Stoney Beach Restoration Alternatives Analysis

November 2023

PREPARED FOR:
ResilientWoodsHole
Woods Hole Oceanographic Institution
Marine Biological Laboratory
NOAA Fisheries

PREPARED BY:
Woods Hole Group, Inc.
A CLS Company
107 Waterhouse Rd
Bourne, MA 02532 USA

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1.0 INTRODUCTION & BACKGROUND

1.1 Overview

The primary goal of the Stoney Beach Restoration Alternatives Analysis project is to explore the potential effectiveness and feasibility of nature-based solutions to address the challenges posed by coastal flooding in the Woods Hole area. Through a careful examination of flood pathways, including those originating from Buzzards Bay, Mill Pond, and Eel Pond, this study sought to understand the specific vulnerabilities of the area and develop strategies to enhance its resilience while also bolstering ecological integrity.

This report provides a detailed account of the study methodology, analysis, and findings related to the Stoney Beach Restoration Alternatives Analysis project. It also presents recommendations for action based on the research conducted.

1.2 Flood Pathways

A flood pathway is a route that allows coastal floodwaters to propagate landward through lower elevation conduits, potentially exposing larger inland areas to coastal flooding. In the Woods Hole area, major flood pathways include the low-lying marsh area behind the Gardiner Road seawall (wave overtopping at shore protection structures can contribute large volumes of water that flows to nearby areas), low spots along Millfield Street coincident with culverts between Eel Pond and the Mill Pond wetland system, and portions of the Stoney Beach dune that have been lowered by foot traffic and natural erosion (Figure 1). Understanding these flood pathways is crucial for developing effective flood mitigation strategies and enhancing the resiliency of the area.

It is important to understand there are other flood pathways that affect Woods Hole, and that the Stoney Beach project has the potential to mitigate *some* of that flood risk. Even with implementation of the Stoney Beach dune restoration, residual flood risk will persist in Woods Hole – due to (1) the possibility of higher water levels and waves overtopping the Stoney Beach project and (2) the propagation of floodwaters to Woods Hole neighborhoods from other sources, especially those named above. As demonstrated in Figure 1, additional adaptation strategies will need to be implemented to reduce the risk of flooding posed by the other flood pathways.

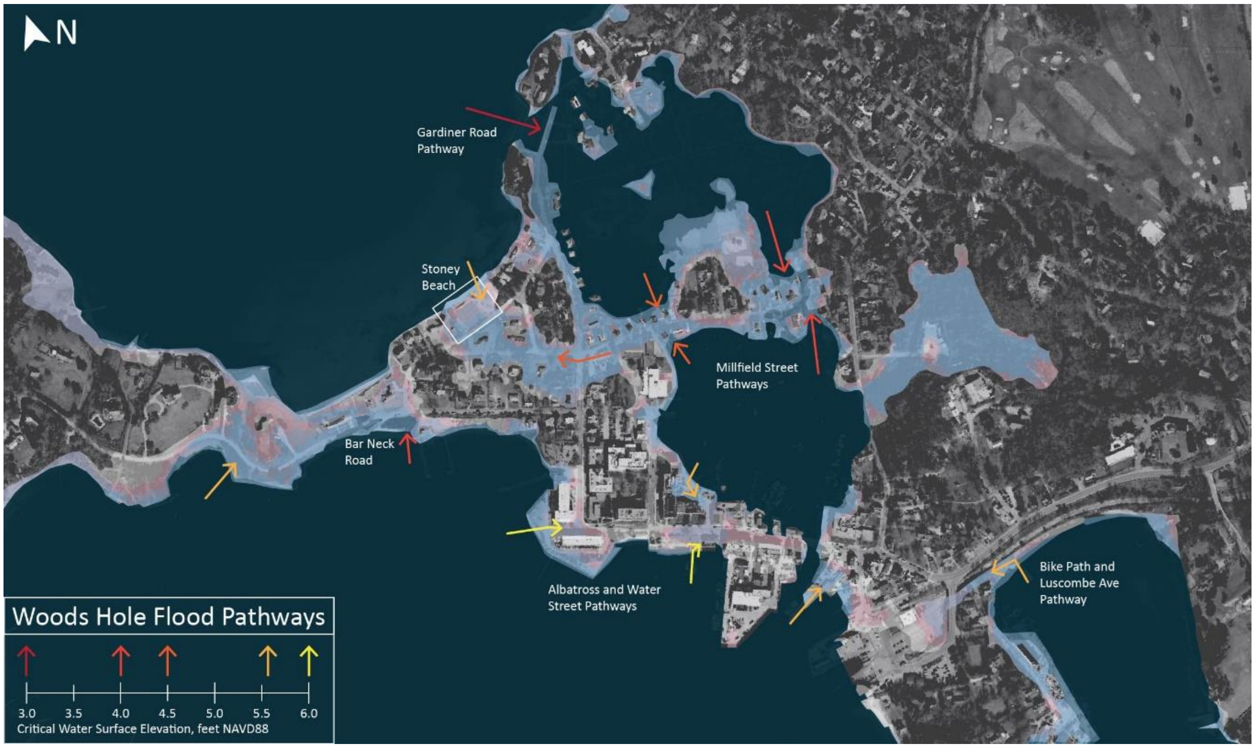


Figure 1: Flood pathways in Woods Hole.

1.3 Feasibility Study

The feasibility study encompassed several key tasks, including a site survey and evaluation of existing conditions, resource area delineation, an assessment of alternatives and conceptual designs for flood mitigation, dune/beach performance modeling, regulatory feasibility review, and reporting with plans and renderings of some of the alternatives.

The site survey and evaluation of existing conditions involved researching property boundaries, conducting a topographic survey of existing infrastructure, natural features and vegetation, and delineation of wetland resources. This information formed the basis of developing an existing conditions plan of Stoney Beach (see Section 2.0).

Numerical modeling of dune/beach performance was completed to assess the level of protection provided by the proposed alternatives and to determine maintenance requirements. The modeling considered present-day water levels and waves, and the feasibility of using nature-based solutions as a way to mitigate the flood pathway through the Stoney Beach property. A performance assessment was conducted to evaluate existing conditions and six (6) alternatives (three dune configurations, with and without beach nourishment) under six (6) different wave and water level permutations for a total of 42 iterations (see Section 3.0).

The study also assessed the permitability of the conceptual alternatives. This involved evaluating the regulatory requirements, environmental considerations, and permitting processes associated with implementing the proposed measures. By evaluating permitability, the study sought to identify any potential challenges or limitations that may arise during the implementation phase and develop strategies to navigate through the regulatory framework effectively (see Section 4.0).

A key component of the feasibility study was the evaluation of the financial aspects associated with the proposed alternatives. This included estimating costs for further design, permitting, construction, and ongoing operation and maintenance (O&M). By considering these financial aspects, the study aimed to provide a comprehensive understanding of the undertaking for the owner of the property, the Marine Biological Laboratory (see Section 5.0).

2.0 EXISTING CONDITIONS

2.1 Topographic Survey

Woods Hole Group conducted surveys in December 2022 and February 2023 to establish existing conditions, including topography of the parcel and the nearshore bathymetry. During the surveys, existing property monuments were documented, as well as other features on the site such as the tennis court, parking area, stone groins, walls/fences on adjacent properties, edge of vegetation, footpaths, stones, trash/recycling receptacles, and wetland resource areas. Ground elevations were surveyed along a series of shore normal transects extending from below the mean low water (MLW) line to the street side of the property. The edge of pavement and catch basins along Gosnold Road were also surveyed. Figure 2 shows the areas captured during the survey. Available LiDAR topography and aerial orthophotography were also used to provide additional details around the site.

Data collected during the survey show that the existing dune crest elevation is between 5.0 and 9.0 ft NAVD88. The access paths are incised into the dune creating more vulnerable flood pathways at the lower elevations of approximately 5.0 ft NAVD88. Elevations behind the dune in the parking lot and tennis court slope down gradually from 9.5 to 5.5 ft NAVD88 from east to west across the property. The vegetated area in the southeast corner of the lot supports the highest elevations on the property at 14.0 ft NAVD99. Results of the survey were used to produce an Existing Conditions Plan of Stoney Beach (Attachment A).

2.2 Wetland Resource Delineation

Wetland resources on site were delineated following the resource area definitions found in the Massachusetts Wetland Regulations (310 CMR 10.00). The following wetland resources were delineated and are shown on the Existing Conditions Plan:

- Land Under the Ocean (310 CMR 10.25): This resource was delineated as areas of the site extending seaward into Buzzards Bay from the mean low water line. This included all areas below mean low water that are located between the two (2) stone groins. Land Under the Ocean at the site is characterized by a sandy gently sloping landform.

- Coastal Beach (310 CMR 10.27): This resource was delineated as all areas of unconsolidated sediment subject to wave, tidal, and coastal storm action that form the shoreline of Buzzards Bay. Coastal Beach at the site occurs between the mean low water line and the toe of Coastal Dune. The high tide beach above the mean high water line is approximately 50 to 55 ft wide and slopes gently to the water at a uniform slope of 10H:1V.

- Coastal Dune (310 CMR 10.28): This resource was delineated as the natural ridge of sediment landward of the Coastal Beach composed of material deposited by wind action or storm overwash. The low-lying dune at the site extends West-southwest (WSW) to East-northeast (ENE) across the property. Uncontrolled foot traffic has created a number of footpaths through the dune. The primary footpath between the parking lot and the beach is at an elevation of 5.0 ft NAVD88, which is approximately 3 to 4 ft below the crest of the adjacent dune. The seaward facing portion of the dune is vegetated with beach grass and the coastal dune along the western property line is vegetated with woody species such as bayberry, beach plum and honeysuckle.

- Land Subject to Coastal Storm Flowage (310 CMR 10.04): Since the entire site falls within the FEMA designated 100-yr floodplain, the entire property is considered Land Subject to Coastal Storm Flowage.

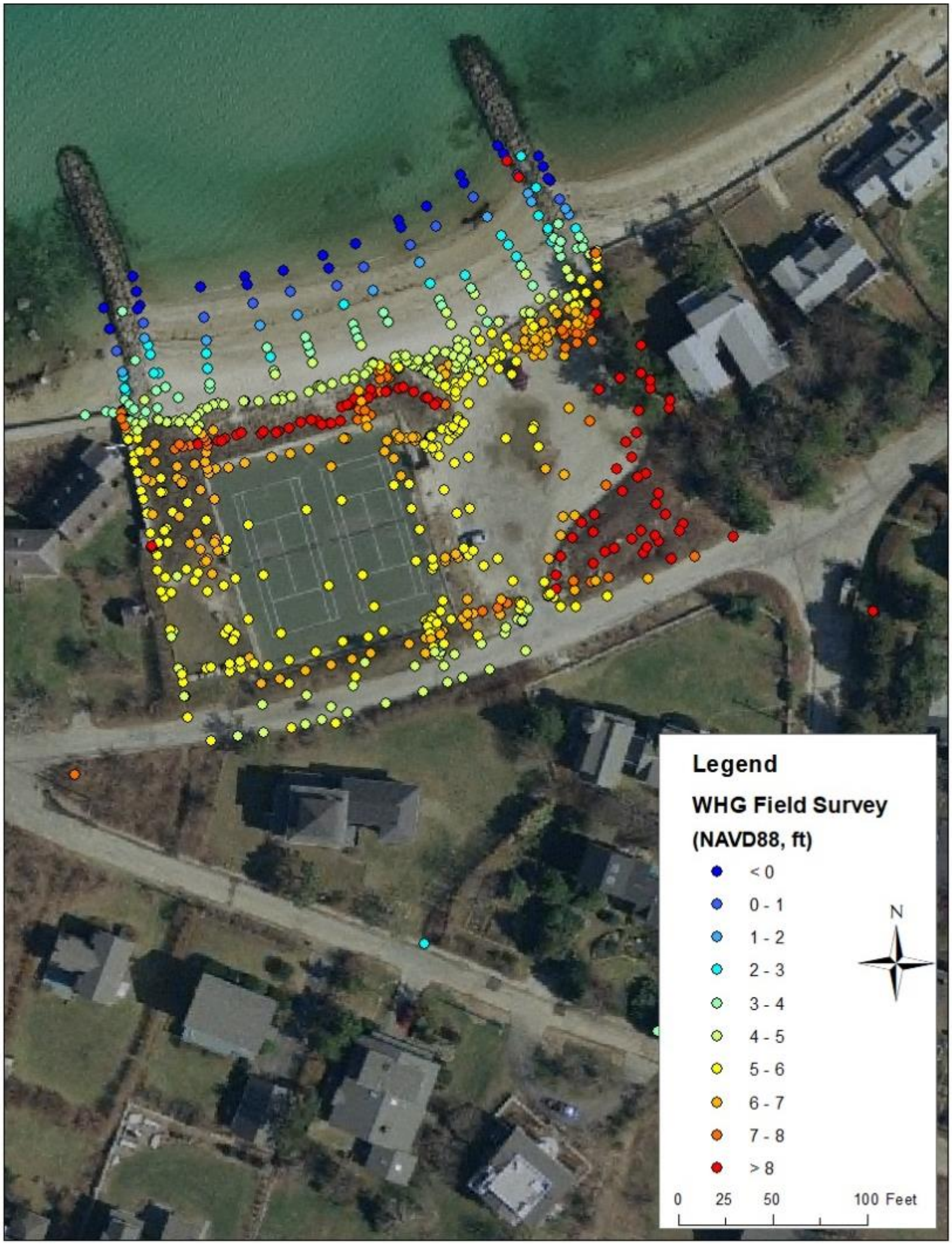


Figure 2: Woods Hole Group topographic survey data collected for Stoney Beach in December 2022 and February 2023.

2.3 Property Research at the Registry of Deeds

The property lines were initially identified by consulting the Town's GIS (Geographic Information System) and verifying the listed owner. The GIS property information was then cross-referenced with the Barnstable County Registry of Deeds, where the deed book and corresponding page for the property were reviewed. Through this work, it was determined that the Stoney Beach property is divided into two parcels. Lot X comprises the western portion of the site with the tennis courts and a portion of the parking lot, while Lot 6 comprises the eastern portion of the site. Both parcels are owned by the Marine Biological Laboratory. Deeds for the adjacent parcels at 24 and 44 Gosnold Road were also reviewed, as were the recorded “Bay Shores” subdivision plans that include Spencer Baird Road, Gosnold Road, and others.

During the investigation, it became evident that some of the original property markers, such as stone and concrete bounds, have been replaced over time. This discovery highlighted the importance of analyzing both current and historical data to accurately identify the property lines. While certain markers depicted on the older deeds were no longer present, the team also encountered additional markers that were not previously documented. The property research and subsequent survey were used to identify the property lines so they could be added to the Existing Conditions Plan of Stoney Beach, along with the property owners (Attachment A).

The deed research also identified a 10 ft wide easement along the western side of Lot X that extends between Gosnold Rd. and the beach. The easement was established in 1911 by the original developer of the property, and passed along to area residents, for the purpose of passing and repassing on foot between Gosnold Rd. and the sea.

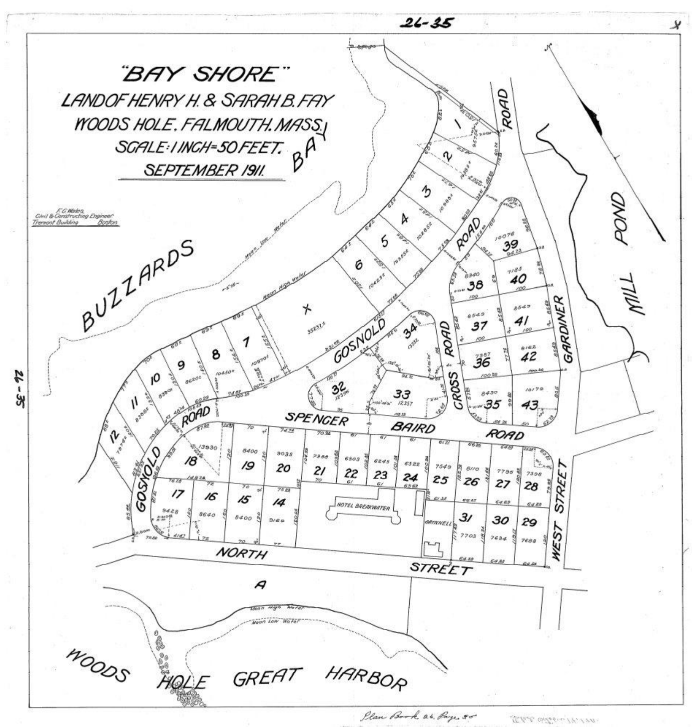


Figure 3: Map of the 1911 subdivision.

2.4 Sediment Sampling

Four (4) sediment samples were collected from the site and sent to a local certified laboratory for grain size analysis (see results in Appendix B). Two (2) samples were collected from the coastal dune and two (2) samples were collected from the coastal beach. Sample locations are shown on the Existing Conditions Plan (Appendix A). Samples collected from the dune are characterized as medium-grained sand with trace percentages of gravel and silt/clay. Samples collected from the beach are composed of coarse to medium-grained sand with some gravel and trace percentages of silt/clay. Sediment characteristics of the beach and dune were used in the performance modeling of the beach and dune nourishment alternatives and will be needed for sourcing compatible material when the project moves to the construction phase.

3.0 ALTERNATIVES ASSESSMENT & PERFORMANCE MODELING

3.1 Develop Present Day Water Levels & Wave Conditions

Water level information needed for the alternatives assessment was obtained from the Massachusetts Coast Flood Risk Model (MC-FRM). This is the same model used to conduct institutional and community flood risk assessments in Woods Hole for prior projects. A summary of water levels extracted from MC-FRM for various return period (years) or annual exceedance probability (AEP) (i.e annual percent chance occurrence) storm events in the Stoney Beach area is provided in Table 1. Dune performance modeling for the various alternatives was conducted using the 20% (5-year return period) and 10% (10-year return period) AEP water levels under present day sea conditions as highlighted in Table 1. Table 1 also shows that similar water levels are projected at higher probability levels (more frequent return periods) in future climate conditions.

Table 1. MC-FRM Extreme Water Levels for the Stoney Beach Area.

AEP (Return Period)	Present Day (2008 centered epoch) (ft, NAVD88)	2030 (ft, NAVD88)	2050 (ft, NAVD88)
1% (100-year)	9.6	10.7	12.7
2% (50-year)	8.7	9.9	11.7
5% (20-year)	7.6	8.7	10.4
10% (10-year)	6.8	7.8	9.5
20% (5-year)	5.8	6.9	8.4
50% (2-year)	4.2	5.4	6.8
100% (1-year)	3.5	4.8	6

Wave height information needed for the alternatives analysis was taken from a combination of MC-FRM and the US Army Corps North Atlantic Coast Comprehensive Study (NACCS). In the MC-FRM, a representative 10% AEP (10-year return period) water level storm corresponded to a peak wave height of 2.4 feet. In the NACCS, the peak wave height associated with a 10% AEP (10-year return period) water level storm was 4.9 feet. Wave heights from these two models were taken from a point 1,100 feet offshore of Stoney Beach where the seafloor elevation is -26.2 ft NAVD88. The dune performance model was then used to transform the waves onshore to Stoney Beach where they interacted with the dune and beach nourishment alternatives. It is important to note that the NACCS model may overestimate the wave heights that could actually reach Stoney Beach, since it does not differentiate wind direction when calculating wave height. As such, an intermediate wave height of 3.6 feet was also considered in the dune performance modeling.

Based on this information, 10% AEP (10-year return period) wave heights of 2.4, 3.6, and 4.9 feet were simulated in conjunction with a stillwater elevation of 6.8 feet NAVD88, which represents a 10% AEP (10-year return period) water level in MC-FRM. The same wave heights were simulated with a lower stillwater elevation of 5.8 feet NAVD88, which represents a 20% AEP (5-year return period) water level. These simulations assume that the 10% AEP (10-year return period) waves occur at the same time as the 10% AEP or 5% AEP (return-period) water levels. Although there is a low probability that these wave and water level conditions would occur at the same time, the simulations bracket a range of high frequency lower energy exposure scenarios at Stoney Beach. This approach allowed for a comprehensive assessment of various scenarios, considering the interaction between water levels and wave heights, to better understand potential impacts on the dune at Stoney Beach under both existing and alternative designs.

3.2 Dune Performance Modeling

To assess the performance of the Stoney Beach dune under storm conditions in its existing configuration and for the various alternatives considered, Woods Hole Group ran the one-dimensional cross-shore model XBeach. The modeling was performed along a shore normal transect through the middle of the site with ground elevations taken from the topobathy dataset (Figure 4). The focus of the analysis was to evaluate the potential for erosion of the dune from exposure to flooding and waves. This assessment utilized the range of present-day water levels (5.8 to 6.8 feet NAVD88) and associated wave conditions (2.4, 3.6 and 4.9 feet) to evaluate the potential for flooding and dune erosion, as it exists today and under a range of restored conditions. Understanding these water level and wave thresholds is crucial for selecting a restoration template, considering the utility of beach nourishment, and estimating the project's potential effective lifespan and maintenance requirements.

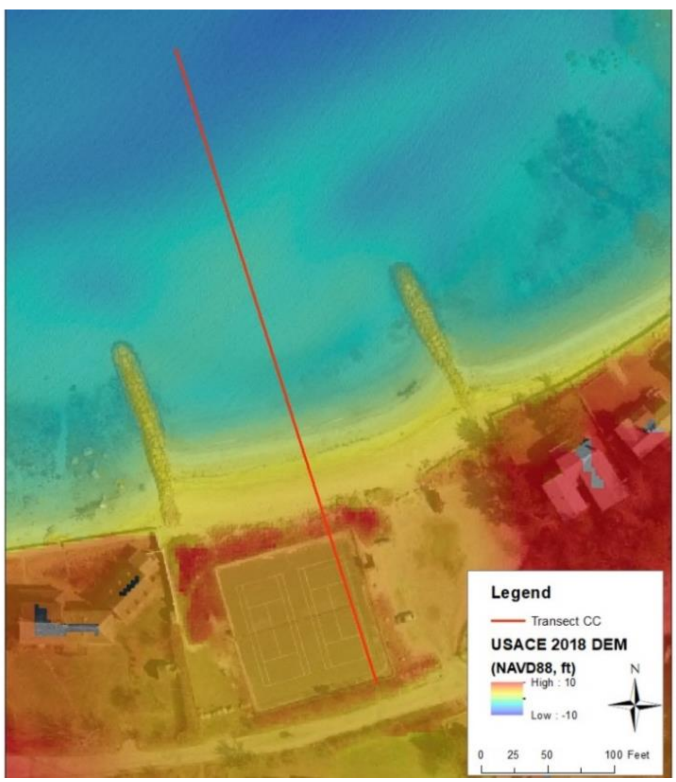


Figure 4: Topobathymetric data and transect location used for the performance modeling.

The design for the dune restoration considered the existing dune elevations and surrounding landscape. Based on elevations on the adjacent property to the east, it was determined that the maximum dune crest elevation that can fit on site and tie-in with existing grades on the adjacent property is 10 ft NAVD88. As such, three different dune crest elevations of 8, 9, and 10 ft NAVD88 were selected for the evaluation. The 10 ft NAVD88 dune crest was the largest that could be built on site and still tie-in with the neighboring property, while the 8 ft NAVD88 would essentially fill low spots at the access paths, and the 9 ft NAVD88 dune crest would represent an intermediate scenario. Dune crest widths of 10 ft were incorporated into each of the designs. This width created a dune that could withstand some erosion along the seaward face without breaching, and also avoided encroaching on the parking lot. The analysis also considered the benefits of adding beach nourishment. The nourishment design included a berm at elevation of 3.0 ft NAVD88 extending seaward 30 ft, and then sloping down gradually at a 10H:1V slope (equivalent to the natural slope of the existing beach) to meet existing grade (Figure 5). The design increased the width of the beach above the high tide line and also allowed the nourishment material to be contained in the area between the two groins, decreasing the potential for loss of material to adjacent beaches.

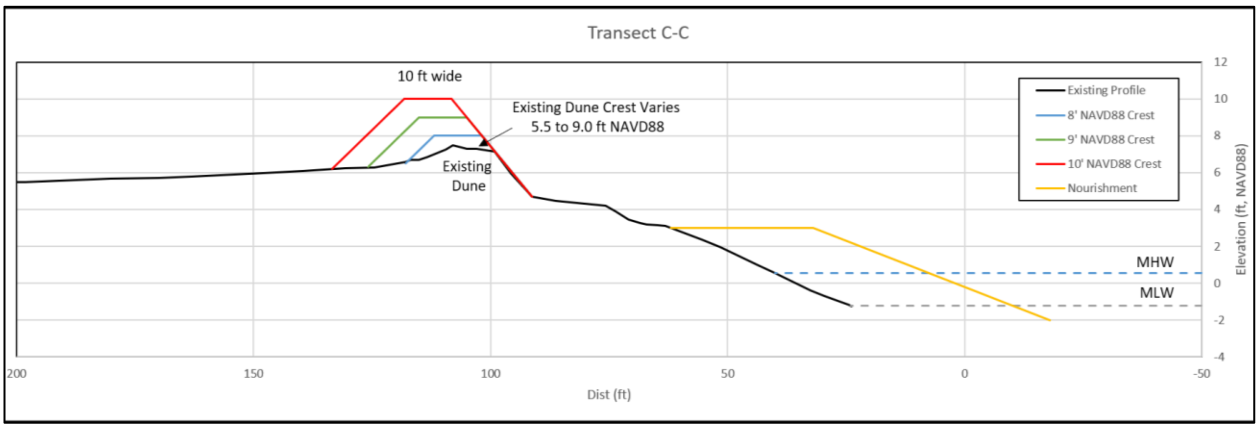


Figure 5: Cross-section of Stoney Beach showing the dune restoration and beach nourishment designs considered for the project.

The alternatives analysis considered the three dune designs separately. It also considered the different dune designs with the addition of beach nourishment to assess added benefits the nourishment may have on minimizing dune erosion. These six alternatives, in addition to the existing conditions case, were run with the wave and water level conditions described above for a total of 42 different simulations.

Results from the existing conditions model simulations illustrate the importance of wave height in influencing the extent of dune erosion. When impacted by a storm with 10% AEP (10-year return period) water levels and smaller waves of 2.4 ft, some erosion of the dune face occurs, but the crest is left intact (Figure 6). However, with lower water levels typical of a 20% AEP (5-year return period) storm and larger waves of 3.6 ft, the entire dune is eroded, leaving little in the way of protection during future storms (Figure 7).

A model simulation on the dune design with a crest elevation of 8 ft NAVD88 during a storm with 10% AEP (10-year return period) water level and a wave height of 3.6 ft is shown in Figure 8. The results once again show complete removal of the dune crest with overwash into the parking area behind the dune. The only way that the 8 ft NAVD88 dune withstands waves of 3.6 ft is with lower water levels encountered during a 20% AEP (5-year return period) storm.

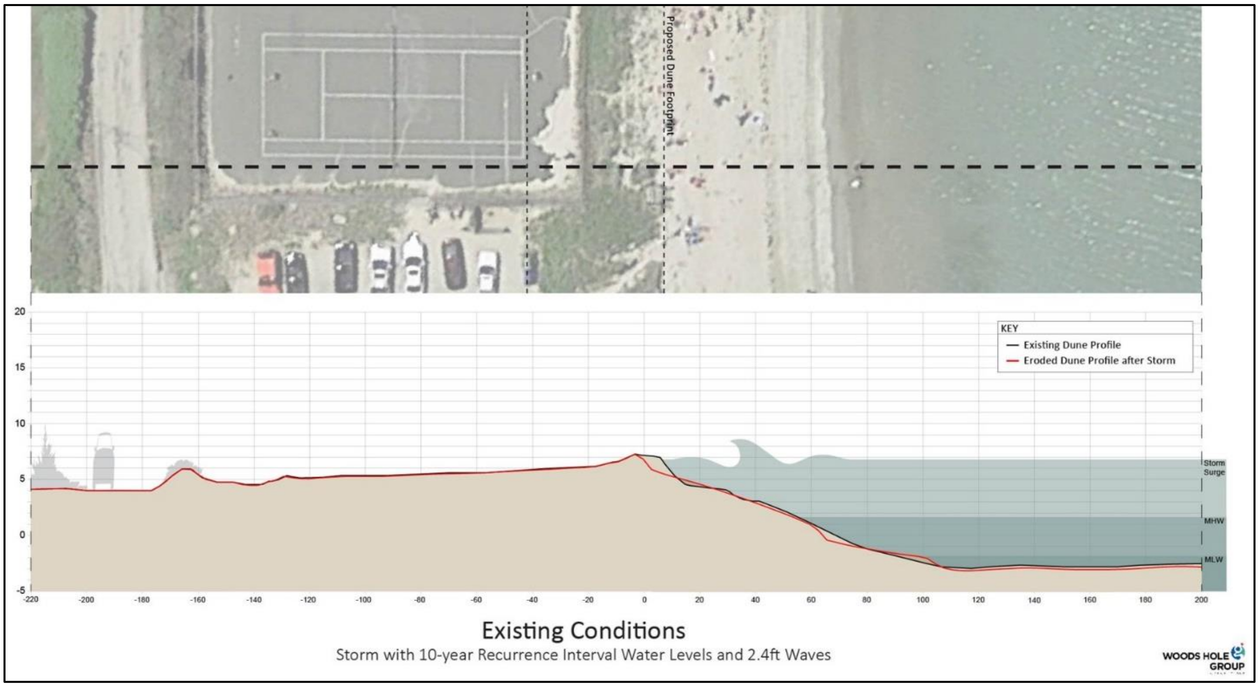


Figure 6: Cross-section of Stoney Beach showing erosion of the existing dune during a storm with a 10-yr return period water level and waves of 2.4 ft.

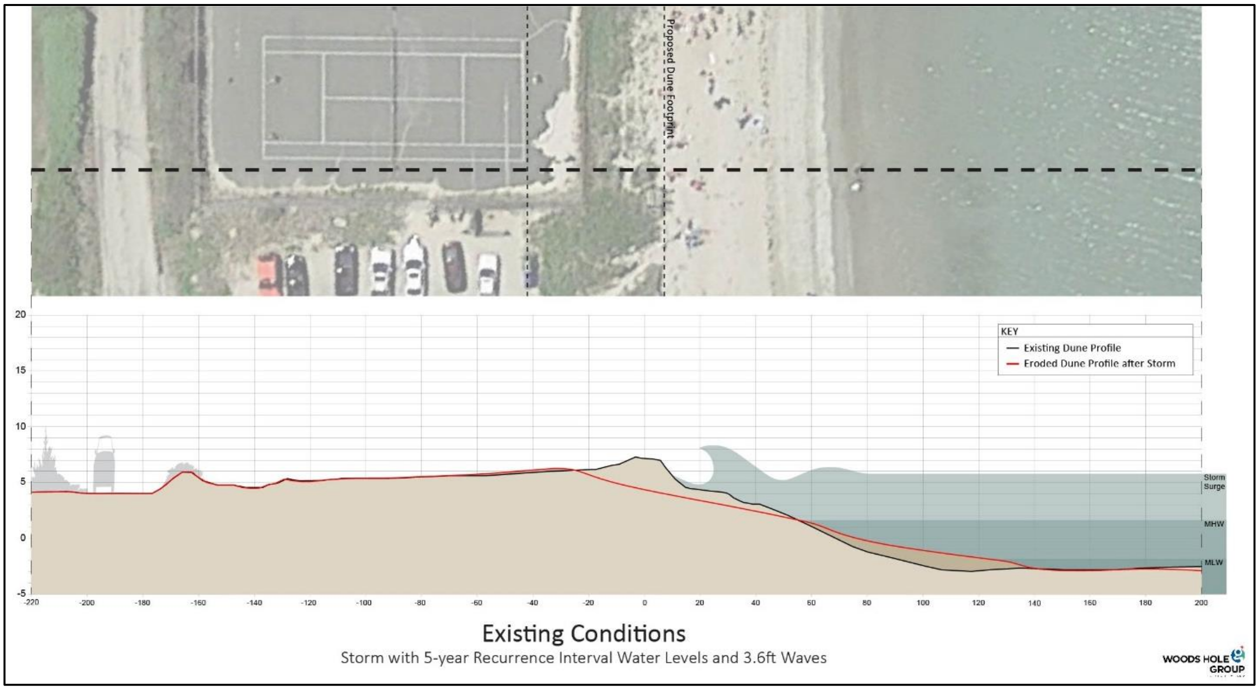


Figure 7: Cross-section of Stoney Beach showing erosion of the existing dune during a storm with a 5-yr return period water level and waves of 3.6 ft.

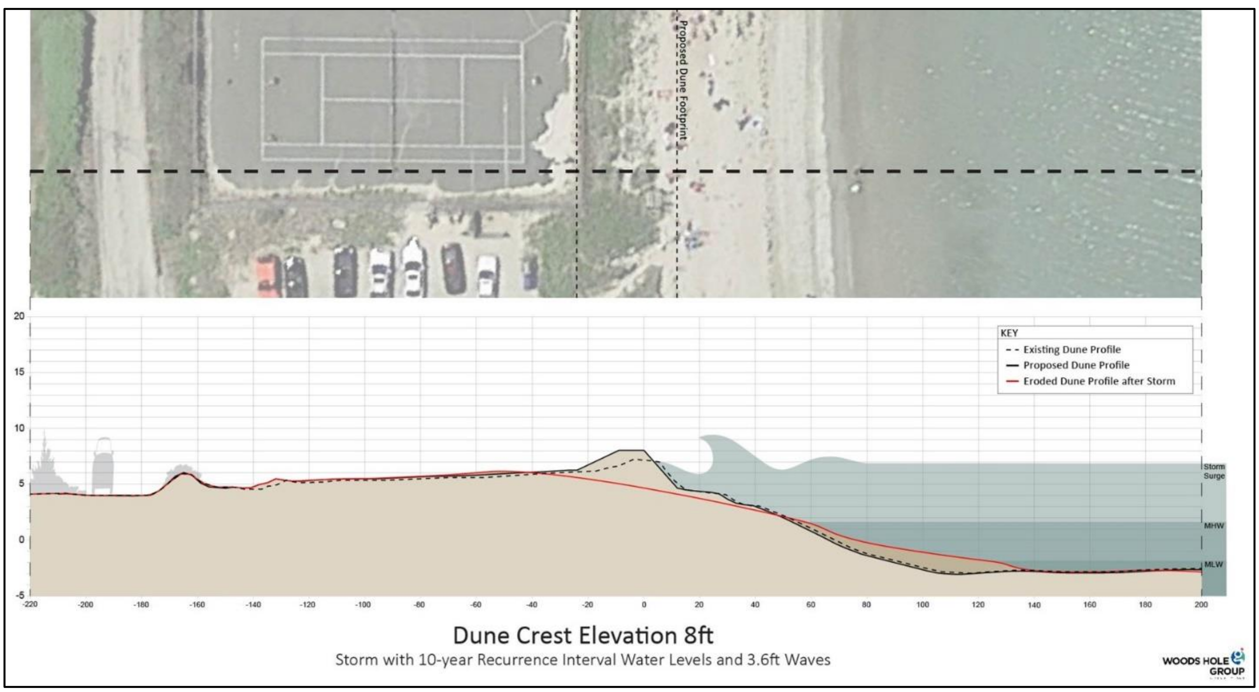


Figure 8: Cross-section of Stoney Beach showing erosion of the dune design with 8 ft NAVD88 crest elevation and no beach nourishment during a storm with a 10-yr return period water level and waves of 3.6 ft.

The benefits of adding beach nourishment to the project are illustrated in Figures 9 and 10. Figure 9 shows a model simulation on the dune design with a crest elevation of 10 ft NAVD88 without beach nourishment, during a storm with 10% AEP (10-year return period) water level and a wave height of 3.6 ft. Under these conditions the seaward portion of the dune is eroded and the crest elevation is lowered by approximately 2 ft (to 8 ft NAVD88). When beach nourishment is added to the design (Figure 10), there is still erosion along the seaward face of the dune, but the crest is lowered by only 1 foot. A portion of the beach nourishment material is shown to erode with deposition further seaward along the toe of the nourishment; however, it is expected that this material would be transported back onshore during calmer summer wave conditions.

The dune performance analysis revealed that with increasing wave heights, adverse impacts to the dune became more pronounced, even with lower water levels. Table 2 summarizes model results for the three dune designs with and without beach nourishment, under the different water level and wave conditions. Scenarios considered to provide flood pathway protection are noted with a green check mark, while scenarios that would result in erosion and flooding of Gosnold Road are noted with a red X mark. The dune performance was considered to be protective against flooding when erosion did not extend landward of the crest, or when the crest was lowered by 1 ft or less.

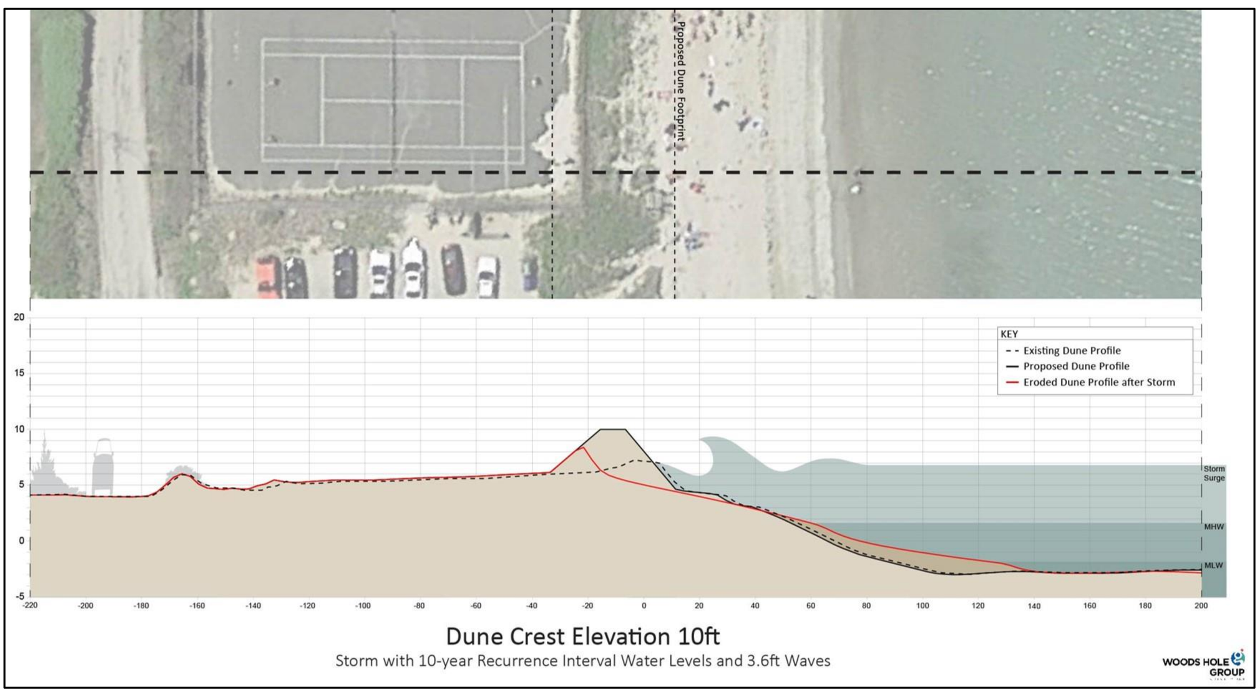


Figure 9: Cross-section of Stoney Beach showing erosion of the dune design with 10 ft NAVD88 crest elevation and no beach nourishment during a storm with a 10-yr return period water level and waves of 3.6 ft.

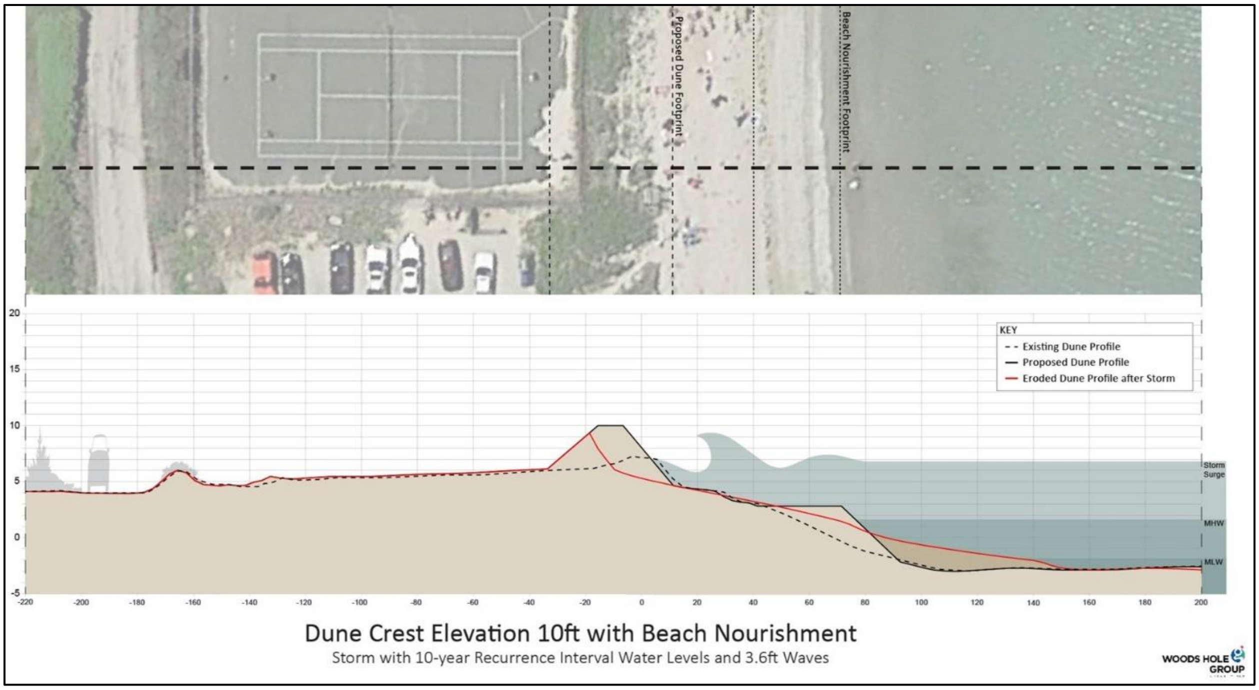


Figure 10: Cross-section of Stoney Beach showing erosion of the dune design with 10 ft NAVD88 crest elevation and beach nourishment during a storm with a 10-yr return period water level and waves of 3.6 ft.

Given the low-lying nature of the existing dune and the incised paths at Stoney Beach, storms with water levels between the 2% and 5% AEP (2-yr to 5-yr return period) cause flooding of the property in the area of the parking lot and tennis court, as well as portions of Gosnold Rd. Modeling conducted for this study showed that all of the dune nourishment alternatives provide a measure of increased flood resiliency during high frequency, low energy storms (i.e., 5% and 10% storms with 2.6 ft waves). With existing site constraints, however; it is not possible to design a nature-based resiliency project that completely eliminates the flood pathway during higher energy storms with waves greater than 3.6 ft that occur at the same time as 5% to 10% AEP water levels. It should be noted there is a low probability that these conditions will occur simultaneously, and as such, the simulations provide a conservative estimate of the extent of dune erosion than would create a new flood pathway. The greatest protection against flooding and erosion is provided by the 10 ft NAVD88 dune coupled with beach nourishment, standing up to a storm with a 20% AEP (5-year return period) water level and 10% AEP (10-yr return period) waves of 4.9 ft , or a storm with 10% AEP (10-year return period) water level and 10% AEP (10-yr return period) waves of 3.6 ft. If beach nourishment is not included, the 10 ft NAVD88 dune is vulnerable to erosion, and landward areas of Gosnold Road subject to flooding, during a storm with a 10% AEP (10-yr return period) water level and 10% AEP (10-yr return period) offshore waves of 3.6 ft or larger.

Table 2. Performance for Existing Conditions and Dune Designs With and Without Beach Nourishment Under Varying Water Level and Wave Conditions.

Water Level & Wave Condition	Existing Conditions	Dune Crest at 8 ft NAVD88	Dune Crest at 9 ft NAVD88	Dune Crest at 10 ft NAVD88
5-yr & 2.4 ft	✓	✓	✓	✓
10-yr & 2.4 ft	✓	✓	✓	✓
5-yr & 3.6 ft	×	✓ (only with nourishment)	✓ (only with nourishment)	✓
10-yr & 3.6 ft	×	×	×	✓ (only with nourishment)
5-yr & 4.9 ft	×	×	×	✓ (only with nourishment)
10-yr & 4.9 ft	×	×	×	×

3.4 Parking Lot Options

The assessment of alternatives for the site also evaluated impacts of changes to the dune on use of the site landward of the existing dune. Currently this area contains an unimproved parking lot with space for 30 cars, a deteriorating tennis court, access to/from Gosnold Road, and natural areas with native and invasive species. Figure 11 illustrates the footprints of the three dune designs in relation to the existing site layout. Unless changes to the parking lot are made, construction of any of the dune designs will result in the loss of parking spaces. To address these conflicts, three designs for the landward portion of the site were developed as described below.

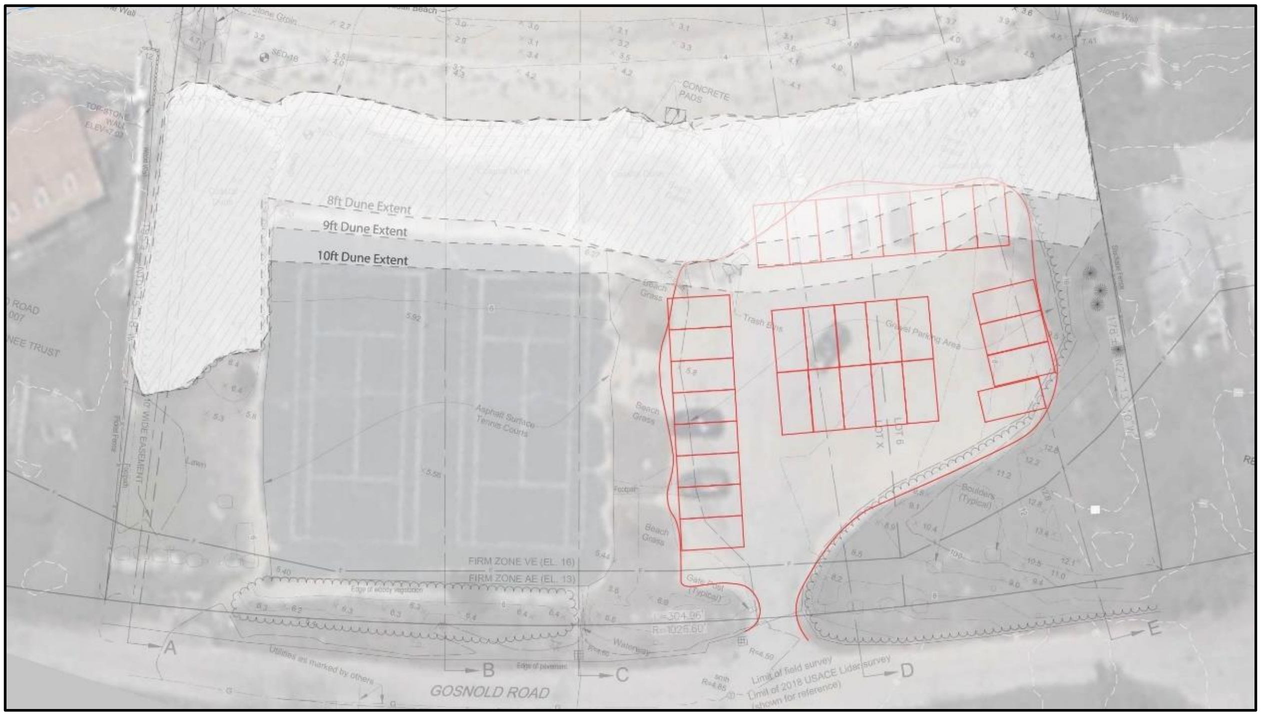


Figure 11: Dune design footprints at Stoney Beach in relation to existing infrastructure across the landward portion of the site.

<u>Option 1:</u> The first option involves re-grading the parking lot to enhance accessibility for the public, whether on foot, by bicycle, or vehicle. However, this option also has a drawback in that the landward edge of the restored dune would encroach on the parking lot, resulting in the loss of approximately seven parking spaces. In this option, the tennis court would be removed and could become a picnic area with an area of habitat restoration (Figure 12).

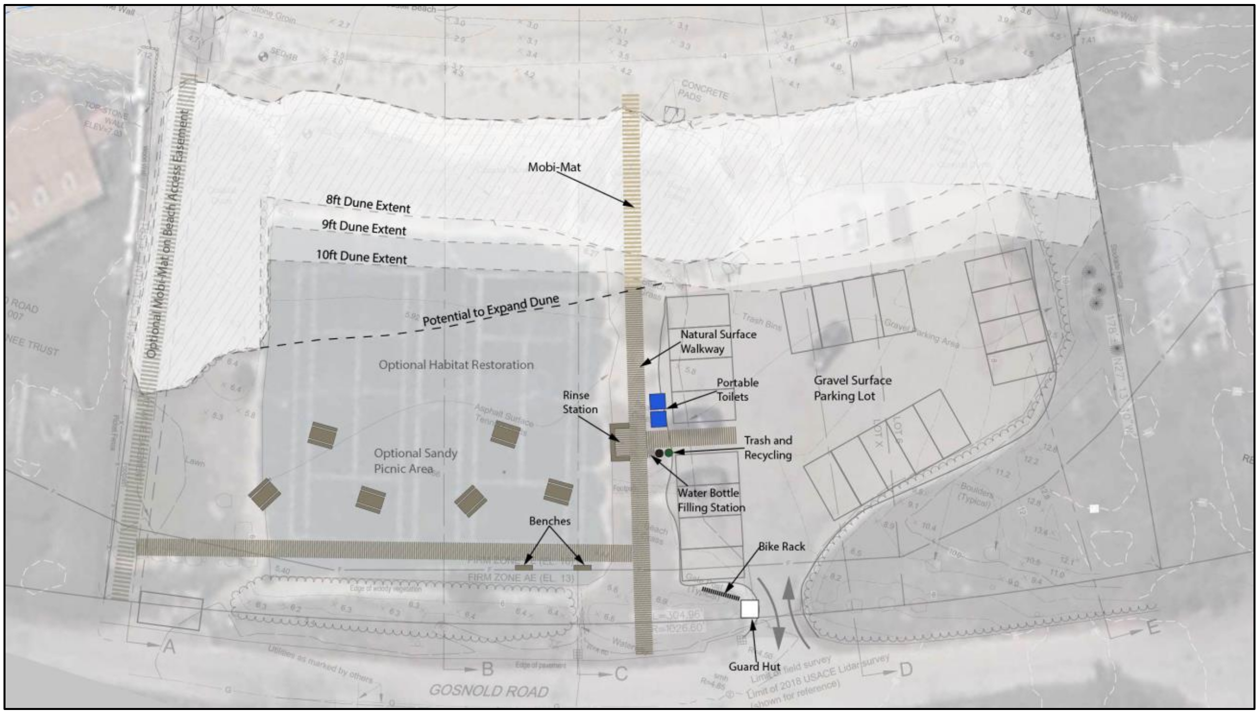


Figure 12: Option 1 for reconfiguration of the site landward of the restored dune.

Option 2: In this option, the parking lot redesign involves expanding its west-east extension and moving the northern boundary southward (Figure 13). This adjustment provides space for the dune to be designed with a gentler backslope and to naturally migrate landward in the future. Diagonal parking spaces would reinforce the proposed one-way traffic pattern, with vehicles entering through the eastern and exiting on the western side of the parking lot. The parking lot would be graded to allow stormwater to collect in a vegetated swale near Gosnold Road. A separate pedestrian entrance would cross the vegetated swale. Additionally, accessible parking spaces could be located next to the Mobi-Mat, providing the public with a seamless access point to the beach. This option includes a total of 30 parking spaces. Figures 14 and 15 show 3D renderings of Option 2.

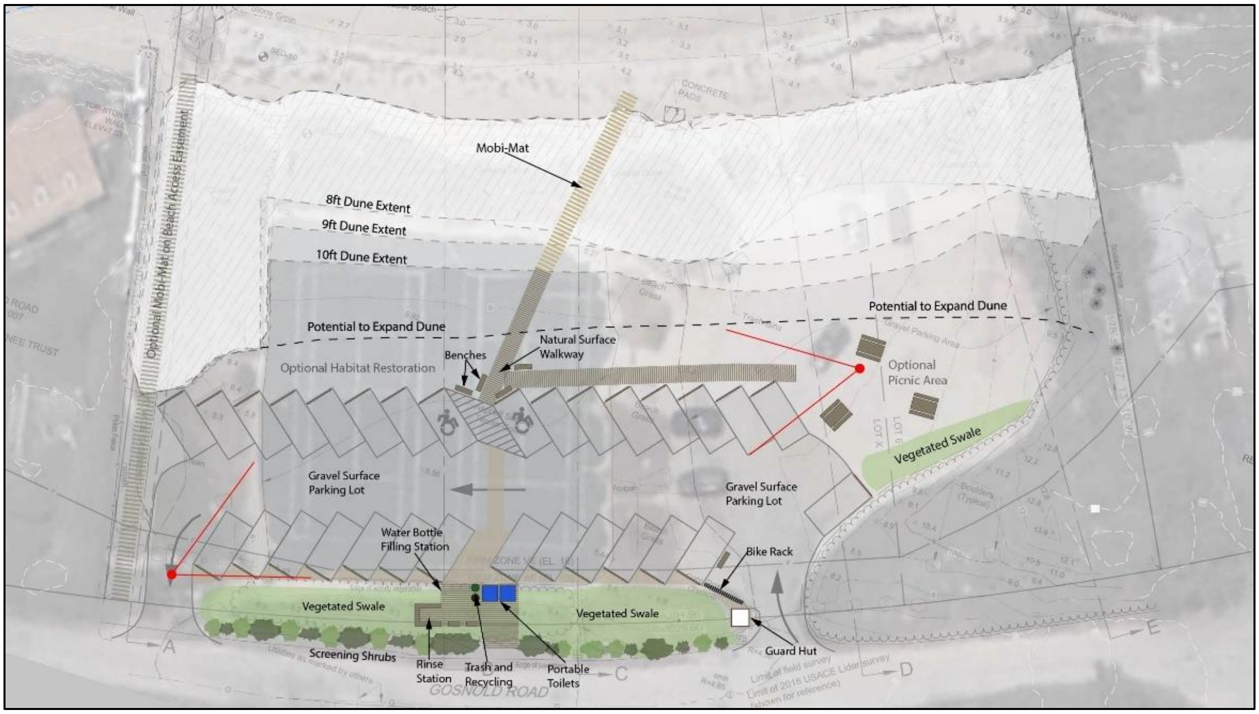


Figure 13: Option 2 for reconfiguration of the site landward of the restored dune.

Figure 14: Rendering of Option 2 from middle of the parking lot looking east.

Figure 15. Rendering of Option 2 from middle of the parking lot looking west.

<u>Option 3</u>: This option also includes a parking lot redesign but is shaped differently. The parking lot would be graded to allow stormwater to collect in a vegetated swale near Gosnold Road. A separate pedestrian entrance from Gosnold Road would cross the vegetated swale. Diagonal parking spaces would reinforce the proposed one-way traffic pattern, with vehicles entering through the eastern and exiting on the western side of the parking lot. Additionally, accessible parking spaces could be located next to the Mobi-Mat, providing the public with a seamless access point to the beach. This options allows for a total of 28 parking spaces. Figures 17 and 18 show 3D renderings of Option 3.

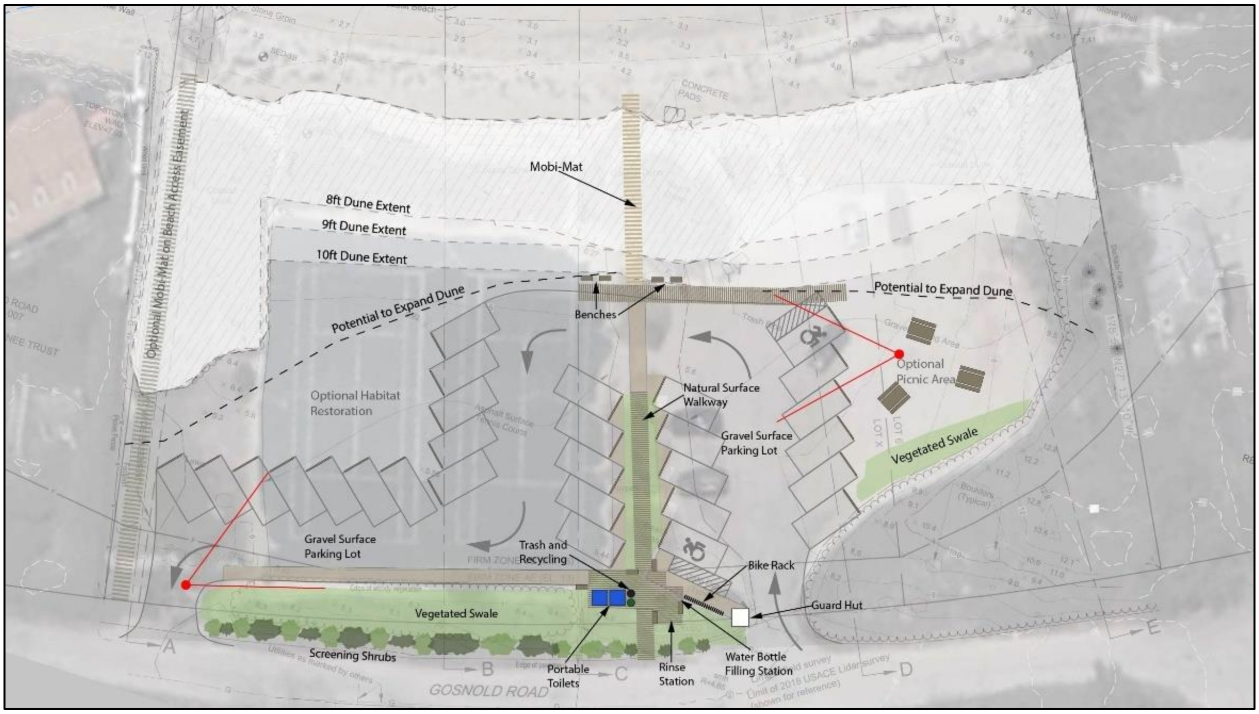


Figure 16: Option 3 for reconfiguration of the site landward of the restored dune.

Figure 17: Rendering of Option 3 from middle of the parking lot looking east.

Figure 18: Rendering of Option 3 from middle of the parking lot looking west.

4.0 ENVIRONMENTAL PERMITTING

Any project at Stoney Beach to nourish the coastal dune or beach, or to reconfigure the parking lot will require environmental permits. The permitting agencies and types of permits are listed below, along with triggers for regulatory review and recommendations for moving forward with the permitting.

Regulatory Agency:

Massachusetts Environmental Policy Act (MEPA) Unit

Type/Name of Permit or Approval:

Secretary's Certificate on the Environmental Notification Form (ENF); Secretary's Certificate on the Environmental Impact Report (EIR), if scoped by the Secretary during review of the ENF.

Trigger(s) for Regulatory Review:

301 CMR 11.03(3)(b) – If the final design includes both dune and beach nourishment, an ENF will be required as the project will trigger the need for a State permit and will involve alteration of a coastal dune and new fill in a FEMA velocity zone. However, if the project focuses only on dune nourishment with no fill below the mean highwater line, then a filing with MEPA would not be required.

Strategy & Considerations:

If the beach nourishment alternative is selected, it is recommend to file a detailed ENF with supporting documentation on alternatives considered, associated impacts, and rationale for selection of preferred alternative. With a more detailed ENF for a smaller project of this scale, it is not likely that the project would be scoped for an EIR.

Regulatory Agency:

Falmouth Conservation Commission

Type/Name of Permit or Approval:

Order of Conditions

Trigger(s) for Regulatory Review:

310 CMR 10.02(2)(a) – Any activity proposed or undertaken within a beach, dune, coastal wetland, land subject to tidal action, land subject to coastal storm flowage that will remove, fill, or alter that area.

FWR 10.38 – Any activity proposed or undertaken in Land Subject to Coastal storm Flowage that will remove, fill, or alter that area.

These regulations apply to the dune nourishment, beach nourishment, and parking lot reconfiguration parts of the project.

Strategy & Considerations:

Submit a Notice of Intent application after completion of the MEPA review process.

Regulatory Agency:

Mass Department of Environmental Protection Waterways Program

Type/Name of Permit or Approval:

Chapter 91 Permit

Trigger(s) for Regulatory Review:

310 CMR 9.04 – Licensing and/or permitting is required for all work in Commonwealth "trust lands", or current or filled tidelands below the mean highwater line.

310 CMR 9.05(2)(a) – A Chapter 91 Permit is required for any beach nourishment on flowed tidelands lying below the mean highwater line.

A Chapter 91 Permit would only be needed if the beach nourishment alternative is included.

Strategy & Considerations:

Submit application after issuance of the Order of Conditions from the Falmouth Conservation Commission (only if beach nourishment is included in the project).

Regulatory Agency:

United States Army Corps of Engineers (USACE)

Type/Name of Permit or Approval:

General Permit

Trigger(s) for Regulatory Review:

Section 10 of the Rivers and Harbors Act – Activities requiring authorization include the construction of any structure in, over or under any navigable waters of the US, or the excavating or dredging from or depositing of material in such waters. Navigable waters of the US are "those waters that are subject to the ebb and flow of the tide".

Section 404 of the Clean Water Act – Activities requiring authorization include the discharge of dredged or fill material into waters of the US. Waters of the US include more than navigable waters of the US and include jurisdictional wetlands.

General Permit 7. Dredging, Disposal of Dredged Material, Beach Nourishment, Rock Removal and Rock Relocation – General Permit required for beach nourishment in waters of the U.S. not associated with dredging.

A USACE General Permit would only be needed for the beach nourishment component of the project.

Strategy & Considerations:

Submit application after MassDEP Chapter 91 Permit application has been filed (only if beach nourishment is included in the project).

Regulatory Agency:

Mass Office of Coastal Zone Management

Type/Name of Permit or Approval:

Federal Consistency Determination

Trigger(s) for Regulatory Review:

Under authority granted by the Coastal Zone Management Act (CZMA) of 1972, the Commonwealth of Massachusetts Coastal Zone Management (CZM) office developed its own specific coastal zone management program. The CZMA gave Massachusetts the authority to review federal projects to ensure they meet state standards defined in the coastal zone management plan through a process called Federal Consistency Review. This Federal Consistency Review is required for projects that (1) are in or can reasonably be expected to affect a use or resource of the Massachusetts coastal zone, and/or (2) require a federal license or permit, receive certain federal funds, or are a direct action of a federal agency. During the MEPA/ENF review, CZM will determine whether an individual federal consistency review is required or if their federal consistency review can occur during the U.S. Army Corps of Engineers General Permit application process.

Strategy & Considerations:

If an individual federal consistency review is required, submit an application after all other permit applications have been filed.

5.0 CONSTRUCTION, OPERATIONS & MANAGEMENT COSTS

The total cost of the Stoney Beach restoration project varies based on the size of the dune chosen, whether or not beach nourishment is selected to accompany dune restoration, and which parking lot reconfiguration is chosen. Table 3 below shows the estimated costs of the alternatives discussed in Section 3.0 above.

Table 3. Cost Estimates for the Design Alternatives Considered for Stoney Beach.

Project Component		Cost	
Dune Restoration	8 ft - 174 cubic yards	$17,121	
	9 ft - 385 cubic yards	$36,960	
	10 ft - 680 cubic yards	$56,540	
Beach Nourishment	1,290 cubic yards	$76,279	
Parking Lot Reconfiguration	Option 1	$88,922	
	Option 2	$95,148	
	Option 3	$92,283	
		Dune Only	Dune & Nourishment
Design & Permitting		$17,500	$57,500
Maintenance (10-Year Period)		$14,135	$33,204
Total Project Cost Range (Dune Only)		**$137,678 to $183,323**	
Total Project Cost Range (Dune & Nourishment)		**$273,026 to $318,671**	

The dune nourishment costs range from $17,121 to $56,540. Costs shown for the dune nourishment include purchase of the sand, trucking, grading, and vegetation with beach grass. Costs for the beach nourishment are estimated to be $76,279 and include purchase of the sand, trucking, and grading in the nearshore area. All costs for dune and beach nourishment include a 15% contingency and 20% escalation for possible project construction in 2025.

The three parking lot reconfiguration alternatives carry a range of estimated costs from $88,922 to $95,148. The parking lot reconfiguration costs include purchase, trucking and regrading/spreading of the parking lot material, native plantings, and construction/plantings in the rain garden. Final cost estimates for the parking lot reconfiguration alternatives factor in a 15% contingency and 20% escalation for possible project construction in 2025. The cost estimates could increase or be minimized depending on material choices, planting design, and design and engineering costs.

Other costs to consider include permitting and maintenance. For the dune only option, final design and permitting costs for the project are estimated to be $17,500. If the project includes both the dune and beach nourishment components, the cost estimate for final design and permitting would increase to $57,500. The periodic addition of sand to repair storm damage of the dune and beach nourishment components of the project should be considered as a routine maintenance cost. These costs will vary depending on the dune design selected, whether or not beach nourishment is included, and the frequency and intensity of storms. Assuming the 10 ft NAVD88 dune is selected, cost estimates for maintenance over a 10-year period could range from

$14,135 for the dune only alternative, to $33,204 for the dune and beach nourishment alternative. These estimates assume that approximately 25% of material in the dune and/or nourishment design is lost from the system due to storm damage. A basic monitoring program to periodically assess the condition of the dune and beach would provide important data on the need for renourishment. This type of monitoring could be completed for approximately $1,500 per year, or at no cost through a citizen science program. Additional periodic maintenance costs to consider include regrading of the parking lot as well as cleaning and vegetation management in any rain gardens. These costs could be further developed as the layout and program of areas behind the dune are refined in further design.

There are a variety of grant programs that could be sought for the funding needed for final design, permitting, and construction of the project. While these grant programs generally require a 10 to 25% match by the local sponsor, the programs are designed to help project proponents and communities build resiliency to the impacts of rising sea levels and climate change.

6.0 TECHNICAL SUMMARY AND RECOMMENDATIONS

Results from the alternatives assessment, modeling of dune and beach nourishment performance, and evaluation of project costs were used to formulate a recommendation for moving forward with a nature-based solution that will reduce flood vulnerability to the Stoney Beach property and surrounding neighborhood. The recommendation includes implementation of the 10 ft NAVD88 dune with beach nourishment and one of the parking lot reconfiguration designs. While Option 2 provides the most room for natural migration of the dune in the future, additional input from landscape architects and traffic engineers should be sought to ensure the selected parking lot layout minimizes conflicts between pedestrians and vehicles. As summarized in Table 4 below, the total estimated cost for the recommended project, assuming Option 2 is selected for the parking lot layout, is $285,467. Once constructed, maintenance costs over a 10-yr period are estimated to be $48,205.

Table 4. Cost Estimates for Recommended Design Alternatives for Stoney Beach.

Project Component		Cost
Dune Nourishment	10 ft (680 cy)	$56,540
Beach Nourishment	1,290 cy	$76,279
Parking Lot Configuration	Option 2	$95,148
Design & Permitting Costs		$57,500
Total Project Cost Estimate		**$285,467**
Maintenance (10-Year Period)		**$48,205**

The project will enhance the existing dune which in turn will remove the flood pathway at Stoney Beach during higher frequency low energy storm events. The dune will provide a natural buffer against coastal flooding and the beach nourishment will extend the potential design life of the dune. Revegetation of the dune with beach grass plantings will help to stabilize the resource and trap windblown sediment which will facilitate future dune growth. Removal of existing hardscape around the tennis courts will allow recolonization by native back-dune vegetation, facilitate natural dune migration processes, and enhance infiltration of rainwater on site. Overall, the project utilizes a nature-based approach to improve flood resiliency while also enhancing the recreational and aesthetic aspects of the site.

Visual observations of the condition of the dune and beach nourishment, as well as periodic surveys will be an important part of the monitoring program, gathering important information on whether renourishment is needed. Monitoring should be considered a necessary part of the project to ensure continued effectiveness of the project. Continued outreach to the Woods Hole community, neighborhood residents, and direct abutters is also recommended to provide updates on the progress of project design, permitting, and construction. This continued communication will be important in maintaining support for the project.

7.0 COMMUNITY FEEDBACK

ResilientWoodsHole engagement included a series of three Neighborhood Working Group (NWG) meetings in 2023, providing an opportunity to solicit feedback on this project.

In March, the first set of meetings engaged individual NWGs in an overview of ResilientWoodsHole work to date (Phases 1, 2 and 3), including a detailed review of the neighborhood-specific dynamic adaptation policy pathways (DAPPs). These NWG meetings also provided an opportunity to introduce the Stoney Beach Restoration Alternatives Analysis project. The project team presented the scope and schedule for the project, a preliminary summary of project goals, and a draft Existing Conditions Plan. Community members in attendance expressed support for the project, consistent with prior survey results from Phase 3 in which respondents expressed preference for nature-based solutions for adaptation where feasible.

In June, the second set of NWG meetings provided an opportunity to conduct a detailed review of the range of building scale adaptation strategies for residential and commercial structures, as well as a follow-up review of neighborhood DAPPs. During these second meetings, the project team provided a progress update for the Stoney Beach project, including a presentation of modeling results and alternative design alternatives presented in this report. General support for the project persisted among NWG participants. Specific feedback, comments and concerns included:

- Support for maximizing the dune crest elevation on site to optimize protective value
  WHG Response: maximizing the dune to the adjacent tie-in elevations makes sense from a flood protection and dune longevity standpoint

- Support for habitat restoration, both for the dune and the back-dune environment
  WHG Response: this is consistent with the goals of a nature-based flood protection strategy and CZM's goals to restore natural processes in the coastal environment

- Support for configurations that facilitated natural dune migration
  WHG Response: this is consistent with the goals of a nature-based flood protection strategy and CZM's goals to restore natural processes in the coastal environment

- Concern about costs for construction and maintenance, as well as funding sources
  WHG Response: estimated construction and maintenance costs were not available for these meetings, but are provided in this report…if design/permitting/construction are pursued, grant money from a range of programs focused on climate resilience could be leveraged to offset the MBL's private investment

- Questions about expected lifespan of the dune, and frequency of renourishment
  WHG Response: modeled erosion from various return period water levels and waves is summarized in this report, and is the basis for renourishment estimates

- Suggestion of including a do-nothing alternative, leaving Stoney Beach as it is

  WHG Response: any alternatives analysis would include a do-nothing alternative…the existing conditions dune performance and flood modeling in this report indicate that a do-nothing alternative would not be conducive to building coastal resilience for Woods Hole

- Concern that investing extensively in this project may divert focus from more impactful, innovative solutions needed to build community resilience in other parts of Woods Hole

  WHG Response: considering the engineering and investment needed for more developed waterfront areas of Woods Hole, closing the Stoney Beach flood pathway with a natural dune replenishment is probably a comparatively low-cost solution

- Concern about loss of usable recreational beach area to dune replenishment, and discussion of tradeoffs of locating the dune further landward on the parcel at the expense of parking and amenities

  WHG Response: as shown in Figure 5, the dune replenishment would build landward from the toe of the existing dune and not encroach on the existing beach berm…further, the recommended beach nourishment to extend the life of the dune would also increase the size of the useable beach

- Support for design layouts that maintain or reduce parking rather than increase it, with suggestions to provide alternative transportation to/from Stoney Beach

  WHG Response: none of the proposed design layouts increase parking from what is estimated to exist at Stoney Beach's current unmarked parking lot

- Support for design layouts that minimize vehicle/pedestrian conflict, although opinions on which layouts achieved these goals differed (some people preferred one-way in and one-way out configurations, while others maintained that the existing in/out driveway was optimal in that it required vehicles to proceed with caution)

  WHG Response: these concerns should be addressed in future design with input from landscape architects and traffic engineers

In August, ResilientWoodsHole convened a third meeting – this time bringing all the NWGs together for an open house event. The meeting provided stations to engage on ResilientWoodsHole's prior work and obtain site-specific flood consultations from Barnstable County's Floodplain Coordinator. One of the stations included an overview of the Stoney Beach project restoration alternatives analysis and designs. Through conversations with the ResilientWoodsHole project staff and some written comments, meeting attendees expressed general support for the Stoney Beach project (Figure 19).

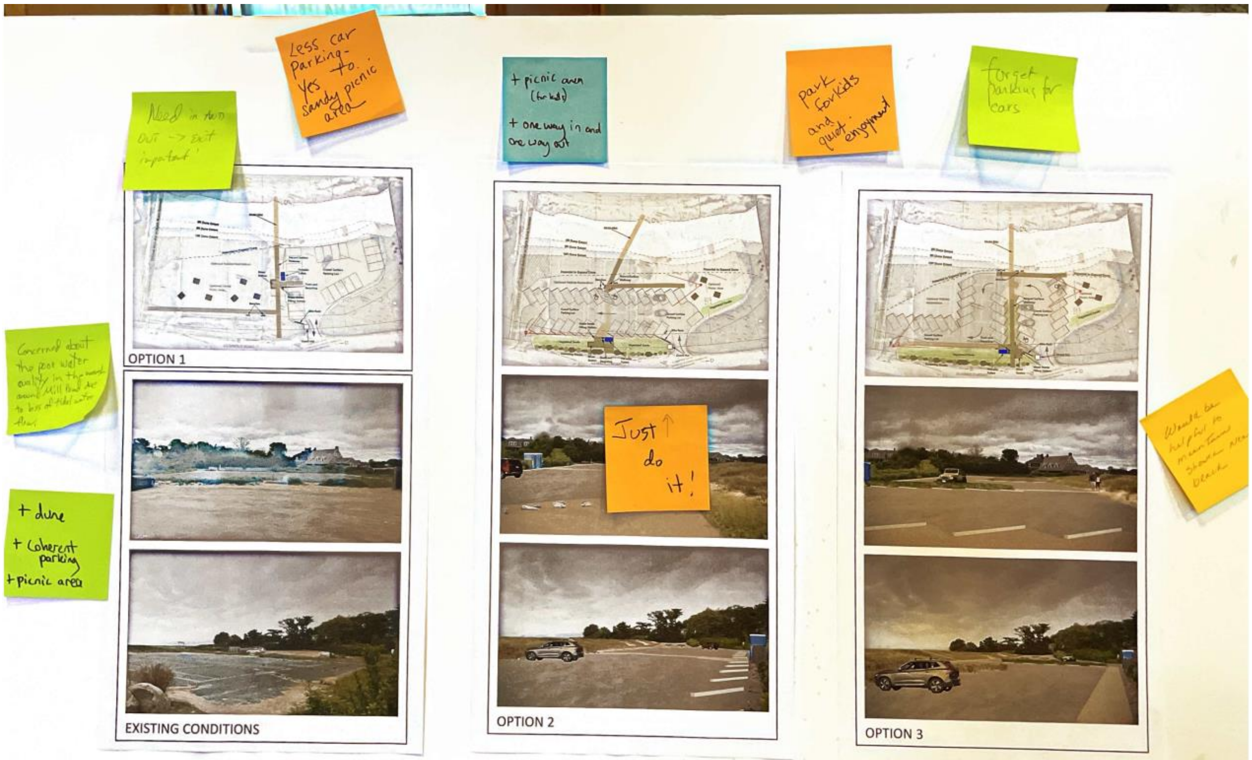


Figure 19: Community Meeting Feedback on Stoney Beach Project.

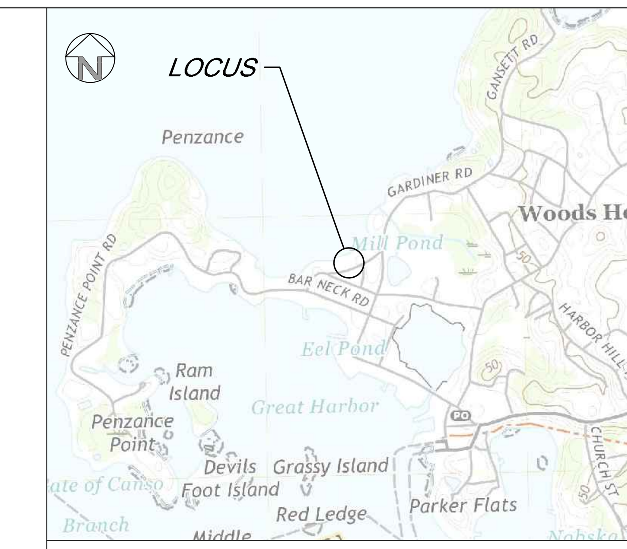
If the MBL elects to advance this project to selection of a preferred alternative, further design, permitting and construction, support from the community and abutters will be critical. The community engagement through this process has laid a solid foundation from which future dialogue and collaborative design can be developed.

8.0 NEXT STEPS

Next steps in the project include selection of the preferred design alternative(s) aimed at reducing flood vulnerability to the Stoney Beach property and surrounding neighborhood. Once a decision has been made on the preferred approach, the engineering design plans must be completed, and permit applications prepared and filed with the appropriate local, state, and federal regulatory agencies. It is expected that grant monies can be secured for this next design and permitting phase of work, which is estimated to take approximately 1 year to complete.

Once all environmental permits have been issued the project will be ready for construction. Grant monies should also be available to help with construction costs. The time of year for construction will be constrained to the winter months to avoid conflicts with summer use and minimize impacts to the environment. Construction should take approximately 1 month to complete.

ATTACHMENT A – EXISTING CONDITIONS PLAN



Location Map Not to Scale

NOTES:

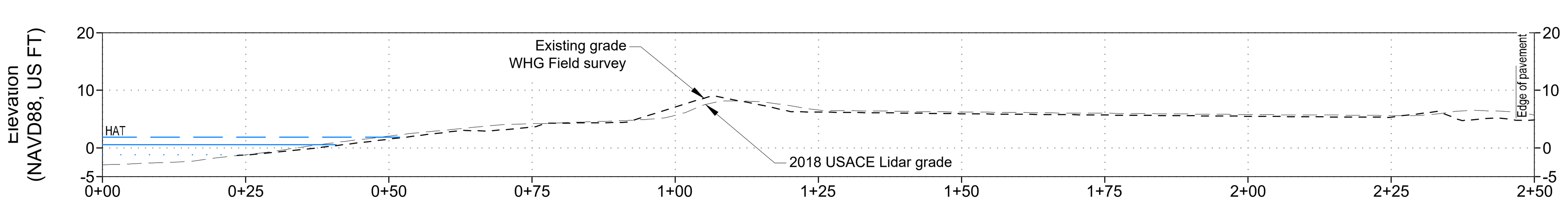
1. ADDRESS: #38 GOSNOLD ROAD (LOT X) & #0 GOSNOLD ROAD (LOT 6)
2. ASSESSORS NO.: 49A 06 039 000X & 006
3. OWNER: N/F MARINE BIOLOGICAL LABORATORY
4. ZONING DISTRICT: RESIDENTIAL/COMMERCIAL (RC)
5. FEMA FLOOD HAZARD ZONES: VE (EL. 16) & AE (EL. 13)
6. PLAN REFERENCE: PLAN BOOK 26 PAGE 35
7. TOPOGRAPHIC INFORMATION COMPILED FROM AN ON-THE-GROUND SURVEY CONDUCTED BY WOODS HOLE GROUP, INC. ON DEC. 19, 2022 AND FEB. 16, 2023.
8. VERTICAL DATUM: NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD88).
9. BENCHMARK: SEE PLAN.
10. ENTIRE SITE IS WITHIN LAND SUBJECT TO COASTAL STORM FLOWAGE.

LEGEND

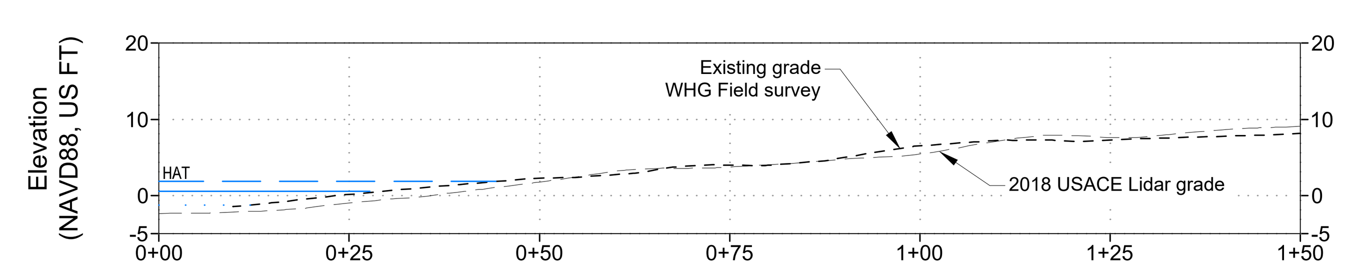
2 / 10	Existing Contours (Ground Survey)
x 1.5	Existing Spot Elevation (Ground Survey)
	Boundary of Existing Survey
2 / 10	Compiled topobathymetric Contours (2018 USACE Lidar)
	Wetland Resource Boundary
F	FEMA FIRM Flood Zone Boundary
R=7.91	Catch Basin rim elevation
	Tree - Deciduous
	Tree - Coniferous
G G	Gas Utility Lines (as marked by others)
W W	Water Utility Lines (as marked by others)
sb/dh	Stone bound with drillhole found
SED-1A	Sediment Sample Location

Datum Notes:
Elevations are referenced to NAVD88 datum.
HAT Elevation = 1.88
MHW Elevation = 0.56 ft
MLW Elevation = -1.23 ft
Tidal datums based on Woods Hole NOAA station.

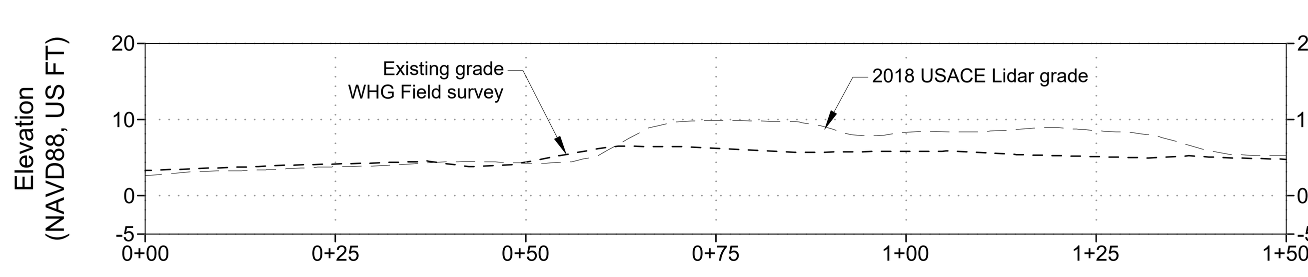
Graphic Scale
20 10 0 20 60
1" = 20'



Transect AA



Transect BB



Transect CC

WOODS HOLE GROUP
A CLS COMPANY
107 WATERHOUSE ROAD, BOURNE, MA 02532
TELEPHONE: (508) 540-8080 FAX: (508) 540-1001

Revisions	Date
1.	
2.	
3.	
4.	
5.	
6.	
7.	

Surveyed By:
Woods Hole Group
107 Waterhouse Road
Bourne, MA 02532
508-540-8080

Title:
Existing Conditions Plan
of
Stoney Beach
Prepared for:
Resilient Woods Hole

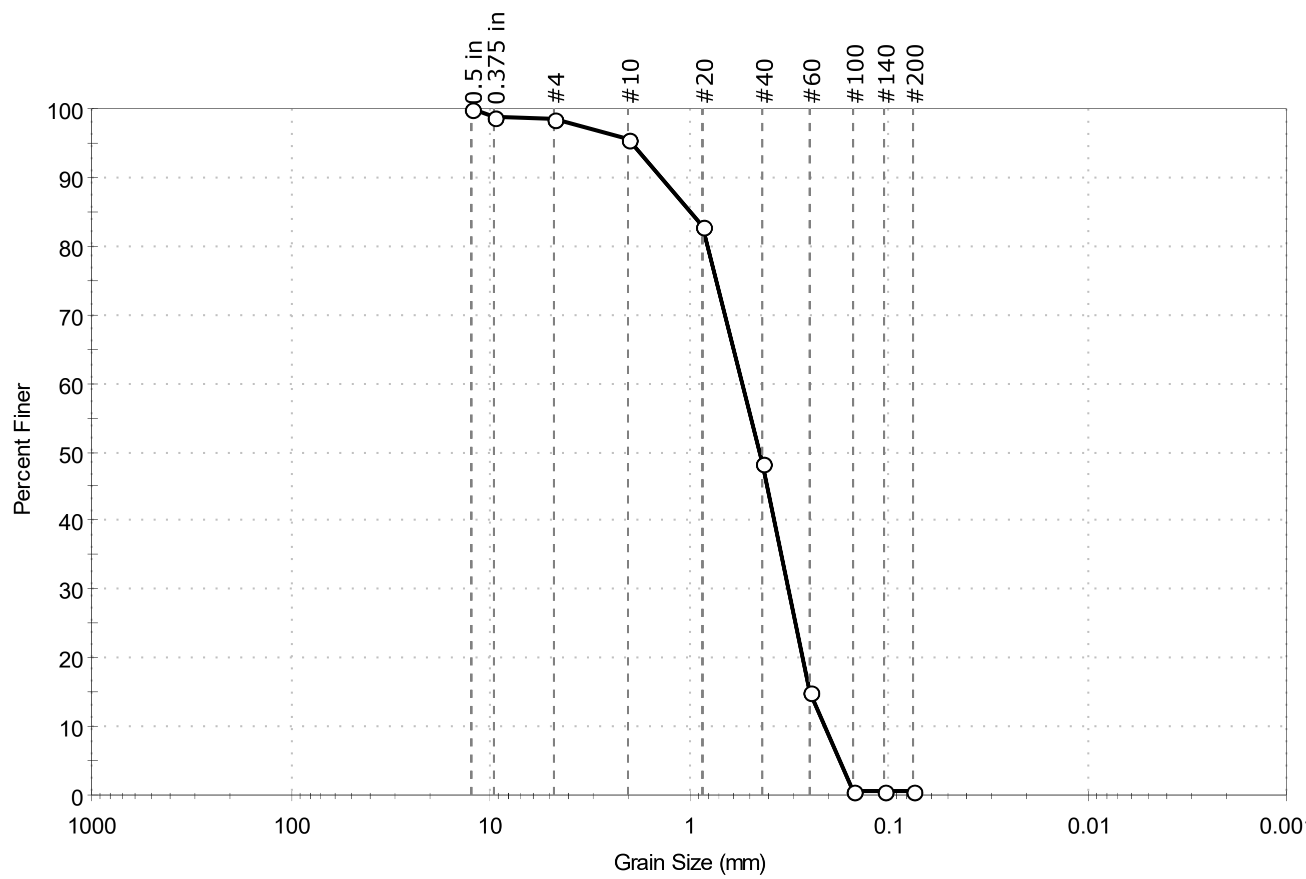
Project Number: 22-0116
Dwg File: 22-0116 WS.dwg
Scale: 1" = 20'
Date: Feb. 16, 2023
Approved:
Drawn: JRK

22-0116 WS.DWG

ATTACHMENT B – LABORATORY GRAIN SIZE ANALYSES

Client:	Woods Hole Group
Project:	Resilient Woods Hole
Location:	Woods Hole, MA
Project No:	GTX-316780
Boring ID:	---
Sample Type:	bag
Tested By:	ckg
Sample ID:	Sed - 1A - East Beach
Test Date:	02/17/23
Checked By:	ank
Depth :	---
Test Id:	705693
Test Comment:	---
Visual Description:	Moist, very pale brown sand
Sample Comment:	---

Particle Size Analysis - ASTM D6913



% Cobble	% Gravel	% Sand	% Silt & Clay Size
—	1.5	97.9	0.6

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
0.5 in	12.50	100		
0.375 in	9.50	99		
#4	4.75	98		
#10	2.00	96		
#20	0.85	83		
#40	0.42	48		
#60	0.25	15		
#100	0.15	1		
#140	0.11	1		
#200	0.075	0.6		

Coefficients

D_{85} =0.9793 mm
D_{30} =0.3177 mm
D_{60} =0.5372 mm
D_{15} =0.2504 mm
D_{50} =0.4397 mm
D_{10} =0.2098 mm
C_u =2.561
C_c =0.896

Classification

ASTM Poorly graded SAND (SP)

AASHTO Stone Fragments, Gravel and Sand (A-1-b (1))

Sample/Test Description

Sand/Gravel Particle Shape : ---

Sand/Gravel Hardness : ---

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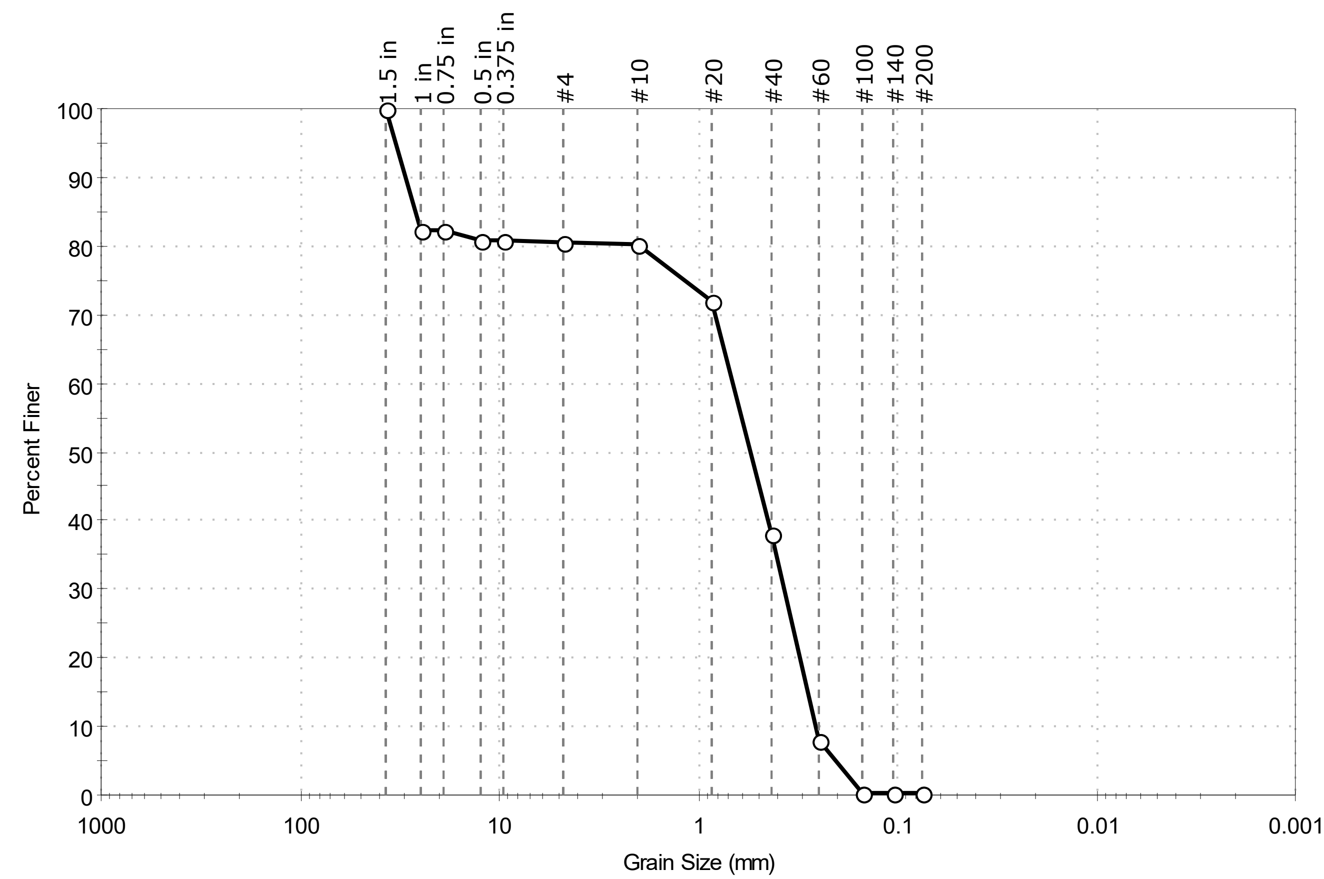
Client:	Woods Hole Group		
Project:	Resilient Woods Hole		
Location:	Woods Hole, MA	Project No:	GTX-316780
Boring ID: ---	Sample Type: bag	Tested By:	ckg
Sample ID: Sed - 1B - West Beach	Test Date: 02/17/23	Checked By:	ank
Depth : ---	Test Id: 705694		
Test Comment:	---		
Visual Description:	Moist, very pale brown sand with gravel		
Sample Comment:	---		

Particle Size Analysis - ASTM D6913



% Cobble	% Gravel	% Sand	% Silt & Clay Size
—	19.6	80.2	0.2

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
1.5 in	37.50	100		
1 in	25.00	82		
0.75 in	19.00	82		
0.5 in	12.50	81		
0.375 in	9.50	81		
#4	4.75	80		
#10	2.00	80		
#20	0.85	72		
#40	0.42	38		
#60	0.25	8		
#100	0.15	0.6		
#140	0.11	0.4		
#200	0.075	0.2		

Coefficients

D_{85} =26.5692 mm | D_{30} =0.3692 mm

D_{60} =0.6659 mm | D_{15} =0.2830 mm

D_{50} =0.5432 mm | D_{10} =0.2591 mm

C_u =2.570 | C_c =0.790

Classification

ASTM Poorly graded SAND with Gravel (SP)

AASHTO Stone Fragments, Gravel and Sand (A-1-b (1))

Sample/Test Description

Sand/Gravel Particle Shape : ---

Sand/Gravel Hardness : ---

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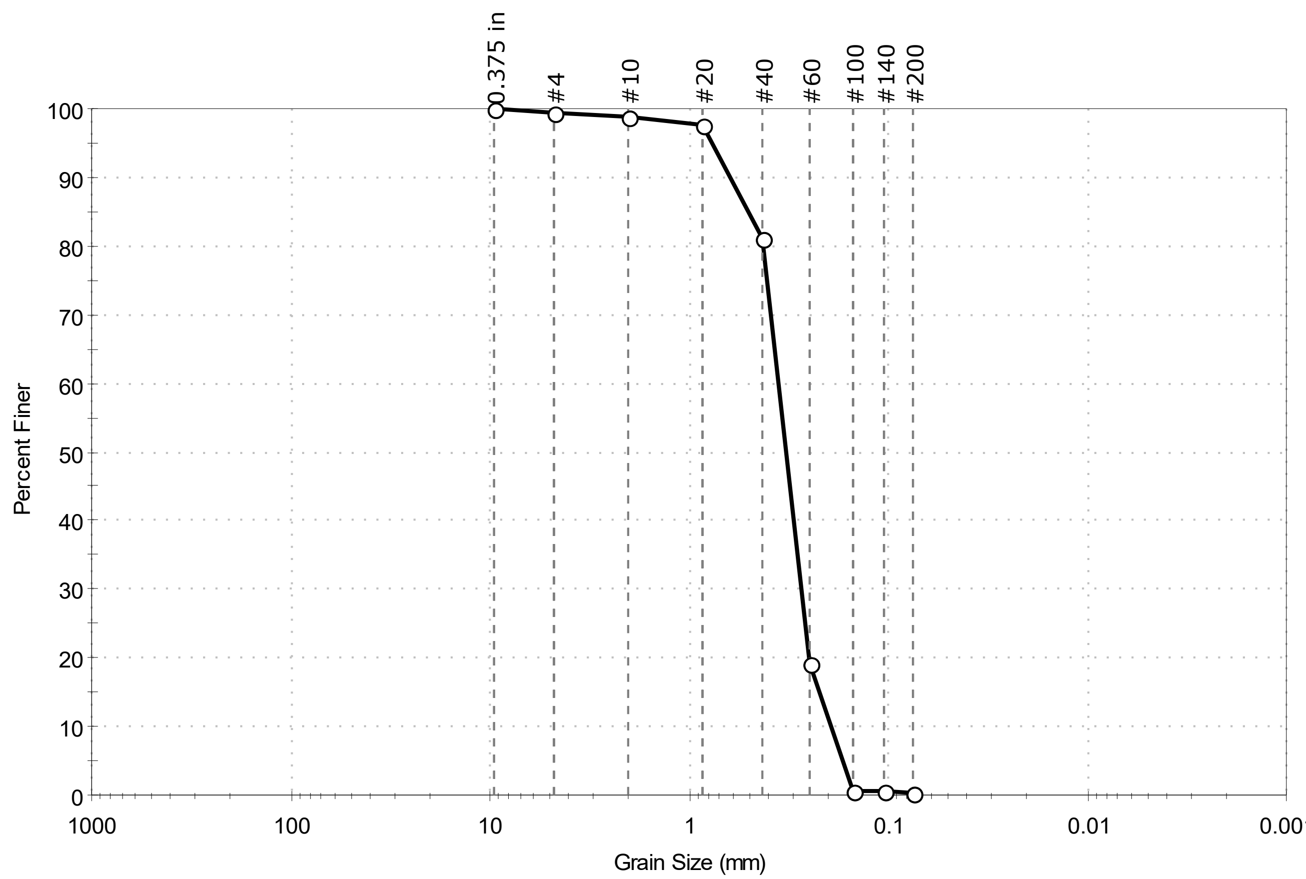
Client:	Woods Hole Group
Project:	Resilient Woods Hole
Location:	Woods Hole, MA
Project No:	GTX-316780
Boring ID:	---
Sample ID:	Sed - 2A - East Dune
Depth :	---
Sample Type:	bag
Test Date:	02/17/23
Test Id:	705695
Tested By:	ckg
Checked By:	ank
Test Comment:	---
Visual Description:	Moist, very pale brown sand
Sample Comment:	---

Particle Size Analysis - ASTM D6913



% Cobble	% Gravel	% Sand	% Silt & Clay Size
—	0.5	99.1	0.4

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
0.375 in	9.50	100		
#4	4.75	100		
#10	2.00	99		
#20	0.85	98		
#40	0.42	81		
#60	0.25	19		
#100	0.15	1		
#140	0.11	0.5		
#200	0.075	0.4		

Coefficients

D_{85} =0.5013 mm

D_{30} =0.2741 mm

D_{60} =0.3548 mm

D_{15} =0.2222 mm

D_{50} =0.3255 mm

D_{10} =0.1937 mm

C_u =1.832

C_c =1.093

Classification

ASTM Poorly graded SAND (SP)

AASHTO Fine Sand (A-3 (1))

Sample/Test Description

Sand/Gravel Particle Shape : ---

Sand/Gravel Hardness : ---

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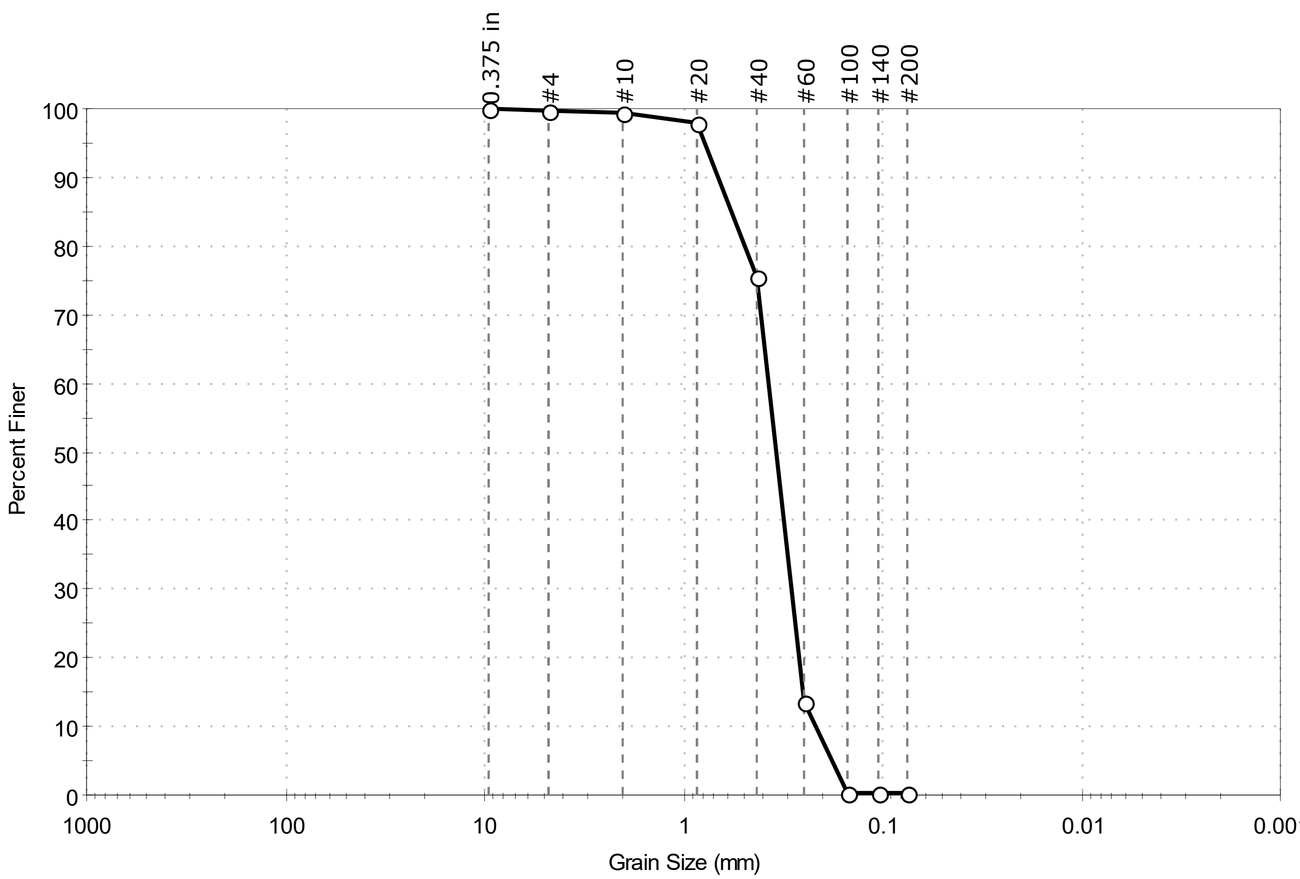
GeoTesting EXPRESS

Client: Woods Hole Group			
Project: Resilient Woods Hole			
Location: Woods Hole, MA		Project No:	GTX-316780
Boring ID: ---	Sample Type: bag	Tested By:	ckg
Sample ID: Sed - 2B - West Dune	Test Date: 02/17/23	Checked By:	ank
Depth : ---	Test Id: 705696		
Test Comment: ---			
Visual Description: Moist, very pale brown sand			
Sample Comment: ---			

Particle Size Analysis - ASTM D6913



% Cobble	% Gravel	% Sand	% Silt & Clay Size
—	0.4	99.4	0.2

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
0.375 in	9.50	100		
#4	4.75	100		
#10	2.00	99		
#20	0.85	98		
#40	0.42	75		
#60	0.25	14		
#100	0.15	0.5		
#140	0.11	0.4		
#200	0.075	0.2		

Coefficients

D_{85} =0.5711 mm　　D_{30} =0.2877 mm

D_{60} =0.3722 mm　　D_{15} =0.2529 mm

D_{50} =0.3416 mm　　D_{10} =0.2174 mm

C_u =1.712　　C_c =1.023

Classification

ASTM　Poorly graded SAND (SP)

AASHTO　Fine Sand (A-3 (1))

Sample/Test Description

Sand/Gravel Particle Shape : ---

Sand/Gravel Hardness : ---

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