## VII. DISCUSSION

This monitoring report evaluated shoreline and volumetric changes along the portions of shoreline re-nourished in 2023 within the Town of Duck as well as portions of the adjacent shorelines to the north and south. The monitoring area extends south from station D-01, located near the northern limits of the Town of Duck, to station D-34, located near the Town of Duck town limits with the Town of Southern Shores. With the construction of the Central Reach beach nourishment project, the monitoring area was divided into three sections, namely, the North Monitoring Area (D-01 to D-10), the Central Reach Project Area (D-10 to D-19), and the South Monitoring Area (D-19 to D-34). Beach profile data collected in May 2023 were used to evaluate long-term shoreline and volumetric changes that have occurred relative to the baseline survey conducted in September 2013. Beach profile data collected in January 2023 (pre-construction) were compared with December 2017 data to evaluate shoreline and volumetric changes that occurred within the Central Reach Project Area between the 2017 and 2023 beach nourishment projects. Recent changes were also evaluated over the past two years based on the April 2021 and May 2023 monitoring surveys.

**Shoreline Change Analysis**

**Central Reach Project Area.** During the period following the completion of the 2017 Central Reach Project in Duck (June 2017) and after approximately 6-months of the project equilibrating and prior to the initiation of the 2023 project, the position of the +6 ft. NAVD88 contour receded landward by an average of 88.3 ft. within the Central Reach Project Area (December 2017 to January 2023). The 2023 beach renourishment project extended the position of the +6 ft. NAVD88 contour seaward an average of 140.9 ft. based on comparisons of the Before Dredge (BD) and After Dredge (AD) surveys. This number reflects the change in the position of the +6 ft. NAVD88 contour based on the placement of unequilibrated fill within the construction beach fill template. Typically, a beach nourishment project experiences dramatic decrease in width in the months following construction as the profile equilibrates (Willson et al., 2017). This equilibration process often results in a relatively high level of negative shoreline change. Monitoring surveys conducted in 2024 may reflect this equilibration process.

**North Monitoring Area.** The average long-term shoreline change rate computed along the North Monitoring Area (stations D-01 to D-10), was -0.7 ft./yr. (landward movement), between September 2013 and May 2023. This period includes the construction of the two beach nourishment projects (2017 and 2023). While the shoreline has remained essentially stable along the North Monitoring Area since September 2013, the average rate between station D-01, located near the northern Town Boundary and station D-04, located at Sanderling Resort, was -1.6 ft./yr. (landward movement); whereas the average long-term shoreline change from Sanderling Resort south to the Central Reach Project Area (stations D-04 to D-10) was a positive 0.1 ft./yr. (seaward movement). This suggests the Central Reach Project may be having more of a positive impact on shoreline change directly adjacent to the Project Area.

Recent surveys, conducted between April 2021 and May 2023, indicate an overall average change in the position of the +6.0 ft. NAVD88 contour of -6.3 ft./yr. (landward movement). However, directly north of the Central Reach Project Area from station D-06 (Martin Lane) to D-10 (Skimmer Way) the average shoreline change trend was +1.3 ft./yr. (seaward movement), whereas, from station D-01 (approximately 300 feet south of the northern Town boundary) to D-06 (Martin Lane) the average rate of change was -9.6 ft./yr., (landward movement). Again, this suggests the Central Reach Project may have a more positive impact on shoreline change directly adjacent to the Project Area.

**South Monitoring Area.** The long-term average shoreline change computed along the South Monitoring Area (stations D-19 to D-34), was -1.1 ft./yr. (landward movement), between September 2013 and May 2023. This time period includes the construction of both the 2017 and 2023 beach nourishment projects. While the shoreline has remained essentially stable along the North Monitoring Area since September 2013,

in the area directly south of the project (stations D-19 to D-22) the average rate was +0.9 ft./yr. (seaward movement). In contrast, from station D-22 (650 ft. south of the FRF Pier) to D-31 (Plover Dr.) the average long-term shoreline trend was -1.9 ft./yr. (landward movement). The +6.0 ft. NAVD88 contour between the end of Plover Dr (station D-31) and 13th Ave. (station D-34) experienced a seaward movement of 0.1 ft./yr. on average. This suggests the Central Reach Project may be having more of a positive impact on shoreline change directly adjacent to the Project Area.

Recent surveys (April 2021 to May 2023) indicate an overall average change in the +6.0 ft. NAVD88 contour of +2.9 ft./yr. The shoreline change rates measured throughout the South Monitoring Area are relatively variable. In the area directly south of the project (stations D-19 to D-26), the average shoreline change rate was +2.7 ft./yr. over the approximate 25-month period from April 2021 to May 2023. In contrast, the average shoreline change measured from station D-26 (Cook Dr.) to station D-31 (Plover Dr.) was -1.2 ft./yr. The +6.0 ft. NAVD88 contour between the end of Plover Dr (station D-31) and 13$^{th}$ Ave. (station D-34) experienced a seaward movement of 8.2 ft./yr. on average. Again, this suggests the Central Reach Project may have a more positive impact on shoreline change directly adjacent to the Project Area.

**Volumetric Change Analysis**

**Central Reach Project Area.** The 2023 beach renourishment project placed a total of 576,800 cubic yards of fill along the Duck shoreline between stations D-10 and D-19 between April and May 2023. The performance of the 2023 project along the Town of Duck will be based on changes that have occurred relative to the post-construction monitoring survey conducted in May 2023.

Rates of change that characterize the performance of the 2017 project were computed from the December 2017 (post-construction) and January 2023 (pre-construction) surveys. The results of this analysis indicated that the 2017 Central Reach Project Area lost approximately 521,800 cy, which equates to an average volumetric change rate of -10.8 cy/ft./yr. when annualized over the 5-year period. As of January 2023, the analysis indicated that the 2017 beach nourishment project had approximately 46% of the initial fill volume placed along the Town of Duck in 2017.

A positive volumetric change of approximately 1,061,000 cubic yards was measured between September 2013 and May 2023. This equates to a positive rate of 12.3 cy/ft./yr. over the 9.7-year period. The changes over this period are obviously driven by the construction of the 2017 and 2023 projects. However, this rate is higher than the negative volumetric change measured between the 2017 and 2023 projects, which suggests that the Central Reach project is more than keeping up with the rate of loss occurring as a result of natural processes and spreading losses from the projects.

**North Monitoring Area.** The long-term average volumetric change rate in the area north of the project measured between September 2013 and May 2023 was +0.7 cy/ft./yr. This rate is essentially the same rate as reported in the 2021 monitoring report (CPE, 2021) given the recent minimal volumetric change measured between April 2021 to May 2023. The average volumetric change along this area over that 25-month period was -0.3 cy/ft. or -0.1 cy/ft./yr.

**South Monitoring Area.** The long-term average volumetric change rate in the area south of the project, measured between September 2013 and May 2023, was +3.0 cy/ft./yr. This positive rate of volumetric change is greater than reported in the 2021 monitoring report (-1.0 cy/ft/yr.) (CPE, 2021), due to recent positive volumetric change measured between April 2021 and May 2023. The average volumetric change along the South Monitoring Area over that 25-month period was +27.6 cy/ft. or +13.3 cy/ft./yr. Although the changes varied from profile to profile, the predominant trend was positive and only one profile in the South Monitoring Area, located at station D-30 (Four Seasons Ln), experienced a negative volumetric change during this period. The positive volumetric changes may be due in part by the construction of the

2022/2023 beach fill project in Southern Shores and due to the onshore migration of offshore sand from beyond the depth of closure. This phenomenon has been observed by CPE in recent surveys along Currituck County.

**Storm Damage Vulnerability Analysis Update:**

Using the previously calibrated SBEACH model and the May 2023 beach profile survey data, an updated storm vulnerability analysis was conducted of the oceanfront beach and dune system along the Town of Duck. The updated SBEACH analysis indicated that 0 structures and 9 pools were identified as vulnerable based on May 2023 conditions. These numbers represent a 100% reduction in the number of structures identified as vulnerable based on 2019 conditions (29 structures) and a 78% reduction in the number of pools identified as vulnerable based on 2019 conditions (40 pools). The significant reduction in the number of vulnerable structures and pools correlates with the positive volumetric changes observed between May 2019 and May 2023.

## VIII. RECOMMENDATIONS

CPE recommends the Town continue to monitor the beach along the entire Town oceanfront in order to assess if shoreline and volume change trends identified in this report persist. Future monitoring will be instrumental for the Town to evaluate future areas of concerns and to develop successful shoreline management strategies to deal with issues as they arise. The monitoring program will continue to provide valuable information on the performance of the 2023 beach nourishment project and aid in the determination as to when additional nourishment is needed in the Central Reach Project Area. Data collected in January 2023 indicates that the 2017 project eroded at a rate of -10.8 cy/ft./yr. when compared to the Dec. 2017 Post-construction survey. This erosion rate and rates computed through the continued monitoring of the 2023 project, will be used to design the next renourishment event.

Outside the Central Reach Project Area, continued monitoring of the North and South Monitoring Areas is instrumental for the Town to evaluate future areas of concerns and longshore transport trends, and to develop successful shoreline management strategies to deal with issues as they arise. Data collected in May 2023 indicates that since 2013, the volumetric trend along the Town's beaches in the North Monitoring Area has been stable. Data collected in May 2023 also indicates a stable volumetric change in the recent period since April 2021.

The South Monitoring Area has experienced a positive volumetric change trend (accretion) since 2013. This is most likely due to sand placed during the 2017 project migrating south of the Project Area. Continued monitoring of the areas outside the Central Reach Project Area is vital to achieving the Town's goal of providing a reasonable level of storm damage reduction to public and private development.