Gulf Intracoastal Waterway, Brazos River Floodgates and Colorado River Locks, Texas

US Army Corps of Engineers®
Galveston District

Texas Department of Transportation®

Final Integrated Feasibility Report and Environmental Impact Statement

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

June 2019

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DEPARTMENT OF THE ARMY
GALVESTON DISTRICT, CORPS OF ENGINEERS
P.O. BOX 1229
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Gulf Intracoastal Waterway, Brazos River Floodgates and Colorado River Locks, Texas

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RECORD OF DECISION

GULF INTRACOASTAL WATERWAY, BRAZOS RIVER FLOODGATES AND COLORADO RIVER LOCKS, TEXAS
BRAZORIA AND MATAGORDA COUNTIES, TEXAS

The Final Integrated Feasibility Report and Environmental Impact Statement (IFR/EIS) dated **DATE OF FEIS**, for the Gulf Intracoastal Waterway, Brazos River Floodgates and Colorado River Locks, Texas Project addresses Brazos River Floodgates (BRFG) and Colorado River Locks (CRL) modification opportunities and feasibility in **Brazoria and Matagorda Counties, Texas**. The final recommendation is contained in the report of the Chief of Engineers, dated **DATE OF CHIEF'S REPORT**. Based on these reports, the reviews by other Federal, State, and local agencies, Tribes, input of the public, and the review by my staff, I find the plan recommended by the Chief of Engineers to be technically feasible, economically justified, in accordance with environmental statutes, and the public interest.

The Final IFR/EIS, incorporated herein by reference, evaluated various alternatives that would alleviate navigational difficulties, delays, and accidents occurring as tow operators' transit through the BRFG and CRL structures and across the Brazos and Colorado Rivers in the study area. The recommended plan is the National Economic Development (NED) Plan and includes:

- At BRFG:
  - Removal of the existing 75-foot gates on both sides of the Brazos River
  - Construction of a new 125-foot sector gate structure approximately 300 feet south of the existing alignment, set back approximately 1,000 feet from the Brazos River on the east side.
  - Construction of a minimum 125-foot open channel on the west side of the Brazos River, with a bottom depth of -12 feet NAVD88 with a bank-to-bank width of approximately 500 feet.

- At CRL:
  - Removal of the existing 75-foot lock structures on both sides of the Colorado River.
  - Construction of a new 125-foot sector gate structure on the east and west sides of the Colorado River crossing.

- Implementation of the environmental compensatory mitigation and associated monitoring and mitigation area adaptive management plan. Monitoring will continue until the mitigation is determined to be successful based on the identified criteria within the Mitigation Plan included in Appendix D-8 of the IFR/EIS. Monitoring is expected to last no more than 5 years.

In addition to a “no action” plan, multiple action alternatives were evaluated at each location. Five BRFG alternatives and three CRL alternatives were carried forward and were evaluated in detail for comparison and plan selection. Chapter 3 of the IFR/EIS discusses the alternative formulation. Non-structural measures were also considered at both locations, including improvements to scheduled maintenance of the gates/locks, improvements to towing schedules using Automatic Identification System (AIS) or similar scheduling systems, and adding buoys and additional navigation lights to help barges. Non-structural measures have been determined to have negligible impacts on the frequency or duration of navigation accidents and were, therefore, not carried forward for further analysis because they would not meet the study objectives. An exception is the addition of mooring locations, which are being analyzed in a separate study, *Gulf Intracoastal Waterway, Texas, Mooring Basin Modifications, Operations, and Maintenance Discretionary Authority Study*. Non-structural measures would still be used as needed to address any remaining residual risks after the recommended plan is constructed.

At the BRFG, the alternatives included rehabilitating the existing gates and guidewalls (Alt 2a); removing the existing gates and constructing new 125-foot (minimum) gates on each side of the river, set back from the current gate locations (Alt 3a); removing the existing west gate completely and constructing a new 125-foot gate on the east side of the river, set back from the current gate location (Alt 3a.1); constructing an open channel on new alignment (Alt 9a), and constructing new 125-foot gates on new alignment, with flood-control structures on the existing alignment (Alt 9c). At the CRL, the alternatives included rehabilitating the existing lock facilities (Alt 2a); removing the existing lock facilities and constructing an open channel (Alt 3b); and converting the locks to floodgates by removing the river-side gates, or by removing all gates and constructing new 125-foot sector gates on each side of the river (Alt 4b.1).

Of the BRFG-CRL alternative combinations, BRFG Alt 9a and CRL Alt 4b.1 (9a-4b.1) yielded the highest net benefits at $11.5 million, but there is significant uncertainty regarding sedimentation rates with the open channel and how sedimentation would impact future navigation functionality and environmental resources. BRFG Alt 3a.1 and CRL Alt 4b.1 (3b.1-4b.1) had similar net benefits at $11.1 million and minimizes the risks associated with the uncertainties identified above. As such, this combination (3b.1-4b.1) provides the best system alternative plan in meeting the U.S. Army Corps of Engineers’ navigation missions for the region and is identified as the NED plan.

The recommended plan includes BRFG Alt 3b.1 and CRL Alt 4b.1. The recommended plan was identified as the environmentally preferable alternative.

For all alternatives, the potential effects were evaluated, as appropriate. A summary assessment of the potential effects of the recommended plan are listed in Table 1:

Table 1: Summary of Potential Effects of Recommend Plan

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

All practicable means to avoid or minimize adverse environmental effects were analyzed and incorporated into the recommended plan. Best management practices (BMPs) as detailed in the IFR/EIS will be implemented to minimize impacts. Planning for the avoidance and minimization of impacts began with the initial alternatives screening and agency coordination and will continue through the Pre-Construction, Engineering, and Design (PED) phase of the project. The proposed realignments and gate construction are as close as possible to the existing alignment while allowing for continued operation of the existing facilities during construction, thereby minimizing impacts to wetlands located along the GIWW banks. All remaining unavoidable impacts are fully compensated with in-kind mitigation.

The recommended plan will result in unavoidable adverse impacts to impacts including the loss of 14.5 acres of estuarine marsh (intertidal marsh and high marsh). Habitat Evaluation Procedures (HEP) models were used to evaluate wetland impacts in terms of average annual habitat units (AAHUs) and to develop an appropriate compensatory mitigation plan. The wetland impacts result in a loss of 12.1 AAHUs. To fully compensate for these unavoidable adverse impacts, the U.S. Army Corps of Engineers will create 14.9 acres of estuarine marsh, which will provide 12.1 AAHUs. A detailed description of the mitigation plan is presented in Appendix D-8 of the IFR/EIS.

Public review of the draft IFR/EIS was completed on 11 April 2018. All comments submitted during the public comment period were responded to in the Final IFR/EIS. A 30-day waiting period and state and agency review of the Final IFR/EIS was completed on **DATE SAR PERIOD ENDED**. **PICK OPTION BASED ON RESULTS OF STATE AND AGENCY REVIEW**.

Pursuant to section 7 of the Endangered Species Act of 1973, as amended, the National Marine Fisheries Service (NMFS) concurred with the effect determinations documented in the Biological Assessment in a letter, dated 10 April 2019. The National Marine and Fisheries Service (NMFS) response determined that the recommended plan will not adversely impact or jeopardize that determined that the recommended plan will not adversely impact or jeopardize the continued existence of the following federally listed species or adversely modify designated critical habitat: green, Kemp's ridley, loggerhead, or hawksbill sea turtles. Informal Section 7 consultation is ongoing with the USFWS and will be completed before the signing of the FIFR/EIS. All terms and conditions, conservation measures, and reasonable and prudent measures resulting from these consultations will be implemented in order to minimize take of endangered species and avoid jeopardizing the species.

Pursuant to section 106 of the National Historic Preservation Act of 1966, as amended, the U.S. Army Corps of Engineers determined that historic properties would not be adversely affected by the recommended plan. The Texas State Historic Preservation Office concurred with the determination on 23 January 2019.

Pursuant to the Clean Water Act of 1972, as amended, all discharges of dredged or fill material associated with the recommended plan have been found to be compliant with the section 404(b)(1) Guidelines (40 CFR 230). The Clean Water Act Section 404(b)(1) Guidelines evaluation is found in Appendix D-1 of the IFR/EIS.

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

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

During a resource agency meeting in April 2018, NMFS indicated that the Corps has sufficiently addressed Essential Fish Habitat (EFH), and no further coordination with NMFS regarding EFH is required. The Corps' EFH Assessment is provided in Appendix D-4 of the IFR/EIS.

Coordination with NMFS under the Marine Mammal Protection Act (MMPA) is ongoing and awaiting a decision on entering formal consultation. If required, USACE will continue to coordinate with NMFS through the MMPA consultation process in compliance with the MMPA or during the Pre-construction, Engineering, and Design phase of the project before construction activities would commence.

Technical, environmental, economic, and cost effectiveness criteria used in the formulation of alternative plans were those specified in the Water Resources Council's 1983 Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies. All applicable laws, executive orders, regulations, and local government plans were considered in evaluation of alternatives. Based on the review of these evaluations, I find that benefits of the recommended plan outweigh the costs and any adverse effects. This Record of Decision completes the National Environmental Policy Act process.

______________________	______________________
Date	R.D. James Assistant Secretary of the Army (Civil Works)

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REPORT

This Final Integrated Feasibility Report and Environmental Impact Statement (FIFR-EIS) documents the formulation, and evaluation of plans for modification to the existing Gulf Intracoastal Waterway (GIWW) Brazos River Floodgates (BRFG) and Colorado River Locks (CRL) projects conducted under the GIWW BRFG-CRL Feasibility Study. This FIFR-EIS has undergone public review, policy review, Agency Technical Review (ATR), and Independent External Peer Review (IEPR).

This study follows the September 2000 reconnaissance report titled, *GIWW Modifications, Texas Section 905(b) Analysis*. It encompassed two locations on the GIWW along the Texas coast.

STUDY INFORMATION

Authority. This report is an interim response to the study authority, Section 216 of the Flood Control Act of 1970 (Public Law 91-611), as amended.

Study Purpose. The study purpose is to address modifications to the projects (BRFG and CRL) that are necessary to alleviate navigational difficulties, delays, and accidents occurring as the tow operator's transit through the BRFG and CRL structures and across the Brazos and Colorado Rivers, respectively.

General Study Area and Location. The FIFR-EIS Study Area (**Figure ES-1**) encompasses the two project sites on the GIWW along the middle of the Texas coast. The BRFG are located about 7 miles southwest of Freeport, Texas, at the intersection of the Brazos River and the GIWW in Brazoria County, Texas. The CRL are located near Matagorda, Texas, at the intersection of the Colorado River and the GIWW in Matagorda County. This area encompasses a large amount of hydraulic connectivity to a variety of water bodies, which expands the study area to approximately 40 miles of the GIWW in Texas.

Navigation System Background and Use. The GIWW is a Federal shallow-draft navigation project. BRFG and CRL are in the western portion of the GIWW, construction of which started prior to 1900 and ended in 1949 with full extension or depth to Brownsville, Texas. The GIWW intersects many bodies of water including the Brazos and Colorado Rivers. These rivers have found the GIWW as an outlet for discharging their sediment-laden flows. In the 1940s, 75-foot wide gated structures aimed at controlling flows and silt into the GIWW at each river crossing were completed. The closing of the gates allows the rivers to perform more naturally by allowing their sediments to continue downstream. The gates on both sides of the Colorado River crossing were upgraded to 1,200-foot-long locks in 1954 by adding gated structures and earthen lock chambers. The locks increase the navigability window at the crossing. Approximately 21 million tons of commodities, averaged from 2010-2014, transited each project.

Figure ES-1 – Overview of Study Area

Study Partner. The study partner is the Texas Department of Transportation (TxDOT). The agency has provided the EIS and technical appendices per a Memorandum of Agreement (MOA) signed with the USACE in August 2016.

Problem Statement. The narrow gate opening and crossing geometry at the two projects create hazardous cross currents and eddies that cause vessels to impact with the structures (allisions). The 75-foot opening at each project requires tows that are assembled into configurations of two barges wide to break down to a single wide configuration for shuttling across the river and then, once through the structures, to reassemble together into their original tow configuration (tripping). Shutdown of operations during high river periods and accident repairs cause significant economic impacts to the navigation industry.

BRFG and CRL have five year averages of 56 and 8 allisions per year, respectively. The cost impacts are approximately $18.5M and $10M at each project, as shown in **Table ES-1**. Accident frequency has generally been increasing since 2002. Lastly, the aging infrastructure at BRFG and CRL facilities leads to structural, electrical and mechanical maintenance issues.

Table ES-1 – Cost Impacts at BRFG & CRL

Category	Brazos	Colorado
Allision repair costs	$1.4M	$0.6M
Processing time cost	$1.5M	$2.2M
Queuing cost	$4.6M	$3.1M
Tripping time cost	$6M	$4.1M
Closure delay cost	$5M	$80K

Planning Objectives. The following planning objectives were used in the formulation and evaluation of alternative plans:

- Reduce navigation delays (tripping, allisions) for vessels transiting the BRFG-CRL system through the 50-year period of analysis
- Increase navigation efficiency (alignment, hydraulic flow, high river periods) of vessels transiting the BRFG-CRL system over the 50-year period of analysis
- Minimize vessel allisions which result in facility closures/ outages for required repairs over the 50-year period of analysis
- Manage Sedimentation into the GIWW from the Brazos and Colorado Rivers over the 50-year period of analysis
- Improve overall operations/functions of the facilities which experience frequent mechanical failures due to age and outdated systems

Alternatives. Measures used to formulate alternatives included both nonstructural and structural measures, as well as a No Action Alternative. Nonstructural measures included measures such as improvements to scheduled maintenance of the locks, improvements to towing schedules using AIS or similar schedule systems. These measures have been employed historically to reduce risks; however, they are not sufficient to alleviate the existing inefficiencies and are already practiced to the greatest extent practicable. As such, non-structural measures were not carried forward. However, non-structural measures would still be used to address any remaining residual risks. Structural measures, were derived from a variety of sources including prior studies, the public scoping process, and team collaboration. The study considered measures for key functional navigation areas that include lock/floodgate structures, flow impacts on the rivers and GIWW, and potential impacts to the surrounding environment (wetland areas, communities, and existing Federal projects (i.e. levees)). Measures were evaluated to determine if they addressed the study objective with those that did not contribute to the objective being dropped from the alternative formulation. Measures were evaluated and screened by the project delivery team through several arrays of alternatives with the No Action Alternative included for all phases of the screening.

Development of Hybrid Alternatives (Stakeholder Engagement). At an October 2017 meeting, the team coordinated the final alternatives with navigation industry groups. Concerns were raised about the open channel crossing and the effects of the increased currents and sedimentation on Freeport Harbor. The team collaborated with the industry groups and a hybrid alternative was developed for each location. The BRFG and CRL alternatives (identified as the Tentatively Selected Plan (TSP)) underwent concurrent review. Significant comments were raised during the public review period that resulted in additional analysis and refinement of the final plans. The comments concerned: 1) impacts to the San Bernard River; 2) navigation impacts at Port Freeport; 3) a narrow 75-foot gate opening at CRL; and 4) increased sedimentation due to temporary construction bypasses. At the Agency Decision Milestone (ADM) Meeting, the Vertical Team concurred with the teams proposed path forward to address the aforementioned concerns and hold an In-Progress Review (IPR) to update the Vertical Team. The PDT and the Vertical Team conducted the IPR and the team subsequently completed refinement of the TSP, now the Recommended Plan. During refinement of the TSP, the team also coordinated the design with District Operations and navigation industry.

RECOMMENDED PLAN

The Recommended Plan for the BRFG-CRL System is alternative (3a.1) for BRFG and alternative (4b.1) for CRL. The BRFG component of the Recommended Plan consists of constructing a new 125-foot sector gate structure approximately 300-feet south of the existing alignment, set back approximately 1,000 feet from the river on the east side, and a minimum 125-foot open channel on the west side of the river crossing. The CRL component of the Recommended Plan consist of constructing new 125-foot sector gate structures approximately 260-feet south of the existing alignment, set approximately mid-way between the existing lock gates. With the wider alignments and increased forebays of the Recommended Plan, accident probabilities would be reduced by approximately 80 percent at BRFG and 99 percent at CRL.

RECOMMENDED PLAN COMPONENTS

BRFG Components. At BRFG, the main features of the Recommended Plan (**Figure ES-2**) are the removal of the existing gates on both sides of the river crossing, the construction of a 125-foot wide open channel on the west side and a new 125-foot wide sector gate structure on the east side. The open channel would have a bottom depth of -12 feet NAVD88 with a bank-to-bank width of approximately 500 feet. The new sector gate on the east side would be set back approximately 1,200 feet from the existing gate structure, providing increased safety and efficient vessel operation through the system, reducing allisions. The gate would be constructed to a top elevation (El) of 16-feet NAVD88 with a sill at El -16 feet NAVD88. New control houses, an administrative office building, warehouse and boat house would be constructed to support the maintenance and operation of the new gate structures. The construction of the open channel and new sector gate would take approximately two years to complete, assuming an adequate funding stream. Assuming one contract, construction would be sequenced as follows:

- An access channel would be dredged on the GIWW side of the east gate structure to permit floating plant access for construction of the structure. Advanced dredging of the new west channel would be performed with the exception of a small plug on the river side of the new channel. Disposal of excavated material from the bypass would be placed in the adjacent placement areas. Suitable material would be re-used for backfill for the new 125-foot sector gates.
- Once dredging for floating access is completed, the production piling for the gate structure would be driven in the wet. Foundation pilings would consist of approximately 246 steel pipe piles measuring 30-inch in diameter and driven to a depth of 125 feet below grade.
- The cofferdam would then be constructed and the gate structure completed. Concrete pours for the sector gate monolith would occur first. Machinery, electrical, and mechanical connections would all be installed after completion of concrete placement. Concurrent with the construction of the gate structure, portions of the guidewalls and end cells not within the footprint of the cofferdam could also be constructed. The new buildings on the lock reservation would constructed concurrently.
- The cofferdam would then be removed and the remaining ancillary features completed.
- The remaining portion of the new channel would be dredged and navigation transferred to the new structure.
- The existing gate structures would then be decommissioned and the southern half of both gate structures would be removed.
- The final grading and construction of the access levee would then be completed.

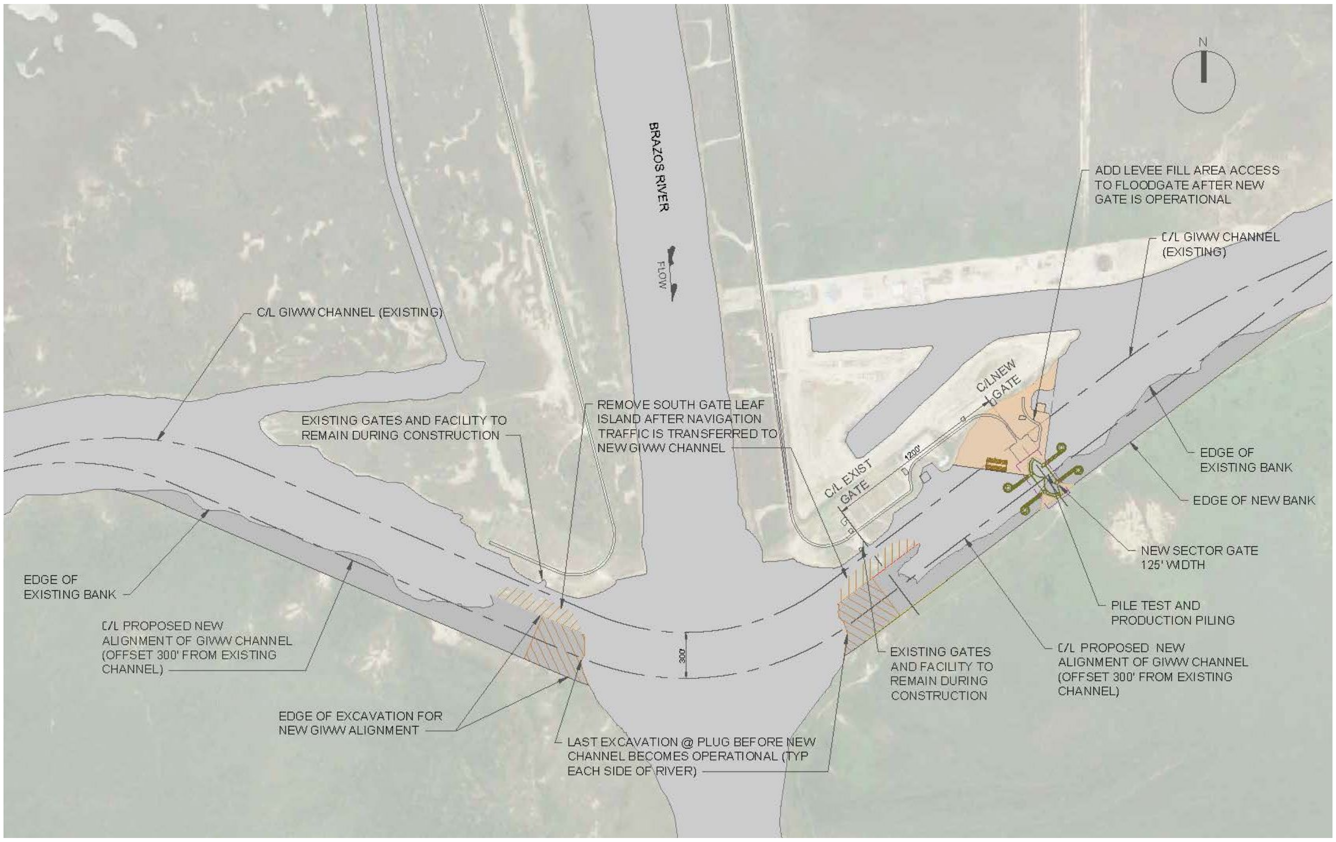

Figure ES-2 – BRFG Recommended Plan Component

CRL Components. At CRL, the main features of the Recommended Plan (**Figure ES-3**) are the construction of new 125-foot sector gate structures on the east and west sides of the river crossing. The new sector gates would be set back approximately 1,000 feet from the river crossing. The gates would be constructed to a top El of 16-feet NAVD88 with a sill at El -16 feet NAVD88. The construction of the new sector gates would take approximately two years to complete, if adequate funding is provided. New control houses, an administrative office building, warehouse and boat house would be constructed to support the maintenance and operation of the new gate structures. Assuming one contract, construction would be sequenced as follows:

- An access channel would be dredged on the GIWW side of each structure to permit floating plant access for construction of the structures. Disposal of excavated material from the bypass will be placed in the adjacent placement areas. Suitable material will be re-used for backfill for the new 125 foot sector gates.
- Once dredging for floating access is completed, the production piling for the gate structure would be driven in the wet. Foundation pilings would consist of approximately 246 thirty-inch steel pipe piles, driven to a depth of 125 feet below grade on the east gate and 130 feet below grade on the west gate.

- The cofferdam would then be constructed and the gate structure completed. Concrete pours for the sector gate monolith would occur first. Machinery, electrical, and mechanical connections would all be installed after completion of concrete placement. Concurrent with the construction of the gate structure, portions of the guidewalls, end cells and rock training wall not within the footprint of the cofferdam could also be constructed. The new buildings on the lock reservation would also be constructed concurrently.
- The cofferdam would then be removed and the remaining ancillary features completed.
- The remaining portion of the new channel would be dredged and navigation transferred to the new structure.
- The existing lock would then be decommissioned and the southern end of the eastern GIWW sector gate would be removed.
- The final grading and construction of the access levee would then be completed.

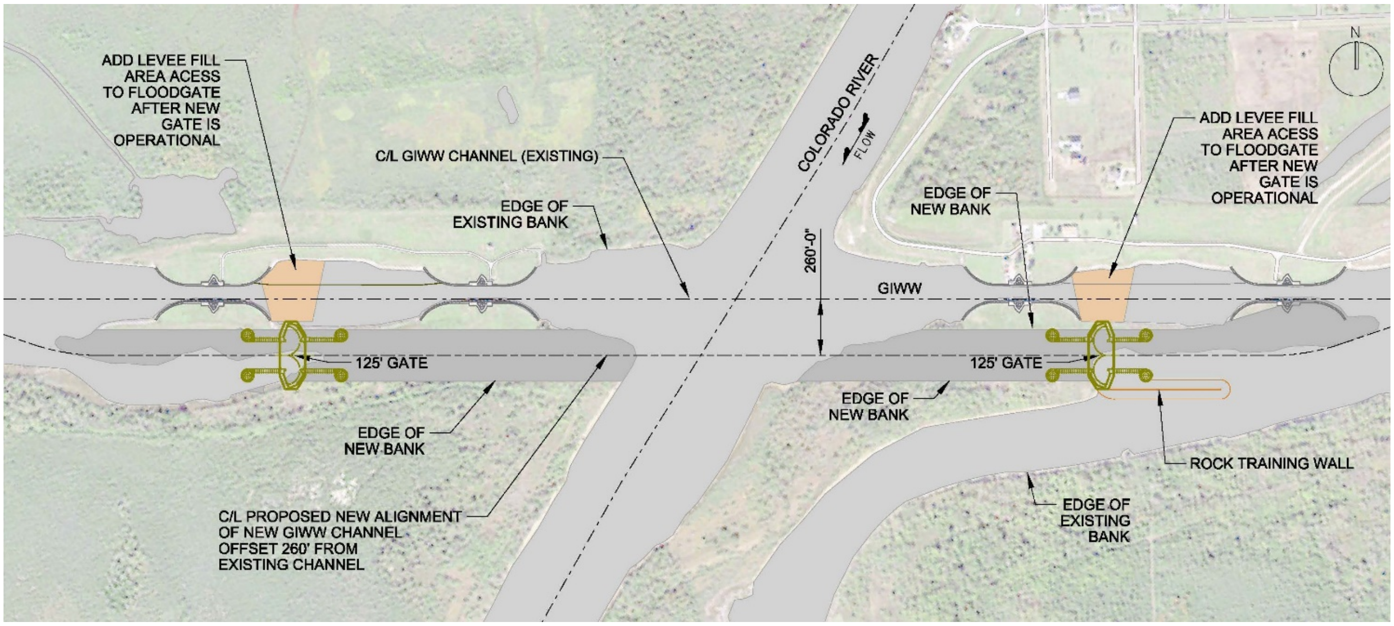

Figure ES-3 - CRL Recommended Plan Component

COST OF THE RECOMMENDED PLAN

Table ES-2 provides the Project First Cost and Fully Funded Cost for the each component of the Recommended Plan and the fully system plan.

Table ES-2 – Project First Cost and Fully Funded Cost for Recommended Plan ($000)

Cost Account	Project Features	Project First Cost			Fully Funded Cost		
		Component		Total	Component		Total
		BRFG	CRL		BRFG	CRL	
		(October 2018 Price Level)					
General Navigation Features (GNF)							
05	Locks	$0	$187,302	$187,302	$0	$209,921	$209,921
06	Fish & Wildlife Features	$696	$37	$733	$780	$42	$822
09	Channels & Canals	$0	$0	$0	$0	$0	$0
15	Floodway Control & Diversion Structures	$116,997	$0	$116,997	$131,126	$0	$131,126
	Total GNF Costs	**$117,693**	**$187,339**	**$305,032**	**$131,906**	**$209,963**	**$341,869**
30	Planning, Engineering, and Design	$23,508	$37,468	$60,976	$27,242	$43,422	$70,644
31	Construction Management	$12,869	$20,604	$33,473	$16,262	$26,036	$42,298
	Total GNF with PED and CM	**$154,070**	**$245,411**	**$399,481**	**$175,410**	**$279,421**	**$454,811**
LERR							
01	Lands and Damages	$199	$45	$244	$212	$48	$260
02	Relocations	$0	$0	$0	$0	$0	$0
	LERR Total Cost	**$199**	**$45**	**$244**	**$212**	**$48**	**$260**
	Total Project Cost	**$154,270**	**$245,457**	**$399,727**	**$175,623**	**$279,469**	**$455,092**

BENEFITS OF THE RECOMMENDED PLAN

During policy review of the DIFR-EIS, concerns were raised regarding commodity traffic projections, which are important factors in NED analysis and conclusions regarding project justification. A key concern was the fact that the projections relied on expected growth in commodity production at a national level rather than at a regional level, and did not account for the recent and rapid growth in crude oil production in west Texas and related impacts to transportation sectors including the GIWW. The traffic projections were updated using the crude oil production forecast for the region. These projections were the basis of the benefits in **Table ES-3** below. Although GIWW crude oil traffic has spiked in recent years, it is highly variable, and there is considerable uncertainty regarding future traffic levels of the commodity given that energy and transportation sectors in the region are in the process of adapting to the changes. For example, companies are adding pipeline and refining capacity along with port and fleet capacity to accommodate the large volumes of oil coming into the markets. In other words, the energy and transportation sectors are in a state of flux; and until the markets stabilize somewhat, predicting how oil will move and by which mode it will move, is difficult. Forecast sensitivities are included in the economic appendix. Other concerns center on potential modal shifts of cargo if waterway congestion became a factor as traffic increases in the future, and the current economic model is not equipped to assess capacity and modal shifts. These and other uncertainties will be the focus of an economic update that will be conducted during PED phase of the project.

Table ES-3 displays cost benefits analysis using growth rates for oil production within the Texas region. The NED analysis yields net benefits of $41,603,000 with a BCR of 3.3.

Table ES-3 – Cost and Benefits ($000)

Category	Regional Forecast		
	Component		
	BRFG	CRL	System (BRFG & CRL)
	October 2018 Price Levels, 2.875 percent Federal Discount Rate		
Total Project Construction Costs	$154,270	$245,457	$399,727
Interest During Construction	$6,717	$10,687	$17,403
Total Investment Cost	**$160,987**	**$256,144**	**$417,130**
Construction Average Annual Costs	$6,109	$9,720	$15,829
OMRR&R	$2,664	$0	$2,664
Total Average Annual Costs	**$8,773**	**$9,720**	**$18,493**
Average Annual Benefits	$44,096	$16,000	$60,096
Net Annual Benefits	$35,323	$6,280	$41,603
Benefit to Cost Ratio	**5.03**	**1.65**	**3.25**

COST APPORTIONMENT

Section 1405 of WRDA 1986, P.L. 99-662, amended Section 203 and 204 of the Inland Waterways Revenue Act of 1978, P.L. 95-502, which originally established the Inland Waterways Trust Fund (IWTF). Expenditures from the IWTF may be made available, as provided by Appropriation Acts, for making construction and rehabilitation expenditures for navigation on those Inland Waterways described in Section 206 of P.L. 95-502, as amended, including the GIWW.

Funding for project construction should be 100 percent Federal expense with the recommendation that that 50 percent of these funds be provided from the IWFT and the remainder from the General Fund of the Treasury.

The project cost for determining the cost-sharing requirements is based on the Project First Cost. The Project First Cost for all project components is separated into expected Federal (Corps) and Federal (IWTF) and detailed in **Table ES-4**.

Table ES-4 – Project First Cost Allocation for Recommended Plan ($000)

Cost Account and Project Features		BRFG Component			CRL Component			Total Project First Cost (BRFG + CRL)
		Federal (Corps)	Federal (IWTF[1])	BRFG Total	Federal (Corps)	Federal (IWTF[1])	CRL Total	
		(Oct 2018 Price Level)						
General Navigation Features (GNF)								
05	Locks	$0	$0	$0	$93,651	$93,651	$187,302	$187,302
06	Fish & Wildlife Features	$348	$348	$696	$19	$192	$37	$733
09	Channels & Canals	$0	$0	$0	$0	$0	$0	$0
15	Floodway Control & Diversion Structures	$58,499	$58,499	$114,346	$0	$0	$0	$116,997
	Total GNF Costs	**$58,847**	**$58,847**	**$117,693**	**$93,670**	**$93,670**	**$187,339**	**$305,032**
30	Planning, Engineering, and Design	$11,754	$11,754	$23,508	$18,734	$18,734	$37,468	$60,976
31	Construction Management	$6,435	$6,435	$12,869	$10,302	$10,302	$20,604	$33,473
	Total GNF with PED and CM	**$77,036**	**$77,036**	**$154,070**	**$122,706**	**$122,706**	**$245,412**	**$399,481**
LERR								
01	Lands and Damages	$100	$100	$199	$23	$23	$45	$244
02	Relocations	$0	$0	$0	$0	$0	$0	$0
	LERR Total Cost	**$100**	**$100**	**$199**	**$23**	**$23**	**$45**	**$244**
	Total Project First Cost	**$77,135**	**$77,135**	**$154,270**	**$122,728**	**$122,728**	**$245,457**	**$399,727**

PUBLIC COORDINATION

The public was afforded an opportunity to comment on the TSP during a 30-day public review of the DIFR-EIS beginning on February 26, 2018. All comments submitted by local governments, industry, and citizens have been considered in preparing the final report (FIFR-EIS) and responses are provided in **Appendix D – Environmental Appendix**. In addition, a number of navigation industry/stakeholder specific web-meetings and in-person meetings were held during the course of this study (February 2017 and October 2017) to determine specific concerns with Blue and Brown water navigation industry pilots and crews. Their feedback and experiences in navigating the BRFG and CRL crossings during various river conditions was invaluable in determining the appropriate measures and alternatives to consider. Post-ADM the team continued to engage these groups in the refinement of the TSP, now the Recommended Plan.

ENVIRONMENTAL COMPLIANCE

USACE has prepared an EIS of the Recommended Plan and alternatives that is integrated into this feasibility report. The environmental impact analyses have determined that the Recommended Plan, with proposed minimization measures and mitigation, would not result in significant adverse impacts. A Notice of Availability that describes the proposed action and the availability of the DIFR-EIS was issued to interested parties, including Federal and State resource agencies, on February 26, 2018. Comments on the DIFR-EIS and the USACE's responses have been included in **Appendix D of the Environmental Appendix** of the final report. The EIS was prepared in accordance with requirements of the National Environmental Policy Act (NEPA) of 1969 and Council on Environmental Quality (CEQ) regulations.

The impact analysis determined there would be no effects to existing prime farmlands or historic properties, and that there would be no negative socio-economic effects. Temporary and minor impacts to water quality, turbidity, benthic organisms, essential fish habitat or managed species, and noise would occur during dredging and placement of piles for the new structures. There would also be minor impacts to salinity and sediment transport resulting from the new structure configuration.

USACE has determined that the Recommended Plan is substantially compliant with all applicable environmental laws and regulations; some final agency consultations are ongoing. A Clean Water Act §404(b)(1) evaluation of the proposed action (**Appendix D-1 of the Environmental Appendix**) describes the effects of the proposed discharges, and has determined that the Recommended Plan is the least environmentally damaging practicable alternative. A request for water quality certification for the Recommended Plan has been requested from the Texas Commission on Environmental Quality. The Texas Council on Environmental Quality (TCEQ) provided a Coastal Zone Consistency determination in a letter dated 21 May 2019 (Appendix D-5). The USFWS concurred that the proposed project qualifies for an exemption under 16 U.S.C 3505(a)2 of the Coastal Barrier Resources Act (**Appendix D-4**). The Biological Assessment determined that the Recommended Plan may affect, but is not likely to adversely affect the piping plover, red knot, whooping crane, green sea turtle, hawksbill sea turtle, Kemp's ridley sea turtle, and loggerhead sea turtle, but would have no effect on the remaining listed species. NMFS and the USFWS concurred with this determination in the NMFS Biological Opinion and the USFWS Coordination Act Report (**Appendix D-2 and D-9,** respectively). Recommendations to adopt measures to prevent potential impacts to threatened and endangered species that may occur in the study area will be implemented. Based on a qualitative analysis, NOx emissions from the BRFG Recommended Plan are not expected to exceed the 100 tons per year de minimis threshold and is exempt from a General Conformity Determination.

The Recommended Plan would impact 13.8 acres of tidal wetlands at the BRFG and 0.7 acre of tidal wetlands at the CRL. These impacts will be mitigated by the creation of tidal wetlands along the original footprint of the facilities utilizing dredged material and/or rock barriers.

No National Register of Historic Places-listed or eligible sites or State Antiquities Landmarks are located within the project's area of potential effect.

AREAS OF CONTROVERSY

No areas of controversy were identified during consultations and coordination with the natural resource agencies. Issues and comments from the public regarding areas of controversy are summarized in the **Public Involvement Appendix (D-11)**.

MAJOR FINDINGS

The proposed actions of this report are in the national interest and provide modifications that would allow for more efficient and safe navigation through the BRFG and CRL projects. The recommendations contained herein reflect the information available at this time.

This Recommended Plan is in support of two of the four goals for USACE contained in the latest (October 2017) USACE Campaign Plan. Specifically, this project supports Goal 2 (Deliver Integrated Water Resource Solutions) and Goal 4 (Prepare for Tomorrow). This plan is available on the internet at the following address: *http://www.usace.army.mil/about/campaignplan.aspx*.

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LIST OF ACRONYMS

Acronym or Abbreviation	Definition or Meaning
AdH	Adaptive Hydraulics Model
APE	Area of Potential Effect
ARA	USACE Abbreviated Cost Risk Analysis
ATB	Articulated Tug Barge
BCR	Benefit-Cost Ratio
BG	Block Group
BGEPA	Bald and Golden Eagle Protection Act
BMP	Best Management Practice
BRFG	Brazos River Floodgates
CAA	Clean Air Act
CAR	Coordination Act Report
CBRA	Coastal Barrier Resources Act
CBRS	Coastal Barrier Resources System
CCC	Coastal Coordination Council
CEPRA	Coastal Erosion Planning & Response Act
CEQ	Council on Environmental Quality
CFR	Code of Federal Regulations
CNRAs	Coastal Natural Resource Areas
CO	Carbon Monoxide
CO-OPS	Center for Operational Oceanographic Products and Services
CPRR	Climate Preparedness and Resilience Register
CRL	Colorado River Locks
CT	Census Tract
CWA	Clean Water Act
dB, dBA	Decibels, A-weighted decibels
DoD	Department of Defense
DHHS	Department of Health and Human Services
DMPA	Dredge Material Placement Area
EFH	Essential Fish Habitat
EIA	U.S. Energy Information Association
EIS	Environmental Impact Statement
EJ	Environmental Justice
El	Elevation
EM	Engineer Manual
EO	Executive Order
EOPs	USACE Environmental Operating Principles
EPA	U.S. Environmental Protection Agency

Acronym or Abbreviation	Definition or Meaning
ER	Engineer Regulation
ERDC	U.S. Army Engineer Research and Development Center
ESA	Endangered Species Act
EQ	Environmental Quality
FEMA	Federal Emergency Management Agency
FCA	Flood Control Act
FHWA	Federal Highway Administration
FIFR-EIS	Final Integrated Feasibility Report and Environmental Impact Statement
FIRM	Flood Insurance Rate Map
FM	Farm-to-Market
FPPA	Farmland Protection Policy Act
FPS	Feet per Second
FR	Federal Register
FTA	Federal Transit Authority
FWCA	Fish and Wildlife Coordination Act
FWOP	Future Without-Project
FY	Fiscal Year
FWP	Future With-Project
GFI	Ground Fault Interrupter
GHG	Greenhouse Gas
GIWW	Gulf Intracoastal Waterway
GLO	Texas General Land Office
GPM	Gallons Per Minute
HAPC	Habitat Areas of Particular Concern
HEP	Habitat Evaluation Procedures
HGB	Houston-Galveston-Brazoria
HRSR	Historic Resources Survey Report
HSI	Habitat Suitability Index
HTRW	Hazardous, Toxic, and Radioactive Waste
HU	Habitat Units
HUC	Hydrologic Unit Code
IWR	U.S. Army Engineer Institute for Water Resources
IWTF	Inland Waterways Trust Fund
LERRDs	Land, Easements, Rights of Way, Relocation, and Disposal Areas
LERR	Land, Easements, Rights of Way, and Relocation
LMSL	Local Mean Sea Level

LIST OF ACRONYMS

Acronym or Abbreviation	Definition or Meaning
LNG	Liquefied Natural Gas
MBTA	Migratory Bird Treaty Act
MHHW	Mean Higher High Water
MHW	Mean High Water
MLLW	Mean Lower Low Water
MLW	Mean Low Water
mm/yr	Millimeter per Year
MMPA	Marine Mammal Protection Act
MOA	Memorandum of Agreement
MPH	Mile per Hour
MSL	Mean Sea Level
MVN	New Orleans District (USACE)
NAAQS	National Ambient Air Quality Standards
NAVD	North American Vertical Datum
NEC	National Electric Code
NED	National Economic Development
NEPA	National Environmental Policy Act
NHPA	National Historic Preservation Act
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NOI	Notice of Intent
NO_x	Nitrogen Oxides
NO_2	Nitrogen Dioxide
NPS	National Park Service
NRC	National Research Council
NRCS	Natural Resources Conservation Service
NRHP	National Register of Historic Places
NWR	National Wildlife Refuge
OCA	Operational Conditional Assessment
ODMDS	Ocean Dredged Material Disposal Site
O&M	operations & maintenance
OMRR&R	Operation, Maintenance, Repair, Replacement and Rehabilitation
OSE	Other Social Effects
O_2	Oxygen
O_3	Ozone
Pb	Lead
P&G	Principles and Guidelines

Acronym or Abbreviation	Definition or Meaning
PCB	Polychlorinated Biphenyls
PCXIN	Inland Navigation Planning Center of Expertise
PCXIN-RED	USACE Planning Center of Expertise for Inland Navigation and Risk-Informed Economics Division
PDT	Project Delivery Team
PED	Pre-Construction Engineering and Design
P.L.	Public Law
PM_{10}, $PM_{2.5}$	Particulate Matter
POA	Period of Analysis
ppt	Parts Per Thousand
RED	Regional Economic Development
REP	Real Estate Plan
RESTORE	*Resources and Ecosystems Sustainability, Tourist Opportunities, and Revived Economies of the Gulf Coast States Act*
RHA	Rivers and Harbors Act
RRC	Texas Railroad Commission
RSLC	Relative Sea Level Change
RSLR	Relative Sea Level Rise
SAL	State Antiquities Landmark
SH	State Highway
SHPO	State Historic Preservation Office
SIP	State Implementation Plan
SWG	Galveston District (USACE)
SO_2	Sulfur Dioxide
TASA	Texas Archeological Sites Atlas
TCEQ	Texas Commission on Environmental Quality
TCMP	Texas Coastal Management Plan
THC	Texas Historical Commission
TIPPC	Texas Invasive Plant and Pest Control
TPCS	Total Project Cost Summary
TPWD	Texas Parks and Wildlife Department
TSP	Tentatively Selected Plan
TWDB	Texas Water Development Board
TxDOT	Texas Department of Transportation
TXNDD	Texas Natural Diversity Database
TxRR	Texas Rainfall Runoff (model)

LIST OF ACRONYMS

Acronym or Abbreviation	Definition or Meaning
U.S.	United States
USACE	U.S. Army Corps of Engineers
USDA	U.S. Department of Agriculture
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
USTs	Underground Storage Tanks
VOC	Volatile Organic Compounds
WLCEN	Waterway Limited Cost Estimator for Navigation
WMA	Wildlife Management Area
WRDA	Water Resources Development Act
WWTP	Wastewater Treatment Plant

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1.0 INTRODUCTION

This Final Integrated Feasibility Report and Environmental Impact Statement (FIFR-EIS) documents the planning process undertaken for the Gulf Intracoastal Waterway (GIWW), Brazos River Floodgates (BRFG) and Colorado River Locks (CRL), Texas, Feasibility Study. The study has investigated improvements to the BRFG and CRL projects, located along the Texas coast within Brazoria and Matagorda Counties, Texas. The study alternatives have been screened, resulting in the identification of the Recommended Plan. Report sections required for compliance with the National Environmental Policy Act (NEPA) are indicated with an asterisk (*) following the section heading.

1.1 STUDY AUTHORITY

This FIFR-EIS is being performed under the authority of Section 216 of the Flood Control Act (FCA) of 1970 (Public Law [P.L.] 91-611), as amended:

> *"The Secretary of the Army, acting through the Chief of Engineers, is authorized to review the operation of projects the construction of which has been completed and which were constructed by the Corps of Engineers in the interest of navigation, flood control, water supply, and related purposes, <u>when found advisable due to significantly changed physical or economic conditions</u>, and to report thereon to Congress with recommendations on the advisability of modifying the structures or their operation, and for improving the quality of the environment in the overall public interest."*

1.2 FEDERAL INTEREST

Addressing the navigation issues in the region is not only significant to Texas residents and workers but to the nation. Various types of commodities are shipped and transported along the GIWW to the country's interior. The top three commodities by tonnage are petroleum / petroleum products, chemicals and related products, and crude materials. Petroleum/crude oil account for 60 percent of the tonnage. The value of goods exported from Texas ports in 2011 was $251 billion, more than that from all other states in the U.S. Port Houston alone generated a statewide economic impact of $178 billion with its 52-mile-long complex of public and private facilities. The Port handled 162.4 million in foreign tonnage in 2012 and its petrochemical complex has a total daily operable refining capacity of 351,776 barrels, one of the largest in the world.

The GIWW links the petrochemical industries, refineries and manufacturing facilities along the Texas coast. Texas deep-draft ports, and other Gulf ports east of Texas transited approximately 80.1 million tons across the Texas portion of the GIWW in 2016. Many of these commodities have to pass through the BRFG and CRL structures to access Freeport and Matagorda, respectively. The BRFG pass approximately 23 million tons of barged material each year. The CRL pass an approximate tonnage of 20 million each year via 15,000 tows, and about 5,000 recreational vessel locks annually. Both structures have a yearly project Operations and Maintenance (O&M) budget of about $1.8 million. Without modifications to the projects, barges and tows will continue to experience costly navigation delays along this portion of the GIWW.

1.3 STUDY PARTNER

The study partner is the Texas Department of Transportation (TxDOT). In 1975, the state legislature passed the *Texas Coastal Waterway Act.* This authorized the State of Texas to act as a local non-Federal Sponsor (NFS) for the GIWW in Texas and designated the State Highway and Public Transportation Commission, now the Texas Transportation Commission, of which the Texas Department of Transportation (TxDOT) is a part of, to act as agent for the state in fulfilling the responsibilities of the NFS. The sponsor works closely with USACE to provide local cooperation and input into Federal projects as they relate to navigation, operations and maintenance (O&M) of structures, environmental protection, and enhancement of wildlife and fisheries.

The agency has provided the EIS and technical appendices per a Memorandum of Agreement (MOA) signed with the USACE in August 2016. The MOA outlines the scope of work and expected products developed by TxDOT.

1.4 STUDY AREA AND CONGRESSIONAL DISTRICT

The overall study area (**Figure 1-1**) encompasses a larger area beyond the immediate structures themselves due to the hydraulic connectivity of surrounding water bodies (rivers, bays, GIWW, Gulf inlets and outlets and the Gulf of Mexico) and all associated shoreline and adjacent impacted lands. The BRFG Project includes floodgates on the GIWW where it intersects the Brazos River. It is important to note that though the term "floodgates" is used for the BRFG project, these gates are actually for the purpose of sediment control and not flood control. The CRL Project includes locks on the GIWW where it intersects the Colorado River. The hydraulic impact of the proposed recommendations also reflects the evaluation of upstream and downstream impacts on said rivers. In general, the potential for changes to water levels, flows and velocities resulting in sediment redistribution, isolated scour, and altered hydrographs served to physically bind the study area. This approximate 40 miles of the GIWW in Texas and the lands and waters towards the Gulf and inland up each subject river are contained within Brazoria and Matagorda Counties. The BRFG are located 7 miles southwest of Freeport, Texas and are accessible via Floodgate Road, 3.5 miles south of State Highway (SH) 36. The CRL are located near Matagorda, Texas. The East Lock is located on Matagorda Street approximately 0.25 miles west of the Farm-to-Market (FM) 2031

Bridge over the GIWW. The West Lock is not accessible by road.

The following Congressional representatives serve the project area: Senators John Cornyn and Ted Cruz, Representative Randy Weber (District 14), and Representative Michael Cloud (District 27).

Figure 1-1 - Study Area Overview

1.5 HISTORICAL BACKGROUND AND GENERAL NAVIGATION USE

The GIWW Federal shallow-draft navigation channel extends from Brownsville, Texas, to the Okeechobee waterway at Fort Myers, Florida. It was proposed by Albert Gallatin, U.S. Secretary of the Treasury, in a report on Public Roads and Canals, and submitted to the United States Senate in 1808. In 1819, Secretary of War John C. Calhoun urged Congress to develop a plan for an improved internal transportation system that included waterways. He proposed that the Army Corps of Engineers be used to develop and, if necessary, supervise construction of the internal improvements. By 1829, much of the route along the eastern portion of the proposed GIWW had been identified; however, a plan was not submitted for the western portion (Donaldsonville, Louisiana, to the Rio Grande) of the GIWW until 1875. A shallow channel had already been dredged by the state of Texas through part of the West Bay inside Galveston Island **(Figure 1-2)**.

Figure 1-2 – GIWW Opening at Port Bolivar, Texas in 1999

In 1892, Congress authorized the enlargement and extension of the channel to Christmas Point in Oyster Bay. Then in 1897, Congress authorized the purchase (completed in 1902) of an eleven-mile canal that connected Oyster Bay to the Brazos River from the Brazos Navigation Company. By 1905, Congress had provided the authorization and funding necessary to tie the various existing canal segments into a continuous 9-foot deep by 100-foot wide channel from New Orleans to Galveston Bay. By 1941, the canal had been extended to Corpus Christi Bay. By 1949, it had been enlarged to 12-foot deep by 125-foot wide and extended to the Brownsville Ship Channel. The Texas portion of the GIWW now stretched from Sabine Pass to the Brownsville Ship Channel for a distance of 423 miles (*https://tshaonline.org/handbook/online/articles/rrg04*).

The BRFG Project was authorized by the Rivers and Harbor Act (RHA) of 1927 as an integral part of the GIWW from the Mississippi River to Corpus Christi, Texas. Construction of the floodgates was completed in September 1943. Each pair of floodgates consists of two structural steel sectors installed in concrete gate recesses and are operated by rack and pinion drive. Major rehabilitation of the East Floodgate guidewalls was completed in 1997.

At the Colorado River crossing, similar floodgates were constructed under the same authorization as the BRFG in September 1943 due to rapid shoaling of the waterway at the crossing. The floodgates were effective for the reduction of silt deposition in the waterway. However, because of navigation delays experienced due to a frequent and excessive head differential caused by the floodwaters in the Colorado River, the floodgates were converted to locks in April 1954. The locks are located on each side of the Colorado River on the GIWW. A pair of sector gates located at each end encloses a 1,200-feet lock chamber. The CRL is unique because they are the oldest operating locks in Texas and are operated 24 hours a day, 365 days a year by the USACE.

A 2000 reconnaissance report entitled, *GIWW Modifications, Texas Section 905(b) Analysis*, documented that it would be in the Federal Interest to evaluate modifications to the configurations of the crossings to reduce traffic accidents and delays where the GIWW intersects the Colorado and Brazos Rivers.

The feasibility study for the CRL was initiated in November 2001, with a scoping meeting held in December 2003. Tow simulations for several design alternatives were completed by the U.S. Army Engineer Research and Development Center (ERDC) in January 2004. The project languished for a number of years thereafter until TxDOT began feasibility-level analyses on the BRFG in 2014. In 2015, the two projects were recommended as a system combined study. The study kickoff occurred in March of 2016 once funds were appropriated.

1.6 STUDY PURPOSE, NEED, AND SCOPE*

This report is an interim response to the study authority. The **purpose** of this report is to present the findings of the feasibility investigations and analyses conducted to determine if there is a Federal interest in making improvements to the existing BRFG and CRL Projects. This FIFR-EIS describes the problems and opportunities of the existing structures and identifies the alternatives and analyses conducted to meet the planning objectives of the study.

The **need** for the study is to investigate improvements to reduce navigational difficulties, delays, and accidents occurring as the tow operator's transit through the BRFG and CRL structures and across the Brazos and Colorado Rivers, respectively.

The **scope** of the study is to:

- Identify existing, future with-project (FWP), and future without-project (FWOP) conditions, with a focus on:
  - Hydraulics (currents, velocities, flows and stage frequency impacts to navigation at crossings)
  - Sedimentation, salinity, erosion, and dredging requirements
  - Assessment of riverine changes
  - Assessment of operational adequacy of the gates/locks dimensions and overall geometry of the projects
  - Economic analysis (delays, allisions, and shipping/tonnage values) to estimate National Economic Development (NED) benefits
  - Environmental impacts
- Evaluate and compare alternatives developed and select a recommended plan.

This FIFR-EIS also provides the information normally included in an EIS and meets the requirements of NEPA. It compares the environmental impacts of the Final Array of Alternatives (including the No-Action plan) and describes the Plan recommended for Congressional authorization.

1.7 DATUMS

All GIWW depths in this report are referenced to the Mean Lower Low Water (MLLW) datum and structures to North American Vertical Datum (NAVD) 88, consistent with Engineer Regulation (ER) 1110-2-8160 and Engineer Manual (EM) 1110-26056, unless specifically stated otherwise.

1.8 PRIOR STUDIES, REPORTS, AND EXISTING WATER PROJECTS

Table 1-1 lists the relevant reports and studies considered during feasibility study investigations. New start and ongoing projects are also considered as part of the existing conditions for this study.

Table 1-1 - Relevant Prior Reports and Studies

Navigation Studies and Reports		Relevance to Study: Data Source	Consistency	Measure Source	FWOP Conditions
1939	Report on the Study of the Intracoastal Waterway Crossing of the Colorado River	X	X		X
1975	Final Environmental Statement, Maintenance Dredging, Gulf Intracoastal Waterway, Texas Section, Main Channel and Tributary Channels, Volumes 1-3	X	X		X
1977	Mouth of Colorado River, Texas, Phase I, General Design Memorandum (Navigation Features)	X	X		X
1981	Mouth of Colorado River, Texas, Phase I, General Design Memorandum and Environmental Impact Statement (Diversion Features)	X	X		X
1999	Colorado River/GIWW Intersection Draft Report	X	X		X
2000	GIWW Modifications, Texas Section 905(b) Analysis, U.S. Army Corps of Engineers	X	X	X	X
2009	Hydraulic Sediment Response Model Study for the Brazos River and Gulf Intracoastal Waterway Crossing Technical Report M45	X	X		X
2016	GIWW Mooring Basin Modification Study (Ongoing), U.S. Army Corps of Engineers	X	X	X	X
2016	Coastal Texas Protection and Restoration Feasibility Study (Ongoing), U.S. Army Corps of Engineers	X	X		X
Federal & Local Significant Projects					
Gulf Intracoastal Waterway (GIWW)		X	X		
Freeport Ship Channel		X	X		
Matagorda and Freeport Levee Systems		X	X		

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2.0 AFFECTED ENVIRONMENT (NEPA REQUIRED)

The conditions described herein focus on summarizing the technical evaluations of the NEPA resources that drive the NED analysis for this feasibility study. The study areas used in this chapter and in technical evaluations of the NEPA resources are defined in Section 2.1.1 below. These study areas are subsets of the larger, general study area discussed in other chapters of this report (note **Chapter 5 *Environmental Consequences for Comparative Analysis*** also utilizes these NEPA study areas). While all NEPA resources are significant to various institutions, this section focuses on those resources that may be directly impacted by the proposed alternatives. Additional descriptions of the resources in the NEPA study areas are provided in **Appendix D – Environmental Appendix**.

2.1 GENERAL ENVIRONMENTAL SETTING OF THE STUDY AREAS

2.1.1 Location

Both sites are located within the Mid-Coast Barrier Islands and Coastal Marshes region of the Texas coast. The areas surrounding the two facilities are low-lying at elevations generally less than 10 feet above sea level, and are largely covered with wetlands and other water resources. For each facility, existing environmental conditions were evaluated within a study area that encompasses the maximum disturbance area for the reasonable alternatives. The San Bernard River falls within the overall study area; however, its influence on navigation and contributions to the NED were limited and determined to be outside of the critical areas experiencing significant navigation delays. In addition, re-opening and maintaining the mouth of the San Bernard River is part of an ongoing local study that received *Resources and Ecosystems Sustainability, Tourist Opportunities, and Revived Economies of the Gulf Coast States Act* (RESTORE Act) funds.

At the BRFG, the NEPA study area encompasses roughly 600 acres and extends along the GIWW one mile east and west of the Brazos River crossing and up to 0.5 mile along the Brazos River, north and south of the GIWW crossing (**Figure 2-1)**. At the CRL, the NEPA study area encompasses roughly 400 acres and extends along the GIWW one mile east and west of the Colorado River crossing and up to 0.25 mile along the Colorado River, north and south of the GIWW crossing (**Figure 2-2)**. Under the reasonable alternatives, all construction activities and associated direct impacts would occur within these study areas. Outside of these study areas, nearby resources were identified and evaluated on a case-by-case basis depending on their potential to be indirectly affected by modifications to the BRFG and/or CRL facilities (e.g., effects of salinity and sedimentation changes at the San Bernard River and nearby piping plover critical habitat).

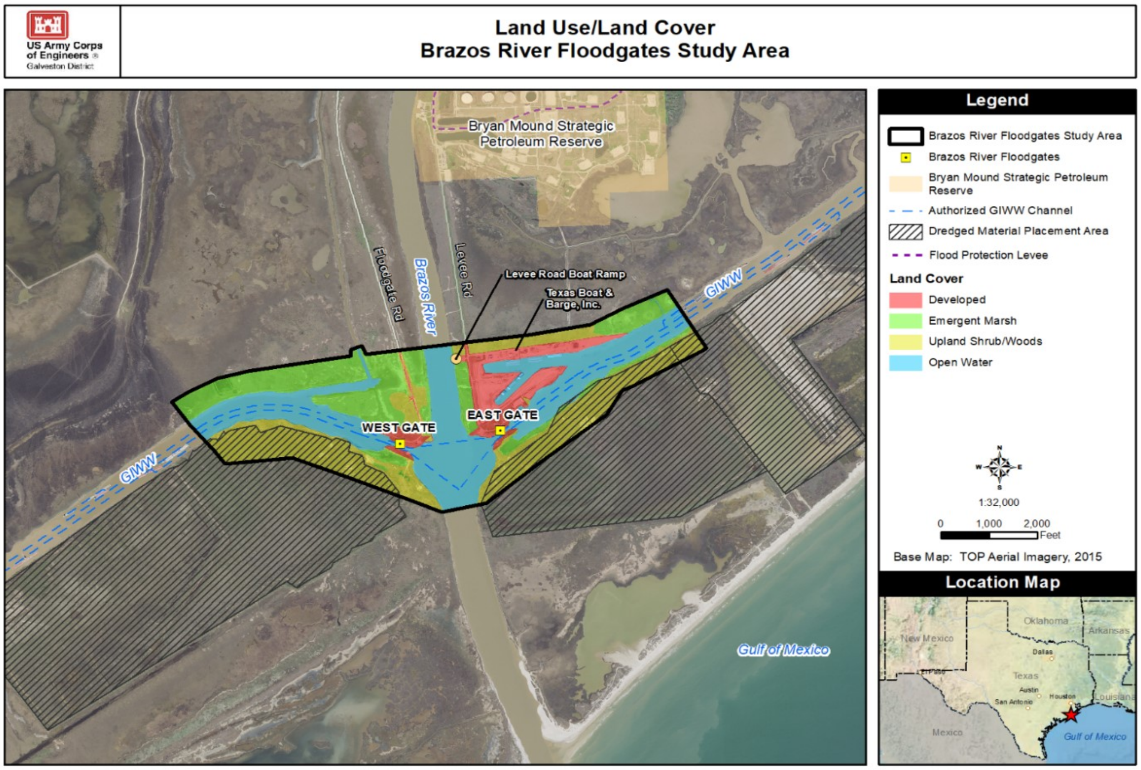

Figure 2-1 - Brazos River Floodgates NEPA Study Area

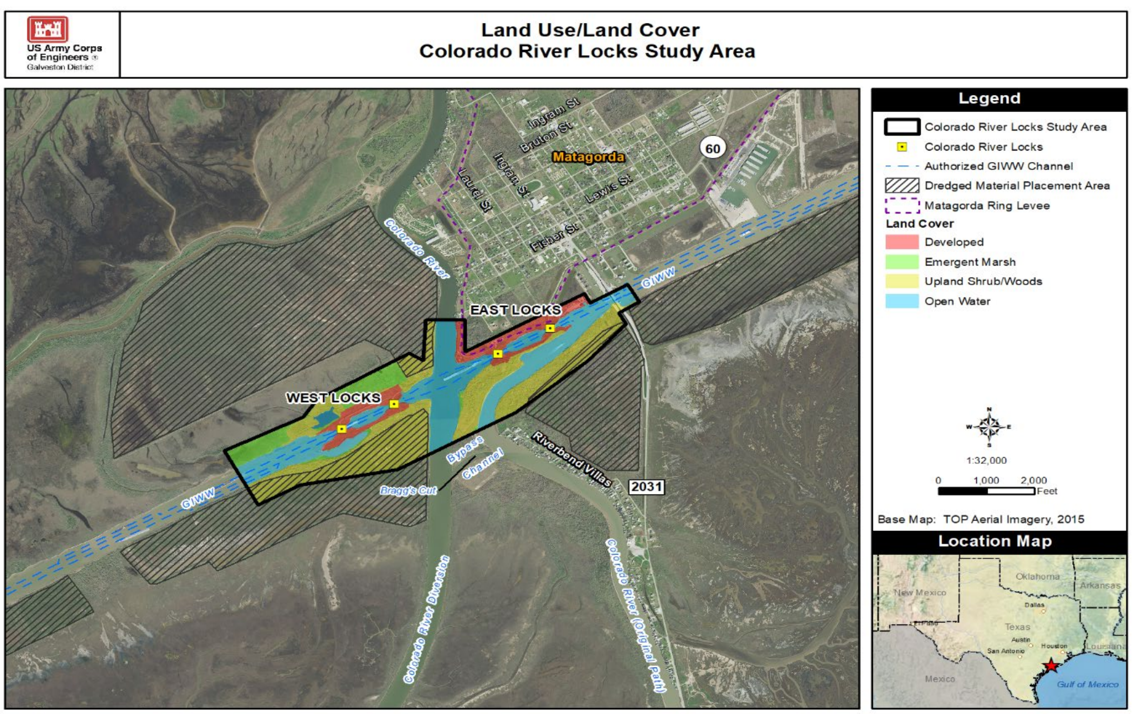

Figure 2-2 - Colorado River Locks NEPA Study Area

2.1.2 Geomorphic and Physiographic Setting

Brazoria and Matagorda Counties are within the West Gulf Coast subdivision of the Atlantic and Gulf Coastal Plains geomorphic province of the U.S. This region of Texas is underlain by rock and sediments that slope toward the Gulf of Mexico and date from the Pleistocene and Holocene epochs (Texas Water Development Board [TWDB] 1982, 1987). Surface geology in the study areas is of the late Pleistocene Beaumont Formation and younger deposits. The Beaumont Formation was deposited as a large alluvial plain, after which sea levels fell during a period of glacial advance. A period of erosion then followed, with incision of stream channels. At the end of the last glacial period, as sea levels rose again, the area was flooded and a series of estuaries and bays formed. As sea levels stabilized, barrier islands developed (Aronow 1981, 2002). Modern barrier islands along the Gulf coast are characterized by subparallel to parallel beach and fore-dune ridges that are closely spaced. In Brazoria County, the action of wind, hurricanes, or other natural processes destroyed the ridged pattern of the barrier islands (Aronow 1981). Ridged barrier islands and reefs persist in Matagorda County (USGS 1952, Hyde 2001). Barrier islands along the Texas coast are generally mapped between the GIWW and the Gulf of Mexico (Coastal Barrier Resources System [CBRS] 2017), and the BRFG and CRL study areas are located partially on and/or adjacent to barrier islands. Discussion and maps of designated coastal barrier resources in the study area are provided in the *Coastal Barrier Resources and Coastal Natural Resources* section below.

ESTUARY

A partially enclosed body of water, and its surrounding coastal habitats, where saltwater from the ocean mixes with fresh water from rivers or streams (*National Oceanic and Atmospheric Administration 2018a*).

2.1.3 Land Use and Land Cover

Based on aerial photograph review and field reconnaissance, much of the BRFG and CRL study areas are undeveloped, with open water, emergent marsh, and upland shrub/woods being the major land cover types in both locations (**Figures 2-1 and 2-2**). Some livestock grazing occurs within these areas. Commercial navigation is a major land use in the overall study area, represented by the GIWW, BRFG and CRL facilities and access roads, and existing dredged material placement areas (DMPAs) along the GIWW. Developed areas near the BRFG facilities include Texas Boat and Barge, Inc., which is a barge storage, cleaning, maintenance, and repair facility located adjacent to the east floodgate. Nearby, the Department of Energy's Bryan Mound Strategic Petroleum Reserve, one of two Federal strategic petroleum reserve sites in Texas, is located about one mile north of the east floodgate (**Figure 2-1**). The nearest residences to BRFG are located at FM 1495 approximately 2.5 miles east of the study area. At the CRL facility, residential areas lie immediately to the north of the east lock and adjacent levee in the town of Matagorda and approximately 0.3 mile south of the east lock along the east bank of the original Colorado River channel (**Figure 2-2**).

2.1.4 Climate, Storms and Hurricanes

The climate of the region is sub-humid, with long, humid summers and short, warm winters. Annual rainfall in Brazoria and Matagorda Counties is about 52 and 48 inches, respectively, most of which falls from April through September (Crenwelge et al. 1981, Hyde 2001). The climate is influenced by the Gulf of Mexico, adjacent bays, and other major surface water features, cold fronts during the fall and winter, and tropical air masses during the spring and summer. The area experiences periodic droughts, flooding, storms, and hurricanes.

Tropical depressions, tropical storms, and hurricanes are relatively common occurrences in the Gulf of Mexico. Tropical storms typically produce the highest wind speeds and greatest rainfall events along the Gulf Coast. The Atlantic hurricane season, which includes the Gulf of Mexico, extends from June 1 to November 30 (National Hurricane Center 2018) and, historically, the frequency of hurricanes making landfall along any 50-mile segment of the Texas coast is one hurricane about every six years (Roth 2010). From 1900 through 2009, 44 hurricanes and 44 tropical storms made landfall on the Texas coast, with Hurricane Ike (2008) and Hurricane Rita (2005) being the largest recent hurricanes during that period, totaling over $48.5 billion in damages (Roth 2010, National Oceanic and Atmospheric Administration [NOAA] National Hurricane Center 2018b). The Galveston Hurricane of 1900, which resulted in an estimated 8,000 deaths, is considered the worst natural disaster in U.S. history in terms of human lives lost (Roth 2010).

Most recently, Hurricane Harvey (2017), the first Category 4 hurricane to make landfall on the Texas coast since Hurricane Carla in 1961, affected the Texas coast from Corpus Christi to Port Arthur, causing record rainfall and flooding, as well as property damage and loss of human life. As of October 2018, NOAA's Office for Coastal Management estimated that Hurricane Harvey had total costs of $125 billion, which makes it the most devastating hurricane in Texas history in terms of property damage and second only to Hurricane Katrina ($161 billion) in the U.S. (NOAA 2018c). The storm surge from Hurricane Harvey increased water and tide levels over most of the Texas coast, with the highest storm tides observed at the Aransas National Wildlife Refuge (NWR) (60 miles southwest of the CRL), where the storm surge levels were more than 12 feet above ground level. Storm surge in Port Lavaca (39 miles west of the CRL) was also more than 10 feet. Elsewhere across South Texas, storm tide levels ranged from near three to six feet above ground level at Seadrift, Port O'Connor, Holiday Beach, Copano Bay, Port Aransas, and Bob Hall Pier (National Weather Service 2017).

Instead of moving inland, Hurricane Harvey stalled over South and Southeast Texas for days, producing catastrophic, deadly flash and river flooding. Southeast Texas bore the brunt of the heavy rainfall, with some areas receiving more than 40 inches of rain in less than 48 hours. Cedar

Bayou in Houston (65 miles northeast of the BRFG) received a storm total of 51.88 inches of rainfall, which is a new North American record (National Weather Service 2017).

2.1.5 **Climate Change**

Consistent with NEPA, including its interpretation by Federal courts and implementing regulations from the Council on Environmental Quality (CEQ), is the policy of USACE to integrate considerations of climate change, climate change preparedness and resilience planning and actions, the potential vulnerabilities of our built and natural water-resource infrastructure to the effects of climate change and variability.

2.1.5.1 Sea Level Change and Subsidence

Based on U.S. Geological Survey (USGS) topographic maps, elevations in the BRFG and CRL study areas range from sea level to approximately 22 feet above mean sea level (MSL) (USGS 1952, 1963, 1964). The tide gage with sea level trend information nearest to the Brazos and Colorado River systems, with over 40 years of record, is located at Freeport, Texas (NOAA Gage 8772440). The NOAA MSL trend at this site (from 1954 to 2006) is equal to 4.35 millimeters per year (mm/yr) or 1.47 feet per century with a 95 percent confidence interval of ± 1.12 mm/yr.

Subsidence in the Freeport vicinity has been attributed primarily to groundwater withdrawals for municipal and industrial use (Ratzlaff 1982). Localized subsidence attributable to subsurface sulfur mining over a salt dome has occurred in the Bryan Mound area, located less than one mile north of the BRFG study area. The elevation at Bryan Mound decreased from 23 feet in 1926, to 19 feet in 1980, to the current elevation of approximately 16 to 18 feet. Subsidence around the perimeter of Bryan Mound has resulted in the creation of Blue Lake to the north and Mud Pit (or "Mud Lake") to the southeast (Kirby and Lord 2015).

> **SUBSIDENCE**
>
> The sinking of the land surface over time due to natural processes and/or man-made causes such as the withdrawal of groundwater, oil and gas, and/or mineral resources *(Ratzlaff 1980, Neighbors 2003, Zilkoski et al. 2015).*

2.1.5.2 Precipitation

According to the 2014 National Climate Assessment, precipitation in the study portion of the United States may be expected to decrease slightly in a warmer climate, though intense rainfall events may increase in frequency. In other words, mean rainfall may decrease while variance increases. However, projections of future precipitation change are especially uncertain in this region because it is located in a transition zone between projected drier conditions to the south and projected wetter conditions to the north.

2.1.6 Tides, Currents, and River Stages

Tides, currents, and river stage/flows vary daily and seasonally, and continuously affect water levels in the study areas. On the Texas coast, tides are considered *diurnal*, meaning that typically a single high and low water level occur each tidal day (Hicks 2006). The *great diurnal range* or *diurnal tide range* is the difference between mean higher high water (MHHW) and MLLW, while the mean tide range is the difference between mean high water (MHW) and mean low water (MLW). For perspective on tidal ranges at the BRFG and CRL, **Table 2-1** summarizes the tide data from the NOAA tide gauge stations nearest to each facility (NOAA 2017a, 2017b). The diurnal tide range and mean tide range are 1.8 feet and 1.39 feet, respectively, in the BRFG vicinity, and 0.41 feet and 0.39 feet, respectively, in the CRL vicinity. Based on data from the Texas Commission on Environmental Quality (TCEQ), the tidally influenced reaches of the Brazos and Colorado Rivers extend 24 to 25 miles upstream from the Gulf (TCEQ 2016a).

Table 2-1 - Tide Levels in BRFG and CRL Study Areas

Tidal Datum	Elevations Relative to MLLW, in Feet	
	BRFG Study Area[1]	CRL Study Area[2]
Mean Higher High Water (MHHW)	1.80	0.41
Mean Sea Level (MSL)	0.97	0.23
Mean Lower Low Water (MLLW)	0.00	0.00
Mean Tide Range[3]	1.39	0.39

[1] BRFG tide data is from NOAA tide gauge station 8772447 (Freeport, TX), which is located at the Freeport Channel entrance, approximately 5.8 miles northeast of the BRFG (NOAA 2017a).
[2] CRL tide data from NOAA tide gauge station 8773146 (Matagorda City, TX), which is located on the GIWW approximately 3.8 miles northeast of the CRL (NOAA 2017b).
[3] Mean tide range is the difference in height between MHW and MLW.

Currents in the GIWW and river crossings are created and influenced by the combination of tidal fluctuations and by non-tidal forces such as river flows and wind. Both the direction and velocity of currents depend on these factors and can affect navigation through the study area. High flows in the Brazos and Colorado Rivers create high-current situations that affect navigation.

The San Bernard River also affects currents at the BRFG. The San Bernard River flows into the GIWW about four miles west of the BRFG, and the GIWW serves as the river's outlet through the west floodgate. **Figures 2-3 and 2-4** show the probability of non-exceedance of velocities in the Brazos and Colorado Rivers at the GIWW crossings.

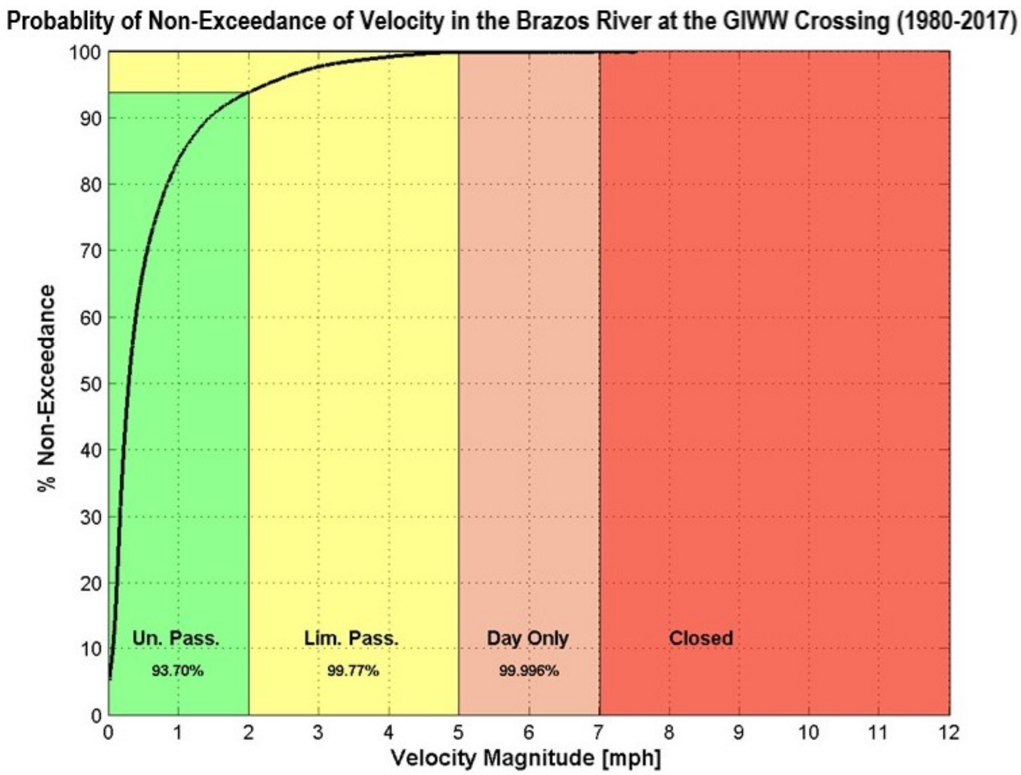

Figure 2-3 – Probability of Non-Exceedance of Velocity (Brazos River at GIWW)

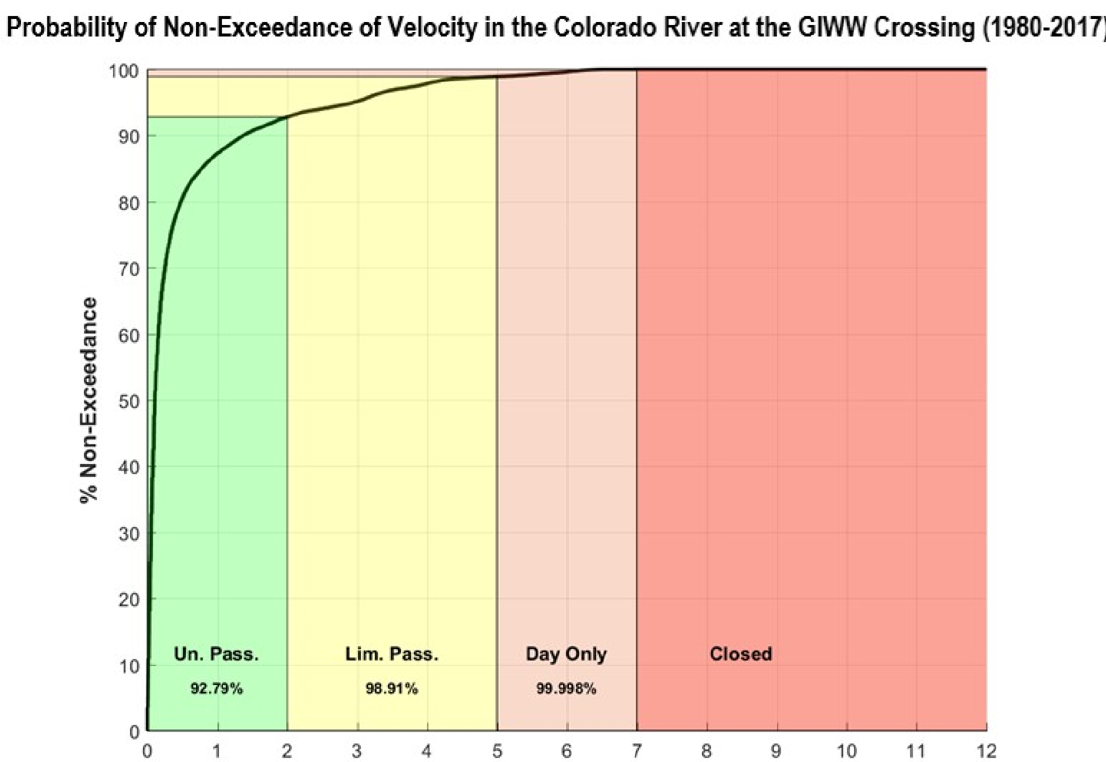

Figure 2-4 – Probability of Non-Exceedance of Velocity (Colorado River at GIWW)

2.2 FLOODPLAINS, WATER AND RIVER RESOURCES

2.2.1 Floodplains and Flood Control

According to the Federal Emergency Management Agency (FEMA) Flood Insurance Rate Map (FIRM) database, the majority of the BRFG and CRL facilities are within the 100-year floodplain (FEMA 2017) (**Figure 2-5**). Flooding events are primarily due to high river flows after heavy rains upstream of the Lower Brazos and Lower Colorado watersheds, although occasional hurricanes and tropical storms from the Gulf cause severe flooding.

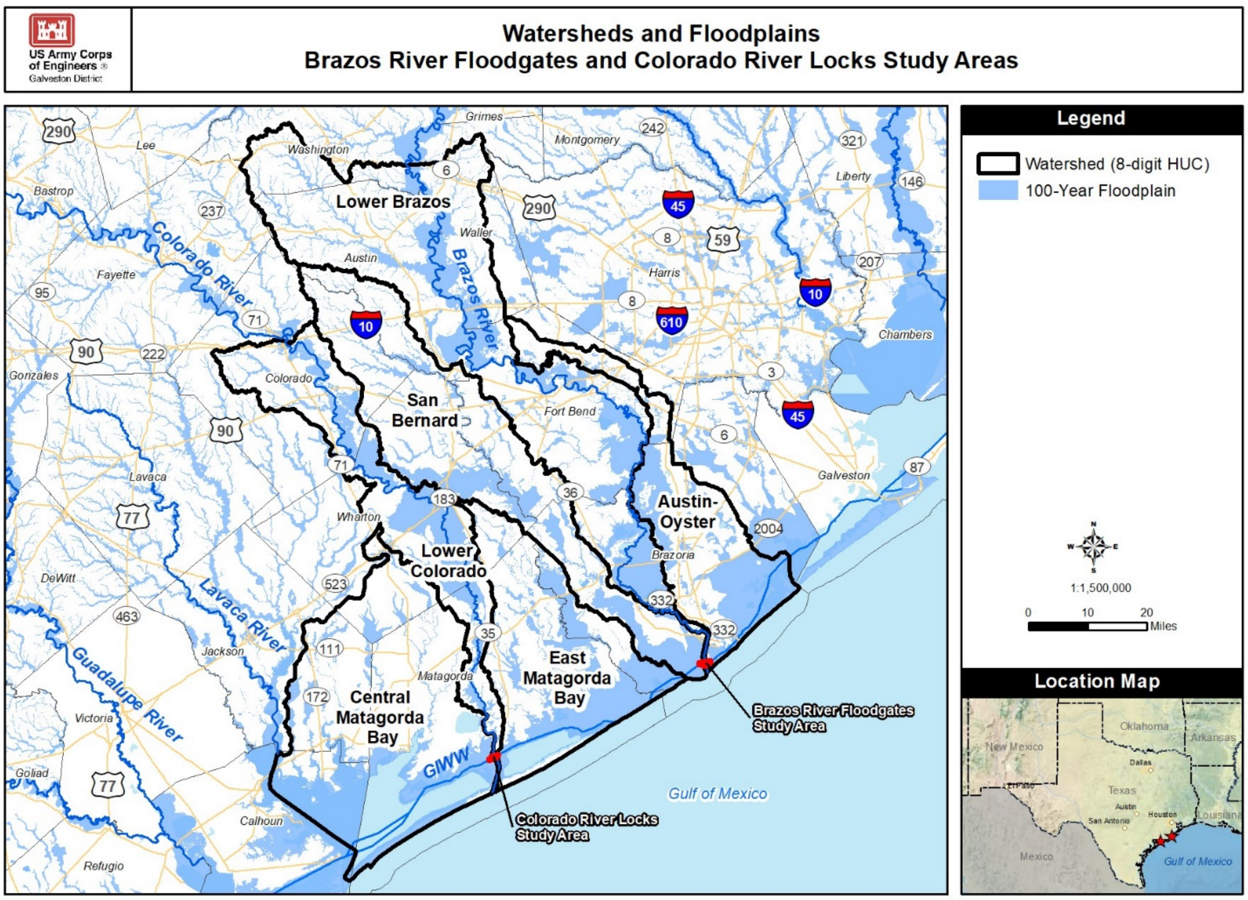

Figure 2-5 - Watersheds and Floodplains

Flood-protection levees have been constructed in the vicinity of the BRFG and CRL facilities to protect the nearby towns and cities. In the BRFG vicinity, the Velasco Drainage District operates and maintains a hurricane-flood protection system around Freeport and the surrounding area that includes 60 miles of levees, 14 pump stations, 34 gravity drainage structures, a navigation control tidal gate structure, and 72.5 miles of outfall ditches. The system's West End Pump Station, capable of pumping 450,000 gallons per minute (GPM), and Clute-Lake Jackson Pump Station, capable of pumping 1.95 million GPM, discharge into the Brazos River approximately 3.5 miles and 10.5 miles upstream of the BRFG, respectively. The nearest levee to the BRFG is on East Floodgate Road approximately 1.2 miles north of the East Floodgate (**Figure 2-6**). According to USACE (2005), the flood control levees around the Freeport area are expected to provide protection from a 100-year storm plus tide event.

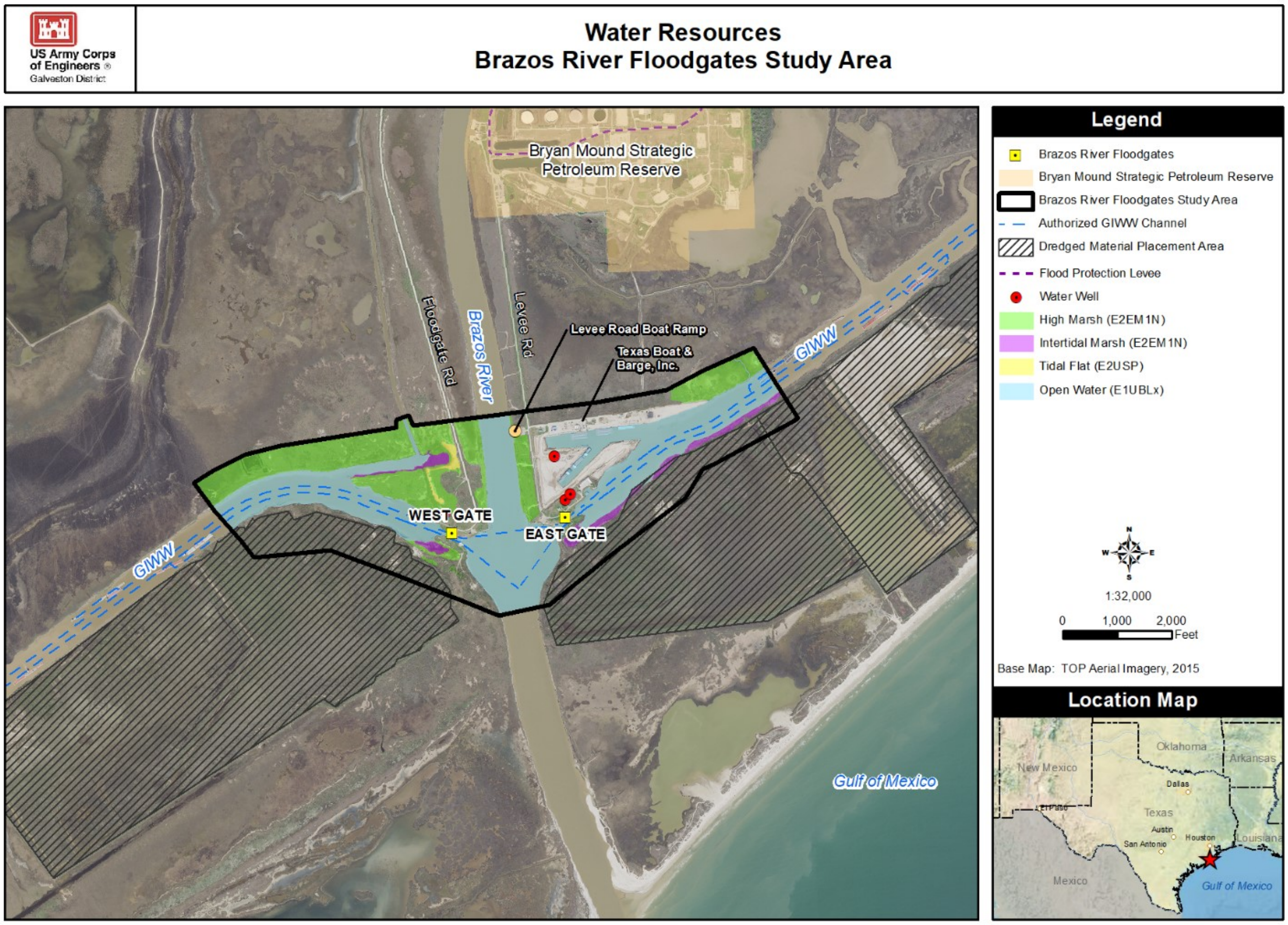

Figure 2-6 - Water Resources in BRFG Study Area

In the CRL vicinity, the USACE has constructed over 40 miles of flood protection levees along the Colorado River in Matagorda County, including a 7-mile ring levee around the town of Matagorda that is designed to provide 100-year flood protection (Matagorda County Flood Mitigation Planning Committee 2010). The East Locks and associated facility are located on and adjacent to the Matagorda ring levee (**Figure 2-7**).

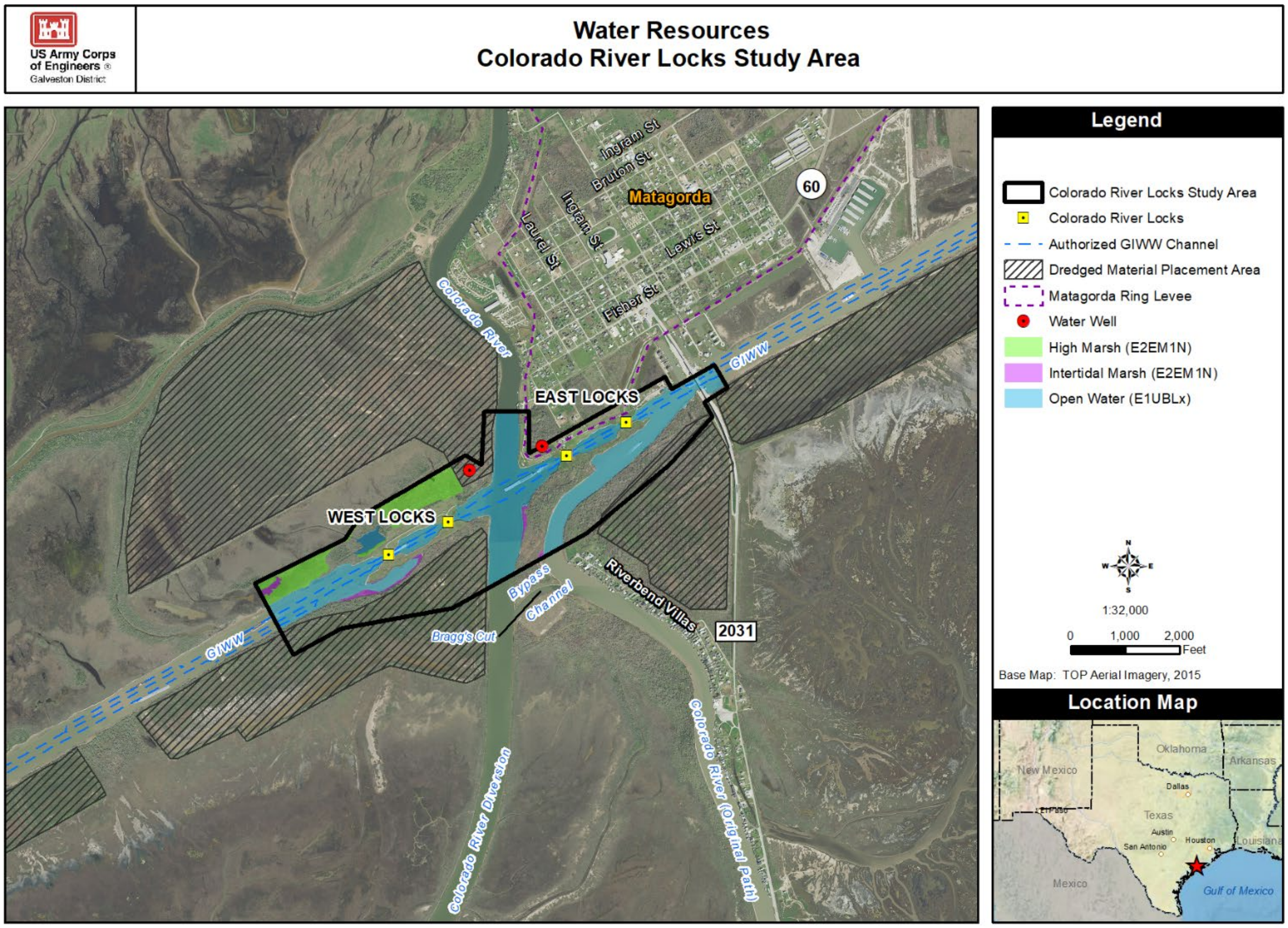

Figure 2-7 - Water Resources in CRL Study Area

2.2.2 Water Resources

> **HYDROLOGIC UNIT CODE (HUC)**
>
> HUCs are a way of identifying all of the drainage basins in the U.S. in a nested arrangement from largest (Regions) to smallest (Cataloging Units). The term watershed is often used in place of drainage basin.
> wiki.epa.gov/watershed2/index.php/Hydrologic_Unit_Codes_(HUCs)

The BRFG study area includes portions of three sub-watersheds (refer back to **Figure 2-5**). The first is the Lower Brazos River watershed (Hydrologic Unit Code [HUC] 12070104) which crosses the central part of the study area and includes the Brazos River and a narrow corridor on either side of the river. The second is the San Bernard watershed (HUC 12090401) which covers the western part of the study area, west of the Lower Brazos. The third sub-watershed is the Austin-Oyster watershed (HUC 12040205) which covers the eastern part of the study area, east of the Lower Brazos (USGS 2017a, b). Based on aerial photography review and field reconnaissance, an estimated 60 percent of the BRFG study area contains water resources, including the GIWW, Brazos River, and adjacent marshes. The San Bernard River, Cedar Lakes, and various other sloughs, lakes, and marshes surround the study area.

Hydraulics in the BRFG area have been modified over the years by various activities. The activities include excavation and maintenance of the GIWW and placement of dredged material; 1929 diversion of the Brazos River; 1943 construction of the BRFG; construction of levees, drainage ditches, pump stations, with a tidal gate structure for hurricane and flood protection; and natural migration and opening/closing of the San Bernard River outlet at the Gulf of Mexico. The San Bernard River flows into the GIWW about four miles west of the BRFG, and the GIWW serves as the river's outlet through the west floodgate when the mouth of the San Bernard River is closed. The mouth of the San Bernard River was opened to the Gulf of Mexico by dredging in 2009 and silted in over the following few years due to low flows and sediment deposition from longshore currents in the Gulf of Mexico. The San Bernard River mouth remained closed until Hurricane Harvey caused it to reopen in August-September 2017. As of September 2018, the mouth was still open, but sand and silt were observed filling in the mouth (Friends of the San Bernard River 2018). Modeling was conducted on the San Bernard mouth to determine the impacts of an open San Bernard mouth on the proposed project. In general, the open San Bernard condition results in increased sedimentation in the West GIWW compared to closed conditions and reduced sedimentation in the San Bernard Gulf Channel when compared to the closed condition, which is to be expected due to increased flow rates and velocities in this area. Based on historical aerial examination, previous dredging attempts, and previous literature, the controlling process for the morphology of the San Bernard mouth was found to be the net westward transport of sediments deposited by the Brazos River into the Gulf of Mexico, and not sediment deposition in the San Bernard channel via the GIWW. Further discussion of the open San Bernard mouth analysis is conducted in the **Hydraulic Engineering Appendix – Colorado River Locks of the Engineering Appendix**

The CRL area also contains portions of three sub-watersheds (refer back to **Figure 2-5**): (1) the Central Matagorda Bay watershed (HUC 12100401) in the western half, (2) the Lower Colorado River watershed (HUC 12090302) in the eastern half, and (3) the East Matagorda Bay watershed (HUC 12090402) in the extreme eastern end (USGS 2017a, b). Based on aerial photography review and field reconnaissance, an estimated 44 percent of the CRL study area contains water resources, including the GIWW, Colorado River, Colorado River Diversion Channel, and adjacent marshes. West Matagorda Bay and East Matagorda Bay are to the southwest and east, respectively, and various other sloughs, lakes, and marshes occur in the surrounding low-elevation coastal plain. Hydraulics in the CRL area have also been modified by activities. These activities include the excavation and maintenance of the GIWW and placement of dredged material; 1944 and 1951 construction of the CRL; levee construction for hurricane and flood protection; diversion of the Colorado River into West Matagorda Bay in the early 1990s; and 2012 excavation of Bragg's Cut between the Colorado River and Colorado River Diversion Channel.

The water resources in the BRFG and CRL areas are considered waters of the U.S. subject to regulation under Section 404 of the Clean Water Act (CWA), and the GIWW, Brazos and Colorado Rivers, and other tidal waters are also navigable waters subject to regulation under Section 10 of the RHA. These statutes are administered by the USACE and regulate the discharge of dredged and fill material and other work in regulated waters. More information on waters of the U.S. is provided in the 404(b)(1) analysis that has been prepared for the project (**Environmental Appendix D, Attachment D-1**).

2.2.3 Water Supply and Use

2.2.3.1 Surface Water

The Brazos and Colorado Rivers are major water sources for irrigation, municipal water supply, manufacturing, electric power, livestock, and mining uses. There are over 40 water supply lakes/reservoirs in the Brazos River Basin and over 30 water supply lakes/reservoirs in the Colorado River Basin (Lower Colorado Regional Water Planning Group 2015; Region H Regional Water Planning Group 2015; TWDB 2016a, 2016b, 2017b). However, there are no water supply lakes or reservoirs in or adjacent to the BRFG or CRL study areas.

Based on TCEQ data, there are water intake/diversion points off the Brazos River at the Bryan Mound Strategic Petroleum Reserve (one mile north of the BRFG) and at the Dow Chemical Plant (over six miles north of the BRFG). The nearest intake/diversion point to the CRL area is at the South Texas Electric Project generating station, located eight miles to the north (TCEQ 2016b).

2.2.3.2 Groundwater

The BRFG and CRL study areas are underlain by the Gulf Coast Aquifer, a major aquifer system that parallels the Gulf of Mexico coastline from the Texas-Louisiana border to the Texas-Mexico border (George et al. 2011, TWDB 2017c). The thickness, water quality, and productivity of the aquifer varies across its range (George et al. 2011, TWDB 2017c). The Gulf Coast Aquifer is comprised of, from shallowest to deepest, the Chicot Aquifer, the Evangeline Aquifer, the Burkeville Confining Unit, and the Jasper Aquifer, with parts of the Catahoula Formation acting as the Catahoula Confining System (Coastal Plains Groundwater Conservation District 2014). The Gulf Coast Aquifer system is used for municipal, industrial, and irrigation purposes (TWDB 2017b, 2017c). The main source of groundwater in Brazoria County is the Chicot Aquifer (Brazoria County Groundwater Conservation District 2012). All registered wells in Matagorda County are in either the Chicot Aquifer or the Evangeline Aquifer (Coastal Plains Groundwater Conservation District 2014). Water level declines in the Gulf Coast Aquifer underlying Harris, Galveston, Fort Bend, Jasper, and Wharton Counties have historically led to land subsidence in some areas outside of the BRFG and CRL study areas (George et al. 2011, TWDB 2017c).

According to the TWDB Groundwater Database and the Submitted Driller's Report Database, there are four groundwater wells within the BRFG area, and two groundwater wells located with the CRL area (**Table 2-2** and **Figures 2-6 and 2-7**) All but one of the wells are part of the BRFG and CRL facilities. The other well is associated with the Texas Boat and Barge, Inc. facility located adjacent to the BRFG east floodgate.

Table 2-2 - Groundwater Wells Located Within the Study Area

State Well ID # or Submitted Driller's Report #	Well Owner	Aquifer Formation	Well Type	Purpose of Use
BRFG Study Area				
8105901	USACE	Chicot Aquifer, Upper	Withdrawal	Plugged or Destroyed
8105902	USACE	Chicot Aquifer, Upper	Withdrawal	Domestic
8105903	USACE #3	Chicot Aquifer, Upper	Withdrawal	Public Supply
5586	Texas Boat and Barge	Not Identified	New Well	Domestic
CRL Study Area				
8117401	USACE	Chicot Aquifer	Withdrawal	Domestic
8117402	USACE	Chicot Aquifer	Withdrawal	Public Supply

Sources: *TWDB 2017b*

2.2.4 Water Quality

The Texas Integrated Report of Surface Water Quality is a requirement of the Federal CWA Sections 305(b) and 303(d) and evaluates the quality of surface waters in Texas (TCEQ 2017a). Section 303(d) requires states to develop lists of impaired waters, which are waters where technology-based regulations and other required controls are not stringent enough to meet the state water quality standards. Based on a review of the Texas Integrated Report and 303(d) lists, there are no threatened or impaired surface waters in the BRFG or CRL study areas (TCEQ 2015). Within the BRFG study area, the Brazos River Tidal segment is designated as Segment 1201 and is in attainment for all water quality parameters. Within the CRL study area, the Colorado River Tidal segment is designated as Segment 1401 and is also in attainment for all water quality parameters. Near both study areas, the Gulf of Mexico is listed as threatened/impaired for mercury in edible tissue on the 2014 303(d) lists.

2.2.5 Salinity

Salinity in the bays, estuaries, and nearshore areas of the Gulf Coast of Texas is strongly influenced by the amount of freshwater inflow from surrounding streams and rivers. Salinity levels in estuaries are categorized as follows: oligohaline (0.5-5 parts per thousand (ppt)), mesohaline (5-18 ppt), polyhaline (18-30 ppt), euhaline (30-40 ppt), and hyperhaline (>40 ppt). Estuaries exhibit a broad salinity range, from freshwater to seawater (0.5 to 35 ppt), and salinity within an estuary can vary daily depending on location, tides, weather, freshwater inflow, and other factors (NOAA 2018a). Salinity levels and fluctuations affect estuary characteristics such as nutrient cycling, benthic organism communities, and estuarine/wetland plant and animal communities, including juvenile fish and shellfish nursery stocks (Longley 1994).

Salinity in the study area ranges widely depending on river stages/flows in the Brazos, San Bernard, and Colorado Rivers. The Brazos River discharges directly into the Gulf of Mexico, so the amount of freshwater flows in the river greatly influences salinity in the study area and surrounding areas. In the BRFG study area, site-specific salinity data measured from late 2012 through mid-2017 at the east floodgate showed monthly salinity levels ranging from less than 0.5 ppt (essentially freshwater) to 33 ppt, which is near the average seawater concentration of 35 ppt. Average monthly salinities during that five-year period ranged from about 9.2 ppt in May to 25.7 ppt in August. These salinities coincide with periods when high river flows reduce salinity, and low river flows allow tidal waters from the Gulf to extend upstream in the river.

Although there is no salinity gauge at the CRL, the USACE collected site specific data within the CRL study area between May and October 2001, and salinity ranged from 8 to 27 ppt during that period. Based on the CRL modeling results (see **Engineering Appendix – Appendix A**), existing average salinities in the CRL study area range from 7 ppt in the GIWW-Colorado River intersection to 18 ppt in the original Colorado River channel. Average salinities in the Colorado River upstream and downstream of the study area are less than 1 ppt and 11 ppt, respectively. Existing salinities in West Matagorda Bay (outside the Colorado River delta) and East Matagorda Bay are 18 and 25 ppt, respectively. Most of the water in the Colorado River drains to West Matagorda Bay at the Colorado River delta, but when the CRL are open, some flow also enters the GIWW and reaches East Matagorda Bay and the Gulf through the original river channel. East Matagorda Bay is considered by some sources to be a lagoon with limited freshwater input, resulting in relatively high average salinities (Palmer et al. 2011, Montagna 2001).

2.2.6 River Sediment Resources

The Brazos River has the highest water and sediment load discharge of all Texas rivers, and the second highest sediment load discharge to the entire Gulf of Mexico, behind the Mississippi River (Milliman and Meade 1983, Carlin 2013). The Colorado River has lower sediment load discharges than the Brazos River but still carries large loads of sediment. In the early 1990s, the mouth of the Colorado River was moved from the Gulf of Mexico to West Matagorda Bay[1] in an effort to enhance seafood productivity of the bay, reduce flood damage potential along the lower Colorado River, and to reduce navigation hazards and channel maintenance costs (USACE 1981). The river now deposits sediments in West Matagorda Bay, creating shallow-water wetlands along the delta.

[1] Note that the Colorado River currently drains to Matagorda Bay, which is often referred to as "West" Matagorda Bay to clearly differentiate it from East Matagorda Bay. Because both bays are referenced multiple times in this document, Matagorda Bay is referred to as West Matagorda Bay throughout the document.

The BRFG and CRL facilities were constructed on the GIWW in part to reduce silt deposition and shoaling of the waterway at the river crossings. Managing sedimentation in the GIWW at the river crossings continues to be a planning objective. Even with the floodgates and locks, sediment accumulates in the GIWW, resulting in the need for maintenance dredging in the vicinity of the rivers. In addition, sediment from the Brazos River that flows into the Gulf of Mexico is transported westward by longshore currents to the San Bernard River mouth; deposition of the sediment, along with low flows in the San Bernard River, contributes to the closing of the San Bernard River outlet at the Gulf.

2.2.7 Shoal Formation Concerns

At the BRFG, high sediment loads result in sediment deposits in the GIWW both east and west of the river, creating shoals in areas where vessels pass. These shoals have caused grounding of vessels, and dredging is required to remove the shoals. Shoaling has also occurred at the CRL, particularly after major flooding events. Major flooding from Hurricane Harvey in August 2017 resulted in shoal formation near the west locks, making the GIWW impassable at this location.

2.2.8 Erosion

According to the Texas General Land Office's (GLO's) 2015 Coastal Erosion Planning & Response Act (CEPRA) Report, 84 percent of the Texas Gulf shoreline is retreating, averaging about 4 feet per year and resulting in 235 acres of lost land per year along the coastline, bays, estuaries, and navigation channels (GLO 2015). These land losses affect properties, extend saltwater intrusion, and affect wetlands and other habitats. Between the 1930s and 2012, the Gulf coastline extending from Quintana to Sargent Beach, which includes the BRFG study area, retreated an average of 9.5 feet per year. Land losses near the CRL study area were less than 5 feet per year during the same period (McKenna 2014, Paine et al. 2014, Bureau of Economic Geology 2016). Causes of coastal erosion include storm impacts, lack of sufficient sediment discharges, long-term sea level rises, and subsidence (McKenna 2014).

In September 2008, three years after Hurricane Rita damaged the upper Texas coast, Hurricane Ike made landfall with a 5- to 10-foot storm surge in Brazoria County and 15- to 20-foot storm surge in Chambers and Galveston Counties to the north, causing major erosion along the coastline. Following Hurricane Ike, the State of Texas required local governments along the Gulf to develop erosion response plans, with the intent of minimizing future public expenditures for erosion and storm damages. Through these plans, various restoration and stabilization projects have helped maintain the shoreline position (McKenna 2014). Brazoria and Matagorda Counties have implemented multiple restoration and stabilization projects with the help of CEPRA funding. These projects include beach nourishment, dune restoration, and shoreline stabilization from

Surfside to Treasure Island (located 5 to 20 miles northeast of BRFG), beach monitoring at Bryan Beach (located at the mouth of the Brazos River one mile south of BRFG), and beach restoration at Sargent Beach (19 miles southwest of BRFG and 19 miles northeast of CRL) (McKenna 2014). The USACE and GLO are also working on the Coastal Texas Protection and Restoration Feasibility Study (Coastal Texas Study), a coastwide study to evaluate large-scale coastal storm risk management and ecosystem restoration alternatives, which includes measures for shoreline erosion control (USACE and GLO 2018).

Within the BRFG and CRL study areas, local shoreline erosion on the south end of the Brazos and Colorado River crossings of the GIWW are ongoing problems. Along the GIWW, barge wakes are one of the biggest sources of erosion. Erosion also occurs where tows push into the GIWW banks while waiting for mooring buoys to become available. Erosion of sediments into the navigation channel is one of the contributors of deposited material that is periodically removed through maintenance dredging. Note that adding mooring buoys was considered as a non-structural measure in the current study but dismissed during the alternatives analysis; this measure is being considered as part of a separate ongoing USACE study, the GIWW Mooring Basin Modification Study.

2.3 VEGETATION, WILDLIFE HABITAT AND RESOURCES

The BRFG and CRL study areas are in the Mid-Coast Barrier Islands and Coastal Marshes portion of the Western Gulf Coastal Plain ecoregion, which stretches from Galveston Bay in the north to Corpus Christi Bay in the south (Griffith et al. 2007). This ecoregion is characterized as having salt marsh on the back side of barrier islands, with fresh or brackish marshes near river deltas. The region contains a matrix of wetland and upland habitats that support a variety of wildlife species.

Vegetation communities/habitat types were mapped using aerial photography review and field reconnaissance. Six general vegetation communities/habitat types were observed within the BRFG and CRL study areas (**Figures 2-8 and 2-9**). **Table 2-3** lists the habitat types and the approximate percentage of each study area that contains the habitat. Descriptions of the habitat types follow the table.

Table 2-3 - Estimated Habitat Types in the BRFG & CRL Study Areas

Habitat Type	Percentage of BRFG Study Area	Percentage of CRL Study Area
Open Water	36	35
Intertidal Marsh	2	1
High Marsh	21	8
Tidal Flat	0.5	0
Upland Shrub/Woods	30	43
Developed	11	13

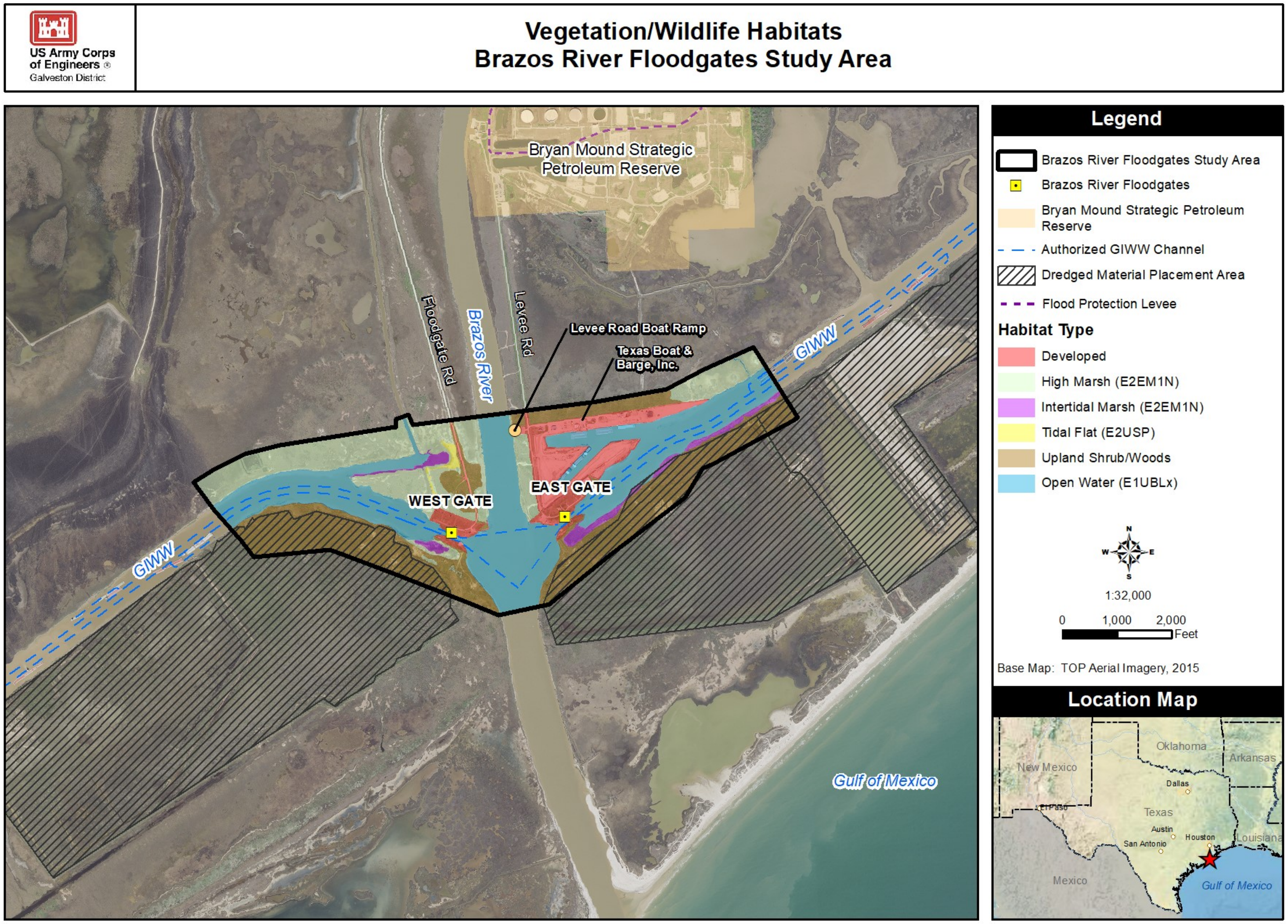

Figure 2-8 – Vegetation & Wildlife Habitats in the BRFG NEPA Study Area

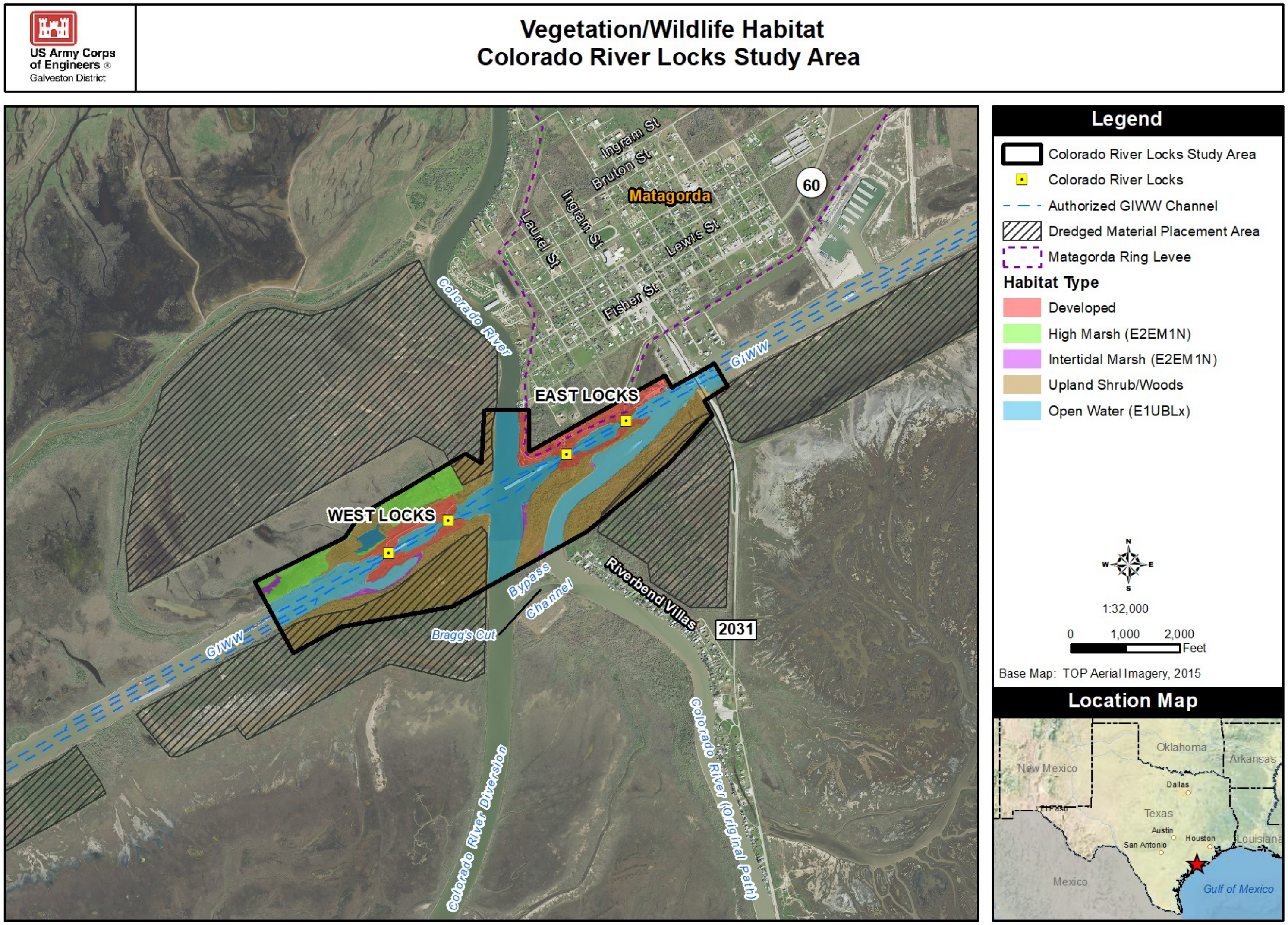

Figure 2-9 – Vegetation & Wildlife Habitats in the CRL NEPA Study Area

Open Water

Open water is a major habitat type in both study areas and is present in the GIWW and the Brazos and Colorado Rivers. The open water areas provide habitat for fish, shrimp, crabs, bottlenose dolphins (*Tursiops truncatus*), and other estuarine species. Most of the open water habitat experiences regular disturbances by barge tows and other vessels traveling through the GIWW, as well as periodic maintenance dredging.

High / Intertidal Marshes

High marsh habitat is the dominant wetland habitat in the study areas, occurring at low elevations but only infrequently inundated by very high tides. Common plant species observed in this habitat include turtleweed (*Batis maritima*), saltgrass (*Distichlis spicata*), saltworts (*Salicornia* spp.), Gulf cordgrass (*Spartina spartinae*), marshhay cordgrass (*S. patens*), sea-oxeye daisy (*Borrichia frutescens*), seepweed (*Suaeda linearis*), and marsh-elder (*Iva frutescens*). Scattered threesquare (*Schoenoplectus pungens*), wolfberry (*Lycium carolinianum*), saltcedar (*Tamarix ramosissima*), smooth cordgrass (*Spartina alterniflora*), and common reed (*Phragmites australis*) were also observed. In the BRFG study area, two small patches of high marsh located south of the GIWW and west of the Brazos River collect some fresh water from overland flow and groundwater seepage from an adjacent DMPA, but they are also influenced by high tides, washover from the GIWW, and/or tidally influenced water table. These wetland patches contain typical high marsh plant species, as well as scattered black willow (*salix nigra*), rattlebush (*Sesbania drummondii*), sand spikerush (*Eleocharis montevidensis*), and commono rush (*Juncus effuses*).

Intertidal marsh, which includes wetland areas that occur at elevations between the low and high tides (intertidal zone), also occurs in both study areas. These areas are dominated by smooth cordgrass (*Spartina alterniflora*), with species common to the high marsh habitat present along the edges. At the BRFG, intertidal marsh lines the south GIWW bank through much of the study area. At the CRL, intertidal marsh occurs as relatively small patches along the south GIWW bank, Bragg's Cut, and interior tidal ponds in the study area.

Tidal Flat

One small area of unvegetated tidal flat is in the BRFG study area. This habitat is adjacent to an intertidal marsh and contained less than 5 percent plant cover (turtleweed, smooth cordgrass, saltwort, and saltgrass). Algal mats covered an estimated 50 percent of the flat during a February 2017 field investigation. The area also showed evidence of disturbance from cattle.

Upland Shrub/Woods

Higher elevations in the study areas, such as portions of the river banks and in DMPAs, support upland shrub/woods vegetation. This habitat includes relatively young (<50 years) riparian vegetation consisting of a mix of common native and non-native plant species. Common plant species observed in this habitat include American elm (*Ulmus americana*), sugar hackberry (*Celtis laevigata*), Chinaberry (*Melia azedarach*), Chinese tallow, honey mesquite (*Prosopis glandulosa*), Hercules'-club (*Zanthoxylum clava-herculis*), osage orange (*Maclura pomifera*), roughleaf dogwood (*Cornus drummondii*), retama (*Parkinsonia aculeata*), elbowbush (*Forestiera angustifolia*), eastern baccharis, saltcedar, Louisiana vetch (*Vicia ludoviciana*), rosettegrass (*Dichanthelium* sp.), catchweed (*Galium* sp.), crow-poison (*Nothoscordum bivalve*), hairyfruit chervil (*Chaerophyllum tainturieri*), giant ragweed (*Ambrosia trifida*), mustang grape (*Vitis mustangensis*), poison ivy (*Toxicodendron radicans*), southern dewberry, Virginia creeper (*Parthenocissus quinquefolia*), and peppervine (*Ampelopsis arborea*).

Developed Areas
Developed areas include the floodgate and lock facilities and Texas Boat & Barge, Inc. (BRFG study area).

2.3.1 Habitat Evaluations

The mix of open water, wetland, and upland habitats provide the opportunity for the study areas to support a variety of aquatic and terrestrial wildlife species. As such, the habitats were evaluated to determine their significance based on institutional, public, and technical recognition. The ER 1105-2-100, Planning Guidance Notebook and the Water Resources Council Principles and Guidelines (P&G) describe the procedures for determining the significance of resources. The Institute for Water Resources' (IWR) Report 97-R-4, *Resource Significance Protocol For Environmental Project Planning*, provides more specific guidance for determining significance (Apogee Research, Inc. 1997). Based on these guidance documents, the wetland habitats in the study areas (high/intertidal marshes and tidal flats) have institutional significance at a national level due to the various laws and statutes that protect wetland resources (e.g., CWA Section 404(b)(1) and Executive Order (EO) 11990 on Protection of Wetlands). Wetland habitats also have technical significance due to their importance to water quality, biodiversity, and ecological productivity. Therefore, detailed habitat evaluations were conducted for wetland habitats in the study areas.

Most of the open water resources in the study areas are within and immediately adjacent to the GIWW and Brazos and Colorado Rivers and have significance for navigation and/or as major freshwater, sediment, and nutrient sources to the local estuaries and Gulf of Mexico. In addition, the GIWW and Brazos and Colorado Rivers are considered essential fish habitat (EFH) in the study areas, and they provide habitat for bottlenose dolphins, which are protected under the Marine Mammal Protection Act (MMPA). Although the open water resources in the study areas are significant, they are not limiting in the project region. Furthermore, the proposed project is intended to improve navigation, and none of the alternatives considered would result in substantial losses to open water habitats. Therefore, no detailed habitat evaluations were conducted for open water resources in the study areas.

The upland shrub/woods habitats in the study areas consist of relatively young (<50 years) woody growth, do not constitute bottomland hardwoods or other significant woodland habitat, and contain both common and non-native shrub and tree species. Although these habitats provide foraging, roosting, and nesting habitat for migratory birds protected under the Migratory Bird Treaty Act (MBTA), they are not unique in this respect (virtually all vegetated habitats support migratory birds), and similar habitats are common in the region. As a result, the upland shrub/woods habitats would not be expected to be considered significant ecological resources following the procedures in ER 1105-2-100, the P&G, and IWR Report 97-R-4.

2.3.1.1 Evaluation of Wetland Habitats

An interagency biological team, including USACE, TxDOT, U.S. Fish and Wildlife Service (USFWS), National Marine Fisheries Service (NMFS), and Texas Parks and Wildlife Department (TPWD) personnel, conducted field visits to evaluate the habitats in the NEPA study areas. Since the wetlands in the study areas were the only habitats determined to be significant resources *and* had the potential to be adversely impacted, this section only provides the results of the wetland habitat evaluations. The interagency team conducted a habitat evaluation of the three wetland habitat types (high marsh, intertidal marsh, and tidal flat) in the study areas using Habitat Evaluation Procedures (HEP) methodology. HEP is a habitat-based assessment methodology developed by the USFWS to estimate habitat values for use in project planning and impact assessment (USFWS 1980). HEP requires the use of Habitat Suitability Index (HSI) models developed for wildlife indicator species that use the habitats. The HSI models evaluate structural habitat composition variables that are contained in optimum habitat, and these variables are measured in the field.

Modeled habitat conditions are expressed as a numeric function (HSI value) ranging from 0.0 to 1.0, where 0.0 represents no suitable habitat for an indicator species and 1.0 represents optimum conditions for the species. HSI values ranging from 0.01 to 0.24 are considered “poor” habitat, 0.25 to 0.49 are considered “below average” habitat, 0.50 to 0.69 are “average” habitat, 0.70 to 0.89 are “good” habitat, and 0.90 to 1.00 are considered “excellent” habitat. Habitat units (HU) are calculated by multiplying the HSI value for each habitat by the number of acres of that specific habitat type present in the study area.

The interagency team met in February and March 2017 to select wildlife indicator species that use each habitat in the BRFG and CRL study areas and then collect field data at representative locations within each habitat. The team selected seven wildlife indicator species for the wetland habitats. As shown in **Table 2-4**, the red drum, brown and white shrimp, and clapper rail were selected as indicator species for intertidal marsh; clapper rail, marsh wren, and mottled duck were selected for high marsh; and least tern for tidal flats. During the field visits, access to private properties in the study areas was limited, so data collection occurred on USACE property, in areas along the GIWW and Brazos and Colorado Rivers, and private properties where access was granted. Data were collected at six locations in wetland habitats in the BRFG study area and four locations in wetland habitats in the CRL study area. Of the high marsh habitats sampled, the interagency team determined that only one site had the potential to be used by the marsh wren and mottled duck.

Table 2-4 – Wetland Habitats, Indicator Species, and HEP Data Sites

Habitat Type	HEP Data Sites	Indicator Species					
		Red Drum	Brown/White Shrimp	Clapper Rail	Marsh Wren*	Mottled Duck	Least Tern
BRFG							
High Marsh	1, 4, 5			x			
Intertidal Marsh	2, 6	x	x	x			
Tidal Flat	3						x
CRL							
High Marsh	1, 2, 3			x	x*	x*	
Intertidal Marsh	4	x	x	x			

** Marsh wren and mottled duck were evaluated only at one high marsh site in the CRL study area. During field investigations, the interagency team determined that the other high marsh habitats at BRFG and CRL were not suitable for these species.*

Average HSI values and HUs for each habitat are summarized in **Table 2-5**. The habitats scored “average” to “excellent” with the exception of the high marsh habitat at CRL, which scored “poor”. The limiting factor causing high marsh habitats in the CRL study area to score “poor” was the lack of tidally influenced waters adjacent to these habitats. As shown earlier in **Figure 2-8**, the high marsh habitats in the CRL study area are mostly separated from the GIWW and Colorado River by upland habitats.

Table 2-5 – Average HIS Values and Habitat Units for Wetland Habitats

Habitat Type	Acreage	Indicator Species							HSI Average	Habitat Units
		Red Drum	Brown Shrimp	White Shrimp	Clapper Rail	Least Tern	Marsh Wren*	Mottled Duck*		
BRFG										
High Marsh	123.5				1.00				1.00	123.50
Intertidal Marsh	15.8	0.37	0.92	0.90	1.00				0.80	12.64
Tidal Flat	3.0					0.80			0.80	2.40
CRL										
High Marsh	32.0				0.15		0.85*	0.00*	0.25	8.00
Intertidal Marsh	4.6	0.45	0.97	0.91	0.98				0.83	3.82

** Marsh wren and mottled duck were evaluated only at one high marsh site in the CRL study area. During field investigations, the interagency team determined that the other high marsh habitats at BRFG and CRL were not suitable for these species.*

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

The vegetation communities/wildlife habitats present in the BRFG and CRL study areas are characteristic of the Texas Gulf coast, and, while they are important resources, none of the habitats are considered regionally rare, unique, or imperiled. Threatened and endangered plant and wildlife species that may occur in the study areas are discussed in the *Threatened and Endangered Species* section below.

2.3.3 Invasive Plant and Animal Species

Several invasive plant species occur in coastal Texas. In terrestrial areas, Chinese tallow, Chinaberry, and Chinese privet (*Ligustrum sinense*) can become rapidly established in disturbed areas, including DMPAs (Texas Invasive Plant and Pest Council [TIPPC] 2017). Invasive aquatic plants include water hyacinth (*Eichhornia crassipes*) and common reed, both of which thrive in fresh to brackish water zones (U.S. Department of Agriculture (USDA) 2017e, Stutzenbaker 1999)). Water hyacinth creates dense cover and root mats that block sunlight, reduce oxygen, and kill plants that provide food for fish and other aquatic life (TPWD 2017a). Common reed creates dense stands that choke out native wetland species. No large stands or concentrations of any of these plants were observed in the study areas during field reconnaissance, although Chinese tallow and Chinaberry trees were common in the upland shrub/woods habitat on the river and GIWW banks and in upland DMPAs at both sites.

Some invasive wildlife species common in the region include feral hogs (*Sus scrofa*), nutria (*Myocastor coypus*), and the red imported fire ant (*Solenopsis invicta*). Feral hogs compete with wildlife and livestock and damage crops and habitats by uprooting vegetation and disturbing the soil. Nutria burrow into wetland soils and eat aquatic vegetation, which creates disturbed, unvegetated areas that erode and become open water. Fire ants damage electrical wiring and some crops, as well as prey on ground-nesting birds, eggs, and other wildlife (TPWD 2017a). Recently, Asian tiger shrimp (*Penaeus monodon*) have been recorded off the Texas Gulf coast and in some Texas bays, and the red lionfish (*Pterois volitans*) has been reported in Tres Palacios Bay, approximately 11 miles west-northwest of the CRL study area (TIPPC 2017). The habitats in the study areas are suitable for feral hogs, fire ants, and nutria, so they could occur there.

2.3.4 **Protected/Managed Lands and Recreation Areas**

The only public recreation facility in either study area is the Levee Road Boat Ramp shown in **Figure 2-10**. This public boat ramp, owned and managed by Brazoria County (Atkins North America 2013), provides access to the Brazos River approximately 0.3 mile north of the GIWW crossing. There are no other designated parks or recreation areas, NWRs, wildlife management areas (WMAs), or other protected or managed lands within the BRFG or CRL study areas (**Figures 2-10 and 2-11**). Protected and managed lands and recreation areas that are near the study areas are listed in **Table 2-6**.

Table 2-6 - Protected/Managed Lands and Recreational Areas near Study Area

Property	Location from Study Area	Description
BRFG Study Area (Figure 2.10)		
Levee Road Boat Ramp	Within study area	Public boat ramp
Justin Hurst WMA	Less than 1 mile northwest of BRFG	Part of Central Coast Wetlands Ecosystem Project; develops/manages habitats for wildlife species with special emphasis on waterfowl
Bryan Beach State Recreation Area	Less than 1 mile south of BRFG study area	Public access for fishing in the Gulf of Mexico and the Brazos River, and for camping
Bryan Beach Park	1.5 mile east of study area	Public park maintained by City of Freeport
San Bernard NWR	3 miles west of study area	54,000-acre refuge that provides a habitat corridor for migrating and wintering birds
CRL Study Area (Figure 2.11)		
Mad Island WMA	1.5 miles west of study area	7,200 acres of fresh to brackish marsh with sparse brush and flat coastal prairie; preserve coastal wetland habitat for wintering waterfowl
Matagorda County Jetty Park	Matagorda Peninsula, 6 miles south of study area	Public park that is a popular birding location

Sources: *TPWD 2017b, eBird 2017, The Go Travel Sites 2017*

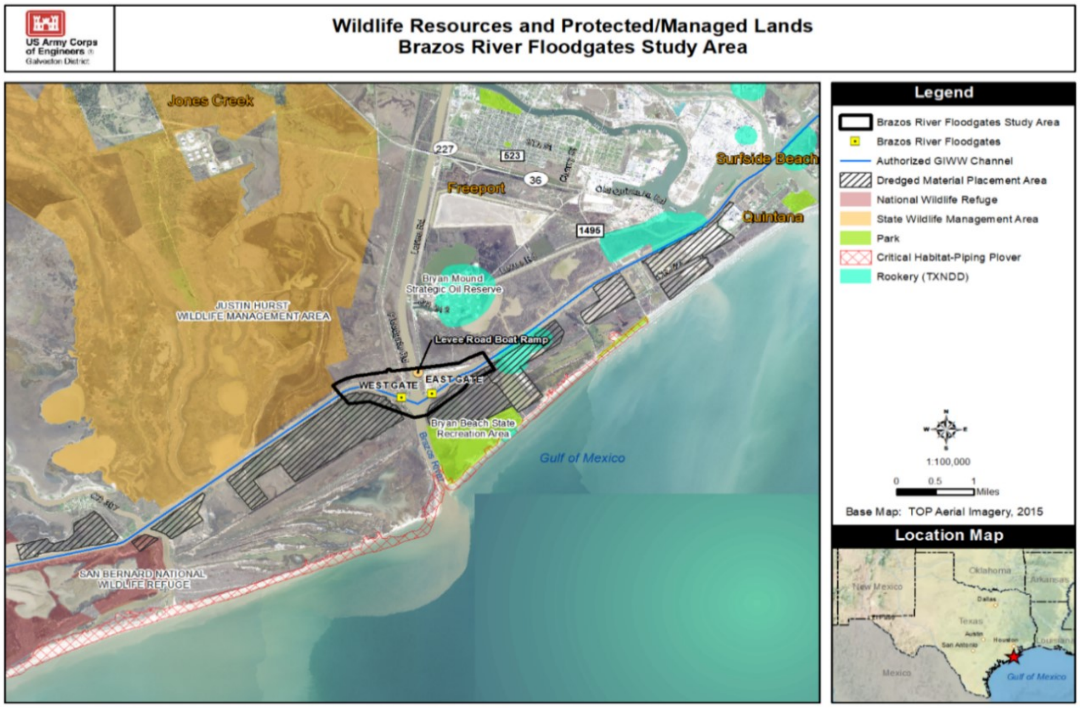

Figure 2-10 - Wildlife Resources and Protected/Management Lands in BRFG Area

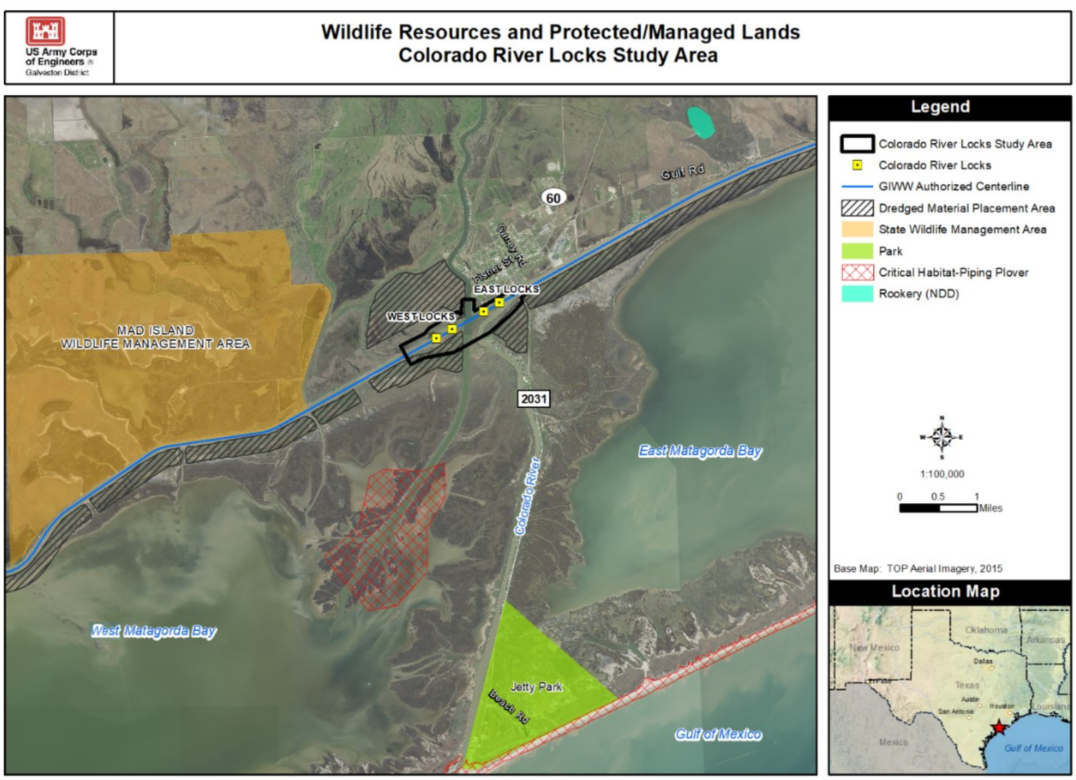

Figure 2-11 - Wildlife Resources and Protected/Management Lands in CRL Area

2.3.5 Threatened and Endangered Species

According to the USFWS' threatened and endangered species lists for Brazoria and Matagorda Counties (USFWS 2017a, 2017b, 2017c) and NMFS' threatened and endangered species list for the Texas portion of the Gulf of Mexico (NMFS 2017), 18 federally listed threatened or endangered species, and four candidates for Federal listing, may occur in Brazoria and Matagorda Counties (**Table 2-7**). In addition, the USFWS has designated critical habitat for the wintering piping plover (*Charadrius melodus*) along the entire Texas Gulf coast including in Brazoria and Matagorda Counties (USFWS 2009, 2017c) and near the study areas. There is no designated or proposed critical habitat for other species in or near the study areas.

Table 2-7 - Federally Listed and Candidate Species with Potential to Occur in Brazoria and Matagorda Counties, Texas

Listed Species		Listing Status	Jurisdiction	Potential to Occur in BRFG and CRL Study Areas?
Common Name	**Scientific Name**			
Birds				
Northern aplomado falcon	*Falco femoralis septentrionalis*	Endangered	USFWS	Yes
Piping plover	*Charadrius melodus*	Threatened	USFWS	Yes
Red knot	*Calidris canutus rufa*	Threatened	USFWS	Yes
Whooping crane	*Grus americana*	Endangered	USFWS	Yes
Mammals				
West Indian manatee	*Trichechus manatus*	Threatened	USFWS	Yes
Fin whale	*Balaenoptera physalus*	Endangered	NMFS	No
Humpback whale	*Megaptera novaeangliae*	Endangered	NMFS	No
Sei whale	*Balaenoptera borealis*	Endangered	NMFS	No
Sperm whale	*Physeter macrocephalus*	Endangered	NMFS	No
Reptiles				
Green sea turtle	*Chelonia mydas*	Threatened	NMFS	Yes
Hawksbill sea turtle	*Eretmochelys imbricata*	Endangered	USFWS; NMFS	Yes
Kemp's ridley sea turtle	*Lepidochelys kempii*	Endangered	USFWS; NMFS	Yes
Leatherback sea turtle	*Dermochelys coriacea*	Endangered	USFWS; NMFS	No
Loggerhead sea turtle	*Caretta caretta*	Threatened	USFWS; NMFS	Yes
Mollusks				
Golden Orb	*Quadrula aurea*	Candidate	USFWS	No
Smooth pimpleback	*Quadrula houstonensis*	Candidate	USFWS	No
Texas fawnsfoot	*Truncilla macrodon*	Candidate	USFWS	No
Texas pimpleback	*Quadrula petrina*	Candidate	USFWS	No
Corals				
Boulder star coral	*Orbicella franksi*	Threatened	NMFS	No
Elkhorn coral	*Acropora palmata*	Threatened	NMFS	No
Lobed star coral	*Orbicella annularis*	Threatened	NMFS	No
Mountainous star coral	*Orbicella faveolata*	Threatened	NMFS	No

Sources: *NMFS 2017; USFWS 2017a, b, c*

Based on habitat assessments and recorded sightings, nine of the federally listed threatened/endangered species listed in **Table 2-7** have the potential to occur in the BRFG and CRL study areas. The following bullets summarize the potential for each species to occur in the study areas. Detailed information is provided in the Biological Assessment prepared for the project (**Environmental Appendix D, Attachment D-2**).

- Northern aplomado falcon (*Falco femoralis septentrionalis*) – A breeding population of northern aplomado falcons exists on Matagorda Island, located 32 miles southwest of the CRL study area. Individual sightings of the species have been recorded about nine miles west of the BRFG study area at San Bernard NWR and about three miles west of the CRL study area at Mad Island WMA (eBird 2017). The study areas contain open habitats that could be used by aplomado falcons; however, no nesting falcons are expected based on the current known nesting range.

  Piping plover and red knot (*Calidris canutus rufa*) – The piping plover and red knot are migratory species that overwinter on the Texas coast and utilize barrier island beaches, exposed tidal flats, washover passes, and mud flats. Designated critical habitat for the piping plover (**Figures 2-10 and 2-11**), is present along the Gulf beach near both study areas, as well as in the Colorado River delta in West Matagorda Bay (USFWS 2017a, 2017b, 2017d). Piping plovers and red knots have been recorded in the vicinity of both study areas (eBird 2017, Texas Natural Diversity Database [TXNDD] 2017).

- Whooping crane (*Grus americana*) – Whooping cranes also overwinter on the Texas coast, mostly in the area surrounding the Aransas NWR located about 30 miles southwest of the CRL study area. They utilize salt marshes and tidal flats on the mainland and barrier islands. Salt marsh habitat is present in both study areas, and whooping cranes have been recorded within 5 miles of both study areas at Justin Hurst WMA, San Bernard NWR, and Mad Island WMA (TXNDD 2017, eBird 2017).

- West Indian manatee (*Trichechus manatus*) – Manatee occurrences in Texas are extremely rare. The Texas Marine Mammal Stranding Network has recovered fewer than 10 manatees along the Texas coast since 1980 (Houston Chronicle 2012). One historical manatee record is from the GIWW near Oyster Creek just north of Freeport. Historical records from Texas waters also include Cow Bayou, Sabine Lake, Copano Bay, the Bolivar Peninsula, and the mouth of the Rio Grande (Natural Science Research Laboratory 2017). In October 2012, live manatee sightings were recorded near Galveston and near Corpus Christi (Houston Chronicle 2012). A West Indian manatee could occur in the GIWW or rivers in the study areas; however, the likelihood of their occurrence is considered low due to their rare occurrence in Texas.

- Whales – Whales are generally restricted to deeper offshore waters (NMFS 2017b) and are not expected to occur in the study areas.

- Sea turtles – The GIWW and Brazos and Colorado Rivers provide open water habitats that could be used by sea turtles. Four of the five sea turtle species are known to use Texas waters; the leatherback sea turtle (*Dermochelys coriacea*) is uncommon in Texas coastal waters and is not likely to occur in the study areas.

- Mollusks (mussels) – The mussel species that are candidates for Federal listing are freshwater species and are not expected to occur in the tidal and brackish waters of the Brazos River, Colorado River, or other waters in the study areas due to salinity fluctuations.

- Corals – The listed corals are offshore species and do not occur in the study areas.

2.3.6 Other Protected Wildlife Species

In addition to species protected under the Endangered Species Act (ESA), other protected wildlife that may occur in the study areas include marine mammals, bald eagles, and general migratory birds. The following sections discuss the regulations protecting these species and their potential to occur in the study areas.

2.3.6.1 Marine Mammals

The MMPA was enacted in 1972 and prohibits the "take" of marine mammals in U.S. waters and by U.S. citizens on the high seas, as well as the importation of marine mammals and marine mammal products into the U.S. (NOAA 2017c). Take, as defined by the MMPA, means "to harass, hunt, capture, or kill, or attempt to harass, hunt, capture, or kill any marine mammal" (16 U.S.C. 1362). Although taking of marine mammals is prohibited, NMFS can issue incidental take authorizations for activities that may unintentionally take marine mammals, such as sonar and noise-producing activities (e.g., military sonar activities, oil/gas development, geophysical surveys, pile-driving, and demolition using explosives).

As discussed above, the five endangered whale species may occur in the Gulf of Mexico; however, they are generally restricted to deeper offshore waters (NMFS 2017b) and are not expected to occur in the study areas. The West Indian manatee has also been recorded along the Texas coast, but occurrences in Texas are extremely rare; therefore, the potential for them to occur in the BRFG and CRL study areas is low.

The only marine mammal species that is likely to occur in the BRFG and CRL study areas is the bottlenose dolphin. Bottlenose dolphins are distributed throughout the Gulf of Mexico and have been documented to reside in Texas bays and associated channels year-round (Gruber 1981, Fertl 1994, Maze and Würsig 1999). As a result, bottlenose dolphins could travel through the BRFG and CRL study areas anytime during the year. The occurrence of dolphins in the study areas is expected to be temporary and limited to sporadic travel of small groups through the area. Additional information on marine mammals is provided in the Marine Mammal Protection Act Report in **Environmental Appendix D, Attachment D-3**.

2.3.6.2 Bald and Golden Eagles

The Bald and Golden Eagle Protection Act (BGEPA) (16 U.S.C. §§ 668-668d) prohibits the take of bald and golden eagles unless pursuant to regulations. The BGEPA defines the "take" of an eagle to include a broad range of actions, including to pursue, shoot, shoot at, poison, wound, kill, capture, trap, collect, molest, or disturb. Based on regulations found at 50 Code of Federal Regulations (CFR) 22.3, the term "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."

Golden eagles are not expected to occur in the study areas except for the possibility of migrating individuals passing through. Bald eagles, however, are well known to occur and nest near major water bodies in the Texas coastal region, including Brazoria and Matagorda Counties (Ortego 2016). Recent records show that the number of reported bald eagle nests in Brazoria and Matagorda Counties is 16 and 13, respectively; Harris County has the most reported nests of the coastal counties, with 23 nests (Ortego 2016).

Bald eagles may forage in the Brazos, San Bernard, and Colorado Rivers, GIWW, East and West Matagorda Bays, and other large water bodies in and near the study areas. No known bald eagle nests are in or adjacent to the study areas (TXNDD 2017). An on-site habitat assessment was conducted in each study area and determined that trees in the study area are too small to support bald eagle nests. No nesting habitat for bald eagles is present in or adjacent to the study areas.

2.3.6.3 Migratory Birds

The MBTA prohibits the taking, killing, possession, transportation, and export of migratory birds, their eggs, parts, and nests without a USFWS permit or other regulatory authorization. The MBTA protects most native bird species occurring in the wild in the U.S. except for gallinaceous birds (upland game birds such as turkeys and quail) that are not considered migratory. In addition, the MBTA does not protect some non-native species such as the house sparrow (*Passer domesticus*), European starling (*Sturnus vulgaris*), rock pigeon (*Columba livia*), and any recently listed unprotected species in the Federal Register (70 FR 12710, March 15, 2005). Besides the MBTA, the USFWS identifies specific Birds of Conservation Concern, which include migratory and non-migratory birds that are not listed as threatened or endangered under the ESA but are considered high conservation priorities (USFWS 2008). Over 40 bird species of conservation concern are listed for the Gulf Coastal Prairie region.

The habitats in the BRFG and CRL study areas are used by various migratory birds for nesting, foraging, loafing, and roosting. Several birds of conservation concern could occur in the study areas; examples include bald eagle (foraging), loggerhead shrike (*Lanius ludovicianus*), painted bunting (*Passerina ciris*), and species that may use wetland and upland habitats temporarily during migration. A number of rookeries that are used by colonial nesting birds are documented in the vicinity of the study areas (TXNDD 2017) (**Figures 2-10 and 2-11**). Species that have been documented nesting in the rookeries include: cattle egret (*Bubulcus ibis*), great egret (*Ardea alba*), tricolored heron (*Egretta tricolor*), great blue heron (*Ardea herodias*), olivaceous cormorant (*Phalacrocorax brasilianus*), snowy egret (*Egretta thula*), roseate spoonbill (*Platalea ajaja*), least tern (*Sternula antillarum*), laughing gull (*Leucophaeus atricilla*), white ibis (*Eudocimus albus*), reddish egret (*Egretta rufescens*), forester's tern (*Sterna forsteri*), and black skimmer (*Rynchops niger*) (TXNDD 2017). The marsh and open water habitats in the study areas provide some foraging habitat for these species.

The Texas coast also provides important stopover habitats for migratory birds crossing the Gulf of Mexico during spring migration. Once they reach the coast, migrating birds sometimes "fallout" in large numbers to seek shelter and food. Fallouts of migratory birds have been recorded in and around the BRFG and CRL study areas, primarily in wooded habitats along the rivers and in DMPAs in the study areas (TXNDD 2017). These fallouts are mostly likely to occur in the spring.

2.3.7 Essential Fish Habitat

The Magnuson-Stevens Fishery Conservation and Management Act, as amended by the Sustainable Fisheries Act of 1996 (P.L. 104-297), addresses the authorized responsibilities for the protection of EFH by NMFS in association with regional Fishery Management Councils (FMC). EFH is defined as "those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity." Habitat Areas of Particular Concern (HAPC) are subsets of EFH that are rare, susceptible to human degradation, ecologically important, or located in an ecologically stressed area, and are therefore priorities for habitat conservation, management, and research (NMFS 2010, Mid-Atlantic FMC 2016).

In estuarine environments such as present in the BRFG and CRL study areas, EFH is defined as "all estuarine waters and substrates (mud, sand, shell, rock, and associated biological communities), including the sub-tidal vegetation (seagrasses and algae) and adjacent inter-tidal vegetation (marshes and mangroves)" (Gulf of Mexico FMC 2004). The estuarine habitats (open water, high marsh and intertidal marsh, and tidal flats) in the BRFG and CRL study areas have been identified as EFH for red drum (*Sciaenops ocellatus*), shrimp, coastal migratory pelagics, 43 species of reef fish, and several shark species: blacknose shark (*Carcharhinus acronotus*), blacktip shark (*Carcharhinus limbatus*), bonnethead shark (*Sphyrna tiburo*), bull shark (*Carcharhinus leucas*), great hammerhead shark (*Sphyrna mokarran*), lemon shark (*Negaprion brevirostris*), scalloped hammerhead shark (*Sphyrna lewini*), and spinner shark (*Carcharhinus brevipinna*) (NMFS 2015).

Although the study areas contain EFH for the above-mentioned species, the study areas are partially developed with navigation-related and commercial facilities and do not provide high-quality EFH. Additionally, marine water column and marine non-vegetated bottoms occur in abundance in the region and are, therefore, not unique to the area. No HAPCs are located in the study areas. Detailed information concerning EFH in the study areas is provided in the EFH Assessment Report in **Environmental Appendix D, Attachment D-4**.

2.3.8 Coastal Barrier Resources and Coastal Natural Resources

The Coastal Barrier Resources Act (CBRA) was enacted in 1982 to discourage development in certain coastal areas that are vulnerable to hurricane damage and are host to valuable natural resources. The stated purpose of the CBRA is to "minimize the loss of human life, wasteful expenditure of Federal revenues, and the damage to fish, wildlife, and other natural resources associated with the coastal barriers…by restricting future Federal expenditures and financial assistance which have the effect of encouraging development of coastal barriers…" (16 U.S.C. §3501(b)). The CBRA prohibits government expenditures on new projects within certain identified coastal barrier resource units unless they fit certain exceptions found within 16 U.S.C. §3505. The CBRA provides that the general prohibition on Federal expenditures affecting the system include the construction of structures in CBRA units (§3504(a)(3)).

A navigation exception at 16 U.S.C 3505(a)(2) provides an exception for "the maintenance or construction of improvements of existing Federal navigation channels (including the Intracoastal Waterway) and related structures (such as jetties), including the disposal of dredge materials related to such maintenance or construction." Based on the definition in 6(b) of the statute, the exception applies only to maintenance or construction of improvements of existing Federal navigation channels and to maintenance or construction of improvements of existing related structures such as jetties. Existing channels are those authorized before the designation of the coastal barrier resource units that the authorized channels may traverse or impact.

The coastal barrier resources system (CBRS) is delineated and maintained by the U.S. Department of the Interior through the USFWS (USFWS 2017e). Federal agencies are required to consult with the USFWS on the applicability of CBRA exceptions and for written comment on planned expenditures for an action excepted under CBRA, 16 U.S.C. §3505(a).

There are two CBRA-designated areas in or near the study areas (CBRS 2017). The BRFG study area includes portions of Brazos River Complex T05/T05P, which is located south of the GIWW in the study area (**Figure 2-12**). At the CRL, Matagorda Peninsula Unit T07/T07P is located outside the study area but comes within 830 feet south of the study area (**Figure 2-13**). At the BRFG, Unit T05 has 4,766 acres, and Unit T05P has 2,759 acres. Unit T05 is a system unit while Unit T05P is designated as an Otherwise Protected Area, which includes undeveloped coastal barriers within the boundaries of lands reserved as wildlife refuges, parks, or for other conservation purposes. At the CRL, Unit T07 encompasses approximately 32,036 acres, and Unit T07P has approximately 43,715 acres (CBRS 2017). Unit T07 is a system unit and Unit T07P is an Otherwise Protected Area.

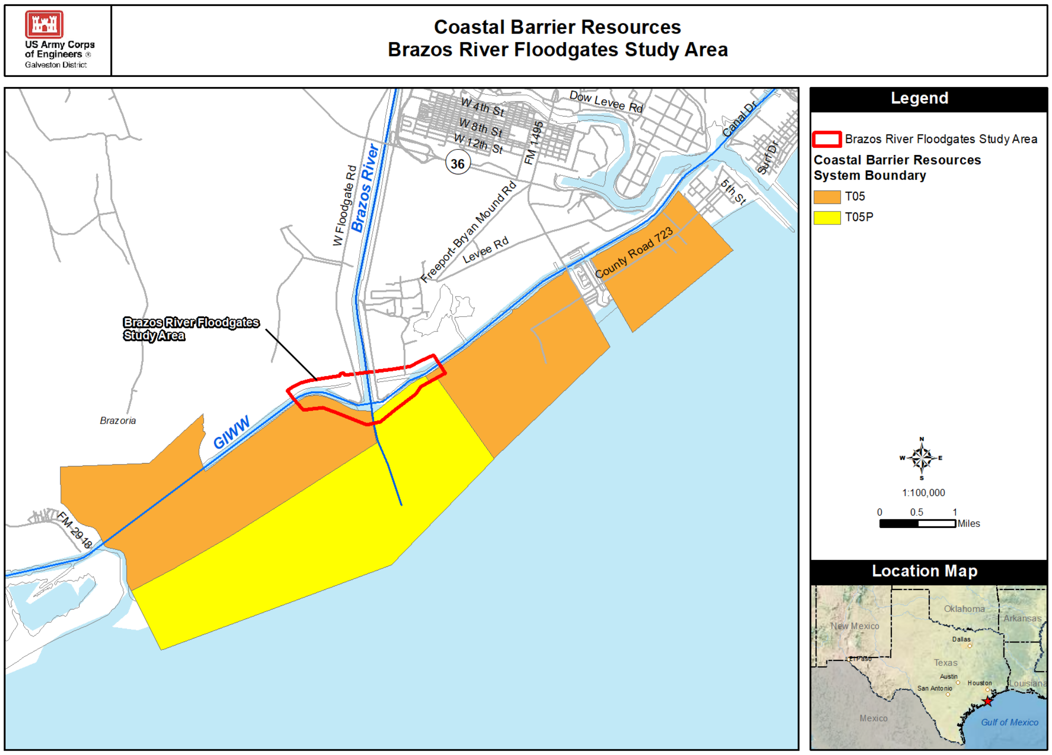

Figure 2-12 – Coastal Barrier Resources in Relation to BRFG Area

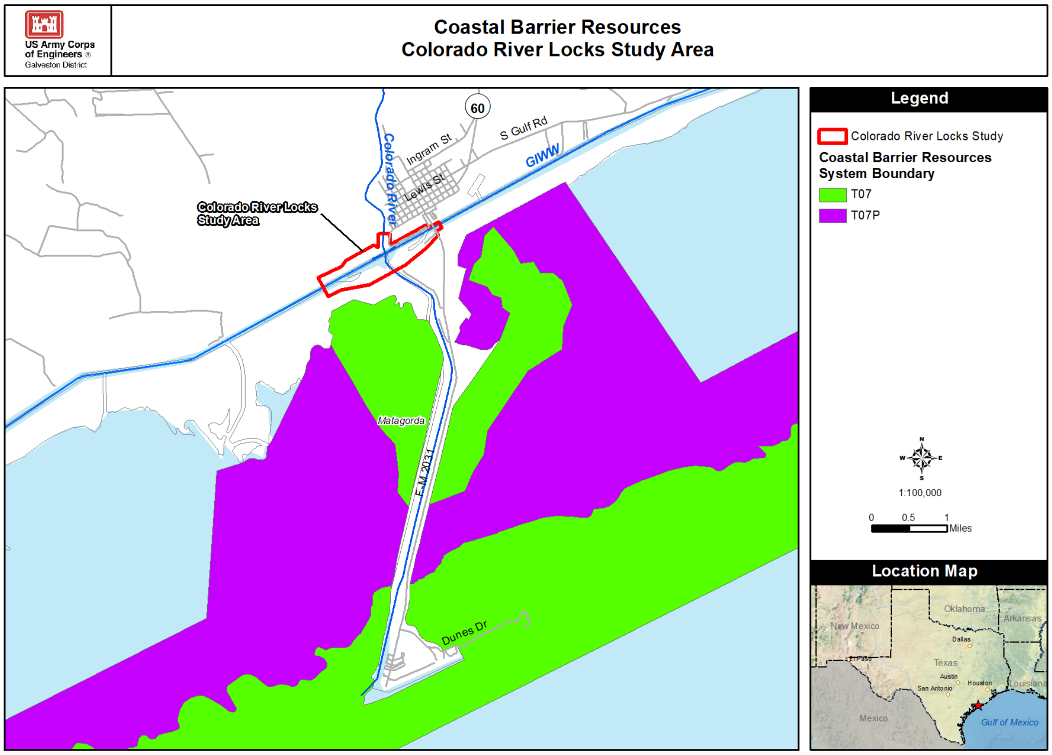

Figure 2-13 – Coastal Barrier Resources in Relation to CRL Area

The Texas Coastal Management Program (TCMP), which was developed to implement the Coastal Zone Management Act of 1972, protects coastal natural resources categorized into 16 Coastal Natural Resource Areas (CNRAs) that are listed at 31 Texas Administrative Code §501.3. A total of 10 CNRAs were identified as occurring in and adjacent to the study areas, including coastal barriers, coastal preserves, coastal shore areas, coastal wetlands, submerged lands, special hazard areas, water of the open Gulf of Mexico, waters under tidal influence, tidal sand or mud flats (BRFG only), and submerged aquatic vegetation (CRL only). Descriptions of the CNRAs are provided in the TCMP Consistency Determination found in **Environmental Appendix D, Attachment D-5**.

2.4 ARCHEOLOGICAL AND HISTORIC RESOURCES

Cultural resources (archeological and historic resources) are protected by a number of laws and regulations, primarily the National Historic Preservation Act (NHPA) and, on lands owned by the State of Texas or political subdivisions of the State, the Antiquities Code of Texas. The following discusses existing conditions regarding archeological resources and non-archeological historic resources within the BRFG and CRL study areas.

2.4.1 Archeological Resources

An archeological background review was conducted for the two study areas (areas of potential effect – APE) around the BRFG and CRL (refer back to **Figures 2-1 and 2-2**). Examination of the online files and maps at the Texas Historical Commission's (THC) restricted-access online Texas Archeological Sites Atlas (TASA) were searched for previously recorded archeological sites, sites listed on the National Register of Historic Places (NRHP), historical markers, and State Antiquities Landmarks (SALs). Additional records affiliated with the National Park Service (NPS), the THC's Online Historical Sites Atlas, and the Texas Archeological Research Laboratory were also consulted.

The files and maps on the TASA show that portions of the BRFG study area and surrounding area have been subject to previous archeological survey by the Department of Energy in 1991; the USACE in 1987, 1991, 1992, and 1998; Prewitt & Associates in 1999; and PBS&J in 2008 and 2009. Based on the TASA, there are no previously recorded archeological sites within the BRFG study area, and the nearest recorded archeological site is in the Bryan Beach State Recreation Area, approximately 0.5 mile south of the BRFG study area. Site 41BO110 was recorded in 1978 as a historic site with ceramics and brick and is listed as a State SAL. It was not found during subsequent investigations in 1998, suggesting either it has been destroyed, buried, or the location was mapped erroneously.

In the CRL vicinity, the TASA shows that several archeological surveys were conducted between 1973 and 1980. There are no previously recorded archeological sites in the CRL study area, and the nearest recorded site is Site 41MG128, which is a historic wooden home built in 1833 that is located 0.2 mile north of the study area. Two shipwrecks and one NRHP-listed cemetery, the Matagorda Cemetery, are also located in the general vicinity but well outside the CRL study area.

Much of the BRFG and CRL study areas has been extensively disturbed by previous excavation of the GIWW, diversion of the Brazos and Colorado Rivers, construction of the BRFG and CRL facilities, and construction of roads, levees, and DMPAs. Therefore, the potential for encountering intact archeological sites is considered relatively low and limited to the few undisturbed areas.

2.4.2 Historic Resources

Historic resources include buildings, structures, objects, and historic districts located above ground. In accordance with Section 106 of the NHPA and its associated regulations (36 CFR 800), the USACE established an APE at BRFG and CRL for non-archeological historic resources in cooperation with the Texas State Historic Preservation Office (SHPO). Due to the insular nature of the study areas, the APE at each facility was established as 500 feet from the study area boundary. Per 36 CFR 800.4, non-archeological historic resource studies were completed to determine if historic-age resources within the APEs are eligible for or listed in the NRHP and may be affected by project alternatives.

A review of the THC's Texas Historic Sites Atlas revealed that there are no non-archeological historic resources listed in the NRHP within the BRFG and CRL APEs. In July and August 2017, a survey was conducted to determine if any non-archeological historic resources within the APEs were NRHP-eligible. A survey cutoff date of 1975 was established based on an estimated date of construction of 2020. Although NPS guidelines state that a property must generally be at least 50 years old to be NRHP eligible, an additional five years was subtracted to account for delays in project planning or funding. The identified pre-1975 historic resources in the APEs are also referred to as "historic-age" resources.

The historic resources survey report (HRSR), which is provided in **Environmental Appendix D, Attachment D-6**, documents a total of 25 historic-age resources within the APEs at BRFG and CRL as identified, inventoried, and evaluated for their NRHP eligibility per NPS criteria. At the BRFG, 10 historic-age resources were identified and inventoried, which included the floodgates and other USACE-owned resources within the BRFG facility (e.g., control houses, power houses, pump house, boat house). At the CRL, 15 historic-age resources were identified and inventoried: 11 were associated with the CRL facility and four were located outside the CRL facility (including the Matagorda ring levee).

To be eligible for inclusion on the NRHP, historic-age properties must:

- Be at least 50 years old
- Meet one of the four following criteria for significance.
    - Criterion A: Event – Significant historical associations with events, trends, or patterns.
    - Criterion B: Person – Significant associations with persons of transcendent importance.
    - Criterion C: Design/Construction – Embody distinctive characteristics of a type, period, or method of construction, represent the work of a master, possess high artistic values, or represent a significant and distinguishable entity whose components may lack individual distinction.
    - Criterion D: Information Potential – Have yielded, or may be likely to yield, information important in prehistory or history.
- Retain and convey historic integrity, as expressed in the seven aspects of integrity: location, design, setting, materials, workmanship, association, and feeling.

As outlined in the HRSR, none of the historic-age structures within the APEs met the above criteria for NRHP eligibility. To summarize, under Criterion A, the BRFG and CRL facilities are not critical to navigation on the GIWW and did not make a significant contribution to the development of commerce and maritime economy in the Freeport and Matagorda areas. Under Criterion B, there is no evidence that the structures are associated with significant people. For Criterion C, research did not indicate that the BRFG or CRL possess engineering significance, are works of a master, or possess high artistic values. Finally, under Criterion D, the BRFG and CRL are standard structures that do not exhibit local variation on a standard design or construction technique that may be considered important. Evaluations of the other historic-age resources in the APEs resulted in similar conclusions (see HRSR for more detail).

2.5 ECONOMIC, SOCIOECONOMIC, AND HUMAN RESOURCES

2.5.1 Economics – Navigation (BRFG)

The Brazos River flows into the Gulf of Mexico, crossing the GIWW near Freeport, Texas. Two 75-foot floodgates, one on each side of the Brazos River crossing of the GIWW, are provided to control flow and sediment into the GIWW. The authorized channel in the GIWW is 125 feet wide and is typically about 12 feet deep. Navigation between the floodgates across the Brazos River is difficult during high flows in the Brazos River. The floodgates were installed at a time when most tug boats pulled barges behind them instead using the modern pushing method. The current angled approaches to each floodgate is not conducive to the pushing method. The cross current and through gate flows cause eddies to form unstable approach conditions. Also, shoaling issues have occurred causing periodic grounding of vessels. This has increased the difficulties faced by pilots navigating between the floodgates.

Tidal effects are present at the project location. Combined with the Brazos River flood stage, this can cause flow both into and out of the GIWW. In addition, the flow velocities through the west floodgate are greatly affected by the San Bernard River. The mouth of the San Bernard River to the Gulf of Mexico within the last decade has silted in due to low flow and the GIWW has become its outlet partly through the west gate structure. This has increased the difficultly on pilots to navigate the structures.

Restrictions are placed on the tows allowed to cross the Brazos River during high flow events by the USACE in accordance with 33 CFR 207.187 (**Table 2-8**). Long periods of high flow through the Brazos River that require "tripping" barges through the gates places a serious economic impact on operation of tows through the reach.

Table 2-8 - Existing Navigation Restrictions – Brazos River Crossing

Condition	River Velocity	Head Differential	Restriction
1	Over 2 mph[1]	0.7 to 1.8 feet	• Single vessel passage • Tows with single loaded barges • Tows with two empty barges • Velocity reaches 1.7 mph, tows with two empty barges only
2	-	Over 1.8 feet	• Closed
3	Over 5 mph	-	• Single vessel passage • Tows with one barge only loaded or empty • Operation during daylight hours only
4	Over 7 mph	-	• Closed

[1]Miles per hour (mph)

The frequencies at which these thresholds are met or exceeded are shown in **Table 2-9** below.

Table 2-9 – Frequency of Existing Navigation Restrictions – Brazos River Crossing

River Velocity	Operation	Frequency
0 - 2 mph	Normal	89.85%
2 - 5 mph	Single barge tripping	8.67%
5 - 7 mph	Single barge tripping during daylight, closure at night	1.28%
> 7 mph	Closure	0.20%
Head Differential	**Operation**	**Frequency**
0 - 0.7 feet	Normal	72.24%
0.7 - 1.8 feet	Single barge tripping	21.72%
> 1.8 feet	Closure	6.04%

Due to the well-known navigation issues associated with these floodgates, individual companies have instituted additional self-imposed regulation on their pilots above and beyond the USACE restrictions in order to minimize risks.

2.5.2 Economics – Navigation (CRL)

The Colorado River flows into West Matagorda Bay, crossing the GIWW near Matagorda, Texas. Two 1,200-foot by 75-foot locks, one on each side of the Colorado River crossing of the GIWW, are provided to control flow/sediment into the GIWW and improve navigation. The authorized dimensions of the GIWW in the study area are 125-feet wide and -14 feet MLLW. The original course of the Colorado River southward of the GIWW was south-southwesterly through the Matagorda Peninsula into the Gulf of Mexico. In the early 1990s, a diversion channel was dredged from the intersection of the Colorado River and GIWW southwest towards West Matagorda Bay. Diversion of flow into Matagorda Bay was performed to route the heavy sediment load into the bay to create shallow wetlands for environmental improvements of biologic productivity.

USACE restrictions are placed on the size of a tow that can cross the Colorado River when current speed in the river immediately upstream of the intersection exceeds 2.0 miles per hour (mph) or 3.0 feet per second (fps) (**Table 2-10**). Long periods of high flow through the Colorado River that require "tripping" place a serious economic impact on operation of tows through the reach.

Table 2-10 - Existing Navigation Restrictions – Colorado River Crossing

Condition	River Velocity	Restriction
1	2 mph (3.0 fps) or higher	• Single vessel passage • Tows with one loaded barge or two empty barges
2	Over 7mph	• Closed

The frequencies at which these thresholds are met or exceeded are shown in **Table 2-11** below.

Table 2-11 – Frequency of Existing Navigation Restrictions – Colorado River Crossing

River Velocity	Operation	Frequency
0 - 2 mph	Normal	97.21%
2 - 5 mph	Single barge tripping	2.50%
5 - 7 mph	Single barge tripping during daylight, closure at night	0.28%
> 7 mph	Closure	0.00%

Head Differential	Operation	Frequency
0 - 0.7 feet	Normal	N/A*
0.7 - 1.8 feet	Single barge tripping	
> 1.8 feet	Closure	

**Because Colorado can act as a lock during high flow in the channel, it does not close currently due to head differential; head differential is voided by the lock. It is estimated that Colorado must act as a lock to process traffic due to high flows in the GIWW channel through the project 16.2% of the time, roughly 1 - 2 hours per day on average.*

2.5.3 Navigation System

The BRFG and CRL System on the GIWW provides shallow-draft navigation between deep-draft ports along the Texas coast and connects these ports to the inland navigation system comprised of the Mississippi River and its tributaries.

2.5.3.1 Traffic Commonality

The BRFG and CRL are separated by 40 miles, with few commercial docks located between the projects. The GIWW is maintained to a bottom width of 125 feet and a project depth of 14-feet. Several streams and rivers flow into the GIWW along this route, with a few areas of minor open water navigation. Aerial imagery shows multiple fleeting/mooring locations in between, but no infrastructure for loading or unloading barges along the GIWW. The San Bernard River meets the GIWW at GIWW Mile 405 and supports limited commercial navigation for approximately 26 miles. This route is highly congested due to bends, river crossings, and private docks. Approximately 500,000 tons of commercial navigation on average takes place along this waterway.

According to lock operators, less than one percent of traffic traverses one lock or gate and turns up the Brazos River, while approximately one million tons on average utilizes one Colorado Lock and travels up the Colorado River without crossing the other lock. **Table 2-12** shows the average annual tonnage at Brazos and Colorado from 2010 through 2014 demonstrates the high level of commonality between projects. As displayed, the Brazos and Colorado River projects have a significantly high level of traffic commonality. This suggests any substantial change at one project has the potential to alter traffic patterns or operations at the other project. These alterations can be beneficial or detrimental. For example, while expanding a chamber at a project could be beneficial in reducing trip costs and delays, it could also mean larger tows may desire to call on other projects in the system less equipped to handle them.

Table 2-12 - Average Annual Tonnage Commonality

Project Name	Average Tonnage	Average Through All	Commonality
Brazos River Floodgates	22,497,593	21,038,012	97%
Colorado River Locks	21,607,965		99%

Source: *Waterborne Commerce Statistics (WCS) 2010-2014*

Table 2-13 shows the traffic commonality with other USACE lock projects within the geographical extent of the GIWW. The relatively low level of commonality suggests that changes to Brazos or Colorado would have little relative impacts on the operational performance of other USACE Lock projects.

Table 2-13 - Traffic Commonality between BRFG, CRL, and Other USACE Projects

Project	Average Tonnage	Average Through Colorado, Brazos, and Lock	Commonality
Algiers	23,029,425	1,750,659	8%
Bayou Boeuf	25,253,375	2,116,894	8%
Bayou Sorrel	18,832,450	1,852,975	10%
Calcasieu	38,127,544	4,568,180	12%
Inner Harbor	15,967,412	425,916	3%
Leland Bowman	37,984,467	4,473,239	12%
Port Allen	19,486,405	1,850,999	9%

Source: *Waterborne Commerce Statistics (WCS) 2010-2014*

2.5.3.2 Historic Annual Commodity Tonnages

Figures 2-14 through 2-16, summarize commodity flow data by commodity category for cargo moving up-bound and down-bound through the BRFG and CRL based on WCSC data. With respect to up-bound traffic, total traffic tonnage has doubled from 8.6 million tons to 16.5 million in 2016. Growth is largely driven by increases in up-bound crude oil tonnage. Crude oil traffic increased from 369,445 tons in 2010 to 2.2 million tons in 2011 and to 10.7 million tons in 2014 reflecting growth in the production of domestic crude. Similarly, up-bound shipments of refined petroleum products have also increased since 1991. Traffic of other commodities does not show significant trends. Crude oil, petroleum products and chemical products moving up-bound through the BRFG and CRL accounted for nearly 80 percent of traffic volume. Due to the decline of aggregates moving up through the BRFG and CRL over the period, in 2016, chemicals, crude oil and petroleum products accounted for 86 percent of up-bound movements. Overall, there was not significant growth in down-bound traffic in which chemical products, petroleum products and crude oil also predominate. Over the historical period, these three commodity groups accounted for 91 percent of the total down-bound moves. In 2016, these three commodity groups accounted for 92 percent of tonnage moving down-bound through the BRFG and CRL.

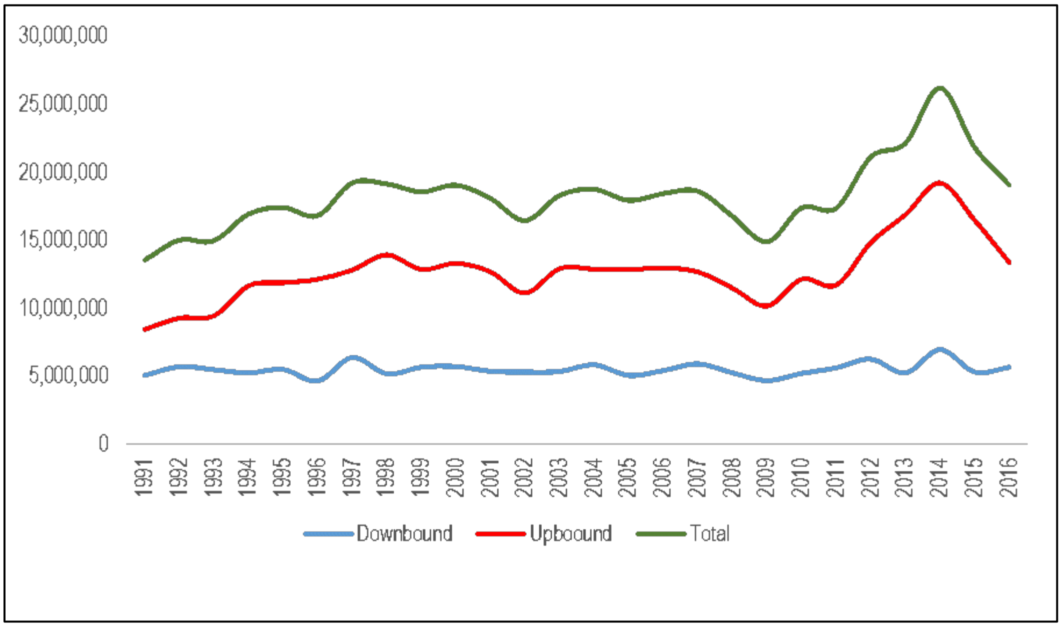

Figure 2-14 – Total Commodity Traffic (tons) through Study Area (1991-2016)

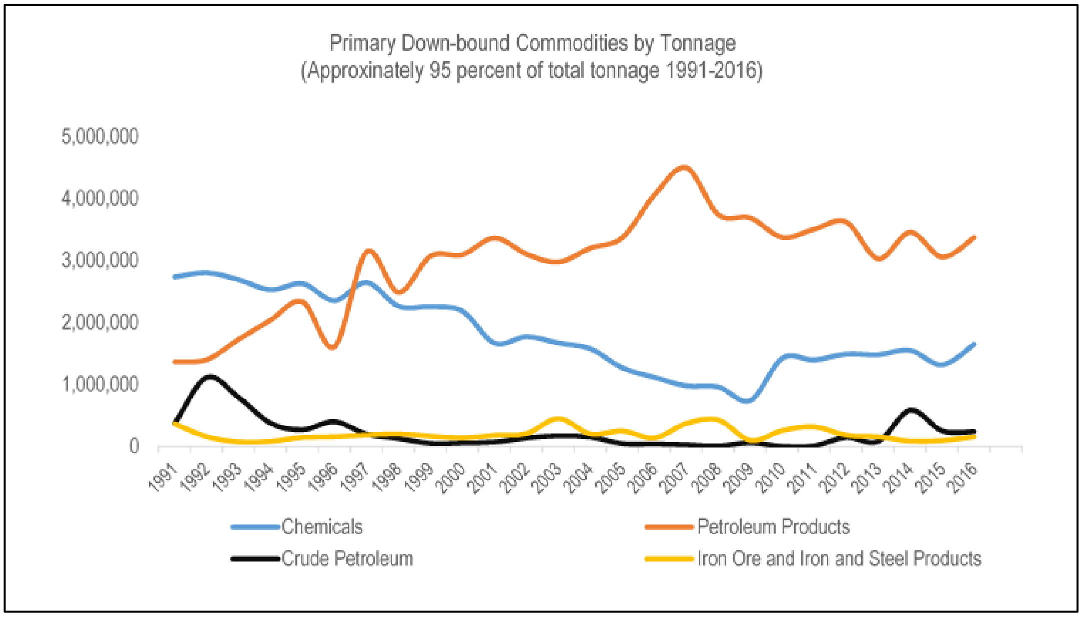

Figure 2-15 – Primary Down-Bound Commodities by Tonnage

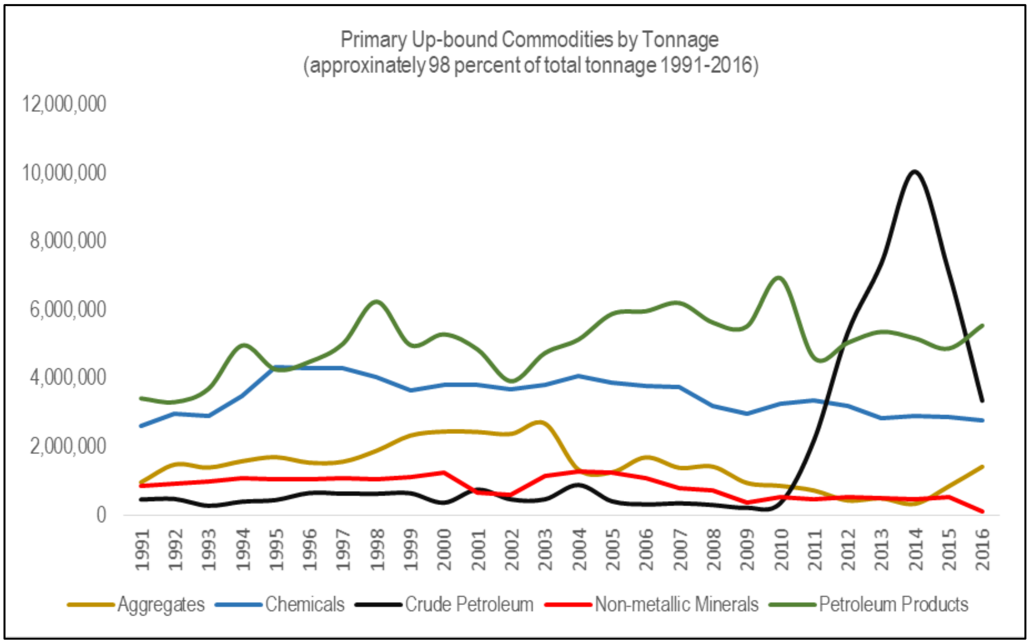

Figure 2-16 – Primary Up-Bound Commodities by Tonnage

2.5.3.3 Commodity Forecasts

Background

Two sets of projections are presented below: 1) projections based on growth rates of oil production output from the entire nation (national projection) submitted on August 22, 2016, and regional projections based on growth rates for oil production output for the Southwest region (regional projection) submitted on October 2, 2018. A detailed discussion of the commodity forecasts is provided in **Appendix B – Economic Appendix, Addendum 1.**

The major distinction between the national and regional study projections centers on projections for crude oil and petroleum products. Regional figures incorporate trends related to recent and significant output growth in the Texas oil and gas industry whereas national level forecasts rely on growth rates for crude oil production as the national level, which is lower than regional growth rates (see methodological discussion below). USACE developed the discussion regarding trends in the Texas oil industry and impacts to inland waterborne commerce. Also included is a discussion of the potential for induced tonnage and modal shifts under the with-project condition. Several important assumptions and caveats are warranted:

1) Commodity traffic is assumed to be driven by economic growth and commodity supply.
2) Given time and budget constraints, projections assume constant modal shares, and although, Addendum 1 discusses modal shifts as they relate to crude oil traffic, the discussion is qualitative in nature.

3) There is a considerable amount of uncertainty in the final commodity projections with respect to crude oil shipments through the project area (discussed in detail below).

Methodology

The methodology and assumptions for regional projections are the same as those for national figures with the following two exceptions. Regional level production forecasts for crude oil serve as drivers for crude oil and petroleum product traffic, and baseline values for all commodity projections are an average of annual traffic volumes in years 2014, 2015 and 2016 as opposed to using 2016 as a baseline.

Given the fact that crude oil, petroleum products and chemicals account for most traffic moving through the BRFG and CRL in both directions, projections focus on these three commodities. Tonnage flows of other cargoes are small in relation, and annual volumes of aggregates, coal, grain, iron ore and steel, non-metallic ores and minerals and other cargo have been relatively small and often show large variations year to year. As a result, lower volume commodities are assumed to remain constant over the period of analysis.

Drivers for study forecasts are industry output projections from various sources. Chemical products rely on figures published by the American Chemical Council and Moody's Analytics. Crude oil and petroleum products use estimated growth rates from the U.S. Energy Information Administration (EIA). National figures assume national level rates of growth, while regional study projections assume regional rates of growth that are higher than national averages due to the fact that almost all expected increases in U.S. oil production will come from the southwestern U.S., particularly the Permian Basin region of Texas.

In recent years, crude oil traffic on the GIWW has spiked from historical annual totals (1991 through 2010) ranging from about 300,000 to 500,000 tons to a high of nearly 11 million tons in 2014. Since 2012, it has ranged from about 4 to 11 million. The spike in crude oil shipments corresponds to the rapid increase in Texas oil production. Over the past 15 years or so, production growth of the U.S. shale gas and oil industry has been remarkable and is having a substantial impact on the nation's economy and industrial supply chains. According to the U.S. EIA, since 2005, when the current surge started to the end of 2017, U.S. production of crude oil rose nearly 80 percent from about 5 million barrels per day to 9.4 million in 2017, and the U.S. is now a major oil exporter. EIA predicts that U.S. crude oil production will average 10.7 million barrels per day in 2018 and 11.7 million in 2019. Today, Texas is producing more crude oil than any other state or region of the U.S – about 3.5 million barrels a day on average (roughly equivalent to 174 million tons per year).

Oil in Texas is coming primarily from two formations – the Eagle Ford Shale region west and southwest of San Antonio and the Permian Basin in central West Texas – and most of it via pipelines to Gulf Coast export terminals and refineries, particularly those in or near the Ports of Corpus Christi and Houston. In fact, Corpus Christi (and perhaps Brownsville) will likely become a major export hub. Given constraints in pipeline capacity, shippers are moving West Texas crude coming into Corpus Christi and Brownsville via GIWW barges or coastwise tankers and Articulated Tug Barges (ATBs) to refineries and export terminals in East Texas and Louisiana. Most is going to refineries to blend with heavier grades of oil, which is a common practice at Gulf refineries.

EIA's 2018 Annual Energy Outlook contains projections for increases in crude oil extraction in the U.S. on a regional basis (**Figure 2-17**). In total, U.S. oil output is expected to grow in the Southwest region (primarily Texas) accounting for the majority growth. EIA expect production to increase by about 4.25 million barrels per day by 2040. As result, traffic on the GIWW will likely increase, and while it is true that the industry is adding pipeline capacity from West Texas to the Gulf, production is increasing at rates that may make it hard for land side transmission infrastructure to keep pace. Regional study projections assume that shipments of crude oil through the BRFG-CLR will increase at rates commensurate with expect oil production in Texas (**Figure 2-17**).

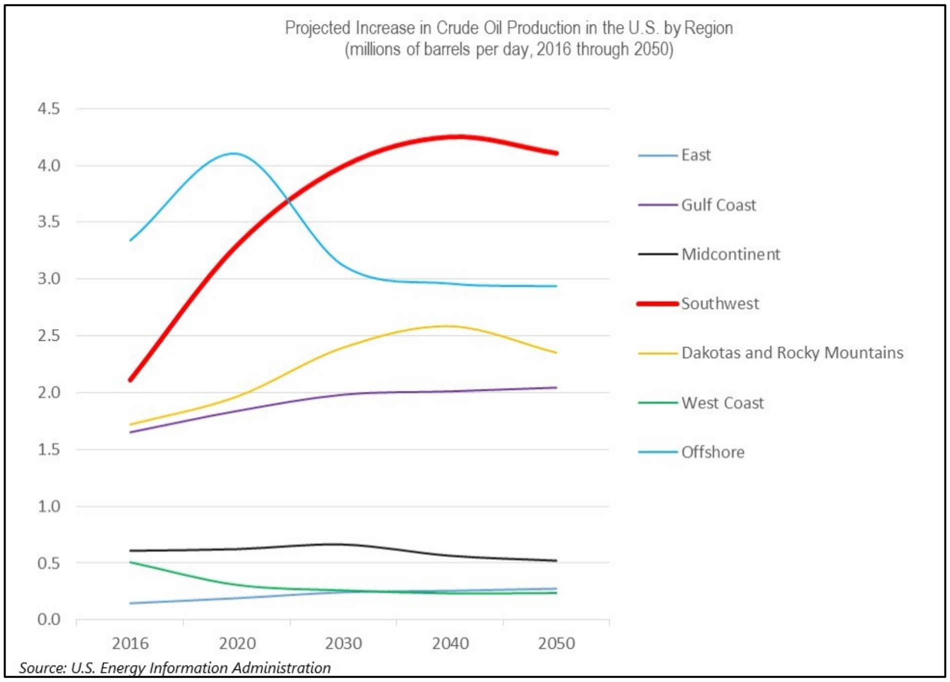

Figure 2-17 – Project Increase in Crude Oil Production in the U.S. by Region

Results

Figure 2-18 and **Table 2-14** summarize national and regional study projections. **Figure 2-18** shows total tonnage while **Table 2-14** breaks downs the forecasts by commodity group. National projections show a 30 percent increase over the planning period (21.9 million tons to 28.3 million tons) at an annual growth rate of 0.5 percent. Regional projections are higher and result in a 61 percent increase over baseline (22.6 million tons to 36.2 million) at rate of 1.0 percent per annum. Again, use of regional production forecasts for crude petroleum and petroleum products in the regional projections produces substantially higher estimates.

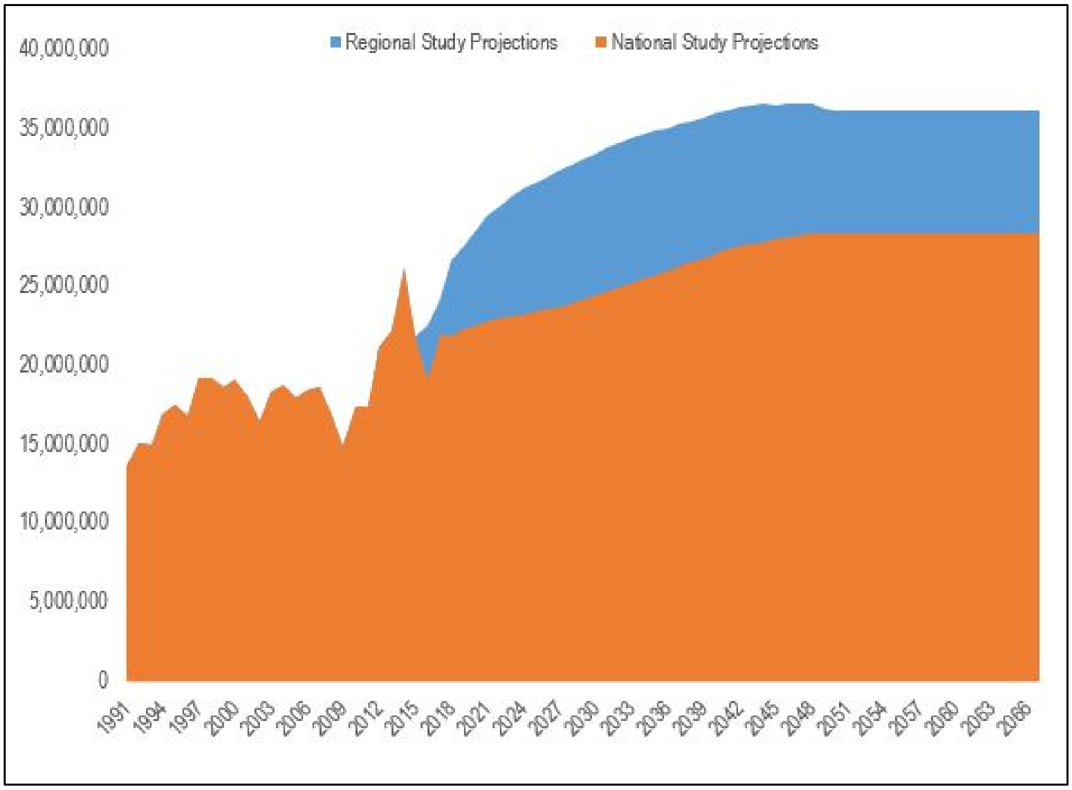

Figure 2-18 – Historical Traffic and National Cargo Forecasts and Regional Cargo Forecasts (tons, 1991-2067)

Table 2-14 – Historical, and National and Regional Study Projections by Commodity, 1000s of tons, 1001-2067

Year	Aggregates	Chemical	Coal	Crude Oil	Grains & Grain Products	Iron Ore, Iron, & Steel Products	Non-Metallic Ores & Minerals	Petroleum Products	Misc.	Total
Historical Projections										
2002	2,423	5,470	17	616	46	258	614	7,042	229	16,716
2003	2,729	5,482	17	654	28	482	1,193	7,733	244	18,565
2004	1,448	5,673	28	1,053	13	286	1,894	8,355	284	19,035
2005	1,377	5,149	85	468	18	318	1,277	9,273	209	18,175
2006	1,748	4,899	89	376	9	193	1,103	10,041	271	18,730
2007	1,402	4,728	89	392	11	454	837	10,720	235	18,869
2008	1,434	4,184	96	322	29	532	787	9,390	235	17,011
2009	976	3,728	43	292	66	200	391	9,223	169	15,090
2010	905	4,704	35	372	82	391	569	10,327	170	17,557
2011	960	4,757	64	2,218	92	609	516	8,125	234	17,577
2012	1,141	4,692	30	5,497	30	436	627	8,680	176	21,310
2013	978	4,340	50	7,460	11	400	532	8,407	167	22,348
2014	1,578	4,469	86	10,653	2	266	541	8,648	181	26,424
2015	1,413	4,208	89	7,402	19	211	559	7,946	158	22,008
National Level Projections										
Baseline	1,413	4,549	89	6,921	19	211	559	8,003	158	21,923
2020	1,413	4,862	89	7,421	19	211	559	8,102	158	22,836
2025	1,413	5,675	89	7,546	19	211	559	7,871	158	23,543
2030	1,413	6,452	89	8,130	19	211	559	7,692	158	24,724
2035	1,413	7,228	89	8,676	19	211	559	7,671	158	26,025
2040	1,413	8,011	89	9,201	19	211	559	7,737	158	27,399
2045	1,413	8,791	89	9,201	19	211	559	7,737	158	28,180
2050	1,413	8,990	89	9,201	19	211	559	7,737	158	28,378
2055	1,413	8,990	89	9,201	19	211	559	7,737	158	28,378
2060	1,413	8,990	89	9,201	19	211	559	7,737	158	28,378
2067	1,413	8,990	89	9,201	19	211	559	7,737	158	28,378
% Change	0.0%	97.6%	0.0%	32.9%	0.0%	0.0%	0.0%	-3.3%	0.0%	29.4%
CAGR [1]	0.0%	1.4%	0.0%	0.6%	0.0%	0.0%	0.0%	-0.1%	0.0%	0.5%
Regional Level Projections										
Baseline[2]	1,536	4,367	97	7,220	33	226	407	8,510	172	22,567
2020	1,536	4,668	97	11,266	33	226	407	10,267	172	28,672
2025	1,536	5,448	97	12,793	33	226	407	10,857	172	31,569
2030	1,536	6,194	97	13,658	33	226	407	11,128	172	33,451
2035	1,536	6,939	97	14,182	33	226	407	11,288	172	34,880
2040	1,536	7,690	97	14,537	33	226	407	11,346	172	36,044
2045	1,536	8,440	97	14,419	33	226	407	11,208	172	36,538
2050	1,536	8,635	97	14,046	33	226	407	11,068	172	36,220
2055	1,536	8,635	97	14,046	33	226	407	11,068	172	36,220
2060	1,536	8,635	97	14,046	33	226	407	11,068	172	36,220
2067	1,536	8,635	97	14,046	33	226	407	11,068	172	36,220
% Change	0.0%	97.7%	0.0%	94.5%	0.0%	0.0%	0.0%	30.1%	0.0%	60.5%
CAGR [3]	0.0%	1.4%	0.0%	1.3%	0.0%	0.0%	0.0%	0.5%	0.0%	1.0%

[1] *Growth rates applied to 2015 values*

[2] *Compound annual growth rate*

[3] *Average of 2014, 2015 and 2016*

Risk and Uncertainties

Several important risks and uncertainties with respect to regional study projections used to estimate NED benefits are warranted:

1) Future volumes of crude oil shipped through the BRFG-CRL will likely depend upon the ability and desire of energy companies to expand regional pipeline capacity. If pipelines are full, there will be overflow that probably ends up on inland barges moving up the GIWW. Whether pipelines will keep up with the amount of production is unclear.

2) Gulf coast refineries are operating at near capacity and have eliminated imports of Brent crude completely. For crude oil volumes to both increase and sustain at projected levels, there may have to additional refining capacity and this is happening. For example, in January of 2019 Exxon announced construction of a new crude-processing unit in Beaumont, Texas that will increase capacity by more than 65 percent, or 250,000 barrels per day. The decision to build this third crude oil unit in the facility's existing footprint will expand light crude refining, supported by increased oil production in the Permian Basin. Start-up is anticipated by 2022.

3) The price of Brent (European) light oil will have to remain higher than West Texas Intermediate (WTI) to sustain GIWW crude oil movements at projected levels. Historically, Brent has been much cheaper than WTI and Gulf refineries would import it for blending; however, Permian production has vastly increased U.S. supplies and since early 2010, WTI has priced below Brent by as much as $25 a barrel. This has made it very attractive to Gulf refineries that use light crude as feedstock.

4) Potential increases in traffic at levels projected may result in more congestion on the waterway, and thus additional queuing in the with-project scenario, which in turn could decrease efficiency or offset project benefits.

5) There are significant uncertainties regarding the oil transportation system's adaptation to different modes of transport. The effect in capacity, volumes and rates of oil productions, and annual volumes shipped through the study area may vary considerably in the future as the oil delivery system adapts to market conditions. Part of the delivery system adaptation includes capacity increases to the navigation system by enlarging the BRFG and CRL from 75-feet to 125-feet, creating an opportunity for increased efficiencies to the coastal oil delivery system.

In light of the risks and uncertainties surrounding study projections given the abrupt and dynamic nature of crude oil and natural gas supply and demand, future economic updates will be critical. As infrastructure develops and the regional transportation for crude petroleum market stabilizes (assuming it does), commodity forecasts that are important drivers of NED benefits and plan evaluation should be reevaluated.

2.5.3.4 System Behavior

Historically, commodity traffic utilizing the GIWW within the study area has functioned as a relatively closed modal system. As shown previously in **Figure 2-15** and **Figure 2-16**, the majority of traffic through the BRFG and CRL has been comprised mainly of bulk liquids, mainly petroleum and chemical products, which are barged up and down the Texas coast for use as an input by the multiple refineries located throughout the region. The products and byproducts of these refineries typically travel by either pipeline, rail, or barge to other facilities throughout the country for further refinement as an intermediate good. Facilities tend to construct their production model around this infrastructure pattern, with intakes tending towards waterborne delivery and refined products being dispersed around the multiple modes of transportation that most efficiently allow it to travel to the next step of the refining process.

The BRFG and CRL have historically not been prone to sustained long-duration outages. While the projects do close relatively frequently due to issues discussed later in this report, the closures are usually stretched across multiple days or weeks with traffic being allowed to pass intermittently during these events. As such, the industries that have developed in the region have not been forced to source their primary inputs via other transportation modes for sustained periods. More typically, they will adjust their production to account for these delays rather than sourcing from land-based modes, which tend to be strained by the capacity of the unloading equipment at the respective facilities. This behavior is typical of petroleum-based industries located throughout the inland transportation system whose primary input is primarily received via water.

Martin Associates conducted interviews with shippers who utilize the shallow-draft transportation system provided by the GIWW in the economic study area of the BRFG and CRL:

> *"It is to be noted that interviews with the key customers using the BRFG (Brazos River Floodgates) and CRL (Colorado River Locks) indicated that the delays under the without project case do not result in the use of surface modes, due to the fact that the waterborne movements are essentially a part of the production process of chemicals and petroleum products, and the shippers do not have the ability to use truck or rail as a substitute. The customers are notified when the barge shipment is within 4 hours of delivery, and at that time the process of berth availability at the shipper's facility is planned. Only in very isolated instances, such as a week or more delay, would*

inventory stocks be jeopardized, and since the average delay time is less than 6 hours, the impact on the logistics supply chain of delays is negligible. This suggests that a reduction in the delay times and the resulting savings in logistics costs will not likely result in a diversion of traffic from truck or rail to barge in the future. The flows will be driven by the production levels and economy as described in this report."

2.5.4 Population, Housing, and Community Cohesion

The NEPA study areas for both the BRFG and the CRL are largely undeveloped (refer back to **Figure 2-1 and Figure 2-2**). The nearest residences to the BRFG are located at FM 1495 approximately 2.5 miles east of the study area near the city of Freeport. Freeport, with a population of just over 12,000, was estimated to have approximately 4,700 housing units (according to the 2010 U.S. Census) with approximately 54 percent of the housing units owner-occupied. Median gross rent of housing units available in the city of Freeport is approximately $613 (U.S. Census Bureau 2017a).

At the CRL facility, residential areas lie immediately north of the east lock and adjacent levee in the town of Matagorda and approximately 0.3 mile south of the east lock along the east bank of the original Colorado River channel. Matagorda is a small fishing and tourist township with a population of about 500 people. Lodging for visitors to the area includes motels, bed and breakfasts, and lodges, as well as condo and beach house rentals.

Community cohesion has been described as the force that bonds people together long enough to establish meaningful interactions, common institutions, and agreed ways of behavior. It is a dynamic process, changing as the physical and human environment changes. Conditions brought about by water resources development can impact community cohesion through changing a right-of-way or constructing a feature that can divide a community, cause the dislocations of a significant number of residents, or requiring the relocation of an important local institution, such as a church or community center. The basic objectives of water resources development have been to provide additional security through hurricane and storm damage risk reduction, improved navigation, environmental restoration, and recreation through civil works, as needed by the local area, region, and Nation.

2.5.5 Employment and Income

Most of the infrastructure located in the BRFG study area supports the floodgate operations. Since the BRFG are owned and operated by the USACE, employment and income within the study area is dominated by government sector jobs associated with the O&M and oversight of the BRFG. Texas Boat and Barge, Inc. is a commercial barge cleaning, maintenance, and repair facility and has been operating for approximately 26 years. Texas Barge & Boat is estimated to generate $8.2

million in annual revenues and employs approximately 60 people at this single location (Buzzfile 2017).

The BRFG are located near the cities of Freeport and Lake Jackson, an area with a large petrochemical industry. Lake Jackson is home to Dow Chemical, one of North America's largest petrochemical complexes, and the number one employer for the Freeport area. According to the City of Freeport business development website, other major employers in the Freeport area include contractor labor, Texas Department of Criminal Justice, Brazosport Independent School District, and other large petrochemical companies. Based on median household income data from the 2011-2015 U.S. Census American Community Survey, the median household income for areas surrounding the BRFG study area is above the U.S. Department of Health and Human Services (DHHS) 2017 threshold for low-income populations (U.S. Census Bureau 2017b, DHHS 2017).

Within the CRL study area, virtually all the infrastructure supports the lock operations, thus employment and income within the study area is dominated by government sector jobs associated with the O&M and oversight of the CRL. According to the Matagorda County Economic Development Corporation, the top industries in Matagorda County include educational services and health care and social services; other major industries include manufacturing, agricultural, and the seafood and fishing industry. Based on the median household income data from the 2011-2015 U.S. Census American Community Survey, the median household income for areas surrounding the CRL study area is above the DHHS 2017 threshold for low-income populations.

2.5.6 **Environmental Justice**

EO 12898, titled "*Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations*," was signed by the president on February 11, 1994. This EO directs Federal agencies to take the appropriate and necessary steps to identify and address disproportionately high and adverse effects of Federal projects on the health of the environment of minority and low-income populations to the greatest extent practicable and permitted by law. The EO requires that minority and low-income populations not receive disproportionately high adverse human health or environmental impacts, and requires that representatives of any low-income or minority populations that could be affected by the proposed project be involved in the community participation and public involvement process.

In compliance with EO 12898, data was collected from the 2010 U.S. Census and the 2011-2015 U.S. Census American Community Survey at the state, county, census tract (CT), block group (BG), and block level (when available). A review of U.S. Census Bureau data on population, race, ethnicity, income, and English proficiency was conducted to determine the potential for persons from minority populations and low-income populations to reside within the study area (U.S. Census Bureau 2017a, b, c).

Residents near BRFG

The BRFG study area is located within a larger BG (BG 2) which is part of an even larger CT (CT 6644). CT 6644-BG 2 encompasses approximately 16,113 acres and has a total population of approximately 1,375. Based on the 2010 U.S. Census, CT 6644-BG 2 is composed of 657 Hispanic or Latino persons (approximately 48 percent of the population), which is lower than the CT (CT 6644) at 58 percent. However, the closest residence to the BRFG is located at FM 1495 approximately 2.5 miles east of the study area.

Residents near CRL

The CRL study area is located within three larger BGs which are part of two larger CTs 7305.01 and CT 7306. CT 7305.01-BG 1, CT 7305.01-BG 4, and CT 7306-BG 1 encompass a combined total of approximately 241,059 acres with a total population of approximately 2,869. Based on the 2010 U.S. Census, all three BGs are composed primarily of non-Hispanic or Latino persons with a majority of residents identifying as White. The percentage of Hispanic or Latino populations within each BG is less than 31 percent, which is lower than the Matagorda County average (approximately 38 percent). The closest residences to the CRL are located immediately north of the east lock and adjacent levee in the town of Matagorda and approximately 0.3 mile south of the east lock along the east bank of the original Colorado River channel.

2.6 AIR QUALITY

2.6.1 National Ambient Air Quality Standards

The Clean Air Act (CAA) of 1970, as amended in 1977 and 1990, regulates air emissions from stationary and mobile sources. The CAA requires the U. S. Environmental Protection Agency (EPA) to set National Ambient Air Quality Standards (NAAQS) for pollutants considered harmful to public health and the environment (40 CFR 50). The CAA establishes two types of NAAQS: primary and secondary. Primary standards define levels of air quality that the EPA judges necessary, with an adequate margin of safely, to protect the public health, particularly to "sensitive" populations such as children, elderly, and asthmatics. Secondary standards define levels of air quality that the EPA deems necessary to protect public welfare, including protection against decreased visibility and damage to animals, crops, vegetation, and buildings (40 CFR 50).

The EPA has established NAAQS for six principal pollutants, called "criteria" air pollutants: carbon monoxide (CO), lead (Pb), nitrogen dioxide (NO_2), ground-level ozone (O_3), particulate pollution or particulate matter (PM_{10} and $PM_{2.5}$), and sulfur dioxide (SO_2) (EPA 2017a). The CAA requires the EPA to monitor ambient air quality and assign a designation to each area based on its compliance with the NAAQS. Based on their NAAQS compliance level, the EPA designates areas as either:

- Attainment – area currently meets the NAAQS
- Maintenance – area currently meets NAAQS, but has previously been out of compliance
- Non-attainment – area currently does not meet the NAAQS, or
- Unclassified – area that cannot be classified based on available data

Ozone nonattainment areas are further classified as extreme, severe, serious, moderate, and marginal depending on the severity of NAAQS exceedance (EPA 2017b).

Under the CAA, if an area is designated as nonattainment, then state and local governments must develop a State Implementation Plan (SIP), a comprehensive plan for an area to meet Federal air quality guidelines. The TCEQ has developed a SIP, with EPA's approval, that describes how Texas will comply with the CAA and how the compliance will be monitored (TCEQ 2017b).

The BRFG study area is located within the Houston-Galveston-Brazoria (HGB) Intrastate Air Quality Control Region, which is in attainment for all criteria pollutants except ozone (EPA 2017c, TCEQ 2017b). The HGB Ozone Nonattainment Area was classified as "severe" by the EPA in October 2008 under the 1997 eight-hour ozone NAAQS. In July 2012, the EPA designated the HGB area as "marginal" for the 2008 ozone NAAQS based on major improvements in air quality for the area but reclassified the HGB area as "moderate" ozone nonattainment in December 2016 because attainment had not been achieved by the imposed deadline (81 FR 90207). As of October 2018, the HGB area remains listed as "moderate" ozone non-attainment; however, the EPA has proposed approval of revisions to the Texas SIP that would address ozone attainment in the HGB area (83 FR 29727-29731).

The CRL study area is in Matagorda County, which is currently unclassified or in attainment of the NAAQS for all six criteria air pollutants.

2.6.2 Conformity of Federal Actions

As required by the CAA, the EPA has established rules to ensure that Federal actions conform to the appropriate SIP. The General Conformity Rule applies to all Federal actions within NAAQS nonattainment areas, except for Federal Highway Administration (FHWA)/Federal Transit

Authority (FTA) actions, which are subject to the Transportation Conformity Rule. The CAA prohibits Federal undertakings (including funding, permitting, constructing, or licensing) that do not comply with the applicable SIP. The General Conformity requirement ensures that Federal agencies consult with State and local air quality managers and allows State agencies to include expected emissions into the appropriate SIP.

Since the BRFG study area is in the HGB moderate ozone nonattainment area, the general conformity rules apply to the BRFG portion of the project. As a result, if the projected emissions from the project exceed 100 tons per year of either nitrogen oxides (NOx) or volatile organic compounds (VOCs), which are the two precursors to ozone formation, a General Conformity Determination will be required (TCEQ 2017c).

The CRL study area is in an area that is unclassified or in attainment for all criteria pollutants; therefore, no emissions analysis or conformity determination is needed for the CRL portion of the project.

2.7 NOISE

The magnitude of noise is generally described by its sound pressure. The range of sound pressure varies greatly, and sound is generally measured on a logarithmic scale, measured in decibels (dB). Environmental measurements of sound are usually made on the A-weighted scale, as this is the frequency range detected by humans; this frequency is expressed as dBA. Common sound/noise levels that an individual may encounter, and the human response, are listed in **Table 2-15**. Included are noise levels of tugs and some common equipment that may be used for construction or maintenance in the BRFG and CRL study areas.

Table 2-15 - Sound Levels and Human Response

Common Sound[1]	dBA	Human Response
Rocket launching pad (no ear protection)	180	Irreversible hearing loss
Carrier deck jet operation / Air raid siren	140	Painfully loud
Thunderclap / Shotgun blast	130	
Jet takeoff (200 feet) /Auto horn (3 feet)	120	Uncomfortably loud; Maximum
Pile driver / Rock concert (20 feet)	110	Extremely loud
Garbage truck / Firecrackers	100	Very loud
Heavy truck (50 feet) / City traffic / **Tug boat** (50 feet)[2] / **High Solids Pump**	90	Very annoying; Hearing damage (8
Alarm clock (2 feet) / Hair dryer / **Excavator Clamshell Dredge** (50 feet)[2]	80	Annoying
Noisy restaurant / Freeway traffic / Business office / **Work Boat** (50 feet)[2]	70	Telephone use difficult
Air conditioning unit / Conversational speech	60	Intrusive
Light auto traffic (100 feet)	50	Quiet
Light auto traffic (100 feet)	40	
Library / Soft whisper (15 feet)	30	Very quiet
Broadcast recording studio	20	
Whisper / Light rainfall	10	Just audible
	0	Threshold of hearing

[1] *Occupational Safety and Health Administration (OSHA) 2017*
[2] *Epsilon Associates, Inc. 2006*
Note: equipment in bold font are examples of equipment that may be used during construction of a navigation project.

Noise generators are limited in the study areas, with tugs and other vessels being a primary source of noise. Operations at the floodgate/lock facilities and Texas Boat and Barge would also generate noise. Tug operators sometimes have to moor the tows along the bank while waiting to transit the BRFG or CRL. Normally, tugs leave their generators running and often leave their main engines running while waiting to transit, contributing to the overall noise environment. There are no sensitive receptors in the study areas, and limited residential or recreational (e.g., the Bryan Beach Recreation Area) land uses near the study areas. The nearest residences to the BRFG are located approximately 2.5 miles to the east. At the CRL facility, residential areas lie immediately north of the east lock and adjacent levee in the town of Matagorda and approximately 0.3 mile south of the east lock along the east bank of the original Colorado River channel.

2.8 OIL, GAS, AND MINERALS

Oil, gas, and mineral resources vary between the BRFG and CRL study areas. Near the BRFG, the Bryan Mound Strategic Petroleum Reserve is the closest major energy and mineral resource; it is located about 1 mile north of the East Floodgate (refer back to **Figure 2-1**). The site stores

245 million barrels of crude oil, or one-third of the nation's oil reserves, in a subterranean salt dome held by the Strategic Petroleum Reserve for use in national emergencies. It has 20 underground chambers and is connected to port facilities at Freeport. A number of other major facilities occur in the BRFG vicinity, including Dow Chemical, Freeport Liquefied Natural Gas (LNG), and facilities around the Port of Freeport and the GIWW.

There are no oil or gas pipelines in the BRFG study area (Texas Railroad Commission (RRC) 2017)). There are four known oil wells in the study area. However, three locations are considered dry holes, and drilling was cancelled or abandoned at the fourth location. There are no oil wells, pipelines, or other oil, gas, or mineral resources in the CRL study area (RRC 2017).

2.9 HAZARDOUS, TOXIC, AND RADIOACTIVE WASTE (HTRW)

In order to complete a feasibility level HTRW evaluation for the GIWW BRFG-CRL Feasibility Study, a records search was conducted following the rules and guidance of ER 1165-2-132: HTRW Guidance for Civil Works Projects, and ASTM E1527-13: Standard Practice for Environmental Site Assessment: Phase 1 Environmental Site Assessment Process.

Several items were found during the records search from both EPA and TCEQ databases. The Bryan Mound Strategic Petroleum Reserve is a Department of Energy underground emergency fuel storage facility located approximately one mile to the north of the BRFG. The site is listed as a generator of hazardous waste, an air emitter under the Clean Air Act, and the site of former petroleum storage tanks. The Texas Barge and Boat facility, located approximately 650 feet north of the BRFG, was listed as another hazardous waste and air emissions generator, and is the current location of several petroleum storage tanks.

Both proposed project sites also were found under listed under other programs in the TCEQ database, with USACE as the responsible entity. The BRFG facility is listed as formerly having three Underground Storage Tanks (USTs). The first was a 1,000 gallon empty tank that was filled in place in 1992. The second and third were 560 gallon diesel USTs that were removed from the ground also in 1992. The CRL is listed as formerly having two USTs: one 1,000 gallon empty tank filled in place in 1988, and one 560 gallon diesel tank removed in 1994.

Hurricane Harvey impacted much of the Gulf Coast including the proposed project area. As far as HTRW, the proposed project sites were not impacted, in that no upland cleanup or hazardous waste sites were created or identified. The potential for encountering contaminated sediment from flooded cleanup sites or existing facilities increased after Harvey, although sediment is not considered HTRW in Civil Works unless it is within a predetermined cleanup area, and will not be considered here. Potential sediment testing and handling is addressed in the Dredged Material

Management Plan (DMMP). The full records search can be found in the **Environmental Appendix Attachment D-7**.

Despite there being no known HTRW in the immediate vicinity of the proposed project, a possibility exists that project elements could uncover previously unidentified HTRW. As a result, a contingency plan for the discovery of HTRW must be included in project plans. This contingency plan should outline procedures for response and notification in the event of HTRW discovery.

3.0 PLAN FORMULATION

3.1 PROBLEMS AND OPPORTUNTIES

3.1.1 Problems

Multifaceted problems exist within the study area and at the BRFG and CRL structures. Each structure has two separate lock and/or floodgate components along this 40-mile stretch of the GIWW, with two river crossings in the middle of each location. These structures operate differently depending on the direction of traffic and river conditions. This makes for a unique system to assess as it is atypical of more commonly assessed reaches along the GIWW (i.e. shipping channels, ports, etc.).

Specific **problems** to each of the structures address the structural configurations, operational conditions, traffic problems experienced at each location (includes transit times, allisions, delays, tripping), and river conditions within the waterway system.

Study Problems

- Hydraulic flows and channel geometry present navigational hazards at river crossings
- Outdated 75-foot width of floodgates at Brazos River and floodgates and lock chambers at Colorado River do not efficiently accommodate current tow configurations along the GIWW, which arrive at structures as wide as 104 feet resulting in multiple trips to transit the crossing
- Aging and outdated lock components and equipment leads to structural, electrical and mechanical maintenance issues.
- Shutdown of operations during high river periods and accident repairs causes significant economic impacts to navigation industry.
- Vessels impact and damage to aging existing structure sheet pile guidewalls.
- Sedimentation at the crossings and along the GIWW impacts the navigation industry.

3.1.1.1 Problems at the Brazos River Floodgates

Floodgate Configuration. Two 75-foot floodgates, one on each side of the Brazos River crossing of the GIWW, are provided to control flood flows from the Brazos River to the GIWW and to control sand and silt deposition from the Brazos River into the GIWW. The floodgates were installed at a time when most tug boats pulled barges behind them instead of using the modern pushing method. The current angled approaches to each floodgate are not conducive to the pushing

Figure 3-1 – Barged Traffic at CRL

method with the limited forebay and narrow gate openings. Cross current and through-gate flows, cause eddies to form unstable approach conditions.

FOREBAY

A forebay is an artificial pool of water in front of a larger body of water. The larger body of water may be natural or man-made and can have a number of functions. One use is to trap sediment and debris which can reduce maintenance. Another is to help vessels align their approach to the structure. https://en.wikipedia.org/wiki/Forebay_(reservoir)

When the floodgates were built in 1943, barges were typically 26- to 35-feet wide. The floodgate chamber is 75-feet wide, and the maximum width of the barge it can accommodate is 55 feet. Today, it is common for towboat operators to push two 35-foot dry cargo barges side by side, for a total width of 70 feet. A typical tank barge measures 54 feet across, so tank barges must transit separately. The necessity to break the tow in order to pass individual barges through the floodgates causes time delays.

The floodgates are situated approximately 600 feet from the river. When crossing the river, towboat operators do not have enough time to recover their course after struggling with the river currents. As a result, an average of 56 accidents occur per year (2006-2015) at BRFG, causing damages to the facility and to the barges. When these accidents involve tank barges, there is the additional risk for hazardous material spills. More detailed information on timing and quantified delay cost is provided in the **Economic Appendix, Section 2.2.3**.

Operational Conditional Assessment. The BRFG project has multiple documented maintenance/operational issues outlined in the 2017 Operational Condition Assessment (OCA). Because of the low elevation of the top of the wall of the gate structure, barges routinely hit the walls and gates, causing damage to the steel railing, concrete walls, and machinery pit. There are up to 8-feet deep scour holes along the steel sheet pile guidewalls on the West and East gates which extend toward the middle of the channel, exceeding the design elevations of the guidewalls. The steel sheet piling for the guidewalls is exhibiting corrosion at the waterline and the bolts for the wale beams are heavily corroded. The guidewall timber bumpers and steel tangent plates are missing or damaged from constant barge impacts. Additionally, the existing design of the guidewall is not resilient to barge impact, requiring repairs to the guidewall for most barge impacts.

Figure 3-2 – Guidewall Damage from Barge

The existing plumbing system (water and septic) and emergency generator/fuel systems are significantly deteriorated with no dependable backup power. The existing electrical power cables within the chamber crossovers are extremely deteriorated. The existing paint system has been ineffective preventing marine growth (particularly gulf oysters) on the structure. This growth has been substantial and adds significant weight, causing damage to the hinges/machinery. The gates have been binding during operation; this is speculated to be caused by the movement of the non-pile founded 2-foot thick slabs. The lock buildings continue to deteriorate with missing roof shingles, asbestos siding, leaking windows and doors, inadequate lighting, no ground fault interrupter (GFI) receptacles (required by the National Electric Code (NEC)), and deteriorated panel boards with exposed wiring.

3.1.1.2 Problems at the Colorado River Locks

Lock Configuration. The narrow 75-foot gate opening and limited forebay is not conducive to safe barge navigation. When crossing the river, towboat operators do not have sufficient time to recover their course after struggling with the river currents. The CRL do not experience as many accidents as the BRFG; however, accidents occur at an average of approximately eight (8) accidents per year. Detailed information on timing and quantified delay cost are provided in **Appendix B, Economic Appendix, in Section 2.2.3**

> **ALLISION VS COLLISION**
>
> In maritime terms, there is a difference between a collision and an allision.
> • **Collision**: when two moving objects strike each other.
> • **Allision**: when a moving object strikes a stationary object.
> wordpress.mrreid.org/2012/07/21/collision-v-allision/

Operational Conditional Assessment. The 2017 OCA also documented multiple maintenance/operational issues for the CRL project. There are five-foot deep scour holes along the tie-back sheet pile guidewalls on both the East and West locks, exceeding the design elevations of the guidewalls. There are scour holes up to 15-feet deep along the steel sheet pile guidewalls and concrete gravity walls on the West and East gates which extend towards the middle of the channel. Wall timbers are missing or damaged.

The existing design of the guidewall is not resilient to barge impact; therefore, most barge impacts result in the need for repairs to the guidewall. The existing plumbing system (water and septic) and emergency generator/fuel systems are significantly deteriorated. The existing gate controls, switchgears and transformers are very old and show signs of significant deterioration. The control houses are in poor condition and do not meet modern codes. The existing electrical conduit running underneath the lock structure is damaged and has rendered the West gates inoperable. The existing paint system has been ineffective preventing marine growth (particularly gulf oysters) on the structure. This growth has been substantial and adds significant weight causing damage to the hinges/machinery.

3.1.1.3 High River Flow Problems

Restrictions are placed on the tows allowed to cross the Brazos and Colorado Rivers during high flow events. These restrictions are codified in 33 CFR 207.187 – Gulf Intracoastal Waterway, Tex: Special Floodgate, Lock and Navigation Regulation. In accordance with 33 CFR 207.187 (c)(1), "*When the current in either river exceeds 2 miles per hour or the head differential at the Brazos River floodgates is between the limits of 0.7 foot and 1.8 feet, both inclusive, or the head differential at the Colorado River locks is 0.7 foot or greater, passage shall be afforded only for single vessels or towboats with single loaded barges or two empty barges…*" In addition, 33 CFR 207.187 (c)(3) states "*The Brazos River Floodgates shall be closed to navigation when the head differential exceeds 1.8 feet. The Colorado River Locks shall be closed to navigation when the current in the river exceeds a critical velocity as determined by the District Engineer, U.S. Army Engineer District, Galveston, Tex.*" It is District Operations policy that when the river flow exceeds 5 mph, traffic is limited to one barge only (loaded or empty) and closed to navigation at night (daylight operation only). When the river flow exceeds 7 mph, all traffic is halted until the flow lowers (below 7 mph).

HEAD DIFFERENTIAL

The difference measured in feet between the water level in the river and that in the waterway when the floodgates or locks are closed.
https://www.law.cornell.edu/cfr/text/33/207.187

3.1.2 **Opportunities**

O**pportunities** include reducing or eliminating costly commercial traffic delays and improving the national and regional economic conditions. Maintaining the effectiveness of the crossing at these locations is critical not only from an economic standpoint but from a national security risk as well due to the types of commodities transported; primarily oil, gas, and agricultural products.

3.2 STUDY GOALS, OBJECTIVES, AND CONSTRAINTS

The overall study **goal** is to provide an efficient and safe BRFG and CRL while contributing to the NED consistent with protecting the nation's environment while continuing to provide water management capability, sediment control, and navigation safety on the GIWW. This will contribute to the improved efficiency of the GIWW as a nationally significant navigation system. The following planning **objectives** were used in the formulation and evaluation of alternative plans:

Objectives

- **Reduce navigation delays** (tripping, allisions) for vessels transiting the BRFG-CRL system through the 50-year period of analysis
- **Increase navigation efficiency** (alignment, hydraulic flow, high river periods) of vessels transiting the BRFG-CRL system over the 50-year period of analysis
- **Minimize vessel allisions** which result in facility closures/ outages for required repairs over the 50-year period of analysis
- **Manage Sedimentation** into the GIWW from the Brazos and Colorado Rivers over the 50-year period of analysis
- **Improve overall operations/functions of the facilities** which experience frequent mechanical failures due to age and outdated systems

Constraints are restrictions/limitations. Plan formulation involves meeting the study objectives while not violating constraints. The study takes into account all applicable county, state, and Federal laws, permitting requirements, regulations, and environmental guidance. Specific study constraints include:

Constraints

- **Minimize Impacts to Navigation Industry:** With limited alternative routes for bulk cargos being shipped through the floodgates and locks, excessive waterway closures that are unacceptable to the navigation industry are to be avoided
- **Minimize Environmental Impacts:** Wildlife Management Areas (WMAs) are found adjacent to the Study area. Adverse impacts to those areas should be avoided or mitigated
- **Avoid Impacting General Infrastructure & Existing Federal Projects:** A state highway bridge and several local roads, as well as residences are found in the study area. Additionally there is Federal flood control levee near the CRL. Adverse effects to the existing infrastructure will be minimized to the extent practicable

3.3 RELATED ENVIRONMENTAL DOCUMENTS

The proposed action is described in sections of this FIFR-EIS in order to satisfy the requirements of NEPA.

3.4 DECISIONS TO BE MADE

This FIFR-EIS will provide recommendations for modifications needed to address safe and efficient navigation through the BRFG and CRL System. Various alternatives were evaluated and specific measures suggested to minimize, or avoid, adverse effects to local resources.

3.5 PLAN FORMULATION RATIONALE

Plan formulation is the process of building alternative plans that meet the planning objectives of the study within the planning constraints. First, management measures are formulated. These measures are **features** that can be implemented at a specific geographic site to address the planning objective(s). Then alternative plans are developed, comprising a set of one or more management measures functioning together to address the planning objective.

FEATURES

Can be a structural element that requires construction or a non-structural action.

Initial study efforts involved a determination of the magnitude and extent of the problems along the BRFG and CRL projects in order to develop and evaluate an array of alternative solutions that meet the existing and long-range future needs of our Partner (TxDOT) and the public. At the initiation of the feasibility phase of the project, lines of communication were opened with Federal, state, and local agencies, private groups, and the affected public.

A Notice of Intent (NOI) for *Public Notice of Intent for Studies and Initial Scoping Meeting for Gulf Intracoastal Waterway Brazos River Floodgates and Colorado River Locks Feasibility* was published in the Federal Register on Wednesday, June 22, 2016 (FR Vol. 81, No. 120). The Galveston District held the Initial Scoping Meeting for the Feasibility Phase of the study in West Columbia, Texas on July 12, 2016. The purpose of the meeting was to solicit comments/concerns on the opportunities to improve navigation along the GIWW at the Brazos and Colorado Rivers, the identification of resources that may occur with the study area, and other social, economic, and environmental concerns.

3.6 MANAGEMENT MEASURES

The main problems with the existing BRFG-CRL system are navigation inefficiencies and accidents (allisions) due to the configuration of the system. Delays result from the need for "tripping", breaking up multi barge tows for safe transit through the structures. This can be due to size of barge tows; however, tripping is required during high river flow conditions or flood events. Facility closures / outages occur due to the need to repair structural damage resulting from vessel allisions. The aging / outdated infrastructure at Brazos and Colorado result in delays due to frequent system / gate failures, during high river stages. Non-structural and structural measures were developed to address at least one of the planning objectives, alone or in combination with other measures.

3.6.1 Non-Structural Measures

Non-structural measures have been employed historically to reduce risks; however, they are not sufficient to alleviate the existing inefficiencies and they are already practiced to the greatest extent practicable.

Non-structural measures included:

- Improvements to scheduled maintenance of the locks
- Improvements to towing schedules using AIS or similar scheduling systems
- Adding buoy's and additional navigation lights to help guide barges.

They have been determined to have negligible impacts on the frequency or duration of navigation accidents, with the exception of additional mooring locations which are being analyzed in a separate study, *Gulf Intracoastal Waterway, Texas, Mooring Basins Modifications, Operations and Maintenance Discretionary Authority Study*. Therefore, non-structural measures were not carried forward for further analysis as they would not meet the study objectives. It is a foregone conclusion that should a final recommended plan be approved and constructed, non-structural measures would still be used to address any remaining residual risks.

3.6.2 Structural Measures

A separate set of measures was developed initially for the BRFG and CRL locations. These measures were derived from a variety of sources including prior studies, the public scoping process, and team collaboration. The study considered measures for key functional navigation areas that include lock/floodgate structures, flow impacts on the rivers and GIWW, and potential impacts to the surrounding environment (wetland areas, communities, and existing Federal projects (i.e. levees)).

All measures were initially screened for their capability to meet objectives and avoid constraints, for engineering, environmental and economic feasibility, and for the level of navigation impact reduction provided after construction. **Table 3-1** and **Table 3-2** provide the structural measures for BRFG and CRL, respectively. The name of each measure is followed by a two letter identifier in parenthesis.

Table 3-1 –BRFG Measures (12)

Floodgate Maintenance (FM): Floodgate maintenance would involve the continued maintenance of the current steel floodgates, concrete gatebay monolith and machinery without any major rehabilitation of the structure.

Major Rehabilitation of Floodgates (MR): Major rehabilitation of the floodgates would restore the reliability of the steel floodgates, concrete gatebay monolith and machinery. This could potentially include new gates, machinery, electrical power, and controls. This measure would improve navigation efficiency through the reduction of closures of the floodgates due to unscheduled maintenance due to structural, mechanical or electrical component failures.

Channel Improvement Structures (CS): Channel improvement structures would consist of training and side channel enhancement structures such as above and/or below water weirs, dikes and other structures to improve hydrodynamic conditions and sediment transport. The improvement to the hydrodynamic conditions at the crossing would improve navigation efficiency by reducing delays due to unscheduled repairs on the structures resulting from allisions.

Dredging at Crossings (DC): Dredging at crossings would consist of modification of the river crossings utilizing conventional dredging techniques to improve hydrodynamic conditions and sediment transport. The improvement to the hydrodynamic conditions at the crossing would improve navigation efficiency by reducing unscheduled repairs on the structures resulting from allisions.

Modify/Construct Guidewalls (MG): Modification or construction of new approach guidewalls would provide a safer approach to the structures, reducing unscheduled repairs on the structures resulting from allisions.

Structure Removal (SR): Structure removal involves the complete removal of the floodgate structures.

Raise/Relocate Gate Operator Buildings (RO): The low elevation of the gate structure causes the gate operator buildings to be struck by vessels frequently during high river events. Raising/relocating the gate operator building involves moving the existing buildings out of the way of navigation to prevent unscheduled repairs on the buildings resulting from allisions and correspondingly raising it to maintain or improve visibility.

Modify Gate Machinery Pit Location (MP): The low elevation of the gate structure puts the machinery pit at risk of being struck by vessels during high river events. Modifying the gate machinery pit involves some sort of modification to the gate machinery pit to prevent unscheduled repairs on the gate machinery resulting from allisions.

Channel Realignment (CR): Channel realignment involves the permanent relocation of the alignment of the GIWW crossing the river to improve efficiency by reduction of delays due to unscheduled repairs on the structures resulting from allisions. This measure refers to a wide range of alternative permanent realignments of the crossing. It is realized that temporary realignments or bypasses might be required to bypass a construction site, but that is designated as CB (see CB definition herein).

Relocate/Setback Gate Structures (RG): This measure would involve the relocation of the gate structure to either a new alignment or setback within the existing alignment.

Construct Temporary Bypass Channel (CB): Construction of a temporary bypass channel involves the temporary realignment or bypass of the GIWW in order to accomplish the permanent construction.

Construct Lock/Earthen Chamber (CL): Construction of the lock/earthen chamber involves the replacement of the existing gate structures with a lock structure. The lock structure may consist of two completely new sets of gates with an earthen chamber or utilization of the existing gates as a river side gatebay monolith. The lock structure may be constructed along the current alignment or along a permanent channel realignment. Construction of a new lock would improve navigation efficiency by reducing unscheduled repairs on the structures resulting from allisions and reducing tripping of vessels due to wider lock more appropriate for the tow configurations on this portion of the GIWW.

Table 3-2 – CRL Measures (15)

Lock Maintenance (LM): Lock maintenance would involve the continued maintenance of the current steel floodgates, concrete gatebay monoliths and machinery without any major rehabilitation of the structure.

Major Rehabilitation of Floodgates (MR): Major rehabilitation of the floodgates would restore the reliability of the steel floodgates, concrete gatebay monoliths and machinery. This could potentially include new gates, machinery, electrical power, and controls. This measure would improve navigation efficiency through the reduction of closures of the floodgates due to unscheduled maintenance due to structural, mechanical or electrical component failures.

Channel Improvement Structures (CS): Channel improvement structures would consist of training and side channel enhancement structures such as above and/or below water weirs, dikes and other structures to improve hydrodynamic conditions and sediment transport. The improvement to the hydrodynamic conditions at the crossing would improve navigation efficiency by reducing delays due to unscheduled repairs on the structures resulting from allisions.

Dredging at Crossings (DC): Dredging at crossings would consist of modification of the river crossings utilizing conventional dredging techniques to improve hydrodynamic conditions and sediment transport. The improvement to the hydrodynamic conditions at the crossing would improve navigation efficiency by reducing unscheduled repairs on the structures resulting from allisions.

Modify/Construct Guidewalls (MG): Modification or construction of new approach guidewalls would provide a safer approach to the structures, reducing unscheduled repairs on the structures resulting from allisions

Structure Removal (SR): Structure removal involves the complete removal of the lock structures.

Relocate Locks South (RS): This measure involves the construction of a new set of locks south of the existing locks.

Construct Floodgates (FG): This measure would involve the construction of wider floodgates (125 to 150 feet wide) on either the existing GIWW alignment or south of the existing alignment.

Bypass Channel (CB): This measure would involve the construction of a temporary construction bypass to the south of the existing GIWW alignment during the construction of the permanent alternative.

Modify Dam (MD): This measure would involve the construction of a flow control structure such as sluice gates in the existing diversion channel dam. The gates would be opened as tows approach to lessen the effects of river flow.

Modify Scheduled Maintenance of Locks (MS): This measure would entail the modification of the maintenance of the lock to reduce delays due to lock shutdown.

Construct Mooring Facilities (CM): This measure would involve the construction of additional mooring buoys on both the east and west sides of the lock to provide adequate mooring facilities to prevent delays and potential environmental damage in the GIWW due to tow boats pushing and maintaining barges against the banks of the existing mooring basins.

Construct Sluice Gates (SG): This measure would involve the construction of sluice gates on an alternative channel alignment to reduce the velocities through the existing lock structure or a proposed new structural alternative.

Construct Southwest Cut to Matagorda (SC): This measure would involve the construction of an outlet for the old Colorado River into East Matagorda Bay. The outlet would consist of a gate/culvert system that would reduce currents at the intersection of the bypass channel and the GIWW on the east side of the east locks.

Construct Chevron in West Matagorda Bay (CC): This measure would involve the construction of a chevron at the mouth of the Colorado in West Matagorda Bay, creating a more effective flood discharge channel and reducing sedimentation upstream in the river.

3.6.3 Initial Screening of Measures Based on Contribution to Objectives

When the measures shown in **Table 3-1** (BRFG) and **Table 3-2** (CRL) were analyzed, the team determined that each measure met at least one objective. Therefore, none of the measures were eliminated. The team combined the measures to form the initial array of alternative plans.

3.7 INITIAL ARRAY OF ALTERNATIVE PLANS

Table 3-3 illustrates how the measures were combined to form an initial array of 11 alternative plans. In the table, a measure abbreviation is provided at the beginning of the description to indicate whether it is located at Brazos, Colorado, or both [e.g., "B"= Brazos; "C" = Colorado; "B/C"=both]. In the "Measures Included" column, refer back to **Table 3-1** and **Table 3-2.**

Table 3-3 – Categories for Initial Array of Alternative Plans

Alt	Description	Measures Included
No Action	No Action or Future Without-Project Condition - Maintain the existing floodgate / locks in their current condition with existing structures.	
Alt 1	B/C-Alt. 1: Minimal improvements to Existing Floodgate/Lock (modify scheduled maintenance, modify gate machinery pit at BRFG, and improve guidewalls).	**BRFG**: FM, DC, MP, MS and **CRL**: LM, DC, CM, MS
Alt 2	B/C-Alt. 2: Major Rehab of existing Floodgate/Lock structures (All of Alt. 1 plus raise/relocate gate operator buildings, and new guidewalls).	**BRFG**: MR, DC, MP, RO, MG, CS, CB and **CRL**: SC, MS, MR, MG, CM, CS, DC, CC
Alt 3	B/C-Alt. 3: Open Channel - Remove Floodgate/Lock Structures (include sediment/water management alternatives plus bypass channel).	**BRFG**: SR, DC, CS, CR and **CRL**: SC, SR, DC, CS, CC, CB
Alt 4	B/C-Alt. 4: Convert Existing Brazos Floodgate into Locks and Colorado River Locks to Floodgates - retain riverside gates in existing alignment at Brazos -widen existing alignment to 150 feet for Colorado.	**BRFG**: MR, CS, DC, MG, CL, WG, CB, MP, RO and **CRL**: SC, SR, DC, CS, CC, CB
Alt 5	C-Alt. 5: Relocate locks south of existing locks.	**CRL**: RS, SC, SR, CS, DC, SC, CC, MG
Alt 6	C-Alt. 6: Rebuild locks in same location and include a temporary bypass.	**CRL**:MG, CB, CS, DC, SR, SC, CC
Alt 7	B/C-Alt. 7: Maintain Existing Channel Alignment (no structures) – Open Channel Alt. 3.	**BRFG**: SR, DC, CB, CS and **CRL**: CB, SC, SR, DC, DS, CC
Alt 8	B/C-Alt. 8: Widen existing channel alignment (150 feet.) - *Includes bypass channel to maintain navigation during construction that can be closed or remain open for recreation access after construction.	**BRFG**: CS, DC, MG, SR, RG, WG, CB and **CRL**: CD, DC, MG, SR, SC, CC
Alt 9	B-Alt. 9: Move channel alignment north/south of existing alignment (5 options).	**BRFG**: RG, CR, CL, CS, DC, SR
Alt 10	B/C-Alt. 10: Open System (no structures at either site) on existing alignment construct weirs, trail dike, or wing dams.	**BRFG**: SR, DC, CB, CS and **CRL**: CB, SC, SR, DC, CS, CC
Alt 11	C-Alt. 11: With Structures- where applicable (construct sluice gates, cut near Matagorda Bay (control flows), chevrons (sediment control), or modify channel dam to control flow).	**CRL**: MR, CS, DC, MG, SG, SC, CC, MD

3.7.1 Screening of the Initial Array of Alternative Plans

Once the Initial Array of Alternatives Plans were developed, the team quantitatively assessed the plans and developed rough cost estimates for the alternatives. The team then performed screening of the initial array of alternatives using the preliminary cost and benefit estimates, and estimates of the degree to which each alternative would buy down the baseline condition risk. The preliminary construction costs were estimated for each alternative based on costs from similar navigation and lock studies. Rough costs for estimated environmental mitigation and real estate costs were included in the preliminary construction costs used to estimate benefits. Benefits were estimated for four general benefit categories; allision repair avoidance, allision delay avoidance, tripping cost reduction, and other delay cost reduction.

The benefits across these four categories were estimated as the total possible benefits available for alternatives to capture, rather than separately for each alternative. From these a rough "project affordability" was estimated using a general rule of thumb that annualized benefits would exceed annualized costs (thus resulting in a benefit-cost ratio (BCR) above 1)) given a project first cost of approximately 10 times the annualized benefit estimate at the current Federal discount rate. This was then compared against preliminary cost estimates for each alternative with the intent of eliminating any alternatives for which cost exceeded the affordability estimate. The benefit/affordability estimates were also weighed against each alternatives qualitatively estimated ability to buy down risk (1 doesn't buy down risk, 2 undetermined or minimally buys down risk, and 3 buys down risk).

Figure 3-3 illustrates the screening process used for the initial array of alternatives. The Project Delivery Team (PDT) eliminated those alternatives where estimated preliminary costs significantly exceeded estimated potential benefits (Alternatives 1 and 5). Those alternatives that provided a medium to high benefit and whose preliminary estimated cost, while high, provides a maximum level view of all potential cost for comparison screening and could yield a favorable benefit to cost ratio, were retained. This resulted in either carrying forward an alternative on its own (Alternatives 2, 3, 4, 6, and 9) or combining the alterative with other alternatives (Alternatives 7, 8, 10, and 11).

Rough Cost and Benefit Screening of Initial Array of Alternatives				
Alternatives	**Implementable Risk Rating**	**Rough Cost**	**Total Benefits per Year**	**Screening Status**
Alt. 1	1	Low	Low	Eliminated
Alt. 2	2	Medium	Medium	Retained
Alt. 3	3	Med-High	High	Retained
Alt. 4	2	Medium	Low	Retained
Alt. 5	1	High	Low	Eliminated
Alt. 6	1	Low	Low	Retained
Alt. 7	2	Medium	Medium	Combined with Alt.3
Alt. 8	3	Low	High	Combines with other alternatives
Alt. 9	2	High	Medium	Retained
Alt. 10	2	High	Low	Combined with Alt. 3
Alt. 11	3	High	Medium	Combines with other alternatives

Rough Cost Range		
Low	**Medium**	**High**
$0 - $50M	$51M - $150M	$151M - $270M
Total Benefits per Year Range		
$0 - $20M	$21M - $40M	$41M - $60M

Qualitative Analysis of:

- Environmental Impacts
- Economic Benefits
  - Allision Repair Avoidance
  - Allision Delay Avoidance
  - Tripping Reduction
  - Other Delay Reduction
- Allision Risk Reduction

Figure 3-3 - Rough Cost Estimate & Benefit Screening of Initial Array

The first screening of alternatives concluded with six alternatives, including the No-Action alternative, identified as the focused array that could apply to either location as part of the system or as a standalone alternative at each structure. Detail on the computation of screening level benefits is available in the **Economic Appendix**.

USACE VERTICAL TEAM

Includes decision-makers and technical expertise from the District, Major Subordinate Command (MSC), which in this case is Southwestern Division (SWD), and Headquarters (which may include Office of Water Project Review (OWPR)). For this study, the Inland Navigation Planning Center of Expertise (PCXIN) is also involved.

The Alternative Milestone Meeting (AMM) was held on September 14, 2016. The USACE Vertical Team concurred with the focused array of alternatives presented at the AMM (**Table 3-4)**.

Table 3-4 - Focused Array of Alternatives

Alternative (Alt)	Location	Description
No Action	BRFG /CRL	Existing condition, no change in operation and maintenance of current structures.
Alt. 2	BRFG /CRL	Major rehab of existing floodgates/locks.
Alt. 3	BRFG /CRL	**BRFG:** Remove existing gates. Install 125 feet minimum width gates each side of river, located further from river. Include temporary bypass channel. **CRL:** Remove existing structures for open channel. Includes bypass channel.
Alt. 4	BRFG /CRL	**BRFG:** Convert floodgates to locks. Retain existing gates and install additional 75 feet width gates to form the locks. **CRL:** Convert locks to floodgates. Remove existing gates and locks. New channel with 125 feet bottom minimum width, with new 125 feet minimum width gates.
Alt. 6	CRL	Rebuild locks at same location and on existing alignment with wider gates and channel. Remove existing gates, install new 125 feet minimum gates. Create 125 feet bottom minimum width channel. Includes temporary bypass channel.
Alt. 9	BRFG	Construct new alignment north of the existing alignment which is along the existing barge mooring facility. There are four configurations: no gates, gate each side of river, gate each side of river with sediment/flow control features in the existing alignment, and locks each side of the river.

Subsequent to this first screening, the alternatives have been separated out. The expectation is that each location (BRFG vs CRL) could be implemented separately so the team decided to further analyze them as separable elements to verify we have the best system combination in the final recommendation. **Table 3-5** provides the Focused Array of Alternatives split to project-level features and the revised identifiers.

Table 3-5 – Revised Focused Array of Alternative Plans

Previous Alt	Revised Alt #	Project	Description
No Action Alt. (Existing Condition)(EC)		BRFG and CRL	Existing condition, no change in operation and maintenance of current structures.
2	**2a**	BRFG	Rehab existing project + guidewalls
	2b	CRL	Rehab existing project
3	**3a**	BRFG	Remove existing gates. Install 125 feet minimum width gates each side of river, located further from river. Include temporary bypass channel.
	3b	CRL	Remove existing structures for open channel. Includes bypass channel.
4	**4a**	BRFG	Convert floodgates to locks. Retain existing gates and install additional 75 feet width gates to form the locks.
	4b	CRL	Convert locks to floodgates. Remove existing gates and locks. New channel with 125 feet bottom minimum width, with new 125 feet minimum width gates.
6	**6**	CRL	Rebuild locks at same location and on existing alignment with wider gates and channel. Remove existing gates, install new 125 feet minimum gates. Create 125 feet bottom minimum width channel. Includes temporary bypass channel.
9	**9a**	BRFG	Use Alignment C which is north of the existing Alignment A and is along the existing barge mooring facility. No gates/open channel.
	9b	BRFG	Use Alignment C which is north of the existing Alignment A and is along the existing barge mooring facility. Gate on each side of river.
	9c	BRFG	Use Alignment C which is north of the existing Alignment A and is along the existing barge mooring facility. Gate on each side of river plus flood control structure in existing alignment.
	9d	BRFG	Use Alignment C which is north of the existing Alignment A and is along the existing barge mooring facility. Locks on each side of the river.

When the alternatives were broken out a mistake in the labeling occurred. Alternative 3 was an open channel at both BRFG and CRL. The BRFG portion of Alterative 3 was inadvertently named as 9a which was the open water alternative but on a new alignment. The 3a alternative is now removing the gates and installing a 125-foot gate on each side of the river. Alternative 8 which was combined, became the new 3b alternative.

3.7.2 Secondary Screening of Alternatives

To facilitate the next round of screening a screening tool was developed and used to define the existing and alternative condition navigation impacts as a function of a series of input parameters, and to compute navigation impacts dynamically based on those inputs. The tool was used to attribute existing delays to different impact categories using available data and existing condition impacts roughly calibrated against other available estimates obtained by TxDOT, the Texas Transportation Institute (GIWW Master Plan), and site operations personnel. The input parameters used in the screening tool for BRFG and CRL are shown in **Table 3-6** and **Table 3-7**, respectively.

Table 3-6 – Input Parameters for BRFG

BRFG	Rehab Existing + Guidewalls (2a)	Rebuild New Floodgates (3a)	Open Channel (9a)[1]	New Alignment - Gates (9b)	New Alignment - Gates + Control (9c)	New Alignment - Locks (9d)
Change in Base Transit Time	100%	80%	50%	80%	80%	110%
"Chamber" Length	1000	1000	1000	1000	1000	1000
"Chamber" Width	75	125	125	125	125	125
Lock?	No	No	No	No	No	Yes
Reduction in other tripping	10%	60%	100%	80%	80%	90%
Velocity Threshold (mph)	2	3	5	5	5	5
Head Differential Threshold (feet)	0.7	1.2	1.8	1.8	1.8	1.8
Accident Percent Reduction	50%	80%	100%	90%	90%	90%
Percent Reduction in Velocity Related Closures	0%	50%	75%	50%	75%	75%
Percent Reduction in Head Diff Related Closures	0%	50%	95%	50%	100%	100%
Changing Dredging Cost	0	0	+2M	0	0	0
WOPC Maintenance/Rehabilitation Costs	2.6M	2.6M	2.6M	2.6M	2.6M	2.6M
WPC Maintenance/Rehabilitation Costs	2.6M	2M	0	2M	2M	2.3M
Total Cost ($000)	**$42,000**	**$130,000**	**$95,000**	**$190,000**	**$190,000**	**$326,000**

Table 3-7 – Input Parameters for CRL

CRL	Rehab Existing (2b)	Open Channel (3b)	Convert Locks to Floodgates (4b)	Rebuild New Locks (6)
Change in Base Transit Time	100%	50%	80%	100%
"Chamber" Length	1000	1000	1000	1000
"Chamber" Width	75	125	125	125
Lock?	Yes	No	No	Yes
Reduction in other tripping	0%	100%	80%	80%
Velocity Threshold (mph)	2	5	3	3
Head Differential Threshold (feet)	0.7	1.8	1.2	1.2
Accident Percent Reduction	0%	100%	50%	50%
Percent Reduction in Velocity Related Closures	0%	75%	50%	50%
Percent Reduction in Head Diff Related Closures	0%	95%	50%	100%
Changing Dredging Cost	0	+2M	0	0
WOPC Maintenance/Rehabilitation Costs	3.3M	3.3M	3.3M	3.3M
WPC Maintenance/Rehabilitation Costs	2.8M	0	3.3M	2.3M
Total Cost ($000)	**$45,000**	**$35,000**	**$130,000**	**$266,000**

The second round of screening was conducted using the screening tool, which used team elicited input assumptions and produced rough order of magnitude BCRs. In general, BCRs were used to screen out alternatives below unity (less than 1). As shown in **Table 3-8**, the Open Channel (9a) alternative at BRFG had the highest net benefits as did the Open Channel (3b) at CRL. The realignments proposed at BRFG had negative net annual benefits; however, because 9c was almost at unity and had the highest annual benefits of the new alignment measures (9b, 9c, 9d) it was retained for further evaluation. Detail on the computation of screening level benefits is available in the **Economic Appendix**.

NET BENEFITS

Benefits minus Cost

At a May 2017 In-Progress Review, the Vertical Team concurred with the methodology presented and requested that the model used should be certified for single use (approved in December 2017).

Table 3-8 –Screening of Alternatives based on Benefit Cost Analysis ($000)

BRFG	Rehab Existing + Guidewalls (2a)	Rebuild New floodgates (3a)	Open Channel (9a)	New Alignment - Gates (9b)	New Alignment - Gates + Control (9c)	New Alignment - Locks (9d)
Annual Benefit	$2,253	$6,858	$11,443	$8,082	$8,177	$8,188
Annual Cost	$1,836	$5,684	$6,154	$8,308	$8,308	$14,255
BCR	1.23	1.21	1.86	0.97	0.98	0.57
Net Annual Benefit	$416	$1,174	$5,289	-$226	-$131	-$6,067
CRL	**Rehab Existing (2b)**	**Open Channel (3b)**	**Convert Locks to Floodgates (4b)**	**Rebuild New Locks (6)**		
Annual Benefit	$629	$7,396	$2,835	$3,619		
Annual Cost	$1,968	$3,530	$5,684	$11,631		
BCR	0.32	2.09	0.50	0.31		
Net Annual Benefit	-$1,338	$3,866	-2,849	-8,012		

The No-Action Alternative is not shown; however, it is carried forward.

In summary, **Table 3-9** provides the alternatives that remain after conducting the secondary screening.

Table 3-9 – Alternatives Remaining Post-Secondary Screening

Location	Alt	Description of Alternative
BRFG	No-Action Alternative	
	2a	Rehab existing project at BRFG + guidewalls
	3a	Remove existing gates at BRFG. Install 125 feet minimum width gates each side of river, located further from river. Include temporary bypass channel.
	9a	Open Channel at BRFG on new alignment (Alignment C)
	9c	Construct 125 foot gates at BRFG on new alignment (Alignment C). Construct flood control structure on existing alignment (Alignment A)
CRL	No-Action Alternative	
	3b	Remove existing structures at CRL for open channel. Includes bypass channel.

3.7.3 Hurricane Harvey

3.7.3.1 Hurricane Harvey Impacts to Study Analysis

As the team was nearing completion of the evaluation and comparison of the alternatives, Hurricane Harvey struck the region from August 24-28, 2017. The team was asked to assess potential impacts (increased sediment or damage to the structures) as a result of the storm. The storm did not directly impact the structures themselves; however, channels experienced increased flows/velocities and increased sediment deposition in the system, especially at CRL.

Analysis of Hurricane Harvey effects allowed the modelers to recalibrate the Adaptive Hydraulic (AdH) models to provide a better representation of the hydrodynamics, especially the sedimentation rates that occur during extreme flooding. This increased confidence in the model's ability to predict the effects of proposed project alternatives. While some sediment material may have already built up around the locks since the last dredging cycle, the AdH models show that the channel configuration contributed significantly to the increased sediment

Adaptive Hydraulics Model (AdH)

AdH is a modular, parallel, adaptive finite-element model for one-, two- and three-dimensional flow and transport.

AdH is a module of the Department of Defense (DoD) Surface-Water Modeling System and Ground-Water Modeling System. It simulates groundwater flow, internal flow and open channel flow.

The AdH module was developed in the Engineer Research and Development Center's Coastal and Hydraulics Laboratory (ERDC/CHL) and is a product of the System-Wide Water Resources Program. AdH was developed to address the environmental concerns of the DoD in estuaries, coastal regions, river basins, reservoirs and groundwater [Appendix A – Engineer Appendix, Section 2.2.1].

build up at the gates and in the forebays at CRL. This configuration would continue to be an issue with more frequent storm events pushing sediment material through the area, causing the locks to become inoperable, and contributing to shipping delays as a result of dredging activities.

For the evaluation of the Colorado River, Hurricane Harvey was evaluated using the AdH model. Observed flows at Bay City, Texas (USGS) were applied to the model as a flow boundary condition. The simulation of Hurricane Harvey allowed the team to re-calibrate sediment parameters. Hurricane Harvey was simulated using directly measured values from the upstream USGS gages and from the offshore tidal gage at Freeport. As such, Hurricane Harvey was simulated directly based on directly measured data, including both elevated river stage and storm surge; not simply as a proxy frequency event. Furthermore, under hurricane conditions the gates are typically pinned open to mitigate the potential impacts to river stage and to minimize damage to the gates and gate operations system. This was also the case in Hurricane Harvey, and was modeled as such. Comparison of model and measurements showed the model produced a similar amount of deposition as recorded in post-flood surveys at the intersection of the GIWW and Colorado River.

Storm surge in the river was not evaluated using any models. The primary purpose of the modeling was to evaluate impacts to currents, sedimentation and salinity for various project alternatives compared to existing conditions. The extreme sedimentation during Hurricane Harvey was due to the storm's rainfall, not the surge. The modeling approach looked at extreme flooding using a record or flows from 1948 to 2017. In that observed record, there are many events that are similar to Hurricane Harvey in terms of volume and peak flows. Extreme floods similar to Hurricane Harvey have occurred in the past including the tropical storm identified as GM 3-4, which occurred 27 June-1 July 1899 and took a similar path as Hurricane Harvey, though with slightly lower rainfall. Therefore, there is nothing "game-changing" about Hurricane Harvey in terms of the findings of the modeling study. Hurricane Harvey was simply another event used to calibrate the model's ability to predict sedimentation. The sedimentation parameters were adjusted to better match observations. More discussion of the Hurricane Harvey hindcast is included in the **Hydraulic Engineering Appendix – Colorado River Locks of the Engineering Appendix.**

HINDCAST

Hindcasting, (or backtesting) is a way of testing a mathematical model. Researchers enter known or closely estimated inputs for past events into the model to see how well the output matches the known results.
http://en.wikipedia.org/wiki/Backtesting

Hurricane Harvey was not modeled at the BRFG. Accurate modeling of Hurricane Harvey would require a full floodplain simulation to accurately capture the overbank flows associated with storms of this magnitude, and would also need to be dynamically coupled with a hydrology model.

Sedimentation surveys were analyzed for pre- and post-storm conditions, and sedimentation rates were quantified for the existing system. Based on information received from USACE, Galveston District Operations, during Hurricane Harvey, the east gate was left pinned open from August 24th, 2017 until September 1st, 2017. The west gate was pinned open from August 24th, 2017 until September 4th, 2017. Even with the pinning open of the west gate during a significant portion of the high flow event, the sedimentation in the GIWW west of the intersection was minimal compared to the sedimentation in the east forebay. It is also worth noting that no shutdowns of the GIWW due to sedimentation occurred as a result of Hurricane Harvey.

3.7.4 **Development of Hybrid Alternatives (Stakeholder Engagement)**

At an October 2017 meeting with navigation industry groups, concerns were raised about the concept of an open channel crossing and the effects of the increased currents and sedimentation on the Freeport Harbor. In response to industry feedback, a hybrid alternative was developed for BRFG (3a.1). This alterative would provide for an open channel along the existing alignment on the west side, where deposition of sediment is not as severe as the east side, and a replacement 125-foot flood gate on the east side.

At this time, the team also recommended a hybrid alternative for the CRL (4b.1) be evaluated. This alternative included removing the riverside floodgates and rehabbing the 75-foot inland gate. This decision was made as result of high initial O&M dredging costs for the open channel alternative. The removal of the river side gates would reduce allisions and tripping frequency due to the longer forebay. **Table 3-10** provides the alternatives with addition of the two hybrids developed in response to the meeting with Industry. Also, in response to the meeting with industry, the AdH models were re-run for the hybrid alternatives and cost estimates developed.

Table 3-10 - Alternatives Remaining Post-Secondary Screening + Hybrids (In Bold)

Location	Alt	Description
BRFG	2a	Rehab existing project at BRFG + guidewalls
	3a	Remove existing gates at BRFG. Install 125 feet minimum width gates each side of river, located further from river. Include temporary bypass channel.
	3a.1*	**Remove existing gate on west side (deposition not as severe as on east side). Construct 125-foot gate on east side. Include temporary bypass channel.**
	9a	Open Channel at BRFG on new alignment (Alignment C)
	9c	Construct 125 foot gates at BRFG on new alignment (Alignment C). Construct flood control structure on existing alignment (Alignment A)
CRL	3b	Remove existing structures at CRL for open channel. Includes bypass channel.
	4b.1*	**Convert Locks to Floodgates Hybrid. Remove existing riverside locks (west) and retain outer gates (east) to create wider channel and forebay. Include temporary bypass channel.**

** Hybrid Alternatives added per Industry feedback at October 18, 2017 Meeting.*

Detailed drawings and descriptions of the Alternatives remaining after the secondary screening are provided in **Section 1.3 of the Engineering Appendix**.

3.8 ENGINEERING ANALYSIS OF FINAL ARRAY OF ALTERNATIVE PLANS

3.8.1 Hydraulic Analysis

A numerical modeling study was performed to evaluate the proposed project alternatives using AdH model software. The purpose of the numerical model study was to evaluate the impacts to navigation and the environment associated with a set of proposed alternatives, including removal or reconfiguration of the lock system. Two specific AdH models were run, one for the Brazos River Crossing and one for the Colorado River Crossing. To develop the AdH model, bathymetric surveys and sediment samples were collected in the project area. The models were validated against observed water levels, velocities, salinities, and sedimentation. Once a sufficient validation was achieved for existing conditions, the models were altered to represent the proposed alternatives. Comparison of modeled alternatives provided useful information toward selection of the Tentatively Selected Plan (TSP).

For the BRFG model, data from the Texas Rainfall Runoff (TxRR) Model (from TWDB) was used to assess the historic seasonal contribution of local hydrology to the hydraulics of the GIWW. The Brazos River has a negligible contribution of local hydrology (i.e. downstream of the USGS-Rosharon gage). Furthermore, while the San Bernard River did have a significant contribution from local hydrology, the overall flow into the system in the San Bernard watershed is an order of magnitude smaller than in the Brazos. Thus, the local hydrology of the San Bernard watershed was also excluded from the model. Like the Brazos, the lower reaches of the Colorado River also have negligible freshwater inflow/tributaries.

For the evaluation of the Colorado River, no hydrologic model was developed. The flows in the Colorado River are measured by the USGS at Bay City, TX. The measured flows were applied as a model boundary condition. Precipitation and evaporation were applied to the Colorado River model. For the reasons stated above, hydrological models were excluded from the Brazos and Colorado AdH model development.

For further details of the AdH models, refer to **Hydraulic Engineering Appendix – Colorado River Locks and Hydraulic Engineering Appendix – Brazos River Floodgates of the Engineering Appendix**

The changes in sedimentation in various areas at the river crossings were used to develop O&M dredging estimates for the various alternatives. **Figure 3-4** depicts the assigned sediment deposition areas for the Brazos River Crossing. The changes in sedimentation volumes relative to the FWOP at Brazos River are provided in **Table 3-11.** The column labeled "Total in Zones Requiring Maintenance" provides a summation of the deposition in areas that will require dredging maintenance, i.e. the West GIWW, Brazos Basin, East GIWW, and Freeport Channel zones only. The Brazos Delta and Freeport Offshore are not included in this maintenance.

Figure 3-4 - BRFG Sediment Deposition Areas

The Brazos Open Channel Alternative (9a), shows significant increases in sedimentation for the Freeport Channel. The Alternative 3a shows similar sedimentation to existing conditions and the hybrid Alternative (3a.1) shows slight increases in sedimentation along the GIWW west of the crossing compared to the FWOP.

Table 3-11 - Average Annual Sediment Deposition and Percent Increase at BRFG

Alternative	West GIWW	Brazos Basin	East GIWW	Freeport Channel	Brazos Delta	Freeport Offshore	Total in Zones Requiring Maintenance
Existing/2a	554,769	48,000	890,769	295,385	44,382,462	208,726	1,788,923
3a	493,846	59,077	902,769	316,615	44,332,615	190,864	1,772,307
	(-11%)	23%	1%	7%	0%	(-8%)	(-0.1%)
3a.1	653,130	58,332	902,653	326,420	44,000,887	196,239	1,940,535
	18%	22%	1%	11%	(-1%)	(-6%)	8%
9a	781,846	92,308	1,079,077	978,462	42,026,769	854,614	2,931,693
	41%	92%	21%	231%	(-5%)	309%	64%
9b	780,923	96,923	1,044,000	550,154	43,232,308	396,989	2,472,000
	41%	102%	17%	86%	(-3%)	90%	38%
9c	781,846	107,077	1,044,000	550,154	43,218,462	395,887	2,483,077
	41%	123%	17%	86%	(-3%)	90%	39%

For detailed information concerning the sediment analysis, see the **Hydraulic Engineering Appendix – Brazos River Floodgates of the Engineering Appendix**.

Figure 3-5 depicts the assigned sediment deposition areas for the Colorado River crossing and **Table 3-12** provides the changes in sedimentation volumes relative to the FWOP at Colorado River. For the Colorado open channel alternative (3b), a significant increase in sedimentation in the GIWW was noted compared to the FWOP condition. Sedimentation patterns for Alternative 4b.1 were nearly identical to the FWOP conditions.

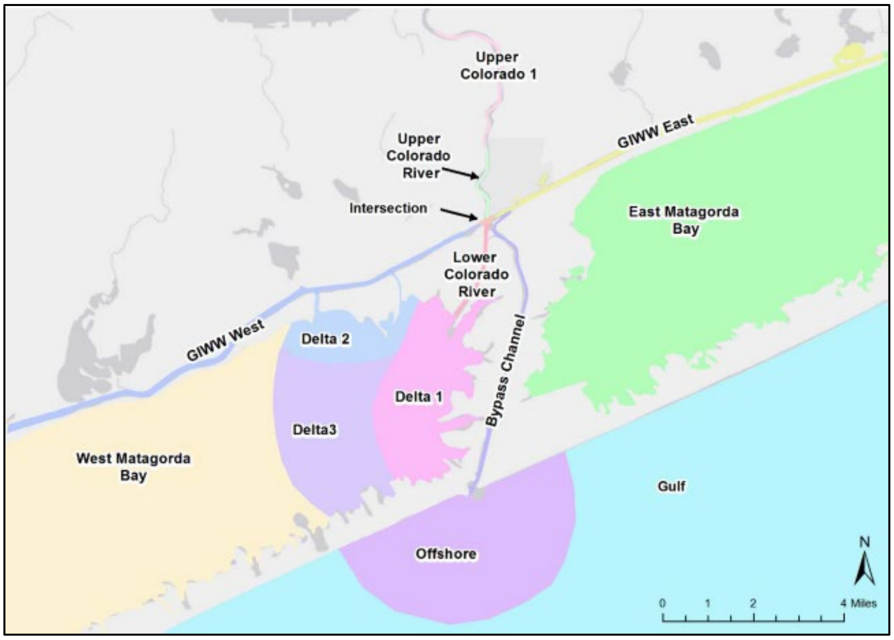

Figure 3-5 - CRL Sediment Deposition Areas

Table 3-12 - Average Annual Sediment Deposition at CRL

Average Annual Deposition - Results Based on 2016 Simulation Regression Analysis			
Area of Interest	**Existing** *(cy)*	**Open Channel** *(cy)*	**Percent Difference**
GIWW East	88,921	476,787	436
GIWW West	212,956	834,907	292
Bypass Channel	70,519	171,101	143
Intersection	11,789	30,017	155
Delta 1	2,432,825	2,206,549	-9
Delta 2	651,095	791,945	22
Delta 3	1,450,778	765,962	-47
Offshore	360,739	799,477	122

Table 3-12 does not include all of the sediment zones depicted in **Figure 3-5**. For detailed information concerning the sediment analysis, see the **Hydraulic Engineering Appendix – Colorado River Locks of the Engineering Appendix**. Complete removal of the locks increases the total volume of suspended sediment because velocity in the main channel increases.

Velocity and stage data for the various alternatives was provided to the economic team to determine the delays associated with each alternative due to the river conditions.

3.8.2 **Structural Analysis for BRFG and CRL**

Rehabilitation of the existing projects was assessed without the use of detailed engineering reliability or economic risk analysis. These analyses are typically used to estimate the expected navigation impacts and other economic impacts due to operating old and unreliable equipment and structures. Detailed reliability risk analysis was not performed because the focus of the feasibility study was accident risk and navigation delays, not a major rehabilitation report. Rehabilitation of the project was based on past practices and expert elicitation from the operating personnel on what components needed to be rehabilitated to ensure continued reliability of the existing projects.

The key issues of the existing structures were location and function of gate operating machinery, damage to guidewall approaches particularly on the river side, damage to existing gates due to normal operation of vessel pass through, and large amount of crustacean life accumulation on gates which overtime has led to substantial weight increases. The structural rehabilitation alternatives focused on providing updated gate operating machinery that can operate when submerged if necessary and appropriate new housing for specific components. Updated electrical systems featuring new wiring and controls would be integrated with the machinery. The gates would be removed, repaired as necessary, sandblasted, and coated with a paint system best suited for saltwater environment of close proximity to the Gulf. The existing sheet pile approach guidewalls would be replaced as necessary with a new composite panel system that can resist impacts to alleviate damage to the guidewalls.

The alternatives consisting of structure replacement at the Brazos River floodgate would consist of new 125-foot-wide sector gates that match the authorized GIWW channel width. The existing gates/locks at both sites are 75 foot wide. The new sector gates features would also include guidewalls, channel rip rap, dewatering equipment, and dewatering storage. The dewatering system would be designed to allow for continued passage through the GIWW while gate recess can be dewatered, gates serviced, and put back into operation. The structures would also feature new control houses for both personnel and operating machinery.

Quantity take-offs for alternatives involving structures were performed to generate costs estimates. Original drawings were used to estimate concrete wall demolition, gate removal, guidewall removal and gate rehabilitation/painting. For new structures, slab/wall thicknesses were estimated based on similar sector gates in the Louisiana hurricane protection system. Gate member sizes were similarly based on known structures. The foundation for the new gate structure was assumed to be 30-inch pipe piles, with pile number and length estimated bases on similar gate foundations in the Southeast Louisiana area. This along with typical guidewall design, dewatering systems, machinery sizes, electrical, pre-engineered control houses, and channel rip rap were quantified for the cost estimate.

3.8.3 **Cost Estimates**

The project cost estimate for the GIWW BRFG and CRL Feasibility Study was developed in the MCACES MII cost estimating software and used the standard approaches for a feasibility estimate structure. An analysis was conducted for each line item evaluating quantity, production rate, and time, together with the appropriate labor, equipment, materials, crews, unit prices, quotes, and sub- and prime contractor markups. The estimate assumes a typical application of tiering subcontractors. The cost estimate was prepared based on readily available New Orleans District (MVN) and Galveston District (SWG) data and quantities provided for CRL by MVN Structures Branch and for BRFG by TxDOT. This philosophy was taken wherever practical and supplemented with estimating information from other sources where necessary such as the previous contracts for the same type work on these same structures, quotes, bid data, and A-E estimates. The intent was to provide or convey a “fair and reasonable” estimate which depicts the local market conditions.

All of the construction work (e.g., sector gate structures, dredging, excavation, dewatering, pilings, rock, etc.) is common to the Gulf coast region. The construction sites are accessible from land and water. Access is easily provided from the Gulf of Mexico, GIWW, or various local highways.

Contingencies were also developed using the USACE Abbreviated Cost Risk Analysis (ARA) program based on cost risks determined by the PDT. A separate ARA was prepared for each alternative to help differentiate between the different alternatives. See **Table 3-13** for a summary of first construction cost. For a detailed breakdown of the costs, refer to **Appendix A, Engineering Appendix, Paragraph 5.2 titled *"Baseline Project Cost for Each Alternative"***.

Table 3-13 – Alternative First Construction Costs ($000)

Brazos River Floodgates	
Alternative	**First Construction Cost**
Existing Condition	$0
2a Rehab	$44,940
3a – Move gates back	$266,819
3a.1 – Move gate back east + open channel west	$147,818
9a – Open Channel	$29,303
9b – New gates align C w/o Sediment Control	$258,087
9c – New gates Align C with Sediment Control	$272,226
Colorado River Locks	
Alternative	**First Construction Cost**
Existing Condition	$0
2b.1 - Major Rehab	$48,409
4a - Remove R/S Gates	$36,862
4b.1 – Hybrid – Rehab inland gate + Remove R/S gate	$63,149
Alt 3.b - Open Channel	$21,592

3.8.4 O&M Costs

Anecdotal O&M data was supplied by SWG Operations Division personnel based on historical data. The data included yearly maintenance costs on the structures, major maintenance cost and frequency on the structures, average yearly dredge quantities along the GIWW, estimated dredging costs based on recent dredging contracts, and remaining capacity of the existing disposal sites.

A comparison of the historical dredge quantities was made versus the sediment deposition predicted by the AdH models. Because the AdH models output total of channel deposition included quantities from top of bank to top of bank and does not account for the consolidation that may occur in the deposited material, the yearly historical dredge quantities were less than those predicted by the AdH model. Therefore, the O&M dredging costs for the various alternatives was developed by pro-rating the quantities predicted by the AdH model by the ratio of the AdH predicted sediment values for the existing condition to the actual historical dredge quantities.

3.9 COMPARISON OF ALTERNATIVES

The team then compared the alternatives to the decision criteria. Criteria used to evaluate the remaining alternatives included a comparison to see if objectives have been met, improvements to system functionality, environmental impacts, and evaluation of costs and benefits of the proposed modifications. At each stage of the process the team looked at the measures, the initial alternatives, the focused alternatives and cross checked them to ensure we were meeting the intent of each objective which also address the study problems; and to determine what the environmental impacts

While rehabilitation of the structures would be a least cost option, it did little in the way of meeting the objectives or improving the navigation functions. The "hybrid" plan(s) for Brazos/Colorado would improve the navigation on the system by creating larger forebays for navigation traffic, thus reducing accidents and allowing for continued sediment management in the GIWW. The open channel would reduce the cost of maintenance and reduce accidents that occur at the structures. However, there is considerable uncertainty in the sediment modeling to determine in any given year the sediment transport through the system or where it would cause shoaling and potential grounding of vessels, as well as shipping delays due to dredging activities. Additionally, the open channel would have increased impacts to downstream navigation operations by pushing sediment down into areas such as Freeport as well as critical environmental habitats near Matagorda Bay which are a part of ongoing studies in the region.

3.9.1 **Economic Analysis of the Final Array of Plans**

To quantitatively analyze and compare alternatives, monetized benefits of the above alternatives were estimated using a stand-alone model developed for the study. The benefits were then compared to estimated costs to develop benefit-cost ratios and net benefits estimates. These metrics were used to select the NED plan, the plan which reasonably maximizes net benefits. Implementation and maintenance costs were developed by engineering members of the PDT. The economic analysis was primarily focused on the estimation of baseline FWOP and alternative transportation costs.

These benefits were calculated utilizing the Waterway Limited Cost Estimator for Navigation (WLCEN) model. The WLCEN model estimates tow level transit times through a user defined navigation system, including incurred delay times due to service disruption events. The model uses a combination of user specified static inputs and probability distributions to define a project or projects within the system, traffic levels and composition, river conditions, operating policies, and probabilistic service disruptions.

The general theory underlying this model is that assuming modal shifts do not commonly occur in response to changes in transportation costs, and thus system equilibrium, traffic given a defined condition should generally mirror observed traffic under the existing condition. The vast majority of existing condition traffic delay or disruption impacts and thus the degree to which an alternative can reduce these impacts (benefits) can be closely approximated by computing the total cost of vessel delays in the existing and alternative conditions, and taking the difference.

A more detailed discussion of the modeling concept and general framework is located in Appendix B: Economics. Per the 04 December 2017 memo: *Modification of the Model Certification Process and Delegation of Model Approval for Use,* which modified EC 1105-2-412, the WLCEN has received a single-use certification from the USACE Planning Center of Expertise for Inland Navigation and Risk-Informed Economics Division (PCXIN-RED) for use on this study.

This custom model was developed to estimate these benefits in lieu of the traditional equilibrium modeling approach. Early in the study process, several unique characteristics of the projects analyzed were identified which necessitated this non-standard modeling approach. These characteristics are as follows:

1. Nature of significant problems/opportunities – The primary identified existing condition issue impacting traffic on this stretch of the GIWW is the frequency of allisions (vessels colliding with gate or lock structures) and the resultant closures of these projects to affect repairs. In particular, at the BRFG, a significant number of accidents occur yearly, and result in periodic closures for repairs. These closures cause direct delays, as well as indirect delays resulting from queuing following the service disruption event. These service disruption events are scheduled closures, occurring Monday through Friday, 7:00 to 17:00, for the duration of the repair. As such, these closures do not result in significant, long duration outages, but rather frequent short duration closures which significantly slow the processing of traffic.

2. Short disruption events – Interviews were conducted by Martin and Associates (by contract with TxDOT) with shippers using the analyzed stretch of the GIWW. These users included Texas Lehigh Cement, Formosa, Philips 66, Oil Tanking, Dow Seadrift, Citgo Refinery, NuStar Energy, and Valero Refinery. These interviews indicated that existing condition delays do not generally result in the use of overland routes, given waterway service disruptions. Interviewed shippers stated that only in very rare cases in which a week or more of contiguous service disruption occurred would inventory stocks be jeopardized. As the majority of service disruption events are scheduled (resulting from accidents), they do not result more than 10 hours of contiguous closure.

3. Traffic Commonality – The BRFG and CRL are separated by 40 miles, with few commercial docks located between the projects. The average width of the GIWW between

the Brazos and Colorado Rivers is estimated between 300-450 feet with the narrowest point being a 130 feet wide bridge underpass located at approximately Mile 418 on the GIWW. Several streams and rivers flow into the GIWW along this route, with a few areas of minor open water navigation. Aerial imagery shows multiple fleeting/mooring locations in between, but no infrastructure for loading or unloading barges along the GIWW. The San Bernard River meets the GIWW at GIWW Mile 405 and supports limited commercial navigation for approximately 26 miles. This route is highly congested due to bends, river crossings, and private docks. Approximately 500,000 tons of commercial navigation on average takes place along this waterway.

According to lock operators, less than one percent of traffic traverses one lock or gate and turns up the Brazos River, while approximately one million tons on average utilizes one Colorado Lock and travels up the Colorado River without crossing the other lock. **Table 3-14** shows the average annual tonnage at Brazos and Colorado from 2010 through 2014 demonstrates the high level of commonality between projects.

Table 3-14 - Average Annual Tonnage Commonality

Project Name	Average Tonnage	Average Through All	Commonality
Brazos Floodgates	22,497,593	21,038,012	97%
Colorado Locks	21,607,965		99%

Source: Waterborne Commerce Statistics 2010-2014

The general theory underlying the WLCEN model is that the vast majority of benefits in terms of reduced traffic delay or disruption impacts can be closely approximated simply by computing the total cost of vessel delays in both the FWOP and FWP conditions, and taking the difference.

An equilibrium analysis would quantify the consumer surplus, or willingness-to-pay for barge transportation in the existing condition and equilibrium traffic levels, and again in each analyzed alternative condition, and subtract the latter from the former to estimate benefits in terms of rate savings. Given however, a sharply inelastic demand curve, as would represent the unavailability or high relative cost of alternate overland modes, the relative contribution of quantifying this consumer surplus towards estimation of FWOP and FWP transportation costs would be very small. If the amount of traffic on the system, as indicated by shippers, is very insensitive to the price of moving commodities on that system, reductions in that price would almost entirely be enjoyed by current users of the system. If the system is in effect a closed one, the vast majority of benefits would accrue to current users of the waterway, and can be accurately captured without the quantification of this consumer surplus.

Extending from this premise, if the total equilibrium cost of waterway transportation for a given movement involves all transportation rates between origin and destination, knowing or quantifying this total linehaul cost is not necessary to evaluate alternative benefits. All components of this linehaul cost other than delay costs will be the same in both the existing condition and alternative condition. As such, the benefits of a given alternative can be defined as the reduction in total vessel delay in hours multiplied by the hourly operating cost. The model is designed to estimate this total vessel delay.

This vessel delay time can be further broken down into the following four categories:

1. Processing time - the time tows spend processing through project non-inclusive of delay
2. Queuing time - the time tows spend waiting in queue to begin processing
3. Tripping time - the time tows spend breaking, reassembling, and performing other tasks necessary to trip multiple barges; and
4. Closure delay time - the time tows spend delayed due to river or accident related closures. These delay categories are the primary output of the WLCEN model

The model performs Monte Carlo uncertainty analysis, by sampling uncertain input parameters from probability distributions. Uncertain inputs include accident probabilities, ranges of river condition, tow size and other characteristics, and others. This results in a distribution of possible outputs (total transit time), which is representative of output uncertainty. Delay times were monetized using average hourly vessel operating cost for various activities. The distribution of baseline FWOP condition outputs (total annual transit cost for all traffic, in dollars) for BRFG and CRL, are illustrated in **Figure 3-6** and **Figure 3-7**, respectively.

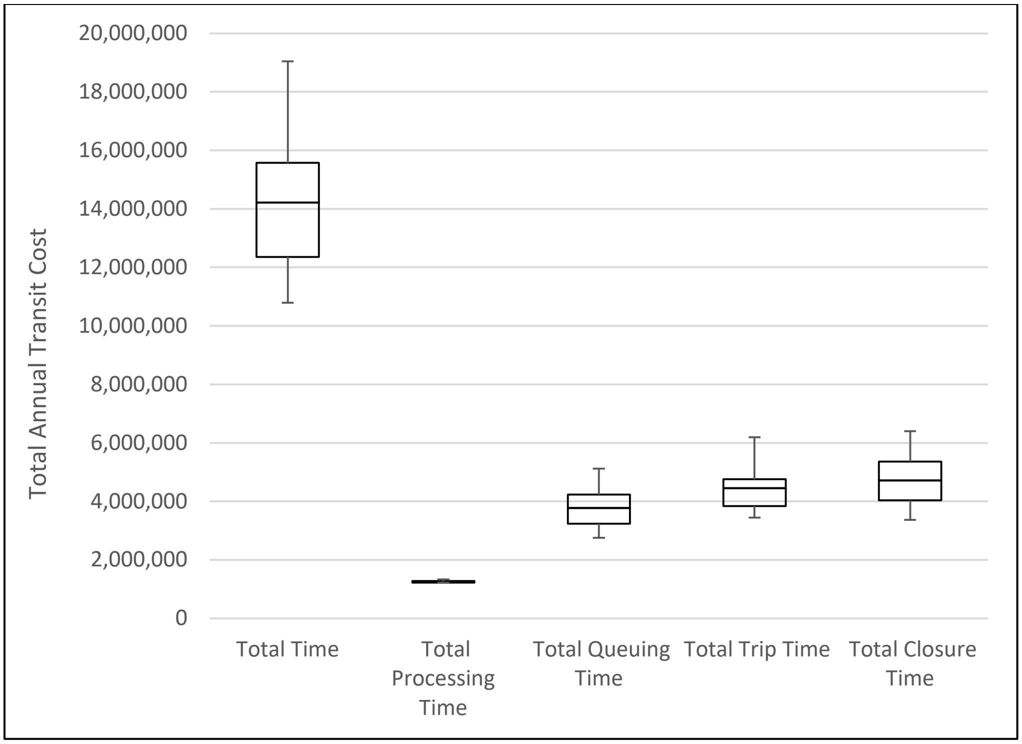

Figure 3-6 - Baseline Total Transit Cost, BRFG

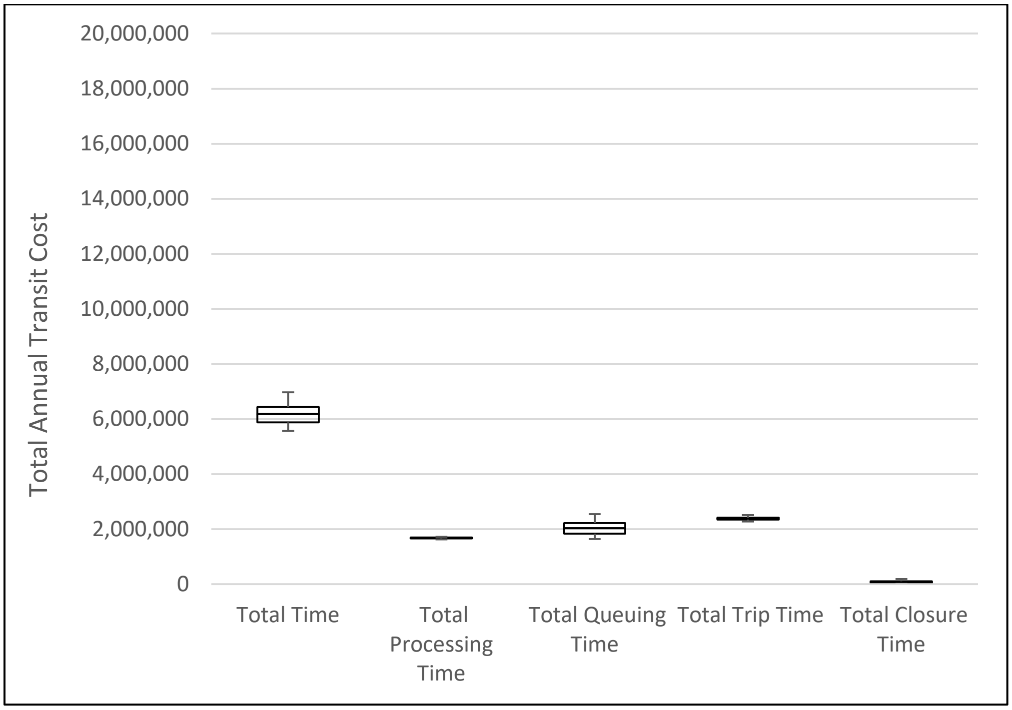

Figure 3-7 - Baseline Total Transit Cost, CRL

First Cost of Construction, as well as incremental (increase or decrease in) O&M, Operations, Maintenance, Repair, Rehabilitation, and Placement (OMRR&R), Upland/Offshore Disposal, Bank Realignment, Accident and Tripping Reductions, Real Estate (LERRDS), and mitigation and monitoring costs are all included in alternative costs. Avoided accident repair costs and avoided OMRR&R represent additional benefit categories.

As the system analyzed includes two projects, alternatives at both projects were analyzed separately (the project specific alternative analyzed in combination with the baseline condition at the other), and together in all possible permutations. Because the project operates as a system, changes at one project can have significant impacts at the other. If for example accident frequency is reduced at the BRFG, the size and frequency of large queues at that project will reduce, which will in turn reduce the frequency of large clusters of down-bound tows arriving consecutively at the CRL, where they will incur additional queuing delay.

Table 3-15 illustrates the annualized cost of each permutation of alternatives and their net benefits as well as their BCR ratio from the TSP milestone economic analysis. The Alternative name in the first column represents the alternative at Brazos first, followed by the alternative at Colorado, with "EC" denoting the existing condition.

Table 3-15 - System Benefit Analysis for Alternatives ($000)

Alt ID	BRFG	CRL	Total Annual Cost	Total Annual Benefit	Net Benefits	BCR
			October 2017 Price Level[1] and 2.75 Percent Interest Rate			
EC-EC	Existing	Existing	-	-	-	-
EC-3b	Existing	Open Channel	5,956	7,737	1,781	1.3
EC-4b.1	Existing	River Side Gate Removal	1,412	8,219	6,807	5.8
9a-EC	Open Channel	Existing	11,467	18,569	7,102	1.6
9a-3b	Open Channel	Open Channel	17,423	24,390	6,967	1.4
9a-4b.1	**Open Channel**	**River Side Gate Removal**	**10,860**	**22,321**	**11,461**	**2.1**
3a-EC	125-foot Gates Existing Align	Existing	10,505	11,432	927	1.1
3a-3b	125-foot Gates Existing Align	Open Channel	16,358	17,421	1,063	1.1
3a-4b.1	125-foot Gates Existing Align	River Side Gate Removal	11,918	17,289	5,371	1.5
9c-EC	12-foot Gates Align C	Existing	20,470	9,715	(10,756)	0.5
9c-3b	125-foot Gates Align C	Open Channel	26,426	15,205	(11,221)	0.6
9c-4b.1	125-foot Gates Align C	River Side Gate Removal	19,863	13,194	(6,669)	0.7
3a.1-EC	125-foot Gate East/Open West	Existing	7,782	14,600	6,817	1.9
3a.1-3b	125-foot Gate East/Open West	Open Channel	13,738	20,376	6,638	1.5
3a.1-4b.1	**125-foot Gate East/Open West**	**River Side Gate Removal**	**7,175**	**18,252**	**11,077**	**2.5**

[1] Screening costs and benefits remain the same as they were when the screening process occurred.

Alternative 9a (open channel) at the Brazos River and 4b.1 (river side gate removal) for Colorado yield the highest net benefits at $11,461,000 with a BCR of 2.1. However, there is significant uncertainty regarding the rate of sedimentation in an open system and how it would impact future navigation functionality and what environmental impacts may be associated with increased sediment loads into areas that are currently important habitats for fishery/aquatic resources.

Additional uncertainty exists as to the logistics of executing the dredging activities costed in the cost/benefit analysis, in particular, if sedimentation volumes exceed those modeled. Uncertainties that have not been sufficiently captured in the analysis to date include how frequently dredging would need to occur, whether or not multiple mobilization and demobilization costs for dredge contracts within one year could be incurred, and whether or not the capability exists to dredge as necessary to maintain a navigable channel without impacts to traffic.

Industry representatives of the Port of Freeport have indicated that during periods in which the existing east gate at Brazos River is open, increased cross currents are observed in the Freeport Channel. It is expected that given an open channel condition these increased velocities could impede traffic in and out of the channel. With these considerations in mind, the team determined that, while the highest net benefits are found in the open channel (9a) at Brazos and Gate Removal (4b.1) at Colorado plan, the potential risk and uncertainty of environmental, navigation, and system impacts may have significant impacts over time; especially with sediment increases at Freeport.

ER 1105-2-100, Planning Guidance Notebook, Exhibit G-1, line 3.c of the General Evaluation Guidelines, states that “Identification of the NED plan is to be based on consideration of the most effective plans for providing different levels of output or service. Where two cost-effective plans produce no significantly different levels of net benefits, the less costly plan is to be the NED plan, even though the level of outputs may be less.” As shown above in **Table 3-15**, the next best alternative that avoids these critical uncertainties in continued system function is 3a.1 at BRFG and 4b.1 at CRL. Given the similarity in net NED benefits between Alternative 9a-4b.1 and Alternative 3a.1-4b.1 as shown above in **Table 3-15,** the latter alternative is assumed to reasonably maximize net benefits, as it minimizes the risk posed by these uncertainties. The presence of the gate on the east side of the Brazos River eliminates the vast majority of expected increase in sedimentation as well as likely minimizes potential velocity impacts to traffic in the Freeport Channel. This combination provides the best system alternative plan in meeting our navigation missions for the region and is identified as the NED plan.

The following tables break out the benefits and costs for the 3a.1-4b.1 Alternative. **Table 3-16** provides the benefit-cost details for the BRFG component of the TSP and **Table 3-17** provides the benefit-cost details for the CRL component of the TSP. **Table 3-18** provides the combined benefit-cost details for the system (BRFG + CRL).

Table 3-16 - Benefit-Cost Detail, Tentatively Selected Plan, BRFG ($000)

Benefit - BRAZOS RIVER FLOODGATES	FWOP	FWP	Benefit
	October 2017 Price Levels and 2.75 % Interest Rate[1]		
Transit Time			
Processing Time	$1,280	$870	$410
Queuing Time	$3,769	$648	$3,121
Tripping Time	$4,450	$1,256	$3,193
Closure Delay Time	$4,713	$454	$4,259
Total	**$14,211**	**$3,228**	**$10,983**
O&M			
Normal O&M	$1,750	$1,750	$0
Maintenance Dredging	$17,905	$20,023	$0
Periodic Major Maintenance	$1,200	$600	$600
Maintenance Closure Impact Costs	$0	$0	$0
Total	**$20,855**	**$22,373**	**$600**
Accidents			
Accident Repair Cost	**$984**	**$185**	**$800**
Total Annual Benefit	**0**	**0**	**$12,383**
Incremental Cost - BRAZOS RIVER FLOODGATES	FWOP	FWP	Cost
Investment Cost			
Annualized Construction Cost w/ IDC	**$0**	**$5,664**	**$5,664**
O&M			
Normal O&M	$1,750	$1,750	$0
Maintenance Dredging	$17,905	$20,023	$2,118
Periodic Major Maintenance	$1,200	$600	$0
Maintenance Closure Impact Costs	$0	$0	$0
Total	**$20,855**	**$22,373**	**$2,118**
Total Annual Cost			**$7,782**
NET BENEFIT			**$4,600**
BCR			**1.59**

[1] These were the costs and benefits post screening at October 2017 price levels and 2.75% interest rate. Costs and benefits are updated for the Recommended Plan in Chapter 4.

Table 3-17 - Benefit-Cost Detail, Tentatively Selected Plan, CRL ($000)

Benefit - COLORADO RIVER LOCKS	FWOP	FWP	Benefit
	October 2017 Price Levels and 2.75 % Interest Rate[1]		
Transit Time			
Processing Time	$1,679	$835	$844
Queuing Time	$2,040	$285	$1,755
Tripping Time	$2,391	$651	$1,740
Closure Delay Time	$75	$61	$14
Total	**$6,185**	**$1,832**	**$4,353**
O&M			
Normal O&M	$1,750	$1,750	$0
Maintenance Dredging	$4,424	$2,405	$2,020
Periodic Major Maintenance	$2,400	$1,200	$1,200
Maintenance Closure Impact Costs	$0	$0	$0
Total	**$8,574**	**$5,355**	**$3,220**
Accidents			
Accident Repair Cost	**$317**	**$0**	**$317**
Total Annual Benefit	**0**	**0**	**$7,889**
Incremental Cost - COLORADO RIVER LOCKS	FWOP	FWP	Cost
Investment Cost			
Annualized Construction Cost w/ IDC	**$0**	**$1,412**	**$1,412**
O&M			
Normal O&M	$1,750	$1,750	$0
Maintenance Dredging	$4,424	$2,405	$0
Periodic Major Maintenance	$2,400	$1,200	$0
Maintenance Closure Impact Costs	$0	$0	$0
Total	**$8,574**	**$5,355**	**$0**
Total Annual Cost			**$1,412**
NET BENEFIT			**$6,477**
BCR			**5.59**

[1] These were the costs and benefits post screening at October 2017 price levels and 2.75% interest rate. Costs and benefits are updated for the Recommended Plan in Chapter 4.

Table 3-18 - Benefit-Cost Detail, Tentatively Selected Plan, BRFG + CRL ($000)

Benefit - SYSTEM TOTAL	FWOP	FWP	Benefit
	October 2017 Price Levels and 2.75 % Interest Rate[1]		
Transit Time			
Processing Time	$2,959	$1,706	$1,253
Queuing Time	$5,808	$933	$4,876
Tripping Time	$6,840	$1,907	$4,933
Closure Delay Time	$4,788	$514	$4,273
Total	**$20,396**	**$5,060**	**$15,336**
O&M			
Normal O&M	$3,500	$3,500	$0
Maintenance Dredging	$22,329	$22,428	$0
Periodic Major Maintenance	$3,600	$1,800	$1,800
Maintenance Closure Impact Costs	$0	$0	$0
Total	**$29,429**	**$27,728**	**$1,800**
Accidents			
Accident Repair Cost	**$1,301**	**$185**	**$1,117**
Total Annual Benefit	**0**	**0**	**$18,252**
Incremental Cost - SYSTEM TOTAL	FWOP	FWP	Cost
Investment Cost			
Annualized Construction Cost w/ IDC	**$0**	**$7,077**	**$7,077**
O&M			
Normal O&M	$3,500	$3,500	$0
Maintenance Dredging	$22,329	$22,428	$99
Periodic Major Maintenance	$3,600	$1,800	$0
Maintenance Closure Impact Costs	$0	$0	$0
Total	**$29,429**	**$27,728**	**$99**
Total Annual Cost			**$7,175**
NET BENEFIT			**$11,077**
BCR			**2.54**

[1] These were the costs and benefits post screening at October 2017 price levels and 2.75% interest rate. Costs and benefits are updated for the Recommended Plan in Chapter 4.

3.10 IDENTIFICATION OF THE NED PLAN (TSP)

The recommended NED system plan for this study is the hybrid alternative (3a.1) for BRFG and a refined alternative (4b.1) for CRL. The BRFG alternative would be in the existing channel alignment with open channel on the west side and a gate structure (125-feet) on the east side (**Figure 3-8**). The CRL would also be in the existing channel alignment and would include gate removal of the riverside locks (west) with retainment of the outer gates (east) (**Figure 3-9**). This would result in the creation of additional forebay at Colorado, reducing barge strikes against the guidewalls.

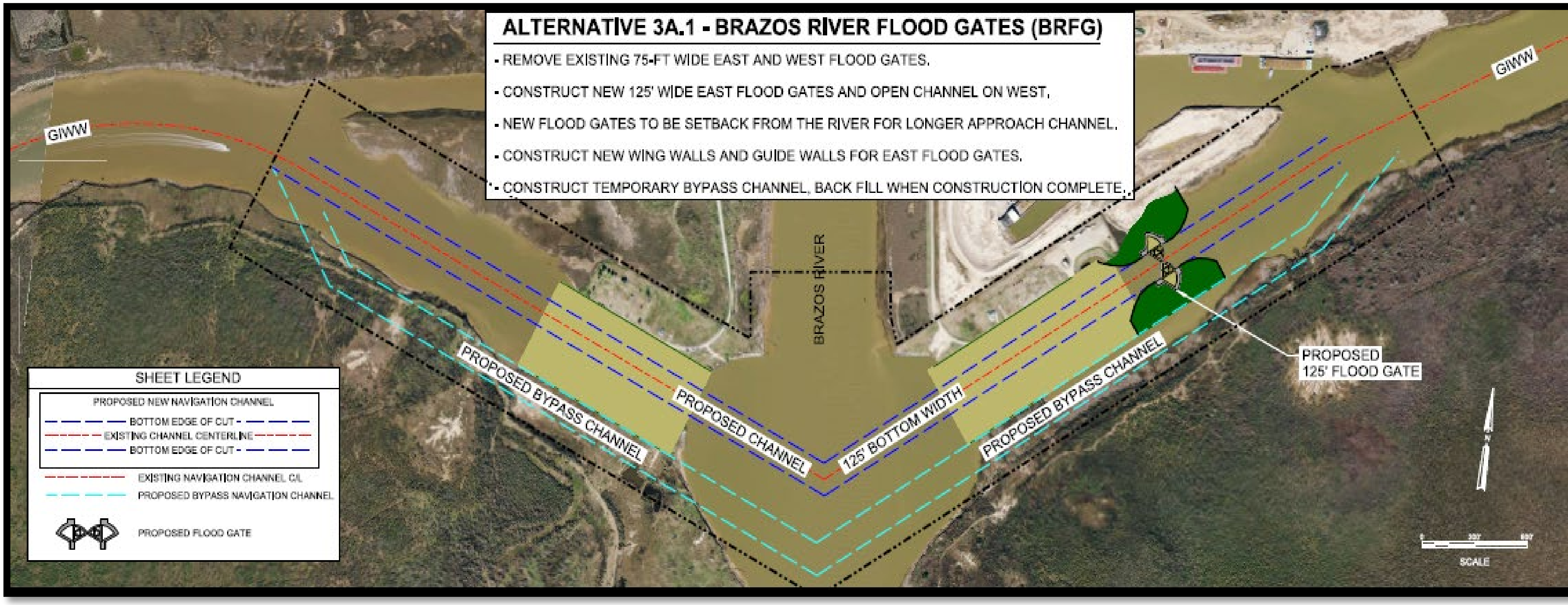

Figure 3-8 - BRFG Components of TSP Plan – Alternative 3a.1

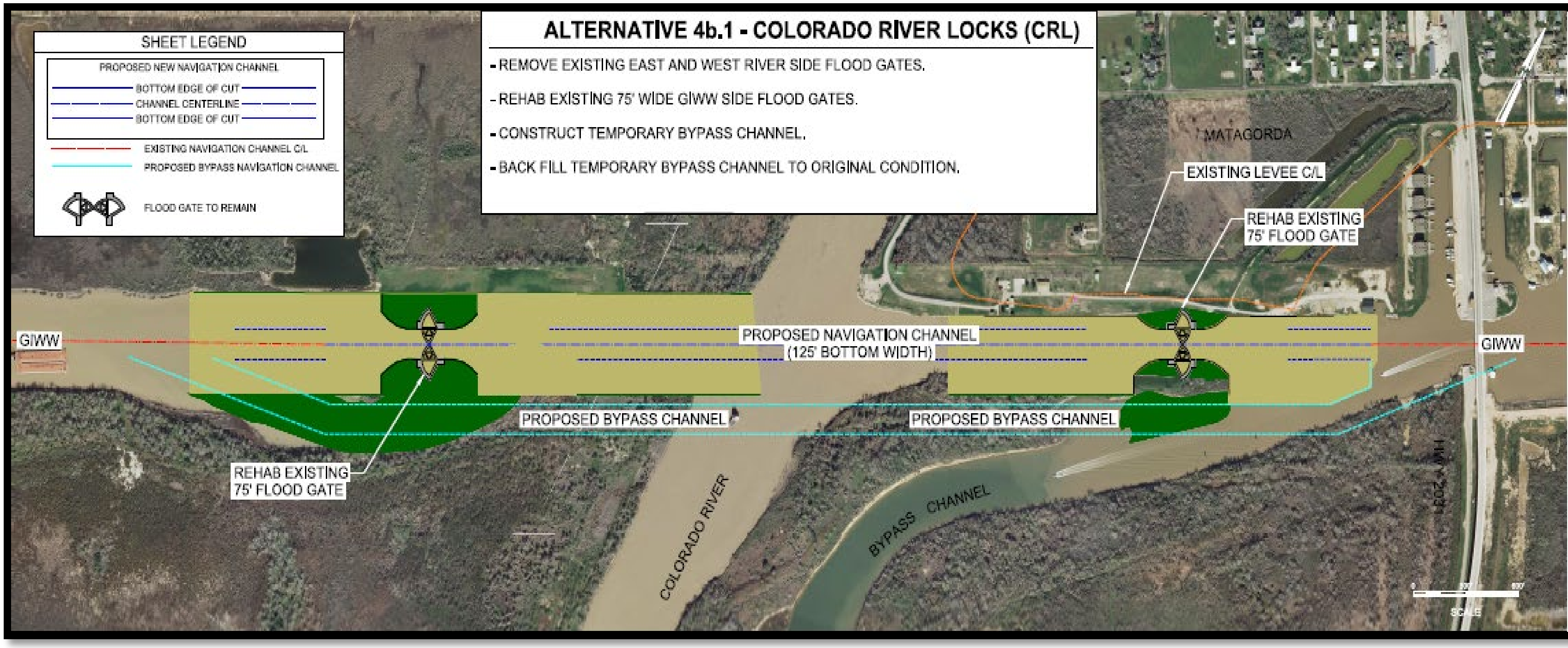

Figure 3-9 - CRL Component of TSP Plan – Alternative 4b.1

The system plan yields a Net Benefit of $11,077,687 with a BCR of 2.5. This Alternative reasonably maximizes the net benefits and has fewer environmental impacts. Unlike the open channel, it reduces uncertainty with sedimentation impacts throughout the wider navigation system. This in turn ensures the continued function and movement of commerce along the GIWW. **Table 3-19** demonstrates the project first cost comparison for the navigation system, at Brazos, and at Colorado.

Table 3-19 - Project First Cost Comparison Summary ($000)

Cost Account and Feature	Project First Cost Totals		
	BRFG	CRL	System
	October 2017 Price Levels and 2.75 % Interest Rate		
Construction	$112,343	$28,008	$140,351
Lands and Damages	$33	$20	$53
Preconstruction Engineering and Design	$22,865	$5,701	$28,566
Construction Management	$12,577	$3,134	$15,711
Total Project First Cost	**$147,818**	**$36,862**	**$184,680**

3.11 PLANNING AND GUIDANCE CRITERIA

Each Alternative was formulated in consideration of the four criteria (completeness, effectiveness, efficiency, and acceptability) described in the *Water Resources Council's Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies*, dated March 1983 (P&G).

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

While all of the alternatives would improve the project in some way while avoiding and minimizing environmental impacts to the greatest extent possible during the 50-year period of analysis, Alternative 3a.1-4b.1 is the plan with the second greatest net excess benefit but without the substantial increase in sediment that the plan with the highest net benefits (9a-4b.1) would cause. Therefore, Alternative 3a.1-4b.1 is considered the most complete, efficient, and effective plan; the plan that best meets the four P&G criteria (**Table 3-20 through Table 3-23**).

Table 3-20 - Comparison of P&G Evaluation Criteria (Acceptability & Completeness) for Alternatives

Alternative #	No Action (EC-EC)	EC-3b	EC-4b.1	9a-EC	9a-3b	9a-4b.1	3a-EC	3a-3b
Criteria	**FWOP**	**BRFG Existing / CRL Open Channel**	**BRFG Existing / CRL River Side Gate Removal**	**BRFG Open Channel / CRL Existing**	**BRFG Open Channel / CRL Open Channel**	**BRFG Open Channel / CRL River Side Gate Removal**	**BRFG 125-foot Gates Existing Alignment / CRL Existing**	**BRFG 125-foot Gates Existing Alignment / CRL Open Channel**
Acceptability (meets all laws, regulations and guidance)	Acceptable	Acceptable	Acceptable	Acceptable	Acceptable	Acceptable	Acceptable	Acceptable
Completeness (provides and accounts for all necessary investments or other actions to ensure the realization of the planning objective)	● No Action is an Incomplete solution to all planning objectives	● Plan is an incomplete solution; it provides some improvement in navigation efficiency over No Action but does not maximize transportation benefits when compared to other alternatives	● Plan is an incomplete solution; it provides some improvement in navigation efficiency over No Action but does not maximize transportation benefits when compared to other alternatives	● Plan is an incomplete solution; it provides some improvement in navigation efficiency over No Action but does not maximize transportation benefits when compared to other alternatives	● Plan is an incomplete solution; it provides some improvement in navigation efficiency over No Action but does not maximize transportation benefits when compared to other alternatives	● Plan is a complete solution; it provides improvement in navigation efficiency over No Action and maximizes transportation benefits when compared to other alternatives, including the Recommended Plan; however, it substantially increases sedimentation	● Plan is an incomplete solution; it provides some improvement in navigation efficiency over No Action but does not maximize transportation benefits when compared to other alternatives	● Plan is an incomplete solution; it provides some improvement in navigation efficiency over No Action but does not maximize transportation benefits when compared to other alternatives

Table 3-21 - Comparison of P&G Evaluation Criteria (Acceptability & Completeness) for Alternatives (Continued)

Alternative #	3a-4b.1	9c-EC	9c-3b	9c-4b.1	3a.1-EC	3a.1-3b	3a.1-4b.1 TSP
Criteria	BRFG 125-foot Gates Existing Alignment / CRL River Side Gate Removal	BRFG 125-foot Gates Align C / CRL Existing	BRFG 125-foot Gates Align C / CRL Open Channel	BRFG 125-foot Gates Align C / CRL River Side Gate Removal	BRFG 125-foot Gate East/Open West / CRL Existing	BRFG 125-foot Gate East/Open West / CRL Open Channel	BRFG 125-foot Gates Existing Alignment / CRL River Side Gate Removal
Acceptability (meets all laws, regulations and guidance)	Acceptable	Acceptable	Acceptable	Acceptable	Acceptable	Acceptable	Acceptable
Completeness (provides and accounts for all necessary investments or other actions to ensure the realization of the planning objective)	● Plan is an incomplete solution; it provides some improvement in navigation efficiency over No Action but does not maximize transportation benefits when compared to other alternatives	● Plan is an incomplete solution; and does not reach unity.	● Plan is an incomplete solution; and does not reach unity.	● Plan is an incomplete solution; and nearly reaches unity.	● Plan is an incomplete solution; it provides some improvement in navigation efficiency over No Action but does not maximize transportation benefits when compared to other alternatives	● Plan is an incomplete solution; it provides some improvement in navigation efficiency over No Action but does not maximize transportation benefits when compared to other alternatives	● Plan is a complete solution; it rates 2nd in improvement in navigation efficiency over No Action but does not maximize transportation benefits when compared to other alternatives

Table 3-22 - Comparison of P&G Evaluation Criteria (Efficiency & Effectiveness) for Alternatives

Alternative #	No Action	EC-3b	EC-4b.1	9a-EC	9a-3b	9a-4b.1	3a-EC	3a-3b
Criteria	FWOP	BRFG Existing / CRL Open Channel	BRFG Existing / CRL River Side Gate Removal	BRFG Open Channel / CRL Existing	BRFG Open Channel / CRL Open Channel	BRFG Open Channel / CRL River Side Gate Removal	BRFG 125-foot Gates Existing Alignment / CRL Existing	BRFG 125-foot Gates Existing Alignment / CRL Open Channel
Efficiency (extent to which an alternative plan is the most cost effective means of achieving the objective)	● No Action does not address the planning objective	● Less total annual cost than Recommended Plan but does not address objectives as effectively; net excess benefits are not maximized and are less than the Recommended Plan	● Less total annual cost than Recommended Plan but does not address objectives as effectively; net excess benefits are not maximized and are less than the Recommended Plan	● Higher total annual cost than Recommended Plan and does not address objectives as effectively; net excess benefits are not maximized and are less than the Recommended Plan	● Higher total annual cost than Recommended Plan and does not address objectives as effectively; net excess benefits are not maximized and are less than the Recommended Plan	● Higher total annual cost than Recommended Plan, addresses objectives; net excess benefits are maximized and are greater than the Recommended Plan but substantially increases sedimentation	● Higher total annual cost than Recommended Plan and does not address objectives as effectively; net excess benefits are not maximized and are less than the Recommended Plan	● Higher total annual cost than Recommended Plan and does not address objectives as effectively; net excess benefits are not maximized and are less than the Recommended Plan
Effectiveness (extent to which the alternative plans contribute to achieve the planning objective)	● Ineffective for improving navigational efficiencies or decreasing accidents	● Not as effective as Recommended Plan for improving navigation efficiency ● CRL only; not system wide improvement	● Not as effective as Recommended Plan for improving navigation efficiency ● CRL only; not system wide improvement	● Not as effective as Recommended Plan for improving navigation efficiency ● BRFG only; not system wide improvement	● Not as effective as Recommended Plan for improving navigation efficiency	Most effective plan for improving navigation efficiency when compared to alternatives evaluated except it substantially increases sedimentation	● Not as effective as Recommended Plan for improving navigation efficiency ● BRFG only; not system wide improvement	● Not as effective as Recommended Plan for improving navigation efficiency

Table 3-23 - Comparison of P&G Evaluation Criteria (Efficiency & Effectiveness) for Alternatives (Continued)

Alternative #	3a-4b.1	9c-EC	9c-3b	9c-4b.1	3a.1-EC	3a.1-3b	3a.1-4b.1 TSP
Criteria	**BRFG 125-foot Gates Existing Alignment / CRL River Side Gate Removal**	**BRFG 125-foot Gates Align C / CRL Existing**	**BRFG 125-foot Gates Align C / CRL Open Channel**	**BRFG 125-foot Gates Align C / CRL River Side Gate Removal**	**BRFG 125-foot Gate East/Open West / CRL Existing**	**BRFG 125-foot Gate East/Open West / CRL Open Channel**	**BRFG 125-foot Gates Existing Alignment / CRL River Side Gate Removal**
Efficiency (extent to which an alternative plan is the most cost effective means of achieving the objective)	● Higher total annual cost than Recommended Plan and does not address objectives as effectively; net excess benefits are not maximized and are less than the Recommended Plan	● Higher total annual cost than Recommended Plan and does not address objectives as effectively; net excess benefits do not reach unity	● Higher total annual cost than Recommended Plan and does not address objectives as effectively; net excess benefits do not reach unity	● Higher total annual cost than Recommended Plan and does not address objectives as effectively; net excess benefits nearly reach unity	● Higher total annual cost than Recommended Plan and does not address objectives as effectively; net excess benefits are not maximized and are less than the Recommended Plan	● Higher total annual cost than Recommended Plan and does not address objectives as effectively; net excess benefits are not maximized and are less than the Recommended Plan	Cost-effective; achieves objective; Ranks 2nd in net excess benefits with less increase in sedimentation
Effectiveness (extent to which the alternative plans contribute to achieve the planning objective)	● Ineffective for improving navigational efficiencies	● Ineffective for improving navigational efficiencies or decreasing accidents	● Ineffective for improving navigational efficiencies or decreasing accidents	● Ineffective for improving navigational efficiencies or decreasing accidents	● Not as effective as Recommended Plan for improving navigation efficiency ● BRFG only; not system wide improvement	● Not as effective as Recommended Plan for improving navigation efficiency	Most effective plan for improving navigation efficiency without substantially increasing sedimentation when compared to alternatives evaluated;

3.12 SUMMARY OF ACCOUNTS AND COMPARISON OF THE NED PLAN

3.12.1 Summary of Accounts

To facilitate evaluation and comparison of the alternatives, the 1983 Principles and Guidelines lay out four Federal Accounts that are used to assess the effects of alternatives. The accounts are NED, Environmental Quality (EQ), Other Social Effects (OSE), and Regional Economic Development (RED).

- The NED account displays changes in the economic value of the national output of goods and services. The 1983 Principles and Guidelines require the identification of an NED plan from among the alternatives.
- The EQ account displays non-monetary effects on significant natural and cultural resources.
- The RED account registers changes in the distribution of economic activity that result from each alternative plan. Evaluations of regional effects are to be carried out using nationally consistent projections of income, employment, output, and population.
- The OSE account registers plan effects from perspectives that are relevant to the planning process, but are not reflected in the other three accounts.

3.12.2 Comparison of the NED Plan and the No-Action Plan

No-Action Plan: There would be no benefits attributable to the no-action plan. The EQ and OSE accounts would remain unchanged. The NED and RED accounts would be adversely impacted as current transit times of waterborne commerce traffic that utilize the existing structures to continue to increase as traffic increases and the frequency of maintenance events increase.

Recommended Plan: The Recommended Plan reasonably maximizes the net NED benefits with a BCR greater than 1. Impacts to EQ account would be minimal, and there would be no impacts to OSE. The RED account would benefit because new and reliable floodgates/locks would increase efficiency of cargo transiting on the GIWW and the reliability of the structures would be increased.

3.13 ASSUMPTIONS, RISKS, AND UNCERTAINTIES OF THE NED PLAN

The following assumptions, risks and uncertainties were made by the study team during the coordination of the TSP and subsequent concurrent review process.

<u>Plan Formulation Assumptions/Risks/Uncertainties</u>: Subsequent to the release of the DIFR-EIS for public review and review of comments received during concurrent public, policy, and technical reviews regarding the TSP, the team refined the design of the TSP hybrid design. This involved

additional engineering and environmental analysis as well as ongoing coordination with industry to support the feasibility design of the TSP. Refinements to the TSP are documented in Chapter 4 of this FIFR-EIS.

Economic Assumptions/Risks/Uncertainties: Existing conditions for navigation and shipping cost nationally/regionally have not been well documented through the floodgates and locks. Tracking systems in place include outdated paper documentation and computerized tracking systems that have inconsistent readings. This may lead to inaccurate data analysis of the economic benefits. Risk management options include using existing data to extrapolate missing pieces and optimization of said data to determine NED benefits. Data processing has been performed by the PCXIN to account for these discrepancies, however this processing requires that assumptions be made to fill in data gaps. Other risk and uncertainty were addressed during the study by sensitivity analysis that evaluated the NED plans performance. This evaluation included sensitivity to the crude oil market condition in West Texas due to significant increases in supply as well as the regional opportunities for exporting those commodities. There are significant uncertainties regarding the oil transportation system's adaptation to different modes of transport. The effect in capacity, volumes and rates of oil productions, and annual volumes shipped through the study area may vary considerably in the future as the oil delivery system adapts to market conditions. Part of the delivery system adaptation includes capacity increases to the navigation system by enlarging the BRFG and CRL from 75-feet to 125-feet, creating an opportunity for increased efficiencies to the coastal oil delivery system. Upon completion of both project components the system is expected to experience system wide behavior changes. The system-wide assessment of the oil delivery system was not performed during the feasibility stage. With the receipt of preconstruction engineering and design (PED) funds an assessment of the system-wide behavior is expected to increase project benefits. The PDT has determined that the risk is acceptable and that TSP selection of the NED plan has not been greatly impacted with our assumption (documented in **Appendix B – Economic Appendix**).

Ship Simulation Assumptions/Risks/Uncertainties: There is risk to selecting a plan without validating the plan with ship simulation. The team's assumption is that the TSP provides for safe and efficient navigation; however, once ship simulations are conducted during the Pre-Construction Engineering and Design (PED) phase it could be determined that modifications are required. This could result in additional costs. Previous ERDC ship simulation work during PED on other projects has resulted in major modifications to the TSP 50 percent of the time when ship simulations were not conducted during feasibility-level design in the study phase. Subsequent meetings with representatives of the navigation industry indicated support for the TSP plans at Brazos River and Colorado River Crossings, satisfying the industry's safety concerns at the crossings. While ship simulation would provide greater refinement of navigation performance, it would be unlikely to change the identification of the TSP. Based on the expert elicitation from industry, it is recommended that ship simulation be performed during PED to validate these assumptions.

Real Estate Assumptions/Risks/Uncertainties: The assumption is that Galveston District has current, valid perpetual easements on all of the lands within the project footprint area. The Real Estate Plan (REP) describes the lands required for the project and the Government's easement interests in the five tracts impacted by the Brazos River Floodgates improvements and the eight tracts impacted by the Colorado River Locks improvements.

Maintenance Dredging Funding Assumptions/Risks/Uncertainties: Some alternatives allow more deposition of material into the GIWW that would otherwise continue out into the delta for both rivers. These deposits would accumulate in areas that would require dredging to maintain the channel comparable to unaffected parts of the GIWW. This would require additional funding for dredging in the annual O&M budget. The TSP is estimated to add approximately $2,000,000 to the annual dredging requirements. If such an alternative is the best solution, then study guidelines require that we assume the budget would be increased adequately to support the dredging need. Currently, the dredging budget for the relevant portions of the GIWW is inadequate to fully meet the mission requirements. The budget is managed by prioritizing the most efficient way to operate the navigation system. First, the authorized channel depth is not met. Second, the delta for the Colorado River needs to be dredged to restore the hydraulic capacity of the river. It follows, that additional future dredging needs would fall onto a budget history that has not been adequate to meet full needs.

Dredging Disposal Cost Assumptions/Risks/Uncertainties: A fully developed DMMP is not available for the portions of the GIWW affected by increased sedimentation associated with some of the alternatives evaluated. Utilizing existing data, remaining capacities in the DMPAs along the GIWW were evaluated. The team assumed that once those capacities were met, dredged material placement would occur offshore, at a significantly higher cost than the cost for disposal in nearby placement areas. Beneficial use (BU) sites were investigated but determined to not be least cost. A fully developed DMMP could result in more cost effective dredge material placement options, potentially lowering operation and maintenance costs over the life of the proposed project.

Environmental Assumptions/Risks/Uncertainties: A mitigation plan is currently being drafted and further consultation and coordination with state and Federal agencies is ongoing and expected to conclude before a Chief's Report is finalized.

4.0 REFINEMENTS POST PUBLIC REVIEW & ADM MILESTONE

The Recommended Plan for navigation improvements for BRFG-CRL has to be responsive to local needs and desires as well as the economic and environmental criteria established by Federal and State law. Significant comments were raised during the public review period that resulted in additional analysis and refinement of the final plans. The comments concerned: 1) adjustments to traffic forecasts, 2) impacts to the San Bernard River; 3) navigation impacts at Port Freeport; 4) a narrow 75-foot gate opening at CRL; and 5) increased sedimentation due to temporary construction bypasses.

4.1 TRAFFIC FORECAST AJUSTMENTS

After the Agency Decision Milestone (ADM), in response to Southwestern Division review comments, traffic forecasts prepared by Martin Associates were updated and the economic model was rerun for the final NED analysis. Major changes between the two sets of traffic forecasts are the use of a 3-year average of historic traffic for the base year rather than a 5-year average used in the original (i.e., "national level") forecasts, and regional growth rates for crude petroleum and petroleum products rather than the national level estimates used in the original forecasts. Section 4.1 briefly summarizes regional conditions with respect to oil and gas. Section 2.5.3.3 of the main report compares tabular and graphical results for regional and national level projections, and the Addendum to the Economics Appendix contains detail including a discussion of the potential for induced tonnage under the with-project condition.

Over the past 15 years or so, production growth of the U.S. shale gas and oil industry has been remarkable and is having a substantial impact on the nation's economy and industrial supply chains. According to the EIA, since 2005 when the current surge started to the end of 2017, U.S. production of crude oil rose nearly 80 percent from about 5 million barrels per day to 9.4 million in 2017, and the U.S. is now a major oil exporter. EIA predicts that U.S. crude oil production will average 10.7 million barrels per day in 2018 and 11.7 million in 2019.

Oil in Texas is coming primarily from two formations – the Eagle Ford Shale region west and southwest of San Antonio and the Permian Basin in central West Texas – and much of it via pipelines to Gulf Coast export terminals and refineries, particularly those in or near the ports of Corpus Christi and Houston. In fact, Corpus Christi (and perhaps Brownsville) will likely become a major export hub. Given constraints in pipeline and rail capacity, shippers are moving West Texas crude coming into Corpus Christi and Brownsville via GIWW barges or coastwise tankers and Articulated Tug Barges (ATBs) to refineries and export terminals in East Texas and Louisiana. In recent years, crude oil traffic on the GIWW has spiked from historical annual totals (1991 through 2010) of about 300,000 to 500,000 tons to a high of nearly 12 million tons in 2014 based on currently available data. Since 2012, it has ranged from about 4 to 12 million.

Crude oil production in West Texas is not expected to peak until around 2040 based on current technology and oil prices. As result, traffic on the GIWW will likely increase, and while it is true that the industry is adding pipeline capacity from West Texas to the Gulf, production is increasing at rates that will make it hard for land side transmission infrastructure to keep pace. In addition to increases in GIWW traffic based on current on current modal shares, improving efficiency and safety on the GIWW in the with-project condition would lower the cost (i.e., price) of shipping on the waterway relative to rail or coastwise vessels and make induce tonnage to the waterway. Induced tonnage has not been quantified for this study given a lack of necessary data such a rate analysis.

USACE expects that shippers will continue to use inland barges to move oil to refineries and export terminals in East Texas and Louisiana. Granted this will not be a “revolution” or “renaissance” for barge transportation on the GIWW. Most of the oil coming out West Texas will do so strictly through pipelines, but volumes shipped by barge on the GIWW will likely stay well above historic levels typical of conditions before tight oil production in Texas began in earnest. However, there is significant uncertainty surrounding future crude oil traffic. Shipments rose sharply in 2010 through 2015, but have since dropped off considerably, although they are still well above historical averages from 1991 through about 2009.

Reasons for the decline are not entirely clear, but a primary factor was likely the lifting of the embargo on exports of domestic crude in 2015. The ability to export has relieved supply pressures and much of the crude that was trying to find a home in the U.S, has ended up at refineries in Europe and Asia. At the time, Gulf coast refineries were (and are) operating near or at capacity, and there is only so much light crude that they can process and blend with heavier grades. At some point, inefficiencies in the refining process prevent adding more light oil to the mix. New pipeline capacity from West Texas to the Gulf probably played a role as well as did the narrowing of the Brent and West Texas Intermediate oil benchmark prices.

While it is true that ports, carriers and pipeline operators are building capacity (i.e., trying to catch up with the glut of oil coming out of the ground) in response to increased West Texas oil production and the market for oil transportation is a state of flux, there may be periods of excess capacity and under capacity. In other words, the market is in disequilibrium, and there are a lot of moving parts related to both capacity, volumes and rates of oil production, and annual volumes shipped through the study may vary considerably. As noted previously in Chapter 2, several key factors will affect regional traffic projections:

1) Future volumes of crude oil shipped through the BRFG-CRL will likely depend upon the ability and desire of energy companies to expand regional pipeline capacity. If pipelines

are full, there will be overflow that probably ends up on inland barges moving up the GIWW. Whether pipelines will keep up with the amount of production is unclear.

2) Gulf coast refineries are operating at near capacity and have eliminated imports of Brent crude completely. For crude oil volumes to both increase and sustain at projected levels, there may have to additional refining capacity and this is happening. For example, in January of 2019 Exxon announced construction of a new crude-processing unit in Beaumont, Texas that will increase capacity by more than 65 percent, or 250,000 barrels per day. The decision to build this third crude oil unit in the facility's existing footprint will expand light crude refining, supported by increased oil production in the Permian Basin. Start-up is anticipated by 2022.

3) The price of Brent (European) light oil will have to remain higher than West Texas Intermediate (WTI) to sustain GIWW crude oil movements at projected levels. Historically, Brent has been much cheaper than WTI and Gulf refineries would import it for blending; however, Permian production has vastly increased U.S. supplies and since early 2010, WTI has priced below Brent by as much as $25 a barrel. This has made it very attractive to Gulf refineries that use light crude as feedstock.

4) Potential increases in traffic at levels projected may result in more congestion on the waterway, and thus additional queuing in the with-project scenario, which in turn could decrease efficiency or offset project benefits.

5) There are significant uncertainties regarding the oil transportation system's adaptation to different modes of transport. The effect in capacity, volumes and rates of oil productions, and annual volumes shipped through the study area may vary considerably in the future as the oil delivery system adapts to market conditions. Part of the delivery system adaptation includes capacity increases to the navigation system by enlarging the BRFG and CRL from 75-feet to 125-feet, creating an opportunity for increased efficiencies to the coastal oil delivery system.

4.2 SAN BERNARD RIVER IMPACTS

Public comments indicated that a project was underway by local organizations for the dredged opening of the mouth of the San Bernard River. Hydraulic modeling conducted up to the TSP milestone was performed with the mouth of the San Bernard River closed to the Gulf unless the river elevation exceeded +4.3 feet NAVD88. This allowed the river to flow to the Gulf only during large flood events. Public comments focused on the negative effects that the proposed open channel on the west side of the GIWW at the Brazos River would have on the mouth of the San

Bernard River if plans to open the mouth were implemented. To address the aforementioned public comments, additional modeling was conducted. The existing AdH model was modified to include an open connection between the San Bernard River and the Gulf of Mexico. Qualitative comparisons were made to analyze the general impact of the proposed TSP on sedimentation within the GIWW and the inlet stability of the San Bernard mouth when compared to existing conditions.

When the San Bernard is open, the TSP showed an increase in sedimentation of approximately 9,700 cy/year in the San Bernard Gulf Channel when compared to existing conditions. Overall, model results show that opening the San Bernard mouth causes additional sedimentation in the West GIWW, approximately 134,800 cy/year for existing conditions, and 114,900 cy/year for BRFG alternative 3a.1. The inlet stability analysis indicated that when open, the San Bernard Inlet has poor stability during existing conditions as well as for the proposed TSP. Any changes in the inlet stability due to implementation of the proposed TSP are expected to be minor, and do not change the stability overall regime of the San Bernard Inlet. Detailed information on the modeling performed is available in the **Hydraulic Engineering Appendix – Brazos River Floodgates of the Engineering Appendix.**

Based on stakeholder concerns over the FWP effects on the San Bernard River and its connection to the Gulf of Mexico, it is recommended that a targeted monitoring program be investigated during PED. The monitoring program could document hydraulic conditions before, during, and after project implementation. The monitoring program could enable USACE to demonstrate to the stakeholders the degree that the implemented FWP condition had not affected the hydraulics of the San Bernard River and its connection to the Gulf of Mexico.

4.3 PORT FREEPORT IMPACTS

Another major concern raised during the public review period dealt with the velocity impacts of the proposed TSP at the crossing of the Freeport Channel at the GIWW. Affected industries along Port Freeport questioned whether the increase from a 75-foot gate opening to a 125-foot gate opening would cause velocities at the crossing that would require additional tug assistance when the 125-foot gate was opened. Velocity data was extracted at the GIWW crossing at the Freeport Channel and along various points along the Freeport Channel. The velocity data indicated minimal changes in velocity for the recommended plan with a 125-foot wide gate at the east side of the Brazos River crossing. Detailed information on the velocity data extracted from the AdH model and analyzed is available in the **Hydraulic Engineering Appendix – Brazos River Floodgates of the Engineering Appendix.** In addition to the concerns over the 125-foot wide gate, Port Freeport users also expressed concerns over sedimentation and current flows due to the temporary bypass channel proposed as part of the TSP. These concerns led to a refinement of the TSP.

4.4 BRAZOS RIVER TSP (3a.1) REFINEMENTS

In response to comments received during public review and subsequent meetings held with Industry, the team refined the BRFG TSP (3a.1) to address those concerns. By offsetting the channel alignment to the south, dredging of a new bypass channel during the construction period is eliminated. Thus, the concerns cited by Port Freeport during the public review period about additional sedimentation and current flows to their harbor during the two-year construction period are fully addressed. The existing floodgates on the east and west side of the Brazos River would remain fully operational during the two-year construction period. At the end of the construction period, the plug at the edge of the river would be excavated on both the east and west sides. Note that the north edge of the plug excavation is shaved to be more perpendicular to the river for improved navigation safety. Following the excavation of the plug, the navigation traffic would be transferred to the new alignment and the new floodgate. Once the new alignment and floodgate become operational, the old floodgate facilities on the east and west side of the river would be decommissioned and left in place. The existing south guidewalls and south monoliths for the existing floodgates are to be removed for additional navigation clearance.

This refinement would save a significant amount on construction costs: 1) eliminating demolition costs (leaving existing floodgate facilities in place); 2) eliminating bypass channel excavation; and 3) savings on road and utility infrastructure costs.

4.5 COLORADO RIVER TSP (4b.1) REFINEMENTS

During the public review period, industry raised concerns that the 75-foot gate proposed in the TSP would result in a bottleneck along the Texas GIWW. Industry comments pointed out that the CRL gate structure would be the only 75-foot constriction along the Texas GIWW. Additionally, the conversion from locks to floodgates as proposed would eliminate the ability to lock in high river velocity conditions, causing additional delays. Industry representatives and lock personnel also noted degradation of the Colorado River outlet, which has resulted in increased differential heads between the GIWW and Colorado River for lower river velocities. While additional survey data was not available to validate the degradation of the river outlet in Matagorda Bay, measured velocities and stages corroborate a degradation in the outlet is occurring, which would result in additional delays not accounted for in the original assessment of the TSP. Detailed information on the analysis performed on the outlet degradation is available in the **Hydraulic Engineering Appendix – Colorado River Locks of the Engineering Appendix.**

In response to the aforementioned concerns, the team refined the CRL TSP (4b.1) to address those concerns. Instead of rehabilitation of the existing 75-foot sector gate, a new 125-foot gate would be constructed on both the east and west sides of the river crossing. The new gate structures would be offset to an alignment to the south. This would eliminate the need for a new bypass channel during the construction period and result in significant savings in maintenance dredging of the GIWW during construction. The wider 125-foot sector gates result in a significant reduction in velocity through the gate structures. Discussions with navigation industry representatives indicated that velocities through the gate opening would dictate navigability through the gate structure and that vessels can operate through a 5 mph current in typical conditions. Modeling indicates that the 5 mph would be exceeded 6 percent of the time, potentially resulting in shutdown of the gate structure. While the 125-foot gate structure may result in total shutdown of navigation more than the existing lock structure, daily required lockages during tidal events for the 75-foot lock structure would be eliminated. The reduction in accidents and lockages associated with the wider 125-foot gate structures result in net benefits over the life of the project. The assumed navigation restrictions developed as a result of industry input will be validated during PED through the use of Ship Simulation modeling.

The existing locks on the east and west side of the Colorado River would remain fully operational during the two-year construction period. At the end of the construction period, final dredging would be performed to complete the new alignment. Then the navigation traffic would be transferred to the new alignment and the new floodgates. Once the new alignment and floodgates become operational, the old lock facilities on the east and west side of the river would be decommissioned and left in place. The existing south guide walls and south monolith for the existing east GIWW floodgate are to be removed for additional navigation clearance.

4.6 RECOMMENDED PLAN

As per the General Evaluation Guidelines presented in ER 1105-2-100, Exhibit G-1, 3.b., the systems models used in the estimates of navigation benefits are fully described and their strengths and limitations presented in the **Economics Appendix, Appendix B**. Identification of the NED plan is based on consideration of the most effective plans for providing different levels of output or service. The refined TSP, now the Recommended Plan for this study, is described below.

4.7 DESCRIPTION OF RECOMMENDED PLAN

The Recommended Plan for the BRFG-CRL System is comprised of the Alternative 3a.1 for BRFG (**Figure 4-1**) and Alternative 4b.1 for CRL (**Figure 4-2**), both of which have been refined per feedback received during concurrent review. The BRFG component of the Recommended Plan consists of constructing a new 125-foot sector gate structure approximately 300-feet south of the existing alignment, set back approximately 1,000 feet from the river on the east side, and a minimum 125-foot open channel on the west side of the river crossing.

The CRL component of the Recommended Plan consist of constructing new 125-foot sector gate structures approximately 260-feet south of the existing alignment, set approximately mid-way between the existing lock gates.

With the Recommended Plan accident probabilities would be reduced by approximately 80 percent at BRFG and 99 percent at CRL.

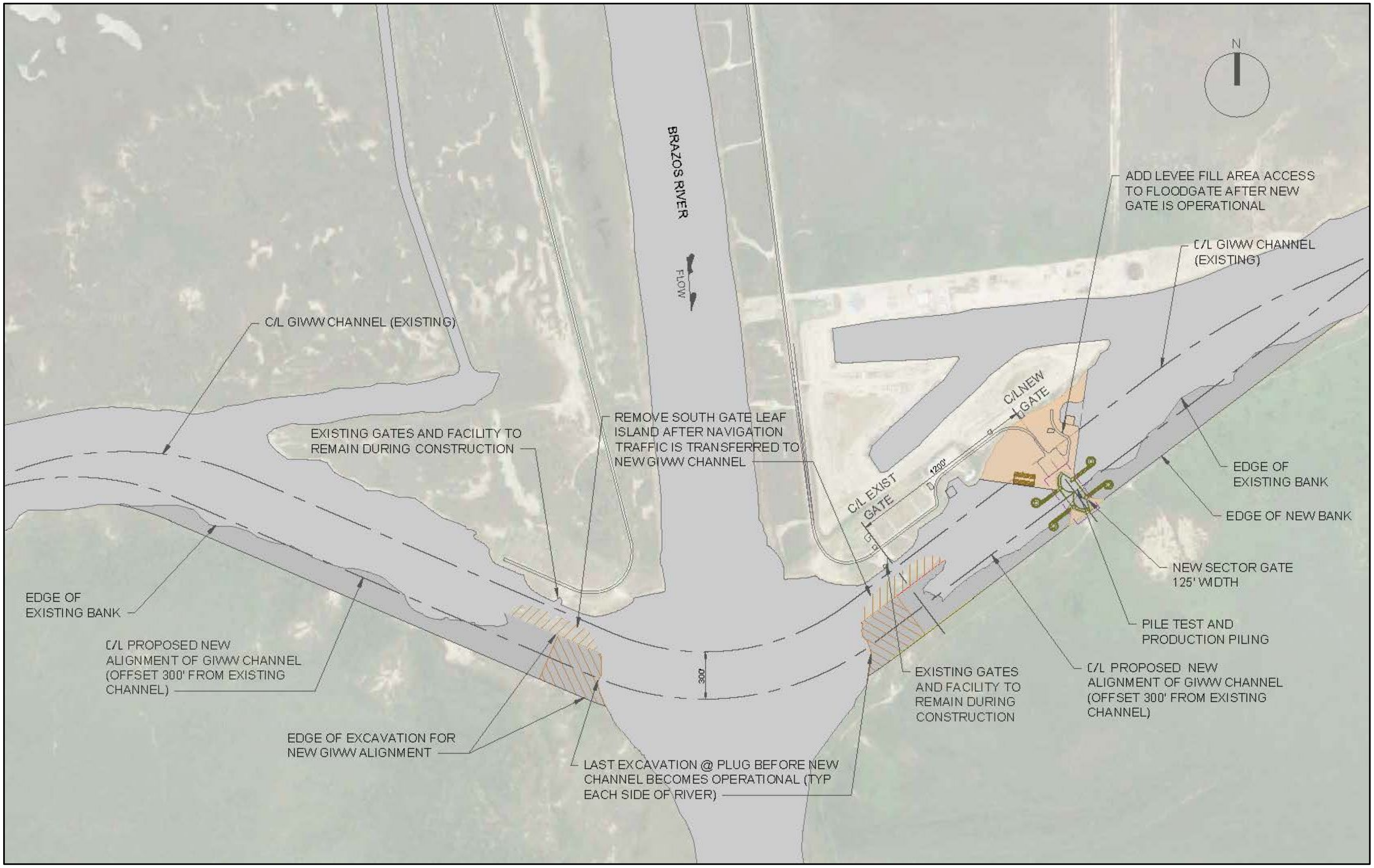

Figure 4-1 - BRFG Component of Recommended Plan [Refined Alternative 3a.1]

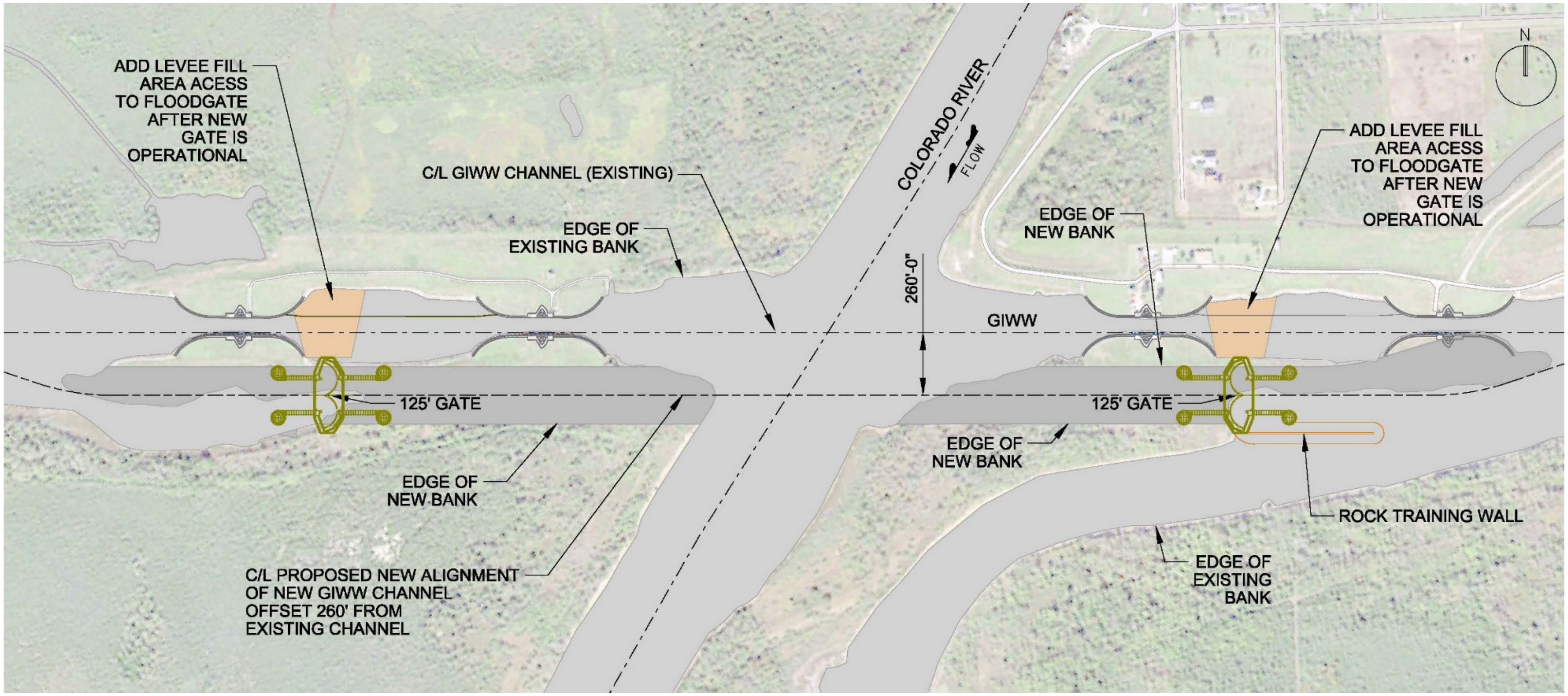

Figure 4-2 - CRL Component of the Recommended Plan – [Refined Alternative 4b.1]

4.7.1 BRFG Plan Components

At BRFG, the main features of the Recommended Plan are the removal of the existing gates on both sides of the river crossing, the construction of a 125-foot wide open channel on the west side and a new 125-foot wide sector gate structure on the east side. The open channel would have a bottom depth of -12 feet NAVD88 with a bank-to-bank width of approximately 500 feet. The new sector gate on the east side would be set back approximately 1,200 feet from the existing gate structure, providing increased safety and efficient vessel operation through the system, reducing allisions. The gate would be constructed to a top elevation (El.) of 16-feet NAVD88 with a sill at El -16 feet NAVD88. New control houses, an administrative office building, warehouse and boat house would be constructed to support the maintenance and operation of the new gate structures. The construction of the open channel and new sector gate would take approximately two years to complete, assuming an adequate funding stream. Assuming one contract, construction would be sequenced as follows:

- An access channel would be dredged on the GIWW side of the east gate structure to permit floating plant access for construction of the structure. Advanced dredging of the new west channel would be performed with the exception of a small plug on the river side of the new channel. Disposal of excavated material from the bypass would be placed in the adjacent placement areas. Suitable material would be re-used for backfill for the new 125-foot sector gates.
- Once dredging for floating access is completed, the production piling for the gate structure would be driven in the wet. Foundation pilings would consist of approximately 246 steel pipe piles measuring 30-inch in diameter and driven to a depth of 125 feet below grade.
- The cofferdam would then be constructed and the gate structure completed. Concrete pours for the sector gate monolith would occur first. Machinery, electrical, and mechanical connections would all be installed after completion of concrete placement. Concurrent with the construction of the gate structure, portions of the guidewalls and end cells not within the footprint of the cofferdam could also be constructed. Construction of the new buildings on the lock reservation would also be constructed concurrently.
- The cofferdam would then be removed and the remaining ancillary features completed.
- The remaining portion of the new channel would be dredged and navigation transferred to the new structure.
- The existing gate structures would then be decommissioned and the southern half of both gate structures would be removed.
- The final grading and construction of the access levee would then be completed.

4.7.2 CRL Plan Components

At CRL, the main features of the TSP are the construction of new 125-foot sector gate structures on the east and west sides of the river crossing. The new sector gates would be set back approximately 1,000 feet from the river crossing. The gates would be constructed to a top El of 16-feet NAVD88 with a sill at EL -16 feet NAVD88. The construction of the new sector gates would take approximately two years to complete, if adequate funding is provided. New control houses, an administrative office building, warehouse and boat house would be constructed to support the maintenance and operation of the new gate structures. Assuming one contract, construction would be sequenced as follows:

- An access channel would be dredged on the GIWW side of each structure to permit floating plant access for construction of the structures. Disposal of excavated material from the bypass will be placed in the adjacent placement areas. Suitable material will be re-used for backfill for the new 125 foot sector gates.
- Once dredging for floating access is completed, the production piling for the gate structure would be driven in the wet. Foundation pilings would consist of approximately 246, 30 inch steel pipe piles, driven to a depth of 125 feet below grade on the east gate and 130 feet below grade on the west gate.
- The cofferdam would then be constructed and the gate structure completed. Concrete pours for the sector gate monolith would occur first. Machinery, electrical, and mechanical connections would all be installed after completion of concrete placement. Concurrently with the construction of the gate structure, portions of the guidewalls, end cells and rock training wall not within the footprint of the cofferdam could also be constructed. Construction of the new buildings on the lock reservation would also be constructed concurrently.
- The cofferdam would then be removed and the remaining ancillary features completed.
- The remaining portion of the new channel would be dredged and navigation transferred to the new structure.
- The existing lock would then be decommissioned and the southern end of the eastern GIWW sector gate would be removed.
- The final grading and construction of the access levee would then be completed.

4.8 RECOMMENDED PLAN PROJECT FIRST COST

Table 4-1 provides the project first cost comparison for the navigation system, at Brazos, and at Colorado.

Table 4-1 - Project First Cost Comparison Summary ($000)

Cost Account and Feature	BRFG Component First Cost	CRL Component First Cost	Project First Cost Total for System
	October 2018 Price Levels		
Construction	$117,693	$187,340	$305,033
Lands and Damages	$199	$45	$244
Preconstruction Engineering and Design	$23,508	$37,468	$60,977
Construction Management	$12,869	$20,604	$33,473
Total Project First Cost	**$154,270**	**$245,457**	**$399,727**

The Total Project Cost Summary (TPCS) for the design and construction of the Recommended Plan was certified on February 11, 2019, at October 1, 2018 price levels (see **Engineering Appendix A, Appendix 4**). The Project First Cost (Constant Dollar Cost at current price level) of the Recommended Plan is $399,727,000. The Total Project Cost or Fully Funded Cost (Constant Dollar Cost fully funded with escalation to the estimated midpoint of construction) is $455,092,000 and shown later in this report (**Table 8-2**). The Recommended Plan does not require any relocations.

4.9 NED BENEFITS

Table 4-2 summarizes the NED analysis for the recommended plan. Calculations assume October 2018 prices levels and the FY 2019 Federal discount rate for water resources planning of 2.875 percent. The NED analysis yields net benefits of $ $41,603,000 with a BCR of 3.3.

In light of the risks and uncertainties surrounding commodity forecast and given the abrupt and dynamic nature of shale oil and gas supply and demand in Texas, future study updates will be critical. As infrastructure develops and the regional transportation for crude petroleum market stabilizes, commodity forecasts that are important drivers of NED benefits and plan evaluation should be reassessed.

The inherent uncertainty in oil production and transportation markets cannot be resolved until the energy and shipping industries adapt to changes in Texas.

Table 4-2 - GIWW BRFG and CRL Equivalent Annual Costs and Benefits Based on Southwest Region Commodity Projections ($1,000s)

Category	BRFG Component	CRL Component	System (BRFG and CRL)
	October 2018 Price Levels, 2.875 percent interest		
Total Project Construction Costs	$154,270	$245,457	$399,727
Interest During Construction	$6,717	$10,687	$17,403
Total Investment Cost	**$160,987**	**$256,144**	**$417,130**
Construction Average Annual	$6,109	$9,720	$15,829
OMRR&R	$2,664	$0	$2,664
Total Average Annual Costs	**$8,773**	**$9,720**	**$18,493**
Average Annual Benefits	$44,096	$16,000	$60,096
Net Annual Benefits	$35,323	$6,280	$41,603
Benefit to Cost Ratio	**5.03**	**1.65**	**3.25**

4.10 REAL ESTATE REQUIREMENTS

A REP describing the real estate requirements and cost for the project can be found in Appendix C. The REP describes the lands, easements, and rights-of-way (LERR) required for the construction, operation and maintenance of the proposed project, including those required for relocations, borrow material, and dredge or excavated material disposal.

Real estate needed for construction of the BRFG and CRL Projects are within current perpetual easements conveyed to the United States. Mitigation is expected to occur onsite at both project locations, however the potential for acquisition of mitigation acreage is addressed in Appendix C and reflected in the cost estimate for real estate. In the event mitigation occurs onsite, real estate costs are minimal and include administrative costs associated with staging areas and project-related administration. The estimated cost of real estate for this project will be the sole responsibility of USACE.

Any borrow material needed for the project will be obtained within the project footprint. There is an assumption that four staging areas will be required for BRFG and two staging areas for CRL. There will not be any displaced persons or businesses entitled to P.L. 91-646 Relocation Assistance.

4.11 OPERATION AND MAINTENANCE, REPAIR, REHABILITATION AND REPLACEMENT

The purpose of OMRR&R is to sustain the constructed project. O&M cost estimates for maintenance of the structures were based on existing expenditures for normal O&M and periodic major maintenance at each river crossing. OMRR&R of the recommended plan after construction will have average annual costs $2,664,000. The USACE is responsible for these costs as federally maintained structures. Refer to the **Engineering Appendix – Appendix A** for more detailed information.

4.12 RELATIVE SEA LEVEL CHANGE

The Brazos and Colorado River crossings are located in the coastal zone. The performance of the system has the potential to be affected by sea level change and other climate changes. The Climate Preparedness and Resilience Register (CPRR) documents the robustness of the project alternative selections to climate change, how the selected plan's performance might be expected to change over time, and how the plan might be adapted to continue to deliver performance in a changing climate. Future conditions were modeled by adjusting the boundary conditions and re-running the AdH simulations for the open channel and existing alternatives. There is no question that local relative sea level is rising (currently at a rate of 4.35mm/yr or 1.47 feet per century). However the rate may change in response to large scale environmental changes elsewhere (e.g., change in heat content of the ocean, and progressive movement or failure of large ice sheets).

LOCAL MEAN SEA LEVEL (LMSL)

Defined as the height of the sea with respect to a land benchmark, averaged over a period of time (such as a month or a year) long enough that fluctuations caused by waves and tides are smoothed out.

http:\\ en.wikipedia.org/wiki/Mean_sea_level

Given the uncertainty in continued and reasonably foreseeable sea level rise and subsidence, a range of relative sea-level rise (RSLR) scenarios were quantitatively evaluated. For this project, a bracketing approach was used rather than the required sea level scenarios. The elevations, which were evaluated for 1.0-feet and 2.0-feet RSLR over LMSL, could occur in the project anywhere between 2028 and 2062 for the 1-foot increase (at high and low scenarios, respectively), and 2059 and 2081 for the 2 foot increase (high and intermediate scenarios, respectively). The modeling shows that sedimentation rates are not highly sensitive to sea level rise. Furthermore, with higher Gulf water levels, navigability is expected to improve, since a higher tailwater would slow velocities at the crossing, and increase channel depths. Finally, modest changes to average salinity occur as a result of SLC. On the other hand, these increases in sea level would also result in increases to surge and other components of the total water surface elevation over the ground, but generally in a nonlinear fashion. As result, the overall effects of SLC on the recommended plan are relatively minor but will be accounted for in the design of features sensitive to elevation changes resulting from SLC at the range of plausible dates. Refer to the **Engineering Appendix –Appendix A** for further details on the impact of RSLC on the Recommended Plan. A qualitative discussion of impacts on the FWP conditions for the high predicted rate of RSLC over the planning horizon (2025-2125) is presented in Section 5.2.4.

4.13 PRECIPITATION CHANGES

As part of Responses to Climate Change Program, USACE has produced a series of documents which characterize climate change for various regions of the country. Studies of trends and nonstationarity in streamflow data collected over the past century have been performed throughout the continental U.S., some of which include the Texas-Gulf Region. There appears to be reasonable consensus among these studies that trends show a general increase in river flow in the Texas-Gulf Region. The general consensus in the recent literature points toward mild increases in annual precipitation and streamflow in the Texas-Gulf Region over the past century.

To further evaluate the long term climate effects on river discharge, a trend analysis was conducted on the annual peak discharges of the Colorado River at Bay City, TX. A trendline was fit through the annual peak discharges from 1948 to 2017. The trend analysis shows a relatively minor increase in peak discharges from 1948 to 2017. Increased discharges are likely to increase sedimentation, although the amount of increase due to climate change is assumed to be small relative to the overall uncertainty in the modeled sedimentation volumes.

Refer to the **Engineering Appendix A-1: Hydraulic Engineering Appendix – Brazos River Floodgates and Engineering Appendix A-2: Hydraulic Engineering Appendix – Colorado River Locks** for further details on the impact of precipitation changes on the Recommended Plan..

4.14 RESILIENCY

In accordance with Engineering and Construction Bulletin (ECB) 2018-2, Implementation of Resilience Principles in the Engineering and Construction Community of Practice, the Recommended Plan incorporated resilience thinking throughout. Resilience is defined as the ability to anticipate, prepare for and adapt to changing conditions; and withstand, respond to and recover from disruptions. Preliminary evaluation of resiliency for this study was performed using the PARA principles, as described below. More refined evaluation will be performed during pre-construction designs and engineering during construction designs.

The *Prepare* principle was used to consider measures that reduce risks or costs under loading conditions beyond those required by technical standards. The feasibility sizing of the concrete walls and pile foundation of the sector gate structures considered extreme events with return periods up to 3,000 years such as extreme barge impact conditions.

The *Absorb* principle was used to identify cost effective measures to limit damage to, or loss of function of, a project component or system due to both acute and chronic loading conditions, including conditions beyond those used for the design. An example of the absorb principle utilized for this study was the use of more robust composite fenders on the timber guidewalls, which are more resilient to repeated barge impact than their timber counterparts.

The *Recover* principle was used to identify cost effective measures that allow for rapid repair or function restoration of a project component or system. An example of the recover principle utilized for this study is the needle girder system proposed to be used for the maintenance dewatering of the structures. This system includes the ability to dewater individual gatebays, allowing navigation to pass as emergency repairs are conducted on the structure.

The *Adapt* principle was used to identify cost effective modifications to a project component or system that will maintain or improve future performance based on lessons learned from a specific loading condition or loadings associated with changed conditions. An example of the adapt principle utilized for this study is the refinement of the gate design utilizing principles from the New Orleans Hurricane and Storm Damage Risk Reduction System Design Guidelines, which was developed in response to an extreme hurricane event.

As described above, the PARA principles will continued to be evaluated and recommendations relating to resiliency will be made throughout PED, construction and O&M of the Recommended Plan. Recommendations might be incorporated into the design when they are permitted by project authorities and do not significantly increase total project life cycle cost, including recovery costs. However, in some cases, recommendations that result in significant cost increases may also be considered, but these recommendations must still be appropriately justified.

4.15 PED DESIGN

The first order of PED design would be to run Ship Simulation to validate the alignment of the draft Recommended Plan developed as part of this study. Minor revisions may be made to the alignment to reduce allisions and difficulty in navigating the crossings if Ship Simulation indicates problems with the draft recommended plan, and a full scale sedimentation and model validation study will be conducted based on two years of live data. The BRFG will be placed in the proposed gate settings and an emergency dredge contract will be on standby to prevent GIWW interruptions.

A foundation investigation program involving borings and CPTs would be initiated to better define the foundation beneath the new 125-foot sector gate proposed to be constructed on the east side of the Brazos River Crossing. A Value Engineering (VE) Study should be initiated to evaluate potential savings and innovation in design items such as the guidewalls, pile foundation, and steel sector gate, followed by plans and specification (P&S) development. The number of construction contracts would depend on available funding and selected acquisition strategy.

5.0 ENVIRONMENTAL CONSEQUENCES FOR COMPARATIVE ANALYSIS

This chapter discusses the environmental consequences of the No Action Alternative (e.g., the FWOP Condition) and the Recommended Plan. Discussions and comparisons of potential environmental impacts associated with other alternatives that were considered during project development are provided in the **Environmental Appendix – Appendix D**. For each resource discussed below, the discussions of impacts associated with the Recommended Plan focus on *direct* impacts to those resources. Indirect and cumulative impacts associated with the Recommended Plan are discussed in Sections 5.15 and 5.16, respectively.

5.1 GENERAL ENVIRONMENTAL SETTING OF THE NEPA STUDY AREA

<u>No Action</u>

Under the FWOP Condition, there will be no changes to the overall location, physiography, or land use of the NEPA study areas resulting from the project. However, the Texas coast is a dynamic environment, and the NEPA study areas will continue to be exposed to environmental factors that will change the landscape. Hurricanes and other storms will periodically affect both NEPA study areas, and continued and reasonably foreseeable sea level rises in the study areas range from roughly 1 foot to over 4 feet over the 50-year period between 2030 and 2080, which would gradually inundate low-elevation areas. The continued and reasonably foreseeable sea level rise would generally result in a lower velocity in the rivers at the GIWW crossings, resulting in higher sedimentation in the GIWW and increased O&M costs.

Both study areas will likely remain undeveloped due to their low elevations, but development could occur on higher elevations along the rivers. Local wildlife refuges/management areas could expand their boundaries to incorporate more of the surrounding coastal wetland habitats. Some wetland areas may gradually disappear either by inundation due to erosion and sea level rises. Wetlands could also be impacted if new DMPAs are established in the area to accommodate future maintenance dredging of the GIWW, although those impacts would likely be mitigated.

Under the FWOP Condition, the mouth of the San Bernard River (located about four miles west of the BRFG) is expected to naturally silt in and close after the 2017 Hurricane Harvey opening due to sediment transport and deposition from longshore currents in the Gulf. The San Bernard River outlet silted in and closed after previous dredging efforts to open the outlet, and as of September 2018, sand and silt were observed filling the mouth again after Hurricane Harvey (Friends of the San Bernard River 2018). This FWOP condition may change because a local study to re-open and maintain the San Bernard River outlet is ongoing and is included in a list of RESTORE Act projects.

Recommended Plan

The Recommended Plan would affect an estimated 125 acres at the BRFG and 86 acres at the CRL. Most of the affected acreage would be temporary impacts to open water during construction. The Recommended Plan would convert some upland and wetland areas to open water and fill some open water areas at both locations; however, the Recommended Plan would not have significant effects on the overall location, physiography, or climate of the study areas. As with the No Action Alternative, the NEPA study areas would continue to be exposed to environmental factors that will affect the area, including hurricanes, climate change and continued and reasonably foreseeable sea level rises, local subsidence, and disposal of dredged material from O&M dredging. Also like the No Action Alternative, existing land uses in the study areas would continue, and the study areas are expected to remain undeveloped if the Recommended Plan is implemented. Without the west floodgate in place at the Brazos River, the Recommended Plan would allow for increased drainage of San Bernard River flows to the Brazos River, but that is not expected to change the overall setting of the BRFG study area. Potential effects of the Recommended Plan on the San Bernard River outlet to the Gulf of Mexico are discussed primarily in **Section 5.15** ***Indirect Impacts of Recommended Plan***.

5.2 RELATIVE SEA LEVEL CHANGE

This document uses current USACE guidance to assess relative sea level change (RSLC). Current USACE guidance—ER 1100-2-8162, December 2013, and Engineer Technical Letter (ETL) 1100-2-1, June 2014—specifies the procedures for incorporating climate change and RSLC into planning studies and engineering design projects. Projects must consider alternatives that are formulated and evaluated for the entire range of possible future rates of RSLC for both existing and proposed projects. USACE guidance specifies evaluating alternatives using "low," "intermediate," and "high" rates of future sea level change.

- Low - Use the historic rate of local mean sea level change as the "low" rate. The guidance further states that historic rates of sea level change are best determined by local tide records (preferably with at least a 40-year data record).
- Intermediate - Estimate the "intermediate" rate of local mean sea level change using the modified NRC Curve I, which is corrected for the local rate of vertical land movement.
- High - Estimate the "high" rate of local mean sea level change using the modified NRC Curve III, which is also corrected for the local rate of vertical land movement.

USACE (ETL 1100-2-1, June 2014) recommends an expansive approach to considering and incorporating RSLC into civil works projects. It is important to understand the difference between the period of analysis (POA) and planning horizon. Initially, USACE projects are justified over a POA, typically 50 years. However, USACE projects can remain in service much longer than the

POA. The climate for which the project was designed can change over the full lifetime of a project to the extent that stability, maintenance, and operations may be impacted, possibly with serious consequences, but also potentially with beneficial consequences. Given these factors, the project planning horizon (not to be confused with the economic POA) should be 100 years, consistent with ER 1110-2-8159. Current guidance considers both short- and long-term planning horizons and helps to better quantify RSLC. RSLC must be included in plan formulation and the economic analysis, along with USACE expectations of climate change and RSLC, and their impacts. Some key expectations include:

- At minimum 20-, 50-, and 100-year planning horizons should be considered in the analysis.
- Reinforces the concept that a thorough physical understanding of the project area and purpose is required to effectively assess the project's sensitivity to RSLC.
- Sea level changes should be incorporated into models at the mean and extreme events.
- Identification of thresholds by the PDT and tipping points within the impacted project area will inform both the selection of anticipatory, adaptive, and reactive options selected and the decision/timing strategies.

5.2.1 Historical RSLC

Historical rates are taken from the Center for Operational Oceanographic Products and Services (CO-OPS) at NOAA, which has been measuring sea level for over 150 years. Changes in MSL have been computed using a minimum 30-year span of observations at each location. These measurements have been averaged by month to eliminate the effect of higher frequency phenomena such as storm surge, in order to compute an accurate linear sea-level trend.

The MSL trends presented are local relative trends as opposed to the global (eustatic) sea-level trend. Tide gauge measurements are made with respect to a local fixed reference level on land; therefore, if there is some long-term vertical land motion occurring at that location, the relative MSL trend measured there is a combination of the global sea-level rate and the local vertical land motion, also known as RSLC.

Historical rates of local RSLC can be obtained from local tide records. The tide gage with sea level trend information nearest to the Brazos and Colorado River systems, with over 40 years of record, is located at Freeport, TX (NOAA Gage 8772440). The NOAA MSL trend at this site is equal to 4.35 mm/yr (1.47 feet/century) with a 95 percent confidence interval of ± 1.12 mm/yr. NOAA has identified an apparent datum shift that occurred at this tide gauge about 1970. A 2013 NOAA report on estimating vertical land movement (subsidence) using long-term tide gage data estimates that the subsidence rate at the Freeport tide gage was -3.65 ± 0.41 mm/year between 1954 and 2006 (NOAA 2013). A vicinity map for NOAA Gage 8772440 is shown in **Figure 5-1**.

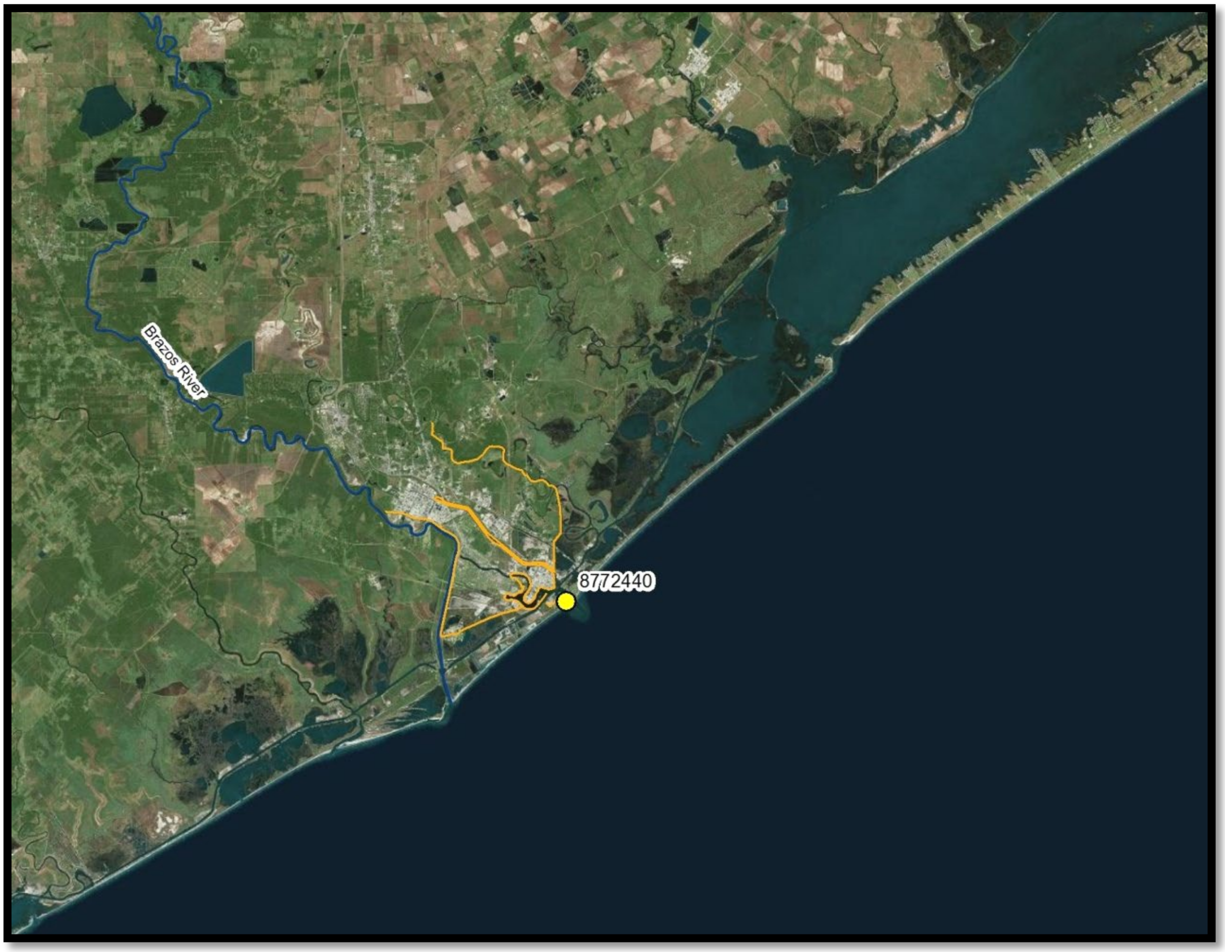

Figure 5-1 - NOAA Gage 8772440 Vicinity Map

5.2.2 Predicted Future Rates of RSLC for 20-Year Period of Analysis

The computed rate of RSLC in this section gives the expected changes between the years 2025 and 2045 for the Brazos and Colorado River systems. RSLC values for this 20-year period are summarized in **Table 5-1** and plotted for in **Figure 5-2.**

Table 5-1 - Estimated RSLC over the First 20 Years of the Project Life (2025-2045)

Tide Gage	Measured Relative SLR Rate (NOAA)	Low	Intermediate	High
		(feet)		
Freeport, TX	4.35 mm/year	0.29	0.44	0.92

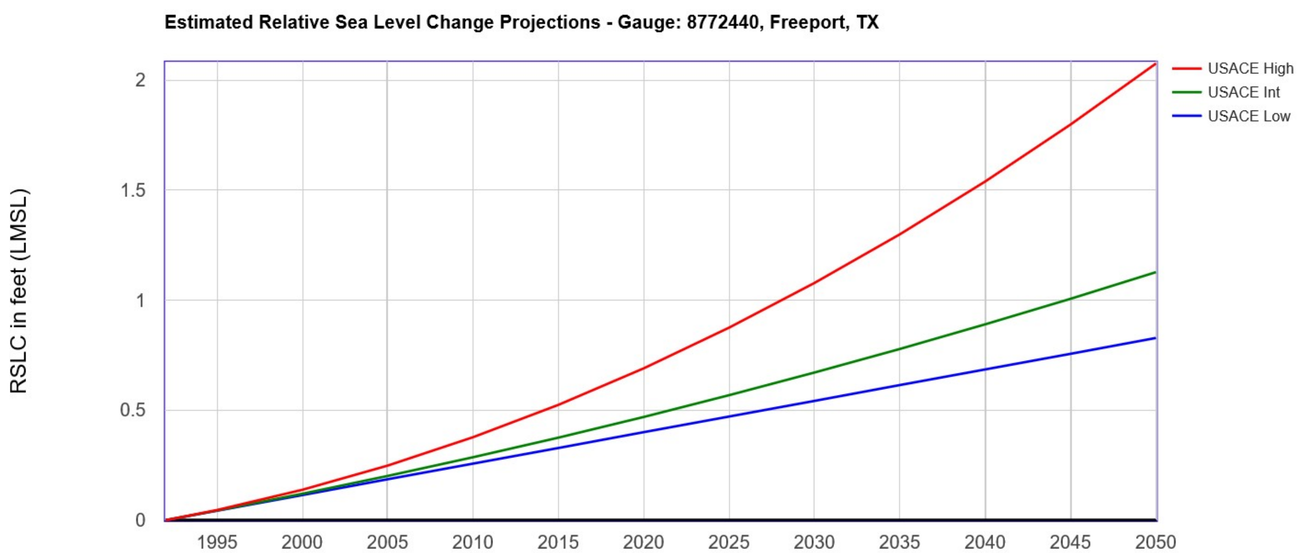

Figure 5-2 - RSLC at Freeport, Texas over 20-Year Period of Analysis (2025 Base Year)

5.2.3 Predicted Future Rates of RSLC for 50-Year Period of Analysis

The computed rates of RSLC in this section give the expected change between the years 2025 and 2075 for the Brazos and Colorado River systems. **Table 5-2** summarizes the RSLC values for this 50-year period. **Figure 5-3** shows the computed sea level change for the Brazos River system based on the current USACE guidance for "low," "intermediate," and "high" rates of change.

Table 5-2 - Estimated RSLC over the First 50 Years of the Project Life (2025-2075)

Tide Gage	Measured Relative SLR Rate (NOAA)	Low	Intermediate	High
		(feet)		
Freeport, TX	4.35 mm/year	0.72	1.23	2.86

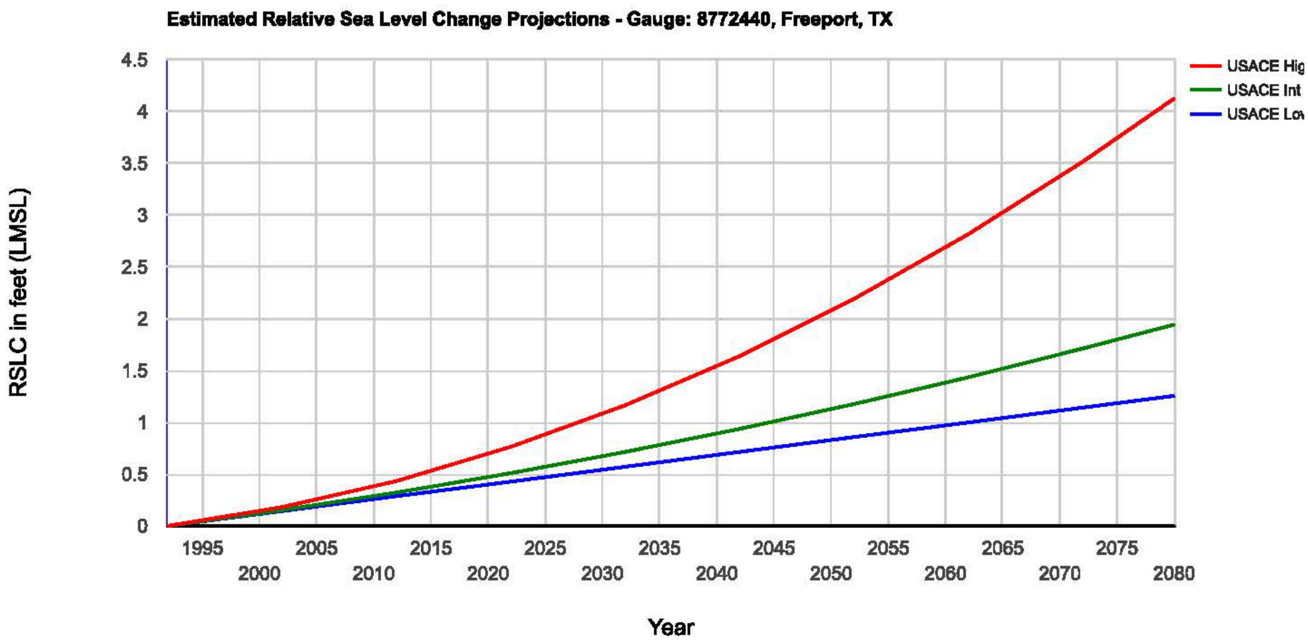

Figure 5-3 - RSLC at Freeport, Texas over 50-Year Period of Analysis (2025 Base Year/2075 End of 50-Year Project Economic Life)

Much of the area in the Freeport vicinity is low-lying. The majority of these low-lying areas are undeveloped, consisting of empty plots of land, some including marshes and wetlands. At 1 foot of sea level rise, several of these plots are inundated. It is important to note that water has begun to impact the Surfside Beach community just east of the Freeport Entrance Channel under this sea level rise scenario. At two feet, water begins to flood some central parts of Surfside Beach, inundating dozens of homes. For all considered sea level rise scenarios, safety from storm surge and wave attack for low-lying areas consistently decreases (**Figure 5-4**).

Given the uncertainty in continued and reasonably foreseeable sea level rise and subsidence, a range of RSLR scenarios were evaluated quantitatively. For this project, a bracketing approach was used rather than the required sea level scenarios. The elevations, which were evaluated for 1.0-feet and 2.0-feet RSLR over LMSL, could occur in the project anywhere between 2028 and 2062 for the 1-foot increase (at high and low scenarios, respectively), and 2059 and 2081 for the 2 foot increase (high and intermediate scenarios, respectively). The modeling shows that sedimentation rates are not highly sensitive to sea level rise. Furthermore, with higher Gulf water levels, navigability is expected to improve, since a higher tailwater would slow velocities at the crossing, and increase channel depths. As result, the overall effects of SLC on the recommended plan are relatively minor but will be accounted for in the design of features sensitive to elevation changes resulting from SLC at the range of plausible dates. Refer to the **Engineering Appendix –Appendix A** for further details on the impact of RSLC on the Recommended Plan.

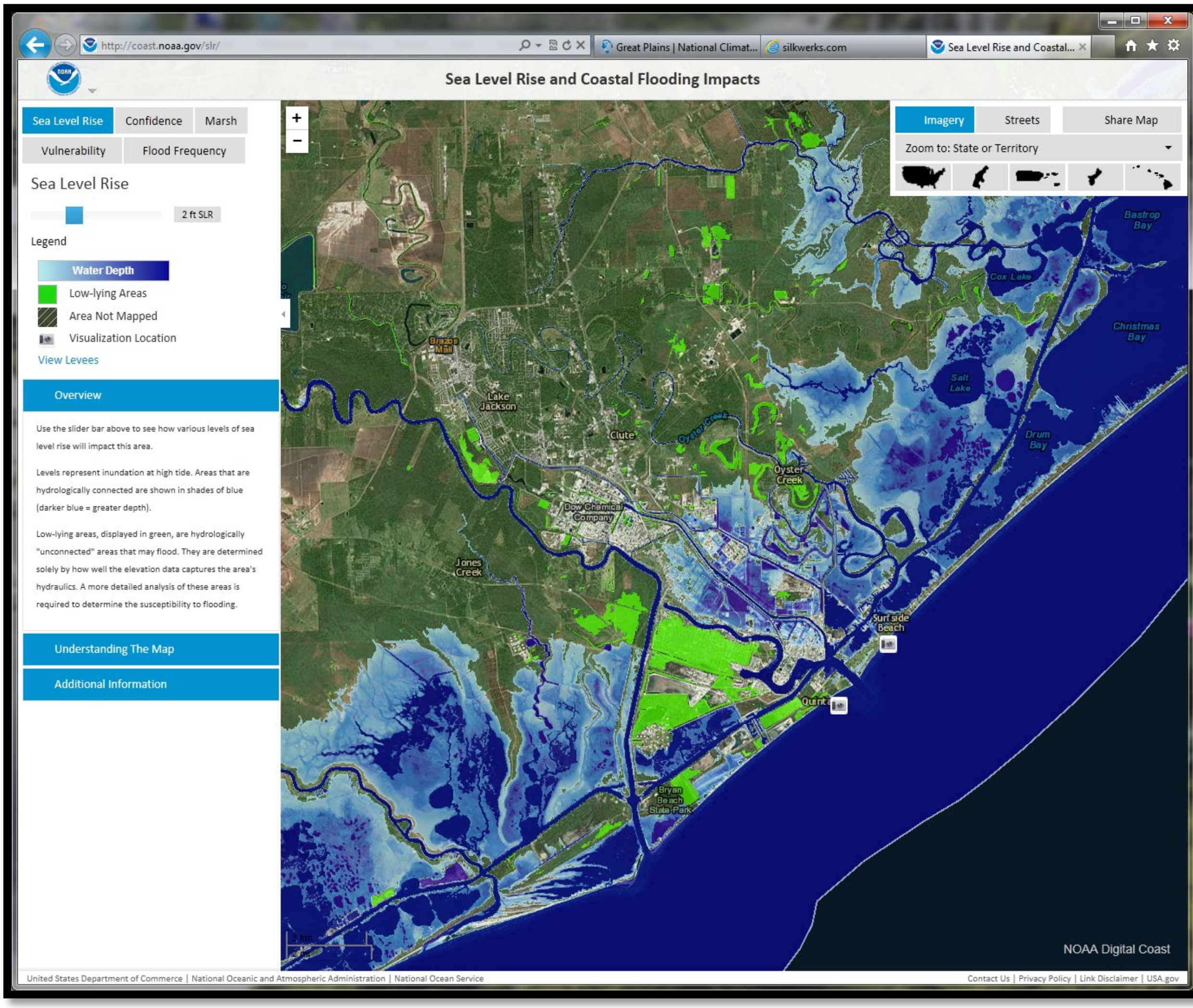

Figure 5-4 - Extent of Inundation at Freeport, Texas with Two-Foot Sea Level Rise

Observed average annual temperature changes in the project area are increasing, as are coldest and warmest daily temperatures and coldest and warmest five-day one-in-ten-year events. These changes are projected to continue. Similarly, annual precipitation has been observed to increase in the local area for the period from 1986-2015 over the average for the first half of the last century (1901-1960). These changes include increased precipitation in winter, spring, and fall, with a decrease possible in spring. Observed seasonal daily precipitation for the 20-year return value event has increased overall as well as in all seasons. Observed changes in very heavy precipitation using four measures developed by NOAA also show increases. Projected changes are more variable (with potential increases in fall and decreases in winter, spring, and summer), though seasonal variations are expected to impact the local area. At the same time, soil moisture is expected to decrease in all seasons. Heavy precipitation events are expected to continue. This would be typified by the recent events in 2015 and 2016, where very heavy precipitation events occurred during drought periods. The 20-year return value of the seasonal daily precipitation is expected to increase more in winter and summer relative to spring and fall.

As discussed in **Section 4.12** and **Engineering Appendix A**, sea level change and other climate changes could affect the performance of the Recommended Plan and other alternatives. Therefore, the PDT evaluated the potential impacts of climate and RSLC on river velocity and sedimentation. Modeling showed that changes in river velocity appear to be uniform across all alternatives at each site, and sedimentation rates are not highly sensitive to sea level rise. Higher Gulf water levels are expected to result in slower velocities at the river crossings and increased channel depths, which would improve navigability. Based on the hydraulic analyses, the overall effects of RSLC on the Recommended Plan are relatively minor (see the **Engineering Appendix – Appendices A and B** for further details on the impact of RSLC on the Recommended Plan).

As discussed in Section 4.13 and **Engineering Appendix A**, studies of precipitation and streamflow trends generally show mild increases in annual precipitation and streamflow in the Texas coastal region over the past century. Increased river discharges in the study areas are likely to increase sedimentation, although the amount of increase due to climate change is assumed to be small relative to the uncertainty in the modeled sedimentation volumes (see the **Engineering Appendix – Appendix A** for further details on the impact of precipitation changes on the Recommended Plan).

5.2.4 Predicted Future Rates of RSLC for 100-Year Period of Analysis

The planning, design, and construction of a large water resources infrastructure project can take decades. Though initially justified over a 50-year economic POA, USACE projects often remain in service much longer. The climate for which the project was designed can change over the full lifetime of the project to the extent that stability, maintenance, and operations may be affected. These changes can cause detrimental or beneficial consequences. Given these factors, the project planning horizon (not to be confused with the economic POA) should be 100 years, consistent with ETL-1110-2-1.

The period of economic analysis for USACE projects has generally been limited to 50 years because economic forecasts beyond that time frame were not considered reliable. However, the potential impacts of RSLC over a 100-year period can be used in the formulation of alternatives and for robustness and resiliency comparisons. ETL 1100-2-1 recommends that predictions of how the project or system might perform, as well as its ability to adapt beyond the typical 50-year economic analysis period, be considered in the decision-making process.

The initial assessment that evaluates the exposure and vulnerability of the project area over the 100-year planning horizon was used in assisting planners and engineers in determining the long-term approach that best balances risks for the project. The three (3) general approaches are anticipatory, adaptive, and reactive strategies. These strategies can be combined or they can change over the life cycle of the project. Key factors in determining the approach include consequences, the cost, and risk. This consideration is of particular importance under a climate change condition where loading and response mechanisms are likely to transition over the life of the project.

Using the high RSLC curve elevation at 100 years, the potential future affected area has been approximately defined. This includes both the vertical and the horizontal extents of potential RSLC impacts. Since this is feasibility level, detailed modeling has not occurred yet. This basic approach will provide a first-level assessment of how the project and project area might be impacted, and follows the guidance in ETL-2-1. During PED, more detailed engineering analyses will be conducted.

The future affected areas, as defined by the 100-year high rate of RSLC, can impact resources, including economics. These resources can be identified and quantified, such as critical infrastructure (schools, roads, water supply, community buildings, etc.), impacted property, life-safety concerns, and environment and ecosystems. The consideration of the potentially larger area of impact facilitates discussion of what actions may need to be considered at certain trigger points. Community, as well as other stakeholder expectations will be better defined. Evaluation of coastal storm-damage risk reduction in the context of RSLC may also involve societal thresholds. Potential system and cumulative effects should be explored qualitatively when formulating plans.

An essential element of developing a good understanding of the project area's exposure and vulnerability is assessing how quickly the individual scenarios might necessitate an action due to thresholds and tipping points. It is important to identify key milestones in the project timeline when impacts are expected. This involves inputs from all members of the PDT as the threshold or tipping point could be a vast variety of different items or combinations of items.

Response strategies for the project planning horizon range from a conservative anticipatory approach, which constructs a resilient project at the beginning to last the entire life cycle (and possibly beyond), to a reactive approach, which would simply be to do nothing until impacts are experienced. Between these extremes is an adaptive management strategy, which incorporates new assessments and actions throughout the project life based on timeframes, thresholds and triggers. A plan may include multiple measures.

Table 5-3 summarizes predicted RSLC values for the 100-year period of analysis. **Figure 5-5** illustrates the predicted changes.

Table 5-3 - Estimated RSLC over the First 100 Years of the Project Life (2025-2125)

Tide Gage	Measured Relative SLR Rate (NOAA)	Low	Intermediate	High
		(feet)		
Freeport, TX	4.35 mm/year	1.43	2.9	7.58

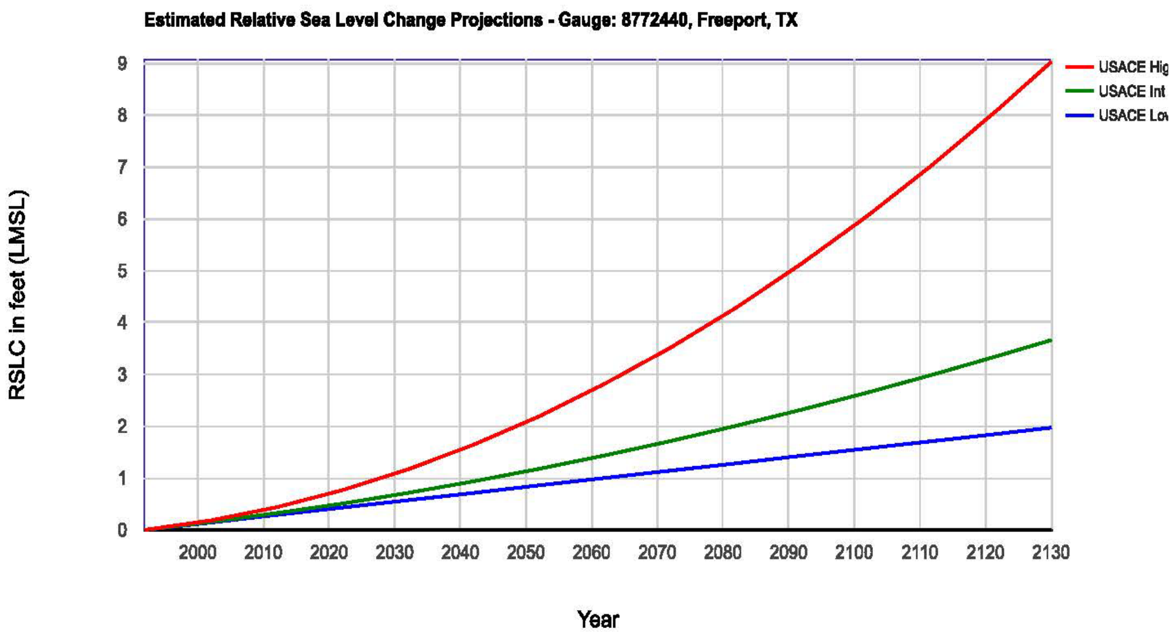

Figure 5-5 – RSLC at Freeport, Texas over 100-Year Period of Analysis (2025 Base Year/2075 End of 50-Year Project Economic Life/2125 End of Project Planning Horizon)

The estimated high rate of RSLC over the 100 year planning horizon could result in nearly 7.58 feet of RSLC. Shortly after the end of the 50-year economic life as RSLC approaches 3 feet, inundation maps (**Figure 5-6**) suggest that additional outlets to the Gulf would develop due to inundation of low lying lands south of the GIWW. Towards the end of the 100-year planning horizon (**Figure 5-7**), nearly the entire GIWW would be open to the Gulf. Under these higher RSLC scenarios, structures would be more likely to be removed or bypassed, which is consistent with industry preference for an open channel on both sides of both river crossings. As more structures are removed or spend more time in the open position, the differences between structural alternatives are reduced, further reducing the information to be gained from a higher RSLR modeling exercise. As the GIWW becomes more open to the Gulf due to increasing RSLC, further adaptive measures will need to be investigated to ensure the continued viability of the waterway.

Example adaptive measures could include shoreline restoration and raising the natural barrier islands and peninsulas that surround the GIWW and protect it from the Gulf.

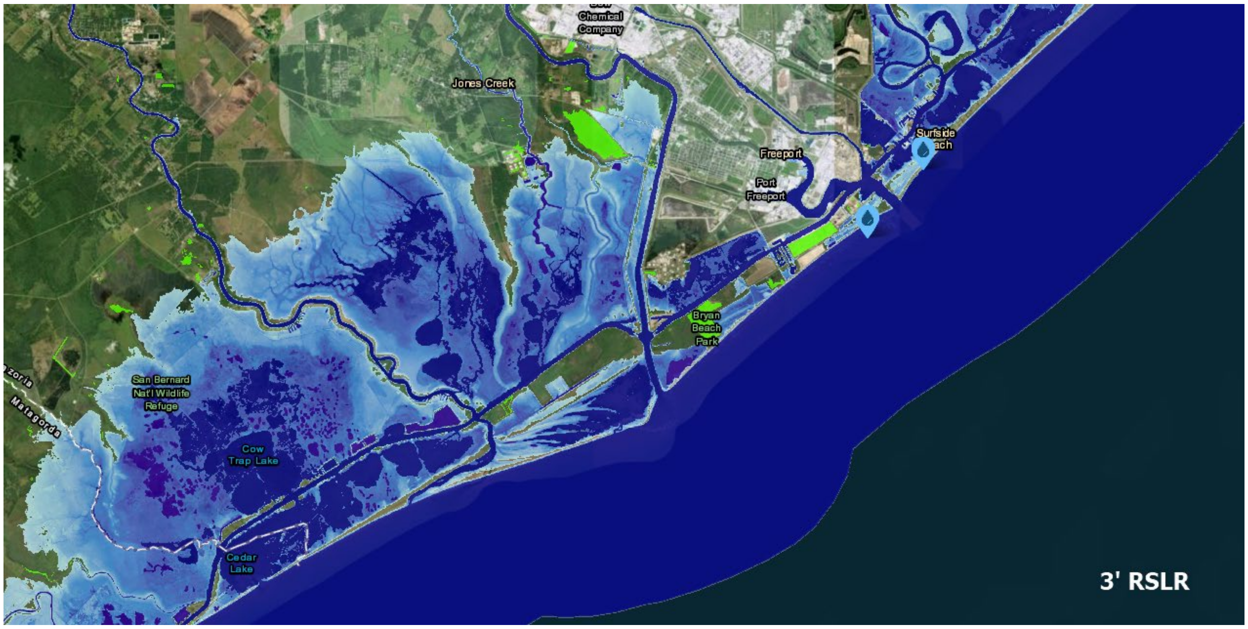

Figure 5-6 – Extent of Inundation at Freeport, Texas with Three-Foot Sea Level Rise

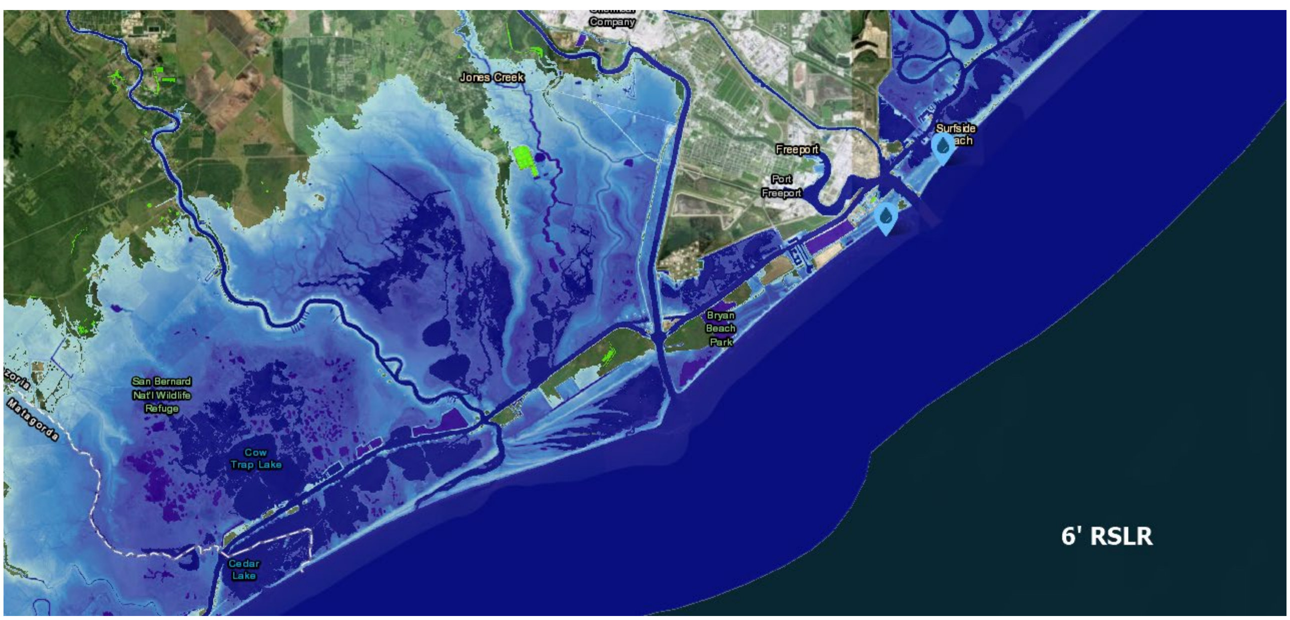

Figure 5-7 - Extent of Inundation at Freeport, Texas with Six-Foot Sea Level Rise

5.3 FLOODPLAIN, WATER AND RIVER RESOURCES

5.3.1 Floodplains and Flood Control

No Action

Under the FWOP Condition, existing river flooding trends will continue, although flooding may increase as the project region and inland areas in the major watersheds (such as Brazos, San Bernard, and Colorado Rivers) are developed and impervious cover increases, resulting in more runoff during storms. In addition, flooding may increase due to projected climate change, sea level rise, and subsidence in the region. The Velasco Drainage District and Matagorda hurricane/flood protection systems may also need to expand in the future to accommodate development, resulting in more water being pumped outside the levee system during and after storm events.

Recommended Plan

Compared to the No Action Alternative, the Recommended Plan is not expected to have significant effects on flooding or flood protection in the BRFG or CRL study areas. Flooding in the BRFG and CRL vicinities would continue to occur after storms upstream and, less frequently, during tropical storms and hurricanes. As with the No Action Alternative, future flooding in the region may be exacerbated by projected climate change, sea level rises, and subsidence.

At the BRFG, the removal of the west floodgate would allow for free exchange between the Brazos River and the West GIWW, which could result in elevated water levels in the GIWW during high river flow events. Therefore, the PDT analyzed the risk of flooding the adjacent land areas along the West GIWW. Descriptions of the analysis and results are provided in **Engineering Appendix A-1: Hydraulic Engineering Appendix – Brazos River Floodgates, Section 3.2 *Hydrodynamic Alternatives Analysis***. To summarize the results, under the Recommended Plan the low water levels in the West GIWW would be reduced, while high water levels would be slightly increased, with the absolute peak water level showing a minor increase of 0.3 to 0.4 feet (3.5 to 5 inches). Comparing the minor increase in peak water level to bank elevations along the West GIWW, the potential increase in peak water level is not expected to increase overtopping of the GIWW banks. Based on this analysis, the Recommended Plan would have a minor permanent impact on water levels in the West GIWW during high water conditions, but this impact is not considered significant because it is not expected to increase flooding of adjacent land areas.

Another concern was that the open connection between the West GIWW and the Brazos River could cause elevated water levels in communities along the San Bernard River. Therefore, the PDT evaluated anticipated water levels near the communities of Rivers End and Sanders Road, which are located on the San Bernard River approximately 0.6 mile and 3.8 miles upstream of the GIWW, respectively. Descriptions of this analysis and results are also provided in **Engineering**

Appendix A-1: Hydraulic Engineering Appendix – Brazos River Floodgates, Section 3.2 ***Hydrodynamic Alternatives Analysis***. Compared to the FWOP Condition, the Recommended Plan at BRFG is expected to reduce water surface elevations at the two communities during low tides, likely because the proposed open channel would allow increased drainage of San Bernard flows to the Brazos River. During other conditions, water levels at the communities is expected to be similar as under the No Action Alternative. The analysis indicated that the Recommended Plan is not expected to have adverse impacts to flooding along the San Bernard River.

5.3.2 Water Resources

No Action

Under the FWOP Condition, no impacts to wetlands or other water resources would occur because of the project itself. Some wetland areas in the NEPA study areas may be converted gradually to open water habitats as sea levels rise and/or subsidence occurs. Wetlands could also be impacted if new DMPAs are established in the area to accommodate future maintenance dredging, although those impacts would likely be mitigated. Water use and supply would not be affected by the FWOP Condition, although sea level rise may increase salinities in the rivers during low-flow periods.

Recommended Plan

Like the No Action Alternative, the Recommended Plan would not affect water use or water supply. **Table 5-4** summarizes the acreage of wetlands and other special aquatic sites (e.g., tidal flats) that would be removed by the Recommended Plan. At the BRFG, the Recommended Plan would remove approximately 13.8 acres of wetlands, most of which consists of intertidal marsh that currently exists along the south side of the GIWW. At the CRL, the Recommended Plan would remove approximately 0.7 acre of wetland.

Table 5-4 - Impacts of Recommended Plan on Wetlands and Other Special Aquatic Sites (acres)

Site (Recommended Plan)	High Marsh	Intertidal Marsh	Tidal Flat	Total
BRFG (Alternative 3a.1)	2.4	11.4	0	**13.8**
CRL (Alternative 4b.1)	0	0.7	0	**0.7**
TOTAL	**2.4**	**12.1**	**0**	**14.5**

In addition to the anticipated wetland losses, the Recommended Plan is expected to affect roughly 94 acres of open water at the BRFG and 61 acres of open water at the CRL. However, most of the open water impacts would consist of temporary construction impacts (e.g., barge access, pile driving, dredging, and turbidity) and were assumed to potentially affect the entire area of open water present in the study area between the points where the new GIWW alignment converges with the existing GIWW alignment. Approximately 6.7 acres of open water at the BRFG and 2.8 acres of open water at the CRL would be filled to construct the new floodgates and levee access.

In contrast, an estimated 27 acres of open water would be created at the BRFG, and an estimated 11 acres of open water would be created at the CRL, by realigning the GIWW and removing existing portions of the existing floodgate structures. Therefore, the Recommended Plan would result in a net increase in open water in the study areas.

Other wetland areas in the study areas may be converted gradually to open water habitats over time as sea levels rise, but this change is expected to be similar under both the No Action Alternative and the Recommended Plan. Since existing DMPAs and Ocean Dredged Material Disposal Site (ODMDS) would be used for the project, the Recommended Plan is not expected to impact wetlands due to dredged material placement. The Recommended Plan would not change local water supply or water use.

During the PED phase, the USACE will incorporate best management practices (BMPs) and other options for further reducing impacts to wetlands, if possible, into detailed design and construction plans. The USACE will also provide on-site, in-kind mitigation for the impacted wetlands. During detailed design, the excavation and placement plan will include areas within both project sites in which to construct high marsh and intertidal marsh. Based on the mitigation analysis conducted for the project, the USACE will create a total of 14.9 acres of wetland habitat to offset the impacted wetlands. This mitigation acreage includes 14.14 acres of wetland habitat at the BRFG (2.45 acres of high marsh and 11.69 acres of intertidal marsh) and 0.76 acre of wetland habitat (intertidal marsh) at the CRL. A mitigation plan is provided in **Environmental Appendix D, Attachment D-8**. The Recommended Plan would result in short-term losses of wetland functions and values during construction, but this impact is not considered significant because the impacted wetlands account for a small percentage of the wetlands in the study areas and surrounding region.

The USACE evaluated the Recommended Plan under the CWA 404(b)(1) guidelines and determined that it complies with the guidelines (see 404(b)(1) analysis in **Environmental Appendix D, Attachment D-1**). In compliance with EO 11990 on Protection of Wetlands, the Recommended Plan at each facility minimizes impacts to wetlands compared to other alternatives that meet the project's purpose and need and satisfy navigation needs based on public input.

5.3.3 Water Quality

<u>No Action</u>

Under the FWOP Condition, periodic disturbance and suspension of sediments in the water column will continue because of O&M dredging operations, barge traffic, and flooding. As the BRFG and CRL facilities continue to age, and/or if barge traffic increases, the potential for accidents resulting in a contaminant spill may increase and may affect water quality. Continued implementation of pollutant protection programs by the EPA and TCEQ and use of BMPs will benefit water quality.

Recommended Plan

Under the Recommended Plan, water-based construction activities such as barge access, pile driving, and dredging would disturb soils and sediments, resulting in suspended sediments and increased turbidity in the GIWW and Brazos and Colorado Rivers. During land-based construction activities adjacent to the GIWW at both facilities, runoff from exposed earth could also contribute to temporary increases in suspended sediment and turbidity in adjacent water. The increase in turbidity would be temporary and is expected to return to existing conditions after construction activities are completed. Maintenance dredging, which is expected to continue to occur on an estimated 24-month schedule, would also temporary increase sediment and turbidity in the area. BMPs would be used to reduce suspended solids from land runoff, including installation of silt fences, fiber rolls, rock berms, or other effective BMPs. Similarly, during the PED phase, the USACE would incorporate BMPs such as turbidity screens or silt collection curtains around construction equipment if needed to reduce the amount of sediment in the water. As under the FWOP Condition, periodic disturbance of sediments and suspension of sediments in the water column would continue due to barge traffic and flooding.

Prior to disturbance, sediment sampling would be conducted at the BRFG and CRL to characterize the contaminants present. If contaminated, the material would be handled and disposed of in accordance with applicable local, state, and federal permits, statutes, and regulations.

With the implementation of appropriate BMPs and handling/disposal procedures as needed, the Recommended Plan would have temporary adverse effects to water quality in the vicinity, but these impacts are not expected to be significant. TCEQ provided a water quality certification in a letter dated 21 May 2019 (**Appendix D, Attachment D-1**).

5.3.4 **Salinity**

No Action

Under the FWOP Condition, existing trends in salinity changes in the study areas would continue, with higher salinities occurring during low river flows and lower salinities occurring during high river flows. In the future, salinities in the study areas are expected to gradually increase due to anticipated sea level rises.

Recommended Plan

At the BRFG, the Recommended Plan is expected to result in salinity changes compared to the No Action Alternative, particularly in the West GIWW where the existing floodgate will be removed and an open channel will remain between the GIWW and Brazos River. Projected salinity changes and associated effects at the BRFG are discussed below. At the CRL, the Recommended Plan includes new floodgates on both sides of the Colorado River, and salinity conditions are expected to be similar to the No Action Alternative. At both facilities, salinities are expected to gradually increase over time regardless of the selected alternative due to continued and reasonably foreseeable sea level rises.

At the BRFG, removal of the west floodgate would allow for free exchange between the Brazos River and the West GIWW, which could cause salinity changes due to saltwater intrusion into the river and/or increased freshwater flows into the GIWW. Therefore, the PDT modeled existing and projected salinity conditions to assess salinity changes attributable to the Recommended Plan. The primary salinity analysis was conducted for four zones, which are shown on **Figure 5-8** and include the West GIWW, Brazos Basin, East GIWW, and Freeport Channel. Descriptions of the modeling and results are provided in **Engineering Appendix A-1: Hydraulic Engineering Appendix – Brazos River Floodgates, Section 4 Salinity Analysis**. **Tables 5-5 and 5-6** summarize the projected average salinities for each of the modeled zones under low and high freshwater flows, respectively. Note that the model was calibrated using salinity data collected during the 13-month period spanning March 2015 through March 2016, which was a relatively wet period when the Brazos River exhibited multiple high flow events and had greater flows throughout the period relative to periods with less rainfall.

Table 5-5 - Mean Salinity (and change from existing) (ppt) at BRFG, October-December (High Freshwater Flow)

Alternative	West GIWW	Brazos Basin	East GIWW	Freeport Channel
Existing (= No Action/FWOP)	5.7	1.7	5.0	15.0
Recommended Plan at BRFG	3.9 (-1.8)	2.1 (0.4)	5.2 (0.2)	15.2 (0.2)

Table 5-6 - Mean Salinity (and change from existing) (ppt) at BRFG, June-August (Low Freshwater Flow)

Alternative	West GIWW	Brazos Basin	East GIWW	Freeport Channel
Existing (= No Action/FWOP)	3.1	0.4	3.8	15.0
Recommended Plan at BRFG	0.9 (-2.2)	0.2 (-0.2)	2.6 (-1.2)	15.1 (0.1)

Figure 5-8 - Zones for Salinity and Sedimentation Analyses near BRFG

Based on the modeling, the greatest salinity change resulting from the Recommended Plan would occur in the West GIWW, where there would be a decrease in salinity during both low and high freshwater flows. The average projected decrease in the West GIWW is 1.8 ppt during low freshwater flows and 2.2 ppt during high freshwater flows. Because modeled existing salinities were already low (5.7 ppt for low flow and 3.1 ppt for high flow), the projected changes represent a 32 percent decrease under the low-flow condition and 71 percent decrease under the high-flow condition.

As noted above, the salinity model was calibrated using data collected during a relatively wet period spanning 13 months. To estimate average salinities based on a larger dataset, the projected percentage decreases reported above were applied to average salinities calculated from the 5-year gauge data discussed in Chapter 2 (see **Section 2.2.5** – average high salinity of 25.7 ppt in August [low freshwater flow] and average low salinity of 9.2 ppt in May [high freshwater flow]). Based on this calculation, estimated salinities in the West GIWW resulting from the Recommended Plan would average 17.5 ppt during low freshwater flows and 2.7 ppt during high freshwater flows.

In contrast to the projected salinity decreases in the GIWW, the model results show an increase in projected salinity in the Brazos Basin during low freshwater flows. Although the salinity change is slight (0.4 ppt), it constitutes a 24 percent increase compared to the existing salinity level. Applying this percent increase to the 5-year gauge data, estimated salinities in the Brazos Basin could average as high as 32 ppt during low freshwater flows. However, this is still within the range of an estuary system, and review of data further upstream in the Brazos River indicate there would be little to no change in salinities upstream. Additional discussion of salinity changes upstream in the Brazos River and other areas farther from the BRFG is provided in **Section 5.15 *Indirect Impacts of Recommended Plan*.**

Although the Recommended Plan would affect salinities, with potentially significant percent decreases in salinity in the West GIWW, the projected salinities are within the broad range of an estuarine system. Furthermore, the projected lowest average salinities would occur temporarily during high flows after rainfall events and would gradually recover as river flows reduce. As a result, salinity changes resulting from the Recommended Plan at the BRFG are not expected to have a significant effect on estuarine habitats or wildlife in or near the study area.

During public review of the DIFR-EIS, the public voiced concern that the Recommended Plan at the BRFG would permanently transform the San Bernard River mouth from a saltwater estuary to a freshwater system. Based on the salinity modeling performed, the San Bernard River mouth would continue to function as a saltwater estuary. Further discussion of potential effects of the Recommended Plan on the San Bernard River mouth are discussed in **Section 5.15 Indirect Impacts of Recommended Plan**.

5.3.5 Sediment

No Action

Under the FWOP Condition, current sedimentation trends in the GIWW will continue, resulting in the need for regular maintenance dredging and dredged material disposal. Continued and reasonably foreseeable sea level rises would generally result in a lower velocity in the rivers at the GIWW crossings, resulting in higher sedimentation in the GIWW and increased O&M costs.

Recommended Plan

To determine the potential changes of the Recommended Plan on sedimentation patterns and volumes in the GIWW, the PDT conducted sedimentation analyses for both the BRFG and CRL sites. The following discusses the results of the analyses.

BRFG Sedimentation Analysis

At the BRFG, the analysis evaluated existing and projected sedimentation within the six zones shown on **Figure 5-8** above. Descriptions of the BRFG sedimentation analysis and results are provided in **Engineering Appendix A-1: Hydraulic Engineering Appendix – Brazos River Floodgates, Section 5 Sedimentation Analysis**. **Table 5-7** summarizes the existing sedimentation volumes and the projected volumes under the Recommended Plan at the BRFG.

Table 5-7 - Average Annual Sediment Deposition at the BRFG under Existing Conditions (No Action) and Recommended Plan based on Simulation Results

Alternative	West GIWW	Brazos Basin	East GIWW	Freeport Channel	Brazos Delta	Freeport Offshore	Total in Zones Requiring Maintenance
	(cubic yards of deposition)						
Existing (No Action)	554,769	48,000	890,769	295,385	44,382,462	208,726	**1,788,923**
Recommended Plan at BRFG	653,130	58,332	902,653	326,420	44,000,887	196,239	**1,940,535**
% Change	18%	22%	1%	11%	(-1%)	(-6%)	**8%**

Based on the analysis, the Recommended Plan would result in a net eight percent increase (151,612 cubic yards) in annual sediment deposition within the six zones at the BRFG. As discussed previously in Chapter 3, the increased sediment in the GIWW will require higher O&M dredging costs. Potential environmental impacts of the sedimentation changes resulting from the Recommended Plan at the BRFG include the following:

Habitat impacts – The projected sediment changes are not expected to have significant adverse effects on wildlife habitats in the area. Increased sedimentation could gradually raise the bottom elevation of open water areas along the edge of the GIWW or other areas where O&M dredging does not remove the sediment. This may have a beneficial effect because it could result in elevations suitable for establishment of marsh vegetation, which would provide additional habitats, provide bank stabilization, and facilitate water quality.

Reduced sediment to the Brazos Delta – The projected annual decrease of sediment to the Brazos Delta would reduce the amount of sediment available for transport by longshore currents westward to beaches, including piping plover critical habitat. However, this impact is not expected to be significant because the projected sediment reduction accounts for less than one percent of the total sediment that reaches the Brazos Delta, and over 44 million cubic yards would still reach the delta annually under the Recommended Plan.

Increased disposal needs – The projected increase in sediment volume requiring O&M dredging would eventually result in the need for additional disposal areas compared to the No Action Alternative. Dredged material resulting from construction of the Recommended Plan and subsequent maintenance would be placed within existing DMPAs until available capacity is exhausted, after which dredged material would be transported offshore to an existing ODMDS that has been approved for Freeport Channel dredging. When that need arises, coordination and approval by the EPA would be required. Developing a full DMMP to address disposal needs, either for future maintenance dredging associated with this project or for a larger GIWW segment that includes the BRFG, could result in more cost-effective placement options, including beneficial uses for dredged material.

Adverse impacts to the San Bernard River outlet dredging – A concern brought forth during public review was that the open channel to the West GIWW would increase sedimentation at the San Bernard River mouth, thereby adversely affecting an ongoing study evaluating the re-opening and maintenance of the San Bernard River mouth. The PDT analyzed sedimentation at the San Bernard River if the outlet were open; the results are provided in **Section 5.15 *Indirect Impacts of Recommended Plan*** and in **Engineering Appendix A-1: Hydraulic Engineering Appendix – Brazos River Floodgate**s, Section 5.4 *Open San Bernard Mouth Modeling*. Based on historical aerial examination, previous dredging attempts, and literature (Kraus and Lin 2002), the controlling process for the morphology of the San Bernard River mouth is the net westward transport of sediments deposited by the Brazos River into the Gulf, not sediment deposition via the GIWW.

CRL Sedimentation Analysis

The sedimentation analysis performed at the CRL is detailed in **Engineering Appendix A-2: Hydraulic Engineering Appendix – Colorado River Locks**. **Figure 5-9** shows the CRL zones where projected sedimentation was evaluated. **Table 5-8** summarizes the existing sedimentation volumes and the projected volumes under the Recommended Plan at the CRL.

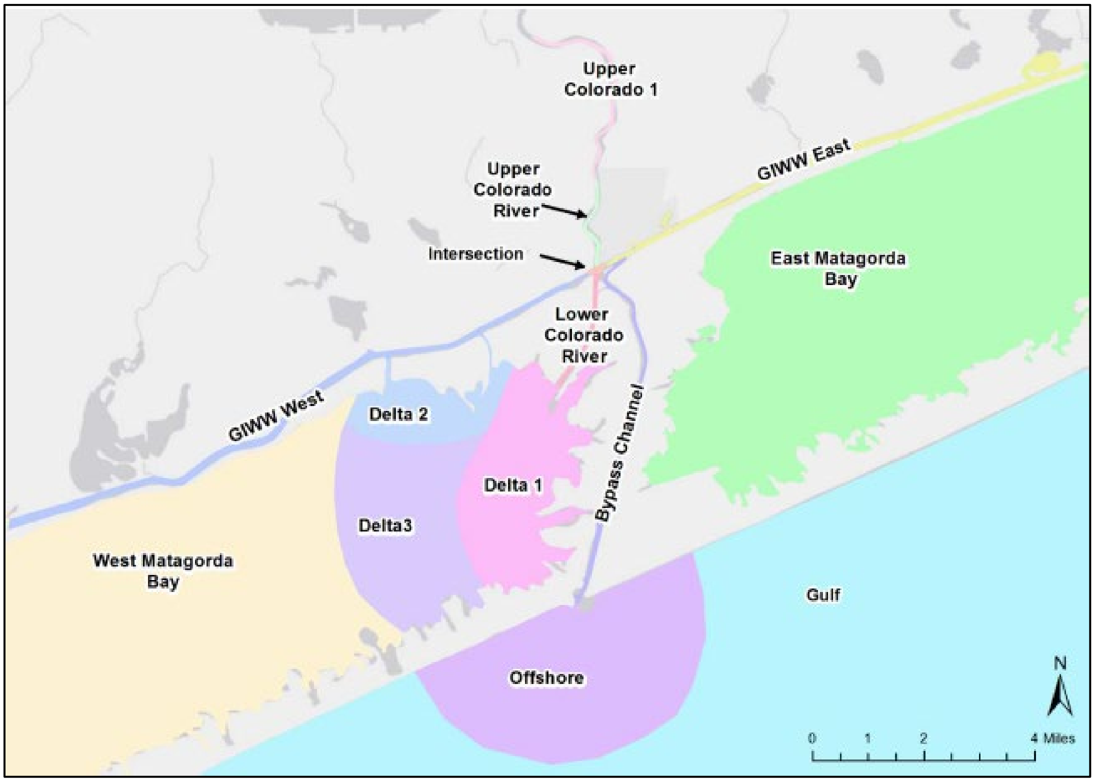

Figure 5-9 - Zones for Sedimentation Analysis near CRL

Table 5-8 - Average Annual Sediment Deposition at CRL under Existing Conditions and Recommended Plan based on 2016 Simulation Regression Analysis (cu yds)

Area of Interest	Existing (No Action)	Recommended Plan	Percent Difference (%)
	(cubic yards)		
GIWW East	88,921	83,387	-6.22%
GIWW West	212,956	206,952	-2.82%
Bypass Channel	70,519	72,813	3.25%
Intersection	11,789	14,695	24.65%
Delta 1	2,432,825	2,523,478	3.73%
Delta 2	651,095	648,468	-0.40%
Delta 3	1,450,778	1,453,523	0.19%
Offshore	360,739	359,459	-0.35%

In general, the projected changes in sediment volumes resulting from the Recommended Plan at the CRL are relatively minor, ranging from less than 1,000 cubic yards to about 6,000 cubic yards annually depending on zone. The largest volume change is at Delta 1, where the Colorado River flows into West Matagorda Bay. The Recommended Plan is expected to result in over 90,000 cubic yards of additional sediment deposition at Delta 1 annually, which will facilitate continued growth of the delta and associated wetlands and piping plover habitat. Overall, the Recommended Plan would result in slightly less sediment in areas requiring maintenance dredging at the CRL than the No Action Alternative, so the Recommended Plan would have minimal to slightly beneficial effect on placement areas.

5.4 VEGETATION, WILDLIFE HABITAT, LAND RESOURCES, AND THREATENED AND ENDANGERED SPECIES

5.4.1 Vegetation and Wildlife Habitat

No Action

Due to their low-lying position and proximity to the Gulf of Mexico, wetlands and other habitats in the BRFG and CRL areas are susceptible to being lost to rising sea levels resulting from climate change under the FWOP Condition. Wetlands and other habitats may also be lost or converted due to continued disposal of dredged material from the GIWW. Habitat losses could result in reduced habitat diversity, particularly for aquatic and semi-aquatic animals, waterfowl, and wading birds. Development in the NEPA study areas is expected to be minimal.

Large areas of wetlands and other native habitats in the BRFG and CRL regions will continue to be protected by the San Bernard NWR, Justin Hurst WMA, and Mad Island WMA, and future wetland losses may be reduced by restoration and shoreline stabilization projects. Impacts to coastal habitats and resources would also be managed and mitigated to some extent by regulations and programs such as the CWA, ESA, CBRA, Coastal Zone Management Act, and TCMP, as well as by continued funding of programs to purchase, preserve, and manage coastal areas.

Recommended Plan

Table 5-9 summarizes the acreages of vegetation/wildlife habitats that would be impacted by the Recommended Plan. At the BRFG, the Recommended Plan would impact an estimated 125 acres, most of which would consist of temporary impacts to open water habitat during construction (e.g., barge access, pile-driving, dredging, turbidity). Approximately 13.8 acres of wetlands and 14.0 acres of upland shrub/woods habitat would be removed at the BRFG, most of which would be converted to open water. Approximately 6.7 acres of open water habitat would be filled and converted to the new floodgate structure. At the CRL, the Recommended Plan would impact an estimated 86 acres, most of which would consist of temporary impacts to open water habitat during construction. Approximately 0.7 acre of wetlands and 11.4 acres of upland shrub/woods would be removed at the CRL, most of which would be converted to open water. Approximately 2.8 acres of open water habitat would be filled at the CRL to construct the new floodgate structures. Since existing DMPAs and ODMDS are proposed for disposal of dredged material from construction and maintenance of the facilities, the Recommended Plan is not expected to impact new areas of vegetation/wildlife habitats due to dredged material placement. BMPs will be used during construction activities to prevent the establishment and spread of invasive plant species.

Table 5-9 - Direct Impacts to Vegetation/Wildlife Habitats by the Recommended Plan (acres) [1]

Alternative	Developed	High Marsh	Intertidal Marsh	Tidal Flat	Upland Shrub/Woods	Open Water[2,3]	Total
	Direct Impacts by the Recommended Plan in Acres						
BRFG (Alt. 3a.1)	3.1	2.4	11.4	0	14.0	94.4[2,3]	**125.3**
CRL (Alt. 4b.1)	12.7	0	0.7	0	11.4	61.0[2,3]	**85.8**

[1] *Most of the impacted areas identified in this table would be converted to open water to realign the GIWW, construct the open channel west of the Brazos River, and remove portions of the existing floodgate structures. Therefore, the project would result in a net increase in open water habitat.*

[2] *Most of the reported impacts to open water are temporary construction impacts (e.g., barge access, pile-driving, turbidity, dredging) and include the entire area of open water present in the study area between the beginning and end of the new GIWW alignment.*

[3] *Approximately 6.7 acres of open water at BRFG and 2.8 acres of open water at CRL would be filled to construct the new floodgates and levee access.*

None of the vegetation communities/wildlife habitats impacted by the Recommended Plan are considered regionally rare, unique, or imperiled. As discussed in **Chapter 2.0, Section 2.3**, the habitats were evaluated to determine their significance and if mitigation is warranted. Based on current USACE guidance and procedures, the wetland habitats have institutional significance at a national level due to the various laws and statutes that protect wetland resources (e.g., CWA Section 404(b)(1) and EO 11990 on Protection of Wetlands), as well as technical significance due to their importance to water quality, biodiversity, and ecological productivity. Therefore, the USACE will mitigate wetland impacts so that the Recommended Plan would result in no net loss of wetland habitats. The mitigation plan is provided in **Environmental Appendix D, Attachment D-8**. With implementation of the mitigation plan, the Recommended Plan will result in short-term losses of wetland functions and values during construction, but this impact is not considered significant because the impacted wetlands account for a small percentage of the wetlands in the study areas and surrounding region.

Although the open water resources in the study areas are significant for multiple reasons discussed in Section 2.3, they are not limited resources in the region, and the Recommended Plan would result in a net increase in open water habitats. Therefore, no mitigation is proposed for open water habitats. Likewise, no mitigation is proposed for upland shrub/woods habitats. Although the impacted upland shrub/woods habitats in the study areas provide foraging, roosting, and nesting opportunities for migratory birds protected under the MBTA, they are not unique in this respect. In addition, the impacted habitats consist of relatively young (<50 years) woody growth, do not constitute bottomland hardwoods or other significant woodland habitat, and contain both common and non-native shrub and tree species. Similar habitats are also common in the region. As a result, the impacted upland shrub/woods habitats are not considered significant ecological resources in the study areas. Therefore, the permanent removal of upland shrub/woods is an adverse effect but is not considered a significant effect.

As discussed in **Section 5.3.4 *Salinity***, projected salinity changes resulting from the Recommended Plan would remain within the broad range of an estuarine system, and the projected lowest average salinities would occur temporarily during high flows after rainfall events and would gradually recover as river flows reduce. As a result, salinity changes resulting from the Recommended Plan are not expected to have a significant effect on estuarine habitats or wildlife in or near the study areas. Over time, other habitats in the study areas may be converted gradually to open water habitats as sea levels rise, but this impact is expected to be similar to the No Action Alternative.

During construction of the Recommended Plan, noise from pile driving, and other construction activities could affect wildlife use of nearby habitats and may result in avoidance of habitats during construction. The most noise-producing activity, pile-driving, is expected to occur during daytime hours, so there would be relief at night. Underwater noise and vibration from pile driving has been documented to cause hearing loss, behavioral changes, physiological effects, and even death in fish (Buehler et al. 2015). BMPs that are implemented into project design and construction to reduce underwater noise levels and potential impacts to threatened and endangered species and marine mammals (see **Section 5.4.3** for discussion) would also reduce impacts on fish and other wildlife. Potential BMPs that may be incorporated into final design include implementing a “soft start” for up to 20 minutes, using vibratory hammers or cushioned impact hammers, or installing piles within a dewatered cofferdam. BMPs will be determined through final consultation with resource agencies prior to project implementation and will be incorporated into the construction plans during the PED phase. With the use of BMPs, temporary impacts of noise from pile driving will be adverse but is not expected to be significant.

5.4.2 **Land Resources (Protected/Managed) and Recreation Areas**

<u>No Action</u>

Under the FWOP Condition, the Levee Road Boat Ramp, located in the BRFG NEPA study area, is expected to continue to be open to the public and maintained by Brazoria County. The San Bernard NWR, Justin Hurst WMA, Mad Island WMA, and other parks and recreation areas near the BRFG and CRL NEPA study areas will continue to operate.

Recommended Plan

Like the No Action Alternative, the Recommended Plan is not expected to impact the operation or use of the Levee Road Boat Ramp or designated parks, recreation areas, NWRs, WMAs, or other protected or managed lands near the BRFG and CRL facilities. Noise during construction may make areas near the facilities temporarily less attractive to use, particularly the Levee Road Boat Ramp. This temporary adverse impact is not expected to be significant because the boat ramp is not likely used on a daily basis, and other boat ramps are available to access the BRFG area.

5.4.3 Threatened and Endangered Species

No Action

Under the FWOP Condition, future losses of wetlands and beaches in the region due to sea level rises, erosion, subsidence, or other effects could have an impact on wintering whooping cranes, piping plovers, and red knots, while future protection, restoration, and stabilization efforts in coastal habitats could benefit these species. Sea turtles may be affected by vessel traffic, industrial development, and dredging operations in the GIWW, although development in the NEPA study areas is expected to be minimal. Potential impacts of various activities would be managed by continued execution of the ESA, including development of conservation plans and measures.

Recommended Plan

Table 5-10 summarizes the anticipated effects of the Recommended Plan on federally listed threatened and endangered species. The Recommended Plan is expected to have no effect on most of the listed species because those species have low potential of occurring in the NEPA study areas and/or proposed improvements could be constructed in a way that would avoid impact to the species or their habitats. The Recommended Plan may affect, but is not likely to adversely affect the following seven species: piping plover, red knot, whooping crane, and green, hawksbill, Kemp's ridley, and loggerhead sea turtles.

Table 5-10 - Anticipated Effects of Recommended Plan on Threatened & Endangered Species

Listed Species		Listing Status	Jurisdiction	May Occur in NEPA Study Areas?	Recommended Plan Effect Determination[1]
Common Name	**Scientific Name**				
Birds					
Northern aplomado falcon	*Falco femoralis septentrionalis*	Endangered	USFWS	Yes	No Effect
Piping plover	*Charadrius melodus*	Threatened	USFWS	Yes	MANLAA; No Adverse CH Modification[1]
Red knot	*Calidris canutus rufa*	Threatened	USFWS	Yes	MANLAA
Whooping crane	*Grus americana*	Endangered	USFWS	Yes	NMANLAA
Mammals					
West Indian manatee	*Trichechus manatus*	Threatened	USFWS	Yes	No Effect
Fin whale	*Balaenoptera physalus*	Endangered	NMFS	No	No Effect
Humpback whale	*Megaptera novaeangliae*	Endangered	NMFS	No	No Effect
Sei whale	*Balaenoptera borealis*	Endangered	NMFS	No	No Effect
Sperm whale	*Physeter macrocephalus*	Endangered	NMFS	No	No Effect
Reptiles					
Green sea turtle	*Chelonia mydas*	Threatened	NMFS	Yes	MANLAA
Hawksbill sea turtle	*Eretmochelys imbricata*	Endangered	USFWS; NMFS	Yes	MANLAA
Kemp's ridley sea turtle	*Lepidochelys kempii*	Endangered	USFWS; NMFS	Yes	MANLAA
Leatherback sea turtle	*Dermochelys coriacea*	Endangered	USFWS; NMFS	No	No Effect
Loggerhead sea turtle	*Caretta caretta*	Threatened	USFWS; NMFS	Yes	MANLAA
Mollusks					
Golden Orb	*Quadrula aurea*	Candidate	USFWS	No	No Effect
Smooth pimpleback	*Quadrula houstonensis*	Candidate	USFWS	No	No Effect
Texas fawnsfoot	*Truncilla macrodon*	Candidate	USFWS	No	No Effect
Texas pimpleback	*Quadrula petrina*	Candidate	USFWS	No	No Effect
Corals					
Boulder star coral	*Orbicella franksi*	Threatened	NMFS	No	No Effect
Elkhorn coral	*Acropora palmata*	Threatened	NMFS	No	No Effect
Lobed star coral	*Orbicella annularis*	Threatened	NMFS	No	No Effect
Mountainous star coral	*Orbicella faveolata*	Threatened	NMFS	No	No Effect

[1] MANLAA = May affect, not likely to adversely affect; CH = Critical habitat
Sources: NMFS 2017; USFWS 2017a, b, c

Discussions of the effect determinations are provided by species below. More information on impacts to threatened and endangered species resulting from the Recommended Plan is provided in the Biological Assessment found in **Environmental Appendix D, Attachment D-2**. Pursuant to section 7 of the Endangered Species Act of 1973, as amended, the NMFS issued a biological opinion, dated 10 April 2019 that determined that the recommended plan will not jeopardize the continued existence of the following federally listed species or adversely modify designated critical habitat: green, Kemp's ridley, loggerhead, or hawksbill sea turtles. As documented in the USFWS Coordination Act Report dated 9 May 2019, the USFWS did not identify any jeopardy to the continued existence of federally listed species or adverse modification to de3signated critical habitat: sea turtles listed above, Northern Aplomado Falcon, Piping Plover, Red Knot, and Whooping Crane.

Northern Aplomado Falcon

Open habitats in the study areas are limited to coastal marshes that could be used by foraging aplomado falcons, but are not their preferred habitats. No nesting sites have been documented in the study areas, and no nesting falcons are expected based on the current known nesting range and lack of suitable nesting habitat. This species is no more likely to occur in the study areas than in other similar habitats in the region. Therefore, the Recommended Plan is expected to have ***no effect*** on northern aplomado falcons.

Piping Plover and Red Knot

No substantial habitat for piping plovers and red knot is located within the study areas, so the Recommended Plan would not result in a direct loss of piping plover and red knot habitat at the BRFG or CRL. Designated critical habitat for the wintering piping plover, which may also be used by wintering red knots, is present along the Gulf beach near both study areas, as well as in the Colorado River delta (Delta 1) in West Matagorda Bay (see **Figures 2-10 and 2-11** in Chapter 2).

At the BRFG, the Recommended Plan would result in a decrease in sediment loads in the Brazos Delta portion of the Gulf of Mexico; the annual reduction would be approximately 381,000 cubic yards (cy) of sediment, which amounts to an 0.8 percent reduction in the average annual sediment discharge to the Gulf at the Brazos River. Grab samples of sediments that were taken in the Brazos River and are expected to best represent the sediment reaching the Brazos Delta showed 6.2 percent and 9.1 percent sand composition. Assuming an average 7.7 percent sand concentration, the projected 381,000 cy/year sediment reduction in the delta under the Recommended Plan is expected to result in roughly 29,000 cy/year reduction in sand reaching the delta. This assumes a uniform redistribution of sand and fine materials from the Brazos Delta to the GIWW under the Recommended Plan, thereby representing a 0.8 percent reduction in the total sand load to the delta. It should be noted that this is likely a conservative assumption, as more fine materials are expected to be redistributed to the GIWW under the Recommended Plan, and more sand is likely to remain in the Brazos Delta.

While the estimated reduction in sand could result in downdrift shoreline change, two important items must be noted. First, Bureau of Economic Geology shoreline change rates show that the area west of the Brazos Delta (where longshore currents transport sediments from the Brazos River) is generally a historically accreting shoreline (Paine et al. 2012). The small reduction in sand reaching this shoreline because of the Recommended Plan may slightly decrease the accretion rate of the shoreline, but it is not expected to result in an erosive environment. Second, in the absence of man-made structures impeding natural translation of the shoreline, an equilibrium beach profile is typically maintained, and dry beach widths are relatively constant over time

(Houston 1996, Hall and Pilkey 1991). The beach typically translates back and forth corresponding to wave environment, seasonal changes in longshore transport, and other environmental forcing conditions. Beach widths tend to change due to seasonal variations in these environmental forcing conditions, but over longer durations, the dry beach width tends to remain relatively constant in the absence of man-made hard stabilization structures (Hall and Pilkey 1991). The section of shoreline between the Brazos and San Bernard Rivers remains natural and does not have any man-made structures impeding shoreline translation.

Based on the above analysis, implementation of the Recommended Plan and resulting changes in the sediment load in the Brazos Delta are expected to cause minimal changes to the dry beach width and beach habitats.

At the CRL, the Recommended Plan is expected to result in over 90,000 cubic yards of additional sediment deposition at Delta 1 annually, which will facilitate continued growth of the delta, associated wetlands, and piping plover and red knot habitat. Therefore, the Recommended Plan not expected to destroy or adversely modify critical habitat.

Construction activities at both facilities will temporarily elevate noise levels; however, this is not expected to contribute to any permanent noise disturbances for piping plovers or red knots. There are no preferred habitats immediately adjacent to the proposed work areas. Overall, the Recommended Plan may have minor but discountable effects on the piping plover and red knot; therefore, the project ***may affect, but is not likely to adversely affect*** these species. The Recommended Plan is not expected to destroy or adversely modify designated critical habitat.

Whooping Crane

Whooping cranes also overwinter on the Texas coast, mostly within in the area surrounding the Aransas NWR located about 30 miles southwest of the CRL. The Recommended Plan would impact salt marshes (foraging habitat), but impacts are considered low compared to the availability of salt marshes in the region, and the impacted marshes will be replaced in-kind through the project's mitigation plan. Since most whooping crane wintering occurs well south of the NEPA study areas, direct effects on the whooping crane due to habitat loss are not anticipated. Construction activities will create temporary, short-term increases in noise levels. However, whooping cranes prefer to forage away from human disturbance and would, therefore, not be likely to occur in the study areas during typical operations and maintenance of the existing facilities, nor are they expected to be present during construction activities or maintenance dredging activities. Overall, the project ***may effect, but is not likely to adversely affect*** whooping cranes.

West Indian Manatee

Texas is the extreme western edge of the West Indian manatee's current distribution, and occurrences in Texas are occasional to rare. Thus, the likelihood of their occurrence in the in the NEPA study areas is considered low, and the Recommended Plan is expected to have ***no effect*** on the West Indian manatee.

Whales

Whales are generally restricted to deeper offshore waters and are not expected to occur in the NEPA study areas. Therefore, the Recommended Plan is expected to have ***no effect*** on the listed whale species.

Sea turtles

Potential impacts to sea turtles were evaluated in terms of habitat loss, noise and vibration, dredging, and turbidity. Anticipated impacts are summarized here and detailed in the Biological Assessment (**Environmental Appendix D, Attachment D-2**). The study areas do not contain preferred foraging habitat for sea turtles, occurrence of sea turtles in the study areas would be temporary, and measures could be implemented as needed to avoid impacting sea turtles during pile driving activities; therefore, the project ***may affect, but is not likely to adversely affect*** green, hawksbill, Kemp's ridley, and loggerhead sea turtles. The project is expected to have ***no effect*** on leatherback sea turtles because they are uncommon in Texas coastal waters and not likely to occur in the study areas.

<u>Habitat Loss</u>

The Recommended Plan is not expected to result in habitat loss for any sea turtle species. The open water habitats in the study areas are largely associated with the GIWW and river crossings and do not provide notable preferred foraging habitats for sea turtles. Furthermore, the Recommended Plan would result in a net increase of open water habitat. The BRFG and CRL sites are approximately one mile and 5 miles, respectively, from the nearest beaches that may provide habitat for sea turtles.

<u>Dredging and Turbidity</u>

Dredging for the project would be completed using mechanical dredges and cutterhead suction dredges, and sea turtles are not known to be vulnerable to entrainment in these dredge types (NMFS 2003). As a result, adverse effects on sea turtles from dredging are discountable.

Although turbidity increases are expected during in-water activities such as dredging and pile driving, turbidity is not expected to affect sea turtle foraging habitat, as none is in the study areas. Since sea turtles breathe air, they are not particularly susceptible to increased turbidity. Based on the temporary and localized nature of turbidity increases, lack of foraging habitat in the study areas, and anticipated infrequency of sea turtles entering the construction area, effects of turbidity on sea turtles are discountable.

Noise and vibration – The Recommended Plan would result in a temporary increase in vessel traffic during construction due to the addition of construction-related vessels. However, vessel traffic noise is not known to cause mortality or potential mortal injury to sea turtles (Popper et al. 2014). Likewise, noise from dredging equipment during construction is not expected to adversely affect sea turtles.

Noise from proposed pile driving at both sites has the potential to adversely affect sea turtles by injury and behavioral effects. Therefore, the PDT estimated noise pressure levels resulting from proposed pile driving by using a model developed by NMFS' Greater Atlantic Regional Fisheries Office (GARFO) as an in-house tool for assessing potential effects on federally listed species from underwater sound produced during pile driving (NMFS 2016). For sea turtles, the GARFO model considers behavioral and physiological thresholds of 166 and 180 decibels (dB) re 1 micro-Pascal root-mean square (μPaRMS), respectively, and predicts the distance to those effects thresholds from pile driving activities, depending on pile type and size, hammer type, and water depth.

Table 5-11 provides estimated worst-case sound levels resulting from pile driving that may occur at the BRFG and CRL under the Recommended Plan. *Note that in some cases, actual sound levels should be lower because the "proxy" used in GARFO involved larger pile sizes than is proposed.* The estimated noise levels for all proposed pile types except guidewall timber piles exceed the injury threshold for sea turtles; this injury noise level would occur up to 30-40 meters from the pile driving.

Table 5-11 - Estimated Distances to Sea Turtle Injury and Behavioral Thresholds from Pile Driving

Project Component	Pile Size and Type	Hammer Type	Distance (m) to 180 dB RMS (injury)	Distance (m) to 166 dB RMS (behavior)
Gate Structure Foundation	24" Steel Pipe	Impact	40.0	86.7
Guidewalls	12-14" Timber	Cushioned Impact	NA	18.0
End Cells	20" Steel Pipe [1]	Impact	33.3	80.0
	24" AZ Steel Sheet [2]	Impact	30.0	58.0
Needle Girder Storage	24" Concrete	Impact	NA (on land)	NA (on land)
Reservation Buildings	12-14" Timber	Impact	NA (on land)	NA (on land)
Flow Separator	24" AZ Steel Sheet [2]	Vibratory	NA	NA

[1] 20" steel pipe used as proxy; actual pile size proposed for the end cells is 18".
[2] 24" AZ steel sheet used as proxy; actual sheet pile proposed for the end cells is 20" PS-31 sheet pile.

Although estimated noise levels exceed sea turtle injury thresholds, measures can be implemented as needed to avoid impacting sea turtles if they occur in the GIWW during construction. Measures include:

- Implement a "soft start" for up to 20 minutes to allow sea turtles to leave the project vicinity before sound pressure increases above injury thresholds. Once noise levels reach the 166 dB RMS behavioral threshold, sea turtles are expected to leave the area and not re-enter.
- Install piles within dewatered cofferdams, providing a 5-10 dB reduction in noise levels.
- Use a vibratory hammer or cushioned impact hammer to reduce noise levels. As is seen in **Table 5-12** below, the GARFO model estimates that noise levels would be below injury thresholds for all anticipated pile driving if a vibratory hammer is used.

Table 5-12 - Estimated Distances to Sea Turtle Injury/Behavioral Thresholds from Pile Driving Vibratory Hammer

Project Component	Pile Size and Type	Hammer Type	Distance (m) to 180 dB RMS (injury)	Distance (m) to 166 dB RMS (behavior)
Gate Structure Foundation	24" Steel Pipe	Vibratory	NA	53.3
Guidewalls	12-14" Timber	Vibratory	NA	NA
End Cells	20" Steel Pipe[1]	Vibratory	NA	46.7
	24" AZ Steel Sheet[2]	Vibratory	NA	NA
Needle Girder Storage	24" Concrete	Vibratory	NA (on land)	NA (on land)
Reservation Buildings	12-14" Timber	Vibratory	NA (on land)	NA (on land)
Flow Separator	24" AZ Steel Sheet[2]	Vibratory	NA	NA

[1] 20" steel pipe used as proxy; actual pile size proposed for the end cells is 18".
[2] 24" AZ steel sheet used as proxy; actual sheet pile proposed for the end cells is 20" PS-31 sheet pile.

Through informal consultation, NMFS identified additional measures that would minimize impacts to sea turtles, which include:

- Using wood cushion blocks as needed for pile driving with impact hammer to maximize attenuation of underwater noise.
- Adhering to NMFS' *Sea Turtle and Smalltooth Sawfish Construction Conditions*
- Conducting in-water work during daylight hours only

Mollusks (mussels) – The mussel species that are candidates for federal listing are freshwater species and are not expected to occur in the tidal and brackish waters of the Brazos River, Colorado River, or other waters in the NEPA study areas due to salinity fluctuations. Therefore, the Recommended Plan would have no effect on the candidate mussel species.

Corals – The listed corals are offshore species and do not occur in the NEPA study areas. Therefore, the Recommended Plan would have no effect on corals.

5.4.4 Other Protected Wildlife Species

No Action

Under the FWOP Condition, overall habitat conditions in the NEPA study areas are expected to be similar to existing conditions, although sea level rises would increase open water areas and decrease wetland areas, which could affect some wildlife species. Bottlenose dolphins may be affected by increased vessel traffic, industrial development, and dredging operations in the GIWW and other waterways. This is expected to be a minor impact because vessel traffic and dredging operations are existing conditions and development in the NEPA study areas is expected to be minimal and not expected to substantially affect bottlenose dolphins using the area.

Natural changes to vegetation/wildlife habitats would alter use of the habitats by migratory birds and other wildlife, but overall the NEPA study areas are expected to remain largely undeveloped and existing NWRS and WMAs would continue protecting coastal habitats.

Recommended Plan

The Recommended Plan could adversely affect marine mammals (bottlenose dolphins) and migratory birds. However, during detailed project design in the PED phase, BMPs will be incorporated into the project design and construction plans to minimize impacts on dolphins, migratory birds, and other wildlife species. With the implementation of BMPs, the Recommended Plan is not expected to have significant effects on protected species. The following paragraphs discuss the potential effects and BMPs for marine mammals, eagles, and migratory birds.

Marine Mammals

Construction of the Recommended Plan would temporarily disturb open water habitats, fill some open water areas to construct the new floodgates, and create open water areas by excavating the new GIWW alignment. Overall, the Recommended Plan would result in a net increase of open water habitat. Bottlenose dolphins may experience increased noise from construction vessels and increased turbidity from in-water dredging, pile driving, and other work, but these impacts are not expected to significantly affect dolphins. No blasting or sonar is anticipated during construction.

Underwater noise from pile driving can result in injury and harassment of dolphins if they are in the study area during construction. To estimate noise pressure levels resulting from proposed pile-driving activities, the USACE used the same NMFS GARFO model (NMFS 2016) that was used to assess noise impacts on sea turtles. For cetaceans, the model considers behavioral thresholds of 160 dB re 1 μPaRMS for impulsive noises (1.e., pile driving using impact hammers) and 120 db µPaRMS for non-pulse noises (i.e., pile driving using vibratory hammers). **Table 5-13** provides estimated distances to cetacean behavioral thresholds resulting from pile driving that may occur at the BRFG and CRL under the Recommended Plan. *Note that in some cases, actual sound levels should be lower because the "proxy" used in GARFO involved larger pile size than is proposed.* The estimated noise levels for all proposed pile types exceed the behavioral thresholds for cetaceans; the distance to the behavior thresholds range from 30 to 107 meters (98 to 351 feet).

Table 5-13 - Estimated Distances to Cetacean Behavioral Thresholds from Pile Driving

Project Component	Pile Size and Type	Hammer Type	Distance (m) to 160 dB RMS (behavior for impulsive noise)	Distance (m) to 120 dB RMS (behavior for non-pulse noise)
Gate Structure Foundation	24" Steel Pipe	Impact	106.7	86.7
Guidewalls	12-14" Timber	Cushioned Impact	30.0	18.0
End Cells	20" Steel Pipe [1]	Impact	100.0	80.0
	24" AZ Steel Sheet [2]	Impact	70.0	58.0
Needle Girder Storage	24" Concrete	Impact	NA (on land)	NA (on land)
Reservation Buildings	12-14" Timber	Impact	NA (on land)	NA (on land)
Flow Separator	24" AZ Steel Sheet [2]	Vibratory	NA	90.0

[1] *20" steel pipe used as proxy; actual pile size proposed for the end cells is 18".*

[2] *24" AZ steel sheet used as proxy; actual sheet pile proposed for the end cells is 20" PS-31 sheet pile.*

Although estimated noise levels exceed behavioral thresholds for cetaceans and may result in harassment of bottlenose dolphins if they come within the distances outlined in **Table 5-13**, dolphins are expected to avoid the areas during construction. If needed, and in final consultation with NMFS, appropriate measures would be incorporated to minimize effects of pile driving on dolphins. Also if needed based on final consultation with NMFS, the USACE would obtain an incidental harassment authorization prior to commencement of pile driving. With the implementation of BMPs, the Recommended Plan is not expected to result in significant adverse effects to marine mammals. NMFS concurred with this assessment in a letter dated 31 May 2019 (**Appendix D, Attachment D-3**).

Bald and Golden Eagles

Golden eagles are not expected to occur in the NEPA study areas except for the possibility of migrating individuals passing through the area. Bald eagles may forage in the Brazos, San Bernard, and Colorado Rivers, GIWW, East and West Matagorda Bays, and other large water bodies in and near the NEPA study areas, but no bald eagle nests are in or adjacent to the NEPA study areas (TXNDD 2017). An on-site habitat assessment was conducted in each study area and determined that trees in the study areas are too small to support bald eagle nests. Therefore, no nesting habitat for bald eagles is present in or adjacent to the facilities, and the Recommended Plan is not expected to affect bald or golden eagles. Prior to construction, the habitats in and adjacent to the impact area will be reassessed for the potential for bald eagle nests, and a nest survey will be conducted if needed.

Migratory Birds

The Recommended Plan will remove wetland and upland habitats that could be used by migratory birds for various activities including nesting, foraging, loafing, and roosting. The Recommended Plan would minimize impacts to migratory birds by minimizing habitat removal and incorporating BMPs, if needed, to avoid removing active nests. Clearing of vegetation will be completed outside of the nesting season (March 1 to August 31), if possible. If clearing of vegetation is required during nesting season, nest surveys will be completed prior to ground disturbance.

During construction of the Recommended Plan, noise from pile driving, and other construction activities could affect bird use of nearby habitats and may result in avoidance of habitats during construction. However, given the mobile nature of birds, abundance of habitats in the region, and temporary nature of the construction, this impact is not expected to be significant. BMPs that are incorporated to reduce noise levels and potential impacts to sea turtles and marine mammals in consultation with the USFWS and NMFS would reduce impacts on wildlife.

5.5 AQUATIC RESOURCES

No Action

Under the FWOP Condition, plankton and benthic resources will continue to be temporarily impacted by activities such as maintenance dredging. Maintenance dredging will affect benthic communities, primarily through removal; however, benthic organisms, particularly the infauna, are known to re-colonize dredged areas within 18 months (Texas Water Resources Institute 1995).

Recommended Plan

Construction of the Recommended Plan at the BRFG and CRL would result in temporary disruption of benthic habitats within the channel, and impacts associated with maintenance dredging would continue. Dredging operations would alter benthic habitats through evacuation of bay bottom and dredged material placement in ODMDS, if used (Montagna et al. 1998). The impact to benthic organisms is likely to be confined to the immediate vicinity of the disturbed area (Newell et al. 1998), and recovery of benthic macroinvertebrates following disturbance is typically rapid (recovering within months rather than years) (Van Der Wal et al. 2011, Wilber et al. 2006, Wilber and Clarke 2001). Benthic communities that present in submerged sediments on the edge of the current channel would be destroyed, but benthic communities have been documented to recolonize within 18 months (Texas Water Resources Institute 1995). Overall, changes to benthic communities resulting from construction of the Recommended Plan are expected to be minor and localized and are not expected to be significant. After construction, effects of O&M dredging are expected to be similar to the FWOP Condition. The Recommended Plan is not expected to have a significant impact on zooplankton.

5.6 COMMERCIAL AND RECREATIONAL FISHERIES

No Action

Under the FWOP Condition, expected land and wetland losses from erosion and sea level rise would result in the loss of important habitat for estuarine and marine fishery species. Erosion and sea level rise are expected to increase open water habitat but decrease wetland habitat that provides nursery grounds for important fishery species. As open water replaces marshes, fishery production is expected to decrease.

Recommended Plan

Implementing the Recommended Plan at the BRFG and CRL is not expected to have a substantial effect on commercial or recreational fisheries or fishery species. Underwater noise and vibration from pile driving has been documented to cause hearing loss, behavioral changes, physiological effects, and even death in fish (Buehler et al. 2015), but pile driving is expected to affect a relatively small area at any one time and is not expected to result in significant impacts to fish communities. Temporary, localized disturbances and turbidity increases would affect fishery habitats and juvenile fish in the immediate vicinity of the construction, but there are large amounts of habitat in the surrounding area that support fisheries. Wetland losses resulting from the Recommended Plan (approximately 14.5 acres) would be mitigated, and projected salinities would still support estuarine habitats and biotic communities. The GIWW would remain open during construction, so area waterbodies would remain accessible for recreational and commercial fishing.

5.7 ESSENTIAL FISH HABITAT

No Action

Under the FWOP Condition, no impacts to EFH would occur because of the project. Existing EFH in the study areas would continue to be affected by normal coastal process, and as sea levels rise, marshes may be converted to open water, which would reduce nursery habitat. Continued and reasonably foreseeable sea level rises would also generally result in lower river velocity at the GIWW crossings, resulting in higher sedimentation and need for additional DMPAs that could affect EFH. Existing NWRs and WMA's in the BRFG and CRL region would continue to protect large areas of coastal marshes, and future wetland losses may be reduced by restoration and shoreline stabilization projects.

Recommended Plan

At the BRFG, the Recommended Plan would remove approximately 13.8 acres of coastal wetlands and fill an estimated 6.7 acres of open water habitat. At the CRL, an estimated 0.7 acre of wetlands would be removed and 2.8 acres of open water habitat would be filled. Overall, however, the Recommended Plan would result in a net increase of open water habitat due to excavating the new GIWW alignment. Over time, other wetlands may be converted gradually to open water habitats as sea levels rise, but this impact is expected to be similar to the No Action Alternative.

The USACE has worked with NMFS and other resource agencies to evaluate the impacted wetland habitats and develop a mitigation plan to offset the anticipated wetland losses. The mitigation plan is provided as **Environmental Appendix D, Attachment D-8** and includes creating a total of 14.9 acres of intertidal and high marsh at the two sites: 14.14 acres at the BRFG (2.45 acres of high marsh and 11.69 acres of intertidal marsh) and 0.76 acre of intertidal marsh at the CRL.

In addition to permanent EFH effects, construction of the Recommended Plan would temporarily affect open water habitats through equipment access, pile driving, and dredging. These activities would disturb the water bottoms, resulting in suspended sediments and increased turbidity in the GIWW and Brazos and Colorado Rivers. The increase in turbidity would be temporary and is expected to return to existing conditions after construction activities are completed. Maintenance dredging, which is expected to continue to occur on an estimated 24-month schedule, would also temporarily increase sediment and turbidity in the area.

Although the Recommended Plan would have adverse impacts on EFH, the impacts would not be significant because most are temporary and the permanent impacts to coastal marshes would be mitigated. Additional information on impacts to EFH and managed fishery species is provided in the EFH Assessment report found in **Environmental Appendix D, Attachment D-4**.

Because of the minor and temporary impacts to EFH no further coordination with NMFS is required. The NMFS EFH staff has stated that projects with minimal impacts to EFH do not need to be coordinated Galveston NMFS office. However, NMFS has participated throughout project planning and concurred with this determination. A detailed assessment of the impacts on EFH is provided in **Appendix D, Attachment D-4**).

5.8 COASTAL BARRIER RESOURCES AND COASTAL NATURAL RESOURCES

No Action

Under the FWOP Condition, development within the Texas coastal zone is expected to continue at current rates and would continue to affect coastal barriers and CNRAs. Impacts to coastal resources would be managed to some extent by regulations such as the CBRA, Coastal Zone Management Act, TCMP, and CWA, as well as by continued allocation of funding to purchase, preserve, and manage coastal areas through Federal, state, and non-governmental agencies. Development in the NEPA study areas is expected to be minimal under the No Action Alternative.

Recommended Plan

The Recommended Plan would affect coastal barrier resources and CNRAs; however, they would not substantially change the overall coastal environment. The Recommended Plan is not expected to change development rates or patterns or induce growth on barrier islands, so development trends in coastal areas are expected to be similar to the No Action Alternative.

As discussed in Chapter 2.0, CBRS units are near but not within the CRL study area; therefore, none of the work associated with the Recommended Plan at the CRL would occur within CBRS units or affect the CBRS. At the BRFG, the Recommended Plan would realign the GIWW to the south, provide an open channel (no floodgate) on the west side of the Brazos River, and construct a new 125-foot-wide floodgate set back on the east side of the river. The proposed work at the BRFG would affect CBRS Units T05 and T05P, as shown on **Figure 5-10**. However, as noted, the project is not expected to change development rates or patterns or induce growth on barrier islands.

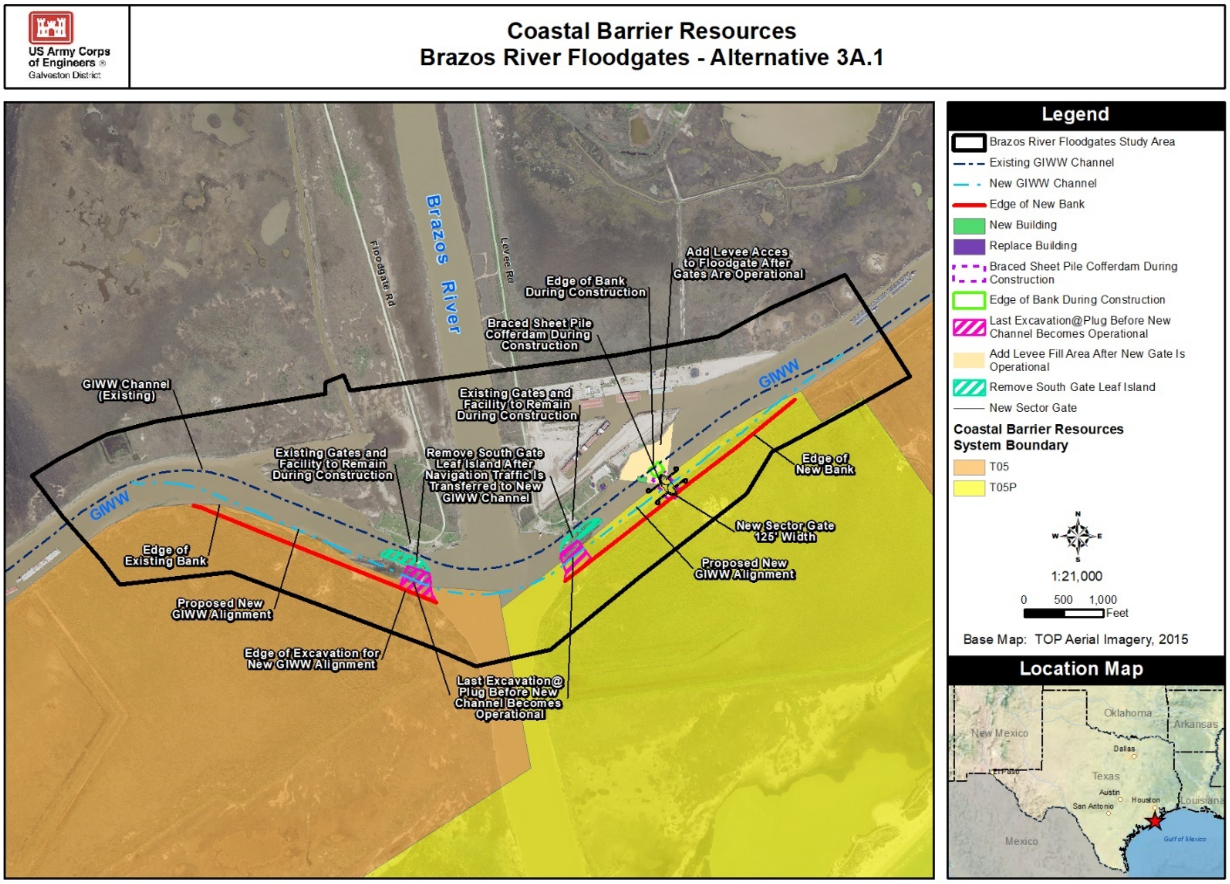

Figure 5-10 - Proposed Work within CBRS Units at the BRFG

As discussed in Chapter 2.0, the stated purpose of the CBRA is to "minimize the loss of human life, wasteful expenditure of Federal revenues, and the damage to fish, wildlife, and other natural resources associated with the coastal barriers...by restricting future Federal expenditures and financial assistance which have the effect of encouraging development of coastal barriers..." (16 U.S.C. §3501(b)). The CBRA prohibits government expenditures on new projects within certain identified CBRS units unless they fit certain exceptions found within 16 U.S.C. §3505. The CBRA provides that the general prohibition on Federal expenditures affecting the system include the construction of structures in CBRA units (§3504(a)(3)).

A navigation exception at 16 U.S.C. 3505(a)(2) provides an exception for "the maintenance or construction of improvements of existing Federal navigation channels (including the Intracoastal Waterway) and related structures (such as jetties), including the disposal of dredge materials related to such maintenance or construction." Based on the definition in Section 6(b) of the statute, the exception applies only to maintenance or construction of improvements of existing Federal navigation channels and to maintenance or construction of improvements of existing related structures such as jetties. Existing channels are those authorized before the designation of the coastal barrier resource units that the authorized channels may traverse or impact.

Federal agencies are required to consult with the USFWS on the applicability of CBRA exceptions and for written comment on planned expenditures for an action excepted under CBRA, 16 U.S.C. §3505(a). Compliance rests with the Federal officer responsible for making the funds available for the action. The USACE has determined that the GIWW is an existing channel subject to the Navigation Exception and has prepared a consultation letter requesting USFWS concurrence with the USACE's determination that the navigation exception applies with regard to CBRS unit T05. The USFWS provided concurrence with this determination in a letter dated 8 May 2019 (**Appendix D-10 of the Environmental Appendix**).

The Recommended Plan would affect CNRAs protected by the TCMP, including coastal barriers, shore areas, wetlands, and special hazard areas (floodplains). Commensurate mitigation would be provided for wetland losses. The USACE has determined that the Recommended Plan complies with the TCMP and would be conducted in a manner consistent with all rules and regulations of the program (**Environmental Appendix D, Attachment D-5)**. The USACE submitted the Consistency Determination to the GLO in February 2018; no response was received.

5.9 HISTORIC AND CULTURAL RESOURCES

No Action

Under the FWOP Condition, the USACE would continue to operate and maintain the BRFG and CRL facilities as they have for the last several decades. It is anticipated that the USACE would continue to repair steel members within the sector gates, replace portions of the timber guidewalls, maintain the USACE support buildings, and dredge the GIWW as needed. These activities are not expected to affect archeological sites, and since the USACE determined that the BRFG and CRL facilities themselves are not NRHP-eligible, the activities would not affect non-archeological historic resources protected by Section 106 of the NHPA.

If cultural resources are present in the project vicinity, they may be impacted by continued shoreline erosion and by development. For projects where Federal and/or State land, funding, or permitting are involved, impacts would be addressed by avoidance, minimization, or mitigation in compliance with applicable regulations.

Recommended Plan

Much of the APEs have been extensively disturbed by previous GIWW excavation, diversion of the Brazos and Colorado Rivers, construction of the BRFG and CRL facilities, and construction of roads, levees, and DMPAs. The work proposed by the Recommended Plan would occur within disturbed areas in and adjacent to the GIWW and DMPAs. Due to previous dredging and construction within the footprint of the Recommended Plan, there is no potential to affect archeological historic properties.

As discussed in Chapter 2.0, a non-archeological historic resources survey identified 10 historic-age resources in the BRFG APE and 15 historic-age resources in the CRL APE. Most of the resources consisted of the floodgates, locks, and other USACE-owned resources within the BRFG and CRL facilities (e.g., control houses, power houses, pump house, boat house). None of the historic-age resources met the NPS criteria for NRHP eligibility, as detailed in the HRSR (**Environmental Appendix D, Attachment D-6**). As a result, the Recommended Plan will not adversely affect historic resources. The Texas SHPO also concurred with this determination by letter dated January 23, 2019 (see consultation letters in **Environmental Appendix D, Attachment D-10**).

5.10 ECONOMIC, SOCIOECONOMIC, AND HUMAN RESOURCES

No Action

Under the FWOP Condition, populations in both NEPA study areas have been stable over the past decade, so rapid increases in growth and expansion are not expected under the FWOP Condition. Some expansion at ports and increased shipping on the GIWW may occur to support future growth and commerce in other portions of Texas. In addition, residential or industrial development may occur along the Brazos, Colorado, and San Bernard Rivers or other high points in the area. Likewise, existing NWRs and WMAs may expand to incorporate more coastal wetland habitats. Distribution of minority and low-income populations in the BRFG and CRL areas is expected to follow current trends. The existing aesthetics of the NEPA study area will not be altered.

Recommended Plan

The Recommended Plan would not impact minority or low-income populations. The duration of the construction would be relatively short (two years at each facility), and therefore, it is not expected that workers would temporarily relocate to the project areas; however, some expansion at ports and increased shipping on the GIWW may occur to support future growth and commerce leading to residential or industrial development in the general area. The Recommended Plan would allow for transit through the GIWW throughout construction, and would provide a long-term economic benefit to the shipping industry by making it more efficient to travel through the BRFG and CRL areas. Overall, the Recommended Plan would have economic benefits compared to the No Action Alternative.

5.11 AIR QUALITY

No Action

Under the FWOP Condition, future population growth within the Brazos, Colorado, and/or San Bernard River watersheds and within the HGB ozone nonattainment area will result in the potential for more contaminant emissions to affect air quality. Maintenance dredging in the GIWW will also continue to result in emissions, although these emissions are expected to be minor. Continued implementation of pollutant protection programs by the EPA and TCEQ, as well as use of BMPs, would benefit air quality. The EPA and TCEQ will continue to monitor air quality in the HGB area and re-evaluate air quality attainment status according to current standards and procedures that are incorporated in the SIP to manage emissions. Based on current population trends in the CRL region, significant air quality concerns are not expected in the near future.

Recommended Plan

Under the Recommended Plan, air emissions would be from construction equipment associated with the project (e.g., dredging equipment, pile driving equipment, support boats, and land-based construction equipment), and from personal vehicles for workers traveling to the project sites. The equipment will emit air pollutants and greenhouse gases (GHGs). Air emissions from new construction would not occur at the same time as O&M dredging. Air emissions are generally dispersed with distance and time, and a relatively slight increase in emissions during construction would correspond to a slight increase in ambient air quality concentrations for that air contaminant.

The CRL facility is in an attainment area for all criterial air pollutants, so no specific emissions determination is needed for the Recommended Plan at the CRL. Since the BRFG facility is in the HGB ozone moderate nonattainment area, calculations of projected pollutant emissions from construction are required to determine if they exceed the General Conformity de minimis threshold, which is 100 tons per year (tpy) for the ozone precursors NO_x and VOCs (2008 8-hour standard). If projected emissions for either of these pollutants exceed 100 tpy, then a General Conformity Determination is required.

At the time this report was finalized, the Recommended Plan design, construction plan (including equipment needs), and schedule were not developed with enough detail to accurately estimate pollutant emissions at the BRFG. However, a qualitative estimate of potential emissions was made by comparing the Recommended Plan to the USACE Galveston District's reevaluation of the nearby Freeport Harbor Channel Improvement Project (FHCIP, USACE 2017). Construction of the additional features addressed in the FHCIP re-evaluation was expected to be completed in one calendar year and projected to result in 115.31 tpy of NO_x emissions and 2.61 tpy of VOC emissions, thereby requiring a General Conformity Determination for the NO_x emissions. Of the projected NO_x emissions, 106.83 tpy (93 percent of total) was from dredging and sheet pile placement, 8.07 tpy (7 percent of total) was from land side dredged material placement, and 0.42 (<1 percent of total) was from employee commuter vehicles. The project involved 1,946,801 cubic yards dredging quantity, 4,300 feet of sheet pile installation over 8 months, and a 1-year construction duration.

Construction of the Recommended Plan at the BRFG is expected to use similar equipment as the FHCIP, including marine equipment (hydraulic cutterhead dredge, crane with pile driver, support equipment such as tugboats, spill barge, and crew boats) and land-based equipment (off-road construction equipment and on-road vehicles). Comparing estimated dredging and pile quantities and construction schedule to the FHCIP, the BRFG Recommended Plan involves:

- 1,022,000 cubic yards dredging quantity (52 percent of FHCIP)
- 930 feet of sheet pile and 794 other piles of various types/sizes (7 months of pile driving)
- Two-year construction duration

Based on these quantities, the emissions of NO_x and VOCs may be similar to less than the FHCIP re-evaluation estimates, but the BRFG emissions would be spread over a 2-year construction period instead of a 1-year period. This qualitative analysis indicates that NO_x emissions from the Recommended Plan would not exceed 100 tpy at the BRFG and would not require a General Conformity Determination. Therefore, the Recommended Plan would not have a significant adverse effect on air quality.

Once the Recommended Plan design, construction plans, and schedule are completed in the PED phase, the USACE will calculate emissions and coordinate them with the TCEQ and EPA to verify that emissions are below de minimis and do not require a Conformity Determination. If calculated emissions exceed de minimis thresholds, the USACE would conduct and coordinate a General Conformity Determination pursuant to the CAA, Section 176(c)(1), to document that emissions would be in conformity with the SIP for the HGB ozone nonattainment area.

By letter dated March 13, 2018 (see **Environmental Appendix D, Attachment D-10**), the TCEQ confirmed that the HGB area is currently classified as moderate nonattainment for the 2008 ozone NAAQS and that the de minimis threshold for NO_x and VOCs is 100 tpy. The TCEQ also stated that it is evaluating the *South Texas Air Quality Management District v. EPA*, No. 15-1115 (D.C. Cir. 2018) decision, which in the future could result in a classification change for previous ozone standards for the HGB area. During PED, the USACE will compare calculated emissions to the most current de minimis thresholds.

5.12 NOISE

No Action

Under the FWOP Condition, noise patterns in the BRFG and CRL vicinities would follow current trends, but increases in vessel traffic at the BRFG and CRL along the GIWW may increase noise levels in the areas, particularly during river flood-stage when the BRFG and CRL are closed or under restriction. This could periodically and temporarily increase noise levels at residences near the CRL, but the effects would likely be minor because residences to the north of the CRL are located behind a levee, and residences to the south of the CRL are buffered by trees.

Recommended Plan

The Recommended Plan would not result in any new permanent noise sources. However, elevated noise levels will occur near both study areas during construction. Noise from most construction activities is expected to be minor and not expected to extend beyond the study areas such that they would affect residences or other noise-sensitive receptors. However, noise from pile driving could extend farther. Depending on methods and equipment used, pile driving can produce noise levels as high as 110 dBA up to 20 feet from the source, which is considered extremely loud and can cause hearing damage if exposed for a long enough period without protection. Sound levels decrease approximately 6 dBA for every doubling of distance from the source. At this rate, a noise level of 110 dBA would require 2,560 feet (0.5 mile) to be at or below 70 dBA, assuming there are no physical features that abate the noise within this distance.

At the BRFG, the nearest residences are located approximately 2.5 miles to the east, so noise from pile driving or other construction activities at the BRFG is not expected to adversely affect residences. Construction noise could affect workers at the adjacent Texas Boat & Barge, Inc. facility, so coordination of construction activities with that business would be conducted. Construction noise could affect users of Justin Hurst WMA and Levee Road Boat Ramp, but any effects are expected to be minor and temporary due to their distance from the anticipated pile driving area and temporary use of those recreational facilities.

At the CRL, a number of residences are within 0.5 mile of the proposed east gate construction, with the closest being about 600 feet from the proposed east gate. Therefore, they could experience elevated noise levels from pile driving. Noise levels to the north of the CRL would be mitigated to some extent by the Matagorda ring levee, which is roughly 20 feet high, and residences to the south of the CRL would be buffered by trees and DMPA. As such, noise impacts are not expected to be significant but monitoring should be considered during PED and project implementation.

5.13 OIL, GAS, AND MINERALS

No Action

Under the FWOP Condition, the Bryan Mound Strategic Petroleum Reserve and other existing oil and gas facilities in the NEPA study areas are expected to continue operations as at present. Any additional oil wells that would be drilled in the NEPA study area would not be impacted by the No Action Alternative.

Recommended Plan

The Recommended Plan would be similar to the No Action Alternative in terms of oil, gas, and mineral resources. It would not affect existing, or induce new, oil and gas wells or pipelines in the BRFG or CRL vicinities, nor is it expected to affect the Bryan Mound Strategic Petroleum Reserve near the BRFG.

5.14 HAZARDOUS, TOXIC, AND RADIOACTIVE WASTE

No Action

Under the FWOP Condition, HTRW at the proposed project locations will largely remain the same. The GIWW is an active waterway, and the potential for spills is always present. The western side of Freeport is relatively urbanized, so contamination related to urbanization and the expansion of the petrochemical industry can be reasonably expected. By contrast, Matagorda and the CRLs are a relatively lightly developed area, but contains a high concentration of oil and gas infrastructure, both onshore and offshore. The manufacture and use of petroleum, chemicals, and other hazardous materials will continue in the project vicinity with or without the implementation of the proposed project. The extent to which HTRW sites continue to be created and discovered is impossible to predict, although currently existing HTRW sites can be expected to be remediated over time.

Recommended Plan

Applies to all alternatives, including Recommended Plan - In order to complete a feasibility level HTRW evaluation for the proposed project, a records search was conducted following the rules and guidance of ER 1165-2-132: *HTRW Guidance for Civil Works Projects*, and ASTM E1527-13: *Standard Practice for Environmental Site Assessment: Phase 1 Environmental Site Assessment Process*. Several HTRW items were found, but none have the potential to affect the proposed project.

Hurricane Harvey impacted much of the Gulf Coast including the proposed project area. As far as HTRW, the proposed project sites were not impacted, in that no upland cleanup or hazardous waste sites were created or identified. The potential for encountering contaminated sediment from flooded cleanup sites or existing facilities increased after Harvey, although sediment is not considered HTRW in Civil Works unless it is within a predetermined cleanup area, and will not be considered here. Potential sediment testing and handling would be addressed in the DMMP.

Although not classified as HTRW, pipelines and oil wells play an important role in determining the acceptability of project alternatives. Most of the project alternatives have the potential to interact in some way with some type of oil and gas infrastructure, and relocations may be required as part of the proposed project.

5.15 INDIRECT IMPACTS OF RECOMMENDED PLAN

This section describes the anticipated indirect impacts associated with the Recommended Plan. Indirect impacts are those impacts that are expected to be caused by the Recommended Plan, but "are later in time or farther removed in distance, but are still reasonably foreseeable. Indirect effects may include growth inducing effects and other effects related to induced changes in the pattern of land use, population density or growth rate, and related effects on air and water and other natural systems, including ecosystems" (40 CFR Section 1508.8). Indirect impacts are also known as secondary or induced impacts.

Overall, the Recommended Plan is expected to benefit the regional and national economy by improving navigation through the BRFG and CRL facilities, reducing navigation delays at the facilities, and reducing the risk of accidents at the facilities. The Recommended Plan would be constructed in and immediately adjacent to the existing GIWW and BRFG/CRL facilities, and no induced growth is expected because of the Recommended Plan. Overall, the Recommended Plan is not expected to have significant indirect effects. The following paragraphs discuss potential indirect effects of the Recommended Plan.

Habitat Conversion Due to Salinity Changes

As discussed in Section 5.3.4, the Recommended Plan at the BRFG is projected to decrease salinity in the West GIWW by as much as 32 percent under low-flow conditions and 71 percent under high-flow conditions, and increase salinities in the Brazos Basin by as much as 25 percent during low-flow conditions. During public review of the DIFR-EIS, the public voiced concern that salinity changes would result in habitat changes, and specifically would permanently transform the San Bernard River mouth from a saltwater estuary to a freshwater system. The PDT evaluated existing and projected salinities at various locations, including the San Bernard River, for the modeled time period (13-month period from March 2015 through March 2016, which was a relatively wet period). **Figure 5-14** shows the areas where estimated salinity changes were evaluated. **Table 5-15** summarizes the anticipate salinity changes. While the potential salinity changes under the Recommended Plan are significant, projected salinities in the San Bernard River area would still be well within the normal range for a saltwater estuary, as would other lakes adjacent to the GIWW. Intertidal and high marsh plant species generally tolerate a wide range of salinities. For example, smooth cordgrass, the dominant species in intertidal marsh along the Texas coast, tolerates salinities from 0 to 60 ppt. As a result, the salinity changes are not expected to result in major habitat changes, and the area would still function as a saltwater estuary.

Table 5-14 - Mean Salinity (ppt) at Select Areas near the BRFG, October-December (High Freshwater Flow)

Location	Existing (= No Action/FWOP)	Recommended Plan at BRFG	Change
San Bernard River	6.1	5.0	-1.1
San Bernard Gulf Channel	7.2	6.3	-0.9
San Bernard Inlet	7.0	6.3	-0.7
Cedar Lakes East	12.4	12.9	0.5
Cedar Lakes Mid	11.6	12.0	0.4
Cedar Lakes West	14.5	14.5	0
Cowtrap Lake	14.3	13.9	-0.4
Brazos River Upstream at Dow	0.02	0.02	0

Table 5-15 - Mean Salinity (ppt) at the BRFG, June-August (Low Freshwater Flow)

Location	Existing (= No Action/FWOP)	Recommended Plan at BRFG	Change
San Bernard River	3.3	1.7	-1.6
San Bernard Gulf Channel	4.4	2.8	-1.6
San Bernard Inlet	5.1	3.0	-2.1
Cedar Lakes East	11.6	5.3	-6.3
Cedar Lakes Mid	7.4	5.0	-2.4
Cedar Lakes West	10.5	7.3	-3.2
Cowtrap Lake	10.5	5.2	-5.3
Brazos River Upstream at Dow	0.10	0.10	0

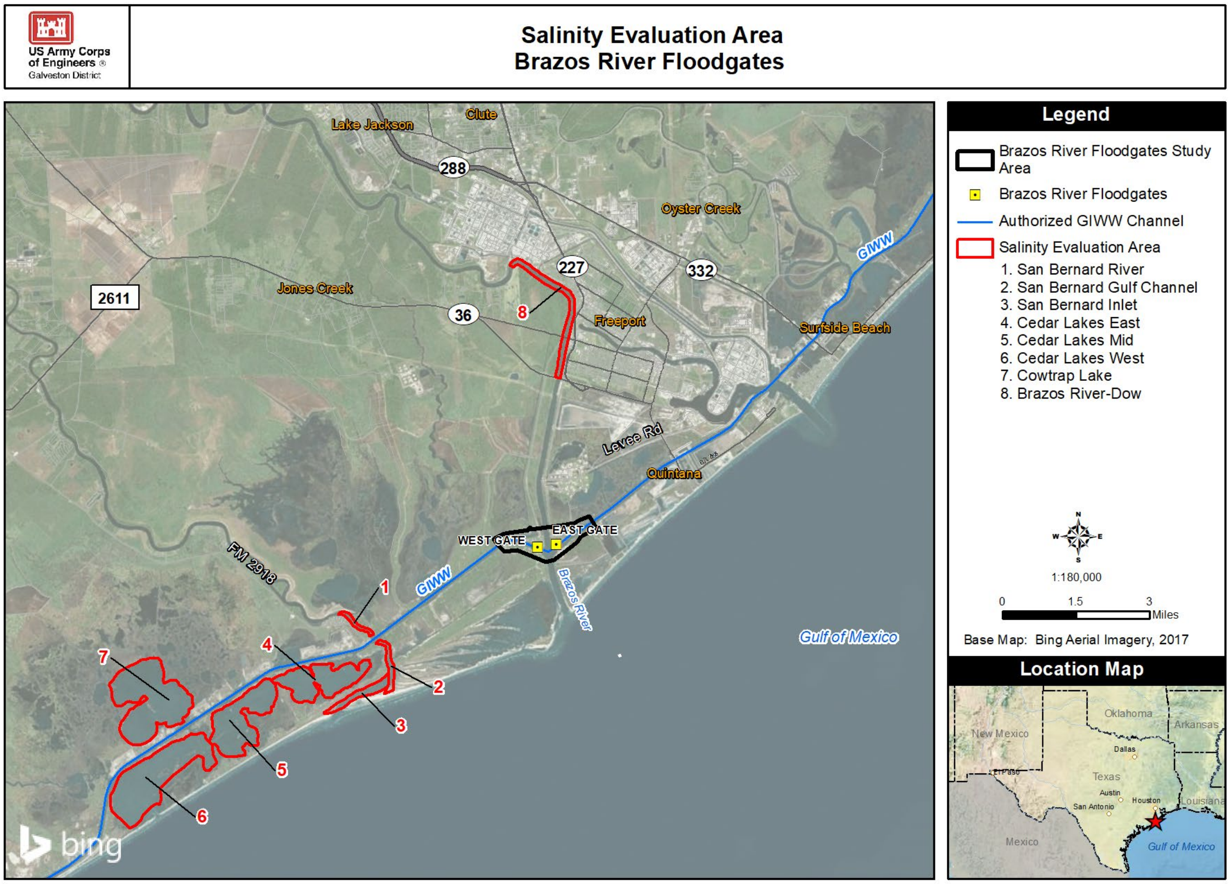

Figure 5-11 - Areas Evaluated for Potential Indirect Effects of Salinity Changes

Indirect Effects of Changes in Sediment Budget

As discussed in Section 5.3.5, the Recommended Plan would change sediment deposition volumes in various areas near the BRFG and CRL facilities, which could indirectly affect existing estuarine habitats over time by gradually raising bottom elevations in open water areas, reducing available sediment to nearby beach habitats, and requiring additional areas for disposal of O&M dredged material. Increased sediment may benefit habitats where dredging does not occur along the GIWW edges and in the Colorado River delta, as increased bottom elevations may eventually result in establishment of marsh vegetation, which would provide additional habitats, provide bank stabilization, and facilitate water quality along the GIWW. In the Colorado River delta, the increased sediments will result in continued growth of the delta and associated wetland and piping plover habitat, as has been ongoing since the river was diverted in the 1990s.

The projected reduction in sediment load reaching the Brazos Delta under the Recommended Plan would reduce the amount of sediment available for longshore transport and deposition to nearby beaches and associated habitats, including piping plover critical habitat. However, the Brazos River has the highest sediment load discharge of all Texas rivers and the projected annual decrease is less than one percent of the total existing sediment load reaching the Gulf. With over 44 million cubic yards of sediment still projected to reach the delta, potential indirect impacts on beach habitats from the project are not expected to be significant.

As currently proposed, the dredged material from construction and O&M dredging over the 50-year planning period for the project will be placed in existing upland DMPAs and ODMDS. Therefore, habitat conversion from long-term dredged material disposal associated with the project is not expected to be significant. There is an overall need for an updated DMMP for the GIWW, which may result in habitat impacts. Based on USACE's policies, these impacts are expected to be offset by mitigation or beneficial uses of dredged material.

Indirect Effects on San Bernard River

Public input during the project planning and review process identified concerns that improvements at the BRFG may adversely affect the San Bernard River. Specific concerns included:

Changing the San Bernard River ecosystem from a saltwater estuary to a freshwater system
Adversely impacting a local project to re-open and maintain the San Bernard River outlet to the Gulf of Mexico by increasing sediment deposition in the West GIWW and San Bernard River outlet.

As discussed above, projected salinity changes resulting from the Recommended Plan would be in the range of an estuarine ecosystem and are not expected to convert the area, including the San Bernard River, to a freshwater ecosystem. To address concerns about the proposed open channel and increased sediment in the West GIWW affecting the opening of the San Bernard River outlet, additional modeling was performed to include an open connection between the San Bernard River and the Gulf of Mexico. Qualitative comparisons were made to analyze the general impact of the Recommended Plan on sedimentation within the GIWW and the inlet stability of the San Bernard mouth when compared to existing conditions. Detailed information on the modeling performed is available in **Engineering Appendix A-1: Hydraulic Engineering Appendix – Brazos River Floodgates**. The results indicate when the San Bernard River outlet is open, the Recommended Plan showed an increase in sedimentation of approximately 9,700 cy/year in the San Bernard Gulf Channel when compared to existing conditions. However, an open San Bernard mouth would cause additional sedimentation in the West GIWW: approximately 134,800 cy/year under existing conditions and 114,900 cy/year under the Recommended Plan. The inlet stability analysis indicated that the San Bernard River outlet has poor stability during both existing conditions and under the Recommended Plan, and that any changes in the inlet stability due to the Recommended Plan would be minor and would not change the stability regime of the San Bernard inlet. In addition, the controlling process for the morphology of the San Bernard River mouth is the net westward transport of sediments deposited by the Brazos River into the Gulf, not sediment deposition via the GIWW.

Indirect Effects on Freeport Channel

Another major concern raised during the public review period was that the proposed wider east floodgate at the BRFG would increase velocities at the crossing of the Freeport Channel and the GIWW, which would adversely affect navigation in the channel and require additional tug assistance when the 125-foot gate is opened. Velocity data was extracted at the GIWW crossing at the Freeport Channel and along various points along the Freeport Channel, and the data indicated minimal increases in velocity for the Recommended Plan with a 125-foot-wide gate (see **Engineering Appendix A-1: Hydraulic Engineering Appendix – Brazos River Floodgates**).

5.16 CUMULATIVE IMPACTS

The CEQ defines cumulative impacts as those impacts "which result from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or non-Federal) or persons undertake such actions." Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time. Impacts include both direct and indirect effects.

Cumulative effects can result from a wide range of activities including the addition of materials to the affected environment, repeated removal of materials from the affected environment, and repeated environmental changes over large areas and long periods. Cumulative impacts may also occur when individual disturbances are clustered, creating conditions where effects of one episode have not dispersed before the next occurs (timing) or are so close that their effects overlap (distance). In assessing cumulative impacts, consideration is given to the following:

- degree to which the proposed action affects public health or safety
- unique characteristics (physical, biological, and socioeconomic) of the geographic area
- degree to which effects on quality of the human environment may be highly controversial
- degree to which possible effects on the human environment are highly uncertain or involve unique or unknown risks; and
- whether the action is related to other actions with individually insignificant, but cumulatively significant, impacts on the environment.

5.16.1 **Assessment Method**

The cumulative impacts analysis followed similar methods as recent analyses conducted by the USACE for Freeport Channel improvements, addressing impacts for a set of criteria and comparing other past, present, and reasonably foreseeable projects in the general vicinity of the

BRFG and CRL areas to the Recommended Plan. For the purposes of this analysis, the cumulative impacts were assessed within an area that included the BRFG and CRL NEPA study areas. Also included were the surrounding areas generally bounded by West Matagorda Bay to the west, Freeport Channel and Harbor to the east, the Gulf of Mexico to the south, and north to the limits of Federal navigation channels in the Colorado, San Bernard, and Old Brazos Rivers (cumulative impact study area).

5.16.2 **Evaluation Criteria**

Evaluation criteria that were considered included key resources that the Recommended Plan would impact and are discussed in NEPA documents and project reports, as listed below:

- Biological/Ecological Environment – the Recommended Plan will affect the following key biological resources:
    - Wetlands
    - Threatened and Endangered Species
    - EFH
- Physical/Chemical Environment – the Recommended Plan will affect the following physical and chemical elements:
    - Water Quality
    - Air Quality
- Human Environment – the Recommended Plan will affect the following human environment resources:
    - Socioeconomic and Human Resources

5.16.3 **Individual Project Evaluation**

Table 5-16 lists the past, present, and reasonably foreseeable projects/activities that were identified in the general cumulative impact study area based on previous reports and available planning documents. The projects were compared to the Recommended Plan presented in this report. **Figures 5-12 and 5-13** show the locations of the various projects.

Table 5-16 - Past, Present, & Reasonably Foreseeable Future Actions - Cumulative Impacts

Project/Activity	Approximate Location
Past or Present Projects/Activities	
Freeport Harbor Jetties	Freeport
Brazos River Diversion Channel	Freeport
Freeport Harbor Channel 45-foot Project	Freeport
GIWW Construction and Maintenance	GIWW in Brazoria and Matagorda Counties
Freeport Hurricane Flood Protection Levees	Freeport
Bryan Mound Strategic Petroleum Reserve	East side of Brazos River 1 mile north of BRFG
Freeport Harbor Channel Outer Bar and Jetty Channels Widening (Widening Project)	Freeport
Freeport LNG Phase I	Quintana Island
Velasco Terminal	Freeport
Bragg's Cut	Less than 0.5 mile south of CRL
STP Nuclear Operating Company	Approximately 9 miles northwest of CRL
Tenaris Bay City Pipe Mill	Bay City
Reasonably Foreseeable Future Projects/Activities	
BP Exploration Gulf of Mexico Fiber Optic Network	Brazoria County
Freeport LNG Phase II	Brazoria County
Re-opening of San Bernard River Outlet	Approximately 4 miles southwest of BRFG
Port Freeport Modifications	Freeport
Freeport Harbor Channel Improvement Project	Freeport
Parcel 14 Developments	Freeport
OXEA Chemicals Bay City Plant Expansion	Bay City
STP Nuclear Operating Company Expansion	Approx. 9 miles northwest of CRL

Sources: Brazoria County 2016; Caswell 2016; Matagorda County Economic Development Corporation (EDC) 2016; USACE 2012

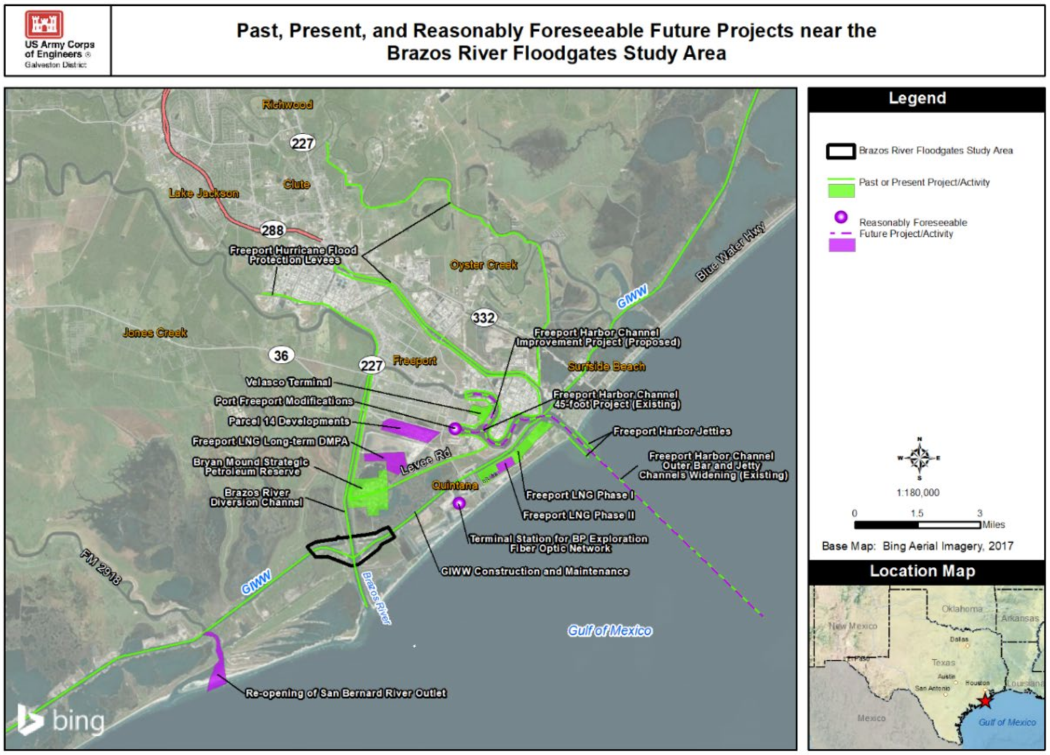

Figure 5-12 - Past, Present, and Reasonably Foreseeable Near the BRFG

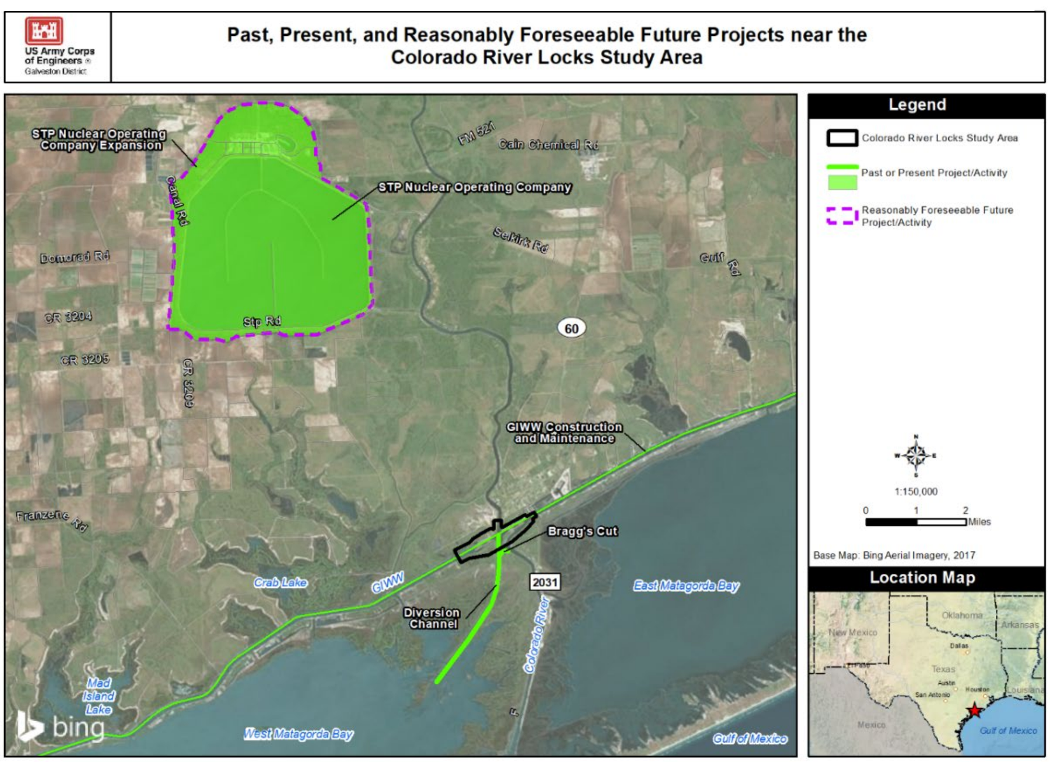

Figure 5-13 - Past, Present, and Reasonably Foreseeable Near the CRL

5.16.4 Resource Impact Evaluation

Biological/ecological, physical/chemical, and human resource impacts were evaluated based on individual project reviews. Summary of impacts from the past, present, and reasonably foreseeable projects, where available, compared to the Recommended Plan, are presented in **Table 5-17**. Direct impacts to specific habitats that could be quantified (e.g., acreages) from existing project documents were considered. Cumulative impact conclusions are provided in Section 5.16.7.

5.16.5 Past or Present Projects/Activities

This section summarizes past and present projects/activities considered in this cumulative impacts analysis. Where available, impacts associated with these projects are included in **Table 5-17**.

The construction of the GIWW likely had a large impact on the study areas, including changes in land use, type and extent of wetlands, available wildlife habitat, and air quality, although quantified impacts are not available because it was constructed in the distant past. The GIWW is a Federal shallow-draft navigation project that was started prior to 1900, with the Texas portion being completed in 1949. At the time, the GIWW in Texas was 12 feet deep, 125 feet wide, and 423 miles long (from Sabine Pass to the mouth of the Brownsville Ship Channel). In 1975, the GIWW was approved for maintenance dredging, and the navigation channel is routinely maintained using a hydraulic pipeline dredge. Dredged material from the GIWW is placed in designated DMPAs. In **Table 5-17**, potential impacts for the GIWW segment(s) within the study area have been generally estimated from the 1975 EIS, although the maintenance segments are not exactly correlated to study area boundaries.

Near the BRFG, several past or present projects/activities may contribute to cumulative impacts to resources. Due to excessive siltation problems at Freeport, the Brazos River was diverted in 1929, through the location of the current BRFG facility. Today, the Brazos River still outfalls into the Gulf of Mexico through the diversion channel, and the old Brazos River channel is developed and serves as the Freeport Channel and Harbor. No quantifiable environmental impacts from the diversion project are available since it was constructed in the distant past.

Several projects have been completed or are ongoing in or adjacent to Freeport Harbor. The 45-foot-deep Freeport Harbor Channel was constructed in 1978. The Freeport Harbor Channel Jetty and Outer Bar channels are currently maintained to -47 feet MLT at 400 feet wide. These existing channels are approximately 6.3 miles long. Routine maintenance removes material for placement in an ODMDS at a roughly 10-month interval. In 2005, Port Freeport (at the time, the Brazos River Harbor Navigation District) applied for a Section 404/10 permit for widening portions of the Freeport Harbor Channel (**Table 5-17**). Additional projects include the Freeport Harbor Jetties, Velasco Terminal, and various industrial developments.

Table 5-17 - Comparison of Environmental Impacts of Past, Present, and Reasonably Foreseeable Future Projects/Activities and Recommended Plan

Resource	Existing SH-45	GIWW	Bryan Mound SPR	CenterPoint Energy Transmission Line (Route 4)	Freeport LNG Phase I	Freeport Channel Widening
Past and Present Projects/Activities						
Wetlands	NA	Disposal: 4,464 ac	20 acres impacted	8 acres impacted	68 acres impacted	NO
T&E Species[1]	NA	NO	NO	NO	NO	MANLAA piping plover, 2 injury or mortality sea turtle takes, 32 non-injurious sea turtle takes allowed
EFH	NA	NA	NA	NA	NI	NA
Water Quality	NO	NO	Possible toxic releases; increased groundwater salinity: NA	NO	Groundwater: NI Surface water: NO	Groundwater: NO Surface water: NO
Air Quality	Odors	NO	Hydrocarbon emissions periodically exceed stds: NA	NA	NO	NO_x exceedances; compliance with SIP
Historic & Cultural Resources	Historic USCG building relocation	NO	NA	NO	NO	NO
Socioeconomic & Human Resources	NA	NA	NA	NA	NA	NO
Reasonably Foreseeable Future Projects/Activities and BRFG-CRL Recommended Plan						
Resource	**BP Fiber Optic Network**	**Freeport LNG Phase II**	**Freeport Harbor Channel Improvement**	**Port Freeport Modifications (Berth 7)**	**Recommended Plan at BRFG**	**Recommended Plan at CRL**
Wetlands	NO	NI	39 acres impacted	2 acres impacted	13.8 acres impacted	0.7 acre impacted
T&E Species[1]	NO	NO	MALAA sea turtles; MANLAA piping plover	NA	MANLAA piping plover, red knot, whooping crane, sea turtles	MANLAA piping plover, red knot, whooping crane, sea turtles
EFH	NO	NI	NO	NA	13.8 acres wetland loss, net gain in open water, temp. disturbances	0.7 acre wetland loss, net gain in open water, temp. disturbances
Water Quality	NO	Groundwater: NI Surface water: NO	Groundwater: NO Surface water: NO	NA	Temporary disturbances	Temporary disturbances
Air Quality	NO	NO	NO_x exceedances	NA	Temp. increase in emissions, not expected to exceed thresholds for HGB ozone non-attainment area	Temporary increase in emissions, no large impact on air quality
Historic & Cultural Resources	NI: 3 anomalies, buffered to avoid	NO	NI: 3 anomalies required diving, additional investigation of 1 site	NA	None anticipated	None anticipated
Socioeconomic & Human Resources	NA	NA	NO	NA	Long-term economic benefit to the shipping industry	Long-term economic benefit to the shipping industry.

[1] T&E = threatened and endangered; MANLAA = may affect, not likely to adversely affect; MALAA = may affect, likely to adversely affect
Impacts in this table are derived from publicly available project impact documents. These impacts are presented as they were in the documents, at the time of the document production. Note: Acreages have been rounded to nearest whole number.
"NO" = No adverse effect from project; limited in duration or extent such that the resource is not adversely affected, according to project document(s). "NI" = Impact mitigated by compensatory or protective measures, as stated in project document(s). "NA" = No impact information is available for the resource in project document.

The USACE led studies in 1958 for hurricane flood protection projects at Freeport and Port Arthur. Both areas had local levee systems at the time, challenged by Hurricane Carla; the newer Federal projects were designed to improve and augment existing protection. At Freeport, approximately 42 square miles (including areas of Freeport, Velasco, Lake Jackson, Clute, Lake Barbara, and Oyster Creek) were protected by approximately 56 miles of levees, wave barriers, floodwalls, drainage structures, pumping plants, and a vertical-lift tide gate with a navigation opening. In 1982, approximately 43 miles of the existing levee system and 2 miles of new levee were constructed, with two pumping stations. The Freeport Harbor levee system is projected to be able to protect the city and port from a 200-year hurricane.

Located on the north and south sides of the Freeport Harbor Channel, the Freeport Harbor Jetties were originally constructed in the early to mid-1880s and repaired and strengthened in 1908. The North Jetty was relocated and South Jetty was rehabilitated as part of channel improvements. Sand moving southwest along the beach at Surfside is carried out along the North Jetty and deposited in the channel, where it is regularly removed and deposited in ODMDS. No quantifiable impacts from this project could be located as it was constructed in the distant past.

The Bryan Mound Strategic Petroleum Preserve occupies 500 acres on the east side of the Brazos River about 1 mile north of the BRFG. The site is authorized to store approximately 232 million barrels. It was operational by 1979 and expanded under two supplemental NEPA documents. A Finding of No Significant Impact was issued in 1993 on a brine pipeline replacement, and a new commercial potable water line was permitted by USACE and completed in 1985. Bryan Mound Strategic Petroleum Preserve operations have contributed to three documented large brine spills: two spills totaled 606,000 barrels at Bryan Mound and West Hackberry in 1985; one 825,000-barrel spill at Bryan Mound in 1989; and one 74,000-barrel spill at Bryan Mound in 1990. The 1989 brine spill removed vegetation in a limited area and resulted in subacute toxicity over a wider area; eventual recovery was achieved over time in some areas through natural flushing and succession, but revegetation and/or drainage enhancement was required to restore completely any poorly drained areas (see impacts in **Table 5-17**).

Freeport LNG Development, LP was permitted to construct the Freeport LNG Import Terminal Project on Quintana Island, Brazoria County, Texas, and provide infrastructure to shippers at the Stratton Ridge Meter Station. This first phase of the Freeport LNG Project was completed in April 2008 and is currently operational (see impacts in **Table 5-17**).

Near the CRL, fewer projects/activities were identified that may contribute to cumulative impacts to resources. Prior to 1930, the Colorado River flowed into Matagorda Bay, which at the time included what is now East Matagorda Bay and Matagorda Bay (Barcak et al. 2007). The bay was divided in 1935 because of freeing a logjam and the formation of a large river delta; at this time, the Colorado River began discharging into the Gulf of Mexico. In 1992, the river was diverted into West Matagorda Bay as part of an environmental enhancement project. The Old Colorado River and the mouth of the river at the Gulf are connected to the GIWW east of the CRL. In 2012, Bragg's Cut was constructed between the Old Colorado River and the diversion channel to allow small recreational vessels an alternative to using the CRL (USACE 2014). Located less than 0.5 mile south of the CRL, Bragg's Cut is an 1,800-foot-long small boat cut that allows for safe passage of small boats and reduced traffic congestion at the CRL.

The South Texas Nuclear Project Electric Generating Station (STP Nuclear Operating Company) is a nuclear power station located approximately 9 miles northwest of the CRL. This site is over 12,000 acres and includes two units, the first of which opened in 1988. The power station includes a 7,000-acre reservoir, which eliminates the need for cooling towers. This site is one of the most productive nuclear power plants in the U.S. (STP Nuclear Operating Company 2018).

The Tenaris Bay City seamless steel pipe mill was constructed on an 1,800-acre site east of Bay City beginning in 2013 (Matagorda County EDC 2016). The $1.8 billion project is capable of producing 600,000 tons of pipe per year and anticipated creating 600 new direct manufacturing jobs with an average salary of $66,000. Operation began in December 2017 and, during the first six years of operation, the projected economic impact in Matagorda County was more than $19 billion (Tenaris 2017).

5.16.6 **Reasonably Foreseeable Future Projects/Activities**

This section provides a summary of reasonably foreseeable future projects/activities considered in this cumulative impacts analysis (**Table 5-16**). Where available, impacts to resources associated with these projects are included in **Table 5-17**.

BP Fiber Optic Cable Network – BP Exploration and Production, Inc. has proposed installing a 725-mile fiber optic cable network extending across the Gulf from Pascagoula, Mississippi, to Freeport, Texas. The proposed network will provide offshore oil and gas facilities in the Gulf with updated telecommunications service. Onshore construction in Freeport has been designed to avoid all wetland impacts (**Table 5-17**). An EA and Statement of Findings was issued August 16, 2007.

Freeport Harbor Channel Improvement Project – The USACE and Port Freeport plans to the Freeport Harbor Channel from 45 feet to 55 feet and selectively widen the channel and associated turning basins (**Table 5-17**).

Freeport LNG Phase II – In July 2005, Freeport LNG Development, LP submitted environmental documentation to FERC to increase the diameter of the previously authorized 9.6-mile send-out pipeline from 36 to 42 inches. As a result, the LNG terminal would also require expansion. The environmental effects for the LNG terminal expansion are presented in an EA approved in 2006. A FEIS was approved in June 2014 to modify its previously approved Phase II facilities discussed in the 2006 EA, as well as, authorization to export up to 13.2 million tons of LNG per year from its proposed Liquefaction Plant and associated facilities in Brazoria County (**Table 5-17**).

Re-opening of San Bernard River Outlet – Brazoria County is proposing to re-open the San Bernard River outlet to the Gulf of Mexico. The project is included in Texas' current Multi-year Implementation Plan for RESTORE Act funding. This project is considered a restoration project intended to restore the outlet and associated habitats.

Port Freeport Modifications -- Several projects were identified by Port Freeport as reasonably foreseeable in the Freeport area, including: Dock 5 Expansion; Cool Storage Facility; Construction of Berth 7; and BASF Polycaprolactam Facility. Because many of these projects are still in the planning stages, there is little information available regarding their potential impacts.

Parcel 14 Developments (Warehouse and Rail Multimodal Facility) – This project involves development of a multimodal facility with on-site warehousing and rail access. A grade separation at FM 1495 and SH 36 would provide contiguous connectivity with other port parcels, with non-port traffic separated from port traffic.

OXEA Chemicals Bay City Plant Expansion – Chemical manufacturer OXEA began construction of a new world-scale propanol unit at its production site in Bay City in 2017; the unit is expected to come on stream in 2018 (BusinessWire 2017). This expansion project will create 19 new full-time, permanent jobs and will be an initial investment of $90 million with a total maximum investment of $250 million (Matagorda County EDC 2016).

STP Nuclear Operating Company Expansion – STP Nuclear Operating Company plans to build two new units to its existing nuclear power generating site (Matagorda County EDC 2016).

5.16.7 **Cumulative Impacts Discussion**

Biological and Ecological Environment

Wetlands

The Recommended Plan would impact approximately 13.8 acres of wetlands at BRFG and 0.7 acre of wetlands at CRL. Other wetland habitat impacts over time are related to the Bryan Mound Strategic Petroleum Preserve, CenterPoint Energy electric transmission line, 45-foot Freeport Channel project, Freeport LNG, and Port Freeport modifications. From the 1950s to 2002, the Brazos Delta and surrounding area have shown a significant estuarine marsh loss trend that can be attributed to erosion at the mouth of the diverted Brazos River, conversion to uplands due to early placement of dredged materials (e.g., the GIWW), agricultural land conversion, and residential and industrial development. Similar losses have occurred at the Colorado River and in East and West Matagorda Bay. The Recommended Plan and other projects identified in this analysis are subject to Section 404 of the CWA and would be required to avoid, minimize, and mitigate impacts to wetlands; wetland losses resulting from the Recommended Plan would be offset by mitigation in the form of wetland creation. As a result, the Recommended Plan is not expected to contribute to significant cumulative impacts to wetlands.

Threatened and Endangered Species

None of the projects included in this analysis are expected to adversely affect threatened or endangered species, except for dredging or pile driving that may affect sea turtles. Coordination with NMFS is required for these projects to avoid or minimize potential impacts to sea turtles during dredging operations; specific protective measures are engaged to prevent adverse impacts to the extent practicable. Any unavoidable impacts will be to individuals, within thresholds established by NMFS; therefore, the overall potential cumulative impacts are not expected to adversely impact sustainable populations. Furthermore, the Recommended Plan is not expected to have a significant contribution to impacts to these species.

Essential Fish Habitat

In general, placement of dredged material into open-water areas may affect food sources, increase turbidity, and release contaminants in EFH. Several projects compared in this analysis use ODMDS in construction and/or maintenance, potentially affecting EFH, albeit temporarily. Impacts to EFH from turbidity associated with ocean placement are not significant. If the material to be dredged is not contaminated, there would be no contamination issues with respect to EFH. Placement of dredged material associated with the projects included in this analysis would occur over time and would be subject to USACE and EPA permitting; therefore, it is reasonable to expect that dredged material placed into open-water sites would not contain contaminants. No significant cumulative impacts to EFH are anticipated.

Physical and Chemical Environment

Water Quality

For those projects that include dredging activities, dredging and placement operations are expected to temporarily degrade water quality locally through increased turbidity and the release of nutrients from the sediment. None of the projects reviewed showed concerns with sediment contamination. Dredging and placement at proposed DMPAs and ODMDS may increase suspended solids, release contaminants and bound nutrients, and deplete oxygen. This impact is temporary, generally insignificant, and the area should return to ambient conditions upon completion of dredging. Although ship traffic in the cumulative impact study area may increase over time and due to some projects, this increase is expected to be offset by efficiency increases derived from those proposed.

Groundwater impacts may occur in two of the projects considered in this analysis; however, no groundwater impacts are foreseeable or expected from implementation of the Recommended Plan. With implementation of BMPs and other permitting requirements, no significant cumulative impacts to surface water quality or groundwater quality are expected.

Air Quality

Objectionable odors (e.g., hydrogen sulfide) may result from the dredging of maintenance sediments containing high concentrations of organic matter in those reviewed projects requiring dredging or digging into aquatic sediments. Current maintenance dredging activities (such as GIWW and Freeport Harbor Channel) and proposed projects that include dredging activities for construction would emit NO_x, CO, particulates, sulfur dioxides, and hydrocarbons. The cumulative impact study area for the BRFG occurs within the HGB moderate nonattainment area for ozone; therefore, all applicable projects in the cumulative impact study area with the potential to affect air quality must evaluate emission thresholds and coordinate with TCEQ in regards to the SIP. This coordination should ensure compliance with emission thresholds and conformity with the SIP, resulting in no significant cumulative impact to air quality.

The cause of global climate change is generally accepted to be the increased production of Greenhouse Gas (GHG) emissions worldwide. Unlike criteria pollutant impacts, which are local and regional, climate change impacts occur at a global level. In addition, the relatively long lifespan and persistence of GHGs require that climate change be considered a cumulative and global impact. It is unlikely that an increase in global temperature or sea level could be directly attributed to the emissions resulting from a single project or combination of a few local projects. Rather, it is more appropriate to conclude that the GHG emissions associated with the Recommended Plan Alternatives, as well as the other projects considered herein, would combine with emissions across the U.S. and the wo to cumulatively contribute to global climate change.

Human Environment

Socioeconomic and Human Resources

TEO 12898 on EJ was instituted in 1994; therefore, several of the projects presented for evaluation in the cumulative impacts analysis did not include this as a criterion. The Recommended Plan is expected to have an overall economic benefit, as would many of the other projects discussed herein. Federal actions are required to follow the EO 12898. Therefore, no cumulative impacts to EJ communities are expected.

5.16.8 **Cumulative Impacts Conclusions**

Cumulative impacts due to past, existing, and reasonably foreseeable future projects, along with the proposed BRFG-CRL improvements, are not expected to have significant adverse effects in the cumulative impact study area. Most of the resources considered in this analysis are not affected by any or are affected by very few of the projects, in minor (small areas, mitigated) and/or temporary (short-term, recoverable with conditions) ways: threatened or endangered species, EFH, water quality, and air quality. Impacts associated with the BRFG-CRL project would be offset by mitigation measures.

5.17 MITIGATION

As discussed in **Section 5.3.2**, the USACE will mitigate for losses of wetland habitats resulting from the Recommended Plan. This section summarizes the proposed mitigation. A mitigation plan is provided in **Environmental Appendix D, Attachment D-8**.

The CEQ and NEPA guidelines state that damages to fish and wildlife resources should be prevented to the extent practicable through planning, design, and incorporating mitigation measures. For USACE projects, mitigation plans should be the most efficient and least costly measures appropriate to reduce fish and wildlife resource losses. The intent is to maintain the integrity and viability of significant natural resources and their contributions to local or regional ecosystems by applying sound ecosystem management techniques.

To estimate the amount of mitigation needed to offset anticipated wetland impacts, Average Annual Habitat Units (AAHUs) were calculated for each wetland habitat type under the FWOP Condition. For the FWOP analysis, existing wetland habitats were assumed to maintain, and not degrade, over the 50-year analysis period. Although climate change, sea level rises, and periodic major storm events may affect wetland habitats over the analysis period, these effects are expected to be similar under both the FWOP Condition and with project implementation. Based on this assumption, the HUs were calculated for the FWOP Condition over the 50-year analysis period and annualized using the annualizer in the IWR Planning Suite to determine AAHUs.

Future habitat values with the implementation of mitigation were also projected to ensure that a mitigation plan would adequately compensate for wetland losses. To predict future habitat values of a potential mitigation site, an interagency biological team met to discuss the anticipated progression of a created wetland in terms of the habitat variables in the HSI models for selected wildlife indicator species. This was performed for each of the wetland habitats that would be impacted by the Recommended Plan and thus created by a mitigation plan: high marsh and intertidal marsh. The data were input into the HSI models, and future HSIs were calculated for each created habitat type at each project site (BRFG and CRL). The HSIs were annualized over the 50-year analysis period using the annualizer in the IWR Planning Suite.

Based on the predicted habitat values of created high marsh and intertidal marsh in the NEPA study areas, 14.9 acres of marsh creation are needed to sufficiently offset the 14.5 acres of marsh habitat that would be impacted by the Recommended Plan. The 14.9 acres of created marsh would provide an estimated 12.10 AAHUs, which would replace the AAHUs that would be lost as a result of the project (**Table 5-18**).

Table 5-18 - Wetland Habitats Impacted by the Recommended Plan and Mitigation Needs

Habitat Type	Average Baseline HSI (*Annualized*)	AAHU	Acres	Projected Mitigation HSI (*Annualized*)	AAHU	Acres
		Lost			Needed	
BRFG						
High Marsh	1.00	2.40	2.4	0.98	2.40	**2.45**
Intertidal Marsh	0.80	9.12	11.4	0.78	9.12	**11.69**
CRL						
Intertidal Marsh	0.83	0.58	0.7	0.80	0.58	**0.74**
Total for Both Sites	**--**	***12.10***	***14.5***	**--**	***12.10***	***14.90***

The USACE considered three alternatives for meeting the identified mitigation needs, two of which had three different planting options/scales. The mitigation alternatives considered included:

1. Purchase mitigation bank credits
2. Establish wetlands off-site with the following planting scales
    - Plugs purchased
    - Plugs collected on site
    - Seeded pots of marsh vegetation
3. Establish wetlands on-site with the following planting scales
    - Plugs purchased
    - Plugs collected on site
    - Seeded pots of marsh vegetation

The mitigation alternatives were screened based on high-level constraints and comparisons. Purchasing mitigation bank credits was screened out because, based on the USACE's Regulatory In-lieu Fee and Bank Information Tracking Information System (RIBITS) website (USACE 2017c), the BRFG and CRL project sites are not within the service area of any active or pending mitigation bank or in lieu fee program that has tidal marsh credits. Both project sites are within the service area of two active mitigation banks: TxDOT's Coastal Bottomlands Mitigation Bank and the Danza del Rio Mitigation Bank. Each of these mitigation banks has freshwater/riverine wetland credits available, but neither has tidal wetland credits. Therefore, at this time, the anticipated tidal wetland impacts resulting from the project cannot be mitigated through mitigation bank or in lieu fee program credits.

Establishing wetlands off-site was also screened out because the projected benefits would be the same as establishing wetlands on site, but the off-site mitigation alternative would result in the addition of real estate costs, as well as contingencies such as finding a suitable off-site mitigation site and developing a cost-effective mitigation plan for the site. The USACE screened several locations for using dredged material from the project to convert open water to emergent wetland, including areas where emergent wetlands historically existed. However, the sites would require pumping dredged material longer distances than using adjacent DMPAs and would require construction of levees to contain the material, which not only adds costs to the mitigation plan but could also result in additional wetland impacts that need to be mitigated. After reviewing the refined Recommended Plans, the USACE determined that the plans at both facilities will provide areas along the existing and proposed GIWW where high marsh and intertidal marsh could be created on-site to mitigate anticipated impacts. During the PED phase, the detailed design and excavation and placement plan will include areas within both project sites in which to construct high marsh and intertidal marsh.

Based on the initial screening, one mitigation alternative was evaluated in further detail: establish wetlands on-site with three planting scales. As noted above, the three planting scales include (1) plugs purchased, (2) plugs collected on site, and (3) seeded pots of marsh vegetation. Leaving the created wetlands to vegetate on their own was not considered because interagency coordination indicated that, if left unplanted, the mitigation areas would establish vegetation very slowly, with a projected 10 percent coverage in 5 years compared to an expected 75 to 100 percent coverage if planted. The analysis of the on-site mitigation alternative assumes that the three planting scales would produce the same habitat benefits (AAHUs); however, the planting scales would affect mitigation cost. As a result, the on-site mitigation options were evaluated using cost effective/incremental cost analysis using the IWR Planning Suite (version 1.0.11). **Table 5-19** provides the preliminary cost estimates for each planting scale.

Table 5-19 – Preliminary Cost Estimates for On-Site Planting at Three Scales

Planting Scale	Cost per Plug	# Plugs/ Acre[1]	Plug Cost/ Acre	Planting Cost/ Acre	Constr. Cost/ Acre[2]	OMRRR Cost/ Acre[3]	Real Estate Cost/ Acre	Total Cost/ Acre[4]	Total Mitigation Cost[5]	Average Annual Cost/ Acre
Plugs purchased	$3.00	12,575	$37,725	$20,000	$30,000	$2,500	$3,400	$93,625	$1,395,013	$3,822
Plugs on-site	$1.00	12,575	$12,575	$20,000	$30,000	$2,500	$3,400	$68,475	$1,020,278	$2,813
Seeded nursery	$10.00	12,575	$125,750	$20,000	$30,000	$2,500	$3,400	$181,650	$2,706,585	$7,352

[1] # plugs/acre is based on planting on 2-foot centers on a triangular grid.
[2]Estimated costs for construction of rock breakwaters and/or placement and contouring of dredged material.
[3] OMRR&R = Operations, Maintenance, Repair, Replacement, and Rehabilitation. Because the mitigation sites should be self-sustaining after the success criteria are met, OMRR&R costs should be minimal.
[4] Note that these costs assume that site prep would be done through the dredged material placement.
[5] Total mitigation cost is based on a total mitigation acreage of 14.9 acres.

Collecting plugs on-site was identified as the Best Buy mitigation plan, as it incurs the lowest average annual cost per acre. An uncaptured ancillary benefit of the on-site plug option is that it promotes the establishment of other native marsh species in addition to the target species because other species or their seeds may be included in the collected plugs.

5.17.1 Mitigation Location

Considering multiple mitigation site alternatives, the USACE determined that creating wetland habitats on the project sites would be the most cost-effective mitigation solution. The PDT determined that the Recommended Plan at both facilities will provide areas along the existing and proposed GIWW where high marsh and intertidal marsh could be created to meet the mitigation requirements. **Figures 5-14 and 5-15** show potential locations for the mitigation wetlands at each facility in relation to the Recommended Plan and study areas. During the PED phase, the final design for dredging and placement at each facility would incorporate areas of sufficient size and with appropriate elevations to establish the mitigation wetlands along the existing and proposed GIWW.

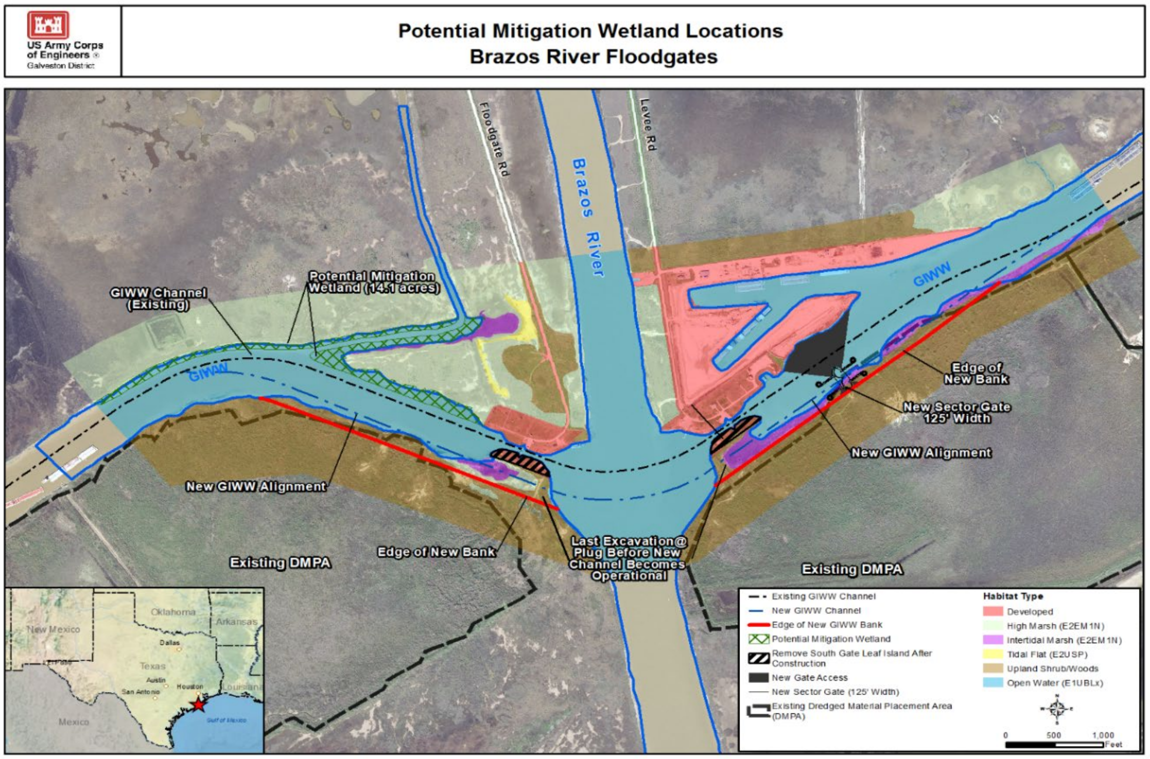

Figure 5-14 – Potential Wetland Mitigation Location at BRFG

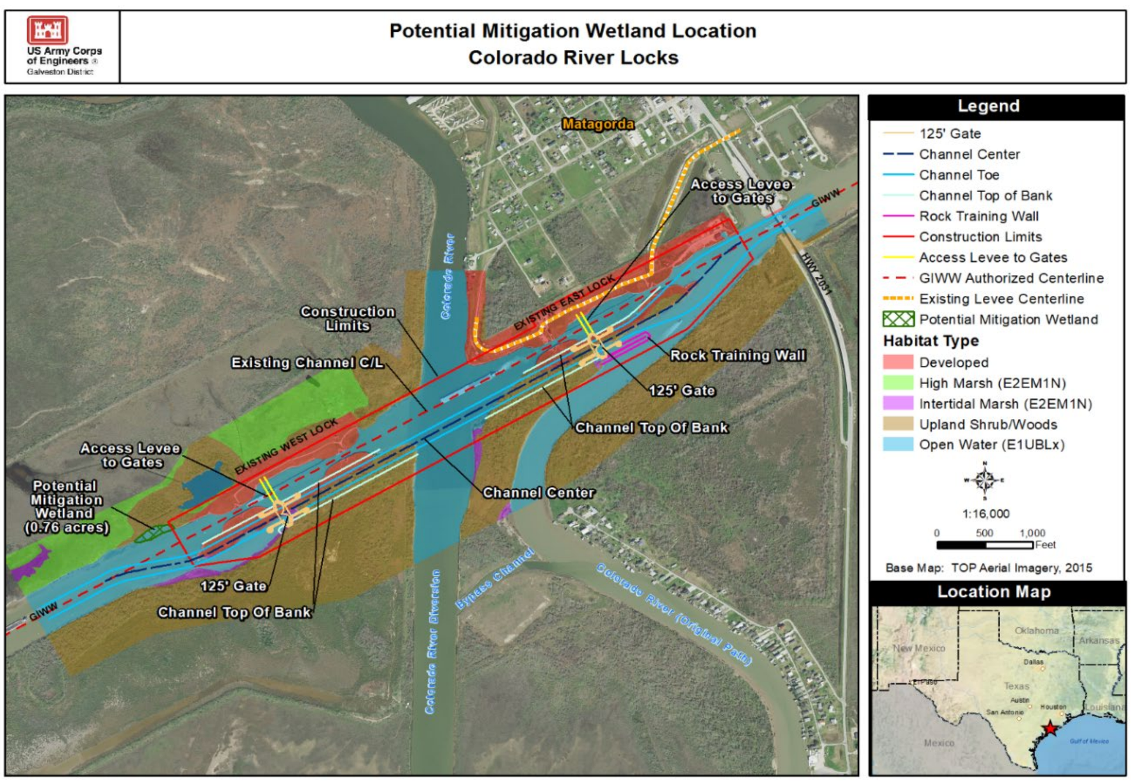

Figure 5-15 – Potential Wetland Mitigation Location at CRL

5.17.2 Mitigation Monitoring and Adaptive Management

The WRDA of 2007, Section 2036 requires that a mitigation plan include a plan for monitoring the implementation and ecological success of the proposed mitigation, and states that the monitoring should continue until the ecological success criteria have been met. This section discusses the feasibility-level monitoring and adaptive management strategies for the anticipated wetland mitigation efforts at the BRFG and CRL facilities. The primary intent of this preliminary Monitoring and Adaptive Management Plan (MAMP) is to identify monitoring and adaptive management actions appropriate for the project's mitigation goals and objectives. The MAMP, including costs, is based on currently available data and information developed during plan formulation of the mitigation plan. Uncertainties remain regarding the project design and construction details, extents of the mitigation areas and associated features, monitoring elements, and adaptive management opportunities. During the PED phase of the project, the USACE will develop a more detailed MAMP that will address uncertainties, provide a detailed cost breakdown, and further assess the establishment and success of the mitigation features proposed in the mitigation plan.

5.17.3 Authority and Purpose

Section 2036 of WRDA 2007 states that mitigation plans shall include "a plan for monitoring the implementation and ecological success of each mitigation measure…" and that "mitigation monitoring shall continue until it has been demonstrated that the mitigation has met the ecological success criteria." Section 2036 also requires mitigation plans to include a contingency plan (Adaptive Management Plan) for taking corrective actions when monitoring shows that mitigation measures are not meeting the ecological success criteria.

5.17.4 Implementation

Pre-construction, during construction, and post-construction monitoring shall be conducted by utilizing a MAMP Team consisting of representatives of the USACE, TxDOT, and contracted personnel. Monitoring will focus on evaluating mitigation success and guiding adaptive management actions by determining if the project has met Performance Standards. Monitoring will be carried out until the project has been determined to be successful (performance standards have been met), as required by Section 2036 of WRDA 2007. Monitoring objectives are summarized in **Table 5-20** and discussed afterward.

Table 5-20 - Monitoring Criteria, Performance Standards, and Adaptive Management Strategies

Measurement	Performance Standard	Adaptive Management Measures
Herbaceous Plant Cover	70 percent cover by target marsh species	• Replanting and/or re-contouring as needed • Changing species composition • Collecting plugs from different locations
Non-native Vegetation	< 10 percent cover by non-native or invasive species	• Mechanical removal • Local herbicide application • Replanting as needed
Water Depth	Target elevation for specific habitat	• Re-contouring as needed
Erosion Control	Minimal erosion observed	• Install breakwaters or other controls • Re-contouring as needed

The mitigation areas will be assessed prior to construction, then monitored initially at 6 months after construction and initial planting is completed. Afterward, the mitigation areas will be monitored every six months for up to 3 years or until the mitigation success criteria, are achieved. The mitigation areas will be considered successful when:

1. herbaceous cover of target plant species is at least 70 percent
2. cover of non-native or invasive plant species is less than 10 percent; and
3. target elevations are present

After any monitoring period, if it is determined that the mitigation areas are not progressing as planned, adaptive management actions outlined in **Table 5-20** will be implemented as appropriate.

5.17.5 **Reporting**

After each monitoring period, a report will be prepared and submitted to the USFWS, NMFS, TPWD, and other interested parties. Permanent locations for photographic documentation will be established to provide a visual record of habitat development over time. The photograph locations will be identified in the pre-construction monitoring report. Photographs taken at each location will be included in monitoring reports.

5.17.6 **Monitoring and Adaptive Management Costs**

Costs to be incurred during PED and construction phases include drafting of the detailed MAMP. Cost calculations for post-construction monitoring are displayed as a 3-year (maximum) total. If ecological success is determined earlier (prior to 3 years post-construction), then the monitoring program will cease and costs will decrease accordingly.

It is intended that monitoring conducted for the wetland mitigation will utilize centralized data management, data analysis, and reporting functions associated at the USACE Fort Worth District office. All data collection activities will follow consistent and standardized processes established in the detailed MAMP. Cost estimates include monitoring equipment, photograph point establishment, data collection, quality assurance/quality control, data analysis, assessment, and reporting for the proposed monitoring elements (**Table 5-21**). More detailed cost information, including assumptions used in the cost estimates is provided in the mitigation plan. The current total estimate for developing the MAMP and conducting monitoring is $147,000. Unless otherwise noted, costs will begin at the onset of the PED phase and will be budgeted as construction costs. With the addition of these MAMP costs to the anticipated constriction and OMRR&R costs, the total cost to construct, maintain, and monitor the proposed mitigation is $1,167,278.

Table 5-21 - Preliminary Cost Estimates for Implementation of the Monitoring and Adaptive Management Plan (MAMP) Development ($000)

Category	Activities	PED Set-up & Data Acquisition	1-Year	2-Year	3-Year	Total
			Cost Post-Construction			
Monitoring: Planning and Management	Monitoring workgroup, drafting detailed monitoring plan, working with PDT on performance measures	$16	$3	$3	$31	$25
Monitoring: Data Collection	Vegetation	$12	$12	$12	$12	$48
Data Analysis	Assess monitoring data and performance standards and prepare reports	$10	$10	$10	$10	$40
Database Management	Database development, management, maintenance	$3	$2	$2	$2	$9
Adaptive Management Program	Detailed Adaptive Management Plan and Program Establishment	$10	--	--	--	$25
	Management of Adaptive Management Program	--	$5	$5	$5	
	Total MAMP Costs	**$51**	**$32**	**$32**	**$32**	**$147**
	Total Construction and OMRRR Cost					**$1,020**
	TOTAL MITIGATION COST					***$1,167***

If implementation of adaptive management measures outlined previously in **Table 5-20** becomes necessary, the implementation would require additional costs, as estimated in **Table 5-22**. The costs for implementing adaptive management measures were estimated based on potential frequency of implementation and estimated level of effort anticipated for each measure. The preliminary total estimate for implementing the adaptive management plan is $50,000.

Table 5-22 – Preliminary Cost Estimates for Implementation of Adaptive Management Measures ($000)

Adaptive Management Measure	Assumptions	Cost
Replanting	Assume 10% of area (1.5 acres) may require one replanting Assume $10,000/acre for preparation, mobilization, plug collection, planting	$15
Re-contouring	Assume minor re-contouring one time at $25,000	$25
Invasive and/or Nuisance Plant Control	None anticipated – mitigation will be mostly intertidal marsh where few species can survive.	$0
Erosion Control	Assume some erosion control will be needed at $10,000	$10
	TOTAL	**$50**

5.18 IRRETRIEVABLE AND IRREVERSIBLE COMMITMENT OF RESOURCES

The labor, capital, and material resources expended in the planning and construction of the Recommended Plan would be irreversible and irretrievable commitments of human, economic, and natural resources. Material resources would include steel, concrete, and other materials needed to construct the structural components of the proposed new gate structures at the BRFG and CRL, as well as fuel spent in dredging, dredged material placement, and other construction activities. The loss of 14.5 acres of wetland habitats would be irreversible but would be fully compensated with in-kind mitigation.

The No Action Alternative would also involve irreversible or irretrievable losses of funding, energy, and labor due to the continued navigation delays that are part of the existing condition at both facilities during high-water events.

6.0 APPLICABLE LAWS AND EXECUTIVE ORDERS

There are many Federal and state laws pertaining to the enhancement, management and protection of the environment. Federal projects must comply with the environmental laws, regulations, policies, rules and guidance in **Table 6-1**, among others. USACE personnel coordinated with Federal and state resource agencies during planning and will continue to coordinate through agency concurrence. Compliance with laws will be accomplished by obtaining final concurrence from appropriate agencies and with the signing of a Record of Decision by the Assistant Secretary of the Army for Civil Works. A summary of the compliance of the project with environmental laws and executive orders is included in **Table 6-1**.

Table 6-1 - Compliance of Recommended Plan with Environmental Laws & Executive Orders

Policies	Compliance of Recommended Plan
Public Laws	
Clean Air Act, 1970, as amended	Compliant
Clean Water Act, 1972, as amended	Compliant
Coastal Zone Management Act, 1972, as amended	Compliant
Endangered Species Act, 1973, as amended	Compliant
Farmland Protection Policy Act	Compliant
Fish and Wildlife Coordination Act, 1958, as amended	Compliant
Magnuson-Stevens Fishery Conservation and Management Act	Compliant
Marine Mammal Protection Act of 1972	Compliant
Bald and Golden Eagle Protection Act of 1940, as amended	Compliant
Migratory Bird Treaty Act, 1918, as amended	Compliant
National Historic Preservation Act, 1966, as amended	Compliant
Coastal Barrier Resources Act of 1982, as amended	Compliant
Executive Orders	
Protection and Enhancement of Environmental Quality (EO 11514)	Compliant
Floodplain Management (EO 11988)	Compliant
Protection of Wetlands (EO 11990)	Compliant
Environmental Justice (EO 12898)	Compliant
Invasive Species (EO 13112)	Compliant
Migratory Birds (EO 13186)	Compliant
Protection of Children (EO 13045)	Compliant

6.1 FEDERAL LAWS

6.1.1 **Clean Air Act of 1970 (Air Quality)**

The CAA sets goals and standards for the quality and purity of air. It requires the EPA to set NAAQS for certain pollutants considered harmful to public health and the environment and requires federal agencies to act in conformity with an applicable SIP. The BRFG study area is located within the HGB Intrastate Air Quality Control Region, which is in attainment for all criteria pollutants except ozone (EPA 2017c, TCEQ 2017b). The HGB Ozone Nonattainment Area was classified as "severe" by the EPA in October 2008 under the 1997 eight-hour ozone NAAQS. In July 2012, the EPA designated the HGB area as "marginal" for the 2008 ozone NAAQS based on major improvements in air quality for the area but reclassified the HGB area as "moderate" ozone nonattainment in December 2016 because attainment had not been achieved by the imposed deadline (81 FR 90207). As of October 2018, the HGB area remains listed as "moderate" ozone non-attainment; however, the EPA has proposed approval of revisions to the Texas SIP that would address ozone attainment in the HGB area (83 FR 29727-29731).

The CRL area is in Matagorda County, which is in attainment for all criteria pollutants. Since the BRFG is in the HGB ozone moderate nonattainment area, calculations of projected pollutant emissions from construction are required to determine if they exceed the General Conformity de minimis thresholds of 100 tpy for the ozone precursors NO_x and VOCs (2008 8-hour standard). However, at the time this report was finalized, the Recommended Plan design, construction plan (including equipment needs), and schedule were not developed with enough detail to accurately estimate pollutant emissions at the BRFG. A qualitative emissions estimate—made by comparing available dredging and pile driving quantities and construction schedule for the Recommended Plan to the nearby FHCIP reevaluation (USACE 2017)—indicates that NO_x and VOC emissions would not exceed 100 tpy at the BRFG and would not require a General Conformity Determination (see Section 5.11). Therefore, the Recommended Plan would not have a significant adverse effect on air quality.

Once the Recommended Plan design, construction plans, and schedule are completed in the PED phase, the USACE will calculate emissions at the BRFG and coordinate them with the TCEQ and EPA to verify that emissions are below de minimis thresholds and do not require a Conformity Determination. If calculated emissions exceed de minimis thresholds, the USACE would conduct and coordinate a General Conformity Determination pursuant to the CAA, Section 176(c)(1), to document conformity with the SIP for the HGB ozone nonattainment area.

By letter dated March 13, 2018 (see **Environmental Appendix D, Attachment D-10**), the TCEQ confirmed that the HGB area is currently classified as moderate nonattainment for the 2008 ozone

NAAQS and that the de minimis threshold for NO_x and VOCs is 100 tpy. The TCEQ also stated that it is evaluating the *South Texas Air Quality Management District v. EPA*, No. 15-1115 (D.C. Cir. 2018) decision, which in the future could result in a classification change for previous ozone standards for the HGB area. During PED, the USACE will compare calculated emissions to the most current de minimis thresholds.

6.1.2 **Clean Water Act of 1972 – Section 401 (Water Quality)**

The CWA sets and maintains goals and standards for water quality and purity. Section 401 requires a Water Quality Certification from the TCEQ that a proposed project does not violate established effluent limitations and water quality standards. During the PED phase, BMPs will be incorporated into the Recommended Plan design and construction plans and may include silt fences, fiber rolls, rock berms, or other effective BMPs to reduce suspended solids from land runoff, as well as turbidity screens or silt collection curtains as needed around construction equipment to reduce the amount of sediment entrained in the water. Prior to disturbance, the USACE will conduct sediment sampling at the BRFG and CRL to characterize any contaminants present and will handle and dispose of any contaminated material accordance with applicable local, state, and federal permits, statutes, and regulations. With the implementation of appropriate BMPs and handling/disposal procedures as needed, the Recommended Plan will have temporary adverse effects to water quality in the vicinity, but these impacts are not expected to be significant. The Recommended Plan is not expected to violate water quality standards.

By letter dated March 13, 2018 (see **Environmental Appendix D, Attachment D-10**), the TCEQ stated that the Office of Water does not anticipate significant long-term environmental impacts from the project if construction and waste disposal activities are completed in accordance with applicable local, state, and Federal environmental permits, statutes, and regulations. The TCEQ also recommended that BMPs be used to control runoff from the construction sites to prevent impacts to surface and ground water. The TCEQ has provided the water quality certification for the Recommended Plan (**Appendix D-10 of the Environmental Appendix**).

6.1.3 **Clean Water Act of 1972 – Section 404(b)(1) (Disposal Sites for Dredged or Fill Material)**

The USACE administers regulations under Section 404(b)(1) of the CWA, which establishes a program to regulate the discharge of dredged and fill material into waters of the U.S. The USACE evaluated the Recommended Plan under the CWA 404(b)(1) guidelines and determined that it complies with the guidelines (see 404(b)(1) analysis in **Environmental Appendix D, Attachment D-1**). Compared to other alternatives that meet the project's purpose and need and satisfy navigation needs based on public input, the Recommended Plan minimizes impacts to wetlands and other water resources; as such, the Recommended Plan is the least environmentally damaging practicable alternative. The USACE has prepared a mitigation plan to offset wetland impacts, which is provided in **Environmental Appendix D, Attachment D-8** and summarized in **Section 5.18.**

6.1.4 Coastal Zone Management Act of 1972 (Coastal Zone Development)

The Coastal Zone Management Act of 1972 establishes a partnership structure allowing states and the Federal government to work together to protect coastal zones from environmentally harmful over-development. In response, Texas developed the TCMP, which protects coastal natural resources categorized into 16 CNRAs. Although the Recommended Plan will affect CNRAs, the effects are not expected to be significant. The USACE evaluated potential project-induced impacts during feasibility level design and determined that the Recommended Plan complies with the TCMP and will be conducted in a manner consistent with all rules and regulations of the program. The USACE submitted a TCMP Consistency Determination (**Environmental Appendix D, Attachment D-5**) to the GLO in February 2018; no response was received.

6.1.5 Endangered Species Act of 1973 (Threatened and Endangered Species)

The ESA is designed to protect and recover threatened and endangered species of fish, wildlife, and plants. The USFWS and NMFS have previously identified several listed species that are known to or may possibly occur in the study areas, including piping plover, red knot, whooping crane, and sea turtles. No threatened or endangered plants were identified as occurring in the study areas. In February and October 2018, the USACE submitted to the USFWS and NMFS a Biological Assessment that evaluates the potential effects of the Recommended Plan on listed species. Based on review of existing data and initial informal consultation, the USACE finds that implementation of the Recommended Plan is not likely to adversely affect any listed species or their critical habitat; as such, no formal Section 7 consultation is expected.

Estimated noise levels from proposed pile driving could exceed sea turtle injury thresholds, so the USACE will implement measures as needed to avoid adverse effects to sea turtles if they occur in the GIWW during construction. Measures may include:

- Implementing a "soft start" for up to 20 minutes to allow sea turtles to leave the project vicinity before sound pressure increases above injury thresholds
- Installing piles within dewatered cofferdams, which would reduce noise levels
- Using a vibratory hammer or cushioned impact hammer to reduce noise levels

Through consultation, NMFS identified additional measures that would minimize impacts to sea turtles, which include:

- Using wood cushion blocks as needed for pile driving with impact hammers to maximize attenuation of underwater noise
- Adhering to NMFS' *Sea Turtle and Smalltooth Sawfish Construction Conditions* (NMFS 2006)
- Conducting in-water work during daylight hours only

NMFS and USFWS has provided a list of measures and recommendations to minimize impacts to fish and wildlife resources, including threatened and endangered species report:

USFWS

- The Service recommends the Corps incorporate BU of dredged material into the DMMP in lieu of using existing or proposed confined upland PAs or offshore disposal sites. BUs for dredged material may include creation and/or restoration of marsh habitats, construction of earthen terraces to control wave action and promoted shoreline stabilization and plant growth, construction of colonial waterbird nesting islands, and other activities that improve and protect coastal habitats. **This measure will be incorporated into the design of the project and mitigation areas where feasible.**
- All new work and maintenance should be tested for contaminants using the standards outlined in the EPA's Testing and Ocean Dumping Manuals prior to being used in any BU projects or being placed in upland confined PAs or offshore disposal sites. Should testing suggest toxic levels of contaminants are present, the Service recommends disposal of material within an approved landfill site. **Measure will be implemented.**
- The Service recommends the USACE incorporate BMPs into their construction strategies. The Service requests that the Corps initiate coordination with the Service during the site design phases of the project and prior to any of the construction activities so the site-specific BMPs can be developed. Measures should be implemented to avoid or minimize the adverse effects of pollution, sedimentation, and erosion by limiting soil disturbances, managing likely pollutants, and limiting the harm that may be caused by accidental discharges of pollutants and sediments, avoiding contact with any wildlife species, removal of trash daily, slower transportation speeds within the project area (on land and in the water), and educating construction staff about the presence of wildlife species within the project area. BMPs attempt to minimizer impacts to fish and wildlife species within the immediate construction and nearby areas and may consist of, but not limited to, floating turbidity curtains, limiting certain construction activities to daylight hours, limiting the use of or shielding lights at night, no vegetation removal or soil disturbance should be allowed

outside of the project area, removal of mature trees providing soil or bank stabilization should be coordinated with the Service and TPWD, erosive banks should be stabilized using bioengineering solutions to minimize the use of riprap, and using monitors in open water areas to identify sensitive species. **Measures will be implemented where appropriate.**

- The Service recommends the Corps incorporate success criteria, monitoring, and adaptive management into the project's wetland mitigation plan. **Measure has been implemented and documented in this report.**
- The Service recommends that the Corps continue to coordinate with the natural resource agencies in designing the proposed marsh mitigation areas, evaluate potential impacts to vessel traffic in the GIWW when designing the mitigation areas, and to adequately protect the mitigation areas from erosion and other impacts that may occur along the GIWW. **Measure will be implemented.**
- Wetland creation areas should be planted as early as possible to minimize erosion. Plant species and planting schedules should be fully vetted and coordinated with the Service, NMFS, and TPWD. **Measure will be implemented.**
- The Service believes that, through construction and mitigation efforts, additional marsh habitat may be negatively impacted (e.g. moving equipment necessary for wetland construction). We expect these additional impacts to be temporary and should not require mitigation. If the Corps deems that additional permanent wetlands impacts may occur, the Service recommends mitigation for any additional permanent direct or indirect impacts with full compensation and in coordination with the Service, NMFS, and TPWD. **Measure will be implemented.**
    - The Service recommends that the Corps initiate coordination with NMFS at (727) 824-5312 regarding sea turtle impacts and mitigation issues for the project, and follow the NMFS's recommendation and construction conditions for in-water work. **Coordination with NMFS is complete and documented in this report. USACE will comply with the mitigation measures provided by NMFS and implement their recommendations where appropriate and feasible.**
    - The Service recommends the Corps evaluate the project's impacts to units protected under the Coastal Barrier Resources Act of 1982 and coordinate the Corps' impact determination with the Service. **Measure has been implemented and coordination with USFWS is complete and documented in this report.**
    - Should this project move to the design and construction phases, the Service recommends that the Corps continue to evaluate the project's effects on threatened and endangered species, bald eagles, wetland habitats, migratory birds, and other natural resources. **Measure will be implemented.**

- If the proposed project features a change, the status of species change, or the project is not implemented within two years of the date of our ESA coordination completion, the Service recommends that the Corps reevaluate the project's effects and species status and initiate any necessary consultation procedures pursuant to Section 7 of the ESA. **Measure will be implemented.**
- The Service recommends the Corps utilize the National Bald Eagle Management Guidelines to identify when and under what circumstances the protective provisions of the BGEPA may apply to their activities. Also, if construction is not implemented within two years following the Corps' analysis, we recommend that the Corps reassess the potential habitats in and adjacent to the impact areas for the potential for bald eagle nests. **Measure will be implemented.**
- The Service recommends that construction occur at least 1,000 feet away from a colonial waterbird rookery site during the breeding season of February 1 through September 1. **No waterbird rookeries were identified within or near the project area during habitat surveys. If a rookery forms prior to construction, USACE will implement this measure. If construction must occur during the breeding season, USACE will coordinate with the USFWS Ecological Service and Migratory Bird Treaty Offices.**
- With respect to other migratory birds, the Service recommends that clearing of vegetation and excavation of potential nesting habitats (e.g. wooded areas along the south side of the GIWW) be conducted outside of bird nesting season. Nesting season is hi8ghly variable, with larger hawks and raptors nesting during winter months and some colonial waterbirds nesting as late as August. If construction cannot be completed outside of bird nesting season, we recommend coordination with the TCESFO – Houston (281) 286-8282 to identify survey times and BMPs. **Measure will be implemented.**
- The Service urges the Corps to consider sea level rise and other potential effects of climate change when planning this and other coastal projects, including habitat mitigation, creation, restoration, stabilization, and protection projects. **Measure has been implemented and documented in this report.**
- The Service requests that the Corps initiate coordination with the Service during the design phases of the project and prior to the commencement of any construction activities so the site-specific BMPs can be developed. Measures should be implemented to avoid or minimize adverse effects of pollution, sedimentation, and erosion by limiting soil disturbances, managing likely pollutants, and limiting the use. **Measure will be implemented.**

- A monitoring and adaptive management plan should be developed prior to construction of the mitigation features for the project. The Service requests the opportunity to provide input and review the development of the plan to ensure the successful implementation of the mitigation measures. **Measure will be implemented.**

NMFS:

- NMFS has no additional conditions or recommendations other than adhering to the NMFS's Sea Turtle and Smalltooth Sawfish Construction Conditions, including the use of turbidity curtains. The adherence to these conditions was documented in the Biological Assessment provided to NMFS.

6.1.6 **Farmland Protection Policy Act of 1981 (Prime Farmland)**

The Farmland Protection Policy Act (FPPA) of 1981 requires consideration of those soils that the U.S. Department of Agricultural Natural Resources Conservation Service (NRCS) defines as best suited for food, forage, fiber, and oilseed production, with the highest yield relative to the lowest expenditure of energy and economic resources. None of the soils in the BRFG NEPA study area are classified as Prime Farmland soils by the NRCS. In the CRL NEPA study area, Norwood loam is classified as a Prime Farmland soil and occurs along the Colorado River banks. The area of the CRL has not been farmed and will not be farmed in the future.

By letter dated March 12, 2018 (see **Environmental Appendix D, Attachment D-10**), the NRCS stated that the "proposed project does not involve activities that will have a negative impact on productive agricultural lands. Due to these reasons the project sites are exempt from provisions of FPPA and no further consideration for protection is necessary."

6.1.7 **Fish and Wildlife Coordination Act of 1934 (Fish & Wildlife)**

The Fish and Wildlife Coordination Act (FWCA) provides authority for USFWS involvement in evaluating impacts to fish and wildlife from proposed water resource development projects. It requires that fish and wildlife resources receive the same consideration as other project features. It also requires Federal agencies that construct, license, or permit water resource development projects to first consult with the USFWS, NMFS, and state resource agencies regarding the impacts on fish and wildlife resources and measures to mitigate these impacts. Section 2(b) of the FWCA requires the USFWS to produce a Coordination Act Report (CAR) that details existing fish and wildlife resources in the project area, potential impacts due to the proposed project and recommendations for the project.

The USACE has coordinated with the USFWS, as well as NMFS and TPWD, regarding habitat and other fish and wildlife resources. The primary concern brought forth during meetings with the agencies was to minimize impacts to wetlands. The USACE assisted the USFWS in preparing the initial draft CAR, and the USFWS provided initial comments that included:

- Consider potential effects to the whooping crane
- Address migratory birds, particularly colonial waterbird rookeries in the area
- Evaluate identified temporary impacts to verify they will not be permanently impact resources
- Clarify when the mitigation location and design will be incorporated into the project
- Consider beneficial use of dredged material
- Include climate change discussion

The Final CAR is provided in **Environmental Appendix D, Attachment D-9**.

6.1.8 Magnuson-Stevens Fishery Conservation and Management Act of 1976 and the Magnuson-Stevens Act Reauthorization of 2006 (Essential Fish Habitat)

The Magnuson-Stevens Fishery Conservation and Management Act and its reauthorization govern marine fisheries management in the U.S. Specific categories of EFH occurring in the project area include estuarine emergent wetlands, estuarine water column and estuarine mud substrate (bottom). The USACE has assessed the effects of the project on EFH and determined that the Recommended Plan would have short-term, localized, and minor adverse effects on EFH because of substrate disturbances and loss of prey during construction and maintenance dredging. The Recommended Plan includes mitigation for impacted marsh habitats and will result in a net increase in open water habitats; therefore, it is not expected to result in permanent adverse effects to EFH. An EFH Assessment Report is provided in **Environmental Appendix D, Attachment D-4**. The PDT coordinated with NMFS throughout project planning and submitted the DIFR-EIS and EFH assessment to NMFS in February 2018. During a resource agency meeting in April 2018, NMFS indicated that EFH was not a concern. No further coordination with NMFS regarding EFH is anticipated.

6.1.9 Marine Mammal Protection Act of 1972 (Marine Mammals)

The MMPA protects whales, dolphins, sea lions, seals, manatees, and other marine mammal species. Whales, sea lions, and seals do not occur in the study areas. Bottlenose dolphins are known to occur in the study areas throughout the year. Occurrence of a manatee in either study area would be extremely rare. Estimated noise levels from proposed pile driving could exceed behavioral thresholds for cetaceans and may result in harassment of bottlenose dolphins; however, dolphins are expected to avoid the areas during construction. In addition, implementation of measures to attenuate underwater noise, as discussed for sea turtles in **Section 6.1.5**, would minimize effects on dolphins. These measures may include:

- Implementing a "soft start" for up to 20 minutes
- Installing piles within dewatered cofferdams, which would reduce noise levels
- Using a vibratory hammer or cushioned impact hammer to reduce noise levels
- Using wood cushion blocks as needed for pile driving with impact hammers to maximize attenuation of underwater noise
- Conducting in-water work during daylight hours only

With the implementation of BMPs, the Recommended Plan is not expected to result in significant adverse effects to marine mammals.

6.1.10 **Bald and Golden Eagle Protection Act of 1940 (Bald and Golden Eagles)**

The BGEPA of 1940, as amended, prohibits the "take" of bald or golden eagles, including parts, eggs, or nests, including to take, possess, sell, purchase, barter, or transport any bald or golden eagle. Take for eagles includes to pursue, shoot, shoot at, poison, wound, kill, capture, trap, collect, molest, or disturb. The Recommended Plan is not expected to affect bald or golden eagles. Golden eagles are not expected to occur in the study areas, except possibly migrating individuals passing through the area. Although bald eagles may forage in the rivers and large water bodies in and near the study areas, no bald eagle nests are in or adjacent to the study areas, and an on-site habitat assessment determined that trees in the study areas are too small to support bald eagle nests. Prior to construction, the habitats in and adjacent to the impact area will be reassessed to determine if they are suitable for bald eagle nesting, and a nest survey will be conducted if needed.

6.1.11 **Migratory Bird Treaty Act of 1918 and Migratory Bird Conservation Act of 1929 (Migratory Birds)**

The MBTA and the Migratory Bird Conservation Act protect migratory birds and their habitat. The wetlands, tidal flats, and upland shrub/woods in the study areas provide nesting, foraging, loafing, and roosting habitat for migratory birds. The USFWS has previously indicated that areas near the project sites may support colonial nesting water birds (e.g., herons, egrets, ibis, night-herons, anhingas, and roseate spoonbills). To minimize impacts to colonial nesting birds and other migratory birds, vegetation clearing will be completed outside the nesting season (March 1 to August 31), if possible. If vegetation clearing is required during nesting season, nest surveys will be completed prior to clearing to minimize removal of active nests. The USACE will conduct pre-construction surveys for colonial nesting birds, and if colonies are found, will adjust the timing of construction activities so that impacts to the nesting birds are avoided.

6.1.12 National Historic Preservation Act of 1966 (Cultural and Historic Resources)

Section 106 of the NHPA and 36 CFR §800 require Federal agencies to identify and consider the potential effects that their undertakings might have on significant historic properties, districts, sites, buildings, structures, or objects that are included in or eligible for inclusion in the NRHP. Additionally, a Federal agency shall consult with any federally recognized tribe that attaches religious and cultural significance to such properties. Federal agencies shall afford the SHPO and tribes a reasonable opportunity to comment before decisions are made.

The USACE reviewed the APEs at both facilities and determined that the proposed undertaking (Recommended Plan) would not pose adverse effects to significant cultural resources that are included in or eligible for the NRHP. There are no previously recorded archeological sites in the APEs, and the work proposed by the Recommended Plan would occur within disturbed areas in and adjacent to the GIWW and DMPAs. Due to previous dredging and construction within the footprint of the Recommended Plan, there is no potential to affect archeological historic properties. Based on a non-archeological historic resources survey of the APEs, the USACE determined that neither the existing floodgates, locks, nor associated resources at the BRFG and CRL facilities (e.g., control houses, power houses, pump house, boat house), nor any other historic-age resource in the APEs are eligible for inclusion on the NRHP. As a result, the Recommended Plan will not adversely affect historic resources.

In compliance with Section 106 of the NHPA, the USACE coordinated the results of the cultural resource investigations and determinations with the Texas SHPO and federally recognized tribes. By letter dated January 23, 2019, the Texas SHPO concurred with the USACE's determinations. The Comanche Nation Historic Preservation Office also reviewed the project and cross-referenced the project location with the Comanche Nation site files, concluding that No Properties were identified. These consultation letters are provided in **Environmental Appendix D, Attachment D-10**.

6.1.13 Coastal Barrier Resources Act of 1982 (Coastal Barriers)

The CBRA was enacted in 1982 to discourage development in certain coastal areas that are vulnerable to hurricane damage and are host to valuable natural resources. The stated purpose of the CBRA is to "minimize the loss of human life, wasteful expenditure of Federal revenues, and the damage to fish, wildlife, and other natural resources associated with the coastal barriers...by restricting future Federal expenditures and financial assistance which have the effect of encouraging development of coastal barriers…" (16 U.S.C. § 3501(b)). The CBRA prohibits government expenditures on new projects within certain identified coastal barrier resource units unless they fit certain exceptions found within 16 U.S.C. §3505. The CBRA provides that the general prohibition on Federal expenditures affecting the system include the construction of structures in CBRA units (§3504(a)(3)).

None of the work associated with the Recommended Plan at the CRL would occur within CBRS units or affect the CBRS. At the BRFG, portions of the proposed work and infrastructure will be within CBRA Unit T05/T05P. The USACE has determined that the GIWW is an existing Federal channel subject to a navigation exception found at 16 U.S.C. 3505(a)(2), which provides an exception for "the maintenance or construction of improvements of existing Federal navigation channels (including the Intracoastal Waterway) and related structures (such as jetties), including the disposal of dredge materials related to such maintenance or construction." In compliance with the CBRA, the USACE has prepared a consultation letter and received concurrence from the USFWS that the navigation exception applies with regard to CBRS Unit T05. The response letter from the USFWS that endorses the exception applicability is provided in **Environmental Appendix D, Attachment D-10.**

6.2 EXECUTIVE ORDERS

6.2.1 Executive Order 11514, Protection and Enhancement of Environmental Quality

EO 11514 directs Federal agencies to "initiate measures needed to direct their policies, plans and programs so as to meet national environmental goals." The proposed action complies with EO 11514 because the USACE considered environmental resources throughout project planning, and the Recommended Plan minimizes environmental impacts to the extent practicable while meeting the project purpose and need and satisfying navigation needs based on public input. Adverse impacts to sensitive wetland habitats due to the Recommended Plan will be mitigated.

6.2.2 Executive Order 11988, Floodplain Management

EO 11988 directs agencies to avoid development in floodplains to the maximum extent feasible. All alternatives that were considered and meet the purpose and need of the project would be located at existing facilities within the base floodplain. No non-floodplain alternatives exist. As discussed in Section 5.3.1, the Recommended Plan is not expected to have significant effects on floodplains, and the proposed action complies with EO 11988.

6.2.3 Executive Order 11990, Protection of Wetlands

EO 11990 directs Federal agencies to avoid, to the extent possible, the long- and short-term adverse impacts associated with the destruction or modification of wetlands, and to avoid direct or indirect support of new construction in wetlands wherever there is a practicable alternative. The Recommended Plan complies with EO 11990, as it minimizes wetland impacts at each facility compared to other alternatives that meet the project's purpose and need and satisfy navigation needs based on public input, and compensatory mitigation will be provided to offset unavoidable wetland impacts. Wetland impacts were minimized by keeping proposed GIWW realignments close to the existing alignment and by planning for dredged material disposal in existing DMPAs and ODMDS. Mitigation for wetland impacts was integrated into project planning by considering, individually and collectively, the CWA mitigation actions of avoiding, minimizing, reducing, and rectifying adverse impacts to wetlands to the extent practicable. The mitigation plan prepared for the project (**Environmental Appendix D, Attachment D-8**) provides for the replacement of functions and values of the impacted wetlands. The Recommended Plan is not expected to change development rates or patterns or induce growth over the No Action Alternative, thereby avoiding direct or indirect support of new construction in wetlands.

6.2.4 Executive Order 12898, Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations

EO 12898 requires Federal agencies to make achieving EJ part of their missions by identifying and addressing disproportionately high and adverse human health or environmental effects of programs, policies, and activities on minority populations and low-income populations. The Recommended Plan would not directly affect residences, business, or otherwise adversely affect minority or low-income populations. The Recommended Plan would allow for transit through the GIWW throughout construction, so work hours or employment should not be affected over the existing condition. Potential noise effects are expected to be minor. Since the Recommended Plan would not have disproportionately high and adverse effects on EJ populations, the proposed action complies with EO 12898.

6.2.5 Executive Order 13112, Invasive Species

EO 13112 directs Federal agencies to prevent the introduction of invasive species; provide for their control; and minimize the economic, ecological and human health impacts that invasive species cause. The Recommended Plan is consistent with EO 13112 to the extent practicable and permitted by law. BMPs such as cleaning earth-moving equipment before soil-disturbing activities and planting native and non-invasive species in restored areas after construction will be used to prevent the establishment and spread of invasive plant species. In addition, the USACE's mitigation plan calls for limiting invasive species in the mitigation areas.

6.2.6 Executive Order 13186, Responsibilities of Federal Agencies to Protect Migratory Birds

EO 13186 directs Federal agencies to take actions to further implement the MBTA. The Recommended Plan has been evaluated for potential effects on migratory birds, with emphasis on species of concern. The BRFG/CRL will be monitored for nesting and feeding migratory birds and activities would be temporally modified if needed to avoid take of migratory birds.

6.2.7 Executive Order 13045, Protection of Children from Environmental Health Risks and Safety Risks, as amended by EO 13229 and EO 13296

These EOs require each Federal agency to ensure that its policies, programs, activities, and standards address disproportionate risks to children that result from environmental health risks or safety risks. No disproportionate environmental health risks or safety risks to children, as defined in EO 13045, are expected from implementation of the Recommended Plan.

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7.0 PUBLIC INVOLVEMENT

As part of this feasibility study, the USACE conducted public involvement activities that included issuance of a NOI and other notices, Public Scoping Meeting, interagency meetings, and industry/stakeholder meetings. These activities are summarized below.

7.1 NOTICE OF INTENT

The NOI for *Public Notice of Intent for Studies and Initial Scoping Meeting for Gulf Intracoastal Waterway Brazos River Floodgates and Colorado River Locks Feasibility Study* was prepared by the USACE and published in the Federal Register, Volume 81, No. 120, on Wednesday, June 22, 2016. A brief description of the proposed action and possible alternatives was provided along with the proposed scoping process, including any meetings and how the public can become involved. The NOI also provided an agency point of contact to answer questions about the proposed action and the NEPA process.

7.2 OTHER NOTICES

The USACE issued a news release on June 29, 2016, which was made available on the USACE Galveston District website and distributed by the Galveston District Public Affairs Office. The news release provided information on the July 12, 2016 Public Scoping Meeting, gave a project overview, and solicited public input.

7.3 PUBLIC SCOPING MEETING

The Public Scoping Meeting took place on July 12, 2016, at the West Columbia Civic Center in West Columbia, Texas, from 6:00 p.m. to 8:00 p.m. The purpose of the meeting was to inform the public and stakeholders about the feasibility study and to obtain public comments and concerns. The meeting was conducted in an open house format, with USACE staff providing an introduction and overview of the project.

Attendees were provided a project pamphlet and a written comment form upon arriving at the meeting. The pamphlet described the project and existing BRFG and CRL facilities, provided information about the NEPA and feasibility study process and instructions on how to submit written comments, and encouraged attendees to offer comments. Attendees were invited to view an informational slideshow that was played on a loop during the open house, as well as view informational display stations around the room that provided project background and information about the NEPA and feasibility study process. USACE and TxDOT representatives were available to answer questions. Attendees were invited to submit comments in writing at the scoping meeting or at any time during the comment period via mail or e-mail.

A total of 56 people attended the meeting, including 14 project team members and 42 members of the public/media. Comments received at the scoping meeting and throughout the commenting period were considered during project development. The scoping commenting period ended August 11, 2016.

7.4 INTERAGENCY MEETINGS

In compliance with the FWCA, USACE and TxDOT representatives held an initial agency scoping meeting with the USFWS, NMFS, and the TPWD on February 13, 2017. The purpose of the meeting was to introduce the project to the agencies and discuss methods of evaluating habitats in the study areas. Following the initial meeting, the interagency team conducted field visits to the BRFG and CRL study areas on February 15 and March 22, 2017, respectively, to collect field data for assessing the habitat types and quality present. Subsequent meetings with the agencies were held on September 12, October 10, and November 1, 2017, and January 9, 2018, to update the team, review alternatives, discuss mitigation possibilities, and predict future habitat values provided by mitigation activities.

7.5 COORDINATION OF DIFR-EIS WITH FEDERAL AND STATE AGENCIES

The DIFR-EIS and Draft Record of Decision were sent to Federal and State agencies including the following:

U.S. Advisory Council on Historic Preservation
U.S. Environmental Protection Agency, Region VI
U.S. Department of Energy, Office of Environmental Compliance
U.S. Department of the Interior, Fish and Wildlife Service
U.S. Department of Commerce, National Marine Fisheries Service
U.S. Department of Agriculture, Natural Resources Conservation Service
U.S. Department of Transportation, Federal Aviation Administration
Texas Department of Transportation – Study Partner
State Historic Preservation Office

The distribution and public engagement list for the DIFR-EIS is included in **Appendix D – Environmental Appendix**.

The public was afforded an opportunity to comment on the TSP during a 30-day public review of the DIFR-EIS beginning on February 26, 2018. Local governments, industry, and citizens submitted a total of 41 comment letters. All comments have been considered in preparing the final report and responses are provided in **Appendix D – Environmental Appendix**.

7.6 NAVIGATION INDUSTRY/STAKEHOLDER MEETINGS

A number of navigation industry/stakeholder specific web-meetings and in-person meetings were held during the course of this study (February 2017 and October 2017) to determine specific concerns with Blue and Brown water navigation industry pilots and crews. Their feedback and experiences in navigating the BRFG and CRL crossings during various river conditions was invaluable in determining the appropriate measures and alternatives to consider. The teams continue to engage these groups in the refinement of the TSP and ultimately the Recommended Plan.

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8.0 IMPLEMENTATION REQUIREMENTS

8.1 PROPOSED CONSTRUCTION FUNDING AUTHORITY

Section 1405 of WRDA 1986, P.L. 99-662, amended Section 203 and 204 of the Inland Waterways Revenue Act of 1978, P.L. 95-502, which originally established the Inland Waterways Trust Fund (IWTF). Expenditures from the IWTF may be made available, as provided by Appropriation Acts, for making construction and rehabilitation expenditures for navigation on those Inland Waterways described in section 206 of P.L. 95-502, as amended, including the GIWW. Funding for project construction should be 100 percent Federal expense with the recommendation that 50 percent of these funds be provided from the IWFT and the remainder from the General Fund of the Treasury.

8.2 COST FOR THE RECOMMENDED PLAN

The Total Project Cost Summary (TPCS) for the design and construction of the Recommended Plan was certified on February 11, 2019, at October 1, 2018 price levels (see **Engineering Appendix A, Appendix 4**). The Project First Cost (Constant Dollar Cost at current price level) of the Recommended Plan is $399,727,000 (**Table 8-1**). The Total Project Cost or Fully Funded Cost (Constant Dollar Cost fully funded with escalation to the estimated midpoint of construction) is $455,092,000 (**Table 8-2**). The Recommended Plan does not require any relocations.

Table 8-1 – Project First Cost for Recommended Plan ($000)

Cost Account	Project Features	BRFG Component	CRL Component	Total
		(Oct 2018 Price Level)		
General Navigation Features (GNF)				
05	Locks	$0	$187,302	$187,302
06	Fish & Wildlife Features	$696	$37	$733
09	Channels & Canals	$0	$0	$0
15	Floodway Control & Diversion Structures	$116,997	$0	$116,997
	Total GNF Costs	**$117,693**	**$187,339**	**$305,032**
30	Planning, Engineering, and Design	$23,508	$37,468	$60,976
31	Construction Management	$12,869	$20,604	$33,473
	Total GNF with PED and CM	**$154,070**	**$245,411**	**$399,481**
LERR				$0
01	Lands and Damages	$199	$45	$244
02	Relocations	$0	$0	$0
	LERR Total Cost	**$199**	**$45**	**$244**
	Total Project First Cost	**$154,270**	**$245,457**	**$399,727**

Table 8-2 – Total Project Cost (Fully Funded) for Recommended Plan ($000)

Cost Account	Project Features	BRFG Component	CRL Component	Total
		(Oct 2018 Price Level)		
General Navigation Features (GNF)				
05	Locks	$0	$209,921	$209,921
06	Fish & Wildlife Features	$780	$42	$822
09	Channels & Canals	$0	$0	$0
15	Floodway Control & Diversion Structures	$131,126	$0	$131,126
	Total GNF Costs	**$131,906**	**$209,963**	**$341,869**
30	Planning, Engineering, and Design	$27,242	$43,422	$70,644
31	Construction Management	$16,262	$26,036	$42,298
	Total GNF with PED and CM	**$175,410**	**$279,421**	**$454,811**
LERR				
01	Lands and Damages	$212	$48	$260
02	Relocations	$0	$0	$0
	LERR Total Cost	**$212**	**$48**	**$260**
	Total Project Cost (Fully Funded)	**$175,623**	**$279,469**	**$455,092**

8.3 COST-SHARING APPORTIONMENT

The project cost for determining the cost-sharing requirements is based on the Project First Cost. This project is 100 percent Federal cost. The Project First Cost for all project components is separated into expected Federal (Corps) and Federal (IWTF) and detailed in **Table 8-3**.

Table 8-3 – Project First Cost Allocation for Recommended Plan ($000)

Cost Account and Project Features		BRFG Component			CRL Component			Total Project First Cost (BRFG + CRL)
		Federal (Corps)	Federal (IWTF[1])	BRFG Total	Federal (Corps)	Federal (IWTF[1])	CRL Total	
		(Oct 2018 Price Level)						
General Navigation Features (GNF)								
05	Locks	$0	$0	$0	$93,651	$93,651	$187,302	$187,302
06	Fish & Wildlife Features	$348	$348	$696	$19	$19	$37	$733
09	Channels & Canals	$0	$0	$0	$0	$0	$0	$0
15	Floodway Control & Diversion Structures	$58,499	$58,499	$116,997	$0	$0	$0	$116,997
Total GNF Costs		**$58,847**	**$58,847**	**$117,693**	**$93,670**	**$93,670**	**$187,340**	**$305,032**
30	Planning, Engineering, and Design	$11,754	$11,754	$23,508	$18,734	$18,734	$37,468	$60,976
31	Construction Management	$6,435	$6,435	$12,869	$10,302	$10,302	$20,604	$33,473
Total GNF with PED and CM		**$77,036**	**$77,036**	**$154,070**	**$122,706**	**$122,706**	**$245,412**	**$399,481**
LERR								
01	Lands and Damages	$100	$100	$199	$23	$23	$45	$244
02	Relocations	$0	$0	$0	$0	$0	$0	$0
LERR Total Cost		**$100**	**$100**	**$199**	**$23**	**$23**	**$45**	**$244**
Total Project First Cost		**$77,135**	**$77,135**	**$154,270**	**$122,728**	**$122,728**	**$245,457**	**$399,727**

8.3.1 Construction Implementation of the Recommended Plan

For information on the construction implementation strategy refer back to **Section 4.71** for BRFG components and **Section 4.7.2** for CRL components.

8.3.2 Study Partner PED Efforts

The study partner for this feasibility study is TxDOT, who has actively participated in the development of the scope, alternative formulation, and analysis of alternatives as they pertain to BRFG, and developed the EIS for the study area. TxDOT fully supports the Recommended Plan which provides for channel modifications and wider gates at both BRFG and CRL. Their work is included in this FIFR-EIS and has undergone appropriate level peer review. The TxDOT cost contribution to this study is estimated to be valued at approximately $1.5 million. They will contribute additional data for PED efforts as needed but will not receive Work-In-Kind (WIK).

8.3.3 Key Social and Environmental Factors

There are currently no social or environmental factors that would prevent this project from being constructed. Work in the region would improve economic development by creating temporary jobs during construction and would contribute overall to the navigation industry in the region as it relates to system improvements and future development in the region.

8.3.4 Environmental Compliance

Environmental consultation and coordination are ongoing for this study. A USFWS CAR is anticipated prior to release of the final report and will be included in **Appendix D - Environmental Appendix**. Section 106 Compliance is also ongoing, however neither SHPO nor Tribes have expressed concern for the areas surrounding the structures, nor has the Advisory Council prohibited modification of the operational structures or if necessary decommissioning of the structures. Ongoing coordination based on the final decision will be conducted with these groups as necessary. There are no anticipated impacts to the environment with placement of dredged material. Some material may be used to mitigate areas of disturbance if the channel is modified at Brazos or if old channels are reopened as bypass channels to maintain navigation during construction.

8.3.5 Navigation Systems Context

The BRFG-CRL study is a navigation focused study whose primary purpose when constructed was to reduce sediment input into the GIWW and consequently further downstream impacts. The Freeport Harbor Channel Improvement Project, Brazoria County, Texas, Final Integrated General Revaluation Report and Environmental Assessment, approved on May 15, 2018, recommends modifications to the Federal Channel in the area of the DOW Chemical Thumb. The projects are independent of one another; however, they operate within the same waterway system. The Freeport Harbor is approximately 10 miles upstream from the BRFG.

The Recommended Plan has been designed to have minimal environmental impacts and does not adversely affect the Freeport area based on modeling results.

8.4 RECOMMENDED PLAN AND RECENT USACE INITIATIVES

These initiatives were developed to ensure USACE success in the future by improving the current practices and decision-making processes of the USACE organization. The goals and objectives outlined in the refreshed Campaign Plan (Fiscal Year (FY) 18-22, October 2017)) include: 1) Support National Security; 2) Deliver Integrated Water Resource Solutions; 3) Reduce Disaster Risks; and 4) Prepare for Tomorrow. This plan is available at the following address: http://www.usace.army.mil/about/campaignplan.aspx. Specifically, this project supports Goal 2 (Deliver Integrated Water Resource Solutions) and Goal 4 (Prepare for Tomorrow).

8.4.1 USACE Actions for Changes as Reflected in the Campaign Plan

- The study analyzed potential effects over the study area.
- Direct and indirect effects of the project on the environment were minimized by changes in project design.
- All environmental impacts of the proposed project have been addressed and a mitigation plan developed.
- Close coordination among the USACE, TxDOT, resource agencies, and interested parties occurred throughout the study process.
- Developed plans over long-term, 50-year period of analysis.
- Utilized latest development in engineering, economic, and environmental modeling.
- Risk analyses conducted throughout the study are summarized in Section 6.8.
- Review and inspection of work would be conducted during design and construction.
- Project risks will be communicated during the public review of the study findings.
- Unlike flood risk management and hurricane protection projects, navigation projects involve minimal risk to the public.
- Independent review of the project documents and analyses was performed internally to the USACE and externally by professionals from academia and expert consultants. Comments from those reviews have been incorporated into the study documents, as appropriate.

8.4.2 Environmental Operating Principles.

The USACE Environmental Operating Principles (EOPs) were developed to ensure our missions include totally integrated sustainable environmental practices. Throughout the study process, these EOPs are considered at the same level as economic issues. Environmental consequences of construction and operation have been considered in developing the Recommended Plan, which avoids and minimizes all significant environmental impacts. Sustainability and risk management were integral considerations in developing a Recommended Plan as was ongoing consultation with stakeholders and resource agencies. Resource agency knowledge and evaluation methods developed for similar projects were applied in the impact analysis. A thorough NEPA and engineering analysis has ensured that we will meet our corporate responsibility and accountability for actions that may impact human and natural environments in the study area. This analysis will be transparent and communicated to all individuals and groups interested in USACE activities. The seven re-energized EOP principles (July 2012) are available at the following webpage: *http://www.usace.army.mil/Missions/Environmental/Environmental-Operating-Principles/*.

8.4.3 Preconstruction Engineering and Design

Detailed design of the BRFG and CRL project will be shared between TxDOT and the USACE contingent upon the execution of a Design Agreement in accordance with the provisions of ER 1165-2-208. All detailed design will be in accordance with USACE's regulations and standards.

9.0 RECOMMENDATIONS

9.1 CONCLUSIONS

I concur with the findings presented in this report. The recommended plan is technically sound, economically justified, and socially and environmentally acceptable. Accordingly, I recommend that navigation improvements for BRFG and CRL be authorized in accordance with the reporting officers' recommended plan with such modifications as in the discretion of the Chief of Engineers may be advisable.

The Project First Cost for the Recommended Plan at October 2018 price levels is $399,727,000 [inclusive of the BRFG Component Project First Cost of $154,270,000 and the CRL Component Project First Cost of $245,457,000.] This includes the cost of constructing the general navigation features (GNF) ($305,032,000), PED ($60,976,000) and Construction Management ($33,473,000) and the value of LERRs estimated as follows: $399,481,000 for modifications and dredged material placement and $244,000 for LERRs. There are no pipeline relocation costs. The GNF includes $733,000 in mitigation costs associated with the Recommended Plan.

Section 1405 of WRDA 1986, P.L. 99-662, amended Section 203 and 204 of the Inland Waterways Revenue Act of 1978, P.L. 95-502, which originally established the IWTF. Expenditures from the IWTF may be made available, as provided by Appropriation Acts, for making construction and rehabilitation expenditures for navigation on those Inland Waterways described in section 206 of P.L. 95-502, as amended, including the GIWW. The GIWW is designated as part of the Nation's Inland Waterway system, and therefore qualifies for 50-50 cost sharing between the IWTF and General Fund of the Treasury for construction of navigation improvements.

Project costs are allocated to the inland navigation purpose and are in October 2018 price levels. The Project First Cost for all project components (BRFG and CRL) would be cost shared 50/50 between Federal (Corps) and Federal (IWTF). The Federal (Corps) portion of the estimated first cost is $199,863,000; ($77,135,000 for BRFG and $122,728,000 for CRL). The Federal (IWTF) portion of the estimated first cost is $199,863,000; ($77,135,000 for BRFG and $122,728,000 for CRL). The Fully Funded Cost for the Recommended Plan is $455,092,000.

As discussed previously in Section 4.1, during policy review of the DIFR-EIS, concerns were raised regarding commodity traffic projections, which are important factors in NED analysis and conclusions regarding project justification. A key concern was the fact that the projections relied on expected growth in commodity production at a national level rather than at a regional level, and did not account for the recent and rapid growth in crude oil mining in west Texas and related impacts to transportation sectors including the GIWW. As such, projections were revised to account for growth in oil production in the Southwest Region of the U.S. Although GIWW crude oil traffic has spiked in recent years, it is highly variable, and there is considerable uncertainty regarding future traffic levels of the commodity given that energy and transportation sectors in the region are in the process of adapting to the changes. For example, companies are adding pipeline and refining capacity along with port and fleet capacity to accommodate the large volumes of oil coming into the markets. In other words, the energy and transportation sectors are in a state of flux; and until the markets stabilize somewhat, predicting how oil will move and by which mode it will move, is difficult. Other concerns center on potential modal shifts of cargo if waterway congestion became a factor as traffic increases in the future, and the current economic model is not equipped to assess capacity and modal shifts.

Table 9-1 displays the NED cost benefits analysis using the regional growth forecast. The NED analysis regional growth forecast yields net benefits of $41,603,000 and a system BCR of 3.3. Risk and uncertainty were addressed during the study by sensitivity analysis that evaluated the NED plans performance. This evaluation included sensitivity to the crude oil market condition in West Texas due to significant increases in supply as well as the regional opportunities for exporting those commodities. There are significant uncertainties regarding the oil transportation system's adaptation to different modes of transport. The effect in capacity, volumes and rates of oil productions, and annual volumes shipped through the study area may vary considerably in the future as the oil delivery system adapts to market conditions. Part of the delivery system adaptation includes capacity increases to the navigation system by enlarging the Brazos River Flood Gates and Colorado River Lock from 75-feet to 125-feet, creating an opportunity for increased efficiencies to the coastal oil delivery system. While the economic appendix provides a sensitivity analysis to some of these uncertainties, an economic update will be conducted during PED to more fully assess these uncertainties.

Table 4-1– Cost and Benefits based on Regional Forecast ($000)

Category	Regional Forecast		
	Component		
	BRFG	CRL	System (BRFG & CRL)
	October 2018 Price Levels, 2.875 percent Federal Discount Rate		
Total Project Construction Costs	$154,270	$245,457	$399,727
Interest During Construction	$6,717	$10,687	$17,403
Total Investment Cost	**$160,987**	**$256,144**	**$417,130**
Construction Average Annual Costs	$6,109	$9,720	$15,829
OMRR&R	$2,664	$0	$2,664
Total Average Annual Costs	**$8,773**	**$9,720**	**$18,493**
Average Annual Benefits	$44,096	$16,000	$60,096
Net Annual Benefits	$35,323	$6,280	$41,603
Benefit to Cost Ratio	**5.03**	**1.65**	**3.25**

9.2 RECOMMENDATION

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

12 JUN 19
Date

*

Lars N. Zetterstrom, P.E.
Colonel, U.S. Army
Commanding

10.0 REFERENCES

This chapter details the project delivery team members and literature cited

Table 10-1 – Project Delivery Team Members

Name	Position	Location
	USACE PDT	
Franchelle Craft	Project Manager	CESWG
Cheryl Jaynes	Lead Planner	RPEC
Daniel Allen	Biologist	RPEC
Mark Peterson	Engineer - Structural	CESWG
David Lovett	Lead Engineer	CEMVN
John Petitbon	Engineer – Cost	CEMVN
Chad Rachel	Engineer - Geotech	CEMVN
Max Agnew	Engineer – Coastal Hydrologic	CEMVN
Jeff Richie	Engineer – Civil/Structural	CEMVN
Jason Ragolia	Engineer – Civil/Structural	CEMVN
Nicole Schlund	Real Estate	CESWG
John Campbell	Cultural Resources	RPEC
Stuart Norvell	Economic Support	RPEC
Eric Russek	Operations Manager	CESWG
Robert George	Lock & Dam Mechanic Supervisor	CESWG
	TxDOT PDT	
Matthew Mahoney	TxDOT Project Manager	TxDOT
Hugo Bermudez	Project Manager	Mott MacDonald Assn.
Patrick McLaughlin	Project Controls	Mott MacDonald Assn.
Jason Schindler	Environmental Task Lead	Blanton Assn.
Joshua Carter	Engineering Task Lead	Mott MacDonald Assn.
Craig Harter	Engineer – Coastal Hydrologic	Mott MacDonald Assn.
Greg Katzenberger	Engineer - Structural	Tetra Tech
Portia Osborne	Environmental Support	Blanton Assn.
John Martin	Economic Task Lead	John-Martin Assn.
	PCXIN-RED PDT	
James Nowlin	Economist/Assistant Chief	CELRD-PCX
Justin Carlson	Statistician	CELRD-PCX
Beth Cade	Planner	CELRD-PCX
Courtney Reed	Economist	CELRD-PCX
Alex Ryan	RTS Economist	CELRD-LRL
	INDC-MCX	
Andy Harkness	Deputy Director	CEMVR
Jeff Stamper	Technical Manager	CEMVR

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