DRAFT: TOWN OF SOUTHERN SHORES NORTH CAROLINA
2019 BEACH ASSESSMENT REPORT

SUBMITTED TO:

TOWN OF SOUTHERN SHORES

SUBMITTED BY:

APTIM COASTAL PLANNING & ENGINEERING OF NORTH CAROLINA, INC.

September 2019

EXECUTIVE SUMMARY

The Town of Southern Shores authorized this study to evaluate long-term and short-term shoreline and volumetric changes that occurred since the completion of the 2018 Vulnerability Assessment and Beach Management Plan. This study provides updated erosional and accretional trends, which aid the Town in assessing needs to sustain the beaches that support a significant portion of their local economy and maintains the tax base of the Town. This report also utilizes the beach profile survey data collected in May 2019 to update the beach fill options included in the Beach Management Plan. The Beach Management Plan provided three (3) beach nourishment options for the Town to consider. Each of the options included placement of beach fill along the southern 15,000 feet of the Towns oceanfront, with varying beach widths. These variable beach widths were formulated with the goal of providing storm damage reduction under a certain set of design storm conditions. This update includes a re-assessment of project extent, an update to the total project volume, and an update to the estimated project costs.

Shoreline Change Analysis

Average long-term MHW shoreline changes measured along the southern 15,000 feet of the Town's oceanfront (South of 3rd Ave.) and along the northern 2,000 ft. of oceanfront (north of 8th Ave.) were less than -1 ft./yr. This rate suggests the shoreline has been relatively stable along these portions of the beach for the respective 12.4 and 5.7-year periods.

The average MHW shoreline change along the Town's oceanfront between December 2017 and May 2019 was -3.1 ft. or -2.2 ft./yr. However, extensive variability in the measured shoreline changes at each profile was observed. In general, the northern and southern 5,000 feet of beach experienced the greatest average negative shoreline changes (landward movement) and the central section of beach experienced an average positive shoreline change (seaward movement).

Volumetric Change Analysis

The report assessed both volumetric changes measured along the entire Town based on the two most recent surveys (December 2017 and May 2019) as well as long-term volumetric change rates along those portions of the Town where beach profile surveys had been conducted prior to December 2017. Volumetric changes measured between December 2017 and May 2019 were assessed in terms of the three (3) distinct portions of the Town as it relates to the proposed beach fill options discussed in the original Beach Management Plan. Those portions include the northern portion of the Town not initially recommended for beach fill in the Beach Management Plan, the central portion of Town referred to as the "Main Placement Area", and the southern 5,000 feet of oceanfront, referred to as the "Transition Area". On average, the area north of the recommended beach fill placement from approximately 70 feet south of 5th Ave. north to the Town boundary, gained volume between December 2017 and May 2019. Likewise, the 10,000-foot area from approximately 3rd Ave. to a point approximately 450 feet south of Chicahauk Trl. (Main Placement Area) also gained volume between December 2017 and May 2019. The area along the southern 5,000 feet of oceanfront averaged a decrease of approximately 27 cy/lf. during the same time period.

Given the gains in the volume present along the northern section of Town, the options presented in this update do not include beach fill placement along that portion of the beach north of 4th Ave. Although modest volume gains were measured along the 10,000-foot section of beach referred to as the Main Placement Area, the overall volume of sand in place is less than the recommended volume; therefore, this section is still recommended for beach fill placement. Along the southern 5,000-feet of oceanfront, the relatively high volume losses resulted in a recommendation that additional sand be placed along this section of beach under Option 3 of the options originally proposed in the Beach Management Plan.

The long-term average volumetric change rate measured from 3rd Ave. (Station -150+00) to the southern Town boundary (Station 0+00) over the approximate 12.6 year period (between October 2006 and May 2019) above the -24.0 feet NAVD88 contour was +2.5 cy/ft./yr. An average volumetric change rate of +1.3 cy/lf./yr. (accretion) was measured over the approximate 5.7 year period along those profiles initially surveyed in September 2013 by APTIM (Stations -197+12 through -177+13). Though both long-term trends are positive, the two most recent surveys show an overall negative average volume loss along the entire Town, with locally higher rates of volume losses present along the southern 5,000 feet. Based on the comparison of the December 2017 and May 2019 surveys, the average volume change rate computed along the southern 15,000 feet of the Town, along which beach nourishment is recommended, is approximately 3 cy/ft./yr. This rate was used to determine advanced fill volumes for the recommended beach fill options.

2019 Beach Management Plan Updates

The update to the Beach Management Plan included in the report focused on:

- An evaluation of the project extent;
- Updates to design volumes based on measured volume changes that have occurred since the December 2017 survey; and
- Updates to project costs as a result to any changes in beach fill volume.

Project Extent: The volume present north of Station -150+00 appears to be sufficient to achieve the stated design goals of the Beach Management Plan and therefore beach fill is not recommended along this section of the Town's oceanfront. Beach fill is still recommended along the Main Placement Area, despite some increases in volume that occurred in this section between December 2017 and May 2019. Given the higher volume losses that were measured between December 2017 and May 2019, in what was referred to as the Transition Area, this update includes placing additional volume along this section to achieve the targeted volume.

Project Volume: A summary of the updates made to beach fill project volumes based on the May 2019 data are provided below:

- The measured rate of erosion that occurred along the portion of the Town where beach fill is being recommended averaged 3 cy/lf./yr. This volume was used to determine the amount of advanced fill to include in the beach fill options, resulting in an increase of 225,000 cy for each option.

- Design Option 1 – The total design volume decreased by 60,000 cy from 600,000 cy to 540,000 cy. However, with the significant increase in the advanced fill, the total volume required for Option 1 increased by 162,750 cy or 24%.
- Given the erosional trend measured along the southern 5,000 feet of the beach, Design Option 2 is essentially the same as Design Option 1.
- Design Option 3 - The total design volume remained the same at 720,000 cy. However, with the significant increase in the advanced fill, the total volume required for Option 3 increased by 222,750 cy or 28%.

Project Cost: The increase in the volume recommended for Option 1 resulted in an updated cost of $14,026,800, which represents a 21% increase. The increase in the volume recommended for Option 3 resulted in an updated cost of $16,749,900, which represents a 24% increase.

Recommendations

Based on the analysis and conclusions drawn from this study, APTIM makes the following recommendations, which are elaborated on in the report:

1. Determine whether to pursue beach nourishment and if so, which option;
2. Continue coordination with County and neighboring local municipalities in order to secure available cost sharing and coordinate efforts that result in reductions of costs for individual municipalities;
3. Initiate financial planning;
4. Initiate permitting and design of the beach fill project (February 2020); and
5. Continue monitoring of the beach profiles to update project costs and to track changes to the beach outside the proposed beach fill project to verify whether sufficient volumes of sand are present in this section to achieve the established level of protection.

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INTRODUCTION

In February 2018, APTIM completed the development of a Beach Management Plan for the Town of Southern Shores, to be used for future planning. The Beach Management Plan provided three (3) beach nourishment options for the Town to consider, which aimed to 1) provide a reasonable level of storm damage reduction to public and private development, 2) mitigate long-term erosion that could threaten public and private development, recreational opportunities, and biological resources, and 3) maintain a healthy beach that supports valuable shorebird and sea turtle nesting habitat. Each of the three (3) options included in the Beach Management Plan involved placement of sand along the southern 15,500 feet of the Town's oceanfront beach. The beach fill options consist of:

- Option 1 - Assumes a targeted volume density above the -24 ft. contour of 846 cy/lf. Option 1 calls for placement of 45 cy/lf. along the 10,000-foot "Main Placement Area" and 30 cy/lf. along the southern 5,000 feet of Town, which is referred to as the "Transition Area". With additional fill to account for a taper on the north and diffusion losses, Option 1 required the placement of 665,650 cy.
- Option 2 – Also assumes a targeted volume density above the -24 ft. contour of 846 cy/lf. Option 2 calls for placement of 30 cy/lf. along the southern 15,000 feet of Town. With additional fill to account for a taper on the north and diffusion losses, Option 3 required the placement of 492,300 cy.
- Option 3 - Assumes a targeted volume density above the -24 ft. contour of 858 cy/lf. Option 3 calls for placement of 57 cy/lf. along the 10,000-foot "Main Placement Area" and 30 cy/lf. along the southern 5,000 feet of Town, which is referred to as the "Transition Area". With additional fill to account for a taper on the north and diffusion losses, Option 3 required the placement of 803,050 cy.

During a series of public meetings between February and April 2019, Town Council discussed the potential of moving forward with a beach nourishment program. In April 2019, the Council held a public hearing on the topic. Following the public hearing, Town Council authorized APTIM to conduct a beach profile survey in 2019 and update the assessment of the extent of the proposed beach nourishment options and the volumes needed to construct recommended options.

This report provides updated long-term shoreline and volumetric change rates based on the 2019 survey data. The report also provides measured shoreline and volume changes that occurred between December 2017 and May 2019. The report then discusses the implications of changes measured between December 2017 and May 2019 to the recommendations included in the Beach Management Plan in terms of the project extent, project volume, and project cost.

PROJECT LOCATION

The Town of Southern Shores is located on the Outer Banks of North Carolina approximately 29 miles south-southeast of the North Carolina and Virginia border. The Town encompasses approximately 9.9 square miles extending along 3.7 miles of Atlantic Ocean shoreline from the Town of Duck south-southeast to the Town of Kitty Hawk. A location map is provided in Figure 1.

The development of the Beach Management Plan is aimed at sustaining the beach along the entirety of the Town of Southern Shores oceanfront. The Town's approximately 3.7 miles of shoreline varies in regards to the height and width of the primary dune, the distance structures are set back from the vegetation, and the rates of volume change that occur from station to station. The options assessed in this report aim to provide equal protection along the Town's oceanfront, as opposed to an equal amount of beach nourishment.

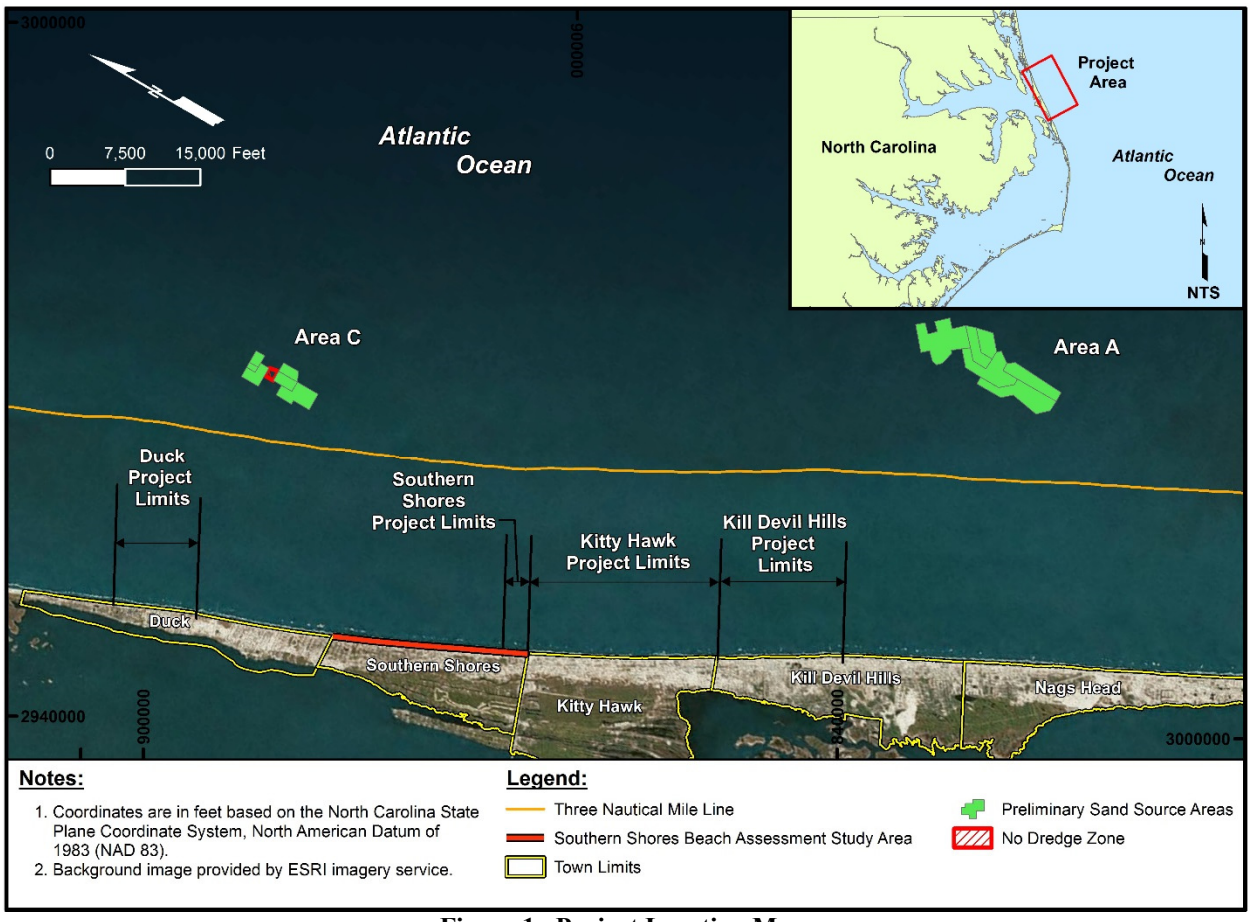


Figure 1. Project Location Map.

DATA COLLECTION

The data collection process entailed conducting beach profile surveys to acquire updated data along the entire Southern Shores beach. Datasets previously compiled and described in the initial Beach Assessment (APTIM, 2018A) were utilized to update long-term and short-term shoreline and volumetric trends. Figure 2 shows the locations of the beach profile stations along the shoreline of Southern Shores. The data sets used include:

- Beach profile data collected by the USACE Field Research Facility (FRF) in 2006 along the southern 15,000 ft. of the Town of Southern Shores (Stations -150+00 to 0+00);
- Beach profile data collected by APTIM in 2013 along the northern 2,000 ft. of the Town of Southern Shores (Stations -197+12 to -177+13);
- Beach profile data collected by APTIM in December 2017 (post-construction) and May 2019, along the entire oceanfront of the Town of Southern Shores (Stations -197+12 to 0+00).

The beach profile surveys conducted by APTIM in May 2019 represent the second Town-wide beach profile survey and were compared to the December 2017 baseline survey for monitoring and analysis. Both the December 2017 and May 2019 surveys consist of a total of 22 profiles with a spacing of roughly 1,000 feet (Stations -197+12 to 0+00). Coordinates and azimuth of these profiles are provided in Table 1. Coordinates shown in Table 1 are referenced to the North Carolina State Plane coordinate system in feet NAD83 and the profile azimuth refers to degrees referenced to true north. Transects listed in Table 1 are shown graphically in Figure 2. The complete survey report, which includes detailed plan view maps and comparative profile cross sections, is included as Appendix A.

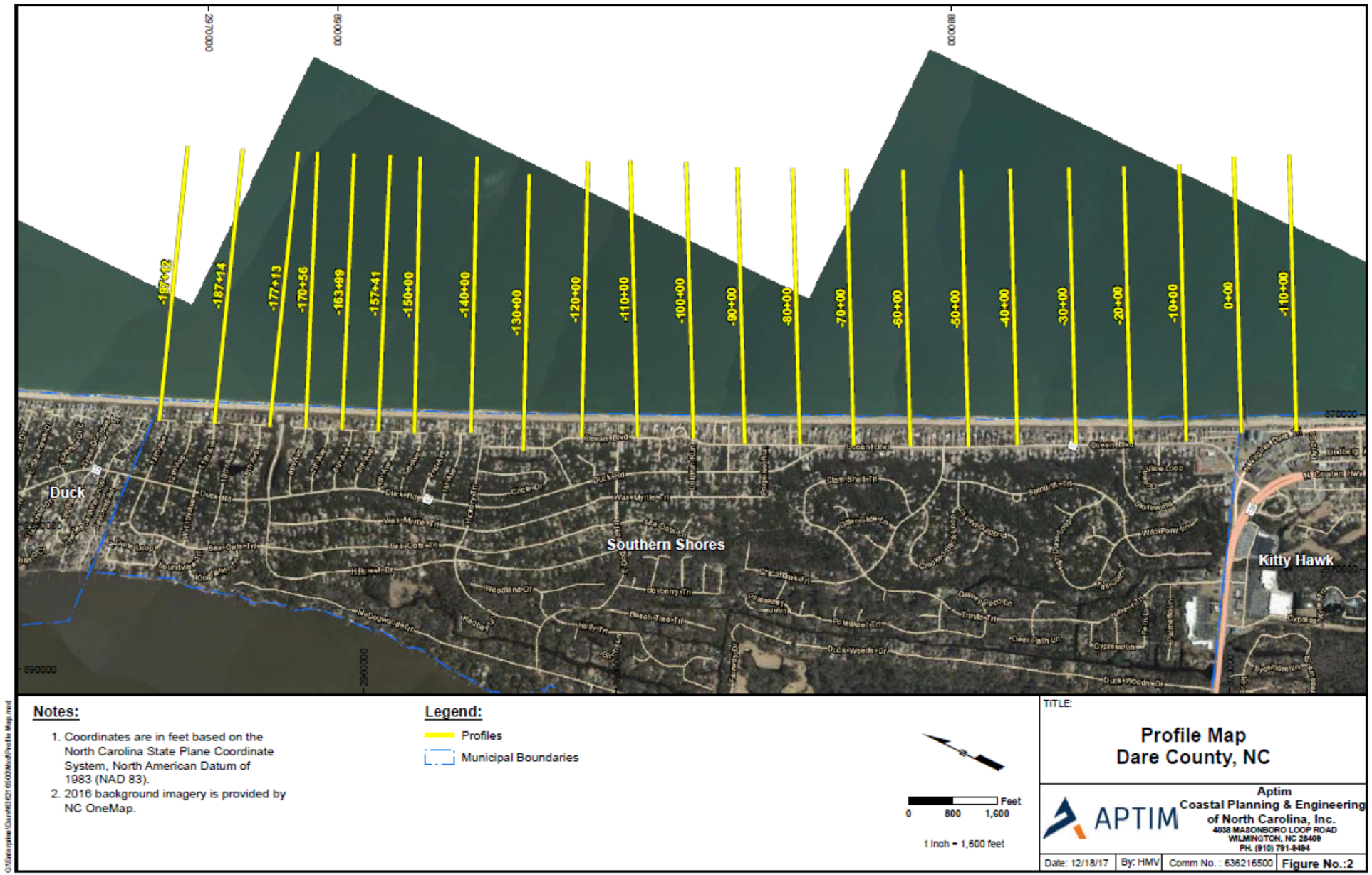


Figure 2. Map showing the location of the beach profiles along the Town of Southern Shores.

Table 1. Profile survey baseline and azimuth

Profile[(1)]	Easting	Northing	Azimuth
-197+12	2962840	889616.1	70
-187+14	2963230	888697.7	70
-177+13	2963619	887775.8	70
-170+56	2963880	887172.9	66.6
-163+99	2964142	886569.9	66.6
-157+41	2964403	885966.9	66.6
-150+00	2964665	885364.0	65.3
-140+00	2965116	884444.0	65.3
-130+00	2965239	883452.0	65.3
-120+00	2965920	882604.0	65.3
-110+00	2966366	881697.0	62.6
-100+00	2966790	880778.0	62.6
-90+00	2967110	879895.0	62.6
-80+00	2967533	878988.0	62.6
-70+00	2967951	878106.0	62.6
-60+00	2968381	877175.0	62.6
-50+00	2968838	876228.0	62.6
-40+00	2969249	875440.0	62.6
-30+00	2969732	874496.1	62.6
-20+00	2970190	873607.2	62.6
-10+00	2970653	872721.0	62.6
0+00	2971224	871890.8	62.6

[(1)]Southern Shores transects (0+00 to -197+12) based on USACE baseline

The May 2019 survey included a topographic survey of the dune, berm, and foreshore section of the beach and a bathymetric survey of the offshore portion of the profile. Beach profiles extended landward from the beach toward the baseline until a structure was encountered or a range of 25 feet beyond the dune was reached, whichever was more seaward. Elevation measurements were also taken seaward along the profile to a range of 2,500 feet beyond the shoreline or to the -30 feet NAVD88 contour, whichever was more landward.

Land-based or "upland" data collection includes 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 is 25 feet. The upland work extended into wading depths sufficiently 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 hydrographic survey work or "offshore" portions of the beach profiles was conducted with an Odom Hydrotrac depth sounder at 200 kHz and RTK GPS systems. Tide corrections were obtained redundantly through the use of RTK GPS and the tide station located at the USACE FRF in Duck, North Carolina. Offshore data points were collected with a maximum spacing of 25 feet.

Horizontal and vertical positioning checks were conducted at the beginning and end of each survey day to confirm that survey control was undisturbed and met the accuracy standards of this project with a horizontal limit of 0.66 feet and a vertical limit of 0.16 ft. for all electronic equipment. Vertical positioning checks for depth measuring equipment were conducted at 5 ft. increments between the minimum and maximum depths expected. These specifications meet the Minimum Performance Standards for the U.S. Army Corps of Engineers (USACE) (EM 1110-2-1003).

As discussed in the initial Beach Assessment (APTIM, 2018A), long-term shoreline and volumetric change rate calculations are limited by available data. Long-term shoreline and volumetric change calculations for the portion of the beach located between 3rd Ave. (Station -150+00) and the southern Town boundary (Station 0+00) utilized USACE beach profile data from 2006. Long-term shoreline and volumetric change calculations for the portion of the beach located between the northern Town boundary (Station -197+12) and approximately 200 ft. south of 9th Ave. (Station -177+13) utilized APTIM beach profile data from September 2013. The December 2017 data set was the first known beach profile survey conducted between 9th Ave. (Station -177+13) and 3rd Ave. (Station -150+00), therefore, no long-term rates are reported for this section of the beach. The December 2017 and May 2019 beach profile surveys were also compared to assess recent shoreline and volumetric changes along the entire oceanfront of Southern Shores.

SHORELINE CHANGE ANALYSIS

Using available beach profile data, a shoreline change analysis was conducted to assess shoreline advance and recession where data were available along the study area. As it relates to shoreline change, the "shoreline" is typically defined as a specified elevation contour. For this study, the shoreline was defined as the Mean High Water (MHW) contour, which represents the +1.2 feet NAVD88 elevation. Shoreline change is calculated by comparing shoreline position along shore perpendicular transects. Figure 3 shows a typical comparison plot of two beach profile surveys conducted approximately 2 years apart along Station -10+00, illustrating graphically how the shoreline change is measured. Shoreline change is provided in terms of the actual linear change measured between surveys and as a rate in an annualized form. The rate is calculated by dividing the measured distance of shoreline change by the time period (number of years) between survey events (i.e. feet per year). These rates are described in terms of positive ("+") or advance (shoreline moving seaward) and negative ("-") or recession (shoreline moving landward).

The position of the MHW shoreline measured in May 2019 along the portion of beach between 3rd Ave. (Station -150+00) and the southern Town boundary (Station 0+00), was compared to the position of the MHW shoreline at the time of the September 2006 survey. An average MHW shoreline change of -5.0 ft. was measured over the approximately 12.6-year period. This equates to an average MHW shoreline change rate of -0.4 ft./yr. This is essentially the same average rate calculated for this section of beach between September 2006 and December 2017 (APTIM, 2018A). A comparison of the long-term MHW shoreline change rates measured as of December 2017 and May 2019 is provided in Figure 4.

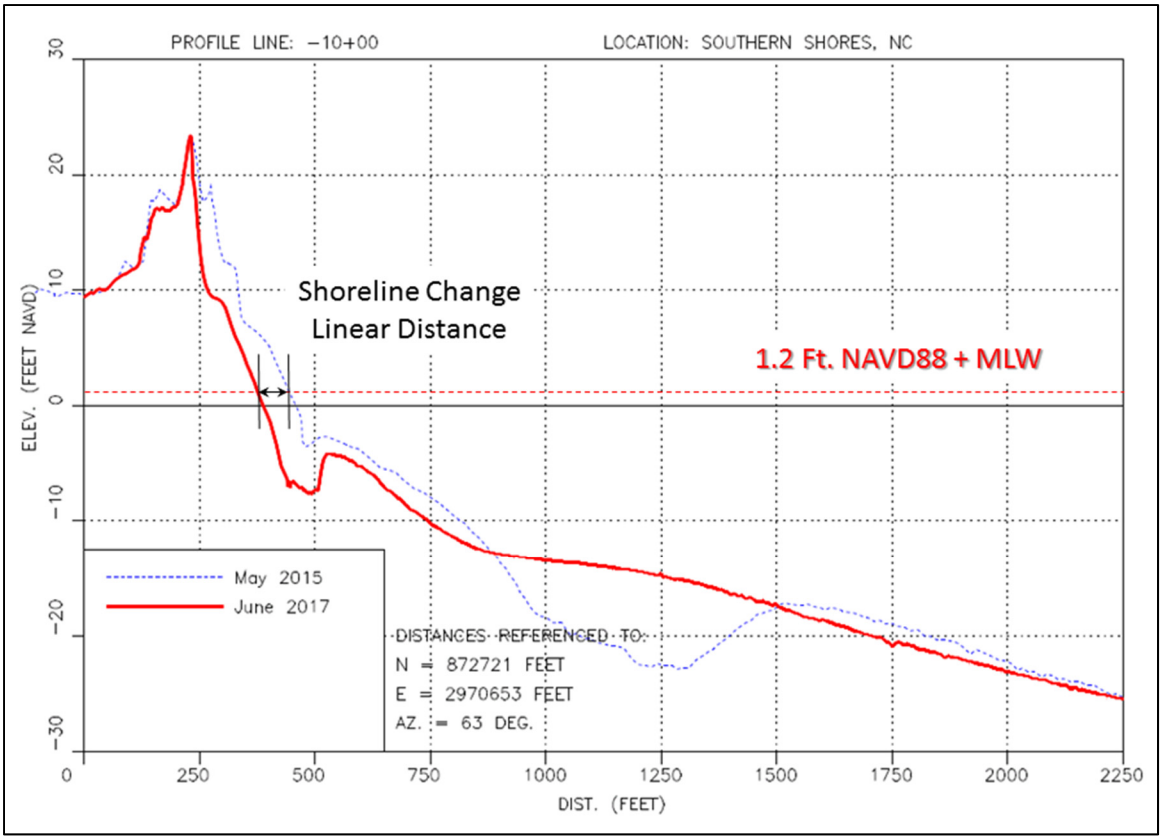


Figure 3. Beach profile cross section illustrating shoreline change.

A profile by profile comparison shows relatively minimal variation throughout the area over the 12.6-year period with rates ranging from -4.2 ft./yr. at Station -70+00 (approximately 500 ft. south of where Ocean Blvd. and Duck Rd. meet) to +3.0 ft./yr. at Station -140+00 (approximately 200 ft. south of 1st Ave).

During the 1.4 year period between December 2017 and May 2019, the average shoreline change rate measured along the beach from Stations -150+00 to 0+00, was -0.4 ft. Profile by profile comparison of the changes that occurred between December 2017 and May 2019 show extensive variability. The greatest positive change rate (seaward) was measured at Station -100+00 located at Dolphin Run (+26.6 ft./yr); whereas the greatest negative change rate (landward) was measured at Station -10+00 located within the area where beach nourishment occurred in August 2017 (near Sea Bass Circle) (-24.3 ft./yr). In fact, each of the three (3) southernmost profiles (Stations -20+00 through 0+00) exhibited negative shoreline change rates (landward) with an average shoreline change of -13.9 ft./yr. In contrast, the area identified in the Beach Management Plan as the "Main Placement Area", from approximately 3rd Ave. south to a point approximately 450 ft. south of Chicahauk St. (Station -50+00), saw an average positive (seaward) shoreline change rate 2.7 ft./yr.

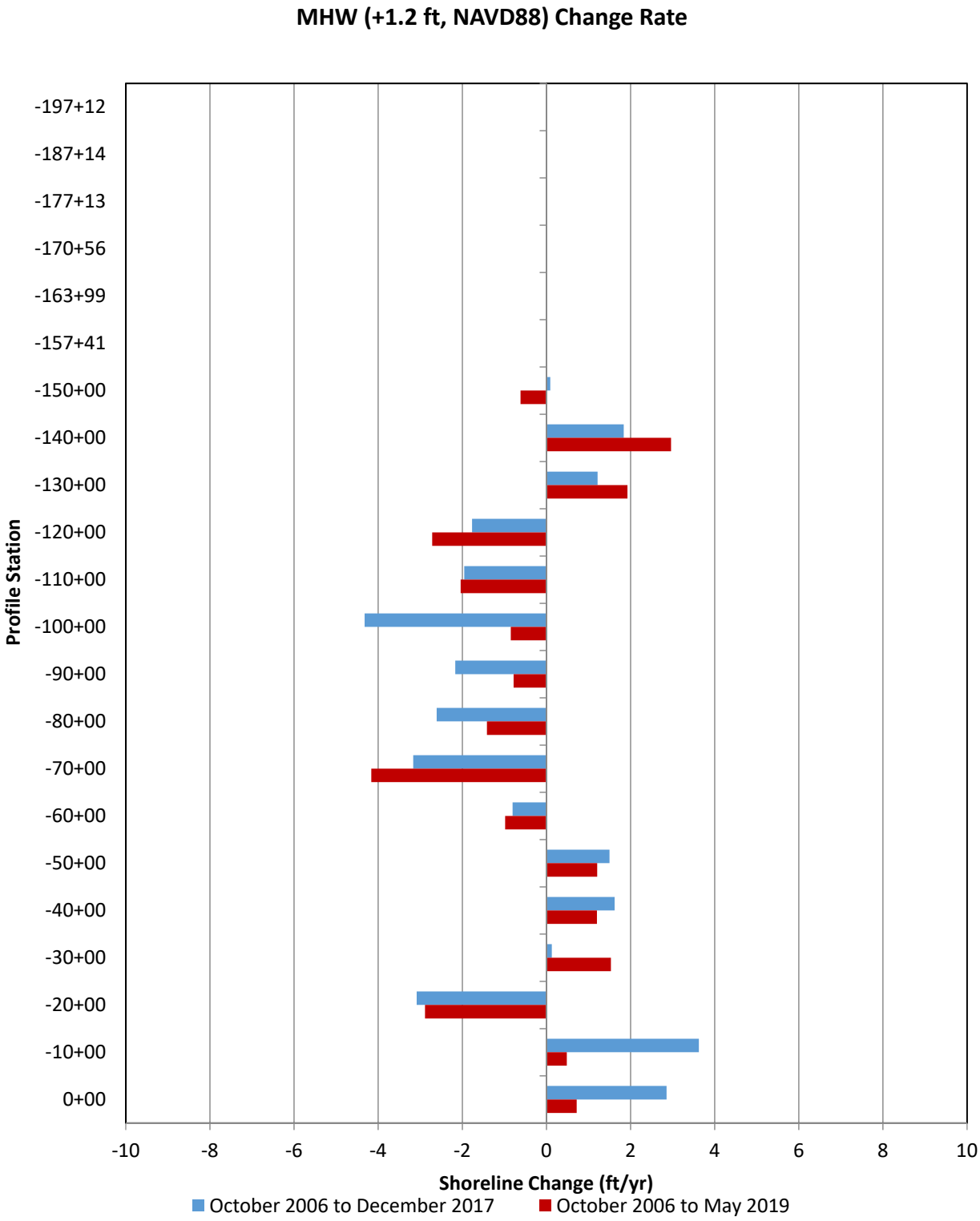


Figure 4. Shoreline change rates measured between October 2006 and December 2017, and October 2006 and May 2019.

The position of the MHW shoreline measured in May 2019 along the northern 2,000 feet of Southern Shores (Stations -197+12 to -177+13), was compared to the position of the MHW shoreline measured during a survey conducted in September 2013 for the Town of Duck. An average MHW shoreline change of -4.1 ft. was measured over the approximately 5.7-year period. This equates to an average MHW shoreline change rate of -0.7 ft./yr. This negative shoreline change rate is a reversal in the trend of positive shoreline change measured between September 2013 and December 2017 (+1.3 ft./yr.). Figure 5 shows the MHW shoreline change rate for each of the three northern profiles measured between September 2013 and December 2017 and between September 2013 and May 2019.

The reversal of the shoreline change trend measured along the northern 2,000-foot section of the Town's oceanfront between September 2013 and May 2019 was driven by higher negative shoreline changes measured between December 2017 and May 2019. During the 1.4 year period between December 2017 and May 2019, the average shoreline change rate measured along this section of beach was -6.7 ft./yr. Negative shoreline change rates (landward) were measured along each of the three beach profiles, ranging from -3.3 ft./yr. at Station -197+12 (northern Town Limit) to -10.8 ft./yr. at Station -177+13 (approximately 200 feet south of 9th Ave.)

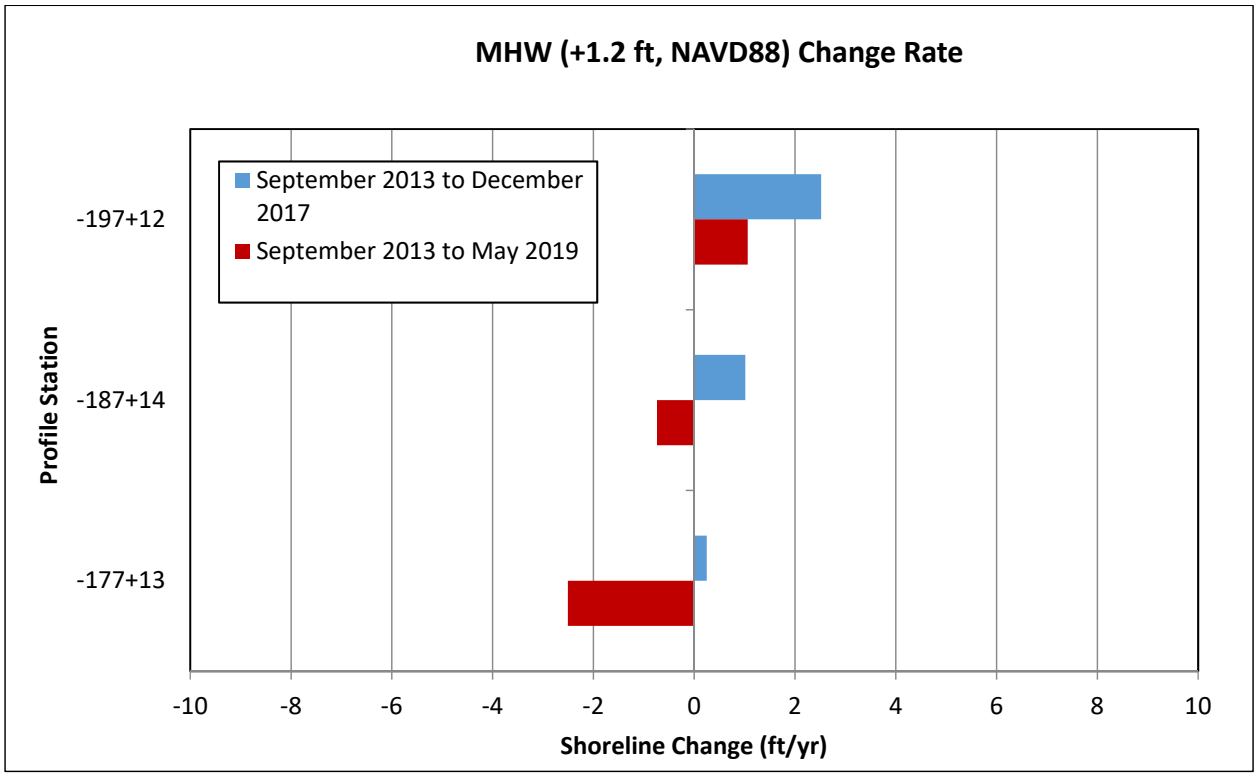


Figure 5. Average shoreline change rates measured from October 2006 to December 2017, and from October 2006 to May 2019.

With data collected during the May 2019 beach profile survey, APTIM was able to compute shoreline changes along the portion of the Town from Station 170+56 located at 8th Ave. to Station -157+41 located approximately 70 feet south of 5th Ave. Previously, December 2017 was the only survey that covered this section of the beach. Shoreline change measured between December 2017 and May 2019 along this section of beach averaged -12.8 feet or 9.0 ft./yr. By comparison, the average MHW shoreline change rate along the Town's entire oceanfront during the same time period was -2.2 ft./yr. It is also of interest that negative shoreline change rates were measured along the seven (7) northernmost profiles (Station -197+12 to Station -150+00) between December 2017 and May 2019, averaging -7.6 ft./yr.

VOLUMETRIC CHANGE ANALYSIS

Sand on the beach is distributed by wind and wave action over the entire active profile (from the dunes/vegetation out to the depth of closure). 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 profile is an important parameter to track in an effort to gauge the sediment budget, the health of the beach, and the performance of nourishment projects. The volume of sand in place is the metric that defines the three-dimensional beach, which provides storm protection. Figure 6 displays the same two profiles shown in Figure 3 with areas between the profiles color-coded to show volumetric gains (green-accretion) and volumetric losses (red-erosion) along the profile. The net difference between these volumetric gains and losses is referred to as volumetric change.

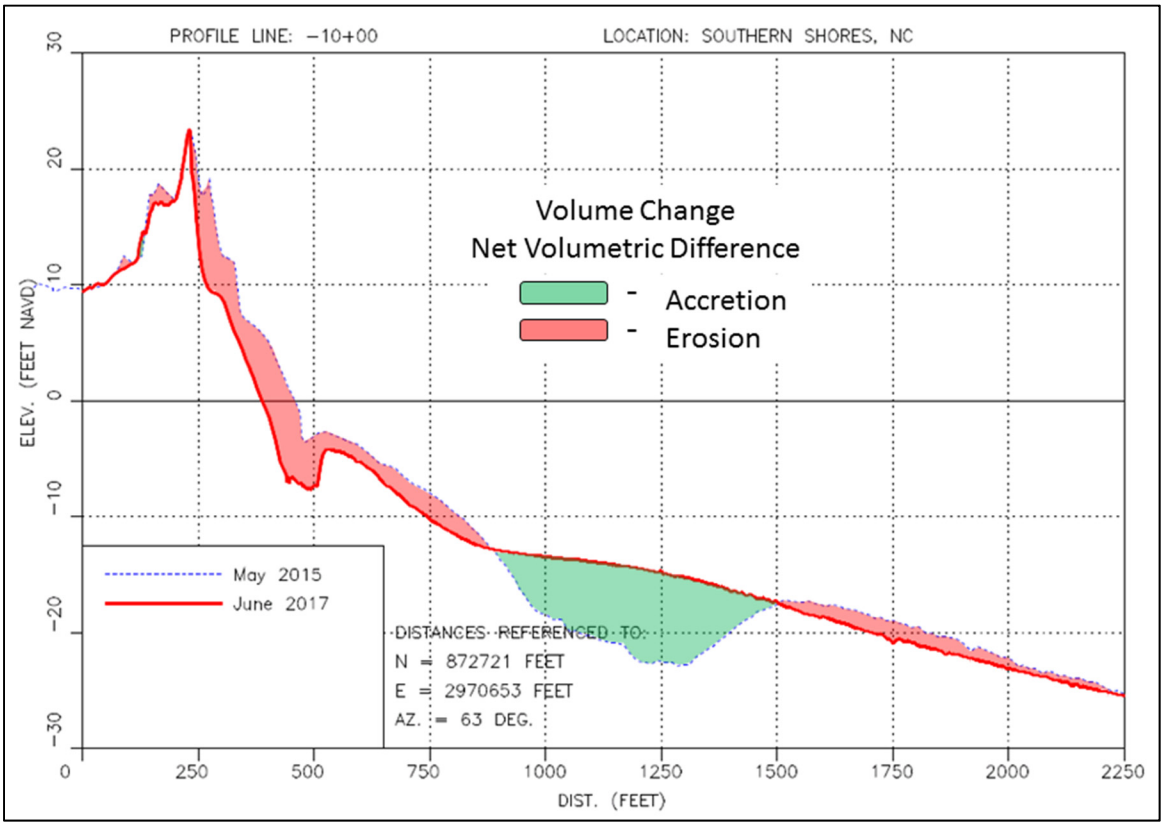


Figure 6. Beach profile cross section illustrating volume change.

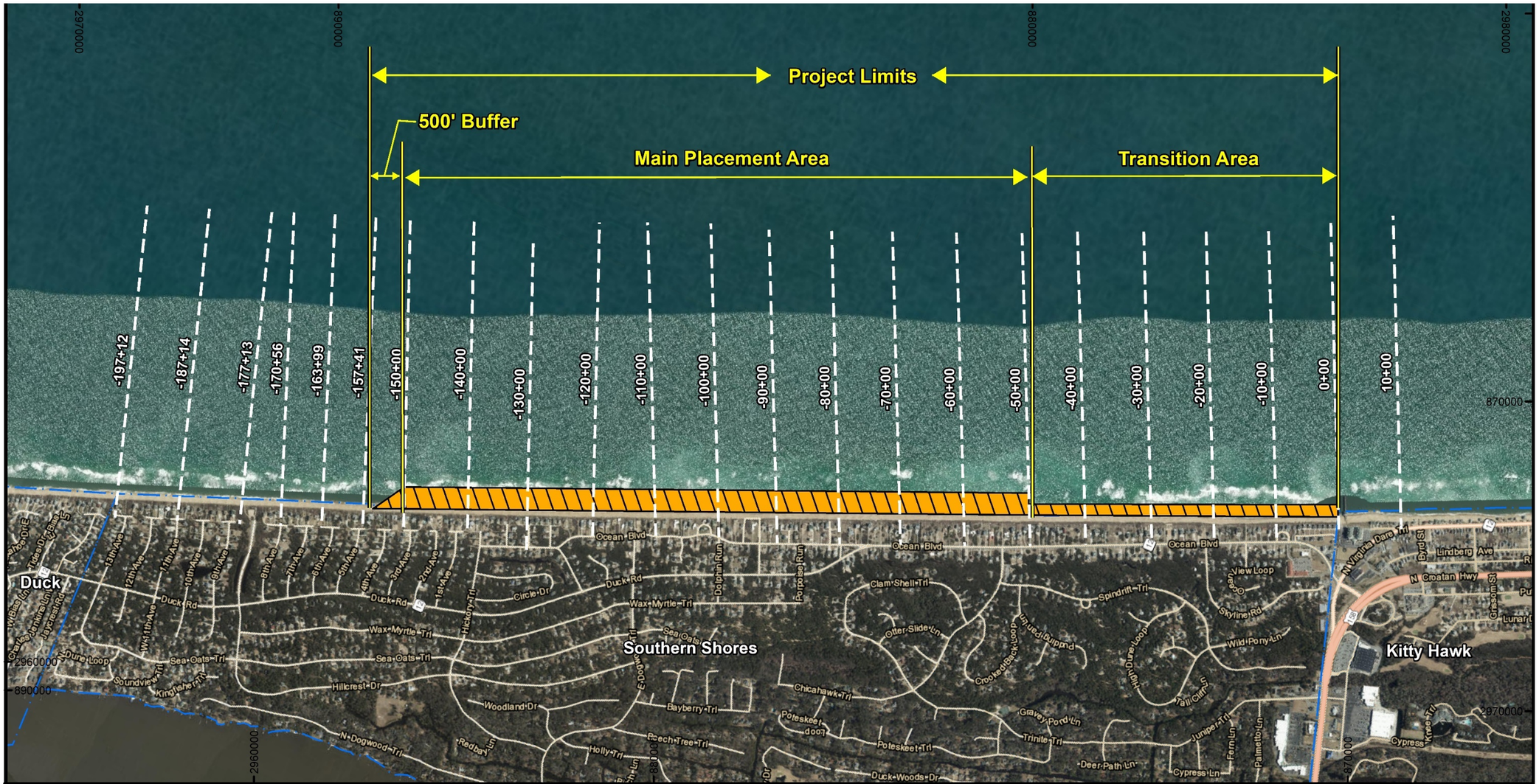
All volumetric changes along a profile or averaged along multiple profiles are given in cubic yards per linear foot (cy/lf.). At times, this report also provides total volume in cubic yards measured between certain profiles. These volumes are based on the average end area method; whereby the average volumetric change between adjacent profiles is multiplied by the distance between stations. Volumetric change rates are given in cubic yards per linear foot of shoreline per year (cy/lf./yr.). The volumetric changes are calculated along the entirety of the profile from the depth of closure (-24 feet NAVD88 contour) to the most landward point at which overlapping data exists.

The following section describes short-term changes in volume that occurred between December 2017 and May 2019 and how those short-term changes impacted previously reported long-term rates. Also discussed are volume changes in terms of three (3) distinct portions of the Town as it relates to the proposed beach fill options discussed in the original Beach Management Plan. Those sections include the "Main Placement Area", which stretches along the central 10,000 feet of the Town, the "Transition Area", which includes the southern 5,000 feet of beach, and the portion of the Town's oceanfront north of the "Main Placement Area", along which no beach fill was proposed in the options presented in the Beach Management Plan. These three (3) portions of the beach can be seen in Figure 7.

The average volumetric change measured over the 1.4-year period between December 2017 and May 2019 along the entire Town (Station -197+12 to Station 0+00) was -1.1 cy/ft., which equates to a volumetric change rate of -0.8 cy/ft./yr. As shown in Table 2, high variability was observed across the profiles examined during this time period, with the greatest positive volumetric change rate observed at Station -130+00 (+25.3 cy/ft./yr.) and greatest negative volumetric change at Station -10+00 (-36.3 cy/ft./yr.). The area in which beach fill was placed in 2017, (Stations 0+00 to -20+00) experienced some of the greatest negative volumetric changes, averaging -33.3 cy/ft. or -23.5 cy/ft./yr. In general, the southern 5,000 feet of oceanfront, experienced relatively high erosion rates between December 2017 and May 2019. The average erosion rate along this portion of the Town, which was referred to as the "Transition Area", was -18.9 cy/ft./yr. The extent of the "Transition Area" is shown on Figure 7. The relatively high erosion rate was driven by higher erosion rates measured at Station -40+00 (northern boundary of the property at 72 Ocean Blvd.), Station -20+00 (located approximately 150 feet south of Skyline Road), and Station -10+00 (located at the northern end of Sea Bass Circle).

The portion of the Town's oceanfront referred to as the "Main Fill" areas in the Beach Management Plan, which stretches from Station -150+00 (located near 3rd Ave.) to Station -50+00 (located approximately 450 feet south of Chicahauk Trl.) as shown on Figure 8, experienced positive volume change with an average rate of 4.6 cy/ft./yr. The majority of profiles experienced positive volume change; however, Stations -80+00 and -50+00, exhibited negative volume change rates of -21.9 cy/lf./ft. and -10.5 cy/lf./ft., respectively.

The area north of the proposed beach nourishment options presented in the Beach Management Plan (Northern Area), which extends from Station -150+00 (located near 3rd Ave.) north to Station 197+12 at the northern Town boundary, experienced an average positive shoreline change of 5.5 cy/ft./yr. Examination of Table 2 shows that the volume change rates measured along this stretch of beach varied from +20.8 cy/lf./yr. at Station -177+13 (located approximately 200 feet south of 9th Ave.) to -8.7 cy/lf./yr. at Station -187+14 (located at 11th Ave.).



Notes:

1. Coordinates are in feet based on the North Carolina State Plane Coordinate System, North American Datum of 1983 (NAD 83).
2. 2016 background imagery is provided by NC OneMap.
3. Placement area is for illustrative purposes only is not indicative of actual placement volume.

Legend:

- Southern Shores Placement Area
- Municipal Boundaries

0 800 1,600 Feet

TITLE:

Southern Shores
Proposed Project Location

Aptim
Coastal Planning & Engineering of North Carolina, Inc.
4038 MASONBORO LOOP ROAD
WILMINGTON, NC 28409
PH. (910) 791-9494

Date: 11/05/18 | By: HMV | Comm No. : 636237805 | Figure No.:8

Figure 7. Location Map showing the recommended project extent including the Main Placement Area and Transition Area.

Table 2. Updated long-term volume change rates measured above the -24 ft. NAVD88 contour.

PROFILE	October 2006 to May 2019 (CY/LF/YR)	September 2013 to May 2019 (CY/LF/YR)	December 2017 to May 2019 (CY/LF/YR)
-197+12	---	4.3	15.5
-187+14	---	-4.0	-8.7
-177+13	---	3.5	20.8
-170+56	---	---	-0.4
-163+99	---	---	12.7
-157+41	---	---	-5.5
-150+00	3.8	---	4.3
-140+00	7.2	---	8.0
-130+00	7.3	---	25.3
-120+00	2.5	---	-0.8
-110+00	2.7	---	8.1
-100+00	2.8	---	16.7
-90+00	1.9	---	10.8
-80+00	1.5	---	-21.9
-70+00	1.0	---	4.3
-60+00	2.5	---	6.6
-50+00	5.5	---	-10.5
-40+00	0.9	---	-26.5
-30+00	1.1	---	-5.8
-20+00	-2.3	---	-30.4
-10+00	0.9	---	-36.3
0+00	1.0	---	-3.7
TOTAL AVERAGE	2.5	1.3	-0.8
NORTHERN AREA (-197+12 TO -150+00)	N/A	N/A	5.5
MAIN FILL AREA (-150+00 TO -50+00)	3.5	N/A	4.6
TRANSITION AREA (-50+00 TO 0+00)	1.2 *	N/A	-18.9

In addition to the volumetric change rates measured between December 2017 and May 2019, Table 2 also includes updated long-term volume change rates in those areas where beach profile surveys had been conducted prior to 2017. Table 2 also provides average volume change rates for the three (3) distinct portions of the beach related to the beach fill options (Main Placement Area, Transition Area, and Northern Area). A profile by profile comparison of the long-term volumetric change rates measured in December 2017 and May 2019 are provided in Figure 8. The average volumetric change rate measured from 3rd Ave. (Station -150+00) to the southern Town boundary (Station 0+00) over the approximate 12.6 year period above the -24.0 feet NAVD88 contour was +2.5 cy/ft./yr. An average volumetric change of +7.2 cy/ft. (accretion) was measured over the approximate 5.7 year period along those profiles initially surveyed in 2013 by APTIM (Stations -197+12 through -177+13). This equates to an average volumetric change rate of +1.3 cy/ft./yr.

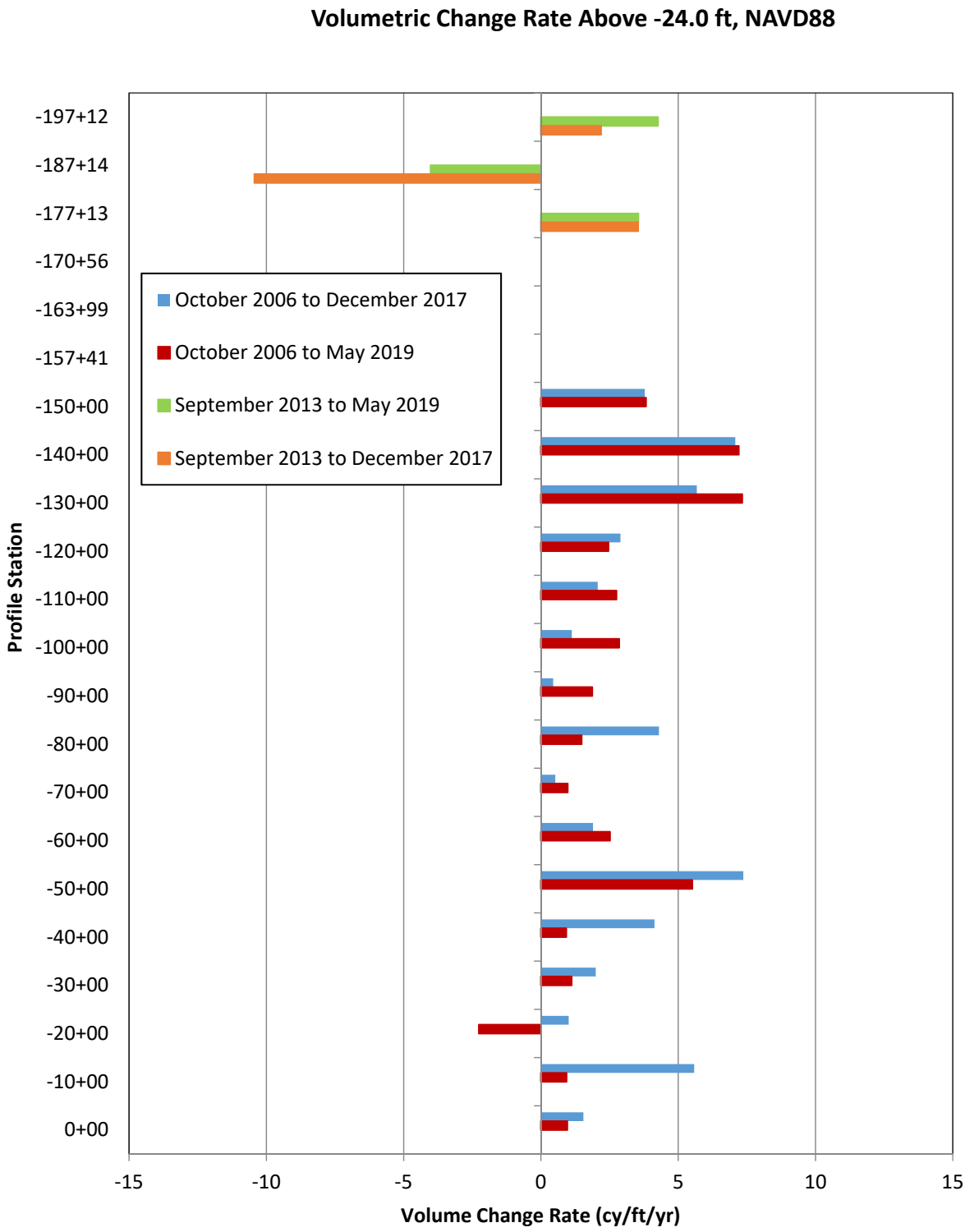


Figure 8. Long-Term Annual Volumetric Change Rate above -24 FT NAVD88 (CY/FT/YR)

Volume Envelope Calculations:

The total volume measured along each profile above the -24 ft. NAVD88 contour and seaward of the +20 ft. NAVD88 contour on the landward side of the dune, was calculated at each profile surveyed. This area of the profile is referred to in this report as the volume envelope. Figure 9 shows a cross section of profile -10+00, which graphically depicts the volume envelope. Comparing the volume measured in the volume envelope along the Town's oceanfront allows for the relative comparison of each profile and was used extensively in the development of the beach fill options included in the Beach Management Plan.

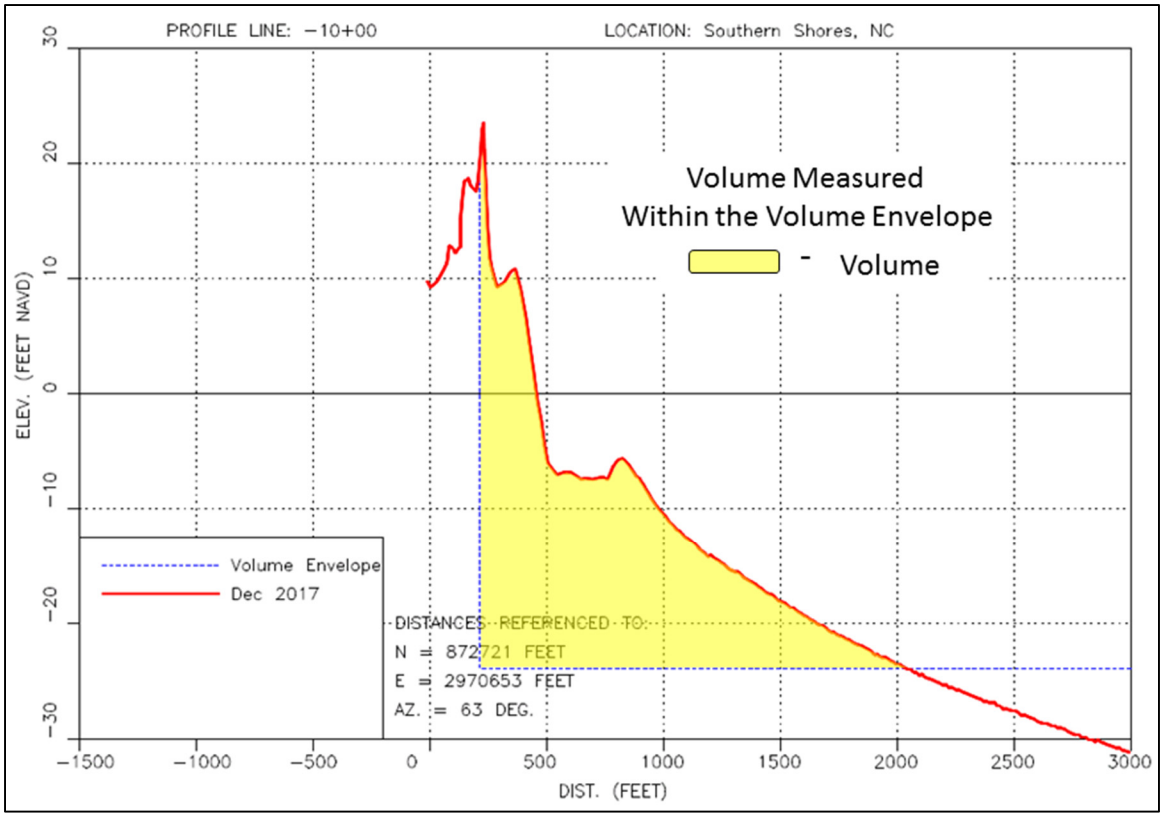


Figure 9. Beach profile cross section illustrating the volume envelope.

Figure 10 shows the volume measured within the volume envelope along each of the 22 Southern Shores profiles surveyed in December 2017 and May 2019. The average volume within the envelope measured along all 22 profiles in December 2017 was 830 cy/ft. and in May 2019 was 829 cy/lf. The volume envelope density is discussed in the subsequent sections in regards to evaluating the project extent and project volume.

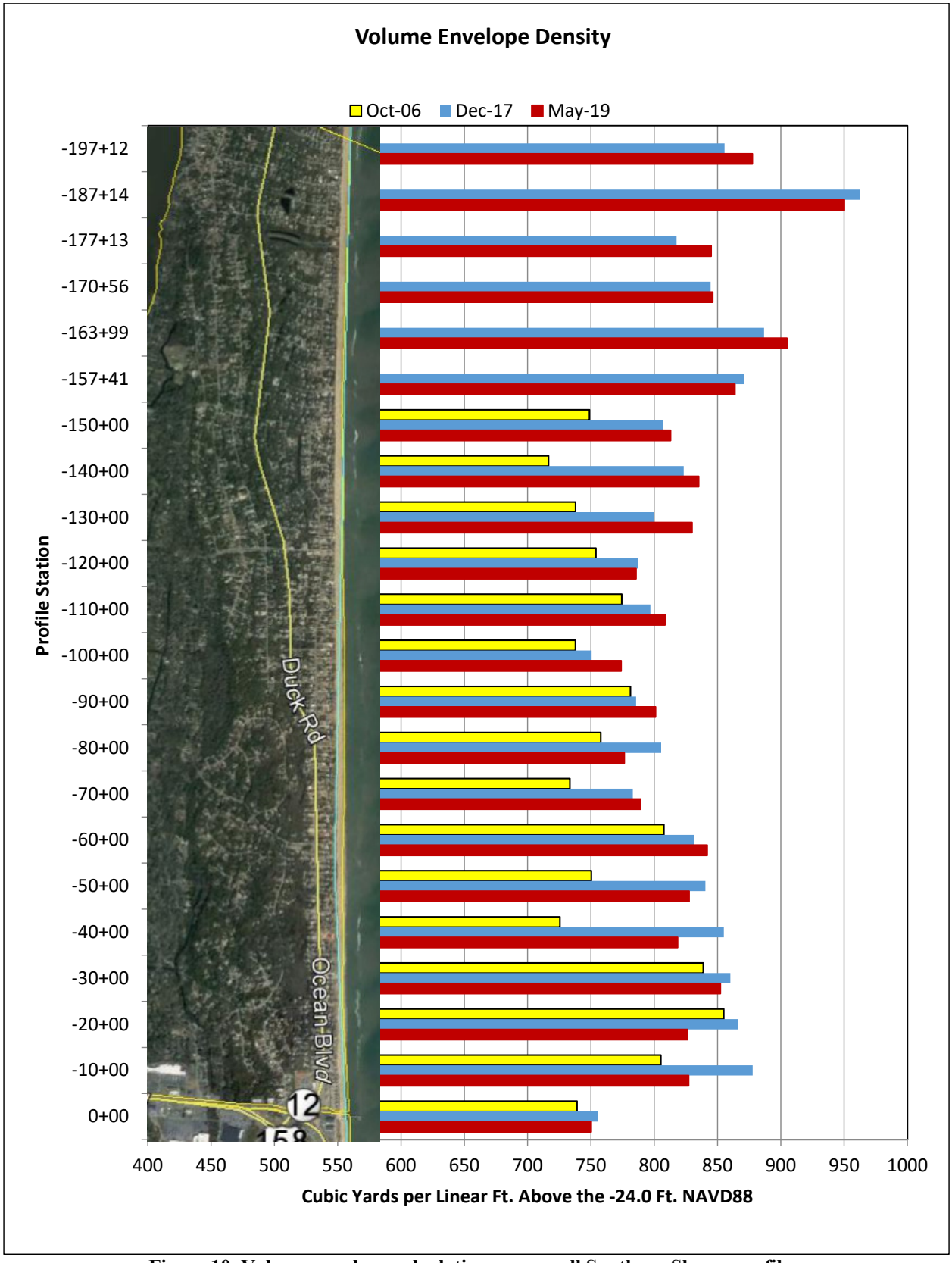


Figure 10. Volume envelope calculations across all Southern Shores profiles.

2019 BEACH MANAGEMENT PLAN UPDATES

The results of the vulnerability analysis, as well as the beach assessment conducted by APTIM in February 2018, were used in the development of a beach management plan for the Town of Southern Shores. The Beach Management Plan included three beach fill design options that were developed based on long-term volume change rates, vulnerability of structures and the dune to specific "design" storms, and the relative overall volume measured within the volume envelope discussed in the previous section. Sections 4.1 and 4.2 of the Beach Management Plan discuss the process whereby the project extent and the project volumes were determined. This update to the Beach Management Plan evaluates both the project extent and volume requirements based on May 2019 conditions. Updated project cost estimates are also included based on the updated project extents and volumes.

Project Extent

In the initial Beach Management Plan (APTIM, 2018B), all three (3) beach fill options included the same project extent, which was based on an analysis of long-term volume changes, a vulnerability assessment, and existing beach volumes. Figure 7 shows the extent of the recommended beach fill options. Essentially, the SBEACH model was used to evaluate the ideal volume density required on any given profile to provide an adequate level of storm damage reduction (APTIM, 2018B). A profile-by-profile evaluation of the SBEACH generated post-storm profiles for various storm scenarios was conducted and these results were used as a proxy for identifying beach conditions that provide adequate storm damage reduction for the design storm characteristics. This analysis resulted in the establishment of a target volume to be maintained on a particular profile to provide an acceptable level of storm damage reduction.

The two storms used to design the beach fill options were: 1) a storm with comparable physical characteristics of Hurricane Isabelle using 2018 sea levels, referred to as "Scenario 3"; and 2) a storm with comparable physical characteristics of Hurricane Isabelle using 2048 sea levels, referred to as "Scenario 11". The SBEACH analysis concluded that a volume envelope density of 846 cy/lf. and 858 cy/lf. would be needed to design to Scenario 3 and 11, respectively. These densities were used as the recommended density within the volume envelope to provide adequate storm damage reduction along the entire Town oceanfront for conditions associated with storm Scenarios 3 and 11.

Table 3 shows the measured volume density within the volume envelope based on the May 2019 beach profile survey. Also included is the deviation between the targeted volume density to design to Scenario 3 and Scenario 11 and the actual measured volume based on the May 2019 surveys. An examination of the data provided in Table 3 shows that on average, the profiles north of Station 150+00, which is located near 3rd Ave., have volume densities, measured within the volume envelope, greater than the targeted volume. For Scenario 3, which was the storm used to design Options 1 and 2, the average volume north of Station -150+00 was 35.2 cy/lf. greater than the design volume. This is an increase in the average volume in excess of the targeted 846 cy/lf. given the December 2017 conditions due to an average density increase of 8.1 cy/lf. measured between December 2017 and May 2019 along the six (6) profiles north of Station 150+00. Table 4 does show that the volume envelope density measured at Station -177+13 (located approximately 200

feet south of 9th Ave.) falls below the targeted 846 cy/lf. density (844.9 cy/lf.); however, on average this section of beach north of Station -150+00 has a greater density than the targeted volume.

Table 3. Calculated volume density within the volume envelope and deviation between volume density and target volume density for Scenarios 3 and 11.

PROFILE	Volume Envelope Density (cy/lf.)	Deviation from Target 846 cy (Scenario 3)	Deviation from Target 858 cy (Scenario 11)
-197+12	877.5	31.5	19.5
-187+14	950.2	104.2	92.2
-177+13	844.9	-1.1	-13.1
-170+56	846.2	0.2	-11.8
-163+99	904.8	58.8	46.8
-157+41	863.8	17.8	5.8
-150+00	812.9	-33.1	-45.1
-140+00	835.1	-10.9	-22.9
-130+00	829.8	-16.2	-28.2
-120+00	785.6	-60.4	-72.4
-110+00	808.5	-37.5	-49.5
-100+00	773.8	-72.2	-84.2
-90+00	801.1	-44.9	-56.9
-80+00	776.3	-69.7	-81.7
-70+00	789.3	-56.7	-68.7
-60+00	841.8	-4.2	-16.2
-50+00	827.5	-18.5	-30.5
-40+00	818.4	-27.6	-39.6
-30+00	852.3	6.3	-5.7
-20+00	826.4	-19.6	-31.6
-10+00	827.2	-18.8	-30.8
0+00	750.2	-95.8	-107.8
AVERAGE	809.8	-16.7	-28.7

For Scenario 11, which was the storm used to design Option 3, the average volume north of Station -150+00 was 23.2 cy/lf. greater than the design volume. Again, this is an increase in the average volume in excess of the targeted design volume in comparison to the December 2017 conditions due to an average density increase of 8.1 cy/lf. measured between December 2017 and May 2019 along the six (6) profiles north of Station 150+00. Table 4 does show that the volume envelope density measured at Stations -177+13 (located approximately 200 feet south of 9th Ave.) and -

170+56 (located at 8th Ave.) falls below the targeted 846 cy/lf. density; however, on average the section of beach north of Station -150+00 has a greater density than the targeted volume.

In the area referred to as the "Main Placement Area" in Figure 7 which extends from Station -150+00 south to Station -50+00, the average fill density measured inside the volume envelope falls below the targeted design volume for both Scenarios 3 and 11 by 38.6 cy/lf and 50.6 cy/lf, respectively. Despite an average increase of 6.6 cy/lf. in the density measured along this section of beach when compared to December 2017 conditions, this section of beach still warrants placement of beach fill based on the goal of designing to the Scenario 3 and Scenario 11 storms.

The area referred to as the "Transition Area" in Figure 7, was labeled as such in the initial Beach Management Plan, due to the fact that sufficient volume was present along this section of beach as to not require beach fill placement based on the goal of designing to the Scenarios 3 and 11 storms. However, all three beach fill options proposed the placement of fill along this Transition Section, to minimize the potential for negative impacts to this stretch of beach, as a result of being located between the Kitty Hawk Project and a proposed Southern Shores project. As described in the previous section of this report on Volume Change, this section of beach experienced some of the highest volume losses between December 2017 and May 2019. The average volume change measured from Stations -50+00 to 0+00 between December 2017 and May 2019 was -26.7 cy/lf. As shown in Table 3 , under Scenario 3, all but one (1) of the profiles in this section fall below the target volume, and even that profile has a volume less than the targeted volume under Scenario 11.

To summarize the findings of the updated assessment on project extent, the volume present north of Station -150+00 appears to be sufficient to achieve the stated design goals of the Beach Management Plan; therefore, beach fill is not recommended along this section of the Town's oceanfront. Beach fill is still recommended along the Main Placement Area despite some increases in volume that occurred in this section between December 2017 and May 2019. Given the higher volume losses that were measured between December 2017 and May 2019 is what was referred to as the Transition Area, this section of beach should be treated as part of the Main Fill Placement Area and appropriate adjustments in proposed volume density should be made to account for this. The adjustments in proposed project volumes are discussed in the following section.

Project Volume

Option 1: As previously mentioned, Option 1 assumed a targeted fill density of 846 cy/lf. should be maintained along the Southern Shores oceanfront to provide adequate storm damage reduction under design storm Scenario 3. The average density measured along the Town's oceanfront in the Main Placement Area, which extends from Stations -150+00 (located near 3rd Ave.) to -50+00 (located approximately 450 feet south of Chicahauk Trl.), in May 2019 was 807 cy/lf. Therefore, the fill density recommended for the Main Placement Area for Option 1 was reduced by 6 cy/lf. for a recommended density of 39 cy/lf. Based on the 2019 data, the Main Placement Area now requires a design volume of 390,000 cy. Updated design volumes for each option, as well as diffusion loss volumes and advanced fill volumes, are provided in Table 4.

As discussed in the previous section on project extent, the section of beach between Station -50+00 and Station 0+00 experienced some of the highest density losses between December 2017 and May 2019. During the initial development of the Beach Management Plan, Option 1 called for a fill density of 30 cy/lf. along this section of beach referred to as the Transition Area. This density was consistent with the proposed beach fill density to be placed along Kitty Hawk during the 2022 beach renourishment. The average deviation from the targeted volume of 846 cy/lf. along the profiles for Station -50+00 to Station 0+00 is -29.0 cy/lf. Therefore, this update recommends maintaining the 30 cy/lf. density recommended in the original design for Option 1. The placement of 30 cy/lf. along this 5,000-foot section of beach would require 150,000 cy of beach fill (Table 4). The fill volume required within the Taper Area would decrease given the decreased fill density called for along the Main Placement Area. The anticipated fill volumes for the Taper Area would be 9,000 cy (Table 4).

Table 4. Updated design option summary based on 2019 in-place volumes

Design	Design Volume[(1)]	Transition Area Volume[(2)]	Diffusion Loss Volume[(3)]	Advanced Fill Volume[(4)]	Taper Volume[(5)]	Total Volume	Avg. Fill Density[(6)]
Option 1	390,000	150,000	54,400	225,000	9,000	828,400	36
Option 2	N/A – Design Volumes and Transition Area Volumes are the Same as Option 1.						
Option 3	720,000[(7)]		68,800	225,000	12,000	1,025,800	48

[(1)]Volume (CY) to construct the Main Placement Area excluding tapers, transition fill, and advanced fill (Stations -150+00 to -50+00).
[(2)]Volume (CY) to construct the Transition Area (Stations -50+00 to 0+00).
[(3)]Volume (CY) included to account for diffusion losses and background erosion (APTIM, 2018)
[(4)]Volume (CY) included to account for background erosion expected to occur throughout the renourishment interval. Re-nourishment interval assumed to be 5 years.
[(5)]Volume (CY) to construct a 500 foot taper on the northern end of the beach fill (Stations -155+00 to -150+00).
[(6)]Total Volume included in the Design Volume and Transition Area divided by 15,000 feet.
[(7)]Total Volume included in the Design Volume and Transition Area for Option 3.

Option 2: Similar to Design Option 1, Design Option 2 also targeted a fill density of 846 cy/lf. to provide adequate storm damage reduction under design storm Scenario 3. Design Option 2 targeted this density across both the Main Placement Area and the Transition Area. Option 2 volumes were based on the average density measured across both of these areas in December 2017. In essence, beach fill placement was required to achieve 846 cy/lf. in the Main Placement Area, but not in the Transition Area, but when averaged together, the entire 15,000-foot section of beach required an average fill density of approximately 30 cy/lf. With the modifications of the Transition Area discussed in the update for Option 1, that being to treat the Transition Area the same as the Main Placement Area in terms of designing to the targeted fill density, Option 2 is now essentially the same as Option 1 and has been eliminated from future discussions in this report.

Option 3: The original Option 3 was formulated in the same way as Option 1, with the difference being an increased targeted volume density of 858 cy/lf., which was based on designing to conditions associated with the Scenario 11 storm. This required a beach fill density of approximately 57 cy/lf. in the Main Placement Area. The Transition Area called for a fill density

of 30 cy/lf. to tie into the Kitty Hawk Project to the south. Given the higher volume losses measured between December 2017 and May 2019 along the stretch of beach from Stations -50+00 to 0+00 discussed herein, this update treats the Main Placement Area and Transition Area as one continuous section. The average density measured along the Town's oceanfront from Stations -150+00 to 0+00, was 810 cy/lf. at the time of the May 2019 survey. Therefore, the fill density recommended for Option 3 in the Main Placement Area and Transition Area is 48 cy/lf. Assuming a 48 cy/lf. fill density along 15,000 feet of beach results in a design volume of 720,000 cy of fill to be placed between Stations -150+00 and 0+00. Coincidently, this volume is the same as what was recommended in the original Beach Management Plan for Option 3 when combining the design volume in the Main Placement Area and the 30 cy/lf. density in the Transition Area. Assuming a fill density at the northern end of the Main Placement Area of 48 cy/lf., a 500 ft. long taper would require approximately 12,000 cy, bringing the total design volume of Option 3 to 732,000 cy (Table 4).

Diffusion Losses and Advanced Fill: As described in the Beach Management Plan (APTIM, 2018B), diffusion losses were calculated for each of the three beach fill options. Diffusion or spreading will occur with any sand placement activity as the nourished beach evolves into an equilibrium planform comparable to the adjacent shorelines (Dean, 2002). Diffusion losses are the result of the fill template spreading alongshore and occurs when the fill material spreads outside a fill placement or project area. A diffusion analysis was conducted as part of the development of the initial Beach Management Plan. The updated analysis conducted by APTIM using May 2019 survey data did not include updating this diffusion analysis. Though diffusion losses may change slightly based on changes to recommended beach fill volumes, this update uses the diffusion losses volumes previously calculated to determine total project volume. Diffusion losses for each option are provided in Table 4.

Typically, a beach nourishment project incorporates both diffusion losses and background erosion into the construction template to account for expected losses that occur during the interim period between nourishment events. The development of the original three (3) options presented in the Beach Management Plan did not include a background erosion component because volume changes that occurred along the project area between October 2006 and December 2017 were positive. The assessment of volume changes that occurred between December 2017 and May 2019 show that the section of beach being proposed for beach nourishment, exhibited a negative volume change. The average volume change rate along the section of beach from Stations -150+00 to 0+00 was approximately 3 cy/lf./yr. Based on a 5-year nourishment interval, a rate of 3 cy/lf./yr., would require 15 cy/lf. of advanced fill to be placed along this 15,000-foot section of beach, which equates to 225,000 cy. This advanced fill volume has been applied to each of the options proposed and is reflected in Table 4.

Summary of Updated Project Volumes: Table 4 provides updated volumes for each option based on the May 2019 volume analysis. A summary of the changes from the initial options presented in the Beach Management Plan (APTIM, 2018B), are provided below.

- Applying a background erosion rate of 3 cy/lf./yr. to determine the amount of advanced fill to include in proposed beach fill options increases the total volume off each option by 225,000 cy.
- Design Option 1 – The total design volume decreased by 60,000 cy from 600,000 cy to 540,000 cy. However, with the significant increase in the advanced fill, the total volume required for Option 1 increased by 162,750 cy or 24%.
- Given the erosional trend measured along the southern 5,000 feet of the beach, Design Option 2 is essentially the same as Design Option 1.
- Design Option 3 - The total design volume remained the same at 720,000 cy. However, with the significant increase in the advanced fill, the total volume required for Option 3 increased by 222,750 cy or 28%.

Project Cost Estimate

Project cost estimates provided in the original Beach Management Plan have been updated primarily based on changes to the beach fill volumes for each Option shown in Table 4. Updated project costs are provided in Table 5. Costs associated with permitting/design anticipated to be required for construction of either Option have not changed from those provided in the original Beach Management Plan. Costs associated with "Pre-Construction/Construction Admin." and "Construction Env. Monitoring Costs" have increased based on the expected increase in the duration of project construction. The total estimated cost includes a 10% contingency. The estimated cost does not include annual monitoring costs or costs associated with dune vegetation or sand fencing.

Table 5. Project Option Cost Estimates

Option	Volume (cy)	Permitting / Design Soft Cost	Construction Cost	Pre-Construction/ Construction Admin.	Construction Env. Monitoring Costs	Contingency Cost (10%)	TOTAL COST
1	828,400	$435,000	$11,758,000	$283,500.00	$275,300.00	$1,275,000	$14,026,800
3	1,025,800	$435,000	$14,146,000	$313,500.00	$332,400.00	$1,523,000	$16,749,900

The increase in the volume recommended for Option 1 resulted in an increase cost of approximately 21%. The increase in the volume recommended for Option 3 resulted in an increase cost of approximately 24%.

CONCLUSIONS

The Town of Southern Shores authorized this study to update long-term and short-term shoreline and volumetric changes that have occurred along its oceanfront beaches and to update recommendations provided in the original Beach Management Plan using the latest data.

Shoreline Change Analysis

Average long-term MHW shoreline changes measured along the southern 15,000 feet of the Town's oceanfront (South of 3rd Ave.) and along the northern 2,000 ft. of oceanfront (north of 8th Ave.) were less than -1 ft./yr. This rate suggests the shoreline has been relatively stable along these portions of the beach for the respective 12.4 and 5.7-year periods.

The average MHW shoreline change along the Town's oceanfront between December 2017 and May 2019 was -3.1 ft. or -2.2 ft./yr. However, extensive variability in the measured shoreline changes at each profile was observed, ranging from measured changes of 37.6 feet (seaward movement) to -34.4 ft. (landward movement). In general, the northern and southern 5,000 feet of beach experienced the greatest average negative volume changes and the central section of beach experienced an average positive shoreline change.

Volumetric Change Analysis

Volumetric changes measured between December 2017 and May 2019 were assessed in terms of the northern portion of the Town not initially recommended for beach fill in the Beach Management Plan, the central portion of Town referred to as the "Main Placement Area", and the southern 5,000 feet of oceanfront, referred to as the "Transition Area". On average, the area north of the recommended beach fill placement from approximately 70 feet south of 5th Ave. north to the Town boundary, gained volume between December 2017 and May 2019. Likewise, the 10,000-foot area from approximately 3rd Ave. to a point approximately 450 feet south of Chicahauk Trl. (Main Placement Area) also gained volume between December 2017 and May 2019. The area along the southern 5,000 feet of oceanfront averaged a decrease of approximately 27 cy/lf. during the same time period.

Given the gains in the volume present along the northern section of Town, the options presented in this update do not include beach fill placement along that portion of the beach north of 4th Ave. Although modest volume gains were measured along the 10,000-foot section of beach referred to as the Main Placement Area, the overall volume of sand in place is less than the recommended volume; therefore, this section is still recommended for beach fill placement. Along the southern 5,000-feet of oceanfront, the relatively high volume losses resulted in a recommendation that additional sand be placed along this section of beach under Option 3.

Long-term average volumetric change rates were also updated in those sections of beach where beach profile surveys had been conducted prior to December 2017. The long-term average volumetric change rate measured from 3rd Ave. (Station -150+00) to the southern Town boundary (Station 0+00) over the approximate 12.6 year period (between October 2006 and May 2019) above the -24.0 feet NAVD88 contour was +2.5 cy/ft./yr. An average volumetric change rate of

+1.3 cy/lf./yr. (accretion) was measured over the approximate 5.7 year period along those profiles initially surveyed in September 2013 by APTIM (Stations -197+12 through -177+13).

Though both long-term trends are positive, the two most recent surveys show an overall negative average volume loss along the entire Town, with locally higher rates of volume losses present along the southern 5,000 feet of the Town. Based on the comparison of the December 2017 and May 2019 surveys, the average volume change rate computed along the southern 15,000 feet of the Town, along which beach nourishment is being recommended, is approximately 3 cy/ft./yr. This rate was used to determine advanced fill volumes for the recommended beach fill options.

2019 Beach Management Plan Updates

The update to the Beach Management Plan included in the report focused on:

- An evaluation of the project extent;
- Updates to design volumes based on measured volume changes that have occurred since the December 2017 survey; and
- Updates to project costs as a result to any changes in beach fill volume.

Project Extent: The volume present north of Station -150+00 appears to be sufficient to achieve the stated design goals of the Beach Management Plan and therefore beach fill is not recommended along this section of the Town's oceanfront. Beach fill is still recommended along the Main Placement Area, despite some increases in volume that occurred in this section between December 2017 and May 2019. Given the higher volume losses that were measured between December 2017 and May 2019, in what was referred to as the Transition Area, this update includes sufficient volume along this section to achieve the targeted volume as opposed to a minimum transition volume.

Project Volume: A summary of the volume updates made to the beach fill options based on the May 2019 data, are provided below:

- The measured rate of erosion that occurred along the portion of the Town where beach fill is being recommended averaged 3 cy/lf./yr. This volume was used to determine the amount of advanced fill to include in the beach fill options, resulting in an increase of 225,000 cy for each option.
- Design Option 1 – The total design volume decreased by 60,000 cy from 600,000 cy to 540,000 cy. However, with the significant increase in the advanced fill, the total volume required for Option 1 increased by 162,750 cy or 24%.
- Given the erosional trend measured along the southern 5,000 feet of the beach, Design Option 2 is essentially the same as Design Option 1
- Design Option 3 - The total design volume remained the same at 720,000 cy. However, with the significant increase in the advanced fill, the total volume required for Option 3 increased by 222,750 cy or 28%.

Project Cost: The increase in the volume recommended for Option 1 resulted in an updated cost of $14,026,800, which represents a 21% increase. The increase in the volume recommended for Option 3 resulted in an updated cost of $16,749,900, which represents a 24% increase.

RECOMMENDATIONS

Based on the analysis and conclusions discussed in this report, APTIM is recommending the following:

1. **Determine Which Option To Pursue:** The Town of Southern Shores should first determine if it wishes to pursue either of the two beach fill options presented herein. If the Town determines that it wishes to pursue one of these options, it must then decide which option provides the most cost effective approach. APTIM is prepared to support the Town with either of these Options. APTIM believes each option will maintain the oceanfront beach and dune to a configuration that 1) provides a reasonable level of storm damage reduction to public and private development, 2) mitigates long-term erosion that could threaten public and private development, recreational opportunities, and biological resources, and 3) maintains a healthy beach that supports valuable shorebird and sea turtle nesting habitat.

2. **Continue Coordination with County and Neighboring Communities:** In February, 2019 a meeting was convened with staff and elected officials of Dare County along with staff and elected officials of other local municipalities within Dare County. During the meeting, the County presented its financial forecast with regards to the funds they project to have on hand to assist with an additional beach nourishment project, not previously constructed. During this meeting, the County recommended to the Town of Southern Shores that if they wish to utilize these available funds, they should make the request as soon as possible given the fact that other communities are discussing the need to use the available funds. If the Town decides to pursue a beach fill project, a request should be made to Dare County as soon as possible to partner with the Town on the project, in order to attempt to secure County cost sharing for the project. The Town should also continue discussions with the other potential project partners (Towns of Duck, Kitty Hawk, and Kill Devil Hills) regarding the need for additional sand sources for future projects. At present, the other Towns are moving forward with a proposed renourishment project scheduled for a 2022 project.

3. **Initiate Financial Planning:** As previously stated in the Beach Management Plan, APTIM recommends the Town seek professional financial advice to properly budget and plan for any beach management program. Successful beach management programs will require a stable revenue stream dedicated to the program. The Town of Southern Shores is in a favorable position to implement a beach management plan given the history of Dare

County's willingness to partner with local communities on such programs. Furthermore, the opportunity to partner with neighboring local communities to cost share in some aspects of the project, allows the Town to reduce its own percentage of the cost. Early and proper financial planning is vital to developing a revenue stream to support a beach management program. Other local communities in Dare County that have implemented similar programs, coordinated early on in the planning process with both Dare County and outside professional financial advisors.

4. **Initiate Permitting and Design of the Beach Fill:** If the Town determines that it wishes to pursue one of the presented beach nourishment options, it will be required to obtain state and federal permits for the proposed project. Included in the original Beach Management Plan was a schedule that included the permitting and design of the project (APTIM, 2018A). That schedule included a project kickoff meeting to be held in February 2020. If the Town is to be in a position to construct the proposed project in 2022, as part of a cooperative project with the other three northern Dare County Towns, every effort should be made to begin permitting and design efforts by February 2020.

5. **Continue Monitoring of the Beach Profiles:** As witnessed along the Town's southern shoreline between 2015 and 2017, and as shown in the comparisons of the December 2017 and May 2019 surveys, the beach is a highly dynamic area. Sand movement due to storm events can cause considerable changes in the level of protection available by dunes and beach berms. For this reason, it is important to regularly monitor the beach profile. Based on observed trends and current beach densities, APTIM recommends that an updated beach profile survey be conducted in the Spring of 2020 to align with the annual beach profile surveys conducted by Duck, Kitty Hawk, and Kill Devil Hills. Continued monitoring of the shoreline will 1) allow for timely updates to the proposed design that may increase or decrease the estimated cost and 2) will allow the Town to track changes to the beach outside the proposed beach fill project to verify whether sufficient volumes of sand are present in this section to achieve the established level of protection.

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