Holden Beach

Annual Beach Monitoring Report 2024

Prepared For:
Town of Holden Beach, North Carolina

February 2025

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ATM
ATM of NC

TABLE OF CONTENTS

1.0 INTRODUCTION

Holden Beach is a 9-mile-long barrier island located in Brunswick County, North Carolina (see Figure 1-1), where long-term and episodic storm erosion continually threatens the coastal habitats, recreational beach, tourism, and upland developments. Consequently, the Town of Holden Beach, referred to herein as the "Town," has undertaken a comprehensive beach management and maintenance program to protect and enhance its beach system. All nourishment and dune enhancement activities resulting from this program have proven valuable in providing a healthy beach system as well as a storm buffer to reduce losses to homeowners and to Town, State, and Federal infrastructure.

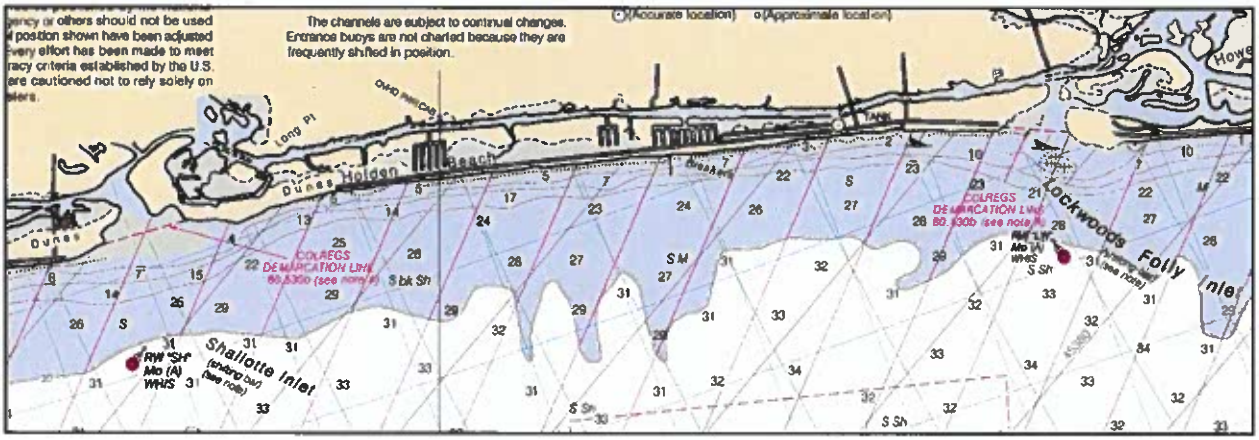

Figure 1-1. Project Location Map of Holden Beach, NC (NOAA Chart 11536)

The Town has been documenting nourishment and dune project performance and environmental effects through annual field surveys, analyses, and monitoring reports according to regulatory agency permit conditions, as well as to remain eligible for Federal Emergency Management Agency (FEMA) mitigation funding related to "engineered" beaches. Another objective is to identify erosional areas of shoreline that warrant future nourishment consideration.

This report summarizes the 2023 to 2024 beach management activities and compares the most recent annual survey (April 2024) with beach profile surveys collected from 2000 through 2023. Beach profile data is used to assess the status of the beach through an evaluation of volume and contour change and to establish rates of change with respect to nourishment projects and historical background erosion rates.

2.0 RECENT AND FUTURE PROJECTS

This section provides a brief project site history, beginning with the 2001/2002 U.S. Army Corps of Engineers (USACE) Wilmington Harbor Deepening nourishment project. Prior to this event, Town and USACE beach management efforts were sporadic and on smaller scales, with the first documented nourishment occurring in 1971. Beach scraping and dune repairs have been documented as far back as 1954, mitigating Hurricane Hazel impacts. Significant erosion and the loss of more than 30 houses on the eastern end of Holden Beach in the 1990s were major factors in establishing current beach management activities. Table 2-1 and Figure 2-1 summarize nourishment activities and locations since 2001.

Following the spring 2002 completion of the USACE Wilmington Harbor Deepening nourishment project, the Town conducted six beach nourishment projects using upland borrow sources. The most recent upland truck haul project occurred in spring 2009, when the Town placed 190,000 cubic yards (cy) of upland fill along approximately 10,000 linear feet (lf) of shoreline. In addition to upland fill beach nourishments, the Town has also taken a more active role in working with the USACE to maximize fill placement from dredging the Lockwood Folly (LWF) Inlet Atlantic Intracoastal Waterway (AIWW) crossing (LWFIX) and the "bend-widener" (which is discussed in Section 2.4.4).

In terms of "major" nourishment activity, the major nourishment activity of 2017 was the Town's Central Reach Project (CRP), which placed approximately 1.31 million cubic yards (mcy) along approximately 4.1 miles of shoreline from January to mid-March 2017. In addition to the 2017 CRP project, the Town also participated in the LWFIX Project that placed approximately 120,000 cy of material dredged from the LWFIX and the bend widener along about 2,400 lf of shoreline in 2017.

The most recent major nourishment activity was the Central Reach Reimbursement (CRR) Project completed in winter/spring 2022. The CRR represents the largest beach fill project on Holden Beach to date, where the Town placed approximately 1.54 million cubic yards (MCY) of sand along the Central Reach from Station 40+00 to Station 260+00. Similar to the 2017 Central Reach Project, the 2022 CRR project took place in conjunction with a USACE LWIFX project which placed approximately 115,000 cy along ~2,000 lf of shoreline on the eastern end of the island.

The two-year post-project movement and spreading of the fill placements from these two 2022 nourishment projects are reflected in the 2024 survey (discussed in Section 3). Further details of these projects are provided in subsequent sections.

Table 2.1. Summary of Holden Beach Nourishment Projects since 2001

Date	Completed By	Beach Stations Nourished	Approx. Volume of Material Placed (cubic yards)	Nourishment Material Source
12/8/01 – 2/20/02	USACE	87+00 – 192+00	525,000	Wilmington Harbor Deepening Project
3/7/02 – 4/30/02	Town of Holden Beach Phase I	66+00 - 90+00, 175+00 – 217+00	141,700	Oyster Harbor upland site
3/02-4/02	USACE	20+00 – 30+00[1)]	32,000	Lockwood Folly Inlet crossing of AIWW
Winter 2002-2003	Town of Holden Beach	90+00 – 175+00	30,000	Boyd Street Disposal Area
9/16/04 – 11/2/04	USACE	15+00 – 40+00	113,230	Lockwood Folly Inlet crossing of AIWW
12/03 – 4/04	Town of Holden Beach	46+00 – 68+00 and 215+00 – 238+00	123,000	Smith borrow site
5/5/06 – 5/24/06	USACE	15+00 – 40+00	62,853	Lockwood Folly Inlet crossing of AIWW
Early 2006	Town of Holden Beach	Eastern Reach	42,000	Smith borrow site
Early 2006	Town of Holden Beach	Western Reach	3,200	Smith borrow site
1/24/08 – 3/28/08	Town of Holden Beach	60+00 – 95+00 and 245+00 – 270+00	201,000	Smith borrow site
2008/2009	USACE	20+00 – 40+00	100,000	Lockwood Folly Inlet crossing of AIWW
03/24/09 – 4/30/09	Town of Holden Beach	55+00 – 110+00 and 210+00 – 255+00	190,000	Smith borrow site
Spring 2010	USACE	20+00 – 55+00	140,000	Lockwood Folly Inlet crossing of AIWW
February 2011	USACE	20+00 – 40+00	32,000	Lockwood Folly Inlet crossing of AIWW
January 2012	USACE	20+00 – 30+00	25,000	Lockwood Folly Inlet crossing of AIWW
2/10/14 - 2/27/14	USACE	18+00 – 50+00	93,000	Lockwood Folly Inlet crossing of AIWW
2/27/14 - 3/15/14	Town of Holden Beach	50+00 –73+00	95,000	Lockwood Folly Inlet crossing of AIWW
9/4/15 - 9/15/15	Town of Holden Beach	Nearshore (60+00 - 90+00)	24,000	Lockwood Folly Outer Navigation Channel
1/3/17 – 3/17/17	Town of Holden Beach	45+00 – 257+00	1,310,000	Offshore borrow area
March 2017	Town / USACE	20+00 – 45+00	120,000	Lockwood Folly Inlet crossing of AIWW
Spring 2020	USACE	15+00 - 45+00	80,000	Lockwood Folly Inlet crossing of AIWW
1/7/22 – 4/14/22	Town of Holden Beach	40+00 – 260+00	1,540,000	Offshore borrow areas
March 2022	USACE	20+00 – 40+00	115,000	Lockwood Folly Inlet crossing of AIWW
February 2024	USACE	20+00 – 40+00	112,000	Lockwood Folly Inlet crossing of AIWW
		Approximate Total Volume since 2001	**5,249,983**	

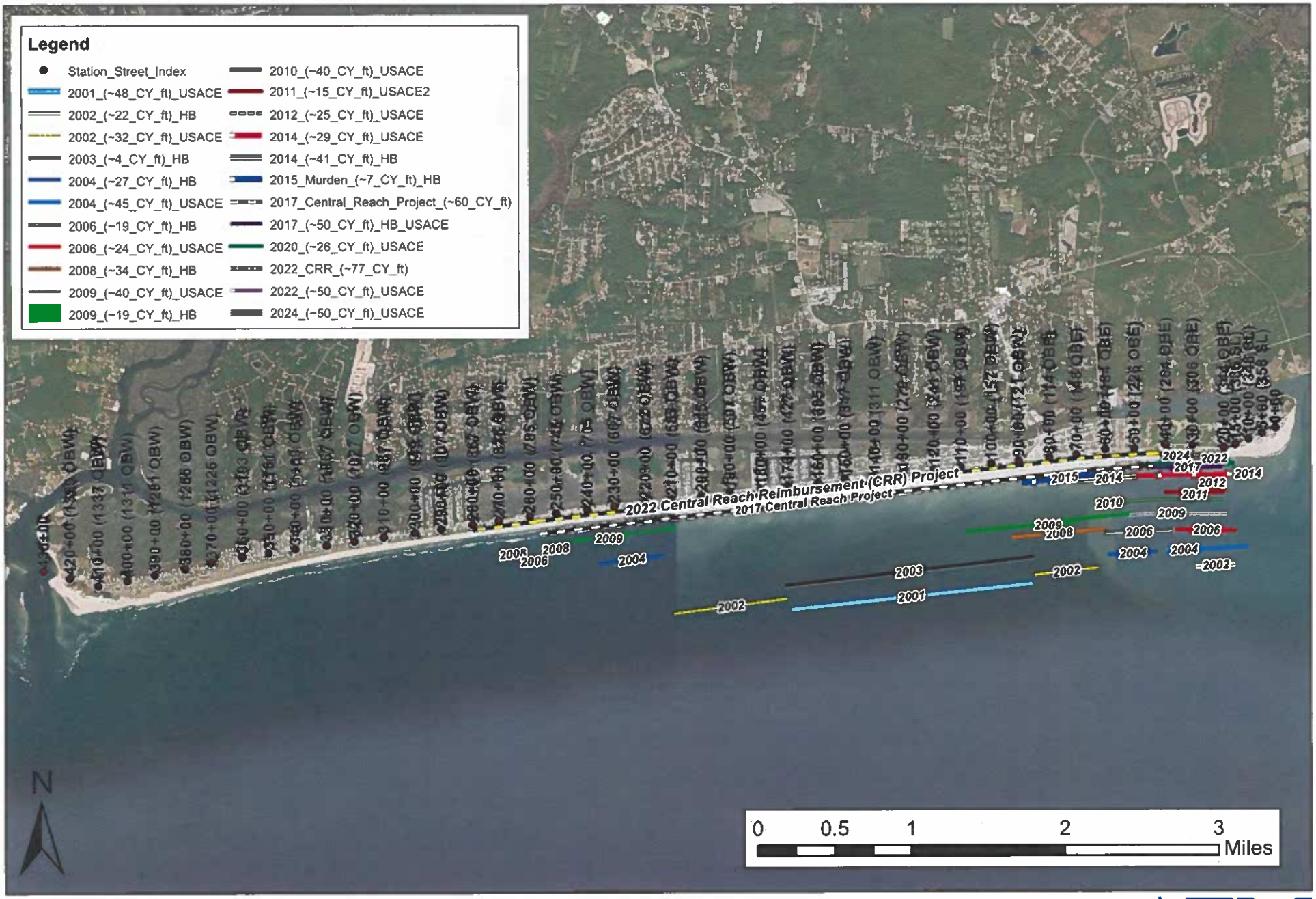

Figure 2-1
Holden Beach nourishments since 2001 and beach stationing for surveying.
Survey stations begin at LWF Inlet (0+00) and are generally at 1,000 foot intervals, ending at Shallotte Inlet (430+00).

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2.1 TOWN UPLAND FILL PROJECTS

The Town has a history of successful upland fill projects, with the most recent occurring in 2009, primarily as Hurricane Hanna mitigation. Approximately 115,000 cy was placed between Stations 55+00 and 110+00 [21 cubic yard per linear foot (cy/lf) average] along the Eastern Reach and 75,000 cy between Stations 210+00 and 255+00 (16.5 cy/lf average) along the Western Reach. Figure 2-2 illustrates the placed-fill footprint and the permitted footprint. Sand was obtained from the Smith upland borrow site.

Note that upland sand has been used in emergency dune rebuilding following Hurricane Hanna in 2008 and Hurricane Irene in 2011.

Figure 2-2. 2009 Constructed Project Reaches and 2009 Permitted Sand Placement (the permitted placement has been modified over the years)

While the last upland-sourced beach nourishment occurred over a decade ago, the use of upland borrow areas remains a feasible alternative for Holden Beach. Fill projects utilizing upland borrow areas can be extremely valuable for unplanned/emergency mitigation efforts, such as the responses to Hurricanes Hanna and Irene.

Additionally, truck haul projects do not involve the expensive mobilization/demobilization costs associated with offshore dredges and can occur much more quickly.

Potential negative aspects of upland borrow areas include variations in sand color, practical volume limitations, and placement methods (i.e., trucking). Additionally, the North Carolina Department of Transportation (NCDOT) requires permitting and has the ability to shut down operations or require roadway mitigation.

The Town owns the Turkey Trap Road upland borrow site whereas other potential borrow area sites have been used in the past and may be available in the future. The Turkey Trap Road and other upland borrow sites (such as the Smith site shown in Figure 2-3) have been successfully permitted, which significantly enhances post-storm mitigation response time. Residential development on the Smith site is currently underway and development demand on other large tracts of land is currently strong however excavating a large lake feature can potentially yield beach compatible sand.

Figure 2-3. Smith Upland Borrow Area during 2009 Holden Beach Nourishment Project

2.2 TOWN 2017 CENTRAL REACH PROJECT (CRP)

The Town Central Reach Project (CRP) nourishment occurred in winter/spring 2017 and represents the second largest beach fill project to date on the island, now that the 2022 Central Reach Reimbursement (CRR) project has been completed. CRP construction began on January 3, 2017 and was completed on March 17, 2017 (74 days) by Weeks Marine using two hopper dredges, the R.N. Weeks and the B.E. Lindholm. The nourishment utilized an offshore borrow area and placed approximately 1.31 mcy along 4.1 miles (22,000 ft) of shoreline [Ocean Boulevard East (OBE) 240 to Ocean Boulevard West (OBW) 781].

Figure 2-4 presents the beach fill project footprint. On average, constructed berm widths were about 150 ft wide and fill placements were about 60 cy/lf (with a range typically varying between 50 and 70 cy/lf).

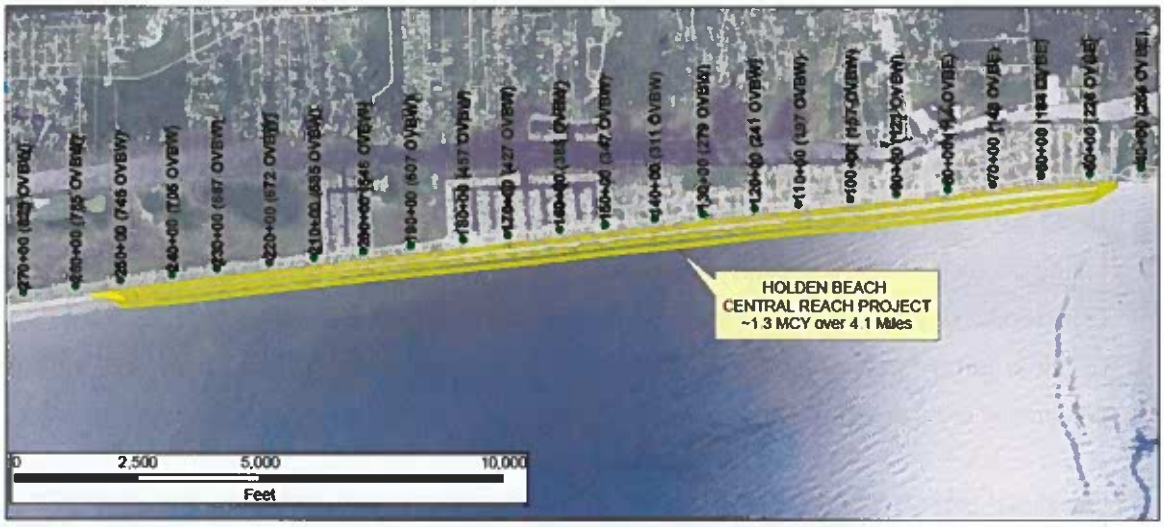

Figure 2-4. Central Reach Beach Fill Placement Footprint (Construction from 1/3/17 to 3/17/17 from Approximately Station 45+00 to Station 257+00)

The 2017 CRP nourishment took place just months after Hurricane Matthew in 2016 and vastly revitalized the beach and dune system. The revitalized beach has and continues to provide added cumulative protection from storms. Surveys over the past years following construction show the project held up well considering impacts from Hurricanes Florence (2018), Michael (2018), Dorian (2019), and Isaias (2020).

More information on the CRP and performance monitoring can be found in previous annual monitoring reports. The favorable performance of the CRP provided a good base of pre-project beach for the 2022 CRR project to expand on.

The CRP utilized an offshore borrow area approximately 5 miles southeast of the Holden Beach project shoreline. Dredge cuts were generally only 2 to 4 ft deep in most areas.

As a result of Hurricanes Florence (2018), Michael (2018), Dorian (2019), and Isaias (2020), a Central Reach Reimbursement (CRR) project design was initiated where the Town could place up to 1.7 mcy in FEMA "engineered beach" mitigation. ATM completed additional offshore borrow area reconnaissance and identified/permitted ~1.9 mcy of beach compatible sand (in addition to the CRP borrow area). The CRR nourishment project utilizing offshore

borrow areas occurred in winter/spring 2022 and placed ~1.54 mcy. More discussion on borrow area reconnaissance and the 2022 CRR project construction is provided in Section 2.3.

2.2.1 STATIC VEGETATION LINE

Due to the 2017 CRP's size, the Division of Coastal Management (DCM) required a Static Vegetation Line (SVL). The SVL is basically the seaward limit of stable dune vegetation prior to a large beach nourishment, and the SVL is the baseline for the Coastal Area Management Act (CAMA) setback distances. The SVL is only along the CRP shoreline (not the east end or western areas of the beach), and the SVL was delineated prior to Hurricane Matthew dune erosion. The SVL was also expanded a few thousand feet westward prior to the 2022 CRR project to match the permitted CRR footprint.

The SVL line may not be an issue for Holden Beach because of the Town's proactive and beneficial dune enhancements over the years. However, if the SVL becomes an issue in the future, two options are available to the Town to exempt itself from the SVL. The first is to develop an SVL exception document that provides data for 30 years' worth of future beach nourishments. This exception must be re-visited every 5 years as well. The second and more recent alternative is for the Town to propose and create a Development Line. The Development Line alternative is a simpler and faster process.

Town and ATM staff have already coordinated with DCM staff regarding the Development Line process and several other towns have used this process since it became effective in 2016.

2.3 2022 CENTRAL REACH REIMBURSEMENT (CRR) PROJECT

The CRR nourishment occurred in winter/spring 2022 and now represents the largest beach fill project to date on the island. The CRR project was a direct result of the Town's significant investments in its beach management program. The CRR was a FEMA mitigation project that placed about 1.54 million cubic yard (mcy) of material along the Central Reach shoreline. The CRR project was 100% reimbursable where FEMA reimbursed 75 percent and the State reimbursed 25 percent. Note that submitted reimbursable costs are thoroughly reviewed/evaluated and that this process can take years.

Project construction began on January 7, 2022 and was completed on April 12, 2022 (96 days) by Weeks Marine. The nourishment utilized two offshore borrow areas and placed approximately 1.54 mcy along ~4.2 miles (~22,000 ft) of shoreline, between 240 Ocean Boulevard East (OBE) to 781 Ocean Boulevard West (OBW).

Similar to the 2017 CRP borrow area dredging, shallow dredge cuts using a hopper dredge were used due to the presence of compatible materials in the upper layer, generally underlain by marginal material. In fact, the same dredging contractor, Weeks Marine, and the same hopper dredges that were used for the 2017 project (the R.N Weeks and B.E. Lindholm), were used for the 2022 project. The project placed sand dredged offshore from two different borrow areas and placed beach compatible sand from Station 40+00 to just west of Station 260+00 (refer to Figure 2-5 below and Figure 2-8 in the following section).

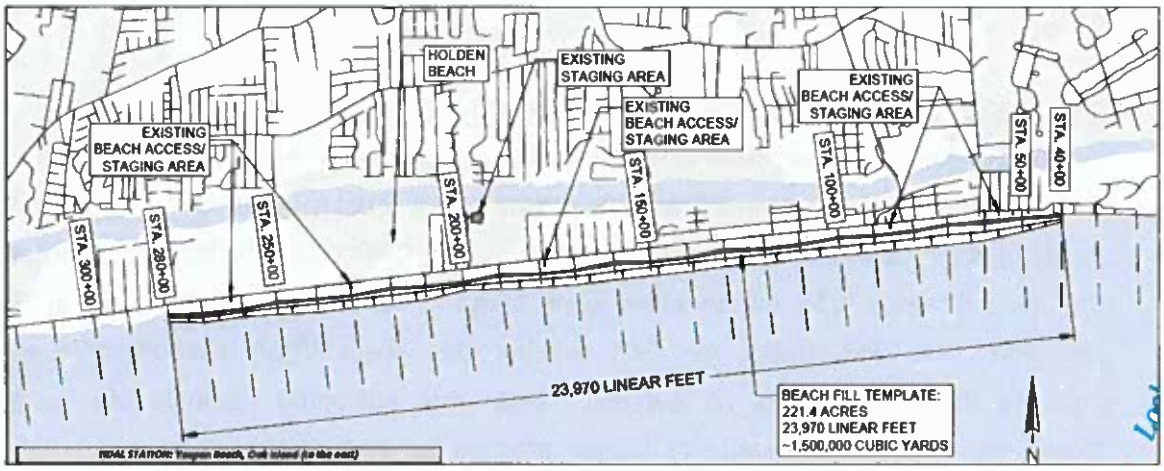

Figure 2-5. CRR Permitted Beach Fill Template. Actual Placement Extended from Station 40+00 to just east of 270+00 (~23,000 Linear Feet from ~240 Ocean Boulevard East to ~815 Ocean Boulevard West)

Taken as a whole, the average fill placement density was ~77 cubic yards per foot along the entire length of the project, including tapers. Figure 2-6 presents a typical fill cross-section following construction. The project included a varying secondary berm feature to blend in with existing dunes, although this secondary berm feature was reshaped/combined into the primary dune during Hurricane Ian on September 30, 2022.

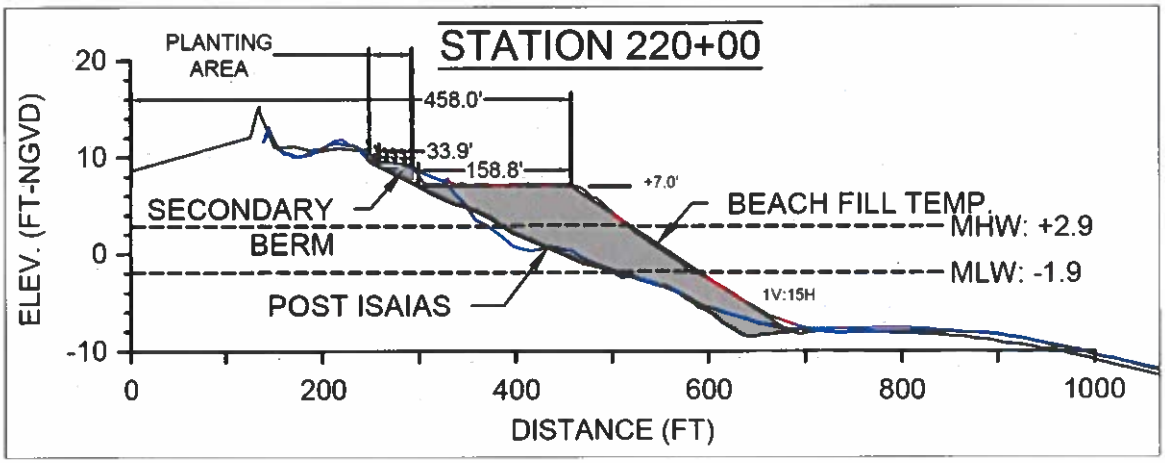

Figure 2-6. Typical CRR "As-Built" Cross-Section Following Completion Shown Relative to August 2020 Post-Hurricane Isaias Beach Profile.

With the help of the two hopper dredges, the Weeks Marine crew worked quickly, pumping sand on the beach and progressing at an average rate of about 300 feet of shoreline per day. Aerial and ground photographs taken during construction can be seen in Figures 2-7 (A-D).

During the end of the project when offshore waters began to warm, turtle trawling in the borrow areas occurred in front of the dredges to mitigate inadvertent "turtle takes" while dredging the borrow area, but unfortunately two small (less than 1-foot carapace length) juvenile Kemp's ridley turtle takes occurred towards the end of the project in late March and early April. Although numerous measures were taken to avoid any detrimental impact to wildlife, incidents like these are sometimes unavoidable, especially when considering the record setting turtle nesting numbers over the last several years. Due to numerous juvenile Kemp's ridley turtle interactions within the entire southeast dredge fleet (on USACE and private projects) and due to USACE regional South Atlantic Regional Biological Opinion (SARBO) Kemp's ridley turtle take limitations, the USACE requested project construction to stop on April 12.

Figure 2-7 (A). Aerial Photograph During CRR Construction, Photo Taken Near East Taper, ~Station 40+00, Looking West (ATM Drone Photo 01/20/22).

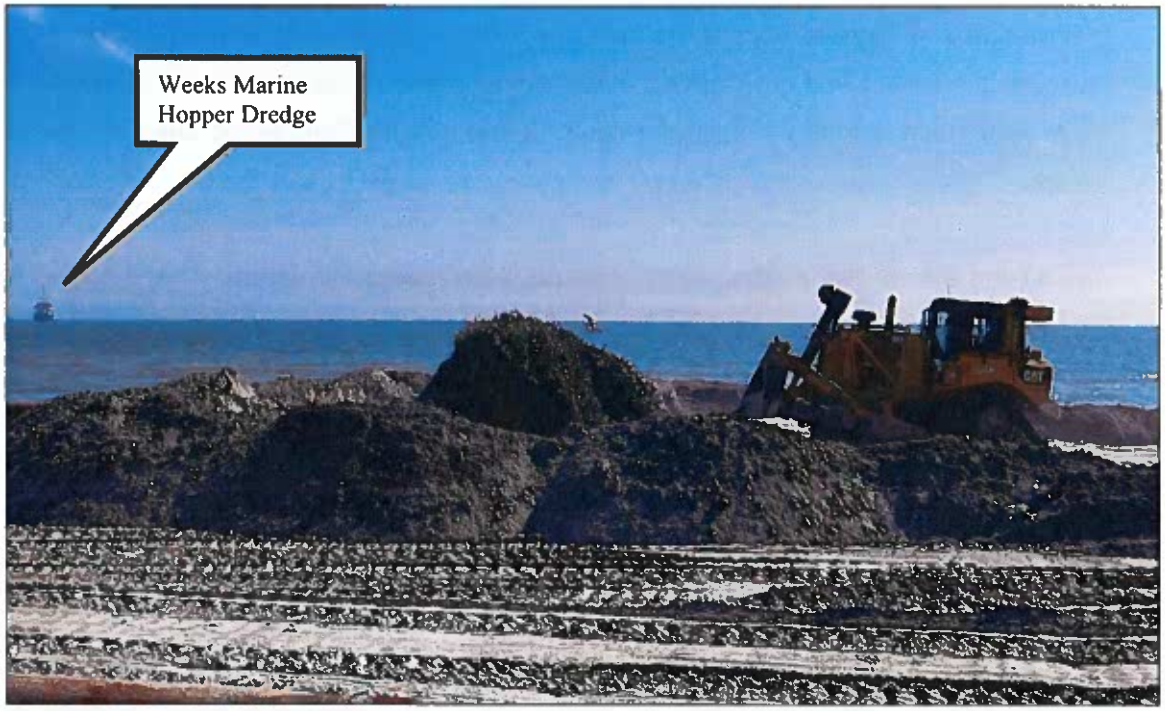

Figure 2-7 (B). CRR Construction Ground Photo (ATM photo taken 02/24/2022).

Figure 2-7 (C). CRR Construction Ground Photo (ATM photo taken 03/03/2022).

Figure 2-7 (D). Aerial Photograph Take From ~Station 180+00 Following CRR Construction During Active Planting Efforts Near Pier (ATM photo taken 04/28/2022).

2.3.1 BORROW AREAS

The two CRR project borrow areas are highlighted in red on Figure 2-8. Borrow Area 1 (BA1) for the CRR project represents the undredged eastern portions of the previously permitted borrow area for the 2017 CRP, approximately 5 miles steam distance from the

Holden Beach project site. Borrow Area 2 (BA2) was delineated in 2020 and is located between ~2 and 3 miles offshore of Holden Beach.

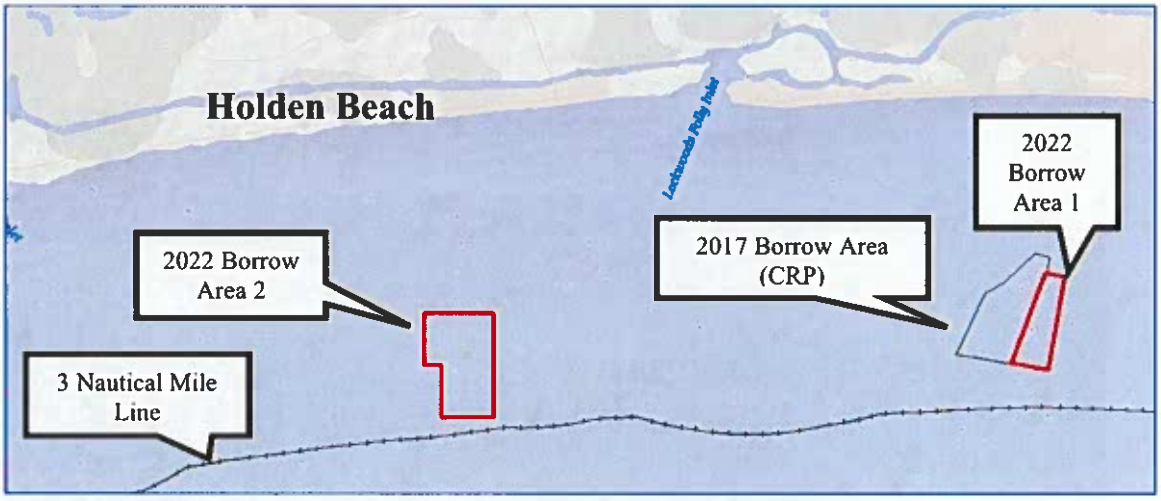

Figure 2-8. CRR Offshore Borrow Areas Outlined in Red.

Estimated potential volume yields of beach compatible sand for maximum cut depth for BA1 and BA2 were ~600,000 cubic yards (cy) and ~1.9 million cy, respectively, assuming 100% volume recovery. Of course, 100% volume recovery is not possible due to losses inherent with the hydraulic dredge process and therefore typical buffers/tolerances of ~15-25% were established to account for losses of excavated to in-place quantities.

Weeks Marine coordinated closely with ATM and Town staff to ensure beach compatible material. Two small pockets of less suitable material (larger sediment/rocks) were discovered in each borrow area. Hoppers have debris screens on board which prevent rocks from reaching the beach, however, some rocks did occur on the beach and beach raking was subsequently performed to remove the incompatible, large rock sediment material. Note that the beach raking effort collected mostly shells and subsequently, shell collectors focused on the beach raking material. Shell and shark-teeth collectors were frequent and consistent during and immediately after the project.

2.3.2 MONITORING AND CRR PERFORMANCE

Sediment monitoring of the placed sand occurred daily throughout the project and immediately following completion. The nourishment sand was found to be a very good match to the existing beach with slightly coarser sand than the native sand (but well within

tolerance standards), which is fortunate as slightly coarser sand erodes less quickly than finer material. Figure 2-9 (A-C) show photographs of the good color and consistency of the nourishment sand placed as well as the significantly widened beach conditions immediately following construction.

Turbidity monitoring was also conducted several times daily throughout the project. Measurements were taken updrift and downdrift of the beach pipe discharge location, as well as a significant distance updrift to determine background turbidity due to environmental conditions (winds, waves, currents, etc.) that is not project related. The effort revealed that background/natural turbidity rates for Holden Beach typically range between 30 and 50 NTUs (Nephelometric Turbidity Units). There were no turbidity concerns/issues during the project construction (which is not unexpected considering the good compatibility of the sand).

The Central Reach Reimbursement (CRR) was very successful and in total the project cost approximately $21.8 million, equating to less than $15 per cubic yard. This is a very favorable rate, especially when compared to similar nearby beach nourishment projects.

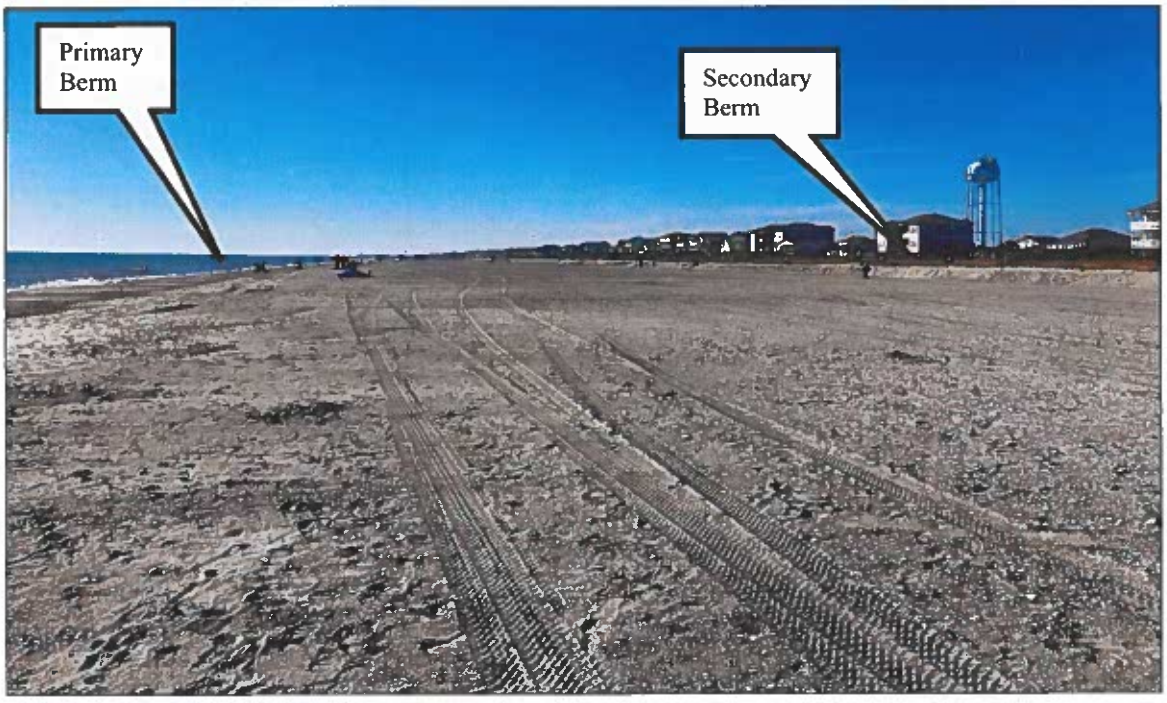

Figure 2-9 (A). CRR Post-Construction Near Station 80+00 (ATM photo taken 02/10/2022).

Figure 2-9 (B). CRR Post-Construction Aerial Photograph Taken Near Pier looking west (ATM photo taken 04/28/2022).

Figure 2-9 (C). CRR Post-Construction Aerial Photograph Taken Near Pier looking east (ATM photo taken 04/28/2022).

This project is designed to last 10 to 12 years (based on historical erosion rates and recent beach nourishment performance) and this report and future annual monitoring surveys will track the spreading and progress of the placed sand. Of course, annual hurricane activity has a major influence on nourishment performance, and it is anticipated that FEMA "engineered beach" mitigation will likely occur in the next 5-10 years.

The 2024 survey and site observations reveal the nourishment is still equilibrating. Additionally, the project held up well from Hurricane Ian impacts in September 2022. Figure 2-10 shows an example profile from the most recent annual surveys (2024 and 2023) and from April 2016, prior to the 2017 CRP nourishment, at a location just west of the pier (at Station 180+00) illustrating how the beach has changed in the last 2 years since the 2022 CRR and relative to 2016 pre-CRP conditions.

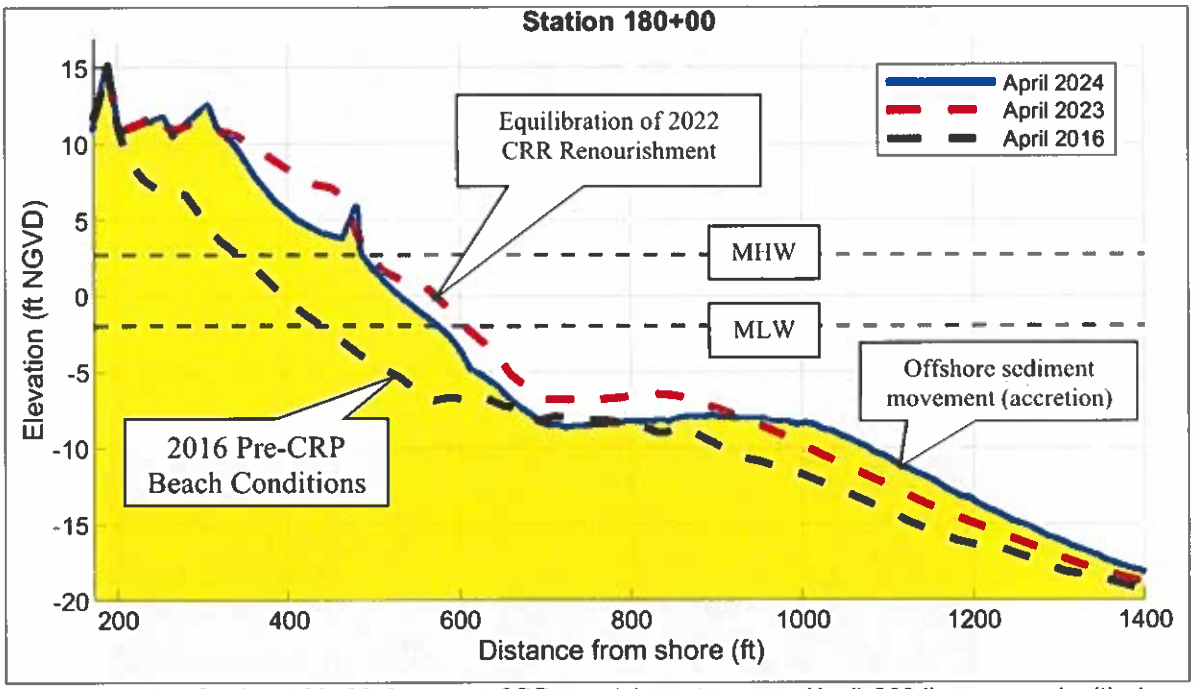

Figure 2-10. Station 180+00 2-yr post-CRR nourishment survey (April 2024) compared with 1-yr post-CRR survey (April 2023) and pre-2017 Central Reach Project (November 2016) conditions.

Recent photographs taken approximately 2.5 years following construction are presented in Figure 2-11 (A-C) and show a wide, healthy beach, dune and vegetation growth throughout the project area.

The results of the latest survey and fill volume measurements are discussed in detail in Section 3.

Figure 2-11 (A). CRR ~2.5 Year Post-Construction Photo Just East of Pier Near Station 170+00 (photo taken October 2024).

Figure 2-11 (B). CRR ~2.5 Year Post-Construction Photo of Pier Near Station 170+00 (photo taken October 2024).

Figure 2-11 (C). CRR ~2.5 Year Post-Construction Photo Near Station 60+00 (photo taken October 2024).

2.4 USACE AND TOWN LWFIX PROJECTS

The LWFIX borrow area has acted as a beneficial use of dredged material (i.e., a borrow area for beach nourishment) since the 1970s. The primary reason for the USACE LWFIX dredging project is navigation; however, the dredged material is beach compatible and Station 20+00 on the east end (typical beginning of the beach fill placement) is less than 4,000 feet away.

The USACE typically performs this project every 1 to 2 years, depending on shoaling and funding. The primary goal of this project is navigation, while a secondary and important benefit is placement of this compatible material on the beach.

The LWFIX project typically includes the AIWW itself as well as a "bend widener." The bend widener typically varies from 50 ft wide (Figure 2-12 [A]) to 400 ft wide (Figure 2-12 [B)]. The 400-ft bend widener is the largest widener allowed by USACE permit conditions. The 400-ft bend widener was rarely dredged by the USACE due to limited Federal funding prior to 2010, however, the USACE did include it for the 140,000-cy project in 2010 due to economic stimulus funding (i.e., American Reinvestment and Recovery Act).

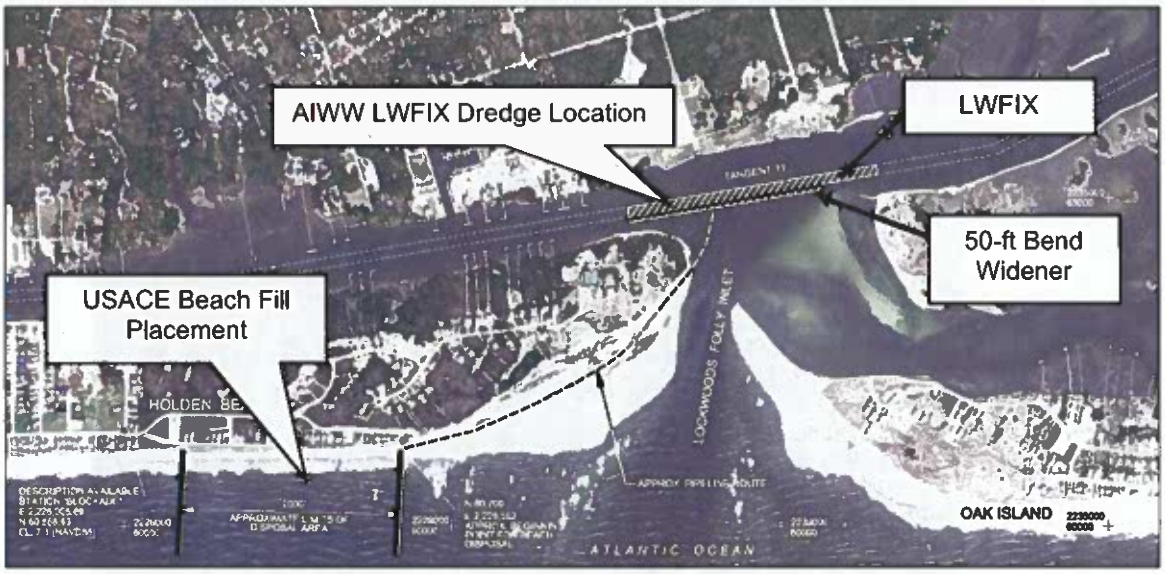

Figure 2-12 (A). USACE LWFIX Dredging and Beach Placement Schematic (source USACE request for proposal). Placement typically occurs between Holden Beach Stations 20+00 and 40+00.

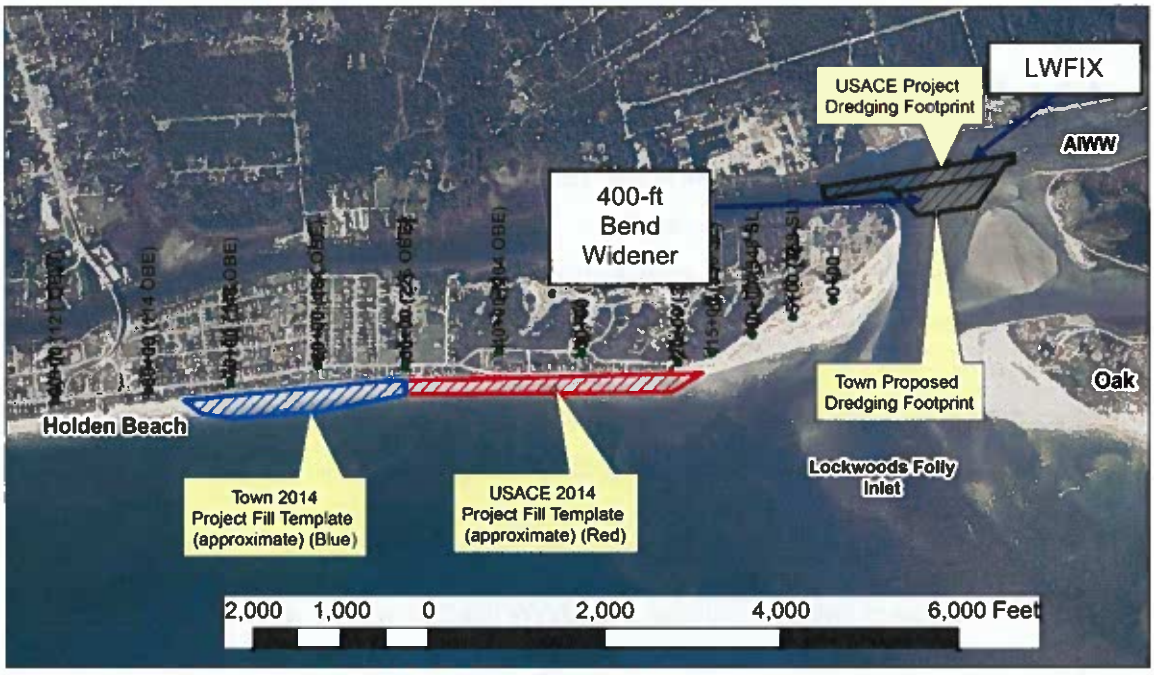

Figure 2-12 (B). USACE and Town LWFIX 2014 Project Dredging and Beach Placement which included the 400-ft bend widener.

Immediately following the successful 2010 USACE LWFIX project, the USACE continued to minimize projects due to limited federal funding despite sufficient sand volume within the bend widener dredge footprint. For example, the February 2011 and January 2012 USACE LWFIX projects provided only 32,000 cy and 25,000 cy of material placed, respectively.

The increased benefits of the bend-widener for the 2010 project in comparison to the 2011 and 2012 reduced volume projects prompted the Town and ATM to actively pursue use of the bend-widener for future projects. In correlation with this effort, the State established a shallow draft dredging fund in 2013, which was a game changer for LWFIX and outer ebb shoal channel dredging.

The Town performed an independent project that "piggybacked" the 2014 USACE LWFIX project and expanded the borrow area to include the 400-ft bend widener so more material could be placed on the beach. Since the 400-ft bend widener is within the authorized Federal navigation project footprint, the Town's separate permitting process was simplified.

The Town's piggybacking of the USACE project maximized sand placement while minimizing costs by use of the dredge already onsite for the Federal project. The Town project placed approximately 95,000 cy of beach-compatible material along approximately 2,300 ft of Holden Beach shoreline, between baseline Stations 50+00 and 73+00 (41 cy/lf average). Figure 2-13 provides an aerial photograph taken during the 2014 LWFIX project.

The Town's 2014 LWFIX project was very successful. Approximately 95,000 cy of material was placed for about $8/cy, which is a very favorable rate (this in addition to the USACE component of the project that placed ~93,000 cy). Nourishment dredging costs are typically much higher than this (depending on the borrow area and pumping distance) and can range from $10/cy to $25/cy. The North Carolina Department of Environmental Quality (NCDEQ) paid for half the project cost, and Brunswick County also contributed to the funding of the project. Additionally, Town resources (staff, equipment, oversight) expended for this project were significantly less than those expended for upland fill projects.

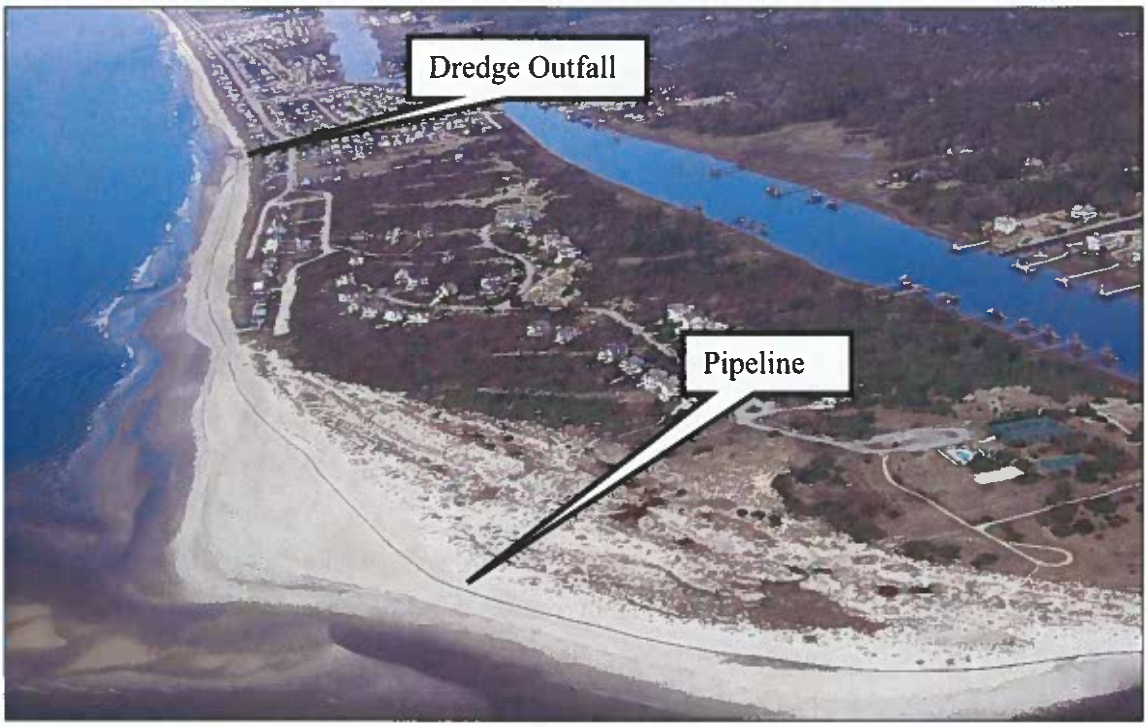

Figure 2-13. Aerial Photograph of 2014 LWFIX Nourishment [source: NC Division of Coastal Management (DCM)].

2.4.1 2017 USACE AND TOWN LWFIX PROJECT

Due to the successes of the 2010 and 2014 LWFIX projects using the 400-ft widener, the Town has been more involved in the LWFIX projects. Following a slightly different course of action than the 2014 LWFIX project, the Town and ATM staff coordinated with the USACE Navigation Branch personnel in charge of this dredging project to include the 400-ft widener under the USACE permit authorizations (not the Town's permits). The project was completed in mid-March 2017 and is also referred to as the Eastern Reach Project.

Figure 2-14 presents a plan view schematic of the 2017 LWIFX dredging and Town nourishment project. Including the 400-ft widener resulted in a total of approximately 130,000 cy that was dredged and approximately 120,000 cy placed along the Eastern Reach Project area (a small percentage of material is always lost during the dredging and construction process). To ensure maximum benefits to the central and eastern reaches of Holden Beach, the dredged material was placed immediately adjacent to the Town's CRP's eastern taper, where CRP construction began in January 2017.

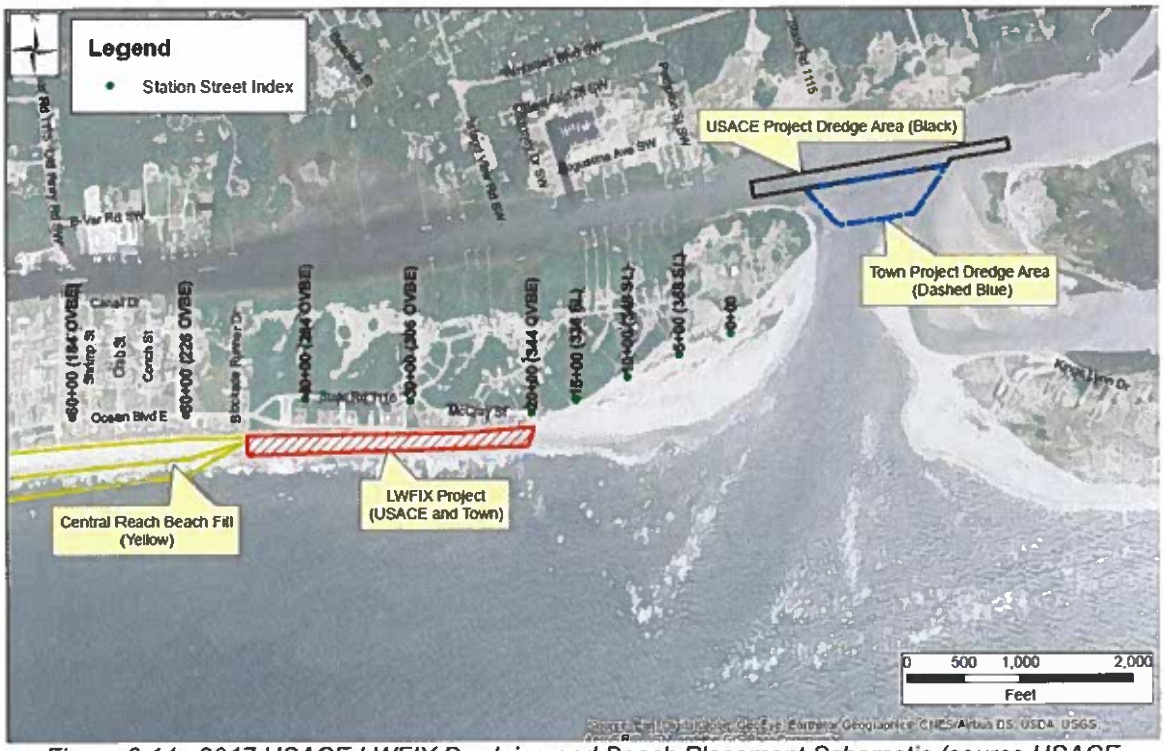

Figure 2-14. 2017 USACE LWFIX Dredging and Beach Placement Schematic (source USACE request for proposal). Placement of Approximately 120,000 cy occurred in March 2017 between Holden Beach Stations 20+00 and 45+00 to meet in with the Central Reach Project.

The Eastern Reach Project was very successful, and photographs taken during construction are presented in Figures 2-15 and 2-16. The Town's involvement allowed for the placement of an additional 60,000 cy at a very inexpensive rate. The cost for the project was $465,000, and the Town's portion was only about $76,000 (with the State providing 66.7 percent).

The timing of this nourishment coincided very well with the CRP and helped fill out much of the remaining shoreline of Holden Beach east of the larger CRP. Moreover, the Town's involvement helped maximize the restoration effort needed following the recent hurricanes and has helped mitigate more recent storm activity.

The eastern end of shoreline has historically shown the highest erosion rates on the island, and LWFIX dredging projects and piggybacking opportunities on the east end are a crucial part of the Town's proactive management strategies to mitigate this.

Figure 2-15. Holden Beach POA Photograph Taken near 323 McCray Street (approximately Station 26+00) during 2017 Eastern Reach Project construction.

Figure 2-16. Holden Beach POA Aerial Photograph taken during 2017 Eastern Reach Project Construction (pumping just west of Station 30+00).

Figure 2-17 presents an October 2024 of the east end. In general and based on site observations, the east end is continuing to benefit from this and the more recent 2022 LWFIX project (discussed in a following section). The east end does need nourishing every

2 years to avoid extreme erosional conditions that have occurred in past decades. More details on beach survey monitoring are provided in Section 3.

Figure 2-17. Recent east end photo (October 2024). The most eastern oceanfront house, Amazing Grace, is shown. Significant dune growth has occurred over the last few nourishment projects however this is still a vulnerable area.

2.4.2 2019 USACE LWFIX PROJECT

The USACE's 2019 LWFIX project occurred in spring 2019 and, unfortunately, the USACE chose to place this material onto Oak Island. Figure 2-18 presents an overview of the project. The project placed about 120,000 cy of material from the LWFIX with only a small 25-ft bend widener. The bend-widener was not a realistic option for this project as the winter/spring dredging window did not allow for additional dredging.

The LWFIX project is combined by the USACE with several other NC shallow draft inlet dredging projects to obtain more competitive pricing. The base-bid projects get priority and delays due to weather (e.g., Hurricanes Florence and Michael) and dredger scheduling/mechanical issues can also limit additional work like bend-widener dredging.

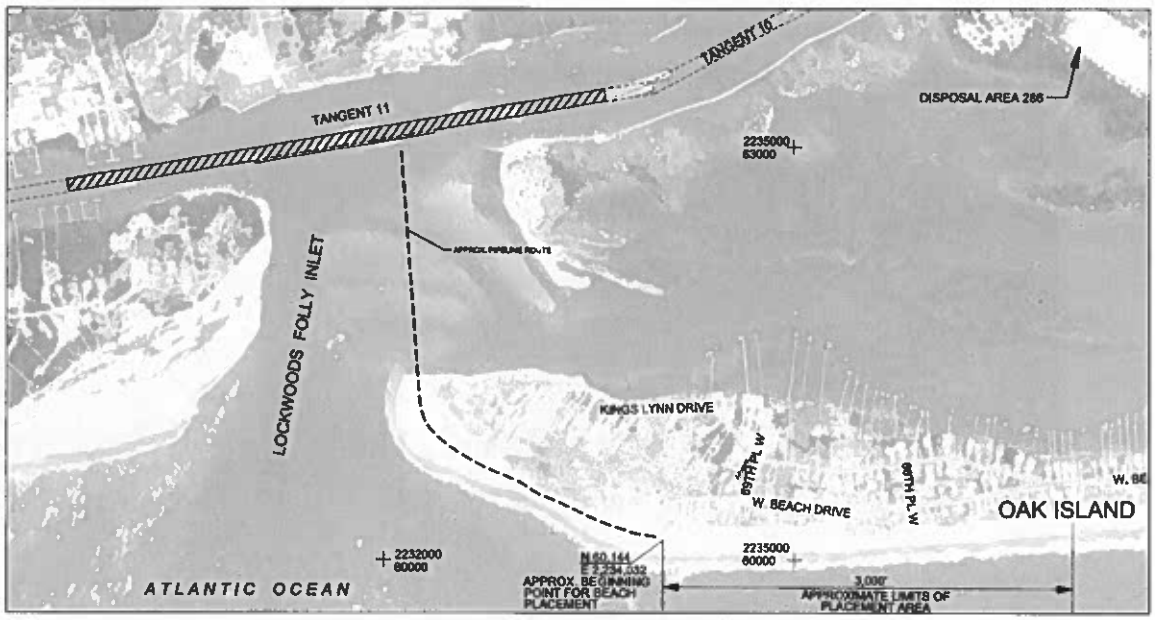

Figure 2-18. Planned 2019 LWFIX Placement on Oak Island. Actual Final Placement Area Approximately 2,500 ft. Refer to Section 3.5 for more information on 2019 LWFIX and Oak Island west end volume changes.

Town and ATM staff have met with USACE and Oak Island staff on several occasions over the past five years regarding placement options. For the 2019 project, the USACE maintained that an easement issue from another USACE project had led them to re-evaluate *all* easements for *all* Wilmington District projects.

According to the USACE, Oak Island fill placement only required easements from the Town of Oak Island (i.e., not from individual homeowners). For the east end of Holden Beach, the USACE identified more than 50 homeowner easements needed, with many of these on active beach (not buildable lots, see Figure 2-19). Updated easements were obtained in 2019 and placement on the east end can now again occur.

Figure 2-19. In 2018, the USACE Required Easements for numerous lots before East End LWFIX Placement Can Resume. Easements were obtained in 2019.

2.4.3 2020 LWFIX PROJECT

The 2020 LWFIX dredging project was completed in early spring of 2020 with placement on the east end of Holden Beach (see Figure 2-20). Goodloe Marine was awarded the USACE contract. Approximately 60,000 cy of dredge material was estimated in the inlet crossing for the base-bid, and ~110,000 cy of material to be dredged was estimated within the 400 ft bend widener.

Figure 2-20. 2020 LWFIX Placement on Holden Beach. 400-ft Bend Widener Included as Bid Option Item (Alt) But Was Only Lightly Dredged During Actual Project.

The bid included the 400 ft bend widener as an optional bid item, however, as mentioned previously the base-bid items get priority and dredger scheduling/mechanical issues or other delays can limit additional work like bend-widener dredging. Some dredging of the bend

widener did occur as part of the 2020 LWFIX Project, but not near the full amount of the alternative bid. Dredge material was placed along ~3,000 linear feet of shoreline on Holden Beach's east end with placements ranging between ~20 to 40 cy/ft. It was estimated the project added approximately 80,000 cy of in-place material to the beach from east of Station 20+00 to past Station 40+00 (based on the April 2020 annual beach survey).

2.4.4 2021 LWFIX PROJECT

Similar to the 2019 LWIFX project, dredging placement for the 2021 LWFIX project was on Oak Island's west end. The project estimated 165,000 cy be dredged from the LWFIX and a 200-ft bend widener (note that volume placed on the beach will be ~20-30% less than volume dredged) (see Figure 2-21).

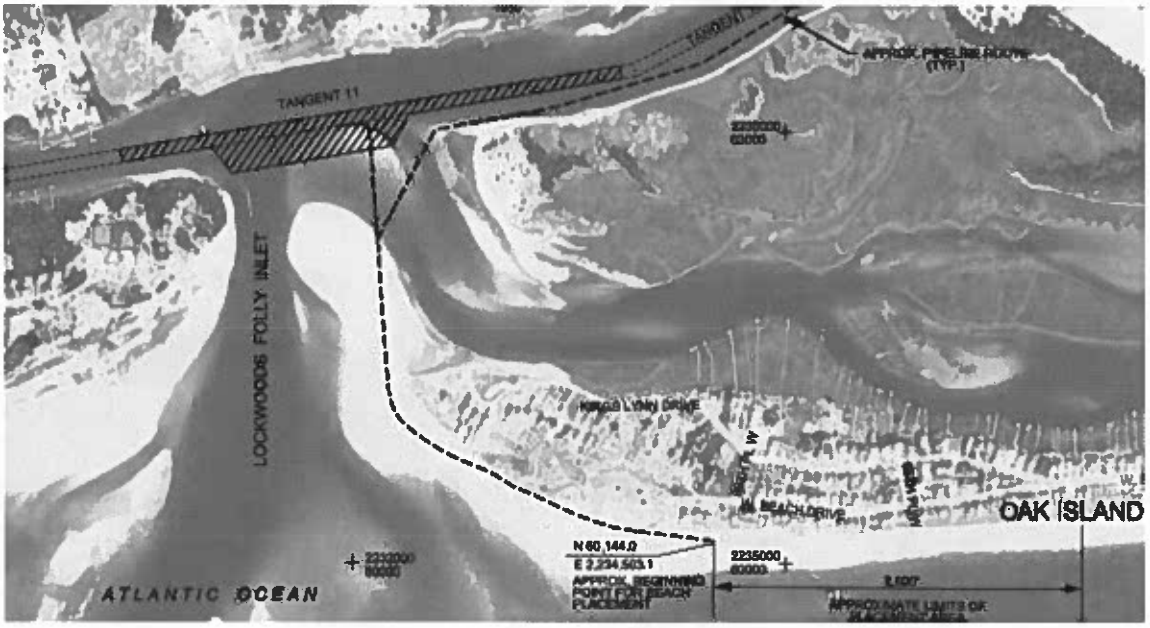

Figure 2-21. LWFIX 2020/2021 bid plans (November 3, 2020 plans).

2.4.5 2022 LWFIX PROJECT

Similar to the 2017 USACE and Town LWFIX Project and the 2017 CRP, the 2022 USACE LWFIX project occurred in conjunction with the Town's 2022 Central Reach Reimbursement Project in winter/spring 2022. The 2022 LWFIX project was completed in the early spring of 2022 with placement along ~2,000 linear feet of shoreline on the east end of Holden Beach (see Figure 2-22). The Town and ATM staff coordinated with USACE-Navigation personnel in order to maximize volume placed on Holden Beach. It was estimated the project added

approximately 115,000 cy of in-place material to the beach from east of Station 20+00 to past Station 40+00 (based on the April 2022 annual beach survey).

Figure 2-22. LWFIX 2021/2022 bid plans and actual placement tying in with the CRR project highlighted. (July 2021 plans).

To avoid overlapping with the CRR, the dredged material was placed from ~Station 20+00 to Station 40+00 with fill placements of ~50 cubic yards per linear foot, which closely matched with the CRR nourishment fill volumes at the east taper where the two projects adjoin, near Station 40+00.

Immediate post-construction photos are shown on Figures 2-23 (A-C), showing the wide dry beach as a result of the recent project. The 2022 USACE LWFIX was very successful and the timing of this nourishment coincided well with the Central Reach Project and to help "fill out" much of the remaining shoreline of Holden Beach east of the larger CRR.

Moreover, the Town's involvement helped maximize the restoration effort needed following the recent hurricanes and will help mitigate against future issues as the eastern end of shoreline has historically shown the highest erosion rates on the island. More detail on east end conditions, volume changes, and recent accretional/erosional trends are provided in Section 3.

Figure 2-23 (A). April 2022 upland photograph taken near Station 40+00 showing healthy dune vegetation and wide beach following 2022 LWFIX construction.

Figure 2-23 (B). April 2022 photograph near Station 40+00 looking east. Note newly constructed secondary berm along east taper of CRR which ties in with the 2022 LWFIX project at this location.

Figure 2-23 (C). April 2022 photograph taken between Station 20+00 and Station 30+00 looking west showing newly constructed 2022 LWFIX beach fill.

2.4.6 2023 LWFIX PROJECT

The 2023 LWFIX project was on Oak Island's west end (spring 2023). The project is estimated to have placed approximately 90,000 cy on the Oak Island west end based on information provided on the Town of Oak Island's website.

2.4.7 2024 LWFIX PROJECT

The most recent 2024 LWIFX project placed sand on the Holden Beach east end. The project included the full 400-ft bend widener for a total of 112,000 cy of material dredged (note that volume placed on the beach was ~20-30% less than volume dredged).

2.4.8 2025 LWFIX PROJECT

The 2025 LWIFX project will place sand on the Oak Island west end. The project will include the full 400-ft bend widener as an optional bid for a total of 65,000 cy of material estimated to be dredged (note that volume placed on the beach will be ~20-30% less than volume dredged) (see Figure 2-24).

Figure 2-24. LWFIX 2025 bid plans (July 2024 plans).

2.5 SHALLOW DRAFT INLET PROGRAM

The NC shallow draft inlet dredging program includes two primary elements: 1) inlet and AIWW reaches landward of the Coast Guard COLREGs (collision regulation) line and 2) outer inlet dredging where small dredges must also be "ocean-certified" by the Coast Guard for potentially rough/dangerous inlet conditions (seaward of the COLREGs line). The USACE side-caster the *Merritt* and the two USACE shallow draft hopper dredges, the *Murden* and the *Currituck* (Figure 2-25) and the *Miss Katie* are the only vessels that can realistically work the shallow draft inlets seaward of the COLREGs line. More discussion on the *Miss Katie* is provided on the next page while the emergency LWF outer shoal dredging in May/June 2023 with the *Miss Katie* is provided in Section 2.6.1.

Figure 2-25. USACE Shallow Draft Split-Hull Hopper Dredge the Currituck Rarely Dredges the LWF Inlet

About 12 years ago, the historical lack of USACE funding for North Carolina shallow draft inlet maintenance led the State, in conjunction with local county and municipal governments, to accomplish the following:

1. Obtain a memorandum of agreement (MOA) with the USACE to fund shallow draft inlet dredging,
2. Obtain permits to maintain the navigability of the State's shallow draft inlets independently of the USACE, and
3. Establish the Shallow Draft Navigation Channel and Lake Dredging Fund; (which has recently been renamed the Shallow Draft Navigation Channel and Aquatic Weed Fund - effective July 1, 2016). Funds can be used for the MOA or independently of Federally sponsored projects.

More information on all these initiatives is provided in the following sections.

One significant item to result from the shallow draft inlet funding program was the construction of another shallow draft hopper dredge. Dare County and the State built a shallow draft hopper dredge, the *Miss Katie*, that primarily serves the Outer Banks (focusing on Oregon and Hatteras Inlets). However the Miss Katie did perform emergency LWF dredging (see Section 2.6.1) and at a minimum, this dredge will ease demand for other USACE shallow draft dredging projects (i.e., LWF Inlet). Shallotte Inlet is not considered a shallow draft inlet due to the large inlet borrow area dredging for the Ocean Isle USACE nourishment program.

2.5.1 STATE AND USACE SHALLOW DRAFT MOA

In November 2013, North Carolina signed an MOA that allows the State and local stakeholders to contribute funds to the USACE for shallow draft inlet maintenance dredging. The North Carolina General Assembly established the Shallow Draft Navigation Channel and Aquatic Weed Fund to provide State funding, which will be endowed by both an increase in boat registration fees and an excise on motor fuel, to the North Carolina Wildlife Resources Commission's boating account. While the limit to the USACE under the MOA is $12 million per year, additional funding is available for shallow draft dredging projects independent of the MOA.

The USACE and NCDEQ have quarterly meetings regarding the implementation of the long-term MOA. Town staff have attended these meetings previously and Town and/or ATM staff will keep abreast of these meetings on a regular basis.

The USACE typically dredges the LWFIX and AIWW every 1 to 2 years, whereas the USACE typically sidecast dredges the outer LWF Inlet once per quarter if adequate funding is available. Each sidecast dredge maintenance event costed between $225,000 and $250,000 back in 2013, including the associated pre-dredging and post-dredging surveys (USACE navigation communication, 2013) and costs have increased since. In recent years, the USACE has reduced the dredging frequency to once every 6 months or even longer. Additional effort can be required if the intervals between dredging events are longer (which occurred this year at LWF Inlet where conditions were too shallow for even the Corps shallow draft dredges).

2.5.2 STATE SHALLOW DRAFT INLET PERMITTING

The State took the lead in the shallow draft inlet permitting following the 2013 Shallow Draft Inlet (SDI) report. This effort was predicated on two major factors: 1) there was only one sidecast dredge that remained in the Federal government fleet, the refurbished *Merritt*, and 2) Federal funding had been limited/absent and this trend was likely to continue.

Following the reconnaissance study, the State gathered the necessary materials (geotechnical data, biological reports, survey data, etc.) to apply for permits for locally held authorizations. These authorizations allow the Town an additional option for maintaining (at current USACE templates) the LWFIX crossing, the inlet throat, and the outer channel beyond the COLREGs line (refer to Section 2.5.4 for more on this topic).

The permits for this effort were issued in May 2016 and have been extended since. The permits are now good until December 31, 2026 and were used for the *Miss Katie* LWF emergency dredging. The authorizations include all currently approved dredge material management locations, including shoreline beneficial placement, nearshore placement and/or upland confined disposal placement. Note that there are some additional monitoring requirements when compared to the USACE authorizations (which were originally developed decades ago).

2.5.3 STATE DREDGING FUND

Independent of the MOA, dredging funds can be obtained directly from the State via the Water Resources Development Grant process. The Town first used this mechanism for the 2014 LWFIX project. In 2014, the State cost-sharing was 50 percent while it is now 66.7 percent for non-tier-one counties. The dredging fund has expanded in scope since its inception and funding has also increased. More than 12 Federally authorized inlets and associated channels are included, and some non-Federal channels are also included (mostly related to State ferry routes). Of course, there is also a lake/freshwater component of the fund (as identified in the fund's name). The fund has shown robust growth and availability since its inception.

2.5.4 LOCKWOOD FOLLY INLET PROJECTS

As previously discussed, LWFIX projects are eligible for State dredging funding while other elements of LWF Inlet maintenance are also eligible. LWF Inlet is a Federally authorized shallow draft inlet. Due to different and separate historical USACE funding sources, two basic routine maintenance activities historically occur at LWF Inlet:

1. Outer bar sidecast dredging, and
2. LWFIX cutter-head dredging and beach fill placement.

Figure 2-26 (A) provides a representation of these two regions. The LWFIX projects are described in detail in Section 2.4. This section focuses on the outer shoal, seaward of the COLREGs line.

The SDI permit authorizations allow the Town (with State, County and potentially Oak Island funding assistance) to dredge/maintain LWF Inlet both landward and seaward of the COLREGs line. The COLREGs line is the Coast Guard collision regulation demarcation that only allows "ocean-certified" dredges seaward of this delineation.

Ocean-certified dredges are typically larger dredges that are much more expensive to mobilize/demobilize (typically between $3 to $5 million per event). The LWFIX dredge projects are predominantly awarded to smaller dredge companies with dredges that are not ocean certified (e.g., Southwinds, Cottrell, Goodloe) since this area is landward of the COLREGs line.

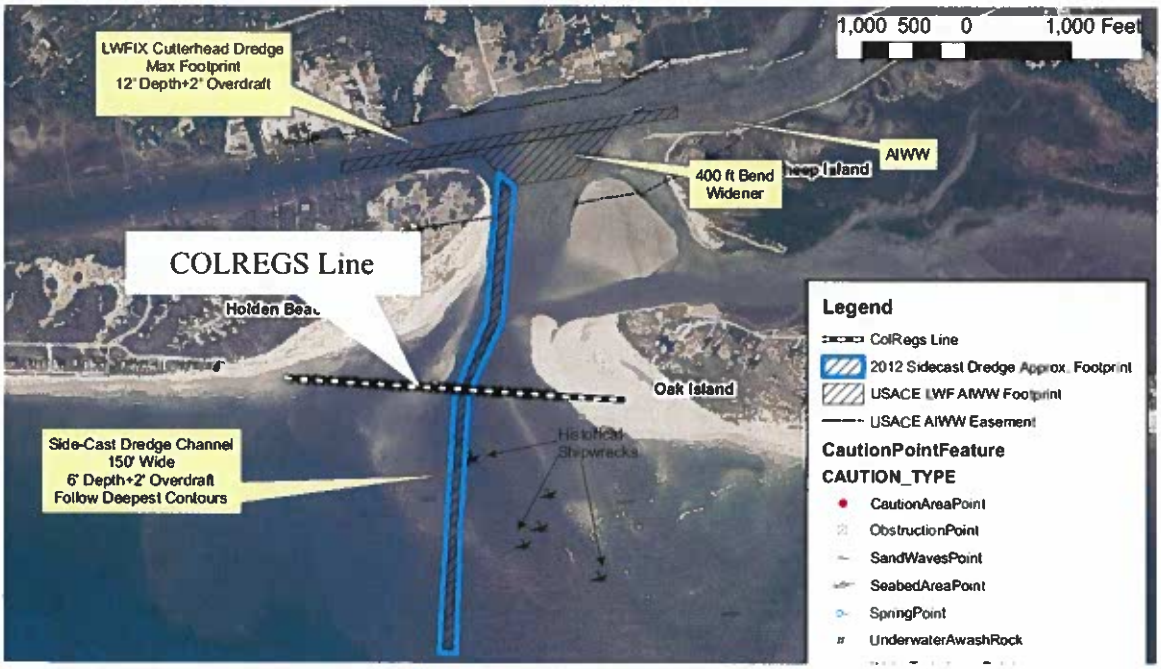

Figure 2-26 (A). LWF Inlet USACE Dredging Projects Include the Outer Channel (sidecaster dredged) and the LWFIX (cutterhead dredged)

Figure 2-26 (B) presents an example USACE LWF Inlet survey identifying several major features involved in sediment transport, including the flood shoal, ebb shoal, and inlet throat. The inlet throat is consistently deep [18-20 feet below mean lower low water (MLLW)] on USACE surveys. The ebb and flood shoals are consistently shallow and typically require dredging for safe navigation. The ebb shoal typically consists of several shallow sandbars that slowly migrate across the inlet from the Oak Island side to the Holden Beach side.

2.6 LWF OUTER EBB SHOAL DREDGING

Outer ebb shoal (see Figure 2-26 [B]) dredging is typically performed by the *Merritt*, which is the USACE's only remaining side-caster; however, the *Murden* and *Currituck* are also used. The *Murden* was used exclusively when the *Merritt* was in extended drydock in 2017/2018. All three shallow-draft dredges (*Merritt*, *Murden*, and *Currituck*) typically spend 1 to 2 months in drydock per year, with some extended drydock maintenance occurring every 5 to 20 years.

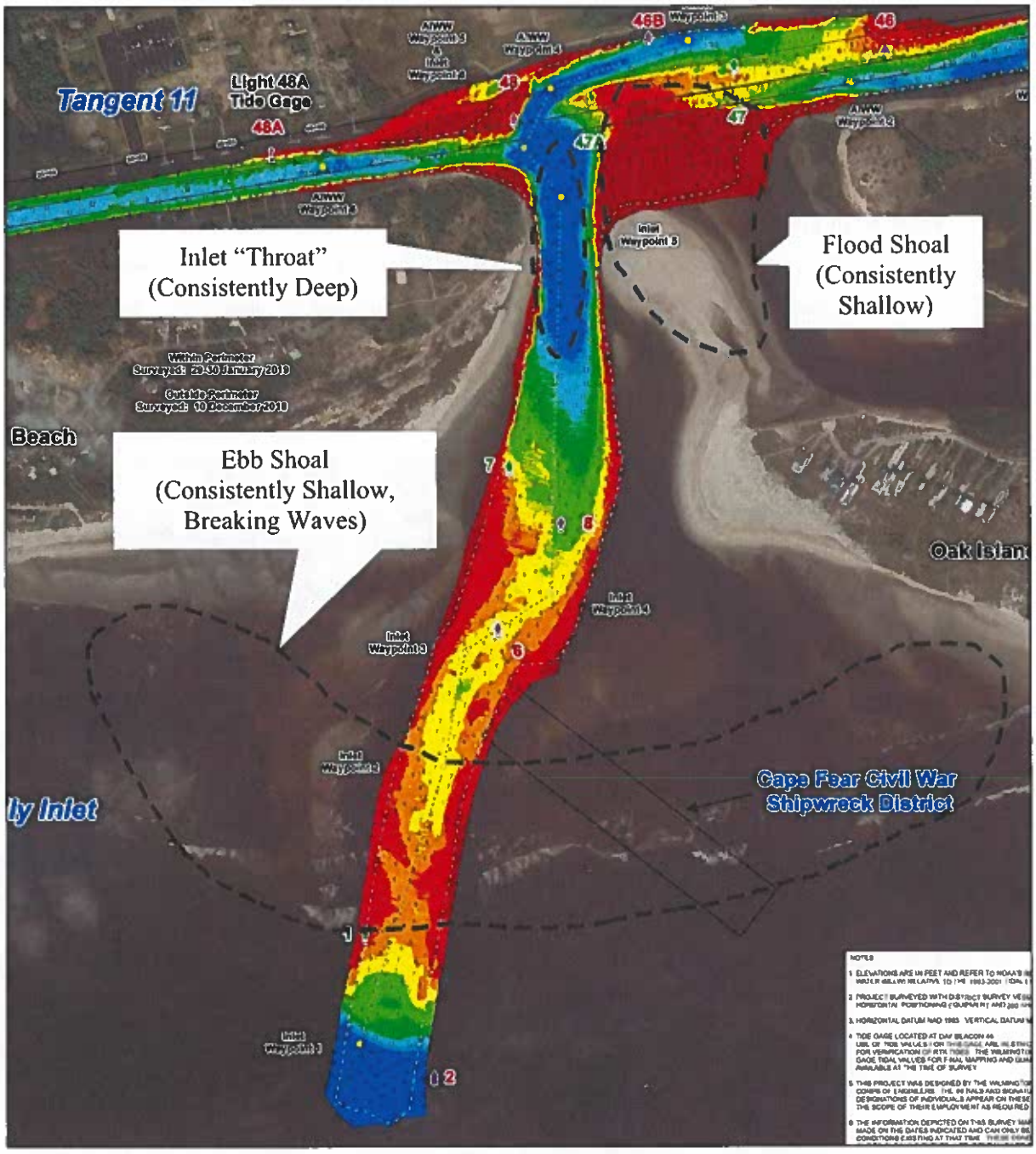

Figure 2-26 (B). Inlet Throat, Flood Shoal and Ebb Shoal at LWF Inlet

(Image Source: USACE Wilmington Navigation Branch)

While the *Merritt* merely sidecasts material about 100 feet to the side, the *Murden* places material nearshore in approximately 8 to 15 feet of water between 500 and 1,000 feet from shore. The nearshore placement generally occurs between Ferry Road (approximately

Station 60+00) and the Holden Beach bridge (approximately Station 90+00). The USACE generally refers to this area as the authorized placement location as determined by its analysis/review decades ago.

Figure 2-26 (C) presents a figure of the 2017 LWF outer bar dredging and nearshore placement in comparison to the 2015 nearshore placement. Placement locations for each load (~300 cy) are shown for the 2015 and 2017 efforts. The 2019 *Murden* dredging also placed material in the same location, however, it did not provide drop-point locations for each load. In 2023, the Town and ATM worked with the Miss Katie to perform a similar project (see Section 2.6.1).

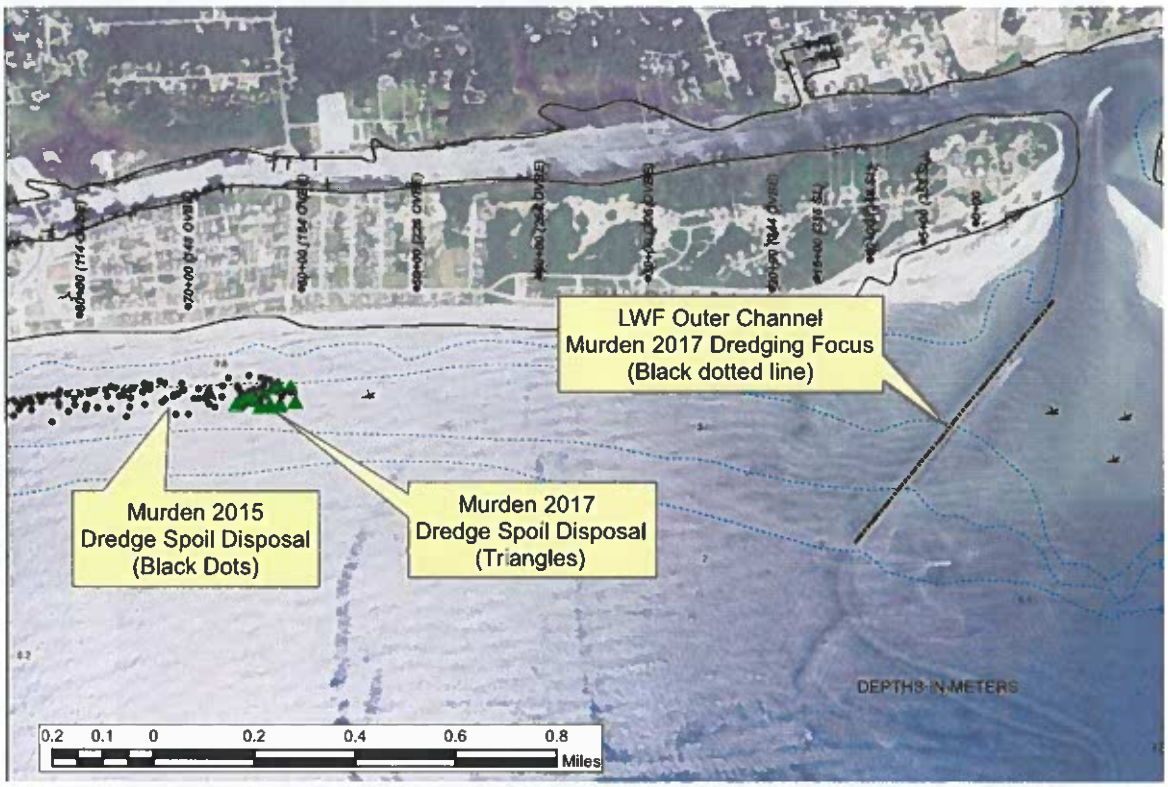

Figure 2-26 (C). LWF Outer Channel USACE Dredging Projects by the Murden in 2015 and 2017. The 2019 Murden project also placed material in this general area however did not provide drop-point locations for each load. The 2023 Miss Katie project was also similar in scope.

The nearshore placement results in mounds generally 2 to 3 feet high. For older projects, subsequent surveys found the mounds to have dispersed; however, their onshore movement could not be detected as these are relatively small amounts of material that quickly assimilate into the littoral system. Nonetheless, ATM believes this nearshore

placement is the best disposal option for the *Murden*, *Currituck* or *Miss Katie* and is favored over side-caster dredging.

2.6.1 2023 MISS KATIE PROJECT

The most recent LWF inlet outer bar dredging and nearshore placement occurred the summer of 2023 (between May and June). At the time of this required dredging, the shoaling had gotten so bad that the USACE said even their shallow draft dredges could not work the inlet. Fortunately, a new opportunity came about through engaging the private dredge "Miss Katie". Miss Katie is commissioned by the Oregon Inlet Task Force but due to permitting/ scheduling issues with Oregon Inlet dredging, the Miss Katie was available at an opportune time to assist dredging LWF just before peak tourist and boating season. A project overview and pre- and post-dredging inlet survey conditions are presented on Figure 2-27.

Emergency permitting of the project was necessary as this project was to occur in May and June (out of the normal environmental window). While existing SDI permits were used for this project, significant permitting coordination was required due to the timing of the project as well as the first-time use of Miss Katie at LWF Inlet. Once permitting was in place, the Miss Katie could only work at high tides at the beginning of the project. The Miss Katie is a split-hull shallow draft vessel but can also side-cast dredge material if necessary. Only a minor amount of side-casting occurred while most of the material was dropped in the designated nearshore area (~60,000 cy total), similar to the 2015, 2017 and 2019 Murden projects. Both the agencies and contractor preferred hopper dredging over side casting, which is also a win-win for Holden Beach as this resulted in more nearshore placement to benefit the beach. The same nearshore disposal area between ~Station 60+00 and Station 90+00 as was used in the past Murden projects was used; however, a relatively larger volume placed.

While the Miss Katie is prioritized for Outer Banks dredging projects, there is potential for Holden Beach to employ its dredging services in the future.

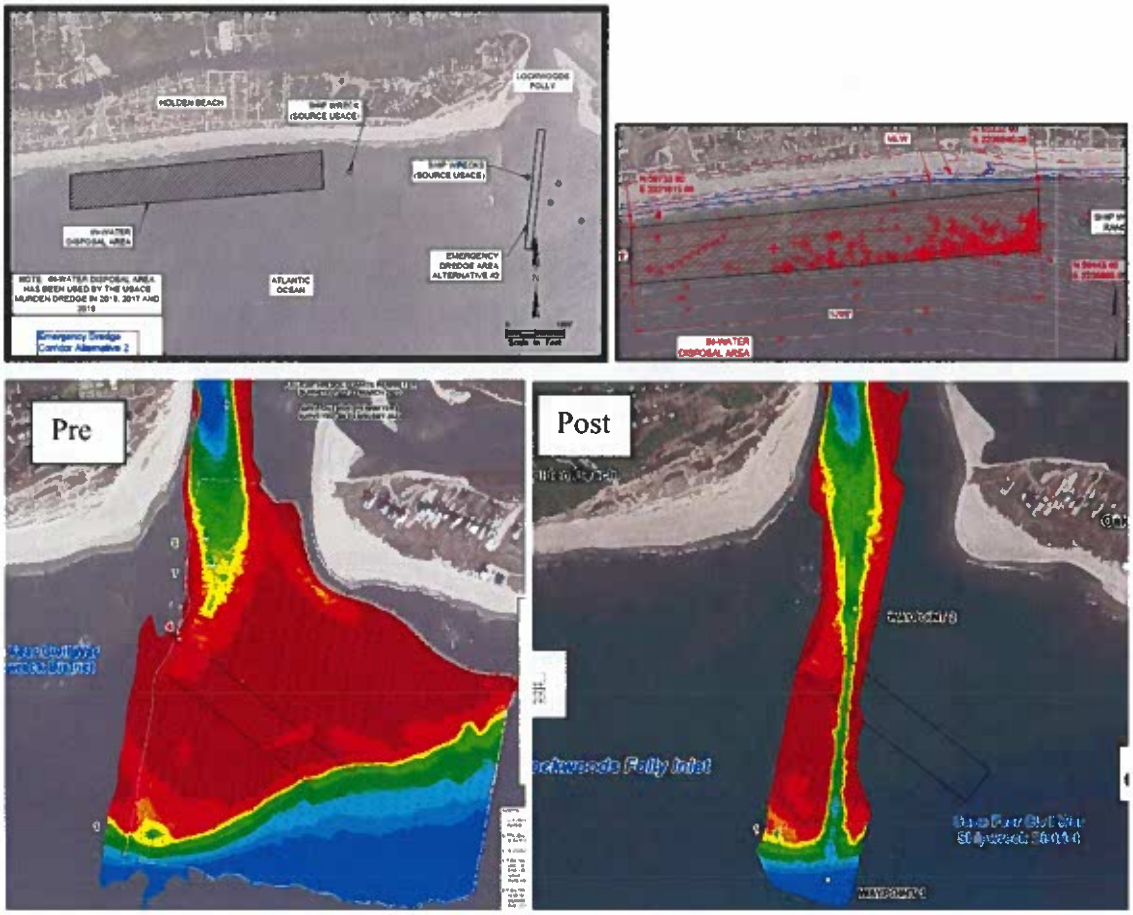

Figure 2-27. LWF Outer Channel 2023 Dredging Project by the Miss Katie dredge. Upper left panel shows project overview and upper right panel shows drop-point locations for each load for the beneficial nearshore disposal. Lower panels show pre-and post-outer channel dredging conditions. Note significant inlet choking just prior to peak tourist season in the lower left hand panel.

2.6.2 COUNTY LWF OUTER SHOAL DREDGING PROJECT

In 2019, Brunswick County rescinded its proposal to dredge a deeper and wider outer LWF ebb channel and to place this material either on Holden Beach or Oak Island. The outer ebb channel is currently authorized to 150 feet wide and 8 feet deep. The County was proposing to deepen the channel to 12 to 14 feet deep and widen it by 50 to 150 feet. The County estimated that at least 250,000 cy would be available for beach nourishment.

ATM was never enthusiastic about this project. In general, utilizing large ebb shoal borrow areas is typically discouraged because it can interrupt the natural sediment bypassing process by creating a "sediment trap." Shallotte Inlet ebb shoal dredging has been cited as acting as an "effective sediment trap" (USACE OCTI report, 2008). Modeling and analysis

also indicated that a deeper/wider channel could detrimentally affect estuarine shorelines and habitat (and significantly more long-term monitoring/analysis would be required). The project qualified for State shallow-draft inlet funding due to its dredging-for-navigation component. Without this State funding, this project would likely not be cost-effective.

2.7 DUNE ENHANCEMENT

In addition to placement of sand, the Town has been proactively enhancing dune habitat on an annual basis. The dune-building program includes the following:

- Vegetation planting (sea oats, American beach grass, bitter panicum, etc.)
- Fertilization
- Sand fence maintenance and expansion
- Dune walkover maintenance

The continued diligence and effort of Holden Beach has resulted in a stable and healthy dune system along a majority of the island, although hurricanes and high-water events still damage the dune system. Dune vegetation planting and sand fencing was a planned component of the 2017 CRP and has stabilized and largely restored the dune system along Holden Beach since Hurricane Matthew. Older dune fencing has gradually been buried as a result of dune growth (see Figure 2-28). Post-project monitoring photographs of the starter dunes and plantings are provided in Figures 2-28 (A) - (D). The observed dune growth over recent years suffered some substantial damage as a result of Hurricane Isaias in August of 2020 and Hurricane Ian in September 2022. Similar to the 2017 CRP, vegetation planting occurred following the 2022 CRR fill placement. An approximate 50 ft wide planting area was conducted for the length of the project template and planting occurred primarily along the newly constructed secondary berm extending seaward from the existing sand fencing (see Figure 2-29). Photos as of September 2023 of the area reveal healthy growth of the new and previous plantings (see Figure 2-30) while Figure 2-31 shows an October 2024 photo.

Some areas of shoreline on the west end experienced dune erosion and vegetation loss in recent years and could benefit from proactive dune enhancement efforts. A large dune system is present along the west end, so planting of more mature vegetation could help to promote growth of a thick maritime forest and increase accretion steadily over the years to come. Recent studies have shown maritime forest vegetation (wax myrtles, holly, shrubs,

etc.) build up the ground, creating "green barriers" as formidable defense against future erosion from rising seas and storm surge. In addition to plantings, the Town of Holden Beach has also received several state grants in recent years for dune improvements (fencing, etc.).

Dune-building vegetation also benefits from fertilization efforts. Analysis of soil salinity levels by local student researchers have revealed high salinity contents that may contribute to poor dune vegetation health. It is recommended to supplement areas of high salinity with organic matter through fertilization and compost placement.

Figure 2-28 (A). Sand Fencing along the Seaward Edge of the Starter Dune for the Central Reach Project at Station ~60+00 Showing Planted Dune Vegetation. (ATM photo, taken August 2018).

Figure 2-28 (B). Sand Fencing for the Central Reach Project at Station 60+00 showing dune vegetation and sand growth about 2-years post project. (ATM photo, taken September 2019).

Figure 2-28 (C). Sand Fencing for the Central Reach Project at Station 60+00 showing dune vegetation and continued sand growth about 3.5-years post project. (ATM photo, taken May 2020).

Figure 2-28 (D). November 2021 Station 60+00 after Hurricane Isaias which created some dune losses

Figure 2-29. November 2022 near Station 80+00 showing new plantings following CRR along newly constructed secondary berm (and after Hurricane Ian).

Figure 2-30. September 2023 between Station 60+00 and Station 70+00 showing plant growth ~1.5-year post CRR along newly constructed secondary berm (and after Hurricane Ian).

Figure 2-31 October 2024 between Station 60+00 and Station 70+00 showing plant growth ~2.5-year post CRR along newly constructed secondary berm (and after Hurricane Ian in 2022).

2.8 STORM ACTIVITY

This section focuses on the 2023 storm season as this falls within pre/post survey events for this report. Figure 2-32 presents a summary of 2023 Atlantic Hurricane tracks. Starting in early June, the 2023 hurricane season had 20 named storms, with 3 storms reaching major hurricane status (i.e., a Category 3 hurricane or greater and noted as "MH" in Figure 2-31). There were 6 more named storms than in the 2022 season. Overall, the 2023 season was relatively mild compared to previous seasons.

In general, however, even when a hurricane does not pass directly nearby, the combination of storm surge and large swells can still create erosional conditions that directly impact the Holden Beach dune system. In addition to tropical systems, periods of sustained southeast winds and winter Nor-easters can also create highly erosive conditions. Hurricane Idalia (number 10 in Figure 2-32) affected Holden Beach in late August 2023 as it passed by the coast of North Carolina, bringing high winds and coastal flooding to Brunswick County (although FEMA mitigation was not required).

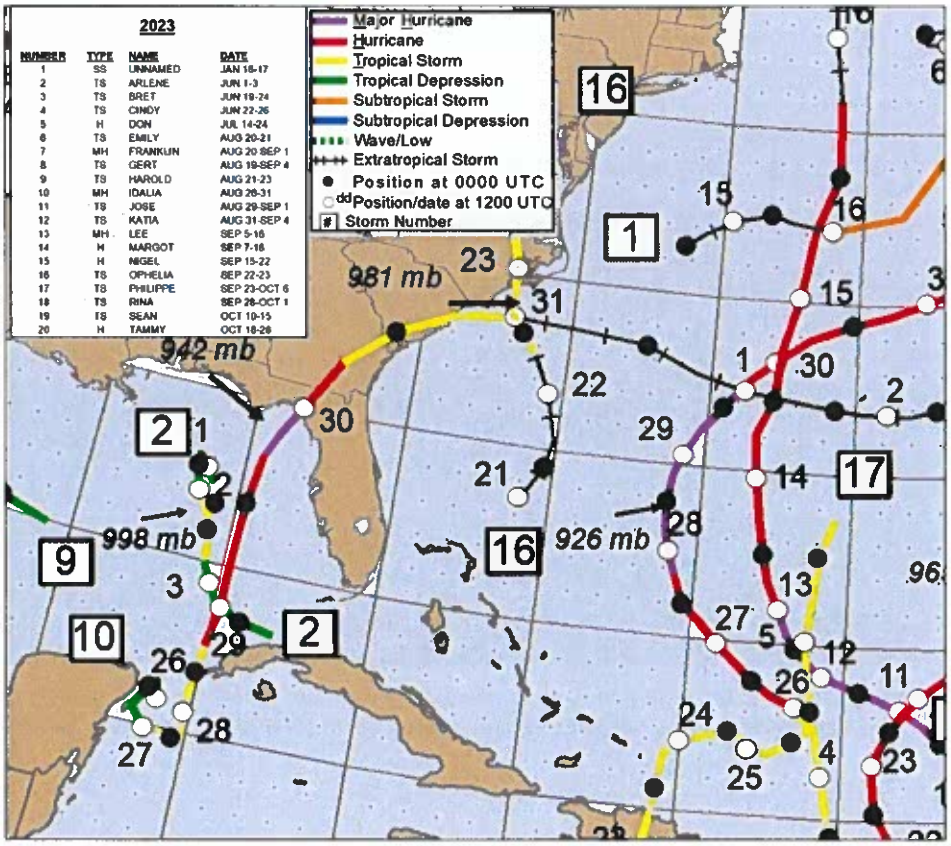

Figure 2-32. 2023 Atlantic Hurricane Summary Overview.

2.9 USACE FEDERAL CSRM POTENTIAL PROJECTS

The USACE coastal storm risk management (CRSM) project was re-initiated several years ago and recently presented its findings to the Town. This is a 50-year project similar to the USACE CSRM (previously referred to as coastal storm damage reduction) projects up and down the coast (e.g., Ocean Isle, Wrightsville Beach, Carolina Beach, etc.). The Corps 50-year project from 15-20 years ago included Holden Beach, Caswell Beach and Oak Island however the current Corps study is only for Holden Beach while Oak Island is about a year behind in their specific project evaluation. Town and ATM staff have coordinated with Corps staff for the last few years to ensure that the Corps are working with the most recent and up-to-date data on the beach and borrow areas.

The Corps 2024 evaluation (including a benefits/costs analysis) for the oceanfront shoreline determined that the Holden Beach oceanfront does not qualify for a 50-yr project. A key takeaway from the Corps October 4, 2024 meeting with Town and ATM staff was that "*the economic analysis has not identified a cost-sharable project on the beach side of the island (based on USACE policy). This includes beach nourishment, a terminal groin, and/or groin fields.*" While details of the analysis have not yet been provided, it is likely that the groin and terminal groin alternatives outperformed the nourishment-only alternative as well-designed and strategically placed groins can minimize erosion. The Corps 2024 benefits/costs analysis for the estuarine shoreline also determined that the Holden Beach estuarine shoreline does not qualify for Corps management and funding.

The major takeaway for the oceanfront shoreline Corps study and their October 4, 2024 presentation is that the Holden Beach shoreline is too healthy and robust to qualify for the Corps project. This is a credit to the Town and their ongoing beach management program which is largely funded by FEMA mitigation. Therefore while the Corps federal funding is not available to the Town, FEMA federal funding will continue to provide essential nourishment funding to the Town (assuming no future major changes to the program).

One major hurdle with the Corps 50-yr study is that the Corps are required to identify 50 years' worth of sand (at least 10 million cubic yards for the Central Reach over 50 years). The Corps evaluated the inlets, nearshore, and offshore but could not find such a significant amount of nourishment sand at a reasonable cost. ATM has had success in identifying 1 to 2 million cubic yard offshore borrow areas, however it is noted that finding 50 years of

nourishment sand is daunting given the offshore geology. LWF Inlet is a reusable sand source (while offshore borrow areas generally are not) however LWF Inlet cannot provide the amount of sand required for the Corps 50-yr timeline.

The Corps did identify a few offshore borrow areas that can provide several million cubic yards of beach compatible material however the Town and ATM will have to refine these borrow areas and perform more studies required for permitting. Nonetheless, the Corps offshore borrow area study can help with future borrow area investigations. The Corps offshore borrow area study is currently ongoing however it should be completed this spring (including post-data collection analysis). Figure 2-33 presents an offshore image from the Corps noting four "potential borrow areas." Potential borrow areas (PBA) 1 and 2 are the inlets, however PBA 3 and 4 are newly identified areas. Other offshore PBAs were also identified however were not advanced past initial stages (too close to hardbottom, not enough sand, marginal material, etc.).

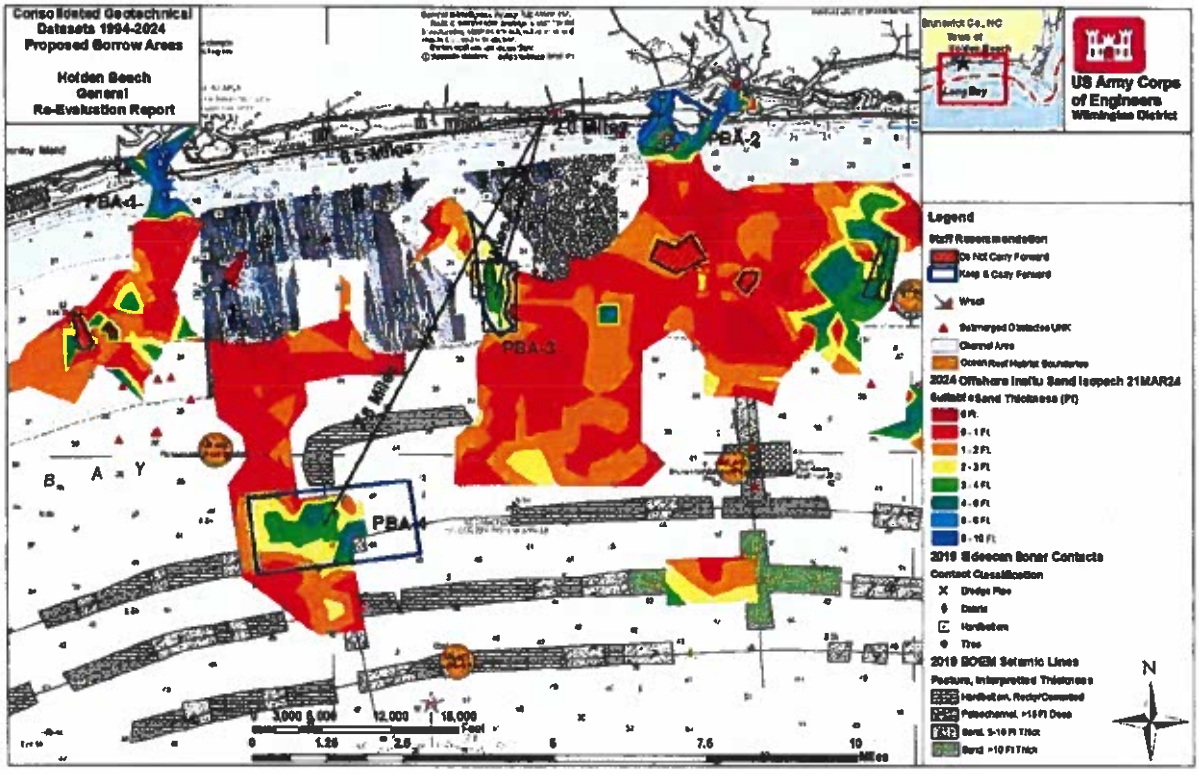

Figure 2-33. Potential borrow areas (PBAs) identified by the Corps CSRM study (source: USACE).

The Corps also studied the estuarine shoreline (also referred to as the back-bay) of Holden Beach and their analysis basically involved bulkheading the entire estuarine shoreline. There were some other options, however the bulkhead system was the preferred alternative and it requires a continuous bulkhead. The canal systems and even the boat ramp were areas where bulkheading would be impractical. Under storm surge conditions, waves and flooding from the backside of the island can be damaging. In the end, the Corps analysis determined that the estuarine shoreline is not a candidate for their cost-sharing project. ATM will continue to work with the Town on living shoreline and other potential solutions for the estuarine shorelines.

2.9.1 SACS PROJECT

The USACE South Atlantic Division (SAD) released a sand needs summary report for the Southeast in September 2020. ATM and Town staff have previously coordinated with researchers. In general, the Sand Availability and Needs Determination (SAND) assessed sand nourishment needs as well as available offshore borrow area sand. A figure showing Brunswick County summary results is provided (Figure 2-34). The overall result for Brunswick County is that the 50-year sand need exceeds known borrow area sand reserves and the Corps 2024 CSRM 50-yr study also confirmed this. Much more SACS information can be found here: https://www.sad.usace.army.mil/SACS/

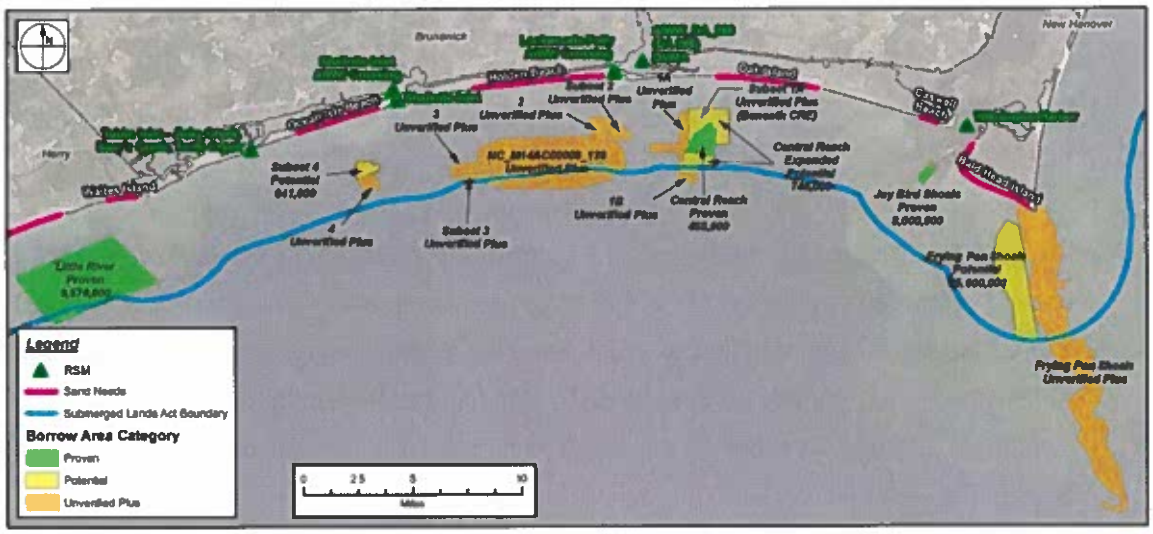

Figure 2-34. SACS summary figure for Brunswick County.

Related to the SACS study, the USACE and BOEM have approached Holden Beach for interest in using Frying Pan Shoals as a sand borrow area. This would be a multi-beach project including other local islands. Two meetings occurred in 2020 and 2021 with the USACE and other agencies to preliminarily discuss the use of Frying Pan Shoals. Overall, Frying Pan Shoals is too far (~15 miles) for an individual beach nourishment on Holden Beach however additional research into this borrow area source by BOEM is encouraged.

In 2022, BOEM coordinated with town and ATM staff (among other towns/interests) in collecting data 3 to 8 nautical miles offshore (i.e., in federal waters). This data collection was used by the Corps for their 50-year CSRM study. As previously mentioned, the offshore data has revealed potential borrow areas (which still require permitting-level data collection, refinement, and analysis).

2.9.2 WILMINGTON HARBOR DEEPENING

Cargo container vessels in three sizes. Feeder ship, panamax class and ultra-large container ship vector illustration

The State Port Authority (SPA) has spent the last ~5 years for studies/permitting to deepen the Wilmington Harbor by 5 ft (from 42 ft to 47 ft MLLW) to allow for larger vessels and remain competitive with other ports along the eastern seaboard. The SPA released a preliminary report on the proposed project in 2019. While annual maintenance dredging is typically composed of mud and fines, "new work" dredging can contain beach-compatible material. This was the case for the 2001/2002 Wilmington Harbor deepening, where 525,000 cy of material was placed on Holden Beach (in addition to other nearby beaches). In reviewing the preliminary report, no official volume of beach-compatible material was provided, however, Town staff have participated in deepening meetings and have made it known that the Town would like to receive beach-compatible sand, if feasible quantities are available. The project was originally slated for construction in 2024 however additional research/study was identified. The Environmental Impact Statement (EIS) process has essentially restarted which should conclude in 2026. Deepening will occur following the conclusion of a successful EIS process. See the following link for more information:

https://www.saw.usace.army.mil/Missions/Navigation/Dredging/Wilmington-Harbor/WHNIP_203_Study/

https://ncports.com/port-improvements/wilmington-harbor-improvements-project/

2.10 INLET HAZARD AREA UPDATE

DCM has been attempting to implement new state inlet hazard areas (IHAs) over the last several years that include Shallotte and LWF Inlets. The current IHAs were established in 1978. IHAs are defined as shorelines especially vulnerable to erosion and flooding, where inlets can shift suddenly and dramatically. IHAs do not affect FEMA flood maps or the National Flood Insurance Program (NFIP), however, they do affect some state regulations related to erosional setbacks, dune reconstruction, environmental windows, etc.

Revised IHAs were previously introduced around 2010, however, these were never implemented. Similarly, the currently proposed 2019 IHAs were scheduled to be implemented in 2020/2021. However, these are also under additional internal review and have not been implemented (and are listed as "pending" on the DEQ website). The 2019 proposed IHAs are expanded for Shallotte and LWF Inlets (as with most of the IHAs statewide). In general, the new methodology for the IHA determination appears reasonable for the east end of Holden Beach bordering LWF Inlet, however, the west end (adjacent to Shallotte Inlet) is accretional and the IHA methodology is overly conservative. The "hybrid-vegetation" line along the west end is decades old.

Figures 2-35 and 2-36 present the proposed IHAs affecting Holden Beach. More information on this topic is available at https://deq.nc.gov/about/divisions/coastal-management. The Coastal Resources Commission (CRC) science panel has recently met on IHA boundaries in late 2024 and other meetings/analysis/hearings are planned for 2025.

2.11 BEACH MANAGEMENT PERMITS

The Town currently has several projects that have required or will require permits, including:

- LWFIX and Bend-Widener
- LWF Outer Bar (side-casting, shallow draft hopper)
- Upland Borrow Area
- Central Reach Reimbursement (CRR) Project (using offshore borrow area)

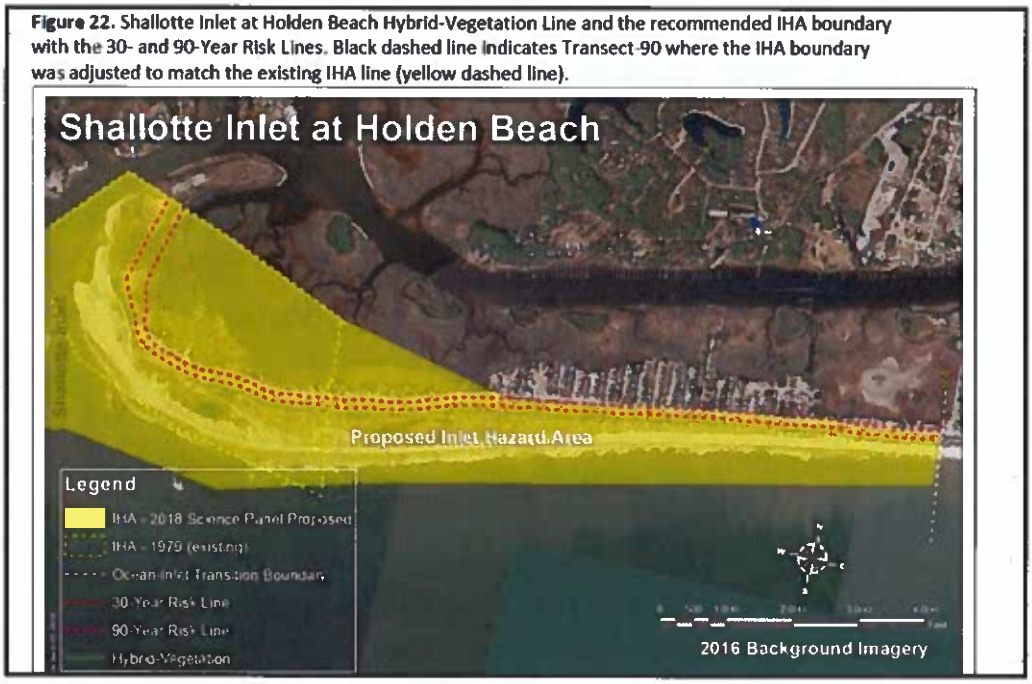

Figure 2-35. Proposed IHA for the west end of Holden Beach (image source: 2019 DCM IHA report)

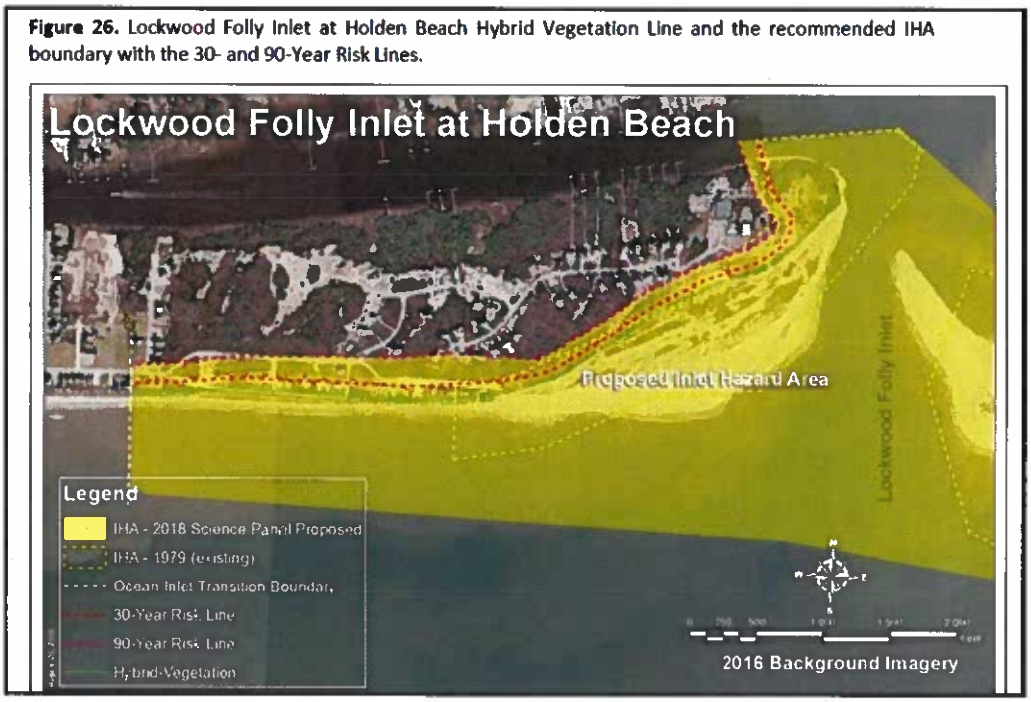

Figure 2-36. Proposed IHA for the east end of Holden Beach (image source: 2019 DCM IHA report

In general, DCM/CAMA prefers to modify the beach nourishment permit initially obtained by the Town in 2002 (permit number 14-02). This follows modifications that included the 2008 and 2009 Town nourishments using the Smith borrow site. The offshore borrow areas are included in this DCM permit. Additional modifications to the DCM permit 14-02 are planned in 2025 for another offshore borrow area that will be permitted by the Town and ATM.

In contrast to DCM, the USACE typically creates new permits for each project (upland fill, LWFIX, CRP). Individual projects including the 2025 offshore borrow area permit application are typically processed under the USACE programmatic general permit (PGP) mechanism.

The NCDWQ permits are project specific and generally follow the lead of DCM/CAMA. The USACE, DCM and DWQ generally coordinate to avoid any permit condition conflicts. If any future modifications are needed, it is anticipated that coordination will be needed with all these agencies.

On a similar note, the County's special exception permit to operate a mine in Brunswick County for the Turkey Trap Road borrow area has no expiration date however some annual "mining permit" coordination with the state is required and has occurred by the Town and ATM. Upland borrow areas need to be reviewed by the Division of Land Resources, which oversees mining operations in the state. The Smith borrow site included a water feature for a residential development; therefore, a special exception permit was not needed (although this is subject to regulatory interpretation). As previously mentioned, the Smith upland site is under development and of no future use as a borrow source.

As discussed in Section 2.5, the Town obtained permits in 2016 to perform SDI projects, including LWFIX dredging and beach placement, as well as outer-channel sidecast dredging. The State permit (DCM 52-16) and USACE permits expire in 2026 (following a few extension requests).

3.0 ANNUAL SURVEY RESULTS

3.1 SURVEY RESULTS

Beach surveys are performed annually as a part of the Town's Beach Management Plan and span from LWF Inlet to Shallotte Inlet. Figure 3-1 presents the stationing and transects established by the monitoring plan. Survey data were collected in April 2024 at 51 transects along Holden Beach, following both the Town CRR and the USACE LWFIX nourishment projects. Beginning with the April 2020 survey, three Shallotte Inlet transects were established and surveyed along the far west end of Holden Beach for additional monitoring of the west end shoreline and Shallotte Inlet related effects.

This annual survey also included an additional seven transects on western Oak Island. The monitoring of these additional Oak Island transects began with the 2012 survey to more closely monitor inlet-related effects and establish more consistent baseline data. Similar to historical trends on the west end of Holden Beach, the west end of Oak Island is generally stable; however, inlet dynamics and major storms have the potential to affect this area.

Figure 3-1. Holden Beach Annual Monitoring Transects, 2024. An additional seven monitoring transects have also been added to western Oak Island beginning with the 2012 survey and three additional Shallotte Inlet transects were recently established beginning with the 2020 survey. Note "Z" is in ft-NGVD29. NGVD29 essentially represents mean sea level.

Figure 3-2 presents example transect surveys comparing April 2023 and April 2024 survey data. The April 2024 survey represents two-year post-construction conditions of the Town's recent 2022 Central Reach Reimbursement and the USACE 2022 LWFIX projects.

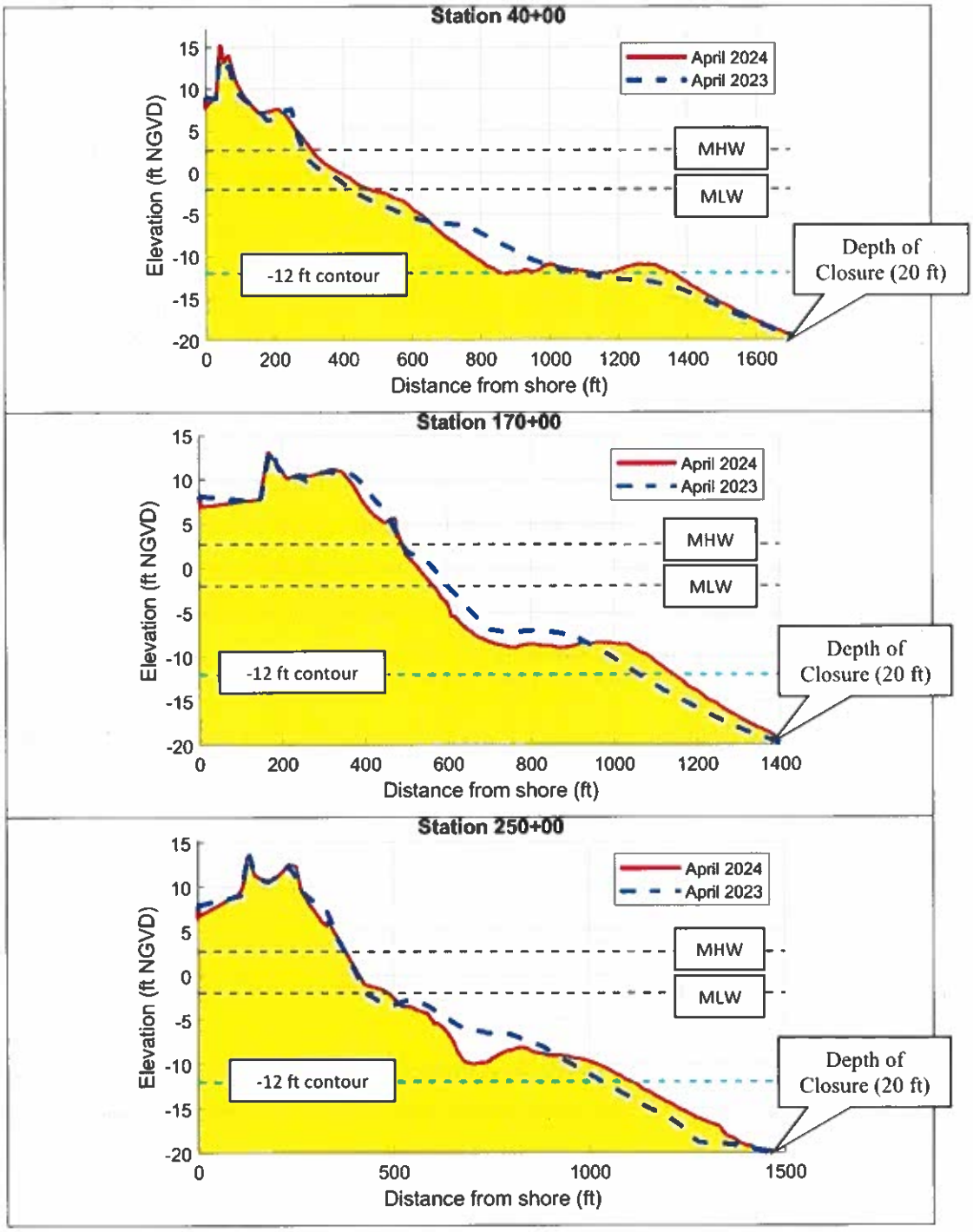

Figure 3-2. Upper panel shows Station 40+00 Profile Transect Comparison on the Town East Reach of Holden Beach. This location is near the eastern taper of the CRR template where it adjoined the USACE LWFIX project. Middle panel shows Station 170+00 Profile Transect Comparison at the Pier. Bottom panel shows transect 250+00 Profile within the Town of West Reach. The -12 ft contour line is plotted to show how sand is moving farther offshore to approximately the 20 ft contour.

The CRR placement extended from Station 40+00 to just east of Station 270+00 and adjoined the USACE 2022 LWFIX on the east end which placed material approximately from Station 40+00 to Station 20+00 (Figure 2-1). Note that CRR placement west of Station 235+00 represented a reduced template due to project logistics with respect to USACE regional South Atlantic Regional Biological Opinion (SARBO) limitations. Since the CRR placement in 2022, we see profiles have generally stabilized into an equilibrium profile. We are seeing more erosion since 2023 in the nearshore regions (out to about 20-ft depths). Sand is shown moving beyond the -12 ft contour which has typically been used as the typical depth limit for sand movement for Holden Beach. Figure 3-2 shows that sand movement in the nearshore between the -12 ft and -20 ft contours occurs for three transects in three separate reaches. For this report, a 20ft depth of closure (DOC) was chosen to better represent the seaward extent of sediment movement. This DOC has historically been monitored in the event of further sand transport seaward as has been observed here. In the most recent survey, we see more sand has moved offshore between the -5ft and -20 ft contours. Also note that FEMA mitigation analysis also typically requires a DOC of about -20 ft as major storms can move material in this deeper water.

Depth of closure (DOC) is essentially the limit for the nearshore littoral sand-sharing system. All sand within the littoral sand-sharing system is important in gaging the health of the beach and inlet system. For this report, when sand is reported as moving "offshore", note that the material is still within the nearshore (-12 to -20 foot depths, typically within ~300 yards from the shore) and the littoral sand-sharing system. In reviewing sediment movement, negligible nourishment sand is "lost" from the littoral sand-sharing system and is still subject to movement from shoaling waves as they propagate towards the beach.

Note that some differences in profiles may be related to recent wave activity and/or nourishment activities and are not necessarily indicative of long-term trends. Appendix A contains all transect data for the 2023 and 2024 annual monitoring surveys.

In general, comparison of the 2023 and 2024 surveys reveals erosion overall however the beach is in good shape and performing well. Erosion was documented along all reaches out to the -20ft contour except at Shallotte Inlet, where variability is to be expected due to the dynamic nature of inlets. The east end historically displays more erosional conditions and showed a similar pattern in the most recent survey. Erosion within the 2022 Central Reach

Reimbursement project area is expected as the material equilibrates and spreads, however, sand primarily moved to the nearshore (with 20 ft depth), not westward as was shown between the 2022 and 2023 surveys.

Areas most likely experienced erosive conditions due to winter storms bringing in elevated surge and wave events. No major hurricanes were recorded in the area that would have significantly contributed to the documented erosion. In reviewing the beach response since the 2022 nourishment, last year erosion was below average while the most recent year was above average but well within expected beach response. The upper secondary berm along with the vegetation and sand fencing efforts help to enhance the dune system buffer, but these areas can still experience damage during high-water events.

It is also important to note that current conditions in the upper beach and nearshore are better than Pre-CRP conditions (2016). Figure 3-3 shows the 2023 and 2024 profiles for Transect 170+00 alongside the 2016 survey profile. This displays the cumulative beneficial effects of the 2017 and 2022 nourishments on the beach. As shown in Figure 3-3, the beach is still over 200 feet wider than it was in 2016 prior to the Town's major nourishment efforts.

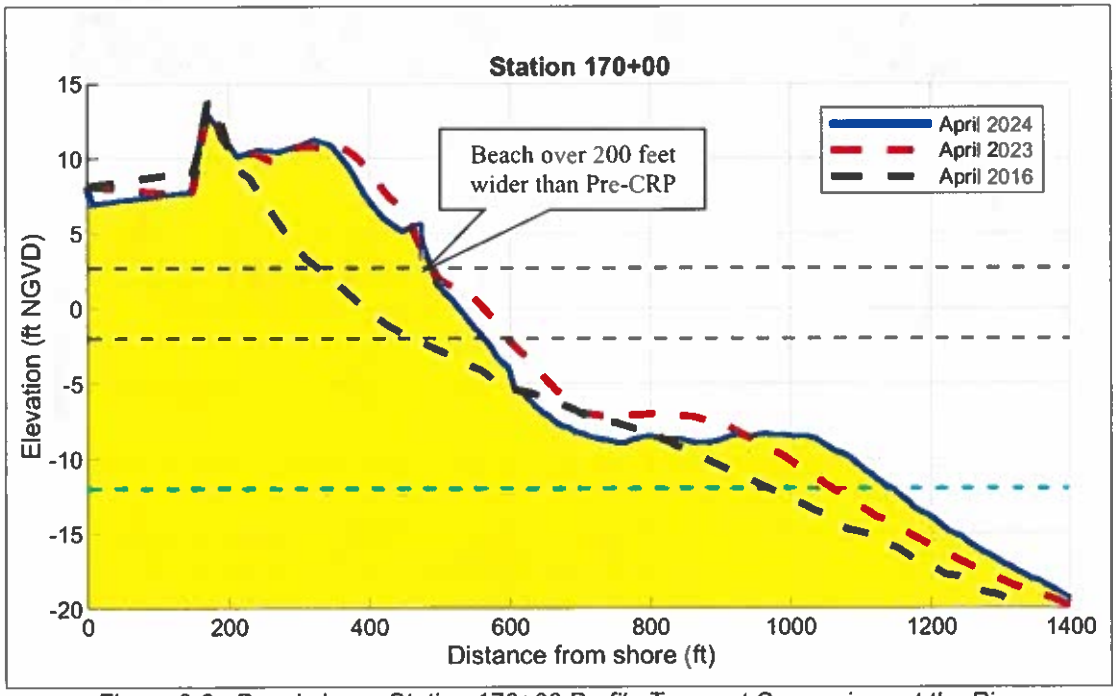

Figure 3-3. Panel shows Station 170+00 Profile Transect Comparison at the Pier.

Sections 3.2 and 3.3 provide more information on volume and shoreline analysis, respectively.

3.2 VOLUME ANALYSIS

Figure 3-4 presents changes in volumes from April 2023 to April 2024 along the entire beach. Volumes are quantified by comparing profile volumes from successive surveys. The USACE Beach Morphology Analysis Program (BMAP) was used to compute changes in profile volumes for each profile and for all surveys during the monitoring period. Volume changes are presented in this section from the dune to the -20 ft depth contour representing the limit of sediment movement, or the depth-of-closure (DOC) and in agreement with FEMA post-storm analysis requirements. A previously discussed, the vast majority of sand transport and profile change typically occurs in waters shallower than the DOC, such as the surf zone and intertidal beach.

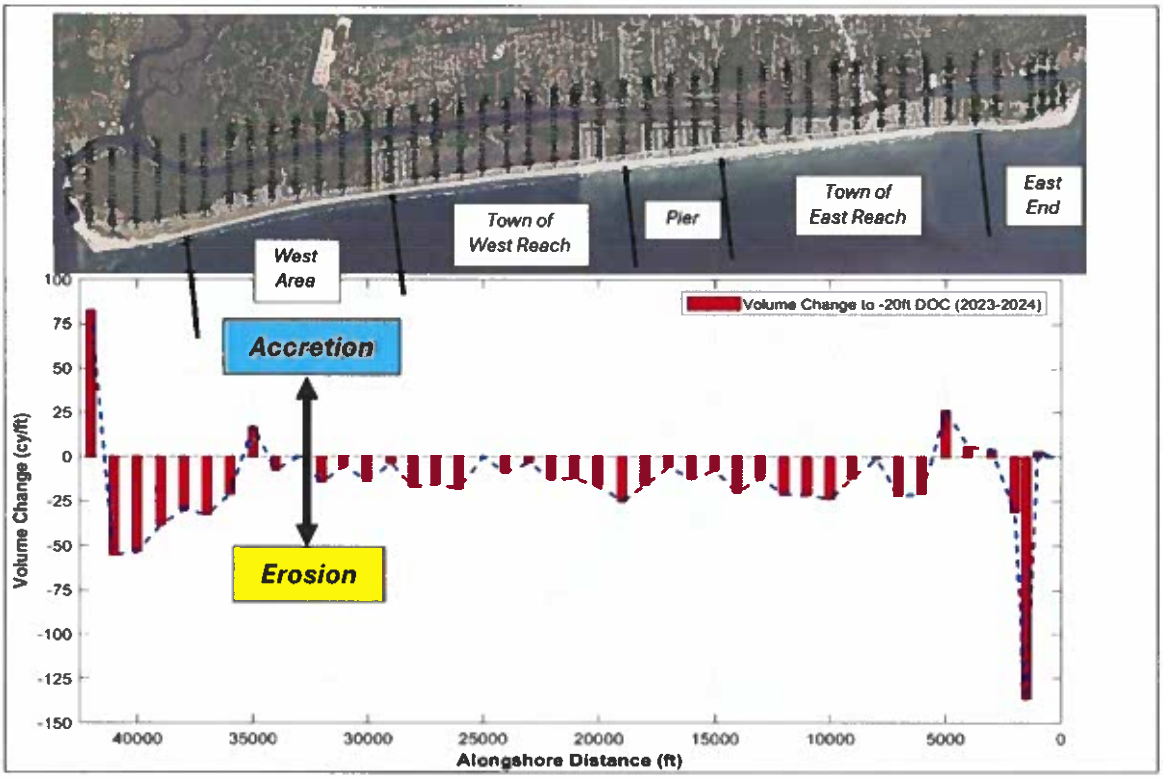

Figure 3-4. Volume Change from the Dune to -20 ft Depth Using April 2023 and April 2024 Surveys. Positive Values Indicate Accretion, Negative Values Indicate Erosion. Erosion in the Nourished Reaches is to be Expected as the Nourished Sand Equilibrates in the Years Following the Project. The Most Significant Erosion over the Past year is Seen Near the Inlets.

During periods of significant energetic wave conditions, however, changes to the beach profile can occur beyond the DOC limit. Therefore, the DOC can vary annually and seasonally depending on storm activity, and extreme storms can move material out to depths of 30 ft. Past surveys have shown more significant changes in locations seaward, deeper than the -12-ft contour and even beyond -20-ft contour as well, due to Hurricanes Florence and Michael in 2018. Changes in these deeper areas (beyond -20 ft) will continue to be monitored to assess any potential future volumetric impacts of sediment transport for Holden Beach.

Figure 3-4 shows mostly mild erosion along the eastern and western reaches of Holden beach. Mild erosion can be expected in the Central Reach where the 2022 nourishment took place, from the Town East Reach to about midway through the Town West Reach. Erosion in the Central Reach is likely due to further equilibration of sand from nourishment activities. The western reaches have been typically more stable and oftentimes accretional in the past. In the 2023 survey, we saw downdrift spreading from the 2022 CRR project, however, in the most recent 2024 survey, we see more erosion and less downdrift spreading from the 2022 CRR project. Though typically stable, the western reaches have shown erosional trends at times in the past, so this is not cause for immediate concern. Erosion may be due to storm activity and/or to high winter wave activity, as there were no significant hurricanes that occurred in the area between surveys that may explain the erosional trend. The most significant erosion and accretion over the past year was observed near the east and west inlets, which is not atypical as inlet dynamics often cause significant volumetric fluctuations. Overall, a healthy beach and a wide healthy dune system is observed over the past year. Survey to survey variations are due to survey precision as well as seasonal variation, and recent wave activity. Additional variation may also be attributed to undulating patterns along the shoreline, which have been documented along nearby beaches[1].

Figure 3-4 also identifies several smaller shoreline reaches (e.g., West Area, Town West Reach, Pier, Town East Reach) along Holden Beach. Over the last 5 years, the east end has benefitted from the eastward spreading of the 2017 CRP and 2022 CRR nourishments as well as USACE LWFIX east end nourishments.

[1] PARK, J.-Y.; GAYES, P.T., and WELLS, J.T., 2009. Monitoring beach renourishment along the sediment-starved shoreline of Grand Strand, South Carolina. *Journal of Coastal Research,* 25(2), 336–349. West Palm Beach (Florida), ISSN 0749-0208

Shallotte Inlet dredging activities have also been documented to have adverse impacts on Holden Beach shorelines in the past and, therefore, this area is monitored for any potential impacts related to the borrow area and any continuing erosional patterns. Shallotte Inlet was last dredged in 2021/2022 for a nourishment on Ocean Isle (in conjunction with the Ocean Isle terminal groin construction). Therefore, some of the erosion we see near the inlet could be at least in part caused by the channel dredging that took place approximately 1,000 ft away from Holden Beach. This area will continue to be monitored for potential negative impacts the dredging may have on the Holden Beach side. Regional net sediment transport at Shallotte Inlet is east to west (similar to all of Holden Beach), therefore there are no anticipated detrimental impacts to the Holden Beach shoreline from the Ocean Isle groin however ATM will review all groin monitoring reports to verify. Ocean Isle has submitted monitoring related to the terminal groin and nourishment using Shallotte Inlet to the town and ATM staff (among others). Their initial 2022 monitoring report summarizes changes between June 2022 and December 2022 (~6 month monitoring). Their most recent 2023 monitoring report (dated April 2024) summarizes short- and long-term changes in shoreline and volumetric changes and rates using surveys conducted in May 2023 and November 2023. More discussion on this topic is presented in Section 3.3.

Volume calculations were also performed from the dune to the -5 ft NGVD contour, which represents the approximate typical surf-zone limit. The -5-ft volume limit is more characteristic of visible/tangible beach conditions than the deeper -12-ft or -20-ft limits that can occur more than a quarter mile offshore.

Figure 3-5 presents the three different boundaries historically used for volume calculations and illustrates some of the offshore erosion that was observed in the West Area at Station 330+00, considerably downdrift/west of the 2017 CRP and the recent 2022 CRR placements (which both ended near Station 260+00).

Table 3-1 presents volume changes estimated by the reaches identified in Figure 3-4 (i.e., East End, Town East Reach, Pier, etc.) from 2023 to 2024. Overall, there was an island wide net loss of 458,000 cy of sand from the dune out to the -20-ft DOC limit, of which more than half of which came from the Central Reach (~65%). Note that the survey area is not a closed system and identifying sediment transport direction can only be inferred based on measured volume change and engineering judgment.

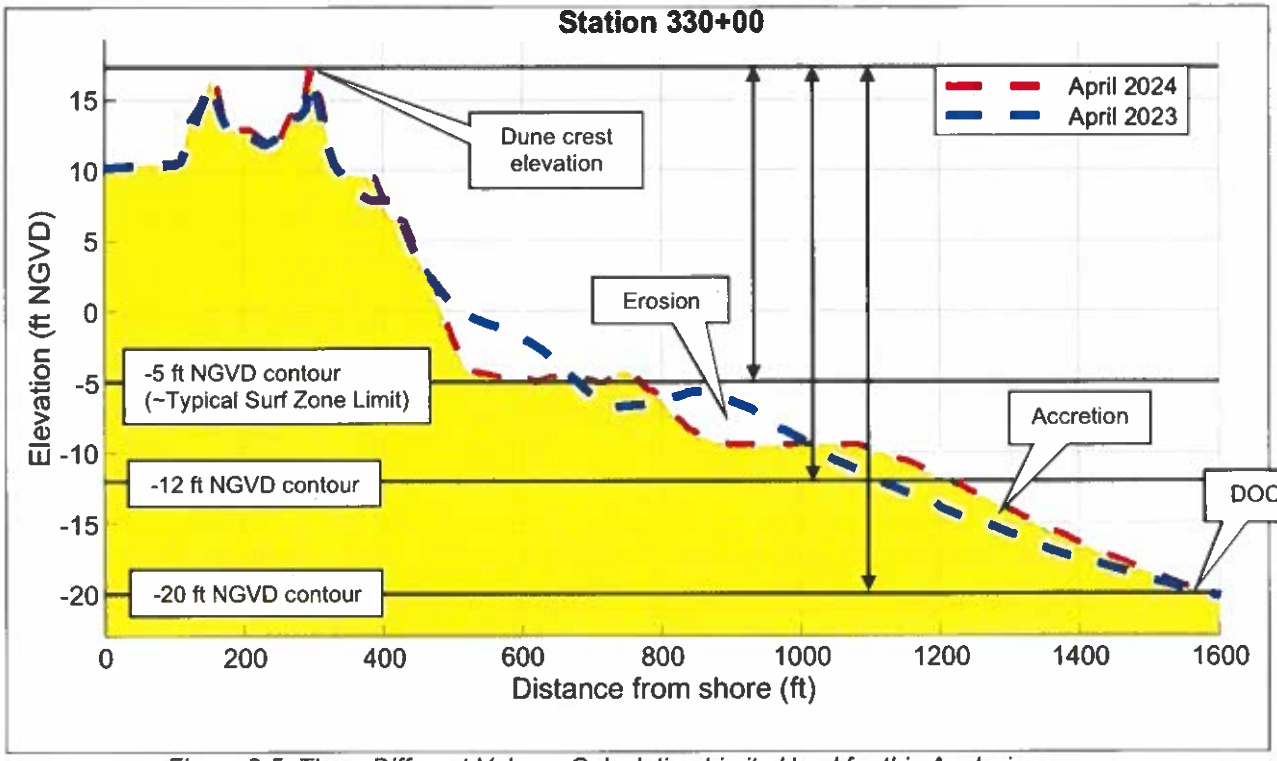

Figure 3-5. Three Different Volume Calculation Limits Used for this Analysis: 1) Dune to -20 ft NGVD, 2) Dune to -12 ft NGVD, and 3) Dune to –5 ft NGVD.

Table 3-1. Volume Change by Shoreline Reach for 2023 and 2024 Surveys

Reach Averages	Stations Included	Total Volume Change (CY) (Dune to -20 ft NGVD)	Dry Beach/Surf Zone Volume Change (CY) (Dune to -5 ft)	Surf Zone/Depth-of-Closure Volume Change (CY) (-5 ft to -20 ft NGVD)*	Offshore Depth-of Closure Volume Change Comparison (CY) (-12 ft to -20 ft NGVD)
LWF Inlet	5 to 15	-32,000	-38,000	+6,000	-1,000
USACE East	15 to 40	-50,000	+24,000	-74,000	+4,000
Town East	40 to 150	-129,000	-153,000	+24,000	+192,000
Pier	150 to 190	-50,000	-69,000	+19,000	+60,000
Town West	190 to 290	-117,000	-138,000	+21,000	+162,000
West Area	290 to 380	-94,000	-145,000	+51,000	+109,000
Shallotte Inlet	380 to 420	+14,000	-69,000	+83,000	+85,000
	TOTAL	**-458,000**	**-588,000**	**+130,000**	**+611,000**
Central Reach	**40 to 290**	**-296,000**	**-360,000**	**+64,000**	**+414,000**

*Negative values indicate likely sediment movement from dry beach/surf zone area to surf zone/depth-of-closure area

As Table 3-1 shows, from the dune to the -20 ft Depth-of-Closure (DOC), the beach experienced overall erosion along all reaches except Shallotte Inlet. Most of the erosion occurred within the dry beach to surf zone area (from the dune to the -5ft contour). Along the entire profile, accretion was observed from the -5ft contour to the -20ft contour for all reaches except for the USACE East reach. Examining volume changes from the -12 ft to the DOC (-20 ft) contours, we find most of the accretion along the profile is occurring from the -12 ft to -20 contour, confirming that sediment is moving further to the nearshore than previous years (with the exception of the LWF Inlet reach). This additional sand in 12 to 20 feet of water provides benefits to the dry beach by increased wave shoaling and breaking farther from shore.

Historical volume changes back to 2012 for the Central Reach (Stations 40+00 to 290+00) and the entire Holden Beach shoreline, calculated from the dune to the historically used -12-ft NGVD DOC are provided in Table 3-2a. The 2022 CRR project represents the largest beach renourishment project on Holden Beach to date. Between 2021 and 2022 the Central Reach experienced a gain of 1,514,000 cy out to the -12 ft DOC.

Table 3-2 presents the 2017 CRP nourishment performance since construction, which now also includes the 2022 CRR. As noted in the table, over 1 million cubic yards was measured to remain in the project area prior to the 2022 CRR. This is largely due to relatively milder years in 2017/2018 and 2021, while LWFIX nourishment activity also has a positive effect. Fortunately, the CRP held up well providing a good base of pre-project beach for the 2022 CRR project to expand on. Since then, even with the above-average beach-wide erosion that occurred over the past year, over 1.76 MCY of material are measured in the Central Reach since 2017 with the two Central Reach nourishments combined (up to the -12 ft contour).

Table 3-2. Central Reach Volume Change and Volume Remaining (cy) since 2017 nourishment project (Dune to -12 ft NGVD)

	2017	2018	2019	2020	2021	2022	2023	2024
Central Reach Total Volume Remaining (cy)	+1,386,000	+1,617,000	+1,475,000	+1,078,000	+1,170,000	+2,684,000	+2,467,000	+1,757,000

The effective storm buffer and protection provided by the 2017 CRP has been demonstrated in each of the major storm events over the past few years, and the 2022 CRR nourishment was conducted with this goal in mind for future storms.

As mentioned previously, the east end area (Stations 5+00 to 40+00) is historically erosional especially at the known erosional hotspot near Station 20+00 (near the Town's eastern-most oceanfront house called *Amazing Grace*). In general, monitoring stations east of Station 40+00 can exhibit highly variable changes based on inlet dynamics and USACE fill activities (timing, volume, placement, etc.). Sidecasting and outer inlet maintenance (or lack thereof) also have an effect.

Several past shoal attachments (documented in previous annual reports) have contributed to localized low-tide beach expanses on the east end in previous years. These shoal attachments have been estimated to be between 5,000 and 50,000 cy and can provide a significant benefit to the sand (littoral) system. These shoals can also create erosional hotspots, depending on their distance from shore, size, attachment location, etc.

Volume change calculations show the USACE East Reach (Stations 15+00 to 40+00) overall is erosional over the entire dune to the DOC zone (-20 ft contour) and exhibited a net loss of about 50,000 cy of material. This erosion likely came from shoal and bar movement within the surf zone to the depth of closure region along the shoreline closer to Lockwood Folly Inlet.

Since the 2022 LWFIX project, the eastern reach of shoreline continues to exhibit a wide and healthy beach (see Figure 3-6) despite the historical trends in erosion and will fortunately benefit from additional material in upcoming LWFIX nourishment project.

The LWF Inlet Reach (Stations 5+00 to 15+00) experienced approximately 32,000 cy of erosion. This was primarily due to erosion that occurred at Station 15+00, likely due to inlet dynamics.

Figure 3-6. Recent Photographs of East End Beach Conditions Taken between Stations 20+00 and 30+00 Looking West (Upper Photo) and East (Lower Photo). ~2.5-year post 2022 LWIFX Placement Showing Wide Beach Present in What Is Typically an Erosional Hotspot Area (Photos Taken October 2024).

The West Area (Stations 290+00 to 380+00) is historically stable and has never been nourished but in the past passively received much of the Central Reach nourishment sand as it migrated westward (net sediment transport direction). The 2024 survey showed the West Area overall lost about -94,000 cy of material in the dry beach to the DOC area (dune to -20 ft) over the past year.

The beach west of Station 380+00 to Shallotte Inlet (Stations 380+00 to 420+00) is subject to episodic erosion, typically with the largest fluctuations along the shoreline closest to the inlet. This reach experienced net volumetric accretion between 2023 and 2024, with a total gain of 14,000 cy of gain from the dune to the -20ft contour. However, most of this accretion occurred offshore near the DOC (-20ft), while the upper beach to surf zone (Dune to -5ft contour) experienced a net loss of -69,000 cy.

Fluctuations in volumes in this region can be attributed to net westerly sand transport, shoreline undulations, inlet-related processes (including shoreline orientation/curvature and shoal formation), and extreme storm conditions.

3.3 SHORELINE ANALYSIS

In addition to a volumetric analysis, shoreline analyses were also performed as another useful metric in gauging beach health. Figure 3-7 was developed to view annual changes in the mean high water (MHW) shoreline contour along Holden Beach.

Average MHW shoreline change by reach is presented in Table 3-3. Similar to the volumetric analysis, the MHW shoreline reveals a mostly erosional shoreline with slightly higher erosion on the east side where the nourishment projects were located along the beach, relative to the non-nourished west side. Within the Central Reach, the MHW shoreline eroded by approximately 16 ft overall.

All areas except for the USACE East section exhibited movement of the MHW line landward since 2023. The USACE East section shows slight accretion. The reaches west of the Central Reach show a generally stable to slightly erosional MHW shoreline over the past year. The far west end close to Shallotte Inlet experienced erosion due to inlet dynamics and shoal movement but well within annual averages.

Figure 3-8 presents the changes in the MHW position from 2023 to 2024 along the westernmost shorelines of Holden Beach. Appendix B provides figures of the 2024 survey MHW results for the entire Holden Beach shoreline.

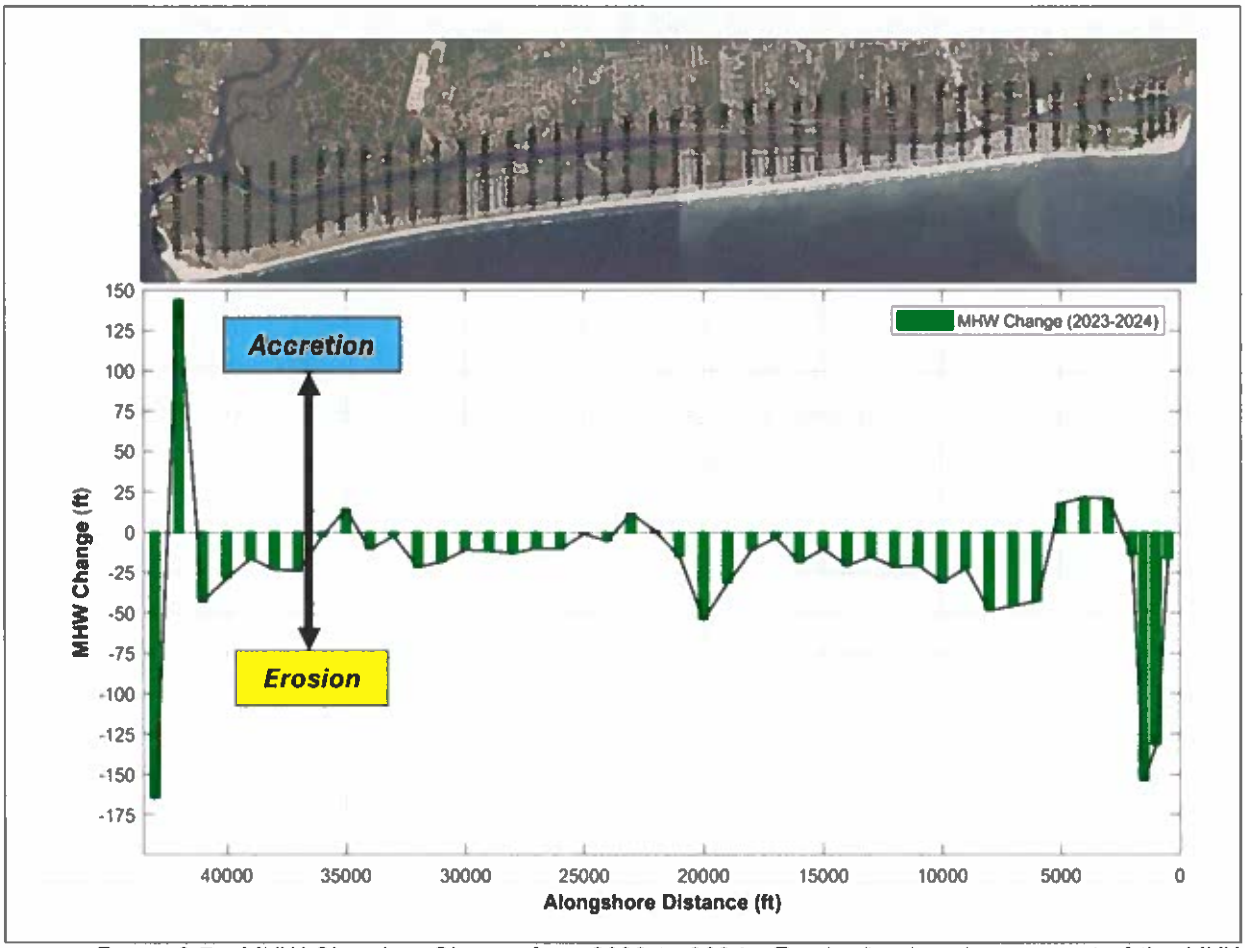

Figure 3-7. MHW Shoreline Change from 2023 to 2024. Erosion/landward movement of the MHW shoreline along most of Holden beach. Erosion to the west edge of Holden Beach most likely due to winter storm activity. Large fluctuations in erosion at the extreme east end are due to inlet dynamics.

Table 3-3. MHW Shoreline Change by Reach for 2023 and 2024 Surveys

Reach Averages	Stations Included	2023 to 2024 MHW Change (ft)
LWF Inlet	5 to 15	-100.7
USACE East	15 to 40	9.6
Town East	40 to 150	-19.8
Pier	150 to 190	-14.9
Town West	190 to 290	-12.5
West Area	290 to 380	-11.0
Shallotte Inlet	380 to 420	-27.7
Central Reach	40 to 290	-15.7

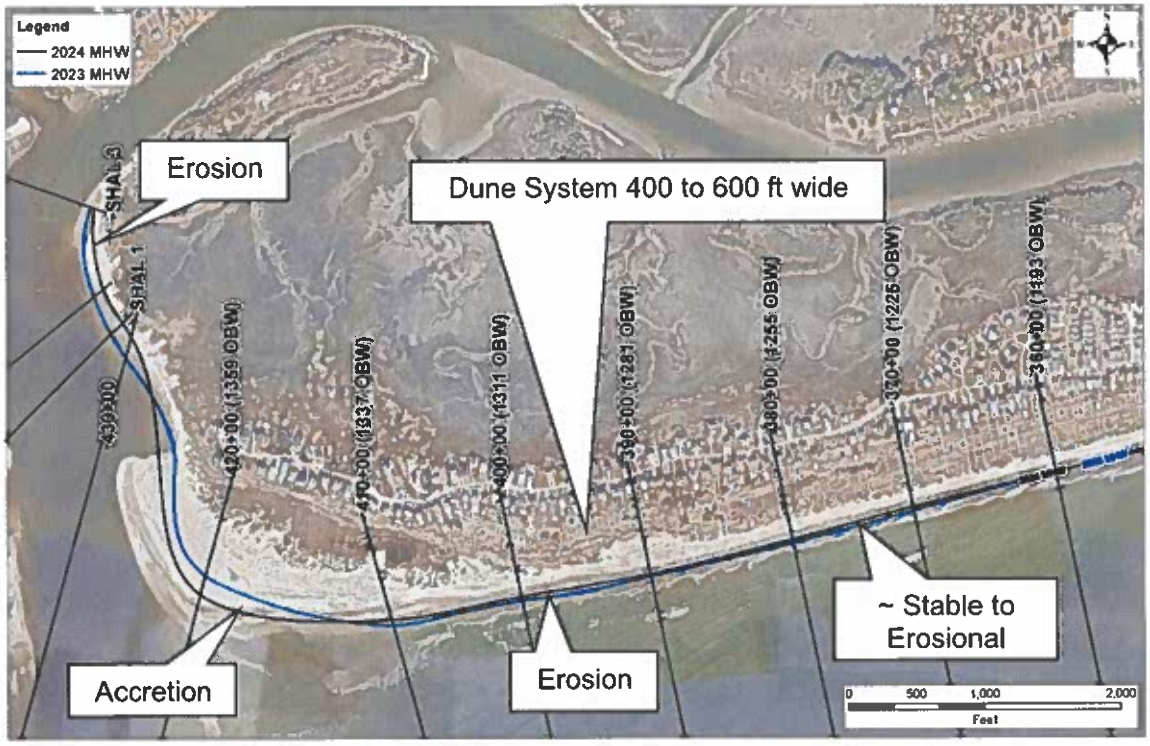

Figure 3-8. 2024 (black) and 2023 (blue) MHW Shoreline Positions along the West End of Holden Beach near Shallotte Inlet. "SHAL 1" begins at the same location as 430+00. (January 2024 aerial shown).

The MHW line and aerial analysis on the west end shows that this section of shoreline remained relatively stable and experienced some mild erosion over the past year. The localized erosion is possibly due to sediment movement during energetic wave conditions and/or inlet related processes. The Shallotte Inlet shoreline on the extreme west end experienced some minor variable erosion and accretion, but overall appears relatively stable over the past year.

Although the MHW shoreline here was relatively stable over the past year, some significant dune scarping, dune walkover damage and vegetation loss was observed near this area following Hurricane Ian in 2022.

Dune system widths in the West Area can be up to 600 ft; therefore, large fluctuations in volume and/or shoreline position in this area are still several hundred feet from residential structures.

This area will continue to be closely monitored and future efforts to enhance vegetation may be implemented as a proactive measure to mitigate erosion. Beach scraping following a major storm event to rebuild the dune is also an option. The substantial addition of material into the system from the 2017 CRP combined with the 2022 Central Reach Reimbursement Project is expected to promote beach growth in this region for years to come as nourishment material continues downdrift spreading.

Several homes on the extreme western end of the Holden Beach, near Station 420+00 (approximately 1359 OBW) are close enough to Shallotte Inlet that close monitoring of inlet migration and USACE/Ocean Isle dredging activities in Shallotte Inlet is warranted.

Three additional monitoring transects (SHAL 1, 2, and 3) have been established along the west end of Holden Beach for detailed monitoring of Shallotte Inlet, which began with the April 2020 survey.

As previously discussed, the Ocean Isle nourishments typically use Shallotte Inlet as a borrow area. The most recent of these nourishment events occurred in the winter/spring of 2021/2022 as part of the USACE Federal Coastal Storm Risk Management (CSRM) project, which coincided with construction of Ocean Isle Beach's terminal groin project (see Figure 3-9).

This project included dredging about 760,000 cy from Shallotte Inlet and placement onto the eastern shoreline of Ocean Isle, west of the newly built structure. Based on the April 2024 monitoring report, minor erosion occurred along the Shallotte Inlet shoreline on the Holden Beach west end, potentially due to the project (i.e., just surpassing trigger established thresholds in a limited area). While the majority of oceanfront and estuarine shoreline change and volumetric change trigger thresholds on Holden Beach were not surpassed, shoreline monitoring will continue to assess any potential effects of this and future activities on the Holden Beach shoreline. Groin-related monitoring of Shallotte Inlet (including the Holden Beach west end) will occur by Ocean Isle as required by permits.

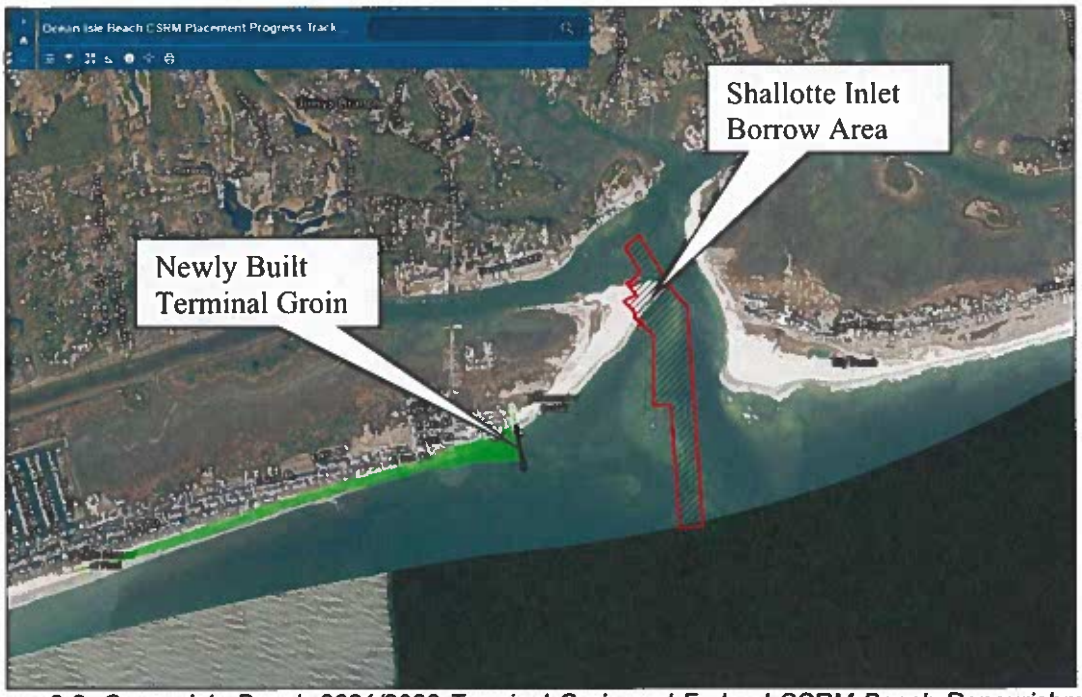

Figure 3-9. Ocean Isle Beach 2021/2022 Terminal Groin and Federal CSRM Beach Renourishment Projects. Shallotte Inlet Borrow Area and Placement Area Shown (USACE Ocean Isle Beach CSRM Placement Progress Tracker)

Smaller (~50,000 cy) Shallotte Inlet AIWW dredging projects also place material on Ocean Isle when dredged material is beach compatible. These smaller dredging projects occur about every two years. The most recent AIWW placement on Ocean Isle was east of the terminal groin (i.e., closer to Shallotte Inlet) (see Figure 3-10).

Figure 3-11 presents the changes in the MHW position from 2023 to 2024 along the easternmost shorelines of Holden Beach. The extreme east end, east of the 2022 LWFIX placement area, shows variable landward and seaward movement of the MHW shoreline from LWF Inlet dynamics. Shoreline position along the east end was primarily stable from 2023 to 2024, with some minor erosion between Station 5+00 and Station 20+00, most likely due to inlet dynamics.

Figure 21. USACE Navigation maintenance material placed on the inlet shoreline, east of terminal groin (Photo taken 2/22/23).

Figure 3-10. Excerpted photo from April 2024 Ocean Isle Beach Terminal Groin monitoring report. Placement of the 2023 Shallotte Inlet crossing sand was downdrift of the terminal groin.

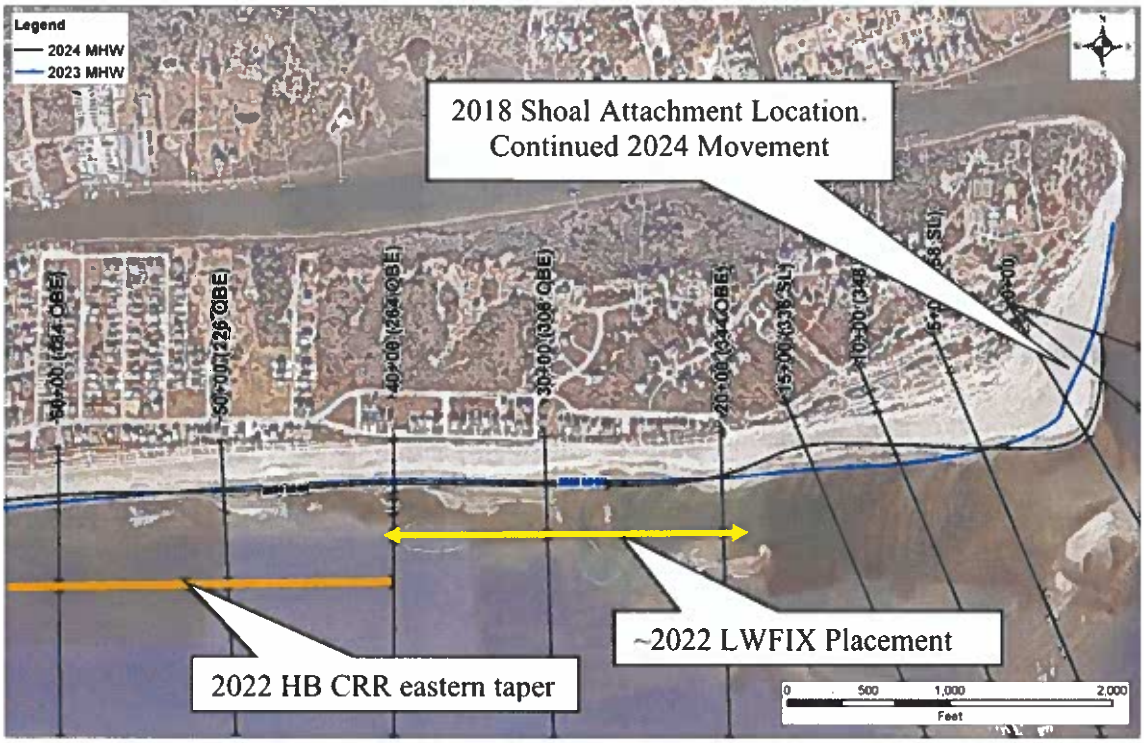

Figure 3-11. 2024 (black) and 2023 (blue) MHW Shoreline Positions along the East End of Holden Beach near Lockwood Folly Inlet. (January 2024 aerial shown).

The toe-of-dune (TOD) shoreline (7 ft NGVD contour) is shown on Figure 3-12 and generally represents the seaward edge of the dune. The TOD shoreline change shows some variable erosion and accretion changes on the west end as we've seen in the past. However, a mostly erosional trend was observed for the island overall. This is likely due to king tide events and waves impacting the dune system following the 2022 CRR construction which included a secondary berm.

The west end dunes suffered damage during Hurricane Ian in 2022 and additional dune erosion was observed here over the past year. Fortunately, dune widths are still significantly wide and healthy in this area. Dune recovery (or lack thereof) will continue to be monitored.

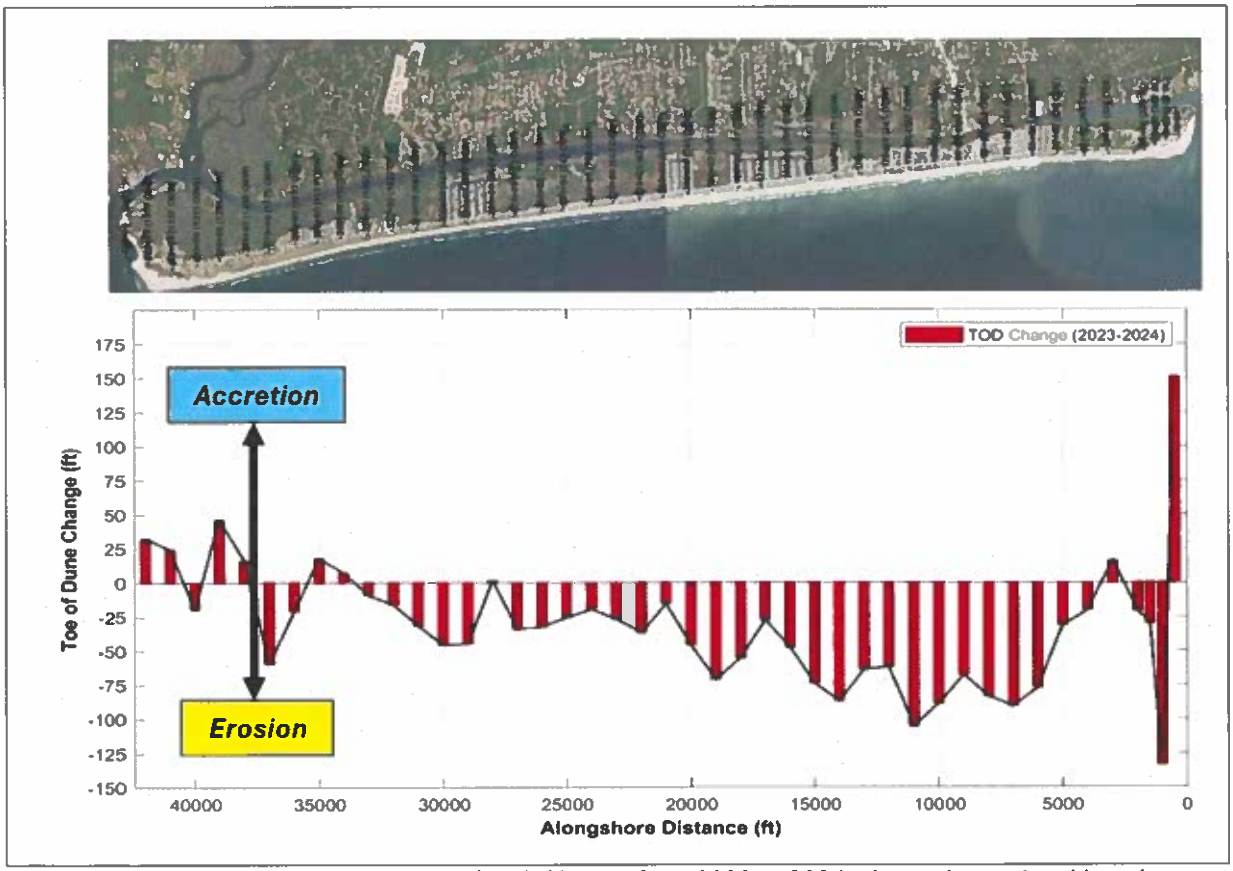

Figure 3-12. Toe of Dune (TOD, +7 ft NGVD) Change from 2023 to 2024. A mostly erosional beach trend is exhibited, though with variability alongshore and high variability at Lockwood Folly Inlet.

Figure 3-13 presents maximum dune heights for each Holden Beach station. Dune heights are generally healthy and were mostly stable over the past year. The dune system is also

noticeably wider for most of the island. Proactive dune enhancements, discussed in Section 2.7, are an important activity related to maintaining a healthy dune system.

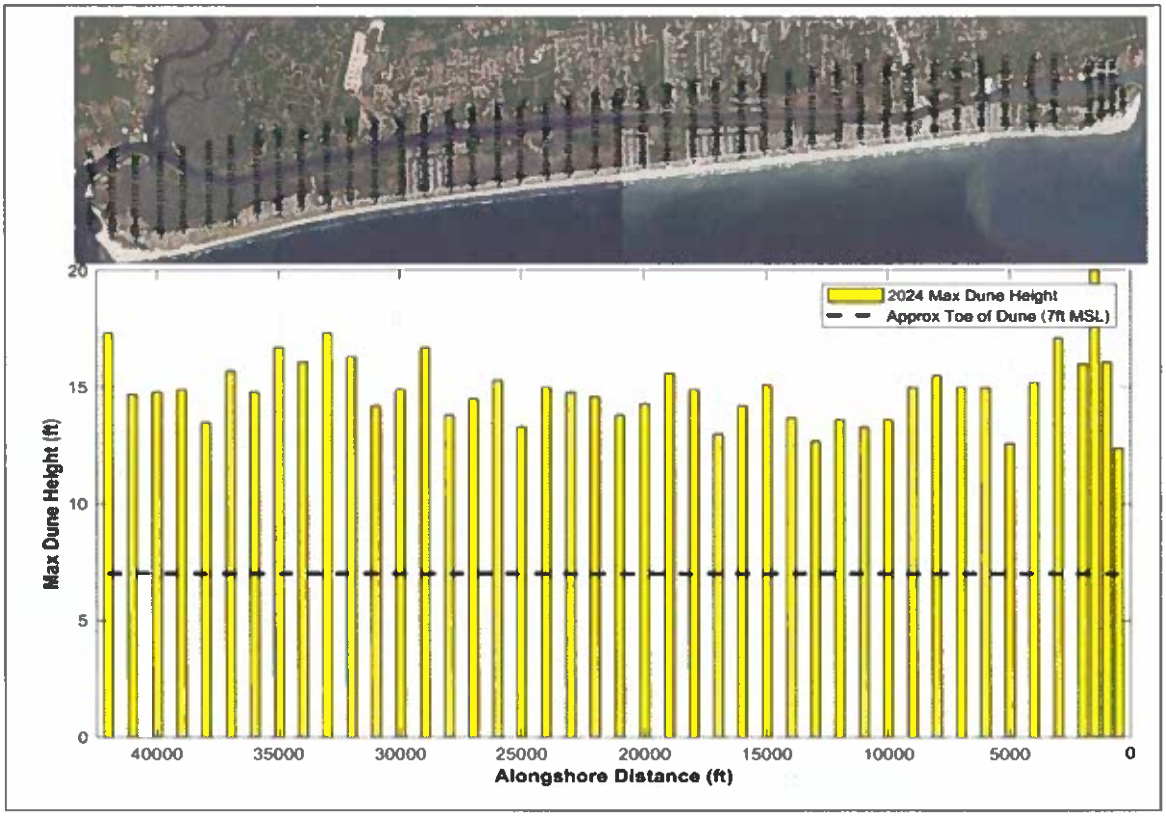

Figure 3-13. Maximum 2023 Dune Height. Using 7 ft NGVD as the dune base, dunes are generally 5' to 8' high.

3.4 HISTORICAL ANALYSIS

Figure 3-14 presents an approximate 24-year MHW shoreline comparison using 2000 and 2024 survey data. The 2000 survey represents a significantly erosional condition. A general accretional trend of 50 to 220 ft is exhibited for the MHW shoreline between 2000 and 2024 (not including the more variable inlet shorelines and east end nourishments).

The most recent North Carolina Division of Coastal Management (NCDCM) long-term background erosion rates from 2019 are included in Figure 3-14 for comparison purposes (DCM assigns a minimum long-term erosion of -2 ft/year). DCM 2019 erosion rates consider recent fill activities and, therefore, reflect lower erosion rates. This is a benefit in terms of reduced setback distances for several areas of the island (when compared to the older 2004

or 2011 DCM erosion rates). The 2019 DCM erosion rate was converted to the same time span (January 2000 to April 2024) as the survey data in Figure 3-14.

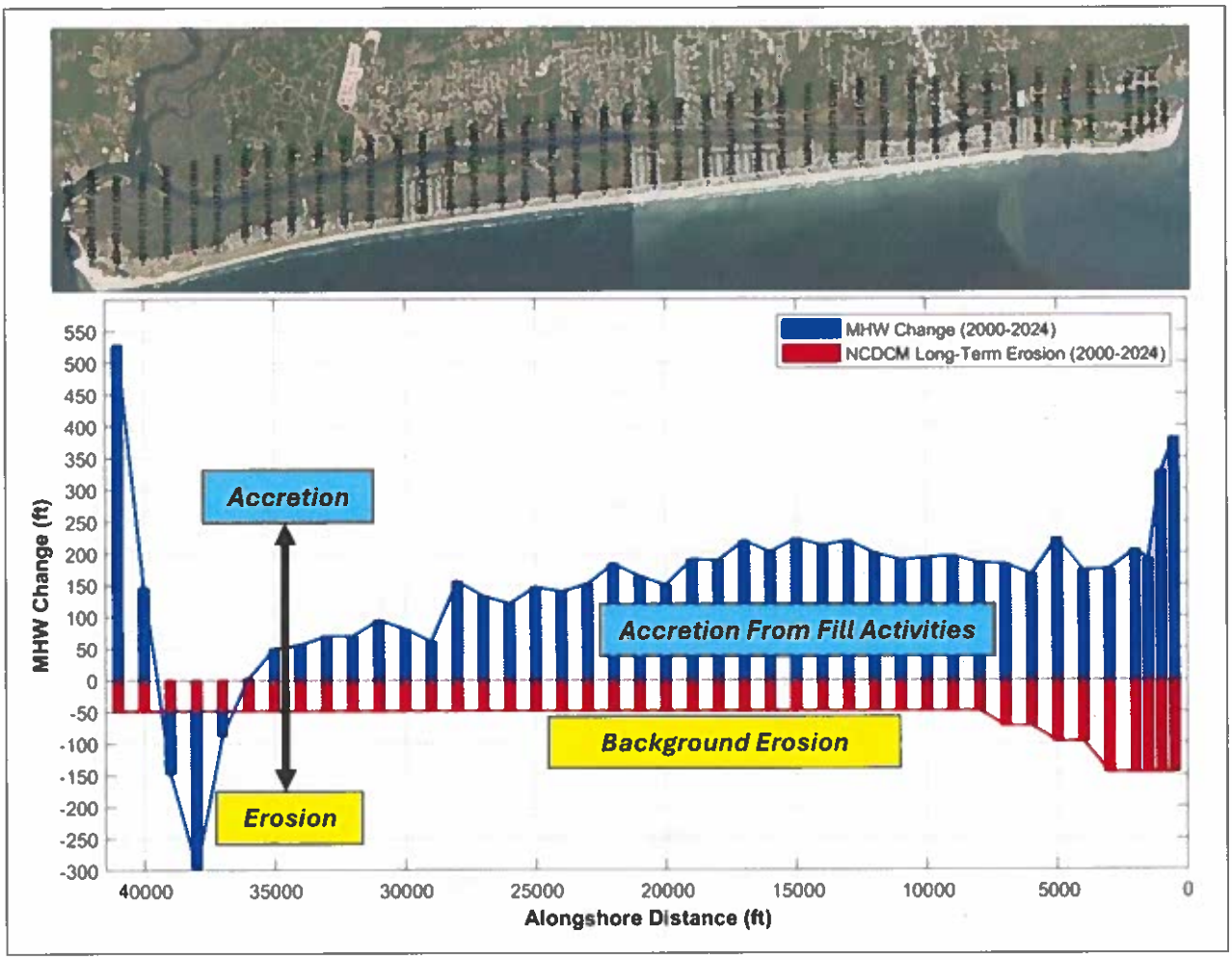

Figure 3-14. MHW Change from 2000 to 2024 Compared to DCM Background Erosion for the Same Period

Table 3-4 presents average MHW change by reach over the last 24 years. Results show that Town and USACE fill and dune enhancement activities have been successful in combating erosion. The 2017 CRP and the recent 2022 CRR were constructed with this goal in mind.

As a result of the Central Reach nourishments the Town East and Pier Reaches exhibit a large increase (~200 ft) in MHW change over the last 24 years, excluding inlet reaches. Similarly, the USACE East and Town West reaches show large increases (~144 to 184 ft),

and an increase is observed in the West Area as well from progression of the 2017 nourishment.

Table 3-4. Historical MHW Shoreline Change by Reach (2000 to 2024)

Reach Averages	Stations Included	Historical MHW Change (2000 to 2024) (ft)
LWF Inlet	5 to 15	+299.9
USACE East	15 to 40	+184.1
Town East	40 to 150	+196.6
Pier	150 to 190	+204.1
Town West	190 to 290	+144.6
West Area	290 to 380	+9.9
Shallotte Inlet	380 to 420	+57.8
Central Reach	40 to 290	+175.3

Figure 3-15 compares a 1993 aerial of Holden Beach with a 2024 aerial. The 2024 MHW line is shown on both aerials for comparison purposes. Figure 3-15 clearly shows that the overall health of the Holden Beach shoreline is significantly better than it was decades ago.

3.5 OAK ISLAND TRANSECTS

The Town has been collecting additional survey data on the western end of Oak Island to establish baseline conditions for this area. Additionally, because regional sediment transport is from east to west, any changes in this area have the potential to affect Holden Beach shorelines (i.e., downdrift). Surveying was needed because Oak Island only performed annual surveys down to the mean low water (MLW) from 1998 to 2013, which is not sufficient to completely capture sediment movement. More recently, Oak Island has conducted surveys to depth-of-closure (DOC).

Oak Island monitoring transects are shown in Figure 3-16. As with the Holden Beach inlet transects, the Oak Island inlet transects 1 through 4 (i.e., not shoreline perpendicular) are excluded from some volume calculations. The west end of Oak Island has more development closer to the active beach than the west end of Holden Beach (where the dune system is up to 600 feet wide) and, therefore, is more vulnerable to short-term erosional episodes (both west ends are historically stable/accretional in the long term).

Figure 3-15
1993 and 2024 Aerial Comparison with 2024 Mean High Water (MHW) line.
2024 aerial and 2024 MHW Line shows overall accretion in comparison wth 1993 conditions.

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Similar to the inlet-influenced transects on the west end of Holden Beach, large variation is typically exhibited for Oak Transects 1 through 4. Oak Transects 5 and 6 are transitional (i.e., partially inlet-influenced), while Oak Transect 7 is generally removed from inlet effects and has historically shown less variability and more stability.

The Town of Oak Island completed their "FEMA Phase II: Hurricane Florence Nourishment Project" in the spring of 2022 around the same time of the CRR project on Holden Beach. This was a large nourishment project (~770,000 cy) to restore material lost from recent hurricanes and included placement of sand along the western half of the Town of Oak Island's engineered beach and the placement ended just west of Transect 6 (see Figure 3-16). Additionally, the USACE LWFIX inlet dredging project placed material on Oak Island's west end in the winter/spring of late 2022/early 2023, which in the past had solely been used to replenish the habitually eroding east end of Holden Beach. The project is estimated to have placed approximately 90,000 cy on the Oak Island west end based on information provided on the Town of Oak Island's website.

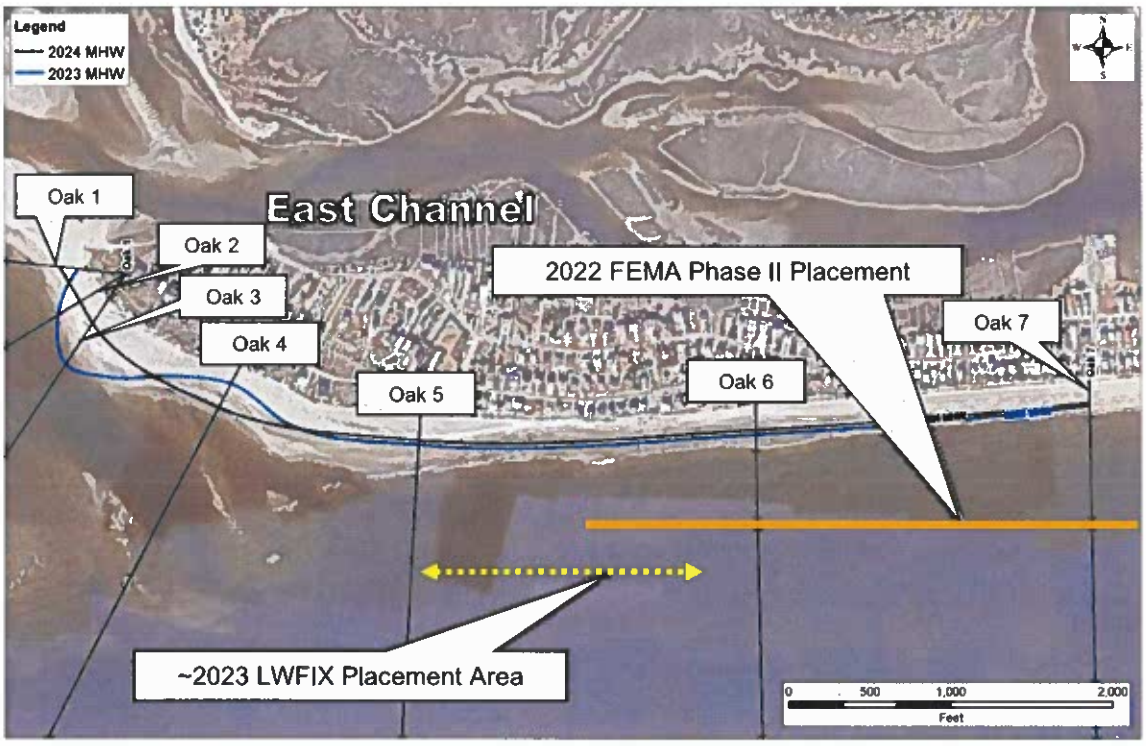


Figure 3-16. Oak Island Transects and approximate 2022 FEMA Phase II Renourishment Placement Location (western taper) Shown with 2024 MHW (black) and 2023 MHW (blue) Lines. "Oak 2" and "Oak 3" transects begin at the same location as "Oak 1." 2023 USACE LWFIX Placement Location also Shown for Reference. (January 2024 aerial shown).

As Figure 3-16 shows, Oak Island Transects 6 and 7 are located within the western taper of the FEMA Phase II Renourishment and show the MHW line eroded slightly over the past year. Transects 1-5 are downdrift of the 2022 and 2023 nourishment templates and showed a slightly erosional MHW over the past year, though with some variability, likely due to spreading and inlet related effects (shoal movement).

Table 3-5 presents the volume changes for the Oak Island transects between the 2023 and 2024 surveys, and Table 3-6 presents the annual MHW shoreline changes since the spring 2012 survey. Oak Transects showed high variability at almost all transects in terms of volume change and MHW line change. Transects closer to the inlet (transects 1-3) and transect 6 showed the largest change in volume from the dune to the -20 ft contour DOC. Of the seven Oak transects, Oak transect 1 showed overall accretion from the dune to the DOC, which was also reflected in a positive change in MHW (movement seaward). Oak transect 4 also experienced seaward MHW movement (accretion), observed through an increase in volume from the dune to the -5 ft contour and minimal change in volume from the dune to the DOC. Other Oak transects (2-3 and 5-7) showed a decrease in volume from the dune to the -5 ft contour, reflected by landward movement (erosion) of the MHW shoreline. Oak transects 5-7 show the lowest variability in MHW and volume change, as expected as they are less influenced by inlet dynamics than Oak transects 1-4.

Town staff and ATM will continue to follow volume and shoreline changes and any upcoming nourishments along the western end of Oak Island since these have the potential to affect LWF Inlet and Holden Beach.

Table 3-5. Oak Island Transect Volume Analysis from 2023 to 2024

Station	Distance to Next Monument (ft)	Volume Change (cy/ft) (Dune to -20 ft*)	Volume Change (cy/ft) (Dune to -5 ft)	Notes
Oak 1	0	47.0	42.5	LWF Inlet
Oak 2	0	-25.1	-21.9	LWF Inlet
Oak 3	890	-257.4	-141.6	LWF Inlet
Oak 4	1100	-7.0	20.7	LWF Inlet Shoulder
Oak 5	2000	11.6	-8.8	Oceanfront perpendicular
Oak 6	2000	-28.2	-21.7	
Oak 7	-	1.6	-11.8	

Table 3-6. Oak Island Transect MHW Change

Transect	2012-2013 MHW Change (ft)	2013-2014 MHW Change (ft)	2014-2015 MHW Change (ft)	2015-2016 MHW Change (ft)	2016-2017 MHW Change (ft)	2017-2018 MHW Change (ft)	2018-2019 MHW Change (ft)	2019-2020 MHW Change (ft)	2020-2021 MHW Change (ft)	2021-2022 MHW Change (ft)	2022-2023 MHW Change (ft)	2023-2024 MHW Change (ft)
Oak1	65.4	-51.9	331.3	-224.8	-103.7	-68.6	90.8	89.1	-235.6	27.6	-125.7	118.9
Oak2	-432.8	105.9	87.0	-27.0	-168.1	-26.4	-8.8	112.4	-265.2	180.2	-48.3	-159.8
Oak3	-338.2	19.4	302.1	-371.5	-57.6	84.4	-155.6	145.9	-184.4	68.8	157.9	-302.9
Oak4	-75.4	-51.9	-134.4	91.1	-242.8	69.7	89.4	-71.9	-198.3	118.9	-45.7	164.6
Oak5	-91.7	-12.6	94.3	-64.6	49.7	-110.8	102.6	-131.4	108.0	6.0	-60.8	-28.0
Oak6	-7.5	-4.0	163.1	-68.9	-13.1	-112.9	78.3	-115.4	79.1	31.4	4.5	-29.3
Oak7	13.7	14.0	-16.9	37.1	-15.7	-48.6	-26.0	4.8	-12.0	102.9	-14.6	-16.9

4.0 SUMMARY

The Holden Beach shoreline has historically exhibited moderate erosion rates (apart from the inlets). As a result, the Town has instituted a nourishment and beach management program to offset this erosion. Dating back to January 2000 (approximately 25 years), the Town and the USACE have placed an average of approximately 230,000 cy/year on the beach. This rate of sand placement has been effective at staying ahead of long-term background erosion.

Holden Beach has suffered significant erosion and damage to the upper beach and dune systems from hurricanes over the years. Similar to "engineered beach" mitigation projects following Hurricanes Hanna (2008), Irene (2011), and Matthew (2016), FEMA assistance was implemented following Hurricanes Florence (2018), Michael (2018), Dorian (2019) and Isaias (2020) which resulted in the Central Reach Reimbursement (CRR) project that occurred in the Winter/Spring of 2022. The CRR project placed a total of about 1.54 mcy of sand primarily funded by FEMA mitigation to replace the Central Reach sand lost in the "engineered beach" that was directly attributed to hurricanes where FEMA was involved. Two offshore borrow areas were used for the CRR nourishment effort.

The 2023 hurricane season was mostly mild for Holden Beach overall. No significant losses directly attributable to Hurricane Idalia were quantified, though the most recent 2024 annual survey reflects beach erosion across most of Holden beach. Additional survey analysis for the 2024 hurricane season will also be included in next year's annual monitoring report. In addition to hurricane activity, off-season storm and surge events have also impacted the Town and will be monitored.

Despite hurricane and storm activity affecting the Holden Beach shoreline, the Town's beach management efforts, including the 2017 Central Reach Project, the 2022 CRR project and LWFIX projects, have helped to provide a significant buffer during these extreme conditions. As a result, a relatively wide pre-project shoreline was still present to provide a good cumulative base prior to the 2022 beach fill projects, and conditions have significantly improved as a result of the large-scale CRR project and USACE LWFIX project.

The most recent annual shoreline survey occurred in April 2024, which represents the 2-year post-project survey for the 2022 CRR project. **Site visits and review of the latest survey data show a healthy beach and dune system with significant dune growth along most of the island (due to nourishment activity and the Town's vegetation and sand fencing program).** The April 2024 survey shows sediment movement to the nearshore to approximately the -20 ft contour (depth-of-closure) and within the littoral sand-sharing system. In comparing this survey to the April 2023 survey, the entire island experienced a net loss of approximately 458,000 cy out to the -20-ft DOC limit. While this loss is higher than last year, the beach system is still quite healthy and the nourishments have performed as expected. Approximately 296,000 cy of loss occurred within the Central Reach (~65% of the total loss) where the 2022 CRR project took place. Erosion in this area can primarily be attributed to nourished beach profiles equilibrating and longshore drift moving sand from the nourishments westward and to the nearshore (-12 to -20 feet of water). Future beach surveys will monitor the progress, equilibration, lateral and nearshore spreading of nourishment material. Note that sand movement to the nearshore (-12 to -20 ft depths) is beneficial and valuable in reducing wave energy prior to reaching the dry beach and still well within the littoral sand-sharing system.

Areas most likely experienced erosive conditions due to winter storms bringing in elevated surge and wave events, causing erosion, though no major hurricanes were recorded in the area between the annual surveys. The upper secondary berm along with the vegetation and sand fencing efforts help to enhance the dune system buffer, but these areas can still experience damage during high-water events.

From a shoreline contour perspective, approximately the center 5 miles of island (Central Reach STA 40+00 to 290+00) exhibited an average MHW erosion of -16 ft between surveys. Due to longshore drift westward and the equilibration of the CRR material, the MHW shoreline has receded to a more stable position. Similar to the volumetric analysis, the MHW shoreline exhibited a mostly erosional trend across the entire island. The western portions of the island exhibited a slightly more stable position than the eastern side, as can be expected with further equilibration of nourishment material. This natural process is expected after nourishment activities. The observed MHW erosion closer to the inlets is likely because of recent wave and water level activity and inlet dynamics.

In comparing the April 2024 survey with the January 2000 survey (24-year span), the beach width based on the MHW shoreline location is on average approximately 157 ft wider for the entire island now than it was ~24 years ago. This is in part due to large-scale nourishment activities in recent years. The Central Reach Reimbursement project and other future projects of this scale are designed to enhance the beach and dune system which will result in protective, ecological, recreational, and economic benefits.

The Central Reach Reimbursement nourishment project, which was completed in April of 2022, represents the largest nourishment project on Holden Beach (over twice the size of the 2001-2002 USACE 933 project). The CRR project placed ~1.54 mcy of offshore beach compatible sand from Stations 40+00 to 270+00 (~23,000 linear feet of shoreline), mimicking and expanding upon the 2017 CRP. The purpose of the project, which is a component of the Town's comprehensive beach management program, is to provide beach restoration along eroding sections of shoreline sufficient to maintain the island's restored protective and recreational beachfront and natural dune system. The 2024 survey represents the 2-year post-project survey of the nourishment, and continued monitoring will assess the equilibration and movement of the project sand.

The 2024 survey shows equilibration is still taking place and a wide, healthy recreational beach is observed.

ATM and Town staff will continue to evaluate the potential piggybacking and/or use of the 400-ft bend widener for any future USACE LWFIX projects. The next upcoming LWFIX project with placement on Oak Island is scheduled to occur this upcoming spring 2025. The Shallow Draft Inlet (SDI) permitting effort has provided the Town with authorizations to dredge the inner and outer portions of LWF Inlet. These permits essentially allow the Town, with potential financial assistance from the County and State, to perform the same inlet maintenance activities that the USACE currently performs (i.e., LWFIX dredging, outer channel sidecasting).

The Town recently used these SDI permits in 2023 for the first time since obtaining them in 2016, and they remain a potential option for future navigation improvements and beach or nearshore placement. This was an exciting undertaking by the Town for dredging of the LWF inlet outer bar and nearshore placement along the Holden Beach east reach when the

USACE was unable to. A private dredge, the "Miss Katie", performed the work, between May and June of 2023, in lieu of the typical USACE Murden dredge which has been used for previous similar projects. The 2023 Miss Katie project was very successful and paves the way for future project flexibility for LWF outer channel dredging to improve navigation and benefit the Holden Beach shoreline with nearshore placement.

The Corps 50-year coastal storm risk management (CSRM) project evaluation for Holden Beach has determined that the oceanfront and estuarine shorelines do not qualify for the Corps management and funding program. The Holden Beach oceanfront shoreline is essentially too healthy for the Corps metrics (where the analysis includes eroding the beach and identifying at-risk infrastructure). The Corps also has to identify 50 years' worth of sand for their analysis and this is a difficult endeavor considering the nearshore/offshore geology off Holden Beach. ATM has had success identifying 1 to 2 million cubic yard offshore borrow areas and can identify additional offshore borrow areas for future nourishments; however identifying 50 years' worth of nourishment sand is more difficult. On a positive note, the Corps did identify a few additional offshore borrow areas that ATM can further pursue for permitting and design. While federal beach nourishment funding from the Corps is not available to the Town (besides LWFIX related projects), federal beach nourishment funding from FEMA will continue and the Town and ATM have had much success in these FEMA-funded projects. It is recommended that the Town stay the course in this respect to participation in the FEMA engineered beach program responding to major storm events. To this end, ATM is working on developing and submitting a beach nourishment permit application this spring/summer for another major nourishment event (~1 million cubic yards) using an offshore borrow area. This permit will allow the Town to expedite FEMA mitigation following any future major storm events.

In summary, the most recent 2016 North Carolina Beaches and Inlets Management Plan (NC BIMP) report estimated the 2013/2014 Beach Recreation Annual Total Impact Output for Holden Beach at $80.4 million, which accounted for 942 jobs. Additionally, the NC BIMP conducted a study of losses attributed to 50 percent beach width loss and found that, for Holden Beach, the 2013/2014 estimated *annual loss* (including output/sales/business activity) would be $12.6 million. The Town's beach management and maintenance program strives to maintain and enhance this important economic and environmental benefit.

Recommendations for future and ongoing beach management activities include the following actions:

- Continue annual island-wide monitoring with beach profiles
- Continue to coordinate with USACE and NCDEQ on future outer LWF Inlet channel sidecast/hopper dredging and nearshore sand placement
- Continue coordination and support of the State's SDI program and quarterly SDI MOA meetings held by the USACE and NCDEQ/NCDWR (regarding LWFIX, etc.)
- Continue proactive dune enhancement activities (planting, fertilizing, fencing, etc.).
- Work closely with Congressional representatives and lobbyists to assure continued support of future FEMA-mitigation nourishment projects for Holden Beach
- Extend/Modify/Apply for DCM and USACE permits as necessary
- Further analyze and refine offshore borrow areas identified by the USACE 50-year CSRM study
- Continue coordination with BOEM on any additional sand-related data collections 3-8 miles offshore of Holden Beach
- Continue to follow NCDEQ Inlet Hazard Area (IHA) re-analysis and CRC meetings
- Continue to monitor nearby Oak and Ocean Isle projects (as well as any County efforts)

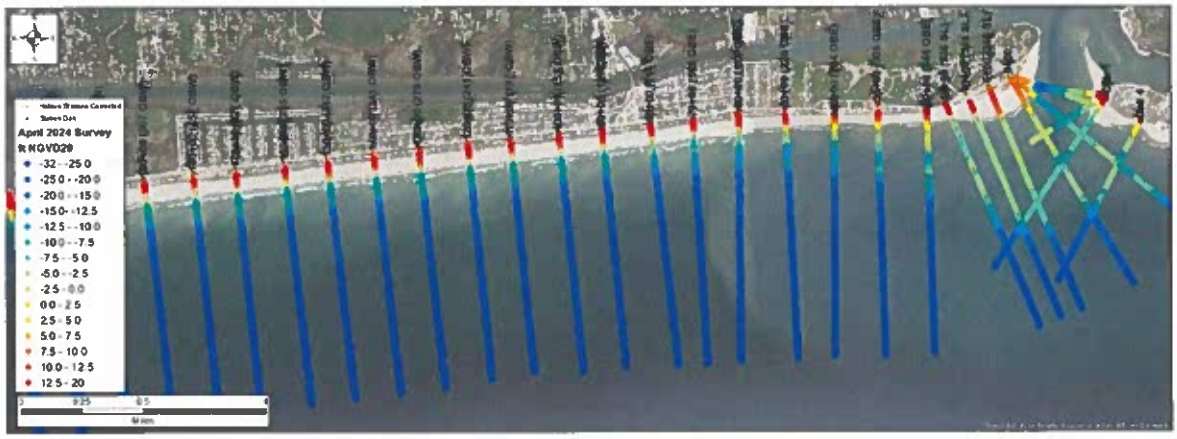
The Town worked proactively with the USACE to maximize the use of the LWFIX borrow area and bend-widener, even before shallow-draft dredging funds were available from the State. With the State SDI dredging fund now available, Oak Island and Brunswick County have expressed increased interest in using LWF Inlet sand resources. Holden Beach is the downdrift beach to LWF Inlet, therefore, the east end of Holden Beach is the most affected and most vulnerable to LWF Inlet processes (including any manmade changes to this system). Town and ATM staff will continue to actively engage in these projects and monitor their potential effects.

Appendix A

Station Profile Analysis

APPENDIX A – ELEVATION PROFILE TRANSECTS

Survey Stationing Figure. Survey points shown with color legend on above figure. Plots below are from east (Lockwood Folly Inlet) to west (Shallotte Inlet). Profile plots are zoomed in to nearshore area (typically from the dune to ~-20ft NGVD depth). Oak Island Transects are at the end of the section. Note "Z" is in ft-NGVD29.

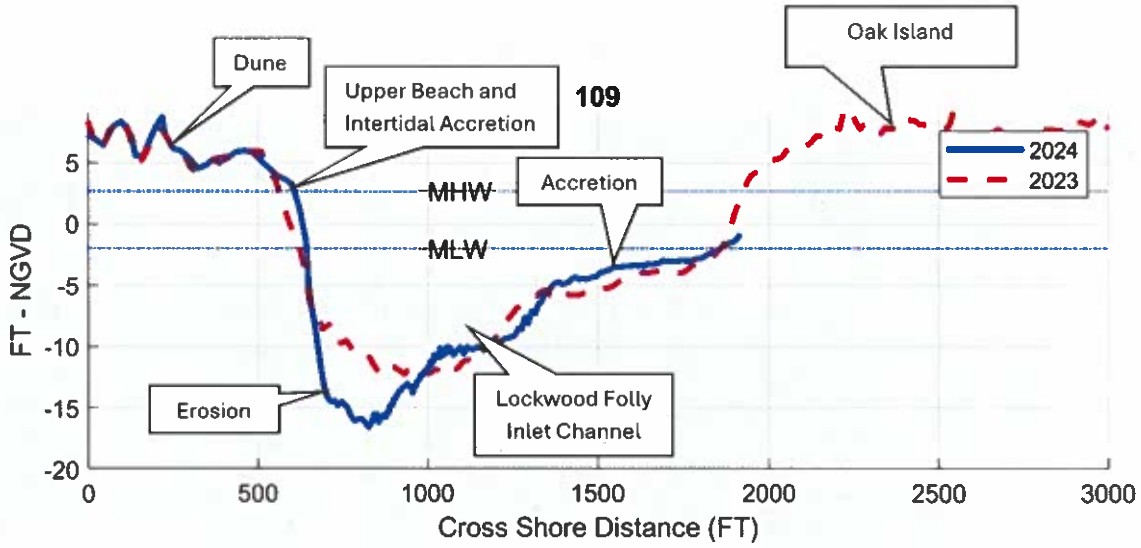


Zoomed in to eastern half of island (station 170+00 is to the left and just east of the pier). Note "Z" is in ft-NGVD29.

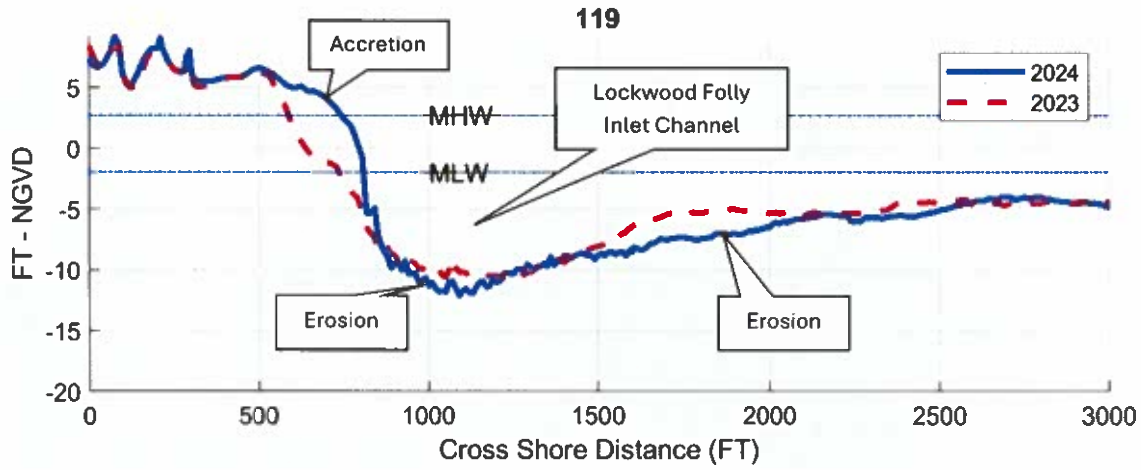
Please Note:

In the following cross sections, the Station Number is shown at the center top of the figure.

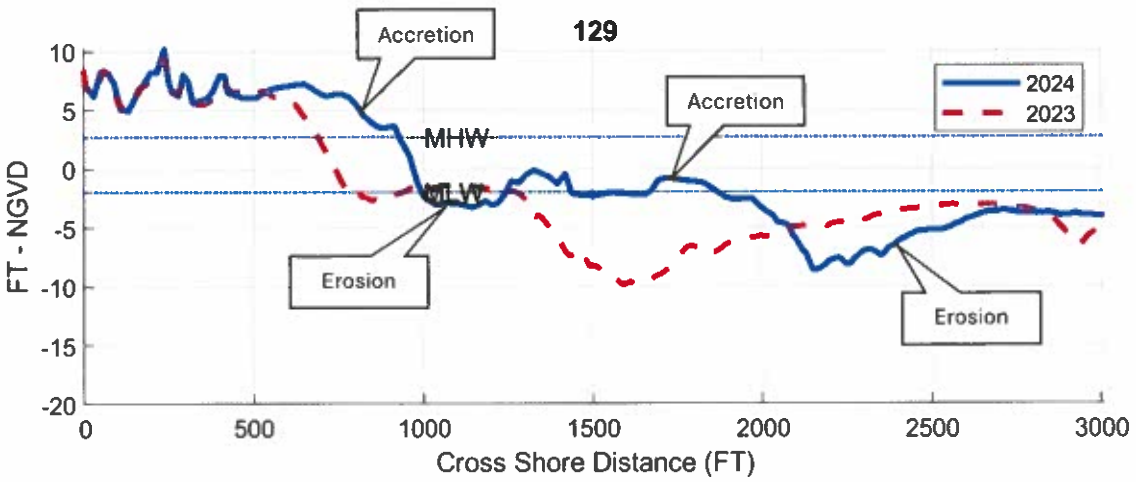
Any notable features are described in "call-outs" or in blue below the figure.



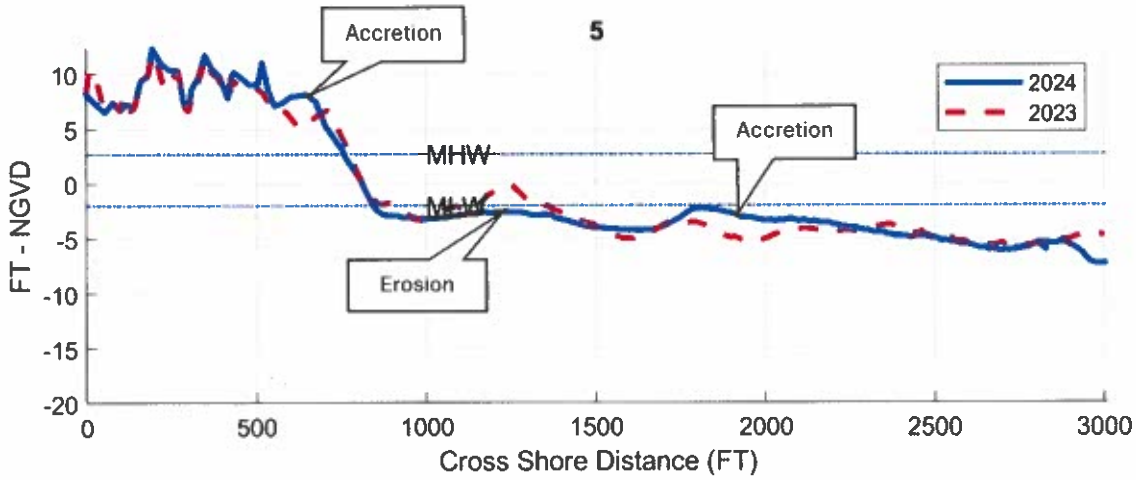
Station 109+00 (far east). Plots typically show from dune (between ~7' and ~15' NGVD) out to ~-20' NGVD. MHW=Mean high water, MLW=mean low water.

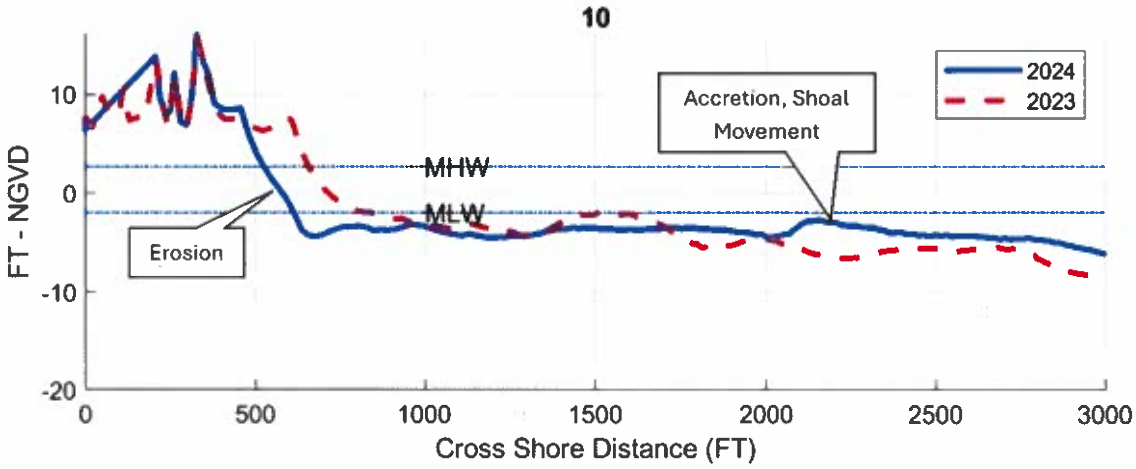


Station 119+00. Upper and intertidal beach showing some accretion. Some erosion of sand offshore is observed adjacent to channel on the Oak Island side; the LWF Inlet channel has become slightly deeper and wider since the 2023 survey.

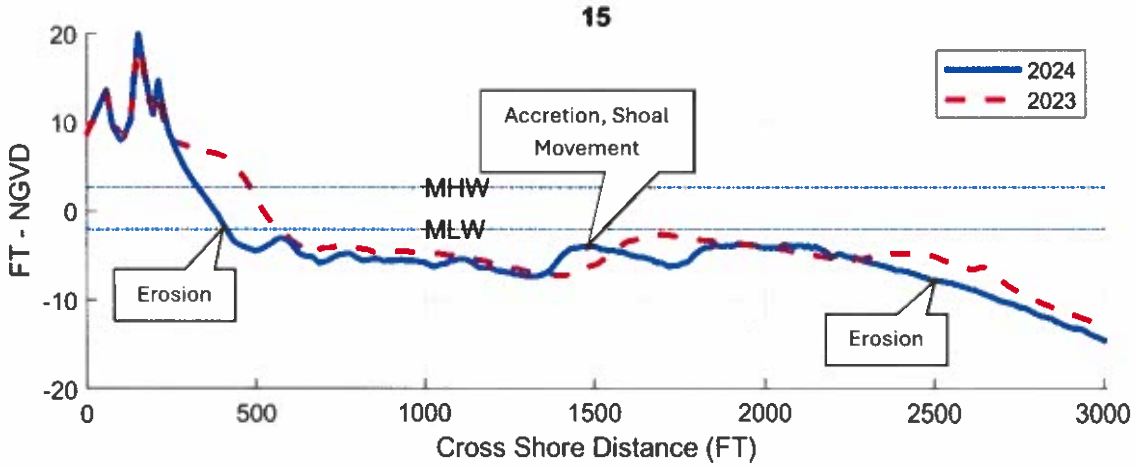


Station 129+00. LWF Inlet Channel. Upper beach and intertidal accretion, accretion in the former inlet channel, and eastward movement of the LWF Inlet Channel is seen since the 2023 survey.

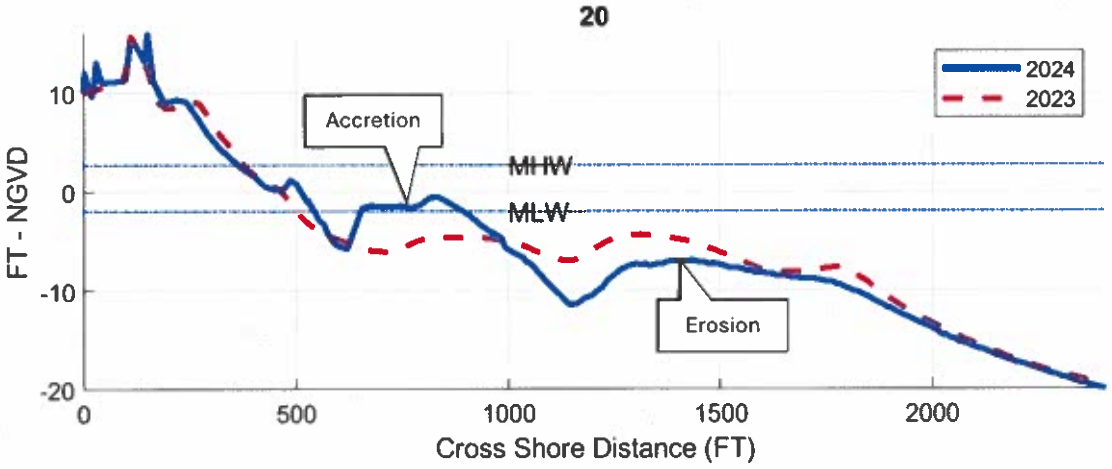




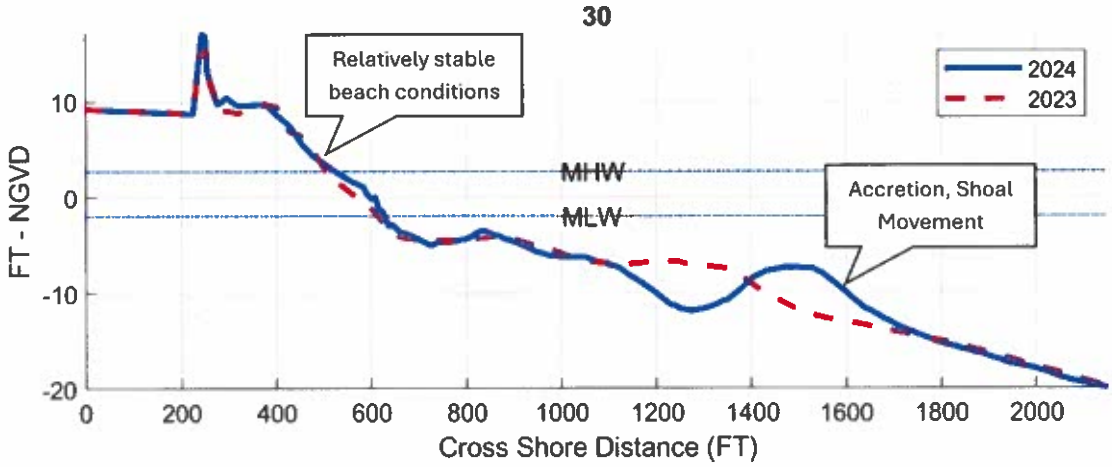
Station 10+00. Upper and intertidal beach erosion and shoal movement seaward has taken place since the 2023 survey.



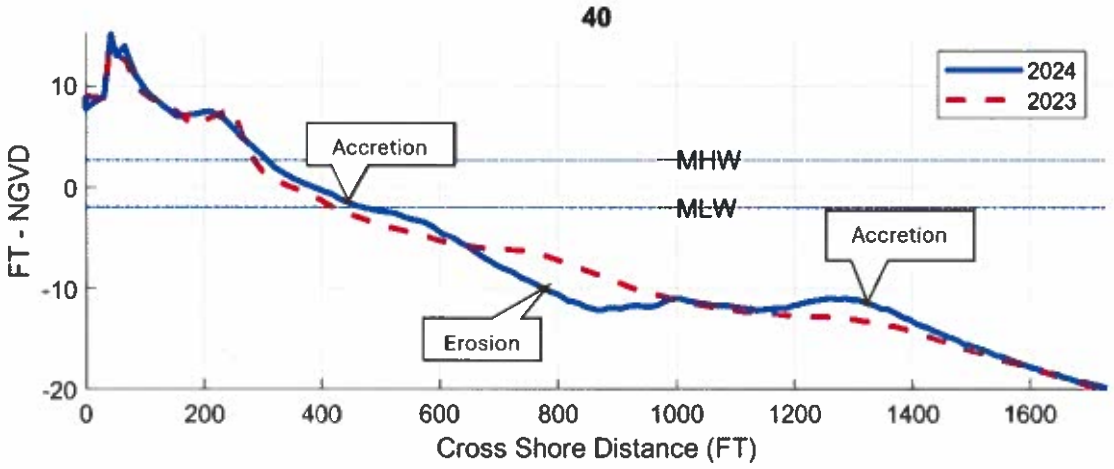
Station 15+00. Upper and intertidal beach erosion has taken place, along with shoal movement landward.

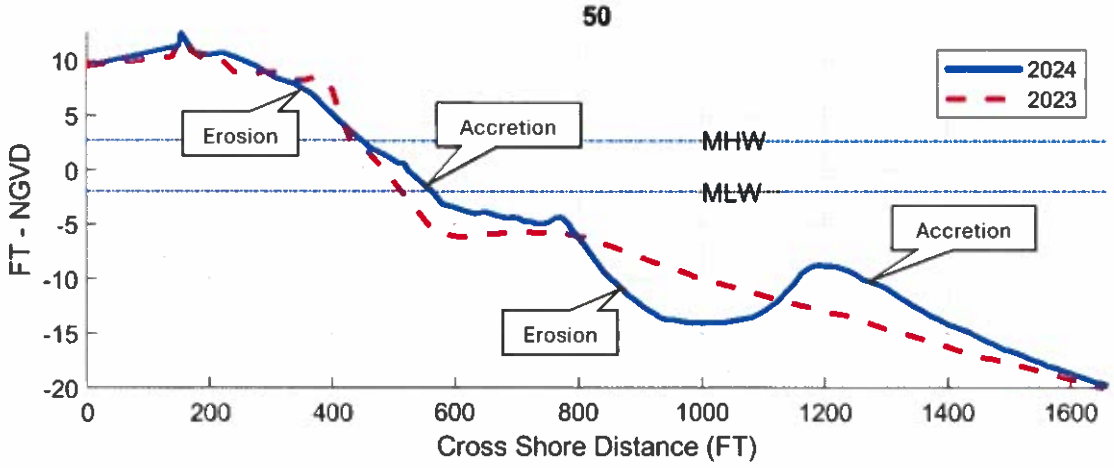


Station 20+00. Some upper beach erosion observed but is relatively stable, indicating equilibration and spreading benefits near the taper of the 2022 LWIFX project. Accretion in nearshore and erosion farther offshore indicate shoal movement landward since 2023 survey.

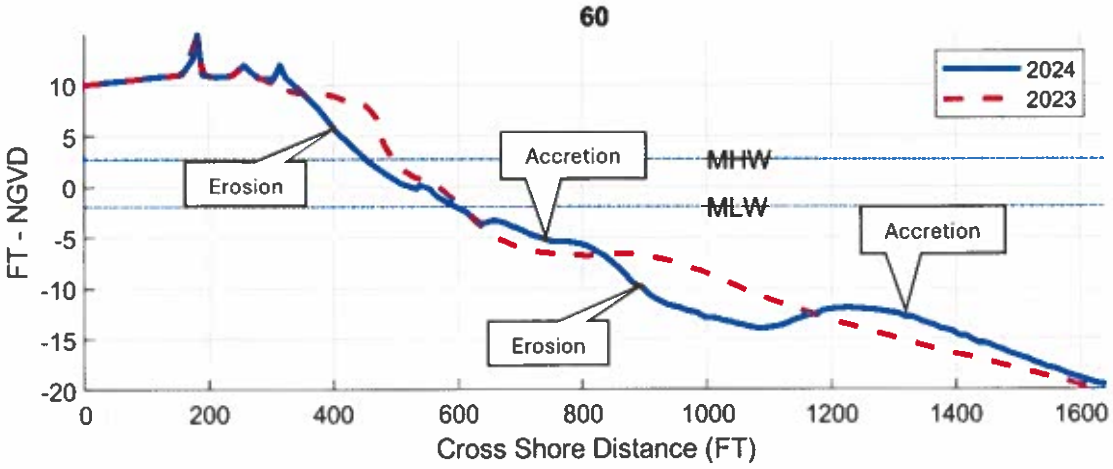


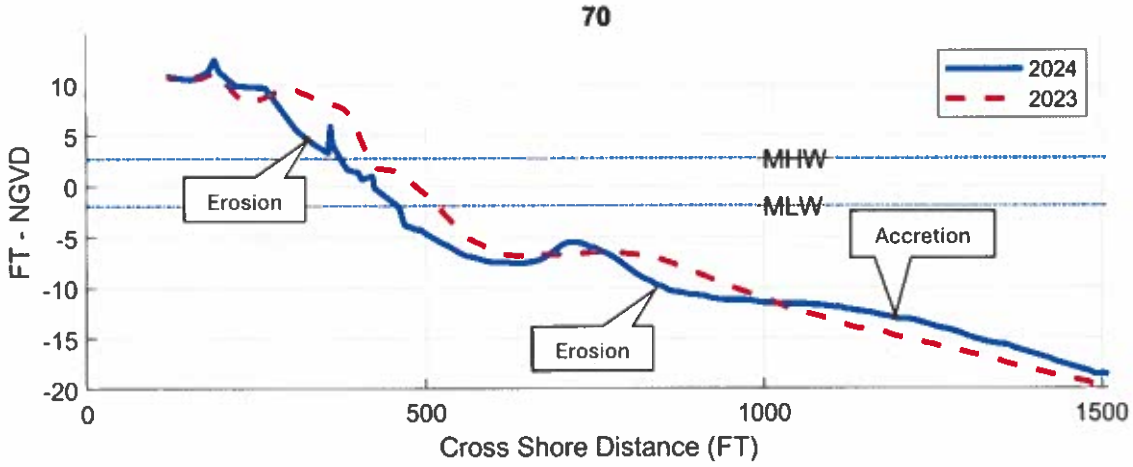
Station 30+00. Upper beach and intertidal area relatively stable, indicating equilibration within extent of the 2022 LWIFX project. Shoal movement seaward observed offshore.

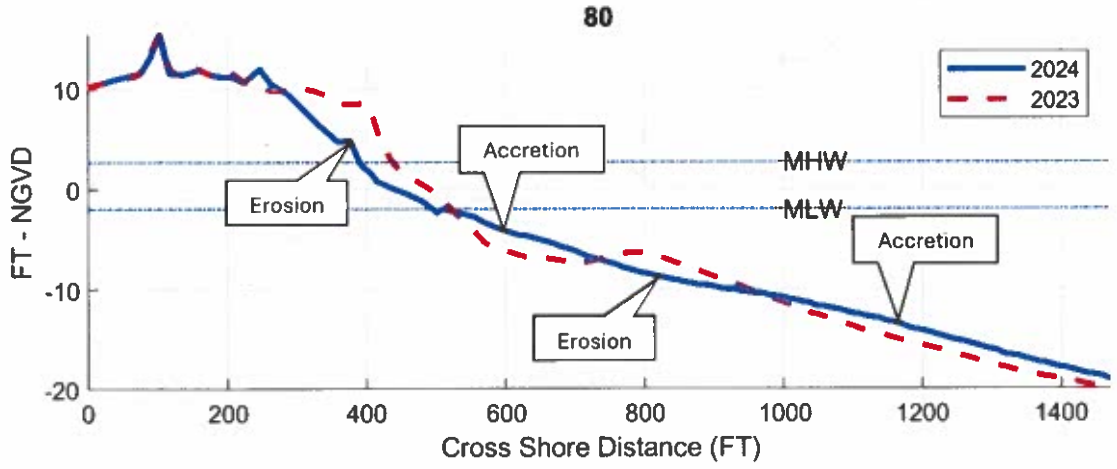


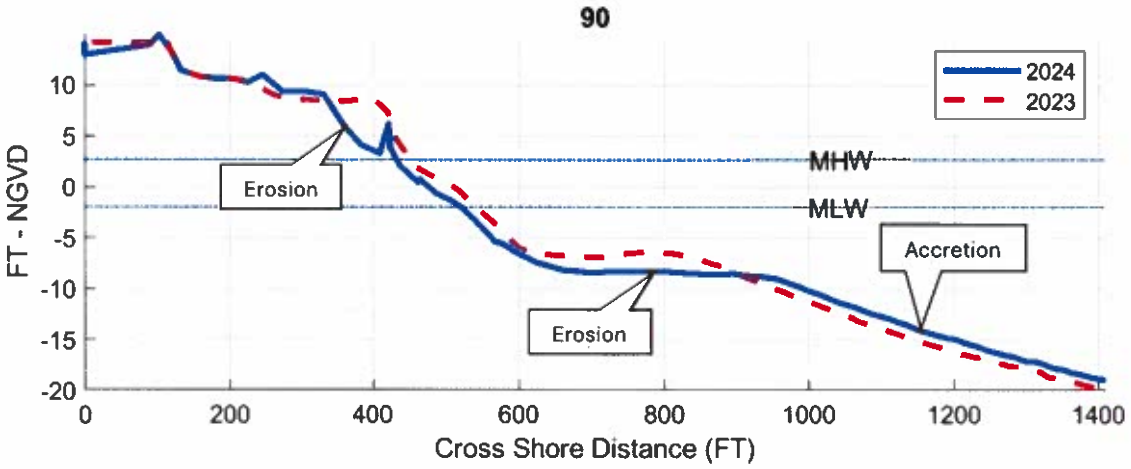


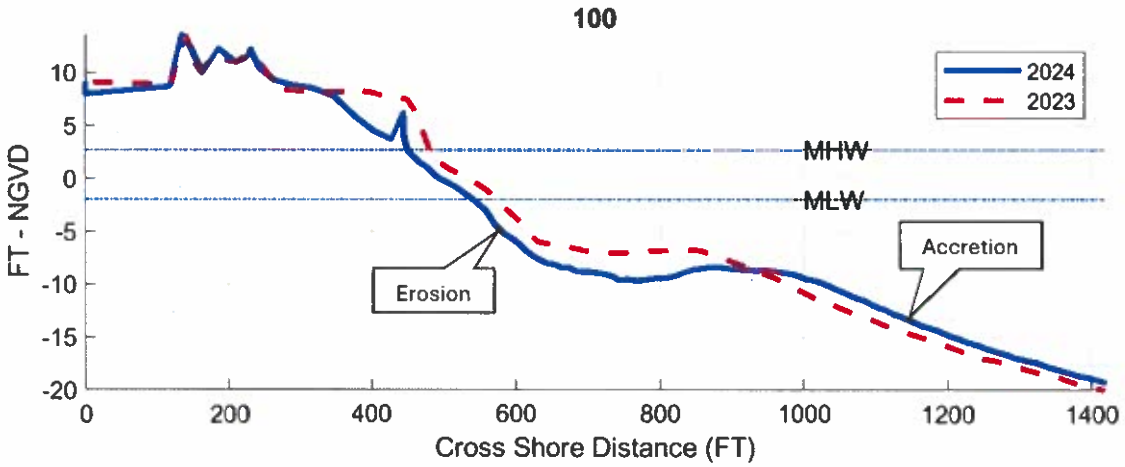
Station 50+00. The Central Reach Reimbursement (CRR) Project was completed in early 2022. Sand placement extended from Station 40+00 to Station 260+00 (ended just east of Station 270+00) and featured a primary berm and secondary berm to promote dune growth. Since the completion of the project, the 2024 surveys show many of the profiles have moved towards an equilibrium beach profile. This is presented as erosion along the beach slope (upper, intertidal and nearshore region) and deposition/accretion farther offshore.

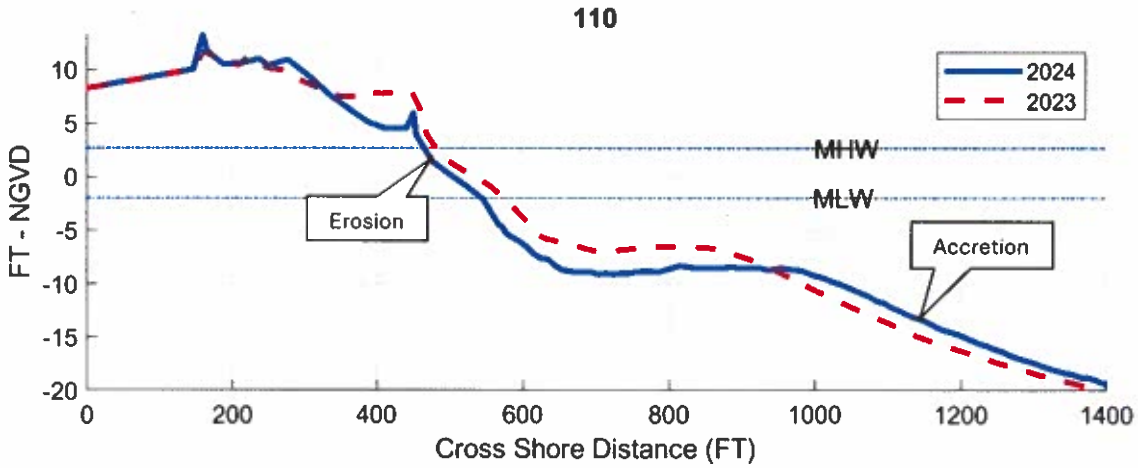

60
2024
2023
Erosion
Accretion
MHW
MLW
Accretion
Erosion
FT - NGVD
Cross Shore Distance (FT)

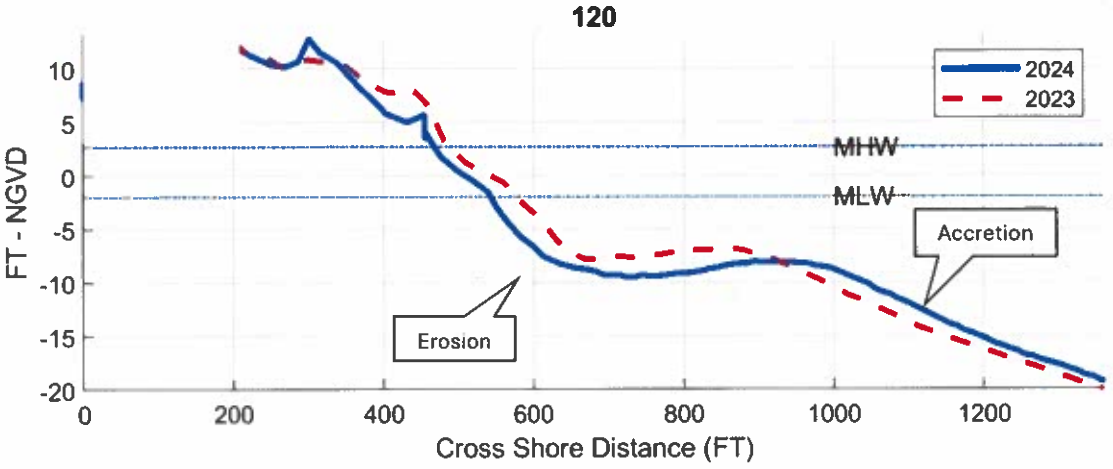

70
2024
2023
Erosion
MHW
MLW
Accretion
Erosion
FT - NGVD
Cross Shore Distance (FT)

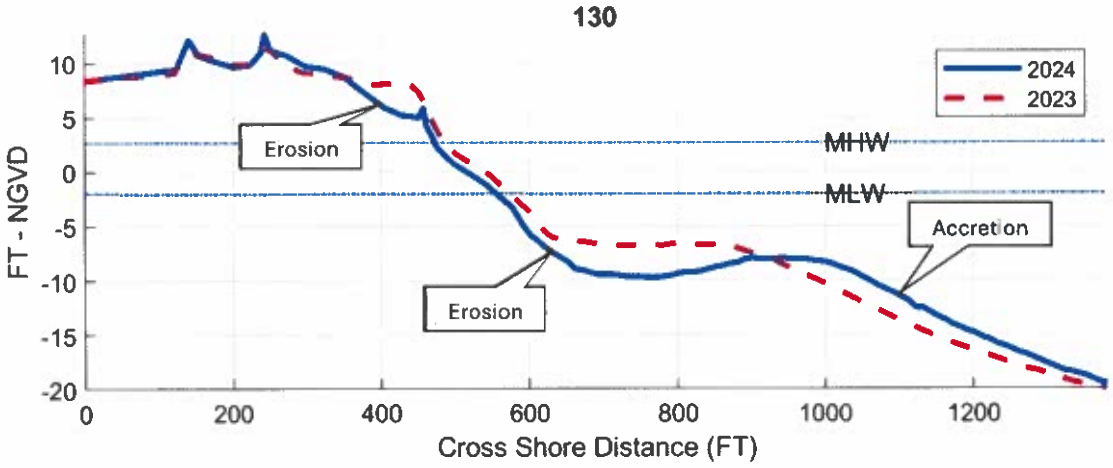

80
2024
2023
Accretion
Erosion
MHW
MLW
Accretion
Erosion
FT - NGVD
Cross Shore Distance (FT)

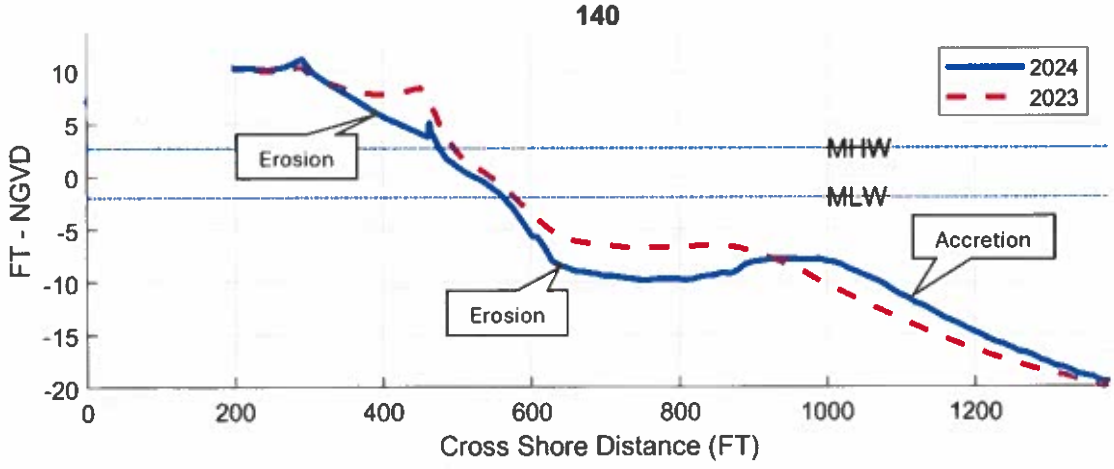

90
2024
2023
MHW
MLW
Erosion
Erosion
Accretion
FT - NGVD
Cross Shore Distance (FT)

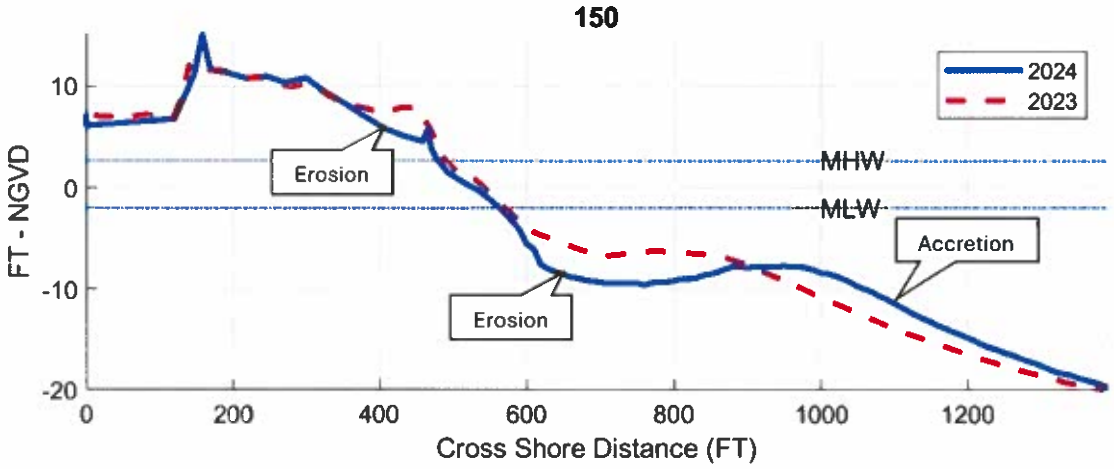

100
2024
2023
MHW
MLW
Erosion
Accretion
FT - NGVD
Cross Shore Distance (FT)

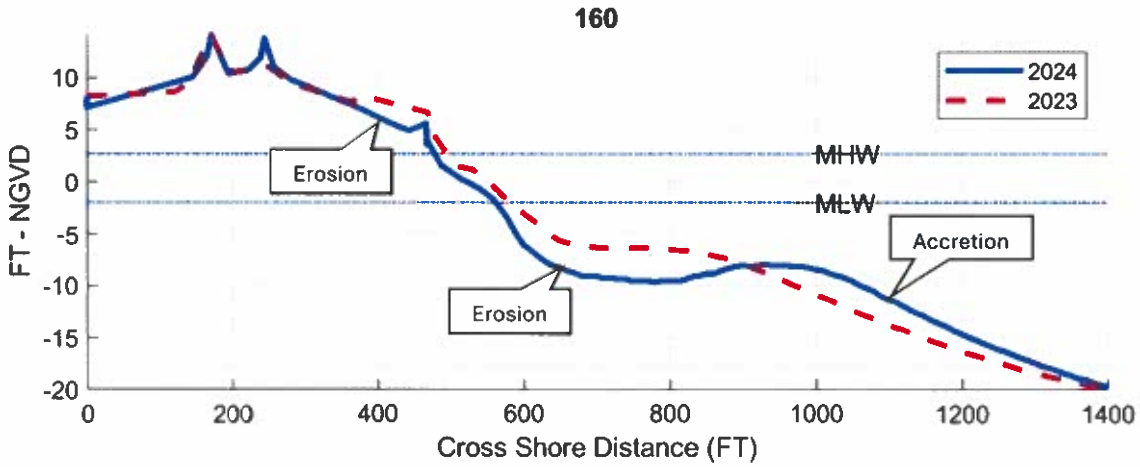

110
2024
2023
MHW
MLW
Erosion
Accretion
FT - NGVD
Cross Shore Distance (FT)

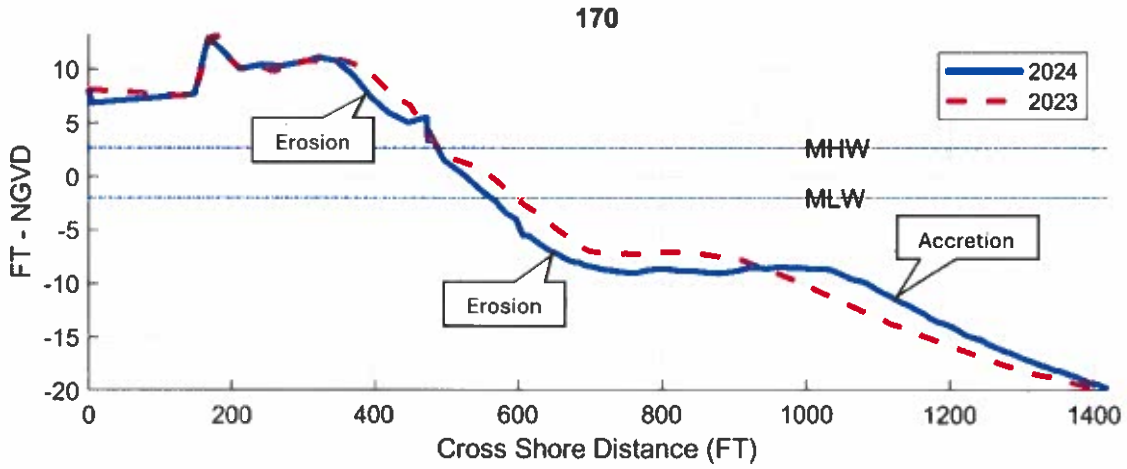

120
2024
2023
MHW
MLW
Accretion
Erosion
FT - NGVD
Cross Shore Distance (FT)

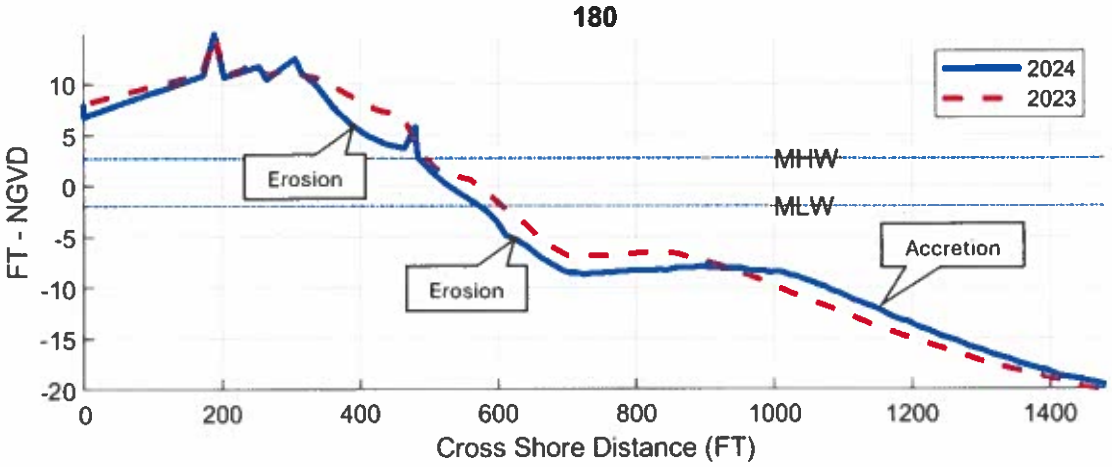

130
2024
2023
Erosion
MHW
MLW
Accretion
Erosion
FT - NGVD
Cross Shore Distance (FT)

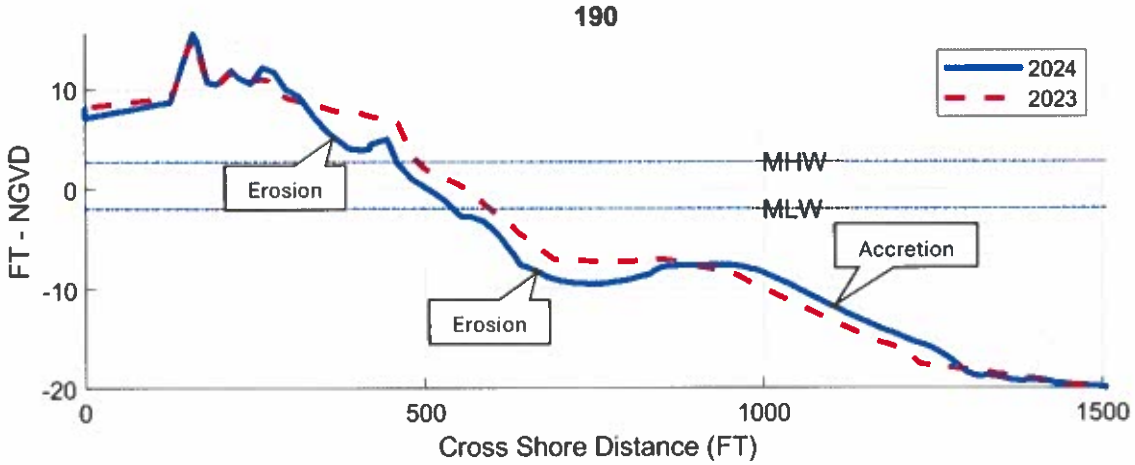

140
2024
2023
Erosion
MHW
MLW
Accretion
Erosion
FT - NGVD
Cross Shore Distance (FT)

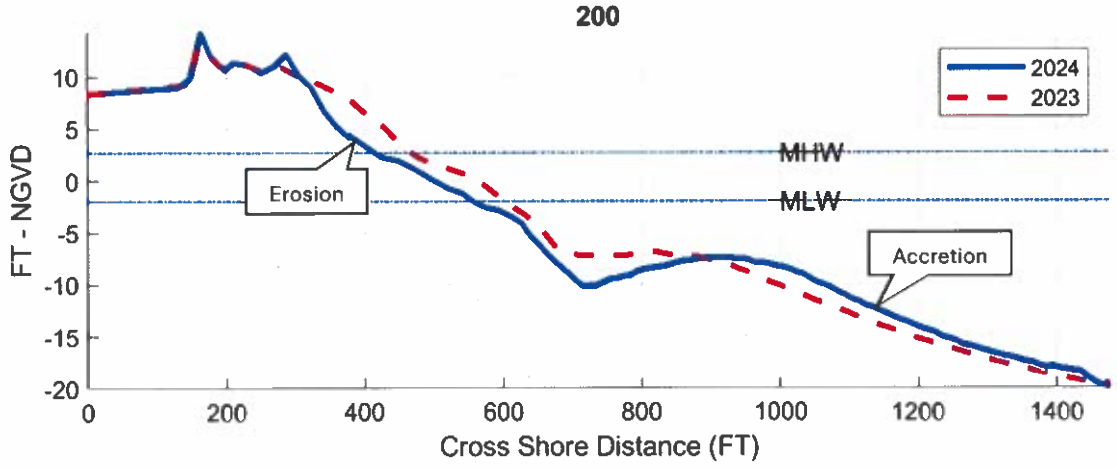

150
2024
2023
MHW
MLW
Erosion
Erosion
Accretion
FT - NGVD
Cross Shore Distance (FT)

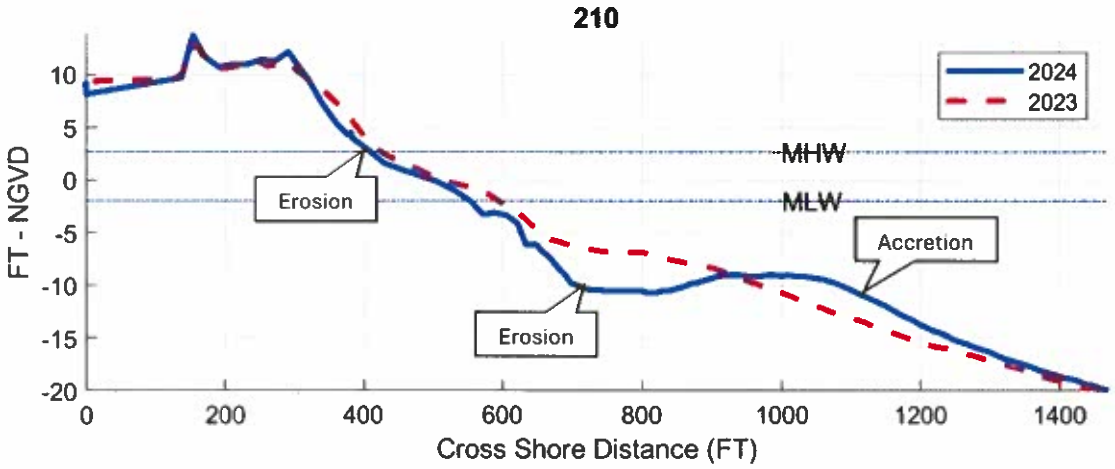

160
2024
2023
MHW
MLW
Erosion
Erosion
Accretion
FT - NGVD
Cross Shore Distance (FT)

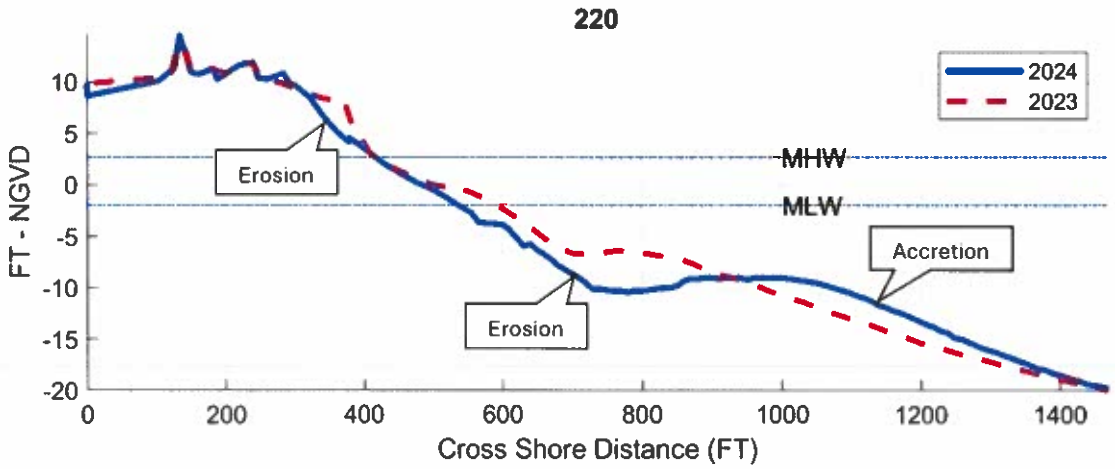

170
2024
2023
MHW
MLW
Erosion
Erosion
Accretion
FT - NGVD
Cross Shore Distance (FT)

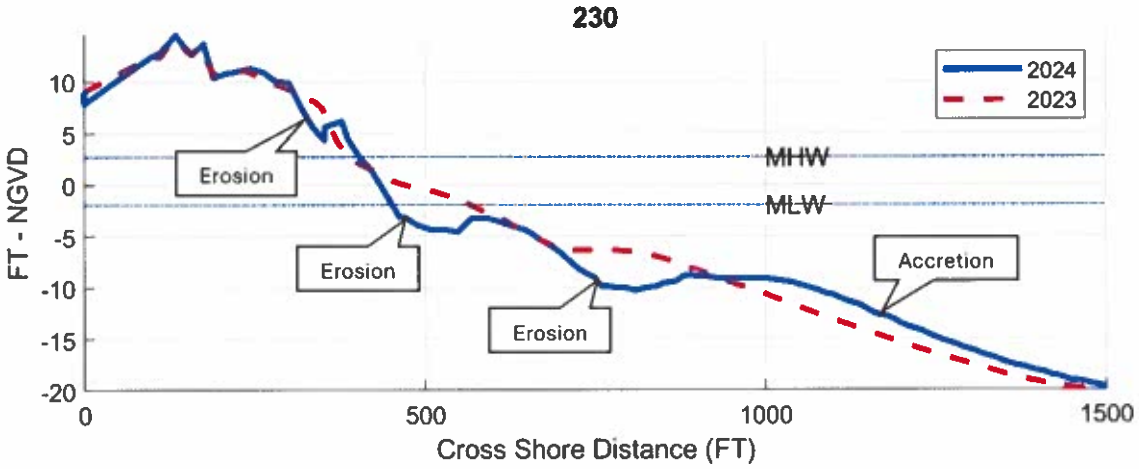

180
2024
2023
MHW
MLW
Erosion
Erosion
Accretion
FT - NGVD
Cross Shore Distance (FT)


190
2024
2023
MHW
MLW
Erosion
Erosion
Accretion
FT - NGVD
Cross Shore Distance (FT)

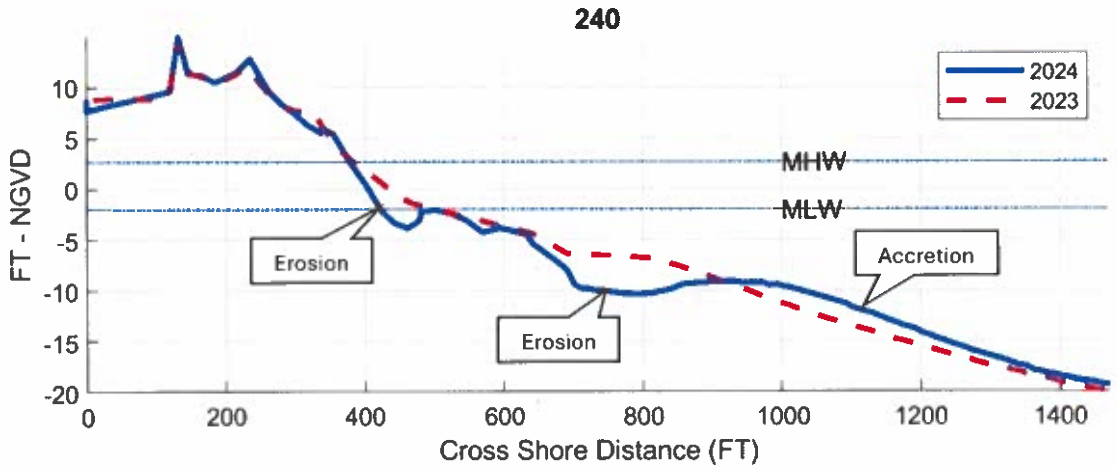

200
2024
2023
MHW
MLW
Erosion
Accretion
FT - NGVD
Cross Shore Distance (FT)

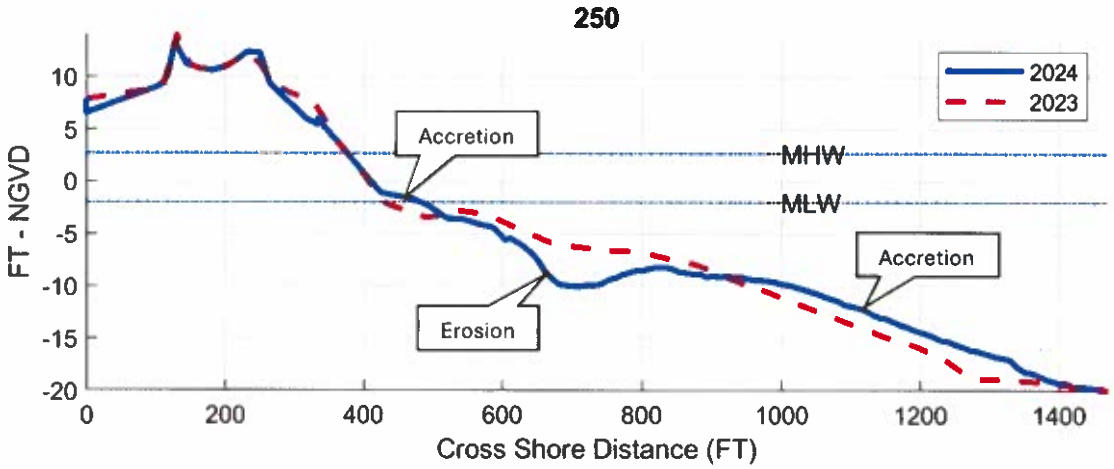

210
2024
2023
MHW
MLW
Erosion
Erosion
Accretion
FT - NGVD
Cross Shore Distance (FT)

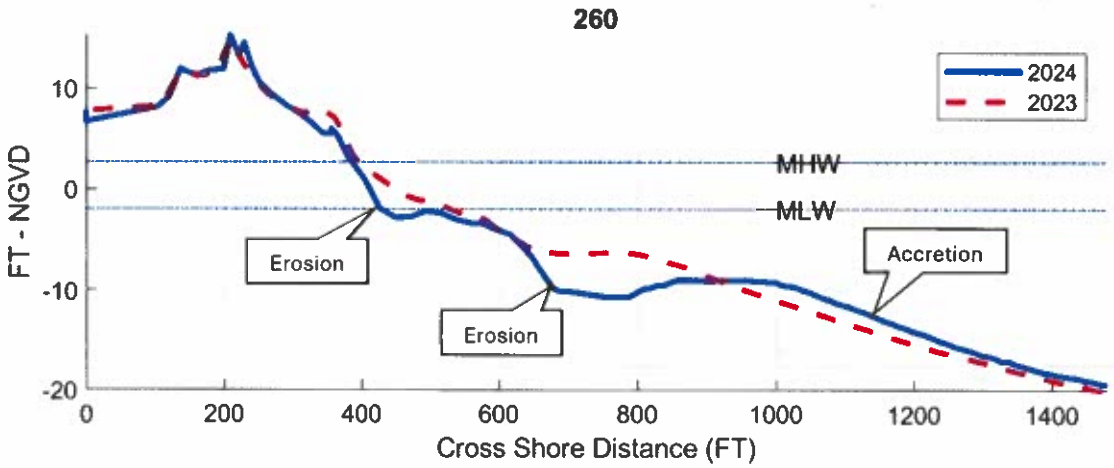

220
2024
2023
MHW
MLW
Erosion
Erosion
Accretion
FT - NGVD
Cross Shore Distance (FT)

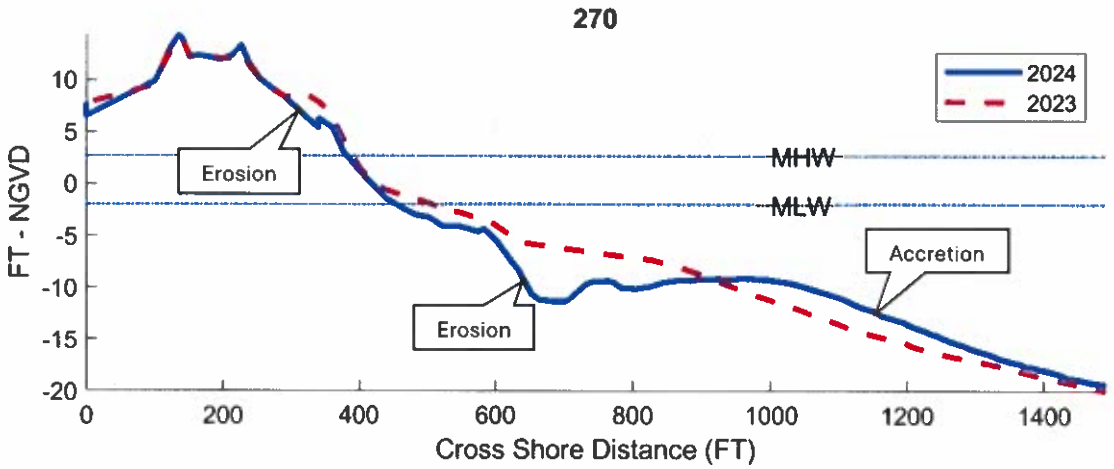


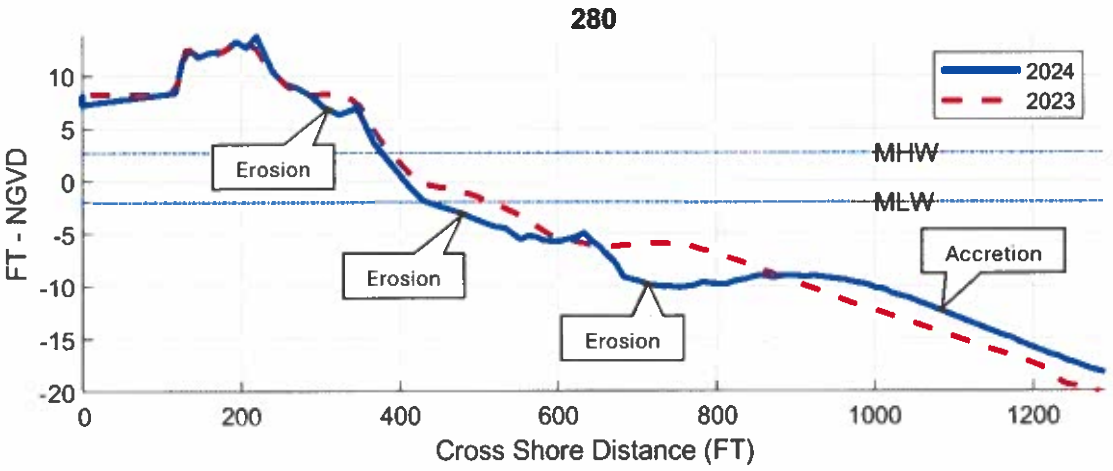
Station 230+00. Approximate west taper of the 2022 CRR project, however, minor fill was placed at Station 260+00. Equilibration of beach fill observed similar to change observed at the other profiles within the CRR template over the past year.

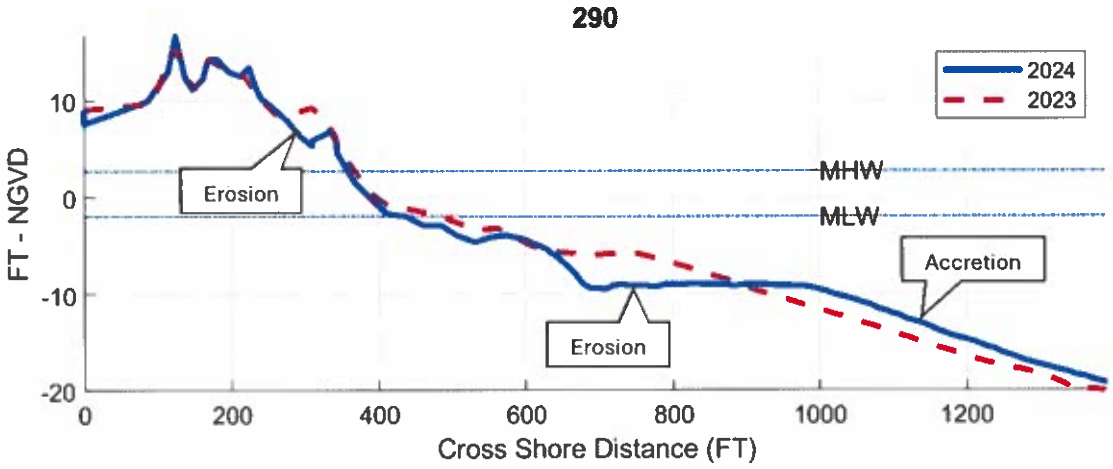


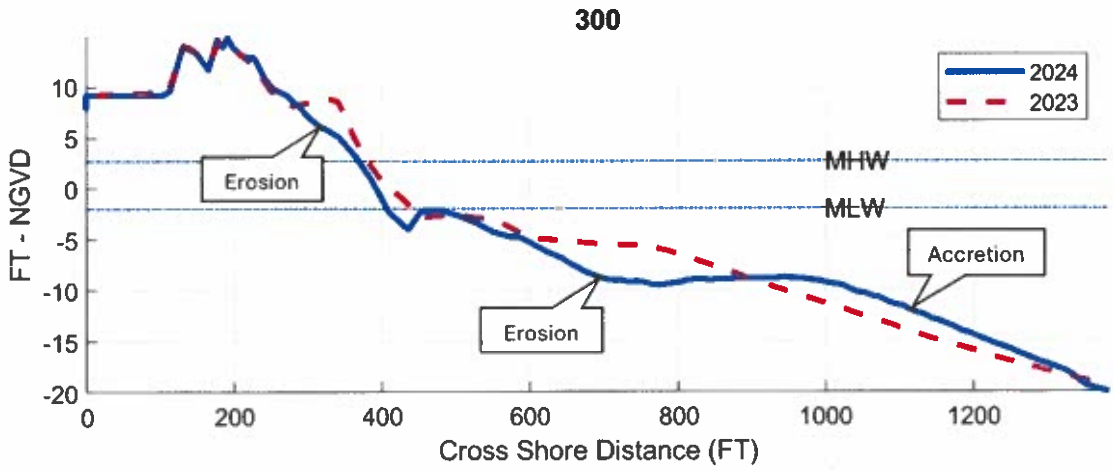

250
2024
2023
Accretion
MHW
MLW
Accretion
Erosion
FT - NGVD
Cross Shore Distance (FT)

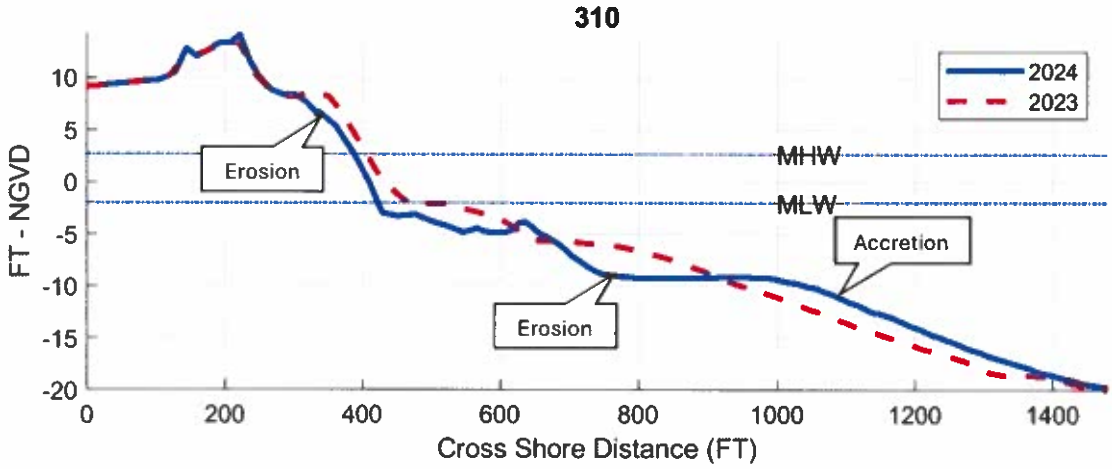

260
2024
2023
MHW
MLW
Erosion
Accretion
Erosion
FT - NGVD
Cross Shore Distance (FT)

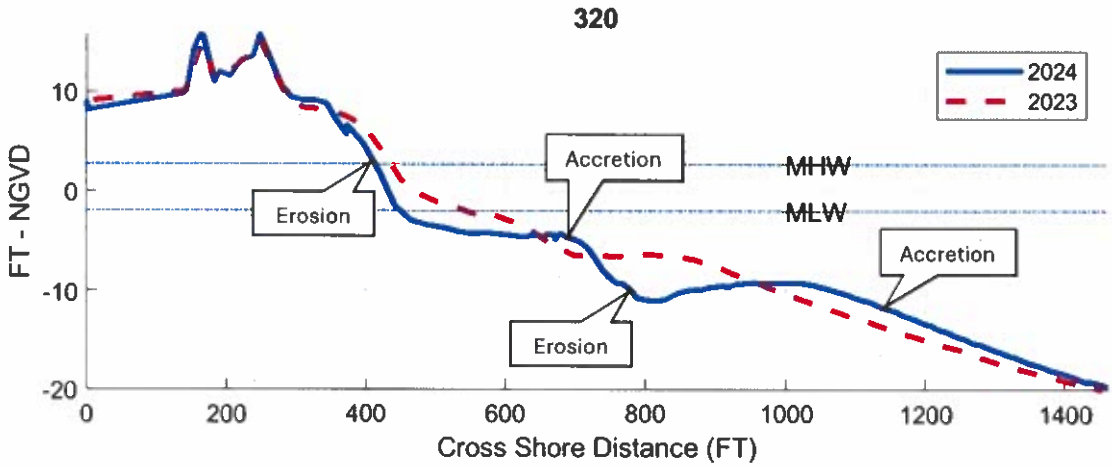

270
2024
2023
Erosion
MHW
MLW
Accretion
Erosion
FT - NGVD
Cross Shore Distance (FT)

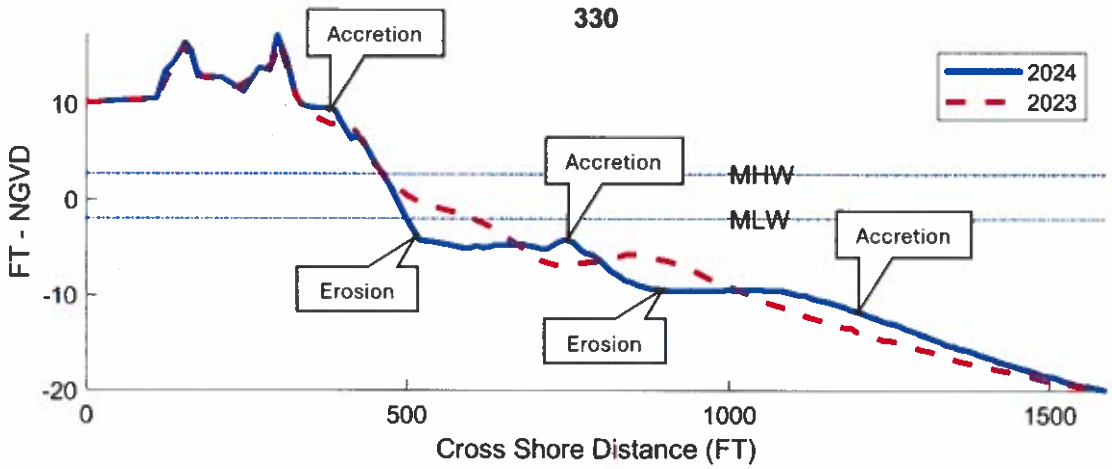

280
2024
2023
MHW
MLW
Erosion
Erosion
Erosion
Accretion
FT - NGVD
Cross Shore Distance (FT)

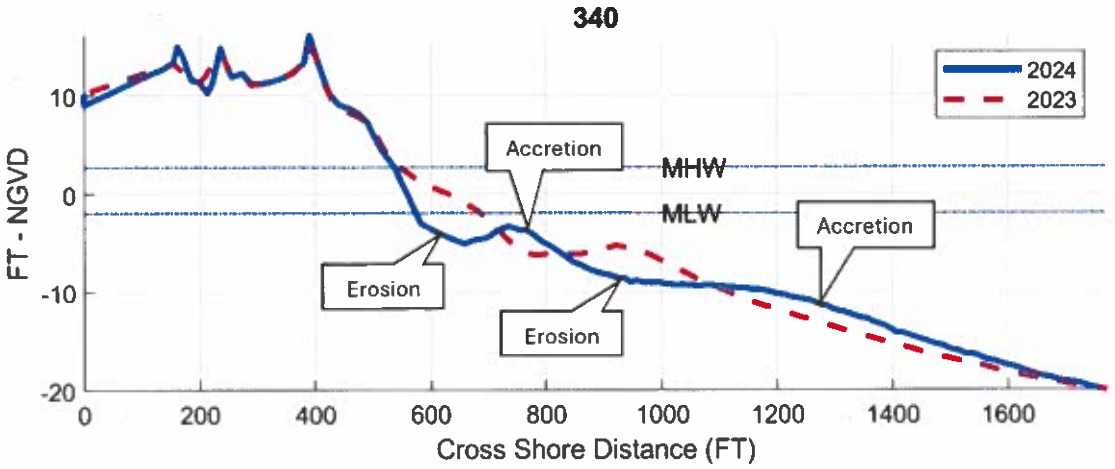

290
2024
2023
MHW
MLW
Erosion
Erosion
Accretion
FT - NGVD
Cross Shore Distance (FT)

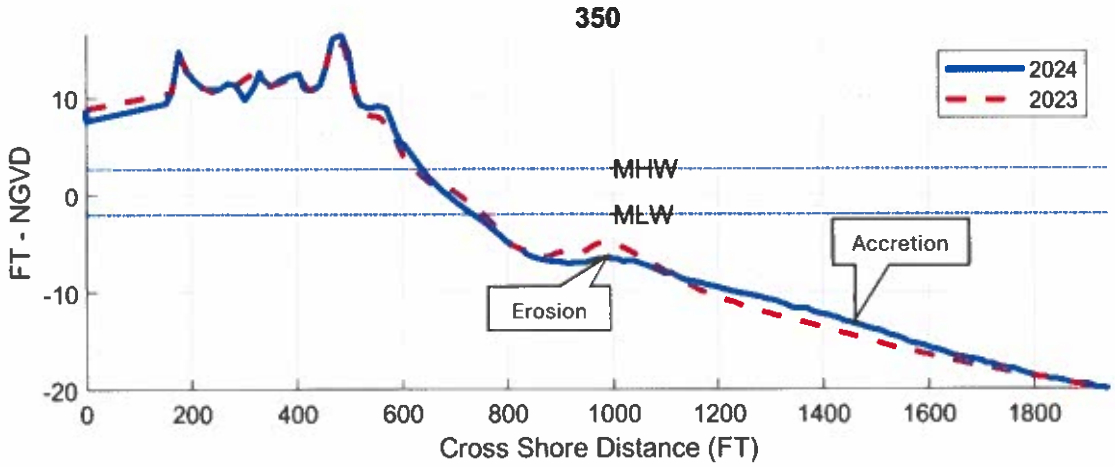

300
2024
2023
MHW
MLW
Erosion
Erosion
Accretion
FT - NGVD
Cross Shore Distance (FT)

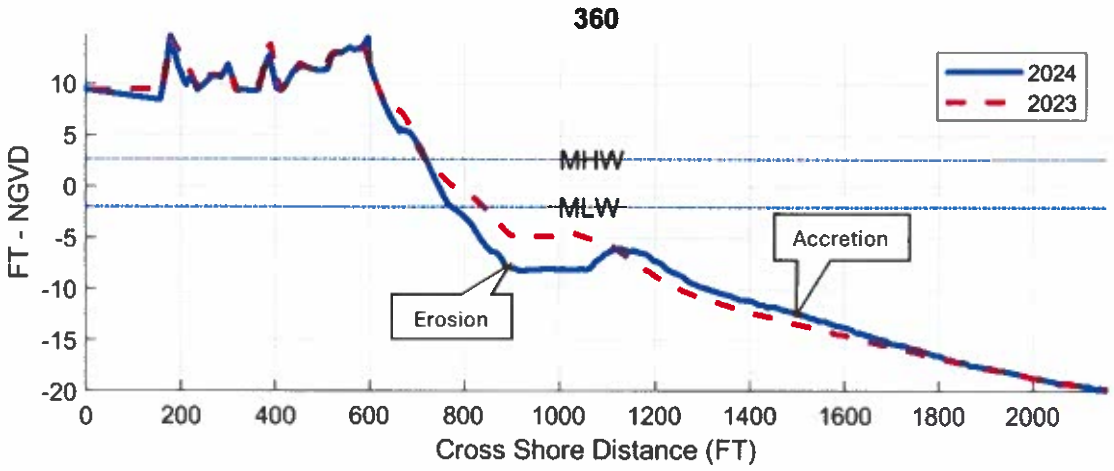

310
2024
2023
Erosion
MHW
MLW
Accretion
Erosion
FT - NGVD
Cross Shore Distance (FT)


320
2024
2023
Accretion
Erosion
MHW
MLW
Accretion
Erosion
FT - NGVD
Cross Shore Distance (FT)

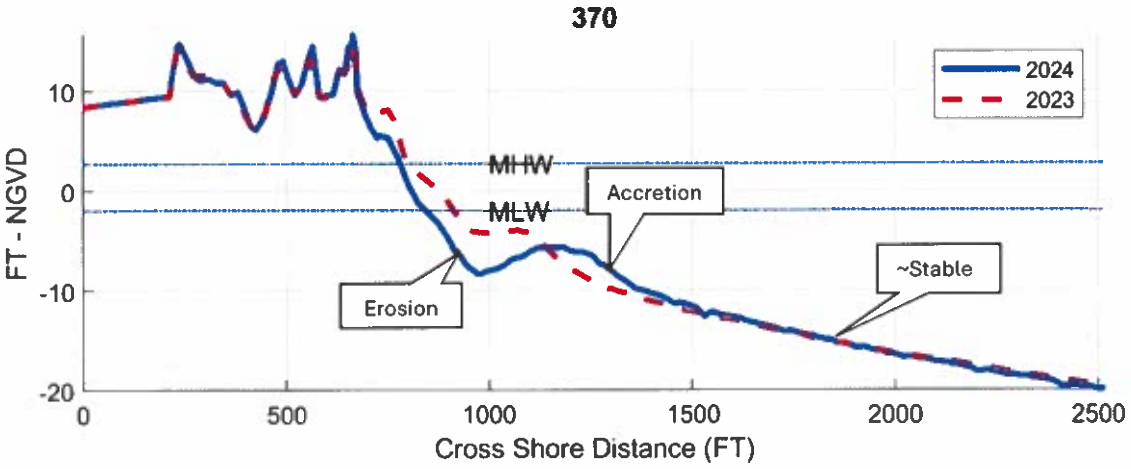

330
Accretion
2024
2023
Accretion
MHW
MLW
Accretion
Erosion
Erosion
FT - NGVD
Cross Shore Distance (FT)

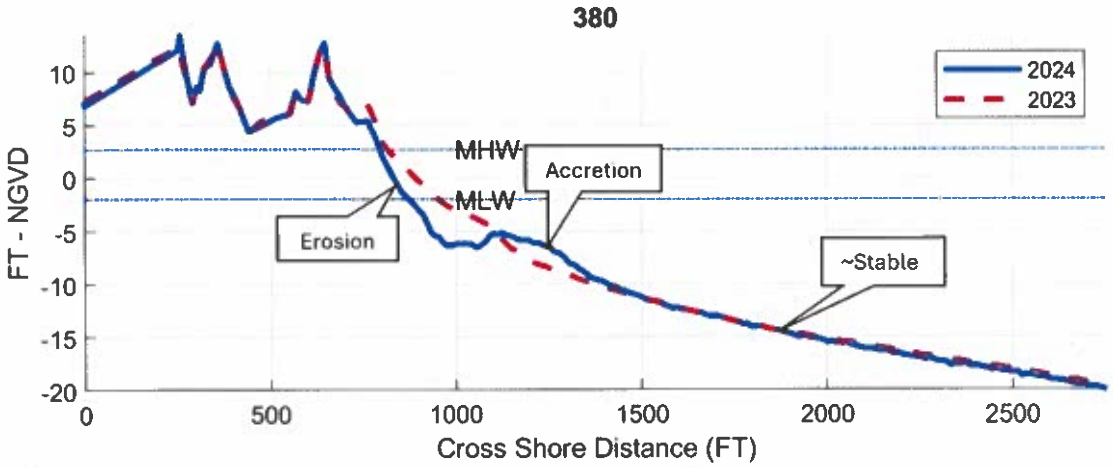

340
2024
2023
Accretion
MHW
MLW
Accretion
Erosion
Erosion
10
0
-10
-20
FT - NGVD
0
200
400
600
800
1000
1200
1400
1600
Cross Shore Distance (FT)

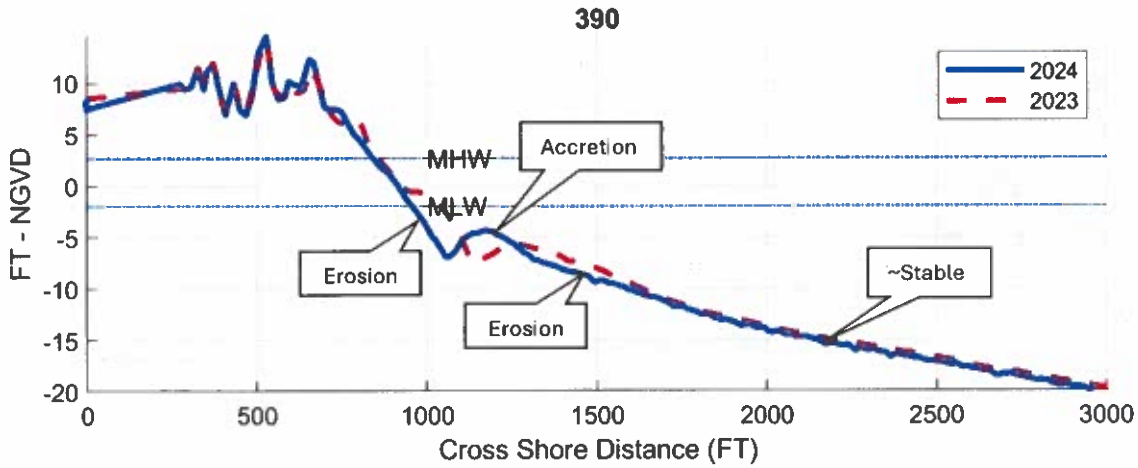

350
2024
2023
MHW
MLW
Accretion
Erosion
10
0
-10
-20
FT - NGVD
0
200
400
600
800
1000
1200
1400
1600
1800
Cross Shore Distance (FT)

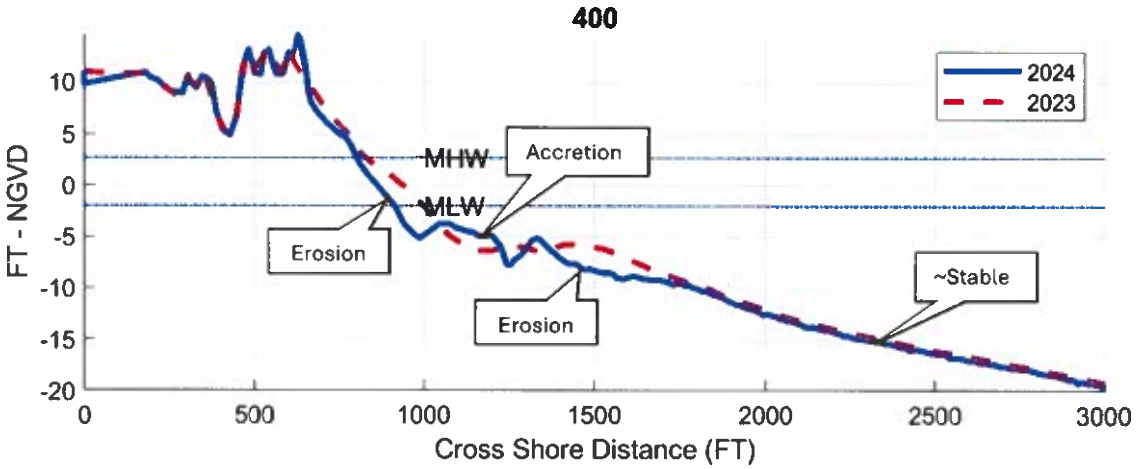


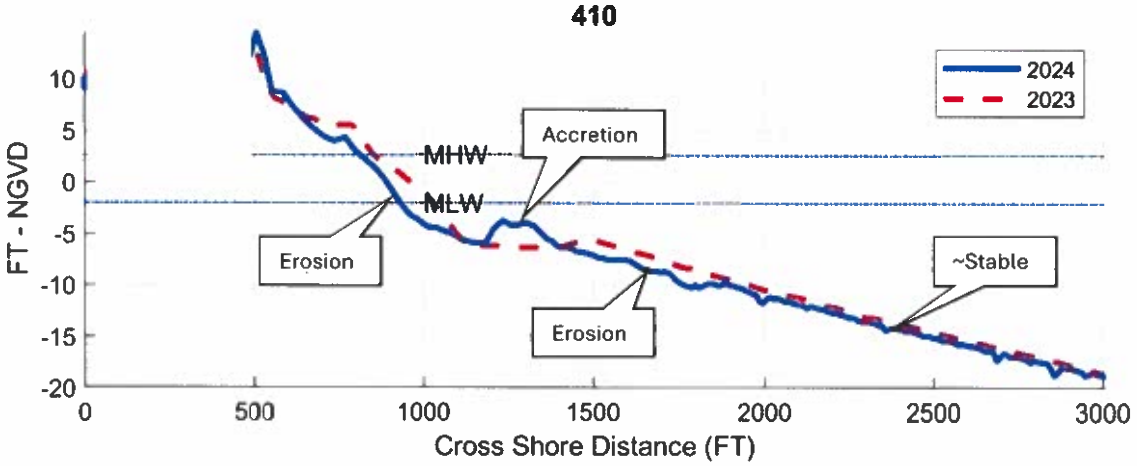
Station 360+00. Dunes are overall very healthy and stable over the past year along the west end continuing towards Shallotte Inlet.

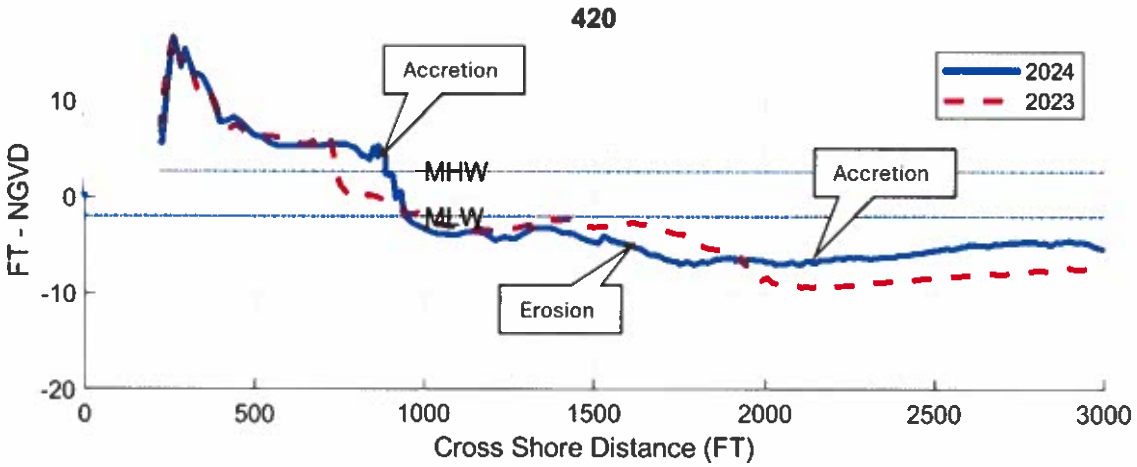

370
2024
2023
MHW
MLW
Accretion
Erosion
~Stable
FT - NGVD
Cross Shore Distance (FT)

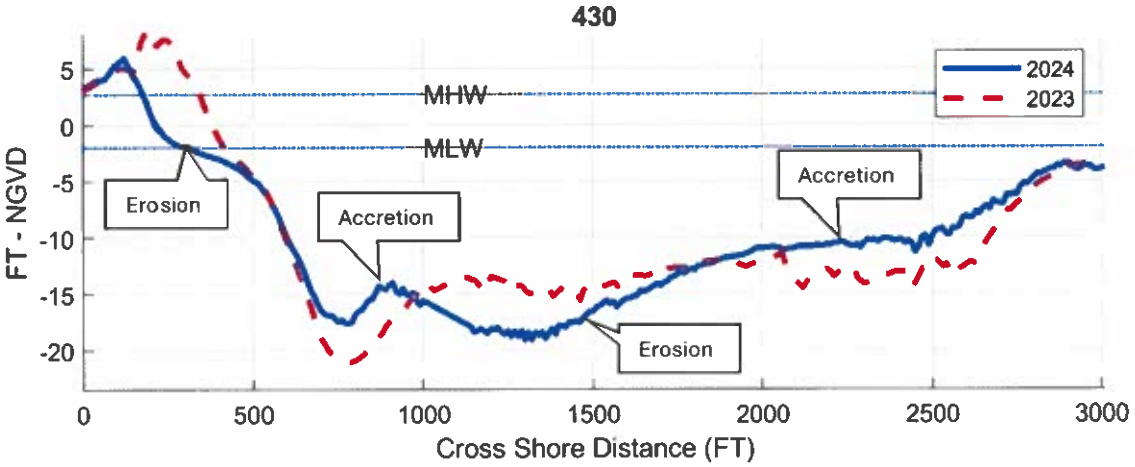

380
2024
2023
MHW
MLW
Accretion
Erosion
~Stable
FT - NGVD
Cross Shore Distance (FT)


390
2024
2023
MHW
MLW
Accretion
Erosion
Erosion
~Stable
FT - NGVD
Cross Shore Distance (FT)

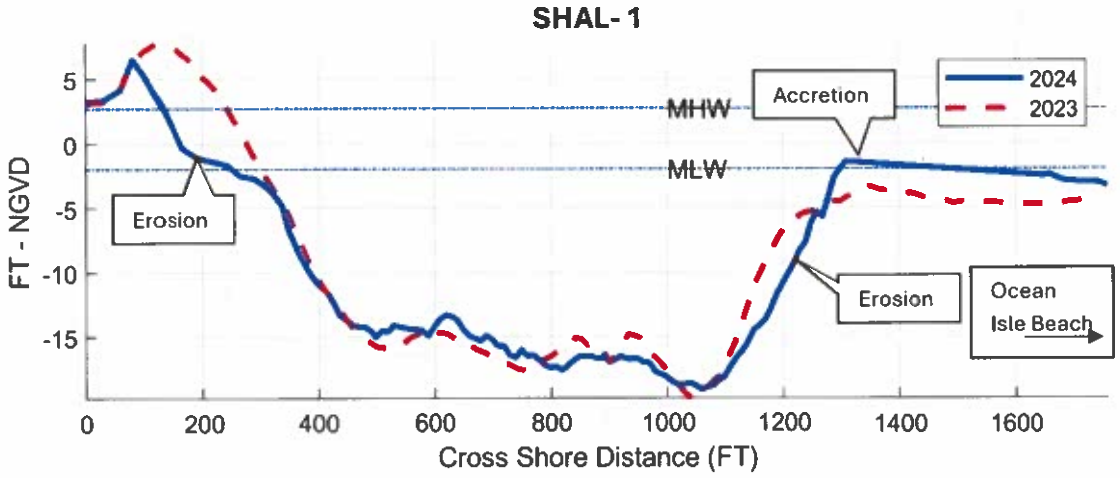

400
2024
2023
MHW
MLW
Accretion
Erosion
Erosion
~Stable
FT - NGVD
Cross Shore Distance (FT)


410
2024
2023
MHW
MLW
Accretion
Erosion
Erosion
~Stable
FT - NGVD
Cross Shore Distance (FT)

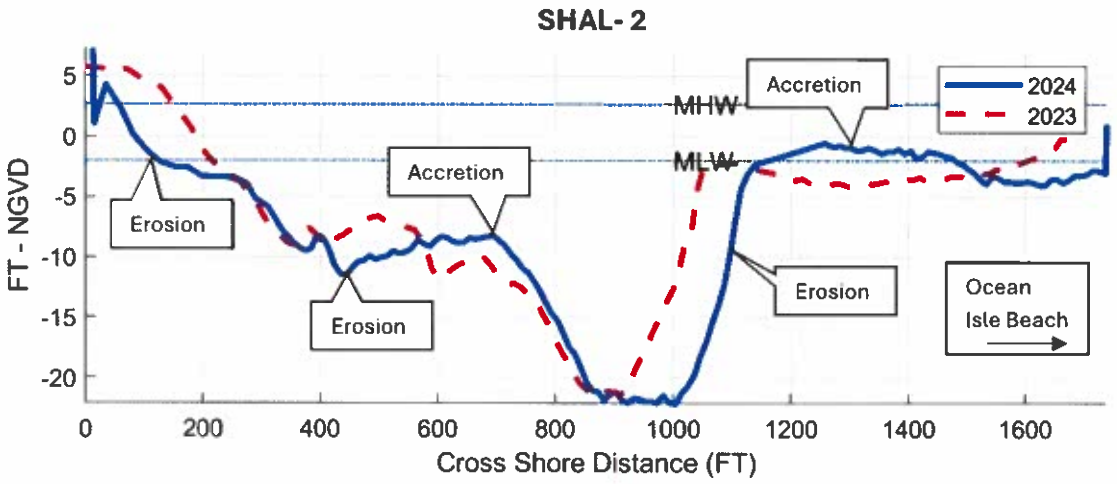

420
2024
2023
Accretion
MHW
MLW
Erosion
Accretion
FT - NGVD
Cross Shore Distance (FT)



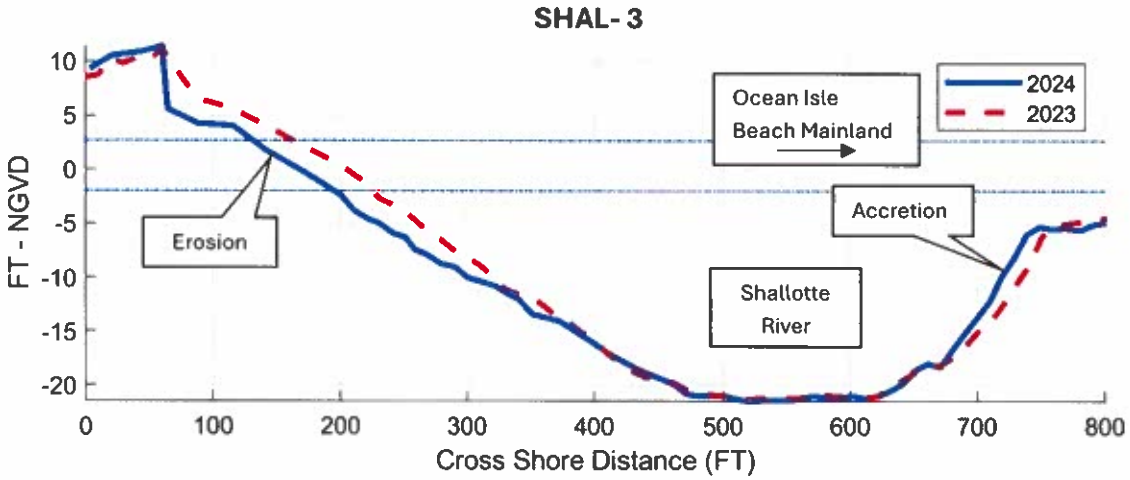
Station 430+00. Some infilling of inlet and channel movement has occurred since dredging of the Shallotte Inlet borrow area in 2022. Erosion of the upper beach observed on the Holden Beach side.



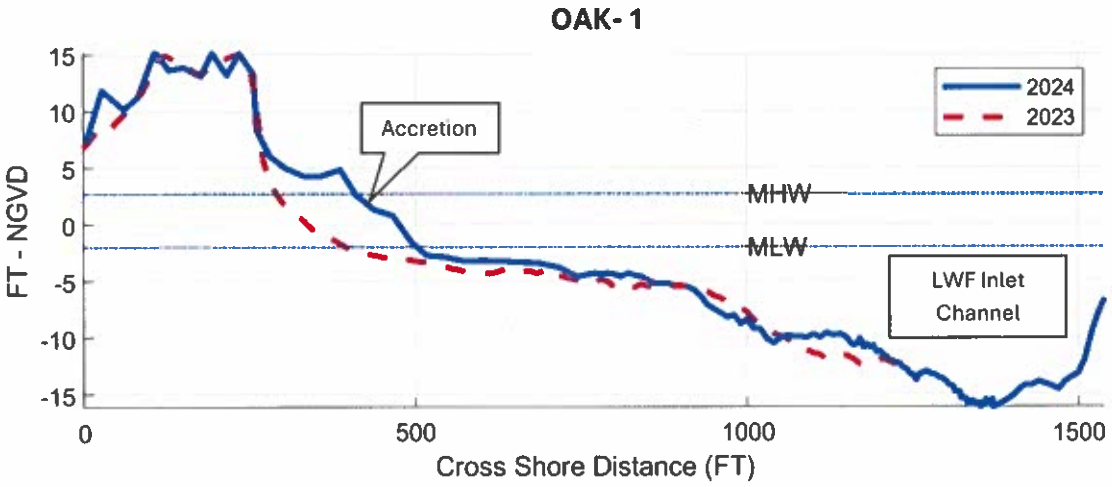
Station SHAL-1. Erosion of the upper beach observed on the Holden Beach side. Some channel widening observed since 2023 survey.



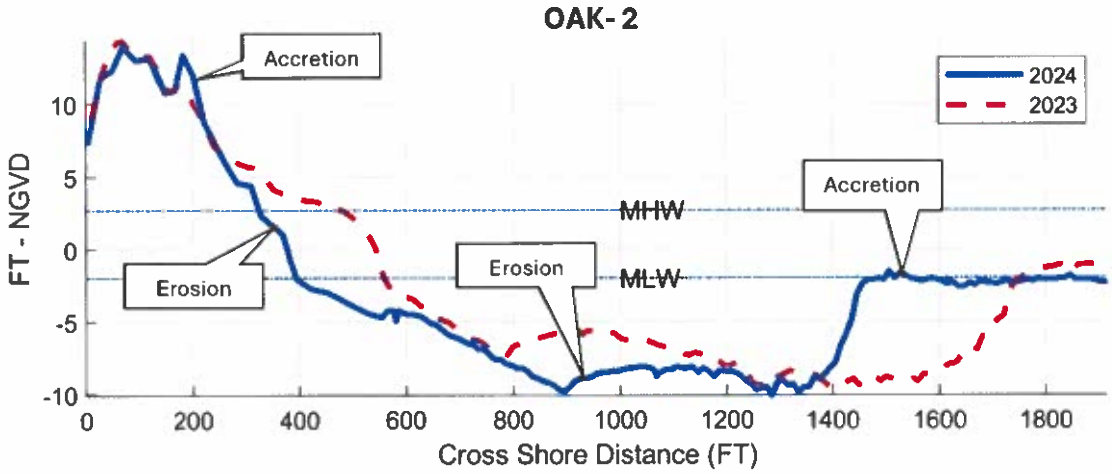
Station SHAL-2. Upper and intertidal erosion on the Holden Beach side. Channel and shoal movement west towards Ocean Isle Beach.



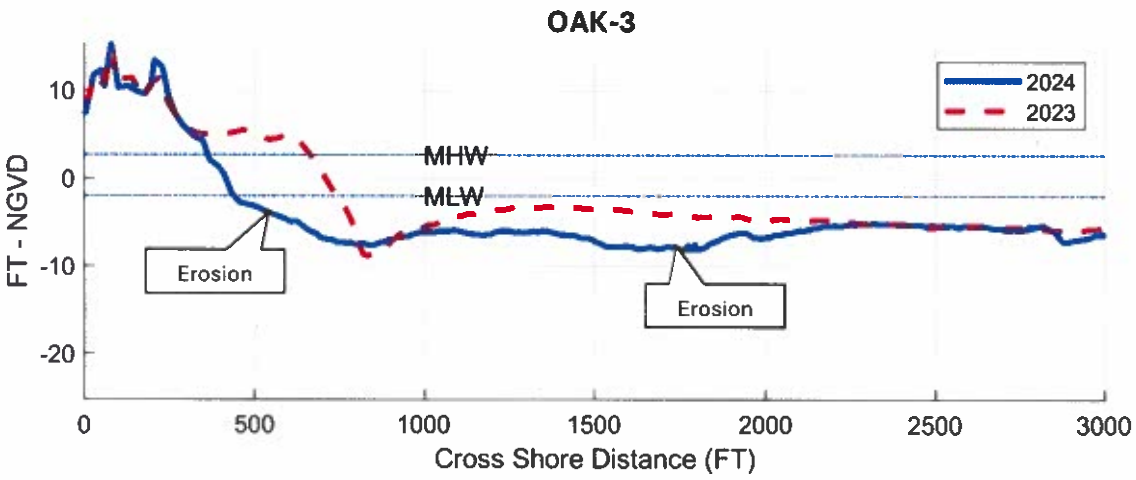
Station SHAL-3. A mostly erosional beach on the Holden Beach side and generally stable channel observed over the past year here.



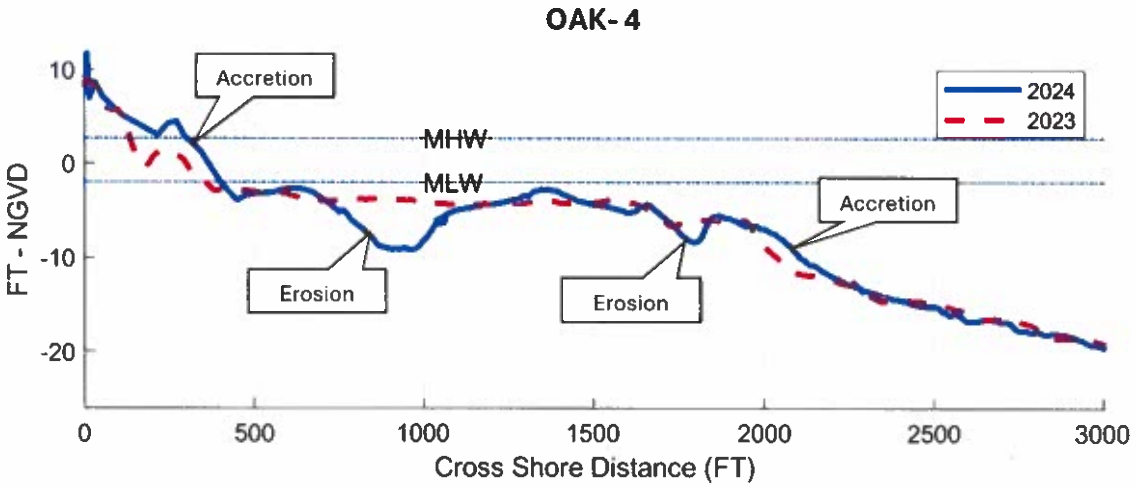
Station OAK- 1. The dune system is healthy and some intertidal accretion is seen along the western-most Oak Island profile.



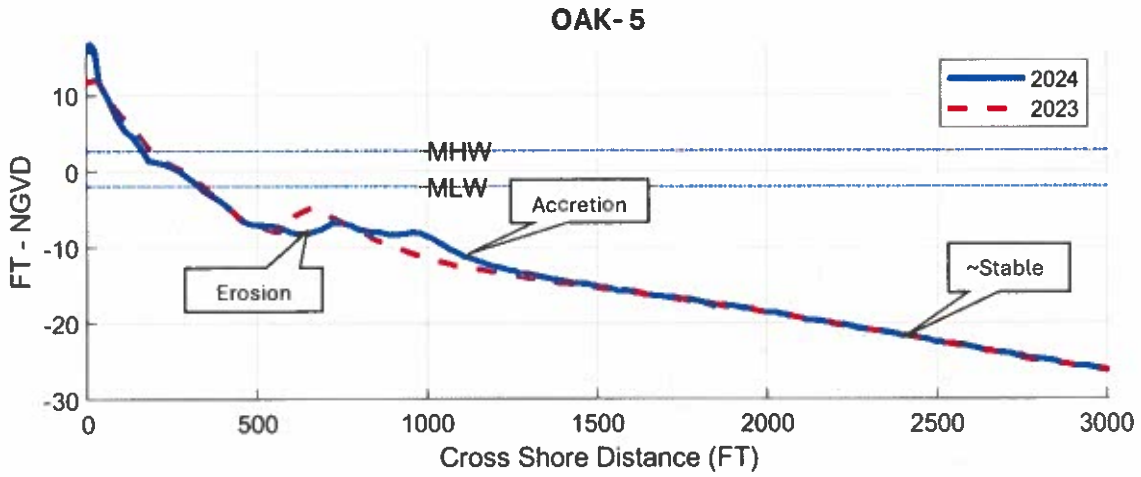
Station OAK- 2. Some intertidal erosion observed here and offshore erosion and bar movement due to inlet dynamics.

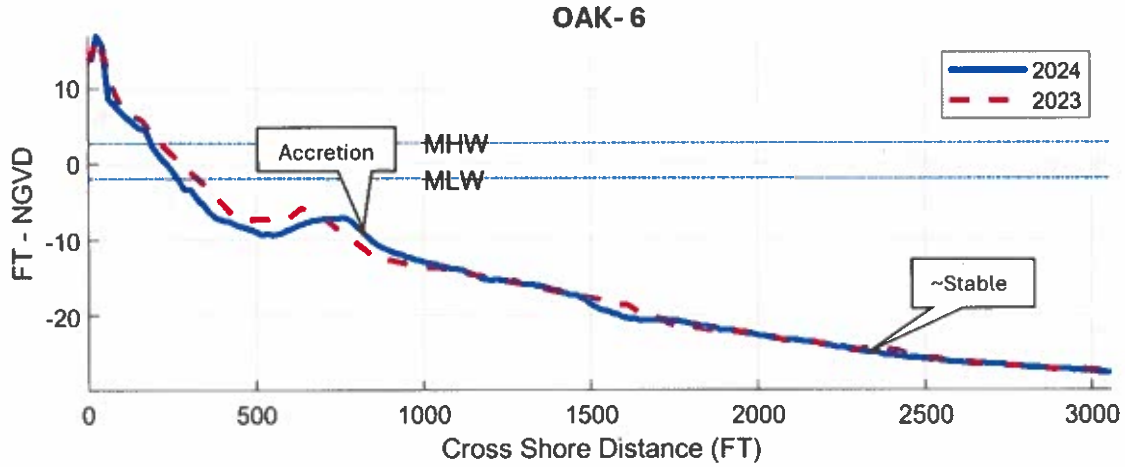


Station OAK-3. Intertidal, upper beach, and offshore erosion observed likely due to inlet dynamics.



Station OAK-4. Some upper and intertidal beach accretion and offshore accretion observed here due to continued equilibration and spreading of the 2021 USACE LWFIX dredging and beach placement and the recent 2022 FEMA Phase II Renourishment placement. Spots of erosion observed offshore.


OAK- 5
2024
2023
MHW
MLW
Accretion
Erosion
~Stable
FT - NGVD
Cross Shore Distance (FT)


OAK- 6
2024
2023
Accretion
MHW
MLW
~Stable
FT - NGVD
Cross Shore Distance (FT)

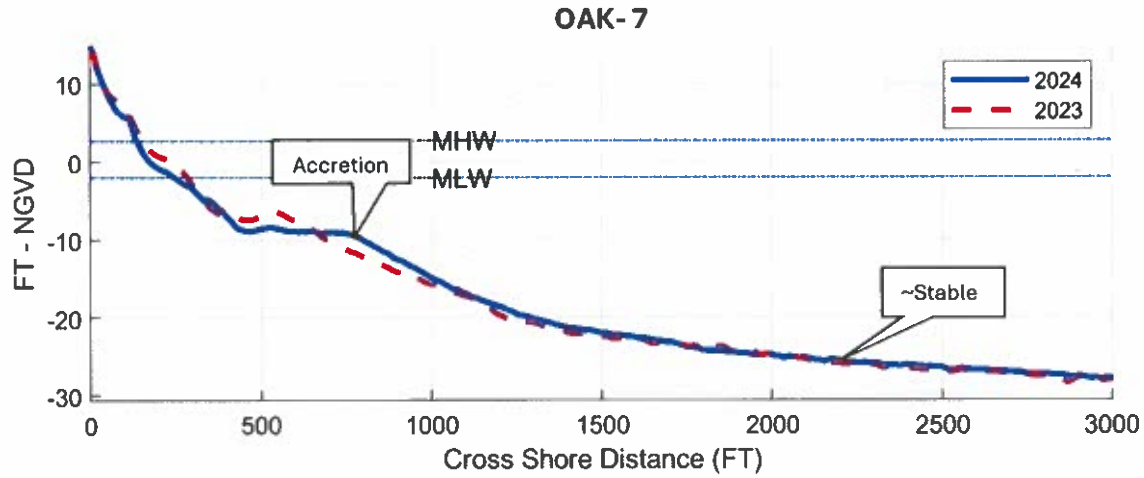

OAK- 7
2024
2023
Accretion
MHW
MLW
~Stable
FT - NGVD
Cross Shore Distance (FT)

TABLE A-1: 2023 to 2024 Survey Transect Analysis

General Notes –
Transects are primarily oceanfront perpendicular and parallel except for inlets and inlet shoulder transects.
Unit Volume (cy/ft) changes at inlet and inlet shoulder transects cannot use "average end" method for calculating volumes.
MHW change at inlet and inlet shoulder is not necessarily perpendicular to the shoreline due to variable orientation.

*all elevations relative to NGVD29

2023 to 2024 Survey Analysis					
STATION	Distance to Next Monument (ft)	Volume Change (cy/ft) (Dune to -12 ft*)	Volume Change (cy/ft) (Dune to -5 ft)	MHW Change (ft)	Notes
109+00	0	-2.0	10.0	45.7	LWF Inlet
119+00	0	44.1	44.1	158.0	LWF Inlet
129+00	500	73.3	73.3	237.8	LWF Inlet
5+00	500	0.6	10.0	-16.3	LWF Inlet Shoulder
10+00	500	3.4	-41.5	-131.7	LWF Inlet Shoulder
15+00	440	-129.8	-80.7	-154.0	LWF Inlet Shoulder
20+00	1000	-24.2	38.1	-14.1	Oceanfront Perpendicular
30+00	1000	1.3	7.7	20.9	
40+00	1000	-9.1	15.4	21.9	
50+00	1000	2.4	15.3	17.8	
60+00	1000	-38.0	-16.4	-42.7	
70+00	1000	-49.4	-31.5	-45.7	
80+00	1000	-22.7	-20.8	-48.5	
90+00	1000	-27.0	-15.3	-22.2	
100+00	1000	-37.7	-21.0	-31.1	
110+00	1000	-36.4	-18.2	-20.4	
120+00	1000	-33.1	-19.4	-21.3	
130+00	1000	-27.8	-12.1	-15.0	
140+00	1000	-34.9	-16.4	-20.6	
150+00	1000	-24.0	-9.4	-10.2	
160+00	1000	-28.7	-14.2	-18.6	
170+00	1000	-22.4	-15.0	-3.3	
180+00	1000	-29.6	-22.4	-10.8	
190+00	1000	-34.3	-24.8	-31.4	
200+00	1000	-28.1	-23.8	-53.9	
210+00	1000	-27.1	-10.2	-14.9	

220+00	1000	-29.3	-15.1	0.9	
230+00	1000	-24.5	-15.8	11.9	
240+00	1000	-25.3	-9.7	-5.2	
250+00	1000	-20.3	-3.5	-1.0	
260+00	1000	-32.8	-12.9	-10.4	
270+00	1000	-35.4	-13.2	-9.6	
280+00	1000	-28.0	-15.3	-13.0	
290+00	1000	-22.9	-12.4	-11.5	
300+00	1000	-26.3	-12.4	-10.8	
310+00	1000	-24.3	-18.6	-18.3	
320+00	1000	-30.3	-18.3	-21.6	
330+00	1000	-18.2	-15.8	-2.4	
340+00	1000	-25.2	-17.4	-10.5	
350+00	1000	1.8	2.5	14.4	
360+00	1000	-30.4	-16.7	-2.4	
370+00	1000	-28.6	-28.5	-23.9	
380+00	1000	-20.1	-27.6	-23.1	
390+00	1000	-21.7	-12.4	-16.4	
400+00	1000	-40.8	-20.4	-28.4	Oceanfront perpendicular
410+00	1000	-39.5	-21.0	-43.1	Shallotte Inlet Shoulder
420+00	1000	82.6	-3.8	144.5	Shallotte Inlet
430+00	-	-	-	-	Shallotte Inlet
SHAL 1	-	-	-	-	Shallotte Inlet
SHAL 2	-	-	-	-	Shallotte Inlet
SHAL 3	-	-	-	-	Shallotte Inlet
	OAK ISLAND TRANSECTS				
OAK 1	0	47.0	42.5	118.9	LWF Inlet
OAK 2	0	-25.1	-21.9	-159.8	LWF Inlet
OAK 3	890	-238.0	-141.6	-302.9	LWF Inlet
OAK 4	1100	-0.6	20.7	164.6	LWF Inlet Shoulder
OAK 5	2000	2.6	-8.8	-28.0	Oceanfront perpendicular
OAK 6	2000	-29.7	-21.7	-29.3	
OAK 7	-	-13.0	-11.8	-16.9	

Appendix B

2024 Survey Plan View Figures

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FIGURE B-1
2024 Survey Data and Established Monitoring Stations Shown. 2024 Mean High Water (MHW) Shoreline, 2023 MHW Shoreline, and 2000 MHW Shoreline. High-Resolution Aerial Imagery from Nearmap.com (January 2024).

FIGURE B-2
2024 Survey Data and Established Monitoring Stations Shown. 2024 Mean High Water (MHW) Shoreline, 2023 MHW Shoreline, and 2000 MHW Shoreline. High-Resolution Aerial Imagery from Nearmap.com (January 2024).

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FIGURE B-3
2024 Survey Data and Established Monitoring Stations Shown. 2024 Mean High Water (MHW) Shoreline, 2023 MHW Shoreline, and 2000 MHW Shoreline. High-Resolution Aerial Imagery from Nearmap.com (January 2024).

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FIGURE B-4
2024 Survey Data and Established Monitoring Stations Shown. 2024 Mean High Water (MHW) Shoreline, 2023 MHW Shoreline, and 2000 MHW Shoreline. High-Resolution Aerial Imagery from Nearmap.com (January 2024).

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FIGURE B-5
2024 Survey Data and Established Monitoring Stations Shown. 2024 Mean High Water (MHW) Shoreline, 2023 MHW Shoreline, and 2000 MHW Shoreline. High-Resolution Aerial Imagery from Nearmap.com (January 2024).