EXECUTIVE SUMMARY

The Town of Duck is located on the Outer Banks of North Carolina, roughly 27 miles south-southeast of the North Carolina and Virginia border. The Town extends along 5.9 miles of Atlantic Ocean shoreline from the Dare County and Currituck County line south to the Town of Southern Shores.

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 a beach nourishment project along 1.6 miles of its oceanfront that was shown to be the most vulnerable portion of the Town's oceanfront. Approximately 1.26 million cubic yards of fill was distributed between Skimmer Way (station D-10) and the northern USACE Field Research Facility (FRF) property boundary (station D-19).

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 nourishment 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 monitoring area is divided into three areas designated as the Project Area (station D-10 to D-19); the area North of the Beach Project (D-01 to D-10), which extends south from the Town limit to Skimmer Way; and the area South of the Beach Project (D-19 to D-34), which extends from the northern boundary of the FRF property south to the Town boundary with Southern Shores.

A shoreline change analysis was completed to assess shoreline advance and recession along the study area. The contour used to monitor shoreline change throughout the Town of Duck is the +6.0 ft. NAVD88 contour. The shoreline change analysis compared the position of the +6.0 ft. NAVD88 contour in September 2013, December 2017, May 2019 and June 2020. The following table summarizes the average shoreline changes (ft.) measured between September 2013 and June 2020 (Long-term), December 2017 and June 2020 (Post-Project), and May 2019 and June 2020 (Short-term), for the Project Area and Areas North and South of the Project.

Table ES-1
Summary of Average Shoreline Changes (ft.) within the Project Area and North and South Monitoring Areas

PROFILE	September 2013 (Baseline) to June 2020 (Year-3)	Dec. 2017 (Post-Con to June 2020 (Year-3)	May 2019 (Year-2) to June 2020 (Year-3)
AREA NORTH OF PROJECT (D-01 TO D-10)	-6.3	8.3	2.8
PROJECT AREA (D-10 TO D-19)	3.9	-74.8	-49.0
AREA SOUTH OF PROJECT (D-19 TO D-34)	-8.3	4.6	-14.5

Similar to the shoreline change analysis, the tracking of long-term volumetric changes within the project area as well as north and south of the project area, are measured by comparing the September 2013 data with the most recent annual monitoring. Volumetric changes that have occurred Post-Project are

determined by comparing the December 2017 data with the most recent annual monitoring data. The monitoring report also provides short-term volumetric changes that occurred over the past annual monitoring cycle (May 2019 to June 2020). Average volumetric change rates above the -24-foot NAVD88 contour (cubic yards/ft./year) for the Project Area and areas North and South of the Project are provided in Table ES-2.

Table ES-2
Summary of Average Volume Changes (cy/ft./yr.) within the Project Area and North and South Monitoring Areas

MONITORING AREAS	September 2013 (Baseline) to June 2020 (Year-3)	December 2017 (Post-Con) to June 2020 (Year-3)	May 2019 (Year-2) to June 2020 (Year-3)
AREA NORTH OF PROJECT (D-01 TO D-10)	1.2	8.3	16.9
PROJECT AREA (D-10 TO D-19)	12.2	-12.4	-4.8
AREA SOUTH OF PROJECT (D-19 TO D-34)	3.1	3.5	11.8

The long-term average volumetric change rates indicate a positive trend throughout the Town; however, the Project Area rate is clearly being influenced by the beach nourishment project constructed in 2017. Since the project was completed, both the area north and south of the project experienced higher rates of positive volumetric change than the long-term rates since 2013. North of the project, the increase in the positive volumetric change rate is nearly 7 times greater than the long-term rate. In the south, the increase in the positive volumetric change rate is a minimal and may be heavily influenced by short-term changes.

With regards to the Project Area, comparison of profile surveys conducted in April 2017 (Pre-Construction) and December 2017 (Post-Construction) suggests the effective volumetric gain to the Project Area due to the 2017 beach nourishment project was 963,100 cubic yards. Monitoring data collected in June 2020 indicate a negative volumetric change within the Project Area of approximately -271,000 cubic yards since December 2017 (Post-construction). This equates to a rate of -12.4 cy/ft./yr. when annualized. As of June 2020, the analysis indicates that the Town of Duck beach nourishment project had approximately 72% of the initial fill volume remaining as measured above the -24-foot NAVD88 contour.

The initial monitoring of the project over the first 3 years following construction indicates a volumetric change rate higher than estimated in the initial project design, which may be related to a number of factors. The Town's maintenance plan calls for an estimated renourishment fill density of approximately 30 cy/ft., every 5 years, which translates to an annual average loss of approximately 6 cy/ft. The actual rate of volumetric change measured since 2017, in the first three years pos-construction, has been 12.4 cy/ft., which is twice the rate programed in the beach management plan. It must be considered, however, that the loss of material from a beach nourishment project typically does not occur in a linear pattern;

rather the trend is to observe higher losses immediately following construction of the project followed by a tapering off of rates over time as the project equilibrates with the surroundings and fill diffusion losses decrease. Given the 2017 project was the initial construction of the Town's project and beach profile data along the Project Area was limited prior to the construction of the 2017 project, the monitoring program is revealing the true erosion rate. The true erosion rate is influenced by the construction of the project itself, recent impacts of storms, alongshore variability, and other factors that may be contributing to the erosion rate beyond the initial estimate. Furthermore, the volumetric change measured over the most recent monitoring period (May 2019 to June 2020) indicates a volumetric change rate of -4.8 cy/ft./yr. as shown in Table ES-2.

While the post-project volumetric change rate may decrease over the next two years, prior to the 2022 project, the Town may need to place additional material on the project in excess of the 30 cy/ft. fill density prescribed in the beach maintenance plan to re-establish and maintain the present design objectives. CPE is currently working on updating these numbers as part of the design of the 2022 project, which can be re-evaluated as additional monitoring data become available.

Following the impact of Hurricane Dorian on the project, the Town contracted with CPE to conduct post-storm surveys to determine storm impacts. CPE completed a volume analysis and design report stating that Hurricane Dorian caused the loss of approximately 170,800 cy of sand (~20 cy/ft.) that should be eligible for FEMA Public Assistance funding. While CPE is working on updating the design for the 2022 project to account for the higher observed erosion rates as discussed previously, it is recommended that the Town plan to at least replace the 170,800 cy of material lost as a result of Hurricane Dorian in addition to the programed placement of 254,000 cy of sand. In the report prepared for FEMA, CPE estimated the additional cost to replace the 170,800 cy of sand to be approximately $2,972,000.