POST-STORM DESIGN REPORT: HURRICANE DORIAN
TOWN OF KITTY HAWK AND TOWN OF KILL DEVIL HILLS
SHORE PROTECTION PROJECTS
DARE COUNTY, NC

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July 2020

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A. Town of Kitty Hawk, Town of Kill Devil Hills Post-Dorian Topographic and Hydrographic Survey Report (Comparative Pre- and Post-Storm Beach Profiles)
B. 2017 Dare County Beach Nourishment Project Completion Report
C. 2017 Dare County Beach Nourishment Project Completion Report Appendix A: As-Built Plan View Drawings and Comparative Beach Profile Cross Sections
D. Town of Kill Devil Hills Shore Protection Project Beach Maintenance Plan, Updated November 2019.
E. USACE Permit No. SAW-2014-02203
F. NC DENR CAMA Permit No. 134-15
G. North Carolina 401 Water Quality Certification No. 4038
H. USACE Permit No. SAW-2014-02204
I. NC DENR CAMA Permit No. 133-15

All Attachments are available online for download at the following address:
https://coastalprotectioneng-my.sharepoint.com/:f:/p/kwillson/Ei-V8GmwPEtDnyyq-F7p2fwBAxJx1InoR5nfWa7HzII1dg?e=M37O50

DRAFT POST-STORM DESIGN REPORT: HURRICANE DORIAN
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I. INTRODUCTION

In September 2019, Hurricane Dorian impacted the 8.3-mile oceanfront shoreline of the Towns of Kill Devil Hills and Kitty Hawk. The eye of Hurricane Dorian made landfall over Cape Hatteras on the morning of September 6th, 2019 as a Category 1 storm. Dorian then weakened to a post-tropical system as it moved east away from the coast and out into the Atlantic Ocean. The storm surge, heavy surf, and elevated water levels created by the slow-moving storm impacted the beach resulting in a loss of sand from within the project area.

The Town of Kill Devil Hills Shore Protection Project and the Town of Kitty Hawk Shore Protection Project are both locally constructed engineered beaches making them eligible for federal assistance under Federal Emergency Management Agency (FEMA) Category G funding. A survey of the project area was conducted in February 2020 to compare with the May 2019 monitoring survey of the beach restoration project (Attachment A). The surveys were used to determine the volume loss on the beach as a result of the storm. The results of this analysis are described herein to provide FEMA with the data needed to develop the Project Worksheet (PW).

Because the two projects are contiguous, this report covers both the Kitty Hawk and Kill Devil Hills projects; however, where possible, we have divided the project-specific aspects, including cost, for each of the Towns. This report provides the details of the design and maintenance for the Towns' projects, damages sustained to the projects as a result of Hurricane Dorian, and details regarding what is required to repair the storm damages. The report includes a project schedule as well as engineering cost estimates which will be required to repair the storm-induced damages.

II. BACKGROUND

The Towns of Kitty Hawk and Kill Devil Hills are located on the Outer Banks of North Carolina roughly 37 and 40 miles south-southeast of the North Carolina / Virginia border, respectively. The Town of Kitty Hawk extends along 3.6 miles of Atlantic Ocean shoreline. The Town of Kill Devil Hills, located immediately south of Kitty Hawk, extends along approximately 4.7 miles of Atlantic Ocean Shoreline. Kitty Hawk is bordered to the north by the Town of Southern Shores, whereas Kill Devil Hills is bordered to the south by the Town of Nags Head.

The Towns of Kitty Hawk and Kill Devil Hills have implemented long-term shoreline management programs that serves to sustain the beaches that support a significant portion of their local economy and maintains the tax base of the Towns. Each community's program contains specific and unique goals and objectives.

The Town of Kitty Hawk Project's objectives include: 1) reducing the vulnerability of public infrastructure including NC 12, town roads between NC 12 and U.S. Highway 158, and utilities to storm-induced erosion; 2) reducing flooding in many non-oceanfront areas throughout the Town

during ocean overwash conditions, including portions of NC 12 and U.S. Highway 158; and 3) reducing the vulnerability of homes within the Town that front the Atlantic Ocean and are exposed to wave events during nor'easters and other large storm events. In order to accomplish these goals, the Town is taking steps to maintain its oceanfront beach and dune to a configuration that: 1) provides a reasonable level of storm damage reduction; 2) provides a reasonable level of flood reduction; and 3) mitigates long-term erosion that could threaten public infrastructure and private property as well as recreational opportunities and biological resources.

The Town of Kill Devil Hills Project was designed to maintain its 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.

Extensive engineering analysis conducted between 2012 and 2015 (CPE-NC, 2012, CPE-NC, 2013, CPE-NC, 2015A, and CPE-NC, 2015B) resulted in a recommendation that a shore protection project be constructed along an approximately 3.6 mile section of the Town of Kitty Hawk and 2.6 mile section of the Town of Kill Devil Hills.

Between June and October of 2017, the Towns constructed the recommended beach nourishment projects. For the Town of Kitty Hawk, approximately 1.85 million cubic yards of fill was distributed between Station -25+00 (Lat. 36.107428° N, Lon. 75.715914° W) and Station 189+87 (Lat. 36.054992° N, Lon. 75.682722° W), which is located between East Sibbern Drive and East Arch Street. For the Town of Kill Devil Hills, approximately 817,359 cubic yards of fill was distributed between Station 189+87 (Lat. 36.054992° N, Lon. 75.682722° W), which is located at the north Town limit, and ending on the south near Station 325+66 (Lat. 36.022517° N, Lon. 75.660097° W), which is located near the Prospect Ave. Beach Access. The total length of the placement area within the Town of Kitty Hawk is 21,489 ft, and for the Town of Kill Devil Hills is 13,579 ft. A location map is provided in Figure 1. This location map shows the limits of the project and the two Outer Continental Shelf (OCS) borrow areas located in Federal waters offshore of Dare County which were used to construct the 2017 project.

Following completion of the initial project construction in 2017, the Towns of Kitty Hawk and Kill Devil Hills developed maintenance plans to serve as documentation that the Towns' Shore Protection Projects meet the criteria established by 44 CFR 206.226(j)(2). The maintenance plans were developed to be consistent with guidance provided by FEMA under Disaster Assistance Fact Sheet 9580.8 issued October 2009 by Elizabeth Zimmerman (FEMA, 2009). These maintenance plans include descriptions of the project design, construction activities to date, anticipated volume and cost for maintenance, schedule of maintenance and the monitoring protocols being employed by the Towns. The maintenance plans are provided in Attachment D. As part of the maintenance plans, post-construction monitoring is on-going within the project areas and adjacent shorelines north and south of the project area. The Kitty Hawk project area, Kill Devil Hills project area, northern and southern monitoring areas and corresponding monitoring stations are depicted in Figure 2 and Figure 3.

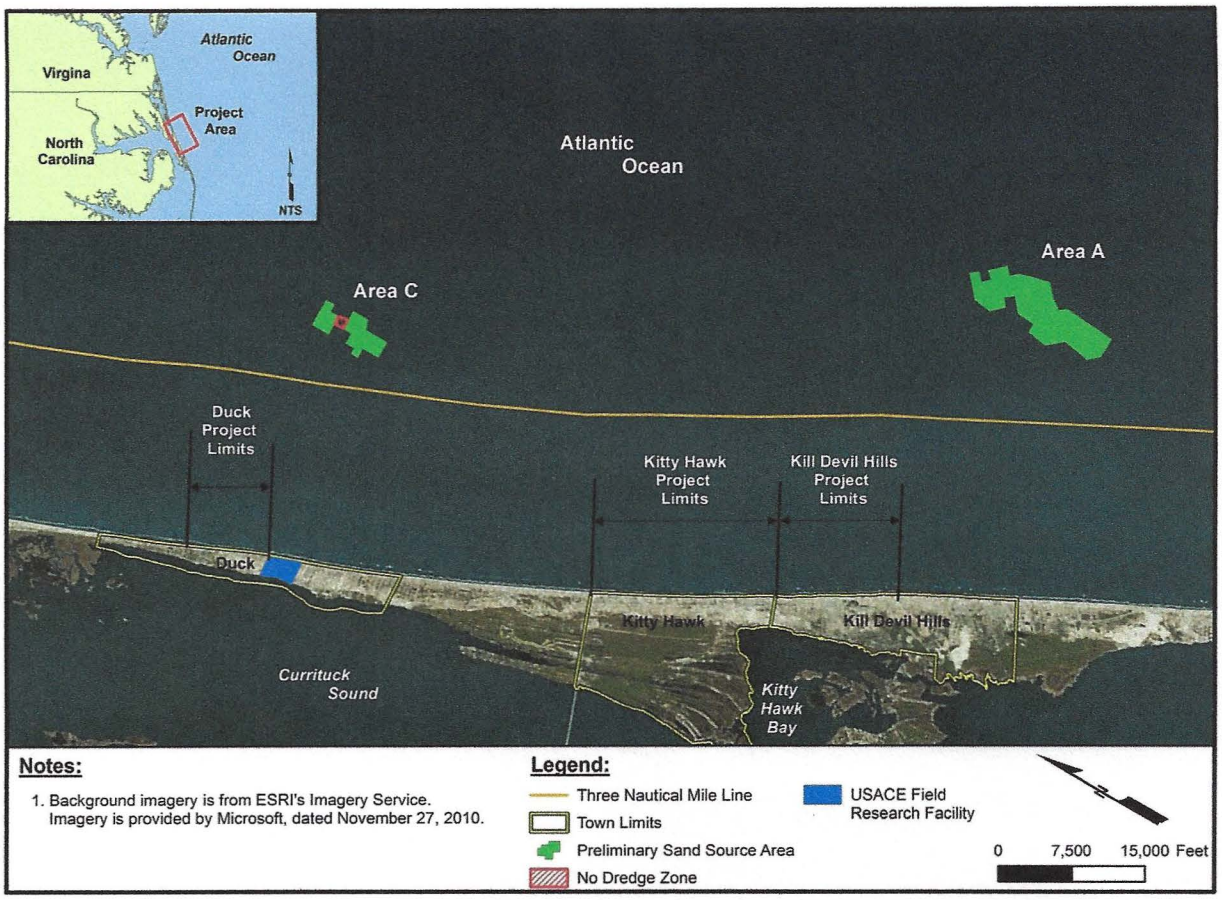

Figure 1. Project Location Map.

III. PROJECT DESIGN

The design intent of the Town of Kitty Hawk Project was to reduce the vulnerability of public infrastructure, reduce flooding in many non-oceanfront areas throughout the Town during ocean over wash conditions and, reduce the vulnerability of homes within the Town that front the Atlantic Ocean and are exposed to wave events during nor'easters and other large storm events. The beach fill design for the project included a 10-foot wide dune at an elevation of +14.0 feet NAVD fronted by a 60-foot wide berm at an elevation of +6.0 feet NAVD. The construction template, which includes design volume and advanced fill volume, includes a uniform slope of 1V:15H from the berm crest to the construction toe of fill. A typical cross-section of the construction template is shown in Figure 4. The post-construction engineering report and As-Built construction plans are provided in Attachment B and C, respectively.

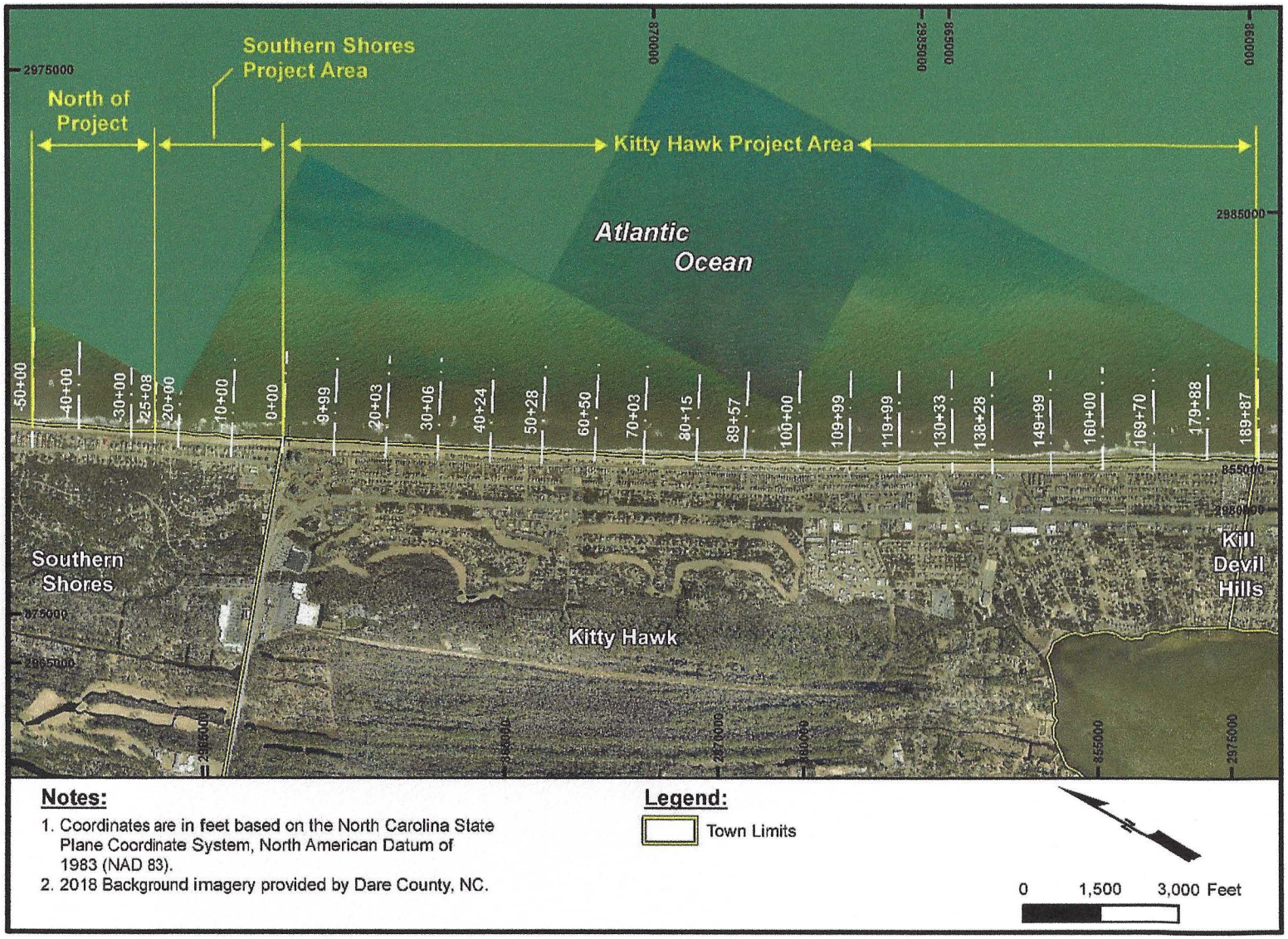

Figure 2. Project map showing the monitoring area for the Kitty Hawk Project.

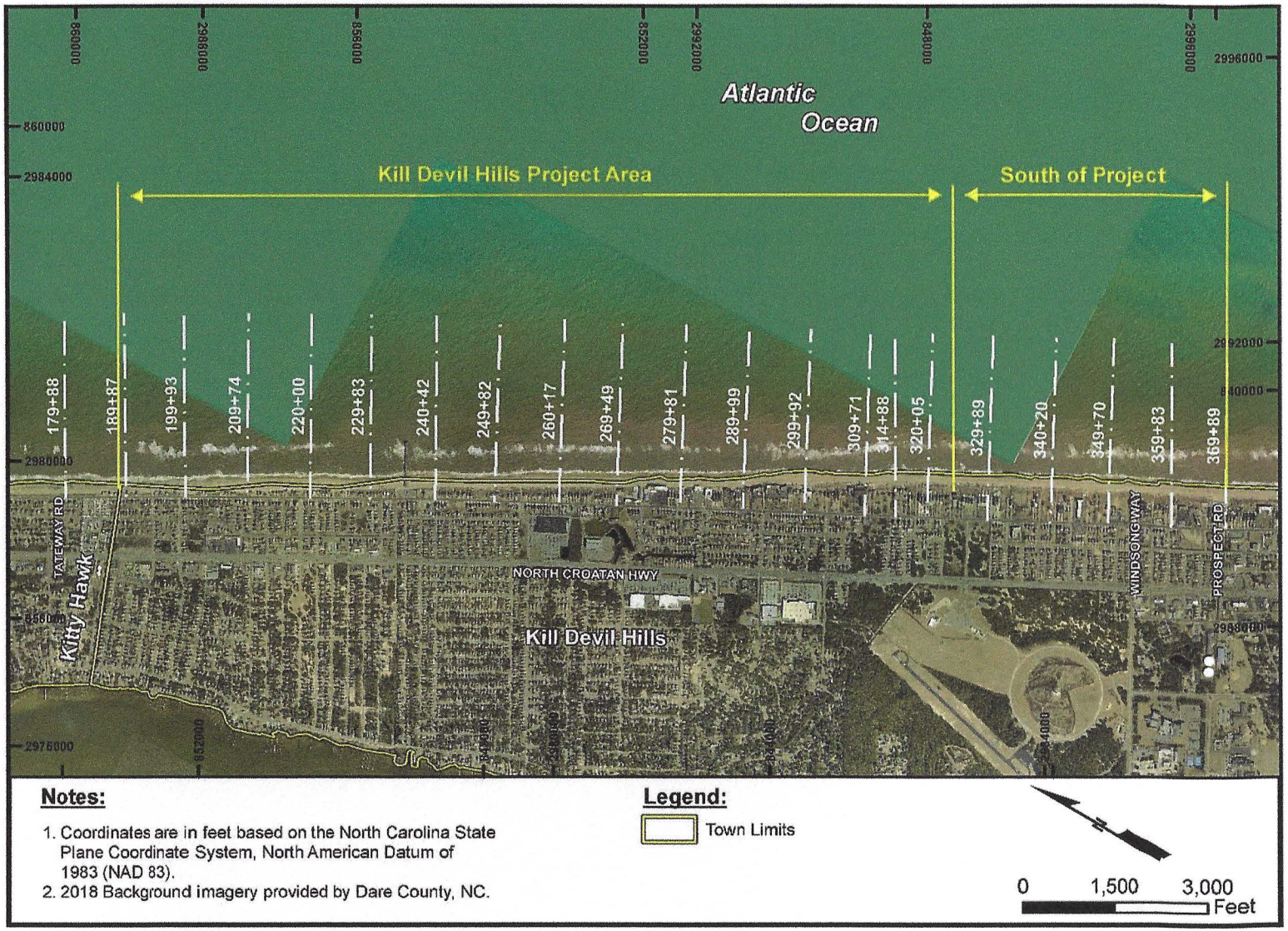

Figure 3. Project map showing the monitoring area for the Kill Devil Hills Project.

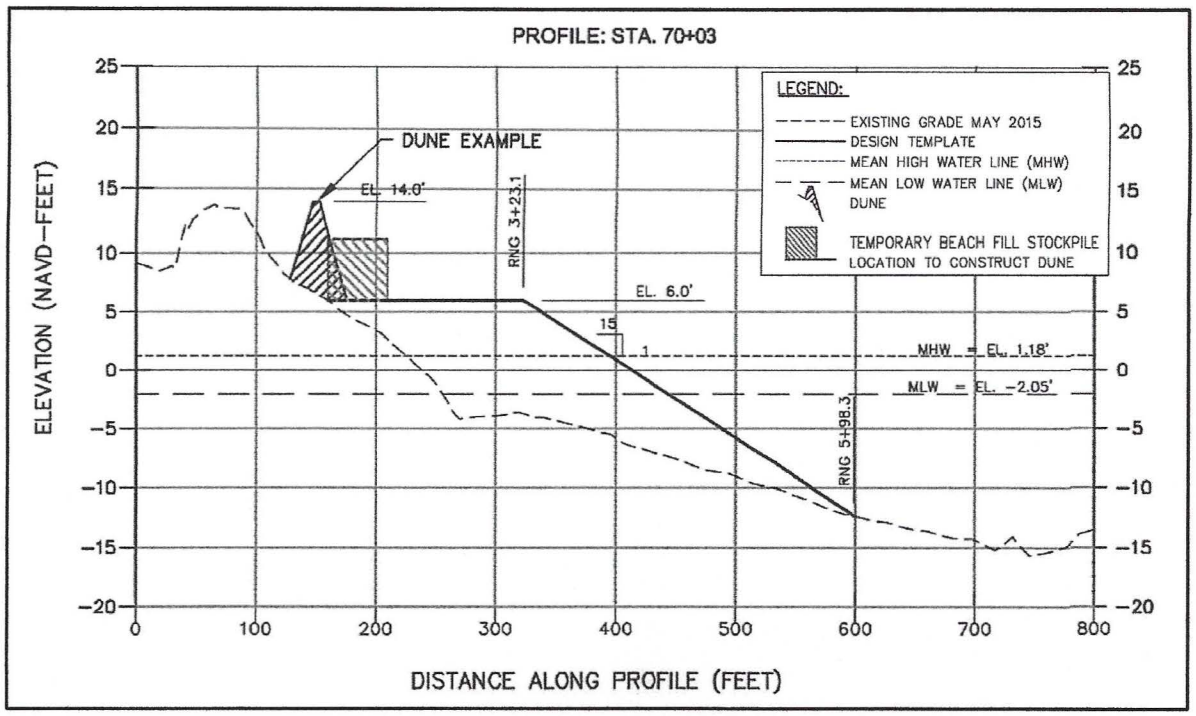

Figure 4. Typical Design Cross-Section for Town of Kitty Hawk Project.

The Town of Kill Devil Hills is focused on a long-term shoreline management program to sustain the beaches that support a significant portion of their local economy, maintain the tax base of the Town of Kill Devil Hills, retain existing recreational resources, and protect existing natural resources. The beach fill design for the project included a 20-foot wide dune at an elevation of +15.0 feet NAVD fronted by a 40-foot wide berm at an elevation of +6.0 feet NAVD. The construction template, which includes design volume and advanced fill volume, includes a uniform slope of 1V:15H from the berm crest to the construction toe of fill. A typical cross-section of the construction template is shown in Figure 5. The post-construction engineering report and As-Built construction plans are provided in Attachment B and C, respectively.

IV. HURRICANE DORIAN

Hurricane Dorian originated in the Central Atlantic and traveled westward where it became a hurricane and rapidly intensified strengthening into a Category 5 hurricane on September 1, 2019 with maximum wind speeds of 185 mph (Figure 6). After making landfall in the Bahamas, the storm weakened to a Category 2 and began to move slowly toward the north-northwest. However, as its core moved over the Gulf Stream, Dorian re-strengthened back to a Category 3 storm offshore of the coast of Georgia and South Carolina. It then continued to travel in a northeastward motion toward the North Carolina coastline.

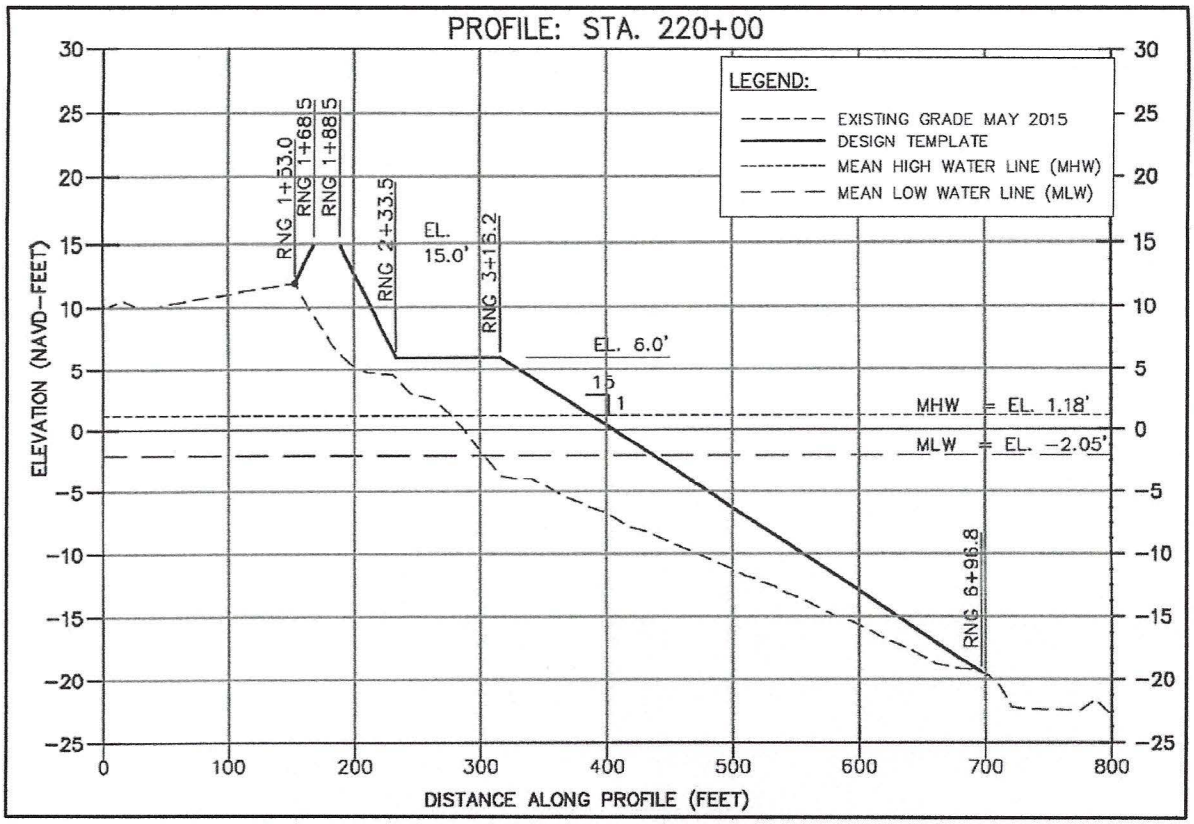

Figure 5. Typical Design Cross-Section for Town of Kill Devil Hills Project.

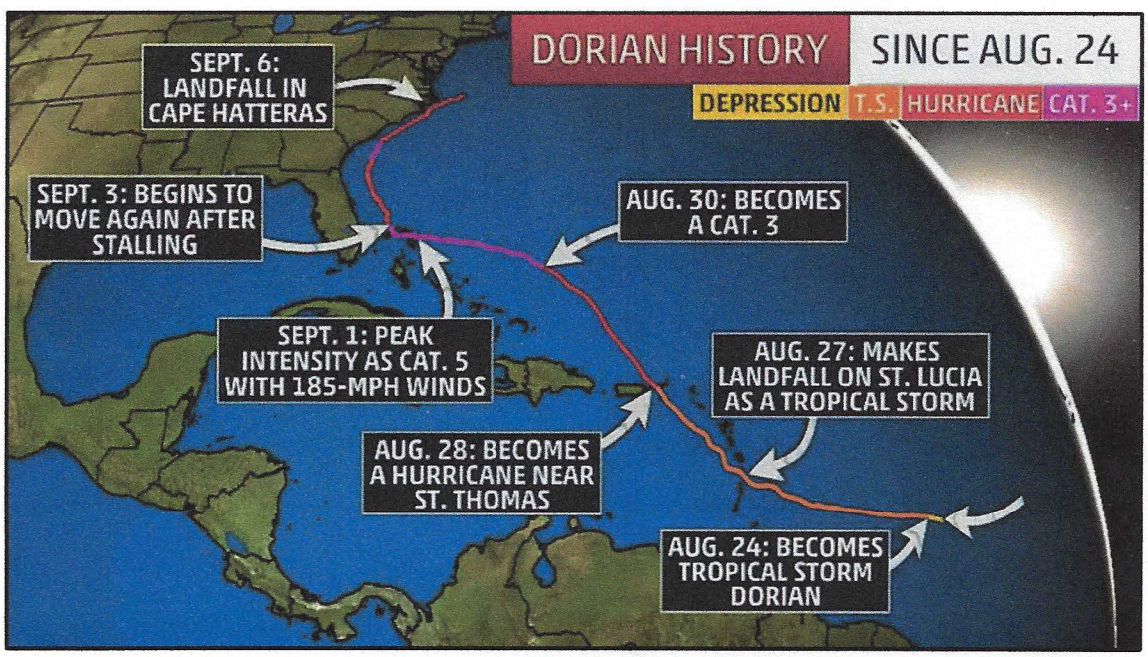

Figure 6. Historical Track of Hurricane Dorian (http://weather.com)

On the morning of September 6th, 2019, Dorian traveled northeast along the North Carolina coast and made landfall at Cape Hatteras as a Category 1 hurricane (Figure 7). After clearing the Outer Banks, Hurricane Dorian continued to accelerate northeastward and became a strong post-tropical cyclone before it reached Canada. Although Dorian was only a Category 1 hurricane when it impacted the project area, its slow movement and prolonged onshore flow generated heavy surf and elevated water levels for several days prior to the storm arriving in the vicinity of the Town of Kitty Hawk and Kill Devil Hills. Figure 8 shows the water level readings from the NOAA gauge located at Duck, NC, between September 5, 2019 – September 7, 2019. Hurricane Dorian also caused severe flooding at inland areas throughout North Carolina.

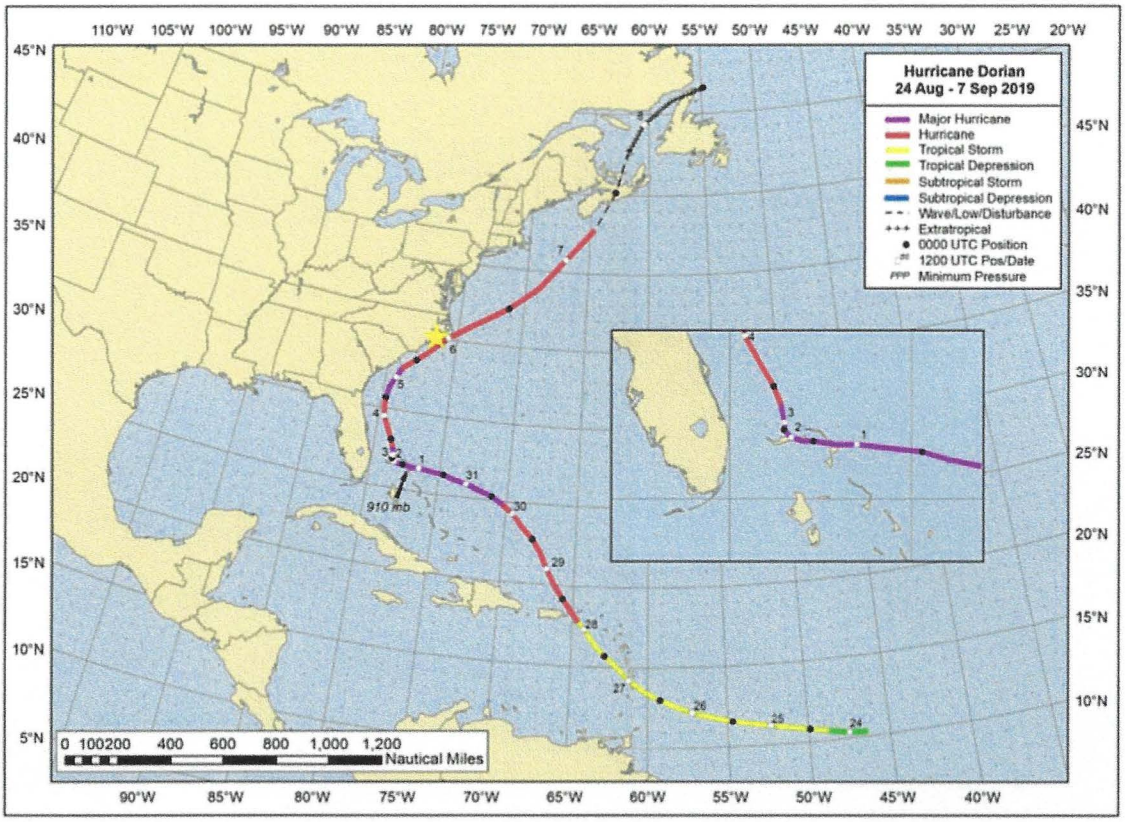

Figure 7. The location of Kitty Hawk and Kill Devil Hills, indicated by the yellow star, relative to the path of Hurricane Dorian (http://nhc.noaa.gov, April 2020).

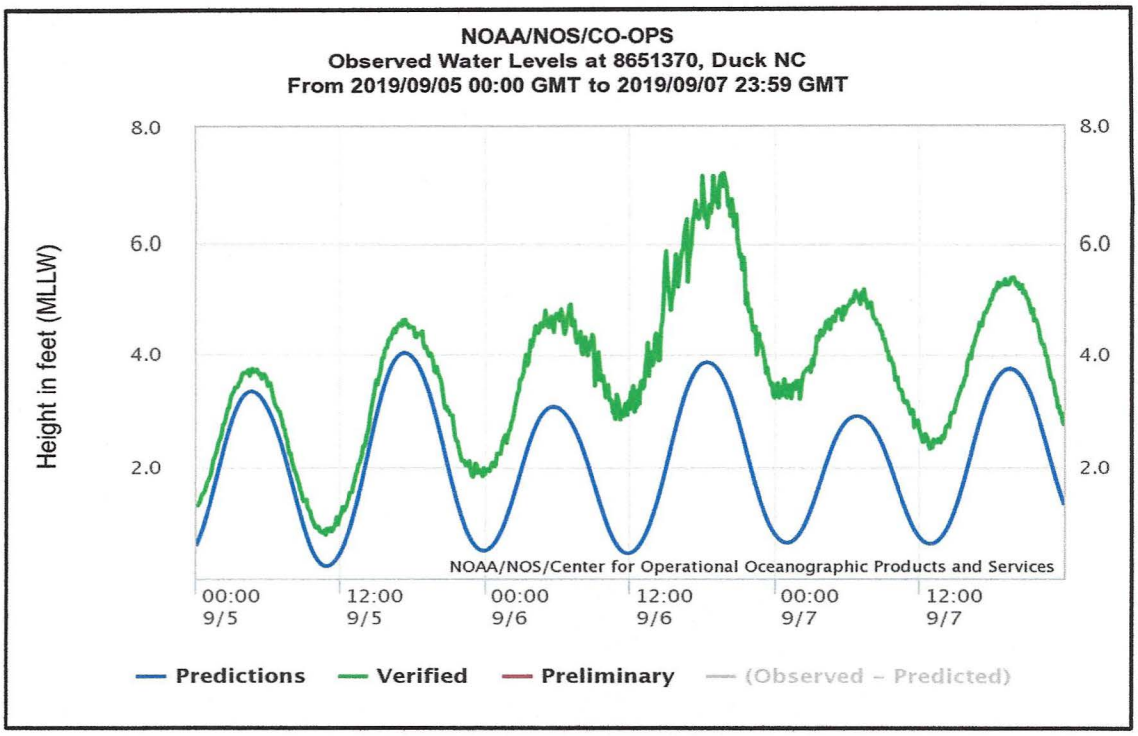

Figure 8. Water levels at Duck, NC from September 5, 2019 – September 7, 2019. (http://tidesandcurrents.noaa.gov, September 2019)

V. VOLUMETRIC CHANGES

Volumetric changes discussed in this report represent the change in the quantity of sediment measured through a comparison of the pre-storm (Hurricane Dorian) and post-storm (Hurricane Dorian) survey data. The method used to determine volumetric changes for both the Kitty Hawk and Kill Devil Hills projects differ from typical beach profile monitoring methodologies. As described in the Town of Kitty Hawk & Kill Devil Hills, North Carolina 2019 Shoreline and Volume Change Monitoring Report (APTIM, 2019A), volumetric calculations for these projects utilize a combination of both beach profile data and shore-parallel bathymetric data referred to as a "hybrid method". Certain areas offshore of the Kitty Hawk and Kill Devil Hills projects are characterized by deep depressions (troughs) and shore oblique sandbars (APTIM, 2019A). The initial assessment of volume change, based on beach profiles collected in December 2017 and June 2018, indicated a strong correlation between the location of the nearshore depressions and locations along the beach in which high volume losses were measured. This initial observation prompted the conduct of a bathymetric survey completed by APTIM in October 2018. This bathymetric survey consisted of shore-parallel lines spaced approximately 200-feet apart, extending from approximately the -10.0 ft. NAVD88 contour out to a depth of at least -30 ft. NAVD88.

In the "hybrid method" of calculating volumetric changes, beach profile data are used to compute volumetric changes along each beach profile from the landward point at which survey data were available for both pre- and post-storm surveys and out to a predetermined point along the profile

located in the vicinity of the -16 ft. NAVD88 contour. The average end area method is used to compute the volumetric changes that occurred along the project area within this portion of the profile labeled as "Landward Portion" in Table 1. The "hybrid method" also includes the use of shore-parallel bathymetry to create a surface, which is compared to the surface created using the previously collected data. Volumetric changes between the two surfaces are then computed for the area along the project area from the seaward limit of the "Landward Portion" out to the depth of closure (-24 ft. NAVD88). The depth of closure is defined as the seaward limit of the active beach profile and was determined to be -24 ft. NAVD88 for both the Town of Kill Devil Hills and Kitty Hawk projects (CPE-NC, 2015A and CPE-NC, 2015B). This "hybrid method" has been adopted as the preferred method to monitor these two projects, as established in the Towns' Beach Maintenance Plans (APTIM, 2019B and APTIM, 2019C).

Table 1. Post Hurricane Dorian Volumetric Changes Above -24 ft. NAVD88 (CY)

PROJECT AREA	Volumetric Change May 2019 to February 2020 (Cubic Yards)		
	Landward Portion (Profiles)	Seaward Portion (Bathymetric Surface)	Total
KITTY HAWK (-25+00 TO 189+87)	199,700	-218,800	-19,100
KILL DEVIL HILLS (189+87 TO 325+66)	-127,900	-190,800	-318,700

The volumetric change analysis described in this report uses the results from the May 2019 monitoring data as the pre-storm data set. The data collected in February 2020 represents the post-storm data set. Beach profile and shore-parallel bathymetric data were collected along the same transects during both the May 2019 (pre-storm) and February 2020 (post-storm) surveys. Volumetric changes computed using the hybrid method, between the pre- and post-storm condition surveys, are provided in Table 1.

Town of Kitty Hawk:

As shown in Table 1, the total (net) volumetric change measured along the Kitty Hawk project area between May 2019 and February 2020 was a net loss of 19,100 cubic yards above the -24 ft. NAVD contour. This represents the volumetric change between Stations -25+00 through 189+87.

Possible volumetric losses from the project area during the 9-month period between May 2019 and February 2020 surveys were estimated using background erosion losses measured between 1996 and 2014 (CPE-NC, 2015B). The report asserts that based on the estimated volume losses between 1996 and 2014, 2.2 cy/lf/yr should be placed on the project area in the Town of Kitty Hawk to account for background erosion. Assuming an erosion rate of 2.2 cy/lf/yr, and the time between surveys of 9 months or 0.75 years (May 2019 to February 2020), a loss of 1.7 cy/ft of fill is

estimated to have occurred along the entirety of the project area. With a total project length of 21,487 feet, the effective volume assumed to have been lost due to background erosion is approximately 36,500 cy in the Town of Kitty Hawk.

Based on the computed volumetric changes measured along the Kitty Hawk Shore Protection Project between May 2019 and February 2020 (-19,200 CY) and the estimated background erosion for this stretch of beach that would have been anticipated between May 2019 and February 2020 (36,500 CY), no storm-related sand losses along the Kitty Hawk Shore Protection Project have been documented.

Town of Kill Devil Hills:

As shown in Table 1, the total (net) volumetric change measured along the Kill Devil Hills project area between May 2019 and February 2020 was a net loss of 318,700 cubic yards above the -24 ft. NAVD contour. This represents the volumetric change between Stations 189+87 and 325+66.

Possible volumetric losses from the project area during the 9-month period between May 2019 and February 2020 surveys were estimated using background erosion losses estimated during the design analysis of the initial project. Based on a sediment budget developed during the design of the project, volumetric losses were estimated to be roughly 0.7 cy/lf/yr (CPE-NC, 2015B). Assuming an erosion rate of 0.7 cy/lf/yr, and the time between surveys of 9 months or 0.75 years (May 2019 to February 2020), a loss of 0.5 cy/ft of fill is estimated to have occurred along the entirety of the Kill Devil Hills project area. With a total project length of 13,579 feet, the effective volume assumed to have been lost due to background erosion is 6,800 cy in the Town of Kill Devil Hills.

Table 2 shows both the volumetric change measured between May 2019 and February 2020 along the project area and the estimated background erosion over the 9-month period between surveys. The total effective volumetric change attributed to Hurricane Dorian within the Project Area for the Town of Kill Devil Hills, as reported in Table 2, is 311,900 cy.

Table 2. Breakdown of the Volumetric Changes Attributed to Hurricane Dorian within the Project Area of the Town of Kill Devil Hills

DESCRIPTION	VOLUME (CUBIC YARDS)
Volumetric Change Measured Between May 2019 and February 2020 (Between 189+87 and 325+66)	-318,700
Estimated Background Erosion Over 9 Months from May 2019 to February 2020	6,800
TOTAL:	**-311,900**

VI. PROJECT REPAIR

As stated in Section V, the data analysis suggest that no measurable sand loss was attributed to the event along the Town of Kitty Hawk. However, along the Town of Kill Devil Hills, it is estimated that Project lost approximately 311,900 cy of sand as a result Hurricane Dorian. The most cost-effective way to repair these damages would be to make the repairs during the proposed 2022 beach re-nourishment project which will serve to provide routine maintenance of the Town's project.

The initial construction of the Town of Kill Devil Hill's beach nourishment project was completed as part of a cooperative effort on the part of the Towns of Duck, Southern Shores, Kitty Hawk, and Kill Devil Hills, as well as Dare County. Between May and October 2017, these communities completed a multi-town beach nourishment project, placing approximately 3,926,700 cubic yards of sand along approximately 8.3 miles of shoreline within the Towns of Duck, Southern Shores, Kitty Hawk, and Kill Devil Hills.

Following the construction of the project, the Towns implemented maintenance programs to monitor the performance of the Shore Protection Projects and to determine when periodic renourishment would be needed to maintain the goals of the projects. Based on monitoring conducted and the overall project performance, the first renourishment of the beach is scheduled for the summer of 2022. The current plan for the multi-town project includes the placement of approximately 2.5 million cy along the same project areas constructed in 2017, plus additional fill along approximately 17,000 feet of the oceanfront of the Town of Southern Shores.

By combining the repair operations with routine maintenance operations, the cost of permitting, design, and mobilization/demobilization of the repair project will be significantly reduced.

The following paragraphs provide information on sand resources and environmental permitting as it relates to the repair project. Also provided is a cost estimate and schedule for the recommended repair project.

Sand Source:

The 2017 Town of Kill Devil Hills and the Town of Kitty Hawk beach nourishment projects utilized sand from the offshore borrow area referred to as Borrow Area A (Figure 1). Borrow Area A is located on the Outer Continental Shelf between 5.0 and 6.5 miles offshore of the Towns of Kill Devil Hills and Nags Head in water depths between 50 and 60 ft. (NAVD88). Surveys conducted following completion of the 2017 project indicated approximately 12.8 million cubic yards of sand remains available within Borrow Area A for future projects (APTIM, 2018a).

Although a sufficient volume of beach quality sand remains within Borrow Area A for both the proposed maintenance project and to repair damages from Hurricane Dorian, the unit cost for sand is highly dependent on the proximity of the sand source to the project. In that regard, the identification of an additional sand source closer to the project area would reduce the cost of a future project. A recent desktop study was performed to identify additional sand resources more proximate to the project area. This study identified an area of investigation between 2 and 4 miles

offshore Kitty Hawk and Southern Shores in the vicinity of the areas labeled "Investigation Areas" in Figure 9. The Towns of Duck, Southern Shores, Kitty Hawk, and Kill Devil Hills are under contract to conduct in-depth offshore sand investigations of these areas.

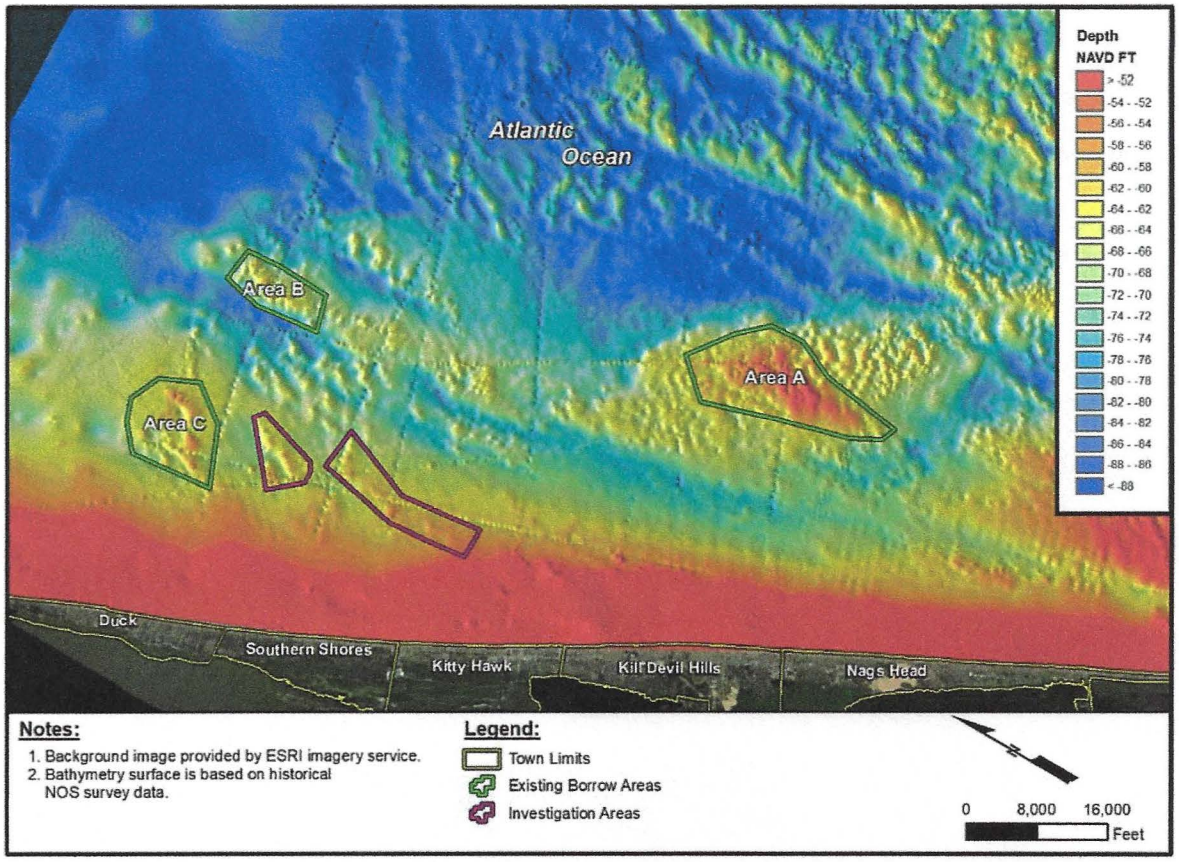

Figure 9. Potential sand sources located directly offshore of Southern Shores.

Permitting:

In preparation for the 2017 initial construction of the Town of Kill Devil Hills project, the necessary permits and authorizations were obtained from the North Carolina Division of Coastal Management (Major CAMA Permit 133-15), North Carolina Division of Water Quality (401 Water Quality Certification), Dept. of Army Individual Permit (SAW-2014-02203), and BOEM Lease Agreement (OCS-A 0513). Both the Dept. of Army Individual Permit and BOEM Lease required full NEPA compliance.

The Town of Kill Devil Hills has already begun the initial coordination with permitting and resource agencies to develop environmental documentation to satisfy both state and NEPA requirements for the proposed 2022 maintenance project. Coordination for the repair project will track along with the coordination for the maintenance project. The Towns will consult with regulatory agencies to determine if any additional permitting requirements are needed for the storm repair project.

Cost Estimate:

The cost estimate to replace sand lost due to Hurricane Dorian is based on obtaining material from Borrow Area A, which was used in part for the 2017 project. The estimate assumes sand would be obtained through the use of a hopper dredge, as it was for the initial construction in 2017. The mobilization/demobilization cost was estimated by utilizing the mobilization/demobilization costs incurred during the initial 2017 construction of the project and applying an inflation factor. The inflation factor was computed based on an evaluation of the marine equipment index between 1982 and 2016. Through the application of this inflation factor and making adjustments based on the increased project area at Southern Shores (approximately 17,000 feet) proposed to be included in the 2022 maintenance project, the total mobilization cost for the proposed 2022 Multi-Towns beach fill project was estimated to be $10,146,000. For the purpose of this cost estimate, "Mobilization Cost" includes the cost for Mob/Demob, Payment & Performance Bonds, and surveys of the borrow site as required by the permits. For comparison purposes, the equivalent mobilization cost for the 2017 project was $8,589,245, which involved the mobilization of 3 different hopper dredges, multiple pump outs staged offshore of the project area for sand to be pumped to the beach from the hopper dredge, and delivery and setup of large quantities of dredge pipes and heavy equipment.

To estimate individual Town cost for the 2022 Multi-Towns beach nourishment project, mobilization/demobilization costs are pro-rated for each Town based on the volume of material to be placed along each project. Table 3 provides a breakdown of the volumes, percentages, and costs used to compute the estimated cost for mobilization/demobilization. The pro-rated portion of the total mobilization/demobilization cost factored into the cost of the repair project, assuming a placement volume of 311,900 cy, is $1,268,000.

Table 3. Breakdown of the Town of Kill Devil Hills Hurricane Dorian Repair Mobilization cost estimate.

DESCRIPTION	VALUE
Estimated Total Volume of 2022 Project (Including Repair Project for Town of Kill Devil Hills) (Cubic Yards)	2,496,200
Estimated Volume Required for Repair Project for Town of Kill Devil Hills (Cubic Yards)	311,900
Percent of Total Multi-Town Project required to Repair Town of Kill Devil Hills Project	12.5%
Total Shared Mobilization Cost Estimate for Multi-Town Project	$10,146,000
TOTAL:	**$1,268,000**

The unit cost for sand used in the project cost estimate is based in part on the actual unit cost for sand during the 2017 project. The same inflation factor previously discussed was then applied to the actual unit cost for sand during the 2017 project to determine the effective unit cost of sand for the Kill Devil Hills repair project.

The cost to replace sand fencing installed by the Town of Kill Devil Hills as part of the project was estimated based on post-storm assessments conducted by Town staff. During the assessment, Town staff identified 100 sections of sand fence that were lost and required replacement and 50 additional sections of sand fencing that were partially damaged and required repair. Based on actual costs paid by the Town for installation and repair of sand fencing, a unit cost of $35 and $20 was used in the estimate to replace and repair sand fencing, respectively. The total installed cost for the 100 sections of sand fence requiring replacement is $3,500 (100 sections x $35/section) and the total repair cost for the 50 sections needing repair is $1,000 (50 sections x $20/section).

The cost to replace dune planting installed by the Town of Kill Devil Hills as part of the project was estimated based on post-storm assessments conducted by Town staff. During the assessment, Town staff identified 100 sections of sand fence that were lost and required replacement and 50 additional sections of sand fencing that were partially damaged and required repair. The areas of the dune in which sand fencing had been installed had also previously been planted by the Town. Sand fence sections measuring 10 feet in length are installed at an angle along the dune with 10-foot spacings. The effective area of the parallelogram between each section is approximately 80 SF. This estimate assumes the entire area between the 100 sections listed as needing to be replaced, requires re-planting and that 50% of the area between the 50 sections listed as needing to be repaired, requires re-planting. The total area requiring re-planting is estimated to be 10,000 SF (100 sections x 80 SF + 50 sections x 40 SF). This equates to approximately 1,100 SY. Plants will be placed on 18-inch centers or 4 plants/SY. Approximately 4,400 plants will be required to plant the damaged portion of the dune slope (1,100 SY x 4 Plants/SY = 4,400 plants). The total installed cost for the dune planting, assuming a unit cost of $1.25 per plant, is $5,500.

The cost estimate associated with permitting and design includes engineering, geotechnical and environmental services associated with developing the beach fill design, conducting the necessary sediment compatibility analysis and borrow area design work, and obtaining environmental permits for the repair project. The efforts needed to design and permit the repair project overlap the costs associated for the same services associated with the maintenance project scheduled for 2022. The volume estimated for the scheduled maintenance of the Kill Devil Hills project in 2022 is 407,000 cy. When combined with the proposed 311,900 cy required to repair the damages from Hurricane Dorian, the percent of sand being placed during the project associated with the hurricane repair is 43.4% of the total volume required for maintenance + storm repair. Therefore, a pro-rated cost estimate for permitting and design for the repair project is equal to 43.4% of the total cost for permitting and design of the beach fill project. More specifically, the total estimated cost for permitting and design of the beach nourishment project is $449,316, therefore, the effective cost estimate for the permitting and design of the repair project is $194,900.

Construction administration and oversight costs include the development of bid documents, assistance with bidding, and construction observations. Some of these costs overlap services that would be required for the scheduled maintenance project and some of the costs are computed based on daily costs to construct the repair portion of the project. In the same way costs were divided for the permitting and design services, services associated with the repair project which overlap the maintenance project were pro-rated based on the 43.4% previously stated. The daily rate for construction oversight was then multiplied by the estimated number of days to complete the repair project. The total cost estimated for construction administration and oversight is $79,400.

The costs associated with environmental monitoring are based on the assumption that similar daily environmental monitoring protocols that were required for the 2017 initial construction, will be required for the repair project. This includes relocation trawling of the offshore borrow area and nesting sea turtle monitoring on the beach. The daily rates are based on actual costs obtained for the 2017 project and the same inflation factor previously discussed was then applied. The total estimated cost associated with environmental monitoring for the repair project is $72,800.

The total estimated cost for the Hurricane Dorian repair project is $4,148,371 as detailed in Table 4.

Table 4. Breakdown of the Town of Kill Devil Hills Hurricane Dorian Repair cost estimate.

ITEM #	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	AMOUNT
1	Mobilization/Demobilization	1	L.S.	$1,268,000	$1,268,000
2	Hydraulic Beach Fill	311,900	CY	$8.09	$2,523,271
3	Sand Fencing (Replacement)	100	Section	$35.00	$3,500
4	Sand Fencing (Repair)	50	Section	$20.00	$1,000
5	Dune Planting	4,400	Plant	$1.25	$5,500
6	Permitting / Design	1	L.S.	$194,900	$194,900
7	Construction Admin/Oversight	1	L.S.	$79,400	$79,400
8	Environmental Monitoring	14	Day	$5,200	$72,800
				TOTAL COST ESTIMATE	**$4,148,371**

Schedule:

The Town of Kill Devil Hills conducted post-storm condition surveys in February 2020 following the impacts of Hurricane Dorian. An interagency meeting was held with federal and state regulatory and resource agencies in April 2020 to discuss the permitting of both the maintenance project and the Hurricane Dorian repair project. The Town is currently working on engineering design, borrow area development and development of environmental documents and permit applications. The anticipated schedule moving forwards is provided below:

- Engineering Design — June 2020 – January 2021
- Borrow Area Development — May 2020 – January 2021
- Development of Environmental Documents — May 2020 – December 2020
- Federal Permitting — April 2020 – June 2021
- State Permitting — January 2021 – June 2021
- Development of Bid Documents — January 2021 – June 2021
- Solicitation of Bids — June 2021 – July 2021
- Award Construction Contract — July 2021 – August 2021
- Construction — May 2022 – June 2022

VII. SUMMARY

The Towns of Kitty Hawk and Kill Devil Hills constructed Shore Protection Projects in June 2017. The Kitty Hawk Project placed approximately 1.85 million cubic yards along 21,489 feet of oceanfront beach, while the Kill Devil Hills project placed approximately 820,000 cubic yards along 13,579 feet of oceanfront beach. The beach compatible sediment was dredged from Borrow Area A located offshore of the Towns of Kill Devil Hills and Nags Head. The Towns of Kitty Hawk and Kill Devil Hills were both impacted by Hurricane Dorian in September 2019. Analysis suggests that the Kitty Hawk project had no measurable sand losses as a result of Hurricane Dorian. However, analysis suggests the Kill Devil Hills area lost approximately 311,900 cubic yards of sand as a result of Hurricane Dorian. The total cost to replace the storm losses for the Town of Kill Devil Hills is estimated to be $4,148,371.

XIII. REFERENCES

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