



Coastal Hazards & Sea-Level Rise Asset Vulnerability Assessment for Virgin Islands National Park

Summary of Results

NPS 161/190213, May 2023



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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 Virgin Islands National Park (VIIS) in 2021. 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 132 buildings/structures (including a visitor center, maintenance facilities, housing, comfort stations, and historical buildings) and 78 transportation assets (including roads/road segments, parking lots, trails, and docks) at VIIS. Forty percent of assets analyzed have high vulnerability to the evaluated coastal hazards and SLR, while almost half (47%) have minimal vulnerability (are not in any of the evaluated hazard zones). Scoring details and results for all assets evaluated at VIIS 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)	VIIS Data (Citation)
Flooding potential (1% annual-chance)	Preliminary FEMA VE & A zones (FEMA 2007)
Shoreline change (coastal proximity)	35-m shoreline proximity buffer (Peek et al. 2022)
SLR inundation (2050)	NPS 8.5 RCP SLR model, 0.23 m rise (Caffrey et al. 2018)
Extreme event flooding (category 3 surge & tsunami inundation)	NOAA national storm surge hazard maps (Zachry et al. 2015), USVI tsunami modeling (NOAA 2018), NOAA 10 ft SLR (NOAA 2022)
Reported coastal hazards (historic flooding)	Questionnaire results & discussions (Peek et al. 2022)

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.

Nearly one-half (48%) of assets evaluated at VIIS have either high or moderate exposure to coastal hazards and SLR (Table 2, and Figure 1). Over one-quarter (27%) of all assets have high exposure, while 21% have moderate exposure. These results are primarily a factor of the high exposure to coastal and extreme event flooding in several portions of the park, as indicated by the Federal Emergency Management Agency (FEMA) VE and AE flood zones (1% annual chance flood, $\pm$ wave velocity), as well as the modeled category 3 storm surge and tsunami inundation extent. Most high exposure assets are in the bay areas of St. John and the Red Hook and Hassel Island areas of St. Thomas.

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

Assets	High Exposure		Moderate Exposure		Low Exposure		Minimal Exposure		Total
	#	%	#	%	#	%	#	%	#
Buildings	27	20%	29	22%	8	6%	68	52%	132
Transportation	29	37%	15	19%	4	5%	30	38%	78
All Assets	56	27%	44	21%	12	6%	98	47%	210

Nine assets (two buildings and seven transportation) at VIIS are within all evaluated exposure zones, including the Hassel Island U.S. Naval Installation, Annaberg Road, Annaberg Sugar Mill Parking, Lameshur Bay Dock, Cruz Bay Marina, and Red Hook Dock. Only 12 assets at VIIS have low exposure, and almost one-half (47%) of assets have minimal exposure. Most of these lower exposure assets are in the higher elevation and inland areas of St. John and Hassel Island on St. Thomas.

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 98 assets at VIIS).

All but one asset analyzed at VIIS have high or moderate sensitivity to coastal hazards and SLR (Table 3). In most cases, the assets with high sensitivity (as opposed to moderate) are in poor condition and have been significantly damaged by coastal flooding in the past. Twice as many buildings have high sensitivity than transportation assets. Thirty-seven of the evaluated assets at VIIS received an unfavorable rating for all sensitivity indicators, including multiple buildings in Trunk and Cinnamon bays, Maho Bay Parking, two segments of Northshore Road, two segments of East End Road, and one segment of Annaberg Road. None of the assets at VIIS are currently elevated above flood levels and only a small percentage are storm resistant or protected by engineering (e.g., seawalls, bulkheads).

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

Assets	High Sensitivity		Moderate Sensitivity		Low Sensitivity		Total Analyzed	Excluded*
	#	%	#	%	#	%	#	#
Buildings	50	78%	14	22%	0	0%	64	68
Transportation	25	52%	22	46%	1	2%	48	30
All Assets	75	67%	36	32%	1	1%	112	98

*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).

Almost one-half (49%) of assets evaluated at VIIS have high or moderate vulnerability to coastal hazards and SLR, and only a few assets (4%) have low vulnerability (Table 4, and Figures 2-5). Under one-half (47%) of assets have minimal vulnerability. Reflecting their exposure, a large portion

of the high vulnerability assets are in the lower elevation areas of St. John and the Hassel Island and Red Hook areas of St. Thomas.

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

Assets	High Vulnerability		Moderate Vulnerability		Low Vulnerability		Minimal Vulnerability		Total
	#	%	#	%	#	%	#	%	#
Buildings	51	39%	7	5%	6	5%	68	52%	132
Transportation	34	44%	12	15%	2	3%	30	38%	78
All Assets	85	40%	19	9%	8	4%	98	47%	210

Eight of the assets evaluated have high vulnerability and a high asset priority index ($API \geq 70$, as reported in FMSS). This includes the Cinnamon Bay Danish Beach Warehouse, Reef Bay Sugar Factory, Cruz Bay Visitor Center Access and Parking, and two segments of Northshore Road (Water Catchment Trail to Peace Hill Parking and Maho Bay Area). Forty-one assets have both high exposure and high sensitivity. This includes the Cinnamon Bay Danish Beach Warehouse, Cruz Bay Visitor Center/Headquarters, Maho Bay Parking, Maho Bay section of Northshore Road, Red Hook Parking and Access Road, Hermitage Plantation and Princess Bay segments of East End Road, and the Mary Creek Rd to Annaberg Sugar Mill segment of Annaberg Road.

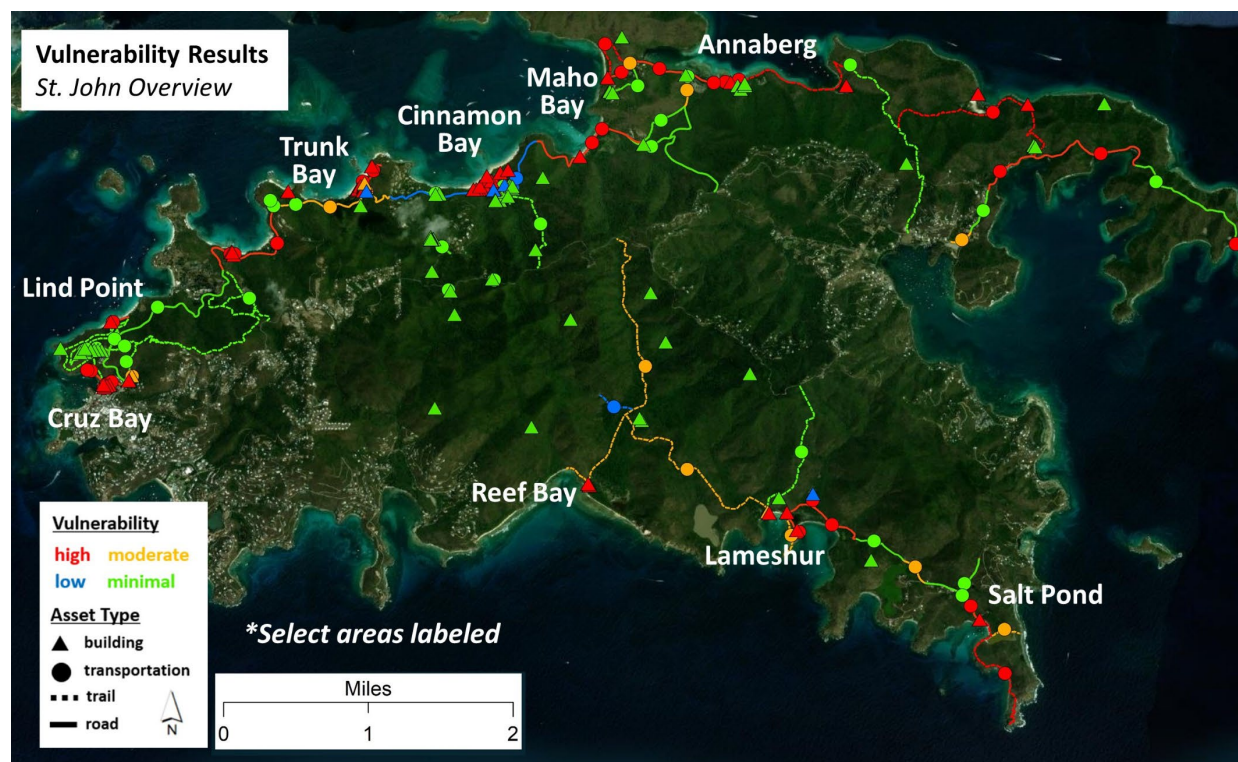


Figure 2. VIIS vulnerability results summary for St. John. Only select areas are labeled. Background is ESRI streaming imagery.

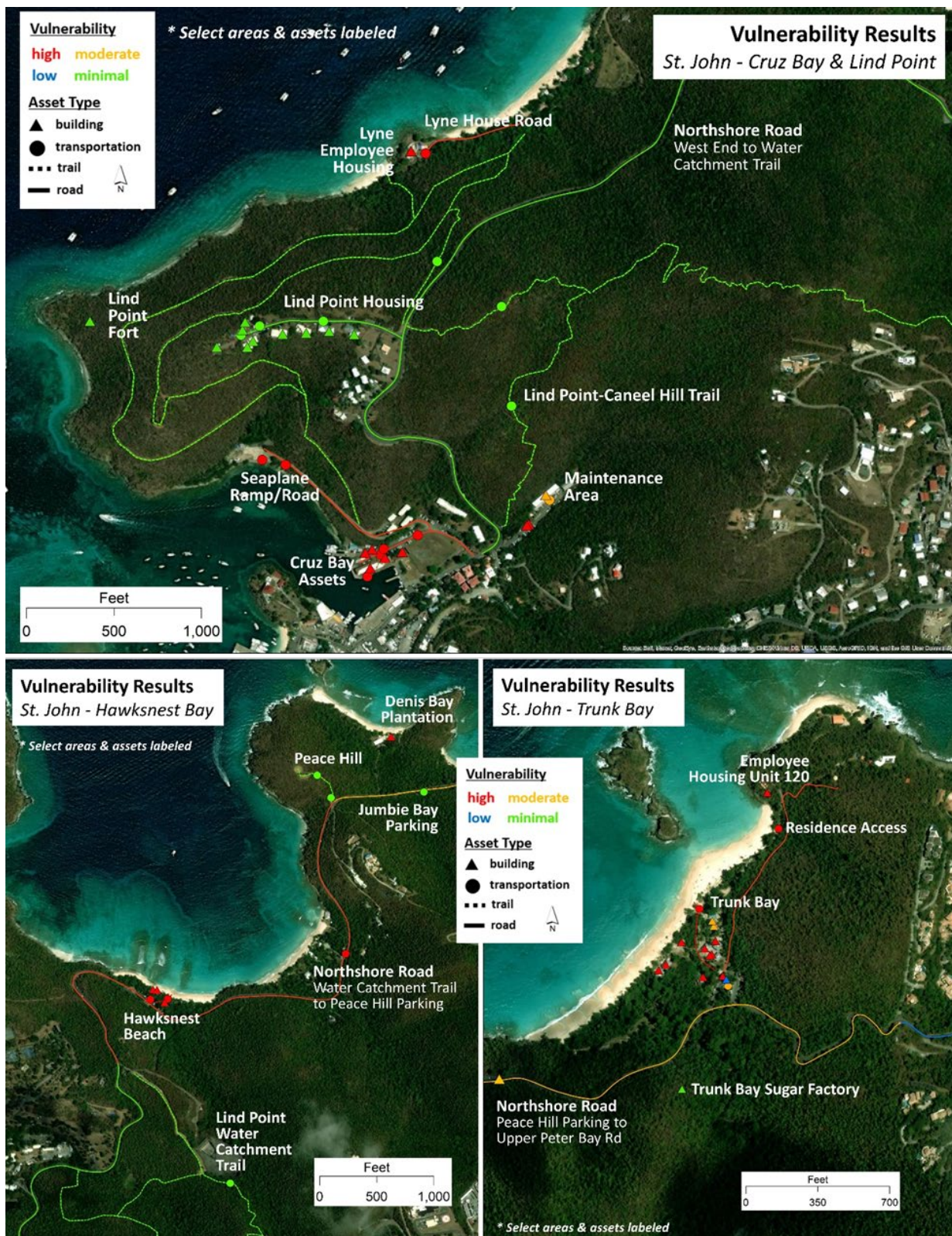


Figure 3. VIIS vulnerability results summary for the Cruz Bay/Lind Point (top), Hawksnest Bay (bottom left), and Trunk Bay (bottom right) areas of St. John. Only select areas and assets are labeled. Background is ESRI streaming imagery.

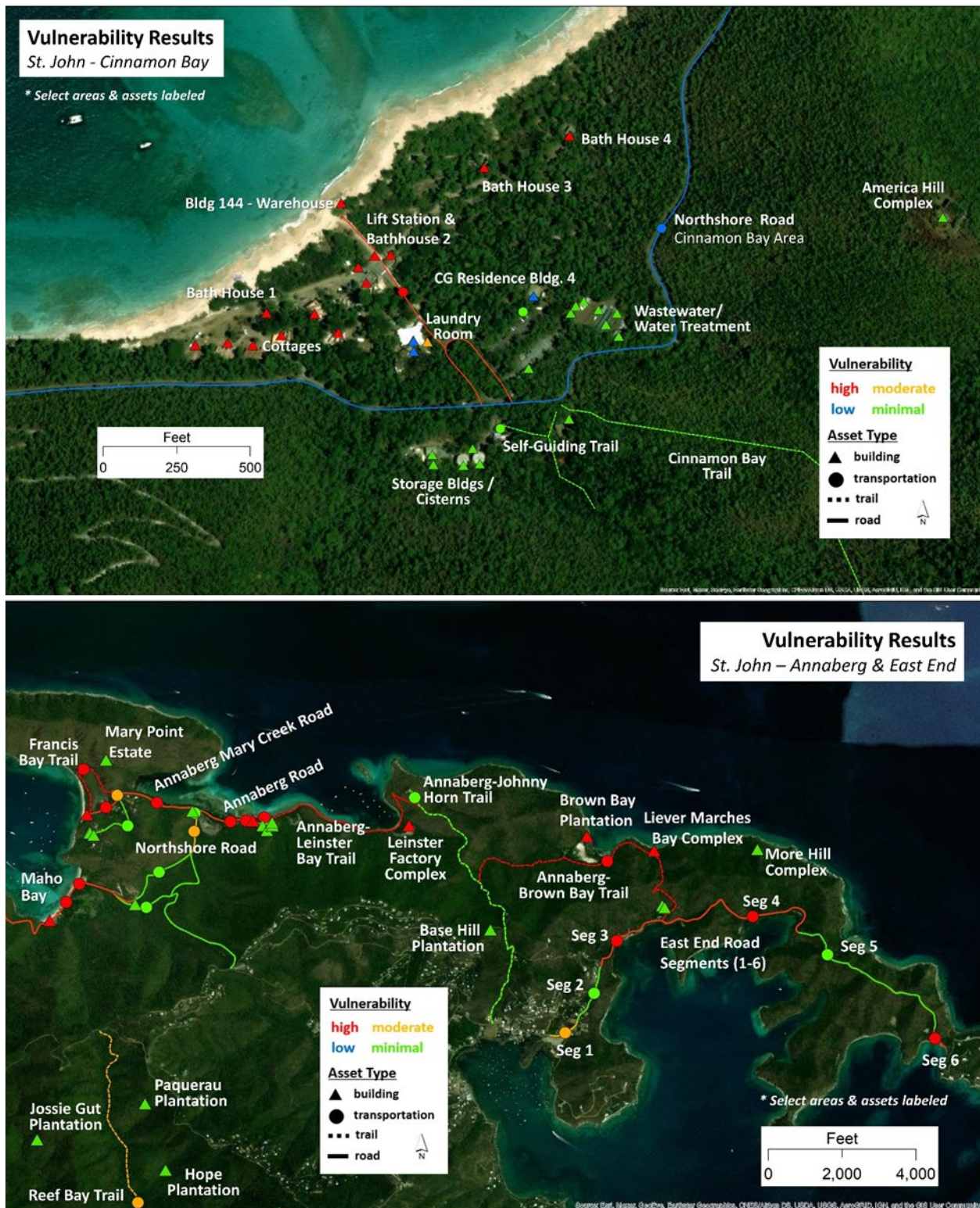


Figure 4. VIIS vulnerability results summary for the Cinnamon Bay (top) and Annaberg/East End (bottom) areas of St. John. Only select assets and areas are labeled. Background is ESRI streaming imagery.



Figure 5. VIIS vulnerability results summary for the Lameshur Bay/Salt Pond areas of St. John (top), and the Hassel Island (bottom left) and Red Hook (bottom right) areas of St. Thomas. Only select assets and areas are labeled. Background is ESRI streaming imagery.

VIIS Unique Considerations

Shoreline change: United States Geological Survey or other shoreline erosion rate data are not available for the coastlines within VIIS. As a result, we used a simple coastal proximity buffer of 35 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 35-year (2050) timeframe of this analysis (Peek et al. 2022).

SLR data: We used the 2050 8.5 Representative Concentration Pathway SLR projection (0.23 m rise) and inundation model (Caffrey et al. 2018) developed specifically for NPS units to score exposure for this indicator. However, we also provided alternate scores using the 2100 4.5 SLR projection (0.5 m rise) for comparison (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; however, these data are not available for VIIS. To evaluate exposure to extreme event flooding (including tsunami and storm surge), we used the National Oceanic and Atmospheric Administration (NOAA) SLOSH Category 3 high tide inundation model (National Storm Surge Hazard Maps - Version 2; Zachry et al. 2015), US Virgin Islands tsunami hazard zone (NOAA 2018), and NOAA SLR 10 ft inundation zone (NOAA 2022).

Road segments: Due to the length of Northshore Road, Lameshur Road, East End Road, and Annaberg Road, we divided each of these roads into multiple smaller 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).

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