

FINAL REPORT

Produced for the Town of Nags Head, NC
October 2024



moffatt & nichol

BEACH MONITORING AND MAINTENANCE PLAN

Town of Nags Head, North Carolina



Beach Monitoring and Maintenance Plan

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Executive Summary

This document updates the Town of Nags Head's previous Beach Monitoring and Maintenance Plan, dated August 2011, with documentation of subsequent renourishment projects, as well as updated maintenance triggers, nourishment volume needs, and borrow sources developed as part of the Town's 2024 Multi-Decadal Beach Nourishment Master Plan.

In 1990, the US Congress authorized a Federal project titled the "Dare County Hurricane Protection and Erosion Control Project", however, funding for this Federal project has never been authorized. Because of the lack of funding and the critically eroded condition of the beach, the Town elected to proceed with a locally funded beach restoration project in 2011. Subsequent renourishment events have occurred in 2019 and 2022. The 2019 project was initially designed as a fully locally funded effort, however, after impacts of the Federally declared disaster Hurricane Matthew in 2016 (DR-4285-NC) and accompanying losses, a portion of this event was funded by FEMA. The 2022 renourishment event was funded by FEMA and was designed to replace beach sand lost during Hurricane Dorian, also a Federally declared disaster (DR-4465-NC). During the time period from 2011 to 2024, the maintenance trigger for renourishment was as established at the time of the initial project: the Town would renourish the beach when a volume of approximately 50 percent of the initial project was lost from above the -19 ft NAVD88 elevation (approximate limit of the active profile).

The Town's initial beach nourishment project and all subsequent renourishment projects have complied and will comply with all Federal and State required environmental monitoring, including sea turtle and benthic organism monitoring if required. The Town also performs physical beach monitoring, in compliance with FEMA requirements for disaster assistance to repair improved beaches. Beach and nearshore profile surveys are conducted annually at a minimum of 500 ft spacing, extending from the landward toe of the foredune to a depth of approximately -30 ft NAVD88. All survey work is performed to the Standards of Practice for Land Surveying in North Carolina. Hydrographic surveys are performed to meet or exceed the minimum performance standards for the Corps of Engineers Hydrographic Surveys, USACE specifications manual EM 1110-2-1003.

The monitoring schedule for each year typically includes a comprehensive survey of the profile transects conducted by late spring/early summer to ensure that seasonal differences in the beach profile are consistently measured from year to year, and to document pre-hurricane season beach conditions. Should a named storm or other significant erosion event occur, the Town undertakes a post-storm survey as soon as practicable. This survey is used to quantify storm-induced erosion and other profile changes. Data analysis includes computation of short- and long-term shoreline and volumetric changes as well as evaluation of beach renourishment project performance.

The Town of Nags Head recently completed a Multi-Decadal Beach Nourishment Master Plan (Master Plan), approved by the Town's Board of Commissioners in July 2024. The plan considers the next 50 years of nourishment planning along the Town's shoreline. As a part of the planning process, the volumetric threshold to trigger the next renourishment project was re-evaluated and reach-specific volumetric triggers based on a level of protection analysis including numerical modelling were developed. These new volumetric triggers are now being used to evaluate conditions in the context of timing the next renourishment event for beach maintenance. Additionally, the available borrow source material was characterized and estimated to be adequate to provide sand for the Town's next 50 years of estimated need.

To fund beach renourishment, the Town typically secures municipal bonds to pay for its portion of the cost at the time of construction, and the bonds are then paid back throughout the life of the project. The Town has developed Municipal Service Districts (MSDs) to levy additional property taxes to provide funding for beach nourishment. In addition to these Town funds, Dare County maintains a Beach Nourishment Fund



which has historically supported the Town's beach renourishment projects. Grant funds may also be available via the State's Coastal Storm Damage Mitigation Fund. Local cost share of at least one non-State dollar for every dollar from the fund is required. For post-storm repairs of beach nourishment projects, FEMA funding based on documentation of losses of beach sand, vegetation, and sand fencing may also be available.



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Glossary

CAMA	Coastal Area Management Act
CDIP	Coastal Data Information Program
CSDM	Coastal Storm Damage Mitigation
CSE	Coastal Science & Engineering
FEMA	Federal Emergency Management Agency
MSD	Municipal Service District
NC DCM	North Carolina Division of Coastal Management
NOAA	National Oceanic and Atmospheric Administration
Town	Town of Nags Head



1. Purpose

The purpose of the Beach Monitoring and Maintenance Plan is to: (1) Provide a brief overview of the morphological setting of the Town of Nags Head; (2) Detail the construction of the Town of Nags Head's initial and subsequent beach nourishment projects and how those projects were funded; (3) Specify the physical beach monitoring activities; (4) Detail the beach maintenance planning guidelines; and (5) Relate a plan for periodic renourishment funding.

This document updates the Town of Nags Head's previous Beach Monitoring and Maintenance Plan, dated August 2011.

1.1. FEMA Guidelines and Applicability for Public Assistance

This plan documents the eligibility of the Nags Head beaches for post-disaster assistance under the Public Assistance Program administered by the Federal Emergency Management Agency (FEMA) via authority of the Stafford Act (FEMA, 2020). Funding from this program could be available to reimburse costs associated with replacing beach sand removed from a beach by a Federally declared disaster event. Conditions for this program are delineated in 44 CFR § 206.226(j) (Code of Federal Regulations, 2024):

(j) **Beaches.**

- (1) Replacement of sand on an unimproved natural beach is not eligible.
- (2) Improved beaches. Work on an improved beach may be eligible under the following conditions:
 - (i) The beach was constructed by the placement of sand (of proper grain size) to a designed elevation, width, and slope; and
 - (ii) A maintenance program involving periodic renourishment of sand must have been established and adhered to by the applicant.

The Town of Nags Head's nourished oceanfront qualifies as an improved beach as the initial and subsequent beach nourishment projects were designed by qualified, licensed engineers and permitted by State and Federal regulatory agencies. Additionally, a monitoring plan and maintenance program involving periodic renourishment of sand was established along with the initial project in 2011. This report provides updates in the monitoring protocols as well as the triggers to initiate subsequent renourishment events, in alignment with the Nags Head Multi-Decadal Beach Nourishment Master Plan, adopted by the Town in June 2024.

The FEMA Public Assistance Program and Policy Guide (2020) details the documentation needed to support eligibility of a beach. It states:

"To document eligibility of a beach as a designed and maintained facility, the Applicant must provide the following information (all required unless the beach was previously determined eligible, in which case FEMA may request only a portion of this information):

- Design studies, plans, construction documents, and as-builts for the original nourishment;
- Documentation and details of the maintenance plan, including how the need for renourishment is determined and funded; and
- Renourishment history, design studies, and as-builts for every renourishment, including construction documents if applicable."

This updated Beach Monitoring and Maintenance Plan provides the required documentation for the Town to support eligibility of the nourished oceanfront.



2. Morphological Setting of Nags Head, NC

The Town of Nags Head encompasses approximately 11 miles of oceanfront shoreline on North Carolina’s Outer Banks, a chain of barrier islands between the Albemarle-Pamlico Sound and the Atlantic Ocean (Figure 2-1). The Town is approximately 90 miles south of Norfolk, Virginia. The Town is bordered by the Town of Kill Devil Hills to the north and the Cape Hatteras National Seashore to the south. Oregon Inlet is located approximately 5 miles south of the Town boundary. The Town has a year-round population of approximately 3,000 (U.S. Census Bureau, 2022), with summer visitors adding thousands more during peak season.

Tides along the oceanfront are semi-diurnal with a mean range of 3.2 ft and a spring tidal range of 3.7 ft. The predominant wave directions are from the east, with mean significant wave heights exceeding 3.3 ft at CDIP Station 433, Duck 17m (55.7 ft) waverider buoy (1997-2024). The Town’s shoreline is frequently impacted by nor’easter storms during the winter months and tropical cyclones in the summer and fall. The NOAA tide gauge at the Duck Field Research Facility (NOAA station 8651370) reports a relative sea level rise rate of 4.88 +/- 0.56 mm/yr based on water level records from 1978 to 2023. Long-term shoreline erosion rates as determined by the North Carolina Division of Coastal Management (NC DCM, 2019) generally increase from north to south, with rates as high as 7-8 ft/year measured within Reach 4 (see Figure 2-1 for reach locations). The median sand grain size is approximately 0.3 mm, based on data collected in 2016 by CSE (M&N, 2024). Additional details of the morphological setting are found in Kana and Kaczkowski (2012).

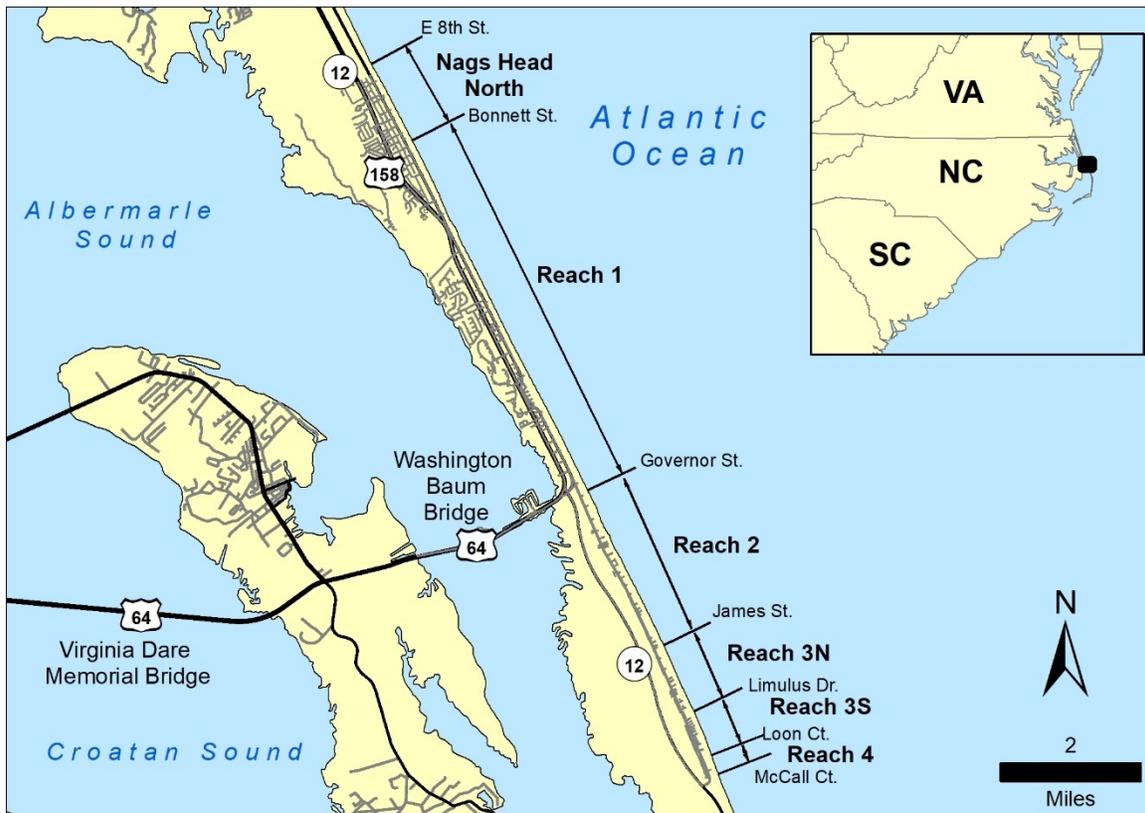


Figure 2-1: Site Vicinity Map of Nags Head, Dare County, NC



3. Engineered Beach Nourishment History

In 1990, the US Congress authorized a Federal project titled the “Dare County Hurricane Protection and Erosion Control Project”. This project included a portion of the Town’s oceanfront shoreline, and identified an offshore borrow area, termed S1, as a sediment source. However, funding for this Federal project has never been authorized. Because of the lack of funding and the critically eroded condition of the beach, the Town elected to proceed with a locally funded beach restoration project in 2011. Subsequent renourishment events have occurred in 2019 and 2022. The 2019 project was initially designed as a fully locally funded effort, however, after impacts of the Federally declared disaster Hurricane Matthew in 2016 (DR-4285-NC) and accompanying losses, a portion of this event was funded by FEMA. The 2022 renourishment event was funded by FEMA and was designed to replace beach sand lost during Hurricane Dorian, also a Federally declared disaster (DR-4465-NC). This section provides additional details of each of these projects, with further information about each project, including design plans, attached in Appendix A.

3.1. Initial 2011 Beach Nourishment Project

The Town of Nags Head carried out the first locally funded beach nourishment project in 2011 along the Town’s shoreline. The 2011 project encompassed approximately 10 miles of shoreline. Reaches were delineated based on historical erosion rates. Two borrow areas (BA2 and BA3) located in the USACE designated borrow area S1 were used in this project (Figure 3-1). The project was designed to restore a protective beach for a minimum of 10 years and to expand the recreational beach for the community. The design template for the beach nourishment extended the berm 50-125 ft at elevation +6 ft NAVD88 and placed approximately 50-140 cy/ft of material. The total volume placed was approximately 4.6 million cubic yards (Mcy) of beach compatible material along the five reaches of Nags Head (Reaches 1, 2, 3N, 3S, and 4, Figure 2-1) between May 24 and October 27, 2011.

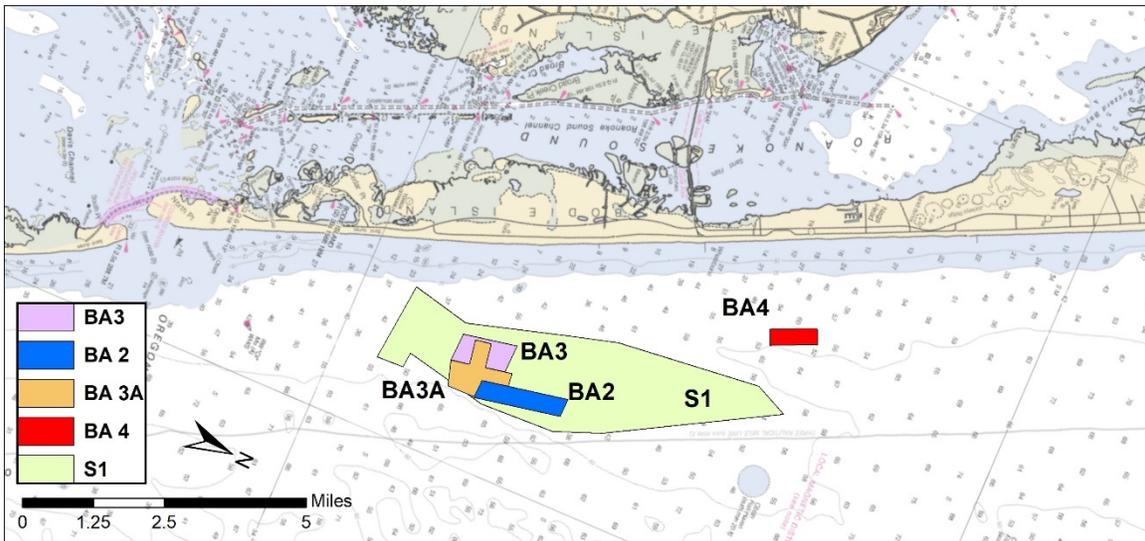


Figure 3-1: Borrow Area Locations

Funding for the initial beach nourishment project in 2011 included the following (Ogburn, 2011):

- \$18 million in cash from the Dare County Beach Nourishment Fund (fund estimated to replenish \$3-\$3.5 million/year from the 1% occupancy tax that it currently receives).
- \$18 million revenue bond to be paid back over 6 years with proceeds from a 1% increase to the occupancy tax. The 1% tax increase will generate about \$2 million/year. Nags Head will be using the \$2 million/year revenue for 5 years to pay back \$10 million of the bond.
- The remainder of the bond was to be paid back through an increase in taxes. The Board has adopted a town-wide tax increase of 2 cents (from 2010’s town tax rate of 15.75 cents to 17.75 cents).



cents) and a tax increase of 15 cents for the ocean-side properties from Bonnett Street (about Mile Post 11.25) south to the National Park Service line.

- \$1 million from the Town's general fund (to cover engineering costs).

3.1.1. Maintenance Trigger - Established 2011

At the time of design of the 2011 nourishment project, the Town's consultant, Coastal Science & Engineering (CSE), had determined that average annual sand losses for 1994-2005 were approximately 275,000 cy/yr. The renourishment trigger set at that time was at the point when less than 50% of the initial nourishment sand remained on the beach within the project boundaries calculated to -19 ft NAVD88. Ongoing monitoring protocols were established to determine the annual losses. At the point in which more than 2.3 Mcy of sand were lost (50% of the initial placement of 4.6 Mcy), the Town would renourish the beach. In addition, when losses were documented as part of a Federally declared disaster, the Town moved forward with seeking reimbursement from FEMA Public Assistance funding.

3.2. 2019 Beach Renourishment Project

In June 2016, the Town retained a consultant (CSE) to plan and design the next renourishment project. During the planning phase, Hurricane Matthew impacted the Town's shoreline and a comprehensive beach condition survey was conducted to determine sand losses due to the storm. On average, Nags Head lost ~27 cy/ft of volume between the foredune and the -19 ft NAVD 88 elevation during Matthew, which is equivalent to a total volume loss of ~1.43 Mcy along the 10-mile project area (Kaczowski and Kana, 2016), which was about 30 percent of the nourishment volume placed during the 2011 project. As a result of these documented losses, the Town obtained funding from FEMA to replace the sand on the beach in the amount of \$16,195,337 which included \$14,567,734.25 for direct construction costs (CSE, 2019).

Consistent with the short-term plan and nourishment trigger which called for renourishment when ~50 percent of the 2011 volume eroded from the project area, the Town of Nags Head incorporated restoration of the volume loss of Hurricane Matthew into a planned four (4) million cubic yards renourishment project along the same 10-mile oceanfront with the following purpose and goals (CSE, 2019):

- 1) Restore sand losses due to chronic erosion and Hurricane Matthew (2016)
- 2) Provide a higher level of storm protection
- 3) Provide wider recreational beach and create habitat for wildlife
- 4) Address high erosion rates at the south end of Nags Head
- 5) Integrate a dune management plan into the renourishment design
- 6) Maintain Nags Head's eligibility for future FEMA community assistance funds

Construction of the 2019 Nags Head Beach Renourishment Project began on May 1, 2019, and was completed on August 18, 2019. Two borrow sources were used for the project: borrow area 3A located in the USACE designated borrow area S1 and borrow area 4 located approximately 1.5 miles offshore from the north central portion of Nags Head beach (Figure 3-1). The entire project took just under 16 weeks, and approximately 4 Mcy of material was placed along the five reaches of Nags Head. Total project construction cost was \$36,644,500 (CSE, 2019).

Funding of the project included contributions from the Dare County Beach Nourishment Fund, Municipal Service District (MSD) taxes within the project limits, a Town-wide tax and reimbursement from FEMA for sand loss due to Hurricane Matthew.

3.3. 2022 Post-Dorian Renourishment Project

Shortly after completion of the 2019 renourishment project, Hurricane Dorian impacted the Town in September 2019. After the storm, the Town applied for and received both Federal and State funding through the FEMA Public Assistance Program and the N.C. Division of Emergency Management Coastal Storm



Damage Mitigation (CSDM) grant program. This funding, which required some local matches, was the basis for the size of the targeted project. A 611,259-cy project was designed with the intention to replace the berm lost during the storm as well as provide some additional berm to allow for an economically constructable fill density.

Borrow areas 2 and 3 (Figure 3-1) within USACE designated borrow area S1 were used to complete the project. The project template consisted of a berm of variable width at +6 ft NAVD88 and a foreshore slope of 1:15 out to the existing ground, landward of the prominent offshore bar. The entire project took approximately 6 weeks to complete, and 614,106 cy of material was placed along four reaches of Nags Head (Reaches 2, 3N, 3S, and 4, Figure 2-1).

The renourishment effort yielded a project totalling 614,106 cy for a total cost of \$11,295,594. Dune planting and sand fencing cost an additional \$29,750 and \$59,800, respectively. The project was paid for with a combination of Local (Town), State (N.C. Division of Emergency Management Funds for Coastal Storm Damage Mitigation), and Federal (FEMA Category G) funds.



4. Monitoring

The Town of Nags Head's initial beach nourishment project and all subsequent renourishment projects have complied and will comply with all Federal and State required environmental monitoring, including sea turtle and benthic organism monitoring if required. The Town also performs physical beach monitoring, in compliance with FEMA requirements for disaster assistance to repair improved beaches. Details of the physical monitoring protocols are presented in this section.

4.1. Physical Beach Profile Survey Protocols

Beach and nearshore profile surveys are conducted annually at a minimum of 500 ft spacing, extending from the landward toe of the foredune to a depth of approximately -30 ft NAVD88. Profile baseline and azimuths for future work will match previous surveys conducted by USACE and the Town to the extent practicable. All survey work is performed to the Standards of Practice for Land Surveying in North Carolina. Hydrographic surveys are performed to meet or exceed the minimum performance standards for the Corps of Engineers Hydrographic Surveys, USACE specifications manual EM 1110-2-1003. Horizontal data are referenced to North Carolina State Plane coordinates or to existing control datum and the vertical datum will be NAVD88.

Overland data are captured beginning at the landward toe of the primary dune and extend out to the surf zone at wading depth (wading occurs at low tide). Hydrographic surveys are collected from -30 ft NAVD88 to the surf zone (during the high tide cycle) to achieve overlapping data as weather/sea conditions allow. Hydrographic survey vessels are fully equipped to meet USACE specifications manual EM 1110-2-1003 including sonar, imu, position, heading and sound velocity.

The monitoring schedule for each year typically includes a comprehensive survey of the profile transects conducted by late spring/early summer to ensure that seasonal differences in the beach profile are consistently measured from year to year, and to document pre-hurricane season beach conditions. Should a named storm or other significant erosion event occur, the Town will undertake a post-storm survey as soon as practicable, meeting the above-described protocols. This survey will be used to quantify storm-induced erosion and other profile changes.

4.2. Data Analysis Protocols

The survey data described in Section 4.1 is used to evaluate shoreline change, volume change, and beach nourishment project performance, as detailed in this section.

4.2.1. Shoreline Change

The beach profile survey data from each survey event will be used to develop a mean high water (MHW) shoreline at elevation +1.18 ft NAVD88. Changes in shoreline position annually and over time will be reported for each of the established reaches.

4.2.2. Volume Change

Volume changes above strategically selected elevations will be computed to ensure the complete tracking of sand movement along the profile. Changes will be computed in accordance with past monitoring efforts from a landward point at the back of the dune out to the seaward edge of the nourishment berm (+6 ft NAVD88), above MHW (+1.18 ft NAVD88), above -6 ft NAVD88 (wading depth), above -14 ft NAVD88 (capturing the offshore bar), above -19 ft NAVD88 (depth of closure), and above -30 ft NAVD88 (approximate seaward extent of surveys), as shown in Figure 4-1. Results at each transect as well as the overall changes for each of the previously established reaches will be evaluated. The volumetric change calculations performed during the annual analyses will be used to update the evaluation of long-term trends by incorporating the current datasets with those acquired during the previous monitoring efforts. Annual volume changes from each year (excluding nourishment) will be evaluated for each transect, allowing for identification of long-term stable locations and erosional hotspots in each survey reach as compared to annual changes that may vary significantly from year to year. The volumetric change calculations performed



during the annual analyses will also be used to update estimates of dune growth/erosion trends, allowing for identification of areas vulnerable to overwash or exhibiting significant dune growth.

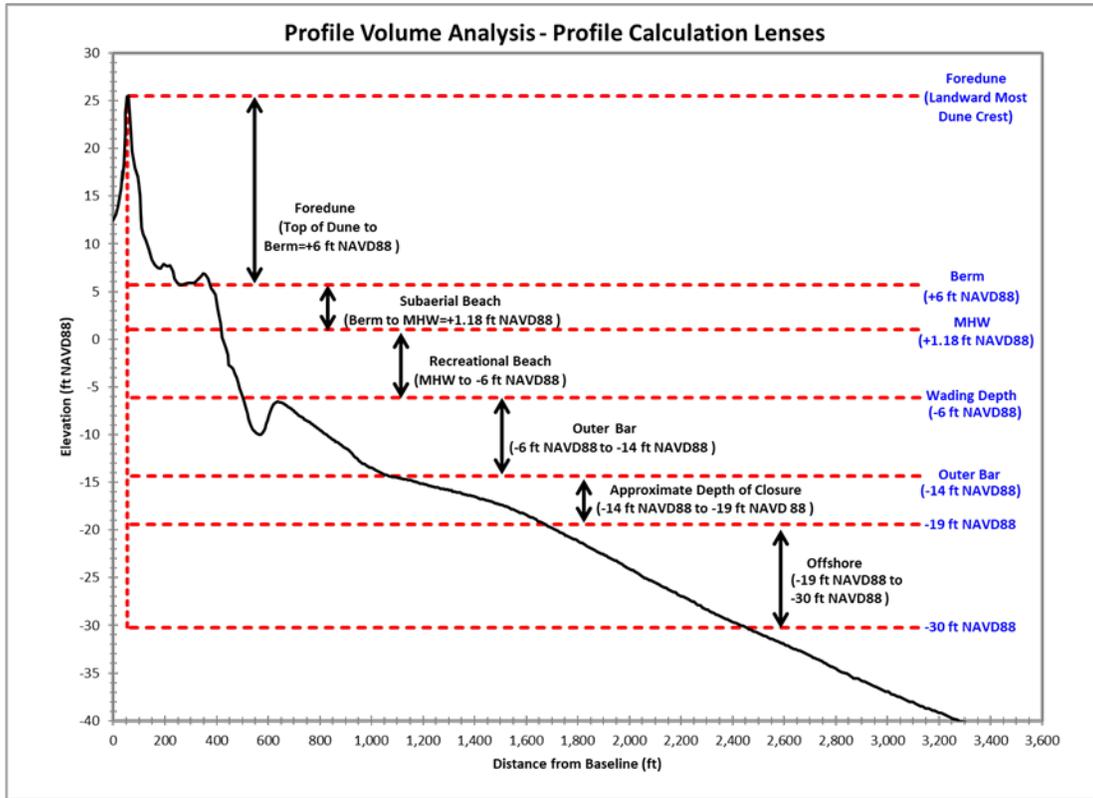


Figure 4-1: Volumetric Calculation Lenses for Profile Volume Analysis

4.2.3. Beach Nourishment Project Performance

The volumetric change calculations performed during the annual analyses will be used to track the performance of any beach nourishment or other maintenance projects. Annual changes from each placement area will be documented throughout the nourishment cycle to gain an understanding of actual volume lost, providing insight into future volume need. Comparisons will be made between the current condition of the beach and the developed renourishment triggers, allowing for estimates of when the next renourishment will be needed.



5. Beach Maintenance Planning: Multi-Decadal Beach Nourishment Master Plan

The Town of Nags Head recently completed a Multi-Decadal Beach Nourishment Master Plan (Master Plan), approved by the Town's Board of Commissioners in July 2024. The Master Plan's purpose is to:

- 1) establish a programmatic plan to facilitate authorization and implementation of beach nourishment events (maintenance and storm response), including borrow source identification and analysis;
- 2) provide a project plan for the long-term maintenance of the dune, beach, and foreshore within the Town of Nags Head to:
 - establish an equivalent level of storm protection to upland property and infrastructure within the town, protecting Nags Head residents' properties as well as protecting the associated local, state, and federal tax bases;
 - ensure the viability of the Nags Head tourism industry;
 - maintain natural resources and associated recreational uses while avoiding and minimizing adverse environmental impacts to the extent feasible; and
- 3) provide an efficient framework to financially and logistically manage the Town of Nags Head's beaches in coordination with Dare County and surrounding communities.

The plan considers the next 50 years of nourishment planning along the Town's shoreline. As a part of the planning process, the volumetric threshold to trigger the next renourishment project was re-evaluated and reach-specific volumetric triggers based on a level of protection analysis including numerical modelling were developed. This section details the updated triggers as well as estimated nourishment needs and borrow sources.

5.1. Maintenance Triggers

Numerical modeling was performed at representative transects along the Nags Head shoreline to develop a preferred beach and dune profile design to achieve adequate Level of Protection (LoP) for habitable structures and infrastructure, along with appropriate trigger conditions for renourishment actions. The representative profiles were established along the Nags Head shoreline, based on the May 2018 profile survey data. These profiles are considered to demonstrate a quasi-natural state of the beach, being surveyed immediately prior to the 2019 beach renourishment project. The 25-year storm was selected as the most appropriate target for adequate LoP. Simulations were performed with the CSHORE 1D profile evolution model using the representative profiles and the 25-year storm conditions to evaluate the quasi-natural LoP of the beach state. Figure 5-1 shows the results of this analysis. In summary, the May 2018 pre-nourishment existing conditions of the beach and dune system are considered to provide a sufficient LoP along the northern and middle portions of Nags Head for up to a 25-year return period design storm event. Before the renourishment event in 2019, the representative profiles at Reaches 2, 3 South and 4 did not have sufficient material available to protect the structures.



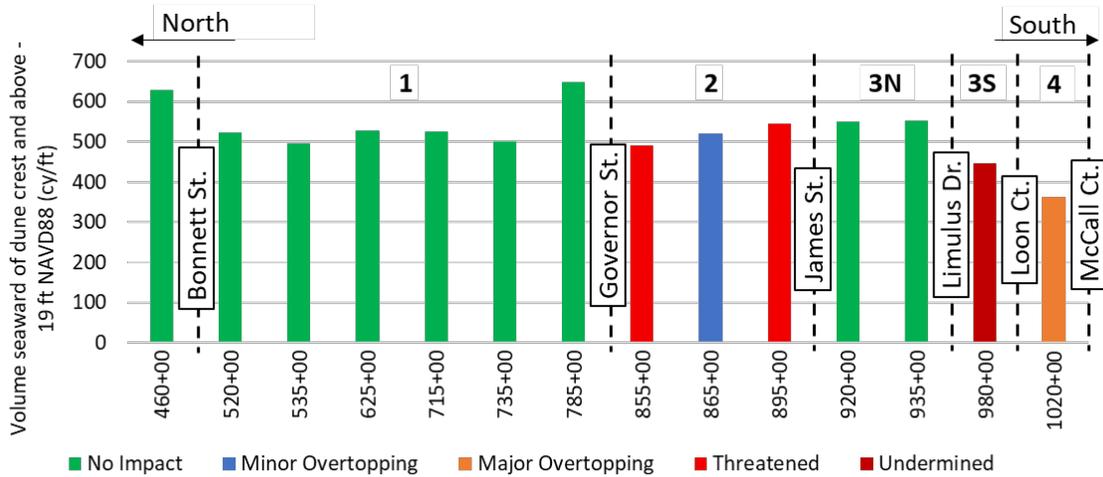


Figure 5-1: Pre-Nourishment Condition CSHORE Pre-Storm Profile Volumes Coded for 25-year Return Period LoP

The CSHORE model was then used along with the representative profiles to adjust the beach profile design to achieve an acceptable LoP along the Town’s oceanfront in the design storm event. For cases where the profiles already provided adequate LoP, (e.g., Nags Head North, Reach 1, Reach 3N) dune and berm volume was removed to determine the threshold volume to meet the minimum LoP. The profiles at Reaches 2, 3 South, and 4 indicated severe impacts, so those were modified by adding dune and berm volumes to provide adequate protection. The volumes required to provide a 25-year LoP at each representative profile and within each reach are presented in Table 5-1. The May 2018 condition at each representative profile is also presented. It is noted that due to the condition of the profiles in Reaches 2, 3 South, and 4 at the time of the May 2018 survey, an estimated 0.6 Mcy would be required to be added to provide the minimum LoP. These triggers provide a basis for comparison with the annual beach monitoring profile surveys. When conditions arise such that the profile volumes are nearing the LoP triggers, the Town will begin planning the next maintenance project. It is noted that there may be individual profiles within a reach where triggers are exceeded which will be considered by the Town, however the composite reach triggers, computed as a weighted average amongst the surveyed beach profiles, are the primary decision-making tool.



Table 5-1: Trigger Volumes Above -19 ft NAVD88 for 25-yr Event

Reach	Length (ft)	Representative Profile	25-yr LoP Trigger Volume (cy/ ft)	Reach Trigger for 25-yr event (cy/ft) (Weighted)	May 2018 Volume Above -19 ft (cy/ ft)
North	6,250	460+00	355	355	578
Reach 1	4,500	520+00	503	470	509
	5,500	535+00	451		472
	7,000	625+00	478		506
	5,500	715+00	479		501
	6,000	735+00	443		490
	2,500	785+00	604		610
Reach 2	5,500	855+00	491	502	446
	2,500	865+00	471		499
	2,500	895+00	526		485
	2,500	920+00	463		504
Reach 3 - North	4,500	935+00	464	446	464
	2,000	980+00	461		407
Reach 3 - South	2,750	1020+00	401		373
TOTAL	59,500				464

5.2. Nourishment Quantities

All of the available long-term monitoring beach profile data was used to perform a statistical analysis of the sediment volume needs for each reach. Volume changes measured since 2011 were used along with the Crystal Ball software package to perform a Monte Carlo simulation and determine volume needs for long-term annual background erosion, as well as additional potential storm impacts, as presented in Table 5-2. Results showed an overall background volume loss along the Nags Head shoreline of approximately 450,000 cy/year at the 50% non-exceedance probability (i.e., there is a 50% likelihood that this volume loss will be exceeded). In order to estimate sediment need over the 50-year planning timeframe, potential impacts of additional storms were considered at the 75% non-exceedance probability (i.e., there is a 25% likelihood that this volume loss will be exceeded, as a conservative approach). An annualized total need of approximately 430,000 cy/year was estimated, considering 16 storms impacting the Town over the 50 years. These annual needs were summed and multiplied by 50 to estimate the 50-year need presented in Table 5-2.

Table 5-2: Nags Head Long-Term Nourishment Need from Background Erosion and Additional Storms

Category	Volume Above -19 ft, NAVD88 (cy)
Annual Background Volume Change (50% non-exceedance probability)	-451,218
Annualized* Storm Volume Change (75% non-exceedance probability)	-431,893
Annual Total Volume Change	-833,111
50-yr Material Need	44,155,550

*16 storms in 50-years



The implications of relative sea level change should also be considered when determining future beach nourishment needs. The dune crest and berm elevations would need to rise by approximately the same amount as relative sea level to maintain an equivalent LoP. An evaluation of the amount of sand volume that would be required to accommodate this required increase in dune crest and berm height and maintain the shoreline position has been performed using the Bruun Rule. Three sea level rise scenarios developed by NOAA for the Duck, NC tide gauge location were used to obtain a range of volume estimates, from 2.6 Mcy to 4.7 Mcy, to meet these needs.

The sea level rise volume need estimates were combined with the background erosion rate need, the additional storm erosion need, and the initial Level of Protection placement need analysis to develop a long-term sediment volume need, considering initial conditions similar to those of May 2018. The total long-term sediment need is presented in Table 5-3. A relatively high estimate of potential volumetric losses during dredging was also computed. This volume estimate is considered to be conservative and can be compared with sand volumes available from identified borrow sources to provide assurance that the beach nourishment master plan can be executed successfully.

Table 5-3: Long-Term (50-Year) Sediment Volume Need

Crystal Ball	Background Erosion 50 years (50%)	22.5 Mcy		
	Additional Storms (16 storms) (75%)	21.5 Mcy		
LoP (25 year) Design		0.6 Mcy		
Relative Sea Level Rise (NOAA, 2022)		Intermediate Low	Intermediate	Intermediate High
		2.6 Mcy	3.4 Mcy	4.7 Mcy
TOTAL		46.7 Mcy	47.5 Mcy	48.8 Mcy
<i>Assumed 20% losses during dredging</i>		<i>56.0 Mcy</i>	<i>57.0 Mcy</i>	<i>58.6 Mcy</i>

5.3. Borrow Sources

A comprehensive evaluation of the previously identified borrow area S1 (Figure 3-1) located offshore of Nags Head was performed as part of the Master Plan development, including collection of detailed geophysical and geological data to characterize and quantify the beach-compatible sand available. Sub-zones were delineated as shown in Figure 5-2, with allowable dredge cut elevation and available beach-compatible sand also presented. Based on this analysis of borrow area S1, approximately 67.9 Mcy of beach compatible material is available. This quantity is considered sufficient to accommodate the estimated placement requirement of approximately 49 Mcy (Intermediate High scenario for sea level rise, Table 5-3) for the town's beach management efforts over the next 50 years.



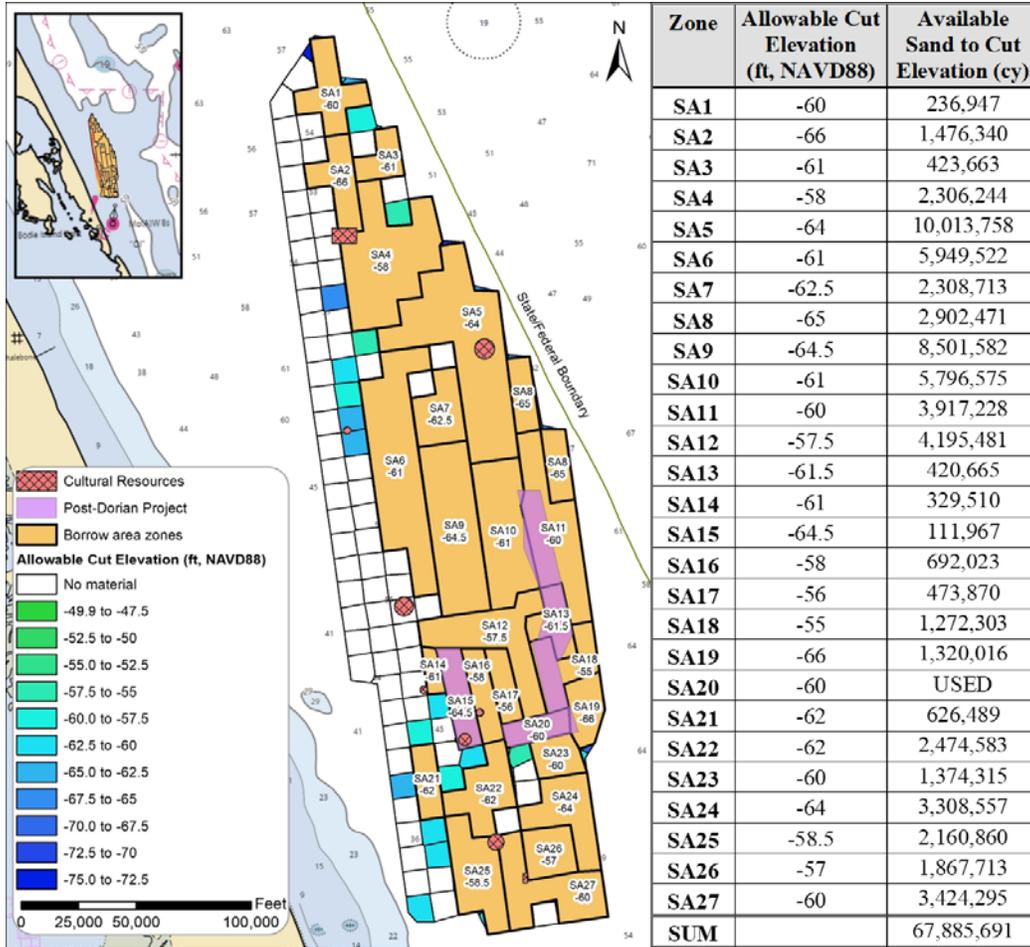


Figure 5-2: Borrow Area Sub-Zones and Corresponding Maximum Dredge Cut Elevations



6. Funding

Previous beach nourishment projects conducted by the Town have been funded using a combination of local (Town and County) and State grant funds. In addition, post-storm damage restoration of sand loss has been funded by FEMA. The Town typically secures municipal bonds to pay for its portion of the cost at the time of construction, and the bonds are then paid back throughout the life of the project.

The Town has developed Municipal Service Districts to levy additional property taxes to provide funding for beach nourishment. The funding plans recognize that the benefits of beach nourishment extend beyond the immediate oceanfront, and the MSD boundaries and rates take this into account. Beach nourishment maintains the beach as a key piece of the Town's infrastructure. A well-maintained beach not only provides protection to properties throughout the Town but also results in increased property values.

In addition to these Town funds, Dare County maintains a Beach Nourishment Fund which has historically supported the Town's beach renourishment projects. A 2 percent portion of the County's 6 percent Occupancy Tax is allocated to this fund. This fund is restricted by legislation to be used for the placement of sand from other sources, planting of vegetation and building of structures that are in conformity with the North Carolina Coastal Area Management Act (CAMA), e.g. dunes and sand fencing, for the purpose of widening the beach to benefit public recreational use and to mitigate damage and erosion from storms to inland property.

The State's CSDM Fund program accepts applications for grant funding by local governments to support beach nourishment, dune construction, or other projects that mitigate or remediate coastal storm damage to the ocean beach and dune systems of the State. Local cost share of at least one non-State dollar for every dollar from the fund is required.

For post-storm repairs of beach nourishment projects, FEMA has provided funding under the Category G Public Assistance program for Permanent Work - Engineered Beaches. Documentation of losses of beach sand, vegetation, and sand fencing is necessary to obtain approvals for the FEMA Category G funding.



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