Coastal Hazards & Sea-Level Rise Asset Vulnerability Assessment for Sagamore Hill National Historic Site

Summary of Results

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PROGRAM FOR THE STUDY OF DEVELOPED SHORELINES

Western Carolina UNIVERSITY

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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 Sagamore Hill National Historic Site (SAHI) in 2022. In this VA, we evaluate the vulnerability (as a combination of exposure and sensitivity) of NPS buildings and transportation assets[1] to identified coastal hazards and climate change factors, approximately to the year 2050 (for full methodology, see Peek et al. 2022).

We assessed 17 buildings/structures at SAHI (including historic structures and maintenance buildings) and 23 transportation assets (roads, parking lots, trails, and a boardwalk). One asset (Eel Creek Boardwalk) analyzed has high vulnerability to the evaluated coastal hazards and SLR, and one (east segment of the Nature Trail) has moderate vulnerability. The majority (95%) of assets have minimal vulnerability, which means they are not in any of the evaluated hazard zones. Scoring details and results for all assets evaluated at SAHI 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)	SAHI Data (Citation)
Flooding potential (1% annual-chance)	Effective FEMA VE & A zones (FEMA 2009)
Shoreline change (coastal proximity)	30-m shoreline proximity buffer (Peek et al. 2022)
SLR inundation (2050 proxy) *	NPS 2100 4.5 RCP SLR model; 0.58 m rise (Caffrey et al. 2018)
Extreme event flooding (category 3 surge)	NPS storm surge inundation model (Caffrey et al. 2018)
Reported coastal hazards (historic flooding)	Questionnaire results & discussions (Peek et al. 2022)

*See Unique Considerations

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[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 this 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.

One asset at SAHI, the Eel Creek Boardwalk, has high exposure to the evaluated coastal hazards (Table 2). The Nature Trail (east segment) has moderate exposure. Most (95%) assets have minimal exposure. These results are a factor of the park's higher elevation, except for assets near Eel Creek.

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

Assets	High Exposure		Moderate Exposure		Low Exposure		Minimal Exposure		Total
	#	%	#	%	#	%	#	%	#
Buildings	0	0%	0	0%	0	0%	17	100%	17
Transportation	1	4%	1	4%	0	0%	21	91%	23
All Assets	1	3%	1	3%	0	0%	38	95%	40

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 38 assets at SAHI).

Both assets analyzed at SAHI have moderate sensitivity to coastal hazards and SLR (Table 3). They are storm resistant and in good condition, but do not have protective engineering. The Eel Creek Boardwalk is elevated but has been significantly damaged by coastal flooding in the past. The Nature Trail (east segment) is not elevated and has not been significantly damaged by coastal flooding.

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

Assets	High Sensitivity		Moderate Sensitivity		Low Sensitivity		Total Analyzed	Excluded*
	#	%	#	%	#	%	#	#
Buildings	0	0%	0	0%	0	0%	0	17
Transportation	0	0%	2	100%	0	0%	2	21
All Assets	0	0%	2	100%	0	0%	2	38

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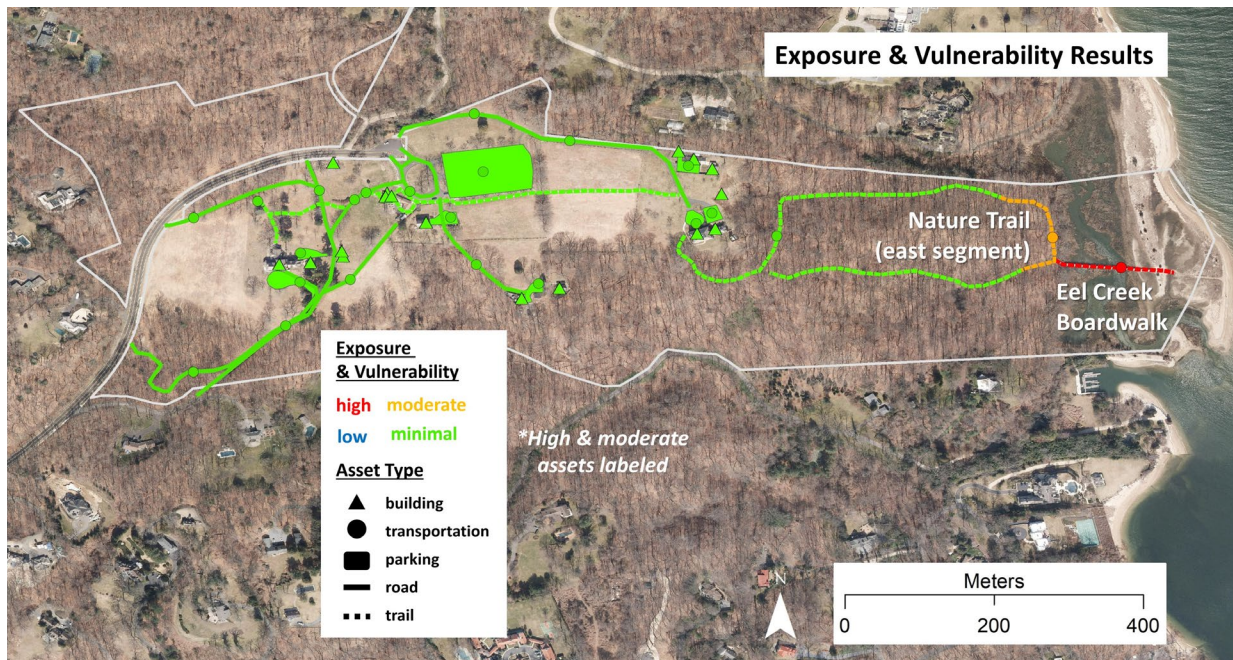
Vulnerability Results

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).

The vulnerability results at SAHI are identical to the exposure results, as the two assets we evaluated for sensitivity were scored as moderate (Table 4, and Figure 1). This lack of variability in sensitivity means that the vulnerability of assets at SAHI is primarily controlled by exposure. The Eel Creek Boardwalk has high vulnerability to the assessed coastal hazards and the Nature Trail (east segment) has moderate. Thirty-eight assets have minimal vulnerability. Both the boardwalk and trail segment have a high asset priority index (API = 85 and API = 71, respectively, as reported in FMSS).

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

Assets	High Vulnerability		Moderate Vulnerability		Low Vulnerability		Minimal Vulnerability		Total
	#	%	#	%	#	%	#	%	#
Buildings	0	0%	0	0%	0	0%	17	100%	17
Transportation	1	4%	1	4%	0	0%	21	91%	23
All Assets	1	3%	1	3%	0	0%	38	95%	40

Figure 1. SAHI exposure and vulnerability results summary. Only high and moderate assets are labeled. Background is ESRI streaming imagery.

SAHI Unique Considerations

Shoreline change data: United States Geological Survey (USGS) or other shoreline erosion rate data are not available for the creek shorelines of SAHI. As a result, we used a simple coastal proximity buffer of 30 meters, which accommodates an erosion rate up to 1 meter/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).

SLR data: We used the 2100 4.5 Representative Concentration Pathway SLR projections and inundation model from Caffrey et al. (2018) developed specifically for NPS units to score exposure for this indictor (0.58 m rise for SAHI). 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).

Linear assets: Due to variable exposure, we divided the Nature Trail into east and west segments. We evaluated each segment individually for exposure, sensitivity, and vulnerability, and assigned each segment a modified location code (segments share the same FMSS attributes).

References

Caffrey, M., R.L. Beavers, and C. Hawkins Hoffman. 2018. Sea level rise and storm surge projections for the National Park Service. Natural Resource Report. NPS/NRSS/NRR—

2018/1648. National Park Service. Fort Collins, Colorado. Available at:
https://irma.nps.gov/DataStore/Reference/Profile/2253283.

Federal Emergency Management Agency (FEMA). 2009. National Flood Hazard Layer.
https://www.fema.gov/flood-maps/national-flood-hazard-layer. Accessed April 2022.

National Park Service (NPS). 2021. Coming to terms with climate change: Working definitions.
National Park Service Climate Change Response Program, Fort Collins, Colorado.

Peek, K.M., B.R. Tormey, H.L. Thompson, and R.S. Young. 2022. Coastal hazards & sea-level rise
asset vulnerability assessment protocol: Updated project description & methodology. Natural
Resource Report. NPS/NRSS/CCRP/NRR—2022/2427. National Park Service. Fort Collins,
Colorado. Available at: https://doi.org/10.36967/2293653.

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