2022 BEACH MONITORING AND BEACH STABILITY ASSESSMENT
CURRITUCK COUNTY, NORTH CAROLINA

PREPARED FOR
CURRITUCK COUNTY

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

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EXECUTIVE SUMMARY

Currituck County has commissioned a three-year Beach Monitoring and Beach Stability Assessment to evaluate long-term and short-term shoreline and volumetric changes occurring along Currituck's oceanfront beaches. The scope includes annual beach monitoring in Year-1, Year-2, and Year-3, an initial beach stability assessment to be completed following Year-1 surveys, and annual reports to be provided in Year-2 and Year-3 updating the County on shoreline and volume change trends. This Year-3 Beach Stability Assessment includes an assessment of volume change trends, an update of shoreline change trends, an update to the projected shoreline changes into the future over a 10-, 20-, and 30-year period, and a final vulnerability analysis.

The stated goals of the Assessment are 1) to better understand the changes that are occurring in the beaches and 2) to assist the County in making informed decisions regarding beach management. The three-year study aims to assess trends and provide a foundation for future coastal management in the County through data collection and beach analyses.

This 2022 (Year-3) report serves to provide an update to the County on the 3-year study in terms of data obtained through Year 3. 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 change over 10-, 20-, and 30-year horizons, and a final vulnerability analysis. The conclusions provided in this Year-3 report are based on data collected in Year-1, Year-2, and Year-3 of a 3-year study.

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 Beaches are 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 Beaches are 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 Beaches extend 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.

The data collection and analysis methodology are described in Sections 2.0 of the main report. Section 3.0 presents a summary of grain size analysis conducted in Year-1 of the study (2020) and a large clast analysis conducted in Year-3 of the study (2022). Section 4.0 provides the results of the shoreline change analysis and the projections of shoreline change rates over a 10-, 20-, and 30-year time horizon. Section 5.0 provides the results of the volumetric change analysis. Section 6.0 provides results of the analysis of the nearshore bathymetric data collected in 2020 and 2022 including the analysis of offshore features that may be impacting sediment transport along the project. Section 7.0 provides an update to the beach vulnerability analysis conducted in Year-1 (2020). This analysis employed the numerical model SBEACH to simulate storm impacts to the Assessment Area based on 2022 conditions. Sections 8.0 and 9.0 provide conclusions drawn from the results of the study and recommendations.

Projected Shoreline Changes: Publicly available lidar data allowed for a long-term shoreline change analysis to be conducted, 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. Seven (7) data sets collected between 2009 and 2022 were analyzed to determine shoreline change rates over the past 13 years. These long-term rates were determined using a linear regression method that considers each of the seven data sets available over this 13-year period. The shoreline change rates computed were then used to project future shoreline changes throughout the Assessment Area over a 10-, 20-, and 30-year time horizon.

The projections show no impacts based on projected shoreline change rates over a 30-year horizon in the Carova Section nor the Pine Island Section. Five (5) oceanfront houses within the Reserve/Refuge Section were shown to be impacted over the 30-year horizon. Four (4) of the houses are located seaward of Sandfiddler Road along an approximately 4,000-foot portion of the oceanfront south of Canary Ln. (between stations C-040 and C-044) and the fifth is located just north of the Currituck Banks Estuarine Reserve between stations C-050 and C-051. The four houses located between station C-040 and C-044 were all shown to be impacted over the 20-year horizon. The two (2) houses between stations C-041 and C-042 were shown to be impacted over the 10-year projection. While the number of houses shown to be impacted in this section may not be significant, the retreat of the shoreline may create pinch points for traffic transiting north and south through these areas as the homes end up out on the dry sand beach.

The greatest number of impacts from projected shoreline changes were observed within the Corolla Section of the Project Area. In total, 158 houses were shown to be impacted over the 30-year horizon throughout the Corolla Section. These houses are all located between the Horse Gate and Wave Arch in the Ocean Lake community (C-080). Of the 158 houses shown to be impacted over the 30-year horizon, 66 of the houses were shown to be impacted over the 20-year horizon and 11 were shown to be impacted over the 10-year horizon. The oceanfront houses along the Corolla Section are concentrated along three general areas. The northernmost area spans from the Horse Gate to Corolla Village Road. Along this approximately 1.3 mile stretch of beach, nearly every ocean front house was shown to be impacted over the 30-year horizon. Approximately 40% of the oceanfront houses along this section were shown to be impacted over the 20-year horizon

and all 11 of the houses in the Corolla Section shown to be impacted over the 10-year horizon are along this stretch of beach. Furthermore, portions of the road along both Atlantic Avenue and Sandcastle Drive are shown as impacted over the 30-year horizon. The second concentrated section of oceanfront structures shown to be impacted over the various time horizons are located along the 2.9 miles of beach fronting Lighthouse Drive. Along the northern 1.9 miles of Lighthouse Drive, approximately 30% of the oceanfront structures were shown to be impacted over the 30-year horizon, and only one of those was shown to be impacted over the 20-year horizon. Along the southern 1.0 mile of Lighthouse Drive, over 95% of the oceanfront structures were shown to be impacted over the 30-year horizon and approximately 55% were shown to be impacted over the 20-year horizon. The southernmost cluster of oceanfront houses within the Corolla Section shown to be impacted over the various time horizons, are located in the Crown Point community (between station C-085 and C-086) and the Ocean Lake community (between station C-087 and C-088). Four (4) of the oceanfront houses in the Crown Point community were shown to be impacted over the 30-year time horizon, while all eight (8) of the oceanfront houses along Tide Arch within the Ocean Lake community were also shown to be impacted over the 30-year time horizon.

Volume Changes:

A complete volumteric analyses was completed as part of the Year-3 Assessment through a comparison of Year-1 (May 2020), Year-2 (June 2021), and Year-3 (May 2022) data. Volume change rates measured between 2020 and 2022 indicates an overall accretional trend during the 2-year period. The average volumetric change rate along the entire Assessment Area was +5.5 cy/ft./yr. between 2020 and 2022; this equates to a net volume gain of 1,314,600 cy. The majority of the volumetric gains were measured north of the Horse Gate along the Carova and Reserve/Refuge Sections. In those two sections a net positive volume change of approximately 1,176,000 cy was measured between May 2020 and May 2022. South of the Horse Gate, a net positive change of approximately 138,700 cy was measured between 2020 and 2022. A positive volumetric change of approximately 363,500 cy was measured along the Corolla Section during this time period; whereas along the Pine Island Section, a negative volumetric change of approximately 224,800 cy was measured.

The finding of overall a net volumetric gain along the Assessment Area was unexpected given the fact that various studies and beach monitoring programs established both north and south of the Currituck County shoreline have documented erosional trends over various periods of time Furthermore, these studies and monitoring programs north and south of Currituck County have prompted Sandbridge, Virginia to the north and the Towns of Duck, Southern Shores, Kitty Hawk, Kill Devil Hills, and Nags Head to the south to implement beach nourishment programs.

A number of various analyses were conducted to better understand volumetric changes in terms of which portions of the beach (both along-shore and across-shore) experienced gains and losses. As mentioned previously the Carova, Reserve/Refuge, and Corolla Sections experienced positive volume changes while the Pine Island Section experience negative volumetric change. A net negative volume change was observed in the portion of the beach that includes the primary frontal dune, the dry sand beach, and the subaerial beach out to a depth of -6 ft. NAVD88. However,

significant positive volumetric changes were measured in the Inner Nearshore portion of the beach, which was defined as the portion of the beach profile between the -6.0 ft. NAVD88 contour seaward to the -19.0 ft. NAVD88 contour. This significant positive volumetric change resulted in a net positive volumetric change along the Assessment Area between May 2020 and May 2022. The -19.0 ft. NAVD88 contour was established as the depth of closure for this study. The concept of depth of closure is used in coastal engineering application to define a theoretical depth along a beach profile where sediment transport is very small or non-existent, dependent on wave characteristics and sediment grain size. The increase in volume measured between the -6.0 ft. NAVD88 contour seaward to the -19.0 ft. NAVD88 contour, which is referred to in this report as the Inner Nearshore portion of the beach, is nearly five (times) greater than the negative volume changes measured landward of the -6.0 ft. contour. This suggests that the volume gains measured within the Assessment Area may be migrating from deeper water seaward of the depth of closure.

As previously stated, the depth of closure typically refers to a theoretical depth along a beach profile where sediment transport is very small or non-existent, depending on wave characteristics and sediment grain size. Given this definition, one would not expect to find considerable volumetric changes occurring seaward of an established depth of closure. However, seaward of the previously established -19.0 ft. NAVD88 depth of closure, positive volumetric changes were also measured between May 2020 and May 2022. More specifically, south of the Horse Gate in the Corolla and Pine Island Sections, a net positive volumetric change of approximately 1,138,300 cy was measured between May 2020 and May 2022 between the -19.0 ft. NAVD88 contour and the -25.0 ft. contour.

Numerous monitoring programs throughout the east coast and gulf coast of the US, established to monitor the performance of beach nourishment projects, have documented a phenomenon in which a large storm or a period of time with multiple large storms, resulted in the movement of sediment from the active beach seaward of the typical depth of closure. Furthermore, these studies have also demonstrated that a multi-year recovery period may follow these storm events, during which sand that had previously migrated into deeper water, migrates landward into the active beach profile.

A general review of wave data reflective of conditions offshore Currituck County was conducted to evaluate whether the offshore wave climate prior to the study period (May 2020 to May 2022) differed significantly from the wave climate during the study period. These wave data indicate that the pre-monitoring period (January 2017 to January 2020) was significantly more active in terms of wave events that produced significant wave events. Specifically, there were three storm events during this three year period where significant wave heights exceeded 20 ft.

The comparison of these wave data, coupled with the observations along beaches north and south of Currituck County, which also experienced positive volumetric changes during portions of the 2020 to 2022 monitoring period, suggests that the positive volumetric changes experienced during the May 2020 to May 2022 monitoring period along the Currituck County beaches may be explained as a recovery following storm induced migration of sand into deeper depths offshore.

Furthermore, if this explanation holds true, negative volume change trends may follow this temporary period of recovery.

Beach Vulnerability:

The Vulnerability Analysis conducted through the use of the SBEACH model, coupled with the results of the shoreline projections provides useful information to determine future vulnerability of public and private development along the County's oceanfront beach. In total, 43 oceanfront homes were determined to be vulnerable from a storm similar in characteristics to Hurricane Isabel, which impacted the County in 2003. These houses were spread throughout the Project Area, and primarily located in areas where shoreline change projections also indicated potential impacts.

No houses were identified as impacted by the SBEACH vulnerability analysis or the projected shorelines over the 30-year horizon in the Carova Section of the Project Area. In the Reserve/Refuge Section, four (4) houses located seaward of Sandfiddler Road along an approximately 4,000-foot portion of the oceanfront south of Canary Lane (stations C-040 to C-044) were identified as vulnerable through both the SBEACH analysis and projection of shoreline change rates. A fifth house, which is the southernmost oceanfront house located north of the Currituck Banks Estuarine Reserve (between station C-050 and C-051), was shown to be impacted by the shoreline change projections over the 30-year horizon; however, was not identified as vulnerable through the SBEACH analysis. These houses could impact traffic through this section of beach should a storm or continued shoreline recession result in the homes being situated on the dry or wet sand beach.

Thirty-nine (39) homes were identified as impacted by the SBEACH Vulnerability analysis south of the Horse Gate in the Corolla and Pine Island Sections of the Project Area. The majority (34) are located within the Corolla Section. The largest stretch of impacted homes is located along an approximate 1.0-mile portion of the Corolla Section between the northern end of Atlantic Avenue and Corolla Village Road. Twenty-nine (29) oceanfront houses identified as vulnerable and several other oceanfront pools are located within this portion of the Project Area. This is generally the same stretch of beach in which projected shoreline recession impacts were indicated at both the 10- and 20- year horizon between the Horse Gate and Corolla Village Road.

The vulnerability analysis conducted as part of the Year-1 (2020) assessment indicated several houses within the Whalehead Beach community were vulnerable. The updated analysis conducted using 2022 conditions and the updated wave data do not indicate any of the oceanfront houses along the Whalehead Beach Community along Lighthouse Drive as vulnerable based on the established criteria. That said, a significant number of oceanfront homes were shown to have been impacted over the 20-year and 30-year horizons. Furthermore, the proximity of the impact line to the oceanfront pools along this portion of the Assessment Area suggest that several pools may be vulnerable based on the established storm vulnerability criteria.

All nine (9) oceanfront homes located along the Spindrift community were determined to be vulnerable based on the established criteria. The Spindrift Community was split between the Pine

Island and Corolla Section. While none of these 9 homes were shown to be impacted by projected shoreline recession between the 10- and 30-year horizons, the lack of suggested impact due to shoreline retreat is primarily a factor of the location of the +4.0 ft. NAVD88 contour in May 2022.

Although no projected shoreline recession impacts were identified along the Pine Island Section south of Yaupon Lane, one oceanfront home was identified as vulnerable through the SBEACH analysis. That home is located near the north end of Salt House Road (station C-117). The volumetric change measured at C-117 was more than twice as high as the volume change measured along any other profile in the Project Area. The significant volumetric loss appears to be due to the formation of a deep trough.

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

1. **Continue Monitoring of the Beach Profiles:** The completion of the 3-year Beach Monitoring and Beach Assessment (2020 through 2022) has established a baseline of shoreline change and volumetric change rates. Given the results of the shoreline and volume change analysis, the distribution of potential impacts from the shoreline projections over 10 to 30 years and the distribution of houses identified through the vulnerability analysis, CPE recommends the County continue to monitor on an annual basis.

   The Corolla and Pine Island Sections of the Assessment Area should be monitored on an annual basis. This recommendation is based on several factors. The first is that the majority of the houses indicated as vulnerable through both the SBEACH analysis and the projected shoreline change rates, are located south of the Horse Gate. Secondly, given the possibility that the positive volumetric changes observed between 2020 and 2022 may be due to a temporary recovery of the beach following a period where sand had been pulled offshore due to storms, annual monitoring is important to track whether the beach is still in a state of recovery or whether it reverts to a trend of volume loss. A third reason to monitor the area south of the Horse Gate on an annual basis is due to the Pine Island Section being the only one of the four (4) Sections to have shown a negative volumetric change over the monitoring period between May 2020 and May 2022. Furthermore, the monitoring will allow for the tracking of the anomalous volumetric loss measured along profile C-117 in Pine Island.

   North of the Horse Gate, in the Carova and Reserve Refuge Area, monitoring could be conducted every other year. This recommendation is based on the fact that only a small number of houses located north of the Horse Gate were indicated as vulnerable coupled with the amount of undeveloped beach north of the Horse Gate.

   If the County decides to continue with a monitoring program, the same profiles established through this assessment should be collected 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).

2. Develop a Beach Management Plan: A Beach Management Plan is a document that first requires the establishment of tangible goals for how a local government desires to manage the beach. Beaches serve a variety of purposes from storm damage reduction, to flood mitigation, to recreational opportunity that draws in tourist dollars, to impacts to transportation or evacuation corridors, to environmental habitat that supports such resources as sea turtles and shore birds. A properly established beach management plan first establishes the local governments goals and then once the goals have been established, a feasibility analysis is conducted to look at multiple options for achieving the desired goals of the plan.

   CPE recommends the County develop a Beach Management Plan. The development of this Beach Management Plan would allow the County to first establish goals for managing the beaches. The development of the beach management plan would then involve the development of various management concepts, which may include beach nourishment, sand fencing/dune vegetation, beach bulldozing (dune push), targeted buyouts, etc. Once various management concepts have been developed, those various concepts would be evaluated in terms of effectiveness, cost, and other aspects used to determine feasibility. Through the evaluation of these various concepts, the County would determine the most feasible options that would both meet the pre-established goals of the plan and be economically feasible to implement. The management plan would ultimately provide thresholds for implementing actions established in the management plan, cost estimates, and schedules for implementing such actions.

3. Coordinate with Dare County on Regional Sand Resource Investigation: Dare County recently commissioned a two-year regional sand investigation study to locate sand for future beach nourishment projects. The investigation is slated to occur over a two year period in 2023 and 2024. The geographic extent of the Study Area includes portions of southern Currituck County including portions offshore of the Corolla and Pine Island Sections as defined in this report. State and federal rules do not limit offshore sand resources to be used only by the adjacent local community. These resources are typically considered state and or federal resources for which permits can be applied for by neighboring municipalities to use these sediments for beach nourishment projects. If Currituck County anticipates the future development of a Beach Management Plan, CPE recommends that County staff should coordinate with Dare County on this regional sand resource investigation.