost sharer to provide operational and construction monitoring, and maintenance funds for mitigation features. Acquisition, habitat development, maintenance, site protection, and management of mitigation lands should be allocated as first-cost expenses of the project, and the local project-sponsor should be responsible for operational costs. If the local project-sponsor is unable to fulfill the financial mitigation requirements for operation, then the Corps should provide the necessary funding to ensure mitigation obligations are met and maintained on behalf of the public interest.

7. Further detailed planning of project features (e.g. Design Documentation Report, Engineering Documentation Report, Plans and Specifications, or other similar documents) should be coordinated with the Service, NMFS, TPWD, NRCS, Environmental Protection Agency (EPA), Texas Commission of Environmental Quality (TCEQ), and the Texas General Land Office (TGLO). The Service shall be provided 30 days to review and submit recommendations on all the work addressed in those reports.

8. The Corps should avoid impacts to state and federal lands. If not feasible, the Corps should establish and continue coordination with state and federal agencies managing lands that may be impacted by a project feature until construction of that feature is complete and prior to any subsequent maintenance. Points of contact for the agencies potential impacts by project features are:

- Texas Chenier Plain National Wildlife Refuges Complex (979) 267-3337
- McFaddin National Wildlife Refuge Manager (979) 971-2909
- J.D. Murphree Wildlife Management Area Manager (979) 736-2551
- Pineywoods Ecosystems Project Manager (936) 569-8547

9. If mitigation lands are purchased for inclusion within a National Wildlife Refuge (NWR), those lands must meet certain requirements; a general summary of some of the requirements is provided in Appendix A. However, prior coordination with the Service's Region 2 Regional Office should be conducted early in the process to gauge the feasibility of such inclusion activities. Other land-managing natural resource agencies may have similar requirements that must be met prior to accepting mitigation lands; therefore agency representatives should be contacted early in the planning phase regarding such requirements.

10. If applicable, a General Plan should be developed by the Corps, through coordination with the Service, and the natural resource agencies in accordance with Section 3(b) of the FWCA for mitigation lands.

11. If the proposed project features change, the status of species change, or the project is not implemented within three years of the date of our Endangered Species Act coordination, we recommend that the Corps reevaluate the project's effects and species status and initiate any necessary consultation procedures pursuant to Section 7 of the Endangered Species Act.

12. In general, the Corps should incorporate larger, numerous openings within a diversity of locations in a protection levee aimed at maintaining estuarine dependent fishery migration.

13. Flood protection water control structures in any watercourse should maintain pre-project width and depth to the maximum extent practicable, especially structures located in tidal passes.

14. To the extent possible given any authorized channel dimensions, any flood protection water control structure sited in canals, bayous, or navigation channels that do not maintain the pre-project cross section should be designed and operated with multiple

openings within the structure. This should include openings near both sides of the channel as well as an opening in the center that extends to the bottom of the channel.

15. Should final surge gate structure designs reduce the cross section of Adams or Cow Bayous more than 50 percent, additional modeling and environmental analysis will be performed to characterize potential hydrologic and fish passage impacts and determine additional mitigation requirements.

16. Flood protection surge gates, sluice gates, culverts, and any other water control structures should remain completely open except during storm events or regularly scheduled maintenance or inspections (See Appendix C). Operation, maintenance, and management plans for structures should be developed in coordination with the Service, NMFS, TPWD, TCEQ, and TGLO.

17. The operation and maintenance plan for the gates and water control structures has not yet been developed. This plan should include a schedule of maintenance events for each gate and culvert and proposed closure times for said maintenance activities. A worst case closure scenario is estimated to be 5-7 days every 10-15 years based on predicted storm surge return intervals high enough to threaten areas targeted for protection. However, in years where more than one storm event occurs, we expect the gates to remain closed (an estimated 5-7 days) for **each** storm event. Periodic maintenance of the gates and culverts (not included in the worst case scenario) may result in additional closures estimated of not more than two weeks for each instance. Therefore, it is assumed by the Corps and representative from the natural resource agencies that closure of the surge gates, sluice gates, and culverts would cause only minor and temporary impacts to fish access and coastal marsh, and no additional mitigation would be needed to offset operational impacts. Any proposed operational deviation from the estimated frequency or duration of structure closures must be assessed in coordination with the Service, NMFS, TPWD, TCEQ, and TGLO at which time additional mitigation would be required to offset such operational impacts.

18. The number and siting of openings in flood protections levees should be optimized to minimize the migratory distance from the opening to enclosed wetland habitats.

19. Flood protection structures within a waterway should include shoreline baffles and or ramps (e.g., rock rubble, articulated concrete mat) that slope up to the structure invert to enhance organism passage. Various ramp designs should be considered and coordinated with various resources agencies for review and comment.

20. To the maximum extent practicable, structures should be designed and/or selected and installed such that average flow velocities during peak flood or ebb tides do not exceed 2.6 feet per second. However, this may not necessarily be applicable to tidal passes or other similar major exchange points.

21. To the maximum extent practicable, sluice gates or culverts (round or box) should be designed, selected, and installed such that the invert elevation is equal to the existing water depth (See Appendix C). The size of the sluice gates or culverts should be selected that would maintain sufficient flow to prevent siltation.

22. Temporary culverts or sluice gates should be installed in construction access roads unless otherwise recommended by the natural resource agencies. We expect these culverts to minimize hydrologic isolation within wetlands and marshes in the area by maintaining hydrologic flows across the landscape to the maximum extent possible. At a minimum, there should be one; 24-inch culvert or sluice gate placed every 500 feet and one at natural stream crossings. If the depth of water crossings allow, larger sized culverts should be used. Culvert spacing should be optimized on a case-by-case basis. A culvert may be necessary if the road is less than 500-feet long and an area would be hydrologically isolated without that culvert.

23. Water control structures should be designed to allow rapid opening in the absence of an off-site power source after a storm passes and water levels return to normal.

24. Levee alignment and water control structure alternatives should be selected to avoid the need for fishery organisms to pass through multiple structures (i.e., structures behind structures) to access an area.

25. Operational plans for water control structures should be developed to maximize the cross-sectional area open for as long as possible.

26. Any proposed change in mitigation features or plans should be coordinated in advance with the Service, NMFS, EPA, TPWD, TCRQ, and TGLO.

27. A report documenting the status of mitigation implementation and maintenance should be prepared every three years by the managing agency and provided to the Corps, the Service, NMFS, EPA, TPWD, TCEQ, and TGLO. That report should also describe future management activities and identify and propose changes to the existing management plan.

28. Fill material used during the construction of the levees or its associated features should come from an approved upland borrow source permitted by the State and testing should comply with TCEQ criteria. The Environmental Protection Agency (EPA)/Corps Inland Testing Manual criteria would apply to dredge material used for marsh restoration at mitigation sites.

29. The Corps shall fully compensate for any unavoidable losses of wetland habitat (including forested wetlands) or non-wet bottom hardwoods caused by project features as dictated by the Wetland Value Assessment modeling.

30. Acquisition, habitat development, maintenance, and management of mitigation lands should be allocated as a first-cost expense of the project to ensure mitigation obligations are met on behalf of the public interest.

Introduction

This final report provides planning assistance on the proposed Sabine Pass to Galveston, Texas Coastal Storm Risk Management (CRSM) and Ecosystem Restoration (ER) Study located in Orange, Jefferson, Chambers, Galveston, Harris, and Brazoria counties (Figure 1). The CRSM study, initiated by the Galveston District Corps of Engineers (Corps), addresses storm risk concerns in the Galveston Region; specifically a reevaluation of existing Freeport and Port Arthur hurricane flood protection systems and the evaluation of new CRSM alternatives for Orange and northeast Jefferson Counties. This study incorporates programmatic recommendation for future Galveston Bay CRSM and ER for all four regions along the Texas coast. The purposes of this report are to identify and describe existing fish and wildlife resources within the proposed study and project areas; evaluate and compare currently proposed alternatives; identify modifications or additional alternatives needed to address fish and wildlife related problems, opportunities, and planning objectives; and recommend preliminary measures for resource protection during early project planning. The Service will provide comments on the Galveston CRSM measures and coast-wide ecological restoration opportunities under the larger mega study when appropriate.

The proposed protection was authorized by a resolution from the Committee on Environmental and Public Works, dated June 23, 2004, entitled "Coastal Texas Protection and Restoration Study". The U.S. Senate directed the Corps to 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 the coast, restoring and preserving marshes and wetlands, improving water quality, and other related purposes to the interrelated ecosystem along the coastal Texas area. Congressional actions direct the Corps to proceed with engineering, design, modification, and construction of a hurricane protection project to provide 100-year hurricane protection. Procedurally, project construction is not authorized, however attached is the report of the Secretary of the Interior that is required by Section 2(b) of the FWCA (48 Stat. 401, as amended; 16 U.S.C. 661 et. seq.). The FWCA requires that Section 2(b) report be made an integral part of any report supporting further project authorization or administrative approval.

The Service bases our evaluation on the current data and analyses available from Corps sources and Service files. The Service understands the project is subject to Congressional approval and TSP funding will occur sometime in the future with or without project modifications. Additional Service involvement for subsequent detailed planning, engineering, design, and construction phases of each planning effort is required to fulfill our responsibilities under the FWCA. The Service recommends the Corps reinitiate coordination under a separate FWCA agreement when construction funding is made available where a thorough review of the project footprint and impacts will be conducted.

The Corps' Draft Integrated Feasibility Report and EIS (DIFR-EIS) presents a programmatic overview of coastal storm risk problems and opportunities in the Galveston Region and a programmatic overview of ER opportunities for the entire six county study area. Using previously conducted studies, the Corps proposes to provide recommendations for future studies in the Galveston Region; no in-depth alternative analyses will be conducted and no recommendations for project construction will be made during this study. As such, no ER

proposals will be fully developed, recommended for construction, or analyzed through this report. We anticipate working with the Corps to develop a full suite of ER recommendations in the near future which will require supplemental FWCA reports.

The Corps proposed federal action (known as the tentatively selected plan or TSP that consists of coastal storm risk management projects in Orange, Jefferson, and Brazoria Counties, Texas. These actions will be carried out by the Corps and the GLO (the non-federal sponsor). The DIFR-EIS was released for public review in September 2015. We expect the final project to require further engineering and recommend continued coordination during the revision process so that environmental impacts can further be assessed.

Background Information

Investigation of surge damage impacts in the Galveston and Jefferson County region began in 2001 after the initiation of a Feasibility Study with the intent of evaluating plans to develop CRSM and ER features. The Corps' 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 and the determination was made in late 2011 to re-scope the study to include surge reduction measures for a six-county region to include Orange, Jefferson, Chambers, Galveston, Harris and Brazoria Counties (USACE, 2014).

This Corps study began under the "SMART Planning" principles and 3x3x3 guidelines developed under the recent Corps planning modernization. SMART Planning (Specific, Measurable, Attainable, Risk Informed, and Timely) studies are now performed with an emphasis on risk-based decision-making and early Corps vertical team (VT) engagement Additionally, the 3x3x3 guidelines limit planning studies to a duration of 3 years and cost of $3 million dollars which are managed through a 3-tier VT within the Corps.

Strict Corps timelines and funding constraints limit the SMART process even further leaving Service staff to evaluate only what limited information and studies are made available by the Corps. While the project is geared to begin on a strong foundation of previously used data (Corps and in some cases other resource agency's data), the Corps' project delivery team must continually ask about the appropriate level of detail necessary to make risk-informed decisions. The study team must balance its choice for additional detail with the funds and time available against the risk and uncertainty of decision outcome (USACE, 2012). To do this, a suite of available tools allows the Corps a more progressively detailed analysis over a smaller array of alternatives until finally identifying the tentatively selected plan. With limited resources and in most cases not able to fund additional studies, the Corps is forced to use previous data, and assume a certain level of risk with each planning decision.

The study focuses on the detailed evaluation of the following non-structural and structural CSRM alternatives:

- evaluation of a new levee system along the lower Neches and Sabine Rivers in the vicinity of Beaumont and Orange, Texas (Figure 2),
- reevaluation of existing HFP at Port Arthur (Figure 3),
- reevaluation of the existing HFP project at Freeport (Figure 4)

This final report focuses on the evaluation of environmental impacts and mitigation alternatives for a new levee system alternative in Orange and Northeast Jefferson Counties and the reevaluation of existing HFP systems in Freeport and Port Arthur.

The Corps and representative from the natural resource agencies met throughout the planning process (detailed below in Table 1) to make recommendations on parameters used in modeling efforts, develop avoidance measures for significant resources and habitats within the project area, and identify potential mitigation alternatives .

Table 1 List of Corps Project Coordination Meetings

Date	Purpose
May 17, 2013	Introduction to the Study
Dec. 10, 2014	Update on study, introducing focus on Orange/Jefferson and Brazoria Counties
Jan. 8, 2015	Vegetation classification in Orange right-of-way
Jan. 23, 2015	Field trip – Orange right-of-way and reference area vegetation mapping
Feb. 26, 2015	Direct impacts modeling meeting
Feb. 27, 2015	Direct impacts modeling meeting
Mar. 5, 2015	Indirect impacts modeling meeting
Mar. 6, 2015	Indirect impacts modeling meeting
Mar. 27, 2015	Further impacts modeling
Jan. 8, 2016	Discussion of mitigation assumptions for modeling
Jan. 9, 2016	Mitigation measures screening
Jan. 25, 2016	Mitigation measures screening
Feb. 11, 2016	Field trip- mitigation areas
Feb. 12, 2016	Field trip – mitigation area
Mar. 2, 2016	WVA modeling of mitigation measures
Mar. 7, 2016	WVA modeling of mitigation measures
Mar. 9, 2016	WVA modeling of mitigation measures
Jun. 15, 2016	Review of Recommended Plan and Mitigation Plan

Hurricane Impacts

Texas' entire Gulf Coast historically averages three tropical storms or hurricanes every four years, generating coastal storm surges and sometimes bringing heavy rainfall and damaging winds hundreds of miles inland (USACE, 2014). Future projections suggest increases in hurricane rainfall and intensity (with a greater numbers of the strongest – Category 4 and 5 – hurricanes) (Melillo 2014). The expected rise in sea level will result in the potential for greater storm surge damage along the Gulf Coast of Texas.

Storm surge modeling conducted by the Corps' Engineer Research and Development Center (ERDC) for this study provided a predicted return interval of 10-15 years for storm surges high enough to threaten the areas targeted for protection in the Sabine Region (USACE, 2014). Over the last ten years, three hurricanes of significant importance have occurred in or near the study area with each incurring billions of dollars in damages.

Table 2 2005-2014 Hurricanes Occurring in Orange and Jefferson Counties

Name	Year	Estimated Damage
Hurricane Rita	2005	$11.3 billion
Hurricane Katrina (came ashore near the study area)	2005	$81.2 billion
Hurricane Ike	2008	$ 29 billion

In September 2005, Hurricane Rita, a Category 3 storm and ranked the fourth most intense Atlantic hurricane ever recorded, caused major flooding in the Port Arthur and Beaumont areas. The storm threatened a large amount of the oil infrastructure left undamaged by Hurricane Katrina just a month before. Communities in the "Golden Triangle" sustained enormous wind damage and Bridge City experienced 2-4 feet of flooding inundating the entire town. The heavy concentration of oil infrastructure in the Gulf of Mexico makes hurricanes of Rita's intensity very problematic. Aside from the catastrophic damage caused by hurricanes along the Texas coast, the loss of oil and gas industry revenue, and some 200,000 jobless claims were attributed to hurricanes Katrina and Rita further creating a drag on the local and national economies.

Hurricane Ike made landfall in September of 2008 as an extremely large Category 2 storm with sustained winds of 110 mph and a 22 ft. storm surge causing widespread coastal flooding. The tropical force winds extended outward up to 275 miles from the center and at its biggest, Ike would have covered most of Texas. Ike compromised many human-made structures, including buildings, roads, bridges, and other critical infrastructure. The 2.7 million workers in the counties of Harris, Galveston, Chambers, Orange, and Jefferson – those most affected by Ike represent 26.6 percent of the state's total employment and contribute $123.5 billion to the state's economy (Division of Emergency Managment, 2008).

Description of the Study Area

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 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 fifty 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 10 largest US seaports are also located in the study area. The growing population, communities, and nationally significant industries are 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. The Corps has determined current hurricane flood protection systems in Port Arthur, Texas City, and Freeport do not meet current design criteria and all warrant improvements.

Figure 1 Texas Coastal Storm Risk Management and Ecosystem Restoration Study Area
Source: Corps 2014

Within the entire project area, the Corps has designated three distinct project areas:

Sabine: This region includes the Sabine Lake system and Gulf shoreline from Sabine Pass to High Island. The Sabine region focuses on Orange and Northeast Jefferson Counties, including the three communities known as the Golden Triangle- Beaumont, Port Arthur and Orange, Texas.

Galveston: This region consists of all of the Galveston Bay system including the Gulf shoreline along Bolivar Peninsula to San Luis Pass. Counties included are: Chambers, Harris, and Galveston.

Brazoria: Included in this region are the Brazos River Diversion and Old River Channels in the vicinity of Freeport, Texas.

Through the DIFR-EIS, the Corps will evaluate environmental impacts for two geographically separate areas only- Sabine and Brazoria Regions. The Galveston Region will be evaluated only at a programmatic level in the DIFR-EIS, will only provide recommendations for future studies with no in-depth analysis, and will provide an overview of ecological restorations opportunities for the entire six county project area.

The Corps identified a TSP with three separate elements. The Orange-Jefferson CSRM Plan and the Port Arthur and Vicinity CRSM Plan are located in the Sabine Region, while the Freeport and Vicinity CRSM Plan is located in the Brazoria Region. The Sabine Region focused on new

Orange and Jefferson CRSM and existing Port Arthur CRSM project areas. The Brazoria Region focused on an existing Freeport CRSM project area.

Figure 2 Proposed Orange County Recommended Plan
Source: (USACE, 2015)

The proposed Orange County Recommended Plan (Figure 2):
The CRSM evaluation includes evaluating various lengths and locations of new levee or floodwall alignments and surge gates on Adams and Cow Bayous and eliminating alternatives for shorter levee system with large, navigable surge gate on the Neches River.

- Orange 3 – 111,228 linear feet (LF) of levee and 32,170 LF of floodwall with a levee crest of 12 feet NAVDD88; total of 27 miles of protection.
- Jefferson Main New Levee- 40,270 LF of levee and 16,500 LF of floodwall with a levee crest of 12 feet NAVDD88; total of 11 miles of protection.
- Beaumont A New Levee – 5,800 LF of levee and 12,981 LF of floodwall with a levee crest of 13 feet NAVDD88; total of 3.6 miles of protection.

After further review, the Corps eliminated the Jefferson Main New Levee and the Beaumont A New Levee elements and will move forward with only the Orange 3 portion of the TSP as the Recommended Plan. The final elevation of the Orange 3 levees is expected to be approximately 17 feet high and 27 miles long. The Corps believes an increase in floodwalls from about 20 percent of the overall system to about 40 percent is necessary. This increase was essential to

avoid impacts to residences, pipelines and minimize impacts to wetlands. The alignment was relocated into several shorter segments resulting in a significant reduction of impacts from 64 to only 30 to existing structures.

Figure 3 Proposed Port Arthur Recommended Plan
Source: (USACE, 2015)

The Port Arthur CRSM will evaluate the need for adding resiliency features to existing levees and floodwall, evaluating the need for an increased level of protection (increasing levee height), and the assumption that all improvements will be constructed within existing right-of-ways.

- 8ft-10ft I-Wall Levee Raise – 7,500 LF of 15-foot wide scour pad and 2,000 LF of levee raised one foot.
- Closure Structure Raise – Structure and 300 LF of 100-foot wide scour pad and 12,000 LF of levee raised one foot.
- I-Wall near Valero Raise – 5,000 LF of 15-foot scour pad and 3,000 LF of levee raised one foot.
- I-Wall near Tank Farm Raise – 1,800 LF of 15-foot wide scour pad and 7,000 LF of levee raised one foot.

Final design work recommended raising 11.3 miles of existing levees and constructing or reconstruction 5.3 miles of floodwalls. Final elevations would range from 14.4 to approximately 19 feet NAVD88 to account for wave run-up and relative sea level rise (RSLR). A separate 1,830 feet of new earthen levee would be constructed in the Port Neches area, in an area covered by a portion of the Jefferson Main element.

Figure 4 Proposed Freeport and Vicinity TSP
Source: (USACE, 2015)

The Freeport CRSM will evaluate the need for adding resiliency features to existing levees and floodwall, evaluating the need for an increased level of protection (increasing levee height), and the assumption that all improvements will be constructed within existing right-of-ways

- Dow Barge Canal Gate Structure – sector gate structure with navigatable opening.
- Oyster Creek Levee Raise – 13,500 LF of levee raised one foot.
- East Storm Levee Raise – 13,155 LF of levee raised one foot, topped with high performance turf reinforcement mat.
- Freeport Dock Floodwall Raise – 3,000 LF of reconstructed floodwall.
- Old River Levee at Dow Thumb Raise – 3,000LF of levee raised one foot.
- Tide Gate I-Wall Raise – reconstructed I-Wall raised one foot, and 2,000 LF of levee raised one foot.

The Recommended Plan will result in the raising or construction of a total of approximately 13.1 miles of existing levee, construct or reconstruct 5.5 miles of floodwalls and install a navigatable sector gate in the Dow Barge Canal. This does include a 5,000 foot reach of South Storm levee improvements that was added to the Recommended Plan during the final design process. The Corps expects the final elevation to range between 15.8 to 23.8 feet NAVD88 to account for wave run-up and RSLC and will only be applied to those areas needing additional height.

Construction will occur within existing right-of-ways where possible, however additional temporary and permanent right-of-ways may be required for Oyster Creek Levee Raise, Tide Gate I-Wall Raise, Old River North at DOW Thumb Levee Raise, and Freeport Dock Floodwall Raise.

The Corps estimates the total direct and indirect environmental impacts of 272.5 acres for the Orange-Jefferson portion of the project over the 50-year period of analysis. Modeling indicates indirect fisheries access impacts (functional loss) of almost 2,137.2 acres of marsh in Adams and Cow Bayou floodplains. Totals (direct, indirect, and functional loss) will result in 2,409.7 acres of forested wetlands and coastal marsh being impacted over the 50-year life span of the project. Total unavoidable impacts in this area will result in unavoidable impacts of 186.0 average annual habitat units (AAHUs) as analyzed by the Wetland Value Assessment (WVA) model (USACE, 2015) (Table 3). The Corps plans to compensate fully with in-kind mitigation for all unavoidable impacts and is discussed in a later section.

Table 3 Unavoidable Impacts Resulting From Orange County Proposed Recommended Plan

Habitat	Acres Lost from Direct and Indirect Impacts	Functional Loss (Acres)	AAHUs
Fresh marsh	24.3	785.2	-30.0
Intermediate marsh	26.0	322.5	-16.6
Brackish marsh	152.7	1029.5	-96.5
Swamp	12.5	0.0	-7.3
Bottomland hardwood	57.0	0.0	-35.4
Total for Orange County	272.5	**2137.2**	**-186.0**

Source: USACE 2016

Environmental impacts for the Port Arthur and Freeport Recommended Plans do not include mitigation since environmental impacts will be minimal and restricted to existing right-of-ways and areas of dense industrial and residential development.

The Corps did consider nonstructural buyouts and found little or no opportunities in Brazoria and Jefferson Counties. Orange County presented only small ancillary opportunities and this option was no longer considered by the Corps. The Service recommends the Corps continue to search for mitigation opportunities, however small, in all counties where impacts may occur.

Vegetative Communities

The vegetative communities of southeast Texas have been thoroughly described in several authoritative books and numerous technical articles, including O'Neil, 1949, Blair, 1950, Harcombe & Neaville, 1977, Gosselink et.al 1979, Smeins et. al. 1991, TNHP 1993, Visser et.al 2000, and TNC, 2013.

State and Federally-designated natural areas in the project area, important because of the large areas of native fish and wildlife habitat and recreational opportunities they represent as well as their inherent susceptibility to project-induced salinity changes, are shown and discussed as well. We summarize major community types in Texas, provide updated acreage estimates, update

recent changes to the current project and other channelization projects, and provide the Service's recommendations as to project-related impacts and minimization measures.

The project area contains three separate watersheds and habitat types including forested wetlands (i.e., bottomland hardwoods and/or swamps), non-wet bottomland hardwoods, marsh, open water, and developed areas. Due to urban development and a forced drainage system in many areas, the natural hydrology of most of the forested habitat has been altered. The forced drainage system has been in operation for many years and subsidence is evident throughout the project area.

Bottomland hardwood forest

Higher, intermittently-flooded strips of land immediately adjacent to the riverine ridge and to meander lakes (oxbows) are often forested by mature bottomland hardwood forest. The largest tracts are at the extreme upper end of the project area, just south of the Neches River saltwater barrier, and along the Sabine River north of I-10, within the Sabine Wildlife Management Area (600+ acres). Bottomland hardwood forest have long been identified as one of the most productive habitat types for wildlife in North America, often harboring up to four times the density and diversity of bird, mammal, and herpetofauna species of upland forests. More recently, bottomland hardwood forests in the northern Gulf of Mexico region were identified as critical fall and spring migrant stopover habitat for huge numbers, perhaps the majority, of the more than 130 species of North America's neotropical migrant songbirds (Gauthreaux, 1971). A vastly diverse and rapidly disappearing habitat, bottomland hardwood forests continues to be a focal habitat along the Texas coast where preservation remains a high priority for the Service.

The primary swamp type is cypress-tupelo swamp, which is characterized by common baldcypress *Taxodium distichum* and tupelo gum *Nyssa aquatica* overstory, and numerous aquatic understory species such as bulltongue *Sagittaria lancifolia*, swamp lily *Crinum americanum*, pickerel weed *Pontederia cordata*, smartweed *Polygonum sp.*, and blue iris *Iris sp.* Large tracts of cypress-tupelo swamp occur in permanently and semi-permanently flooded areas along the Neches River north of Interstate 10 (I 10) and along the Sabine River north of I 10 (PBS&J, 2003).

Marsh

Wetlands provide valuable water quality functions such as reduction of excessive dissolved nutrients levels, filtering of waterborne contaminants, and removal of suspended sediments. In addition, coastal wetlands buffer storm surges reducing their damaging effects to man-made infrastructure within the coastal area. Wetlands (forested, marsh, and scrub-shrub) within the study area provide plant detritus to adjacent coastal waters and thereby contribute to the production of commercially and recreationally important fishes and shellfishes. Many marsh and wetlands areas in Orange and Jefferson Counties areas experienced subsidence, salt water intrusion leading to die out of marsh vegetation, species (flora and fauna) composition change, and conversion to a much more unproductive open water habitat. White, et al., 1987 documents that over 90 percent of the emergent marshes of the Lower Neches River delta have been converted to open water. According to Sutherlin, 1997, this loss results in over half of the total wetlands loss in the state of Texas.

Marsh types within the project area include fresh, intermediate, brackish, and saline. Fresh marsh occurs at the upper ends of interdistributary basins and are often characterized by floating or semi-floating organic soils and minimal daily tidal action. Vegetation may include maidencane *Panicum hemitonon*, bulltongue *Sagittaria lancifolia*, cattail *Typha* sp., California bulrush *Schoeniplectus californicus*, pennywort *Hydrocotyle verticillata*, giant cutgrass *Zizaniopsis miliacea*, American cupscale *Sacciolepis striata*, spikerushes *Eleocharis* sp., waterhyssop B*acopa* sp., and alligatorweed *Alternanthera philoxeroides*. Associated open water habitats may often support extensive beds of floating-leafed and submerged aquatic vegetation including water hyacinth *Eichhornia crassipes*, Giant salvinia *Salvinia molesta* duckweeds *Lemna* sp., American lotus *Nelumbo lutea*, white water lily *Nymphaea odorata*, water lettuce *Pistia stratiotes*, coontail *Ceratophullum demersum*, Eurasian milfoil *Myriophyllum spicatum*, hydrilla *Hydrilla* sp., pondweeds *Potamogeton* sp., Southern naiad *Najas guadalupensis*, fanwort *Cabomba caroliniana*, wild celery *Apium graveolens*, water stargrass *Heteranthera dubia*, elodea, and others.

Intermediate marshes are a transitional zone between fresh and brackish marshes and are often characterized by organic, semi-floating soils. Typically, intermediate marshes experience low levels of daily tidal action. Salinities are negligible or low throughout much of the year, with salinity peaks occurring during late summer and fall. Vegetation includes saltmeadow cordgrass *Spartina patens*, deer pea vetch *Vicia ludoviciana*, three-cornered grass *Schoenoplectus americanus*, cattail *Typha* sp., bulltongue *Sagittaria lancifolia*, seashore paspalum *Paspalum vaginatum*, wild millet *Panicum miliaceum* , fall panicum *Panicum dichotomiflorum* , and waterhyssop B*acopa* sp. Ponds and lakes within the intermediate marsh zone often support extensive submerged aquatic vegetation including southern naiad *Najas guadalupensis*, Eurasian milfoil *Myriophyllum spicatum*, and wigeongrass *Rupia maritima*.

Brackish marshes are characterized by low to moderate daily tidal energy and by soils ranging from firm mineral soils to organic semi-floating soils. Freshwater conditions may prevail for several months during early spring; however, low to moderate salinities occur during much of the year, with peak salinities in the late summer or fall. Brackish marsh is generally considered "slightly salty"; with salinity levels varying over a wide range from location to location. In coastal Texas, the typical brackish marsh vegetation pattern occurs in areas within approximately the 4 to 15 parts per thousand (ppt) (normal) salinity range. Common, usually dominant, vegetation in these areas is saltmarsh bulrush *Bulboschoenus robustus*, seashore saltgrass *Distichlis spicata*, marshhay cordgrass *Spartina patens*, dwarf spikerush *Eleocharis parvula*, waterhemp *Amaranthus australis*, and marsh pea *Vigna luteola*. Vegetation is usually dominated by saltmeadow cordgrass, but also includes saltgrass, three-cornered grass, leafy three-square, and deer pea. Shallow brackish marsh ponds occasionally support abundant beds of wigeongrass.

Brackish marsh areas have cyclically high waterfowl populations, especially in years following high-salinity events when freshwater levels return to normal and periodic "blooms" of prime food plants such as widgeongrass and *Paspalum* sp. occur. Furbearers such as muskrat, formerly an important commercially-harvested animal in the project area, also occur in cyclically high numbers. Brackish marshes have suffered some of the highest rates of marsh loss due to subsidence and loss of organic materials as formerly fresh areas are subjected to salinity intrusion, resulting in plant loss.

Saline marshes occur along the fringe of the coastal wetlands and are higher in salinity due to repeated flooding by sea water every day. Those marshes usually exhibit fairly firm mineral soils and experience moderate to high daily tidal energy. Vegetation is dominated by saltmarsh cordgrass but may also include saltgrass *Spartina alterniflora*, saltmeadow cordgrass, black needlerush *Juncus roemerianus*, and leafy three-square *Schoenoplectus robustus* . Submerged aquatic vegetation is rare. These low-lying areas of the marsh are often covered with large, flat expanses of mud call mud flats and can harbor mussels *Mytilus* sp., clams *Cyrtopleura* sp., oysters *Crassostrea virginica*, fiddler crabs *Uca* sp., sand shrimp *Crango* sp., and bloodworms *Glycera* sp.

Scrub-Shrub Habitats

Scrub-shrub habitat is often found along the flanks of distributary ridges and in marshes altered by spoil deposition or drainage projects. Typically it is bordered by marsh at lower elevations and by developed areas, cypress-tupelo swamp, or bottomland hardwoods at higher elevations. Some scrub-shrub habitat is an early successional stage of bottomland hardwood forests.

Swamp scrub and freshwater marsh are often intermixed within cypress-tupelo tracts, either in natural meander scars or in areas completely logged in the past which have not reforested. The 1,750-acre tract immediately east of downtown Beaumont and north of I-10 is a good example of an area crisscrossed by logging ("star") canals dug in the early 1900's for extraction of commercially valuable bald cypress, which has not yet completely reforested and remains in freshwater marsh/scrub-shrub. Primary plant species here are buttonbush *Cephalanthus occidentalis*, rattlebean *Sesbania drummondii*, box elder *Acer negundo*, swamp privet *Foresteria acuminata*, cattail *Typha latifolia*, elderberry *Sambucus nigra*, wax myrtle *Morella cerifera*, black willow *Salix nigra*, Drummond red maple *Acer rubrum*, Chinese tallow-tree *Triadica sebifera*, groundselbush *Senecio vulgaris*, and Virginia tea *Itea virginica*. Because this habitat type has experienced high land loss rates, habitat restoration (beneficial use of dredge material) may want to target freshwater marsh/scrub shrub habitat, although cypress-tupelo swamp should be the long term goal in this area, due to its high productivity and recreational value to wetland users, primarily waterfowl hunters, fishermen, and birdwatchers

Open Water Habitats

Open-water habitat within the project area consists of ponds, lakes, canals, bays, and bayous. Natural marsh ponds and lakes are typically shallow, ranging in depth from 6 inches to over 2 feet. Typically, the smaller ponds are shallow and the larger lakes and bays are deeper. In fresh and low-salinity areas, ponds and lakes may support varying amounts of submerged and/or floating-leaved aquatic vegetation. Brackish and, much less frequently, saline marsh ponds and lakes may support wigeongrass beds.

Canals and larger bayous typically range in depth from 4 or 5 feet, to over 15 feet. Strong tidal flow may occur at times through those waterways, especially where they provide hydrologic connections to other large waterbodies. Such canals and bayous may have mud or clay bottoms that range from soft to firm. Dead-end canals and small bayous are typically shallow and their bottoms may be filled in to varying degrees with semi-fluid organic material. Erosion due to wave action and boat wakes, together with shading from overhanging woody vegetation, tends to retard the amount of intertidal marsh vegetation growing along the edges of those waterways.

Drainage canals in the project area may become stagnant except when pumps are operating to remove water. Runoff from developed areas has likely reduced the habitat value of that aquatic habitat by introducing various urban pollutants, such as oil, grease, and excessive nutrients. Clearing and development has eliminated much of the riparian habitat that would normally provide shade and structure for many aquatic species.

Developed Areas

Developed habitats in the study area include residential and commercial areas, as well as roads and existing levees. Those habitats do not support significant wildlife use. Most of the development is located on higher elevations, natural levees, and former distributary channels; however, vast acreages of swamp and marsh are under forced drainage systems and developed. Limited amounts of agricultural lands occur throughout the area; agriculture includes sugarcane farming, cattle production, and haying. Some development in wetlands is also occurring as a result of permitted fill activities.

Fish and Wildlife Resources

Terrestrial

Mammals known to occur in the project area bottomland hardwoods and marshes include mink *Neovison vison*, raccoon *Procyon lotor*, swamp rabbit *Sylvilagus aquaticus* , nutria Myocastor coypus, river otter *Lontra canadensis* , and muskrat *Ondatra zibethicus*. Those habitats also support a variety of birds including herons, egrets, ibises, least bittern, rails, gallinules, olivaceous cormorant *Phalacrocorax brasilianus* , white pelican *Pelecanus erythrorhynchos* , pied-billed grebe *Podilymbus podiceps*, black-necked stilt *Himantopus mexicanus* , sandpipers, gulls, and terns. Forested and scrubshrub habitats within the study area also provide habitat for many resident passerine birds and essential resting areas for many migratory songbirds including warblers, orioles, thrushes, vireos, tanagers, grosbeaks, buntings, flycatchers, and cuckoos. Many of these and other passerine birds have undergone a decline in population primarily due to habitat loss.

The study area also supports resident raptors and owls including the bald eagle *Haliaeetus leucocephalus*, red-shouldered hawk *Buteo lineatus* , barn owl *Tyto alba*, common screech owl *Megascops asio*, great homed owl *Bubo virginianus*, and barred owl *Strix varia*. The red-tailed hawk *Buteo jamaicensis*, marsh hawk *Circus cyaneus*, and American kestrel *Falco sparverius* are seasonal residents utilizing forested and wetland habitats within the study area.

Given the extent of development and drainage, waterfowl use within the hurricane protection system is likely minimal, except in the adjacent wetlands outside the levees. Swamps, fresh and intermediate marshes usually receive greater waterfowl utilization than brackish and saline marshes because they generally provide more waterfowl food. Migratory waterfowl species expected to occur in the project area include gadwall *Anas strepera* , green-Winged teal *Anas carolinensis*, blue-winged teal *Anas discors* , northern shoveler *Anas clypeata* , mallard *Anas platyrhynchos* , pintail *Anas acuta*, American widgeon *Anas americana*, lesser scaup *Aythya affinis*, ring-necked duck *Aythya collaris*, redhead *Aythya americana*, and canvasback *Aythya valisineria*. Resident species expected to occur include the mottled duck *Anas fulvigula* and wood duck *Aix sponsa*.

Amphibians such as the pig frog *Rana grylio*, bullfrog *Rana catesbeiana* , leopard frog *Rana sphenocephala*, cricket frog *Acris crepitans*, and Gulf coast toad *Incilius valliceps* are expected to occur in the fresh and low salinity wetlands of the study area. Reptiles such as the American alligator *Alligator mississippiensis*, snapping *turtle Chelydra serpentine*, softshell turtle *Apalone spinifera*, red-eared turtle *Trachemys scripta elegans*, and diamond backed terrapin *Malaclemys terrapin* are also expected to occur in the project-area wetlands and waterbodies.

Aquatic

Due to this dynamic salinity regime, Sabine Lake supports several rich and diverse fish, plankton, and invertebrate benthic communities. Heavy seasonal growths of both freshwater and marine phytoplankton, mostly diatoms (45 percent total biomass), along with the ubiquitous green algae (36 percent total biomass) occur and are heaviest in the summer (Espey, Hutson, and Associates, 1976). Zooplankton is most abundant during summer and early fall, which is similar to what occurs in Galveston Bay but opposite from what is found in the more southerly and higher salinity mid- and lower coast bays. Copepods are by far the dominant species group (over 95 percent total biomass). Dominant infaunal benthic organisms consist of the *Rangia* clam, capitellid polychaetes, and *Tubificoides* oligochaetes (Vittor and Associates, 1997).

Aquatic fauna changed since the original manmade opening of Sabine Pass from a freshwater system similar to that currently present in the upper Neches and Sabine Rivers portions of the study area, to a saline/brackish system typical of Galveston Bay and other Texas estuaries. Important forage and predator fish are typified by alligator gar *Lepisosteus spatula*, ladyfish *Elops saurus*, finescale menhaden *Brevoortia gunteri*, gizzard shad *Dorosoma cepedianum*, bay anchovy *Anchoa mitchilli*, river carpsucker *Carpiodes carpio*, hardhead catfish *Arius felis*, channel catfish *Ictalurus punctatus*, Gulf killifish *Fundulus grandis*, white bass *Morone chrysops*, largemouth bass *Micropterus punctulatus*, black crappie *Pomoxis nigromaculatus*, crevalle jack *Caranx hippos*, pigfish *Orthopristis chrysoptera*, spotted seatrout *Cynoscion nebulosus*, black drum *Pogonias cromis*, striped mullet *Mugil cephalus*, Spanish mackerel *Scomberomorus maculates*, southern flounder *Paralichthys lethostigma*, and lizardfish *Synodus foetens* (Louisiana Department of Natural Resources, 1999). These species represent fresh, marine, and euryhaline assemblages. Commercial finfish harvest is insignificant at only an average of 2,186 pounds worth $1,385 annually. Recreational fish harvest is much more important, with an estimated 500,000 man-hours of fishing and is second only to Galveston Bay (Blackburn et. al, 2001).

Important nektonic shellfish are blue crab *Callinectes sapidus*, white shrimp, brown shrimp, and swamp crayfish (*Procambarus clarkii*). The Sabine Lake blue crab fishery accounts for almost 25 percent of the total Texas commercial landings, with almost two million pounds landed annually, for a total value of $2,330,553 (NOAA, 2013).

Project-area marshes and associated open-water provide important habitat (i.e., nursery, escape cover, feeding grounds) for a variety of freshwater and estuarine-dependent fish and shellfish. Most of the economically important saltwater fishes and crustaceans harvested in Texas spawn offshore and then use estuarine areas for nursery habitat (Herke, 1995). Nekton use of estuaries is largely governed by the seasons (Day, 1989). Different species use the same locations in different seasons, and different life stages of the same species use different locations. Aquatic

species diversity peaks in the spring and summer, and is typically low in the winter. Some marine species which use estuaries as nursery habitat also have estuarine dependent life stages, typically larvae and juveniles. Larvae or juveniles immigrate into the project area during incoming tides and take advantage of the high productivity of the estuary.

Waterfowl

Southeast Texas (Jefferson and Orange Counties) and southwest Louisiana contain some of the most important and heavily utilized waterfowl habitats remaining on the Gulf coast, with many of these areas located adjacent to or a short distance from the Sabine Neches Water Way. Important Texas habitat tracts are located within Texas Point NWR, McFaddin NWR, J. D. Murphree WMA, and on privately owned marsh and swamp tracts along the Neches and Sabine Rivers. More detailed descriptions of these publicly-owned refuges are provided in the *Protected (State and Federal) Natural Sites in Project Area* section of this report.

Waterfowl use and economic impacts from hunting and outdoor-related activities in the immediate project area are impressive. The U. S. Fish and Wildlife Service's Mid-Winter Waterfowl Census numbers for 2004-2005 were very low compared to previous years, probably due to high-salinity marsh conditions. January 2005 flight lines over McFaddin NWR and Texas Point NWR counted 27,964 geese and 12,688 ducks. Peak 2005 estimates for Sabine NWR were 125,000 geese and 200,000 ducks (McFaddin/Sea Rim NWR files). McFaddin NWR hosted 1,470 hunter-days who harvested 3,694 ducks and 76 geese during the 2005-2006 season. Texas Point NWR hosted 338 hunter-days who took 501 ducks and 28 geese during the 2005-2006 season. J.D. Murphree WMA hosted 1,997 hunter-days taking 5,014 ducks and 93 geese for the 2005-2006 season. The 2.5 birds per hunter-day was one of the highest ratios of any Texas public hunting area. Numerous waterfowl guides in Texas host hunters on private marshes, rice fields, and coastal marshes in the Jefferson County. Private lands hunters almost certainly account for more hunting days and greater harvest than those on public areas.

The 2011 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation report (USDOI, 2011) shows hunter participation and expenditures by state, but not by county or region. In 2011, 1.2 million hunters in Texas (both resident and non-resident) spent 1.6 million days afield and an estimated $1.8 billion. Of these, approximately 1.1 million hunters, or 42 percent, hunted migratory birds, primarily waterfowl. While these statistics are not compiled by county, a large proportion of waterfowl hunters have historically used the marshes within the project area.

Colonial Waterbirds

Twenty-three species of cormorant, pelican, heron, egret, spoonbill, gull, tern, and skimmer regularly nest in large numbers along the Texas and Louisiana coasts, frequently on bay islands, both natural and manmade. In recent years, the majority of successful Texas colonies have been located on islands wholly or partially maintained by dredged material (Glass 1994). Colonial waterbirds are an important wildlife resource on the Gulf Coast and in the project area because of their abundance (an estimated 2,835 nesting pairs annually since 1995 in the project area), their economic significance to the tourism industry, and their status as indicators of aquatic ecosystem health. Since 1973, the Texas Colonial Waterbird Society (TCWBS) has conducted annual censuses of all coastal Texas colonies and maintains a comprehensive database which provides annual census numbers and colony locations (TCWC 2015).

While locations of most important Texas colonies are on small offshore islands (TCWC 2015), most of those in the project area are in semi-protected industrial sites and other semi-urban sites. Sydney Island, a formerly important nesting island in upper Sabine Lake, has become inactive in recent years, probably due to predator invasion (Bailey, personal communication).

Regional waterbird population trends are a more accurate picture of waterbird population health than comparing individual colony counts from specific years, since nesting populations are known to shift frequently in response to predation, habitat conditions, parasite levels, and human disturbance. For purposes of comparison, Jefferson and Orange Counties, Texas, are considered the project area, and county dimensions are probably appropriate considering known waterbird home ranges and habitat use (Custer et al. 1978). In 2005, Jefferson and Orange Counties contained 10 known colonies with a total estimated population of 8,462 nesting pairs belonging to 13 species. Only one species of gull or tern was present, in comparison to Galveston Bay, where most years the laughing gull comprises over 50 percent of the nesting pairs (TCWC 2006). Most of the nesting birds belong to the heron, egret and ibis families, which are important components of freshwater marsh and swamp systems.

Endangered and Threatened Species

The Service recommends the Corps evaluate the project effects on listed species (with consultation if necessary) on each portion of the project where impacts are expected to occur. Should the design plans change significantly, the project is relocated, or construction is not implemented within 1 year following that analysis, we recommend that the Corps reevaluate the project footprint and coordination with this office.

According to Section 7(a)(2) of the Endangered Species Act (ESA) and the implementing regulations, it is the responsibility of each federal agency to ensure that any action they authorize, fund, or carry out is not likely to jeopardize the continued existence of any federally listed species. Therefore, you should use this and other current information to evaluate the project for its potential effects to listed species. The Service's Consultation Handbook (http://endangered.fws.gov/consultations/s7hndbk/s7hndbk.htm) is available to assist you with further information on definitions, process, and fulfilling ESA requirements.

Our review of the proposed project only focused on the effects of the levee and water control structure installation on sea turtle nesting since the Service only has jurisdiction of sea turtles while on land. The National Marine Fisheries Service (NMFS) has jurisdiction of sea turtles in the oceans, seas, bays, and estuaries. Based on the possible impacts the project may have on sea turtle migration within the coast's bays, we recommend that you contact NMFS at 727-824-5312 regarding their findings on the matter.

While there is no sea turtle nesting habitat within the proposed project areas, sea turtles are known to frequent the Gulf of Mexico, the Gulf Intracoastal Waterway, and adjacent bays, during the spring, summer, and fall months. Special precautions should be taken to avoid impacts to any of the sea turtle species during the construction processes.

The West Indian manatee *Trichechus manatus* is a rare visitor to the Texas coast and may be found within the project area. Manatees forage on sea grasses found in the shallow bays and

estuaries along the Texas coast. In the event a manatee is encountered during the construction processes, please contact the TCESFO – Houston at (281) 286-8282.

Other Legally Protected Species

The Migratory Bird Treaty Act (MBTA) protects all native migratory birds and prohibits the taking, killing, possession, and transportation (among other actions) or migratory birds, their eggs, and parts, except when specifically permitted by regulations for specific intentional uses. A list of birds protected under the MBTA can be found in 50 CFR 10 of the MBTA and at http://www.fws.gov/birds/policies-and-regulations/laws-legislations/migratory-bird-treaty-act.php.

The Service published the *Birds of Conservation Concern 2008* (BCC) in December, 2008. The overall goal of the BCC is to accurately identify the migratory and non-migratory bird species (beyond those already designated as federally threatened or endangered) that represent our highest conservation priorities and to draw attention to species in need of conservation action (US. Fish and Wildlife Service, 2008). The Bird Conservation Region (BCR) 37 (Gulf Coastal Prairie U.S. Portion only) lists bird species that may utilize the habitat types within or immediately adjacent to the project area (Table 4) Mud flats, gravelly bars, beaches, shallow bays, dredge spoil, ponds, and coastal marshes support these birds for one or more of the species' lifecycles (breeding, feeding, sheltering etc.).

Table 4 Service Birds of Conservation Concern List BCR 37

Audubon's Shearwater *Puffinus lherminieri* (nb)	Red Knot (rufa ssp
Band-rumped Storm-Petrel *Oceanodroma castro* (nb)	Buff-breasted Sandpiper *Tryngites subruficollis* (nb)
American Bittern *Botaurus lentiginosus*	Short-billed Dowitcher *Limnodromus griseus* (nb)
Least Bittern *Ixobrychus exilis*	Least Tern *Sternula antillarum* (c)
Reddish Egret *Egretta rufescens*	Gull-billed Tern *Gelochelidon nilotica*
Swallow-tailed Kite *Elanoides forficatus*	Sandwich Tern *Thalasseus sandvicensis*
Bald Eagle (b) *Haliaeetus leucocephalus*	Black Skimmer *Rynchops niger*
White-tailed Hawk *Geranoaetus albicaudatus*	Short-eared Owl *Asio flammeus* (nb)
Peregrine Falcon *Falco peregrinus* (b) (nb)	Loggerhead Shrike *Lanius ludovicianus*
Yellow Rail *Coturnicops noveboracensis* (nb)	Sedge Wren *Cistothorus platensis* (nb)
Black Rail *Laterallus jamaicensis*	Sprague's Pipit *Anthus spragueii* (nb)
Snowy Plover *Charadrius nivosus* (c)	Prothonotary Warbler *Protonotaria citrea*
Wilson's Plover *Charadrius wilsonia*	Swainson's Warbler *Limnothlypis swainsonii*
Mountain Plover *Charadrius montanus* (nb)	Botteri's Sparrow *Peucaea botterii*
American Oystercatcher *Haematopus palliatus*	Grasshopper Sparrow *Ammodramus savannarum*
Solitary Sandpiper *Tringa solitaria* (nb)	Henslow's Sparrow *Ammodramus henslowii* (nb)
Lesser Yellowlegs *Tringa flavipes* (nb)	LeConte's Sparrow *Ammodramus leconteii* (nb)
Upland Sandpiper *Bartramia longicauda* (nb)	Nelson's Sharp-tailed Sparrow *Ammodramus nelsoni* (nb)
Whimbrel *Numenius phaeopus* (nb)	Seaside Sparrow *Ammodramus maritimus* (c)
Long-billed Curlew *Numenius americanus*	Painted Bunting *Passerina ciris*

Hudsonian Godwit *Limosa haemastica* (nb)	Dickcissel *Spiza americana*
Marbled Godwit *Limosa fedoa* (nb)	
Red Knot (*roselaari* ssp.) (nb)	

(a)ESA candidate, (b) ESA delisted, (c) non-listed subspecies or population of Threatened or Endangered species, (d) MBTA protection uncertain or lacking, (nb) non-breeding in the BCR.

Several birds listed above can be found nesting within colonial bird rookeries from February through August. Portions of the three proposed TSP locations are located where colonial nesting waterbirds may be present. The Service and its partner's monitor 26 species of nesting colonial waterbirds annually along the Texas coast and the TCWBS currently maintains a database of these colonies locations. While most colonies persist over time, colonies can move should resources prove better elsewhere. We recommend a comprehensive project wide survey is conducted by a qualified biologist to determine the location of newly-established nesting colonies during the nesting season. If colonies are found, work should not be conducted within 1,000 feet of the colony during the nesting season and immediate contact with TCESFO (281-286-8282) should be made. These rookeries, whether found on shore or on adjacent islands, can be easily disturbed by human presence ultimately causing nest failure in some cases. While it is entirely possible to see various avian species foraging and loafing within the project area, most nesting activity is usually confined to nearby colony locations. Review of the TCWBS Database (Texas, 2015) indicates there are four historic rookery sites located within and immediately adjacent to portions of the Jefferson Main New Levee (Table 4). The Service does not know if these sites are active or inactive at this time and as a result, the rookery sites should be re-evaluated prior to any construction.

Table 5 Rookery Sites Within and Adjacent to the Jefferson Main New Levee Footprint

Name	Location	Colony Code	Last Active
DuPont Spoils Area	-94.02222, 29.99981	587-123	2006
Beaumont Cattail Marsh	-94.00251, 29.99995	601-147	2003
Nederland Spoil Area	-94.01083, 30.01027	587-122	2001
Beaumont Ship Channel	-94.00583, 30.01583	587-121	1990

Two rookery sites are located within the Orange 3 New Levee footprint (Table 6). Again, these are historical sites and suitable habitat may or may not be present for nesting birds. Dooms Island and Sydnes Island supported large rookeries during the 1980 and 1990s. However, Sydnes has succumbed to excessive erosion and subsidence over the years where only a fraction of the island exists today. Allied Chemical and Shangrila rookery sites should be re-evaluated and surveyed for nesting waterbirds. Last active dates may be the last time the sites were surveyed.

Table 6 Colonial Nesting Sites Within and Adjacent to the Orange 3 New Levee Footprint

Name	Location	Colony Code	Last Active
Allied Chemical	-93.7593, 30.0448	588-008	1992
Shangrila	-93.73333, 30.09861	588-009	2006

Dooms Island	-93.84888, 29.96694	601-121	1995
Sydnes Island	-93.82083, 29.97694	601-120	1992

Should an active nesting colony be located within 1000-feet of the proposed construction area, please contact the Service's Texas Coastal Ecological Services Field Office – Houston (TCESFO) at (281) 286-8282 for further details and instructions.

Outside of the February through August nesting season, caution should still be exercised as many of the waterbirds can be found on the shorelines and adjacent marshes within the project area taking advantage of the abundant feeding opportunities along the Texas coast. The Service's suggested Priority of Migratory Bird Conservation Actions for Projects can be found in Appendix A. Should you feel the take of migratory species will be necessary for this project, please contact the TCESFO at (281) 286-8282 for further details and instructions.

The MBTA (40 Stat. 755, as amended~ 16 U.S.C. 703 et seq.) and the Bald and Golden Eagle Protection Act (BGEPA) (54 Stat. 250, as amended, 16 U.S .C. 668ad) offer additional protection to many bird species within the project area including colonial nesting birds and the bald eagle. Forested habitat in the Orange and Jefferson County study area may provide nesting habitat for the bald eagles. Although the bald eagle was removed from the threatened and endangered species list, it continues to be protected under the MBTA and the BGEPA. The Service developed the National Bald Eagle Management Guidelines (NBEMG) to provide landowners, land managers, and others with information and recommendations regarding how to minimize potential project impacts to bald eagles, particularly where such impacts may constitute "disturbance," which is prohibited by the BGEPA. Those guidelines recommend maintaining: (1) a specified distance between the activity and the nest (buffer area); (2) natural areas (preferably forested) between the activity and nest trees (landscape buffers); and (3) avoiding certain activities during the breeding season. The buffer areas serve to minimize visual and auditory impacts associated with human activities near nest sites. Ideally, buffers would be large enough to protect existing nest trees and provide for alternative or replacement nest trees. On-site personnel should be informed of the possible presence of nesting bald eagles within the project boundary, and should identify, avoid, and immediately report any such nests to the TCESFO at 281-286-8282. A copy of the NBEM Guidelines is available at: http://www.fws.gov/southdakotafieldoffice/NationalBaldEagleManagementGuidelines.pdf If after consulting those guidelines you need further assistance in determining the appropriate size and configuration of buffers or the timing of activities in the vicinity of a bald eagle nest, the please contact the TCESFO at 281-286-8282.

National Wildlife Refuges, Parks, 404(c) areas

The unique geographic location of the project study area at the confluence of the Central and Mississippi migratory bird flyways and its inherent natural diversity is reflected in the fact that six major state or Federally-protected parks and refuges are located here (Figures 5). This list does not include private sanctuaries, city, or county parks.

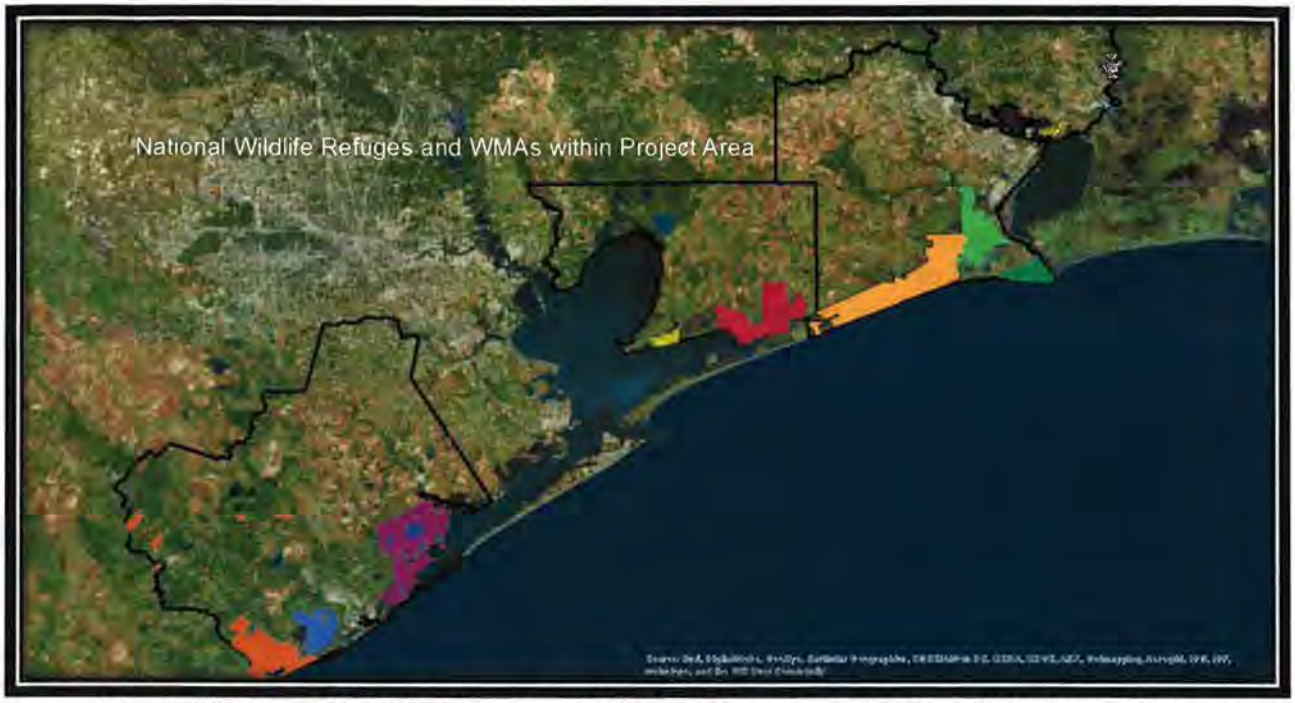

Figure 5 National Wildlife Refuges and Wildlife Management Areas within the project area

Anahuac National Wildlife Refuge
Established in 1963, the 34,000 acre tract was purchased to protect and manage the coastal marsh for migrating, wintering, and breeding waterfowl, shorebirds, and waterbirds, and to provide strategic and crucial nesting areas for the neotropical migratory songbirds migrating across the Gulf of Mexico.

McFaddin National Wildlife Refuge
This 55,000-acre Service refuge was established in 1980 and contains the largest tracts of coastal freshwater marsh remaining in Texas. The 5,400-acre White Marsh tract was added in 2000. Most of McFaddin NWR is saline to brackish marsh. It was probably was a freshwater marsh prior to GIWW construction in the 1940's and erosion and subsidence in the 1970's. Large freshwater areas still exist in interior areas west of Clam Lake. McFaddin NWR hosts approximately 10,000 visitors annually, including 2,400 annual hunter-days of waterfowl hunting. The degradation of State Highway 87 along the coastline has reduced visitation due to a 1993 hurricane.

Texas Point National Wildlife Refuge
This 11,422 acre tract lies adjacent to the Sabine Neches Water Way at Sabine Pass and extends for almost 13.5 miles along the Gulf of Mexico. This unit contains 4,898 acres of saline marsh, 2,398 acres of brackish marsh, 1,605 acres of intermediate marsh, 100 acres of fresh marsh, 1,413 acres of other upland areas, and 1,008 acres of open water. Baseline salinities for this area average 5.75 ppt for intermediate, 8.5 ppt for brackish and 12.5 ppt for the saline marshes. It should be noted that periodic hurricanes and tropical depressions do inundate these areas with high salinity waters, but usually are then punctuated by long periods of freshwater recovery (Gooch, 1996). This pattern tends to serve the beneficial function of removal of surplus above-ground vegetation, much like periodic wildfires in prairie regions, thus allowing highly productive new-growth vegetation to recover, to the benefit of wildlife populations. This is different from encroachment of chronic, slightly higher salinity levels in these communities,

which is shown to alter vegetation patterns to a less diverse and less productive state for wildlife (Palmisano, 1972).

Sea Rim State Park
This TPWD-administered, 4,141-acre tract lies south and east of McFaddin NWR. The headquarters is located and most visitations occur within the 5.2-mile long Gulf beach frontage tract located to the south of SH 87. This state park contains important beach dune, backdune marsh and prairie, and freshwater wetlands and is especially important as spring neotropic migrant songbird and waterbird habitat due to its location.

J.D. Murphree Wildlife Management Area
This State of Texas WMA is composed of three separate tracts (Big Hill, Hillebrandt, and Lost Lake Units) totaling 24,250 acres lying east of McFaddin NWR and on both the north and south sides of the GIWW. It was purchased from the McFaddin family in 1950. The fresh, intermediate, and brackish marshes of this WMA are some of the most important migrant and stopover habitat in the Central Flyway and host upwards of 50,000 ducks per year. Some marsh tracts are managed to maintain intermediate to freshwater marsh characteristics optimum for waterfowl. Round Lake, a 500-acre natural lake within a protective levee system constructed in the 1960s when salinity intrusion first became a serious problem contains some of the highest-quality freshwater aquatic habitat remaining on the upper Texas coast. Large flocks of canvasback traditionally use this area on a seasonal basis (Sutherlin, 1997).

Lower Neches Wildlife Management Area
The 7,998-acre Nelda Starks Unit and the Old River Unit are located along the Neches River north of the SH 87 (Rainbow) bridge, immediately north of the confluence of the Neches River and Sabine Lake. These brackish marshes have suffered considerable losses, accelerated during the 1960s from land subsidence and salinity intrusion into formerly freshwater systems. Two projects at Bessie Heights have restored over 250 acres of subsided open water habitat back to emergent marsh, a hopeful sign that this trend is being reversed.

Brazoria National Wildlife Refuge
Established in 1966, this 44,413 acre refuge serves as an end point for ducks and geese migrating south along the Central Flyway. Comprised of freshwater sloughs, salt marshes, native bluestem prairies, woody thickets, and coastal prairies, the refuge manages most of these habitats for fish and terrestrial wildlife. More than 300 species of birds call the refuge home for the all or part of the year and benefit from ongoing fire management and wetland restoration.

San Bernard National Wildlife Refuge
Established in 1966, this refuge is home to one of the largest tracts of old growth forest in the south. The Dance Bayou tract (1,271 acres) is comprised of bottomland hardwoods, riparian wetlands, and fluvial woodlands. San Bernard NWR was designated as an Internationally Significant Shorebird Site by the Western Hemisphere Shorebird Reserve Network due to its importance to waterfowl and migrating birds. This 54,000 acre refuge includes beach, fresh and salt water marsh, bayous, ponds, Columbia Bottomland Hardwood forests, and native coastal prairie habitats. Due to the significant loss of wetlands, wetland restoration and management remains one of the refuge's top priorities.

Wetland Value Assessment (WVA) Ecological Model(s)

Modeling was conducted by the Corps for years with project and without project conditions and for direct and indirect impacts for each of the WVA models selected. At each step, the Service along with the interagency coordination team, worked with the Corps to develop acceptable ranges for many of variables used in each WVA. For a comprehensive analysis of the WVA modeling conducted for this study, please refer to the Corps' 2015 *Sabine Pass to Galvestion Integrated Feasibility Study and Environmental Impact Study Draft Appendix O Wetland Value Assessment Modeling* (USACE, 2015) report. The Service has highlighted some of the key points from the WVA modeling effort below.

The WVA methodology was developed in the early 1990's in Louisiana for assessment and rating of wetland restoration projects by the Coastal Wetlands Planning, Protection, and Restoration Act (CWPPRA) Environmental Work Group interagency team. The WVA methodology (USFWS, 2002) was considered appropriate for this project analysis by the Corps and the natural resource agencies because it incorporates large-scale measurements of predicted changes to salinity and vegetation of coastal Louisiana habitats identical to those of the project area.

The Corps utilized the WVA Coastal Marsh (Version [V] 1.0), Swamp (V 1.0), and Bottomland Hardwood (V 1.0) models to calculate ecosystem impacts and develop mitigation for the TSP. Recognizing that only the swamp and bottomland hardwood models are certified, the Corps requested and received approval from Headquarters on the use of the Coastal Marsh Community Model Version 1.0 for this study. The Corps was directed to conduct sensitivity analyses for application for the marsh models using a spreadsheet prepared by ERDC. Sensitivity analyses of the WVA Coastal Marsh Version 2.0 and 2.90B will be conducted after the plan is finalized.

The WVA modeling efforts evaluated only the Orange-Jefferson County portion of the TSP. Analysis of the Freeport and Port Arthur portions were not necessary because construction would be confined to existing right-of-ways not impacting any wetland habitat. Should the final alignments identify wetland impacts, these areas will be evaluated using the appropriate certified WVA model and will be compensated for appropriately with in kind mitigation.

The WVA methodology requires predictions within model units, including predictions of future changes to land loss rates. Therefore, the interagency team determined historic land loss rates for each wetland habitat type within each project hydrologic unit by GIS comparison of historic aerials from the past 20 to 25 years. From this, Future With Out Project (FWOP) land loss rates, then a Future With Project (FWP) land loss rate and projected historical rates over the 50-year project life were established using the Productivity-based Land Loss Increase Method modified from Visser et al. 2004a and 2004b. This salinity-effect information was then used in the WVA models (USFWS 2002b) by marsh habitat type. This method is based on a direct linear correlation between decreased primary productivity due to salinity increases with increased land losses due to the project.

Figure 6 Orange-Jefferson County TSP
Source: (USACE, 2015)

The WVA modeling evaluated and quantified direct, indirect impacts, and function loss (affected areas) of the Orange and Jefferson CRSM Plans. Direct and indirect impacts for each reach have been summarized in Table 7.

Mitigation is necessary to compensate for the loss of 42.7 AAHUs from forested wetlands and 143.3 AAHUs from coastal wetlands. Planning for the avoidance and minimization of impacts began with the initial selection of the Orange-Jefferson levee 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 impacts. Opportunities to further avoid and minimize environmental impacts will be identified 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. Preliminary mitigation cost estimates were developed based on these conceptual plans for use in the incremental analysis of levee reaches. Corps staff reports that mitigation costs are small in relation to overall

Wetland Type	Direct Impacts		Indirect Impacts				Total Impacts (acres)	Total AAHUs Lost
	Direct Wetland Impacts (acres)	AAHUs	Indirect Wetland Impacts (acres)	AAHUs	Functional Impacts (affected acres)	AAHUs		
Forested Wetlands								
Swamp	10.6	-7.2	1.9	-0.1	0.0	0.0	12.5	-7.3
Bottomland Hardwood	44.3	-30.3	12.7	-5.1	0.0	0.0	57.0	-35.4
Subtotal	54.9	-37.4	14.6	-5.2	0.0	0.0	69.5	-42.7
Coastal Marsh								
Fresh Marsh	24.3	-11.4	0.0	0.0	785.2	-18.8	809.5	-30.2
Intermediate Marsh	6.8	-4.0	19.2	-8.5	322.5	-4.1	348.5	-16.6
Brackish Marsh	74.2	-33.7	78.5	-35.2	1029.5	-27.6	1182.2	-96.5
Subtotal	105.3	-49.0	97.7	-43.7	2137.2	-50.5	2340.2	-143.3
Total Impacts*	**160.2**	**-86.5**	**112.3**	**-48.9**	**2137.2**	**-50.5**	**2409.7**	**-186.0**
* Totals may not add exactly due to rounding.								

Source: USACE 2016

Table 7 Recommended Plan Total Direct and Indirect Impacts

project construction costs, and therefore a final mitigation plan and more developed mitigation cost estimates are not needed to support plan selection. Final mitigation plans and cost estimates will be prepared during final feasibility planning for the Agency Decision Milestone

Relative Sea Level Rise

The Corps made 50-year-projections of relative sea-level rise (RSLR) for three scenarios – low (historic), intermediate and high as referenced in Table 8. The low or historic rate of RSLR was calculated by USGS for 12 subunits of the Sabine study area analyzing multiple dates of cloud free Landsat imagery from 1984-2014. USGS assumed the conversion of wetland acres to open water as the low or historic rate of RSLR. The RSLR values were then incorporated into the WVA modeling. The Service along with the other natural resource agencies agreed with the Corps' RSLR assumptions during the planning process. However, should there be new evidence supporting more aggressive sea level rise projections, the Service recommends the Corps reevaluate the project for negative effects not previously accounted for here and reinitiate coordination with the natural resource agencies for additional comment and recommendations.

Table 7 Relative Sea Level Rise Scenarios for Sabine Pass, Texas

Tidal Gage	Low RSLR (ft)	Intermediate RSLR (ft)	High RLSR (ft)
Sabine Pass, TX	1.63	2.32	4.51

Salinity

The Corps utilized outputs from the Sabine Neches Water Way hydrodynamic salinity modeling efforts conducted in 2009 in the WVA impacts modeling for this study and subsequently used these outputs for modeling the historic or low RSLR scenario. However, the Corps chose not to model the intermediate and high salinity scenarios for this study (due to time and funding constraints) but instead utilized efforts for the three RSLR scenarios in accordance with the same guidance utilized for the Corps' study (USACE, 2013). The Galveston District Corps adjusted the findings to accommodate the significantly higher rates of subsidence in the Corps' Morganza-to-the-Gulf Study area by reducing figures by the percentage difference between the RSLR rates between Morganza and Sabine regions. These adjusted percentage change for intermediate and high scenarios were applied to the baseline salinities to provide FWOP salinities in the 2080 and are reflected below in Table 9. The Service along with the other natural resource agencies agreed with the Corps 'salinity assumptions at this point. However, should there be new evidence supporting more aggressive salinity projections, the Service recommends the Corps reevaluate the project for negative effect not previously accounted for here.

Table 8 Method for estimating FWOP intermediate and high salinities for Sabine Region

Morganza Average Modeled Salinities from RSLR Scenarios			
	Average Salinity (ppt)		
RSLR Scenario	Brackish	Intermediate	Fresh
Historic (Low)	9.1	4.4	0.5
Intermediate	10.7	4.9	0.5
High	12.1	5.0	0.7
Percentage Morganza Salinity Change for RSLR Scenarios			
Difference between	Brackish	Intermediate	Fresh
Historic - Intermediate RSLR	18.2%	10.4%	2.6%
Historic - High RSLR	33.5%	11.8%	32.1%
Percentage Change Adjusted for Difference in Subsidence Rates			
	RSLR (ft over 75 yrs)		
RSLR Scenario	Morganza	Sabine	% Difference
Historic (Low)	1.7	0.93	-45.3%
Intermediate	2.4	1.49	-37.9%
High	4.8	3.26	-32.1%
Percentage Change in Salinity Adjusted for Difference in RSLR for Sabine Region			
Difference between	Brackish	Intermediate	Fresh
Historic - Intermediate RSLR	11.3%	6.5%	1.6%
Historic - High RSLR	22.7%	8.0%	21.8%

Period of Analysis/Target Years
The environmental period of analysis for the Orange/Northeast Jefferson County levee/floodwall system is a total of 61 years based on the following assumptions: the construction period is assumed to begin in 2020 and end in 2030; all direct impacts are assumed to occur in the first year of construction (2020); this is a conservative assumption since construction would not impact the entire project area in the first year of construction, and construction is not currently projected to be complete until 2030; indirect impacts may begin later but all are assumed to begin by 2031; mitigation area construction is assumed to be concurrent with levee system construction, beginning in 2020 and ending in 2030. The period for which mitigation benefits are analyzed is 2031-2080, which is the same as the 50-year economic period of analysis. A target year summary is provided in Table 9.

Table 9 Target Year Summary

TY0	2019 (the year before impacts begin)
TY1	2020 (all impacts occur)
TY11	2030 (levee and mitigation construction complete)
TY12	2031 (mitigation and economic benefits begin)
TY61	2080 (end of mitigation and economic period of analysis)

Service Alternatives Analysis

The Corps identified 250 potential CRSM and ER measures as part of this study through public meetings. Because of the breadth of the alternatives, the Service will only evaluate the measures put forth by the Corps, namely the TSP and Recommended Plans for Orange, Jefferson, and Brazoria Counties. While the overall footprint of the project remains quite large, the Service in coordination with the other federal and state natural resource agencies sought to avoid and minimize impacts to the greatest extent possible for each of the proposed TSPs and Recommended Plans. The result was several iterations of levee realignments reducing impacts to commercial and residential structures, marsh and forested wetland habitats, while improving hydrological connectivity with additional culverts to areas bisected by levee construction. The team also recommended staging areas within current right-of-ways minimizing impacts to adjacent property, and developed measures to reduce invasive species during times of disturbance throughout the project footprint.

Orange 3 –This area is a mosaic of commercial, industrial, and residential development where the outlined hurricane protection measures of the Recommended Plan meet the economic goals for the public at large. The final levee footprint as seen in the Recommended Plan was successively reduced to avoid and minimize impacts to all natural resources in the area. While not all habitat was spared, the Service continues to recommend the Corps fully mitigate for all impacts with in-kind mitigation measures. Please see the Mitigation Section for further mitigation recommendations.

The construction of the levee will involve the removal of structures, namely residential homes. The Service acknowledges the possible negative impacts during construction to resident aquatic and terrestrial trust species. While most terrestrial species expected to be encountered in this area are used to human presence, the Service recommends the Corps implement conservation measures during the construction phase to avoid and minimize any impacts to trust resources.

The Service has thoroughly reviewed the Corps' Recommended Plan for this portion of the study and believes the Corps should incorporate all of the Service's recommendations outlined below for the project to be successful.

Port Arthur- Considered a deep draft port; the Port of Port Arthur channel runs 40 feet deep and has a current width of 450 feet. This Port ranks 24th in total tonnage for the nation adding an annual economic impact of $128 million. Port of Port Arthur

The Recommended Plan would raise or construct a total of about 17.0 miles of levees and floodwalls in Port Arthur (this includes the construction of the new 1,830-foot levee segment) and will provide the hurricane protection measures necessary to meet the economic goals of the public at large while avoiding impacts to fish and wildlife species. No additional impacts are expected from the construction of the new levee section as all impacts will occur within existing right-of-ways. Should construction take place within the adjacent waters, any aquatic species can easily swim away and little if any suitable habitat remains for terrestrial wildlife species. Highly industrialized areas adjacent to Port Arthur bayous may not provide the habitat necessary to maintain the life cycle of for many of the fish species common to the study area. We would expect any aquatic species in the immediate area to vacate any areas impacted by construction. Those wildlife species that remain are highly adapted to human presence and should be able vacate any areas impacted by construction. The Service has thoroughly reviewed the Corps' Recommended Plan for this portion of the study and believes the Corps should incorporate all of the Service's recommendations outlined below for a successful project.

Freeport –This area is a highly industrialized petrochemical site situated along the GIWW with a Gulf of Mexico entrance via the Freeport Channel. Considered a deep draft port, the channel had a depth of 45 feet and a width of 400 feet. The Freeport Channel imports and exports a variety of goods however, the Port plans to export 13.9 million metric tonnes per annums of Liquid Natural Gas goods each year. The Port of Freeport is currently ranked 24th in foreign tonnage and 30th in total tonnage in the nation (Texas Department of Transportation, 2014). Currently, the Port of Freeport has an annual economic impact of almost $18 billion with over 13,000 direct jobs.

The Recommended Plan would raise or reconstruct approximately 18.6 miles of levees and floodwalls to occur within current right-of-ways (additional temporary staging areas may be required within currently industrialized areas) with no additional impacts to the environment are expected. Aquatic species can easily swim away and little if any suitable habitat remains for terrestrial wildlife species. Those wildlife species that remain are highly adapted to human presence and should be able to leave any areas impacted by construction. The Service has thoroughly reviewed the Corps' Recommended Plan for this portion of the study and believes the Corps should incorporate all of the Service's recommendations outlined below for the project to be successful.

Service Alternative Recommendations

Globally, coastal wetlands are considered important for a wide range of ecosystems services such as water purification, erosion control, carbon sequestration, recreation, and providing habitats for a diverse array of fish and wildlife species (Valiela, Kinney, Culbert, Peacock, & Smith, 2009) Evidence that coastal wetlands reduce storm surge and attenuate waves is well known in support of restoring Gulf Coast wetlands to protect coastal communities and property from hurricane

damage (Barbler, Georgiou, Enchelmeyer, & Reed, 2013). The President's Gulf Coast Ecosystem Restoration Task Force recommended extensive wetland restoration, given that the "Gulf's wetlands provide a natural flood attenuation function, which may reduce the impacts of flooding associated with storms" (Gulf Coast Ecosystem Recovery Task Force, 2011). The Service supports the acquisition, creation, and restoration of wetland habitats along the entire Texas coast as a first line defense for storm surge reduction to the maximum extent practicable. We have reviewed all the alternatives, TSP and Recommended Plans for this study, and believe the Corps has minimized impacts to the greatest extent possible as it relates to the scope of the project.

However, the Service recommends the Corps initiate the development of a project wide analysis focused on strategic wetland acquisition, restoration, and creation along portions of the project area where wetlands could provide the same level of storm surge protection as the proposed Recommended Plans. The Port Arthur and Freeport Recommended Plans expect construction to occur within current right-of-ways with no additional impacts to any aquatic or terrestrial habitats. In these areas, wetland habitat may not be a feasible alternative due to the proximity to the navigation channels and lack of available space for such as project. Yet, the Orange 3 Recommended Plan proposes to construct miles of new levee. In this instance, the Service continues to recommend the Corps fully consider the use of wetland habitat as a storm surge reduction alternative wherever possible. Commercial and residential buyouts, while considered and subsequently ruled out by the Corps, should receive greater consideration and used in conjunction with wetland acquisition, restoration, and creation opportunities to reduce flooding damages from coastal storms.

Mitigation

On August 31, 2009, the Corps' Directorate of Civil Works – Planning Community issued implementation guidance for Section 2036(a) of the Water Resources Development Act of 2007. This guidance requires that the preferred alternative contain a mitigation plan for the fish and wildlife resources that are lost as a result of the unavoidable impacts caused by the project. These impacts must be compensated to the extent justified and the preferred alternative must have adequate mitigation that will ensure the proposed storm surge reduction measures will not have any measurable adverse impact to the significant resources in the area. The Corps also recognizes that the wetland resources outlined in this document are significant and could suffer long term impacts due to the preferred alternative.

The resource agencies assisted the Corps with recommended mitigation opportunities and recognize the final mitigation alternatives have not been identified or selected at this time. We urge the Corps to continue to coordinate with all the natural resource agencies to fully vet out all mitigation possibilities. The Service (along with the other resource agencies) recommends the following mitigation and BU goals:

1) No net loss of wetland acres,
2) Replace lost AAHU's 1:1,
3) Replace AAHU's in-kind,

The President's Council on Environmental Quality defined the term "mitigation" in the National Environmental Policy Act regulations to include:

(a) avoiding the impact altogether by not taking a certain action or parts of an action; (b) minimizing impacts by limiting the degree or magnitude of the action and its implementation; (c) rectifying the impact by repairing, rehabilitating, or restoring the affected environment; (d) reducing or eliminating the impact over time by preservation and maintenance operations during the life of the action; and (e) compensating for the impact by replacing or providing substitute resources or environments.

The Service supports and adopts this definition of mitigation and considers its specific elements to represent the desirable sequence of steps in the mitigation planning process. Based on current and expected future without-project conditions, the planning goal of the Service is to develop a balanced project, i.e., one that is responsive to demonstrated hurricane protection needs while addressing the co-equal need for fish and wildlife resource conservation.

The Service's Mitigation Policy (Federal Register, Volume 46, No. 15, January 23, 1981) identifies four resource categories that are used to ensure that the level of mitigation recommended by Service biologists will be consistent with the fish and wildlife resource values involved. Considering the high value of forested wetlands and marsh for fish and wildlife and the relative scarcity of that habitat type, those wetlands are usually designated as Resource Category 2 habitats, the mitigation goal for which is no net loss of in-kind habitat value. The degraded (i.e., non-wet) bottomland hardwood forest and any wet pastures that may be impacted, however, are placed in Resource Category 3 due to their reduced value to wildlife, fisheries and lost/degraded wetland functions. The mitigation goal for Resource Category 3 habitats is no net loss of habitat value. Project impacts to wetlands will be minimized to some extent by hauling in material for the levee. Because the project is already constructed, avoiding the project impacts altogether (i.e., the "no action" alternative) is not feasible. Therefore, remaining project impacts should be mitigated via compensatory replacement of the habitat values lost.

Toward that end, the Service recommends that the following planning objectives be adopted to guide future project studies:

1. Conserve important fish and wildlife habitat (i.e., bottomland hardwoods, cypress swamps, fresh and estuarine marsh and associated shallow open water habitats) by minimizing the acreage of those habitats directly affected by flood control features.
2. Minimize enclosure of wetlands with new levee alignments. When enclosing wetlands is unavoidable, acquire non-development easements on those wetlands, or maintain hydrologic connections with adjacent, un-enclosed wetlands to minimize secondary impacts from development and hydrologic alteration.
3. Operate water control structures in levees to allow for (or maintain) fish and shellfish access into enclosed wetland areas.
4. Avoid adverse impacts to bald eagle nesting locations and wading bird colonies through careful design of levees, other project features and timing of construction.
5. Fully compensate for any unavoidable losses of wetland habitat or non-wet bottomland hardwoods caused by project features.

The Corps has identified 161 preliminary mitigation alternative areas such as those located in the floodplains of the Neches and Sabine Rivers within and adjacent to the study area. Additional sites may be identified during the final feasibility planning or suggested by resource agencies. We expect the Corps to analyze mitigation measures aimed at conservation to include coastal

marsh restoration, acquisition of and long-term conservation of bottomland hardwoods and/or swamps, and forested wetlands (See Table 12 below).

Table 10 Mitigation Measures Defined

Measure Type	Measure Description
Marsh Restoration	Fresh, intermediate and brackish marsh restoration utilizing maintenance material from the adjacent Sabine-Neches Waterway to create marsh in open water areas of degraded marsh or in former borrow pits
Hydrologic Restoration	Restoration of natural riverine, tidal, and overland flows to all wetland types by degrading levees, canal berms, roads, filling or blocking small channels which facilitate salinity intrusion, and/or installing culverts to restore connectivity.
Preservation	Preservation of forested wetland areas or emergent marsh under a perpetual conservation easement, or permanent transfer to an appropriate state conservation agency for preservation in perpetuity.
Forested Wetland Restoration	Replanting cypress-tupelo or bottomland forest vegetation in degraded wetland areas or in former borrow pits, and/or removal and long term control of Chinese tallow or other invasive vegetation species.

The primary objective of the Corps proposed mitigation plan is to restore approximately 453 acres of emergent marsh, and to preserve in perpetuity approximately 559 acres of forested wetlands. All of the impacted terrestrial and aquatic habitats play a vital conservation role along the upper Texas coast and long-term preservation of these habitats are critical for the continued economic growth and ecological resiliency of Orange, Jefferson and Brazoria Counties. The Service along with the Corps and the other natural resource agencies have selected a suite of appropriate mitigation alternatives satisfying the AAHUs necessary to satisfy the mitigation target for each habitat type (See Table 13). The Corps subsequently preformed a coast analysis and selected the Best Buy mitigation plan for each wetland type adversely affected by the Recommended Plan.

The Corps in conjunction with the natural resource agencies developed a series of assumptions for each of the mitigation modeling efforts. Appendix P of the Corps' Final Integrated Feasibility Report and Environmental Impact Study details the mitigation, monitoring, and adaptive management plans for the entire Sabine Pass to Galveston Bay Coastal Strom Risk Reduction and Ecosystem Restoration study area (USACE, 2016) and is used to reference the tables below.

Table 11 Mitigation Compensation by Habitat Type

Habitat Type	Mitigation Target	Best Buy Plan	Mitigation Compensation (AAHU)
Swamp	-7.3	S11	13.2
Bottomland Hardwood	-35.4	BH161	49.3
Fresh Marsh	-30.2	F52	33.4
Intermediate Marsh	-16. 6	I31	60.4
Brackish Marsh	-96.5	B28 and B29	100.4
Total	-186.0		262.9

The Corps used marsh restoration, preservation, and forest wetland restoration to build the seventeen mitigation alternatives that were advanced for further screening. The final screening resulted in the Recommended Plan preserving in perpetuity of 559.3 acres of swamp and bottomland hardwoods in Mitigation Area 11 in the bottomlands of the Sabine River and in Mitigation Area 161 on the upland/wetlands margin of the Neches River in the Bessie Heights area. An additional 452.8 acres of marsh (fresh, intermediate, and brackish), shallow ponds, and sinuous channels within the marsh in Mitigation Areas 28,29,31,52 (Figures 7, 8, 9, 10 and 11).

Figure 7 Mitigation Area 11

Source: USACE 2016

Figure 8 Mitigation Area 161

Source: USACE 2016

Figure 9 Mitigation Areas 28 and 29

Source: USACE 2016

Figure 10 Mitigation Area 31

Source: USACE 2016

Figure 11 Mitigation Area 52

Source: USACE 2016

The Corps plans to use sediments shoaled from maintenance dredging of adjacent deep-draft navigation channels to restore marsh in areas of open water within Mitigation areas 28, 29, 31 and 52. Target elevations were developed by natural resource agency staff during the mitigation plan formulation, however the Service recommends the Corps re-evaluate target elevations just

prior to the commencement of restoration construction and adjust accordingly. An appropriate reference marsh within close proximity to the mitigation site should be identified and used to meet the target elevations. Close coordination with resource agency staff during the construction phases will assure a successful mitigation project.

The Mitigation Plan Summary (Table 14 below) demonstrates how the Corps plans to fully compensate for all wetland impacts. The Service accepts the mitigation strategy as outlined by the Corps below. However, the Service recognizes that some or all parcels of land outlined for preservation may not be available for purchase if and when the Recommend Plan becomes fully funded. The Service recommends a thorough analysis of the mitigation alternatives at that time to determine availability of said Mitigation Areas. Should any of Mitigation Areas 11, 28, 29, 31, 52, and 161 not be available for preservation or restoration as formally outlined in the Corps Mitigation Plan, the Service recommend immediate coordination to define a new array of mitigation alternatives.

Table 12 Mitigation Plan Summary

Mitigation Area ID	Wetland Type	Total Wetland Acres Preserved in Perpetuity	Total Restored Wetland (acres)*	Total Compensation (AAHUs)	Mitigation Target (AAHUs)
11	Cypress-Tupelo Swamp	291.2		13.2	-7.3
	Bottomland Hardwood	155.7		6.2	
161	Bottomland Hardwood	112.4		49.3	-35.4
	Subtotal	559.3		68.7	-42.7
28	Brackish Marsh	**	133.2	58.5	-96.6
29	Brackish Marsh	**	106.0	41.9	
31	Intermediate Marsh	**	150.7	60.4	-18.2
52	Fresh Marsh	206.8	62.9	33.4	-30.2
	Subtotal	206.8	452.8	194.2	-145.0
	Total	**860.5**		**262.9**	**-187.7**

* Total acres of restored marsh and water

** Property already owned by TPWD so it is already in preservation status.

Final Recommendations

The Service has the following final recommendations for the proposed project:

1. Situate flood protection features so that destruction of wetlands and non-wet bottomland hardwood forests are avoided or minimized to the maximum extent practicable. The Corps shall fully compensate for any unavoidable losses of wetland habitat or non-wet bottomland hardwoods caused by project features.

2. Minimize enclosure of wetlands with levee alignments. When enclosing wetlands is unavoidable, establish non-development easements directly adjacent to those wetlands, or maintain hydrologic connections with adjacent, un-enclosed wetlands to minimize secondary impacts from development and hydrologic alteration.

3. Avoid adverse impacts to bald eagle nesting locations and wading bird colonies through careful design protection features and timing of construction. The National Bald and Golden Eagle Management Guidelines are included.

4. Forest clearing associated with project features should be conducted during the fall or winter to minimize impacts to nesting migratory birds, when practicable. The Migratory Bird Treaty Act (MBTA) protects all native migratory birds and prohibits the taking, killing, possession, and transportation (among other actions) of migratory birds, their eggs, and parts, except when specifically permitted by regulations of specific intentional uses. A list of birds protected under the MBTA can be found in 50 CFR 10 of the MBTA and at http://www.fws.gov/migratorybirds/regulationspolicies/mbta/mbtandtx.html.

5. A complete mitigation plan to compensate for direct and indirect habitat impacts should be developed in consultation with the Service and other state and federal natural resource agencies during final feasibility planning and presented in the Final IFR-EIS. The Final IFR-EIS should specify the mitigation plan that will be implemented concurrently with project construction. The Service understands the scale of the mitigation and levee construction features of this project and the time required for beneficial use projects to be completed. The Corp should complete initial construction of mitigation features at any given mitigation use site within two years and additional features (channel and pond construction) to be completed as soon as possible.

6. The project's first Project Cooperation Agreement (or similar document) should include language that includes the responsibility of the local-cost sharer to provide operational and construction monitoring, and maintenance funds for mitigation features. Acquisition, habitat development, maintenance, site protection, and management of mitigation lands should be allocated as first-cost expenses of the project, and the local project-sponsor should be responsible for operational costs. If the local project-sponsor is unable to fulfill the financial mitigation requirements for operation, then the Corps should provide the necessary funding to ensure mitigation obligations are met and maintained on behalf of the public interest.

7. Further detailed planning of project features (e.g. Design Documentation Report, Engineering Documentation Report, Plans and Specifications, or other similar documents) should be coordinated with the Service, NMFS, TPWD, NRCS, Environmental Protection Agency (EPA), Texas Commission of Environmental Quality (TCEQ), and the Texas General Land Office (TGLO). The Service shall be provided 30 days to review and submit recommendations on all the work addressed in those reports.

8. The Corps should avoid impacts to state and federal lands. If not feasible, the Corps should establish and continue coordination with state and federal agencies managing lands that may be impacted by a project feature until construction of that feature is

complete and prior to any subsequent maintenance. Points of contact for the agencies potential impacts by project features are:

- Texas Chenier Plain National Wildlife Refuges Complex (979) 267-3337
- McFaddin National Wildlife Refuge Manager (979) 971-2909
- J.D. Murphree Wildlife Management Area Manager (979) 736-2551
- Pineywoods Ecosystems Project Manager (936) 569-8547

9. If mitigation lands are purchased for inclusion within a National Wildlife Refuge (NWR), those lands must meet certain requirements; a general summary of some of the requirements is provided in Appendix A. However, prior coordination with the Service's Region 2 Regional Office should be conducted early in the process to gauge the feasibility of such inclusion activities. Other land-managing natural resource agencies may have similar requirements that must be met prior to accepting mitigation lands; therefore agency representatives should be contacted early in the planning phase regarding such requirements.

10. If applicable, a General Plan should be developed by the Corps, through coordination with the Service, and the natural resource agencies in accordance with Section 3(b) of the FWCA for mitigation lands.

11. If the proposed project features change, the status of species change, or the project is not implemented within three years of the date of our Endangered Species Act coordination, we recommend that the Corps reevaluate the project's effects and species status and initiate any necessary consultation procedures pursuant to Section 7 of the Endangered Species Act.

12. In general, the Corps should incorporate larger, numerous openings within a diversity of locations in a protection levee aimed at maintaining estuarine dependent fishery migration.

13. Flood protection water control structures in any watercourse should maintain pre-project width and depth to the maximum extent practicable, especially structures located in tidal passes.

14. To the extent possible given any authorized channel dimensions, any flood protection water control structure sited in canals, bayous, or navigation channels that do not maintain the pre-project cross section should be designed and operated with multiple openings within the structure. This should include openings near both sides of the channel as well as an opening in the center that extends to the bottom of the channel.

15. Should final surge gate structure designs reduce the cross section of Adams or Cow Bayous more than 50 percent, additional modeling and environmental analysis will be performed to characterize potential hydrologic and fish passage impacts and determine additional mitigation requirements.

16. Flood protection surge gates, sluice gates, culverts, and any other water control structures should remain completely open except during storm events or regularly scheduled

maintenance or inspections (See Appendix C). Operation, maintenance, and management plans for structures should be developed in coordination with the Service, NMFS, TPWD, TCEQ, and TGLO.

17. The operation and maintenance plan for the gates and water control structures has not yet been developed. This plan should include a schedule of maintenance events for each gate and culvert and proposed closure times for said maintenance activities. A worst case closure scenario is estimated to be 5-7 days every 10-15 years based on predicted storm surge return intervals high enough to threaten areas targeted for protection. However, in years where more than one storm event occurs, we expect the gates to remain closed (an estimated 5-7 days) for **each** storm event. Periodic maintenance of the gates and culverts (not included in the worst case scenario) may result in additional closures estimated of not more than two weeks for each instance. Therefore, it is assumed by the Corps and representative from the natural resource agencies that closure of the surge gates, sluice gates, and culverts would cause only minor and temporary impacts to fish access and coastal marsh, and no additional mitigation would be needed to offset operational impacts. Any proposed operational deviation from the estimated frequency or duration of structure closures must be assessed in coordination with the Service, NMFS, TPWD, TCEQ, and TGLO at which time additional mitigation would be required to offset such operational impacts.

18. The number and siting of openings in flood protections levees should be optimized to minimize the migratory distance from the opening to enclosed wetland habitats.

19. Flood protection structures within a waterway should include shoreline baffles and or ramps (e.g., rock rubble, articulated concrete mat) that slope up to the structure invert to enhance organism passage. Various ramp designs should be considered and coordinated with various resources agencies for review and comment.

20. To the maximum extent practicable, structures should be designed and/or selected and installed such that average flow velocities during peak flood or ebb tides do not exceed 2.6 feet per second. However, this may not necessarily be applicable to tidal passes or other similar major exchange points.

21. To the maximum extent practicable, sluice gates or culverts (round or box) should be designed, selected, and installed such that the invert elevation is equal to the existing water depth (See Appendix C). The size of the sluice gates or culverts should be selected that would maintain sufficient flow to prevent siltation.

22. Temporary culverts or sluice gates should be installed in construction access roads unless otherwise recommended by the natural resource agencies. We expect these culverts to minimize hydrologic isolation within wetlands and marshes in the area by maintaining hydrologic flows across the landscape to the maximum extent possible. At a minimum, there should be one; 24-inch culvert or sluice gate placed every 500 feet and one at natural stream crossings. If the depth of water crossings allow, larger sized culverts should be used. Culvert spacing should be optimized on a case-by-case basis. A culvert may be necessary if the road is less than 500-feet long and an area would be hydrologically isolated without that culvert.

23. Water control structures should be designed to allow rapid opening in the absence of an off-site power source after a storm passes and water levels return to normal.

24. Levee alignment and water control structure alternatives should be selected to avoid the need for fishery organisms to pass through multiple structures (i.e., structures behind structures) to access an area.

25. Operational plans for water control structures should be developed to maximize the cross-sectional area open for as long as possible.

26. Any proposed change in mitigation features or plans should be coordinated in advance with the Service, NMFS, EPA, TPWD, TCRQ, and TGLO.

27. A report documenting the status of mitigation implementation and maintenance should be prepared every three years by the managing agency and provided to the Corps, the Service, NMFS, EPA, TPWD, TCEQ, and TGLO. That report should also describe future management activities and identify and propose changes to the existing management plan.

28. Fill material used during the construction of the levees or its associated features should come from an approved upland borrow source permitted by the State and testing should comply with TCEQ criteria. The Environmental Protection Agency (EPA)/Corps Inland Testing Manual criteria would apply to dredge material used for marsh restoration at mitigation sites.

29. The Corps shall fully compensate for any unavoidable losses of wetland habitat (including forested wetlands) or non-wet bottom hardwoods caused by project features as dictated by the Wetland Value Assessment modeling.

30. Acquisition, habitat development, maintenance, and management of mitigation lands should be allocated as a first-cost expense of the project to ensure mitigation obligations are met on behalf of the public interest.

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Appendix A

Summary of basic/general mitigation land requirements before land is transferred to the U.S. Fish and Wildlife Service

SUBJECT: Revised Summary of basic mitigation land requirements before land is transferred over to the Service.

The following represents a summary of basic mitigation land requirements before land is transferred over to the Service. This does not necessarily represent a comprehensive list, but does represent our best effort to identify all land requirements within reason. Coordination with the Service's affected Region will be necessary to evaluate feasibility of land transfer activities pursuant to the following requirements and should occur very early in the process.

1. For inclusion into the National Wildlife Refuge (NWR) system the lands must be located within a refuge's acquisition boundary.

2. The Service must be provided copies of any easements/agreements for right-of-way on the property especially as it pertains to maintenance of such right-of-way, frequency of maintenance and costs associated with that maintenance if the maintenance is to be performed by the landowner.

3. The area must be surveyed prior to acquisition by the United States or transfer to the Fish and Wildlife Service. The survey will be conducted by the Corps of Engineers (Corps) or an approved contractor. Boundaries must be marked and permanent monuments set at all comers. Copies of the surveyor notes, plats, etc. resulting from such survey must be provided to Service.

4. Language must be placed in the deed dedicating the mitigation land to fish and wildlife conservation in perpetuity.

5. When possible any restrictive covenants or liens shall be removed, especially if they could interfere with mitigation implementation, operation and/or maintenance.

6. Completion of a Level 1 survey for hazardous, toxic, and/or radioactive wastes with a copy being provided to the Service. If the Level 1 survey indicates the need for further investigations/surveys, those investigations/surveys must be completed and a copy provided to the Service. Lands having unremediated hazardous, toxic, and/or radioactive wastes present may not be accepted into a NWR. Remediated sites will be assessed for inclusion on a case-by-case basis. Documentation of the level of remediation is to be provided to the Service.

7. Funding mechanism for operation and maintenance of the mitigation lands and mitigation features (e.g., water control structures, timber stand improvements, etc.).

8. Documentation must be provided to the Service describing the mitigation goals and objectives in addition to a description of necessary operation and maintenance activities needed to accomplish the stated goals and objectives.

9. Mineral rights should be purchased. If it is not possible to purchase, then protection of surface rights via the following language:

> "The vendors reserve for themselves, their successors and assigns, the right to explore, for, operate, produce, remove and transport, oil and gas from the lands herein described. The

vendors reserve unto themselves, their successors and assigns, the right of ingress and egress over the said lands in pursuance of the reservations set forth above.

The land is now subject to oil and gas lease in favor of

_____, as per lease of record in the records of

_____, pages _____ of

Book_____, and the conveyance is subject to the rights of the lessee in said lease.

The oil and gas reservations made by the vendors herein in favor of themselves, their successors and assigns, shall be subject to the following stipulations, and any lease made by the vendors, their successors or assigns, subsequent to the date of this deed, shall contain the following stipulations for the protection of the vendee.

The vendors, their successors and assigns, agree that prior to entry upon the land for purposes of exploration, development or production of, oil and/or gas, they shall obtain a Special Use Permit from the U.S. Fish and Wildlife Service, which permit is for the purpose of providing for access and protecting the natural resources of the area for which the land was acquired, and whose terms and conditions will not unreasonably restrain the activities of the vendors, and their successors and assigns.

It is mutually understood between the parties that the intention of the Government in acquiring this area is to create a refuge for, and the protection of, wildlife in the area herein acquired, and the vendors will conform to, and be governed by, and the vendors herein bind themselves, their successors and assigns, agents and employees, to conform to, and be governed by, the rules and regulations pertaining to the protection of wildlife and refuge administration prescribed from time to time by the Secretary of the Interior or his/her authorized agent, the Director of Fish and Wildlife Service, except that such regulations shall not unreasonably restrain the exercise and use by the vendors, their successors and assigns, of the reservation set out in this agreement. [1]

10. The Service would need a title commitment and policy in favor of United States of America that is in the American Land Title Association (ALTA) U.S. Policy 9/28/91 format as provided in Title Standards 2001 .

If the title remains with the local-sharer or the Corps a General Plan as provided for under Section 3 of the Fish and Wildlife Coordination Act (48 Stat. 401; 16 U.S.C. 661 et seq.) must be written. However, the Service may choose to not manage lands for which it does not have title.

Appendix B

Suggested Priority of Migratory Bird Conservation Actions for Projects
U.S. Fish and Wildlife Service, Migratory Bird Management
(For External Distribution)
March 9, 2010

1. Avoid any take of migratory birds and/or minimize the loss, destruction, or degradation of migratory bird habitat while completing the proposed project or action.

2. Determine if the proposed project or action will involve below- and/or above-ground construction activities since recommended practices and timing of surveys and clearances could differ accordingly.

3. If the proposed project or action includes a reasonable likelihood that take of migratory birds will occur, then complete actions that could take migratory birds outside of their nesting season. This includes clearing or cutting of vegetation, grubbing, etc. The primary nesting season for migratory birds varies greatly between species and geographic location, but generally extends from early April to mid-July. However, the maximum time period for the migratory bird nesting season can extend from early February through late August. Also, eagles may initiate nesting as early as late December or January depending on the geographic area. Due to this variability, project proponents should consult with the appropriate Regional Migratory Bird Program (USFWS) for specific nesting seasons. Strive to complete all disruptive activities outside the peak of migratory bird nesting season to the greatest extent possible. Always avoid any habitat alteration, removal, or destruction during the primary nesting season for migratory birds. Additionally, clearing of vegetation in the year prior to construction (but not within the nesting season) may discourage birds from attempting to nest in the proposed construction area, thereby decreasing chance of take during construction activities.

4. If a proposed project or action includes the potential for take of migratory birds and/or the loss or degradation of migratory bird habitat and work cannot occur outside the migratory bird nesting season (either the primary or maximum nesting season), project proponents will need to provide the USFWS with an explanation for why work has to occur during the migratory bird nesting season. Further, in these cases, project proponents also need to demonstrate that all efforts to complete work outside the migratory bird nesting season were attempted, and that the reasons work needs to be completed during the nesting season were beyond the proponent's control.

   Also, where project work cannot occur outside the migratory bird nesting season, project proponents must survey those portions of the project area during the nesting season prior to construction occurring to determine if migratory birds are present and nesting in those areas. In addition to conducting surveys during the nesting season/construction phase, companies may also benefit from conducting surveys during the prior nesting season Such surveys will assist the company in any decisions about the likely presence of nesting migratory birds or sensitive species in the proposed project or work area. While individual migratory birds will not necessarily return to nest at the exact site as in

previous years, a survey in the nesting season in the year before construction allows the company to become familiar with species and numbers present in the project area well before the nesting season in the year of construction. Bird surveys should be completed during the nesting season in the best biological timeframe for detecting the presence of nesting migratory birds, using accepted bird survey protocols. USFWS Offices can be contacted for recommendations on appropriate survey guidance. Project proponents should also be aware that results of migratory bird surveys are subject to spatial and temporal variability. Finally, project proponents will need to conduct migratory bird surveys during the actual year of construction, if they cannot avoid work during the primary nesting season (see above) and if construction will impact habitats suitable for supporting nesting birds.

5. If no migratory birds are found nesting in proposed project or action areas immediately prior to the time when construction and associated activities are to occur, then the project activity may proceed as planned.

6. If migratory birds are present and nesting in the proposed project or action area, contact your nearest USFWS Ecological Services Field Office and USFWS Region Migratory Birds Program for guidance as to appropriate next steps to take to minimize impacts to migratory birds associated with the proposed project or action.

* Note: these proposed conservation measures assume that there are no Endangered or Threatened migratory bird species present in the project/action area, or any other Endangered or Threatened animal or plant species present in this area. If Endangered or Threatened species are present, or they could potentially be present, and the project/action may affect these species, then consult with your nearest USFWS Ecological Services Office before proceeding with any project/action.

** The Migratory Bird Treaty Act prohibits the taking, killing, possession, and transportation, (among other actions) of migratory birds, their eggs, parts, and nests, except when specifically permitted by regulations. While the Act has no provision for allowing unauthorized take, the USFWS realizes that some birds may be killed during construction and operation of energy infrastructure, even if all known reasonable and effective measures to protect birds are used. The USFWS Office of Law Enforcement carries out its mission to protect migratory birds through investigations and enforcement, as well as by fostering relationships with individuals, companies, and industries that have taken effective steps to avoid take of migratory birds and by encouraging others to implement measures to avoid take of migratory birds. It is not possible to absolve individuals, companies, or agencies from liability even if they implement bird mortality avoidance or other similar protective measures. However, the Office of Law Enforcement focuses its resources on investigating and prosecuting individuals and companies that take migratory birds without identifying and implementing all reasonable, prudent and effective measures to avoid that take. Companies are encouraged to work closely with Service biologists to identify available protective measures when developing project plans and/or avian protection plans, and to implement those measures prior to/during construction or similar activities.

*** Also note that Bald and Golden Eagles receive additional protection under the Bald and Golden Eagle Protection Act (BGEPA). BGEPA prohibits the take, possession, sale, purchase,

barter, offer to sell, purchase, or barter, transport, export or import, of any Bald or Golden Eagle, alive or dead, including any part, nest, or egg, unless allowed by permit. Further, activities that would disturb Bald or Golden Eagles are prohibited under BGEPA. "Disturb" means to agitate or bother a Bald or Golden Eagle to a degree that causes, or is likely to cause, based on the best scientific information available, (1) injury to an Eagle, (2) a decrease in its productivity, by substantially interfering with normal breeding, feeding, or sheltering behavior, or (3) nest abandonment, by substantially interfering with normal breeding, feeding, or sheltering behavior. If a proposed project or action would occur in areas where nesting, feeding, or roosting eagles occur, then project proponents may need to take additional conservation measures to achieve compliance with BGEPA. New regulations (50 CFR § 22.26 and § 22.27) allow the take of bald and golden eagles and their nests, respectively, to protect interests in a particular locality. However, consultation with the Migratory Bird, Ecological Services, and Law Enforcement programs of the Service will be required before a permit may be issued.

Appendix C

National Marine Fisheries Service Baton Rouge Field Office
April 2008 Version

Fisheries Friendly Design and Operation Considerations for Hurricane and Flood Protection Water Control Structures

SUMMARY

The purpose of this document is to: 1) identify design and operational guiding principles that would optimize passage of estuarine dependent marine fisheries species, or at least, minimize adverse impacts to their passage through hurricane and flood protection water control structures planned for the New Orleans District of the U.S. Army Corps of Engineers; and, 2) provide background literature for environmental justification and documentation. Specific projects for which this guidance should be considered include the Mississippi River and Tributaries, Morganza to the Gulf of Mexico Hurricane Protection Project; Donaldsonville to the Gulf Project; Supplemental Appropriations Projects, and the Louisiana Coastal Protection and Restoration Project (LACPR). However, these guiding principles would also pertain to any civil works projects that could include combinations of levees and/or water control structures. Project delivery teams should remain flexible to adapt these design principles on a case-by-case basis as new fishery resource information and project-specific hydraulics data become available.

In general, the ability of estuarine dependent marine fishery organisms to migrate to and from coastal habitats decreases as structural restrictions increase, thereby reducing fishery production. 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.

Data on marine fishery species migrations in the Gulf of Mexico are too limited to allow the development of definitive design and operational considerations for water control structures that would guarantee the protection of marine fishery production. Anecdotal comparisons can be made with data from water intake and fish passage studies from the west and east coasts. 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 to fishery passage. In addition, biological background information is provided in the appendices to assist in preparation of environmental documents required by the National Environmental Policy Act (NEPA).

Summary of guiding principles for designing and operating flood protection water control structures to maintain marine fishery passage:

- **Generally, bigger and more numerous openings in hurricane and flood protection levees better maintain estuarine dependent fishery migration. As much opening as practicable, in number, size, and diversity of location should be considered.**
- **Flood protection water control structures in any watercourse should maintain pre-project cross section in width and depth to the maximum extent practicable, especially structures located in tidal passes.**
- **Flood protection water control structures should remain completely open except during storm events.**
- **Any flood protection water control structure sited in canals, bayous, or navigation channels that does not maintain the pre-project cross section should be designed and operated with multiple openings within the structure. This should include openings near both sides of the channel as well as an opening in the center of the channel that extends to the bottom.**
- **The number and siting of openings in flood protection levees should be optimized to minimize the migratory distance from the opening to enclosed wetland habitats.**
- **Structures should include shoreline baffles and/or ramps (e.g., rock rubble, articulated concrete mat) that slope up to the structure invert to enhance organism passage. Various ramp designs should be considered.**
- **To the maximum extent practicable, structures should be designed and/or culverts selected such that average flow velocities during peak flood or ebb tides do not exceed 2.6 feet/second. This may not necessarily be applicable to tidal passes or other similar major exchange points.**
- **To the maximum extent practicable, culverts (round or box) should be designed, selected, and installed such that the invert elevation is equal to the existing water depth. The size of the culverts should be selected that would maintain sufficient flow to prevent siltation.**
- **Culverts should be installed in construction access roads unless otherwise recommended by the natural resource agencies. At a minimum, there should be one, 24-inch culvert placed every 500 feet and at natural stream crossings. If the depth of water crossings allow, larger sized culverts should be used. Culvert spacing should be optimized on a case-by-case basis. A culvert may be necessary if the road is less than 500-feet long and an area would hydrologically isolated without that culvert.**
- **Water control structures should be designed to allow rapid opening in the absence of an offsite power source after a storm passes and water levels return to normal.**
- **Levee alignments and water control structure alternatives should be selected to avoid the need for fishery organisms to pass through multiple structures (i.e., structures behind structures) to access an area.**
- **Operational plans should be developed to maximize the cross-sectional area open for as long as possible. Operations to maximize freshwater retention or redirect freshwater flows could be considered if hydraulic modeling demonstrates that is possible and such actions are recommended by the natural resource agencies.**

INTRODUCTION

Various flood protection and environmental water control structures in hurricane protection levees are being designed and considered for inclusion with ongoing local and federal civil works projects within the boundaries of the New Orleans District. Design purposes of the structures vary and may include maintaining safe navigation and optimizing drainage and passage of fishery organisms. For the Sabine to Galveston hurricane protection project, the ICT identified economically important fishery species that should be considered when assessing structure impacts on estuarine fisheries migration. Both the federal and state governments manage some of these species. Primary species that could be affected by flood protection structures in Lousiana include brown shrimp, white shrimp, blue crab, red drum, black drum, spotted seatrout, sand seatrout, southern flounder, and gulf menhaden. Some information is included herein on forage species, the production of which is important to maintain as they serve as important links of the aquatic food web for many of the managed fishery species.

The Baton Rouge office of NMFS has developed preliminary design principles for hurricane and flood protection water control structures to reduce impacts to living marine resources, especially related to migrations of estuarine dependent species. The basis for the following recommended guiding principles is briefly discussed where supporting literature is available. Basic behavior and physiology effects on the passage of fishery organisms are discussed in detail in appendices C and D, to aid federal agencies in environmental evaluations and descriptions under NEPA.

This document has been developed in consideration of input from the interagency HET, university faculty, fish passage staff of various agencies, and cursory literature reviews. These design considerations are intended to address potential impacts to living marine resources pursuant to the Fish and Wildlife Coordination Act and the Magnuson-Stevens Fishery Conservation and Management Act. Impacts to resources managed under other authorities, such as the Endangered Species Act or the Marine Mammal Protection Act, are not addressed in this document.

GUIDING PRINCIPLES FOR DESIGNING FISHERIES FRIENDLY FLOOD PROTECTION WATER CONTROL STRUCTURES

1. Generally, bigger and more numerous openings in hurricane and flood protection levees better maintain estuarine dependent fishery migration. As much opening as practicable, in number, size, and diversity of location should be considered.

Most of Louisiana's commercial and recreational fishery species must have access to estuarine marshes to successfully complete some part of their life cycle (i.e., they are estuarine-dependent). Estuarine-dependent fishery productivity is a measure of standing crop (the number of fishery organisms present at a point in time) and the turnover rate (the rate at which the population is replaced). All things being equal, fishery production would be lower following levee and water control construction if structures retard turnover rate. This would be the case even while standing crop may appear normal. Restrictions in tidal movement caused by water control structures and levees would result in degraded or substantially changed species composition, which could alter fishery production and/or displace fisheries.

Marine transient species emigrate (i.e., move from coastal marshes towards Gulf waters) towards higher salinity water; therefore, a structure that maintains the greatest degree of opening while allowing the project objectives to be met would be desirable (Rogers et al. 1992).

2. Flood protection water control structures in any watercourse should maintain pre-project cross section in width and depth to the maximum extent practicable, especially structures located in tidal passes.

Water control structures should be designed to have a water flow capacity (and similar dimensions where possible) comparable to the waterway before construction. Restricted water exchange in marshes enclosed by levees and water control structures diminishes recruitment and standing stocks of species that must migrate from coastal spawning sites to marsh nurseries (Rogers et al. 1994). As the amount of hydrologic control increases, the effect on migration and production of marine transients and residents increases. Greater restriction decreases turn over rate of estuarine-dependent fishery organisms, which decreases their production (Rogers et al. 1992a). Slotted and fixed crest weirs have been found to delay immigration. As the degree of restriction increased from slotted weirs, to low elevation weir, and to fixed crest weirs, greater impacts to different fisheries species and their emigration were observed.

Design considerations for hurricane and flood protection water control structures should include features to accommodate vertical and horizontal fishery distribution patterns within interior marsh tidal pathways and coastal passes. Fishery organisms exhibit preferences by species, life stage, and in some cases tide cycle, for vertical and horizontal distribution within smaller or interior marsh tidal connections (Table 1). Behavioral and physiological responses, such as diel vertical migration, affect these preferred distribution patterns.

Study of Keith Lake Pass in Texas revealed that all portions of the water column, both vertically and horizontally, are used by fishery organisms (Hartman et al. 1987). Most estuarine-dependent fishery species preferred the bottom or shore zones during flood tides, but were much more dense near the shores of the pass, in slower moving water, on ebb tide. This lateral movement on slack to ebb tides appears to be a behavioral action to prevent displacement from the pass during ebb tide to accelerate movement to marsh nursery areas. The study identified the response to light cycles with midday densities greatest at bottom and densities greatest at surface during dawn to dusk. Similar within pass distribution patterns were reported by Sabins and Truesdale at Grand Isle, Louisiana (1974) .

Table 1. Table on fishery preference within the water column (Marotz et al. 1990; Herke and Rogers 1985; Hartman et al. 1987; Sabins and Truesdale 1974). "a" denotes juveniles; "b" denotes immigrating; "c" denotes emigrating; "e" denotes ebb tide; "f" denotes flood tide.

	Vertical Distribution			Horizontal Distribution
Species	Surface	Mid-depth	Bottom	Shore/Nearshore
brown shrimp[b]	X	X		X[e]
white shrimp[b]	X	X		
white shrimp[c]		X		X[e]
blue crab	X			Xe
red drum[a]				X[e]
red drum[b]		X	X	
red drum[c]			X	
bay anchovy	X			
striped mullet	X			
Atlantic croaker[a]	X	X		X[e]
Atlantic croaker		X	X	X[e]
spotted seatrout		X	X	
sand seatrout		X	X	X[e]
gulf menhaden	X	X		
southern flounder				X[f]
black drum				X[e]

3. Flood protection water control structures should remain completely open except during storm events.

Fish passage should be optimized by the duration that structures remain fully open. Rozas and Minello (1999) reported that even when water-control structures were open, the densities of transient species were low inside areas enclosed by levees and water control structures as compared to natural areas.

Fisheries migration that temporarily may be impacted with storm related closures are listed in Table 2. The degree of impact would be influenced by the timing and duration of a structure closure relative to peak migration.

Table 2. Migration of economically important fisheries in Louisiana that temporarily may be impacted with storm related closures.

Species	Migration Period Overlapping with Hurricane Season
brown shrimp	April - mid July
white shrimp	July – November
blue crab	June – September
spotted seatrout	April – October
sand seatrout	April – October
red drum	August - December
black drum	March – July
southern flounder	September - October

4. Any flood protection water control structures sited in canals, bayous, or navigation channels that do not maintain the pre-project cross section should be designed and operated with multiple

openings within the structure. This should include openings near both sides of the channel as well as an opening in the center of the channel that extends to the bottom.

Hartman et al. (1987) recommended structures not be constructed in a tidal pass. If a structure was constructed, they recommended the incorporation of several gates at several vertical and horizontal locations, with baffles near shore. Baffles near shore are to direct shore or near shore fish passage on ebb tides through the available structure opening(s) (e.g., gates in wing walls).

Structures should be designed and operated with multiple openings if the pre-project water depth and widths of a channel are not maintained. Multiple openings are necessary to optimize passage of fishery organisms that prefer to migrate along the sides, bottom, and top of channels. For example, Rogers et al. (1992[a]) recommended opening some vertical slots and top, middle, and bottom gates in a structure with multiple slots and gates.

5. The number and siting of openings in flood protection levees should be optimized to minimize the migratory distance from the opening to enclosed wetland habitats.

The location and number of structures likely affects the abundance and distribution of estuarine fishery species within habitats that would be located on the protected side of levees and water control structures. Rogers et al. (1992[c]) determined that marine transient species were most numerous nearest the structures, partially due to the proximity of the openings with respect to the area enclosed. Similarly, other studies have shown there is a decrease in fishery species abundance and diversity the greater the distance from the access point (Peterson and Turner 1994). This can become more pronounced if an environmental gradient (e.g., salinity) exists between an access point and the interior habitat located on the protected side of structures (Cashner 1994).

6. Structures should include shoreline baffles and/or ramps (e.g., rock rubble, articulated concrete mat) that slope up to the structure invert to enhance organism passage. Various ramp designs should be considered.

Study of Keith Lake Pass in Texas revealed vertical and horizontal distribution patterns of fishery organisms in the pass (Hartman et al. 1987). Estuarine-dependent fishery organisms preferred the bottom or near shore zones on flood tides. Most organisms appeared near shores of the pass on ebb tide in slower moving water. Baffles near shore are to direct shore or near shore fish passage through the structure.

Many fish migrate along the water bottom. Water control structures with crests or inverts higher than the lower portion of a channel could impede migration through the deep-water portions of channels. Ramps can provide a means to guide organisms over and through structures and increase access of fisheries organisms to enclosed habitat (Lafleur 1994). Various ramp designs need to be investigated.

7. To the maximum extent practicable, structures should be designed and/or culverts selected such that average flow velocities during <u>peak</u> flood or ebb tides do not exceed 2.6 feet/second.

In this preliminary investigation, no studies were located that evaluated the impacts of swimming speeds for the fishery species and life stages of concern in Louisiana. To avoid preventing or

reducing ingress or egress of fishery organisms, preliminary guidance on water velocities through structures in Louisiana could be based on anecdotal comparisons with data available on general swimming speeds from studies on the west and east coasts (Tables 3 and 4).

Swimming speeds of estuarine and marine fish and crustaceans is a function of shape, stage of development, length, ambient temperature, light, and duration required for swimming performance. For most species, absolute speed increases as size increases. Generally, fish swimming speeds range from 2-4 body lengths/second with burst speeds up to 5 body lengths/second (Meyers et al. 1986).

Water intake studies have shown that maintaining water velocities less than 0.5 ft/sec would protect most fish and their life stages from being adversely affected by those flows (USEPA 2004). The species and life stages of fish for that study could not be located at this time and further investigation for Gulf of Mexico species is warranted. They also recommended creating horizontal velocity fields to avoid adverse effects on fish because fish are better able to orient to horizontal verses vertical flow. This could allow selective avoidance of water flows not preferred by fish or minimize disorientation or mortality rates caused by flows.

Eberhardt (personal communication) reported velocities exceeding 0.82 feet/second began to impede fish passage. Fish passage was decreased by 50% for velocities exceeding 2.6 feet/second. Based on evaluation of freshwater species, Gardner (2006) recommends keeping velocities through round culverts less than 1.8 ft/sec during 90% of the fish migration season. To improve fish passage through culverts, installing baffles within culverts should be considered to reduce flow velocity barriers for fish (Pacific Watershed Associates 1994).

Table 3. Water flow velocity thresholds for affecting fish passage or avoiding impingement within flows or on screens.

Source	Water Flow Velocity (ft/sec)	
Alyson Eberhardt, personal communication	0.82	Begin to impede
	2.62	Decreased fish passage by 50%
Gardner 2006	1.8	Critical velocity (freshwater fish)
Meyers et al. 1986	<0.49	To avoid impingement
USEPA 2004	<0.50	Protected 96% of the fish tested from impingement

Table 4. Sustained fish swimming speeds. Adapted from Meyers et al. (1986). Note that no data was located for the fisheries species and life stages for the Gulf of Mexico.

Fish/life stage	Swimming Speeds (ft/sec)
Atlantic herring	0.19 – 0.3
Mullet	4.19
Horse mackerel	4.46
Sole	0.19 - 0.3
most larvae	0.82 – 0.98

Based on these limited data, larval fish could be adversely impacted by water flow rates exceeding 0.82 feet/second. Post-larval and juvenile stages of flounders could be impacted by flow rates around 1.0 ft/sec. Other species or larger life stages likely would not be adversely impacted until flow rates exceed 2.62 feet/second based on inferences from these data. Water flow velocity monitoring in the Terrebonne Basin by the U.S. Fish and Wildlife Service has found maximum flows through existing open channels exceeding 1.0 feet /second and in larger saline marsh channels and passes exceeding 2.0 feet/second.

If the spatial extent of flow velocity fields exceed the distance that can be traveled with sustained or burst swimming speeds of fishery organisms, those flows could prevent or reduce ingress or egress during the time which those flows exist. However, the degree of mortality from not being able to access nursery and foraging habitat is not known. High flow rates may aid passage of larval fish that primarily depend on passive transport for migratory distribution and access to estuarine habitat on the protected side of levees, if the high flows do not induce mortality from injury or fatigue. Water flow could exceed the fish swimming rates for short periods and still provide passage during low flows or during still water.

8. To the maximum extent practicable, culverts (round or box) should be designed, selected, and installed such that the invert elevation is equal to existing water depth. The size of the culverts should be selected that would maintain sufficient flow to prevent siltation.

Design considerations should include installing baffles within culverts to reduce flow velocity barriers (Pacific Watershed Associates 1994). Passage of salmon and herring species has been shown to be impaired by culverts. With baffles or other similar features, still water areas could be created to enhance fish passage.

If water control structures include plunge pools, the invert elevation of the structure could be equal to the depth of the plunge pool if the plunge pool is deeper than the pre-project water depth. This deeper invert would optimize passage of fisheries species, in particular bottom dweller species.

Fish often require visual cues for orientation and exhibit faster swimming speeds at increased light levels. Herring type fish (e.g., gulf menhaden) are particularly sensitive to light levels. However, although herring exhibited a preference for unshaded portions of treatments during both day and night periods, as little as 1.4% of the ambient light was necessary for their passage through a culvert (Mosser and Terra 1999).

9. Culverts should be installed in construction access roads unless otherwise recommended by the resource agencies. At a minimum, there should be one, 24-inch culvert placed every 500 feet and at all water crossings. If the depth of water crossings allow, larger sized culverts should be used. Culvert spacing should be optimized on a case-by-case basis. A culvert may be necessary, even if the road is less than 500 feet long, if an area would be hydrologically isolated without that culvert.

10. Water control structures should be designed to allow rapid opening in the absence of an offsite power source after storm passage and return of normal water levels.

Regardless of structure size, designs and contingency plans should include means to rapidly open the water control structures when flooding risks subside after a storm. Designs and plans should include infrastructure, equipment, and staff necessary to open the structures even if offsite electricity is not available. Design safeguards should be developed to protect the structures from being damaged rendering them inoperable and locked in a closed configuration after passage of a storm.

11. Levee alignment and water control structure alternatives should be selected to avoid the need for fishery organisms to pass through multiple structures (i.e., structures behind structures) to access an area.

12. Operational plans should be developed to maximize the cross-sectional area open for as long as possible. Operations to maximize freshwater retention or redirect freshwater flows could be considered if hydraulic modeling demonstrates that is possible and such actions are recommended by the natural resource agencies.

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APPENDIX A

BEHAVIOR

The physical ability (i.e., swimming speed) to navigate a structure is not the only factor influencing fish passage, especially for small structures. Behavioral responses to stimuli individually or interactively affect passage with physiological constraints or responses. Behavior generally can be categorized as schooling and non-schooling behavior.

SCHOOLING BEHAVIOR

Schooling behavior consists of strategies that provide hydrodynamic efficiency, reduced predation, increased efficiency in finding food, and increased reproductive success. Water control structures for flood protection impact large numbers of fishery organisms due to this group response. This could be because fish exhibit the tendency to approach and orient to other members of the species (i.e., biotaxis). This orientation confers a hydrodynamic advantage that is more efficient than individuals due primarily to vortices setup by lead fish. Schools function as a living organism where the group reacts to stimuli as an individual. It is this group reaction that influences greater affect on passage through water control structures.

NON-SCHOOLING BEHAVIOR

Agonistic, territorial, and hierarchical behavior are examples of non-schooling behavior exhibited by fish. Agonistic and territorial behaviors are largely unknown for the listed estuarine and marine fishery species of concern and their life stages. Structures that create physically taxing water flow velocities and some low flow areas may encourage these behaviors as fish compete for resting areas similar to competition seen with fish competing for resting areas within shrimp trawls or behind rocks in river riffle/pool habitat. It is possible these behavioral responses overall may not be that influential on fish passage through a structure, but may come more into play during low flow conditions such as lower tides or slack tide. Hierarchical behavior can often be driven by a combination of physiological responses and will be discussed in that section. Overall, investigation on behavioral responses to water control structures is needed to avoid and minimize adversely impacting fishery passage if not optimizing it.

APPENDIX B

PHYSIOLOGICAL

Fishery species and life stages react differently to a current of water (i.e., rheotaxis). Generally, fish are better able to orient to horizontal verses vertical flow (Meyers et al. 1986).

Locomotion

There are two means for migratory transport of estuarine and marine fish and crustaceans: passive and active transport. Passive transport is drift of organisms carried by the tides and currents. Larval and post-larval fish and crustacean life stages are predominately transported passively by tides and currents. Passive transport via tidal forcing can play a strong role in migration of sub-adult and adult brown shrimp, white shrimp, and blue crabs. Active transport is movement by swimming, which is the primary means of locomotion for sub-adults and adult fish.

SWIMMING SPEED

Refer to guiding principles number 7 for details on swimming speeds relative to impacts on fish passage.

BEHAVIORAL/PHYSIOLOGY INTERACTION

Many fishery organisms exhibit hierarchical behavior. This is a direct response to stimuli, such as astronomical (e.g., tidal rhythm) or meteorological driven flows. For example, brown shrimp mediate transport by circadian or diel vertical migration. Brown shrimp move down in the water column or cease activity as the become negatively buoyant when low salinity and temperature water develop in estuaries with north winds associated with spring fronts. Brown shrimp activity resumes with their movement up in the water column with increasing water temperature, salinity, and hydrostatic pressure associated with the southerly gulf return following after a cold front (Rogers et al. 1993). Similar selective tidal stream transport was reported by Hartman et al. (1987). Fishery organisms identify tide changes by detecting altered velocity, salinity, temperature, all of which can cue staging for immigration with an incoming tide. Future tidal pass or inlet studies are needed for better information on vertical distribution, depth preferences, and changes in buoyancy or behavior to evaluate active and passive transport of fishery organisms.

APPENDIX C - Reference Websites, Fish Passage Agency Representatives, and University Faculty

Baker, C. and J. Boubee. 2003. Using ramps for fish passage past small barriers. Water and Atmosphere 11(2). June.
http://www.niwascience.co.nz/pubs/wa/11-2/passage

Corps Portland District, Fish Passage Team
http://www.nwp.Corps.army.mil/pm/e/en_fish.asp

Corps, ERDC, Coastal Hydraulics Lab
http://chl.erdc.Corps.army.mil/CHL.aspx?p=s&a=ResearchAreas;22
USFWS Fish Passage Decision Support System
http://fpdss.fws.gov/index.jsp

NC State's Center for Transportation and the Environment website:
http://www.itre.ncsu.edu/

http://itre.ncsu.edu/CTE/gateway/downloads/Culvert%20Impact%20Study(December2002).pdf

http://itre.ncsu.edu/CTE/gateway/downloads/FishPassage.pdf

FishXing software and learning systems for fish passage through culverts. This software is intended to assist engineers, hydrologists, and fish biologists in the evaluation and design of culverts for fish passage. It is free and available for download.
http://stream.fs.fed.us/fishxing/

- Allows for comparison of multiple culverts designs within a single project.

- Calculates hydraulic conditions within circular, box, pipe-arch, open-bottom arch, and embedded culverts.
- Contains default swimming abilities for numerous North American fish species.
- Contains three different options for defining tailwater elevations.
- Calculates water surface profiles through the culvert using gradually varied flow equations, including hydraulic jumps.
- Outputs tables and graphs summarizing the water velocities, water depths, outlet conditions, and lists the limiting fish passage conditions for each culvert.

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