National Park Service
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Natural Resource Stewardship and Science

Coastal Hazards & Sea-Level Rise Asset Vulnerability Assessment for Statue of Liberty National Monument

Summary of Results

NPS 356/186784, November 2022

PROGRAM FOR THE STUDY OF DEVELOPED SHORELINES

Western Carolina University

ON THE COVER
Statue of Liberty at Statue of Liberty National Monument
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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 Statue of Liberty National Monument (STLI) 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 75 buildings/structures (including housing, corridors, covered ways, kiosks, sheds, and monuments) and 14 transportation assets (parking lots, bridges, walkways/paths, docks, piers, and a ferry slip) at STLI. Over three-quarters (88%) of assets analyzed have high vulnerability to the evaluated coastal hazards and SLR, while 9% have moderate vulnerability, and only 3% have low vulnerability. No assets evaluated have minimal vulnerability. Scoring details and results for all assets evaluated at STLI 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)	STLI Data (Citation)
Flooding potential (1% annual-chance)	Preliminary Post-Sandy FEMA VE & A zones (FEMA 2015)
Shoreline change (coastal proximity)	30-m shoreline proximity buffer (Peek et al. 2022)
SLR inundation (2050 proxy) *	NPS 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

[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.

The majority (79%) of assets analyzed at STLI have high exposure to the evaluated coastal hazards (Table 2, and Figures 1-2). Just under one-fifth (19%) have moderate exposure, and only two assets have low exposure (2%). Eight are within all evaluated exposure zones, including the Main Pass Arrival Bulkhead, Granite Seawall, and Steel Bridge on Ellis Island, as well as the Granite Seawall and Ferry Slip on Liberty Island. The Statue of Liberty and Pedestal are the only assets at STLI with low exposure to the evaluated coastal hazards (only within the category 3 storm surge zone).

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

	High Exposure		Moderate Exposure		Low Exposure		Minimal Exposure		Total
Assets	**#**	**%**	**#**	**%**	**#**	**%**	**#**	**%**	**#**
Buildings	58	77%	15	20%	2	3%	0	0%	75
Transportation	12	86%	2	14%	0	0%	0	0%	14
All Assets	70	79%	17	19%	2	2%	0	0%	89

Figure 1. STLI exposure results summary for the Liberty Island Area. Only high exposure assets are labeled. Background map is ESRI streaming imagery.

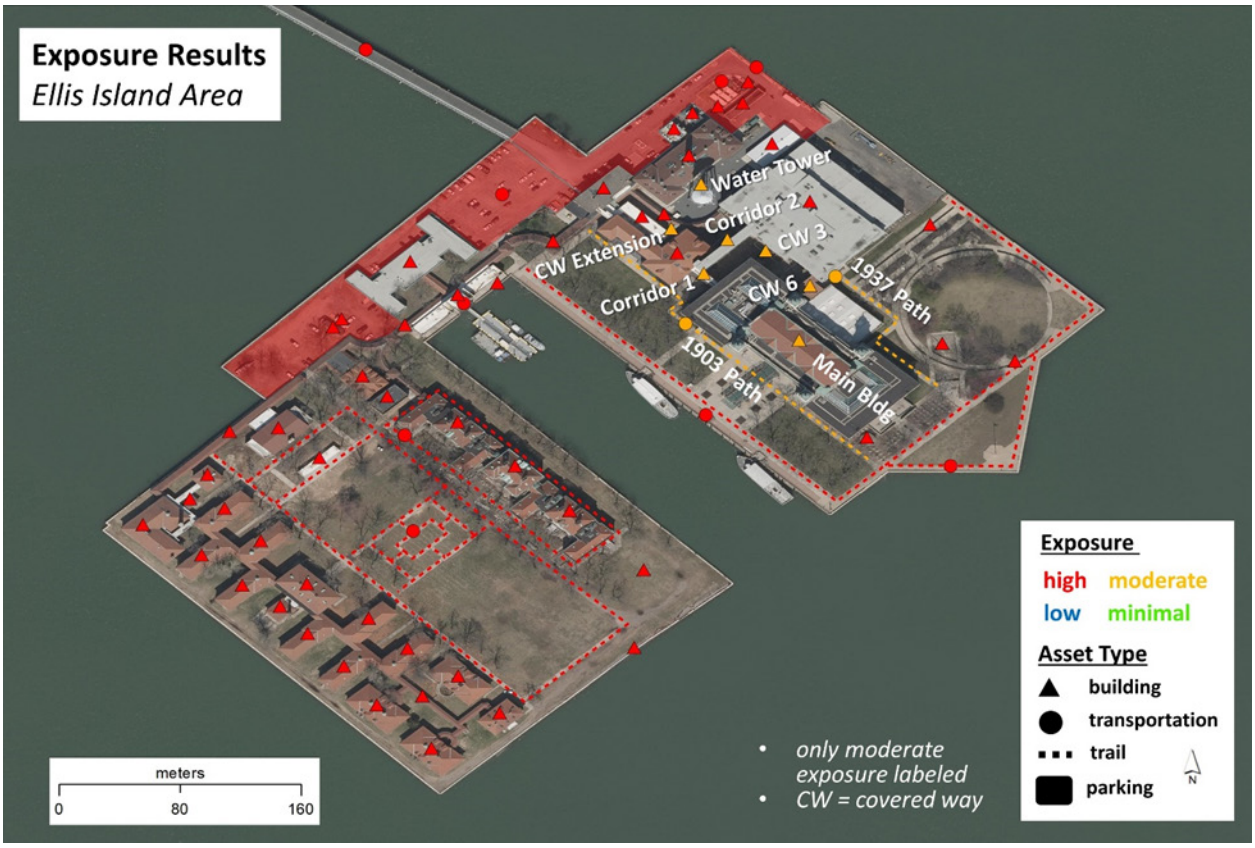

Figure 2. STLI exposure results summary for the Ellis Island Area. Only moderate exposure assets are labeled. Background map is ESRI streaming imagery.

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.

Twenty-five assets (28%) analyzed at STLI have high sensitivity to coastal hazards and SLR, including the Main, Ferry, and New Immigration buildings on Ellis Island, and Concession, Administrative, and Maintenance buildings on Liberty Island (Table 3). The majority (67%) of assets have moderate sensitivity, and only 4% have low sensitivity. Almost all assets that are high sensitivity (compared to moderate) have been damaged in the past by coastal floods. Few assets at STLI are significantly elevated above local ground level, storm resistant, or protected by effective engineering (e.g., seawalls, bulkheads).

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

	High Sensitivity		Moderate Sensitivity		Low Sensitivity		Total Analyzed	Excluded
Assets	**#**	**%**	**#**	**%**	**#**	**%**	**#**	**#**
Buildings	21	28%	50	67%	4	5%	75	0
Transportation	4	29%	10	71%	0	0%	14	0
All Assets	25	28%	60	67%	4	4%	89	0

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 majority (88%) of assets analyzed at STLI have high vulnerability to the evaluated coastal hazards, 9% have moderate vulnerability, and only 3% have low vulnerability (Table 4, and Figures 3-5). None of the assets evaluated have minimal vulnerability. One-quarter of assets (8 transportation and 14 buildings) have both high exposure and high sensitivity. Six of these assets also have a high asset priority index (API ≥ 70, as reported in FMSS), including the Kitchen and Laundry Building, Bakery and Carpentry Building, and Ferry Building on Ellis Island, as well as the Walkways and Ferry Slip on Liberty Island. Three high vulnerability assets have the highest possible API (100): Main Building, Granite Seawall Ellis, and Granite Seawall Liberty Island.

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

	High Vulnerability		Moderate Vulnerability		Low Vulnerability		Minimal Vulnerability		Total
Assets	**#**	**%**	**#**	**%**	**#**	**%**	**#**	**%**	**#**
Buildings	64	85%	8	11%	3	4%	0	0%	75
Transportation	14	100%	0	0%	0	0%	0	0%	14
All Assets	78	88%	8	9%	3	3%	0	0%	89

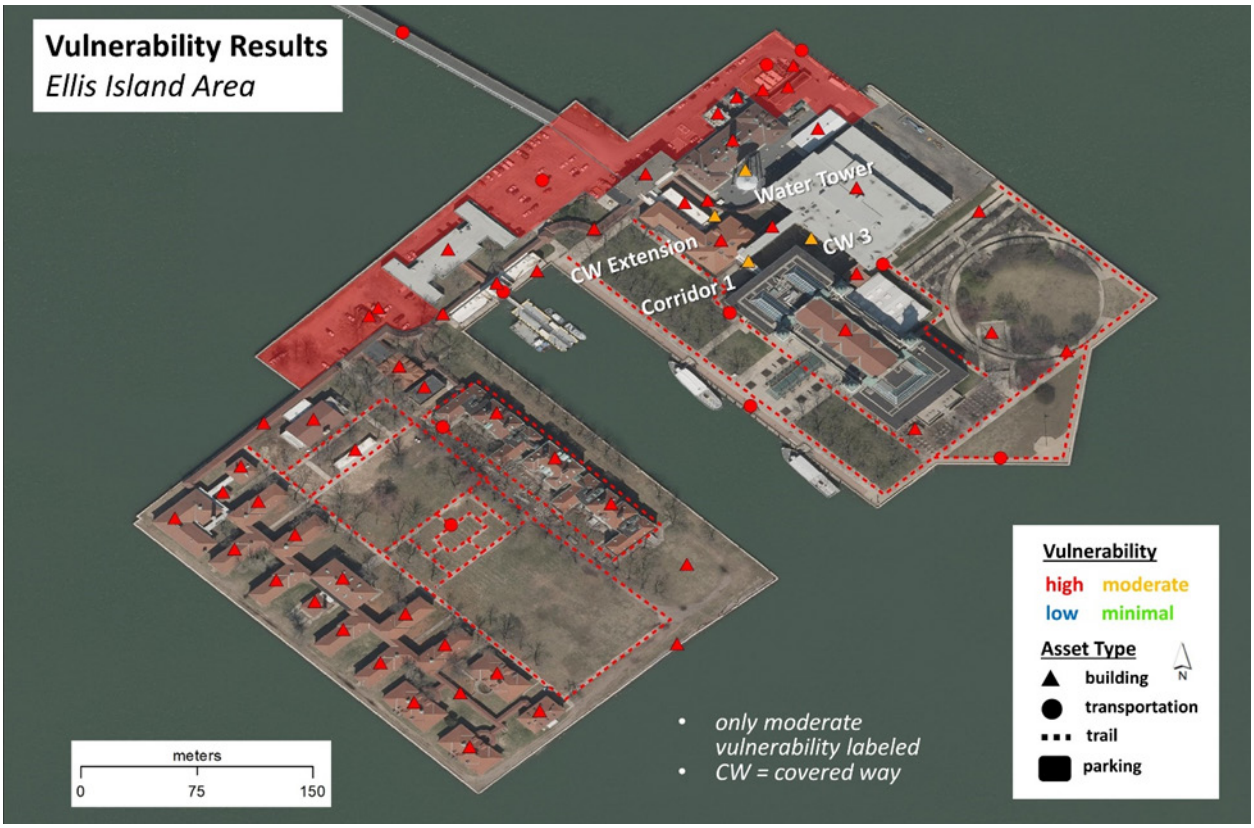

Figure 3. STLI vulnerability results summary for the Ellis Island area. Only moderate vulnerability assets are labeled. Background is ESRI streaming imagery.

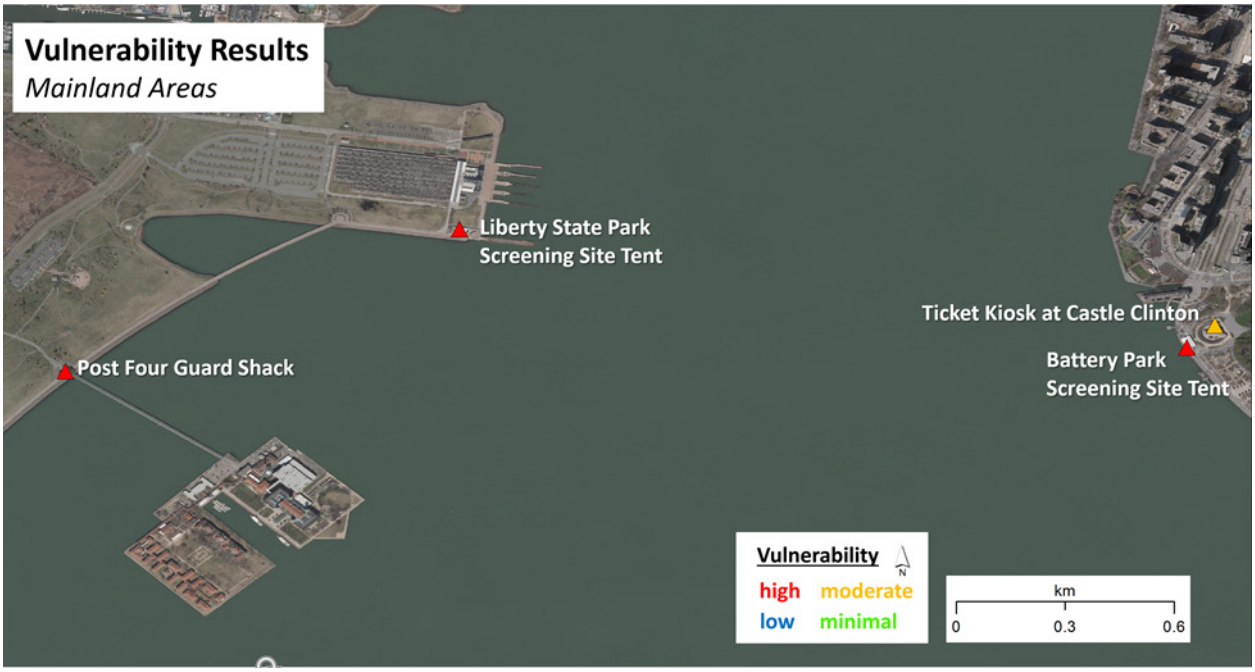

Figure 4. STLI vulnerability results summary for the mainland areas. Background is ESRI streaming imagery.

Figure 5. STLI vulnerability results summary for the Liberty Island area. Only high vulnerability assets are labeled. Background is ESRI streaming imagery.

STLI Unique Considerations

Shoreline change: USGS (or other) shoreline erosion rate data are not available for STLI, which has non-oceanfront coastlines. 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).

SLR data: We used the 2100 4.5 RCP SLR projections and inundation model from Caffrey et al. (2018) developed specifically for NPS units to score exposure for this indicator (0.58 m rise for STLI). These data are used as a proxy for 2050 SLR to accommodate higher SLR projections recently released by NOAA (see Peek et al. 2022).

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). 2015. Preliminary FEMA Map Products. https://hazards.fema.gov/femaportal/prelimdownload/. Accessed March 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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