CEPRA Beach Monitoring Phase 8
Surveys and Analysis: 2017 Monitoring Year
Volume 1

TXGLO

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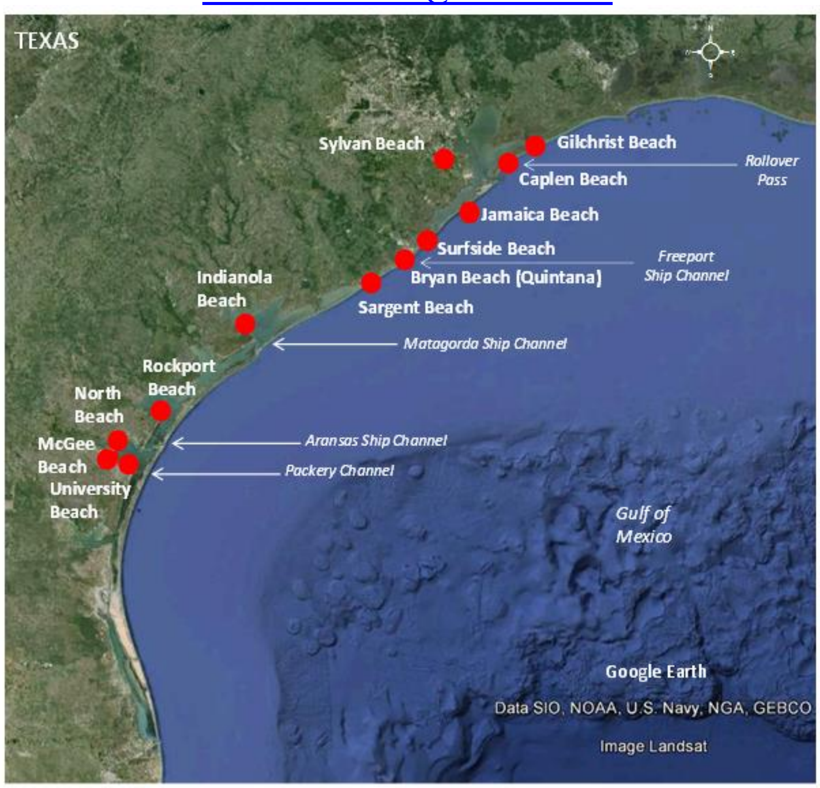

CEPRA beach locations monitored during 2017

Table of Contents

Introduction

The CEPRA Beach Monitoring Program provides a comprehensive assessment of beach status over the annual reporting period, key temporal periods of interest, as well as relative to nourishment/dune restoration efforts and storm damage. The project goal is to monitor CEPRA beach nourishment/restoration sites along the Texas Coast and provide an assessment that supports TGLO resource management decisions that are defined in the Beach Monitoring and Maintenance Plan (BMMP). The analysis and guidance provided by this program supports research-based management of these beach resources. Annual beach profile and shoreline position (MHHW) surveys were conducted at eleven (11) CEPRA beach locations during 2017 (Fig. A1). The timing of contract authorization coincided with the landfall of Hurricane Harvey and therefore the annual survey at each CEPRA beach was applied as the post-storm survey.

This report serves to document the surveys and analysis conducted at each CEPRA beach site and provides a summary of the findings to include 1) average rate of shoreline change over study period, 2) estimated beach volume change (Erosion rate as applicable), and 3) Beach Width (relative to Action Width and Target Width). Recommendations for maintenance tasks including nourishment and dune restoration are provided for guidance based on these assessments. The report serves as a guide to allow TGLO staff to prepare for future beach nourishment/restoration where analysis to date indicates potential need within 1 to 5 years. For additional historic information, Williams (2009, 2013-2016) discusses detailed analysis over previous reporting periods (2007-2009, 2007-2012/2013, 2012/2013-2014, 2014-2015 and 2016-2017). Reporting is provided in two volumes with Volume 1 documenting the status of CEPRA beach locations that were not recommended for FEMA review after Harvey. Volume 2 provides the reporting for the seven (7) CEPRA beaches that were recommended for FEMA review after the initial post-Harvey assessment.

CEPRA Beach Surveys

The following sections provide a summarization of analysis over the reporting period (2016 to 2017) as well as historic data for ease of reference. The surveys were initiated late in the summer season and therefore served as both the annual survey and post-storm survey. The date of each survey as well as previous survey dates are provided in Table A1. Two types of surveys were conducted at all sites; 1) shoreline position surveys at MHHW and 2) beach profile surveys. An additional backshore survey was conducted at six beaches to allow for a more detailed documentation of the backshore limit of the beach at sites without well-defined dunes, or anthropogenic limiting structures. In most cases these sites are areas in which active dune restoration is in process or backshore erosion during periods of inundation occurs regularly. Backshore surveys were conducted at, Caplen Beach, Gilchrist Beach, Indianola Beach, Jamaica Beach and Sargent Beach. These surveys provide for the re-evaluation of the functional beach width that is applied to estimate fill volume for nourishment and to document change in backshore limits at these dynamic beach locations with a history of severe backshore and dune erosion.

Data from the survey suites are applied to determine the rate of shoreline change at each beach and also volumetric change where applicable historic data is available. All elevations are reported relative to NAVD88 (U.S. feet). Surveys were conducted by Naismith Marine Services Inc. under the direction of Mr. Jim Naismith and Mr. Seth Gambill, in coordination with CBI. Mr. Naismith reviewed control data and providing review of historic data (performed by entities other than CBI) at each CEPRA beach site to allow for comparative analysis by CBI. Details related to survey protocol are provided in the SOW supplied with the original proposal package.

Comparing shoreline position change over time provides a useful tool for determining the relative stability of a beach. The position of Mean Higher High Water (MHHW) was measured at each beach during the beach profile survey. MHHW was determined at each location through occupation of local control at the closest NOAA tide station. Shoreline recession or advance can be interpreted quickly from this data and hot spots of erosion can be identified or targeted for further investigation. Recession is defined as the landward shift of the shoreline indicating either localized or widespread erosion of the berm and thus narrowing of the beach. Shoreline advance is defined as the seaward migration of the shoreline indicating widespread or localized accretion and thereby an increase in the beach width relative to a specified datum. For each CEPRA beach location, the MHHW shoreline position provides the most conservative estimate of beach width but is only effective as an interpretive tool when combined with beach profile data documentation of the volume and elevation of the berm and duneline. Beach width is reported as the distance from the land limiting feature (seawall, dune toe, vegetation line, sand fencing, revetment or sidewalk) that is unique at each CEPRA Beach location to the position of MHHW. This landward limit established in the original surveys is applied during each successive survey unless otherwise noted. The beach might actually be wider or narrower on any given day dependent on water level, storm surge and wind forcing. This conservative estimate of shoreline position, and thus beach width, provides guidance for local management concerns that are on a shorter temporal scale, particularly where vehicular access or storm impact to backshore infrastructure where a concerns, as well as for small beaches where moderate change in shoreline position can result in substantial impact to the recreational area of the beach.

The rate of shoreline change relative to storm events and beach nourishment activities is provided for each beach where applicable. In addition, the maximum and minimum distance of advance and recession is provided to indicate the degree of alongshore variability. The average rate of shoreline change was calculated applying the end point method to support comparison to BEG shoreline data. Although shoreline position surveys provide valuable insight into localized change that may be indicative of erosion or accretion, this method does not take into account the following; 1) focused erosion and volume change along the backshore and duneline, 2) changes across the immediate nearshore and 3) changes in berm and dune elevation. Therefore, shoreline position change is applied in tandem with beach profile surveys. Together these data provide for a comprehensive assessment, particularly at beach sites with coastal structures such as groins, breakwaters, jetties and inlets because trends in sediment transport may be complicated by the influence of these structures.

Beach profile surveys are conducted to document change across the beach between the landward and offshore limit of sediment exchange. Beach profile surveys were conducted along a regularly spaced, repeatable grid recommended by the TGLO Beach Monitoring and Maintenance Plan (BMMP) at each beach according to the schedule in Table A1. Historic transect locations have been occupied where applicable and based upon analysis the grids were adjusted as recently as the 2014 survey to enhance future analysis capabilities. Existing survey data obtained from other sources was referenced qualitatively where applicable, although quantitative analysis was limited to the surveys conducted by CBI during 2007-2017 due to local changes at CEPRA beaches that limited confirmation of local control that had been applied during the pre-existing surveys by other entities. Change in beach volume was calculated using the average end area method.

Survey data collected by CBI during the 2017 survey year is available for online review through the Coastal Habitat Restoration GIS (CHRGIS) mapping tool and beach profile tool (http://cartogram.tamucc.edu/chrgis/maps/ and http://cartogram.tamucc.edu/chrgis/profiles/). All historic data collected by CBI is available for review on CHRGIS and historic data is provided for reference although CBI is not responsible for the accuracy of the data collected outside of the monitoring program. The CHRGIS Profile Tool provides an online interface for the comparison and query of beach profile data. Plots comparing historic beach profile data and shoreline position data are provided in Appendix A.

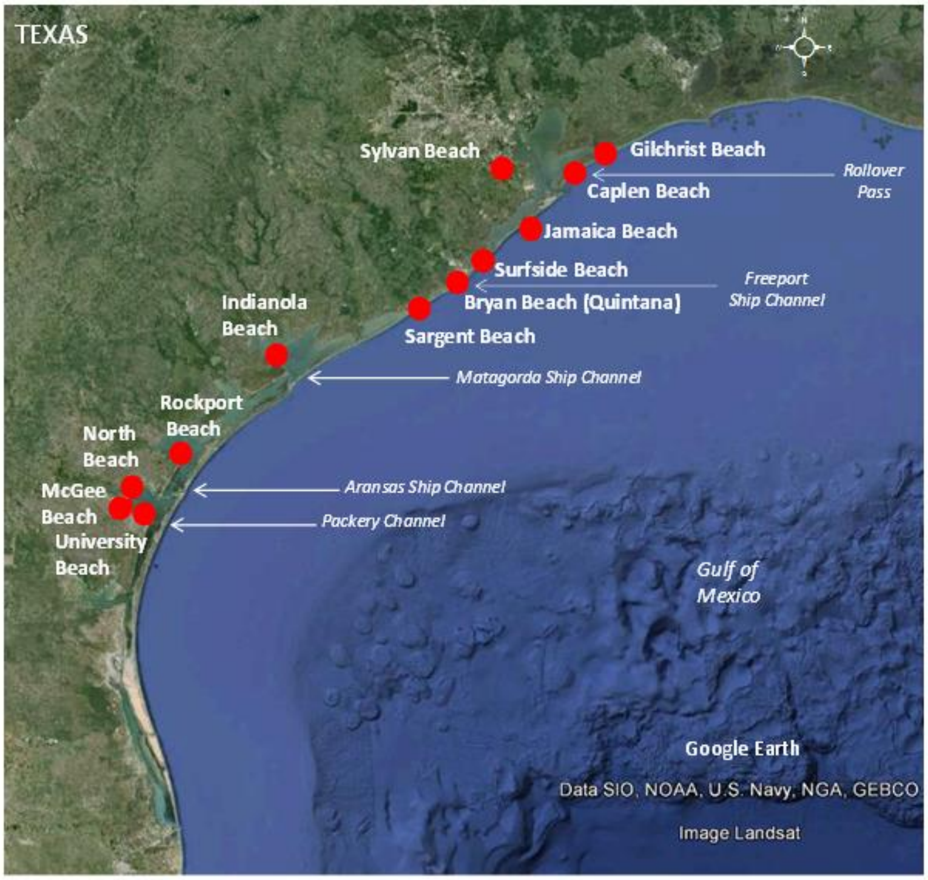

Figure A1. CEPRA bayside and Gulf beaches monitored during 2017

Aerial Imagery

Aerial imagery was applied for the interpretation of changes in vegetative coverage and adjacent regions that may influence the stability of the beach but are located outside of the active survey grid. Post-Harvey aerial imagery was provided by the TGLO during the reporting period. Additional imagery was obtained from the China National Space Administration (CNSA) as well as TNRIS Google imagery and NAIP sources. The images applied were selected based on temporal agreement and adequate resolution. The source and date of the aerial imagery applied at each CEPRA Beach location for the 2017 reporting period is provided in Table A2. The aerial photographs applied in the reporting are available for viewing using the Coastal Habitat Restoration GIS (CHRGIS) mapping tool.

Coastal Habitat Restoration GIS (CHRGIS)

Coastal Habitat Restoration GIS consists of a website and online mapping tools that support resource managers in accessing and reviewing coastal data sets, in particulate beach profile, shoreline position, topography, bathymetry and aerial imagery. All data described in the following report can be visualized and compared and queried using the Mapping Tool (planview) and the Profile Tool (cross section). The CHRGIS Mapping Tool was upgraded to HTML5/JavaScript during 2017 and now supports all current browsers and functions on mobile devices. The link to the website, Mapping Tool and Profile Tool are:
https://cbi.tamucc.edu/CHRGIS/
http://cartogram.tamucc.edu/chrgis/maps/
http://cartogram.tamucc.edu/chrgis/profiles/

Nourishment Criteria

Beach nourishment is recommended when the beach or individual beach cell within a larger beach system reaches 50% of the Target or recommended width or if the rate of shoreline recession indicates 50% of the beach will reach the Action Width within 2 years. Recommendations may also be based on other maintenance triggers that are more specific to each beach such as dune restoration (Jamaica Beach) and sand redistribution to restore nearshore depth (University Beach). A detailed list of Target Width, surveyed width and associated Action Width (width at which nourishment is recommended within 1 to 2 years) for each beach is given in Table 3A and in a table within the narrative assessment section for each beach. With that said, each beach in the monitoring program is unique with often subtle differences in location/orientation along the coast, coastal structures, size, grain size, and influence of primary forcing mechanisms (wind waves, open ocean waves, vessel wake, aeolian transport). Therefore, individualized guidance is provided to accommodate the wide range of issues associated with each location and these alternative guidelines are updated during future annual surveys.

Recommendations

Recommendations for action at the monitoring sites were separated into three Tiers based upon analysis of change over the period for which data was available (Table A4-A5). Recommendations are based on Tiers defined as:

- Deferred: In cases where a beach has been recently nourished within 1 year of the survey date or a nourishment is planned to initiate within 1-year of the survey (Not Applicable 2017)
- Tier 1 Beaches: widespread erosion or hot spots where infrastructure is threatened, Action Width has been reached or is anticipated within 2 years, or widespread dune restoration is ongoing. Initiation of planning toward action is recommended within 1-year. Action is recommended at Tier 1 Beaches within 1-2 years.
- Tier 2 Beaches: special considerations such as limited erosion isolated to hot spots (Rockport Beach), recent nourishment (Multiple locations), or nearshore depth restriction (University Beach).
- Tier 3 Beaches: relatively stable over the available survey history but may require action within 5 years. Annual surveys are recommended to determine if a change in status is warranted. (Not Applicable 2017)

Recommendations are revised annually upon review of additional survey data.

Table A1. Aerial Imagery: Date and Source

CEPRA Locations	Source of Aerial Images	Date of Aerial Images	Additional Information
Bolivar Peninsula	Sanborn Aerial	9 Sep2017	Upper coast post-Harvey
Indianola Beach	Sanborn Aerial	9 Sep 2017	Upper coast post-Harvey
Jamaica Beach	Hurricane Harvey: Emergency Response Imagery of the Surrounding Regions	Aug 2017	Limited metadata: month/year only
McGee Beach	Texas Imagery Service	30 Aug 2017	N/A
North Beach	Texas Imagery Service	30 Aug 2017	N/A
Bryan Beach (Quintana)	Hurricane Harvey: Emergency Response Imagery of the Surrounding Regions	Aug 2017	Limited metadata: month/year only
Rockport Beach	Texas Imagery Service	30 Aug 2017	N/A
Sargent Beach	Hurricane Harvey: Emergency Response Imagery of the Surrounding Regions	Aug 2017	Limited metadata: month/year only
Surfside Beach	Hurricane Harvey: Emergency Response Imagery of the Surrounding Regions	Aug 2017	Limited metadata: month/year only
Sylvan Beach	Hurricane Harvey: Emergency Response Imagery of the Surrounding Regions	Aug 2017	Limited metadata: month/year only
University Beach	Texas Imagery Service	30 Aug 2017	N/A

Notes:
https://storms.ngs.noaa.gov/storms/harvey/download/metadata.html
https://tnris.org/texas-imagery-service/

Table A2. CEPRA Beach Action and Target Width Criteria 2017
*** Project area within larger study area**
^ Post-Nourishment
Note: At or within 10 ft of Action Width (50% Target)

Beach Name	Target Width (ft) (MHHW)	Survey Width Minimum (ft)				Action Width (ft)	Additional Criteria/ Status
Bolivar Peninsula Gilchrist Beach	Historic		**2015**	**2016**	**2017**		**Gilchrist Recommended:** Stable Continue Dune Reinforcement
Jetty to 130+0	120		127-158	130-149	115-168	60	
135+0 to 155+0	120		96-120	93-117	102-125	60	
160+0 to 200+0	120		74-104	72-115	86-114	60	
Caplen Beach							**Caplen Completed:** BUDM Feb 2015 BUDM Dec 2016 BUDM Apr 2018
Jetty 115+0 to 120+0	120		40-62	20-52	16-25	60	
110+5 to 105+0*	120		5-73	39-79	16-70	60	
100+0 to 75+0*	120		64-115	66-98	55-108	60	
West 20+0 to 70+0	120		46-118	45-99	33-100	60	
West 15+0 to 0+0	120		76-98	70-78	70-73	60	
Indianola Beach	**Design (75 ft)** (MLLW)		**2015 Min**	**2016 Min**	**2017 Min**		**Recommended** Nourishment Cells 1-4 and 7 **Nourishment: July 2017** **Harvey Damage: Renourishment** Cell 7
Cell 1	70		15	15	6	35	
Cell 2	70		18	18	15	35	
Cell 3	70		20	13	5	35	
Cell 4	70		38	21	16	35	
Cell 5	70		69	57	45	35	
Cell 6	70		60	44	42	35	
Cell 7	70		63	40	45	35	
Cell 8	70		60	60	60	35	
Cell 9 (Open cell)	NA		N/A	N/A	N/A	N/A	
Jamaica Beach		**2014**	**2015**	**2016**	**2017**		**Recommended** Continued dune reinforcement No need for additional nourishment indicated
STA 385+00	120	114	107	86	86	60	
STA 390+00	120	132	129	98	110	60	
STA 395+00	120	159	154	122	140	60	
STA 400+00	120	137	129	97	113	60	
STA 405+00	120	126	124	92	107	60	
STA 410+00	120	111	107	82	90	60	
STA 415+00	120	122	117	92	98	60	
STA 420+00	120	91	91	66	66	60	
STA 425+00	120	88	82	46	65	60	
McGee Beach	**Record Max 2007**		**Min. 2015**	**Min. 2016**	**Min. 2017**		**Recommended** Relatively Stable Recommendation: South end spot nourishment or redistribution to restore width near multiple structures
South End (Holiday Inn)	100		68	78	62	50	
Central Section	220		184	184	190	110	
North End	240		208	200	200	120	

Table Continues Next Page

Table A2. CEPRA Beach Action and Target Width Criteria 2017

*** Project area within larger study area**
^ Post-Nourishment
Note: At or within 10 ft of Action Width (50% Target)

Beach Name	Target Width (ft) (MHHW)	Beach Width (ft) 2014	Beach Width (ft) 2015	Beach Width (ft) 2016	Beach Width (ft) 2017	Action Width (ft)	Additional Criteria/ Status
North Beach			**2015**	**2016**	**2017**		**Nourishment:**
SWest End at Lex							**April 2016**
STA 2 to STA 6	120		4-60	95-155	67-98	60	Nourishment and
STA 7 to STA 12	100		85-96	164-177	95-160	50	infrastructure
STA 14 to STA 22	100		23-99	92-148	81-143	50	restoration
Beach Parks							
Golf Place (STA 14)	100		23	92	81	50	**Recommendation** Post-Harvey
Burleson (STA 24)	100		37	82	78	50	FEMA
Surfside (STA 32 -36)	100		55	70	70	50	Reimbursement
Gulfspray (STA 46)	100		105	89	95	50	**Status**
East End (STA 70)	100		195	103	125	50	Review IP
Quintana:	**Design** 2005 150 (Max)		**2015**	**2016**	**2017**		**Recommended:** Nourishment/ dune restoration
Bryan Beach							
-25+0 to -5+0	N/A		127-194	95-158	85-144	75	**Nourishment**
0+0*	150		144	155	120	75	Completed
5+0*	150		80	79	60	75	Feb 2016
10+0*	150		76	79	50	75	
15+0*	150		76	72	48	75	
20+0*	150		76	68	39	75	
25+0	150		78	59	32	75	
30+0	150		94	54	39	N/A	
35+0	150		80	45	27	N/A	
Rockport Beach	**Record Max 2007**		**2015**	**2016**	**2017**		**Nourishment Completed:** Jan 2016
East End	80		34-60	70-85	72-105	40	
Center, East and West	100		81-101	90-99	90-99	50	**Stable 2016**
Park Facility	170		168	168	168	85	
West End	80		42-58	47-66	55-72	40	
Sargent Beach	**Revised 2014 (120ft)**	**2014**	**2015**	**2016**	**2017**		**Recommended** Cyclic(Biannual) Nourishment
(STA-25+0-STA -15+0)	N/A	60-87	37-58	21-40	0-25	N/A	
(STA -10+0 -STA 10+0)	N/A	92-101	62-63	28-40	(-6)-28	N/A	Consistent high rate of
STA 15+0	200	72	54	47	19	100	erosion
STA 20+0	200	92	62	40	24	100	**Project Area:**
STA 25+0	200	101	63	40	23	100	-87 cy/ft
STA 30+0*	200	117	94	54	41	100	**Study Area:**
STA 35+0*	200	135	127	90	70	100	-108 cy/ft
STA 40+0*	200	139	134	87	71	100	
STA 45+0*	200	118	99	97	53	100	**Exposures**
STA 50+0*	200	104	90	67	33	100	***West:***
STA 55+0	200	107	94	59	35	N/A	Clay substrate
STA 65+0	200	99	96	65	48	N/A	**Central:** Concrete
STA 70+0 to STA 95+0)	N/A	84-119	102-152	58-95	45-72	N/A	***East:***
(STA 100+0-STA 125+0)	N/A	11-94	7-91	(-8)-96	(-19)-32	N/A	Revetment

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Table A2. CEPRA Beach Action and Target Width Criteria 2017
*** Project area within larger study area**
^ Post-Nourishment
Note: At or within 10 ft of Action Width (50% Target)

Beach Name	Target Width (ft) (MHHW)	Beach Width (Ft)				Action Width (ft)	Additional Criteria/ Status
Surfside Beach	**Design 2011**	**2015**	**2016**	**2017**			**Recommended: Nourishment**
West End Jetty to -5+0	125	39-71	11-38	5-7		63	Alternatives under
Revet(W) 0+0 to 15+0*	125	(-14)-34	(-27)-16	(-57)-0		63	review by GLO
Revet(C) 20+0-30+0*	125	49-72	22-40	10-23		63	
Revet(E) 35+0* E.	125	121	83	66		63	
40+0-75+0	N/A	93-157	75-130	75-130		N/A	
East end 80+0-105+0	N/A	100-124	65-79	65-79		N/A	
Sylvan Beach	Design	**2014**	**2015**	**2016**	**Oct 2017**		**Partial Nourishment:**
North Cell	2009						Completed May 2017
South End	75	33	30	20	45	37	
Mid-Point S-C	75	32	25	13	30	37	**Recommended:**
Center	75	70	62	48	50-72	37	Full Nourishment to
North End	75	107-148	94-130	81-126	95-125	37	design specification
South Cell							within 2 years. Interim
South End	75	40	37	28	59	37	nourishment on south
Mid-Point S-C	75	33	48	19	46	37	end to restore volume
Center	75	70	60	49	49	37	lost during Harvey
North End	75	103-141	89-123	78-119	91-119	37	within 1year
University Beach	**Design Width 2001**	**2015**	**2016**	**2017**			**Recommended** -Depth Limited -Mechanically
West (IR9-IR11)	150	118-175	120-180	105-175		75	redistribute sand
Center (BR2-BR4)	150	104-124	108-130	100-127		75	from nearshore
East (IR4-IR6)	150	108-118	122-129	117-126		75	

Table A3. Status and Recommendations (2017)
List in order of Relative Priority

Tier 1. Implement Action Within 1-2 years

Beach	Action Width	Area of Concern	Threat to Backshore Infrastructure	Rate of Shoreline Change	Status/ Recommendation
1. Sargent Beach	✓	**Action Width:** **Project Area** STA 15+0 to 50+0 100% of beach in the project area and along the entire study area to the east and west is at or less than the Action Width **Exposures:** ***West*** Clay Substrate (Variable) ***Central/West*** Concrete (Foreshore) ***East*** Revetment (MHHW)	**Imminent** Access, Park Facilities Shoreline is at or approaching revetment east of the project area STA 15+0 to STA -25 Due to erosion of berm and erosion exposing revetment, public access is limited east of FM 457	**Recession ft/yr** **Project Area** -26.7 (2016-2017) -20.6 (2015-2016) -11.5 (2014-2015) **Full Study Area** -27.0 (2016-2017)	**Nourishment** Project Area *(STA 15+0 to 50+0)* **Estimated volume:** **As-Built (120 ft wide)** 201,500 cu yd (> 2X 2016 estimate) ***> Width (200 ft wide)*** 437,500 cu yd ***Add 1,500 ft alongshore to East*** **As-Built (120 ft)** +99,000 cu yd **> Width (200 ft)** +133,000 cu yd
2. Surfside Beach	✓	Narrow beach along revetment and shoreline recession landward of west end of revetment **Action Width** **Project Area** (STA -5+00 to 37+5) 100% at Action Width Revetment STA 0+0 to STA 30+0 100% at Action Width No Beach STA 0+0 to 15+5 Rock reinforcement exposed -5+0 to revetment	**Imminent and Persistent** High historic rate of erosion and recession Limited beach fronting west end of the revetment	**Recession ft/yr** **2016-2017** **Post Harvey** -15.0 **Project Area** -15.2 Study Area **Historic Recession** **Project Area** **-5.0** **2012-2017** -7.0 (2007-2017) -5.5 (2000-2017)	**Recommendation:** **Nourishment** ***Project Area:*** STA -5+0 to STA 37+5 329,000 cu yd ***Revetment Only*** 0+50 to 35+0 250,000 cu yd ***Previously Defined Project Area*** **STA 5 to STA 20** **(for ref.)** 120,000 cu yd **Pending Project** Groins/Nourishment in planning stages as per GLO

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Table A3 Continued. Status and Recommendations (2017)
List in order of Relative Priority

Tier 1. Implement Action Within 1-2 years

Beach	Action Width	Area of Concern	Threat to Backshore Infrastructure	Rate of Shoreline Change	Status/ Recommendation
3. Bryan Beach (Quintana)	✓	Highest rate of recession identified along Project Area and to the to the east and west of the project area over data record (2007-2017) including post-Ike Erosion focused across entire berm Action Width: 90% of project area is at or < Action Width Exception is beach fronting	Threat highest fronting S Lake Dr. Decreasing width of beach increases potential for storm damage to backshore and duneline	**Recession ft/yr** ***Project Area*** -31.0 (2016-2017) -13.4 (2015-2016) ***Full Study Area*** -32.0 (2016-2017) -16.6 (2015-2016)	**Recommendation** Nourishment to Target Width Due to high rate of recession historically and narrow beach at or ±5 ft of Action Width during 2015 and 2016 and less than Action Width during 2017 **Project Area** STA 0+0 to STA 20+0 Fill volume 110,000 cu yd **Nourishment Completed:** **Mar 2016** BUDM
4. North Beach	✓ 40% of beach fronting Parking Lot at southwest end at Action Width	Beach in Front of City Parks narrow due to focused erosion along the southwest side of the beach that is reinforced by inadequate setback of facilities	Lack of dunes,low elevation along backshore and inadequate setback of facilities and businesses provide for inland damage during periods of high water and onshore forcing	**Recession ft/yr** Erosion Focused on Southwest Side **Post-Harvey Southwest Side** -14.5 **Full Study Area** Pre Post Nourish +6.4 2015-2016 -6.2 (2014-2015) -12.2 (2009-2012) Post-Nourish -9.0 (2007-2016) Pre-Nourish -9.0 (2007-2015)	**Recommendation:** Nourishment of at a minimum of the southwest end fronting the Parking Lot at Lex **Alternative #1** **STA 2+0 to STA 5+0** 31,300 cu yd **Alternative #2** **STA 2+0 to STA 8+0** 24,000 cu yd **Alternative #3** **STA 2+0 to STA 14+0** 13,200 cu yd **Increase Action Width** to 70 ft along southwest end to provide opportunity to plan for nourishment due to rapid recession rate

Table Continues Next Page

Table A3. Status and Recommendations (2017)
List in order of Relative Priority

Tier 1. Implement Action Within 1-2 years

Beach	Action Width	Area of Concern	Threat to Backshore Infrastructure	Rate of Shoreline Change	Status/ Recommendation
5. Rockport Beach	100 % of beach exceed Action Width	West End of beach remains narrow (45-55 ft wide)	None Identified Potential for Compromised Public Access	**Recession ft/yr** +2.4 (Harvey) Pre/Post Nourish +6.0 (2015-2016) -0.4 (2014-2015) -0.8 (2007-2015) -1.34 (2007-2012) Post-Harvey position of MHHW influenced by berm erosion	**Recommendation:** **Annual Assessment** **Nourishment** recommended to restore the volume and elevation of the berm that was reduced after Harvey (2017) Completed January 2016 Restore post-2016 nourishment volume and berm elevation
6. Sylvan Beach	✓ North Cell: South End	High recession rate continues in both beach cells Persistent focused erosion along south end of each beach cell Storm deposition in nearshore beyond limit of anticipated onshore exchange	Anticipate need for focused placement on south end within 2 years post-nourishment (2017)	**Recession** Avg Rate per month: -2.9 ft/month (North) -1.7ft/month (South) Episodic Event Rate (Nourish to Harvey) -8.7 ft/event (North) -5.1 ft/event (South) Abbrev. Study Period 5-month Rate (May-Oct 2017) -14.5 ft/event (North) -8.5ft/event (South)	**Recommendation** - Restore Target Width and design elevation at North and South Sylvan - Restore volume lost during Harvey along south end of both beach cells as interim restoration until full restoration is funded. **Completed** May 2017 nourishment
7. Indianola Beach	✓	Cells 1-4: < Action Width Cell 7: Net loss of 30% of June 2017 fill volume	Not imminent Nourishment toward restoring Target Width to support longevity of public access	**Variable ft/yr** Highest Rate Observed to date Post-Harvey Cell 1: -13.4 Cell 2: -3.7 Cell 3: -5.4 Cell 4: -4.1 Cell 7: -19.0	**Recommendation** Nourishment Cells 1-4: < AW Cell 7: Restore post-nourishment volume due to net loss sustained during Harvey

Table Continues Next Page

Table A3. Status and Recommendations (2017)
List in order of Relative Priority

Tier 1. Implement Action Within 1-2 years

Beach	Action	Area of Concern	Threat to Backshore Infrastructure	Rate of Shoreline Change	Status/ Recommendation
8. **Bolivar Peninsula** **Caplen Beach**	✓	**Action Width:** 40% of Project Area 70% of Study Area **High rate of shoreline recession** after Harvey despite BUDM 2014-2016	Persistent erosion despite multiple frequent BUDM/dune restoration Potential for impact to residential property and public access	**Recession ft/yr** **Project Area** -1.6 Jan 2017 **Full Study Area** -5.33 (2015-Jan2017) -14.3 (2014-2015) -7.7 (2009-2017) -2.8 (2000-2015)	**Recommendation** Continued annual BUDM placement as nourishment and dune reinforcement Supplemental Beach Nourishment to reinforce BUDM

Table A4. Status and Recommendations (2017)

Tier 2. Implement Action Within 2-3 years

Beach	Action Width	Area of Concern	Threat to Backshore Infrastructure	Rate of Shoreline Change	Recommendation
1. Bolivar Peninsula **Gilchrist**	100% > Action Width (2009-2017) 80% < Target Width (2017)	None Identified During 2017	None Identified During 2017	**Recession ft/yr** +3.9 (2016-2017) +0.2 (2015-2016) -11.2 (2014-2015) -2.7 (2000-Jan2017)	**Recommendation:** Although recovery continues the continued support of dune restoration and associated beach nourishment
2. Jamaica Beach	**Project Area:** 100% > Action Width 90% < Target Width **Full Study Area:** 100% > Action Width 80% < Target Width	**Concerns:** No concerns identified during 2017	No imminent threat but Recovering duneline remains low and narrow. Annual assessment are recommended due to high rate of recession during 2016 reporting period	**Recession ft/yr** +12.7 (2016-2017) -23.5 (2015-2016) -2.8 (2014-2015) -4.6 (2013-2016) +1.3 (2000-2016) -1.5 (2006*-2016) *nourishment	**Recommendation:** Continue dune reinforcement due to limited width of duneline, proximity of backshore infrastructure, historic erosion, and recent trend of recession/erosion
3. University Beach	**Depth- Limite Criteria** 100% > Action Width 75% < Target Width	1. Shallow nearshore reduces functionality 2.Shallow nearshore promotes growth of vegetation and potential for wetland development	No imminent threat to infrastructure	**Recession ft/yr** -9.1 (2016-2017) *Highest rate since 2009 tropical season* +3.6 (2015-2016) -3.2 (2001-2016)	**Recommendation:** Redistribute/reclaim sand from inside beach cell to nourish berm and > water depth **Method:** Land-based sand re-distribution Reclaim sand from tombolo Estimated volume of reclaimed sand: 10,000 cu yd

Table A5. 2017 CEPRA Beach Survey Prioritization and Historic Survey Dates (Revised Dec 2017) *Application limited by data extent CBI (Conrad Blucher Institute) NMS (Naismith Marine Surveying)		
	Bayside Beach Locations	
CEPRA Location	**Anticipated 2018 Survey Date**	**Historic Survey Dates**
North Beach* (previously Corpus Christi Beach)	TBD Revised Upon Contract Authorization	Sep 2007 (CBI-sps City-bps) May 2009 (CBI-NMS) 20 Jun 2012 (CBI-NMS) 22 Jul 2014 (CBI-NMS) 16 Sep 2015 (CBI-NMS) 28 Nov 2016 (CBI-NMS) 06 Sep 2017 (CBI-NMS)
Rockport Beach*	TBD Revised Upon Contract Authorization	Apr 2007 (CBI-NMS) Apr 2009 (CBI-NMS) 29 May 2012 (CBI-NMS) 25 Apr 2014 (CBI-NMS) 15 Sep 2015 (CBI-NMS) 01 Dec 2016 (CBI-NMS) 07 Sept 2017 (CBI-NMS)
Sylvan Beach	TBD Revised Upon Contract Authorization	Apr 2008* Jan 2010 06 Jun 2012 (CBI-NMS) 06 Jun 2013 (CBI-NMS) 15 May 2014 (CBI-NMS) 24 Sep 2015 (CBI-NMS) 30 Nov 2016 (CBI-NMS) 25 Oct 2017 (CBI-NMS)
Indianola Beach	TBD Revised Upon Contract Authorization	Mar 2007 (CBI-NMS) May 2009 (CBI-NMS) 11 Jun 2012 (CBI-NMS) 28 Apr 2014 (CBI-NMS) 17 Sep 2015 (CBI-NMS) 16 Dec 2016 (CBI-NMS) 05 Oct 2017 (CBI-NMS)
University Beach	TBD Revised Upon Contract Authorization	Aug 2001-Aug 2010 (CBI-NMS) 07 Aug 2012 (CBI-NMS) 20 Aug 2014 (CBI-NMS) 03 Nov 2015 (CBI-NMS) 26 Dec 2016 (CBI-NMS) 03 Oct 2017 (CBI-NMS)
McGee Beach	TBD Revised Upon Contract Authorization	Jun 2007 (CBI-NMS) Apr 2009 (CBI-NMS) 01 Jun 2012 (CBI-NMS) 03 Jun 2014 (CBI-NMS) 03 Nov 2015 (CBI-NMS) 26 Dec 2016 (CBI-NMS) 19 Sep 2017 (CBI-NMS)

Table A5. 2017 CEPRA Beach Survey Prioritization and Historic Survey Dates
(Revised Dec 2017)
*Application limited by data extent
CBI (Conrad Blucher Institute) NMS (Naismith Marine Surveying)

Gulf Locations		
CEPRA Location	**2017 Survey Date**	**Historic Survey Dates**
Sargent Beach	TBD Revised Upon Contract Authorization	2000 (BEG)* 2008 Nov 2013 (RVE)* 2011 (Coastal Tech.)* 07 Jun 2013 (CBI-NMS) 02 May 2014 (CBI-NMS) 30 Sep 2015 (CBI-NMS) 05 Dec 2016 (CBI-NMS) 10 Oct 2017 (CBI-NMS)
Surfside Beach	TBD Revised Upon Contract Authorization	Apr 2007* Nov 2008* Jan 2010 Jan 2011 11 July 2012 (CBI-NMS) 23 Jul 2014 (CBI-NMS) 24 Sep 2015 (CBI-NMS) 20 Dec 2016 (CBI-NMS) 11 Oct 2017 (CBI-NMS)
Quintana Bryan Beach	TBD Revised Upon Contract Authorization	Mar 2005 Jul 2007 Oct 2008 25 July 2012 (CBI-NMS) 24 Jul 2014 (CBI-NMS) 22 Sep 2015 (CBI-NMS) 20 Dec 2016 (CBI-NMS) 11 Oct 2017 (CBI-NMS)
Bolivar Peninsula Gilchrist Beach Caplen Beach	TBD Revised Upon Contract Authorization	Jul 2009* Mar 2012 (Caplen)* (pre/post-placement) 27 June 2012 (CBI-NMS) 28-31 Jul 2014 (CBI-NMS) 10 Nov 2015 (CBI-NMS) 18 Jan 2017 (CBI-NMS) 29 Nov 2017 (CBI-NMS)
Jamaica Beach	TBD Revised Upon Contract Authorization	2000 (BEG)* 2006 (LAN)* 2008 (TGLO)* 2010 (HDR)* 2011 (HDR)* 2012 (LAN)* 04 Jun 2013 (CBI-NMS) 19 May 2014 (CBI-NMS) 29 Sep 2015 (CBI-NMS) 28 Dec 2016 (CBI-NMS) 07 Nov 2017 (CBI-NMS)

Caplen Beach

Caplen Beach is located west of Rollover Pass with the study area extending approximately 12,000-ft alongshore from the pass to Casamare Ln. (Fig 1). Five (5) recent beach nourishment projects have been conducted as beneficial use of dredge material (BUDM) applications by the USACE (Mar 2012, Jan 2014, Feb 2015, Nov 2016, Dec 2016 and Apr 2018). The Jan 2017 survey served as both the annual survey for the period between 2015 and 2016 as well as a post-nourishment survey for the two BUDM placements during Nov and Dec 2016. The Dec 2017 survey serves as both the annual survey and the post-Hurricane Harvey survey. Since 2000, several previous projects have been conducted along Caplen Beach to address damage sustained during Tropical Storm Francis (1998) and later Hurricane Ike (2008) as well as ongoing background erosion west of Rollover Pass (Table 1). The annual re-occurring nourishment and dune restoration in the project area is focused within 4,000 ft of the inlet, corresponding roughly to the region defined as STA 110+50 (East) to STA 70+0 (West). Recent post-nourishment survey data, consisting of limited as-built surveys for the 2014-2017 USACE projects, was not received by the time of this reporting; therefore, reporting will be updated upon receipt of the data. These data will be included in analysis and uploaded to the GIS archive (CHRGIS) upon review for applicability.

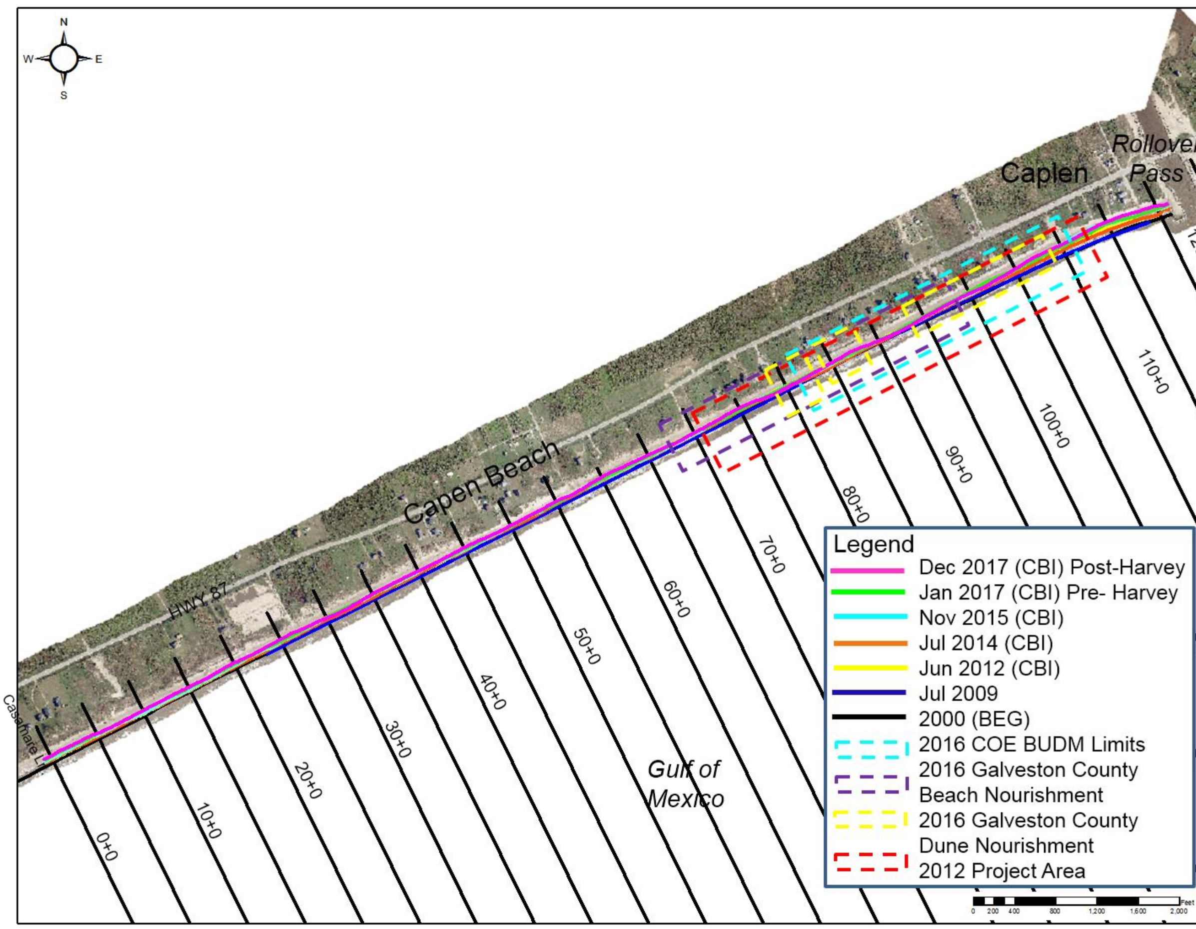

Figure 1. Caplen Beach is located west of Gilchrist Beach and immediately west and adjacent to Rollover Pass

Shoreline Analysis: Caplen Beach

Between Jan 2017 and Dec 2017, shoreline recession continued to dominate along the Project Area at Caplen Beach as previously observed over the entire data record (2009-2017) and the long-term study period between 2000 (BEG) and Dec 2017 (Fig 2-9). The average rate of shoreline change over the annual assessment period included influence of the BUDM placement completed during April 2017 as well as the more recent influence by Hurricane Harvey. The annual average rate of shoreline change in the Project Area between Jan 2017 and Dec 2017 was -1.6 ft/yr, which is in close agreement with the rate measured between Nov 2015 and Jan 2017 and with the average over the CBI monitoring history (2012-Dec 2017). The rate of shoreline change over intervals of interest for the Project Area and Study Area are shown in Table 2. The average rate of shoreline change between 2009 and 2017 was -6.2 ft/yr in the Project Area and -5.5 ft/yr in the Study Area. Applying the BEG 2000 shoreline as a baseline, the rate of change observed since 2000 was in close agreement in both the Project Area (-2.8 ft/yr) and broader reaching Study Area (-3.0 ft/yr).

The shoreline positions measured during Dec 2017 and Jan 2017 represent the two most landward positions measured since 2009. Both surveys were conducted during the winter season, therefore the shoreline position may have been influenced by forcing over the months, or as few as days, immediately preceding the surveys. In addition, the Dec 2017 shoreline position reflects the influence of forcing and higher water levels associated with Hurricane Harvey. The greatest uninterrupted shoreline recession was focused east of the Project Area between the Freeport Jetty and STA 105+0, where the shoreline receded between 10 to 38 ft. West of this focused recession, shoreline advance dominated along the 1,500 ft segment of the beach from STA 105+0 westward to STA 90+0. A 1,000-ft stretch of this segment coincided with the location of the 1,500-ft long dune restoration that was conducted during 2016 where the shoreline advanced up to 30 ft. West of STA 90+0, shoreline change was variable with a limited segment of advance coinciding with the location of the smaller, approximately 700-ft long, area of dune restoration in the vicinity of STA 80+0 and 85+0. West of STA 80+50 shoreline change was variable with recession interrupted by segments of relative stability and limited advance.

Interpreting the annual average rate of shoreline change at Caplan is challenging and can be misleading due to the frequency of nourishment and seasonal differences in timing of surveys. The highest rate of recession along the Study Area is located east of the Project Area between STA 110+0 and the south jetty. The shoreline position at the east end of Caplen Beach near the south jetty continues to be located well landward of that along the western terminus of Gilchrist Beach. The shoreline south of the inlet was located 190 ft landward of the seaward end of the revetment as opposed to the position of the shoreline bordering Rollover Pass at Gilchrist Beach, which was within 50 ft of the end of the revetment. The shoreline at the jetty is located landward of the landward end of the revetment providing the opportunity for breach and the exacerbation of erosion near the structure.

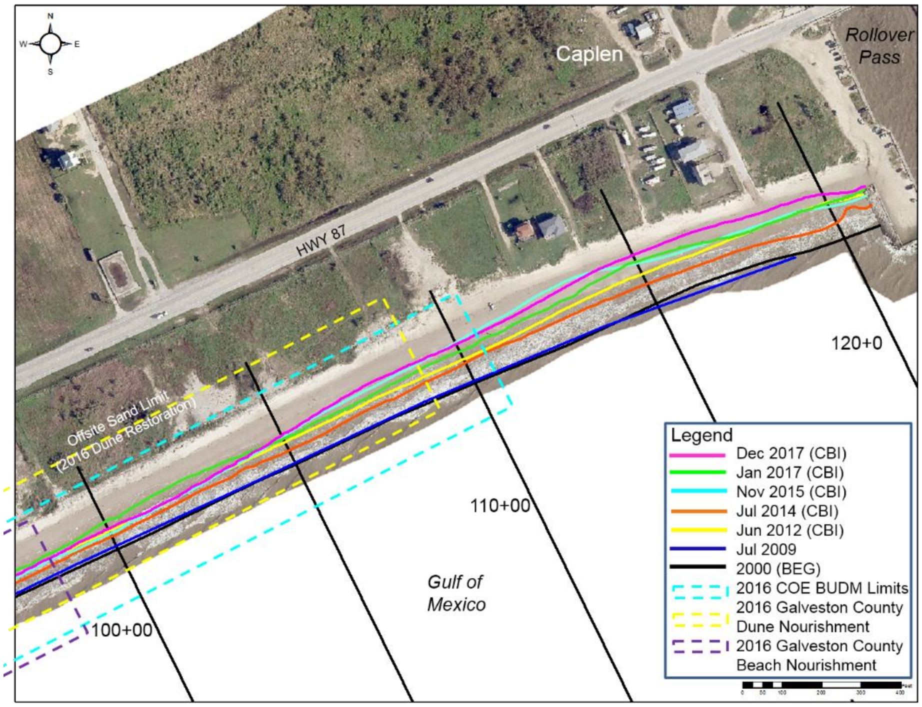

Figure 2. Recession dominated from Rollover Pass to the east end (STA 110+0) of the Project Area (Dec 2017). Note position of Dec 2017 shoreline landward of the landward limit of the landward end of the jetty at Rollover Pass

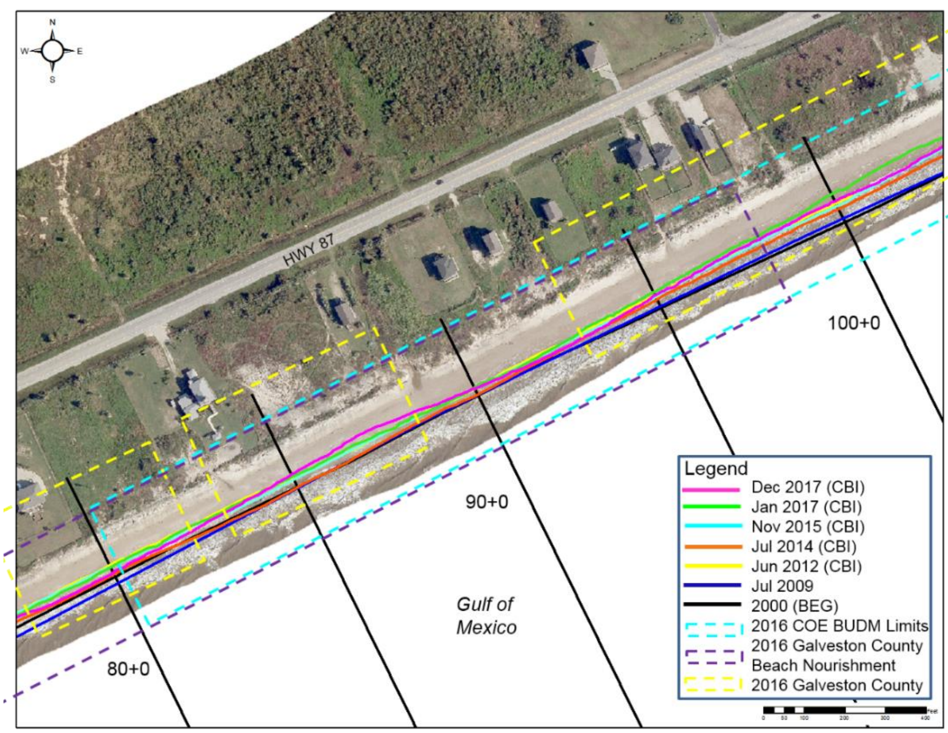

Figure 3. Advance dominated westward from STA 105+0 to STA 90+0 (Dec 2017) with shoreline change becoming more variable fronting the small-scale dune restoration with recession on the east end (STA 90+0 to STA 85+0) and advance on the west end (STA 85+0 to STA 80+50)

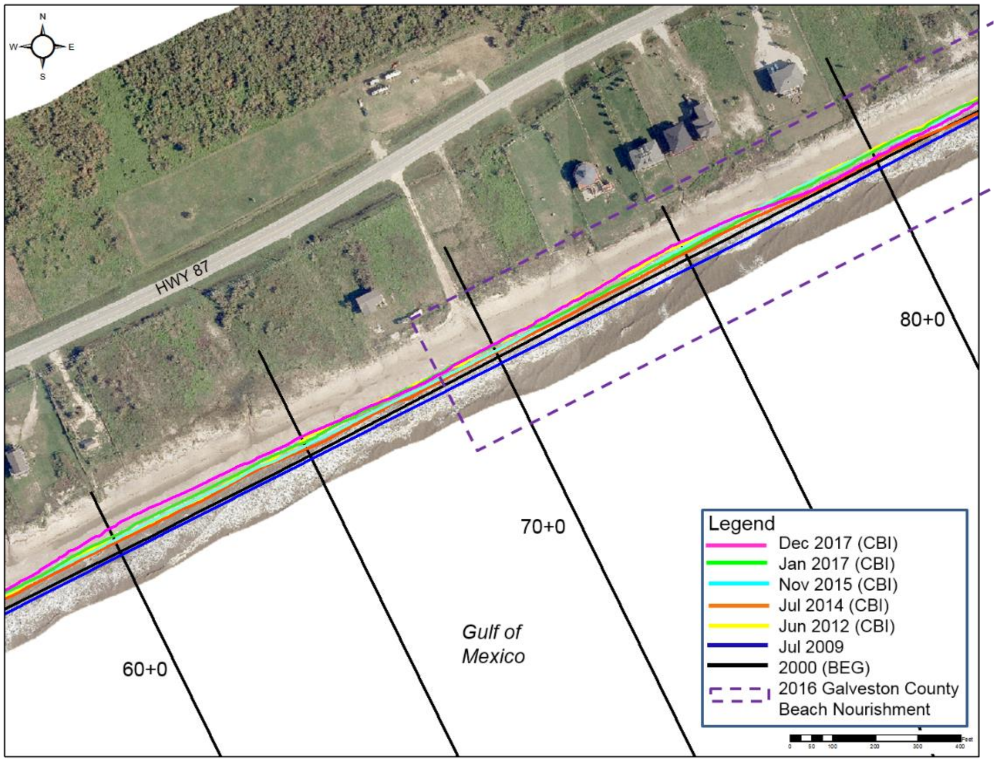

Figure 4. Shoreline recession dominated east of the Project Area from STA 75+0 to STA 60+0 (Dec 2017)

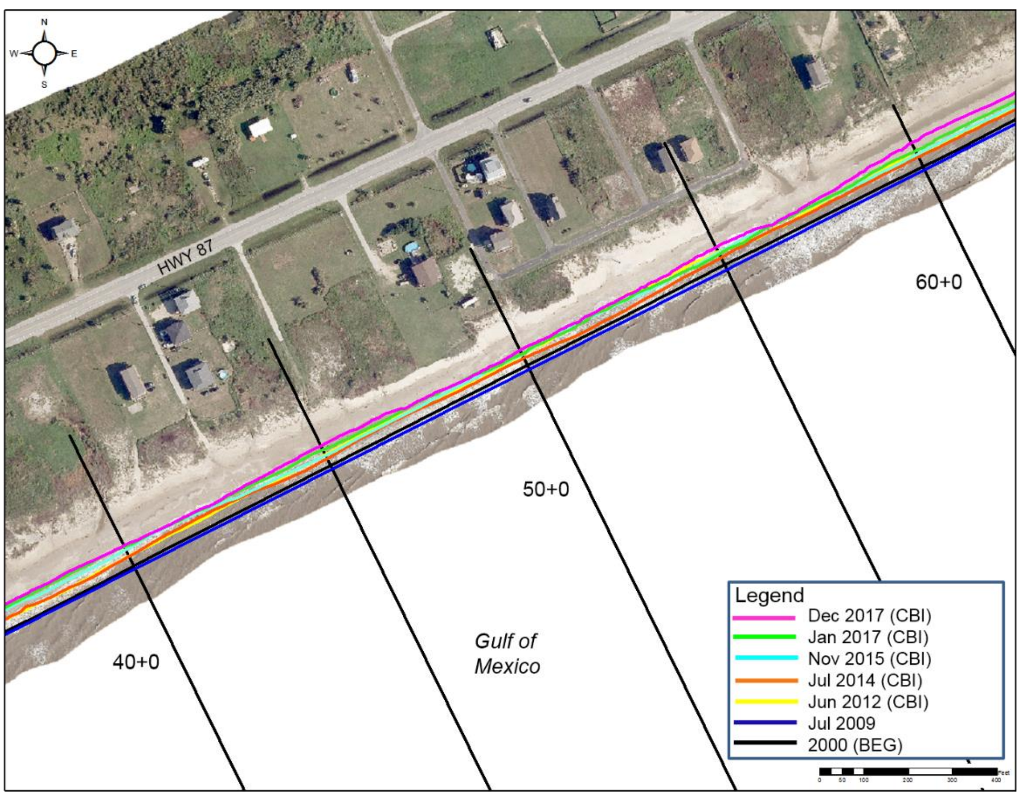

Figure 5. Shoreline change was variable with segments of recession interrupted by small segments of stability and advance from STA 60+0 to STA 40+0 (Dec 2017)

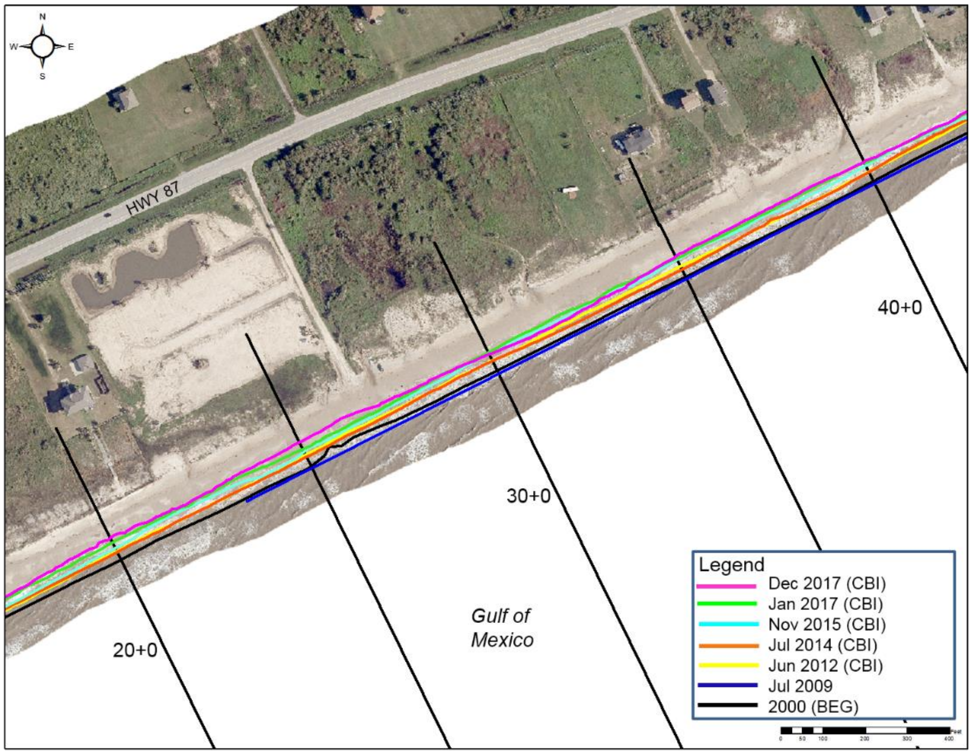

Figure 6. Shoreline change was variable with segments of recession interrupted by small segments of stability and advance from STA 40+0 to STA 20+0 (Dec 2017)

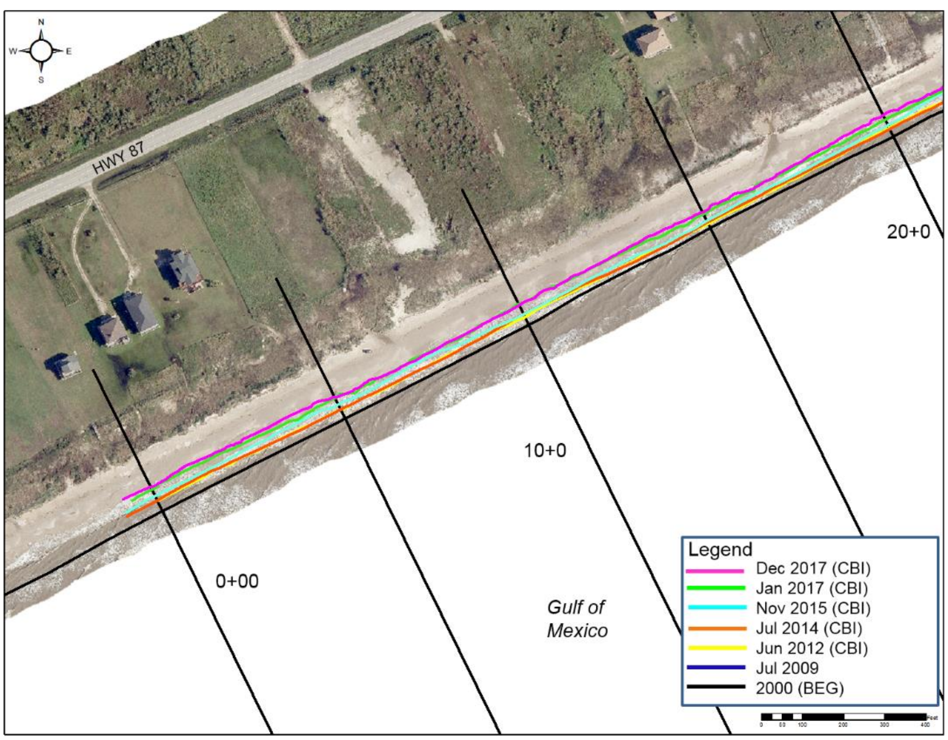

Figure 7. Shoreline change was variable with segments of recession interrupted by small segments of stability and advance from STA 20+0 to STA 0+0 (Dec 2017)

Table 1. Rate of Shoreline Change: Caplen Beach (STA 0+00 to STA 120+00) 2017				
Project Area (STA 75+50-115+50)				
Interval (Year)	**Description**	**Rate of Change + Advance - Recession (ft/yr)**	**Distance ft**	
			Max +	**Min -**
Jan 2017-Dec 2017	**Annual (Post Harvey)**	-1.6	+32	-31
Nov 2015-Jan 2017	**Annual (Nourishment)**	-1.0	+36	-29
Jul 2014-Nov 2015	**Annual (Nourishment)**	-15.6	0	-66
Jun 2012-Dec 2017	**5-yr Multiple Fill Projects**	-1.3	+34	-18
Jun 2012-Jul 2014	**Post-nourishment**	-6.1	+10.4	-33
2009-Dec 2017	**Period of Data Record** Tropical Storm Bill Hurricane Harvey 6 BUD Placement	-6.2	0	-131
2000-Jan 2017	**Historic (BEG baseline)**	-2.8	0	-108
Full Study Area (STA 0+00 to STA 125+00)				
Jan 2017-Dec 2017	**Annual (Post Harvey)** **BUDM Placement** **Jan 2017 applied as 2016**	-6.6	+32	-41
Nov 2015-Jan 2017	**Annual** **BUDM Placement** **Jan 2017 applied as 2016**	-5.3	+36	-29
Jul 2014-Nov 2015	**Annual** **BUDM Placement** Tropical Storm Bill	-14.3	0	-66
Jun 2012-Jul 2014	**Bi-annual Survey** **BUDM Placement** (no significant tropical storms)	+ 5.7	+30	-4
2012-Jan 2017	**5-yr Multiple Fill Projects** **Jan 2017 applied as 2016**	-2.8	18	-37
2009-Dec 2017	**Period of Data Record** Tropical Storm Bill Hurricane Harvey 6 BUD Placement	-5.5	0	-151
2009-Jan 2017	**Post-Ike Recovery Period** Tropical Storm Bill 5 BUD Placement	-7.1	0	-129
2009-Jun 2012	**Full Study Area: Post-storm recovery period and nourishment influence** (STA 0+00 to 120+00)	-11.5	0	-35
2000-Dec 2017	**Historic (BEG baseline)**	-3.0	0	-141
2000-Jan 2017	**Historic (BEG baseline)**	-2.8	0	-120
Surveys Nov 2015-Dec 2017: STA 0+00 to 125+00 Jul 2014: STA 0+00 to 125+00 Jun 2012: STA 0+00 to 125+00 Mar 2012: STA 75+50 to 115+50 Feb 2012: STA 75+50 to 115+50 Jul 2009: STA 20+50 to 120+50 (baseline)		**Reported BUDM Placement** (STA 70+00 to STA 115+00) Apr 2018 Dec 2016 Feb 2016 Feb 2015 Jan 2014 Mar 2012 Jul 2009		

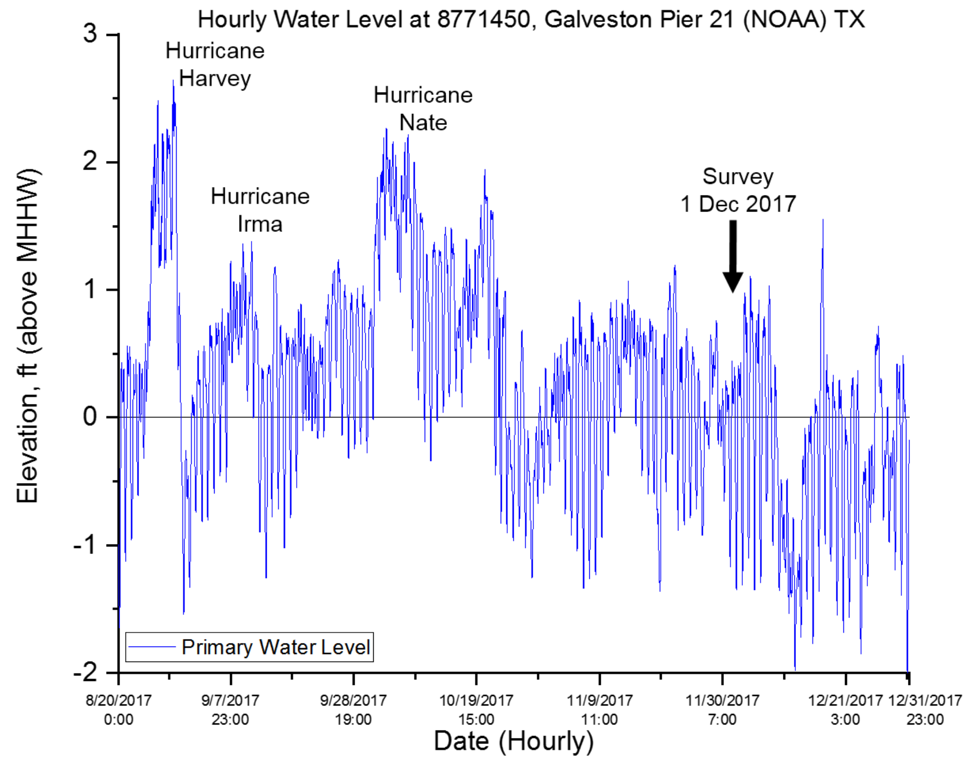

Figure 8. High variability in water level with extremes in excess of MHHW and lows of up to -2 ft over the 2-month period prior to the Dec 2017 survey at Caplen Beach

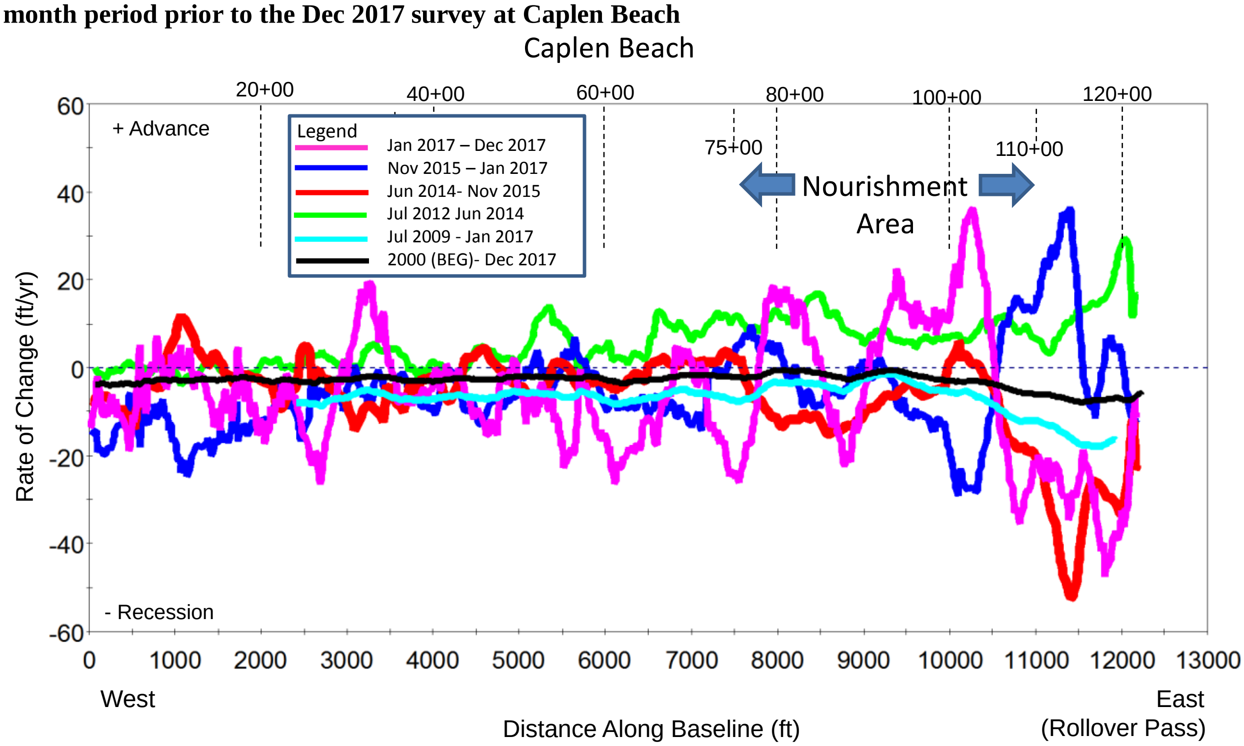

Figure 9. Comparison of variability in rate of shoreline change with alongshore position over key intervals over the extended assessment period that includes the 17-yr period based on BEG 2000 baseline

Beach Width: Caplen Beach

During Dec 2017, 70% of the beach in the Project Area exceeded the Action Width (60 ft). The remaining 30% of the beach ranged from 16 to 55 ft with the narrowest segments in the same general locations (STA 110+50 to 110+0 and STA 75+0) as during the previous reporting period (Jan 2017). The central region (STA 105+0 to STA 80+0) of the Project Area was relatively stable between Jan 2017 and Dec 2017 and the west end (STA 70+0) of the Project Area has remained relatively stable since 2015. The average width of the beach in the Project Area was 74 ft during Dec 2017.

As during previous reporting periods, the narrowest segment of beach was located at the east end of the Study Area near Rollover Pass, which includes the eastern limit of the Project Area (STA 110+0). The beach was widest in the central Project Area. The average beach width in the Study Area was 60 ft during Dec 2017. The average beach width east of the Project Area was 21 ft and the average width of the beach west of the Project Area was 56 ft during Dec 2017. The average beach width in the Project Area decreased from 104 ft (2014) to 74 ft (Dec 2017). The average beach width in the Study Area decreased from 92 ft (2014) to 60 ft (Dec 2017). For ease of reference, Table 2 provides the width of the beach at reoccupied stations over the data record from 2000 to Dec 2017.

Volumetric Analysis and Morphologic Change: Caplen Beach

Despite focused erosion along the shoreface along the majority of the Study Area, accretion dominated at Caplen Beach between Jan 2017 and Dec 2017. Although accretion dominated along the Study Area, focused erosion was significant immediately adjacent to Rollover Pass between STA 110+0 and STA 120+0. Erosion dominated at the interface of the shoreface and immediate nearshore, while the volume of the berm and duneline remained relatively stable with accretion evident along the backshore. The stability of the landward extent of the beach, despite the influence of persistent high water levels in excess of MHHW, reflects the cumulative influence of the BUDM placement at Caplen Beach on beach resilience. In addition, a single well-formed bar developed in closer proximity to the foreshore than in previous surveys. These changes in morphology are characteristic of beach response to storm forcing. In this case, contributions from both winter storms and during Harvey contributed to these distinct changes in morphology.

The morphology in the project area reflects the moderate influence of storm forcing and highly fluctuating water levels along the beach profiles nearest the south jetty where the narrow beach was flooded during an extended period of higher than typical water levels that dominated over the two months prior to the Dec 2017 survey. Due to the focused nature of erosion along the shoreface there was limited damage to the dunes both in the Project Area and the Study Area. The dunes increased in elevation and volume from STA 120+0 (Rollover Pass) to STA 110+0 (East Limit of Project Area) between Jan 2017 and Dec 2017. Persistent erosion was focused at the shoreface along the majority of the study area indicates recent storm forcing including contributions from both Harvey and winter storms. Key changes in morphology over the 2015 to 2017 reporting periods are provided in Figures 10-23. The influence of storm forcing is evident both along the shoreface and in the immediate nearshore. The single well-developed bar is a signature feature of post-storm nearshore morphology and this feature was clearly evident in profiles nearest Rollover Pass (STA 120+0) and along the nourished region from STA 105+0 to STA 75+0. Limited to no bar development was evident between STA 115+0 and STA 110+0 and at the west end of the study area between STA 5+0 and STA 0+0). A second seaward bar with limited development was located along the beach immediately west of the Project Area between STA 75+0 and STA 40+0.

Table 2. Change in Beach Width: Caplen
Target Width = 120 ft Action Width = 60 ft
60 ± 5 (Action Width)
***2012/2014 Placement Area**

Location	Beach Width (ft)									
Station	2000 (BEG)	Jul 2009 (Post-N)	Feb 2012 (Pre-N)	Mar 2012 (Post-N)	Jun 2012	Jul 2014	Nov 2015	Jan 2017	Dec 2017	▲ Jan 2017 Dec 2017 Post Harvey
STA 120+00	N/A	152	N/A	N/A	50	107	62	52	25	-27
STA 115+00	152	162	N/A	N/A	69	97	27	20	16	-19
STA 110+50*	158	151	70	83	77	94	5	39	16	-23
STA 110+00*	148	142	69	105	81	91	35	60	40	-20
STA 105+00*	150	146	88	146	86	110	73	79	70	-9
STA 100+00*	158	149	121	150	107	122	115	83	108	20
STA 95+00*	143	139	116	130	108	101	110	98	108	10
STA 90+00*	100	98	90	90	80	96	95	93	80	5
STA 85+00*	113	116	110	114	89	114	92	86	80	-5
STA 80+00*	91	107	91	98	59	84	64	66	80	14
STA 75+00*	97	118	104	117	60	82	69	76	55	-21
STA 70+00*	134	150	N/A	N/A	105	121	109	99	100	-5
STA 65+00	98	108	N/A	N/A	60	81	73	66	50	-16
STA 60+00	92	100	N/A	N/A	64	68	63	53	33	-20
STA 55+00	86	97	N/A	N/A	52	67	54	60	42	-18
STA 50+00	75	85	N/A	N/A	48	57	46	45	42	-10
STA 45+00	97	105	N/A	N/A	69	79	72	56	45	-11
STA 40+00	103	110	N/A	N/A	78	79	62	54	52	-2
STA 35+00	112	117	N/A	N/A	84	93	66	63	57	-6
STA 30+00	110	119	N/A	N/A	83	85	62	62	70	8
STA 25+00	118	122	N/A	N/A	86	91	79	72	52	-20
STA 20+00	106	N/A	N/A	N/A	84	87	75	60	47	-13
STA 15+00	118	N/A	N/A	N/A	107	101	96	78	72	-6
STA 10+00	127	N/A	N/A	N/A	105	97	98	70	73	3
STA 5+00	129	N/A	N/A	N/A	105	103	90	73	70	-3
STA 0+00	131	N/A	N/A	N/A	103	102	90	72	73	1
Average	2000 (BEG)	Jul 2009 (Post-N)	Feb 2012 (Pre-N)	Mar 2012 (Post-N)	Jun 2012	Jul 2014	Nov 2015	Jan 2017	Dec 2017	▲ Post Harvey
Project Area	131	133	87	105	86	105	77	78	74	-3
Study Area	113	100	N/A	N/A	81	93	72	67	60	-7
East of Project Area	140	151	N/A	N/A	53	95	45	44	21	-23
West of Project Area	107	107	N/A	N/A	81	84	73	64	56	-8

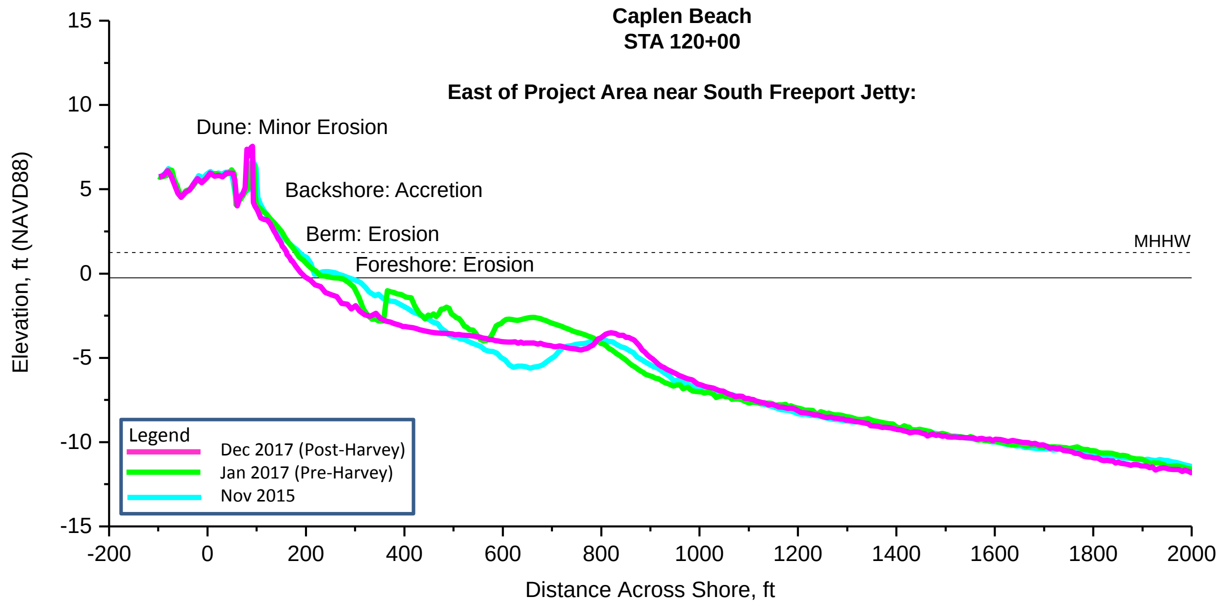

Figure 10. East End of Study Area: Although erosion dominated from the backshore to foreshore, the dune remained relatively stable with limited erosion. Bar development was dampened up to 600 ft offshore where a storm bar was fully developed (Dec 2017)

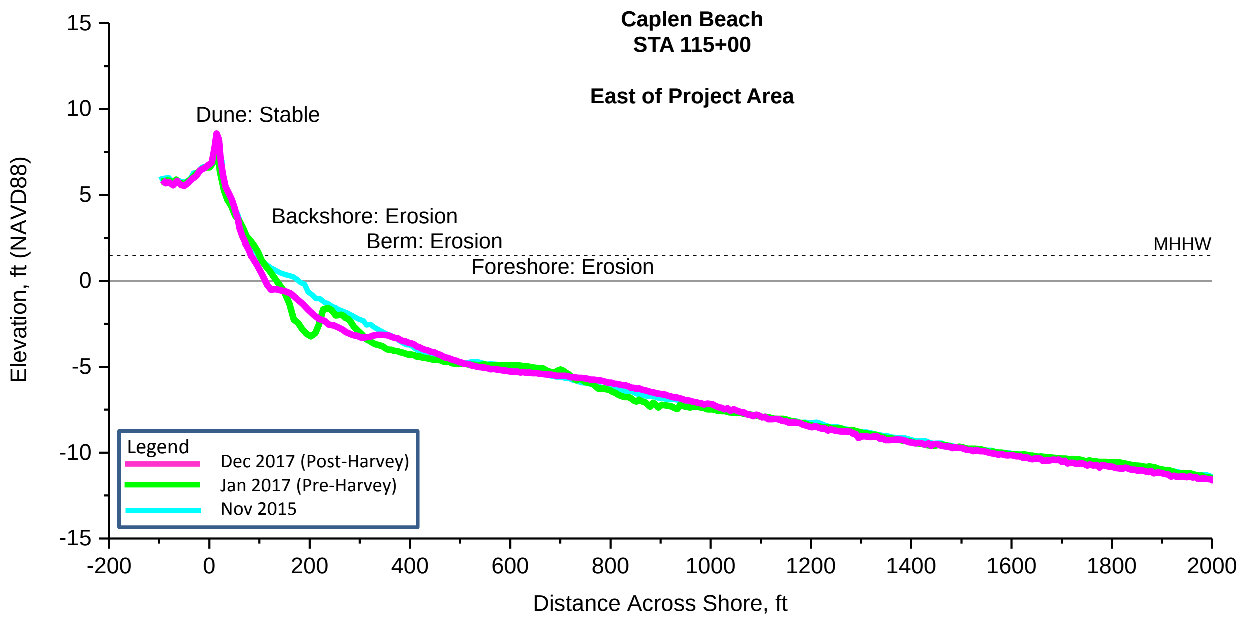

Figure 11. East of Project Area: Although the duneline remained stable, the entire beach eroded, with erosion extending into the nearshore where bar development was dampened (Dec 2017)

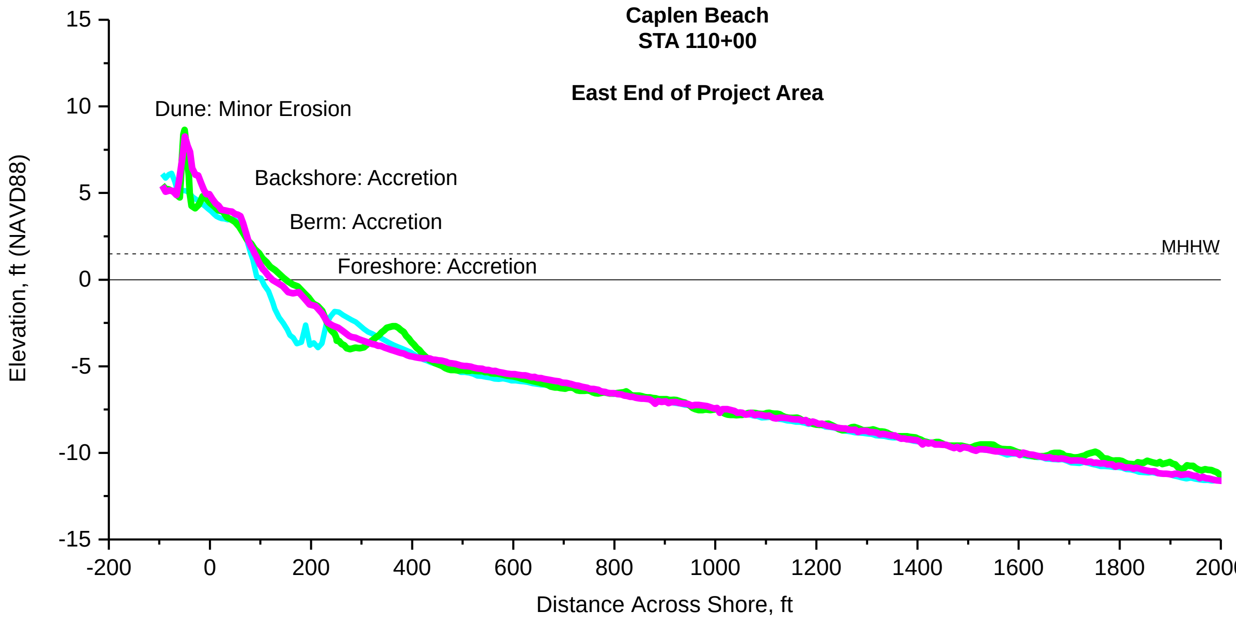

Figure 12. East End of Project Area: Stability across the entire beach profile from the dune to nearshore was associated with influence of recent large-scale BUDM dune restoration and nourishment. Bar development was absent (Dec 2017

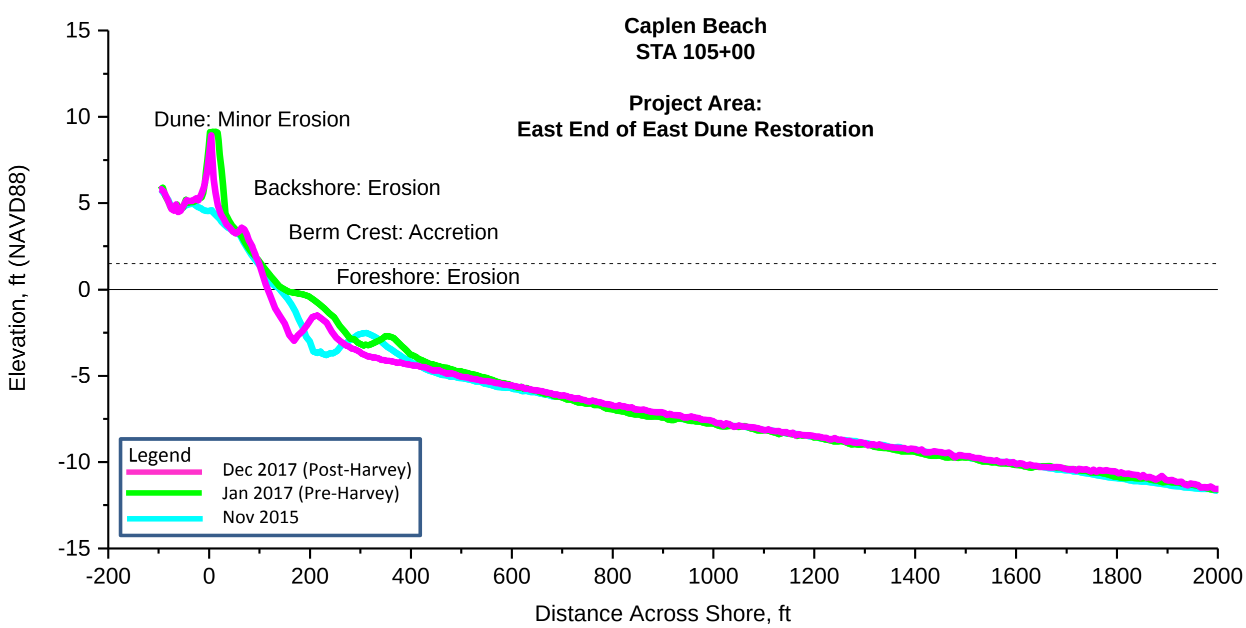

Figure 13. Eastern End of Project Area: Significant erosion focused along shoreface and immediate nearshore while a storm berm developed landward with the berm flanked by a relatively stable dune exhibiting minor erosion (Dec 2017)

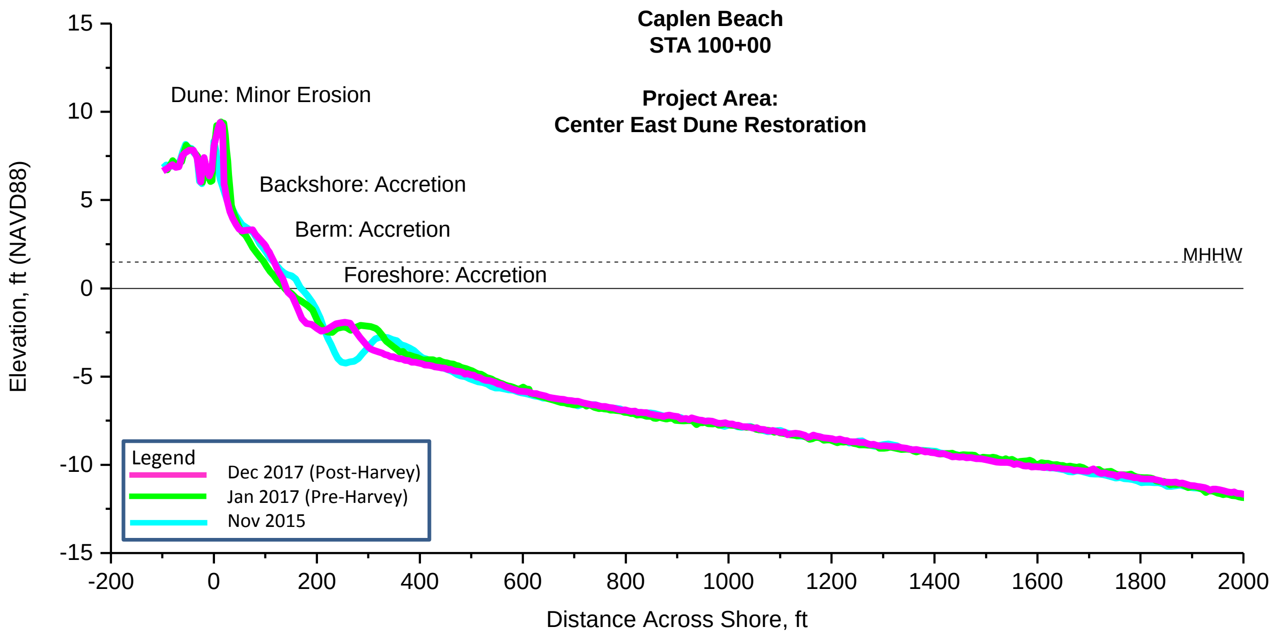

Figure 14. East of Center Project Area: Western limit of section of large-scale dune restoration. Beach stability related to cumulative influence of annual BUDM placement. Accretion dominated with minor dune and foreshore/nearshore erosion. Limited storm-influenced bar development (Dec 2017)

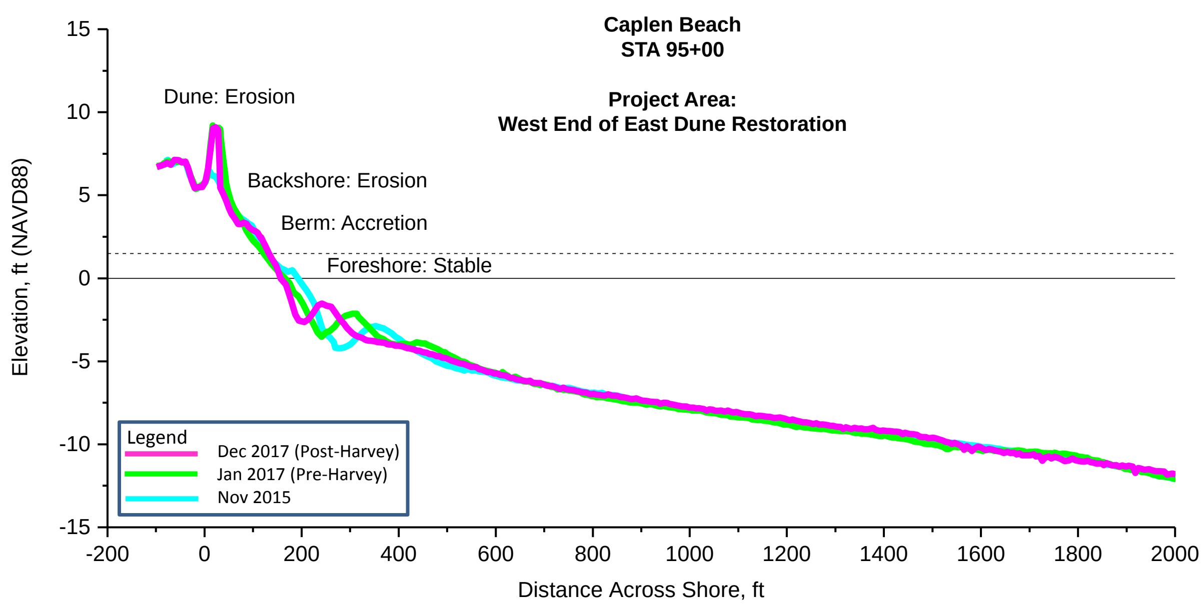

Figure 15. Center Project Area: Minor backshore and dune erosion with stability across the berm. Erosion resumes at foreshore/nearshore interface followed by storm-influenced bar development (Dec 2017)

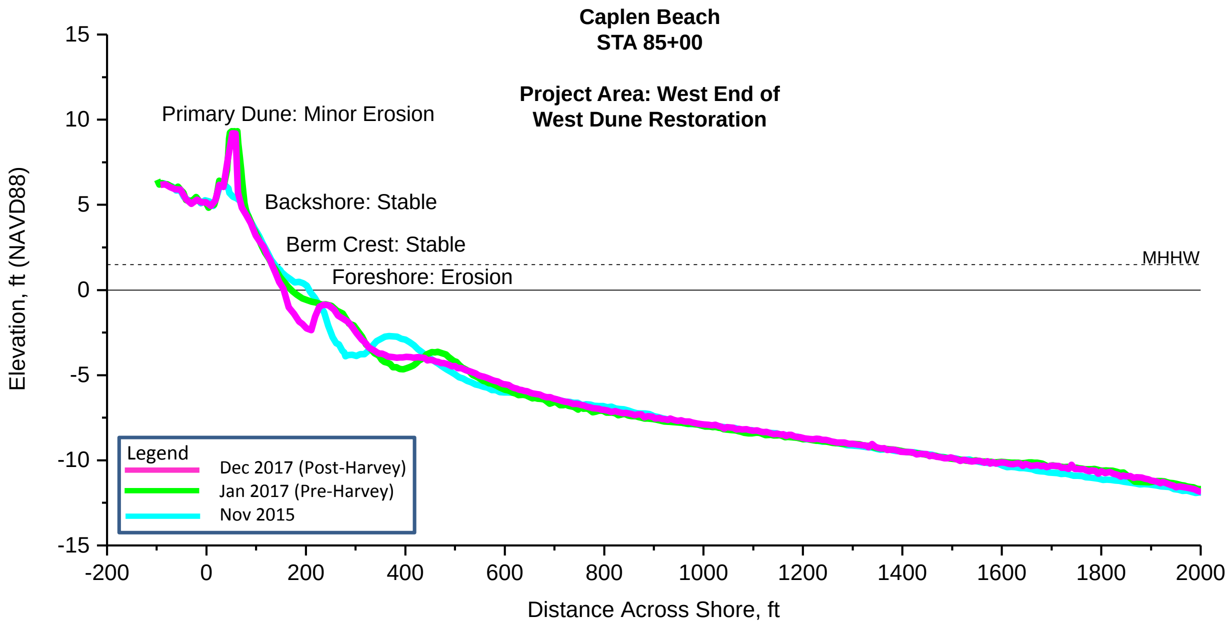

Figure 16. West of Center Project Area: Stability from backshore to berm crest with minor erosion of primary dune and erosion at foreshore/nearshore interface. Well-developed single storm-influence bar development (Dec 2017)

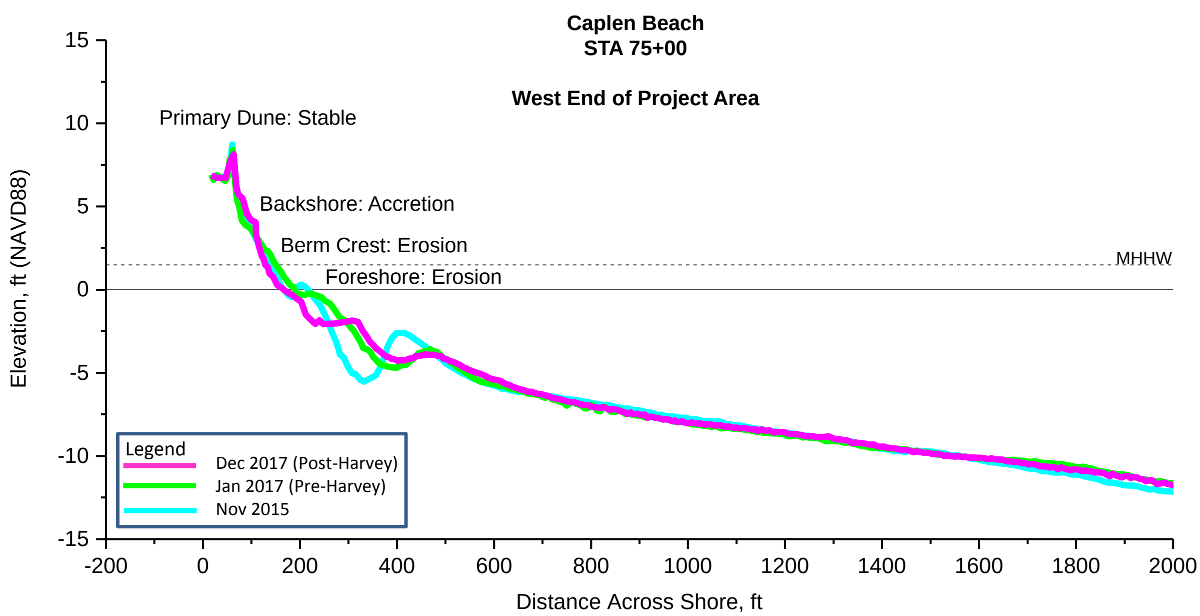

Figure 17. West End of Project Area: Western limit of beach and dune stability that was directly influenced by BUDM placement with direct benefit extending into the immediate nearshore. Storm influenced bar and limited seaward bar development (Dec 2017)

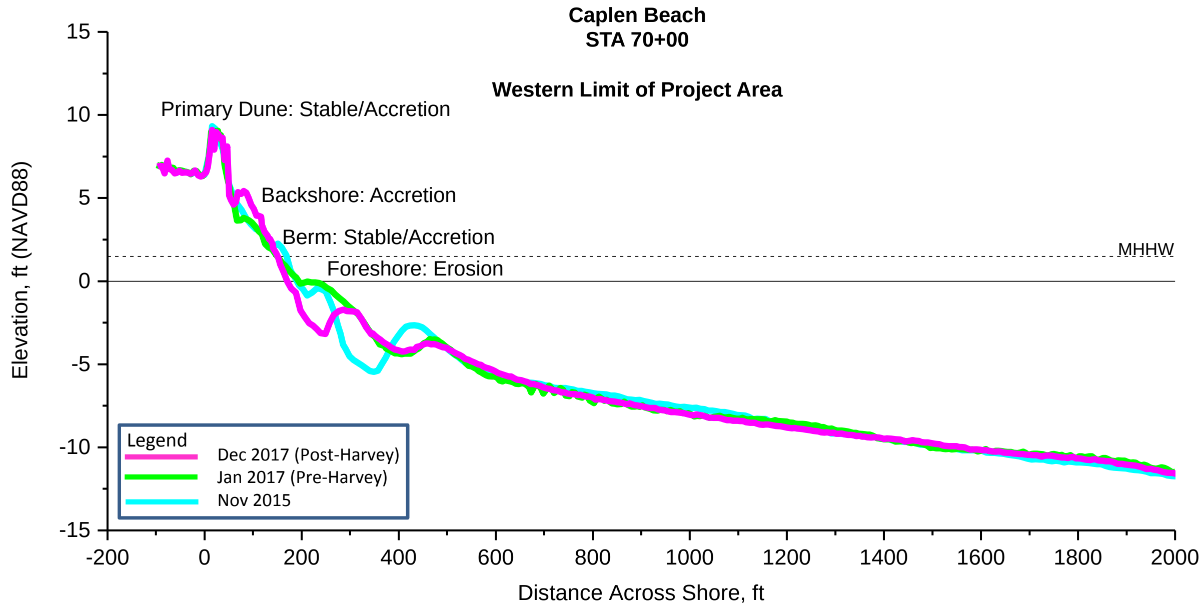

Figure 18. West of Project Area: Backshore/Dune stability with focused erosion at the shoreface and immediate nearshore, storm bar and limited seaward bar development (Dec 2017)

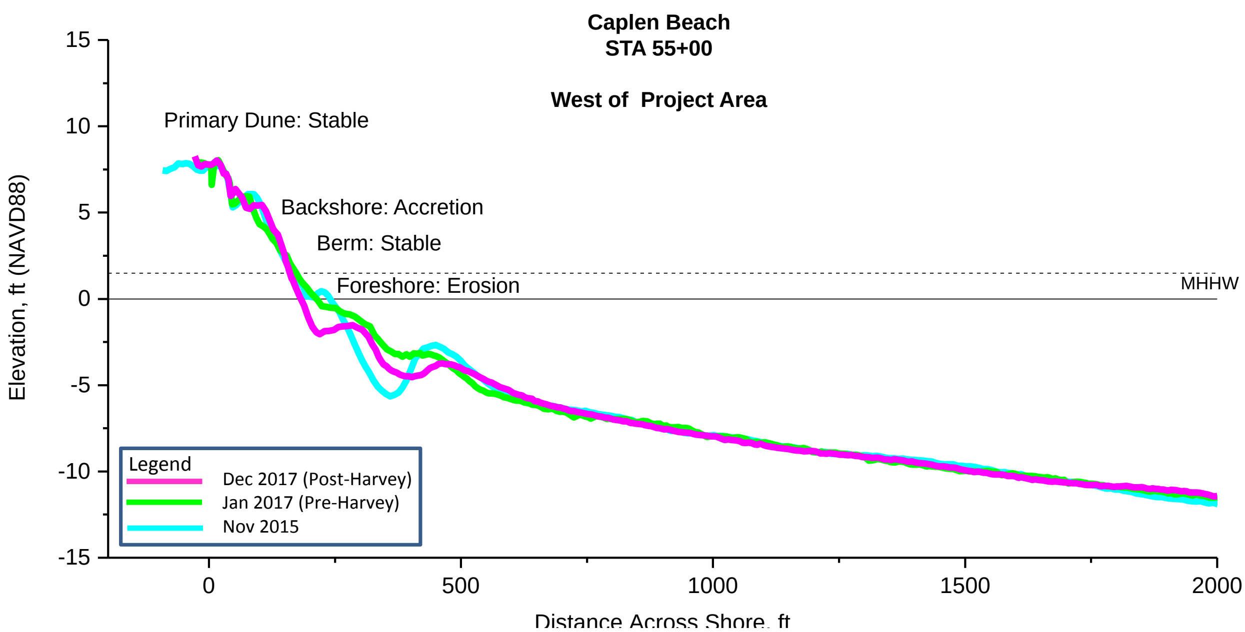

Figure 19. West of Project Area: Backshore/Dune stability with focused erosion at the shoreface and immediate nearshore with development of two longshore bars (Dec 2017)

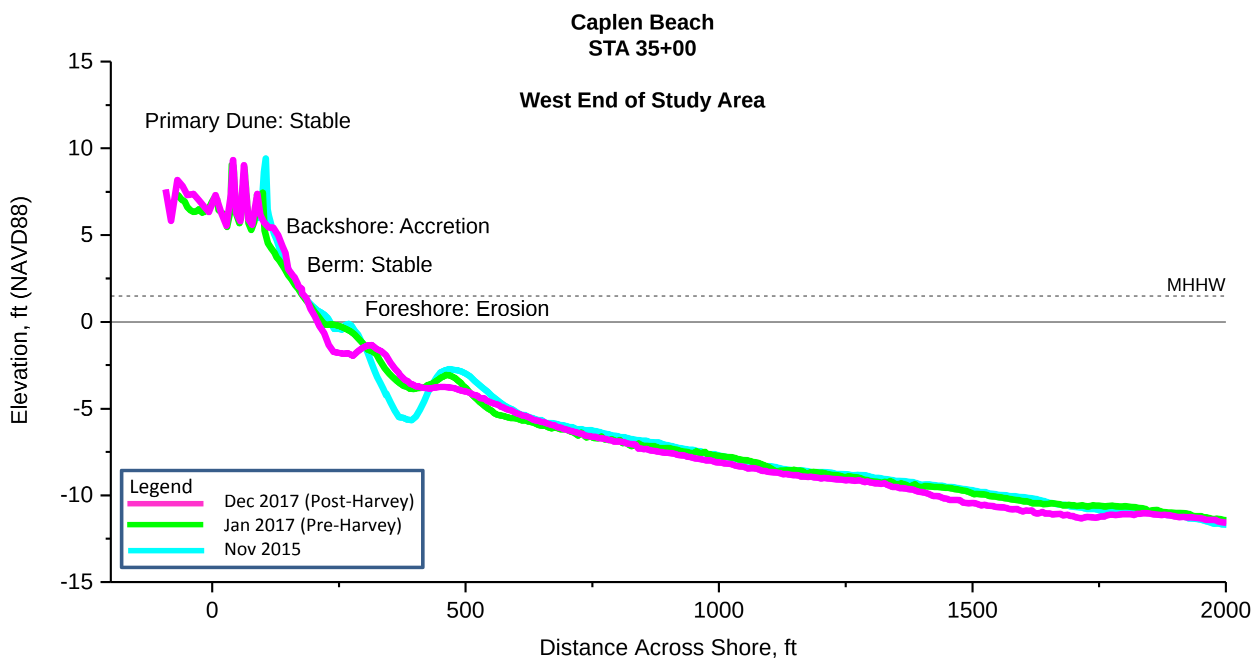

Figure 20. Western end of Study Area: Backshore/Dune stability with focused erosion at the shoreface and immediate nearshore with development of a single storm influenced longshore bar (Dec 2017)

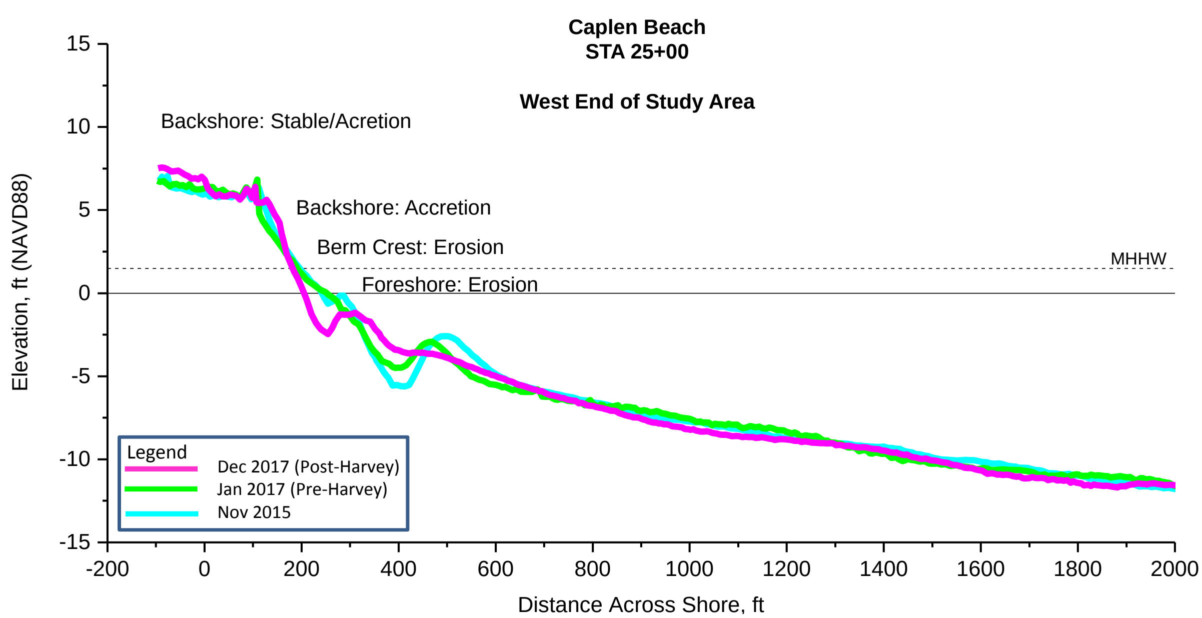

Figure 21. Western end of Study Area: Backshore/Dune stability with focused erosion at the shoreface and immediate nearshore, single storm bar positioned landward of former location (Dec 2017)

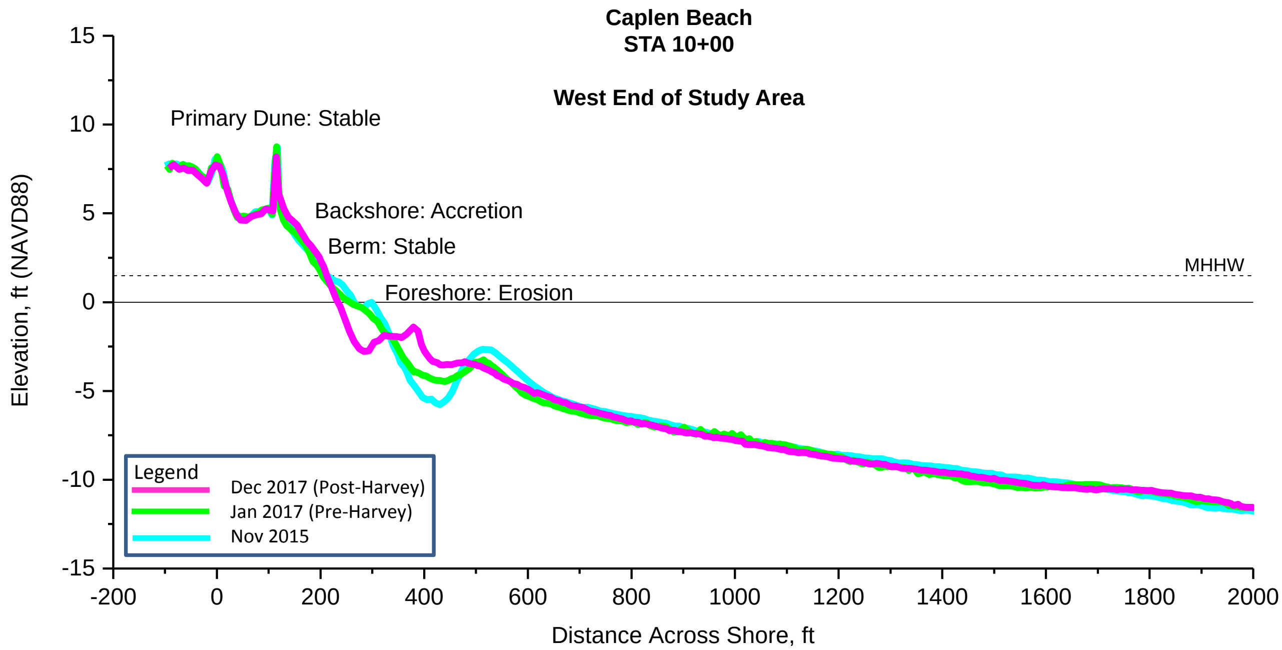

Figure 22. Western end of Study Area: Backshore stability with erosion focused at the shoreface and immediate nearshore. Storm-influenced bar located landward of form position and limited seaward bar development (Dec 2017)

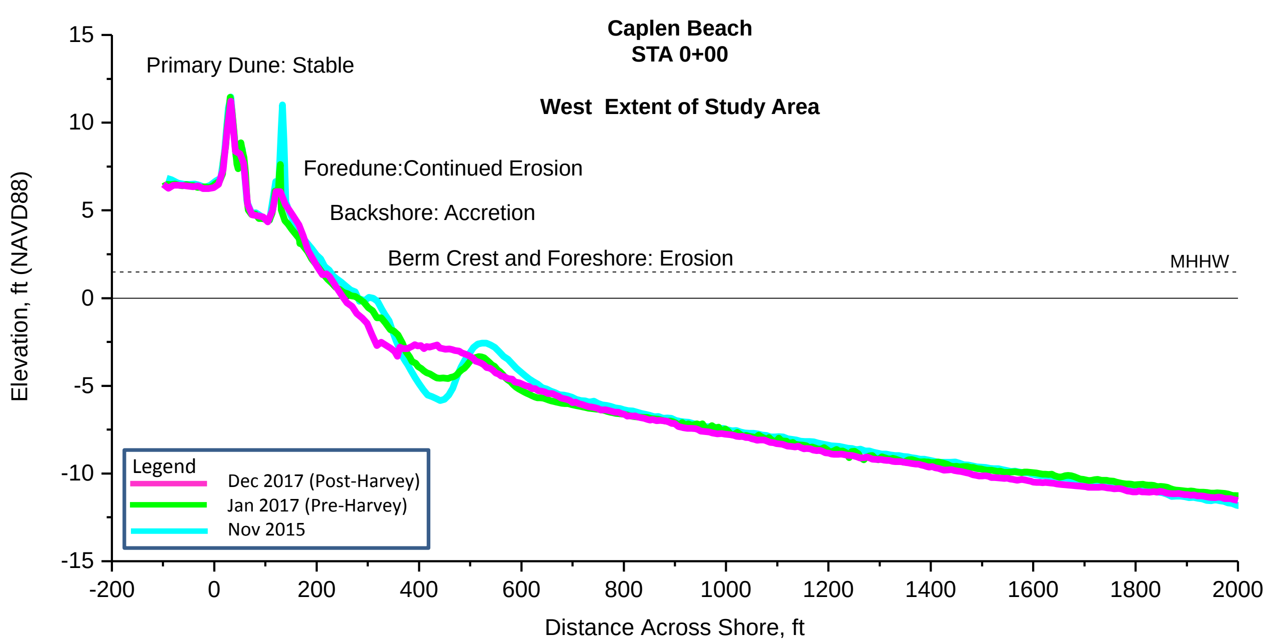

Figure 23. West end of the Study Area: Stable dune with erosion focused across backshore to the foreshore and limited single low elevation bar in nearshore (Dec 2017)

Due to the identification of anomalies in the offshore segment of the beach profile along the upper Texas coast, the change in sand volume across the beach was quantified along two sections of the profile, 1) Standard active region of transport: Primary dune crest to DOC (-23 ft) and 2) Modified active region of transport: Primary dune crest to -13 ft. Accretion dominated at Caplen Beach, although focused erosion was identified along the shoreface both in the Project Area as well as the full Study Area. In addition erosion was identified along three segments; 1) West of the Freeport Jetty along a 1,600 ft beach segment (STA 120+0 to STA 105+0), 2) Immediately west of the Project Area along a 3,000 ft-long segment of beach (STA 70+0 and to STA 40+0), and 3) at the western limit of the study area (STA 0+0 to STA 10+0).
Accretion dominated along the study area between Jan 2017 and Dec 2017. The net rate of accretion along the study area was 60,600 cu yd/yr. The net rate of accretion along the Project Area was 64,100 cy/yr, indicating that sand was redistributed within the study area and that erosion was greater outside of the Project Area. The change in beach volume was calculated along the 12,100-ft study area between STA 0+0 and STA 120+0 which is located near Rollover Pass, as well as along the 4,000-ft Project Area (STA 75+0 to STA 115+0). The net increase in volume that has been indicated in past reporting periods was significantly lower due to the focused areas of erosion that occurred over the 2017 reporting period. The highest rate of erosion was along the beach segment nearest Rollover Pass between STA 110+0 to 120+0 (Figs 10 -12).

The net volume change at Caplen Beach was calculated for both the Project Area and Full Study area. As during previous reporting periods, sediment transport was calculated across a standard active region of sediment transport with an offshore limit at DOC, as well as a modified active region of sediment transport with an offshore limit at -13 ft. This is a similar to the process outlined for Gilchrist Beach. This approach is applied to isolate and investigate localized active sediment transport between the nearshore and subaerial beach from sediment transport that is associated with large-scale alongshore sediment transport processes within the deeper region of the broader littoral cell. The offshore limit for the standard cross sectional area was taken as -23 ft (DOC) while the offshore limit for the modified active region of transport was defined as -13 ft. In general, accretion dominated across the offshore region of the profile between the Project Area as well as the Full Study area at Caplen Beach between Jan 2017 and Dec 2017. The net rate of accretion in the full Study Area (-23 ft) was 61,000 cy/yr (5 cy/ft) between Jan 2017 and Dec 2017, as opposed to 367,000 cy/yr (30 cy/ft) between 2015 and 2016. The net rate of accretion in the Project Area (-23 ft NAVD88) was approximately 39,000 cy/yr (10 cy/ft) as opposed to 190,000 cy/yr (48 cy/ft) measured between 2015 and 2016. Across the modified profile, from the duneline to the -13 ft contour, erosion dominated in both the Study Area and Project Area at a rate of -90,700 cy/yr and -7,800 cu yd/yr respectively between Jan 2017 and Dec 2017, indicating significant alongshore transport of sediment along the broader littoral cell offshore of the -13 ft contour. The lowest rates of erosion and thus greatest stability were located in the Project Area fronting the dune restoration between STA 100+0 (east) and STA 75+0 (west). The highest rate of erosion was located along the segment west of the Project Area from STA 70+0 to STA 35+0 (Fig 24)

Accretion has dominated along the study area, calculated for the standard profile, over two reporting periods 2015-2017. Prior to this period of accretion, erosion dominated from 2012-2015.

Recommendations: Caplen Beach

The beach segments fronting and in close proximity to the dune restoration exhibited the greatest stability at Caplen Beach. The restored duneline also remained relatively stable over the reporting period with limited change to the dune elevation and volume. In general, erosion at Caplen Beach was focused along the shoreface between Jan 2017 and Dec 2017. The location of focused erosion along with changes in morphology in the immediate nearshore (-1 to -13 ft contour) reflects the influence of extremes in variability in water level and onshore forcing.

Within the project area, 30% of the beach was at or within 10 ft of the Action Width an increase of 10 % from the previous reporting period. Along the full study area, 54% of the beach, in agreement with the percent reported in 2016, was at or within 10 ft of the Action Width. With the average rate of shoreline change taken as between -1.6 ft/yr (Dec 2017 Project Area annual rate) to -6.2 ft/yr (average annual rate over CBI monitoring period 2012-Dec 2017), 90 % of the study area would be at Action Width within the next 1 to 4 years in the absence of continued collaborative BUDM nourishment and dune restoration. Therefore, Caplen Beach remains on the Tier 1 recommendation due to transient stability of the berm and shoreline position despite the influence of cumulative BUDM placement, limited intervals of recovery/stability over the survey record, and a historically high rate of erosion that has impacted both beach and dunes. Annual surveys and assessment are recommended to determine if the rate of erosion along the Project Area increases as the beach continues to decrease in width despite annual nourishment. The calculation of the volume required to restore the beach to the Target Width is differed until as-built surveys of recent nourishment are provided to apply as the design template. The report will be amended to reflect this information.

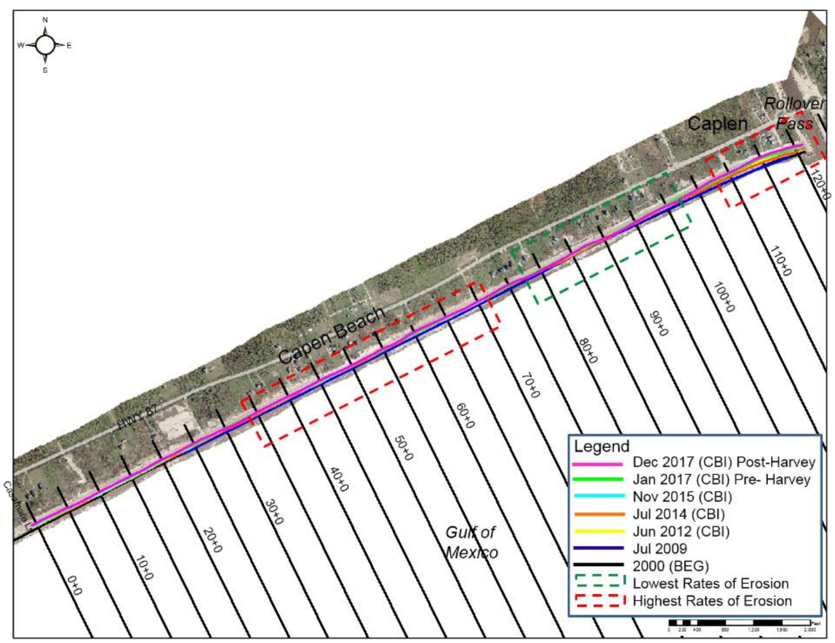

Fig 24. Beach segments with the lowest rate of erosion were located in the Project Area fronting the dune restoration between STA 100+0 (east) and STA 75+0 (west), while the segments with the highest rate of erosion were located along the segment west of the Project Area from STA 70+0 to STA 35+0 and between Rollover Pass and STA 100+0

Gilchrist Beach

Gilchrist Beach is located east of Rollover Pass and the study area stretches approximately 7,500 ft from the pass to east of Ledger's Street (Fig 25). Gilchrist has a history of beach nourishment and dune restoration starting with two efforts conducted during 2000 and 2004, with the most recent effort conducted during 2012 (Post-Ike restoration). The 2000 restoration was in response to damage caused by Tropical Storm Frances (1998) and included the placement of geotubes along both Gilchrist and Caplen Beach as temporary storm surge protection. Remnants of the geotubes were revealed along the foreshore after Hurricane Harvey and periodically since placement. Historic data is limited for Gilchrist Beach. Recent CBI surveys (2012, 2014-2017) agree in both alongshore extent and in offshore limit that terminates at DOC (-23 ft NAVD88). A 2009 survey provided by the TGLO is included in the analysis as it documented post-Ike damage and was taken as the baseline applied for the calculation of change in shoreline position and volume. The BEG 2000 shoreline positon was applied to estimate change over more than a decade. Persistent periods of high water in excess of MHHW influenced sediment transport at Gilchrist to a lesser degree than at other CEPRA beaches surveyed after Hurricane Harvey (Fig 26).

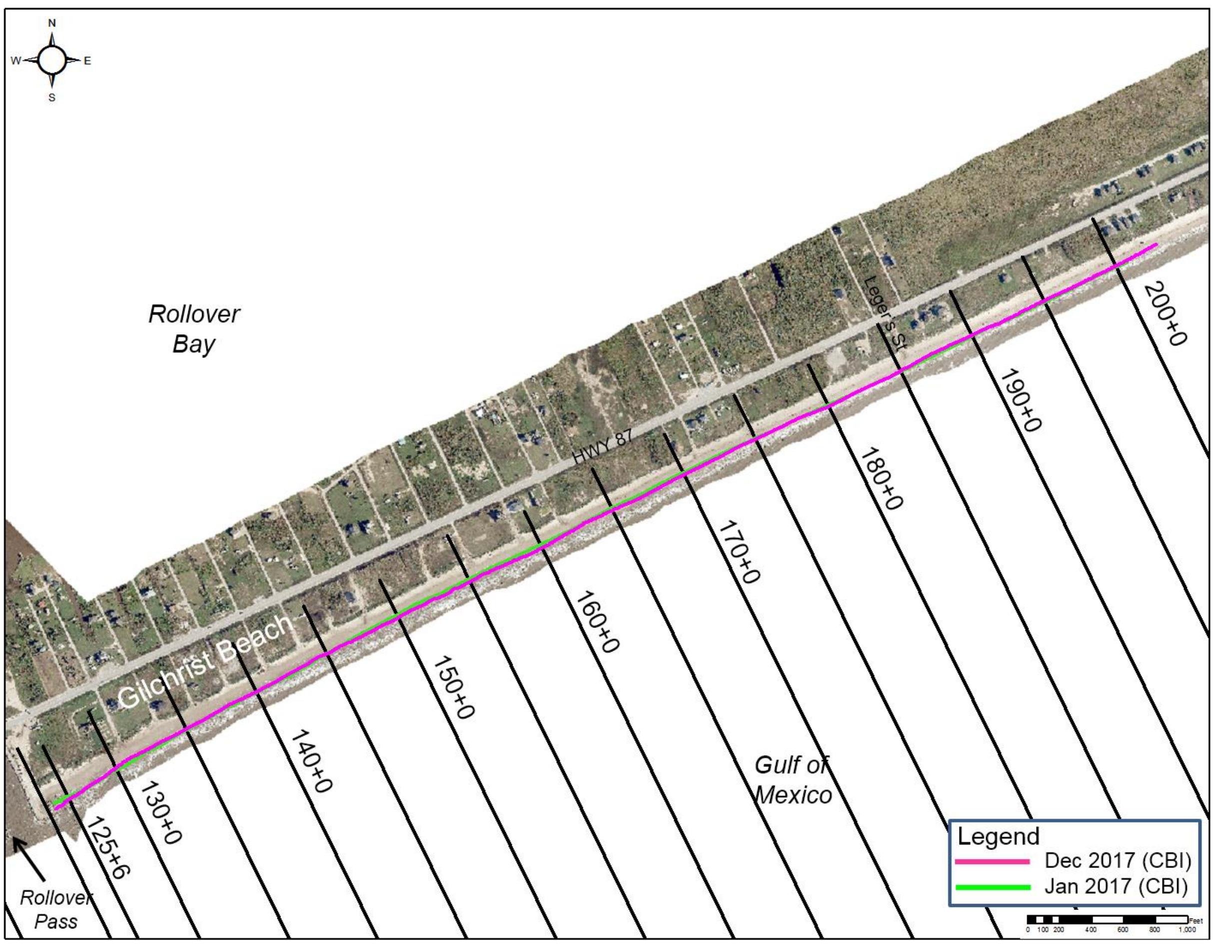

Figure 25. Shoreline change relative to transect locations along the full Gilchrist Beach study area (Jan 2017-Dec 2017)

Shoreline Analysis: Gilchrist Beach

In contrast to the previous reporting period during which variable but limited change in shoreline position was identified, the change in shoreline position was highly variable with alongshore position at Gilchrist Beach between Jan 2017 and Dec 2017 with well-developed advance and recession along intermittent segments. The shoreline position during Dec 2017 was landward of the 2000 (pre-Ike) position along the entire study area as during previous reporting periods. The distance between the 2000 (BEG) and Dec 2017 shoreline position increased with distance from Rollover Pass indicating that erosion has increased with distance from the inlet since 2000. The Dec 2017 shoreline position was in advance (seaward) of the Jan 2017 position along 53% of the beach. The Dec 2017 shoreline position was intermittently seaward of the 2009 position along close to 50 % the study area (Figs 27-31), along the remainder of the beach the shoreline was in close agreement or landward (recession) of the 2009 position. The greatest advance (seaward) was located along two primary segments 1) adjacent to Rollover Pass (Jetty to STA 128+0) and 2) between STA 152+0 and STA 170+0

The shoreline along Gilchrist Beach was relatively stable between Jan 2017 and Dec 2017, despite extremes in water level and onshore forcing. Shoreline advance dominated along 75% of the beach at an average rate of 3.9 ft/yr. Over the last reporting period the net rate of change in shoreline position was effectively null and over previous reporting periods the net rate of change has been highly variable ranging from -11.2 ft/yr (Jul 2014 to Nov 2015) to +7.4 ft/yr (Jun 2012 to Jul 2014). Over the full study period (2000 to 2017), recession dominated with an average annual rate of shoreline change at -2.7 ft/yr. The rate of shoreline change over the recovery period after severe erosion during Hurricane Ike was null due to extreme alongshore variability in the rate of change. The rate of shoreline change for periods of interest are provided in Table 3. The variability in the rate of shoreline change relative to alongshore shoreline position for four intervals of interest; 1) Jan 2017-Dec 2017 (Annual), 2) 2015-Jan 2017 (Previous study period), 4) 2014 -2015 4) 2009-Dec 2017 (data record) and 5) full study period (2000 BEG-Dec 2017) is shown in Figure 32.

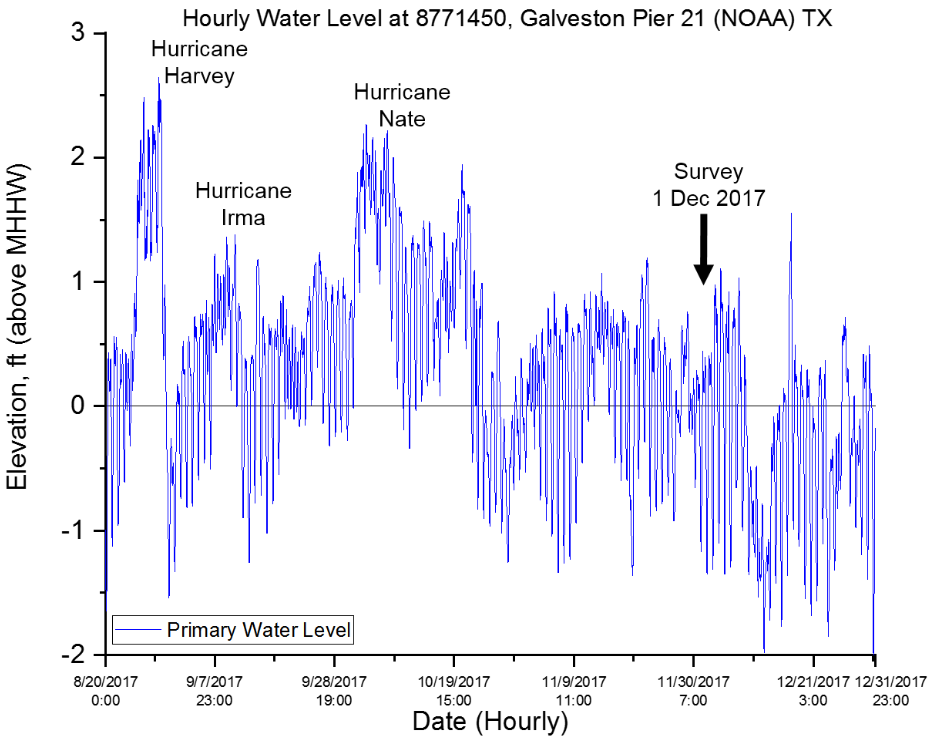

Figure 26. Extremes in water level prior to the Dec 2017 survey at Gilchrist Beach

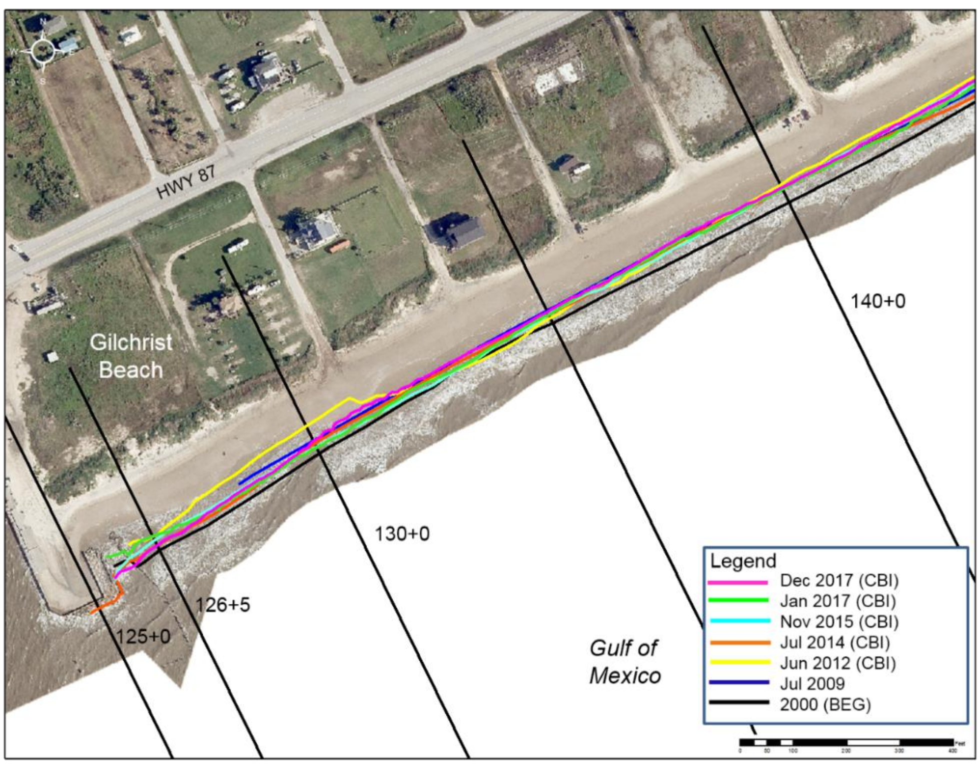

Figure 27. Variability in shoreline position at the west end of Gilchrist Beach near Rollover Pass (2000-Jan 2017)

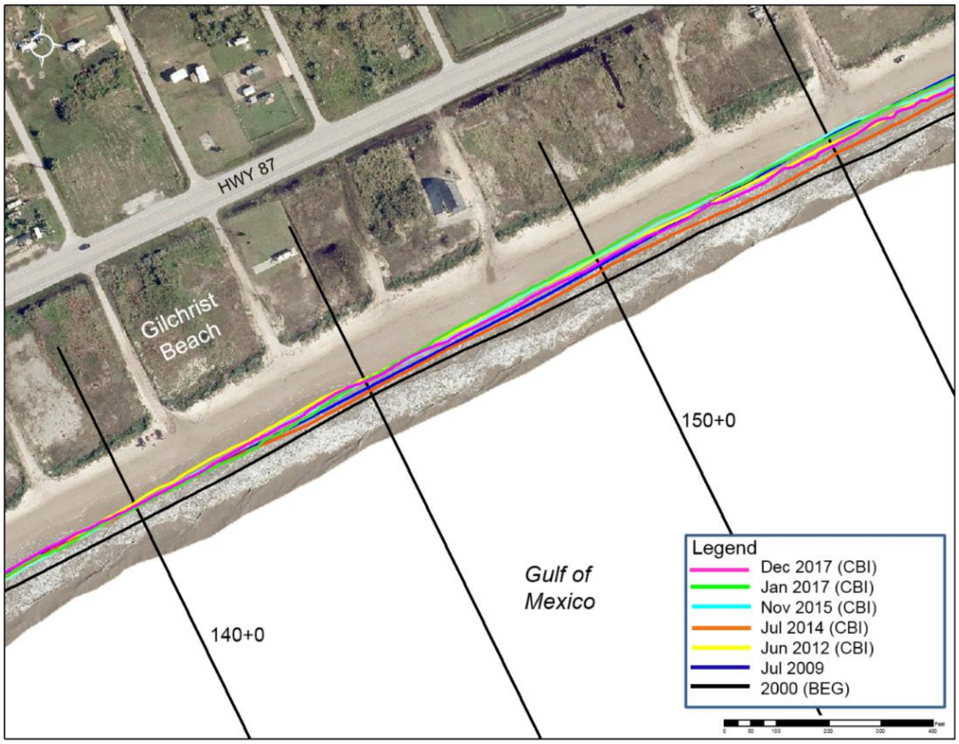

Figure 28. Shoreline position during Jan 2017 was at or landward of 2009 post-Ike position near the west end of Gilchrist Beach as during 2015

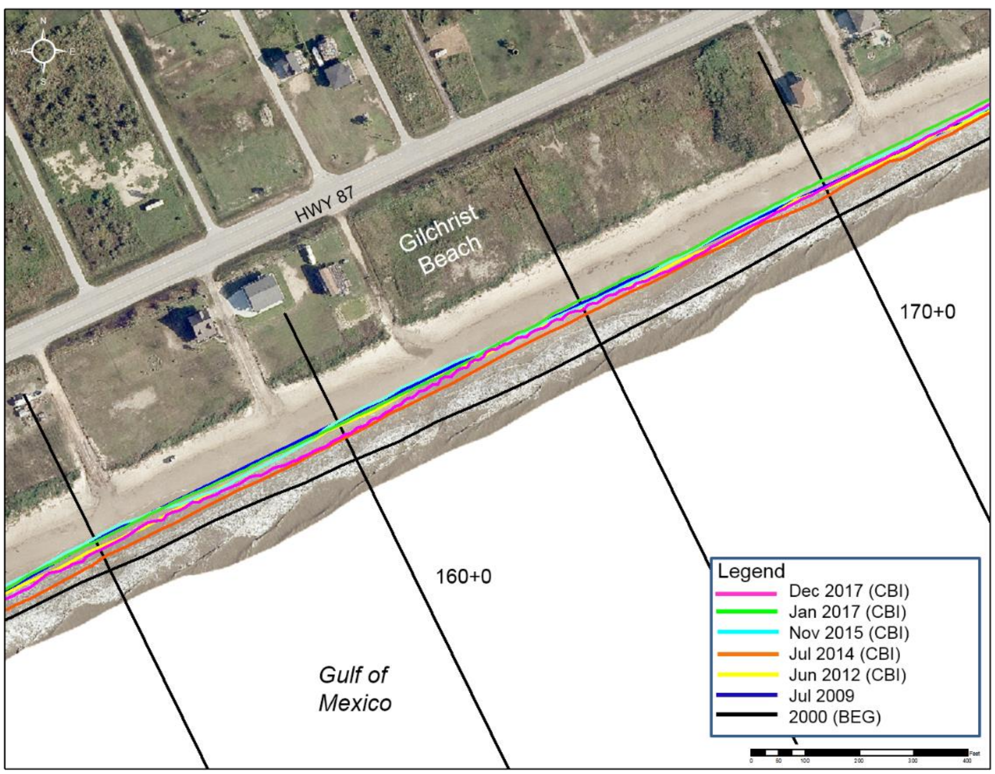

Figure 29. Shoreline position during Jan 2017 was landward of the 2009 post-Ike position near the mid-point of the study area

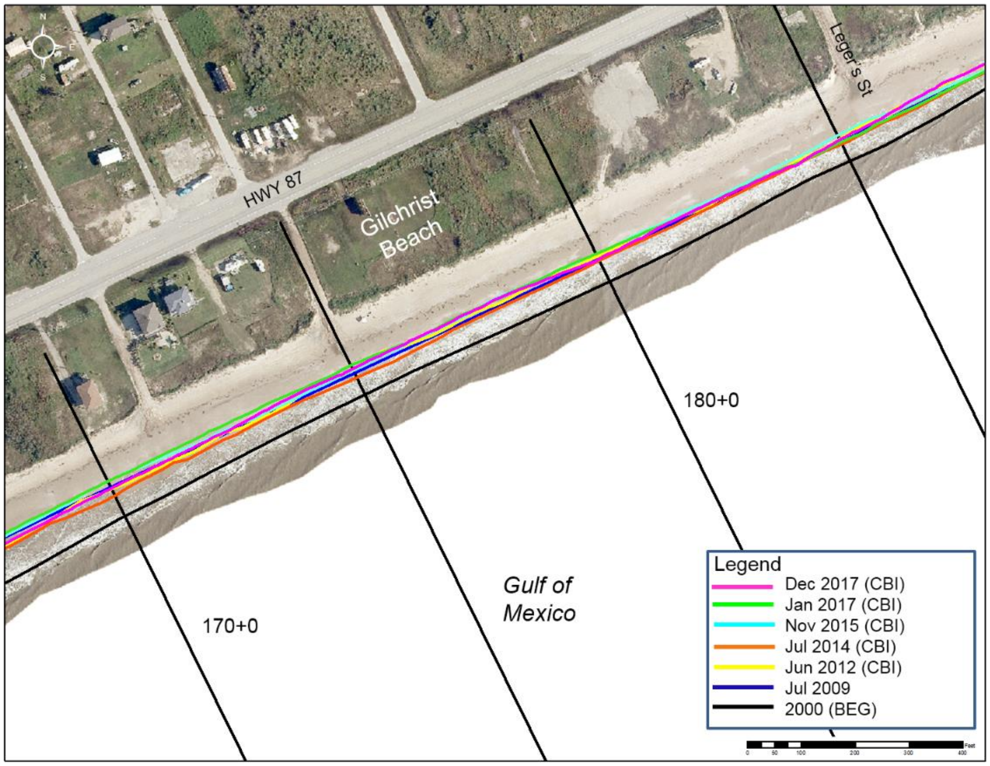

Figure 30. Shoreline position during Jan 2017 was landward of the 2009 post-Ike position near east end of the study area

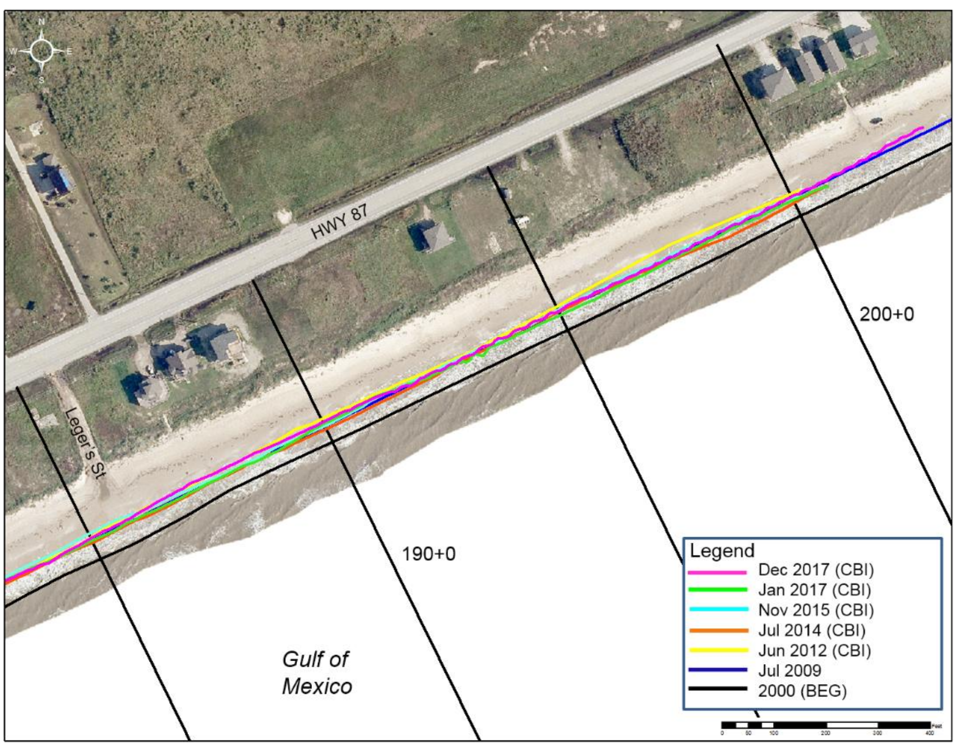

Figure 31. Shoreline position was in close agreement with the post-Ike (2009) position along the east end of study area and in advance of the 2009 position at the east end (STA 195+0 to 200+0)

Table 3. Variability in Shoreline Position Change: Gilchrist Beach 2017 (MHHW = 1.3) Gilchrist Beach (STA 125+0 to STA 200+0)				
Interval (Year)	**Description**	**Average Rate of Change + Advance - Recession (ft/yr)**	**Max -**	**Max +**
Full Study Area				
Annual and Survey Baseline				
Jan 2017-Dec 2017	Annual (Post-Harvey)	+3.9	-25	+37
Nov 2015-Jan 2017	Annual	+0.2	-26	+14
Jul 2014-Nov 2015	Annual Tropical Storm Bill	-11.2	-34	+11
Jun 2012-Jul 2014	Bi-annual Survey No significant tropical storm damage	+7.4	-8	+20
2009-Dec 2017	Period of Survey Record	0.0	-19	+31
2000-Dec 2017	Historic (BEG) Baseline	-2.4	-81	0
Intervals of Interest				
2009-Jan 2017	Previous Period of Survey Record	-0.3	-27	+20
2009-Nov 2015	Post-Ike Recovery Period Feb 2012 COE dredge placement Tropical Storm Bill	-0.5	-3	+3
2009-Jul 2012	Post-Ike recovery period Feb 2012 COE dredge placement	-1.2	-12.2	+8.3
2000-Jan 2017	Previous Historic (BEG) Baseline	-2.7	-91	0

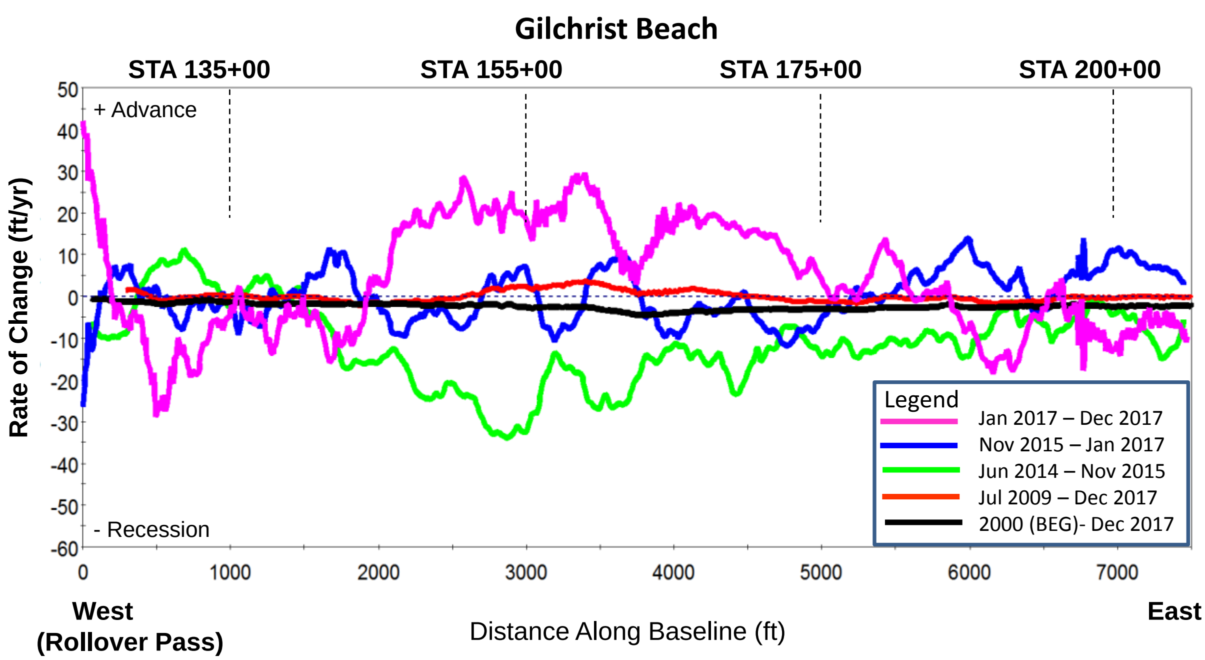

Figure 32. Comparison of variability in rate of shoreline change with alongshore position at Gilchrist Beach between five intervals 1) Jan 2017 and Dec 2017 (Post-Harvey/Annual), 2) Nov 2015 – Jan 2017), 3) Jun 2014-Nov 2015 (Annual), 4) Jul 2009-Dec 2017 (data record) and 4) 2000 BEG-Dec 2017(Full study period)

Beach Width: Gilchrist Beach

Due to the distance-dampened influence of forcing associated with Hurricane Harvey, the beach width was relatively stable at Gilchrist Beach. The width along 56% of Gilchrist Beach was stable between Jan 2017 and Dec 2017. This was in close agreement with 63% between 2015 to 2016. The stability in beach width over the last two reporting periods was in contrast to the 2014-2015 reporting period during which 90% of the beach decreased in width. Only 37% of the beach decreased in width between Jan 2017 and Dec 2017 (Table 4). The average beach width was 107 ft during Dec 2017. The beach width ranged from 102 to 168 ft along the western reach while the eastern end of the beach ranged from 86 to 106 ft wide. In general, the beach was most narrow (74-92 ft) along the eastern reach between STA 160+0 and STA 200+0 and widest (114-168 ft) along the western reach from STA 125+0 to STA 145+0. The greatest decrease in beach width of 13 ft was located close to Rollover Pass (STA 130+0). The entire beach was in excess of the Action Width, with the west end of the beach (STA 125+0 to 160+0) in excess of 100 ft. The beach was at or in excess of the Target Width in the vicinity of STA 126+5, STA 145+0 and STA 155+0. The average change in width along Gilchrist Beach was +5 ft with a range of -13 to +22 ft.

The west end of the beach has exhibited the greatest stability since monitoring began in 2009. The location of the minimum and maximum beach width have remained relatively consistent since 2009. The Target Width at Gilchrist Beach is 120 ft, based on the observed width at more stable beaches along the upper Texas Coast. Under 20% of the beach was at or exceeding the Target Width during Dec 2017. The entire beach has consistently exceeded the Action Width of 60 ft since 2009.

Table 4. Change in Beach Width: Gilchrist Beach Dec 2017 Target Width = 120 ft Action Width = 60 ft								
Location		**Beach Width, ft**						**Post-Harvey**
Station	**2000 (BEG)**	**Jul 2009**	**Jun 2012**	**Jul 2014**	**Nov 2015**	**Jan 2017**	**Dec 2017**	**Δ Dec 2017 Jan 2017**
STA 126+5	178	N/A	150	168	158	150	168	18
STA 130+0	141	114	84	120	127	128	115	-13
STA 135+0	126	100	115	108	107	107	102	-5
STA 140+0	143	106	112	113	115	117	112	-5
STA 145+0	149	132	115	140	120	116	120	4
STA 150+0	148	115	98	125	96	90	110	20
STA 155+0	168	106	121	142	102	108	125	17
STA 160+0	165	88	96	120	87	92	114	22
STA 165+0	171	87	93	108	91	80	99	19
STA 170+0	145	85	89	103	74	74	88	14
STA 175+0	144	99	88	103	88	79	87	8
STA 180+0	143	97	91	100	87	87	96	9
STA 185+0	144	105	100	109	92	105	100	-5
STA 190+0	129	95	80	101	96	90	86	-4
STA 195+0	148	N/A	98	109	104	115	106	-9
STA 200+0	138	100	93	111	100	105	96	-9
Avg. Study Area	149	95	101	118	103	103	107	5

Volumetric Analysis and Morphology: Gilchrist Beach

Erosion dominated at Gilchrist Beach between Jan 2017 and Dec 2017 at a low rate reflecting a significant volume of sand accreting along the offshore segment between the -15 and -23 ft contour. Similar to the variability observed in the rate of shoreline change, the rate of erosion was highly variable in both alongshore position and between monitoring periods. Lower rates of erosion and accretion were focused along the central segment of the beach between STA 145+0 and STA 170+0.

Over the reporting period (Jan 2017 to Dec 2017), a wide region of deposition seaward of the -15 ft contour once again replaced erosion that was indicated during Jan 2017. This former region of erosion has been consistently identified between the -10 and -20 ft contour along the entire length of the beach. Accretion dominated in the region in the survey that followed Hurricane Ike (Jul 2009). Similar morphology was also identified in the nearshore along Caplen Beach and is indicative of regional scale alongshore sediment transport. Therefore, the rate of erosion was determined across a “Standard” as well as “Modified” beach profile to provide for a better understanding of the volume of sand associated with this seaward section of the beach profile. Isolating the contribution of the offshore section of the profile provides a better understanding of the volume change along subaerial beach and immediate nearshore. Accretion and erosion in this offshore segment of the nearshore beach profile may provide for an over-estimate of volume change relative to practical applications of nourishment and dune restoration assessment.

The net change in volume in the modified (offshore limit -15 ft) region of active sediment transport was -68,600 cu yd (-9.3 cy/ft). The net change in volume along the standard (-23 ft) region of active sediment transport was lower at -11,300 cu yd (-1.5 cy/ft) owing to the significant contribution of deposition of approximately 57,300 cu yd of sand offshore of the -15 ft contour. Erosion also dominated across the modified active region of sediment transport over the previous reporting period (Nov 2015 to Jan 2017) with net change of -31,000 cu yd; in sharp contrast with significant deposition of 270,000 cu yd offshore of the -10 ft contour. This disparity between the dominance of accretion along the offshore segment of the profile and a low rate of erosion along the modified region of transport resulted in net accretion across the standard region of sediment transport over the previous reporting period (Nov 2015 to Jan 2017).

Volume change was calculated along a 7,400-ft reach between Rollover Pass and STA 200+0. As during previous reporting periods, the rate of change was calculated across both the standard active region of sediment transport ending at the DOC (-23 ft) and modified region ending at the -15 ft contour in order to quantify change associated with the distinct delineation in nearshore morphology that has been documented along Gilchrist Beach. The dune crest functions as the landward limit of both the standard and modified active region of sediment transport. Since 2009, sediment transport in the nearshore region has supported the development of a single longshore bar and frequently a transient bar feature immediately seaward of or merged with this bar (STA 160+ to 170+0). The lack of a well-developed multiple bar system, such as that observed further south along the Texas Coast, indicates that exchange of sediment between the beach and region beyond the -10 to -15 ft contour may be limited during typical forcing conditions.

The variability in morphology along the full beach profile (standard active region of sediment transport) at representative of locations along the beach is shown in Figures 33-37. Profiles for the following years were included in Figures 33-37 with plots showing the available data set in the Appendix. Stability in the dune and across the berm is evident along the majority of the beach. A single longshore bar was located in the immediate nearshore along the majority of the beach as previously documented (2009-2017) with the exception of; 1) center beach from STA 160+0 to STA 170+0 (Fig 36) and 2) east of center beach (STA 175+0) where an a-typical single bar developed approximately 1,000 ft offshore of the position documented since 2009 (Fig 37).

As described in previous reporting, sediment transport in the most offshore segment of the nearshore, beyond the -10 to -15 ft contour, appears to be dominated by seasonal pulses of strong alongshore currents that may be reinforced by storm activity. Strong alongshore directed currents are potentially capable of transporting significant volumes of sand over seasonal time-scales. Sand eroding from or transiently stored in the offshore segment seaward of -15 ft contour and located 1,400 to 2,500 ft from the position of MHHW, may not serve as a repository available for direct exchange with the berm and immediate nearshore at Gilchrist Beach under typical forcing conditions. The nearshore region located seaward of the -10 to -15 ft contours is well beyond the limits of the structures that stabilize the mouth of Rollover Pass. Therefore, sediment transported alongshore toward the west has unimpeded entry into Rollover Pass from the Gilchrist Beach. This section of the profile functions as a conduit for alongshore transport of sand similar to the seaward nearshore region fronting Caplen Beach and further south, Sargent Beach. As during previous reporting periods, changes in transient nearshore morphology in this zone indicates the transient presence of lenses of sand that accumulate during storms or other periodic strong alongshore forcing to later be gradually eroded and transported beyond direct exchange with the subaerial beach. The contrasting net rate of volume change onshore or offshore of the -10 to 15 ft contour reflects the transient nature of this zone of transport.

Key characteristics of beach morphology along Gilchrist during Dec 2017 included the dominance of stability across the beach profile both at the landward extreme and at the foreshore along the central section of the beach. The duneline was stable along 100 % of the Study Area with 37% of the duneline exhibiting accretion. In contrast to Caplen Beach where over 60 % of the foreshore was eroding, at Gilchrist over 50% of the foreshore exhibited consistent accretion over the reporting period, particularly between STA 145+0 and STA 180+0. This stable region was flanked to the east and west by minor foreshore erosion that continued into the immediate nearshore.

Along the majority of the nearshore, the position of the single longshore bar was in agreement with the position in the previous reporting period (Jan 2017). Closer to Rollover Pass the single longshore bar shifted landward indicating a transient period of onshore forcing (STA 126+5 to STA 140+0). Further east, two longshore bars were located between STA 160+0 and STA 170+0 with position in agreement with that documented during Jan 2017. In contrast to the stable position of the single longshore bar to the east and two bars to the west, the longshore bar at STA 70+0 shifted over 1,000 ft offshore, indicating a transition point in sediment transport of unknown origin.

Erosion dominated at Gilchrist Beach due to the contribution of focused erosion at the east and west ends of the study area. Although erosion dominated along the study area, a relatively stable region with intermittent lower rates of erosion and accretion was located along the central segment of the beach (STA 145+0 to STA 175+0).

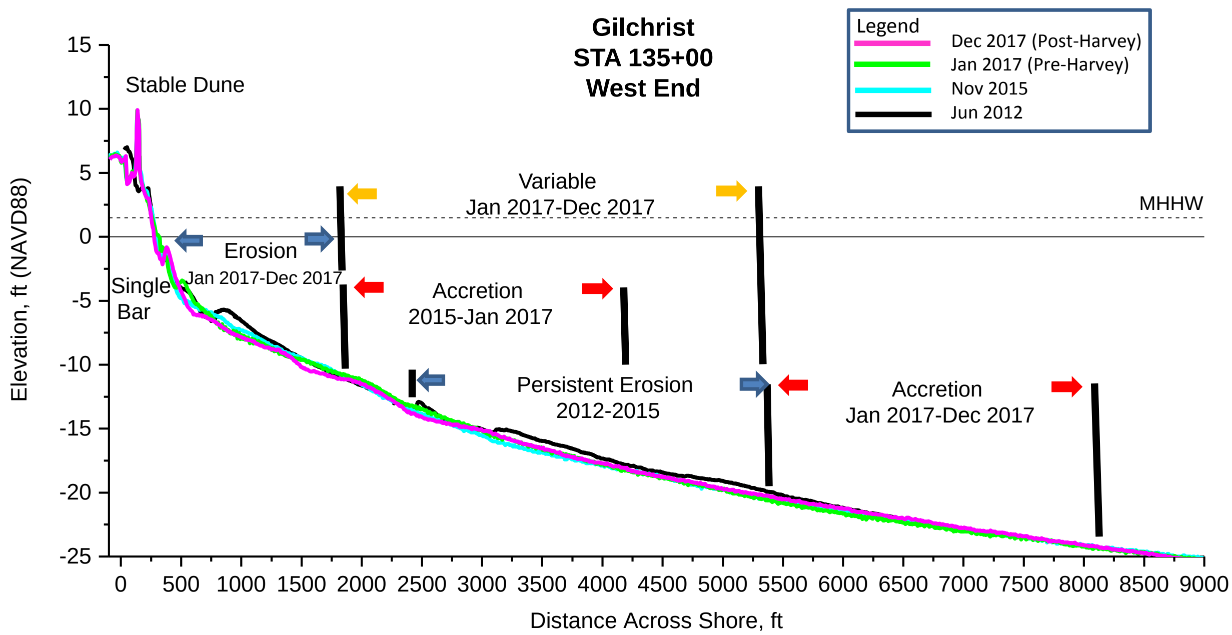

Figure 33. West End: Typical beach and nearshore morphology at the west end of Gilchrist Beach near Rollover Pass (Select years: Complete data record in Appendix)

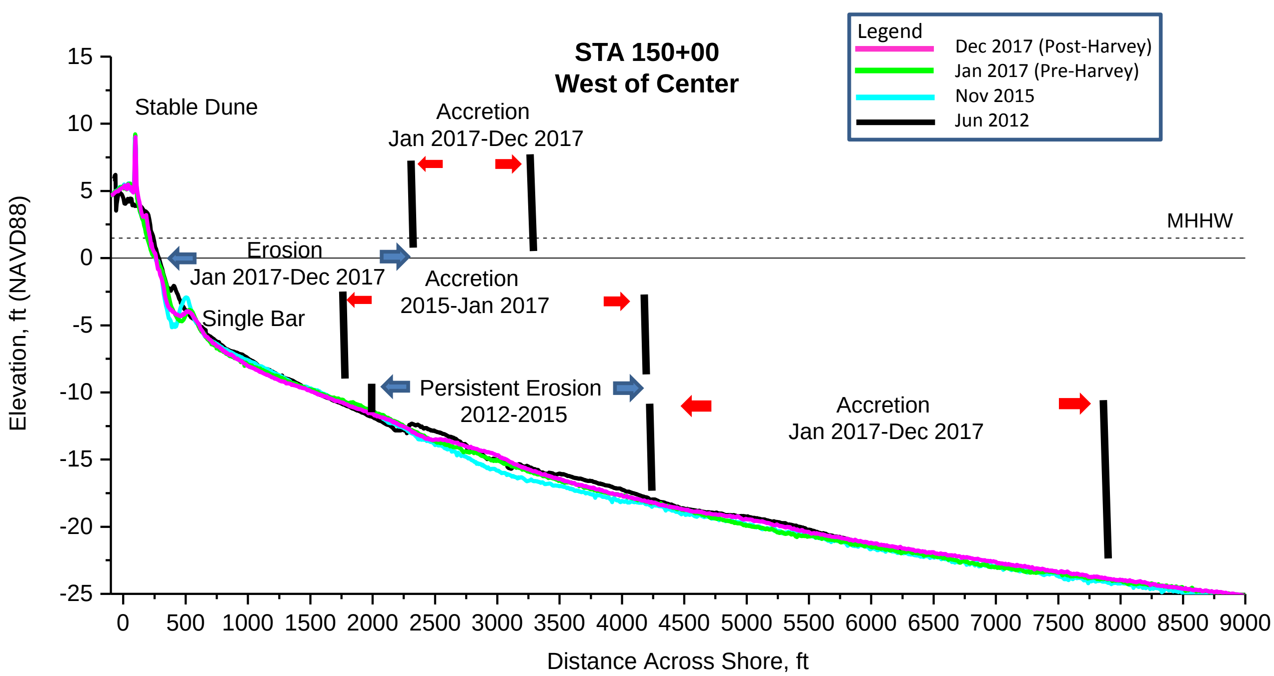

Figure 34. West of Center Beach: Typical beach and nearshore morphology west of center at Gilchrist Beach

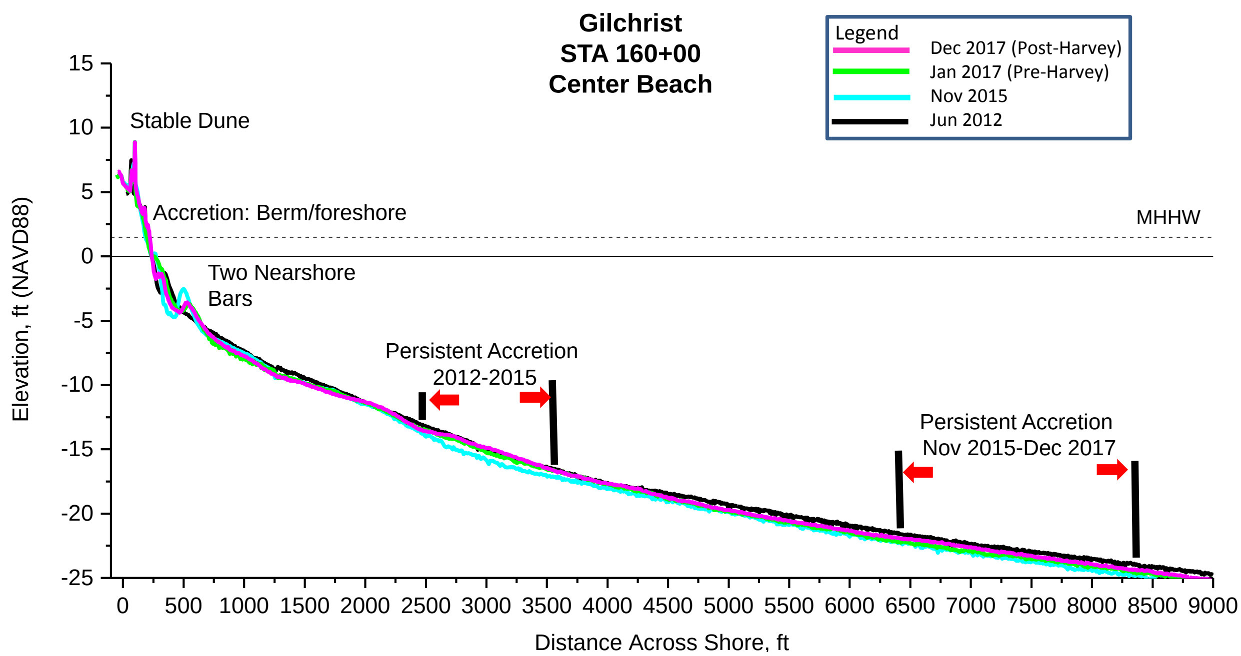

Figure 35. Center Beach: Typical beach and nearshore morphology with distinct development of two longshore bars close to the foreshore between STA 160+0 and STA 170+0

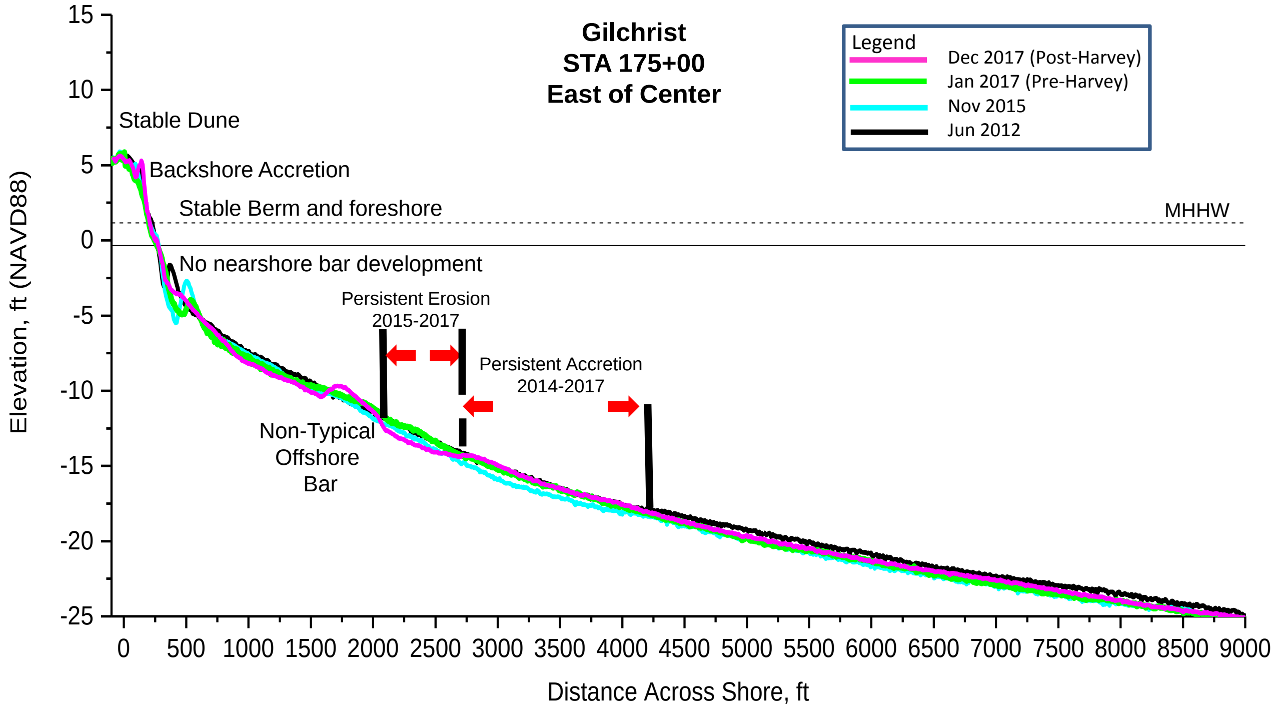

Figure 36. East of Center Beach: Stable dune and berm, with no nearshore bars and development of non-typical offshore bar

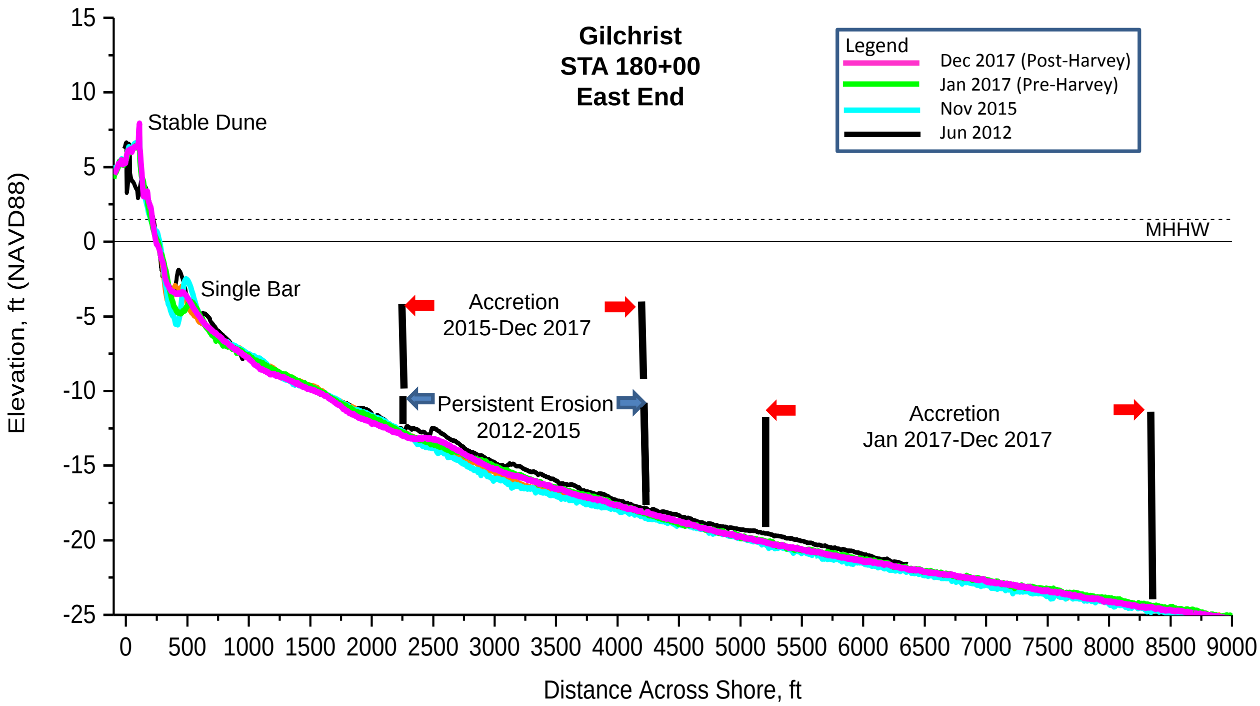

Figure 37. East End of Beach: Stable dune and berm, with development of low-elevation single nearshore bar

Recommendations: Gilchrist Beach

Prior to the initiation of monitoring at Gilchrist, the beach had a history of rapid erosion of both the berm and duneline under tropical storm and hurricane forcing, as well as subsequent slow post-storm recovery and intermittent intervals of erosion and shoreline recession. Despite this history, the duneline has demonstrated an increase in stability since 2009 as the beach and duneline recovered after Hurricane Ike. Since 2009, dune stability has been documented along 100% of the beach with net accretion measured along 37% of the duneline between Jan 2017 and Dec 2017. Although the majority of the backshore was stable, there were isolated locations of backshore erosion on the west end of the beach. The majority of erosion over the reporting period was identified along the foreshore and immediate nearshore. Despite the dominance of erosion, shoreline advance dominated at a rate of 3.9 ft/yr. The relative stability at Gilchrist Beach after Hurricane Harvey is attributed to the distance of the beach from landfall of the storm.

Although Gilchrist Beach did not meet the criteria that trigger nourishment during 2016 or 2017, this beach remains recommended for Tier 2 consideration based on the severity of erosion that has occurred there during past storm events, the continued slow recovery of the duneline and the continued gradual reduction in width along 50% of beach between Jul 2009 and Dec 2017.

Jamaica Beach

Jamaica Beach is located in Brazoria County approximately mid-way between the Galveston Ship Channel and San Luis Pass. The eastern end of Jamaica Beach lies at the CBRS boundary, which stretches over 2 miles toward the east (Fig 38). The development of the City of Jamaica Beach began in 1956; the private community includes homes and roadways in close proximity to the Gulf of Mexico. After development began, the landward limit of this short, just over 4,000-ft long, segment of beach consisted of a narrow row of intermittent low coppice mounds that have been repeatedly destroyed or compromised during frequent storms. More recently, several dune restoration projects have supported the establishment of higher elevation dunes along the backshore although two access roads and multiple pathways interrupt the continuity and effectiveness of protection afforded by the still narrow duneline. Various alternatives such as rubble, sand filled tubes and nourishment have been placed along this section of beach to protect backshore infrastructure and limit inundation, particularly during tropical storms.

With regard to beach erosion and shoreline recession in recent years, Jamaica Beach is located along a relatively stable segment of Galveston Island (City of Galveston 2012, BEG 2011, Morton 1985). The entire dune system and all vegetation along the backshore was eliminated during Hurricane Ike (2008). Jamaica Beach experienced a period of recovery and stability after Hurricane Ike with the width of the beach gradually increasing up until 2014. Of greater concern has been the lack of sustainable dunes along this stretch of coast, which allows for inundation of the backshore infrastructure of the City of Jamaica Beach during tropical storms. Therefore, projects at Jamaica Beach have focused on dune restoration and reinforcement rather than extensive beach nourishment other than that in support of dune restoration.

Several studies have addressed changes in the beach, dunes and shoreline position at Jamaica Beach. Erosion response alternatives were investigated during CEPRA Cycle 2-Cycle 5 including studies of the coastal processes acting at San Luis Pass. A dune restoration project was completed in August of 2006 along a 2,840-ft section of the beach (CEPRA 1214). The dune restoration consisted of the placement of approximately 26,100 cu yd of sand between STA 386+75 and STA 417+20 (BMMP 2010). Hurricane Ike (September 2008) caused extensive damage to the dune line at Jamaica Beach as well as erosion of the beach. Planning toward implementation of an additional dune stabilization project continues as of this reporting.

The 2013 CBI monitoring program established a baseline data set applied to assess the need for dune restoration and beach nourishment toward the long-term stability of Jamaica Beach. This study defined a Target Width and Action Width as well as determining the base rates of shoreline change and erosion based on the analysis of beach profile and shoreline position data. The 2014-2017 monitoring surveys provided an annual assessment of change in morphology, including dune stability, as well as the rate of shoreline position change toward support of proactive beach and dune management.

The Project Area at Jamaica beach is defined as STA 390+0 to STA 420+0 in the footprint of previous dune restoration and beach nourishment projects. The Study Area is defined as from STA 385+0 (East end) to STA 425+0 (West end).

Data Review: Jamaica Beach

Jamaica Beach was added to the CEPRA Beach Monitoring Program during 2013. The 2013 survey was the first to apply the BMMP survey grid at this location. There is limited availability of comprehensive historic data that describes the region of active transport from dune crest to the DOC (Williams 2014). The lack of suitable historic data applicable for beach management and assessment of long-term local change is due to the focus of local projects on dune restoration rather than a comprehensive beach assessment. Therefore, the portion of the berm that was directly impacted by construction served as the seaward limit of the surveys. The majority of the available survey data has been focused on the immediate construction area and dune line in the form of as-built surveys and spatially limited pre-construction surveys. Surveys under the regional description of West Galveston in the BMMP terminate just east of Jamaica Beach at STA 385+00. A catalog of the available data, along with location and limitations is provided in Table 5 for ease of reference. Several of these data sets do not extend seaward to MHHW (1.3 ft NAVD88) and do not include measurements across the complete berm. The 2013-2017 CBI surveys span the complete beach from landward of the dune crest or landward limiting feature to the DOC at each transect location from STA 385+0 to STA 425+0. The 2013 survey serves as the baseline for future comparison and calculation of rate of shoreline change and erosion rate.

Shoreline Analysis: Jamaica Beach

Following a reporting period dominated by a high rate of recession (-23.5 ft/yr), shoreline advance dominated at Jamaica Beach between 2016 and 2017 at a relatively high rate of 12.7 ft/yr. There is no evidence that forcing during Hurricane Harvey contributed to recovery. Higher water levels may have contributed to stability in the absence of onshore forcing winds prior to the survey (Fig 39). It is more likely that this relatively stable area of the coast had experience accretion between the 2016 survey and the 2017 post-Harvey survey with limited impact from storm forcing during the hurricane. Although erosion due to Harvey was evident within 25 miles to the south of Jamaica at Surfside Beach, the beach at Surfside has a higher erosion rate and history of exacerbated erosion under similar forcing conditions. The Post-Harvey shoreline position was in advance (seaward) of the 2016 position but landward of the 2012-2014 shoreline positions due to erosion that occurred from 2014-2016 (Figs 40-42).

The greatest advance in shoreline position was observed from 300 ft east of STA 390+0 (near the CBRA boundary) westward to STA 420+0. Nearly continuous shoreline advance was interrupted by a short 200-ft long segment of minimal change along a stable central segment located east of the project area at STA 385+0 and along another 200-ft long segment centered at STA 420+0. The degree of change in shoreline position was relatively consistent ranging from 5 to 20 ft with an average of 10.7 ft.

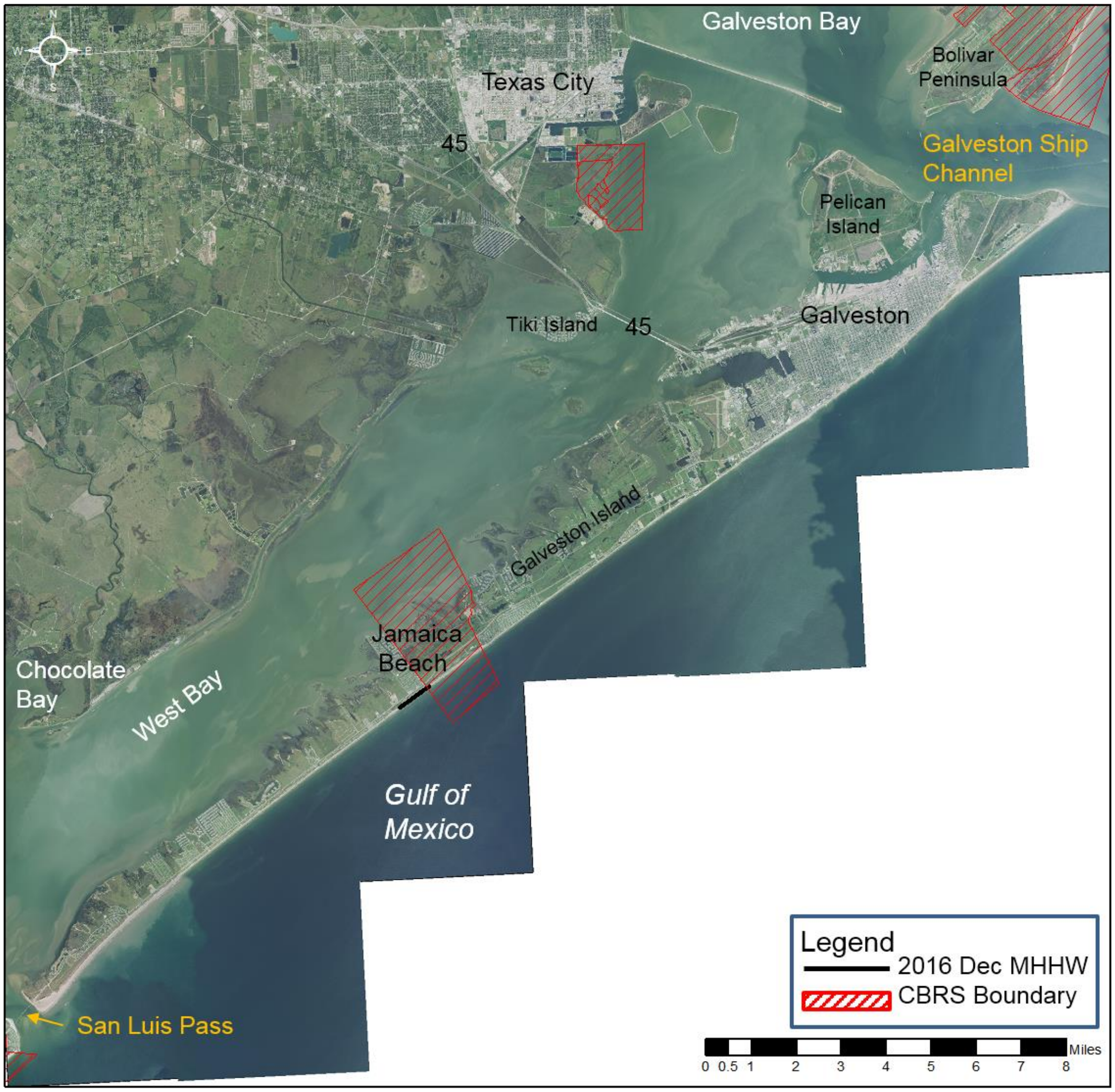

Figure 38. Location of Jamaica Beach relative to San Luis Pass and the Galveston Ship Channel

Table 5. Catalog of Available Survey Data: Jamaica Beach		
Date	**Source**	**Description**
2000	BEG	Shoreline polyline interpolated from aerial image Extent: West Galveston Island No beach profiles
2006	LAN (Coastal Surveying of TX)	Beach Profiles: as-built survey; Dune crest to + 1.5 to +2.5ft Extent: STA 335+00 to 365+00 No MHHW (applied interpolation for best estimate)
2008	TGLO	Limited as built berm only
2010	HDR (Naismith)	Beach Profile: 1-transect to DOC: STA 411+00 Translated for profile view
2011	HDR (Naismith)	Beach Profile: 1-transect to DOC: STA 411+00 Translated for profile view
2012	LAN (Coastal Surveying of TX)	Beach Profile Limited: Dune, MHHW-MLLW; No Berm Extent: STA 335+00 to 365+00 Grid does not agree with BMMP grid (335+00, 345+00, 355+00 and 365+00 (60-ft Horiz. offset)
2013	CBI (Naismith)	Beach Profile: Landward of dune to DOC Extent: STA 385+00 to 425+00 (BMMP grid) Beach Profile and Shoreline Position Survey (MHHW)
May 2014	LAN	Beach Profile: Dune crest to ≈ -1.5 ft Grid does not agree with BMMP grid Alongshore Extent: STA 385+00 to 425+00 (66-ft offset) Translated for profile view
June 2014	CBI (Naismith)	Beach Profile: Landward of dune to DOC Extent: STA 385+00 to 425+00 (BMMP grid) Beach Profile and Shoreline Position Survey (MHHW)
Sep 2015	CBI (Naismith)	Beach Profile: Landward of dune to DOC Extent: STA 385+00 to 425+00 (BMMP grid) Beach Profile and Shoreline Position Survey (MHHW)
Dec 2016	CBI (Naismith)	Beach Profile: Landward of dune to DOC Extent: STA 385+00 to 425+00 (BMMP grid) Beach Profile and Shoreline Position Survey (MHHW)
Nov 2017	CBI (Naismith)	Beach Profile: Landward of dune to DOC Extent: STA 385+00 to 425+00 (BMMP grid) Beach Profile and Shoreline Position Survey (MHHW)

Shoreline Change (2008-2016)

For context, the two-year period of accelerated shoreline recession at Jamaican Beach (2014-2016) resulted in the shoreline receding between -28 and -42 ft. The shoreline recession that occurred between 2014 and 2015 was the first documented since Ike impacted the Texas Coast. The rate of recession increased significantly during the 2015-2016 study period with the average rate of shoreline position change increasing from -2.8 ft/yr (2015) to -24 ft/yr (2016). Although the rate was highly variable with alongshore position, the highest rate was generally associated with the eastern segment of the beach. The average rate of change for the CBI study period (2013-2016) was -4.6 ft/yr. Over the post-Ike recovery period, shoreline advance dominated with the average rate of change of +20 ft/yr between 2008 and 2014. The rate of shoreline change over intervals of interest in Table 6.

Shoreline Change 2000 (BEG) -2017

The 2000 BEG shoreline has been applied as the baseline for long-term trend analysis as this shoreline is representative of a relatively stable period from 1995 to 2001. Over this period, the shoreline position along Jamaica Beach was relatively stable, prior to influence by numerous tropical storms starting with Tropical Storm Fay (2002) and more recently Hurricane Ike (2008) and Hurricane Harvey (2017). The shoreline advanced at a rate of 4.0 ft/yr from Aug/Sep 2000 to May 2014, amounting to a total seaward shift of approximately 56 ft over 14 years. The average rate of change over the 2000-2017 study period increased to +1.8 ft/yr, owing to the dominance of accretion between 2016 and 2017.

Rate of Shoreline Position Change: Jamaica Beach

The average annual rate of shoreline position change has been highly variable since analysis began in 2013. Although the annual average rate of change has been highly variable (Table 2), fluctuating between advance and recession, the average over the CBI monitoring period (2009-2017) was relatively low at -1.3 ft/yr. Figure 43 shows the contrast and variability in the rate of shoreline change with alongshore position for the reporting period (2016-2017) compared to the rate from previous reporting periods (2013-2014, 2014-2015 and 2015-2016), over the CBI monitoring period (2012-2017) and the longer historic study period referenced to the BEG data (2000-2017). These surveys all represent conditions potentially influenced by winter storm forcing with the exception of the 19 May 2014 survey and potentially minimal influence during the 29 Sep 2015.

Beach Width: Jamaica Beach

Between 2016 and 2017, a moderate but relatively consistent increase in beach width was measured along 90% of the project area with relative stability along the remaining 10% located just east and west of STA 420+0. The beach width ranged from a minimum of 46 ft at the western limit of the project area to 120 ft at the widest point located near the east end at STA 395+0. The greatest increase in width occurred between STA 390+0 and STA 405+0 and at the west end (STA 425+0). The average increase in beach width was 11 ft. The beach along the entire study and project area was in excess of the Action Width (60 ft). A Target Beach Width of 120 ft was selected for future nourishment based on both the historic range in beach width over the recent period of stability, and agreement with other CEPRA beaches along the upper Texas coast. As during 2016, only a small segment of the beach has maintained a width at or in excess of the Target Width. The beach was at Target Width along an isolated segment near STA 395+0, located adjacent to an access road and influenced by its proximity. The history of change in beach width over time is provided in Table 7. Table 7 also provides a summary of key morphologic features.

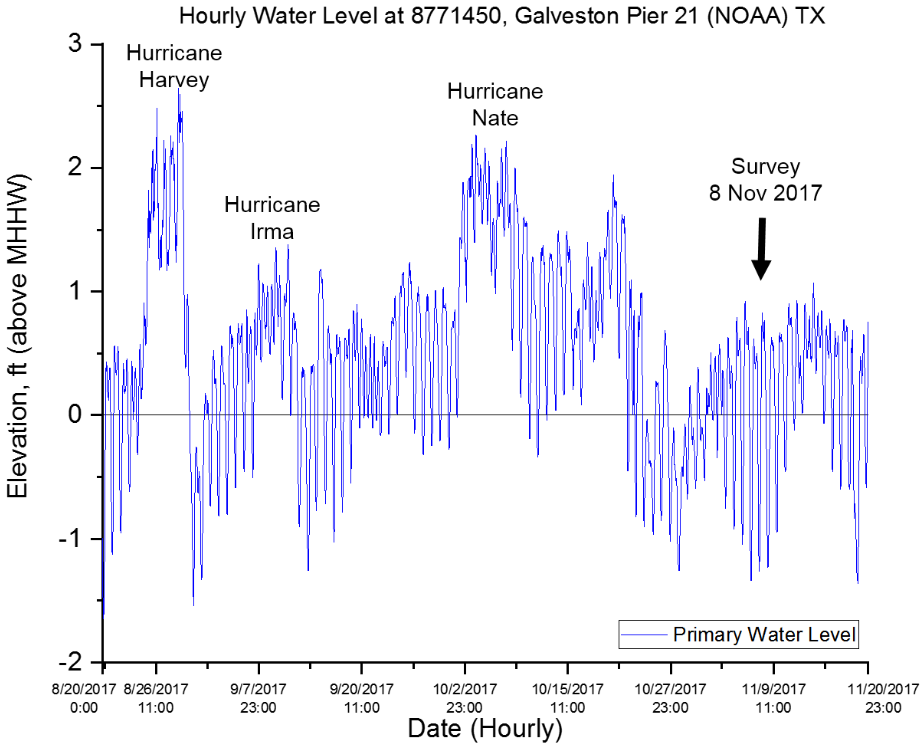

Figure 39. Persistence of elevated water level in excess of MHHW preceding the 2017 survey at Jamaica Beach

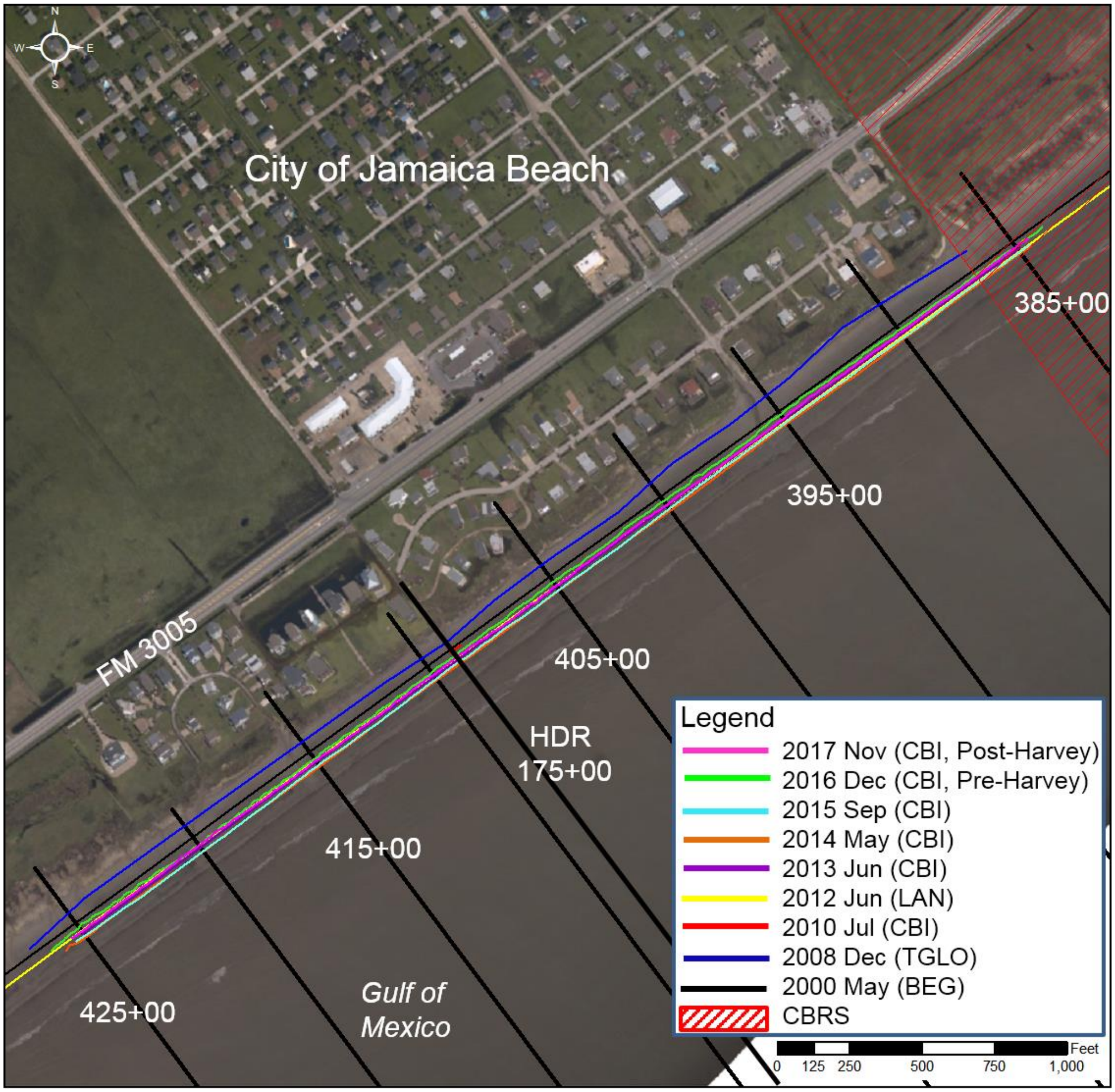

Figure 40. Shoreline position change at Jamaica Beach over the full study area (2000-2017)

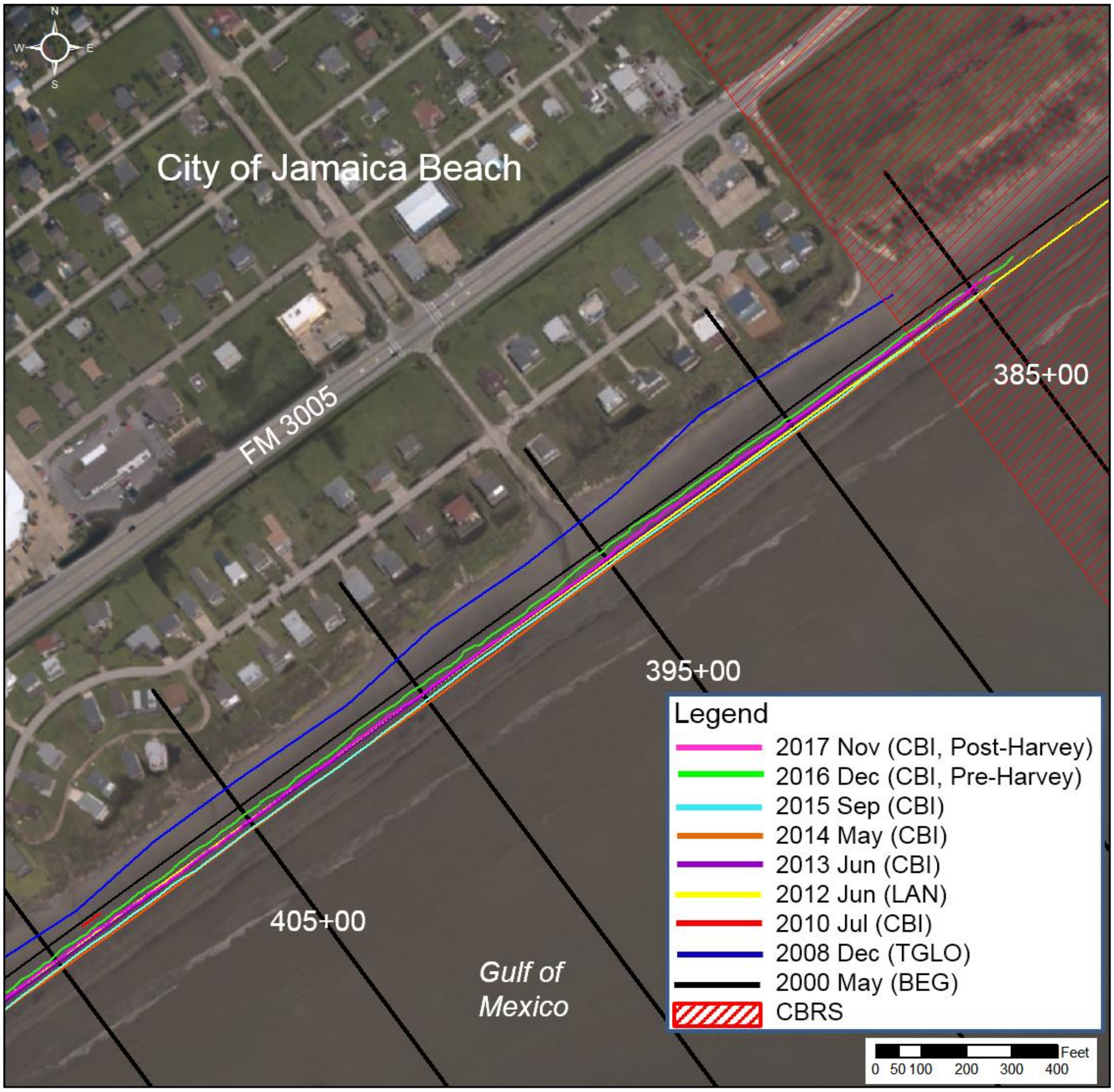

Figure 41. In contrast to the previous reporting period, shoreline advance dominated along the east end of Jamaica Beach between 2016 and 2017

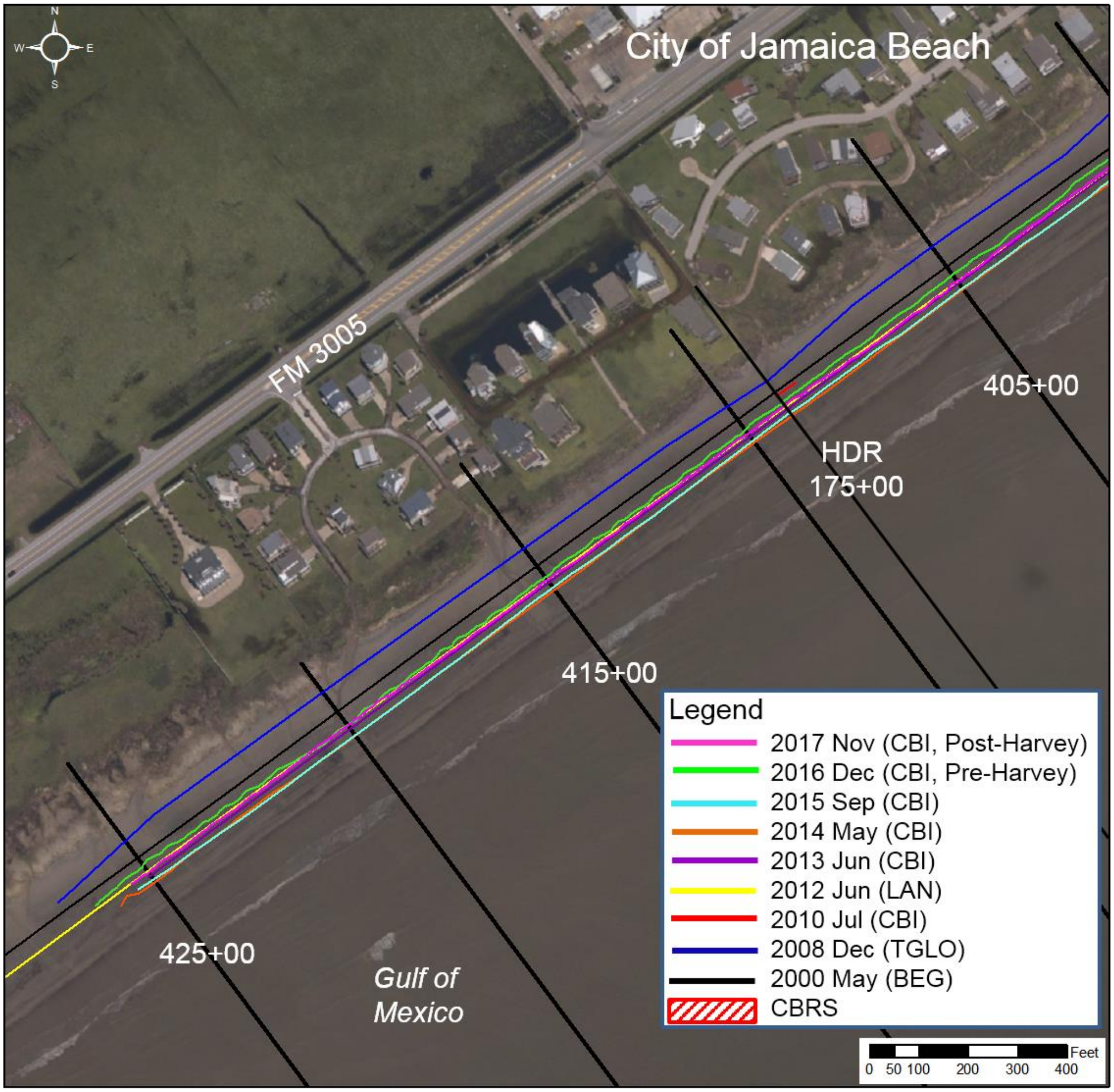

Figure 42. Stability in shoreline position or advance dominated along the west end of Jamaica Beach (2016-2017)

Line of Vegetation Applied as Backshore Limit

The width of Jamaica Beach was measured from the LOV (2014) to the position of MHHW. As previously reported, the 2013 LOV was originally applied as the landward limit of the beach for the purposes of calculating beach width but was re-evaluated during 2014 due to the high level of disturbance and inconsistencies in the seaward limit of the duneline along the backshore at Jamaica Beach. The width of the beach was re-calculated for all previous data sets reflecting the application of the more detailed 2014 survey. The 2014 LOV was generally located 10 to 20 ft seaward of the 2013 LOV, reducing the previously reported beach width values. Although the 2014 LOV is applied as the baseline for present and future calculations, the position of the LOV continues to be measured annually to identify/document areas of instability and to apply toward the assessment of change after future restoration projects.

The 2016 LOV was in close agreement with the envelope of change defined by the 2014 and 2015 positions with closest agreement with the 2015 position over the majority of the beach (Fig 44-47). The 2017 LOV was significantly landward of the 2016 LOV west of STA 405+0 and although variable with alongshore position, in closer agreement east of STA 405+0. Interpretation of 2016 aerial imagery (Google Earth) indicated that change in vegetative coverage was generally insignificant during 2016 but that the LOV had receded along the western section of the project area after Harvey (Aug 2017 aerial imagery).

Table 6. Shoreline Change Rate: Jamaica Beach 2017

Date	Rate Average ft/yr	Description
Annual and Monitoring Program Average (CBI Survey Data)		
Dec 2016 to Nov 2017	+12.7	Annual (Post-Harvey)
Sep 2015 to Dec 2016	-23.5	Annual
May 2014 to Sep 2015	- 2.8	Annual
Jun 2013 to May 2014	+ 17.9	Annual
Jun 2012 to Jun 2013	+1.7	Annual
Jun 2013 to Nov 2017	-1.3	CBI Monitoring History (CBI)
2012 Nov 2017	-0.72	CBI Monitoring History (CBI)
Intervals of Significance		
Jun 2013 to Dec 2016	-4.6	Previous CBI Monitoring History (CBI)
2012-2016	-3.3	LAN 2012 Survey
2000-2017	+1.8	Historic (BEG) Full Study Period (Dune restoration**, tropical storms, Ike and Harvey)
2000 to 2016	+1.3	Previous Historic (BEG) Full Study Period (Dune restoration**, storms, Ike)
Dec 2008 to May 2014	+ 20.0	Post-Ike recovery
May 2000 to Dec 2008	- 6.5	Influence of Ike, dune restoration**
2006* to 2008	-11	Post-Ike (Interpolated from profile data)
2000* to 2006	+5.6	Pre-Ike (BEG and Interpolated from profile data
Notes: * interpolated best estimate ** Dune restoration (2006)		

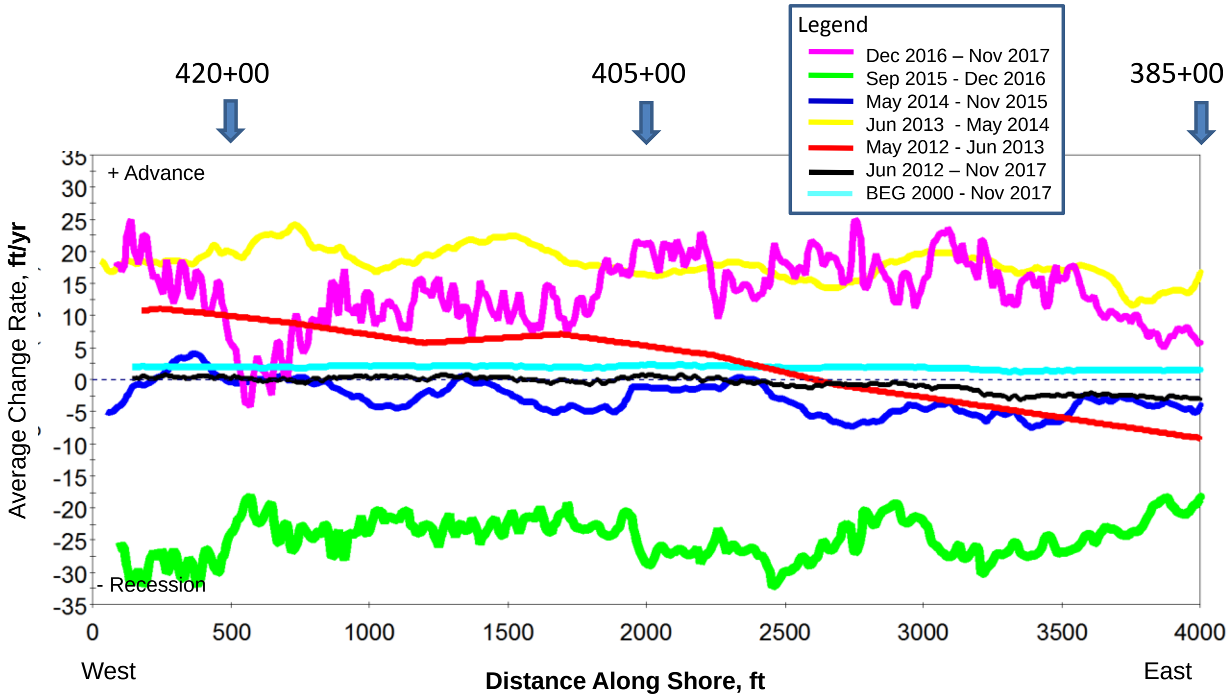

Figure 43. Comparison of variability in average rate of change in shoreline position at annual intervals and over the monitoring program interval (2012-2017) and extended historic period of BEG data record (2000 to 2017).

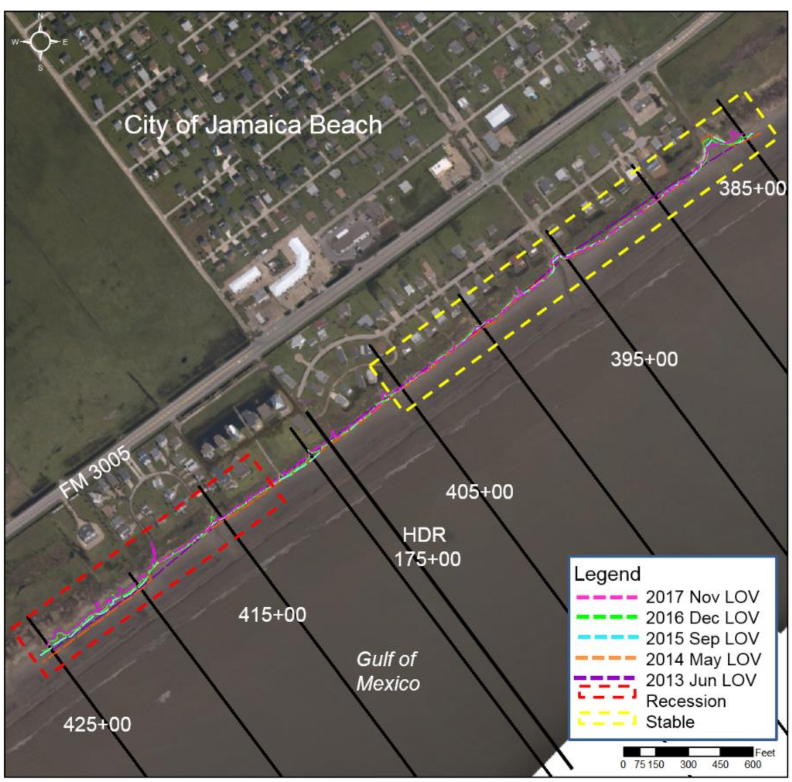

Figure 44. Location of recession and relative stability of the LOV during 2017

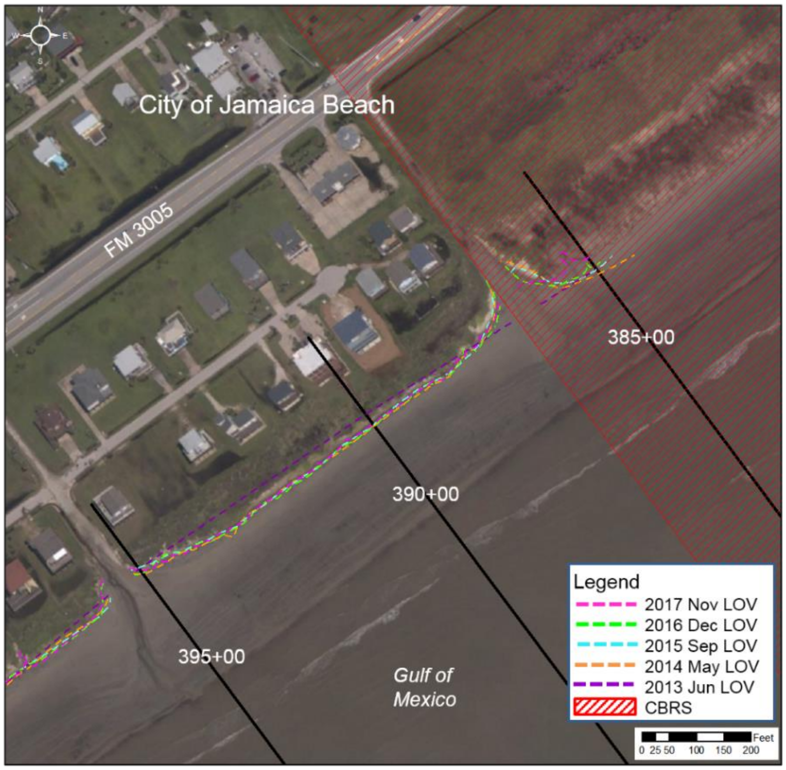

Figure 45. LOV position was relatively stable along the east end of Jamaica Beach between 2016 and 2017

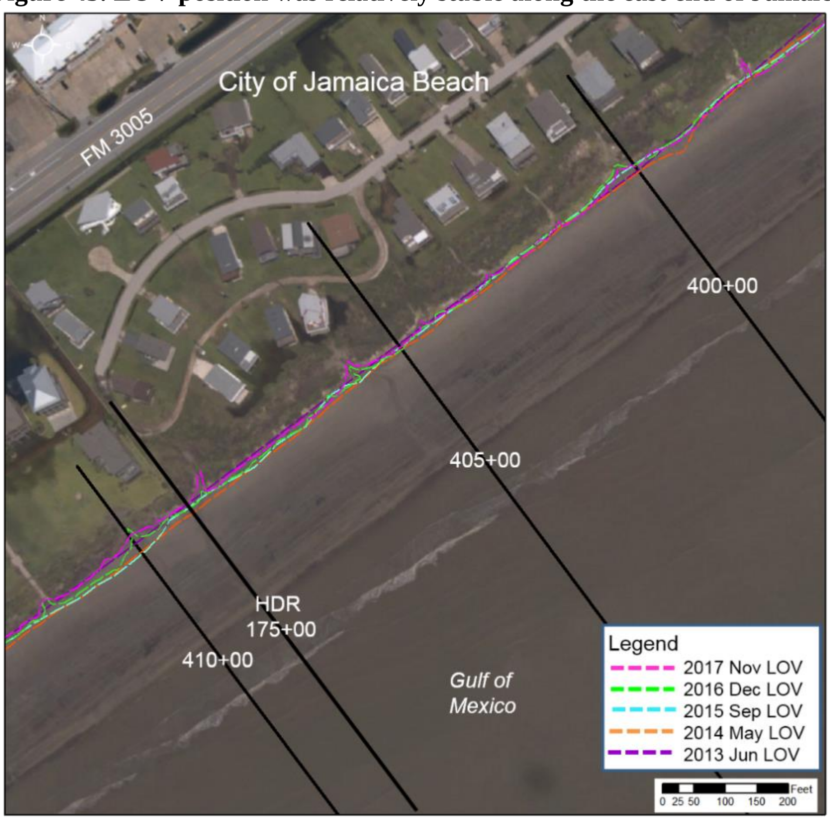

Figure 46. LOV position was relatively stable along the central segment between 2016 and 2017

Figure 47. LOV position receded along the west end of Jamaica Beach between 2016 and 2017

Volumetric Analysis: Jamaica Beach

Accretion dominated at Jamaica Beach over the reporting period, following a period of extended net erosion that culminated during the 2015-2016 reporting period and resulted in the most significant documented decrease in beach width since Hurricane Ike impacted the area. The beach eroded at a net rate of -45,000 cy/yr between 2015 and 2016, effectively doubling the net rate of -21,000 cy/yr measured over the previous reporting period (2014-2015).

The net rate of accretion at Jamaica Beach was approximately 45,500 ft/yr between Dec 2016 and Nov 2017. The volume of sand deposited over the reporting period was in close agreement with the volume of sand that eroded over the previous reporting period (2015-2016). The rate of accretion was variable with alongshore position and with no distinct trend. The highest rate of accretion was from STA 390+0 to STA 395+0, in the vicinity of STA 405+0 and between STA 420+0 and STA 425+0. A low rate of erosion was identified just east of the project area at STA 385+0. The lowest rate of accretion was at STA 400+0 and between STA 410+0 and STA 415+0.

For context, previous studies have estimated the average net rate of erosion at Jamaica Beach at 30,000 cy/yr (Coast and Harbor 2010) based on a shoreline recession rate of 9.1 ft/yr along a 3,045 ft long stretch (Station 386+75 to 417+20); a significantly higher shoreline recession rate than previously observed between 2000 and 2015 as well as during 2017.

The template for calculating volume change extended from the primary dune crest to the DOC. The DOC applied at Jamaica Beach was -25 ft as per the BMMP. The DOC may be revised as additional beach profile data extending to DOC are collected in the future. As at other locations along the north Texas Gulf Coast, there is no indication that sediment beyond -12 to -18-ft contour is actively transported onshore due to strong alongshore directed currents. At Jamaica Beach the comparison of the available data sets that extend to DOC indicates that the functional region of sediment transport, where significant change has been quantified (2003-2016), was located between the -11 and -13 ft contour. Beyond this point, the profile was effectively featureless with limited indication of change in elevation within limits of coastal survey accuracy.

Beach morphology at Jamaica Beach during Nov 2017 reflected a period of transition due, in part, to contributions of Harvey followed by an extended period of higher than average water level and winter storms. As during the previous 2016 survey, the beach profile reflected the influence of strong onshore forcing in the nearshore indicated by modified bar development. One storm bar was well developed along the entire study area. The nearshore landward of the storm bar was relatively featureless with either a low elevation shelf-like feature or a developmentally dampened bar with a blunt cropped crest. There was the slight indication of a low elevation bar seaward of the storm bar with minor development at the east and west terminus of the study area decreasing to limited to no development with approach to the central project area.

The morphology of the subaerial beach was relatively stable with the exception of the beach east of the project area at STA 385+0. The berm was either stable or accreting with an increase in both width and elevation. The duneline in the project area was stable or accreting with the exception of erosion and onshore migration of the foredune at STA 410+0, located along a stretch typified by low dunes at elevations of between 5 and 7 ft (NAVD88). Typical beach and nearshore morphology between 2015 and 2017 is shown at key locations in Figures 48-53.

Table 7. Beach Width: Jamaica Beach 2017 (Post-Harvey)
***Outside Project Boundary**
Action Width: 60 f < Target Width: 120
2014 LOV

STA #	2000 BEG	Dec 2008 TGLO	Jun 2012 LAN	Jun 2013 CBI	Jan 2014 LAN	May 2014 CBI	Sep 2015 CBI	Sep 2016 CBI	Nov 2016 Nov 2017	▲ 2016 2017	▲ 2017 Target	Dune Status < Erosion > Accretion
385+0*	65	N/A	106	96	N/A	112	107	86	86	0	-10	Stable primary dune Stable Backshore < Berm crest < Foreshore No landward bar 1 fully formed bar 1 Limited seaward bar
390+0	81	-14	121	113	119	132	129	98	110	12	20	stable primary dune NC Foredune NC Backshore > Berm crest > Foreshore 1 dampened landward bar 1 fully formed bar No seaward bar
395+0	109	40	148	144	138	159	154	122	140	17	-7	Stable Primary dune < Foredune (minor) > Backshore > Berm > Foreshore 1 dampened landward bar 1 fully formed bar No seaward bar
400+0	78	19	116	115	114	137	129	97	113	17	-13	Stable primary dune Stable Foredune > Backshore > Berm > Foreshore No dampened landward bar 1 Fully formed bar No seaward bar
405+0	70	19	106	111	118	126	124	92	107	15	-30	Stable Stable primary dune < Foredune (minor) > Backshore > Berm > Foreshore No dampened landward bar 1 Fully formed sandbar 1 limited seaward bar
410+0	55	20	90	97	102	111	107	82	90	9	-22	< Primary dune (minor) < Foredune > Berm > Foreshore 1 dampened bar 1 fully formed sandbar 1 limited offshore bar
415+0	62	18	98	103	112	122	117	92	98	7	-54	> Primary dune > Foredune > Berm > Foreshore 1 dampened bar 1 fully formed sandbar 1 limited offshore bar
420+0*	31	-18	66	75	82	91	91	66	66	0	-55	Stable Primary dune > Foredunes > Berm > Foreshore 1 dampened bar 1 fully formed sandbar 1 limited offshore bar
425+0*	28	-14	62	73	76	88	82	46	65	19	-10	Stable primary dune Stable foredune > Backshore > Berm crest > Foreshore 1 dampened bar 1 fully formed sandbar 1 limited offshore bar

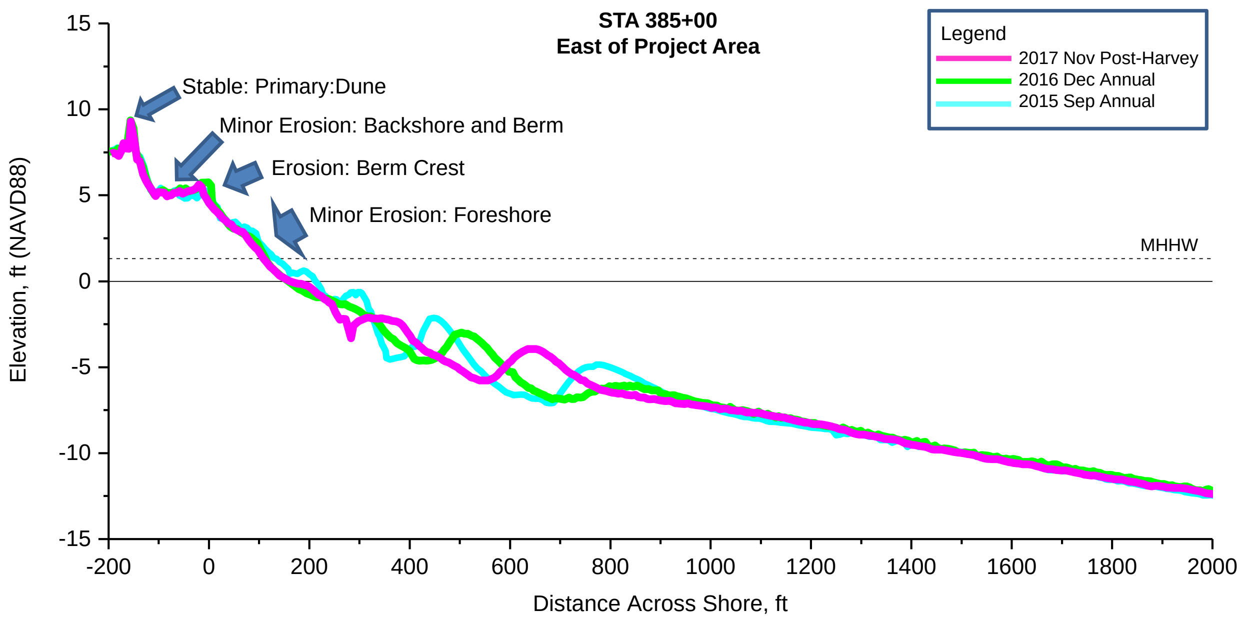

Figure 48. East of Project Area 2017: Minor Erosion of backshore and foreshore and significant erosion of berm crest (2015-2017)

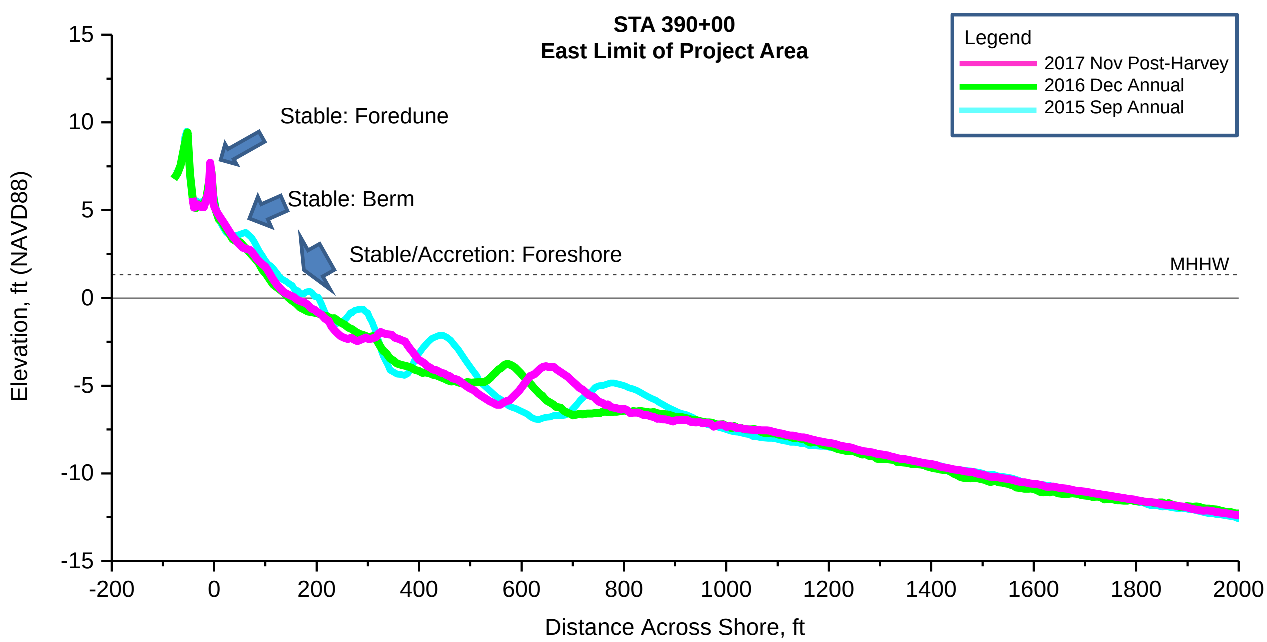

Figure 49. East Limit of Project area: Beach increased in stability from foredune to foreshore with accretion dominating, with atypical dampened bar morphology between the 0 and -5 ft contour and no seaward bar development (2015-2017)

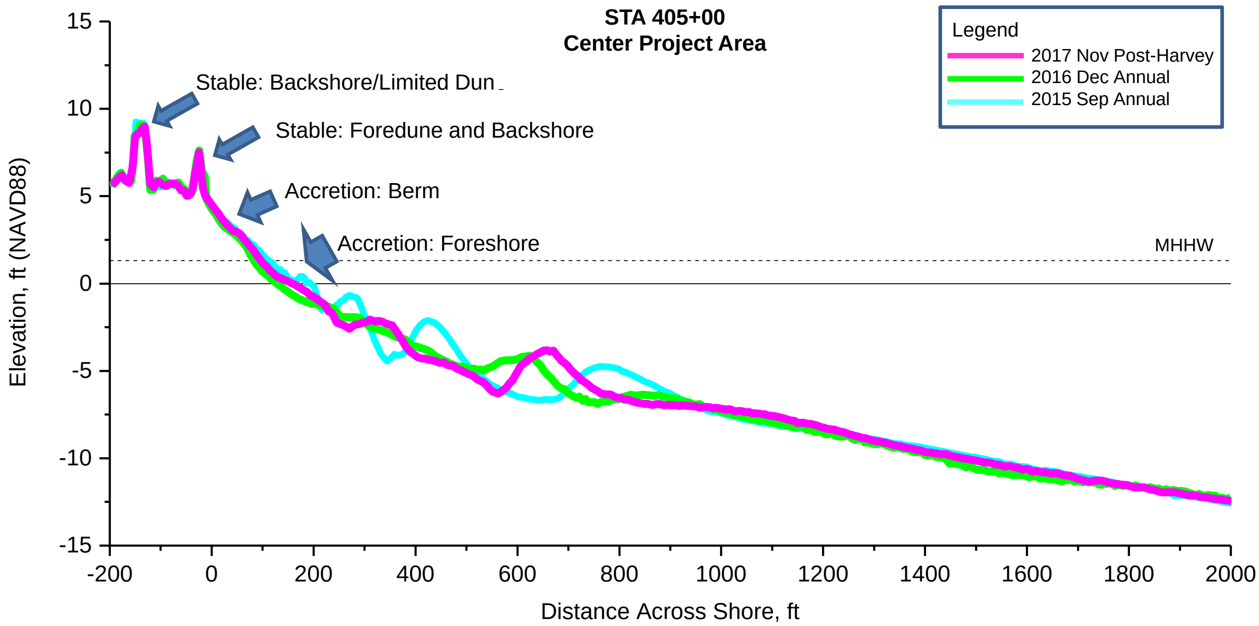

Figure 50. Center Project Area: Stability or accretion dominated along entire profile with atypical dampened bar morphology between the 0 and -5 ft contour and no seaward bar development (2105-2017)

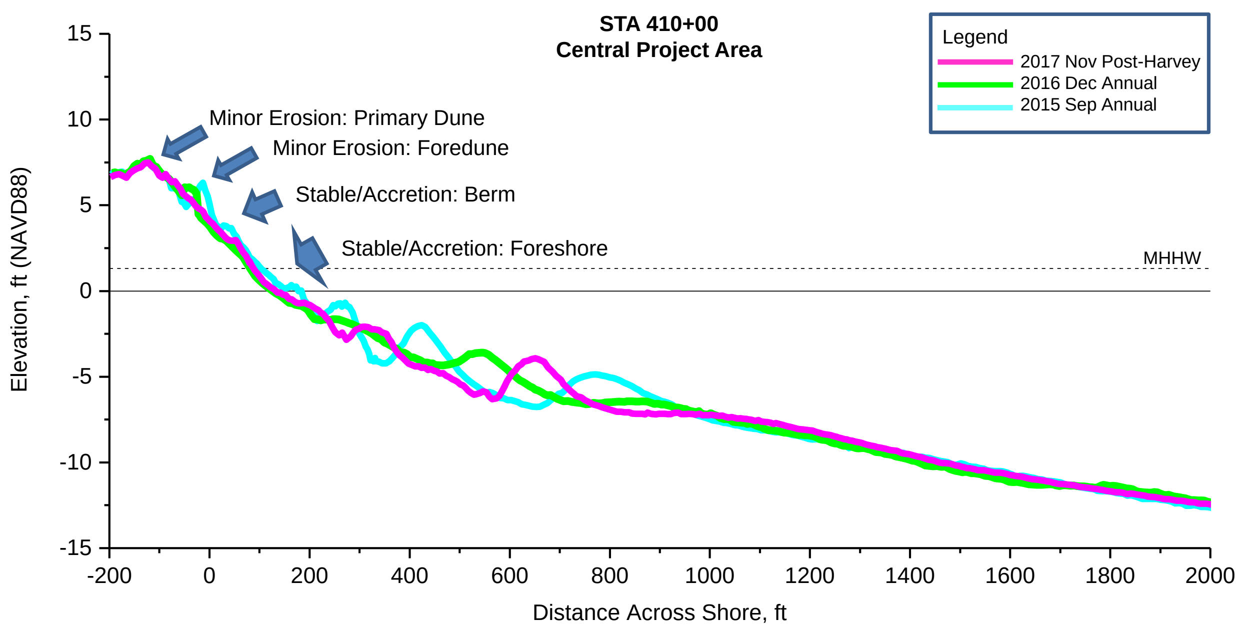

Figure 51. Center Beach (2015-2017): Erosion dominated from dune to NAVD88 = 0 (2017)

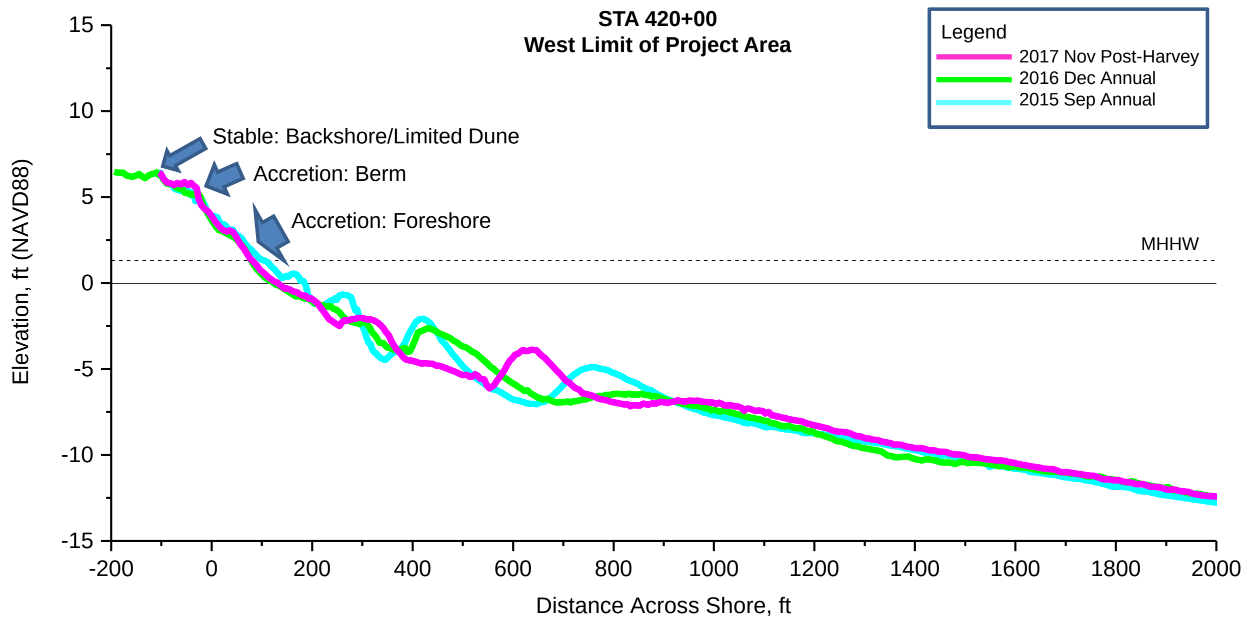

Figure 52. Western Limit of Project Area (2015-2017): Stable dune and backshore, accretion across berm and foreshore (2017)

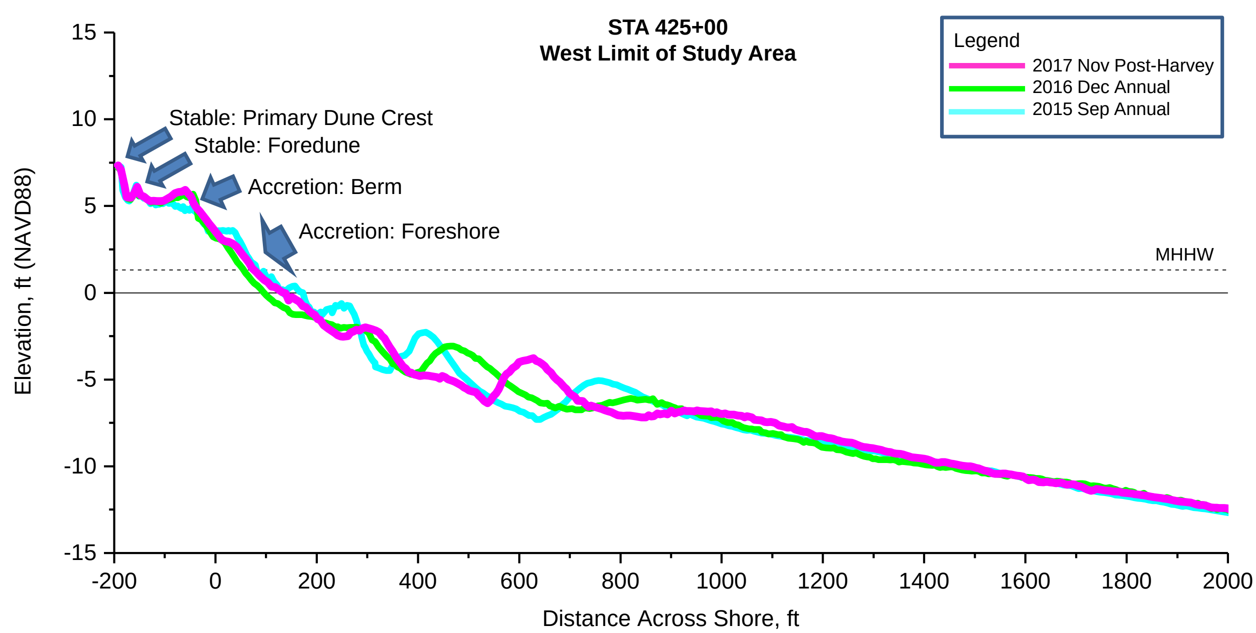

Figure 53. Western Limit of Study Area (2015-2017): Stable dune, accretion across backshore and berm and foreshore (2017)

Recommendations: Jamaica Beach

Accretion dominated at Jamaica Beach between 2016 and 2017 despite an extended period of persistently high water levels in excess of MHHW and periodic onshore forcing over several months prior to the 2017 survey. This period of stability followed a two-year period dominated by erosion (2014-2016). Over the reporting period, the duneline was predominantly stable and the berm not only expanded seaward but also increased in elevation. The beach was well in excess of the Action Width, although only less than 10% of the beach was at the Target Width. The only damage that can potentially be attributed to Hurricane Harvey is the erosion of the berm crest along the beach east of the Project Area. Therefore, the 2018 survey, which is anticipated to initiate prior to the winter season, will provide for the documentation of the peak summer condition and more accurate assessment toward nourishment recommendation.

The beach width remained in excess of the Action Width along 90% of the beach despite influence of Hurricane Harvey and winter storms and there was a low rate of recession; therefore, the recommendation for beach nourishment was again deferred at the time of this reporting. Due to the high rate of recession observed during 2016 along with a 2-year trend of shoreline recession (2014 to 2016), the need for nourishment at Jamaica Beach will be re-assessed after the 2018 survey. The 2017 survey supports the hypothesis that the high rate of erosion during 2016 was related to seasonal variability and may have been influenced by persistent nuisance flooding and contributions of winter storms immediately prior to the survey and not indicative of a trend. Restoring the summer survey schedule would eliminate the influence of winter storms and periods of higher water level that are seasonal and related to astronomical tides. Removing these contributions could assist in determining if higher erosion rates are a continuing trend or isolated to seasonal and storm events along the Texas Coast.

McGee Beach

McGee Beach is located along Corpus Christi Bay fronting the seawall in downtown Corpus Christi. The beach is bordered by the Corpus Christi Municipal Marina breakwater to the north and an approximately 400-ft long terminal groin at the border of Emerald Beach to the south (Fig 54). The nearly 1,800-ft long beach is further stabilized by five low-elevation, typically submerged, groins spaced at 300-ft intervals. These low groins are located in the proximity of STA 3+0, 6+0, 9+0, 12+0 and 15+0. Due to the extent of the surrounding coastal structures related to the Corpus Christi Marina sediment transport is relatively compartmentalized at McGee Beach. The beach was last nourished in 2003/2004 (CEPRA Cycle 2), including modification by placement of a sand veneer to improve sand quality. The City of Corpus Christi grooms the beach regularly to manage windblown sand and low areas subject to pooling. Recent improvements landward of the beach have contributed to increasing usage of the beach park over the last year. Improvements directly associated with the beach include an enhanced handicapped access ramp.

CBI monitoring began in 2007 (CMP Cycle 9), four years after the most recent nourishment was completed. Subsequently surveys were conducted during 2009 (CMP Cycle 12), 2012, and annually between 2014 and 2017. Beach profile surveys are conducted along a tight grid of transects spaced at a maximum interval of 150-ft along the beach. The position of MHHW is at 0.89 ft, NAVD88. The depth of closure, originally approximated at -5 ft due to limited availability of historic data reaching beyond wade depth, has been revised and approximated at -9 ft (NAVD88) based on comparison of historic data sets (2007-2017). In general, the actual position of the DOC is variable with alongshore position and increases in offshore extent from south to north.

A focused nourishment effort was originally recommended during 2012 reporting to address the persistently narrow beach at the south end near the terminal groin. Implementation was differed by the City of Corpus Christi due to the focused nature of erosion along the narrow region, with intent to maintain the beach width by mechanical sand redistribution during maintenance grading and grooming. This approach has proven transiently successful in maintaining the width of the south end of the beach in excess of the Action Width with improvement documented during 2014 and 2016 after a period of recession dominated at the south end during 2015.

Shoreline Analysis and Beach Width: McGee Beach

Shoreline Position

Shoreline advance dominated at McGee Beach for the second reporting period in a row, despite the influence of Hurricane Harvey. The rate of advance was greater, at 4.3 ft/yr, than during 2016 (1.0 ft/yr). Although net advance dominated after Harvey, shoreline recession was persistent along the segment of beach south of near center beach (6+0). Shoreline change was near null in the immediate center of the beach, historically the most stable segment of McGee Beach (STA 6+0 to 9+0). Advance dominated north of this central stable segment. During Sep 2017 advance dominated along approximately 50% of the beach, focused north of center (Fig 54-56).

Table 8 shows the average rate of shoreline position change for various intervals over the monitoring history that are representative of 1) contribution of Hurricane Ike (2007-2009), 2) moderate tropical activity (2009-2012), 3) previous study periods (2012-2016), 4) annual assessment that functioned as Post-Harvey (2016-2017) and 5) period of record since nourishment (2007-2017). The rate of change relative to alongshore position for the recent study period (2016-2017) is shown compared to the rate of change over the previous reporting period (2015-2016) and the 10-year post-nourishment study period (2007-2017) in Figure 57. The average rate of recession over the post-nourishment study period, -2.3 ft/yr, is one of the lowest rates observed along the Texas Coast. With that said, during Sep 2017 the shoreline was on average 20 ft landward of the 2007 shoreline position. In addition, during Sep 2017 the shoreline from STA 6+0 to the terminal south groin was at the most landward position measured since monitoring began in 2007.

The McGee Beach shoreline remained relatively stable despite an extended period of inundation subsequent to Harvey (Fig 58). The stability observed at McGee Beach built on that reported over the previous reporting period. As previously reported, bayside beaches respond rapidly to seasonal and short-term fluctuations in water level and onshore forcing, more so than documented along Gulf facing beaches. These successive years of stability were proceeded by a year dominated by recession (2014-2015). Therefore, the rates shown in Table 8 represent the envelope of change to be expected at this bayshore location. The compartmentalized state and orientation with regard to frontal passage limit significant onshore forcing at McGee Beach that contributes to long-term stability. The orientation once again served to protect McGee Beach during Hurricane Harvey, as the majority of forcing due to wind during the storm was directed side to offshore. In addition, the 2017 survey indicates that frequent and purposeful beach maintenance has continued to reinforce stability at this popular urban beach.

Beach Width

During September 2017, the beach width ranged from 62 ft to 218 ft with the narrowest sections located at the south end where focused erosion was evident (Table 9). The width was measured from the bulkhead or seawall, which function as a backshore-limiting feature, across the berm to the position of MHHW. In contrast to the previous reporting period, the beach width increased by approximately 14 to 19 ft on the north end and decreased by 10 to 22 ft along the south end of the beach. Consistent with previous reporting periods, the central region was stable with limited change of $\leq$ 5 ft. The entire beach remained in excess of the Action Width.

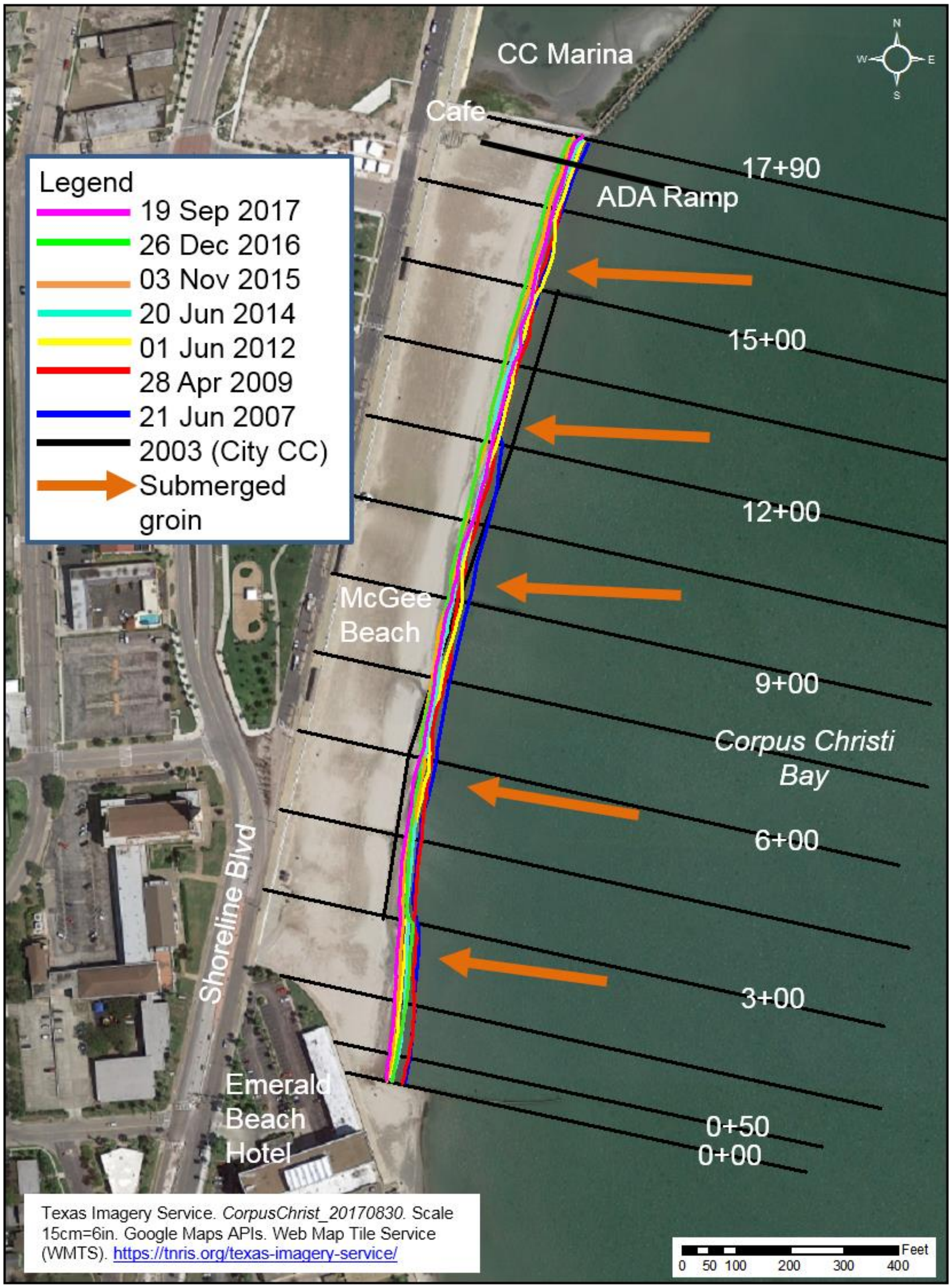

Figure 54. Historic shoreline position relative to key features and transect locations at McGee Beach

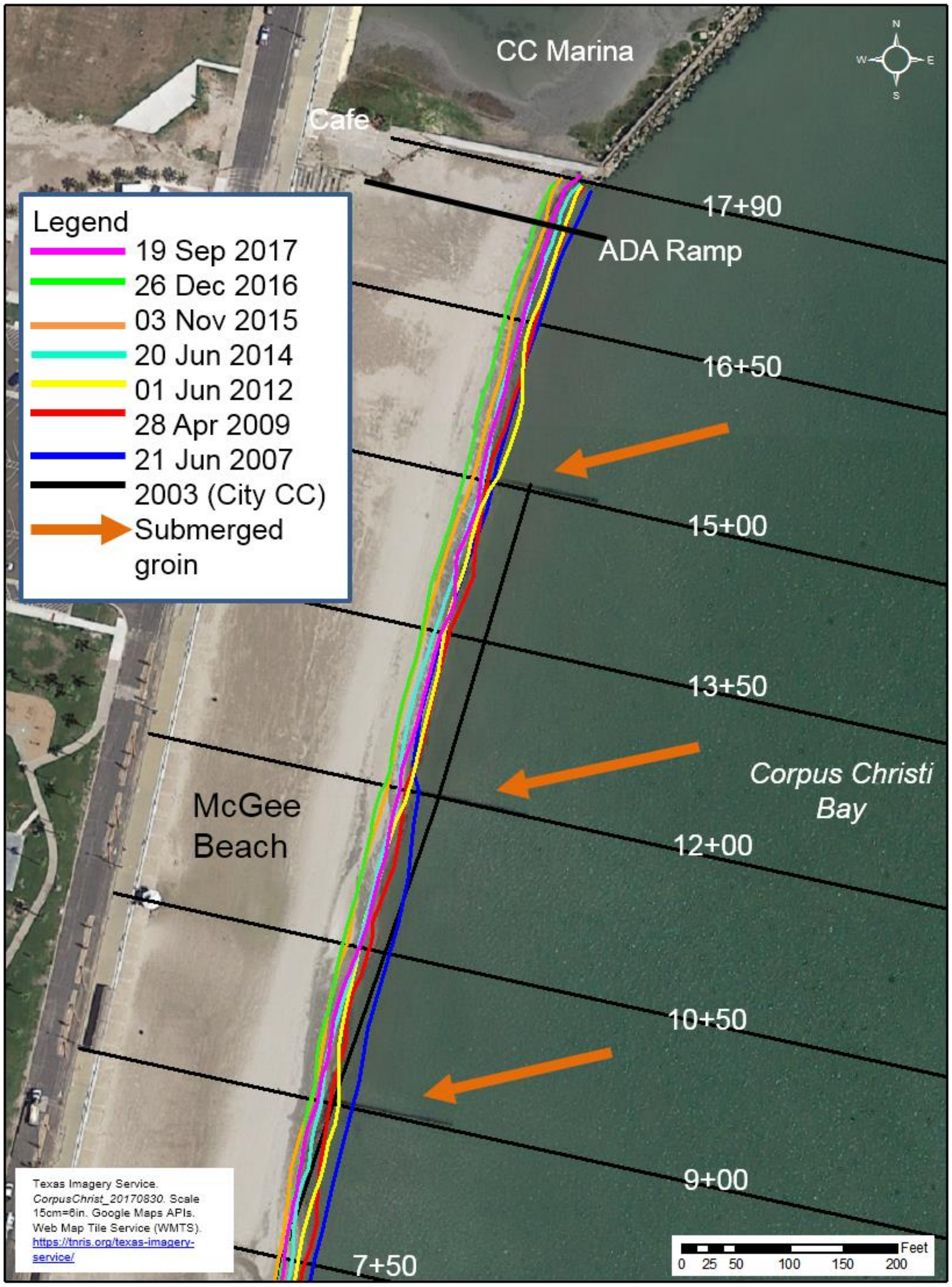

Figure 55. Variability in shoreline position along the north section of McGee Beach (2003-2017)

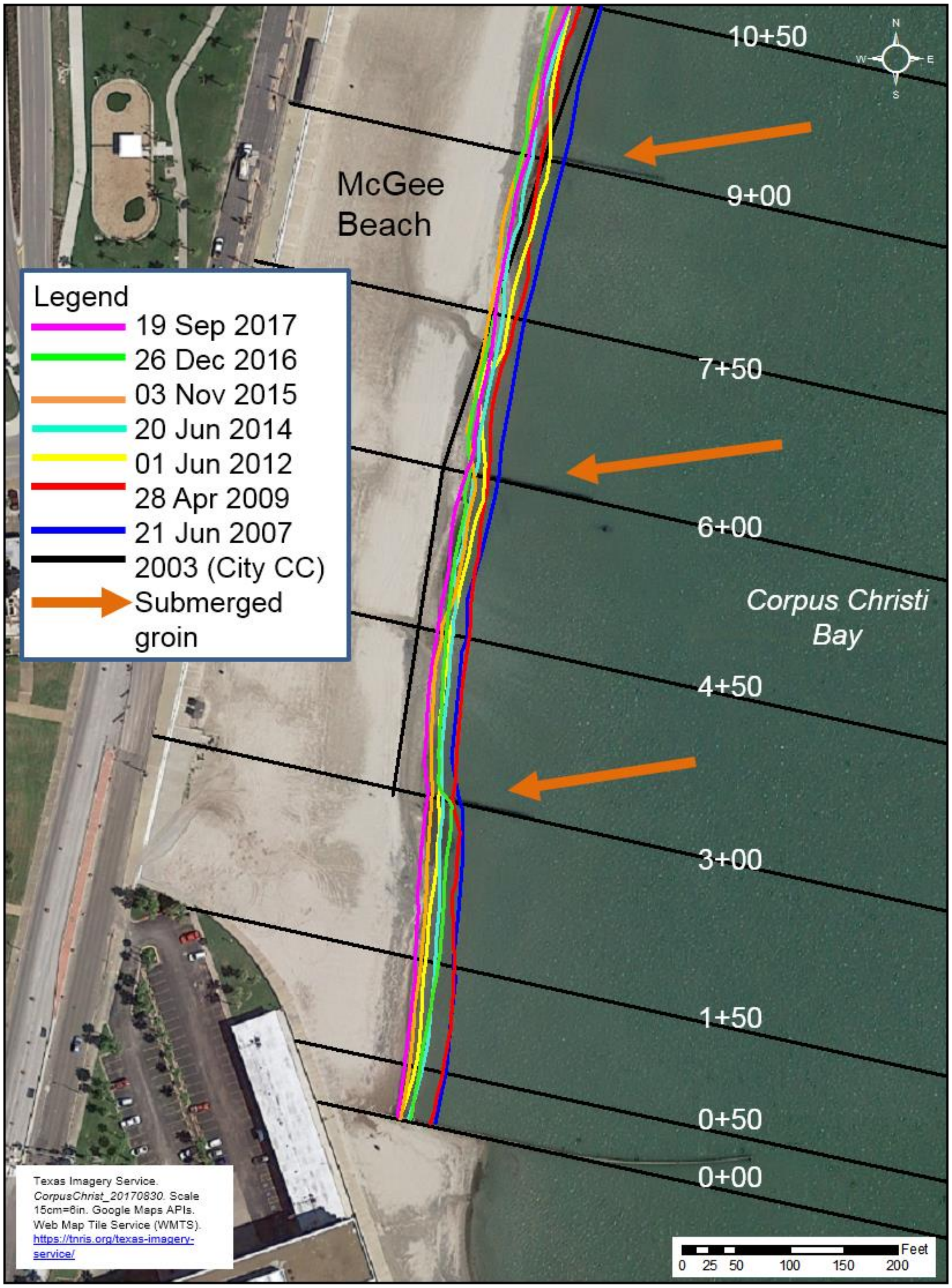

Figure 56. Variability in shoreline position along south section of McGee Beach (2003-2017)

Table 8. Variability in Rate of Shoreline Position Change:		McGee Beach
Interval (Year)	**Description**	**Rate of Change (ft/yr) + Advance - Recession**
2007-2017	CBI Monitoring Period Average (10-yr avg.)	-2.3
2016-2017	Annual Survey (Post-Harvey)	+4.3
2015-2016	Annual Survey	+1.0
2014-2015	Annual Survey	-7.2
2012-2014	Biannual Survey (no tropical storms)	-2.4
2009-2012	Active Tropical Storm Season (2009)	-2.5
2007-2009	Contribution Hurricane Ike	-3.1

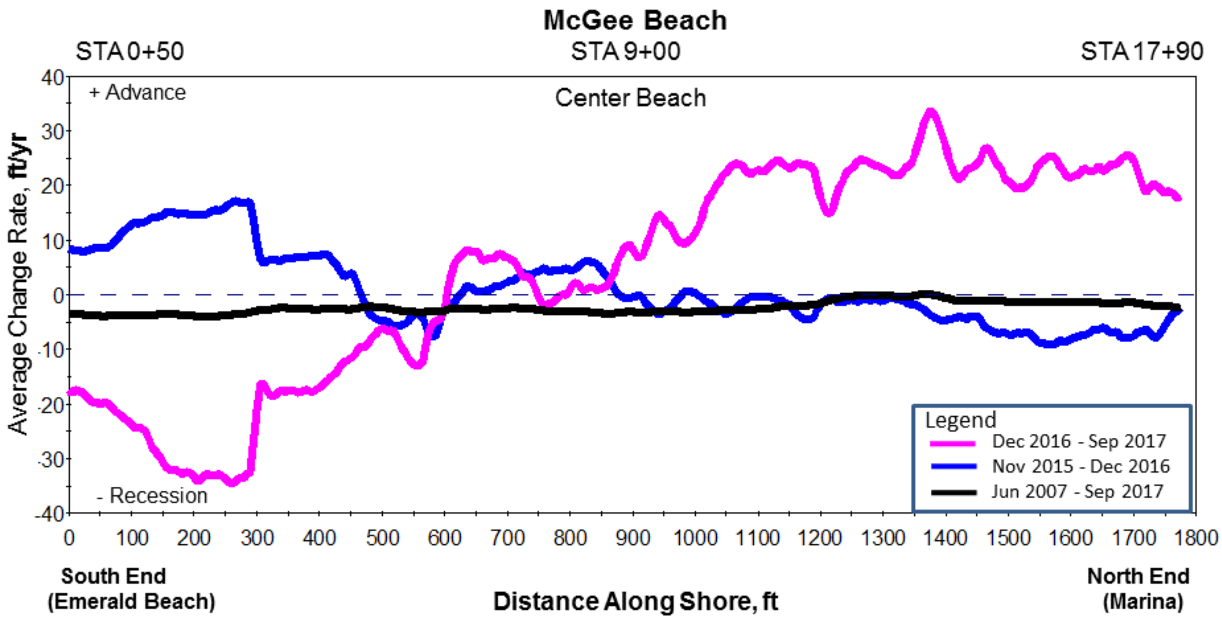

Figure 57. Average rate of shoreline change associated with alongshore position over the recent study period (2016-2017) as compared to the previous reporting period (2015-2016) and historic study period (2007-2017)

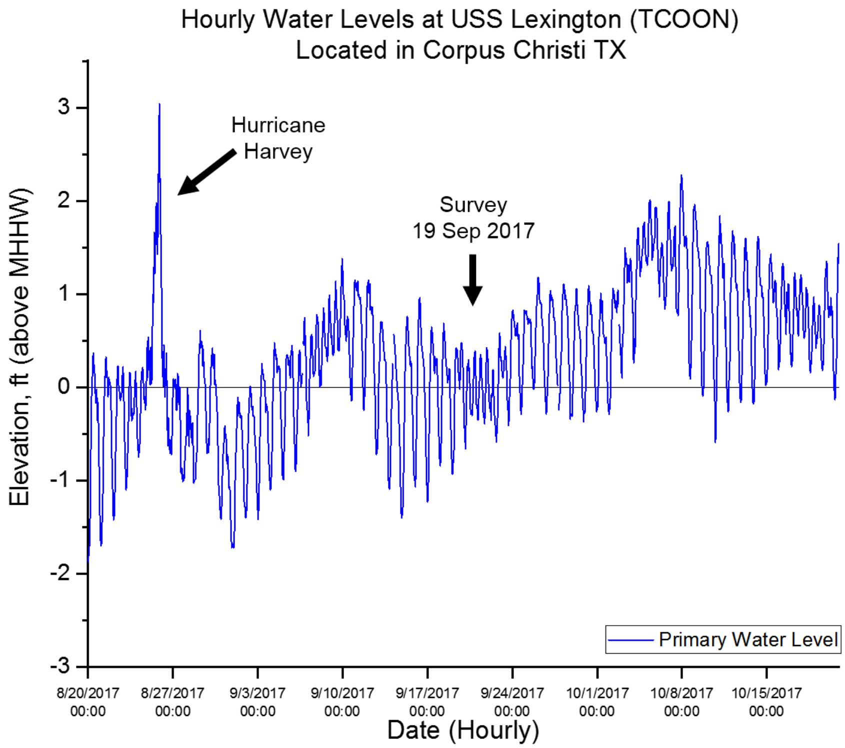

Figure 58. Frequency of water level in excess of MHHW prior to the 2017 survey at the closest water level station at the USS Lexington

Table 9. Beach Width: McGee Beach 2016
***Interpolated from limited data set mid-nourishment**
**** CBI Surveys**
Action Width: Variable due to backshore limiting features and initial nourishment limitations
South End 50 ft (Groin to STA 1+5)
Center 110 ft (STA 1+5 to 16+50)
North End 120 ft (STA 16+50 to Groin)

Station	Beach Width, ft									Location
	2003 * Post-Nourish	2007 ** 4-yrs Post-Nourish	2009 **	2012 **	2014 **	2015 **	2016 **	2017 ** Post-Harvey	▲ 2016-2017 Post-Harvey	
STA 0+00	N/A	103	97	65	75	68	74	62	-16	Groin/Seawall S. End
STA 0+50	N/A	130	126	100	106	94	104	89	-15	Groin/Seawall
STA 1+50	N/A	217	218	190	200	185	200	178	-22	Seawall
STA 3+00	N/A	207	209	210	215	200	215	197	-18	Seawall
STA 4+50	185	230	232	215	218	208	212	202	-10	Seawall
STA 6+00	176	228	218	215	205	205	202	199	-3	Seawall
STA 7+50	188	218	210	204	198	185	190	190	0	Seawall
STA 9+00	203	222	200	209	192	184	184	191	7	Seawall
STA 10+50	213	217	198	190	188	176	171	189	18	Seawall
STA 12+00	238	219	207	209	200	190	186	200	14	Seawall
STA 13+50	248	209	214	210	200	191	189	208	19	Seawall
STA 15+00	257	223	218	225	214	204	195	211	16	Seawall
STA 16+50	N/A	233	229	225	218	208	200	218	18	Seawall
ADA Ramp	N/A	214	210	208	200	190	181	196	15	ADA Ramp
STA 17+90	N/A	160	150	149	146	126	124	138	14	Seawall N End

Volumetric Analysis: McGee Beach

Since 2007, McGee Beach has exhibited the greatest overall stability of the CEPRA beaches monitored by CBI. Although the dominance of shoreline recession is an indicator applied to assess stability, this parameter does not take into account the storage capacity of the nearshore or changes in elevation across the berm, therefore the review of volume change is critical to determining the overall stability of the beach.

Erosion is limited, at McGee Beach, by the coastal structures that shelter the beach from significant wave attack and restrict sediment transport beyond the terminal structures at the north and south ends of the beach. As described previously, the stability afforded by the surrounding coastal structures is complimented by the orientation of the beach which shelters the beach further from onshore forcing both during the dominate southeasterly winds and winter storms that are directed out of the north. The rate of erosion over the proceeding study period during 2016 was effectively null, within the constraints of coastal surveying accuracy, with an estimated change in volume of less than 1,000 cu yd. The net volume loss after Hurricane Harvey remained minimal at 1,400 cu yd. In addition, maintenance practices continue to reinforce beach stability by 1) maintaining backshore and berm elevation to decrease the incidence and duration of pooling that was problematic in the past and 2) redistributing windblown sand toward the south end of the beach.

A widespread decrease in elevation along the backshore and berm did not contribute to a significant increase in rate of erosion at McGee Beach between Dec 2016 and Sep 2017. The decrease in berm elevation was likely the result of an extended period of inundation and subsequent pooling during and after Hurricane Harvey. This decrease was relatively uniform at less than 0.5 ft along most transects. In general, the sand volume at McGee Beach has been relatively stable since monitoring began in 2007 with the most significant erosion having occurred immediately after nourishment (2004-2007). The average erosion rate for McGee Beach remains at 1,000 ft/yr with a net loss of sand at approximately 10,000 cu yd since monitoring began in 2007. Although the rate of erosion remained low over the study period, the decrease in backshore elevation has the potential to promote pooling. This will require the City to continue purposeful redistribution of sand during grooming by City Staff toward maintaining the natural beach slope.

Post-Harvey, erosion was focused on the foreshore and berm crest along the beach located south of center beach, while accretion was focused along the foreshore north of center beach. The greatest erosion occurred at the south end of the beach between the south groin and STA 3+00. A comparison of typical changes in morphology at key locations alongshore between 2013 and 2017, with a reference to 2007, is shown in Figures 59-62.

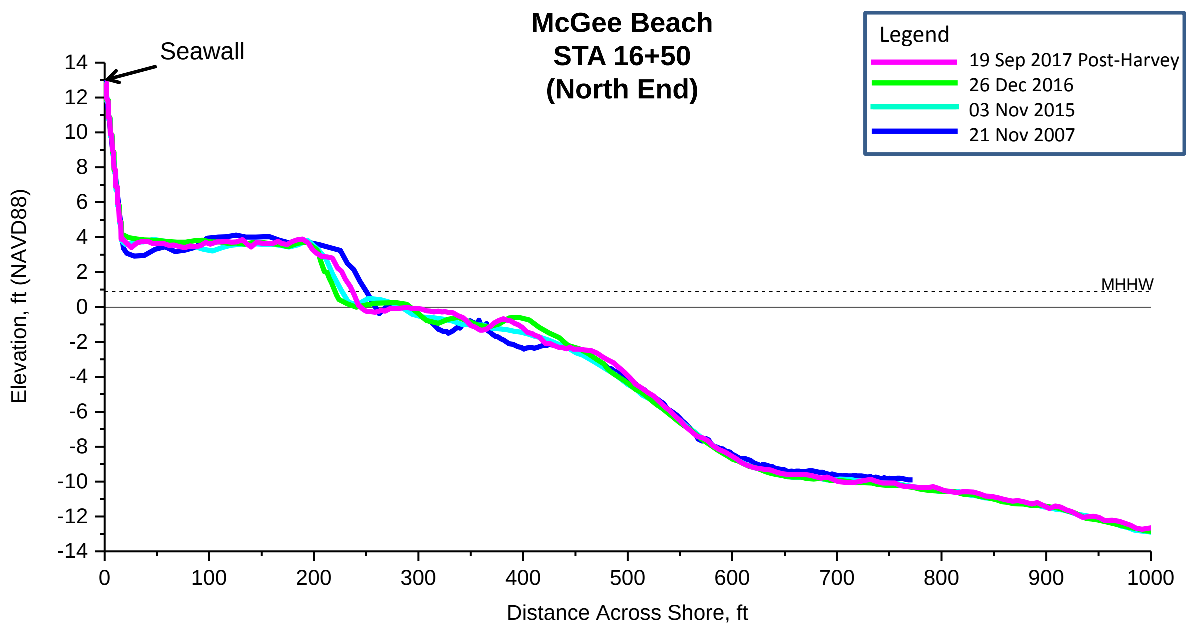

Figure 59. Accretion focused at foreshore on the north end of McGee Beach after Hurricane Harvey (Sep 2017)

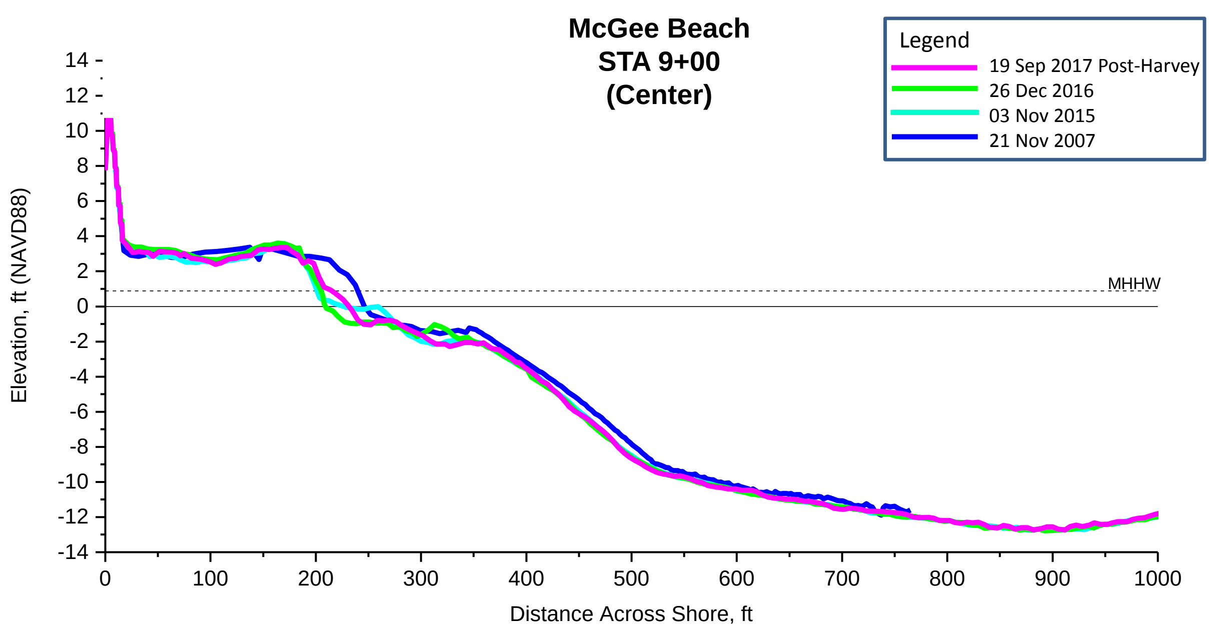

Figure 60. Relative stability of berm and backshore with foreshore exhibited at center beach between Dec 2016 and Sep 2017 (Post-Harvey)

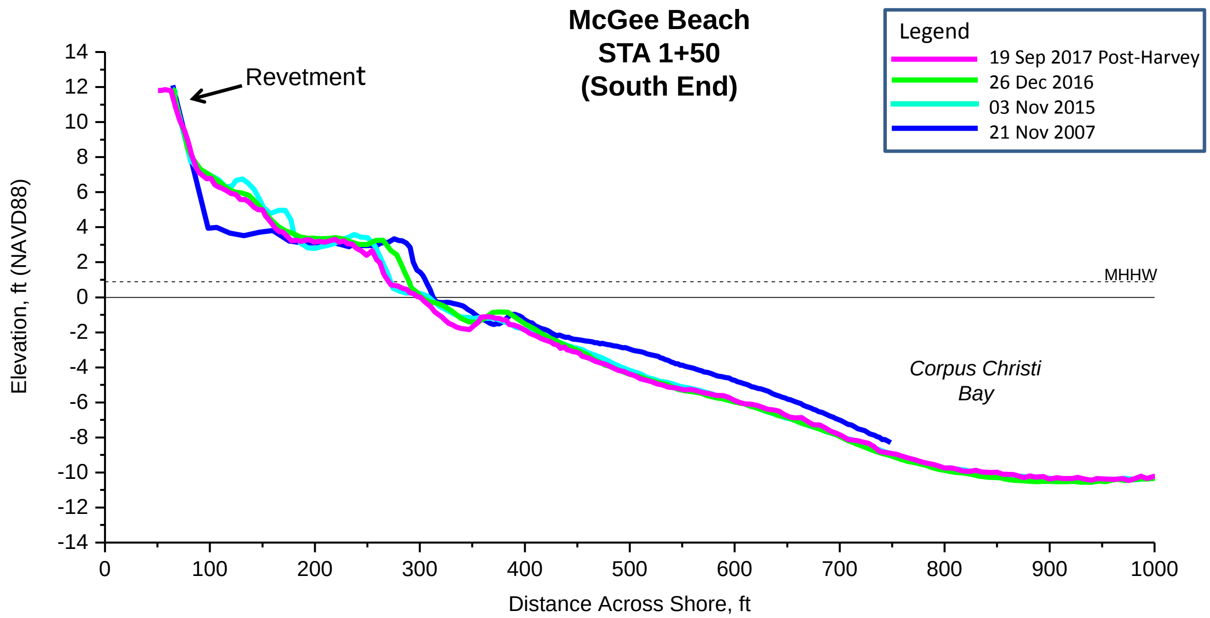

Figure 61. Erosion of berm crest and foreshore near south end of McGee Beach between Dec 2016 and Sep 2017

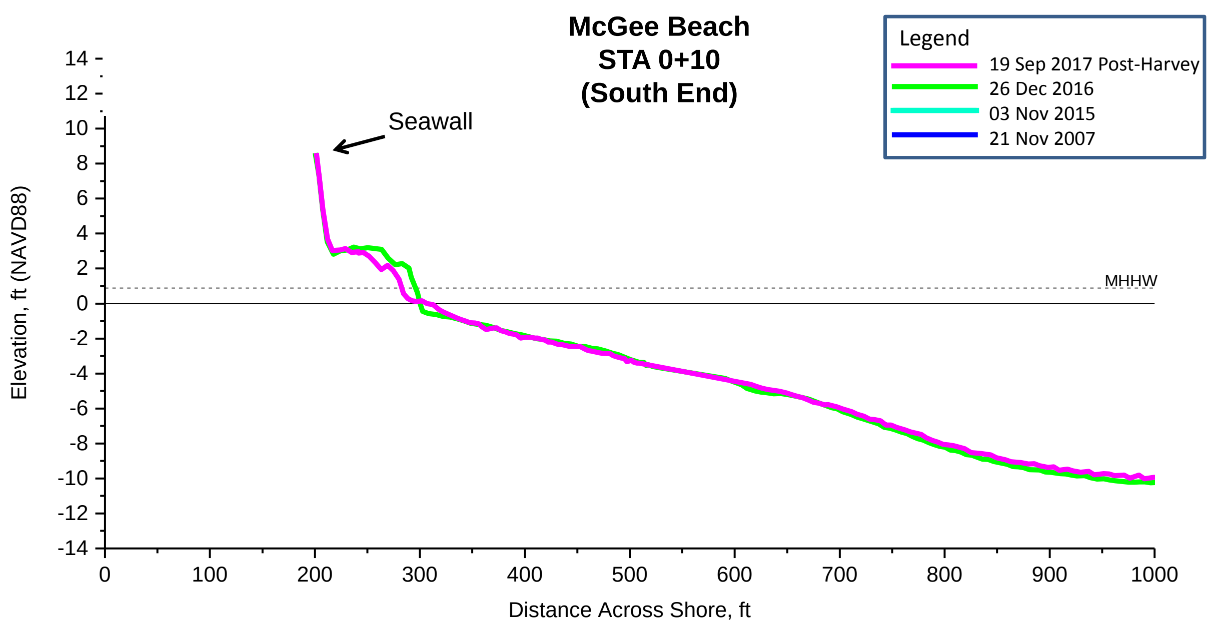

Figure 62. Erosion of berm crest and foreshore near at south end of McGee Beach between Dec 2016 and Sep 2017

Recommendations: McGee Beach

McGee beach is a focal point of the newly branded downtown City of Corpus Christi Park, Water's Edge Park. McGee Beach continues to increase in popularity and is host to numerous events both serving national venues such as the International Youth Sailing Championship (July 2018) as well as supporting diverse local community events. Both the isolation of the beach by coastal structures and an orientation that restricts onshore forcing both during winter storms and directly by strong southeasterly wind driven forcing over the majority of the year limit erosion and loss of sand from the beach system. The orientation of the beach, which faces east, served to protect McGee Beach from direct onshore forcing during Hurricane Harvey.

This bayside beach has one of the lowest average recession rates of the CEPRA monitoring locations and associated low rate of erosion. Prior to Hurricane Harvey, during the 2016 monitoring year, the rate of erosion was effectively null and shoreline advance dominated. After Harvey only limited and focused areas of erosion were documented along less than 50% of the beach with stability or accretion dominating along the remaining beach. McGee Beach had a low net loss of 1,400 cu yd of sand, despite an extended period of inundation both during and after Harvey.

After Harvey, the entire beach remained in excess of the Action Width, as observed since 2007. Over 80 % of the beach was in excess of 150 ft wide. Although the beach is relatively stable with a low rate of recession, the south end of the beach remains narrow and lies at the most landward position measured since 2007. The narrow south end of the beach is bordered by hard reflective structures consisting of a short groin and a backshore revetment/seawall. The terminus of the beach at the groin was within 10 ft of Action Width during September 2017. This is the same beach segment recommended for focused nourishment in 2014 due to the proximity of multiple hard structural interfaces with the persistently narrow beach. Continued reinforcement of this narrow terminus during maintenance is recommended as an interim solution. This section of the beach was completely eliminated by erosion prior to the 2003 nourishment and is therefore re-evaluate annually in order to identify accelerated and sustained erosion or shoreline recession.

Since 2007, shoreline recession at McGee Beach has proven transient and manageable by routine maintenance and redistribution of sand alongshore and across shore. Regular grooming has contributed to maintaining natural slope, thereby discouraging pooling and has contributed to the reinforcing the width of the south end of the beach in the past. Based on these observations, particularly stability under storm forcing during 2017, nourishment is not anticipated at McGee Beach within the next 2 to 5 years, barring 1) the influence of tropical storms or other significant erosional events and 2) with continuation of proactive maintenance procedures that have been successful in the past. McGee Beach is recommended for annual re-evaluation due to a history of erosion, particularly along the south end of the beach.

University Beach

University Beach is located along the southern shore of Corpus Christi Bay fronting Texas A&M University-Corpus Christi. In an effort to restore a beach that had eroded some 60-years prior, University Beach was constructed in 2001 (CEPRA Cycle 1) (Williams 1999, 2000 and 2002). Although located directly fronting TAMUCC, University Beach is one of three City of Corpus Christi beaches in the CEPRA monitoring program. Prior to restoration, the shoreline was stabilized with discarded concrete that restricted user access to bay waters. The beach has not required re-nourishment since its completion, with stability attributed to the cellular design. The cellular design includes a 1,200-ft long beach stabilized by two terminal groins and three detached breakwaters (DBWs). Fill material consisted of beach-quality quarry sand with a greater median grain size (0.35 mm) than the native sand (0.15 mm). The fill volume placed by the contractor was 5,000 cu yd less than the design volume of 50,000 cu yd. The coarser than native fill material was selected in an effort to increase both foreshore slope, due to the relatively flat nearshore, and stability.

University Beach demonstrates a unique design feature in that sand eroding from the dry beach is impounded in the nearshore. This design offers the potential for “self-nourishment” where sand can potentially be redistributed from the nearshore to the berm by land-based equipment. Reclaiming sand from the nearshore reduces the costs typically associated with importing quarry sand for beach nourishment. Redistribution of sand within the beach cell has been recommended since 2014. The redistribution of sand from the tidally emergent tombolos landward of the DBWs will not only supply sand to restore the subaerial beach to Target Width but will also restore an adequate nearshore depth within the beach cell. Maintaining an adequate depth in the nearshore discourages persistent seagrass growth and supports the original intent of the beach for recreational access. Maintaining the design depth supports the potential for greater diversity of recreational activities at University Beach.

As reported previously, the beach has been surveyed at a minimum of annually since completion in 2001 with the exception of during 2011 and 2013 when funding was not available. The dominant direction of sediment transport is toward the northwest, due to persistent and strong wind forcing out of the southeast but reversals in sediment transport accompany tropical storms and frontal system during the winter. Key features and environmental considerations at University Beach are shown in Figure 63. Figure 64 shows transect locations relative to structures and sinusoidal shoreline. The distinct sinusoidal signature of the shoreline is the result of wave diffraction from the tips of the detached breakwaters resulting in the development of salient features behind the structures. Sand eroding from the berm tends to migrate into the nearshore where it is deposited in the sheltered region landward of the detached breakwaters. A salient was first observed on the west end of the beach shortly after construction during 2001. The salient was well developed by 2002 and the first of the three tombolos that are present today began to form at the west end. Tombolo are now persistent, well-developed features in the nearshore, landward of all three DBWs. Accretion along each tombolo extends from the shoreline to the detached breakwater and during periods of low water level a tombolo can be exposed as a land bridge stretching from the berm to each breakwater.

As described in the previous reporting period, depositional features have developed both in the nearshore and along the backshore at University Beach. The development of depositional features in the nearshore is indicative of the impoundment of sand eroding from the berm. These features represent a source of sand that could be reclaimed and applied to renourish the eroding berm in order to maintain the Target Width. Sediment entering the beach cell from the surrounding nearshore also contributes to accretion in this shallow region. Accretion also continues along the backshore in the form of low coppice dunes that have formed along the bluff. The coppice dunes have melded with the bluff and the sand extends up the bluff in excess of 5 ft. These coppice dunes have increased in both volume and vegetative coverage since 2001. The seaward limit of the dunes continues to gradually advance. The expansion of the dunes increases the stability of the backshore while reducing the functional width of the berm by 20 to 30 feet (2016). The development of dunes along the backshore at University Beach demonstrates that indeed bayside beaches can develop a full beach profile if provided adequate undeveloped backshore limits. Truncated beach profiles reduce the storage capacity of other bayside beaches (such as McGee and North Beach) and limit the natural processes of recovery at bayside beaches.

Environmental Considerations

Beach maintenance at University Beach has occurred on an as needed basis supported by TAMUCC since construction in 2001. During the 2015 reporting period, neither TAMUCC nor the City of Corpus Christi planned to continue periodic grading and no grading was conducted between Sep 2016 and June 2017. As anticipated, growth of vegetation expanded during this time, covering the majority of the west side of the beach up to the berm crest. New facility operation management at TAMUCC was educated on the need for regular beach maintenance and re-initiated periodic grading during July 2017. Subsequent grading has continued to periodically reduce vegetative growth as needed with the last grading conducted during the spring of 2018 prior to the start of Least Tern nesting season. The density of vegetation, typically non-native grasses and weeds, as well as low bushes/trees increases toward the western end of the beach. The persistence of vegetation along the west end of the beach is likely due to the reduced pedestrian usage of that side of the beach and lack of grading during bird nesting season (March through July). Vehicles occasionally access the beach and in the past both grading practices and unauthorized vehicles have damaged the coppice dunes along the bluff. No evidence of such damage was observed during 2017.

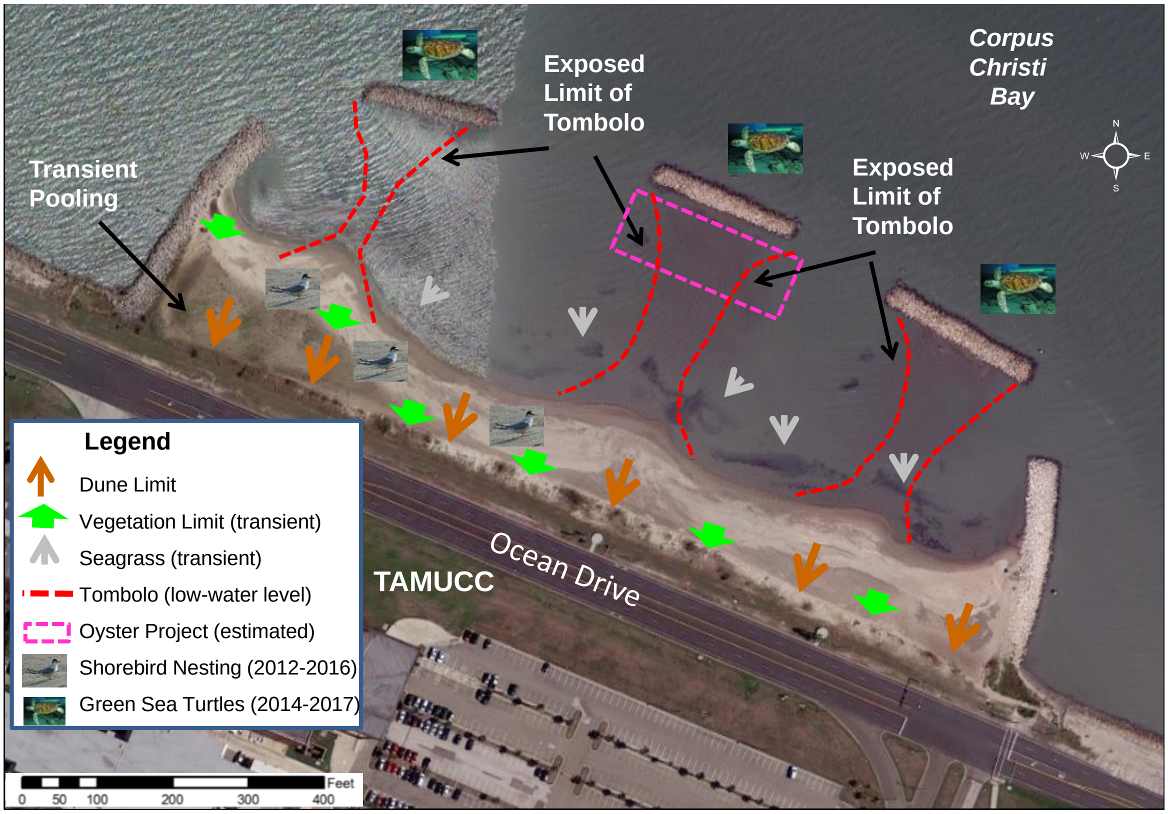

Figure 63. Location of key environmental features and habitat at University Beach

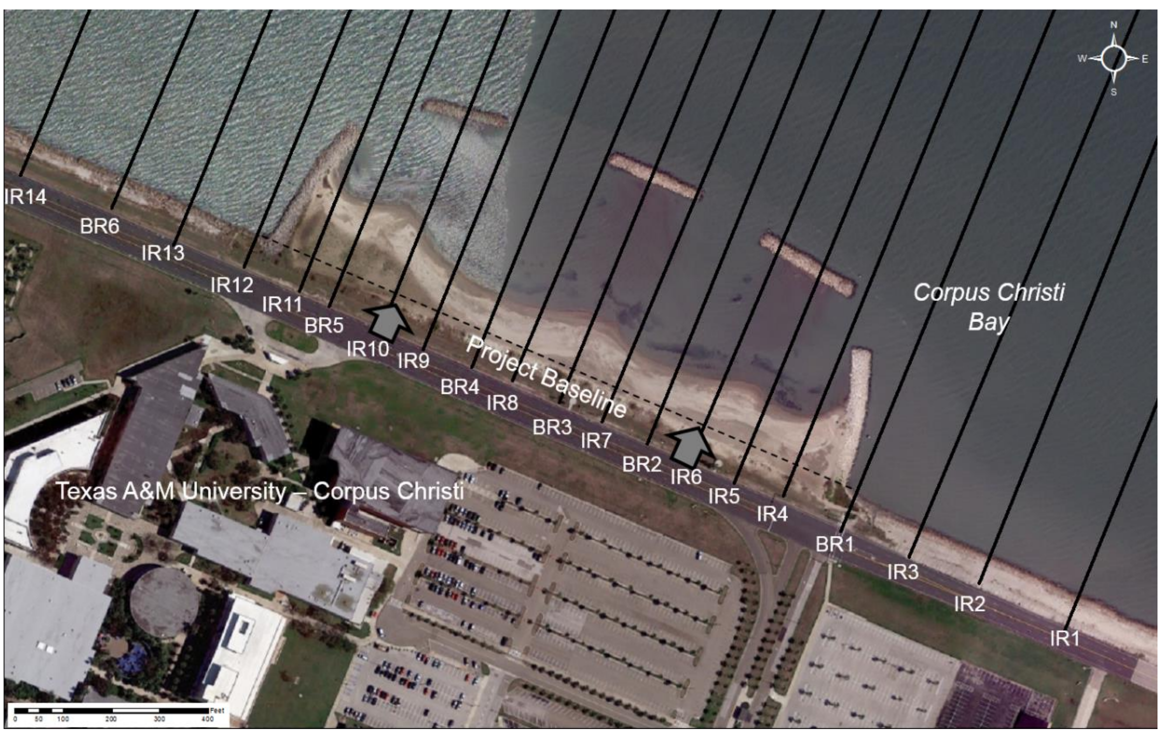

Figure 64. Location of transects and project baseline (former shoreline) relative to coastal structures

Several updates are provided related to environmental issues at University Beach that have been identified in previous reporting to include; shorebird nesting, green turtles, oyster placement and removal of the Miradores in 2016 (bayside pavilions) (Fig 64). This urban recreational beach has served as a nesting area for Least Terns (2011-2016) and for Wilson's Plover (2016). Fencing of the primary nesting area on the west end of the beach was implemented by community volunteers led by Mr. David Newstead (Coastal Bend Bays and Estuary Program) from July to Aug 2017. Green turtles were again documented during 2017 with continuous sightings since 2014. The 2017 reporting period marks the fourth consecutive year of green turtle documentation at University Beach. The presence of green sea turtles at University Beach is supported by the proximity of Packery Channel where large populations of the green turtles feed along the jetties.

A project conducted within the beach cell at University Beach has the potential to influence both the rate of sedimentation as well as future reclamation of sediment in the nearshore for application to beach nourishment. The oyster habitat and associated rebar infrastructure that was placed landward of the central DBW by the Center for Coastal Studies during May 2015 has to date not been removed. The project included the placement of un-stabilized oyster shells adjacent to the landward side of the central DBW. Oyster shell was reportedly placed in rectangular beds parallel to the DBW and focused along the west and east sides of the exposed rock structure. Limited reconnaissance indicates that shells have been redistributed by waves and currents around the landward nearshore region. Shell material near the central breakwater has been for the most part covered by sediment. The associated rebar infrastructure is corroding and has been intermittently exposed during low tide. An increase in shoaling was documented in the nearshore region adjacent to the central DBW between 2015 and 2016.

Shoreline Analysis: University Beach

University Beach remains one of the most stable beaches in the CEPRA Monitoring Program with an average rate of shoreline recession over the project lifetime at -3.6 ft/yr (2001-2016). Recession dominated during 2017 due to the influence of Hurricane Harvey with a rate of -9.1 ft/yr. This is the highest rate of recession measured at University Beach, exceeding the post-Ike rate of shoreline recession rate of -8.9 ft/yr (2008). After Harvey, due to cumulative effects of erosion since 2001, the shoreline position was at the most consistently (east to west) landward position measured over the 17-year lifespan of the beach. Interestingly, the shoreline position has been landward of the post-Harvey position along focused segments several times in the past (2008, 2010, 2012, 2014, and 2015), after which the shoreline has recovered and advanced. The east and west ends of the beach were the most stable segments after Harvey with limited recession and shoreline advance closest to the groins. The most significant recession occurred along the shoreline segments that correspond to the gaps between the breakwaters where the conditions are typically most dynamic. This was due to onshore forcing directed from the northwest during Harvey combined with water levels in excess of MHHW for an extended period (Fig

Although University Beach has a relatively low average rate of shoreline recession, the rate has been highly variable with alongshore location and period of study. The variability in rate of shoreline change with alongshore position is compared in Figure 67 over three study intervals: 1) Annual/Post-Harvey (2016-2017), 2) Previous Annual (2016-2017), 2) Annual (2015-2016), and 3) Full study period over the project lifespan to date (2001-2017).

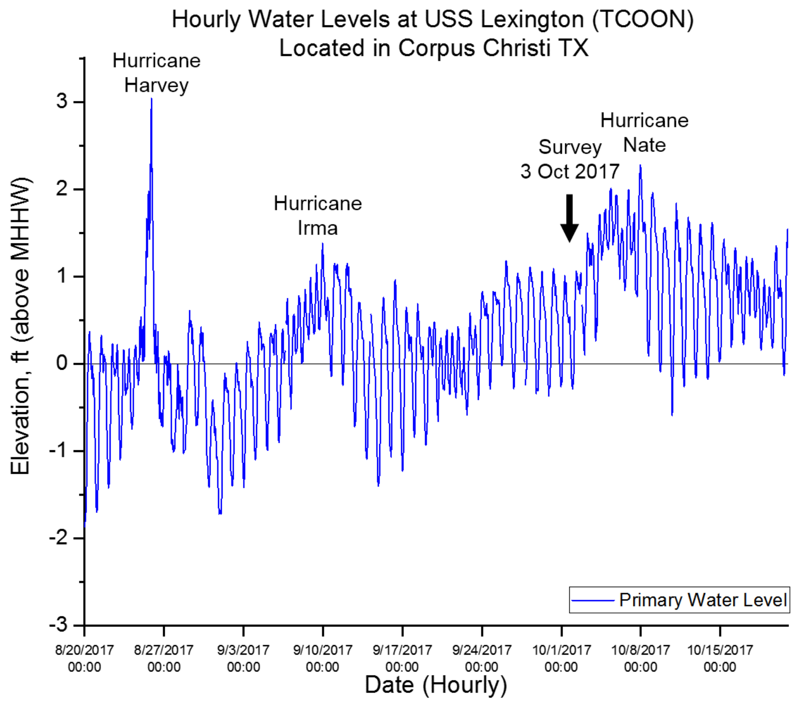

Figure 65. Frequent and persistent periods of water level in excess of MHHW preceding the 2017 survey

The shoreline change rate has been highly variable since construction in 2001, which is typical of bayshore beaches. The rate of shoreline position change can vary significantly between annual surveys due to the rapid response of bayside beaches to reversals in forcing direction associated with wind reversals. At University Beach, this occurs when the predominant southeast wind is interrupted periodically from fall to winter by frontal systems and more rarely tropical storms and hurricanes. As anticipated, the highest rate of shoreline recession and most landward position of the shoreline has been focused along the central section of the beach and landward of the gaps on either side of the central DBW. This location is where the energy is highest during the summer and winter months. The envelope of change in shoreline position (2001-2017), as compared to the post-construction position (2001) is shown in Figure 66. Data from the 2002-2005 surveys were not plotted to improve clarity of comparison between the more recent survey data. All shoreline data between 2001 and 2017 may be viewed on the CHRGIS website.

Although recession has dominated over the project lifespan, shoreline advance has periodically dominated along the west end of the beach over annual and biannual reporting periods. Accretion at the west end is due to alongshore sediment transport under the forcing of winds directed out of the southeast. Advance at the west end occurred gradually between 2001-2013. The peak in shoreline advance was during 2012 and the shoreline receded landward of the 2001 position along the west end for the first time during 2014. The shoreline stabilized at the 2014 position during both 2015 and 2016. During Harvey only limited recession occurred and was focused at the peak of the salient located landward of the west DBW.

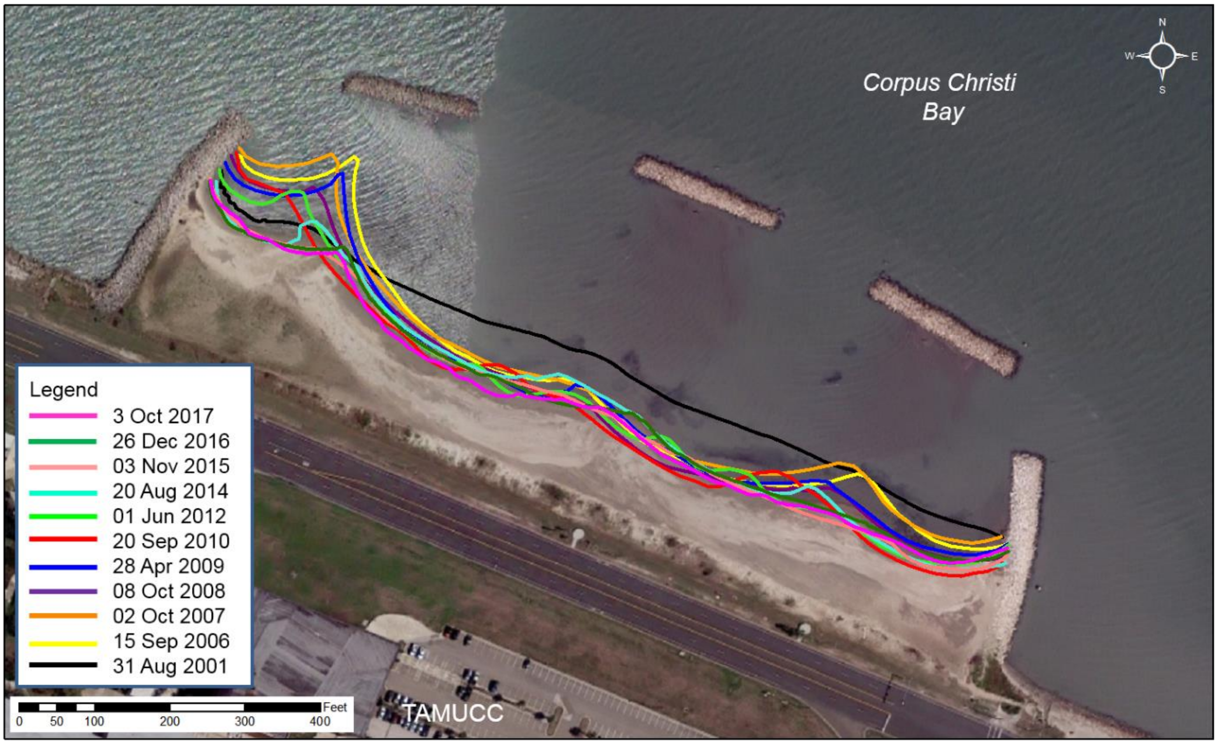

Figure 66. Comparison of select shoreline positions from 2001 to 2017 to the post-construction shoreline position. All shoreline positions available for viewing with CHRGIS Mapping Tool.

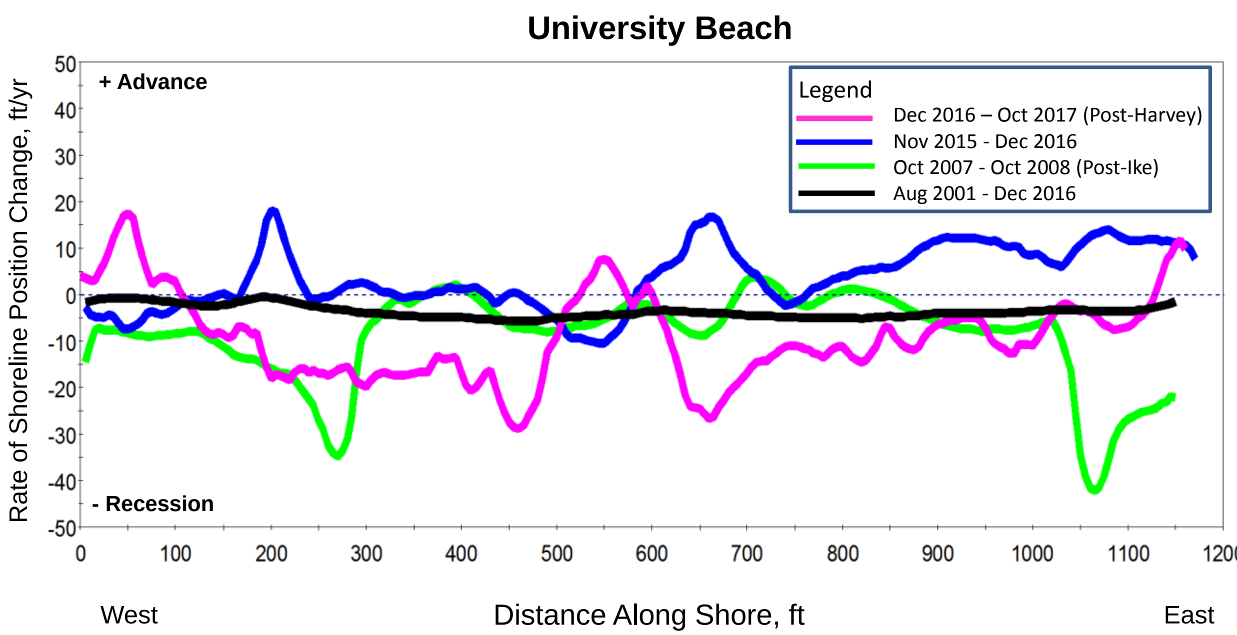

Figure 67. Comparison of the rate of shoreline change with alongshore position over the 1) Post-Harvey reporting period (2016-1017), 2) Previous annual reporting period (2015-2016) 3) Post-Ike (2017-2008) and 4) period of record (2001-2017) at University Beach

Table 10. Variability in Rate of Shoreline Position Change: University Beach		
Interval (Year)	**Description**	**Avg. Rate of Change (ft/yr) + Advance - Recession**
2016-2017	Annual (Post-Harvey)	- 9.1
2001-2017	Average (Project lifespan to date)	- 3.6
2015-2016	Annual (No major storms)	+ 3.6
2014-2015	Annual (No major storms)	- 7.2
2012-2014	Annual (No major storms)	+ 0.2
2010-2012	Recovery and no major storms	+ 2.2
2009-2010	Active Tropical Storm Season	- 17.2
2008-2009	Recovery (Hurricane Ike)	+ 6.5
2007-2008	Annual (Influence of Hurricane Ike)	- 8.9
2001-2016	Pre-Harvey Avg. (Project lifespan to date)	- 3.2

Beach Width: University Beach
The width of the entire beach at University Beach has remained in excess of the Action Width since placement in 2001 and in excess of the Target Width, in this case the design width, on the west end of the beach between IR10 and IR11 (2001-2017). Despite the focused erosion along the central region of the beach, the beach width remained in excess of the Action Width. The beach has continues to exceed the Action Width despite the migration of sand from the berm to the immediate nearshore where it is impounded due to the sheltering of the detached breakwaters. Table 11 shows the width of the beach at both transect locations and regions of interest over key intervals of significance since 2001. Although the original design width of University Beach was 150 ft, the post-construction width was actually between 170 and 190 ft to allow the beach to approach equilibrium while maintaining the design width after placement. Due to the low slope of the native bay bottom, the sand did not erode rapidly toward equilibrium. This in effect provided advance nourishment that extended the original lifespan of the beach from a beach width perspective.

At its peak, Hurricane Harvey forced waves toward University Beach from out of the northwest. The magnitude of the force that was directed toward the beach is evident from the damage to Oso Pier, located less than a mile to the west. The direction of peak impact is also evident from the tilt of the remaining posts at Oso Pier and sign posts at the beach itself. The orientation of the west groin and the DBWs protected the beach from more significant erosion. Minimum beach widths were located along the beach fronting the gaps between the breakwaters were the maximum forcing was directed (East: BR2, IR7, BR3 and West: BR4, IR9, IR10). The minimum beach width in these two areas was on the order of 100 ft which is 25 ft in excess of the Action Width and 50 ft less than the Target Width. The decrease in beach width along these two segments ranged from 11 to 27 ft. The width decreased along 67% of the beach between 2016 and 2017.

As previously reported, although the beach was relatively stable with regard to width prior to Hurricane Harvey; the beach has several continuing challenges including; 1) Continued backshore dune expansion seaward that reduces the functional beach width available for recreation and activities, 2) Advancing vegetation continues to decrease the usable sandy beach, and 3) Increasingly shallow (< 2 ft) nearshore inside the beach cell that restricts water based activities and provides for the establishment of seagrass beds and impoundment of fine sediment/organics which could allow for evolution of the beach to a sheltered wetland.

Table 11. Beach Width: University Beach 2017													
Design beach width = 150 Post-construction width exceeded by 25 to 35 ft Target Width = 150 Action Width = 75													
	Width, ft												
STA	2001	2006	2007	2009	2010	2012	2014	2015	2016	2017	Δ 2016 2017	Δ 2001 2017	Location
IR4	178	149	156	138	108	123	119	117	129	126	-3	-52	Gap East End
IR5	176	159	157	133	102	110	113	118	127	120	-7	-56	DBW East
IR6	180	154	182	155	135	117	142	108	122	117	-5	-63	DBW East
BR2	180	113	148	113	120	124	107	104	111	100	-11	-80	Gap
IR7	175	107	109	108	88	120	116	111	115	100	-15	-75	DBW Center
BR3	183	128	134	135	104	117	141	124	130	103	-27	-80	DBW Center
IR8	183	129	135	110	114	109	133	118	107	127	20	-56	Gap
BR4	172	120	125	108	102	110	110	105	108	103	-5	-69	Gap
IR9	171	144	139	124	114	119	124	118	120	105	-15	-66	Gap
IR10	181	217	194	194	148	166	175	163	180	168	-12	-13	DBW West
BR5	181	243	263	218	222	222	153	157	155	155	0	-26	Gap
IR11	189	243	250	214	236	199	173	175	168	175	7	-14	Gap West End
Minimum Width at General Locations (not located at transect location)													
Location	2001	2006	2007	2009	2010	2012	2014	2015	2016	2017	Δ 2016 2017	Δ 2001 2017	
East End	173	183	149	129	99	105	109	107	121	118	-3	-55	Between IR4 IR5
Gap Center-east	179	105	112	105	89	90	107	106	106	98	-8	-81	Between IR7 and BR2
Central DWB	173	118	114	112	94	108	118	122	111	110	-1	-63	Between BR2 and BR3
Gap Center-west	170	119	126	123	93	98	109	104	104	87	-17	-83	Between IR8 and BR4
West End	174	230	246	209	146	165	152	157	150	154	4	-20	Between IR10 and BR5

Volume Change: University Beach

Erosion dominated at University Beach with the most significant volume loss measured since the beach was construction in 2001. The net volume loss between 2016 and 2017 was 3,100 cu yd. This period of erosion initiated by Hurricane Harvey, followed a period of accretion of on the order of the same magnitude (3,000 cu yd) over the previous reporting period and a series of intermittent annual periods of low volume net erosion and accretion over the past several years. Since construction, the volume of the region between the low duneline extending offshore to the breakwaters (approx. 500 ft offshore) has increased a total of approximately 8,000 cu yd (2001-2017). Since construction, accretion has been concentrated between the shoreline position at MHHW and the breakwaters due to gradual erosion of the berm and foreshore. Significant accretion was only indicated in one location at the west limit of the west DBW during Dec 2017.

Erosion was focused at both the foreshore and berm crest along the majority of the beach with the exception of the beach segment in the shadow of the center DBW (BR3 and IR 8). The only region that experienced accretion was in the nearshore in the lee of the west breakwater. This was likely due to forcing of sand that had previously accreted as a tombolo behind the west breakwater. Morphology typical along the east, center and west beach segments is shown in Figures 68-75.

As reported previously, although there has been evidence of sand exchange between the beach cell and the surrounding nearshore, the confining structures make quantification of the volume moving between the two regions challenging. In the nearshore region, sand transport out of the cell is discouraged by the groins and detached breakwaters. The transport of sand into the cell from the adjacent open bay nearshore has balanced the limited volume of sand exiting the beach cell since construction. In addition, due to the protected area afforded by the structures, the reduction in current flow has allowed for settling of fine suspended sediment from open bay waters within the beach cell. The native sediment introduced from outside the beach cell is composed of fine sand, silt and organic material, which once settling in the shallow nearshore, contribute to the growth of isolated regions of seagrass which have increased in extent.

Removal of sand by wind is common at Texas beaches due to strong prevailing southeasterly wind as well as strong pulses of wind directed out of the north during the winter. As reported previously, at University Beach the transport of windblown sand away from the active beach is limited by the 13 to 16-ft bluff that borders the entire beach along Ocean Drive. The bluff limits significant sand loss during the prevailing onshore winds. Windblown sand is conserved in a row of coppice dunes that began to develop within 1-year after construction and extend continuously along the entire length of the beach. A significant volume of sand, on the order of 3,000 cu yd, has accumulated along the base of the bluff at a rate of approximately 240 cy/yr. Although the most significant contribution to the developing dunes occurred over the first two years post-construction, accretion along the duneline has continued at a slower rate over the last 5 years. The rate of change between 2016 and 2017 was limited with minor accretion along the west end of the beach at a low rate. Persistent growth of a mixture of native and invasive plant species further stabilizes the coppice dunes. The height and width of the dunes has increased to form a persistent feature that links the region between the tall bluff along Ocean Drive and the beach below, thereby facilitating pedestrian access. The modified slope presented by the dune is most effective as an interface for pedestrian access from the east end to center beach. Vegetation has become persistent across the berm on the west end of the beach over the course of the last two years.

As sand continues to migrate from the berm into the nearshore, the depth of the nearshore within the beach cell has continued to decrease to the extent that during periods of lower water level emergent features (tombolos) are well defined landward of all three breakwaters. The extent of tombolo development both horizontally and in elevation is variable but in general, the peak elevation of each tombolo has ranged from 1.3 ft (BR3 2016) to in excess of + 2.0 ft (IR10 2016). The peak has developed immediately adjacent to the DBWs. Figures 68, 69 and 70 show the extent of tombolo development along transects located landward of the DBWs as well as accretion in the gap area adjacent to the DBWs. Deeper nearshore regions of -1 ft to -2.5 ft were previously maintained only on either side of the east and west DBW decreased after Harvey and were only observed at the offshore limit of the beach cell near the DBWs. Since construction, the depth of the submerged region between the shoreline and the breakwaters has decreased on the order of 1 to 3 ft. The only region where an increase in depth has been identified is immediately seaward of the breakwaters and immediately adjacent to the breakwaters in the gaps where the depth has increased up to 3 ft due to scour during periodic strong onshore forcing.

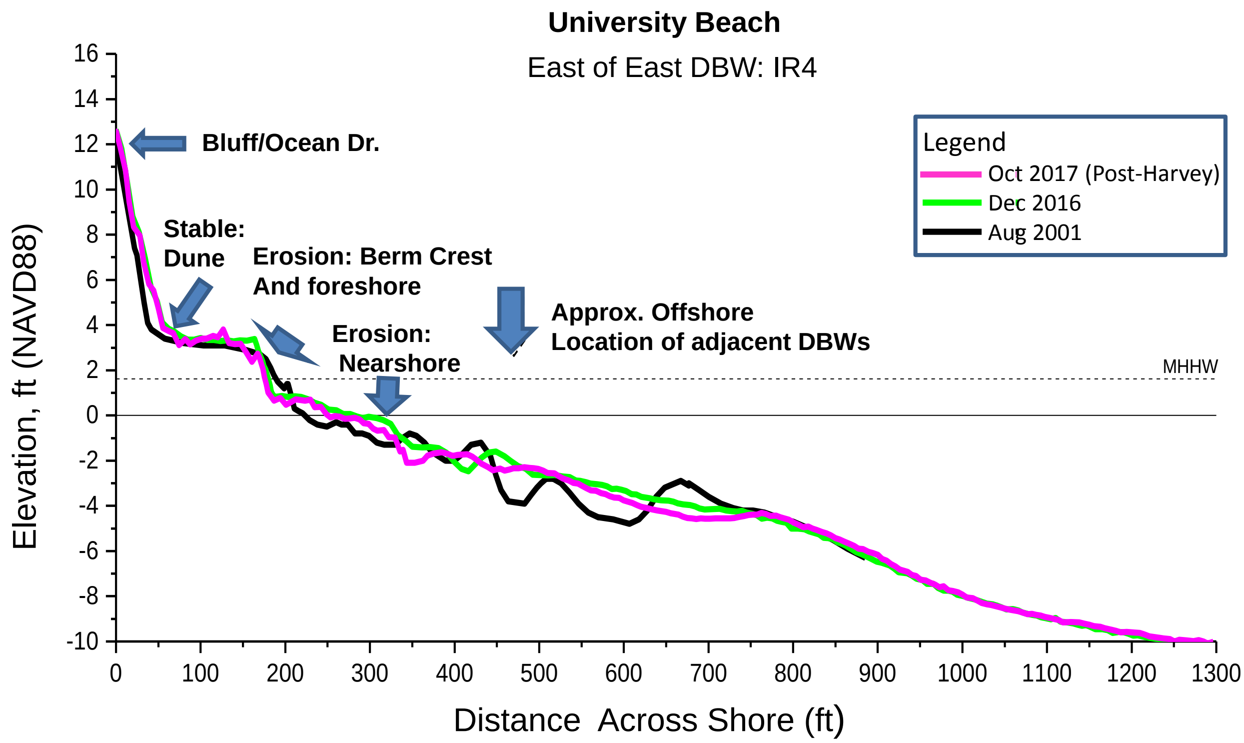

Figure 68. East End of Beach – Between East Groin and East DBWs: Erosion focused at berm crest and foreshore at low rate compared to beach to the west (2016-2017 Post Harvey)

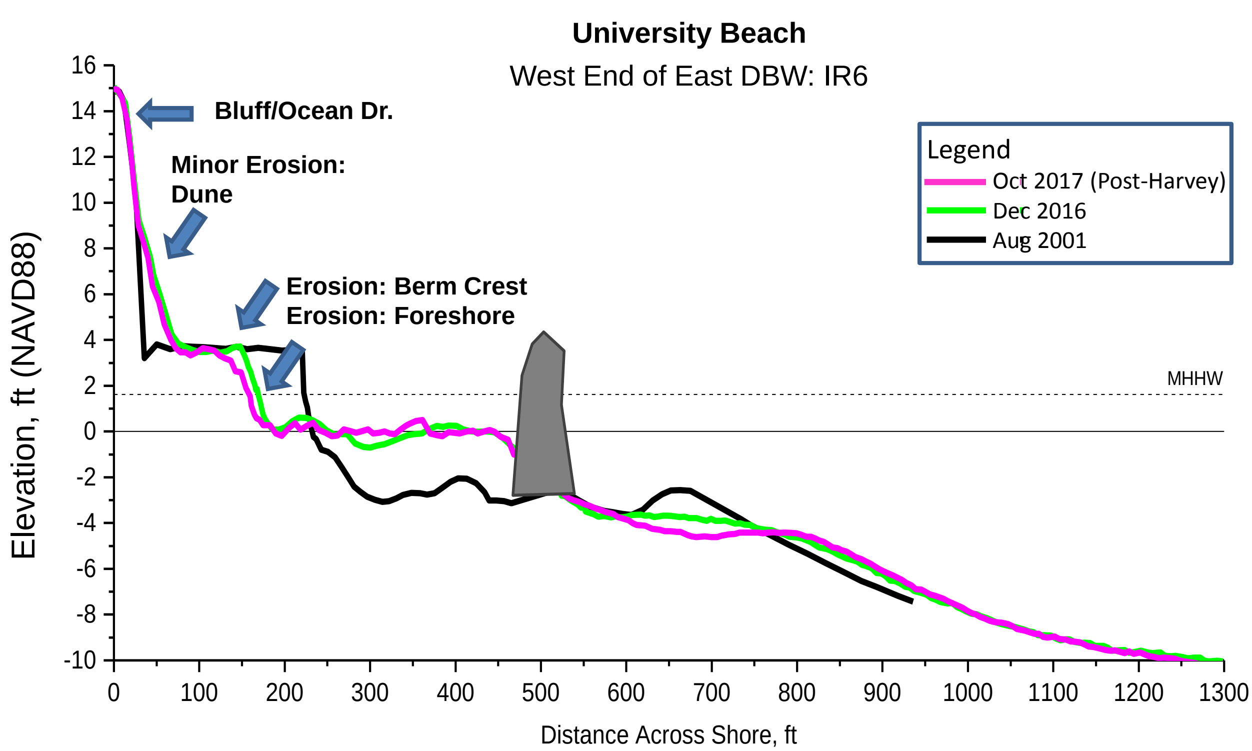

Figure 69. East Side of Beach: Erosion dominates across entire profile to DOC (2016-2017 Post Harvey)

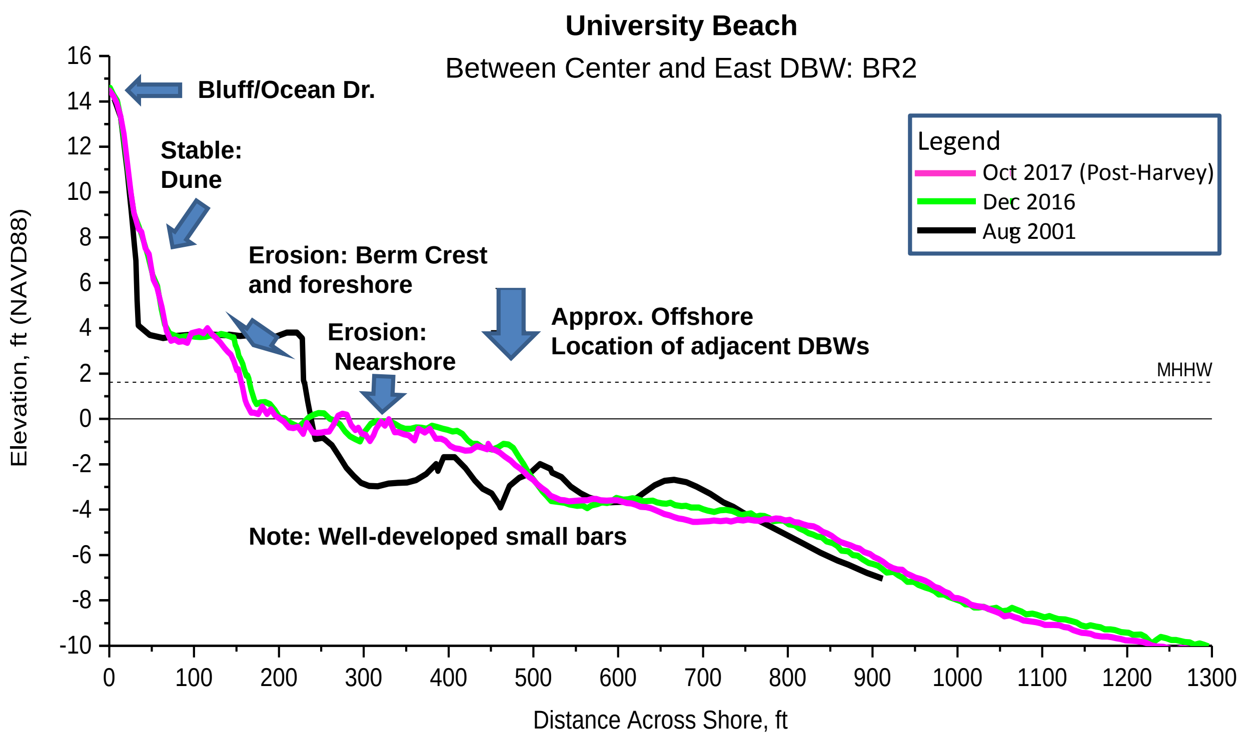

Figure 70. Between East DBW and Center DBW: Erosion dominated across berm into nearshore (2016-2017 Post-Harvey)

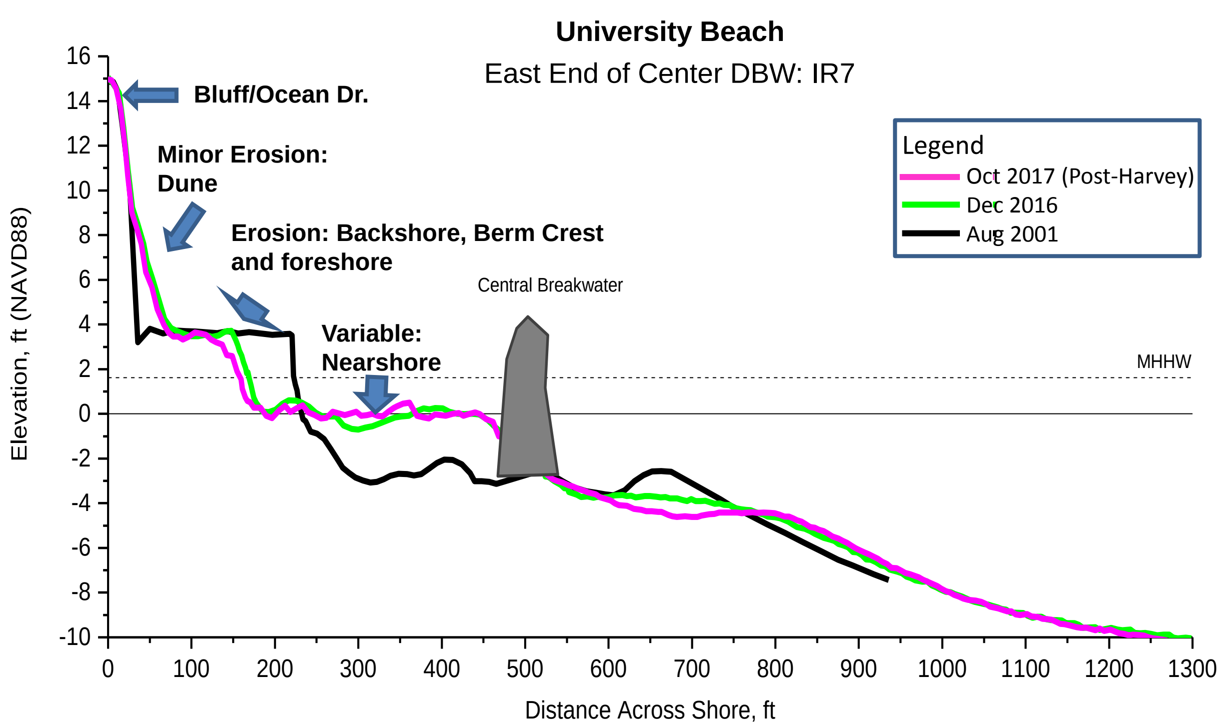

Figure 71. Center Beach- East End of Center DBW: Minor erosion at duneline increasing at berm crest and foreshore with significant modification of nearshore (2016-2017 Post-Harvey)

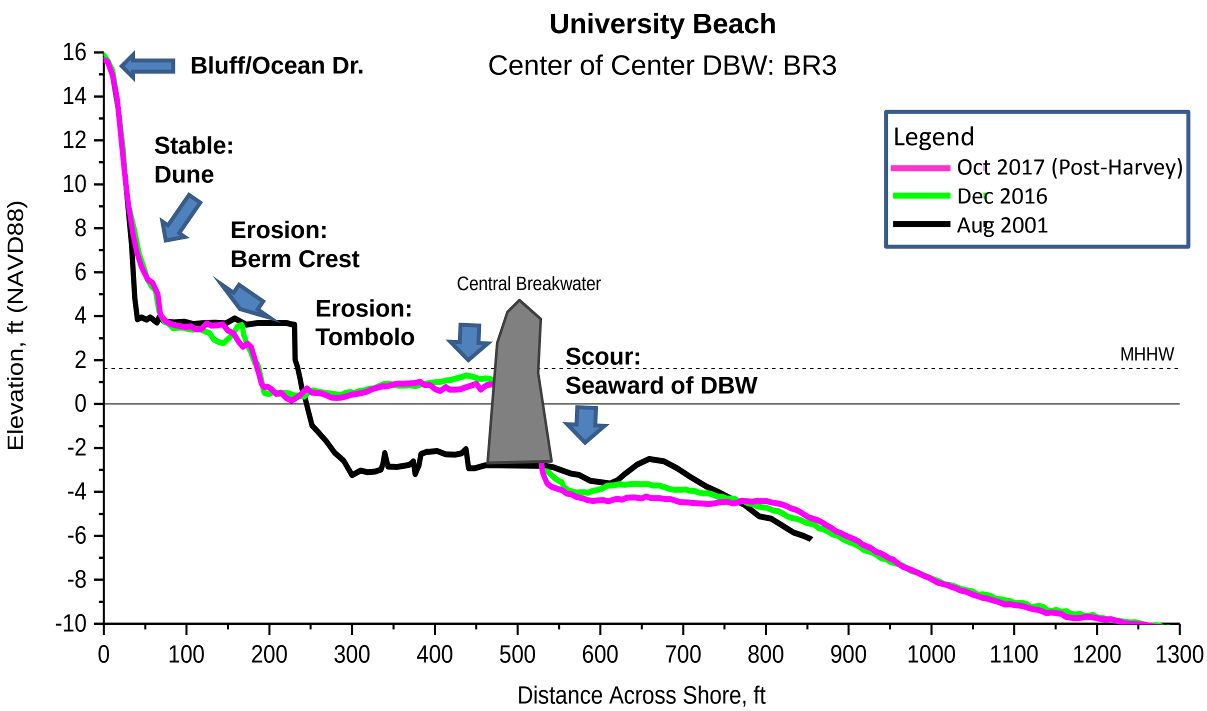

Figure 72. Center Beach- Center of Center DBW: Stable backshore/dune with erosion focused at berm crest and along seaward end of tombolo (2016-2017 Post-Harvey)

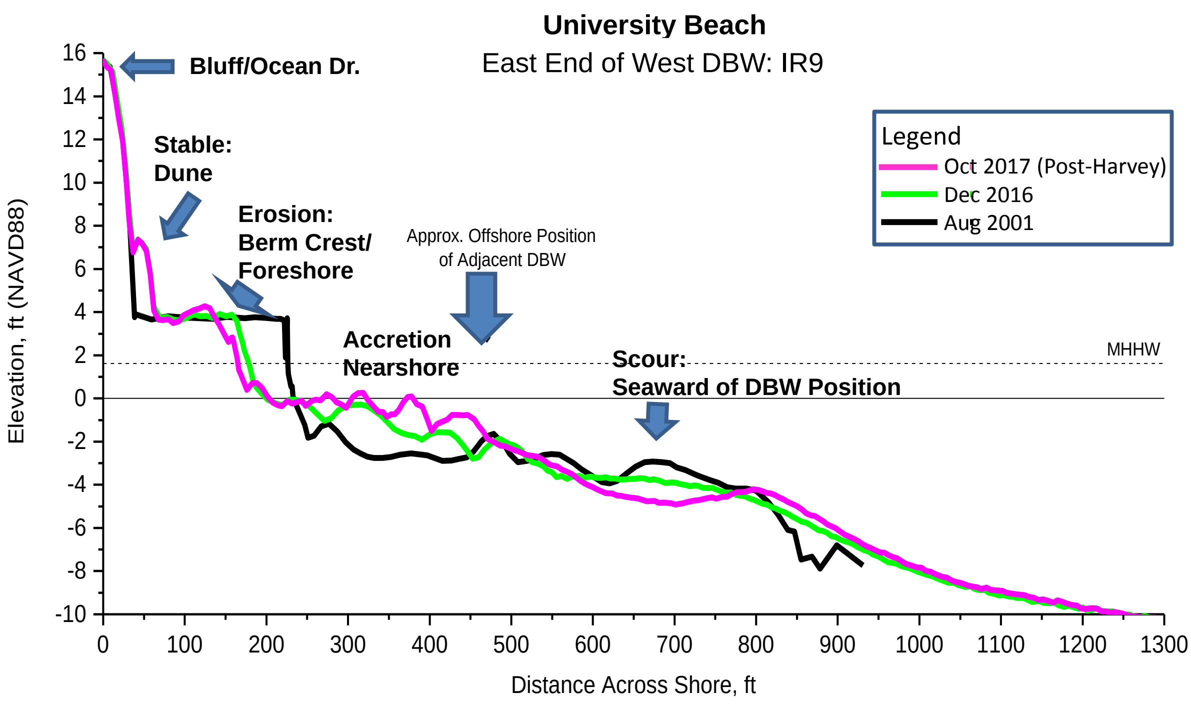

Figure 73. West Side of Beach- East End of West DBW: Stable duneline with focused erosion at berm crest and foreshore leading to significant accretion in immediate nearshore (2016-2017 Post-Harvey)

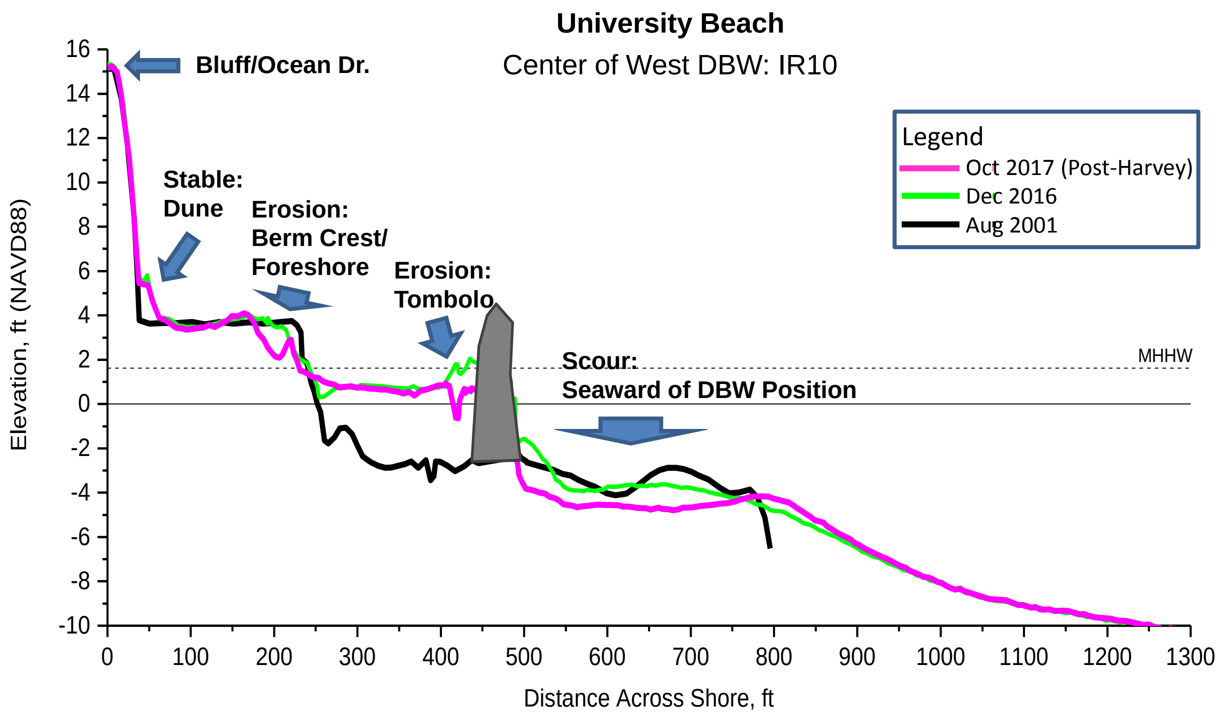

Figure 74. West End-Center of West DBW: Stable duneline/backshore with focused erosion at berm crest and seaward limit of tombolo due to forcing from northwest entering between the west groin and west DBW

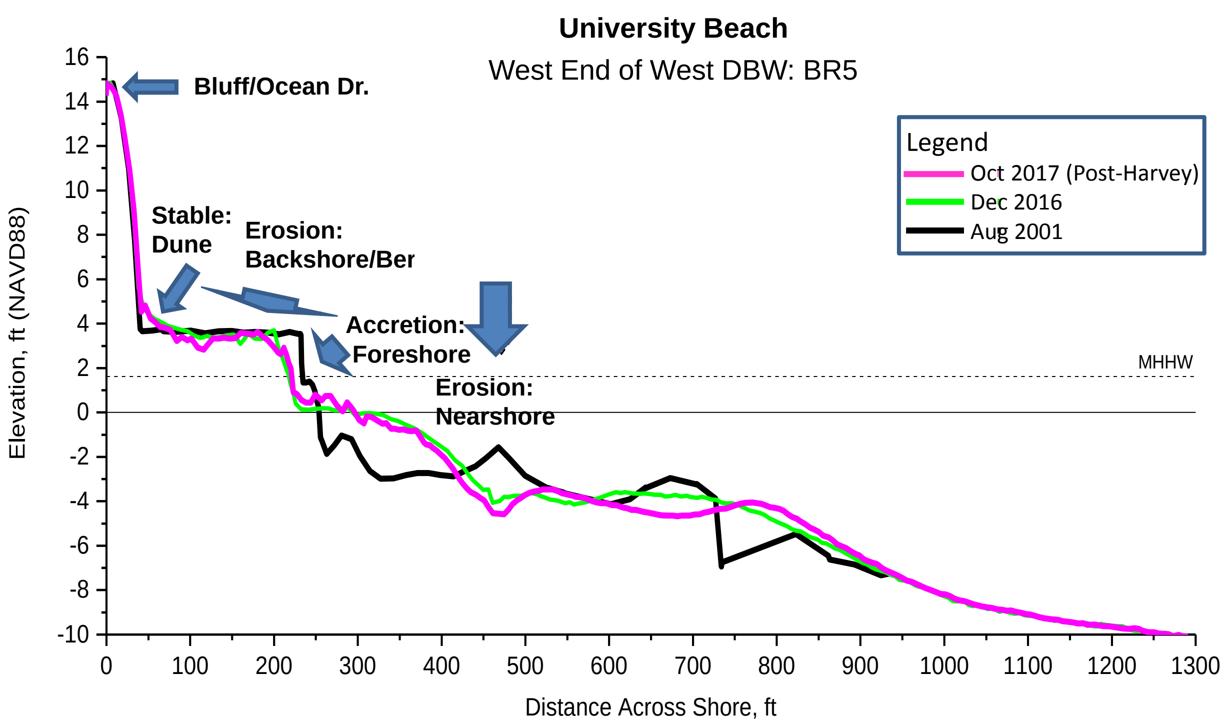

Figure 75. West End-Between West Groin and West DBW: Erosion across berm and berm crest with accretion at foreshore and immediate nearshore and limited erosion further seaward

Recommendations: University Beach

University Beach demonstrates a successful cellular design in which sand eroding from the berm is impounded in the nearshore, the cellular system is reaching its sand storing capacity after 17 years of low volume introduction of sediment from the surrounding nearshore. Despite significant erosion due to storm forcing during Hurricane Harvey, the beach has well exceeded its design performance expectations. During design, it was anticipated that University Beach would require at a minimum of a partial nourishment after 10 years.

Sand has been conserved in two locations 1) nearshore between foreshore and breakwater and 2) along the backshore in the form of a low persistent coppice duneline. The stability of the duneline has been reinforced by the tall bluff that forms the backshore limit of the beach. The isolation of the beach from typical erosional forces has resulted in a unique situation where the beach has gained sand post-construction rather than suffering from persistent sand loss, which is `common at Texas bayside beaches. The cellular design offers the potential for a self-sustaining system where sand can be mechanically redistributed from the nearshore, landward of the detached breakwaters, to the berm. Similar to backpassing, mechanical redistribution of sand is more cost-effective than importing sand from offsite locations as land-based equipment is utilized to implement reclamation and redistribution of localized sand. University Beach has not met the standard criteria for restoration due to the great stability the beach has demonstrated after 17 years post-construction (2001).

The nearshore region at University Beach is depth-limited with greater than 50% of the nearshore at a depth of less than -1 ft (NAVD88) where the pre-construction depth ranged from -1.0 ft to -3.5 ft. The shallowest regions are located along the tombolo that extends from the peak in salient offshore up to each DBW. Each tombolo is primarily emergent during periods of lower water level but theses depositional features have been transiently exposed during higher water levels after episodic deposition. During 2016 the tombolo landward of the west and central DBW were fully exposed over the typical tidal range at an elevation of 2.0 ft near the intersection with the structure. The tombolo located landward of the east DBW has not developed to the point of exposure over the typical tidal range but has been regularly exposed during seasonal low water levels. To restore the post-construction (2001) nearshore depth that is adequate to support recreational activities, reduce the opportunity for submerged vegetation to flourish and insure adequate flushing to maintain water quality would require the reclamation of approximately 19,000 cu yd of sand (Dec 2017).

The nearshore along this region of Corpus Christi Bay is shallow, a characteristic resulting from the nearshore consisting of a relict shoreline shelf composed primarily of clay with a veneer of sand. The substrate presents a fixed slope over which sediment transport occurs thereby limiting the slope and depth in the immediate nearshore. By design, the structures limit typical wave energy, thereby reducing the opportunity for re-suspension and transport of the sand out of the beach cell. The detached breakwaters function as a barrier to offshore transport of sediment and support accretion on the landward facing side of the structure. The sheltered region fosters sedimentation as currents and waves introduce sediment from the surrounding nearshore into the beach cell. The combination of increasingly shallow depth and the introduction of fine sediment may lead to a potential change in the character of the beach, promoting persistent growth of submerged vegetation that has been identified thus far as seasonal or transient. The growth of seagrass was initially identified only on the eastern end of the beach cell but seagrass growth has expanded toward the west. Redistribution of sand from the nearshore within the beach cell to the berm has been recommended in past reporting. Delaying the redistribution of sand within the beach cell allows for continued introduction of sediment that does not meet beach-quality sand characteristics as defined for this location due to the higher percentage of fine material and organic material (Williams 2013, 2015 and 2016).

As previously reported, the cellular design of University Beach has successfully functioned to conserve an adequate volume of sand in the nearshore to provide for the renourishment of the eroding central section of the berm. The sand impounded in the nearshore, within the landward shadow of the DBW, could be accessed using land-based equipment at a significant savings as compared to import of offsite sand. To restore the beach to the Design/Target Width would require increasing the width by 24 to 50 ft. This would require between 9,000 cu yd (most recent 2017 assessment) to 10,000 cu yd (Maximum calculated since 2001) of sand reclaimed from the nearshore region. The estimated volume of accessible nearshore sand is between 10,000 cu yd and 19,000 cu yd, dependent on the depth to which the nearshore is restored, either -2 ft or – 3 ft, respectively and the design width selected. An additional consideration is that the volume of beach quality sand that will be reclaimed from the nearshore will be more clearly defined after core analysis is conducted to determine the sediment grain size and composition of the material prior the reclamation. It is anticipated that due to the 17 yr period since construction that lenses of fine material will be encountered in the sediment extracted from the nearshore, particular on the east end of the beach. Therefore, the volume of beach quality sand would need to be assessed immediately prior to reclamation. One alternative could be to place lower quality sand as a substrate for subsequent placement of the higher quality sand. This is particularly feasible along the stable backshore, as this region has not been breached since construction in 2001.

The location of sand placement would extend from the east groin westward up to station IR10, after which the beach has remained in excess of the design width and maintained an approximate elevation of 3 ft across the berm since 2001. After restoring the elevation of the berm to a design elevation of 3.5 ft, the placement would concentrate on redefining the berm crest with the MHHW position at an offshore limit of 150 ft.

There are location specific considerations with regard to reclamation of sand from the nearshore; 1) seasonal access considerations, 2) seasonal avian nesting and foraging considerations, 3) sediment quality, 4) abandoned rebar infrastructure landward of the center DBW, 5) potential for oyster shell in matrix of sediment and finally 6) Coordination with resource agency staff regarding presence of green turtles. The seasonal considerations with regard to scheduling the redistribution of sand remain as previously reported (2013-2016). For the salient and tombolo to be effectively applied as "land bridges" to support the reclamation of sand from the nearshore, the redistribution should be planned for periods of peak low water level, which occurs during September/October and again during January/February. During this time, there is the greatest opportunity for an extended period of low water level during which the depositional feature is emergent. Crews would also need to schedule around periodic onshore forcing events such as winter cold fronts which could increase water levels for short periods of time (days to weeks). A pre-nourishment survey is recommended within the season of implementation due to the rapid and significant response of this beach to seasonal/event forcing. In preparation for mobilization, a detailed survey of the nearshore at reduced transect spacing of 50 ft to identify the full extent of the reclamation area is recommended. Implementation during the winter season is recommended to avoid shorebird-nesting season. The nesting season for shorebirds extends from spring to late summer (May to Aug) with active nesting areas fenced for protection during this time.

The location of sediment reclamation may be influenced by sediment quality for two reasons, first the length of time that native bay sediment from outside of the beach cell has accumulated (17 years) and the introduction of oyster shell into the beach cell by an abandoned oyster reef project. The introduction of finer native sediment that has entered the beach cell along with the increasingly shallow nearshore has provided an environment that provides for transient seagrass growth and an increase in organic material related to growth cycles. Therefore, sediment grain size analysis is recommended for early in the planning process. This identify locations within the beach cell where the greatest successful reclamation of beach quality sand can be expected. Due to the length of time that has passed since the beach was placed, it is likely that significant accumulation of fine and organic material has occurred periodically within the beach cell. Therefore, an additional plan for beneficial offsite relocation of non-beach quality material will also need to be explored to accommodate any sediment that does not meet beach quality standards. Possible offsite locations could include TAMUCC and City of Corpus Christi sponsored locations in close proximity.

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