



Coastal Hazards & Sea-Level Rise Asset Vulnerability Assessment for Boston Harbor Islands National Recreation Area

Summary of Results

NPS 035/196688, March 2025



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Boston Light at Boston Harbor Islands National Recreation Area

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Program for the Study of Developed Shorelines
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Executive Summary

This document presents the results of the **Coastal Hazards & Sea-Level Rise (SLR) Asset Vulnerability Assessment (VA)** completed by Western Carolina University at Boston Harbor Islands National Recreation Area (BOHA) in 2023. In this VA, we evaluate the vulnerability (as a combination of exposure and sensitivity) of NPS buildings and transportation assets¹ to identified coastal hazards and climate change factors, approximately to the year 2050 (for full methodology, see Peek et al. 2022).

We assessed 93 buildings (including shade shelters, fortifications, historic structures, seawalls, and memorials), and 51 transportation assets (roads, parking lots, trails/walkways, waterfront systems, docks, and marinas) at BOHA. Over half of the assets evaluated at BOHA have high (42%) or moderate (10%) vulnerability to the evaluated coastal hazards and SLR, while 11% have low vulnerability. Over one-third (37%) of evaluated assets have minimal vulnerability (outside of all hazard zones). Scoring details and results for all assets evaluated at BOHA are reported in the provided Excel sheets.

Exposure Results

Exposure is a measure of the character, magnitude, and rate of changes a target may experience (e.g., from the impacts of climate change or a natural hazard influenced by climate change; NPS 2021). In this VA, we evaluate the exposure of each asset to the following coastal hazard indicators: flooding potential, shoreline change, SLR inundation, extreme event flooding, and reported coastal hazards (Table 1).

Table 1. Exposure indicators and hazard data sources used.

Exposure Indicator (Description)	BOHA Data (Citation)
Flooding potential (1% annual-chance)	Effective FEMA VE & A zones (FEMA 2012; 2014; 2016)
Shoreline change (coastal proximity)	30-m shoreline proximity buffer (Peek et al. 2022)
SLR inundation (2050 proxy) *	NPS 2100 4.5 RCP SLR model; 0.45 m rise (Caffrey et al. 2018)
Extreme event flooding (category 3 surge)	NPS storm surge inundation model (Caffrey et al. 2018); MassGIS Hurricane Surge Inundation Zones (MassGIS 2021)
Reported coastal hazards (historic flooding)	Questionnaire results & discussions (Peek et al. 2022)

*See Unique Considerations

¹ The NPS Facility Management Software System (FMSS) database defines assets as “...a physical structure or grouping of structures, land features, or other tangible property that has a specific service or function, such as a farm, cemetery, campground, marina, or sewage treatment plant. The term ‘asset’ shall also be applied to movable items, such as vehicles and equipment.”

Assets with high exposure are within at least four exposure indicator hazard zones. Assets with moderate exposure are within two or three exposure indicator hazard zones. Assets with low exposure are within only one exposure indicator hazard zone. The asset could still be seriously impacted by any single hazard. Assets with minimal exposure are not in any exposure indicator hazard zone. This does not mean that the asset has no exposure to coastal hazards, but it is not within the exposure hazard data used in this study.

Fifty-eight assets at BOHA (40%) have high exposure to the evaluated coastal hazards and SLR (Table 2, and Figures 1-4). Twenty-three of those assets are within all evaluated exposure zones, including the Graves Light Station, Nixes Mate Marker and Base, as well as waterfront systems (marinas/docks) and seawalls throughout the park. Eighteen assets (13%) at BOHA have moderate exposure and 14 (10%) have low exposure. Over one-third (38%) of evaluated assets at BOHA have minimal exposure (not in any hazard zone); most of these minimal assets are historic buildings and fortification-related structures on Georges and Peddocks islands (Figures 3 and 4B).

Table 2. BOHA exposure results. Sum of percentages may not equal 100 due to rounding.

Assets	High Exposure		Moderate Exposure		Low Exposure		Minimal Exposure		Total
	#	%	#	%	#	%	#	%	#
Buildings	27	29%	12	13%	9	10%	45	48%	93
Transportation	31	61%	6	12%	5	10%	9	18%	51
All Assets	58	40%	18	13%	14	10%	54	38%	144

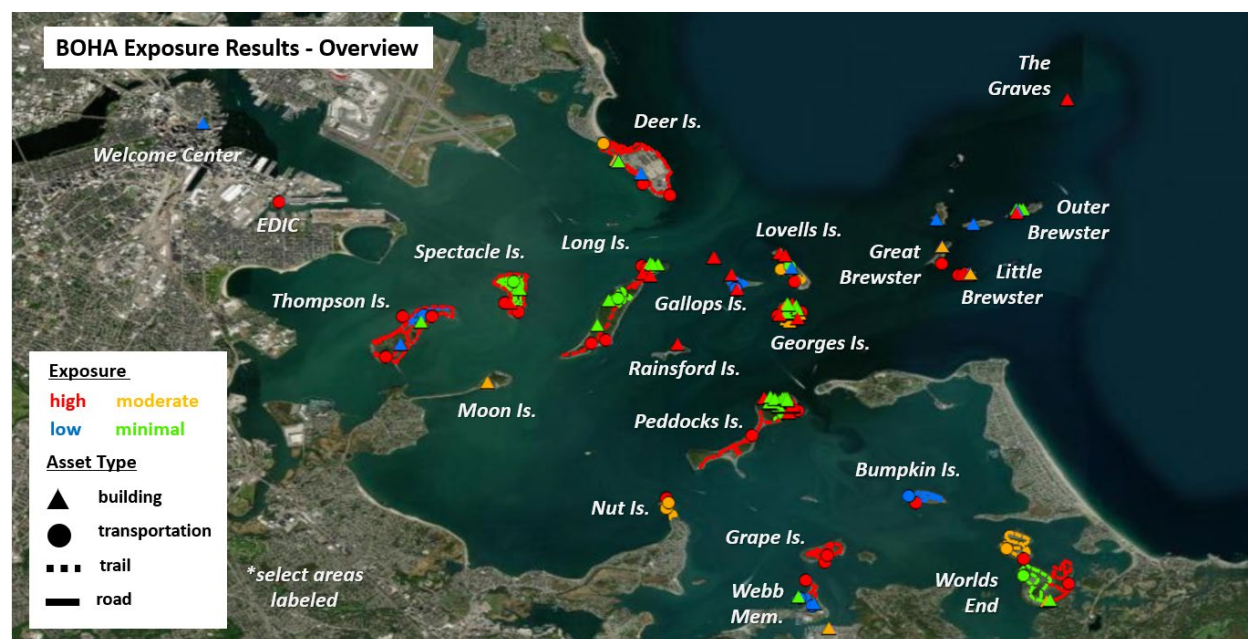


Figure 1. BOHA exposure results summary overview, with select areas/islands labeled. Background is ESRI streaming imagery.

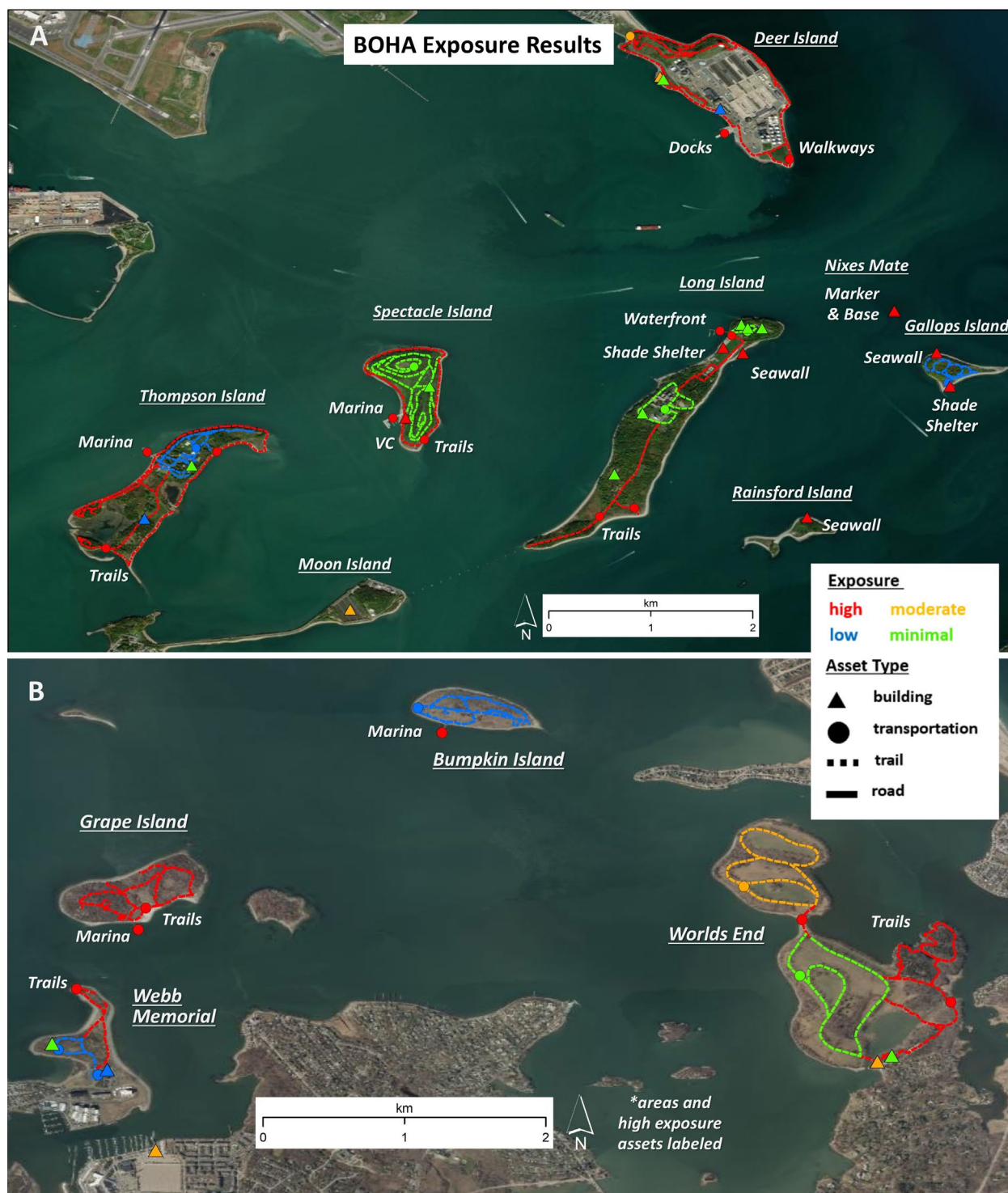


Figure 2. BOHA exposure results summary for the A) western and B) eastern areas of Boston Harbor. Background is ESRI streaming imagery.

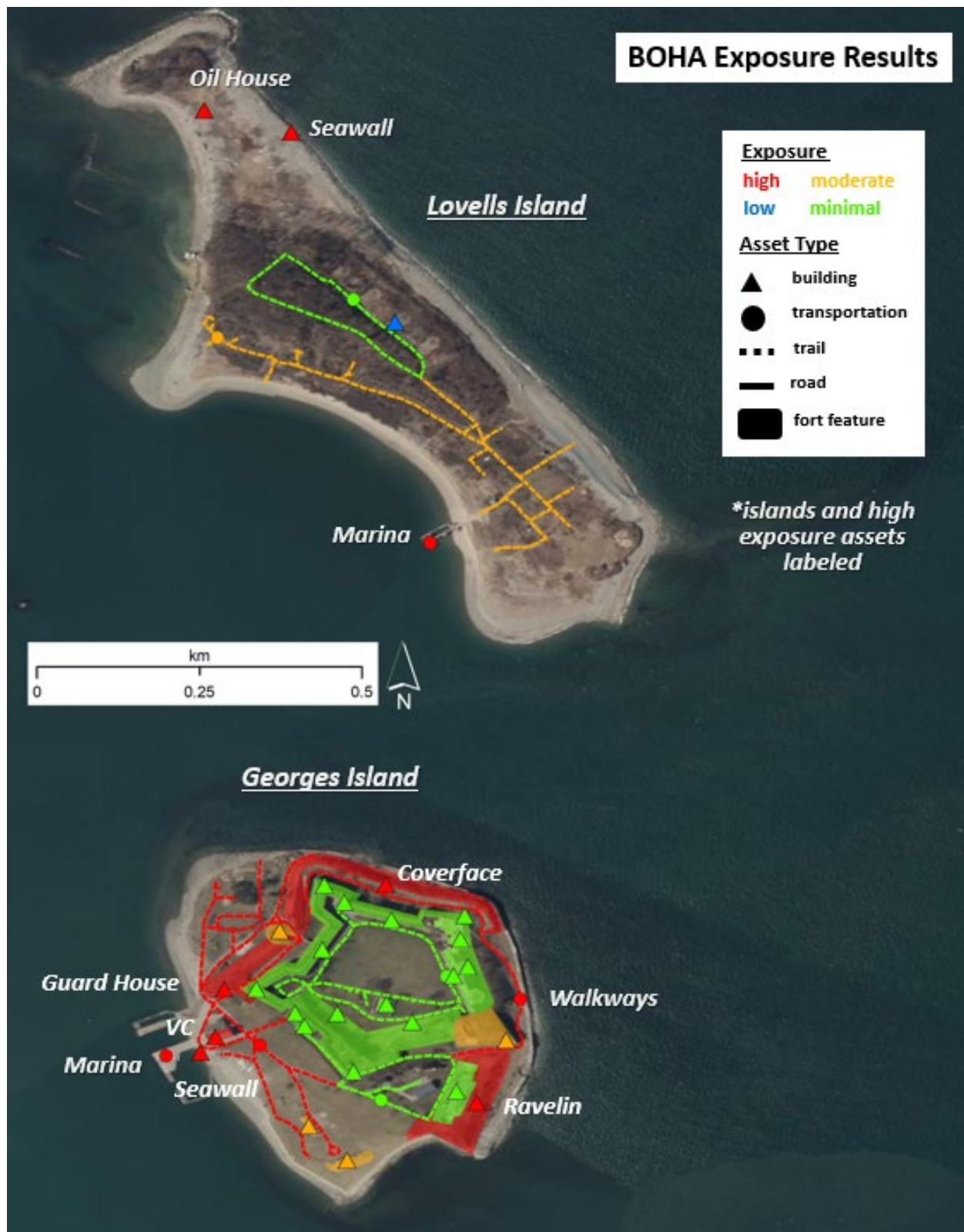


Figure 3. BOHA exposure results summary for Lovells Island and Georges Island. Background is 2021 Massachusetts streaming aerial imagery.



Figure 4. BOHA exposure results summary for A) Nut Island, B) Peddocks Island, and C) Calf and Brewster islands. Background is 2021 Massachusetts streaming aerial imagery. Inset is zoomed view of Little Brewster Island (background is 2018 USACE aerial imagery).

Coastal Shoreline Change Exposure

Many of the moderate and low exposure assets at BOHA are higher in elevation and therefore only exposed to shoreline change hazards (in the coastal erosion hazard zone and/or displaying signs of active erosion or retreat). While these assets are not ranked as high exposure within this VA protocol, shoreline change (e.g., bluff erosion, cliff retreat/failure) can cause irreversible damage to nearby infrastructure. Great Brewster Island, for example, has been experiencing bluff retreat in several locations (Black et al. 2025). The northern portion of the island is experiencing bluff retreat on three sides, which threatens the remnants of a WWII battery and fortification-related infrastructure (Figure 5A). Part of this infrastructure was perched on the edge of the northwestern bluff for a number of years (Figure 5B) and has recently collapsed.



Figure 5. A) Google earth aerial image of the eroding bluffs on northern Great Brewster Island. B) 2016 image of the infrastructure on the northwestern eroding bluff on Great Brewster Island (Google Maps photo). C) Oblique image of Little Brewster Island (looking west) showing the vertical rock cliff adjacent to Boston Light (Adobe Stock photo).

Another area of concern for BOHA is near the Boston Light National Historic Landmark on Little Brewster Island. Boston Light was the longest-running manned lighthouse in the U.S. (until 2020) and is one of two National Historic Landmarks on the islands. The lighthouse (and the Fog Signal/Generator Building) sits less than 15 feet from a vertical rock cliff with the potential for

fracturing and failure (Figure 5C). The U.S. Coast Guard has previously attempted to stabilize and protect portions of Little Brewster Island through the addition of rock gabions, which have since failed. However, freeze/thaw and storm wave action continues to fracture the rock, increasing instability. A significant failure of this cliff could cause a partial or complete collapse of the adjacent Boston Light or the Fog Signal/Generator Building.

Sensitivity Results

Sensitivity reflects the degree to which a resource is affected by exposure (NPS 2021). In this VA, we assess the following sensitivity indicators: flood damage potential/elevated, storm resistance and condition, historic damage, and protective engineering. In general, assets with high sensitivity have unfavorable determinations for 3 or 4 of these indicators, moderate-sensitivity assets have unfavorable determinations for 2 indicators, and low-sensitivity assets have unfavorable determinations for 0 or 1 indicator. Assets with minimal exposure are not analyzed for sensitivity (this is the case for 53 assets at BOHA).

Almost all assets analyzed at BOHA have high (47%) or moderate sensitivity (50%) to coastal hazards and SLR (Table 3), while only 3 have low sensitivity. While many assets are in good condition, few are significantly elevated above local ground level, storm resistant, or have protective engineering, and many have been historically damaged by coastal flooding.

Seven assets received an unfavorable rating for all sensitivity indicators, including the Historic Seawall on Gallops Island (not currently in FMSS), Mine Casement Building Visitor Center (VC) and Waterfront Seawall on Georges Island, the Concrete Walks on Little Brewster Island, and the Waterfront System and southern trails on Long Island. Only three of the evaluated assets have low sensitivity: the Docks on Deer Island, the Visitor Area Shade Shelter on Long Island, and the Boston Light: Tower and Museum on Little Brewster Island.

Table 3. BOHA sensitivity results. Sum of percentages may not equal 100 due to rounding.

Assets	High Sensitivity		Moderate Sensitivity		Low Sensitivity		Total Analyzed	Excluded*
	#	%	#	%	#	%	#	#
Buildings	23	48%	23	48%	2	4%	48	45
Transportation	19	45%	22	52%	1	2%	42	9
All Assets	42	47%	45	50%	3	3%	90	54

*Minimal exposure assets were excluded from the sensitivity analysis; total number analyzed is different for sensitivity.

Vulnerability Results

Vulnerability is a measure of the degree to which park resources and assets are “susceptible to harm from direct and indirect effects of climate change, including variability and extremes” (NPS 2021). In this VA, we evaluate the vulnerability of infrastructure assets as a simple combination of exposure and sensitivity ratings. It should be noted that the vulnerability of any asset can change with time (e.g., due to adaptation actions or the result of geomorphic change).

Over 40% of assets evaluated at BOHA have high vulnerability to the evaluated coastal hazards and SLR, and 12% have moderate vulnerability (Table 4; Figures 6-8). A higher percentage of transportation assets have high vulnerability compared to buildings/structures (63% versus 31%). However, a large portion of these assets are marinas/waterfront systems that inherently have high exposure (and therefore, commonly have high vulnerability).

Seventeen buildings/structures have both high exposure and high sensitivity, including the Electric Distribution Shed, New Guardhouse VC, Storehouse, Chapel, Stable, and Carpenter Shop on Peddocks Island (Figure 8D); the Guard House, Mine Casement VC, Ravelin, and Seawall on Georges Island (Figure 8B); the historic seawalls on Gallops, Long, Lovells, and Rainsford islands; and the Boat House on Little Brewster Island (Figure 7B). Seventeen transportation assets also have both high exposure and high sensitivity; all of these assets are trails or marinas/waterfront systems across the islands.

Table 4. BOHA vulnerability results. Sum of percentages may not equal 100 due to rounding.

Assets	High Vulnerability		Moderate Vulnerability		Low Vulnerability		Minimal Vulnerability		Total
	#	%	#	%	#	%	#	%	#
Buildings	29	31%	12	13%	7	8%	45	49%	93
Transportation	32	63%	5	10%	5	10%	9	18%	51
All Assets	61	42%	17	12%	12	8%	54	38%	144

Only 8% of assets evaluated at BOHA have low vulnerability, while a significant portion (38%) have minimal vulnerability. Most of the minimal vulnerability assets are buildings set well back from the shoreline (see exposure results).

Next Steps

A few other complementary hazard and climate change projects are currently underway in the BOHA region, including a nine-island coastal exposure risk analysis of shoreline erosion due to increased SLR and storms (Hughes et al. 2024) and a study of future impacts of Nor’easters based on modeled flood and SLR scenarios (Ginis et al. 2024). Once complete, it will be important to compare and synthesize the results of these studies to those within this VA to better inform decision-making at BOHA. Additionally, this VA could be updated in the future using new hazard data from these complementary efforts.



Figure 6. BOHA vulnerability results for A) Deer Island; B) Thompson, Spectacle, and Moon islands; C) Long and Rainsford islands; D) Nut Island; E) Gallops Island; and F) Nixes Mate. Background is 2021 Massachusetts streaming aerial imagery.

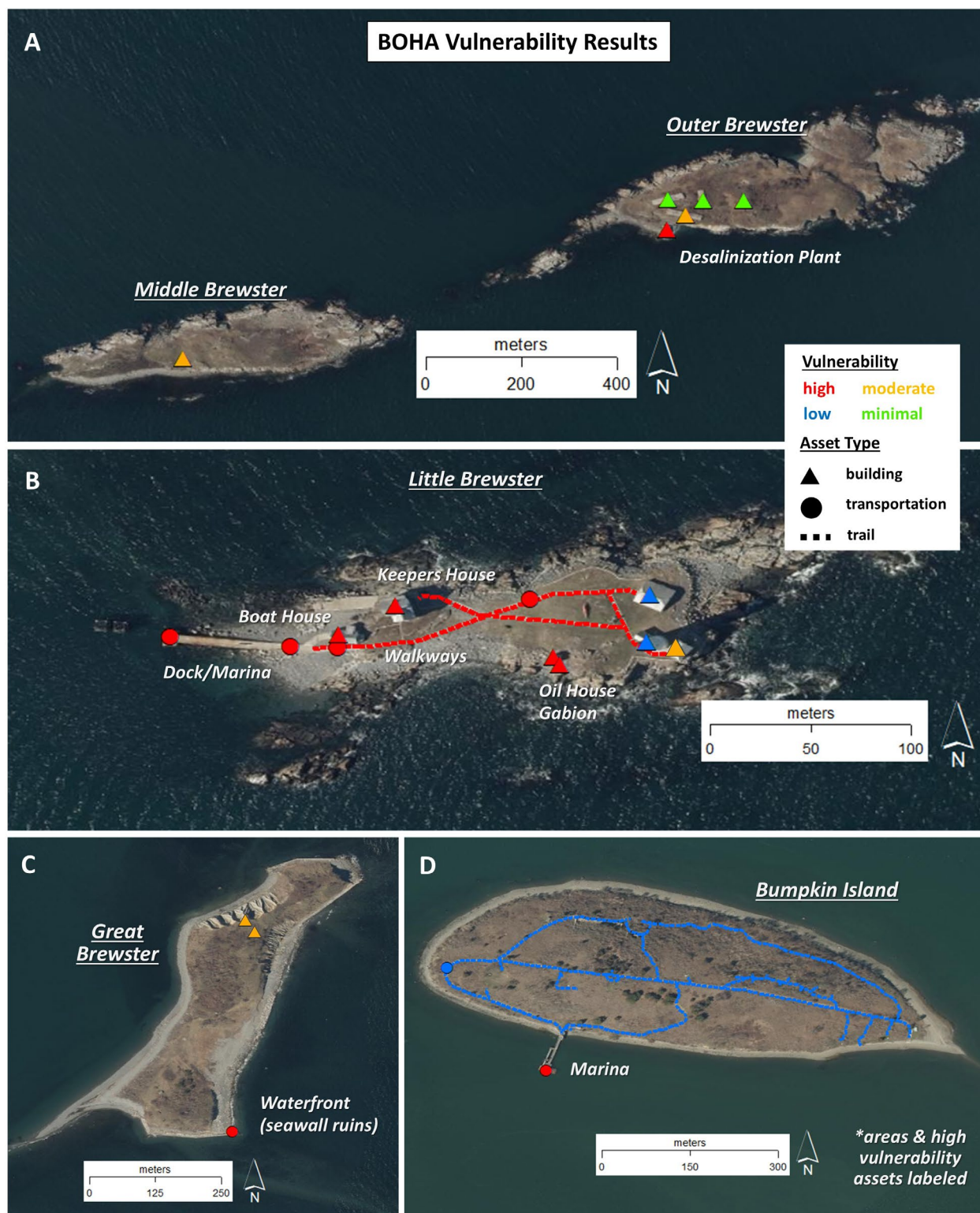


Figure 7. BOHA vulnerability results for A) Middle Brewster and Outer Brewster islands; B) Little Brewster Island; C) Great Brewster Island; and D) Bumpkin Island. Background is 2021 Massachusetts streaming aerial imagery.

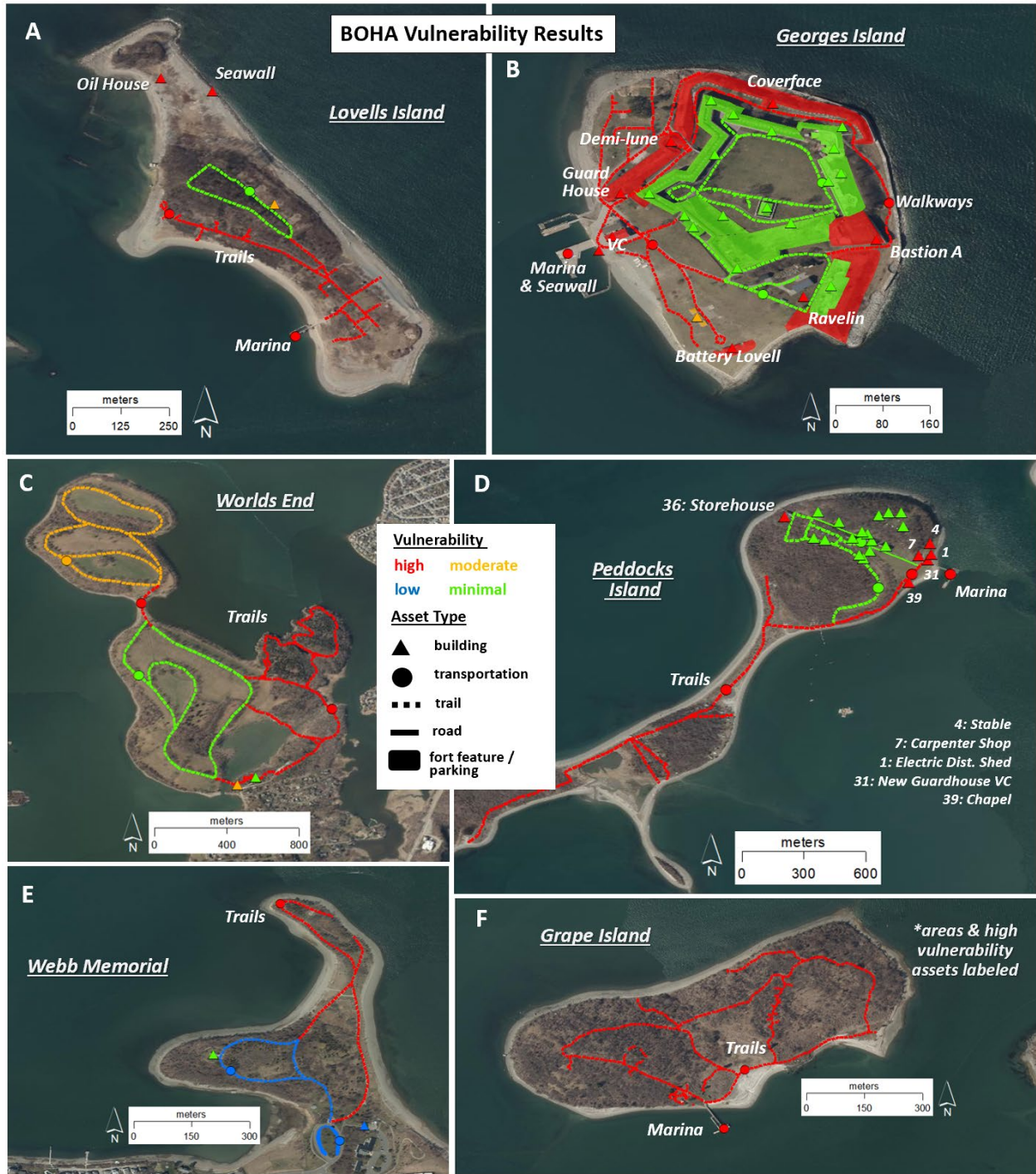


Figure 8. BOHA vulnerability results for A) Lovells Island; B) Georges Island; C) Worlds End; D) Peddocks Island; E) Webb Memorial; and F) Grape Island. Background is 2021 Massachusetts streaming aerial imagery.

BOHA Unique Considerations

Shoreline change: Short-term (45-year) shoreline change data from the U.S. Geological Survey (USGS; Himmelstoss et al. 2019) were consulted but showed accretion/no statistical change in almost all locations near evaluated assets (Figure 9). As a result, we used a simple coastal proximity buffer of 30 meters, which accommodates an erosion rate up to 1m/year and assumes that infrastructure near the coast is likely to experience multiple coastal hazards within the 30-year (approximately 2050) timeframe of this analysis (see Peek et al. 2022). Only a few of the USGS transects show erosion rates higher than the 1 m/year assumed in this proximity buffer, and these transects are in areas far from the assets evaluated in this study (Figure 9).

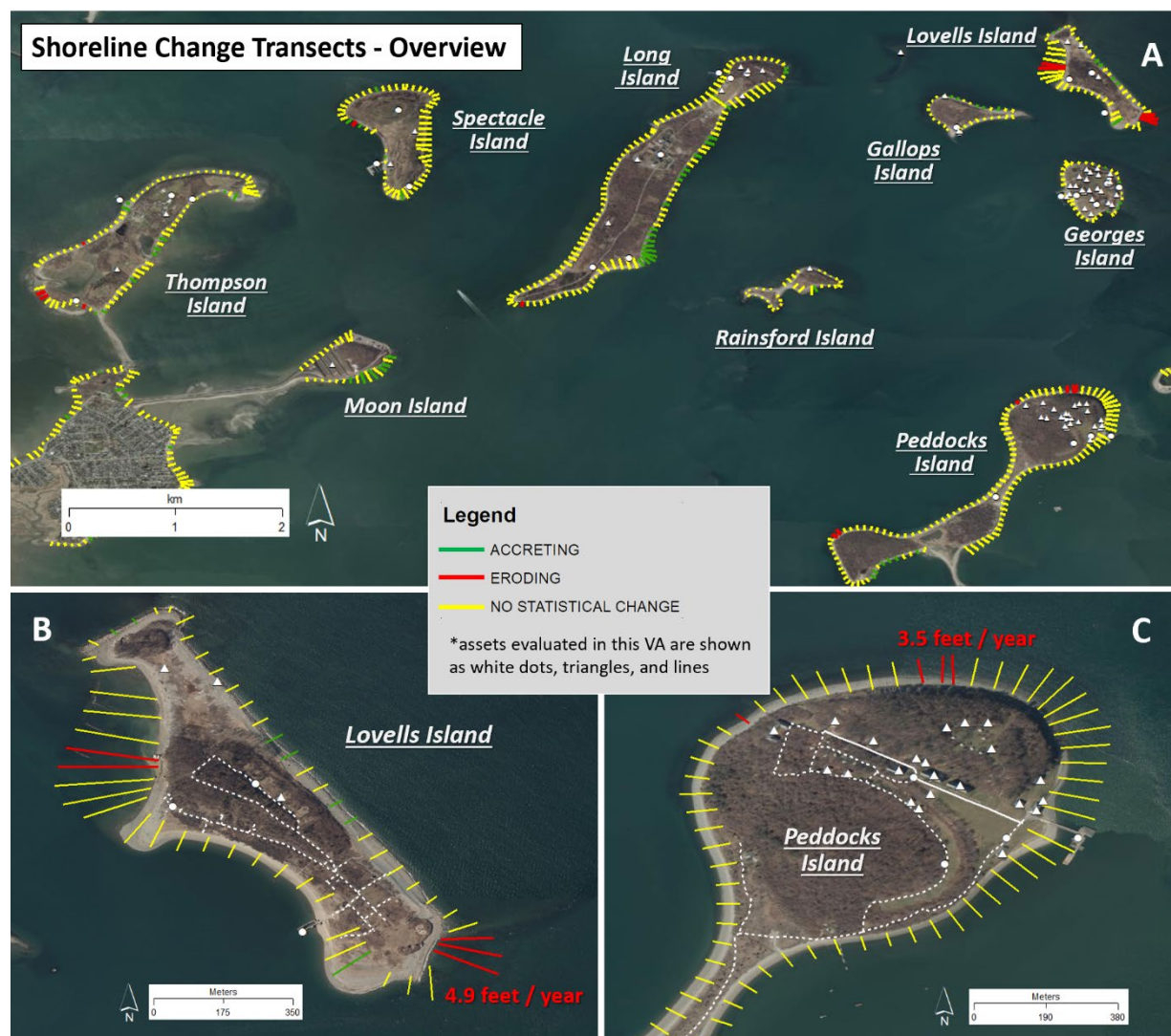


Figure 9. Sample of USGS short-term shoreline change transects consulted at BOHA (data from Himmelstoss et al. 2019). A) Overview of the shoreline change transects across multiple islands, showing only a few locations as eroding (red transects). The highest erosion rates (red text) across the park are from B) Lovells Island and C) Peddocks Island. Background is 2021 Massachusetts streaming aerial imagery.

SLR data: We used the 2100 4.5 Representative Concentration Pathway SLR projection and inundation model from Caffrey et al. (2018) developed specifically for NPS units to score exposure for this indicator (0.45 m rise for BOHA). These data are used as a proxy for 2050 SLR to accommodate higher SLR projections recently released by the National Oceanic and Atmospheric Administration (see Peek et al. 2022).

Extreme event flooding data: In most cases, we use storm surge models produced by NPS (Caffrey et al. 2018) within this protocol. For BOHA, we also used the category 3 MassGIS Hurricane Surge Inundation Zone (MassGIS 2021).

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