

Project Report

Executive Summary for the Flood Vulnerability Assessment

Scarborough, Maine

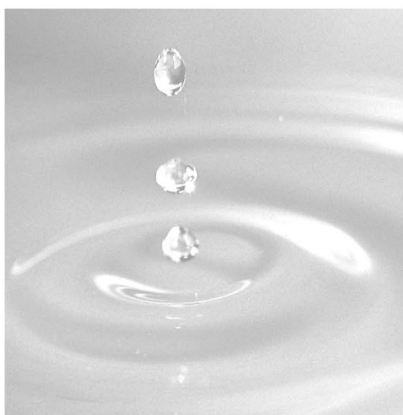
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1. Introduction

The Town of Scarborough, Maine, faces growing risks of coastal flooding from increasing tide cycles, sea level rise, and storm surge placing low-lying infrastructure and property at increased risk of inundation. Transportation networks along the tidally-influenced Scarborough Marsh are particularly at risk of coastal flooding. To prepare for regular inundation and increased flood depths and durations at high-volume roads, the Town partnered with GEI Consultants, Inc. (“GEI”) to perform a Flood Vulnerability Assessment—an integrated effort to understand flood risk, prioritize vulnerable assets, and identify strategies for long-term resilience.

This project brings together science, planning, and public engagement into a unified roadmap for action that included several key elements:

- **Data review and technical analysis** – Using recent climate science, including Maine Climate Council guidance on sea level rise.
- **Scenario-based modeling** – Evaluating 10 present and future coastal flooding scenarios (to 2100).
- **Infrastructure and asset prioritization** – Assessing flood vulnerabilities across roads, parcels, buildings, and other assets.
- **Adaptation strategy development** – Identifying both structural and non-structural adaptation measures.
- **Pilot and concept projects** – Advancing planning-level designs at Payne Road and Higgins Beach.
- **Neighborhood homeowner guidance** – Creating a tailored adaptation guide for Pine Point residents.
- **Ordinance review** – Identifying regulatory gaps and opportunities.
- **Community engagement** – Workshops, working group meetings, and an interactive StoryMap to communicate results and gather feedback.

The work by GEI was overseen by a Working Group comprised of Town staff and representatives from the Scarborough Sanitary District and the Pine Point, Prouts Neck, and Higgins Beach neighborhoods.

This document serves as an Executive Summary, or a high-level review, of the overall project. In-depth detail of methodology, results, and recommendations are provided in the accompanying documents which can be found through links on the StoryMap. The StoryMap and the memos, results, and guides are also listed in References section of this Executive Summary (GEI, 2025a, b, c, d, e, f, g, h)

Elevations in this report are referenced to the North American Vertical Datum of 1988 (NAVD88) unless otherwise specified.

2. Flood Vulnerability Assessment

The technical foundation of the project was a town-wide flood vulnerability analysis. Using Maine Climate Council guidance, the study evaluated 10 flood scenarios ranging from present-day extreme tides (2025) to 2100 coastal storm conditions with 7.4 feet of sea level rise. A summary of the flood scenarios is provided in Table 2-1 with corresponding water surface elevations and the time horizons when each flood scenario would be expected to occur. Using these flood scenarios and the location of key assets, the flood vulnerability assessment identified where and when critical assets, such as roads, buildings, and parcels, would face flood exposure. Results showed that low-lying roads that cross through the Scarborough Marsh were particularly vulnerable, as were the Higgins Beach and Pine Point neighborhoods.

Table 2-1. Summary of Flood Scenario

Flood Scenario	Water Surface Elevation (ft)	Flood Risk Time Horizon	
		Coastal Storm Event	“High Tide”
1	7.3	Now	2030
2	8.0	Now	2050
3	8.8	Now	2050
4	9.6	Now	2100
5	10.3	2030	2100
6	10.8	2050	2100
7	11.4	2050	2100
8	12.8	2100	2100
9	13.9	2100	2100
10	16.9	2100	2100

Notes:

1. “Now” represents 2025.

The Data Review Memo (GEI, 2025a) developed as part of this project provides background on water surface elevations, sea level rise projections, GIS asset data, and topography used for this project. A link to the Data Review Memo is included in the StoryMap (GEI, 2025h)

Another key element was the Flood Vulnerability Analysis Results Memo (GEI, 2025b) , which summarized assets at risk of flooding for the 10 scenarios. Details in this memo include, for example, number of buildings, boat launches, and parcels inundated, and flood exposure to important stormwater structures (i.e. catch basins, culverts, detention ponds, outfalls, etc.). The results of the analysis are highlighted in the StoryMap, where flood extents for the 10 flood scenarios included in the study can be explored.

An example of a flood risk summary table for roads is provided in Table 2-2 below.

Table 2-2. Public Roads Flood Exposure Summary

Scenario	1	2	3	4	5	6	7	8	9	10	Length/ Number in Study
Length Inundated, miles	0.5	1.2	2.7	4.1	5.4	6.5	8.2	14.6	18.5	25.1	194.5
Number of Roads Impacted	7	13	29	38	47	53	62	93	99	111	433

Notes:

1. Asset information (location, area, etc.) from the Roads GIS layer (Scarborough, 2024).

A key finding from the Flood Vulnerability Analysis Results memo was that transportation infrastructure emerged as one of the most pressing concerns, with 111 public roads identified as being at risk of flood exposure for the scenarios included in this study, 62 of which would be at risk of flooding by the year 2050. See the Scarborough Flood Vulnerability Analysis Results memo (GEI, 2025b) for the complete set of results from the study, including a summary of flood exposure for buildings, beaches, sand dunes, pump stations, parcels, and other assets included in the study.

2.1. Road Prioritization

Building on the finding of roads identified at risk of flood exposure, a risk-based prioritization process was undertaken to develop an approach for road adaptation. The prioritization process provided a method to quantify risk for each road (i.e., risk = probability of flooding times the consequence of flood exposure). The consequences included area impacted, impact to public safety, damage potential, environmental impact, and economic impact. Based on this process, 30 roads were identified as high priorities, including Route 1, Route 9, and Sawyer Street, which are all currently undergoing adaptation projects. Multiple roads in both the Higgins Beach and Pine Point neighborhoods were also identified.

The top 30 ranked roads based on the risk-based prioritization process are summarized in alphabetical order in Table 2-3. For details on the methodology and the complete ranking of public roadways at risk of coastal flooding, please review the Adaptation Prioritization Methodology for Public Roadways memo (GEI, 2025c).

Table 2-3. Top 30 Ranked Roads Based on Weighted Risk Score, Alphabetical Order

Road Name		
Avenue 1	E Grand Ave	Pine Point Rd*
Avenue 2	Ferry Rd	Route 1
Avenue 5	Jones Creek Dr	Route 9*
Avenue 6	Kent St	Sawyer St
Avenue 7	King St	Shipwreck Rd
Bayview Ave	Milliken Rd	Snow Canning Rd
Black Point Rd	Morning St	Spurwink Rd
Champion St	Ocean Ave	Vesper St
Clay Pits Rd	Old Neck Rd	Winnocks Neck Rd

Road Name		
Driftwood Ln	Payne Rd	Winnocks Neck to Plummer Island

Note:

1. Route 9 refers to the section of Route 9 near the Scarborough Marsh Audubon Center currently planned for adaptation as part of the MaineDOT Route 1 and Route 9 Adaptation Project. Pine Point Road refers to the section of Route 9 near Jones Creek.

3. Adaptation Strategies

For this phase of the project, we developed general adaptation strategies across four categories. The four categories and examples of corresponding adaptation measures included:

1. **Structural Measures** – Road elevation, building elevation or floodproofing, pump station protection, shoreline stabilization, and dune restoration.
2. **Nature-Based Solutions** – Dune nourishment, marsh migration space, and green infrastructure.
3. **Non-Structural Measures** – Monitoring, early warning systems, temporary barriers, community preparedness programs.
4. **Policy and Governance** – Updating ordinances to integrate sea level rise projections, incentivizing resilient design, and directing growth away from high-risk areas.

The work included examples of adaptation strategies along with conceptual drawings of structural adaptation measures.

In addition to an overview of general coastal flood adaptation strategies, the project provided specific adaptation strategy options for several of the top 30 ranked roads, the pump stations, several important community assets (like the Pine Point Fire Station, the Wastewater Treatment Plant, and the Public Works Facility), and the Higgins Beach and Pine Point neighborhoods on a neighborhood scale. For the assets, the specific adaptation strategies were provided in table form, with recommendations for up to three adaptation options per asset.

Additionally, to support the planning process, the study included relative cost estimates for the recommendations using a dollar sign symbol to represent relative magnitude. The intent was to convey the general level of effort required by the Town to fund a project. Cost estimate magnitudes were assumed to represent the following:

- **\$** – Low-cost measures likely feasible within a single fiscal year using existing Town funds.
- **\$\$** – Moderate-cost measures requiring capital improvement planning, but potentially achievable within one budget cycle.
- **\$\$\$** – High-cost measures requiring substantial funding or a multi-year implementation approach.
- **\$\$\$\$** – Very high-cost measures likely requiring multiple funding sources and long-term planning.

A review of the cost-of-inaction underscored that delaying investment could lead to greater damage, higher long-term costs, and loss of natural resources.

An example of adaptation options is provided in Table 2-4 below, which presents options and relative cost estimates for the Pine Point Fire Station.

Table 2-4. Example Adaptation Options Entry for Pine Point Fire Station

Road Name	Option 1	Cost 1	Option 2	Cost 2	Option 3	Cost 3
Pine Point Fire Station	Floodproof first floor of building using flood panels/flood barriers. Elevate sensitive systems within building.	\$	Deployable flood barrier around north side of building.	\$	“Do nothing” Estimated costs depend on flood damage and economic losses.	\$ to \$\$\$\$

The full set of recommendations are provided in the Coastal Flood Adaptation Strategies report (GEI, 2025d).

3.1. Neighborhood-Scale Adaptation: Higgins Beach and Pine Point

Neighborhood-scale adaptation recommendations were provided for the Higgins Beach and Pine Point neighborhoods, with an emphasis on safety. Both neighborhoods are located within a mapped Maine Coastal Sand Dune System and include areas in the Federal Emergency Management Agency (FEMA) special flood hazard zones, which impose regulatory constraints on certain adaptation measures. Specifically, the construction of new sea walls along the shorelines of these neighborhoods would not be allowed under existing regulations as of the writing of this report. The recommendations provided focus on life safety, infrastructure protection, and long-term resilience planning. The recommendations for these neighborhoods are provided below:

- **Establish Evacuation Routes** – For Higgins Beach, coordinate with Piper Shores to formalize an evacuation route using Greenwood Avenue and Piper Road during flood events that inundate Ocean Avenue while also working towards adapting Ocean Avenue through elevation or by other means. For Pine Point – prioritize elevating Pine Point Road and/or elevating East Grand Ave while also coordinating with the Town of Old Orchard Beach for broader adaptation to assist with evacuation.
- **Consider Long-Term Plans for Road Elevation** – For both neighborhoods, weigh the benefits of elevating roads in the back dune areas against the topographic constraints and implications on local drainage.
- **Designate Emergency Shelters** to use for warmth and shelter during periods of flood inundation.
- **Implement a neighborhood flood alert system** – Develop a localized flood alert system to notify residents of impending coastal flooding events. Consider integrating an audible alarm or siren to prompt evacuation. Make sure to notify and educate seasonal renters and guests of emergency protocols for evacuation.
- **Streamline Dune Restoration Efforts** – Establish a streamlined and recurring dune restoration program—such as the annual placement of recycled holiday trees—to reinforce dune systems and reduce erosion and storm damage to inland infrastructure.
- **Deploy Temporary Flood Barriers** – Consider installing seasonal flood barriers around vulnerable areas of the neighborhoods for up to seven months per year per Maine Sand Dune rules to reduce exposure to coastal storm impacts.

- **Enhance Public Education and Outreach** – Continue neighborhood education efforts around flood risk, including targeted education for renters and seasonal residents on flood risks, shelter locations, and evacuation procedures to improve preparedness and response.
- **Develop an Adaptation Roadmap** – Create a guidance document outlining feasible approaches to floodproofing or elevating structures within the constraints of current permitting regulations.
- **Plan for Long-Term Managed Retreat** – Evaluate the feasibility of voluntary managed retreat in areas projected to experience daily tidal flooding by 2050. This may include property buyouts or land use transitions to open space or natural buffers.

4. Pilot Projects

Three pilot projects were included as part of this study to advance adaptation recommendations to the next phase of conceptual design. The three pilot projects included:

- Payne Road Adaptation Alternatives Analysis
- Higgins Beach Shoreline Stabilization Concept Designs and Regulatory Meeting
- Pine Point Homeowner Adaptation Guide

Each of these pilot projects is summarized below.

4.1. Payne Road Pilot Project

The Payne Road pilot project was a planning-level alternatives analysis for the section of Payne Road identified as being at risk of flood inundation, which spans from Milliken Road to just beyond the Scottow Hill Road intersection. The purpose of this pilot project was to evaluate alternatives for road adaptation to reduce the risk of present day and future flood inundation. The adaptation options evaluated included elevating the road to 10 feet or 12 feet NAVD88.

The project also identified opportunities to enhance tidal connectivity through culvert upgrades at the Dunstan River, Finnerd Brook, and Beaver Brook crossings, which would benefit marsh health and promote salt marsh migration. Conceptual plans for elevating the roadway were included with the pilot project. The pilot project report included next steps for adaptation of Payne Road, which includes selecting a preferred design alternative and securing funding to advance design, permitting, and construction.

The Payne Road Adaptation Pilot Project report (GEI, 2025e) provides details of the alternatives analysis.

4.2. Higgins Beach Concept Designs

The pilot project at Higgins Beach included the development of conceptual shoreline stabilization options for a stretch of shoreline adjacent to Bayview Avenue between Pearl Street and Ashton Street, immediately east of the existing revetment along the shoreline. This area was selected based on the damage incurred along Bayview Avenue during the January 2024 coastal storm event, which eroded the dune system and damaged portions of the road surface and foundation as well as utilities buried within the road right of way. An existing sewer main lies beneath Bayview Avenue and is considered a critical piece of infrastructure for the Town. Shoreline stabilization methods would help reduce future damage potential of the roadway and sewer infrastructure in this area.

Three shoreline stabilization concepts were introduced: a traditional revetment, a dune system with an engineered core, and a fully nature-based dune restoration. Concepts were prepared for the traditional revetment option and the dune with the engineered core. The purpose of the development of these concepts was to bring them to a Maine Department of Environmental Protection (DEP) pre-application meeting to gain clarity on the permitting restrictions in this area given the existence of a mapped frontal

sand dune. The permitting basis for a revetment would involve removing the existing riprap in the area, which was put in place historically to stabilize the parking lot of the Silver Sands Hotel, and relocating the revetment landward along the existing roadside.

As of the writing of this summary, the Maine DEP was still in the process of responding to clarifying questions via email. The Town will have a copy of the email responses when they come through. Based on the responses, the Town should have an indication of the type of stabilization method that would be permitted in this area.

4.3. Pine Point Homeowner Adaptation Guide

For Pine Point, a neighborhood-specific guide was prepared to help homeowners evaluate flood risk, understand regulatory requirements, and explore adaptation measures, such as elevating a home. The guide provides clear steps for homeowners to go from evaluating flood risk to hiring a contractor. Due to the presence of coastal sand dunes and FEMA Special Flood Hazard Areas, the regulations around elevating a home are complex. Under existing permitting regulations, some areas of Pine Point would require houses to be elevated on open pilings, while others would allow houses to be elevated using fill. This guide aims to provide homeowners with more clarity about their options.

This guide was prepared for Pine Point but could also be used for homeowners in other neighborhoods across Scarborough. The guide is provided in the report titled the “Coastal Flood Risk Building Adaptation Guide for the Pine Point Neighborhood” (GEI, 2025f).

5. Ordinance Review

Four ordinances were reviewed as part of this project for the purpose of identifying sections where revisions could be made to increase the Town's resiliency to flood risk. The four ordinances reviewed included:

- Chapter 405, Zoning Ordinance
- Chapter 405B, Site Plan Review Ordinance
- Chapter 405C, Shoreland Zoning Ordinance
- Chapter 406, Subdivision Ordinance

The recommendations in the review emphasized reducing long-term risk, aligning local standards with state and federal requirements, and supporting natural systems that buffer the shoreline from wave action. The recommendations are intended to help the Town adapt to sea level rise and coastal storms by steering growth to safer areas, minimizing repeated damages, and maintaining the protective capacity of dunes, wetlands, and beaches. Key themes and suggested changes included:

- **Ordinance Consistency** – revise ordinance language to be consistent across other Town of Scarborough ordinances and aligned with or more stringent than state rules, as applicable.
- **Account for Changing Flood Risk** – revise ordinances to include the effect of sea level rise in defining high flood risk.
- **Promotion of Proactive Resilience Measures** – revise ordinances to promote or incentivize resilient development, such as using Transfer of Development Rights in areas of high flood risk, supporting resilient design measures, and adding a coastal flood resilience overlay zone.
- **Protect Natural Resources** – revise ordinance language to protect natural resources by strengthening limits/constraints on foot traffic, vegetation removal, and alteration of sand dunes.

The ordinance review is provided as a standalone technical memo titled "Ordinance Review Memo" (GEI, 2025g).

6. Community Engagement and StoryMap

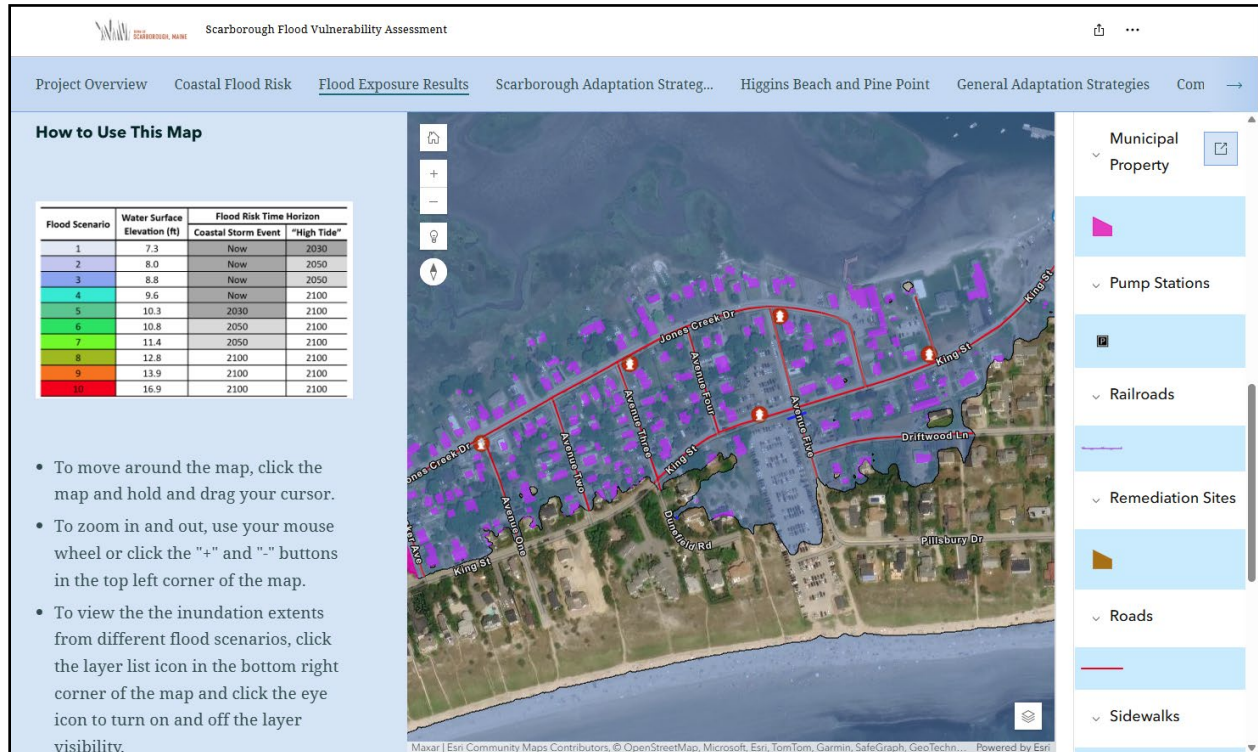
The project featured robust community outreach to collect information on community values and present study results. Community engagement culminated in the delivery of an interactive StoryMap, allowing residents to explore flood scenarios, vulnerable assets, and adaptation options visually, making the technical findings accessible to a broad audience. Public engagement was central to this project. Efforts included:

- Working group meetings with Town staff and local stakeholders.
- Public workshops to share results and gather feedback including four neighborhood-specific meetings, one town-wide presentation, and one presentation to the Town Council.
- An interactive ArcGIS StoryMap allowing residents to explore flood scenarios, vulnerable assets, and adaptation strategies at their own pace.

Feedback received from the public emphasized the importance of maintaining access to homes, businesses, and beaches; and balancing engineered solutions with marsh and dune health.

A snapshot of what it looks like to explore the flood scenarios in the StoryMap is provided in Figure 6-1.

Figure 6-1. Snapshot of the Flood Vulnerability Assessment StoryMap



7. Next Steps and Conclusion

The Scarborough Flood Vulnerability Assessment provides an initial step towards understanding flood risks and reviewing adaptation options and infrastructure priorities. By integrating technical analysis, community input, and pilot projects, the Town is better positioned to make informed decisions to increase resiliency in the face of current and future coastal flood risks. Several next steps were identified as part of this project to increase resiliency efforts. These include:

- **Advance Pilot and Concept Projects** – Select preferred alternatives for Payne Road and Higgins Beach, secure funding, and move into design and permitting.
- **Select Projects for Adaptation** — Use the results of the Flood Vulnerability Assessment to prioritize and choose adaptation projects to pursue.
- **Strengthen Local Policy Frameworks** – Incorporate sea level rise projections into zoning and land use regulations, discourage development in at-risk areas, and incentivize development in areas not at risk of coastal flooding.
- **Maintain Public Engagement** – Continue education and outreach through workshops and digital tools.
- **Pursue Strategic Funding** – Target resilience-focused grants and partnerships to fund design and construction for adaptation efforts.
- **Continue Discussions on Managed Retreat** — For areas in the town subject to daily flooding by 2050 and beyond, begin and continue discussions around managed retreat.
- **Collaborate Regionally** — Coordinate with neighboring towns, such as Old Orchard Beach and Cape Elizabeth, on regional resiliency efforts.

8. Limitations

This document serves as an Executive Summary for the broad flood vulnerability assessment project for the Town of Scarborough. This report does not include detailed project methodology, assumptions, results, or recommendations. The corresponding reports, highlighted throughout this document, should be referenced for project details.

The project relied on readily available online information, limited field investigations, published references, and our professional judgement. The purpose of this project was to provide a high-level vulnerability assessment and adaptation recommendations for infrastructure at-risk of coastal flooding.

This project did not include an evaluation of the structural integrity of roadways, culverts, bridges, dams, and other appurtenances. Actual storm events and water surface elevations will vary from events presented in this report.

Advancing infrastructure-based adaptation strategies will require additional phases of work before the recommendations can be implemented, such as site survey, preliminary design, permitting, and final design. The adaptation recommendations provided in this project constitute a high-level assessment of risk and an introduction to adaptation options.

Reuse of this report for any purpose, in part or in whole, is at the sole risk of the user.

9. References

GEI (2025a). Data Review Memo. Flood Vulnerability Assessment. Scarborough, Maine, March.

GEI (2025b). Flood Vulnerability Analysis Results. Flood Vulnerability Assessment. Scarborough, Maine, March.

GEI (2025c). Adaptation Prioritization Methodology for Public Roadways Memo. Flood Vulnerability Assessment. Scarborough, Maine, August.

GEI (2025d). Coastal Flood Adaptation Strategies. Flood Vulnerability Assessment. Scarborough, Maine, August.

GEI (2025e). Payne Road Adaptation Pilot Project. Flood Vulnerability Assessment. Scarborough, Maine, September.

GEI (2025f). Coastal Flood Risk Building Adaptation Guide for the Pine Point Neighborhood. Flood Vulnerability Assessment. Scarborough, Maine, August.

GEI (2025g). Draft Ordinance Review memo. Flood Vulnerability Assessment. Scarborough, Maine, June.

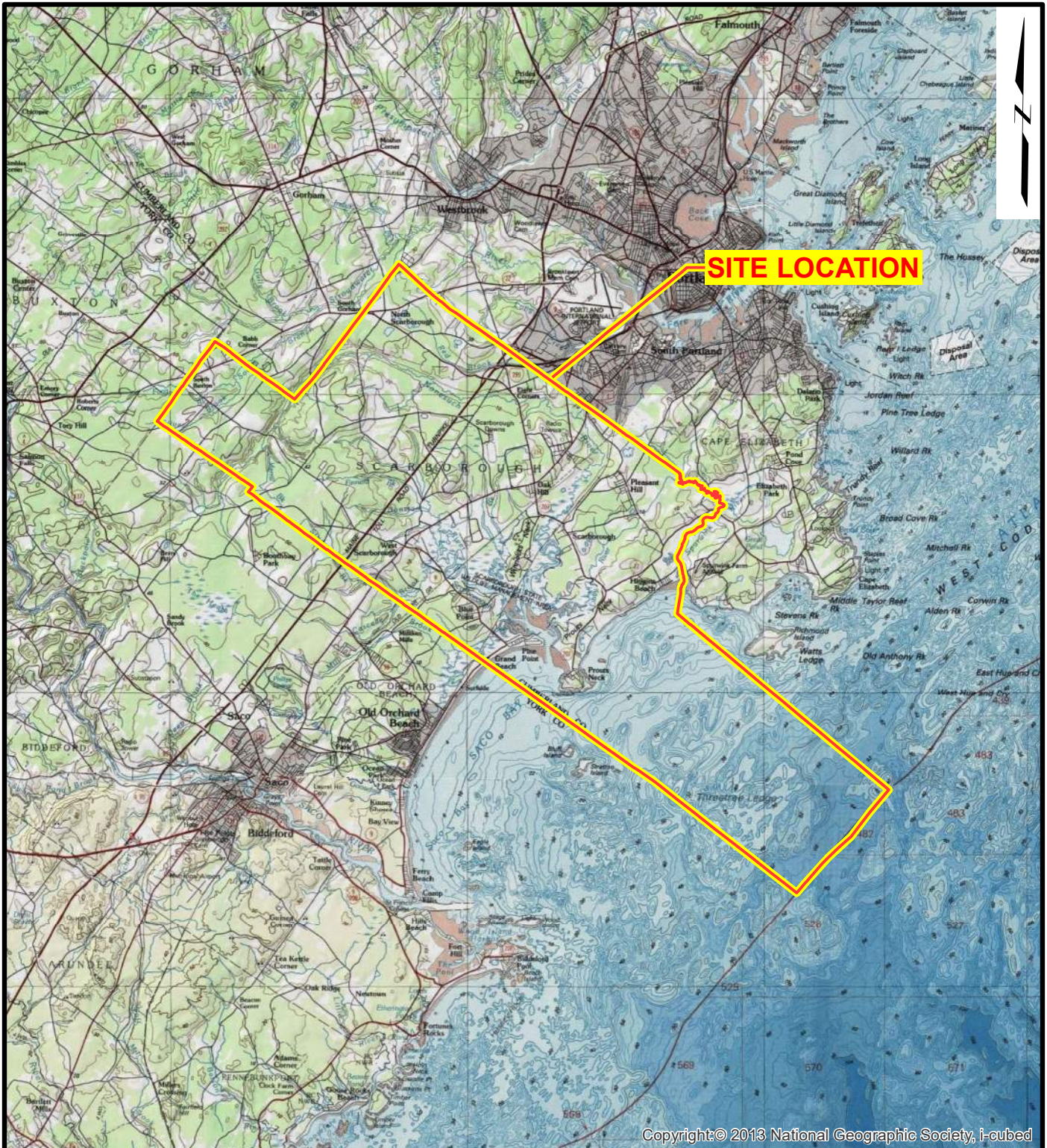
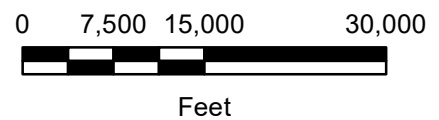
GEI (2025h). StoryMap, Scarborough Flood Vulnerability Assessment, Scarborough, Maine. Initially released by GEI February 5, 2025, updated periodically by the Town of Scarborough. The StoryMap may be accessed via the Town of Scarborough Vulnerability Assessment web page.

<https://www.scarboroughmaine.org/stay-connected/municipal-projects/vulnerability-assessment>.

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Figures

Figure 1 Site Location



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Flood Vulnerability Assessment
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Project 2403961

SITE LOCATION

October 2025

Fig. 1