New Hampshire Route 1A Revetment Reconstruction Phase 1: North Hampton and Rye

FY 2023 Promoting Resilient Operations for Transformative, Efficient, and Cost-Saving Transportation (PROTECT) Discretionary Grant Program: At-Risk Coastal Infrastructure Grant Application

New Hampshire Department of Transportation
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1. BASIC PROJECT INFORMATION

New Hampshire State Route 1A (NH Rt 1A) is a coastal roadway along the Atlantic Ocean maintained by the New Hampshire Department of Transportation (NHDOT). The 2016 NH Coastal Risk and Hazards Commission's report, *Preparing New Hampshire for Projected Storm Surge, Sea-Level Rise, and Extreme Precipitation*, identified the roadway as "the transportation asset most vulnerable to coastal flooding and disruption from sea-level rise" and "highly vulnerable…to storms." (page 25)[1]

Between North Hampton and Rye, 14 stone revetments and mortar rubble masonry walls (MRM walls) separate the roadway from the ocean. Given the proximity to the ocean, the roadway is susceptible during nor'easter coastal storms. Storm surge, waves, and wave overtopping contribute to roadway flooding and cause structural damage to the MRM walls and stone revetments and dislodge revetment stone into the roadway. NHDOT monitors the roadway during storms, implementing road closures until flood waters recede and maintenance crews are able to clear the roadway of revetment stone.

As the frequency and intensity of coastal storms increase and sea levels rise, the vulnerability of NH Rt 1A and the communities the roadway serves is increasing. With its role for first responder response and as an emergency evacuation route for both coastal storms and the Seabrook Nuclear Power Station, the resilience of NH Rt 1A is critical to the state's coastal communities.

During the series of nor'easters in March 2018, the MRM walls and revetments sustained significant damage. Through a planning study, conceptual repairs and improvements were identified for the revetments which incorporate measures to reduce storm-related road closures and NHDOT's post-storm clean-up efforts. NHDOT is currently engaging GZA GeoEnvironmental, Inc. (GZA) for the design of repairs and resilience mitigation measures, and to obtain the necessary regulatory environmental approvals and permits. The overall project covers approximately 3.2 miles between North Hampton and Rye and is subdivided into 14 sections: five MRM wall repair sections and nine stone revetment repair sections. The intent is for the 14 sections to be grouped into five construction contracts to be let over five years, upon securing regulatory approvals.

One of the first revetment priority projects includes three revetment reconstruction sections totaling approximately 0.6 miles located near the town line between North Hampton and Rye in the areas of Fox Hill Point and Rye Ledge. **Figure 1**, below, shows the proximity of one of the three revetments (Section 13) to both NH Rt 1A and the Atlantic Ocean. The project will mitigate wave overtopping impacts, improve revetment stone stability, and reduce post-storm clean-up by reconstructing with engineered revetments that are designed for the specific coastal exposures and wave conditions at each site, and incorporate sea level rise considerations.

It is for this initial priority construction project that NHDOT is applying for funding from the Department of Transportation's (DOT) Promoting Resilient Operations for Transformative, Efficient, and Cost-Saving Transportation (PROTECT) Discretionary Grant Program under the At-

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[1] NH Coastal Risk and Hazards Commission. *Preparing New Hampshire for Projected Storm Surge, Sea-Level Rise, and Extreme Precipitation* (2016). https://www.nhcrhc.org/wp-content/uploads/2016-CRHC-final-report.pdf

Risk Coastal Infrastructure category. NHDOT is applying for approximately $20 million, which represents approximately 80% of the total estimated construction costs for this priority project.

Figure 1: NH Rt 1A, Section 13 – Revetment with pedestrian path

1.1 Location

The NHDOT NH Rt 1A project is located in Rockingham County, which spans New Hampshire's coastline. Rockingham County is currently the second most populated county in the state and the fastest growing, with a 6.4% increase in population between 2010 and 2020 according to U.S. Census data. New Hampshire is becoming more diverse with a 74.4% increase in the number of residents identifying as a racial or ethnic minority according to the New Hampshire Fiscal Policy Institute's (NHFPI) *New Hampshire Policy Points: Population and Demographics* report from February 20, 2023. New Hampshire's overall population is aging with a median age of 43.1 years, which resembles other northern New England states.[2] In order to serve the area's growing and aging population in the face of climate change, it is imperative that NHDOT reduce the number and frequency of road closures along NH Rt 1A.

According to the *State of New Hampshire Multi-Hazard Mitigation Plan: Update 2018,* coastal flooding and storms are among the natural hazards threatening NH Rt 1A. One of the state's leading and growing industries is tourism to beaches, mountains, and lakes.[3] In addition to being a major local road for residents, NH Rt 1A provides access to the state's public beaches and coastal tourist amenities. The roadway also serves as a critical emergency evacuation route for both coastal storms and the Seabrook Nuclear Power Station.

NHDOT's overall NH Rt 1A coastal improvements project covers approximately 3.2 miles between North Hampton and Rye and is subdivided into 14 sections: five MRM wall repair sections and nine stone revetment repair sections (**See Figure 2**). NHDOT is beginning the reconstruction project in the southern portion of the state's coastline with repairs to the revetments at Sections 7, 10, and 13, which represent the greatest area of coastal storm vulnerability to NH Rt 1A (**See Graphics 1 through 3**). Running along the coastline between Little Boars Head and Sawyers Beach in the Towns of North Hampton and Rye, reconstruction of these revetment

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[2] NH Fiscal Policy Institute. *New Hampshire Policy Points: Population and Demographics* (February 20, 2023). https://nhfpi.org/blog/new-hampshire-policy-points-population-and-demographics/

[3] Homeland Security Emergency Management. *State of New Hampshire Multi-Hazard Mitigation Plan* (Update 2018). https://prd.blogs.nh.gov/dos/hsem/wp-content/uploads/2015/11/State-of-New-Hampshire-Multi-Hazard-Mitigation-Plan-Update-2018_FINAL.pdf

sections stands to significantly reduce road closures and post-storm roadway clean-up in coastal communities vulnerable to the increasing intensity and frequency of coastal storms and rising sea levels.

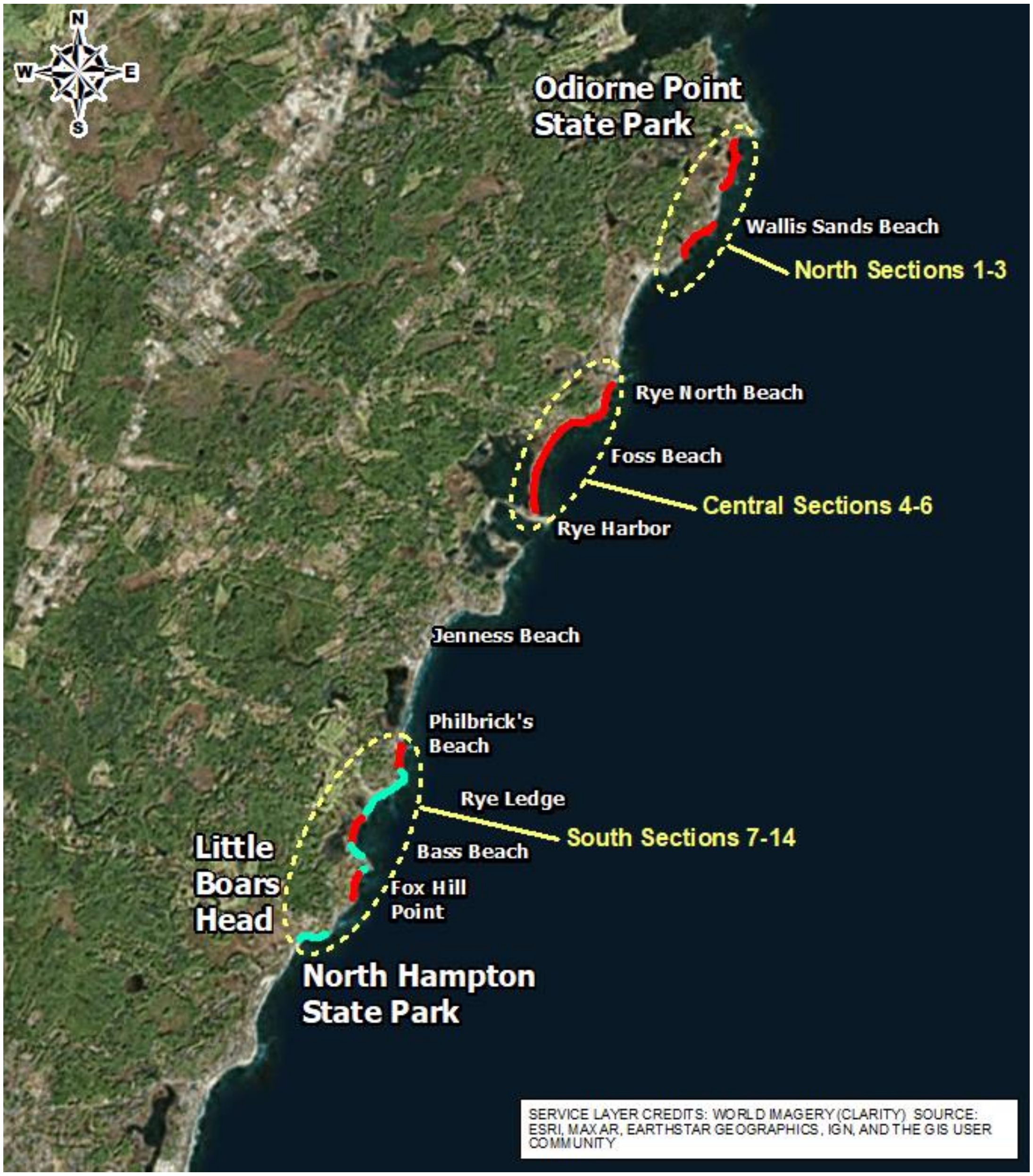

Figure 2: Shoreline Sections for revetment reconstruction (Revetment Sections shown with red outline. MRM Wall Sections shown in light teal outline.)

March 3, 2018
Storm Damage
(immediately north of Section 7)

NHDOT S.R. Section 7.kmz

Graphic 1: Section 7 located along Philbrick's Beach to just north of Rye Ledge in Rye, NH (959 linear feet)

March 3, 2018
Storm Damage

NHDOT S.R. Section 10.kmz

Graphic 2: Section 10 located along Bass Beach in North Hampton, NH (1,230 linear feet)

March 5, 2018
Post Storm Damage

NHDOT S.R. Section 10.kmz

Graphic 3: Section 13 located south of Fox Hill Point to north of Little Boars Head in North Hampton, NH (1,020 linear feet)

NH Rt 1A is located within the 1% annual chance flood hazard as defined by Federal Emergency Management Agency. Revetment Sections 7, 10, and 13 have crest elevations between EL 17[4] and 20 and are within VE zones with estimated elevations between EL 16 and 24 (**See Figure 3**). For comparison, NH Rt 1A is between EL 9 and 16 along these revetment sections.

[4] Elevations are measured in feet and reference the North American Vertical Datum of 1988 (NAVD88).

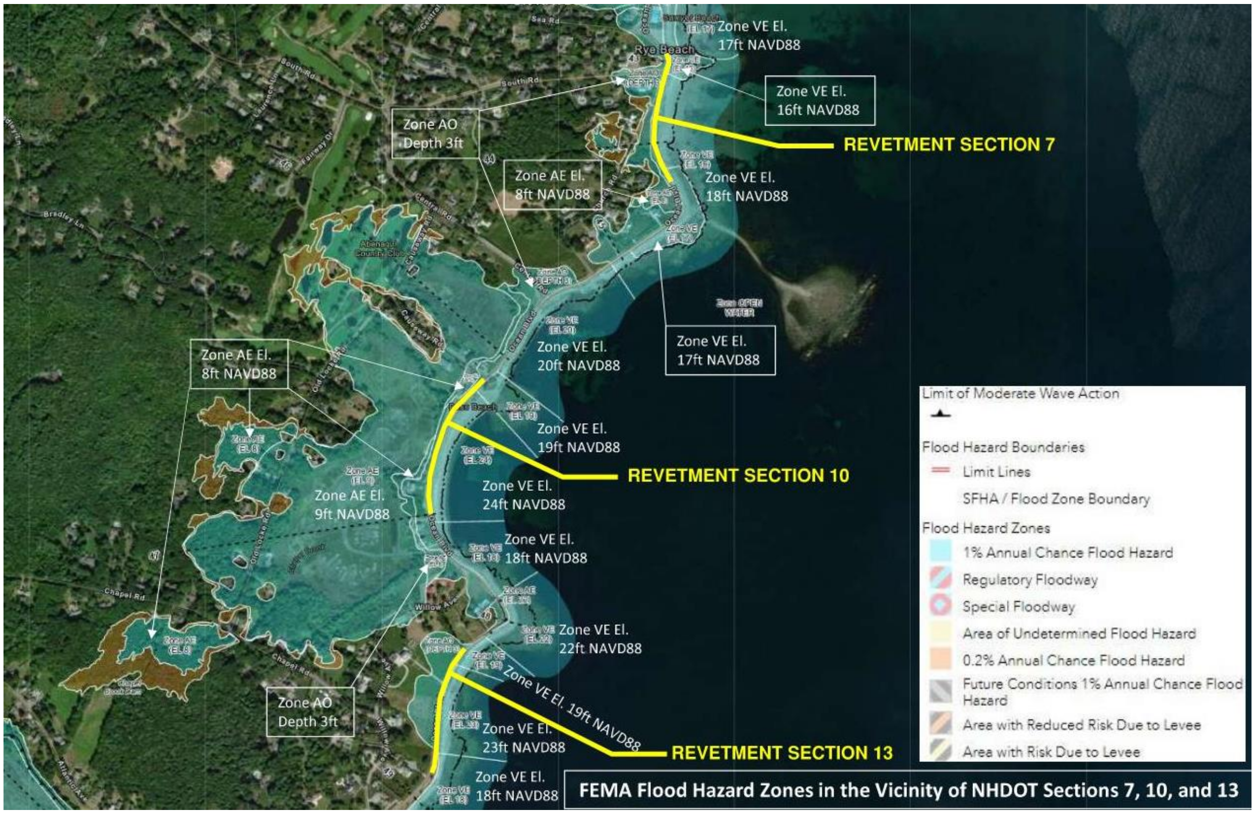

Figure 3: FEMA Flood Hazard Zones along NH Rt 1A Revetment Sections 7, 10 and 13 (FIRM Panel 33015C0434F effective 1/29/2021 and 33015C0432F effective 1/29/2021)

1.2 Project History

NHDOT archive records for repair of damage resulting from the storm of February 6 to 7, 1978, indicate that shoreline protection along NH Rt 1A either existed prior to that storm or was constructed as part of the post-storm emergency relief work. The shore protection included dry rubble sea walls (which have since been mortared), mortar rubble masonry walls, and shale piles protected on the oceanside slope with either a single layer of protective stone ("stone blanket") or layers of larger stone (revetment). There are no available records for the design of the 1978 construction, however, the record drawings do include annotations of field revisions made during construction. The annotations make reference to shale and armor stones that were placed but then removed by waves before construction was completed, providing insight into the exposure conditions. Annotations include references to shale stone that was "placed but disappeared" and shale stone "placed but will not remain due to backwash."

While the existing MRM walls and revetments (shale piles with stone blankets and revetments) provide some protection to NH Rt 1A, routine damage to the MRM walls and revetments and post-storm cleanup of the roadway have become more frequent and significant than in the past. Storm clean-up requires NHDOT maintenance personnel to utilize snow plows, roadway graders, front-end loaders, and other heavy equipment to remove shale and stone from the roadway and place it back on the revetment; repair the MRM walls, roadway shoulders, walking paths and related ancillary items; and complete drainage system inspections and clearing of storm debris. The level of effort and time required for storm clean-up varies by storm event intensity and timing relative to the tidal water levels.

During a series of nor'easters in March 2018, the MRM walls and revetments along NH Rt 1A sustained significant damage and required extended closures of NH Rt 1A. The storm damage led to an emergency declaration by the Federal Emergency Management Agency (FEMA). FEMA conducted site inspections of the revetments with NHDOT after the storms and issued their findings in November 2018. Subsequently, NHDOT engaged GZA to conduct a coastal revetment resilience study to assess the vulnerability of the revetments and develop conceptual revetment improvement recommendations with associated construction cost estimates. The study's recommendations included reconstruction options for in-kind repairs and for improvements to reduce storm-related road closures and NHDOT's post-storm clean-up efforts. The report was issued in 2021 and is posted on NHDOT's project web page North Hampton-Rye 42312 | Project Specific Information | Project Center | NH Department of Transportation.

While NHDOT does not have a State Resilience Improvement Plan for guidance, one is currently in development. The Department does incorporate resilience measures into projects. Recognizing the repetitive storm related costs along NH Rt 1A and the importance of the roadway to the communities and the state, NHDOT has engaged GZA for the *NH Route 1A Coastal Revetment Project*. The scope of work includes final design of repairs with resilience mitigation measures accounting for projected sea level rise and preparation of the necessary regulatory environmental approvals and permits. The overall project covers approximately 3.2 miles between North Hampton and Rye, and is subdivided into 14 repair sections: five MRM wall sections and nine stone revetment sections. The intent is for the 14 sections to be grouped into five construction contracts to be let over five years, upon securing regulatory approvals. The first priority project includes three revetment sections, Sections 7, 10, and 13, along the area with the greatest coastal storm vulnerability to NH Rt 1A. NHDOT is advancing the work such that construction can commence in the fall of 2025.

NHDOT used state funds to support data collection and initial design services for the 2021 resilience study and conceptual design report. Federal and state funding, including PROTECT Formula funds, Surface Transportation Block Grant (STBG) funding, Turnpike Toll Credits, and State DOT funds have been allocated in the NH State Fiscal Years 2023 to 2026 budgets for engineering, design, and permitting services to continue advancing the project in preparation of letting the projects out to bid for construction.

1.3 Parties

NHDOT is the lead applicant for this Promoting Resilient Operations for Transformative, Efficient, and Cost-Saving Transportation (PROTECT) Discretionary Grant Program application. NHDOT has extensive experience with the receipt and expenditure of Federal-aid highway program funds. Federal funding is used by NHDOT for all phases of project development on eligible roads and activities. Further, NHDOT administers the Local Public Agency program to support municipalities in following federal rules for locally managed projects funded with federal grants.

NHDOT contracted GZA, an interdisciplinary engineering and consulting firm with a strong coastal services practice, for the coastal revetment resilience study of the nine revetment sections along NH Rt 1A. The study report was issued in June 2021 and included conceptual revetment improvement recommendations. Since that time, GZA has continued to support NHDOT with information and data on the revetment sections for the Department's planning purposes.

NHDOT awarded GZA with the next phase of the project for final design of the MRM wall and revetment repairs and preparation of applications for permitting and regulatory approvals. Given the extent of regulatory permitting and approvals, GZA's team includes subconsultants for specialty services (**See Table 1)**. The GZA team will provide engineering, project oversight, and community engagement support services through the construction timeframes.

TABLE 1: NHDOT'S CONSULTANT DESIGN TEAM FOR COASTAL IMPROVEMENTS ALONG NH ROUTE 1A

Prime Consultant	
GZA GeoEnvironmental, Inc	Engineering analysis, final MRM wall and revetment designs, and environmental regulatory permit applications. Design team project management and execution. Construction administration support.
Subconsultants	
HNTB Corporation	NEPA documentation, public outreach, roadway and drainage design, traffic analysis.
Doucet Survey, Inc.	Topographical survey
Independent Archaeological Consulting, LLC	Phase IA archaeological sensitivity assessment
Preservation Company	Historic survey

2. GRANT FUNDS, SOURCES AND USES

NHDOT is applying for funds to support the first component of a five-phase reconstruction project to improve resiliency along NH Rt 1A. The full project includes 14 sections that will be divided into five construction contracts to be let over five years. NHDOT's first construction project includes revetment Sections 7, 10, and 13, which are the highest priority revetments based on vulnerability to coastal storms, the frequency of required roadway closures and post-storm cleanup and maintenance requirements.

To date, NHDOT has used state funds for data collection and the initial design services for the 2021 report. For the design and permitting phase between fiscal years 2023 and 2026, NHDOT has secured and allocated PROTECT Formula funds, Surface Transportation Block Grant (STBG) funding, Turnpike Toll Credits, and other state funds (See **Appendix A)**.

NHDOT respectfully requests funding from the PROTECT Discretionary Grant Program to support reconstruction of the first priority project encompassing revetment Sections 7, 10, and 13 as outlined in **Table 2** below.

TABLE 2: GRANT ACTIVITY BUDGET*

PROTECT Discretionary Grant Activities	Cost
Section 7	
Administrative and regulatory expenses	$54,000
Engineering and project oversight	$54,000
Revetment reconstruction	$4,500,000
Inflation allowance	$897,000
Project contingency	$826,000
Subtotal	*$6,331,000*
Section 10	
Administrative and regulatory expenses	$96,000
Engineering and project oversight	$96,000
Revetment reconstruction	$8,000,000
Inflation allowance	$1,594,000
Project contingency	$1,468,000
Subtotal	*$11,254,000*
Section 13	
Administrative and regulatory expenses	$66,000
Engineering and project oversight	$66,000
Revetment reconstruction	$5,500,000
Inflation allowance	$1,096,000
Project contingency	$1,010,000
Subtotal	*$7,738,000*
PHASE 1 TOTAL	**$25,323,000**
NHDOT Match funded by Turnpike Toll Credits	$5,064,600
TOTAL FUNDING REQUESTED	**$20,258,400**

* Construction costs are estimated based on conceptual designs included in GZA's 2021 study. A contingency of 15%, and inflation allowance of 3.7% are included to allow for changes in price and final design details.

Project element costs outside the scope of this grant are estimated in **Table 3** below. Current funding sources are summarized in **Table 4**.

TABLE 3: NH RT 1A PROJECT BUDGET BEYOND GRANT SCOPE

Non-PROTECT Discretionary Grant Activities	Cost
Data Collection Phase (Completed)	
Coastal revetment resilience study	$126,390
Design and Permitting (Current)	
Through final design and preparing permit applications	$3,725,000
Construction Phases 2 through 5 (Conceptual Cost Estimates, 2021 $)	
Section 1	$6,500,000
Section 2	$3,500,000
Section 3	$11,500,000
Section 4	$4,500,000
Section 5	$9,500,000
Section 6	$18,500,000
Sections 8, 9, 11, 12, and 14	$500,000
TOTAL	**$58,351,390**

TABLE 4: NH RT 1A CURRENT FUNDING SOURCES

Funding Secured		
Source	***Activity***	***Amount Allocated***
Surface Transportation Block Grant (STBG)	Design, permitting, and construction NH State FY 2023	$2,000,000
Turnpike Toll Credits	Design, permitting, and construction NH State FY 2023	$200,000
State DOT funds	Coastal revetment resilience study 2021	$126,390
State DOT funds	Permitting and Engineering NH State FY 2024	$180,000
State DOT funds	Right of Way and Construction NH State FY 2024	$5,050,000
	TOTAL	**$7,556,390**

3. MERIT CRITERIA

3.1 Vulnerability and Risk

NH Rt 1A is highly vulnerable to the effects of sea level rise and damage from coastal storms of both increasing frequency and intensity due to its proximity to the ocean and the existing conditions of the MRM walls and revetment structures.

3.1.1 Exposure

As part of the coastal revetment resilience study completed for the project, metocean data analyses (See **Appendix B**) and numerical wave model simulations using the SWAN (Simulating Waves Nearshore) model[5] were completed to evaluate nearshore and onshore wave transformation along the project area. The analyses were completed for the existing revetment geometries and the record archive 1978 revetment geometries. Current day storm water levels and projected sea level rise conditions were evaluated for each of the geometries considered. For the 10-year, 50-year, and 100-year flood recurrence intervals, the revetements were evaluated for potential damage to the revetment and potential use impacts to the NH Rt 1A roadway. The following evaluations were completed:

- Comparison of existing D_{50} stone size on the ocean side to the calculated D_{50} stone size required for the wave conditions.
- Occurrence of wave overtopping and flowrate impacts to vehicular use along NH Rt 1A.
- Occurrence of wave overtopping and flowrate impacts resulting in displacement of shale stone from the crest and roadway-side slope (backslope) of the revetment.

Summary tables of the results for the above evaluations are included in **Appendix C**. A complete narrative is included in the 2021 conceptual design report (North Hampton-Rye 42312 | Project Specific Information | Project Center | NH Department of Transportation). The general conclusions of the evaluations include:

[5] Delft University of Technology. *SWAN.* https://www.tudelft.nl/en/ceg/about-faculty/departments/hydraulic-engineering/sections/environmental-fluid-mechanics/research/swan

- Average existing D_{50} stone is undersized for current water levels with the 50-year and 100-year flood recurrence intervals, and is undersized for projected sea level rise with the 10-year through 100-year flood recurrence intervals.
- Unsafe driving conditions occur on NH Rt 1A along approximately 50% of the revetment sections for the 10-year flood recurrence interval. Driving conditions are unsafe at all but one revetment section with the 50-year flood recurrence interval, and are unsafe at all revetment sections with the 100-year flood recurrence interval.
- Under projected sea level rise conditions, roadway use becomes unsafe over the majority of the revetments for the 10-year flood recurrence interval and over all of the revetments for the 50-year and 100-year flood recurrence intervals. See **Appendix D** for sea level rise and wave runup overtopping impacts to NH Rt 1A along Sections 7, 10, and 13.
- Potential for wave overtopping to displace unprotected shale stone from the revetments begins under existing water levels and the 10-year flood recurrence interval. The potential increases with the 50-year and 100-year flood recurrence intervals for the current water levels. Under projected sea level rise conditions, the analyses suggest that the majority of the revetments will experience shale displacement over the full length of the revetment section.

NHDOT's revetment reconstruction project will reduce the exposure vulnerability of NH Rt 1A to storm damage by reconstructing the revetments with outer stone sized for the site-specific wave environment under projected sea level rise conditions, and by protecting the revetment crests and backslopes from wave overtopping damage.

3.1.2 Sensitivity

The conceptual design recommendations for the revetments along NH Rt 1A[6] were based on analyses of the revetments under various storm conditions, water levels, and projected sea level rise. The results of the analyses provided the metric for establishing the sensitivity of the revetments to their site-specific exposure conditions. The results of the analyses were corroborated by the types of revetment damage observed after the March 2018 storms.

Post-storm damage documentation by NHDOT provided evidence of the damage that was expected by the storms based on the metocean data analyses and numerical wave model simulations. The analyses showed that the most significant vulnerability in terms of impacts to NH Rt 1A is the erosion and displacement of shale material from the revetment crest and backslope. Wave runup and overtopping flow velocities that exceed stability of the shale material leads to erosion of the crest and backslope, scour, and deposition of shale as overwash in the roadway. Such revetment damage and roadway vulnerability are supported by NHDOT's documentation of the March 2018 storms. See **Figures 4 through 6** for examples of post-storm damage.

[6] 2021 Conceptual Design Report at https://www.nh.gov/dot/projects/northhamptonrye42312/index.htm

Figure 4: Evidence of Revetment Damage After March 2018 Storms

Figure 5: Evidence of Unprotected Shale Damage from Wave Overtopping After March 2018 Storms

Figure 6: Stone Overwash Cleanup After March 2018 Storms

The degree of revetment vulnerability varies for, and within, each section of revetment based on exposure conditions and revetment geometry. However, each revetment section has similar conditions affecting integrity and performance. Multiple storm events have displaced armor stone on the ocean side of the revetments. Displaced armor stone reduces the stability and effectiveness of NH Rt 1A's revetments and increases their vulnerability to subsequent storms/wave loads. The revetments' stability is further compromised by a lack of filtration beneath the existing armor stone. The lack of a filtration layer contributes to piping and erosion of revetment core material, which deteriorates the armor stones' foundation. Further, at certain locations, the existing armor stone is significantly undersized for current wave loads.

NHDOT's revetment reconstruction project will reduce the sensitivity of the revetments to a wider range of storm conditions by reconstructing the revetments with outer stone sized for the site-specific wave environment under sea level rise conditions, and by protecting the revetment crest and backslope from wave overtopping damage. Thus, the project mitigates storm damage and the resulting impacts to NH Rt 1A.

3.1.3 Adaptive Capacity

NHDOT's revetment reconstruction project is inherently adaptive to the coastal environmental conditions. The design of the revetments is based on various flood recurrence intervals (storms) and a projected +2 foot sea level rise in accordance with the *NH Coastal Flood Risk Summary Part II*: *Guidance for Using Scientific Projections*[7] and a low risk tolerance for NH Rt 1A.

3.2 Criticality to Community

NH Rt 1A is a primary roadway running North-South in Rockingham County, providing access to New Hampshire's most popular beaches, working waterfronts, and tourist amenities.[8] As climate change increases the frequency of storm and flood events, it is imperative that NHDOT reduce NH Rt 1A closures and post-storm cleanup due to coastal storms. Extended road closures impact emergency responders' ability to reach coastal residential communities; block evacuation routes for residents and tourists for both coastal storms and Seabrook Nuclear Power Station; and cause traffic congestion on surrounding roads that impacts residents, tourists, and commuters.

Under current conditions, storm surge, waves, and wave overtopping contribute to roadway flooding and cause structural damage to the stone revetments which dislodges revetment stone into the NH Rt 1A. Improvements to the revetments will stabilize the structures and their stone components, thereby reducing the time and effort required to clear the roadway following storm events and the frequency and duration of road closures. As an example, during the March 2018 storms which coincided with high tides, the extensive damage to the revetments required road closures along portions of NH Rt 1A for extended periods of time during the storm and during cleanup (See **Table 5)**.

TABLE 5: MARCH 2018 NH ROUTE 1A
CUMULATIVE FULL ROADWAY CLOSURES ALONG REVETMENT SECTIONS

Revetment Section	1	2	3	4	5	6	7	10	13
Cumulative Full Roadway Closure Time (Hours: Minutes)	3:52	3:52	3:52	23:52	23:52	16:56	15:55	37:36	37:36
Number of Full Roadway Closure Periods	1	1	1	4	4	4	4	8	8

Between 2011 and 2021, portions of NH Rt 1A were closed for the equivalent of approximately seven full days following storm events. Portions of Sections 7, 10, and 13 included in this grant application were closed for the equivalent of more than three full days between 2011 and 2021. See **Appendix E** for a record of road closures along NH Rt 1A from 2011 to 2021.

On average 2,000 to 9,000 vehicles use NH Rt 1A per day, with up to 10,000 vehicles using the road per day during peak summer months. Tourism is one of New Hampshire's primary industries and the coastline is a popular tourist destination. Hampton Beach, in particular, provides important revenue to the state economy. NH Rt 1A is the primary access to Hampton Beach, all coastal State Beach Parks, as well as other tourist attractions. Essential elements of this project are part of the

[7] New Hampshire Coastal Flood Risk Science and Technical Advisory Panel. *New Hampshire Coastal Flood Risk Summary, Part II: Guidance for Using Scientific Projections* (2020). https://scholars.unh.edu/ersc/211/
[8] Rockingham Planning Commission. *Seacoast Transportation Corridor Vulnerability Assessment & Plan* (2022). https://www.therpc.org/STCVA

Rockingham Planning Commission's (RPC) Seacoast Transportation Corridor Vulnerability Assessment and Resiliency Plan Site Prioritization list (page 26).[9]

In addition to inhibiting travel for those living on and visiting the coast, extended closures for coastal storm events cause congestion on nearby roads as traffic is diverted. These detours limit the mobility of residents; increase response times for first responders; and interrupt the emergency evacuation route for coastal storms and the Seabrook Nuclear Power Station.

3.3 Design Elements

NHDOT's intent for the revetment reconstruction project is to mitigate erosion and displacement of the revetment shale core and improve armor stone stability to improve resiliency of the overall revetment structures, and thereby decrease maintenance requirements and cleanup of NH Rt 1A following storm events. In considering that the science around climate change and sea level rise projections is dynamic, the revetment reconstruction project is based on a 2050 design horizon (reflecting an anticipated 25-year design life) and a sea level rise projection for a low risk tolerance for NH Rt 1A. The proposed geometries for the revetment reconstruction also consider the 1978 design geometries, the existing geometries, and the feasibility for significant deviations without requiring roadway reconstruction, right-of-way conflicts, or "taking" of the natural resource area. The resulting designs are a balance of each of these factors and the site-specific coastal exposures.

An overview of the observed revetment conditions in 2020 and the conceptual revetment cross section for revetment Sections 7, 10, and 13 are included in **Appendix F**. The conceptual cross sections reflect engineered revetments consisting of the existing shale stone as the revetment core with geotextile and a system of filter stone, armor stone on the ocean side slope and crest, and layers of riprap on the roadway side backslope. Because of the direct ocean exposure and wave action at the sites, nature-based solutions were determined to be infeasible for this project. The following parameters were factors in developing the revetment reconstruction cross sections:

- Crest elevation set at the greater of the existing crest elevation and the 1978 crest elevation.
- Crest width similar to existing conditions, including a pedestrian walkway if one currently exists.
- Ocean side slope of 2.0 to 2.5 horizontal to 1 vertical with a toe location approximately similar to existing conditions to limit additional regulatory permitting considerations and extending further into the natural resource.
- Ocean side armor stone sized for wave conditions and stability based on the 100-year flood occurrence interval + 2 feet of sea level rise. Armor stone specifically placed for interlocking and roughness to dissipate wave energy.
- Backslope of 1.5 to 2.0 horizontal to 1 vertical with a toe location approximately similar to existing locations to maintain NH Rt 1A shoulder width, drainage, and existing right-of-way.
- Backslope stone equivalent to NHDOT Class III riprap (12-inch nominal width, 24-inch maximum width) to protect the shale core from displacement during wave overtopping flow rates.

[9] Rockingham Planning Commission. *Seacoast Transportation Corridor: Vulnerability Assessment and Resiliency Plan* (March 2022). https://www.therpc.org/application/files/3816/6196/9236/STCVA_Plan_FINAL_08312022.pdf

While the conceptual revetment cross-sections will reduce duration of roadway closures and post-storm cleanup-up resulting from dislodged revetment stone, they are not focused on reducing the frequency of roadway flooding. Flooding is anticipated to occur during storm events with wave overtopping and backwater flooding (floodwaters entering into the estuary and flooding the roadway from the estuary side). Mitigation for addressing backwater flooding will require a broader evaluation and more comprehensive approaches with collaboration between NHDOT, the municipalities, the regional planning commission, and numerous local, state, and federal agencies.

However, the revetment reconstruction project is an initial step to increase the resiliency of NH Rt 1A by reducing physical hazards, road closures, and repetitive maintenance and cleanup expenditures by NHDOT, the municipalities, and private land owners to repair damage resulting from nor'easter coastal storms. In addition, by reducing road closures and detours, the revetment reconstructions will improve access to local resources, amenities, businesses, and homes and increase safety for residents, visitors, and emergency response personnel during and immediately after coastal storm events.

3.3.1 Maintenance Plan

NHDOT will continue to maintain NH Rt 1A and the associated revetments through NHDOT's maintenance and winter storm budget. Because the revetment reconstruction projects will reduce the repetitive costs for road closures and post-storm clean-up of the roadway, it is expected that maintenance costs for the reconstructed revetments will be substantially reduced to NHDOT personnel performing:

- Routine revetment conditions inspections,
- Routine inspections of drainage outfalls through the revetments, and
- Post-storm revetment and outfall condition inspections

If revetment damage is identified in the future, NHDOT will contract with a design consultant to determine the necessary repairs and with a qualified contractor to complete the work. Estimated costs for repairs cannot be projected as they are wholly dependent on the type and extent of damage.

3.4 Public Engagement, Partnerships and Collaboration

NHDOT has begun initial community engagement for the project. A project web page provides the project status, NHDOT contact information and project files and information. Please see North Hampton-Rye 42312 | Project Specific Information | Project Center | NH Department of Transportation. As the project advances, NHDOT and the consulting design team will engage and inform the public through project materials and targeted community outreach including, but not limited to:

- Distributing informational cards about the project to municipal officials to assist them with informing their communities.
- Conducting meetings with public officials and emergency response leaders in North Hampton and Rye.
- Conducting two or more public information meetings in both towns, Rye and North Hampton, to provide project updates and collect feedback.
- Conducting a public hearing as part of the NEPA process.
- Updating the NHDOT project website throughout design, permitting, and construction.

NHDOT anticipates engaging with the Rockingham Planning Commission and the NH Coastal Adaptation Workgroup (NH CAW) to share information to better inform the revetment reconstruction project and to provide project awareness for other local projects that may be advancing on similar timelines and require coordination to minimize construction impacts to the community. NHDOT is a member of NH CAW, which is a collaboration of various organizations including NH Department of Environmental Services, NH Fish and Game, coastal municipalities, NOAA, The Nature Conservancy, Sea Grant NH, University of NH, Seabrook-Hamptons Estuary Alliance, Great Bay National Estuarine Research Reserve, GZA, and others. NH CAW assists communities in the state's coastal watershed to "prepare for the impacts of extreme weather and long-term climate change by providing resources, facilitation, and guidance that enhance readiness and resilience."[10]

NHDOT is already engaged with the NH Homeland Security and Emergency Management (HSEM) for this project, as well as FEMA and the Federal Highway Administration.

3.5 Equity and Justice40

According to the Climate and Economic Justice Screening Tool's Climate Change measures, the Town of Hampton, which NH Rt 1A runs through, includes a disadvantaged area (**See Figure 7**). The tract is in the 98th percentile for projected flood risk, and the 68th percentile of residents with low incomes.[11] Additionally, off-season rentals throughout coastal New Hampshire serve lower income households who struggle to secure market-rate housing.

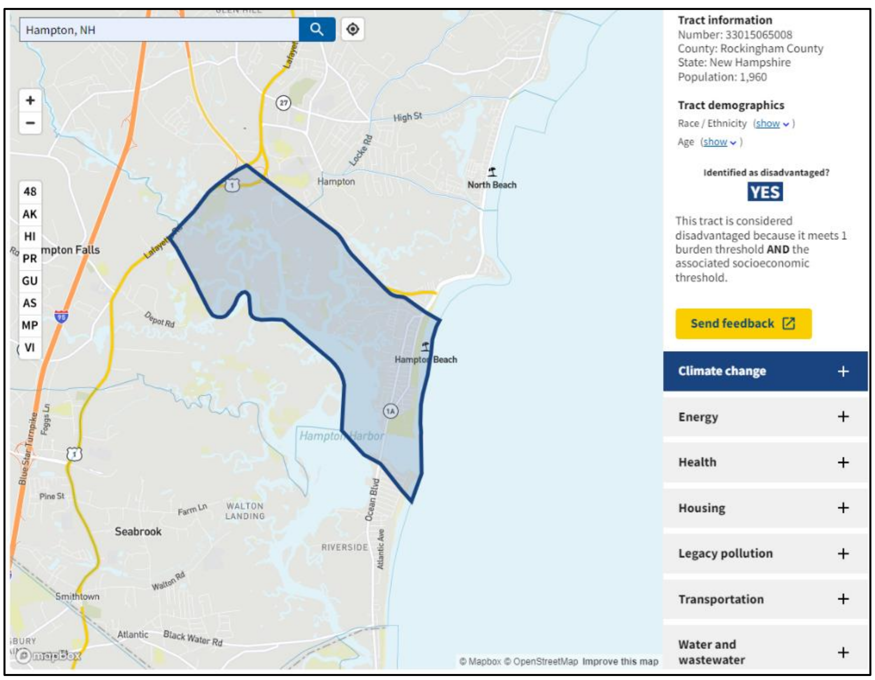

Figure 7: Climate and Economic Justice Screening Tool: Hampton, NH

[10] New Hampshire Coastal Adaptation Workgroup. *Our Mission* (2023). https://www.nhcaw.org/what/our-mission/
[11] Climate and Economic Justice Screening Tool. *Explore the Map* (2023). https://screeningtool.geoplatform.gov/en/#12.33/42.91058/-70.82484

NH Rt 1A serves an aging population, with most communities along the coastal corridor in the 80th to 98th percentile for number of residents over the age of 64, according to the EPA's Environmental Justice Screening and Mapping Tool.[12] (**See Figure 8**.) Extended road closures hinder aging residents' access to evacuation routes and essential services.

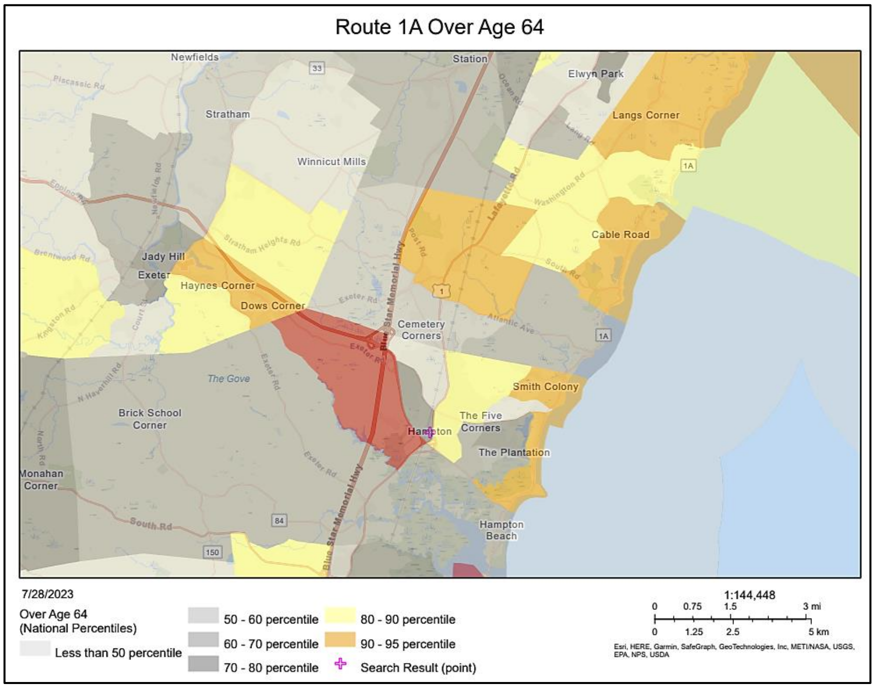

Figure 8: EJScreen map showing concentrated aging populations in the project area

In addition to North Hampton and Rye residents, NH Rt 1A serves the greater New Hampshire community, providing access to public beaches and local businesses that support the state's tourism economy.

Public meetings will be held in accessible spaces to support the engagement of aging, low-income, and other disadvantaged populations along NH Rt 1A.

3.6 Climate Change and Sustainability

NHDOT's revetment reconstruction project is designed to improve coastal resilience along NH Rt 1A to better protect the roadway against climate change effects including sea level rise, storm surge, and wave impacts. The project also offers a reduction in greenhouse gas emissions by reducing the need to use heavy construction equipment for post-storm cleanup and reducing lengthened travel times due to detours during coastal storm related roadway closures.

To assist with controlling construction costs and minimize the use of new materials, the revetment reconstructions will incorporate the existing smaller shale stone and armor stone as the core material and the larger existing armor stone that meet the size and suitability requirements into the revetment layers. The intent is to minimize the amount of new material to be imported as much as

[12] EPA. *EJSCcreen* (2023). https://ejscreen.epa.gov/mapper/

possible. The reuse of suitable material provides sustainability of materials and reduces potential additional emissions that would be generated if all the material were to be removed and all new material used for the project.

The project also allows NHDOT to maintain use of the existing NH Rt 1A roadway without reconstruction of the road, intersections, driveways, or drainage systems.

3.6.1 Reducing Greenhouse Gas Emissions

NHDOT's revetment reconstruction project will reduce the time and expense required for post-storm cleanup to reopen NH Rt 1A following storms. These cleanup efforts require heavy machinery to clear rocks and debris from the roadway. Reducing the need for these cleanup efforts will reduce emissions from road clearing equipment. Additionally, detours cause longer travel times. Reducing the time to reopen the roadway will reduce congestion and emissions from vehicles in the area.

The revetment reconstruction project maintains bicycle and pedestrian ways to support multimodal transportation and further reduce emissions.

Please see Section 3.6 for how potential emissions are reduced by the reuse of existing materials.

3.6.2 Resilience Features

NHDOT's revetment reconstruction project will improve resilience of the roadway by reducing storm damage and road closures resulting from dislodged revetment stones. The project is designed to increase resilience specifically for projected climate change effects on coastal storms and tidal water levels along the New Hampshire coast. The design considers storm surge, water levels, and wave characteristics for a 100-year storm event with +2 feet of sea level rise. The revetment stone is designed in accordance with the Coastal Engineering Manual best practices, with the additional consideration for the projected sea level rise and increased wave impacts.

Figure 9: Revetment Section 5 During April 9, 2020 Storm

3.6.3 Avoiding Adverse Environmental Impacts

NHDOT's revetment reconstruction project is designed to minimize adverse environmental impacts. The conceptual revetment cross sections were developed with the intentional consideration to limit the revetment footprint to approximately within the 1978 design and/or the existing footprint. This generally resulted in the toe of slope on the ocean side to be at or above Mean Higher High Water which limits potential permanent impacts to the beach habitat and coastal resource. Please see Section 3.3 for additional details on how the revetment design avoids environmental impacts by working within the footprint of the 1978 design and existing revetment extents.

3.7 Schedule and Budget

3.7.1 Project Schedule

It is anticipated that final design and issuance of regulatory permits will be completed early in calendar year 2025 and NHDOT will award a construction contract for construction to commence in the fall of 2025 (Federal Fiscal Year 2026). Construction is anticipated to require 6 to 9 months between October and May to minimize the impacts to the summer beach tourism season. However, with the project location directly exposed to the Atlantic Ocean, a contingency for winter conditions and other weather related delays is incorporated into the construction period. Please see below for the intended overall project schedule.

Design and Permitting ....January 2024 through August 2025
(not part of this grant application)

Construction Contract Award ....October 2025

Construction Period..October 2025 - November 2026
(includes contingency for winter weather delays)

3.7.2 Conceptual Construction Cost Estimate

The 2021 Conceptual Design Report included an opinion of construction cost estimates for the revetment reconstruction. Based on the conceptual design stone sizes and the existing stone sizes, the conceptual construction cost estimates assumed that 70% of the existing armor stone and 70% of the existing shale stone are suitable for reuse in the reconstruction. Material costs were based on GZA's database of revetment and breakwater construction projects and experience and on NHDOT's weighted average unit price data where applicable. Being conceptual design, a 25% contingency was included in the construction cost estimates.

The existing revetment structures do not provide the targeted resilience for NH Rt 1A that NHDOT needs for the roadway to withstand climate change impacts from coastal storms. To integrate the resilience measures as described herein, full reconstruction of the revetments is necessary. Therefore, the full constructions costs are considered as eligible under this grant application.

To provide a comprehensive understanding of NHDOT's undertaking with the complete project, **Table 6** provides a summary of conceptual construction cost estimates for all nine revetment sections. (Note: Only revetment Sections 7, 10, and 13 are included in this grant application.) The construction costs shown in **Table 6** are estimates for the construction contractor's work only. They do not include fees associated with engineering design, regulatory permitting, design related field services, or construction administration. See **Appendix G** for the conceptual construction cost estimate breakdown for revetment Sections 7, 10, and 13.

TABLE 6: REVETMENT RECONSTRUCTION CONCEPTUAL CONSTRUCTION COST ESTIMATES

Revetment Section	2021 Conceptual Design Construction Cost Estimate
1	$6.5M
2	$3.5M
3	$11.5M
4	$4.5M
5	$9.5M
6	$18.5M
7	$4.5M
10	$8.0M
13	$5.5M
Total 2021 Dollars	**$72M**
Inflation Adjustment*	**$14.4M**
Adj. Total 2026 Dollars	**$86.4M**

* Inflation adjustment accounts for 3.7% average inflation for the five years from the 2021 conceptual design to the 2026 construction for the first of five construction projects. Average interest rate is consistent with NHDOT's 10-year plan. Actual inflation rate may vary. Actual construction costs may vary depending on project phasing, when the work is completed, labor and material costs and the marine construction bid environment.

NHDOT intends to let out the revetment projects grouped into five construction contracts over five years. The first priority project includes Sections 7, 10, and 13 with construction scheduled to begin in the fall of 2025. For this priority project, NHDOT estimates the total project cost at $25,323,000 and is requesting $20,258,400 under the PROTECT Discretionary Grant Program under the At-Risk Coastal Infrastructure category.

Please see *Section 2. Grant Funds, Sources and Uses* for a detailed description of the total project costs, funding sources and funding request under this grant application.

3.8 Innovation

NHDOT's design consultant, GZA, implemented emerging best practices to incorporate a design sea level rise projection into their wave model simulations and used a risk-based performance evaluation relative to a range of probabilistically determined coastal flood conditions for the conceptual design of the revetment reconstruction. Working with our design consultant, NHDOT considered ideal revetment geometries and balanced the risks, costs, and environmental resource impacts to inform the project direction. The project represents a responsible approach for integrating resilience, sustainability, and risk tolerance to an important asset in NHDOT's transportation network and the state's economic well-being.

4. ECONOMIC ANALYSIS

Between 2010 and 2020, NH had five extreme weather events that cost close to $500 million in damages.[13] NH Rt 1A was closed for nearly seven full days (cumulative) between 2011 and 2021. In March of 2018, the roadway along revetment Section 7 was closed four times for a total of 15 hours and 55 minutes. The roadway along Sections 10 and 13 were both closed eight times for a total of 37 hours and 36 minutes each. While these sections of NH Rt 1A were closed, traffic was diverted to smaller, local roads, increasing congestion and travel times. Clearing stones and debris from the roadway extended these closures for longer than the period of roadway flooding.

The damage resulting from the March 2018 storms led to an emergency declaration by FEMA. FEMA conducted site inspections of the revetments with NHDOT after the storms and issued their findings in November 2018. Subsequently, NHDOT engaged GZA to conduct a coastal revetment resilience study to assess vulnerability of the revetments and develop conceptual improvement recommendations and associated construction cost estimates. The conceptual recommendations are focused on limiting post-storm roadway cleanup operations by improving the resilience of the revetments.

Repairs to the revetments will reduce the duration of closures by mitigating the need for cleanup following flooding and storm events. NHDOT will be able to reopen roads sooner, reducing local congestion, increasing access to public beaches, and reducing maintenance expenses associated with emergency clean ups, improving access for tourists, commuters, and residents, and importantly, maintaining access to a critical evacuation route for coastal storms and the Seabrook Nuclear Power Station.

5. FHWA PRIORITY CONSIDERATIONS

5.1 Construction Readiness

Conceptual revetment reconstruction designs were completed in June 2021 that are based on climate projections for year 2050. NHDOT is currently engaged with GZA to prepare the final designs and permitting. The anticipated timeline lets out the first project for construction bids in the fall of calendar year 2025 with construction commencing in the Fall/Winter of 2025 for revetment reconstruction in Sections 7, 10, and 13. Reconstruction is expected to take six to nine months. The project is expected to be completed by November 2026, with contingencies for winter construction and weather delays.

5.2 Funding Needs

NHDOT is receiving an estimated $30,299,891 from the PROTECT Formula Program over the course of five years.[14] In 2017, New Hampshire received a C- on its infrastructure report card from the American Society of Civil Engineers.[15] As of 2022, there were more than 200 bridges and almost 700 miles of highway in poor condition in NH. Between 2011 and 2022, commute times

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[13] Whitehouse.gov. *American Jobs Plan: The Need for Action in New Hampshire* (2021). https://www.whitehouse.gov/wp-content/uploads/2021/04/AJP-State-Fact-Sheet-NH.pdf

[14] U.S. Department of Transportation, Federal Highway Administration. *5-Year PROTECT Formula Program by State* (July 29, 2022). https://www.fhwa.dot.gov/bipartisan-infrastructure-law/protect_5year_funding_by_state.cfm

[15] American Society of Civil Engineers: New Hampshire Section. *Report Card for New Hampshire's Infrastructure* (2017). https://www.ascenh.org/nh-report-card

increased by almost 6% in New Hampshire and drivers paid an average of $476 in annual maintenance and repairs resulting from driving on roads in need of repair.[16]

The full cost of reconstructing all 14 sections of revetment is estimated at approximately $72 million (2021 dollars), not including engineering, permitting, and project management. NHDOT has already invested $126,390 in engineering fees for conceptual design evaluations and has budgeted $7,430,000 for New Hampshire state fiscal years 2023 to 2026 to address final engineering and permitting, among other project expenses. NHDOT seeks support from the PROTECT Discretionary Grant Program for the NHDOT's construction project for incorporating resiliency thereby reducing repetitive costs incurred for post-storm clean-up efforts.

Figure 10: Revetment stone on NH Rt 1A

5.3 Scalable Project Options

NHDOT has divided the NH Rt 1A project into 14 sections to be addressed in five construction contracts let over five years. Sections 7, 10, and 13 have been identified as the highest priority due to their proximity to the shore, history of cleanup expenses, and importance to the local community.

NHDOT aims to address these three sections in one construction contract for economic and construction efficiency. However, the construction project structure can be limited to one or two revetment sections, if full funding is not available. NHDOT would request a minimum grant funding of $5,064,800 to complete reconstruction of revetment Section 7, which has an estimated construction project cost of $6,331,000, the lowest estimated construction cost for the three priority sections. With award of the full funding request, NHDOT would be able to more efficiently and cost-effectively manage revetment reconstruction at all three of the revetment sections along the southern portion of the NH Rt 1A project area.

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[16] U.S. Department of Transportation: Office of Public Affairs. *The Bipartisan Infrastructure Law Will Deliver for New Hampshire* (2022). https://www.transportation.gov/sites/dot.gov/files/2022-01/BIL_New_Hampshire.pdf (p. 1)

Appendix A

NH DOT 2023-2026 Statewide Transportation Improvement Project (STIP) Report List Budget

NHDES (42875)

All Project Cost: **$239,730**

Route/Road/Entity: New Hampshire Dept of Environment

Scope: Purch & instll 3 EV charging stations, 2 Concord (Fruit St/Hazen Dr) & 1 in Franc. Notch (CMSP)

Phase	Year	Federal	State	Other	Total	Funding
Construction	2024	$191,784	$0	$47,946	$239,730	Congestion Mitigation and Air Quality Program, Other
		$191,784	**$0**	**$47,946**	**$239,730**	

Regionally Significant: No **Managed By:** Muni/Local **CAA Code:** ATT **RPC:** CNHRPC, NCC

NORTH HAMPTON (24457)

All Project Cost: **$6,725,052**

Route/Road/Entity: US Route 1

Scope: Superstructure replacement of bridge carrying US 1 over Boston & Maine RR (Red List Br No 148/132)

Phase	Year	Federal	State	Other	Total	Funding
ROW	2023	$275,000	$0	$0	$275,000	STBG-State Flexible, Toll Credit
Construction	2024	$5,377,552	$0	$0	$5,377,552	Hwy Infrastructure, STBG-50 to 200K, Toll Credit
		$5,652,552	**$0**	**$0**	**$5,652,552**	

Regionally Significant: No **Managed By:** DOT **CAA Code:** E-19 **RPC:** RPC

NORTH HAMPTON - RYE (42312)

All Project Cost: **$7,550,000**

Route/Road/Entity: NH 1A

Scope: Reconstruct NHDOT Stone Revetment seawalls/Berms

Phase	Year	Federal	State	Other	Total	Funding
PE	2023	$2,200,000	$0	$0	$2,200,000	STBG-50 to 200K, Toll Credit
PE	2024	$0	$180,000	$0	$180,000	Non Par DOT
ROW	2024	$0	$50,000	$0	$50,000	Non Par DOT
Construction	2024	$0	$5,000,000	$0	$5,000,000	Non Par DOT
		$2,200,000	**$5,230,000**	**$0**	**$7,430,000**	

Regionally Significant: No **Managed By:** DOT **CAA Code:** ATT **RPC:** RPC

Appendix B

Metocean Analysis

Proactive by Design

GEOTECHNICAL
ENVIRONMENTAL
ECOLOGICAL
WATER
CONSTRUCTION MANAGEMENT

MEMORANDUM

To: Internal Project Memorandum

From: Tianyi Liu, Ph.D., P.E.
Daniel C. Stapleton, P.E.

Date: April 2, 2020

File No.: 04.0190838.04

Re: Metocean Data Analysis
NH Route 1A Coastal Revetment Resilience Study

NHDOT has requested that GZA develop conceptual alternatives for incorporating coastal resilience into the shale pile and shale pile with revetment-facing structures along select portions of NH Route 1A. The current study focus is on the road sections from immediately south of Odiorne Point State Park to 0.25 mile north of Little Boars Head, including approximately 0.12 mile of shale pile structure (Shale) and 2.4 miles of shale pile with revetment facing (S.R.) (See **Table 1** and **Figures 1** and **2**).

This memorandum presents the results of GZA's metocean data analysis, which was performed to characterize the topography and bathymetry and environmental conditions (water levels and waves) for use in evaluation of the existing structures and engineering and design of proposed structures.

Coastal Site Setting

New Hampshire Route 1A, located along the ocean shoreline of New Hampshire, is exposed to the Atlantic Ocean (**Figure 1**) and vulnerable to the effects of coastal flooding. The project shoreline, effectively, has an open fetch to the Atlantic Ocean. A small complex of islands is located across a portion of the project shoreline, approximately 6 miles offshore.

Along the seaward side, the roadway is bordered by a revetment that varies between shale pile (Shale) and shale pile with stone rip rap revetment (S.R.). During coastal storms, the storm surge, waves, and wave overtopping result in revetment damage, and overwash into the roadway.

Coastal flooding of the New Hampshire coast predominantly occurs due to extratropical storms (nor'easters) and post-tropical cyclones. Occasionally, tropical cyclones (including hurricanes) track within Massachusetts Bay.

Topographic and Bathymetric Data

GZA compiled available topographic and bathymetric data. Supplemental field survey is planned along defined transects to provide greater topographic accuracy of the existing structures, and NHDOT will provide the supplemental topo survey for the project.

GZA created a Digital Elevation Model (DEM) of the project area based on available Lidar, specifically the 2014 CMGP Post Sandy LiDAR DEM published by USGS and downloaded from NH GRANIT (3-foot horizontal resolution, Reference 1) - see **Figure 3**. The vertical datum of the 2014 CMGP Post Sandy LiDAR DEM is NAVD88. Preliminary elevation profiles were developed by GZA along three transects at each NHDOT section – see **Figures 7** through **60**. Bathymetric features at NH coast and Atlantic Ocean based on 3-second resolution 1998 NOAA Coastal Relief Model (Reference 2) – see **Figure 61**, and the vertical datum for the source bathymetric data was generally mean lower low water (MLLW) (0 ft MLLW = -5.0 ft NAVD88 at the project site).

Metocean Data

A metocean data analysis was performed to characterize the environmental site conditions (combined wind, tide, storm surge and waves), including:

- Tidal elevations;
- Coastal flood-frequency;
- Storm surge hydrographs,
- Sea level rise projections;
- Wind speed; and
- Wave heights.

Supplemental, numerical wave modeling and wave overtopping calculations are planned to further characterize the wave effects on the project structures.

Tides

The tidal datums in the vicinity of the NHDOT project sections are based on the NOAA Fort Point Tidal Station located to the north of the project site (Reference 3, see **Figure 2** for location):

- Mean Higher High Water (MHHW): 4.39 feet NAVD88
- Mean High Water (MHW): 3.97 feet NAVD88
- Mean Sea Level (MSL): -0.31 feet NAVD88
- Mean Low Water (MLW): -4.66 feet NAVD88
- Mean Lower Low Water (MLLW): -5.00 feet NAVD88

Coastal Flood Elevations

The coastal stillwater flood elevations (i.e., coastal flood frequency data) include storm surge plus astronomical tide, and represents the storm flood elevation in the absence of wave effects. The storm surge is the elevated change in water level above predicted tide levels. Total Water Levels include the stillwater plus wave set-up. The wave crest elevation is the elevation of the Total Water Level plus a portion of the wave height. The water levels vary over time during a storm event due to changes in tidal elevation, storm surge height and wave height. The wave crest elevation also varies over time due to local variability in wind speed and direction, bathymetric features, changes in the storm tide elevation and effects of currents. Stillwater and Total Water Levels are typically characterized in terms of peak conditions associated with an annual probability of occurrence (the annual recurrence interval or annual exceedance probability [AEP]).

The coastal flood elevations were developed from available public data including: 1) FEMA; 2) the USACE; and 3) NOAA extreme water level analysis at representative tidal stations.

FEMA

The effective and preliminary FEMA Flood Insurance Study (FIS) (Reference 4) and effective Flood Insurance rate Maps (FIRMs) present: 1) peak stillwater and Total Water elevations; 2) predicted wave set-up; 3) flood hazard zones; and 4) the Base Flood Elevations (BFEs). The Base Flood is the flood associated with the 100-year recurrence interval flood. **Tables 2** and **3** present FEMA-predicted flood elevations at representative coastal transects. **Table 2** presents the 10-year and 100-year stillwater elevations at coastal transects (see **Figure 5**) along NH Route 1A based on the effective FEMA FIS (2005). **Table 3** presents the 10-year, 50-year, 100-year and 500-year stillwater elevations at coastal transects (see **Figure 6**) based on the revised preliminary FEMA FIS (2016). The effective (2005) and revised preliminary (2016) FEMA FIS are generally consistent relative to the predicted stillwater elevations at coastal transects located near NHDOT sections: the 10-year stillwater elevation ranges from about 7.2 to 7.5 feet NAVD88 and 100-year stillwater elevation is 8.4 feet NAVD88 (**Table 4**). FEMA water levels are developed based on interpolation of historical NOAA tide gage data.

The FEMA-predicted wave set-up during the 100-year recurrence interval flood at the coastal transects (**Table 3**) near the NHDOT sections is approximately 3.2 feet, with the 100-year Total Water elevation in the range of 11.4 to 11.8 feet NAVD88 (**Table 3**). The FEMA flood hazard zones in the vicinity of the NHDOT sections are presented in **Figures 9** to **58**, and are generally classified VE, indicating high flow velocity conditions due to peak wave heights greater than 3 feet. The FEMA Base Flood Elevation (BFE), which approximately represents the peak wave crest elevation associated with the 100-year recurrence interval flood, ranges between 13 feet and 23 feet NAVD88 at the NHDOT sections based on FEMA effective FIS (2005) from FEMA National Flood Hazard Layer (NFHL). FEMA wave-set up is estimated using empirical correlation methods (i.e., Direct Integration Method).

USACE NACCS

Predicted storm surge and total water level data are also available from the US Army Corps of Engineers (USACE) North Atlantic Coast Comprehensive Study (NACCS) (Reference 5). The USACE performed extensive regional coastal flood hazard analyses after Hurricane Sandy (i.e., the North Atlantic Coast Comprehensive Study). These analyses utilized interpretation of meteorological parameters, numerical computer modeling of storm surge and waves, and statistical analysis (e.g., Joint Probability Method-Optimum Sampling, Empirical Simulation Technique) to characterize regional flood hazards. **Figure 4** presents the locations of the NACCS save points (i.e., study output stations) in the vicinity of NHDOT sections, and the mean NACCS-predicted total water elevations associated with the 10-year, 50-year, 100-year and 500-year recurrence interval flood are presented in **Table 4** and **Figure 62**.

Note that the NACCS points are typically located outside the limit of wave set-up and are generally reflective of stillwater elevations. The NACCS save points are located in offshore coastal water, as shown in **Figure 4**, and the wave setup is unlikely to contribute much to the total water level due to minor wave breaking in offshore deep water outside the surf zone. Therefore, the 100-year total water levels (8.2 to 8.3 feet NAVD88) at the NACCS save points in **Table 4** are generally consistent with the FEMA stillwater elevation (i.e., 8.4 feet NAVD88), while the relatively higher total water levels (9.0 to 9.2 feet NAVD88) at save points that are closer to the coast (i.e., save points 18974, 51 and 18972) may indicate a larger contribution from wave setup.

NOAA

Statistical analyses of extreme water levels have been performed by NOAA on most NOAA tide gages. While these analyses are not available at nearby tide stations (NOAA Fort Point, NH and Wells, ME tide stations), extreme water level frequency curves are developed for the NOAA Boston and Portland gages (see **Figure 2** for locations), which are located approximately 50 miles in the north and south of the NHDOT sections. NOAA stillwater flood elevation-frequency data are presented in **Figure 63.** The NOAA stillwater elevations are summarized in **Table 4**. The 100-year stillwater elevation at Portland, ME (i.e., 8.6 feet NAVD88) is consistent with FEMA FIS and NACCS estimates, while the 100-year stillwater elevation at Boston (i.e., 9.4 feet NAVD88) is higher.

The highest observed water levels at the NOAA Boston and Portland gages are presented in **Table 5**, indicating that most historical extreme water levels at Boston and Portland were caused by extratropical nor'easters. **Figure 64** presents the observed water level hydrograph during a recent nor'easter in March 2018 at the NOAA Fort Point, NH gage which is the closest NOAA gage to the NHDOT sections (note that the peak water level at approximately 12:00 3/2/2018 EST at this gage is not recorded but was greater than 7.5 feet NAVD88). **Figure 65** presents the observed time series water level data at NOAA Boston, Fort Point, Wells and Portland gages during the March 2018 nor'easter. Based on the peak flood elevations observed at these stations, the March, 2018 flood resulted in stillwater elevations reflective of coastal flood events with a 10-year to 50-year recurrence interval.

Sea Level Rise

Sea Level Rise (SLR) is the rise of global ocean waters. Relative sea level change (RSLC) is the change of sea level relative to the adjacent land mass and is unique to a given geographic location. RSLC is caused by several factors, including: 1) ground settlement due to post-glacial isostatic adjustment; 2) warming of ocean waters, resulting in volume expansion; 3) increase in ocean volumes due to melting Arctic and land ice; 4) ocean density gradients due to the infusion of lower density fresh water; and 5) changes to global ocean circulation patterns (e.g., the Gulf Stream and Labrador Current).

<u>NOAA Observation Gage</u>

The observed RSLC at the NOAA Boston, Portland and Seavey Island (see **Figure 66** for location) tide stations (Reference 6), over the last approximately 100 years for Boston and Portland tide stations and 60 years for Seavey Island Gage, indicates a historical mean sea level rise trend of 2.83 mm/year (Boston), 1.88 mm/year (Portland), 1.76 mm per year (Seavey Island); 95% confidence intervals are +/- 0.15 mm, +/- 0.14 mm and +/- 0.30 mm per year, respectively. Observed sea level rise trends are not available for the NOAA Fort Point and Wells tide stations. The difference between the observed sea level trends from Boston to Seavey Island is due principally to the differences between observed post-glacial isostatic adjustment (vertical land movement), which is settling at Boston, neutral at Portland and rising at Seavey Island.

<u>NOAA et al. (2017)</u>

While the sea level at New England coast is rising, predicting the future rate of sea level rise is complex, highly uncertain, and dependent on many unknown factors (such as future emissions of greenhouse gases, rate and amount of ice melt, etc.). NOAA et al. (2017) projections (Reference 7, also referred to as Sweet et al. 2017) are provided in vicinity of NHDOT sections at a NOAA tide gage Seavey Island, ME (**Figure 67**, **Table 6**), relative to the year 2000. Corrected values representing sea level rise from current (year 2020) sea levels are presented in **Table 7**. These projections were developed using the USACE Sea Level Change Curve Calculator (version 2019.21) (Reference 8) and are based on NOAA et al. (2017) projections. NOAA et al. (2017) utilizes six descriptive categories: VLM (representing vertical land movement); Low; Intermediate-Low; Intermediate; Intermediate-High; High; and Extreme, and these categories correspond to different greenhouse-gas emission levels (NOAA et al. 2017). In GZA's opinion based on NOAA et al. (2017), the median "Intermediate-Low" is generally considered appropriate as an "analysis and planning lower bound" and either the median "Intermediate" or median "Intermediate-High" is appropriate as an "analysis and planning upper bound". **Table 8** presents estimated exceedance probabilities associated with the six NOAA et al. (2017) projections (shown in **Figure 67**) for several possible future climate scenarios (Representative Concentration Pathways RCP 2.6, RCP 4.5, RCP 8.5) adopted by the Intergovernmental Panel on Climate Change (IPCC) for its fifth Assessment Report (AR5).

The variance between the NOAA et al. (2017) projections increases significantly by mid-century. The NOAA et al. (2017) Intermediate-Low projection has a high (possible to certain) likelihood of occurrence (49% to 96% by 2100). The NOAA et al. (2017) Intermediate projection has low to moderate (possible to certain) likelihood of occurrence (2% to 17% by 2100). The NOAA et al. (2017) Extreme GMSL scenario is a worst case scenario. At NOAA Seavey Island, ME gage in vicinity of the NHDOT sections, the Extreme RSLC scenario for the year 2100 is about 10 feet. Note that the probabilities presented here are approximate; however, they are appropriate for use in understanding the risk of different sea level rise scenarios and planning.

New Hampshire Coastal Flood Risk Science and Technical Advisory Panel (2020) (NHCFR Guidance)

The New Hampshire Coastal Flood Risk Science and Technical Advisory Panel provided guidance in 2020 to help decision makers assess and incorporate best available projections for relative sea-level rise (RSLR) (Reference 10, referred to as NHCFR Guidance). The NHCFR Guidance is based on the study of *2019 New Hampshire Coastal Flood Risk Summary, Part I: Science* (Reference 9, referred to as NHCFR Science) which used scenario-based probabilistic projections based on different global greenhouse gas concentration scenarios represented by different RCPs. The RCPs represent a broad range of climate outcomes, consistent with a range of different socioeconomic and policy futures, including an ambitious mitigation scenario (RCP 2.6), two intermediate stabilization scenarios (RCP 4.5 and RCP 6.0), and a growing greenhouse gas concentration scenario (RCP 8.5).

The NHCFR Guidance recommends use of RCP 4.5 RSLR estimates, while project proponents may be justified in using RSLR estimates for alternative RCPs. The recommended RSLR Estimates for Coastal New Hampshire under the stabilized greenhouse gas concentration scenario (RCP 4.5), and using 2000 sea levels as the baseline, are (**Table 9**, References 9 and 10):

- Coastal New Hampshire is likely (67% probability) to experience RSLR of 0.5 to 1.3 feet between 2000 and 2050. There is a 1-in-20 chance that RSLR will exceed 1.6 feet, a 1-in-100 chance that RSLR will exceed 2.0 feet, a 1-in-200 chance that RSLR will exceed 2.3 feet, and a 1-in-1000 chance that RSLR will exceed 2.9 feet by 2050.

- Coastal New Hampshire is likely (67% probability) to experience RSLR of 1.0 to 2.9 feet between 2000 and 2100. There is a 1-in-20 chance that RSLR will exceed 3.8 feet, a 1-in-100 chance that RSLR will exceed 5.3 feet, a 1-in-200 chance that RSLR will exceed 6.2 feet, and a 1-in-1000 chance that RSLR will exceed 8.7 feet by 2100.

- Coastal New Hampshire is likely (67% probability) to experience RSLR of 1.2 to 4.6 feet between 2000 and 2150. There is a 1-in-20 chance that RSLR will exceed 6.4 feet, a 1-in-100 chance that RSLR will exceed 9.9 feet, a 1-in-200 chance that RSLR will exceed 11.7 feet, and a 1-in-1000 chance that RSLR will exceed 18.1 feet by 2150.

The NHCFR Science compared RSLR estimates with NOAA et al. (2017) (Reference 7) discussed in the above section, which indicate that the 2050 RSLR projections from NHCFR Science for coastal New Hampshire under the stabilized greenhouse gas concentration scenario (RCP 4.5) are consistent with NOAA et al. (2017), but the 2100 RSLR projections are lower under a stabilized greenhouse gas concentration scenario (RCP 4.5) and very similar under the growing greenhouse gas concentration scenario (RCP 8.5) when compared to the NOAA et al. (2017).

Additional Sea Level Rise Information

GZA noted multiple sources on sea level rise estimates and analyses for New Hampshire coast. For instance, in 2015, the Rockingham Planning Commission assessed the influences of sea level rise on vulnerability of New Hampshire coastal municipalities including Portsmouth, New Castle, Rye, North Hampton, Hampton, Hampton Falls and Seabrook (Reference 11), and a “highest” sea level rise scenario is 6.3 feet for the year 2100, which can be found in several other studies (Reference 12, 13, 14). In 2014, the New Hampshire Coastal Risk and Hazards Commission Science and Technical Advisory Panel published a summary of sea-level rise projections, which stated that, using 1992 as a baseline, coastal New Hampshire’s sea levels would rise between 0.6 and 2.0 feet by 2050 and between 1.6 and 6.6 feet by 2100 (Reference 15). This study had been cited in multiple analysis (e.g., Reference 16, 17), but was updated in the 2019 NHCFR Science and Guidance discussed in the above section.

Summary

In consideration of the information presented above, it is recommended that the most up-to-date study of 2020 NHCFR Guidance by the New Hampshire Coastal Flood Risk Science and Technical Advisory Panel (2020) be used for planning purposes. Multiple project sections presented in **Figure 2** are located along evacuation route for Town of Seabrook (Reference 14), and thus may be considered as "Low Risk Tolerance" facilities described in NHCFR Guidance. "Low Risk Tolerance" refers to a 1 in 100 exceedance probability. For an assumed typical 30 to 50 years project design life for roadways (year 2050 to 2070 relative to current year of 2019), the sea level rise relative to 2000 sea level for low risk tolerance projects is 2 feet and 3.3 feet for year 2050 and 2070, respectively (Table 3 in Reference 10, RSLR of 3.3 feet for year 2070 was linearly interpolated based on 2 feet RSLR in 2050 and 5.3 feet RSLR in 2100). For more information on RSLR in coastal New Hampshire, it is recommended to refer to the comprehensive studies in NHCFR Science and Guidance (Reference 9, 10). These approximately correspond to NOAA 2017 Intermediate-High sea level rose projections.

The effect of sea level rise, at a minimum, is to increase the elevation and associated probability of coastal flood levels. It is reasonable to linear superimpose (i.e., add) the projected sea level rise to the current stillwater elevation-frequency data to predict future flood stillwater elevations.

Wind Climate Analysis

To analyze the local wind patterns at NHDOT sections, GZA conducted statistical analyses of historical wind data from the nearby Pease International Tradeport and Isle of Shoals (**Figure 68**) for the prevailing and extreme conditions. GZA also reviewed ASCE 7 design gusts.

Wind Observations

The Pease International Tradeport airport has a 63 year record (1956 to 2019) of hourly wind data (speed and direction) (Reference 17). The site at Isle of Shoals has a 35 year record (1985 to 2019) (Reference 18). The observed wind data at the two observation sites during the March 2018 nor'easter is presented in **Figure 69**, which indicates the wind is generally from the northeast direction during the storm. The wind speed at Pease International Tradeport located approximately 6 miles from the coast is lower than that at Isle of Shoals which is located in the open ocean, which may be due to the land reduction effects by vegetation in the coastal region.

Prevailing Wind Analysis

"Prevailing" winds refers to the dominant, non-storm winds. The cumulative probabilities of the complete wind data set at Pease International Tradeport and Isle of Shoals in 22.5-degree directional bins are presented in **Figures 70** and **71**, respectively, and the data are also plotted as a wind rose which shows wind frequency and magnitude throughout the historical record coming from 32 different directional bins (**Figure 72**). To determine the direction from which the strongest winds impact the project site (and therefore the biggest storms), these data were also divided into six categories of magnitude from winds 0 to10 mph to winds greater than 50 mph, and a wind rose was plotted for each category (**Figures 73** and **74**). The results of that analysis indicate the following:

- The prevailing, low velocity, winds are generally from the western quadrant. At Pease International Tradeport, wind is primarily westerly between southwest and northwest, while at Isle of Shoals, wind is westerly and southerly between northwest and southeast.
- At Pease International Tradeport, about 60% of the 1-minute sustained wind speeds are less than 10 miles per hour (mph); about 30% of the sustained wind speeds are between 10 mph and 20 mph and about 4% are between 20 mph and 30 mph.

- At Isle of Shoals, about 20% of the 1-minute sustained wind speeds are less than 10 miles per hour (mph); about 40% of the sustained wind speeds are between 10 mph and 20 mph; about 32 % are between 20 mph and 30 mph and about 8% are above 30 mph.
- For high wind speeds which are greater than 50 mph, only one record was observed at Pease International Tradeport (i.e., 52 mph at 07/18 20:36 1997 UTC), while at Isle of Shoals, most of the high winds with speed greater than 50 mph are from northeast direction (**Figure 74**) which may represent a typical wind feature during nor'easter.

Extreme Wind Analysis

ASCE 7-16 presents wind speeds (3-second gust) for the project area for 10-Year, 25-Year, 50-Year and 100-Year recurrence intervals (**Figure 75**) (Reference 19). The 3-second gust is converted to a 1-minute sustained wind speed at 10 meters height with the conversion factor of 1.23 (Reference 20) based on assumed condition "onshore winds at a coastline", and the converted ASCE 1-minute sustained wind speed is presented in **Table 10**.

GZA performed statistical analysis on wind data records (1-minute averaging duration) at Pease International Tradeport and Isle of Shoals. GZA's statistical analysis was based on Generalized Extreme Value (GEV) analysis which produces a frequency curve corresponding to a series of recurrence intervals. The wind frequency curves for Pease International Tradeport and Isle of Shoals are presented in **Figures 76** to **84** and **Figures 85** to **93**, respectively. The wind speeds at 10-year, 50-year, 100-year and 500-year recurrence intervals from GZA statistical analysis are summarized in **Table 10**.

The comparison of the ASCE wind and GZA wind statistical analysis at Pease International Tradeport in **Table 10** and **Figures 76** to **84** indicate that the GZA wind statistical analysis based on data is quite lower than ASCE winds for all-direction wind and each directional bin. This is probably because the wind data from Pease International Tradeport is influenced by land reduction due to vegetation and topographic features in the coastal region. The GZA wind statistics based on data at Isle of Shoals compare well with ASCE wind speeds, as shown in **Table 10** and **Figures 85** to **93**: the GZA wind statistics are in good agreement with ASCE wind speeds for all-direction records (**Figure 85**), as well as west (**Figure 86**), south (**Figure 88**) and east (**Figure 90**) directional bins. Therefore, the ASCE 7-16 wind speeds presented in **Figure 85** and **Table 10** are supported by the site specific-statistical analysis based on wind data at Isle of Shoals in the vicinity of the NHDOT sections, and are therefore recommended to use for the wind climatology at the project site.

Wave Climate Analysis

Wave climate is defined as the distribution of wave parameters (e.g., wave height, wave period and wave direction) averaged over a defined time interval at a particular location. Nearshore waves play a significant role in raising stillwater elevation by wave setup and causing inland flooding by wave runup and overtopping. Waves are also the principal mechanism for causing structural damage.

Wave Observation

Wave observation data is not available at the coastline near the NHDOT sections but is available at wave buoys that are located 10 to 20 miles offshore from the project site. The wave buoys include USACE WIS (Wave Information Studies) buoys 63042, 63043, 63044, 63045 (**Figure 2**, about 10 to 15 miles to the east of the NHDOT sections, data record: 1980 to 2014) and the NERACOOS (Northeastern Regional Association of Coastal Ocean Observing Systems) B01 buoy (**Figure 2**, located about 20 miles to the northeast of the NHDOT sections, data record: 2002 to 2019). The offshore waves recorded at the WIS and NERACOOS buoys are deep water waves (water depth presented in **Table 11**) and can differ significantly from the nearshore waves at the coast due to wave shoaling over complex shoreline and bathymetric features near the coast. However, the deep water waves can still present similar characteristics (e.g., dominant wave direction, wave period) as nearshore waves which evolved from deep water waves under influence of local wind. Therefore, the wave observations at the WIS and NERACOOS buoys are assessed for the wave climate at the NHDOT sections at the coast.

The wave rose at the WIS wave buoys is presented in **Figure 94**, indicating that waves are predominantly from the southeast direction, and the extreme wave frequency curves are presented in **Figure 95**, indicating the 100-year wave height at the WIS buoys is approximately 27 feet (about 8 meters). Wave direction is not provided in NERACOOS buoy records; therefore no directional analysis can be performed with such data. The wave height and wave period during the March 2018 nor'easter observed at the NERACOOS B01 buoy are presented in **Figure 96**, indicating that wave heights reached approximately 28 feet at this buoy which is located about 8.5 miles off the coast of Maine and about 20 miles from the NHDOT sections (generally consistent with the 100-year recurrence interval wave height).

USACE NACCS

The USACE NACCS also developed wave height statistics for the U.S. North Atlantic coast (Chesapeake Bay to New Hampshire) using numerical, coupled storm surge and wave modeling (ADCIRC+STWAVE) and the Joint Probability Method (JPM) statistical methodology. The wave height statistics at NACCS save points (see **Figure 3** for location) in the vicinity of NHDOT sections are summarized in **Table 12**. The water depths at the NACCS save points are presented in **Table 11**. High resolution numerical modeling of wave generation and propagation is recommended for more detailed and accurate assessment of the wave characteristics at the NHDOT sections at the coast.

Depth-Limited Wave Heights

The immediate vicinity of the project revetments and adjacent roadway are submerged during coastal flood events. Wave heights at the seaward toe of the revetments will be depth-limited and can be estimated using the following equation:

Depth-limited wave height = (Total Water elevation – ground surface elevation) * 0.78

Wave Modeling

Utilizing input from the metocean data analysis, GZA performed a numerical wave analysis using the SWAN (Simulating WAves Nearshore) model to evaluate waves generated by wind and deep-water waves at the NHDOT sections for 100-year recurrence interval. SWAN is a third-generation wave model developed by the Delft University of Technology. SWAN calculates random, short-crested wind-generated waves in coastal regions and inland waters. The model results present wave vectors. The simulated wave heights presented here represent significant wave heights, Hs and breaking wave heights, H_b (where depth limited wave conditions exist).

GZA's SWAN model, with variable resolution, is built based on the 2014 CMGP Post Sandy LiDAR DEM (**Figure 3**) and 1998 NOAA Coastal Relief Model (**Figure 61)**. The metocean inputs to the SWAN model for the 100-year recurrence interval are summarized in **Table 13**. The simulated wave heights are presented in **Figures 12** through **60,** and are summarized in **Table 13** for the transects of each section.

Flood Inundation Mapping

GZA created inundation maps based on the DEM with flood elevations from 6 to 12 ft NAVD88 with 0.5-foot increment. The flood maps with flood elevation of 8.5 ft NAVD88 which is similar as the 100-Year stillwater elevation (i.e., 8.4 ft NAVD88 from FEMA) are presented in **Figures 10** to **58** for each section. The inundation maps indicate back water flooding on the landward side of the NH Route 1A, which is generally due to low elevation grounds along the shoreline and brings flood risk to the road, although the total water level is below the top of the revetment. The back water flooding conditions at representative transects of each section are summarized in **Tables 14** – **16** for 100-year, 50-year and 10-year recurrence intervals.

Wave Runup and Overtopping

Wave runup at the revetments along Routh 1A was calculated using EurOtop Manual (Reference 25). This approach is consistent with the latest FEMA guidance for runup and overtopping (Reference 26). This method uses the significant deep water wave height, H_{m0}, and the slope angle, α, to estimate the wave runup on slopes with armored rubble slopes and mounds, as shown in **Figure 97**. The wave runup height exceeded by 2% of incoming waves is calculated using Equation 6.2 of the EurOtop Manual:

$$\frac{R_{u2\%}}{H_{m0}} = 1.75 * \gamma_b * \gamma_f * \gamma_\beta * \xi_{m-1,0}$$

where:

$R_{u2\%}$ = wave runup height exceeded by 2% of the incoming waves (feet);

H_{m0} = significant deep water wave height (feet);

γ_b = influence factor for a berm (dimensionless);

γ_f = influence factor for roughness elements on a slope (dimensionless);

γ_β = influence factor for oblique wave attack (dimensionless);

$\xi_{m-1,0}$ = breaker parameter (dimensionless):

$$\xi_{m-1,0} = \frac{\tan\alpha}{\sqrt{s_{m-1,0}}}$$

where:

α = angle of the slope relative to horizontal direction (degree);

$s_{m-1,0}$ = wave steepness (dimensionless): $s_{m-1,0} = \frac{H_{m0}}{L_{m-1,0}}$, where $L_{m-1,0}$ is the wave length.

The overtopping discharge rate is then estimated using Equation 6.6 and 5.12 as presented in the EurOtop Manual for the scenario of wave overtopping on slopes with armored rubble slopes and mounds, as shown in **Figure 97**. The equations to estimate the overtopping discharge rate for slopes with armored rubble slopes and mounds are indicated below:

$$\frac{q}{\sqrt{gH_{m0}^3}} = \frac{0.026}{\sqrt{tan\alpha}}\gamma_b \xi_{m-1,0} \exp\left[-\left(2.5\frac{R_c}{\xi_{m-1,0} H_{m0}\gamma_b\gamma_f\gamma_\beta}\right)^{1.3}\right]$$

with a maximum of: $\frac{q}{\sqrt{gH_{m0}^3}} = 0.1035\exp\left[-\left(1.35\frac{R_c}{H_{m0}\gamma_f\gamma_\beta}\right)^{1.3}\right]$ for steep slopes 1:2 to 1:4/3

where:

q = overtopping flowrate (feet^2/sec);

α = slope angle (degree);

R_c = freeboard (feet).

GZA performed survey at the NHDOT sections and developed the revetment stone characteristics and slope features. Based on the surveyed information and metocean analysis described in above sections, the wave runup and wave overtopping flowrate were calculated at multiple transects at each NHDOT section for 10-Year, 50-Year and 100-Year recurrence intervals. The incoming wave heights for calculating wave runup and overtopping were selected at deep water locations which are approximately 50 – 100 feet off the coast. The calculated wave runup and overtopping are presented in **Tables 14** – **16**, and the revetment condition and the influences on traffic safety were assessed by the overtopping discharge rate for multiple transects based on USACE Coastal Engineering Manual (Reference 27).

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Table 1. Conceptual design focus areas.

NHDOT IDENTIFICATION*	CONSTRUCTION TYPE†	APPROX. LENGTH ALONG COASTLINE‡
Section 1	S.R.	1,400 LF
Section 2	Shale	625 LF
Section 3	S.R.	1,800 LF
Section 4	S.R.	825 LF
Section 5	S.R.	1,925 LF
Section 6	S.R.	3,720 LF
Section 7	S.R.	1,050 LF
Section 10	S.R.	1,160 LF
Section 13	S.R.	1,020 LF

* Based on Northern, Central and Southern Location Maps provided by NHDOT.
† Shale = shale pile. S.R. = shale pile with stone revetment facing.
‡ The approximate length is based on measurement using Google Earth, and is subject to revision based on supplemental survey from NHDOT.

Table 2. Transect data from Effective FEMA FIS (2005), Rockingham County, NH.

TABLE 7 – TRANSECT DATA

FLOODING SOURCE	STILLWATER ELEVATION (feet NGVD 29) 10-YEAR	100-YEAR	ZONE	BASE FLOOD ELEVATION[1] (feet NGVD 29)
ATLANTIC OCEAN				
Transects 1-2	8.2	9.2	VE	11-18
			AE	9-13
Transects 3-10	8.3	9.2	VE	12-22
			AE	9-12
			AO	1'-2' (Depth)
Transects 11-12	8.3	9.2	VE	14-23
			AE	9
			AO	1' (Depth)
Transects 13-14	8.2	9.2	VE	12-14
			AE	9

[1]Because of map scale limitations, base flood elevations shown on the FIRM represent average elevations for the zones depicted

Note:

The datum conversion between NGVD29 and NAVD88 is based on NOAA VDatum (Reference 22) for the project site (longitude/latitude: -70.728743/43.008696): 0 ft NAVD88 = 0.78 ft NGVD29, so the flood elevations in NGVD29 are converted to NAVD88 as follows:

8.2 ft NGVD29 = 7.4 ft NAVD88
8.3 ft NGVD29 = 7.5 ft NAVD88
9.2 ft NGVD29 = 8.4 ft NAVD88

Table 3. Transect data corresponding to NHDOT sections from Revised Preliminary FEMA FIS (2016), Rockingham County, NH

Transect	Stillwater Elevation (feet NAVD88*)				Total Water Elevation 1-Percent Annual Chance[1]	Zone	Base Flood Elevation* (feet NAVD88**)	NHDOT Section
	10-Percent Annual Chance	2-Percent Annual Chance	1-Percent Annual Chance	0.2-Percent Annual Chance				
16	7.24	7.98	8.36	9.43	11.53	VE	16[2]-18	1
						AE	16[2]	
						AO	3	
						AE	8-9	
17	7.24	7.98	8.36	9.43	11.61	VE	17[2]-18	2
						AE	17[2]	
						AO	3	
19	7.24	7.98	8.36	9.43	11.76	VE	16[2]-18	3
						AE	16[2]	
						AO	3	
20	7.24	7.98	8.36	9.43	11.63	VE	20[2]	
						AE	20[2]	
						AO	3	
26	7.24	7.98	8.36	9.43	11.72	VE	19	4
						AE	19[2]	
						AO	3	
						AE	8-10	
27	7.24	7.98	8.36	9.43	11.51	VE	17[2]-18	5
						AE	17[2]	
						AO	3	
28	7.24	7.98	8.36	9.43	11.57	VE	19[2]	6
						AE	19[2]	
						AO	3	
						AE	8-9	
29	7.24	7.98	8.36	9.43	11.64	VE	20[2]	
						AO	3	
						AE	8-9	

Note:

*Due to map scale limitations, base flood elevations shown on the FIRM represent average elevations for the zones depicted.

**North American Vertical Datum of 1988

[1]Including stillwater elevation and effects of wave setup

[2]Wave runup elevation.

Table 3 cont. Transect data corresponding to NHDOT sections from Revised Preliminary FEMA FIS (2016), Rockingham County, NH – continued

Transect	Stillwater Elevation (feet NAVD88*)				Total Water Elevation 1-Percent Annual Chance[1]	Zone	Base Flood Elevation* (feet NAVD88**)	NHDOT Section
	10-Percent Annual Chance	2-Percent Annual Chance	1-Percent Annual Chance	0.2-Percent Annual Chance				
30	7.24	7.98	8.36	9.43	11.67	VE	21[2]	6
						AE	21[2]	
						AO	3	
						AE	8-10	
31	7.24	7.98	8.36	9.43	11.66	VE	20[2]	
						AE	20[2]	
						AO	3	
						AE	8-10	
43	7.24	7.98	8.36	9.43	11.47	VE	16[2]-18	7
						AE	16[2]	
						AO	3	
44	7.24	7.98	8.36	9.43	11.53	VE	18[2]	
						AE	18[2]	
46	7.24	7.98	8.36	9.43	11.66	VE	20[2]	10
						AE	20[2]	
						AO	3	
						AE	8-9	
47	7.24	7.98	8.36	9.43	11.21	VE	24[2]	
						AE	24[2]	
						AO	3	
						AE	8-9	
48	7.24	7.98	8.36	9.43	11.82	VE	22[2]	13
						AE	22[2]	
49	7.24	7.98	8.36	9.43	11.7	VE	18[2]	
						AE	18[2]	

Note:

*Due to map scale limitations, base flood elevations shown on the FIRM represent average elevations for the zones depicted.

**North American Vertical Datum of 1988

[1]Including stillwater elevation and effects of wave setup

[2]Wave runup elevation.

Table 4. Coastal flood elevations in vicinity of NHDOT sections based on publicly available sources.

Recurrence Interval	FEMA Stillwater Elevation (ft, NAVD88)		FEMA Total Water Elevation (ft, NAVD88)	NACCS Stillwater Water Elevation (ft, NAVD88)[4]							NOAA Stillwater Elevation (ft, NAVD88)	
	Effective FIS (2005)[1]	Revised Preliminary FIS (2016)[2]	Revised Preliminary FIS (2016)[3]	NHDOT Sections 7 through 13		NHDOT Sections 1 through 6		Not recommended for project sites[7]				
				2025	2032	18974	51	2045	2046	18972	Boston[5]	Portland[6]
1-year				5.9	5.9	5.9	6.0	5.8	5.8	5.9	6.5	6.4
2-year				6.4	6.4	6.6	6.6	6.4	6.4	6.6	7.4	7.1
5-year				7.0	7.0	7.2	7.3	6.9	7.0	7.2	7.7	7.5
10-year	7.5	7.2		7.3	7.3	7.6	7.8	7.3	7.3	7.7	8.3	7.8
50-year		8.0		8.0	8.0	8.6	8.9	8.0	8.1	8.8	9.1	9.3
100-year	8.4	8.4	11.6	8.2	8.3	9.0	9.2	8.2	8.3	9.1	9.4	8.6
500-year		9.4		8.7	8.8	9.7	10.0	8.7	8.8	10.0		

Note:

1. Based on representative Transects 3 through 10 in Table 2.
2. Based on all transects presented in Table 3.
3. See Table 3 for specific transect locations relative to NHDOT revetment sections. The total water elevation of 11.6 ft NAVD88 for the 100-year recurrence interval listed here is for transect 28 in Table 3 and is approximately the median total water elevation for all transects in Table 3. Total water elevation equals to stillwater elevation plus wave setup (footnote 1 for Table 3), so the wave setup at transect 28 in 100-year recurrence interval = 11.6 – 8.4 = 3.2 ft.
4. Locations of NACCS save points are indicated in Figure 2.
5. Converted from MHHW to NAVD88 based on datum at NOAA Boston gage (Reference 23).
6. Converted from MHHW to NAVD88 based on datum at NOAA Portland gage (Reference 24).
7. NACCS save point 2045, 2046 and 18972 water levels are in deeper water and also reflective of estuary effects and may not be representative of conditions at NHDOT section 1, 2 and 3.

Table 5. Top Ten Highest Water Levels[1] at NOAA Boston and Portland Gage.

Boston, MA			Portland, ME		
Time	**Water Level[2] (ft, NAVD88)**	**Storm Type**	**Time**	**Water Level[2] (ft, NAVD88)**	**Storm Type**
1/4/2018	9.66	Nor'Easter	2/7/1978	8.87	Nor'Easter
2/7/1978	9.59	Nor'Easter	1/9/1978	8.68	Nor'Easter
3/2/2018	9.13	Nor'Easter	1/4/2018	8.26	Nor'Easter
1/2/1987	8.69	Nor'Easter	3/16/1976	8.01	Nor'Easter
10/30/1991	8.63	Nor'Easter	12/4/1990	8.00	Nor'Easter
1/25/1979	8.53	Nor'Easter	11/20/1945	7.99	Nor'Easter
12/12/1992	8.52	Nor'Easter	11/30/1944	7.99	Nor'Easter
12/29/1959	8.47	Nor'Easter	3/2/2018	7.91	Nor'Easter
2/19/1972	8.39	Nor'Easter	4/16/2007	7.91	Nor'Easter
1/3/2014	8.33	Nor'Easter	1/2/1987	7.88	Nor'Easter

Note:

1. Source data provided by NOAA, available at http://tidesandcurrents.noaa.gov/est/Top10_form_ft.pdf.
2. Water levels were converted to NAVD88 from source data.

Table 6. Sea Level Rise Projections (using the USACE Relative Sea Level Change Calculator for NOAA et. al. 2017 projections; relative to the year 2000) for Seavey Island, ME, NOAA2017 VLM (vertical land movement): -0.00092 feet/yr, all values are expressed in feet.

Year	NOAA2017 VLM	NOAA2017 Low	NOAA2017 Int-Low	NOAA2017 Intermediate	NOAA2017 Int-High	NOAA2017 High	NOAA2017 Extreme
2019	-0.08	-0.08	-0.08	-0.08	-0.08	-0.08	-0.08
2040	-0.11	0.38	0.55	1.00	1.50	1.99	2.25
2050	-0.12	0.51	0.71	1.37	2.05	2.84	3.27
2070	-0.14	0.74	1.04	2.22	3.37	4.74	5.76
2100	-0.17	0.94	1.37	3.66	5.86	8.55	10.65

Table 7. Sea Level Rise Projections (using the USACE Relative Sea Level Change Calculator for NOAA et. al. 2017 projections; relative to the year 2019) for Seavey Island, ME, NOAA2017 VLM (vertical land movement): -0.00092 feet/yr, all values are expressed in feet.

Year	NOAA2017 VLM	NOAA2017 Low	NOAA2017 Int-Low	NOAA2017 Intermediate	NOAA2017 Int-High	NOAA2017 High	NOAA2017 Extreme
2019	--	--	--	--	--	--	--
2040	-0.01	0.24	0.34	0.64	0.95	1.29	1.48
2050	-0.02	0.37	0.50	1.01	1.50	2.14	2.50
2070	-0.04	0.60	0.83	1.86	2.82	4.04	4.99
2100	-0.07	0.80	1.16	3.30	5.31	7.85	9.88

Table 8. Probability of Exceeding Global Mean Sea Levels in 2100 for Several Representative Concentration Pathways (RCP) Scenarios.

GMSL Rise Scenario	RCP 2.6	RCP 4.5	RCP 8.5
Low (0.3 m)	94%	98%	100%
Intermediate-Low (0.5 m)	49%	73%	96%
Intermediate (1.0 m)	2%	3%	17%
Intermediate-High (1.5 m)	0.4%	0.5%	1.3%
High (2.0 m)	0.1%	0.1%	0.3%
Extreme (2.5 m)	0.05%	0.05%	0.1%

Table 9. NHCFR recommended RSLR Estimates for Coastal New Hampshire under the stabilized greenhouse gas concentration scenario (RCP 4.5).

Year	Likely Range	1-in-20 Chance	1-in-100 Chance	1-in-200 Chance	1-in-1000 Chance
	67% probability SLR is between	5% probability SLR meets or exceeds	1% probability SLR meets or exceeds	0.5% probability SLR meets or exceeds	0.1% probability SLR meets or exceeds
2050	0.5 – 1.3	1.6	2.0	2.3	2.9
2100	1.0 – 2.9	3.8	5.3	6.2	8.7
2150	1.2 – 4.6	6.4	9.9	11.7	18.1

Table 10. Wind Speed Statistics (1-min, 10-meter) based on ASCE 7-16 and GZA wind statistical analysis.

Analysis	Wind Direction	Wind Speed (mph) Statistics			
		10-year	50-year	100-year	500-year
ASCE 7-16	All Direction	60	72	78	--
GZA Statistical Analysis on Pease Intl Tradeport	All Direction	42	49	53	62
	North	33	39	42	50
	Northeast	36	41	43	46
	East	34	38	39	41
	Southeast	36	41	43	47
	South	31	36	37	41
	Southwest	32	39	41	47
	West	37	43	46	52
	Northwest	36	39	39	41
GZA Statistical Analysis on Isle of Shoals	All Direction	65	76	81	96
	North	57	62	64	68
	Northeast	59	63	64	66
	East	59	69	73	82
	Southeast	57	60	61	62
	South	50	59	64	76
	Southwest	47	52	54	59
	West	54	62	65	73
	Northwest	52	55	55	57

Table 11. Wave depth under mean sea level (MSL) at WIS and NERACOOS wave buoys and NACCS save points.

Stations	Station ID	Water Depth (ft)
WIS Buoys	63042	236
	63043	223
	63044	148
	63045	282
NERACOOS Buoy	B-01	203
NACCS Save Points	2025	33
	2032	35
	51	9
	2045	32
	2046	34

Table 12. Wave height statistics at NACCS save points in vicinity of NHDOT sections.

Return Period	Wave height (ft) at NACCS save points[1]				
	2025	2032	51	2045	2046
1-year	11.0	10.0	8.4	10.3	10.4
2-year	15.6	14.0	9.9	14.9	14.9
5-year	19.5	18.3	10.5	18.6	18.6
10-year	21.4	20.6	10.9	20.6	20.7
50-year	23.5	23.9	11.5	23.8	24.8
100-year	23.8	24.8	11.8	24.8	26.4
500-year	24.4	26.1	12.3	26.3	29.5

Note:

1. Wave height statistics are unavailable for NACCS save points 18972and 18974 (see Figure 2 for location).

Table 13. SWAN Wave Modeling for 100-year recurrence interval.

SWAN Model Input	Stillwater Elevation[1] (ft, NAVD88)		8.4
	Wave Input at eastern open boundary	Significant Wave Height[2] (ft)	26.9
		Wave Period[2] (sec)	12
		Wave Direction	From due east
	Wind	Speed[3] (mph)	78
		Direction	From due east
SWAN Model Output of Significant Wave Height[4] (ft)	Section 1	Transect 1	2.6
		Transect 2	2.8
		Transect 3	3.1
	Section 2	Transect 1	1.5
		Transect 2	2.8
		Transect 3	3.5
	Section 3	Transect 1	4.6
		Transect 2	4.6
		Transect 3	4.0
	Section 4	Transect 1	2.8
		Transect 2	3.0
		Transect 3	3.3
	Section 5	Transect 1	3.2
		Transect 2	3.8
		Transect 3	2.0
	Section 6	Transect 1	3.0
		Transect 2	3.5
		Transect 3	3.3
	Section 7	Transect 1	3.5
		Transect 2	3.4
		Transect 3	3.3
	Section 10	Transect 1	4.1
		Transect 2	3.9
		Transect 3	4.0
	Section 13	Transect 1	4.1
		Transect 2	4.1
		Transect 3	4.2

Note:

1. Based on FEMA Preliminary FIS (2016) (see **Table 4**);
2. Based on wave data at WIS buoy 63044 (see **Figure 2**);
3. 1-min sustained wind speed, based on ASCE 7-16 (see **Table 10**).
4. The output location for each transect is approximately at the intersection point between the section line and the transect line shown in **Figures 7** through **60**.

Table 14. Assessment of wave runup, overtopping and revetment conditions for 100-Year storm condition.

NHDOT Section	NH RT 1A Coastal Revetment Survey					Metocean Characteristics				Revetment Condition				Wave Runup		Wave Overtopping	Risk Assessment		
	Approx. Station[1]	Distance to North Transect	Crest EL.	Toe EL.	Slope	Stillwater Level	Total Water Level[2]	Incident Wave Height	Peak Wave Period	Free board	Revetment Inundated?	Back Water Flood?	RT 1A Flood?	Runup $R_{2\%}$	Wave Runup EL.	Flowrate per foot	Wave Runup Impact	Wave Overtopping Impact[3]	
		ft	ft, NAVD88	ft, NAVD88	%	ft, NAVD88	ft, NAVD88	ft	sec	ft				ft	ft, NAVD88	cfs	Above/Below Revetment Crest	Traffic	Pedestrians
1			-	-	-														
Transect 1	806+33	0	15	9	33	8.4	11.53	2.6	13.5	6.6	No	Yes	Yes	6.0	14.4	1.61E-04	Below	Unsafe parking	Uncomfortable but not dangerous
Transect 2	818+0.0	70	15.7	9.6	31	8.4	11.53	2.6	13.5	7.3	No	Yes	Yes	5.8	14.2	4.18E-05	Below	Unsafe driving at high speed	Wet but not uncomfortable
Transect 3	817+30	110	14	6.5	43	8.4	11.53	2.5	13.5	5.6	No	Yes	Yes	6.4	14.8	6.45E-04	Above	Unsafe parking	Dangerous
Transect 4	816+20	325	12.2	6	25	8.4	11.53	3.2	13.5	3.8	No	Yes	Yes	6.3	14.7	9.29E-02	Above	Unsafe at any speed	Very dangerous
Transect 5	812+95	145	13.8	2.8	42	8.4	11.53	3.1	13.5	5.4	No	Yes	Yes	7.4	15.8	8.74E-03	Above	Unsafe at any speed	Dangerous
Transect 6	811+50	225	15.5	5.3	44	8.4	11.53	3.5	13.5	7.1	No	Yes	Yes	7.8	16.2	2.88E-03	Above	Unsafe parking	Dangerous
Transect 7	809+25	225	15.5	4.3	36	8.4	11.53	4.0	13.5	7.1	No	Yes	Yes	8.7	17.1	1.11E-02	Above	Unsafe at any speed	Very dangerous
2																			
Transect 1	800+24	0	15	4	44	8.4	11.61	4.7	13.5	6.6	No	Yes	Yes	10.5	18.9	6.90E-02	Above	Unsafe at any speed	Very dangerous
Transect 2	805+50	310	15	7.5	30	8.4	11.61	4.7	13.5	6.6	No	Yes	Yes	9.0	17.4	6.90E-02	Above	Unsafe at any speed	Very dangerous
Transect 3	802+40	216	14.8	10	30	8.4	11.61	4.0	13.5	6.4	No	Yes	Yes	8.1	16.5	2.38E-02	Above	Unsafe at any speed	Very dangerous
3																			
Transect 1	767+06	0	13.5	4.7	40	8.4	11.7	6.8	13.5	5.1	No	No	No	14.0	22.4	1.45E+00	Above	Unsafe at any speed	Very dangerous
Transect 2	782+75	175	13.3	5.6	43	8.4	11.7	7.1	13.5	4.9	No	No	No	14.9	23.3	1.89E+00	Above	Unsafe at any speed	Very dangerous
Transect 3	781+0.0	480	14	8.3	81	8.4	11.7	6.8	13.5	5.6	No	No	No	18.1	26.5	1.12E+00	Above	Unsafe at any speed	Very dangerous
Transect 4	776+20	370	17	9.4	40	8.4	11.7	5.3	13.5	8.6	No	No	No	10.9	19.3	3.29E-02	Above	Unsafe at any speed	Very dangerous
Transect 5	772+50	350	18.5	9	44	8.4	11.7	4.8	13.5	10.1	No	No	No	10.4	18.8	3.25E-03	Above	Unsafe parking	Dangerous
Transect 6	769+0.0	150	15.9	8.8	45	8.4	11.7	4.9	13.5	7.5	No	No	No	10.4	18.8	4.33E-02	Above	Unsafe at any speed	Very dangerous
4																			
Transect 1	687+83	0	15	10	31	8.4	11.72	4.7	13.5	6.6	No	Yes	No	9.0	17.4	6.90E-02	Above	Unsafe at any speed	Very dangerous
Transect 2	695+50	350	16	10	47	8.4	11.72	3.9	13.5	7.6	No	Yes	No	8.8	17.2	4.88E-03	Above	Unsafe at any speed	Dangerous
Transect 3	692+0.0	340	14.6	7.5	142	8.4	11.72	5.1	13.5	6.2	No	No	No	16.4	24.8	1.67E-01	Above	Unsafe at any speed	Very dangerous
5																		Safe driving at all speeds	Wet but not uncomfortable
Transect 1	669+70	0	16.4	10	100	8.4	11.51	4.7	13.5	8	No	No	No	14.1	22.5	1.94E-02	Above	Unsafe at any speed	Very dangerous
Transect 2	686+40	340	15.6	9.8	76	8.4	11.51	4.6	13.5	7.2	No	No	No	12.5	20.9	3.40E-02	Above	Unsafe at any speed	Very dangerous
Transect 3	683+0.0	275	16	6.5	43	8.4	11.51	4.6	13.5	7.6	No	No	No	10.0	18.4	2.34E-02	Above	Unsafe at any speed	Very dangerous
Transect 4	680+25	355	16.2	7.4	93	8.4	11.51	4.1	13.5	7.8	No	No	No	12.4	20.8	6.49E-03	Above	Unsafe at any speed	Dangerous
Transect 5	676+70	100	15	4.4	61	8.4	11.51	3.8	13.5	6.6	No	No	No	9.6	18.0	1.21E-02	Above	Unsafe at any speed	Very dangerous
Transect 6	675+70	470	16	4.5	51	8.4	11.51	3.1	13.5	7.6	No	No	No	7.4	15.8	3.21E-04	Below	Unsafe parking	Uncomfortable but not dangerous
6																			
Transect 1	631+64	0	14.5	4	60	8.4	11.65	3.1	13.5	6.1	No	Yes	No	7.9	16.3	3.17E-03	Above	Unsafe parking	Dangerous
Transect 2	669+0.0	225	16.7	6.6	46	8.4	11.65	3.3	13.5	8.3	No	Yes	No	7.5	15.9	2.59E-04	Below	Unsafe parking	Uncomfortable but not dangerous
Transect 3	666+75	475	16.4	6.8	56	8.4	11.65	3.2	13.5	8	No	Yes	No	8.0	16.4	2.66E-04	Below	Unsafe parking	Uncomfortable but not dangerous
Transect 4	662+0.0	250	17.4	10	43	8.4	11.65	3.5	13.5	9	No	Yes	No	7.7	16.1	2.14E-04	Below	Unsafe parking	Uncomfortable but not dangerous
Transect 5	659+50	650	17.6	11.5	50	8.4	11.65	4.4	13.5	9.2	No	Yes	No	10.3	18.7	3.04E-03	Above	Unsafe parking	Dangerous
Transect 6	653+0.0	1540	17.3	8.6	49	8.4	11.65	3.9	13.5	8.9	No	Yes	Yes	9.2	17.6	1.03E-03	Above	Unsafe parking	Dangerous

NHDOT Section	NH RT 1A Coastal Revetment Survey					Metocean Characteristics				Revetment Condition				Wave Runup		Wave Overtopping	Risk Assessment		
	Approx. Station[1]	Distance to North Transect	Crest EL.	Toe EL.	Slope	Stillwater Level	Total Water Level[2]	Incident Wave Height	Peak Wave Period	Free board	Revetment Inundated?	Back Water Flood?	RT 1A Flood?	Runup $R_{2\%}$	Wave Runup EL.	Flowrate per foot	Wave Runup Impact	Wave Overtopping Impact[3]	
		ft	ft, NAVD88	ft, NAVD88	%	ft, NAVD88	ft, NAVD88	ft	sec	ft				ft	ft, NAVD88	cfs	Above/Below Revetment Crest	Traffic	Pedestrians
Transect 7	637+60	160	14.9	4	47	8.4	11.65	3.7	13.5	6.5	No	Yes	Yes	8.6	17.0	1.07E-02	Above	Unsafe at any speed	Dangerous
Transect 7	636+0.0	160	14.9	4	86	8.4	11.65	3.7	13.5	6.5	No	Yes	Yes	11.1	19.5	1.07E-02	Above	Unsafe at any speed	Dangerous
7																			
Transect 1	336+19	0																	
Transect 2	345+44	132	17.7	5.3	40	8.4	11.5	4.5	13.5	9.3	No	No	No	9.7	18.1	3.52E-03	Above	Unsafe parking	Dangerous
Transect 3	344+12	312	17	5	44	8.4	11.5	4.8	13.5	8.6	No	No	No	10.6	19.0	1.35E-02	Above	Unsafe at any speed	Very dangerous
Transect 4	341+0.0	358	17	6	46	8.4	11.5	4.5	13.5	8.6	No	No	No	10.2	18.6	7.18E-03	Above	Unsafe at any speed	Dangerous
10																			
Transect 1	297+51	0	20.2	7.6	65	8.4	11.4	4.7	13.5	11.8	No	No	No	12.0	20.4	4.49E-04	Above	Unsafe parking	Dangerous
Transect 2	307+0.0	100	20.6	12.5	55	8.4	11.4	4.1	13.5	12.2	No	No	No	9.9	18.3	3.50E-05	Below	Unsafe driving at high speed	Wet but not uncomfortable
Transect 3	306+0.0	262	20.5	6.6	44	8.4	11.4	4.2	13.5	12.1	No	No	No	9.5	17.9	5.91E-05	Below	Unsafe driving at high speed	Uncomfortable but not dangerous
Transect 3	303+38	262	20.5	6.6	77	8.4	11.4	4.2	13.5	12.1	No	No	No	11.9	20.3	5.91E-05	Below	Unsafe driving at high speed	Uncomfortable but not dangerous
Transect 4	303+38	453	19	6	73	8.4	11.4	4.2	13.5	10.6	No	No	No	11.6	20.0	3.56E-04	Above	Unsafe parking	Dangerous
Transect 4	298+85	453	19	6	31	8.4	11.4	4.2	13.5	10.6	No	No	No	8.4	16.8	3.56E-04	Below	Unsafe parking	Dangerous
13																			
Transect 1	272+25	0	17.5	12	37	8.4	11.76	4.4	13.5	9.1	No	No	No	9.3	17.7	3.38E-03	Above	Unsafe parking	Dangerous
Transect 2	281+05	295	20.5	12.5	50	8.4	11.76	4.5	13.5	12.1	No	No	No	10.5	18.9	1.74E-04	Below	Unsafe parking	Uncomfortable but not dangerous
Transect 3	278+10	275	18.3	10.9	52	8.4	11.76	4.6	13.5	9.9	No	No	No	10.8	19.2	2.44E-03	Above	Unsafe parking	Dangerous
Transect 4	275+35	145	13.7	6.4	29	8.4	11.76	4.9	13.5	5.3	No	No	No	9.3	17.7	2.65E-01	Above	Unsafe at any speed	Very dangerous
Transect 5	273+90	175	21.7	7.2	44	8.4	11.76	5.0	13.5	13.3	No	No	No	10.9	19.3	2.35E-04	Below	Unsafe parking	Uncomfortable but not dangerous

Notes:

1. Refer to drawings for location of stations;
2. Total water level includes stillwater level plus wave setup, which was provided by FEMA only for 100-Year return period.
3. Based on USACE Coastal Engineering Manual (Reference 27) for safety assessment based on overtopping discharge.

Table 15. Assessment of wave runup, overtopping and revetment conditions for 50-Year storm condition.

NHDOT Section	NH RT 1A Coastal Revetment Survey					Metocean Characteristics				Revetment Condition				Wave Runup		Wave Overtopping	Risk Assessment		
	Approx. Station[1]	Distance to North Transect	Crest EL.	Toe EL.	Slope	Stillwater Level	Total Water Level[2]	Incident Wave Height	Peak Wave Period	Free board	Revetment Inundated?	Back Water Flood?	RT 1A Flood?	Runup $R_{2\%}$	Wave Runup EL.	Flowrate per foot	Wave Runup Impact	Wave Overtopping Impact[3]	
		ft	ft, NAVD88	ft, NAVD88	%	ft, NAVD88	ft, NAVD88	ft	sec	ft				ft	ft, NAVD88	cfs	Above/Below Revetment Crest	Traffic	Pedestrians
1			-	-	-														
Transect 1	806+33	0	15	9	33	8.0	NA	2.3	13.3	7	No	Yes	Yes	5.4	13.4	1.03E-05	Below	Safe driving at all speeds	Wet but not uncomfortable
Transect 2	818+0.0	70	15.7	9.6	31	8.0	NA	2.3	13.3	7.7	No	Yes	Yes	5.2	13.2	2.07E-06	Below	Safe driving at all speeds	Wet but not uncomfortable
Transect 3	817+30	110	14	6.5	43	8.0	NA	2.2	13.3	6	No	Yes	Yes	5.7	13.7	4.89E-05	Below	Unsafe driving at high speed	Uncomfortable but not dangerous
Transect 4	816+20	325	12.2	6	25	8.0	NA	3.0	13.3	4.2	No	Yes	Yes	5.9	13.9	3.58E-02	Above	Unsafe at any speed	Very dangerous
Transect 5	812+95	145	13.8	2.8	42	8.0	NA	2.8	13.3	5.8	No	Yes	Yes	6.8	14.8	1.69E-03	Above	Unsafe parking	Dangerous
Transect 6	811+50	225	15.5	5.3	44	8.0	NA	3.3	13.3	7.5	No	Yes	Yes	7.4	15.4	8.37E-04	Below	Unsafe parking	Dangerous
Transect 7	809+25	225	15.5	4.3	36	8.0	NA	3.8	13.3	7.5	No	Yes	Yes	8.3	16.3	4.19E-03	Above	Unsafe parking	Dangerous
2																			
Transect 1	800+24	0	15	4	44	8.0	NA	4.5	13.3	7	No	Yes	Yes	10.1	18.1	3.43E-02	Above	Unsafe at any speed	Very dangerous
Transect 2	805+50	310	15	7.5	30	8.0	NA	4.5	13.3	7	No	Yes	Yes	8.6	16.6	3.43E-02	Above	Unsafe at any speed	Very dangerous
Transect 3	802+40	216	14.8	10	30	8.0	NA	3.8	13.3	6.8	No	Yes	Yes	7.7	15.7	9.61E-03	Above	Unsafe at any speed	Dangerous
3																			
Transect 1	767+06	0	13.5	4.7	40	8.0	NA	6.6	13.3	5.5	No	No	No	13.6	21.6	1.03E+00	Above	Unsafe at any speed	Very dangerous
Transect 2	782+75	175	13.3	5.6	43	8.0	NA	6.9	13.3	5.3	No	No	No	14.4	22.4	1.39E+00	Above	Unsafe at any speed	Very dangerous
Transect 3	781+0.0	480	14	8.3	81	8.0	NA	6.7	13.3	6	No	No	No	17.8	25.8	8.47E-01	Above	Unsafe at any speed	Very dangerous
Transect 4	776+20	370	17	9.4	40	8.0	NA	5.1	13.3	9	No	No	No	10.5	18.5	1.67E-02	Above	Unsafe at any speed	Very dangerous
Transect 5	772+50	350	18.5	9	44	8.0	NA	4.6	13.3	10.5	No	No	No	10.0	18.0	1.31E-03	Below	Unsafe parking	Dangerous
Transect 6	769+0.0	150	15.9	8.8	45	8.0	NA	4.7	13.3	7.9	No	No	No	10.0	18.0	2.13E-02	Above	Unsafe at any speed	Very dangerous
4																			
Transect 1	687+83	0	15	10	31	8.0	NA	4.5	13.3	7	No	Yes	No	8.6	16.6	3.43E-02	Above	Unsafe at any speed	Very dangerous
Transect 2	695+50	350	16	10	47	8.0	NA	3.6	13.3	8	No	Yes	No	8.1	16.1	1.21E-03	Above	Unsafe parking	Dangerous
Transect 3	692+0.0	340	14.6	7.5	142	8.0	NA	4.9	13.3	6.6	No	No	No	15.7	23.7	9.30E-02	Above	Unsafe at any speed	Very dangerous
5																		Safe driving at all speeds	Wet but not uncomfortable
Transect 1	669+70	0	16.4	10	100	8.0	NA	4.5	13.3	8.4	No	No	No	13.5	21.5	8.77E-03	Above	Unsafe at any speed	Dangerous
Transect 2	686+40	340	15.6	9.8	76	8.0	NA	4.4	13.3	7.6	No	No	No	12.0	20.0	1.58E-02	Above	Unsafe at any speed	Very dangerous
Transect 3	683+0.0	275	16	6.5	43	8.0	NA	4.4	13.3	8	No	No	No	9.6	17.6	1.05E-02	Above	Unsafe at any speed	Dangerous
Transect 4	680+25	355	16.2	7.4	93	8.0	NA	3.9	13.3	8.2	No	No	No	11.8	19.8	2.40E-03	Above	Unsafe parking	Dangerous
Transect 5	676+70	100	15	4.4	61	8.0	NA	3.6	13.3	7	No	No	No	9.1	17.1	4.41E-03	Above	Unsafe parking	Dangerous
Transect 6	675+70	470	16	4.5	51	8.0	NA	2.9	13.3	8	No	No	No	6.9	14.9	6.32E-05	Below	Unsafe driving at high speed	Uncomfortable but not dangerous
6																			
Transect 1	631+64	0	14.5	4	60	8.0	NA	2.9	13.3	6.5	No	Yes	No	7.4	15.4	8.01E-04	Above	Unsafe parking	Dangerous
Transect 2	669+0.0	225	16.7	6.6	46	8.0	NA	3.1	13.3	8.7	No	Yes	No	7.1	15.1	5.48E-05	Below	Unsafe driving at high speed	Uncomfortable but not dangerous
Transect 3	666+75	475	16.4	6.8	56	8.0	NA	3.0	13.3	8.4	No	Yes	No	7.5	15.5	5.39E-05	Below	Unsafe driving at high speed	Uncomfortable but not dangerous
Transect 4	662+0.0	250	17.4	10	43	8.0	NA	3.4	13.3	9.4	No	Yes	No	7.5	15.5	7.78E-05	Below	Unsafe driving at high speed	Uncomfortable but not dangerous
Transect 5	659+50	650	17.6	11.5	50	8.0	NA	4.2	13.3	9.6	No	Yes	No	9.9	17.9	1.13E-03	Above	Unsafe parking	Dangerous
Transect 6	653+0.0	1540	17.3	8.6	49	8.0	NA	3.7	13.3	9.3	No	Yes	Yes	8.7	16.7	3.10E-04	Below	Unsafe parking	Uncomfortable but not dangerous

NHDOT Section	NH RT 1A Coastal Revetment Survey					Metocean Characteristics				Revetment Condition				Wave Runup		Wave Overtopping	Risk Assessment		
	Approx. Station[1]	**Distance to North Transect**	**Crest EL.**	**Toe EL.**	**Slope**	**Stillwater Level**	**Total Water Level[2]**	**Incident Wave Height**	**Peak Wave Period**	**Free board**	**Revetment Inundated?**	**Back Water Flood?**	**RT 1A Flood?**	**Runup $R_{2\%}$**	**Wave Runup EL.**	**Flowrate per foot**	**Wave Runup Impact**	**Wave Overtopping Impact[3]**	
		ft	ft, NAVD88	ft, NAVD88	%	ft, NAVD88	ft, NAVD88	ft	sec	ft				ft	ft, NAVD88	cfs	Above/Below Revetment Crest	Traffic	Pedestrians
Transect 7	637+60	160	14.9	4	47	8.0	NA	3.5	13.3	6.9	No	Yes	Yes	8.2	16.2	3.74E-03	Above	Unsafe parking	Dangerous
Transect 7	636+0.0	160	14.9	4	86	8.0	NA	3.5	13.3	6.9	No	Yes	Yes	10.5	18.5	3.74E-03	Above	Unsafe parking	Dangerous
7																			
Transect 1	336+19	0																	
Transect 2	345+44	132	17.7	5.3	40	8.0	NA	4.4	13.3	9.7	No	No	No	9.4	17.4	1.78E-03	Below	Unsafe parking	Dangerous
Transect 3	344+12	312	17	5	44	8.0	NA	4.6	13.3	9	No	No	No	10.2	18.2	6.03E-03	Above	Unsafe at any speed	Dangerous
Transect 4	341+0.0	358	17	6	46	8.0	NA	4.3	13.3	9	No	No	No	9.7	17.7	2.91E-03	Above	Unsafe parking	Dangerous
10																			
Transect 1	297+51	0	20.2	7.6	65	8.0	NA	4.5	13.3	12.2	No	No	No	11.5	19.5	1.55E-04	Below	Unsafe parking	Uncomfortable but not dangerous
Transect 2	307+0.0	100	20.6	12.5	55	8.0	NA	4.0	13.3	12.6	No	No	No	9.7	17.7	1.36E-05	Below	Unsafe driving at high speed	Wet but not uncomfortable
Transect 3	306+0.0	262	20.5	6.6	44	8.0	NA	4.0	13.3	12.5	No	No	No	9.0	17.0	1.55E-05	Below	Unsafe driving at high speed	Wet but not uncomfortable
Transect 3	303+38	262	20.5	6.6	77	8.0	NA	4.0	13.3	12.5	No	No	No	11.3	19.3	1.55E-05	Below	Unsafe driving at high speed	Wet but not uncomfortable
Transect 4	303+38	453	19	6	73	8.0	NA	4.1	13.3	11	No	No	No	11.3	19.3	1.56E-04	Above	Unsafe parking	Uncomfortable but not dangerous
Transect 4	298+85	453	19	6	31	8.0	NA	4.1	13.3	11	No	No	No	8.2	16.2	1.56E-04	Below	Unsafe parking	Uncomfortable but not dangerous
13																			
Transect 1	272+25	0	17.5	12	37	8.0	NA	4.2	13.3	9.5	No	No	No	8.8	16.8	1.27E-03	Below	Unsafe parking	Dangerous
Transect 2	281+05	295	20.5	12.5	50	8.0	NA	4.3	13.3	12.5	No	No	No	10.1	18.1	5.36E-05	Below	Unsafe driving at high speed	Uncomfortable but not dangerous
Transect 3	278+10	275	18.3	10.9	52	8.0	NA	4.4	13.3	10.3	No	No	No	10.4	18.4	9.30E-04	Above	Unsafe parking	Dangerous
Transect 4	275+35	145	13.7	6.4	29	8.0	NA	4.7	13.3	5.7	No	No	No	8.9	16.9	1.50E-01	Above	Unsafe at any speed	Very dangerous
Transect 5	273+90	175	21.7	7.2	44	8.0	NA	4.8	13.3	13.7	No	No	No	10.5	18.5	8.28E-05	Below	Unsafe driving at high speed	Uncomfortable but not dangerous

Notes:

1. Refer to drawings for location of stations;
2. Total water level includes stillwater level plus wave setup, which was provided by FEMA only for 100-Year return period.
3. Based on USACE Coastal Engineering Manual (Reference 27) for safety assessment based on overtopping discharge.

Table 16. Assessment of wave runup, overtopping and revetment conditions for 10-Year storm condition.

NHDOT Section	NH RT 1A Coastal Revetment Survey					Metocean Characteristics				Revetment Condition				Wave Runup		Wave Overtopping	Risk Assessment		
	Approx. Station[1]	Distance to North Transect	Crest EL.	Toe EL.	Slope	Stillwater Level	Total Water Level[2]	Incident Wave Height	Peak Wave Period	Free board	Revetment Inundated?	Back Water Flood?	RT 1A Flood?	Runup $R_{2\%}$	Wave Runup EL.	Flowrate per foot	Wave Runup Impact	Wave Overtopping Impact[3]	
		ft	ft, NAVD88	ft, NAVD88	%	ft, NAVD88	ft, NAVD88	ft	sec	ft				ft	ft, NAVD88	cfs	Above/Below Revetment Crest	Traffic	Pedestrians
1			-	-	-														
Transect 1	806+33	0	15	9	33	7.2	NA	2.0	12.8	7.8	No	Yes	Yes	4.8	12.0	8.11E-08	Below	Safe driving at all speeds	Wet but not uncomfortable
Transect 2	818+0.0	70	15.7	9.6	31	7.2	NA	2.0	12.8	8.5	No	Yes	Yes	4.6	11.8	1.11E-08	Below	Safe driving at all speeds	Wet but not uncomfortable
Transect 3	817+30	110	14	6.5	43	7.2	NA	1.9	12.8	6.8	No	Yes	Yes	5.0	12.2	4.45E-07	Below	Safe driving at all speeds	Wet but not uncomfortable
Transect 4	816+20	325	12.2	6	25	7.2	NA	2.7	12.8	5	No	Yes	Yes	5.4	12.6	4.36E-03	Above	Unsafe parking	Dangerous
Transect 5	812+95	145	13.8	2.8	42	7.2	NA	2.5	12.8	6.6	No	Yes	Yes	6.1	13.3	9.18E-05	Below	Unsafe driving at high speed	Uncomfortable but not dangerous
Transect 6	811+50	225	15.5	5.3	44	7.2	NA	2.9	12.8	8.3	No	Yes	Yes	6.5	13.7	3.74E-05	Below	Unsafe driving at high speed	Wet but not uncomfortable
Transect 7	809+25	225	15.5	4.3	36	7.2	NA	3.4	12.8	8.3	No	Yes	Yes	7.5	14.7	3.89E-04	Below	Unsafe parking	Dangerous
2																			
Transect 1	800+24	0	15	4	44	7.2	NA	4.1	12.8	7.8	No	Yes	Yes	9.2	16.4	6.49E-03	Above	Unsafe at any speed	Dangerous
Transect 2	805+50	310	15	7.5	30	7.2	NA	4.2	12.8	7.8	No	Yes	Yes	8.0	15.2	8.25E-03	Above	Unsafe at any speed	Dangerous
Transect 3	802+40	216	14.8	10	30	7.2	NA	3.5	12.8	7.6	No	Yes	Yes	7.1	14.3	1.48E-03	Below	Unsafe parking	Dangerous
3																			
Transect 1	767+06	0	13.5	4.7	40	7.2	NA	6.3	12.8	6.3	No	No	No	12.9	20.1	5.27E-01	Above	Unsafe at any speed	Very dangerous
Transect 2	782+75	175	13.3	5.6	43	7.2	NA	6.6	12.8	6.1	No	No	No	13.7	20.9	7.47E-01	Above	Unsafe at any speed	Very dangerous
Transect 3	781+0.0	480	14	8.3	81	7.2	NA	6.3	12.8	6.8	No	No	No	16.7	23.9	3.90E-01	Above	Unsafe at any speed	Very dangerous
Transect 4	776+20	370	17	9.4	40	7.2	NA	4.8	12.8	9.8	No	No	No	9.8	17.0	4.35E-03	Above	Unsafe parking	Dangerous
Transect 5	772+50	350	18.5	9	44	7.2	NA	4.2	12.8	11.3	No	No	No	9.1	16.3	1.55E-04	Below	Unsafe parking	Uncomfortable but not dangerous
Transect 6	769+0.0	150	15.9	8.8	45	7.2	NA	4.4	12.8	8.7	No	No	No	9.2	16.4	5.13E-03	Above	Unsafe at any speed	Dangerous
4																			
Transect 1	687+83	0	15	10	31	7.2	NA	4.1	12.8	7.8	No	Yes	No	7.8	15.0	6.49E-03	Above	Unsafe at any speed	Dangerous
Transect 2	695+50	350	16	10	47	7.2	NA	3.3	12.8	8.8	No	Yes	No	7.4	14.6	1.22E-04	Below	Unsafe parking	Uncomfortable but not dangerous
Transect 3	692+0.0	340	14.6	7.5	142	7.2	NA	4.5	12.8	7.4	No	No	No	14.4	21.6	2.34E-02	Above	Unsafe at any speed	Very dangerous
5																		Safe driving at all speeds	Wet but not uncomfortable
Transect 1	669+70	0	16.4	10	100	7.2	NA	4.1	12.8	9.2	No	No	No	12.3	19.5	1.33E-03	Above	Unsafe parking	Dangerous
Transect 2	686+40	340	15.6	9.8	76	7.2	NA	4.1	12.8	8.4	No	No	No	11.1	18.3	3.32E-03	Above	Unsafe parking	Dangerous
Transect 3	683+0.0	275	16	6.5	43	7.2	NA	4.1	12.8	8.8	No	No	No	8.9	16.1	2.11E-03	Above	Unsafe parking	Dangerous
Transect 4	680+25	355	16.2	7.4	93	7.2	NA	3.7	12.8	9	No	No	No	11.1	18.3	4.60E-04	Above	Unsafe parking	Dangerous
Transect 5	676+70	100	15	4.4	61	7.2	NA	3.4	12.8	7.8	No	No	No	8.5	15.7	7.91E-04	Above	Unsafe parking	Dangerous
Transect 6	675+70	470	16	4.5	51	7.2	NA	2.6	12.8	8.8	No	No	No	6.1	13.3	2.04E-06	Below	Safe driving at all speeds	Wet but not uncomfortable
6																			
Transect 1	631+64	0	14.5	4	60	7.2	NA	2.6	12.8	7.3	No	Yes	No	6.6	13.8	4.18E-05	Below	Unsafe driving at high speed	Wet but not uncomfortable
Transect 2	669+0.0	225	16.7	6.6	46	7.2	NA	2.8	12.8	9.5	No	Yes	No	6.4	13.6	2.18E-06	Below	Safe driving at all speeds	Wet but not uncomfortable
Transect 3	666+75	475	16.4	6.8	56	7.2	NA	2.8	12.8	9.2	No	Yes	No	6.9	14.1	3.88E-06	Below	Safe driving at all speeds	Wet but not uncomfortable
Transect 4	662+0.0	250	17.4	10	43	7.2	NA	3.1	12.8	10.2	No	Yes	No	6.8	14.0	4.41E-06	Below	Safe driving at all speeds	Wet but not uncomfortable
Transect 5	659+50	650	17.6	11.5	50	7.2	NA	4.0	12.8	10.4	No	Yes	No	9.3	16.5	2.27E-04	Below	Unsafe parking	Uncomfortable but not dangerous
Transect 6	653+0.0	1540	17.3	8.6	49	7.2	NA	3.5	12.8	10.1	No	Yes	Yes	8.2	15.4	4.39E-05	Below	Unsafe driving at high speed	Uncomfortable but not dangerous

NHDOT Section	NH RT 1A Coastal Revetment Survey					Metocean Characteristics				Revetment Condition				Wave Runup		Wave Overtopping	Risk Assessment		
	Approx. Station[1]	Distance to North Transect	Crest EL.	Toe EL.	Slope	Stillwater Level	Total Water Level[2]	Incident Wave Height	Peak Wave Period	Free board	Revetment Inundated?	Back Water Flood?	RT 1A Flood?	Runup $R_{2\%}$	Wave Runup EL.	Flowrate per foot	Wave Runup Impact	Wave Overtopping Impact[3]	
		ft	ft, NAVD88	ft, NAVD88	%	ft, NAVD88	ft, NAVD88	ft	sec	ft				ft	ft, NAVD88	cfs	Above/Below Revetment Crest	Traffic	Pedestrians
Transect 7	637+60	160	14.9	4	47	7.2	NA	3.3	12.8	7.7	No	Yes	Yes	7.6	14.8	6.26E-04	Below	Unsafe parking	Dangerous
Transect 7	636+0.0	160	14.9	4	86	7.2	NA	3.3	12.8	7.7	No	Yes	Yes	9.8	17.0	6.26E-04	Above	Unsafe parking	Dangerous
7																			
Transect 1	336+19	0						4.2											
Transect 2	345+44	132	17.7	5.3	40	7.2	NA	4.1	12.8	10.5	No	No	No	8.8	16.0	2.86E-04	Below	Unsafe parking	Uncomfortable but not dangerous
Transect 3	344+12	312	17	5	44	7.2	NA	4.3	12.8	9.8	No	No	No	9.5	16.7	1.21E-03	Below	Unsafe parking	Dangerous
Transect 4	341+0.0	358	17	6	46	7.2	NA	4.1	12.8	9.8	No	No	No	9.2	16.4	6.59E-04	Below	Unsafe parking	Dangerous
10																			
Transect 1	297+51	0	20.2	7.6	65	7.2	NA	4.2	12.8	13	No	No	No	10.7	17.9	1.95E-05	Below	Unsafe driving at high speed	Wet but not uncomfortable
Transect 2	307+0.0	100	20.6	12.5	55	7.2	NA	3.7	12.8	13.4	No	No	No	8.9	16.1	9.56E-07	Below	Safe driving at all speeds	Wet but not uncomfortable
Transect 3	306+0.0	262	20.5	6.6	44	7.2	NA	3.8	12.8	13.3	No	No	No	8.5	15.7	1.93E-06	Below	Safe driving at all speeds	Wet but not uncomfortable
Transect 3	303+38	262	20.5	6.6	77	7.2	NA	3.8	12.8	13.3	No	No	No	10.7	17.9	1.93E-06	Below	Safe driving at all speeds	Wet but not uncomfortable
Transect 4	303+38	453	19	6	73	7.2	NA	3.8	12.8	11.8	No	No	No	10.4	17.6	1.59E-05	Below	Unsafe driving at high speed	Wet but not uncomfortable
Transect 4	298+85	453	19	6	31	7.2	NA	3.8	12.8	11.8	No	No	No	7.5	14.7	1.59E-05	Below	Unsafe driving at high speed	Wet but not uncomfortable
13																			
Transect 1	272+25	0	17.5	12	37	7.2	NA	3.9	12.8	10.3	No	No	No	8.2	15.4	1.78E-04	Below	Unsafe parking	Uncomfortable but not dangerous
Transect 2	281+05	295	20.5	12.5	50	7.2	NA	4.0	12.8	13.3	No	No	No	9.3	16.5	5.37E-06	Below	Safe driving at all speeds	Wet but not uncomfortable
Transect 3	278+10	275	18.3	10.9	52	7.2	NA	4.1	12.8	11.1	No	No	No	9.6	16.8	1.38E-04	Below	Unsafe parking	Uncomfortable but not dangerous
Transect 4	275+35	145	13.7	6.4	29	7.2	NA	4.4	12.8	6.5	No	No	No	8.3	15.5	4.61E-02	Above	Unsafe at any speed	Very dangerous
Transect 5	273+90	175	21.7	7.2	44	7.2	NA	4.5	12.8	14.5	No	No	No	9.8	17.0	1.11E-05	Below	Unsafe driving at high speed	Wet but not uncomfortable

Notes:

1. Refer to drawings for location of stations;
2. Total water level includes stillwater level plus wave setup, which was provided by FEMA only for 100-Year return period.
3. Based on USACE Coastal Engineering Manual (Reference 27) for safety assessment based on overtopping discharge.

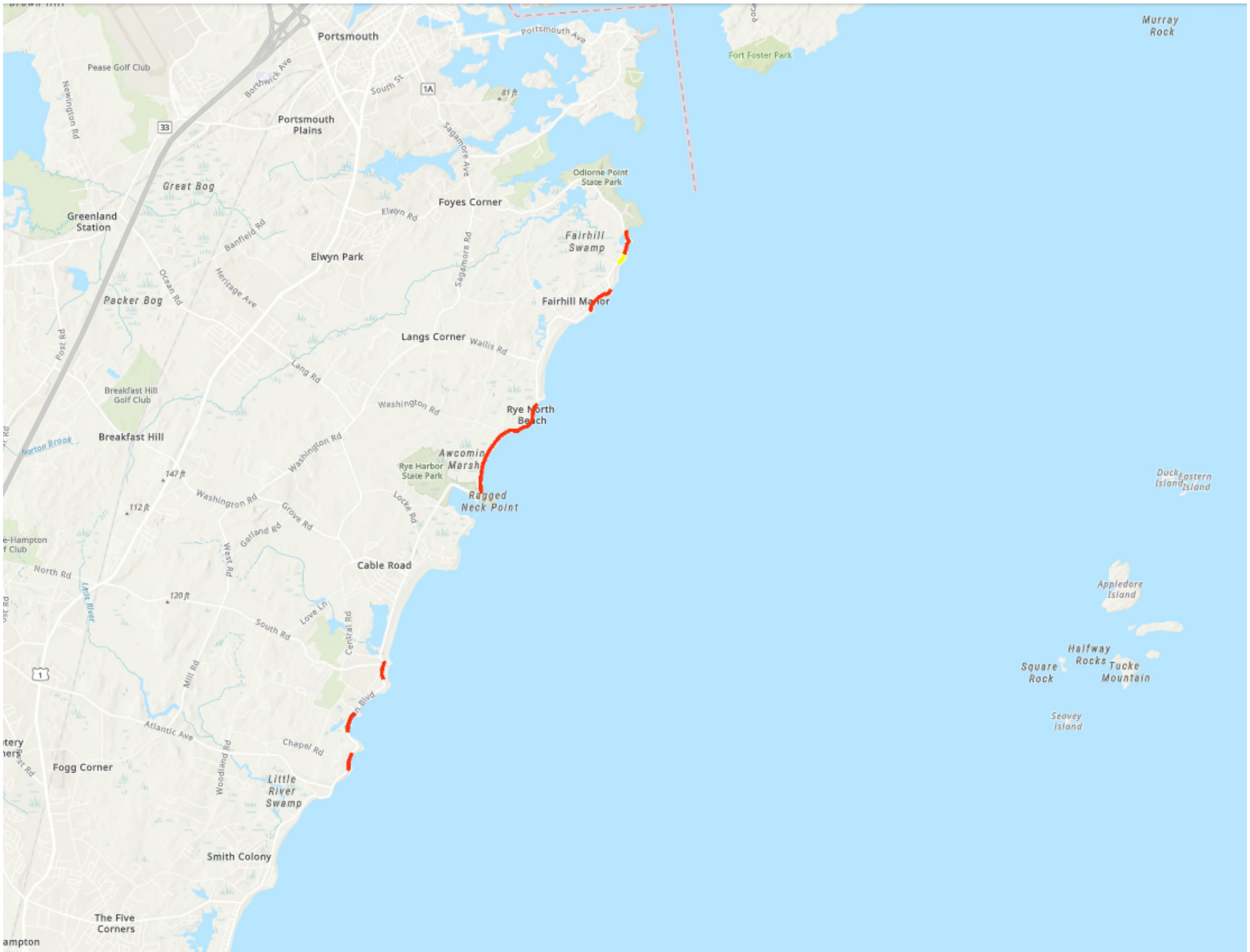


Figure 1. Location of NHDOT sections.

Figure 2. Location of NHDOT sections and observation sites for water level (NOAA gages), wave (WIS buoys and NDBC 44007) and wind (NDBC IOSN3 and NDBC 44073).

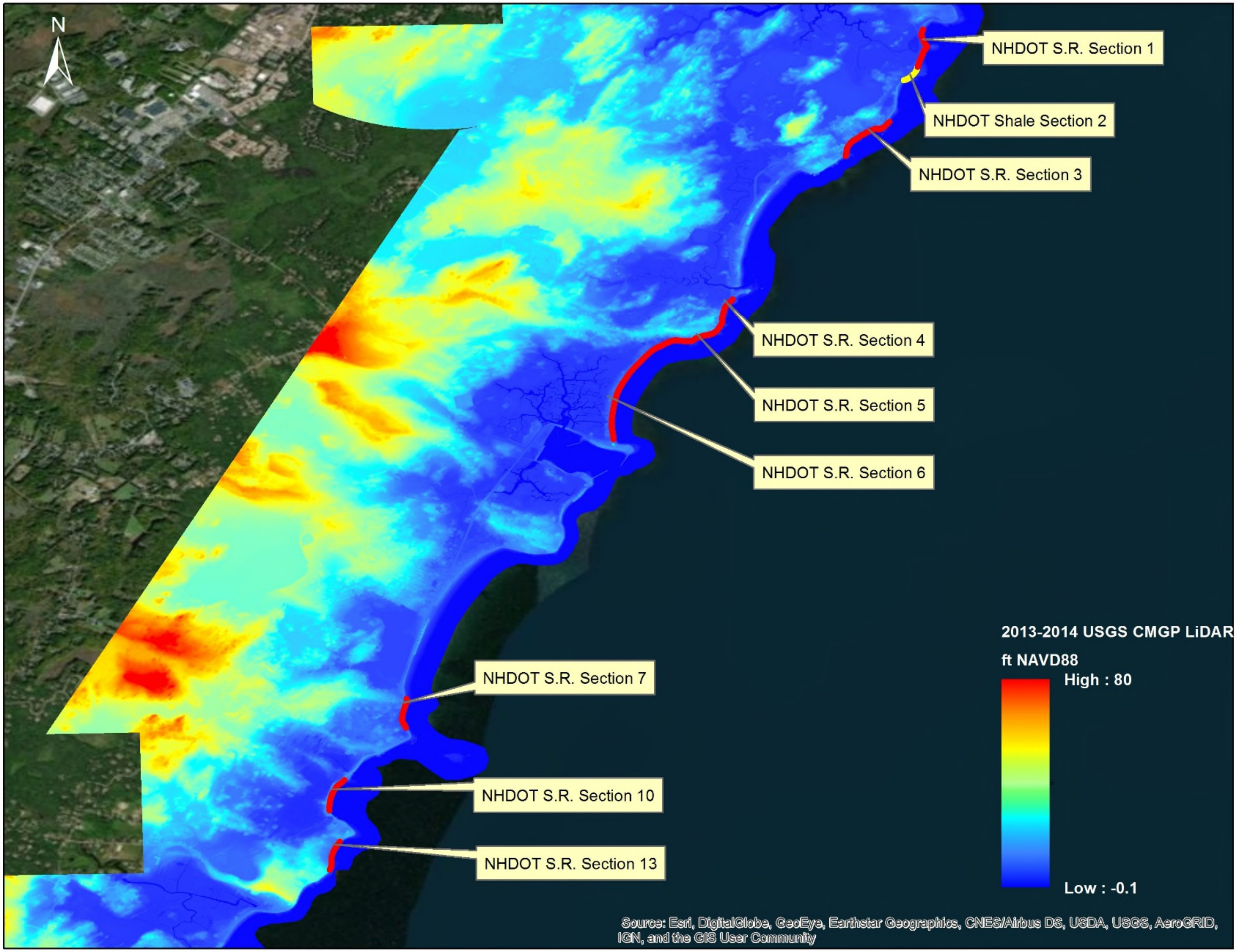


Figure 3. New England CMGP Sandy Lidar (2013-2014).

Figure 4. Location of NHDOT sections, nearby tide gage, WIS wave buoy and NACCS save points.

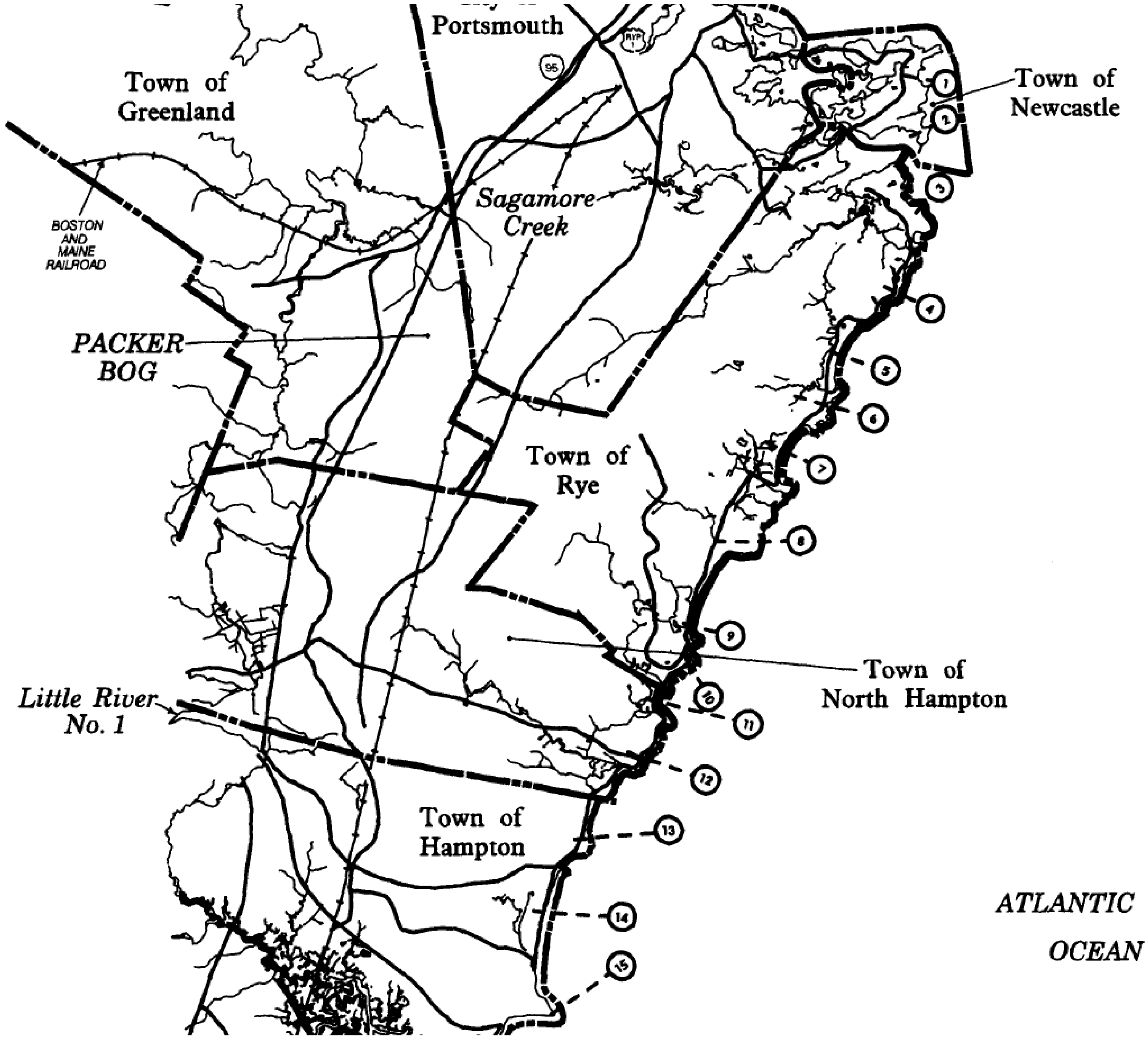


Figure 5. Coastal transects for Effective FEMA FIS (2005) at Town of Rye and Town of Hampton, NH.

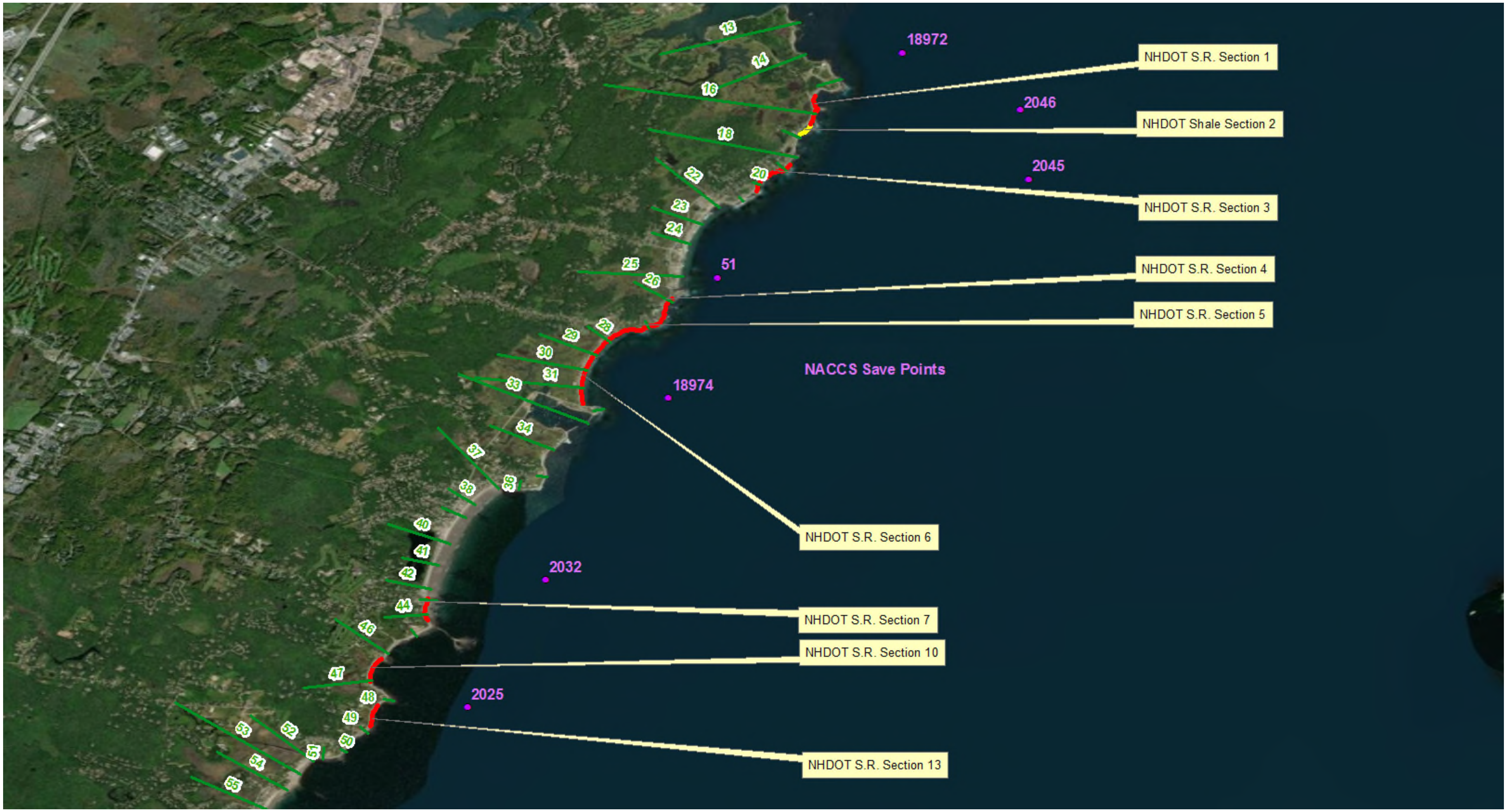


Figure 6. Coastal transects for Revised Preliminary FEMA FIS (2016) at Town of Rye and Town of Hampton, NH.

Figure 43. Transect Locations at NHDOT S.R. Section 7.

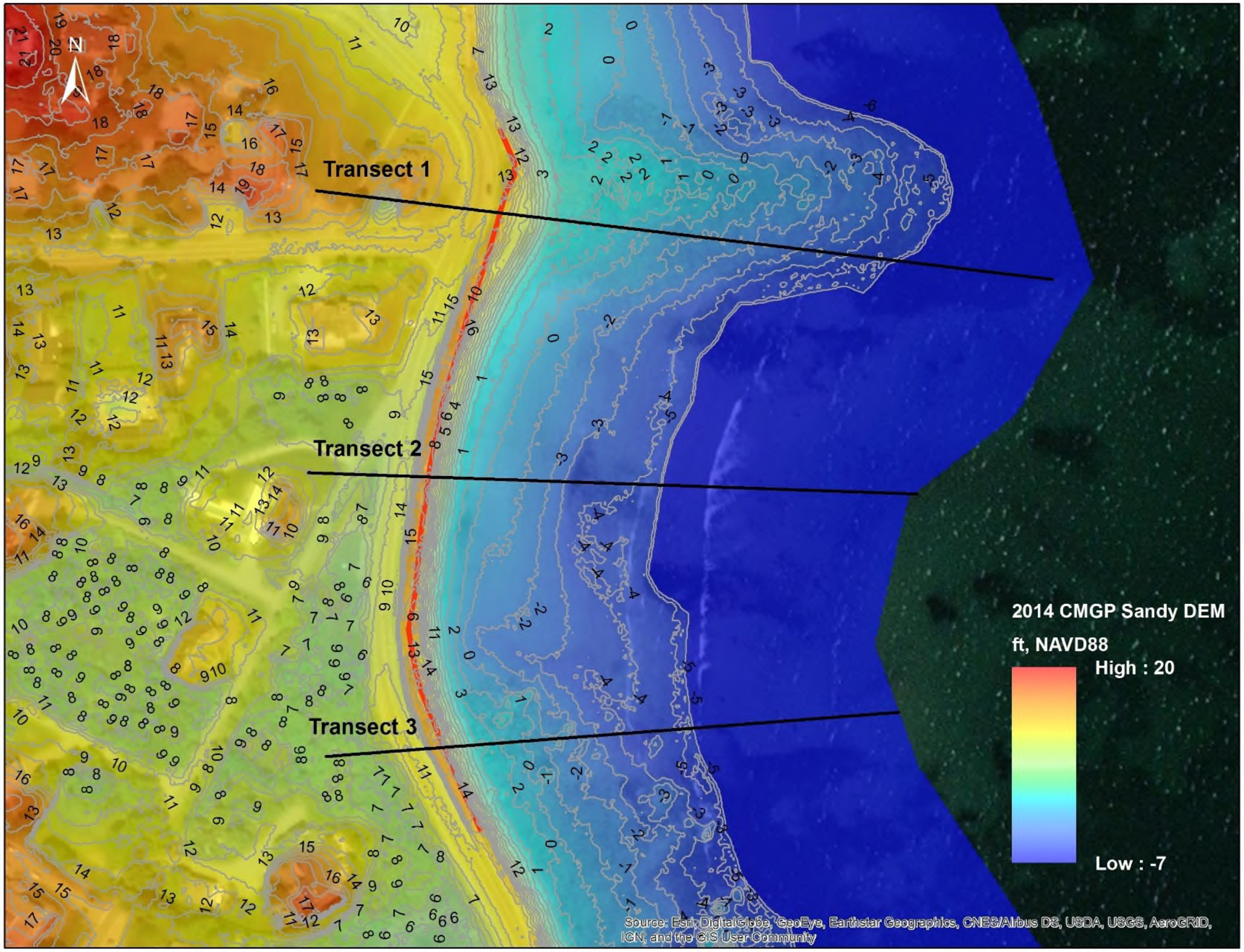


Figure 44. Transects and elevations at NHDOT S.R. Section 7.

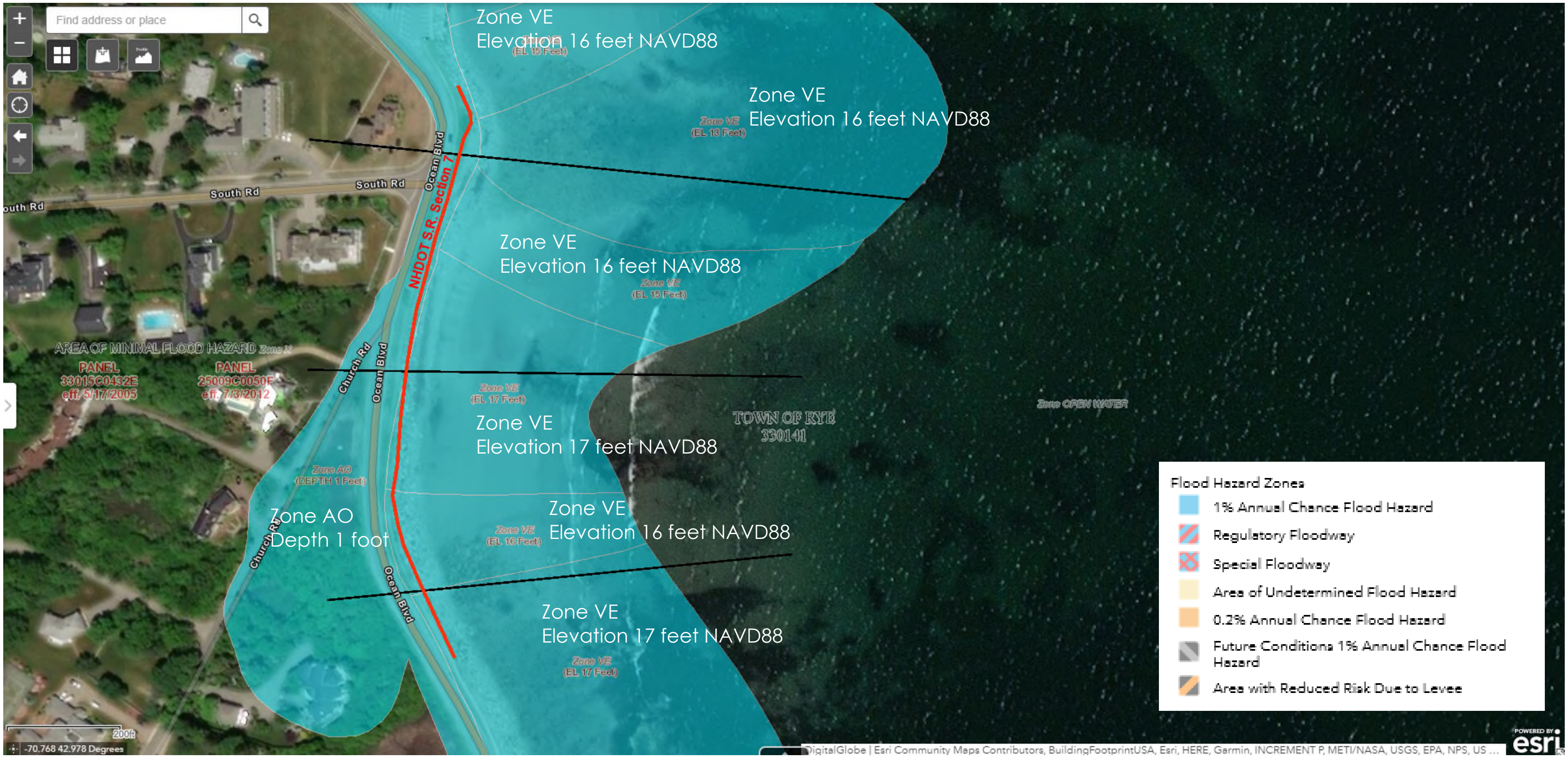


Figure 45. FEMA Flood Hazard Zones in vicinity of the NHDOT sections – Section 7.

Figure 46. Flood inundation at Stillwater Elevation 8.5 feet NAVD88 – Vicinity of Section 7.

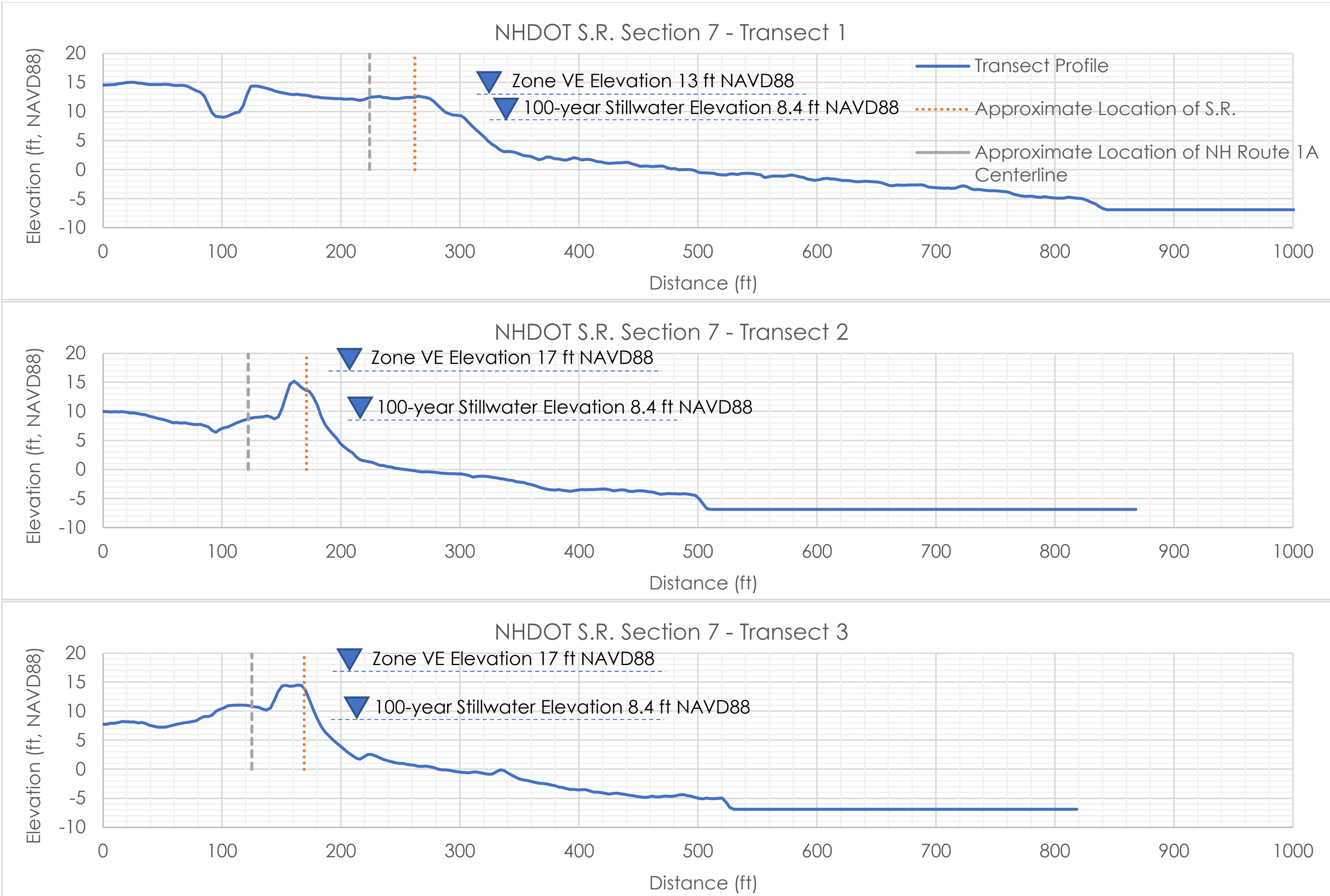


Figure 47. Elevation profile for Transect 1, 2, 3 at NHDOT S.R. Section 7.

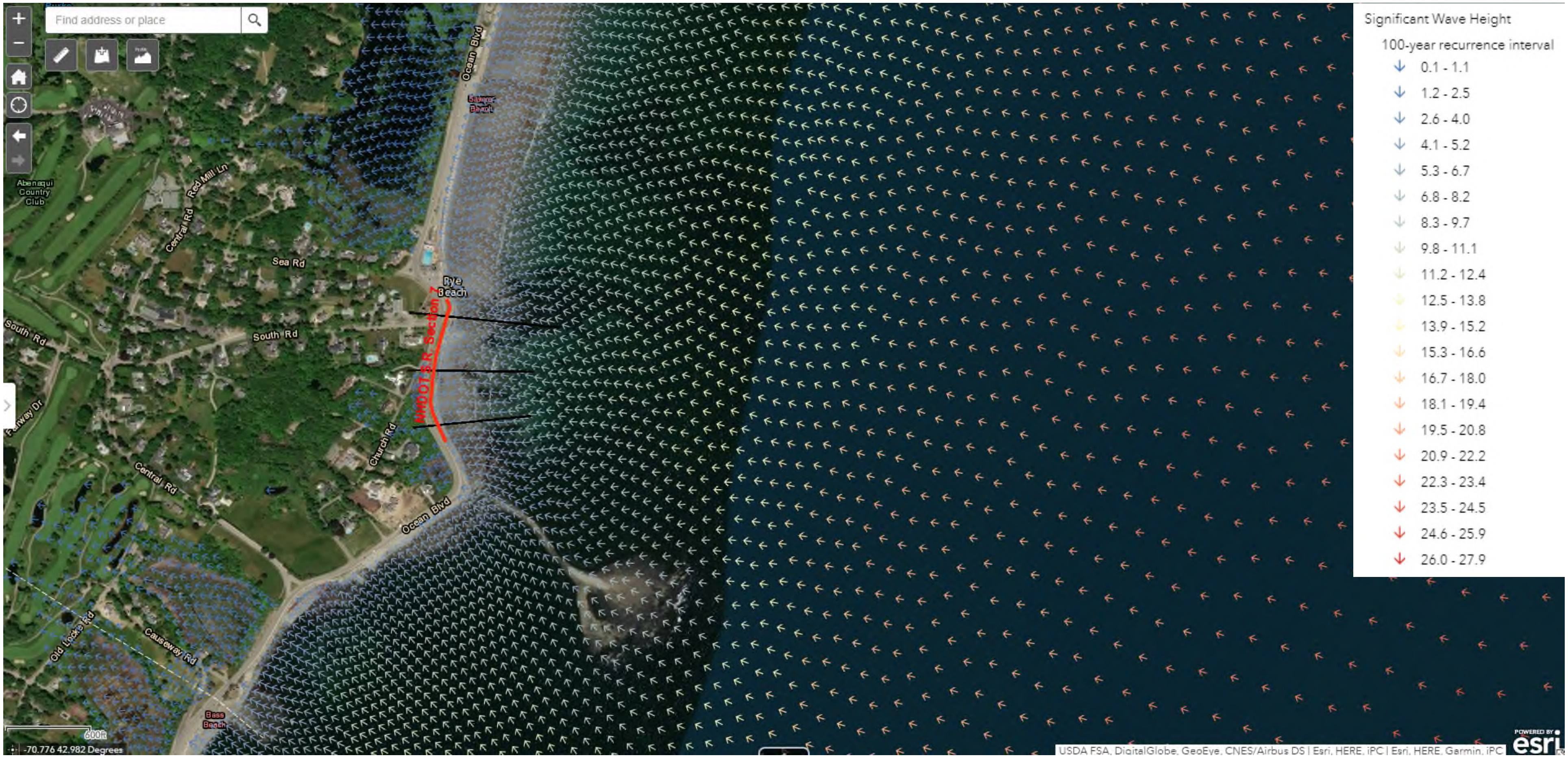


Figure 48. 100-year Recurrence Interval Wave Height (feet) for Transect 1, 2, 3 at NHDOT S.R. Section 7.

Figure 49. Transect Locations at NHDOT S.R. Section 10.

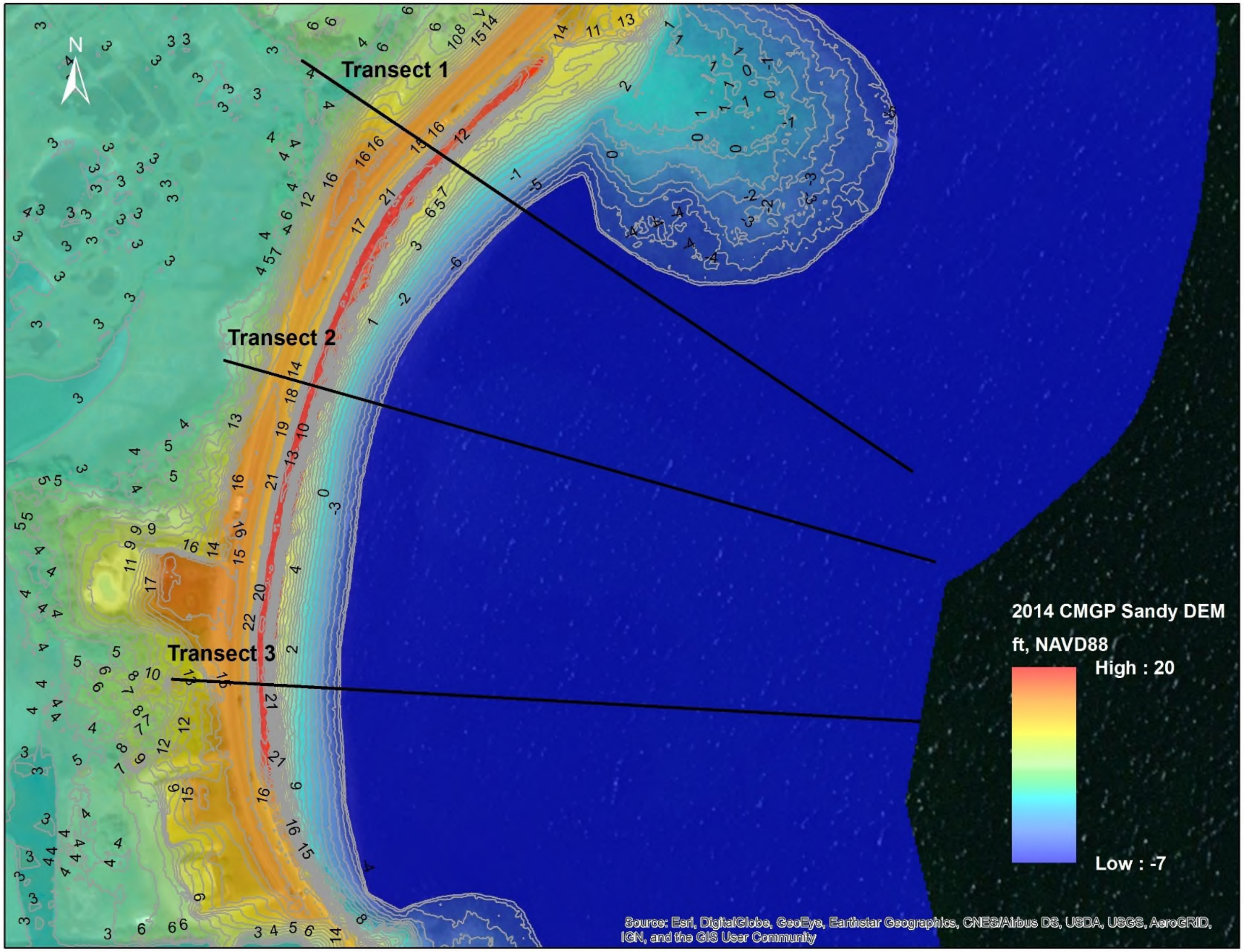


Figure 50. Transects and elevations at NHDOT S.R. Section 10.

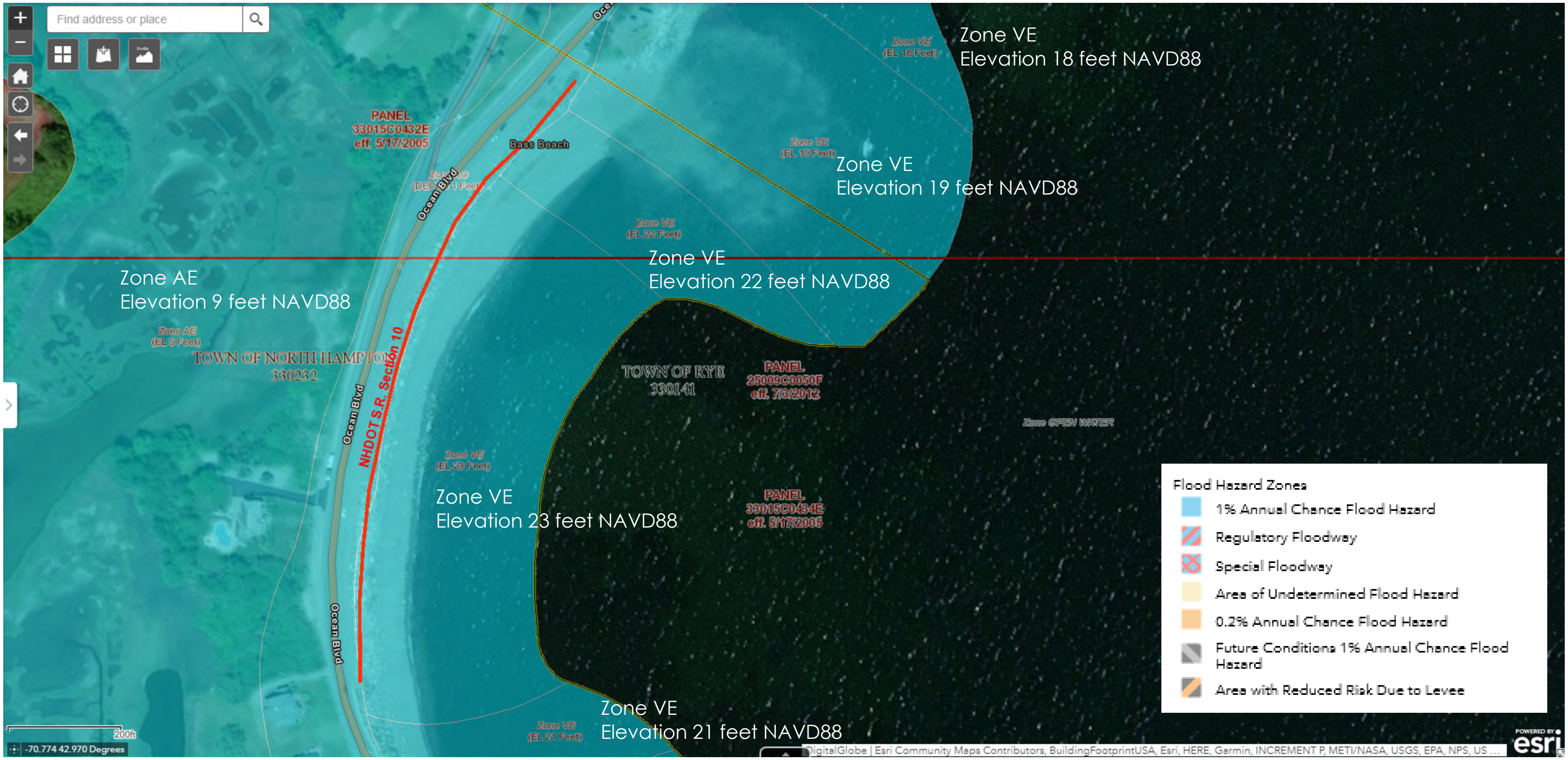


Figure 51. FEMA Flood Hazard Zones in vicinity of the NHDOT sections – Section 10.

Figure 52. Flood inundation at Stillwater Elevation 8.5 feet NAVD88 – Vicinity of Section 10.

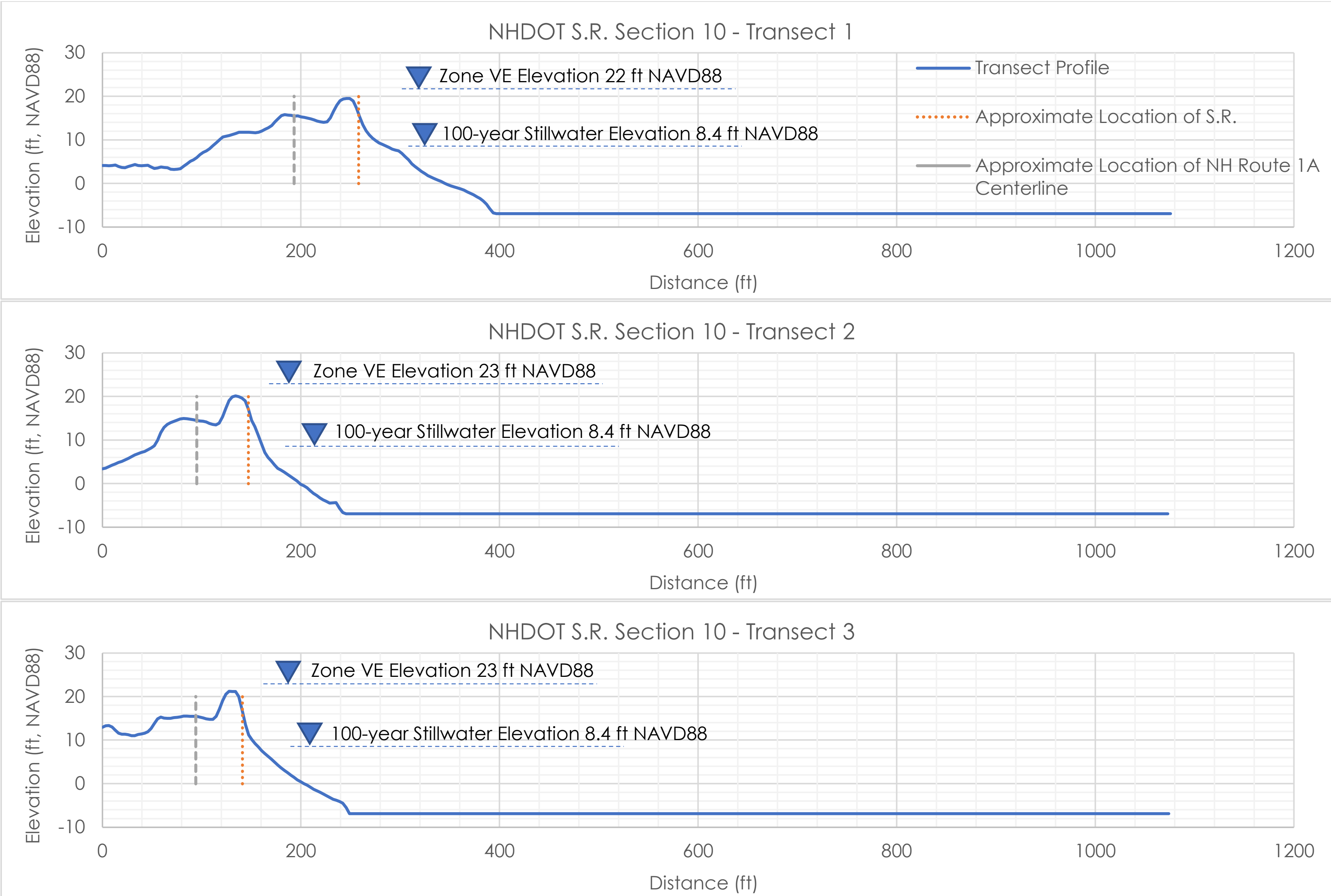


Figure 53. Elevation profile for Transect 1, 2, 3 at NHDOT S.R. Section 10.

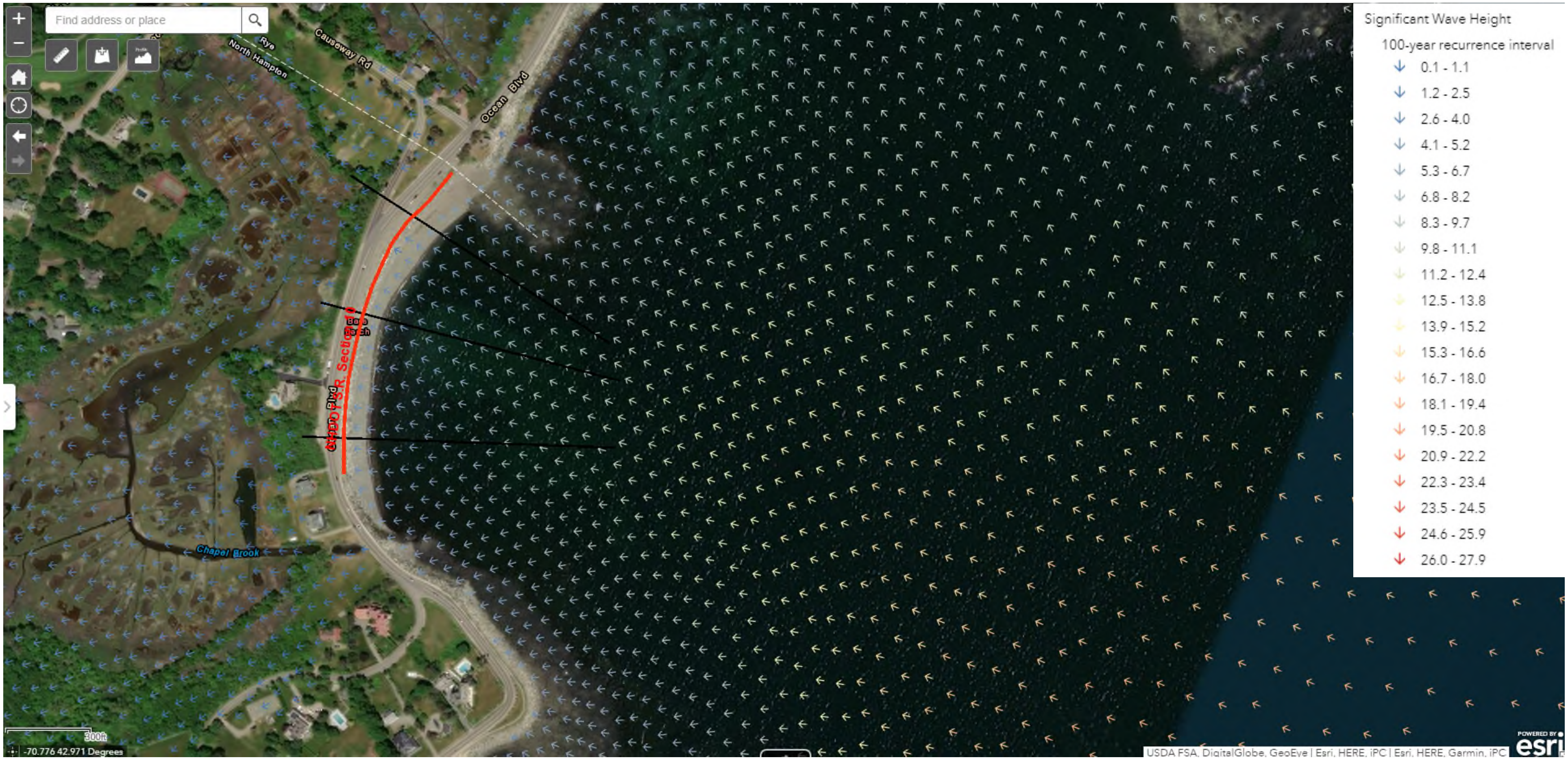


Figure 54. 100-year Recurrence Interval Wave Height (feet) for Transect 1, 2, 3 at NHDOT S.R. Section 10.

Figure 55. Transect Locations at NHDOT S.R. Section 13.

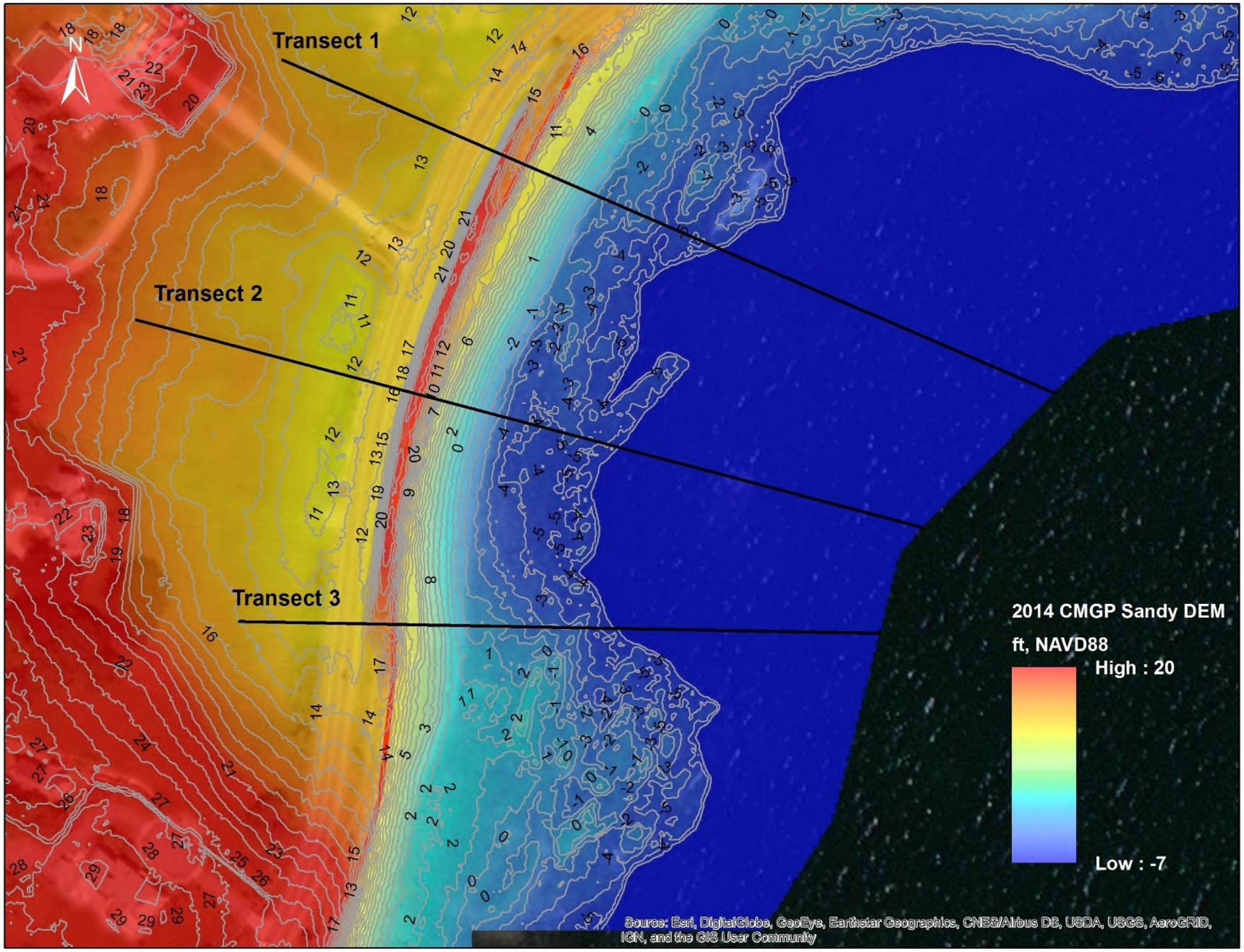


Figure 56. Transects and elevations at NHDOT S.R. Section 13.

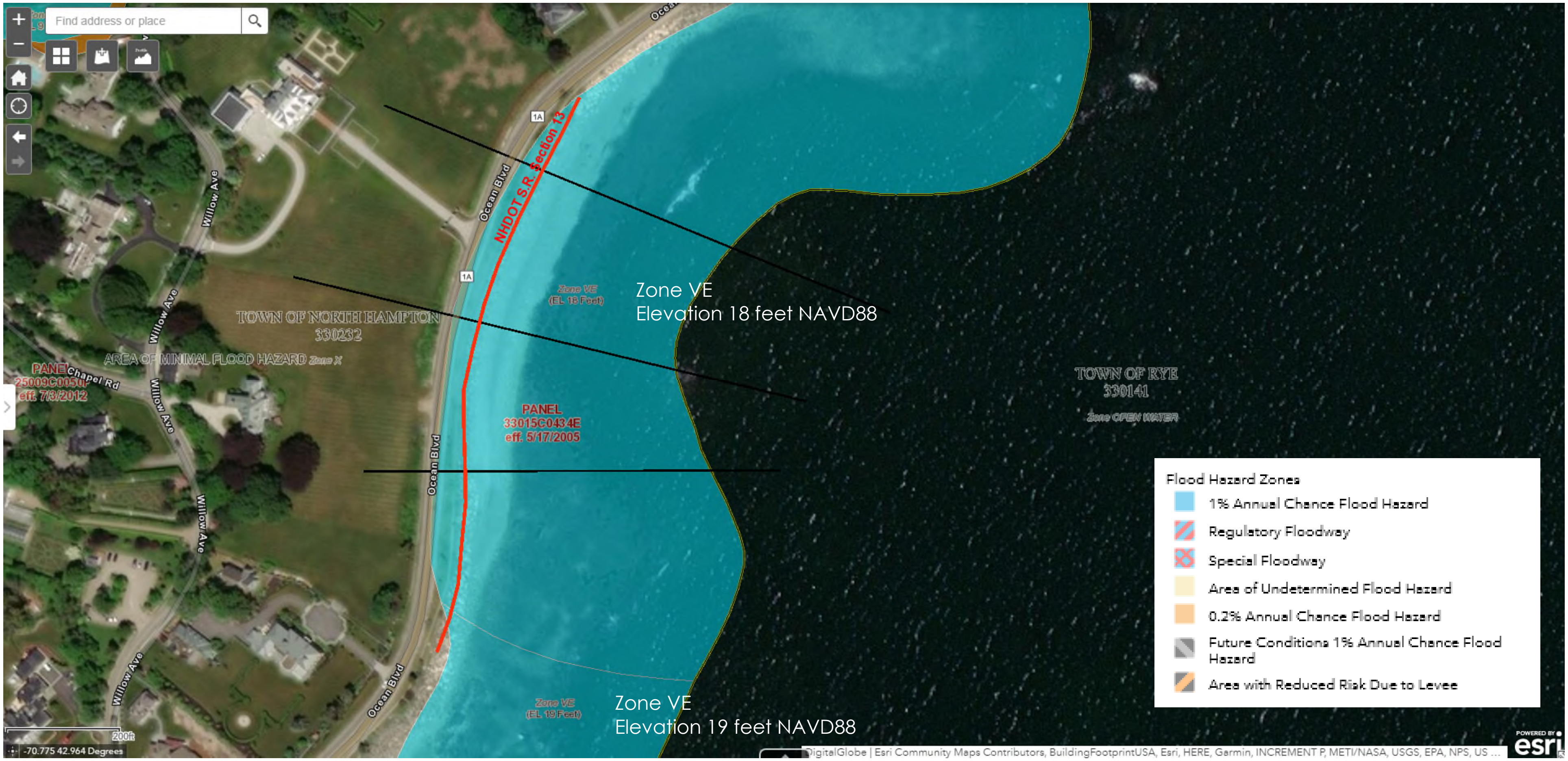


Figure 57. FEMA Flood Hazard Zones in vicinity of the NHDOT sections – Section 13.

Figure 58. Flood inundation at Stillwater Elevation 8.5 feet NAVD88 – Vicinity of Section 13.

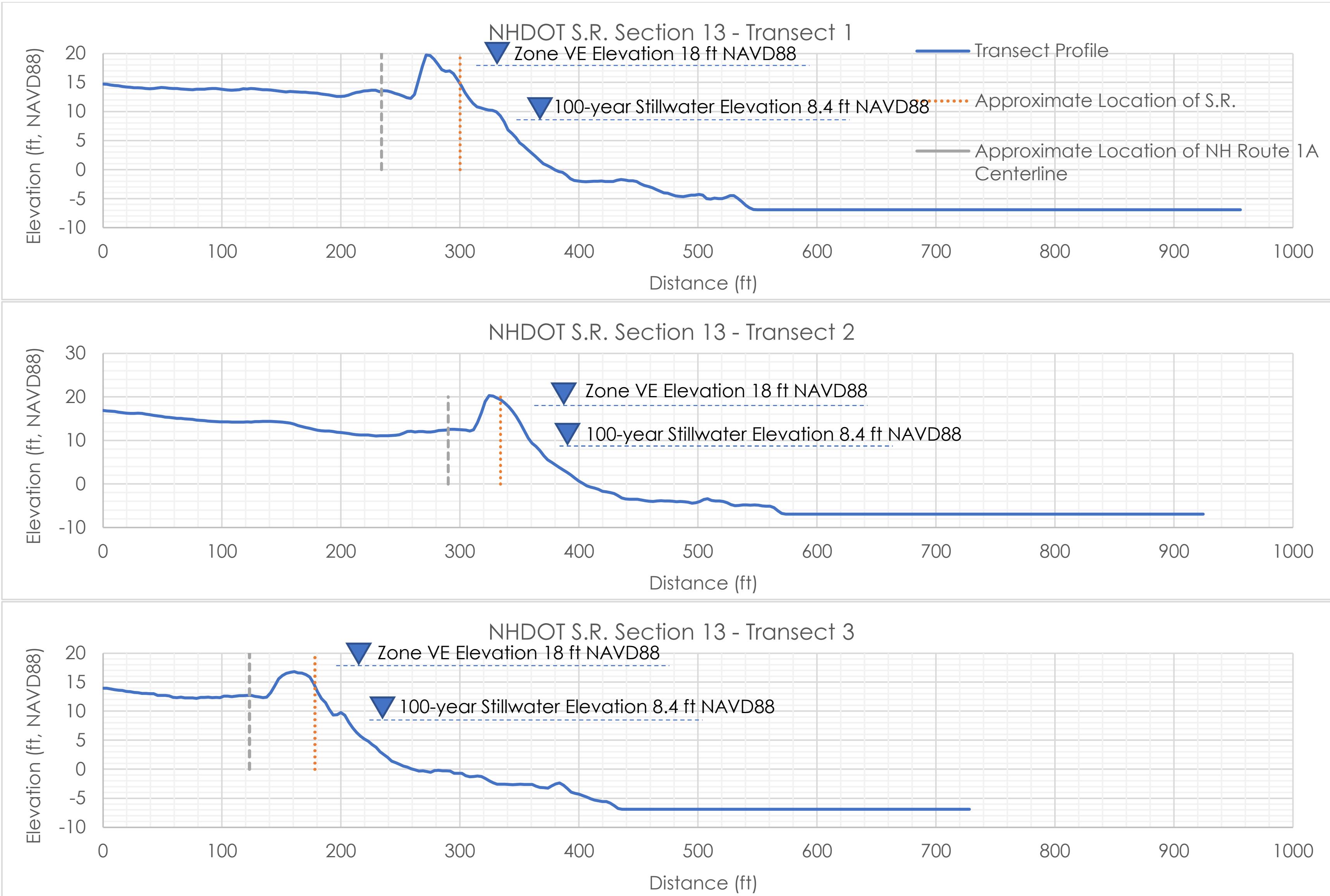


Figure 59. Elevation profile for Transect 1, 2, 3 at NHDOT S.R. Section 13.

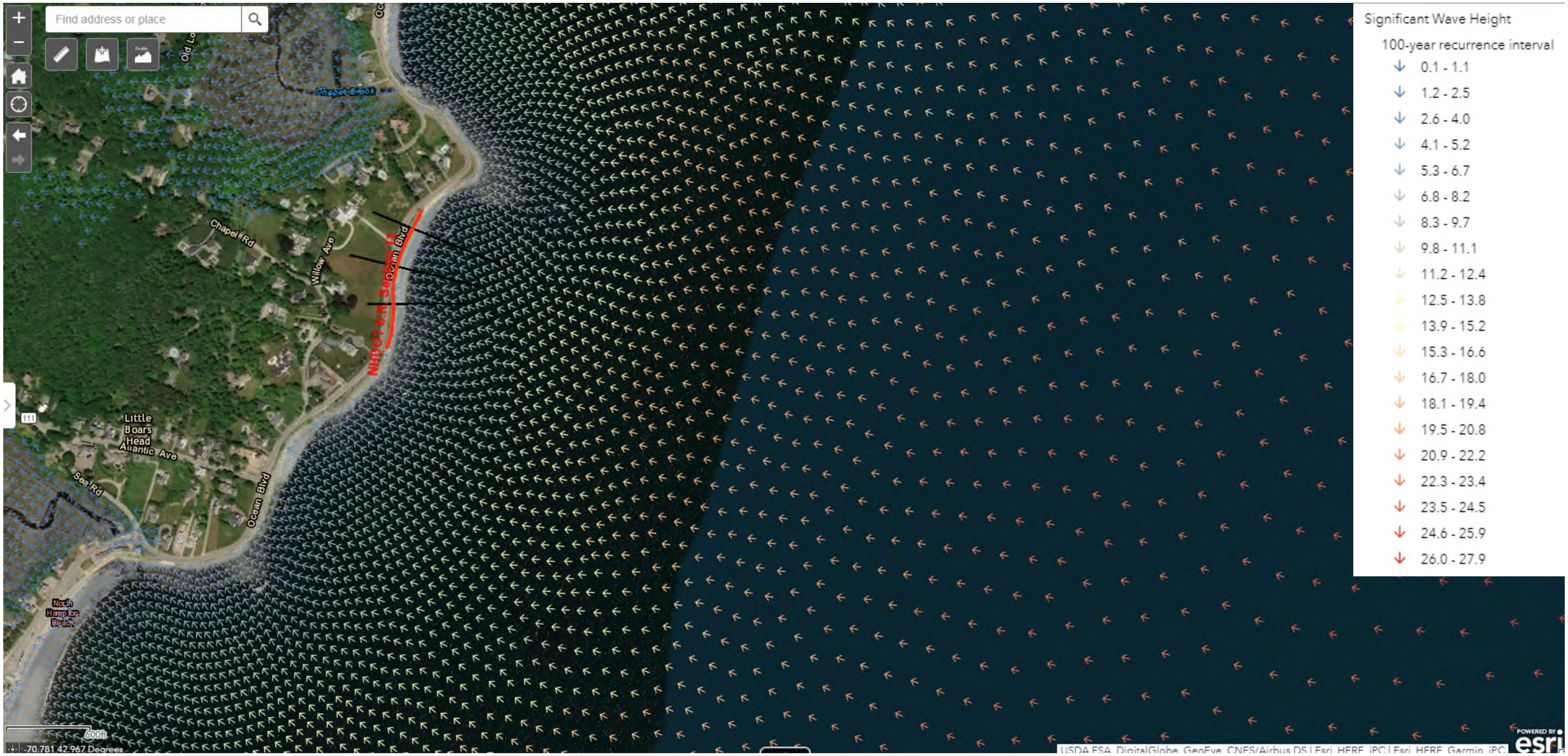


Figure 60. 100-year Recurrence Interval Wave Height (feet) for Transect 1, 2, 3 at NHDOT S.R. Section 13.

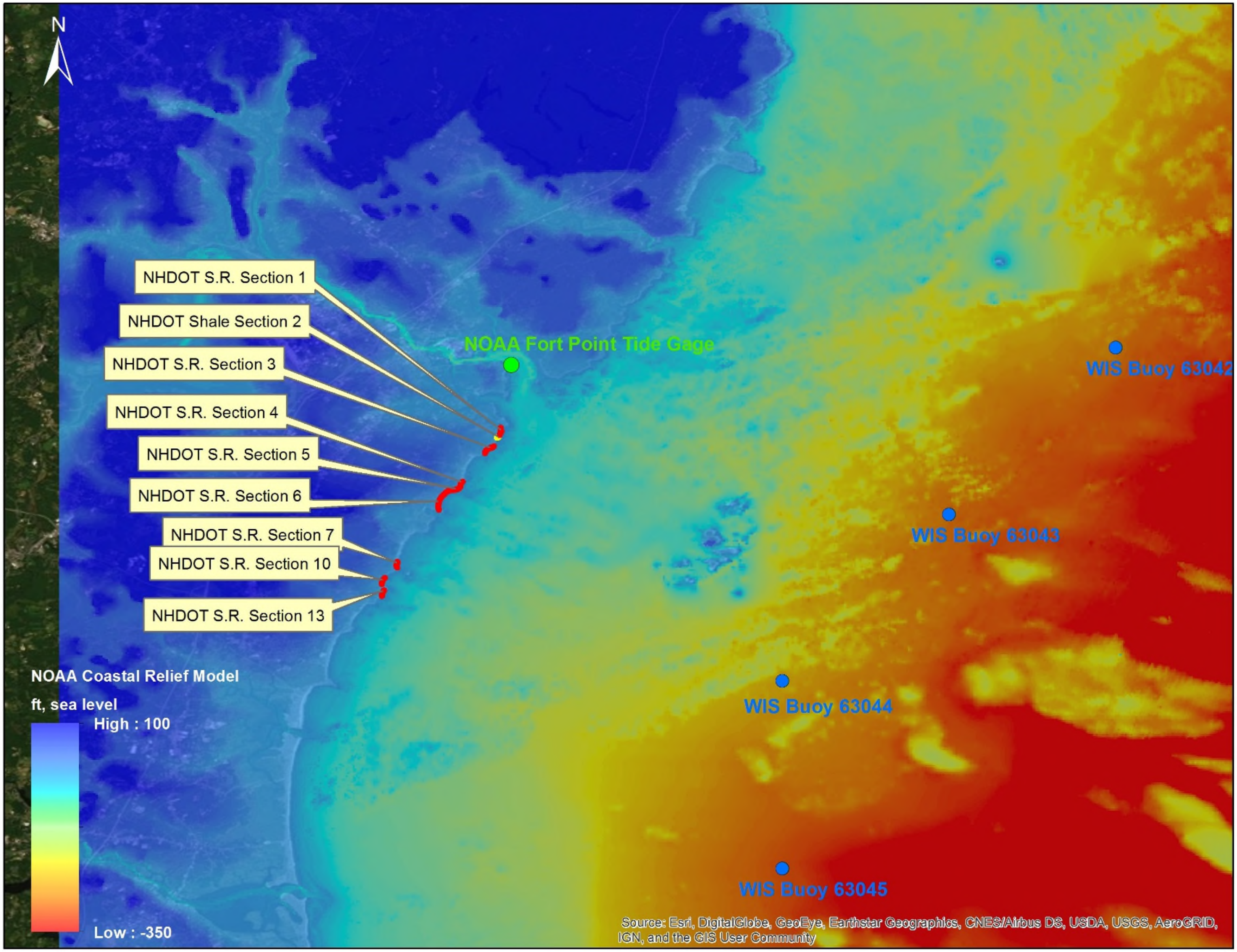


Figure 61. NOAA Coastal Relief Model (1998).

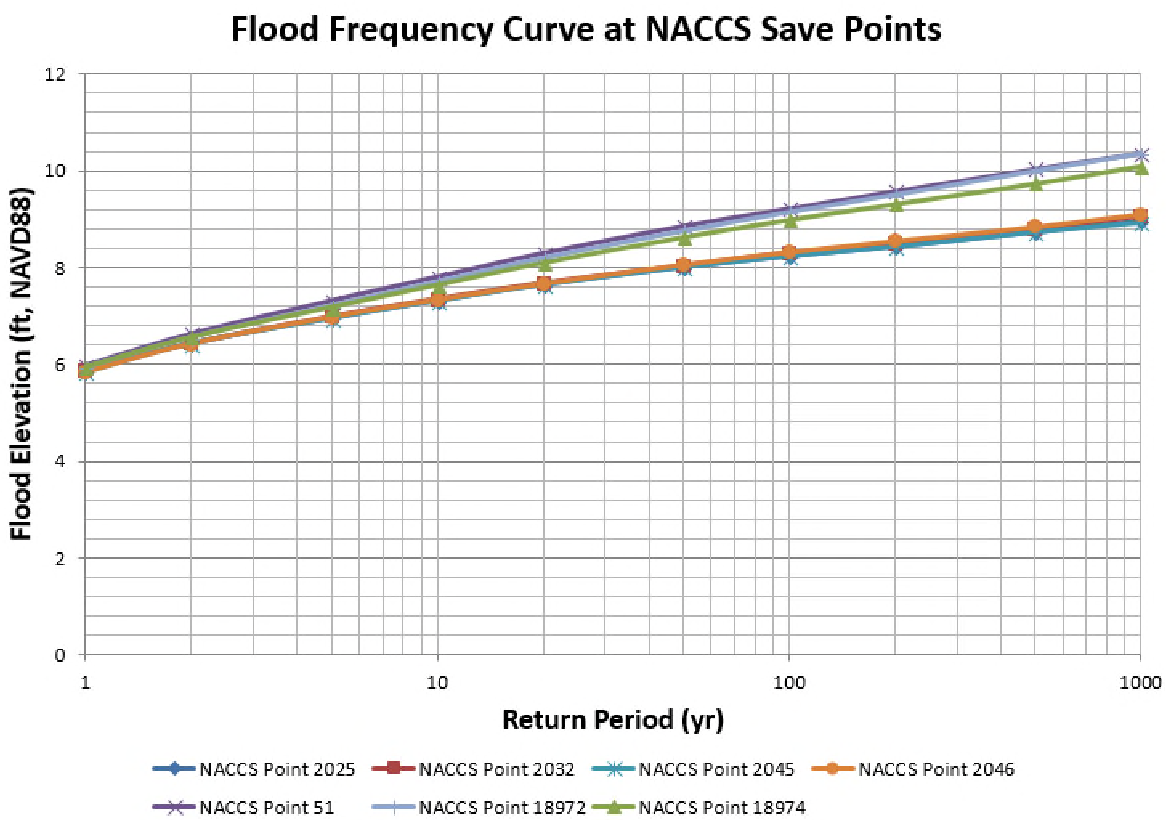


Figure 62. Flood frequency curve at NACCS save points (locations shown in **Figure 2**).

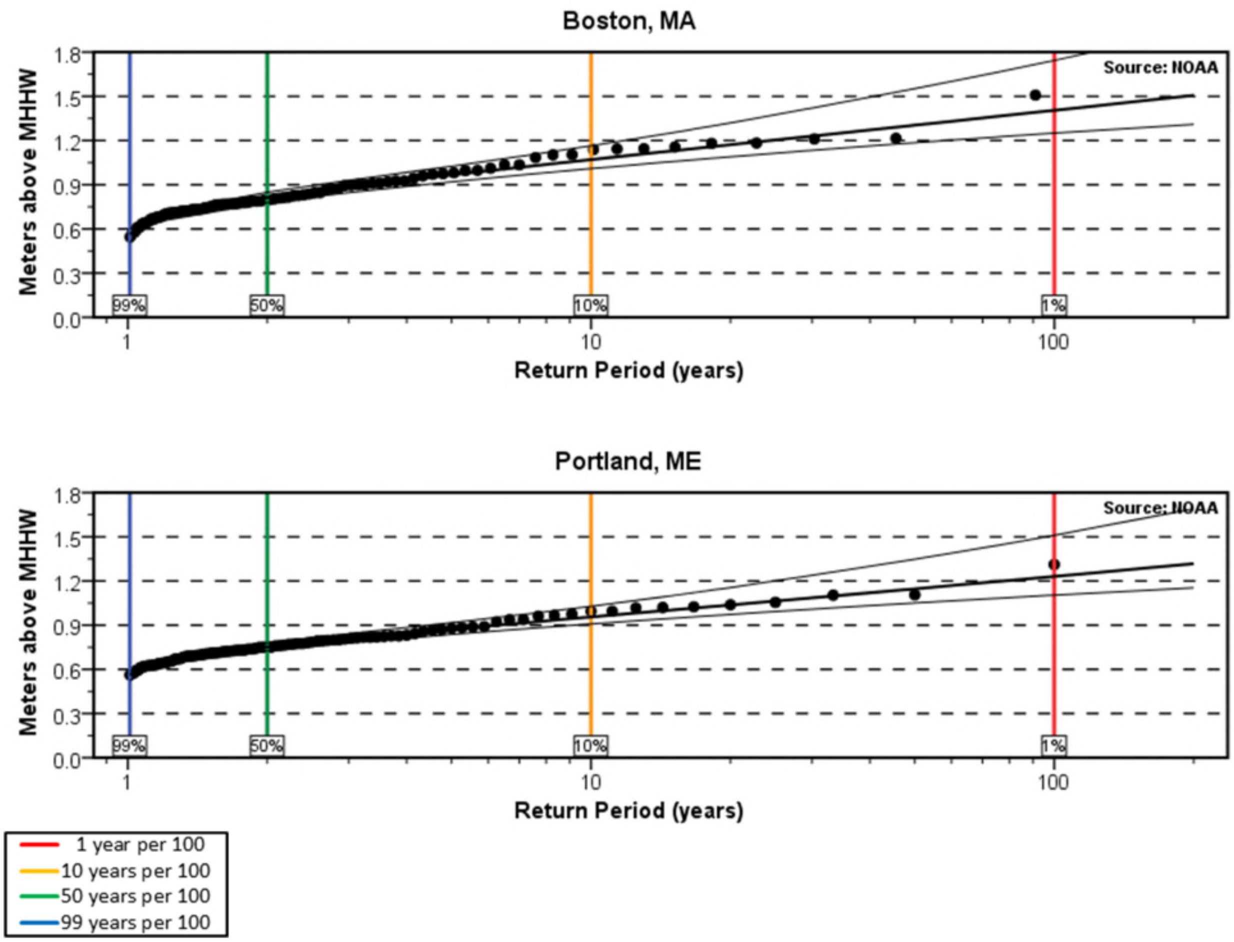


Figure 63. Flood frequency curve at NOAA Boston and Portland tide gage.

Figure 64. Water level data at NOAA Fort Point Gage during March 2018 Nor'Easter.

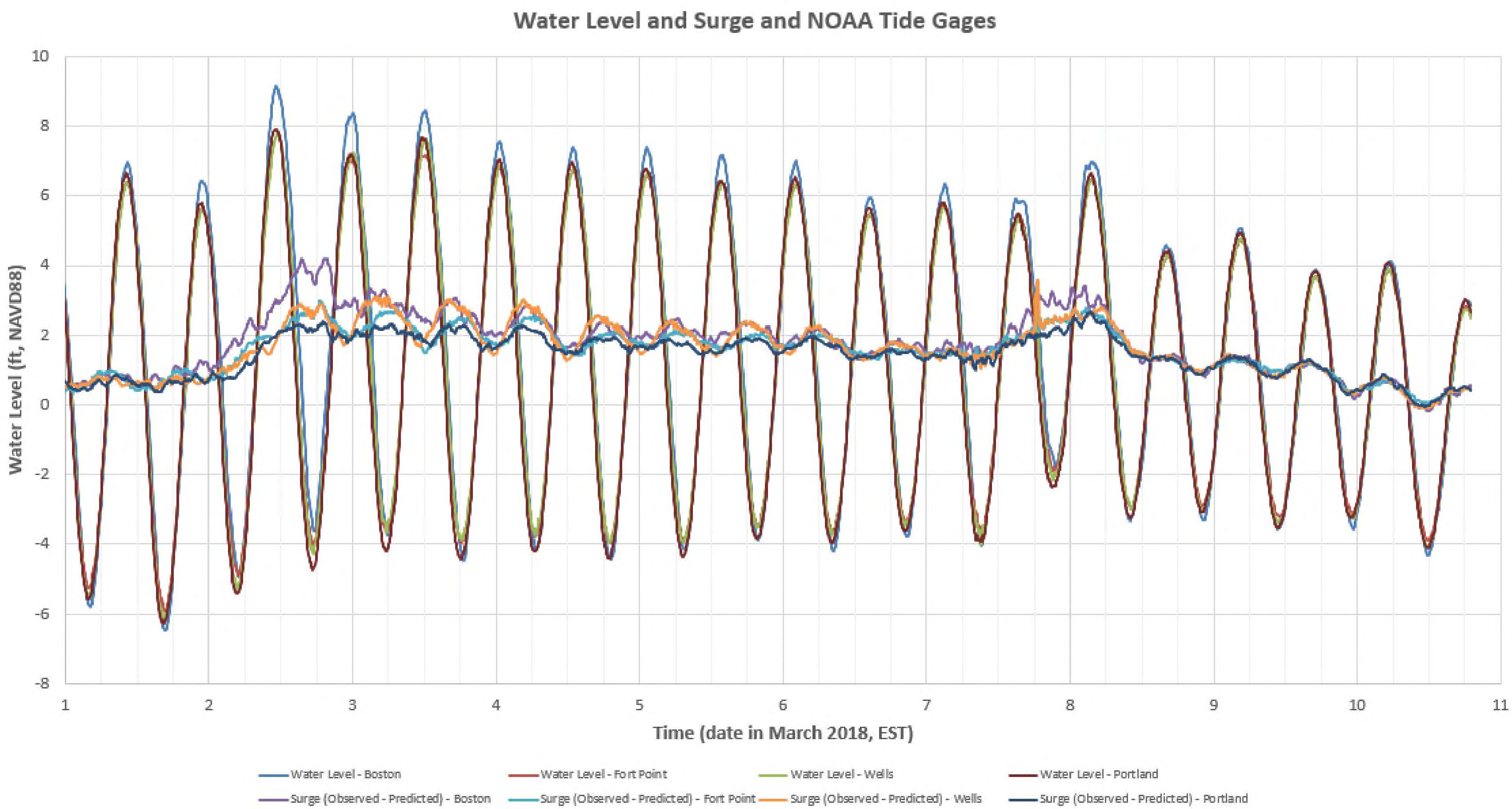
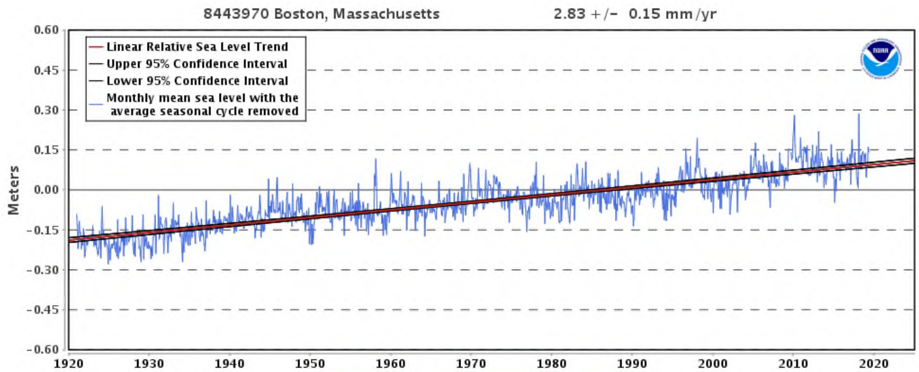


Figure 65. Water level data at NOAA Boston, Fort Point, Wells and Portland Gages during March 2018 Nor'Easter.

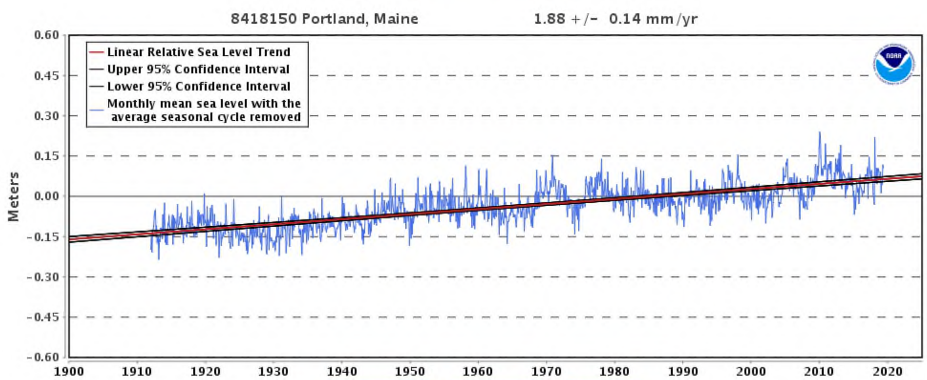
Relative Sea Level Trend
8443970 Boston, Massachusetts



EXPORT TO TEXT | EXPORT TO CSV | SAVE IMAGE

The relative sea level trend is 2.83 millimeters/year with a 95% confidence interval of +/- 0.15 mm/yr based on monthly mean sea level data from 1921 to 2018 which is equivalent to a change of 0.93 feet in 100 years.

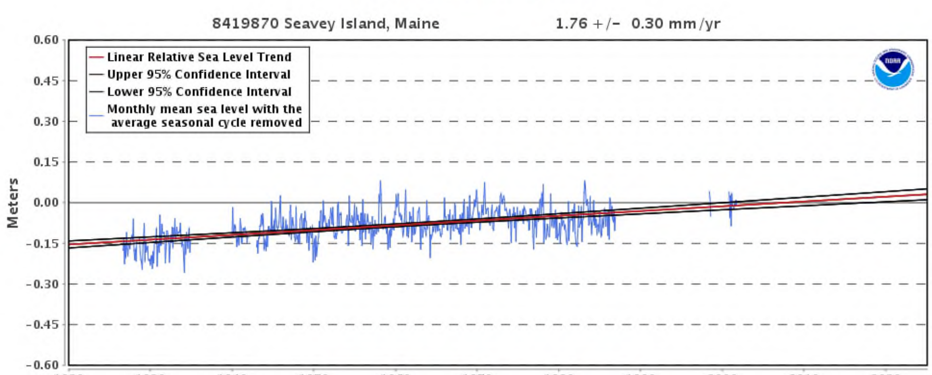
Relative Sea Level Trend
8418150 Portland, Maine



EXPORT TO TEXT | EXPORT TO CSV | SAVE IMAGE

The relative sea level trend is 1.88 millimeters/year with a 95% confidence interval of +/- 0.14 mm/yr based on monthly mean sea level data from 1912 to 2018 which is equivalent to a change of 0.62 feet in 100 years.

Relative Sea Level Trend
8419870 Seavey Island, Maine



EXPORT TO TEXT | EXPORT TO CSV | SAVE IMAGE

The relative sea level trend is 1.76 millimeters/year with a 95% confidence interval of +/- 0.3 mm/yr based on monthly mean sea level data from 1926 to 2001 which is equivalent to a change of 0.58 feet in 100 years.

Figure 66. Relative sea level trend at NOAA Boston, Portland and Seavey Island Gage.

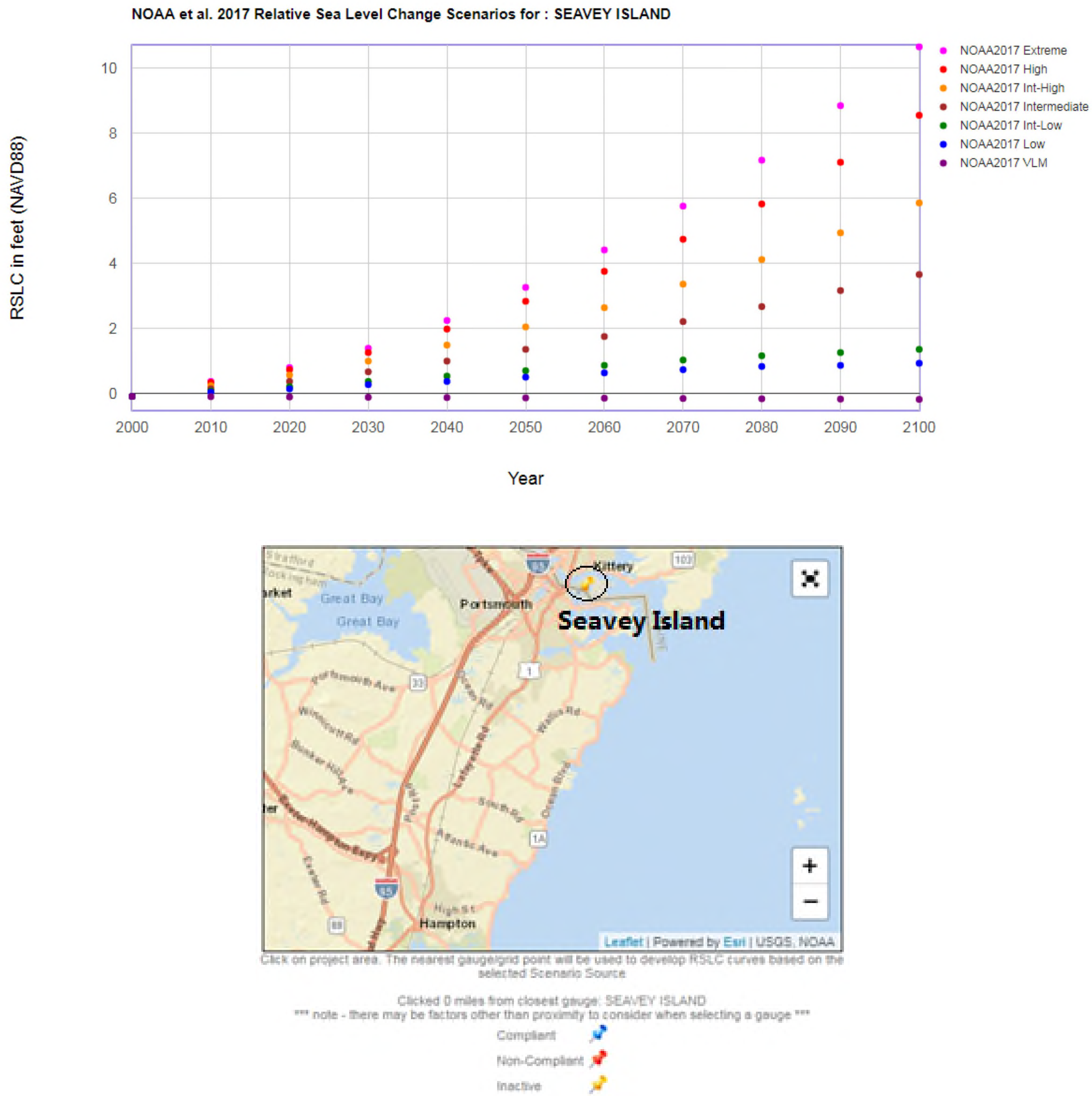


Figure 67. Sea Level Rise Projections at Seavey Island (using the USACE Relative Sea Level Change Calculator for NOAA et al. 2017 projections.

Figure 68. Location of wind observation sites.

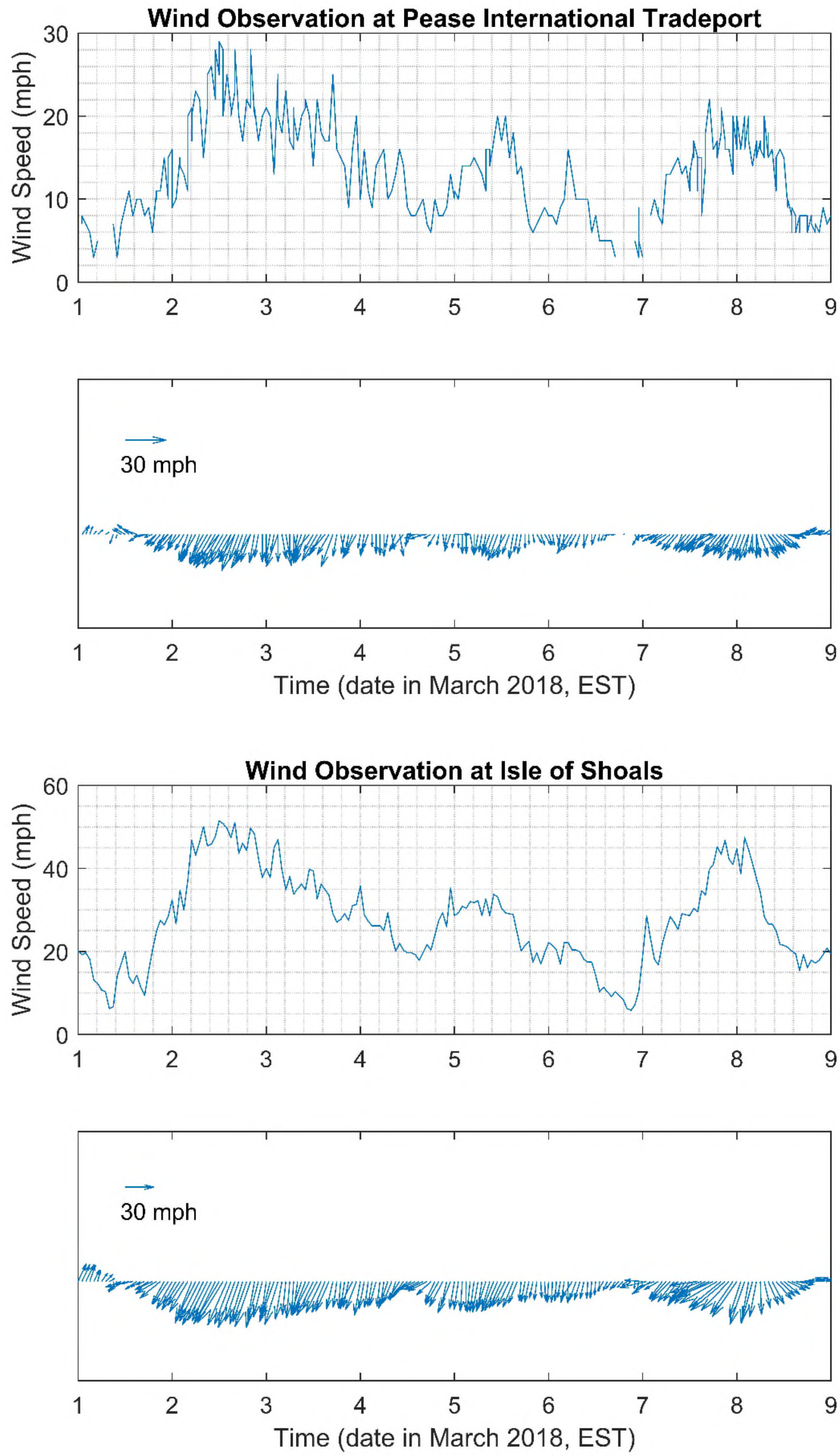


Figure 69. Wind observation during March 2018 Nor'Easter.

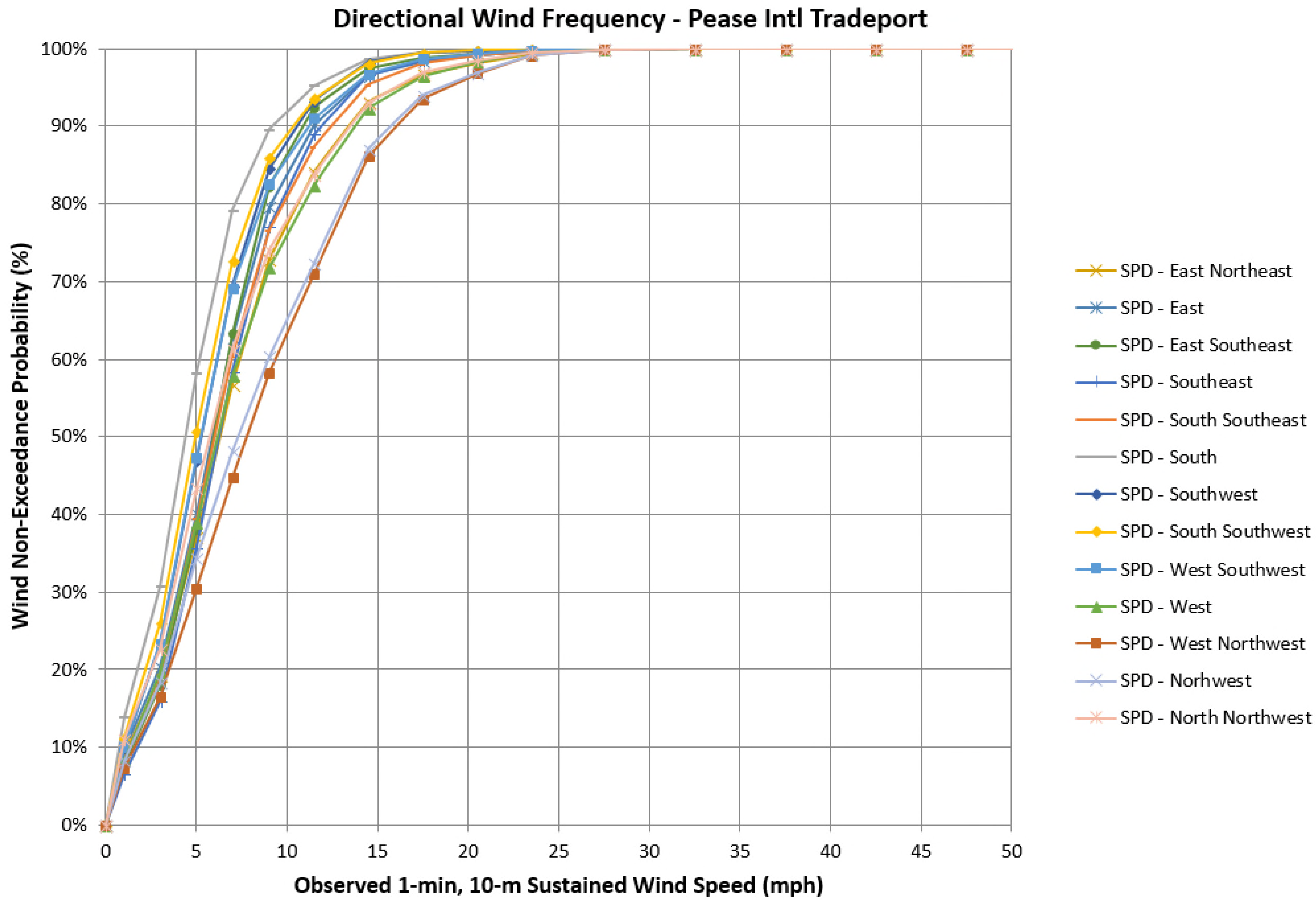


Figure 70. Directional Wind Frequency at Pease International Tradeport.

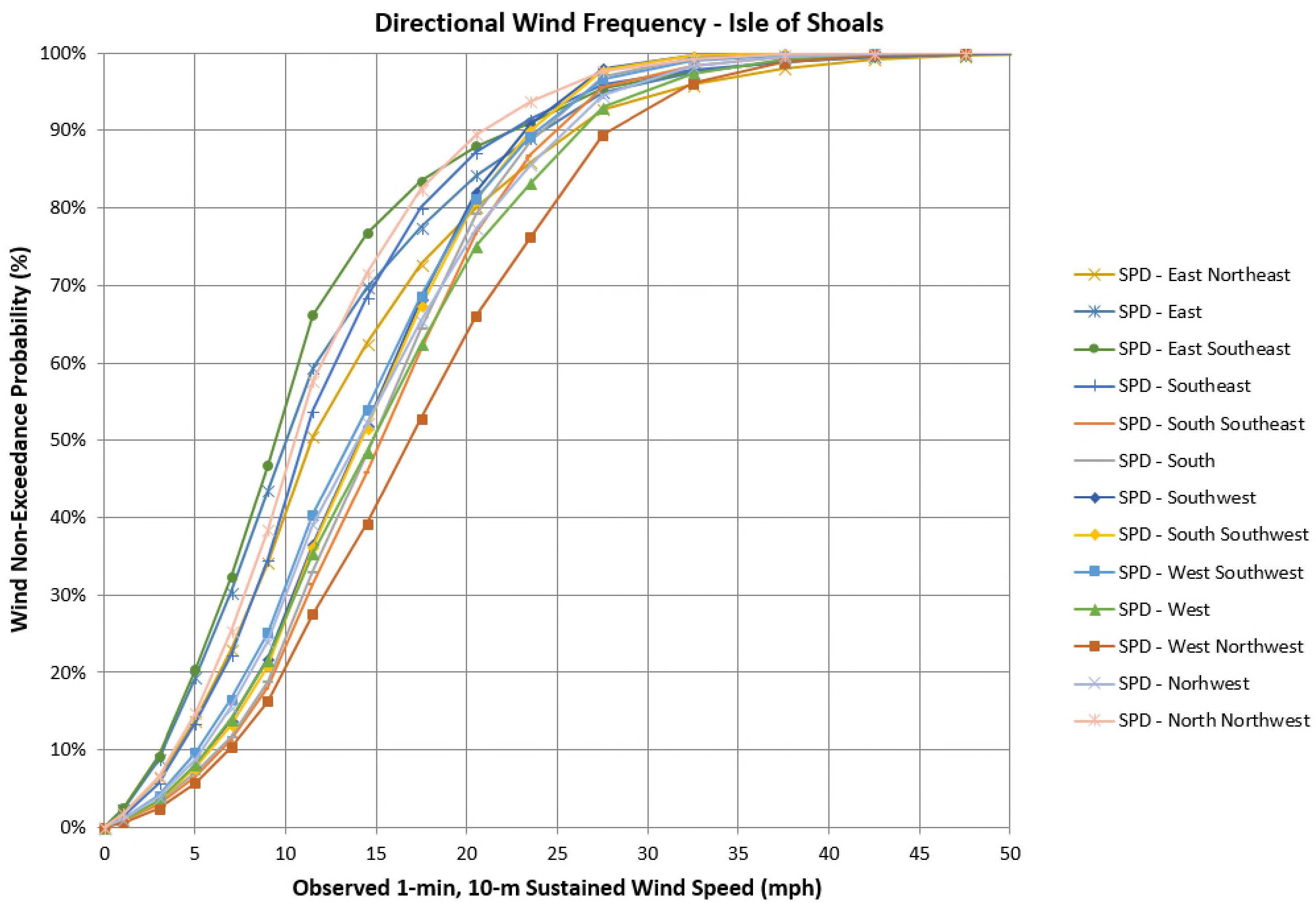
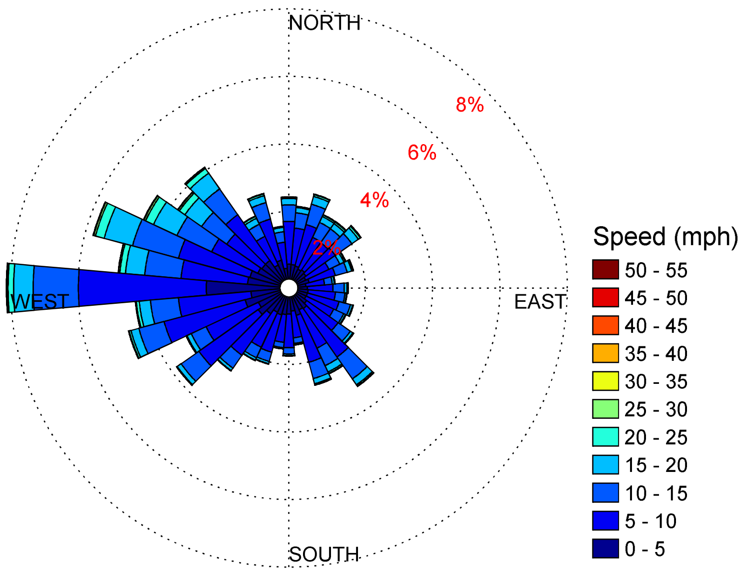


Figure 71. Directional Wind Frequency at Isle of Shoals.

Wind from Pease International Airport (1956 - 2019)



Wind from Isle of Shoals (1985 - 2019)

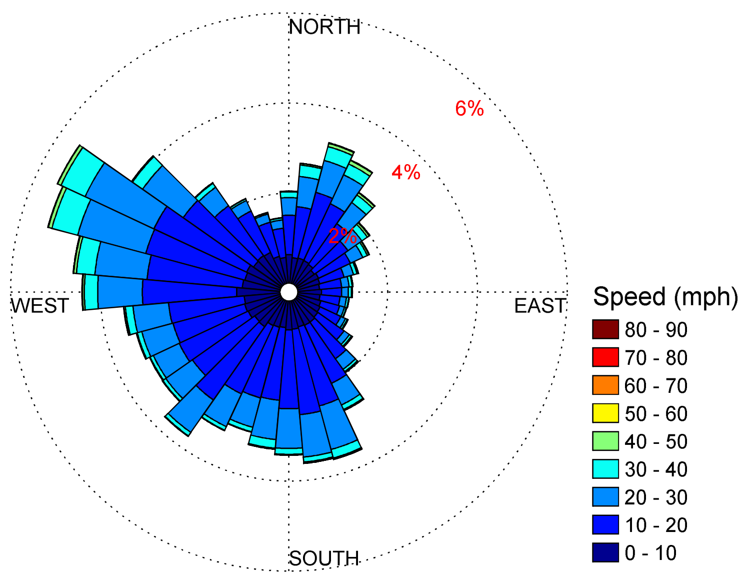


Figure 72. Wind rose based on all data records at Pease Intl Tradeport and Isle of Shoals.

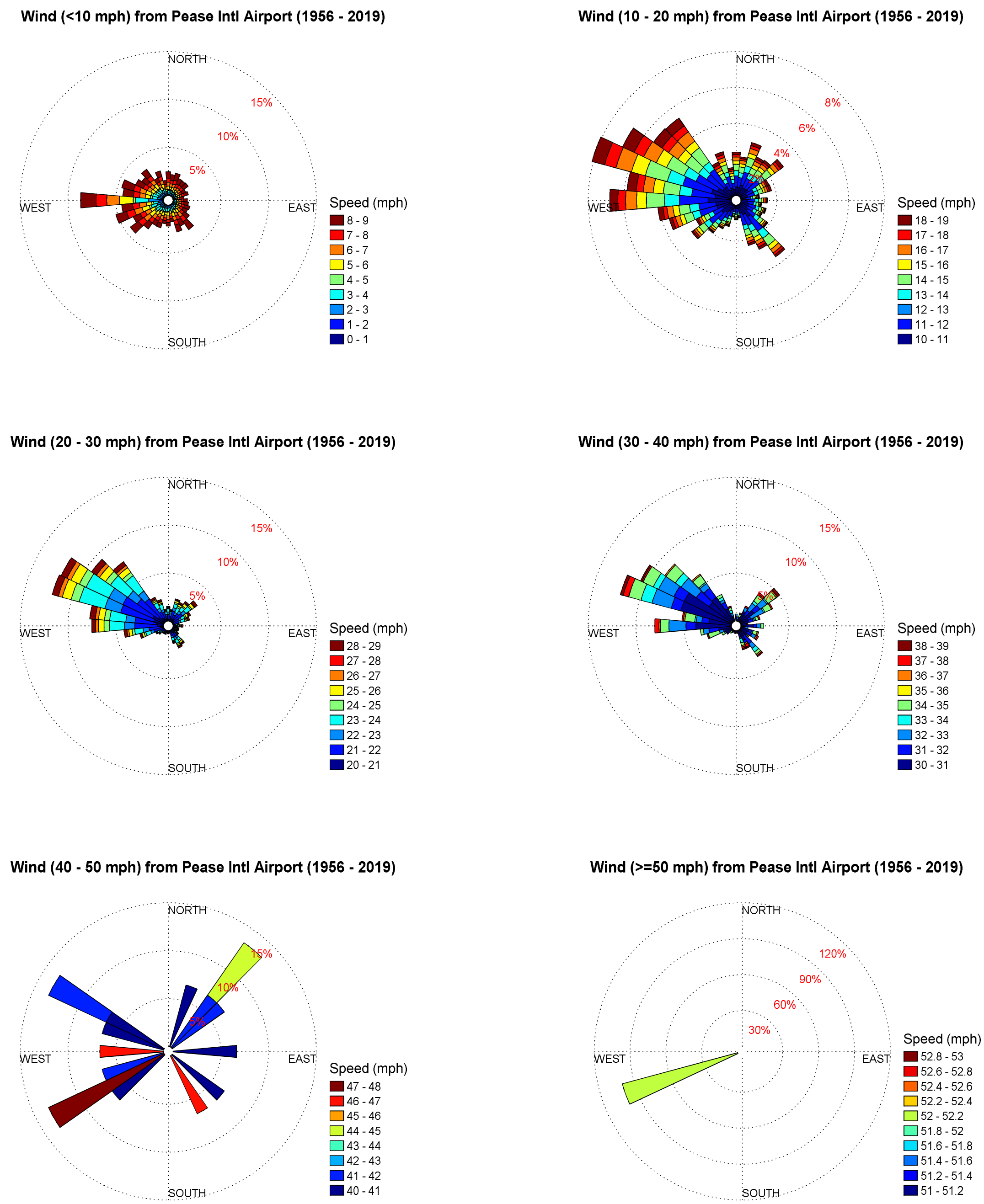


Figure 73. Wind rose for various speed ranges based on wind data at Pease Intl Tradeport.

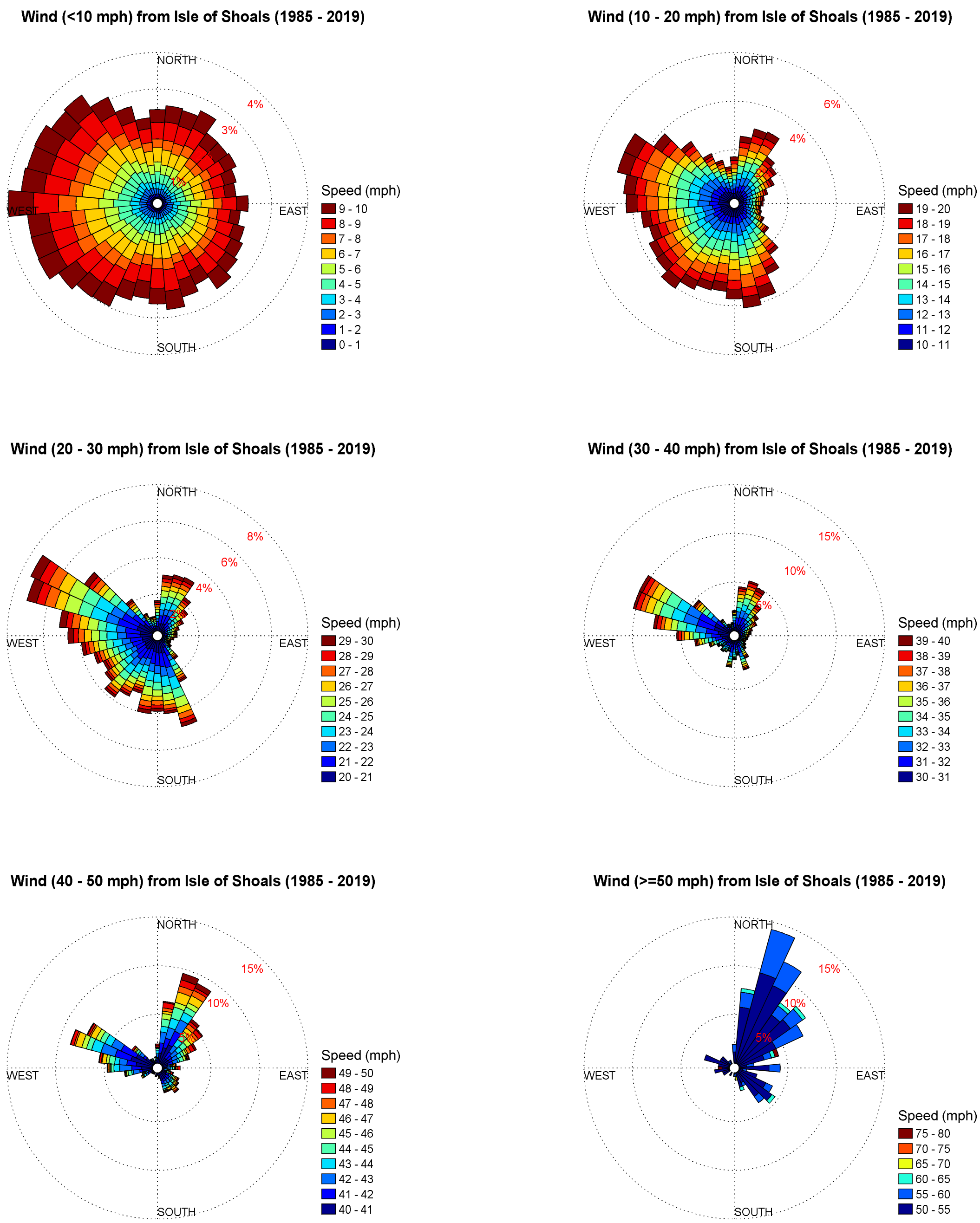
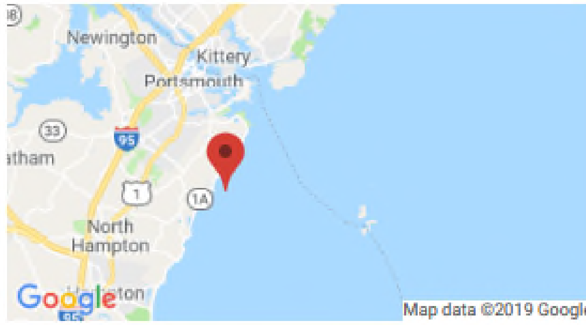


Figure 74. Wind rose for various speed ranges based on wind data at Isle of Shoals.

ATC Hazards by Location

Search Information

Coordinates:	42.999670316129595, -70.73487910185548
Elevation:	ft
Timestamp:	2019-08-02T19:59:36.777Z
Hazard Type:	Wind



ASCE 7-16

MRI 10-Year	74 mph
MRI 25-Year	83 mph
MRI 50-Year	88 mph
MRI 100-Year	96 mph
Risk Category I	107 mph
Risk Category II	116 mph
Risk Category III	124 mph
Risk Category IV	129 mph

ASCE 7-10

MRI 10-Year	78 mph
MRI 25-Year	87 mph
MRI 50-Year	94 mph
MRI 100-Year	100 mph
Risk Category I	113 mph
Risk Category II	123 mph
Risk Category III-IV	⚠ 134 mph

If the structure under consideration is a healthcare facility and you are also within 1 mile of the coastal mean high water line, you are in a wind-borne debris region. If other occupancy, use the Risk Category II basic wind speed contours to determine if you are in a wind-borne debris region.

ASCE 7-05

ASCE 7-05 Wind Speed	102 mph

The results indicated here DO NOT reflect any state or local amendments to the values or any delineation lines made during the building code adoption process. Users should confirm any output obtained from this tool with the local Authority Having Jurisdiction before proceeding with design.

Figure 75. ASCE wind speeds (3-sec gust) at NHDOT sections.

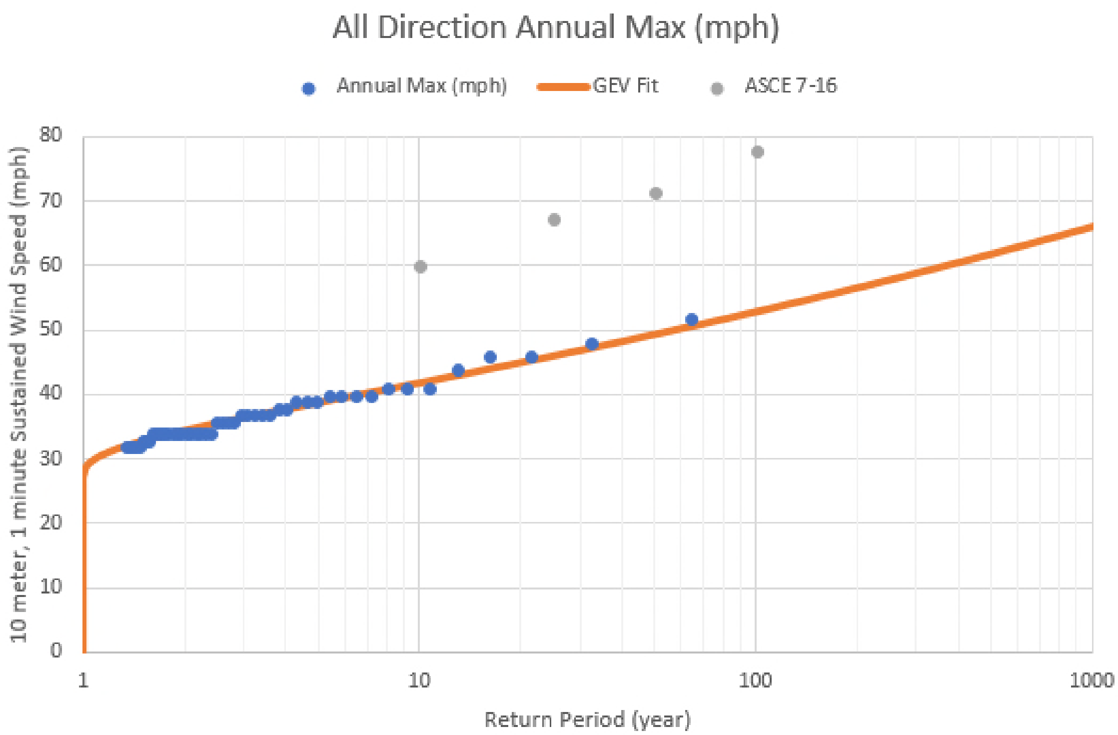


Figure 76. Wind Speed Frequency Curve at Pease International Tradeport based on GZA Wind Statistical Analysis – all direction wind.

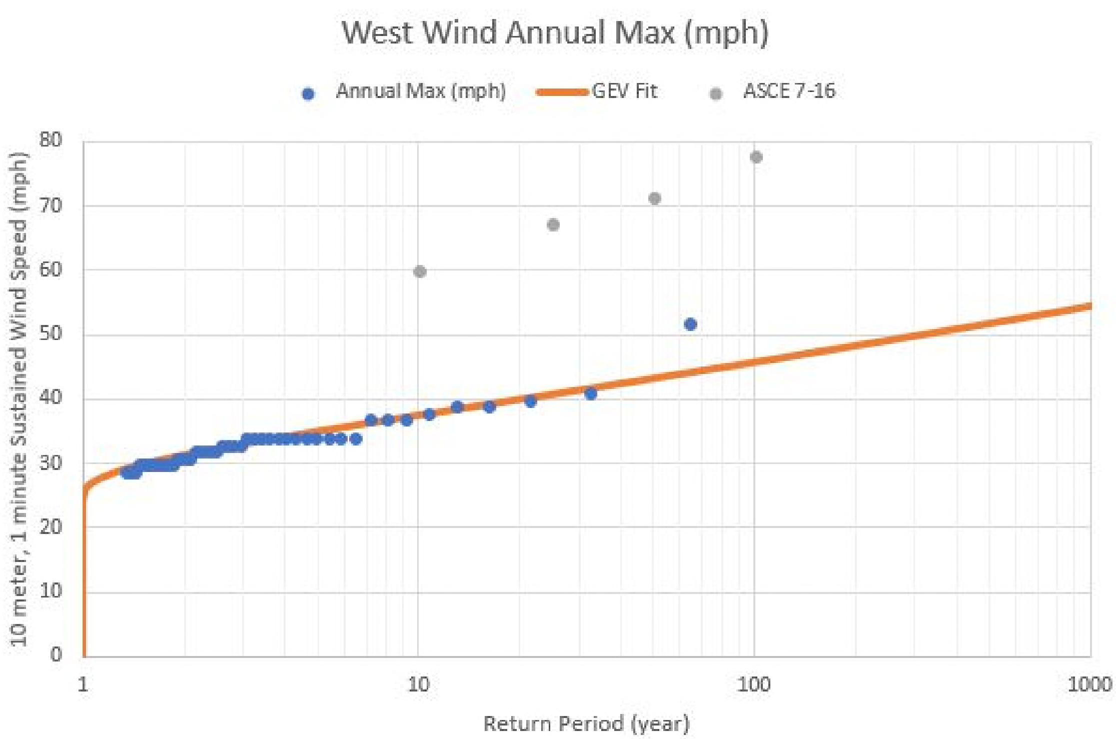


Figure 77. Wind Speed Frequency Curve at Pease International Tradeport based on GZA Wind Statistical Analysis – west wind.

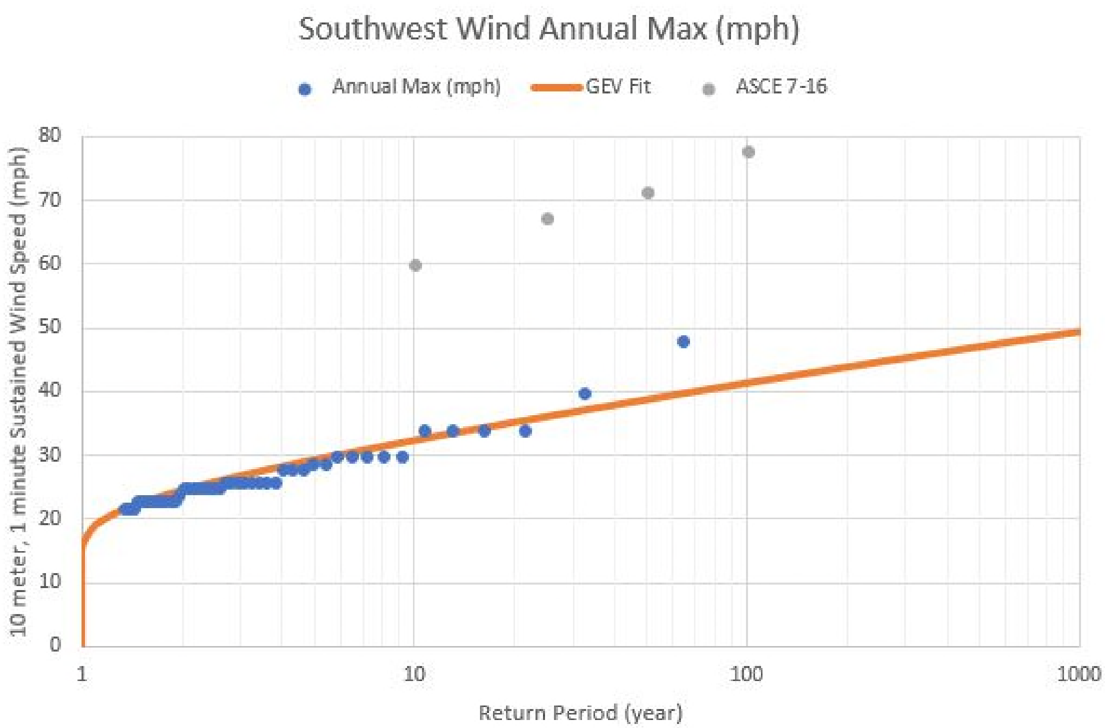


Figure 78. Wind Speed Frequency Curve at Pease International Tradeport based on GZA Wind Statistical Analysis – southwest wind.

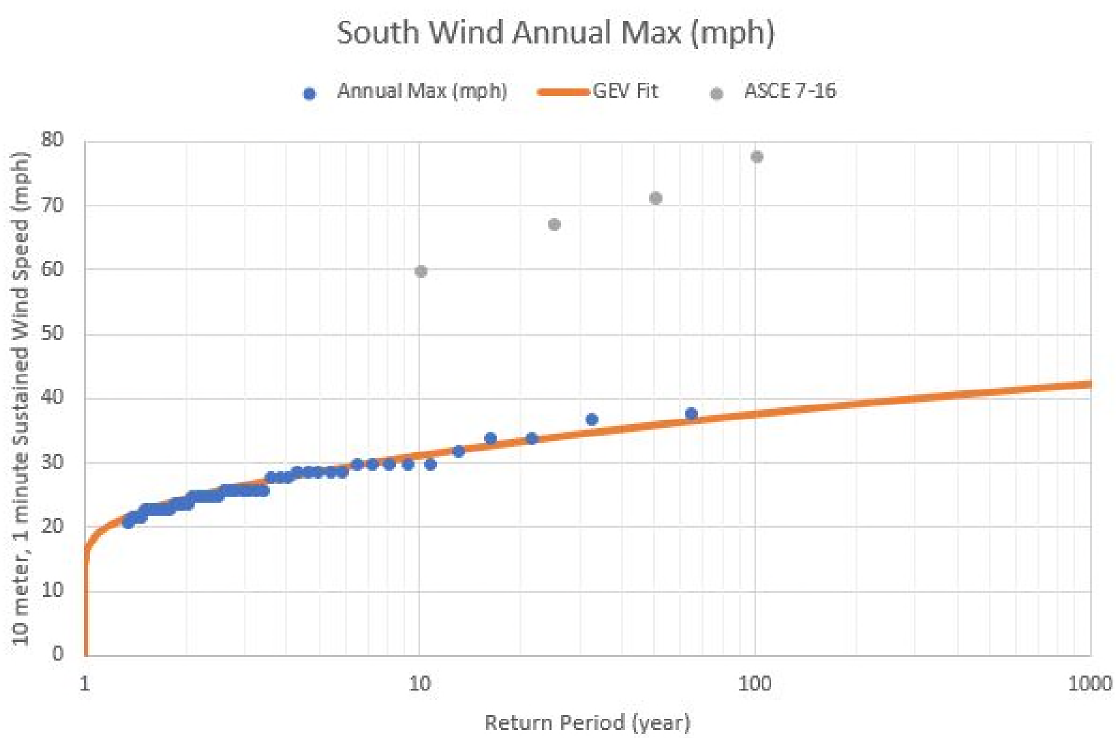


Figure 79. Wind Speed Frequency Curve at Pease International Tradeport based on GZA Wind Statistical Analysis – south wind.

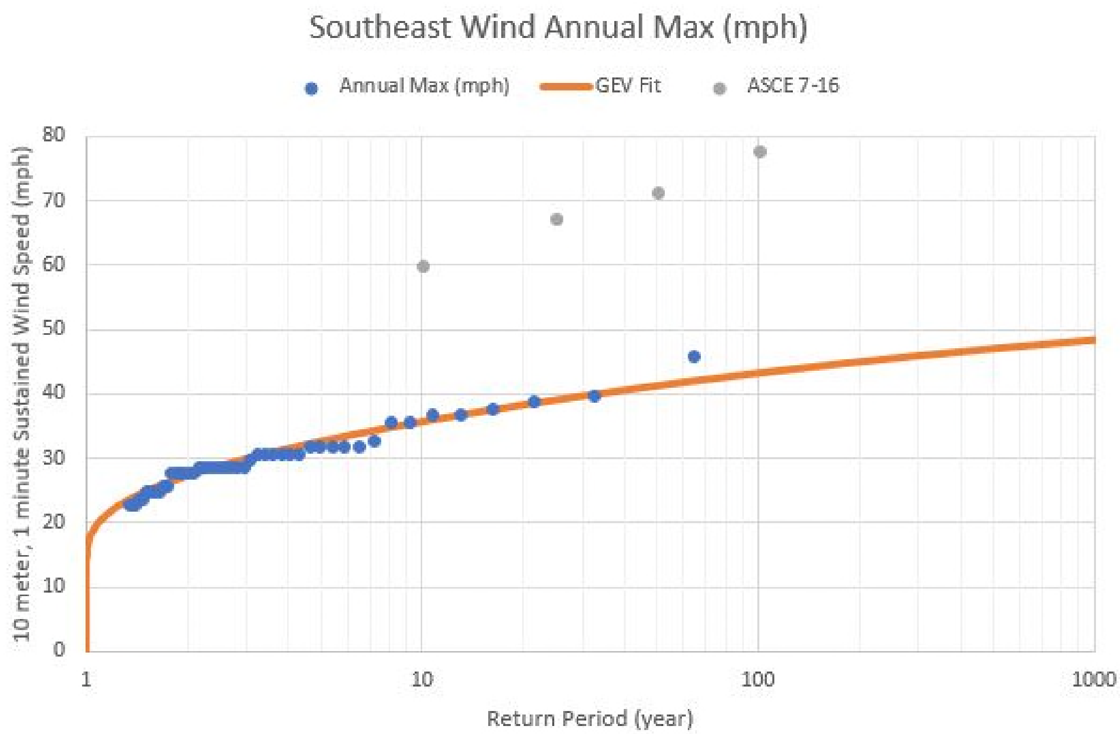


Figure 80. Wind Speed Frequency Curve at Pease International Tradeport based on GZA Wind Statistical Analysis – southeast wind.

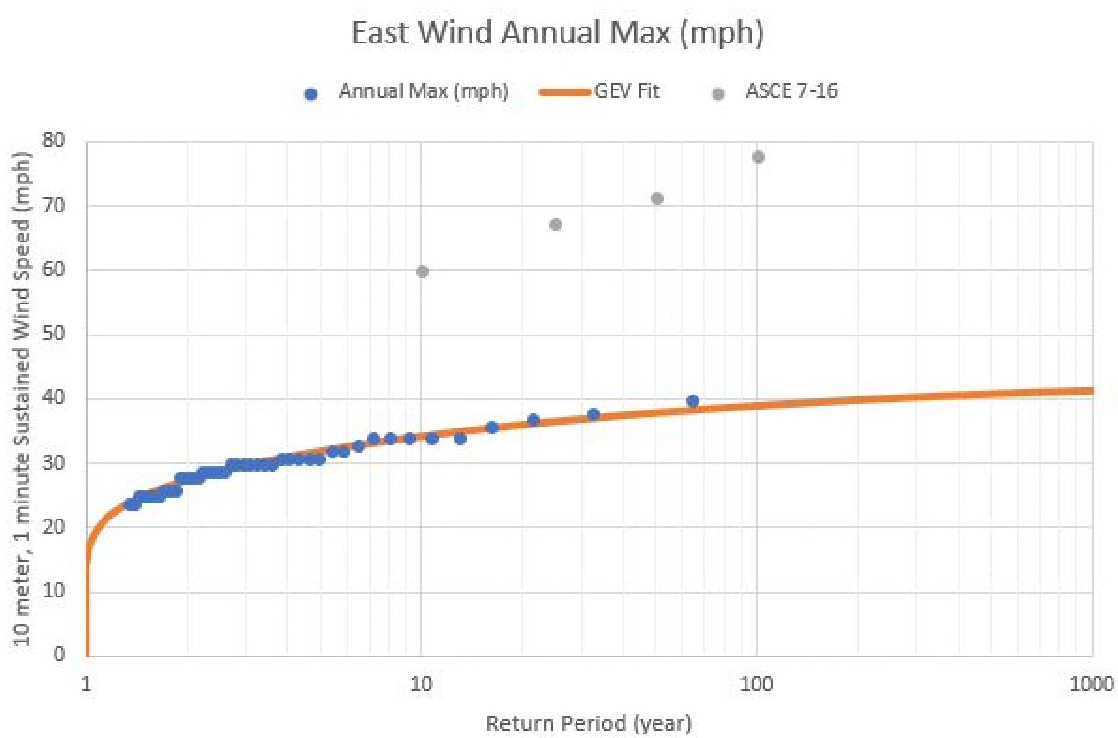


Figure 81. Wind Speed Frequency Curve at Pease International Tradeport based on GZA Wind Statistical Analysis – east wind.

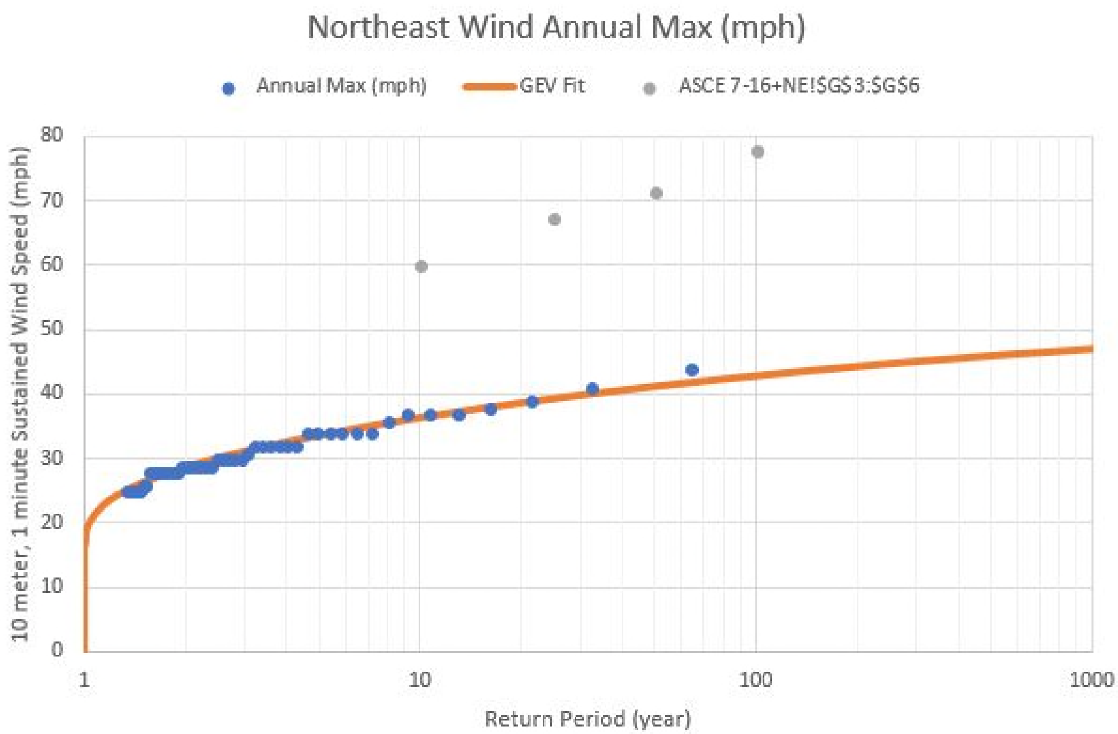


Figure 82. Wind Speed Frequency Curve at Pease International Tradeport based on GZA Wind Statistical Analysis – northeast wind.

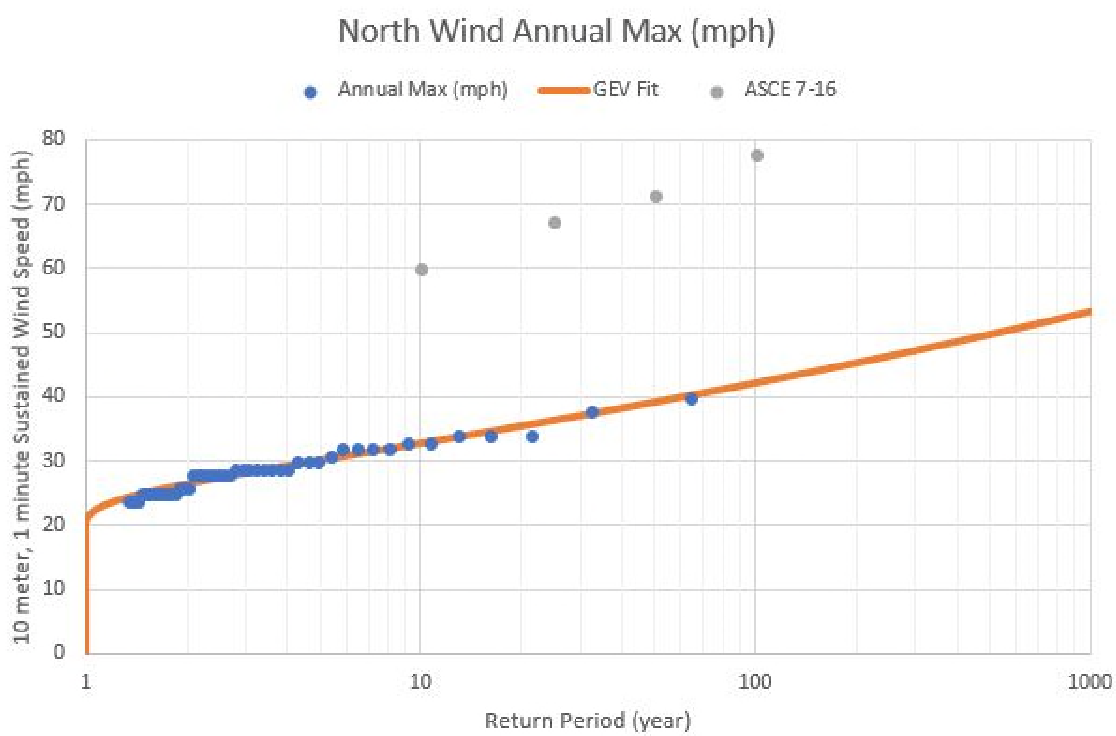


Figure 83. Wind Speed Frequency Curve at Pease International Tradeport based on GZA Wind Statistical Analysis – north wind.

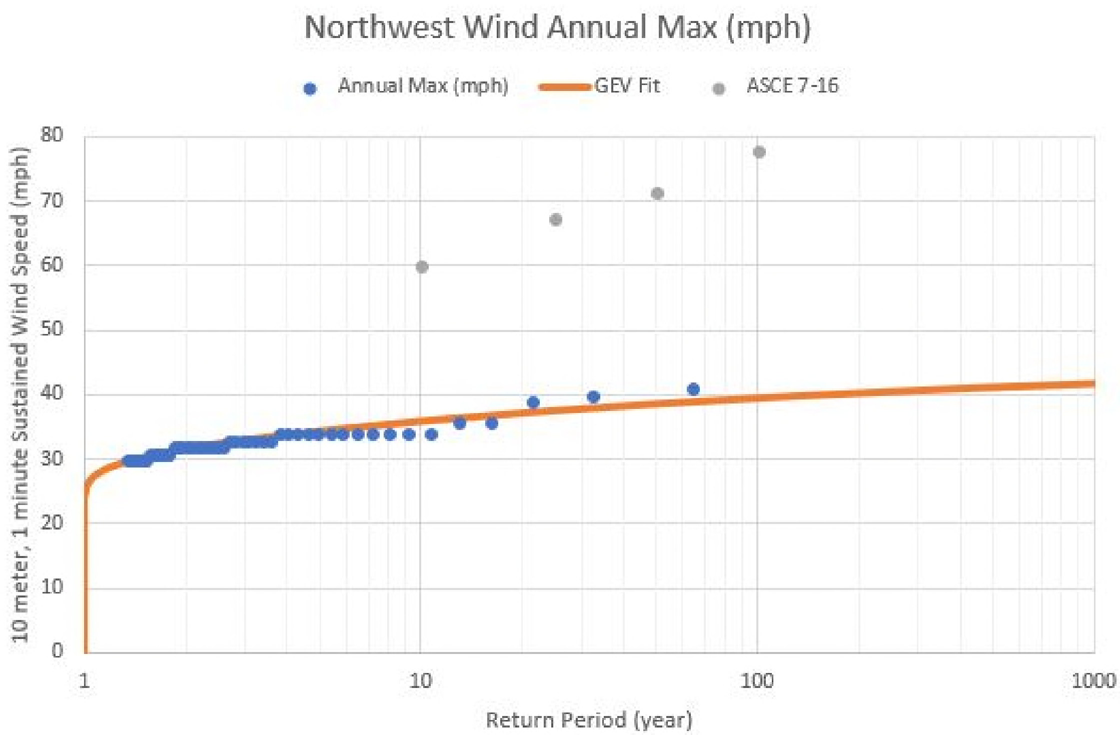


Figure 84. Wind Speed Frequency Curve at Pease International Tradeport based on GZA Wind Statistical Analysis – northwest wind

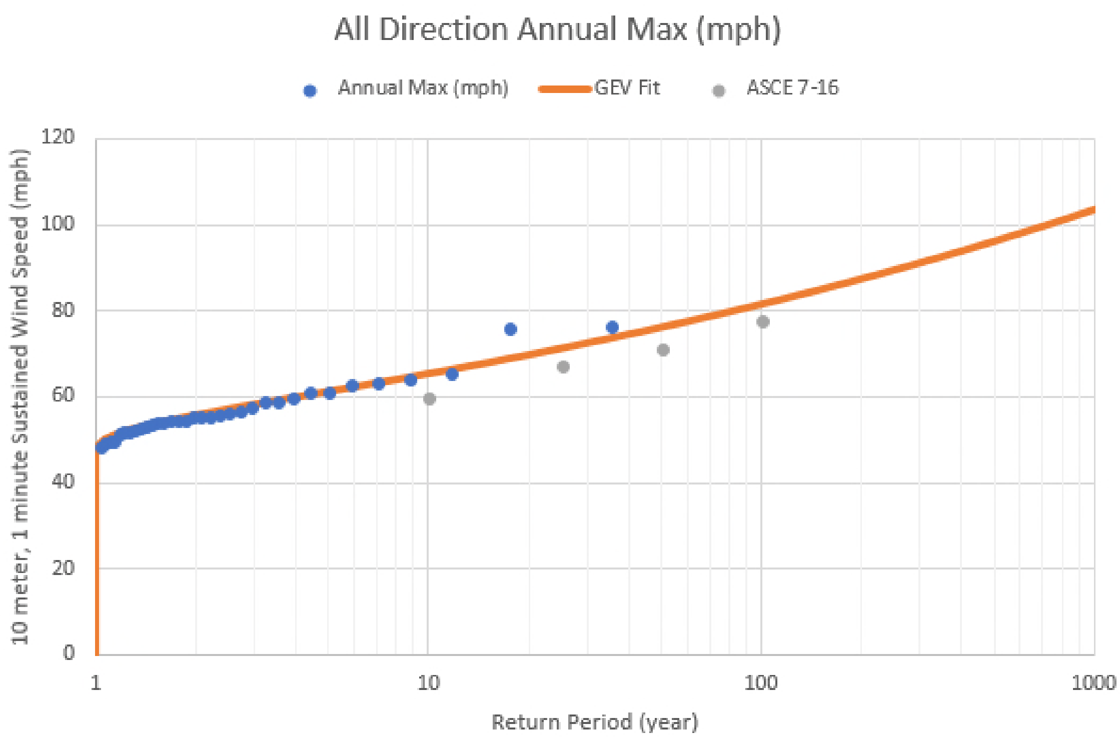


Figure 85. Wind Speed Frequency Curve at Isle of Shoals based on GZA Wind Statistical Analysis – all direction wind.

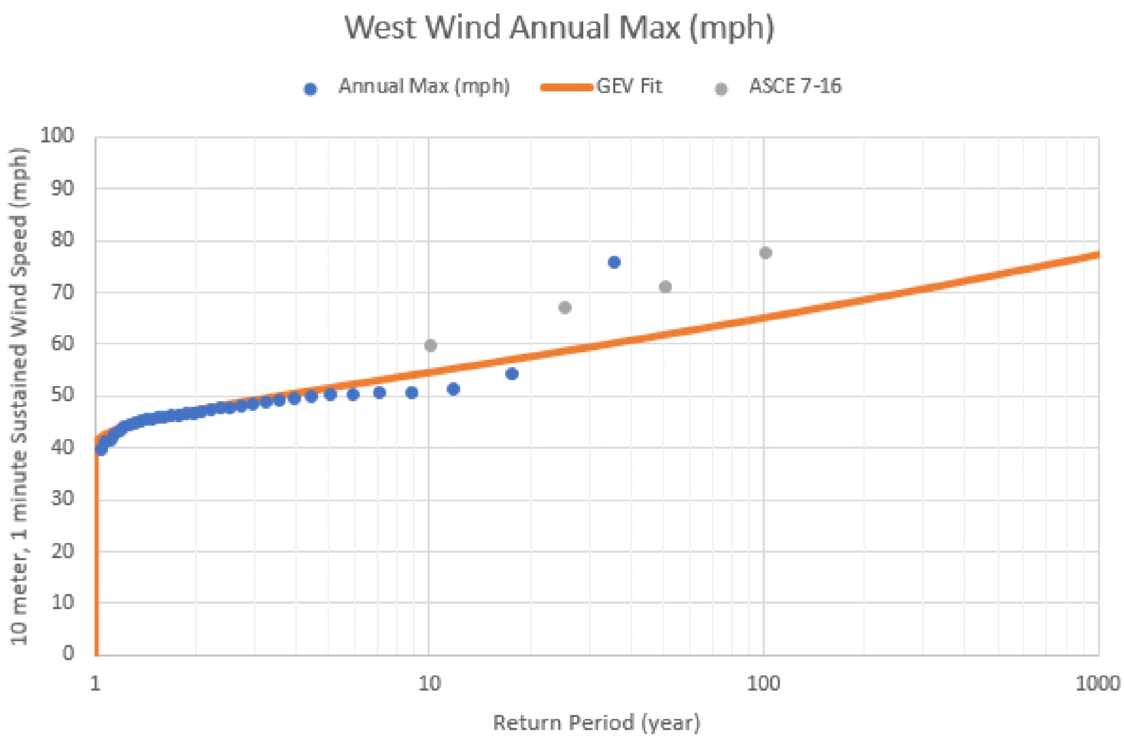


Figure 86. Wind Speed Frequency Curve at Isle of Shoals based on GZA Wind Statistical Analysis – west wind.

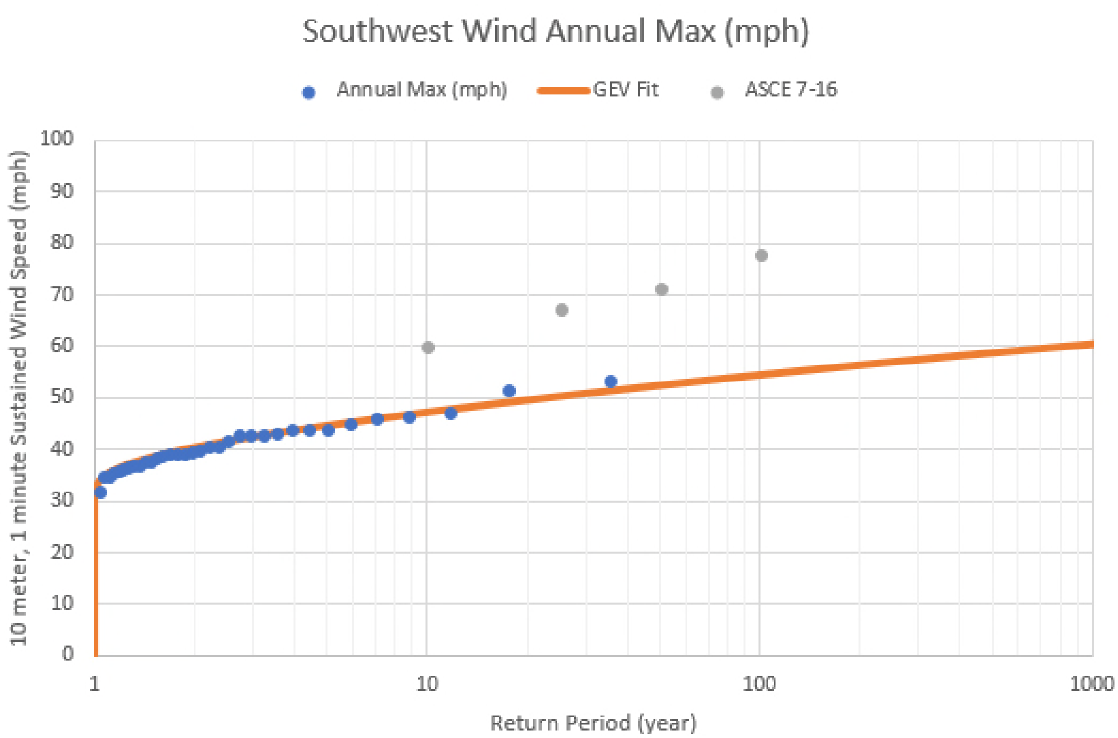


Figure 87. Wind Speed Frequency Curve at Isle of Shoals based on GZA Wind Statistical Analysis – southwest wind.

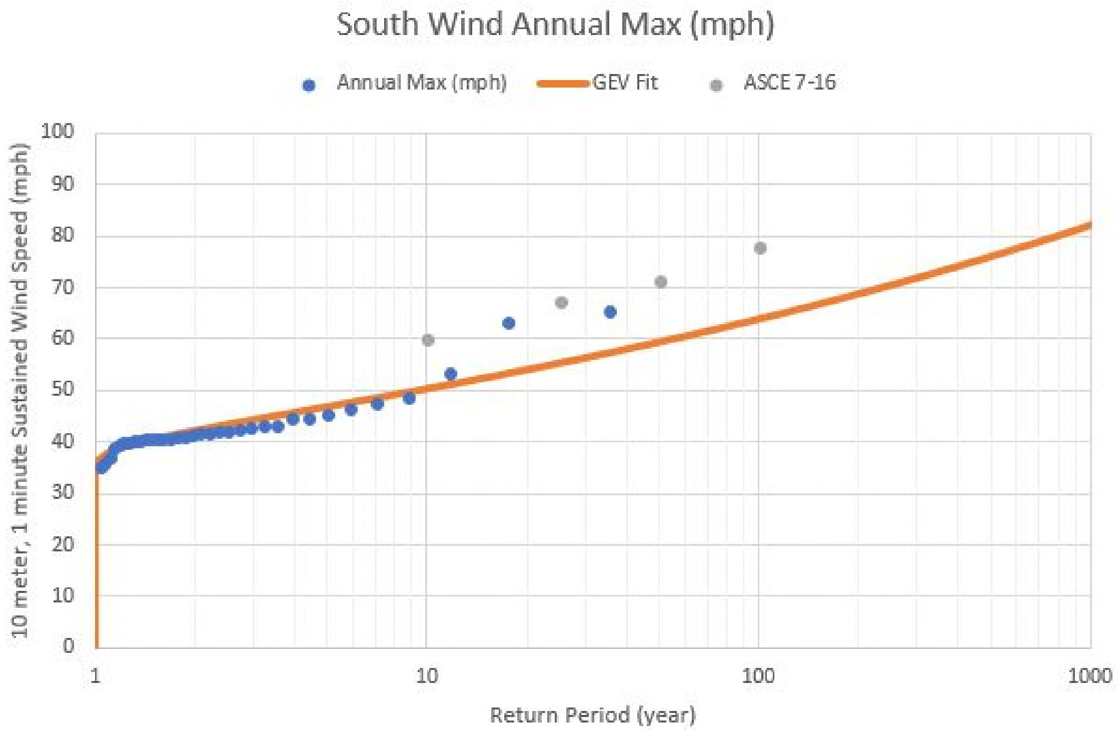


Figure 88. Wind Speed Frequency Curve at Isle of Shoals based on GZA Wind Statistical Analysis – south wind.

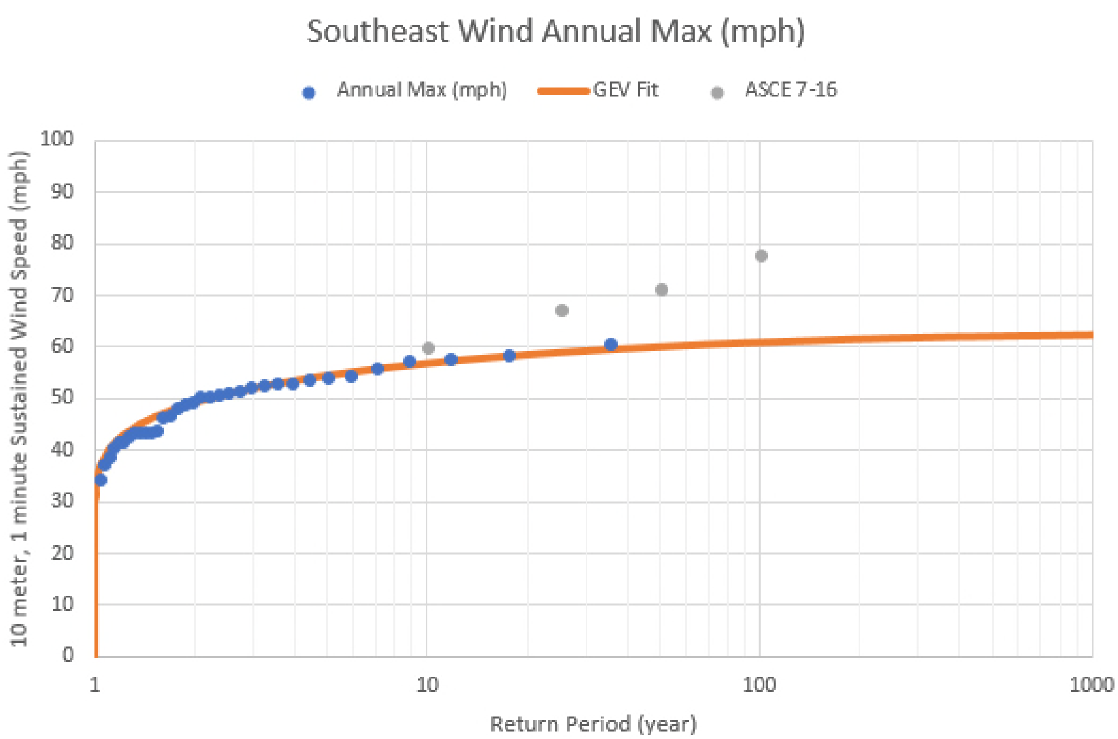


Figure 89. Wind Speed Frequency Curve at Isle of Shoals based on GZA Wind Statistical Analysis – southeast wind.

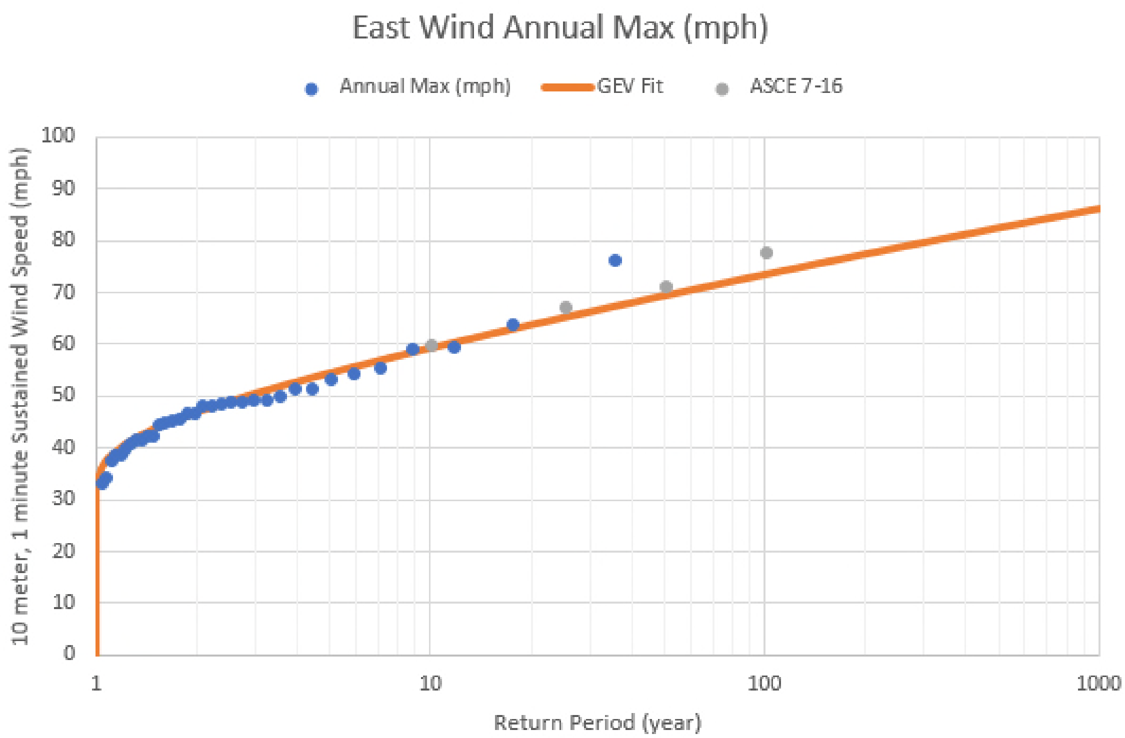


Figure 90. Wind Speed Frequency Curve at Isle of Shoals based on GZA Wind Statistical Analysis – east wind.

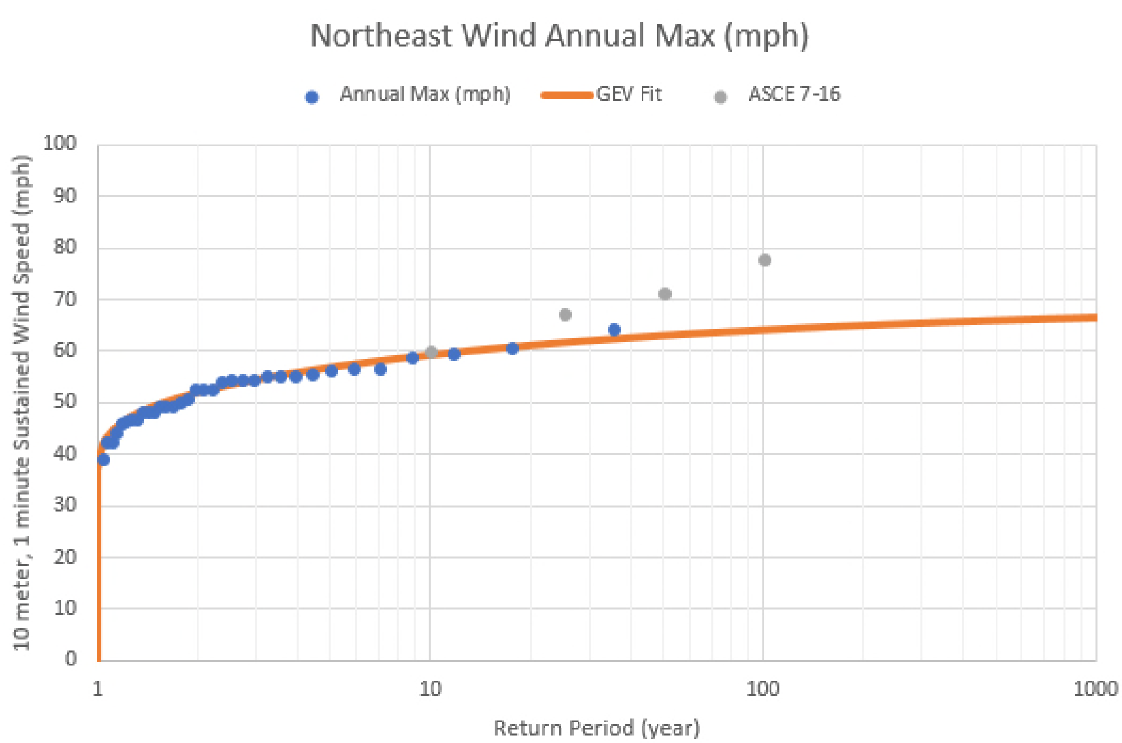


Figure 91. Wind Speed Frequency Curve at Isle of Shoals based on GZA Wind Statistical Analysis – northeast wind.

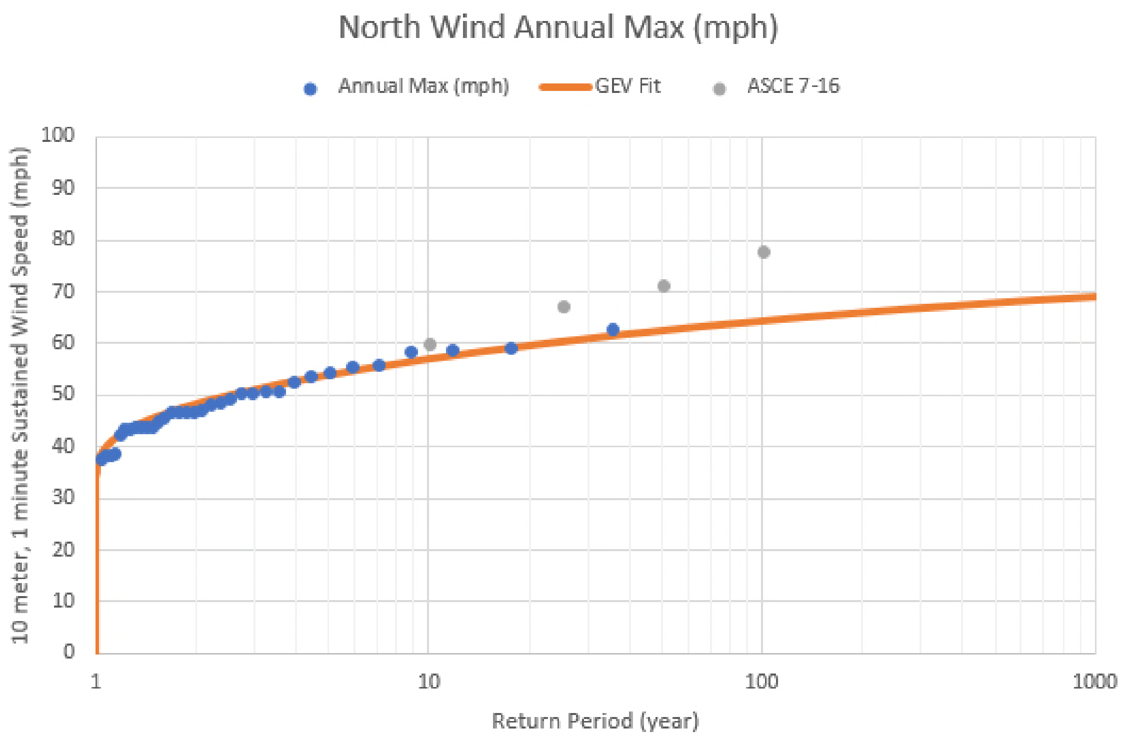


Figure 92. Wind Speed Frequency Curve at Isle of Shoals based on GZA Wind Statistical Analysis – north wind.

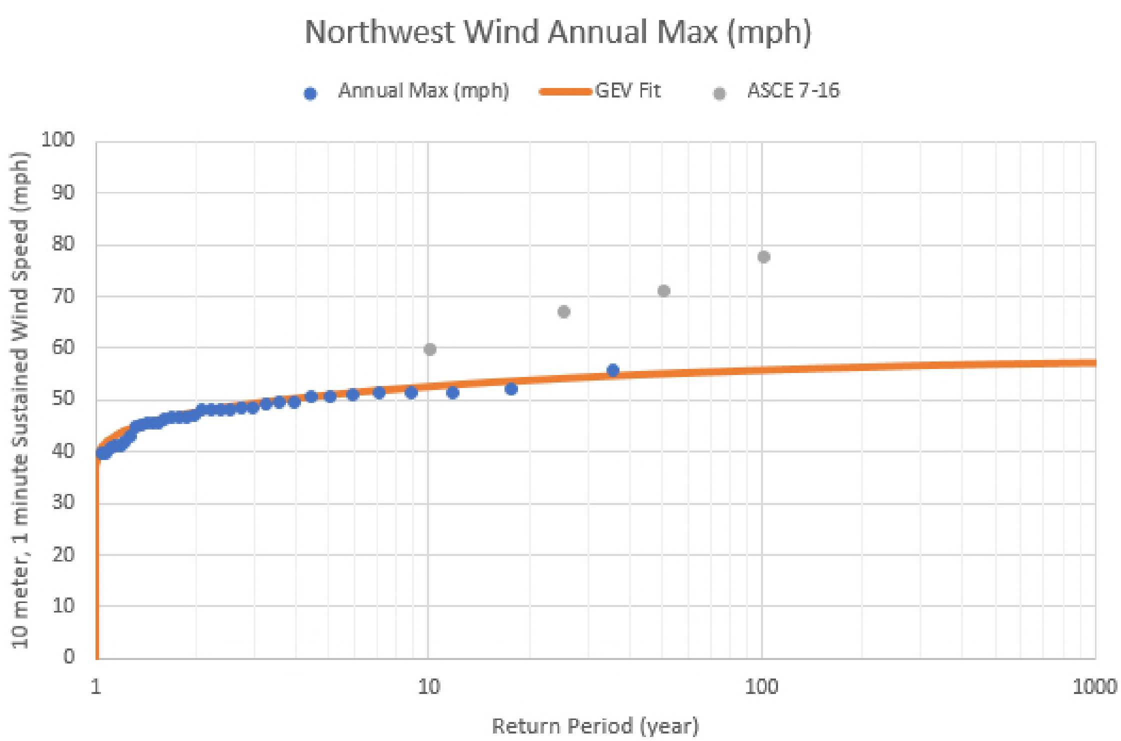


Figure 93. Wind Speed Frequency Curve at Isle of Shoals based on GZA Wind Statistical Analysis – northwest wind.

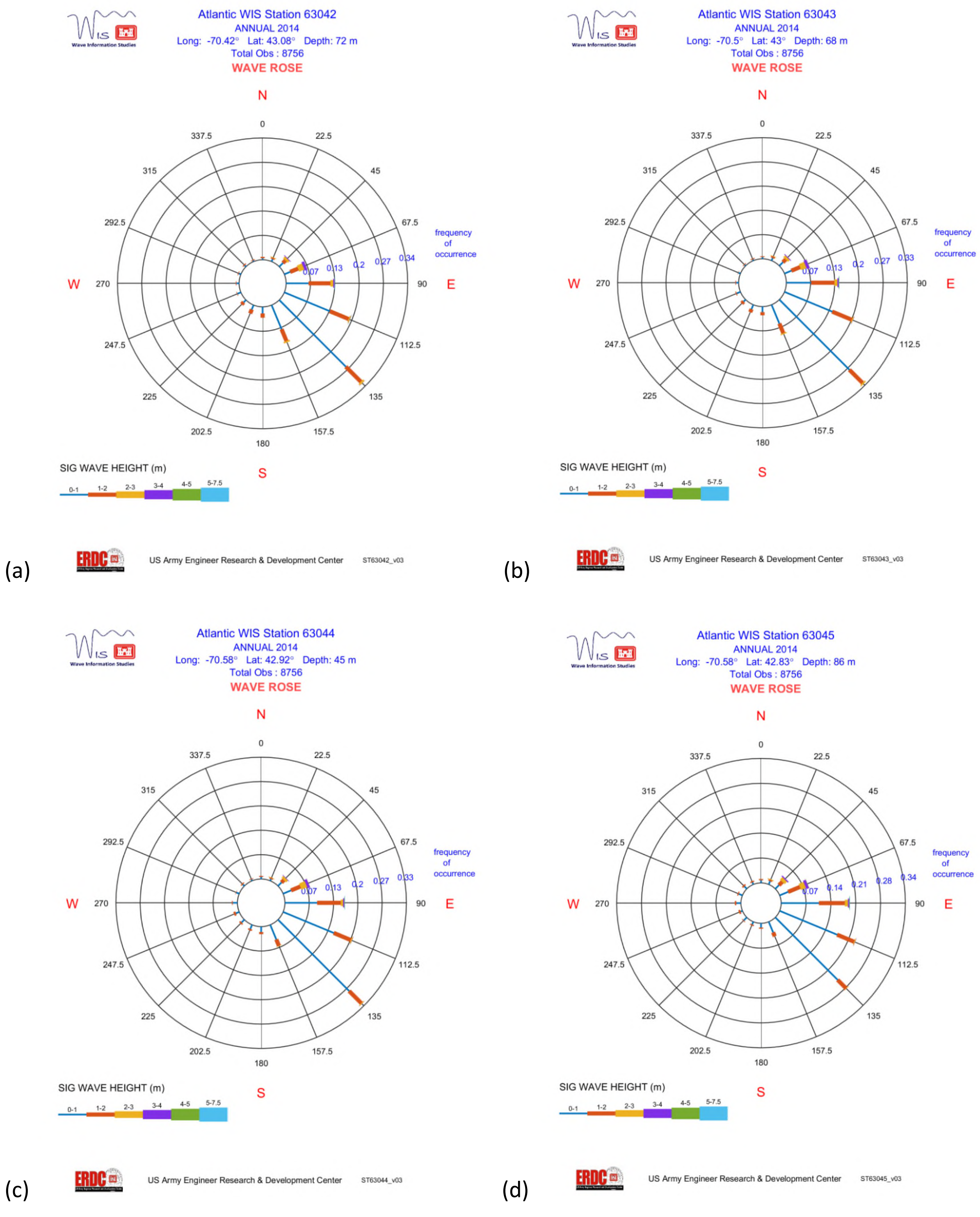


Figure 94. Wave rose at WIS wave buoys (a) 63042; (b) 63042; (c) 63042; (d) 63045.

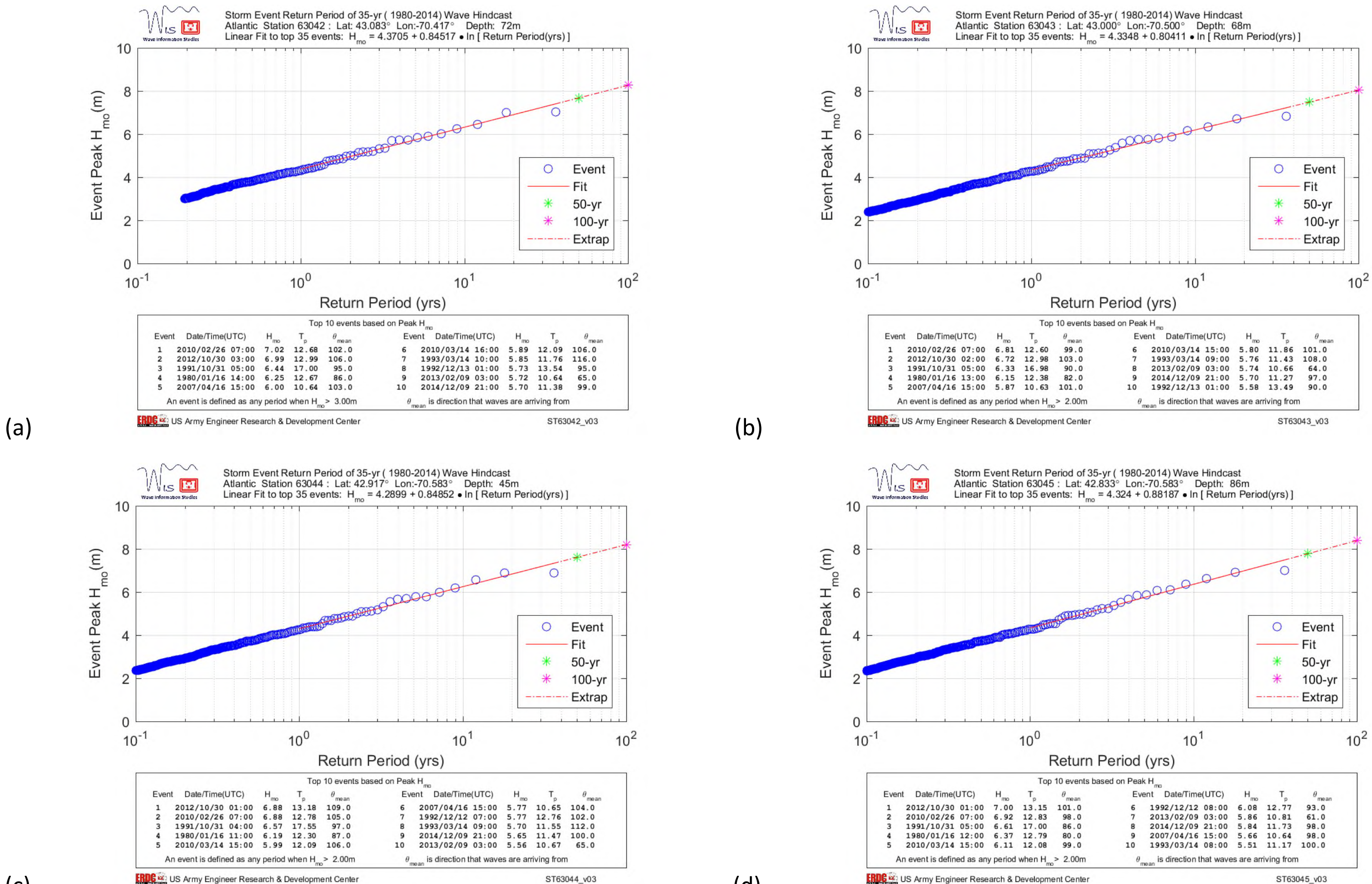
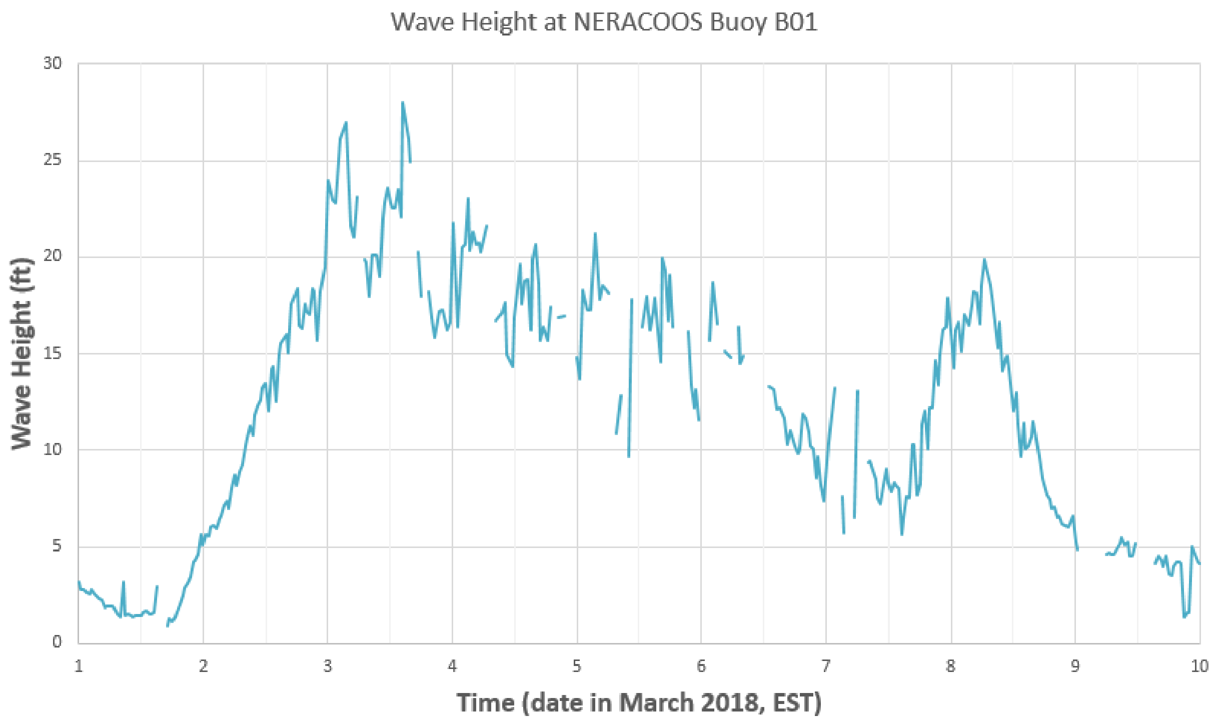


Figure 95. Extreme wave analysis at WIS wave buoys (a) 63042; (b) 63042; (c) 63042; (d) 63045.



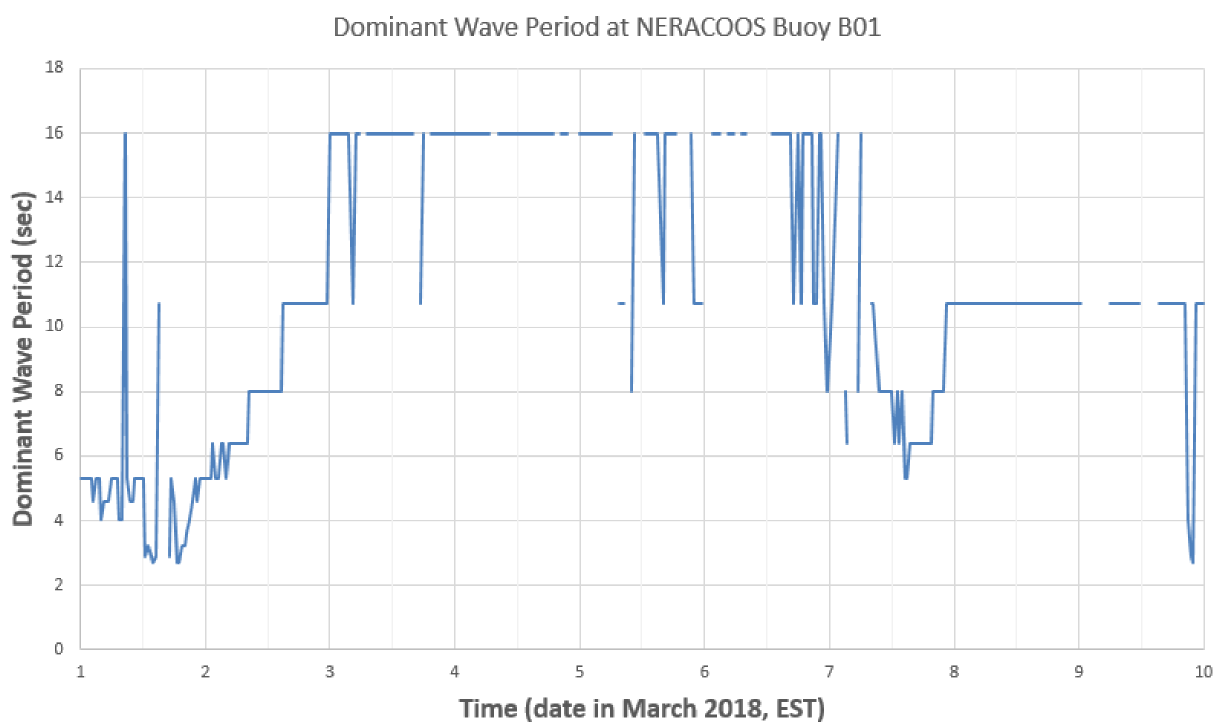


Figure 96. Observed wave height and wave period at NERACOOS buoy B01 during March 2018 Nor'Easter.

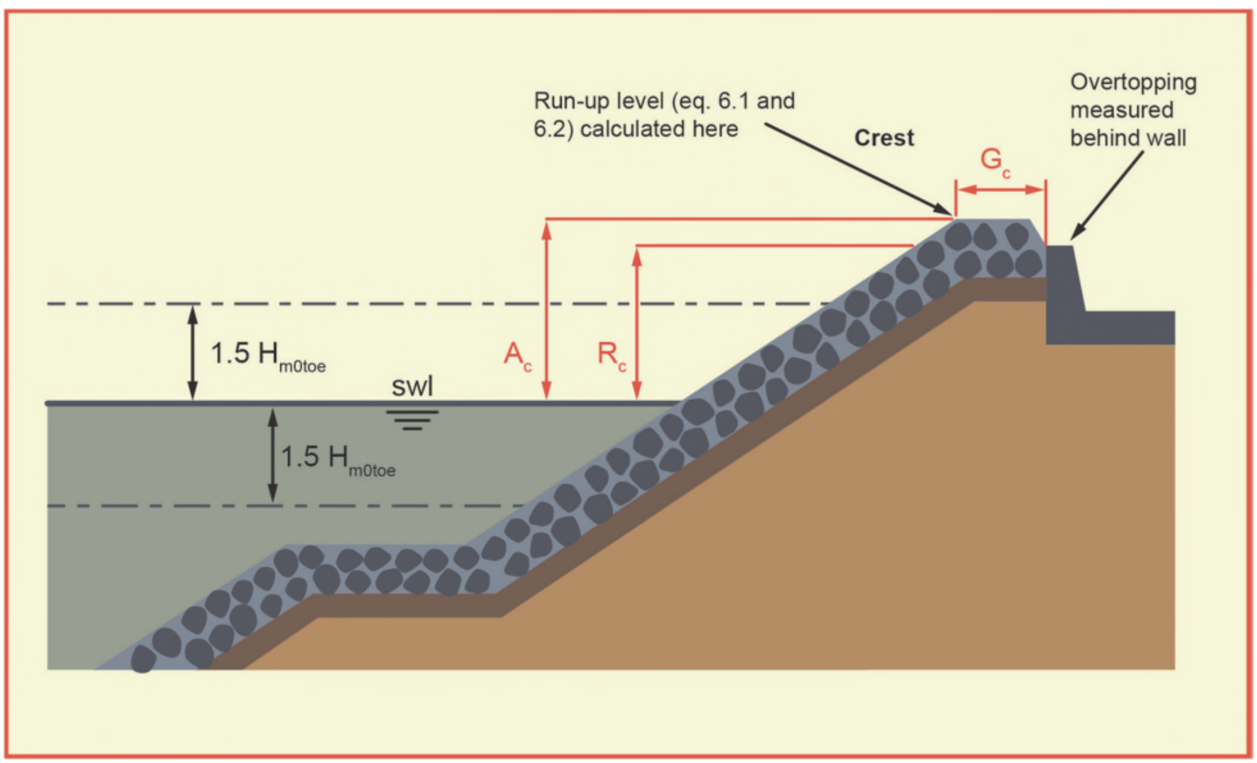


Figure 97. Applicable wave runup and overtopping condition for coastal revetments at Routh 1A (figures are from Figure 6.1 and Figure 6.4 from EurOtop Manual).

Appendix C

Wave Summary Tables

10-Year Flood Recurrence Interval Evaluation Summary Table	Revetment Section along NH RT 1A								
	1	2	3	4	5	6	7	10	13
Linear Feet of Revetment along NH Route 1A	1242	609	1750	846	1813	3806	959	1230	1020
10-yr Flood Recurrence - Existing Geometry									
Back Water Flood	✓	✓	-	✓	-	✓	-	-	-
NH Rt 1A Flood	✓	✓	-	-	-	-	-	-	-
Overtopping	-	-	✓	✓	✓	✓		✓	✓
% Length Unsafe Driving - High Speed	-	-	-	-	16%	-	-	20%	-
% Length Unsafe Driving - Any Speed	-	-	66%	14%	68%	11%	-	-	11%
% Length w/Oceanside D50 Armor Stone Damage	8%	-	75%	-	82%	40%	24%	20%	100%
% Length w/Shale Overtopping Damage	-	-	66%	-	-	-	-	-	11%
10-yr + 2ft SLR Flood Recurrence - Existing Geometry									
Back Water Flood	✓	✓	✓	✓	✓	✓	-	-	-
NH Rt 1A Flood	✓	✓	-	✓	-	✓	-	-	-
Overtopping	✓	✓	✓	✓	✓	✓	✓	✓	✓
% Length Unsafe Driving - High Speed	-	-	-	-	-	-	-	-	-
% Length Unsafe Driving - Any Speed	91%	100%	92%	100%	100%	100%	100%	80%	64%
% Length w/Oceanside D50 Armor Stone Damage	37%	100%	91%	41%	100%	71%	43%	80%	100%
% Length w/Shale Overtopping Damage	91%	100%	91%	100%	100%	66%	100%	20%	64%
10-yr Flood Recurrence - 1978 Geometry									
Back Water Flood	✓	✓	-	✓	-	✓	-	-	-
NH Rt 1A Flood	✓	✓	-	-	-	-	-	-	-
Overtopping	✓	✓	✓	✓	✓	-	✓	-	-
% Length Unsafe Driving - High Speed	-	-	-	-	-	-	-	-	-
% Length Unsafe Driving - Any Speed	100%	100%	75%	100%	100%	-	100%	-	-
% Length w/Oceanside D50 Armor Stone Damage	62%	100%	75%	73%	100%	52%	100%	-	100%
% Length w/Shale Overtopping Damage	42%	100%	26%	73%	100%	-	-	-	-
10-yr + 2ft SLR Flood Recurrence - 1978 Geometry									
Back Water Flood	✓	✓	✓	✓	✓	✓	-	-	-
NH Rt 1A Flood	✓	✓	-	✓	-	✓	-	-	-
Overtopping	✓	✓	✓	✓	✓	✓	✓	-	✓
% Length Unsafe Driving - High Speed	-	-	-	-	-	-	-	-	-
% Length Unsafe Driving - Any Speed	100%	100%	92%	100%	100%	100%	100%	-	100%
% Length w/Oceanside D50 Armor Stone Damage	100%	100%	92%	100%	100%	100%	100%	100%	100%
% Length w/Shale Overtopping Damage	100%	100%	92%	100%	100%	52%	100%	-	100%

50-Year Flood Recurrence Interval Evaluation Summary Table	Revetment Section along NH RT 1A								
	1	2	3	4	5	6	7	10	13
Linear Feet of Revetment along NH Route 1A	1242	609	1750	846	1813	3806	959	1230	1020
50-yr Flood Recurrence - Existing Geometry									
Back Water Flood	✓	✓	-	✓	-	✓	-	-	-
NH Rt 1A Flood	✓	✓	-	-	-	✓	-	-	-
Overtopping	✓	✓	✓	✓	✓	✓	-	✓	✓
% Length Unsafe Driving - High Speed	-	-	-	-	-	-	-	-	-
% Length Unsafe Driving - Any Speed	40%	55%	66%	14%	85%	19%	-	20%	11%
% Length w/Oceanside D50 Armor Stone Damage	8%	100%	75%	-	82%	40%	43%	80%	100%
% Length w/Shale Overtopping Damage	40%	-	66%	-	34%	-	-	-	11%
50-yr + 2ft SLR Flood Recurrence - Existing Geometry									
Back Water Flood	✓	✓	✓	✓	✓	✓	-	-	-
NH Rt 1A Flood	✓	✓	✓	✓	-	✓	-	-	-
Overtopping	✓	✓	✓	✓	✓	✓	✓	✓	✓
% Length Unsafe Driving - High Speed	-	-	-	-	-	-	-	-	-
% Length Unsafe Driving - Any Speed	100%	100%	100%	100%	100%	100%	100%	100%	100%
% Length w/Oceanside D50 Armor Stone Damage	58%	100%	100%	41%	100%	83%	43%	100%	100%
% Length w/Shale Overtopping Damage	100%	100%	100%	100%	100%	100%	100%	47%	80%
50-yr Flood Recurrence - 1978 Geometry									
Back Water Flood	✓	✓	-	✓	-	✓	-	-	-
NH Rt 1A Flood	✓	✓	-	-	-	✓	-	-	-
Overtopping	✓	✓	✓	✓	✓	-	✓	-	✓
% Length Unsafe Driving - High Speed	-	-	-	-	-	-	-	-	-
% Length Unsafe Driving - Any Speed	100%	100%	92%	100%	100%	-	100%	-	100%
% Length w/Oceanside D50 Armor Stone Damage	73%	100%	92%	100%	100%	52%	100%	-	100%
% Length w/Shale Overtopping Damage	100%	100%	66%	100%	100%	-	100%	-	11%
50-yr + 2ft SLR Flood Recurrence - 1978 Geometry									
Back Water Flood	✓	✓	✓	✓	✓	✓	-	-	-
NH Rt 1A Flood	✓	✓	✓	✓	-	✓	-	-	-
Overtopping	✓	✓	✓	✓	✓	✓	✓	✓	✓
% Length Unsafe Driving - High Speed	-	-	-	-	-	-	-	-	-
% Length Unsafe Driving - Any Speed	100%	100%	100%	100%	100%	100%	100%	80%	100%
% Length w/Oceanside D50 Armor Stone Damage	100%	100%	100%	100%	100%	100%	100%	100%	100%
% Length w/Shale Overtopping Damage	100%	100%	100%	100%	100%	100%	100%	-	100%

100-Year Flood Recurrence Interval Evaluation Summary Table	Revetment Section along NH RT 1A								
	1	2	3	4	5	6	7	10	13
Linear Feet of Revetment along NH Route 1A	1242	609	1750	846	1813	3806	959	1230	1020
100-yr Flood Recurrence - Existing Geometry									
Back Water Flood	✓	✓	-	✓	-	✓	-	-	-
NH Rt 1A Flood	✓	✓	-	✓	-	✓	-	-	-
Overtopping	✓	✓	✓	✓	✓	✓	✓	✓	✓
% Length Unsafe Driving - High Speed	-	-	-	-	-	-	-	-	-
% Length Unsafe Driving - Any Speed	40%	79%	66%	14%	85%	60%	81%	20%	11%
% Length w/Oceanside D50 Armor Stone Damage	26%	100%	75%	-	82%	71%	43%	80%	100%
% Length w/Shale Overtopping Damage	40%	79%	66%	14%	69%	11%	-	-	11%
100-yr + 2ft SLR Flood Recurrence - Existing Geometry									
Back Water Flood	✓	✓	✓	✓	✓	✓	-	-	-
NH Rt 1A Flood	✓	✓	✓	✓	✓	✓	-	-	-
Overtopping	✓	✓	✓	✓	✓	✓	✓	✓	✓
% Length Unsafe Driving - High Speed	-	-	-	-	-	-	-	-	-
% Length Unsafe Driving - Any Speed	100%	100%	100%	100%	100%	100%	100%	100%	100%
% Length w/Oceanside D50 Armor Stone Damage	71%	100%	100%	41%	100%	83%	100%	100%	100%
% Length w/Shale Overtopping Damage	100%	100%	100%	100%	100%	100%	100%	100%	100%
100-yr Flood Recurrence - 1978 Geometry									
Back Water Flood	✓	✓	-	✓	-	✓	-	-	-
NH Rt 1A Flood	✓	✓	-	✓	-	✓	-	-	-
Overtopping	✓	✓	✓	✓	✓	✓	✓	-	✓
% Length Unsafe Driving - High Speed	-	-	-	-	-	-	-	-	-
% Length Unsafe Driving - Any Speed	100%	100%	92%	100%	100%	52%	100%	-	100%
% Length w/Oceanside D50 Armor Stone Damage	100%	100%	92%	100%	100%	52%	100%	80%	100%
% Length w/Shale Overtopping Damage	100%	100%	75%	100%	100%	-	100%	-	27%
100-yr + 2ft SLR Flood Recurrence - 1978 Geometry									
Back Water Flood	✓	✓	✓	✓	✓	✓	-	-	-
NH Rt 1A Flood	✓	✓	✓	✓	✓	✓	-	-	-
Overtopping	✓	✓	✓	✓	✓	✓	✓	✓	✓
% Length Unsafe Driving - High Speed	-	-	-	-	-	-	-	-	-
% Length Unsafe Driving - Any Speed	100%	100%	100%	100%	100%	100%	100%	100%	100%
% Length w/Oceanside D50 Armor Stone Damage	100%	100%	100%	100%	100%	100%	100%	100%	100%
% Length w/Shale Overtopping Damage	100%	100%	100%	100%	100%	100%	100%	47%	100%

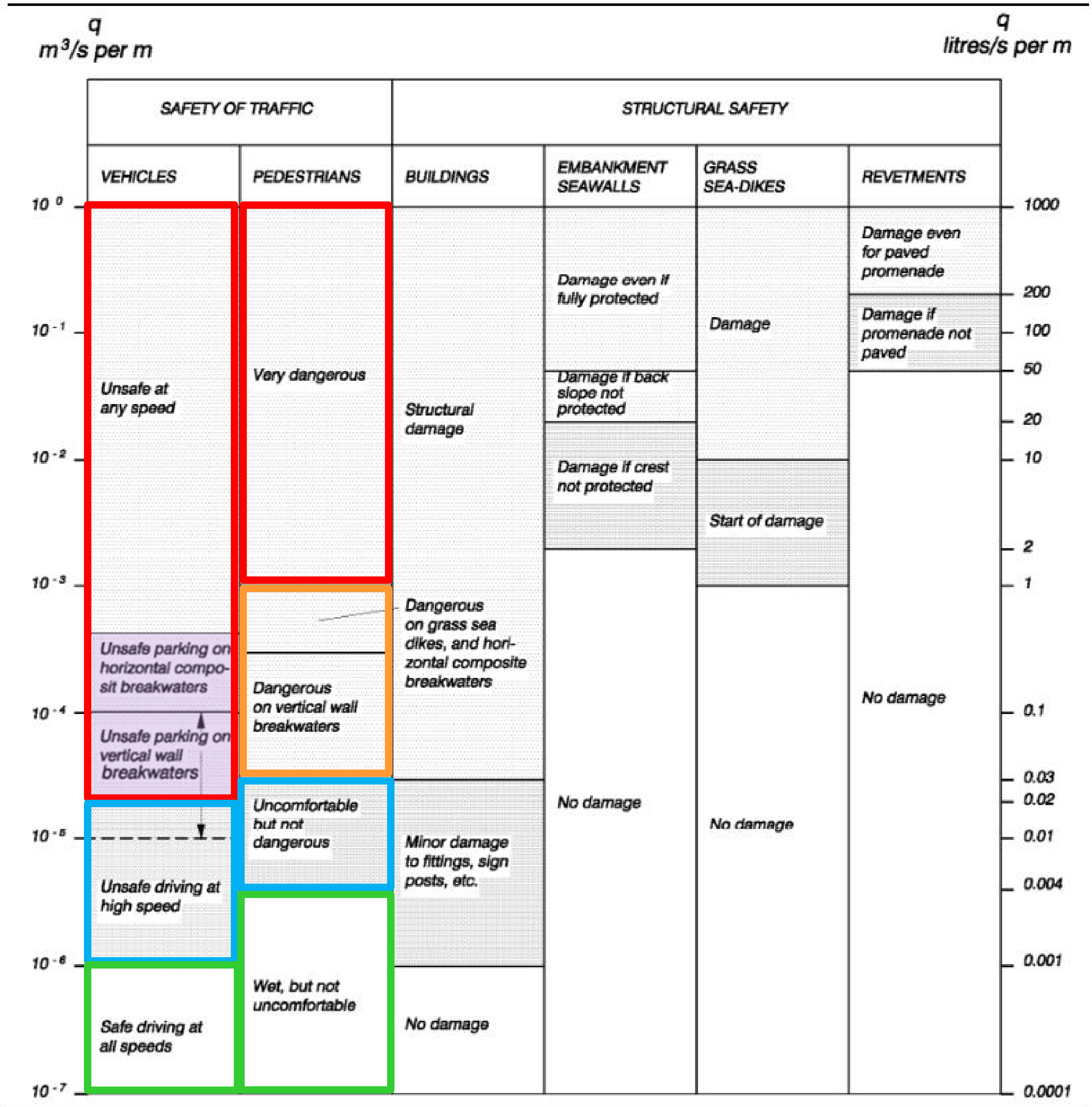
Appendix D

Sea Level Rise and Wave Runup Projections

<u>Basis of Evaluation for Vehicular and Pedestrian Roadway Use Impacts</u>

Roadway flood risk criteria in accordance with *Engineering Manual 1110-2-1100 – Coastal Engineering Manual, U.S. Army Corps of Engineer*s, September 2011

Table VI-5-6
Critical Values of Average Overtopping Discharges



Excerpt from: EM 1110-2-1100 (Part VI) Change 3 (28 Sep 11)

Section 7 – Current Water Levels

	Crest EL ft, NAVD88	Toe EL ft, NAVD88	SWL EL ft, NAVD88	Wave Runup EL ft, NAVD88	LF of Section with Wave Runup above	Roadway Use - Wave Overtopping Impact					
						Traffic Condition	LF	% LF_{total}	Pedestrians Condition	LF	% LF_{total}
			100-yr 8.4	Max 17.4	781	No overtopping	178	19%	Wet but not uncomfortable	0	0%
	1978	1978		Min 16.8	81%	Safe driving at all speeds	0	0%	Uncomfortable but not dangerous	0	0%
Section 7	15	Break: -		Ave 17.1		Unsafe driving at high speed	0	0%	Dangerous	781	81%
959		Toe: 1.5				Unsafe driving at any speed	781	81%	Very dangerous	0	0%
LF			50-yr 8.0	Max 16.3	0	No overtopping	959	100%	Wet but not uncomfortable	0	0%
	Current	Current		Min 16.0	0%	Safe driving at all speeds	0	0%	Uncomfortable but not dangerous	0	0%
	Max 17.7	Max 6.0		Ave 16.2		Unsafe driving at high speed	0	0%	Dangerous	0	0%
	Min 17.0	Min 17.0				Unsafe driving at any speed	0	0%	Very dangerous	0	0%
	Ave 17.2	Ave 5.4	10-yr 7.5	Max 15.2	0	No overtopping	959	100%	Wet but not uncomfortable	0	0%
				Min 14.7	0%	Safe driving at all speeds	0	0%	Uncomfortable but not dangerous	0	0%
				Ave 15.0		Unsafe driving at high speed	0	0%	Dangerous	0	0%
						Unsafe driving at any speed	0	0%	Very dangerous	0	0%

Section 7 – + 2 Feet Sea Level Rise

	Crest EL ft, NAVD88	Toe EL ft, NAVD88	SWL EL ft, NAVD88	Wave Runup EL ft, NAVD88	LF of Section with Wave Runup above	Wave Overtopping Impact					
						Traffic Condition	LF	% LF_{total}	Pedestrians Condition	LF	% LF_{total}
			100-yr 10.4	Max 22.0	959	No overtopping	0	0%	Wet but not uncomfortable	0	0%
SLR = 2'	1978	1978		Min 21.6	100%	Safe driving at all speeds	0	0%	Uncomfortable but not dangerous	0	0%
Section 7	15	Break: -		Ave 21.9		Unsafe driving at high speed	0	0%	Dangerous	0	0%
959		Toe: 1.5				Unsafe driving at any speed	959	100%	Very dangerous	959	100%
LF			50-yr 10.0	Max 21.1	959	No overtopping	0	0%	Wet but not uncomfortable	0	0%
	Current	Current		Min 20.8	100%	Safe driving at all speeds	0	0%	Uncomfortable but not dangerous	0	0%
	Max 17.7	Max 6.0		Ave 21.0		Unsafe driving at high speed	0	0%	Dangerous	0	0%
	Min 17.0	Min 17.0				Unsafe driving at any speed	959	100%	Very dangerous	959	100%
	Ave 17.2	Ave 5.4	10-yr 9.5	Max 19.8	959	No overtopping	0	0%	Wet but not uncomfortable	0	0%
				Min 19.3	100%	Safe driving at all speeds	0	0%	Uncomfortable but not dangerous	0	0%
				Ave 19.5		Unsafe driving at high speed	0	0%	Dangerous	0	0%
						Unsafe driving at any speed	959	100%	Very dangerous	959	100%

LF = linear feet along NH Route 1A stationing per NHDOT survey December 2019

EL = elevation

Toe EL = elevation of ocean side toe of revetment slope

SWL = Stillwater level

SLR = Sea level rise

Section 10 – Current Water Levels

	Crest EL ft, NAVD88	Toe EL ft, NAVD88	SWL EL ft, NAVD88	Wave Runup EL ft, NAVD88	LF of Section with Wave Runup above	Roadway Use - Wave Overtopping Impact					
						Traffic Condition	LF	% LF_{total}	Pedestrians Condition	LF	% LF_{total}
			100-yr 8.4	Max 22.5	249	No overtopping	981	80%	Wet but not uncomfortable	0	0%
	1978	1978		Min 17.8	20%	Safe driving at all speeds	0	0%	Uncomfortable but not dangerous	0	0%
Section 10	19 (roadside)	Break: -		Ave 19.8		Unsafe driving at high speed	0	0%	Dangerous	249	20%
1,230	21.5 (oceanside)	Toe: 11.1				Unsafe driving at any speed	249	20%	Very dangerous	0	0%
LF			50-yr 8.0	Max 21.5	249	No overtopping	981	80%	Wet but not uncomfortable	0	0%
	Current	Current		Min 16.9	20%	Safe driving at all speeds	0	0%	Uncomfortable but not dangerous	0	0%
	Max 20.6	Max 12.5		Ave 18.8		Unsafe driving at high speed	0	0%	Dangerous	249	20%
	Min 19.0	Min 6.0				Unsafe driving at any speed	249	20%	Very dangerous	0	0%
	Ave 20.0	Ave 7.6	10-yr 7.5	Max 19.4	249	No overtopping	981	80%	Wet but not uncomfortable	0	0%
				Min 15.7	20%	Safe driving at all speeds	0	0%	Uncomfortable but not dangerous	249	20%
				Ave 17.2		Unsafe driving at high speed	249	20%	Dangerous	0	0%
						Unsafe driving at any speed	0	0%	Very dangerous	0	0%

Section 10 – + 2 Feet Sea Level Rise

	Crest EL ft, NAVD88	Toe EL ft, NAVD88	SWL EL ft, NAVD88	Wave Runup EL ft, NAVD88	LF of Section with Wave Runup above	Wave Overtopping Impact					
						Traffic Condition	LF	% LF_{total}	Pedestrians Condition	LF	% LF_{total}
			100-yr 10.4	Max 29.1	1230	No overtopping	0	0%	Wet but not uncomfortable	0	0%
SLR = 2'	1978	1978		Min 22.7	100%	Safe driving at all speeds	0	0%	Uncomfortable but not dangerous	0	0%
Section 10	19 (roadside)	Break: -		Ave 25.3		Unsafe driving at high speed	0	0%	Dangerous	0	0%
1,230	21.5 (oceanside)	Toe: 11.1				Unsafe driving at any speed	1230	100%	Very dangerous	1230	100%
LF			50-yr 10.0	Max 28.0	1230	No overtopping	0	0%	Wet but not uncomfortable	0	0%
	Current	Current		Min 21.7	100%	Safe driving at all speeds	0	0%	Uncomfortable but not dangerous	0	0%
	Max 20.6	Max 12.5		Ave 24.3		Unsafe driving at high speed	0	0%	Dangerous	650	53%
	Min 19.0	Min 6.0				Unsafe driving at any speed	1230	100%	Very dangerous	580	47%
	Ave 20.0	Ave 7.6	10-yr 9.5	Max 25.4	980	No overtopping	250	20%	Wet but not uncomfortable	0	0%
				Min 20.3	80%	Safe driving at all speeds	0	0%	Uncomfortable but not dangerous	0	0%
				Ave 22.5		Unsafe driving at high speed	0	0%	Dangerous	731	59%
						Unsafe driving at any speed	980	80%	Very dangerous	249	20%

LF = linear feet along NH Route 1A stationing per NHDOT survey December 2019
EL = elevation
Toe EL = elevation of ocean side toe of revetment slope

SWL = Stillwater level
SLR = Sea level rise

Section 13 – Current Water Levels

	Crest EL ft, NAVD88	Toe EL ft, NAVD88	SWL EL ft, NAVD88	Wave Runup EL ft, NAVD88	LF of Section with Wave Runup above	Roadway Use - Wave Overtopping Impact					
						Traffic Condition	LF	% LF_{total}	Pedestrians Condition	LF	% LF_{total}
			100-yr 8.4	Max 18.8	110	No overtopping	910	89%	Wet but not uncomfortable	0	0%
	1978	1978		Min 16.9	11%	Safe driving at all speeds	0	0%	Uncomfortable but not dangerous	0	0%
Section 13	16.9	Break: -		Ave 17.8		Unsafe driving at high speed	0	0%	Dangerous	0	0%
1,020		Toe: 8.3				Unsafe driving at any speed	110	11%	Very dangerous	110	11%
LF			50-yr 8.0	Max 17.3	110	No overtopping	910	89%	Wet but not uncomfortable	0	0%
	Current	Current		Min 16.1	11%	Safe driving at all speeds	0	0%	Uncomfortable but not dangerous	0	0%
	Max 21.7	Max 12.5		Ave 16.8		Unsafe driving at high speed	0	0%	Dangerous	0	0%
	Min 13.7	Min 6.4				Unsafe driving at any speed	110	11%	Very dangerous	110	11%
	Ave 18.3	Ave 9.8	10-yr 7.5	Max 16.0	110	No overtopping	910	89%	Wet but not uncomfortable	0	0%
				Min 14.9	11%	Safe driving at all speeds	0	0%	Uncomfortable but not dangerous	0	0%
				Ave 15.5		Unsafe driving at high speed		0%	Dangerous	0	0%
						Unsafe driving at any speed	110	11%	Very dangerous	110	11%

Section 13 – + 2 Feet Sea Level Rise

	Crest EL ft, NAVD88	Toe EL ft, NAVD88	SWL EL ft, NAVD88	Wave Runup EL ft, NAVD88	LF of Section with Wave Runup above	Wave Overtopping Impact					
						Traffic Condition	LF	% LF_{total}	Pedestrians Condition	LF	% LF_{total}
			100-yr 10.4	Max 23.7	1020	No overtopping	0	0%	Wet but not uncomfortable	0	0%
SLR = 2'	1978	1978		Min 21.7	100%	Safe driving at all speeds	0	0%	Uncomfortable but not dangerous	0	0%
Section 13	16.9	Break: -		Ave 22.6		Unsafe driving at high speed	0	0%	Dangerous	0	0%
1,020		Toe: 8.3				Unsafe driving at any speed	1020	100%	Very dangerous	1020	100%
LF			50-yr 10.0	Max 22.7	1020	No overtopping	0	0%	Wet but not uncomfortable	0	0%
	Current	Current		Min 20.7	100%	Safe driving at all speeds	0	0%	Uncomfortable but not dangerous	0	0%
	Max 21.7	Max 12.5		Ave 21.6		Unsafe driving at high speed	0	0%	Dangerous	200	20%
	Min 13.7	Min 6.4				Unsafe driving at any speed	1020	100%	Very dangerous	820	80%
	Ave 18.3	Ave 9.8	10-yr 9.5	Max 21.2	655	No overtopping	365	36%	Wet but not uncomfortable	0	0%
				Min 19.4	64%	Safe driving at all speeds	0	0%	Uncomfortable but not dangerous	0	0%
				Ave 20.2		Unsafe driving at high speed	0	0%	Dangerous	0	0%
						Unsafe driving at any speed	655	64%	Very dangerous	655	64%

LF = linear feet along NH Route 1A stationing per NHDOT survey December 2019
EL = elevation
Toe EL = elevation of ocean side toe of revetment slope
SWL = Stillwater level
SLR = Sea level rise

Appendix E

NH Rt 1A Storm-Related Road Closures 2011-2021

NH Rt 1A Storm-Related Road Closures 2011-2021

Start Event Date	Start Event Time	End Event Date	End Event Time	Full Closure Time	Partial Closure Time	Total Closure Time	Total Event Time	Closure Type	Reason for Closure	Roadway	Start Point	End Point	Town
06/25/11	8:25	06/25/11	16:11	8:25	0:00	8:25	7:46	Full	Flooding	NH 1A	Sea Road		Rye
12/27/12	10:18	12/27/12	16:40	6:22	0:00	6:22	6:22	Full	Rockslide	NH 1A	Atlantic Avenue	Central Road	Rye
02/09/13	9:10	02/09/13	18:25	9:13	0:00	9:13	9:15	Full	Flooding	NH 1A	Atlantic Avenue	Odium Point Hampton	Hampton
03/08/13	7:31	03/08/13	11:26	3:55	0:00	3:55	3:55	Full	Flooding	NH 1A	NH 111/Atlantic Avenue	Church Street	Rye
03/08/13	21:30	03/09/13	1:55	4:20	0:00	4:20	4:25	Full	Flooding	NH 1A	NH 111/Atlantic Avenue	Church Street	Rye
03/09/13	9:03	03/09/13	15:20	6:17	0:00	6:17	6:17	Full	Flooding	NH 1A	South Road		Rye
03/02/17	11:22	03/02/17	13:29	2:04	0:00	2:04	2:07	Full	Trees/Wires	NH 1A	NH 1B	Harbor View Drive	Rye
01/04/18	12:26	01/04/18	18:10	5:36	0:00	5:36	5:44	Full	Flooding	NH 1A	Harbor Road	Washington Road	Rye
01/04/18	13:09	01/04/18	18:08	4:53	4:53	9:46	4:59	Partial	Flooding	NH 1A	Ashworth Avenue	Ashworth Ave	Rye
01/04/18	14:29	01/04/18	18:07	1:33	1:33	3:06	3:38	Partial	Flooding	NH 1A	Brackett Road	Brackett Road	Rye
01/04/18	14:20	01/04/18	18:06	3:42	0:00	3:42	3:46	Full	Flooding	US 1	NH 101	NH 101	Hampton Falls
03/02/18	11:03	03/02/18	13:27	2:17	0:00	2:17	2:24	Full	Flooding	NH 1A	Dumas Avenue	High Street	Hampton
03/02/18	23:37	03/03/18	3:33	3:52	0:00	3:52	3:56	Full	Flooding	NH 1A	Odiorne State Park	Marsh Road	Rye
03/02/18	23:20	03/03/18	3:39	4:09	0:00	4:09	4:19	Full	Flooding	NH 1A	Causeway Road	NH 27	Rye
03/02/18	23:20	03/03/18	4:09	4:46	0:00	4:46	4:49	Full	Flooding	NH 1A	Harbor Road	Washington Road	Rye
03/02/18	13:21	03/02/18	14:37	1:09	0:00	1:09	1:16	Full	Flooding	NH 1A	NH 101	Ashworth Avenue	Hampton
03/03/18	21:00	03/05/18	5:45	32:38	0:00	32:38	32:45	Full	Flooding	Marsh RD	Brackett Road	NH 1A	Rye
03/03/18	21:00	03/04/18	7:10	10:08	0:00	10:08	10:10	Full	Flooding	NH 1A	Wallis Road	Brackett Road	Rye
03/03/18	23:18	03/04/18	7:14	7:52	0:00	7:52	7:56	Full	Flooding	NH 1A	Atlantic Avenue	Causeway Road	Rye
03/03/18	10:08	03/03/18	17:26	7:10	0:00	7:10	7:18	Full	Flooding	NH 1A	Atlantic Avenue	Rye T/L	Hampton /Rye
03/04/18	0:43	03/04/18	7:07	6:23	0:00	6:23	6:24	Full	Flooding	NH 1A	Boars Head Road	Brackett Road	Hampton / Rye
03/04/18	12:39	03/04/18	16:23	3:41	0:00	3:41	3:44	Full	Flooding	NH 1A	Sea Road	Marsh Road	Rye
03/04/18	1:13	03/04/18	13:41	0:27	0:00	0:27	12:28	Full	Flooding	US 1	Pages Lane	Taylor River Bridge	ampton Falls / Hampto
03/05/18	13:24	03/05/18	14:28	0:59	0:00	0:59	1:04	Full	Flooding	NH 1A	NH 27	Atlantic Avenue	Rye
03/05/18	2:00	03/05/18	5:43	3:40	0:00	3:40	3:43	Full	Flooding	NH 1A	NH 27	Brackett Road	N. Hampton / Rye
03/06/18	13:55	03/06/18	16:28	2:30	0:00	2:30	2:33	Full	Flooding	NH 1A	NH 111	Causeway Road	Rye
03/06/18	11:10	03/06/18	14:28	3:12	0:00	3:12	3:18	Full	Flooding	NH 1A	Washington Road	Harbor Road	Rye
03/08/18	3:30	03/08/18	8:14	4:40	0:00	4:40	4:44	Full	Flooding	NH 1A	NH 27	Atlantic Avenue	Hampton / Rye
02/02/21	15:06	02/02/21	17:33	2:22	0:00	2:22	2:27	Full	Flooding	NH 1A	Willow Avenue	Causeway Road	Rye
02/02/21	13:20	02/02/21	17:34	4:08	0:00	4:08	4:14	Full	Flooding	Ocean Blvd	Sea Road	Appledore Avenue	Rye
10/27/21	3:38	10/27/21	8:27	4:41	0:00	4:41	4:49	Full	Flooding	NH 1A	Willow Avenue	Causeway Road	North Hampton

2011-2021 NH Rt 1A Cumulative Closure Time (hrs:minutes) = 165:13
Equivalent Days = 6:53

Appendix F

Conceptual Design

Revetment Sections 7, 10, and 13

<u>SECTION 7</u>

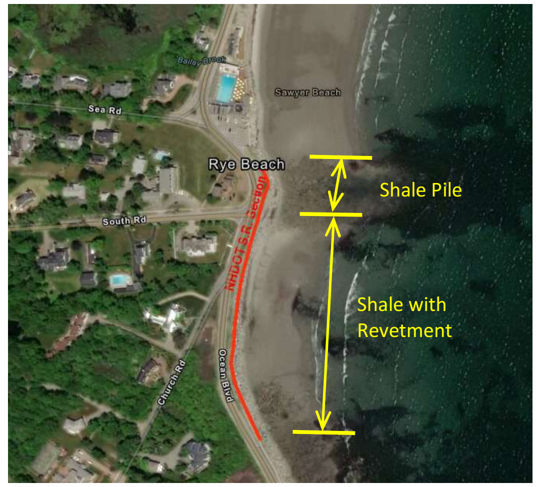
Begin STA 336+19 End STA 345+78

Length 959 LF

Stone type: 93 LF Shale pile
866 LF Shale Pile with revetment

Revetment Stone:
D_{min} = ranges from 18” to 3’
D_{50} = ranges from 3’ to 6’
D_{max} = ranges from 6’ to 12’

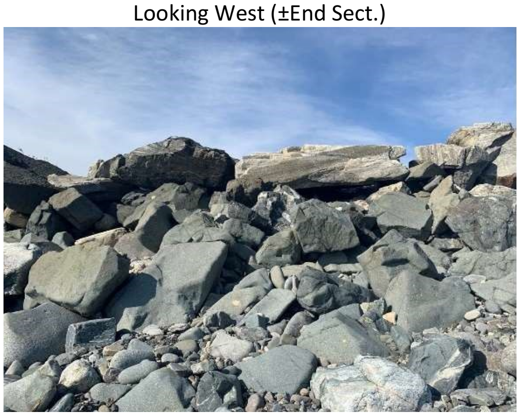
Slope: Ranges from 40% to 48%



Photographs:

Shale Pile at Beach Access
Looking West (±End Sect.)

Loosely Placed revetment Stone Near Top of Slope
Looking Southwest (±334+50)



Loosely Placed Revetment Stone; Possible Revetment
Damage - Looking West (±341+50)

Revetment Stone
Looking South

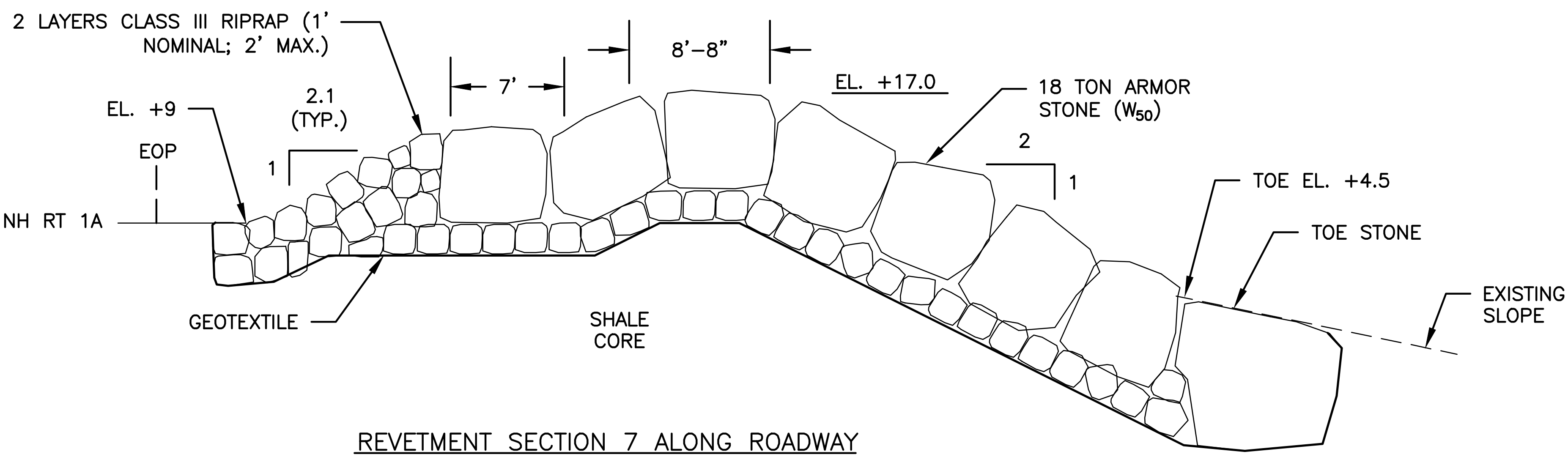
SECTION 7: Photographs Cont'd:

Revetment Stone
Looking Southwest (±Sta. 340+20)

Revetment stone
Looking West towards ±Begin Sect.

Top of Revetment; Defined Walking Path
Looking Northwest (±Begin Sect.)

Top of Revetment; Defined Walking Path
Looking Southwest (±344+40)



REVETMENT SECTION 7 ALONG ROADWAY

SCALE: 1"=10'

NO.	ISSUE/DESCRIPTION	BY	DATE

NHDOT NORTH HAMPTON-RYE 42312
CONCEPT REVETMENT SECTIONS

PREPARED BY:
GZA GeoEnvironmental, Inc.
Engineers and Scientists
www.gza.com

PREPARED FOR:
NHDOT

CONCEPT REVETMENT SECTIONS
SK-6

PROJ MGR: CWC	REVIEWED BY:	CHECKED BY: CWC	DWG 6
DESIGNED BY: CWC/RKT	DRAWN BY: RKT	SCALE: AS NOTED	
DATE: APRIL, 2021	PROJECT NO. 04.0190838.04	REVISION NO.	SHEET NO. 6 OF 6

SECTION 10

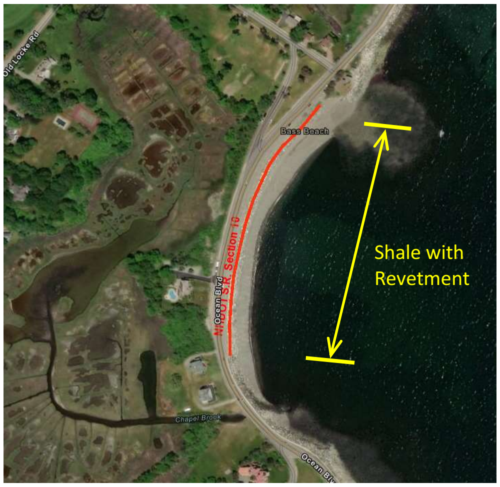
Begin STA 297+51 End STA 309+81

Length 1,230 LF

Stone type: 1,230 LF Shale pile with revetment

Revetment Stone: D_{min} = ranges from 3' to 4'
D_{50} = ranges from 5' to 6'
D_{max} = ranges from 7' to 10'

Slope: Ranges from 31% to 77%



Photographs:

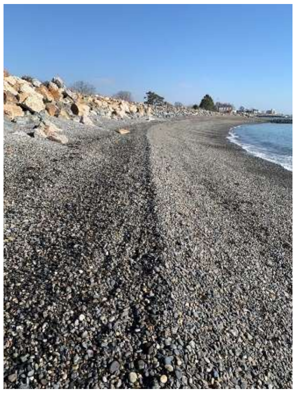
Revetment Stone; Evidence of Revetment Damage – Looking North (±Begin Sect.)

Revetment Stone; Evidence of Revetment Damage - Looking South (±Sta. 300+75)

Revetment Stone; Evidence of Revetment Damage – Looking East (±Sta. 301+50)

Revetment Stone; Evidence of Revetment Damage – Looking Southwest

SECTION 10: Photographs Cont'd:



Revetment Stone and Cobble Berm
Looking Northeast (±Sta. 303)

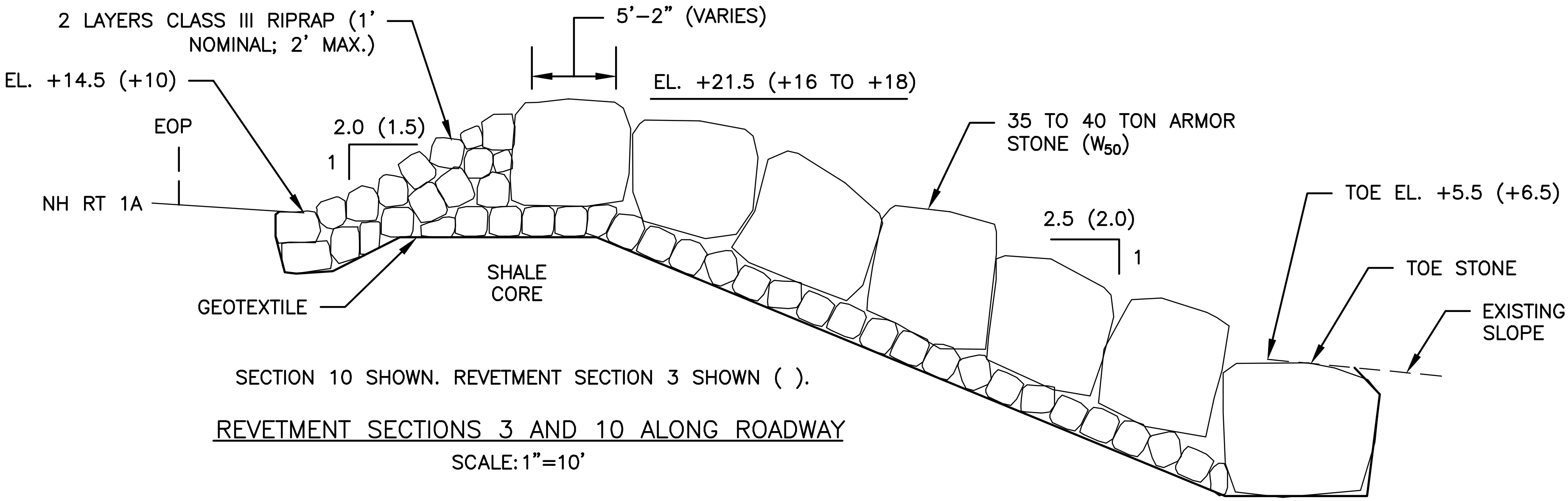
Revetment Stone
Looking North (±Sta. 304+60)

Revetment Stone; Possible Revetment Subsidence
Looking Northwest (±Sta. 307)

Revetment Stone
Looking Northeast towards ±End Sect.

Top of Revetment
Looking North towards ±End Sect

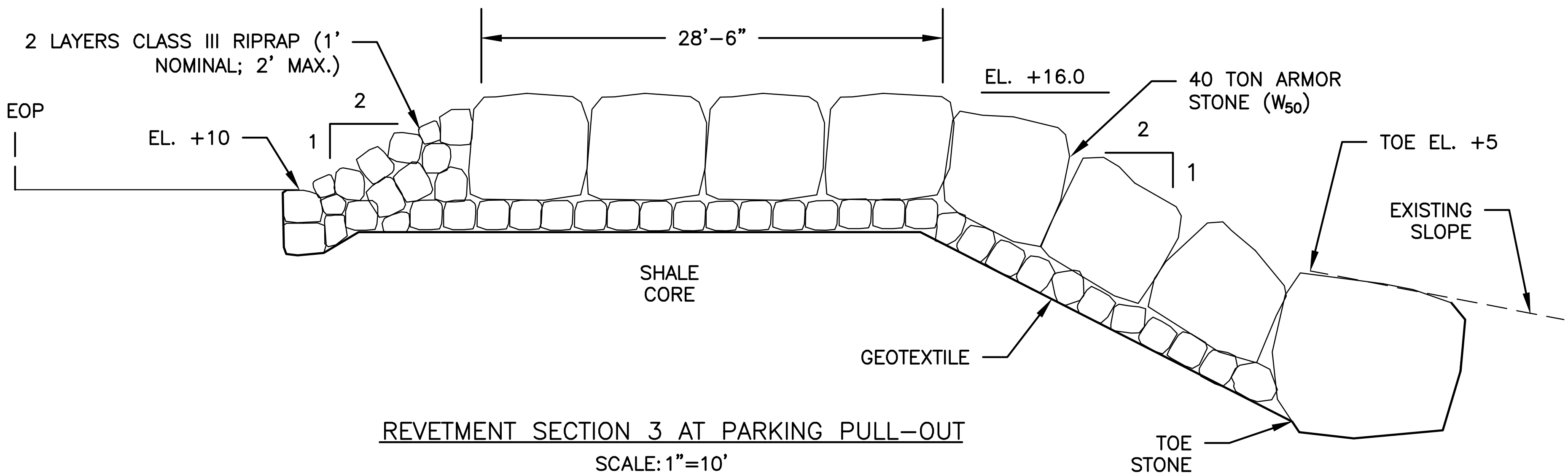
Top of Revetment
Looking Southwest



SECTION 10 SHOWN. REVETMENT SECTION 3 SHOWN ( ).

REVETMENT SECTIONS 3 AND 10 ALONG ROADWAY

SCALE: 1"=10'



REVETMENT SECTION 3 AT PARKING PULL–OUT

SCALE: 1"=10'

NO.	ISSUE/DESCRIPTION	BY	DATE

NHDOT NORTH HAMPTON-RYE 42312
CONCEPT REVETMENT SECTIONS

PREPARED BY:
GZA GeoEnvironmental, Inc.
Engineers and Scientists
www.gza.com

PREPARED FOR:
NHDOT

CONCEPT REVETMENT SECTIONS
SK-3

PROJ MGR: CWC	REVIEWED BY:	CHECKED BY: CWC	DWG
DESIGNED BY: CWC/RKT	DRAWN BY: RKT	SCALE: AS NOTED	3
DATE: APRIL, 2021	PROJECT NO. 04.0190838.04	REVISION NO.	SHEET NO. 3 OF 6

<u>SECTION 13</u>

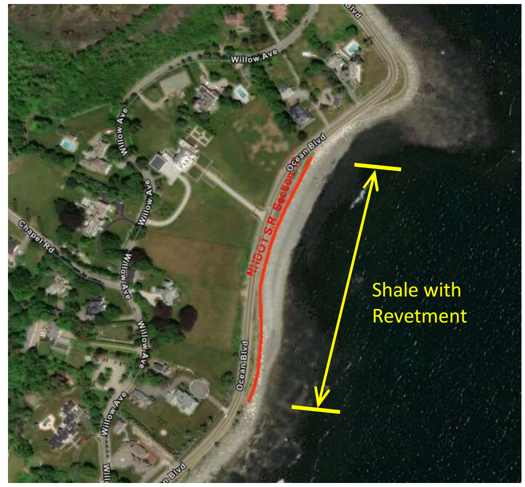
Begin STA 272+25 End STA 282+45

Length 1,020 LF

Stone type: 1,020 LF Shale pile with revetment

Revetment Stone: D_{min} = ranges from 6” to 2’
D_{50} = ranges from 14” to 4’
D_{max} = ranges from 4’ to 8’

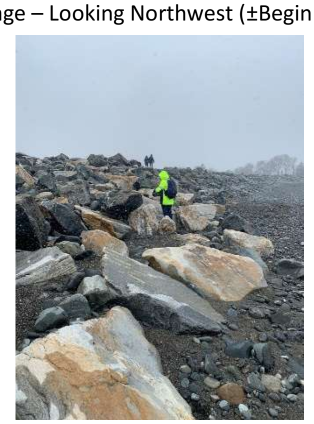
Slope: Ranges from 29% to 50%



Photographs:

Revetment Stone; Evidence of Revetment Damage – Looking Northwest (±Begin Sect.)

Revetment Stone; Evidence of Revetment Damage – Looking Northwest (±Begin Sect.)



Revetment Stone; Evidence of Revetment Damage – Looking East (±Sta. 275)

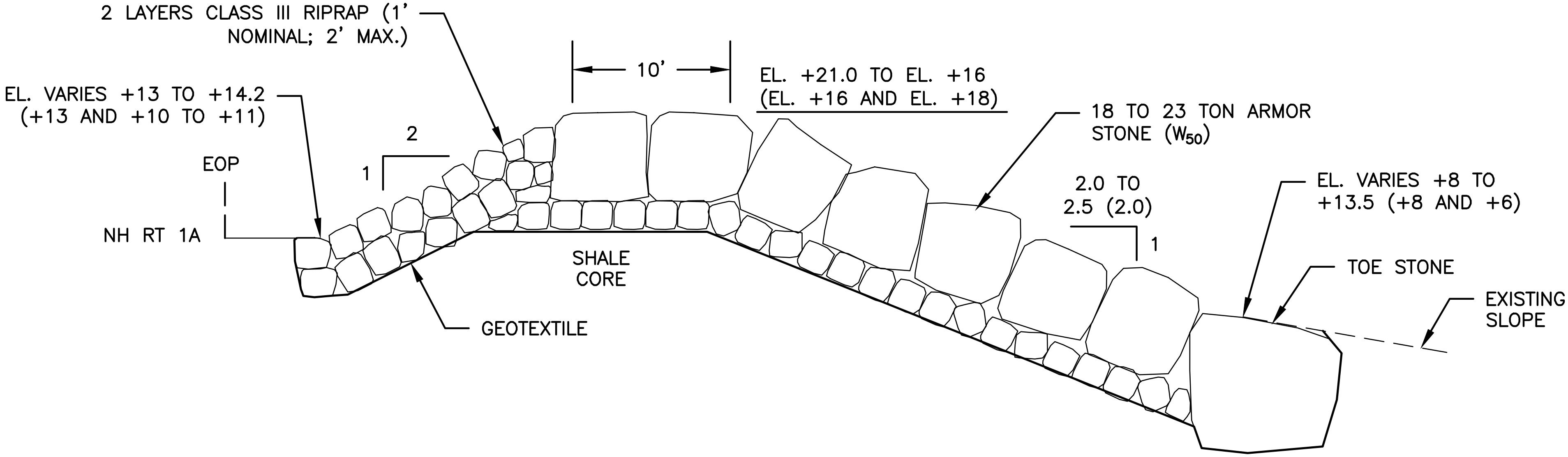
Loosely Placed Revetment Stone Looking North (±End Sect.)

SECTION 13: Photographs Cont'd:

Revetment Stone
Looking South (±End Sect.)

Top of Revetment; Possible Damage
Looking North (±Begin Sect.)

Top of Revetment Defined Walking Path
Looking North (±Sta. 280+30)



REVETMENT SECTIONS 4, 6 AND 13 ALONG ROADWAY

SCALE: 1"=10'

SECTION 13 SHOWN. REVETMENT SECTION 4 AND 6 SHOWN ( ).

NO.	ISSUE/DESCRIPTION	BY	DATE

NHDOT NORTH HAMPTON-RYE 42312
CONCEPT REVETMENT SECTIONS

PREPARED BY:
GZA GeoEnvironmental, Inc.
Engineers and Scientists
www.gza.com

PREPARED FOR:
NHDOT

CONCEPT REVETMENT SECTIONS
SK-5

PROJ MGR: CWC	REVIEWED BY:	CHECKED BY: CWC	DWG 5
DESIGNED BY: CWC/RKT	DRAWN BY: RKT	SCALE: AS NOTED	
DATE: APRIL, 2021	PROJECT NO. 04.0190838.04	REVISION NO.	SHEET NO. 5 OF 6

Appendix G

Conceptual Construction Cost Estimates

Revetment Sections 7, 10, and 13

SECTION 7 - CONCEPTUAL CONSTRUCTION COST ESTIMATE

FULL RECONSTRUCTION WITH CREST AND BACK SLOPE ARMOR STONE

FURNISH			CONSTRUCTION	
Armor Stone	**Riprap Stone**	**Remove Excess & Unsuitable Material**	**Remove & Construct ($1400/LF)**	**Access ($600/LF)**
$1,100,000	$110,000	$30,000	$1,300,000	$600,000
$1,240,000			$1,900,000	
Total			$3,140,000	
25% Conceptual Design Contingency			$800,000	
Conceptual Design Estimate			$3,940,000	$4,200 per LF
Say			**$3.5M to $4.5M**	$3,700 - $4,800 per LF

* This conceptual cost estimate is for general planning purposes for reconstruction of revetment sections along NH Route 1A. Actual cost may vary depending on the project phasing, when the work is completed, labor and material costs and the waterfront marine construction bid environment. Individual line items are order of magnitude estimates with respect to the total project cost estimate. Actual costs may vary and could be significantly more, or less, than shown.

SECTION 10 - CONCEPTUAL CONSTRUCTION COST ESTIMATE

FULL RECONSTRUCTION WITH CREST AND BACK SLOPE ARMOR STONE

FURNISH			CONSTRUCTION	
Armor Stone	Riprap Stone	Remove Excess & Unsuitable Material	Remove & Construct ($1400/LF)	Access ($600/LF)
$3,400,000	$220,000	$100,000	$1,700,000	$700,000
$3,720,000			$2,400,000	
Total			$6,120,000	
25% Conceptual Design Contingency			$1,500,000	
Conceptual Design Estimate			$7,620,000	$6,400 per LF
Say			**$7M to $8M**	$5,900 - $6,700 per LF

* This conceptual cost estimate is for general planning purposes for reconstruction of revetment sections along NH Route 1A. Actual cost may vary depending on the project phasing, when the work is completed, labor and material costs and the waterfront marine construction bid environment. Individual line items are order of magnitude estimates with respect to the total project cost estimate. Actual costs may vary and could be significantly more, or less, than shown.

SECTION 13 - CONCEPTUAL CONSTRUCTION COST ESTIMATE

FULL RECONSTRUCTION WITH CREST AND BACK SLOPE ARMOR STONE

FURNISH			CONSTRUCTION	
Armor Stone	**Riprap Stone**	**Remove Excess & Unsuitable Material**	**Remove & Construct ($1400/LF)**	**Access ($600/LF)**
$2,000,000	$30,000	$50,000	$1,400,000	$600,000
$2,080,000			$2,000,000	
Total			$4,080,000	
25% Conceptual Design Contingency			$1,000,000	
Conceptual Design Estimate			$5,080,000	$5,100 per LF
Say			**$4.5M to $5.5M**	$4,500 - $5,500 per LF

* This conceptual cost estimate is for general planning purposes for reconstruction of revetment sections along NH Route 1A. Actual cost may vary depending on the project phasing, when the work is completed, labor and material costs and the waterfront marine construction bid environment. Individual line items are order of magnitude estimates with respect to the total project cost estimate. Actual costs may vary and could be significantly more, or less, than shown.

DISCLOSURE OF LOBBYING ACTIVITIES

Complete this form to disclose lobbying activities pursuant to 31 U.S.C.1352

OMB Number: 4040-0013
Expiration Date: 02/28/2025

1. * Type of Federal Action:
- [ ] a. contract
- [x] b. grant
- [ ] c. cooperative agreement
- [ ] d. loan
- [ ] e. loan guarantee
- [ ] f. loan insurance

2. * Status of Federal Action:
- [x] a. bid/offer/application
- [ ] b. initial award
- [ ] c. post-award

3. * Report Type:
- [x] a. initial filing
- [ ] b. material change

4. Name and Address of Reporting Entity:

- [x] Prime
- [ ] SubAwardee

** Name* New Hampshire Department of Transportation

** Street 1* 7 Hazen Drive *Street 2*

** City* Concord *State* NH: New Hampshire *Zip* 03302

Congressional District, if known:

5. If Reporting Entity in No.4 is Subawardee, Enter Name and Address of Prime:

6. * Federal Department/Agency:
FHWA

7. * Federal Program Name/Description:
Highway Planning and Construction

CFDA Number, *if applicable:* 20.205

8. Federal Action Number, *if known:*
693JJ323NF00013

9. Award Amount, *if known:*
$

10. a. Name and Address of Lobbying Registrant:

Prefix ** First Name* NA *Middle Name*

** Last Name* NA *Suffix*

** Street 1* NA *Street 2*

** City* NA *State* *Zip*

b. Individual Performing Services (including address if different from No. 10a)

Prefix ** First Name* NA *Middle Name*

** Last Name* NA *Suffix*

** Street 1* NA *Street 2*

** City* NA *State* *Zip*

11. Information requested through this form is authorized by title 31 U.S.C. section 1352. This disclosure of lobbying activities is a material representation of fact upon which reliance was placed by the tier above when the transaction was made or entered into. This disclosure is required pursuant to 31 U.S.C. 1352. This information will be reported to the Congress semi-annually and will be available for public inspection. Any person who fails to file the required disclosure shall be subject to a civil penalty of not less than $10,000 and not more than $100,000 for each such failure.

*** Signature:** Completed on submission to Grants.gov

***Name:** *Prefix* ** First Name* NA *Middle Name*

** Last Name* NA *Suffix*

Title: **Telephone No.:** **Date:** Completed on submission to Grants.gov

Federal Use Only:

Authorized for Local Reproduction
Standard Form - LLL (Rev. 7-97)

CERTIFICATION REGARDING LOBBYING

Certification for Contracts, Grants, Loans, and Cooperative Agreements

The undersigned certifies, to the best of his or her knowledge and belief, that:

(1) No Federal appropriated funds have been paid or will be paid, by or on behalf of the undersigned, to any person for influencing or attempting to influence an officer or employee of an agency, a Member of Congress, an officer or employee of Congress, or an employee of a Member of Congress in connection with the awarding of any Federal contract, the making of any Federal grant, the making of any Federal loan, the entering into of any cooperative agreement, and the extension, continuation, renewal, amendment, or modification of any Federal contract, grant, loan, or cooperative agreement.

(2) If any funds other than Federal appropriated funds have been paid or will be paid to any person for influencing or attempting to influence an officer or employee of any agency, a Member of Congress, an officer or employee of Congress, or an employee of a Member of Congress in connection with this Federal contract, grant, loan, or cooperative agreement, the undersigned shall complete and submit Standard Form-LLL, ''Disclosure of Lobbying Activities,'' in accordance with its instructions.

(3) The undersigned shall require that the language of this certification be included in the award documents for all subawards at all tiers (including subcontracts, subgrants, and contracts under grants, loans, and cooperative agreements) and that all subrecipients shall certify and disclose accordingly. This certification is a material representation of fact upon which reliance was placed when this transaction was made or entered into. Submission of this certification is a prerequisite for making or entering into this transaction imposed by section 1352, title 31, U.S. Code. Any person who fails to file the required certification shall be subject to a civil penalty of not less than $10,000 and not more than $100,000 for each such failure.

Statement for Loan Guarantees and Loan Insurance

The undersigned states, to the best of his or her knowledge and belief, that:

If any funds have been paid or will be paid to any person for influencing or attempting to influence an officer or employee of any agency, a Member of Congress, an officer or employee of Congress, or an employee of a Member of Congress in connection with this commitment providing for the United States to insure or guarantee a loan, the undersigned shall complete and submit Standard Form-LLL, ''Disclosure of Lobbying Activities,'' in accordance with its instructions. Submission of this statement is a prerequisite for making or entering into this transaction imposed by section 1352, title 31, U.S. Code. Any person who fails to file the required statement shall be subject to a civil penalty of not less than $10,000 and not more than $100,000 for each such failure.

* APPLICANT'S ORGANIZATION

State of New Hampshire Department of Transportation

* PRINTED NAME AND TITLE OF AUTHORIZED REPRESENTATIVE

Prefix: Mr.   * First Name: Tobey   Middle Name:

* Last Name: Reynolds   Suffix:

* Title: Asssistant Director of Project Development

* SIGNATURE: Completed on submission to Grants.gov   * DATE: Completed on submission to Grants.gov

BUDGET INFORMATION - Construction Programs

NOTE: Certain Federal assistance programs require additional computations to arrive at the Federal share of project costs eligible for participation. If such is the case, you will be notified.

COST CLASSIFICATION	a. Total Cost	b. Costs Not Allowable for Participation	c. Total Allowable Costs (Columns a-b)
1. Administrative and legal expenses	$ 216,000.00	$	$ 216,000.00
2. Land, structures, rights-of-way, appraisals, etc.	$	$	$
3. Relocation expenses and payments	$	$	$
4. Architectural and engineering fees	$	$	$
5. Other architectural and engineering fees	$ 216,000.00	$	$ 216,000.00
6. Project inspection fees	$	$	$
7. Site work	$	$	$
8. Demolition and removal	$	$	$
9. Construction	$ 18,000,000.00	$	$ 18,000,000.00
10. Equipment	$	$	$
11. Miscellaneous	$ 3,587,000.00	$	$ 3,587,000.00
12. SUBTOTAL *(sum of lines 1-11)*	$ 22,019,000.00	$	$ 22,019,000.00
13. Contingencies	$ 3,304,000.00	$	$ 3,304,000.00
14. SUBTOTAL	$ 25,323,000.00	$	$ 25,323,000.00
15. Project (program) income	$	$	$
16. TOTAL PROJECT COSTS *(subtract #15 from #14)*	$ 25,323,000.00	$	$ 25,323,000.00

FEDERAL FUNDING

17. Federal assistance requested, calculate as follows: (Consult Federal agency for Federal percentage share.) Enter the resulting Federal share.	Enter eligible costs from line 16c Multiply X 80 %	$ 20,258,400.00

ASSURANCES - CONSTRUCTION PROGRAMS

OMB Number: 4040-0009
Expiration Date: 02/28/2025

Public reporting burden for this collection of information is estimated to average 15 minutes per response, including time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding the burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to the Office of Management and Budget, Paperwork Reduction Project (0348-0042), Washington, DC 20503.

PLEASE DO NOT RETURN YOUR COMPLETED FORM TO THE OFFICE OF MANAGEMENT AND BUDGET. SEND IT TO THE ADDRESS PROVIDED BY THE SPONSORING AGENCY.

NOTE: Certain of these assurances may not be applicable to your project or program. If you have questions, please contact the Awarding Agency. Further, certain Federal assistance awarding agencies may require applicants to certify to additional assurances. If such is the case, you will be notified.

As the duly authorized representative of the applicant:, I certify that the applicant:

1. Has the legal authority to apply for Federal assistance, and the institutional, managerial and financial capability (including funds sufficient to pay the non-Federal share of project costs) to ensure proper planning, management and completion of project described in this application.

2. Will give the awarding agency, the Comptroller General of the United States and, if appropriate, the State, the right to examine all records, books, papers, or documents related to the assistance; and will establish a proper accounting system in accordance with generally accepted accounting standards or agency directives.

3. Will not dispose of, modify the use of, or change the terms of the real property title or other interest in the site and facilities without permission and instructions from the awarding agency. Will record the Federal awarding agency directives and will include a covenant in the title of real property acquired in whole or in part with Federal assistance funds to assure non-discrimination during the useful life of the project.

4. Will comply with the requirements of the assistance awarding agency with regard to the drafting, review and approval of construction plans and specifications.

5. Will provide and maintain competent and adequate engineering supervision at the construction site to ensure that the complete work conforms with the approved plans and specifications and will furnish progressive reports and such other information as may be required by the assistance awarding agency or State.

6. Will initiate and complete the work within the applicable time frame after receipt of approval of the awarding agency.

7. Will establish safeguards to prohibit employees from using their positions for a purpose that constitutes or presents the appearance of personal or organizational conflict of interest, or personal gain.

8. Will comply with the Intergovernmental Personnel Act of 1970 (42 U.S.C. §§4728-4763) relating to prescribed standards of merit systems for programs funded under one of the 19 statutes or regulations specified in Appendix A of OPM's Standards for a Merit System of Personnel Administration (5 C.F.R. 900, Subpart F).

9. Will comply with the Lead-Based Paint Poisoning Prevention Act (42 U.S.C. §§4801 et seq.) which prohibits the use of lead-based paint in construction or rehabilitation of residence structures.

10. Will comply with all Federal statutes relating to non-discrimination. These include but are not limited to: (a) Title VI of the Civil Rights Act of 1964 (P.L. 88-352) which prohibits discrimination on the basis of race, color or national origin; (b) Title IX of the Education Amendments of 1972, as amended (20 U.S.C. §§1681 1683, and 1685-1686), which prohibits discrimination on the basis of sex; (c) Section 504 of the Rehabilitation Act of 1973, as amended (29) U.S.C. §794), which prohibits discrimination on the basis of handicaps; (d) the Age Discrimination Act of 1975, as amended (42 U.S.C. §§6101-6107), which prohibits discrimination on the basis of age; (e) the Drug Abuse Office and Treatment Act of 1972 (P.L. 92-255), as amended relating to nondiscrimination on the basis of drug abuse; (f) the Comprehensive Alcohol Abuse and Alcoholism Prevention, Treatment and Rehabilitation Act of 1970 (P.L. 91-616), as amended, relating to nondiscrimination on the basis of alcohol abuse or alcoholism; (g) §§523 and 527 of the Public Health Service Act of 1912 (42 U.S.C. §§290 dd-3 and 290 ee 3), as amended, relating to confidentiality of alcohol and drug abuse patient records; (h) Title VIII of the Civil Rights Act of 1968 (42 U.S.C. §§3601 et seq.), as amended, relating to nondiscrimination in the sale, rental or financing of housing; (i) any other nondiscrimination provisions in the specific statue(s) under which application for Federal assistance is being made; and (j) the requirements of any other nondiscrimination statue(s) which may apply to the application.

11. Will comply, or has already complied, with the requirements of Titles II and III of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970 (P.L. 91-646) which provide for fair and equitable treatment of persons displaced or whose property is acquired as a result of Federal and federally-assisted programs. These requirements apply to all interests in real property acquired for project purposes regardless of Federal participation in purchases.

12. Will comply with the provisions of the Hatch Act (5 U.S.C. §§1501-1508 and 7324-7328) which limit the political activities of employees whose principal employment activities are funded in whole or in part with Federal funds.

13. Will comply, as applicable, with the provisions of the Davis-Bacon Act (40 U.S.C. §§276a to 276a-7), the Copeland Act (40 U.S.C. §276c and 18 U.S.C. §874), and the Contract Work Hours and Safety Standards Act (40 U.S.C. §§327-333) regarding labor standards for federally-assisted construction subagreements.

14. Will comply with flood insurance purchase requirements of Section 102(a) of the Flood Disaster Protection Act of 1973 (P.L. 93-234) which requires recipients in a special flood hazard area to participate in the program and to purchase flood insurance if the total cost of insurable construction and acquisition is $10,000 or more.

15. Will comply with environmental standards which may be prescribed pursuant to the following: (a) institution of environmental quality control measures under the National Environmental Policy Act of 1969 (P.L. 91-190) and Executive Order (EO) 11514; (b) notification of violating facilities pursuant to EO 11738; (c) protection of wetlands pursuant to EO 11990; (d) evaluation of flood hazards in floodplains in accordance with EO 11988; (e) assurance of project consistency with the approved State management program developed under the Coastal Zone Management Act of 1972 (16 U.S.C. §§1451 et seq.); (f) conformity of Federal actions to State (Clean Air) implementation Plans under Section 176(c) of the Clean Air Act of 1955, as amended (42 U.S.C. §§7401 et seq.); (g) protection of underground sources of drinking water under the Safe Drinking Water Act of 1974, as amended (P.L. 93-523); and, (h) protection of endangered species under the Endangered Species Act of 1973, as amended (P.L. 93-205).

16. Will comply with the Wild and Scenic Rivers Act of 1968 (16 U.S.C. §§1271 et seq.) related to protecting components or potential components of the national wild and scenic rivers system.

17. Will assist the awarding agency in assuring compliance with Section 106 of the National Historic Preservation Act of 1966, as amended (16 U.S.C. §470), EO 11593 (identification and protection of historic properties), and the Archaeological and Historic Preservation Act of 1974 (16 U.S.C. §§469a-1 et seq).

18. Will cause to be performed the required financial and compliance audits in accordance with the Single Audit Act Amendments of 1996 and OMB Circular No. A-133, "Audits of States, Local Governments, and Non-Profit Organizations."

19. Will comply with all applicable requirements of all other Federal laws, executive orders, regulations, and policies governing this program.

20. Will comply with the requirements of Section 106(g) of the Trafficking Victims Protection Act (TVPA) of 2000, as amended (22 U.S.C. 7104) which prohibits grant award recipients or a sub-recipient from (1) Engaging in severe forms of trafficking in persons during the period of time that the award is in effect (2) Procuring a commercial sex act during the period of time that the award is in effect or (3) Using forced labor in the performance of the award or subawards under the award.

SIGNATURE OF AUTHORIZED CERTIFYING OFFICIAL	TITLE
Completed on submission to Grants.gov	Asssistant Director of Project Development
APPLICANT ORGANIZATION	**DATE SUBMITTED**
State of New Hampshire Department of Transportation	Completed on submission to Grants.gov

ATTACHMENTS FORM

Instructions: On this form, you will attach the various files that make up your grant application. Please consult with the appropriate Agency Guidelines for more information about each needed file. Please remember that any files you attach must be in the document format and named as specified in the Guidelines.

Important: Please attach your files in the proper sequence. See the appropriate Agency Guidelines for details.

1) Please attach Attachment 1	Letter of Support Congressman	Add Attachment	Delete Attachment	View Attachment
2) Please attach Attachment 2	Letter of Support New Hampshi	Add Attachment	Delete Attachment	View Attachment
3) Please attach Attachment 3	Letter of Support New Hampshi	Add Attachment	Delete Attachment	View Attachment
4) Please attach Attachment 4	Letter of Support United Stat	Add Attachment	Delete Attachment	View Attachment
5) Please attach Attachment 5	Letter of Support Town of Rye	Add Attachment	Delete Attachment	View Attachment
6) Please attach Attachment 6		Add Attachment	Delete Attachment	View Attachment
7) Please attach Attachment 7		Add Attachment	Delete Attachment	View Attachment
8) Please attach Attachment 8		Add Attachment	Delete Attachment	View Attachment
9) Please attach Attachment 9		Add Attachment	Delete Attachment	View Attachment
10) Please attach Attachment 10		Add Attachment	Delete Attachment	View Attachment
11) Please attach Attachment 11		Add Attachment	Delete Attachment	View Attachment
12) Please attach Attachment 12		Add Attachment	Delete Attachment	View Attachment
13) Please attach Attachment 13		Add Attachment	Delete Attachment	View Attachment
14) Please attach Attachment 14		Add Attachment	Delete Attachment	View Attachment
15) Please attach Attachment 15		Add Attachment	Delete Attachment	View Attachment

CHRIS PAPPAS
First District, New Hampshire
COMMITTEE ON VETERANS' AFFAIRS
COMMITTEE ON TRANSPORTATION AND INFRASTRUCTURE
COMMITTEE ON SMALL BUSINESS
Pappas.House.gov

Congress of the United States
House of Representatives

WASHINGTON OFFICE:
452 Cannon House Office Building
Washington, DC 20515
P: (202) 225-5456

MANCHESTER OFFICE:
889 Elm Street
Manchester, NH 03101
P: (603) 935-6710

DOVER OFFICE:
660 Central Avenue, Suite 101
Dover, NH 03820
P: (603) 285-4300

Peter P. M. Buttigieg, Secretary
U.S. Department of Transportation
Federal Highway Administration
Office of Acquisition and Grants Management
1200 New Jersey Ave., SE.
Washington, DC 20590
PROTECTdiscretionary@dot.gov

Re: NHDOT Application for PROTECT Grant Funds for NH Route 1A

Dear Secretary Buttigieg:

I am writing in strong support of the New Hampshire Department of Transportation's (NHDOT) application for grant funding to reconstruct the seawall along Route 1A in North Hampton-Rye under the Promoting Resilient Operations for Transformative, Efficient, and Cost-Saving Transportation (PROTECT) Program. NHDOT is requesting $20 million in grant funds to be used on the first project with a cost of $25.3 million.

NH Route 1A is an essential coastal route for local and regional transport. It provides vital access to the state's beaches, supporting the seacoast region's economy and local surrounding communities. It also serves as the emergency evacuation route for the towns of North Hampton and Rye in the event of coastal storms or a malfunction within the Seabrook Nuclear Power Plant.

NHDOT is applying for the PROTECT program to fund the first in a series of projects that will provide critical resilience improvements along NH Route 1A to strengthen coastal safety and access for New Hampshire's residents and visitors. The roadway is vulnerable during nor'easter storms, and storm surges, waves, and wave overtopping contribute to significant roadway flooding. Inclement weather causes structural damage to the seawall that separates the roadway from the Atlantic Ocean, and a mixture of flooding and dislodged stones create road closures. These storms have a detrimental impact on NH's seacoast area and economy, and the frequency of storm and flood events causing extended road closures for cleanup have increased in the last 10 years.

The Department is requesting grant funds of $20 million for the first project, to work on sections of the seawall from North Hampton to Rye. This first project will focus on reconstructing sections of the existing seawall to make it more resilient to higher intensity storms and a rising sea level. Redesigns will focus on constructing the seawall to better address coastal storm conditions, and minimizing the hazards created when waves impact the seawall's stones. It will reduce the need for road closures and costly post-storm clean-up efforts by NHDOT, municipalities, and property owners. This project is significant to the safety and economic well-being of a considerable area of New Hampshire's Seacoast region.

Considering these facts, I respectfully request that the NHDOT's application for grant funding be given thorough consideration in accordance with all applicable laws and regulations. Thank you for your time and attention to this matter. If you have any further questions for my office, please do not hesitate to reach out to my office at (603) 935-6710.

Sincerely,

Chris Pappas

Chris Pappas
Member of Congress

STATE OF NEW HAMPSHIRE
OFFICE OF THE GOVERNOR

CHRISTOPHER T. SUNUNU
Governor

August 8, 2023

Peter P. M. Buttigieg, Secretary
U.S. Department of Transportation
Federal Highway Administration
Office of Acquisition and Grants Management
1200 New Jersey Ave., SE.
Washington, DC 20590
PROTECTdiscretionary@dot.gov

Re: NHDOT Application for PROTECT Grant Funds for NH Route 1A

Dear Secretary Buttigieg:

I am writing in strong support of the New Hampshire Department of Transportation's (NHDOT) application for grant funding to reconstruct the seawall along Route 1A in North Hampton-Rye under the Promoting Resilient Operations for Transformative, Efficient, and Cost-Saving Transportation (PROTECT) Program. NH Route 1A is an essential coastal route for local and regional transport. It provides vital access to the state's beaches, supporting the seacoast region's economy and the local communities, as well as serves as the emergency evacuation route for the towns of North Hampton and Rye for coastal storms and the Seabrook Nuclear Power Plant. NHDOT is requesting $20 million in grant funds to be used on the first project with a cost of $25.3 million.

NH Route 1A is vulnerable during nor'easter coastal storms. Storm surges, waves, and wave overtopping contribute to roadway flooding and cause structural damage to the seawall that separates the roadway from the Atlantic Ocean. Given NH's minimal amount of shoreline, the storms have an exponential impact on NH's seacoast area and economy. Unfortunately, the frequency of storm and flood events causing extended road closures for flooding and cleanup along NH Route 1A have increased in the last 10 years. NHDOT is applying for the PROTECT program to fund the first in a series of projects that will provide critical resilience improvements along NH Route 1A to strengthen coastal safety and access for New Hampshire's residents and visitors.

107 North Main Street, State House - Rm 208, Concord, New Hampshire 03301
Telephone (603) 271-2121 • FAX (603) 271-7640
Website: http://www.governor.nh.gov/ • Email: governorsununu@nh.gov
TDD Access: Relay NH 1-800-735-2964

The Department is requesting grant funds of $20 million for the first project to work on sections of the seawall from North Hampton to Rye with a total cost of $25.3 million. This first project involves reconstructing sections of the existing seawall to its original elevation when it was constructed in 1978. NHDOT plans to re-design and reconstruct the seawall to better address coastal storm conditions. The project will minimize the hazards created when waves dislodge large seawall stones and deposit them onto NH Rt 1A and will reduce the need for road closures and costly post-storm clean-up borne by NHDOT, municipalities, and property owners. This project is significant in terms of safety and economics for a considerable area of New Hampshire's coastline.

Sincerely,

Christopher T. Sununu
Governor

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The Senate of the State of New Hampshire

107 North Main Street, Concord, N.H. 03301-4951

Peter P. M. Buttigieg, Secretary
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NH Route 1A is an essential coastal route for local and regional transport. It provides vital access to the state's beaches, supporting the seacoast region's economy and the local communities. It also serves as the emergency evacuation route for the towns of North Hampton and Rye for coastal storms and the Seabrook Nuclear Power Plant.

This important roadway is vulnerable during nor'easter coastal storms. Storm surges, waves, and wave overtopping contribute to roadway flooding and cause structural damage to the seawall that separates the roadway from the Atlantic Ocean. The seawall is technically referred to as a "stone revetment" and is comprised of boulder-sized stones. The roadway becomes unsafe during significant storms due to flooding and dislodged stones, resulting in road closures. Given NH's minimal amount of shoreline, the storms have an exponential impact on NH's seacoast area and economy. Unfortunately, the frequency of storm and flood events causing extended road closures for flooding and cleanup along NH Route 1A have increased in the last 10 years.

NHDOT is applying for the PROTECT program to fund the first in a series of projects that will provide critical resilience improvements along NH Route 1A to strengthen coastal safety and access for New Hampshire's residents and visitors.

The Department is requesting grant funds of $20 million for the first project to work on sections of the seawall from North Hampton to Rye with a total cost of $25.3 million. This first project involves reconstructing sections of the existing seawall to its original elevation when it was constructed in 1978 with the goal of making the seawall more resilient to higher intensity storms and the rising sea level. NHDOT plans to re-design and reconstruct the seawall to better address coastal storm conditions. The project will minimize the hazards created when waves dislodge large seawall stones and depositing them onto NH Rt 1A and will reduce the need for road closures and costly post-storm clean-up borne by NHDOT, municipalities, and property owners. Improvements to the seawall will reduce road closure times and the potential impacts to emergency responses. This project is significant in terms of safety and economics for a considerable area of New Hampshire's coastline.

Sincerely,

Denise Ricciardi

Senator Denise Ricciardi
Senate District 9
Chair, Senate Transportation Committee

David H. Watters

Senator David Watters
Senate District 4
Vice Chair, Senate Transportation Committee

MARGARET WOOD HASSAN
NEW HAMPSHIRE

SUITE SH–324
HART BUILDING
WASHINGTON, DC 20510
(202) 224–3324

United States Senate

August 18, 2023

The Honorable Peter Buttigieg
Secretary
U.S. Department of Transportation
1200 New Jersey Ave., SE.
Washington, DC 20590

Dear Secretary Buttigieg,

I write today in strong support of the New Hampshire Department of Transportation's (NHDOT) application for grant funding to reconstruct the seawall along Route 1A in North Hampton-Rye under the Promoting Resilient Operations for Transformative, Efficient, and Cost-Saving Transportation (PROTECT) Program.

Funding from the PROTECT Program will fund the first in a series of projects that will create critical resilience improvements along NH Route 1A to strengthen coastal safety and access for New Hampshire's residents and visitors. This coastal route is essential for local and regional transport and provides access to New Hampshire's state beaches, which in turn supports our state's economy and local communities. It also serves as the emergency evacuation route for the towns of North Hampton and Rye for coastal storms and in the event of an incident at the Seabrook Nuclear Power Plant.

This roadway is vulnerable to nor'easter coastal storms and other severe weather. Storm surges, waves, and wave overtopping contribute to roadway flooding and cause structural damage to the seawall that separates the road from the Atlantic Ocean. The seawall is comprised of boulder-sized stones and becomes unsafe during significant storms due to flooding and dislodged stones, resulting in road closures that have a significant negative impact on the regional economy. Over the past 10 years, the frequency of storms has caused extended road closures due to flooding and cleanup along the route.

PROTECT Program funding will allow NHDOT to reconstruct sections of the existing seawall to the original elevation, with the goal of making the seawall more resilient to higher-intensity storms and rising sea level. The project will minimize the hazards created when waves dislodge large seawall stones and deposit them onto NH Route 1A. It will also reduce the need for road closures and costly post-storm clean-up borne by NHDOT, municipalities, and property owners. In addition, improvements to the seawall will reduce road closure times when they do happen.

These improvements are critical not only to the economy of the region, but also to the safety of residents and visitors along a considerable area of New Hampshire's coastline.

I encourage you to look favorably upon this strong application. If my office or I can be of any further assistance, please do not hesitate to contact my staff at 603-622-2204.

With every good wish,

Maggie Hassan

Margaret Wood Hassan
United States Senator

TOWN OF RYE • OFFICE OF SELECTMEN
10 Central Road
Rye, NH 03870-2522
(603) 964-5523 • Fax (603) 964-1516

August 17, 2023

Peter P. M. Buttigieg, Secretary
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Washington, DC 20590
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Dear Secretary Buttigieg:

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NH Route 1A is an essential coastal route for local and regional transport. It provides vital access to the state's beaches, supporting the seacoast region's economy and the local communities. It also serves as the emergency evacuation route for the towns of North Hampton and Rye for coastal storms and the Seabrook Nuclear Power Plant.

This important roadway is vulnerable during nor'easter coastal storms. Storm surges, waves, and wave overtopping contribute to roadway flooding and cause structural damage to the seawall that separates the roadway from the Atlantic Ocean. The seawall is technically referred to as a "stone revetment" and is comprised of boulder-sized stones. The roadway becomes unsafe during significant storms due to flooding and dislodged stones, resulting in road closures. Given NH's minimal amount of shoreline, the storms have an exponential impact on NH's seacoast area and economy. Unfortunately, the frequency of storm and flood events causing extended road closures for flooding and cleanup along NH Route 1A have increased in the last 10 years.

NHDOT is applying for the PROTECT program to fund the first in a series of projects that will provide critical resilience improvements along NH Route 1A to strengthen coastal safety and access for New Hampshire's residents and visitors.

The Department is requesting grant funds of $20 million for the first project to work on sections of the seawall from North Hampton to Rye with a total cost of $25.3 million. This first project involves reconstructing sections of the existing seawall to its original elevation when it was constructed in 1978 with the goal of making the seawall more resilient to higher intensity storms and the rising sea level. NHDOT plans to re-design and reconstruct the seawall to better address coastal storm conditions. The project will minimize the hazards created when waves dislodge large seawall stones and depositing them onto NH Rt 1A and will reduce the need for road closures and costly post-storm clean-up borne by NHDOT, municipalities, and property owners. Improvements to the seawall will reduce road closure times and the potential impacts to emergency responses. This project is significant in terms of safety and economics for a considerable area of New Hampshire's coastline.

Sincerely,
Rye Select Board

Thomas King

Thomas King, Chairman

William Epperson, Vice-Chairman

Bob McGrath, Selectman