

**SABINE PASS TO GALVESTON BAY, TEXAS**  
**MEASURES 6-1.1, 6-1.2, 6-2, 6-3, 6-4.1, 6-4.2, 6-5.1, 6-5.2, 6-5.3, 6-6.1, 6-6.2**  
**INFORMATION SHEET**

**DESCRIPTION OF MEASURES**

These measures focus on shoreline protection for the Gulf Intracoastal Waterway (GIWW). Since its construction, the GIWW has eroded to several times its original width. Two types of protection measures are proposed: shoreline breakwaters and barrier island restoration. These measures would prevent further erosion of the coastal marshes that attenuate storm surge.

**Measure 6-1.1 GIWW Breakwater at Old River Cove, Orange County.**

This measure would provide shoreline protection for the north shore of the GIWW at Lower Neches Wildlife Management Area, Old River Unit. An offset rock breakwater would be constructed following example of Ducks Unlimited breakwater design (SWG-2012-0077-in folder). See drawing S15 for breakwater typical section.

**Measure 6-1.2 GIWW Barrier Island Restoration, Old River and Hickory Coves, Orange County.**

This measure would restore islands that once protected the GIWW at the northern end of Sabine Lake in front of Old River Cove and Hickory Cove. See drawing S13 for breakwater typical section.

**Measure 6-2 GIWW Breakwaters, Neches River to High Island, Jefferson County.**

This measure would provide shoreline protection for the unprotected GIWW shoreline (north and/or south banks) in Jefferson and Chambers counties. See drawing S15 for breakwater typical section.

**Measure 6-3 GIWW Barrier Island Restoration, North Pleasure Island, Jefferson County.**

This measure would restore an island that once protected the GIWW at the northern end of Sabine Lake at Pleasure Island. Island remnants exist to a varying degree. See drawing S13 for breakwater typical section.

**Measure 6-4.1 GIWW Breakwaters, Bolivar Peninsula, Galveston County.**

This measure would provide shoreline protection for the unprotected GIWW shorelines on the Bolivar Peninsula. See drawing S15 for breakwater typical section.

**Measure 6-4.2 GIWW Barrier Island Restoration, Bolivar Peninsula, Galveston County.**  
This measure would restore an island that once protected the GIWW in the Bolivar Peninsula. See drawing S13 for breakwater typical section.

**Measure 6-5.1 GIWW Breakwaters, West Bay, Galveston County.**

This measure would provide shoreline protection for the unprotected GIWW north shorelines in West Bay. See drawing S15 for breakwater typical section.

**Measure 6-5.2 GIWW Barrier Island Restoration, West Bay 1, Galveston County**

This measure would restore an island that once protected the GIWW in West Bay. Island remnants exist to a varying degree. See drawing S13 for breakwater typical section.

**Measure 6-5.3 GIWW Barrier Island Restoration, West Bay 2, Galveston County**

This measure would restore an island that once protected the GIWW in West Bay. Island remnants exist to a varying degree. See drawing S13 for breakwater typical section.

**Measure 6-6.1 GIWW Breakwaters, Brazoria County**

This measure would provide shoreline protection for unprotected GIWW shorelines in Brazoria County. See drawing S15 for breakwater typical section.

**Measure 6-6.2 GIWW Barrier Island Restoration, West Bay, Brazoria County**

This measure would restore an island that once protected the GIWW in West Bay, Brazoria County. Island remnants exist to a varying degree. See drawing S14 for breakwater typical section.

**LOCATION OF MEASURES (See attached drawings)**

Measures 6-1.2, 6-3, 6-4.2, 6-5.2, 6-5.3, 6-6.2:

Typical Section S-13: GIWW Shore Protection Island Restoration

Measures 6-5.2, 6-5.3, 6-6.2: Typical Section S-14: Levee Armor

Measures 6-1.2, 6-2, 6-4.1, 6-5.1, 6-6.1: Typical Section S-15: GIWW Shore Protection

Measure 6-1.1: GIWW Breakwater at Old River Cove, Orange County

Measure 6-1.2: GIWW Barrier Island Restoration, Old River and Hickory Coves, Orange County

Measure 6-2: GIWW Breakwaters, Neches River to High Island, Jefferson County

Measure 6-3: GIWW Barrier Island Restoration, North Pleasure Island, Jefferson County

Measure 6-4.1: GIWW Breakwaters, Bolivar Peninsula, Galveston County

Measure 6-4.2: GIWW Barrier Island Restoration, Bolivar Peninsula, Galveston County

Measure 6-5.1: GIWW Breakwaters, West Bay, Galveston County

Measure 6-5.2: GIWW Barrier Island Restoration, West Bay 1, Galveston County

Measure 6-5.3: GIWW Barrier Island Restoration, West Bay 2, Galveston County

Measure 6-6.1: GIWW Breakwaters, Brazoria County

Measure 6-6.2: GIWW Barrier Island Restoration, West Bay, Brazoria County

## **DESIGN ASSUMPTIONS**

### **Measure 6-1.1**

- Construct offset rock breakwater following example of Mad Island Marsh or Ducks Unlimited breakwater design to protect GIWW at Sargent Marsh (SWG-2012-0077-in folder).
- Breakwater would be placed sufficiently far from GIWW centerline for safe navigation.
- Constructed in depths of approx - 1.5 ft MSL with 8-inch graded riprap.
- Should allow fisheries access and circulation sufficient for accumulation of sediment behind breakwater.
- Breakwater length - 17,400 ft. Volume = 65,733 CY.

### **Measure 6-1.2**

- Containment levee is needed to be constructed to hold hydraulic material until it settles.
- Levee length = 17,400 ft; Volume = 65,733 CY.

### **Measure 6-2**

- Design should allow fisheries access and circulation sufficient for accumulation of sediment behind the breakwater.
- These measures could include "living shorelines" concepts (reef block, oyster bags, etc), but for initial screening, assume offset breakwaters like Mad Island or Sargent marshes.
- Total breakwater shoreline coverage is approximately 159,800 ft. Volume = 603,689 CY.

### **Measure 6-3**

- Containment levee would need to be constructed to hold hydraulic material until it settles.
- Levee length – 10,200 ft Volume = 87,644 CY.
- Island area 42 acres. Volume of fill 271,040 CY.

### **Measure 6-4.1**

- Design should allow fisheries access and circulation sufficient for accumulation of sediment behind the breakwater.
- These measures could include "living shorelines" concepts (reef block, oyster bags, etc), but for initial screening, assume offset breakwaters like Mad Island or Sargent marshes.
- Total breakwater shoreline coverage is approximately 124,825 ft. Volume = 471,561 CY.

#### **Measure 6-4.2**

- Containment levee is necessary (type of dike, source of fill material, and existing bottom elevation to be determined by Engineering).
- Levee would need to be constructed to hold hydraulic material until it settles.
- Levee length - 20,500 ft. Volume = 176,148 CY.
- Island area = 200 acres. Fill volume = 113,056 CY.

#### **Measure 6-5.1**

- Should allow fisheries access and circulation sufficient for accumulation of sediment behind breakwater.
- These measures could include "living shorelines" concepts (reef block, oyster bags, etc), but for initial screening, assume offset breakwaters like Mad Island or Sargent marshes.
- Total breakwater shoreline coverage is approximately 38,215 ft. Volume = 144,368 CY.

#### **Measure 6-5.2**

- Containment levee is necessary (type of dike, source of fill material, and existing bottom elevation to be determined by Engineering).
- Armoring needed on bay and GIWW sides.
- Levee would need to be constructed to hold hydraulic material until it settles.
- Levee length - 18,900 ft; Volume = 162,400 CY
- Island area - 58 acres. Volume of fill 374,293 CY.
- Riprap shore protection. Length = 18,900. 28,300 tons.

#### **Measure 6-5.3**

- Containment levee is necessary, (Armoring needed on bay and GIWW sides).
- Levee would need to be constructed to hold hydraulic material until it settles.
- Levee length - 7,600 ft; Volume = 65,304 CY.
- Island area = 14 acres. Volume of fill is 90,347 CY
- Fill material obtained from GIWW.

#### **Measure 6-6.1**

- Should allow fisheries access and circulation sufficient for accumulation of sediment behind breakwater.



- These measures could include "living shorelines" concepts (reef block, oyster bags, etc), but for initial screening, assume offset breakwaters like Mad Island or Sargent marshes.
- Total breakwater shoreline length is approximately 191,235 ft. Volume = 722,443 CY.

### **Measure 6-6.2**

- Containment levee is necessary, (Armoring needed on bay and GIWW sides).
- Levee would need to be constructed to hold hydraulic material until it settles.
- Levee length - 33,400 ft; Volume = 286,993 CY.
- Island area = 120 acres. Fill volume = 774,400 CY.

## **REAL ESTATE**

A detailed breakdown of Real Estate costs can be found in the supplemental document 'Sabine Pass to Galveston Bay, Texas Preliminary Real Estate Cost Estimate'. Costs identified as \$0 are generally associated with Federal and/or State lands.

- Measure 6-1.1: GIWW Breakwater at Old River Cove, Orange County  
Total Estimated Real Estate Cost: \$0
- Measure 6-1.2: GIWW Barrier Island Restoration, Old River and Hickory Coves, Orange County  
Total Estimated Real Estate Cost: \$0
- Measure 6-2: GIWW Breakwaters, Neches River to High Island, Jefferson County  
Total Estimated Real Estate Cost: \$0
- Measure 6-3: GIWW Barrier Island Restoration, North Pleasure Island, Jefferson County  
Total Estimated Real Estate Cost: \$0
- Measure 6-4.1: GIWW Breakwaters, Bolivar Peninsula, Galveston County  
Total Estimated Real Estate Cost: \$0
- Measure 6-4.2: GIWW Barrier Island Restoration, Bolivar Peninsula, Galveston County  
Total Estimated Real Estate Cost: \$0
- Measure 6-5.1: GIWW Breakwaters, West Bay, Galveston Island  
Total Estimated Real Estate Cost: \$0
- Measure 6-5.2: GIWW Barrier Island Restoration, West Bay 1, Galveston County  
Total Estimated Real Estate Cost: \$0
- Measure 6-5.3: GIWW Barrier Island Restoration, West Bay 2, Galveston County  
Total Estimated Real Estate Cost: \$0
- Measure 6-6.1: GIWW Breakwaters, Brazoria County  
Total Estimated Real Estate Cost: \$0
- Measure 6-6.2: GIWW Barrier Island Restoration, West Bay, Brazoria County

Total Estimated Real Estate Cost:

\$0

## ENVIRONMENTAL

Offset breakwaters and barrier islands would be constructed along the GIWW to stop shoreline erosion. Environmental benefits for the breakwater measures are based on the acres of erosion that would be prevented over the 50-year period of analysis. The 50-year estimate of acres lost was developed by measuring shoreline loss over specific time periods using Google Earth. The shorelines of the GIWW are largely undeveloped and therefore protected areas are assumed to be wetland marshes. Environmental benefits of the island restoration measures were calculated as the sum of the restored island acres and acres of erosion prevented on the mainland shoreline over the 50 year period of analysis. Some of these measures would protect portions of several National Wildlife Refuges and Wildlife Management Areas.

Measure Description	Acres of Erosion Prevented Over 50 Years
Measure 6-1.1 (GIWW Breakwater at Old River Cove, Orange County)	50
Measure 6-1.2 (GIWW Barrier Island Restoration, Old River and Hickory Coves, Orange County )	131
Measure 6-2 (GIWW Breakwaters, Neches River to High Island, Jefferson County)	761
Measure 6-3 (GIWW Barrier Island Restoration, North Pleasure Island, Jefferson County )	64
Measure 6-4.1 (GIWW Breakwaters, Bolivar Peninsula, Galveston County)	867
Measure 6-4.2 (GIWW Barrier Island Restoration, Bolivar Peninsula, Galveston County)	246
Measure 6-5.1 (GIWW Breakwaters, West Bay, Galveston County )	222
Measure 6-5.2 (Brazos River to Brazos River Diversion Channel)	112
Measure 6-5.3 (GIWW Barrier Island Restoration, West Bay 2, Galveston County)	35
Measure 6-6.1 (GIWW Breakwaters, Brazoria County)	1,110
Measure 6-6.2 (GIWW Barrier Island Restoration, West Bay, Brazoria County)	215

## BENEFITS

All benefits are assumed be environmental for this phase of analysis.

## **COSTS**

These costs do not include Real Estate.

Measure 6-1.1: The estimated cost for this measure is \$20,480,000

Measure 6-1.2: The estimated cost for this measure is \$10,215,000

Measure 6-2: The estimated cost for this measure is \$181,509,000

Measure 6-3: The estimated cost for this measure is \$3,542,000

Measure 6-4.1: The estimated cost for this measure is \$141,782,000

Measure 6-4.2: The estimated cost for this measure is \$10,017,000

Measure 6-5.1: The estimated cost for this measure is \$43,406,000

Measure 6-5.2: The estimated cost for this measure is \$9,764,000

Measure 6-5.3: The estimated cost for this measure is \$4,037,000

Measure 6-6.1: The estimated cost for this measure is \$219,877,000

Measure 6-6.2: The estimated cost for this measure is \$18,202,000

Cost assumptions for Breakwater measures: 6-1.1, 6-2, 6-4.1, 6-5.1, and 6-6.1 :

- Riprap will be barged in to site.
- A 9 ft deep flow channel will need to be excavated to bring in the rock barge.
- Riprap will be placed from the barge.
- A standard 25% contingency, E&D of 8%, and CM of 6% were added to the cost.

Cost assumption for Island measures : 6-1.2, 6-4.2, 6-5.2, 6-5.3, and 6-6.2:

- Riprap will be barged in to site.
- A 9 ft deep flow channel will need to be excavated to bring in the rock barge.
- Riprap will be placed from the barge.
- Levee fill is side cast from access channel construction and loosely placed non-compacted shaped to levee template.
- The island interior is filled 4 feet deep with dredge material.
- Island dredge fill will be from maintenance material from GIWW, along side of the island, and 12,000 LF on each side.
- A standard 25% contingency, E&D of 8%, and CM of 6% were added to the cost.

## **REFERENCE DOCUMENT**

DU permit IR SWG 2012-0077 at GIWW-Sargent Marsh

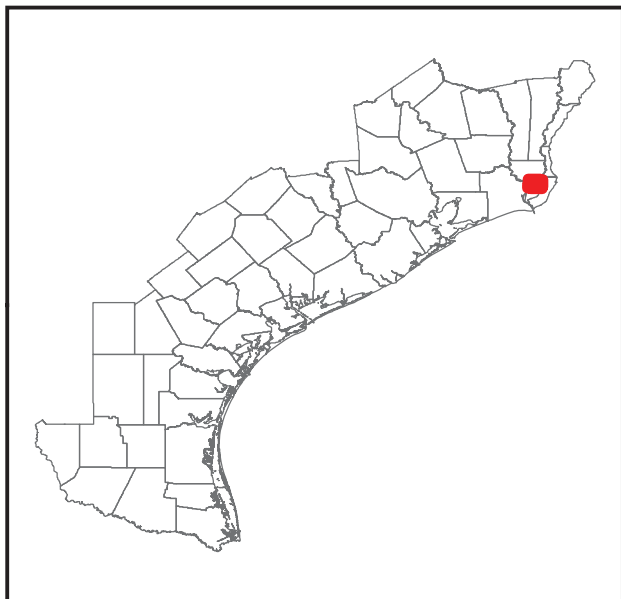
## **RISKS**

- Geotechnical and structural feasibility of the proposal was not reviewed.



- No review of available public information or data from in-house files relative to the general geology and soil conditions for the proposed features was conducted.



# Measure 6-1.1 and 6-1.2 - Breakwater and Barrier Island Restoration - Orange County



## Legend

-  Breakwater
-  Barrier Island Restoration



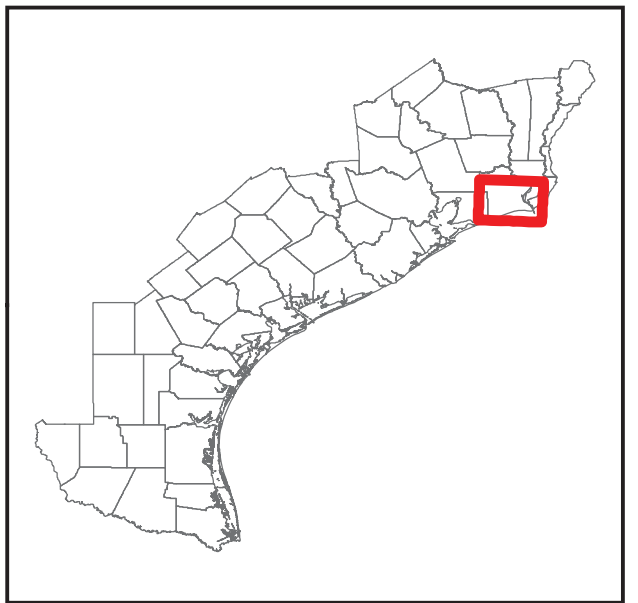
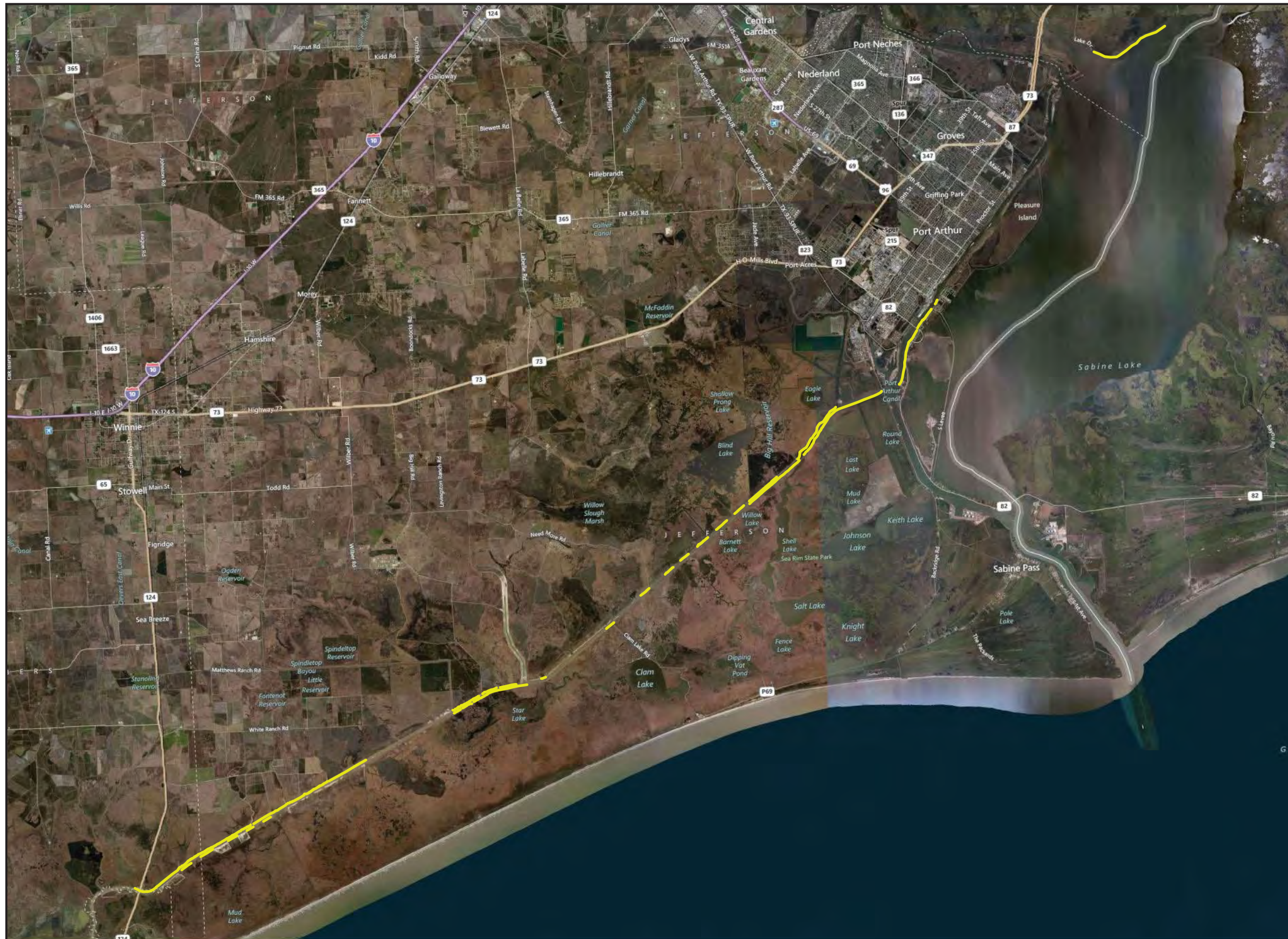
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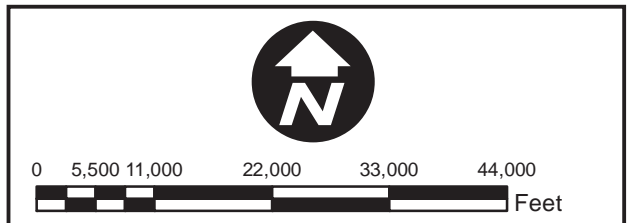


# Measure 6-2 - GIWW Breakwaters, Neches River to High Island, Jefferson County



## Legend

 GIWW Breakwaters



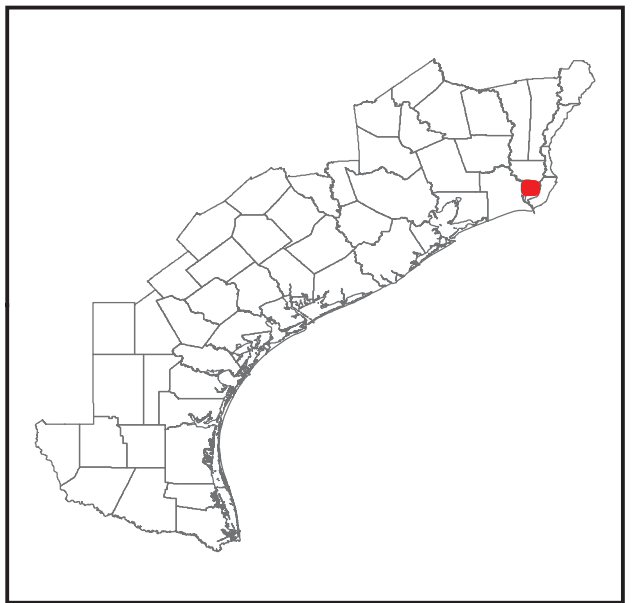
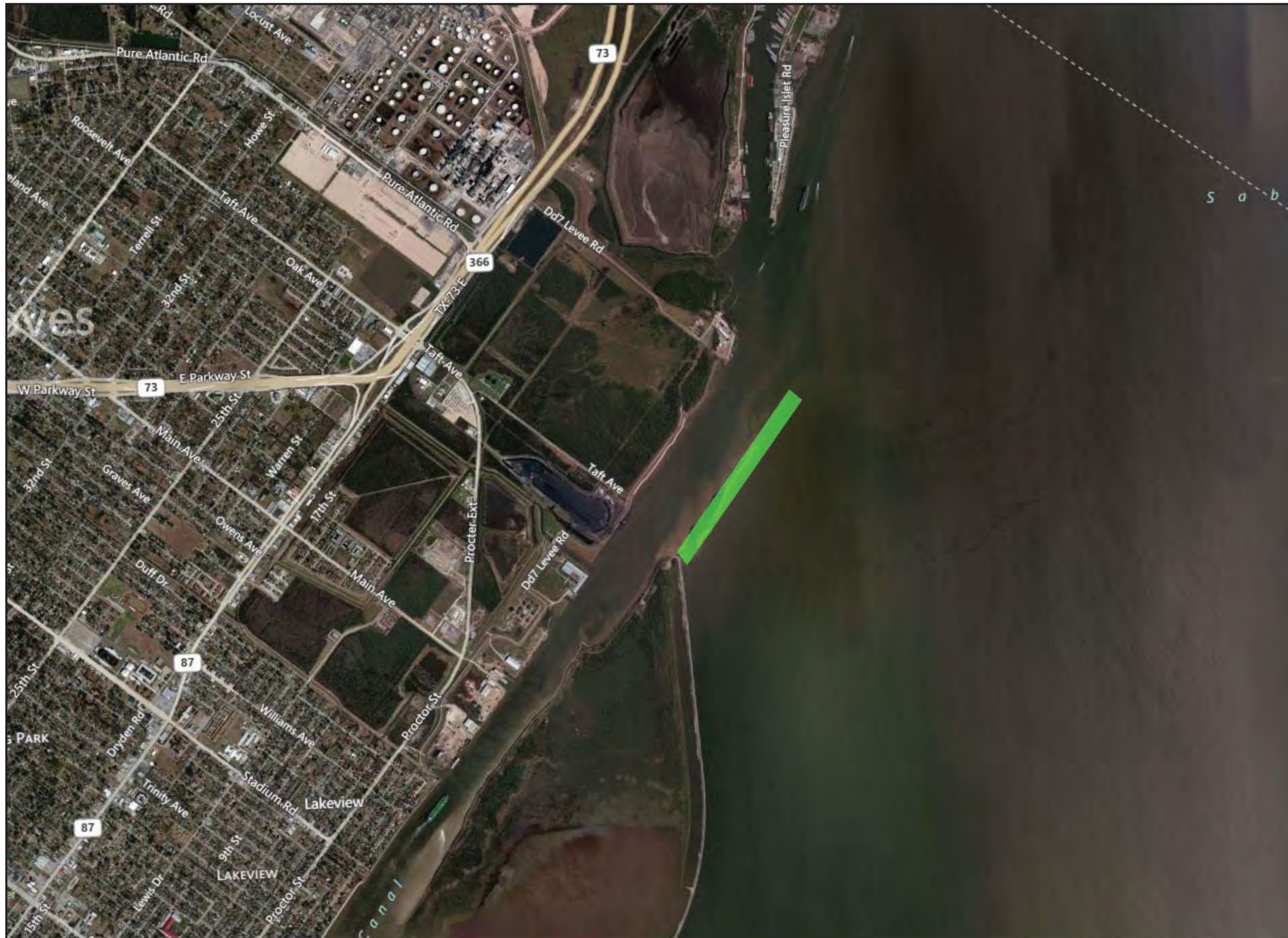
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# Measure 6-3 - GIWW Barrier Island Restoration, North Pleasure Island, Jefferson County




### Legend

 Barrier Island Restoration



0 750 1,500 3,000 4,500 6,000 Feet

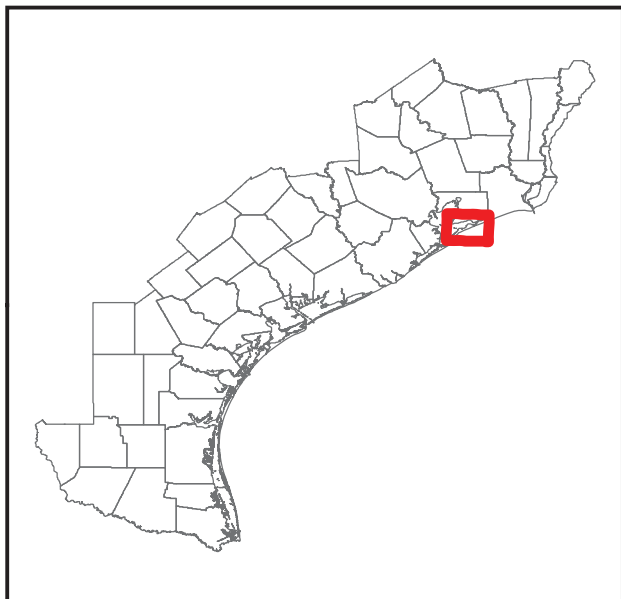
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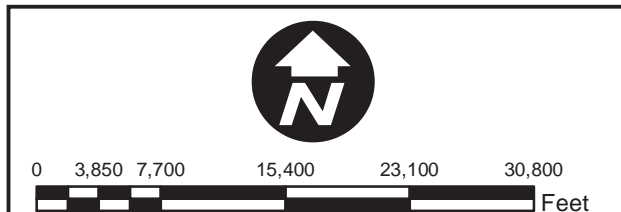


## Measure 6-4.1 - GIWW Breakwaters, Bolivar Peninsula, Galveston County



### Legend

 GIWW Breakwaters



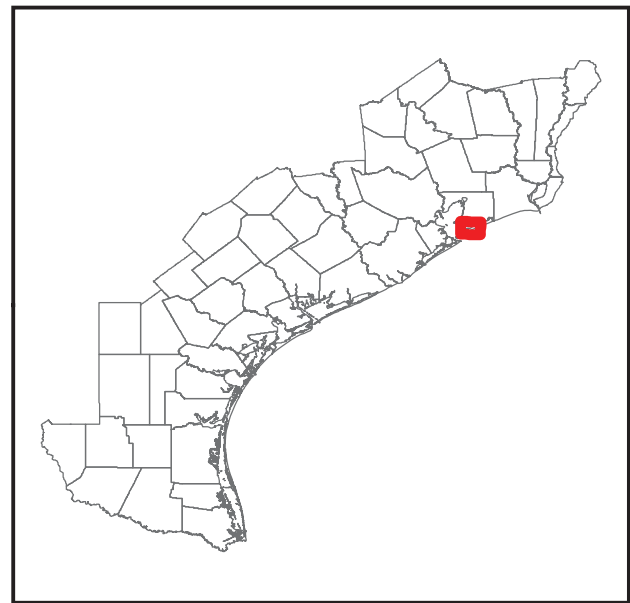
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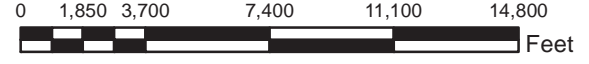
**Measure 6-4.2 - GIWW Barrier Island Restoration, Bolivar Peninsula, Galveston County**



**Legend**

Barrier Island Restoration






0 1,850 3,700 7,400 11,100 14,800 Feet

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## Measure 6-5.1 - GIWW Breakwaters, West Bay, Galveston County



### Legend

 GIWW Breakwaters



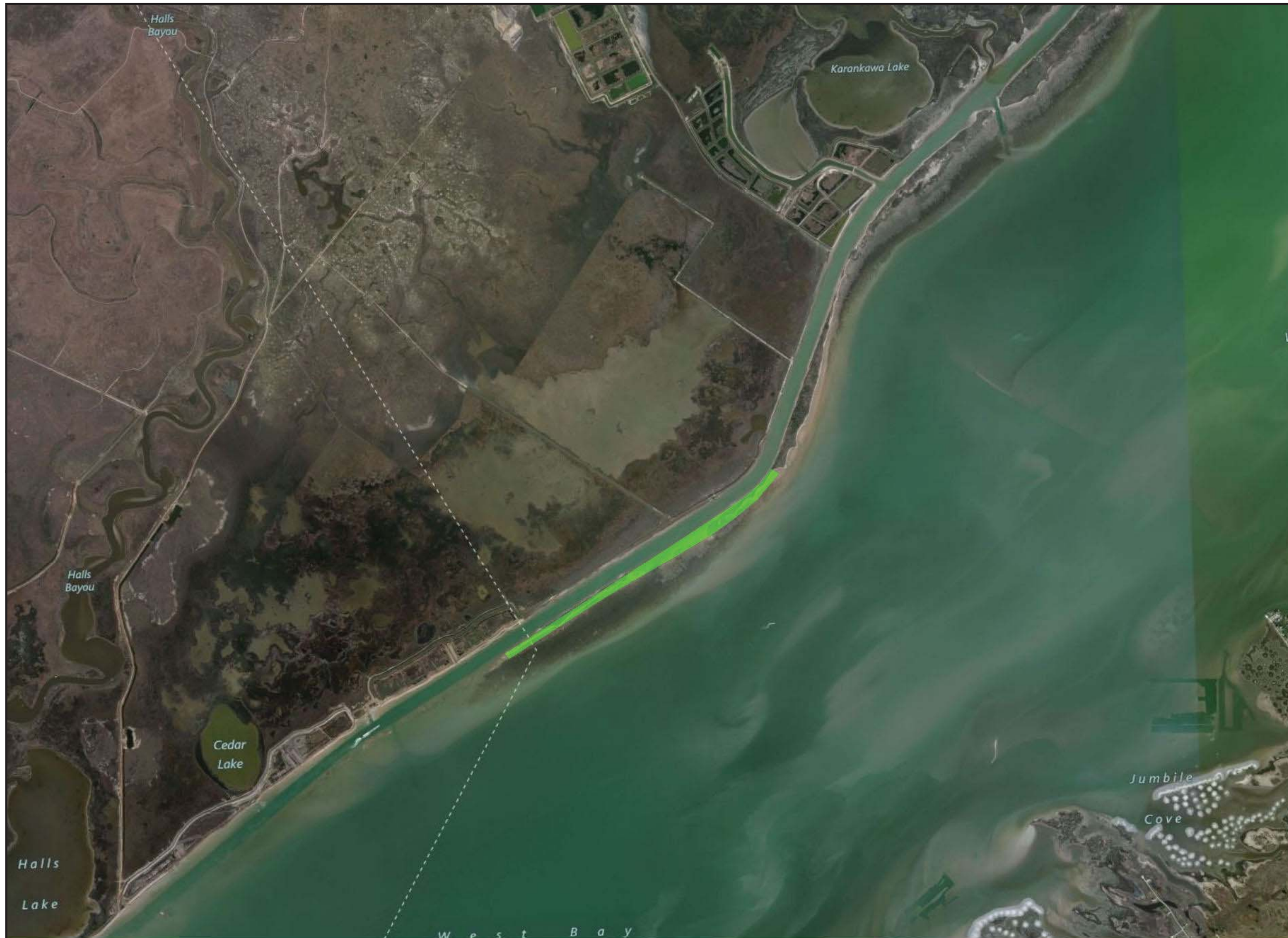
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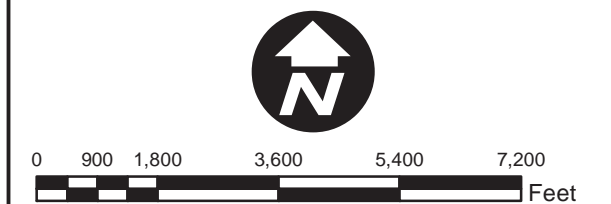


# Measure 6-5.2 - GIWW Barrier Island Restoration, West Bay 1, Galveston County



## Legend

 Barrier Island Restoration



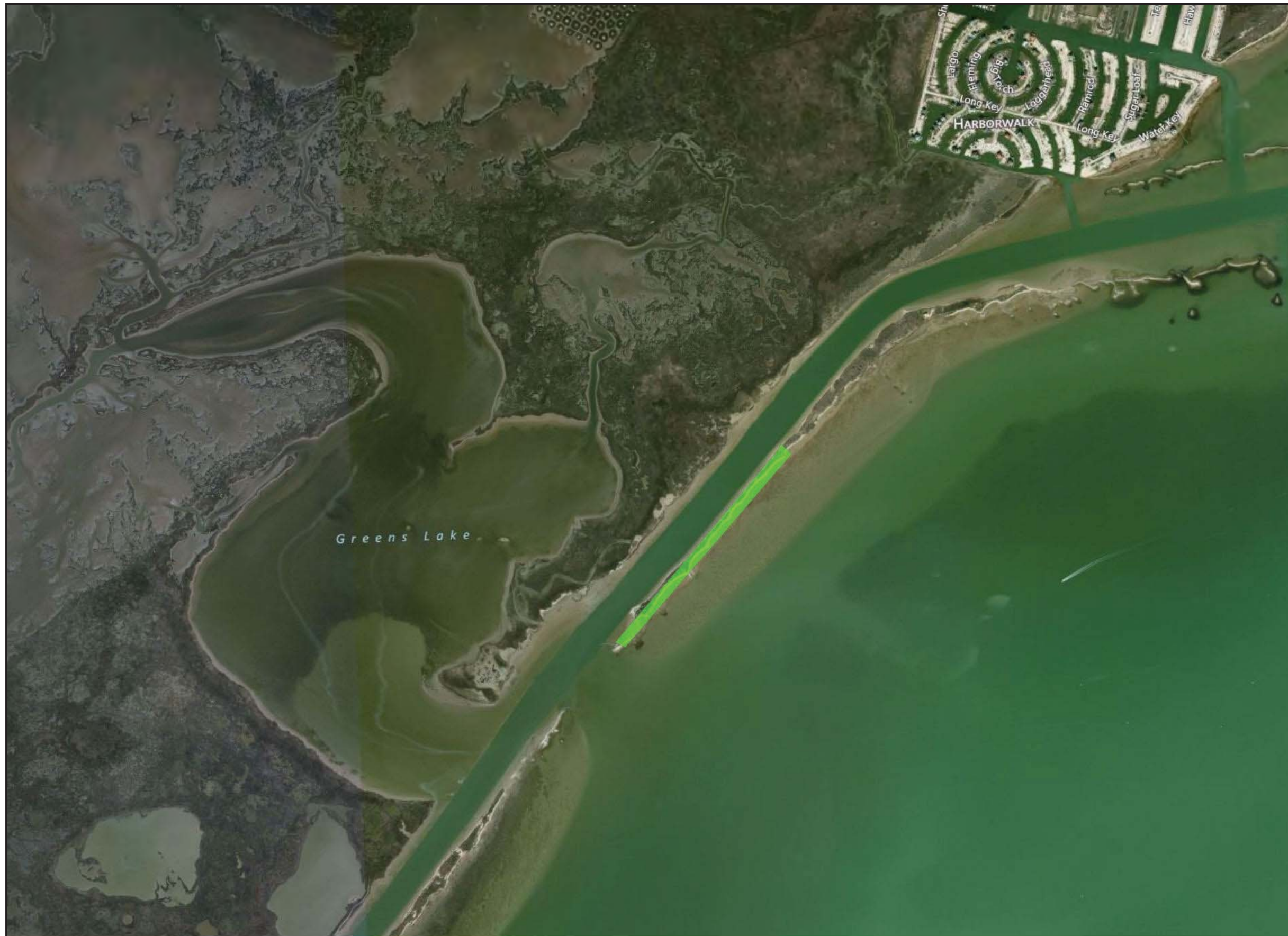
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## Measure 6-5.3 - GIWW Barrier Island Restoration, West Bay 2, Galveston County



### Legend

 Barrier Island Restoration



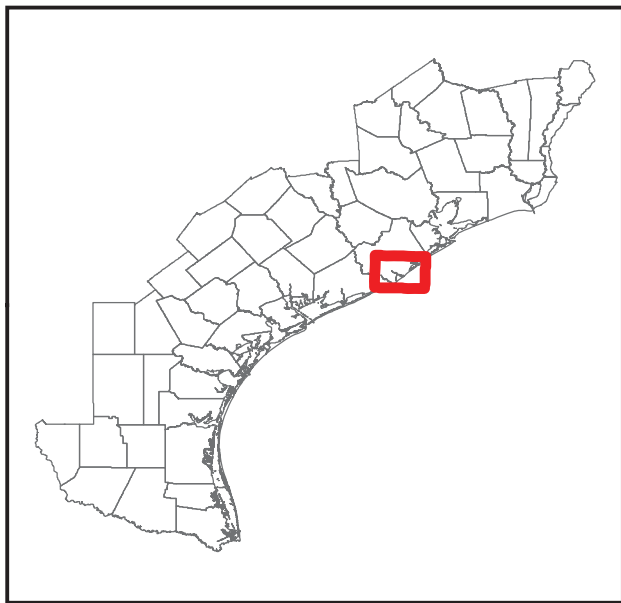
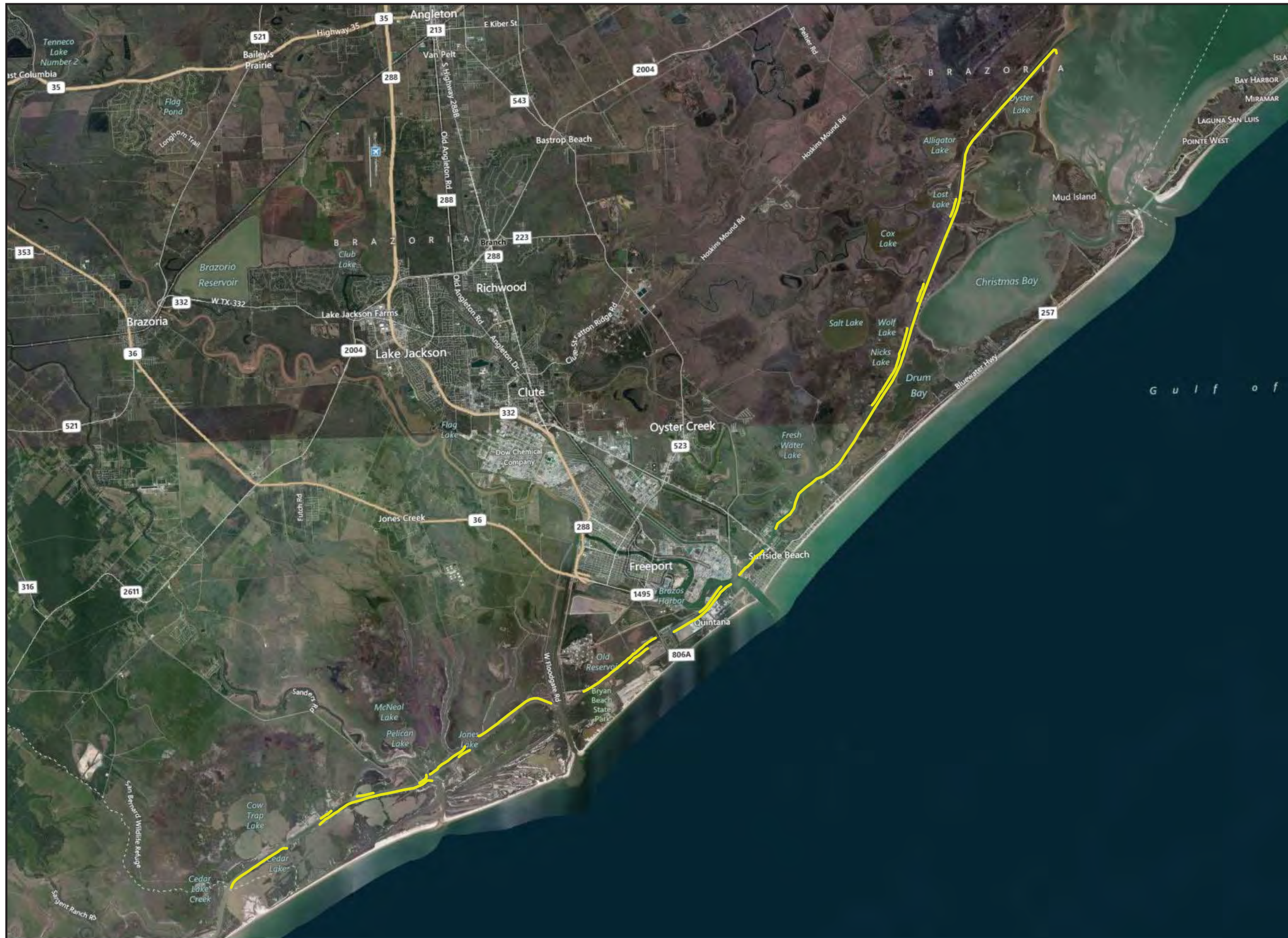
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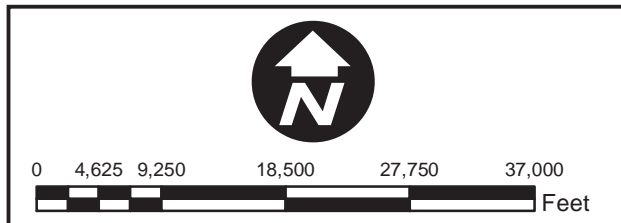


## Measure 6-6.1 - GIWW Breakwaters, Brazoria County



### Legend

 GIWW Breakwaters



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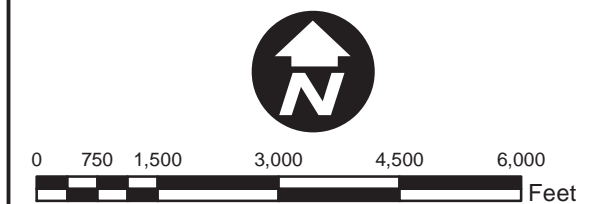


## Measure 6-6.2 - GIWW Barrier Island Restoration, West Bay, Brazoria County



### Legend

 Barrier Island Restoration

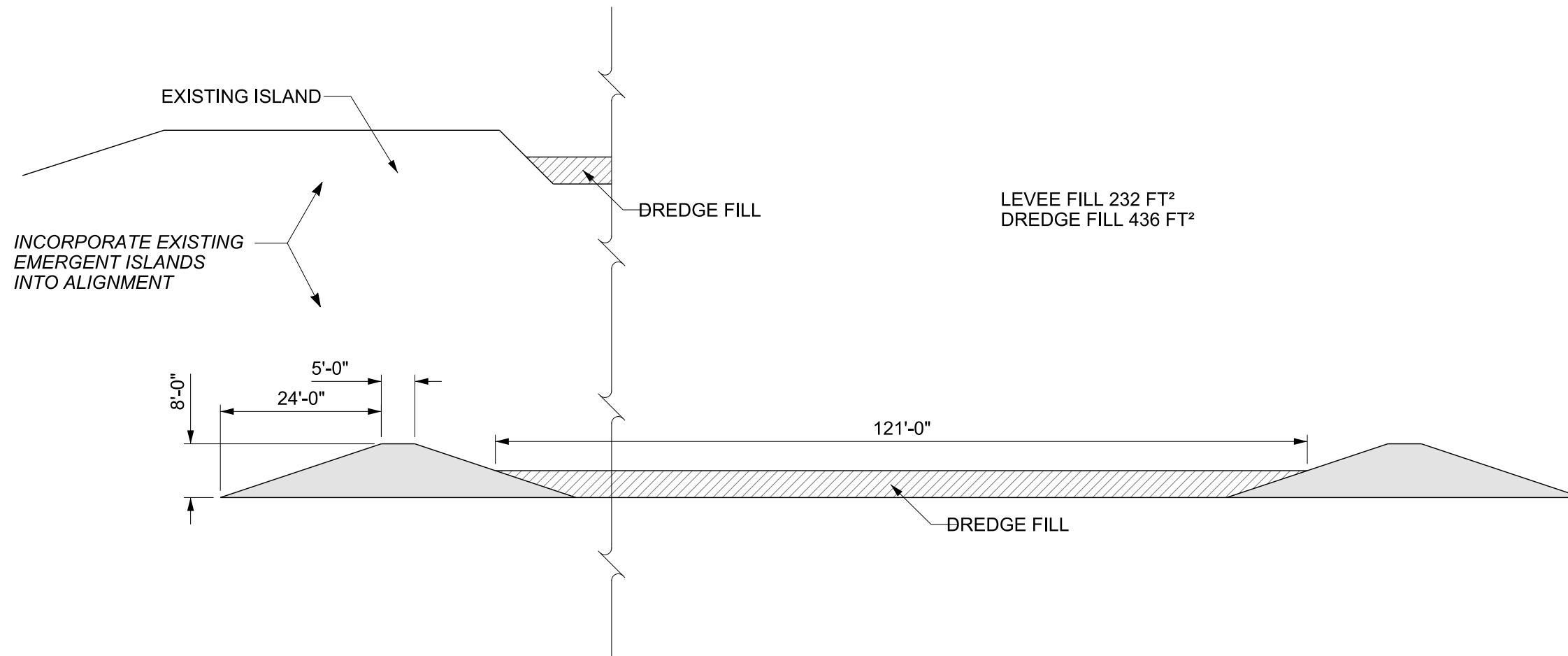


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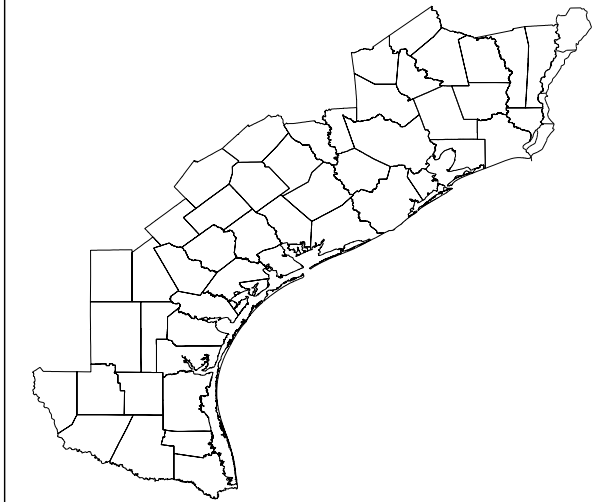


## Typical Section S-13: GIWW Shore Protection Island Restoration



**ASSUMPTIONS:**

- 1: LEVEE FILL IS LOOSELY PLACED NON COMPACTED
- 2: LEVEE FILL IS SIDE CAST FROM ACCESS CHANNEL CONSTRUCTION
- 3: LEVEE TEMPLATE IS FOUNDED ON THE -4FT CONTOUR
- 4: DREDGE FILL IS A UNIFORM 4FT THICKNESS
- 5: VOLUME IS BASED ON CROSS SECTION AREA MULTIPLIED BY LENGTH
- 6: INCORPORATE EXISTING EMERGENT ISLANDS INTO ALIGNMENT



Typical Section S-13

Measure:

- 6-1.2
- 6-3
- 6-4.2
- 6-5.2 (Existing Islands)
- 6-5.3 (Existing Islands)
- 6-6.2
- 7-3 (Existing Islands)

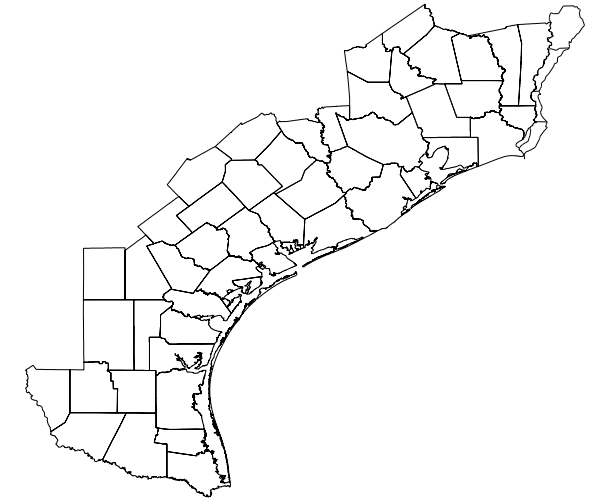
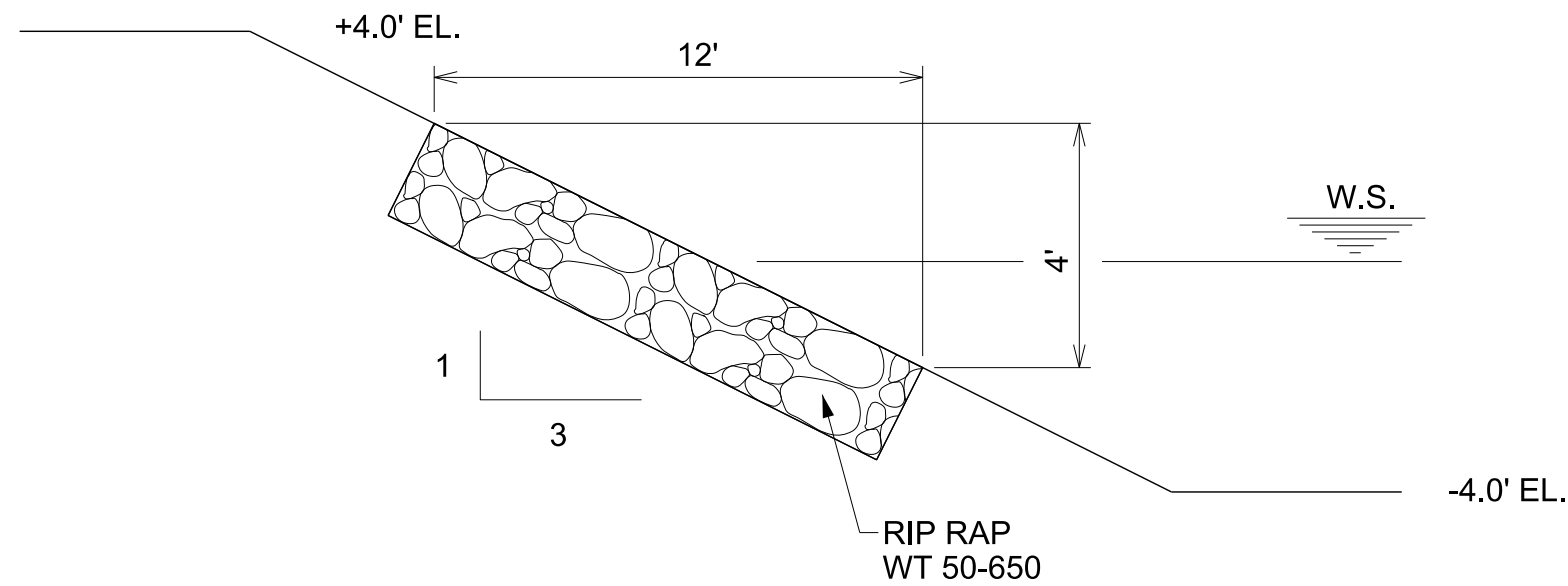


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Date Created: 4/24/2013



# Typical Section S-14: Levee Armor



Typical Section S-14

- Measures:  
6-5.2  
6-5.3  
6-6.2



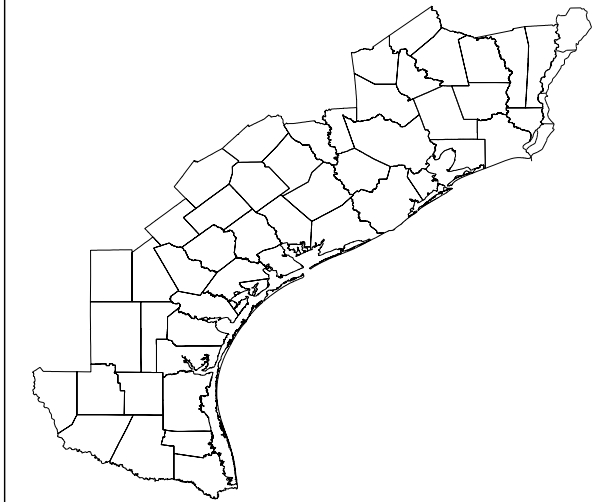
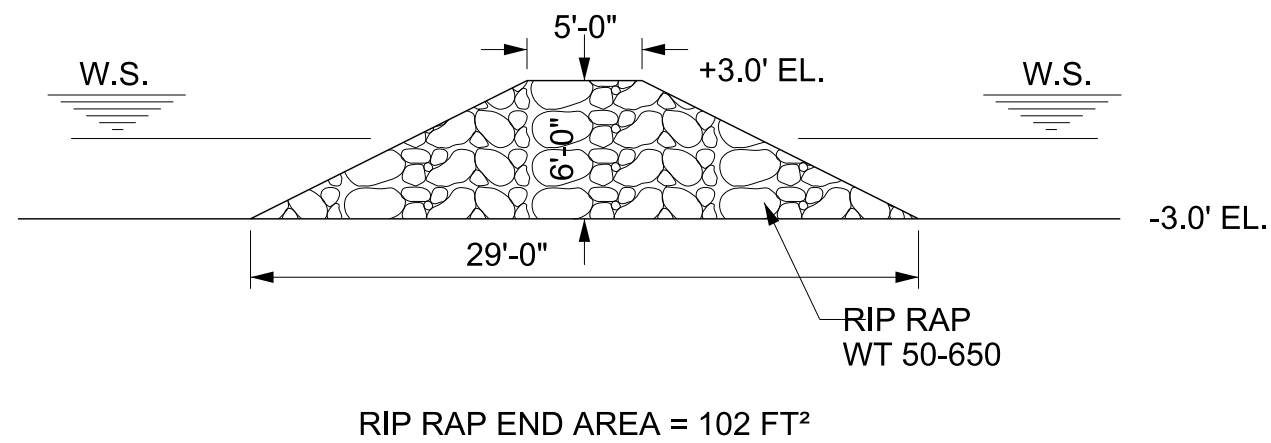
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Date Created: 4/24/2013





Typical Section S-15: GIWW Shore Protection



Typical Section S-15

Measures:

- 6-1.1
- 6-2
- 6-4.1
- 6-5.1
- 6-6.1
- 7-1
- 7-2
- 8-4
- 8-6
- 8-7



ASSUMPTIONS:

- 1: BREAKWATER IS PLACED IN 3 FT DEEP WATER
- 2: BREAKWATER IS CONTINUOUS
- 3: VOLUME IS BASED ON CROSS SECTION AREA MULTIPLIED BY LENGTH

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Date Created: 4/24/2013



**SABINE PASS TO GALVESTON BAY, TEXAS**  
**MEASURES 7-1, 7-2, 7-3**  
**INFORMATION SHEET**

**DESCRIPTION OF MEASURES**

**Measure 7-1 Shoreline Protection, East Bay, Chambers County.**

This measure would install shoreline protection along 22 miles of East Bay shoreline, north shore of East Bay. See drawing S-15 for breakwater typical section. The measure would allow fisheries access and circulation sufficient for accumulation of sediment behind breakwater.

**Measure 7-2 Shoreline Protection, Bastrop Bay, Brazoria County.**

This measure would install shoreline protection along 3.2 miles of Bastrop Bay. See drawing S-15 for breakwater typical section. The measure would allow fisheries access and circulation sufficient for accumulation of sediment behind breakwater.

**Measure 7-3 Island Restoration, Vingt-et-un, Chambers County.**

This measure would reconstruct islands that formerly protected Smith Point from wave attack. A containment levee would be constructed and filled to reestablish the island. A levee would need to be constructed to hold hydraulic material in place until it settles. See Drawing S-13 for Island Restoration typical section.

**LOCATION OF MEASURES** (See attached drawings)

Measure 7-1: East Bay Shoreline Protection, Chambers County

Measure 7-2: Bastrop Bay Shoreline Protection, Brazoria County

Measure 7-3: Vingt-et-un Island Restoration, Chamber County

Measures 7-1, 7-2: Typical Section S-15: GIWW Shore Protection

Measure 7-3: Typical Section S-13: GIWW Shore Protection Island Restoration

**DESIGN ASSUMPTIONS**

**Measure 7-1:**

- Should allow fisheries access and circulation sufficient for accumulation of sediment behind the breakwater.
- Breakwater is placed in 3 feet deep water.
- Breakwater is continuous for the entire length (not segmented). Length = 116,640 ft (22 mi).
- Volume is based on cross sectional area multiplied by total length. Volume = 440,640 CY.

- Riprap size is W50-650.
- Quantities are neat line, settlement not accounted for.
- Access channel is 9 feet deep and 50 feet wide with 1:1 side slopes, excavated material is side cast and left in place.

**Measure 7-2:**

- Should allow fisheries access and circulation sufficient for accumulation of sediment behind breakwater.
- Breakwater is placed in 3 feet deep water.
- Breakwater is continuous for entire length (not segmented). Length = 17,370 ft.
- Volume is based on cross sectional area multiplied by total length. Volume = 65,620 CY.
- Riprap size is W50-650.
- Quantities are neat line, settlement not accounted for.
- Access channel is 9 feet deep and 50 feet wide with 1:1 side slopes, excavated material is side cast and left in place.

**Measure 7-3:**

- Levee fill is side cast from access channel construction and loosely placed non-compacted shaped to levee template.
- Levee template is founded on the -4 foot contour. Length = 33,400 ft.
- Levee volume is based on cross sectional area multiplied by total length. Volume = 286,993 CY.
- Quantities are neat line, settlement not accounted for.
- Access channel is 9 feet deep and 50 feet wide with 1:1 side slopes, excavated material used for levee template.
- Containment levee can tie into existing islands.
- Island area is 27 and interior dredge fill is 4 feet deep. The area fill volume is 332,037 CY.
- Island dredge fill from maintenance material from Channel to Liberty along side of island and 12,000 LF on each side.
- No erosion protection applied to outside of levees.

**REAL ESTATE**

A detailed breakdown of Real Estate costs can be found in the supplemental document 'Sabine Pass to Galveston Bay, Texas Preliminary Real Estate Cost Estimate'. Costs identified as \$0 are associated with Federal navigational servitude.

- Measure 7-1: Shoreline Protection, East Bay, Chambers County

Total Estimated Real Estate Cost of Measure 7-1: \$0

- Measure 7-2: Shoreline Protection, Bastrop Bay, Brazoria County

Total Estimated Real Estate Cost of Measure 7-2: \$0

- Measure 7-3: Island Restoration, Vingt-et-un, Chambers County

Total Estimated Real Estate Cost of Measure 7-3: \$5,000 ®

## **ENVIRONMENTAL**

For measures 7-1 and 7-2, environmental benefits are presented in wetland acres that would be protected by this measure. The wetland acres were calculated with a GIS analysis of National Wetland Inventory wetland maps (USFWS, 2012).

Measure 7-1 would protect the north shore of East Bay which has experienced a shoreline erosion rate of up to 4.5 feet per year since 1970. The breakwaters would protect the shoreline of the Moody and Anahuac National Wildlife Refuges (NWR) and the Candy Abshier Wildlife Management Area, preventing the erosion of approximately 600 wetland acres over the 50 year period of analysis.

Measure 7-2 would protect the west shore of Bastrop Bay. Nearshore breakwaters would be constructed along the shorelines of Bastrop Bay which has experienced erosion of up to 2 feet per year since 1943. This erosion is threatening to open the bay to the more saline waters of the GIWW. The breakwaters would protect the shoreline of the Brazoria NWR and prevent the erosion of approximately 40 wetland acres over the 50 year period of analysis, while maintaining the protected shallow bay aquatic environment.

Measure 7-3 would restore the Vingt-et-Un Islands which once protected Smith Point from wave attack erosion. The total acreage of the restored islands would be 27 acres. There was no attempt to calculate erosion that would be prevented based on restoration of the islands.

## **COSTS:**

These cost do not include real estate cost.

Measure 7-1: The estimated cost for this measure is \$137,121,000.

Measure 7-2: The estimated cost for this measure is \$20,420,000.

Measure 7-3: The estimated cost for this measure is \$5,381,000.

Cost assumptions for Measures 7-1 and 7-2:

- Riprap will be barged in to site.
- A 9 ft deep flow channel will need to be excavated to bring in the rock barge.
- Riprap will be placed from the barge.

Cost assumptions for Measure 7-3:

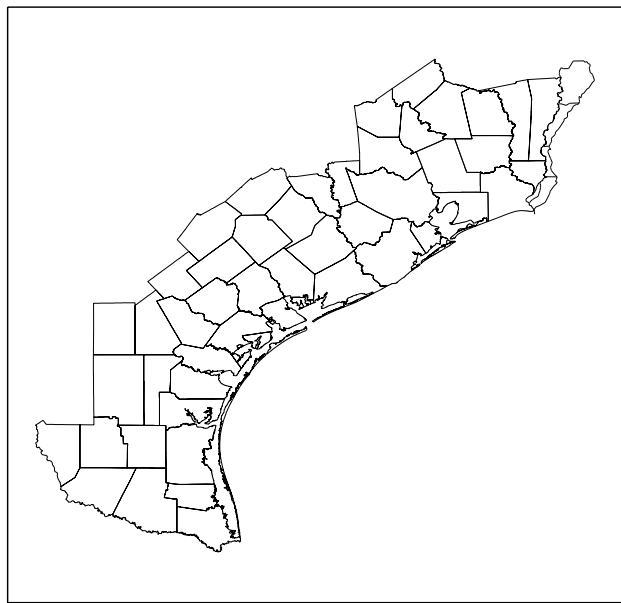
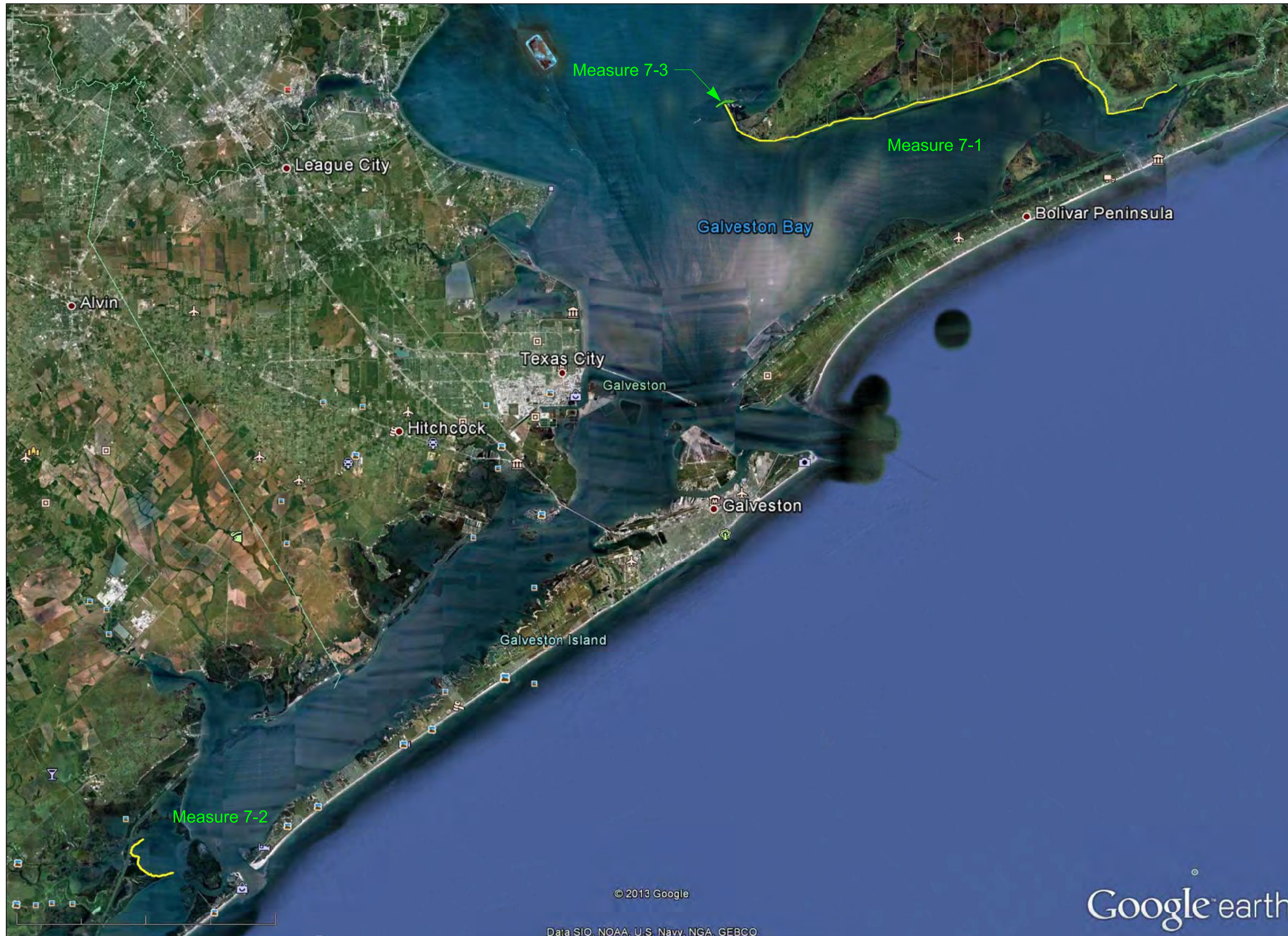
- Riprap will be barged in to site.
- A 9 ft deep flow channel will need to be excavated to bring in the rock barge.
- Riprap will be placed from the barge
- Levee fill is side cast from access channel construction and loosely placed non-compacted shaped to levee template.
- Island interior is filled with dredge material 4 feet deep.
- Island dredge fill will be from maintenance material from GIWW along side of island and 12,000 LF on each side.
- A standard 25% contingency, E&D of 8%, and CM of 6% were added to the cost.

**RISKS:**

- Geotechnical and structural feasibility of the proposal was not reviewed.
- No review of available public information or data from in-house files relative to the general geology and soil conditions for the proposed features was conducted.




Measure 7: Bay Shoreline Protection and Island Restoration, Chambers and Brazoria Counties




### Legend

— Measure 7



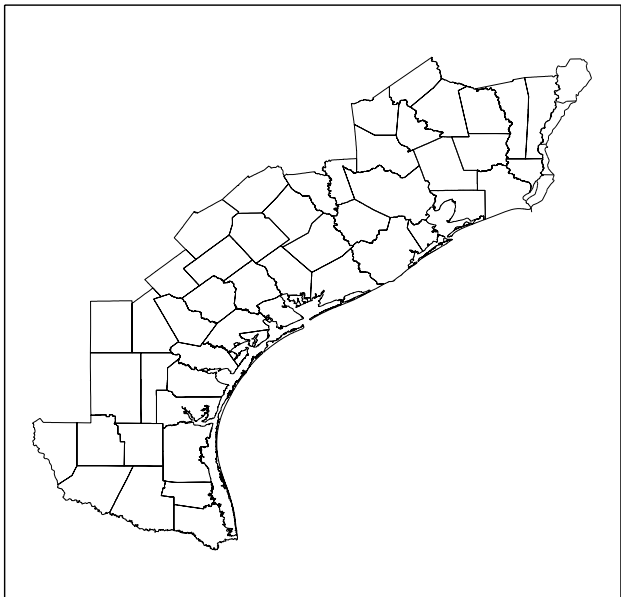
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Date Created: 4/24/2013



Measure 7-1: Shoreline Protection, East Bay, Chambers County



### Legend

— Measure 7-1



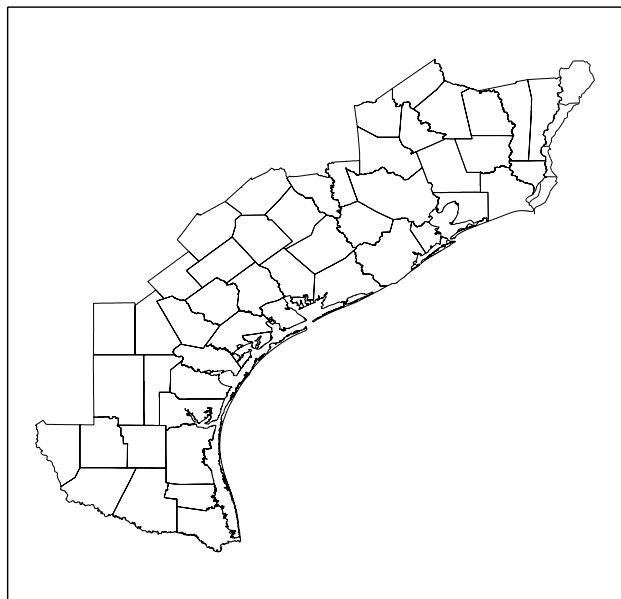
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Measure 7-2: Shoreline Protection, Bastrop Bay, Brazoria County



### Legend

— Measure 7-2



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Date Created: 4/24/2013

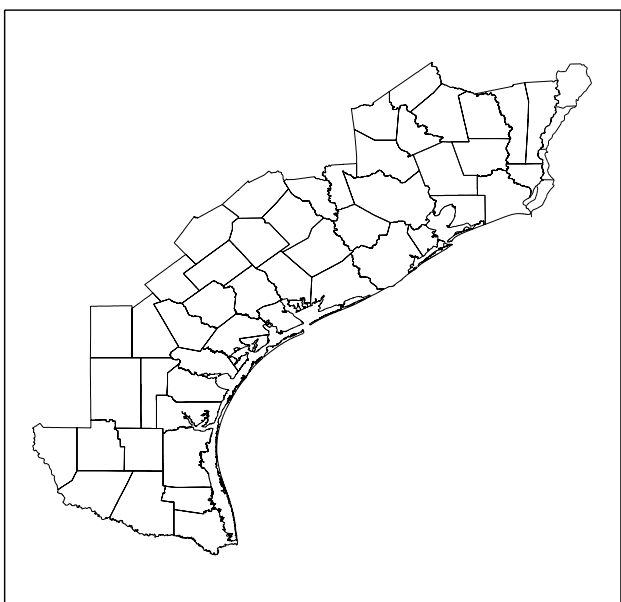


Google earth

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Image © 2013 TerraMetrics  
Data SIO, NOAA, U.S. Navy, NGA, GEBCO



Measure 7-3: Island Restoration, Vingt-et-un, Chambers County



### Legend

— Measure 7-3



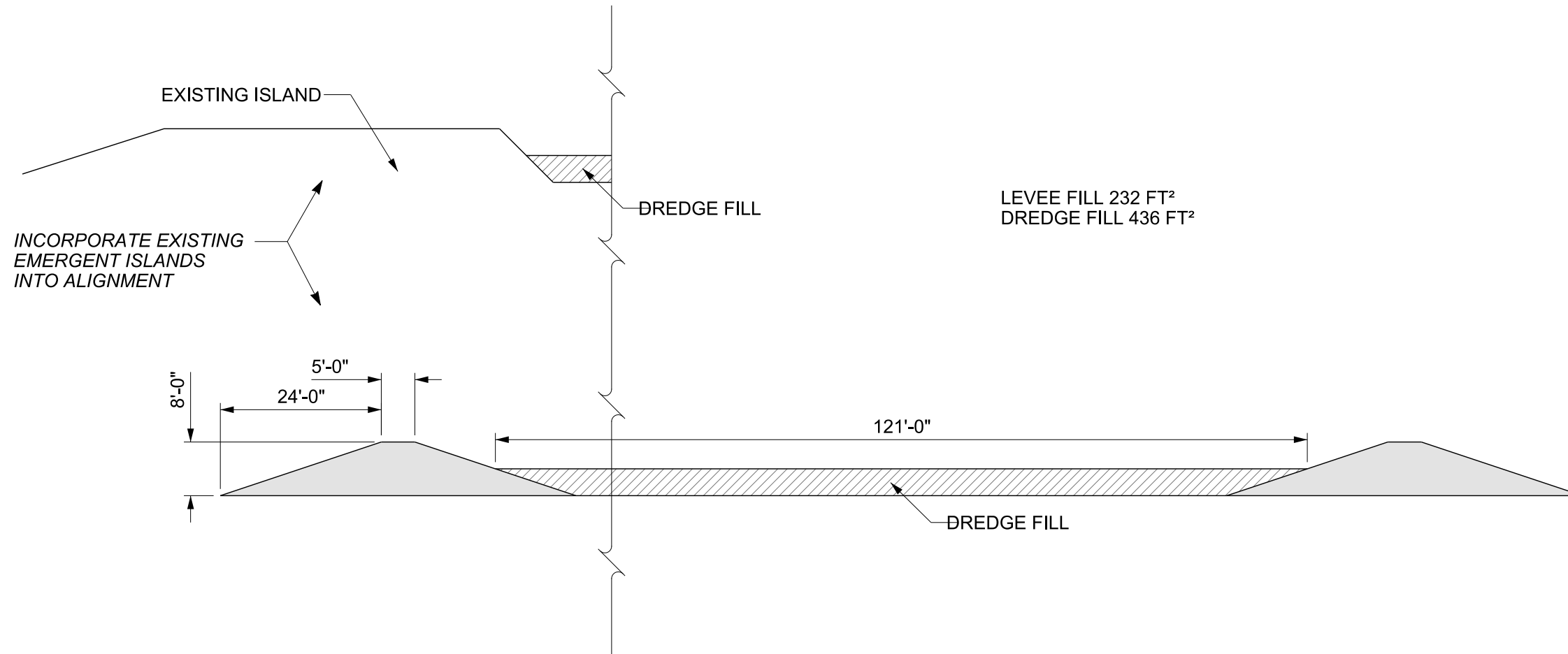
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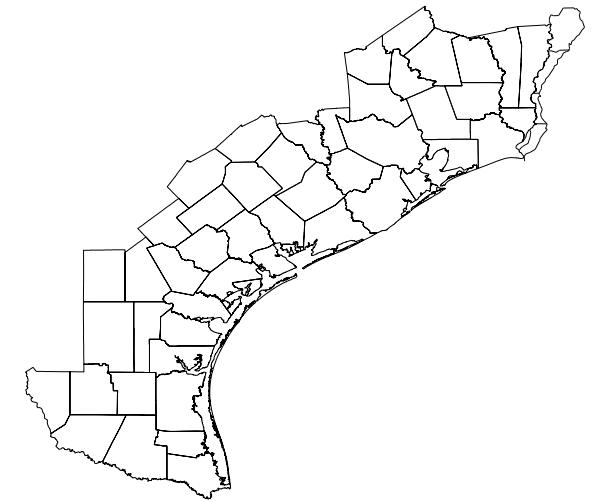


## Typical Section S-13: GIWW Shore Protection Island Restoration



**ASSUMPTIONS:**

- 1: LEVEE FILL IS LOOSELY PLACED NON COMPACTED
- 2: LEVEE FILL IS SIDE CAST FROM ACCESS CHANNEL CONSTRUCTION
- 3: LEVEE TEMPLATE IS FOUNDED ON THE -4FT CONTOUR
- 4: DREDGE FILL IS A UNIFORM 4FT THICKNESS
- 5: VOLUME IS BASED ON CROSS SECTION AREA MULTIPLIED BY LENGTH
- 6: INCORPORATE EXISTING EMERGENT ISLANDS INTO ALIGNMENT



Typical Section S-13

Measure:

- 6-1.2
- 6-3
- 6-4.2
- 6-5.2 (Existing Islands)
- 6-5.3 (Existing Islands)
- 6-6.2
- 7-3 (Existing Islands)

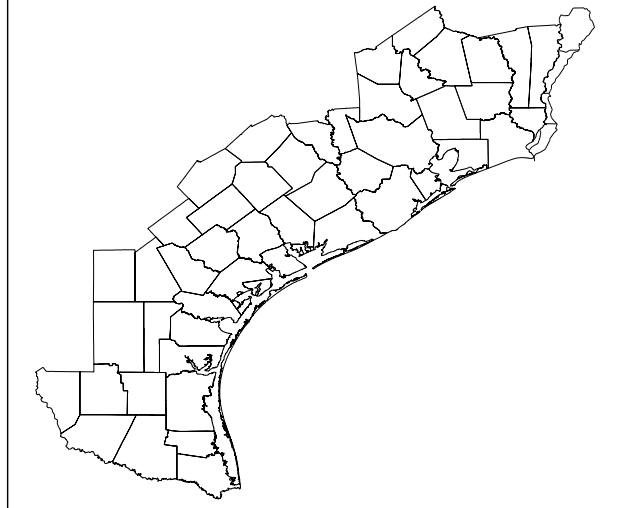
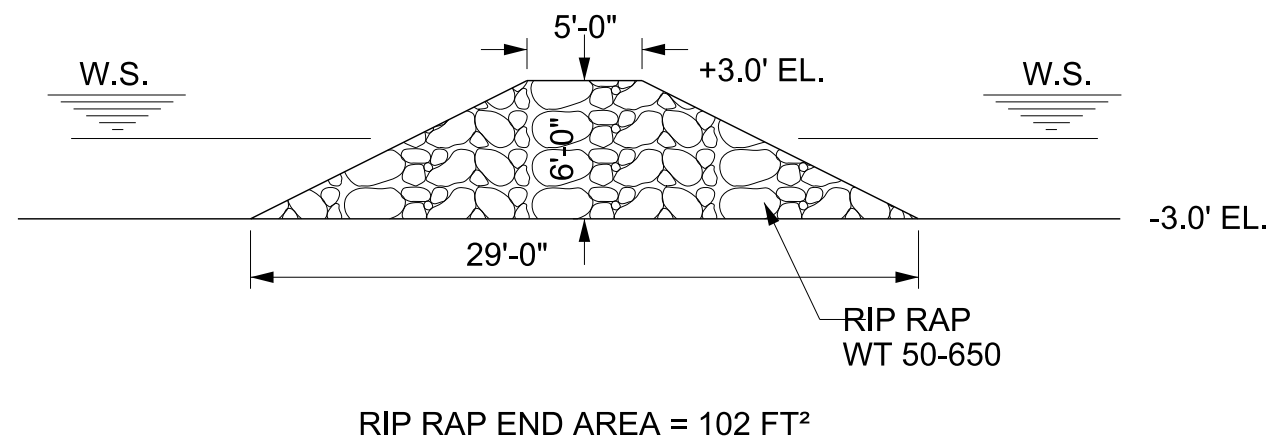


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Date Created: 4/24/2013



Typical Section S-15: GIWW Shore Protection



Typical Section S-15

Measures:

- 6-1.1
- 6-2
- 6-4.1
- 6-5.1
- 6-6.1
- 7-1
- 7-2
- 8-4
- 8-6
- 8-7



ASSUMPTIONS:

- 1: BREAKWATER IS PLACED IN 3 FT DEEP WATER
- 2: BREAKWATER IS CONTINUOUS
- 3: VOLUME IS BASED ON CROSS SECTION AREA MULTIPLIED BY LENGTH

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Date Created: 4/24/2013



**SABINE PASS TO GALVESTON BAY, TEXAS  
MEASURE 8-1, 8-2, 8-3  
INFORMATION SHEET**

**DESCRIPTION OF MEASURES**

These measures would restore large, degraded marsh systems on the Neches River. The restored marshes would attenuate storm surge and reduce impacts to communities such as Bridge City and Vidor, which are located on the river terraces north of the marshes.

**Measure 8-1 Marsh Restoration, Bessie Heights East , Orange County**

This measure would restore 679 acres of brackish and 1,190 acres of intermediate marsh, 660 acres of shallow-water habitat, and nourish 651 acres of existing marsh. The total influence area is 3,180 acres.

**Measure 8-2 Marsh Restoration, Old River Cove , Orange County.**

This measure would restore 639 acres of brackish marsh, 139 acres of shallow-water habitat, and nourish 432 acres of existing marsh. The total influence area is 1,210 acres.

**Measure 8-3 Marsh Restoration, Rose City East, Orange County.**

This measure would restore 345 acres of fresh marsh, 72 acres of shallow water, and nourish 151 acres of existing marsh. The total influence area is 568 acres.

**LOCATION OF MEASURES 8-1, 8-2, 8-3 (See attached drawings)**

Measure 8-1 Marsh Restoration, Bessie Heights East , Orange County

Measure 8-2 Marsh Restoration, Old River Cove, Orange County

Measure 8-3 Marsh Restoration, Rose City East, Orange County

**DESIGN ASSUMPTIONS**

- Marshes would be constructed with maintenance material from Sabine-Neches Waterway (SNWW), Neches River Channel.
- The costs were originally developed for the SNWW Feasibility Report, and updated to current price levels.
- A standard 25% contingency, E&D of 8%, and CM of 6% were added to the cost.
- Containment levees would be constructed with in-situ material.

**REAL ESTATE**

A detailed breakdown of Real Estate costs can be found in the supplemental document 'Sabine Pass to Galveston Bay, Texas Preliminary Real Estate Cost Estimate'.

- Measure 8-1: Marsh Restoration, Bessie Heights East, Orange County  
Total Estimated Real Estate Cost: \$1,145,000 ®

- Measure 8-2: Marsh Restoration, Old River Cove, Orange County  
Total Estimated Real Estate Cost: \$440,000 ®
- Measure 8-3: Marsh Restoration, Rose City East, Orange County  
Total Estimated Real Estate Cost: \$205,000 ®

**ENVIRONMENTAL**

Badly degraded marshes on the Neches River would be restored using maintenance material from the SNWW – Neches River Channel. Environmental benefits are based upon the total acreage influenced by the beneficial use of dredged material. Some of the existing, open water areas would be converted to emergent marsh, existing marsh would be nourished with the fine-grained material in the effluent, and deeper water areas would be improved by the creation of shallower waters which are more suitable for submerged aquatic vegetation. Measures 8-1 and 8-3 would restore portions of the Lower Neches Wildlife Management Area (Nelda Stark and Old River Units).

Measure Description	Acres of Restored Marsh System
Measure 8-1 (Marsh Restoration, Bessie Heights East , Orange County)	2,076
Measure 8-2 (Marsh Restoration, Old River Cove , Orange County)	1,210
Measure 8-3 (Marsh Restoration, Rose City East , Orange County)	568

**BENEFITS**

All benefits are assumed be environmental for this phase of analysis.

**COSTS**

These costs do not include any real estate costs.

Measure 8-1: The estimated cost for this measure is \$176,542,450.

Measure 8-2: The estimated cost for this measure is \$23,365,000.

Measure 8-3: The estimated cost for this measure is \$25,627,501.

The following cost assumptions were made for measure 8-1, 8-2, and 8-3:

- The costs were originally developed for the SNWW Feasibility Report, and updated to current price levels.
- A standard 25% contingency, E&D of 8%, and CM of 6% were added to the cost.

## **REFERENCE DOCUMENTS**

USACE. 2011. Final Feasibility Study and Environmental Impact Statement for the Sabine-Neches Waterway Channel Improvement Project, Southeast Texas and Southwest Louisiana. Galveston District.

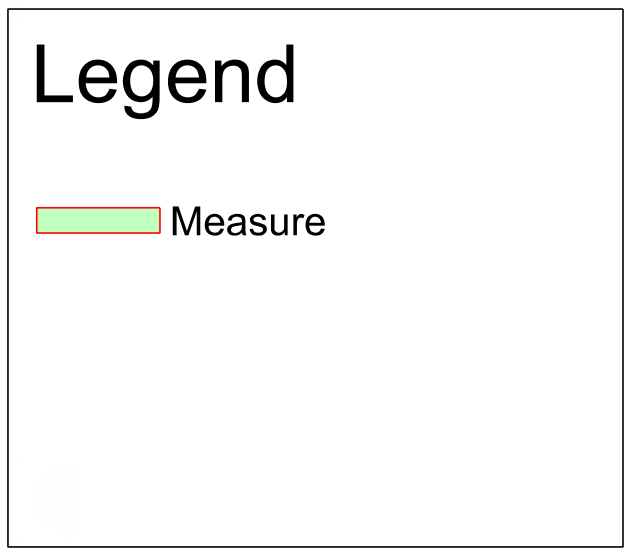
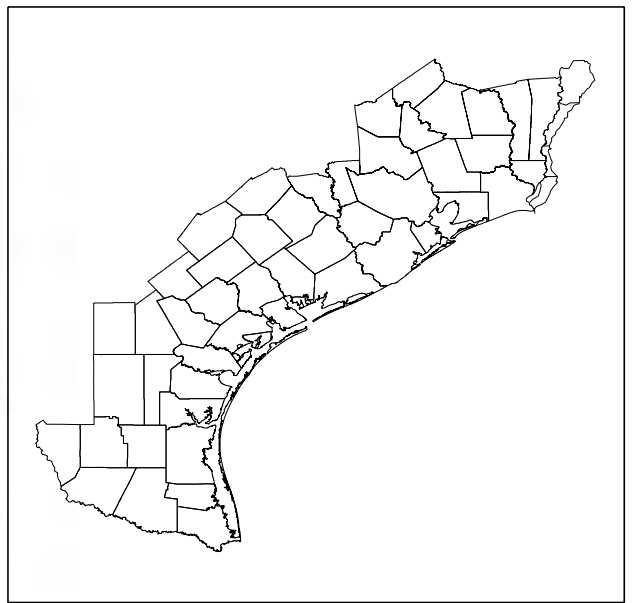
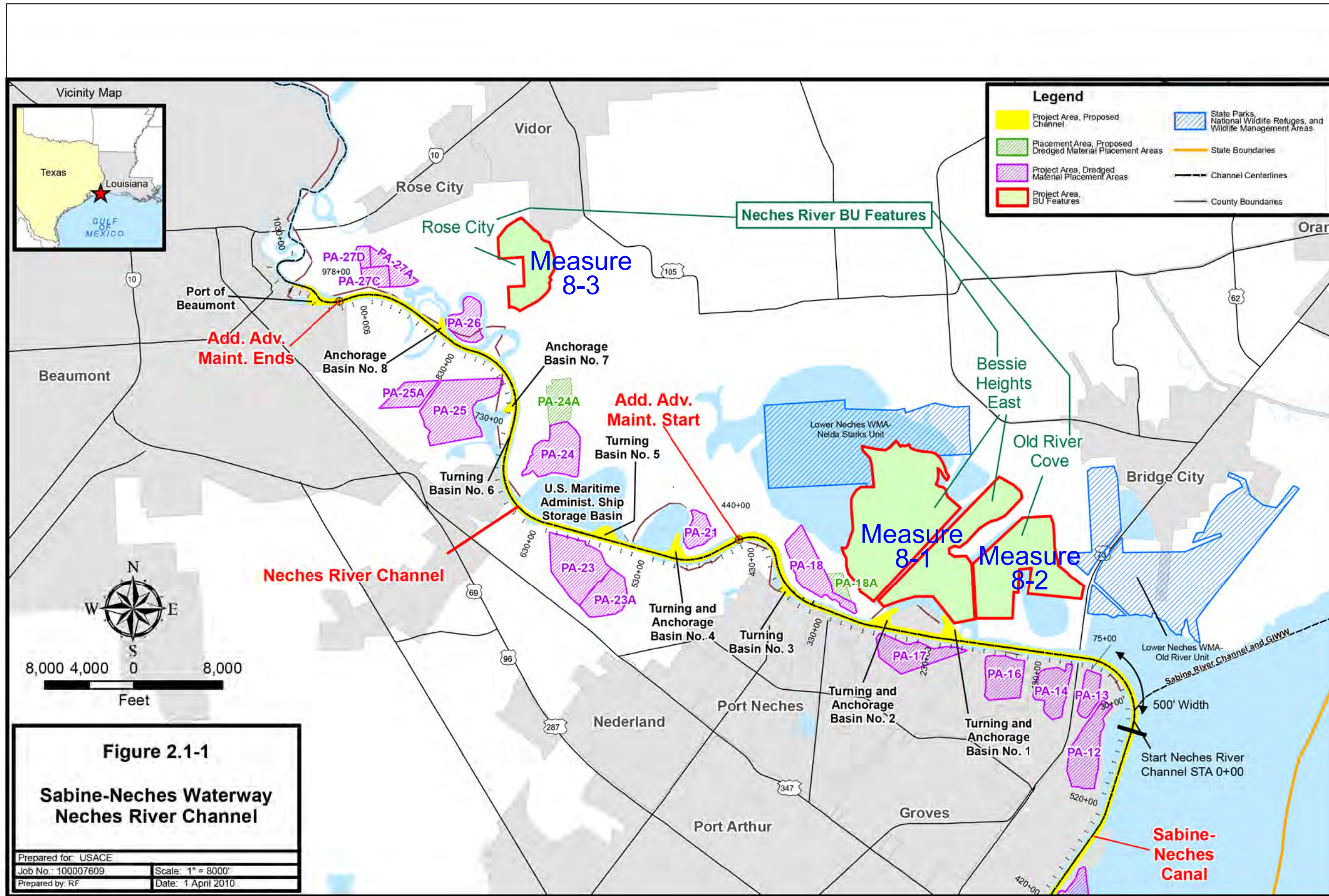
## **RISKS**

- Geotechnical and structural feasibility of the proposal was not reviewed.
- No review of available public information or data from in-house files relative to the general geology and soil conditions for the proposed features was conducted.
- Implementation of this measure would require a revised Dredged Material Management Plan (DMMP) for the existing SNWW navigation project. Additional document preparation and coordination through USACE O&M would likely be required.



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

## Measure 8-1 8-2 8-3: Marsh Restorations, Bessie Heights, Old River Cove, and Rose City



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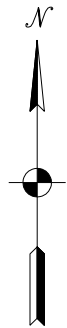
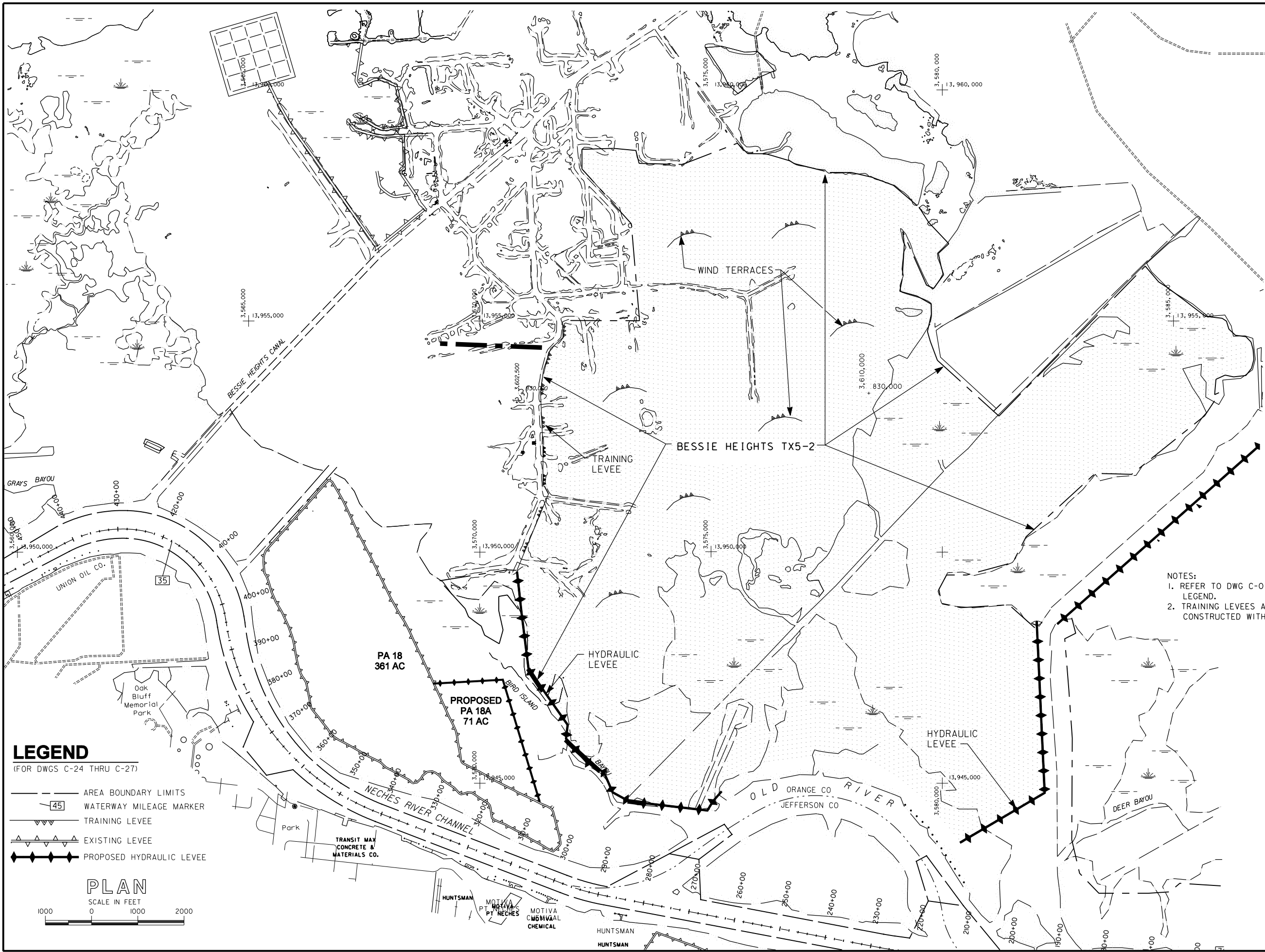


Rev.	Date	Description

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Checked by: <td>AD</td> <td>Scale:</td> <td>AS SHOWN</td>	AD	Scale:	AS SHOWN
Submitted by: <td>AD</td> <td>Approval/Recommendation: <td> </td> </td>	AD	Approval/Recommendation: <td> </td>	
DAVID R. BRUNN, P.E.		DAVID R. BRUNN, P.E.	
Chief, Design/Construction Section		Chief, Engineering Branch	
Approved:		Approved:	
PETE G. PEREZ, P.E.		PETE G. PEREZ, P.E.	
Chief, Engineering and Construction Division		Chief, Engineering and Construction Division	

SABINE NECHES WATERWAY, TEXAS  
CHANNEL IMPROVEMENT STUDY  
48' PROJECT  
BESSIE HEIGHTS PLAN  
TEXAS

Drawing No.:  
**C-24.R**



**LEGEND**  
(FOR DWGS C-24 THRU C-27)

- AREA BOUNDARY LIMITS
- [45] WATERWAY MILEAGE MARKER
- TRAINING LEVEE
- EXISTING LEVEE
- PROPOSED HYDRAULIC LEVEE

NOTES:  
1. REFER TO DWG C-01 FOR ADDITIONAL LEGEND.  
2. TRAINING LEVEES ARE MECHANICALLY CONSTRUCTED WITH SIDE BORROW MATERIAL.

**PLAN**  
SCALE IN FEET

PA 18  
361 AC

PROPOSED  
PA 18A  
71 AC

WIND TERRACES

BESSIE HEIGHTS TX5-2

TRAINING LEVEE

HYDRAULIC LEVEE

HYDRAULIC LEVEE

TRANSIT MAX  
CONCRETE &  
MATERIALS CO.

HUNTSMAN

MOTIVA  
PT. NECHES  
MOTIVA  
CHEMICAL

HUNTSMAN

OLD ORANGE CO RIVER  
JEFFERSON CO

DEER BAYOU

UNION OIL CO.  
35

Oak Bluff  
Memorial  
Park

Park

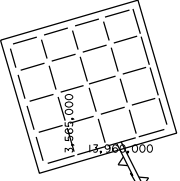
NECHES RIVER CHANNEL

BIRD ISLAND

BAYOU

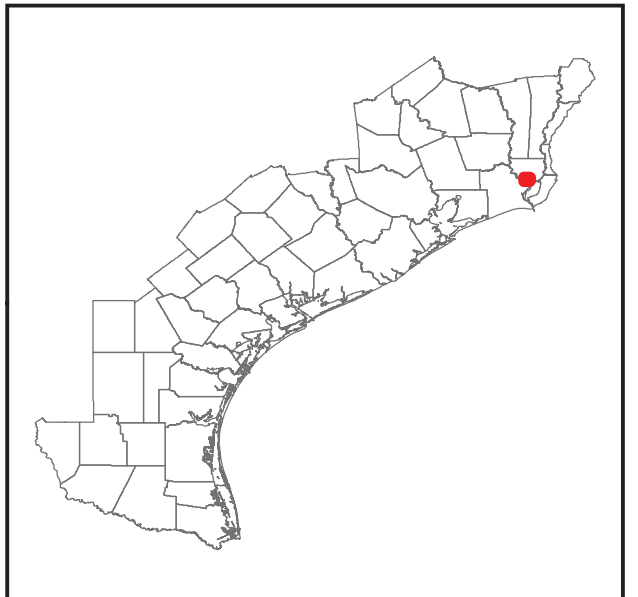
GRAYS BAYOU

BESSIE HEIGHTS CANAL





## Measure 8-1 - Marsh Restoration, Bessie Heights, Orange County



### Legend

 Marsh Restoration



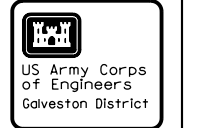
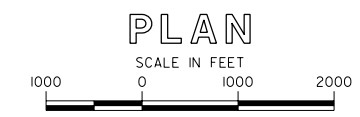
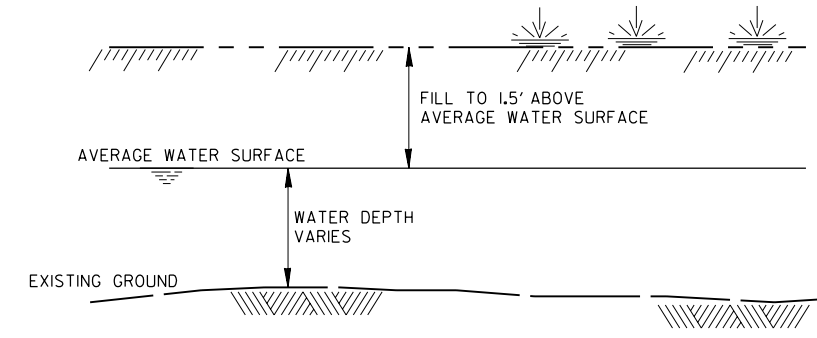
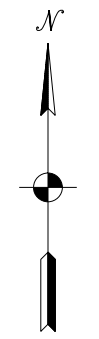
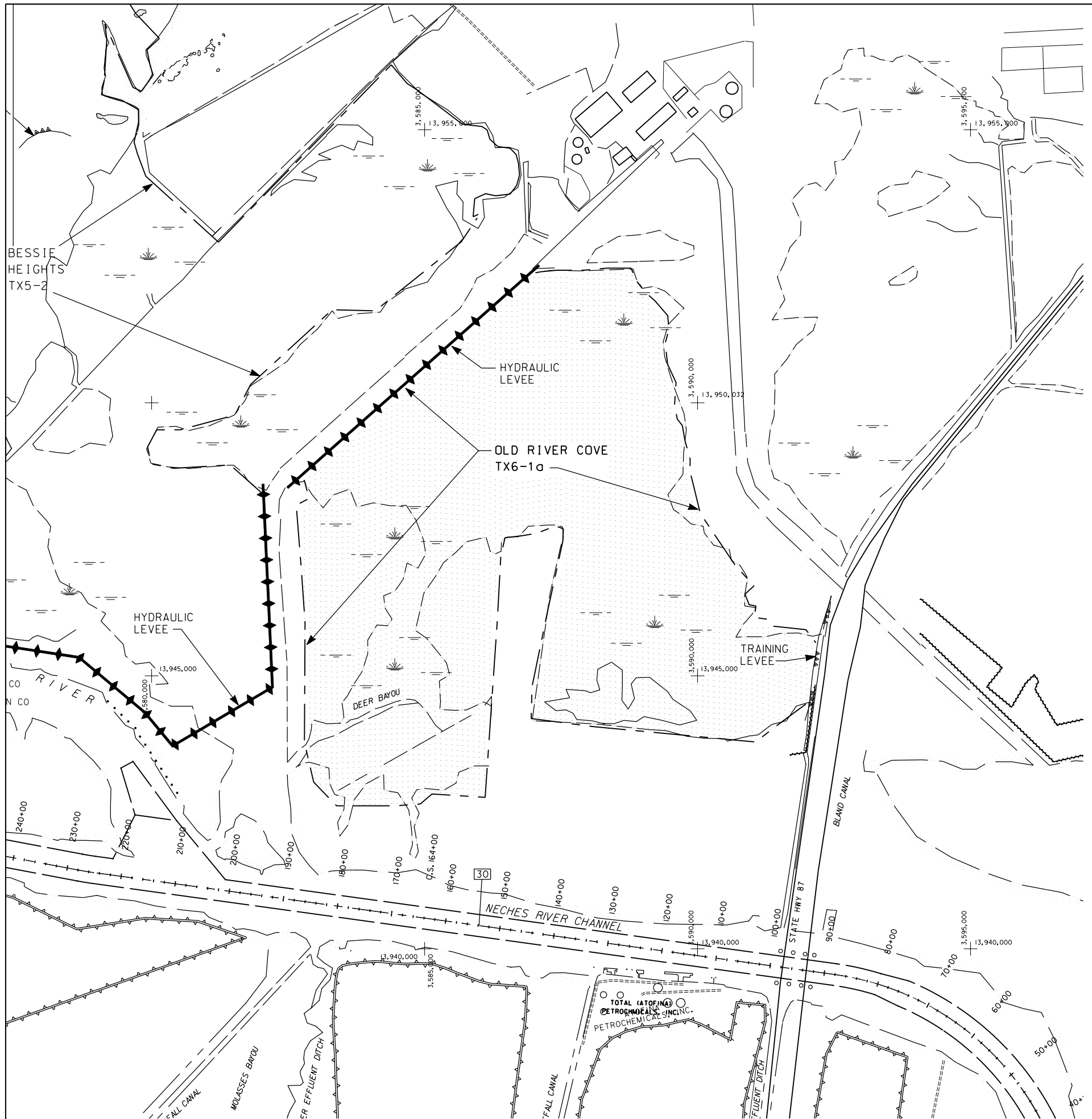
0 550 1,100 2,200 3,300 4,400  
 Feet

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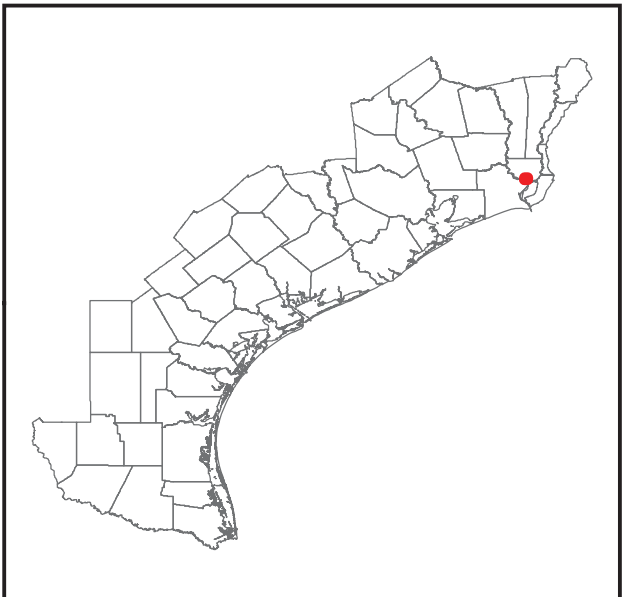
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<b>Checked by:</b> MD	<b>Approval Recommended by:</b> HARRISON, T. SUTCLIFF, PE Chief, Engineering Section	
<b>Submitted by:</b> DAVID R. BROWN, P.E. Chief, Engineering Branch	<b>Approved by:</b> PETE G. PEREZ, P.E. Chief, Engineering and Construction Division	
<b>U.S. ARMY ENGINEER DISTRICT, GALVESTON CORPS OF ENGINEERS GALVESTON, TEXAS</b>		
<b>PREPARED UNDER THE DIRECTION OF DAVID C. WESTON, COL., C.E., DISTRICT COMMANDER</b>		

<b>SABINE NICHES WATERWAY, TEXAS CHANNEL IMPROVEMENT STUDY 48<sup>th</sup> PROJECT</b>	<b>OLD RIVER COVE PLAN TEXAS</b>
--	--------------------------------------

<b>Drawing No.:</b> <b>C-25</b>
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## Measure 8-2 - Marsh Restoration, Old River Cove, Orange County



### Legend

— Marsh Restoration



0 255 510 1,020 1,530 2,040 Feet

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Date Created: 4/12/2013



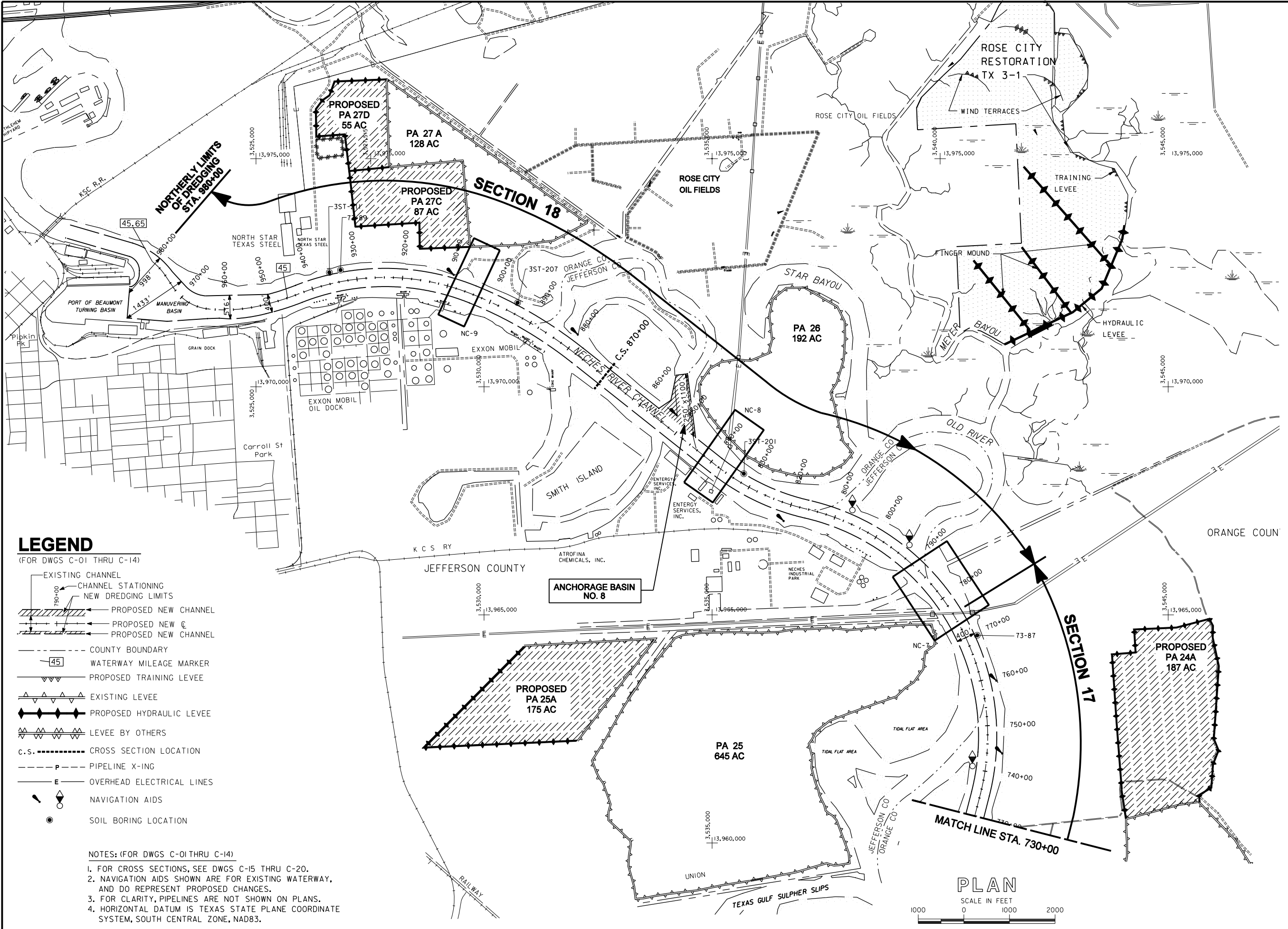


Rev.	Description	Date	By

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Checked by <td>AS SHAWN</td> <td> </td> <td> </td>	AS SHAWN		
Submittal by <td>MD</td> <td> </td> <td> </td>	MD		
Submitted by <td>DAVID B. BROWN, P.E.</td> <td> </td> <td> </td>	DAVID B. BROWN, P.E.		
Approved by <td>DAVID C. WESTON, COL, C.E.</td> <td> </td> <td> </td>	DAVID C. WESTON, COL, C.E.		
Chief, Engineering Section <td> </td> <td> </td> <td> </td>			
Chief, Engineering and Construction Division <td> </td> <td> </td> <td> </td>			

SABINE NICHES WATERWAY, TEXAS  
CHANNEL IMPROVEMENT STUDY  
48' PROJECT  
DREDGING PLAN  
NICHES RIVER CHANNEL  
STA. 980+00 TO STA. 730+00

Drawing No.:  
**C-01.R**



**LEGEND**

(FOR DWGS C-01 THRU C-14)

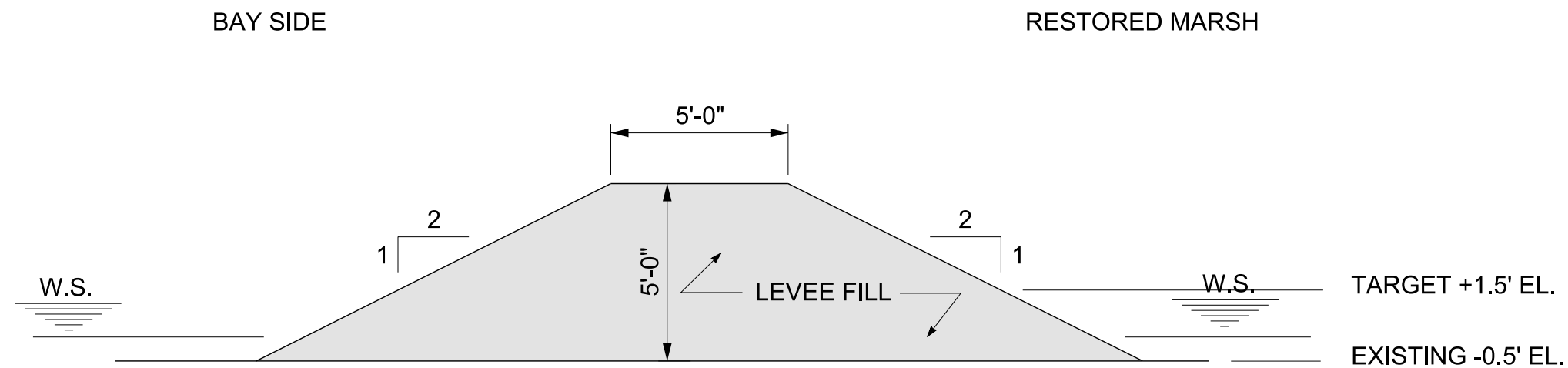
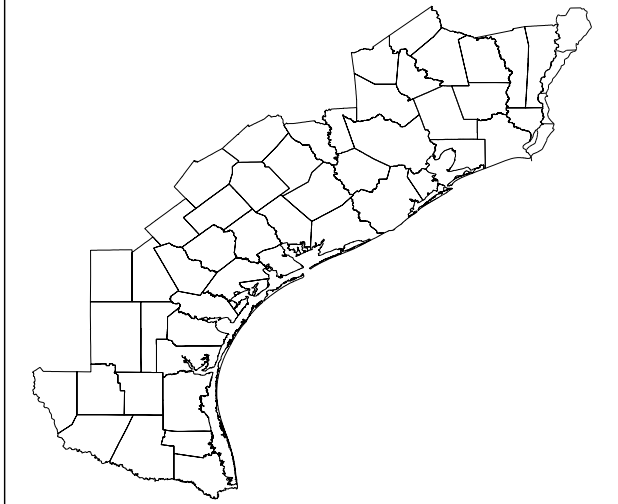
- EXISTING CHANNEL
- CHANNEL STATIONING
- NEW DREDGING LIMITS
- PROPOSED NEW CHANNEL
- PROPOSED NEW CHANNEL
- PROPOSED NEW CHANNEL
- COUNTY BOUNDARY
- WATERWAY MILEAGE MARKER
- PROPOSED TRAINING LEVEE
- EXISTING LEVEE
- PROPOSED HYDRAULIC LEVEE
- LEVEE BY OTHERS
- C.S. CROSS SECTION LOCATION
- PIPELINE X-ING
- OVERHEAD ELECTRICAL LINES
- NAVIGATION AIDS
- SOIL BORING LOCATION

- NOTES: (FOR DWGS C-01 THRU C-14)
- FOR CROSS SECTIONS, SEE DWGS C-15 THRU C-20.
  - NAVIGATION AIDS SHOWN ARE FOR EXISTING WATERWAY, AND DO REPRESENT PROPOSED CHANGES.
  - FOR CLARITY, PIPELINES ARE NOT SHOWN ON PLANS.
  - HORIZONTAL DATUM IS TEXAS STATE PLANE COORDINATE SYSTEM, SOUTH CENTRAL ZONE, NAD83.

PLAN  
SCALE IN FEET  
0 1000 2000



Typical Section S-16: Marsh Restoration Containment Levee



Typical Section S-16

Measures:

- 8-4
- 8-5
- 8-6
- 8-7



ASSUMPTIONS:

- 1: CONTAINMENT LEVEE FILL OBTAINED FROM ONSITE BORROW AREA
- 2: RESTORED MARSH FILL HYDRAULICALLY PUMPED
- 3: CONTAINMENT LEVEE FOUNDED ON -0.5' CONTOUR

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Date Created: 4/24/2013



**SABINE PASS TO GALVESTON BAY, TEXAS**  
**MEASURES 8-4.1, 8-4.2, 8-5.1, 8-5.2, 8-6.1, 8-6.2, 8-6.3, 8-7.2, 8-7.3, 8-7.4, 8-7.5, 8-7.6**  
**INFORMATION SHEET**

**DESCRIPTION OF MEASURES**

These measures would reestablish emergent marshes at Sabine Pass and in East and West Bays of the Galveston Bay system which have been degraded or lost due to erosion. Some of the marshes would help restore and preserve National Wildlife Refuges and Wildlife Management Areas at Sabine Pass, and others would be managed by local non-governmental organizations as natural preserves (Sweetwater Preserve, Pierce Marsh, Greens Marsh). The majority are on private property and, in addition to their other significant ecological functions, would also serve as storm surge buffers to communities such as the City of Sabine Pass, and several small communities on the West End of Galveston Island. The measures on the West End of Galveston Island and the bay side of Bolivar Peninsula would improve the resiliency of these barrier islands and help preserve their important role as the first line of defense. One measure at the Interstate Highway 10 (IH) Causeway would help protect a vital hurricane evacuation route from Galveston Island. Information on existing conditions and coastal processes affecting sediment use in some of these areas was taken from the recent West Galveston Bay Regional Sediment Plan, prepared by the Gulf of Mexico Foundation.

**Measures 8-4.1 and 8-4.2**

Two locations on the bayside of Bolivar Peninsula in Galveston County would use dredged material from sources such as the Gulf Intracoastal Waterway (GIWW), the Houston Ship Channel (HSC), and/or private channels. Dredged material would be pumped to fill open water within the breaking marsh. A containment dike would need to be constructed to hold hydraulic material until it settles. After the new marsh platform settles, a concrete bag wall protection would be installed along bay shoreline and dikes would be removed or degraded to the existing marsh elevation.

- **Measure 8-4.1 Marsh Restoration, Pepper Grove Cove, Galveston County**  
Restore 294 acres with a containment dike of 4.0 miles and shoreline protection of 1.7 miles.
- **Measure 8-4.2 Marsh Restoration, Long Point Marsh, Galveston County**  
Restore 1,661 acres of emergent marsh with a containment dike of 13.2 miles and 9.6 miles of shoreline protection.



### **Measures 8-5.1 and 8-5.2**

These measures would restore marsh systems south of Keith Lake and in the Texas Point National Wildlife Refuge (NWR) in Jefferson County. Maintenance material would be pumped in from the nearby federal navigation channel (Sabine Neches Waterway) and private berths at Cheniere and Golden Pass LNG facilities. Containment dikes would be constructed with in-situ material. No shoreline protection is needed for these measures.

- **Measure 8-5.1 Marsh Restoration, South of Keith Lake, Jefferson County**  
Restore 4,132 acres of breaking marsh. A containment dike would only be needed on the north and west sides (total of 7.5 mi) as a chenier ridge on southeast serves as barrier.
- **Measure 8-5.2 Marsh Restoration, Texas Point NWR, Jefferson County**  
Restore 5,172 acres of breaking marsh. A containment levee would only be needed on the east and south sides (total of 9.7 mi). A chenier ridge serves as a barrier.

### **Measures 8-6.1, 8-6.2, 8-6.3 8-6**

These measures are located in Galveston County on the north shore of West Bay. Dredged material would be pumped from the GIWW and/or local canals to fill degraded marshes in three areas on the north shore of West Galveston Bay. A containment dike would be constructed from in-situ material to hold hydraulic material. After new marsh platforms are settled, concrete bag wall protection systems would be installed just in front of new bay shorelines, and dikes would be removed or degraded to existing marsh elevations.

- **Measure 8-6.1 Marsh Restoration, Pierce Marsh, Galveston County**  
Restore 2,076 acres of marsh. A 7.2-mile containment dike and bay shoreline protection of 1.6 miles would also be needed.
- **Measure 8-6.2 Marsh Restoration, IH-10 Causeway, Galveston County**  
Located south of causeway and east of Bayou Vista. It includes restoration of 633 acres of marsh, a containment dike of 4.8 miles, and bay shoreline protection of 1.6 miles.
- **Measure 8-6.3 Marsh Restoration, Greens Lake, Galveston County**  
Would restore 3,293 acres of restored marsh with a 15.9 mile containment dike. Assume shoreline protection under GIWW Shoreline Protection Measure 6-5.1.

**Measures 8-7.1, 8-7.2, 8-7.3, 8-7.4, 8-7.5, and 8-7.6**

Located bayside at the west end of Galveston Island in Galveston County, these measures would pump dredged material from the GIWW and/or local canals to fill degraded marshes in six separate areas. A containment dike constructed with in-situ material would be constructed to hold hydraulic material. After new marsh platforms are settled, a concrete bag wall protection would be installed just in front of the new bay shoreline. Dikes would be removed or degraded to existing marsh elevation.

- **Measure 8-7.1 Marsh Restoration, Gangs to Oxen Bayou, Galveston County** would restore 176 acres of marsh between Gangs and Oxen Bayous, and include a containment dike of 2.4 miles and bay shoreline protection 0.6 miles.
- **Measure 8-7.2 Marsh Restoration, Oxen to Mantel Bayou, Galveston County** would restore 390 acres of marsh and include a 4.0 mile containment dike and bay shoreline protection of 1.3 miles.
- **Measure 8-7.3 Marsh Restoration, Dana Cove, Galveston County** would restore 213 acres of marsh and include a 3.75 mile containment dike, and 1.2 miles of bay shoreline protection.
- **Measure 8-7.4 Marsh Restoration, Jumbile Cove, Galveston County** would restore 316 acres of marsh, and include a 11.4 mile containment dike and 1.25 miles of shoreline protection.
- **Measure 8-7.5 Marsh Restoration, Bird Island to Maggies Cove, Galveston County** would restore 467 acres of marsh, and include 7.5 miles of containment dike and 2.1 miles of shoreline protection.
- **Measure 8-7.6 Marsh Restoration, Snake Island Cove, Galveston County** would restore 457 acres of marsh, and include 6.9 miles of containment dike and 1.7 miles of shoreline protection.

**LOCATION OF MEASURES** (See attached drawings)

Measures 8-4, 8-6, 8-7:

Typical Section S-15: GIWW Shore Protection

Typical Section S-16: Marsh Restoration Containment Levee

Measure 8-4.1 Marsh Restoration, Pepper Grove Cove, Galveston County



Measure 8-4.2 Marsh Restoration, Long Point Marsh, Galveston County  
Measure 8-5 Marsh Restoration at Sabine Pass. Jefferson County  
Measure 8-5.1 Marsh Restoration, South of Keith Lake, Jefferson County  
Measure 8-5.2 Marsh Restoration, Texas Point NWR, Jefferson County  
Measure 8-6 Marsh Restoration on North Shore of Galveston Bay, Galveston County  
Measure 8-6.1 Marsh Restoration, Pierce Marsh, Galveston County  
Measure 8-6.2 Marsh Restoration, IH-10 Causeway, Galveston County  
Measure 8-6.3 Marsh Restoration, Greens Lake, Galveston County  
Measure 8-7 West Galveston Island, Bay-Side Marsh, Galveston County  
Measure 8-7.1 Marsh Restoration, Gangs to Oxen Bayou, Galveston County  
Measure 8-7.2 Marsh Restoration, Oxen to Mantel Bayou, Galveston County  
Measure 8-7.3 Marsh Restoration, Dana Cove, Galveston County  
Measure 8-7.4 Marsh Restoration, Jumbile Cove, Galveston County  
Measure 8-7.5 Marsh Restoration, Bird Island to Maggies Cove, Galveston County  
Measure 8-7.6 Marsh Restoration, Snake Island Cove, Galveston County

## **DESIGN ASSUMPTIONS**

**Measures: 8-4.1, 8-4.2, 8-5.1, 8-5.2, 8-6.1, 8-6.2, 8-6.3, 8-7.1, 8-7.2, 8-7.3, 8-7.4, 8-7.5, 8-7.6.**

- Construction of dike completed using a marsh buggy excavator with fill materials found on site.
- Existing marsh elevation is -0.5 feet MSL and the proposed elevation 1.5 feet MSL.
- Quantities provided are neat line based on available information, settlement of constructed items and bulking of dredged fill not accounted for.
- Geotechnical properties of fill and breakwater/levee foundation assumed to be adequate for the work being performed.
- Containment dike is 5' tall with a 5' crown and 2:1 slopes.
- Breakwater volume is based on cross sectional area multiplied by total length.
- Breakwater riprap size is W50-650.

### **Assumptions for Individual Measures**

#### **Measure 8-4.1 Marsh Restoration, Pepper Grove Cove, Galveston County**

- Fill for marsh area hydraulically pumped from maintenance material from GIWW along side of project area and 12,000 feet to the east and west.
- The marsh volume is 948,640 CY.
- Breakwater follows lines shown for shoreline protection on measure 8-4.1.
- The breakwater volume is 33,909 CY.

- The containment dike requires a volume of 58,667 Breakwater construction performed from barge whose access is via GIWW 4,200 feet away.
- Access channels 10 feet deep and 50 feet wide with 1:1 side slopes are required for breakwater.
- Excavated material is side cast and left in place.

**Measure 8-4.2 Marsh Restoration, Long Point Marsh, Galveston County:**

- Fill for marsh area hydraulically pumped from maintenance material from GIWW along side of project area and 12,000 feet to the east and west.
- The volume of marsh fill is 5,359,493 CY.
- The containment dike volume is 193,600 CY.
- Breakwater is placed in water 3 feet deep.
- Breakwater follows lines shown for shoreline protection on measure 8-4.2.
- The breakwater volume is 51,861 CY. 83,000 tons of rock.
- Geotechnical properties of fill assumed to be adequate for the work being performed.
- Breakwater construction performed from barge whose access is via GIWW 12,000 feet away.
- Access channels 10 feet deep and 50 feet wide with 1:1 side slopes required for breakwater, excavated material is side cast and left in place.

**Measure 8-5.1 Marsh Restoration, South of Keith Lake, Jefferson County**

- Fill for marsh area hydraulically pumped from maintenance material from GIWW, SNWW, and private berths on SNWW, pump distances can be up to 24,000 feet.
- A fill volume of 13,332,587 CY is needed for the marsh.
- The containment dike volume is 110,000 CY.
- Mobilization and demobilization distance is 12 miles (from Port Arthur).

**Measure 8-5.2 Marsh Restoration, Texas Point NWR, Jefferson County:**

- Fill for marsh area hydraulically pumped from maintenance material from GIWW, SNWW, and private berths on SNWW, pump distances can be up to 24,000 feet.
- The volume of the marsh is 16,688,320 CY.
- The volume of the containment dike is 142,267 CY.
- Mobilization and demobilization distance is 12 miles (from Port Arthur).

**Measure 8-6.1 Marsh Restoration, Pierce Marsh, Galveston County:**

- Fill for marsh area hydraulically pumped from maintenance material from GIWW along side of project area and 12,000 feet to the east and west.
- The volume of the marsh is 6,698,560 CY.



- The volume of the containment dike is 105,600 CY.
- The breakwater is placed in 3 feet deep water.
- The breakwater volume is 31,915 CY. 51,100 tons of rock.
- Breakwater follows lines shown for shoreline protection on measure 8-6.1.
- Breakwater riprap size is W50-650.
- Breakwater construction performed from barge whose access is via GIWW 3,500 feet away.
- Access channels 10 feet deep and 50 feet wide with 1:1 side slopes required for breakwater, excavated material is side cast and left in place.

**Measure 8-6.2 Marsh Restoration, IH-10 Causeway, Galveston County:**

- Fill for marsh area hydraulically pumped from maintenance material from GIWW. along side of project area and 12,000 feet to the east and west.
- The volume of the marsh is 2,042,480 CY.
- The volume of the containment dike is 70,400 CY.
- Breakwater is placed in 3 feet deep water.
- The breakwater volume is 31,915 CY. 51,100 tons of rock.
- Breakwater follows lines shown for shoreline protection on measure 8-6.2.
- Breakwater construction performed from barge whose access is via GIWW and access channel built for measure 8-6.1 600 feet away.
- Access channels 10 feet deep and 50 feet wide with 1:1 side slopes required for breakwater, excavated material is side cast and left in place.

**Measure 8-6.3 Marsh Restoration, Greens Lake, Galveston County:**

- Fill for marsh area hydraulically pumped from maintenance material from GIWW along side of project area and 12,000 feet to the east and west.
- The volume of the marsh is 10,625,413 CY.
- The volume of the containment dike is 233,200 CY.
- Breakwater is placed in 3 feet deep water.
- The breakwater volume is 1,530,000 CY. 90,700 tons of rock.
- Breakwater follows lines shown for shoreline protection on measure 8-6.3
- Breakwater construction performed from barge whose access is via GIWW
- No access channels required.

**Measure 8-7.1 Marsh Restoration, Gangs to Oxen Bayou, Galveston County:**

- Fill for marsh area hydraulically pumped from maintenance material from local channels and from GIWW up to 24,000 away.
- The volume of the marsh is 567,893 CY.

- The volume of the containment dike is 35,200 CY.
- Breakwater is placed in 3 feet deep water.
- The breakwater volume is 11,968 CY. 19,100 tons of rock.
- Breakwater follows lines shown for shoreline protection on measure 8-7.1.
- Breakwater construction performed from barge whose access is via local channels 500 feet away.
- Access channels 10 feet deep and 50 feet wide with 1:1 side slopes required for breakwater, excavated material is side cast and left in place.

**Measure 8-7.2 Marsh Restoration, Oxen to Mantel Bayou, Galveston County:**

- Fill for marsh area hydraulically pumped from maintenance material from local channels and from GIWW up to 24,000 away.
- The volume of the marsh is 1,258,400 CY
- The volume of the containment dike is 58,667 CY.
- Breakwater is placed in 3 feet deep water.
- The breakwater volume is 25,931 CY. 41,500 tons of rock.
- Breakwater follows lines shown for shoreline protection on measure 8-7.2.
- Breakwater construction performed from barge whose access is via local channels 500 feet away.
- Access channels 10 feet deep and 50 feet wide with 1:1 side slopes required for breakwater, excavated material is side cast and left in place.

**Measure 8-7.3 Marsh Restoration, Dana Cove, Galveston County:**

- Fill for marsh area hydraulically pumped from maintenance material from local channels and from GIWW up to 24,000 away.
- The volume of the marsh is 687,280 CY
- The volume of the containment dike is 55,000 CY.
- Breakwater is placed in 3 feet deep water.
- The breakwater volume is 23,936 CY. 38,300 tons of rock.
- Breakwater follows lines shown for shoreline protection on measure 8-7.3.
- Breakwater construction performed from barge whose access is via local channels.
- Additional 1,100 feet of access channel added because of gap between breakwaters.
- Access channels 10 feet deep and 50 feet wide with 1:1 side slopes required for breakwater, excavated material is side cast and left in place.



**Measure 8-7.4 Marsh Restoration, Jumbile Cove, Galveston County:**

- Fill for marsh area hydraulically pumped from maintenance material from local channels and from GIWW up to 24,000 away.
- The volume of the marsh is 1,019,627,280 CY.
- The volume of the containment dike is 116,600 CY.
- Breakwater is placed in 3 feet deep water.
- The breakwater volume is 24,933 CY. 39,900 tons of rock.
- Breakwater follows lines shown for shoreline protection on measure 8-7.4.
- Breakwater construction performed from barge whose access is via local channels.
- Additional 1,100 feet of access channel added because of gap between breakwaters.
- Access channels 10 feet deep and 50 feet wide with 1:1 side slopes required for breakwater, excavated material is side cast and left in place.

**Measure 8-7.5 Marsh Restoration, Bird Island to Maggies Cove, Galveston County:**

- Fill for marsh area hydraulically pumped from maintenance material from local channels and from GIWW up to 24,000 away.
- The volume of the marsh is 1,506,853 CY.
- The volume of the containment dike is 110,000 CY.
- Breakwater is placed in 3 feet deep water.
- The breakwater volume is 40,891 CY. 65,400 tons of rock.
- Breakwater follows lines shown for shoreline protection on measure 8-7.5.
- Breakwater construction performed from barge whose access is via local channels.
- Additional 2,000 feet of access channel added because of gap between breakwaters.
- Access channels 10 feet deep and 50 feet wide with 1:1 side slopes required for breakwater, excavated material is side cast and left in place.

**Measure 8-7.6 Marsh Restoration, Snake Island Cove, Galveston County:**

- Fill for marsh area hydraulically pumped from maintenance material from local channels and from GIWW up to 24,000 away.
- The volume of the marsh is 1,474,587 CY.
- The volume of the containment dike is 101,200 CY.
- Breakwater is placed in 3 feet deep water.
- The breakwater volume is 33,909 CY. 54,300 tons of rock.
- Breakwater follows lines shown for shoreline protection on measure 8-7.6.
- Breakwater construction performed from barge whose access is via local channels.
- Additional 2,000 feet of access channel added because of gap between breakwaters.

- Access channels 10 feet deep and 50 feet wide with 1:1 side slopes required for breakwater, excavated material is side cast and left in place.

## **REAL ESTATE**

A detailed breakdown of Real Estate costs can be found in the supplemental document 'Sabine Pass to Galveston Bay, Texas Preliminary Real Estate Cost Estimate'. Costs identified as \$0 are generally associated with Federal and/or State lands.

- Measure 8-4.1: Marsh Restoration, Pepper Grove Cove, Galveston County  
Total Estimated Real Estate Cost: \$111,000 ®
- Measure 8-4.2: Marsh Restoration, Long Point Marsh, Galveston County  
Total Estimated Real Estate Cost: \$614,000 ®
- Measure 8-5.1: Marsh Restoration, South of Keith Lake, Jefferson County  
Total Estimated Real Estate Cost: \$1,500,000 ®
- Measure 8-5.2: Marsh Restoration, Texas Point NWR, Jefferson County  
Total Estimated Real Estate Cost: \$0
- Measure 8-6.1: Marsh Restoration, Pierce Marsh, Galveston County  
Total Estimated Real Estate Cost: \$756,000 ®
- Measure 8-6.2: Marsh Restoration, IH-10 Causeway, Galveston County  
Total Estimated Real Estate Cost: \$234,000 ®
- Measure 8-6.3: Marsh Restoration, Greens Lake, Galveston County  
Total Estimated Real Estate Cost: \$1,205,000 ®
- Measure 8-7.1: Marsh Restoration, Gangs to Oxen Bayou, Galveston County  
Total Estimated Real Estate Cost: \$66,300 ®
- Measure 8-7.2: Marsh Restoration, Oxen to Mantel Bayou, Galveston County  
Total Estimated Real Estate Cost: \$146,000 ®
- Measure 8-7.3: Marsh Restoration, Dana Cove, Galveston Island  
Total Estimated Real Estate Cost: \$81,200 ®



- Measure 8-7.4: Marsh Restoration, Jumbile Cove, Galveston County  
Total Estimated Real Estate Cost: \$124,000 ®
- Measure 8-7.5: Marsh Restoration, Bird Island to Maggies Cove, Galveston County  
Total Estimated Real Estate Cost: \$178,000 ®
- Measure 8-7.6: Marsh Restoration, Snake Island Cove, Galveston County  
Total Estimated Real Estate Cost of Measure 8-7.6: \$173,000 ®

## ENVIRONMENTAL ASSUMPTIONS

Marshes serve as buffers for storm surge, water storage, improve water quality and provide important nursery habitat. The environmental benefits for these measures are assumed to be equivalent to the total acres restored (see table below).

### Environmental Benefits

Measure Number and Location	Restored Marsh (acres)
Measure 8-4.1 (Marsh Restoration, Pepper Grove Cove, Galveston Co.)	294
Measure 8-4-2 (Marsh Restoration, Long Point Marsh, Galveston Co.)	1,661
Measure 8-5.1 (Marsh Restoration, South of Keith Lake, Jefferson Co.)	4,132
Measure 8-5.2 (Marsh Restoration, Texas Point NWR, Jefferson Co.)	5,172
Measure 8-6.1 (Marsh Restoration, Pierce Marsh, Galveston Co.)	2,076
Measure 8-6.2 (Marsh Restoration, IH-10 Causeway, Galveston Co.)	633
Measure 8-6.3 (Marsh Restoration, Greens Lake, Galveston Co.)	3,293
Measure 8-7.1 (Marsh Restoration, Gangs to Oxen Bayou, Galveston Co.)	176
Measure 8-7.2 (Marsh Restoration, Oxen to Mantel Bayou, Galveston Co.)	390
Measure 8-7.3 (Marsh Restoration, Dana Cove, Galveston Co.)	213
Measure 8-7.4 (Marsh Restoration, Jumbile Cove, Galveston Co.)	316
Measure 8-7.5 (Marsh Restoration, Bird Island to Maggies Cove, Galveston Co.)	467
Measure 8-7.6 (Marsh Restoration, Snake Island Cove, Galveston Co.)	457

## BENEFITS

All benefits are assumed be environmental for this phase of analysis.

## **COSTS**

These costs do not include Real Estate.

Measure 8-4.1: The estimated cost for this measure is \$16,936,000

Measure 8-4.2: The estimated cost for this measure is \$44,947,000

Measure 8-5.1: The estimated cost for this measure is \$64,131,000

Measure 8-5.2: The estimated cost for this measure is \$80,098,000

Measure 8-6.1: The estimated cost for this measure is \$51,417,000

Measure 8-6.2: The estimated cost for this measure is \$21,245,000

Measure 8-6.3: The estimated cost for this measure is \$69,513,000

Measure 8-7.1: The estimated cost for this measure is \$7,596,000

Measure 8-7.2: The estimated cost for this measure is \$15,533,000

Measure 8-7.3: The estimated cost for this measure is \$12,220,000

Measure 8-7.4: The estimated cost for this measure is \$14,528,000

Measure 8-7.5: The estimated cost for this measure is \$21,996,000

Measure 8-7.6: The estimated cost for this measure is \$19,538,000

### **Cost Assumptions used for breakwater measures 8- 4.1, 8-4.2, 8-6.1, 8-6.2, 8-6.3, 8-7.1, 8-7.2, 8-7.3, 8-7.4, 8-7.5, 8-7.6**

- Breakwater Construction:
- Riprap will be barged into area.
- A 10 ft deep access channel will be excavated as needed to bring in the rock barge.
- Riprap will be placed from the barge.
- Marsh Work:
- The containment dike will be constructed from material excavated at site.
- Marsh fill will be hydraulically pumped maintenance material from the GIWW next time maintenance dredging occurs in the area.
- A standard 25% contingency, E&D of 8%, and CM of 6% were added to the cost.

### **Cost Assumptions used for measures 8-5.1, and 8-5.2**

- The containment dike will be constructed from material excavated at the site.
- Dredge fill from maintenance material from GIWW, SNWW, and private berths on SNWW will be used to fill the area to the required elevation.
- A standard 25% contingency, E&D of 8%, and CM of 6% was used with the cost.



## **REFERENCE DOCUMENT**

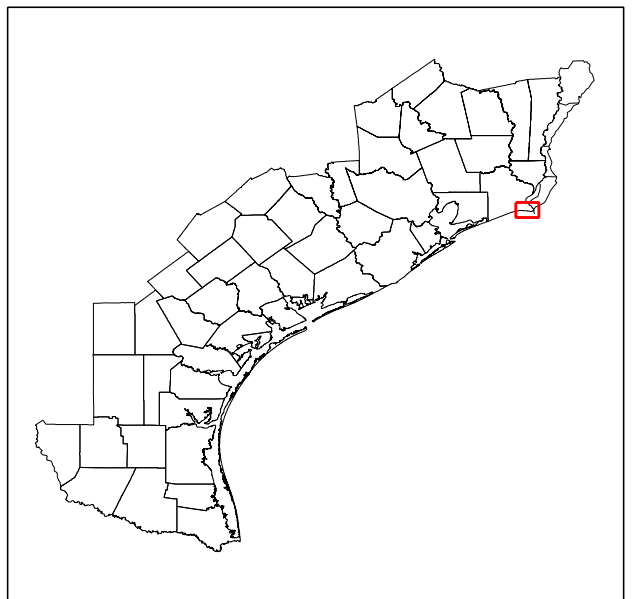
Gulf of Mexico Foundation. no date. West Galveston Bay Regional Sediment Management Plan Report. Prepared for Habitat Conservation and Restoration Team, Gulf of Mexico Alliance by Atkins Global.

## **RISKS**

- Geotechnical properties of fill assumed to be adequate for the work being performed.
- No review of available public information or data from in-house files relative to the general geology and soil conditions for the proposed features was conducted.
- Implementation of this measure would require a revised Dredged Material Management Plan (DMMP) for the existing SNWW and GIWW navigation projects. Additional document preparation and coordination through USACE O&M would likely be required.



Measure 8-4.1: Marsh Restoration, Pepper Grove Cove, Galveston County



## Legend

- Marsh Restoration
- Shoreline Protection



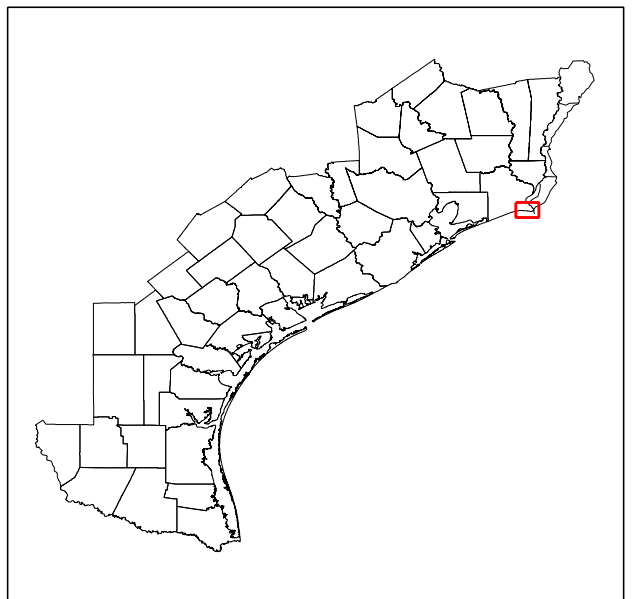
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Date Created: 5/1/2013





Measure 8-4.2: Marsh Restoration, Long Point Marsh, Galveston County



### Legend

- Marsh Restoration
- Shoreline Protection



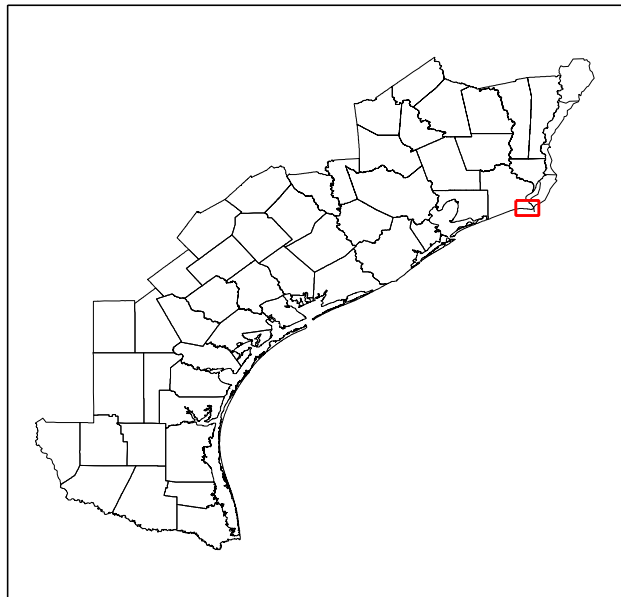
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Date Created: 5/1/2013





## Measure 8-5: Marsh Restoration at Sabine Pass, Jefferson County



### Legend

— Measure 8-5



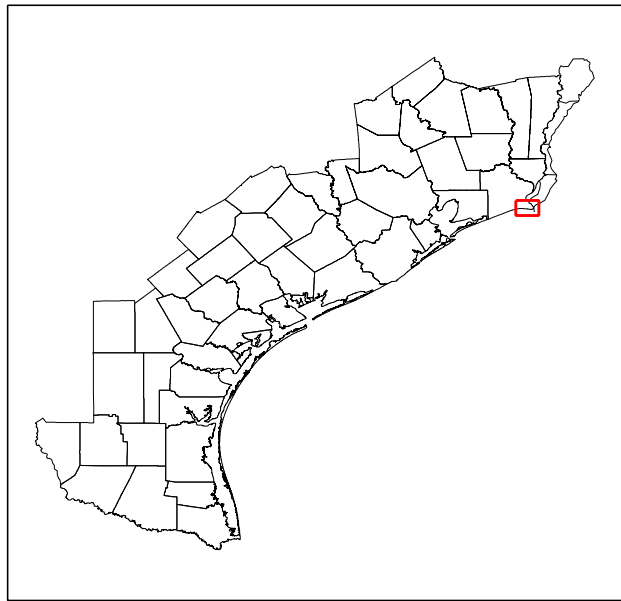
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Date Created: 4/11/2013






Measure 8-5.1: Marsh Restoration, South of Keith Lake, Jefferson County




### Legend

— Measure 8-5.1



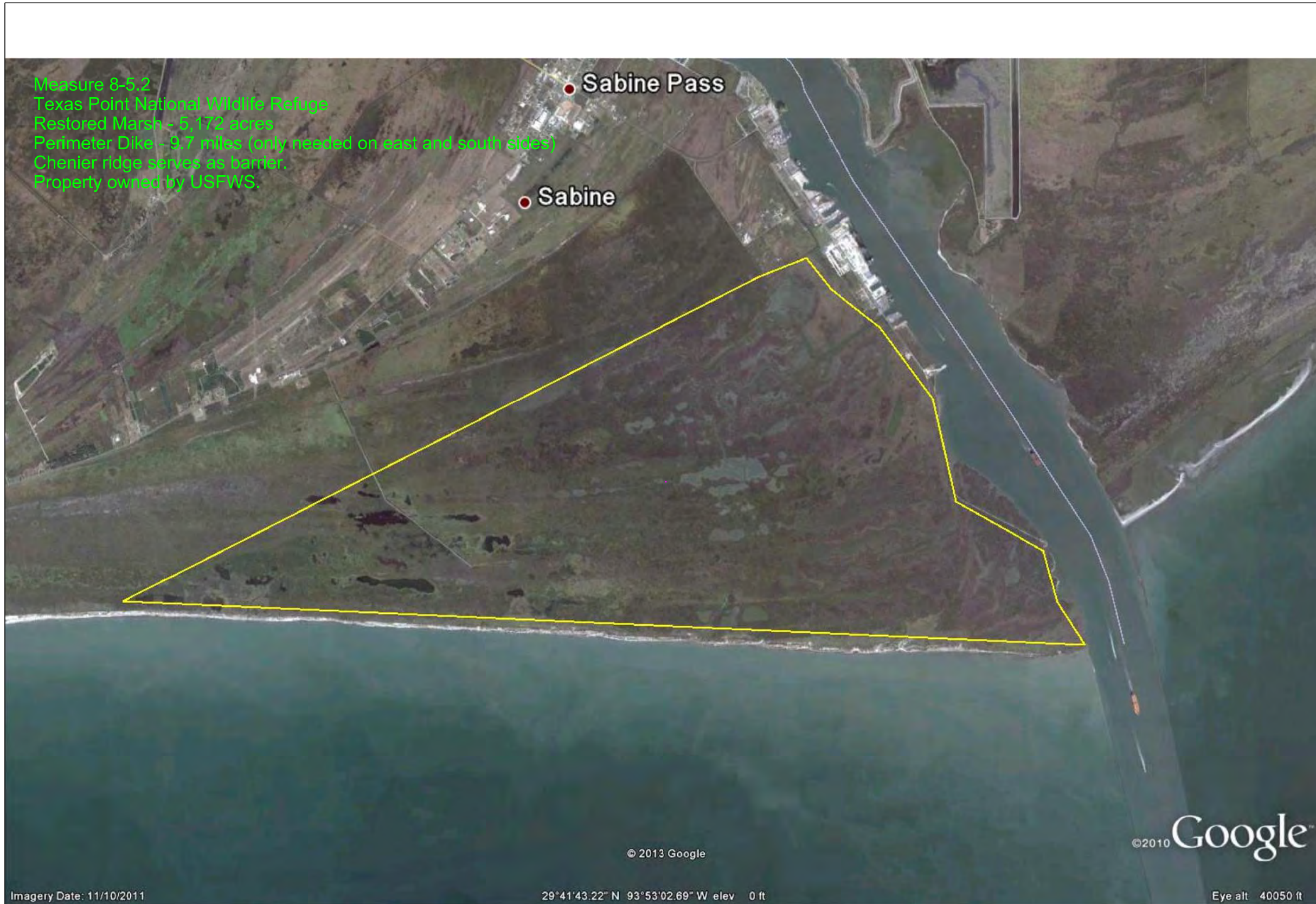
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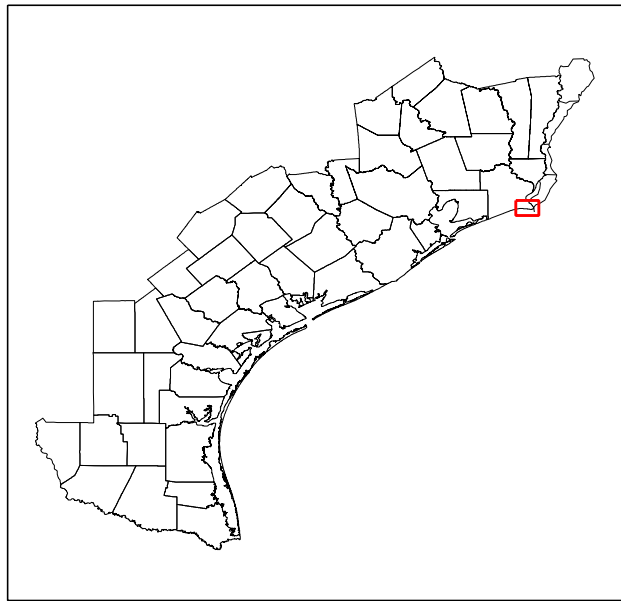
Date Created: 4/11/2013



Measure 8-5.2: Marsh Restoration, Texas Point NWR, Jefferson County

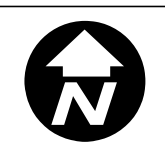


Measure 8-5.2  
Texas Point National Wildlife Refuge  
Restored Marsh - 5,172 acres  
Perimeter Dike - 9.7 miles (only needed on east and south sides)  
Chenier ridge serves as barrier.  
Property owned by USFWS.



### Legend

— Measure 8-5.2



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Imagery Date: 11/10/2011

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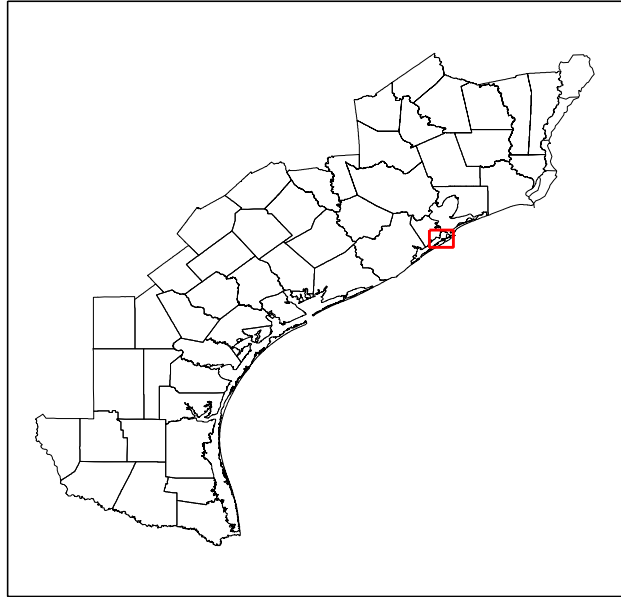
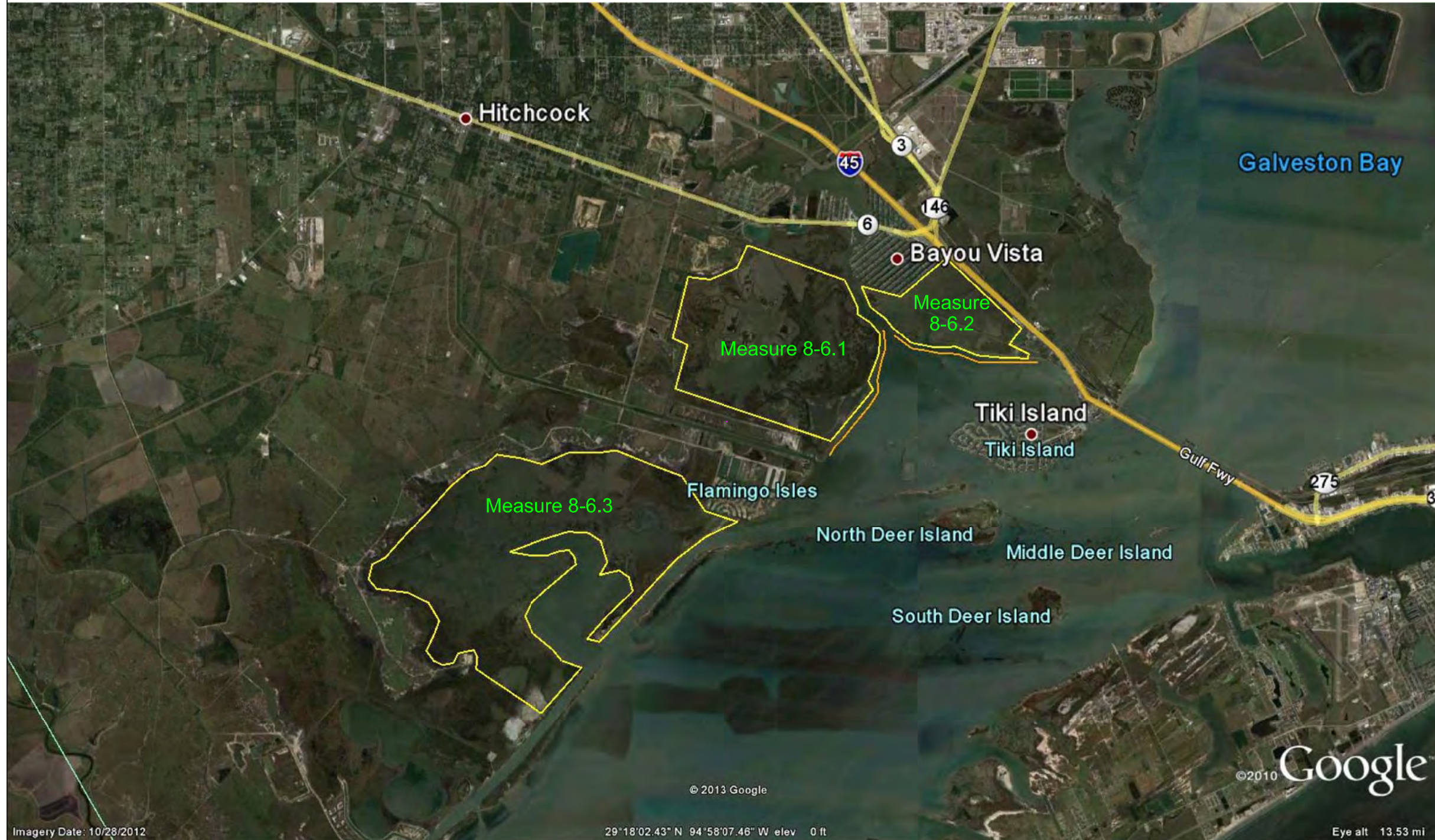
Eye alt 40050 ft

Date Created: 4/11/2013





Measure 8-6: Marsh Restoration on North Shore of Galveston Bay, Galveston County



### Legend

— Measure 8-6



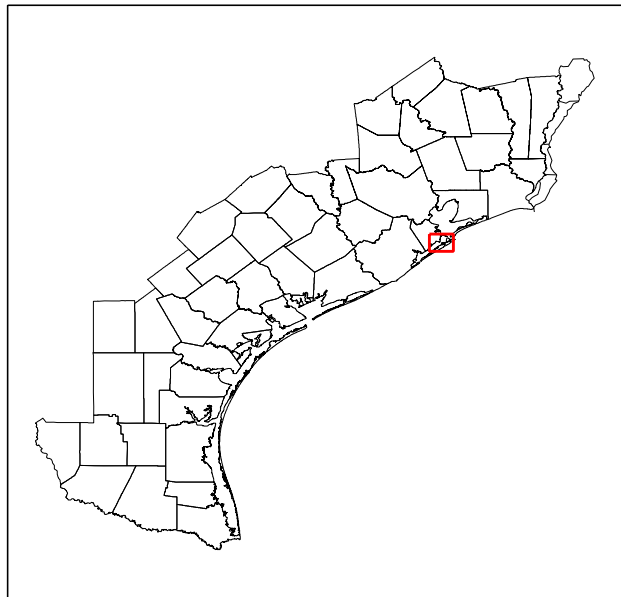
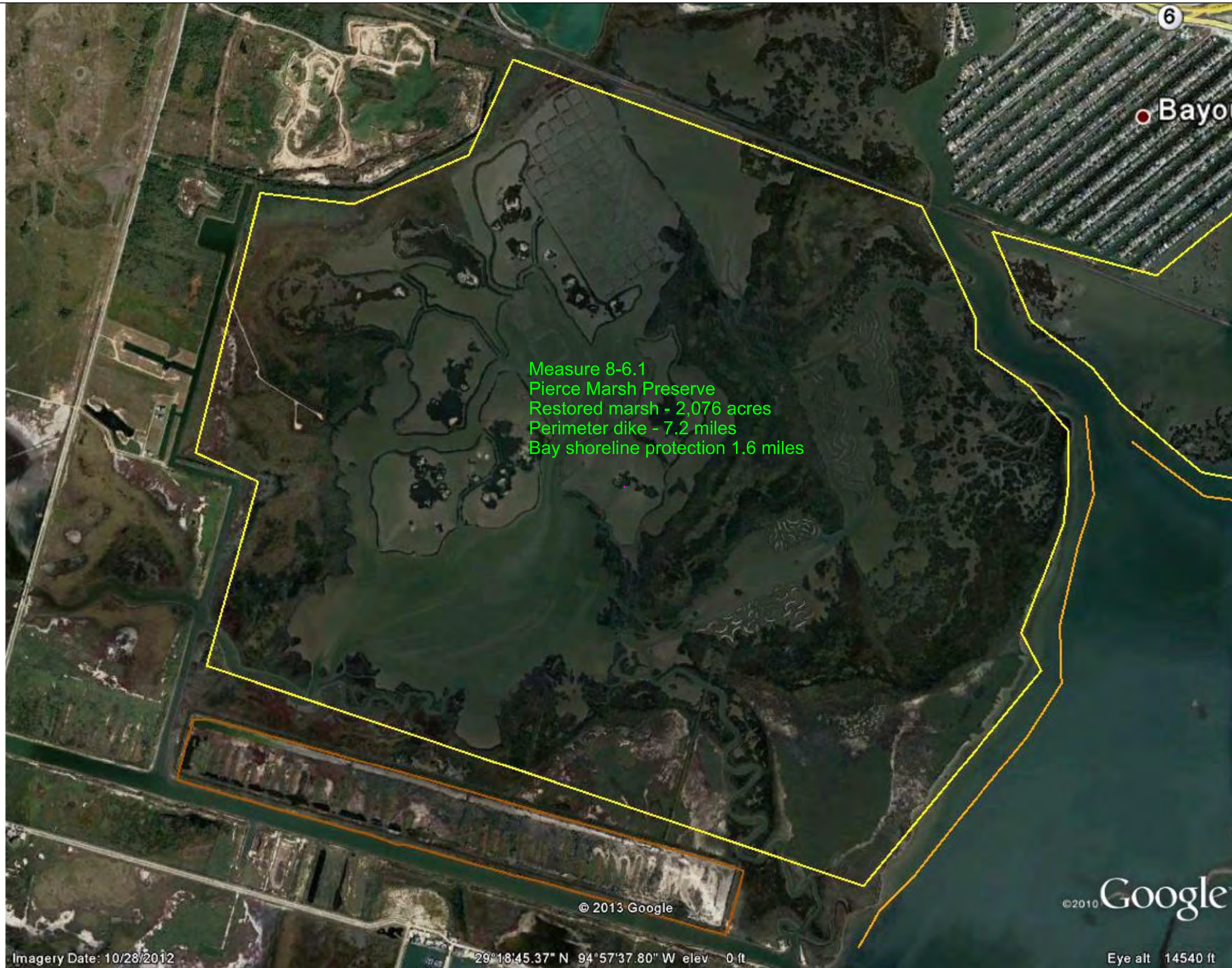
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Measure 8-6.1: Marsh Restoration, Pierce Marsh, Galveston County



### Legend

— Measure 8-6.1



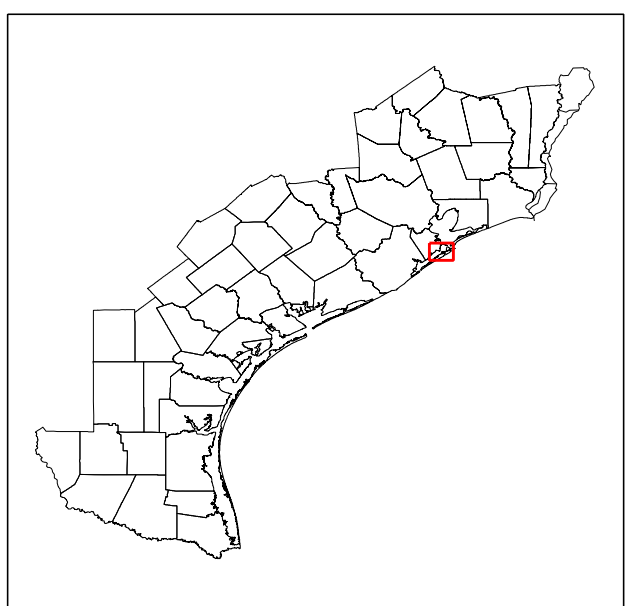
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Date Created: 4/11/2013



## Measure 8-6.2: Marsh Restoration, IH-45 Causeway, Galveston County



### Legend

— Measure 8-6.2



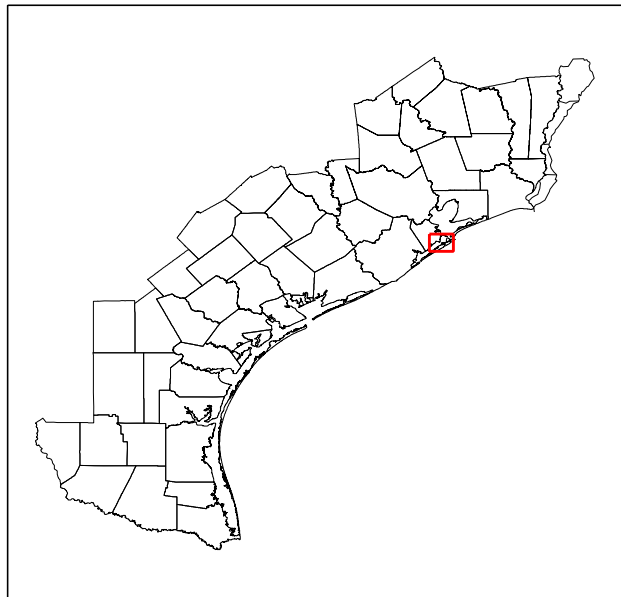
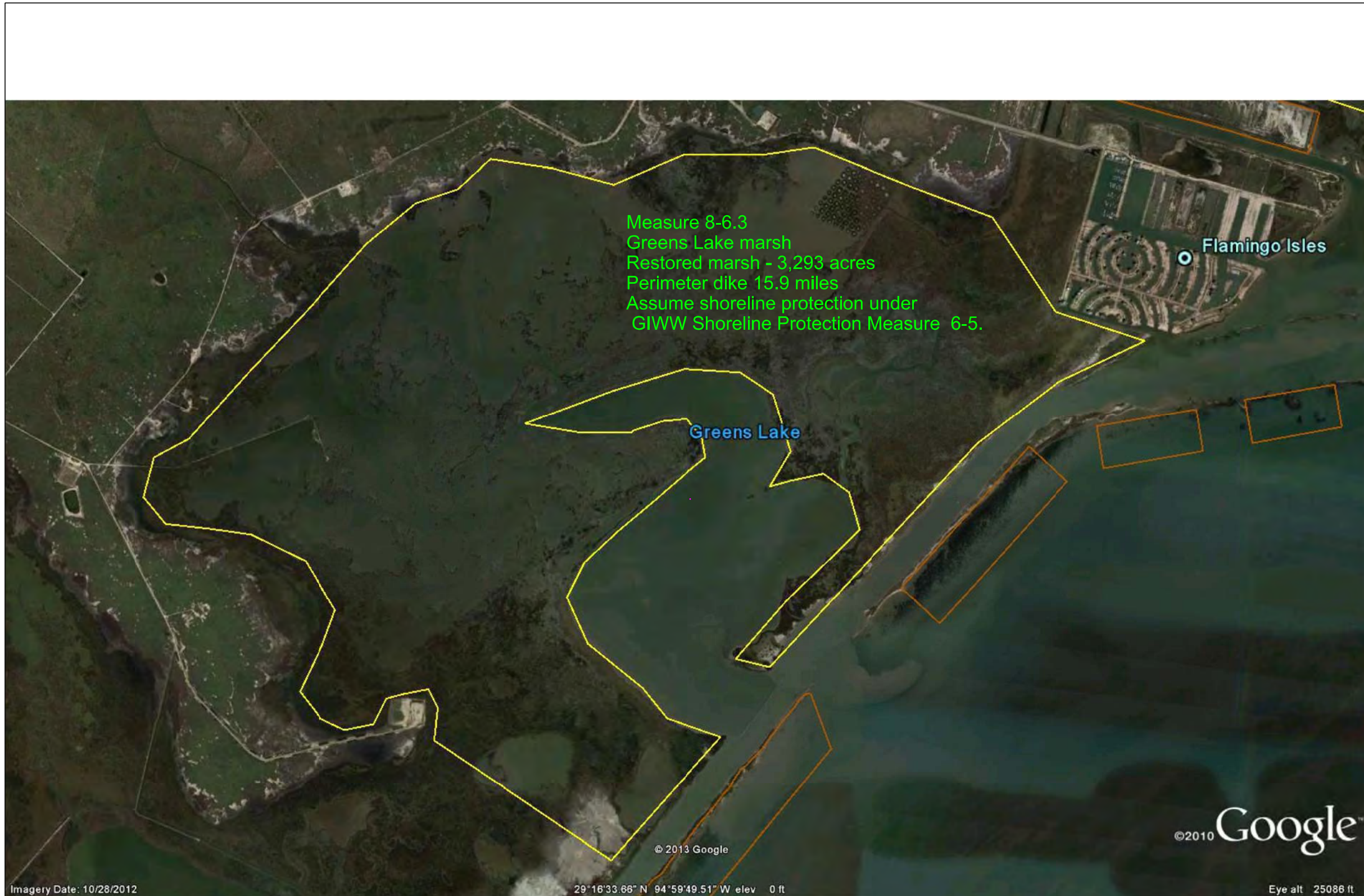
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Date Created: 4/11/2013





Measure 8-6.3: Marsh Restoration, Greens Lake, Galveston County



## Legend

— Measure 8-6.3



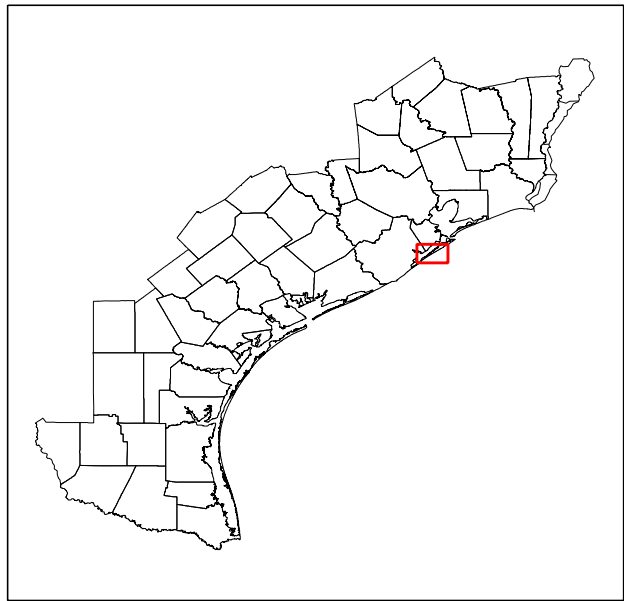
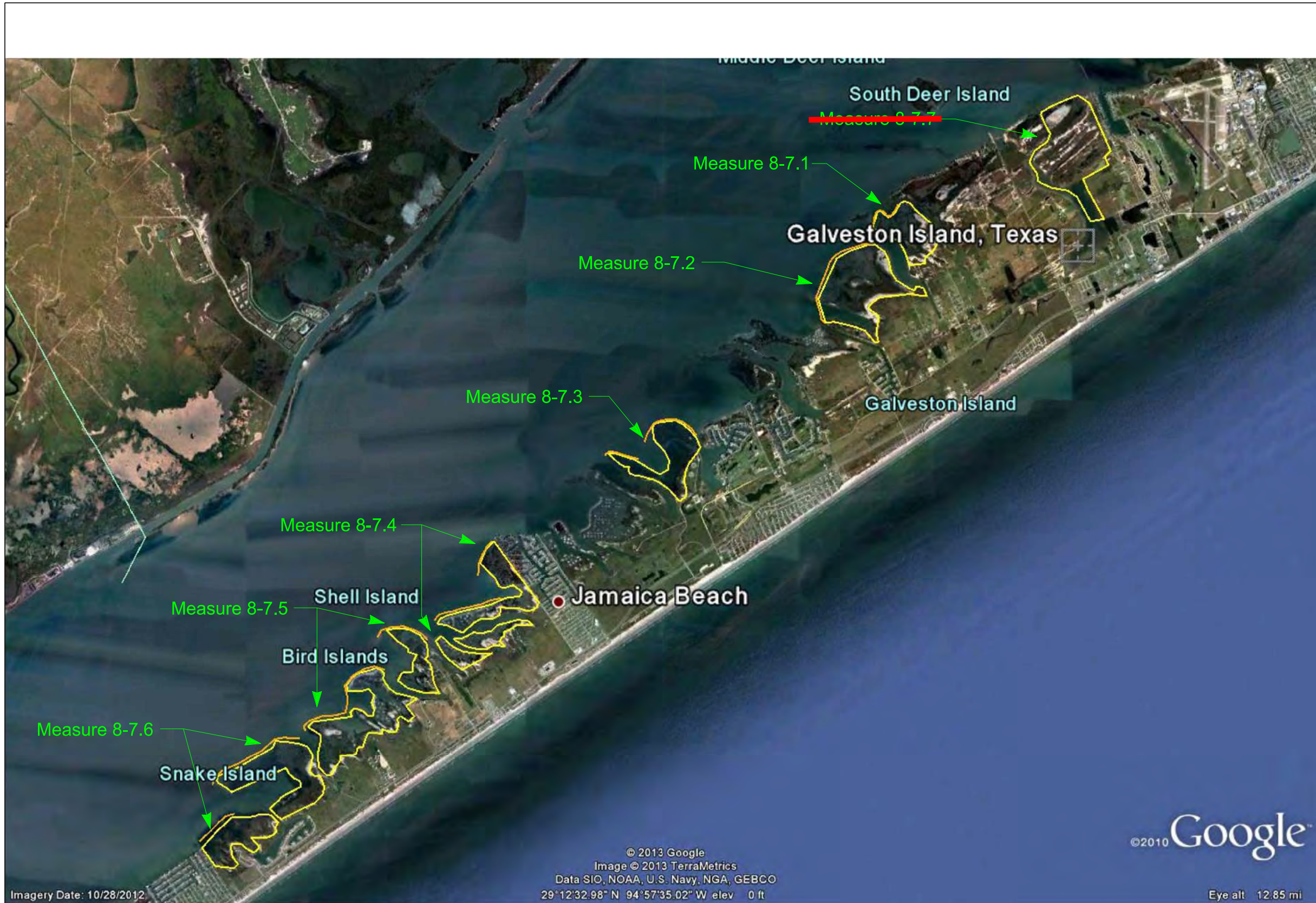
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Date Created: 4/11/2013





Measure 8-7: Marsh Restoration, West Galveston Island Bay-Side Marsh, Galveston County



## Legend

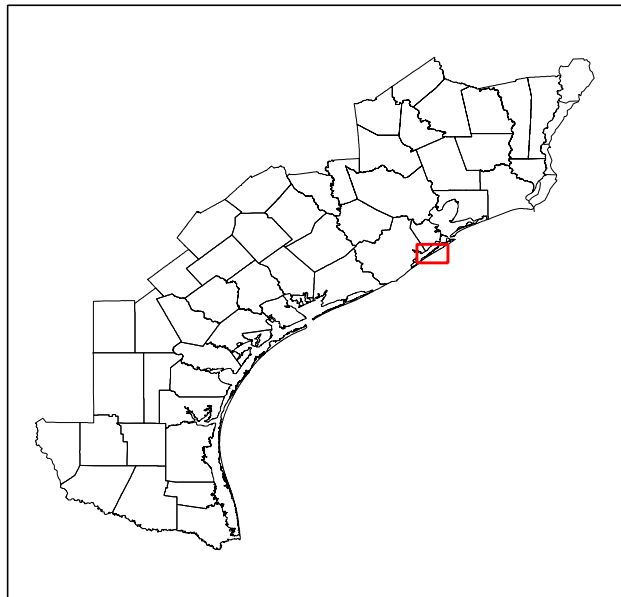
— Measure 8-7

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Date Created: \$DATES\$



Measure 8-7.1: Marsh Restoration, Gangs to Oxen Bayou, Galveston County



## Legend

— Measure 8-7.1



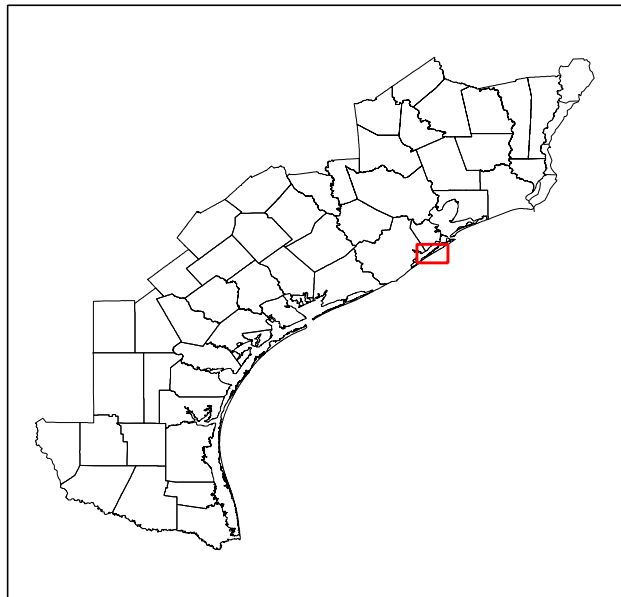
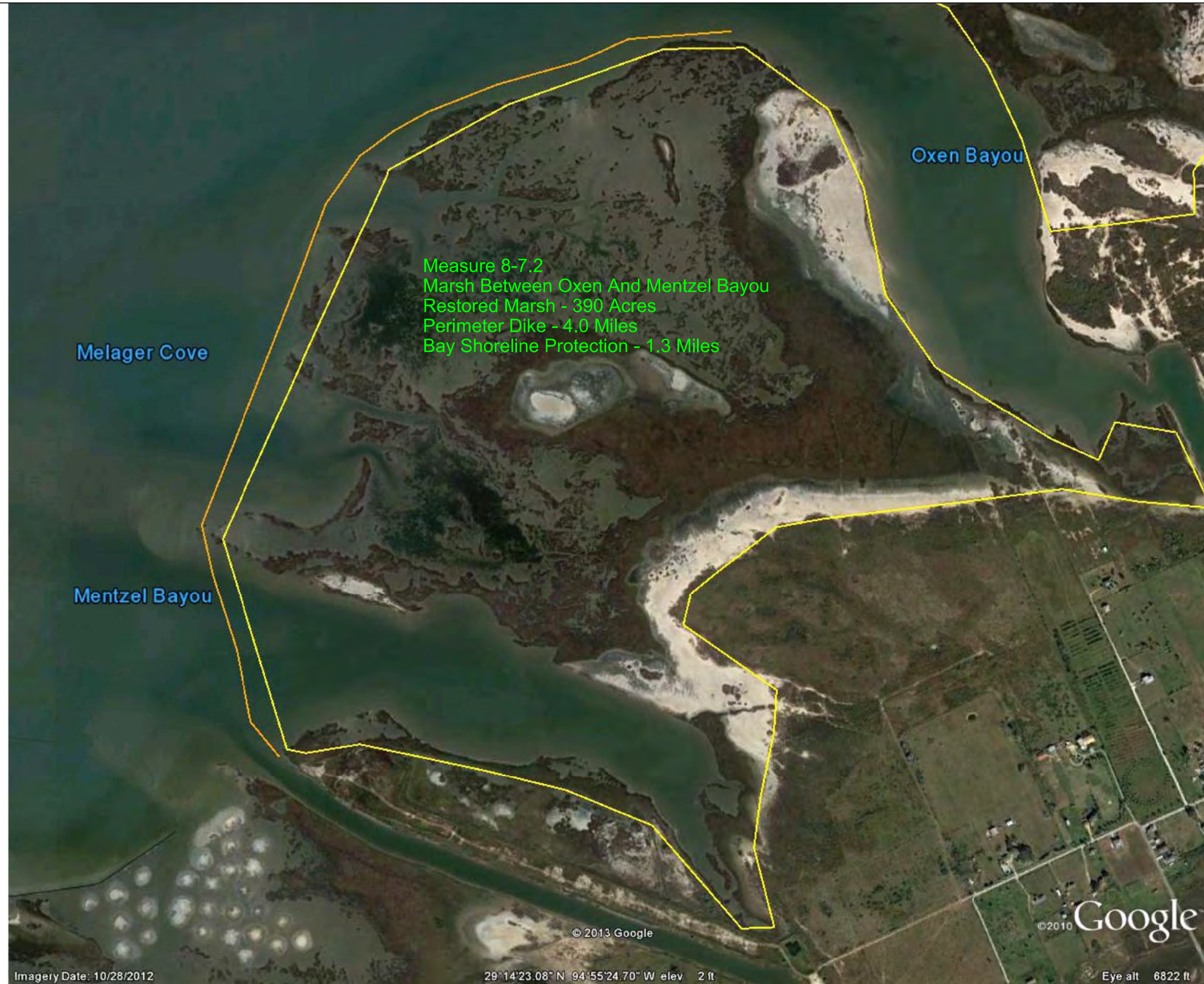
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Date Created: \$DATES\$





Measure 8-7.2: Marsh Restoration, Oxen to Mantel Bayou, Galveston County



### Legend

— Measure 8-7.2



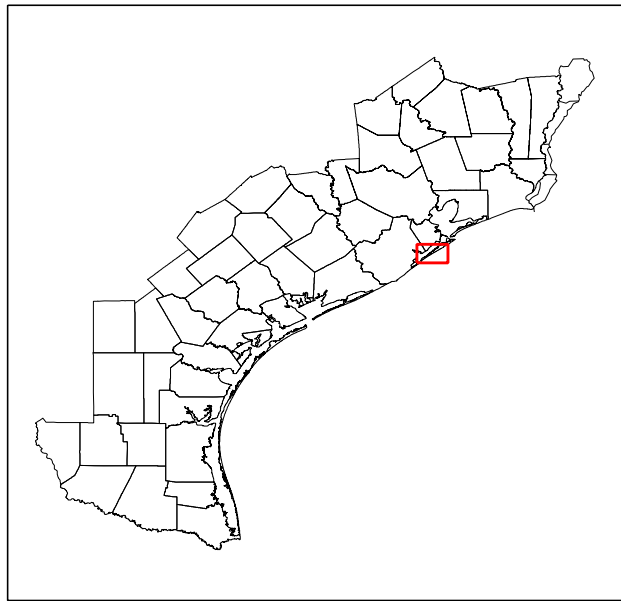
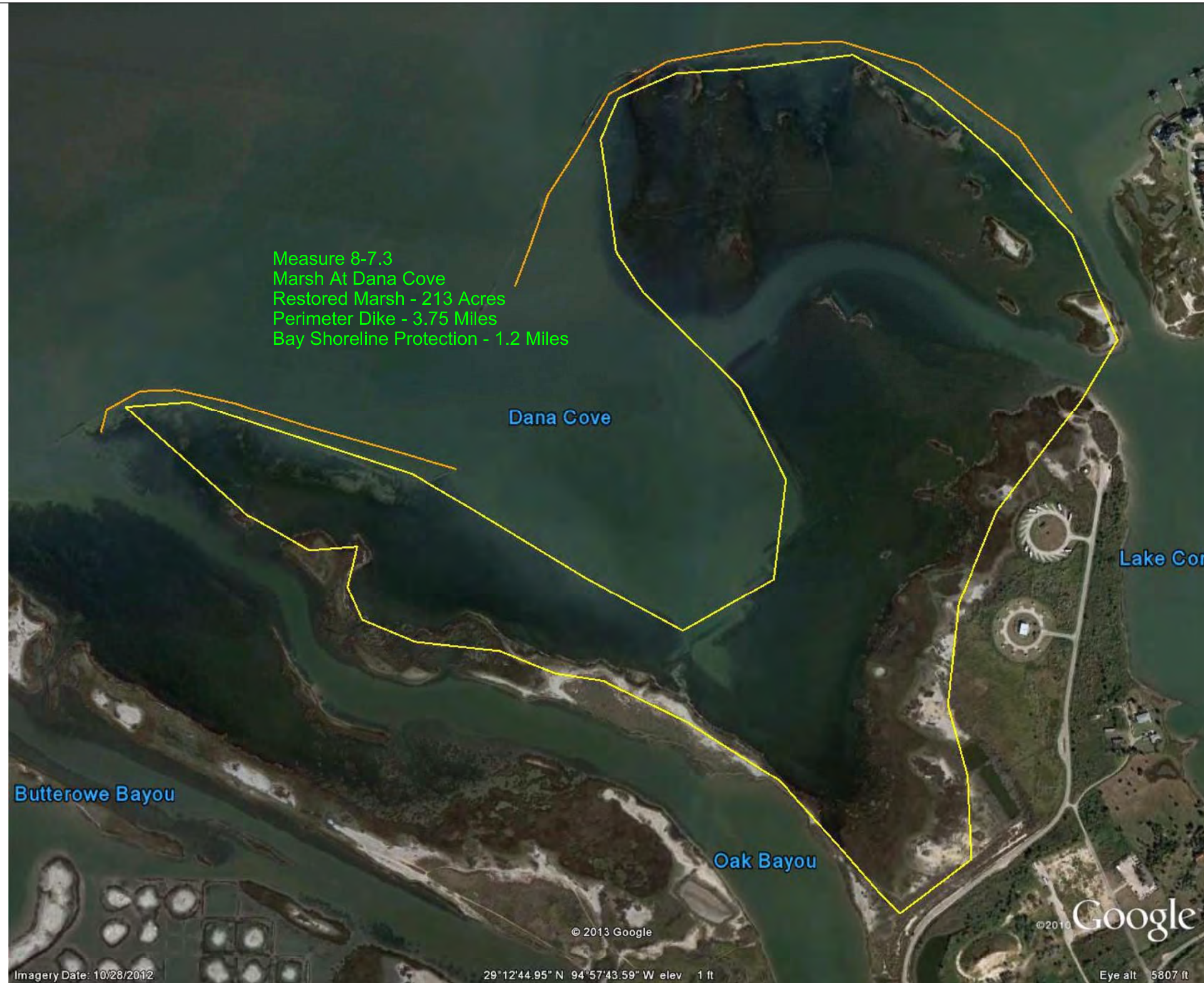
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Date Created: \$DATES\$






Measure 8-7.3: Marsh Restoration, Dana Cove, Galveston County




### Legend

— Measure 8-7.3



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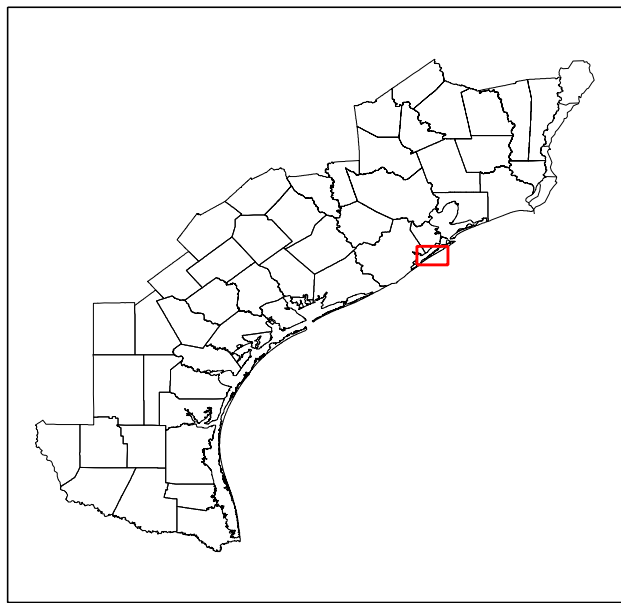
Date Created: \$DATES\$



Measure 8-7.4: Marsh Restoration, Jumbile Cove, Galveston County



- Measure 8-7-4  
Marsh At Jumbile Cove
- A. Restored Marsh - 196 Acres  
Perimeter Dike - 4.2 Miles  
Bay Shoreline Protection - 1.25 Miles
  - B. Restored Marsh - 68 Acres  
Perimeter Dike - 2.15 Miles  
No Bay Shoreline Protection
  - C. Restored Marsh - 52 Acres  
Perimeter Dike - 1.6 Miles  
No Bay Shoreline Protection



## Legend

— Measure 8-7.4

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Measure 8-7.5: Marsh Restoration, Bird Island to Maggies Cove, Galveston County



Measure 8-7.5  
Marsh At Bird Island Cove To Maggies Cove

A. Restored Marsh - 120 Acres  
Perimeter Dike - 2.5 Miles  
Bay Shoreline Protection - 0.65 Miles

B. Restored Marsh - 347 Acres  
Perimeter Dike - 5 Miles  
Bay Shoreline Protection - 1.4 Miles

Maggies Cove

Ostermayer Bayou

Bird Islands

Bird Island Cove

A

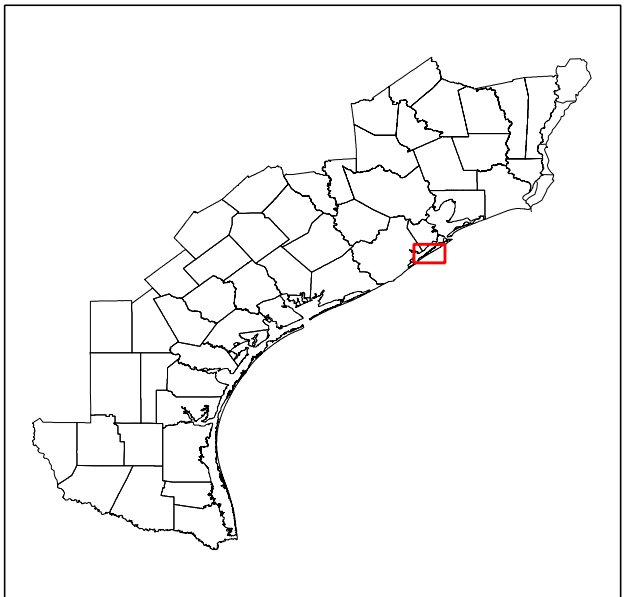
B

© 2010 Google

Imagery Date: 10/28/2012

29°10'21.62" N 95°00'43.33" W elev. 0 ft

Eye alt 10129 ft



## Legend

— Measure 8-7.5



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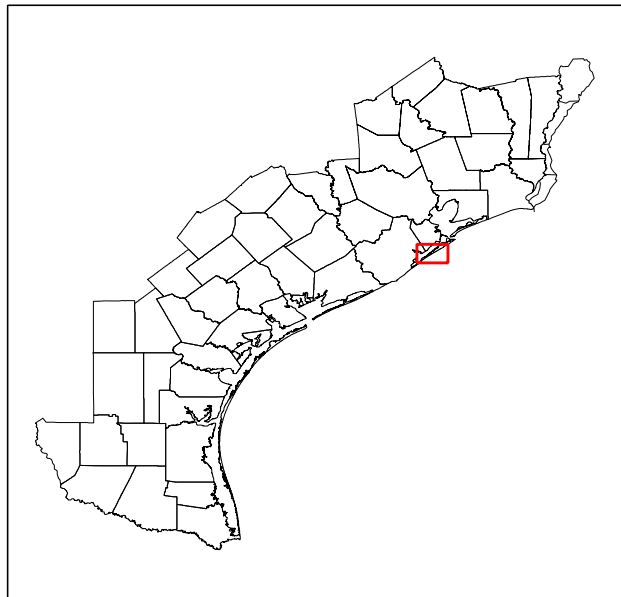


Measure 8-7.6: Marsh Restoration, Snake Island Cove, Galveston County

Measure 8-7.6  
Marsh At Snake Island Cove

A. Restored Marsh - 287 Acres  
Perimeter Dike - 4.2 Miles  
Bay Shoreline Protection - 1.2 Miles

B. Restored Marsh - 170 Acres  
Perimeter Dike - 2.7 Miles  
Bay Shoreline Protection - 0.5 Miles



## Legend

— Measure 8-7.6



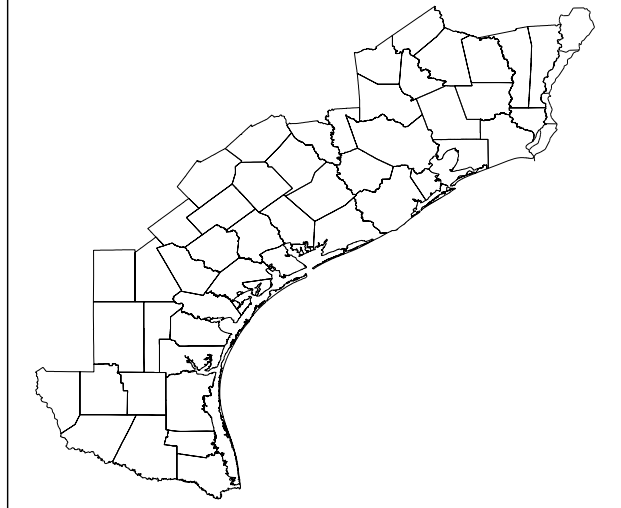
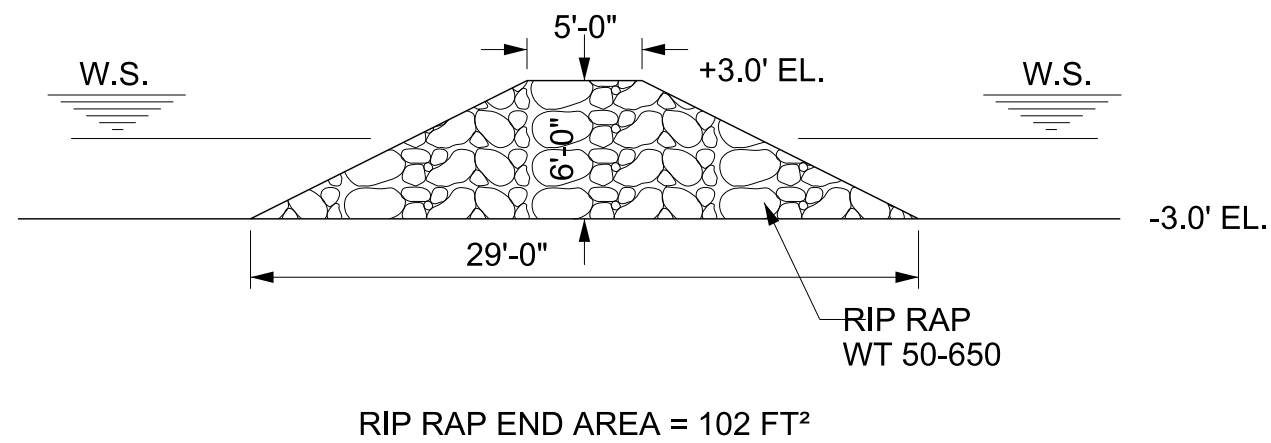
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Date Created: \$DATES\$





Typical Section S-15: GIWW Shore Protection



Typical Section S-15

Measures:

- 6-1.1
- 6-2
- 6-4.1
- 6-5.1
- 6-6.1
- 7-1
- 7-2
- 8-4
- 8-6
- 8-7



ASSUMPTIONS:

- 1: BREAKWATER IS PLACED IN 3 FT DEEP WATER
- 2: BREAKWATER IS CONTINUOUS
- 3: VOLUME IS BASED ON CROSS SECTION AREA MULTIPLIED BY LENGTH

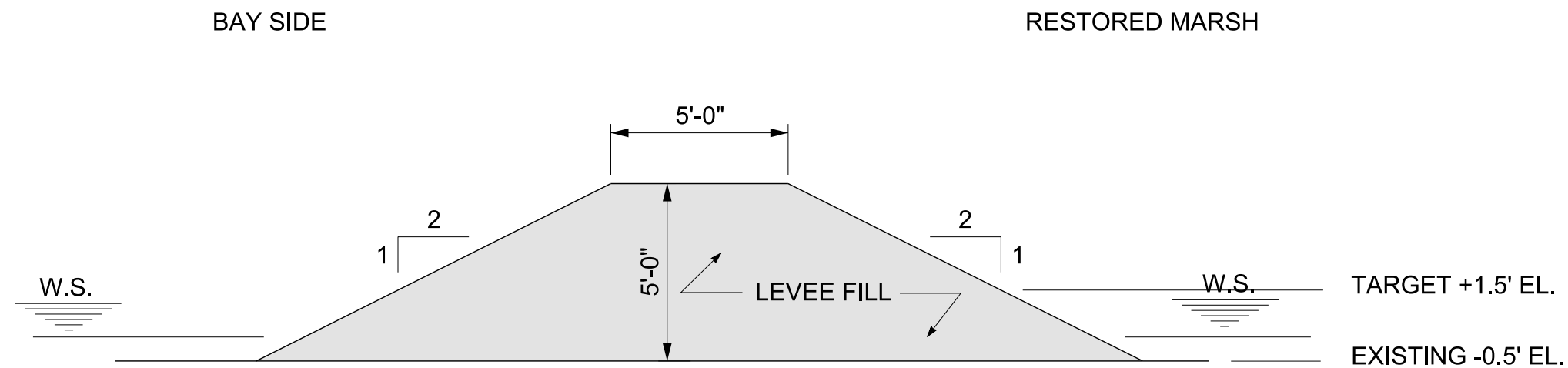
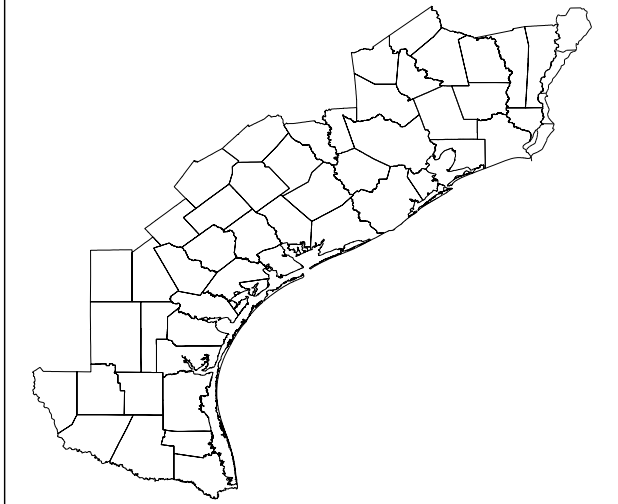
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Date Created: 4/24/2013





Typical Section S-16: Marsh Restoration Containment Levee



Typical Section S-16

Measures:

- 8-4
- 8-5
- 8-6
- 8-7

ASSUMPTIONS:

- 1: CONTAINMENT LEVEE FILL OBTAINED FROM ONSITE BORROW AREA
- 2: RESTORED MARSH FILL HYDRAULICALLY PUMPED
- 3: CONTAINMENT LEVEE FOUNDED ON -0.5' CONTOUR



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Date Created: 4/24/2013



**SABINE PASS TO GALVESTON BAY, TEXAS**  
**MEASURE 8-7.7**  
**INFORMATION SHEET**

**DESCRIPTION OF MEASURE**

**Measure 8-7.7 Marsh and Bayou Restoration, Sweetwater Preserve, Galveston County:**

This measure would restore a marsh and bayou system in the Sweetwater Preserve by establishing marsh elevations in disturbed uplands and reducing the width and depth of the bayou to dampen tidal intrusion. Current areas that are now higher than the marsh elevation would be excavated to an average target marsh elevation of 1.5 ft MSL. A survey would be required to determine the amount of disturbed uplands requiring excavation and to identify the areas to add excavated fill to reduce width of Sweetwater Bayou. Excavated material would be used to reduce the width of bayou connecting Sweetwater Lake with West Bay. Reclaimed land in the former bayou would be built up to an average target marsh elevation 1.5 ft MSL. The total area is 447 acres and the footprint perimeter is 4.1 miles. No shoreline protection on Galveston Bay is needed as it has already been installed.

**LOCATION OF MEASURE 8-7.7: (SEE ATTACHED DRAWING)**

Measure 8-7.7: Marsh and Bayou Restoration, Sweetwater Preserve, Galveston County

**DESIGN ASSUMPTIONS**

Measure 8-7.7:

- Total area 447 acres, of which 323 acres needs to be degraded an average of two feet to meet target elevation of 1.5' MSL.
- The volume of excavated material is 1,042,300 CY.
- Excavated material moved to remaining portions of work area and used to reduce width of bayou connecting Sweetwater Lake to West Bay.
- Access via local roads, bulldozers and dump trucks can be used to complete work.
- No additional maintenance work will need to be performed for the 50 year.

**REAL ESTATE:**

A detailed breakdown of Real Estate costs can be found in the supplemental document 'Sabine Pass to Galveston Bay, Texas Preliminary Real Estate Cost Estimate'. Costs identified as \$0 are generally associated with Federal and/or State lands.



- Measure 8-7.7: Marsh and Bayou Restoration, Sweetwater Preserve, Galveston County  
Total Estimated Real Estate Cost: \$122,000 ®

## **ENVIRONMENTAL:**

This marsh would serve as a buffer for storm surge, water storage, improve water quality and provide important nursery habitat. The environmental benefits are equivalent to the total acres restored (447 acres).

## **BENEFITS**

All benefits are assumed be environmental for this phase of analysis.

## **COSTS**

No real estate cost is included.

The estimated cost for Measure 8-7.7 is \$7,135,000.

## **The following Cost Assumptions were used for measures: 8-7.7**

- The existing area will be degraded using a dozer to move the existing material around to the required elevation,
- reduce the width of the bayou connecting Sweetwater Lake and West Bay.
- A standard 25% contingency, E&D of 8%, and CM of 6% was used with the cost

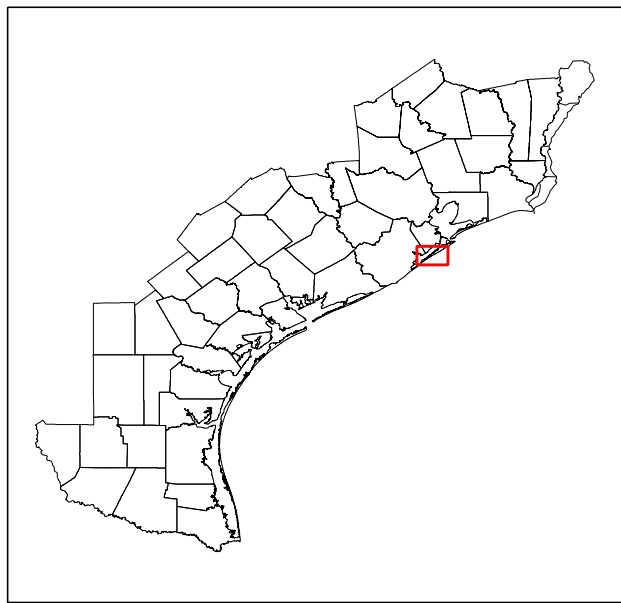
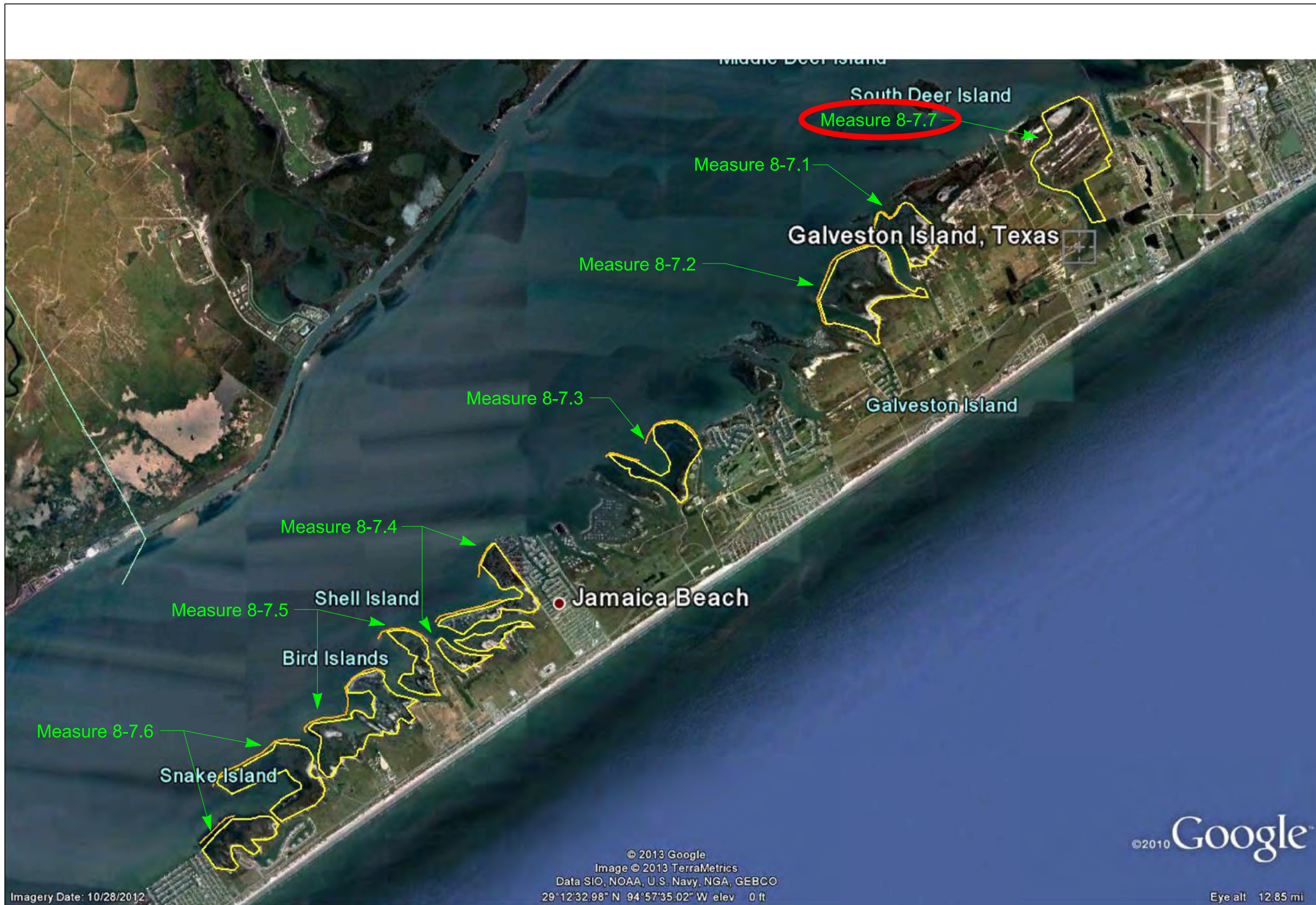
## **REFERENCE DOCUMENT**

Gulf of Mexico Foundation. no date. West Galveston Bay Regional Sediment Management Plan Report. Prepared for Habitat Conservation and Restoration Team, Gulf of Mexico Alliance by Atkins Global.

## **RISKS**


- Geotechnical properties of fill assumed to be adequate for the work being performed.
- No review of available public information or data from in-house files relative to the general geology and soil conditions for the proposed features was conducted.

Measure 8-7: Marsh Restoration, West Galveston Island Bay-Side Marsh, Galveston County




## Legend

— Measure 8-7



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Date Created: \$DATES\$

Imagery Date: 10/28/2012

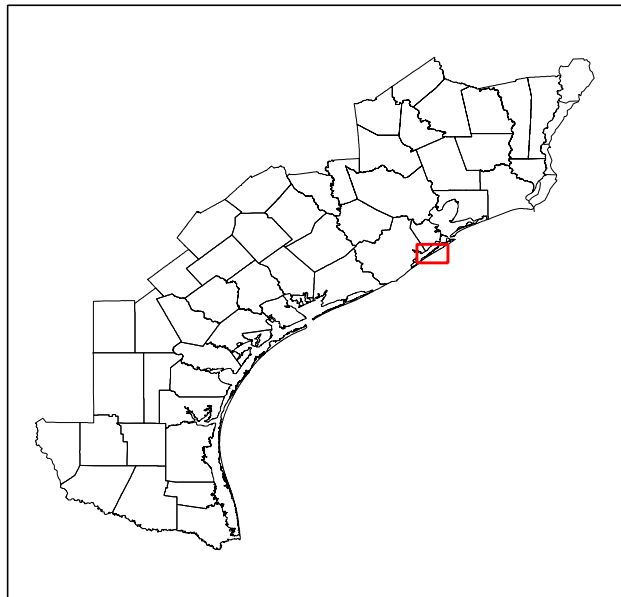
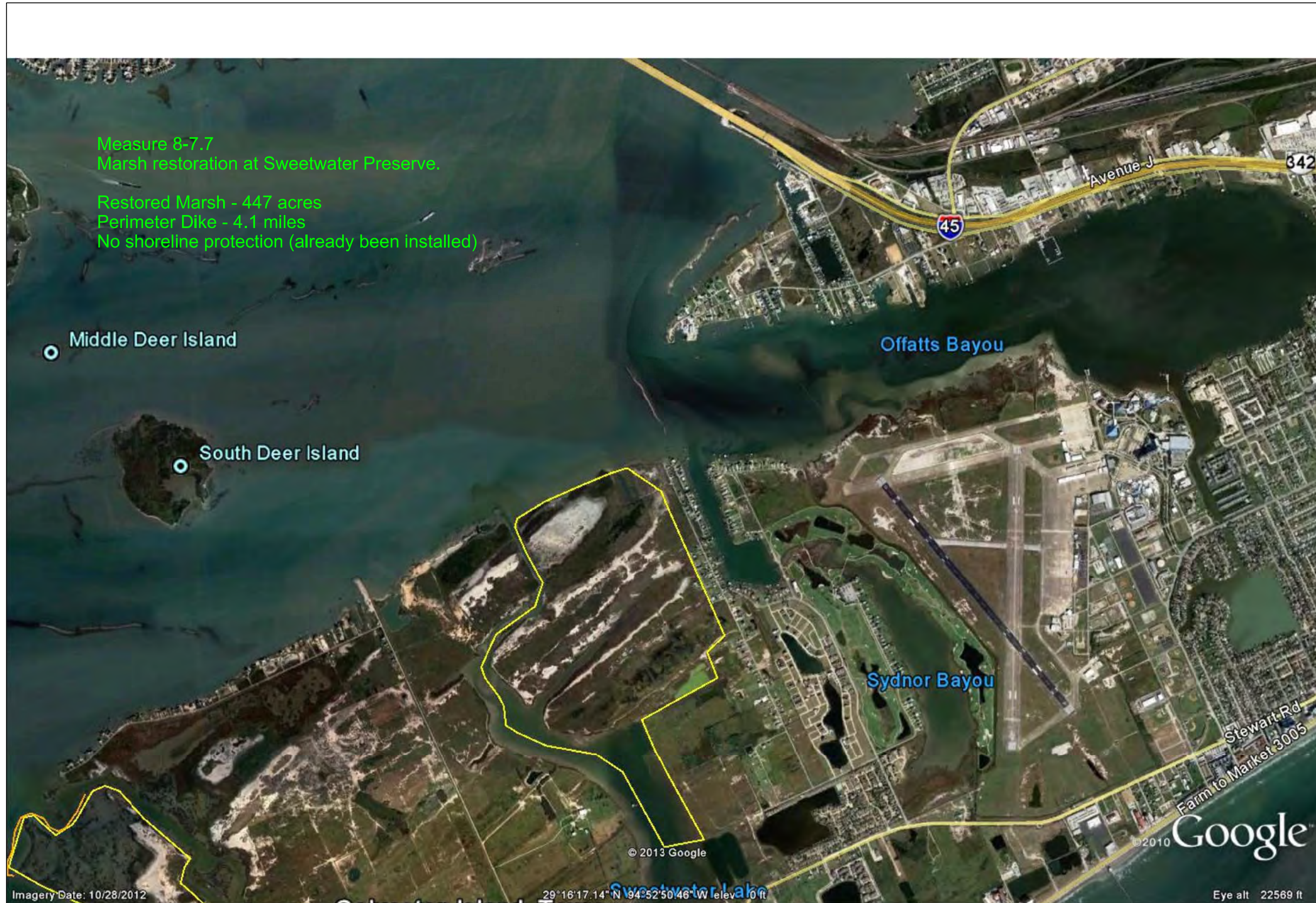
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 Image © 2013 TerraMetrics  
 Data SIO, NOAA, U.S. Navy, NGA, GEBCO  
 29°12'32.98" N 94°57'35.02" W elev 0 ft

©2010 Google

Eye alt 12.85 mi



Measure 8-7.7: Marsh and Bayou Restoration, Sweetwater Preserve, Galveston County



### Legend

— Measure 8-7.7



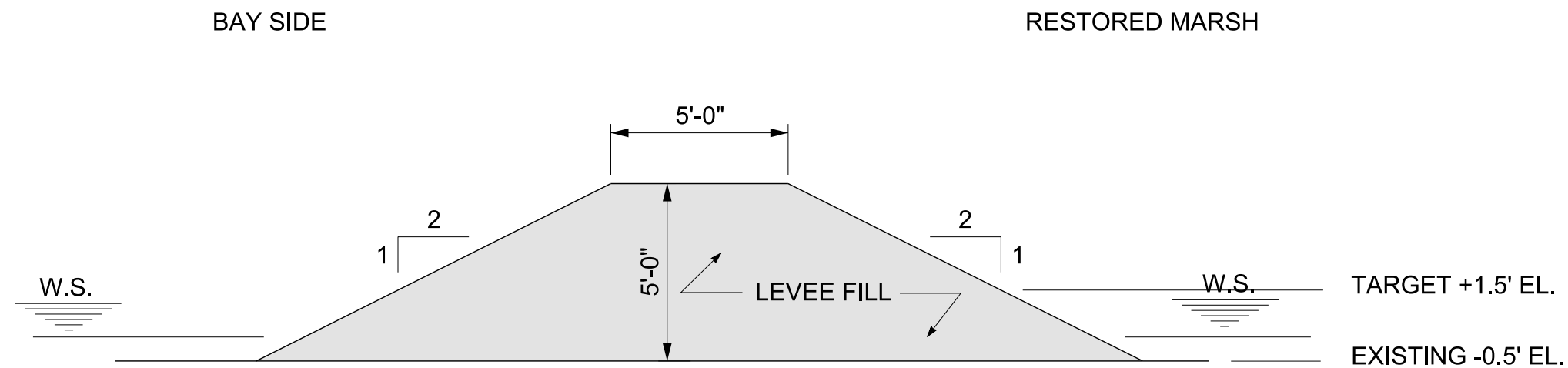
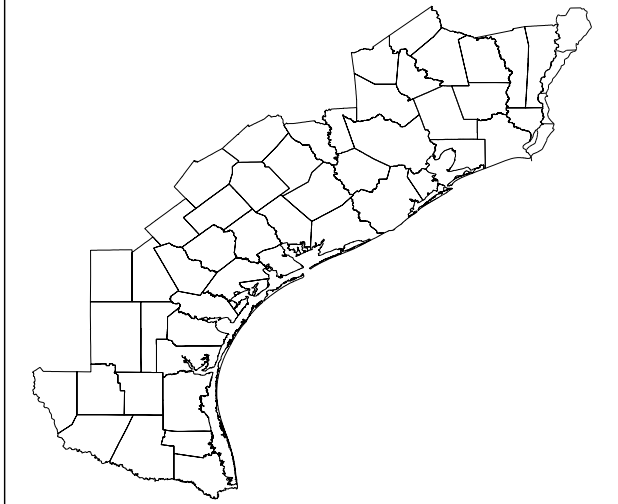
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Typical Section S-16: Marsh Restoration Containment Levee



Typical Section S-16

Measures:

- 8-4
- 8-5
- 8-6
- 8-7



ASSUMPTIONS:

- 1: CONTAINMENT LEVEE FILL OBTAINED FROM ONSITE BORROW AREA
- 2: RESTORED MARSH FILL HYDRAULICALLY PUMPED
- 3: CONTAINMENT LEVEE FOUNDED ON -0.5' CONTOUR

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Date Created: 4/24/2013





**SABINE PASS TO GALVESTON BAY, TEXAS**  
**MEASURES 9-1 and 9-2**  
**INFORMATION SHEET**

**DESCRIPTION OF MEASURES 9-1 and 9-2**

The purpose of these measures is hydrological restoration of the Salt Bayou Watershed. A combination of natural processes and human activities, most notably construction of the GIWW and the Sabine-Neches Waterway navigation channels, has modified the landscape connecting what was once a predominantly freshwater wetland system to tidal waters with marine salinities. Over time, the influx of saline water has contributed to a significant change in and loss of freshwater marsh vegetation throughout a wide area of the wetland. At the same time, there has been an increase in the production of estuarine fish and shellfish species as access points facilitate ingress and egress through various control structures and the Keith Lake Fish Pass. Under current conditions, the system serves as an important site for wetland flora, migratory waterfowl, and estuarine species. The restoration proposed here strikes a balance between the historical freshwater wetland function and the more contemporary estuarine functions which are controlled by the balance of fresh and salt water in the system.

This measure includes 2 separate items which together will decrease salinity in the Salt Bayou watershed south of the GIWW:

**Measure 9-1 Salt Water Control Structure, Keith Lake Fish Pass, Jefferson County**  
Involves the construction of a water control structure within the Keith Lake Fish Pass (KLFP), an artificial channel which connects a network of freshwater and brackish lakes and bayous in the Salt Bayou marsh system south of the GIWW to the 40-foot deep draft Sabine-Neches Waterway navigation channel. The structure would reduce salinity intrusion and tidal energy through the KLFP and help preserve about 50,000 acres of significant emergent coastal marsh while maintaining the marsh's accessibility and value as an important estuarine nursery.

**Measure 9-2 Inverted Siphons Under GIWW, Jefferson County**

Restore freshwater inflows into the Salt Bayou system by hydrologically connecting the Taylor Bayou watershed north of the GIWW to the Salt Bayou system south of the GIWW. Natural stream and sheet flows once moved from north to south into the Salt Bayou watershed. This flow was blocked when the GIWW was constructed. The siphons would reestablish some of the lost freshwater flow to the now isolated wetlands south of the GIWW. Water would flow through two sets of pipes acting as inverted siphons under the GIWW. One (9-2A) would take

water from Magnolia Cut and discharge it into the Salt Bayou watershed . The second (9-2B) would move water from Oil Field Cut into marshes near Barnett Lake.

The majority of the area affected by this measure is part of the U.S. Fish and Wildlife Service's (USFWS) McFaddin National Wildlife Refuge (NWR), Texas Parks and Wildlife's (TPWD) J.D. Murphree Wildlife Management Area (WMA) and Sea Rim State Park. This complex of state and federal lands protects one of the largest remaining freshwater marshes on the Texas coast and thousands of acres of intermediate to brackish marsh (USFWS, 2005).

Attached are engineering drawings and maps showing the location and details of the 9-1 (the Keith Lake Fish Pass structure) and 9-2 (A and B; the siphons). The design for the 9-1 structure was developed by USACE in conjunction with a proposed but suspended CAP study. The designs for the siphons were prepared by the USFWS as part of their permit application SWG-2010-00016. The permit has been issued, but funding has not been available.

#### **LOCATION OF MEASURE 9-1, 9-2 (See attached Drawings)**

Measure 9: Saltwater Control Structure and Inverted Siphons, Jefferson County  
 Measure 9-1: Salt Water Control Structure, Keith Lake Fish Pass, Jefferson County  
 Measure 9-2A: Inverted Siphons Under GIWW, Magnolia Cut, Jefferson County  
 Measure 9-2B: Inverted Siphons Under GIWW, Oil Field Cut, Jefferson County  
 Keith Lake Fish Pass Plan View F-02  
 Keith Lake Fish Pass Plan View F-03  
 Keith Lake Fish Pass Plan View F-04  
 McFaddin Drawings pgs. 1-12

#### **DESIGN ASSUMPTIONS**

##### **Measure 9-1 Salt Water Control Structure, Keith Lake Fish Pass, Jefferson County**

Consists of a rock weir crossing the midpoint of KLFP (reference the measure map). The opening in the rock weir would have a sill at -5.42 feet (MLLW) by 80 feet wide at the base with a triangular cross-section opening about 100 ft wide at the top. The upstream and downstream approaches to the sill would have a very gradual slope to smooth water flow over the sill. Rock levees, approximately 100 feet wide (from the weir to the bank) and 150 feet long (longitudinally in the channel), would flank the opening and connect to each bank. The crest of these levees would match adjoining bank elevations. The foot print of the control structure at Keith Lake will be approximately 350' x 300'. The height of the structure is proposed from EL -12 to EL +1. Datum is NAVD88 and MLLW See attached drawings. All construction would be performed from the north bank of KLFP to minimize impacts to wetlands that line both banks of the KLFP.



MATERIAL	QUANTITY
Dolometric Limestone riprap (40 – 650 lbs)	23,000 tons
Geotextile	3,000 square yards
Excavation	8,000 cubic yards
Backfill	80 cubic yards
Borings	5 borings

### **Measure 9-2 Inverted Siphons Under GIWW, Jefferson County**

Inverted siphons under GIWW consists of two sets of two 66-inch diameter pipes installed to cross beneath the GIWW, with flap gates north and screw gates south of the waterway. The first set of pipes would cross the GIWW at Oil Field Cut, and the second at Magnolia Cut. The pipelines would be placed in trenches that would be dredged to 33 feet deep using a dragline on a barge anchored on the south side of the GIWW in each location respectively. The dredge material would be placed behind existing breakwaters on the south side of the GIWW, behind breakwaters on the north side of the GIWW, and on the shoreline of the north side of the GIWW. The entrance of Oil Field Cut would have a rock groin installed on either side of the shoreline. This measure would also involve excavation of a diversion pond and channel on the southern portion of the Oil Field Cut pipelines on the south side of the GIWW. The materials excavated for the creation of the diversion pond and channel would be placed on the adjacent southern GIWW shoreline. See attached drawings.

#### Assumptions

1. Construction is completed from barges using a clamshell dredge, no access roads to this area
2. Pipeline trench is 18' wide at bottom, 21' below the ground surface, with 1:1 side slopes,
3. Quantities provided are neat line
4. Trench cross sectional area stays constant across the length of the cut and trench elevation follows the elevation of the surface above.
5. Two high density polyethylene pipes size 72" OD, 66" ID and 1000' long
6. Siphons have aluminum box on north end (no flap gates), screwgate on south end
7. Aluminum box intake is 10' wide, 10' long, and 8' deep with aluminum grating on top
8. Siphon anchors are wooden piling with an embedment length of 16', 6 piles for each siphon pipe on both north and south ends
9. Box intakes are supported by nine 12" diameter 16' long wooden piles

## A. Magnolia cut Siphon quantity Summary

Work Detail	Quantity	Length	Volume	Total
Pipeline Excavation Trench (21' deep)	1 ea	1000 ft	819000 FT <sup>3</sup>	30333 CYD
Pipeline Backfill	1 ea	1000 ft	762451 FT <sup>3</sup>	28239 CYD
Pipe (3" thick and 66" inside diameter)	2 ea	1000 ft		2000ft
Box intake (10'x10' aluminum box with grate)	2 ea			2 ea
Aluminum/Stainless Steel Screwgates (South of GIWW)	2 ea			2 ea
Siphon Anchor Piling (12" diameter, 24' length)	24 ea			24 ea
Box Intake Piling (12" diameter, 16' length)	18 ea			18 ea

## Assumptions B

1. Diversion channel is 4 feet deep, 6 feet wide at base, 22 feet wide at top and 2200 feet long
2. Diversion pond will be 30' diameter with a depth of 8 feet
3. Breakwaters are existing and in place. Removal and reinstallation will be required during trench construction.
4. Assume 650 lb graded riprap resting on geotextile fabric with 4' crest width, 1:2 side slopes, and 5' height.
5. Construction is completed from barges using a clamshell dredge, no access roads to this area.
6. Pipeline trench is 18' wide at bottom, 21' below the ground surface, with 1:1 side slopes, quantities provided are neatline
7. Trench cross sectional area stays constant across the length of the cut and trench elevation follows the elevation of the surface above.
8. Two high density polyethylene pipes size 72" OD, 66" ID and 1000' long
9. Siphons have aluminum box on north end (no flap gates), screwgate on south end
10. Aluminum box intake is 10' wide, 10' long, and 8' deep with aluminum grating on top
11. Siphon anchors are wooden piling with an embedment length of 16', 6 piles for each siphon pipe on both north and south ends
12. Box intakes are supported by nine 12" diameter 16' long wooden piles

## B. Oil Field Cut Siphon Quantity Summary

Work Detail	Quantity	Length	Volume	Total
<b>Diversion Pond and Channel Excavation</b>	1 ea	2200 ft	128855 FT <sup>3</sup>	4772 CYD
Breakwaters (removal and reinstallation)		230 ft	8400	311



			FT <sup>3</sup>	CYD
Pipeline Excavation Trench (21' deep)	1 ea	1000 ft	819000 FT <sup>3</sup>	30333 CYD
Pipeline Backfill	1 ea	1000 ft	762451 FT <sup>3</sup>	28239 CYD
Pipe (3" thick and 66" inside diameter)	2 ea	1000 ft		2000 FT
Box Intake (10'x10' aluminum box with grate)	2 ea			2 ea
Aluminum/Stainless Steel Screwgates (South of GIWW)	2 ea			2 ea
Siphon Anchor Piling (12" diameter, 24' length)	24 ea			24 ea
Box Intake Piling (12"diameter, 16' length)	18 ea			18 ea

## HYDRAULICS & HYDROLOGY

Hydrodynamic and particle modeling were conducted by ERDC (Brown and Lackey, 2011) to identify the structure most effective in reducing tidal energy and salinity, while minimizing adverse effects on larval recruitment through the structures into the Salt Bayou system.

Hydrologic modeling exploring the effectiveness of the proposed siphons was conducted by the Texas Water Development Board (TWDB, 2009). Bathymetric, water quality, water level and velocity data were collected and used to develop and calibrate a high resolution, three-dimensional hydrodynamic and salinity transport model for the region.

## REAL ESTATE

- Measure 9-1: Salt Water Control Structure, Keith Lake Fish Pass, Jefferson County.  
Total Estimated Real Estate Cost of Measure 9-1: \$15,400 ®
- Measure 9-1: Inverted Siphons Under GIWW, Jefferson County.  
Total Estimated Real Estate Cost of Measure 9-1: \$71,000 ®

## ENVIRONMENTAL

Historically, Salt Bayou was a fresh to intermediate wetland that transitioned into brackish conditions near the downstream confluence with Taylor Bayou and Sabine Lake. Construction of the GIWW in 1933, however, severed Salt Bayou from the upper drainage basin, and eliminated the primary source of freshwater inflow to the wetland. For decades, rainfall has been the main

source of freshwater for this wetland and the only source available to ameliorate salinity intrusion. Presently, two sources of saline water contribute to sustained increases in salinity throughout the system. These two sources are (1) the Keith Lake Fish Pass which connects Keith Lake/Salt Bayou to the SNWW and the Sabine Lake estuary and (2) erosion of the beach ridge along the McFaddin NWR property which allows Gulf seawater to wash into interior marshes during high tides and storm surges (addressed by measures 4-2.1 and 5-3).

Measure 9-1 (Keith Lake Fish Pass Structure) would reduce the frequency of salinity spikes over the 50,000 acres of the Salt Bayou system, while maintaining an acceptable level of fishery and larval access through the structure. Modeling indicates that the frequency of these high salinity episodes would be reduced by about 20 percent, lowering stress on the fresher portions of the marsh and preserving the health of the marsh system (ERDC, 2011).

Measure 9-2 (Siphons Under the GIWW) would restore hydrologic connectivity to freshwater flows and help to reduce salinities across the 50,000-acre Salt Bayou system. Modeling results have shown that both siphon locations are able to reduce salinities, but that the extent of salinity reduction would vary throughout the year (TWDB, 2009).

Both measures affect the same 50,000-acre Salt Bayou system. Environmental benefits are presented in wetland acres that would be protected by this measure. The wetland acres were calculated with a GIS analysis of National Wetland Inventory wetland maps (USFWS, 2012). The environmental benefit for both measures (taken together) are 20,200 wetland acres (emergent marsh, bottomland hardwood forest, swamp and scrub-shrub). The Salt Bayou System has national, state and local significance and restoration to the system would contribute to numerous Federal, state and local programs and plans.

## **BENEFITS**

All benefits are assumed be environmental for this phase of analysis.

## **COSTS**

No real estate cost have been included. The cost estimate for measure 9-1 is \$ 7,254,000.

Cost Assumptions for 9-1:

- Construction would require clearing and grubbing
- No access road available
- Wood Pallets need for construction
- 12” Cutter-Suction Pipeline Dredge (and/or Clamshell Dredge/Barge)
- Backfill and Compact, Geotextile, and Limestone



- Prime 8(a) with Sub (LB), markups in unit prices,
- Contingency was increased to 30% to account for unspecified dredge material placement area requirements; type of access (water and/or road)

The cost estimate for measure 9-2 is \$ 11,711,000.

#### Cost Assumptions for 9-2:

- All water access.
- Construction is completed from barges using a clamshell dredge.
- Large hopper scows with 4 extra, resting on GIWW (one-way traffic) for each site with an additional 10 large hopper scows to account for grounding at 12 ft depth. i.e half filled.
- Start and finish Site before starting and finishing site 2.
- Prime 8(a) with Sub (LB), markups in unit prices,
- Contingency was increased to 45% to account for GIWW traffic; ability to acquire 20 large hopper scows and scow tie-ups/grounding along GIWW not to impede traffic and potential de-grounding of each scow and maintenance dredging of grounding disturbance; type of access (all water); slumping of trench cut in GIWW; control of water structures at levee/marsh breach (fresh/salt mix).

## REFERENCES

Evaluation of Proposed Salinity Mitigation Measures Modifications at Keith Lake Fish Pass  
Gary L Brown and Tahirih Lackey, USACE-ERDC-CHL, November 30, 2011

SWG-2010-00016 USWFS Permit Application, public notice date 19 April 2010.

TWDB (D. Pothina and C. Guthrie). 2009. Evaluating Inverted Siphons as a Means of Mitigating Salinity Intrusion in the Keith Lake/Salt Bayou System, Jefferson County, Texas. Report submitted to U.S. Environmental Protection Agency, Gulf of Mexico Program.

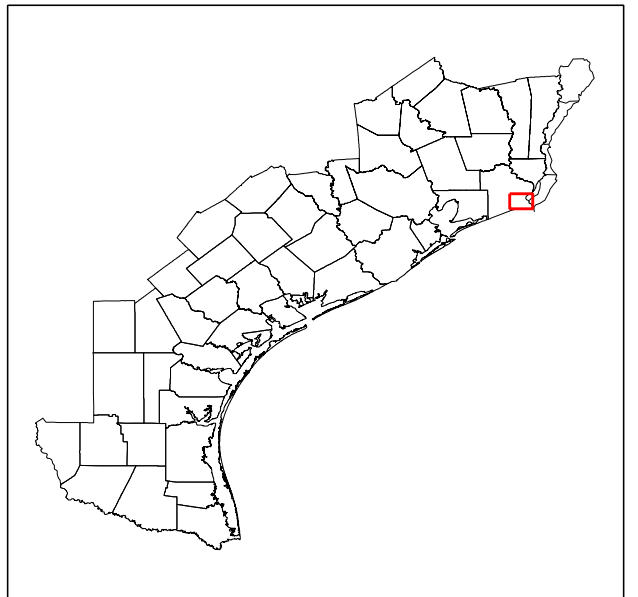
## RISKS

1. Measure 9-2 there is no road access. All water access.
2. The existing design does not include shoreline protection to prevent flanking; H&H modeling indicated that erosion could be a problem east of the structure. Rock armoring of the KLFP shoreline would need to be added on both sides east of the structure to prevent erosion during






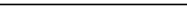

high ebb flows. Armoring is not needed west (upstream) of the structure as flows are not expected to exceed existing conditions with the structure in place



Measure 9: Saltwater Control Structure and Inverted Siphons, Jefferson County



## Legend

-  Measure 9
-  PLACEMENT AREA LIMITS
-  CHANNEL CURVE LIMIT DIMENSION
-  CHANNEL TOE
-  CHANNEL CENTERLINE
-  CHANNEL TOE
-  CHANNEL STATIONS



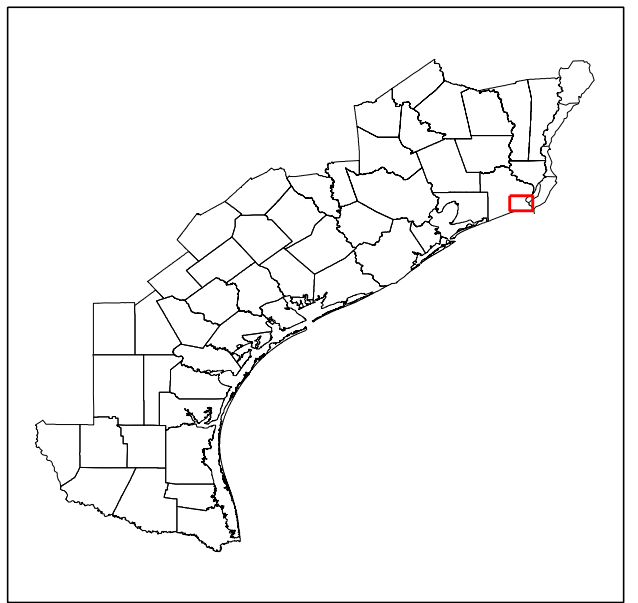
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Date Created: 4/15/2013













Measure 9-1: Salt Water Control Structure, Keith Lake Fish Pass, Jefferson County




## Legend

-  Measure 9-1
-  PLACEMENT AREA LIMITS
-  CHANNEL CURVE LIMIT DIMENSION
-  CHANNEL TOE
-  CHANNEL CENTERLINE
-  CHANNEL TOE
-  CHANNEL STATIONS



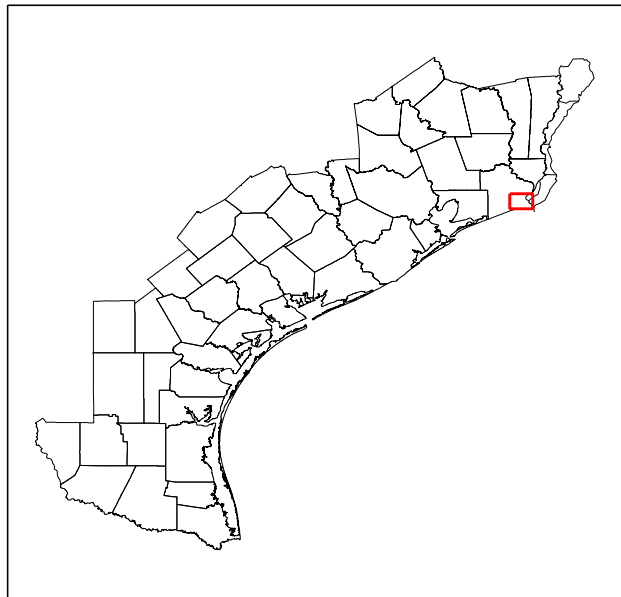
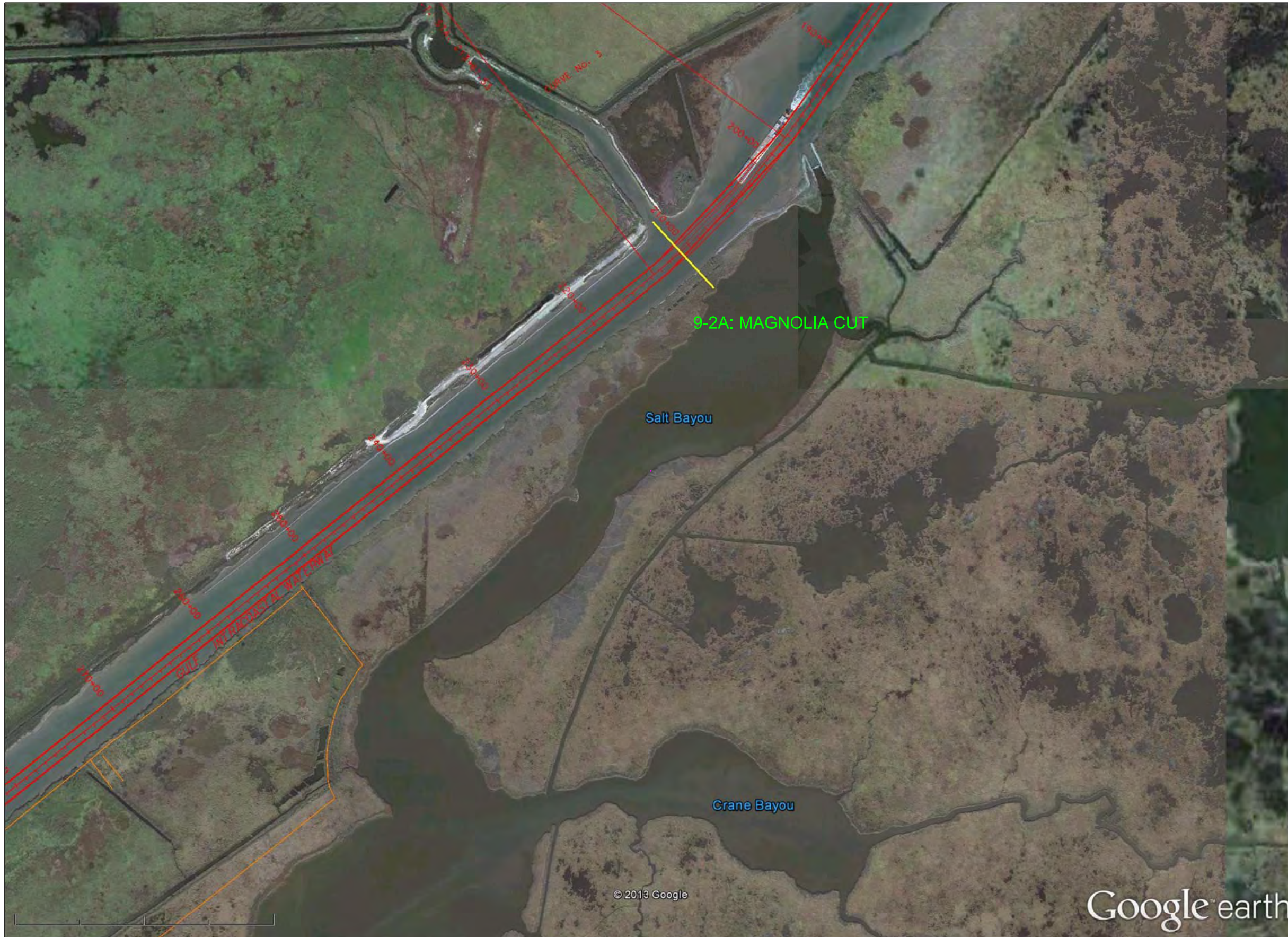
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Measure 9-2: Inverted Siphons Under GIWW, Magnolia Cut, Jefferson County



## Legend

— Measure 9-2A

- PLACEMENT AREA LIMITS
- CHANNEL CURVE LIMIT DIMENSION
- CHANNEL TOE
- CHANNEL CENTERLINE
- CHANNEL TOE
- CHANNEL STATIONS



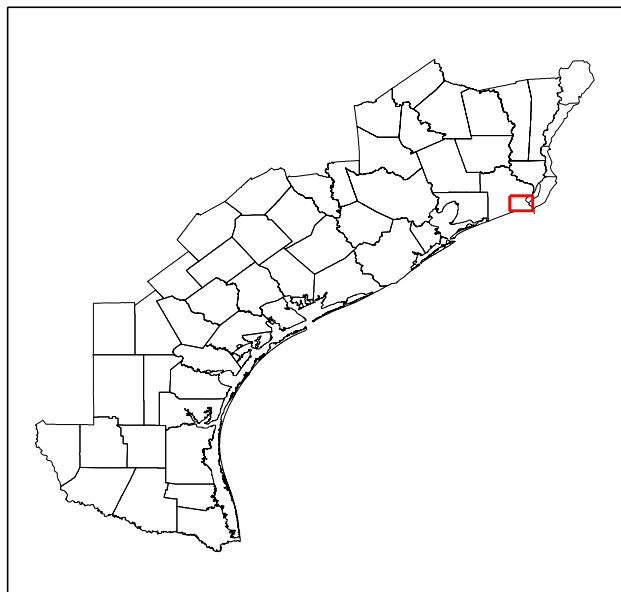
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Date Created: 4/15/2013






Measure 9-2: Inverted Siphons Under GIWW, Oil Field Cut, Jefferson County




## Legend

- Measure 9-2B
- PLACEMENT AREA LIMITS
- CHANNEL CURVE LIMIT DIMENSION
- CHANNEL TOE
- CHANNEL CENTERLINE
- CHANNEL TOE
- CHANNEL STATIONS



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Date Created: 4/15/2013



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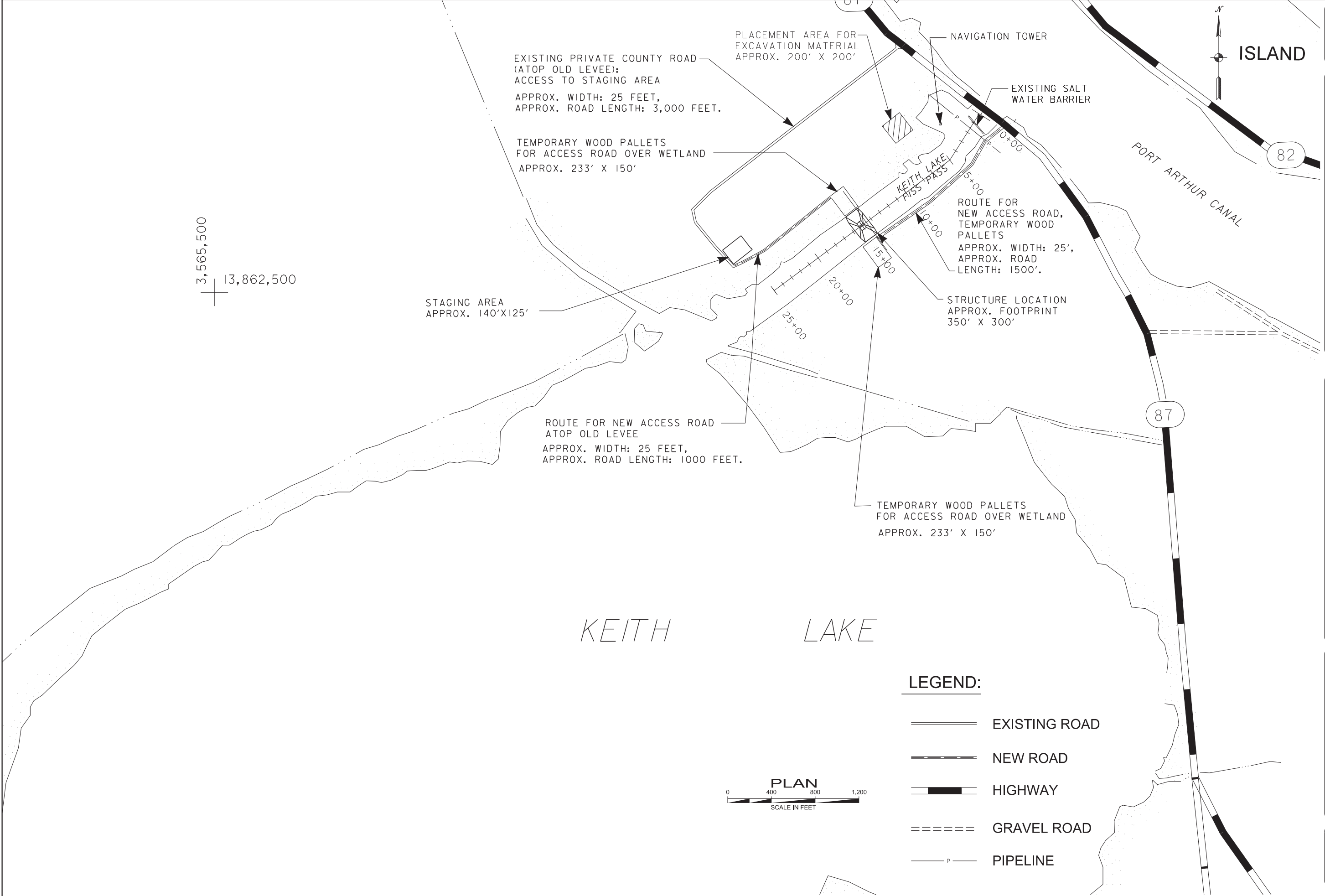

Drawn by: P.N.C.	Date: SEPT, 2011	Rev.
Designed by: C.M.C.	Scale: AS SHOWN	
Checked by: C.M.C.	Approval:	
Submitted by: LORI K THOMAS, P.E.	Approval Recommended by:	
Chief Geotechnical Section	JOSEPH L. KINGS, P.E.	Chief, Engineering Branch
Approved by: ROBERT B.C. HOWELL, P.E.	Deputy Chief, Engineering and Construction Division	

U.S. ARMY ENGINEER DISTRICT, GALVESTON  
CORPS OF ENGINEERS  
GALVESTON, TEXAS  
PREPARED UNDER THE DIRECTION OF  
CHRISTOPHER W. SALLESE, Col., C.E.,  
DISTRICT COMMANDER

SABINE-NECHES WATERWAY, TEXAS  
KEITH LAKE FISH PASS  
SECTION 1135 PROJECT  
PLAN VIEW

Drawing No.:  
**F-02**  
Sheet 2 of XX  
File No. xxx XXX-XXX

File: W:\Cadd\Projects\Keith Lake\Drawings\F-02-(PLAN).dgn  
TIME: 12/25/11 PM



**ISLAND**

PORT ARTHUR CANAL

**LEGEND:**

- ===== EXISTING ROAD
- ===== NEW ROAD
- ====+==== HIGHWAY
- ===== GRAVEL ROAD
- P ----- PIPELINE

**PLAN**  
SCALE IN FEET

*KEITH LAKE*

STAGING AREA  
APPROX. 140' X 125'

EXISTING PRIVATE COUNTY ROAD  
(ATOP OLD LEVEE):  
ACCESS TO STAGING AREA  
APPROX. WIDTH: 25 FEET,  
APPROX. ROAD LENGTH: 3,000 FEET.

TEMPORARY WOOD PALLETS  
FOR ACCESS ROAD OVER WETLAND  
APPROX. 233' X 150'

ROUTE FOR NEW ACCESS ROAD  
ATOP OLD LEVEE  
APPROX. WIDTH: 25 FEET,  
APPROX. ROAD LENGTH: 1000 FEET.

ROUTE FOR  
NEW ACCESS ROAD,  
TEMPORARY WOOD  
PALLETS  
APPROX. WIDTH: 25',  
APPROX. ROAD  
LENGTH: 1500'.

STRUCTURE LOCATION  
APPROX. FOOTPRINT  
350' X 300'

TEMPORARY WOOD PALLETS  
FOR ACCESS ROAD OVER WETLAND  
APPROX. 233' X 150'

PLACEMENT AREA FOR  
EXCAVATION MATERIAL  
APPROX. 200' X 200'

NAVIGATION TOWER

EXISTING SALT  
WATER BARRIER

KEITH LAKE  
FISH PASS

82

87

3,565,500  
+  
13,862,500

Rev.	Description	Date	By

Drawn by:	P.N.	Date:	SEPT. 2011
Designed by:	C.M.C.	Scale:	AS SHOWN
Checked by:	C.M.C.	Approval:	Recommended
Submitted by:	C.M.C.	Approved by:	JOSEPH L. KING, P.E. Chief, Civil/Structural Section
			Chief, Engineering Branch
			ROBERT B.C. HOWELL, P.E. Deputy Chief, Engineering and Construction Division

U.S. ARMY ENGINEER DISTRICT, GALVESTON  
CORPS OF ENGINEERS  
GALVESTON, TEXAS

PREPARED UNDER THE DIRECTION OF  
CHRISTOPHER W. SALLESE, Col., C.E.,  
DISTRICT COMMANDER

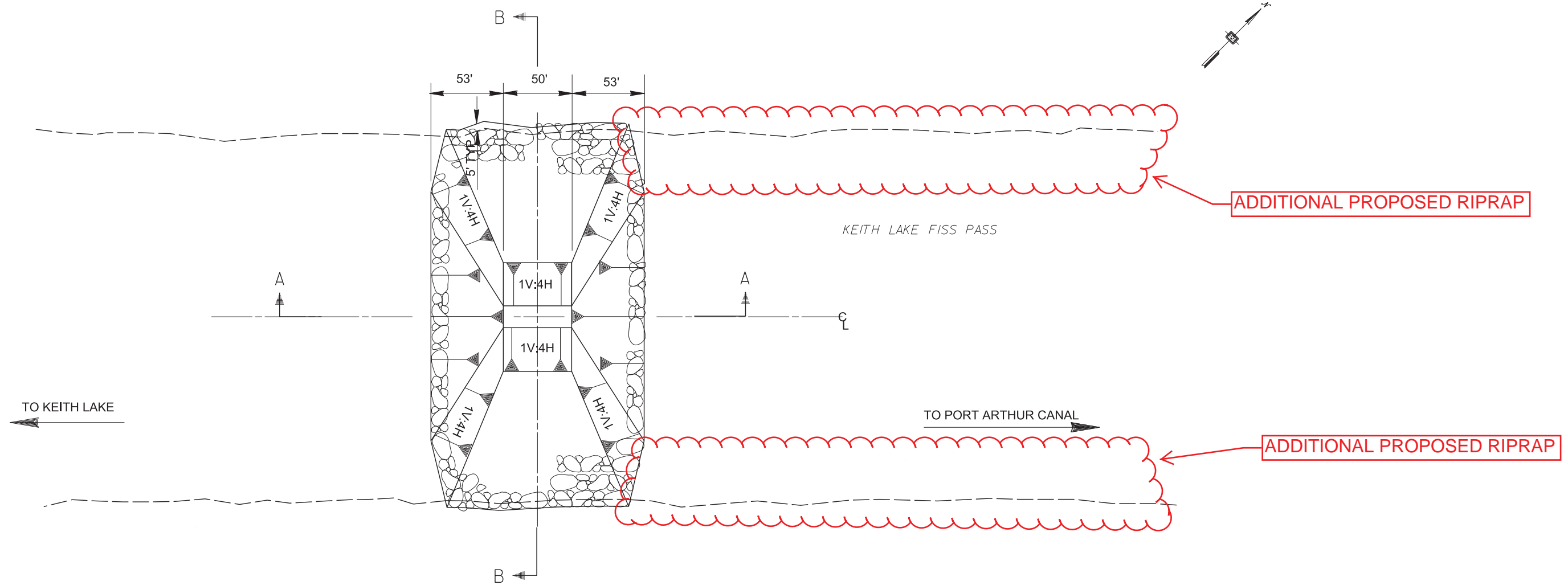
SABINE-NECHES WATERWAY, TEXAS  
KEITH LAKE FISH PASS  
SECTION 1135 PROJECT

FISH PASS  
PLAN VIEW AND SECTION

Drawing No.:  
**F-03**

Sheet of XX  
File No. xxx XXX-XXX

BY: M8ECPXJN DATE: 11/30/2011 TIME: 11:18:31 AM



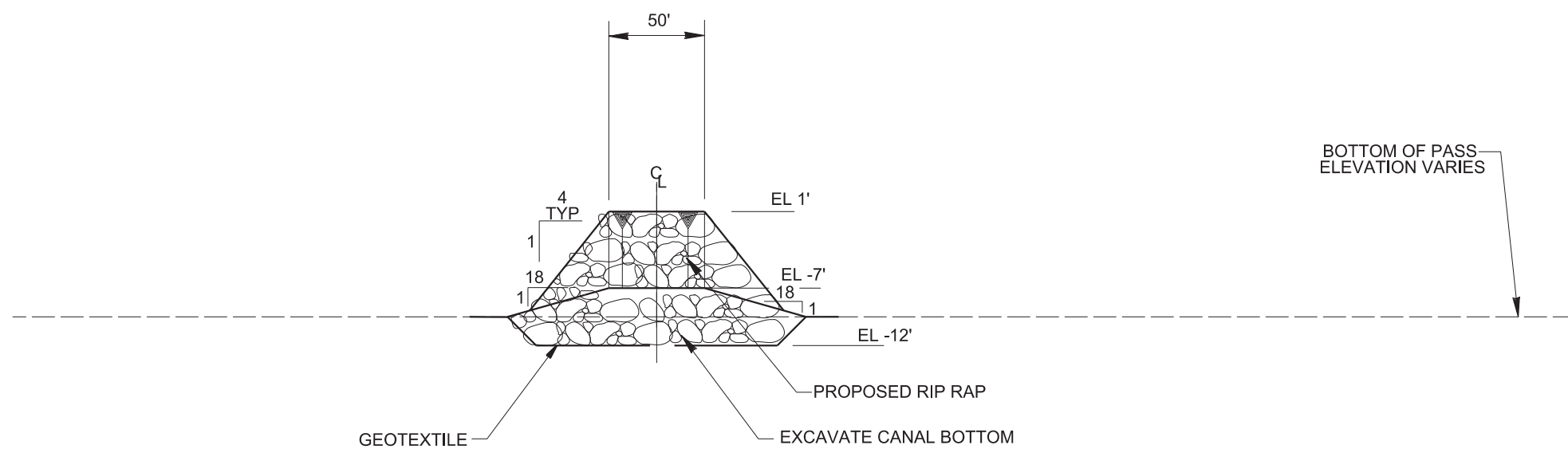
PLAN VIEW

PLAN

SCALE IN FEET



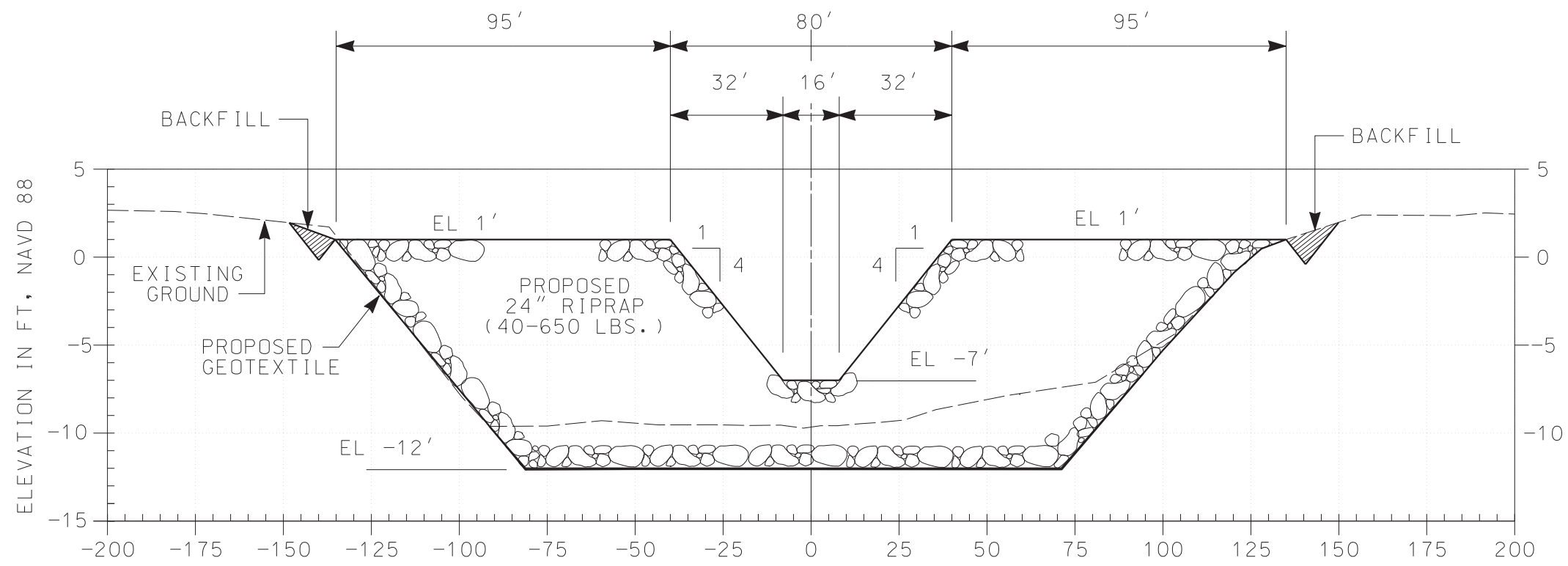
NOTE:  
1. SEE SHEET F-04 FOR SECTION B-B.



SECTION A-A



Rev.	Description	Date	By



SECTION B-B  
SCALE: AS SHOWN

DATUM	
NAVD 88	MLLW
0'	0.42'
-7.0'	-7.42'

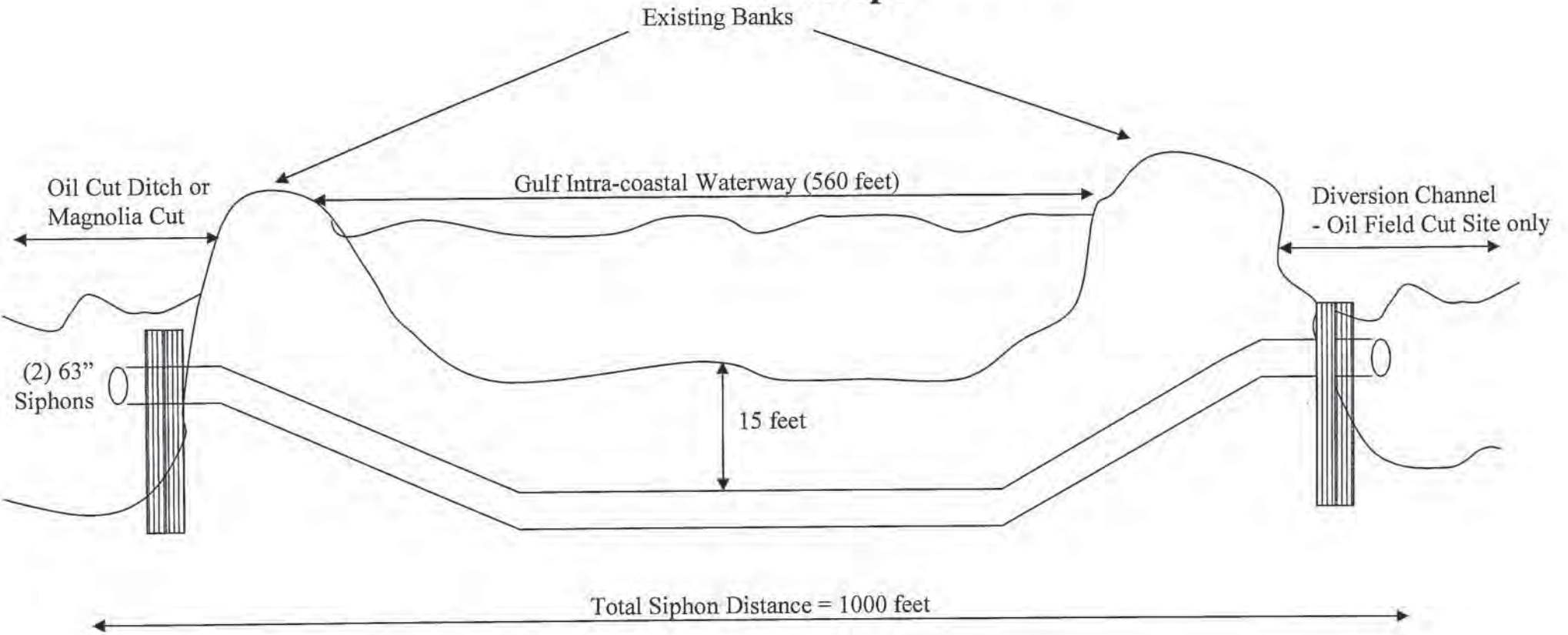
- NOTE:
- SEE SHEET F-03 FOR PLAN VIEW.
  - GEOTEXTILE FABRIC TO BE TURNED DOWN 2' AT 1V:1H SLOPE.

Drawn by:	P.N.	Date:	SEPT. 2011	Rev.
Designed by:	C.M.C.	Scale:	AS SHOWN	
Checked by:	C.M.C.	Approval:	Recommended:	
Submitted by:	LORI K THOMAS, P.E.	Submitted by:	JOSEPH L. KING, P.A.	
	Chief Geotechnical Section		Chief, Engineering Branch	
	Approved by:	ROBERT B.C. HOWELL, P.E.	Deputy Chief, Engineering and Construction Division	
U.S. ARMY ENGINEER DISTRICT, GALVESTON CORPS OF ENGINEERS GALVESTON, TEXAS				
PREPARED UNDER THE DIRECTION OF CHRISTOPHER W. SALLESE, Col., C.E., DISTRICT COMMANDER				

SABINE-NECHES WATERWAY, TEXAS  
KEITH LAKE FISH PASS  
SECTION 1135 PROJECT  
FISH PASS  
SECTION B-B

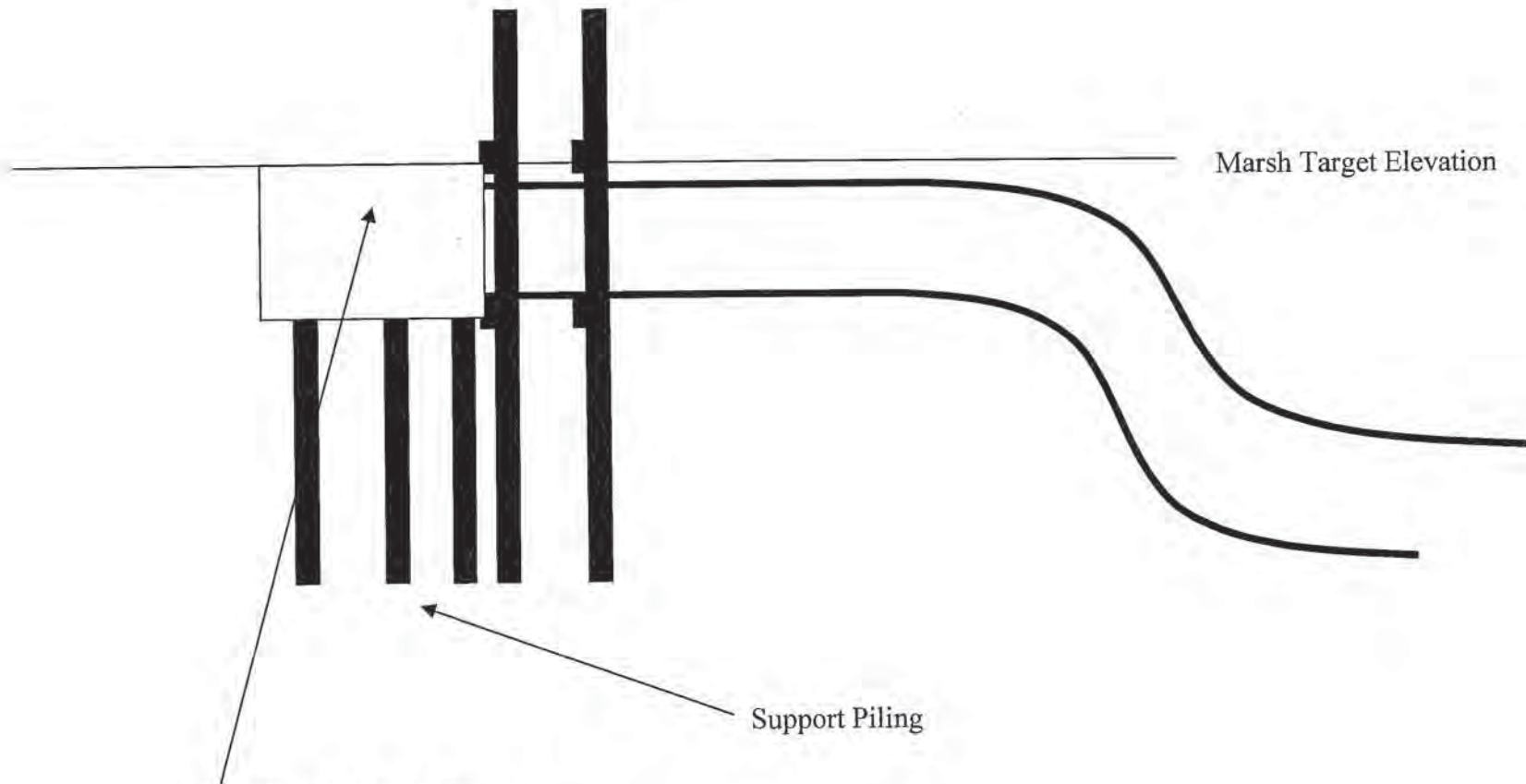
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**F-04**  
Sheet 4 of XX  
File No. xxx XXX-XXX

# Siphon Cross Section View Concept



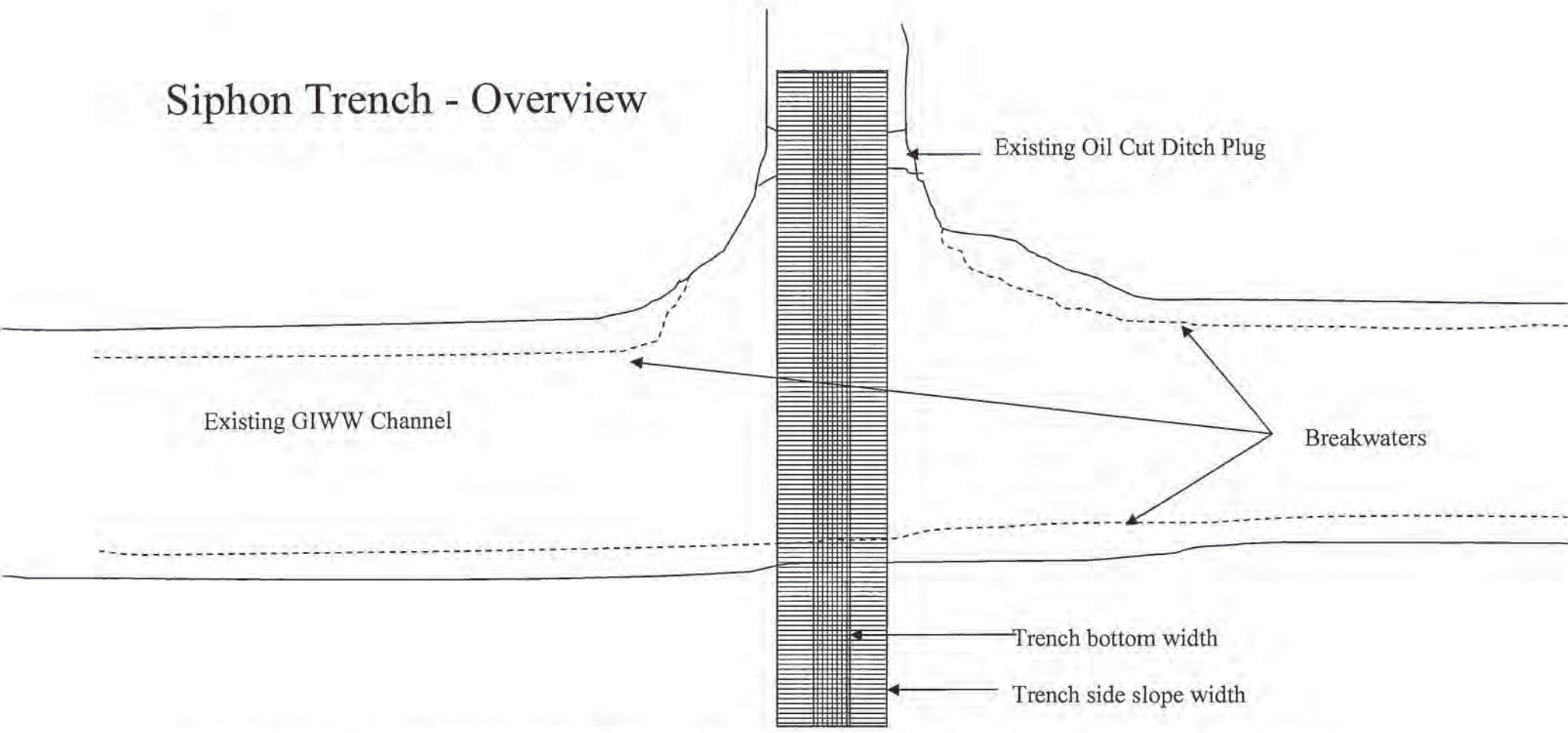


# North End of Siphons – Box intake



Aluminum box with open top  
Top elevation set to marsh elevation.  
Box will be 10 feet long and 10 feet wide with aluminum grate covering the top

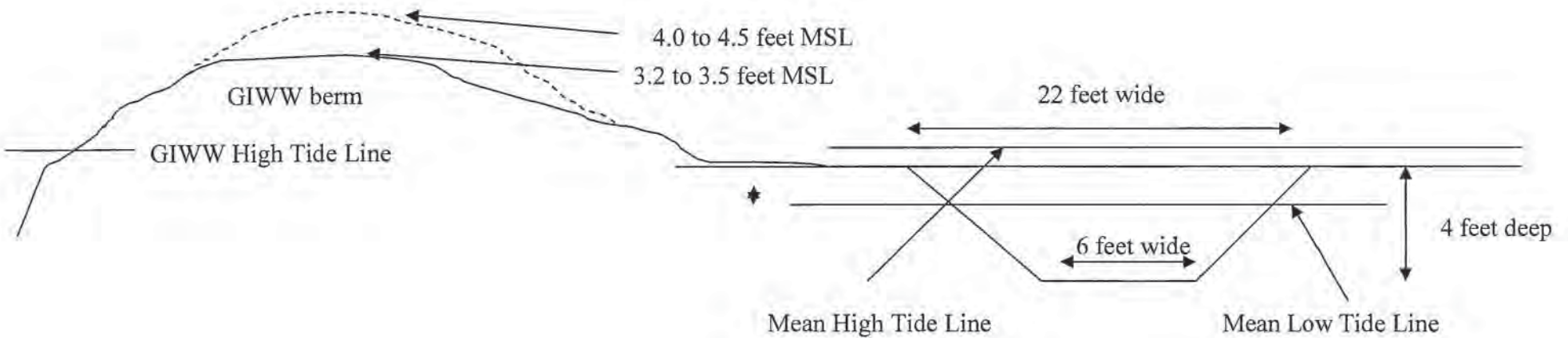
# Siphon Trench - Overview



Trench will have a depth of 33 feet (6' for pipe + 15' below channel depth + 12' channel) and bottom width of 18 feet. Trench side slope with will be a 1:1 ratio and extend 21 feet either side of center of trench. Total Trench width will be 60 feet wide.



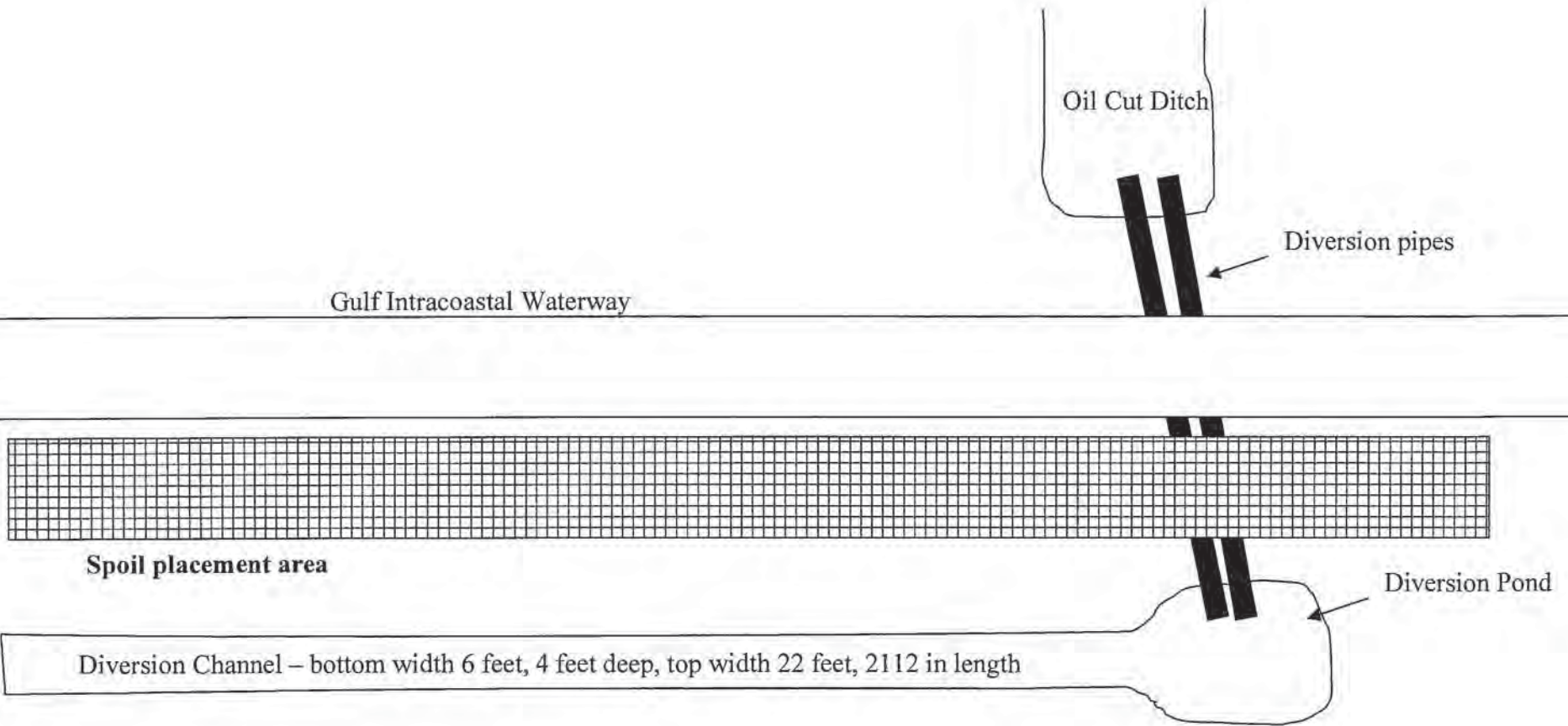
## Cross Section View of Diversion Channel



- Water depth at mean high tide is 2 inches above marsh elevation.
- Water depth at mean low tide is 6 inches above marsh elevation.
- Tidal exchange limited to sheet flow across the marsh from Barnett Lake located over 2200 feet away.
- Channel construction will require 4646 cubic yards of spoil to be removed from ditch, to be placed on the existing GIWW spoil shoreline
- Diversion channel moves water to the west into the Wild Cow Bayou marsh then through structures into the marsh surrounding Barnett Lake.
- GIWW shoreline will be elevated between 1 to 2 feet with spoil material to help stop salt water intrusion from the GIWW.

Notice: These water levels are inside a structurally controlled area.

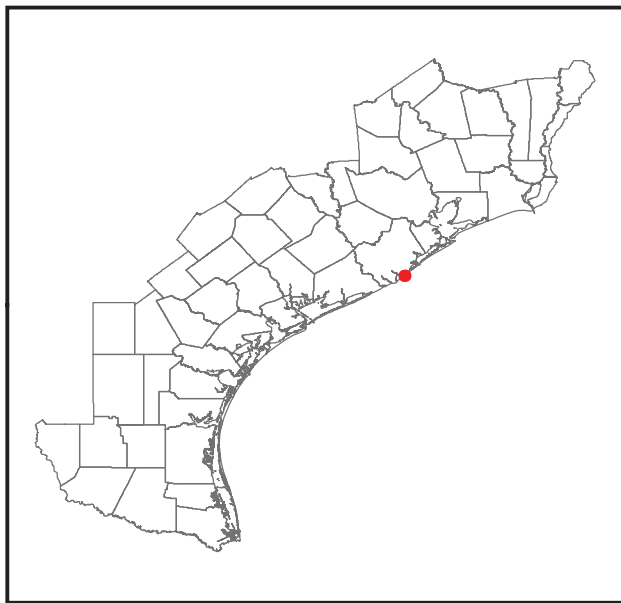
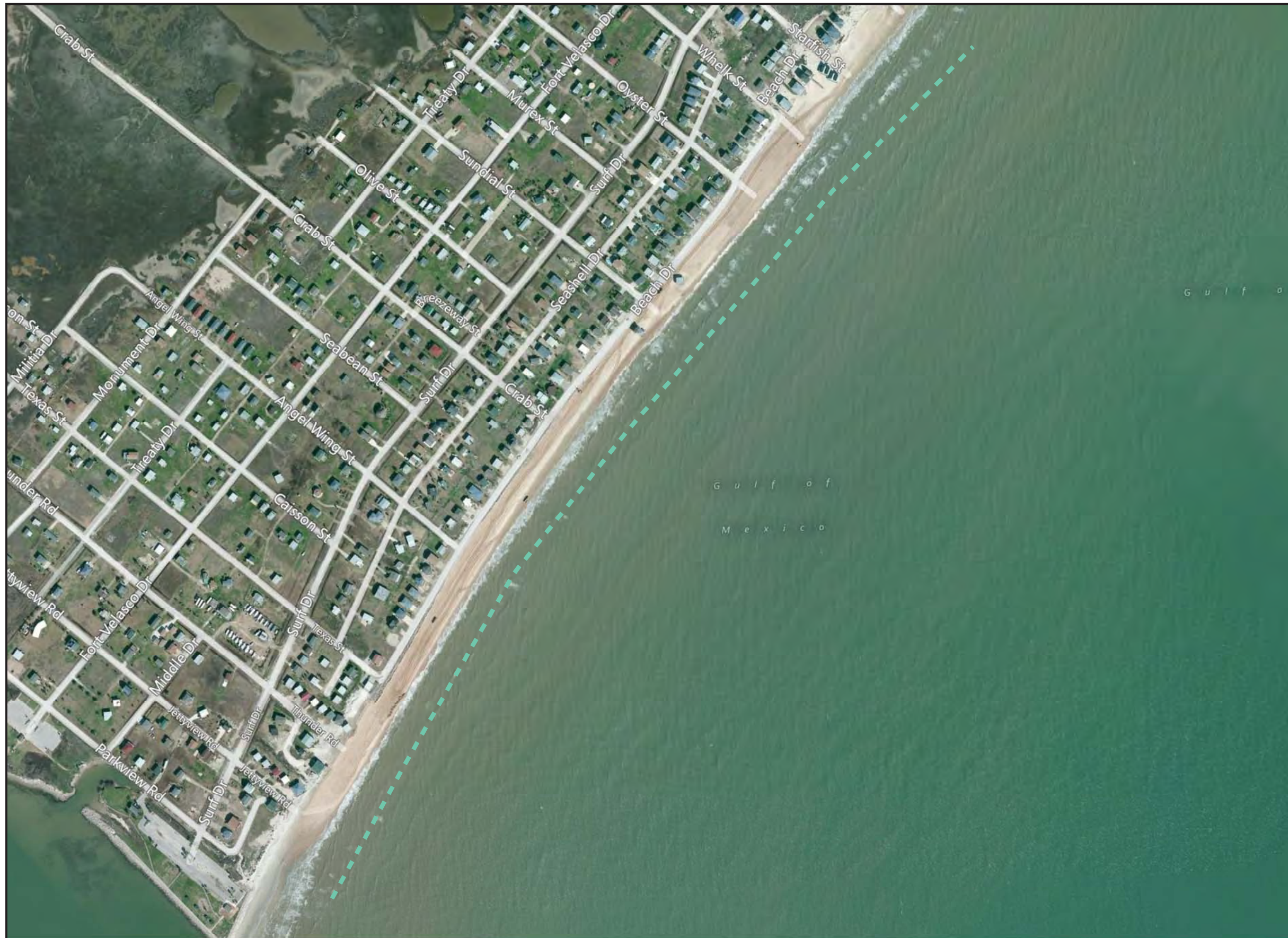
# Aerial View of Siphon and Diversion Channel



Diversion Channel's spoil material will be place on the existing shoreline to increase GIWW elevation to stop salt water intrusion. Diversion channel will create 4646 cubic yards of material from the ditch will be placed on the existing shoreline berm. Pond will be 30 feet diameter with a depth of 8 feet. Spoil material to be placed on GIWW shoreline berm. Pond will create 267 cubic yards of material from the pond site which will be placed on the existing shoreline berm.

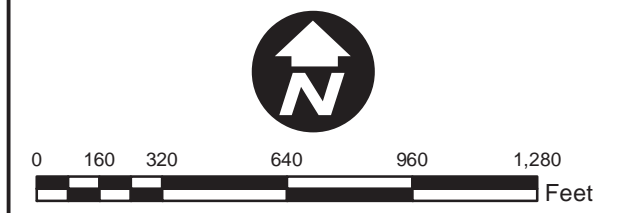


## Measure 5-15: Brazoria County - Segmented Near-Shore Breakwaters



### Legend

 Submerged Breakwaters



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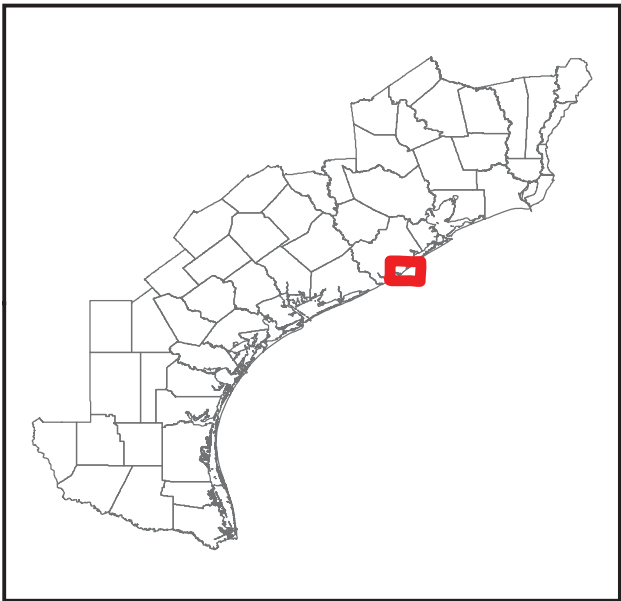
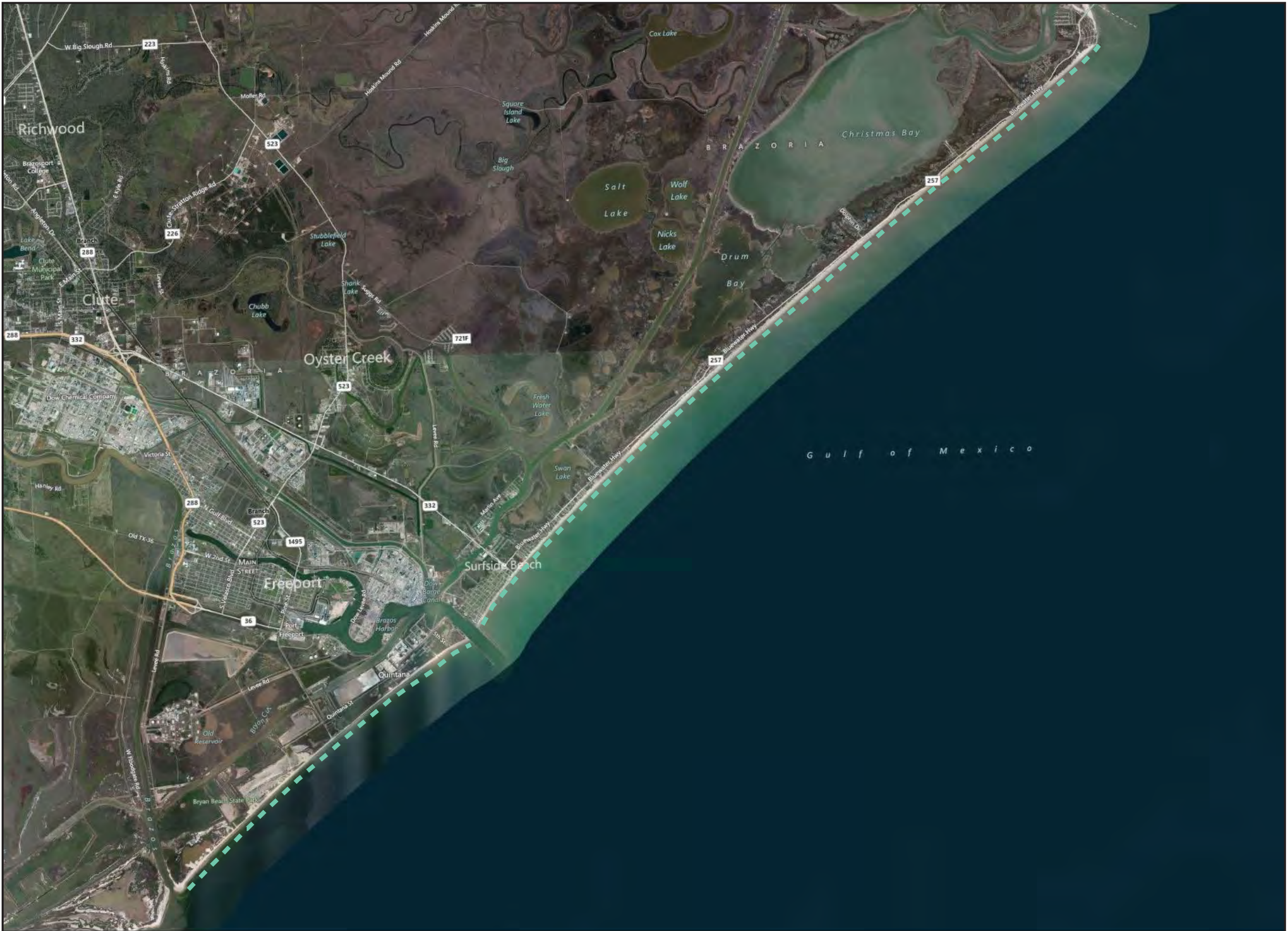
Date Created: 2/26/2013







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

**Measure 5-15: Segmented Nearshore Breakwaters, San Luis Pass to Brazos River Diversion Channel, Brazoria County**



**Legend**

- - - Nearshore Breakwaters
- - - Nearshore Breakwaters

  
 0 2,800 5,600 11,200 16,800 22,400  
 Feet

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