# GULF INTRACOASTAL WATERWAY COASTAL RESILIENCE STUDY, TEXAS

## DRAFT INTEGRATED FEASIBILITY REPORT AND ENVIRONMENTAL ASSESSMENT

January 2022

US Army Corps of Engineers®
Galveston District

Texas Department of Transportation®

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**DEPARTMENT OF THE ARMY**
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# Gulf Intracoastal Waterway, Coastal Resilience Study, Texas
# Integrated Feasibility Report and Environmental Assessment
# Brazoria and Matagorda Counties

January 2022

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## FINDING OF NO SIGNIFICANT IMPACT

**Gulf Intracoastal Waterway Coastal Resilience Study**
**Brazoria and Matagorda Counties, Texas**

The U.S. Army Corps of Engineers, Galveston District (Corps) has conducted an environmental analysis in accordance with the National Environmental Policy Act of 1969, as amended. The final Integrated Feasibility Report and Environmental Assessment (IFR/EA) dated **DATE OF IFR/EA**, for the **Gulf Intracoastal Waterway Coastal Resilience Study (GIWW CRS)** addresses **Resilience and Navigation** 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**.

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The Final IFR/EA, incorporated herein by reference, evaluated various alternatives that would increase system resilience, improve navigability and navigation safety, reduce overall dredging and structure maintenance, reduce commercial transit delays and accidents, and enhance regional sediment management practices in the study area. The recommended plan is the Resiliency Plan and includes:

- The Resilience Plan which includes:
  - Increment 12.3.2 which is a combination of shoreline stabilization using breakwaters and channel widening in zone 12 protecting 16 acres of barrier island and 951 linear feet of channel for $17.7 million. This increment also addresses a grounding hotspot which has posed safety risks to navigation.
  - Increment 13.6.1 which is a combination of shoreline stabilization using breakwaters and sediment placement in zone 13 protecting/restoring 438 acres of barrier island and protecting 19,000 linear feet of channel for $60.9 million.
  - Increment 14.6.1 which is a combination of shoreline stabilization using breakwaters and sediment placement in zone 14 protecting/restoring 114 acres of barrier island and protecting 4,329 linear feet of channel for $15.8 million.
  - Increment 16.6.1 which is a combination of shoreline stabilization using breakwaters and sediment placement in zone 16 protecting/restoring 376 acres of barrier island and protecting 7,704 linear feet of channel for $32.4 million.

- Increment 18.6.1 which is a combination of shoreline stabilization using breakwaters and sediment placement in zone 18 protecting/restoring 1161 acres of barrier island and protecting 33,115 linear feet of channel for $125.1 million.

**Table 1: Summary of Potential Effects of the Recommended Plan**

| | Insignificant effects | Insignificant effects as a result of mitigation* | Resource unaffected by action |
|---|---|---|---|
| Aesthetics | ☒ | ☐ | ☐ |
| Air quality | ☒ | ☐ | ☐ |
| Aquatic resources/wetlands | ☒ | ☐ | ☐ |
| Invasive species | ☐ | ☐ | ☒ |
| Fish and wildlife habitat | ☐ | ☒ | ☐ |
| Threatened/Endangered species/critical habitat | ☒ | ☐ | ☐ |
| 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 | ☒ | ☐ | ☐ |

Compensatory mitigation is required to offset potential impacts from the measures included in the Resilience Plan to sea grass meadows and oyster reef. The mitigation plan includes the creation of 3 acres of oyster reef and 87 acres of sea grass meadow in East Matagorda Bay and 10 acres of oyster reef in Matagorda Bay. Habitat surveys will be performed in the Preconstruction Engineering and Design phase of project delivery to update the mitigation acreages and to inform the selection of mitigation sites. Monitoring of the mitigation sites would occur for at least 3 years and would end when the ecological success criteria are met and would not exceed 10 years. Adaptive management strategies for the mitigation sites is included in the Mitigation Plan and include the additional placement of cultch material for oyster reef sites and replanting sea grass plugs in the sea grass sites. All practicable and appropriate means to avoid or minimize adverse environmental effects were analyzed and incorporated into the recommended plan. Best management practices (BMPs) as detailed in the IFR/EA will be implemented, if appropriate, to minimize impacts.

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The recommended plan will result in unavoidable adverse impacts to approximately 5.5 acres of oyster reef and 54 acres of sea grasses. To mitigate for these unavoidable adverse impacts, the U.S. Army Corps of Engineers will re-establish 3 acres of oyster reef and 87 acres of sea grass meadow in East Matagorda Bay and 10 acres of oyster reef in Matagorda Bay.

Public review of the draft IFR/EA and FONSI was completed on 23 February 2022. All comments submitted during the public review period will be responded to in the Final IFR/EA and FONSI.

Pursuant to section 7 of the Endangered Species Act of 1973, as amended, the U.S. Army Corps of Engineers determined that the recommended plan may affect but is not likely to adversely affect the following federally listed species or their designated critical habitat: the West Indian Manatee (*Trichechus manatus*), the Eastern Black Rail (*Laterallus jamaicensis jamaicensis*), the Piping Plover (*Charadrius melodus*), Red Knot (*Calidris canutus rufa*), the Whooping Crane (*Grus americana*), the green sea turtle (*Chelonia mydas*), the Hawksbill sea turtle (*Eretmochelys imbricata*), the Kemp's Ridley sea turtle (*Lepidochelys kempii,* and the loggerhead sea turtle (Caretta caretta). The Corps is pursuing informal consultation with the U.S. Fish and Wildlife Service and the National Marine Fisheries Service and is in the process of seeking concurrence with the aforementioned determination.

Pursuant to section 106 of the National Historic Preservation Act of 1966, as amended, the U.S. Army Corps of Engineers is coordinating with the Texas SHPO to ensure compliance with the National Historic Preservation Act of 1966, as amended.

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

A water quality certification pursuant to section 401 of the Clean Water Act will obtained from the Texas Commission on Environmental Quality prior to construction. In a letter dated **DATE OF LETTER**, the **STATE, TERRITORY, OR TRIBE** stated that the recommended plan appears to meet the requirements of the water quality certification, pending confirmation based on information to be developed during the pre-construction engineering and design phase. All conditions of the water quality certification will be implemented in order to minimize adverse impacts to water quality.

A determination of consistency with the State of Texas Coastal Zone Management program pursuant to the Coastal Zone Management Act of 1972 will be obtained from the Texas General Land Office prior to construction. In a letter dated **DATE OF LETTER**, the **STATE OR TERRITORY NAME** stated that the recommended plan appears to be consistent with state Coastal Zone Management plans, pending confirmation based on information to be developed during the pre-construction engineering and design phase. All conditions of the consistency determination shall be implemented in order to minimize adverse impacts to the coastal zone.

All applicable environmental laws have been considered and coordination with appropriate agencies and officials has been completed.

Technical, environmental, and economic 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.[1] Based on this report, the reviews by other Federal, State and local agencies, Tribes, input of the public, and the review by my staff, it is my determination that the recommended plan would not cause significant adverse effects on the quality of the human environment; therefore, preparation of an Environmental Impact Statement is not required.[2]

| | |
|---|---|
| ________________________ | ________________________ |
| Date | Timothy R. Vail<br>Colonel, Corps of Engineers<br>District Commander |

[1] 40 CFR 1505.2(B) requires identification of relevant factors including any essential to national policy which were balanced in the agency decision.

[2] 40 CFR 1508.13 stated the FONSI shall include an EA or a summary of it and shall note any other environmental documents related to it. If an assessment is included, the FONSI need not repeat any of the discussion in the assessment but may incorporate by reference.

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# EXECUTIVE SUMMARY* (NEPA required)

## BACKGROUND

The Gulf Intracoastal Waterway (GIWW) is a man-made inland waterway that spans 1,100 miles connecting ports along the Gulf of Mexico from Brownsville, Texas to St. Marks, Florida. The GIWW is the nation’s third busiest inland navigation waterway and a critical component of the nation’s transportation network. The cargo carried on the GIWW produces significant economic benefits being the most fuel-efficient and producing the least emissions per ton of cargo, and it also reduces congestion and maintenance of highway and rail systems by providing an alternate mode of transportation.

The Texas portion of the GIWW generally consists of a 12 to 14-feet deep by 125-feet wide channel along approximately 423 miles, and the main channel extends 379 miles from Sabine River to Port Isabel, Texas. The Texas portion of the GIWW also includes flood gates and navigation lock structures at the Brazos and Colorado Rivers, respectively. Mooring basins and buoys are maintained at 10 separate locations along the length of the GIWW which support heavy barge traffic at approximately 45,000 trips per year in fiscal year (FY) 2017. The Texas portion of the GIWW provides an intermodal link between the Texas deep draft and shallow draft ports which is critical in supporting the petrochemical industry and the inland port facilities along the Texas coast. In 2018, the amount of commercial tonnage transiting the Texas portion of the GIWW was about 78 million short tons consisting of more than 70 percent of all GIWW traffic.

## AUTHORITY

The study is authorized under the Water Resources Development Act of 2016, Section 1201 (25). The Secretary is authorized to conduct a feasibility study for the following projects for water resources development and conservation and other purposes, as identified in the reports titled ‘‘Report to Congress on Future Water Resources Development’’ submitted to Congress on January 29, 2015, and January 29, 2016, respectively, pursuant to section 7001 of the Water Resources Reform and Development Act of 2014 (33 U.S.C. 2282d) or otherwise reviewed by Congress: “GULF INTRACOASTAL WATERWAY, TEXAS, BRAZORIA AND MATAGORDA COUNTIES, TEXAS. Project for navigation and hurricane and storm damage reduction, Gulf Intracoastal Waterway, Brazoria and Matagorda Counties, Texas.”

## NON-FEDERAL PARTNER

Texas Department of Transportation (TXDOT) is the non-Federal study partner. However, this study is 100 percent federally funded, and a Feasibility Cost Sharing Agreement is not required.

Upon approval of the final report, chief's report and construction by OMB, the construction project will be reviewed and compete for Inter Waterways User Board (IWUB) funds (IWUF).

## STUDY AREA

The authorized project area encompasses 85 miles of the Texas portion of the GIWW in Brazoria and Matagorda counties which was divided into 20 zones for detailed analysis according to geography and ecology. As the evaluation progressed during the study, the study area focused on Zones 12, 13, 14, 16 and 18 as shown in Figure ES-1 below.

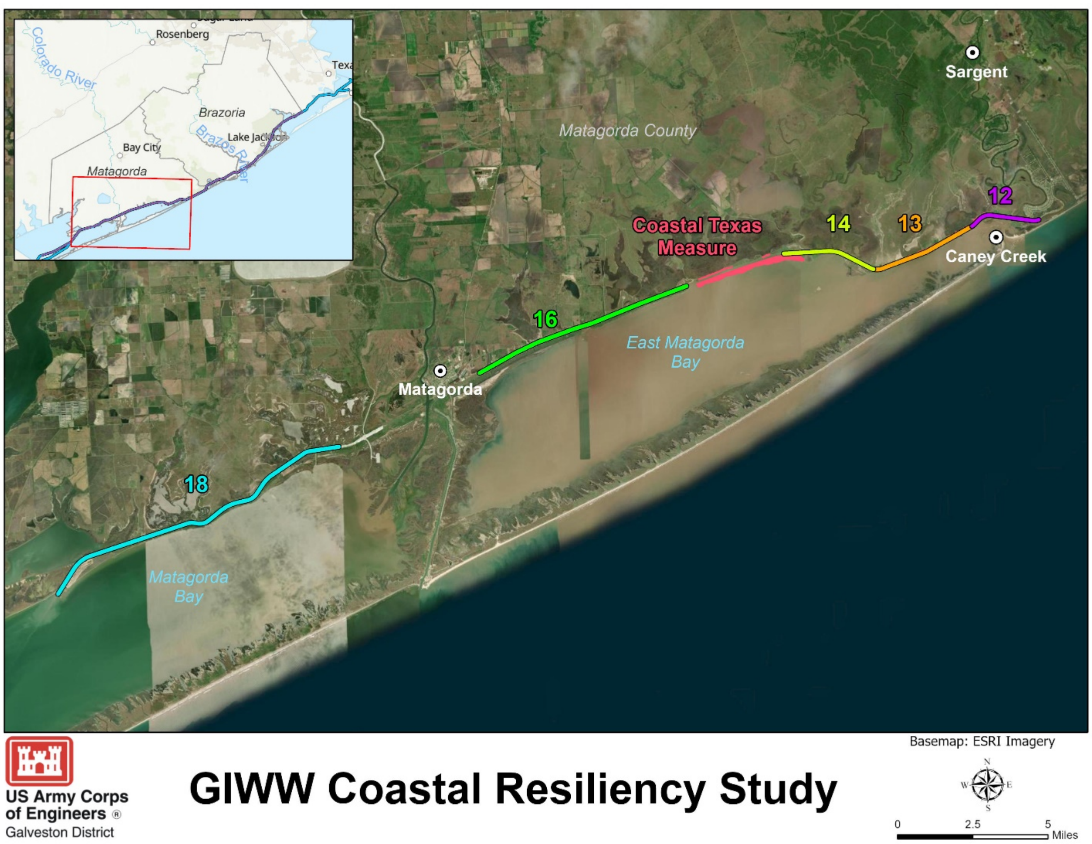


**Figure ES-1: GIWW Study Area Map**

## Resiliency

Executive Order 13653 (Preparing the U.S. for the Impacts of Climate Change), defines resiliency as: “the ability to anticipate, prepare for and adapt to changing conditions and withstand and recover from disruptions.” Engineer Pamphlet (EP) 1100-1-2, USACE Resilience Initiative Roadmap 2016 expands the definition and specifies four principles of resiliency: prepare, absorb, recover, and adapt (Figure ES-2).

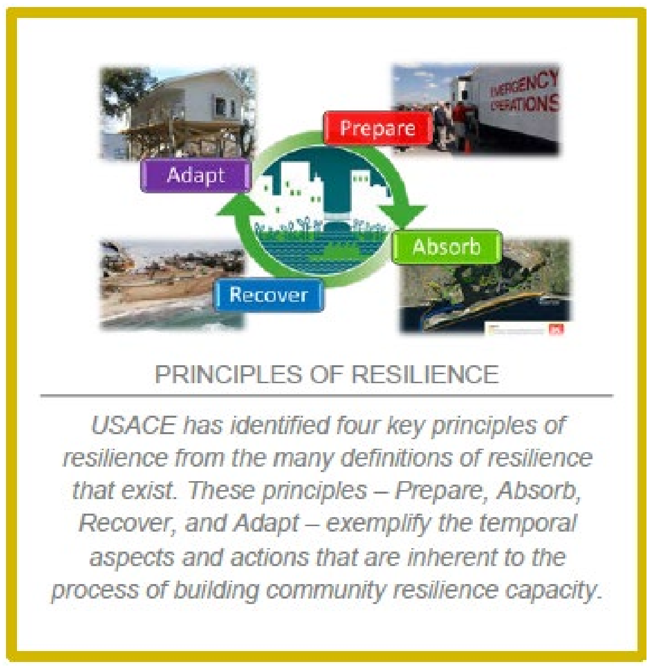


**Figure ES-2: Principles of Resilience**

Prepare: A navigation system such as the GIWW must maintain a certain level of service to be of value to the nation. In a typical navigation study, a PDT analyzes changes over time that lead to different markets and economies and are reflected in development of new facilities and larger vessels. Change is natural, but sometimes change is not gradual. It can be swift and disruptive, and can shock a system and result in serious, long-lasting impacts. Such changes can stem from physical events such as floods, storms, serious accidents, or even global pandemics such as COVID-19. Changes can also be driven by policy and regulation such as Congress lifting the ban on U.S. crude exports in 2016. When shocks to a system occur, waterborne commerce can increase or decline substantially in a short period of time. The PDT must identify potential shocks or changes and prepare plans for how a system can absorb, recover, and adapt to them. The plan that is most proactive best satisfies this principle. This feasibility study phase is part of the preparation phase as are any subsequent actions recommended by the study.

Absorb/Withstand: When disruptive conditions such as a major storm impact the GIWW, actions identified in the preparation phase allow the system to absorb the impact from these events. In the case of a navigation channel, protecting and restoring barrier islands (e.g., living shorelines, sediment placement, and restoration of marshes) enable them to withstand storms and other erosional forces such as barge and wave wake by establishing physical boundaries that reduce sediment and land loss when exposed to coastal forces.

The PDT developed increments of alternatives with increasing levels of effectiveness to absorb disruptive events in order to determine the most cost-effective alternative. The restoration of barrier islands also allows for the navigation channel to absorb changes in sea level and improve maintenance objectives with beneficial use of dredged material. The measures described above help the navigation channel absorb physical shocks minimizing interruptions and providing shorter recovery periods. How effectively the plan absorbs the disruptive events is the most important demonstration of satisfying this principle.

Recover: Once a storm event or other stressor occurs, a resilient navigation channel recovers quickly, and navigation can resume normal operations. This recovery time is the measure applied from a resilience perspective, (i.e., how quickly do normal operations return or how easily does the transportation network absorb the shock to the system or the ongoing problem?). A resilient navigation channel also allows the overall transportation network (including other modes of transportation) to absorb shocks. In 2016, when Congress lifted the ban on crude oil exports, large volumes of crude oil began moving on the GIWW to deep ports along the Gulf because, at the time, pipelines from West Texas oilfields lacked capacity to accommodate the rise in transportation demand. Thus, the availability of barge transport on the GIWW was a form of resiliency in the overall crude oil transportation system in Texas. In short, the multi-modal aspects of the GIWW are a form of resiliency. This form of the navigation channel offers value to the rest of the transportation network and helps the rest of the navigation system be resilient. The plan that allows the quickest resumption of normal operations after a disruptive event is the most applicable for this principle.

Adapt: As conditions change (e.g., sea level rise, increased frequency and intensity of major storms and hurricanes, sediment placement areas, and commodities markets), adaptability is key to responding to both anticipated and unanticipated changes over time. Considering the adaptability of features during the planning and design phases of the project can be key to ensuring that features can be modified over time in response to changing conditions. The plan that can most easily be modified to adapt to changing conditions is the most desired for this principle.

## Study Problems

This study addresses three main issues within the navigation channel: 1) the chronic and episodic coastal storm erosion of the shorelines and barrier islands that have historically protected vessels on the GIWW; 2) sea level rise and continued hurricanes and tropical storms that will likely exacerbate the loss of barriers around the channel; and 3) sediment carried by coastal storms from eroded shorelines shoals in the channel leading to light-loading and unintentional groundings of vessels resulting in navigation safety risks.

Barrier islands provide the navigation channel with a buffer against disruptive episodic storm events, as well as the chronic effects, of high wind and wave conditions in the study area that affect navigation efficiency, channel operations and maintenance. According to testimonies from local barge pilots, representatives of the Gulf Intracoastal Canal Association (GICA), and the non-federal sponsor the Texas Department of Transportation (TXDOT), disruptions to the navigation channel have become more frequent in this stretch of the GIWW. In the study area, chronic shoaling and forces of winds and waves occur regularly throughout the year, causing shipping companies to change their schedules to match the tide and weather conditions. USACE personnel in Operations and local industry have reported that these situations are already occurring, and out of cycle dredging is often required to remove shoals that cause draft restrictions to navigation. In future conditions, as the barrier islands continue to erode and expose the navigation channel to the bay, delays and unintentional groundings are expected to increase and become potentially more dangerous for vessels.

The Corps Shoaling Analysis Tool (CSAT) was used to determine the annual shoaling rate from historical survey and dredging data. This shoaling rate was then used to develop the annual shoaling rate for the FWOP condition. This analysis produces realistic sedimentation estimates for Zones, 12, 14, 16, and 18 since the barrier islands for these areas are expected to be minimally intact through 2080. Since the barrier island in Zone 13 is expected to be essentially gone by the year 2030, the "closed system" sedimentation assumption is considered to underestimate sedimentation rates for this zone. An alternate approach for sedimentation analysis would be an "open system" assumption. An "open system" sedimentation assumption would provide a more realistic estimate of future shoaling since by the end of the project performance period (2080) there would be no barrier island in Zone 13. In an "open system" situation, the bottom sediments in exposed portions of Zone 13 would seek equilibrium and would silt-in to the depth of the surrounding bay, which is estimated at 3-8 foot in depth. This would restrict, if not impede the passage of vessels though any shallow portions. Given the underestimation of sedimentation in Zone 13, it is apparent that the benefits attributed to increments in this zone are underestimated. The PDT expects to be able to refine the sedimentation estimates for Zone 13 prior to the ADM.

Shoaling events caused by major storms necessitate additional restrictions such as light loading. In addition, significant erosion and sediment deposits coming from the mainland waterways are severe in the aftermath of major storms from the Gulf of Mexico, even when the storms do not directly make landfall in the study area. This was evident following Hurricane Harvey. Post Hurricane Harvey, USACE modified three contracts to conduct emergency dredging at the Colorado River Locks and East Matagorda Bay. These two areas shutdown the GIWW completely for about two weeks, after which USACE was able to incrementally open the channel in stages over an additional 2-3 weeks.

In terms of storm risk, problems include storm-induced accelerated erosion of barrier islands and the resulting shoaling, as well as exposure of the navigational channel to an open bay environment. Absent additional protection, the risk associated with hurricane storm surge is anticipated to increase over time for multiple reasons including continued population growth and economic expansions within at-risk coastal areas, forecasted increases in storm intensity due to changes in climate patterns, and forecasted increases in relative sea level. (USACE, August 2021, Coastal Texas Protection and Restoration Feasibility Study, Final Environmental Impact Statement, p.1-11)

The barrier islands on the south side of the GIWW have long been a necessary thin line of defense for the channel against strong currents and wave attack from East and West Matagorda Bay. Of the five zones included in the plan, Zone 18 is an excellent example of the problem experienced along the length of the channel within Matagorda County. Over the years, the barrier islands have experienced severe erosion which was expedited by the rough conditions of the bay. Although maintenance material has prolonged the protective service life of the barrier islands, there is continued erosive loss due to increased wind and current velocities associated with chronic and episodic storms and associated wave attacks from the bay.

Barrier islands also provide more robust protection of the navigation channel than breakwaters against episodic disturbances, such as major storm events, as well as the day-to-day navigation and erosion impacts from winds and waves. This is due to the larger footprint and the higher crest elevation of the barrier island and earthen berm which are able to *absorb* harsher conditions. By withstanding harsher conditions, barrier islands enable the GIWW to *recover* and resume normal operations more quickly after episodic disturbances.

The use of barrier islands as placement areas for dredged material also provides additional flexibility to *adapt* to changing conditions.

The breakwater features protect the barrier islands, but the two measure complement each other and there is some interdependence. The barrier islands reinforce the breakwater toes from bed degradation. The natural process for barrier features is erosion and landward/lateral drift. They are naturally dynamic features, but the GIWW needs to be a reliable transportation corridor, so the barrier features need shoreline stabilization to ensure a more static condition. The breakwaters reduce shoreline erosion caused by wind-driven or vessel-induced waves. In addition, the breakwaters actually capture suspended sediment from wave overtopping, so they actually lead to a positive sediment budget.

Restoration and protection of the barrier islands reduces the likelihood of breaches and barrier island loss from erosion and storm events. Predicted erosion estimates show that much of the barrier islands in the study area will be lost in the next 10 to15 years if measures to combat that erosion are not put in place. Therefore, this study also evaluates the resiliency of using shoreline stabilization and dredged materialas a means to: recover and adapt from the episodic impacts from coastal storms, chronic wind and wave attack, and strong currents from the bay. This study considers the operations and maintenance life cycle costs to reduce project costs over time instead of a least cost option that may have fewer lasting benefits.

The restoration of lost barrier islands could become cost-prohibitive in the future requiring major reconstruction efforts to reestablish them if steps are not taken to arrest continued erosion. Addressing loss of the barrier islands and exposure to the open bay now is substantially less than what it would cost in 2030 when barrier islands are estimated to be essentially lost.

## Alternative Formulation and Plan Comparison

The overarching objective of the study is to find an effective and environmentally acceptable solution to make the navigation channel more resilient to episodic and chronic events to reduce loss of barrier islands and vulnerability to the open bay; along with reducing O&M life cycle risks and safety issues with unintentional groundings. Each planning objective applies to the study area for a 50-year period of analysis (2030 to 2080). Specific objectives were: 1) improve navigation resiliency of GIWW; 2) improve economic efficiency of GIWW; and 3) reduce safety risks within the GIWW.

Plan formulation is an iterative process that develops and compares solutions to the water resources problems identified within the study area. The process consists of incremental development of measures, strategic combination of those measures into alternatives, and screening with increasing details in phases that support risk informed decision making. The plan formulation process for this study was completed in two distinct iterations with several screening steps that are briefly characterized as follows:

### Plan Formulation First Iteration

- **Formulated measures to address problems within Zones 1 – 20 for the study area;**
- **Combined measures into conceptual initial array of alternatives for Zones 1 - 20;**
- **Screened zones within the study area based on FWOP assumptions; and**
- **Compared and qualitatively screened initial alternatives for Zones 12, 13, 14, 16 and 18.**

A management measure is a structural or non-structural feature for a specific geographic site that addresses one or more planning objectives. Measures were formulated based on problems within each of the 20 zones; and a system resiliency analysis. Next, the measures were grouped into five categories for formulation:

1. Hard Stabilization features
2. Natural Stabilization features
3. Channel Modifications
4. Sediment Placement
5. Aids to Navigation

Preliminary plans were formulated by combining management measures using an additive approach formulation strategy. Using data and best professional judgment about the problems in the defined zones, the PDT identified potential measures that could be employed to solve these problems, and combined similar measures into a suite of actions to solve related problems across the applicable zones. These combined measures were identified as stand-alone alternatives where logical, and then further combined into hybrid alternatives aimed at a more comprehensive solution to address multiple different, but related, problems.

The PDT developed distinctively different plans using the 5 categories of management measures in various combinations as well alternatives required by policy (No-action and non-structural). There were 7 alternatives developed initially:

1. No Action
2. Non-Structural
3. Shoreline stabilization
4. Sediment Placement
5. Channel Modification and Sediment Placement
6. Combination of Shoreline Stabilization and Sediment Placement
7. Combination of Shoreline Stabilization and Channel Modification

As the PDT developed Future Without Project (FWOP) conditions, it was determined that the Coastal Texas and GIWW Brazos River Flood Gates and Colorado River Locks (GIWW BRFG-CRL) Feasibility Studies would collectively address zones 1 through 10, which cover all zones in Brazoria County, and also zones 15 and 17 in Matagorda County. The PDT also determined that zone 11 would be addressed through the maintenance of an existing USACE revetment structure and a Texas General Land Office (GLO) project.

As a result of eliminating the above-mentioned zones, the updated study area carried forward for further evaluation included zones 12, 13, 14, 16, and 18 which covers approximately 30 miles of the GIWW channel in Matagorda County.

The PDT screened out four (4) of the initial alternatives as stand-alone alternatives, but carried forward Non-Structural and Channel modification as measures to be evaluated with other alternatives. Therefore, resulting in the three (3) alternatives carried forward for further evaluation and described below:

**Alternative 1 – No Action Plan –** This alternative continues to implement scheduled and emergency dredging to maintain the navigation channel in the study area. The erosion, coastal storms, and shoaling and their impacts to navigation would continue to worsen.

**Alternative 3 – Shoreline Stabilization –** This alternative utilizes hard stabilization measures including breakwaters and reef balls. Breakwater crest elevation would be constructed from 3 to 7 feet above the NAVD88 sea level datum depending on location to sufficiently protect the navigation channel from wind waves and prevent further erosion of the existing barrier islands. These elevations also account for sea level rise through 2080.

**Alternative 6 – Shoreline Stabilization and Sediment Placement –** This alternative utilizes a combination of the hard stabilization described in alternative 3 and additional natural stabilization measures including: beneficial use of dredged material placement to create or replenish earthen berms; and marsh plantings to prevent rapid erosion of the sediment placement. All breakwater crest elevations for alternative 6 would be constructed at 3 feet above the NAVD88 sea level datum because the purpose is to contain the sediment placement and prevent erosion. The crest elevations of earthen berms would be 8 feet above the NAVD88 sea level datum to protect the navigation channel from higher wind and wave conditions, but the elevation could easily be adjusted with the sediment placement on the berm. These elevations also account for sea level rise through 2080.

Alternatives 3 and 6 aim to address the study problems and achieve the study objectives using different approaches. Alternative 3 intends to prevent the loss of existing barrier islands and protect the navigation channel by utilizing only hard stabilization measures such as breakwaters and reef balls. Alternative 3 was also intended to have lower project first costs than alternative 6. Alternative 6 intends to go beyond just preventing barrier island loss; in fact, it proposes to restore areas of barrier islands that are or will be lost in zones 13, 14, 16, and 18 by utilizing natural stabilization measures such as beneficial use of dredged material and marsh plantings.

**Plan Formulation Second Iteration**

- **Evaluated final array of alternatives (Alternatives 1, 3, and 6) by evaluating each zone individually and incrementally adding measures for Alternative 3 and 6 within each zone based on performance with traditional NED criteria and resilience metrics measured as navigation cost savings by reduced interruptions in future navigation use;**
- **Compared Alternative 6 - NED Plan and Alternative 6 - Resilience Plan; and**
- **Next steps, PDT will refine TSP to maximize performance and achieve most cost-effective approach for the period of analysis (Next steps to be performed after concurrent reviews prior to ADM and final report).**

The PDT then evaluated Alternative 3 and Alternative 6 for various increments within each zone. The increments can be found in Table ES-1 below. The PDT screened out increments that are addressed in the Coastal Texas study or violated constraints[3] resulting in a final list of increments. A list with a description for each of these final increments follows.

All zones in the study area had an alternative with positive net benefits except Zone 13. Zone 12 has two alternatives with positive net benefits. Two alternatives (12.3.1 and 12.3.2) in Zone 12 and two alternatives in Zone 13 (13.3.1 and 13.6.1) were carried forward for additional consideration using resiliency criteria. For the other zones, the alternative with the highest net benefits was carried forward without further screening.

**ALTERNATIVE 3 BY ZONE:**

Increment 12.3.1 includes:

- Zone 12
- Alternative 3 – shoreline stabilization
- Channel bayside breakwaters only to minimize impacts to critical habitatand endangered species
- Project first cost: $12M
- BCR 2.7

Increment 12.3.2 includes:

- Zone 12
- Alternative 3 – shoreline stabilization with widening measure
- Channel bayside breakwaters and widening of the channel for this zone
- Project first cost: $17.7M (widening adds $5.7M)
- BCR: 1.6

Increment 13.3.1 includes:

- Zone 13
- Alternative 3 – shoreline stabilization
- Bayside breakwaters and channel bayside breakwaters
- Project first cost: $ 39.1M
- BCR: 0.6

[3] GIWW CRS Study constraints are: 1. avoid or minimize impacts to critical habitat; and 2. do not negatively impact existing placement areas or CSRM projects.

**ALTERNATIVE 6 BY ZONE:**

Increment 13.6.1 includes:

- Zone 13
- Alternative 6 – combination plan
- Bayside breakwater, channel bayside breakwater, berm, and sedimentplacement
- Project first cost: $ 61M
- BCR: 0.4

Increment 14.6.1 includes:

- Zone 14
- Alternative 6 – combination plan
- Bayside breakwater, channel bayside breakwater, berm, and sedimentplacement
- Project first cost: $15.8M
- BCR: 1.5

Increment 16.6.1 includes:

- Zone 16
- Alternative 6 – combination plan
- Bayside breakwater, channel bayside breakwater, berm, and sedimentplacement
- Project first cost: $ 32.3M
- BCR: 1.2

Increment 18.6.1 includes:

- Zone 18
- Alternative 6 – combination of shoreline stabilization and sedimentmanagement plan
- Bayside breakwater, channel bayside breakwater, and sedimentplacement
- Project first cost: $125M
- BCR: 1.1

The economic considerations in the evaluation of the final array were developed from vessel traffic data obtained from the U.S. Coast Guard's Automatic Identification System (AIS) data and USACE Waterborne Commerce Statistics Center data, which showed that more than a 95 percent commonality of traffic between the GIWW Brazos River Floodgates – Colorado River Locks (GIWW BRFG-CRL), and that commonality is expected to continue into the future. The forecasted growth rates are presently flat for the TSP, but final numberswill show growth rates similar to the GIWW BRFG-CRL recently authorized project. The average delays per vessel are expected to get worse as the barrier island continues to erode in the FWOP condition. Present speeds observed in Zone 14 were used as the baseline condition for future with-project condition. Cost and benefits were annualized using a discount rate of 2.5% and are in fiscal year (FY) 2021 dollars. The resilience metrics evaluated were acres of barrier island lost and linear feet of shoreline protected.

The PDT evaluated the final array using economic and resiliency considerations. The PDT estimated transportation costs savings, O&M cost savings, safety, and estimated benefits in terms of acres of barrier island lost and linear feet of shoreline protected. The resilience plan is restoring the barrier island landform to benefit navigation and in doing that restoration, benefits to storm damage reduction to the navigation channel and the ecosystem are realized, along with adaptation options with sediment placement. In all but two Zones, NED and resiliency coincide, i.e., the problems created by loss of the barrier islands are addressed with a resiliency plan that has positive net benefits. The following discussion supplies the rationale to recommend a plan beyond NED in Zone 12 and 13 for resiliency of the navigation system and is summarized in Table ES-1.

Increment 12.3.1 provides highest net benefits in Zone 12. Net benefits are similar ($340K difference) to increment 12.3.2 but has approximately $5.7 million in additional costs. ER 1105-2-100 Appendix G Exhibit G-1 states "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." Increment 12.3.2 provides an additional safety benefit, for these reasons the team is requesting increment 12.3.2 for the resiliency plan recommendation. The safety issue in Zone 12 is described as follows. Waterway users have identified areas of significant shoaling where the channel width is often draft-restricted. The area where the GIWW intersects Caney Creek (Zone 12) in particular, is a location of both high current velocities and shoaling due to the proximity to the Gulf of Mexico, as well as the typical chronic and episodic erosion experienced in the channel. This creates navigation safety risks for barges traversing this intersection. Barge tows must often “crab-walk” across the currents at Caney Creek, and tows risk damage to their rudders and wheels during groundings on large sediment shoals exacerbated by erosion in the vicinity. These groundings pose a safety risk to life, property, and the environment. Additionally, the channel shoreline on the mainland side of the GIWW has also suffered significant erosion loss, increasing shoaling in the GIWW. Due to the compelling safety risks in Zone 12, an NED exception is proposed.

The PDT recommends action in Zone 13 to address further barrier island erosion and resiliency for the navigation system. Two alternatives considered in Zone 13 include the breakwater (13.3.1) and the breakwater and barrier island (13.6.1). As mentioned previously, shoaling conditions are expected to become much worse in the future, over what is currently captured in the shoaling model for the study. Similar to Zone 12, erosion of the channel shoreline on the mainland side of the GIWW introduces additional maintenance material into the GIWW and threatens brackish and freshwater marsh habitats on the mainland shoreline due to potential saltwater intrusion. The PDT will be conducting additional analysis in Zone 13 to reduce uncertainty and determine if the shoaling issues can be further characterized, and additional O&M benefits captured to account for worsening conditions. Additional refinements to the design assumptions will also explore potential reductions in costs. Until the work is complete, it is uncertain whether an increment in Zone 13 will be economically justified, or which increment.

Of the two alternatives considered for Zone 13, 13.3.1 (breakwater) and 13.6.1 (breakwater and barrier island), the PDT recommends the 13.6.1 increment for the following reasons:

- Additional buffer protection from wind/waves from the open bay;
- Restoration of barrier island;
- Additional placement area for sediment placement; and
- Restoration of habitat.

The different increments of alternatives 3 and 6 were evaluated on maximizing net economic benefits, maximizing resilience benefits, most cost-effective increment, in terms of resilience, and other alternatives that trade resilience benefits for economic benefits.

In this study, these metrics were defined as follows:

- **Maximize net economic benefits –** the PDT evaluated whether the marginal benefit exceeded the marginal cost as units were added to the plan. If the additional benefit of a unit exceeded the additional cost, then it was deemed to be economically justified.

- **Maximize resilience benefits –** the PDT evaluated whether the plan meets PARA criteria defined as:
  - Prepare means to identify and implement actions to address potential disruption of navigation operations;
  - Absorb is the ability of the actions to allow the navigation system to absorb the impact from disruptive chronic stressors and episodic shocks;
  - Recover is the ability of the navigation channel to quickly return to normal operations following a disruption;
  - Adapt means that the plans and actions can be adjusted to changing conditions or stressors over time.

- **Effectiveness** is the extent to which the alternative plan achieves one or more of the planning objectives(s). Effectiveness will also consider the resiliency of the plan, the contribution of redundant features to overall plan effectiveness, and the robustness of the plan. Redundancy is the duplication of critical components of a system with the intention of increasing reliability of the system. Robustness is the ability of a system to continue to operate as intended across a wide range of foreseeable operational conditions, with minimal damage, alteration, or loss of functionality, and to fail in a predictable way outside of that range.

- **Efficient** is the extent to which an alternative plan is a cost-effective means of achieving one or more objectives of the study.

**Alternative 1 - No Action Plan** is the future without project (FWOP) condition and baseline to which all other alternatives are compared. The No Action Plan does not address study problems or meet study objectives. Although there are no additional costs or environmental impacts, it does not provide any economic, resilience, or safety benefits. Worsening erosion, shoaling, and coastal storms of increasing frequency and intensity will continue to exacerbate the problems in the study area.

**Alternative 3 - Most Efficient Plan and Maximizes Net Benefits** is increment 12.3.1 at a project first cost of $12.0 million, and it has the highest BCR of 2.7. The Most Efficient Plan improves the shoaling hotspot in Zone 12 by reducing erosion and sediment flow into the channel, but it does not address the grounding safety risk. The Most Efficient Plan is the least effective and the least cost-effective plan in terms of resilience. Implementing this plan will still cause a net loss of 996 acres of the existing barrier islands by 2080.

**Alternative 6 Zone Increments:**

**Alternative 6 - National Economic Development (NED) Plan** includes increments 12.3.1, 14.6.1, 16.6.1, and 18.6.1 which provide the maximum net economic benefits at a project first cost of $185.3 million and a Benefit-Cost Ratio (BCR) of 1.26. The economic benefits are comprised of average annualized transportation cost savings and operation and maintenance (O&M) cost savings which are calculated using a discount rate over the 50-year period of analysis from 2030 to 2080. The net economic benefits were determined by subtracting the average annualized costs from the benefits. While the NED Plan provides the highest net economic benefits, it leaves significant resilience and safety benefits on the table by not addressing the grounding safety risk at Zone 12 and excluding Zone 13 which completely exposes this portion of the channel to East Matagorda Bay. Implementing this plan essentially prevents the net loss of existing barrier islands by 2080.

**Alternative 6 - Resilience Plan** includes increments 12.3.2, 13.6.1, 14.6.1, 16.6.1, and 18.6.1 which provide the maximum resilience benefits at a project first cost of $251.8 million and a BCR of 0.98. The Resilience Plan is the costliest plan but also the most effective plan because it provides the most acres of barrier island protected or restored by 2080. Barrier islands are the most effective measure of providing resilience to the navigation channel. For an additional $66.6 million above the NED Plan, the Resilience Plan addresses the grounding safety risk at Zone 12 and includes restoration of the barrier islands at Zone 13 which also provides much-needed additional placement area in case shoaling volumes increase. Implementing this plan prevents the loss of existing barrier islands while also creating 435 acres of new barrier islands by 2080.

**Table ES-1: Comparison of Increments**

| | | Economic Metrics | | | | | Resilience Metrics | | | | Tradeoff Notes | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Increment | Total project First Cost | Average Annual Transportation Savings | Average Annual O&M Cost Savings | Average Annual net Benefits | BCR | Acres of Barrier Island Protected or Restored by 2080 | Annualized Cost per acre | Linear Feet of channel exposure reduced by 2080 | Annualized Cost per Linear foot of channel protected | Beneficial | Adverse |
| **Alternative 1 - No Action Alternative** | | | | | | | | | | | | |
| No Action | None | $ - | $ - | $ - | $ - | N/A | 0 | $ - | 0 | $ - | - No Cost | - 1,037 acres of existing barrier islands will be lost by 2080.<br>- No transportation or O&M savings to be gained<br>- Erosion |
| **Alternative 3 – Shoreline Stabilization** | | | | | | | | | | | | |
| Most Efficient Increment | 12.3.1 | $ 12,023,356 | $ 898,000 | $ 260,714 | $ 734,794 | 2.7 | 16 | $ 27,297 | 951 | $ 446 | - Highest Efficiency (BCR)<br>- Improves some problematic navigation conditions at Zone 12 | - Does not fully address sponsor and stakeholder safety concerns at zone 12.<br>- Least cost effective for resilience<br>- Least resilience in acres and linear feet |
| Safety Reduction Increment | 12.3.2 | $ 17,703,372 | $ 898,000 | $ 120,865 | $ 394,678 | 1.6 | 16 | $ 40,192 | 951 | $ 656 | - Cost Efficient (BCR)\<br>- Additional improvement with shoaling and maneuvering room for cross-current at zone 12 | - Additional cost<br>- Portion of the barrier island will still be lost by 2080 |
| Zone 13 Stabilization Increment | 13.3.1 | $ 39,124,868 | $ 580,000 | $ 191,391 | $ (608,076) | 0.6 | 3 | $ 414,254 | 19,000 | $ 73 | - Improves some problematic navigation conditions at Zone 13 | - High cost<br>- Additional vulnerability to wind/waves from open bay with just breakwaters |
| **Alternative 6 – Combination Alternative** | | | | | | | | | | | | |
| Zone 13 Barrier Island Restoration Increment | 13.6.1 | $ 60,907,295 | $ 580,000 | $ 212,408 | $ (1,355,064) | 0.4 | 438 | $ 4,906 | 19,000 | $ 113 | - Additional 435 acres from increment 13.3.1<br>- Additional buffer protection from wind/waves from open bay with restoration of barrier island<br>- Additional Placement Area (PA) | - High cost<br>- Lower efficiency (BCR) |
| NED | 12.3.1, 14.6.1, 16.6.1, 18.6.1 | $ 185,259,621 | $ 2,424,000 | $ 5,775,965 | $ 1,668,070 | 1.26 | 1,666 | $ 3,921 | 46,099 | $ 142 | - Highest Net Benefits<br>- 2nd most effective plan for resilience | - Does not address the safety risk concern at Zone 12<br>- Additional vulnerability to wind/waves from open bay with breakwater only at Zone 13<br>- 2nd highest project first cost |
| Resilience | 12.3.2, 13.6.1, 14.6.1, 16.6.1, 18.6.1 | $ 251,846,932 | $ 3,004,000 | $ 5,758,958 | $ (116,676) | 0.98 | 2,104 | $ 4,221 | 65,099 | $ 136 | - Most effective plan providing the most resilience<br>- For an additional $5.7M above NED, addresses safety risk concern at Zone 12.<br>- Restores 435 barrier island and much needed PA at zone 13 while protecting an additional 19K linear feet of channel | - Highest project first cost<br>- Negative Net Benefits<br>- Lower Efficiency (BCR) |

***Note: AA is the average annualized calculation using a discount rate of 2.5% from 2030 to 2080**

Table ES-2 below shows how the NED Plan and Resilience Plan compared against the 1983 P&G evaluation criteria.

**Table ES-2: Comparison of Plans Against Evaluation Criteria**

| Plans | Complete | Effective | Efficient | Acceptable |
|---|---|---|---|---|
| Alternative 6 - NED Plan | - This plan is complete and accounts for all actions to meet the estimated benefits. | - Highest Net Benefits (Total Cost $185M)<br><br>- Most Cost-effective Combination per Acre | BCR = 1.26 | Avoids impacts to ENV, CR, HTRW, or RE |
| Alternative 6 - Resilience Plan[4] | - This plan is complete and accounts for all actions to meet the estimated benefits. | - Highest Resilience (Total Cost: $251.8 M)<br><br>- Zone 12 additional $5.7M for channel modification measure to address safety risk and resilience<br><br>- Zone 13 additional $61M for resiliency of the barrier island to the bay<br><br>- Most Cost-effective Combination per Linear Foot | BCR = 0.98<br><br>This is an efficient consideration for resiliency given the price tag for Zone 13 is $1,768 annualized cost per acre. | Avoids impacts to ENV, CR, HTRW, or RE |

The resiliency plan maximizes reduction in safety within zone 12 and maximizes acres restored and linear feet protected outputs within Zone 13. No other combination produces higher outputs. This plan is the most efficient consideration for resiliency. Table ES-3 below compares the Non-Monetary Outputs for Zones 12 and 13.

[4] This includes 12.3.2 as a total project first cost of $17.8M, which includes channel modification ($5.8M) and the stabilization increment (12.3.1) ($12M). Increment 12.3.1 is part of 12.3.2, so those measures for stabilization for $12M are part of both the NED and Resilience Plan as shown in the Table 1 above.

**Table ES-3: Non-Monetary Outputs for Zones 12 and 13**

| | Non-Monetary Outputs | | | |
|---|---|---|---|---|
| | Resilience Metrics (acres of barrier island restoration by 2080) | Prepare, Absorb, Recover Adapt (PARA) | Safety Risk Reduction | Ancillary AAHU |
| **Zone 12** | | | | |
| 12.3.1 | 16 | Partially Met | Partially Met | 33* |
| 12.3.2 | 16 | Fully Met | Fully Met | 33* |
| **Zone 13** | | | | |
| 13.3.1 | 3 | Partially Met | n/a | n/a |
| 13.6.1 | 438 | Fully Met | n/a | 275* |

* Zones 12 and 13 only apply to the Recommended Plan and not the NED Plan
**12.3.1 does not include the creation of habitat; the breakwater prevents loss of existing habitats

Table ES-4 below compares how the NED Plan and Resilience Plan meet the study objectives. The difference in plans is that the resilience plan is comprehensive and protects the entire study area and does not leave a zone open to the bay and vulnerable. The cost difference is $66.5M (NED cost $185.3M and the Resilience Plan cost $251.8M). The risk difference is that the NED plan does not address the safety risk of unintentional groundings at Zone 12 or the exposed channel with vulnerability to the open bay at Zone 13.

**Table ES-4: Comparison of Plans Against Study Objectives**

| Plans | Objective 1: Improve Navigation Resiliency of GIWW | Objective 2: Improve Economic Efficiency of GIWW | Objective 3: Reduce Safety Risks in the GIWW |
|---|---|---|---|
| **Alternative 6 - NED Plan** | Provides 1,666 Acres of barrier island and 46,099 Linear Feet of channel protection | Provides $8.19M in average annualized benefits and a BCR of 1.26 | Safety risk at Zone 12 not addressed, and Zone 13 left exposed and vulnerable to bay |
| **Alternative 6 - Resilience Plan** | Provides 2,104 (+21%) Acres of barrier island and 65,099 (+30%) Linear Feet of channel protection (compared to NED Plan) | Provides $8.76M (+6%) in average annualized benefits and a BCR of 0.98 (-22%) (compared to NED Plan) | Zone 12 safety risks addressed, and reducing safety risk at Zone 13 |

The PDT's conclusions from the comparisons are as follows:

- Both Plans are complete and equally acceptable;
- Resilience Plan provides more restoration of the barrier islands and protection of the channel by 21% in additional Acres and 30% in Linear Feet of protection than the NED plan; and,
- Resilience Plan provides reduction in safety risk at Zone 12, a significant concernby the sponsor and stakeholders, and the entire length of Zone 13.
- Resilience Plan offers reduction in safety risks in Zone 12 and channel protection from the open bay in Zone 13.

## Recommended Plan

The Resilience Plan provides maximum resilience benefits and reasonable economic benefits. The average annualized economic benefits of the TSP are $8.76 million per year, while the average annualized costs are $8.88 million per year. The economic benefits are a combination of transportation and O&M cost savings. The benefit-cost ratio (BCR) is 0.98 with an average annualized net benefit of -$116,676 per year. However, the TSP also provides non-monetary resilience benefits which are 2,104 acres of barrier islands protected/restored and 65,099 linear feet of channel exposure reduced by 2080. The total project first cost of the TSP is $251.8 million.

Based on the conclusions from the comparison of Alternative 6 - NED Plan and Alternative 6 – Resilience Plan against the evaluation criteria and study objectives, the PDT recommends the Resilience Plan for the TSP. TSP includes increments: 12.3.2, 13.6.1, 14.6.1, 16.6.1, and 18.6.1. The recommended TSP is the NED Plan plus additional measures for safety reduction in Zone 12 and resiliency in Zone 13, which are described in more detail below. See Figure ES-3 below for elements in the Resilience Plan.

Feedback from the USFWS (Ecological Field Office), TPWD, and NMFS on the TSP plan has been favorable. Recommendations from the agencies were incorporated into the TSP, which most changes occurred within Zone 12. The environmental compliance is ongoing; however, there are no known environmental compliance contentious points. NEPA public comment period is scheduled to begin after determination of the NED exception with draft documents for ESA, EFH, CZMA and 401 WQC. Informal consultation with USFWS for Section 7 ESA compliance is expected to take the longest to complete, with approximately 120 days from transmittal.

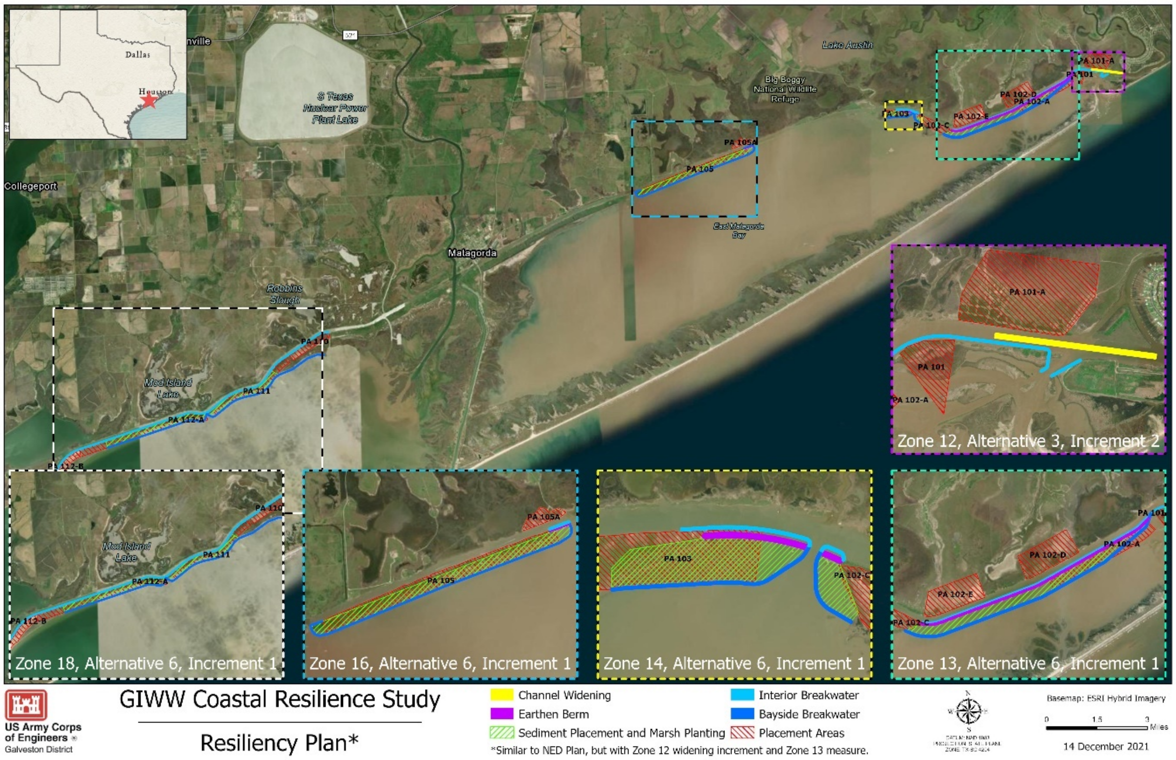


**Figure ES-3: Resilience Plan**

**<u>Zone 12 for safety reduction</u>**:
Increment 12.3.2 at zone 12 has an additional project first cost of $5.7M for the channel modification measure to address unintentional groundings and significant sediment issues. These groundings pose a safety risk to life, property, and the environment. U.S. Coast Guard data for unintentional groundings reported within Zone 12 at Caney Creek indicate that there were 13 reported groundings during the 2018 through 2020, three-year period requested. 12 out of the 13 were in the year 2020 and one in 2019. Two emergency dredging contracts were executed between FY 18 and FY 20 for shoaling at Caney Creek. One additional emergency dredging contract was executed in early FY21 for shoaling at Caney Creek.

As stated, waterway users have identified areas of significant shoaling where the channel width is often draft-restricted. The area where the GIWW intersects Caney Creek (Zone 12) in particular, is a location of both high current velocities and shoaling due to the proximity to the Gulf of Mexico, as well as the typical chronic and episodic shoaling experienced in the channel. This creates navigation safety risks for barges traversing this intersection. Barge tows must often “crab-walk” across the currents at Caney Creek, and tows risk damage to their rudders and wheels during groundings on large sediment shoals exacerbated by erosion in the vicinity. These groundings pose a safety risk to life, property, and the environment. Additionally, the channel shoreline on the mainland side of the GIWW has also suffered significant erosion loss, increasing shoaling in the GIWW. This allows saltwater intrusion into ecologically important and diverse brackish and freshwater marsh habitats along the north side of the GIWW.

**Zone 13 for resilience:**

At Zone 13, there is an additional project first cost of $61M for restoration of the barrier to support navigation resilience.

Proposed measures at zone 13 promote *PARA*. Breakwaters and restoration of the barrier island allow navigation to:

- *prepare* for storms by building more protection and stabilization;
- *absorb* and protect the channel from wind/waves and lessen shoaling;
- *recover* more quickly from the impacts due to the protection and decreased shoaling; and
- *adapt* by providing options for dredge material to be placed where it is most effective and offers maximum protection from the shoaling and storm impacts in the future.

If no action is taken in Zone 13, then Zone 13 is the weakest link in the system. At over 3.8 miles long, it would also represent the only non-protected reach of the GIWW greater than 500 ft between Galveston Bay and Matagorda Bay. Further, it would be the only section open to East Matagorda Bay and would be susceptible to all the Bay's tidal flushing through the GIWW, focalizing all that flow and sediment movement into that area, making it a hotspot for channel shoaling, higher cross-current velocities, and unmitigated wave action. It would be extremely susceptible to disruption during small and large events as compared to the standard for the rest of the GIWW within the project counties.

The PDT will continue to refine Zones 12 and 13 measures to optimize costs and benefits. Additional modeling for Zones 12 & 13, will expand the CMS model that was used to evaluate qualitatively several structural alternatives in Zone 12. The model will be expanded to include and assess improvements in Zones 13 through 16, to understand the influence of open water sediment transport that contributes to shoaling in the GIWW.

The model will also be expanded to assess channel widening/deepening improvements in Zone 12 and the overall simulations will be expanded from 1 month to 2-3 years to assess the long-term shoaling responses. This additional modeling will be approximately $50K and is estimated to take 3 to 4 months (completed by February 2022). Upon completion and analysis of this additional modeling, the PDT will evaluate the design and cost associated with Zone 12 and 13 for further refinement and optimization. The ADM is currently scheduled in March of 2022.

The NED Plan is also a viable plan providing the maximum economic benefits and reasonable resilience benefits with a project first cost of $185.3 million and a BCR of 1.26. The NED Plan proposes to save $66.6 million or about 26 percent of the project first cost less than the Resilience Plan. In exchange for the lower cost, the NED Plan excludes 438 acres or about 21 percent of barrier islands protected or restored by 2080 and 19,000 linear feet or about 29 percent of channel exposure reduced by 2080. In the case that the NED Exception policy waiver is not approved, the NED Plan is recommended for selection.

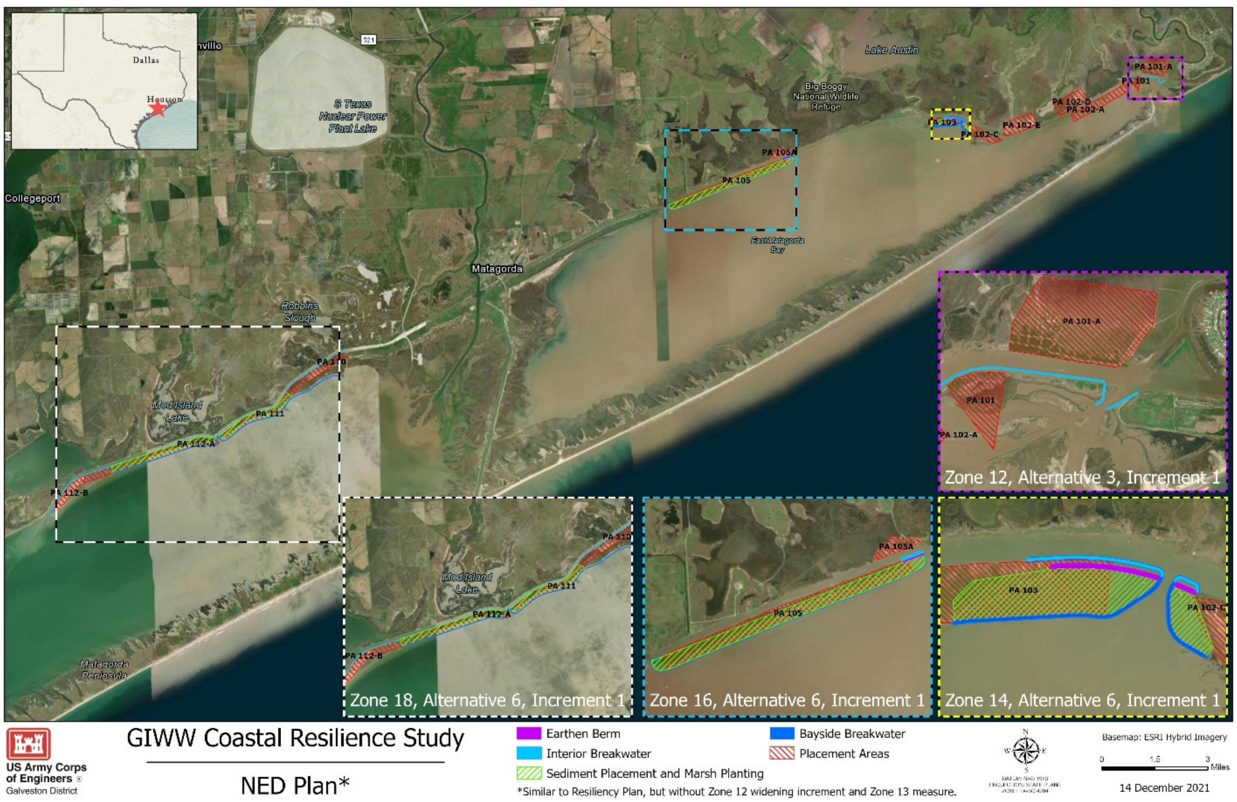


**Figure ES-4: NED Plan**

**Post-TSP Analysis:**

PDT will continue to refine costs and benefits for Zones 12 and 13 following the draft report release. The NED exception will be revisited and reshaped following the draft report review and prior to the ADM where additional comments can be gathered from peer review, industry, public and agencies. The TSP for the draft report is recommended to be the “Resiliency Plan.” This allows additional flexibility for NEPA compliance and the final report to make recommendations for the NED versus the Resiliency Plan because the NED is a subset of the Resiliency Plan. The PDT is performing additional analysis during the concurrent reviews and prior to the Agency Decision Milestone in late Spring 2022.

**Environmental Assessment**

The Resilience Plan was selected not only for its ability to meet the project goals, but also because it restores over 2,090 acres of barrier island habitat. 1,567 acres of which will be beneficial use marsh. Through coordination with the federal resource agencies, the Resilience Plan meets all environmental laws, regulations, and was deemed environmentally acceptable. ER 1105-2-100 states: “Mitigation planning objectives are clearly written statements that prescribe specific actions to be taken to avoid and minimize adverse impacts, and identifies specific amounts (units of measurement, e.g., habitat units) of compensation required to replace or substitute for remaining, significant unavoidable losses.” Compensating for the impact by replacing or providing substitute resources or environments. “Replacing" means the replacement of fish and wildlife resources in-kind. "Substitute" means the replacement of fish and wildlife resources out-of-kind. Substitute resources, on balance, shall be at least equal in value and significance as the resources lost.

Selection of potential mitigation sites and updates to the modeling of benefits will be conducted in PED and will be coordinated with the resource agencies. Field surveys will be conducted in PED to refine the impact acreage. Impact acreages for this mitigation plan were estimated using geospatial data provided by the TXGLO, TPWD, and the NMFS. While the exact locations of the mitigation sites have not been selected at this point for oyster reef and sea grass mitigation construction, discussions with NMFS, TPWD, and USFWS have indicated that placing the features near the respective zones is preferable. Further discussions with these agencies and their local biologists will continue during the PED and construction phases to confirm the best location for reef and sea grass mitigation.

The preferred option for oyster reef restoration identified in the MSCIP IFR-EIS is through artificial cultch placement. This method entails placing a hard substrate on the bay bottom which allows oyster spat to attach and mature into adults and develop into reefs. This is the most common method employed along the Texas Gulf coast. The most common method of providing artificial cultch for reef development is the use of crushed limestone of river pebble placement. Placement of this material in layers of thickness from 6-9” thick has been shown to be the most successful method of oyster reef creation. The use of rock allows for small pore spaces for the oyster spat to attach, but does not allow for larger spaces for predators, such as crabs and oyster drills, to settle. The mass placement of rock allows for effective coverage of the bay bottom to accomplish our goal of 90 percent cultch coverage.

Field surveys will be conducted in PED to identify suitable seagrass mitigation areas. Coordination with the resource agencies will occur in PED to optimize the mitigation site selection and the final mitigation work plan. Seagrass mitigation work may include use of dredge material to match nearby healthy seagrass grades, installation of wave breaks to protect the mitigation sites, planting with seagrass plugs from approved donor sites.

**CONCLUSION**

Both Alternative 6 – NED Plan and Alternative 6 – Resilience Plan are complete and effective plans. However, for all the reasons stated below, the PDT is recommending the Alternative 6 - Resilience plan. This recommendation requires a NED Exception, which is still pending approval by the ASA(CW). Therefore, either plan could ultimately be selected at the Agency Decision Milestone in the late Spring of 2022.

Therefore, the PDT recommends Alternative 6 – Resilience Plan which includes increments 12.3.2, 13.6.1, 14.6.1, 16.6.1, and 18.6.1 and provide the maximum resilience benefits at a project first cost of $251.8 million and a BCR of 0.98. The Resilience Plan is the most effective plan in restoring the acres of barrier islands for the period of analysis (2030 – 2080). Barrier islands are the most effective measure at providing resilience to the navigation channel. The additional $67M above the NED Plan addresses the unintentional grounding safety risk at Zone 12 and restoration of the barrier islands at Zone 13. Restoration within Zone 13 also provides necessary additional placement area for increasing shoaling within the navigation channel. Alternative 6 – resilience plan prevents the loss of existing barrier islands, which initiates vulnerability of the navigation channel to those exposed areas to the open bay. This plan also restores 435 acres of barrier islands for additional protection of the channel, absorption of shock to the system, increased recovery time, and adaptability of the navigation channel.

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*** SECTIONS REQUIRED FOR NATIONAL ENVIRONMENTAL POLICY ACT COMPLIANCE (***Required by Council on Environmental Quality (CEQ) Regulations 40 CFR 1502.10***)**

# FIGURES

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# APPENDICES*

## List of Acronyms

| | |
|---|---|
| AAHUs | Average Annual Habitat Units |
| AAEQ | Average Annual Equivalent |
| ACHP | Advisory Council on Historic Preservation |
| ACS | American Community Survey |
| ADCIRC | Advanced CIRCulation |
| ADM | Agency Decision Milestone |
| ALU | High Aquatic Life Use; Water Quality Classification |
| AMM | Alternatives Milestone Meeting |
| AOC | Area of Concern |
| AOM | Assumption of Maintenance |
| APE | Area of Potential Effect |
| ATR | Agency Technical Review |
| BA | Biological Assessment |
| BCR | Benefit-to-Cost Ratio |
| BMP | Best Management Practice |
| BP | Before Present |
| BU | Beneficial Use |
| CAA | Clean Air Act |
| CBIA | Coastal Barrier Improvement Act |
| CBRA | Coastal Barrier Resources Act |
| CBRS | Coastal Barrier Resources System |
| CCAC | Coastal Coordination Advisory Committee |
| CCC | Coastal Coordination Council |
| CDF | Confined Disposal Facility |
| CEQ | Council on Environmental Quality |
| CFR | Code of Federal Regulations |
| CNRA | Coastal Natural Resource Areas |
| CTR1 | Coastal Texas Ecosystem Protection and Restoration, Texas, Feasibility Study, Region 1 |
| CWA | Clean Water Act |
| CY | Cubic Yards |
| CZMA | Coastal Zone Management Act |
| DA | Department of Army |
| DIFR-EA | Draft Integrated Feasibility Report and Environmental Assessment |

| | |
|---|---|
| DMMP | Dredged Material Management Plan |
| DO | Dissolved Oxygen |
| DoD | Department of Defense |
| DSHS | Department of State Health Services |
| DWT | Dead Weight Tons |
| EFH | Essential Fish Habitat |
| EIS | Environmental Impact Statement |
| EJ | Environmental Justice |
| EM | Engineer Manual |
| EOP | Environmental Operating Principles |
| EO | Executive Order |
| EPA | U.S. Environmental Protection Agency |
| EQ | Environmental Quality |
| ER | Engineer Regulation |
| ERL | Effects Range Low |
| ERM | Effects Range Meridian |
| ERDC | Engineer Research and Design Center |
| ESA | Endangered Species Act |
| ETL | Engineer Technical Letter |
| ºF | Degrees Fahrenheit |
| FCA | Flood Control Act |
| FCU | Fish Consumption Use; Water Quality Classification |
| FEMA | Federal Emergency Management Agency |
| FMC | Fishery Management Councils |
| FMP | Fishery Management Plan |
| FWCA | Fish and Wildlife Coordination Act |
| FWOP | Future Without-Project |
| FY | Fiscal Year |
| GC | General Conformity |
| GCD | General Conformity Determination |
| GIS | Geographic Information System |
| GMFMC | Gulf of Mexico Fishery Management Council |
| GNF | General Navigation Feature |
| GOM | Gulf of Mexico |
| GRBO | Gulf Regional Biological Opinion |
| GRP | Gross Regional Product |

| | |
|---|---|
| GU | General Use; Water Quality Classification |
| HHS | U.S. Department of Health and Human Services |
| HQ | Headquarters |
| HTRW | Hazardous, Toxic and Radioactive Waste |
| IEPR | Independent External Peer Review |
| ITA | Incidental Take Authorization |
| LERRs | Lands, Easements, Rights-of-Way, and Relocations |
| LERRDs | Lands, Easements, Rights-of-Way, and Relocations and Disposal Areas |
| LOA | Length Overall |
| LOOP | Offshore crude terminal |
| LRR | Limited Reevaluation Report |
| LSF | Local Service Facilities |
| MII or Mii | MII is the Second Generation of MCACES |
| MBTA | Migratory Bird Treaty Act |
| MCACES | Micro Computer Aided Cost Engineering System |
| Ug/kg | Microgram/kilogram |
| MCY | Million Cubic Yards |
| Mg/kg | Milligram/kilogram |
| MHW | Mean High Water |
| MLLW | Mean Lower Low Water |
| MLT | Mean Low Tide |
| MMPA | Marine Mammal Protection Act |
| MM/YR | Millimeters per Year |
| MOU | Memorandum of Understanding |
| MPRSA | Marine Protection, Research, and Sanctuaries Act |
| MSA | Metropolitan Statistical Area |
| MSC | Major Subordinate Command |
| MSFCMA | Magnuson-Stevens Fishery Conservation and Management Act |
| MSL | Mean Sea Level |
| NAA | Nonattainment Area |
| NAAQS | National Ambient Air Quality Standards |
| NED | National Economic Development |
| NEPA | National Environmental Policy Act |
| NFS | Non-Federal Sponsor |
| NMFS | National Marine Fisheries Service |

| | |
|---|---|
| NOA | Notice of Availability |
| NOAA | National Oceanic and Atmospheric Administration |
| NOI | Notice of Intent |
| $NO_x$ | Nitrogen Oxide |
| NPL | National Priorities List |
| O&M | Operations and Maintenance |
| ODMDS | Ocean Dredged Material Disposal Site |
| OSE | Other Social Effects |
| OWPR | Office of Water Project Review |
| OWU | Oyster Waters Use; Water Quality Classification |
| P&G | Principles and Guidelines |
| PA | Placement Area |
| PAH | Polycyclic Aromatic Hydrocarbons |
| PAL | Planning Aid Letter |
| PCB | Polychlorinated Biphenyls |
| PB | Planning Bulletin |
| PDT | Project Delivery Team |
| PED | Preconstruction Engineering and Design |
| P.L. | Public Law |
| PMP | Project Management Plan |
| PPT | Parts Per Trillion |
| PPTH | Parts Per Thousand |
| RCRA | Resource Conservation and Recovery Act |
| RECONS | USACE Online Regional Economic System |
| RED | Regional economic development |
| REP | Real Estate Plan |
| RFMC | Regional Fishery Management Councils |
| RGL | Regulatory Guidance Letter |
| RHA | Rivers and Harbors Act |
| ROD | Record of Decision |
| RSLC | Regional Sea Level Change |
| RU | Recreation Use; Water Quality Classification |
| S&A | State and Agency |
| SAV | Submerged Aquatic Vegetation |
| SH | State Highway |
| SHPO | State Historic Preservation Officer |

| | |
|---|---|
| SIP | State Implementation Plan |
| SMMP | Site Monitoring and Management Plan |
| SWD | Southwestern Division |
| T&E | Threatened and Endangered |
| TCEQ | Texas Commission on Environmental Quality |
| TCMP | Texas Coastal Management Program |
| TDSHS | Texas Department of State Health Services |
| TEU | Twenty-Foot Equivalent Units |
| TMDL | Total Maximum Daily Load |
| TPWD | Texas Parks and Wildlife Department |
| TSP | Tentatively Selected Plan |
| TWDB | Texas Water Development Board |
| TXGLO | Texas General Land Office |
| USACE | United States Army Corps of Engineers |
| USCG | U.S. Coast Guard |
| USFWS | U.S. Fish and Wildlife Service |
| USGS | U.S. Geological Survey |
| VLCC | Very Large Crude Carriers |
| VOC | Volatile Organic Compound |
| WIIN Act | Water Infrastructure Improvements for the Nation Act |
| WMA | Wildlife Management Area |
| WRDA | Water Resources Development Act |
| WRRDA | Water Resources Reform and Development Act |

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# 1 STUDY INFORMATION

## 1.1 INTRODUCTION

The Gulf Intracoastal Waterway (GIWW) is a man-made inland waterway that spans 1,100 miles connecting ports along the Gulf of Mexico from Brownsville, Texas to St. Marks, Florida. The GIWW is the nation's third busiest inland navigation waterway and a critical component of the nation's transportation network. The cargo carried on the GIWW produces significant economic benefits being the most fuel-efficient and producing the least emissions per ton of cargo, and it also reduces congestion and maintenance of highway and rail systems by providing an alternate mode of transportation.

The Texas portion of the GIWW generally consists of a 12 to 14-feet deep by 125-feet wide channel along approximately 423 miles, and the main channel extends 379 miles from Sabine River to Port Isabel, Texas. The Texas portion of the GIWW also includes flood gates and navigation lock structures at the Brazos and Colorado Rivers, respectively. Mooring basins and buoys are maintained at 10 separate locations along the length of the GIWW which support heavy barge traffic at approximately 45,000 trips per year in fiscal year (FY) 2017. The Texas portion of the GIWW provides an intermodal link between the Texas deep draft and shallow draft ports which his critical in supporting the petrochemical industry and the inland port facilities along the Texas coast. In 2018, the amount of commercial tonnage transiting the Texas portion of the GIWW was about 78 million short tons consists of more than 70 percent of all GIWW traffic.

## 1.2 STUDY AUTHORITY

The study is authorized under the Water Resources Development Act of 2016, Section 1201 (25). The Secretary is authorized to conduct a feasibility study for the following projects for water resources development and conservation and other purposes, as identified in the reports titled: ''Report to Congress on Future Water Resources Development'' submitted to Congress on January 29, 2015, and January 29, 2016, respectively, pursuant to section 7001 of the Water Resources Reform and Development Act of 2014 (33 U.S.C. 2282d) or otherwise reviewed by Congress: "GULF INTRACOASTAL WATERWAY, TEXAS, BRAZORIA AND MATAGORDA COUNTIES, TEXAS. Project for navigation and hurricane and storm damage reduction, Gulf Intracoastal Waterway, Brazoria and Matagorda Counties, Texas."



* Required by CEQ Regulations 40 CFR 1502.10

## 1.3 NON-FEDERAL PARTNER

Texas Department of Transportation (TXDOT) is the non-Federal study partner. However, this study is 100 percent federally funded, and a Feasibility Cost Sharing Agreement is not required.

Upon approval of the final report, chief's report and construction by OMB, the construction project will be reviewed and compete for Inter Waterways User Board (IWUB) funds (IWUF).

## 1.4 STUDY PURPOSE, NEED, AND SCOPE*

The purpose of this study is to investigate and determine modifications that would:

- Increase system resilience,
- Improve navigability and navigation safety,
- Reduce overall dredging and structure maintenance,
- Reduce commercial transit delays and accidents; and,
- Enhance regional sediment management practices along the GIWW.

The demonstrated need for this investigation comes from numerous examples of coastal storms which have caused episodic shoaling and erosion resulting in channel closures, transportation delays, and create potential navigational safety issues.

This study is evaluating alternatives that would benefit the GIWW navigation system by reducing ongoing shoreline erosion and shoaling in the channel and mitigating impacts of periodic coastal storms. Considerations of ecosystem restoration or damage reduction benefits are incidental to the primary navigation purpose of the GIWW. Analyses focused on identifying:

- Causes of transportation service interruptions or capacity reductions
- Reaches most vulnerable to effects of erosion, shoaling, storm damages, and changes due to relative sea level rise
- Local sediment resources that have the potential for beneficial uses of dredged material (e.g. used to restore degraded sandbars, islands, and wetlands)
- Methods to reduce impacts of currents and wind fetch on navigation through restoration of coastal features and,
- High shoaling areas that require significant expenditures for operations and maintenance (O&M) such as dredging.

The scope is specifically analyzing the portion of the GIWW located within the Brazoria and Matagorda Counties, Texas and the adjacent portions of the tributaries, estuaries, and other habitats that boarded this portion of the GIWW.

## 1.5 FEDERAL INTEREST

The Texas portion of the GIWW handles approximately 70 percent of GIWW traffic (80 million tons of cargo annually) and connects 20 ports along the coast. The GIWW is an integral link in supply chains for national and regional petrochemical and manufacturing industries. Approximately 90 percent of Texas GIWW cargo consists of petroleum or chemical products.

## 1.6 STUDY AREA, PROJECT AREA, AND CONGRESSIONAL DISTRICT

The authorized project area encompasses 85 miles of the Texas portion of the GIWW in Brazoria and Matagorda counties which was divided into 20 zones according to geography and ecology as shown on Figure 1 below.

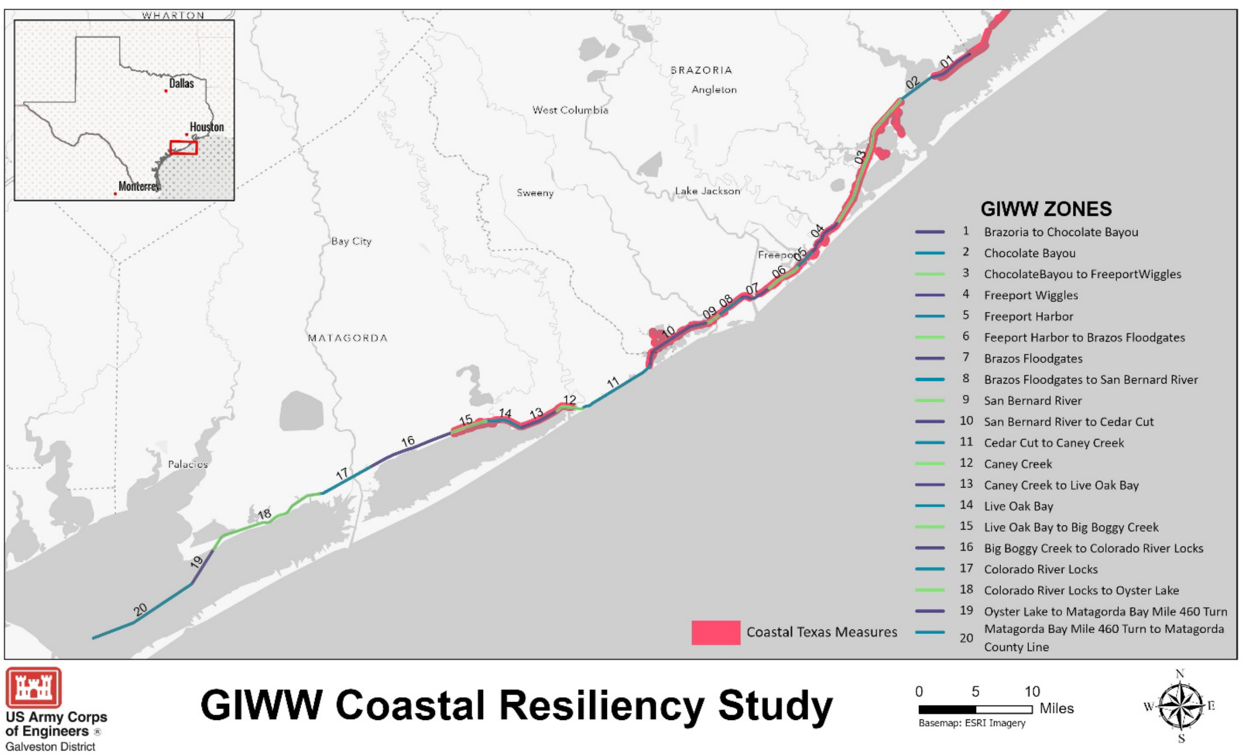


**Figure 1: GIWW CRS Authorized Project Area**

While developing the future without project (FWOP) conditions for this study, it was determined that the proposed measures from the Coastal Texas Protection and Restoration Feasibility Study would address all areas of zones 1 through 10 which cover all of Brazoria County; partial areas of zones 12, 13, 14; and all of zone 15 in Matagorda County. For more information on the analysis and screening for each of the zones (1 – 20), see the Engineering Appendix D, Section 2.4.2.

The FWOP condition was also determined to include maintenance of an existing USACE revetment structure and a Texas General Land Office (GLO) project that would address all of zone 11, and the GIWW Brazos River Flood Gates and Colorado River Locks Feasibility Study that would address all of zone 17. Finally, zones 19 and 20 were identified as open water areas in Matagorda Bay that are not limited to the navigation channel.

As a result of determining the above-mentioned FWOP conditions including proposed measures by other studies and projects, the study area evaluated through the Tentatively Selected Plan (TSP) was reduced to zones 12, 13, 14, 16, and 18 along approximately 30 miles of the GIWW in Matagorda County as shown on Figure 2.

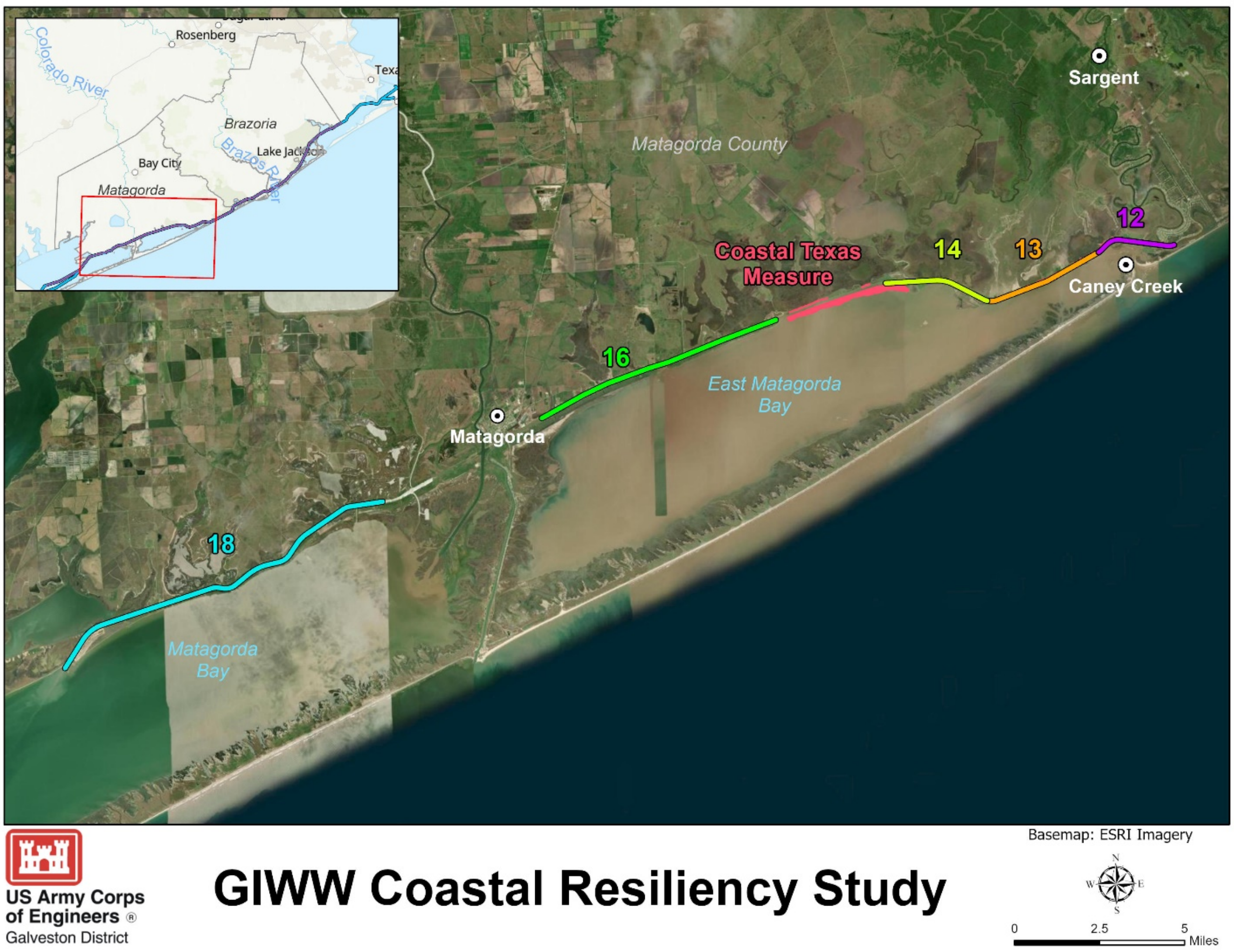


**Figure 2: Study Area**

As authorized by the U.S. Congress, the portion of the GIWW in Texas is 125-feet wide and 12 feet deep at mean low tide (MLT). The Corps Galveston District (District) has completed converting the navigable depth rating based on mean low tide to mean lower low water (MLLW) that results in depths of 13 to 14 feet MLLW in about 406 miles of the channel.[5]

## 1.7 Resiliency

Executive Order 13653 (Preparing the U.S. for the Impacts of Climate Change), defines resiliency as: "the ability to anticipate, prepare for and adapt to changing conditions and withstand and recover from disruptions." Engineer Pamphlet (EP) 1100-1-2, USACE Resilience Initiative Roadmap 2016 expands the definition and specifies four principles of resiliency: prepare, absorb, recover, and adapt (**Figure 3**).


**Figure 3: Principles of Resilience**

Prepare: A navigation system such as the GIWW must maintain a certain level of service to be of value to the nation. In a typical navigation study, a PDT analyzes changes over time that lead to different markets and economies and are reflected in development of new facilities and larger vessels. Change is natural, but sometimes change is not gradual. It can be swift and disruptive, and can shock a system and result in serious, long-lasting impacts. Such changes can stem from physical events such as floods, storms, serious accidents, or even global pandemics such as COVID-19. Changes can also be driven by policy and regulation such as Congress lifting the ban on U.S. crude exports in 2016. When shocks to a system occur, waterborne commerce can increase or decline substantially in a short period of time. The PDT must identify potential shocks or changes and prepare plans for how a system can absorb, recover, and adapt to them. The plan that is most proactive is desired for this principle. This

[5] Galveston District has historically used mean low tide (MLT) as vertical datum control for navigation projects. MLT in the context of District projects is a legacy datum dating from the 1960s and is geodetically tied to terrestrial benchmarks such as NGVD 29 and NAVD 88. At its inception, MLT was empirically and subjectively derived and represented the lowest expected water level including both astronomical and meteorological forcing. In contrast, mean of the lower low water (MLLW) heights is the arithmetic mean of observed tides over a specific 19-year metonic cycle (the NTDE), and is the depth (sounding) datum used on NOAA nautical charts; and internationally recognized as the average minimum tidal depth likely to be encountered by maritime operators.

feasibility study phase is part of the preparation phase as are any subsequent actions recommended by the study.

Absorb/Withstand: When disruptive conditions such as a major storm impact the GIWW, actions identified in the preparation phase allow the system to absorb the impact from these events. In the case of a navigation channel, protecting and restoring barrier islands (e.g., living shorelines, sediment placement, and restoration of marshes) enable them to withstand storms and other erosional forces such as barge and wave wake. Barrier islands are most effective at reducing current and wind wave impacts to vessels increasing navigation safety. The PDT developed increments of alternatives with different levels of effectiveness to absorb disruptive events in order to determine the most cost-effective alternative. The restoration of barrier islands also allows for the navigation channel to absorb changes in sea level and improve maintenance objectives with beneficial use of dredged material. The measures described above help the navigation channel absorb physical shocks minimizing interruptions and providing shorter recovery periods. How effectively the plan absorbs the disruptive events is the most desired for this principle.

Recover: Once a storm event or other stressor occurs, a resilient navigation channel recovers quickly, and navigation can resume normal operations. This recovery time is the measure utilized from a resilience perspective, (i.e., how quickly do normal operations return or how easily does the transportation network absorb the shock to the system or the ongoing problem). A resilient navigation channel also allows the overall transportation network (including other modes of transportation) to absorb shocks. In 2016, when Congress lifted the ban on crude oil exports large volumes of crude oil began moving on the GIWW to deep ports along the Gulf because, at the time, pipelines from West Texas oilfields lacked capacity to accommodate the rise in transportation demand. Thus, the availability of barge transport on the GIWW was a form of resiliency in the overall crude oil transportation system in Texas. In short, the multi-modal aspects of the GIWW are a form of resiliency. This form of the navigation channel offers value to the rest of the transportation network and helps the rest of the navigation system be resilient. The plan that allows the quickest resuming of normal operations after a disruptive event is the most desired for this principle.

Adapt: As conditions change (e.g., sea level rise, increased frequency and intensity of major storms and hurricanes, sediment placement areas, and commodities market), adaptability is key to responding to both anticipated and unanticipated changes over time. Considering the adaptability of features during the planning and design phases of the project can be key to ensuring that features can be modified over time in response to changing conditions. The plan that can most easily be modified to adapt to changing conditions is the most desired for this principle.

## 1.8 PRIOR STUDIES, REPORTS, AND EXISTING WATER PROJECTS

### 1.8.1 Prior Studies and Reports

Table 1: Prior Reports and Existing Federal Water Resources Projects summarizes past navigation investigations. Since 1975, the Corps has published major studies addressing issues in or near the study area and most have information relevant to the GIWW Coastal Resiliency Study (GIWW CRS).

**Table 2: Prior Reports and Existing Federal Water Resources Projects**

| Navigation Studies and Reports | | Relevance to GIWW CRS | | | |
|---|---|---|---|---|---|
| | | Data Source | Consistency | Measure Source | FWOP Conditions |
| 1975 | Final Environmental Statement, Maintenance Dredging, Intracoastal Waterway, Texas Section, Main Channel and Tributary Channels, Volumes 1-3 | X | | | |
| 1997 | Preliminary Chocolate Bayou Wye Ship Simulation Study | X | | | |
| 1998 | Final Report - Freeport Wiggles Channel Improvement Study (Ship Simulation) | X | | | |
| 2003 | Gulf Intracoastal Waterway High Island to Brazos River Section 216 Study Final Feasibility Report | | | | |
| 2014 | Reducing shoaling in the Texas GIWW and Erosion of Barrier Islands Along West Galveston Bay | X | | | X |
| 2016 | Coastal Texas Protection and Restoration Study (Ongoing), U.S. Army Corps of Engineers | X | X | X | X |
| 2019 | Gulf Intracoastal Waterway, Brazos River Floodgates and Colorado River Locks, Texas, Final Integrated Feasibility Report and Environmental Impact Statement | X | X | | X |

### 1.8.2 Existing Water Projects

Table 2 summarizes past existing federal water resources projects. Existing federal projects include the GIWW, the Matagorda Ship Channel and the Freeport Ship Channel.

**Table 3: Other Existing Federal Projects for GIWW**

| Federal Navigation Projects in the Vicinity | | | | |
|---|---|---|---|---|
| Gulf Intracoastal Waterway (GIWW), Texas | X | X | | |
| Freeport Ship Channel, Texas | X | X | | |
| Matagorda Ship Channel, Texas | X | X | | |

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# 2 EXISTING & FUTURE WITHOUT-PROJECT CONDITIONS *

## 2.1 GENERAL

This chapter presents a description of the existing conditions for environmental resources and other disciplines, that could be affected from implementing the proposed alternative in compliance with the National Environmental Policy Act (NEPA), the Council on Environmental Quality (CEQ), and 32 CFR 775 guidelines. The level of detail used in describing a resource is commensurate with the anticipated level of potential environmental impact.

The study area contains approximately 30 miles of shoreline that includes many acres of beach and dune systems, lagoons, seagrass beds, oyster reefs, and tidal marshes. These coastal habitats are utilized by commercially and recreationally important Gulf of Mexico (Gulf) finfish and shellfish, as well as migratory birds and waterfowl which depend on these habitats during a portion of their life cycles. These biological and geomorphic systems contribute to much of the coast's productivity, economy, and quality of life.

Texas is one of the Nation's top states for waterborne commerce, with Texas' coast ports generating over $82.8 billion in economic value to the region. More than 500 million tons of cargo pass through Texas ports annually, including machinery, grain, seafood, oil, cars, retail merchandise, and military freight. The State's maritime system is a critical gateway to international trade and provides Texas with a multitude of economic opportunities through the movement of waterborne commerce. Texas is one of the Nation's leading states in the maritime industry, handling 15.8 percent of total U.S. cargo between 2007 and 2011. Texas ports managed 20.1 percent of the Nation's total export tonnage during this period, making it the Nation's leading export state. Texas ports are also home to four of the eight largest refineries in the country (providing 25 percent of national refinery capacity) and most of the National Petroleum Reserve. Port Arthur is also the number one port for military deployments, and the GIWW is the third busiest shallow draft channel in the United States.

The GIWW plays a key role in all of the economic sectors. It is the Nation's third busiest inland waterway, with the Texas portion handling over 63 percent of its traffic. Over $25 billion cargo passes annually through the 406-mile section of the GIWW that runs along the Texas coast.

Three Texas ports are designated by the Department of Defense as "strategic military ports," providing surface deployment and distribution for strategic military cargo worldwide. The Port of Beaumont, Port of Port Arthur, and the Port of Corpus Christi all serve in the U.S. Maritime Administration's National Port Readiness Network, supporting deployment of U.S. military forces during defense emergencies.

Barrier islands provide shelter for resilient transit of commercial vessels on the GIWW against waves and currents of the open Gulf of Mexico and to a lesser degree the Bay systems. Erosion of the coastal barriers occurs naturally, from coastal storms and seasonal winds, waves, and currents, and anthropogenically, from vessel induced waves. In general, erosion caused by natural processes occurs mostly on the Gulf side of the GIWW either at the Gulf-barrier or the Bay Barrier, and anthropogenic erosion occurs along the shorelines of the interior of navigation channels such as the GIWW. Both sources of erosion cause an influx of sediment material into the system, and shoreline erosion rates suggest that natural processes produce higher erosion rates. In areas where the barrier is intact, this sediment material that is eroded is generally blocked from entering the GIWW system; however, in places where there are no barriers or there are cuts or breaches, sediment material is able to cycle into the system, especially as these cuts or breaches widen due to erosion. Once a barrier is eroded, wind-driven waves will accelerate erosion of the shoreline on the other side of the GIWW. In addition, material also enters the system through the watershed runoff and river systems. This is important because sediment influx into the GIWW system results in shoaling which both reduces system reliability and increases system maintenance costs, both negative economic consequences. To reduce shoaling, either the source of the material must be stabilized so it is less erosive or the pathways by which material enters the GIWW be reduced.

## 2.2 Climate

The climate of the study area is humid subtropical with warm to hot summers and mild winters. The average annual high temperature is about 76 degrees Fahrenheit, with an average summer high of about 88 degrees for the months of June, July, and August, and an average annual winter low temperature of 66 degrees. Periods of freezing temperatures are infrequent and rainfall averages about 44 inches annually (National Weather Service, 2020). Severe weather occurs periodically in the form of thunderstorms, tornadoes, tropical storms, and hurricanes.

Within the study area, temperatures range from winter lows to summer highs with warming temperatures in the spring and cooling temperatures in the fall. Rainfall is the main form of precipitation along the coast and tends to occur most frequently and in greatest ants in the spring and late summer/early fall. Rainfall rates decrease, and temperatures increase moving south along the coast. Coastal relative humidity averages slightly more than 60 percent over the year (Nielsen-Gammon, 2016).

During the winter, rapid drops in temperature occur 10 to 20 times a year with the passage of fast-moving cold fronts called “blue northers.” The rapid temperature drops, sometimes to below freezing, have caused massive fish and sea turtle mortality events along the coast. In some instances, dolphins have been affected. Freezing temperatures are relatively uncommon along the coast, but more likely to be experienced along the upper coast than the lower coast (Martin and McEachron, 1996). High velocity winds associated with these events cause “blow outs” of the bays when water levels may drop more than a foot below normal low tide. Low pressure systems can form in the Gulf during the winter causing long periods of steady rains along the coast. In rare cases these systems can strengthen, generating high winds and water levels substantially above high tide (Contreras, 2003). Prevailing southerly and southeasterly winds blow warm, humid air from the Gulf onshore much of the year. High temperatures in the 80- and 90-degrees Fahrenheit (°F) occur in the summer along the coast (Nielsen-Gammon, 2016).

## 2.3 History of Severe Storms and Hurricanes

The probability of hurricane landfall on the Texas Coast is about one every 6 years. (Roth, 2010). The most active area for hurricanes over the past 160 years is the upper Texas coast with 28 landfalls, followed by the mid Texas coast with 25 landfalls, and lastly the lower Texas coast with 15 landfalls. Hurricane Harvey was the costliest storm damage causing over $125B worth of damages, occurring nine (9) years after Hurricane Ike (2008) in Texas with over $29.5 billion worth of damage (**Table 3**). The top four costliest storms for Texas have all occurred since 2000, one of which (Allison) only reached tropical storm status (Blake et al., 2011).

**Table 4: Costliest Texas Storms (1900 – 2010)***

| Name | Year | Category | Landfall | Cost of Damages |
|---|---|---|---|---|
| Harvey | 2017 | 4 | South Texas | $ 125.0 B |
| Ike | 2008 | 2 | Galveston | $ 29.5 B |
| Rita | 2005 | 3 | Sabine Pass | $ 12.0 B |
| Allison | 2001 | TS | Freeport | $ 9.0 B |
| Alicia | 1983 | 3 | Galveston | $ 2.0 B |
| Dolly | 2008 | 1 | South Padre Island | $ 1.1 B |
| Celia | 1970 | 3 | Corpus Christi | $ 930 M |
| Allen | 1980 | 5 | South Padre Island | $ 700 M |

Source: Blake et al. (2011), Handbook of Texas Online (2017).

* Not adjusted for inflation and include adjusted National Flood Insurance Program flood damage amounts beginning in 1995.
TS = tropical storm

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).

## 2.4 Geology

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).

## 2.5 Soils

The Farmland Protection Policy Act (FPPA) (Public Law 97-98, Title XV, Subtitle I, Section 1539-1549 requires federal actions to minimize unnecessary and irreversible conversion of farmland to nonagricultural uses, specifically prime farmlands. The Act defines prime farmlands as "…land that has the best combination of physical and chemical characteristics for producing food, feed, fiber, forage, oilseed, and other agricultural crops with minimum inputs of fuel, fertilizer, pesticides, and labor, and without intolerable soil erosion…" The Natural Resources Conservation Service (NRCS) is responsible for designating soils as prime farmland soils. In addition, the Texas Department of Agriculture has designated soils that are of local importance for the production of food, feed, fiber, forage, or oilseed crops as soils of Statewide Importance.

The project area consists of a water navigation channel and adjacent marine industrial and commercial industries. The proposed footprint of the project does not include land or soil suitable for agricultural activities or designated as prime farmland (NRCS 2011).

## 2.6 Water Quality

The Texas Commission on Environmental Quality (TCEQ) (2020) Integrated Report of Surface Water Quality for the Clean Water Act Sections 305(b) and 303(d) has designated water quality segments for individual components of the GIWW between Sargent Beach and Matagorda Bay, which contains a series of classified water bodies designated Segments 2501 and 2441 respectively in the Bays and Estuaries category. Water body uses of this section are: High Aquatic Life Use; Contact Recreation Use; General Use; Fish Consumption Use, and Oyster Waters Use. Inventory data from 2018 indicate the quality of water in the vicinity of the project is generally considered to be good; Aquatic Life Use, Fish Consumption Use, Contact Recreation Use and General Use are fully supported or of no concern for the Matagorda Bay water segment (TCEQ, 2018a). Only Oyster Waters Use was non-supporting as a result of high levels of bacteria (TCEQ, 2018a), which were also attributed to non-point sources associated with urban runoff and storm sewers (TCEQ 2018b), resulting in restrictions on shellfish harvesting in East Matagorda Bay.

A review of the National Response Center web page (NRC, 2020) was also conducted. Records for the past three years did not reveal any reports of significant chemical or petroleum spills in the project vicinity. But there were several incidences of minor spills of hydraulic oil, diesel fuel, leaks from a sinking vessel, or unknown sheens. These releases were either secured or left to dissipate, as appropriate.

## 2.7 Tides and Salinity

The normal daily mean tidal range along the project study area is about 0.4 to 0.7 feet, depending on proximity to the Gulf, with larger variations dependent upon the wind. During winter, weather fronts out of the northwest are usually accompanied by strong winds that may depress the water surface as much as 4 feet below mean sea level. At other times of the year, predominantly southerly winds, when coupled with higher-than-normal tides (i.e. spring tides), may occasionally and temporarily raise surface water elevations; this effect. Large fluctuations in water surface elevation may also occur during tropical storms and hurricanes (USACE, 1975).

Salinity varies along the GIWW in Matagorda and Brazoria Counties from negligible (<0.5ppt) where freshwater inputs like the Colorado River intersect to hyper-saline (+35 ppt), like in back bay areas of East Matagorda where tidal exchange is weak, freshwater input is low, and evaporation accentuates saline concentrations. In general, most salinity falls between 10 to 30 ppt, but concentrations are heavily dependent on freshwater input and seasonality. For additional information, see Engineering Appendix D, Section 2.3.5.

In general, salinity can be expected to increase slightly with sea level change, as higher tidal elevations impact greater area, but in some cases, additional tidal prism may actually encourage greater mixing, connectivity, and exchange leading to reduced hyper-salinity where it exists. Future barrier loss is also expected to influence system salinity; however these bay systems have been productive for a long period of time both prior to and after barrier loss.

## 2.8 Sea Level Change

USACE guidance (ER 1100-2-8162, June 2019 and Engineer Technical Letter (ETL) 1100-2-1, March 2019) specify the procedures for evaluating and incorporating climate change and relative sea level change into USACE planning studies and engineering design projects.

USACE guidance recommend that projects be evaluated using three different projections of future sea level change, i.e., “low, intermediate, and high,” as follows:

1. 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).

2. Intermediate – Estimate the “intermediate” rate of local mean sea level change using the modified NRC Curve I. The modified curve corrects for the local rate of vertical land movement.

3. High – Estimate the “high” rate of local mean sea level change using the modified NRC Curve III. The modified curve corrects for the local rate of vertical land movement.

Additionally, USACE guidance also recommend that RSLC be evaluated at planning horizons other than the one used in the economic analysis, recommending at a minimum, RSLC analysis at 20-, 50-, and 100-years post-construction.

Utilizing the online sea level calculator referenced in ER 1100-2-8162, estimates of future RSLC were determined. The computed future rates of RSLC in **Table 4** below give the predicted low, intermediate, and high estimates of sea level change at the 20-, 50- and 100-year planning horizons.

**Table 5: Estimated Change in Relative Sea Level over 20-, 50- and 100-year (2020-2120) period of analysis for the Low, Intermediate and High-Rate Scenarios**

| **Scenario** | **2020** | **2070** | **2120** |
|---|---|---|---|
| Low Rate | 0.30 | 1.25 | 1.82 |
| Intermediate Rate | 0.37 | 1.79 | 2.86 |
| High Rate | 0.59 | 3.50 | 6.15 |

## 2.9 Wetlands

Wetlands are defined as areas where the frequent and prolonged presence of water at or near the soil surface drives the natural system including the type of soils (i.e. hydric soils) that form, the plants that grow and the fish and/or wildlife that use the habitat. The existing project footprint (Figure 4 below) covers approximately 1,500 acres with a majority of that occurring in Estuarine and Marine Deep-water wetlands. Using the latest aerial imagery from the National Agriculture Imager Program (NAIP), almost all of the Estuarine and Deep-Water wetlands found in the National Wetlands Inventory (NWI) GIS data were open-water habitat due to erosion and natural coastal processes. The remaining wetland habitats are split up among 4 wetland types consisting of 320 acres of Estuarine and Marine Wetlands, 2.4 acres of Lakes, 3 acres of Freshwater Ponds, and 0.1 acres of Freshwater Emergent Wetland. The Estuarine System consists of deep-water tidal habitats and adjacent tidal wetlands that are used semi enclosed by land but have open access to the ocean. Submerged aquatic vegetation is unlikely to occur within these deep-water wetland types. The immediate shoreline located on the banks of the GIWW and along existing barrier islands is populated by saltmarsh cordgrass (*Spartina alterniflora*), saltmeadow cordgrass (*S. patens*), saltwort (*Batis maritima*), sea-ox eye daisy (*Borrichia frutescens*), big leaf sumpweed (*Iva frutescens*) and gulf cordgrass (*S. spartinae*)).


**Figure 4: Wetlands within Project Study Area**

## 2.10 Coastal Barrier Resources

When the GIWW was initially dredged, some sections of land on the “bay sides” of the channel became islands and some mimic barrier resources in that they are linear landforms that can have sand flats, mud flats, and isolated scrub type habitat. During that initial dredging of the GIWW in the 1940’s, dredge material was commonly placed on these “bay side” features which caused them to have elevations above the natural grade. Most of these linear features are deteriorating from multiple stressors, including but not limited to, fetch, ship wakes, coastal storm surges, relative sea level change, and tidal influences.

Project Zones 12, 13, and 14 overlap Coastal Barrier Resources System (CBRS) units T07 and T07P in Matagorda County, Texas. The Coastal Barrier Resources Act (CBRA) of 1982 established the Coastal Barrier Resources System (CBRS) to minimize the loss of human life, wasteful Federal expenditures, and damage to fish, wildlife, and other natural resources associated with coastal barriers.

CBRS unit T07P contains critical habitat for the Piping Plover (*Charadrius melodus*). The designation of the critical habitat in 50 CFR Part 17 includes a description of the existing barrier resources are described in constituent elements for unit TX-28 as containing sand flats with little or no emergent vegetation, areas with surf-cast algae, and unvegetated or sparsely vegetated sandy backbeach and washovers which are used by overwintering Piping plovers for roosting, sheltering, and feeding. Additional discussions on critical habitat for the Piping Plover can be found in the Biological Assessment included in the Environmental Appendix.

The Bureau of Economic Geology (Paine *et al*. 2014) identified long-term (1930's - 2012) and recent (2000 – 2012) shoreline change rates for Matagorda Peninsula and Matagorda Island that range from -0.57 meters per year to -1.24 meters per year. Both the long-term and short-term projections for CBRS units T07 and T07P include continued erosion of gulf shoreline which is expected to contribute to a loss of Coastal Barrier Resources in the project area.

## 2.11 Biological Resources

The study area is 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.

### 2.11.1 Vegetation

Barrier shorelines and associated back marsh areas are dynamic areas with considerable spatial and temporal variation in plant species distribution. Vegetation is one of the most important factors in trapping and retaining sediments in the barrier shoreline system. The zones, or communities, of barrier island vegetation, and the extent of their diversity, are related to elevation, degree of exposure to salt spray, and storm events that cause overwash. Plant colonies trap and retain suspended sediment (those essential for platform accretion) and protect newly deposited material from erosion. Vegetation also contributes to soil structure, nutrients, and trophic level food supply through their decomposition and subsequent accumulation of organic matter (detrital material). In addition to the structural and nourishment benefits, vegetation also provides habitat function and serves as an indirect indicator of wildlife and fisheries species vigor and condition.

In the Matagorda Bay area, low salt marsh is typically dominated by smooth cordgrass (Spartina alterniflora) and common species such as saltgrass (Distichlis spicata), glasswort (Salicornia spp.), saltwort (Batis maritima), saltmarsh aster (Symphyotrichum tenuifolium), and mangrove (Avicennia germinans). High salt marshes may include more halophytic species such as shoregrass (Monanthochloe littoralis), annual seepweed (Sueda linearis), sea ox-eye daisy (Borrichia frutescens), and seapurslane (Sesuvium portulacastrum).

Higher elevations in the study areas, such as portions of the riverbanks 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 sugar hackberry (*Celtis laevigata*), Chinaberry (Melia azedarach), Chinese tallow, honey mesquite (Prosopis glandulosa), Hercules'-club (*Zanthoxylum clava-herculis*), , 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*), Virginia creeper (*Parthenocissus quinquefolia*), and peppervine (*Ampelopsis arborea*).

Approximately 180 acres of Seagrass can be found in the Study Area. The seagrass beds in the study are most likely comprised of Shoal Grass (Halodule beaudettei), Widgeon Grass (Ruppia maritima), and Star Grass (Halophila engelmanni). Seagrasses are ecologically important, as they are primary producers that provide food for snails, crustaceans, and fishes as well as providing shelter for juvenile fishes and invertebrates. Seagrasses are also important to sea turtle species that either graze directly on seagrass or use seagrass beds as foraging grounds to feed on crustaceans or other prey. Seagrasses are also important for coastal resiliency since they suppress wave action, which reduces the effects of coastal erosion and stabilizes sediments.

### 2.11.2 Aquatic Resources

Open-water habitats support communities of benthic organisms and corresponding fisheries populations. Phytoplankton (microscopic algae) are the major primary producers (plant life) in the open bay, taking up carbon through photosynthesis and nutrients for growth. Phytoplankton are the base of the food chain and are fed upon by zooplankton (small crustaceans), fish, and benthic consumers. Zooplankton are most abundant during the spring, with the minimum occurring in the fall. Benthic marine organisms are an ecologically important component of the marine resources, serving as a major source of food for many species of fish and shellfish of commercial and recreational importance. Benthic organisms are also primary consumers, feeding on micro- algae and plant detritus, providing an important link in the marine food chain. The most abundant benthic organisms in the project area include annelid worms (polychaetes and oligo- chaetes), peracarid crustaceans (amphipods and tanaidaceans), and mollusks (bivalves and gas- tropods) (GBNEP, 1992).

Nekton assemblages (organisms that swim freely in the water column) consist mainly of secondary consumers feeding on zooplankton or juvenile and smaller nekton. The Matagorda Bay system supports a diverse nekton population including fish, shrimp, and crabs. Some of these species are resident species, spending their entire life in the bay, whereas others are migrant species spending only a portion of their life cycle in the estuary (Armstrong et al., 1987).

Approximately 45 acres of oyster reefs can be found in the Study Area. Eastern Oysters are a commercially important species across the US. The Eastern Oyster is the primary species of oyster found in the Gulf of Mexico, and is ecologically important since they filter water from the surrounding environment, provide habitat for small fishes and invertebrates, provide food for certain aquatic animals, and serve as natural breakwaters to reduce coastal erosion.

### 2.11.3 Wildlife

Birds found in the area include a variety of waterfowl, shorebirds and wading birds, a variety of gulls and terns (Laridae family), and herons and egrets (Ardeidae family). Other birds that may be found in the area include the brown pelican (Pelecanus occidentalis), white-faced ibis (Plegadis chihi), black rail (Laterallus jamaicensis), red-winged blackbird (Agelaius phoeniceus), and the marsh hawk (Circus cyaneus) (The Nature Conservancy of Texas, 2009).

Piping plover (Charadrius melodus) are also known to winter along the Texas Gulf Coast on beaches and bayside mud or sand flats.

Mammals potentially found within terrestrial areas in and adjacent to the project area include the hispid cotton rat (Siomodon hispidus), the eastern cottontail (Svlvilaous floridanus), opossum (Didelphis virginiana), raccoon (Procyon lotor), coyote (Canis latrans), and white-tailed deer (Odocoileus virginianus). The common bottlenose dolphin (Tursiops truncatus) is the most abundant, year-round marine mammal inhabiting the waters of project area.

The most common marine reptiles inhabiting bay waters of the project area are the Kemp's ridley sea turtle (Lepidochelys kempii) and loggerhead sea turtles (Caretta caretta).

## 2.12 Threatened and Endangered Species

According to the USFWS's Information for Planning and Consultation (IPaC) website and the NMFS's (https://www.fisheries.noaa.gov/southeast/consultations/gulf-mexico) Gulf of Mexico Consultations website, 28 threatened or endangered species need consideration for projects located in Matagorda County, Texas. Those species and the determination of the potential for them to occur in the project area is provided in Table 5 below.

The project would also involve work within federally designated piping plover critical habitat. Specifically, in Zone 12, 1,120 linear feet of rock breakwater would be installed within a total of 1.13 acre of Piping Plover critical habitat (Figure 5). Initial plans considered barrier restoration and breakwaters on the bay side of Zone 12 to address projected barrier loss; however, as a result of agency coordination, the design was iteratively scaled back. Hydrodynamic, Salinity, and Sediment Transport Modeling was performed for the project and the analysis is presented in Appendix C, Engineering Design, Cost Estimates, and Cost Risk Analysis.

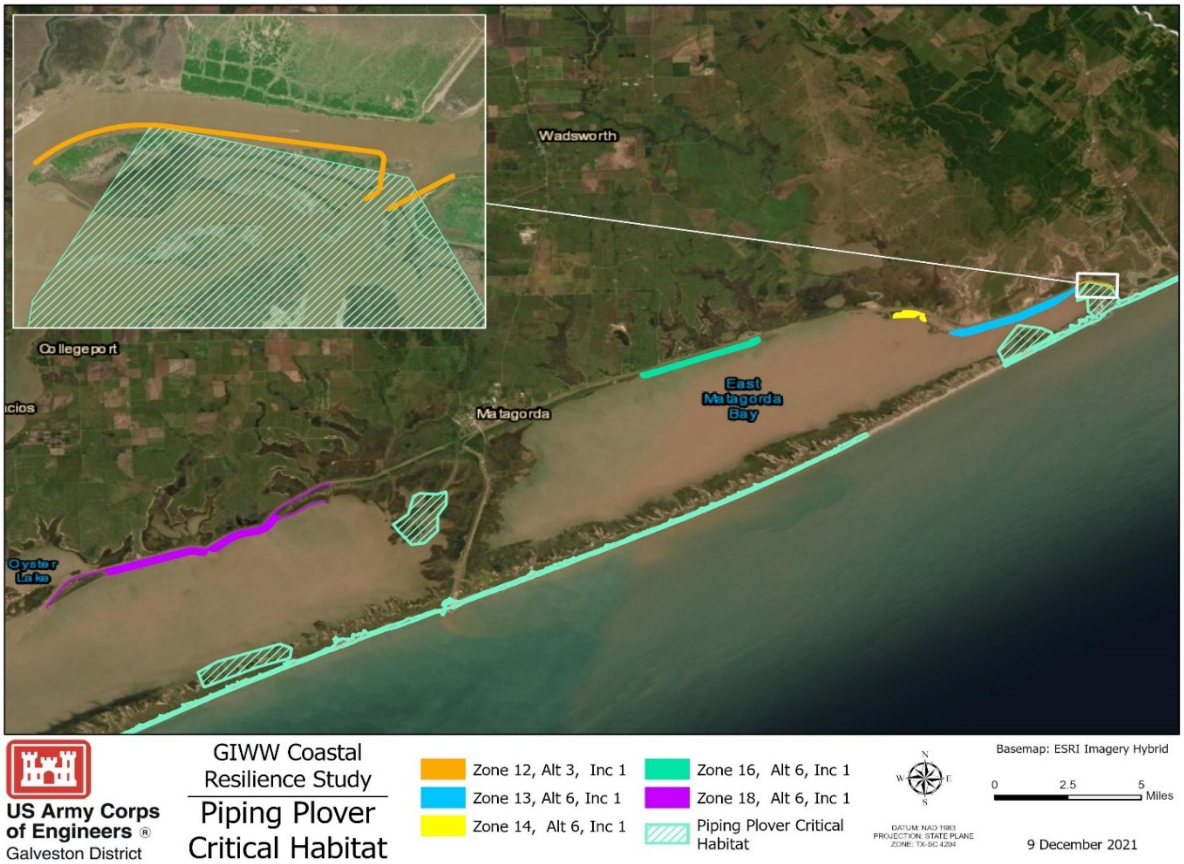


**Figure 5: Piping Plover Critical Habitat within the project vicinity.**

A draft Biological Assessment (BA) has been prepared that includes information on the distribution and habitat requirements of these species, as well as their likelihood of occurrence within the project area (see Appendix D). This BA addresses the proposed project's potential impact on federally listed threatened and endangered species.

**Table 6: Federally Listed Threatened and Endangered Species for Matagorda County, Texas**

| Listed Species Common Name | Scientific Name | Listing Status | Agency Trust Resource | Potential to Occur in GIWW-CRS study area? |
|---|---|---|---|---|
| Mammals | | | | |
| West Indian manatee | *Trichechus manatus* | Threatened | USFWS | Yes |
| Sperm Whale | *Physeter macrocephalus* | Endangered | NMFS | No |
| Rice's Whale | *Balaenoptera ricei* | Endangered | NMFS | No |
| Birds | | | | |
| Eastern Black Rail | *Laterallus jamaicensis ssp.* | Threatened | USFWS | Yes |
| Northern Aplomado Falcon | *Falco femoralis septentrionalis* | Endangered | USFWS | No |
| Piping Plover | *Charadrius melodus* | Threatened | USFWS | Yes |
| Red Knot | *Calidris canutus rufa* | Threatened | USFWS | Yes |
| Whooping Crane | *Grus americana* | Endangered | USFWS | Yes |
| Reptiles | | | | |
| Green Sea Turtle | *Chelonia mydas* | Threatened | USFWS; 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* | Threatened | USFWS; NMFS | Yes |
| Invertebrates | | | | |
| Texas Fawnsfoot | *Truncilla macrodon* | Proposed Threatened | USFWS | No |
| Texas Pimpleback | *Cyclonaias petrina* | Proposed Endangered | USFWS | No |
| Monarch Butterfly | *Danaus plexippus* | Candidate | USFWS | Yes |
| Elkhorn Coral | *Acropora palmata* | Threatened | NMFS | No |
| Staghorn Coral | *Acropora cervicornis* | Threatened | NMFS | No |
| Boulder Star Coral | *Orbicella franksi* | Threatened | NMFS | No |
| Mountainous Star Coral | *Orbicella faveolata* | Threatened | NMFS | No |
| Lobed Star Coral | *Orbicella annularis* | Threatened | NMFS | No |
| Pillar Coral | *Dendrogyra cylindrus* | Threatened | NMFS | No |
| Rough Cactus Coral | *Mycetophyllia ferox* | Threatened | NMFS | No |
| Fish | | | | |
| Smalltooth Sawfish | *Pristis pectinata* | Endangered | NMFS | No |
| Gulf Sturgeon | *Acipenser oxyrinchus desotoi* | Threatened | NMFS | No |
| Nassau Grouper | *Epinephelus striatus* | Threatened | NMFS | No |
| Oceanic Whitetip Shark | *Carcharhinus longimanus* | Threatened | NMFS | No |
| Giant Manta Ray | *Manta birostris* | Threatened | NMFS | No |

## 2.13 Aquatic Nuisance Species

Ballast water discharged from ships may contribute to the introduction and spread of aquatic nuisance species (ANS) from distant ports of call into U.S. waters. ANS are invasive, non-native or exotic species that may displace native species, degrade native habitats, spread disease, and disrupt human social and economic activities that depend on water resources (U.S. Coast Guard (USCG), 2011a). ANS that are known to occur within the study area that may have been introduced as a result of ballast water discharge or boat hull fouling include the Australian jellyfish (Phylloriza punctata), the Pacific white shrimp (Litopenaeus vannamei), the white crust tunicate (Didenum perlicidum), and sauerkraut grass (Zoobotryon vertcillatum).

In response to national concerns, the National Invasive Species Act of 1996 (NISA) was reauthorized and amended the Nonindigenous Aquatic Nuisance Prevention and Control Act of 1990 (NANPCA). Initially a voluntary program beginning in 1998, the USCG established a national mandatory ballast water management program in 2004 to comply with the NISA to prevent the introduction of ANS. The implementing regulations for the program may be found at 33 Code of Federal Regulations (CFR) 151 Subparts C and D (USCG, 2011b).

The program applies to all vessels equipped with ballast water tanks and requires mandatory ballast water management plans and practices for all vessels that operate in U.S. waters or are bound for ports or places in the United States. Ballast water management practices may include conducting mid-ocean ballast water exchanges, retaining ballast water onboard, or using an alternative environmentally sound ballast water management method approved by the USCG.

### 2.13.1 Recreational Resources

The Texas Gulf Coast along the project study area contains important habitat for recreationally sought estuarine fish and crustaceans, including red and black drum, spotted and sand seatrout, Atlantic croaker, flounder, striped mullet, sheepshead, brown and white shrimp, blue crab, and oyster. Sports fishermen find the beaches and bays excellent for recreation because of the quantity and diversity of game fish. Moderate hunting for waterfowl and a great amount of bird watching and other wildlife-oriented recreation also occur in the project area. Recreational fishing includes both trips on commercial vessels (headboats, or boats that charge by the person for fishing trips) and privately owned recreational fishing boats. All of these are part of the commercial and recreational navigation baseline.

Development of the area as a recreational destination relates to its proximity to the population of the Houston-Galveston metropolitan area. The marshes, beaches, lakes, bays, and other natural amenities found along the study area have historically attracted residents and tourists. The warm climate and scenic sites provide public and private recreational facilities year-round. For example, the 5,000-ac Big Boggy National Wildlife Refuge (NWR) located adjacent to the project area, is a coastal salt marsh that provides ample bird watching, saltwater fishing, and waterfowl hunting opportunities. Other form of recreational activities includes biking, camping, boating, water and jet skiing, hiking, and picnicking.

## 2.14 Socioeconomics

Socioeconomics is defined as the basic attributes and resources associated with the human environment, particularly population, demographics, and economic development. Demographics entail population characteristics and include data pertaining to race, gender, income, housing, poverty status, and educational attainment. Economic development or activity typically includes employment, wages, business patterns, an area's industrial base, and its economic growth. The socio-economic characteristics of the City of Bay City, Texas, located near the project study area, compared to the rest of the state are presented in Table 6. The City of Bay City had a population of 17,528 living in 8,304 households in 2017. The racial makeup of the city was 35.8 percent White, 14.5 percent African American, 0.4 percent Native American, 0.1 percent Asian, 0.1 percent other, and 1.6 percent from two or more races. Of the total population, 46.9 percent were of Hispanic or Latino origin. Approximately 27.1 percent of families in the City live below the poverty line compared to 14.7 percent in the state (CDM, 2020).

**Table 7: Population Data for Bay City, Texas**

| Population Metric | Bay City, Texas | Texas |
|---|---|---|
| | **Population** | |
| Total Population | 17,528 | 25,145,561 |
| Total Households | 8,304 | 9,977,436 |
| | **Race and Ethnicity** | |
| White | 35.8% | 45.3% |
| Black or African American | 14.5% | 11.5% |
| Native American or Alaska Native | 0.4% | 0.3% |
| Asian | 0.1% | 3.5% |
| Native Hawaiian or Other Pacific Islander | 0.1% | 0.1% |
| Other Race | 0.1% | 0.1% |
| Two or More Races | 1.6% | 1.3% |
| Hispanic | 46.9% | 37.6% |
| | **Age** | |
| Under 5 years | 7.3% | 15.3% |
| 6 to 18 years | 28.1% | 15.0% |
| 19 to 65 years | 50.3% | 62.7% |
| Over 65 years | 14.3% | 7.0% |
| | **Education** | |
| High School Diploma | 75.7% | 80.0% |
| | **Household Income** | |
| Median Household Income | $44,677 | $59,206 |
| Less than $14,999 | 9.5% | 13.4% |
| $15,000 to $24,999 | 11.8% | 11.4% |
| $25,00 to $49,999 | 39.8% | 25.5% |
| $50,000 to $74,999 | 28.8% | 18.1% |
| Greater than $75,000 | 11.06% | 31.6% |
| USCB, 2020 | | |

## 2.15 Environmental Justice

In compliance with Executive Order (EO) 12898, Federal Action to Address Environmental Justice in Minority and Low-Income Populations, an analysis was performed to determine whether the proposed project would have a disproportionately adverse impact on minority or low-income population groups in the vicinity of the project area. Low-income persons are defined as “a person whose household income is at or below the Department of Health and Human Services (HHS) poverty guidelines.” The 2020 HHS poverty guideline for a family of three is $21,720. This analysis consisted of determining characteristics of residential populations in the project area. The proposed project would not separate, or isolate any distinct neighborhoods, ethnic groups, or other specific groups. There are no disproportionate impacts on any minority and/or low-income populations associated with the project.

## 2.16 Noise

Federal and local governments have established noise guidelines and regulations for the purpose of protecting citizens from potential hearing damage and from various other adverse physiological, psychological, and social effects associated with noise. The Federal Interagency Committee on Urban Noise developed land-use compatibility guidelines for noise in terms of day-night average sound level (DNL). It is recommended that no residential uses, such as homes, multifamily dwellings, dormitories, hotels, and mobile home parks, be located where the noise is expected to exceed a DNL of 65 decibels (dBA). For outdoor activities, the EPA recommends DNL of 55 dBA as the sound level below which there is no reason to suspect that the general population would be at risk from any of the effects of noise (EPA, 1974). Noise-sensitive receptors are facilities or areas where excessive noise may disrupt normal activity, cause annoyance, or loss of business. Land uses such as residential, religious, educational, recreational, and medical facilities are more sensitive to increased noise levels than are commercial and industrial land uses.

## 2.17 Air Quality

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

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

The project area is located within Matagorda County, Texas, and is part of an area designated as in attainment, meaning concentrations of criteria pollutants are below the levels established by the NAAQS. Due to the de minimis finding and the area's NAAQS attainment status, a General Conformity determination is not required.

## 2.18 Hazardous, Toxic, and Radioactive Waste

To complete a feasibility level HTRW evaluation for the Gulf Intercoastal Waterway Coastal Resiliency Study, a report was completed 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. These two documents outline a process which has three main components (excluding the report itself): the records review, site reconnaissance, and interviews.

### 2.18.1 Records Review

Perhaps the most critical part of the feasibility level HTRW evaluation is the records review. In this, records, maps and other documents that provide environmental information about the project area are obtained and reviewed. To complete the records review, USACE used publicly available environmental databases. This records review was completed using the proposed footprint of the project, and the standard ASTM environmental record sources, along with an approximate 1 Mile search distance for each of the sources shown in the below **Table 7.** Once the database searches were complete, USACE analyzed the results for recognized environmental conditions (RECs) that could affect the proposed project or need further investigation, given the proposed project measures. Due to the conservative search distances and specifics of the proposed project, many of the record search results can be dismissed from further consideration in this study. The results of that analysis, specifics of the REC (where applicable), and justification for dismissal from further evaluation (where applicable) are discussed below.

**Table 8: Standard ASTM Search Distances and Records Review Results**

| ASTM Source | ASTM Distance (miles) | Searched Distance (miles) | Number of Results |
|---|---|---|---|
| Federal National Priorities List (NPL) site list | 1.0 | 1.0 | 0 |
| Federal Delisted NPL site list | 0.5 | 1.0 | 0 |
| Federal CERCLIS (SEMS) list | 0.5 | 1.0 | 0 |
| Federal NFRAP (SEMS archive) site list | 0.5 | 1.0 | 0 |
| Federal RCRA Corrective Action facilities list | 1.0 | 1.0 | 0 |
| Federal RCRA TSD facilities list | 0.5 | 1.0 | 0 |
| Federal RCRA generators list | Property and adjacent properties only | 1.0 | 0 |
| Federal ICs/Engineering Control registry | Property only | 1.0 | 0 |
| Federal ERNS list | Property only | 1.0 | 0 |
| State and tribal equivalent NPL list | 1.0 | 1.0 | 0 |
| State and tribal equivalent CERCLIS | 0.5 | 1.0 | 0 |
| State and tribal landfill and/or solid waste disposal sites | 0.5 | 1.0 | 1 |
| State and tribal leaking AST/UST sites | 0.5 | 1.0 | 0 |
| State and tribal registered storage tank list | Property and adjacent properties only | 1.0 | 1 |
| State and tribal ICs/Engineering Control registry | Property only | 1.0 | 0 |
| State and tribal voluntary cleanup sites | 0.5 | 1.0 | 0 |
| Federal, State and tribal Brownfields site list | 0.5 | 1.0 | 0 |

Federal Institutional Controls (IC)/Engineering Controls Registry – Engineering controls and ICs are both methods of preventing exposure to contaminants on a particular site. This database is a listing of sites where one or both of those controls are in place. There weren't any sites with these measures in place that were identified within a one-mile radius of GIWW project footprint. However, the ASTM standard only requires that the proposed project property be searched for ICs or engineering controls.

State and Tribal Solid Waste Facilities/Landfill Sites – This search is designed to check any state or tribal databases for solid waste handling facilities or landfills in the project vicinity. The search found 1 closed site within 0.5 miles that handled primarily only solid waste and thus, will not be carried forward as a REC.

State and Tribal Registered Storage Tanks – This list is a combination of the State of Texas registered UST and AST databases, representing sites with storage tanks registered with the State of Texas. Within a mile radius there was 1 tank identified. However, the existence of a registered storage tank (UST or AST) is not sufficient to believe that contamination is likely to be generated, and therefore it will not be carried forward as a REC.

### 2.18.2 CONCLUSION

In order to complete a feasibility level HTRW evaluation for GIWW Coastal Resiliency Study project footprint, this report was completed 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. No sites were found that had recognized environmental conditions.

## 2.19 Cultural Resources

### 2.19.1 Background

Federal agencies are required under Section 106 of the National Historic Preservation Act to "consider the effects of their undertakings on historic properties" and consider alternatives "to avoid, minimize or mitigate the undertaking's adverse effects on historic properties" [(36 CFR 800.1(a-c)] in consultation with the State Historic Preservation Officer (SHPO) and appropriate federally recognized Indian Tribes (Tribal Historic Preservation Officers - THPO) [(36 CFR 800.2(c)]. In accordance with this and other applicable regulations, including the National Environmental Policy Act of 1969 (NEPA), the Native American Graves Protection and Repatriation Act (NAGPRA), the Antiquities Code of Texas, and Engineer Regulation (ER) 1105-2-100, USACE has reviewed of the Texas Historical Commission (THC) ATLAS Database to better determine the existing conditions and potential risks of encountering cultural resources.

Human habitation along the north central coast in the vicinity of Matagorda Bay has only been identified in the region as early as 7,500 BP. This region has broad coastal estuarine systems and bays and coastal prairies further inland. Sediments in the region consist of fluvial deposits and delta formations overlying Pleistocene aged clay. Prehistoric archeological sites are primarily located adjacent to brackish estuarine systems. Shell midden sites are especially common in the region along the shorelines and upland areas adjacent to rivers and bays and on the barrier islands. This portion of the central Texas Coast is very rural, and historic sites are located in small urban centers, but farmsteads, ranches, and plantations also occur across the region. Shipwrecks are also common in the general area.

### 2.19.2 Cultural Resources and Area of Potential Effects

The activities associated with the proposed undertaking include all new construction, improvements, and maintenance activities related to the proposed Gulf Intracoastal Waterway (GIWW) Coastal Resilience Study, Texas. The Area of Potential Effect (APE) includes the footprint of all areas in the recommended plan that will be directly impacted and all areas within 1,000 meters of the footprint that will be indirectly impacted. Direct impacts will include the new construction of structures, construction of staging and access areas, dredge areas, ecosystem restoration features, construction of ecological features, marsh nourishment, and project maintenance. Indirect impacts include primarily the visual impacts of elevated structures that have a potential to affect historic buildings, structures, or landscapes. The APE will also include activities that may be added during Preconstruction Engineering and Design (PED).

Twenty terrestrial cultural resource investigations have been performed within 1,000 meters of the APE. These investigations consist entirely of archeological investigations. Eighteen archeological sites and one shipwreck have been identified within 1,000 meters of the project area. The resources are listed in **Table 8**.

**Table 9: Archeological Sites**

| Site Number | National Register of Historic Places Eligibility | Cultural Affiliation | Site Type |
|---|---|---|---|
| 41MG1 | Undetermined | Historic, Possible Prehistoric | Battlefield, Possible Shell Midden |
| 41MG2 | Undetermined | Prehistoric | Shell Midden |
| 41MG11 | Undetermined | Prehistoric | Shell Midden |
| 41MG54 | Undetermined | Prehistoric | Shell Midden |
| 41MG55 | Undetermined | Prehistoric | Shell Midden |
| 41MG56 | Undetermined | Prehistoric | Shell Midden |
| 41MG57 | Undetermined | Prehistoric | Shell Midden |
| 41MG60 | Ineligible | Prehistoric | Shell Midden |
| 41MG64 | Undetermined | Prehistoric | Shell Midden |
| 41MG111 | Undetermined | Prehistoric | Unknown |
| 41MG117 | Ineligible | Prehistoric | Shell Midden |
| 41MG118 | Ineligible | Prehistoric | Shell Midden |
| 41MG119 | Ineligible | Prehistoric | Shell Midden |
| 41MG120 | Undetermined | Prehistoric | Shell Midden |
| 41MG121 | Undetermined | Prehistoric | Shell Midden |
| 41MG122 | Undetermined | Prehistoric | Shell Midden |
| 41MG123 | Ineligible | Prehistoric | Shell Midden |
| 41MG124 | Undetermined | Prehistoric | Shell Midden |
| 2484 | Undetermined | Historic | 1864 Shipwreck |

### 2.19.3 Recommendations

There could be the potential for the proposed project to impact historic properties. The features proposed for this project could involve the construction of structures that have a potential to affect historic properties directly and indirectly in both terrestrial and submerged environments. The proposed project is in an area that would be considered to have a high probability for terrestrial and submerged cultural resources to occur. If the recommended plan would involve construction in previously undisturbed environments, USACE would recommend an intensive cultural resources survey for all proposed project areas to include marine and terrestrial archeological investigations and a historic building and structure survey to determine the presence or absence of historic properties within the APE. These investigations would be conducted prior to construction during the USACE PED phase. The scope of these investigations would be determined in concert with the Texas State Historic Preservation Officer and Native American Tribes and in accordance with the Programmatic Agreement for this project.

## 2.20 H&H EXISTING CONDITIONS

Barrier islands provide shelter for resilient transit of commercial vessels on the GIWW against waves and currents of the open Gulf of Mexico and to a lesser degree the Bay systems. Erosion of the coastal barriers are caused naturally, by coastal storms and seasonal winds, waves, and currents, and anthropogenically, by vessel induced waves.

In general, erosion caused by natural processes occur mostly on the Gulf side of the GIWW either at the Gulf-barrier or the Bay Barrier, whereas anthropogenic erosion, occurs along the shorelines of the interior of navigation channels such as the GIWW. Both natural and anthropogenic erosion cause an influx of sediment material into the system, but based on examination of shoreline erosion rates, natural processes are producing higher erosion rates. In areas where the barrier is intact, this sediment material that is eroded is generally blocked from entering the GIWW system; however, in places where there are no barriers or there are cuts or breaches, sediment material is able to cycle into the system, especially as these cuts or breaches widen due to erosion.

Once a barrier is eroded, wind-driven waves will accelerate erosion of the shoreline on the other side of the GIWW. In addition, material also enters the system through the watershed runoff and river systems. This is important because sediment influx into the GIWW system results in shoaling which both reduces system reliability and increases system maintenance costs, both negative economic consequences.

Intermediate projections of relative sea level rise from year 2020 are estimated at 0.25-ft for the 2030 project design year and 1.75-ft by year 2080, 50-year design consideration. This rise in water will inundate and submerge much of the barrier between the GIWW and the Gulf. In addition, coastal storms are predicted to become more frequent and intense due to climate change. This is important because under coastal storms, the remaining emergent barrier system, which will become smaller under SLR, will be more susceptible to inundation and erosion from coastal storms because it will be more frequently overtopped. Essentially, sea level rise and coastal storms due to climate change will accelerate barrier loss faster than existing loss rates.

## 2.21 H&H Analyses

Engineering analysis involved collection of existing data and evaluation of existing study area conditions and projection of future study area conditions with the use of USACE navigation support and coastal H&H models. The Corps Shoaling Analysis Tool (CSAT version 2.2.0) was applied in this study to estimate historical annual shoaling rates within Matagorda and Brazoria Counties. Future shoaling rates and coastal geomorphology were assessed using historical shoreline erosion rates, sediment budget analyses, and numerical hydrodynamic and sediment transport modelling.

Existing conditions and the considered alternatives were simulated using the Coastal Modeling System (CMS). The CMS is a depth-averaged hydrodynamic and wave model well suited for the project area. In addition to the flow and wave simulations, the CMS calculates sediment transport and morphologic change throughout the simulations. The CMS model covers the East Matagorda Bay. The CMS model was forced at the boundary using water surface elevation from nearest NOAA stations.

## 2.22 Channel Shoaling Analysis

U.S. Army Corps of Engineers developed eHydro to provide enterprise performance-based analyses and budgeting for coastal navigation channels through geospatial data to be used for uniform method of data dissemination and comparison of latest conditions on coastal navigation channels. The Galveston District processes and reports channel condition data through the eHydro reporting process for all high and moderate commercial use channels, followed by low use channels.

CSAT was applied in this study to estimate annual shoaling rates along all National Channel Framework (NCF) reaches within Matagorda and Brazoria Counties using the eHydro data. NCF is a geodatabase of high-and medium-tonnage Congressionally authorized navigation channels maintained by the USACE. The NCF geodatabase and CSAT-generated high-resolution shoaling maps supported identification of areas with high rates of shoaling and erosion, or “hot spots”. CSAT shoaling estimates are developed by assessing channel dimensions, dredging events, and meteorological events and seasonal variations in rainfall that may influence sediment flux in the system. Results of the shoaling analysis are presented in two groupings, 2011-2015 & 2016-2020, because data was collected with different datum at one point in the period of record. Additional detail on the methodology and results of the CSAT analysis can be found in Annex 2 of the Engineering Appendix D.

The CSAT generated shoaling estimates within Matagorda and Brazoria counties during the 2011-2015 and 2016-2020 time periods were found to be reasonable. These shoaling and sedimentation estimates are consistent/not consistent with the problems described by channel users and USACE navigation experience. The intersection of Caney Creek and Mitchell Cut at the GIWW has been identified as a major area of concern by GICA due shoaling and due to dangerous cross currents during Ebb flow that draw vessels into the Cut.

Average annual shoaling rates along the GIWW from Freeport to the Brazos River Crossing (“Jetty Channel,” “Jetty to Brazosport,” “Brazosport Turning Basin,” “Freeport Harbor to Brazos River,” and “Brazos River Crossing” reaches) were significantly higher in comparison to other reaches with shoaling rate values exceeding 2 ft/yr for both time periods.

## 2.23 Sediment Budget Analysis

The objective of the sediment budget analysis was to develop an annual shoaling rate (ft) for each year of the project at 100-ft increments along the channel. This information would then be used to evaluate the impacts to the Dredge Material Management Plan (DMMP) which will be developed in the future.

To develop the annual shoaling rate for the Future Without Project (FWOP) and Future With Project (FWP) conditions, a baseline first needed to be established, so the historical shoaling rate was estimated using the Corps Shoaling Analysis Tool (CSAT) based on historical survey and dredging history. Data was processed from 2011-2015 and 2016-2020 and then averaged. This was performed for both Brazoria and Matagorda Counties to establish a baseline historical shoaling rate in the channel.

To project shoaling changes over time and by plan, the factors influencing the shoaling rate needed to be assessed. The three primary sedimentary inputs to the system are shoreline erosion, watershed runoff, and open-water circulation. Sediment that enters the system either shoals in the channel or is deposited in the bay or is released out into the Gulf through inlets.

To estimate the shoreline erosion, a geospatial analysis was performed using aerial imagery from 2018, 2011, 1995, and 1943. Shoreline shapefiles were created for each year. The shoreline was categorized as either Channel Landward (CL), Channel Bayside (CB), or Barrier Bayside (BB). Shoreline erosion for each of these categorizations were computed from 2018 to 2011 and converted into an annual erosion rate. In addition a weighted smoothing algorithm was performed +/- 500-ft along the channel.

In addition, shapefiles were created for any existing or planned armoring. Existing armoring included existing revetments, breakwaters, and bulkheads, as well as the Sargent Beach revetment. Planned armoring included Coastal Texas and the GIWW-CR measures, all anticipated for 2030. In the analysis, whenever armoring was identified, the erosion rate was set to zero and the shoreline was set to the location of the armoring.

From the shoaling analysis, the existing highest area of concern is Zone 12, but is followed closely by the transition between Zone 18 and Zone 19. It is interesting to see in the historical CSAT the changes between the 2011-2015 and 2016-2019 rates, particularly zone 13, where the rates have gone up as a result of the barrier being heavily breached. In terms of future shoaling changes, the area of greatest concern is zone 18, followed by zone 16 as these are two areas that will have barrier breached. For additional information about the sediment budget analysis, see the Engineering Appendix D.

## 2.24 Sediment Transport Model

The intersection of Caney Creek and Mitchell Cut at the GIWW has been identified as a major area of concern by GICA due to shoaling and dangerous cross currents during Ebb flow that draws vessels into the Cut. These issues are a result of the dynamic nature of a tidal inlet.

In 2012/2013, a study was performed (Thomas and Dunkin 2012, Rosati et al. 2013) that assessed the erosion at Sargent Beach and recommended improvements; however this study did not evaluate the shoaling or currents at Caney Creek. The Coastal Modeling System (CMS) numerical model created for the Sargent Beach study was advanced to be used for this project to describe existing conditions at the intersection of Caney Creek and Mitchell's Cut.

CMS is a depth-averaged hydrodynamic and wave model well suited for the project area. In addition to the flow and wave simulations, the CMS calculates sediment transport and morphologic change throughout the simulations. The CMS model domain covers East Matagorda Bay, Sargent Beach and the GIWW (Figure 6). The CMS model was forced at the open water boundary using water surface elevation from nearest NOAA station.

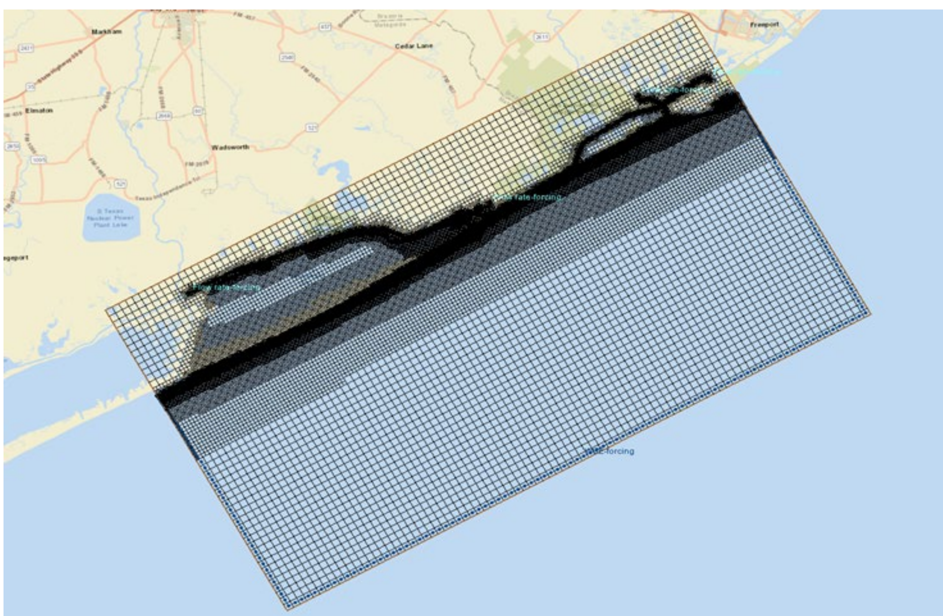


**Figure 6: CMS Computational domain and grid**

### 2.24.1 Summary by Zone

The most vulnerable section of the GIWW within Matagorda and Brazoria county is Sargent Beach (Zone 11). It is the only section of the GIWW that only has a single line of defense between the Gulf and the GIWW. All other sections, except for the open water stretch of

Matagorda Bay (Zones 19 and 20), East Matagorda Bay (Zone 15,14,13), Chocolate Bay (Zone 2), and West Galveston Bay (Zone 1) have a Gulf-Barrier that separates the Gulf from the Bay systems and a Bay-barrier which separates the Bay from the GIWW. These latter zones are not immediately next to the Gulf shoreline and are already open water, so are less vulnerable than Sargent Beach, which is less than 250 ft at its narrowest. The next most vulnerable zones besides the ones previously listed are those where the Bay barrier is intact but is eroding quickly includes Zones 18 and 16. Because the Gulf barriers at 19, 20, and 2 are fairly sizeable and zones 1,15 are being addressed as part of CTX, the next most important and vulnerable sections of the GIWW due to barrier loss after Sargent Beach are Zones 13,14,16, and 18.

Between a barrier that has fully eroded (Zones 1 and 15), and a barrier that is eroding but has not fully breached (Zones 11, 16 and 18), it is the current barrier that is the most vulnerable because it is still a resource and a potential vulnerability to its mass of material it can erode into the system. As a result, the barriers at Zones 11, 16, and 18 are of significant importance, because they represent an existing resource that should it be lost would be more detrimental to lose than the impacts of the ones already lost. If existing barriers, such as along Zone 18 are not stabilized, then within 20 years, that barrier is expected to completely be lost. Currently that section of the GIWW is protected, but if the barrier is lost, the material from that barrier will erode into the GIWW along with the wind driven material from the Bay. In addition, eroded barriers not addressed in the Coastal Texas Plan (Zones 13 and parts of Zone 14) are a vulnerability that should be addressed due to erosion of sediment material caused by winds driven across the Bay that bring material into the channel and erode the unprotected interior shoreline.

The greatest contributors of sediment material into the system that cause shoaling besides barrier losses are the Colorado River (Zone 17), Brazos River (Zone 7), and Caney Creek (Zone 12) crossings. Because the Colorado and Brazos River are part of another USACE study, Caney Creek / Mitchel's Cut crossing is by default the most vulnerable section of the GIWW due to shoaling caused by a river crossing; however the role of the Brazos and Colorado as regional sediment resources should not be neglected. The Caney Creek / Mitchell's Cut crossing is also significant because currents at that intersection have been documented to cause navigation hazards. Shoaling in that area is also linked to erosion at Sargent Beach, so this is area is opportune for synergistic solutions.

As described above, the most vulnerable segments of the GIWW not addressed by other studies, are Zones 11-14, 16, and 18. This includes Sargent Beach (Zone 11), Caney Creek intersection (Zone 12), the unprotected stretches of Zones 13-14, and the eroding barriers of Zones 16 and 18.

## 2.25 GEOTECHNICAL EXISTING CONDITIONS

The current dredged material placement plan requires approximately one-third of the O&M dredge material to be placed into existing upland confined placement areas (PAs) DA 99, DA 100, and PA 102-C. If the O&M dredge material is suitable for beach placement the dredge material will be pumped to PA 98 and PA 98-A to restore the eroding shoreline of Sargent Beach. Generally two-thirds of dredge material is suitable to be placed into Sargent Beach placement areas. Zone 12 experiences high rates of shoaling and requires frequent emergency dredging to remove areas of high shoaling O&M dredge material from the channel.

Future O&M shoaling rates remain relatively constant until 2030 when Texas Coastal Project has construction planned in this zone. Due to the construction of the Texas Coastal Project the annual shoaling quantities decrease immediately from approximately 110,600 CY per year to 104,400 CY per year in 2030. The shoaling rates are expected to increase gradually from approximately 104,400 CY per year in 2030 to 105,600 CY per year in 2080. The Texas Coastal Project will require 247,778 CY of dredge material to be mined from the San Bernard to Colorado River reach and 1,195,299 CY to be mined from PA 102-C in 2030. Approximately one-third of the O&M dredge material will be placed into existing upland confined placement areas (PAs) DA 99, DA 100, and PA 102-C. PAs will be raised as necessary to contain the O&M dredge material. One raise is required in DA 99 and one raise in DA 100 to provide sufficient dredge material capacity until 2080. Approximately two-thirds of the O&M dredge material is suitable to be placed in the surf zone in PA 98 and PA 98-A to restore the eroding shoreline. The frequency of emergency dredging is expected to stay the same through 2080. For more information about the FWOP Placement plan for dredge material, see Sections 3.4 through 3.9 of the Engineering Appendix D.

## 2.26 ECONOMIC CONDITIONS – EXISTING

### 2.26.1 Commodities Overview

The following section details the number of vessels and types of commodities utilizing the Texas portion of the GIWW.

All commercial vessel operators are required to report their vessel trip details to USACE on a monthly basis. These data are recorded by the Waterborne Commerce Statistics Center (WCSC). The following graphs illustrate the historic tonnage that is annually transported on the GIWW.

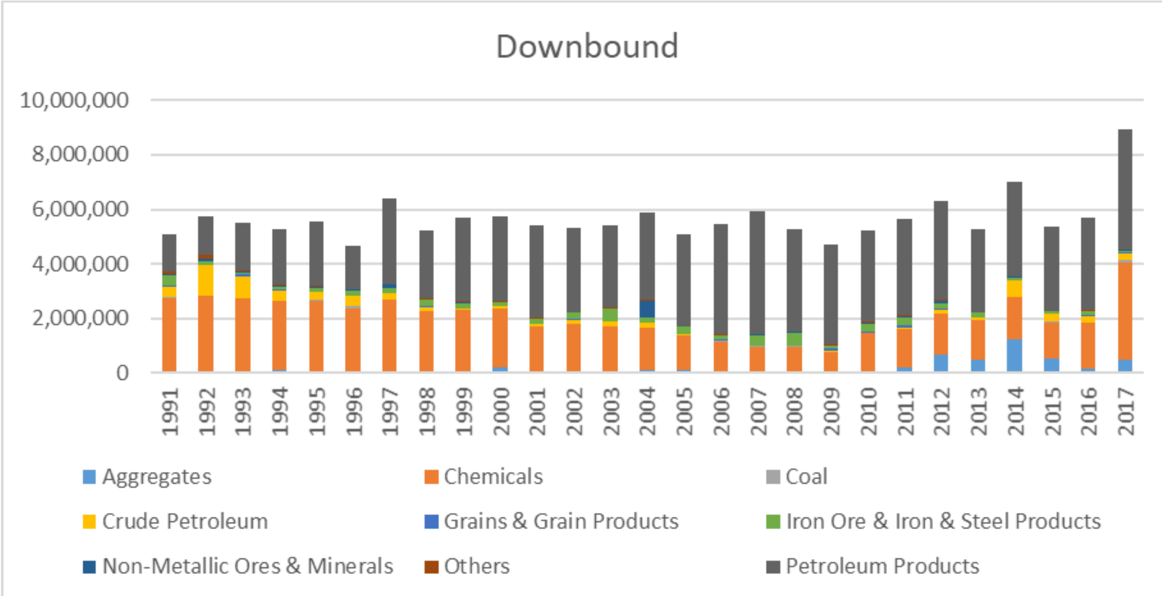


**Figure 7: GIWW Downbound WCSC historic tonnage**

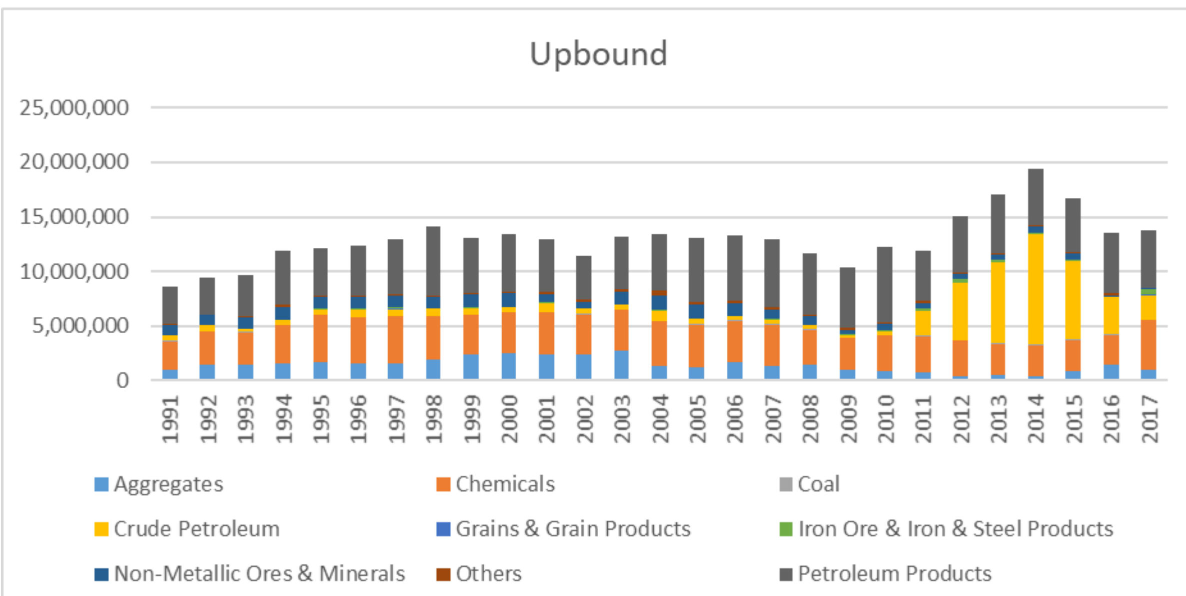


**Figure 8: GIWW Upbound WCSC historic tonnage**

Crude petroleum tonnage on the GIWW has fluctuated dramatically since 2010. In 2009 and 2010, the price of oil was low and pumping in West Texas was limited. As the price of oil climbed, additional wells came online. In 2012, a major discovery of oil and gas was found in the Eagle Ford shale play. Additional oil discoveries have been made in the Permian Basin since 2012. The infrastructure was not in place to accommodate the large increases in tonnages being transported. To capitalize on the market opportunities, initially, large quantities were trucked or railed to the coast to be refined or exported since the pipelines were already operating at capacity. Since water transport is significantly cheaper than truck or rail for longer distances, the preferred method of transport was to use the GIWW. As the market stabilized and additional pipelines came online, the demand to transport oil along the GIWW waned and has now returned to historical levels. If the GIWW was not a resilient channel and could adapt to sudden market changes, billions of dollars in economic activity would not have been realized in the past decade.

**Table 10** displays vessel trips at the Brazos River Floodgates and Colorado River Locks as reported in WCS. These include empty and loaded trips for all towboats and self-propelled commercial vessels. The annual average vessel count in recent years between the two rivers is approximately 4,000 vessels per year traveling each direction upbound and downbound.

**Table 10: Total Commercial Vessels through Brazos River Floodgates and Colorado River Locks**

| Year | Brazos River Flood Gates | Colorado River Locks |
|---|---|---|
| 2013 | 9,252 | 8,835 |
| 2014 | 10,403 | 10,002 |
| 2015 | 8,646 | 8,153 |
| 2016 | 7,102 | 6,631 |
| 2018 | 7,996 | 7,996 |
| 2019 | 7,686 | 7,686 |
| Annual Average | 8,514 | 8,217 |

Source: Waterborne Commerce 2013-2016, AISAP 2018-2019

### 2.26.2 Commodity Forecast

Given the recent market disruptions from the pandemic, determining a reasonable traffic forecast is challenging. The traffic in 2020 and 2021, with all the supply chain disruptions, are probably not reflective of future years, and therefore are not considered as part of the base levels. Additionally, this project is primarily based on vessel delays, and therefore the benefits may not be highly correlated to tonnage growth as typical studies. The growth rate applied is the same growth rate that was used in the BRFG-CRL study completed in 2019. For a detailed description of how that growth rate was developed, the Economic Appendix of the BRFG-CRL study can be reviewed. Chemicals, petroleum products, and crude petroleum are the primary commodities transported on the GIWW, so they were the focus of the growth forecasts.

Since this analysis is primarily based on delays, benefits were calculated first, using existing delays as a base, and then a tonnage growth rate was applied to the benefits calculation to implement traffic growth rather than growing future vessel traffic.

The tables below show historic tonnage and forecasted tonnage for each commodity and totals for both downbound traffic and upbound traffic.

**Table 11: Downbound Historic Tonnage and Forecasted Tonnage (1,000s)**

| Year | Chemicals | Crude Petroleum | Petroleum Products | Other | Total | Index |
|---|---|---|---|---|---|---|
| 1991 | 2,736 | 372 | 1,364 | 627 | 5,100 | 0.77 |
| 1995 | 2,627 | 271 | 2,333 | 307 | 5,540 | 0.83 |
| 2000 | 2,184 | 57 | 3,094 | 419 | 5,756 | 0.86 |
| 2005 | 1,268 | 46 | 3,370 | 412 | 5,099 | 0.77 |
| 2010 | 1,426 | 2 | 3,374 | 447 | 5,250 | 0.79 |
| 2015 | 1,317 | 253 | 3,056 | 721 | 5,348 | 0.80 |
| 2016 | 1,650 | 241 | 3,374 | 431 | 5,697 | 0.86 |
| 2017 | 3,601 | 281 | 4,426 | 629 | 8,937 | 1.34 |
| **Projections (Base Case)** | | | | | | |
| 2020 | 2,189 | 258 | 3,618 | 595 | 6,662 | 1.00 |
| 2025 | 2,555 | 293 | 3,826 | 595 | 7,271 | 1.09 |
| 2030 | 2,905 | 313 | 3,922 | 595 | 7,736 | 1.16 |
| 2035 | 3,254 | 325 | 3,978 | 595 | 8,154 | 1.22 |
| 2040 | 3,607 | 333 | 3,999 | 595 | 8,535 | 1.28 |
| 2045 | 3,958 | 330 | 3,950 | 595 | 8,835 | 1.33 |
| 2050 | 4,094 | 322 | 3,901 | 595 | 8,913 | 1.34 |
| 2060 | 4,094 | 322 | 3,901 | 595 | 8,913 | 1.34 |
| 2070 | 4,094 | 322 | 3,901 | 595 | 8,913 | 1.34 |
| 2080 | 4,094 | 322 | 3,901 | 595 | 8,913 | 1.34 |

**Table 12: Upbound Historical Tonnage and Forecasted Tonnage (1,000s)**

| Year | Chemicals | Crude Petroleum | Petroleum Products | Other | Total | Index |
|---|---|---|---|---|---|---|
| 1991 | 2,617 | 472 | 3,431 | 2,091 | 8,613 | 0.59 |
| 1995 | 4,351 | 458 | 4,276 | 3,009 | 12,095 | 0.82 |
| 2000 | 3,829 | 380 | 5,307 | 3,963 | 13,479 | 0.92 |
| 2005 | 3,879 | 420 | 5,902 | 2,870 | 13,073 | 0.89 |
| 2010 | 3,278 | 369 | 6,952 | 1,704 | 12,304 | 0.84 |
| 2015 | 2,890 | 7,149 | 4,889 | 1,728 | 16,657 | 1.14 |
| 2016 | 2,773 | 3,362 | 5,561 | 1,854 | 13,551 | 0.92 |
| 2017 | 4,564 | 2,205 | 5,308 | 1,700 | 13,777 | 0.94 |
| **Projections (Base Case)** | | | | | | |
| 2020 | 3,409 | 4,238 | 5,253 | 1,762 | 14,663 | 1.00 |
| 2025 | 3,979 | 4,813 | 5,554 | 1,762 | 16,109 | 1.10 |
| 2030 | 4,523 | 5,138 | 5,693 | 1,762 | 17,118 | 1.17 |
| 2035 | 5,067 | 5,336 | 5,775 | 1,762 | 17,941 | 1.22 |
| 2040 | 5,616 | 5,469 | 5,805 | 1,762 | 18,653 | 1.27 |
| 2045 | 6,163 | 5,425 | 5,734 | 1,762 | 19,085 | 1.30 |

| Year | Chemicals | Crude Petroleum | Petroleum Products | Other | Total | Index |
|---|---|---|---|---|---|---|
| 2050 | 6,374 | 5,284 | 5,662 | 1,762 | 19,084 | 1.30 |
| 2055 | 6,374 | 5,284 | 5,662 | 1,762 | 19,084 | 1.30 |
| 2060 | 6,374 | 5,284 | 5,662 | 1,762 | 19,084 | 1.30 |
| 2065 | 6,374 | 5,284 | 5,662 | 1,762 | 19,084 | 1.30 |
| 2070 | 6,374 | 5,284 | 5,662 | 1,762 | 19,084 | 1.30 |
| 2075 | 6,374 | 5,284 | 5,662 | 1,762 | 19,084 | 1.30 |
| 2080 | 6,374 | 5,284 | 5,662 | 1,762 | 19,084 | 1.30 |

The graph below illustrates the growth rates applied to the benefits calculations. The growth rates were based on total tonnage, separated by upbound and downbound traffic.

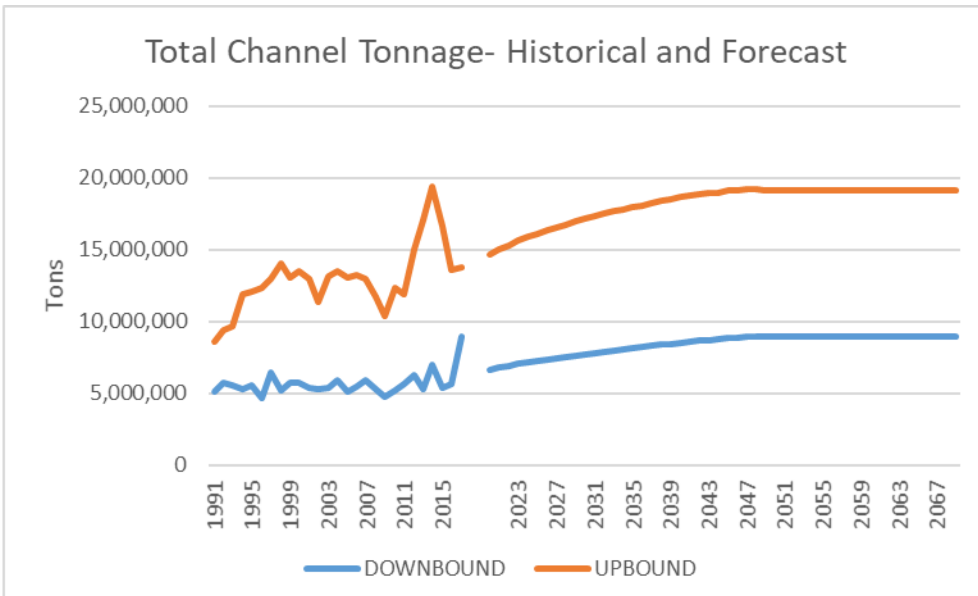


**Figure 9: Projected Growth Rate of GIWW Vessel Traffic**

Two major projects are planned in the study area that have direct overlap with the economics on this study: The Brazos River Floodgates and Colorado River Locks project, and the Coastal Texas project. For study purposes, it is assumed these projects will be built and therefore is included in the Future Without Project condition. Multiple other projects are being studied as well in the area and the fringes outside of the scope of this project.

The Brazos River Floodgates project consists of flood gates on each side of the Brazos River that are 75 feet wide by 750 feet long. The Colorado River Locks project consists of two lock chambers on each side of the Colorado River consisting of two sector gates, each gate creates a chamber 75 feet wide by 1,200 feet long. Both projects serve to control flood flows from the Brazos and Colorado Rivers to the GIWW, improve navigation safety by controlling traffic flow and currents at the intersection with the GIWW, and aid in preventing sand and silt deposition into the GIWW. The Colorado River is within the boundaries of this project, but the modifications to that project will not contribute to the benefits on this project.

The Coastal Texas project includes a study area covering the entire Texas Gulf Coast from the mouth of the Sabine River to the mouth of the Rio Grande, and includes the Gulf and tidal waters, barrier islands, estuaries, coastal wetlands, rivers and streams and adjacent areas that make up the interrelated ecosystem along the coast of Texas. The study area encompasses 18 coastal counties along the Gulf Coast and bayfronts. The study area has been divided into four regions loosely based on major bay systems and habitats. The project design includes design of hurricane levee systems and development of features along the existing levee systems which are anticipated to require redundancy, resiliency, and/or robustness to prevent failure during storm events. Additionally, there are life safety concerns which must be addressed so the project will likely involve features that could be a concern to human life/safety assurance. Coastal Texas is addressing some areas along the GIWW that affect navigation and shoaling, and these areas will be discussed in more detail later in the report. Since Coastal Texas is assumed to be completed, features included in that study are part of the Future Without Project condition and the benefits of the Coastal Texas project is not included in this study.

The conditions observed presently are expected to continue in the future without project condition. As traffic increases, delays are expected to increase proportionally. However, the delays may not be a linear increase and may increase exponentially as traffic increases, similar to congestion on an interstate following properties of fluid mechanics. Once the traffic reaches a certain threshold, which is unknown on the GIWW without further study, the congestion builds and delays are prolonged for each vessel. For simplicity in this analysis, average delays are expected to remain constant over time per vessel.

A caveat to the above assumption is that the erosion expected to occur will affect future traffic that is not reflective in the existing data. As barrier islands wither away, the channel becomes more vulnerable to the elements, and traffic could be impacted significantly. For example, wind may have a more frequent disturbance to traffic. Waves and currents could also impact future navigation. Increased shoaling could prompt more frequent light loading until emergency dredging can occur. See Table 13 below.

Table 13: FWOP Condition for Zones 12, 13, 14, 16, and 18

| Zone | FWOP Condition (beginning year 2030) |
|---|---|
| 12 | Scouring hole on west side of Caney Creek. Shoaling high spots on east of Caney Creek. Cross currents. Channel landside breakwater included in Coastal Texas study. |
| 13 | Barrier Island completely gone by 2030. Channel landside breakwater included in Coastal Texas study. |
| 14 | Channel landside breakwater included in Coastal Texas study. |
| 16 | Barrier Island completely gone by 2030. |
| 18 | Barrier Island breached around year 2035. Little barrier island left by 2040 in portion of Zone 18. |

Delays experienced in 2018 and 2019 are expected to continue or get worse in the future. The data illuminate some noteworthy observations. For more information, s*ee* Economic Appendix A.

First, February experiences the fewest number of vessels per month. This could be due to market factors and seasonality of the industry. However, as the data also shows, February is also the month with the greatest delays per vessel. With greater delays, product is more expensive to transport. Industry could be adjusting its operations either by using other modes for part of their transport or making adjustments to operations and transporting some of the February product in January or March when the channel is more reliable and has fewer delays.

Second, generally the winter months experience greater delays than the summer months. This could be due to several factors, including fog, strong north winds, and shoaling, among others.

Third, Zone 11 Downbound, Zone 12 both directions, and Zone 13 Upbound experience higher delays in the month of May. This appears to be due to upbound traffic crossing Caney Creek. The month of May experiences higher rainfall totals, thereby increasing current flow crossing Caney Creek and making navigability more challenging. A wider channel in this locale would likely help alleviate some of the navigability challenges.

Fourth, Zone 14 is an extremely reliable area presently. The entire year, the average travel time only varied by 8 minutes in either direction. According to the channel users, this is attributable to the presence of barrier islands providing shelter for the vessels from the elements. In contrast, Zone 15, which has no barrier island presently, varied 20 minutes in average travel time. That is a greater variance than any other zone, with the exception of delays crossing

Caney Creek or the Colorado River. Hence, the lack of barrier islands present much more vulnerability to the channel than the presence of barrier islands.

Fifth, downbound traffic in Zone 18 appear to have a wide variance of travel times, with the month of February being the greatest and the summer months being the least. There could be a number of factors for increased travel times in this zone. As vessels approach Matagorda Bay, wind, waves, currents, fog, and shoaling could pose impediments to smooth navigation.

# 3 PLAN FORMULATION

This section summarizes the plan formulation process. Plan Formulation is the process of formulating management measures and building plans that meet planning objectives and develop alternatives within the planning constraints.

Alternative plans are a set of one or more management measures functioning together to address one or more planning objectives. Measures include construction and restoration of protective channel features that would reduce shoaling, improve transportation efficiency, and reduce operations and management (O&M) costs; creation and restoration of existing dredge material placement areas; and measures that use dredge spoil as beneficially as possible.

Plan formulation for this study was conducted in accordance with the six-step planning process described in *Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies (*1983) and the P*lanning Guidance Notebook* (ER 1105-2-100, dated April 2000). The six-step iterative process is:

Step 1 - Specify the water and related land resource problems and opportunities for the project area (Section 3.1);
Step 2 - Inventory and forecast existing & future without conditions (Section 3.2);
Step 3 - Formulate alternative plans (Section 3.4);
Step 4 - Evaluate alternative plans (Section 3.5);
Step 5 - Compare alternative plans (Section 3.7 through Chapter 4 Environmental Consequences); and
Step 6 - Select the recommended plan (Chapter 5 – TSP).

## 3.1 STEP ONE – SPECIFIY PROBLEMS, OPPORTUNTITES, OBJECTIVES AND CONSTRAINTS FOR PROJECT AREA

### 3.1.1 PROBLEMS

Coastal storm events and routine sediment processes have significantly eroded the land barrier between the GIWW and the Gulf of Mexico (Gulf), as well as wetlands adjacent to the GIWW, which historically have provided sheltered passage for shallow draft vessels. Relative Sea Level Rise (RSLR) will exacerbate these impacts in the future. Land loss decreases the potential for safe vessel passage by allowing greater exposure to the Gulf and open sea conditions, as well as increasing the frequency and magnitude of channel shoaling. Study problems center on the navigation channel, the effects of coastal storms, and ecosystem features.



* Required by CEQ Regulations 40 CFR 1502.10

Problems specific to this study include:

1. Erosion and coastal storms have eroded channel shorelines and the barriers that have historically protected vessels on the GIWW.

2. Sea Level Rise and storms of increasing frequency and intensity will likely exacerbate the loss of barriers around the channel.

3. Shoaling in the GIWW increases grounding risks and leads to delays/light loading.

### 3.1.2 OPPORTUNITIES

Opportunities exist in this study to:

1. Increase the flexibility and adaptability of maintenance dredging practices.

2. Create new or prolong the life of barrier islands and/or dredged material placement areas that provide protection for the channel.

### 3.1.3 PLANNING OBJECTIVES

The federal objective of water and related land resources project planning is to contribute to national economic development consistent with protecting the nation's environment pursuant to national environmental statutes, applicable executive orders, and other federal planning requirements.

Objectives for this study include:

1. Improve navigation resiliency from episodic disturbances (storms, hurricanes and floods) and ongoing erosion processes.

2. Improve the economic efficiency of the GIWW.

3. Reduce safety risks for vessels operating within the GIWW navigation system.

### 3.1.4 PLANNING CONSTRAINTS

Constraints for the GIWW-CSR are:

1. Avoid or minimize impacts to critical habitat.

2. Do not negatively impact existing placement areas or CSRM projects.

### 3.1.5 FORMULATION STRATEGY

This navigation study authority requires that the PDT formulate, screen and recommend the alternative that reasonably maximize the National Economic Development Benefits from navigational cost savings, and best achieves the additional objective of achieving resiliency in the study area. This presents unique challenges to weigh non-monetary resilience and safety benefits in combination with monetary economic benefits to assess cost effectiveness and efficiency of proposed solutions. Although it is understood that monetary benefits would be realized by implementing measures that provide navigation resilience and safety, insufficient historical data is available to quantify the impact of hurricanes and storms in terms of monetary benefits of reduced damages from these episodic events over the period of analysis of 50 years between 2030 and 2080. The identification of a tentatively selected plan will require the assessment of how much navigation resilience and safety measures are worth purchasing at the expense of traditional economic metrics in the form of transportation and O&M cost savings.

#### 3.1.5.1 RESILIENCY

This study is centered on resiliency of the Gulf Intracoastal Waterway (GIWW) navigation system. In contrast, most navigation studies focus on economic efficiency or address navigation related safety problems. The GIWW Brazos River Floodgates and Colorado River Locks Study (2019) addressed critical navigation safety issues at those two projects. For more information about resiliency, refer to Chapter 1, Section 1.7.

## 3.2 STEP 2 – INVENTORY AND FORECAST EXISTING AND FUTURE WITHOUT PROJECT CONDITIONS

### 3.2.1 Existing conditions

The existing conditions in the coastal region include a dynamic economic environment that combines populations and investments in an area that is exposed to coastal forces. Coastal storms have the potential to damage property and infrastructure and pose life safety risk to residents and workers. The continuing exposure to less intense coastal forces erode sediment along the GIWW and result in habitat loss and safety concerns for navigation. Development in the region is dense and expected to continue over time.

More than one-quarter of the Texas population has lived within the coastal counties with over 6.4 million residents in the study area, and over 80 percent of those residing along the upper Texas coast (Wilson and Fischetti, 2010, U.S. Census Bureau, 2018). Within the study area, numerous coastal communities are at risk from storm surge, where approximately 673,346 structures are located. Over 3,500 critical infrastructures, including electricity, gas distribution, water supply, transportation, education, and community services (e.g., police, fire department, etc.) are at risk. Severe storm surge events threaten the health and safety of residents living within the study area. Loss of life, injury, and post flood health hazards may occur in the event of catastrophic flooding. There are 140 medical care facilities, 364 police stations/sheriff's offices, and 672 fire stations (parish and volunteer) located within the study area (NOAA, 2018). Within the study area, 14.8 percent of the population fell below the poverty level, much of those populations are found in the lower coastal counties. Minority residents make up 16 percent of the population in the study area. Recreation and tourism play a large role in the study area, with over 50 NWRs, WMAs, State Parks, preserves, etc.; outstanding fishing, birding, and waterfowl hunting opportunities; and nature tourism opportunities.

For more detailed information about existing conditions refer to Chapter 2 of this report.

### 3.2.2 Future Without Project (FWOP) Condition Assumptions

The Future without Project (FWOP) condition is the prediction and assumptions the PDT made of the future 50-year period analysis without a federal project. This means, what will occur and happen along the GIWW navigation channel over the next 50-years if there is no project and nothing is done. The PDT evaluated existing information and preliminary data to determine the future without project (FWOP) condition assumptions. Those assumptions are as follows:

a. *Projects Not Yet Authorized.* For the period of analysis (2030 to 2080), the PDT's assumption is that the future without project (FWOP) condition will have approved and constructed projects by Texas General Land Office (GLO) and USACE including the Coastal Texas and GIWW BRFG-CRL selected plans.

b. *Economic Trends.* Traffic levels and commodity tonnage are expected to continue as indicated in regional forecast prepared for the recently completed GIWW-BRFG/CRL feasibility study.

c. *Navigation Channel Operations*. The navigation channel will be increasingly exposed to winds and waves as barrier islands erode. According to Gulf Intracoastal Canal Association (GICA), vessels stop normal operations in areas of the channel exposed to the bay when winds exceed 35 mph.

d. *Hazardous Toxic and Radioactive Waste*. Based on the findings of the HTRW survey, the probability of encountering contaminated sites or toxic substances without project construction is considered low. Information compiled by this assessment indicates additional investigations are not warranted at this time.

e. *Real Estate*. It is expected that much of the privately-owned land in the scope of this study will have eroded by the beginning of the period of analysis (2030). Therefore, these lands are considered to fall under federal navigational servitude.

f. *Climate Stressors.* The impacts of erosion and coastal storms are expected to be exacerbated by changing sea level conditions. To evaluate the impacts of Relative Sea Level Rise (RSLR) on future conditions, the following reference years are used:

- Reference year 2030: Assume construction is complete and project is operating, economic benefits begin

- Reference year 2080: End of quantitative period of analysis for economics

Tables 1 and 2 show the RSLR in feet for the Local Mean Sea Levels (LMSL) at Galveston Pier 21 and Rockport, respectively. The RSLR numbers are starting from reference year 2030 and ending at reference year 2080. The USACE Sea Level Change Curve Calculator version 2021.12 and USACE 2013 projection curves were used to determine the RSLR values below.

**Table 14: Estimated Relative Sea Level Rise (feet) at Galveston Pier 21 (Region 1)**

| | USACE | | |
|---|---|---|---|
| Year | Low | Intermediate | High |
| **2030** | **0.80** | **0.93** | **1.33** |
| **2080** | **1.85** | **2.53** | **4.72** |

**Table 15: Estimated Relative Sea Level Rise (feet) at Rockport (Regions 2 and 3)**

| | USACE | | |
|---|---|---|---|
| Year | Low | Intermediate | High |
| **2030** | **0.44** | **0.56** | **0.92** |
| **2080** | **1.29** | **1.96** | **4.10** |

The USACE 2013 Intermediate curve was assumed to be the most likely scenario for FWOP conditions, and a sensitivity analysis was performed to ensure this assumption would not significantly impact the performance of the alternatives.

## 3.3 STEP 3 – FORMULATE ALTERNATIVE PLANS *

Plan formulation is an iterative process that develops and compares solutions to the water resources problems identified within the study area. The process consists of incremental development of measures, strategic combination of those measures into alternatives, and screening with increasing details in phases that support risk informed decision making. The plan formulation process for this study was completed in phases that can be briefly characterized as follows:

1st Plan Formulation Iteration:

- Formulated measures to address problems within Zones 1 - 20;
- Combined measures into conceptual initial array of alternatives for Zones 1 - 20;
- Screened zones within the study area based on FWOP assumptions;
- Compared and qualitatively screened initial alternatives (including Zones 12, 13, 14, 16 and 18);

2nd Plan Formulation Iteration:

- Evaluated final array of alternatives (Alternative 1, 3, and 6) by evaluating the zone individually and incrementally adding measures for Alternative 3 and 6 within each zone based on performance with traditional NED criteria and resilience metrics measured as navigation cost savings by reduced interruptions in future navigation use (See Tables 16-18 and Figures 3-8);
- Compared Alternative 6 - NED Plan and Alternative 6 - Resilience Plan (Tables 19 – 20 below); and
- Next steps, PDT will refine TSP to maximize performance and achieve most cost-effective approach for the period of analysis (Next steps to be performed after concurrent reviews prior to ADM and final report).

### 3.3.1 MANAGEMENT MEASURES

Management measures are proposed to address the study area problems of increased transit times, transit interruptions, and safety risk for people and vessels in the GIWW that are the result of gradual and episodic coastal forces. A management measure can be structural or non-structural for a specific geographic site that addresses one or more planning objectives. Measures were formulated based on problems in each of the 20 zones specified for plan formulation and a system resiliency analysis. See Plan Formulation Appendix E for more details.

#### 3.3.1.1 Nonstructural Measures

Nonstructural measures would allow continued vessel transit to the greatest extent possible without implementing a high-cost construction project. Nonstructural measures considered for this study include light loading, lightering, operational scheduling, speed restrictions, and new current meters for vessels navigating the GIWW. Light loading is when a vessel carries less cargo tons than maximum capacity to reduce the displacement of water and allow navigation through a shallower channel. Lightering is removing oil or other chemicals from a compromised vessel to another vessel. Operational scheduling of vessels would propose scheduling movement of vessels during favorable conditions such as high tide and low wind. Buy-outs and relocations are in reference to properties along the navigation channel. Speed restrictions would reduce the vessel wakes which contribute to erosion of the channel-side lands and barrier islands. New current meters would allow vessels to detect the strength and direction of currents flowing around them using state-of-the-art technologies which would assist with maneuvering in high-risk areas.

#### 3.3.1.2 Structural Measures

Structural measures include variations of stabilization measures. Hard stabilization structural measures considered for this study include breakwaters, reef balls, jetties, wavebreaks, and revetments. These structures reduce the intensity of wave action in nearshore waters to provide safer navigation conditions in the channel.

Natural stabilization structural measures considered for this study include living shorelines, levees and dikes, windbreak and dune fences, earthen berms, barrier islands, and marsh plantings. Living shorelines are coastal edges protected with various natural materials such as plants, sand, and rock which create habitat for local species promoting biodiversity while also improving water quality. Levees and dikes are areas of raised ground and embankments made of earthen material along shorelines providing protection from winds and flooding. Windbreak and dune fences are used to accumulate windblown sand in a desired area creating a natural barrier for winds and flooding conditions. Earthen berms are areas of raised earthen material which provide protection from wind and floods. Barrier islands are natural or man-made islands that provide the navigation channel with the most robust protection from winds, waves, and flooding. Marsh planting is the installation of vegetation to reduce the effect of wind and wave erosion by anchoring the soil in place with the plants. Natural stabilization structural measures act as natural barriers from harmful conditions for the navigation channel and vessels operating in it.

Channel modification structural measures are various methods to reconfigure the channel or control the material in the channel. Channel modifications considered for this study include bend easing and minor realignments, channel widening and straightaways for vessel meeting, bedload collectors, sediment traps, deepening (dredging), and additional moorings and fleeting.

Sediment placement structural measures are various methods to manage the dredged material from the channel. Sediment placement measures considered for this study include offshore sediment placement, new dredged material placement, vessel sidecast dredging, sediment bypass tunnels, and beneficial use of dredged material by thin layer placement, nearshore unconfined placement, and amended material.

Aids to navigation (ATON) structural measures are man-made objects used by mariners to determine location or a safe passage. ATON measures considered for this study include buoys and markers, which are already provided by the U.S. Coast Guard at another federal cost.

The early screening out of measures and their rationale are shown below on **Table 16.** See Plan Formulation Appendix E for more details.

**Table 16: Measures Screened from further evaluation**

| Structural Measures (Hard Stabilization Features) | Rationale |
|---|---|
| Wavebreaks | Does not attenuate waves as effectively as breakwaters |
| Jetties | Does not attenuate waves as effectively as breakwaters |
| Revetments | Does not attenuate waves as effectively as breakwaters |
| **Structural Measures (Natural Stabilization Features)** | **Rationale** |
| Living Shoreline | Extremely costly, benefits are unlikely to be worth it |
| Levees and Dikes | Extremely costly, benefits are unlikely to be worth it |
| Windbreak and Dune Fence | Only addresses wind and flooding, not wave action |
| **Structural Measures (Channel Modification)** | **Rationale** |
| Bend Easing and Minor realignments | Significant need was not identified |
| Straightaways for Meeting | Significant need was not identified |
| Bedload Collector | Significant need was not identified |
| Additional Moorings and Fleeting | Significant need was not identified |
| **Structural Measures (Sediment and Placement)** | **Rationale** |
| Offshore Placement | Already being implemented as a last resort measure |
| Sidecast Dredging | Not a sustainable measure as material ends up in channel |
| Sediment Bypass | Extremely costly, benefits are unlikely to be worth it |
| Beneficial Use: Thin layer Placement, Near shore unconfined placement, Amend material | Extremely costly, benefits may not be counted |
| **Aids to Navigation (ATONS):** | **Rationale** |
| Buoys and Markers | Already being implemented as needed |

## 3.3.2 INITIAL ARRAY OF ALTERNATIVE PLANS

The measures carried forward to formulate the initial array of alternative plans and their rationale are shown in Table 17 below. See Plan Formulation Appendix E for initial array of alternatives and screening.

**Table 17: Measures Carried Forward for formulating alternatives**

| Nonstructural Measures | Rationale |
|---|---|
| Light loading / Lightering | Opportunity for benefits with minimal costs |
| Operational Scheduling | Opportunity for benefits with minimal costs |
| Speed Restrictions | Opportunity for benefits with minimal costs |
| New Current Meters | Opportunity for benefits with minimal costs |
| **Structural Measures (Hard Stabilization Features)** | **Rationale** |
| Breakwaters | Most effective structural measure at attenuating waves |
| Reef Balls | Can be implemented with breakwaters for fish passage |
| **Structural Measures (Natural Stabilization Features)** | **Rationale** |
| Barrier Islands | Most effective structural measure for overall resilience |
| Earthen Berms | Most effective structural measure at attenuating high winds |
| Marsh Plantings | Vegetation is needed to keep the sediment in place |

| Structural Measures (Channel Modification) | Rationale |
|---|---|
| Channel Widening | This measure would address problem areas for shoaling |
| Sediment Traps | This measure would address problem areas for shoaling |
| Deepening (Dredging) | This measure would address problem areas for shoaling |
| **Structural Measures (Sediment and Placement)** | **Rationale** |
| Creating New Dredge Material Placement Area | Shoaling increases dredging volumes which need capacity |

The above measures carried forward were then combined to formulate seven (7) distinct alternative plans including the No Action plan which is the baseline and future without project (FWOP) condition. These seven (7) alternative plans are described below.

**Alternative 1 (No Action)** is the baseline to which all other alternatives are compared. Alternative 1 does not meet study objectives. Although there are no additional capital or O&M costs or environmental impacts associated with Alternative 1, it would not provide additional benefits or increase resiliency of the system. A key assumption for the No Action or Future without Project Condition (FWOP) is that recommended plans from the Coastal Texas Protection and Restoration and GIWW Brazos River Floodgates and Colorado River Locks (BRFG-CRL) Feasibility Studies are in place and operational at the start of this study's period of analysis which is the year 2030.

**Alternative 2 (Non-structural)** would use non-structural measures to allow continued vessel transit to the greatest possible extent; however, some are already practiced alleviating existing navigation inefficiencies. Non-structural alternatives would be used wherever needed to address any residual risks associated with the recommended plan. Non-structural measures include light-loading, lightering, operational scheduling, speed restrictions, and new current metering.

**Alternative 3 (Shoreline Stabilization)** would address shoaling problems by reducing sediment input from eroding shorelines and upland placement areas and barriers caused by vessel wake and wind driven waves. Alternative 3 would employ hard stabilization measures including breakwaters and reef balls which could also be designed to address areas with crosscurrents.

**Alternative 4 (Alternative 2 Combined with Sediment and Placement)** builds upon Alternative 2 (non-structural measures) by addressing sedimentation and will assess how the dredged material is managed within minimal federal standards, which may be more expensive than current methods, and analyze options to improve system resiliency.

**Alternative 5 (Alternative 4 Combined with Channel Modifications)** builds on measures for Alternative 4 and also includes potential channel modifications including channel widening, sediment traps, and deepening[6]. Alternative 5 would use dredged material to enhance or create placement areas and increase the resiliency and flexibility of the navigation system by creating spaces (sediment banks) where sediment would

[6] Deepening in this study is not defined as increasing the authorized depth of the channel. The intent of "deepening" is to identify measures that improve the reliability of the authorized channel to increase economic efficiencies while enhancing resilience to disturbances.

accumulate outside of the channel. Sediment would then be dredged and placed in a manner that benefits navigation.

**Alternative 6 (Alternative 4 Combined with Alternative 3)** builds on combined measures in Alternative 4 by incorporating shoreline stabilization measures from Alternative 3. Alternative 6 would employ the most effective combination of hard and natural stabilization measures to satisfy resiliency metrics. Placement of dredged material would not necessarily be based on the least cost option (base plan) per federal standards but would consider resiliency metrics as well.

**Alternative 7 (Alternative 5 Combined with Alternative 3)** builds on the combination of measures included in Alternative 5 by incorporating shoreline stabilization measures from Alternative 3. The primary difference between Alternative 6 and 7 is that Alternative 7 includes channel modifications. Alternative 7 would combine both hard and natural stabilization measure to satisfy resiliency metrics. In addition, appropriate channel modifications would address site specific issues in zone 12. Placement of dredged material would not necessarily be based on the least cost option (base plan) of the federal standard but would consider resiliency metrics as well.

## 3.4 STEP 4 - EVALUATION ALTERNATIVE PLANS

The initial array of alternative plans was evaluated based on the effectiveness criteria from the previous section because there was not enough cost information to determine efficiency at this initial screening of the study. The completeness and acceptability criteria were assumed to be met by the alternatives carried forward from this initial screening. See the table below and Plan Formulation Appendix E for more information on the evaluation and qualitative screening.

## 3.5 Phased Screening of measures and alternatives

Plan formulation and screening of proposed measures was conducted in an iterative process of risk informed planning, to evaluate and compare performance of alternatives with increasing detail at each decision point. Initial screening of measures relied upon professional judgment of the physical conditions in the area and expected performance of the scale and function of the conceptual alternative/measure. The second and third decision points required increasing detail to quantify and compare performance of alternatives and then increments in terms of dollar denominated benefits.

**Alternative 1 (No Action)** is the baseline to which all other alternatives are compared. There are no additional capital or O&M costs, or benefits provided by this alternative.

**Alternative 2 (Non-structural)** was screened out as a stand-alone alternative because most of the non-structural measures are already being practiced or implemented currently. However, non-structural alternatives will be added to any alternative to address any residual risks associated with the recommended plan.

**Alternative 3 (Shoreline Stabilization)** was evaluated as having the most effective hard stabilization structural measures which was predicted to provide the most economic benefits by focusing on protecting the navigation channel. Economic benefits are comprised of transportation cost savings and O&M cost savings. This alternative was carried forward for further evaluation.

**Alternative 4 (Alternative 2 Combined with Sediment and Placement)** was screened out because placing sediment without providing hard stabilization to protect it would cause the sediment to erode rapidly from wave action and was not considered to be as resilient as a stand-alone alternative.

**Alternative 5 (Alternative 4 Combined with Channel Modifications)** was screened out for the same reason as alternative 4.

**Alternative 6 (Alternative 4 Combined with Alternative 3)** was evaluated as having the most effective combination of hard and natural stabilization measures which would provide resiliency benefits in addition to economic benefits. The presence of barrier islands was identified as the most effective measure because it provides the navigation channel with the most robust protection from day-to-day wind and wave conditions as well as episodic hurricane and storm damage. Barrier islands are also an adaptable placement area that provide flexibility for placing dredged material. Therefore, protecting and restoring barrier islands was perceived as the highest effectiveness for providing resilience.

**Alternative 7 (Alternative 5 Combined with Alternative 3)** was screened out because the channel modifications were not needed for the majority of the study area. Channel modifications could be evaluated as optimization and refinement measures in problem areas and shoaling hotspots, but system-wide channel modifications were screened out.

Table 186 provides a relative qualitative assessment of the Initial Array of Alternatives. The PDT is developing the criteria for evaluation and comparison of the alternatives to determine the Tentatively Selected Plan.

**Table 18: Relative Qualitative Assessment of Alternatives**

| Color Key | |
|---|---|
| No Change | Highest Preferred |
| Highest | ↑ |
| High | |
| Medium - High | |
| Medium | |
| Low - Medium | ↓ |
| Low | |
| Least | Least Preferred |

| Alt # | Description | System Resilience | Initial Cost | Economic Benefits | Environmental Quality | Engineering Feasibility | Real Estate Requirements |
|---|---|---|---|---|---|---|---|
| 1 | No Action | NA - No Change from existing | NA - No Change from existing | NA - No Change from existing | NA - No Change from existing | NA - No Change from existing | NA - No Change from existing |
| 2 | Non-structural | Low: limited resilience | Lowest: Low cost NS measures | Low: low effective | High: Little environmental impact expected | High: Few engineering challenges | Lowest: Little to no real estate required |
| 3 | Shoreline Stabilization | Medium-High: Stabilization measures are the most likely measures to lead to resilience of navigation system | Medium-High: Construction of stabilization structures anticipated to be among most costly measures | Medium: May reduce O&M costs over time | Medium: Hard structures have the potential for Environmental Impacts but Natural features likely to benefit (may offset) | Medium: Some novel methods of natural stabilization may provide engineering challenges | Medium-High: Stabilization measures may require a significant amount of real estate |
| 4 | Alt 2 + Sediment Placement | Low-Medium: The incorporation of sediment placement would marginally increase resilience | Low-Medium: Sediment Placement is relatively inexpensive in comparison to other measures | Low-Medium: While this is likely to be an efficient method of disposal, unlikely to produce additional efficiencies | Medium-High: Low impact from NS measures, Placement options vary in effects but no substantial negative effects anticipated | Medium-High: Some potential challenges with placement but relatively routine from an engineering perspective | Medium-High: Placement areas likely to require a significant amount of real estate |
| 5 | Alt 4 + Channel Modifications | Medium: Channel modifications would increase resilience over Alt 2, but may not significantly address resilience over time | Medium: Channel modifications are less numerous than stabilization measures and less expensive to implement | High: Channel Modifications are likely to perform best at increasing economic efficiency | Low-Medium: Incorporation of channel modifications with Alt 4 likely to increase potential for Environmental Impacts | Medium: Some novel methods of channel modifications may provide engineering challenges | Medium-High: Same as Alt 4; In channel work not likely to increase real estate requirement |
| 6 | Alt 3 + Alt 4 | High: Incorporation of sediment and placement likely to expand resilience over Alt 3 | High: Second most costly, includes most measures except channel modifications | Medium: May reduce O&M costs over time | Low-Medium: Incorporation of sediment and placement with Alt 3 could lead to some additional Environmental impacts | Low-Medium: Incorporation of sediment and placement with Alt 3 could lead to some additional Environmental impacts | High: Second largest footprint requiring real estate |
| 7 | Alt 3 + Alt 5 | Highest: Offers the most robust and resilient set of measures to address problems over time | Highest: Includes all measures, would be the most costly | High: Channel Modifications are likely to perform best at increasing economic efficiency | Low: Includes the greatest footprint and potential for impacts, although some benefits may be off-setting | Low: Presents the greatest potential suite of engineering challenges | Highest: Greatest footprint requiring real estate |



* Required by CEQ Regulations 40 CFR 1502.10

Another screening point evaluated the two alternatives that were confirmed at the Alternative Milestone Meeting to be the viable choices for further evaluation and comparison to the no-action plan: a Stabilization Alternative (No. 3) and a Stabilization plus Sediment Placement Alternative (No. 6). The primary difference between Alternative 3 and Alternative 6 is the addition of sediment placement, both as an initial feature and as a new O&M policy throughout the project design life.

Both alternatives focus on the priority zones established during the IPR after AMM which includes zones 12, 13, 14, 16, and 18. Alternative 3 proposes the implementation of a breakwater along the GIWW shoreline of the barrier islands and another breakwater along the bay shoreline of the barrier islands. Alternative 6 is identical to Alternative 3, but includes the design of additional barrier islands between the two breakwaters proposed in Alternative 3.

The intention of this study is to develop alternatives that improve the resiliency of a system, which is namely its toughness or ability of the system to recover quickly and efficiently, whether it is from sea level rise, coastal storms, or operational and maintenance dredging and placement challenges. While both alternatives improve resiliency of the navigation channel by developing a reinforced coastal barrier, the difference of sediment placement in Alternative 6, increases the level of resiliency to coastal storms and operational and maintenance challenges by instituting recovery and resiliency into the barrier itself and operational and maintenance placement practices.

Engineering analysis supported these iterations to identify the Tentatively Selected Plan required a Sediment Budget Analysis and application of CMS to simulate the difference in shoaling and erosive conditions in the FWOP and FWP conditions.

### 3.5.1 Engineering Analysis

The technical engineering approach included the following steps:

1) CSAT was applied to estimate annual shoaling rates within Matagorda and Brazoria to confirm underlying background conditions.
2) Historical shoreline changes were estimated from aerial imagery and linearly projected to characterize future geomorphology based on plan measures.
3) A sediment budget analysis was performed to forecast the FWOP and FWP shoaling rates for all 20 zones at 100-ft increments.
4) CMS was applied to assess existing sediment transport phenomena and to assess the morphological response that may result from construction of the incremental measures and alternatives.

Conservatively, the sediment budget analysis assessed the change in underlying conditions and performance under the existing (low) rates of sea level change. These analyses are described in greater detail of the results for each segment of the study area is presented in Section 2.4 of Appendix C, Engineering Design, Cost Estimates, and Cost Risk Analysis.

A combination of engineering analysis and judgement was applied to assess performance of potential measures. Areas of higher shoreline erosion and higher channel shoaling were targeted for stabilization measures, particularly breakwaters either on the channel or bay side. Not all channel shoaling is primarily correlated to shoreline erosion, as other factors, such as watershed yield and open water contribution may be more significant. Two areas where this is the case are Caney Creek / Mitchell's Cut intersection and the west end of Zone 18. Whereas the vast majority of the study area only required the Sediment Budget Analysis to assess measure performance, at Caney Creek, a CMS model was used.

Engineers drew conclusions from a 2012/2013 study that created a numerical model that included the GIWW CRS study area but did not investigate shoaling in the GIWW. A subsequent 2019/2020 RSM study investigated alternatives to reducing shoaling in the GIWW and did investigate several options to reduce shoaling at Mitchell's Cut. It included a sediment trap and offshore breakwaters, but neither were proven to naturally reduced shoaling. The sediment traps did provide some relief, but their long-term effectiveness was not evaluated. The study did not consider groins or channel stabilization.

Sediment traps are effective for reducing shoaling but will not address cross-currents that create navigation safety concerns. Engineering judgment suggests that channel stabilization, groins, and channel modification are viable measures. Channel stabilization can reduce channel dynamism, particularly erosion along the channel and address the currents at the GIWW. Groins can reduce sediment accumulation in the GIWW by blocking littoral drift. Channel modification, such as channel widening, can reduce velocities and increase navigable crossing area.

The CMS model was applied to simulate the existing conditions and the performance of the proposed alternatives. The model simulates flow and waves, and calculates sediment transport and morphologic change throughout the simulations. The CMS model was used to define relevant history of currents, water level, and shoaling at the GIWW and Caney Creek/Mitchell Cut intersection for PWOP and FWOP conditions, characterize the problem and assess whether the shoaling and currents in the GIWW will increase, decrease or stay the same, considering relative sea level change. Time series comparisons of depth, morphological changes and current at different locations provide a preliminary assessment of the overall effectiveness of measures.

### 3.5.2 Final array of Alternatives

The PDT screened out four (4) of the initial alternatives resulting in the three (3) alternatives carried forward for further evaluation and described below:

**Alternative 1 (No Action)** is the baseline to which all other alternatives are compared. There are no additional capital or O&M costs, or benefits provided by this alternative.

**Alternative 3 (Shoreline Stabilization)** was evaluated as having the most effective hard stabilization structural measures which was predicted to provide the most economic benefits by focusing on protecting the navigation channel. Economic benefits are comprised of transportation cost savings and O&M cost savings.

**Alternative 6 (Alternative 4 Combined with Alternative 3)** was evaluated as having the most effective combination of hard and natural stabilization measures which would provide resiliency benefits in addition to economic benefits. The presence of barrier islands was identified as the most effective measure because it provides the navigation channel with the most robust protection from day-to-day wind and wave conditions as well as episodic hurricane and storm damage. Barrier islands are also an adaptable placement area that provide flexibility for placing dredged material. Therefore, protecting and restoring barrier islands was perceived as the highest effectiveness for providing resilience.

Alternative 1 does not address any study problems nor achieve any study objectives while alternatives 3 and 6 aim to address the study problems and achieve the study objectives using different approaches. Alternative 3 intends to prevent the loss of existing barrier islands and protect the navigation channel by utilizing only hard stabilization measures such as breakwaters and reef balls. Alternative 3 was also intended to have lower project first costs than alternative 6. Alternative 6 intends to go beyond just preventing barrier island loss; in fact, it proposes to restore areas of barrier islands that are or will be lost in zones 13, 14, 16, and 18 by utilizing natural stabilization measures such as sediment placement and marsh plantings.

Barrier islands prevent more harm to the navigation channel than breakwaters as evidenced by other USACE studies such as GIWW High Island to Brazos River Section 216 and Reducing Shoaling in the GIWW and Erosion of Barrier Islands Along West Galveston Bay. Also, the loss of barrier islands could become irreversible if threatened and endangered species migrate into the gradually eroded areas and create a critical habitat. Therefore, barrier islands are more proactive at directly addressing the study problems to prepare for future conditions. Barrier islands also provide more robust protection of the navigation channel than breakwaters against episodic disturbances, such as major storm events, as well as the day-to-day navigation and erosion impacts from winds and waves. This is due to the larger footprint and the higher crest elevation of the barrier island and earthen berm which are able to absorb harsher conditions. By withstanding harsher conditions, barrier islands enable the GIWW to recover and resume normal operations more quickly after episodic disturbances. The use of barrier islands as placement areas also provides additional flexibility to use dredged material beneficially as needed and adapt to changing conditions. Therefore, alternative 6 offers more resilience as defined by the four principles: prepare, absorb, recover, adapt.

The following sections summarize the design methodology of the measures considered for Alternative 3 and Alternative 6, respectively.

### 3.5.3 Design Methodology for Final Array - Alternative 3: Stabilization

The intent of Alternative 3 is to create a stable coastal barrier by constructing breakwaters along the channel and bay sides, that will: 1) reduce erosion of the existing coastal barrier; 2) naturally capture sediment from overtopping waves; and 3) reduce erosion of the interior shoreline by attenuating waves from the bay.

#### 3.5.3.1 Interior Breakwater Design

The purposes of the interior breakwater will be to 1) reduce erosion of the coastal barrier by breaking vessel induced waves from the GIWW prior to hitting the barrier 2) capturing sediment from overtopping waves from the GIWW, and 3) limiting transport of material during coastal storms from the barrier into the GIWW.

The interior breakwater will follow the same concept of a rubble-mound berm breakwater design. This design consists of a thin layer of bedding stone atop geotextile cloth as the foundation and the remainder of the structure consists of a uniform gradation of stone.

The primary erosive force will vessel-induced waves. The optimal breakwater crest elevation is slightly above MHHW, because:

1) it will be emergent and thereby visible to boat traffic for navigation safety,
2) vessels will rarely traffic under storm conditions, so it doesn't need to be higher, and
3) some overtopping is encouraged to allow for movement of water and channel sediments behind the breakwater.

The MHHW at NOAA station 8773146 on the GIWW is 0.47-ft and it's mid-epoch is 1992, so with 2.35-ft of SLR, the 2080 MHHW would be 2.82-ft NAVD88. Rounding up, the post-settlement design crest elevation of 3-ft was chosen.

The following design considerations were made when examining the placement of the interior breakwater:

1) The breakwater needs to be far enough from the barrier island to account for barrier migration. A 50-ft offset was assumed based on engineering judgement; although an overtopping analysis should be performed in PED to investigate this assumption.

2) The breakwater needs to be far enough from the channel to reduce risk of vessel damage, as well as far enough to ensure that the breakwater does not fall into the channel.

3) The toe of the breakwater should be deep enough to reduce immediate toe scour due to wave breaking.

Based on review of existing bathymetry, an average bed elevation of -2.0-ft at 200-ft offset from the channel centerline was selected. The following feasibility level design was estimated:

- Stone Size: R-150
- Toe Elevation = -2.0 ft
- Crest Elevation = 3.0 ft
- Crest Width = 5.0 ft
- Side Slopes = 2:1
- Bottom Width = 25 ft

#### 3.5.3.2 Bayside Breakwater

The intent of the bay breakwater is similar to the interior breakwater, except that it is intended to reduce erosion due to wind waves as opposed to vessel-induced waves. In addition, the bayside breakwater has potential to also serve as an oyster cultch and provide a sheltered location which is capable of supporting marsh habitat between the structure and the barrier islands.

To serve the 50-year design life, the structure stability was estimated to be designed for the 50-yr storm which identified from the CTX study resulted in a design stone of R-700. With regard to crest elevation, a design post-settlement crest elevation of 5.0-ft was selected, as that represented the higher end of the spectrum for ground elevations on the landward side of the channel. This was selected as opposed to a design stillwater or sea level rise calculation, because ultimately, if the bayside breakwater is higher than the natural ground on the opposite bank, waves that would break on that ground will break on the breakwater instead. It is understood that some of the existing barrier may erode, but the eroded material will be contained within the interior and bayside breakwater encirclement, and it will only erode under low-recurrent storm events. The channel offset of the bayside breakwater will vary based on bathymetry on the bayside, but in general will range from 600 ft to 1200 ft when combined with an interior breakwater.

To address circulation and tidal interchange within the breakwater system, the elevations will be segmented and may alternate either between single row reefball sections or breakwaters with a lower weir crest elevation. For cost estimation, it is assumed that the reefball sections will be 100 ft wide and alternate every 900 ft. This breakwater can also be applied in areas where the barrier is currently eroded. It will reduce wind waves across the channel and prevent sediment migration from the bay into the channel. The spacing and design of the hydrologic breaks will be optimized in PED.

### 3.5.4 Design Methodology for Final Array - Alternative 6: Combination of Stabilization with Sediment Placement

This alternative is similar to Alternative 3, except that an earthen barrier is maintained through beneficial use nourishment. The interior breakwater remains the same as in Alternative 3, with some minor changes to the alignment; whereas the bayside breakwater's crest elevation changes from 5 ft to 3 ft, as the barrier is allowed to erode, because it will be renourished. The additional feature is the earthen berm and nourishment.

#### 3.5.4.1 Sediment Placement Plan

Alternative 6 which is the combination of stabilization measures along with dredge material placement is described in more detail in the Engineering Appendix D, Sections 3.4 to 3.8. However, below is a summary for each zone within Alternative 6 for evaluation.

Zone 12 will not have marsh creation and will implement only the channel side breakwater construction along with channel widening as described further detail in Section 3.4 of the Engineering Appendix D.

According to current assumption within Zone 13, the 376-acre maximum marsh planting capacity will be reached by approximately 2150. If implemented the BU will likely be resized or cells will be created within BU 102-B to create areas for marsh planting at a faster rate. The size of these cells will need to be determined in PED.

According to current assumptions within Zone 14, the 86.5-acre maximum marsh planting capacity will be reached by approximately 2040. Thin layer placement will likely be utilized to construct BU 102-C and BU 103. After achieving target elevation and marsh is established the thin layer placement will continue and theoretically continue to raise the beneficial use sites with over time.

According to current assumptions within Zone 16, the 401-acre maximum marsh planting capacity will be reached by approximately 2120. If implemented the BU will likely be resized or cells will be created within BU 102-B to create areas for marsh planting at a faster rate. The size of these cells will need to be determined in PED.

According to current assumptions within Zone 18, the 708-acre maximum marsh planting capacity will be reached by approximately 2055. Thin layer placement will likely be utilized to construct BU 111 and BU 112-A. After achieving target elevation and marsh is established the thin layer placement will continue and theoretically continue to raise the beneficial use sites with over time.

Shrinkage and swelling are generally not able to be accurately calculated in a planning study with dredging due to the insufficient soils data for O&M material. The assumption was made that the shrinkage and swelling factor for dredged material is 1.0 for all increments. The Texas Coastal Project will require 247,778 CY of dredge material to be mined from the San Bernard to Colorado River reach and 1,195,299 CY to be mined from PA 102-C in 2030. The shoaling data was generated from the CSAT analysis performed by the Hydraulics and Hydrology Branch and quantities were calculated assuming a uniform channel width of 125 feet. The stationing for emergency dredging was identified by observing high shoaling areas from CSAT shoaling data and quantities were generated for appropriate stationing assuming a uniform channel width of 125 feet. Single zone increments and FWOP increments were evaluated based on a 3-year cycle as this is the current dredging cycle except for Zone 12 with channel widening. When increments were combined, they were evaluated based on a 4-year cycle as the combination of features of work done in multiple zones compounded shoaling savings and reduced the need for emergency dredging. Dike raises will be performed when the placement area dike reaches capacity and approximately 3 ft of freeboard is reached. Current placement areas are all assumed to have a crest width of approximately 10 feet. The crest width will be changed to 15 ft after the first lift. Increasing the crest width allows for minor erosion to occur while crest remains to be easily navigable by vehicles for inspection and construction purposes. See Engineering Appendix D, Section 3.10 for more details.

#### 3.5.4.2 Earthen Berm

The primary goals of the berm are to 1) protect the GIWW from wind and wave attack from the bay(s) and the Gulf of Mexico, 2) reduce sediment shoaling within the GIWW, and 3) provide a sustainable and reusable beneficial use (BU) site for O&M dredged material from adjacent portions of the GIWW. The secondary goal of the barrier island is to provide suitable conditions for marsh development. Intermittent breaks in the barrier will be optimized in PED to ensure navigation and system connectivity between the GIWW and East Matagorda Bay.

The earthen berm was designed to mimic natural coastal barrier elevations, so a crest elevation of 8.0-ft was selected with a 5:1 interior slope. A minimum crest-elevation of 100-ft was selected for the initial berm construction, so that any wave overtopping would have minimal erosion. The centerline of the berm was set 162.5 ft from the centerline of the interior breakwater so that the toe of the berm was offset a minimum 50 feet from the toe of the interior breakwater. This distance would allow for some minor landward migration of the earthen berm without risking the interior breakwater.

The average earthen berm's square footage will be 600 sq. ft., so a borrow cut of 400 to 800 sq ft. is expected based on bulking and losses of the soils.

#### 3.5.4.3 Nourishment and Plantings

Regardless of the exact location, the construction of the barrier island will require the excavation of material directly adjacent to the construction site equal to the volume of material needed to construct the barrier island. These "borrow sites" are not anticipated to be any deeper than -3 ft, which is common to East Matagorda Bay and not anticipated to cause water quality issues like low DO; however water quality optimization will be performed during PED to design hydrologic exchange measures.

After construction has been completed, these "borrow sites" will then be filled in over the course of the project life with O&M material from the GIWW as part of a dynamic sediment placement strategy. Future placement of O&M material from the GIWW will be performed using various BU strategies including marsh cells, thin layer placement, and training berms for sea grass. The breakwaters are intended to reduce barrier erosion; however erosion can and will occur, so the BU sites are intended for future adaptability, which may include earthen berm replenishment in addition to marsh creation. Because sea level change and barrier erosion will continue, the barriers and BU sites are not intended to have a completion date, but rather be adaptable for additional placement as needed. Some of the zone BU sites nearing design capacity by 2050; whereas others extending past 2080, but incrementally, marsh cells will be completed and planted with each dredge placement cycle until the site nears full capacity.

The purpose of the marsh nourishment and plantings is to create marsh habitat that emulates the naturally occurring inertial marsh in these bay systems. This beneficial use (BU) of dredge material would provide additional O&M capacity while creating habitat and increasing the resilience of the berms to coastal stressors. Marsh in close proximity to berms has been shown to protect berms by reducing erosion and dampening energies. During the PED phase of project, the PDT will coordinate with resource agencies to identify nearby target sites which will be surveyed to determine the final substrate elevation and composition (open water, marsh, edge). Since the BU locations are expected to be intertidal estuarine marsh, the plan is broadcast locally sourced *S. alterniflora* seed across the edges of the BU locations once these are constructed. The resource agencies will be consulted to ensure proper species and sourcing are attained and to ensure any TPWD or TXGLO permissions are received prior to plantings.

## 3.6 STEP 5 – COMPARISON OF THE FINAL ARRAY OF ALTERNATIVES

After the initial screening of alternatives, an incremental analysis was performed on alternatives 3 and 6 to deconstruct the alternatives into smaller increments. Each increment had varying extents of measures and were scrutinized for whether the measures appropriately addressed the unique issues at each zone. The separated measures include bayside breakwaters, channel bayside breakwaters, channel landside breakwaters, reef balls, berms, and sediment placement which includes marsh plantings. Increments at zones 12, 13, and 14 with channel landside breakwaters were screened out because the Coastal Texas Protection and Restoration Feasibility Study already proposes to construct them at these zones. Increments at zone 16 that included channel bayside and channel landside breakwaters were also screened out because the shoaling data did not justify constructing them at these locations.

The U.S. Fish and Wildlife Services (USFWS) was consulted regarding the presence of critical habitat and the potential impacts to threatened and endangered species at zone 12. USFWS requested eliminating sediment placement and breakwaters that would completely enclose the barrier island at zone 12. As a result, all alternative 6 increments were screened out as well as the alternative 3 increment with breakwaters on both sides of the barrier island at zone 12 in order to comply with the study’s constraints to avoid or minimize impacts to critical habitat.

Channel widening and sediment traps were analyzed as additional increments at zone 12 because of sponsor and stakeholder concerns on the higher safety risks compared to other zones.

Consequently, 14 increments were carried forward for evaluation for the TSP which are shown on the maps in Table 16 and Figures 6-11 with descriptions of measures included in each zone and increment. The Increment naming convention is by zone, alternative, and incremental step. For example, Zone 12, Alternative 3, Increment 1 is named 12.3.1. See Appendix C, Engineering Design, Cost Estimates, and Cost Risk Analysis for additional section and plan details.

**Table 19: Final Array of Alternatives – comparison within zones and scaling of measures**
**(Note: Green highlighted rows were carried forward)**

| Alternative | Zone | Increment | Measures | Notes |
|---|---|---|---|---|
| **Alternative 3 – Zone 12** | | | | |
| 3 | 12 | 12.3.0 | Bayside Breakwater | Screened out after USFWS requested not to close off this area due to critical habitat. |
| 3 | 12 | 12.3.1 | Channel Bayside Breakwater | Only Channel Bayside Breakwater allowed due to section 7 critical habitat, see note above. |
| 3 | 12 | 12.3.2 | Channel Bayside Breakwater + widening of channel | Channel widening was requested to be included in the TSP evaluation by study sponsor and stakeholders. |
| 3 | 12 | 12.3.3 | Channel Bayside Breakwater + widening of channel + sediment traps | Sediment Traps may be evaluated further by the PDT after the TSP milestone. |
| 3 | 12 | 12.3.4 | Bayside Breakwater + Channel Landside Breakwater | Screened out. Coastal TX Study Scope will include the Channel Landside breakwaters. |
| 3 | 12 | 12.3.5 | Bayside Breakwater + Channel Bayside Breakwater + Channel Landside Breakwater | Screened out. Coastal TX Study Scope will include the Channel Landside breakwaters. |
| **Alternative 3 – Zone 13** | | | | |
| 3 | 13 | 13.3.0 | Bayside Breakwater | Screened out. Bayside breakwater functions the same as the Channel Bayside Breakwater; Islands will be gone by 2030; Area of open water between two existing barriers would be too wide and would not fill in. |
| 3 | 13 | 13.3.1 | Channel Bayside Breakwater | Only Channel Bayside Breakwater needed; see notes in above row. |
| 3 | 13 | 13.3.2 | Bayside Breakwater + Channel Landside Breakwater | Screened out. Coastal TX Study Scope will include the Channel Landside breakwaters. |
| 3 | 13 | 13.3.3 | Bayside Breakwater + Channel Bayside Breakwater + Channel Landside Breakwater | Screened out. Coastal TX Study Scope will include the Channel Landside breakwaters. |
| 3 | 14 | 13.3.4 | Bayside Breakwater | Screened out. It doesn't make sense to only have Bayside Breakwater for these short distances. |
| **Alternative 3 – Zone 14** | | | | |
| 3 | 14 | 14.3.1 | Bayside Breakwater + Channel Bayside Breakwater | The breakwaters here are C-shaped so Bayside Breakwaters and Channel Bayside Breakwaters are one measure since these are short distances. |
| 3 | 14 | 14.3.2 | Bayside Breakwater + Channel Landside Breakwater | Screened out. Coastal TX Study Scope will include the Channel Landside breakwaters. |
| **Alternative** | **Zone** | **Increment** | **Measures** | **Notes** |
| 3 | 14 | 14.3.3 | Bayside Breakwater + Channel Bayside Breakwater + Channel Landside Breakwater | Screened out. Coastal TX Study Scope will include the Channel Landside breakwaters. |
| **Alternative 3 – Zone 16** | | | | |
| 3 | 16 | 16.3.1 | Bayside Breakwater | Keep as is. |
| 3 | 16 | 16.3.2 | Bayside Breakwater + Channel Bayside Breakwater | Screened out. The data does not show significant shoaling in the channel for this zone. |

| | | | | |
|---|---|---|---|---|
| 3 | 16 | 16.3.3 | Bayside Breakwater + Channel Landside Breakwater | Screened out. The data does not show significant shoaling in the channel for this zone. |
| 3 | 16 | 16.3.4 | Bayside Breakwater + Channel Bayside Breakwater + Channel Landside Breakwater | Screened out. The data does not show significant shoaling in the channel for this zone. |
| **Alternative 3 – Zone 18** | | | | |
| 3 | 18 | 18.3.1 | Bayside Breakwater | Keep as is. |
| 3 | 18 | 18.3.2 | Bayside Breakwater + Channel Bayside Breakwater | Keep as is. |
| 3 | 18 | 18.3.3 | Bayside Breakwater + Channel Bayside Breakwater + Channel Landside Breakwater + Reef balls | Channel Landside Breakwater include Reef balls. |
| 3 | 18 | 18.3.4 | Bayside Breakwater + Channel Landside Breakwater | Screened out. It doesn't make sense to have Channel Landside Breakwaters without Channel Bayside Breakwaters here. The prioritization should go to Channel Bayside Breakwaters. |
| **Alternative 6 – Zone 12** | | | | |
| 6 | 12 | 12.6.1 | (Bayside Breakwater + Berm + Channel Bayside Breakwater) | Screened out after USFWS requested not to place material in this area due to critical habitat. |
| 6 | 12 | 12.6.2 | Bayside Breakwater + Berm + Channel Bayside Breakwater + Channel Landside Breakwater | Screened out after USFWS requested not to place material in this area due to critical habitat. |
| **Alternative** | **Zone** | **Increment** | **Measures** | **Notes** |
| **Alternative 6 – Zone 13** | | | | |
| 6 | 13 | 13.6.1 | (Bayside Breakwater + Berm + Channel Bayside Breakwater) + Sediment Placement | Keep as is. |
| 6 | 13 | 13.6.2 | Bayside Breakwater + Berm + Channel Bayside Breakwater + Channel Landside Breakwater | Screened out. Coastal TX Study Scope will include the Channel Landside breakwaters. |
| **Alternative 6 – Zone 14** | | | | |
| 6 | 14 | 14.6.1 | (Bayside Breakwater + Berm + Channel Bayside Breakwater) + Sediment Placement | Keep as is. |
| 6 | 14 | 14.6.2 | Bayside Breakwater + Berm Breakwater | Screened out. Coastal TX Study Scope will include the Channel Landside breakwaters. |
| **Alternative 6 – Zone 16** | | | | |
| 6 | 16 | 16.6.1 | (Bayside Breakwater + Berm + Channel Bayside Breakwater) + Sediment Placement | Keep as is. |

| | | | | |
|---|---|---|---|---|
| 6 | 16 | 16.6.2 | Bayside Breakwater + Berm + Channel Bayside Breakwater + Channel Landside Breakwater | Screened out. The data does not show significant shoaling in the channel for this zone. |
| **Alternative 6 – Zone 18** | | | | |
| 6 | 18 | 18.6.1 | (Bayside Breakwater + Channel Bayside Breakwater) + Sediment Placement | No berm required due to barrier islands acting as berms. |
| 6 | 18 | 18.6.2 | (Bayside Breakwater + Channel Bayside Breakwater) + Channel Landside Breakwater + Sediment Placement + Reef balls | No berm required due to barrier islands acting as berms. Channel Landside Breakwater include Reef balls. |

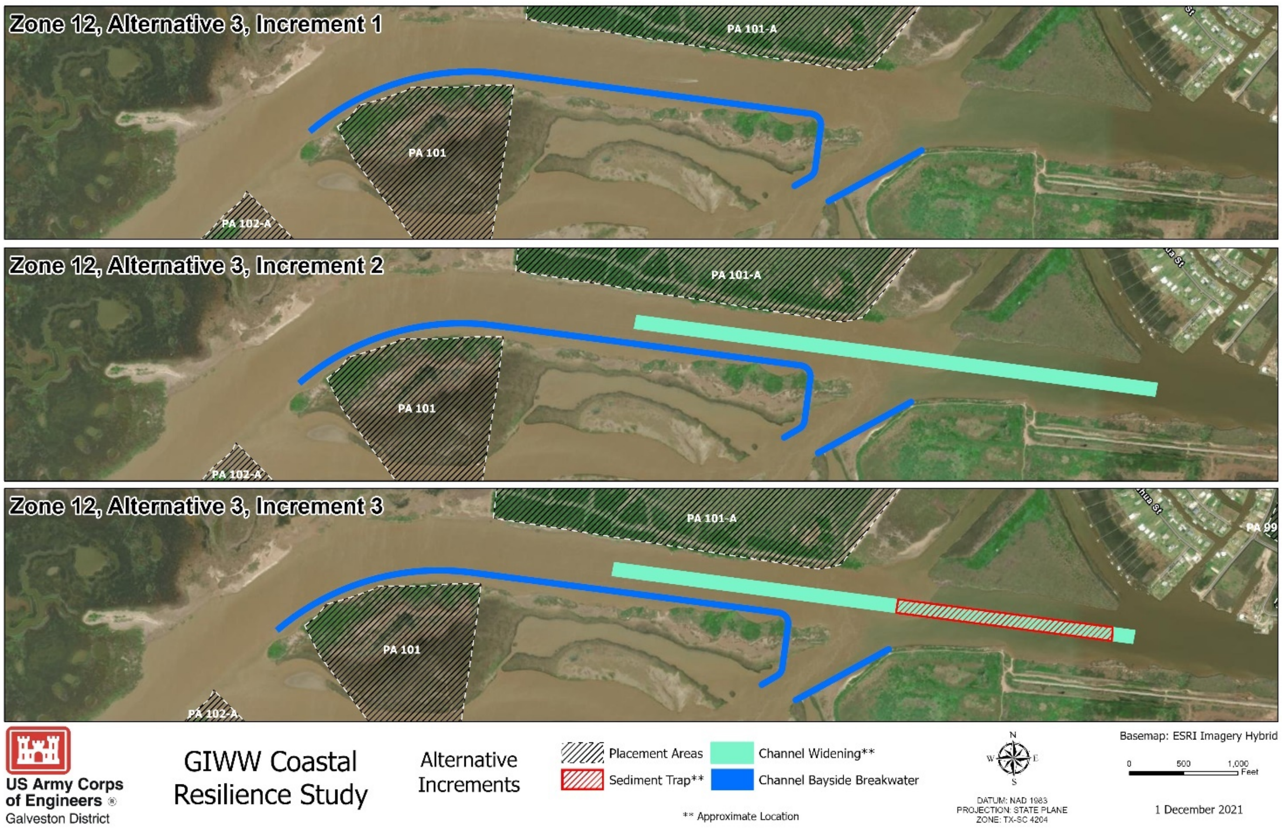


**Figure 10: Zone 12 - Alternative 3 Increment Maps**

**Top Map - Zone 12 – Alternative 3- Increment 1 (12.3.1) - Breakwater Crests = 7 feet NAVD88**

**Middle Map – Zone 12 – Alternative 3 - Increment 2 (12.3.2) Breakwater = 7 feet NAVD88 + channel widening**

**Bottom Map – Zone 12 – Alternative 3 - Increment 3 (12.3.3) Breakwater 7 feet Crests = 7 feet NAVD88 + Channel Widening + Sediment traps**

Figure 10 shows increments 12.3.1, 12.3.2, and 12.3.3 which are the increments evaluated for Zone 12. Increment 12.3.1 proposes breakwaters to be constructed with crests at 7 feet above the North American Vertical Datum of 1988 (NAVD88) on the channel bayside of the GIWW. The breakwaters are designed to protect the vessels in the channel from waves and also protect the existing barrier islands from vessel wake which cause erosion. The breakwaters near the intersection at Caney Creek are also intended to reduce the effects of the strong crosscurrents reported by navigation vessels at this location. The alignment of the breakwaters at the intersection of Mitchell's Cut and GIWW is intended to trace the future shoreline as projected. At first glance, it may appear that it is cutting through the barrier, but that barrier spit is anticipated to completely erode by project construction. In addition, the hourglass shape of the shoreline protection will allow for greater dissipation of ebb and flood currents.

Increment 12.3.2 proposes to add channel widening as an optimization measure to the breakwaters in 12.3.1. The channel widening is intended to provide vessels with more room to navigate in the portion of the channel which is identified as a shoaling hotspot. This location also poses a safety risk for vessels where 12 groundings were reported in the 2020 calendar year. Material dredged for the channel is planned to be placed in PA 99 and PA 100.

Increment 12.3.3 proposes to add a sediment trap as an optimization measure to the measures in 12.3.2. The sediment trap is intended to allow for more accumulation of sediment between scheduled dredging which would reduce or eliminate out-of-cycle dredging.

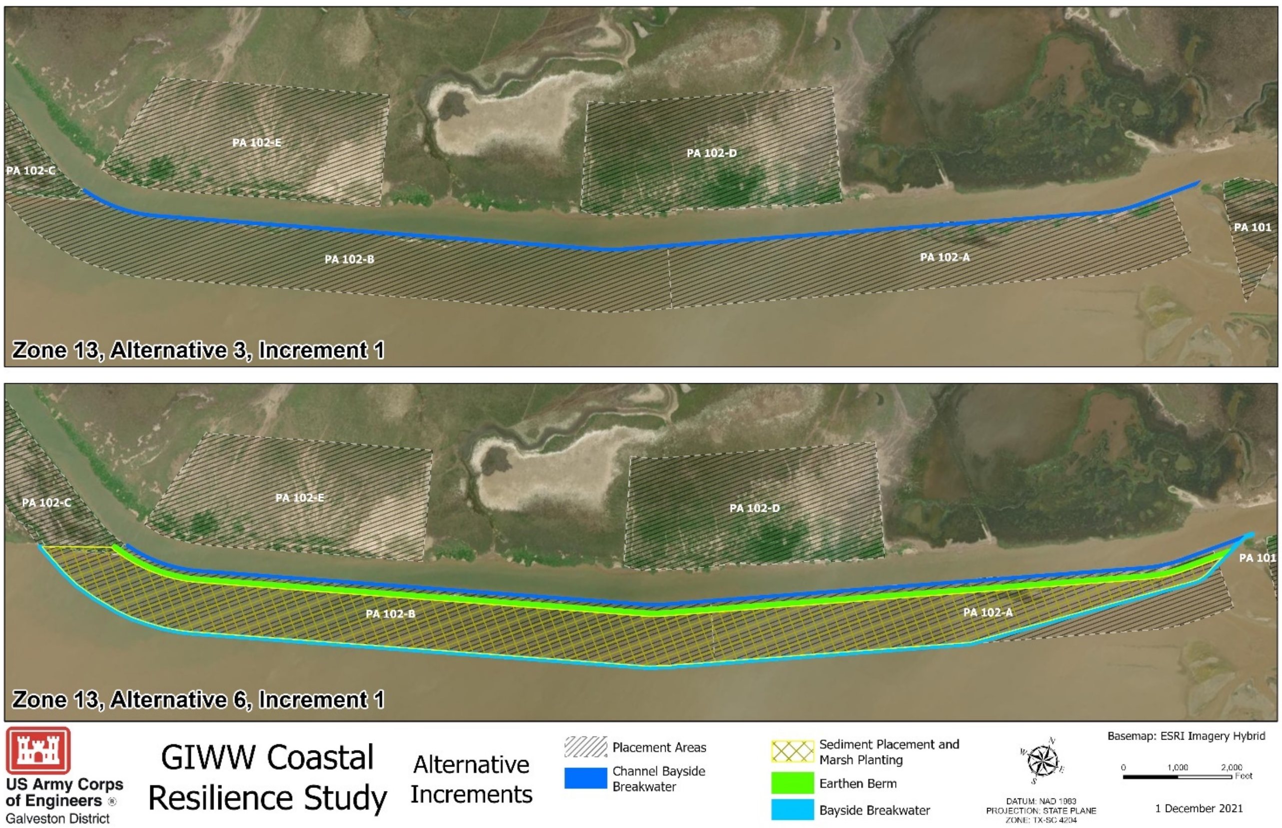


**Figure 11: Zone 13 Alternatives 3 & 6 Maps**

**Top Map - Zone 13 – Alternative 3- Increment 1 (13.3.1) Breakwater Crests = 7 feet NAVD88**

**Bottom Map = Zone 13 – Alternative 6 – Increment 1 (13.6.1) Breakwater Crests = 3 feet NAVD88 + Berm Crest = 8 feet NAVD88 + Barrier Restoration & Sediment Placement**

Figure 11 shows increments 13.3.1 and 13.6.1 which are the increments evaluated for Zone 13. Increment 13.3.1 proposes breakwaters to be constructed with crests at 5 feet NAVD88 on the channel bayside of the GIWW. The breakwaters are designed to protect the vessels in the channel from waves and also protect the existing barrier islands from vessel wake which cause erosion. The FWOP condition would lead to higher shoaling in the GIWW and greater landward shoreline erosion, which is guarded against by these breakwaters. Not illustrated in the figure are navigational and hydrologic breaks that will be optimized during PED. It is anticipated that at least one barrier opening will be implemented near the west end of this increment. These openings will have negligible reduction on overall project cost and BU capacity. The opening dimensions will be evaluated in PED to ensure hydrologic connectivity and navigation stability. The east end of this increment tapers to avoid critical habitat and transition into the zone 12 increment measures.

Increment 13.6.1 proposes a combination of sediment placement, an earthen berm, marsh plantings, and breakwaters. The sediment placement is intended to restore the barrier islands which would nearly be completely lost by the end of the period of analysis in year 2080. Borrow material will be sourced from the BU footprint. Marsh plantings are intended to prevent rapid erosion from wind and wave exposure by stabilizing the sediment with vegetation. The earthen berm is proposed to be constructed with a crest elevation of 8 feet NAVD88 and is designed to attenuate the crosswinds that vessels in the channel would be exposed to. Breakwaters are proposed to be constructed with crests at 3 feet NAVD88 on the channel bayside and bayside of the GIWW and are designed to contain the sediment in the placement area and prevent rapid erosion from wave exposure.

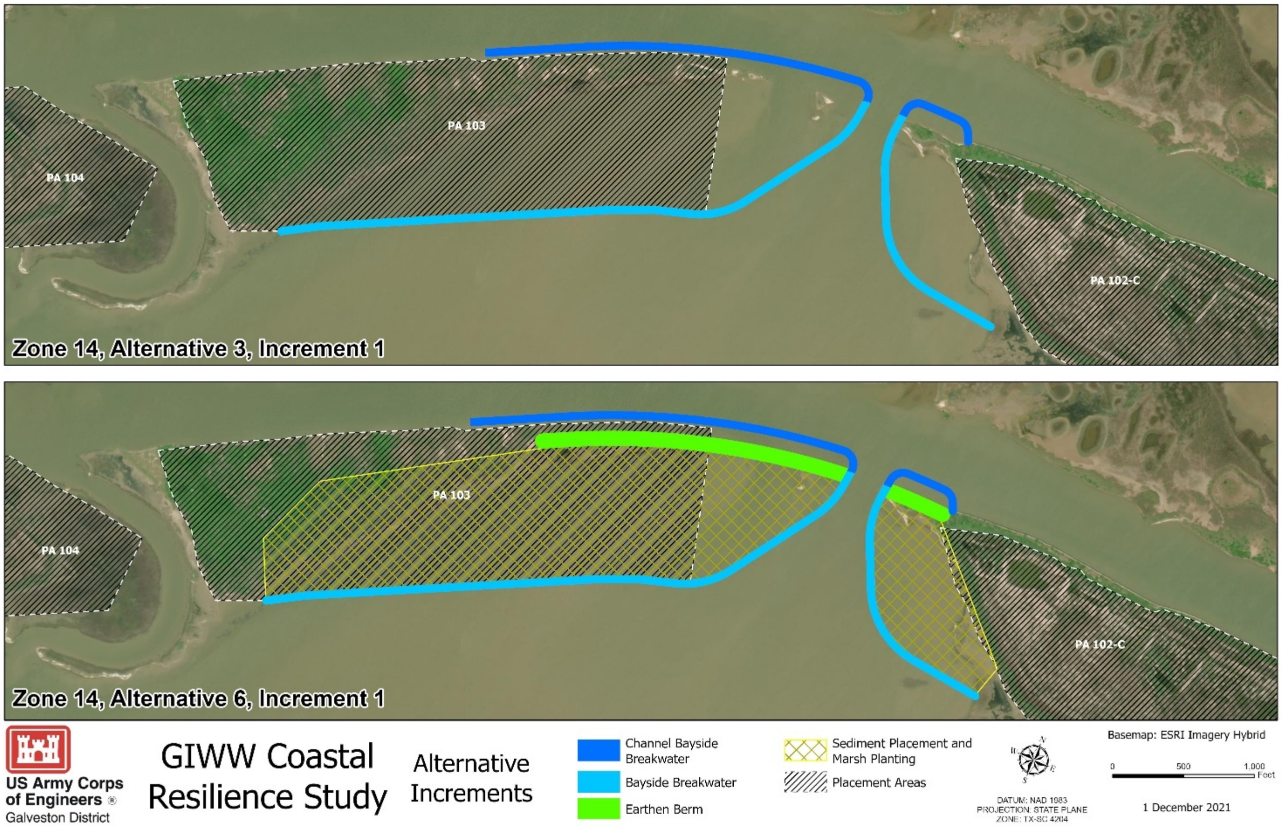


**Figure 12: Zone 14 Alternatives 3 & 6 Maps**

**Top Map = Zone 14 - Alternative 3 – Increment 1 (14.3.1) Bayside Breakwater Crests = 5 feet NAVD88 + Channel Bayside Breakwater = 3 feet NAVD88**

**Bottom Map = Zone 14 – Alternative 6 – Increment 1 (14.6.1) Breakwater Crests = 3 feet NAVD88 + Berm Crest = 8 feet NAVD88 + Barrier Restoration – Sediment Placement**

Figure 12 shows increments 14.3.1 and 14.6.1 which are the increments evaluated for Zone 14. Increment 14.3.1 proposes breakwaters to be constructed on the channel bayside and bayside of the GIWW with crests at 3 feet and 5 feet NAVD88, respectively. The breakwaters are designed to protect the vessels in the channel from waves and also protect the existing barrier islands from waves from the bay and vessel wake which cause erosion. Under the FWOP condition, the barriers will be further breached and lost. This would lead to higher shoaling in the GIWW and greater landward shoreline erosion, which is guarded against by these breakwaters. The opening dimensions will be further evaluated in PED to ensure hydrologic connectivity. The proposed hourglass shape design was implemented per Fish and Wildlife request. The extent of marsh and BU implementation will be subject to shoreline conditions at time of construction. What is shown in the plan represents approximate projections for shoreline erosion, which is why the future BU appears to overlap existing barriers.

Increment 14.6.1 proposes a combination of sediment placement, earthen berms, marsh plantings, and breakwaters. The sediment placement is intended to restore the barrier islands, much of which would be lost by the end of the period of analysis in year 2080. Borrow material will be sourced from the BU footprint. Marsh plantings are intended to prevent rapid erosion from wind and wave exposure by stabilizing the sediment with vegetation. The earthen berm is proposed to be constructed with a crest elevation of 8 feet NAVD88 and is designed to attenuate the crosswinds that vessels in the channel would be exposed to. Breakwaters are proposed to be constructed with crests at 3 feet NAVD88 on the channel bayside and bayside of the GIWW and are designed to contain the sediment in the placement area and prevent rapid erosion from wave exposure.

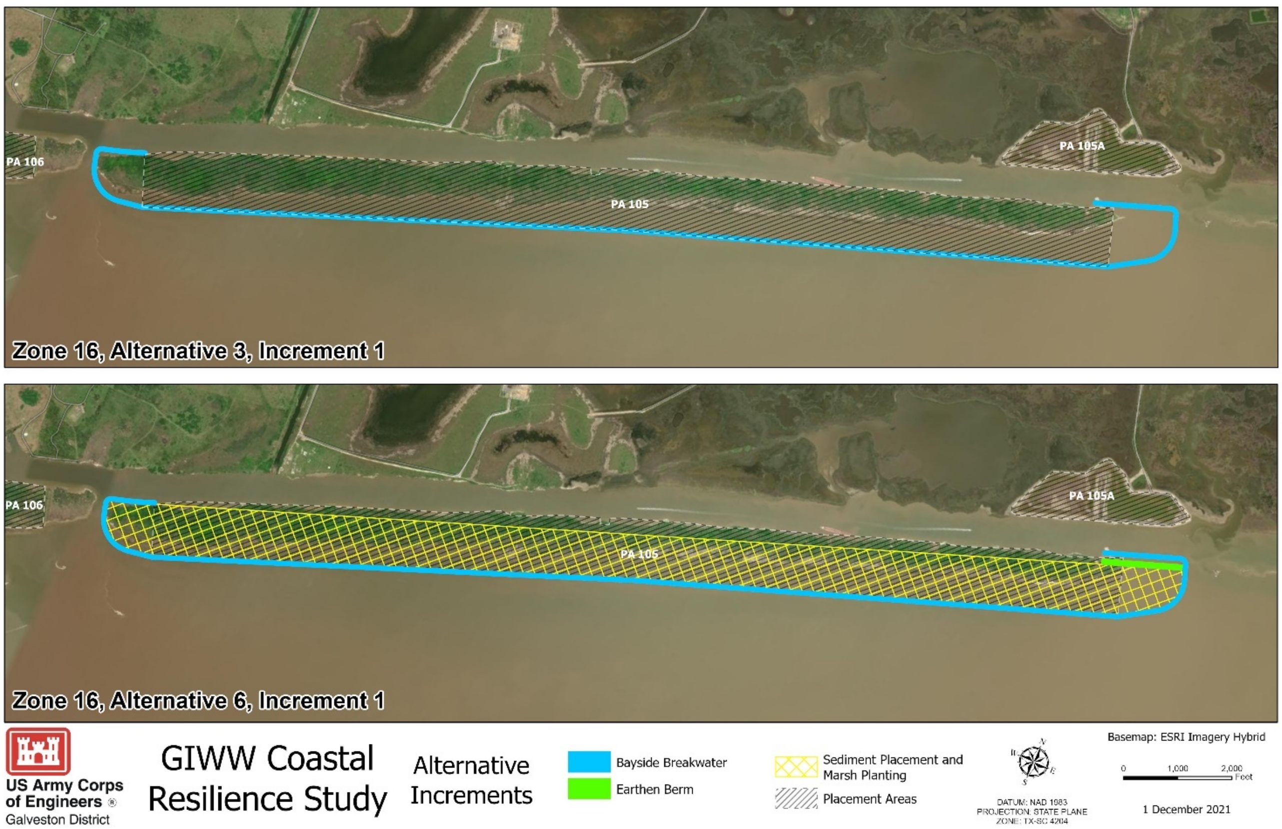


**Figure 13: Zone 16 Alternatives 3 & 6 Maps**

**Top Map – Zone 16 – Alternative 3 – Increment 1 (16.3.1) - Breakwater Crests = 5 feet NAVD88**

**Bottom Map – Zone 16 – Alternative 6 – Increment 1 (16.6.1) - Breakwater Crests = 3 feet NAVD88 + Berm Crest = 8 feet NAVD88 + Barrier Restoration – Sediment Placement**

Figure 13 shows increments 16.3.1 and 16.6.1 which are the increments evaluated for Zone 16. Increment 16.3.1 proposes breakwaters to be constructed on the bayside of the GIWW with crests at 5 feet NAVD88. The breakwaters are designed to protect the barrier islands from waves from the bay which cause erosion. The barrier islands protect the vessels in the channel from winds and waves. Under the FWOP condition, a majority of this barrier is projected to be breached and lost. This would lead to higher shoaling in the

GIWW and greater landward shoreline erosion, which is guarded against by these breakwaters.

Increment 16.6.1 proposes a combination of sediment placement, earthen berms, marsh plantings, and breakwaters. The sediment placement is intended to restore the barrier islands, much of which would be lost by the end of the period of analysis in year 2080. Borrow material will be sourced from the BU footprint. Marsh plantings are intended to prevent rapid erosion from wind and wave exposure by stabilizing the sediment with vegetation. The earthen berm is proposed to be constructed with a crest elevation of 8 feet NAVD88 and is designed to attenuate the crosswinds that vessels in the channel would be exposed to. Breakwaters are proposed to be constructed with crests at 3 feet NAVD88 on the channel bayside and bayside of the GIWW and are designed to contain the sediment in the placement area and prevent rapid erosion from wave exposure.

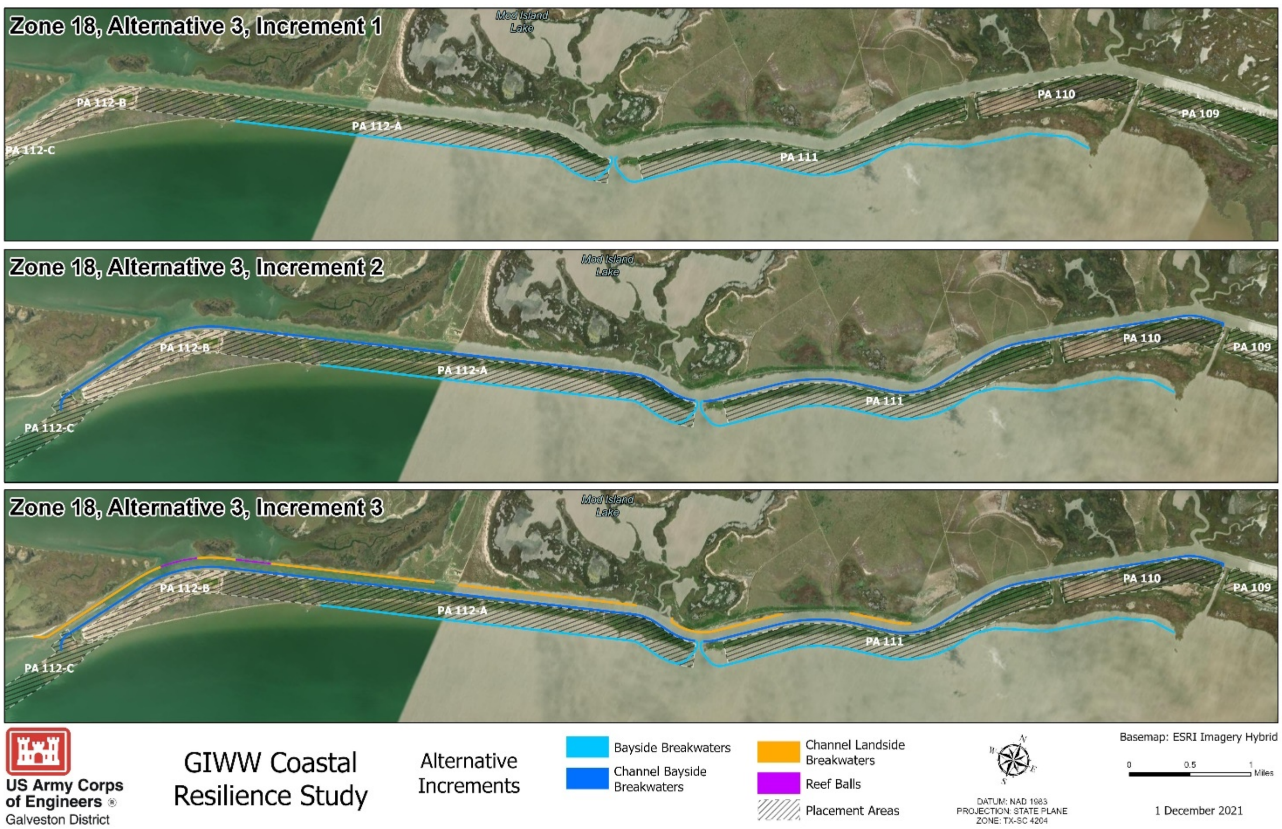


**Figure 14: Zone 18 Alternative 3 Increment Maps**

**Top Map – Zone 18 – Alternative 3 - Increment 1 (18.3.1) – Bayside Breakwater Crests = 5 feet NAVD88**

**Middle Map – Zone 18 – Alternative 3 - Increment 2 (18.3.2), Bayside Breakwater Crests = 5 feet NAVD88 + Channel Bayside Breakwater Crests = 3 feet NAVD88**

**Bottom Map – Zone 18 – Alternative 3 – Increment 3 (18.3.3) Bayside Breakwater Crests = 5 feet NAVD88 + Channel Bayside Breakwater Crests = 3 feet NAVD88 + Channel Landside Breakwater Crests= 3 feet NAVD88**

Figure 14 shows increments 18.3.1, 18.3.2, and 18.3.3 which are the alternative 3 increments evaluated for Zone 18. Increment 18.3.1 proposes breakwaters to be constructed with crests at 5 feet NAVD88 on the bayside of the GIWW and are designed to protect the barrier islands from waves from the bay which cause erosion. The barrier islands protect the vessels in the channel from winds and waves. Under the FWOP condition, the barriers are projected to be lost along several miles of the GIWW. This would lead to higher shoaling in the GIWW and greater landward shoreline erosion, which is guarded against by these alternatives. Increment 18.3.1 only guards against wind-driven waves from the Bay side.

Increment 18.3.2 proposes to add breakwaters on the channel bayside of the GIWW in addition to the breakwaters in 18.3.1. The breakwater crests on the channel bayside are proposed to be constructed to 3 feet NAVD88 and are designed to protect the barrier islands from vessel wake which cause erosion. The barrier islands protect the vessels in the channel from winds and waves.

Increment 18.3.3 proposes to add breakwaters and reef balls on the channel landside of the GIWW in addition to the breakwaters in 18.3.2. The breakwater crests on the channel landside are proposed to be constructed to 3 feet NAVD88 and are designed to protect the coastal lands from vessel wake which cause erosion. The reef balls are designed to attenuate waves while also allowing fish passage at the openings to Oyster Lake.

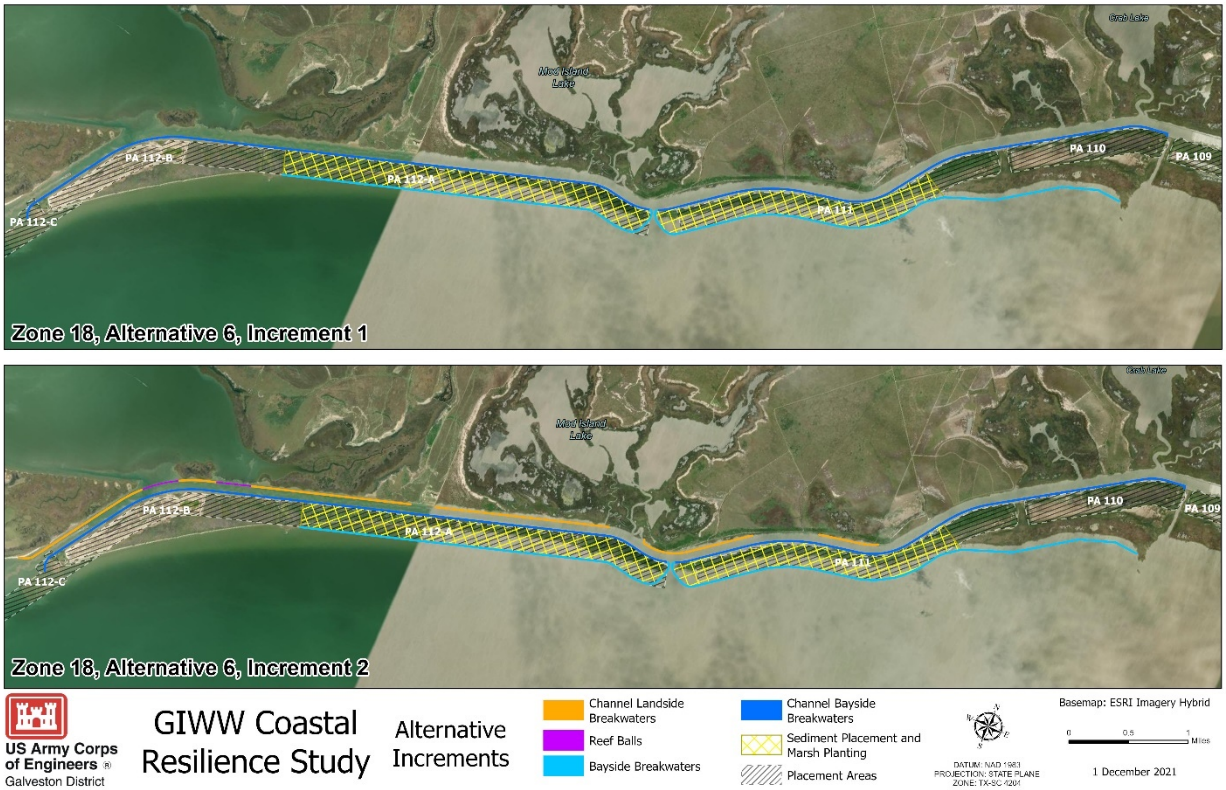


**Figure 15: Zone 18 Alternative 6 Increment Maps**

**Top Map – Zone 18 – Alternative 6 - Increment 1 (18.6.1) - Breakwater Crests = 3 feet NAVD88 + Barrier Restoration – Sediment Placement**

**Bottom Map – Zone 18 – Alternative 6 – Increment 2 (18.6.2) - Breakwater Crests= 3 feet NAVD88 + Barrier Restoration – Sediment Placement + Reef balls**

Figure 15 shows increments 18.6.1 and 18.6.2 which are the alternative 6 increments evaluated for Zone 18. Increment 18.6.1 proposes a combination of sediment placement, marsh plantings, and breakwaters. The sediment placement is intended to restore the barrier islands, most of which would be lost but not breached by the end of the period of analysis in year 2080. Because it is not projected to be beached new earthen berms are not anticipated. Marsh plantings are intended to prevent rapid erosion from wind and wave exposure by stabilizing the sediment with vegetation. Breakwaters are proposed to be constructed with crests at 3 feet NAVD88 on the channel bayside and bayside of the GIWW and are designed to contain the sediment in the placement area and prevent rapid erosion from wave and vessel wake exposure.

Increment 18.6.2 proposes to add breakwaters and reef balls on the channel landside of the GIWW in addition to the sediment placement, marsh plantings, and breakwaters in 18.6.1. The breakwaters on the channel landside are designed to protect the coastal lands from vessel wake which cause erosion. The reef balls are designed to attenuate waves while also allowing fish passage at the openings to Oyster Lake.

### 3.6.1 Planning Model

After completing the incremental analysis, the PDT held another IPR in June of 2021 with the vertical team to present the progress towards the TSP milestone and determine the decision framework to further define and capture resilience and its cost-effectiveness in order to develop the final array of alternatives and select the TSP. Due to the difficult and subjective nature of quantifying resilience, some of the PDT and Vertical Team members subsequently held multiple focus-group meetings to confirm the best approach to quantifying the additional contributions of resiliency within the decision framework. The result of discussions with the Vertical Team was that the decision framework for the TSP would be based on both economic and resilience metrics through a one-time-use Planning Model. The economic metrics include straightforward values such as project first costs, transportation costs, and O&M costs which are then used to calculate benefits in dollar cost savings. These economic metrics are similar to the ones used in a traditional inland navigation study's Economic Models. However, because this study also measures resilience benefits, a customized Planning Model was used which included resilience metrics that were decided in discussion between the PDT and the Vertical Team. Although less straightforward, the following resilience metrics were added to the Planning Model in order of importance: 1) acres of barrier island erosion protected or restored by 2080, 2) linear feet of channel exposure reduced by 2080, 3) cost per acre of barrier island in dollars, and 4) cost per linear foot in dollars. The resilience metrics 1 and 2 measure the amount of resilience provided by each increment, and metrics 3 and 4 measure the cost-effectiveness of the respective acre or linear feet of resilience provided by each increment.

### 3.6.2 Further Screening of Increments

The PDT used the economic and resilience metrics calculated in the Planning Model to further screen out the increments. Increments 14.3.1, 16.3.1, 18.3.1, 18.3.2, 18.3.3, and 18.6.2 were screened from further evaluation for less favorable values in both economic and resilience metrics compared to their counterparts within the same zones. Increment 12.3.2 had unusable shoaling data and hence inaccurate economic metrics, but it was still carried forward due to strong support from the sponsor and stakeholders related to addressing the particularly problematic unintentional groundings which pose a navigation safety risk at zone 12. Further analysis would be required to develop usable shoaling data for increment 12.3.2, but the additional shoaling analysis is being done as a refinement after the TSP milestone. Increment 12.3.3 was screened out due to lack of usable shoaling data from the incremental analysis and the decision was made to include it as an additional optimization measure for refining increment 12.3.2 if the additional shoaling analysis produced favorable data to support it. Increment 13.3.1 was screened out because it had similarly poor economic metrics and 435 acres less of barrier island when compared to increment 13.6.1. As a result of the above-mentioned screening, the final list of increments includes 12.3.1, 12.3.2, 13.6.1, 14.6.1, 16.6.1, and 18.6.1.

### 3.6.3 Incremental Comparison

The final six (6) increments were combined to compare the final alternatives 3 and 6 using different logical combinations and scaling of those alternatives within each zone. Strategies for combining these six increments or scaled plans included focusing on maximum net economic benefits, maximum resilience benefits, most efficient, most cost-effective in terms of resilience, and other alternatives that trade resilience benefits for economic benefits. The final array of alternatives is shown on the following.

**Table 20: Evaluation of Incremental Measures for the Final Array of Alternatives**

| | | Economic Metrics | | | | | Resilience Metrics | | | | Tradeoff Notes | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Increment | Total project First Cost | Average Annual Transportation Savings | Average Annual O&M Cost Savings | Average Annual net Benefits | BCR | Acres of Barrier Island Protected or Restored by 2080 | Annualized Cost per acre | Linear Feet of channel exposure reduced by 2080 | Annualized Cost per Linear foot of channel protected | Beneficial | Adverse |
| **Alternative 1 - No Action Alternative** | | | | | | | | | | | | |
| No Action | None | $ - | $ - | $ - | $ - | N/A | 0 | $ - | 0 | $ - | - No Cost | - 1,037 acres of existing barrier islands will be lost by 2080.<br>- No transportation or O&M savings to be gained<br>- Erosion |
| **Alternative 3 – Shoreline Stabilization** | | | | | | | | | | | | |
| Most Efficient Increment | 12.3.1 | $ 12,023,356 | $ 898,000 | $ 260,714 | $ 734,794 | 2.7 | 16 | $ 27,297 | 951 | $ 446 | - Highest Efficiency (BCR)<br>- Improves some problematic navigation conditions at Zone 12 | - Does not fully address sponsor and stakeholder safety concerns at zone 12.<br>- Least cost effective for resilience<br>- Least resilience in acres and linear feet |
| Safety Reduction Increment | 12.3.2 | $ 17,703,372 | $ 898,000 | $ 120,865 | $ 394,678 | 1.6 | 16 | $ 40,192 | 951 | $ 656 | - Cost Efficient (BCR)\<br>- Additional improvement with shoaling and maneuvering room for cross-current at zone 12 | - Additional cost<br>- Portion of the barrier island will still be lost by 2080 |
| Zone 13 Stabilization Increment | 13.3.1 | $ 39,124,868 | $ 580,000 | $ 191,391 | $ (608,076) | 0.6 | 3 | $ 414,254 | 19,000 | $ 73 | - Improves some problematic navigation conditions at Zone 13 | - High cost<br>- Additional vulnerability to wind/waves from open bay with just breakwaters |
| **Alternative 6 – Combination Alternative** | | | | | | | | | | | | |
| Zone 13 Barrier Island Restoration Increment | 13.6.1 | $ 60,907,295 | $ 580,000 | $ 212,408 | $ (1,355,064) | 0.4 | 438 | $ 4,906 | 19,000 | $ 113 | - Additional 435 acres from increment 13.3.1<br>- Additional buffer protection from wind/waves from open bay with restoration of barrier island<br>- Additional Placement Area (PA) | - High cost<br>- Lower efficiency (BCR) |
| Most Cost-Effective Increment | 18.6.1 | $ 60,907,295 | $ 580,000 | $ 212,408 | $ (1,355,064) | 0.4 | 438 | $ 4,906 | 19,000 | $ 113 | - Additional buffer protection from wind/waves from open bay with restoration of barrier island | - High cost<br>- Lower efficiency (BCR) |

| | | Economic Metrics | | | | | Resilience Metrics | | | | Tradeoff Notes | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Increment | Total project First Cost | Average Annual Transportation Savings | Average Annual O&M Cost Savings | Average Annual net Benefits | BCR | Acres of Barrier Island Protected or Restored by 2080 | Annualized Cost per acre | Linear Feet of channel exposure reduced by 2080 | Annualized Cost per Linear foot of channel protected | Beneficial | Adverse |
| NED | 12.3.1, 14.6.1, 16.6.1, 18.6.1 | $ 185,259,621 | $ 2,424,000 | $ 5,775,965 | $ 1,668,070 | 1.26 | 1,666 | $ 3,921 | 46,099 | $ 142 | - Highest Net Benefits<br>- 2nd most effective plan for resilience | - Does not address the safety risk concern at Zone 12 voiced by sponsor and stakeholders and vessel operators<br>- Additional vulnerability to wind/waves from open bay with just breakwater at Zone 13<br>- 2nd highest project first cost |
| Resilience | 12.3.2, 13.6.1, 14.6.1, 16.6.1, 18.6.1 | $ 251,846,932 | $ 3,004,000 | $ 5,758,958 | $ (116,676) | 0.98 | 2,104 | $ 4,221 | 65,099 | $ 136 | - Most effective plan providing the most resilience in acres of barrier island restored and linear feet of channel protection<br>- For an additional $5.7M above NED, addresses safety risk concern at Zone 12 voiced by sponsor, stakeholders and vessel operators.<br>- For an additional $60.1M above NED, restores 435 barrier island and much needed PA at zone 13 while protecting an additional 19K linear feet of channel | - Highest project first cost<br>- Negative Net Benefits<br>- Lower Efficiency (BCR) |
| NED minus Zone 18 | 12.3.1, 14.6.1, 16.6.1, | $ 60,156,385 | $ 1,680,000 | $ 1,731,288 | $ 1,290,291 | 1.6 | 505 | $ 4,199 | 46,099 | $ 163 | - 2nd highest Net benefits<br>- Cost $125M less than NED Plan | - Provides less than 30% of resilience of NED Plan<br>- 1,161 fewer acres of erosion reduced and 33K fewer linear feet of shoreline protected<br>- Provides less than 50% of resilience of Increment 18.6.1 by itself<br>- 438 fewer acres of erosion reduced and 19K fewer linear feet of shoreline protected.<br>- 664 acres of remaining barrier island will be lost by 2080 |
| Resilience minus Zone 18 | 12.32, 13.6.1, 14.6.1, 16.6.1 | $ 126,743,696 | $ 2,260,000 | $ 1,714,281 | $ (494,456) | 0.9 | 943 | $ 4,740 | 31,984 | $ 140 | - 50% cost of Resilience Plan<br>- Additional $60.1M restores 435-acre barrier island and much needed PA at zone 13 while protecting an additional 19k linear feet of channel | - Most Negative net benefits<br>- Lowest efficiency (BCR)<br>- 667 acres of remaining barrier island will be lost by 2080 |

***Note: AA is the average annualized calculation using a discount rate of 2.5% from 2030 to 2080**

### 3.6.3.1Alternative 1 –

The **Alternative 1 - No Action Plan** is the future without project (FWOP) condition and baseline to which all other alternatives are compared. The No Action Plan does not address study problems or meet study objectives. Although there are no additional costs or environmental impacts, it does not provide any economic, resilience, or safety benefits. Worsening erosion, shoaling, and coastal storms of increasing frequency and intensity will continue to exacerbate the problems in the study area.

### 3.6.3.2Alternative 3 Increment –

The **Alternative 3 - Most Efficient Plan** is increment 12.3.1 at a project first cost of $12.0 million and has the highest BCR of 2.7. The Most Efficient Plan improves the shoaling hotspot in Zone 12 by reducing erosion and sediment flow into the channel, but it does not address the grounding safety risk. The Most Efficient Plan is the least effective and the least cost-effective plan in terms of resilience. Implementing this plan will restore 16 acres of barrier island, but will still have a net loss of 996 acres of the existing barrier islands by 2080. This loss is because there is no stabilization features on the channel bayside, due to serious environmental concerns regarding critical habitat and T&E species.

The **Alternative 3 - Safety Measure Plan** is increment 12.3.2 at a project first cost of $17.7 million and a BCR of 1.6. The Safety plan improves the shoaling hotspot in Zone 12 along with a channel modification measure that allows more maneuvering room for cross currents within Zone 12. For an additional 5.7 million, the safety issue is reduced Implementing this plan will restore 16 acres, but will still have a net loss of 996 acres of the existing barrier islands by 2080. This loss is because there is no stabilization features on the channel bayside, due to serious environmental concerns regarding critical habitat and T&E species.

The **Alternative 3 - Stabilization Zone 13 Plan** is increment 13.3.1 at a project first of $37 million and a BCR of 0.6. The stabilization increment plan provides minimal protection of the navigation channel with breakwaters; however, it only restores 3 acres and is not as cost effective as the next increment for 13.6.1 indicated below which restores 438 aces for a project first cost of $61 million. For an additional $24 million, there is almost 400 times the restoration of barrier islands and a needed placement area for future use. In addition, to providing the protection of the navigation to the open bay. For these reasons, this increment was screened from further evaluation.

### 3.6.3.3Alternative 6 Increments –

The **Alternative 6 - National Economic Development (NED) Plan** includes increments 12.3.1, 14.6.1, 16.6.1, and 18.6.1 which provide the maximum net economic benefits at a project first cost of $185.3 million and a Benefit-Cost Ratio (BCR) of 1.26. The economic benefits are comprised of average annualized transportation cost savings and operation and maintenance (O&M) cost savings which are calculated using a discount rate over the 50-year period of analysis from 2030 to 2080. The net economic benefits were determined by subtracting the average annualized costs from the benefits. While the NED Plan provides the highest net economic benefits, it leaves significant resilience and safety benefits on the table by not addressing the grounding safety risk at Zone 12 and excluding Zone 13 which completely exposes this portion of the channel to East Matagorda Bay. Implementing this plan essentially prevents the net loss of existing barrier islands by 2080.

The **Alternative 6 - Resilience Plan** includes increments 12.3.2, 13.6.1, 14.6.1, 16.6.1, and 18.6.1 which provide the maximum resilience benefits at a project first cost of $251.8 million and a BCR of 0.98. The Resilience Plan is the costliest plan but also the most effective plan because it provides the most acres of barrier island protected or restored by 2080. Barrier islands are the most effective measure of providing resilience to the navigation channel. For an additional $66.6 million above the NED Plan, the Resilience Plan addresses the grounding safety risk at Zone 12 and includes restoration of the barrier islands at Zone 13 which also provides much-needed additional placement area in case shoaling volumes increase. Implementing this plan prevents the loss of existing barrier islands while also creating 435 acres of new barrier islands by 2080.

The **Alternative 6 - NED Plan without Zone 18** includes increments 12.3.1, 14.6.1, and 16.6.1 and provides the second most net economic benefits at a significantly reduced project first cost of $60.2 million. While the project first cost is about a third of the NED Plan's, the resilience provided is also reduced to less than 30 percent of the NED Plan which is measured in acres of barrier island and linear feet of channel exposure reduced. Implementing this plan will still cause a net loss of 664 acres of the existing barrier islands by 2080.

The **Alternative 6 - Most Cost-effective Plan** is increment 18.6.1 at a project first cost of $125.1 million and is the most cost-effective plan in terms of resilience. The Most Cost-effective Plan provides about half of the resilience compared to the Resilience Plan. Implementing this plan will still cause a net loss of 355 acres of the existing barrier islands by 2080.

The **Alternative 6 - Resilience Plan without Zone 18** includes increments 12.3.2, 13.6.1, 14.6.1, and 16.6.1 at a project first cost of $126.7 million which is about half of the Resilience Plan's. This plan creates 435 acres of barrier island and much-needed additional placement area at Zone 13, but it has the worst negative net economic benefits and the lowest BCR of 0.9. Implementing this plan will still cause a net loss of 657 acres of the existing barrier islands by 2080.

## 3.7 COMPARISON AND EVALUTION TO SELECT TENTATIVELY SELECTED PLAN (TSP)

The Alternative 1 - No Action Plan, Alternative 6 - NED Plan (Alt 6 – NED), and Alternative 6 - Resilience Plan (Alt 6 – Resilience) were carried forward as the most viable plans from the final array of alternatives. All other plans from the final array of alternatives were screened out from further consideration. The No Action Plan was carried forward as a baseline condition. The rationale for carrying Alt 6 NED forward is to focus on maximizing economic benefits, and the rationale for carrying Alt 6 Resilience forward is to focus on maximizing resilience benefits.

The No Action Plan provides no economic or resilience benefits, but it also does not have any costs. The worsening erosion, shoaling, and coastal storms of increasing frequency and intensity will continue to exacerbate the problems in the study area. By taking no action, the GIWW could eventually become too economically inefficient for cargo transportation in the long-term future.

Alt 6 NED provides average annualized net economic benefits of $1.67 million per year during the period of analysis from 2030 and 2080. The project first cost is the second highest at $185.3 million, but the NED Plan has a BCR of 1.26 and provides about 80 percent of the acres of barrier islands and 70 percent of the linear feet of channel exposure reduced by 2080 compared to the Alt 6 Resilience. Alt 6 NED is also the second most cost-effective plan in terms of resilience.

Alt 6 Resilience provides maximum resilience benefits with 2,104 acres of barrier island protected/restored along the GIWW by 2080 and reduces 65,099 linear feet of channel exposure by 2080 for a total project first cost of $251.8 million and a BCR of 0.98. Although the Resilience Plan has slightly negative net economic benefits, it addresses the channel exposure in Zone 13 by restoring 435 acres of barrier island and also addresses the grounding safety risk at Zone 12.

The following tables compare the Alt 6 NED and Alt 6 Resilience based on how effectively they meet the evaluation criteria, achieve the study objectives, and address the study problems. The trade-offs between the Alt 6 NED and Alt 6 Resilience will be weighed and discussed further. Table 18 below shows how Alt 6 NED and Alt 6 Resilience compared against the 1983 P&G evaluation criteria.

**Table 21: Comparison of Plans Against Evaluation Criteria**

| Plans | Complete | Effective | Efficient | Acceptable |
|---|---|---|---|---|
| Alt 6 NED | - This plan is complete and accounts for all actions to meet the estimated benefits. | - Highest Net Benefits (Total Cost $185M)<br><br>- Most Cost-effective Combination per Acre | BCR = 1.26 | Avoids impacts to ENV, CR, HTRW, or RE |
| Alt 6 Resilience[7] | - This plan is complete and accounts for all actions to meet the estimated benefits. | - Highest Resilience (Total Cost: $251.8 M)<br><br>- Zone 12 additional $5.7M for channel modification measure to address safety risk and resilience<br><br>- Zone 13 additional $61M for resiliency of the barrier island to the bay<br><br>- Most Cost-effective Combination per Linear Foot | BCR = 0.98<br><br>This is an efficient consideration for resiliency given the price tag is $50,345 per acre. | Avoids impacts to ENV, CR, HTRW, or RE |

Table 19 below compares how the NED Plan and Resilience Plan meet the study objectives.

**Table 22: Comparison of Plans Against Study Objectives**

| Plans | Objective 1: Improve Navigation Resiliency of GIWW | Objective 2: Improve Economic Efficiency of GIWW | Objective 3: Reduce Safety Risks in the GIWW |
|---|---|---|---|
| **Alt 6 - NED** | Provides 1,666 Acres of barrier island and 46,099 Linear Feet of channel protection | Provides $8.19M in total net benefits and a BCR of 1.26 | Safety risk at Zone 12 not addressed, and Zone 13 left exposed and vulnerable to bay |
| **Alt 6 - Resilience** | Provides 2,104 (+21%) Acres of barrier island and 65,099 (+30%) Linear Feet of channel protection (compared to NED Plan) | Provides $8.76M (+6%) in total net benefits and a BCR of 0.98 (-22%) (compared to NED Plan) | Zone 12 safety risks addressed, and reducing safety risk at Zone 13 |

[7] This includes 12.3.2 as a total project first cost of $17.8M, which includes channel modification ($5.8M) and the stabilization increment (12.3.1) ($12M). Increment 12.3.1 is part of 12.3.2, so those measures for stabilization for $12M are part of both the NED and Resilience Plan as shown in the Table 1 above.

The PDT's conclusions from the comparisons are as follows:

- Both Plans are complete and equally acceptable;
- Alt 6 Resilience provides more barrier creation and protection of the channel by 21% in additional Acres and 30% in Linear Feet of protection than Alt 6 NED; and,
- Alt 6 Resilience provides reduction in safety risk at Zone 12, a significant concernby the sponsor and stakeholders, and the entire length of Zone 13.

Based on the conclusions from the comparison of plans against the evaluation criteria and study objectives, the PDT recommends the Resilience Plan for the TSP. TSP includes increments: 12.3.2, 13.6.1, 14.6.1, 16.6.1, and 18.6.1. The TSP is the NED Plan plus additional measures for safety reduction in Zone 12 and resiliency in Zone 13.

**Zone 12 for safety reduction**:

Increment 12.3.2 at zone 12 has an additional project first cost of $5.7M for the channel modification measure to address unintentional groundings and significant sediment issues. These groundings pose a safety risk to life, property, and the environment.

U.S. Coast Guard data for unintentional groundings reported within Zone 12 at Caney Creek indicate that there were 13 reported groundings during the 2018 through 2020, three-year period requested. 12 out of the 13 where in the year 2020 and one in 2019.

Two emergency dredging contracts were executed between FY 18 and FY 20 for shoaling at Caney Creek. One additional emergency dredging contract was executed in early FY21 for shoaling at Caney Creek. Post Hurricane Harvey, USACE modified three contracts to conduct emergency dredging at the Colorado River Locks and East Matagorda Bay. These two areas shutdown the GIWW completely for about two weeks, after which USACE was able to incrementally open channel in stages over an additional 2-3 weeks.

As stated, waterway users have identified areas of significant shoaling where the channel width is often draft-restricted. The area where the GIWW intersects Caney Creek (Zone 12) in particular, is a location of both high current velocities and shoaling due to the proximity to the Gulf of Mexico, as well as the typical chronic and episodic shoaling experienced in the channel. This creates navigation safety risks for barges traversing this intersection. Barge tows must often "crab-walk" across the currents at Caney Creek, and tows risk damage to their rudders and wheels during groundings on large sediment shoals exacerbated by erosion in the vicinity. These groundings pose a safety risk to life, property, and the environment. Additionally, the channel shoreline on the mainland side of the GIWW has also suffered significant erosion loss, increasing shoaling in the GIWW. This allows saltwater intrusion into ecologically important and diverse brackish and freshwater marsh habitats along the north side of the GIWW.

**Zone 13 for resilience:**

At Zone 13, there is an additional project first cost of $61M ($50,345 per acre) for restoration of the barrier to support navigation resilience. This barrier will be eroded by 2030, requiring substantial amounts of material to restore a buffer between the channel and the bay. This further illustrates that the longer these problems are not addressed, the more expensive the solution due to the extent of restoration requiredand the potential for mitigation costs.  Navigation at this zone will become even more difficult due to strong winds as there will be no structure to attenuate the high wind and wave impacts without this resiliency increment.

Proposed measures at zone 13 promotes *PARA*.  Breakwaters and restoration of the barrier island allow navigation to:

- *prepare* for storms by building more protection and stabilization;
- *absorb* and protect the channel from wind/waves and lessen shoaling;
- *recover* more quickly from the impacts due to the protection and decreased shoaling; and
- *adapt* by providing options for dredge material to be placed where it is most effective and offers maximum protection from the shoaling and storm impacts in the future.

If no action is taken is Zone 13, then zone 13 is the weakest link in the system. At over 3.8 miles long, it would also represent the only non-protected reach of the GIWW greater than 500 ft between Galveston Bay and Matagorda Bay. Further, it would be the only section open to East Matagorda Bay and would be susceptible to all the Bay's tidal flushing through the GIWW, focalizing all that flow and sediment movement into that area, making it a hotspot for channel shoaling, higher cross-current velocities, and unmitigated wave action. It would be extremely susceptible to disruption during small and large events as compared to the standard for the rest of the GIWW within the project counties.

The PDT will continue to refine Zones 12 and 13 measures to optimize costs and benefits. Additional modeling for Zones 12 & 13, which will expand the CMS model that was used to evaluate qualitatively several structural alternatives in Zone 12. The model will be expanded to include and assess improvements in Zones 13 through 16, to understand the influence of open water sediment transport that contributes to shoaling in the GIWW.

The model will also be expanded to assess channel widening/deepening improvements in Zone 12 and the overall simulations will be expanded from 1 month to 2-3 years to assess the long-term shoaling responses. This additional modeling will be approximately $50K and is estimated to take 3 to 4 months (completed by February 2022). Upon completion and analysis of this additional modeling, the PDT will evaluate the design and cost associated with Zone 12 and 13 for further refinement and optimization. The ADM is currently scheduled in March of 2022.

Refinements to benefits and costs will require a revisiting economic justification of Zones 12 and 13 following the draft report review. The PDT proposes an NED exception to account for 13.6.1 potentially not being economically justified with further refinements. This NED exception would be revisited and reshaped following the draft report review and prior to the ADM where additional comments can be gathered from peer review, industry, public and agencies. The TSP for the draft report is recommended to be the “Resiliency Plan.” This allows additional flexibility for NEPA compliance and the final report to make recommendations for the NED versus the Resiliency Plan because the NED would be a subset of the Resiliency Plan.

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# 4 ENVIRONMENTAL CONSEQUENCES*

This section discusses the environmental consequences of the final alternatives chosen for more detailed analysis, as required under NEPA. Numerous alternatives were formulated, evaluated, and screened as described in Chapter 3. The final array of alternatives includes: Alternative 1 No-Action; Alternative 6 NED Plan; and Alternative 6 Resilience Plan described in more detail below.

The information used to determine environmental consequences of Alternative 1 - No-Action, Alternative 6 – NED Plan, and Alternative 6 – Resilience Plan is derived from initial descriptions and draft engineering drawings of the alternatives, field reconnaissance and desktop analysis.

When considering impacts, it was assumed that, at a minimum, best management practices (BMPs) identified throughout this chapter would apply during project construction. Assumed BMPs are based primarily on widely accepted industry, State and Federal standards for construction activities.

The **Alternative 1 - No-Action Plan** is the future without project (FWOP) condition and baseline to which all other alternatives are compared. The No Action Plan does not address study problems or meet study objectives. Although there are no additional costs or environmental impacts, it does not provide any economic, resilience, or safety benefits. worsening erosion, shoaling, and coastal storms of increasing frequency and intensity will continue to exacerbate the problems in the study area.

The **Alternative 6 - National Economic Development (NED) Plan** includes increments 12.3.1, 14.6.1, 16.6.1, and 18.6.1 which provide the maximum net economic benefits at a project first cost of $185.3 million and a Benefit-Cost Ratio (BCR) of 1.26. The economic benefits are comprised of average annualized transportation cost savings and operation and maintenance (O&M) cost savings which are calculated using a discount rate over the 50-year period of analysis from 2030 to 2080. The net economic benefits were determined by subtracting the average annualized costs from the benefits. While the NED Plan provides the highest net economic benefits, it leaves significant resilience and safety benefits on the table by not addressing the grounding safety risk at Zone 12 and excluding Zone 13 which completely exposes this portion of the channel to East Matagorda Bay. Implementing this plan essentially prevents the net loss of existing barrier islands by 2080.

The **Alternative 6 - Resilience Plan** includes increments 12.3.2, 13.6.1, 14.6.1, 16.6.1, and 18.6.1 which provide the maximum resilience benefits at a project first cost of $251.8 million and a BCR of 0.98. The Resilience Plan is the costliest plan but also the most effective plan because it provides the most acres of barrier island protected or restored by 2080. Barrier islands are the most effective measure of providing resilience to the navigation channel. For an additional $66.6 million above the NED Plan, the Resilience Plan addresses the grounding safety risk at Zone 12 and includes restoration of the barrier islands at Zone 13 which also provides much-needed additional placement area in case shoaling volumes increase. Implementing this plan prevents the loss of existing barrier islands while also creating 435 acres of new barrier islands by 2080.

## 4.1 Water Quality

### 4.1.1 No-Action Alternative

Under the No-Action Alternative, periodic maintenance dredging and placement activities for the existing GIWW may result in short-term adverse impacts such as elevated levels of suspended solids (TSS). However, these levels are expected to be similar to existing levels routinely experienced in the GIWW and Matagorda Bay, which is often naturally turbid due to wind-induced re-suspension of bay sediments. Consequently, aquatic organisms are adapted to this type of disturbance. Therefore, any such impacts from continued dredged material placement operations are expected to be minor and would be temporary. These impacts would continue to be short term, lasting only the duration of the maintenance dredging event(s).

### 4.1.2 Alternative 6 - NED Plan

Under the NED Plan, the temporary impacts to water quality in Zones 12, 14, 16, and 18 are anticipated from the construction of breakwaters, berm, and marsh nourishment activities. Construction activities would result in temporary, adverse impacts to water quality. Anticipated water quality impacts are expected to be localized and occur only during placement of breakwater materials and dredge materials. Impacts may include an increase in turbidity and total suspended solids (TSS). A ten-foot plume extending from the construction site is expected to impact water quality during construction at the placement site, but would be expected to dissipate within 24 hours of material placement. It is also anticipated that TSS and turbidity levels would return to baseline conditions once construction activities have been completed.

BMPs like dredge booms silt curtains, and training berms will be used to minimize the temporary impacts to water quality that are expected during construction. During dredge material placement, effluent from the dredge discharge pipe would be directed to the placement site for nourishment. Dredged material is expected to be free of contaminants and would be suitable for placement in the aquatic habitat in accordance with the CWA Section 404(b)(1) and is not expected to result in adverse effects to aquatic organisms. Dredging would occur during regularly scheduled maintenance events; therefore, water quality and salinity impacts during dredging would be the same as those described under the No Action.

The NED plan would have long term benefits to water quality albeit minor benefits, the breakwaters would reduce erosion along adjacent shorelines which would cause a minor reduction in turbidities adjacent to the project area. The Geotechnical Annex to the Engineering Appendix includes an estimation that both the NED plan and the Resilience Plan would reduce the amount of maintenance dredging days over the 50-year period of analysis by approximately 533 days. Or approximately 1/3 less time maintenance dredging required for the zones in question. Also, the marsh nourishment (BU) areas provide water quality benefits as wetlands can sequester and break down harmful toxins and are important for nitrogen cycling.

### 4.1.3 Alternative 6 – Resilience Plan

The Resilience Plan includes all of the work included in the NED plan plus additional work in zone 13 and 12. Specifically, the Resilience Plan would create an additional **364** acres of marsh and **118** acres of barrier island which would have additional temporary adverse effects to water quality during construction but would also have the additional long-term benefits from the additional marsh and breakwater which will reduce erosion in East Matagorda Bay. The Resilience Plan would also reduce the amount of maintenance dredging days over the 50-year period of analysis by approximately 533 days. Or approximately 1/3 less time maintenance dredging required for the zones in question.

By including Zone 13 in the Resilience Plan, it shields East Matagorda Bay from an additional 19,000 linear feet of the GIWW when compared with the NED Plan. As discussed above wave energies from ship wakes can resuspend sediments and increase turbidities.

## 4.2 Tides and Salinity

For each of the alternatives, tidal and salinity variations may be affected but are expected to be so minor that there would be nothing more than a negligible effect to any natural resources. Each alternative represents a binary variation in barrier condition (i.e. barrier or no barrier), similar to historical conditions. Historically, barriers lined the GIWW and have since eroded at various rates. The system has been productive for a long period of time whether a barrier existed or not, so changes to the barrier system, while it may affect tides and salinity, are not anticipated to introduce a non-pre-existing condition. See Appendix C, Engineering Design, Cost Estimates, and Cost Risk Analysis for modeling details.

### 4.2.1 No-Action Alternative

Under the No-Action alternative, the tidal variations are expected to be similar to the existing condition. The salinity variation is also expected to be similar to the existing condition if no action is taken.

### 4.2.2 Alternative 6 - NED Plan

Under the NED Plan, the tidal and salinity variations are expected to be the same as the pre-eroded barrier condition.

### 4.2.3 Alternative 6 – Resilience Plan

Under the Resilience Plan, the tidal and salinity variations are expected to be similar to the pre-eroded barrier condition.

## 4.3 Sea Level Change

### 4.3.1 No-Action Alternative

The effects of RSLC (relative sea level change) would occur throughout the project area, as the average sea level rise would be the same at various locations. The trend of RSLC should remain the same as discussed in Section 3.6.

### 4.3.2 Alternative 6 - NED

The effects of RSLC for the NED plan are expected to be the same as the No-Action Alternative.

### 4.3.3 Alternative 6 - Resilience Plan

The effects of RSLC for the Resilience Plan are expected to be the same as the No-Action Alternative.

## 4.4 Wetlands

### 4.4.1 No-Action Alternative

With the No Action Alternative, current trends regarding wetlands are expected to continue. Tremblay and Calnan (2010) found that on a local scale, expansion of estuarine open water since 1956 has reduced the amount of palustrine and estuarine marshland. They also stated that subsidence due to subsurface fluid withdrawal, combined with relative sea-level rise, increased the frequency of flooding. Rate of subsidence and relative sea-level rise apparently exceeded the rate of marsh vertical accretion, and the marsh was replaced primarily by open water. tidal flats suffered significant losses across the study area, as is the case along much of the Texas Coast. Of the flat loss area, roughly 70% was replaced by estuarine open water and estuarine marsh.

### 4.4.2 Alternative 6 - NED Plan

In addition to impacts from RSLC, minor negative impacts to wetlands are expected during the construction of breakwaters and restoration of barrier islands via material placement. Construction of the breakwaters would be placed in open water areas absent of wetlands and therefore have no direct impact to wetland habitats. However, the long-term presence of the breakwaters would protect against the loss of existing wetlands from erosion and saltwater intrusion into interior marshes. As well, based on observations at other locations, the breakwaters may accrete sediments behind the structure resulting in a net increase in available land for marshes to establish.

### 4.4.3 Alternative 6 - Resilience Plan

Resilience Plan is expected to be the same as described above for the NED Plan. These impacts would be localized to the placement of sediment for barrier island restoration and the construction of breakwaters for Increment 13.6.1, which is not included in the NED Plan. The restoration of the barrier island for Zone 13 would provide long term benefits to local marsh habitat by protecting it from erosion. Additional plantings of marsh species at Zone 13 would further offset any loss to wetlands during construction.

## 4.5 Coastal Barrier Resources

### 4.5.1 No-Action Alternative

Under the No-Action Alternative, the coastal barrier resources vegetation species would remain as described in Section 2.9 of this document. Without intervention, the coastal barrier resources would continue to deteriorate and migrate in an inland direction.

### 4.5.2 Alternative 6 - NED Plan

Under the NED Plan, work within CBRS units T07 and T07P include the construction of 12,160 linear feet of breakwater, 2,677 linear feet of earthen berm, and 87.7 acres of marsh through BU of dredged material. These features would restore “bay side” features that historically contained habitats that mimic barrier resources. There are no long adverse impacts anticipated to coastal barrier resources from the NED Plan.

### 4.5.3 Alternative 6 – Resilience Plan

The Resilience Plan includes all the work described in the previous Section plus additional work in Zone 13. Under the NED Plan, work within CBRS units T07 and T07P totals the construction of 49,019 linear feet of breakwater, 23,550 linear feet of earthen berm, and 493.1 acres of marsh through BU of dredged material. There are no long adverse impacts anticipated to coastal barrier resources from the Resilience Plan. The Resilience Plan would restore and improve the resiliency of an additional 453.2 acres “bay side” island features that can function as coastal barrier resources.

## 4.6 Biological Resources

### 4.6.1 Vegetation

#### 4.6.1.1 No-Action Alternative

Under the No-Action Alternative, vegetation conditions and trends are expected to stay the same as the existing condition. Additional vegetative communities are expected to transition to marsh and open water habitat. Continuing erosion and shoreline degradation is expected to transition uplands and wetlands to unconsolidated habitat with soft (fine sediments) substrate.

#### 4.6.1.2 Alternative 6 - NED Plan

Under the NED Plan, vegetation conditions across most of the project study area are expected to stay the same as the existing condition. There may be negative short-term impacts to vegetation, as plants may be covered with material or destroyed during construction of breakwaters, earthen berms, and barrier island restoration. Long-term benefits to vegetation are expected due to the construction of breakwaters in Zones 12, 14, 16, and 18, which will protect marsh habitat in the future from erosion and may allow for marsh vegetation to re-establish. Additionally, long-term benefits are expected from barrier island restoration measures that include plantings in Zones 14, 16, and 18 that will further enhance or restore native vegetation such as *Spartina alterniflora.*

#### 4.6.1.3 Alternative 6 - Resilience Plan

Impacts to vegetation for the Resilience Plan are expected to be the same as the NED Plan, but with the addition of Zone 13, which includes breakwater construction, barrier island restoration, and marsh plantings.

### 4.6.2 Aquatic Resources

#### 4.6.2.1 No-Action Alternative

Under the No-Action Alternative, the benthic habitat within and adjacent to the GIWW will continue to be disturbed due to maintenance dredging operations and ship traffic. Impacts from current maintenance dredging include increased water column turbidity during, and for a short time after, dredging activities and burial of benthic organisms. Maintenance dredging of the existing portion of the GIWW displaces marine benthic channel bottom. Maintenance activities may disturb and remove small free-swimming and benthic marine organisms in the immediate vicinity of the dredging work that are caught by the dredge cutter head or pulled into the pipeline by the pump. Most free-swimming organisms will not be impacted since they are able to avoid the slow-moving cutter head. Recolonization of the benthic community between maintenance cycles is expected to occur. As such, impacts to the existing marine benthic population that occurs during maintenance dredging is minor and temporary. No long-term effects are expected.

#### 4.6.2.2 Alternative 6 - NED Plan

Under the NED Plan, the benthic habitat within and adjacent to the GIWW in Zones 12, 14, 16, and 18 will continue to be disturbed due to maintenance dredging operations and ship traffic. Due to reduced shoaling rates within the GIWW as a result of the construction of the adjacent barrier islands, the frequency of maintenance dredging impacts will be reduced. Impacts from the construction of the barrier islands and current maintenance dredging include increased water column turbidity during, and for a short time after, dredging activities and burial of benthic organisms. Maintenance dredging of the existing portion of the GIWW displaces marine benthic channel bottom. Maintenance activities may disturb and remove small free-swimming and benthic marine organisms in the immediate vicinity of the dredging work that are caught by the dredge cutter head or pulled into the pipeline by the pump. Most free-swimming organisms will not be impacted since they are able to avoid the slow-moving cutter head. Recolonization of the benthic community between maintenance cycles is expected to occur. As such, impacts to the existing marine benthic population that occurs during maintenance dredging is minor and temporary. No long-term effects are expected.

Additionally, this alternative would adversely impact approximately 42 acres of sea grasses and 5.5 acres of oyster reef. To offset those impacts, a mitigation plan which would replace 68 acres of sea grasses in East Matagorda Bay, 3 acres of oyster reef in East Matagorda Bay, and 10 acres of oyster reef in Matagorda Bay would be required.

#### 4.6.2.3 Alternative 6 - Resilience Plan

Under the Resilience Plan, impacts to Aquatic Resources are expected to be the same as the NED Plan, but with additional dredging operations during construction, placement of maintenance material, and maintenance dredging added to include Zone 13 measures for breakwater construction and barrier island restoration.

The Resilience Plan in Zone 13 would adversely affect 12 additional acres of sea grasses which would bring the mitigation requirements to a total of 87 acres of sea grasses in East Matagorda Bay, 3 acres of oyster reef in East Matagorda Bay, and 10 acres of oyster reef in Matagorda Bay.

### 4.6.3 Wildlife

#### 4.6.3.1 No-Action Alternative

Maintenance dredging of the existing channel results in temporary, minor disturbances to wildlife that may occur in the project area. Maintenance dredging produces disturbances similar to those expected from the work being proposed. Continued residential development occurring in the area could have an impact on wildlife. Any temporarily displaced wildlife would have suitable habitat immediately available to them in the project vicinity.

#### 4.6.3.2 Alternative 6 - NED Plan

The construction of the breakwaters under the NED Plan results in minor, short-term negative impacts to wildlife that may occur in Zones 12, 14, 16, and 18. Construction of breakwaters in these zones may displace or disturb any wildlife inhabiting the terrestrial or aquatic environment nearby as part of the dredging operations for the NED Plan's measures. Placement of dredged material for barrier island restoration at Zones 14, 16, and 18 would impact wildlife similarly. Any temporarily displaced wildlife would have suitable habitat immediately available to them in the project vicinity and will be able to avoid impacts from the project.

#### 4.6.3.3 Alternative 6 - Resilience Plan

Impacts to wildlife for the Resilience Plan are expected to be the same as described for the NED Plan, but with the addition of Zone 13 measures. Additional breakwater construction and placement of material for barrier island restoration would result in a minor expected increase of disturbance and impacts to wildlife.

## 4.7 Threatened and Endangered Species

### 4.7.1 No-Action Alternative

Under the No-Action Alternative, continued maintenance dredging of the GIWW has a minor chance to have negative impacts to sea turtle species, due to potential turtle take or disturbance of foraging activities. Hydraulic dredges are not generally thought to pose adverse effects to sea turtle species, but temporary noise and turbidities could cause harassment leading to the avoidance of an area.

### 4.7.2 Alternative 6 – NED Plan

Under the NED Plan, the construction of barrier islands and marshes along the GIWW in Under the NED Plan, the construction of barrier islands and marshes along the GIWW in Zones 12, 14, 16, and 18 would create temporary disturbances including the presence of construction equipment, noise, temporary increases in turbidities, and the use of work lights. The potential of these activities to create temporary adverse effects to species led to the development of avoidance and minimization measures including, the use of biological monitors with stop work authority, educating work crews on identification of species and reporting procedures to monitors, and best management practices like laying down cranes at night to reduce the likelihood of bird strikes. With the inclusion of these avoidance and minimization measures the project avoidance and minimization measures, the NED Plan may affect but is not likely to adversely affect the following federally listed species or their designated critical habitat: the West Indian Manatee (*Trichechus manatus*), the Eastern Black Rail (*Laterallus jamaicensis jamaicensis*), the Piping Plover (*Charadrius melodus*), Red Knot (*Calidris canutus rufa*), the Whooping Crane (*Grus americana*), the green sea turtle (*Chelonia mydas*), the Hawksbill sea turtle (*Eretmochelys imbricata*), the Kemp's Ridley sea turtle (*Lepidochelys kempii,* and the loggerhead sea turtle (Caretta caretta).

It is very likely that the NED plan would have long-term minor beneficial effects to the species mentioned above. The engineering estimates include 533 fewer dredge workdays for both the NED and Resilience Plans over the FWOP condition. Also, reduction in turbidities from reduced erosion would cause a long-term minor increase in water quality which would benefit all of the species. Finally, beneficially using dredge material to create marsh habitat could improve the ecological productivity of the system. Tidal marsh is important habitat for numerous species.

### 4.7.3 Alternative 6 - Resilience Plan

The resilience plan includes the slightly more potential to cause temporary disturbances during construction as the NED Plan because it includes the additional work in Zones 12 and 13. The initial construction timeframes are expected to be similar because multiple work crews could work in parallel to complete the project. With the inclusion of the same avoidance and minimization measures discussed in Section 4.7.2 these potential adverse effects have been reduced to negligible or discountable. The complete analysis can be found in the BA (Appendix D). The Resilience Plan would have long-term minor beneficial effects than the NED Plan because it shields East Matagorda Bay from an additional 19,000 linear feet of the GIWW and would provide an additional 328 acres of marsh creation through BU.

## 4.8 Aquatic Nuisance Species

### 4.8.1 No-Action Alternative

Vessel ballast water discharges or exchanges in coastal waters have the potential to introduce ANS. To minimize this potential threat, all vessels calling on the port must comply with established USCG regulations that: (1) require mandatory ballast water management practices for all vessels that operate in U.S. waters, (2) establish additional practices for vessels entering U.S. waters after operating beyond the extraterritorial economic zone, and (3) require the reporting and recordkeeping of ballasting operations by all vessels.

### 4.8.2 Alternative 6 - NED Plan

Under the NED Plan, there are no expected changes to occur to ANS. Conditions to ANS are expected to remain as those described in the existing condition.

### 4.8.3 Alternative 6 - Resilience Plan

Under the Resilience Plan, there are no expected changes to occur to ANS. Conditions to ANS are expected to remain as those described in the existing condition.

## 4.9 Recreational Resources

### 4.9.1 No-Action Alternative

Under the No-Action Alternative, continued land erosion and subsidence is likely to increase open water areas. Recreational fishing opportunities would be indirectly impacted by the resulting effect on spawning, nursery and foraging habitats. Current maintenance dredging operations would continue and impacts to recreational resources would include altering productive fishing grounds and short-term increases in turbidity, although reductions in the numbers of important species are not expected. Fish would avoid direct dredging impacts from continued maintenance dredging of the exiting channel by swimming away from the disturbance. Recreational fishing opportunities in the vicinity of maintenance dredging would likely temporarily decrease. The channel would continue to be maintained at its present dimensions. Recreational navigation activity would be expected to continue along historical trends.

### 4.9.2 Alternative 6 - NED Plan

Under the NED Plan, land erosion and subsidence are likely to decrease open water areas with the construction of barrier islands and marshes in Zones 12, 14, 16, and 18. Recreational fishing opportunities would be indirectly impacted during construction by the resulting effect on spawning, nursery and foraging habitats. Current maintenance dredging operations would continue and impacts to recreational resources would include altering productive fishing grounds and short-term increases in turbidity, although reductions in the numbers of important species are not expected. Fish would avoid direct dredging impacts from continued maintenance dredging of the exiting channel by swimming away from the disturbance. Recreational fishing opportunities in the vicinity of maintenance dredging would likely temporarily decrease. The channel would continue to be maintained at its present dimensions. Recreational navigation activity would be expected to continue along historical trends.

### 4.9.3 Alternative 6 - Resilience Plan

Under the Resilience Plan, land erosion and subsidence are likely to decrease open water areas with the construction of barrier islands and marshes. Recreational fishing opportunities would be indirectly impacted during construction by the resulting effect on spawning, nursery and foraging habitats. Current maintenance dredging operations would continue and impacts to recreational resources would include altering productive fishing grounds and short-term increases in turbidity, although reductions in the numbers of important species are not expected. Fish would avoid direct dredging impacts from continued maintenance dredging of the exiting channel by swimming away from the disturbance. Recreational fishing opportunities in the vicinity of maintenance dredging would likely temporarily decrease. The channel would continue to be maintained at its present dimensions. Recreational navigation activity would be expected to continue along historical trends.

An access channel is proposed in Zone 13 to maintain recreational boat access to East Matagorda Bay from the GIWW. The approximate location of the access channel is shown on Page 6 of 7 of the Engineering Plates included in the Engineering Appendix C.

## 4.10 Socioeconomics

### 4.10.1 No-Action Alternative

Populations in the affected area will continue to grow according to historic trends. According to data from the Texas Demographic Center, Matagorda County's population is projected to grow by about 8,700 residents between 2020 and 2027.

### 4.10.2 Alternative 6 - NED Plan

Populations in the affected area under the NED Plan will continue to grow according to historic trends. According to data from the Texas Demographic Center, Matagorda County's population is projected to grow by about 8,700 residents between 2020 and 2027.

### 4.10.3 Alternative 6 - Resilience Plan

Populations in the affected area under the Resilience Plan will continue to grow according to historic trends. According to data from the Texas Demographic Center, Matagorda County's population is projected to grow by about 8,700 residents between 2020 and 2027.

## 4.11 Environmental Justice

### 4.11.1 No-Action Alternative

The minority and low-income populations living within the project area vicinity would not likely experience any adverse changes to the demographic, economic, or community cohesion characteristics within their neighborhoods

### 4.11.2 Alternative 6 - NED Plan

The minority and low-income populations living within the project area vicinity would not likely experience any adverse changes to the demographic, economic, or community cohesion characteristics within their neighborhoods as a result of the NED Plan.

### 4.11.3 Alternative 6 - Resilience Plan

The minority and low-income populations living within the project area vicinity would not likely experience any adverse changes to the demographic, economic, or community cohesion characteristics within their neighborhoods as a result of the Resilience Plan.

## 4.12 Soils

### 4.12.1 No-Action Alternative

Prime or unique farmland soils are not present in the project area; therefore, no impacts would occur to these resources.

### 4.12.2 Alternative 6 - NED Plan

Prime or unique farmland soils are not present in the project area; therefore, no impacts would occur to these resources.

### 4.12.3 Alternative 6 - Resilience Plan

Prime or unique farmland soils are not present in the project area; therefore, no impacts would occur to these resources

## 4.13 Noise

### 4.13.1 No-Action Alternative

Under the No-Action Alternative, impacts related to noise would continue to be associated with periodic maintenance dredging and placement activities for the existing channel, primarily from the use of a cutterhead dredge (68 dBA). These impacts would continue to be short term, lasting only the duration of the maintenance dredging event.

### 4.13.2 Alternative 6 - NED Plan

Under the NED Plan, impacts related to noise would exist from barrier island construction activities in Zones 12, 14, 16, and 18. Noise would continue to be associated with periodic maintenance dredging and placement activities for the existing channel, primarily from the use of a cutterhead dredge (68 dBA). These impacts would continue to be short term, lasting only the duration of the maintenance dredging event.

### 4.13.3 Alternative 6 - Resilience Plan

Under the Resilience Plan, impacts related to noise would exist from barrier island construction activities in Zones 12, 13, 14, 16, and 18. Noise would continue to be associated with periodic maintenance dredging and placement activities for the existing channel, primarily from the use of a cutterhead dredge (68 dBA). These impacts would continue to be short term, lasting only the duration of the maintenance dredging event.

## 4.14 Air Quality

### 4.14.1 No-Action Alternative

The project is within an area classified as “attainment”. No new construction or dredging air contaminant emission sources are associated with the No-Action Alternative. Air contaminant emissions that may result from ongoing maintenance dredging activities would include exhaust emissions from fuel combustion in engines that power the marine vessels (dredge and support), on-shore construction equipment for dredged material placement, and employee commuter vehicles. Emissions associated with maintenance dredging are not expected to change from current conditions.

### 4.14.2 Alternative 6 - NED Plan

The project is within an area classified as “attainment”. New construction or dredging air contaminant emission sources, associated with the NED Plan, will be minimal. Air contaminant emissions that may result from barrier island construction and ongoing maintenance dredging activities in Zones 12, 14, 16, and 18 would include exhaust emissions from fuel combustion in engines that power the marine vessels (dredge and support), on-shore construction equipment for dredged material placement, and employee commuter vehicles. Emissions associated with maintenance dredging are expected to decrease with reduced dredging cycle frequency.

### 4.14.3 Alternative 6 - Resilience Plan

The project is within an area classified as “attainment”. New construction or dredging air contaminant emission sources, associated with the Resilience Plan, will be minimal. Air contaminant emissions that may result from barrier island construction and ongoing maintenance dredging activities in Zones 12, 13, 14, 16, and 18 would include exhaust emissions from fuel combustion in engines that power the marine vessels (dredge and support), on-shore construction equipment for dredged material placement, and employee commuter vehicles. Emissions associated with maintenance dredging are expected to decrease with reduced dredging cycle frequency.

## 4.15 Hazardous Toxic and Radioactive Waste

### 4.15.1 No-Action Alternative

Based on the findings of the HTRW survey, the probability of encountering contaminated sites or toxic substances without project construction is considered low. Information compiled by this assessment indicates additional investigations are not warranted at this time.

### 4.15.2 Alternative 6 - NED Plan

Under the NED Plan, the probability of encountering contaminated sites or toxic substances without project construction is considered low. Information compiled by this assessment indicates additional investigations are not warranted at this time.

### 4.15.3 Alternative 6 - Resilience Plan

Under the Resilience Plan, the probability of encountering contaminated sites or toxic substances without project construction is considered low. Information compiled by this assessment indicates additional investigations are not warranted at this time.

## 4.16 Cultural Resources

### 4.16.1 No-Action Alternative

Under the No Action Alternative, there would be no horizontal or vertical impact to known cultural resources within the study area, aside from natural formation and erosion processes that occur over time. Any non-structural alternative would have to be evaluated in consultation with the Texas Historical Commission, federally recognized Tribal Nations, and other interested parties.

### 4.16.2 Alternative 6 - NED Plan

Under the NED Plan, there would be no horizontal or vertical impact to known cultural resources within the study area.

### 4.16.3 Alternative 6 - Resilience Plan

Under the Resilience Plan, there would be no horizontal or vertical impact to known cultural resources within the study area.

# 5 TENTATIVELY SELECTED PLAN (TSP)

Both Alternative 6 – NED Plan and Alternative 6 – Resilience Plan are complete and effective plans. However, for all the reasons stated below, the PDT is recommending the tentatively selected plan (TSP) as Alternative 6 - Resilience plan. This recommendation requires a NED Exception, which is still pending approval by the ASA(CW). Therefore, either plan could ultimately be selected at the Agency Decision Milestone in the late Spring of 2022.

## 5.1 Alternative 6 - Resilience Plan

The recommended Tentatively Selected Plan (TSP) is the Resilience Plan because it is the most effective at meeting the evaluation criteria, addressing the study problems, and achieving the study objectives. While the Resilience Plan is the costliest plan with a project first cost of $251.8 million, it also provides reasonable economic benefits and a BCR of 0.98. For an additional $66.6 million project first cost above the NED Plan, the Resilience Plan prevents the complete exposure of Zone 13 and addresses the grounding safety risk at Zone 12. See Figure 16: Alternative 6 – Resilience Plan.

The Resilience Plan includes increments 12.3.2, 13.6.1, 14.6.1, 16.6.1, and 18.6.1 which are described below:

- Increment 12.3.2 is a combination of shoreline stabilization using breakwaters and channel widening in zone 12 protecting 16 acres of barrier island and 951 linear feet of channel for $17.7 million. This increment also addresses a problem area for grounding which has posed safety risks to navigation.

- Increment 13.6.1 is a combination of shoreline stabilization using breakwaters and sediment placement in zone 13 protecting/restoring 438 acres of barrier island and protecting 19,000 linear feet of channel for $60.9 million.

- Increment 14.6.1 is a combination of shoreline stabilization using breakwaters and sediment placement in zone 14 protecting/restoring 114 acres of barrier island and protecting 4,329 linear feet of channel for $15.8 million.

- Increment 16.6.1 is a combination of shoreline stabilization using breakwaters and sediment placement in zone 16 protecting/restoring 376 acres of barrier island and protecting 7,704 linear feet of channel for $32.4 million.

- Increment 18.6.1 is a combination of shoreline stabilization using breakwaters and sediment placement in zone 18 protecting/restoring 1161 acres of barrier island and protecting 33,115 linear feet of channel for $125.1 million.

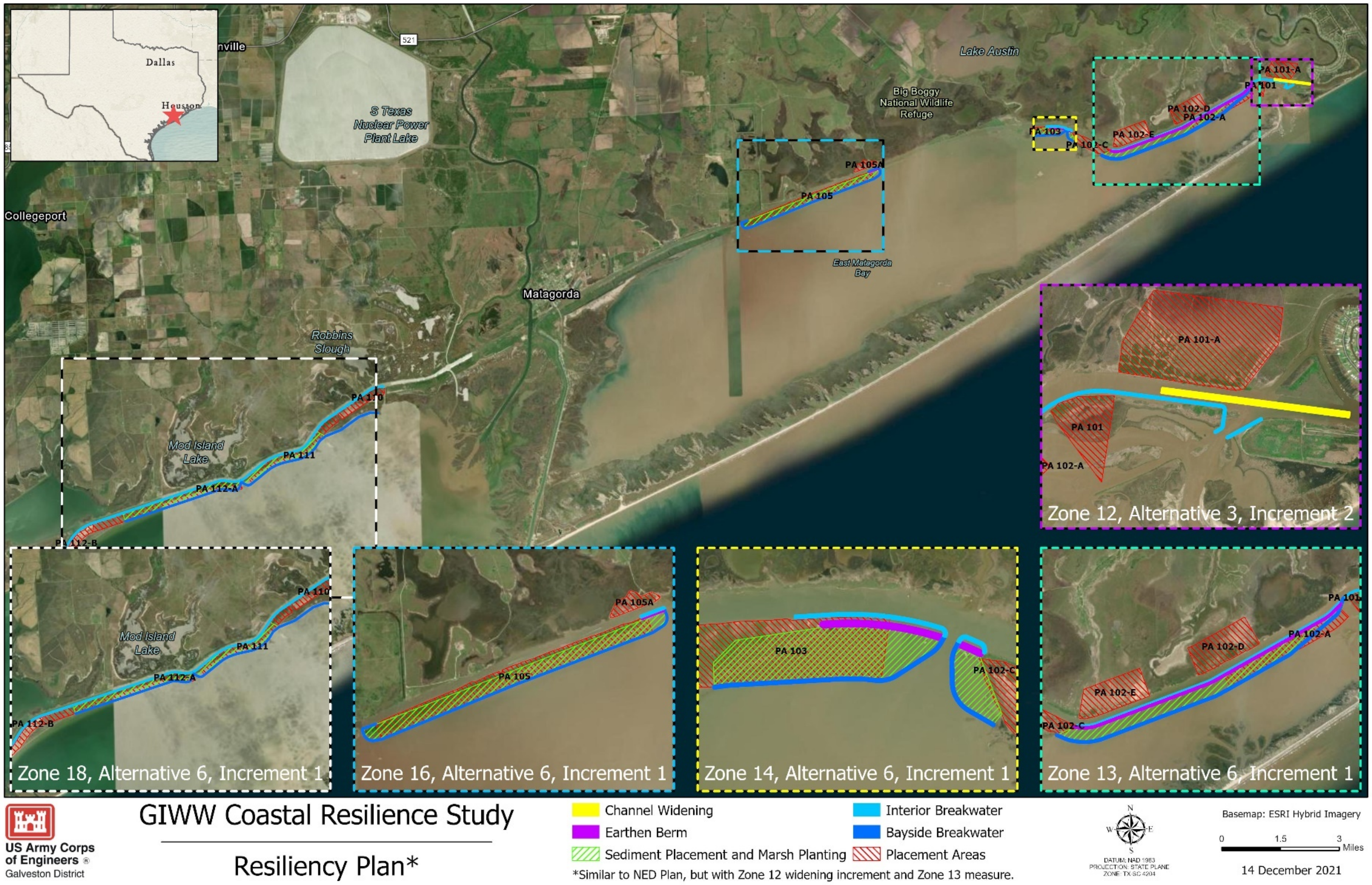


**Figure 16: Alternative 6 – Resilience Plan (Recommended TSP)**

## 5.2 Alternative 6 – NED Plan

The NED Plan is also a viable plan providing the maximum economic benefits and reasonable resilience benefits with a project first cost of $185.3 million and a BCR of 1.26. The NED Plan proposes to save $66.6 million or about 26 percent of the project first cost less than the Resilience Plan. In exchange for the lower cost, the NED Plan excludes 438 acres or about 21 percent of barrier islands protected or restored by 2080 and 19,000 linear feet or about 29 percent of channel exposure reduced by 2080. In the case that the NED Exception policy waiver is not approved, the NED Plan is recommended for selection.

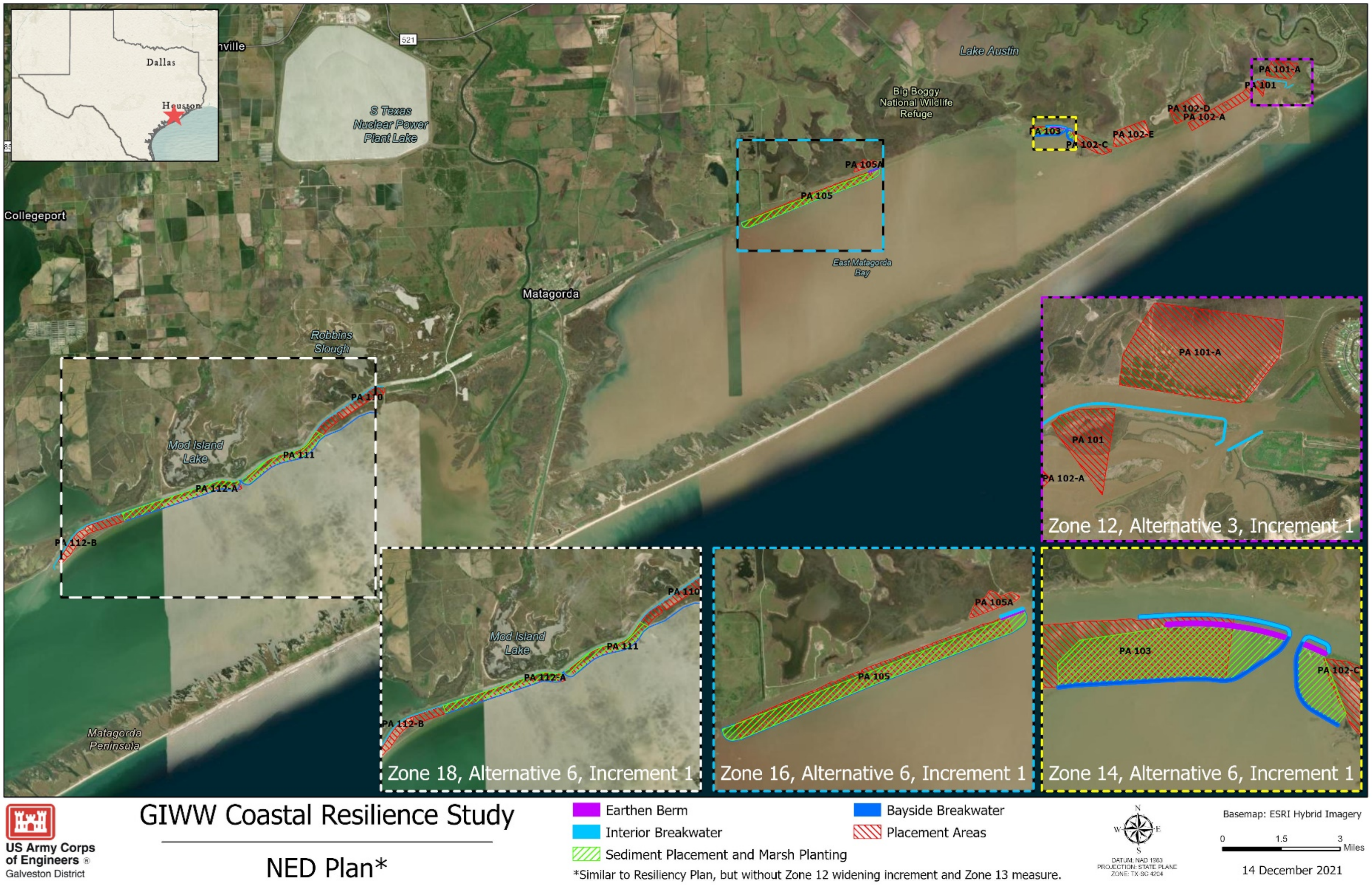


**Figure 17: Alternative 6 – NED Plan**

## 5.3 Dredged Material

Due to the implementation of project measures after 2030 the annual shoaling quantities are expected to immediately decrease in each zone where work is performed. Decrease in shoaling means that less material will need to be dredged per O&M cycle decreasing the required placement capacity during the 50-year period of analysis. The majority of dredged material will be placed into newly constructed beneficial use sites. Therefore, upland placement areas should not need to be raised to contain dredged material during the 50-year period of analysis.

## 5.4 Environmental Impacts

A full list of the anticipated environmental impacts associated with both Alternative 6 – Ned Plan and Alternative 6 - Resilience Plan were described in Chapter 4 of this report.

## 5.5 Cost Estimate

The project first costs consist of construction costs, environmental costs, and real estate costs. For Alternative 3 increments, construction costs consist of the costs for engineering and design, mobilization, construction management, and materials for breakwaters and reef balls. For Alternative 6 increments, construction costs include the same costs described for Alternative 3 and also add the costs for building earthen berms including the dredging mobilization required. In June of 2021, the PDT conducted an Abbreviated Risk Analysis (ARA) and the resulting risks were used to develop the cost contingency of 35% which were applied to the project first costs for all increments.

Class 3 cost estimates were developed in MCACES (Micro-Computer Aided Cost Estimating System), also known as MII, for the final alternatives: Alternative 6 - NED and Alternative 6 - Resilience designed by the project delivery team (PDT).

Alternative 6 - NED plan is divided into two (2) contracts and Alternative 6 - Resiliency plan is divided into three (3) contracts. Each contract is organized in accordance with a work breakdown structure. Midpoint dates for the construction contracts were developed in conjunction with the PM and the PDT for developing the fully funded costs. The estimates were prepared in accordance with ER 1110-2-1302 Civil Works Cost Engineering and EM 1110-2-1304 Civil Works Construction Cost Index System (CWCCIS), dated 30 September 2021.

Marine fuel price is averaged, locked in at $3.00/gallon (October 2021). Diesel fuel price is locked in at $3.47/gallon (October 2021). There are no impacts to utilities anticipated. There are no Hazardous, Toxic, and Radioactive Wastes anticipated. The Operation and Maintenance estimate is dated October 2021, with an effective pricing date of October

2021. A formal Cost Risk Analyses is performed with the cooperation of the PDT and Cost Engineering Directory of Expertise (DX) of the Walla Walla District (October 2021). The risks were quantified, and a cost risk model developed to determine a contingency at 80% Confidence Level (CL). An ATR Certification of Cost Estimate is provided by Walla Walla District.

Costs were developed incrementally so PDT could break down the cost estimates for different plans. Seventeen increments were developed to isolate cost impacts by zone and feature. These increments were combined into seven (7) final alternatives for which the costs are detailed in the Cost Appendix. The NED Plan and the Resilience Plan cost breakdowns are shown below in Table 24.

Table 23: Cost for Alternative Plans, October 2021 Price Level, First Cost

| Code of Accounts | NED | Resilience |
|---|---|---|
| **Non-Federal Costs** | | |
| 01 Lands and Damages | $ 97,772 | $ 97,772 |
| **Total Non-Federal Costs** | $ 97,772 | $ 97,772 |
| | | |
| **Federal Costs** | | |
| 01 Lands and Damages | $ 34,425 | $ 37,125 |
| 06 Fish & Wildlife Facilities | $ 25,682,760 | $ 32,124,552 |
| 10 Breakwaters and Seawalls | $132,786,596 | $175,871,080 |
| 12 Navigation Ports & Harbors | $ 3,858,838 | $ 12,730,299 |
| 30 Planning, E&D | $ 12,986,256 | $ 17,664,470 |
| 31 Construction Management | $ 9,739,692 | $ 13,248,352 |
| **Total Federal Costs** | $185,088,567 | $251,675,878 |
| | | |
| **Total Project Cost** | $185,186,338 | $251,773,649 |
| | | |
| **Total Proj Cst (Rounded)** | $185,186,000 | $251,774,000 |

## 5.6 Project Schedule and Interest During Construction

Alternative 6 - NED plan is divided into two (2) contracts and Alternative 6 - Resiliency plan is divided into three (3) contracts. Each contract is organized in accordance with a work breakdown structure. Midpoint dates for the construction contracts were developed in conjunction with the PM and the PDT for developing the fully funded costs. The estimates were prepared in accordance with ER 1110-2-1302 Civil Works Cost Engineering and EM 1110-2-1304 Civil Works Construction Cost Index System (CWCCIS), dated 30 September 2021.

**Alternative 6 - NED Plan:**
Alternative 6 - NED plan is split into two contracts.

Contract 1:
This contract covers construction in zone 12, zone 14, and zone 16. Breakwaters will be constructed in each zone. Earthen berms will be constructed in zones 14 and 16. Oyster reefs will be constructed in zone 16 and seagrass will be planted. The approximate duration is 13 months.

Contract 2:
This contract covers construction in zone 18. Construction involves breakwaters, oyster reefs, and sea grass. The approximate duration is 16 months.

**Alternative 6 - Resilience Plan:**
Alternative 6 - Resilience plan is split into three contracts.

Contract 1:
This contract covers construction in zone 12 and zone 13. Breakwaters will be constructed in each zone. Earthen berms and oyster reefs will be constructed in zones 13. The approximate duration is 18 months.

Contract 2:
This contract covers construction in zone 14 and zone 16. Breakwaters will be constructed in each zone. Earthen berms will be constructed in zones 14 and 16. Oyster reefs will be constructed in zone 16 and seagrass will be planted. The approximate duration is 10 months.

Contract 3:
This contract covers construction in zone 18. Construction involves breakwaters, oyster reefs, and sea grass. The approximate duration is 16 months.

For more information, see the Cost Engineering Appendix G.

## 5.7 DESIGN AND CONSTRUCTION CONSIDERATIONS

The TSP is a combination of breakwaters, barrier islands, marshlands, and channel modifications. Considerations for the design and construction of these features include sea level rise, vessel induced waves, wind-driven waves and storm surge, navigation safety, shoaling, dredged material management, environmental stewardship, and vegetation establishment and stability.

The breakwaters along the channel should be designed to: 1) attenuate vessel induced waves so as to minimize shoreline erosion, 2) not impact navigation safety or efficiency, 3) act as temporary containment for the (re)construction of barrier islands, 4) facilitate tidal exchange and aquatic connectivity between the channel and barrier islands, and 5) be structural stable over the course of their design life.

Per the plan, they are offset 200 ft from the main channel and targeted with a toe between the -1 and -2 ft NAVD88 contour in order to avoid vessel interference and not impact navigation safety. The channel-side breakwaters have crest elevations at 3 ft NAVD88 to allow for visible exposure under MHHW and with intermediate sea level rise. They will be sheltered on the bay-side by the higher crest elevation of barrier islands so will not be vulnerable to wind-driven waves but should be designed to be stable under vessel-induced waves. They should feature small gaps or breaks at intervals along their length to facilitate tidal exchange without sacrificing shoreline stability.

It is anticipated that construction of the breakwaters along the channel will not require access channels, as the GIWW should facilitate adequate room; however field survey should be collected to determine if some areas require access dredging. Any access dredging should be performed at sufficient distance to avoid compromising the structural integrity of the bed near the proposed breakwater.

The breakwaters along the bay side of the barrier islands should be designed to 1) attenuate wind-driven waves so as to minimize shoreline erosion, 2) minimize impact to established environmental communities, 3) act as temporary containment for the (re)construction of barrier islands, 4) facilitate tidal exchange and aquatic connectivity between the channel and barrier islands, and 5) be structural stable over the course of their design life.

Per the plan, they are aligned with the original or existing established southern edge of real estate which coincides roughly with a toe between the -1 and -2 ft NAVD88 contour. The bay-side breakwaters have crest elevations at 3 ft NAVD88 to allow for visible exposure under MHHW and with intermediate sea level rise. They should be designed to be structurally stable for wind-driven waves and storm surge, and balance attenuation of storm generated waves with the resilience and renourishment of the barrier islands. In other words, they are not intended to attenuate all storm generated waves, but rather reduce their impacts to a threshold that can be addressed through dredge material management practices. Similar to the channel-side breakwaters, they should feature small gaps or breaks at intervals along their length to facilitate tidal exchange without sacrificing shoreline stability.

It is anticipated that construction of the bay-side breakwaters will require access channels. These access channels are to be constructed on the leeward side of the breakwater and the barrier islands with the material being dredged for the access channel to be used to renourish the barrier island. The access channel will not need to be refilled as it will act as future beneficial use capacity. Any access dredging should be performed at sufficient distance to avoid compromising the structural integrity of the bed near the proposed breakwater.

The barrier islands and marsh lands are an integrated system. The barrier islands should be designed to 1) neither breach nor spill into the GIWW during storm generated events, allow sufficient interchange between the GIWW and the bay, and 3) have sufficient initial footprint and capacity to be structural stable over the course of their design life balancing and optimizing sea level rise and storm generated erosion with beneficial use renourishment. The marsh lands should be designed to transition between the bay-side breakwater and barrier islands so as to minimize erosion to the bay side of the barrier island and establish optimal beneficial use capacity and efficacy.

The slopes, crest width, and crest elevation of the barrier island are to be designed with life-cycle sustainability and adaptability in-mind. Operations and maintenance dredge material can be used to raise the crest and or repair any storm generated erosion but should be initially optimized to reduce use of O&M material for barrier island repair, which will allow for it to be used for quicker beneficial use placement and establishment. The barrier island should be immediately established with plantings; whereas the marshlands can be incrementally established as they are constructed. Reinforced gaps through the barrier islands should be established to allow interchange across the GIWW so that watershed connectivity with the Bay is maintained.

It is anticipated that construction of the barrier island will require material from adjacent borrow areas to be dredged between the barrier island and the bay-side breakwaters. The resulting temporary hole will be a beneficial use site filled with operations and maintenance dredge material over the course of the project life and ultimately create marshlands between the barrier island and bay-side breakwater.

Channel modifications at zone 12 should be designed to 1) address navigation safety impacted by strong cross-currents and shoaling, 2) reduce emergency dredging operations caused by frequent and high shoaling.

The channel modifications are to be a combination of widening and deepening across the intersection of Caney Creek and Mitchell’s Cut. The widening shall begin with adequate distance east and west of the intersection to account for vessel drift.

It is anticipated that construction of the channel modifications will supply material to be used in the creation of the barrier islands.

## 5.8 Resilience to Sea Level Rise and Storm Surge

Resilience is defined as the ability to prepare, absorb, recover, and adapt. As previously defined, the project site is projected to have 1.5 ft of sea level rise under the intermediate scenario. The project site is also in area of high vulnerability to storm generated waves and surge. Each feature in the plan is prepared for these occurrences; however they are designed to absorb, recover, and adapt, as opposed to statically withstand initial extreme projections. This means that the hard (rock) and soft (earthen) EWN features were selected based on their ability to initially absorb the anticipated sea level rise and storm impacts in terms of their crest elevations and dimensions and supplemented with operations and maintenance strategies to assist with recovery and adaptation. For example, the beneficial use of operations and maintenance material can be used to recover initial dimensions of the barrier islands should they be eroded by a storm or adapt their elevation and width for changing conditions.

## 5.9 Post-TSP Analysis of Resilience Plan

PDT will continue to refine costs and benefits for Zones 12 and 13 following the draft report release. The NED exception will be revisited and reshaped following the draft report review and prior to the ADM where additional comments can be gathered from peer review, industry, public and agencies. The TSP for the draft report is recommended to be the “Resiliency Plan.” This allows additional flexibility for NEPA compliance and the final report to make recommendations for the NED versus the Resiliency Plan because the NED is a subset of the Resiliency Plan. The PDT is performing additional analysis during the concurrent reviews and prior to the Agency Decision Milestone in late Spring 2022.

## 5.10 REAL ESTATE CONSIDERATIONS

### 5.10.1 Lands, Easements, and Rights-of-Way

This section will outline any new real estate requirements required for the construction and future operations and maintenance (O&M) the recommended TSP which vary by increment. It will also describe the anticipated estates necessary for acquisition. The sections below outline the new real estate requirements specific to each increment.

### 5.10.2 New Real Estate Requirements for Increment 12.3.2

The proposed alignment for widening of the channel at zone 12 impacts only submerged lands and would be constructed under navigation servitude. However, portions of the proposed breakwaters impact emergent private lands and lands owned by the State of Texas. These impacts total approximately 1.6 acres of land. In tidal areas, navigational servitude extends to all lands below the mean high-water mark. Due to high erosion rates in the project area, it is likely that a portion, if not all, of the privately owned impacted lands will be submerged by the start of construction and will, therefore, fall under navigational servitude. However, if any portions of these lands are still emergent at the time of construction, perpetual easements will need to be acquired from the owners for the construction and maintenance of the breakwaters. Please see Figure 12: New real Estate Requirements for Increment 12.3.2 below.

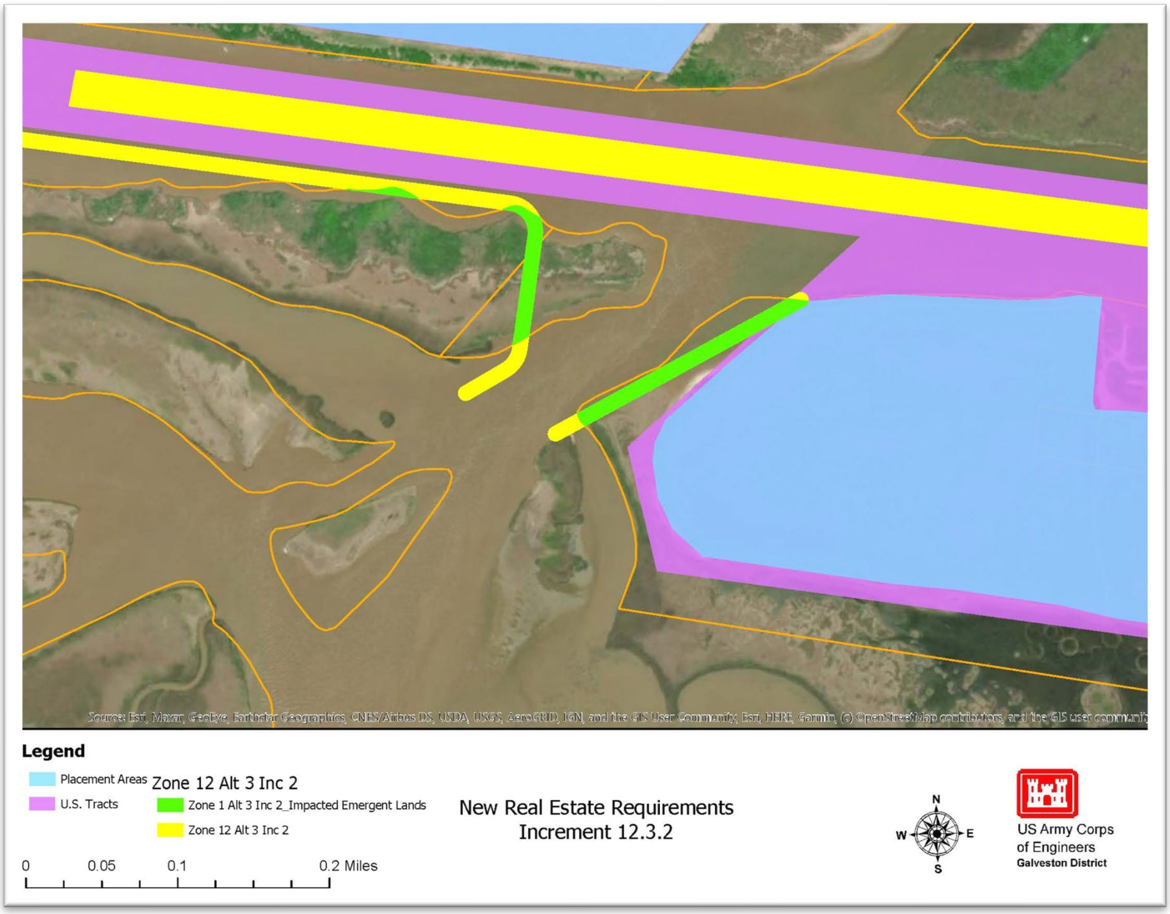


**Figure 18: New real Estate Requirements for Increment 12.3.2**

### 5.10.2.1 New Real Estate Requirements for Increment 13.6.1

The proposed, earthen berm, sediment placement and marsh planting at zone 13 fall entirely within submerged lands and existing USACE Placement areas or Tracts. No acquisition of real estate is required for this increment. Please see Figure 13: New Real Estate Requirements for Increment 13.6.1 below.


**Figure 19: New Real Estate Requirements for Increment 13.6.1**

#### 5.10.2.2 New Real Estate Requirements for Increment 14.6.1

Like Increment 13.6.1, the proposed breakwaters, earthen berm, sediment placement and marsh planting at zone 14 fall entirely within submerged lands and existing USACE Placement areas or Tracts. No acquisition of real estate is required for this increment. Please see Figure 14: New Real Estate Requirements for Increment 14.6.1 below.

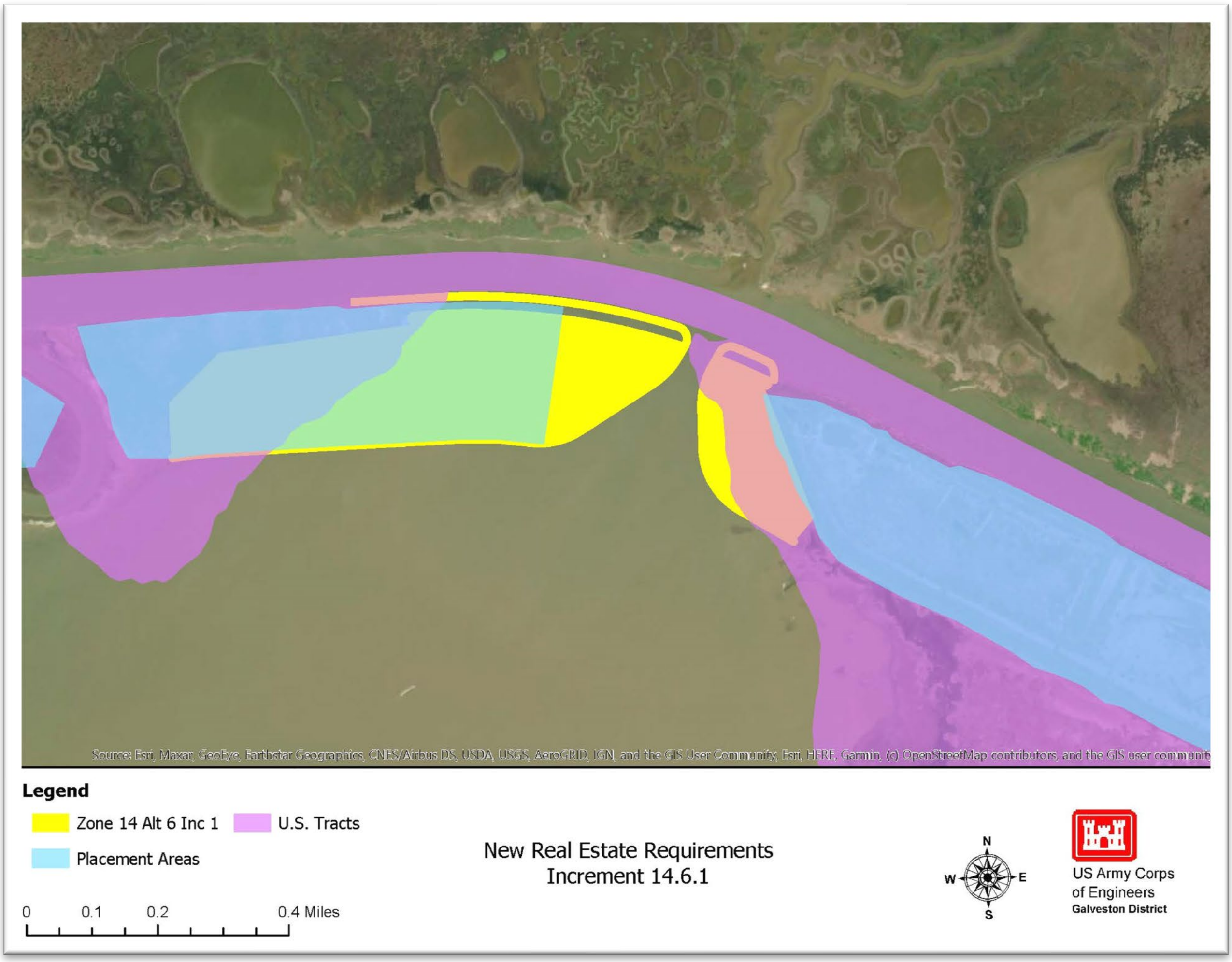


**Figure 20: New Real Estate Requirements for Increment 14.6.1**

#### 5.10.2.3 New Real Estate Requirements for Increment 16.6.1

The proposed breakwaters, earthen berms and sediment placement at zone 16 fall almost entirely within existing USACE Placement Areas and Tracts. However, there are approximately 13 acres of impacted privately owned lands. In tidal areas, navigational servitude extends to all lands below the mean high-water mark. Due to high erosion rates in the project area, it is likely that a portion, if not all, of the privately owned impacted lands will be submerged by the start of construction and will, therefore, fall under navigational servitude. However, if any portions of these lands are still emergent at the time of construction, perpetual easements will need to be acquired from the owners for the construction and maintenance. Please see Figure 15: New real Estate Requirements for Increment 16.6.1 below.

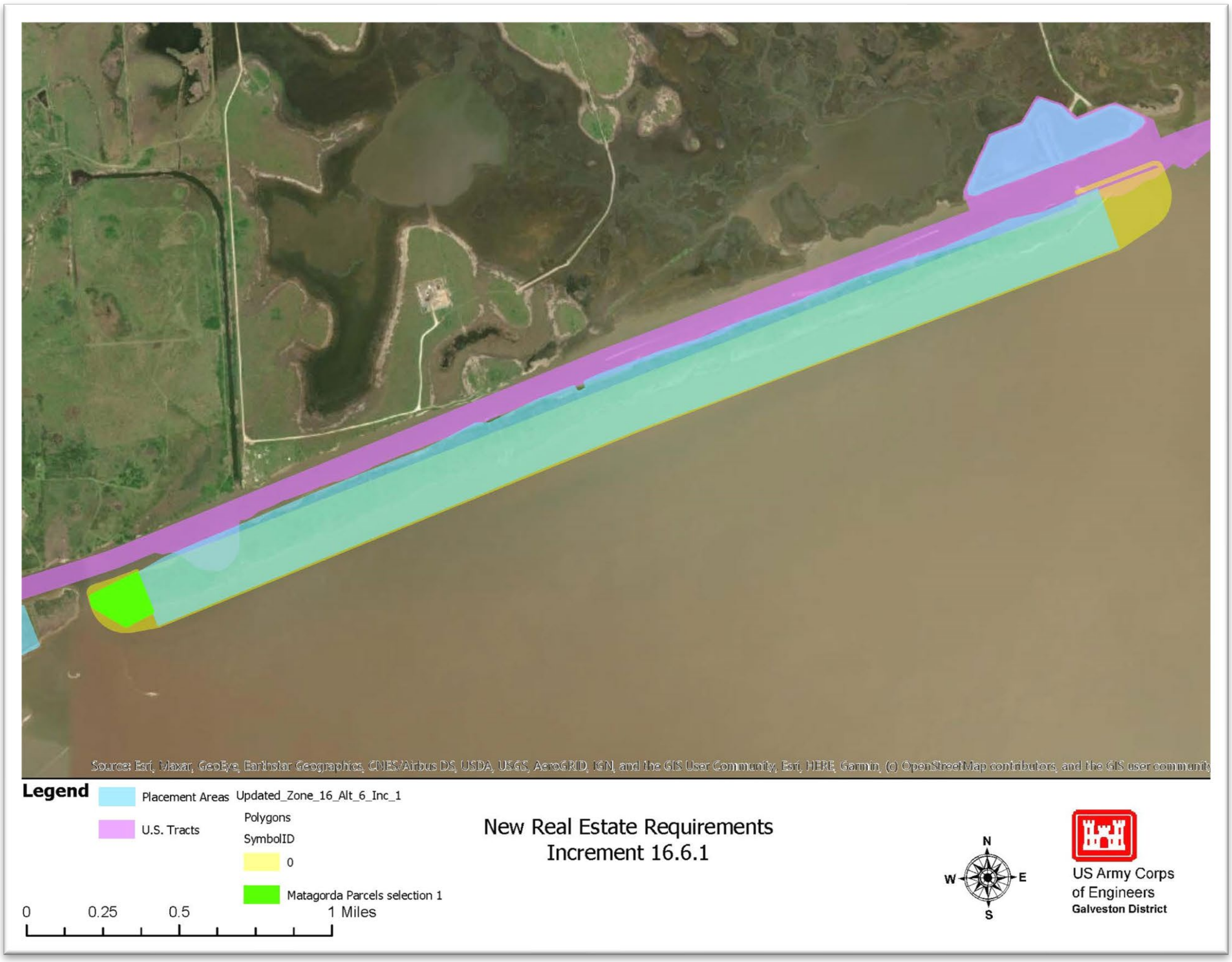


**Figure 21: New Real Estate Requirements for Increment 16.6.1**

### 5.10.2.4 New Real Estate Requirements for Increment 18.6.1

The proposed breakwaters, sediment placement and marsh planting at zone 18 fall almost entirely within existing USACE Placement Areas and Tracts or submerged lands. However, there are approximately 5 acres of impacted lands owned by the State of Texas. In tidal areas, navigational servitude extends to all lands below the mean high-water mark. Due to high erosion rates in the project area, it is likely that a portion, if not all, of the privately owned impacted lands will be submerged by the start of construction and will, therefore, fall under navigational servitude, but any remaining emergent lands not covered by existing Placement Areas or Tracts will require a perpetual easement for the construction and maintenance of the project. Please see Figure 16: New Real Estate Requirements for Increment 18.6.1 below.

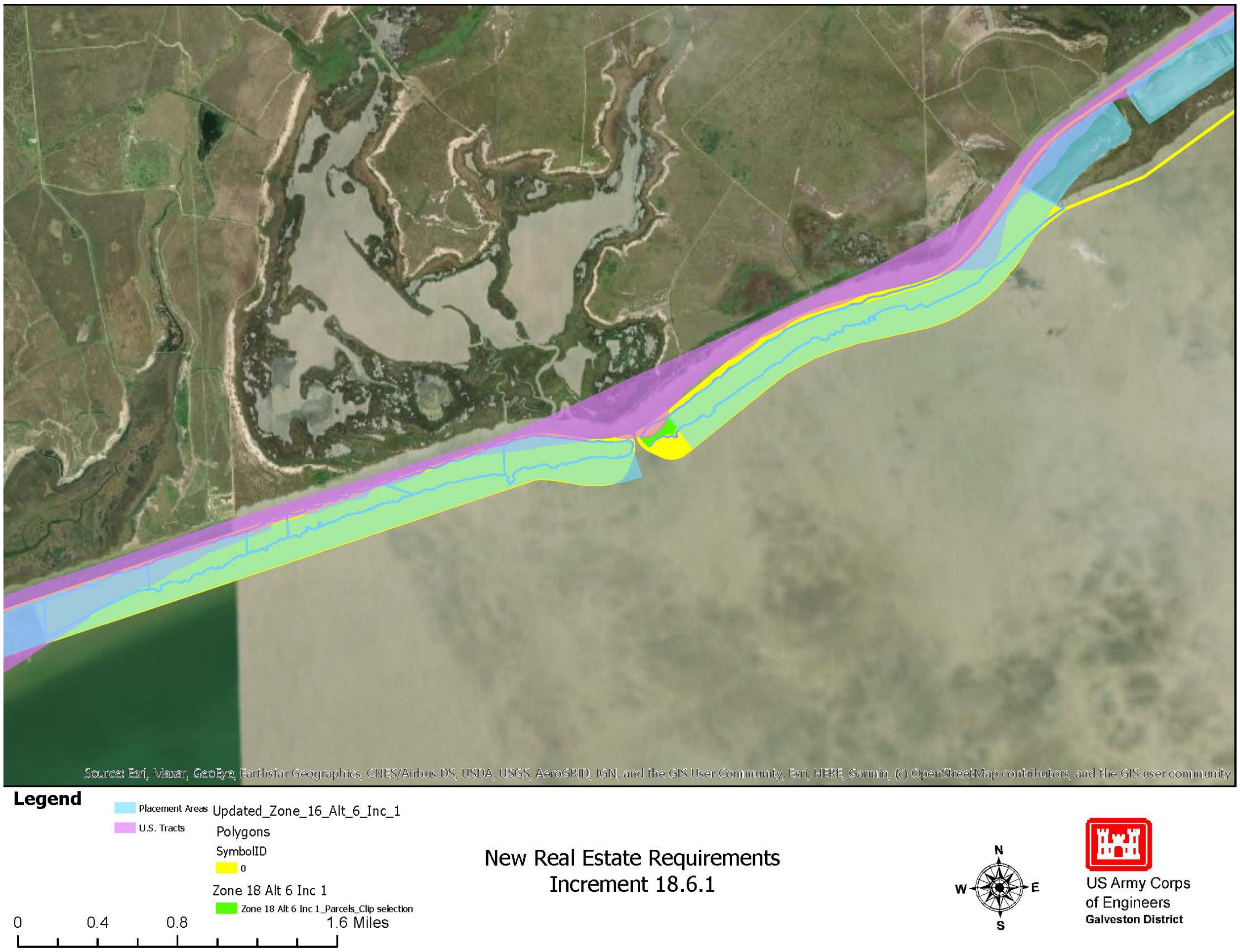


**Figure 22: New Real Estate Requirements for Increment 18.6.1**

## 5.10.3 Facility Removals/Deep-Draft Utility Relocations

There are nine pipelines that intersect the project footprint. These pipelines are identified in Figure 17 and Table 22 below. At this stage of feasibility, it is not anticipated that these pipelines will interfere with the construction of breakwaters and berms, sediment placement or marsh planting. Therefore, it is not believed that any relocations will be necessary.

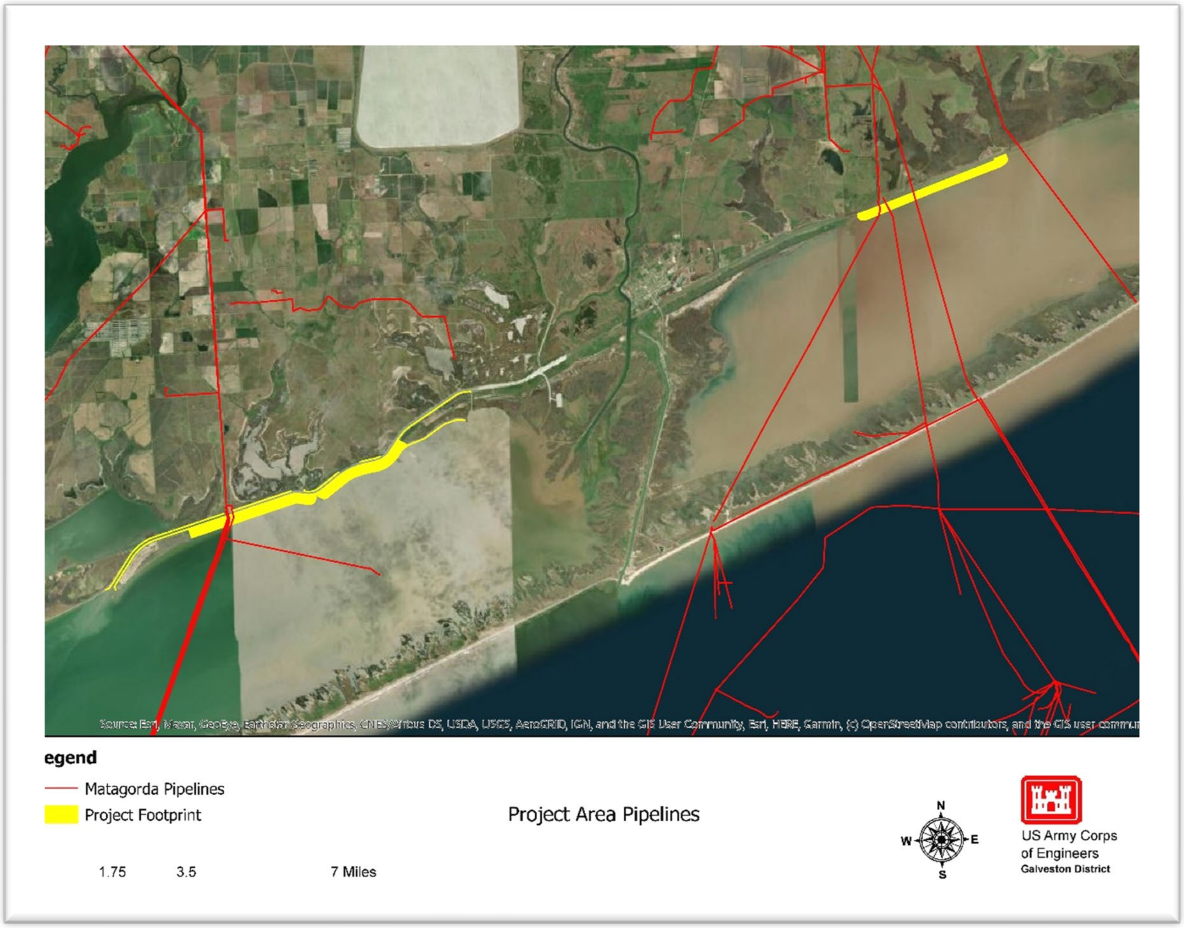


**Figure 23: *Pipelines in the Project Area***

**Table 24: Pipelines within the Project Area**

| # of Lines | T4 Permit # | P5 # | Operator | Size (in) | Commodity | Status |
|---|---|---|---|---|---|---|
| 1 | 01681 | 036064 | ATINUM ENERGY, INC. | 6.63 | Crude Oil | Abandoned |
| 1 | 09607 | 300192 | GENESIS OFFSHORE HOLDINGS, LLC | 24 | Natural Gas | In Service |
| 1 | 05358 | 864444 | TRANSCONTINENTAL GAS P.L. CO,LLC | 30 | Natural Gas | In Service |
| 1 | 05130 | 253368 | ENTERPRISE PRODUCTS OPERATING, LLC | 20 | Natural Gas | In Service |
| 1 | 02878 | 253368 | ENTERPRISE PRODUCTS OPERATING, LLC | 24 | Natural Gas | In Service |
| 1 | 05130 | 253368 | ENTERPRISE PRODUCTS OPERATING, LLC | 20 | Natural Gas | In Service |
| 1 | 16181 | 036064 | ATINUM ENERGY, INC. | 6.63 | Crude Oil | Abandoned |

| # of Lines | T4 Permit # | P5 # | Operator | Size (in) | Commodity | Status |
|---|---|---|---|---|---|---|
| 1 | 06285 | 638515 | PANTHER PIPELINE, LLC | 16 | Natural Gas | In Service |
| 1 | 00749 | 404520 | HOUSTON PIPELINE COMPANY LP | 18.63 | Natural Gas | In Service |

Data reflected in this table is TRRC data

### 5.10.4 Other Facilities/Utilities

A desktop review identified no other facilities or utilities within the proposed project footprint.

In accordance with er 405-1-12, "any conclusion or categorization contained in this report that an item is a utility or facility relocation to be performed is preliminary only. The government will make a final determination of the relocations necessary for the construction, operation, and maintenance of the project after further analysis and completion and approval of final attorney's opinions of compensability for each of the impacted utilities and facilities."

## 5.11 OPERATIONS AND MAINTENANCE CONSIDERATIONS

Cyclical dredging quantities in Zone 12 are expected to increase due to the channel widening, although less emergency dredging contracts should be required as vessels should be able to avoid high shoaling areas with the wider channel. Newly constructed upland beneficial use sites and breakwaters will have to be maintained over the lifetime of this project. The construction of breakwaters and beneficial use sites will allow for shorter pump distances and increased dredge capacity.

## 5.12 RISK AND UNCERTAINTY

### 5.12.1 Engineering Data and Models

Uncertainty for the TSP recommendation exist in the form of cost and decision risks. The cost risks were mitigated by including a 35 percent contingency to the total project first cost estimates as well as a sensitivity analysis to determine how much the cost could change depending on the most sensitive factor which was breakwater quantities. The decision risks are being mitigated by proposing additional shoaling analyses following the TSP milestone in order to reduce the uncertainty in the shoaling data. The descriptions of these risks and their mitigations are provided in the following sections.

Site Elevations:

- Cost Risk: No field surveys were performed to determine elevations.
- Assumption: Elevations for this study are based on LiDAR and Bathymetry data.
- Risk Rating: The overall risk is low due to a low likelihood and medium consequences from changes in elevation.
- Mitigation: Contingency is included in the cost estimates to absorb the additional cost in case an increase in elevation results in an increase in breakwater elevation. A sensitivity analysis was also performed to determine the range of potential cost change.

Soil Settlement:

- Cost Risk: No borings were taken to determine soil settlement.
- Assumption: Soil settlement was assumed to be 1 foot based on Vibracore tests nearby.
- Risk Rating: The overall risk is low due to a low likelihood and medium consequences from changes in soil settlement.
- Mitigation: Contingency is included in the cost estimates to absorb the additional cost in case an increase in soil settlement results in an increase in breakwater elevation. A sensitivity analysis was also performed to determine the range of potential cost change.

Sea Level Rise in Breakwater Costs:

- Cost Risk: About 60% of the Project First Costs in this study are the cost of breakwaters.
- Assumption: Breakwater elevations are based on USACE Intermediate Sea Level Rise.
- Risk Rating: The overall risk is medium due to a medium likelihood and medium consequences from changes in Sea Level Rise.
- Mitigation: Contingency is included in the cost estimates to absorb the additional cost in case an increase in sea level rise results in an increase in breakwater elevation. A sensitivity analysis was also performed to determine the range of potential cost change.

The sensitivity analysis was conducted by calculating costs for fully constructed breakwaters at elevations +/- 1 foot of the current design and then weighted at 60% since breakwaters make up about 60% of the total project first cost. The results are tabulated in Table 29 below.

**Table 25: Sensitivity Analysis**

| Alternative | Increment | -1 Ft El. of Breakwaters | Project First Cost | +1 Ft El. of Breakwaters |
|---|---|---|---|---|
| 3 | 12.3.1 | $12,230,003 | $13,971,820 | $15,910,327 |
| 3 | 13.3.1 | $40,044,851 | $45,748,104 | $52,095,381 |
| 3 | 14.3.1 | $19,930,284 | $22,768,787 | $25,927,821 |
| 3 | 16.3.1 | $45,583,791 | $52,075,910 | $59,301,131 |
| 3 | 18.3.1 | $82,936,739 | $94,748,726 | $107,894,545 |
| 3 | 18.3.2 | $179,611,382 | $205,191,930 | $233,661,085 |
| 3 | 18.3.3 | $228,087,008 | $260,571,534 | $296,724,279 |
| 6 | 13.6.1 | $56,398,024 | $67,096,279 | $79,390,513 |
| 6 | 14.6.1 | $14,466,409 | $17,210,571 | $20,364,111 |
| 6 | 16.6.1 | $29,979,664 | $35,666,567 | $42,201,850 |
| 6 | 18.6.1 | $115,535,251 | $137,451,365 | $162,636,955 |
| 6 | 18.6.2 | $189,397,116 | $225,324,235 | $266,611,011 |

For Alternative 3 increments, subtracting 1 foot of breakwater height resulted in a 12.5% decrease in cost, and adding 1 foot of breakwater height resulted in a 13.9% increase in cost.

For Alternative 6 increments, subtracting 1 foot of breakwater height resulted in a 15.9% decrease in cost, and adding 1 foot of breakwater height resulted in a 18.3% increase in cost.

Bulking Factor:
- Decision Risk: Shoaling problems and benefits may be underestimated by up to 300%.
- Assumption: Bulking factor was assumed to be 1 to be conservative in shoaling volumes.
- Risk Rating: The overall risk is high due to the high likelihood and high consequence of higher bulking factors that would also increase the O&M benefits.
- Mitigation: Include Zone 13 in the recommended TSP which is a much-needed additional placement area while keeping the bulking factor as is to be conservative. This study does not allow the time, budget, or human resources to conduct additional laboratory bulking and settling column tests to verify the actual bulking factors at individual zones within the study area. Therefore, the additional placement area in Zone 13 provides more capacity for sediment in case the shoaling increases.

Sea Level Rise in Shoaling and Erosion Data:
- Decision Risk: Shoaling and erosion data are based on USACE Intermediate Sea Level Rise. Sea Level Rise could range from 66% to 210% of the Intermediate Curve.
- Assumption: High Sea Level Rise would deepen the navigation channel while requiring an increase in breakwater elevation, and Low Sea Level Rise would

cause the navigation channel to become shallower while decreasing the breakwater elevation.

- Risk Rating: Low due to the low likelihood that changes to the shoaling and erosion data would be significantly detrimental because an increase in sea level rise would also deepen the navigation channel reducing other risks such as grounding due to increased shoaling.
- Mitigation: Accept the risk by keeping the intermediate sea level rise assumption. The risk to the shoaling and erosion data is likely to cancel out other risks by deepening the navigation channel.

No Open Water Contribution in Shoaling Data:

- Decision Risk: The shoaling data doesn't include open water contribution of sediment from the bay which may underestimate shoaling problems and benefits by up to 500% based on the USACE study *Reducing Shoaling in the GIWW and Erosion of Barrier Islands Along West Galveston Bay*.
- Assumption: The open water contribution was excluded from the initial shoaling analysis of the study due to schedule and human resource constraints.
- Risk Rating: The overall risk is high due to the high likelihood and high consequence of the open water contribution increasing shoaling volumes.
- Mitigation: Conduct further shoaling analyses to include open water contribution and include Zone 13 in the recommended TSP which is a much-needed additional placement area. This placement area allows for more sediment capacity in case shoaling increases.

### 5.12.2 Economic Data and Models Analysis

To capture benefits broken down by each zone, a dataset was needed that could be divided by geographic location and by travel time to capture speeds/delays in each reach. The Engineer Research and Development Center (ERDC) has a tool and dataset using Automatic Identification System (AIS) data to help delineate the data into a useful format. The Automatic Identification System Analysis Package (AISAP) by ERDC is a web-based tool for acquiring, analyzing, and visualizing near-real-time and archival data from the U.S. Coast Guard. The AISAP can be used to investigate questions of historical travel time, capacity limitation, and the effects of weather or accidents on the flow of freight through waterways. Although the dataset was helpful, data gaps still existed, and interviews of operators were needed to explain some observations in the data. Analysts with USACE's Planning Center of Expertise for Inland Navigation and Risk-Informed Economics Division (PCXIN-RED) were made aware of certain data limitations at the outset of this study and were included throughout the study process.

### 5.12.3 Environmental Data and Analyses

Uncertainty for the TSP recommendation exist in the form of the presence of environmental resources where they are not anticipated. The impact to environmental resources risks were mitigated by conducting multiple meetings with the federal resource agencies, as well as a desktop survey of the project area to determine the historical presence of environmental resources within the project study area. The descriptions of these risks and their mitigations are provided in the following section.

Seagrass Bed and Oyster Mitigation Estimates:

- Decision Risk: The current data used to determine the presence of environmental resources within the project study area may not accurately depict what resources are present.
- Assumption: Visual review of the project study area to estimate the presence of seagrass and oyster beds was completed using GIS software and recent aerial photography. It is assumed that all resources present within the study area were observed and accounted for in the desktop review.
- Risk Rating: Low due to the guidance of the resource agencies that are familiar with the local resources and the clarity of the aerial scans used in the visual survey.
- Mitigation: A 10% contingency was added to the acreages of all environmental resources observed within the project footprint. Any discrepancies should be overestimated instead of underestimated as a result.

# 6 CONSISTENCY WITH OTHER STATE AND FEDERAL LAWS

The following sections summarize actions being taken in this study to comply with various statutes applicable to Federal study or project.

## 6.1 Clean Air Act

The Clean Air Act (CAA) contains provisions under the General Conformity (GC) Rule to ensure that actions taken by Federal agencies in air quality nonattainment and maintenance areas do not interfere with a state's plans to meet national standards for air quality. Under the General Conformity Rule (the Rule), Federal agencies must work with state, Tribal and local governments in a nonattainment or maintenance area to ensure Federal actions conform to the air quality plans established in the applicable state or tribal implementation plan. The regulations codifying the Rule under 40 CFR Part 93, Subpart B, specify that no Federal agency shall engage in, or provide financial assistance for any activity which does not conform to an applicable implementation plan.

An estimate of construction emissions will be conducted in the next planning phase to determine if the de minimis thresholds applicable to the Corpus Christi-Victoria AQCR for the ozone precursors NOx and VOCs under this rule would be exceeded. The Corpus Christi-Victoria AQCR is currently in attainment status for all NAAQS.

It is not anticipated emissions would be above de minimis requiring a Formal Determination of Conformity. A Draft General Conformity Determination (GCD) would be prepared to help determine if emissions that would result from construction of the proposed action are in conformity with the Texas State Implementation Plan (SIP) for the Corpus Christi-Victoria AQCR and consultation and coordination with the TCEQ and the EPA would be initiated. The Draft GCD will be publicly coordinated in accordance with 40 CFR Part 93, and a Final GCD, with the results and details of the air conformity threshold analysis issued after the coordination and required public noticing and comment period. A public notice of availability for the Final GCD will also be published as required by 40 CFR Part 93.

## 6.2 Clean Water Act

Section 404 of the CWA regulates dredge and/or fill activities in U.S waters. The proposed action would require dredging in U.S. waters. Since 1989, the USACE and EPA have implemented policy under the Section 404 program to achieve a Presidential goal of “no net loss” of wetlands. This program is responsible for ensuring the Administration's policy regarding “no net loss” of wetlands by requiring permit applicants to make every effort to avoid and minimize aquatic resource impacts and provide compensatory mitigation to offset any permitted impacts. Therefore, impacts to wetlands and achieving no net loss of wetlands are important factors in complying with the CWA. No wetlands would be impacted by the recommended plan channel modifications or placement of material.

The regulations implementing the CWA Section 404 also include the mandatory guidelines developed to implement Section 404(b)(1) which prescribes procedures for specifying dredged material disposal sites and determining the suitability of dredged material for placement. An extensive review of existing past maintenance and new work sediment testing data covering the GIWW was performed to determine the next steps in applying the procedures pursuant to USACE Regulatory Guidance Letter (RGL) 06-02, the Section 404(b)(1) guidelines, and the related joint testing manuals developed for them, including the Upland, and Inland Testing Manuals, as needed and appropriate, for the placement methods and sites selected during the development of the DMMP for the recommended plan. A 404(b)(1) Evaluation Form for the recommended plan and DMMP will be prepared and released concurrently with the release of the Draft EA. A Water Quality Certification is still required from TCEQ.

## 6.3 Section 103 of the Marine Protection, Research, and Sanctuaries Act

Section 103 of the Marine Protection, Research, and Sanctuaries Act (MPRSA) prescribes regulations, procedures, and evaluations applicable to Federal projects for the disposal of dredged materials in offshore waters. The currently permitted Offshore Dredged Material Disposal Site (ODMDS) has been identified as one of the existing placement areas in the Matagorda Bay system that will be considered for maintaining recommended plan features. New work Material from the existing channel is approved to be placed in the ODMDS. It is expected that maintenance material from the recommended plan improvements directly adjacent to the existing MSC in this reach is similarly of suitable quality and would be approved for placement there. This necessary testing to establish suitability according to the Ocean Testing Manual will be identified and performed in later planning phases and coordination with EPA Region 6 will be conducted to verify the suitability.

## 6.4 Section 7 of the Endangered Species Act

Compliance with the Endangered Species Act (7 U.S.C. 136; 16 U.S.C. 460 et seq.) is being coordinated with the USFWS and the National Oceanic and Atmospheric Administration (NOAA) for those species under their respective jurisdictions. A final BA will be included with the public release of the DIFR-EIS (See Appendix D). USACE is providing a copy of the BA to the USFWS and NOAA. Consultation with USFWS is being initiated.

The BA covers the proposed actions in the recommended plan. The determination of may affect, but not likely to adversely affect, was made for sea turtles with respect to placement of material. The determination of may affect, but not likely to adversely affect, was made for all of the sea turtle species except for the leatherback which is not anticipated to be present in the project area. The determination of may affect, but not likely to adversely affect, was made for the Manatee, Eastern Black Rail, Piping Plover, Red Knot, and Whooping Crane because by avoiding overwintering windows or using avoidance and minimization strategies (e.g. biological monitors) the potential adverse effects are reduced to discountable.

## 6.5 Magnuson-Stevens Fishery Conservation and Management Act

The MSFCMA (PL 94-265), as amended, establishes procedures for identifying EFH and required interagency coordination to further the conservation of federally managed fisheries. Regulations codifying the Act in 50 CFR Sections 600.805–600.930 specify that any Federal agency that authorizes, funds, or undertakes, or proposes to do, an activity that could adversely affect EFH, is subject to the consultation provisions of the Act and identifies consultation requirements. EFH consists of habitat necessary for spawning, breeding, feeding, or growth to maturity of species managed by Regional Fishery Management Councils (RFMC) in a series of FMP. The Gulf of Mexico Fishery Management Council (GMFMC) is the RFMC applicable to the project location. EFH is designated for the project area in which the recommended plan is located. Consultation with NMFS has been initiated. An analysis of the recommended plans effects on EFH is included in Appendix D-4.

## 6.6 Section 106 of the National Historic Preservation Act

See Appendix F for Cultural Resources documents the consultation that was required under Section 106 of the National Historic Preservation Act (54 U.S.C. § 306108) (NHPA), as amended, and its implementing regulations (36 CFR 800). The resulting Programmatic Agreement was executed on 25 April 2021.

## 6.7 Coastal Zone Management Act

The CZMA of 1972, as amended, provides for the effective management, beneficial use, protection, and development of the resources of the nation's coastal zone. The CZMA directs Federal agencies proposing activities within or outside of the coastal zone that could affect any land or water use or natural resource of the coastal zone, to assure that those activities or projects are consistent, to the maximum extent practicable, with the approved State programs. The Texas Coastal Management Program is the State entity that participates in the Federal Coastal Zone Management Program created by the CZMA. The TCMP designates the coastal zone and coastal natural resource areas (CNRA) requiring special management in that zone, including coastal waters, waters under tidal influence, coastal wetlands, submerged lands and aquatic vegetation, dunes, coastal historic areas, and other resources.

The following CNRAs are found in the vicinity of the recommend plan and PAs:

- Water under tidal influence – Matagorda Bay waters
- Submerged land – Matagorda Bay bottom in the project area.
- Hard substrate reefs and oyster reefs – Hard-bottom habitat and oyster reef discussed in Section 4.12.3

- Coastal wetlands – Estuarine wetlands (saltwater marsh etc.) discussed in Section 4.10.

- Submerged aquatic vegetation – Channel area is not characterized as having large expanses of SAVs.

- Coastal barriers – The recommended plan is not directly located in any designated coastal barrier.

- Gulf beaches – The Matagorda Peninsula contains Gulf beaches, though no dredging or placement will take place there.

- Critical erosion areas – The shoreline from Chocolate Bay to Powderhorn Lake is listed as eroding per latest Texas Bureau of Economic Geology data.

- Tidal sand or mud flats – Tidal sand flats located between and around the fringes of existing PAs 14 and 15 or unarmored shoreline.

- Coastal preserves – Welder Flats Coastal Preserve is located in the study area, though not within the recommend plan. Of these CNRAs, the first five are found in the recommended plan and DMMP footprint. All other CNRAs would be avoided. Changes in 2012 to the TCMP resulted in the Coastal Coordination Advisory Committee (CCAC) replacing the previous Coastal Coordination Council (CCC). The CCAC is composed of several State agencies and local officials, to advise the GLO Commissioned on administering the TCMP. The TCMP reviews all Federal actions that may affect natural resources in the coastal zone for consistency with the Federal goals and objectives. The Federal Agency proposing the action prepares a Consistency Determination for review by the GLO for consistency with the TCMP. A Statement of Compliance with the TCMP has been received from the GLO.

## 6.8 Fish and Wildlife Coordination Act

The USACE's proposed action under the recommended plan is being coordinated with the USFWS, NMFS, TPWD and other State and Federal resource agencies through resource agency meetings being held for this study, and additional coordination and consultation. Additionally, the USFWS, NMFS and TPWD will be sent copies of the DIFR-EA for review and comment during the agency and public review period. Pursuant to Fish and Wildlife Coordination Act (FWCA), the USFWS will provide a draft Planning Aid Letter (PAL) to assist with the planning of the proposed project by providing comments and recommendations related to impacts on fish and wildlife resources. The Coordination Act Report will be completed prior to submission of the Chief's Report.

## 6.9 Marine Mammal Protection Act of 1972

The Marine Mammal Protection Act (MMPA) was passed in 1972 and amended through 2007. It establishes a moratorium on the taking and importation of marine mammals and marine mammal products by persons subject to the jurisdiction of the U.S, with certain exceptions. The definition of “persons” also includes any officer, employee, agent, department, or instrumentality of the Federal Government. The Act is intended to conserve and protect marine mammals and it established the Marine Mammal Commission, the International Dolphin Conservation Program, and a Marine Mammal Health and Stranding Response Program. Review and consultation for the MMPA is also triggered via the ESA when actions involve marine mammals.

The only marine mammals covered under the MMPA expected to regularly be present in Matagorda Bay are bottlenose dolphins (*Tursiops truncatus*). These are highly mobile species that would be able to readily avoid dredging activities and vessels. As avoidance of the area would be only during construction, and there is an abundance of similar habitat within the area, the proposed action would have minimal and temporary impacts, by way of disturbance, to the individuals present.

## 6.10 Federal Water Project Recreation Act

This Act directs ". . . that . . . in investigating and planning any Federal navigation, flood control, reclamation, hydroelectric, or multipurpose water resource project, full consideration shall be given to the opportunities, if any, which the project affords for outdoor recreation." Any such features are subject to cost sharing with the beneficiaries of the recreational feature.

## 6.11 Farmland Protection Policy Act of 1981 and the CEQ Memorandum on Prime and Unique Agricultural Lands

The purpose of the Farmland Protection Policy Act is to minimize the extent to which Federal programs contribute to the unnecessary and irreversible conversion of farmland to nonagricultural uses. The act requires among other things, agencies to identify and consider the adverse effects of Federal programs on the preservation of prime and unique farmlands, and consider alternative actions, as appropriate that could lessen such adverse effects. The CEQ issued a memorandum “Analysis of Prime and Unique Agricultural Lands in Implementing the National Environmental Policy Act” that supplemented NEPA procedures to include analysis of these impacts in NEPA documents. The regulation codifying the Act in 7 CFR Part 658 specified procedures and criteria for the analysis of these impacts. The definitions in this regulation specify that farmland does not include land already used as water storage, which would include open water. The recommended plan channel modifications are in open water or along the shoreline. No terrestrial resources are impacted by the recommended plan breakwater installations, and therefore, no prime or unique farmlands would be affected.

## 6.12 Executive Order 11988, Floodplain Management

This EO directs Federal agencies to avoid possible impacts associated with the modification of floodplains and to avoid support of floodplain development wherever there is a practicable alternative. In carrying out the activities described above, each agency has a responsibility to evaluate the potential effects of any actions it may take in a floodplain associated with the one percent annual chance event.

The tentatively selected plan is in sections of Matagorda County mapped by the Federal Emergency Management Agency including Zones VE, AE, and X. Zone VE is considered a 1% or greater chance of flooding and additional hazards with storm waves; 26% chance of flooding over a 30-year mortgage. Zone X is considered minimal or moderate risk of flooding and can either be subject to flooding during 100-year to 500-year storms or outside of the risk of flooding during 500-year storms. Zone X is also determined to be protected by levee from 100-year floods. Zone AE is considered the base floodplain elevation and subject to inundation by the 1% annual chance flood event.

As discussed in Appendix D, the Resilience Plan is not expected to have substantial hydrodynamic impacts including tidal variations or surge conditions, based on recent modeling studies for other channel modification projects, which will be confirmed by hydrodynamic modeling in the next planning phase.

## 6.13 Executive Order 11990, Protection of Wetlands

This EO directs Federal agencies to avoid undertaking or assisting in new construction located in wetlands, unless no practical alternative is available, and the proposed action includes all practicable measures to minimize harm to wetlands which may result from such use. The EO directs agencies to take such actions in carrying out its responsibilities in (1) acquiring, managing, and disposing of Federal lands and facilities; and (2) providing federally undertaken, financed, or assisted construction and improvement; and (3) conducting Federal activities and programs affecting land use, including but not limited to water and related land resources planning, regulating, and licensing activities. As discussed in Section 6.9.2, the CWA Section 404 program is responsible for ensuring the Presidential policy to achieve “no net loss” of wetlands. This EO further strengthens the commitment for Federally implemented and permitted projects to achieve no net loss of wetlands, primarily through avoidance of impacts. The recommended breakwater installations would not impact any wetlands; wetlands in the project area are expected to be lost due to RSLR unrelated to project actions. Therefore, impacts to wetlands and achieving no net loss of wetlands are important factors in complying with this EO.

## 6.14 Executive Order 12898, Environmental Justice

This EO directs Federal agencies to determine whether their programs, policies, and activities would have a disproportionately high or adverse effect on minority or low-income population groups within the Project Area. As documented in Section 3.14, examination of the census where populated land was closest to the recommended plan indicated an average of approximately 64% percent minority and an average median household income of $44,677 in Bay City, approximately 33% below the state average. Bay City would be closest to the recommended plan footprint where direct effects experienced would be their greatest. Given the income and percent minority of those blocks, an EJ issue would not be expected. Therefore, the proposed action is not expected to have any disproportionately high or adverse effect on low-income or minority population groups.

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

This EO directs Federal agencies to increase their efforts under the Migratory Bird Treaty Act, Bald and Golden Eagle Protection Acts, Fish and Wildlife Coordination Act, the ESA of 1973, NEPA of 1969, and other pertinent statutes to avoid or minimize impacts on migratory bird resources. The 2006 Memorandum of Understanding (MOU) between the DOD and the USFWS developed pursuant to this EO lists activities covered under the purpose and scope of the MOU, including natural resource management activities. The EO directs DOD to encourage incorporation of comprehensive migratory bird management objectives in the preparation of DOD planning documents, including NEPA analyses. The EO also directs DOD to, prior to starting any activity likely to affect migratory birds populations, 1) identify the species likely to occur in the area of the proposed action and determine if any species of concern could be affected by the activity, 2) assess and document the effect of the proposed action on species of concern through the NEPA process when applicable, and 3) engage in early planning and scoping with the USFWS to proactively address conservation, and initiate appropriate actions to avoid or minimize the take of migratory birds.

The proposed action is not expected to permanently impact migratory bird populations. Options to avoid migratory and nesting bird impacts may include adjusting the construction timeline to accommodate the nesting season or re-sequencing construction activities to work in areas where no active nests are present.

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

This EO mandates that federal agencies identify and assess disproportionate environmental health and safety risks to children, and ensure that its policies, programs, activities, and standards address them. “Environmental health risks and safety risks” are defined as risks to health or safety that are attributable to products or substances that the child is likely to come in contact with or ingest, such as air, food, drinking or recreational use of water, soil children may live on, and products they use or are exposed to. The proposed action of building the recommended plan was evaluated for disproportionate effects towards children. Construction of the recommended plan and the associated temporary ambient air and noise emissions will not have an impact that particularly targets or disproportionately affects children given the distance and general nature of the temporary impacts. Therefore, there would be no disproportionate effects on children due to environmental health or safety risks.

## 6.17 Executive Order 13751, Safeguarding the Nation from the Impacts of Invasive Species

EO 13751, dated December 5, 2016, which amends EO 13112 (1999), directs federal agencies to expand and coordinate their efforts to prevent the introduction, establishment, and spread, as well as to eradicate and control populations of invasive species, (i.e. noxious plants and animals not native to the U.S.). Non-native flora and fauna can cause significant changes to ecosystems and upset ecological processes and relationships. Numerous factors can facilitate the spread of plant and animal species outside their natural range, both domestically and internationally. Invasive species damage the habitats that native plants and animals need to survive, and they hurt economies and threaten human well-being. Standard operating procedures for construction operations should minimize the likelihood of invasive species being introduced into the project area.

## 6.18 Rivers and Harbors Act of 1899

Section 9 of the Rivers and Harbors Appropriation Act of 1899 (33 USC 403; Chapter 425, March 3, 1899) is commonly known as the Rivers and Harbors Act of 1899. This act prohibits construction of any dam, dike, bridge, or causeway over or in the navigable waters of the United States without Congressional approval. Section 10 of the Act requires approval of the Chief of Engineers for excavation or fill within navigable waterways of the U. S. The Final Integrated Feasibility Report – Environmental Assessment will be provided to the Chief of Engineers for approval of construction activities as it relates to the recommended plan.

## 6.19 Coastal Barrier Resources Act

The Coastal Barrier Resources Act (CBRA) of 1982 established the Coastal Barrier Resources System (CBRS) to minimize the loss of human life, wasteful Federal expenditures, and damage to fish, wildlife, and other natural resources associated with coastal barriers. The Coast Barrier Improvement Act of 1990 was enacted to reauthorize the CBRA of 1982. The act defines coastal barriers as "bay barriers, barrier islands, and other geological features composed of sediment that protect landward aquatic habitats from direct wind and waves." As part of the program, the Federal government refrains from spending money that encourages development on designated undeveloped coastal barriers. The Resilience Plan includes the construction of project features in Zones 12, 13, and 14 that are located within portions of CBRS units T-07 and T-07P (See the CBRA Section of the Environmental Appendix for more information). A federal expenditure is allowable within the CBRS, if it meets any of the exceptions (16 U.S.C.23§ 3505(a)(1)-(5)). The NED Plan and/or Resilience Plan should both meet exception 16 U.S.C.23§ 3505(a)(2): "The maintenance or construction of improvements of existing federal navigation channels (including the Intracoastal Waterway) are related structures (such as jetties), including the disposal of dredged materials related to such maintenance or construction. A federal navigation channel or a related structure is an existing channel or structure, respectively, if it was authorized before the date on which the relevant System unit or portion of the System unit was included within the CBRS."

The project meets this exception because the project purpose is to investigate opportunities to maintain and improve a section of the Intracoastal Waterway. The federal funding source is navigation funds from the IWUF. CBRS Units T07 and T07P have a System Unit Establishment Date of November 16, 1991. The section of the GIWW reviewed in this project was originally authorized in 1941 to 9-foot-deep and 100-foot-wide. The GIWW in Matagorda County, Texas, was authorized to the current dimensions (12-foot-deep and 125-foot-wide) in 1949. Both authorizations dates for the GIWW predate the System Unit Establishment Date in question.

# 7 IMPLEMENTATION REQUIREMENTS

## 7.1 Division of Plan Responsibilities and Cost-Sharing Requirements

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.

## 7.2 Cost for the TSP

The Total Project Cost Summary (TPCS) for the design and construction of the Recommended Plan utilizes FY21 price levels (see Cost Engineering Appendix G).

**Table 26: Project First Cost FY21 price levels**

| Code of Accounts | NED | Resilience |
|---|---|---|
| **Non-Federal Costs** | | |
| 01 Lands and Damages | $ 97,772 | $ 97,772 |
| **Total Non-Federal Costs** | $ 97,772 | $ 97,772 |
| | | |
| **Federal Costs** | | |
| 01 Lands and Damages | $ 34,425 | $ 37,125 |
| 06 Fish & Wildlife Facilities | $ 25,682,760 | $ 32,124,552 |
| 10 Breakwaters and Seawalls | $132,786,596 | $175,871,080 |
| 12 Navigation Ports & Harbors | $ 3,858,838 | $ 12,730,299 |
| 30 Planning, E&D | $ 12,986,256 | $ 17,664,470 |
| 31 Construction Management | $ 9,739,692 | $ 13,248,352 |
| **Total Federal Costs** | $185,088,567 | $251,675,878 |
| | | |
| **Total Project Cost** | $185,186,338 | $251,773,649 |
| | | |
| **Total Proj Cst (Rounded)** | $185,186,000 | $251,774,000 |

## 7.3 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).

## 7.4 Views of Non-Federal Sponsor and Others

Texas Department of Transportation (TXDOT), the study's non-federal partner, is fully supportive of the TSP although there is no cost share agreement due to the study being fully federally funded. The Gulf Intracoastal Canal Association has also provided valuable insight in order to define and validate the problems in the study area.

## 7.5 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.

## 7.6 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**. There are no anticipated impacts to the environment with placement of dredged material. The Recommended Plan has been designed to have minimal environmental impacts.

## 7.7 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).

## 7.8 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.

## 7.9 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/.

### 7.9.1 Preconstruction Engineering and Design

Detailed design of the 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.

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# 8 RECOMMENDATIONS

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 resiliency improvements for GIWW-CRS 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 TSP at FY2021 levels is $251.8 million. There are no pipeline relocation costs.

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.

As discussed previously in Section 4.1, during policy review of the DIFR-EA, 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.

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 IWUB, the State, interested Federal agencies, and other parties will be advised of any modifications and will be afforded an opportunity to comment further.

| | |
|---|---|
| Date | Timothy R. Vail, P.E<br>Colonel, U.S. Army<br>Commanding |

* Final Report To be signed

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