# Indian Point Shoreline Protection Feasibility Study

**Publication CBBEP – 79**
**Project Number – 1115**
**June 2012**

**<u>Prepared by</u>**

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Submitted to:
**Coastal Bend Bays & Estuaries Program**
1305 N. Shoreline Blvd. Ste 205
Corpus Christi, Texas 78401

# Indian Point Shoreline Protection Feasibility Study

## CBBEP Work Order No. ES/HDR-1115-3

# Technical Memorandum

**Prepared for:**

COASTAL BEND BAYS & ESTUARIES PROGRAM

1305 N Shoreline Boulevard, Suite 205
Corpus Christi, Texas 78401

**June 2012**

HDR

HDR Engineering, Inc.
Texas Registration No. 754
HDR Project No. 185186

STATE OF TEXAS
RONALD L. McPHERSON
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LICENSED
PROFESSIONAL ENGINEER
6/1/2012

# EXECUTIVE SUMMARY

A feasibility study was performed to assess methods to help protect wetlands, seagrass, and other related aquatic and coastal habitat at Indian Point from erosion associated with shoreline retreat. In addition to the benefits of protecting valuable habitat, the project would also provide an increased level of protection to public infrastructure at Indian Point Park including a roadway, parking lot, and pier entrance. This feasibility study is intended as a precursor to development of a U.S. Army Corps of Engineers (USACE) permit application.

To support development of engineering concepts, a reconnaissance-level characterization of existing site conditions was conducted including compilation of metocean data, a topographic/bathymetric survey, and cursory delineation of seagrass. Historical aerial photographs, historical shorelines, and published shoreline change rates were reviewed to assess long-term shoreline changes and general trends. Based on this review, the shorelines along both sides (east and west) of Indian Point have experienced significant erosion. The west side appears to have experienced up to 470 ft of shoreline retreat from 1958 to 1985, likely exacerbated by impacts from Hurricanes Beulah, Celia, and Allen. The east side appears to be experiencing significant chronic erosion, with approximately 85 ft of shoreline retreat from 2005 to 2011 (~14 ft/yr) in some areas. The point itself has not historically experienced significant erosion, likely due to continued maintenance of the area and the shoreline being lined with concrete rubble/debris.

The general concept for the proposed shoreline protection system has two parts, with the primary component being a riprap (quarrystone) breakwater located seaward of existing seagrass on both sides of the point. The secondary component would address protection directly at the point adjacent to park infrastructure. Three options were considered for this location: (1) no action (because this area is presently lined with concrete rubble), (2) a riprap revetment, and (3) continuation of the segmented breakwater. Conceptual-level layouts and cross-sections were developed for these concepts.

Based on the conceptual-level design, approximate construction costs were developed to assist with project planning and budgeting. The conceptual-level opinion of construction cost for each approach is as follows:

| | |
|---|---|
| (1) Segmented breakwater with no action at point: | $3,286,000 |
| (2) Segmented breakwater with revetment at point: | $3,466,000 |
| (3) Segmented breakwater along entire project length: | $3,558,000 |

Considering potential cost and performance, the recommended approach for proceeding with preparation of a U.S. Army Corps of Engineers permit application is Option 2, a segmented breakwater with a revetment at the point. If the project proceeds to detailed design, additional engineering should include a geotechnical investigation to assess soil foundation conditions, wave numerical modeling to further assess breakwater alignment and gap spacing, and more detailed topographic/bathymetric survey to better characterize existing site conditions and estimate construction/material quantities.

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# 1.0 INTRODUCTION

## 1.1 Authorization

This document was prepared under contract with the Coastal Bend Bays and Estuaries Program (CBBEP), Work Order Number ES/HDR-1115-03. Authorization for this Work Order was issued on May 14, 2012 by Mr. Ray Allen at CBBEP. Mr. Dustin Cravey served as CBBEP's project manager.

## 1.2 Overview and Purpose

The purpose of this memorandum is to document data gathering, site investigation findings, and conceptual-level engineering analyses for shoreline protection at Indian Point. The primary project goal is to protect seagrass, wetlands, and related habitat at Indian Point from shoreline erosion/retreat. A secondary benefit of the project is to provide an increased level of protection to the public infrastructure located at Indian Point Park including a roadway, parking lot, and pier entrance. The results of this feasibility study will be applied to develop a U.S. Army Corps of Engineers permit application and to assist with planning and budgeting for potential project implementation.

The project site, Indian Point Park, is on the northwest perimeter of Corpus Christi Bay along the Portland Causeway. The area being targeted for shoreline protection extends approximately 5,200 ft northeast from the southern tip of Indian Point Peninsula (at the causeway), a straight-line distance of approximately 4,000 ft. Figure 1.1 provides the general project location and Figure 1.2 shows an aerial photograph of the proposed shoreline protection location.

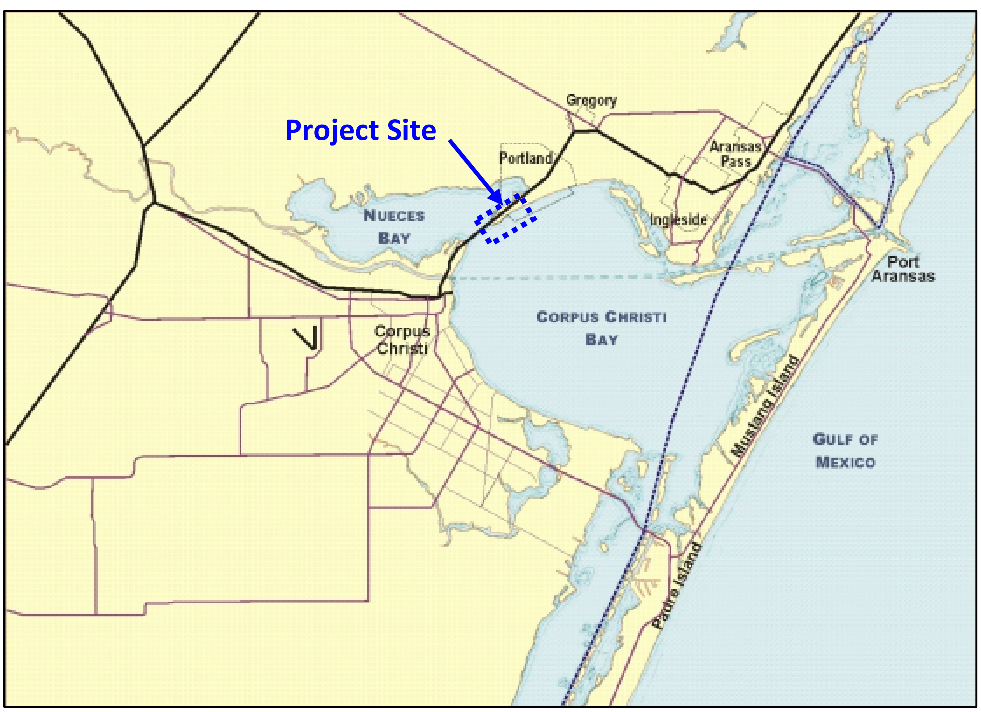


**Figure 1.1 General location map.**

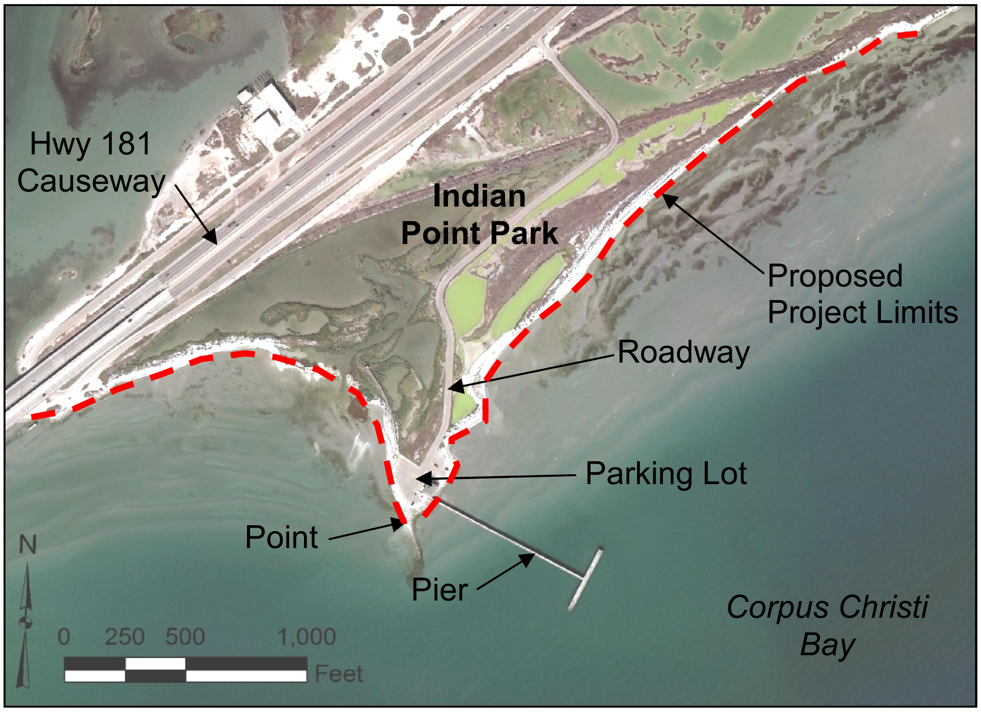


**Figure 1.2 Aerial of proposed project location.**

# 2.0 EXISTING CONDITIONS

## 2.1 Bathymetry and Topography

Bathymetric and topographic surveys of the project area were performed by Naismith Marine Services, Inc. on May 16, 2012. The elevations are referenced to NAVD (North American Vertical Datum of 1988). The survey included 10 beach transects beginning on land and extending offshore to an elevation of -6 ft to -10 ft NAVD. In addition, bathymetry was collected along a shore-parallel transect approximately 700 ft to 1,000 ft from the shoreline.

The nearshore area along the site consists of a shallow shelf with elevations ranging from 0 ft to -2 ft NAVD and a width of 500 ft to 700 ft in most areas. Near the point (where the pier is located) the shelf is narrowest, approximately 200 ft. The nearshore has prominent sandbars along the entire length of the project shoreline. Seaward of the shelf, the depth rapidly increases to approximately -8 ft to -10 ft NAVD at a slope of approximately 50H:1V.

The upper shoreface is relatively steep with a slope of approximately 10H:1V. The dry beach is narrow and typically reaches an elevation of +4 ft NAVD before decreasing in elevation and transitioning to wetlands. The dry beach primarily consists of sand, shells, and shell fragments, which contributes to steepness of the upper shoreface.

Figure 2.1 shows the survey data in plan-view. Survey transects are labeled T1 through T10. Selected transects were plotted in profile view and are shown in Figure 2.2.

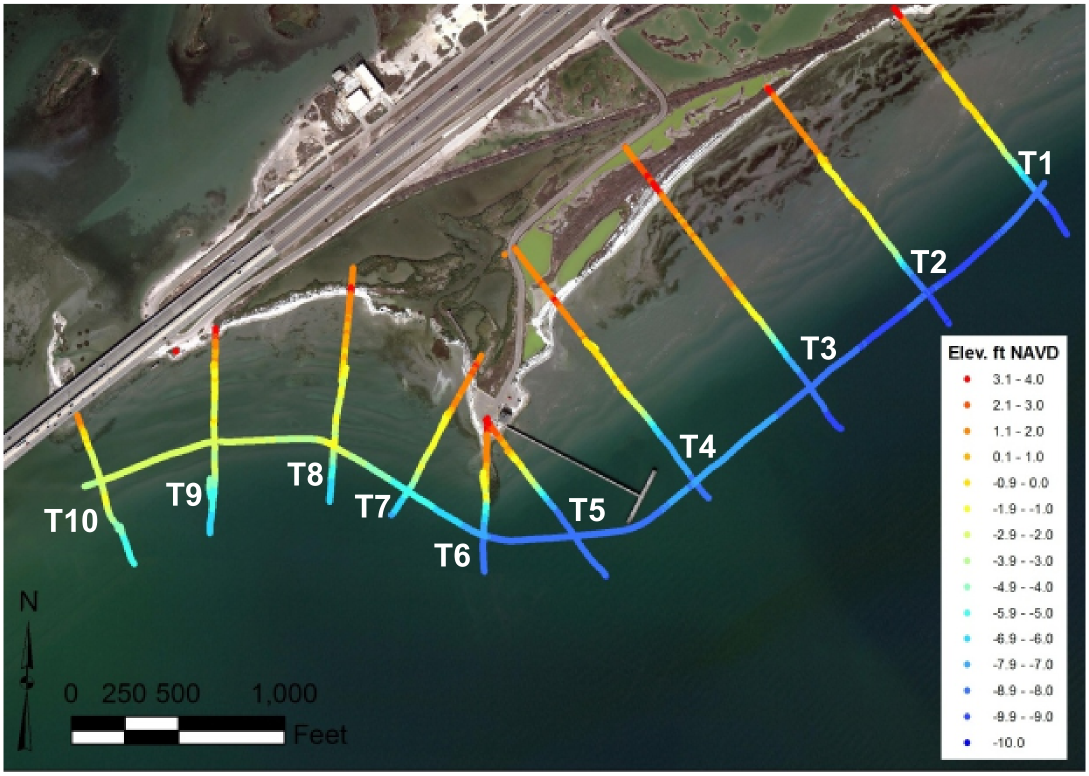


Figure 2.1 Plan-view of survey data.

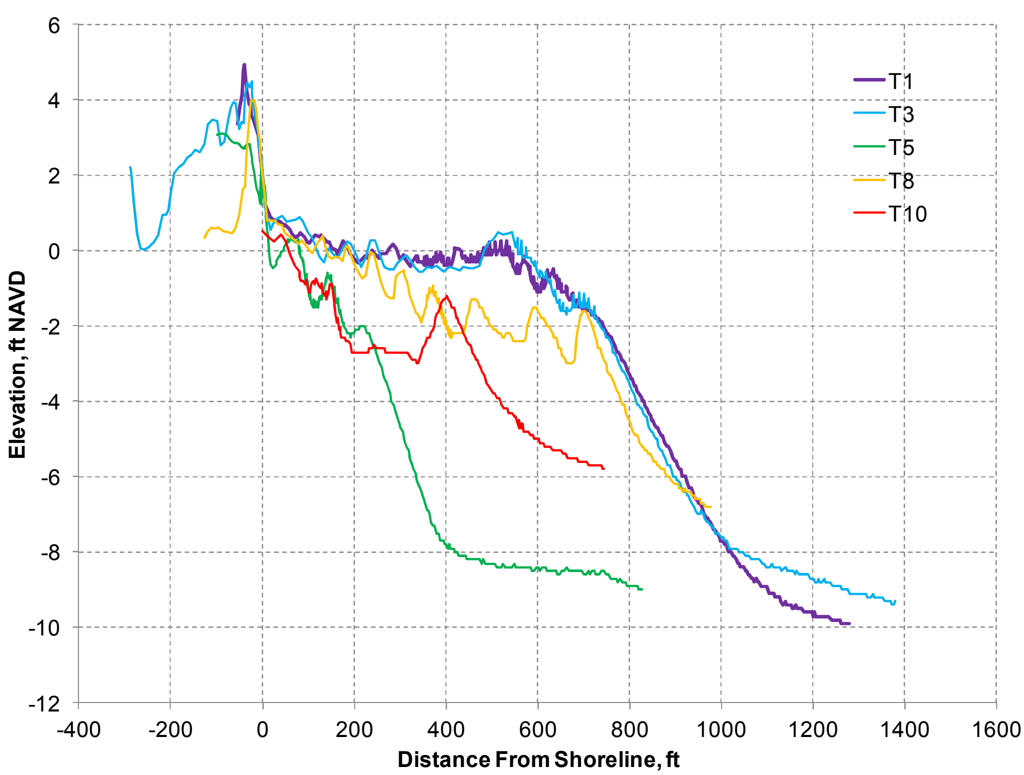


Figure 2.2 Select survey transects (transect labels correspond to Figure 2.1).

## 2.2 Water Levels

Water level data were obtained from the Texas Coastal Ocean Observation Network (TCOON) Station 008 at the Texas State Aquarium. Figure 2.3 shows the location of the TCOON stations in the general area of the project. Based on the Texas State Aquarium station, the greater diurnal tide at the northwestern portion of Corpus Christi Bay is approximately 0.6 ft. Tidal datums are shown referenced to NAVD in Table 2.1. Water level data were gathered for the period from 2002 to 2012 and are summarized based on frequency of exceedance in Figure 2.4. Based on this plot, the water level is between +0.3 ft and +2 ft approximately 90% of the time.

Extreme water level information was gathered from the Federal Emergency Management Agency (FEMA) Flood Insurance Study (FIS) of San Patricio County. According to the FIS, the 10, 50, and 100 year return period still water elevations are 2.1, 7.9, and 9.4 ft NAVD, respectively (FEMA 2004).

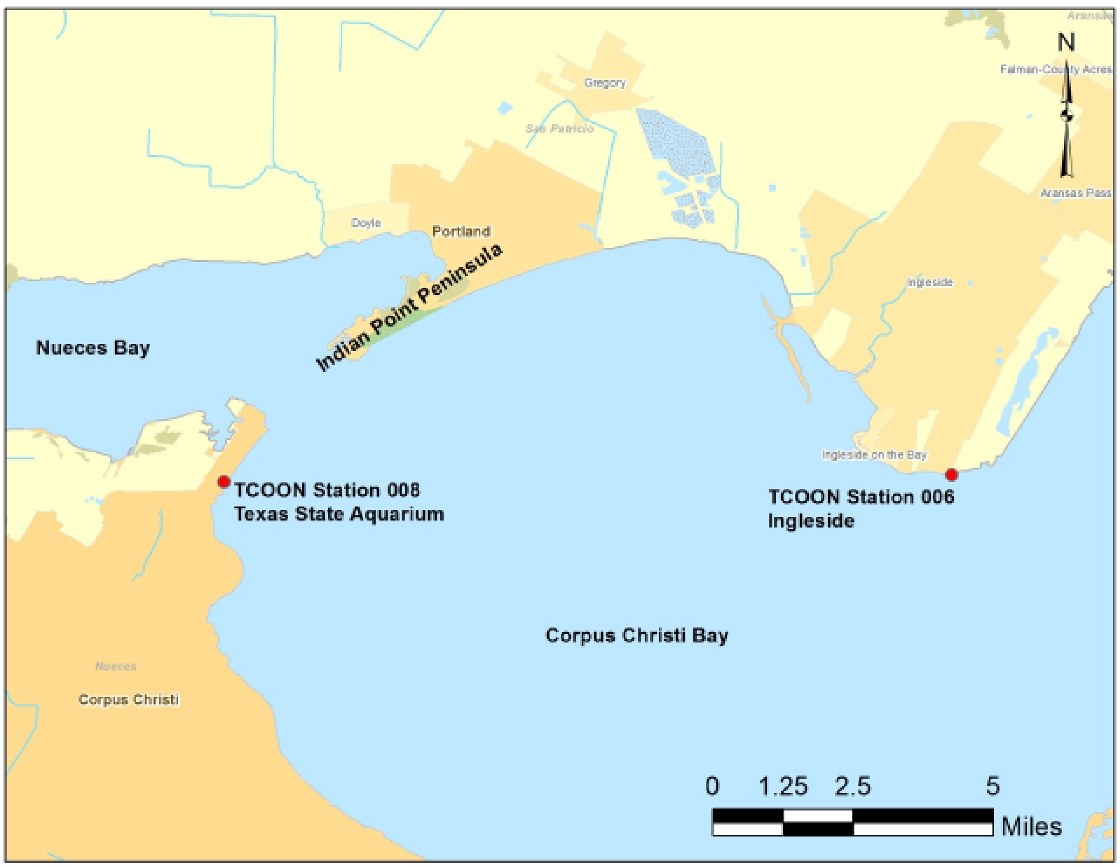


**Figure 2.3 Location of TCOON stations.**

| Table 2.1 Tidal Datum at TCOON Station 008, TX State Aquarium | |
|---|---|
| **Datum** | **Elevation (ft, NAVD)** |
| MHHW | 1.03 |
| MHW | 1.02 |
| MSL | 0.75 |
| MLW | 0.41 |
| MLLW | 0.39 |

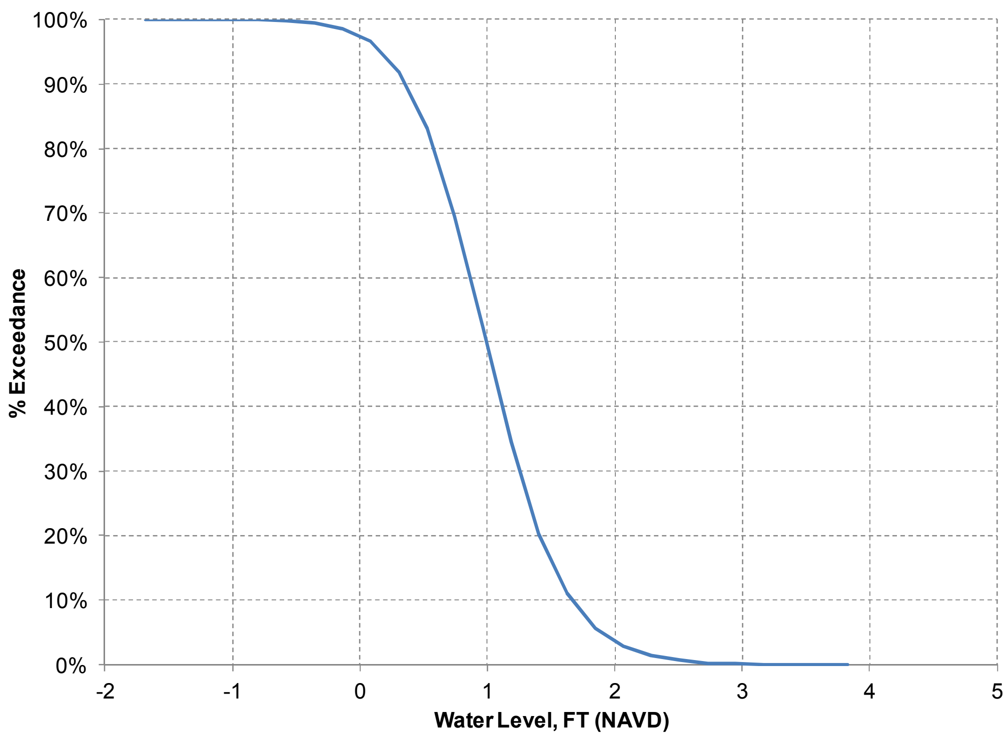


**Figure 2.4 Tidal exceedance at TCOON Station 008, Texas State Aquarium from 2002-2012.**

## 2.3 Wind Climate

Extreme wind statistics for coastal areas within the United States are available from ASCE (2002). For the northern Corpus Christi Bay area, wind speed is plotted as a function of return period in Figure 2.5. Both 20-minute average and 3-second gust wind speeds are shown in Figure 2.5 for comparison.

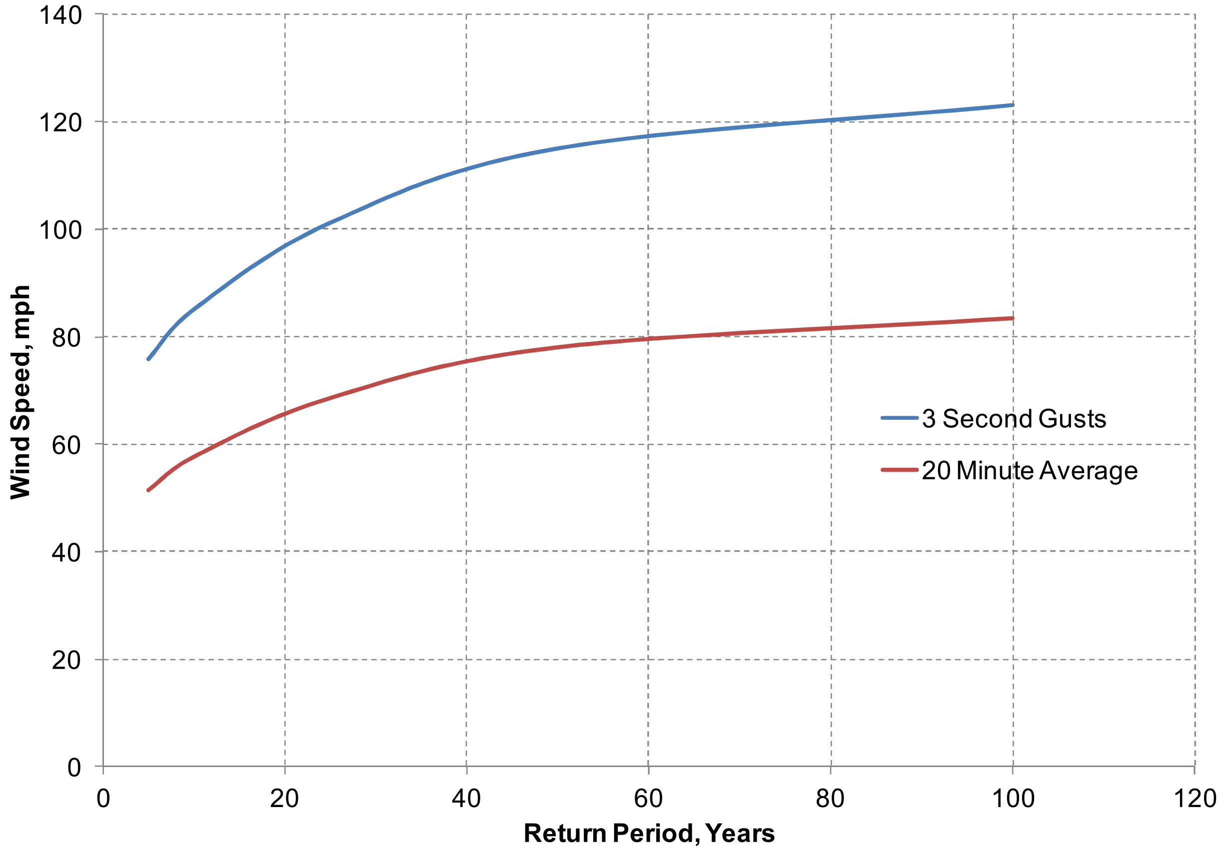


**Figure 2.5 Extreme wind speed based on Return Period (ASCE 2002).**

The nearest TCOON station having readily-available wind data is TCOON Station 006 at Ingleside. Figure 2.6 shows a wind rose developed from this station from 2002 to 2012. Wind roses provide a graphical means of describing the intensity and direction of wind. The wind speed shown in Figure 2.6 represents the 20-minute average.

From Figure 2.6, it can be seen that the majority of the wind, as well as the fastest winds, typically come from the southeast. An outline of Indian Point Peninsula is overlaid on the wind rose to help visualize shoreline orientations relative to the wind directions.

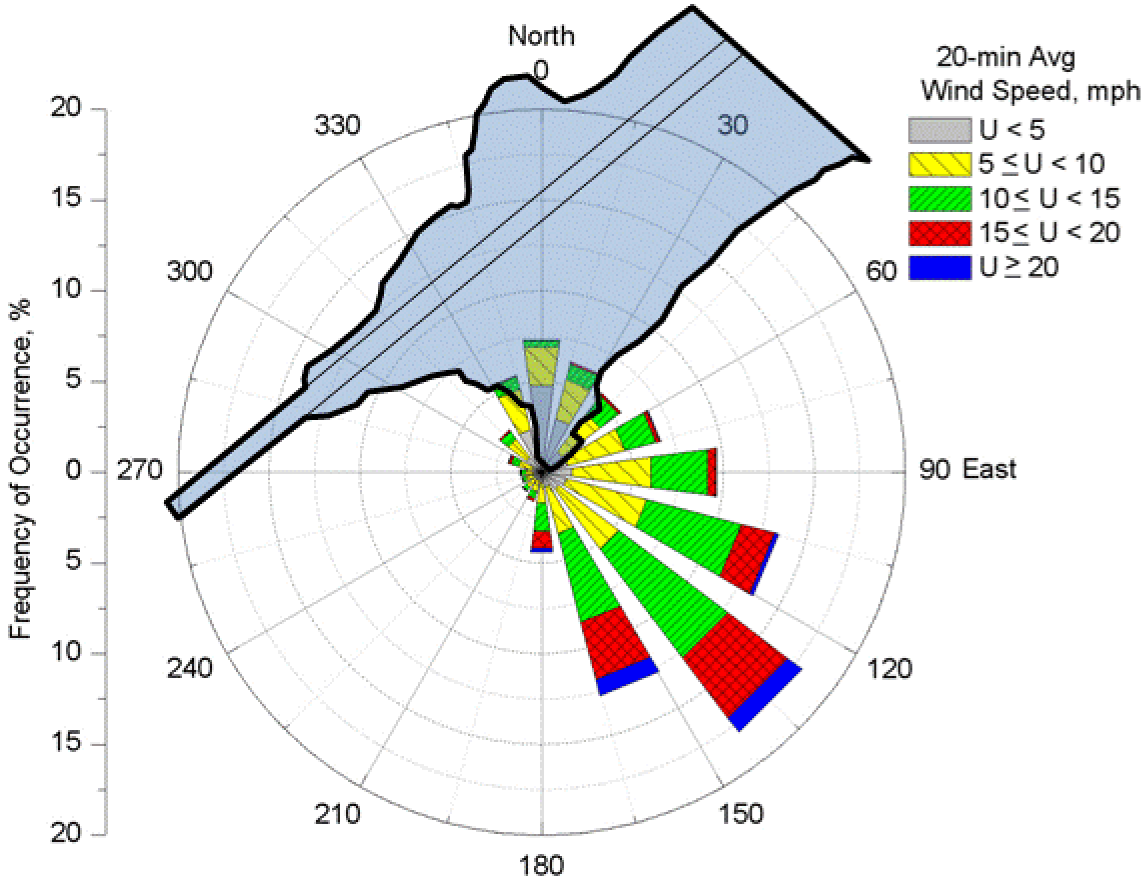


**Figure 2.6 Hindcast wind rose using TCOON Station 006, Ingleside from 2002-2012.**

## 2.4 Site Investigation and Cursory Survey of Habitat

A site visit was performed by HDR on May 21, 2012 to assess the general condition of the shoreline and nearshore areas as well as perform a cursory-level biological assessment of the project area. During the site visit the nearshore area along the entire project limits was walked to locate the approximate seaward limit of seagrass and help identify any other areas of biological significance. Figure 2.7 shows the approximate limit of seagrass as delineated during the site visit and supplemented with 2011 aerial photography. Ground photographs taken during the site visit are provided in Appendix A.

The following are notable observations made during the site visit:

- The upper shoreface and dry beach consists primarily of shell and shell fragments mixed with sand transitioning to a high marsh/upland ridge backed by intertidal wetlands.
- The shoreline adjacent to the parking lot, pier, and causeway is lined with concrete rubble/debris.
- The groin-like feature extending into the bay from the point consists of concrete rubble/debris.
- Nearshore sediments appear to be primarily sand with some silt. Sediments near the point and northwest of the point contain shell fragments

- No live oysters were observed.
- Local scour at the pier pilings was not observed to be significant (typically on the order of 0.5 ft).
- No significant scarps or obvious evidence of recent erosion were observed.

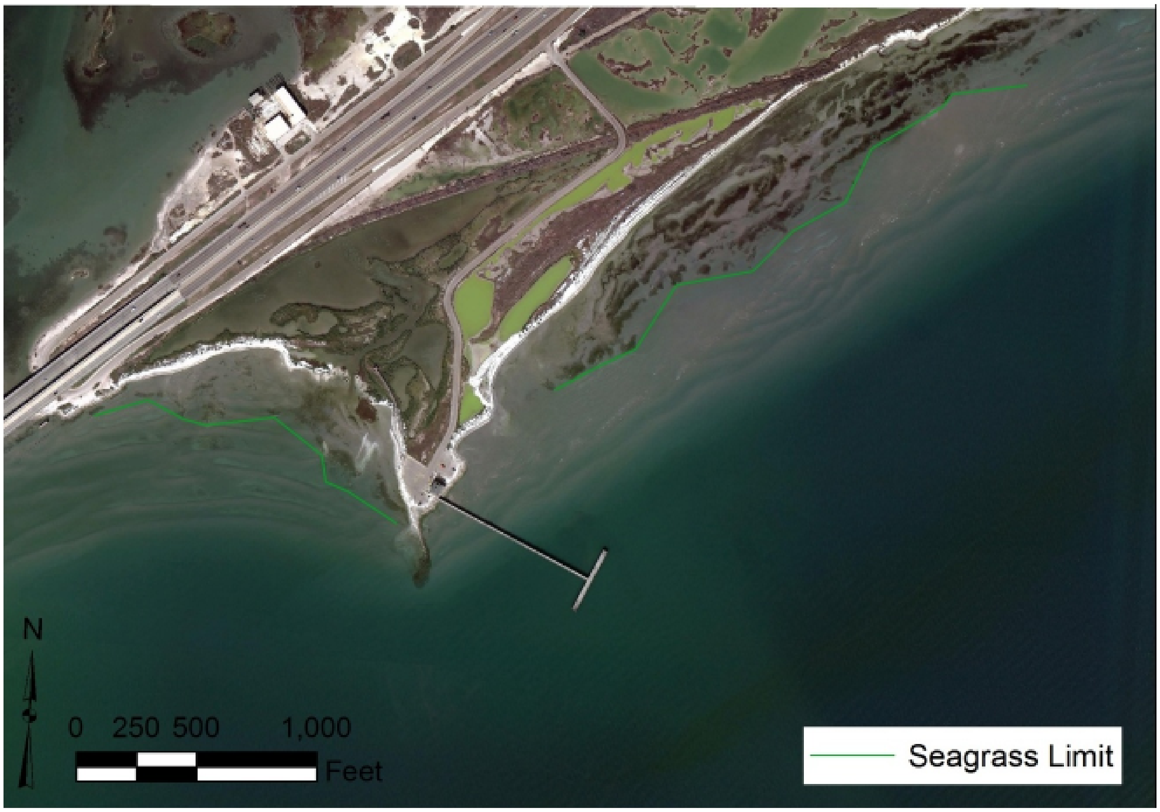


**Figure 2.7 Approximate seaward limit of seagrass as surveyed on May 21, 2012 (aerial photograph date 2011.**

## 2.5 Shoreline Change

Identifying the cause and frequency of erosion within the project area is important for design of a shoreline protection structure. Shoreline change was assessed by reviewing published shoreline change rates from the University of Texas – Bureau of Economic Geology (BEG), historical aerial photographs, and historical shorelines previously digitized by BEG.

BEG's shoreline change rates are available for two locations representative of the project area, Station 16 and Station 17. Station 16 is located approximately 1 mile northeast of Indian Point. Station 17 is located at Indian Point near the pier. Table 2.2 shows the published BEG shoreline change rates.

| Table 2.2 Historical Shoreline Change Rates (BEG 1984) | | | | |
|---|---|---|---|---|
| Dates | Station 16 | | Station 17 | |
| | Distance (ft) | Rate (ft/yr) | Distance (ft) | Rate (ft/yr) |
| 1867 to 1930 | +25 | <+0.5 | +75 | +1.2 |
| 1930 to 1982 | -100 | -1.9 | 0 | 0 |
| 1867 to 1982 | -75 | -0.7 | +75 | +0.7 |


Available historical aerial photograph years reviewed include: 1949, 1955, 1960, 1978, 1984, 1989, 1995, 2002, 2003, 2004, 2005, 2006, 2008, 2009, and 2011. These aerials are provided in Appendix B. In addition to reviewing these aerial photographs, historical shorelines delineated by BEG were gathered from 1930, 1958, and 1995. Figure 2.8 shows approximate historical shoreline locations using both the BEG shoreline data as well traced shorelines from historical photographs superimposed on a recent 2011 aerial photograph.

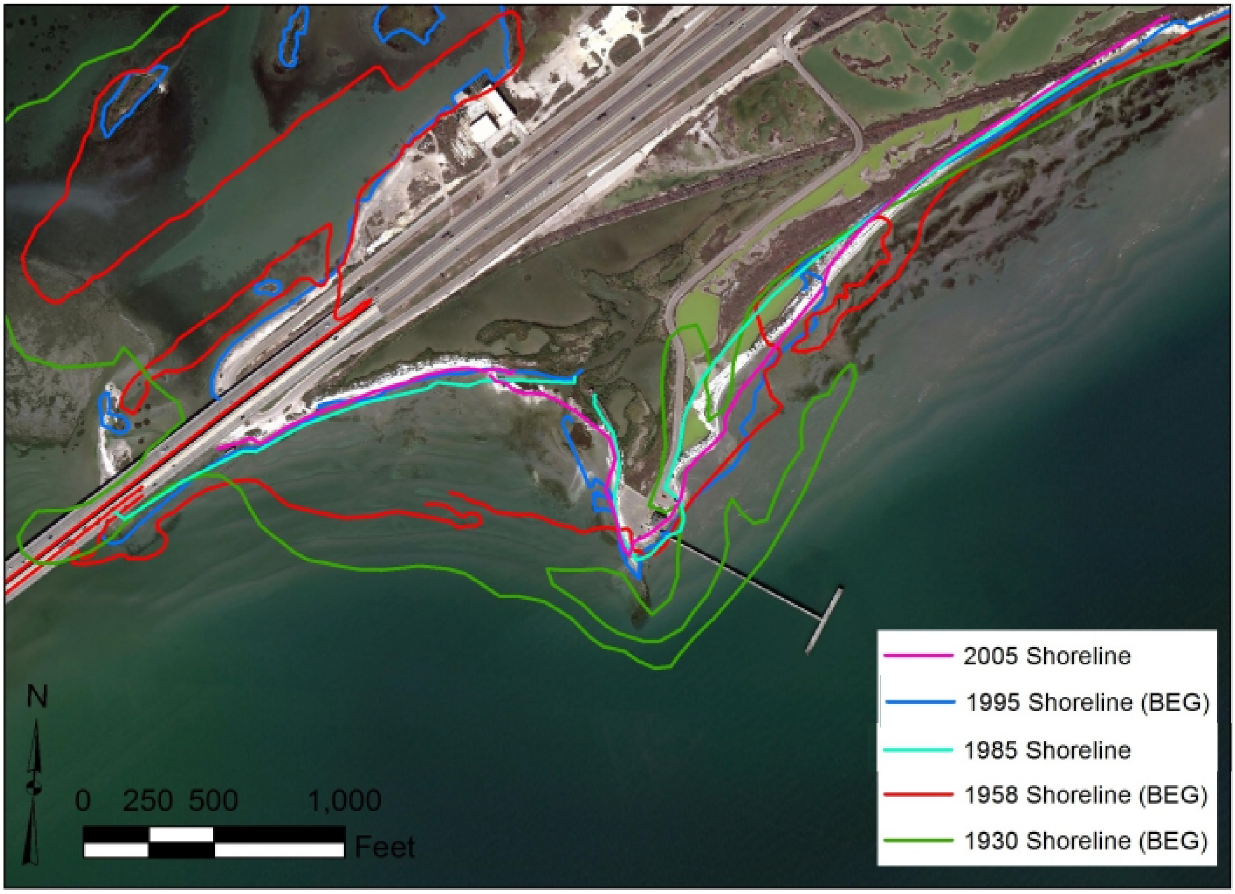


**Figure 2.8 Approximate historical shorelines superimposed on November 2011 aerial photograph.**

From Figure 2.8, the greatest historical shoreline change appears to have occurred on the west side of the point where approximately 250 ft of shoreline retreat occurred between 1930 and 1958 (~8.9 ft/yr) and approximately 470 ft of shoreline retreat occurred between 1958 and 1985 (~17.4 ft/yr). Shoreline retreat during that latter period was likely accelerated by a series of significant storms during that period, including Hurricane Beulah in 1967, Hurricane Celia in 1970, and Hurricane Allen in 1980. Since 1985, this area has retreated at a significantly lesser rate of approximately 1 to 2 ft/yr.

On the east side of the point, there have been periods of both shoreline retreat and accretion. This area was described as "dynamically stable" during a prior assessment by Coast and Harbor (2011). When comparing the 2011 aerial photograph and 2005 shoreline, two localized areas of shoreline retreat are evident just northeast of the point, as shown in greater detail in Figure 2.9. Based on this comparison, up to 85 ft of shoreline retreat occurred between 2005 and 2011 (~14.2 ft/yr). Contrary to the west side of the point, the shoreline retreat east of the point appears to be progressive (occurring steadily over time) and not episodic (occurring during a major storm).


**Figure 2.9 Approximate 1995 shoreline location superimposed on 2011 aerial photograph.**

In addition to the infrastructure at risk due to the shoreline retreat in this area, lagoons within the wetlands complex are in close proximity to the shoreline. If the shoreline is breached and the lagoons become connected to the open bay, a new shoreline may form on the landward side of the lagoons, posing greater risk to the roadway and resulting in significant wetland loss (potentially 4 to 5 acres in single event).

# 3.0 CONCEPTUAL DESIGN

This section presents a conceptual design layout for shoreline protection at Indian Point Peninsula. For conceptual level design, only quarrystone riprap breakwater and revetment structures were considered. During subsequent, more detailed design phases, other types of shoreline protection methodologies/materials should be considered to assess potential cost savings and/or improved performance.

## 3.1 Conceptual Design Criteria

The following is a list of preliminary criteria considered for conceptual design of shoreline protection at Indian Point Peninsula. Specific criteria regarding project life or stability against a particular return period event or storm intensity (i.e. 100 year event, Category 1 Hurricane, etc.) were not considered for conceptual level design as no wave analysis has been conducted at this time.

Conceptual Design Criteria:

- Attenuate wave energy to protect existing wetlands and promote seagrass expansion.
- Avoid displacing seagrass, wetlands, and any related habitat.
- Help protect and/or maintain existing infrastructure.

Based on the above criteria and discussion with CBBEP personnel, the general concept for the shoreline protection consists of a graded riprap breakwater located seaward of existing seagrass on both sides of the point of Indian Point as the primary component. At the point, the following three alternatives were considered:

1) No Action
2) Graded Riprap Revetment
3) Continuation of Segmented Breakwater.

The "no action" alternative was considered because the point is already lined with concrete rubble which provides some level of protection. A graded riprap revetment or segmented breakwater in place of the broken concrete rubble would provide a better-quality shoreline protection structure engineered to a defined level of protection.

Construction of the structure would likely be done using the breakwater foundation as a temporary haul road with the parking lot as an access point. Once construction of the breakwater foundation/haul road reached the far limit of the breakwater, an additional lift of graded riprap would be placed to top off the breakwater to its full height, and any specified gaps would be added. Water-based construction of the breakwater is not recommended because it would likely require dredging a flotation channel which would significantly increase cost and complicate the permitting process.

## 3.2 Conceptual Design Layout

The conceptual design layouts are shown in Figure 3.1 to Figure 3.3. To avoid displacing existing seagrass, the proposed breakwater alignment is just seaward of the seagrass limit with a minimum additional buffer of approximately 20 ft. At this location the bottom elevation of the breakwater would generally be between -0.5 and -2 ft NAVD. The breakwater would likely be segmented to reduce overall cost, promote water exchange, and provide additional pathways for marine life. Further analysis in subsequent design will be required to determine maximum allowable breakwater gap widths and spacing that would provide a suitable balance between cost and performance.

### 3.3 Conceptual Design Cross-Sections

Conceptual design templates were developed for both the breakwater cross-section and revetment cross-section and are shown in Figure 3.4. Wetland habitat is generally most susceptible to wave damage when the water level is below or very near the elevation of the wetland. When the water level is much higher than the wetland, much of the wave energy is able to pass over the area causing little damage. This allows the breakwater to be a relatively low-crested structure. For conceptual design, an incident significant wave height of 3.2 ft was assumed[1]. General dimensions were then developed based on a transmitted significant wave height of 1 ft, which is a common "rule-of-thumb" threshold applied for marsh stability (USACE 1995, Shafer *et al*. 2003).

### 3.4 Conceptual Opinion of Probable Construction Cost

A conceptual-level opinion of probable construction cost (cost) was developed for the breakwater with the three alternatives at the point. Costs of materials, mobilization, and ancillary items were largely based on past similar projects built in the general vicinity of Corpus Christi Bay.

Based on conceptual-level design of the three approaches, the approximate construction costs for the three concepts are as follows (see Appendix C for detailed cost breakdowns):

1) Segmented Breakwater with No Action at point $3,286,000
2) Segmented Breakwater with Revetment at point $3,466,000
3) Segmented Breakwater (entire project length) $3,558,000

[1] Incident wave height value is based on a depth limited wave occurring at a water level of +3.5 ft NAVD (just below typical elevation of shoreline ridge) and bottom elevation of -2 ft NAVD (deepest breakwater toe elevation). No formal wave analysis or modeling was performed at this level of design.

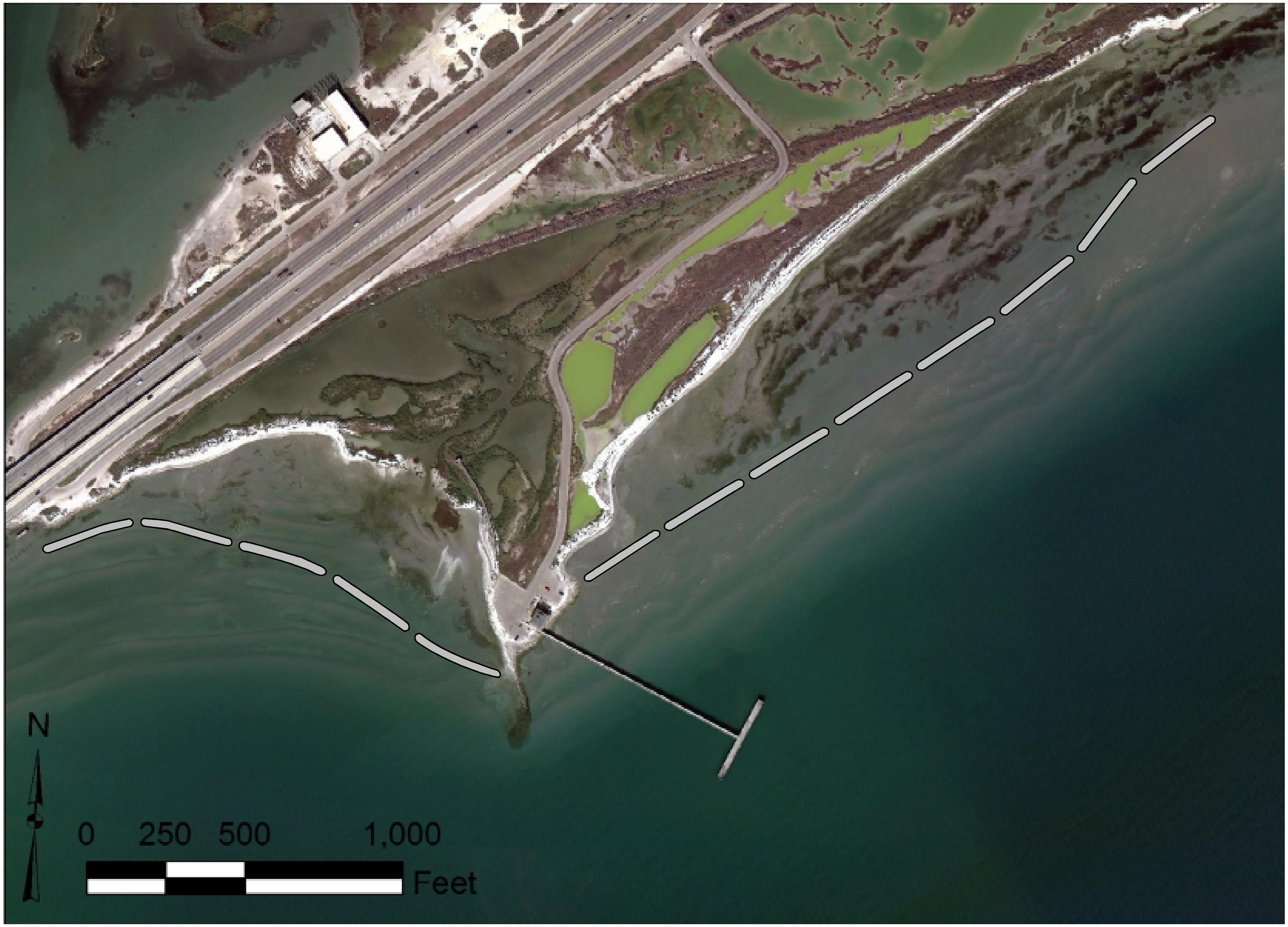


**Figure 3.1 Alternative 1: Segmented Breakwater with No Action Alternative at Point (Conceptual).**

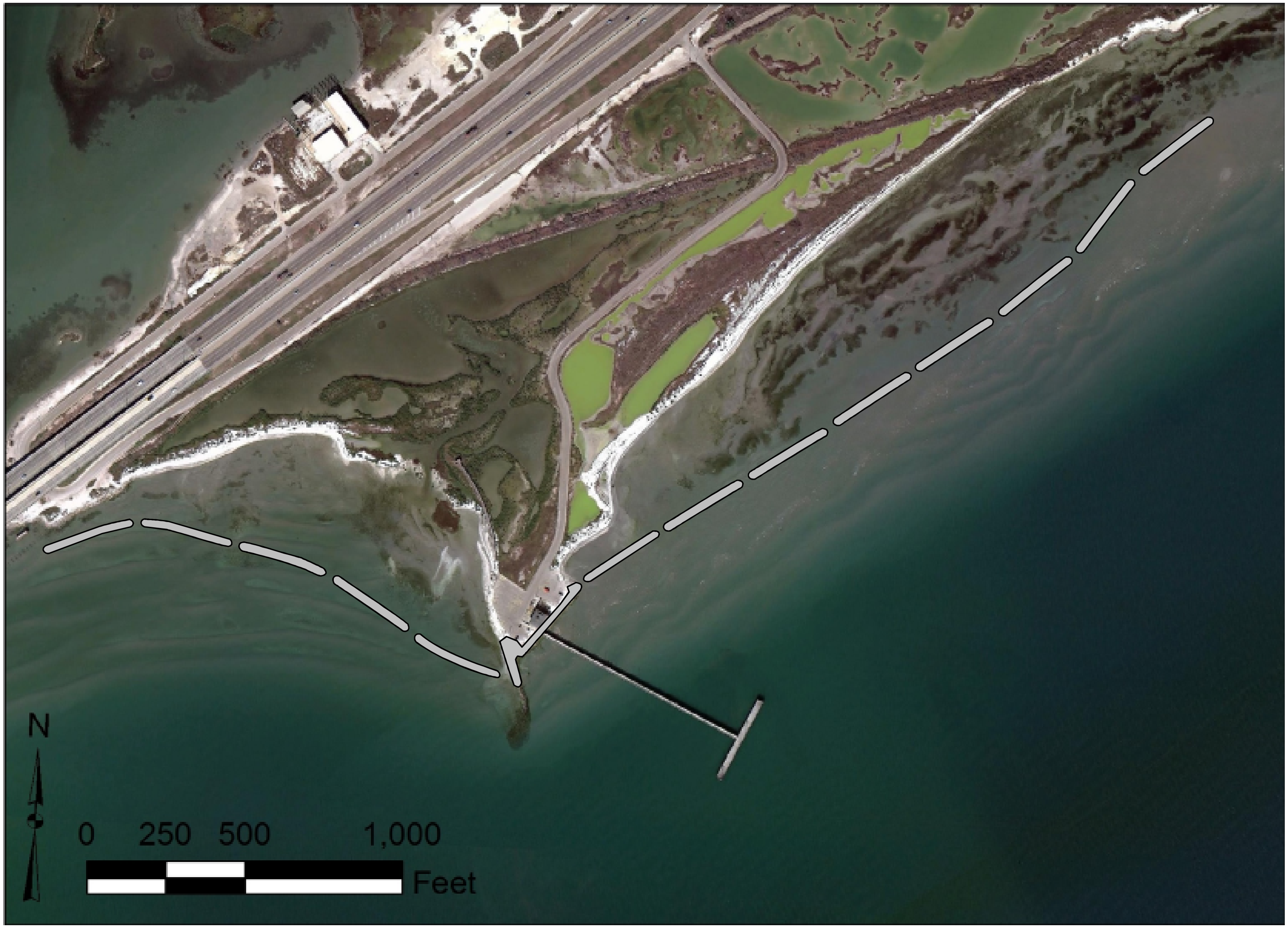


**Figure 3.2 Alternative 2: Segmented Breakwater with Revetment Alternative at Point (Conceptual).**

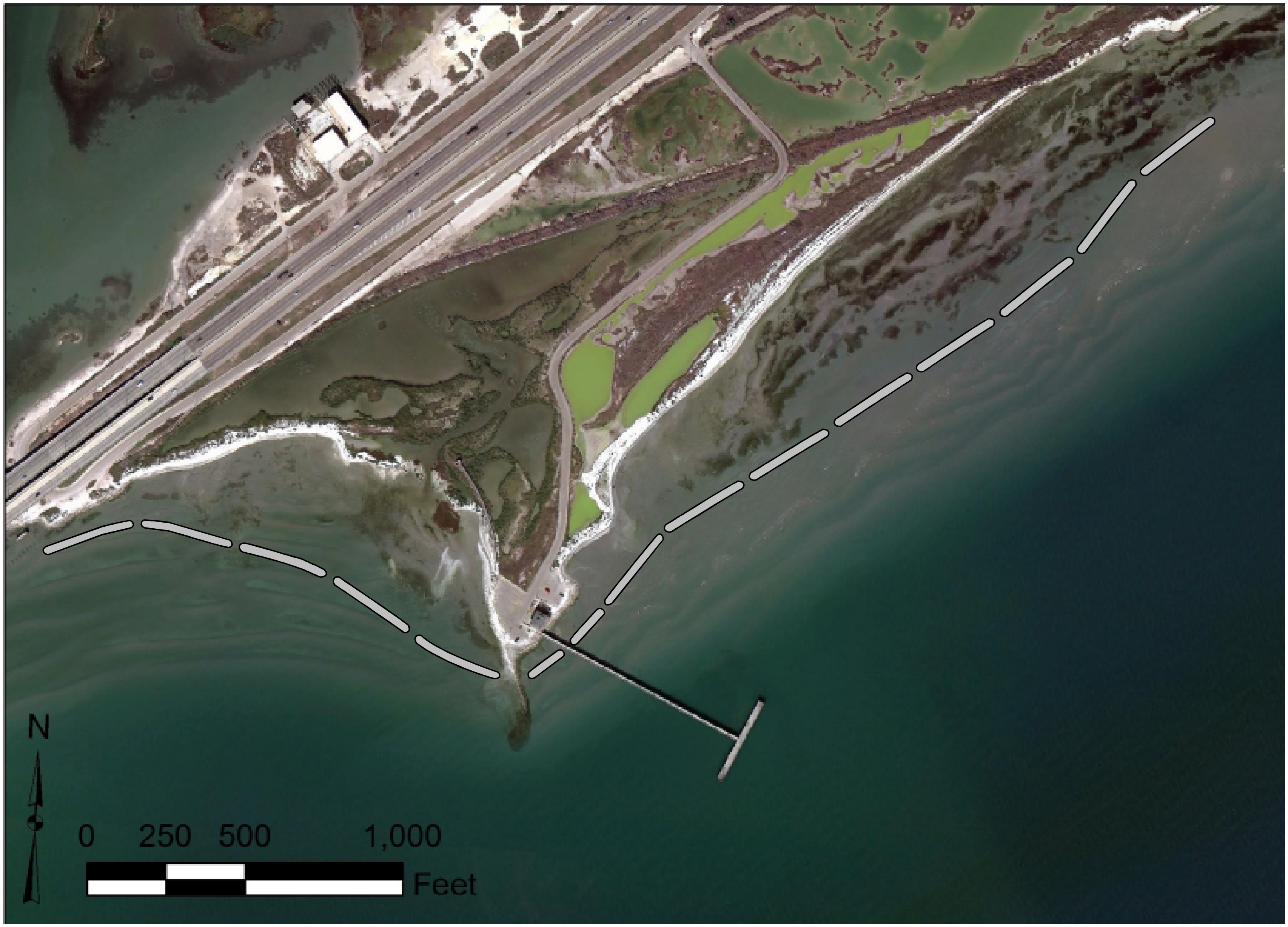


**Figure 3.3 Alternative 3: Segmented Breakwater with Continued Breakwater Alternative at Point (Conceptual).**

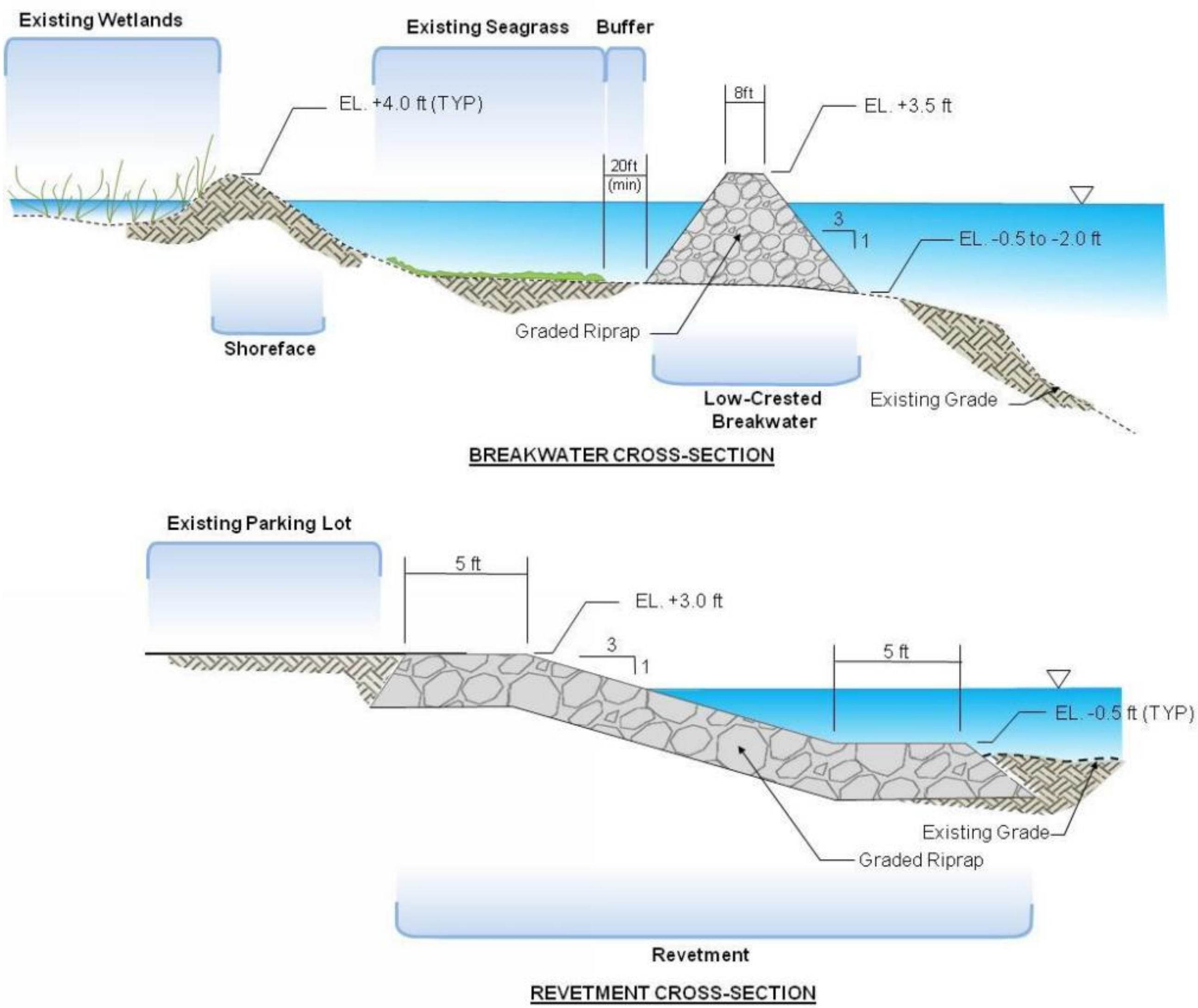


**Figure 3.4 Breakwater and Revetment Conceptual Cross-Sections (*Schematic – dimensions are approximate*).**

# 4.0 SUMMARY AND RECOMMENDATIONS

Cursory-level engineering analysis was performed to assess the feasibility of shoreline protection at Indian Point Peninsula. Data gathering including compilation of metocean parameters, a reconnaissance topographic/bathymetric survey, and preliminary seagrass survey were performed and documented to assist in the engineering analysis. The following is a summary of preliminary findings:

- Shoreline retreat on the west side of Indian Point has been in excess of 470 ft since 1958 and appears to have been strongly influenced by hurricanes. Shoreline retreat on the east side of the point in the past decade appears to have been progressive (not caused by discrete storm events) and averaged approximately 14 ft/yr.
- To help avoid displacing extensive seagrass present in the nearshore, a breakwater is recommended for a majority of the project area.
- In the vicinity of the point, seagrass is not present. In addition, this portion of the shoreline has been previously lined with concrete rubble/debris and is relatively stable.
- Three shoreline protection configurations were developed. These include:

  1. Segmented Breakwater with No Action at Point – Would rely on existing concrete rubble at point and new breakwater elsewhere. Based on the conceptual level opinion of probable construction cost, the estimated construction cost for this configuration is approximately $3,286,000.
  2. Segmented Breakwater with Revetment at Point – Revetment would replace the existing concrete rubble and new breakwater would be constructed elsewhere. Based on the conceptual level opinion of probable construction cost, the estimated construction cost for this configuration is approximately $3,466,000.
  3. Segmented Breakwater (entire length) – Based on the conceptual level opinion of probable construction cost, the estimated construction cost for this configuration is approximately $3,558,000.

The following are recommendations for subsequent permitting and design of the Indian Point Peninsula shoreline protection project:

- Establish preferred alternative for shoreline protection at the point. Based on the conceptual performance and constructability assessment presented herein, the revetment alternative is the recommended approach from an engineering standpoint. However, if the projected construction cost exceeds anticipated funding, the no action alternative may be warranted. The only reason to move forward with the segmented breakwater option (at the point) would be an unforeseen factor (i.e. environmental, property owner, aesthetic, alternative use, etc.) in constructing the revetment.
- Establish specific design criteria (such as protection against certain storm intensity, desired lifespan, etc.).
- Perform wave analysis with a numerical wave model. This is especially important for stone stability calculations and breakwater gap design.
- Perform geotechnical investigation to determine geotechnical stability of proposed structure.

- Perform more detailed topographic and bathymetric survey for potential minor refinements to breakwater alignment and more accurate quantity takeoffs.
- Assess potential for down-drift or adverse effects of constructing a shoreline protection structure.
- Explore feasibility of other materials and configurations for improved cost savings, environmental benefits, and/or performance.

# 5.0 REFERENCES

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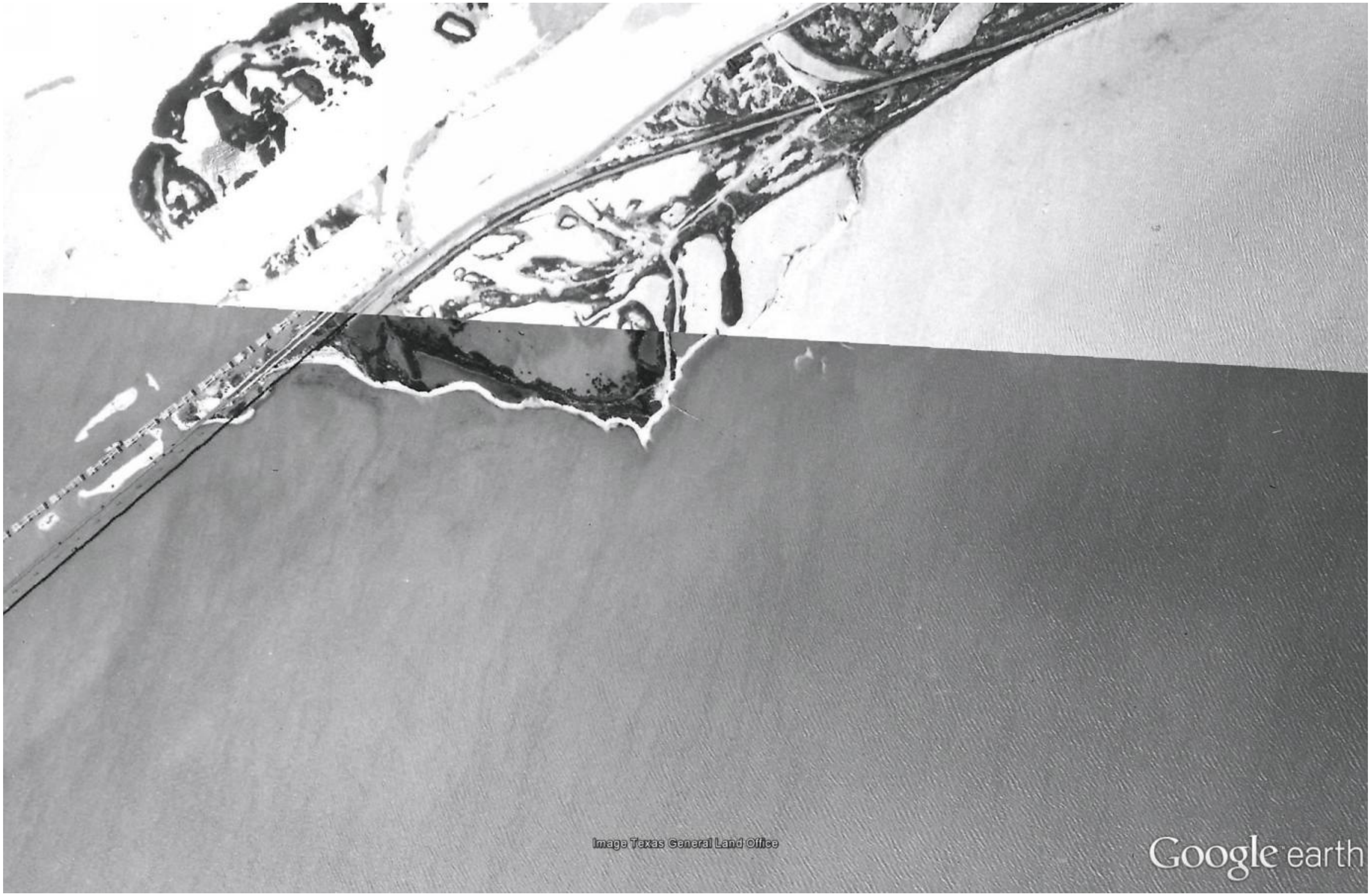
Shafer, D.J., Roland, R., and Douglass, S.L. 2003. Preliminary Evaluation of Critical Wave Energy Thresholds at Natural and Created Coastal Wetlands. WRP Technical Notes Collection (ERDC TN-WRP-HS-CP-2.2), U.S. Army Engineer Research and Development Center, Vicksburg, MS.

USACE. 1995. Design of Coastal Revetments, Seawalls, and Bulkheads. EM 1110-2-1614, Engineering Research and Development Center – Coastal and Hydraulics Laboratory, Vicksburg, MS.

# Appendix A
# Site Visit Ground Photographs
# 5/21/2012

# Appendix B
# Historical Aerial Photographs

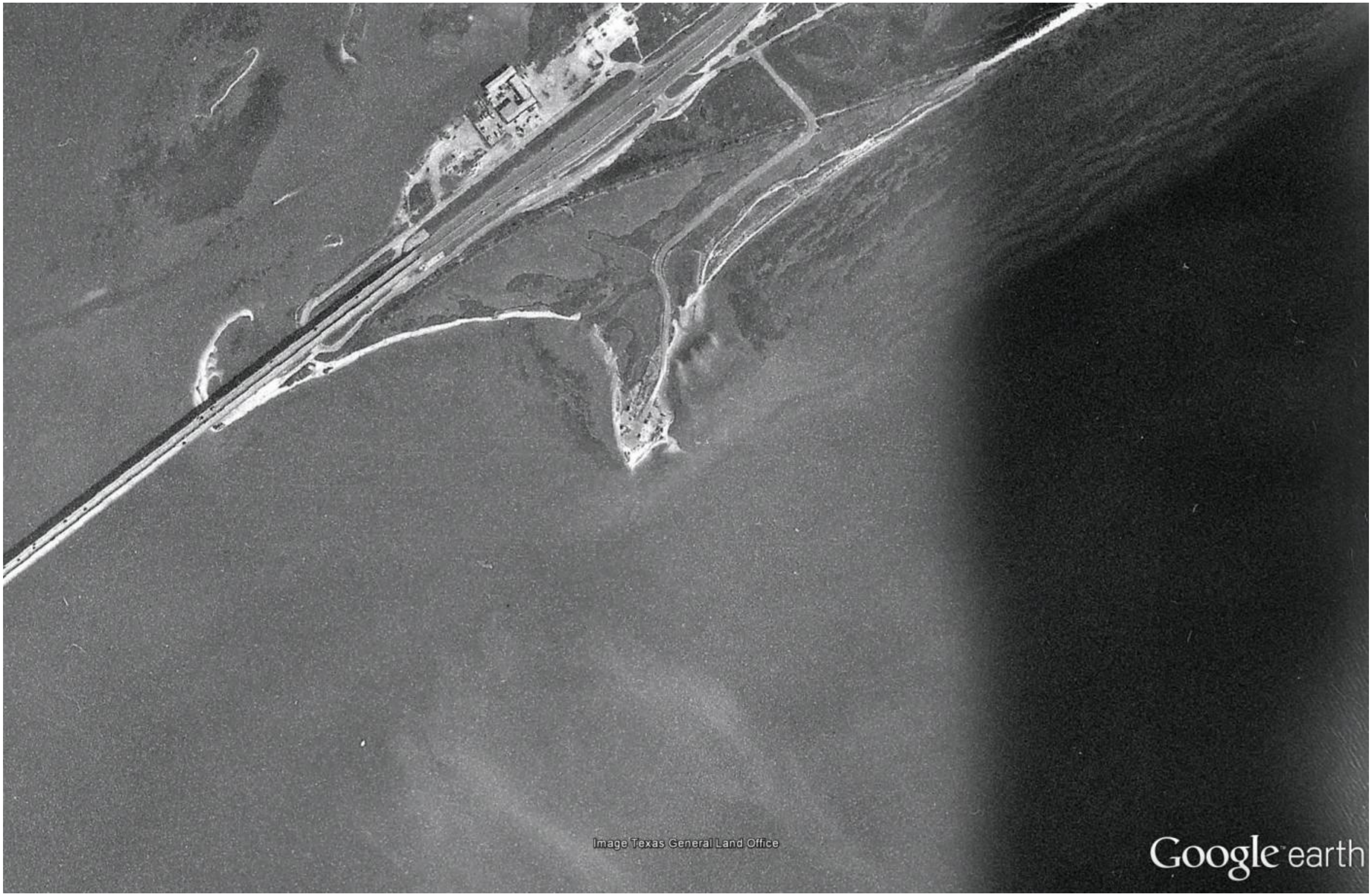



1949

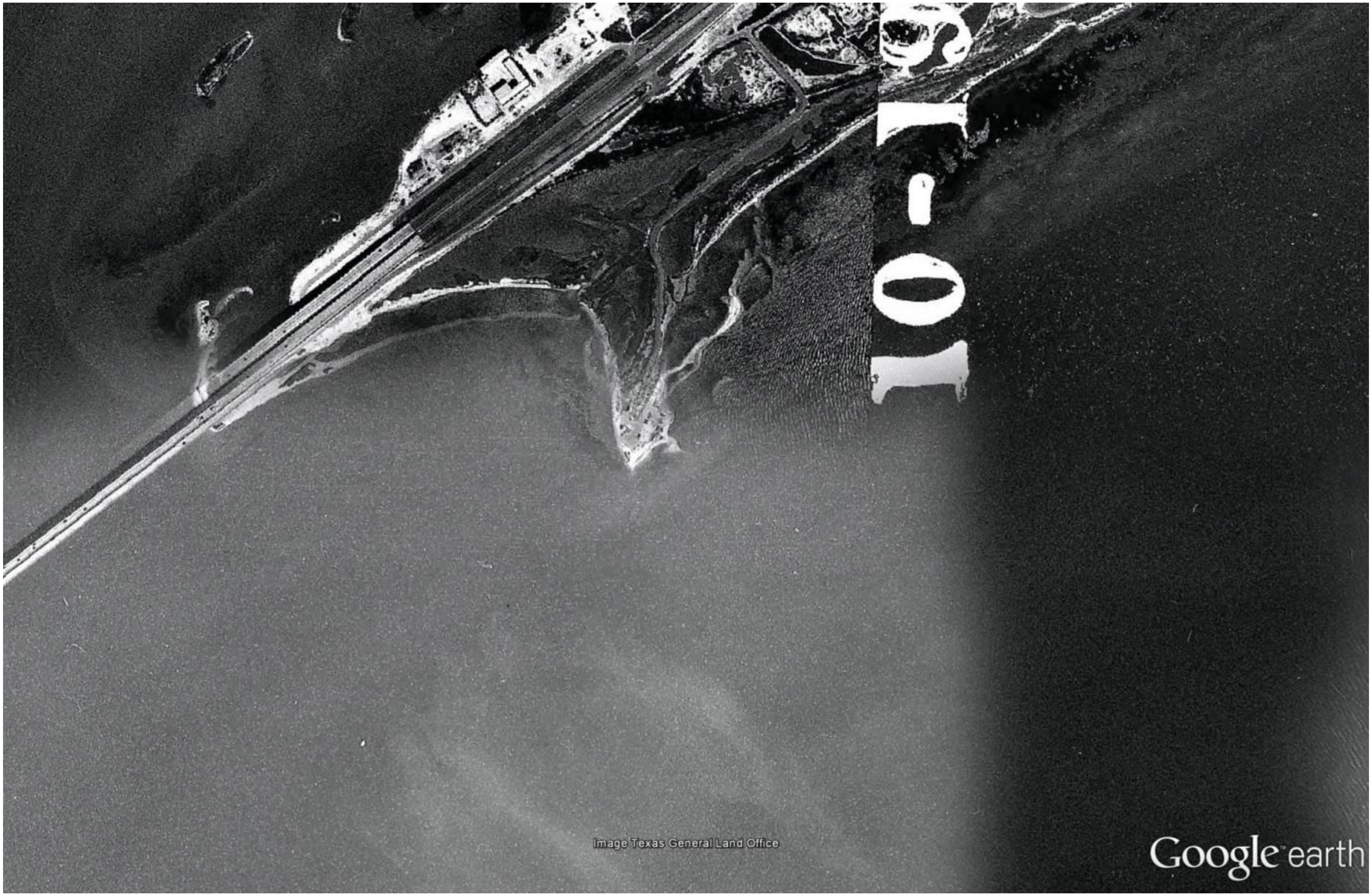

1955


1960


1978

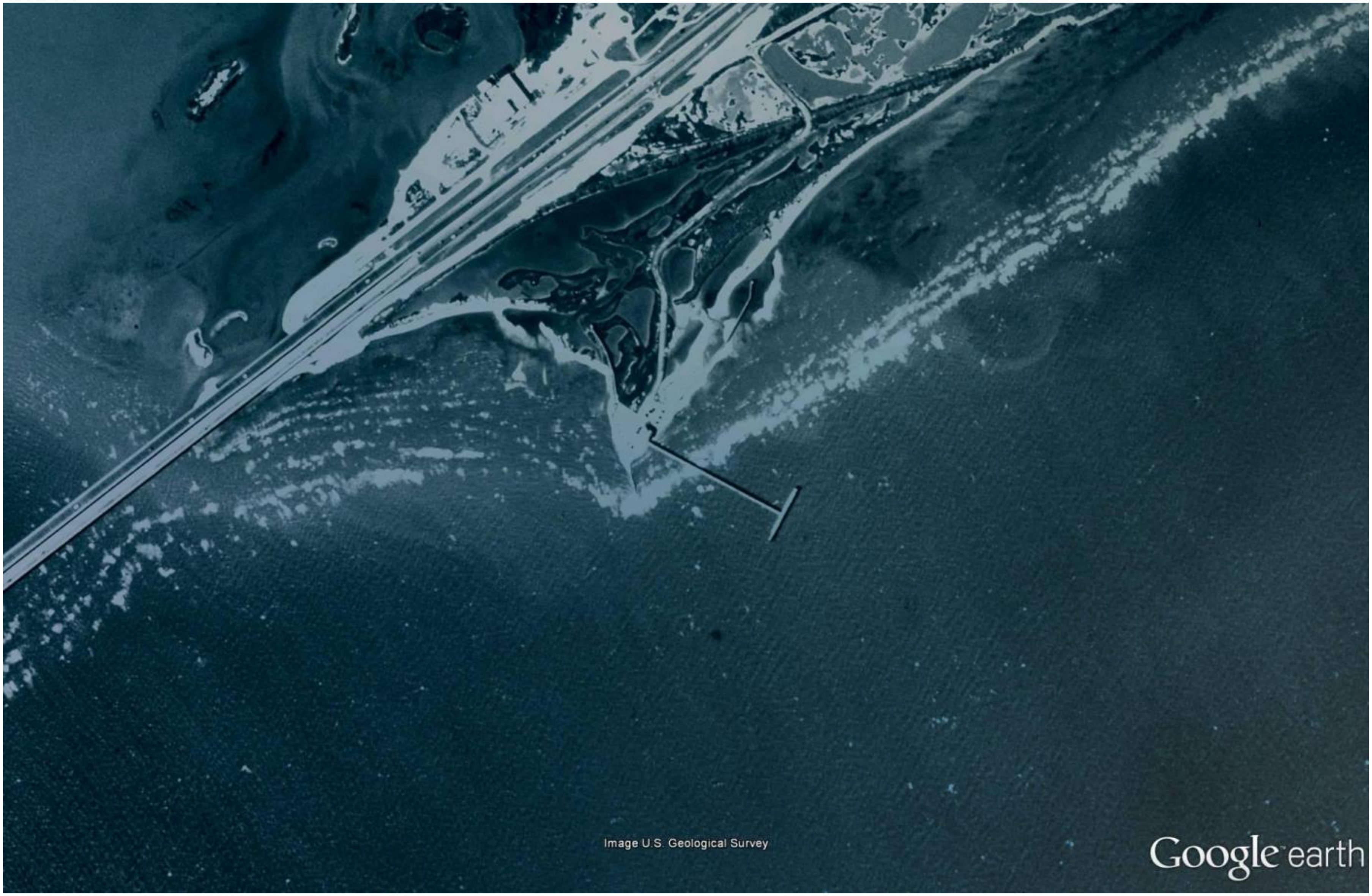



1984

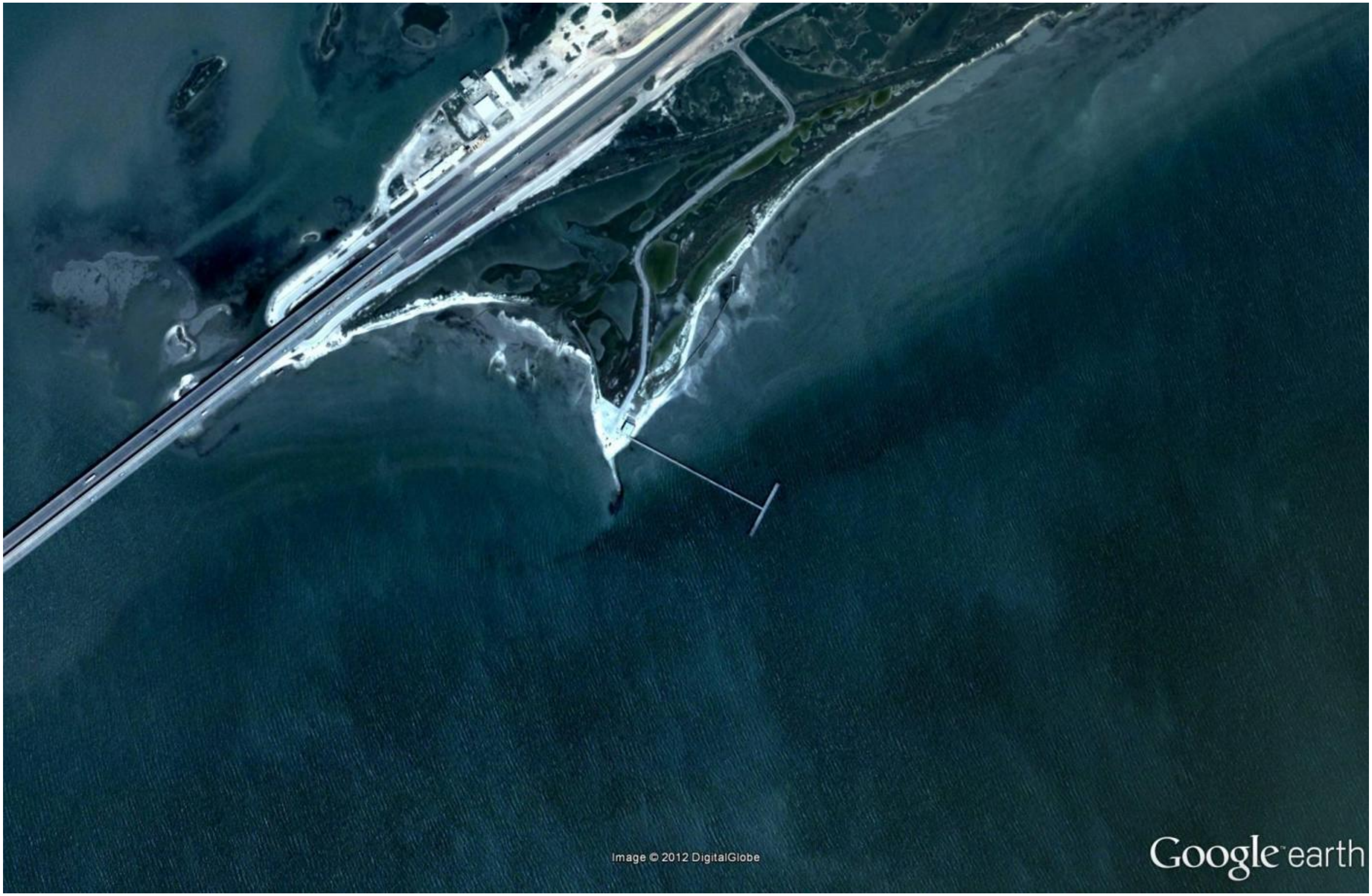



1989


1995




2002




2003

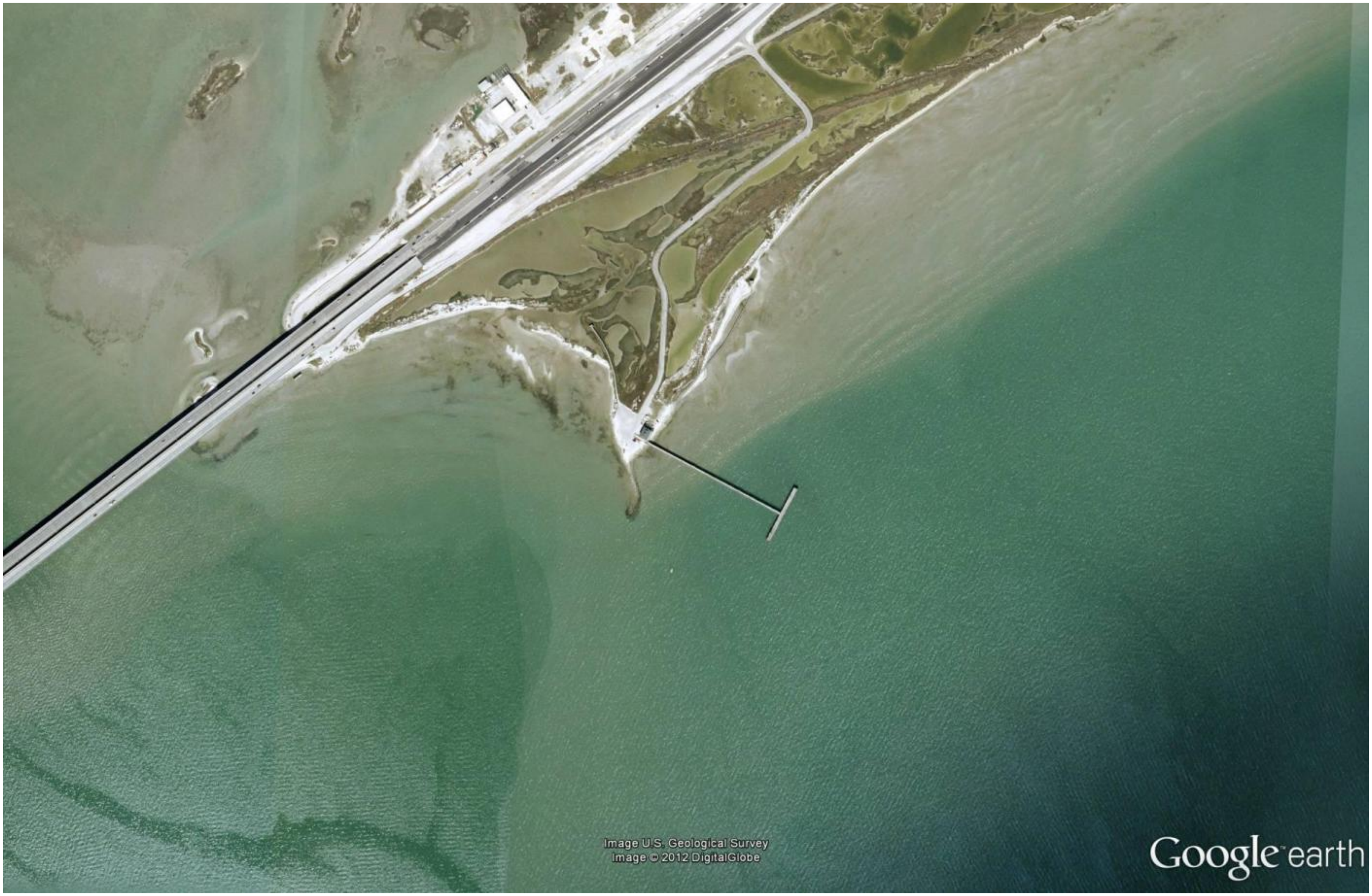
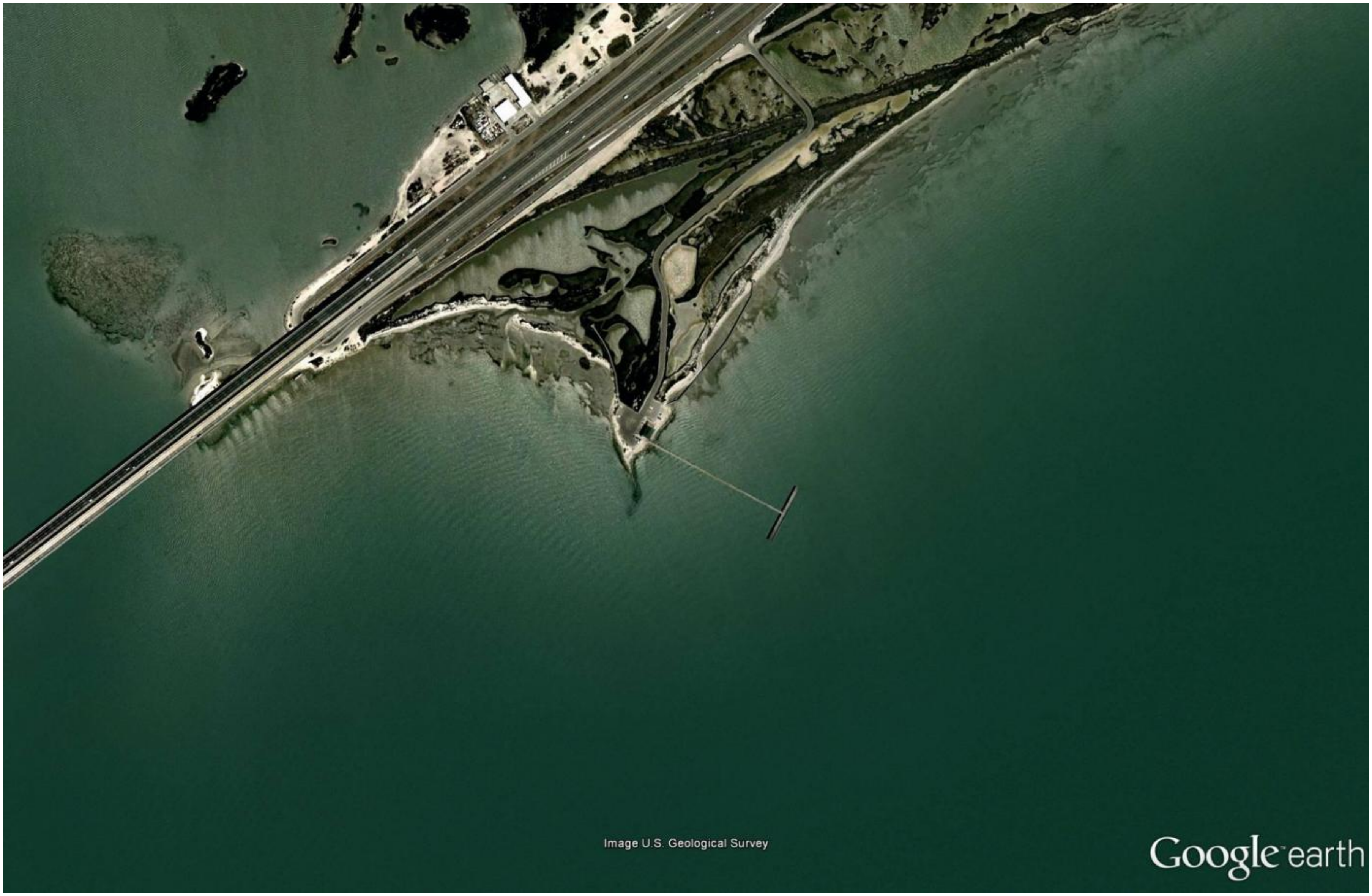


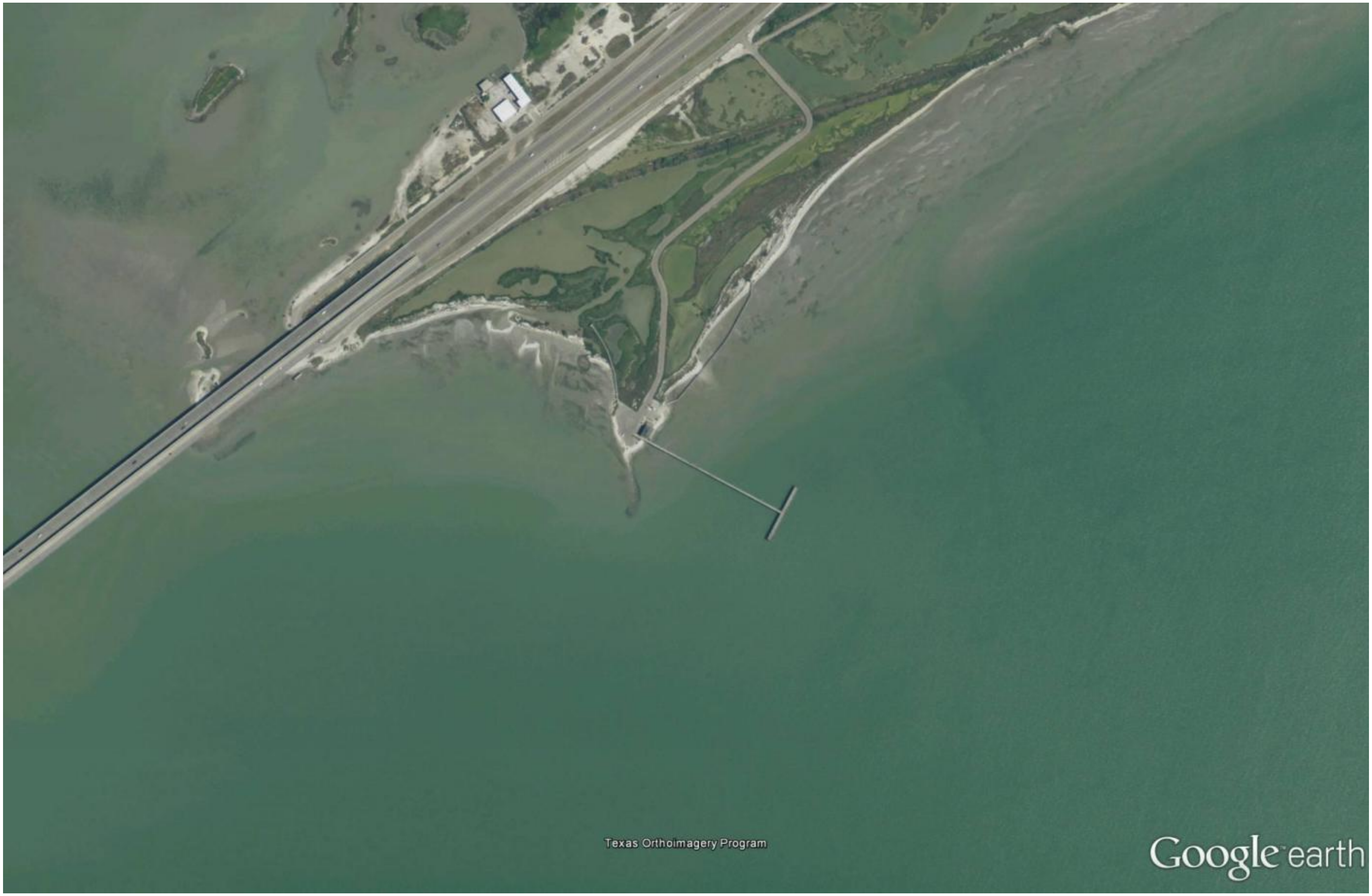
Image U.S. Geological Survey
Image © 2012 DigitalGlobe
Google earth

2004

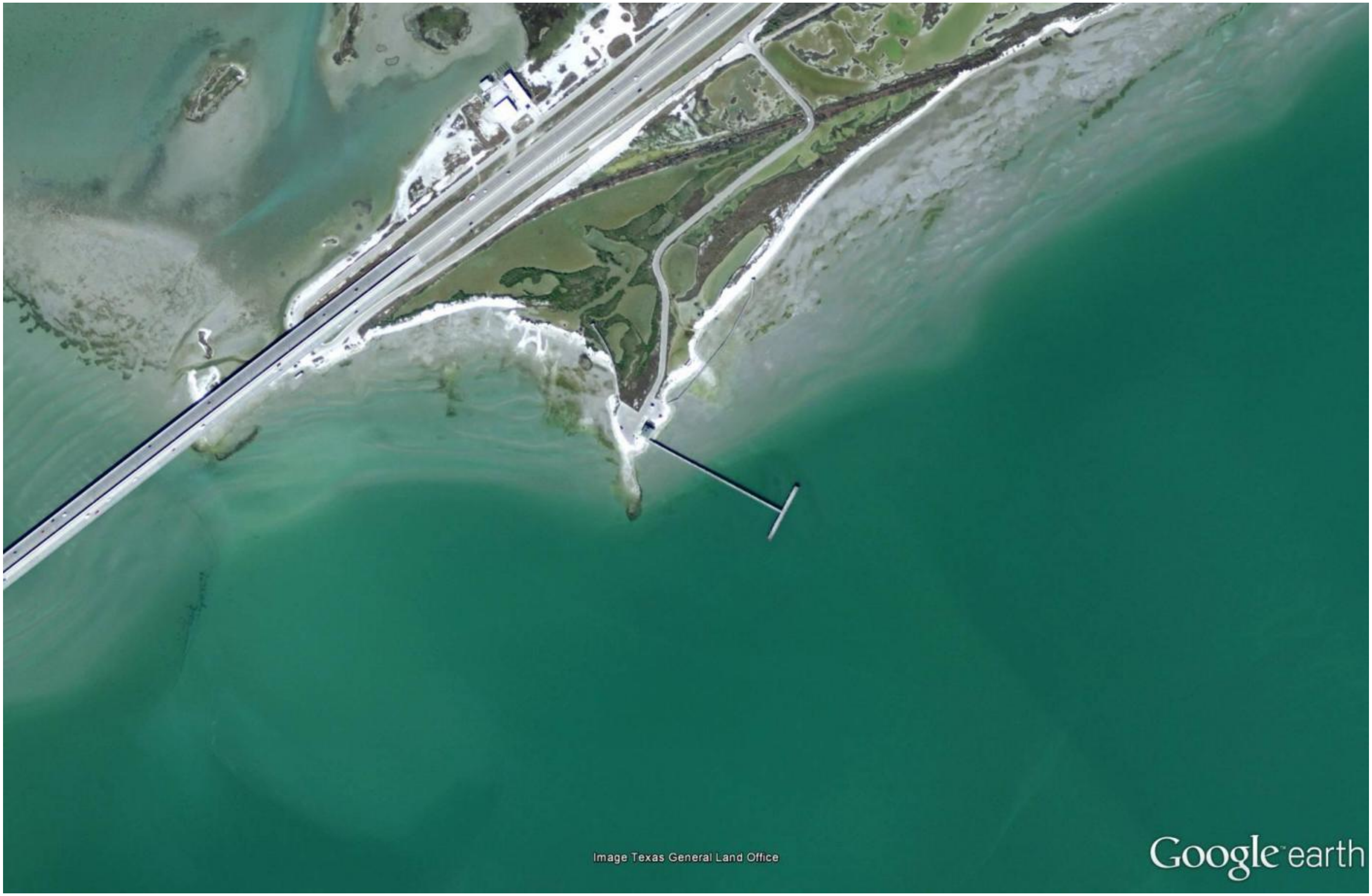

2005



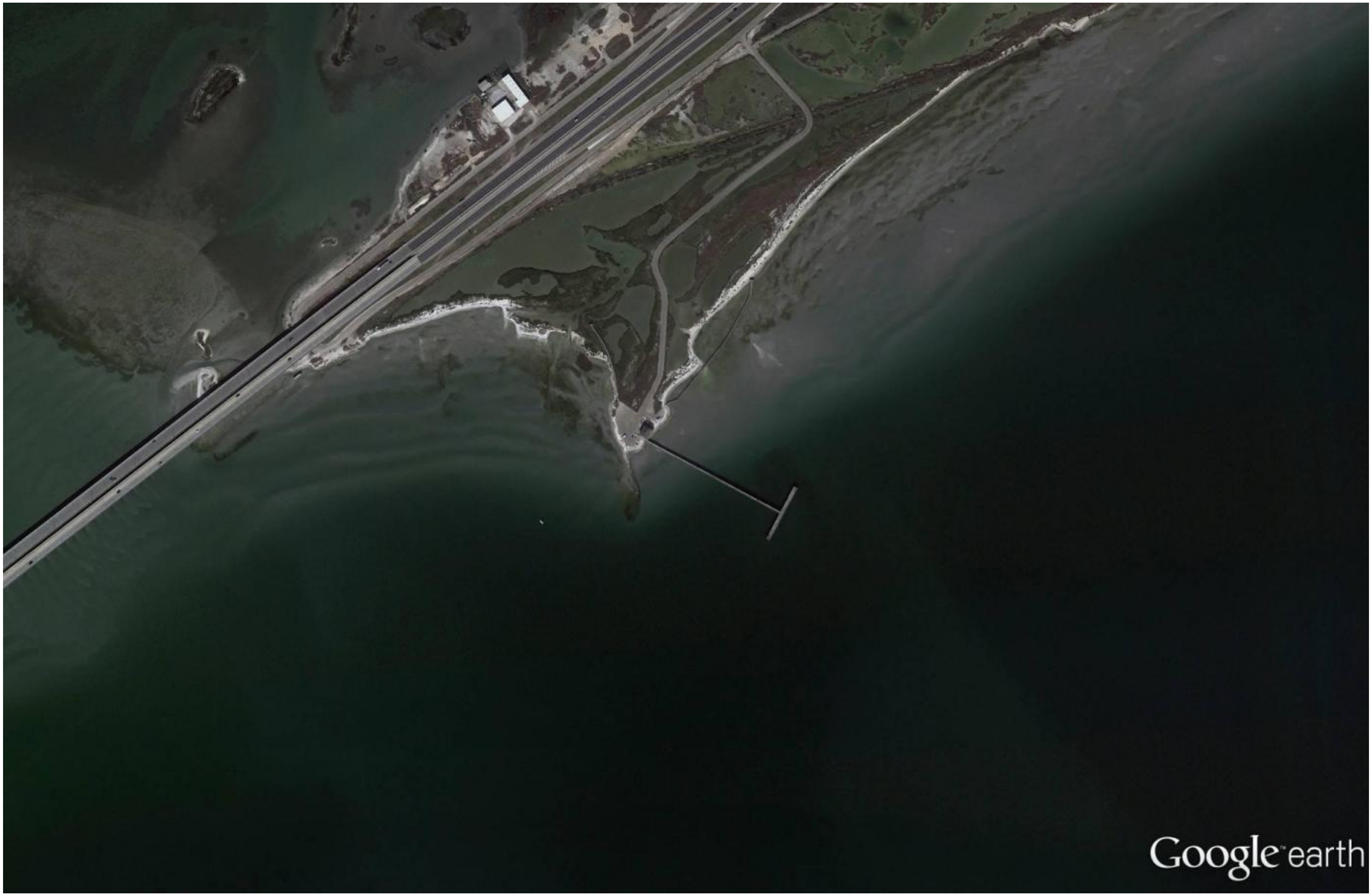

2006




2008




2008




2009


2011

# Appendix C
# Conceptual Level Opinion of Probable Construction Cost

## COASTAL BEND BAYS AND ESTUARIES PROGRAM
## INDIAN POINT SHORELINE PROTECTION PROJECT

### CONCEPTUAL LEVEL OPINION OF PROBABLE CONSTRUCTION COST

| | ITEM | QUANTITY | UNIT | UNIT PRICE | EXTENSION |
|---|---|---|---|---|---|
| **Segmented Breakwater (Base Project)[c]** | | | | | |
| 1. | *Mobilization/Demobilization* | 1 | LS | $150,000 | $150,000 |
| 2. | *Pre-Construction Hazard Survey* | 1 | LS | $5,000 | $5,000 |
| 3. | *Bathymetric and Topographic Surveys* | 1 | LS | $50,000 | $50,000 |
| 4. | *Acceptance Aerial Photograph* | 1 | LS | $3,000 | $3,000 |
| 5. | *Geotextile Fabric and Grid* | 19,300 | SY | $12 | $231,600 |
| 6. | *Graded Riprap* | 23,200 | TON | $90 | $2,088,000 |
| | | | | 30% Contingencies: | $758,280 |
| | | | | *Subtotal:* | $3,286,000 |
| **Revetment at Point (Alternative)[d]** | | | | | |
| 7. | *Concrete Rubble Removal* | 400 | LF | $20 | $8,000 |
| 8. | *Geotextile Fabric and Grid* | 1,100 | SY | $12 | $13,200 |
| 9. | *Graded Riprap* | 1,300 | TON | $90 | $117,000 |
| | | | | 30% Contingencies: | $41,460 |
| | | | | *Subtotal:* | $180,000 |
| **Continued Breakwater at Point (Alternative)[d]** | | | | | |
| 10. | *Geotextile Fabric and Grid* | 1,700 | SY | $12 | $20,400 |
| 11. | *Graded Riprap* | 2,100 | TON | $90 | $189,000 |
| | | | | 30% Contingencies: | $62,820 |
| | | | | *Subtotal:* | $272,000 |

**Summary**

| | | |
|---|---|---|
| **Segmented Breakwater with No Action Alternative at Point** | **TOTAL:** | **$3,286,000** |
| **Segmented Breakwater with Revetment Alternative at Point** | **TOTAL:** | **$3,466,000** |
| **Segmented Breakwater (Entire Length)** | **TOTAL:** | **$3,558,000** |

**Notes:**
(a) Project assumes that construction activites will be land-based.
(b) Engineering, bidding, and construction adminstration costs are not included.
(c) Base project does not include shoreline protection at the point.
(d) Revetment and Continued Breakwater Alternatives include shoreline protection at the point only.