



Coastal Hazards & Sea-Level Rise Asset Vulnerability Assessment for Pearl Harbor National Memorial

Summary of Results

NPS 570/197684, March 2025



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USS Arizona Memorial at Pearl Harbor National Memorial

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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 Pearl Harbor National Memorial (PERL) in 2025. 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 21 buildings (including memorials, bungalows, structures, and shelters), and 25 transportation assets (parking lots, roads, trails/walkways, docks, mooring quays, and ship ruins) at PERL. Almost half of the evaluated assets (48%) at PERL have high vulnerability to the assessed coastal hazards and SLR. Ten assets have both high exposure and sensitivity, including the USS Utah and USS Arizona ruins, Theater Building, and all Mooring Quays. Only 20% of the assets have moderate vulnerability, 28% have low vulnerability, and two assets (4%) have minimal vulnerability.

Exposure Results

Exposure is a measure of the character, magnitude, and rate of changes a target may experience (e.g., from the impacts of natural hazards or 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 for PERL.

Exposure Indicator (Description)	Data (Citation)
Flooding potential (1% annual-chance)	Effective FEMA VE & A zones (FEMA 2014)
Shoreline change (coastal proximity)	30-m shoreline proximity buffer (Peek et al. 2022)
SLR inundation (2050)	NPS 2050 8.5 RCP SLR model; 0.23 m rise (Caffrey et al. 2018) NOAA 1 ft SLR inundation zone (NOAA 2022)
Extreme event flooding	Tsunami evacuation zones (City and County of Honolulu 2024)
Reported coastal hazards (historic flooding/active erosion)	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. Low exposure assets could still be seriously impacted by this hazard. Assets with minimal exposure are not in any exposure indicator hazard zone. Minimal exposure does not mean that the asset has no exposure to coastal hazards, but it is not within the mapped exposure hazard zones used in this study.

Almost two-thirds (65%) of assets analyzed at PERL have high or moderate exposure to the coastal hazards evaluated (Table 2, and Figures 1-3). Transportation assets make up the majority of the high exposure assets across the park, most of which are water-related assets such as piers, docks, ship ruins, and mooring quays. Five buildings/structures have high exposure, including the USS Arizona Memorial Structure and Contemplation Circle which are in all evaluated exposure zones. Almost one-third of assets evaluated at PERL have low exposure (30%) and only two assets have minimal exposure (Bungalow #68 on Ford Island and Leased Building #416).

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

Assets	High Exposure		Moderate Exposure		Low Exposure		Minimal Exposure		Total
	#	%	#	%	#	%	#	%	#
Buildings	5	24%	9	43%	5	24%	2	10%	21
Transportation	15	60%	1	4%	9	36%	0	0%	25
All Assets	20	43%	10	22%	14	30%	2	4%	46



Figure 1. PERL exposure results for the Ford Island and Battleship Row areas. Note the direction of north. Background is 2022 Google Earth world imagery.



Figure 2. PERL exposure results for the Visitor Center area. Note the direction of north. Background is 2022 Google Earth world imagery.

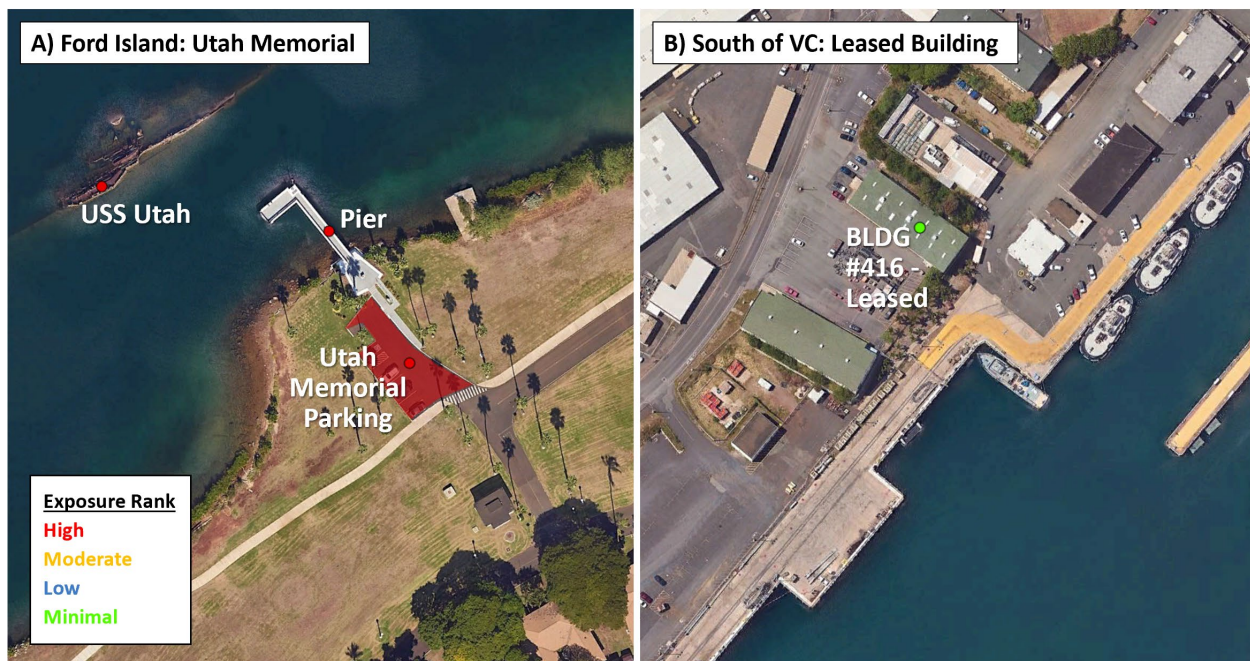


Figure 3. PERL exposure results for the A) Ford Island: Utah Memorial and B) South of VC: Leased Building areas. Background is 2022 Google Earth world imagery.

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 three or four of these indicators, moderate sensitivity assets have unfavorable determinations for two indicators, and low sensitivity assets have unfavorable determinations for zero or one indicator. Assets with minimal exposure are not analyzed for sensitivity (this is the case for two assets at PERL).

Over one-third (34%) of all assets analyzed at PERL have high sensitivity to the coastal hazards evaluated (Table 3). The majority (61%) have moderate sensitivity and only two assets have low sensitivity. Few assets are significantly elevated above local ground level, storm resistant, or protected by effective engineering. In most cases, assets were high sensitivity (versus moderate) due to the condition indicator. Seven assets received unfavorable rankings for all sensitivity indicators: Mooring Quays F6S, F7N, F7S, F8N, and F8S; and the USS Arizona and USS Utah ruins.

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

Assets	High Sensitivity		Moderate Sensitivity		Low Sensitivity		Total Analyzed	Excluded*
	#	%	#	%	#	%	#	#
Buildings	6	32%	12	63%	1	5%	19	2
Transportation	9	36%	15	60%	1	4%	25	0
All Assets	15	34%	27	61%	2	5%	44	2

*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 half of the evaluated assets (48%) at PERL have high vulnerability to the assessed coastal hazards and SLR (Table 4, and Figure 4-6). Seven buildings/structures and three transportation assets have both high vulnerability and a high asset priority index ($API \geq 70$, as reported in FMSS), including the Remembrance Circle and Contemplation Circle (included as part of the Central Court and Interior Walks in FMSS), and the Oklahoma Memorial Structure. Three assets have high vulnerability and the highest possible priority ($API = 100$): Theater Building, Shoreside Dock, and USS Arizona Memorial Dock.

Ten assets have both high exposure and sensitivity, including the USS Utah and USS Arizona ruins, Theater Building, and all Mooring Quays. Only 20% of all assets evaluated at PERL have moderate vulnerability, 28% have low vulnerability, and two assets (4%) have minimal vulnerability (Table 4, and Figures 4-6).

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

Assets	High Vulnerability		Moderate Vulnerability		Low Vulnerability		Minimal Vulnerability		Total
	#	%	#	%	#	%	#	%	
Buildings	7	33%	8	38%	4	19%	2	10%	21
Transportation	15	60%	1	4%	9	36%	0	0%	25
All Assets	22	48%	9	20%	13	28%	2	4%	46

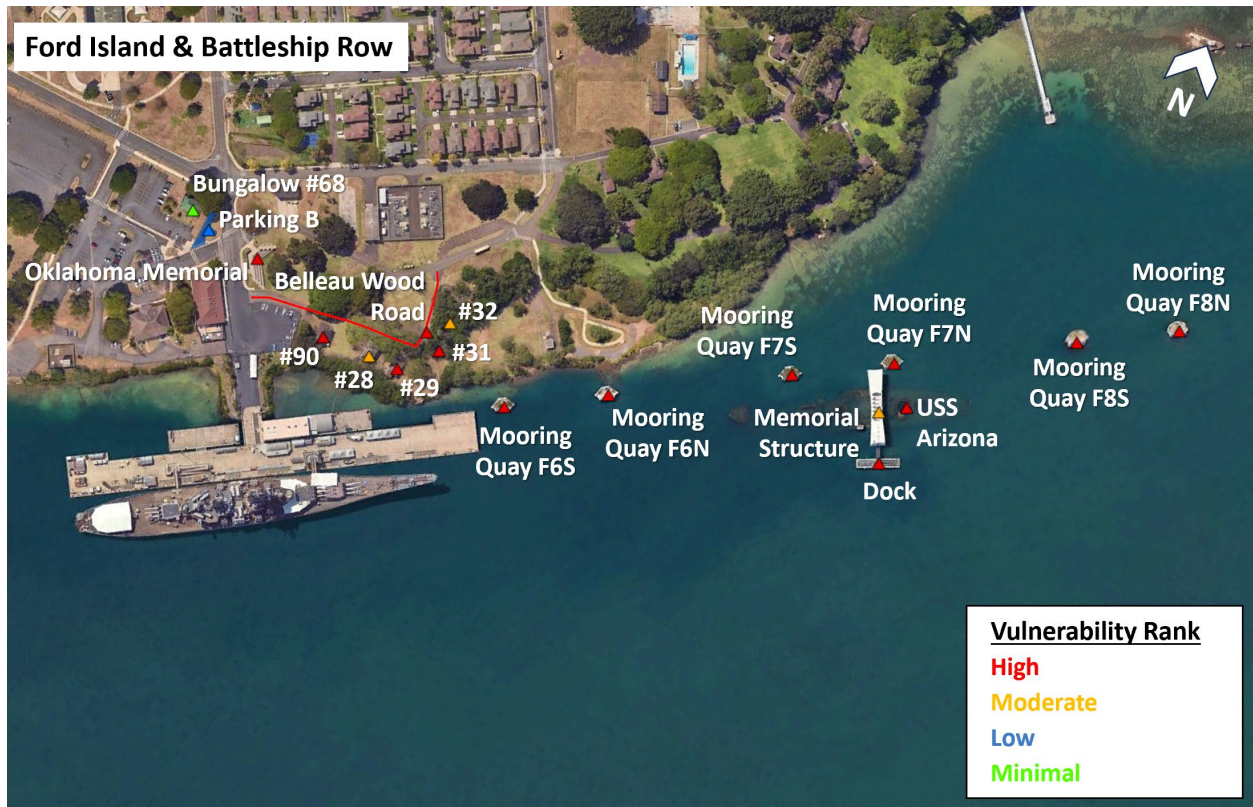


Figure 4. PERL vulnerability results for the Ford Island and Battleship Row areas. Note the direction of north. Background is 2022 Google Earth world imagery



Figure 5. PERL vulnerability results for the Visitor Center area. Note the direction of north. Background is 2022 Google Earth world imagery.

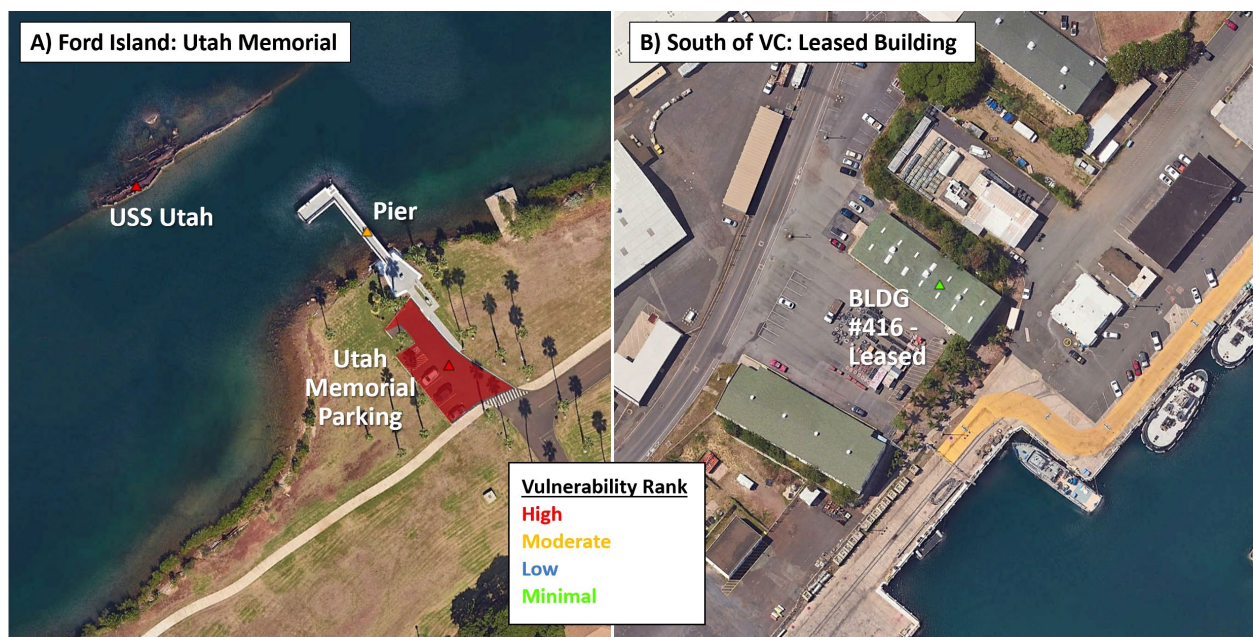


Figure 6. PERL vulnerability results for A) Ford Island: Utah Memorial and B) South of VC: Leased Building areas. Background is 2022 Google Earth world imagery.

PERL Unique Considerations

FMSS assets: Two assets were analyzed at PERL that are not listed in FMSS: the USS Arizona and USS Utah ruins. These assets are owned by the US Navy but are two of the key components of the park. The Remembrance and Contemplation circles are not listed individually within the FMSS database, but instead are part of the VC Central Court and Interior Walks (grounds). Within this VA, only the circles are analyzed (grounds are not typically evaluated in this protocol, see Peek et al. 2022).

Linear assets: Due to exposure variability, we segmented one trail (All Sidewalks and Walkways) into three segments: Shoreline Trail, Paths to Shoreline Trail, and Parking Lot Paths. We evaluated each segment individually for exposure, sensitivity, and vulnerability, and assigned each segment a modified location code (segments share the same FMSS attributes). Any statistics or estimates of value represent the entire road, even if only a small portion has high exposure or vulnerability.

SLR data: We used two sources for the SLR indicator: 1) National Oceanic and Atmospheric Administration (NOAA) 1 ft SLR model (2022), and 2) NPS 2050 8.5 Representative Concentration Pathway SLR projection and inundation model (Caffrey et al. 2018; 0.23 m or 0.75 ft rise for PERL).

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