2025 BEACH MONITORING AND BEACH STABILITY ASSESSMENT
CURRITUCK COUNTY, NORTH CAROLINA

PREPARED FOR
CURRITUCK COUNTY

PREPARED BY
COASTAL PROTECTION ENGINEERING OF NORTH CAROLINA, INC.
ENGINEERING LICENSE CERTIFICATE #: C-2331

NORTH CAROLINA PROFESSIONAL SEAL 048852 ENGINEER ADAM TAFT PRIEST

ADAM T. PRIEST, PE NO. 048852

2/12/26
DATE

January 2026

EXECUTIVE SUMMARY

In 2020, Currituck County initiated a Beach Monitoring and Beach Stability Assessment to evaluate long-term and short-term shoreline and volumetric changes occurring along Currituck's oceanfront beaches. The initial study was completed in 2022 following three (3) consecutive years of monitoring. The stated goals of the Assessment were 1) to better understand the changes that are occurring on the beaches and 2) to assist the County in making informed decisions regarding beach management. At the conclusion of the initial Assessment, Currituck County requested that annual monitoring continue to track and assess long-term and short-term shoreline and volumetric changes along its oceanfront beaches.

This 2025 report serves to provide an update to the County in terms of data obtained through June 2025. The report provides an assessment of both long-term and short-term shoreline change trends, an analysis of the impact of projected long-term shoreline changes over 10-, 20-, and 30-year horizons, and an assessment of both long-term and short-term volume change trends.

The Currituck County barrier island beaches extend approximately 22.6 miles along the Atlantic Ocean. The beaches extend from the North Carolina/Virginia border south-southeast to the Town of Duck in Dare County, North Carolina. The Currituck County beach is divided up into several segments of privately developed residential and commercial property and publicly owned property. The northernmost 10.9 miles of the Currituck County beach is only accessible via off-road driving. South of the off-road access at N. Beach Access Road and south of the "Horse Gate", the Currituck County beach extends approximately 11.7 miles to the southern County boundary with Dare County. This section of beach is almost entirely developed.

Given the differences in land use, land management, and geomorphology (changes in the dune and beach slope configuration over time), the Assessment Area has been divided into four (4) sections for reporting purposes. The northernmost section is referred to as the Carova Section, which encompasses approximately 4.9 miles of the Assessment Area from the northern County boundary to the northern boundary of the Currituck National Wildlife Refuge. The approximately 6.0-mile section of the Assessment Area that includes the Currituck National Wildlife Refuge, the Currituck Banks Estuarine Reserve, and the developed area along Sandpiper Road and Ocean Pearl Road is referred to as the Reserve/Refuge Section. The largest section, referred to as the Corolla Section, extends approximately 8.2 miles from approximately 250 feet south of the Horse Gate to approximately 500 feet north of Yaupon Lane. The southernmost 3.5 miles of the Assessment Area is referred to as the Pine Island Section.

Projected Shoreline Changes: Publicly available lidar data and beach profile data collected by CPE since 2020, has been used to conduct shoreline change analysis, which provides insight into overall trends. Shoreline change is calculated by comparing shoreline positions along shore perpendicular transects over time to evaluate the rate in which the shoreline moves landward or seaward. Ten (10) data sets collected between 2009 and 2025 were analyzed to determine shoreline change rates over the past 16 years. These rates were determined using a linear regression method that considers each of the ten data sets available over this 16-year period. The shoreline change rates

were then used to project future shoreline changes throughout the Assessment Area over a 10-, 20-, and 30-year time horizon. It should be noted that the beach south of the Horse Gate was the only beach area analyzed in this 2025 report as the 2025 survey only included those beach monitoring profiles located south of the Horse Gate (stations C-059 to C-120).

Overall, the number of structures indicated as impacted in 2025 based on the shoreline projections, is lower than reported in 2024. The reduction in the number of structures identified was due to a general decrease in the updated shoreline recession rates, which incorporate the June 2025 data. The updated 2025 projections show the greatest number of impacts from projected shoreline changes within the Corolla Section of the Assessment Area. In total, 43 houses were shown to be impacted over the 30-year horizon throughout the northern Corolla Section. All of these houses are located between the Horse Gate (station C-059) and Carotank Drive (station C-065). Of the 43 houses shown to be impacted over the 30-year horizon, 19 of the houses were shown to be impacted over the 20-year horizon and 0 were shown to be impacted over the 10-year horizon. Along this stretch of beach (C-059 to C-065), approximately 66% of the oceanfront houses were shown to be impacted over the 30-year horizon. Approximately 29% of the oceanfront houses along this stretch were shown to be impacted over the 20-year horizon and none of the houses were shown to be impacted over the 10-year horizon along this stretch of beach.

In contrast to 2024, the 2025 analysis did not indicate any impacts to oceanfront houses in the Whalehead Beach community (station C-068 to station C-084), or the Spindrift community (stations C-101 and C-103) based on the 10-, 20-, or 30-year projected shorelines. In the southernmost Section (Pine Island) of the Assessment Area, the projected shoreline change methodology did not indicate any impacts to oceanfront houses based on the 10-, 20-, or 30-year projected shorelines.

Volume Changes:

A volumteric analyses was completed as part of the 2025 Assessment through a comparison of May 2020, May 2022, June 2023, June 2024, and June 2025 data. Volume change rates measured between 2020 and 2025 continue to show an overall positive volumetric trend over the 5.1-year period. The average volumetric change rate along the 2025 Assessment Area (south of the Horse Gate – stations C-059 to C-120) was +1.8 cy/ft./yr. between 2020 and 2025. This equates to a net volume gain of approximately 549,700 cy. A positive volume change of approximately 305,800 cy (1.4 cy/ft./yr.) was measured in the Corolla Section over the 5.1-year period while a positive volumetric change of approximately 243,900 cy (2.7 cy/ft./yr.) was measured in the Pine Island Section.

The overall volumetric trend measured south of the Horse Gate from May 2020 to June 2025 was positive, however observations of volumetric trends measured over this period indicate an inflection point in the volumetric trends. While a positive volumetric trend was observed between May 2020 and June 2023, the volumetric trend observed between June 2023 and June 2025 has been negative.

The following conclusions were drawn from the results of both the shoreline projection analysis and volumetric change analysis:

- The northern portion of the Corolla Section, between the Horse Gate and Corolla Village Road (station C-059 to station C-065) within the Ocean Hill community has continuously been called out as one of the most vulnerable areas of the County's oceanfront. In 2025, all 43 houses identified in the Corolla Section as impacted over the 30-year horizon were located in the Ocean Hill community. This represents approximately 66% of the oceanfront houses between C-059 and C-065. The 43 houses also represent a 65% increase in the number of houses along this section of beach compared to the number identified as impacted over the 30-year horizon in 2024 (26 houses). Both the shoreline projections and previous SBEACH storm vulnerability analyses have indicated structures along this stretch of the County oceanfront are vulnerable both to long-term shoreline change and storms. The volumetric changes measured between May 2020 and June 2025 indicate this area has experienced minor losses, at an average rate of -1.7 cy/ft./yr., over the approximate 5-year period. However, more recently, between June 2023 and June 2025 the average volumetric change rate along this portion of the Corolla Section was -16.7 cy/ft./yr.
- Another area of concern is within the Whalehead Beach community along Lighthouse Drive (station C-068 to station C-084). Previous shoreline projection analyses have consistently identified oceanfront structures along this area as impacted over the 30-year projection horizon. Likewise past SBEACH storm vulnerability analyses have indicated some oceanfront houses and pools along this area are vulnerable (CPE, 2020 and CPE, 2023a). The 2025 shoreline projection analysis did not indicate any oceanfront homes as impacted over the 30-year shoreline projection analysis. The 2024 Assessment reported 30 oceanfront houses located between the Sturgeon Beach Access (station C-071) and Marlin Beach Access (station C-081), as impacted over the 30-year horizon. This reduction from the 2024 Assessment to the 2025 Assessment was due to a slight decrease in the average shoreline change rates used along this area in the shoreline projection analysis (-4.5 ft./yr. for the 2025 analysis compared to an average rate of -5.5 ft./yr. for the 2024 analysis) and a seaward movement of the average shoreline position (21.9 feet). The volumetric changes measured between May 2020 and June 2025 indicate the Whalehead Beach community (C-068 to C-084) experienced a net positive volumetric change rate of 3.1 cy/ft./yr. above the depth of closure. However, more recently, between June 2023 and June 2025 the average volumetric change rate along this area was -5.2 cy/ft./yr.
- The Spindrift community (station C-101 to station C-103) is another area of concern, where shoreline projection analyses have identified this area to be vulnerable. While the most recent analyses performed with the 2024 and 2025 conditions and rates did not indicate impacts along this community, previous analyses have shown impacts to the nine (9) oceanfront homes located along Land Fall Ct. The trends in this area are the opposite of the trend generally observed throughout the study area. The volume change analysis indicated minor losses between May 2020 and May 2022, followed by considerable

volumetric gains at a rate of +7.2 cy/ft./yr. between May 2022 and June 2025. The area remained stable with minor losses of -0.1 cy/ft./yr. on average, over the recent 12-month period. It should also be noted that approximately 7,000 cy of sand was placed to construct a dune in front of the Spindrift community via a truck haul project in March 2023. The gains observed between May 2022 and June 2025 may be attributed to this project.

Recommendations: Based on the various beach assessments described in this report and conclusions drawn from those assessments, CPE provides the following recommendation for the County's consideration as they seek to make informed decisions regarding beach management:

Continue Monitoring of the Beach Profiles: The initial 3-year Beach Monitoring and Beach Stability Assessment (2020 through 2022) established a baseline of shoreline change and volumetric change rates. Given the results of the shoreline and volume change analyses, the distribution of potential impacts from the shoreline projections over 10 to 30 years and the distribution of houses identified through the vulnerability analysis, the County continued the monitoring plan through 2025 and initiated the development of a Beach Management Plan in 2024. Beginning in 2023, the County, in alignment with recommendation in the 2022 Assessment (CPE, 2023a), authorized annual surveys of the Corolla and Pine Island Sections, with biennial surveys (every other year) for the Carova and Reserve/Refuge Sections for 3 additional years.

The recommendation to only survey the Carova and Reserve/Refuge Sections (north of the Horse Gate) in the odd years, was based on the fact that only a small number of houses located north of the Horse Gate were indicated as vulnerable, and the amount of undeveloped beach north of the Horse Gate. The County contracted with CPE in early 2023 to continue monitoring as recommended through 2025. In 2023 and 2025, beach monitoring surveys were conducted south of the Horse Gate in the Corolla and Pine Island Sections only; whereas in 2024, the entire County oceanfront was surveyed (both north and south of the Horse Gate).

The County should continue to monitor the oceanfront beaches at the established frequency, with annual surveys conducted south of the Horse Gate in the Corolla and Pine Island Sections annually and survey north of the Horse Gate in the Carova and Reserve/Refuge Sections biennially (every other year). With the Beach Management Plan anticipated to be completed in 2026, continued monitoring will inform the County's decisions on when to take various actions to achieve the goals of the Plan.

The County has recently discussed several houses indicated as vulnerable in the portion of the beach between Canary Lane and just north of Malbon Drive (stations C-039 to C-048) in the Reserve/Refuge Section north of the Horse Gate. The discussions have focused on the potential impacts to ingress/egress along the offroad sections of the County beaches due to these vulnerable structures. Depending on whether the County anticipates taking

any actions in this location, it may be beneficial to increase monitoring in these particular areas.

If the County elects to continue monitoring of the beaches, beach profile surveys should be conducted along the same profiles established at the beginning of the County-wide assessment in 2020 at a similar time of year to reduce the impacts of seasonal changes on conditions of the profile, particularly the portion of the profile above Mean High Water (MHW).

2025 BEACH MONITORING AND BEACH STABILITY ASSESSMENT CURRITUCK COUNTY, NORTH CAROLINA

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1 INTRODUCTION

In 2020, Currituck County initiated a Beach Monitoring and Beach Stability Assessment to evaluate long-term and short-term shoreline and volumetric changes occurring along the County's oceanfront beaches. The initial study was completed in 2023 following three (3) consecutive annual monitoring events (2020, 2021, and 2022). Based on recommendations from that initial Assessment (CPE, 2023a), Currituck County chose to continue the annual monitoring of the beaches from 2023-2025 to track and assess long-term and short-term shoreline and volumetric changes along the beach.

Based on recommendations from the 2022 Assessment, annual monitoring is focused on the Corolla and Pine Island Sections, south of the Horse Gate, while biennial monitoring is conducted north of the Horse Gate. This recommendation was based on the fact that the majority of vulnerable houses were located south of the Horse Gate and that Pine Island was the only section that saw negative volumetric changes over the initial monitoring period from 2020 to 2022 (CPE, 2023a). The June 2023 survey only covered the area south of the Horse Gate, while the June 2024 survey covered all Sections north and south of the Horse Gate. The June 2025 survey discussed in this report only covered areas south of the Horse Gate.

1.1 Project Location

Currituck County is located on the Outer Banks of North Carolina just south of the Virginia border. The County encompasses approximately 527 square miles, which is divided by the Currituck Sound. This geographical division creates two distinct regions namely, the Currituck Mainland, and the Currituck Barrier Island Beaches. The Currituck Barrier Island Beaches extend approximately 22.6 miles along the Atlantic Ocean. The beaches extend from the North Carolina/Virginia border south-southeast to the Town of Duck in Dare County, North Carolina. A location map is provided in Figure 1.

The Currituck County beaches are divided up into several segments of privately developed residential and commercial property and publicly owned property. The Assessment Area has been divided into four sections referred to throughout the report, with consideration given to differences in land use, land management, and geomorphology (changes in the dune and beach slope configuration over time). The northernmost section is referred to as the Carova Section, which encompasses approximately 4.9 miles of the Assessment Area from the northern County boundary to the northern boundary of the Currituck National Wildlife Refuge. The approximately 6.0-mile section of the Assessment Area that includes the Currituck National Wildlife Refuge, the Currituck Banks Estuarine Reserve, and the developed area along Sandpiper Road and Ocean Pearl Road is referred to as the Reserve/Refuge Section. The largest section, referred to as the Corolla Section, extends approximately 8.2 miles from approximately 250 feet south of the Horse Gate to approximately 500 feet north of Yaupon Lane. The southernmost 3.5 miles of the Assessment

Area is referred to as the Pine Island Section. The sections are shown in Figure 1, and the length, geographical limits, and baseline stations for each section are provided in Table 1.

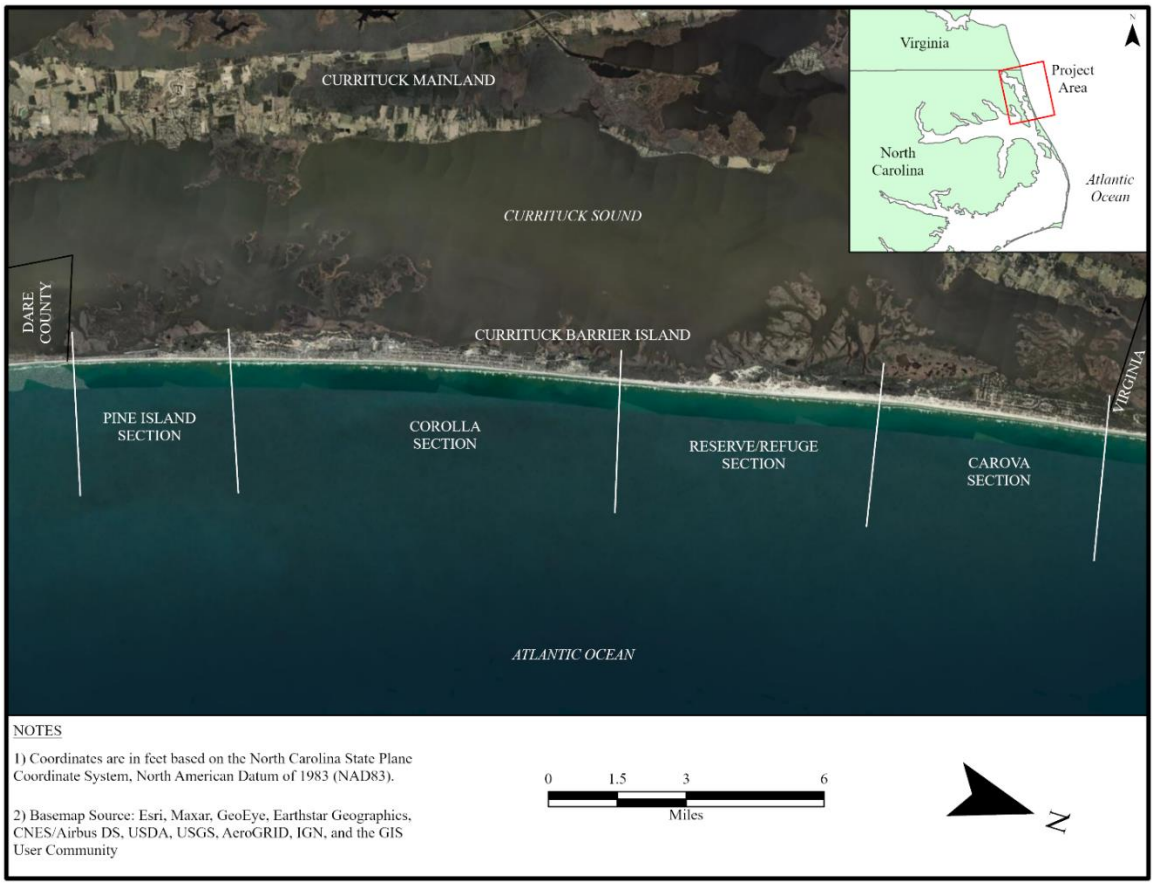

Figure 1. Currituck Project Location Map

Table 1. Section Descriptions

Section Name	Approx. Length	Geographic Extent	Baseline Stations
Carova	4.9 Miles	Northern County Boundary to Currituck Wildlife Refuge	C-001 to C-027
Reserve/Refuge	6.0 Miles	Northern boundary of Currituck Wildlife Refuge to 250 feet south of Horse Gate	C-027 to C-059
Corolla	8.2 Miles	250 feet south of Horse Gate to 500 feet north of Yaupon Lane	C-059 to C-102
Pine Island	3.5 Miles	500 feet north of Yaupon Lane to southern County boundary	C-102 to C-120

Several papers have described historic inlets that had existed along the Currituck County beaches (Mallinson et al., 2011 and Moran et al., 2015). Like many modern day, unmanaged inlets, these features were likely not stationary but rather migrated throughout their history. Though the exact locations of these inlets are unknown, the southernmost inlet, known as Caffey's Inlet, is believed to have existed in the area between the Hampton Inn (station C-110) and the southern County

boundary (station C-120). Caffey's Inlet is believed to have been open between 1770 and 1811. Though little is known of the specifics of the inlet, it has been theorized that the extensive back barrier marsh west of this portion of the barrier beach is built upon the relic flood tide delta system of Caffey's Inlet. Research conducted by Moran et al., (2015) suggested that Caffey's Inlet "accommodated a significant tidal prism", meaning that it was a significant inlet for the region.

2 DATA COLLECTION

Data used in this study included thirteen (13) different data sets including the most recent beach profile data acquired by CPE in 2025. See Table 2 below for dates and description of the datasets that were used.

Table 2. Dataset Descriptions

Agency/Firm	Survey Type	Date Range	Stations
USACE	Lidar	6/18/2009-6/25/2009	C-001 to C-120
CSE	Profile Survey	09/2015	C-097 to C-120
USACE	Lidar	6/9/2017-9/16/2017	C-001 to C-120
CSE	Profile Survey	10/2017	C-097 to C-120
USACE	Lidar	8/24/2018-8/28/2018	C-001 to C-120
USACE	Lidar	6/18/2019-6/25/2019	C-001 to C-120
CPE	Profile Survey/Offshore Bathymetry	4/24/2020-5/15/2020	C-001 to C-120
CPE	Profile Survey	6/1/2021-6/9/2021	C-001 to C-120
CPE	Profile Survey	5/14/2022-5/22/2022	C-001 to C-120
CPE	Offshore Bathymetry	5/21/2022-6/15/2022	C-001 to C-120
CPE	Profile Survey	6/6/2023-6/10/2023	C-059 to C-120
CPE	Profile Survey	5/28/2024-6/1/2024	C-001 to C-120
CPE	Profile Survey	6/3/2025-6/4/2025	C-059 to C-120

Throughout this report, elevations provided are referenced to the North American Vertical Datum (NAVD88). Table 3 provides tidal datums used in this study. The beach profiles are shown visually along the oceanfront in Figure 2 through Figure 6.

Table 3. Tidal Datums

Datum	Elevation (ft., NAVD88)
Mean High Water (MHW)	+1.24
Mean Tide Level (MTL)	-0.41
Mean Low Water (MLW)	-2.05

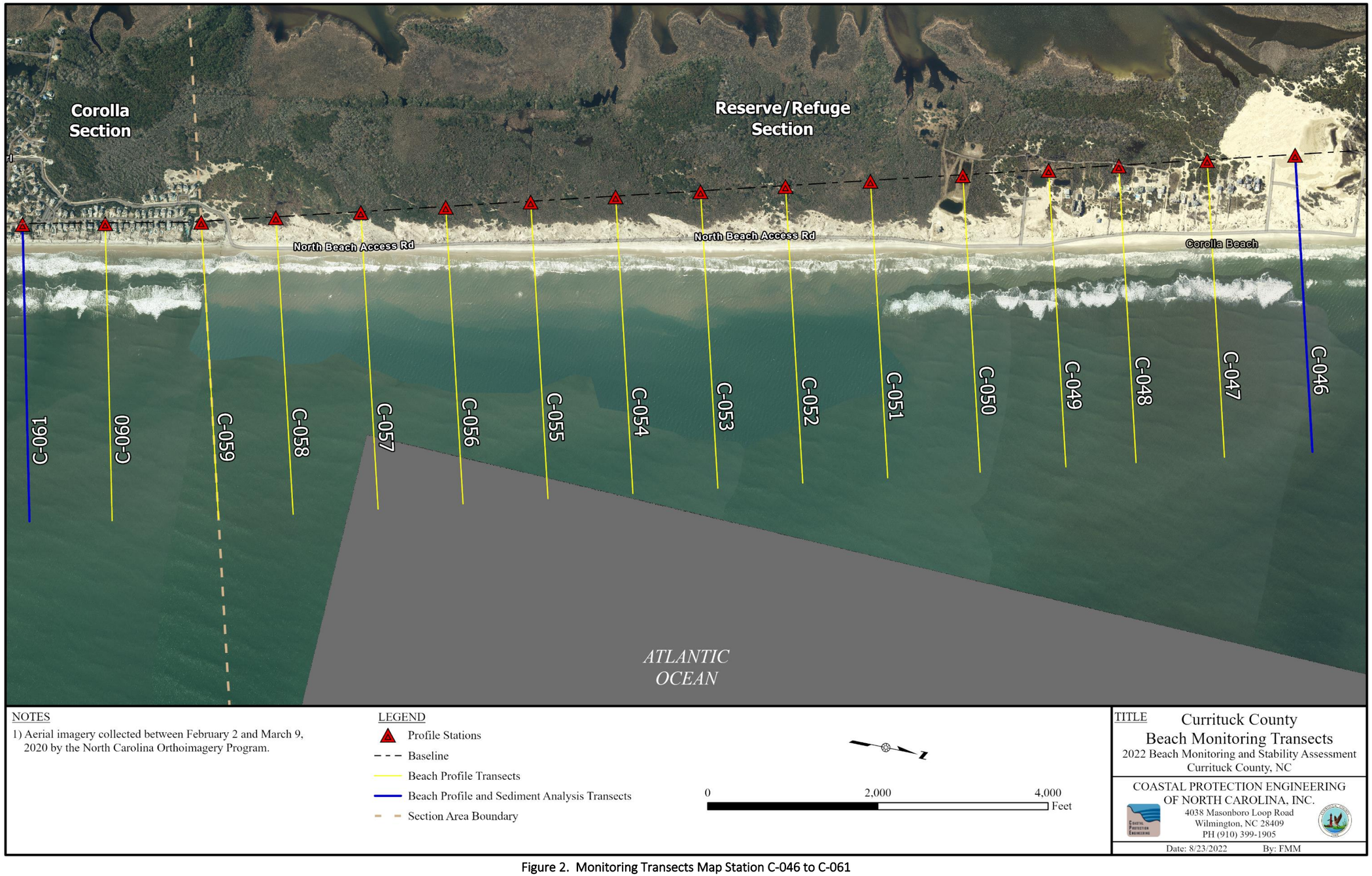

Figure 2. Monitoring Transects Map Station C-046 to C-061

Figure 3. Monitoring Transects Map Station C-061 to C-076

Figure 4. Monitoring Transects Map Station C-076 to C-091

Figure 5. Monitoring Transects Map Station C-091 to C-106

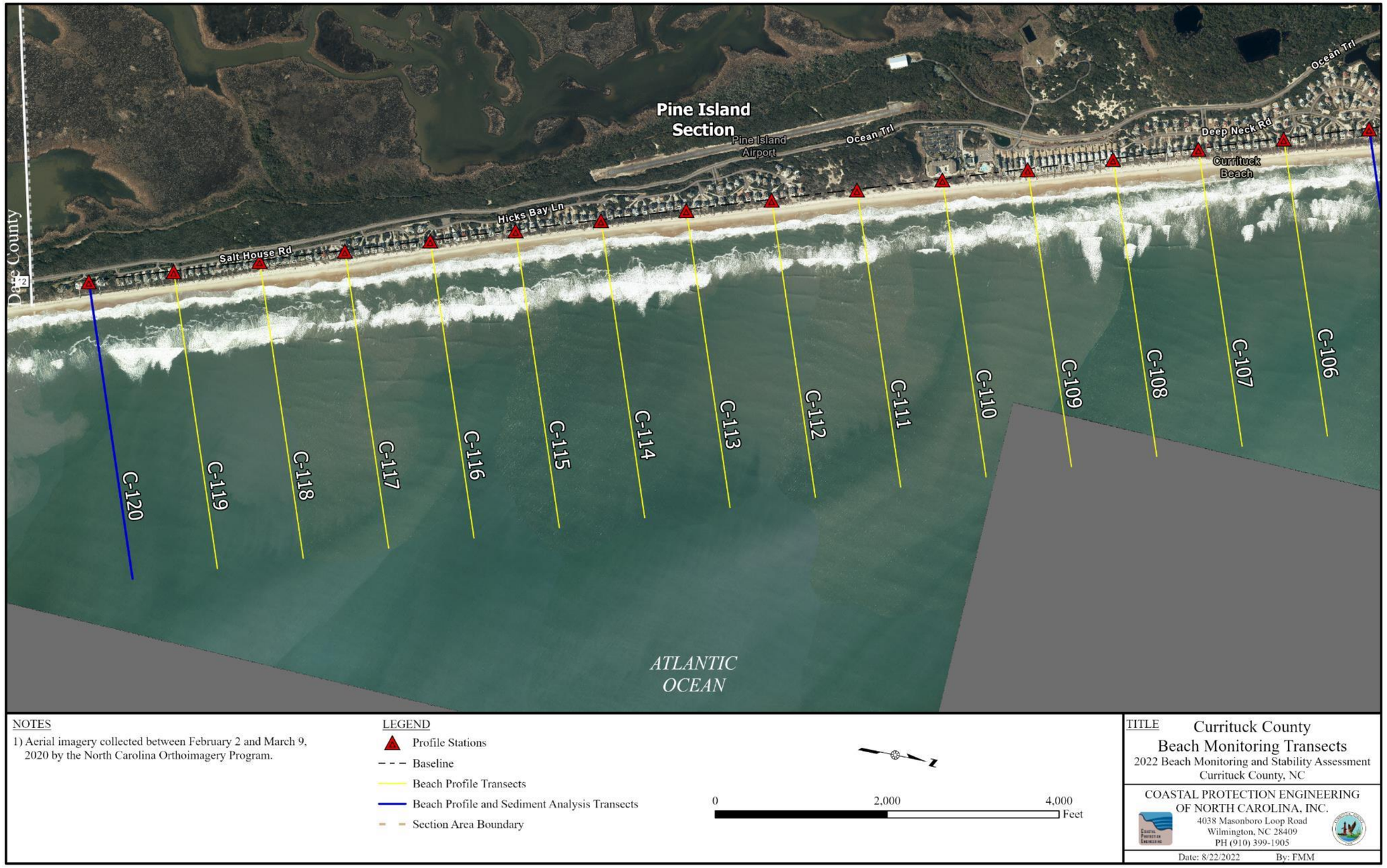

Figure 6. Monitoring Transects Map Station C-106 to C-120

2.1 NC DCM Long-Term Average Annual Shoreline Change Rates

As described on the North Carolina Division of Coastal Management's (NC DCM) website, long-term average annual shoreline change rates are computed for the sole purpose of establishing oceanfront construction setback factors. The change rates are calculated using the endpoint method, which uses the earliest and most current shoreline data points where they intersect a given shore-perpendicular transect. The distance between the shoreline position of the two data sets is computed and divided by the time between the data sets. Typically, the State rates represent a 50-year rate. The shoreline position change rate information provided by the State is admittedly not predictive, nor does it reflect the short-term erosion that can occur during storms. The change rates acquired from the North Carolina 2019 Oceanfront Setback Factors & Long-Term Average Annual Erosion Rate Update Survey report created by the NC DCM (NC DCM, 2019) are compared to the shoreline change rates computed as part of this monitoring report (See Section 3).

2.2 USACE Lidar Data

Light Detection and Ranging (Lidar) is a remote sensing method that uses light in the form of a pulsed laser to measure ranges (variable distances) to the Earth (NOAA, 2012). These light pulses, combined with other data recorded by the airborne system, generate precise, three-dimensional information about the shape of the Earth and its surface characteristics.

A Lidar instrument principally consists of a laser, a scanner, and a specialized GPS receiver. Airplanes are used for acquiring lidar data over broad areas. There are two types of Lidar, topographic and bathymetric. Topographic Lidar typically uses a near-infrared laser to map the land, while bathymetric Lidar uses water-penetrating green light to also measure seafloor and riverbed elevations.

Lidar systems allow scientists and mapping professionals to examine both natural and manmade environments with accuracy, precision, and flexibility. NOAA and USACE scientists are using lidar to produce more accurate shoreline maps, make digital elevation models for use in geographic information systems, assist in emergency response operations, and in many other applications. Lidar data from August 2009 was determined to be the earliest reliable topographic data and was selected for the long-term analysis include herein.

2.3 CSE Beach Profile Data

Beach profile survey data were collected by CSE in September 2015 and October 2017 as part of the Pine Island, Currituck County, Beach Condition Monitoring (CSE, 2018). The monitoring study initiated by the Pine Island Property Owners Association (PIPOA) included beach profile surveys encompassing approximately 5.3 miles of the beach, 1 mile north and south of the Pine Island community. These profiles were spaced every 500 feet alongshore extending from the foredune to a depth greater than 30 ft. CSE profiles 0+00 through 230+00 were used by CPE for the County

study. Table 4 shows a comparison between the CSE referenced stations and the names of the stations used in the County Study (C-097 through C-120).

Table 4. CPE and CSE Monitoring Station Comparison

CPE Station	CSE Station
C-097	000+00
C-098	010+00
C-099	020+00
C-100	030+00
C-101	040+00
C-102	050+00
C-103	060+00
C-104	070+00
C-105	080+00
C-106	090+00
C-107	100+00
C-108	110+00
C-109	120+00
C-110	130+00
C-111	140+00
C-112	150+00
C-113	160+00
C-114	170+00
C-115	180+00
C-116	190+00
C-117	200+00
C-118	210+00
C-119	220+00
C-120	230+00

2.4 CPE Beach Profile Data

CPE conducted beach profile surveys for Currituck County in May 2020, June 2021, May 2022, June 2023, June 2024, and June 2025. The 2020 through 2022 surveys included 120 profiles (station C-001 to station C-120) along the beachfront of Currituck County. The June 2023 survey was limited to the 62 profiles (station C-059 to station C-120) along the beachfront of Currituck County south of the Horse Gate. The June 2024 survey included all 120 profiles (station C-001 to station C-120) along the entire beachfront of Currituck County. The most recent survey, conducted in June 2025, was limited to the 62 profiles (station C-059 to C-120) south of the Horse Gate in Currituck County. All of the CPE beach profile surveys include a topographic survey of the dune, berm, and foreshore section of the beach and a bathymetric survey of the offshore portion of the profile. See Appendix A for 2025 Currituck County Data Acquisition Survey Report.

Beach profiles extended landward from the beach toward the monitoring baseline until a structure was encountered or a range of 150 feet beyond the dune was reached, whichever was more seaward. Elevation measurements were also taken seaward along each profile to a range of 2,500 feet beyond the shoreline or to the -30-ft. NAVD88 contour, whichever was more landward.

Land-based or "upland" data collection included all grade breaks and changes in topography to provide a representative description of the conditions at the time of the work. The maximum spacing between data points along individual profiles was 25 feet. The upland work extended into wading depths sufficient to provide a minimum 50-foot overlap with the offshore data. This overlap between the topographic and bathymetric surveys provides quality control and quality assurance of the survey.

The nearshore portion of the profile data collection commenced from a point overlapping the upland data by 50 feet to ensure seamless transitions and extended seaward to a point overlapping the offshore data collected by the survey vessel by a minimum of fifty (50) feet. The nearshore portion of the profiles were surveyed by two (2) surveyors with an Extended Rod Trimble RTK GNSS rover and a controller who entered the water wearing personal floatation devices. This system allowed for the collection of RTK GNSS data in the nearshore region while maintaining data accuracy and personal safety.

The offshore hydrographic survey was conducted using Teledyne Odom Hydrographic's ECHOTRAC E-20 (or equivalent) on a survey vessel with a centrally located hull-mounted transducer at a frequency of 200 kHz. Offshore data points were collected at 20-50 Hz (pings per second), and the data was sorted to a maximum spacing of 25 feet. An Applanix POS MV Inertia Navigation system was used onboard the survey vessel to provide instantaneous tide corrections as well as pitch, roll, and heave corrections. Tide corrections were checked at the beginning and end of the survey day using a Trimble RTK GNSS unit to measure the water surface elevation. During data processing a local tide gauge was compared with the tide collected to meet the requirements for the specific work. In order to maintain the vessel's track along the profile lines, HYPACK navigation software was used for real time navigation and data acquisition.

The sounder was calibrated with a sound velocity probe and conventional bar-check at the beginning and end of each survey day. The AML CTD Base X sound velocity probe provides a fast and accurate sounder calibration. Bar-checks were performed as a redundant calibration from a depth of five (5) feet to a minimum depth of twenty-five (25) feet.

Offshore profiles extended seaward, beyond the projected depth of closure. Depth of closure (DOC) is a theoretical depth along a beach profile where sediment transport is typically negligible. For more information pertaining to the determination of the depth of closure for this project, please refer to the 2020 Beach Monitoring and Beach Stability Assessment (CPE, 2020). The offshore data collection landward limit was based on a safe approach distance for the survey vessel based on conditions. Offshore data had a minimum overlap of fifty (50) feet with the nearshore beach profile.

3 SHORELINE ANALYSES

Shoreline change is calculated by comparing shoreline positions along shore perpendicular transects over time. This linear change in the position of the shoreline moving either landward or seaward, is often easier for the general public to visualize; however, shoreline changes are not always synonymous with volumetric changes. Figure 7 shows a typical comparison plot of two beach profile surveys conducted approximately 10.6 years apart along station C-001, illustrating graphically how the shoreline change is measured.

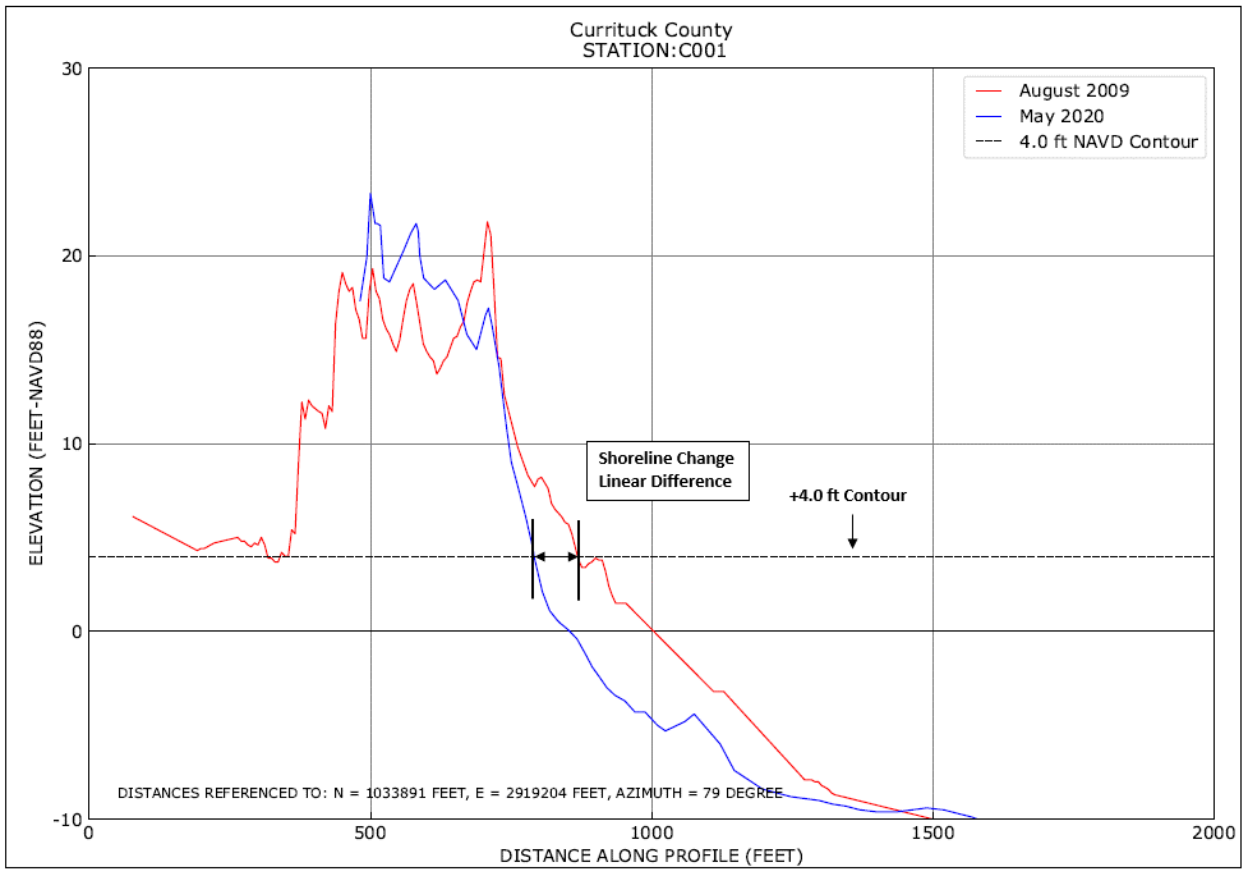

Figure 7. Beach Profile Cross Section Illustrating Shoreline Change.

As previously mentioned, the State of North Carolina maintains long-term shoreline change rates for the State's shoreline with the sole purpose of establishing construction setbacks. Figure 8 shows an example of the State long-term average shoreline change rates along a portion of the Currituck County oceanfront.

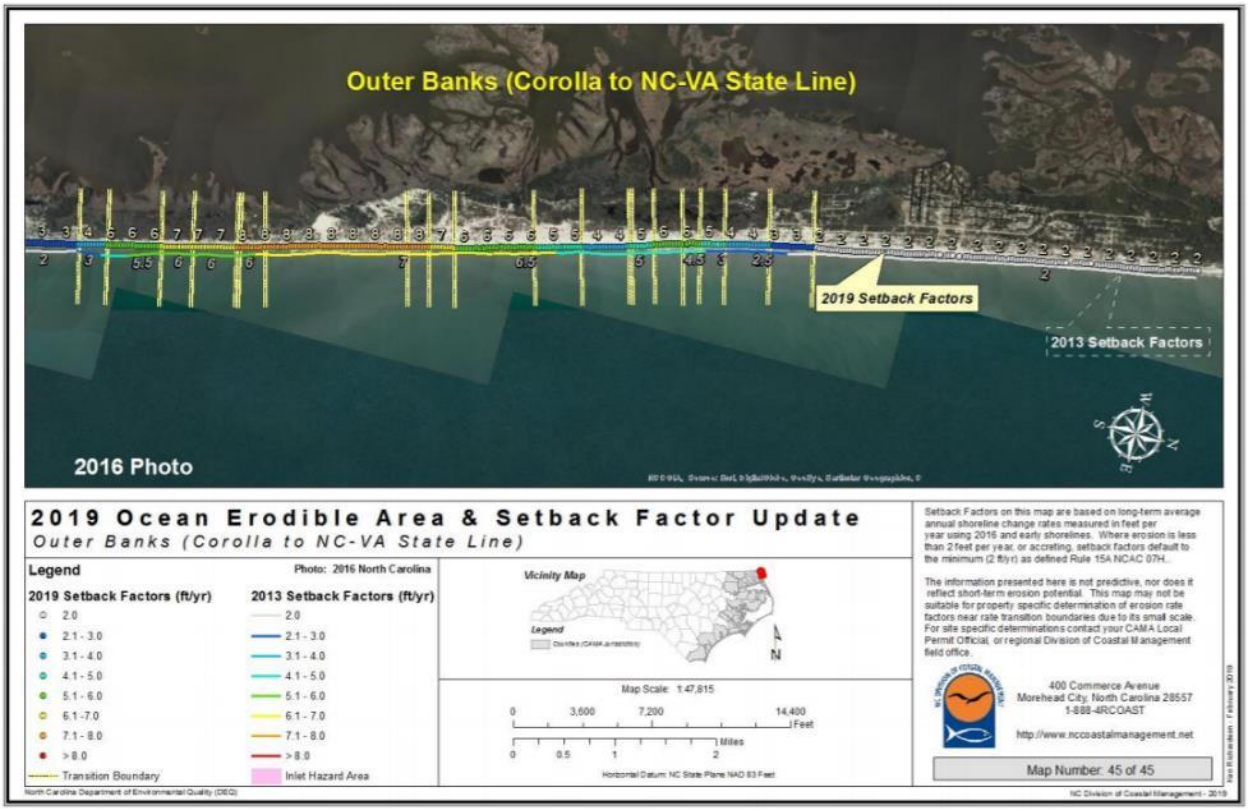

Figure 8. Map showing the SBF for Reserve/Refuge and Carova Sections of Currituck County

The average, maximum, and minimum Set Back Factor's (SBF's) for each of the 4 sections of the Assessment Area are provided in Table 5. As shown in the table, the average SBF for the Carova, Corolla, and Pine Island Sections are between 2 and 3 ft./yr., whereas the average SBF for the Reserve/Refuge Section is over 6 ft./yr. The SBF published by the State for the Pine Island Section (station C-102 located near Spindrift Trail to station C-120 located near Station 1 Lane) is 2 ft./yr. However, the State does not publish a SBF of less than 2.0 ft./yr. and therefore, this value may indicate shoreline change of less than 2 ft. per year, or accreting. This default SBF is defined by Rule 15 NCAC 07H. However, as noted by the State in their disclaimer, the shoreline position change rates are not predictive and do not reflect short-term erosion that can occur over shorter periods of time (i.e. decadal, seasonally or during storm events).

Table 5. NC DCM 2019 Setback Factors

Section	Average Setback Factor (ft./yr.)	Maximum Setback Factor (ft./yr.)	Minimum Setback Factor (ft./yr.)
Carova (C-001 to C-027)	2.49	6.00	2.00
Reserve/Refuge (C-027 to C-059)	6.57	8.00	4.00
Corolla (C-059 to C-102)	2.28	6.00	2.00
Pine Island (C-102 to C-120)	2.00	2.00	2.00
Total Assessment Area (C-001 to C-120)	3.37	8.00	2.00

Setback factors infer a recession rate or movement of the shoreline landward

Rates computed for the 2025 Assessment were calculated using a linear regression method. The rate is calculated by determining the slope of the linear trendline for a certain shoreline position (+4 ft. NAVD88) for all available survey events. Figure 9 illustrates the approach showing shoreline positions (black dots) and the trendline for station C-059. These rates are described in terms of positive (+) for advance (shoreline moving seaward) and negative (-) for recession (shoreline moving landward).

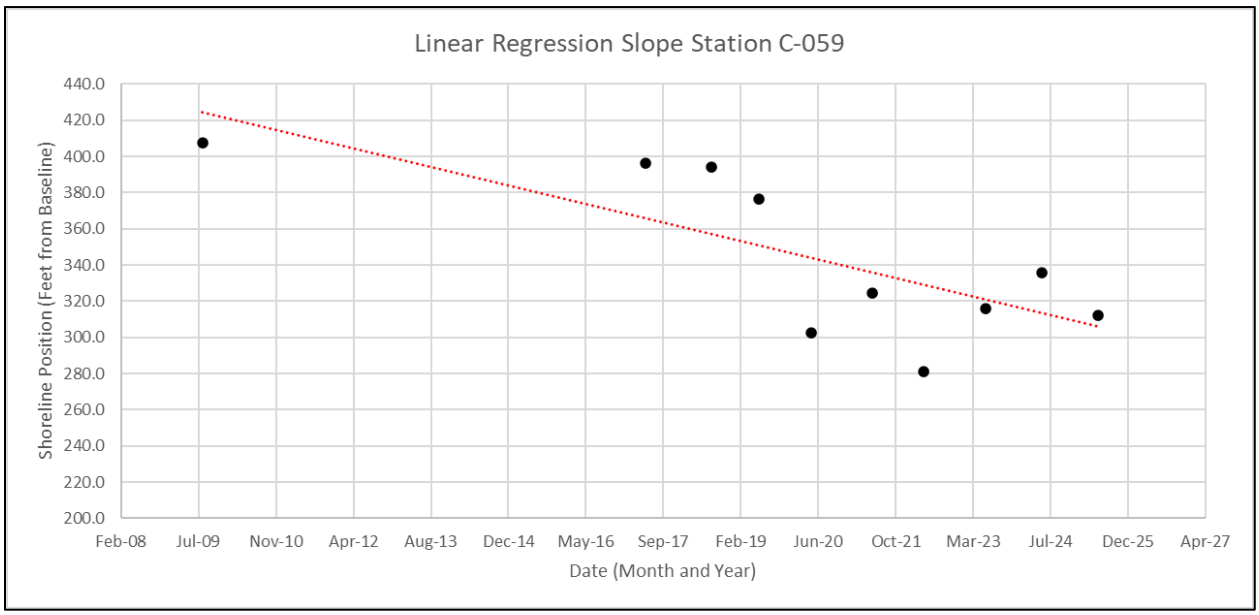

Figure 9. Example of Linear Regression Slope

Using available beach profile and Lidar data, a shoreline change analysis was conducted to assess shoreline advance and recession along the Assessment Area. As it relates to shoreline change, the "shoreline" is typically defined as a specified elevation contour. Often times the Mean High Water (MHW) contour is chosen as the representative contour. For this study, the shoreline was defined as the +4 ft. NAVD88 contour for two primary reasons. The first is that the older Lidar data sets used, such as the 2009 data, do not reliably capture the MHW contour on every profile. The +4 ft. NAVD88 contour appears to be consistently and reliably captured along the Assessment Area. The second reason the +4 ft. NAVD88 contour was used is that this contour more closely aligns with the shoreline position that is used by the State of North Carolina in their long-term shoreline change rates.

It is important for the reader to note that although shoreline change can be an indicator of loss or gain of beach width, the nature of sand movement in response to wave and water level conditions makes shoreline position highly variable temporally. The response of a beach due to storm conditions typically results in a steepening of the beach slope near the water line and the movement of sand in the seaward direction forming offshore sand bars. During calmer wave periods, the beach often recovers as sand moves landward. Along the Outer Banks, the beach exhibits a steeper slope and narrower dry sand beach in the winter; whereas the beach slope is less steep in the summer and the dry beach is generally wider.

3.1 12-Month Period (June 2024 to June 2025)

Data collected south of the Horse Gate between June 2024 and June 2025 were examined to compare the positions of the +4 ft. NAVD88 contour and determine shoreline change rates. The averages were determined by computing a weighted average based on distance. The 12-month shoreline change rate south of the Horse Gate was -21.0 ft./yr. The large negative change measured over the 12-month period resulted in an increase in the historical and long-term rates discussed in Sections 3.2 and 3.3, respectively. A summary of the historical, long-term, and 12-month average annualized shoreline change rates computed for the +4 ft. NAVD88 contour for each section of the Assessment Area, as well as an overall project average, are provided in Table 6.

Corolla Section: The average 12-month shoreline change rate calculated for the Corolla Section was -15.6 ft./yr. This rate is a notable decrease from the anomalous positive rate measured between 2023 and 2024, which was +43.9 ft./yr. Negative shoreline change rates were measured at 31 of the 44 profiles in this section. The shoreline change rates in this section ranged from -58.8 ft./yr. at station C-068 to +53.0 ft./yr. at station C-067.

Pine Island Section: The average 12-month shoreline change rate calculated for the Pine Island Section was -34.0 ft./yr. This is a reversal in the large positive accretion rate measured between 2023 and 2024, which was +42.9 ft./yr. A negative shoreline change rate was measured at 18 of the 19 profiles in this section. The shoreline change rates in this section ranged from -59.8 ft./yr. at station C-113 to +14.2 ft./yr. at station C-120.

3.2 Historical Period (August 2009 to June 2025)

Data collected throughout the Assessment Area between August 2009 and June 2025 were examined to compare the positions of the +4 ft. NAVD88 contour and determine shoreline change rates. Shoreline change rates were determined using a linear regression method given the various data sets available between August 2009 and June 2025. The averages were determined by computing a weighted average based on distance. Table 6 provides a summary of the historical, long-term, and 12-month average annualized shoreline change rates computed for the +4 ft. NAVD88 contour for each Section of the Assessment Area surveyed in June 2025, as well as an overall average.

Table 6. Summary of Average Historical, Long-Term, and Recent Shoreline Change Rates by Monitoring Section

Section	Historical Rate (ft./yr.) (Aug. 2009 to June 2025)	Long-term Rate (ft./yr.) (May 2020 to June 2025)	12-Month Rate (ft./yr.) (June 2024 to June 2025)
Corolla (C-059 to C-102)	-3.9	+7.4	-15.6
Pine Island (C-102 to C-120)	-1.0	+2.4	-34.0
Total Assessment Area (C-059 to C-120)	**-3.1**	**+5.9**	**-21.0**

Historical and long-term shoreline change rates at each station along the Assessment Area are provided in Table 7 and are shown graphically in Figure 10.

Table 7. Summary of Historical and Long-Term Shoreline Change Rates

Station	Historical Rate (ft./yr.) (Aug. 2009 to June 2025)	Long-Term Rate (ft./yr.) (May 2020 to June 2025)	Station	Historical Rate (ft./yr.) (Aug. 2009 to June 2025)	Long-Term Rate (ft./yr.) (May 2020 to June 2025)
C-059	-7.5	3.4	C-090	-3.9	6.9
C-060	-7.5	6.9	C-091	-2.4	6.4
C-061	-7.3	7.5	C-092	-3.7	3.7
C-062	-7.1	3.1	C-093	-2.8	6.2
C-063	-6.3	2.9	C-094	-2.3	2.0
C-064	-4.4	0.5	C-095	-3.2	7.9
C-065	-5.6	5.2	C-096	-1.2	3.1
C-066	-3.1	10.2	C-097	-2.9	6.8
C-067	-4.1	5.7	C-098	-2.3	1.9
C-068	-4.1	9.6	C-099	-6.0	8.2
C-069	-3.4	9.4	C-100	-1.5	9.7
C-070	-2.2	5.1	C-101	-3.2	8.0
C-071	-4.0	5.7	C-102	-3.5	5.9
C-072	-6.1	0.2	C-103	-3.3	3.1
C-073	-4.5	4.7	C-104	-1.1	4.9
C-074	-4.6	6.9	C-105	-0.4	1.6
C-075	-5.1	3.1	C-106	-0.7	6.7
C-076	-5.0	4.8	C-107	1.1	3.3
C-077	-2.4	8.3	C-108	-1.5	2.3
C-078	-3.9	6.0	C-109	0.5	5.1
C-079	-2.9	13.7	C-110	0.6	3.9
C-080	-6.5	12.2	C-111	-2.5	3.0
C-081	-3.8	11.8	C-112	-0.9	2.7
C-082	-2.3	17.4	C-113	-1.3	-2.3
C-083	-2.7	16.0	C-114	-1.1	2.0
C-084	-2.2	11.5	C-115	-2.4	0.2
C-085	-3.7	13.7	C-116	-3.9	-3.5
C-086	-2.6	10.5	C-117	-1.8	-0.3
C-087	-3.2	13.4	C-118	1.2	-3.7
C-088	-4.2	10.6	C-119	1.3	5.9
C-089	-2.7	7.3	C-120	-0.2	11.0

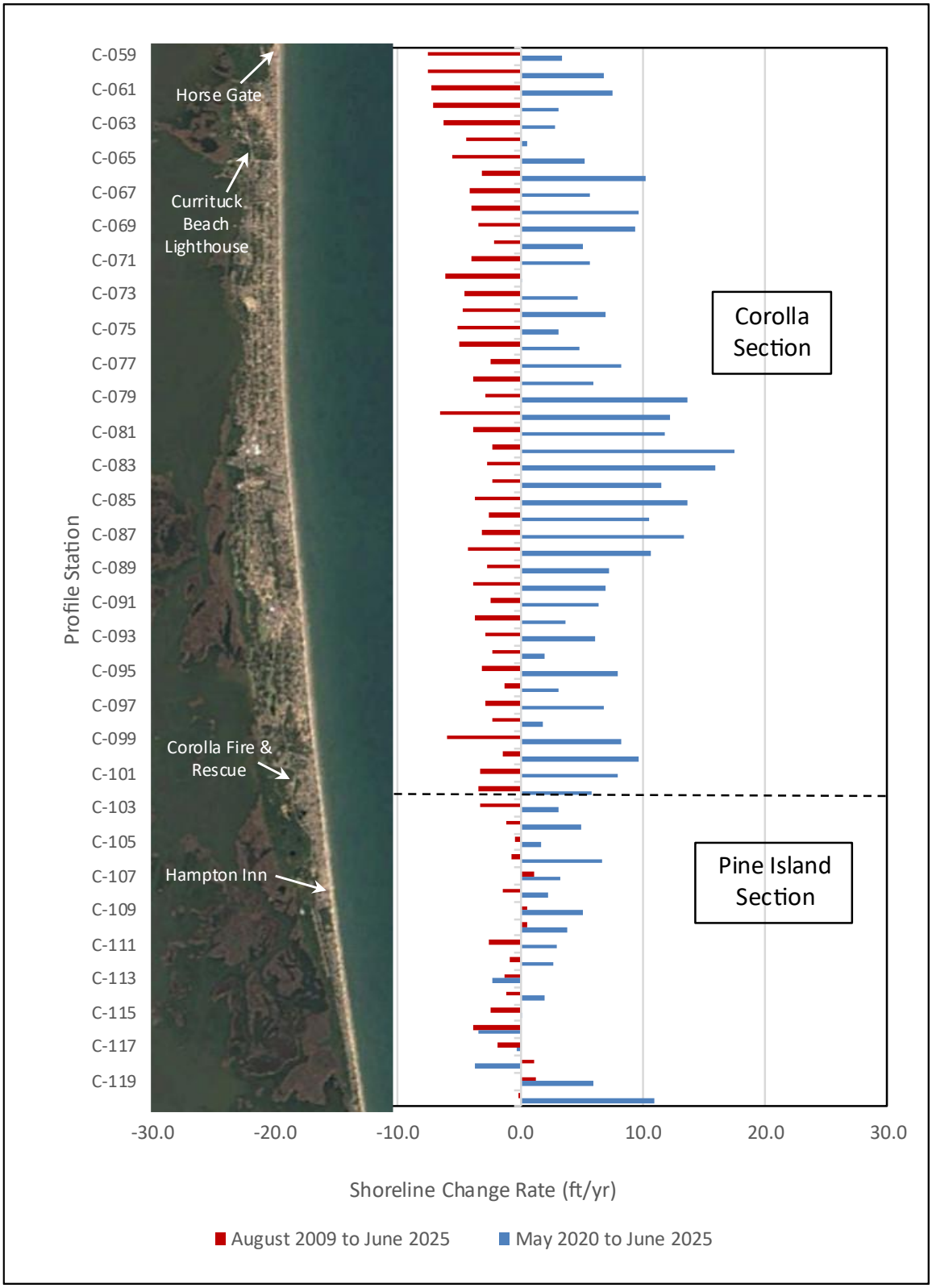

Figure 10. Historical and Long-term Shoreline Change Rates (+4 ft. NAVD88) South of the Horse Gate (C-059 to C-120)

Corolla Section: The average historical shoreline change rate calculated for the Corolla Section was -3.9 ft./yr. This is a decrease in the historical erosion rate measured between 2009 and 2024, which was -4.4 ft./yr. The State determined an average SBF of 2.28 ft./yr. in the Corolla Section (note SBF's infer a recession rate or movement of the shoreline landward). A negative shoreline change rate was measured at each profile along the Corolla Section of the Assessment Area, ranging from -7.5 ft./yr. at station C-059 and C-060 to -1.2 ft./yr. at station C-096.

Pine Island Section: The average historical shoreline change rate between August 2009 and June 2025, in the Pine Island Section was relatively stable, measuring -1.0 ft./yr. This is an increase in the historical erosion rate measured between 2009 and 2024, which was -0.6 ft./yr. The State determined an average SBF of 2.0 ft./yr. in the Pine Island Section (station C-102 to station C-120) (note SBF's infer a recession rate or movement of the shoreline landward). Shoreline change rates varied along the Pine Island Section from -3.9 ft./yr. at station C-116 (located approximately 500 feet north of Yaupon Lane) to +1.3 ft./yr. at station C-119 (located at the south end of Salt House Rd).

3.3 Long-term Rate (May 2020 to June 2025)

The average long-term shoreline change rate between May 2020 and June 2025 along the area surveyed in 2025 (station C-059 to station C-120) was +5.9 ft./yr. Long-term shoreline change rates at each station along the Assessment Area are provided in Table 7. A summary of the recent, long-term, and historical average annualized shoreline change rates computed for the +4 ft. NAVD88 contour for each section of the Assessment Area, as well as an overall project average, are provided in Table 6. Shoreline change rates for the long-term and historical periods are shown graphically in Figure 10.

Corolla Section: The average shoreline change rate calculated for the Corolla Section between May 2020 and June 2025 was +7.4 ft./yr. This is a decrease in the positive shoreline change rate trend measured between 2020 and 2024, which was +8.1 ft./yr. No stations measured landward movement in this section over this period. A profile-by-profile comparison shows shoreline change rates in this section ranging from +0.2 ft./yr. at station C-072 to +17.4 ft./yr. at station C-082.

Pine Island Section: The average shoreline change rate calculated for the Pine Island Section between May 2020 and June 2025 was +2.4 ft./yr. This is a decrease in the positive rate measured between 2020 and 2024, which was +5.8 ft./yr. Shoreline change rates varied along the Pine Island Section from -3.7 ft./yr. at station C-118 (located along the middle of Salt House Rd) to +11.0 ft./yr. at station C-120 (located at 101 Station Lane). Only four stations (C-113, C-116, C-117, and C-118) had negative rates along Pine Island during this period.

3.4 Shoreline Projections

As part of this study, the shoreline change model previously developed to project shoreline change over a 10-, 20-, and 30- year period was updated to incorporate the June 2025 survey data. The

June 2025 shoreline location of the +4 ft. NAVD88 contour was projected into the future for periods of 10-, 20-, and 30-years based on the historical shoreline change rates calculated between August 2009 and June 2025.

A three-point average was applied to the individual shoreline change rates that were measured at each station in order to smooth the data along the Assessment Area, while maintaining the observed trends. This is consistent with the method used for shoreline projections presented in the previous Currituck County Beach Monitoring and Beach Assessment reports. For the stations on the north end of the Assessment Area (station C-059) and south end of the Assessment Area (station C-120), the actual measured shoreline change rate was used to determine projected shorelines. For those profiles on which the three-point average shoreline change rate was positive, indicating a seaward trend in the shoreline movement, no shoreline projection is shown. Maps showing the results of the projected shoreline change are included in Appendix B.

This analysis identified a house as "impacted" if any part of the footprint of the structure, as shown in the Currituck County GIS, was seaward of the 10-, 20-, or 30-year projected shorelines. Table 8 shows the number of houses in each of the four project sections shown to be impacted over the 10-, 20-, and 30-Year time horizons. The analysis does not include specific evaluations of damages to individual houses due to direct flooding, wave impacts, or wind impacts, nor will it quantify the economic impacts resulting from the damage or loss of such structures. If the County requires this type of economic impact, additional analyses will be required.

Table 8. Number of houses shown to be impacted over the 10-, 20-, and 30-year time horizons

Section	10-Year	20-Year	30-Year
Corolla (C-059 to C-102)	0	19	43
Pine Island (C-102 to C-120)	0	0	0
Total Assessment Area (C-001 to C-120)	**0**	**19**	**43**

In the Corolla Section of the Assessment Area, the projected shoreline change shown in Table 8 indicates extensive numbers of oceanfront houses may be impacted over a 30-year time horizon. Along the northern portion of the Corolla Section from 1281 Sandcastle Drive (station C-060) to south of Carotank Drive (station C-065), a total of 43 houses were shown to be impacted over the 30-year horizon. Out of those 43 houses, 19 were impacted over the 20-year horizon and 0 were impacted over the 10-year horizon. The number of houses indicated as impacted along this portion of the Corolla Section over the 30-year horizon represents an increase of approximately 65% compared to the number of houses reported as impacted in the 2024 analysis.

In contrast to 2024, the 2025 projected shoreline change methodology did not indicate any impacts to oceanfront houses in the Corolla Section between Carotank Drive (station C-065) and station C-084, which includes the beaches along the Whalehead Beach community, based on the 10-, 20-, or 30-year projected shorelines. The 2024 analysis indicated 30 houses along this portion of the Corolla Section as impacted by the 30-year projection. South of station C-084, neither the

2024 or 2025 assessment identified any oceanfront houses impacted by the shoreline change projections over 30-years.

In the southernmost Section (Pine Island) of the Assessment Area, the projected shoreline change methodology did not indicate any impacts to oceanfront houses based on the 10-, 20-, or 30-year projected shorelines. This is consistent with results from the 2024 analysis.

4 VOLUME ANALYSES

As discussed in the previous section, changes in the shoreline position represented by a single elevation contour can vary considerably based on sea conditions leading up to the time in which the surveys were conducted. Sand on the beach is distributed by wind and wave action over the entire active profile. The dry beach often observed above the water represents only a fraction of the active beach profile. Therefore, the volume of sand measured on the entire active profile is an important parameter to track to gauge the health of the beach. As provided in previous monitoring reports, volumetric change was calculated between the dune and the depth of closure (-19 ft. NAVD88), this represents the landward and seaward limits of the active profile as defined for this particular assessment. Additional information on the determination of the depth of closure can be found in the 2020 report (CPE, 2020).

A volumteric analyses was completed as part of the 2025 Assessment through a comparison of May 2020, June 2024, and June 2025 data. A long-term rate was calculated between May 2020 and June 2025 and a short-term rate was calculated between June 2024 and June 2025. The results of this volumetric analysis are detailed in Section 4.1. Beginning with the 2022 Beach Assessment, an additional assessment of volumetric change was incorporated into the annual monitoring. This additional method split the active profile into 4 parts or “Lenses” in the cross-shore direction (CPE, 2023a). This analysis was performed as part of the 2025 Beach Assessment and results of volumetric changes measured within each lens are provided in Section 4.2 and discussed further in Section 5.0.

4.1 Volumetric Change (-19 Ft. NAVD88 Depth of Closure)

As discussed above, volumetric change was computed using the 2025 data out to the -19 ft. NAVD88 depth contour. Figure 11 shows the same profile shown in Figure 7 with areas between the profiles shaded to show areas of volume gains (green-accretion) and volumes losses (red-erosion) along the profile. The net difference between these gains and losses is referred to as the volume change.

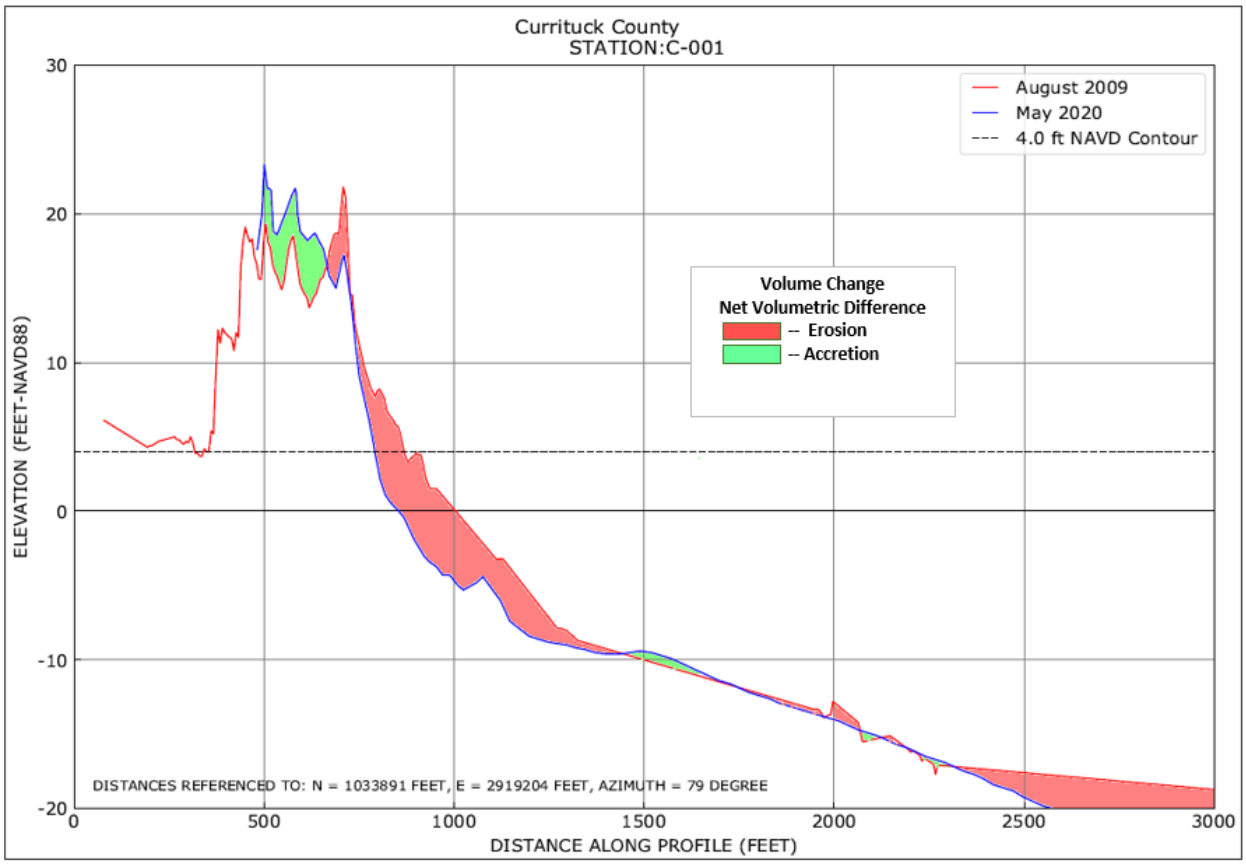

Figure 11. Beach Profile Cross Section Illustrating Volume Change

Volumetric changes along a profile, or volumetric changes averaged over multiple profiles, are provided in cubic yards per linear foot of beach. At times, this report also provides total volume change in cubic yards measured between certain profiles. These volumes are determined using the average end area method; whereby the average volume change between adjacent profiles is multiplied by the distance between those profiles. Volumetric change rates are given in cubic yards per linear feet of beach per year and cubic yards per year. The volumetric changes are calculated along the entirety of the profile from the depth of closure to the landward most point at which overlapping data between surveys exists.

With the collection of the June 2025 beach profile data along the southern half of the Currituck County beach, south of the Horse Gate, long-term and short-term volumetric changes were computed between May 2020 and June 2025 (long-term) and June 2024 and June 2025 (12-month). The average density change rate and total volumetric change for the Corolla and Pine Island Sections and the overall 2025 Assessment Area (south of the Horse Gate) are provided in Table 9.

Table 9. Summary of Average Volumetric Change Rates and Total Volume Changes Measured to -19 ft. NAVD88.

Section	Long-term and 12-month Average Density Change Rate (cy/ft./yr.)		Long-term and 12-month Total Volume Change (cy)	
	May 2020 to June 2025	June 2024 to June 2025	May 2020 to June 2025	June 2024 to June 2025
Corolla	1.4	-6.5	305,800	-282,000
Pine Island	2.7	0.4	243,900	7,100
Total Assessment Area (C-059 to C-120)	**1.8**	**-4.5**	**549,700**	**-275,000**

4.1.1 Long-term Period May 2020 to June 2025

The average long-term volumetric change rate of the overall Assessment Area (south of the Horse Gate) measured between May 2020 and June 2025 was +1.8 cy/ft./yr., resulting in a cumulative positive volumetric change of approximately 549,700 cubic yards (Table 9). Both the Corolla and Pine Island Sections experienced a positive volumetric change during this period. Table 10 lists the individual volumetric change rates computed for each profile (stations C-059 to C-120) between May 2020 and June 2025. Figure 12 shows the 2020 to 2025 change rates graphically.

Corolla Section: The average long-term volumetric change rate in the Corolla Section was +1.4 cy/ft./yr., which equates to a net volume gain of approximately 305,800 cy over the 5.1-year period, or a gain of 60,200 CY per year. In comparison, the average volume change rate measured between May 2020 and June 2024 in this section was +3.3 cy/ft./yr. (CPE, 2025). Negative volumetric change rates were measured on 19 of the 44 profiles in this section (Table 10 and Figure 12) between May 2020 and June 2025. A profile-by-profile comparison shows volumetric change rates in this section ranging from -4.6 cy/ft./yr. at station C-093 to +10.3 cy/ft./yr. at station C-083.

The Corolla Section was analyzed further for observable trends within the section. Between the northern boundary of the Corolla Section, which is located approximately 250 feet south of the Horse Gate, and approximately 400 feet north of the Herring Beach Access within the Whalehead Beach community (station C-059 to station C-073), the average volumetric change rate was slightly negative at -0.6 cy/ft./yr. From approximately 400 feet north of the Herring Beach Access within the Whalehead Beach community to approximately 200 feet south of the access at Tern Arch (station C-073 to station C-090), the average volumetric change rate was +4.0 cy/ft./yr. From approximately 200 feet south of the access at Tern Arch to the north end of Breakers Arch (station C-090 to station C-098), the average volumetric change rate was -1.4 cy/ft./yr. From station C-098 (north end of Breakers Arch) south to station C-102, approximately 500 feet north of Yaupon Lane, the average volumetric change rate was +3.1 cy/ft./yr.

Table 10. Volumetric Change Rates May 2020 to June 2025 and June 2024 to June 2025.

Station	Long-term Rate (cy/ft./yr.) (May 2020 to June 2025)	Recent Rate (cy/ft./yr.) (June 2024 to June 2025)	Station	Long-term Rate (cy/ft./yr.) (May 2020 to June 2025)	Recent Rate (cy/ft./yr.) (June 2024 to June 2025)
C-059	-2.0	-9.7	C-090	1.1	-14.6
C-060	-0.6	-14.1	C-091	-1.3	-34.1
C-061	-3.3	-17.6	C-092	-3.9	-6.5
C-062	-1.8	6.2	C-093	-4.6	-17.0
C-063	-0.9	-14.1	C-094	-1.0	7.5
C-064	-4.5	-8.8	C-095	-0.8	-5.7
C-065	3.6	-16.5	C-096	-0.4	13.1
C-066	-0.2	-14.7	C-097	-1.6	-8.5
C-067	2.0	3.0	C-098	3.1	-11.5
C-068	-0.6	-27.5	C-099	0.3	5.1
C-069	3.2	-23.7	C-100	2.5	-1.5
C-070	-3.5	-16.8	C-101	5.1	5.5
C-071	1.3	-2.1	C-102	5.8	-2.1
C-072	-2.7	-2.1	C-103	0.5	-1.5
C-073	2.4	0.5	C-104	-0.3	16.0
C-074	-2.1	-7.1	C-105	1.9	19.7
C-075	1.3	-18.2	C-106	1.5	-2.4
C-076	1.9	-8.1	C-107	-2.2	-13.7
C-077	8.8	1.0	C-108	4.2	11.5
C-078	5.9	-15.2	C-109	2.0	-10.4
C-079	8.4	-8.5	C-110	1.8	-6.9
C-080	2.7	-12.2	C-111	5.5	0.5
C-081	7.2	13.9	C-112	3.3	-7.4
C-082	3.2	-19.4	C-113	1.8	-7.1
C-083	10.3	5.9	C-114	7.4	-0.8
C-084	4.3	-7.2	C-115	1.0	2.5
C-085	4.8	5.6	C-116	3.6	40.7
C-086	2.5	4.3	C-117	-1.1	-22.3
C-087	0.5	-3.5	C-118	1.6	-12.4
C-088	6.2	8.2	C-119	8.6	-11.0
C-089	-0.5	4.4	C-120	7.8	27.1

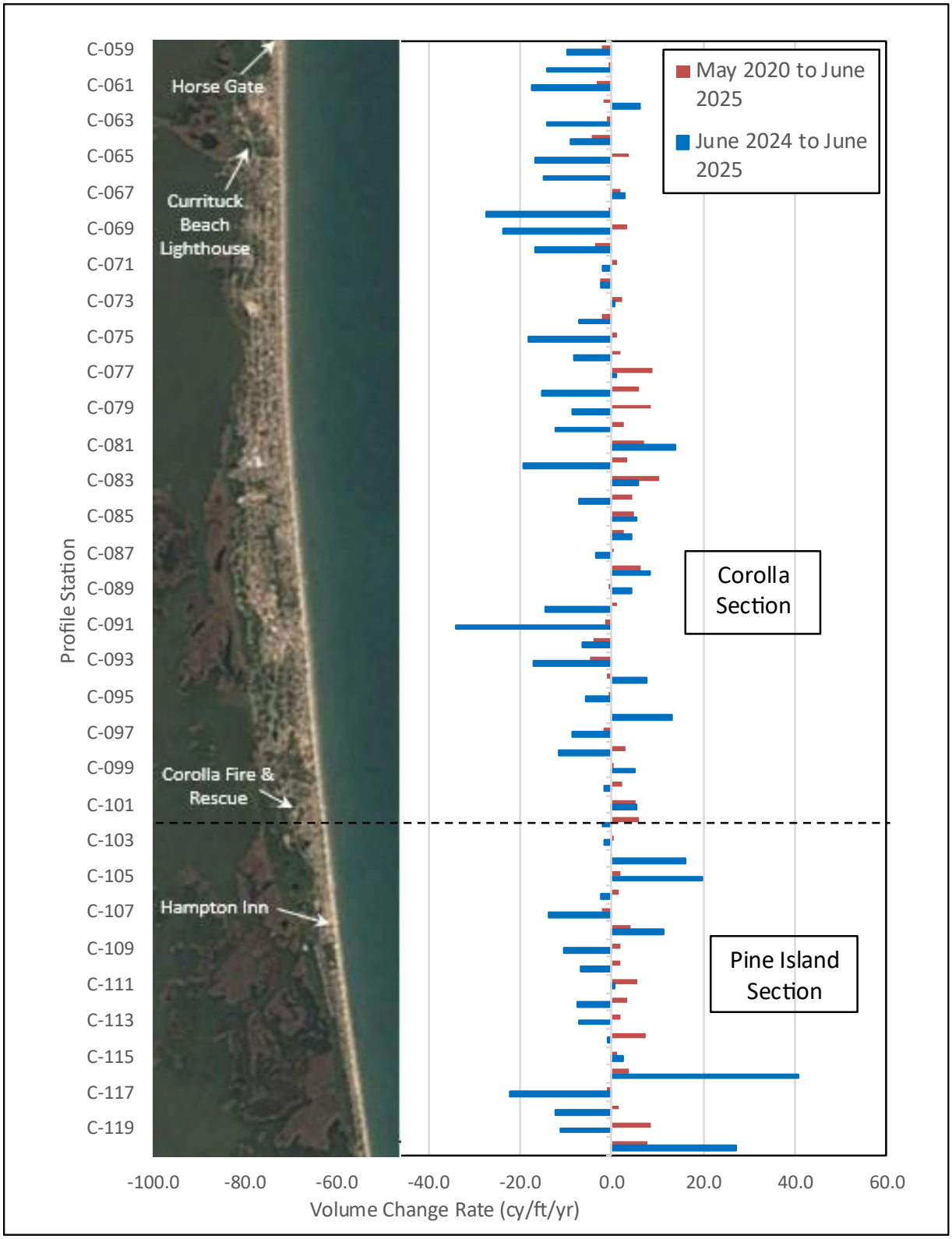

Figure 12. Volume Change Rate Above -19 ft. NAVD88 - South of the Horse Gate May 2020 to June 2025 and June 2024 to June 2025.

Pine Island Section: The average long-term volumetric change rate in the Pine Island Section was +2.7 cy/ft./yr. This equates to a net volume gain of approximately 243,900 cy over the 5.1-year period, or a gain of 48,000 CY per year. In comparison, the average volume change rate measured between May 2020 and June 2024 in this section was +3.2 cy/ft./yr. (CPE, 2025). Negative volumetric change rates were only measured at 3 of the 19 profiles: stations C-104, C-107, and C-117 along this section (Table 10 and Figure 12). A profile-by-profile comparison shows volumetric change rates in this section ranging from -2.2 cy/ft./yr. at station C-107 to +8.6 cy/ft./yr. at station C-119.

The Pine Island Section was analyzed further for observable trends within the section. Between the northern boundary of the Pine Island Section, which is located approximately 500 feet north of Yaupon Lane, and the Hampton Inn (station C-102 to station C-110), the average volumetric change rate was +1.4 cy/ft./yr. From the Hampton Inn to approximately 101 Station 1 Lane, (station C-110 to station C-120), the average volumetric change rate was +3.7 cy/ft./yr.

4.1.2 12-Month Period June 2024 to June 2025

The average volumetric change rate measured south of the Horse Gate over the 12-month period between June 2024 to June 2025 was -4.5 cy/ft./yr., resulting in a cumulative negative volumetric change of approximately -275,000 cubic yards. Table 10 lists the individual volumetric rates computed for each profile in the Corolla and Pine Island Sections between June 2024 and June 2025. Figure 12 shows the June 2024 to June 2025 volume change rates graphically.

Corolla Section: The average volumetric change rate in the Corolla Section was -6.5 cy/ft./yr. This equates to a net volume loss of approximately -282,000 cy over the 12-month period from June 2024 to June 2025. In comparison, the average volume change rate measured between June 2023 and June 2024 in this section was -3.5 cy/ft./yr. (CPE, 2025). This is the second time in a row a negative change has been measured in the Corolla Section over a recent period since the monitoring surveys began in 2020. Negative volume changes were measured at 30 of the 44 profiles along the Corolla Section between June 2024 and June 2025. A profile-by-profile comparison shows volumetric change rates in this section ranging from -34.1 cy/ft./yr. at station C-091 to +13.9 cy/ft./yr. at station C-081 (Figure 12).

Similar to the analysis of long-term trends, the Corolla Section was analyzed further for observable trends within discrete portions of the section. Between the northern boundary of the Corolla Section, which is located approximately 250 feet south of the Horse Gate, and approximately 400 feet north of the Herring Beach Access within the Whalehead Beach community (station C-059 to station C-073), the average volumetric change rate was -11.1 cy/ft./yr. From approximately 400 feet north of the Herring Beach Access within the Whalehead Beach community to approximately 200 feet south of the access at Tern Arch (station C-073 to station C-090), the average volumetric change rate was -3.7 cy/ft./yr. From approximately 200 feet south of the access at Tern Arch to the north end of Breakers Arch (station C-090 to station C-098), the average volumetric change rate was -8.0 cy/ft./yr. Along the southern portion of the Corolla Section, between station C-098

(north end of Breakers Arch) and station C-102 (located approximately 500 feet north of Yaupon Lane), the average volumetric change rate was +0.6 cy/ft./yr.

Pine Island Section: The average volumetric change rate in the Pine Island Section over the 12-month period from June 2024 to June 2025 was +0.4 cy/ft./yr. This equates to a small net volume gain of approximately 7,100 cy. The positive change rate for this 12-month period is a reversal from the large negative change rate measured between June 2023 and June 2024 (-11.8 cy/ft./yr.). Between June 2024 and June 2025, negative volume changes were measured at 12 of the 19 profiles along the Pine Island Section. The rate was highly influenced by the large positive rate at station C-116 (+40.7 cy/ft./yr.), located at the south end of Hicks Bay Lane. A profile-by-profile comparison shows volumetric change rates in this section ranging from -22.3 cy/ft./yr. at station C-117 to +40.7 cy/ft./yr. at station C-116.

Similar to the analysis of long-term trends, the Pine Island Section was analyzed further for observable trends within discrete portions of the section. Between the northern boundary of the Pine Island Section, which is located approximately 500 feet north of Yaupon Lane, and the Hampton Inn (station C-102 to station C-110), the average volumetric change rate was +1.8 cy/ft./yr. From the Hampton Inn to approximately 101 Station 1 Lane, (station C-110 to station C-120), the average volumetric change rate was -0.7 cy/ft./yr.

4.2 Volumetric Change (Lens Calculations)

As previously stated, a second volumetric analysis was incorporated into the annual monitoring assessment beginning in 2022 to further resolve volumetric changes occurring in various lenses of the beach from the dune out to depths beyond the established depth of closure (-19 ft. NAVD88). This additional method provides insight into cross-shore variability in volumetric change. This method splits the profiles into various lenses based on depth contours. For this analysis, the beach was divided into four discreet lenses, which include the Dune, Visible Beach, the Inner Nearshore, and the Outer Nearshore portions of the profile. Figure 13 provides an illustration of the limits of each lens. The elevation contours used as the limits of the lenses were determined by profile inspection and reviewing results of the initial volume change analysis. As part of that profile inspection and initial review of volume changes, cross-shore changes were observed beyond the established -19 ft. NAVD88 contour. However, the offshore limit of these changes appeared to vary along the original Assessment Area, which includes the entire Currituck County oceanfront. North of the Horse Gate, the average depth of closure between May 2020 and May 2022 was determined to be approximately -22 ft. NAVD88, whereas, south of the Horse Gate, the average depth of closure was determined to be approximately -25 ft. NAVD88. Guidance on the determination of elevation limits for the lenses also comes from the "2017 Beach Condition Monitoring Pine Island, Currituck County, North Carolina" (CSE, 2018). In this report, since only the Sections south of the Horse Gate are included, the offshore limit used for the Outer Nearshore Lens is -25 ft. NAVD88.

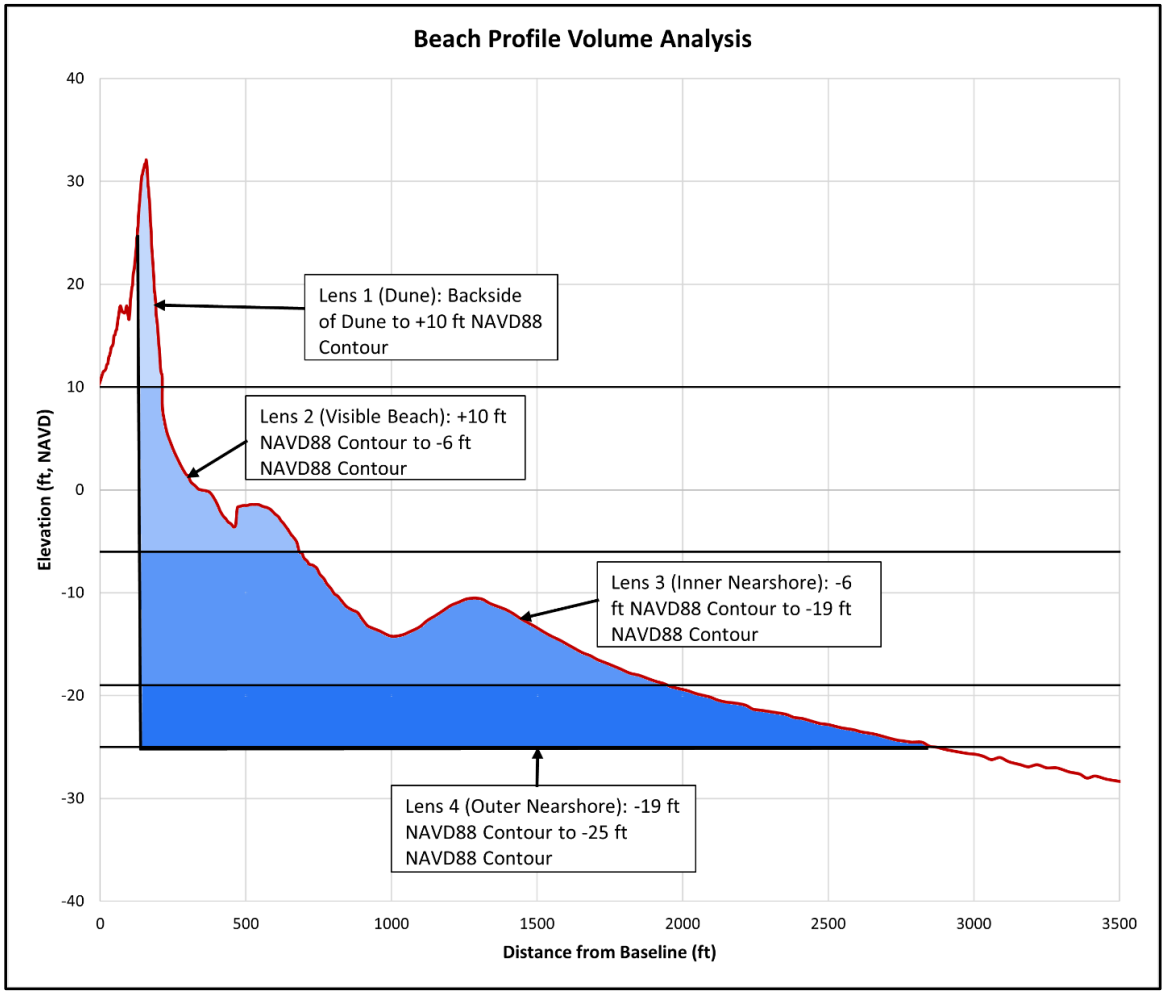

Figure 13. Beach Profile Cross Section Illustrating Lenses

- Lens 1 (Dune): Volume from Backside of the Dune to +10 ft. NAVD88 — The volume between the backside of the primary frontal dune and the +10 ft. NAVD88 contour is a measure of the sand quantity in the dunes. The +10 ft. NAVD88 contour typically is representative of the approximate toe of the dune though this elevation can change seasonally and spatially. This lens of sand would also be landward of runup experienced during minor storms.
- Lens 2 (Visible Beach): Usable Beach (+10 ft. to −6 ft. NAVD88) — This lens includes the dry-sand beach ("berm") and wet-sand beach (sloping wave swash zone) to low-tide wading depth at −6 ft. NAVD88. This is the primary recreational portion of the beach.
- Lens 3 (Inner Nearshore): Outer Surf Zone (−6 ft. to −19 ft. NAVD88) — This lens represents the underwater part of the beach extending seaward of the bar to the previously established depth of closure.
- Lens 4 (Outer Nearshore): Outer limits of the Active Beach Profile (−19 ft. to −22 ft. NAVD88 north of the Horse Gate and -19 ft. to -25 ft. NAVD88 south of the Horse Gate) — This lens represents the underwater part of the beach profile in and around the various observed depths of closure during this study.

4.2.1 Long-term Period May 2020 to June 2025

Lens 1 (Dune): The average volumetric change rate measured between May 2020 and June 2025 in the Dune Lens was +0.2 cy/ft./yr., resulting in a cumulative positive volumetric change of approximately 73,800 cubic yards along the Assessment Area, south of the Horse Gate. A volumetric change of +0.1 cy/ft./yr. was measured between May 2020 and June 2025 along the Corolla Section. Similarly, a positive volumetric change rate of +0.6 cy/ft./yr. was measured along the Pine Island Section over the same period. The average rates of volumetric change and total volumetric change calculated for the Dune Lens along the Assessment Area south of the Horse Gate and within each of the two (2) Sections are provided in Table 11. The rates of volumetric change for each station are provided in

Table 12 and are shown graphically in Figure 14.

A profile-by-profile comparison shows volumetric change rates computed for the Dune Lens range from -1.7 cy/ft./yr. at station C-059 (located approximately 250 feet south of Horse Gate) to +2.0 cy/ft./yr. at station C-098 (north end of Breakers Arch). A graphical representation of the volumetric changes in the Dune and Visible Beach Lenses is provided in Figure 14. In general, volumetric changes were positive along the Assessment Area (Corolla and Pine Island Sections only) with approximately 75% of the profiles experiencing a positive volume change. As shown in Figure 14, negative volumetric changes were measured in the Dune Lens along the northern 8,000 feet of the Corolla Section between station C-059 (250 feet south of Horse Gate) and station C-067 (located approximately 1,200 feet south of Corolla Village Road) with the exception of station C-063.

Table 11. Summary of Average Volumetric Change Rates and Total Volume Changes

Sections	May 2020 to June 2025 Density Change Rate (cy/ft./yr.)			
	Lens 1 Dune	Lens 2 Visible Beach	Lens 3 Inner Nearshore	Lens 4 Outer Nearshore
Corolla	0.1	1.9	-0.6	1.8
Pine Island	0.6	2.0	0.1	2.5
Total	0.2	1.9	-0.4	2.0
May 2020 to June 2025 Volume (cy)				
Corolla	20,300	413,600	-128,000	391,500
Pine Island	53,500	184,400	6,000	227,500
Total	73,800	598,000	-122,000	619,000

Table 12. Lens Volumetric Change Rates (May 2020 to June 2025) (cy/ft./yr.)

Station	Lens 1 Dune	Lens 2 Visible Beach	Lens 3 Inner Nearshore	Lens 4 Outer Nearshore[1]	Station	Lens 1 Dune	Lens 2 Visible Beach	Lens 3 Inner Nearshore	Lens 4 Outer Nearshore[1]
C-059	-1.7	0.4	-0.7	-0.2	C-090	0.8	0.9	-0.7	2.4
C-060	-0.2	1.3	-1.7	0.4	C-091	1.4	1.9	-4.6	0.7
C-061	-1.7	0.3	-1.8	-0.2	C-092	0.1	-0.2	-3.7	1.2
C-062	-0.8	0.3	-1.3	-1.4	C-093	-0.3	-0.9	-3.4	0.9
C-063	0.1	0.4	-1.4	0.5	C-094	0.8	-0.7	-1.0	1.4
C-064	-1.3	0.7	-3.9	-0.1	C-095	0.1	0.4	-1.2	0.2
C-065	-0.3	3.2	0.8	1.3	C-096	0.8	0.2	-1.4	1.3
C-066	-0.9	1.1	-0.5	0.8	C-097	0.8	0.4	-2.8	0.9
C-067	-0.9	3.4	-0.5	1.2	C-098	2.0	0.5	0.6	3.1
C-068	0.2	1.7	-2.5	-0.6	C-099	0.7	2.0	-2.5	1.7
C-069	0.3	2.0	1.0	0.1	C-100	0.4	1.5	0.6	3.7
C-070	0.1	-0.1	-3.4	-0.1	C-101	0.2	3.9	0.9	3.8
C-071	0.2	1.1	0.0	0.8	C-102	0.2	4.4	1.3	4.8
C-072	0.0	-0.4	-2.3	-0.2	C-103	-0.1	3.6	-3.0	1.8
C-073	0.3	1.9	0.2	1.8	C-104	0.7	1.0	-2.0	2.3
C-074	-0.6	1.7	-3.2	0.5	C-105	0.4	2.6	-1.1	1.4
C-075	0.3	0.9	0.1	1.2	C-106	0.5	2.5	-1.5	1.7
C-076	-0.5	3.6	-1.2	1.0	C-107	1.6	0.5	-4.3	-0.1
C-077	0.2	4.7	3.9	3.7	C-108	1.9	3.3	-1.0	3.3
C-078	0.5	4.3	1.1	3.8	C-109	1.0	3.3	-2.2	3.7
C-079	0.0	5.3	3.1	4.2	C-110	0.2	1.9	-0.3	4.3
C-080	0.1	3.2	-0.6	3.1	C-111	0.9	3.5	1.0	2.6
C-081	0.0	3.4	3.8	5.2	C-112	0.4	1.8	1.0	4.3
C-082	0.3	2.6	0.4	4.4	C-113	0.2	0.7	0.8	1.2
C-083	0.6	6.2	3.5	5.1	C-114	-0.2	2.5	5.1	3.7
C-084	0.2	3.2	0.9	3.2	C-115	-0.2	0.4	0.8	1.7
C-085	-0.5	2.6	2.7	3.8	C-116	-0.1	-1.0	4.8	4.2
C-086	0.0	2.6	-0.1	2.7	C-117	0.8	-0.9	-1.0	0.0
C-087	0.3	1.8	-1.6	1.6	C-118	1.1	1.6	-1.1	3.9
C-088	0.8	3.8	1.6	3.4	C-119	0.8	4.1	3.7	0.8
C-089	0.4	2.1	-3.1	1.9	C-120	0.6	5.7	1.5	3.1

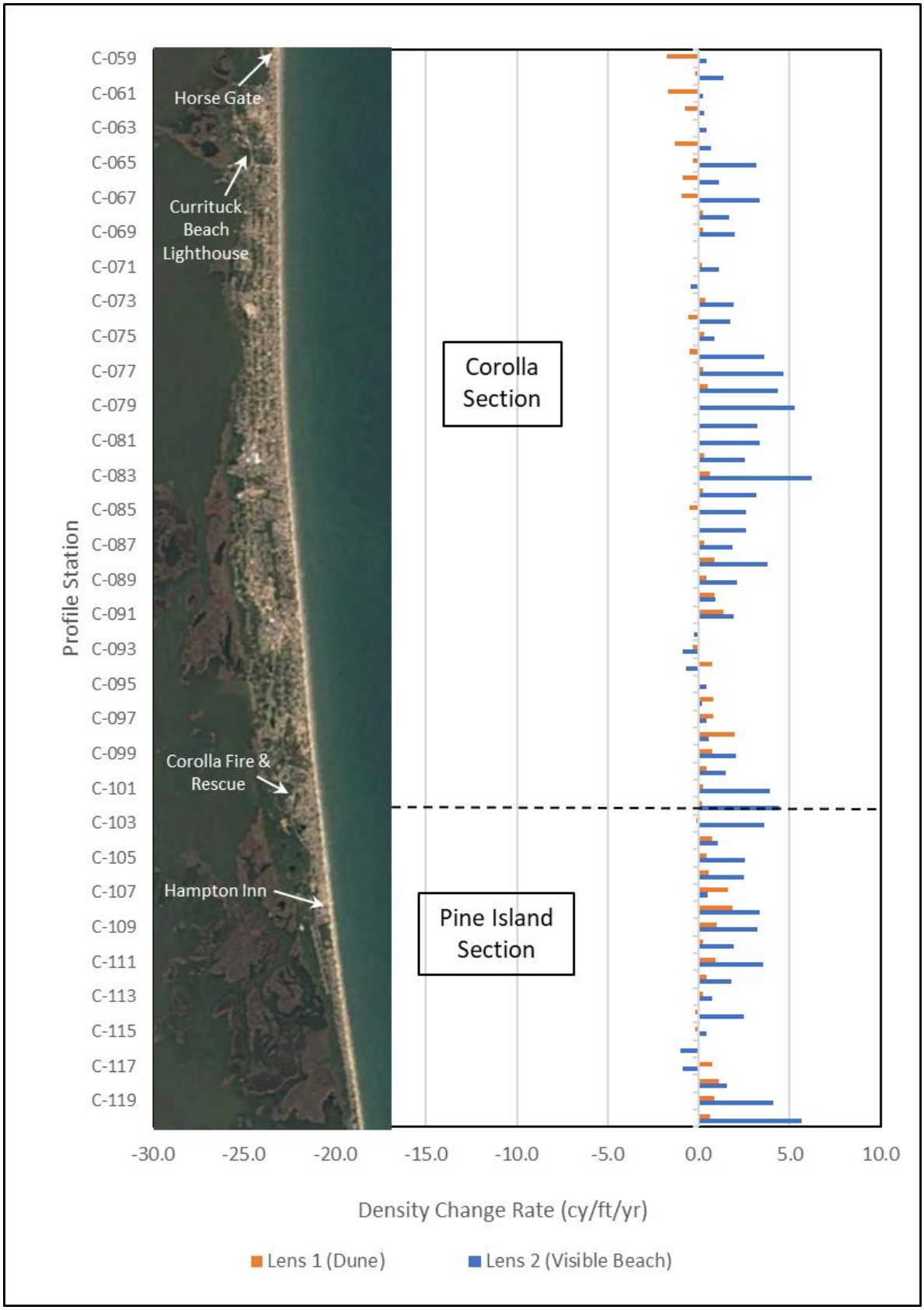

Figure 14. Volume Change Rate Lens 1 and Lens 2 - May 2020 to June 2025

Lens 2 (Visible Beach): The average volumetric change rate measured between May 2020 and June 2025 within the Visible Beach Lens was +1.9 cy/ft./yr., resulting in a cumulative positive volumetric change of approximately 598,000 cubic yards. As shown in Table 11, the average rate of change and total volumetric change was positive in both the Corolla (+1.9 cy/ft./yr.) and Pine Island (+2.0 cy/ft./yr.) Sections.

Lens 3 (Inner Nearshore): The average volumetric change rate measured between May 2020 and June 2025 within the Inner Nearshore Lens was -0.4 cy/ft./yr., resulting in a cumulative negative volumetric change of approximately -122,000 cubic yards. As shown in Table 11, the average rate of change and total volumetric change was negative for the Corolla Section and slightly positive for the Pine Island Section. The average volumetric change rates within the Inner Nearshore Lens in the Corolla and Pine Island Sections were -0.6 cy/ft./yr. and +0.1 cy/ft./yr., respectively. The average rates of change measured within Lens 3 for each profile are shown graphically in Figure 15.

Lens 4 (Outer Nearshore): The average volumetric change rate measured between May 2020 and June 2025 within the Outer Nearshore Lens was +2.0 cy/ft./yr., resulting in a cumulative positive volumetric change of approximately 619,000 cubic yards (Table 11). Positive volumetric changes in the Outer Nearshore Lens were calculated in both the Corolla and Pine Island Sections. The average volumetric change rates measured along the Corolla and Pine Island Sections were +1.8 cy/ft./yr. and +2.5 cy/ft./yr., respectively. The average rates of change measured within Lens 4 for each profile are shown graphically in Figure 15.

4.3 Pine Island Section Volumetric Change Rates

As previously stated, two beach profile surveys were conducted along the Pine Island Section of the Assessment Area in September 2015 and October 2017 (CSE, 2018). CSE reported a volumetric change rate along Pine Island from Yaupon Dr. to the southern boundary of Currituck County of +2.6 cy/ft./yr., which equated to a net volume gain of approximately 46,000 cy. This analysis employed a similar method as was described in Section 4.2 in which volumetric changes were examined within discreet lenses. The analysis showed that although volumetric losses were measured from the dune crest to the -6 ft. NAVD88 contour, the overall volumetric change was positive due to additional gains in the offshore portion of the profile (-6 ft. NAVD88 to -19 ft. NAVD88).

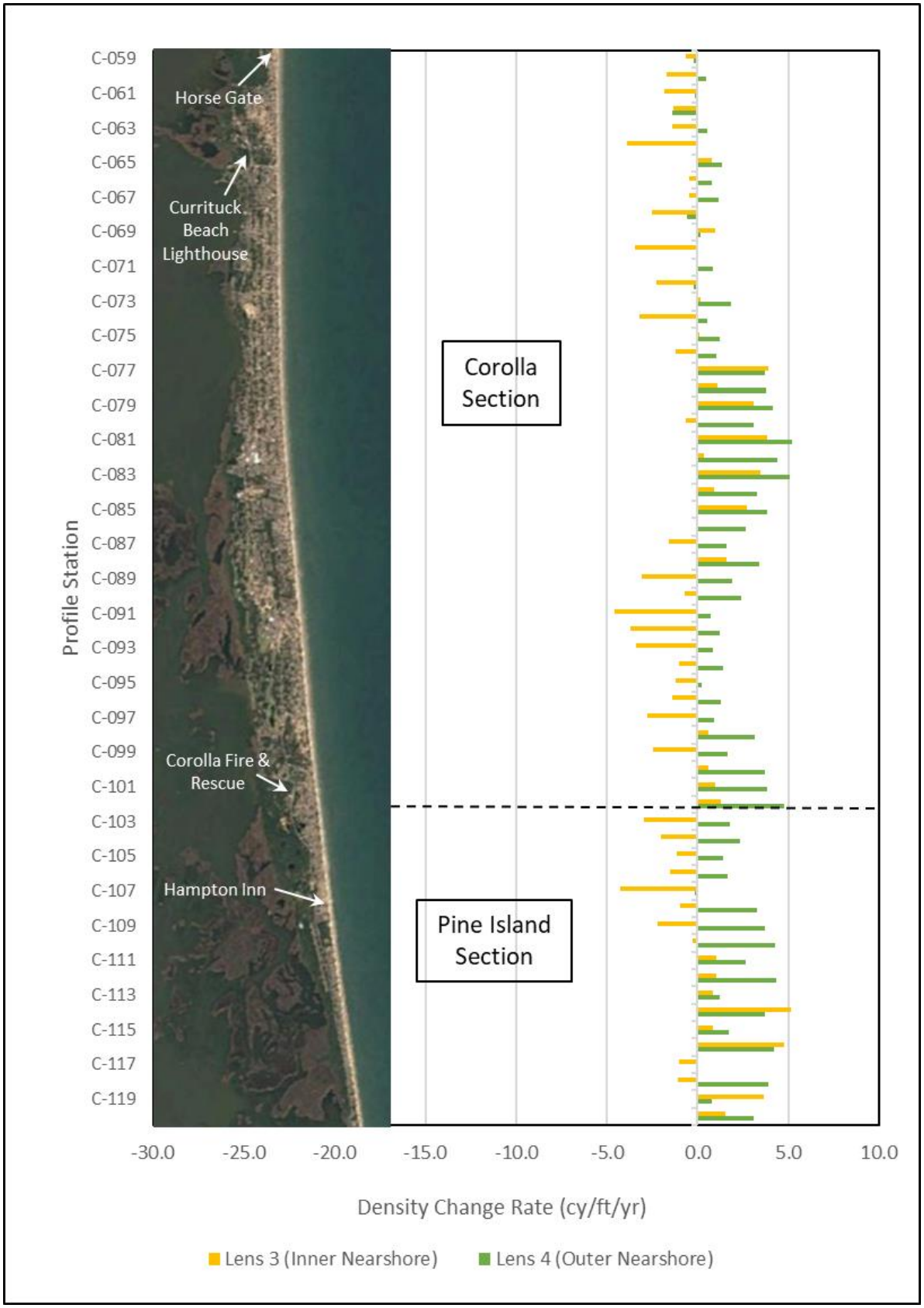

Figure 15. Volume Change Rate Lens 3 and Lens 4 - May 2020 to June 2025

Volumetric change rates were computed between surveys conducted in September 2015 (CSE) and June 2025 (CPE) to provide additional long-term volumetric change trends where data exists. The average volumetric change rate between September 2015 and June 2025 along the Pine Island Section was relatively stable at -0.7 cy/ft./yr., resulting in a cumulative negative volumetric change of approximately -118,500 cubic yards. **Error! Not a valid bookmark self-reference.** lists the individual volumetric change rates computed for each profile out to the -19 ft. NAVD88 contour between September 2015 and June 2025. Figure 16 shows a graphical comparison of the 2015 to 2025 rates. Negative volumetric changes were measured along eleven (11) of the nineteen (19) profiles along the Pine Island section.

Table 13. Pine Island Long-term Volume Change Rate 2015 to 2025

Stations	September 2015 to June 2025 (cy/ft./yr.)
C-102	-3.4
C-103	-2.6
C-104	-2.8
C-105	-0.5
C-106	-4.7
C-107	-0.7
C-108	0.8
C-109	0.1
C-110	-0.9
C-111	0.9
C-112	-1.0
C-113	0.0
C-114	0.5
C-115	-0.8
C-116	-0.2
C-117	-2.3
C-118	0.0
C-119	3.5
C-120	0.8
Average	**-0.7**
Max	**3.5**
Min	**-4.7**

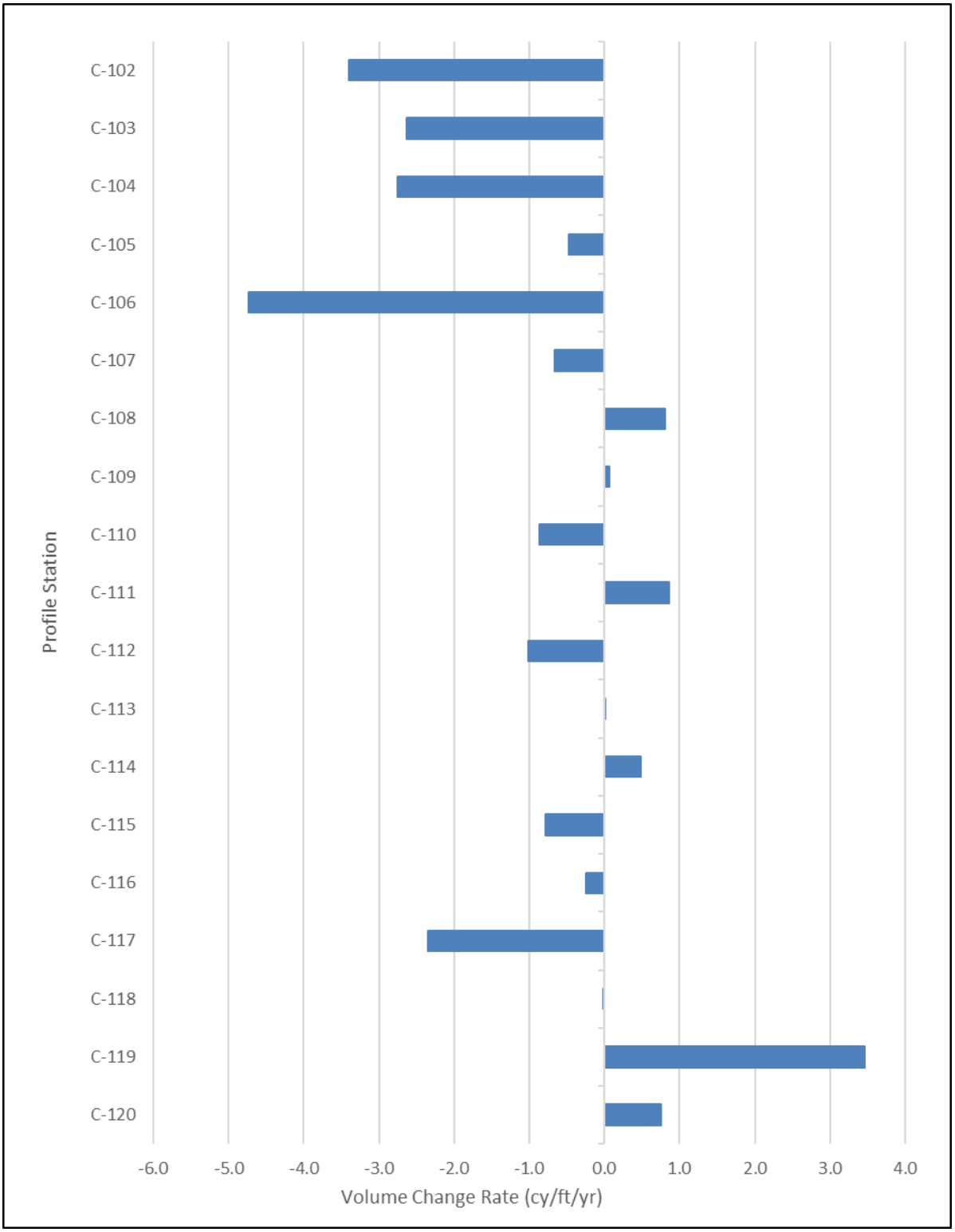

Figure 16. Pine Island (C-102 to C-120) Volume Change Rates Above -19.0 ft. NAVD88 – Sept. 2015 to June 2025

5 CONCLUSIONS

This 2025 Beach Monitoring and Beach Stability Assessment evaluated long-term and short-term shoreline and volumetric changes occurring along the County's beaches. The County initiated an annual monitoring program in 2020 with the initial goals of better understanding the changes occurring to the beaches and to assist the County in making informed decisions regarding beach management. The continued annual monitoring of the oceanfront beaches allows managers to track long-term and short-term trends and provides specific quantified data to facilitate informed management decisions. The conclusions provided in this section were drawn from the results of the various analyses described in this report.

5.1 Shoreline Change and Projected Shorelines

Shoreline change rates measured between 2009 and 2025 were computed using a linear regression method that considers various shoreline position data available between 2009 and 2025 including shoreline positions measured during each of the six surveys commissioned by the County since May 2020. The average historical shoreline change rate measured along the Corolla Section (250 feet south of the Horse Gate to 500 feet north of Yaupon Lane) was -3.9 ft./yr. The average historical shoreline change rate measured along the Pine Island Section (500 feet north of Yaupon Lane to Southern County boundary) was -1.0 ft./yr.

While average rates along the Corolla and Pine Island Sections provide general information on overall trends, considerable variability exists along both Sections. Shoreline change rates measured at each station along the Assessment Area between 2009 and 2025 were used to project future shoreline positions throughout the Assessment Area over a 10-, 20-, and 30-year time horizon. These projected shorelines are shown in the maps in Appendix B. The projected shorelines were then compared to the footprint of oceanfront houses and roads to evaluate potential impacts over the various time horizons.

Based on June 2025 conditions, a total of 43 houses were shown to be impacted over the 30-year horizon throughout the southern half of the Assessment Area. This represents a decrease from the 56 houses identified as impacted in the 2024 analysis for the same portion of the Assessment Area. While the total number of houses identified as impacted over the 30-year horizon decreased from 2024 to 2025, the change is a result of a considerable increase in the number of houses identified as impacted over the 30-year horizon in the Ocean Hill community and a decrease in the number in the Whalehead Beach community.

All 43 of the houses identified in 2025 were located in the Ocean Hill community located in the northern 1-mile of the Corolla Section between 1281 Sandcastle Drive (station C-060) and Carotank Rd (C-065). This represents approximately 66% of the oceanfront houses along this portion of the Assessment Area. The 43 houses also represent a 65% increase in the number of houses along this section of beach compared to the number identified as impacted over the 30-year horizon in 2024 (26 houses). The historical shoreline change rate in this area is -6.3 ft./yr.

which is approximately 60% greater than the average for the Corolla Section during this timeframe. Furthermore, the position of the +4.0 ft. NAVD88 contour along the Ocean Hill community (stations C-060 to C-065) is on average, approximately 35.6 ft. landward of where it was in 2024 when the last shoreline projection analysis was conducted. Of the 43 houses shown to be impacted over the 30-year horizon in 2025 along this portion of the Corolla Section, 19 of the houses were shown to be impacted over the 20-year horizon, which represents approximately 29% of the houses along this portion of beach, while none were shown to be impacted over the 10-year horizon.

The number of impacted structures identified in this year's analysis is less than the total identified in the 2024 Assessment (CPE, 2025). For instance, in 2024, the number of structures indicated as impacted within the Whalehead Beach community was 30; whereas the 2025 analysis indicated 0 oceanfront houses impacted over the 30-year horizon. However, the Ocean Hill community did see an increase from 26 impacted structures in 2024 to 2025 at which time 43 structures were identified as impacted, as a result of increased shoreline recession between 2024 and 2025.

While the number of houses identified as impacted over the 30-year projection along the Ocean Hill community went up between June 2024 and June 2025, the number of houses identified along the Whalehead Beach community decreased. In fact, while 30 houses along the Whalehead Beach community were identified as impacted over the 30-year projection in 2024, none were identified in the 2025 Assessment. In the 2024 analysis, 25 houses located between the Sturgeon Beach Access (station C-071) and Mackerel Beach Access (station C-076) and 5 houses between Sailfish Street (station C-080) and Marlin Beach Access (station C-081), were shown to be impacted over the 30-year horizon. The average of the historical shoreline change rates used in the analysis between stations C-071 and C-081 was -4.5 ft./yr. for the 2025 analysis compared to an average rate of -5.5 ft./yr. for the 2024 analysis. Furthermore, the position of the +4.0 ft. NAVD88 contour along this portion of the beach (C-071 to C-081) is on average, approximately 21.9 ft. seaward of where it was in 2024 when the last shoreline projection analysis was conducted.

While the shoreline projections provide useful information to evaluate trends and determine future potential impacts, oceanographic conditions that influence shoreline change are not constant (water levels, storm frequency, dominant wind direction). Temporary changes to the slope of the beach as a result of sea conditions that impact the area immediately prior to surveys, can have considerable impacts on shoreline position, resulting in significant variability when evaluating shoreline changes. In that regard, a thorough evaluation of volumetric changes is vital to fully assessing the beach.

5.2 Volume Change

A positive volumetric change was measured along the County oceanfront south of the Horse Gate between May 2020 and June 2025. Since the initiation of the County-wide Beach Assessment and Beach Monitoring program in May 2020, the cumulative volumetric change trends have indicated a positive volume trend or a gain of sand. This has been the case for the cumulative volumetric change over the entire Assessment Area as well as for the measured volumetric changes north

and south of the Horse Gate. However, analysis conducted as part of the 2024 Beach Assessment (CPE, 2025), indicated that there may be an inflexion point at which point the volumetric trend has shifted from a positive change to negative change. This inflection point can best be illustrated by plotting the cumulative volume change over time as shown in Figure 17. The purple line shown in Figure 17 represents the cumulative change in volume along the entirety of Currituck County between May 2020 and June 2024. Given the 2025 survey only included the portion of the Assessment Area south of the Horse Gate, the cumulative volume change along the entire County oceanfront could not be tracked through June 2025.

An examination of the purple line in Figure 17 indicates a relatively large volumetric gain (approx. 1.2 million cubic yards) between May 2020 and June 2021, followed by additional gains measured between June 2021 and May 2022. While the net volumetric change over time between May 2020 and June 2024 is clearly positive, the trend between May 2022 and June 2024 was negative as reported in the 2024 Assessment (CPE, 2025).

Figure 17 also shows the cumulative volume changes along the County oceanfront South of the Horse Gate (blue line) and North of the Horse Gate (green line). With the surveys conducted in June 2025 only covering the areas south of the Horse Gate, the blue line tracks the cumulative volumetric change south of the Horse Gate from May 2020 to June 2025, while he green line, which represents cumulative volume change north of the Horse Gate, only tracks the change through June 2024. North of the Horse Gate, the cumulative volumetric change follows a similar pattern of the overall cumulative volumetric change trend (purple line). Between May 2020 and May 2022, the trend was positive, followed by a two-year period from May 2022 to June 2024 where the trend was negative.

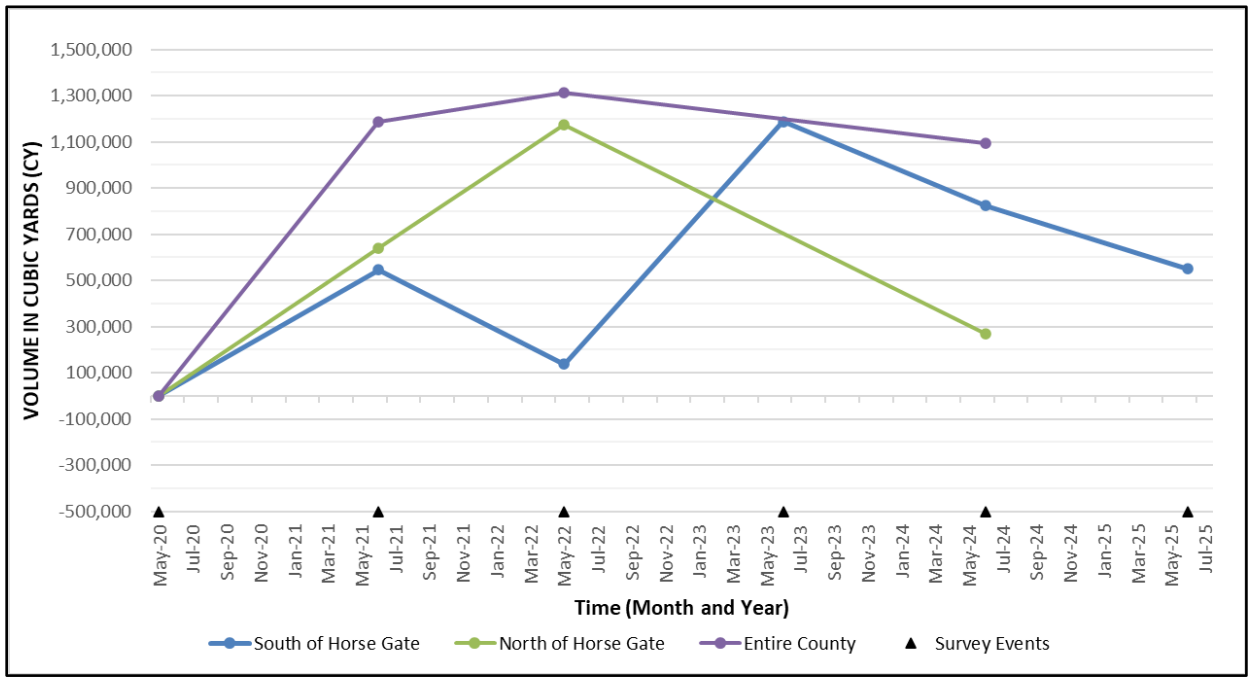

Figure 17. Graph showing Cumulative Volume Change along Currituck County since May 2020

The cumulative volumetric trend observed south of the Horse Gate, between May 2020 and June 2025, differs from the trend observed north of the Horse Gate. Between May 2020 and June 2021 positive volumetric gains were measured south of the Horse Gate. However, volumetric losses measured between June 2021 and May 2022 nearly matched the volumetric gains that occurred during the preceding monitoring period. Significant positive volumetric change was measured between May 2022 and June 2023 and then two consecutive years of negative volumetric change followed between June 2023 and June 2025.

Table 14 provides a summary of the average volume change rates and volume changes for the Corolla and Pine Island Sections and the overall Assessment Area south of the Horse. The table includes three different time periods to demonstrate the change in the volume trends shown in Figure 17. The time periods include the Assessment period from May 2020 to June 2025, the three-year period from May 2020 to June 2023 during which positive volumetric changes were observed, and the two-year period from June 2023 to June 2025 during which negative volume changes were observed. The long-term average volume change rate between May 2020 and June 2025 was +1.8 cy/ft./yr., which indicates the area south of the Horse Gate has experienced a net positive volume gain over the Assessment period. While the overall rate was net positive, Table 14 also shows that between May 2020 and June 2023, the average volume change rate south of the Horse Gate was +6.3 cy/ft./yr., indicating a trend of accretion. Over the two-year period between June 2023 and June 2025, the average volumetric change rate was -5.2 cy/ft./yr. south of the Horse Gate, indicating a trend of erosion that is a reversal from the positive trend observed prior to this period.

Table 14. Summary of Average Volumetric Change Rates and Total Volume Changes Measured to -19 ft. NAVD88.

Section	Density Change Rate (cy/ft./yr.)			Total Volume Change (cy)		
	May 2020 to June 2025	May 2020 to June 2023	June 2023 to June 2025	May 2020 to June 2025	May 2020 to June 2023	June 2024 to June 2025
Corolla	1.4	5.6	-5.1	305,800	740,300	-435,900
Pine Island	2.7	8.1	-5.7	243,900	448,600	-204,700
South of the Horse Gate (C-059 to C-120)	**1.8**	**6.3**	**-5.2**	**549,700**	**1,189,000**	**-640,600**

Over the past several monitoring reports (CPE, 2023a and CPE, 2023b), a hypothesis has been provided to explain the reasons for the net volumetric gains measured along the Assessment Area since the initial baseline survey conducted in May 2020. The hypothesis discussed in the previous reports suggested that the multi-year positive volumetric trend observed between 2020 and 2022 may have been the result of landward cross-shore sediment transport (sand moving from deeper water to shallower water). This effect has been documented and sometimes referred to as "recovery" following a previous period of storm induced seaward cross-shore sediment transport (sand moving from shallower water to deeper depths). More information can be found in the 2022 Beach Monitoring and Beach Stability Assessment (CPE, 2023a).

A review of wave data over the past several years supports this hypothesis and is consistent with conclusions presented in previous reports (CPE, 2025). The previous reports theorized that the observed period of volumetric recovery could be temporary and followed by a return to negative volume change trends. The negative volumetric changes observed across the Assessment Area between May 2022 and June 2025 (Figure 17) may therefore indicate that Currituck County beaches are reverting to an erosional volumetric trend. Wave data representative of conditions offshore Currituck County were qualitatively reviewed, comparing wave climate conditions prior to the study period (January 2017 to January 2020), during the period of greatest measured volumetric gains (May 2020 to May 2022), and during the subsequent 25-month period from May 2022 to June 2025. Significant wave height measurements from a waverider buoy located in approximately 26 m of water offshore of the USACE Duck Field Research Facility pier were reviewed and are presented in Figure 18.

The upper panel shows the wave data for the three-year period prior to the commencement of the Currituck County Beach Monitoring and Beach Stability Assessment (January 2017 to January 2020). The lower panel shows the wave data for the 5.5-year period from January 2020 to June 2025, which includes the monitoring conducted as part of this Assessment. These wave data indicate that the pre-monitoring period (January 2017 to January 2020) was more active in terms of wave events that produced significant wave heights greater than 15 feet. Specifically, there were three storm events during this three-year period where significant wave heights exceeded 20 ft. The first was a nor'easter in March 2018. This event was an extratropical cold front that brought strong winds, heavy snow, and tremendous coastal flooding to communities from the Mid-Atlantic to northern Maine. The second event with significant wave heights in excess of 20 ft. occurred in December 2018. The third event with significant wave heights in excess of 20 ft. was Hurricane Dorian, which occurred in September 2019. This storm caused significant impacts to the beach fill projects at Duck, Kill Devil Hills, Nags Head, and Buxton. Approximately two (2) months following the impacts of Hurricane Dorian, a major Nor'easter impacted the Outer Banks in mid-November of 2019 that produced significant wave heights at the same buoy of nearly 18 ft. A significant storm surge was also experienced during the November 2019 event.

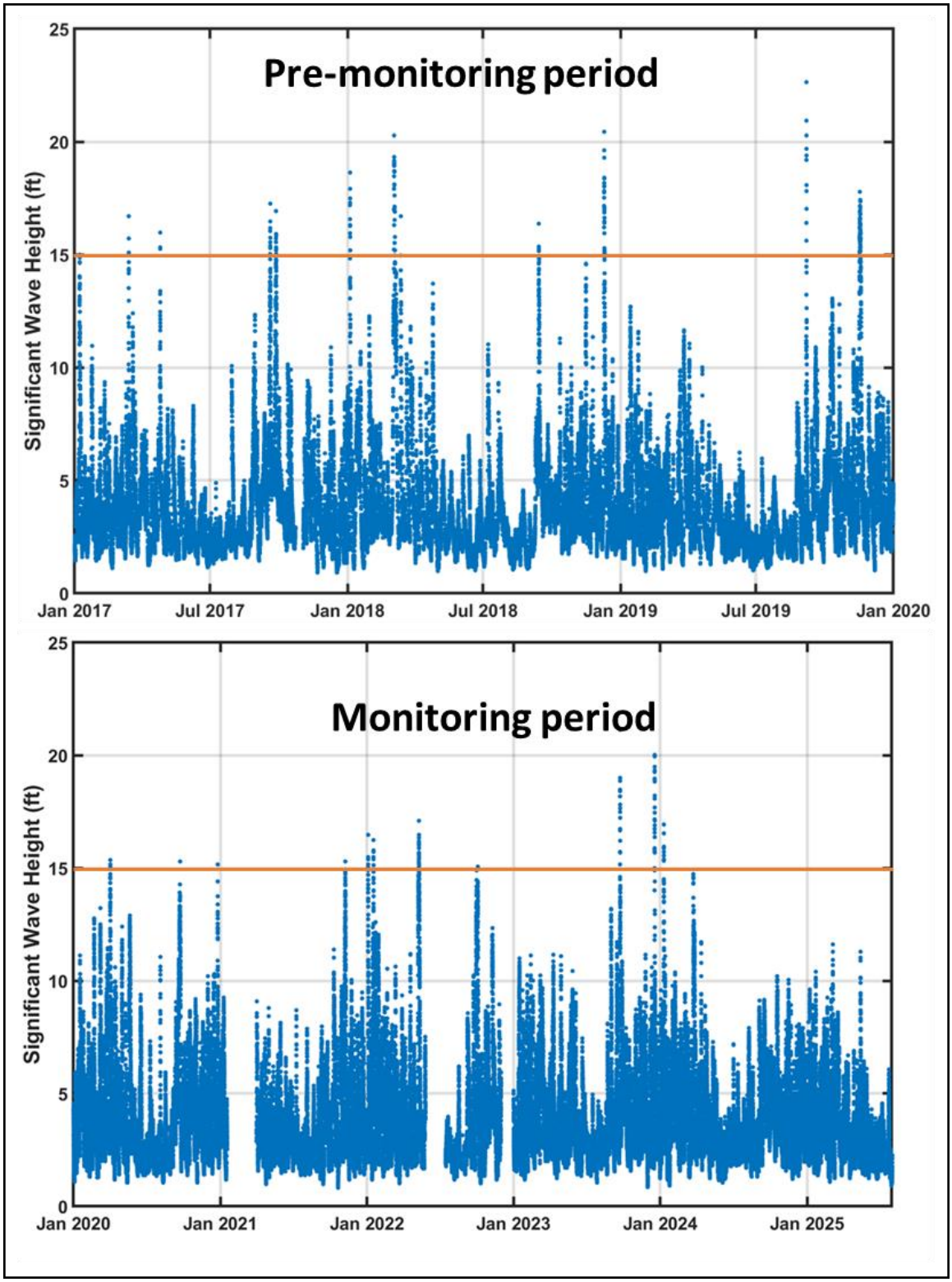

Figure 18. Significant Wave Height data prior to and during the monitoring period from waverider buoy located in 26 m of water offshore Duck, NC (Station 44100).

An examination of the wave data shown in the lower panel of Figure 18, indicates that between January 2020 and July 2023, there were no wave events in which significant wave heights exceeded 20 ft. and less wave events in which significant wave heights exceeded 15 ft. Effectively, during this period the Currituck County oceanfront generally experienced an overall wave climate that was calmer than the preceding three years (January 2017 to January 2020). This correlates with the period in which positive volumetric changes were observed. However, between July 2023 and June 2024, two wave events occurred in which significant wave heights exceeded 20 ft. The first event was Hurricane Ophelia which affected the Assessment Area from September 22nd to 24th, 2023. The second event was a nor'easter that impacted the Assessment Area between December 17th and 20th, 2023. This storm caused ocean overwash along portion of highway NC-12 near Hatteras, NC. The period in which larger storms were observed generally correlates with negative volumetric changes being observed. Although the data indicates that the erosional conditions continued between June 2024 and June 2025, Figure 18 indicates the Assessment Area did not experience any wave events in which significant wave heights exceeded 15 ft. This may indicate that erosion losses between June 2024 and June 2025 are more influenced by longshore transport than cross-shore transport.

The 2022 Beach Assessment also pointed to the Lens volume analysis results as supporting the "recovery" hypothesis (CPE, 2023a). That report documented considerable gains in the inner nearshore lens and even the outer nearshore lens for the area south of the Horse Gate, beyond the depth of closure, between May 2020 and May 2022. The analysis does show the gains continued within the inner nearshore lens as of June 2023 but over the next two-years (June 2023 to June 2025), both the inner nearshore and outer nearshore lenses for the area south of the Horse Gate experienced erosion similar to the trend shown in Figure 17.

The following conclusions were drawn from the results of both the shoreline projection analysis and volumetric change analysis:

- The northern portion of the Corolla Section, between the Horse Gate and Corolla Village Road (station C-059 to station C-065) within the Ocean Hill community has continuously been called out as one of the most vulnerable areas of the County's oceanfront. In 2025, all 43 houses identified in the Corolla Section as impacted over the 30-year horizon were located in the Ocean Hill community. This represents approximately 66% of the oceanfront houses between C-059 and C-065. The 43 houses also represent a 65% increase in the number of houses along this section of beach compared to the number identified as impacted over the 30-year horizon in 2024 (26 houses). Both the shoreline projections and previous SBEACH storm vulnerability analyses have indicated structures along this stretch of the County oceanfront are vulnerable both to long-term shoreline change and storms. The volumetric changes measured between May 2020 and June 2025 indicate this area has experienced minor losses, at an average rate of -1.7 cy/ft./yr., over the approximate 5-year period. However, more recently, between June 2023 and June 2025 the average volumetric change rate along this portion of the Corolla Section was -16.7 cy/ft./yr.

- Another area of concern is within the Whalehead Beach community along Lighthouse Drive (station C-068 to station C-084). Previous shoreline projection analyses have consistently identified oceanfront structures along this area as impacted over the 30-year projection horizon. Likewise past SBEACH storm vulnerability analyses have indicated some oceanfront houses and pools along this area are vulnerable (CPE, 2020 and CPE, 2023a). The 2025 shoreline projection analysis did not indicate any oceanfront homes as impacted over the 30-year shoreline projection analysis. The 2024 Assessment reported 30 oceanfront houses located between the Sturgeon Beach Access (station C-071) and Marlin Beach Access (station C-081), as impacted over the 30-year horizon. This reduction from the 2024 Assessment to the 2025 Assessment was due to a slight decrease in the average shoreline change rates used along this area in the shoreline projection analysis (-4.5 ft./yr. for the 2025 analysis compared to an average rate of -5.5 ft./yr. for the 2024 analysis) and a seaward movement of the average shoreline position (21.9 feet). The volumetric changes measured between May 2020 and June 2025 indicate the Whalehead Beach community (C-068 to C-084) experienced a net positive volumetric change rate of 3.1 cy/ft./yr. above the depth of closure. However, more recently, between June 2023 and June 2025 the average volumetric change rate along this area was -5.2 cy/ft./yr.
- The Spindrift community (station C-101 to station C-103) is another area of concern, where shoreline projection analyses have identified this area to be vulnerable. While the most recent analyses performed with the 2024 and 2025 conditions and rates did not indicate impacts along this community, previous analyses have shown impacts to the nine (9) oceanfront homes located along Land Fall Ct. The trends in this area are the opposite of the trend generally observed throughout the study area. The volume change analysis indicated minor losses between May 2020 and May 2022, followed by considerable volumetric gains at a rate of +7.2 cy/ft./yr. between May 2022 and June 2025. The area remained stable with minor losses of -0.1 cy/ft./yr. on average, over the recent 12-month period. It should also be noted that approximately 7,000 cy of sand was placed to construct a dune in front of the Spindrift community via a truck haul project in March 2023. The gains observed between May 2022 and June 2025 may be attributed to this project.

6 RECOMMENDATIONS

Based on the various beach assessments described in this report and conclusions drawn from those assessments, CPE provides the following recommendation for the County's consideration as they seek to make informed decisions regarding beach management:

<u>Continue Monitoring of the Beach Profiles:</u>

The initial 3-year Beach Monitoring and Beach Stability Assessment (2020 through 2022) established a baseline of shoreline change and volumetric change rates. Given the results of the shoreline and volume change analyses, the distribution of potential impacts from the shoreline projections over 10 to 30 years and the distribution of houses identified through the vulnerability analysis, the County continued the monitoring plan through 2025

and initiated the development of a Beach Management Plan in 2024. Beginning in 2023, the County, in alignment with recommendation in the 2022 Assessment (CPE, 2023a), authorized annual surveys of the Corolla and Pine Island Sections, with biennial surveys (every other year) for the Carova and Reserve/Refuge Sections for 3 additional years.

The recommendation to only survey the Carova and Reserve/Refuge Sections (north of the Horse Gate) in the odd years, was based on the fact that only a small number of houses located north of the Horse Gate were indicated as vulnerable, and the amount of undeveloped beach north of the Horse Gate. The County contracted with CPE in early 2023 to continue monitoring as recommended through 2025. In 2023 and 2025, beach monitoring surveys were conducted south of the Horse Gate in the Corolla and Pine Island Sections only; whereas in 2024, the entire County oceanfront was surveyed (both north and south of the Horse Gate).

The County should continue to monitor the oceanfront beaches at the established frequency, with annual surveys conducted south of the Horse Gate in the Corolla and Pine Island Sections annually and survey north of the Horse Gate in the Carova and Reserve/Refuge Sections biennially (every other year). With the Beach Management Plan anticipated to be completed in 2026, continued monitoring will inform the County's decisions on when to take various actions to achieve the goals of the Plan.

The County has recently discussed several houses indicated as vulnerable in the portion of the beach between Canary Lane and just north of Malbon Drive (stations C-039 to C-048) in the Reserve/Refuge Section north of the Horse Gate. The discussions have focused on the potential impacts to ingress/egress along the offroad sections of the County beaches due to these vulnerable structures. Depending on whether the County anticipates taking any actions in this location, it may be beneficial to increase monitoring in these particular areas.

If the County elects to continue monitoring of the beaches, beach profile surveys should be conducted along the same profiles established at the beginning of the County-wide assessment in 2020 at a similar time of year to reduce the impacts of seasonal changes on conditions of the profile, particularly the portion of the profile above Mean High Water (MHW).

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