NOTICE OF SHORELINE TASK FORCE REGULAR MEETING
CITY OF SOUTH PADRE ISLAND

TUESDAY, JULY 26, 2022

3:00 PM AT THE MUNICIPAL COMPLEX BUILDING
2ND FLOOR CITY COUNCIL CHAMBERS
4601 PADRE BOULEVARD SOUTH PADRE ISLAND, TX 78597

1. Call to Order

2. Pledge of Allegiance

3. Public Comments and Announcements
This is an opportunity for citizens to speak to the board relating to agenda or non-agenda items. Speakers are required to address the Shoreline Task Force at the podium and give their name before addressing their concerns. [Note: State law will not permit the Task Force to discuss, debate, or consider items that are not on the agenda. Citizen comments may be referred to City Staff or may be placed on the agenda of a future Shoreline Task Force meeting]

4. Regular Agenda

4.1. Discussion and action to approve the minutes from the regular meeting on July 12, 2022. (Hughston)

4.2. Update and discussion on the final report and recommendations received from the Coastal Management Program (CMP)'s Cycle 24 updated beach/dune study. (Boburka)

4.3. Discussion and action on a new meeting time for the regular meeting on August 9, 2022. (Boburka)

5. Adjourn

NOTE:
One or more members of the City of South Padre Island City Council may attend this meeting; if so, this statement satisfies the requirements of the OPEN MEETINGS ACT.

DATED JULY 21, 2022

Angelique Soto, City Secretary

I, THE UNDERSIGNED AUTHORITY, DO HEREBY CERTIFY THAT THE ABOVE NOTICE OF MEETING OF THE SHORELINE TASK FORCE OF THE CITY OF SOUTH PADRE ISLAND, TEXAS IS A TRUE AND CORRECT COPY OF SAID NOTICE AND THAT I POSTED A TRUE AND CORRECT COPY OF SAID NOTICE ON THE BULLETIN BOARD AT CITY HALL/MUNICIPAL BUILDING ON **JULY 21, 2022**, AT/OR BEFORE 3:00 PM AND REMAINED SO POSTED CONTINUOUSLY FOR AT LEAST 72 HOURS PRECEDING THE SCHEDULED TIME OF SAID MEETING.

Angelique Soto, City Secretary

THIS FACILITY IS WHEELCHAIR ACCESSIBLE, AND ACCESSIBLE PARKING SPACES ARE AVAILABLE. REQUESTS FOR ACCOMMODATIONS OR INTERPRETIVE SERVICES MUST BE MADE 48 HOURS PRIOR TO THIS MEETING. PLEASE CONTACT BUILDING OFFICIAL, GEORGE MARTINEZ AT (956)761-8103.

CITY OF SOUTH PADRE ISLAND

CITY OF SOUTH PADRE ISLAND
SHORELINE TASK FORCE
AGENDA REQUEST FORM

MEETING DATE: July 26, 2022

NAME & TITLE: Kristina Boburka, Shoreline Director

DEPARTMENT: Shoreline Department

ITEM
Discussion and action to approve the minutes from the regular meeting on July 12, 2022. (Hughston)

ITEM BACKGROUND
Meeting minutes from July 12th, 2022.

BUDGET/FINANCIAL SUMMARY
N/A

COMPREHENSIVE PLAN GOAL
Chapter 9: Shoreline

LEGAL REVIEW
Sent to Legal:
Approved by Legal:

RECOMMENDATIONS/COMMENTS:

MINUTES OF REGULAR MEETING
CITY OF SOUTH PADRE ISLAND
SHORELINE TASK FORCE

Tuesday, July 12th, 2022

I. CALL TO ORDER.

The Shoreline Task Force of the City of South Padre Island, Texas, held a regular meeting on Tuesday, July 12th, 2022, at the Municipal Complex Building, 2nd Floor, 4601 Padre Boulevard, South Padre Island, Texas. Chairman Robert Nixon called the meeting to order at 3:00 p.m. A quorum was present with Chairman Robert Nixon, Task Force Vice Chairman Stormy Wall, Task Force Members Abbie Mahan, Michael Sularz, and Todd Williams. Excused absence for Task Force Member Norma Trevino.

City Council present included Ken Medders. City staff present included City Manager Randy Smith, Shoreline Director Kristina Boburka, and Coastal Coordinator Erika Hughston.

II. PLEDGE OF ALLEGIANCE.

Chairman Robert Nixon led the Pledge of Allegiance.

III. PUBLIC COMMENTS AND ANNOUNCEMENTS:

Task Force Member Mahan noted that the curb on Sunset Street had been painted and that traffic flow may be more successful following the new addition. Task Force Member Bolstad commented that she enjoyed the crab signs that had been placed with the dune restoration.

IV. REGULAR AGENDA

I. DISCUSSION AND ACTION TO APPROVE THE MINUTES FROM THE REGULAR MEETING ON MAY 31, 2022. (HUGHSTON)

Task Force Member Wall made a motion to approve the minutes, seconded by Task Force Member Mahan. Motion carried unanimously.

II. DISCUSSION AND ACTION TO APPROVE THE MINUTES FROM THE JOINT SHORELINE TASK FORCE AND CITY COUNCIL WORKSHOP ON JUNE 1, 2022. (HUGHSTON)

Task Force Member Mahan made a motion to approve the minutes, seconded by Task Force Member Wall. Motion carried unanimously.

III. DISCUSSION AND ACTION TO RECOMMEND TO CITY COUNCIL APPROVAL OF APPLICATION SUBMISSION FOR STATE ASSISTANCE FROM THE BEACH MAINTENANCE REIMBURSEMENT FUND FOR THE FISCAL YEAR 2023. (BOBURKA)

Shoreline Director Boburka gave background that this is a reoccurring yearly application to maintain state assistance for beach maintenance. Task Force Member Williams made a motion to recommend the submission of the Beach Reimbursement Fund for fiscal year 2023 to City Council, seconded by Task Force Member Wall. Motion carried unanimously.

IV. DISCUSSION AND ACTION TO PROVIDE A RECOMMENDATION TO CITY COUNCIL ON THE FINAL PLANS FOR SEA ISLAND CIRCLE IMPROVEMENTS PARTIALLY FUNDED UNDER THE COASTAL MANAGEMENT PROGRAM (CMP)'S CYCLE 26. (HUGHSTON)

Task Force Member Mahan made a motion to recommend final plans for Sea Island Circle Improvements to City Council, seconded by Task Force Member Sularz. Motion carried unanimously.

V. UPDATES ON DEPARTMENT PROJECTS. (BOBURKA, HUGHSTON)

- **COASTAL MANAGEMENT PROGRAM (CMP)'S CYCLE 24**
- **CMP CYCLE 25**
- **MARISOL BOAT RAMP (RESTORE ACT & TEXAS PARKS AND WILDLIFE DEPARTMENT GRANTS)**
- **WIND AND WATER SPORTS VENUE**

Shoreline Director Boburka and Coastal Coordination Hughston gave project updates at this time.

V. ADJOURNMENT.

There being no further business, Chairman Nixon adjourned the meeting at 3:30 p.m.

______________________________ ______________________________

Erika Hughston, Coastal Coordinator Robert Nixon, Chairman

Item No. 4.2

CITY OF SOUTH PADRE ISLAND
SHORELINE TASK FORCE
AGENDA REQUEST FORM

MEETING DATE: July 26, 2022

NAME & TITLE: Kristina Boburka, Shoreline Director

DEPARTMENT: Shoreline Department

ITEM
Update and discussion on the final report and recommendations received from the Coastal Management Program (CMP)'s Cycle 24 updated beach/dune study. (Boburka)

ITEM BACKGROUND
Discuss the final report and recommendations from this project and to understand what the study found and what the predictions are for our area.

BUDGET/FINANCIAL SUMMARY
Grant closeout has been initiated.

CMP Cycle 24 funds: $90,000
Local funds: $60,000

COMPREHENSIVE PLAN GOAL
Chapter 9: Shoreline

LEGAL REVIEW
Sent to Legal:
Approved by Legal:

RECOMMENDATIONS/COMMENTS:

Assessment and Investigation of the Beach and Dune Conditions at South Padre Island

Final Report

A report funded by a Texas Coastal Management Program Grant approved by the Texas Land Commissioner pursuant to National Oceanic and Atmospheric Award No. NA19NOS4190106

Prepared for
City of South Padre Island
ATTN: Kristina Boburka, Shoreline Director
321 Padre Boulevard
South Padre Island, TX 78597

Prepared by
integral consulting inc.
1790 Hughes Landing Blvd.
Suite 400
The Woodlands, TX 77380

June 07, 2022

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ACRONYMS, ABBREVIATIONS, AND DEFINITIONS

1-D	one-dimensional
ADAPT	Adaptation Decision and Planning Tool
BUDM	Beneficial-Use Dredge Material (program)
CBI	Conrad Blucher Institute
ERP	erosion response plan
EVA	extreme value analysis
GoM	Gulf of Mexico
HDR	HDR Engineering, Inc.
Integral	Integral Consulting Inc.
lidar	light detection and ranging
MSL	mean sea level
NAVD88	North American Vertical Datum of 1988
NOAA	National Oceanic and Atmospheric Administration
QA/QC	quality assurance and quality control
SLR	sea level rise
SPI	South Padre Island
SWAN	Simulating WAves Nearshore
SWL	still water level
TWL	total water level
USACE	U.S. Army Corps of Engineers
USGS	U.S. Geological Survey
Beach width	Cross-shore horizontal distance between the shoreline and the dune toe
Dune height	Absolute elevation of the primary dune in NAVD88

1 EXECUTIVE SUMMARY

South Padre Island (SPI) is a narrow, low-relief barrier island along the south Texas coastline that is impacted frequently by erosive winter storm events and infrequent but extremely damaging major hurricanes. Relative rates of sea level rise (SLR) are higher than global averages as a result of subsidence along the Texas coastline, which exacerbates flooding and increases the inland incursion of storm waves. The dune field that backs the beach along the City of SPI coastline from the Brazos-Santiago Pass to the northern end of the City limits is discontinuous because of the numerous beach access points and removal of sand by beachfront property owners. The present dune system is composed of a semi-natural dune field that varies in elevation and width alongshore, and has an extensive vegetation-planting program that helps to provide some resistance to dune erosion and dissipate aeolian transport of sand.

Scarping of the beach and dune is common in the winter, particularly towards the northern, more erosive part of the beach system. Overall, the beach-dune system provides critical protection to the community of SPI from storm waves and elevated water levels. The beaches and dunes are nourished and planted on a regular basis, thus maintaining a first line of protection for the City and its infrastructure from storm events.

Integral Consulting Inc. (Integral) was awarded a contract with SPI in 2020 to assess and investigate the beach and dune conditions at SPI. The project was undertaken in phases (Figure 1-1) following an Integral-developed framework called Coastal ADAPT (Adaptation Decision and Planning Tool) that uses a variety of analysis and modeling approaches to examine adaptation options for increasing resilience to coastal hazards and SLR-related climate change risks. The project also included a Dune Management and Maintenance Plan that was subcontracted to BIO-WEST, provided as Appendix D in this document.

The first phase of the study is an analysis of the current and historical state of the beaches and dunes based on a record of beach profile data going back to 1995, and includes a new survey collected as part of this contract in 2021. Morphometrics, or morphologic features used to analyze changes to the system, were extracted using a semi-automated approach and the results were imported into graphical data viewers that generated statistics of state and change through time. The analyses showcase the historical evolution of the system and identify the impact of specific tropical cyclones, as well as human-induced changes such as beach nourishment. The profile data and morphometrics viewers allowed for the examination of 25 profile locations, each with 10 dates of profiles and metrics from the historical and modern record.

The profiles revealed large variations in space and time, but overall, most profiles have prograded (moved seaward) as compared to the historical data. This is largely attributed to the regular beach nourishment and dune planting programs at SPI. The profiles were found to have a fairly complex morphology, with most profiles having a triple offshore bar system, and the dune field containing numerous swales and blowouts. The morphometrics analysis included an assessment of changes through time and space of the dune crest and toe elevations, beach widths, and profile volumes. Overall, it was found that the beaches and dunes of SPI are in a relatively resilient state at present, again, due primarily to the ongoing beach nourishment and dune vegetation planting programs. Based on the historical investigation, the most resilient state appears to be one with a primary dune of ≥12.5 ft, and a beach width no narrower than 200 ft. The northern portion of SPI is consistently less resilient than the central and southern areas.

Following the completion of the beach and dune assessment, the next phase involved modeling of future potential impacts due to storms combined with SLR. Advanced state-of-the-science modeling was utilized, incorporating measured data from wave buoys to simulate waves along the SPI coastline. To assess the resiliency of the future beaches and dunes, the profile data from 2021 were used as a baseline to assess an array of storm events, from mild to severe, over several future SLR scenarios, and to identify predicted changes to the profiles. The modeling was conducted using an open-source software program called XBeach. The storm and SLR scenarios modeled included 2-, 10-, and 100-year storm events, and SLR projected for 2040 and 2070.

The outcomes indicate that the lower portion of the beach near the shoreline is the most highly impacted portion of the system, and that the lower beach acts as a sacrificial beach, helping to prevent waves from causing damage to the dune system, under most scenarios. These results suggest that if SPI can maintain a resilient beach and dune system, it will be able to prevent catastrophic impacts to the infrastructure further inland in the short- to medium-term time scale. As sea level approaches the NOAA predicted 3.5 ft (2070) levels, it may be necessary to maintain beach wider than 200 ft. If this is unlikely to be feasible, SPI will need to consider other adaptation strategies for protection of infrastructure and resources. Based on the historical analysis, the most resilient beach has a width that is ≥ 200 ft. Lastly, the modeled total water levels during storm events did indicate that the primary dune system may be overtopped in areas where the crest elevation is lower than ~ 12 ft, supporting the recommended 12.5 ft crest elevation based on the historical analysis.

The final phase of the study addresses future adaptation strategies and makes key recommendations for maintaining a resilient coastal system, some of which are project-based and others that likely will require changes to local ordinances. The adaptive management strategy is laid out in an adaptation pathway, both for policy and projects, and shows when in time a new or different action will need to be undertaken due to changing conditions or triggers that are expected to cause change. The key recommendations are restoring a continuous dune system, as it is currently interrupted by walkways through the dunes (rather than elevated walk-overs), and in some areas, dunes have been removed for recreational and beach access purposes. Both of these conditions leave the system less resilient and vulnerable to future impacts. In addition, current ordinances allow for the primary dune to be lowered to 10 ft if it accumulates higher than that elevation. This study shows by both historical analysis and modeling that maintaining a 12+ ft dune is critical to the resilience of the system.

This study is the first of its kind since 1993, and modern technologies and techniques have allowed for a much more robust analysis of the beach and dune system at SPI. The outcomes are intended to help City managers and planners understand the current state of the beaches and dunes and to determine what types of projects and policy changes will need to start being planned now so that SPI can maintain its economically valuable resource that also protects the inland infrastructure.

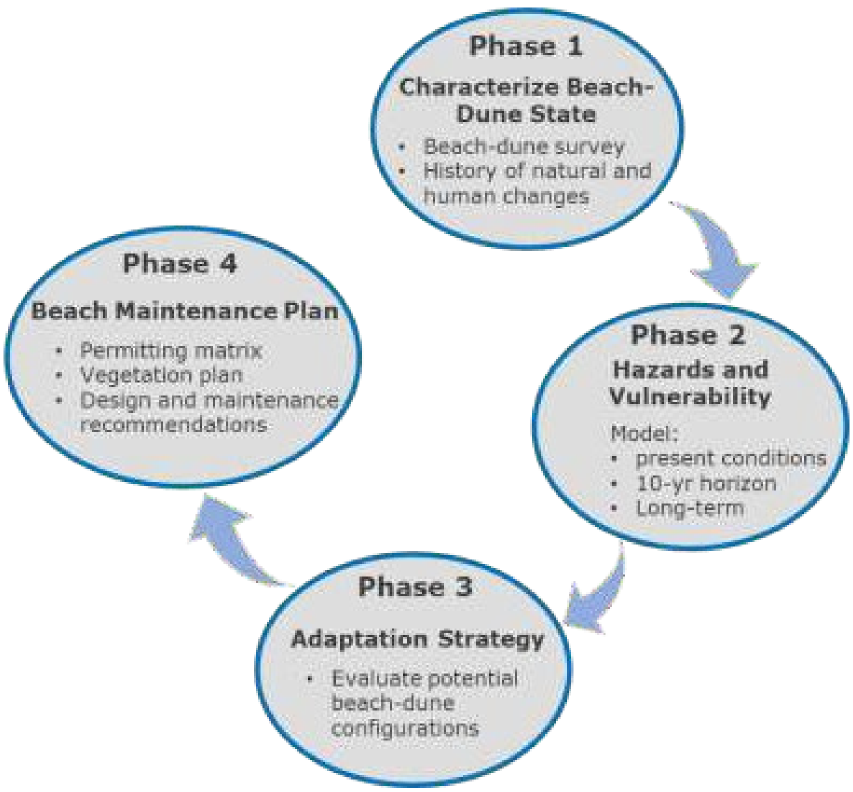

Figure 1-1. Workflow for Informing a Beach Maintenance Plan That Includes Multiple Phases to Achieve an Actionable Outcome

2 BACKGROUND

Studies and monitoring of the beach and dunes at SPI have occurred since an original 1993 beach and dune management plan was developed; the science, engineering, and geomorphological understanding of beaches and dunes and various approaches to improving community resiliency have evolved since then. A substantial amount of data exist for SPI, both in a long record of historical shorelines (1930s to 2019) and a variety of light detection and ranging (lidar) topographic data and field-surveyed beach profiles. Our beach and dune assessment and investigation leverages the previous studies and utilizes existing data. An updated survey of the established beach profiles was collected in June 2021 on the 25 Conrad Blucher Institute (CBI) lines (Figure 2-1).

Previous investigations of the beach and dune system at SPI include evaluation and assessment of shoreline position and annual averaged rates of change, dune elevation and width, and dune vegetation reported in the 2012 Erosion Response Plan (ERP). The shoreline positions and rates of change in the ERP were obtained from the Texas Shoreline Change Project (https://www.beg.utexas.edu/research/programs/coastal/the-texas-shoreline-change-project). The ERP divides SPI into three areas—north, central, and south—and presents the averaged shoreline change rate within each area, as opposed to providing a detailed alongshore perspective. The dune elevations are reported as averages or ranges for each of the three areas. Lastly, the ERP provides descriptions of dune "depth" or how wide the dune field is in a cross-shore direction, and concludes and recommends that a 200-ft-wide dune field needs to be maintained to prevent the beaches and dunes from rapidly eroding, which would result in the loss of protection to community infrastructure. In addition to the largely qualitative 2012 ERP, a statewide shoreline change assessment by Paine and Caudle (2020) includes SPI and provides an update to the 2012 rates of change reported in the ERP.

In addition to the analyses presented in the ERP, HDR Engineering, Inc. (HDR) conducted the design and permitting of several beach-dune nourishment projects. As part of its effort, HDR established an annual monitoring program (2008–2015) to assess how the beach changed over time on profiles spaced approximately 1,000 ft apart at long-established survey control monuments. In addition to beach profile changes, shoreline positions were extracted from the profiles to evaluate shoreline change over the project period. The study included a wave modeling component to assess alongshore variability in wave forcing to provide insight for the variable alongshore rates of coastal change.

The current project presents a more quantitative assessment of the beach and dune system at SPI than the earlier studies, but is complementary and builds on the earlier work. This report describes the methodology and findings for seven analyses: hydrodynamics, beach and dune profile changes, shoreline change, 3-dimensional elevation change, morphometric change, vegetation line changes, and current state of the beach-dune system.

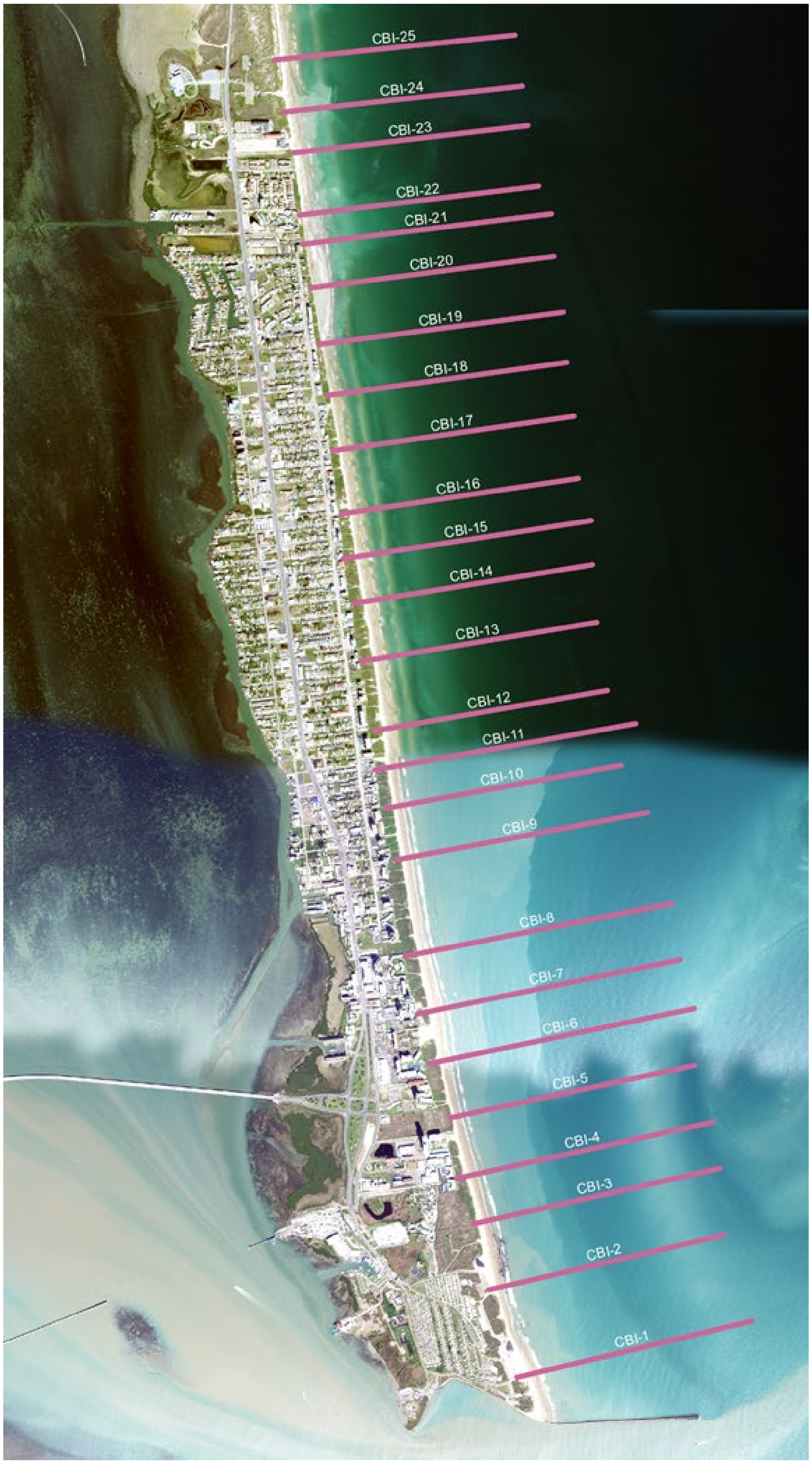

Figure 2-1. Location of 25 CBI Profiles That Were Analyzed for the SPI Beach and Dune Assessment Project

It also includes an explanation of various adaptation strategies to be considered for maintaining a resilient coastal system into the future with rising sea levels and future storms. Recommendations for policy changes and project implementation are made within the framework of an adaptation pathway, and recommendations for future studies are also included in the adaptation discussion including a comprehensive vulnerability assessment of SPI.

3 COASTAL PROCESSES AND HAZARDS

Coastal processes along SPI that create coastal hazards include tides, waves, and related storm conditions. An important measure of coastal hazards is the total water level (TWL) elevation—the combined effect of wave run-up height, storm surge, tides, and sea level elevations (Figure 3-1). River discharge is not a contributing factor to TWL at SPI. A combination of large waves occurring at high tides during storm conditions poses the largest potential to impact coastal erosion. As sea levels rise, both the wave run-up dynamics and the tide elevations will change, leading to higher total water levels for longer durations. Each coastal process is summarized below.

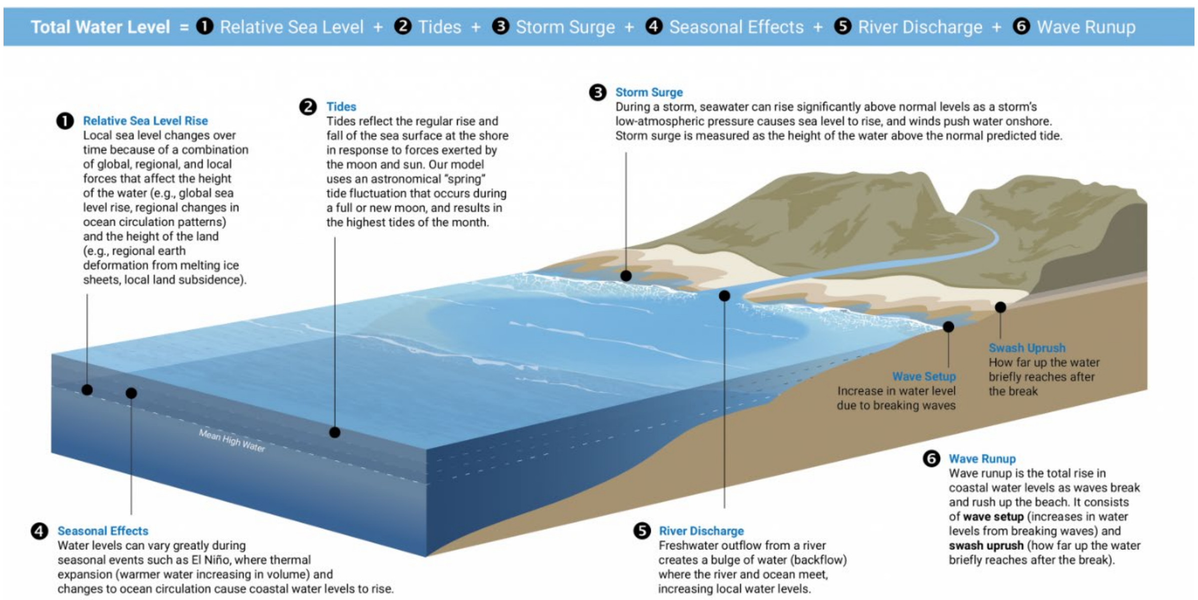

Figure 3-1. Conceptual Diagram of the Components of Total Water Level. Image courtesy of Our Coast Our Future Web Platform (Point Blue and USGS 2021).

3.1 WAVES

Waves, created by distant and local winds, are one of the key drivers of wave run-up and resulting coastal change. Local wind-driven seas typically develop rapidly when low pressure systems track near a locale, especially in the summer and fall months during hurricane season, or when strong sea breezes are generated during the spring and summer. Although the mean wave climate is modulated by winter cold fronts, the most extreme events are related to hurricanes (Appendini et al. 2014).

When distantly generated waves approach the coast as swell, they interact with coastal and bathymetric features. A wave measured at a buoy offshore in deep water is quite different from one that breaks at the coast near SPI. The Yucatan Peninsula, for example, may block swell from the south, while a large northeast or east swell from an offshore storm or hurricane may approach SPI leading to an increased potential for coastal erosion. Modeling of the changing waves based on bathymetry and swell conditions is called wave transformation and was an important component in assessing vulnerabilities for this project.

Waves break offshore in depths that are related to the wave height and the wave period. In general, the bigger the wave and the longer the wave period, the deeper the water in which the wave will break. Smaller waves can travel much closer to shore before breaking and often pose more risk of causing damage than the biggest waves. Once the wave breaks, it runs up the shoreline and the slopes and roughness affect its elevation and inland extent across the surf zone and beach. Depending on the frequency of breaking waves, wave setup can occur when a series of breaking waves can pile up water allowing subsequent waves to travel closer to shore on the piled-up water before breaking with more energy. As sea levels rise, not only will the still water level (SWL) be affected, but the deeper water close to shore will allow waves to break closer to shore with less potential to dissipate the wave energy.

For this study, the historical wave record was compiled from NOAA wave gauge 42020 (Figure 3-1-1), going back to 1992. Major storms that had some impact at SPI are shown with red "x's" in Figure 3-1-2 and listed in Table 3-1.

Figure 3-1-1. Location Map of SPI Showing Study Area and Locations of the NOAA Wave Buoy. The tide gauge is located within the Brazos-Santiago Pass, immediately adjacent to the southern boundary of the SPI study area.

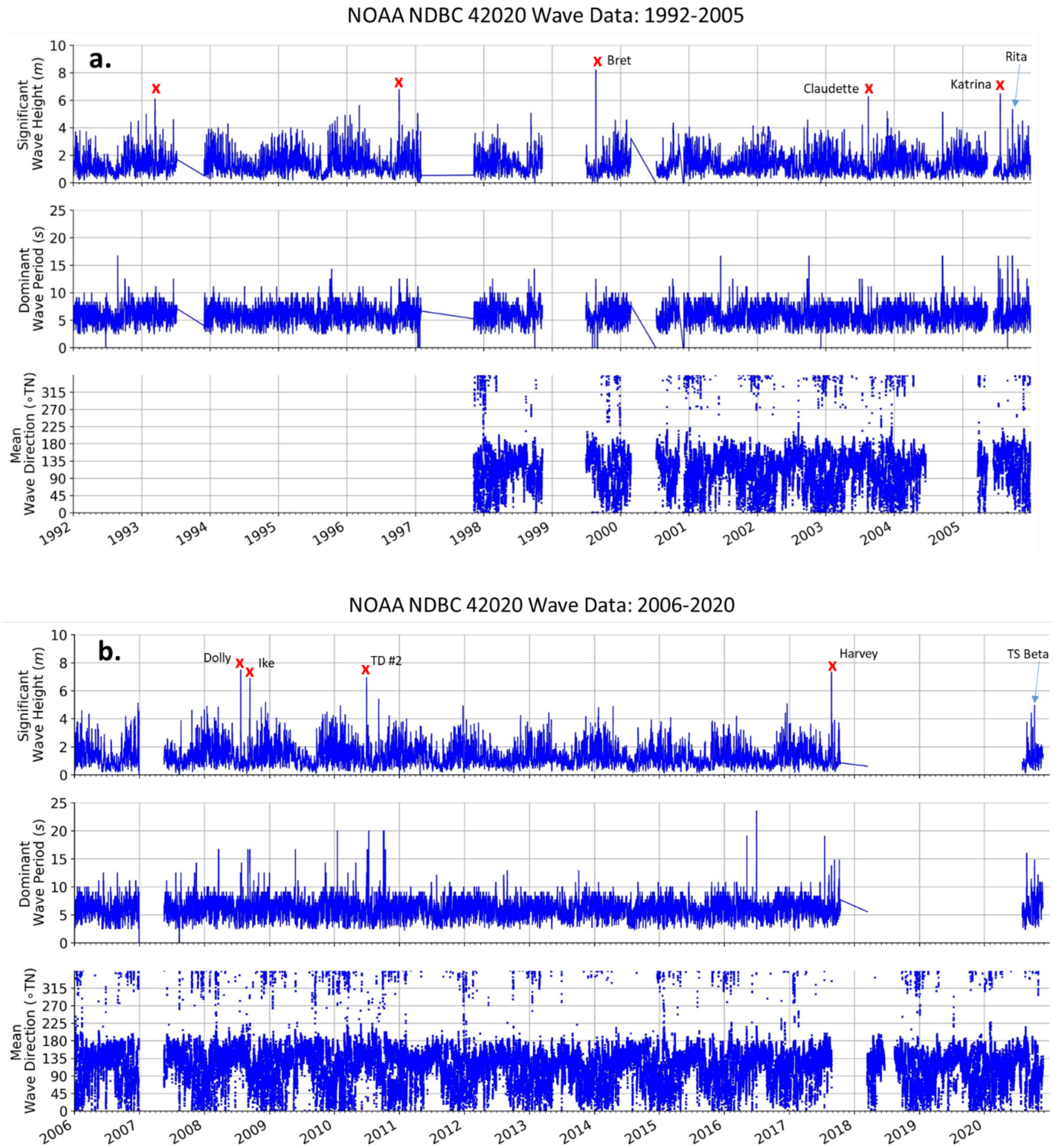

Figure 3-1-2. Wave Data from the Closest Directional Wave Buoy to SPI. The time series is separated into two plots for 1992–2005 (a); and 2006–2020 (b) in order to better resolve individual events. The red "x's" indicate known, documented tropical storms that had impacts to SPI beaches and dunes (see Table 3-1). Note the wave heights are reported in meters.

Table 3-1. Notable Documented Storms on Record That Impacted Beaches and Dunes at SPI

Landfall Date	Name	TS	HX	Cat	Landfall	Comments
1967-09-20	Beulah		Y	3	Just N of Rio Grande	Extensive damage to SPI
1999-08-23	Bret [a]		Y	3	Padre Island, between Brownsville and Corpus	
2003-07-15	Claudette [a]		Y	1	Matagorda	
2005-08-28	Katrina [a]		Y	3	New Orleans	Extensive erosion to City beaches
2005-09-24	Rita [a]		Y	3	Louisiana	Extensive erosion to City beaches
2008-07-23	Dolly [a]		Y	1	City of SPI	Extensive damage to SPI
2008-09-13	Ike [a]		Y	4	Galveston	Moderate damage to SPI/Extensive Erosion
2010-06-30	Alex		Y	2	Soto La Marina	Heavy rain
2010-07-08	TD 2 [a]	-	-	-	South Padre Island	
2010-09-07	Hermine [a]	Y			NE Mexico	3.4 ft storm surge at Port Aransas
2011-06-30	Arlene	Y			Cabo Rojo	
2015-06-16	Bill	Y			Matagorda Island	
2017-08-25	Harvey [a]		Y	4	Rockport	Tidal surge
2020-07-25	Hanna		Y	1	Padre Island, Kennedy County	Minor
2020-09-22	Beta*	Y			Matagorda Peninsula, TX	Damage to dunes

Notes:
Blue shaded rows = Hurricanes
* =
Cat = Category
HX = Hurricane
TS = Tropical Storm
[a] Identifiable in wave record as red “x’s” in Figure 3-2.

3.2 TIDES AND WATER LEVEL DATA

The closest National Oceanic and Atmospheric Administration (NOAA) tide gauge station is located at the entrance to the Brazos Santiago ship channel immediately south of SPI. Tides in the area are a diurnal type, meaning there is one high and one low tide each day. Tides are driven predominantly by the gravitational pull of the sun and the moon with elevations based on a tidal epoch, a 19-year period of which average tidal elevations are statistically analyzed. These tidal elevations are reported in either a tidal datum or a fixed vertical reference datum.

Tidal datum elevations are typically relative to mean lower low water—the average of lowest low tides—a useful measurement for navigation purposes. A fixed vertical reference datum is established using geodetic land-based measurements. For this study, elevations will be reported in fixed land-based vertical reference datum using the North American Vertical Datum of 1988 (NAVD88).

Tide elevations vary monthly and annually based on the lunar orbit and solar positioning. During new and full moon when the gravitational pull of the sun and moon are aligned, spring tides have a higher tide range. During certain atmospheric conditions or wind conditions, tide observations can be much higher than predicted tides due to storm surge components. SWL is the term used to describe the elevation of the tide and the combination of non-wave components. Future SLR rise will raise the SWL elevations, thus affecting the height and extent of the potential for coastal erosion.

Figure 3-2 shows the water level record from 2017 to 2021 at the Santiago Brazos Pass NOAA tide gage, and captures a number of higher-than-average water levels in 2017–2019 that fall in October. These are not relatable to any known tropical storms and may represent astronomical yearly high tides, since they consistently occur in late October. The tide gage record does capture elevated water levels from storm surge associated with Hurricane Hanna and Tropical Storm Beta in 2020.

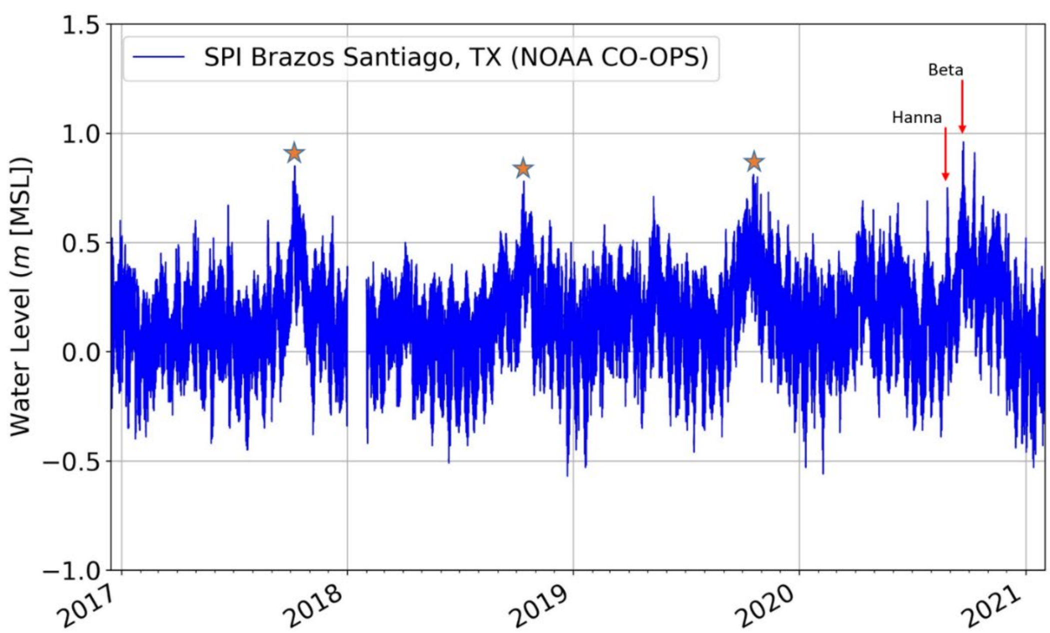

Figure 3-2. Water Level Data from a NOAA Tide Gage at Brazos Santiago Pass. The data time series appears to capture yearly astronomical high tides (orange stars) as well as storm surge from Hurricane Hanna and Tropical Storm Beta in 2020.

3.3 SEA LEVEL RISE

Increases in greenhouse gas emissions, primarily from the burning of fossil fuels, are contributing to an increase in atmospheric and ocean temperatures, causing ocean waters to warm and expand, and continental glaciers and the ice sheets of Greenland and Antarctica to lose ice mass and melt. As a result, the global rate of SLR has increased to rates of about 0.15 in./year between 1993 and 2018 (Nerem et al. 2018).

However, SLR is not the same everywhere around the world. Because of local differences in tectonic uplift; subsidence caused by oil, gas, and groundwater extraction; and sediment deposition and saltwater intrusion, the land itself can move vertically.

Local or relative SLR is more important to this study than global rates of SLR. The tide gauge at the SPI Coast Guard Station (Station ID: 8779748) has recorded an SLR of 0.17 in./yr ± 0.02 in./yr between 1958 to 2021, equivalent to a change of 1.4 ft in 100 years (Figure 3-3). This is equivalent to the average global rate of SLR ~0.15 in./yr; however, this trend, relative to global SLR, will change in the future (IPCC 2021).

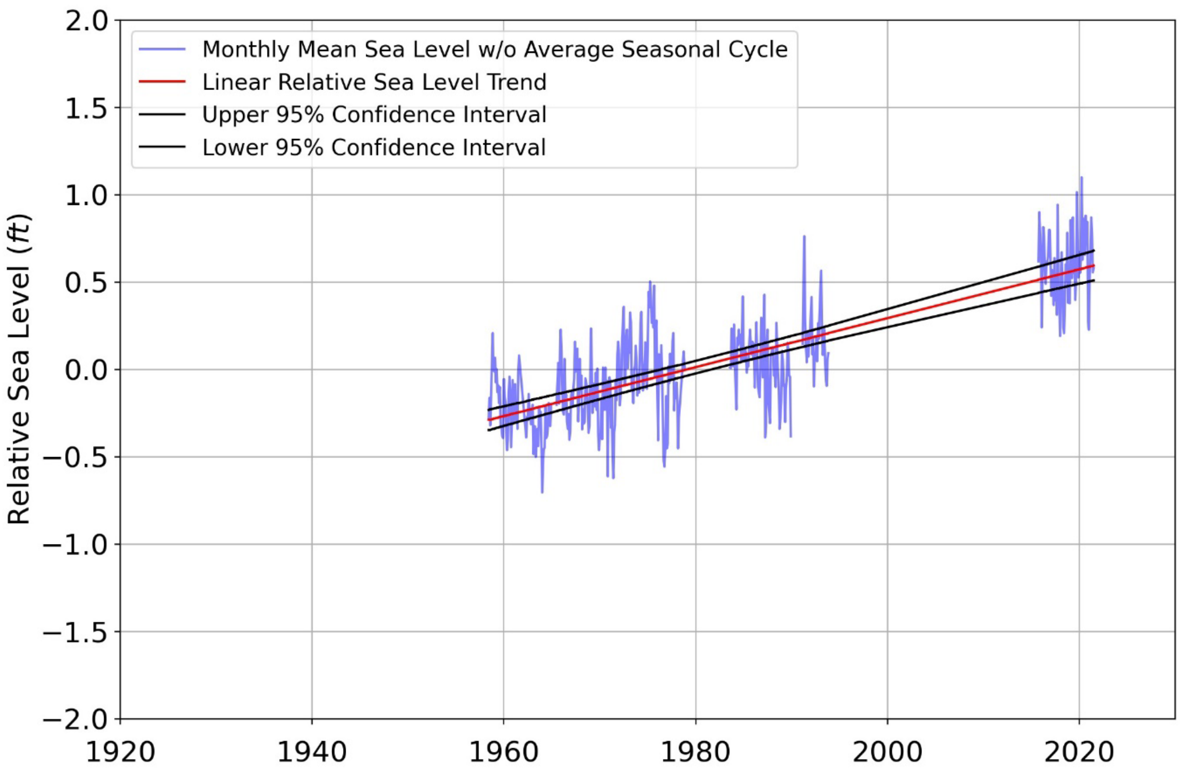

Figure 3-3. Relative Sea Level Trend at the South Padre Island, Texas, NOAA Tide Gauge 8779748. Source: https://tidesandcurrents.noaa.gov/waterlevels.html?id=8779748.

4 HISTORICAL BEACH AND DUNE PROFILES

Forty-five beach profile data sets spanning 27 years were downloaded and/or otherwise obtained for SPI from sources such as Shiner Moseley, the U.S. Army Corps of Engineers (USACE), Texas A&M, HDR, and Naismith. The beach profiles are perpendicular to the orientation of the shoreline (Figure 2-1), and extend across the primary dune, the beach, and offshore to water depths of 30–40 ft. All beach profile data sets were formatted for consistency, tested for quality assurance and quality control (QA/QC), and imported into ArcGIS for geospatial analysis. In analyzing the data, it became evident that the original surveys were conducted on a set of lines spaced approximately 1,000 ft (herein CBI profiles), located by a series of survey monuments, and repeated throughout the entire time series. However, in the mid-part of the time series, a new survey strategy was developed with more closely spaced profiles based on a linear distance from a starting point adjacent to Brazos Santiago Pass. Fortunately, the surveys also continued to include the CBI profiles, and this analysis focused on those 25 profiles that are consistent throughout the time series (Figure 2-1). In addition, as part of the present study, a survey conducted in June 2021 collected data on the 25 CBI profiles. In order to stay within the scope of the project, we filtered the data to analyze nine survey dates, providing a time series of 25 years. Initially, we intended to include a June 2005 profile data set, but after detailed QA/QC, it was determined there were irreconcilable uncertainties in the data that suggested some type of offset or methodology error in the survey, and it was removed from the final analysis. The time series is provided in Table 4-1 and data were chosen to include historical representation (1995), and then approximately every 3–4 years unless a major storm occurred, in which we attempted to select data sets that would capture before- and after-storm conditions of the beaches and dunes. We also attempted to select surveys from approximately the same time of year so seasonal changes were less likely to bias the analysis.

Table 4-1. Historical Beach Profile Data Obtained for Analysis

Survey Date	Surveyor
February 1995	Conrad Blucher Institute
June 2002	Texas A&M
~~June 2005~~	~~Shiner + Texas A&M~~
June 2006	HDR/Shiner Moseley/Frontier
July 2007	Terrasond
July 2008	Naismith
August 2011	Naismith
July 2014	Naismith
December 2018	Naismith
May 2020	Naismith

To best view the profile data through time, an html-format viewer was created using code written in the statistical software package R, along with Plotly, which allows for visualization, analysis, and interpretation of the large data set (Figure 4-1). The viewer allows the user to visualize how the profiles change through both space and time by allowing each profile to be displayed individually or with other dates to see changes through time.

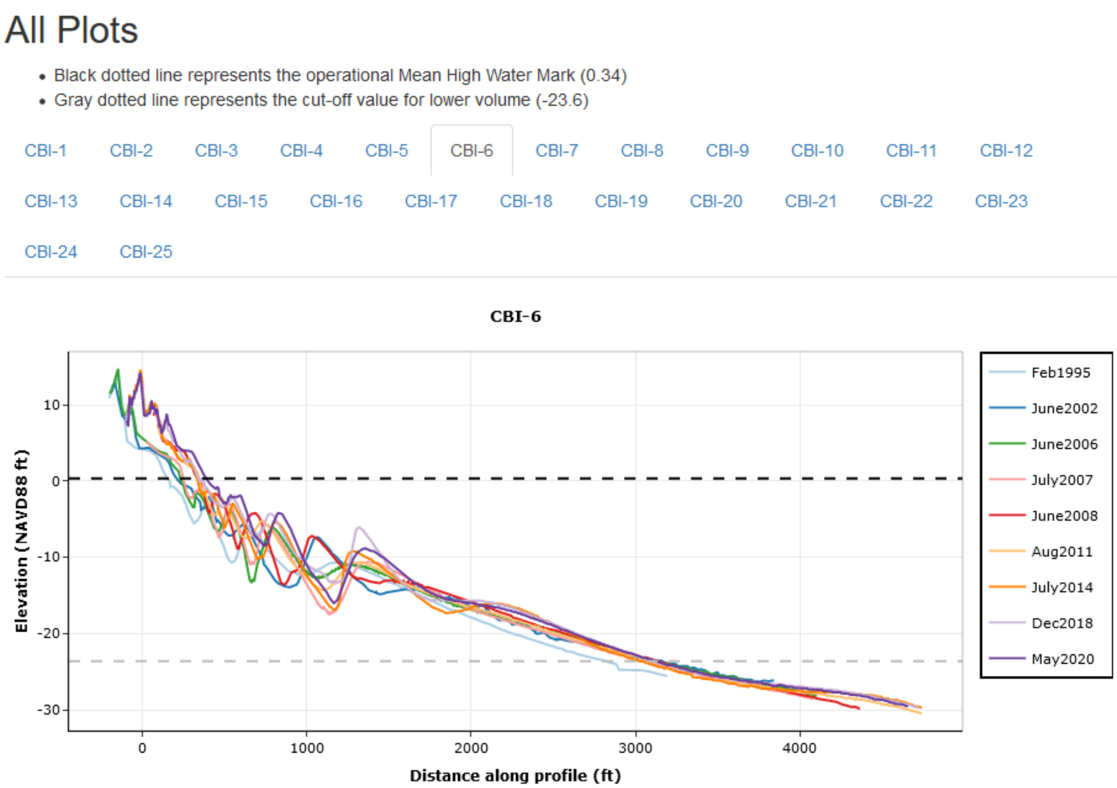

Figure 4-1. Data Viewer Created Based on Beach Profile Time Series for the 25 CBI Profiles

An assessment of the overall morphology of the beach profiles at SPI reveals a relatively "typical" barrier island morphology—dunes and beaches are exposed subaerially and a well-formed and persistent offshore bar is present in the underwater portion of the beach profile. All beach profiles exhibit a double- or bar system with the exception of CBI-1 (Figure 4-2), and many have three offshore bars (Figure 4-3), the outermost of which is in water depths of 10 ft or greater and varies considerably alongshore in its distance from the shoreline. The presence of multiple offshore bars is generally indicative of an ample sediment supply, although more commonly occurs in coastal systems with wide, dissipative beaches (Splinter et al. 2018), which does not describe SPI.

Analysis of the long-term (February 1995–May 2020; 25-year) beach profile change identifies a dominant accretional trend in the 1-dimensional beach and dune profiles. Of the 25 profiles analyzed, only two are substantially farther landward in 2020 than they were in 1995: CBI-1 and CBI-2 at the very southern end of the island (Figure 4-2). This portion of the island has been substantially altered by human activities associated with recreational facilities at Isla Blanca Park. The majority of the 25 profiles have shifted seaward (Figure 4-3) or exhibit negligible change over the 25 years covered by the study.

In general, the profile morphology tends to be much more highly variable through time and along the coast on the subaerial and shallow water (<15 ft) portion of the beach as the beaches and dunes are reworked by water, wind, and people.

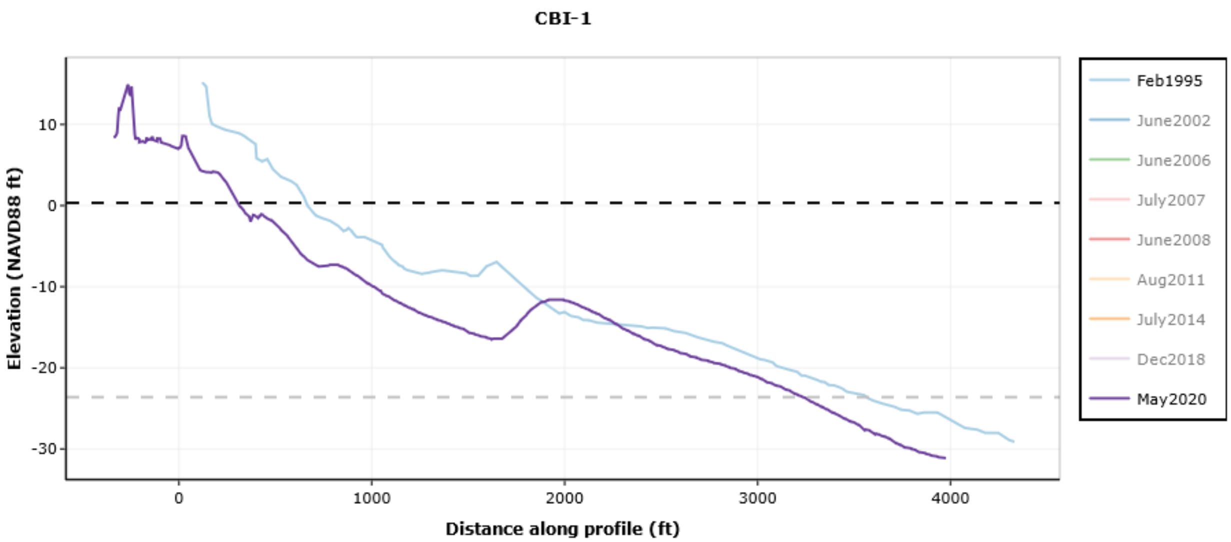

Figure 4-2. Profile Change from 1995 to 2020 at Profile CBI-1. This was one of 2 profiles that experienced systemic retreat, or landward movement.

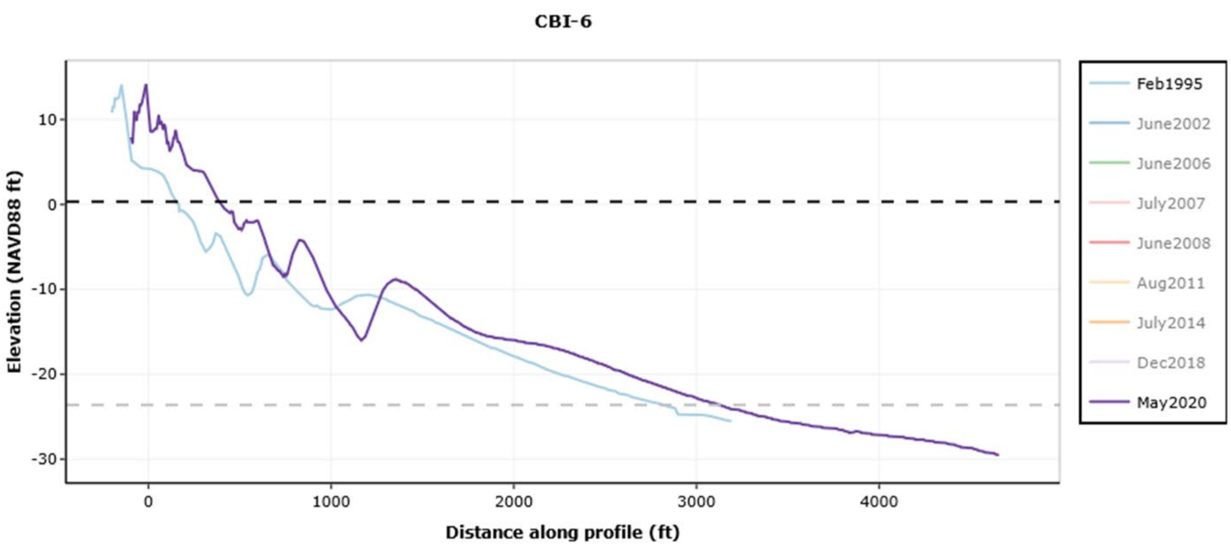

Figure 4-3. Morphologic Change between 1995 and 2020 Typical of the Majority of Profiles Showing Seawards Progradation of the Profile

5 SHORELINE CHANGE

Long-term shoreline change data were obtained from the Texas General Land Office Bureau of Economic Geology; they were generated as part of an updated shoreline change assessment for the entire Texas coast from 1930–2019 (Paine and Caudle 2020). The rates were calculated using a long-term series of shorelines dating from the 1930s, when they were digitized from historical maps, and including shorelines digitized from aerial imagery from a number of periods from the 1960s–2007. The most recent shorelines used in the study (2012 and 2019) were derived from airborne lidar data. The analysis for this project refines the previous study by focusing in on patterns and trends of change only within the boundaries of the study area (the City of SPI), and rates were calculated on shore perpendicular transects spaced 164 ft (50 m) using a linear regression method. Figures 5-1 and 5-2 show the results for the entire study area for two time periods (1930s–2019 and 2000–2019) to provide a perspective on both long- and short-term shoreline change (CBI profile locations shown for reference, only). Larger-scale maps showing more detail of the results are provided in Appendix A.

The findings of the long-term (1930s–2019) shoreline change analysis (Figure 5-1) identify a distinct pattern, previously described by Morton (1993), of high rates of erosion in the northern portion of the study area (CBI profiles 17–25), generally stable in the central portion (CBI profiles 13–16), and primarily accretional in the southern section (CBI profiles 1–12; Figure 5-1). The average rate of shoreline change for the long-term (90 year) time period, across the entire study area, was accretional, +0.6 ft/year.

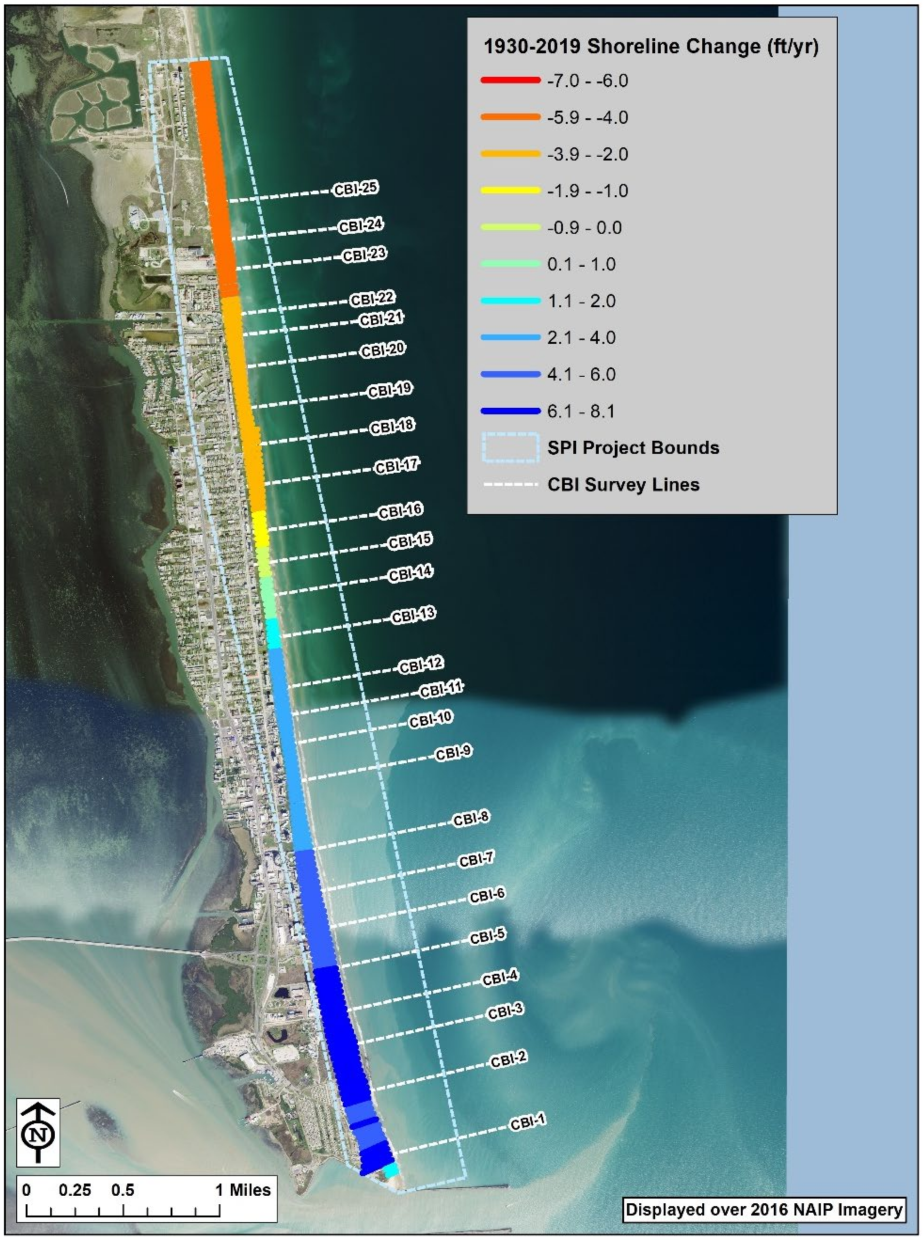

Figure 5-1. Long-Term Rates of Shoreline Change in feet/year from the 1930s to 2019

In the most recent two decades (2000–2019), the rates of change varied substantially more along coast (Figure 5-2 and Appendix A) compared to the long-term analysis. This difference in the shoreline change trends is a function of a number of factors: shorter-term data sets contain more noise, which is caused by changes from storm events, tides, seasonality, and human activities, such as beach nourishment. The occurrences, while present in longer-term data sets, tend to be smoothed over long periods of time. Between 2000 and 2019 at SPI, there is no distinct pattern along coast; there is an erosion hot spot in the very northern portion of the study area (beyond the extent of the CBI profiles), where rates of retreat are as high as 6–7 ft/year in one location. Change rates modulate between erosion or accretion along much of the central portion of the island (CBI-9 to CBI-25), and an area of moderate erosion (–0.4 to –1.4 ft/year) occurs along the coast from CBI-5 to CBI-9. South of this erosional zone, the shoreline becomes primarily accretional to the inlet jetty.

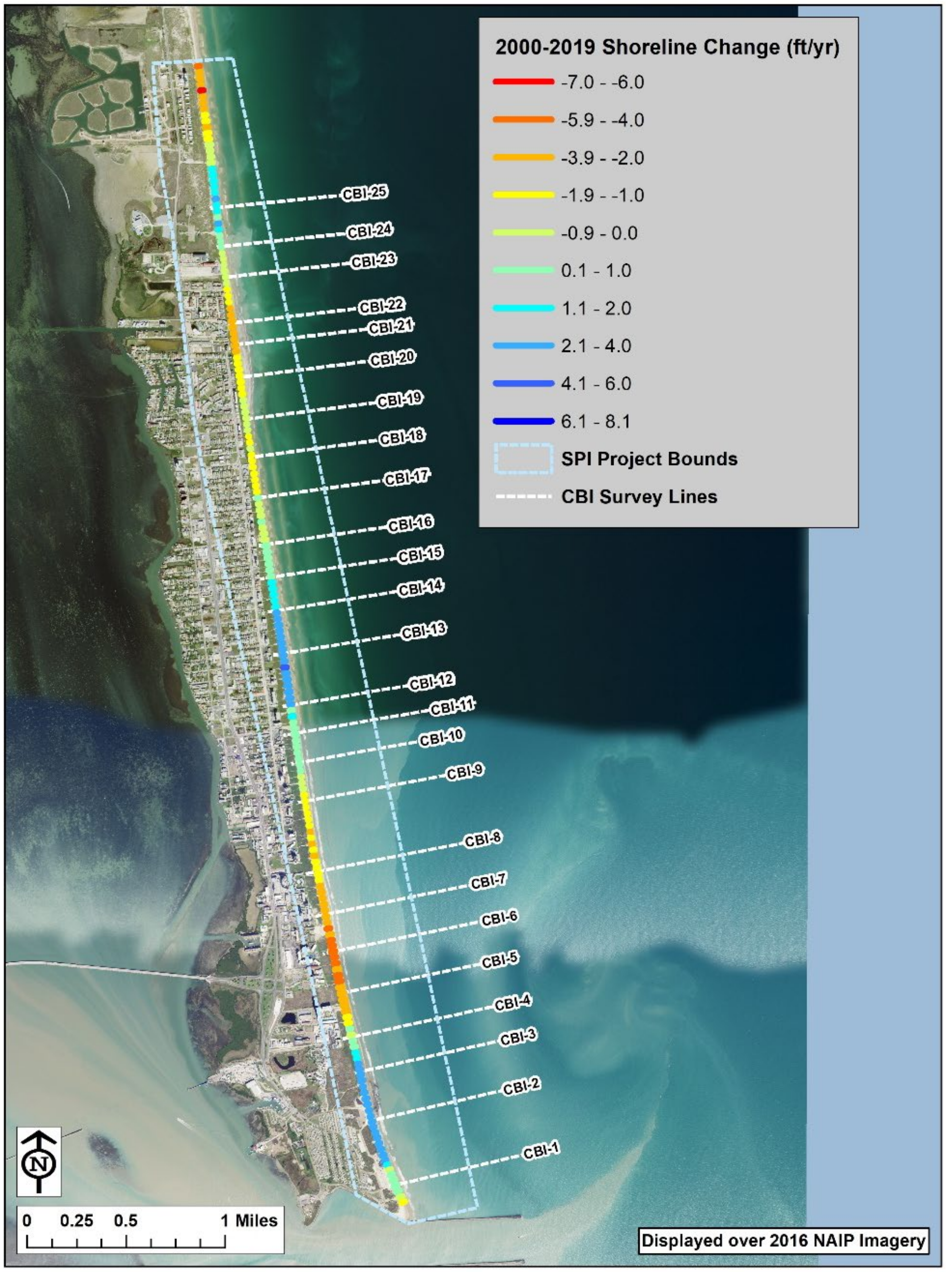

Figure 5-2. Short-Term Rates of Shoreline Change from 2000 to 2019

6 3-DIMENSIONAL ELEVATION CHANGE

To analyze very short-term changes to the topography of the entire beach-dune system, we obtained two lidar data sets from 2016 and 2018. Both raster data sets have a cell size resolution of 3.28 ft (1 m), and were downloaded from NOAA's Digital Coast website (https://coast.noaa.gov/digitalcoast/data/). USACE, as part of its National Coastal Mapping Program, collected the 2016 data, and the 2018 data were contracted by the U.S. Geological Survey (USGS). The data were imported into ArcGIS and a standard raster subtraction was applied to create a map of the changes in elevation between the two time periods.

Along the length of the island, the pattern of change is generally vertical accretion of the dunes, especially at the seaward edge of the dune field, and appears to be related dune construction associated with beach nourishment (Figures 6-1 to 6-3 and Appendix B). There was onshore placement of sand in October 2016, several months following the 2016 lidar data collection, which increased the sediment volume of the beach and dune system. The consistent elevation increase across the dune field could be attributable to a number of factors, including aeolian transport of sand from the beaches to the dunes (the persistent wind direction at SPI is out of the east–southeast), and increases in vegetation canopy height if the lidar data did not reach bare earth. The fact that the constructed dunes are still largely intact 2 years after the beach nourishment project is testament that nourishment is successful in maintaining a healthy dune system. The established dune vegetation-planting program also helps to maintain the dunes.

Also persistent along much of the study area is elevation loss of the lower beach, with evidence of scarping at or near the swash zone, shown by the abrupt change from blue (accretion) to red (erosion) (e.g., CBI-23 and CBI-24; Figure 6-1). The beach erosion is persistently higher in the northern section of the island (Figure 6-1) from CBI 21 to 25 and the area north of CBI-25. The severity of the beach erosion decreases to the south (Figures 6-2 and 6-3), and there are a few locations where the beach experienced some accretion, such as CBI-2 and CBI-5 (Figure 6-3), and CBI- 13 to -15, and -19 (Figure 6-2). The extreme values of some of the high erosion areas, as much as 6 ft of vertical loss, is suggestive of extreme storm erosion and scarping, and likely represents the erosion caused by Hurricane Harvey, which occurred in late August 2017, approximately 6 months prior to the date the 2018 lidar data were collected (March 2018). Slow recovery of a beach system from a major storm event is also exacerbated by regular winter storms, which would be expected in the months prior to the March 2018 data collection.

There is indication of increased elevation of the mid- and upper portion of the beach, which is consistent with some landward deposition of sediment on the upper beach during storm events. The highest areas of accretion occur at the toe of the dunes (e.g., CBI-14), and could be the result of landward transportation and deposition of material from the lower to the upper beach during storms, aeolian transport, or beach nourishment.

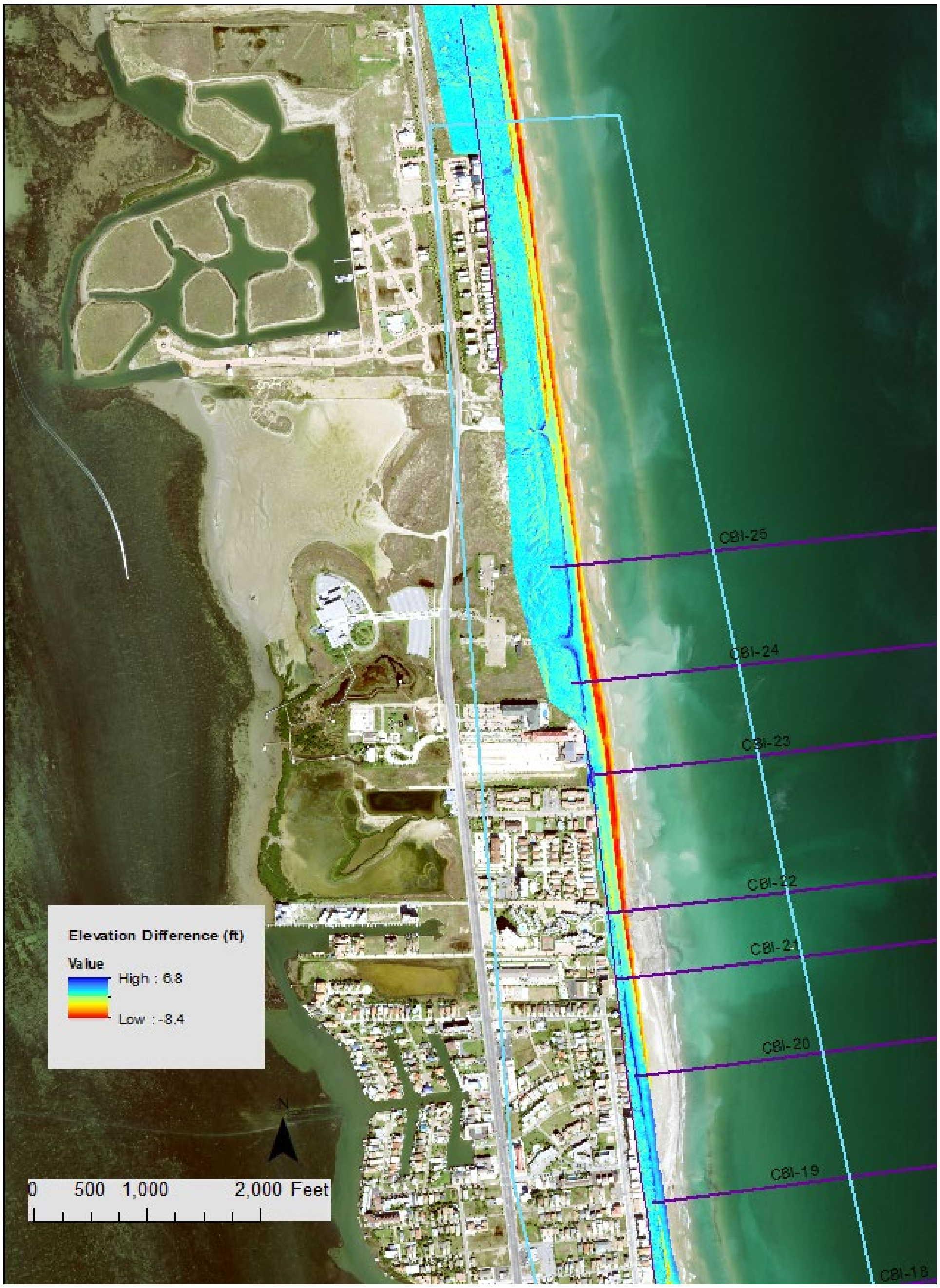

Figure 6-1. Topographic Difference Map between 2016 and 2018 of the Northern Portion of the Study Area Including the Locations of the CBI Profiles for Reference

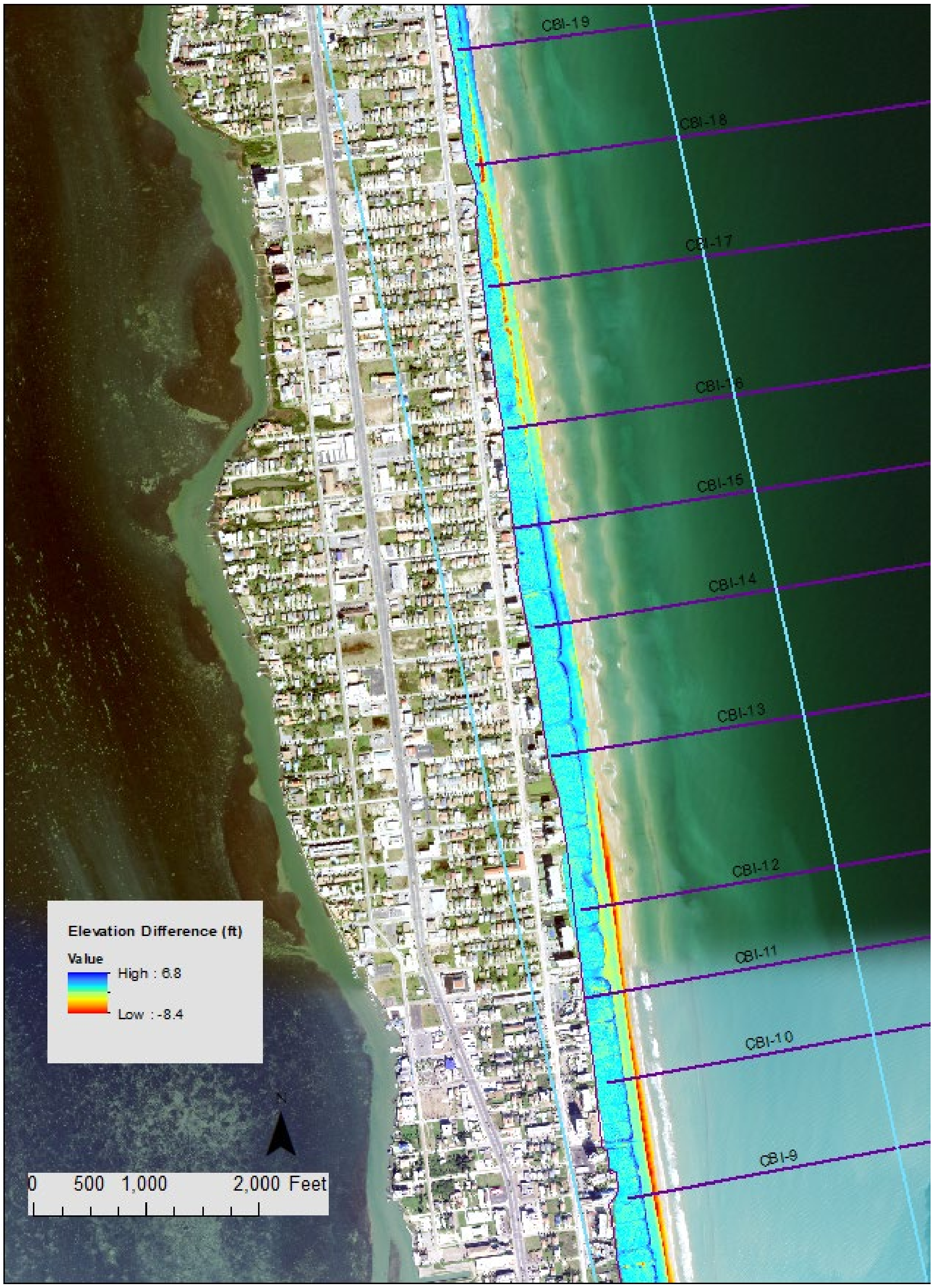

Figure 6-2. Topographic Difference Map between 2016 and 2018 of the Central Portion of the Study Area Including the Locations of the CBI Profiles for Reference

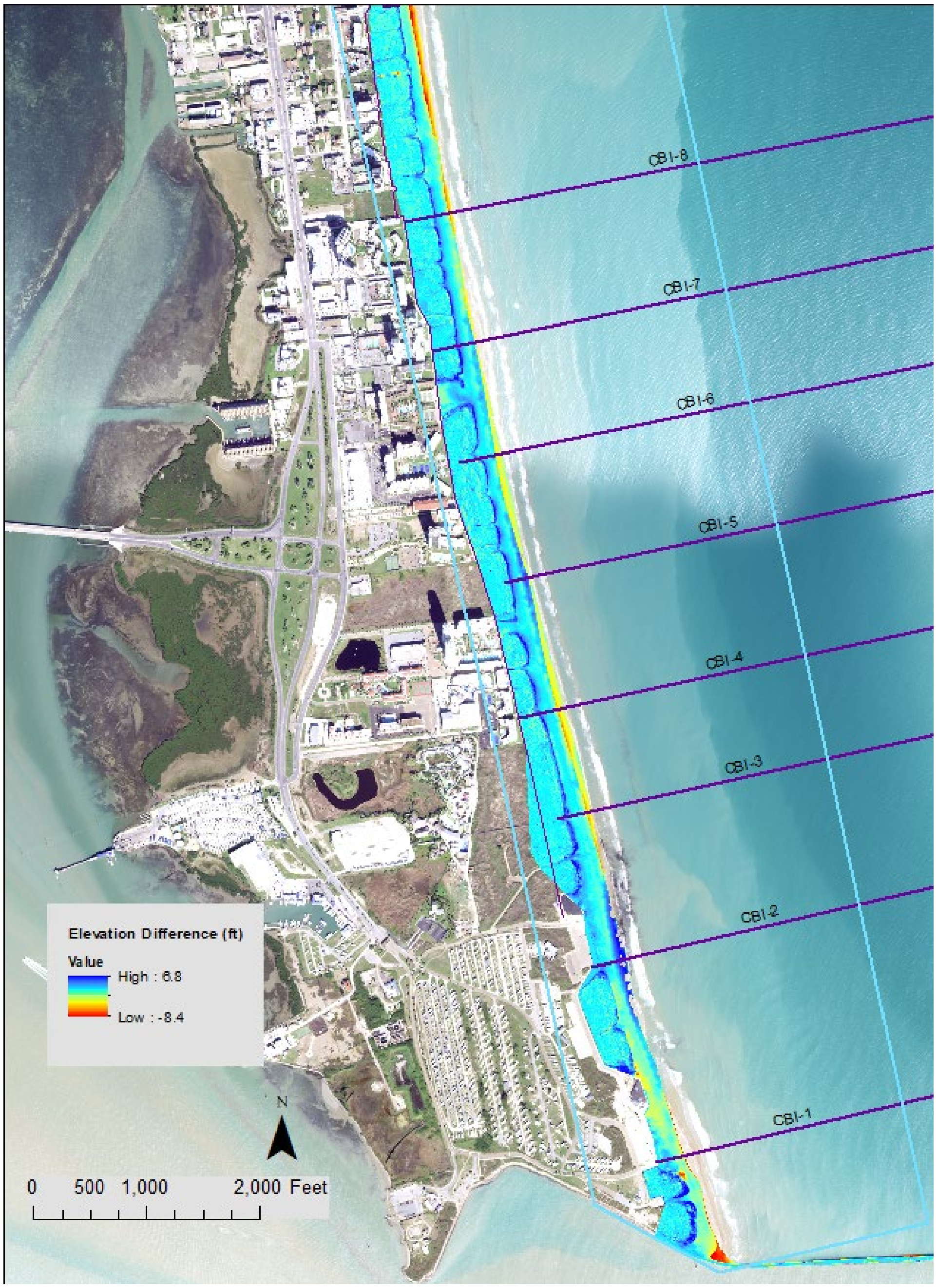

Figure 6-3. Topographic Difference Map between 2016 and 2018 of the Southern Portion of the Study Area Including the Locations of the CBI Profiles for Reference

7 MORPHOMETRIC CHANGES

A variety of metrics that describe changes to the morphology of the beach and dunes through both time and space were identified and extracted from the time series of the 25 CBI profiles. Metrics include dune crest and dune toe elevations, beach width, and profile volumes. The open-source tool PyBeach (https://github.com/TomasBeuzen/pybeach) was run on the entire time series to extract the dune crest, dune toe, and a shoreline position. The beach width was subsequently calculated in Excel by determining the distance between the shoreline and the dune toe. The beach volumes (onshore, offshore, and total) were calculated using a trapezoid method available in the Python numerical library Numpy (https://numpy.org/doc/stable/reference/generated/numpy.trapz.html).

Similar to the profile data visualization, an html-format viewer was created using code written using the statistical software package R, along with Plotly, to allow for visualization, analysis, and interpretation of the morphometric data set (Figure 7-1 shows the dune crest elevation).

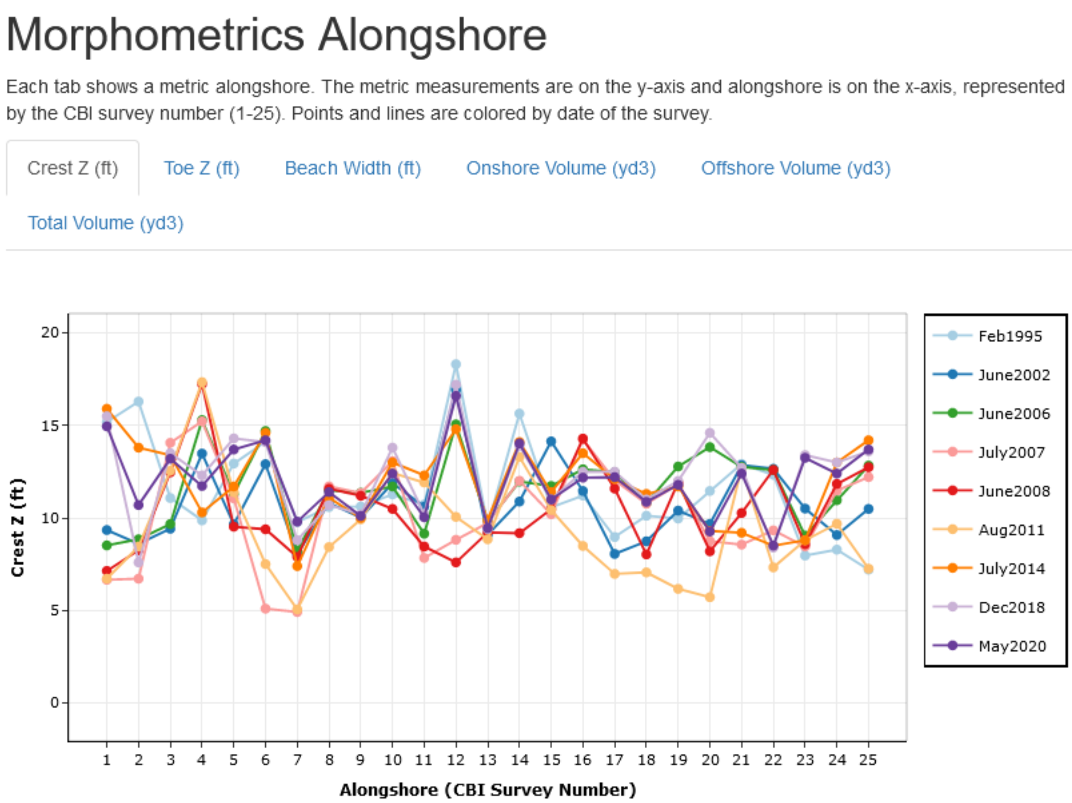

Figure 7-1. Data Viewer Created Based on Morphometrics Extracted from the 25 CBI Profiles for the Nine Survey Dates Selected for Analysis

7.1 DUNE CREST

The first part of the analysis focuses on how the dune crest changes during the earlier portion of the time series, from 1995 to 2007. Figure 7-1-1 shows the alongshore variation in the dune crest elevations over 12 years. Although variable in space and time as expected on a dynamic beach-dune system, the elevations followed similar trends from 1995 to 2006, but in 2007 there was overall more sustained elevation loss. The exceptions in general consistency from 1995 to 2006 are several profile locations in the southern portion of the study area (Figure 7-1-1; CBI-1 and CBI-2) when there are large, sustained losses post-1995. This can be attributed to human activities associated with facilities at Isla Blanca Park. In general, the crest elevations are lower in 2011 than in the previous time periods, with an alongshore average elevation of 9.4 ft. Over the rest of the time series, the averaged dune elevations ranged from 10.3 to 12.4 ft. The overall loss in 2007 does not appear to correlate with significant storm events, but could be remnants of overall system sediment losses from the back-to-back major storms, Hurricanes Katrina and Rita, in 2005. This is not atypical in other investigations of frequent, extreme storms disrupting barrier island equilibrium (Hapke et al. 2016) where it can take as much as a decade for the system to fully recover. The storm impacts are not reflected in the 2006 survey however, which may be due to nourishment following the events.

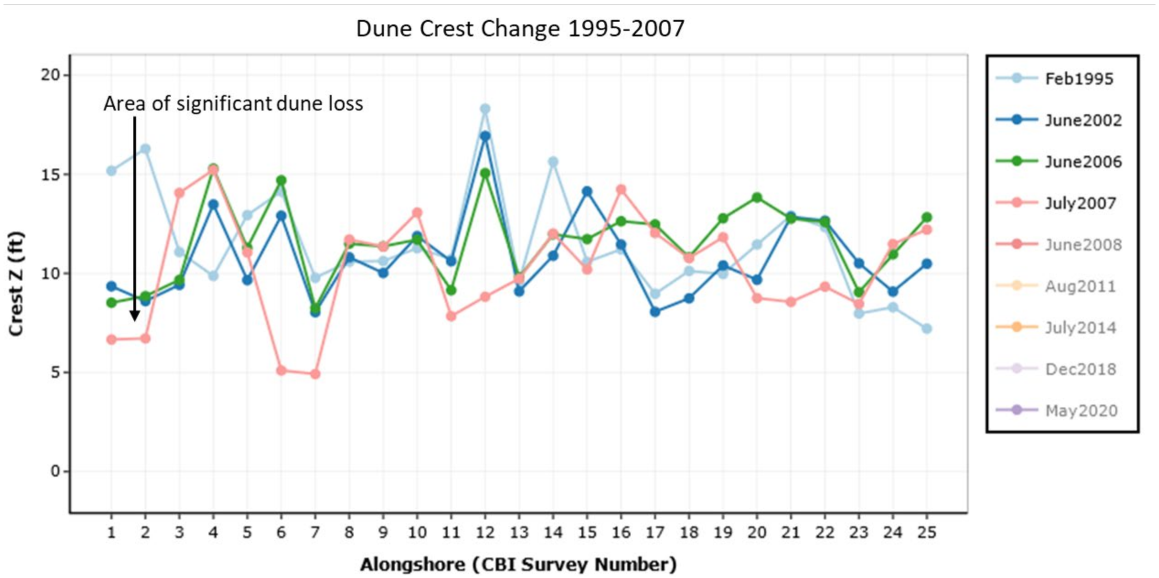

Figure 7-1-1. Dune Crest Elevations for the Earlier Portion of the Time Series from 1995 to 2007

In the latter part of the time series, the dune crest elevations are generally lower in the earlier 2 years (Figure 7-1-2), with 2011 being the lowest average crest elevation of the entire time series (average 9.4 ft). Figure 7-3 does not include all data from 2007 to 2020 for clarity. A number of tropical storms occurred between 2008 and 2011, including Dolly and Ike in 2008. Both Dolly and Ike occurred after the 2008 survey was collected, so storm impacts would not be expected to be reflected in the 2008 data set.

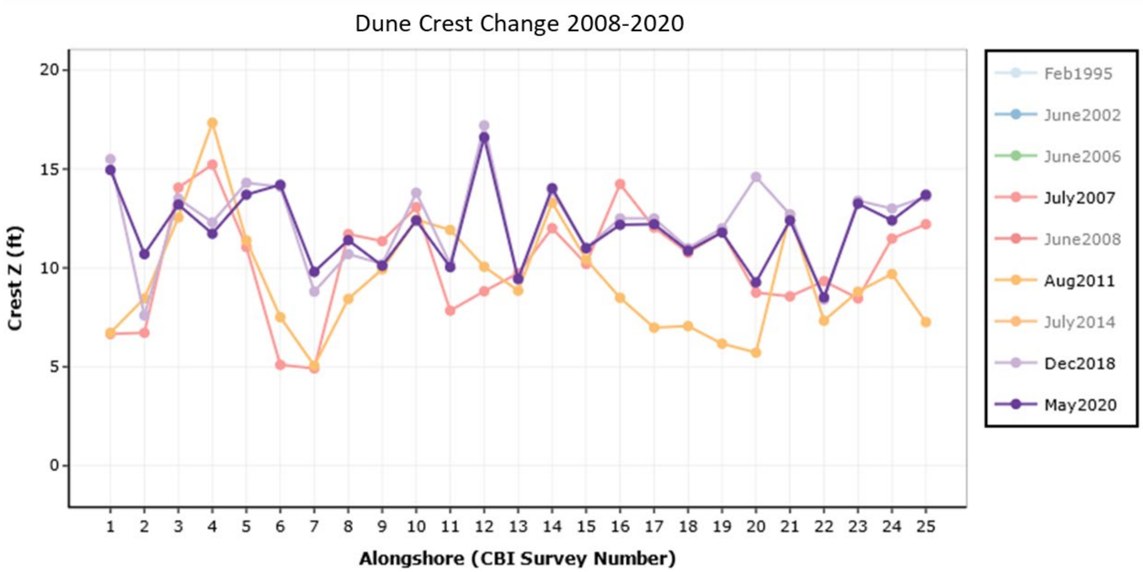

Figure 7-1-2. Dune Crest Elevations for the Earlier Portion of the Time Series from 2007 to 2020. The 2008 and 2014 data are not shown for clarity of the data trends.

7.2 DUNE TOE

The dune toe elevation is variable alongshore, and a comparison of the elevation for the earliest and most recent dates, 1995 and 2020, underscores the alongshore variability. However, outside of several outliers, the dune toe elevation over time is relatively stable (Figure 7-2) with a mean of 7 ft. The lowest overall elevation in the time series occurred in 2008 when the averaged alongshore elevation dropped to 5.8 ft.

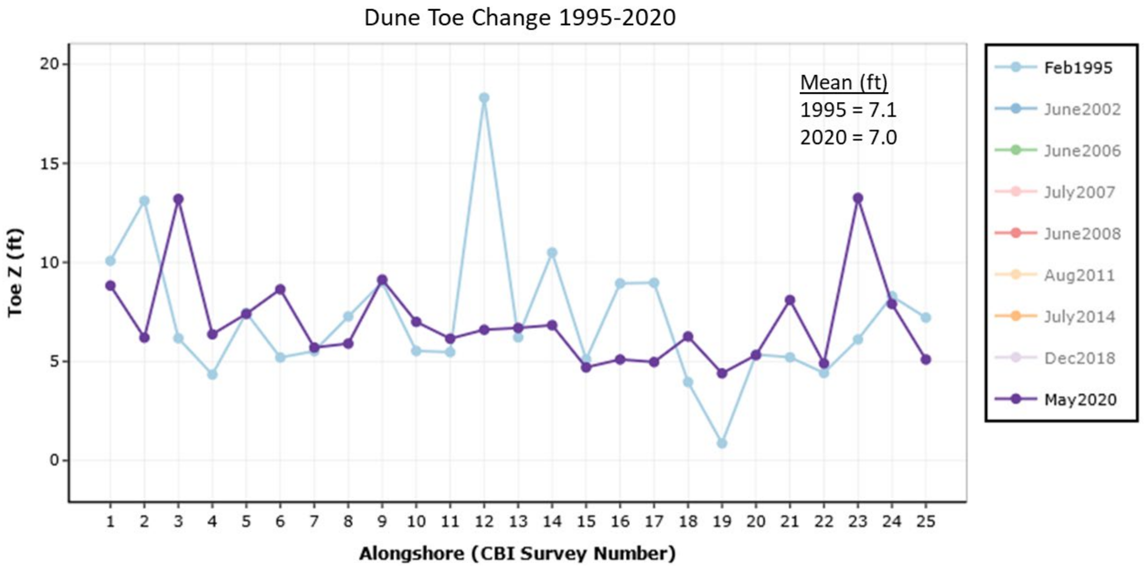

Figure 7-2. Alongshore Dune Toe Elevations for 1995 and 2020

7.3 BEACH WIDTH

Beach width and dune crest elevation are the two metrics most likely to influence how resilient a system will be to impact from event-driven change. Beach width is perhaps the most highly variable morphometric because it is the portion of the beach regularly affected by waves, tides, currents, seasonality, and human activities. For beach width at SPI, three dates of the time series are shown to highlight the substantial alongshore variation (Figure 7-3). In some cases, there is a reverse correlation wherein profiles with wide beaches in 2002 had narrow beaches in 2020 (e.g., CBI-7 and CBI-8). In other locations, the widths are similar for all three time periods. Large variations like these can be attributed to natural processes, sometimes in the formation of beach cusps in which the beach forms regularly spaced embayments and promontories in the alongshore directions, as well as human activities such as beach nourishment. Statistically, the average alongshore beach width captured in the time series was largest in 1995, and remained closer to 200 ft through 2002–2020.

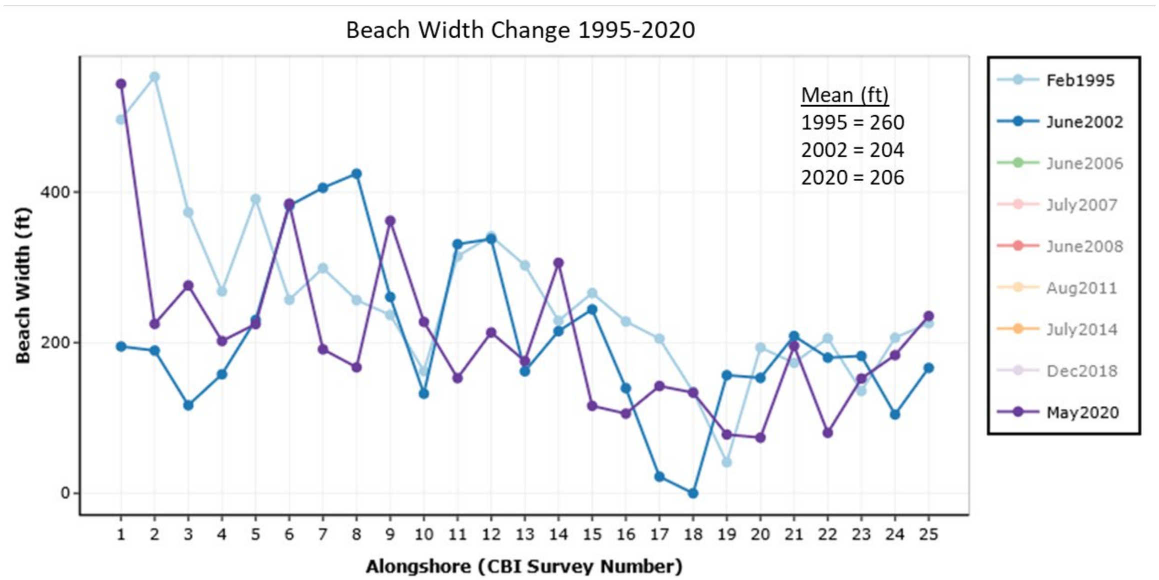

Figure 7-3. Beach Width Variations Alongshore and Over Time

7.4 PROFILE VOLUMES

The final metrics examined for the characterization of the beach-dune system at SPI are the profile volumes. Volumes were quantified for the total profile volume and separately for the onshore and offshore portions of each profile. A baseline elevation offshore was established for the measurement of volume (Figure 7-4-1) and is the depth to which all profiles in the time series were surveyed. Many profiles extended deeper, but the baseline elevation was used to maintain consistency in the volumetric calculations. The offshore volume was calculated as the square-foot area beneath the profile, above the baseline elevation and to the vertical extension of the operational mean high water times a standard width of 1 ft. The operational mean high water is a datum established by USGS (Weber et al. 2005), which represents a locally determined mean high water for the region that includes SPI. The onshore volume is calculated as the square-foot area beneath the profile, above the operational mean high water to the building line established by the City of SPI times the standard 1-ft width (Figure 7-4-1). The resulting volumes (in cubic feet) were then converted to cubic yards to align with industry standard reporting.

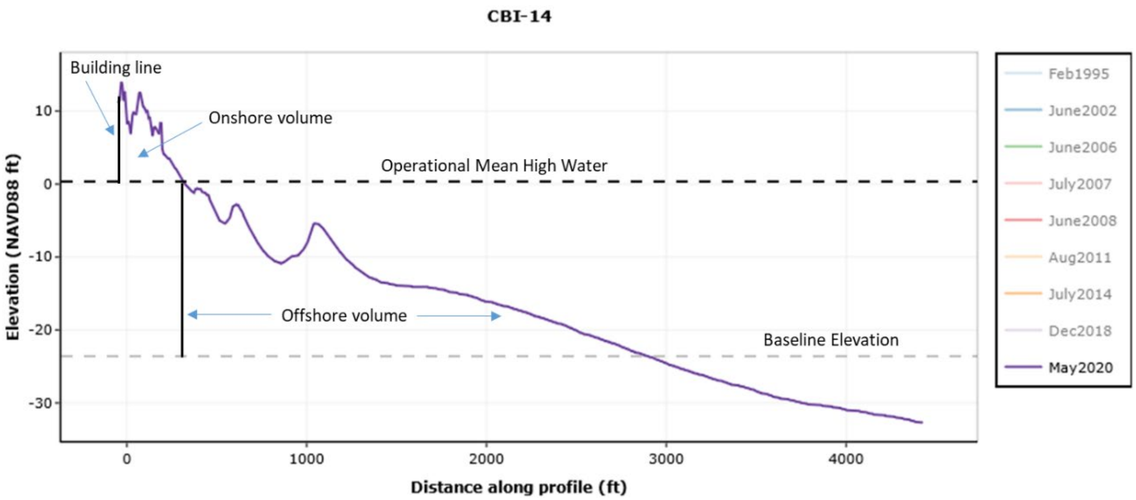

Figure 7-4-1. Example Profile with Explanation of How the Onshore and Offshore Profile Volumes Were Determined

The volume profiles do not include CBI-1, CBI-2, CBI-24, or CBI-25 because there is no building line in these areas (Isla Blanca Park and the undeveloped northernmost section of the study area). As with the majority of the morphometrics, the profile volumes are highly variable (Figure 7-4-2). Note that the vertical axes are different in the two profiles shown in Figures 7-4-2, and that the offshore profiles have much higher volumes than the onshore profiles. This is a function of the larger area measured for the offshore volumes. The onshore profile volumes have some consistent patterns (Figure 7-4-2a): greater sustained volumes in the south and central portions of the profile, and a distinct shift to increased volume in more recent times, beginning in 2014. The offshore volumes do not have a consistent temporal trend (Figure 7-4-2b), but there is a trend towards lower volumes in the central portion of the study area (~CBI-10 to CBI-16).

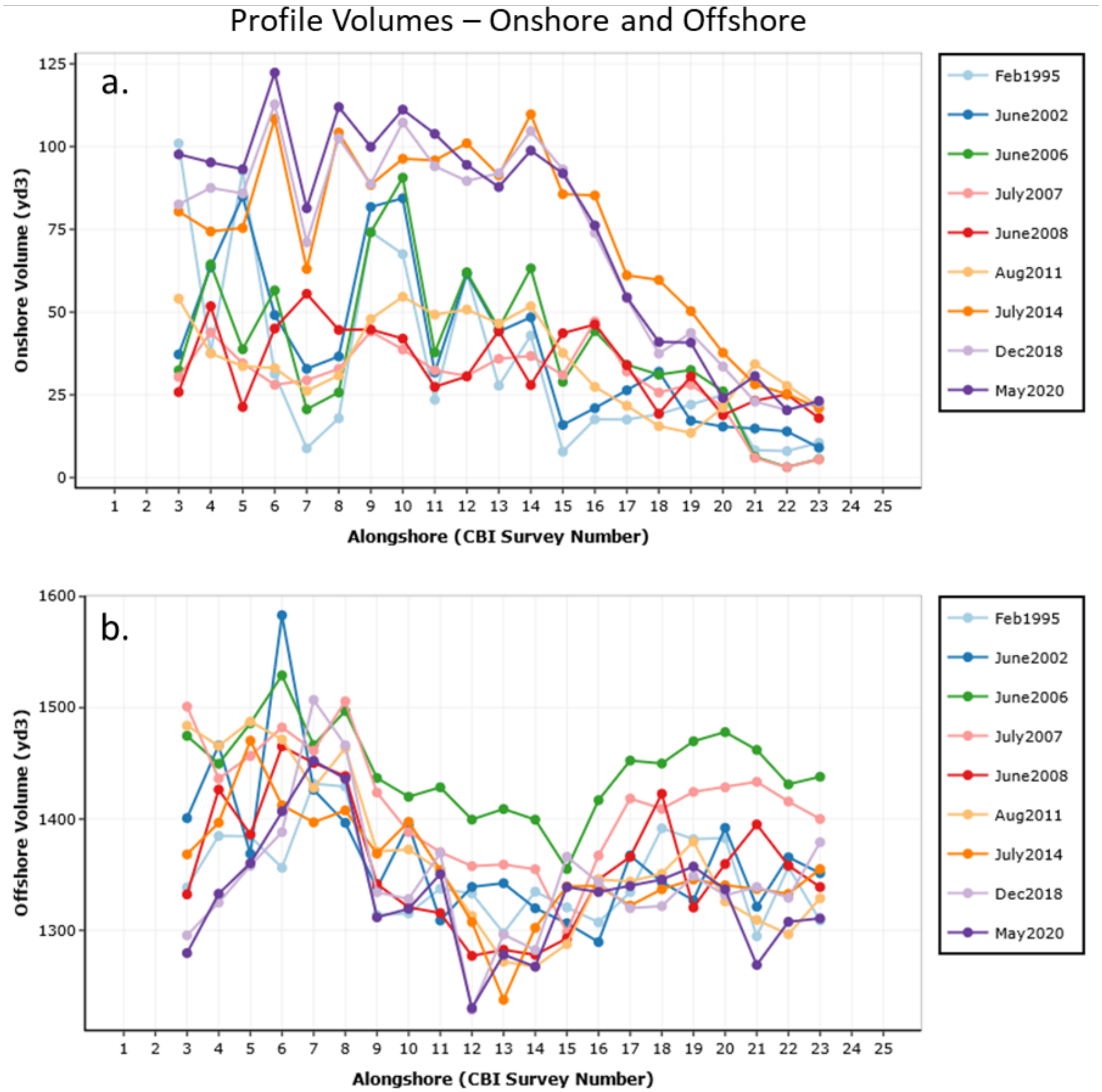

Figure 7-4-2. Full Time Series of Volumes Alongshore for the Onshore (a) and Offshore (b) Portions of the CBI Profiles

To gain perspective on historical change and present state of the profile volumes, the data for only the long term, 1995 and 2020, were evaluated (Figure 7-4-3). As was noted for the full time series discussion, the onshore profile volumes (Figure 7-4-3a) have a sustained greater volume in 2020 than in the earlier period, likely due to the robust beach nourishment, and dune building and planting programs. The trend towards low volumes to the north is persistent and as a result, this portion of SPI is more vulnerable to coastal hazards. The offshore volume, while spatially variable, has remained relatively stable over the 25-year period of the analysis.

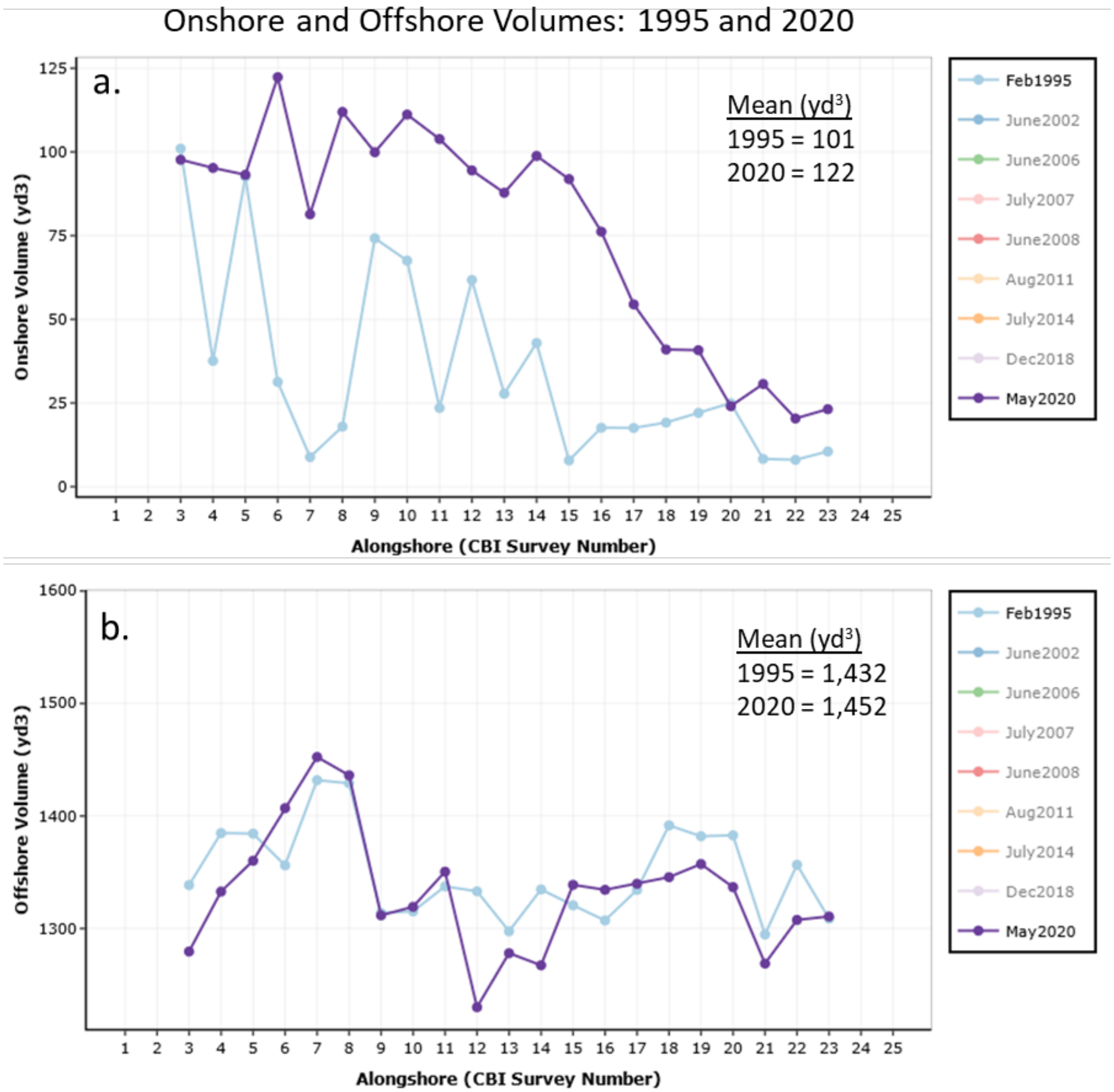

Figure 7-4-3. Alongshore Volumes for 1995 and 2020 for the Onshore (a) and Offshore (b) Portions of the Profiles

8 VEGETATION LINE

Vegetation lines were digitized from 2002, 2007, 2016, and 2020 from available aerial photography. The 2020 line only extends along the southern and central portions of the study area to between CBI-17 and CBI-18 (Figure 8-1) due to the limited extent of the 2020 aerial imagery. The remaining three dates cover the entirety of SPI, providing a time series of 14 years. The vegetation lines were visually interpreted as the seaward-most boundary between identifiable dune vegetation and sand. Large-scale spatial series of the vegetation line maps for the entire study are provided in Appendix C for a more detailed perspective of the changes, and several key findings are discussed below.

In 2002, the vegetation line is consistently landward as compared to the later years; thus, the vegetated dune area is much narrower and closer to the building line than in the more recent years. In some locations, for example between CBI-18 to CBI-20, the vegetation line is right up against the buildings or is nonexistent (Figure 8-1). Between 2002 and 2007, the vegetation line propagated significantly seaward, resulting in a more robust, wider vegetated dune field. The vegetated dune width from 2002 to 2020 was measured as the distance from the building line to the vegetation line, in areas where they both exist (e.g., at certain CBIs, no vegetation was present) (Figure 8-2). The dune field width on average doubled over that time period due to a substantial effort after the 2008 Hurricanes Dolly and Ike to not only build and protect the beach and dunes, but to develop a rigorous planting effort, adding thousands of specialty native dune plants to help stabilize the dune field (City of South Padre Island 2012). These efforts have clearly had a major impact in holding the dune line and affording the City and oceanfront property added protection in the form of a healthy, wide dune field.

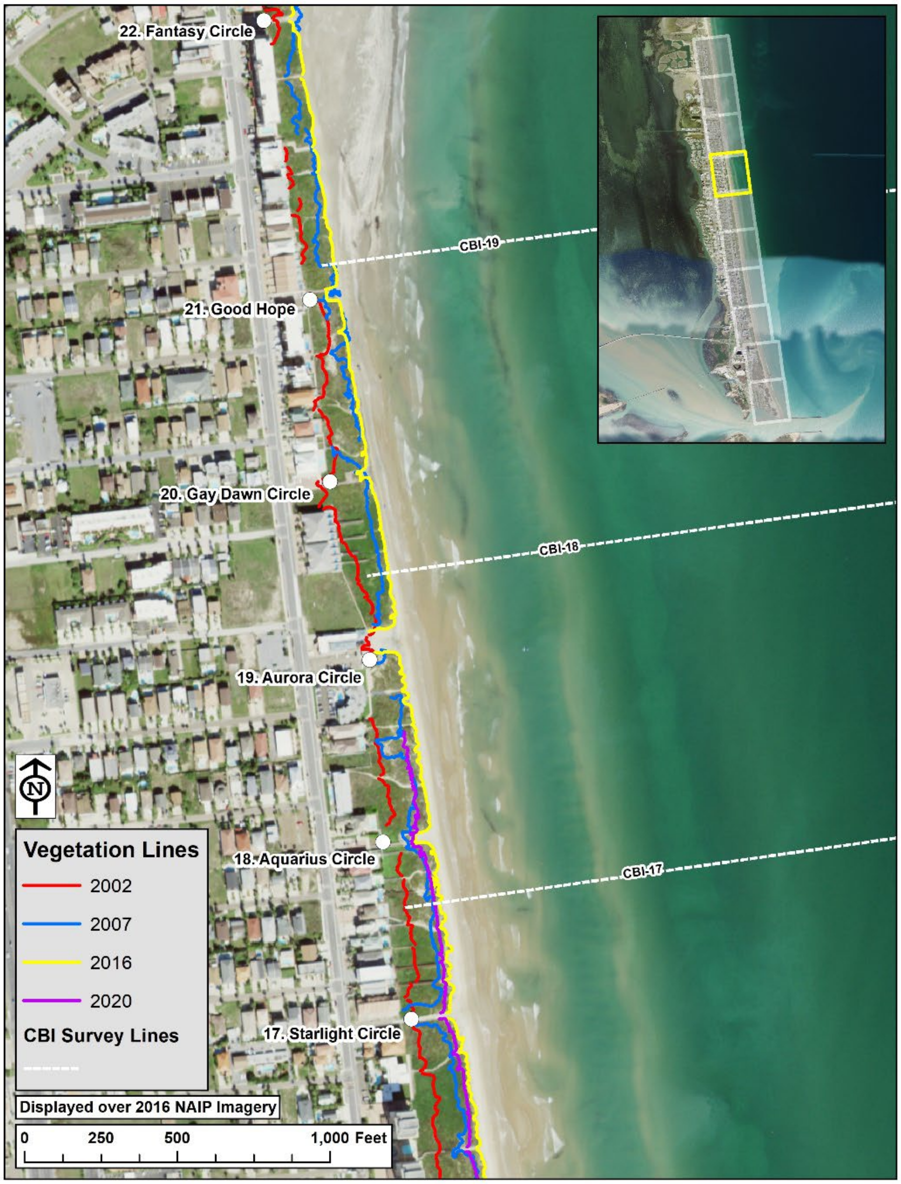

Figure 8-1. A North–Central Section Map Showing Vegetation Lines from 2002 to 2020. Note the 2020 line ends between CBI-17 and CBI-18. This map is also provided at full scale in Appendix D. The dots and numbered place names are the names of beach access locations at SPI.

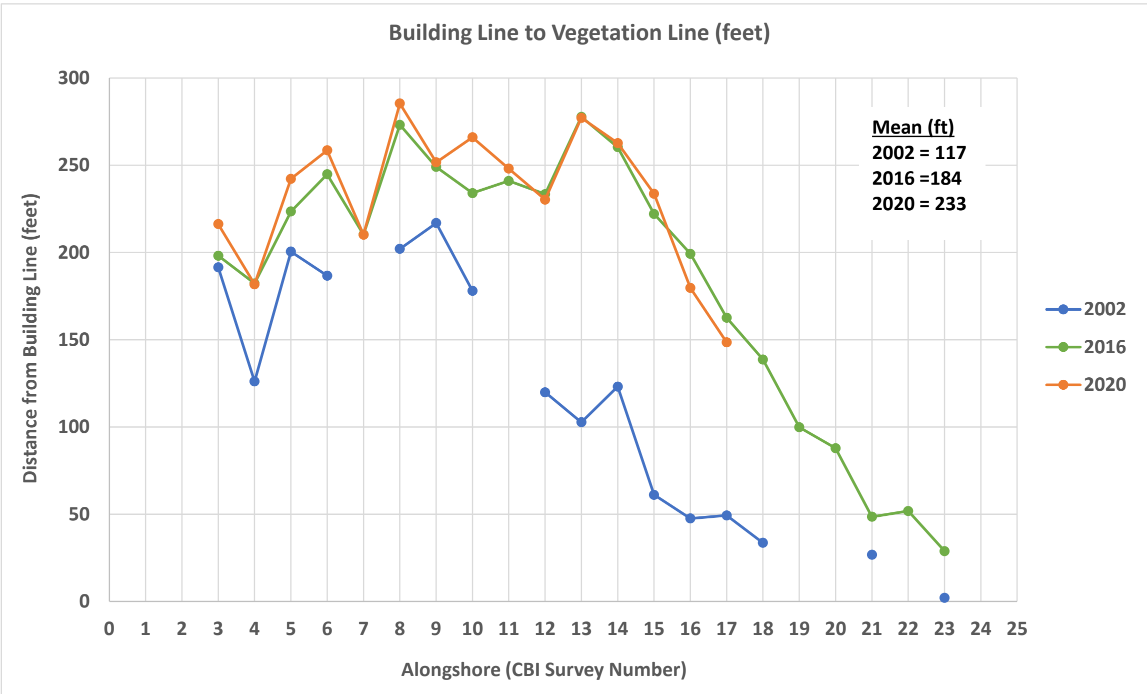

Figure 8-2. Alongshore Width of Dune Field as Measured between the Vegetation Line and the SPI Building Line for 2002, 2016, and 2020

9 SUMMARY OF HISTORICAL RESPONSE AND CURRENT STATE

One of the primary objectives of Phase 1 of the beaches and dunes project is to present an evaluation of the current state of the coastal system. To accomplish this objective, plots of summary statistics of the various morphometrics through time were created to show the current state relative to the historical one. The analysis considers not only the current state based on the morphometrics, but also includes the shoreline, vegetation, and elevation change components of the study.

The average dune crest and toe changes through time are shown in Figure 9-1. The crest and toe do vary through time, but overall oscillate only slightly. There is a general trend of elevation increase in the more recent time periods starting in 2014. Although there is a slight decrease in both metrics between 2018 and 2020, overall, the frontal dune appears relatively robust and the summer 2021 nourishment will provide material to sustain the dunes. In addition to the frontal dune elevation, the width of the dune field is important in considering the resiliency of the system. The alongshore vegetation line series in Appendix C shows much of the dune field has gained substantially in width in the time period between 2002 and 2020 due to an earnest dune rebuilding and replanting program by the City of SPI. There are locations, however, especially concentrated in the northern section of the study area, where the dune field is very narrow or nonexistent. These areas, as well as the numerous beach access points, are highly vulnerable to storm waves, which further exacerbate existing erosion issues.

The dune crest elevation, dune field width, and beach width are the three metrics most likely to influence how resilient a system will be to impact from event-driven change. The current (2020) width of the beach is healthy compared to the extreme low in 2007, although it has narrowed slightly since 2018 (Figure 9-2). As with the dunes, the summer 2021 beach nourishment project will likely help keep the beach width stabilized.

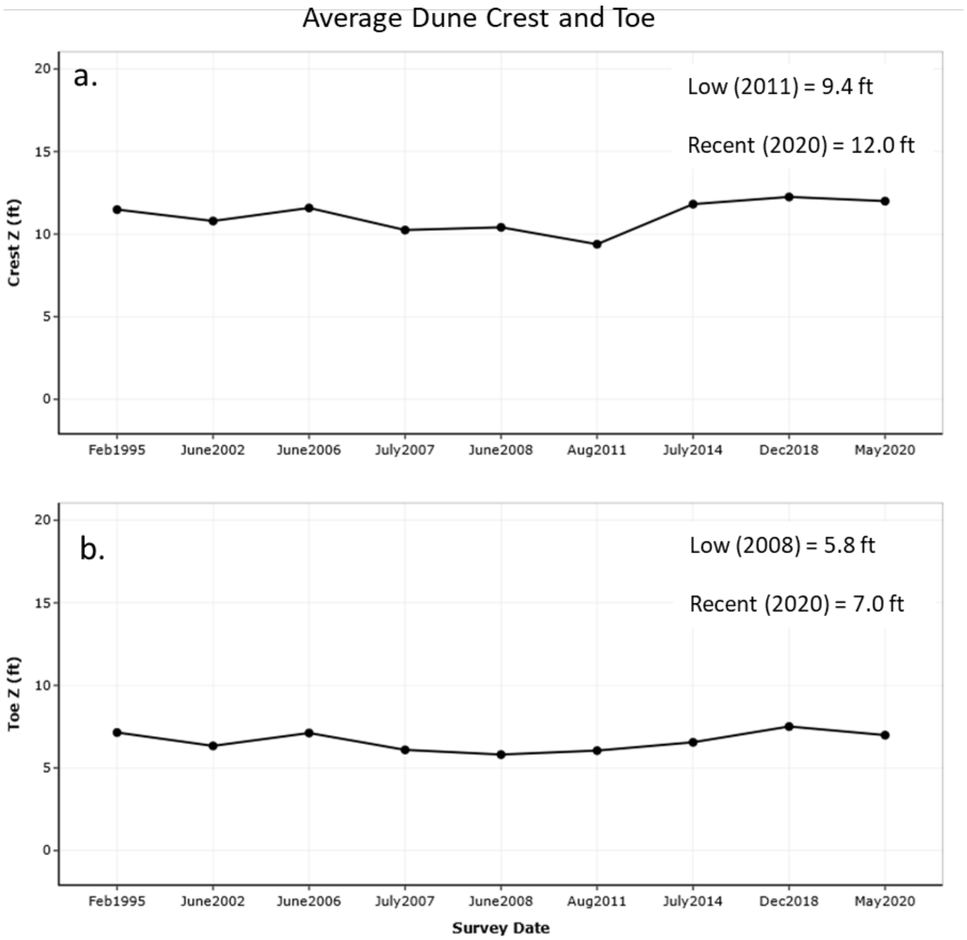

Figure 9-1. Averaged Dune Crest (a) and Dune Toe (b) Elevations through Time Showing Both the Time Series (averaged) Low and the Current State of Each Feature

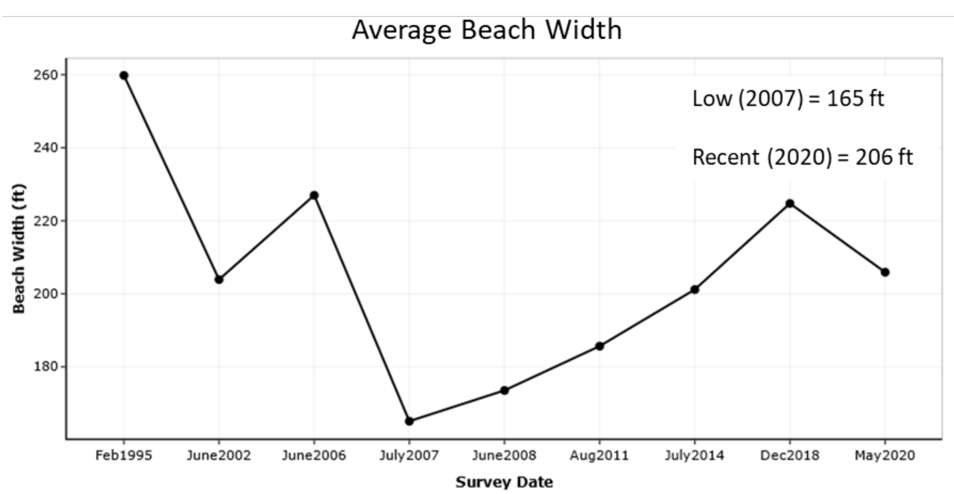

Figure 9-2. Averaged Beach Width through Time Showing Both the Time Series (averaged) Low and the Current State of the Beach

The shoreline change analysis shows that in more recent times, the shoreline is fluctuating both spatially and temporally (Appendix A). Continued regular beach nourishment will likely address localized erosion hot spots when they occur and the shoreline position should remain, although it will always be impacted by wave events. The elevation difference maps of the short-term (2-year) indicate that storm influences include significant scarping of the beach. However, if the beach width and dune elevations are maintained, sustained erosion can be limited for the most part to the lower beach, except in response to yearly winter storms, from which the profile generally recovers.

Changes to the volume of a beach system reflect variations in sediment availability that influence beach and dune changes over longer time periods than changes to the dunes, shoreline, and beach width. The onshore versus offshore volume changes through time are interestingly opposite through time (Figure 9-3). The onshore volume was low until 2014 where it increased significantly, and then even further in 2020. The increase can likely be attributed to the regular nourishment program, but the beach also may be experiencing influx from the offshore, given that despite offshore sand placements in 2018, 2019, and 2020, the volume of the offshore profile has been decreasing, and is currently (2020) in its lowest state in the time series. Further investigation and monitoring of this phenomenon are recommended to evaluate where and why the loss of sediment in the offshore is occurring.

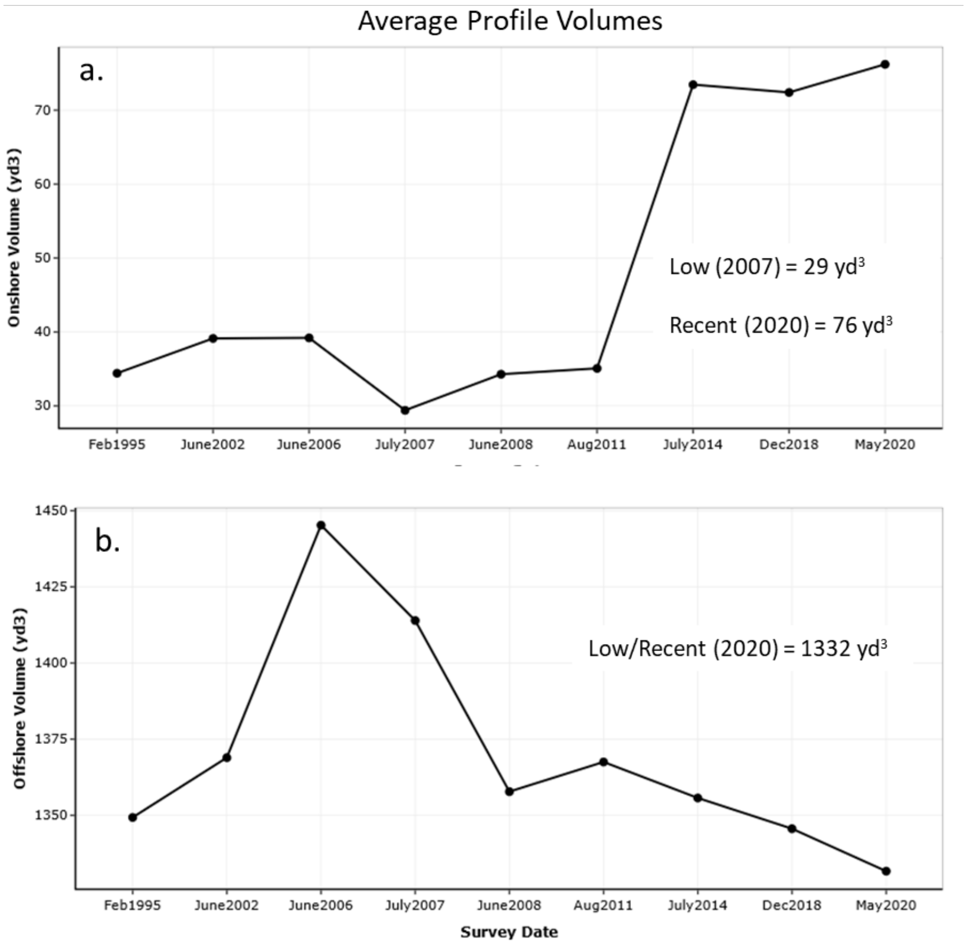

Figure 9-3. Averaged Onshore (a) and Offshore (b) Profile Volumes through Time Showing Both the Time Series Low and the Current State of Each Feature

10 COASTAL EROSION ASSESSMENT

The major technical task of this study was to evaluate the potential for coastal erosion of SPI beaches and dunes for a range of projected storm events in addition to future SLR scenarios. Overall, the methods to conduct this coastal change analysis included assessment of site topographic and nearby bathymetric conditions, the regional wave climate and wave refraction to the shoreline adjacent to the site, and XBeach modeling to predict coastal erosion potential. This section summarizes the methods and focuses on the modeling and the results of the analyses. This study considered the following coastal hazards:

- **Coastal Erosion and Accretion**: Erosion and accretion along the SPI beaches and dunes from projected storm conditions associated with various recurrence frequencies. The different recurrence intervals help to gain a better understanding of the storm frequency over time to which the beaches and dunes may be exposed, and are listed below:
  - 2-year, also referred to as a 50% annual chance storm event
  - 10-year, also referred to as a 10% annual chance storm event
  - 100-year, also referred to as a 1% annual chance storm event.
- **Rising Sea Level**: Rise in the predicted tide levels due to SLR and its influence on coastal change.

NOAA and other government agencies and universities have substantially invested in SLR science that assigns probabilities to various SLR elevations occurring by a certain time in the future (Sweet et al. 2017). For this study, the intermediate-high risk scenario was applied, consistent with existing policy guidance (Table 10-1; Sweet et al. 2017).

Table 10-1. Future Sea Level Rise Projections at the South Padre Island, Texas, Coast Guard Station Based on NOAA 2017 Guidance

Sea Level Rise Scenario (ft)	Projected Years
0.0	2020 (Baseline Year)
1.54	2040 (Intermediate High)
3.54	2070 (Intermediate High)

10.1 ANALYSIS TRANSECTS

Six shoreline profiles were selected from the 25 profiles analyzed in the historical morphodynamic analysis to perform XBeach simulations and evaluate the coastal change potential. The selected profiles were CBI-03, CBI-06, CBI-13, CBI-17, CBI-22, and CBI-24

(Figure 10-1). These profiles were selected using the June 2021 survey data, carried out as part of the present project. Because CBI-22 was undergoing nourishment during the June 2021 survey, the elevation data for this profile are from the May 2020 survey. The profiles were selected based on unique morphologies and historical behavior to be a subset that is representative of the different distinct morphologies and geography in the area of interest. These include representing the three portions of the island that have been identified in long-term analyses as having variable evolution (south, central, and north). The following describe the specific characteristics of the chosen profiles:

- CBI-03: southern portion of SPI; development set far back (more representative of natural location)
- CBI-06: southern portion of SPI without potential jetty impacts; has experienced consistent vegetation progradation
- CBI-13: central portion of SPI; stable profile morphology
- CBI-17: central portion of SPI; stable profile morphology
- CBI-22: northern portion of SPI; lack of vegetation and dune historically; low dune maintained in more recent times, since ~2008
- CBI-24: northern portion of study area; undeveloped region (no building line); dune field widened and has maintained stable configuration in recent years (2018–2021).

The range of wave conditions within the Gulf of Mexico (GoM) responds to the topography and bathymetry in and along the coastline of SPI. Of primary importance is the site-specific nearshore bathymetric and topographic data along selected beach profiles.

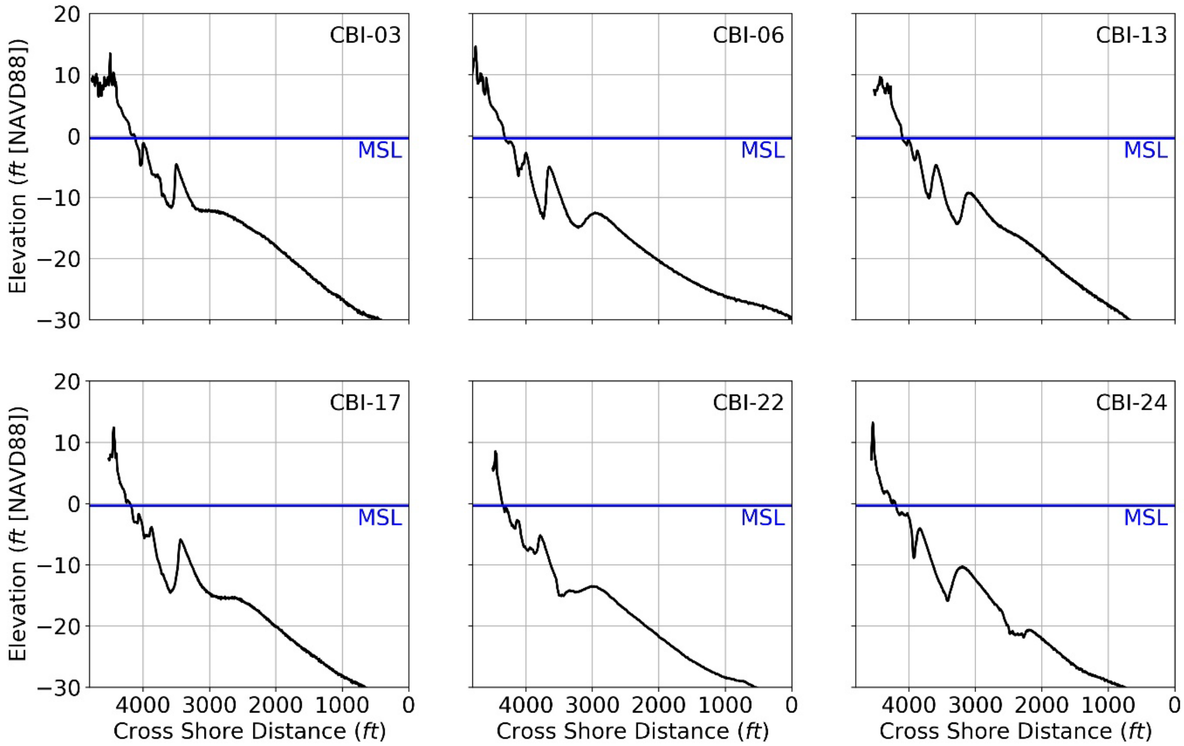

Figure 10-1. Selected SPI Shoreline Profiles with Mean Sea Level Line (June 2021, except CBI-22 in May 2020)

10.2 XBEACH MODELING

XBeach is a numerical model used to predict coastal erosion and accretion, and was used to model coastal change potential along the selected set of shoreline profiles under a range of storm wave and future SLR conditions (Roelvink et al. 2009). The model assesses the interaction of waves with bathymetry and topography. XBeach is particularly suited for modeling coastal change (e.g., volume, width, elevation) processes on timescales of single storm and wave events; it simulates tidal and wave-driven sediment transport and resulting coastal change, and is a readily available, free, open-source model.

10.2.1 XBeach Grid

Each of the six selected profiles were discretized into a number of grid cells representing a discrete distance in the cross-shore direction, and each grid cell was assigned an average water depth. There is only a single grid cell in the alongshore direction. The resolution of the grid cells in the cross-shore direction varied from 40 ft at the farthest offshore cells where erosion and accretion are expected to be limited, to 1.6 ft along the beach and dune profile where a majority of the erosion and accretion is expected. The grid configuration is only in the cross-shore direction, and is called the XBeach 1-D, or one-dimensional mode. In the 1-D mode, the model domain represents a single shoreline profile, and longshore transport gradients are ignored. The varying grid spacing and use of XBeach 1-D were used to provide high-resolution predictions along the beach and dune while minimizing the number of offshore grid cells to maintain computational efficiency.

10.2.2 XBeach Boundary Conditions

At the offshore boundary at each of the XBeach grids, the application of wave conditions can take multiple forms. For this study, at each of the six selected profiles, bulk wave parameters—significant wave height, peak period, wave direction, and a directional spreading factor—accessed from the closest NOAA wave buoy, were applied at the offshore end. The bulk wave parameters were held constant over a 30-hour simulation period to represent the worst-case scenario during a selected storm event.

10.2.3 Extreme Value Analysis

The range of wave processes in response to the wide sloping continental shelf along the coast of the GoM necessitates a qualitative and quantitative understanding of existing wave conditions. In an effort to summarize the existing wave conditions along SPI, the full data record from the closest NOAA wave buoy was downloaded and analyzed. This NOAA buoy, station 42020, is located ~68 miles northeast of the Brazos Santiago Channel and the south end of SPI, and has a data record from 1990 to present (Figure 10-2-3-1). The NOAA buoy is in 280 ft of water near the edge of the continental shelf and is equipped with sensors to collect meteorological data, water temperature, and directional wave data. Over the full data record at this NOAA buoy, the mean wave height is 4.3 ft, the mean wave period is 6.3 seconds, and the median wave direction is 120°. The median is defined as the middle wave direction of the entire record. To evaluate the impact of extreme storm events on the coastal resiliency of SPI beaches and dunes, extreme values of wave height, representative of an array of storm events, were computed for use in the XBeach model. The extreme value analysis (EVA) provided the highest wave heights for various return periods (e.g., 2, 10, and 100 years) from a 30-year measured data record (Table 10-2-3-1).

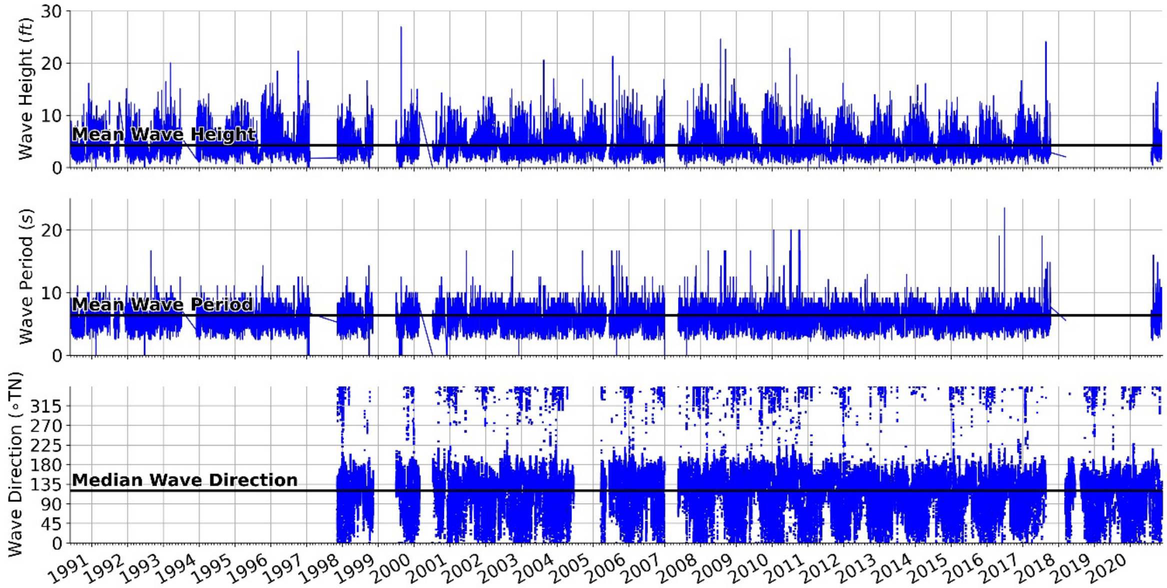

Figure 10-2-3-1. Full Record of Wave Height, Wave Period, and Wave Direction including Average Values from NOAA Buoy 42020

Table 10-2-3-1. Wave Height Return Period Values from EVA for the Offshore NOAA Buoy

Return Period	Offshore Significant Wave Height (ft)
1-year	16.2
10-year	22.9
100-year	41.7

The NOAA buoy measurements used in the EVA are typically in deep water where the influence of the bathymetry and local nearshore bathymetric features do not affect the waves. Thus, it is critically important to transform the waves from the deep water to the nearshore zone to evaluate site specific wave exposure. Linear Airy wave theory was used to transform the deep-water waves into the nearshore region as shallow water waves, considering the effects of the shallower nearshore water depths and profile slope, and how the waves will be influenced. These transformed wave heights were used as the XBeach boundary conditions for the six selected profiles (Table 10-2-3-2). The nearshore wave heights, along with the offshore wave heights derived from the EVA, sequentially increase for the 2-, 10-, and 100-year return periods and contribute to increased wave run-up and the potential for beach and dune erosion and accretion. The return period storm events, combined with the three SLR scenarios discussed above, resulted in 54 individual XBeach model simulations representing three different significant storm events and three SLR scenarios along the six selected profiles. The wave period was held constant across the 54 XBeach simulations, set as 16 seconds, a typical wave period generated from an offshore storm event in the Gulf of Mexico. XBeach was set to run for 30 hours, representative of a typical storm event duration, and to capture a full tidal cycle. During the 30-hour period, constant wave and time varying water level boundary conditions were applied.

Table 10-2-3-2. Nearshore Significant Wave Height Used for Selected Profiles

Return Period	Offshore Significant Wave Height (feet)	Nearshore Significant Wave Height (feet)
2-year	16.2	13.2
10-year	22.9	17.8
100-year	41.7	22.9

In addition to the wave conditions at the offshore boundary, a time-varying water level was applied. A time-varying water level provided a more realistic storm impact, as it would occur over a tidal cycle, and the higher tides would increase the probability of erosion and accretion along the shoreface. These data were selected from the measured data record at NOAA station # 8779749, SPI Brazos Santiago, Texas (Figure 10-2-3-2) and subset to a transition from a neap to spring tide. This simulates an increasing water level resulting from storm surge, along with the constant wave conditions.

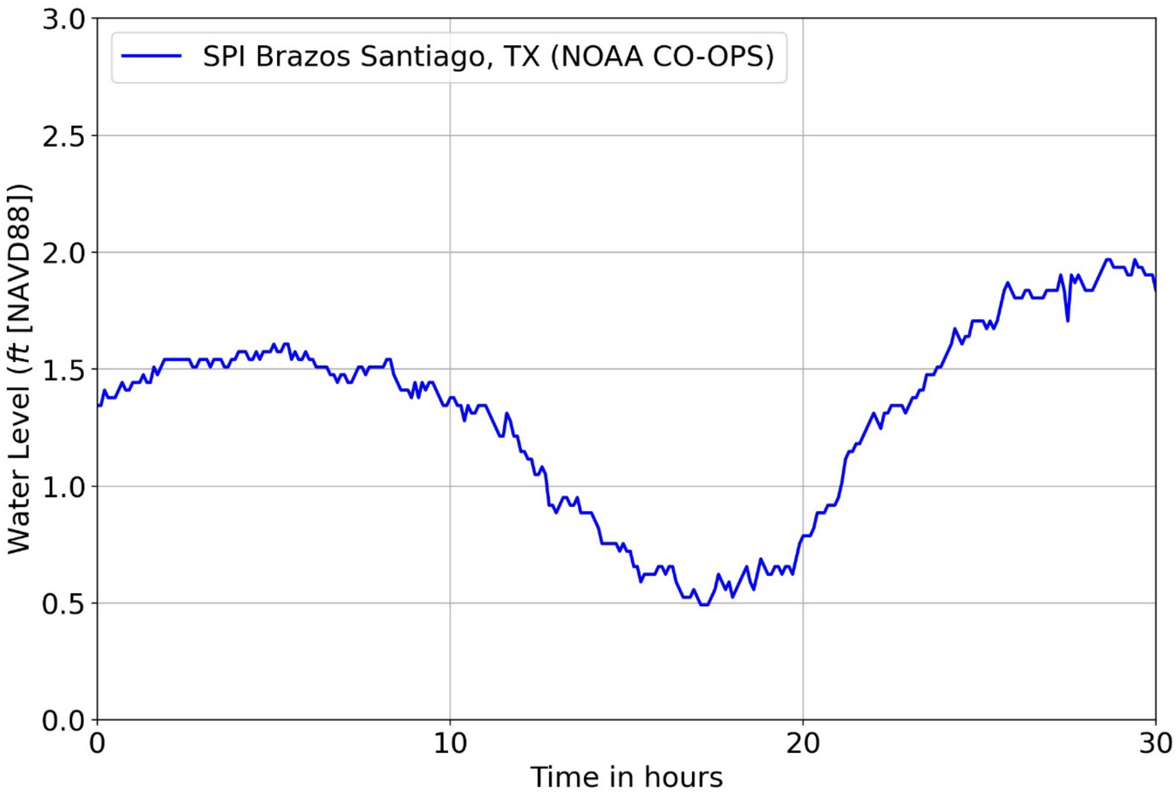

Figure 10-2-3-2.Time Varying Water Level Boundary Condition Applied to XBeach Simulations

In addition to the wave and water level boundary conditions, vegetation and sediment physical characteristics were defined along each of the selected profiles. The location of the vegetation line was identified in the beach profile survey data. The vegetation feature in XBeach provides additional roughness for predicting the wave run-up and erosion of the dunes. The sediment physical characteristics (i.e., D50, D90, porosity, and bulk density) were defined based on typical sandy beaches along the Gulf Coast region. These model parameters provide a more realistic sediment bed when simulating erosion and accretion.

10.3 XBEACH RESULTS

The model predictions provide an evaluation of coastal erosion and accretion potential along each of the selected profiles due to defined storm events. Each of the 54 simulations were evaluated and quantitative metrics were computed to assess the predicted changes to each profile under various storm conditions and SLR scenarios. The metrics include changes to the beach width, the shoreline position, and the dune toe position. The results of the analyses are presented below.

10.3.1 Beach Width

As an initial metric to evaluate the change in each profile over the range of storm events and SLR scenarios, beach width change was computed for the 54 simulations (Tables 10-3-1-1 to 10-3-1-3). The positive values in the three tables, light to dark blue, represent an increase in beach width, while the negative values, light to dark red, represent a decrease in beach width.

To compute the beach widths, the results from the 54 simulations were run through the Python dune analysis package Pybeach (https://pybeach.readthedocs.io/en/latest/). The maximum curvature method (maximum slope change) was chosen to calculate the dune toe and shoreline for each simulation, including the starting profiles. Beach width was then calculated as the distance from the Pybeach-derived dune toe and shoreline. The pre-storm beach width was then subtracted from the post-storm simulated beach width.

Overall, the changes in beach widths are highly variable across profiles, storm events, and SLR scenarios. As reported in the Phase 1 Report "Assessment and Investigation of the Beach and Dune Conditions at South Padre Island" and based on historical analysis, the magnitude of beach width change increases when moving north along SPI, a result consistent with the rates of change derived from beach nourishment and offshore sand placement. The pattern is variable along the coast, with erosion hotspots in the very northern portion of the study area (beyond the extent of the CBI profiles), accretion or low erosion rates (< 0.9 ft/yr) along much of the central portion of the island (CBI-09 to CBI-25), and an area of moderate erosion (–0.4 to –1.4 ft/yr) along the coast from CBI-05 to CBI-09. South of this erosional zone, the shoreline becomes accretional to the inlet jetty.

As shown in Tables 10-3-1-1 to 10-3-1-3, the beaches were predicted to increase in width in 29 of the 54 profile simulations. Twenty-four profiles showed a decrease in beach width across the simulations and one of the simulations, profile CBI-17 for the 2-year wave event and 2070 SLR scenario, was predicted to have no change (Table 10-3-1-1).

Profile CBI-06, near the south end of SPI, was predicted to have the largest increase in beach width, while CBI-24, one of the most northerly profiles, was predicted to have the largest decrease in beach width. An interesting trend shows that the largest changes in beach width are not necessarily during the largest wave events or highest SLR scenarios. This is a result of the influence of bathymetry and topography on the wave run-up and wave forces responsible for coastal erosion and accretion. During the 0.0-ft SLR scenario, smaller waves (e.g., the 10-year wave event) can travel closer to shore before breaking, thus potentially causing more erosion of the beach. During the 2040 and 2070 SLR scenarios, the breaking depths of the profiles change, impacting where the wave breaks, and if it breaks at all. The importance of this finding is that more frequent smaller wave events could increase the potential for coastal erosion. Explanations for increasing beach widths under storm and SLR conditions, when intuitively one might expect to see decreases in the beach width, are two-fold. Sediment can be transported onshore during storm events and material eroded from the dunes can be deposited on the beach. In the latter case, one would expect there to be measurable erosion of the dune. In this analysis, it appears that where there are large increases in beach width, material is moved from the very shallow submerged portions of the profiles onto the beach.

Table 10-3-1-1. Predicted Change in Beach Width, in feet, for the 2-Year Wave Event

Sea Level Rise (ft)	CBI-03	CBI-06	CBI-13	CBI-17	CBI-22	CBI-24
0.00	-31.2	16.4	11.5	-42.7	14.8	13.1
1.54 (2040)	-8.2	52.2	37.3	1.6	14.8	-31.2
3.54 (2070)	-3.3	33.3	66.4	0.0	32.0	4.9

Table 10-3-1-2. Predicted Change in Beach Width, in feet, for the 10-Year Wave Event

Sea Level Rise (ft)	CBI-03	CBI-06	CBI-13	CBI-17	CBI-22	CBI-24
0.00	-8.2	21.3	39.4	-36.1	39.4	-42.7
1.54 (2040)	-4.9	18.1	68.0	-18.0	-1.6	-4.9
3.54 (2070)	-3.3	125.1	68.0	-4.9	21.3	-23.0

Table 10-3-1-3. Predicted Change in Beach Width, in feet, for the 100-Year Wave Event

Sea Level Rise (ft)	CBI-03	CBI-06	CBI-13	CBI-17	CBI-22	CBI-24
0.00	-45.9	14.8	32.8	-45.9	34.5	-62.3
1.54 (2040)	-36.1	11.5	1.6	-67.3	9.8	-95.1
3.54 (2070)	-13.1	113.2	98.4	6.6	14.8	-70.5

10.3.2 Shoreline and Dune Toe Position Change

The computation of the beach width change requires the identification of the shoreline and dune toe position along each profile. In addition to examining the beach width change, we also examined changes in the positions of the shoreline and dune toe, which are presented below. This was conducted for each of the 54 simulations using Pybeach (Tables 10-3-2-1 to 10-3-2-6). The positive values in the tables, light to dark blue, represent a predicted shoreline advance, or seaward movement, while the negative values, light to dark red, represent a shoreline retreat, or landward movement.

For shoreline position changes (Tables 10-3-2-1 to 10-3-2-3), 23 of the 54 simulations predicted an advance of the shoreline. On 28 profiles, shoreline retreat was predicted, and three simulations predicted no change in the shoreline position. Profile CBI-17 for the 100-year wave event and 2070 SLR scenario, and CBI-13 for the 100-year wave event for the current and 2040

SLR scenarios, had no predicted shoreline position change but did have predicted beach width change (Table 10-3-2-3).

Similar to the changes in beach width, profile CBI-06 was predicted to have the largest shoreline advance, during the 2-year wave event and the 2040 SLR scenario (Table 10-3-2-1). Across each of the storm wave events and SLR scenarios, profile CBI-06 was predicted to have an advance in its shoreline position. Profile CBI-24 was predicted to have the largest shoreline retreat, which occurs during the 100-year wave event, 2040 SLR scenario (Table 10-3-2-3). Most of the remaining simulations were shown to have predicted shoreline retreat.

Table 10-3-2-1. Predicted Change in Shoreline Position, in feet, for the 2-Year Wave Event

Sea Level Rise (ft)	CBI-03	CBI-06	CBI-13	CBI-17	CBI-22	CBI-24
0.00	-31.2	16.4	11.5	-42.7	14.8	13.1
1.54 (2040)	-8.2	52.2	37.3	1.6	13.1	-31.2
3.54 (2070)	-3.3	33.3	35.2	-3.3	30.4	1.6

Table 10-3-2-2. Predicted Change in Shoreline Position, in feet, for the 10-Year Wave Event

Sea Level Rise (ft)	CBI-03	CBI-06	CBI-13	CBI-17	CBI-22	CBI-24
0.00	-8.2	21.3	6.6	-36.1	18.0	-42.7
1.54 (2040)	-4.9	18.1	35.2	-18.0	23.0	-4.9
3.54 (2070)	-3.3	31.6	35.2	-13.1	19.7	-29.5

Table 10-3-2-3. Predicted Change in Shoreline Position, in feet, for the 100-Year Wave Event

Sea Level Rise (ft)	CBI-03	CBI-06	CBI-13	CBI-17	CBI-22	CBI-24
0.00	-45.9	14.8	0.0	-45.9	18.0	-62.3
1.54 (2040)	-36.1	11.5	0.0	-41.0	1.6	-100.1
3.54 (2070)	-14.8	19.7	16.4	0.0	13.1	-80.4

The change in position of the dune toe was also computed for each of the 54 simulations. The positive values in the three tables, light to dark blue, represent a predicted dune toe advance, or seaward movement, while the negative values, light to dark red, represent a landward dune toe retreat.

As shown in Tables 10-3-2-4 to 10-3-2-6, 29 of the 54 simulations predicted no change in dune toe position. An additional 13 simulations predicted less than 10 ft of dune toe retreat. The dune at the southernmost profile, CBI-03, was not predicted to be impacted during the 2- or 10-year wave events under the three SLR scenarios. Moving northwards along the SPI coastline, the dune generally was predicted to be impacted during the 2-year wave event and the 2070 SLR scenario. During the 10-year and 100-year wave events, as would be expected, the dunes were impacted during the three SLR scenarios for profiles CBI-06, -13, -17, -22, and -24 (Tables 10-3-2-5 and 10-3-2-6).

As a note, the –32.8-ft change for the four simulations at profile CBI-13 are a result of the Pybeach analysis selecting the dune toe location landward of where the starting profile dune toe was located. After a post-processing analysis, it was found that the dune toe was minimally impacted during these four simulations. In addition, the 24.6-ft advance of the dune toe predicted for profile CBI-22 (10-3-2-5) was a result of Pybeach selecting a dune toe location shoreward of the actual dune toe. After a post-processing analysis, it was found that the dune toe position did retreat similar to the 10-year wave event and present SLR scenario (Table 10-3-2-5). This update would result in the predicted beach width change for profile CBI-22, during the 10-year wave event and 2040 SLR scenario, to increase.

Table 10-3-2-4. Predicted Change in the Dune Toe Position, in feet, for the 2-Year Wave Event

Sea Level Rise (ft)	CBI-03	CBI-06	CBI-13	CBI-17	CBI-22	CBI-24
0.00	0.0	0.0	0.0	0.0	0.0	0.0
1.54 (2040)	0.0	0.0	0.0	0.0	-1.6	0.0
3.54 (2070)	0.0	0.0	-31.2	-3.3	-1.6	-3.3

Table 10-3-2-5. Predicted Change in the Dune Toe Position, in feet, for the 10-Year Wave Event

Sea Level Rise (ft)	CBI-03	CBI-06	CBI-13	CBI-17	CBI-22	CBI-24
0.00	0.0	0.0	-32.8	0.0	-21.3	0.0
1.54 (2040)	0.0	0.0	-32.8	0.0	24.6	0.0
3.54 (2070)	0.0	-93.5	-32.8	-8.2	-1.6	-6.6

Table 10-3-2-6. Predicted Change in the Dune Toe Position, in feet, for the 100-Year Wave Event

Sea Level Rise (ft)	CBI-03	CBI-06	CBI-13	CBI-17	CBI-22	CBI-24
0.00	0.0	0.0	-32.8	0.0	-16.4	0.0
1.54 (2040)	0.0	0.0	-1.6	26.2	-8.2	-4.9
3.54 (2070)	-1.64	-93.5	-82.0	-6.6	-1.6	-9.8

Profile CBI-13 showed substantial erosion of the dune toe during the 10- and 100-year wave events and for the three SLR scenarios (Tables 10-3-2-5 and 10-3-2-6). The large increase in beach width for CBI-13 was a result of an advance of the shoreline position, but the sediment for that accretion likely eroded from the dune toe.

The largest predicted advance in the position of the dune toe was along profile CBI-22 for the 10-year wave event and 2040 SLR scenario (Table 10-3-2-5). The same profile was predicted to have a similar advance in its shoreline position, which resulted in a minimal change in the beach width.

10.3.3 Dune Crest Height

The final quantitative metric evaluated for this study, change in dune crest height, was computed independent of beach width. The dune crest height represents the highest elevation along the dune of each of the selected profiles. The dune crest height change was computed for each of the 54 simulations by using Pybeach to extract the pre-storm and post-storm dune crest elevations, and then the pre-storm dune crest elevation was subtracted from the post-storm dune crest elevation (Tables 10-3-3-1 to 10-3-3-3). The negative values in the three tables below, highlighted in light to dark red, represent a decrease in dune crest height. There were no predicted increases in dune crest height.

Table 10-3-3-1. Predicted Change in the Dune Crest Height, in feet, for the 2-Year Wave Event

Sea Level Rise (ft)	CBI-03	CBI-06	CBI-13	CBI-17	CBI-22	CBI-24
0.00	0.0	0.0	0.0	0.0	0.0	0.0
1.54 (2040)	0.0	0.0	0.0	0.0	0.0	0.0
3.54 (2070)	0.0	0.0	0.0	0.0	-3.3	0.0

Table 10-3-3-2. Predicted Change in the Dune Crest Height, in feet, for the 10-Year Wave Event

Sea Level Rise (ft)	CBI-03	CBI-06	CBI-13	CBI-17	CBI-22	CBI-24
0.00	0.0	0.0	0.0	0.0	-0.2	0.0
1.54 (2040)	0.0	0.0	0.0	0.0	-0.1	0.0
3.54 (2070)	0.0	0.0	0.0	0.0	-3.3	0.0

Table 10-3-3-3. Predicted Change in the Dune Crest Height, in feet, for the 100-Year Wave Event

Sea Level Rise (ft)	CBI-03	CBI-06	CBI-13	CBI-17	CBI-22	CBI-24
0.00	0.0	0.0	0.0	0.0	0.0	0.0
1.54 (2040)	0.0	0.0	0.0	0.0	-3.2	0.0
3.54 (2070)	0.0	0.0	0.0	0.0	-3.3	0.0

As shown in Tables 10-3-3-1 to 10-3-3-3, 48 of the 54 simulations had no predicted change in dune crest height. Two of the simulations predicted decreases in dune crest elevation of 0.2 ft or less. CBI-22 was the only profile where the dune crest height was predicted to erode. CBI-22 had the lowest starting dune crest height of the six selected profiles. The changes in dune crest height at CBI-22 signify that some overtopping of the dune was predicted, though mostly during the 2070 SLR scenario for the three wave events, and during the 2040 SLR scenario only during the 100-year wave event. Overtopping can lead to flooding in the dune swales, potentially impacting dune fauna and flora. Dune crest elevation changes were predicted for profile CBI-22 with the largest changes predicted for the three wave events during the 2070 SLR scenario, when the dune crest elevation decreases by 3.3 ft.

10.3.4 Maximum Wave Run-up

For the maximum wave run-up analysis, wave run-up elevation along each profile is based on the TWL, a combination of tides, surge, and wave conditions (Figure 3-1). The TWL analysis considers multiple worst-case scenarios, which include a range of SLR scenarios and storm wave events at differing recurrence intervals (2-year, 10-year, and 100-year). The combination of SLR and wave heights along each profile were evaluated using XBeach to predict potential wave run-up elevation and inland flood exposure to SPI in the future.

The predicted maximum wave run-up along each of the profiles, for each of the storm scenarios, and each of SLR scenarios are presented in Tables 10-3-4-1 to 10-3-4-3. Overall, the XBeach results illustrate that, in general and as expected, as the offshore wave heights increase and as the SWL elevation increases with SLR, the potential wave run-up height increases.

Wave run-up elevation values during the 100-year storm events with moderate (2040) and high (2070) SLR are approaching elevations in which dune overtopping may occur. As a note, the predicted maximum run-up along profile CBI-03 during the 10-year wave event was higher for the 2040 SLR scenario as compared to the 2070 SLR scenario (Table 10-3-4-2). The reason is a result of the influence of bathymetry and topography on the breaking waves. With the deeper water depths during the 2070 SLR scenario, the influence of the seafloor on the wave is reduced; as a result, the wave may not break along the shoreface and not create as high of run-up compared to the shallower water depths.

Table 10-3-4-1. Predicted Maximum Wave Run-up, in feet NAVD88, for the 2-Year Wave Event

Sea Level Rise (ft)	CBI-03	CBI-06	CBI-13	CBI-17	CBI-22	CBI-24
Pre-Storm Dune Crest Elevation (ft)	13.35	14.57	9.58	12.37	8.5	13.12
0.00	5.4	6.0	4.4	5.3	5.3	3.9
1.54 (2040)	5.3	5.6	7.3	6.4	8.6	5.9
3.54 (2070)	7.2	6.2	8.1	8.3	8.6	6.5

Table 10-3-4-2. Predicted Maximum Wave Run-up, in feet NAVD88, for the 10-Year Wave Event

Sea Level Rise (ft)	CBI-03	CBI-06	CBI-13	CBI-17	CBI-22	CBI-24
0.00	6.4	5.7	5.8	6.7	5.8	6.6
1.54 (2040)	7.9	8.0	7.8	8.3	8.5	7.1
3.54 (2070)	7.7	9.3	10.1	9.6	8.8	10.2

Table 10-3-4-3. Predicted Maximum Wave Run-up, in feet NAVD88, for the 100-Year Wave Event

Sea Level Rise (ft)	CBI-03	CBI-06	CBI-13	CBI-17	CBI-22	CBI-24
0.00	9.3	8.7	8.4	6.3	7.7	9.4
1.54 (2040)	9.3	10.4	8.1	9.2	8.6	10.7
3.54 (2070)	11.5	10.1	8.9	9.4	9.6	11.2

10.4 INDIVIDUAL PROFILES

The next stage of analysis focused on the individual profiles and their predicted accretion and erosion as a result of the storm events and SLR scenarios.

Figure 5-3 illustrates the initial condition of one of the profiles, CBI-03, before the impact of a single storm event. A line for the MSL elevation was added for reference. The SWL, at the start of each simulation, was derived from the NOAA water level data shown in Figure 5-1.

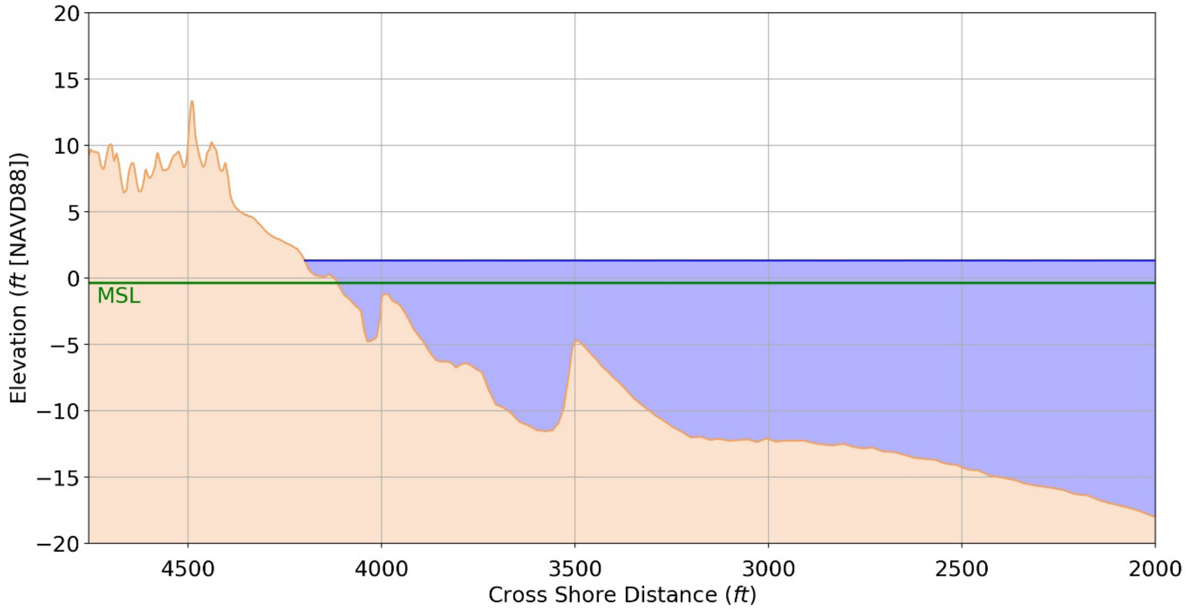

Figure 10-4. Initial Still Water Level and Bed Elevation for Profile CBI-03. MSL datum shown for reference.

10.4.1 CBI-03

The predicted changes to the CBI-03 profile for the 2-, 10-, and 100-year wave events, across the three SLR scenarios, are shown in Figures 10-4-1-1 to 10-4-1-3. The beach width for CBI-03 decreased across the nine simulations. The change in beach width during the 100-year wave event under present SLR was largest for this storm scenario (Figure 10-4-1-3, top). Each of the storm events and SLR scenarios was predicted to decrease the beach width for this profile. The beach profile was steepened as a result of the breaking waves along the shoreline, thus reducing the distance from the dune toe to the shoreline. The smaller reductions in beach width during the SLR scenarios are a result of the waves breaking farther up the beach, and eroding sand, although sand is predicted to be deposited along the beach at or just below MSL. The 100-year wave event for the present and 2040 SLR scenarios had the largest change in beach width, and the smallest was during the 2-year and 10-year wave events and the 2070 SLR scenario.

The primary factor in the predicted decreases in beach width across the nine simulations was the retreat of the shoreline position. The dune toe was impacted only during the 100-year wave event for the 2070 SLR scenario, when the waves and the water levels were the highest. As a note, the foredune was predicted to erode during the 100-year wave event and the 2070 SLR scenario, though this was not shown in the dune crest height tables presented above because it is not the highest dune along the profile (Figure 10-4-1-3, bottom).

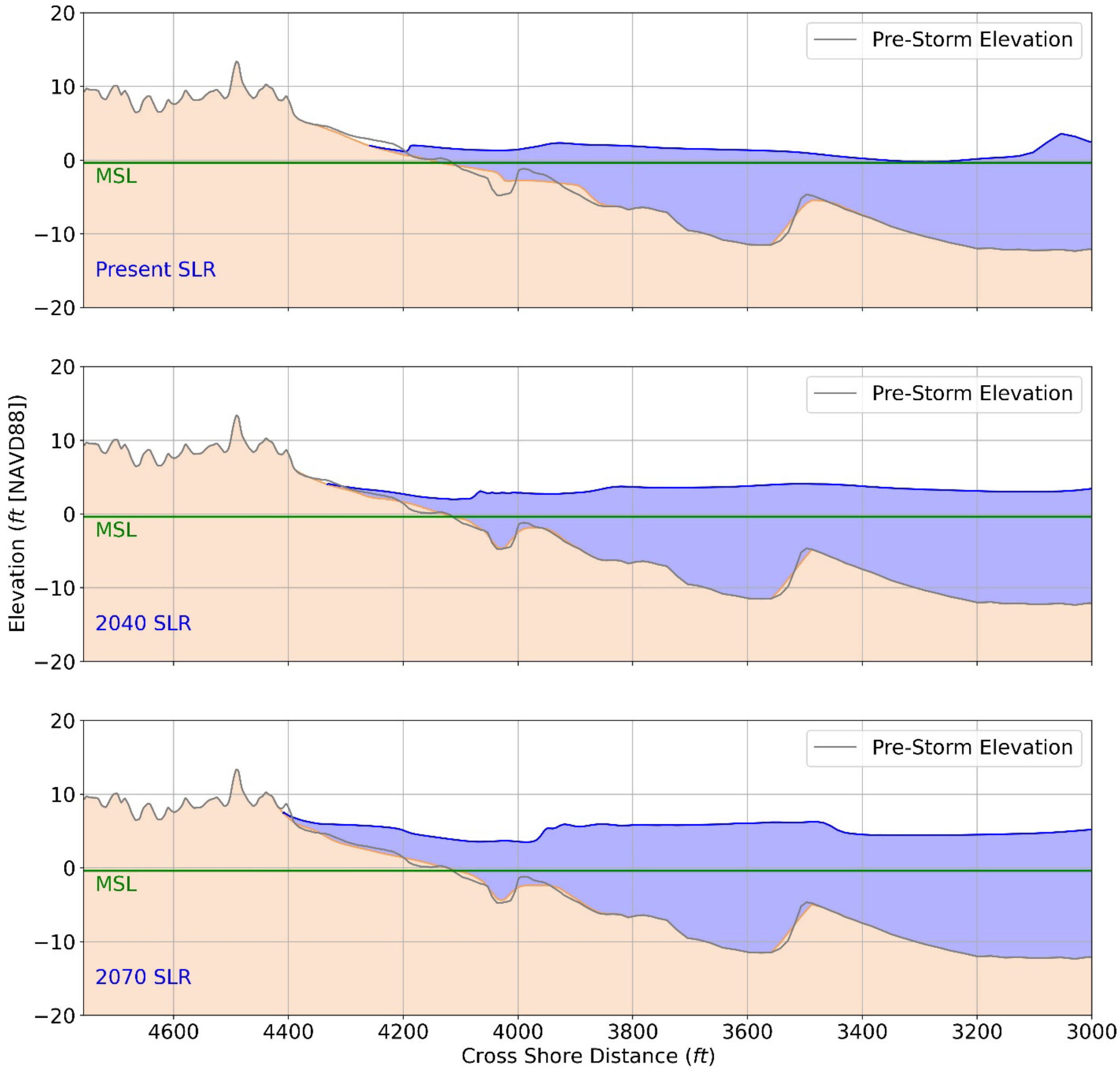

Figure 10-4-1-1.Predicted Shoreline Elevation for CBI-03 after 30 Hours of Exposure to a 2-Year Storm Event and Three SLR Scenarios

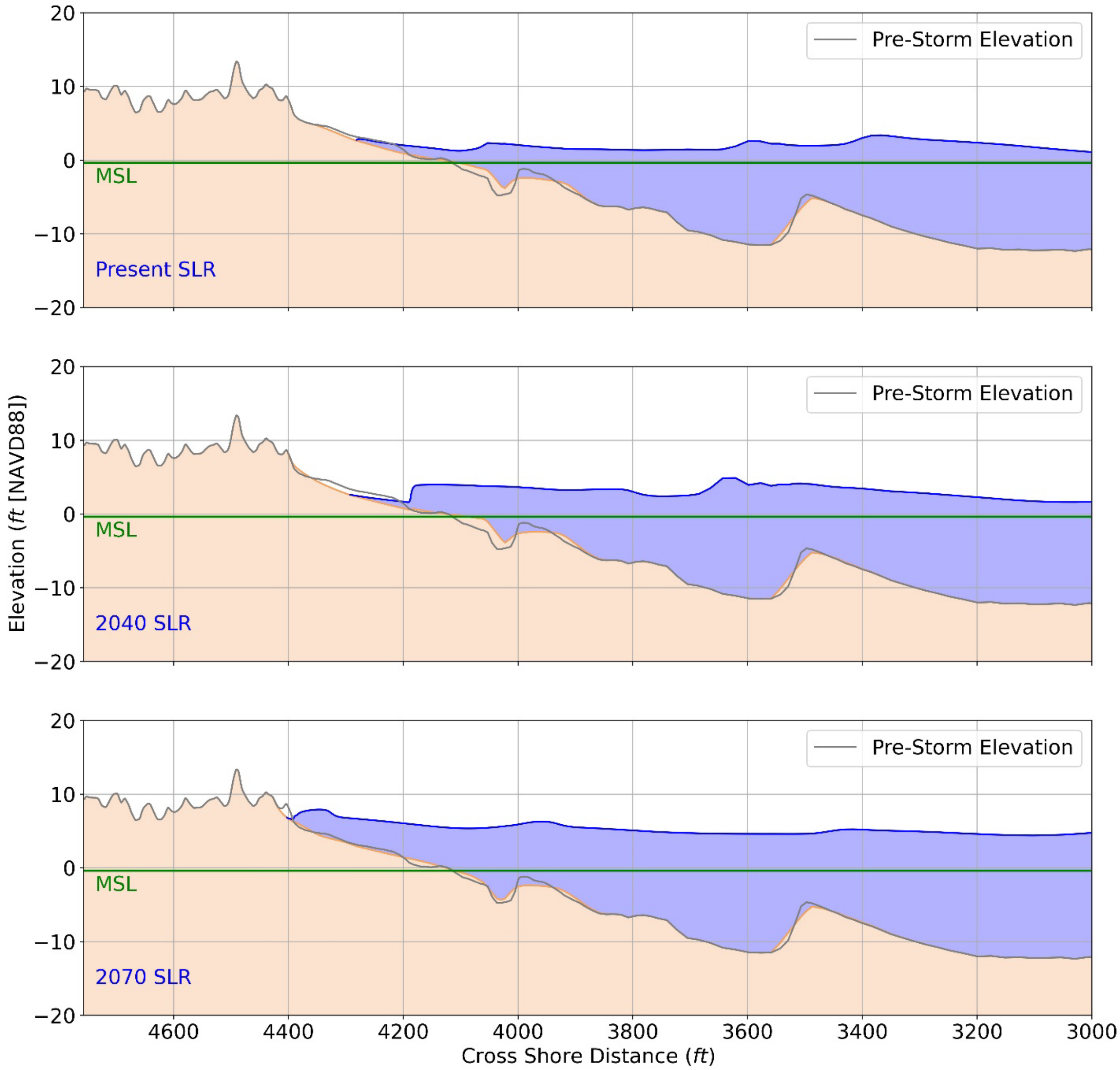

Figure 10-4-1-2.Predicted Shoreline Elevation for CBI-03 after 30 Hours of Exposure to a 10-Year Storm Event and Three SLR Scenarios

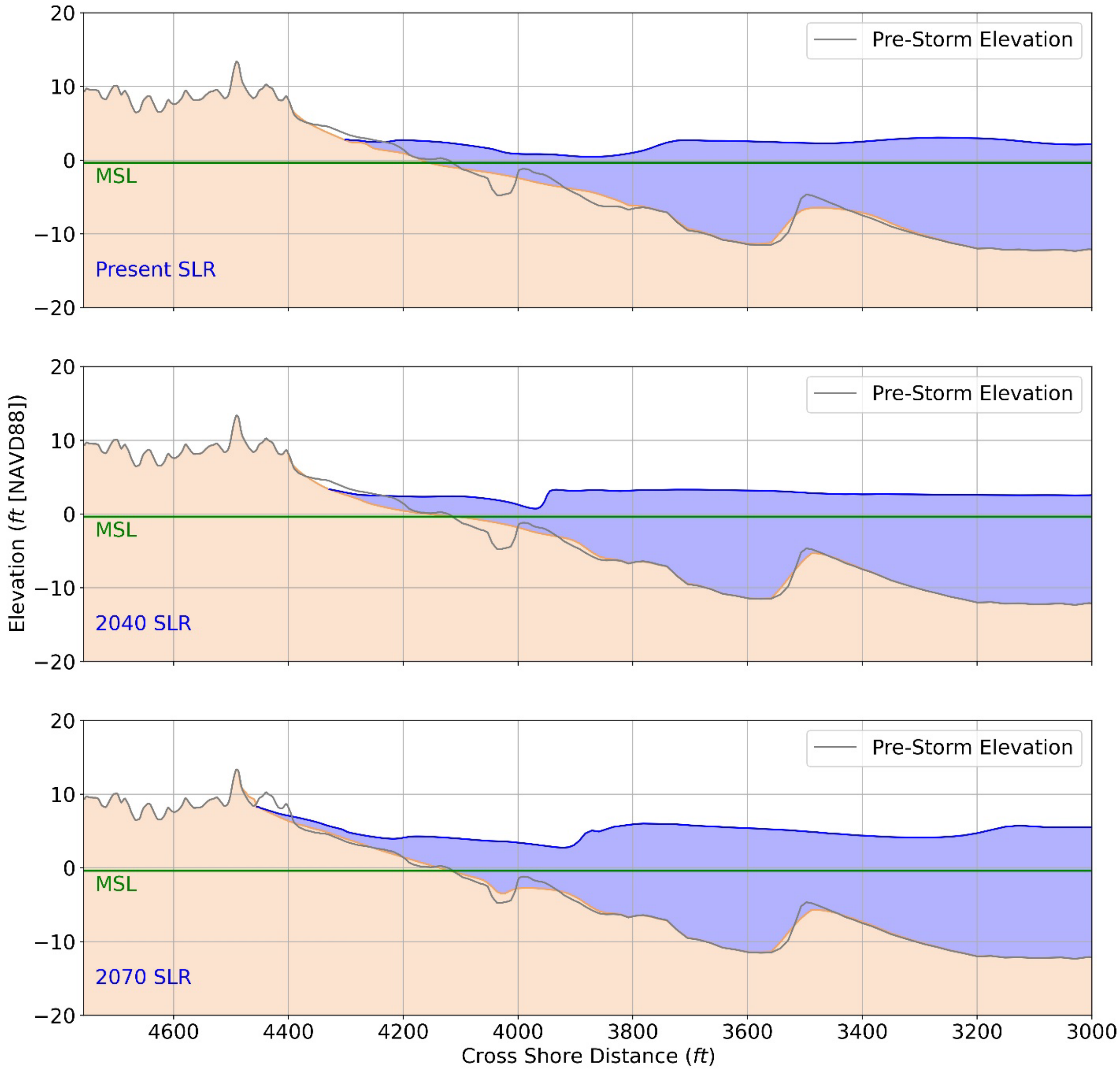

Figure 10-4-1-3.Predicted Shoreline Elevation for CBI-03 after 30 Hours of Exposure to a 100-Year Storm Event and Three SLR Scenarios

10.4.2 CBI-06

The predicted changes to the CBI-06 profile for the 2-, 10-, and 100-year wave events, across the three SLR scenarios, are shown in Figures 10-4-2-1 to 10-4-2-3. The beach width was predicted to increase for the nine simulations along CBI-06, although as discussed earlier, the largest increase in beach width during the 10-year wave event was due to a large amount of erosion on the foredune (Figure 10-4-2-2, bottom). A similar beach width increase was predicted for the

100-year wave event and 2070 SLR scenario, a result of the retreating dune toe (Figure 10-4-2-3, bottom).

The primary factor in the predicted increases in beach width across the nine simulations was the advancement in the shoreline position. The dune toe was impacted only during the 10- and 100-year wave events for the 2070 SLR scenario, when the waves and the water levels were the highest. Interestingly, the foredune was predicted to erode during the 10-year wave event and the 2070 SLR scenario, though this was not shown in the dune crest height tables presented above because it is not the highest dune along the profile (Figure 10-4-2-2, bottom). The reason for the 10-year wave event causing foredune erosion and not during the 100-year wave event, with the same SLR scenario, is a result of the influence of bathymetry and topography on the breaking waves. Smaller waves, representative of those during the 10-year wave event, can travel closer to shore before breaking especially with higher sea levels. These waves would likely break closer to the foredune, causing the predicted erosion. Overtopping of the foredune was predicted for the 100-year wave event and the 2070 SLR scenario, though the foredune was not eroded. This is likely the reason for the dune toe change table showing an impact similar to that for the 10-year wave event (Table 10-3-2-5).

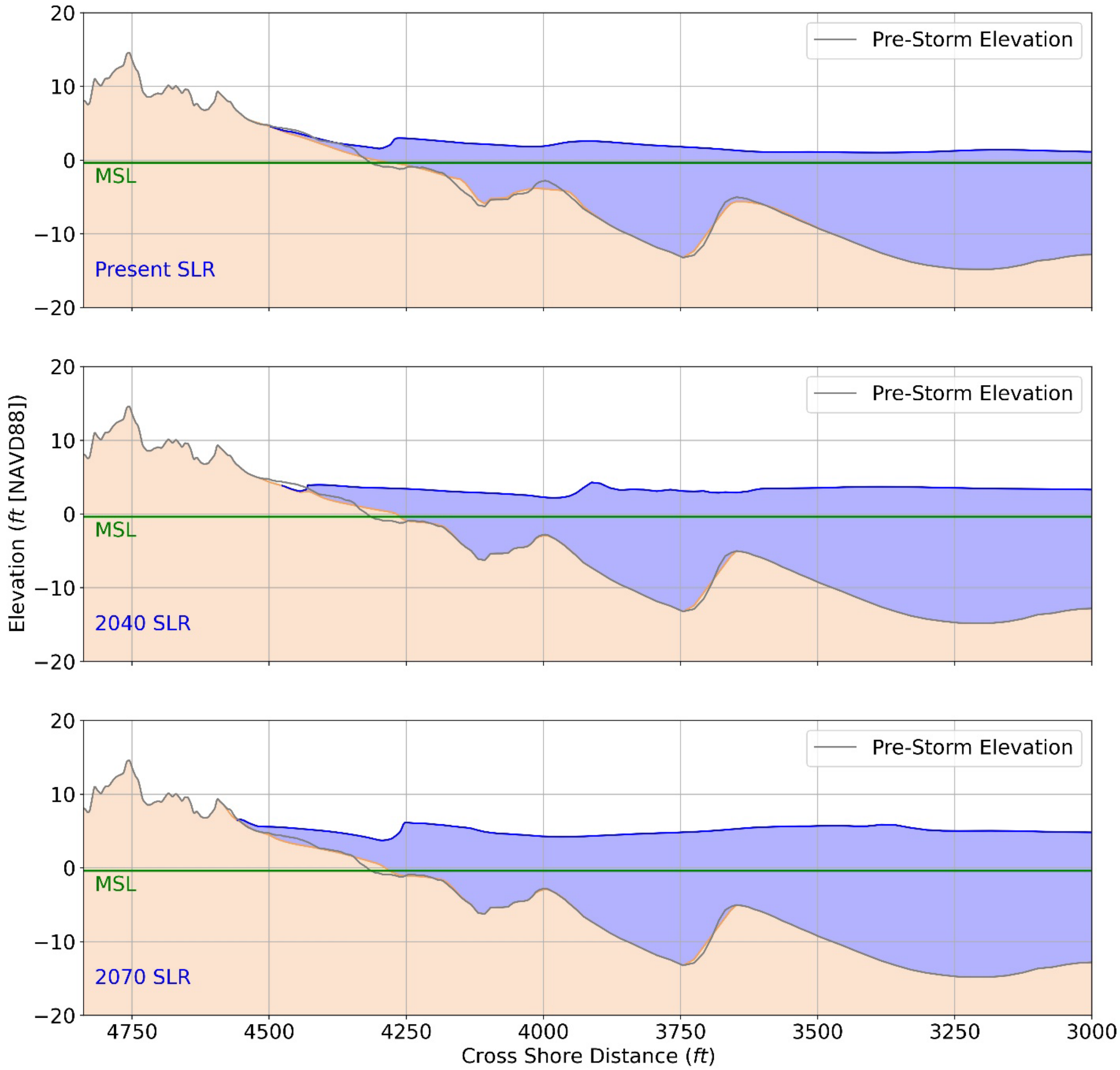

Figure 10-4-2-1.Predicted Shoreline Elevation for CBI-06 after 30 Hours of Exposure to a 2-Year Storm Event and Three SLR Scenarios

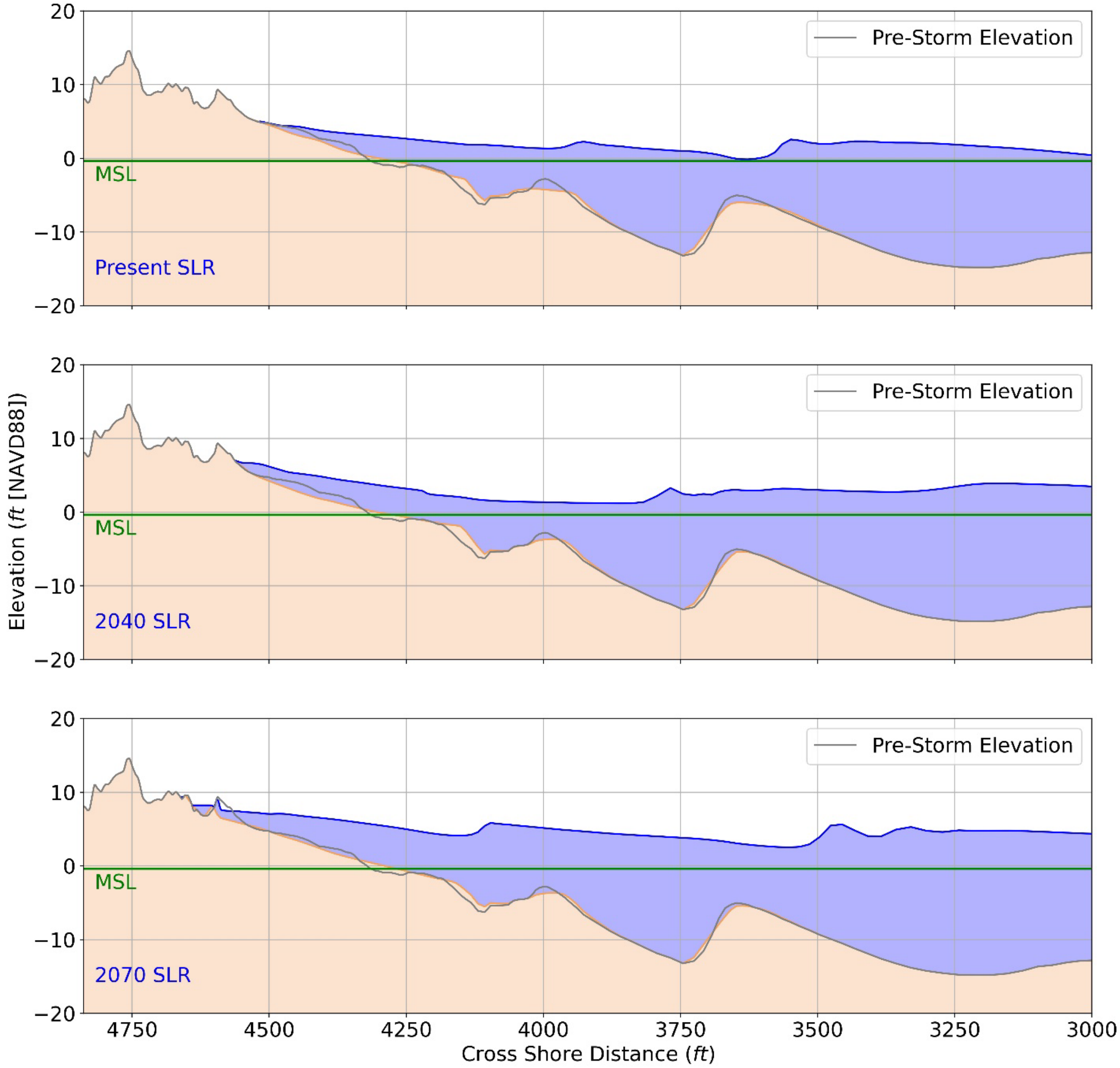

Figure 10-4-2-2.Predicted Shoreline Elevation for CBI-06 after 30 Hours of Exposure to a 10-Year Storm Event and Three SLR Scenarios

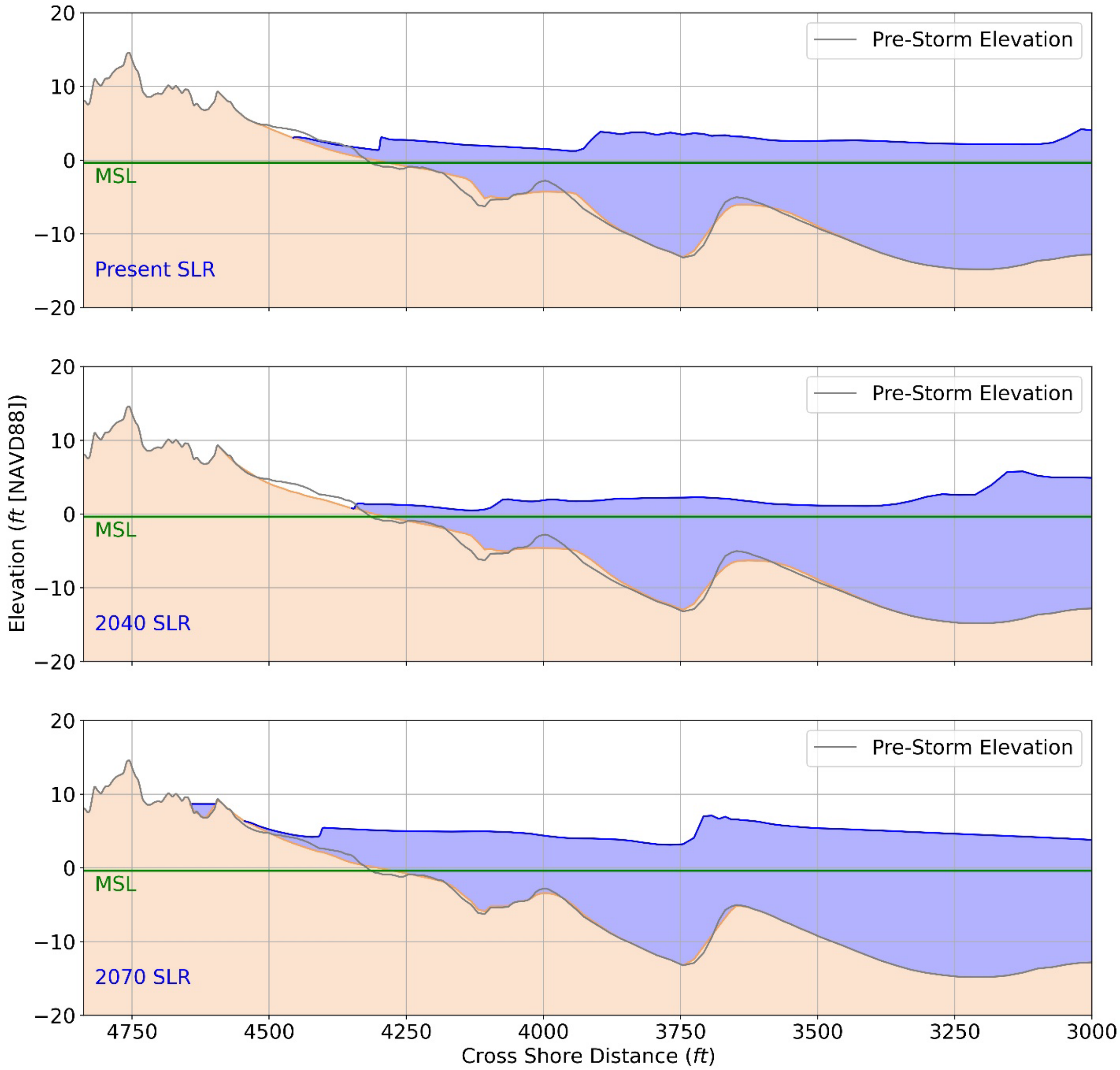

Figure 10-4-2-3.Predicted Shoreline Elevation for CBI-06 after 30 Hours of Exposure to a 100-Year Storm Event and Three SLR Scenarios

10.4.3 CBI-13

The predicted changes to the CBI-13 profile for the 2-, 10-, and 100-year wave events, across the SLR scenarios, are shown in Figures 10-4-3-1 to 10-4-3-3. Similar to CBI-06, the beach width for the nine simulations along CBI-13 is predicted to increase. The largest increase in beach width occurred during the 100-year wave event and the 2070 SLR scenario, although this was again as a result of a retreat of the dune toe (Figure 10-4-3-3, bottom). Most of the other simulations had a similar retreat of the dune toe, resulting in the predicted increase in beach width.

The shoreline position and dune toe position were shown to generally advance and retreat, respectively, for CBI-13. This was likely a result of erosion of the foredune and material subsequently being deposited on the beach, resulting in the increases in beach width. The foredune was predicted to have some erosion during the 2- and 10-year wave events and the 2070 SLR scenario, though this was not shown in the dune crest height tables presented above because it is not the highest dune along the profile (Figures 10-4-3-1 and 10-4-3-2, bottom). Overtopping of the foredune was predicted during the 100-year wave event and the 2040 and 2070 SLR scenarios (Figure 10-4-3-3, middle and bottom).

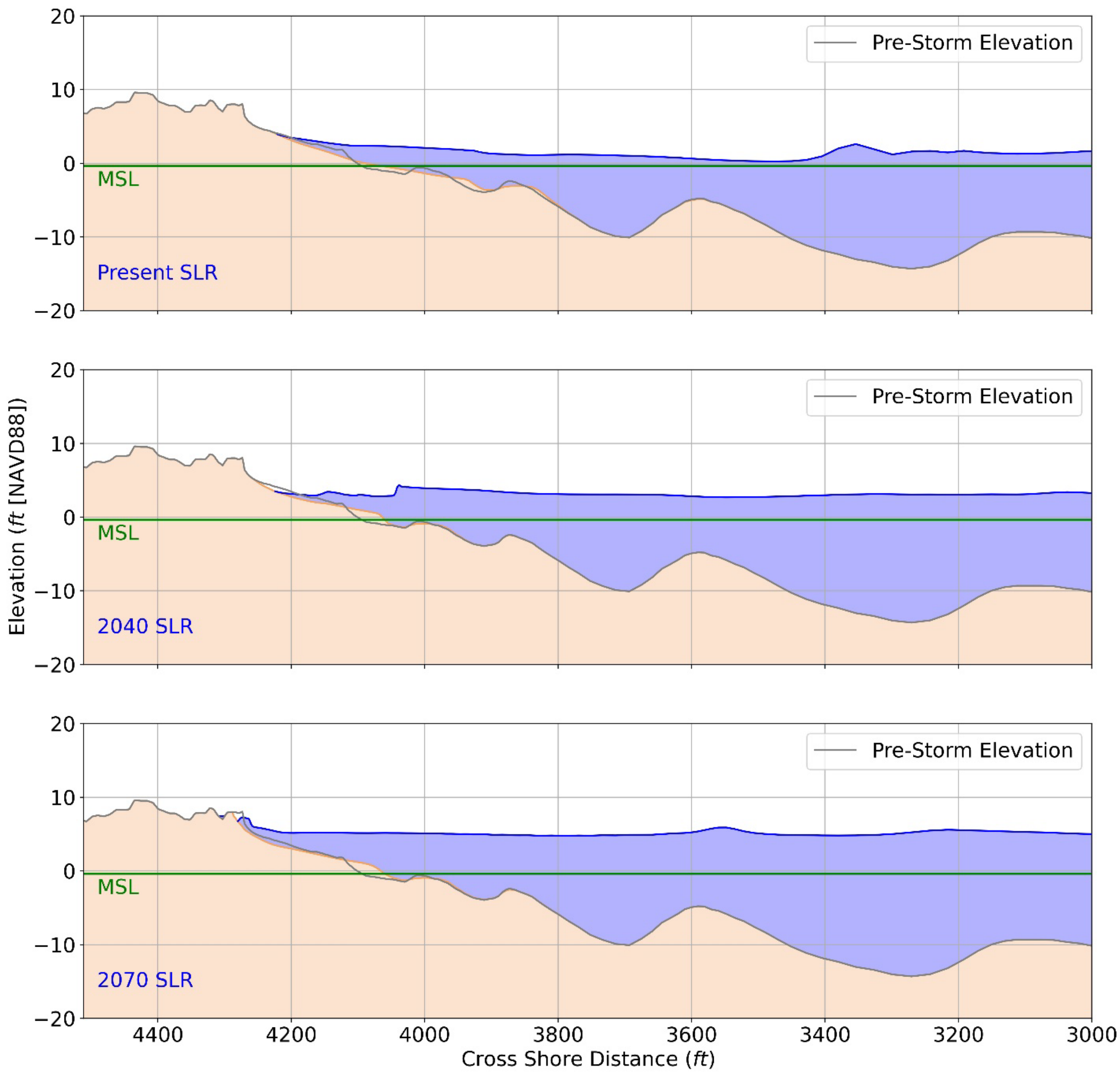

Figure 10-4-3-1.Predicted Shoreline Elevation for CBI-13 after 30 Hours of Exposure to a 2-Year Storm Event and Three SLR Scenarios

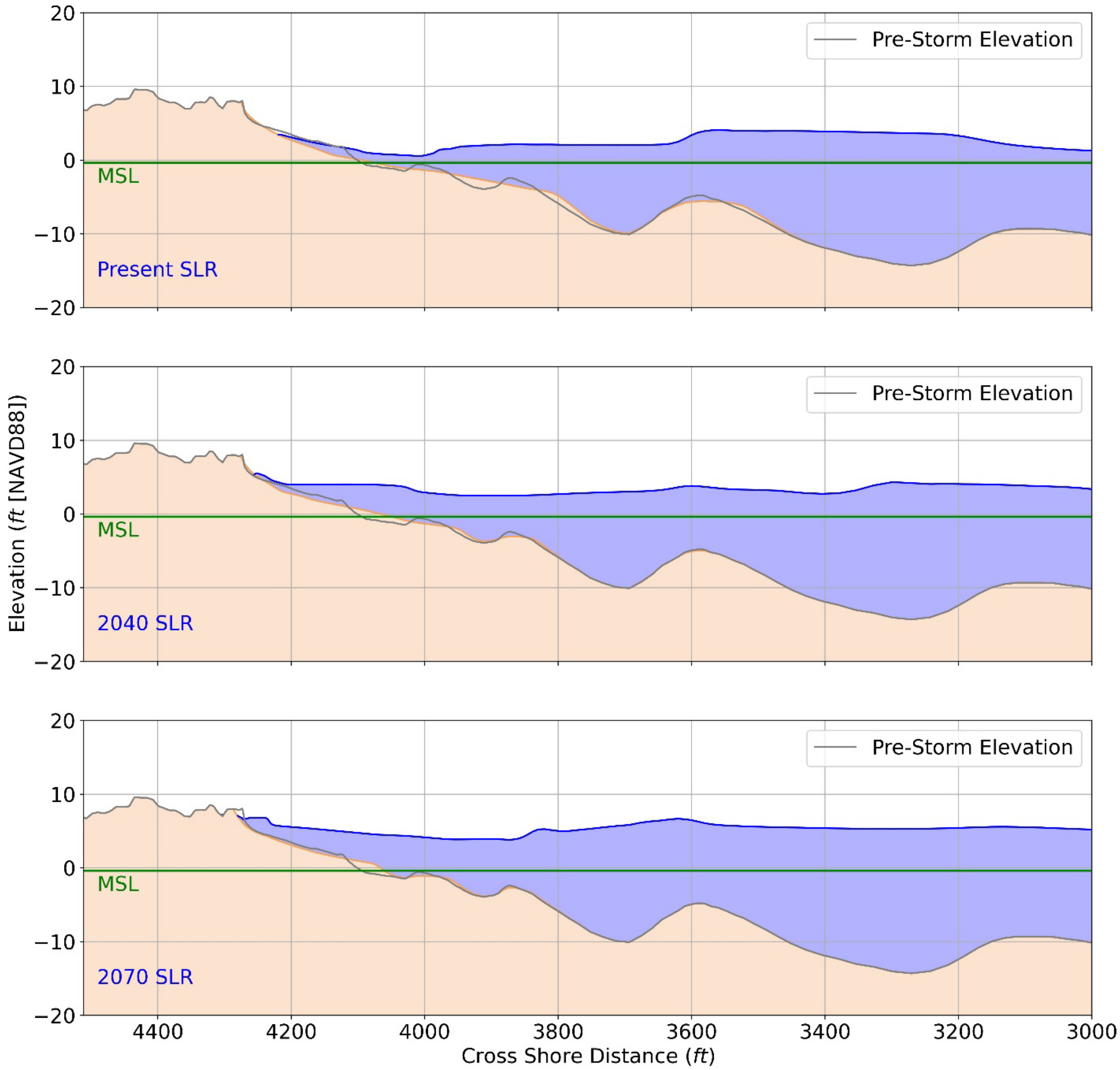

Figure 10-4-3-2.Predicted Shoreline Elevation for CBI-13 after 30 Hours of Exposure to a 10-Year Storm Event and Three SLR Scenarios

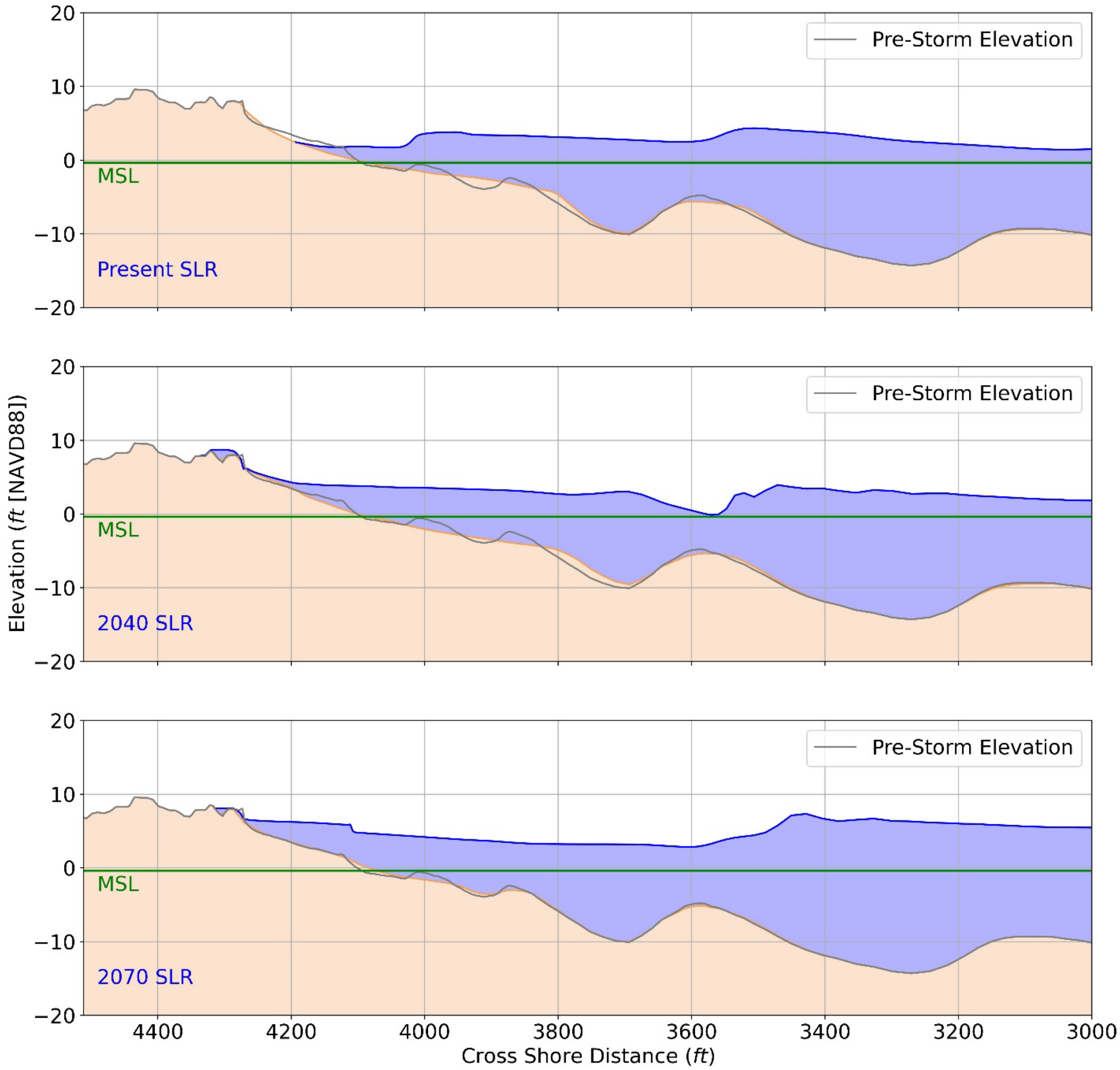

Figure 10-4-3-3.Predicted Shoreline Elevation for CBI-13 after 30 Hours of Exposure to a 100-Year Storm Event and Three SLR Scenarios

10.4.4 CBI-17

The predicted changes to the CBI-17 profile for the 2-, 10-, and 100-year wave events, across the SLR scenarios, are shown in Figures 10-4-4-1 to 10-4-4-3, respectively. A decreasing beach width was predicted for all but three of the CBI-17 simulations. One of those three simulations had no predicted change in beach width, and the remaining two had changes up to 6.6 ft. The largest changes in beach width occurred during the 100-year wave event under the present and 2040 SLR scenarios. This is a result of a steepening of the lower beach, and material deposited seaward of the shoreline, below MSL (Figure 10-4-4-2 and Figure 10-4-4-3, top). The shoreline position was the primary factor in the decrease in beach width along this profile. Four of the nine simulations along this profile had predicted changes to the dune toe position. Three of those four occurred during the 2070 SLR scenario, and the largest occurred during the 100-year wave event and the 2040 SLR scenario. No beach width change was predicted for the 2-year wave event and 2070 SLR scenario (Figure10-4-4-1, bottom), though the profile along the lower beach was altered.

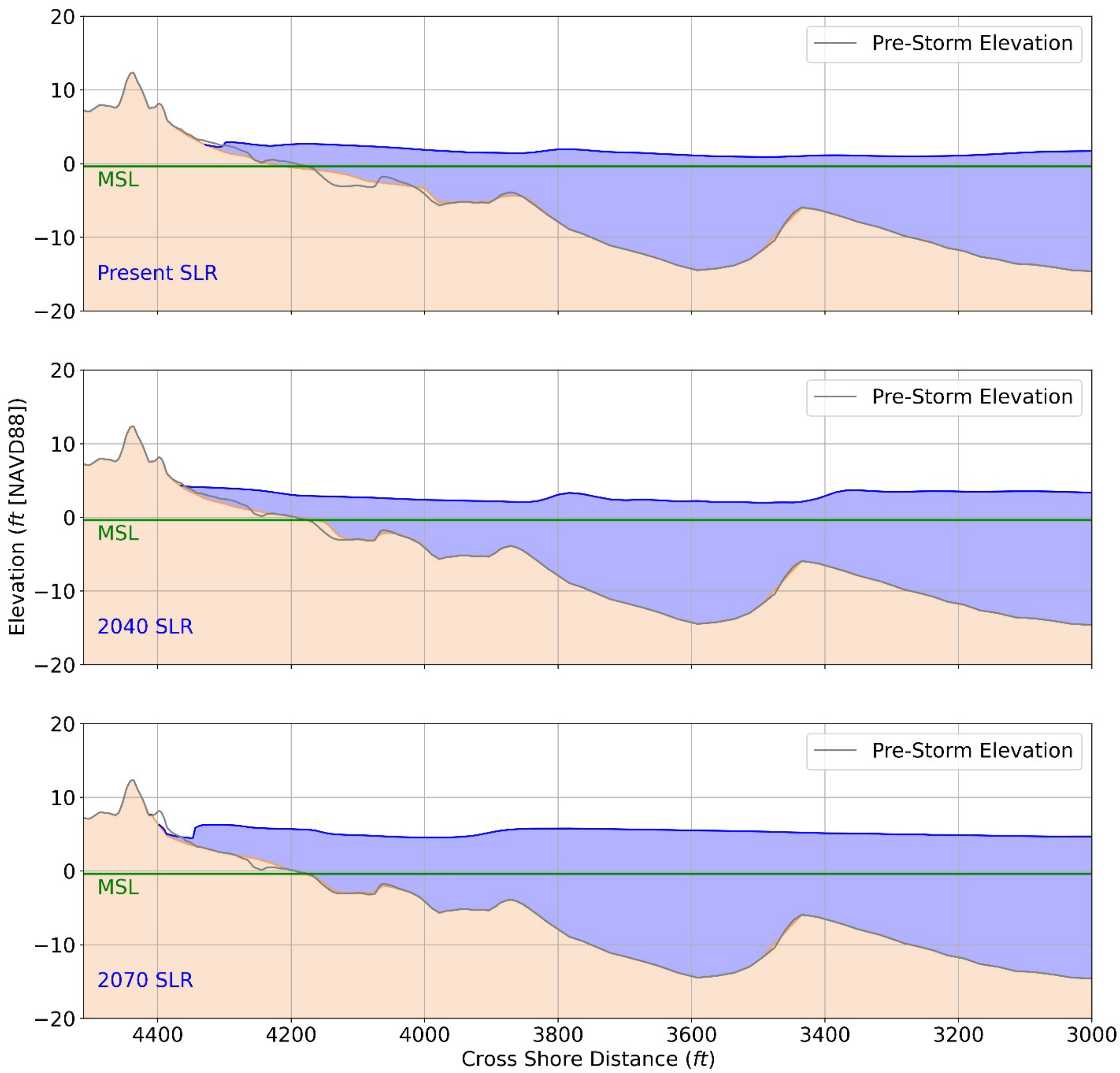

Figure 10-4-4-1.Predicted Shoreline Elevation for CBI-17 after 30 Hours of Exposure to a 2-Year Storm Event and Three SLR Scenarios

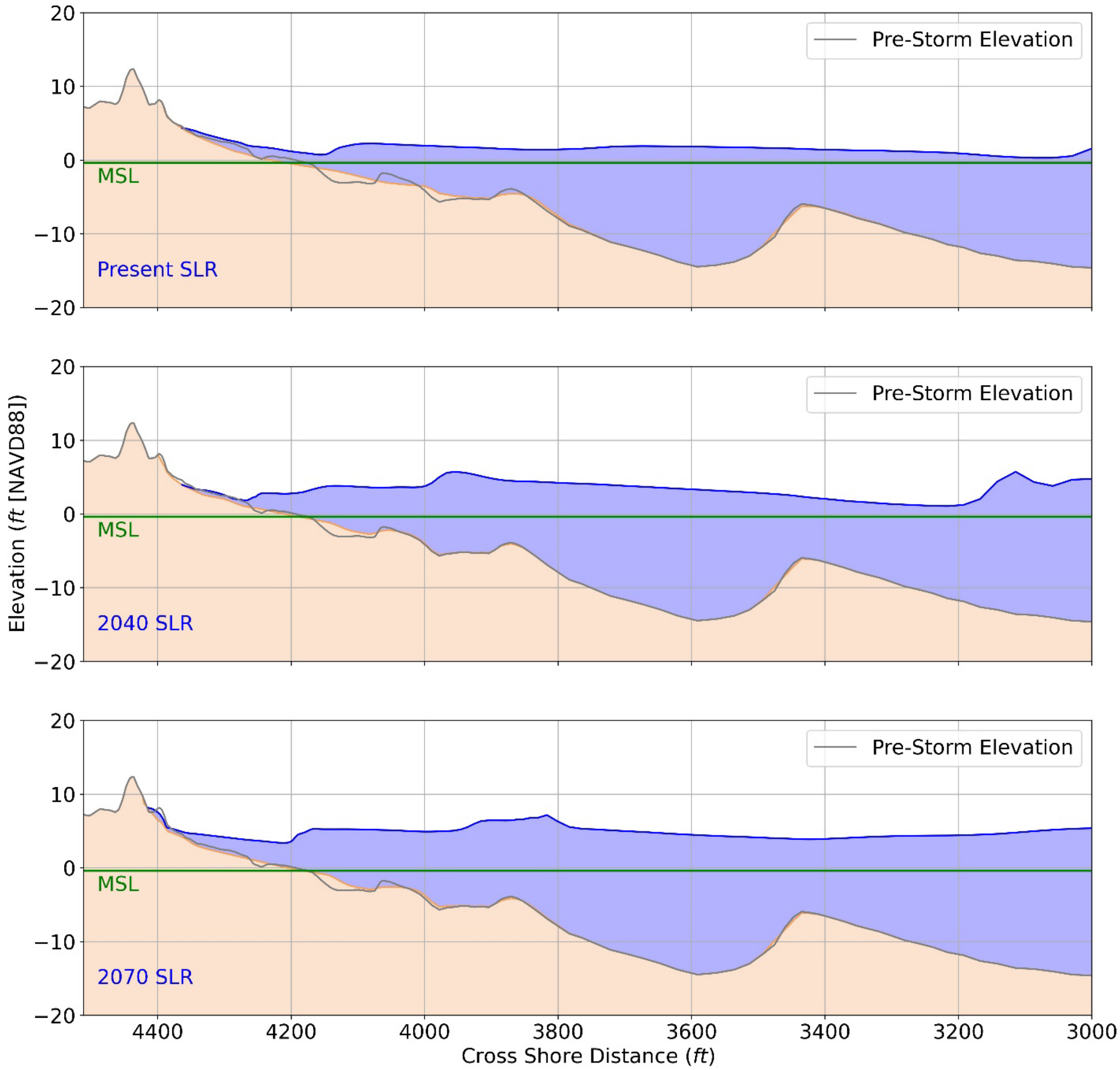

Figure 10-4-4-2.Predicted Shoreline Elevation for CBI-17 after 30 Hours of Exposure to a 10-Year Storm Event and Three SLR Scenarios

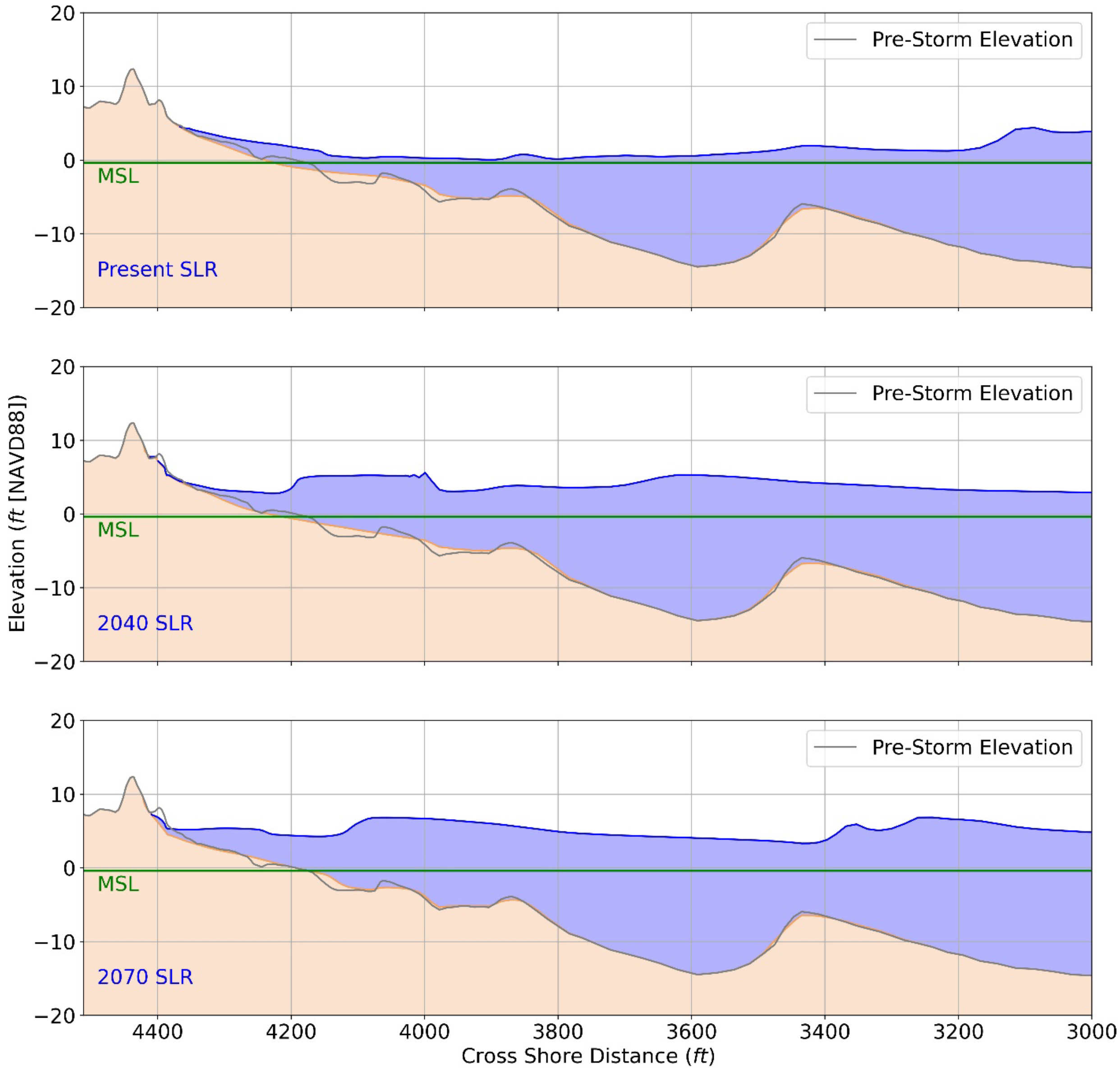

Figure 10-4-4-3.Predicted Shoreline Elevation for CBI-17 after 30 Hours of Exposure to a 100-Year Storm Event and Three SLR Scenarios

10.4.5 CBI-22

The predicted changes to the CBI-22 profile for the 2-, 10-, and 100-year wave events, across the SLR scenarios, are shown in Figures 10-4-5-1 to 10-4-5-3. An increasing beach width was predicted for each of the CBI-22 simulations, except one. The increasing beach width was generally a result of an advancing shoreline position and retreat of the dune toe.

Interestingly, the 10-year storm event under present SLR conditions predicted a larger amount of erosion along the foredune as compared to the 100-year storm event (Figure 10-4-5-2). This is a result of the influence of bathymetry and topography on the wave energy. Smaller waves can travel closer to shore before breaking, especially with varying water levels. At the offshore point of the profile, the 100-year wave height is higher than the 10-year wave height (Table 10-2-3-2). As a result, the larger offshore wave of the 100-year event comes in contact with the seafloor at a deeper depth and will break, expelling its energy before rushing up to the foredune, thus reducing the potential for erosion. The 10-year offshore wave will break closer to the shoreline, thus increasing the potential for erosion. The importance of this finding is that more frequent wave events, rather than larger waves, could cause increased potential for coastal erosion. However, the occurrence of this is dependent on the local bathymetry as most of the other selected profiles were predicted to have larger amounts of erosion during the 100-year storm event, as would be expected.

The entire dune system was predicted to erode in four of the nine simulations at CBI-22, also confirmed in the dune crest height tables (Tables 10-3-3-1 to 10-3-3-3). The erosion was only predicted for the 2070 SLR scenario for the 2- and 10-year wave events (Figures 10-4-5-1 and 10-4-5-2, bottom). For the 100-year wave event, the dune erosion was predicted for the 2040 and 2070 SLR scenarios (Figure 10-4-5-3, middle and bottom). While the magnitudes of the changes in dune crest elevations were similar for these four simulations, upon closer inspection of the figures below, the new eroded profile is different, except for the height of the dune crest.

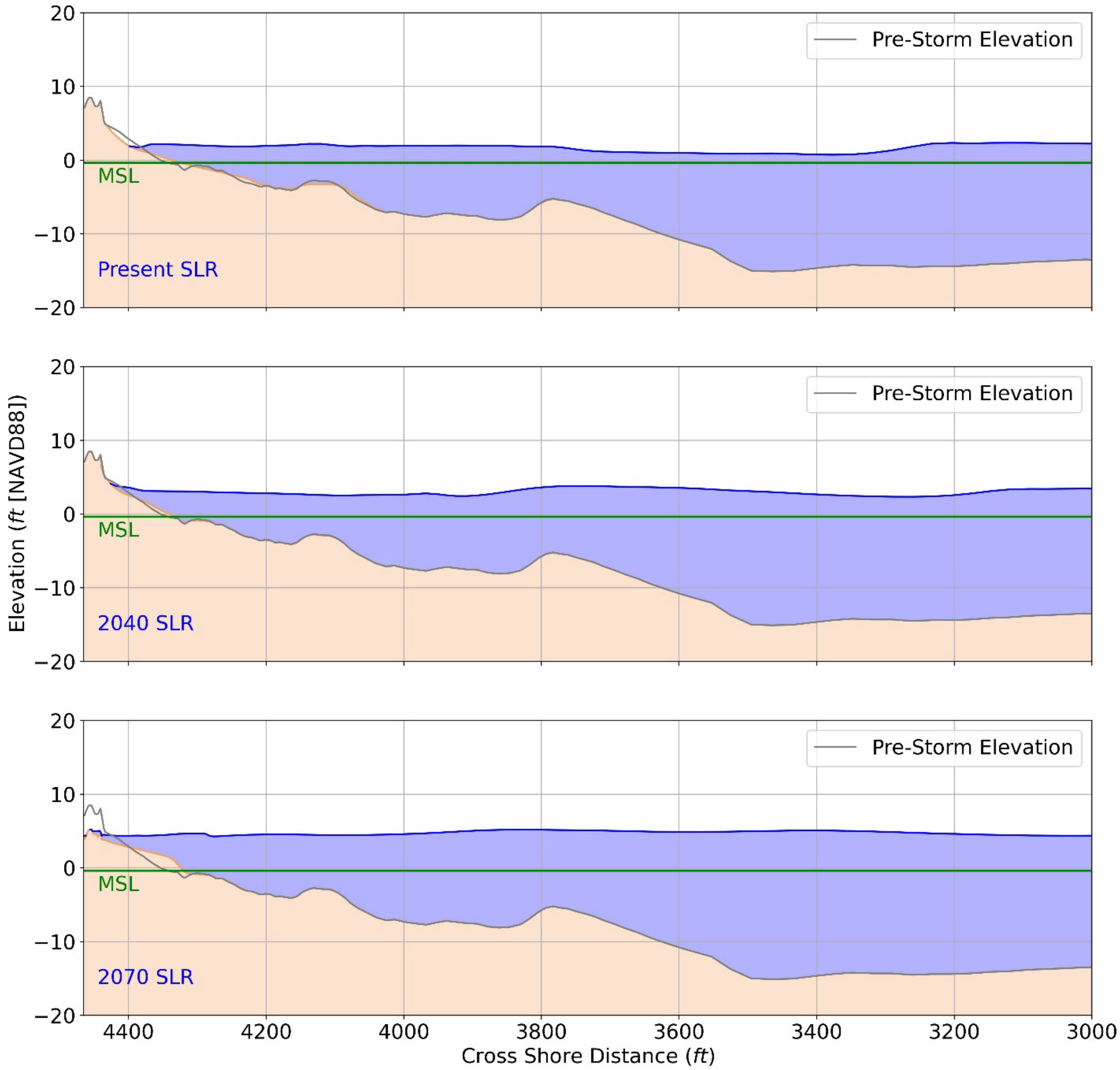

Figure 10-4-5-1.Predicted Shoreline Elevation for CBI-22 after 30 Hours of Exposure to a 2-Year Storm Event and Three SLR Scenarios

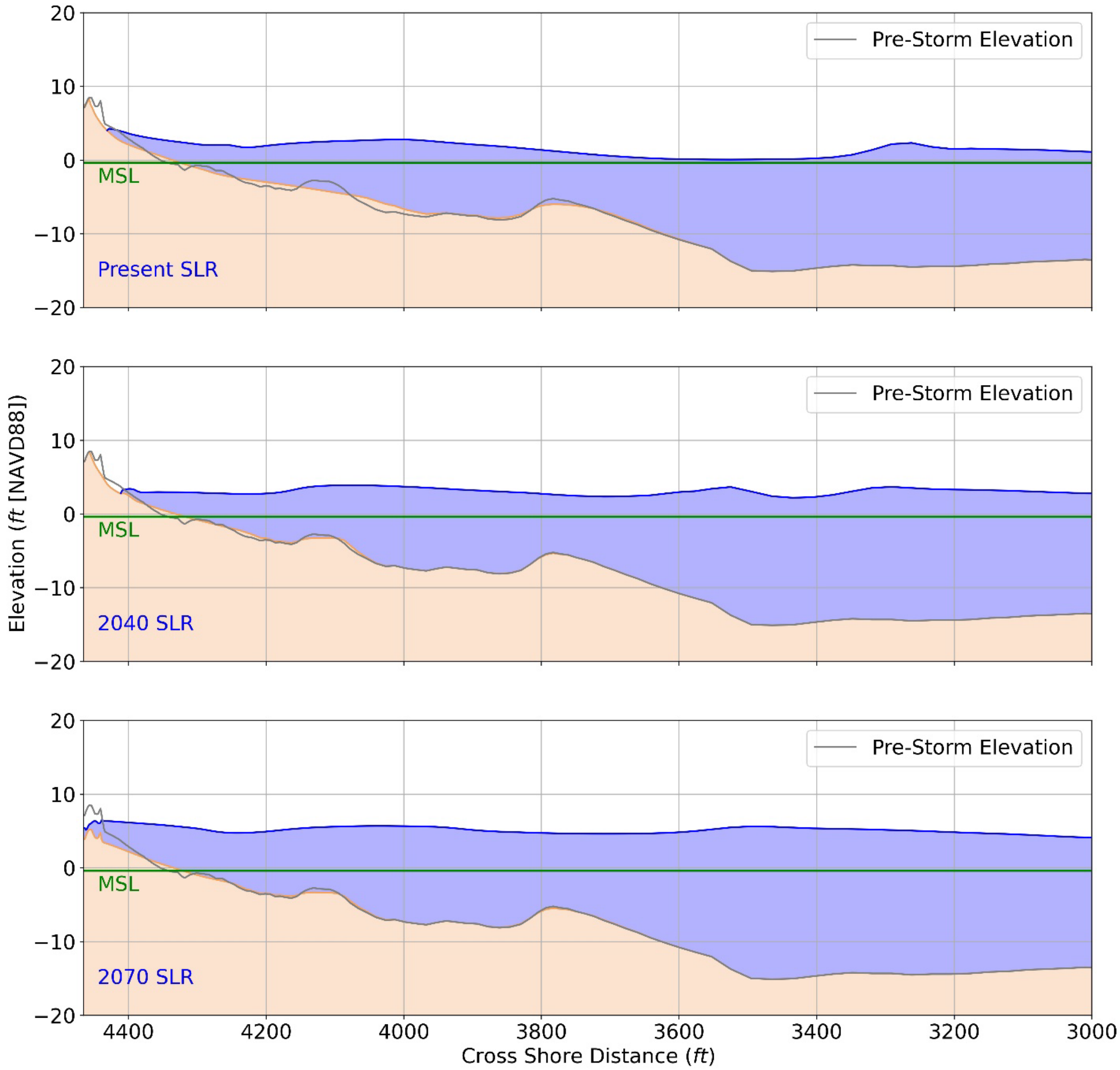

Figure 10-4-5-2.Predicted Shoreline Elevation for CBI-22 after 30 Hours of Exposure to a 10-Year Storm Event and Three SLR Scenarios

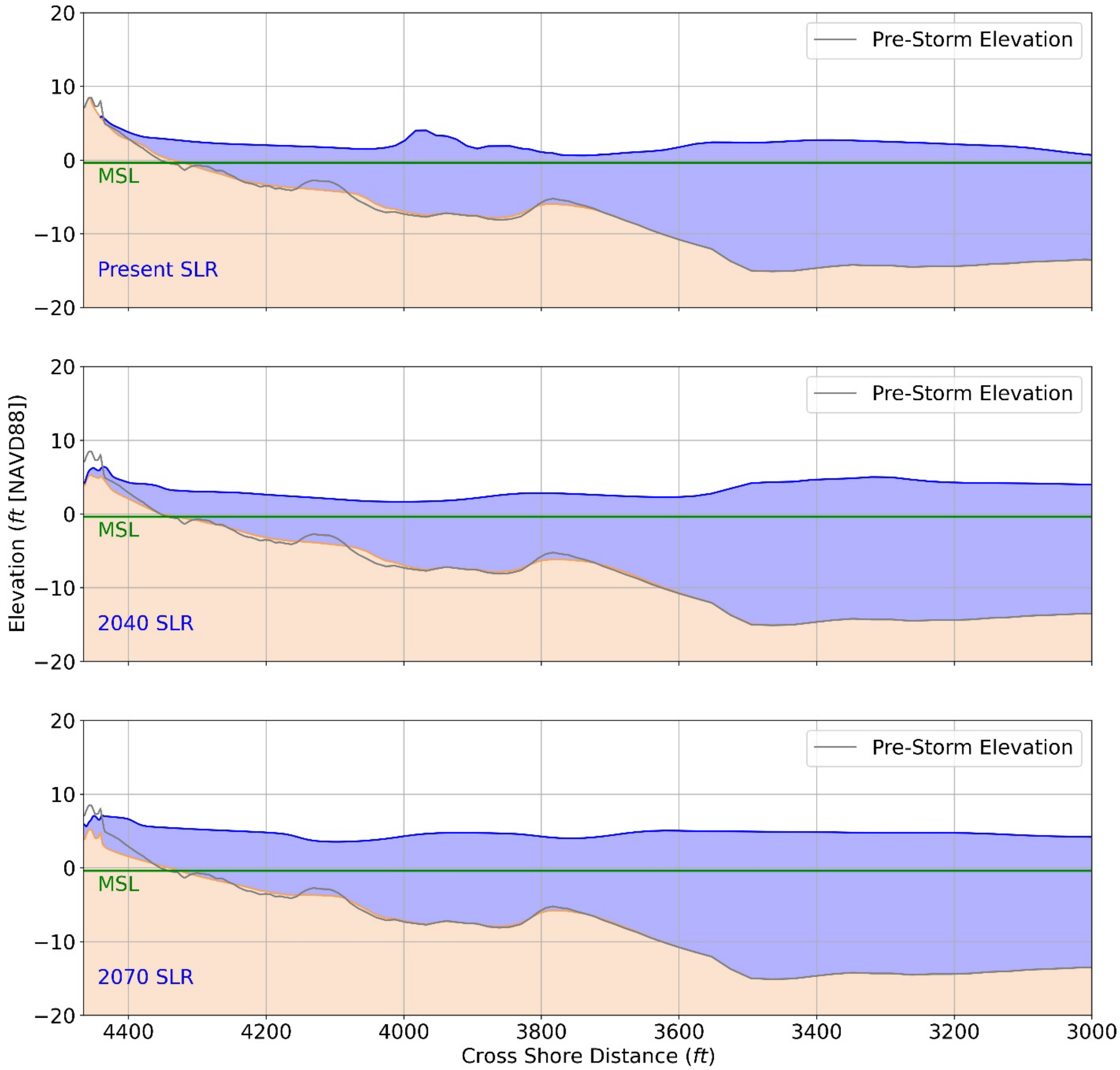

Figure10-4-5-3. Predicted Shoreline Elevation for CBI-22 after 30 Hours of Exposure to a 100-Year Storm Event and Three SLR Scenarios

10.4.6 CBI-24

The predicted changes to the CBI-24 profile for the 2-, 10-, and 100-year wave events, across the SLR scenarios, are shown in Figures 10-4-6-1 to 10-4-6-3, respectively. This profile was predicted to have the largest decreases in beach width, and is the northernmost profile that was evaluated with XBeach. During the 2-year wave event, the beach width was predicted to increase for the present and 2070 SLR scenarios, a result of a shoreline position advancement and, in the case of the 2070 SLR scenario, retreating dune toe. For the 10- and 100-year wave events, the beach width was predicted to decrease, primarily as a result of retreat of the shoreline position. This is a result of a steepening of the shoreface due to erosion and deposition of material seaward of the shoreline, below MSL.

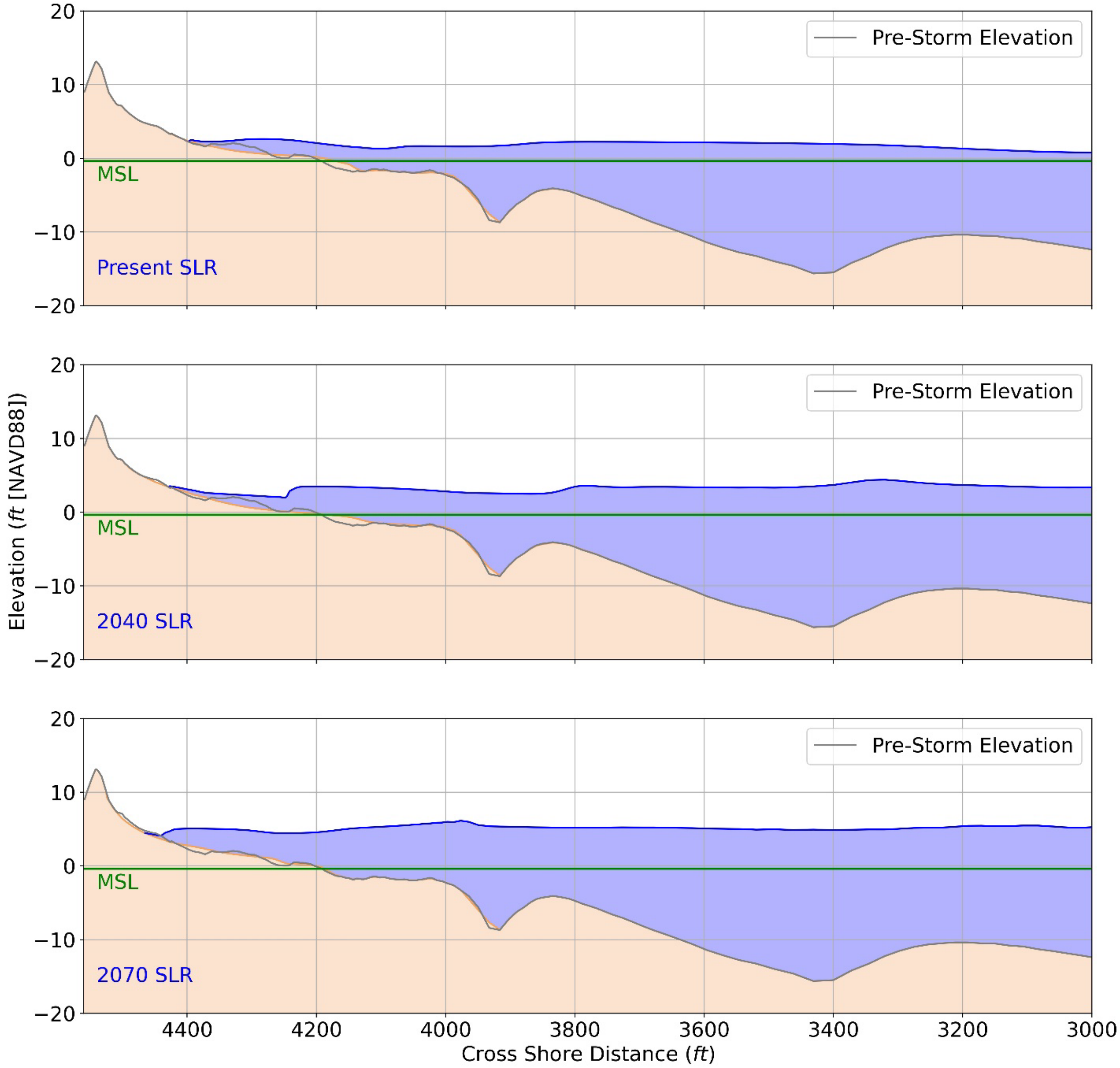

Figure 10-4-6-1.Predicted Shoreline Elevation for CBI-24 after 30 Hours of Exposure to a 2-Year Storm Event and Three SLR Scenarios

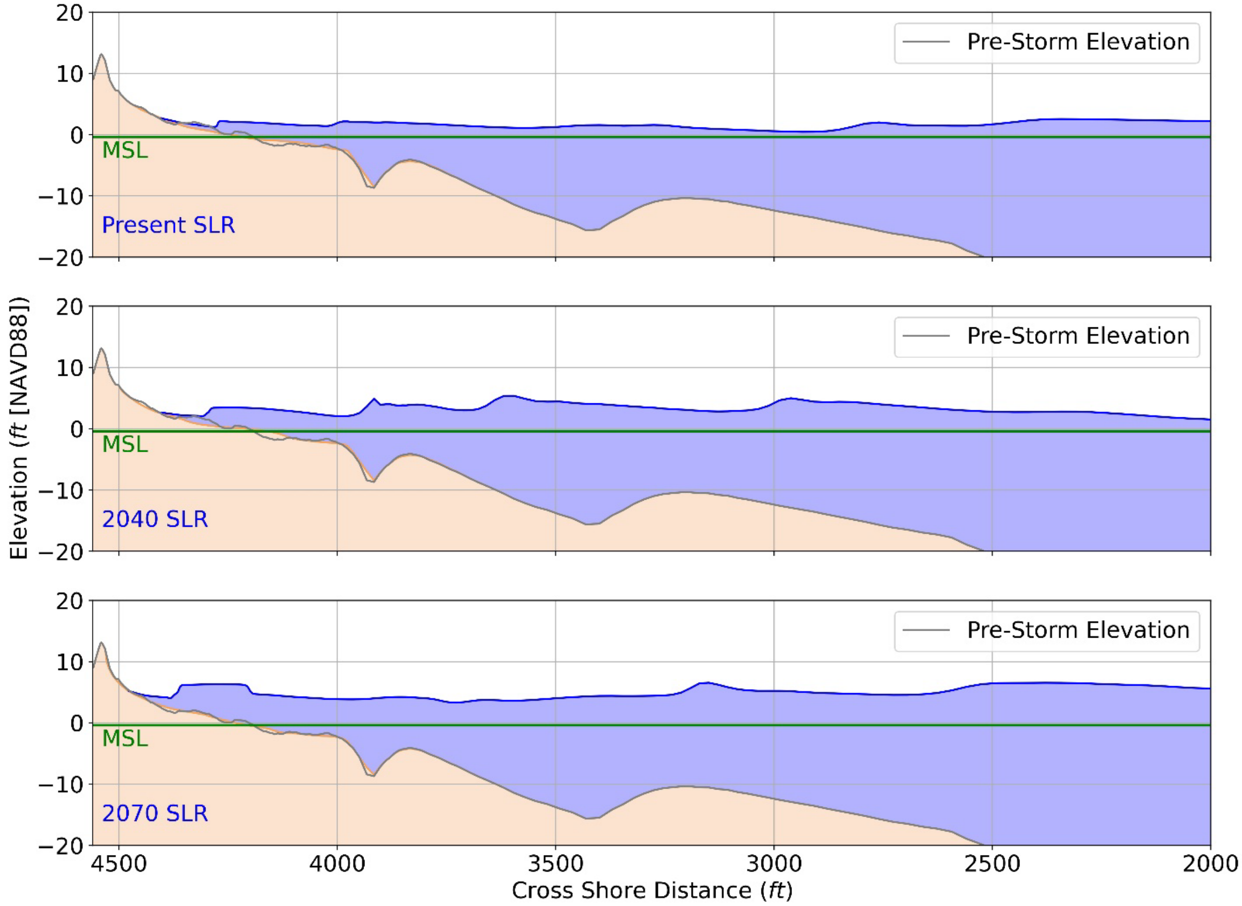

Figure 10-4-6-2.Predicted Shoreline Elevation for CBI-24 after 30 Hours of Exposure to a 10-Year Storm Event and Three SLR Scenarios

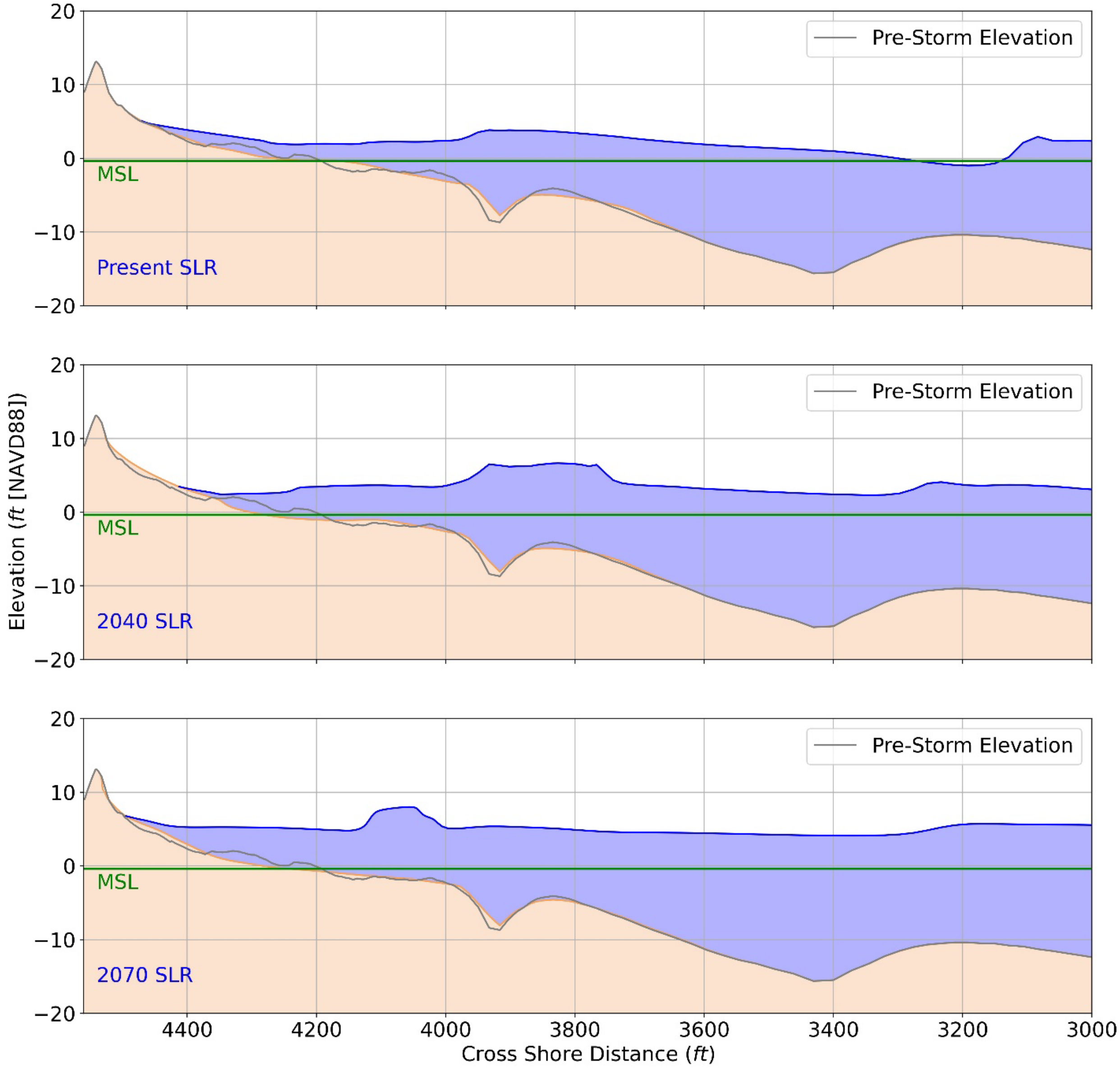

Figure 10-4-6-3.Predicted Shoreline Elevation for CBI-24 after 30 Hours of Exposure to a 100-Year Storm Event and Three SLR Scenarios

10.5 MODEL UNCERTAINTY

Model grid resolution and bathymetry interpolation lead to potential sources of model uncertainty. Modeled bathymetry within a grid cell, while reflective of the mean bathymetry measured using an echo sounder, might be shallower or deeper in certain regions of the cell, leading to enhanced sub-grid-scale erosion/deposition in nature that is not captured by the model.

In addition, uncertainties can arise when assigning values to the sediment bed properties. Sediment bed properties were defined uniformly and contain primarily sand. Variability of these properties within a profile can lead to variability in predicted erosion and accretion, and hence uncertainty in model predictions. The effect of this variability can be evaluated by undertaking sensitivity tests that vary the sediment bed composition during the selected storm events.

However, the net effect of these uncertainties on the short-term sediment transport along each of the profiles is assumed minimal relative to the predictions of erosion and accretion, and conform to the scope of this project. In addition, uniform sediment bed definition along the length of each profile is assumed based on limited data and may not be explicitly representative of erosion parameters in a specific area. Because the modeling represents acute storm events, the accuracy of predicted changes in bottom elevation is only qualitatively evaluated against the survey data in terms of the model's ability to predict overall patterns of coastal erosion and accretion potential.

Finally, there are uncertainties associated with the auto-derivation of metrics from the model-output profiles. PyBeach uses a code written in Python, and although typical methods were used to extract the dune crest, dune toe, and shoreline, the results can be impacted by the complex topography of the dunes along the selected SPI profiles. However, this method was used to extract the same metrics from the actual survey data, and we qualitatively checked the outputs and results.

10.6 SUMMARY OF FINDINGS OF FUTURE CONDITIONS MODELING

The coastal hazard analysis of six selected profiles along South Padre Island, Texas, identifies key areas of future concern for the beaches and dunes. The study identified predicted impacts of potential coastal change during storm events under future SLR along SPI.

There was a wide range of predicted changes for the selected profiles along SPI in response to the 2-, 10-, and 100-year wave events, and the present, 2040, and 2070 SLR scenarios. As shown in the tables and figures previously presented, most of the predicted beach width change, which is the change in distance between the shoreline and the dune toe, is due to changes in the shoreline position as opposed to changes in the dune toe position. In general, the predicted wave impacts for most of the 54 simulations are along the lower beachface, causing erosion or accretion at or near the shoreline, and the dune toe is not being eroded in most cases, with a wide beach configuration. The starting average beach width for the modeling was from the 2021 field survey and was 340 ft.

Beach width increases are primarily a function of progradation of the shoreline from either erosion of the foredunes or deposition of sediment from either cross-shore transport. During an actual storm event, beach sediment is commonly transported in both cross-shore and alongshore directions. However, the XBeach modeling applied in this study is 1-dimensional and cannot resolve alongshore transport. Two of the profiles representing the southern and central portions of SPI, CBI-06 and CBI-13, were predicted to have an increase in beach width during all storm and SLR scenarios, suggesting this portion of the island is more resilient than the northern portion, a finding corroborated in the historical profile and shoreline analysis. This is also supported in that the largest predicted retreat of the shoreline was found in CBI-24, the northernmost profile modeled for this analysis and predicted impacts to the foredune were also more common in the northerly profiles.

Overtopping of the foredune occurred along multiple profiles, primarily during the 2070 SLR scenario storms. However, only one profile in the northern portion of the study area (CBI-22) was predicted to have overtopping of the entire dune system.

The predicted maximum wave run-up values from the modeling support that maintaining a robust primary dune is essential for future resiliency; run-up values during the 100-year storm events with moderate (1.5 ft; ~2040) and high (3.5 ft; ~2070) SLR are approaching elevations in which dune overtopping may occur. The practice of lowering dunes that exceed 10 ft in elevation will exacerbate overtopping, leading to more erosion of the dunes and potential inland flooding. It is widely accepted in the coastal literature that wide beaches, and wide and high dunes, optimally mitigate inland flooding and help to maintain a robust recreational resource. The modeling shows that when there is a wide beach and dune system, the impacts from storms plus SLR may erode the beach, but help to prevent the dunes from severe impacts. Based on the future predicted wave run-up maximums, a primary dune height of ≥ 12.5 ft should be maintained for the most resilient configuration at SPI. The most resilient beach widths are at minimum 200 ft, although a greater width would provide more protection to the dunes. This resilient configuration is evaluated against competing community interests (e.g., viewsheds) in Section 11.

11 ADAPTATION FOR RESILIENCE

Sea level rise adaptation planning requires considering the causative hazards for each identified vulnerability and taking effective and timely action to alleviate the range of consequences. Good adaptation planning considers secondary impacts and examines how different adaptation measures could be used to alleviate vulnerability in one area, and interact with the other measures for other areas. An interwoven tapestry of adaptation measures is needed to develop a sustainable beach resiliency plan. Good adaptation planning is "collaborative" and considers the interconnected environmental, ecological, social, political, and economic systems, including adjacent jurisdictions.

SLR risks can be addressed by reducing vulnerability or exposure through the development of forward-thinking policies combined with the implementation of specific projects. Failure to implement forward-thinking approaches to adaptation will result in increasing maintenance costs. As not all issues can be addressed at once, it is important that responses to risks be prioritized and phased to maximize the use of the community's resources while avoiding costly emergency response where possible.

Strategies for addressing SLR hazards require proactive planning to balance the protection of coastal resources with physical development and recreational use. **No one category or specific adaptation strategy is considered the "best" option forever.** The effectiveness of different adaptation strategies varies across space and time with changing strategies able to accommodate various coastal hazards and elevations of sea level rise. The strategies considered as part of this project are focused on beach and dune maintenance, and enhancements and policy changes arising from the scope of the study.

Policy approaches such as altering ordinances on beach and dune management, and requiring SLR considerations in development permits can help educate community members and improve resilience. Specific early investments, particularly in policy changes, can avoid costly maintenance and potentially avoid legal claims in the future. Reviewing current City programs and policies associated with risk reduction is the first step to identifying potential short-term adjustments to alleviate or eliminate risks. Where adjustments to current practices will not sufficiently address the risks, more substantial actions should be identified and implemented.

Of utmost importance to the successful implementation of an adaptation strategy is communicating the issues and proposed response strategies to the community. Studies repeatedly show that knowledgeable and prepared communities with educated decision-makers who understand how to respond to extreme events will be far more resilient. An informed community is also more likely to support decisions and new programs reflecting its knowledge. All of these factors enable community members to contribute to developing a vision to face SLR and other climate change hazards.

11.1 ADAPTATION PATHWAYS APPROACH

Adaptation to coastal erosion and SLR along the SPI coast will require multiple approaches over time. Uncertainties in the timing of large storm waves occurring at high tides, the elevation of SLR in the future, and projected extents of future coastal erosion, require consideration of feasible adaptation strategies over both short- and long-term time scales with an adaptation pathways approach.

An adaptation pathway (Figure 11-1) helps visualize the sequences of possible adaptation responses through time in a stepwise manner. Each modification is designed to meet a certain performance level over a period of time, and once it reaches a threshold where the results are no longer acceptable, a transition to another strategy is required. Before this point is reached, planning should be undertaken to identify possible triggers and anticipate the lag times associated with outreach, permitting, design, and construction. Due to the uncertainty over future physical conditions, natural variability, and changing societal values, adaptation pathways should remain flexible.

The moment of an adaptation tipping point or trigger helps identify when a change in path is necessary; however, not all actions can be implemented at once. As a result, trigger points are used that are hindcast from a potential tipping point, providing lead time for permitting and other considerations. The following tipping points may be considered when laying out an adaptation pathway:

- **By SLR elevation (or rate of SLR)**—SPI is already vulnerable to hazards that may occur from tropical storms or winter cold fronts; however, SLR could increase the severity and impacts of these storms. By monitoring sea level from the nearest NOAA tide gauge at Brazos-Santiago Pass, triggers could be tied to an elevation change from present conditions over a 6-month period (to avoid seasonal signals) or a rate of SLR increase that would allow SPI to implement further actions in advance of projected SLR impacts.
- **By physical distance**—Through a monitoring program, routinely measure distances, especially following storm or erosion events, such as when the width of the beach or elevation of the primary dune decreases below a specified distance or height.
- **By storm exposure and frequency**—Monitor the frequency of exposure to wave action (e.g., how frequently are the foredunes in the northern portion of SPI eroded, or how often does a high scarp form on the lower beach?). To monitor the frequency of erosion, SPI could track and record erosion events and include the date, location, type, amount, and severity. This could be partially accomplished by implementing a citizen science program, which increases community engagement while preserving financial resources.

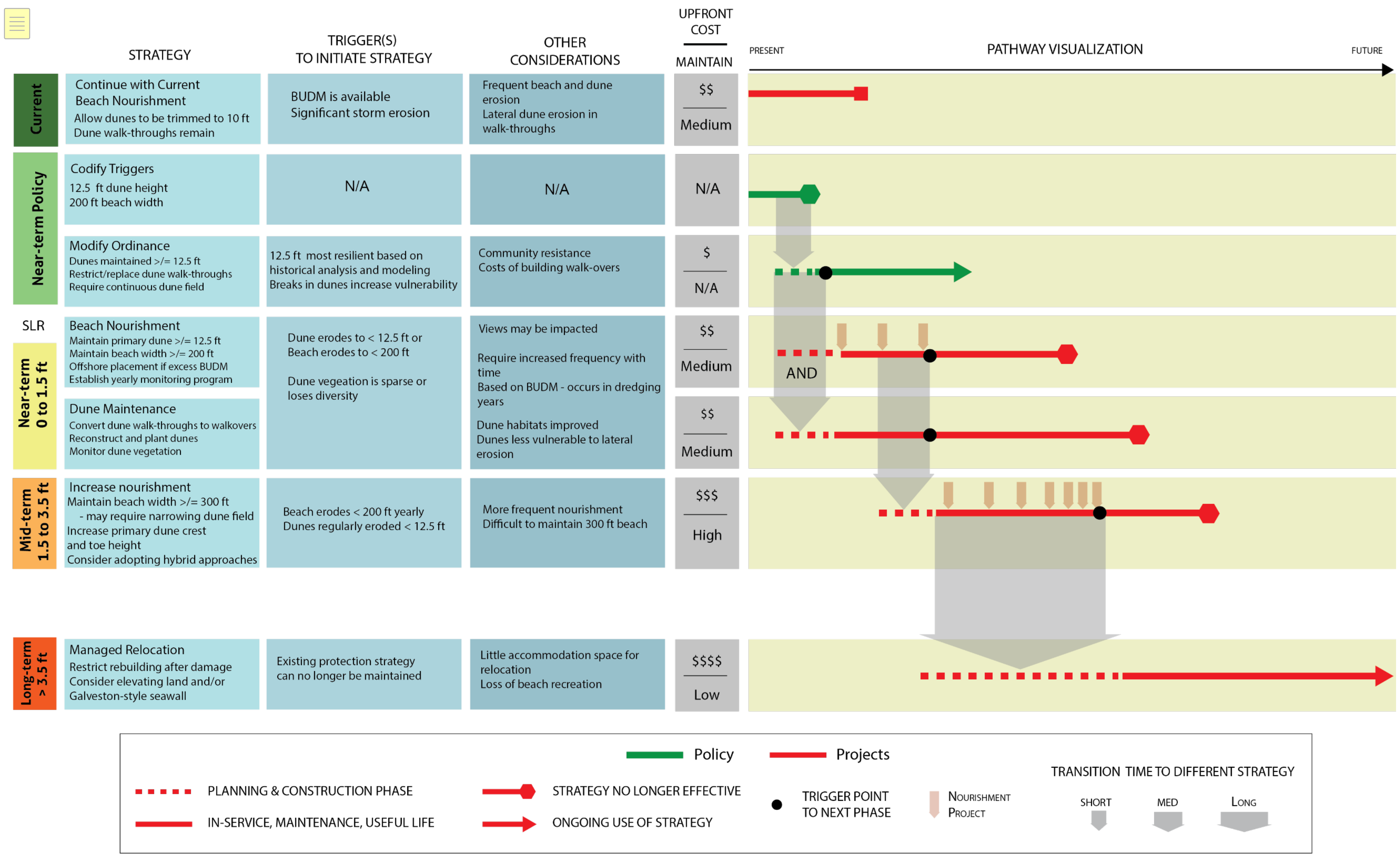

Figure 11-1. Adaptation Pathway for Beach and Dune Maintenance and Future Actions as Rising Sea Levels Require Changes in Actions for Adaptation.

Adaptation plans that utilize selected triggers in a robust manner are important for facilitating planning, which incorporates the inherent uncertainty and risk surrounding the effects of SLR and climate change hazards on coastal areas.

11.2 POLICY ADAPTATION

Policy-based adaptation strategies can be effective in the initial period of implementation to enact the necessary regulations for enhancing coastal resiliency. For instance, SPI's beaches and dunes are less resilient than ideal because of human activities, which include:

- Trimming the primary dune height to 10 ft when it exceeds that value through natural accretion
- Removing dunes completely to allow space for recreational and beach access use
- Having beach access pathways through the dunes, rather than over them.

Both the historical analysis (Phase 1 Report: Characterization of the Beach and Dune State) and the future modeling (Phase 2 Report: Modeling Future Conditions of the Beach and Dunes) indicate that dunes greater than 12.5 ft in elevation provide the most protection, especially if a wide beach is maintained. When storms or high water-level events occur, the up-rushing water can flow through the existing dune access walkthroughs, causing lateral erosion of the dunes, further compromising them. If the water flows to the base of the coastal infrastructure, it can begin to scour the dunes from the back and potentially cause damage to the structure(s) it encounters.

For the policy adaption pathway (Figure 11-1) the first step is to codify the required elevation of the dune and width of the beach that will define the triggers for a nourishment or restoration project. In the adaptation pathway for SPI, this is a first step, to be undertaken in the very near term. The next stage is to modify the existing ordinance to require dunes be maintained at an elevation of ≥12.5 ft, with a protective (and recreational) beach maintained at widths of ≥ 200 ft. These steps should be included in an updated shoreline management plan. It is also suggested that modified ordinances include replacing dune access walk-throughs with appropriately aligned walkovers, and consolidating the number of areas where dunes can be completely removed for recreation or access. This may require a campaign of educating the local community and property owners about the necessity of adapting and making changes to habitual ways of doing things in light of climate change induced SLR and increased storm intensities. Planning will be needed to determine how to fund or subsidize the conversion of walk-throughs to walkovers.

11.3 PHYSICAL ADAPTATION

Physical adaptation at SPI will continue to be in the form of soft protection—beach nourishment and dune maintenance—for the foreseeable future, dependent on drastic changes to SLR rates or other hazards, in which case other alternatives may have to be considered, such as hybrid strategies. Sand nourishment programs refer to efforts to maintain or increase the local sediment supply to widen beaches, repair dunes, increase coastal recreational opportunities, and mitigate coastal erosion. Sand nourishment programs tend to be cyclic and are often in the form of nourishment projects that place large volumes of sand to widen and elevate beaches. Longer-term sand management programs can be in the form offshore placement of sand to allow natural nearshore processes to redistribute the material, or localized placement to add sand at a specific location on a periodic basis. Such programs aim to create higher sand volumes, and improve coastal recreation and access, and resilience.

In addition to beach nourishment, dune restoration and maintenance, accompanied by a vegetation planting program is a nature-based strategy that includes the process of both restoring and assisting in the development of new coastal dunes, and may include beneficial placement of sand to form back-beach dunes where they are narrow or nonexistent. This can serve as a natural way to mitigate backshore erosion and maintain a wider beach. This process is suited for wider beaches and can be effective in slowing erosion.

SPI has had a long-term beach nourishment and dune maintenance program in place for several decades. The location benefits from its proximity to the Santiago-Brazos Pass, which is a navigational channel that requires regular dredging to maintain appropriate channel depth. The material is placed on the beaches and dunes at SPI as part of a Beneficial-Use Dredge Material (BUDM) program. Occasional dredging of the Mansfield Channel also makes available sand for use on SPI beaches.

11.4 THE RISK OF MAINTAINING THE STATUS QUO — "DO NOTHING" STRATEGY

One adaptation strategy is to do nothing, that is, continue with the current beach nourishment program, nourishing when sand is available from dredging of the pass (top of adaptation pathway in Figure 11-1). In the do-nothing case, the policy changes would not be implemented and the dunes would continue to have vulnerable elevations and walk-through access points. **Over the course of the next several decades, rising sea level elevations and increased storm activity will likely result in a severely eroded beach and dune system, with occasional damage to oceanfront infrastructure and the likelihood of flooding.**

11.5 ADAPTATION PATHWAY AND RECOMMENDATIONS

Figure 11-1 shows the implementation of a recommended shoreline management plan in the form of an adaption pathway, which also includes a dune maintenance plan. The Dune Maintenance Plan documentation is included as Appendix D in this report. Enforcing a new policy will require a beach and dune monitoring program to identify when the specified triggers have been exceeded. From the results of this study, triggers include the primary dune elevation falling below 12.5 ft and a beach width narrower than 200 ft. It is unlikely that the exceedance of a trigger in a single location would require an action, but rather, it should be viewed as a systemic state for the majority of the system.

There may be periods of relatively calm weather, when BUDM is available but the nourishment triggers have not been exceeded. In this case, an option would be to undertake an offshore sand placement as has been done in the past, allowing natural processes to redistribute the material along the island.

In the same period that the beach and dune system is being constructed and monitored as part of the shoreline management plan, dune walk-throughs are converted to dune walkovers, dunes that have been completely removed are reconstructed and planted, and the vegetation is monitored for coverage and diversity.

As seas continue to rise through time and SLR exceeds 1.5 ft and trends towards 3.5 ft, the rate of nourishment required to maintain a resilient beach and dunes will substantially increase. At some point in the future, with continued SLR and storms, it will become challenging or unrealistic to continue to rely on nourishment projects alone to mitigate flooding and storm damages at SPI, as the need for sand exceeds the availability of BUDM or other sediment sources. Knowing this as a likely future condition, planning for the next stage should begin relatively early in the process.

In order to fully understand current and future vulnerabilities to community assets and resources, it is recommended that SPI undertake a comprehensive vulnerability assessment. The assessment should include modeling to predict increasing vulnerabilities with future conditions, and to identify and place cost estimates on expected damages. This will better constrain the timing that the actions laid out in the adaptation pathway will need to be prepared for and implemented.

A vulnerability assessment should also include a more granular assessment of specific representative locations where walkways through the dunes exist or areas where the dune has been removed or repeatedly lowered to 10 ft, to further support that these activities decrease the resiliency of the system. This will provide another line of evidence to support the recommendations made herein and in the adaptation pathway.

The community will ultimately need to decide if it will attempt to fund and build a Galveston-style seawall as well as raise the elevation of the land with fill, and begin the process of managed relocation—moving oceanfront properties or not allowing those significantly damaged in storms to rebuild. An early and accurate assessment of individual property seawall elevations and coastal defenses currently in place, including an assessment of their efficacy and continuity, will be invaluable in evaluating present-day gaps in the existing hard infrastructure that may be the only line of defense in the event of dune failure, before other solutions have been implemented.

This study and adaptation plan are focused on examining the resilience of the beaches and dunes and making recommendations for managing them into the future. A full adaptation plan might include options for gray infrastructure that could be considered and could also include cost–benefit analyses of different options, as well as an examination of secondary impacts and trade-offs. However, these efforts are beyond the scope of the present study.

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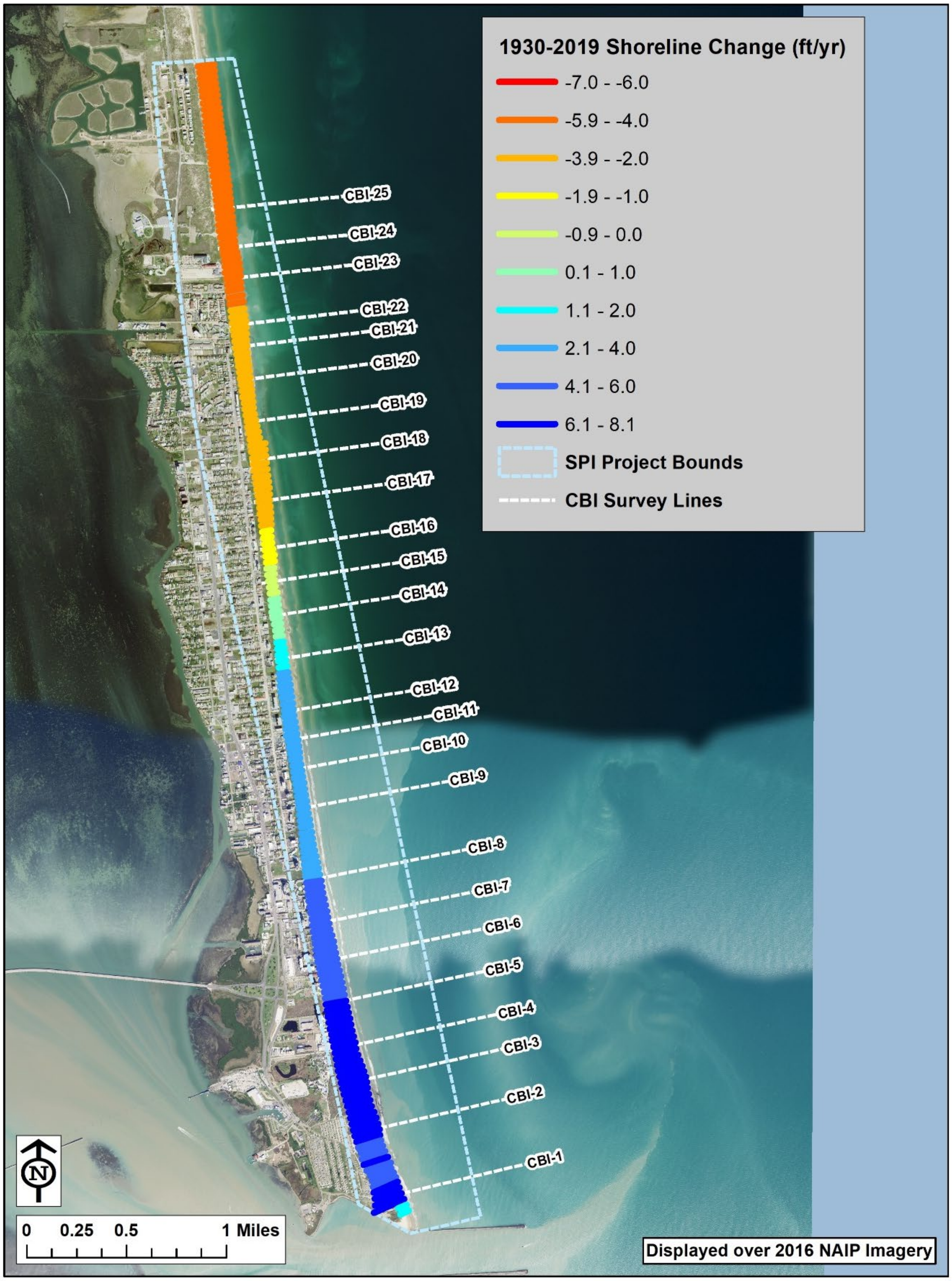
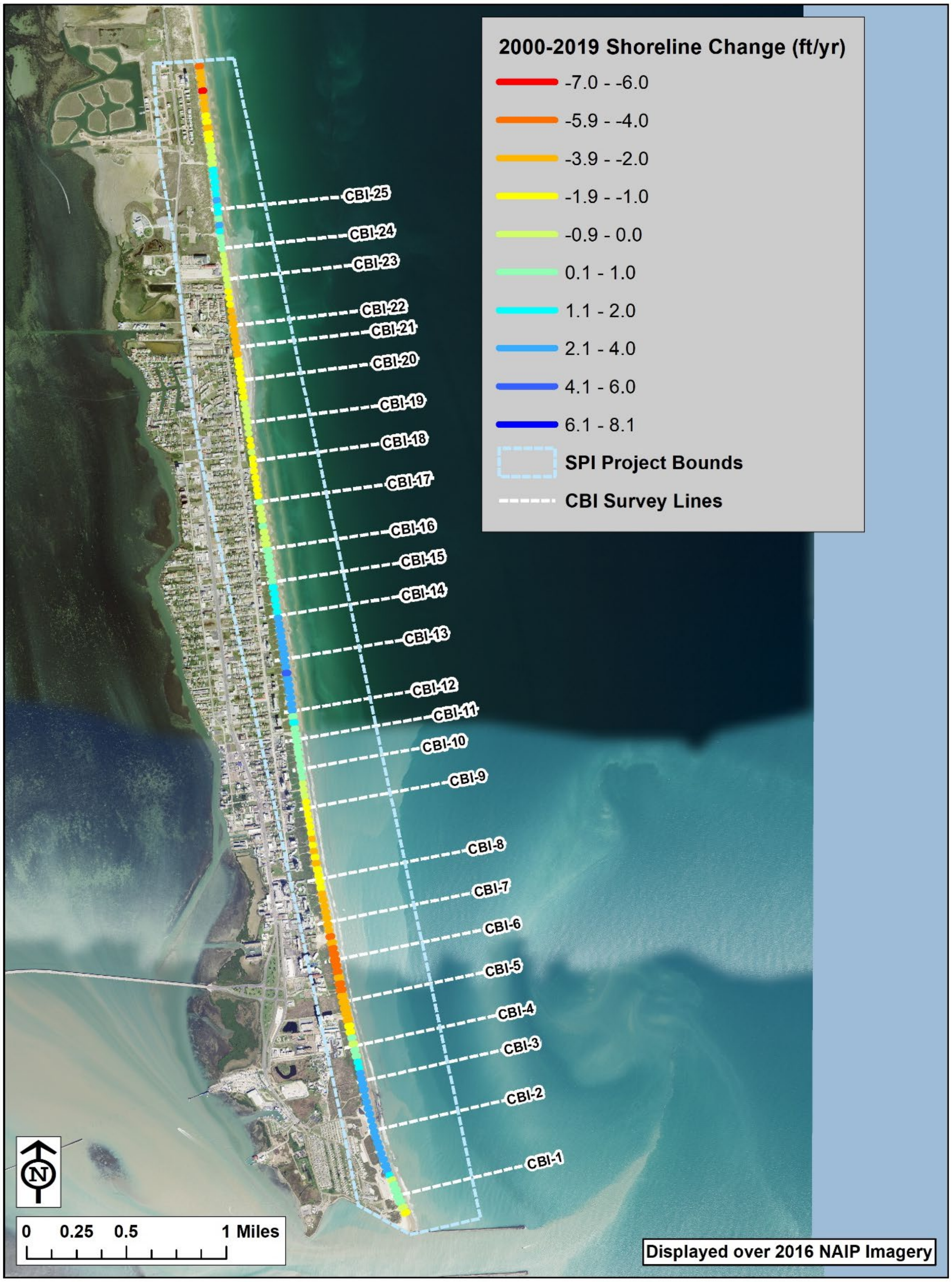
13 APPENDIX A: SHORELINE CHANGE MAPS



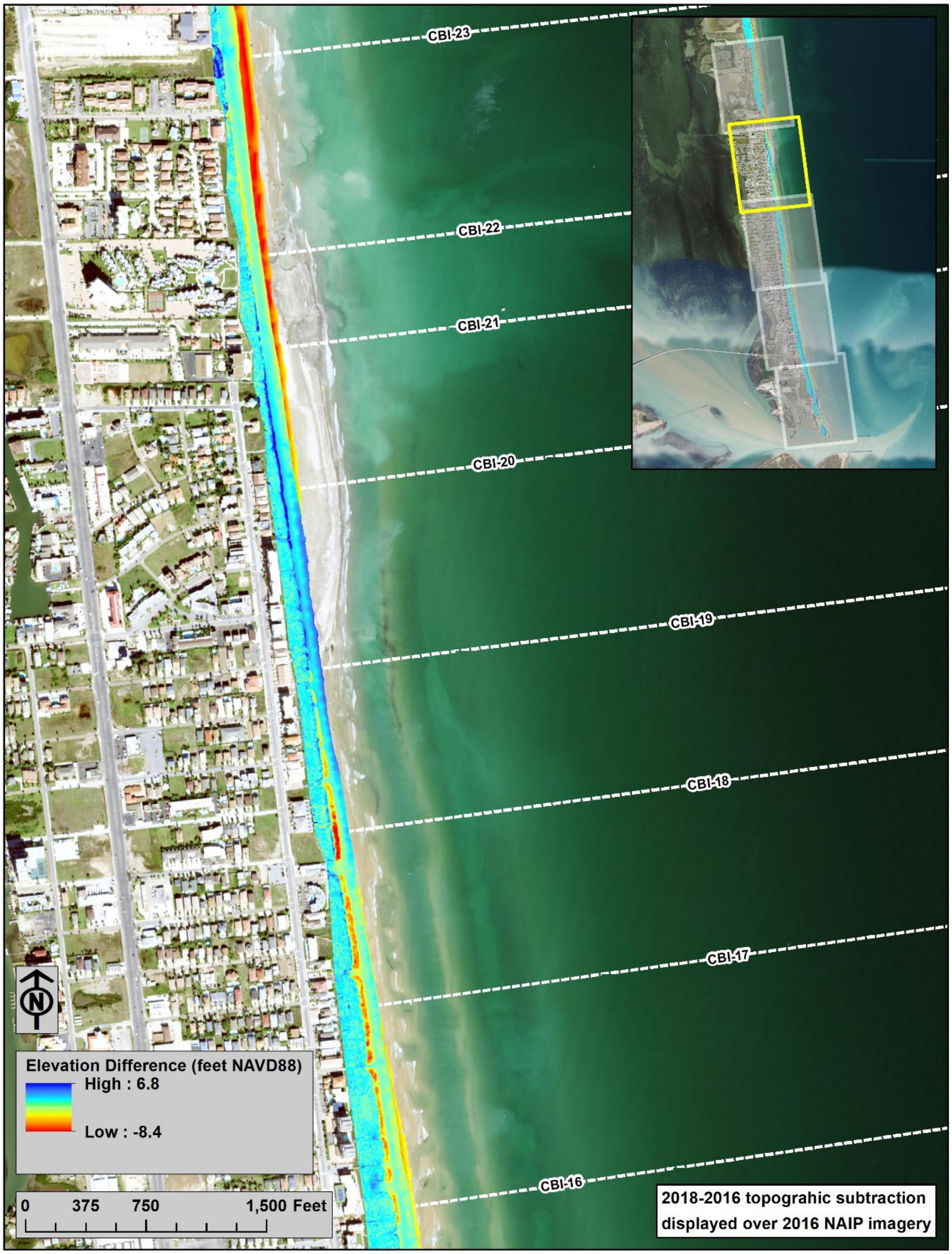
Shoreline change rates for the period from 1930 to 2019 using a linear regression analysis (ft/yr)



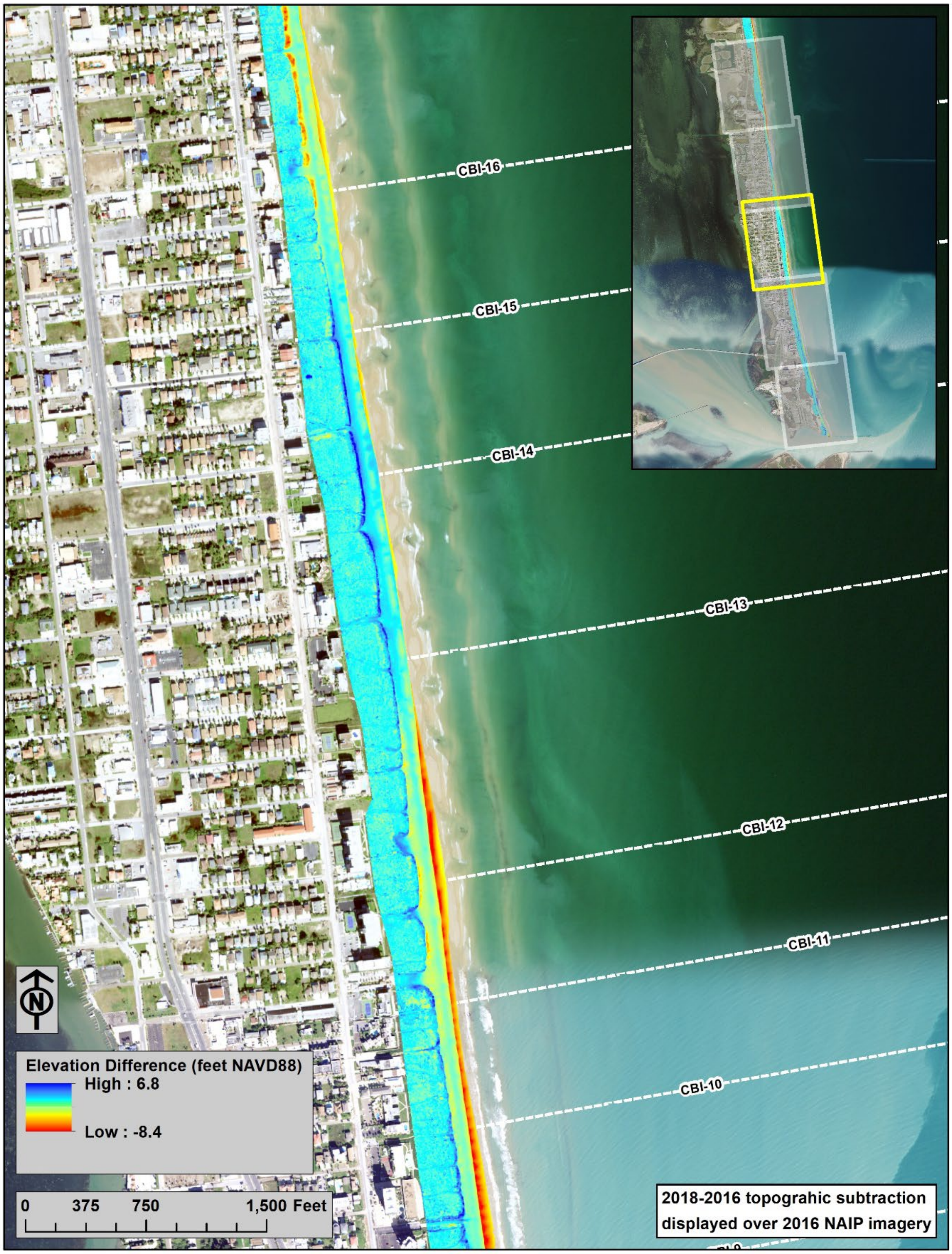
Shoreline change rates for the period from 2000 to 2019 using a linear regression analysis (ft/yr)

14 APPENDIX B: 3-DIMENSIONAL ELEVATION CHANGE MAPS

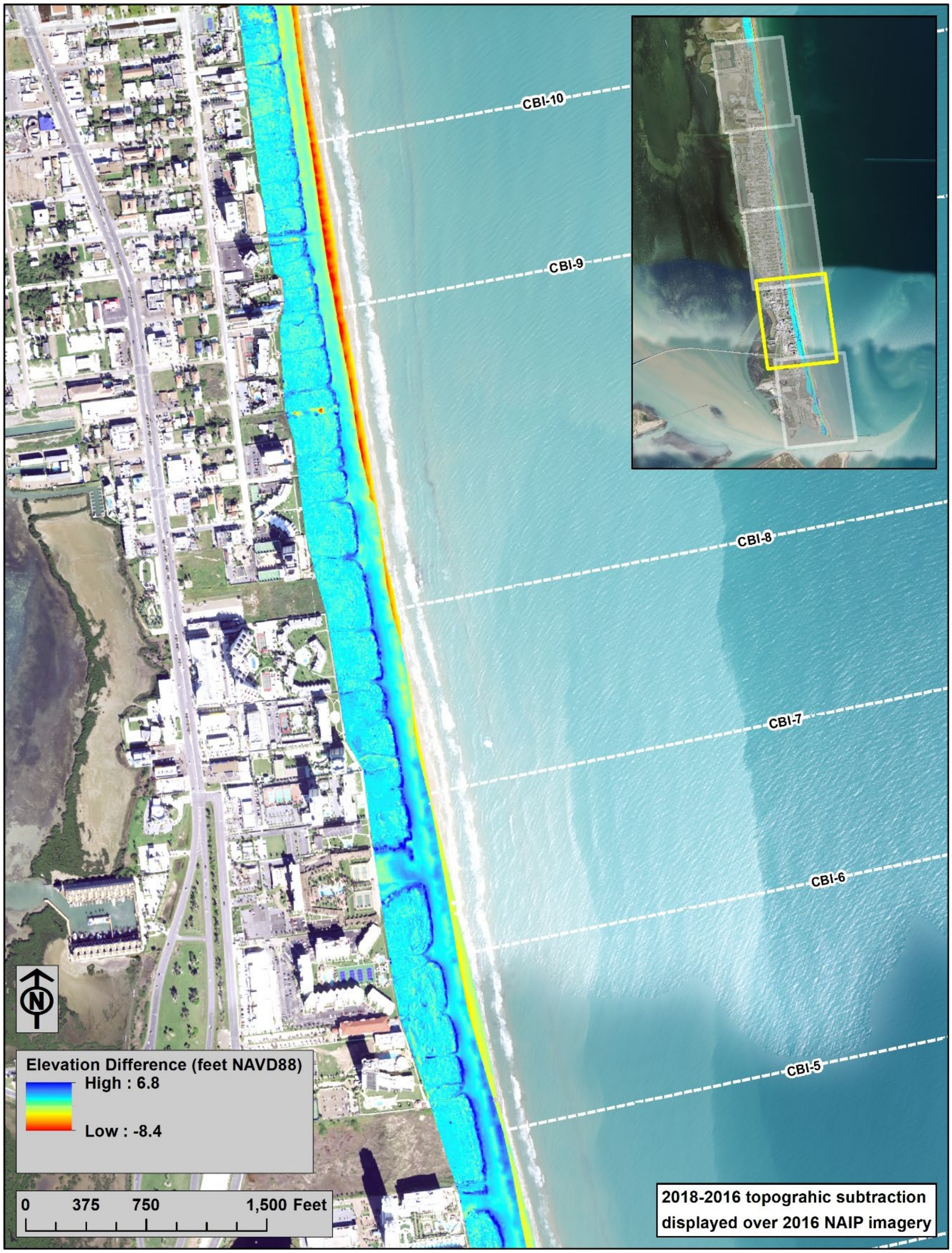
Elevation difference map for the northernmost section of SPI (see inset map).



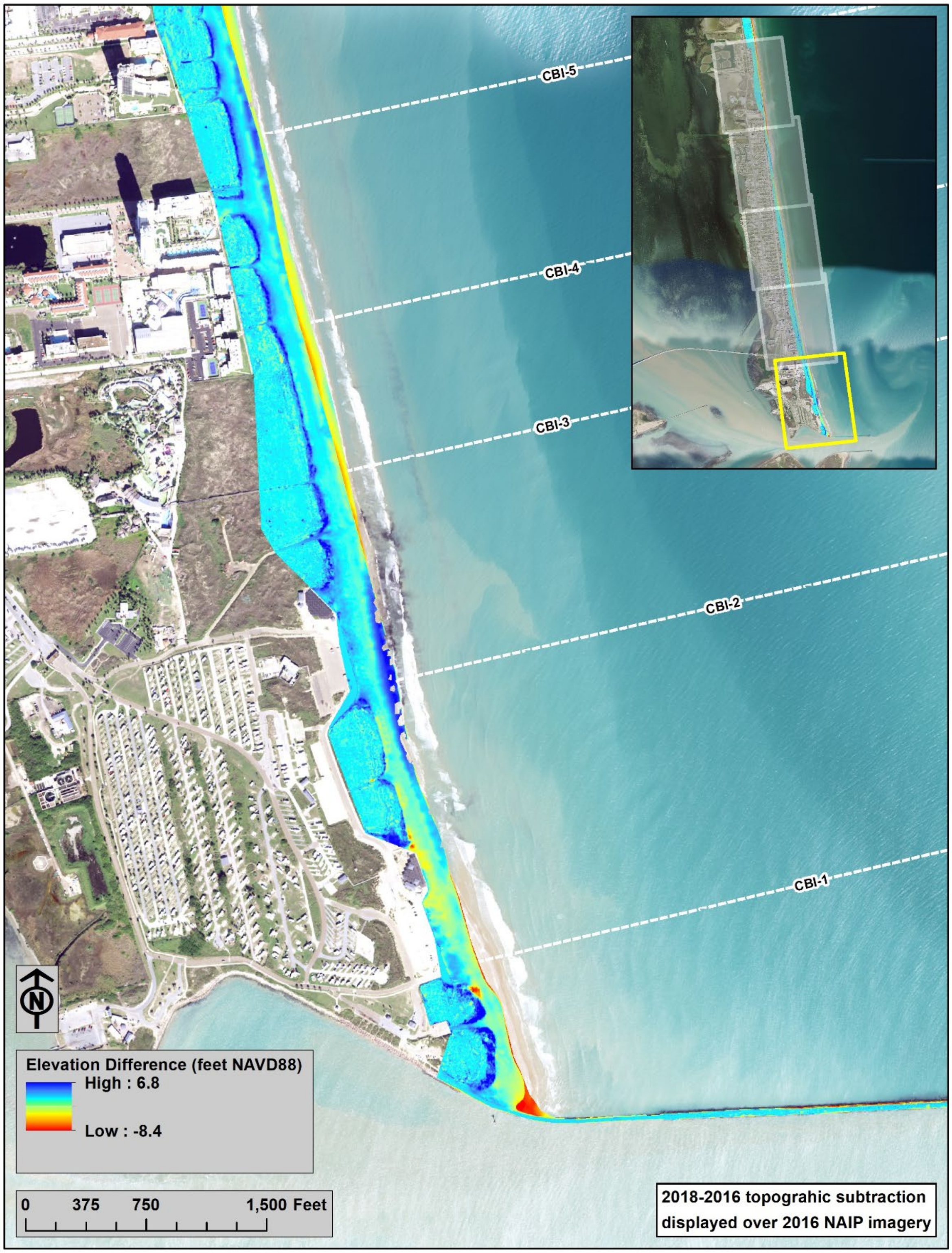
Elevation difference map for the north-central section of SPI (see inset map).



Elevation difference map for the central section of SPI (see inset map).



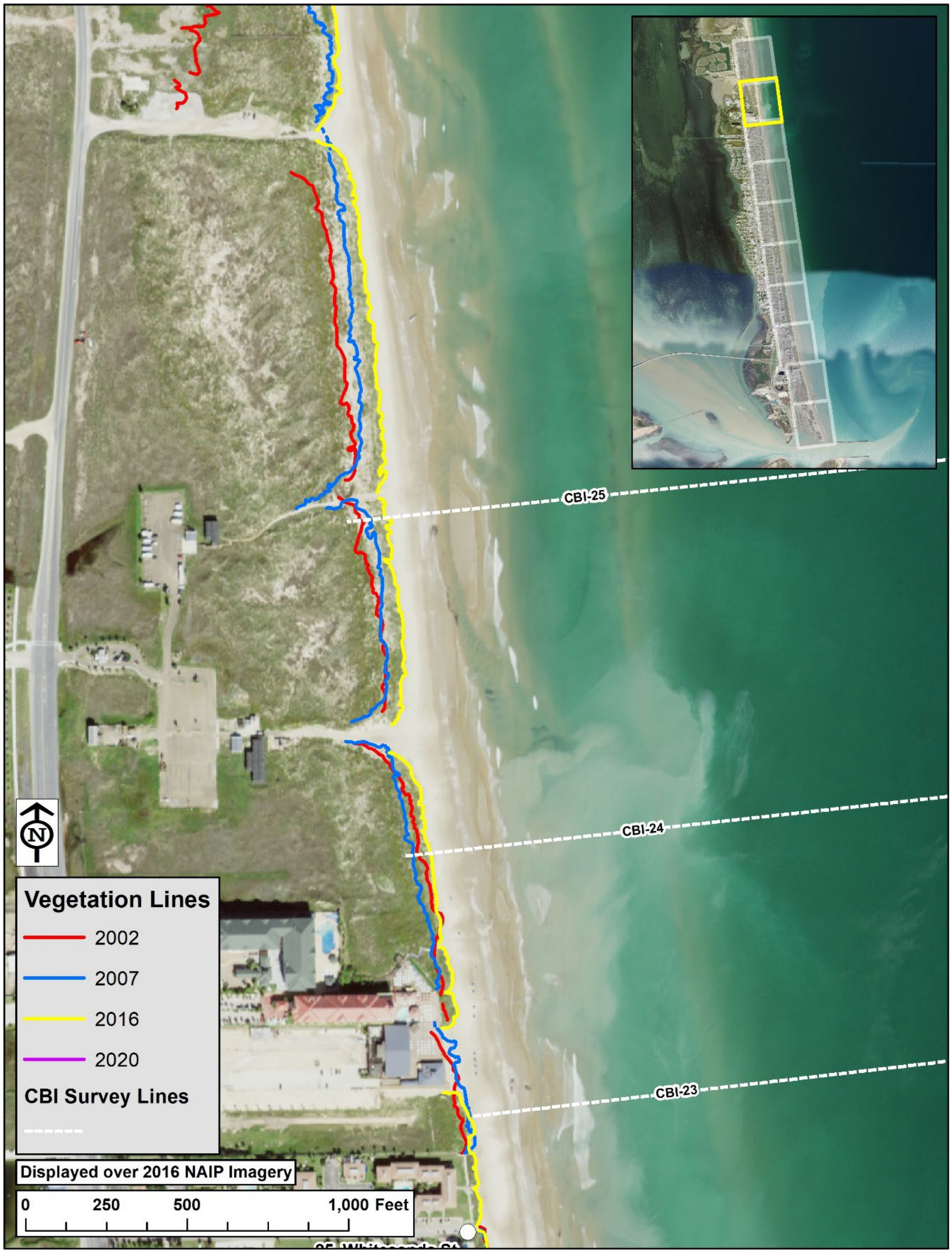
Elevation difference map for the south-central section of SPI (see inset map).



Elevation difference map for the south section of SPI (see inset map).

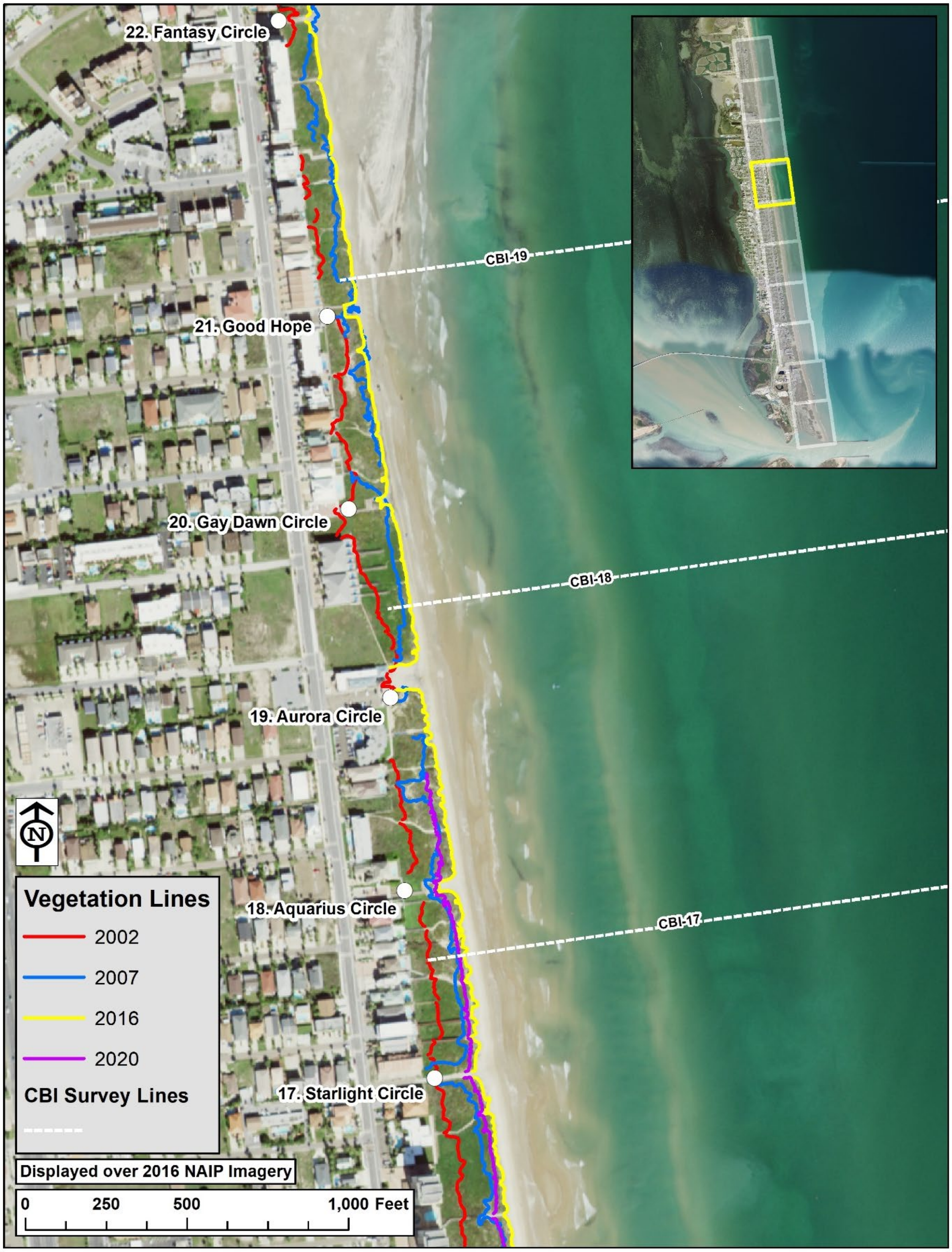
15 APPENDIX C: VEGETATION LINE MAPS

Vegetation line maps for the northern section of SPI shown in the inset map. The labeled numbers on the maps are public beach access locations.

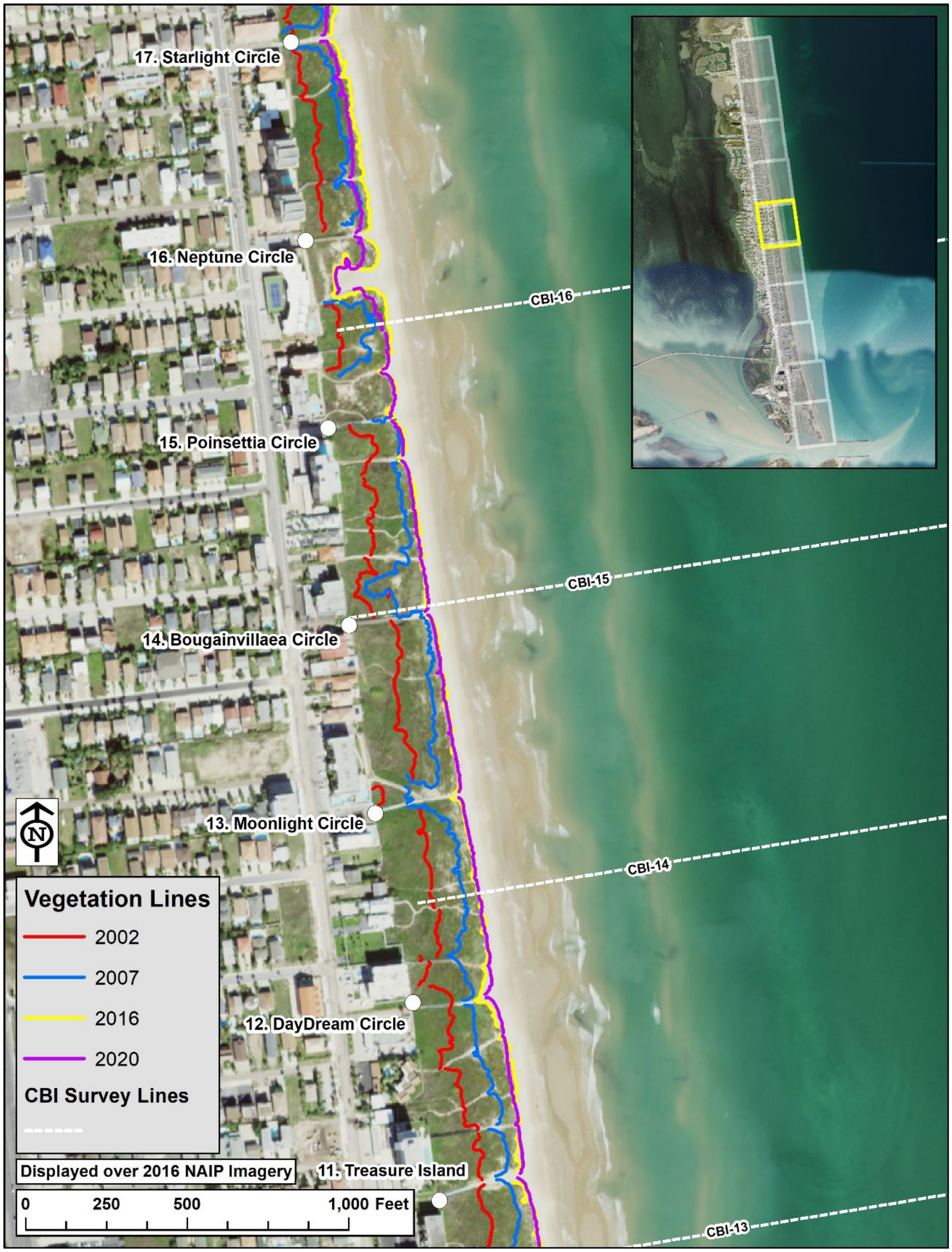


Vegetation line maps for a northern portion of SPI shown in the inset map. The labeled numbers on the maps are public beach access locations.

Vegetation line maps for a central portion of SPI shown in the inset map. The labeled numbers on the maps are public beach access locations.


22. Fantasy Circle
21. Good Hope
20. Gay Dawn Circle
19. Aurora Circle
18. Aquarius Circle
17. Starlight Circle
CBI-19
CBI-18
CBI-17
N
Vegetation Lines
2002
2007
2016
2020
CBI Survey Lines
Displayed over 2016 NAIP Imagery
0
250
500
1,000 Feet

Vegetation line maps for a central portion of SPI shown in the inset map. The labeled numbers on the maps are public beach access locations.



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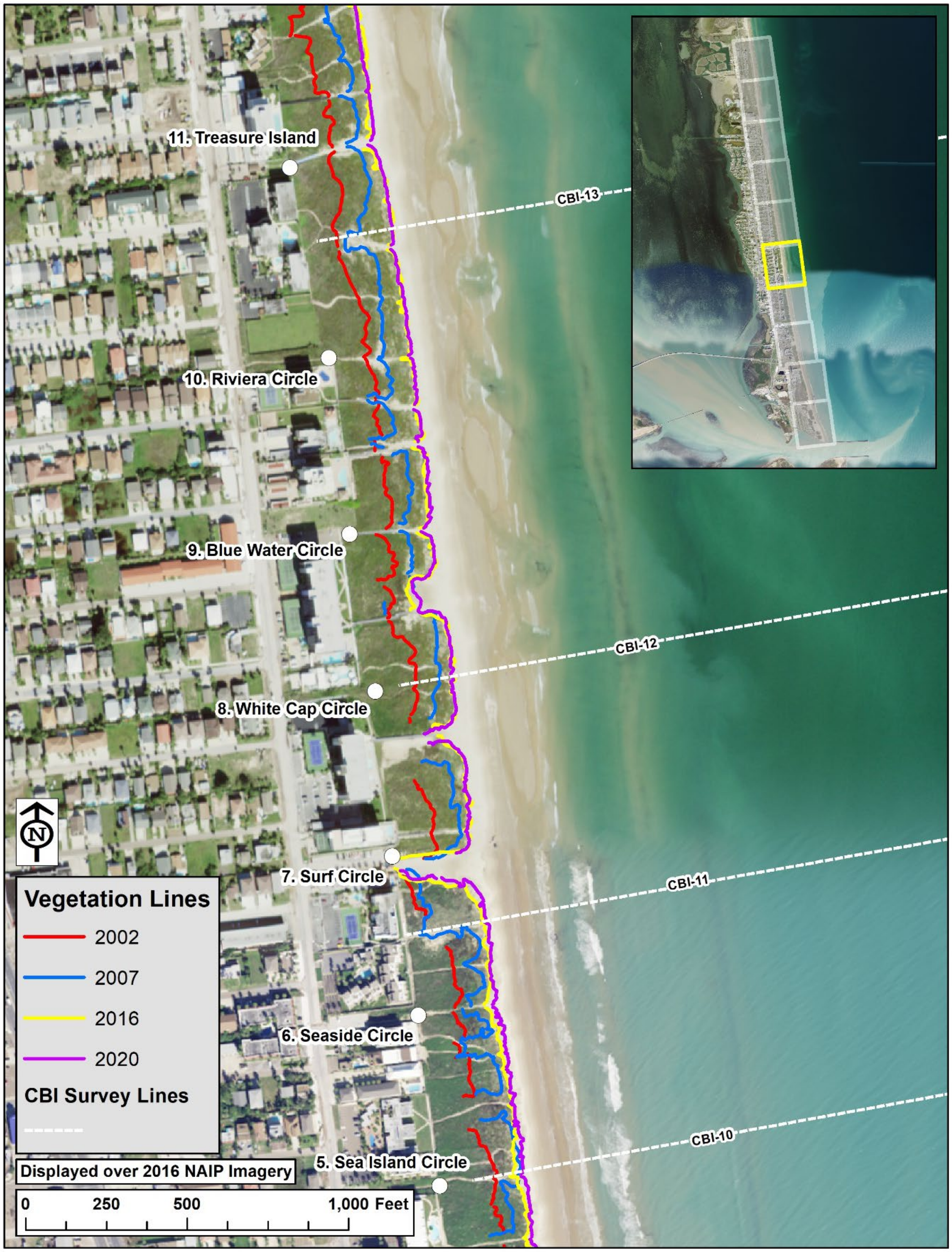

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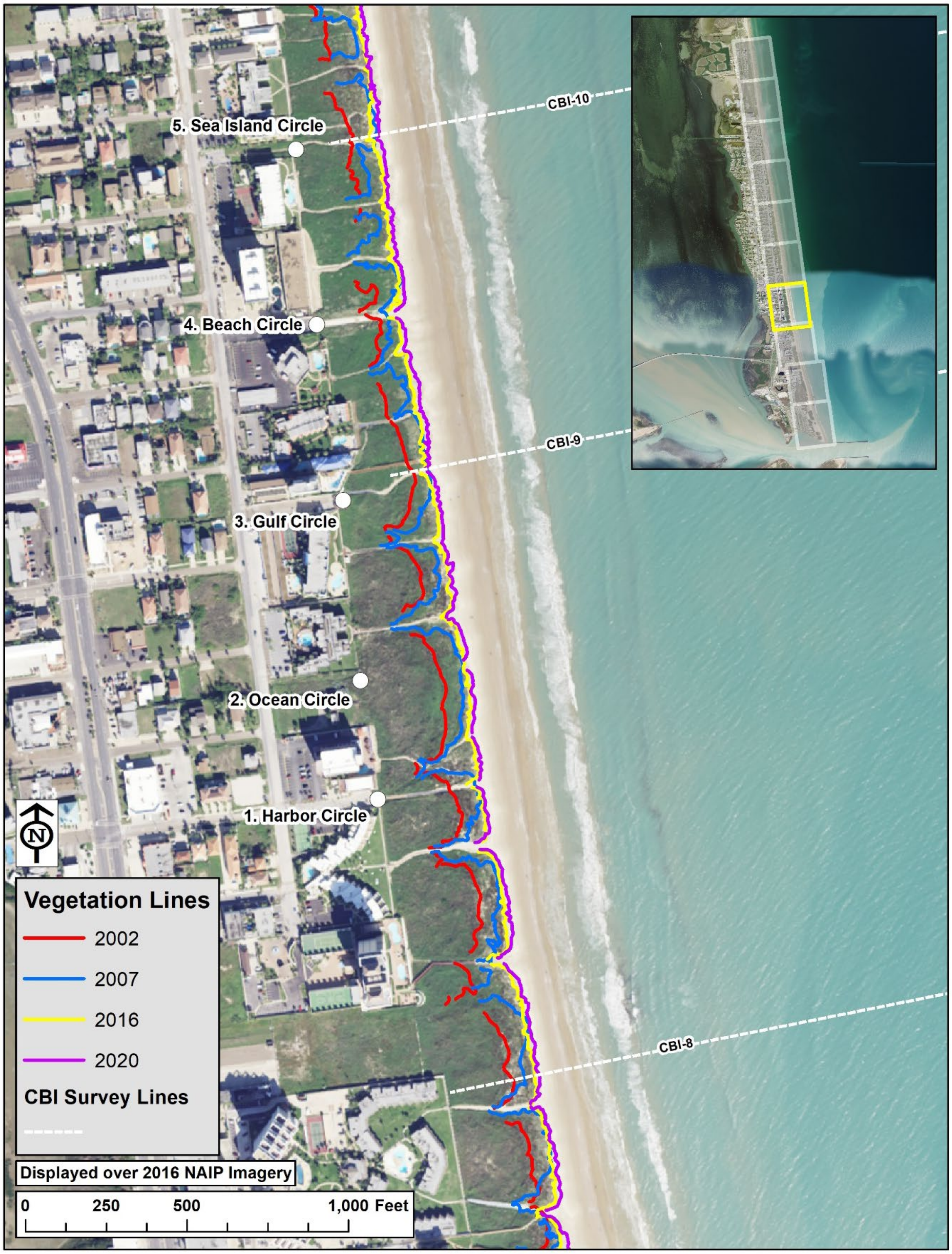
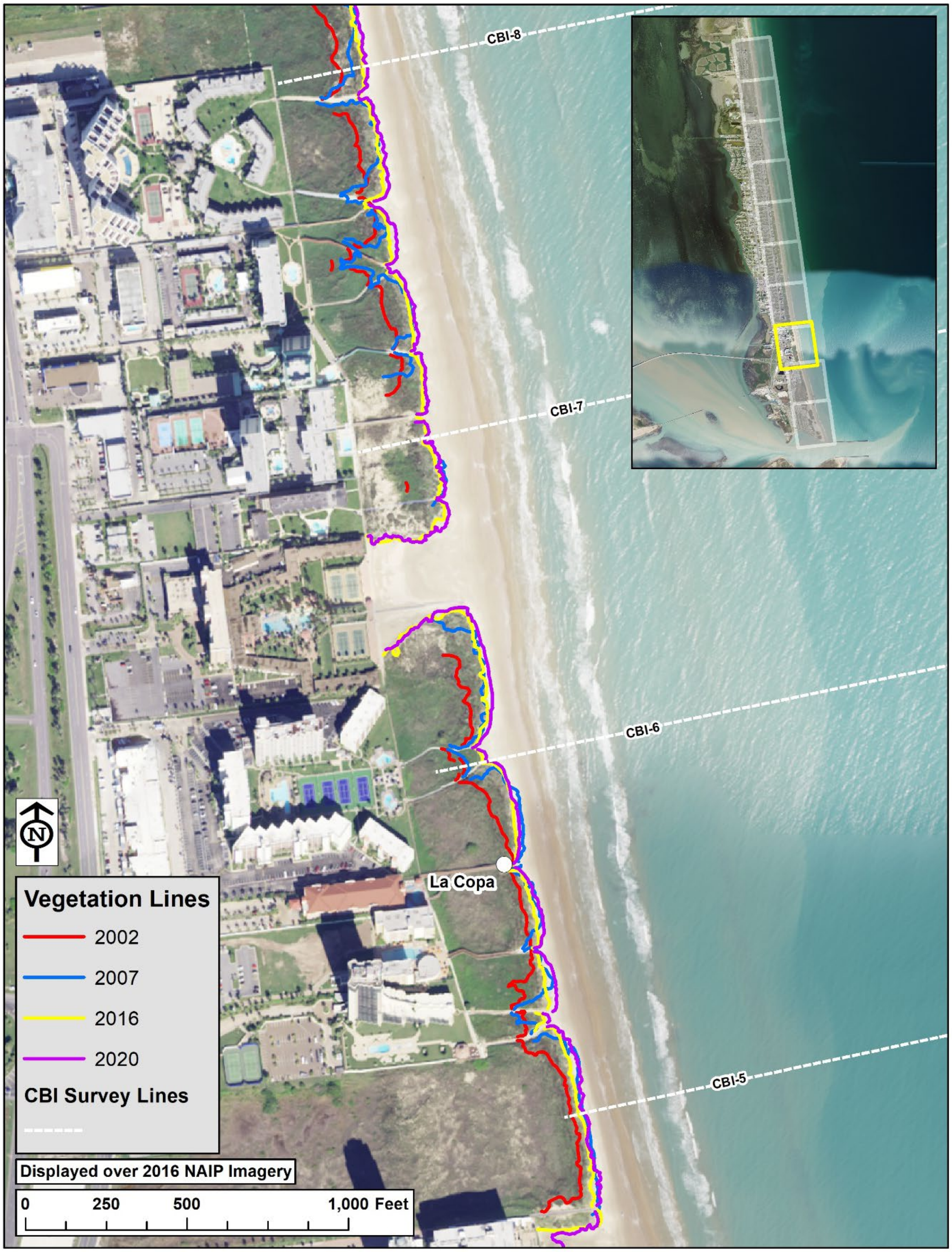
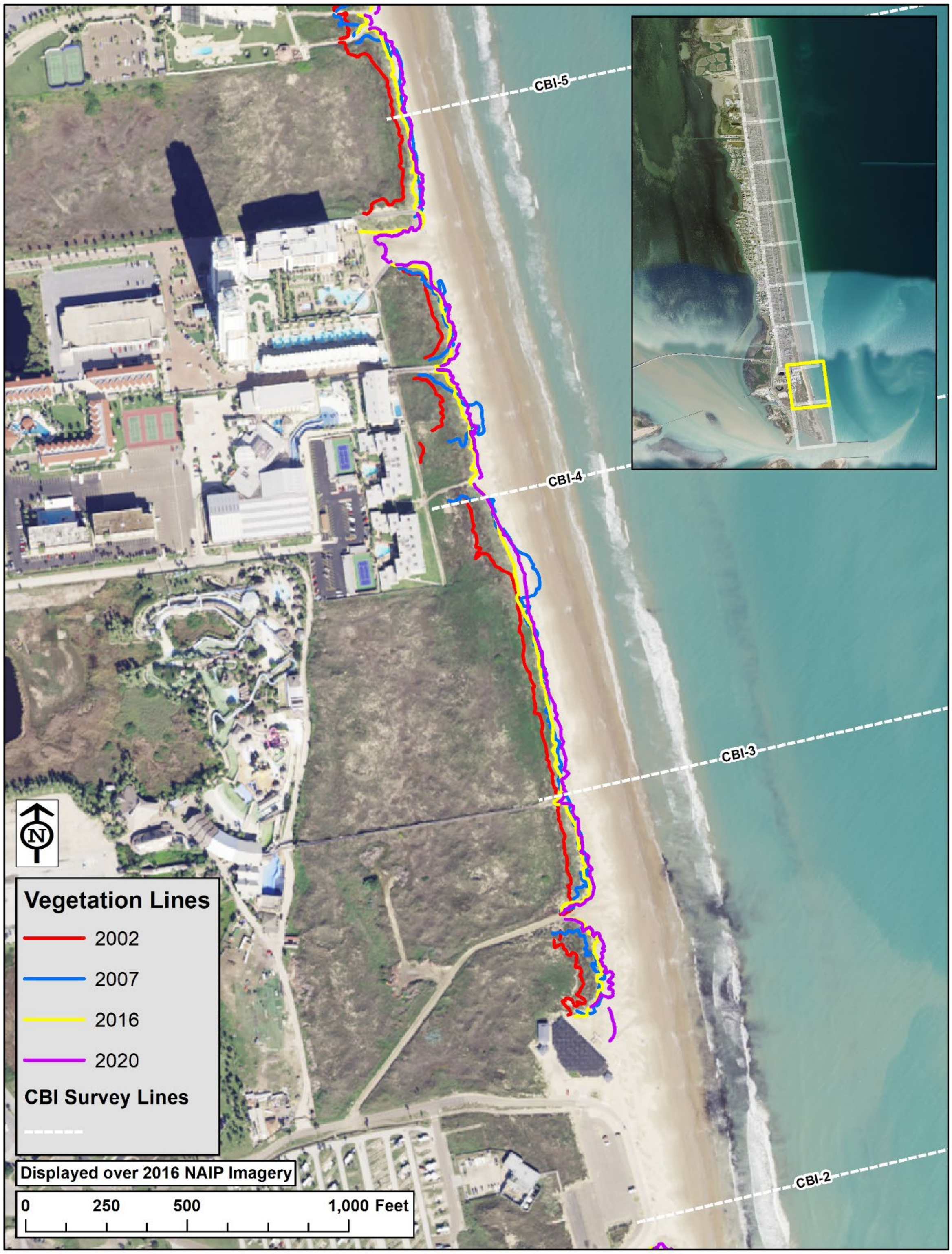


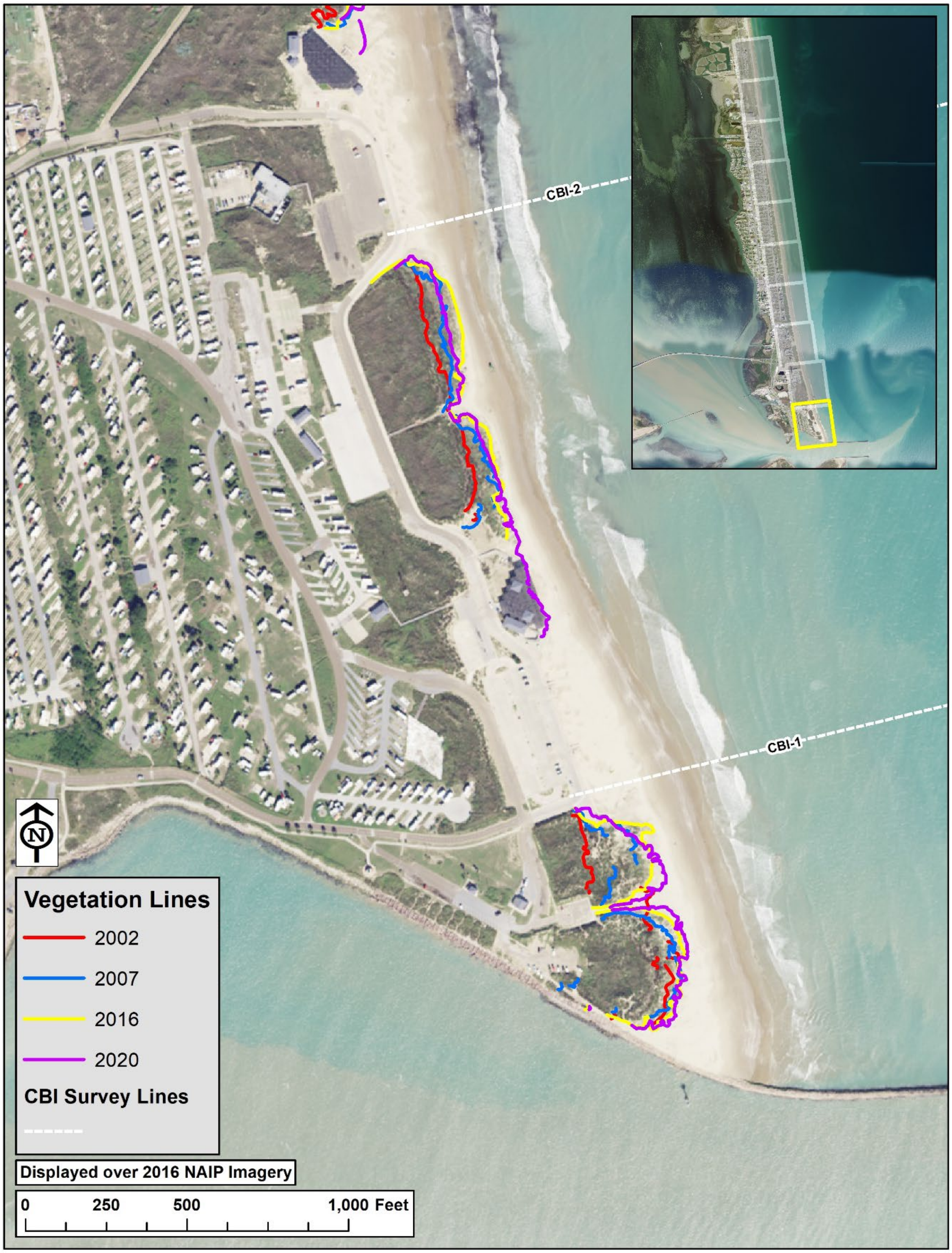
Vegetation line maps for a central portion of SPI shown in the inset map. The labeled numbers on the maps are public beach access locations.



Vegetation line maps for a south-central portion of SPI shown in the inset map. The labeled numbers on the maps are public beach access locations.



Vegetation line maps for a southern portion of SPI shown in the inset map.



Vegetation line maps for a southern portion of SPI shown in the inset map.

16 APPENDIX D: DUNE MAINTENANCE AND MANAGEMENT PLAN

Assessment and Investigation of the Beach and Dune Conditions at SPI

Dune Maintenance and Management Plan at SPI

Prepared for

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4601 Padre Boulevard
SPI, TX 78597

Integral Consulting, Inc.
ATTN: Cheryl Hapke, Senior Consultant
1790 Hughes Landing Blvd., Suite 400
The Woodlands, TX 77380

Prepared by:

BIO-WEST
1625 Cottonwood School Road
Rosenberg, Texas 77471

March 23, 2022

CONTENTS

LIST OF FIGURES

ACRONYMS AND ABBREVIATIONS

ADA	Americans with Disabilities Act
ADAPT	Adaptation Decision and Planning Tool
BLS	Building Setback Line
CCC	Texas Coastal Coordination Council
CEPRA	Coastal Erosion Planning and Response Act
CFR	Code of Federal Regulations
CMP	Texas Coastal Management Program
CWA	Clean Water Act
FEMA	Federal Emergency Management Agency
GLO	Texas General Land Office
Integral	Integral Consulting Inc.
LF	linear feet
LOV	line of vegetation
CMP	Texas Coastal Management Program
MHT	mean high tide
MLW	mean low water
MOCZM	Massachusetts Office of Coastal Zone Management
NOAA	National Oceanic and Atmospheric Administration
NRC	Texas Natural Resources Code
NRCS	U.S. Department of Agriculture - Natural Resources Conservation Service
PVC	polyvinyl chloride
PWC	Parks and Wildlife Code
RGL	Regulatory Guidance Letter
RHA	Rivers and Harbors Act
SLR	sea level rise
SPI	SPI
the City	the City of SPI
the Plan	Dune Maintenance and Management Plan
U.S.C.	United States Code
USACE	U.S. Army Corps of Engineers
USEPA	U.S. Environmental Protection Agency
USFWS	U.S. Fish and Wildlife Service

1. EXECUTIVE SUMMARY

South Padre Island (SPI) is a narrow, low-lying, naturally occurring barrier island along the south Texas coastline that is frequently impacted by erosive winter storm events and infrequent but extremely damaging major hurricanes. As a resilient natural barrier to the destructive forces of wind and waves, the coastal sand dune and swales ecosystems of SPI are a valuable and effective defense against storm-surge flooding and beach erosion. Dunes absorb the impact of storm surge and high waves, preventing or delaying intrusion of waters into inland areas well as retaining sand that replaces eroded beaches after storms in a dynamic cycle. This positive feedback loop can be strengthened by increasing the height and stability of existing dunes, repairing washouts and erosional areas, and reestablishing native vegetation. Beach and dune restoration and protection is important along the Texas Gulf Coast, particularly in areas experiencing shoreline erosion and concentrated urban development.

Integral Consulting Inc. (Integral) was awarded a contract with the City of SPI (the City) in 2020 to assess and investigate the beach and dune conditions along the SPI shoreline. The project is being undertaken in four phases following an Integral-developed and managed framework called Coastal ADAPT (Adaptation Decision and Planning Tool) that uses a variety of modeling approaches to examine adaptation options for increasing resiliency to coastal hazards and sea level rise (SLR)-related climate change risks. Under this contract, Integral contracted with BIO-WEST, Inc. (BIO-WEST) to draft a Dune Maintenance and Management Plan (the Plan) that analyzes the current beach-dune ecosystem, morphology, and trends with respect to storm events and human activities; compares these datasets with potential modeling outcomes of future response to SLR, winter storm events and major hurricanes; and produces a framework for use by the City and local stakeholders.

The primary purpose of this Plan is to develop a set of guidelines and rules that will assist the SPI community in developing and maintaining a stable, ecologically functional dune system appropriate for the south Texas coast that reduces maintenance costs, alleviates public safety concerns, and benefits the aesthetic and culture of SPI. Additionally, this Plan is designed to provide background information on the unique coastal ecosystems of the south Texas coast, their functions and services, and how they can mitigate the impacts of coastal storms, as well as to enable users to make informed decisions on coastal resilience by incorporating beach and dune dynamics with suitable plantings, proper structures, and define processes.

This Plan is comprised of four sections. The first section provides a brief regulatory, permitting, and coordination framework to follow, while the second section discusses the basic information associated with dune establishment, repair, and restoration, highlighting erosion repairs activities planting, fencing, and other important considerations related to dune construction. The third section focuses on management techniques and access issues to protect newly restored areas and the fourth section concludes with a brief summary and potential recommendations.

17REGULATORY REVIEW AND FRAMEWORK

17.1 FEDERAL GUIDELINES

Wetlands and waterbodies are the primary regulatory nexus related to coastal dune ecology. Several major federal laws govern filling and dredging of these areas, including Section 404 of the Clean Water Act (CWA; 33 United States Code [U.S.C.] 1344) and Section 10 of the Rivers and Harbors Act (RHA; 33 U.S.C 403). Between 1987 and the present, multiple federal agencies including the U.S. Army Corps of Engineers (USACE), the U.S. Fish and Wildlife Service (USFWS), the U.S. Environmental Protection Agency (USEPA), and the U.S. Department of Agriculture Natural Resources Conservation Service (NRCS) drafted guidance related to discharge of fill material into wetland and waters, including the 1987 USACE Wetlands Delineation Manual, Regional Supplements to the USACE Wetlands Delineation Manual, and Regulatory Guidance Letters (RGLs). Figure 1 below provides an illustrative view of USACE and USEPA jurisdiction.

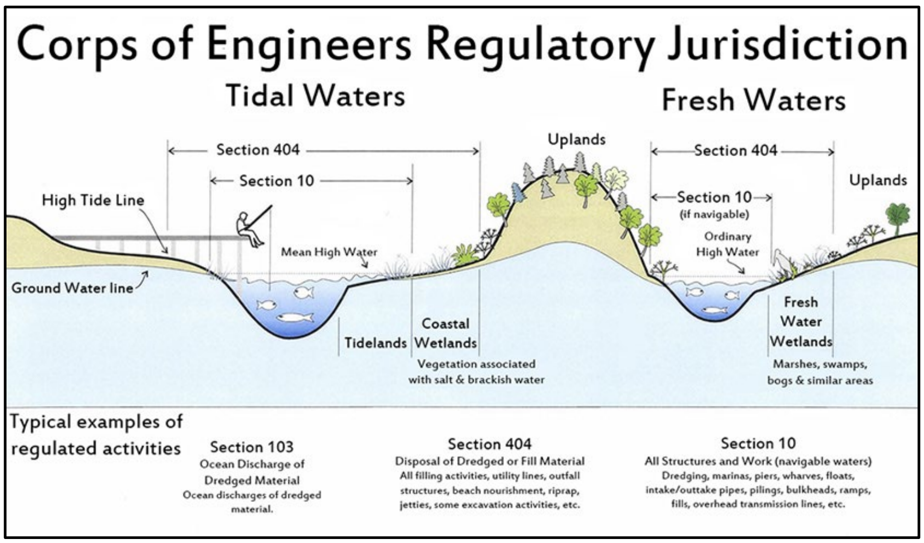

Figure 1: Graphical Depiction of USACE/USEPA Jurisdiction (USACE, 2022)

In almost all cases, the USEPA and USACE are the primary governing agencies that issue federal permits for activities in coastal dune systems. Questions regarding jurisdictional wetlands and waterbodies in Texas and procedures for obtaining proper permits should be directed to the City and/or to the USACE - Galveston District.

In addition to wetlands and waterbodies, the Federal Emergency Management Agency (FEMA) classifies all foredunes and many surrounding areas as coastal high-hazard areas or high-velocity zones (V-zones). A V-zone is defined by FEMA as:

> *Areas along coasts subject to inundation by the 1-percent-annual-chance flood event with additional hazards associated with storm-induced waves. Because detailed hydraulic analyses have not been performed, no Base Flood Elevations (BFEs) or flood depths are shown. Mandatory flood insurance purchase requirements and floodplain management standards apply.* (44 Code of Federal Regulation [CFR] §64.3)

Figure 2 and Figure 3 below provide a basic understanding of the various hazards and issues associated with coastal development.

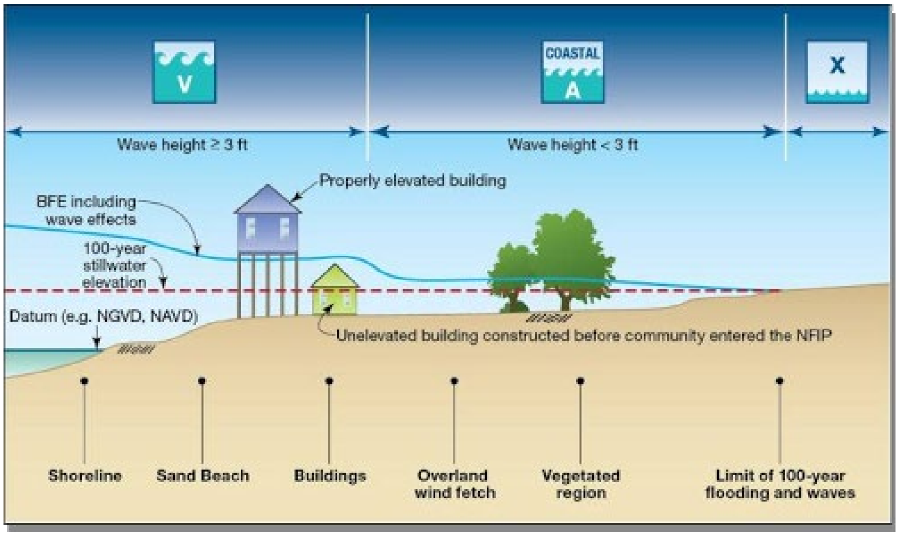

Figure 2: FEMA Depiction of Coastal High Hazard Areas

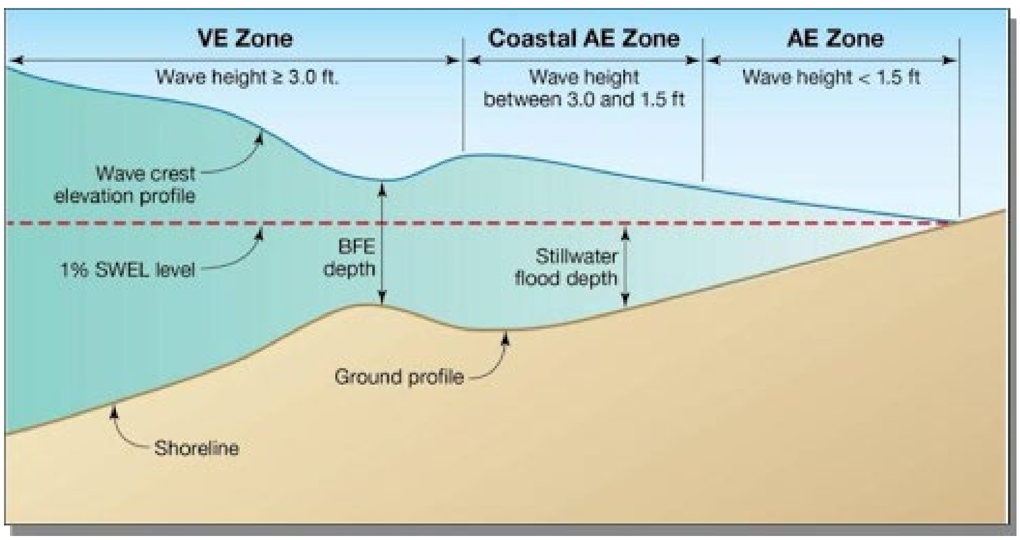

Figure 3: FEMA Depiction of Coastal Hazard Zones

FEMA has issued construction standards within V-zones (44 CFR §60.3) and also prohibits "any human-caused alterations of sand dunes which could increase potential flood damage." For more information concerning V-zones, and to obtain flood maps, contact a FEMA representative or the Cameron County Office of Emergency Management.

17.2 STATE AND LOCAL GUIDELINES

The Open Beaches Act (Texas Natural Resources Code [NRC] Chapter 61), passed by the Texas Legislature in 1959 and amended in 1991, states that the public "*shall have the free and unrestricted right of ingress and egress to and from the state-owned beaches bordering on the seaward shore of the Gulf of Mexico...extending from the line of mean low tide to the line of* *vegetation bordering on the Gulf of Mexico*." The act makes it unlawful to declare a beach closed to the public or otherwise prevent or obstruct access to or use of the public beach, by either erecting barriers, posting signs, etc. As the state governing agency, the Texas General Land Office (GLO) is required to protect the public beach from adverse effects on public access and critical dune areas by regulating beachfront construction and other activities occurring along the shoreline of the Gulf of Mexico. The GLO has an experienced and knowledge staff that can help determine if any violations to the Open Beaches Act have occurred as well as assist with dune re-vegetation, restoration, establishment, and walkover projects.

The Dune Protection Act (NRC Sections 63.001 through 63.181), passed by the Texas Legislature in 1973 and amended in 1991, required the Cameron County Commissioners Court to establish a dune protection line on the Gulf shoreline. This requirement also applied to mainland shoreline that fronts the open Gulf as well as to the Gulf shoreline of islands and peninsulas. Cameron County accomplished this task in 1994 through the Cameron County Dune Protection and Beach Access Plan (last amendment December 11, 2018; Cameron County, 2018). As of the 2018 amended version, Cameron County has established a Building Setback Line (BLS) of 230 linear feet (LF) landward from the line of vegetation (LOV). In addition, as part of this countywide Plan, Cameron County delegated the authority to the City of SPI to develop and implement its own dune protection program within the City's corporate municipal limits only.

The Texas Coastal Management Program (CMP), funded mainly by the National Oceanic and Atmospheric Administration (NOAA) and managed by the Texas Land Commissioner, focuses on the state's coastal natural resource areas and ensures the continued focus on the state's environmental and economic functions and values. The primary directive of the CMP is to review federal actions, activities, projects, and/or applications for federal assistance to ensure their consistency with the current directives, goals, and policies of the CMP. CMP guidelines allow the Texas Coastal Coordination Council (CCC) to review coastal projects for consistency. The CCC may review local statutes related to dune restoration and walkovers, beachfront construction certificates, dune protection permits, and dune protection and beach access plans as well as applications for federal assistance for programs outside of the CMP.

In 1999, the Texas Legislature passed the Coastal Erosion Planning and Response Act (CEPRA) to provide funding to coastal communities for projects that mitigate, slow, or other offset the effects of coastal and shoreline erosion. According to NRC §33.603(e), beach nourishment projects require at least 25 percent match funding while other coastal erosion response studies or projects require at least 40 percent match funding, and under this structure, CEPRA is entering its 12th, two-year cycle. Dune restoration and beach nourishment projects may be funded through this program, and communities may submit proposals to the GLO for such projects.

Under NRC §61.211 through §61.227, the State of Texas regulates the removal of sand, marl, gravel, or shell from islands, peninsulas, and land perennial waterbodies and within 1,500 feet of mainland public beaches outside corporate limits. For SPI, the Cameron County Commissioner's Court issues permits for the excavation of any of these materials unless the material is to be moved by an individual landowner, or with an individual landowner's consent, from one location to another on the same parcel. Additionally, no permit would be required if the removal is undertaken by a federal, state, or local governmental entity. An incorporated city, town, or village may not authorize the removal of sand, marl, gravel, or shell from a public beach within its boundaries for any purpose other than the construction of a public sponsored recreational facility or a shoreline protection structure.

Related to NRC §61.211 through §61.227, TPWD also regulates the disturbance and removal of marl, sand, gravel, shell, or mudshell located within perennial and marine open water areas for any purpose other than that necessary or incidental to navigation or dredging under state or federal authority (Parks and Wildlife Code [PWC] §86).

To provide clarity and efficiency in permitting process, the City currently operates a robust permitting program in place through the Office of Shoreline Management accessible here:

https://www.myspi.org/department/division.php?structureid=174

As part of the current permitting program, potential applicants are encouraged to complete the following steps to expedite permitting approvals through the City:

- Develop project purpose and need, and a detailed construction plan that is easy to interpret and understand
- Document site conditions through ground and aerial photography, as available, to provide the City with accurate, real-time information
- Contact the City of South Padre Island Shoreline Department as early as possible to allow adequate time for review and approval, while still meeting the applicant's schedule.
- Respond promptly within two to four business days to all requests for additional information or clarification from the City

18 DUNE MAINTENANCE ACTIVITIES

The primary purpose of this section is to provide guidance to the City for coastal dune restoration and maintenance portions of various projects. This section provides techniques for site preparation, planting efforts, dune repairs, fencing installation, and protective measures post-construction. Several methods may be used to increase the height and stability of existing dunes, repair damaged dunes, encourage sand accretion, or establish/repair dunes where a low sand supply exists or where dunes have been destroyed from adjacent development. The City should gauge and evaluate each proposed project in conjunction with other projects and in consideration of the City's over strategic goals.

In all cases, each project site or restoration area should be evaluated both individually and in combination with other foreseeable projects of similar size, scope, and scale for their potential for natural sand accumulation prior to restoration efforts. At their discretion, the City may also proactively reach out to landowners adjacent to a given restoration site to gauge interest in joint projects with larger potential footprints.

Given the history of storm-driven erosion on SPI (Integral, 2021a and 2021b), native vegetative re-establishment should be the primary and preferred method for dune construction, improvement, and repair. The approval evaluations should focus and prioritize restoration areas that exhibit fresh, natural sand sources forming around existing obstructions and structures and that are most capable of sustaining native vegetation communities. Since natural dune formation is the end goal, establishment of native vegetation would generally be the most economical and least intrusive option to accelerate dune formation, with the support of structural barriers and appropriate protective measures.

In areas where the local sand supply is insufficient for these two sand-trapping methods to be effective, dunes can be artificially constructed with imported sand from a local source or from GLO-established offshore sand sources.

18.1 SITE PREPARATION AND SELECTION

Each restoration area must be evaluated to determine the existing conditions of the site, available natural resources (i.e., sand) and obstructions, and construction access among other issues. Many factors will play a part in this determination, but the most important question is whether native plants would survive on their own once the planting is complete. The distance from the proposed planting site to the tide line must be considered; the GLO recommends a minimum distance of 200 feet from the mean low tide line and at least 50 feet from the storm tide line, which is generally defined by an offshore wrack line or layer of debris along the beach (GLO 2009). Both of these recommendations will help prevent individual plants from being washed away from high waves. Additionally, based on Integral's recommendations (2021a and 2021b), the minimum width of the restoration area should be 200 feet.

Figure 4 provides a typical dune cross-section that would conform to the recommended dune dimensions from Integral (2021b) and the GLO (2009).

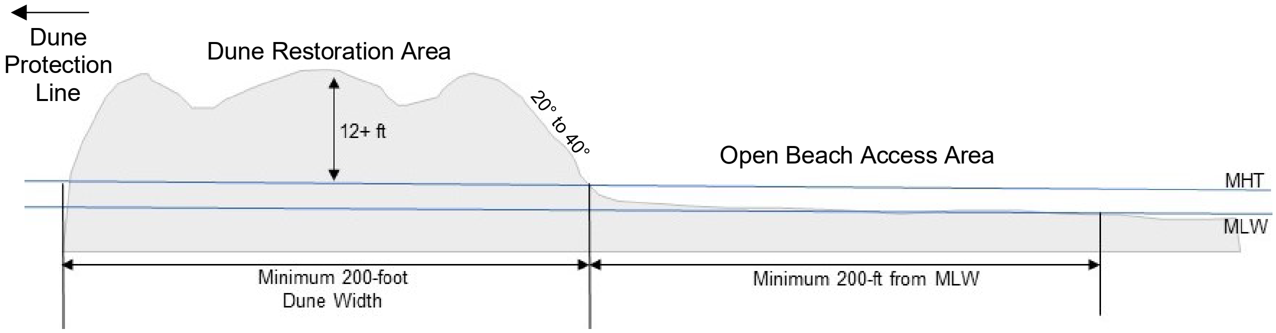

Figure 4: Typical Dune Restoration Cross-Section

It is important to consider future or existing residential structures or homes, frequently used walkways or plans for future walkovers, improvements to beach facilities, and future plans for construction or earthwork. Any major construction requiring machinery within a close approximation of the beach or dune system can be detrimental to newly planted sand dunes. Accessibility is also an important factor when bringing water and supplies to the restoration area; each planting location must be evaluated to determine the existing conditions of the site. Although the majority of restoration sites may contain suitable soils for planting, shallow subsurface geotechnical samples may be necessary to make sure a clay lenses or other inappropriate layer is not present that will inhibit vegetation growth. Samples should be focused on the top 24 inches of sediment and provided to the City if requested.

18.2 DUNE AND EROSION REPAIR

Some Texas beaches, particularly along the upper (northern) coast, are sand-starved. Natural sand accumulation occurs very slowly, and it may take as long as 20 years for a six-foot-high dune to form. Fortunately for SPI, sand is relatively available, and erosion and accretion patterns are variable as evidenced by Integral's Xbeach modeling efforts (Integral 2021b). According to the modeling results, erosion hotspots exist in the very northern portion of the shoreline, while accretion or low erosion rates are anticipated along much of the central portion of the shoreline (less than 0.9 feet/year), and moderate erosion (between -0.4 to -1.4 feet/year) is present a little further south between Corral Street (near Beach Access #3) and the Pearl Beach Access. South of this moderate erosional zone, the shoreline becomes accretional to the inlet jetty along the Brownsville Ship Channel.

Although there are erosion hotspots of in the northern portions of the SPI shoreline, the City has been successfully controlling erosion over a number of years, with a via a regular beach nourishment program, beginning in 2005, prior to 2005, there were other nourishment projects but they were not undertaken as part of a systematic program. In fact, much of the current dune field has substantially increased in width between 2002 and 2020 due to an earnest rebuilding and replanting program by the City (Integral 2021a). Additionally, according to recent studies (Integral 2021a and 2021b), the primary cause of erosion and foredune scarping is wave and storm surge events. Although portions of the system tend to move back to a dynamic equilibrium state after these acute events, these studies also show that having an intact continuous dune system is important to the resiliency of the overall system. In locations where dunes have been removed completely or simply scalped (artificially lowered or cut down without complete removal) for recreation or other purposes, the system is inherently more vulnerable as large storm waves can reach the base of the buildings or infrastructure. These impacts are not limited to the area where the dunes have been removed; up-rushing waves reaching a seawall or building may deflect off hardened structures (i.e., bulkheads) and push water laterally, causing erosion of adjacent dunes.

To combat these issues, it is recommended that limited dune repairs and importation of sand from either offshore sources or reputable sand suppliers in Cameron County be used to repair and restore potential dune communities. As an important note, sand should not be taken directly from the beach, as doing so robs potential future donor areas of the material necessary for maintenance of the beach and dunes, and may increase erosion. As reported by Integral (2021b), dunes that have been removed completely by property owners should be replaced to create a continuous dune at SPI. Removal of sand and other materials from barrier islands and peninsulas is also regulated by state laws (See Integral's report, to which this BIO-West report is attached, Section 2.2).

Man-made dunes should be of the same general height, slope, width, and shape as natural dunes in the vicinity. According to baseline reports (Integral, 2021a; Figure 4), natural dune heights historically have ranged from 10 to 12 feet above mean high tide (MHT), although multiple areas along the existing shoreline have been scalped to allow for first and second story residential views of the Gulf of Mexico.

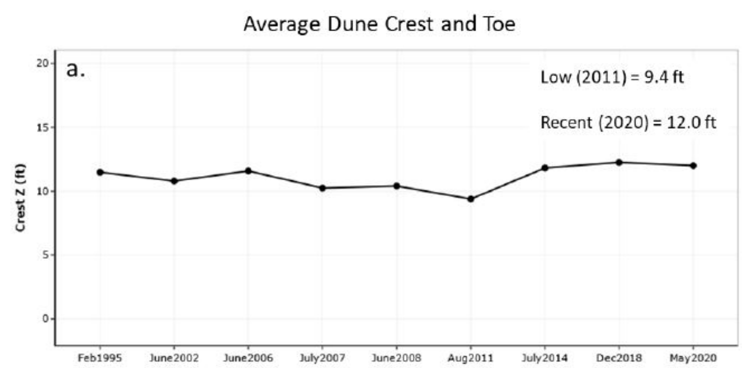

Figure 5: Historical Dune Crest Height (Integral 2021a)

Dune slopes tend to range from 15° to 55° along the SPI shoreline, depending on location, past development activities, and site protection measures. The GLO recommends a slope of between 20° and 40°, with gentler slopes the preferred option (GLO 2009). Based on the observed natural dune heights compared to the GLO's recommendations, the initial dune base widths for repair and restoration work should be at least 50 feet. A narrower dune base would not have the capacity to support the taller dunes normally associated with this shoreline and would not be sufficient to provide storm protection.

Dune restoration and erosion area repairs should be constructed slightly landward of the location where foredunes would naturally occur to allow for natural seaward expansion. Dunes built too close to the Gulf can be destroyed by wave action during even minor storms and may interfere with public access along the beach. Additional sand placement options are illustrated below in Figure 5, but should be coordinated with the City prior to placement activities.

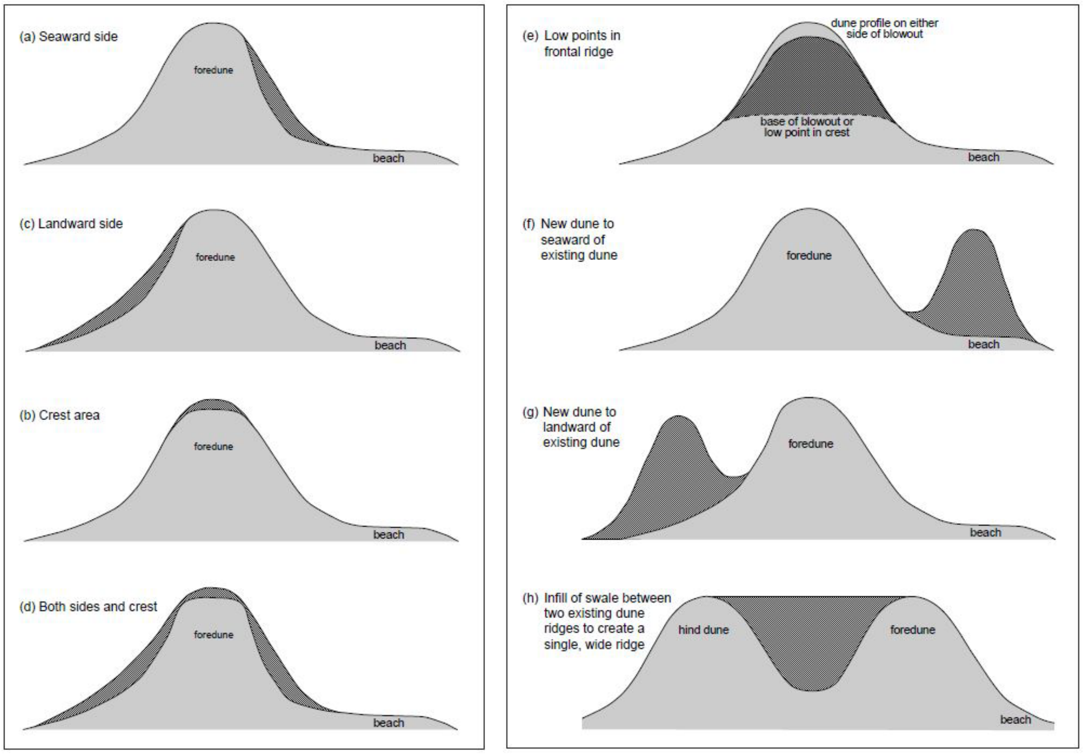

Figure 6: Sand Placement Alternatives (Pye et al 2007)

Note that the dune is a phalanx line, therefore a weak spot, e.g., an unvegetated area, can ultimately be the entry point for overwash, exacerbating erosion or system change without the need for the crest to be breached. An important consideration is that dunes take in the order of 7+ years to gain a real foothold (B. Charbonneau – Pers. Comm.), and they cannot exist without a beach to seawards.

18.3 PLANTINGS AND VEGETATION

Coastal dunes exhibit a wide diversity of native vegetation, each with specific habitat requirements and specific functions that keeps the overall dune system stable and healthy. Native species have adapted to different dune structures, local weather patterns, sand conditions, light attenuation, and provide wildlife with food and shelter. Some native species have specially adapted root systems that can stabilize sandy soils, or are deep-rooted in the swale communities between dune ridges to take advantage of moisture content due to daily shading and lower elevations. Other species tend to grow in the partially shaded areas under clump grasses while some are pioneer species to newly established and barren dunes. Dune plants along the Texas coast can grow either forbs, vines, woody species, or upright bunchgrass, and each growth type presents a unique function to the stabilization of the sand dune. Figure 5 provides a simple diagram of a typical beach profile, illustrating the various components of a dune system that are colonized by native vegetation.

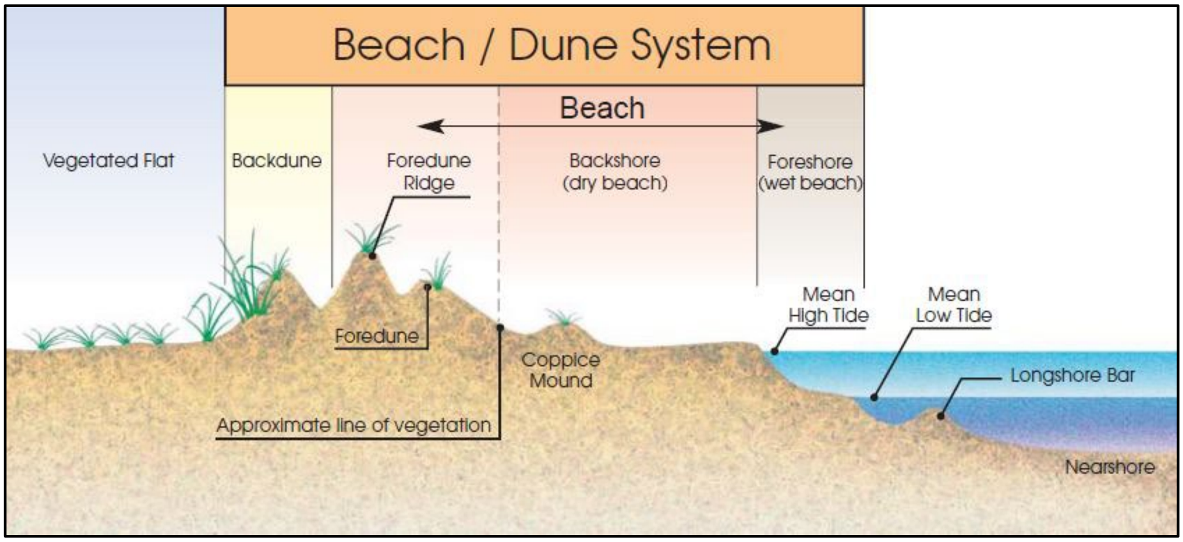

Figure 7: Typical Barrier Island Beach Profile (GLO 2009)

Based on a review of multiple sources (GLO 2009, GPB 2014, Craig 1984, Mendelssohn et al 1991, and Morton et al 2004), three species of grass are historically appropriate for dune restoration projects on the Texas coast: bitter panicum (*Panicum amarum*), sea oats (*Uniola paniculata*), and marshhay cordgrass (*Spartina patens*). Vegetation assessments of the SPI shoreline dune communities were performed in September 2021 and confirmed that these three species were most prevalent in dune communities that also exhibited the most diversity in dune structure (i.e., multiple crests, swales, and slopes) and vegetation.

Sea Oats

An icon of the Texas coastal shoreline, sea oats are one of the few natives that is perennial and has an extensive, deep root system. It propagates through rhizomes and seed dispersal, and grows rapidly enough to avoid being smothered in rapidly shifting sand. Although less tolerant of salt spray than bitter panicum and marshhay cordgrass, this particular species is very important to the production of foredunes due to its roots. Sea Oats thrive in loose sandy soil and tend to be very productive on the top of sand mounds or the higher parts of the sand dune ridges. They also have very large flowering plumes that are attractive to both people and wildlife. Interplanting sea oats and bitter panicum tends to reduce the risk of disease or pest infestation.

Bitter Panicum

According to the GLO, bitter panicum is one of the most suitable species for dune stabilization and restoration along the Texas coast (GLO 2009). This native beach plant is an extremely hardy grass, is already prevalent along the entire Texas coast, and has a higher salt tolerance than many other coastal species. Its leaves are smooth, bluish-green, ¼ to ½ inch wide, and four to 110 inches long. New plants are generated from tillers - shoots that grow from nodes on the roots. Bitter panicum has been used in multiple coastal areas to prevent erosion along sand dunes and sandy hillsides. It prefers sandy loam, well-drained soil and is extremely drought tolerant. The species is a perennial warm-season grass that grows from short, strong rhizomes. Over time, these rhizomes form open clumps, which can fuse to form a dense mat of vegetation. The blooms, which arrive in late summer and fall, produce abundant seeds that attract a variety of resident and migratory birds. Although bitter panicum produces small, viable seeds, its main method of propagation is from rhizomes and is therefore best propagated from stem cuttings.

Marshhay Cordgrass

Marshhay cordgrass, a small, wiry-bladed perennial clump grass, is commonly found in high marshes, but can also be found on the foredune ridges and back dunes. It does well on the landward side of dunes, but if planted on the seaward side, is easily buried, and destroyed by shifting sands. Unlike most vegetation, marshhay cordgrass grows well in saturated soils and inundated areas, is halo-tolerant and grows well in the trough and swale areas between the foredunes and succeeding dunes. It spreads using rhizomes, which allow the shoots, or blades of grass, to grow horizontally. These rhizomes form dense mats beneath the surface, which aid in preventing erosion. Mixing marshhay cordgrass with bitter panicum produces excellent results.

Other Recommended Native Restoration Herbaceous Species Include:

- *Schizachyrium littorale* (shore little bluestem)
- *Paspalum monostachyum* (Vasey gulfdune paspalum)
- *Sorghastrum nutans* (Indiangrass)
- *Muhlenbergia capillaris* (Gulf hairawn muhly)
- *Eragrostis secundiflora* (Red lovegrass)
- *Andropogon glomeratus* (Bushy bluestem)
- *Borrichia frutescens* (Bushy seaoxeye)
- *Distichlis spicata* (Saltgrass)
- *Ipomoea pes-caprae* (Goat-foot morning-glory)
- *Ipomoea imperati* (Beach morning-glory)
- *Oenothera drummondii* (Beach evening primrose)
- *Passiflora foetida* (Fetid passionflower)
- *Eriogonum multiflorum* (Heartsepal wildbuckwheat)
- *Vigna luteola* (Hairypod cowpea)

As with most re-planting efforts, not every recommended species will be available when required for restoration. Therefore, coordination with the City's Shoreline Management Department will be necessary to approve any planting plan. Additionally, based on the existing species recorded along the SPI shoreline as of September 2021, no woody species are recommended at this time. Invasive, noxious, and exotic species management and prevention is included in Section 20 below.

When comparing options for restoration, the choice is generally between transplants and nursery-grown plugs. As with all restoration projects, transplants from the project are more likely to survive as they are already acclimated to the climate and region. If suitable stands cannot be found within the same location as the restoration project, they may be able to be sourced from adjacent dunes. Permits from Cameron County and/or the Office of Shoreline Management will be required if the harvesting or planting site is seaward of a dune restoration project.

For the SPI shoreline, the best time of year to either plant or transplant vegetation is January to February. Plants should not be taken from foredunes or other degraded areas that are sparsely vegetated or exhibited signs of erosion. Transplants should only come from existing, healthy, dense stands of native vegetation with no invasive, noxious, and exotic species present within 50 feet due to the potential for seed presence in the root balls. Care should be taken to avoid trampling plants that are not being harvested, and transplants should be removed in a dispersed grid-like pattern at intervals of at least three feet (GLO 2009, Wooten 2016). Plants should not be pulled or tugged out of the ground since each plug requires an intact root system for successful transplant. Individual plants should be excavated with a hand tool like a dibble bar, sharpshooter or similar device to maintain a good root structure to increase survival chances. Small areas and steep slopes at the project site are best vegetated by hand.

When transplanting at the restoration site, place single plants into individual holes made with a shovel or dibble bar, and pack each planting firmly into its hole. Larger, flat areas with less than 5% slope can be planted with conventional transplanters with their shoes extended to make holes six to nine inches deep. According to the GLO, 1,000 plants should stabilize an approximately 50- by 100-foot (5,000 square feet) strip within a year on 2.25-foot centers (GLO 2009).

Due to the drier nature of dune communities, post-transplant irrigation is generally not required, and regular watering is necessary only in drought conditions as defined by NOAA (2022). Mulch is a good option after planting to regulate soil temperature, minimize wind erosion, and retain moisture. Hay, natural fiber mesh like jute, and burlap may be used as it is on similar projects along the Texas coast. All of these materials are biodegradable and will eventually break down. In areas where high winds are common, burlap or screen anchored with stakes is recommended instead of hay.

Generally, nursery-grown and transplanted vegetation needs little maintenance. While watering new plants is helpful, fertilization may be used during the first year after transplanting but is usually unnecessary thereafter. An approved soils testing laboratory can provide fertilizer recommendations for a particular location, after approval from the City. Mowing is not recommended since it destroys dune grasses' ability to trap sand by removing leaf and blade materials, and may even kill individual plants if the mower deck height is set too low.

Monitoring should be conducted within 60 days of the restoration effort and again between April and June each year for a period of five years, for a total of six monitoring events. Typical monitoring events should include both qualitative and quantitative vegetation assessments using appropriately sized linear quadrat sampling, photo-documentation, and data analysis, at the discretion of the City. A simple letter report should be submitted to the Shoreline Management Department within 30 days of a monitoring event.

A planting restoration project is considered successful if the percent coverage reaches 75% after the first two monitoring years (three monitoring events), at which point the Office of Shoreline Management may elect to modify or discontinue monitoring at their discretion. This percentage reflects a healthy community, based on past vegetation assessments of the SPI shoreline.

If the survival rate is between 45% and 75% after five monitoring events, the monitoring should continue until the percent cover reaches 75% as referenced above.

If the survival rate is less than 45%, the area should be replanted during the next suitable planting window. Planting requirements should follow the methodology presented above.

18.4 SAND FENCING

Sand fencing installed in a beach or dune gap can assist in building a new foredune or fill gaps in dune ridges, and successful sand fences become buried as sand is trapped. Fencing reduces wind speeds, allowing sand to fall out of the wind column and accumulate. Different fence configurations also can create different dune forms and heights. For example, fencing running parallel to the shoreline can assist with repairing foredunes and sealing breaches and blowouts (Grafals-Soto and Nordstrom 2009; Etienne, K., et al. 2016; see Figure 6 and Figure 7) and are the easiest to install over large areas with medium to heavy foot traffic.

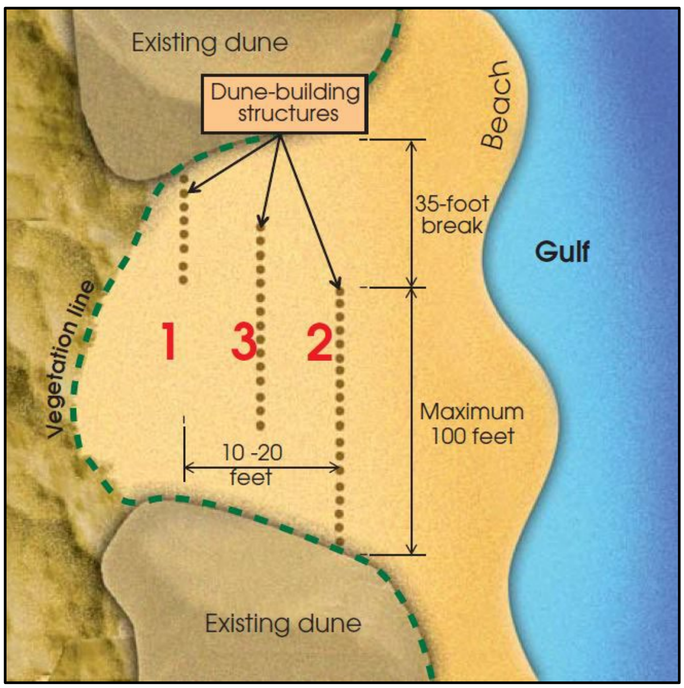

Figure 8: Parallel Sand Fencing for Blowout Repair (GLO 2009)

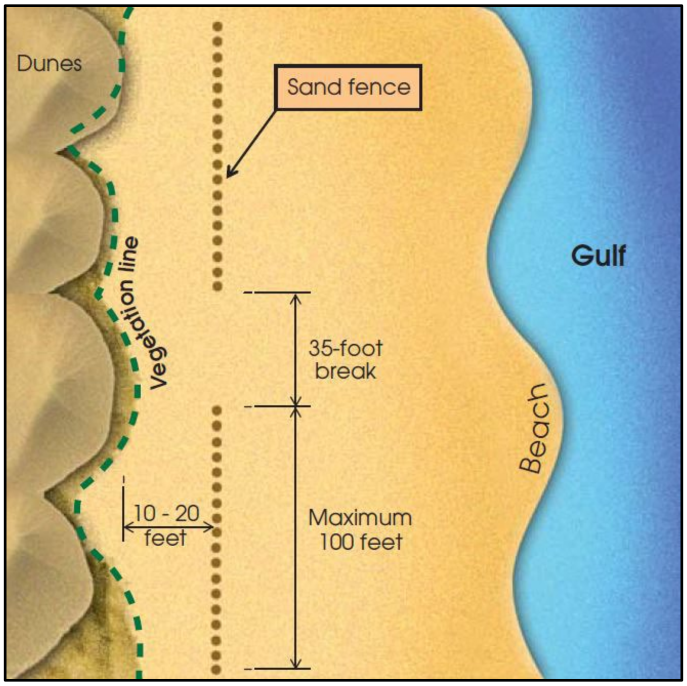

Figure 9: Parallel Sand Fencing for Foredune Repair (GLO 2009)

Angled patterns can create a wider, more meandering dune system that can be considered more natural looking and provide more area for vegetation growth (Grafals-Soto and Nordstrom 2009; Eichmanns et al, 2021; see Figure 8 and Figure 9). These patterns generally require more fence material than the shore-parallel style and can limit pedestrian access. Additionally, the fence installation angle to prevailing winds should be a minimum of 35° to maximize sand capture, while not adversely affect seat turtle nesting and other threatened and endangered species (GLO, 2009; Grafals-Soto 2011). Angled patterns can also be constructed in either single row or double row configurations, depending on existing, local site conditions and the restoration goal.

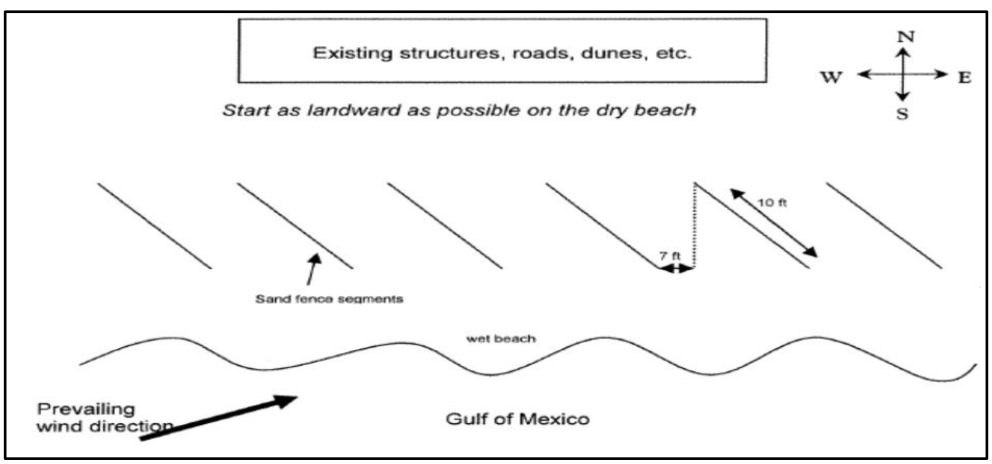

Figure 10: Single Row Angled Sand Fence Installation (FDEP, 2020)

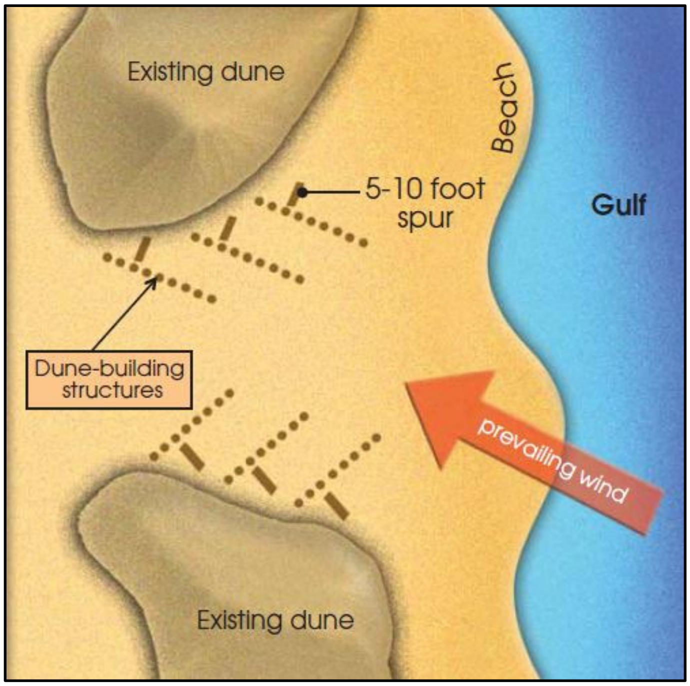

Figure 11: Double Row Angled Sand Fencing Installation (GLO, 2009)

Based on Integral Phase I and Phase II reports (2021a and 2021b), storms are the primary driver of dune erosion within SPI. Specifically, most of the beach width change within the SPI shoreline is due to changes in the shoreline position as opposed to changes in the dune toe position, and the wave impacts are concentrated along the lower beach face, causing erosion or accretion at or near the shoreline, and the dune toe is not eroding in most cases (Integral, 2021a and Integral, 2021b). Wind-borne sand supply is anticipated to be lower after a large storm, and there is no expectation that sand will quickly collect in large volumes within the project area. Therefore, the proposed primary purpose of sand fencing along the SPI shoreline would be to restrict access to recently restored dune areas, promote growth of naturally occurring dunes, and planted vegetation by creation of a lower-energy microclimate.

As referenced in several beach restoration guides and reference manuals (GLO 2009, GPB 2014, and Wooten et al 2016), a slatted wood sand fencing is standard practice for dune-building because it is inexpensive, readily available, easy to handle, and can be erected quickly. While plastic fencing options have the advantage of being non-flammable, stronger than wood, non-degradable, and reusable, it is generally more expensive than wood alternatives.

Slatted fencings should be a minimum four feet tall after installation as measured from the ground surface for successful dune-building and restoration. In areas where sand conditions are poor or lacking existing dune structures, a minimum of two feet can be utilized. The fencing can be supported with wooden posts or metal poles at intervals between eight and ten feet. Wooden posts should be cedar, cypress, or similar wood capable of withstanding the weather and winds for at least one year. Treated pine may be used as well if no other sources are available. The minimum practical length for support posts is six feet, but a length of seven to eight feet is preferred. The post should be buried to a minimum of ½ the depth as height above ground. As an example, a post with five feet above ground would need to be buried at least 2.5 feet into the ground and a post with four feet above ground would need to be buried two feet in the ground. Wooden posts should be between two and three inches in diameter, and be secured to the fencing material with three or four, 10- or 12-gauge galvanized wire ties. The slatted fencing should also be weaved between the posts so that every other post has fencing on the seaward side (O'Connell, 2008). Figure 10 provides a typical fencing panel layout.

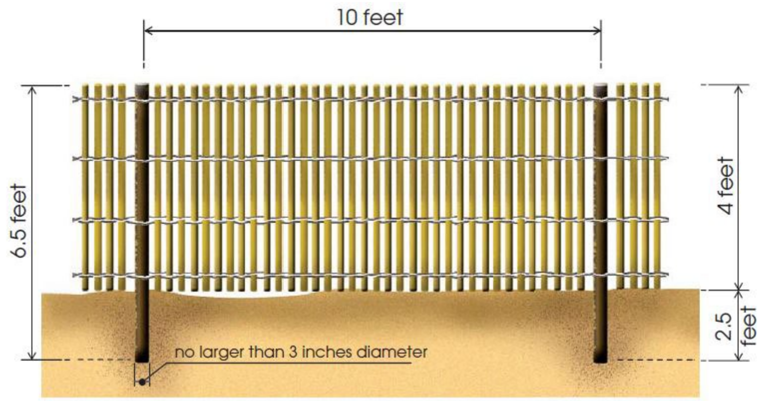

Figure 12: Typical Fencing Measurements (GLO 2009)

If the base of a sand fence is placed at ground level, dunes can build over the fencing resulting in a dune lift over the course of several years, as demonstrated in Figure 11. Although the fencing material may be buried, a new line of fencing can be constructed at a higher elevation up the dune face, resulting in a positive feedback loop and growing the foredune system toward the Gulf of Mexico.

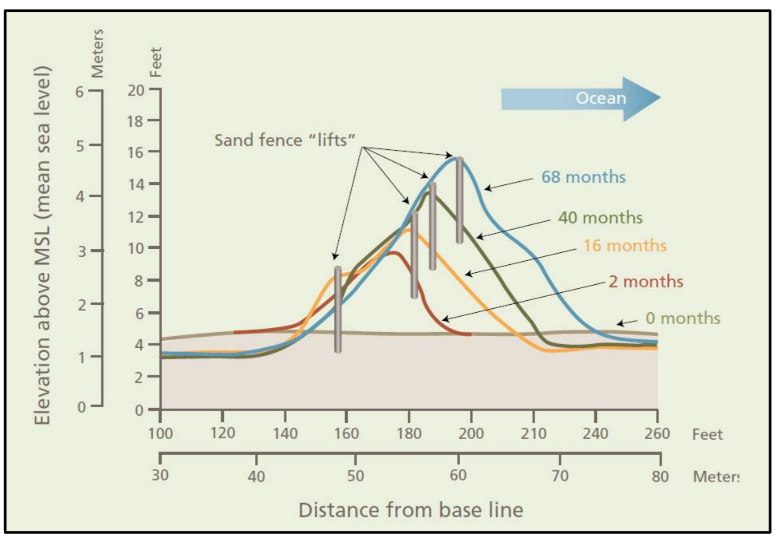

Figure 13: Dune Growth Through Sand Fencing (Savage and Woodhouse, 1969)

By contrast, if the base of the sand fence is elevated between three and six inches above grade, dunes can build on the downwind side, and the fencing can be retrieved and reused, especially plastic fencing material. Figure 12 illustrates this landward movement of the dune system.

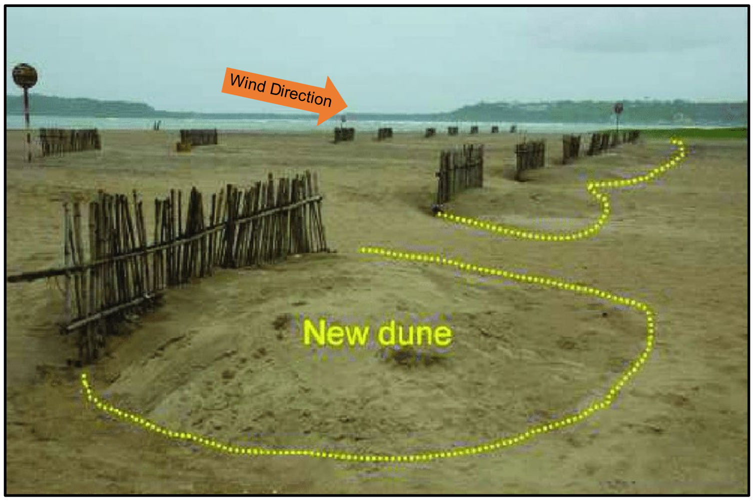

Figure 14: Dune Accretion Landward of Sand Fencing (Mascarenhas, 2008)

In either scenario, care should be taken to determine which direction dune growth and accretion is needed. Sand fencing should be placed 10 to 15 feet seaward of the damaged area, in non-continuous, diagonal segments at least 35 degrees to the shoreline so as not to adversely affect nesting sea turtles.

18.5 ALTERNATIVE METHODS

Several other dune restoration and creation, and sand accretion methods exist that may assist a potential applicant in enhancing and reestablishing a healthy dune community on or adjacent to their property.

Sargassum sp. is a genus of large brown seaweed (a type of algae) that floats in island-like masses and never attaches to a hard surface like other algaes or seagrasses (Casazza and Ross, 2022). As a locally abundant and very inexpensive material, it is well suited as a core material for dune construction. When it generally begins to accumulate in January and February, it provides a heavy and stationary foundational core for sand accumulation and accretion along the foredune line. Historically, the City has maintained a program that rakes and collects sargassum mounds, and adds them to the toe of existing, degraded dunes. These smaller mounds have formed the core of new sand dunes, and tend to retain high levels of moisture (Figlus et al, 2015). They have subsequently been planted with native vegetation through a city-wide restoration effort, resulting in higher functioning, more resilient dune communities. When used as either slight to moderately compacted bales or unconsolidated mounds, the resulting dune communities can be designed to resemble the more natural dunes north of SPI. Figure 13 illustrates a typical placement of sargassum at the toe of a foredune for a dune restoration project. The raked and collected material is placed equidistant from the toe of slope, with even volumes on either side of the elevation break. This ensures adequate support for dune formation while providing sufficient surface area for accretion (Figlus et al, 2015).

Figure 15: Typical Placement at the Toe of the Foredune (Miller at et 2018)

Christmas trees have also been used frequently for dune restoration projects along the Texas coast, although usually in conjunction with sand fencing. With decorations removed, the trees can be placed on their sides and secured by kicking sand over the lower branches or staking in a similar arrangement as standard sand fencing. Effective at trapping sand, needles fall off in the first year, and branches decay during the second and third year, depending on sand accumulation and coverage. Similar to fencing, individual trees or small groups of trees can also be useful in patching pedestrian and vehicular pathways, as they act as a visual barrier and discouraged unnecessary pedestrian and vehicular traffic. Trees with "flocking" or other paint or chemical applications should not be used for these efforts, as they present a potential chemical hazard to the future dune community.

Both potential organic core options (sargassum and Christmas trees) also exhibit higher organic content and percent moisture compared to natural dune creation cycles, resulting in two to four times more vegetation by biomass and stem counts (Figlus et al, 2015, and Williams and Feagin, 2010) compared to natural systems. Additionally, the benefits of these organic core methods were amplified when coupled with proper vegetation planting as referenced in Section 3.3. Figure 13 below illustrates a typical Christmas tree or sargassum line at the toe of a foredune.

Figure 16: Typical Christmas Tree Placement (Pye et al, 2007)

Due to transportation costs, material composition, and poor suitability for root system establishment, clay-core dunes are not recommended within the SPI region. Additionally, inorganic materials such as plastic netting, wire, concrete, automobiles, or tires is not recommended, as these materials can present safety hazards and are not biodegradable.

18.6 PROTECTION MEASURES

Even the best-vegetated or constructed dune will not remain that way unless site restrictions are implemented and reasonable protection measures are followed. Planted and fenced areas should be protected from vehicles, pedestrians, and grazing animals with temporary fencing, and signs should be placed at the site to explain the purpose and importance of the project. The City should also maintain a compliance program in coordination with local law enforcement to ensure restored sites are protected and restricted.

19 DUNE MANAGEMENT

Beach and dune ecosystems along the Texas Coast are dynamic ecosystems that display immense variability and resiliency. Despite experiencing daily harsh winds, frequent water inundation, and the effects of intensive development, they have been able to remain fairly stable, sustain numerous plants and animals, and serve as an irreplaceable natural ecosystem and place of recreation. Specific to SPI, land development and severe erosion from waves and storm surge comprise some of the long-term challenges with restoration projects. The efforts to replenish the beaches to combat the eroding factors costs the City in man-hours, money, and resources as new sand is pumped in to replenish the sand lost from natural causes. This section will cover several fundamental techniques aimed at preventing the loss of newly established dunes and installed vegetation, and reducing both short-term and long-term management costs.

19.1 WALKOVERS

Typically, any break or gap in a dune becomes an area where the erosive power of storm surge, waves, and winds are concentrated. In order to avoid creating the potentially hazardous condition of the concentration of the water and wind through breaks in a dune line, dune walkovers are considered the preferred means of beach access, since they allow the dune line to remain continuous. Damage to dunes from pedestrian traffic can also be avoided by the use of elevated walkovers. Walkovers that are conveniently placed near access points, parking areas, subdivisions, and public facilities, pedestrians will be less likely to cut their own footpaths through the dunes. Also, providing walkovers should funnel pedestrian traffic and allow for targeted education through signage and educational placards that increases public awareness of the importance of dunes and promotes an appreciation of the sensitivity of the dune environment.

A walkover should begin landward of the foredune (see Figure 5) and extend no farther seaward than the most landward point of the public beach that does not interfere with public use of the beach at normal high tide. If any coordination is required, a request should be made to the City. The walkover should be oriented at a minimum 30° angle to the prevailing wind direction, which is south-south east. With a south-south east prevailing wind direction, most of the walkways and walk-throughs at SPI are oriented 40-45º from the prevailing wind. Figure 13 provides a potential option for combining walkovers in an appropriate orientation to limit dune impacts while still providing public and private access. Whenever practicable, individual proposed walkovers should be evaluated in combination with potential adjacent locations to determine if one walkover can safely and efficiently service multiple property owners.

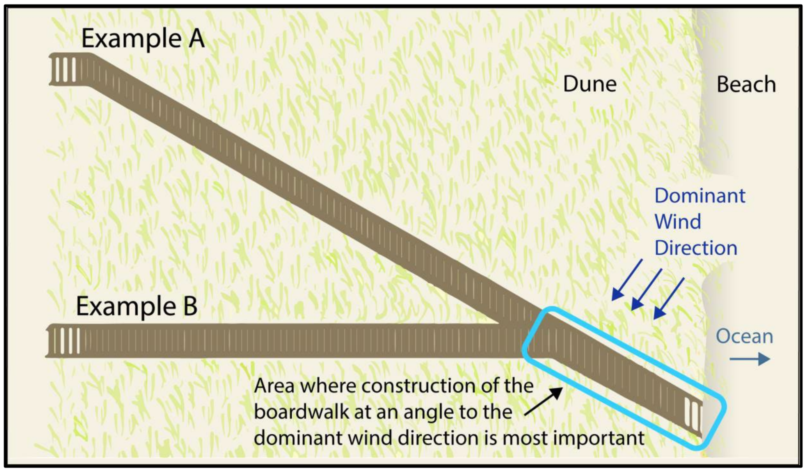

Figure 17: Potential Walkover Layouts (MOCZM, 2022)

As recommended by the GLO, a typical walkover cross-section is included in Figure 14. Walkovers should be constructed of wood as it is generally less expensive than steel, aluminum, or composite materials, does not collect and retain heat like steel or aluminum, and is easy to utilize for different construction designs. Although composite or polyvinyl chloride (PVC) walkovers currently exist, treated lumber and galvanized nuts and bolts are still the preferred option for walkover construction.

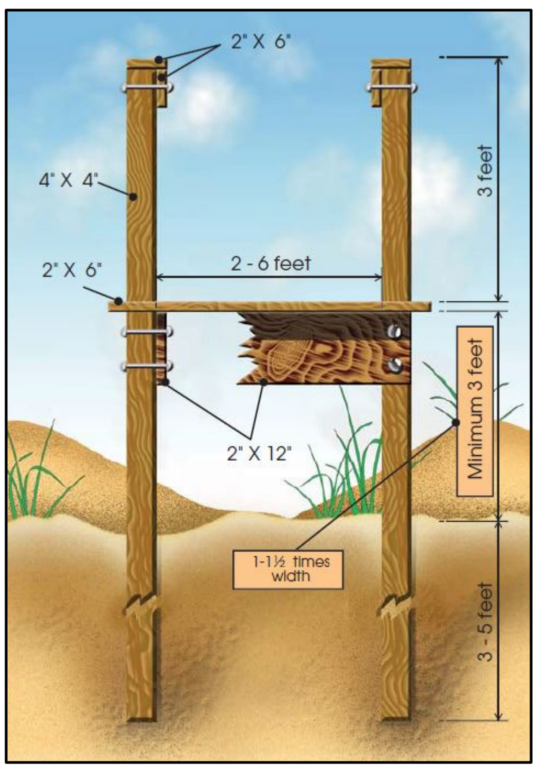

Figure 18: Typical Walkover Cross-section (GLO 2009)

The width of a walkover should be based on the expected volume of pedestrian traffic. If a walkover will be infrequently used, a width of two feet should be sufficient. Walkovers intended for two-way passage should be wider, with a max width of six feet. Consideration should be given for heavy traffic walkovers and Americans with Disabilities Act (ADA) compliance. With all construction in dune areas, priority should be given to least intrusive, minimal necessary design that still meets the project need.

The structure's height should be at least one to one and a half times its width to reduce light attenuation and allow daylight to reach potential shaded vegetation. The spacing between wooden deck boards should be a minimum ½-inch so sunlight and rainfall can reach to underlying vegetation below and rainfall will not accumulate on and potentially rot the deck material.

Since the supporting piers could aid in dune creation and sand accretion if constructed properly, consideration for future underlaying dune expansion and growth should also be a factor in height evaluations. The supporting piers should be spaced as far apart as practicable along the length of the structure, with a minimum distance of six feet between piers. As with sand fencing, each supporting piers should be planted in the ground at least three feet to ensure stability, but a depth of six feet or more is recommended to allow for erosion around the piers during large storms, similar to the events referenced in the baseline reports (Integral 2021a and 2021b). Supported pilings should be installed with a hand auger or posthole digger rather than with a tractor to reduce site specific erosion potential, and cement footings are not recommended. Since dune systems are dynamic and very suspectable to minor impacts, care should be taken to repair damage to the surrounding area as soon as practicable.

Handrails at least three feet high from the decking on both sides of the walkover are also the recommended design standard from a safety perspective, as well as to discourage people from leaving the preferred beach access route. To enable wheelchair use of a walkover per ADA, ramps should not exceed a 20% slope or a one-foot rise for every five feet in length at each end of the structure. Large walkovers with heavy pedestrian traffic (i.e., city access areas, subdivisions that combine resources, state parks, etc.) are highly encourage to utilize ramps.

All walkovers should be inspected on a regular basis and repaired as needed. For repair activities, workers should enter the dune area on foot rather than by vehicle. In the case where a vehicle or machinery is required, the City should work with the walkover owner to allow vehicle access down the beach but will not allow vehicular access over dune areas through the current Beach Access Permitting program. As states earlier, we strongly recommend that the City provide incentives or other regulatory measures over single subdivisions to pool their resources and consolidate walkover structures to minimize damage to dunes by the proliferation of walkovers.

Figure 15 and Figure 16 show two of the most common designs for dune walkovers and are variations of the common pier-supported structure employing telephone pole or fence post piers. Figure 15 follows the dune elevation with flat deck and steps at each end. Figure 16 has ramps instead of steps, and the deck is arched where dune formation is highest. The conventional pier-supported walkover is relatively easy to build, but the services of a qualified contractor or architect may be required for more accommodating designs. Prior to construction, a permit would be required from the Office of Shoreline Management.

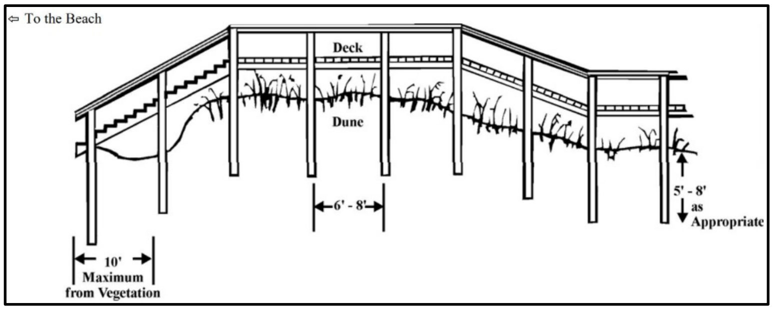

Figure 19: Pier-Supported Walkover with Steps (FDEP 2016)

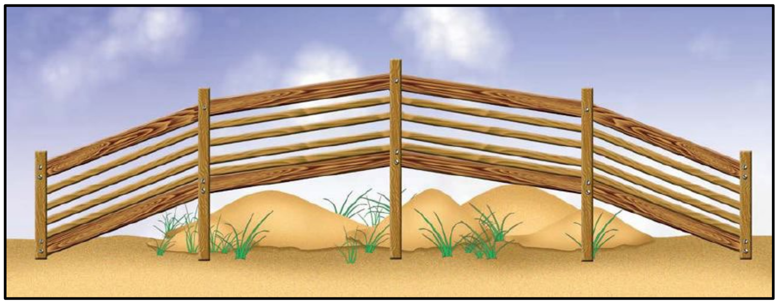

Figure 20: Pier-Supported Walkover with Ramps (GLO 2009)

19.2 ACCESS ROADS AND PATHS

Unrestricted off-road vehicle use and pedestrian traffic can do significant damage to the delicate and often relatively unobtrusive plants that grow in coastal dune communities, as well as crush the eggs of beach-nesting birds and frighten birds from their nests. Additionally, as the public drives or walks on foredunes in particular, they can crush the expanding dune grasses as they spread seaward, preventing the growth of the dunes and increasing erosion (Kluft and Ginsberg 2009).

The need for public roads to provide access to beaches often conflicts with the need to protect dunes especially with the state laws in effect in Texas; however, damage to dune areas by access roads can be minimized if the roads are properly designed. To minimize dune destruction, access roads should be as narrow as practicable, usually between 14 and 18 feet wide, and lined with regularly maintained sand fencing to restrict erosion potential and confine vehicular and pedestrian traffic. More durable slatted plastic fencing may be appropriate in for road installation, to decrease long term maintenance costs. Additionally, any dune area damaged during road construction should be revegetated.

If roads are constructed parallel to the shoreline, they should be located as far landward of the dunes as possible. Beach access roads built perpendicular to the beach should be located in washover or blowout areas whenever possible and follow natural land contours. Beach access roads should be oriented at a 20° to 35° angle to the prevailing wind direction (Figure 17), similar to sand fencing placement, to reduce the chance that water and wind will be channelized and erode the dunes during storm events.

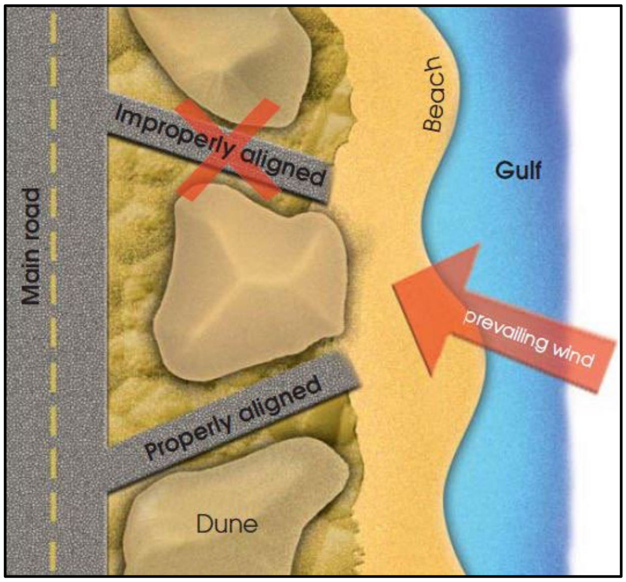

Figure 21: Recommended Access Road Alignment (GLO 2009)

Access roads near beaches should also be elevated over existing dunes to reduce the chance of water channelization and erosion during storms and high tides. Additionally, drainage patterns resulting from access road construction must not erode dunes, the public beach, or adjacent properties. New roadside channels should be graded to drain to the bayside of SPI and away from critical dune areas. Where practicable, these drainages should be directed into the naturally occurring dune swales on bayside or landward side of the back dunes (see Figure 5 above). If necessary, the installation of a small retention pond to collect and contain rainwater until it can seep into the ground or the installation of flow reduction materials like small sediments traps or riprap-lined swales may be required based on the proposed footprint of the access road. A pond should be large enough to contain the anticipated volume of runoff and located where it will receive the maximum amount of drainage, but not impact any critical dunes areas. Riprap-lined swales or sediments traps should be periodically inspected and cleaned out as necessary. A qualified professional should design any potential access road system, seek approval from the City, and oversee its construction to ensure compliance with applicable local and state laws and there is no damage to the existing dune communities.

Aside from access roads and walkovers, the public may attempt to access the beach via pedestrian trails that are inaccessible to vehicles, carts, or conveyances. If a ground level path is required, then an applicant should seek approval prior to installation and follow similar guidelines for access roads and walkovers. The planned path should follow existing contours and not excavate or other move any sand or existing dunes. A curved path is preferred to reduce wind and water erosion potential, and the path should be sand fenced on both sides to prevent wandering and impacts to adjacent dunes. As standard sand fencing is designed to retain sand and build dunes, symbolic (string and post) fences may also be used instead to channel public use away from sensitive vegetation or wildlife habitat but it must be regularly maintained.

19.3 INVASIVE PLANT MANAGEMENT

The loss of coastal dune ecosystems to human development can mean vegetation specialized to these habitats can become uncommon and rare. To exacerbate this issue, additional threats can be posed by noxious, exotic, and invasive species that outcompete native species and lead to monocultures. Non-native species compete with and overwhelm more stable native dune plants, threatening the stability and biodiversity of the dune system. Reducing the presence of aggressive, non-native vegetation preserves and promotes the structural integrity and biodiversity of the dune. Species of concern in SPI include common reed (*Phragmites australis*), popinac (*Leucaena leucocephala*) and salt cedar (*Tamarix* spp.). Potential sources for these undesired species include windblown and water-washed in seeds, restoration and planting efforts that transplants root balls from infested areas, trampling of native species from trespassers (e.g., general public, vagrants), unauthorized trimming or mowing, homeless and vagrant activities, and man-made fires.

It is recommended that any areas that contain noxious, exotic, and invasive species be monitored and these species fully removed as soon as practicable after identification. Removal consists of physical removal of all vegetative mass, including leaves, stems, and trunks, and roots, and legally disposed of off-site. As with planting efforts, all removals activities should be undertaken with hand tools; mechanized equipment is not recommended. If mechanized equipment is required and can be used without impacting existing dune communities, it should be coordinated with and approved by the Office of Shoreline Management.

Post and rope fencing and sand fencing may be temporarily removed for access prior to removal, but it should be replaced upon completion of each section as soon as practicable. If approved, mechanized equipment may also be permitted on the soft sands of the beach, access roads, boardwalks, or beachwalks on a case-by-case basis.

Additionally, no on-site shredding, mulching, or chipping should be allowed. During removal, care and special precautions should be taken to ensure minimal impact to the existing dune during the exotic removal efforts. The use of herbicides should also be prohibited at the discretion of the City.

20 SUMMARY AND RECOMMENDATIONS

The primary purpose of this Plan is to develop a set of guidelines and rules that will assist the SPI community in developing and maintaining a stable, ecologically functional dune system appropriate for the south Texas coast that reduces maintenance costs, alleviates public safety concerns, and benefits the aesthetic and culture of SPI. The Office of Shoreline Management has been instrumental in developing a program to guide development activities toward a more sustainable and resilient dune system. The baseline reports (Integral 2021a and 2021b) also support the conclusion that an intact continuous dune system is important to the resiliency of the ecosystem, and the system is inherently more vulnerable as large storm waves can reach the base of the buildings or infrastructure without that protective dune line.

Implementing this Plan is anticipated to provide the framework to continue and further dune restoration efforts within the City of SPI in both the short and long term. Common sense construction and re-vegetation processes should provide the consistency and efficiency the public and private sector need to reinstall the resiliency into the coastal dune systems that were once prevalent along the entire Texas Coast.

Based on coordination with Integral and the Office of Shoreline Management, developing industry standards related to beach and dune restoration, and our professional experience, BIO-WEST recommends the following supplemental actions in addition to the three sections above that would further increase the resiliency of the SPI coastal dune system:

- Reduce the number of permitted walkways, have walkways converted to walkovers, and combine future walkovers to service multiple properties.
- Limit or restrict the current dune scalping that decreases the dune crest height below 10 feet and maintain a minimum dune height of 12 feet (Integral 2021b)
- Implement mandatory re-vegetation requirements for dune restoration applicants through the current city permitting program that could include the following:
    - Re-vegetation plan with location, methods, and plant list clearly defined
    - Re-vegetation success criteria (see Section 3.3)
    - Yearly monitoring and reporting requirements
- Consider additional city funding, public grants, and/or other incentive programs for volunteer dune restoration activities
- Consider providing city employee assistance, coordination, and support to potential volunteer dune restoration projects in locating and obtaining non-city funding and grant monies
- Continue existing incentive programs for volunteer planting/revegetation programs
- Continue public involvement initiatives including the beach access handbook and volunteer-led restoration efforts
- Increase access restrictions to current and future beach restoration and enhancement projects by implementing a project protection permitting process, increasing signage and fencing requirements, providing incentive programs for voluntary access restrictions, and engaging compliance officers or local law enforcement

- Implement a compliance program to identify and remediate any unauthorized paths and trails
- Consider changes to City ordinances to ensure restoration of dunes removed by property owners

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CITY OF SOUTH PADRE ISLAND
SHORELINE TASK FORCE
AGENDA REQUEST FORM

MEETING DATE: July 26, 2022

NAME & TITLE: Kristina Boburka, Shoreline Director

DEPARTMENT: Shoreline Department

ITEM
Discussion and action on a new meeting time for the regular meeting on August 9, 2022. (Boburka)

ITEM BACKGROUND
Propose an earlier meeting time for the regular meeting on August 9, 2022.

BUDGET/FINANCIAL SUMMARY
N/A

COMPREHENSIVE PLAN GOAL
Chapter 9: Shoreline

LEGAL REVIEW
Sent to Legal:
Approved by Legal:

RECOMMENDATIONS/COMMENTS: