EXECUTIVE SUMMARY

The Town of Duck has implemented a long-term beach management program to sustain the beaches that support a significant portion of their local economy and maintains the tax base of the Town. In May and June 2017, the Town constructed its initial beach nourishment project that placed approximately 1.26 million cubic yards of fill along 1.6 miles of oceanfront between Skimmer Way (station D-10) and the northern boundary of the USACE Field Research Facility (FRF) property (station D-19). Between April and May 2023, the Town constructed the first maintenance of the beach nourishment project along the same area nourished in 2017, placing approximately 576,800 cubic yards of fill.

As part of its long-term beach management program, the Town has implemented an annual monitoring program to assess both the performance of the beach renourishment project and to track the overall health of the beach along the entire Town. The annual monitoring focuses on analyzing shoreline and volume changes. The beach is divided into three areas designated as the Central Reach Project Area (station D-10 to D-19); the North Monitoring Area (D-01 to D-10), which extends south from the Town limit to Skimmer Way; and the South Monitoring Area (D-19 to D-34), which extends from the northern boundary of the FRF property south to the Town boundary with Southern Shores.

Shoreline Change:

A shoreline change analysis was completed to assess shoreline advance and recession along the Central Reach Project Area and both North and South Monitoring Areas. The contour used to monitor shoreline change throughout the Town of Duck is the +6.0 ft. NAVD88 contour, which is the design berm elevation used when the nourishment projects are constructed.

The following table summarizes the average shoreline change rates (ft./yr) in the position of the +6.0 ft. NAVD88 contour measured between the recent and long-term periods used to evaluate the Central Reach Project Area and North and South Monitoring Areas. Average shoreline change rates are shown for the periods from September 2013 to June 2025, which represents long-term changes that include the construction of the 2023 beach nourishment project, May 2023 (Post-construction) to June 2025 (changes since project construction), and June 2024 to June 2025 (recent changes).

Table ES-1
Summary of Average Shoreline Change Rates (ft./yr.) Measured Along the Town of Duck.

MONITORING AREAS	Sept. 2013 (Baseline) to June 2025 (Year-2)	May 2023 (Post-Con) to June 2025 (Year-2)	June 2024 (Year-1) to June 2025 (Year-2)
NORTH MONITORING AREA (D-01 TO D-10)	-0.5	4.7	13.1
CENTRAL REACH PROJECT AREA (D-10 TO D-19)	2.9	-57.6	-48.5
SOUTH MONITORING AREA (D-19 TO D-34)	-0.3	-0.5	-18.8

The longest timeframe extends from the September 2013 survey to the most recent survey (June 2025). This period is most applicable to tracking long-term shoreline change in the North and South Monitoring Areas where no nourishment has been implemented. As shown in Table ES-1, the average long-term rates in the North Monitoring Area (-0.5 ft./yr.) and South Monitoring Area (-0.3 ft./yr.) have been relatively

stable over the approximately 11.75-year period. Over the long-term, the Central Reach Project Area had a positive rate of 2.9 ft./yr, which is indicative of the construction of the beach fill projects in 2017 and 2023.

The second timeframe extends from May 2023 to June 2025, which represents the time since the construction of the 2023 beach renourishment project. This period represents the performance of the 2023 project over the first 2 years following the 2023 maintenance event. As shown in Table ES-1, the average shoreline change rate measured along the Central Reach Project Area during this period between the 2023 and the 2025 surveys was -57.6 ft./yr. While this period represents project performance in the first two years since construction it is not uncommon to see higher rates of shoreline change over the first few years of a project due to the concept of equilibration of the fill. Future monitoring data will provide a more representative rate of shoreline change as it relates to project performance.

The third timeframe extends from June 2024 to June 2025 and represents the shoreline changes measured over the most recent 12-month period of monitoring. The average rates listed in Table ES-1 suggest a positive rate in the North Monitoring Area, a high negative rate in the Central Reach Project Area, and a negative rate in the South Monitoring Area. In the North Monitoring Area, the rate was positive compared to the slightly negative rate measured in the previous monitoring year. Additionally, the trend in the South Monitoring reversed, with a negative rate this year compared to last year's positive rate. The consistent relatively high rate of negative shoreline change measured along the Central Reach Area is primarily associated with the post-construction equilibration of the beach fill placed in May 2023.

Volume Change:

In addition to the shoreline change analysis, volumetric change analyses were also conducted along the Town of Duck oceanfront. Volumetric change was evaluated using the same three timeframes and the same three Monitoring Areas of the Town as those used in the shoreline change analysis. Volumetric change and volumetric change rates are computed based on the volumetric change measured along each beach profile survey transect out to a depth of -24 feet NAVD88. Average volumetric change rates calculated (cubic yards/ft./year) for the North Monitoring Area, Central Reach Project Area, and South Monitoring Area are provided in Table ES-2.

Table ES-2
Summary of Average Volumetric Change Rates (cy/ft./yr.) Measured along the Town of Duck.

MONITORING AREAS	Sept. 2013 (Baseline) to June 2025 (Year-2)	May 2023 (Post-Con) to June 2025 (Year-2)	June 2024 (Year-1) to June 2025 (Year-2)
NORTH MONITORING AREA (D-01 TO D-10)	1.9	7.7	6.6
CENTRAL REACH PROJECT AREA (D-10 TO D-19)	8.9	-11.4	-21.7
SOUTH MONITORING AREA (D-19 TO D-34)	3.4	7.7	6.8

Central Reach Project Area: The long-term average volumetric change rate, covering the period from September 2013 to June 2025 and reported in Table ES-2, indicates a positive rate of 8.9 cy/ft./yr. This positive rate is indicative of the benefits of the 2017 and 2023 beach nourishment projects on the Central Reach Project Area. The 2023 beach nourishment project placed a total of 576,800 cubic yards of fill along

the Duck shoreline between stations D-10 and D-19 (Central Reach Project Area). Approximately 870,000 more cubic yards of sand were measured within the Central Reach Project Area in June 2025 than were measured at the time of the baseline survey conducted in September 2013, prior to any nourishment.

A rate of -12.3 cy/ft./yr. was measured between December 2017 and January 2023, which represents the performance of the 2017 beach nourishment project over an approximate 5-year interval (CPE, 2024). As shown in Table ES-2, a rate of -11.4 cy/ft./yr. was measured between May 2023 and June 2025, which represents the 2-year rate of performance of the 2023 beach nourishment project. The desired outcome is that the 2023 project will continue to outperform the 2017 beach nourishment project. This is expected due in part to the optimized beach fill design developed for the 2023 beach nourishment project, as well as the often-seen trend of erosion rates stabilizing after multiple nourishment cycles.

As shown in Table ES-2, the rate measured from June 2024 to June 2025 was -21.7 cy/ft./yr., representing a loss of approximately 180,000 cy during the most recent monitoring year. Adding this to the volume loss recorded between May 2023 and June 2024 (approx. -23,300 cy) shows that, 25 months after completion, the Central Reach Project Area has retained approximately 65% of the sand placed during the 2023 project. With that said, it is noteworthy that the general trend in the North and South Monitoring Areas were more positive than the long-term average, indicating that overall, the entire Town experienced lower erosion rates since the September 2013 baseline survey.

North Monitoring Area: The long-term average volumetric change rates (Sept. 2013 to June 2025) shown in Table ES-2 for the North Monitoring Area, reflect a positive volumetric rate of 1.9 cy/ft./yr. Although discrete periods of volumetric losses have been observed along the North Monitoring Area between 2013 and 2025, the overall volumetric trend over this period has been positive. Despite the absence of direct sand placement within the North Monitoring Area during the 2017 and 2023 beach nourishment projects, a cumulative net gain of approximately 196,500 cubic yards was measured over the 11.75-year monitoring period. Of this total, approximately 52,700 cubic yards of sediment accretion occurred between June 2024 and June 2025.

Historically, the determination of whether a reasonable level of storm damage reduction is being maintained for public and private development along the Town's oceanfront has been based on the results of a storm simulation model known as SBEACH. The SBEACH model is used to simulate storm scenarios equivalent to a modern-day version of Hurricane Isabel, which impacted the Town in 2003, to determine impacts based on current conditions. Simulations conducted in 2019, based on May 2019 beach conditions, identified only one (1) oceanfront structure and no oceanfront pools along the North Monitoring Area that would have been impacted based on the SBEACH analysis. That SBEACH analysis was then updated in 2023 using May 2023 beach conditions and the results of that analysis indicated no oceanfront houses or pools in the North Monitoring Area would have been impacted by the design storm.

The short-term (June 2024 to June 2025) average volumetric change measured along the North Monitoring Area was a gain of approximately 52,700 cy. This equates to a change rate of +6.6 cy/ft./yr., which indicates an above average period of positive volumetric change along the North Monitoring Area over this most recent period. While the SBEACH analysis was not updated based on the June 2025 conditions, the fact that this area continues to experience a volumetric gain suggests that a reasonable level of storm damage reduction to public and private development existed along the North Monitoring Area as of June 2025.

South Monitoring Area: The long-term average volumetric change rates (Sept. 2013 to June 2025) shown in Table ES-2 for the South Monitoring Area, reflect a positive volumetric rate of 3.4 cy/ft./yr. Although discrete periods of volumetric losses have been observed throughout the South Monitoring Area between 2013 and 2025, the overall volumetric trend over this period has been positive. Although no sand was

directly placed in the South Monitoring Area through beach nourishment during the long-term period, a net increase of approximately 544,500 cy of sand was measured over the 11.75-year monitoring interval.

The short-term (June 2024 to June 2025) average volumetric change measured along the South Monitoring Area was a gain of approximately 92,700 cy. This equates to a change rate of +6.8 cy/ft./yr., which indicates an above average period of positive volumetric change along the South Monitoring Area over this most recent period.

As previously stated, the determination of whether a reasonable level of storm damage reduction along the oceanfront is being maintained is based on the results of a storm simulation model known as SBEACH. Simulations conducted in 2019, based on May 2019 beach conditions, identified 28 oceanfront structures and 40 oceanfront pools along the South Monitoring Area, particularly south of the USACE Field Research Facility, that would have been impacted based on the SBEACH analysis. That SBEACH analysis was then updated in 2023 using May 2023 beach conditions and the results of that analysis indicated no oceanfront structures and nine (9) oceanfront pools in the South Monitoring Area would have been impacted by the design storm.

The decrease in the number of oceanfront structures and pools identified as impacted through the SBEACH Analysis, between May 2019 and May 2023, coincides with a volumetric gain of approximately 202,000 cy between station D-23, which is located just north of the southern boundary of the USACE Field Research Facility, and D-34, which is located at the southern Town boundary. While the SBEACH analysis was not updated based on the June 2025 conditions, this same stretch of the Town from near the southern boundary of the USACE Field Research Facility to the southern Town Boundary experienced a volumetric gain of approximately 47,000 cy between June 2024 and June 2025 This positive volumetric change suggests that a reasonable level of storm damage reduction to public and private development existed along the South Monitoring Area as of June 2025.

Recommendations:

CPE recommends the Town continue to monitor the beach along the entire Town oceanfront to assess 1) the performance of the May 2023 beach renourishment project and 2) shoreline and volume change trends along the portions of the Town outside the Central Reach Project Area. For continued monitoring of the Central Reach Project Area, the May 2023 survey should represent the post-construction conditions. Future annual monitoring reports should reference shoreline and volume changes in the Central Reach Project Area relative to the May 2023 condition to track the short- and long-term performance of the 2023 project and aid in the determination of when additional nourishment is needed in the Central Reach Project Area and surrounding beaches. Continued annual monitoring of the project will also provide a pre-storm condition survey that can be used to estimate damages if the project is impacted by a significant storm.

Continued monitoring of the North and South Monitoring Areas is vital to achieving the Town's goal of providing a reasonable level of storm damage reduction to public and private development along the entire Town oceanfront. This continued monitoring will allow the Town to evaluate future areas of concern and longshore transport trends, and to develop successful shoreline management strategies to deal with issues as they arise.