National Park Service
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Natural Resource Stewardship and Science

Coastal Hazards & Sea-Level Rise Asset Vulnerability Assessment for Gulf Islands National Seashore

Updated Summary of Results

NPS 635/194634, September 2024

PROGRAM FOR THE STUDY OF DEVELOPED SHORELINES

Western Carolina UNIVERSITY

ON THE COVER
Opal Beach at Gulf Islands National Seashore
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Program for the Study of Developed Shorelines
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Executive Summary

In 2015, Western Carolina University completed the initial **Coastal Hazards & Sea-Level Rise (SLR) Asset Vulnerability Assessment (VA)** of Gulf Islands National Seashore (GUIS; Peek et al. 2015). Since this assessment, the park has experienced multiple storms and landscape changes, and many of the original asset and hazard data sources have been revised or updated. This document presents results for the updated VA at GUIS completed in 2023.

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 147 buildings/structures (buildings, shelters, fortifications, batteries, amphitheaters, seawalls, and towers), and 148 transportation assets (roads, road segments, trails, parking lots, bridges, and marinas) at GUIS. Due to the large geographic area at GUIS, summary results are also divided and reported by individual state (Florida [FL] and Mississippi [MS]).

Over half (56%) of the assets analyzed at GUIS have high vulnerability to the evaluated coastal hazards and SLR. The overall percentage of high vulnerability assets has not changed significantly compared to the initial VA completed at GUIS (Peek et al. 2015). A higher percentage of transportation assets have high vulnerability compared to buildings, mainly due to the inclusion of trails in the updated VA. Over one-quarter (26%) of the assets evaluated at GUIS have moderate vulnerability, 5% have low, and 13% have minimal vulnerability. Scoring details and results for all assets evaluated are reported in the provided Excel sheets, and changes to data and assets are noted in the GUIS Unique Considerations & Updates.

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). The exposure data used within this VA differ slightly from Peek et al. (2015), as updated datasets were used for the flooding potential, shoreline change/coastal proximity, SLR inundation, and extreme event flooding indicators (see GUIS Unique Considerations & Updates).

[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."

Table 1. Exposure indicators and hazard data sources used at GUIS.

Exposure Indicator (Description)	Data (Citation)
Flooding potential (1% annual-chance)	Effective FEMA VE & A zones (FEMA 2006; 2009; 2021); Preliminary FEMA VE & A zones (FEMA 2017)
Shoreline change (coastal proximity)	USGS short term shoreline change rates (Himmelstoss 2017; Kratzmann 2021); 30-m shoreline proximity buffer (Peek et al. 2022)
SLR inundation (2050 proxy) *	NPS 2100 4.5 RCP SLR model; 0.55 m rise (Caffrey et al. 2018)
Extreme event flooding (category 3 surge)	NPS storm surge inundation model (Caffrey et al. 2018); NOAA national storm surge hazard maps (Zachry et al. 2015)
Reported coastal hazards (historic flooding)	Questionnaire results & discussions (Peek et al. 2022)

*See Unique Considerations

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.

Under one-third of all assets analyzed at GUIS have high exposure to the coastal hazards evaluated (Table 2). Transportation assets make up the majority of the high exposure assets across the park. Compared to the Peek et al. (2015) analysis, slightly fewer assets (approximately 7%) are now scored as high exposure. These changes are due to a combination of updated exposure hazard data (e.g., FEMA, surge; see GUIS Unique Considerations & Updates) and FMSS-listed assets. Almost half of all assets evaluated at GUIS have moderate exposure, 8% have low exposure, and 13% have minimal exposure.

Table 2. Exposure results for all assets at GUIS. Sum of percentages may not equal 100 due to rounding.

	High Exposure		Moderate Exposure		Low Exposure		Minimal Exposure		Total
Assets	**#**	**%**	**#**	**%**	**#**	**%**	**#**	**%**	**#**
Buildings	37	25%	68	46%	16	11%	26	18%	147
Transportation	56	38%	71	48%	8	5%	13	9%	148
All Assets	93	32%	139	47%	24	8%	39	13%	295

Florida Exposure Results

Over one-quarter (27%) of assets located in the FL district of GUIS have high exposure to the coastal hazards evaluated, while one-half have moderate exposure (Table 3, Figures 1-4). Only 5% of these assets have low exposure, and 18% have minimal exposure. All low and minimal exposure assets in FL are in the Fort Barrancas, Pensacola Lighthouse, and Naval Live Oaks areas (Figures 1 and 4). Seven assets in this district are within all evaluated exposure hazard zones: Fort Pickens Ferry Pier Marina, Fort Pickens Marina/Waterfront (Fishing Pier), Fort Pickens Ranger Station Marina, the east segment of Fort Pickens Road, Perdido Key Waterfront (Canoe Launch), Perdido Key Natural Trail Parking, and Okaloosa Marina and Waterfront.

Table 3. Exposure results for the FL district of GUIS. Sum of percentages may not equal 100 due to rounding.

	High Exposure		Moderate Exposure		Low Exposure		Minimal Exposure		Total
Assets	**#**	**%**	**#**	**%**	**#**	**%**	**#**	**%**	**#**
Buildings	22	20%	58	53%	4	4%	26	24%	110
Transportation	36	36%	48	48%	6	6%	11	11%	101
All Assets	58	27%	106	50%	10	5%	37	18%	211

Figure 1. GUIS exposure results summary for the Naval Live Oaks area of the FL district. Background is 2021 ESRI world imagery.

Figure 2. GUIS exposure results summary for the A) Perdido Key (Fort McRee area not shown), B) Fort Pickens - West, and C) Fort Pickens - East areas of the FL district. Background is 2021 ESRI world imagery.

Figure 3. GUIS exposure results summary for the A) Santa Rosa - West, B) Santa Rosa - East, and C) Okaloosa areas of the FL district. Background is 2021 ESRI world imagery.

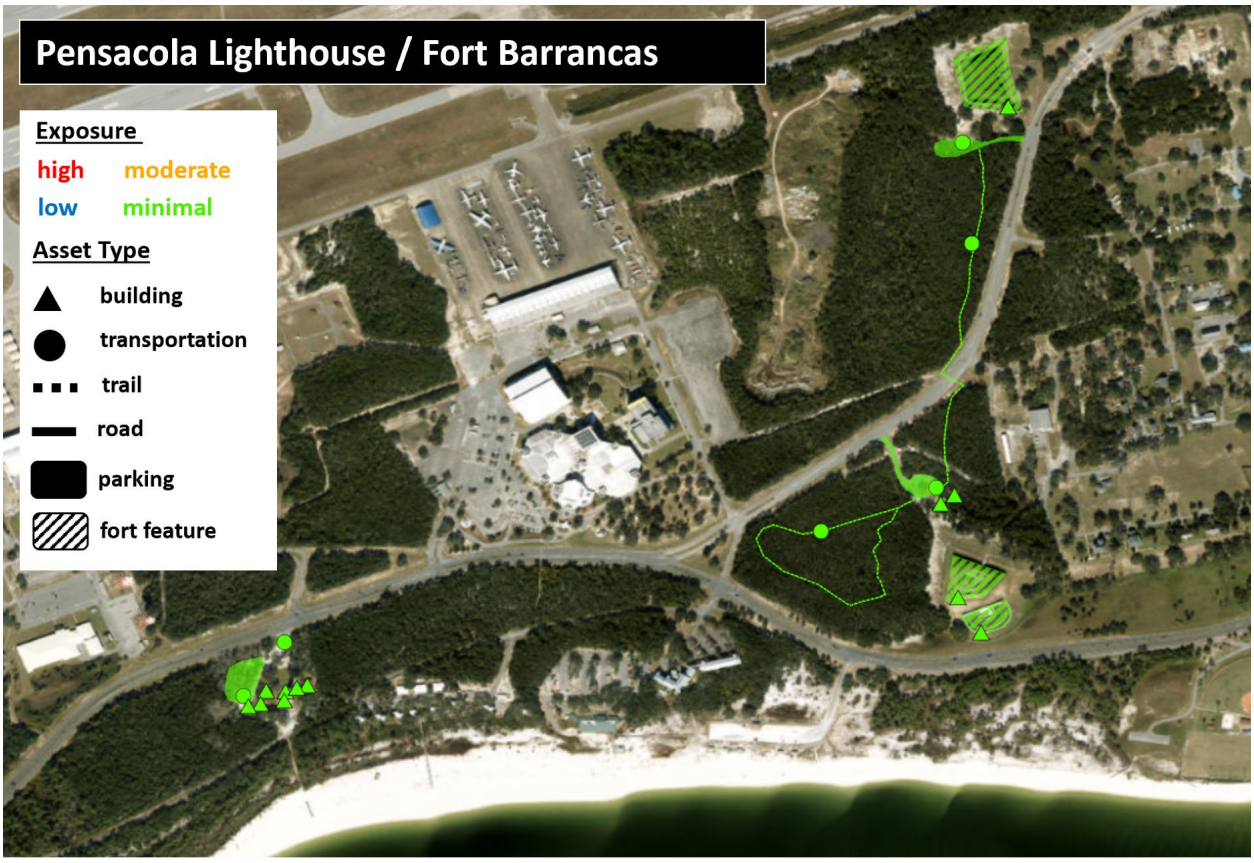

Figure 4. GUIS exposure results summary for Pensacola Lighthouse/Fort Barrancas area of the FL district. Background is 2021 ESRI world imagery.

Mississippi Exposure Results

Under half (42%) of assets located in the MS district have high exposure to the coastal hazards evaluated, over one-third (39%) have moderate, and 17% have low exposure (Table 4, and Figure 5). Only two assets in MS (Pabst Road Bridge and Old US Route 90 Bridge in the Davis Bayou area) have minimal exposure. Fourteen assets in the MS district are within all evaluated exposure hazard zones, including the marinas at Davis Bayou, Cat Island, and Ship Island, as well as Davis Bayou Robert McGee Culvert Bridge and Davis Bayou Government Boat Dock Parking.

Table 4. Exposure results for the MS district of GUIS. Sum of percentages may not equal 100 due to rounding.

	High Exposure		Moderate Exposure		Low Exposure		Minimal Exposure		Total
Assets	**#**	**%**	**#**	**%**	**#**	**%**	**#**	**%**	**#**
Buildings	15	41%	10	27%	12	32%	0	0%	37
Transportation	20	43%	23	49%	2	4%	2	4%	47
All Assets	35	42%	33	39%	14	17%	2	2%	84

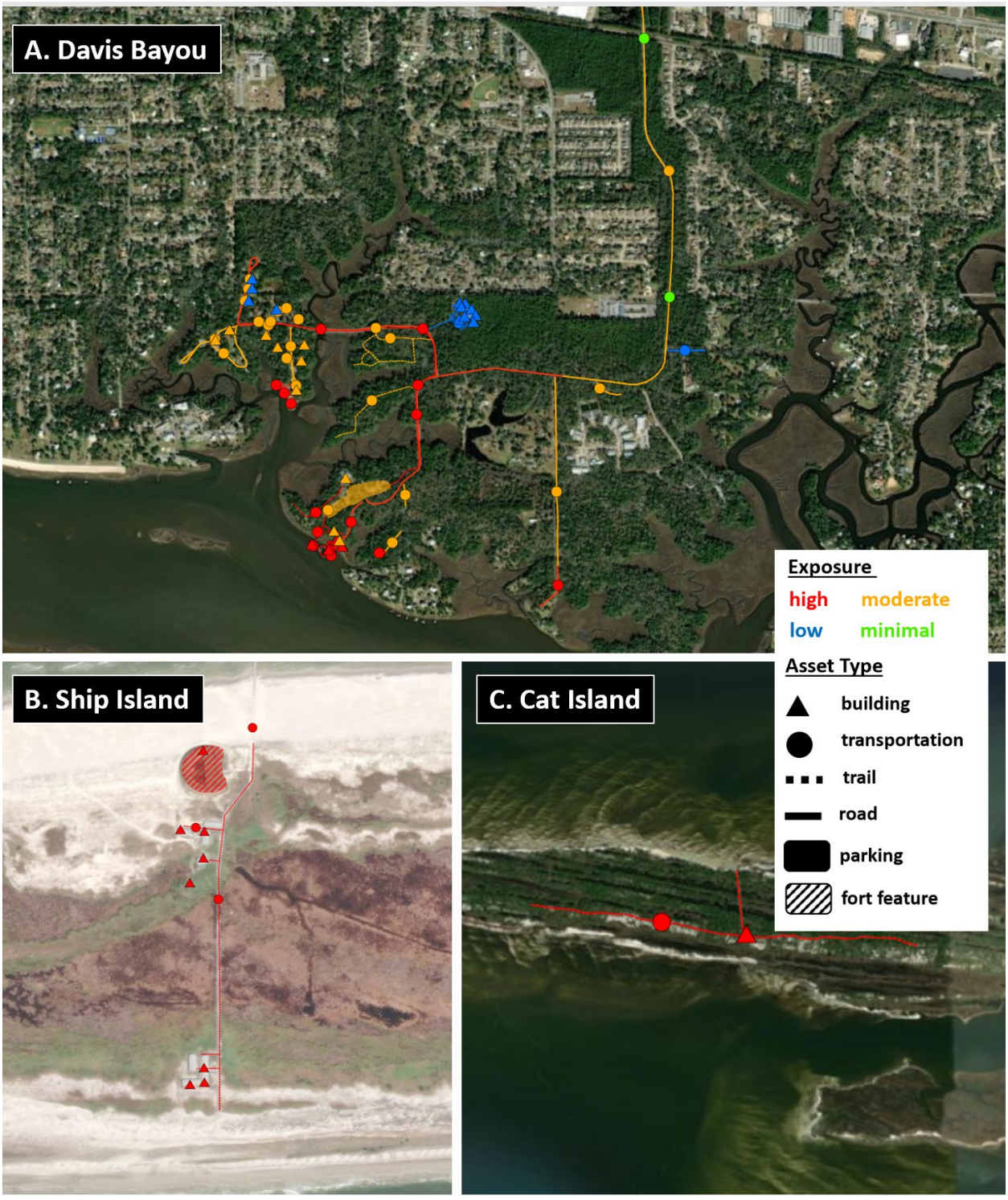

Figure 5. GUIS exposure results for the A) Davis Bayou, B) Ship Island, and C) Cat Island areas of the MS district. Background is 2021 ESRI world imagery.

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 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 39 assets at GUIS).

Almost two-thirds (61%) of all assets analyzed at GUIS have high sensitivity to the coastal hazards evaluated (Table 5). The remaining assets have moderate sensitivity (no assets have low sensitivity). Slightly more transportation assets at GUIS have high sensitivity compared to buildings (10% difference). Compared to the Peek et al. (2015) analysis, more assets (approximately 9%) are now scored as high sensitivity. This shift is primarily due to the high sensitivity of trails, which were not included in the initial VA.

Table 5. Sensitivity results for all assets at GUIS. Sum of percentages may not equal 100 due to rounding.

	High Sensitivity		Moderate Sensitivity		Low Sensitivity		Total Analyzed	Excluded*
Assets	**#**	**%**	**#**	**%**	**#**	**%**	**#**	**#**
Buildings	67	55%	54	45%	0	0%	121	26
Transportation	88	65%	47	35%	0	0%	135	13
All Assets	155	61%	101	39%	0	0%	256	39

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

Florida Sensitivity Results

The majority (70%) of assets located in the FL district of GUIS have high sensitivity to the coastal hazards evaluated, while 30% have moderate sensitivity (Table 6). Most FL assets are not elevated (above local ground level or FEMA Base Flood Elevation), storm resistant, or protected by effective engineering. Roughly half of these assets were reported as poor condition. Over one-quarter of these assets have been damaged in the past by coastal flooding. Overall, transportation assets have higher sensitivity, primarily due to widespread historical damage, and a lack of storm resistance and protective engineering.

Table 6. Sensitivity results for the FL district of GUIS. Sum of percentages may not equal 100 due to rounding.

	High Sensitivity		Moderate Sensitivity		Low Sensitivity		Total Analyzed	Excluded*
Assets	**#**	**%**	**#**	**%**	**#**	**%**	**#**	**#**
Buildings	48	57%	36	43%	0	0%	84	26
Transportation	73	81%	17	19%	0	0%	90	11
All Assets	121	70%	53	30%	0	0%	174	37

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

Mississippi Sensitivity Results

Fewer assets in the MS district of GUIS have high sensitivity to the coastal hazards evaluated (only 41% compared to 70% in the FL district). The majority (59%) of assets in MS have moderate sensitivity (Table 7). Most MS assets are not elevated (above local ground level or FEMA Base Flood Elevation), storm resistant, or protected by effective engineering. Under one-half of these assets have been damaged in the past by coastal flooding. However, less than one-quarter of these assets were reported as poor condition. A lower percentage of MS transportation assets have high sensitivity, primarily due to a significant number of roads and parking lots in the Davis Bayou area that are in good condition and have not been previously damaged by flooding.

Table 7. Sensitivity results for the MS district of GUIS. Sum of percentages may not equal 100 due to rounding.

	High Sensitivity		Moderate Sensitivity		Low Sensitivity		Total Analyzed	Excluded*
Assets	**#**	**%**	**#**	**%**	**#**	**%**	**#**	**#**
Buildings	19	51%	18	49%	0	0%	37	0
Transportation	15	33%	30	67%	0	0%	45	2
All Assets	34	41%	48	59%	0	0%	82	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).

Over half of the assets at GUIS have high vulnerability to the evaluated coastal hazards and SLR (Table 8, and Figures 6-15). Sixteen buildings and 12 transportation assets have both high vulnerability and a high asset priority index (API ≥ 70, as reported in FMSS). The overall percentage of high vulnerability assets has not changed significantly compared to the Peek et al. (2015) analysis. However, a higher percentage of transportation assets now have high vulnerability compared to buildings (the opposite was true in the initial VA). This change is partially due to the addition of trails, most of which have high vulnerability. Over one-quarter (26%) of all assets evaluated at GUIS have moderate vulnerability, 5% have low, and 13% have minimal vulnerability (Table 8, and Figures 6-15).

Table 8. Vulnerability results for all assets at GUIS. Sum of percentages may not equal 100 due to rounding.

	High Vulnerability		Moderate Vulnerability		Low Vulnerability		Minimal Vulnerability		Total
Assets	**#**	**%**	**#**	**%**	**#**	**%**	**#**	**%**	**#**
Buildings	74	50%	35	24%	12	8%	26	18%	147
Transportation	92	62%	41	28%	2	1%	13	9%	148
All Assets	166	56%	76	26%	14	5%	39	13%	295

Florida Vulnerability Results

Over half (57%) of the assets located in the FL district of GUIS have high vulnerability to the coastal hazards evaluated, while one-quarter have moderate exposure (Table 9, and Figures 6-12). No FL assets have low exposure, and 18% have minimal exposure. Transportation assets make up the majority of the high vulnerability assets in this district. Forty-eight assets have both high exposure and high sensitivity, including multiple restrooms, picnic shelters, and parking lots in the Santa Rosa area, as well as several segments of Fort Pickens, Johnson Beach, and Earle Bowden roads (Figures 6, 10-12).

Thirteen buildings in the FL district have both high vulnerability and a high API, most of which are historic structures in the Fort Pickens area (Figures 9-10). This includes four batteries (Cooper, Langdon, Van Swearingen, and Worth), the seawall, and the Lifesaving Station, which has the highest possible API (100). Six transportation assets have high vulnerability and a high API, including the Florida National Scenic Trail, Fort Pickens Marina (Fishing Pier), and the Blackbird

Marsh Nature Trail. It should be noted that all segments of Fort Pickens Road and Earle Bowden Road also have high vulnerability (Figures 11-12). These assets only had an API of 65 in FMSS at the time of the analysis but are two of the primary transportation corridors in the FL district of the park.

Table 9. Vulnerability results for the FL district of GUIS. Sum of percentages may not equal 100 due to rounding.

	High Vulnerability		Moderate Vulnerability		Low Vulnerability		Minimal Vulnerability		Total
Assets	**#**	**%**	**#**	**%**	**#**	**%**	**#**	**%**	**#**
Buildings	52	47%	32	29%	0	0%	26	24%	110
Transportation	69	68%	21	21%	0	0%	11	11%	101
All Assets	121	57%	53	25%	0	0%	37	18%	211

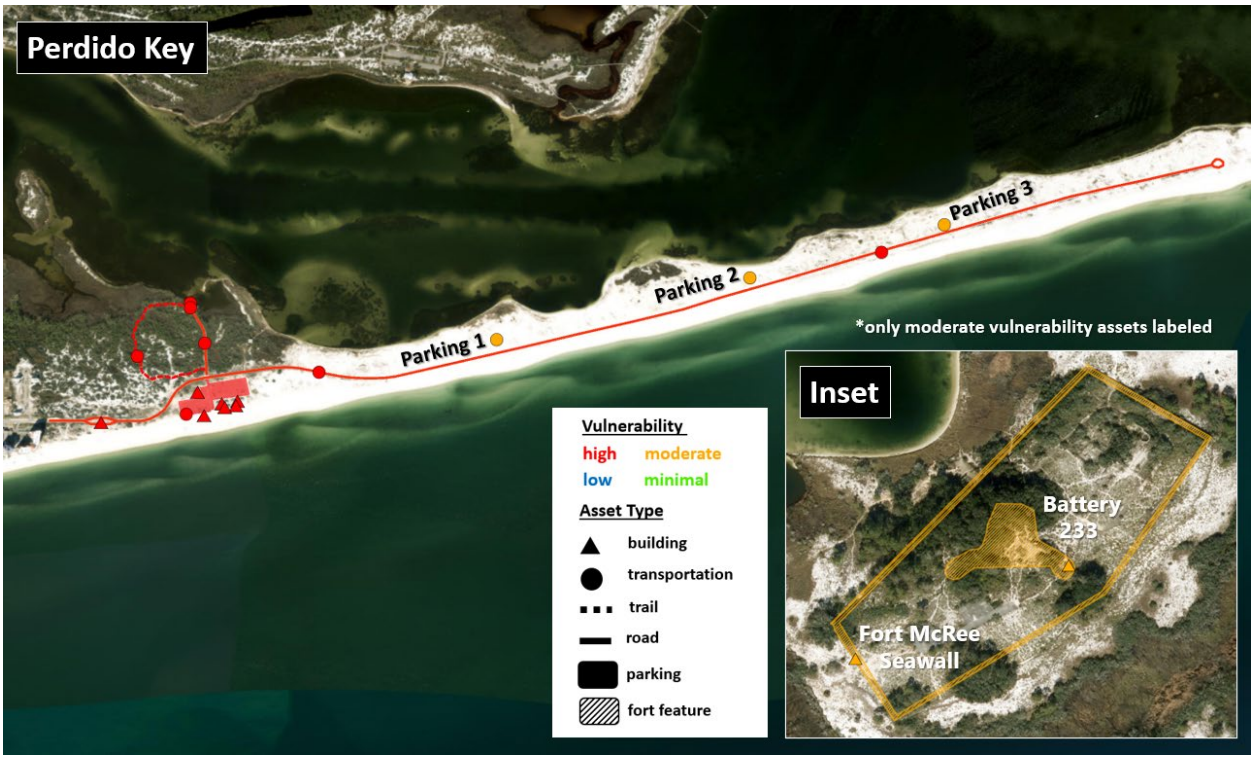

Figure 6. GUIS vulnerability results for the Perdido Key area of the FL district (inset shows Fort McRee area). Background is 2021 ESRI world imagery. Only moderate vulnerability assets are labeled.

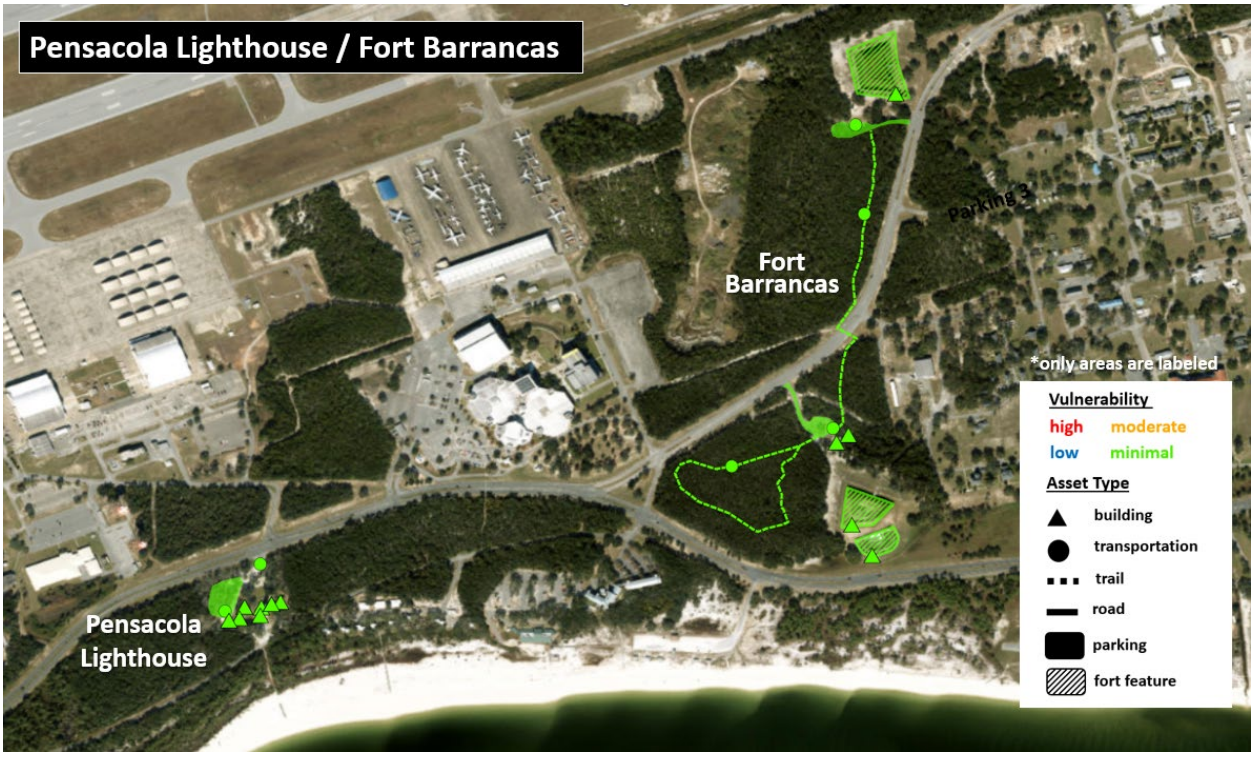

Figure 7. GUIS vulnerability results for the Pensacola Lighthouse and Fort Barrancas areas of the FL district. Background is 2021 ESRI world imagery. Only areas are labeled (all assets are minimal vulnerability).

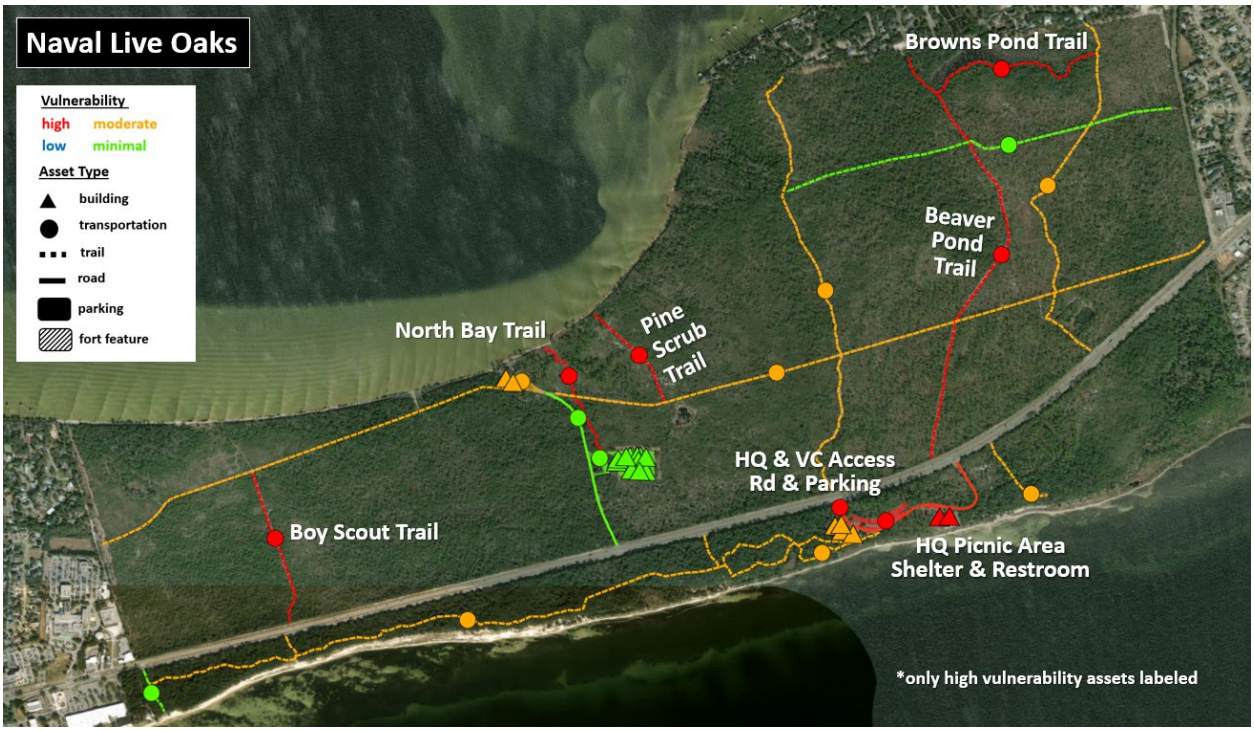

Figure 8. GUIS vulnerability results for the Naval Live Oaks area of the FL district. Background is 2021 ESRI world imagery. Only high vulnerability assets are labeled.

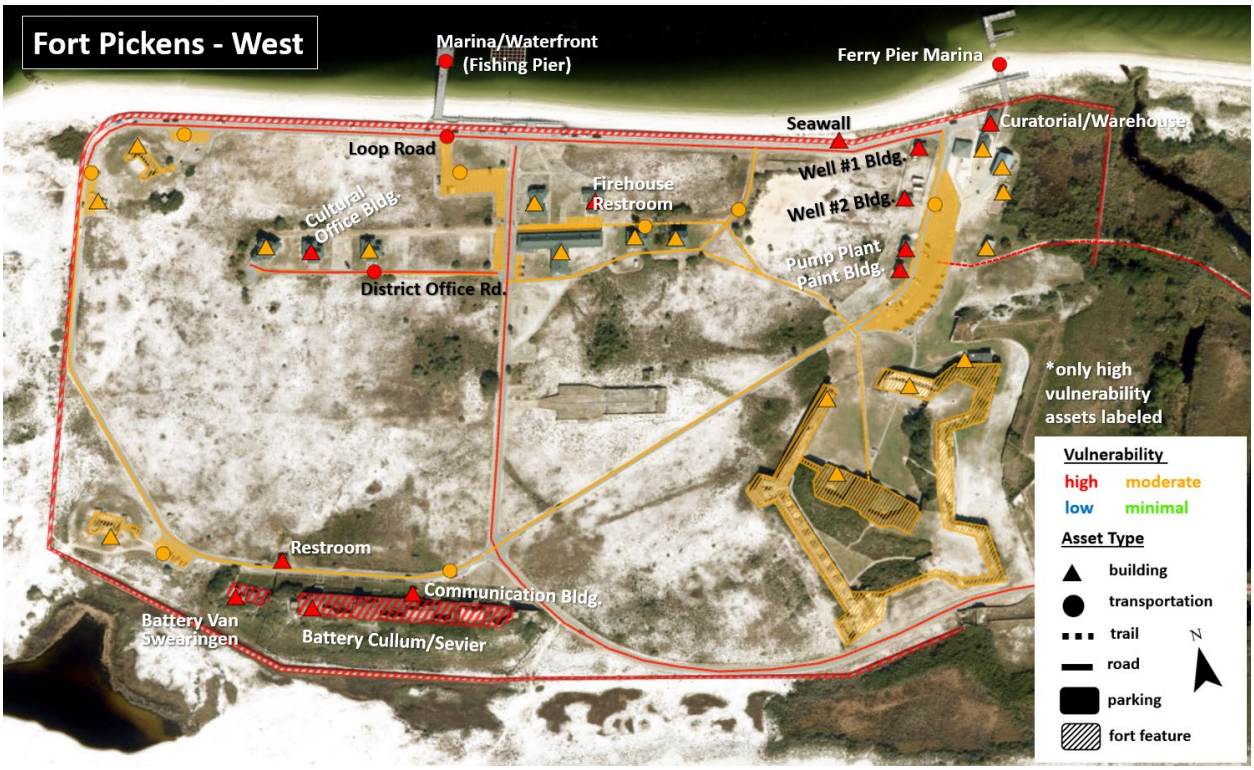

Figure 9. GUIS vulnerability results for the Fort Pickens - West area of the FL district. Background is 2021 ESRI world imagery. Only high vulnerability assets are labeled. Note the direction of north.

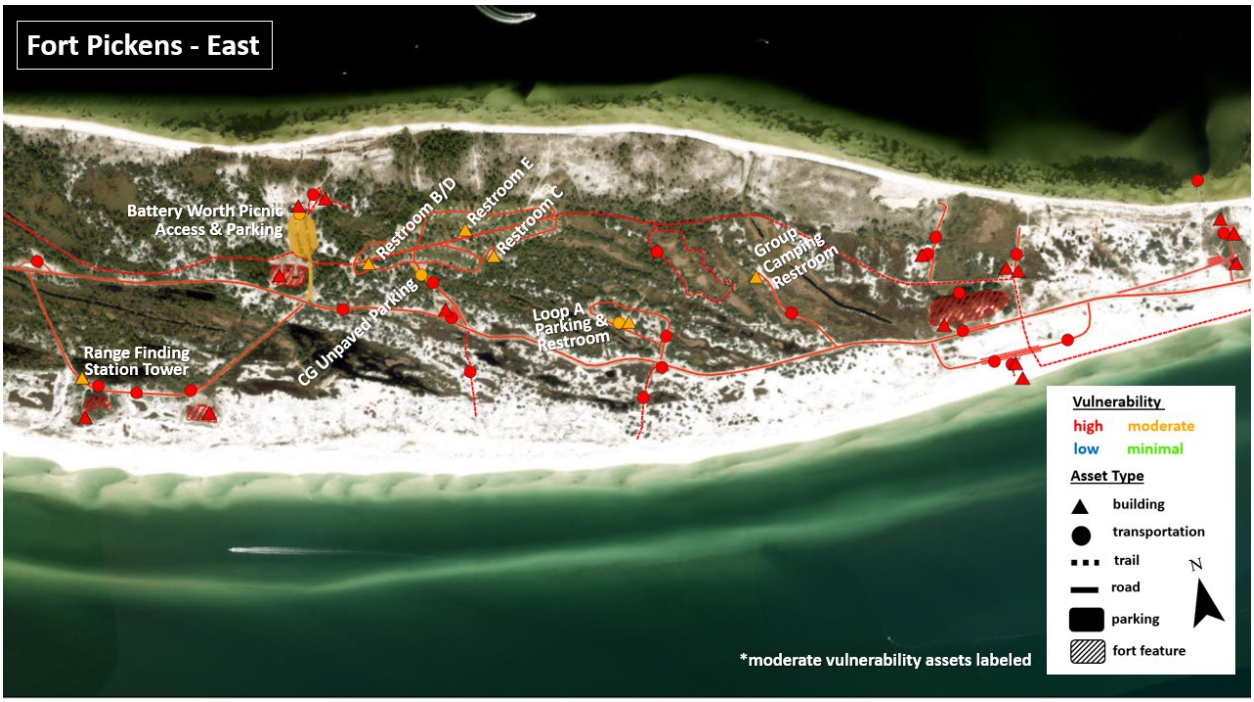

Figure 10. GUIS vulnerability results for the Fort Pickens - East area of the FL district, including the locations of Battery 234/Cooper, Campground, and Langdon. Background is 2021 ESRI world imagery. Only moderate vulnerability assets are labeled. Note the direction of north.

Figure 11. GUIS vulnerability results for the A) Fort Pickens - Entrance and B) Santa Rosa - West areas of the FL district. Background is 2021 ESRI world imagery. Note the direction of north.

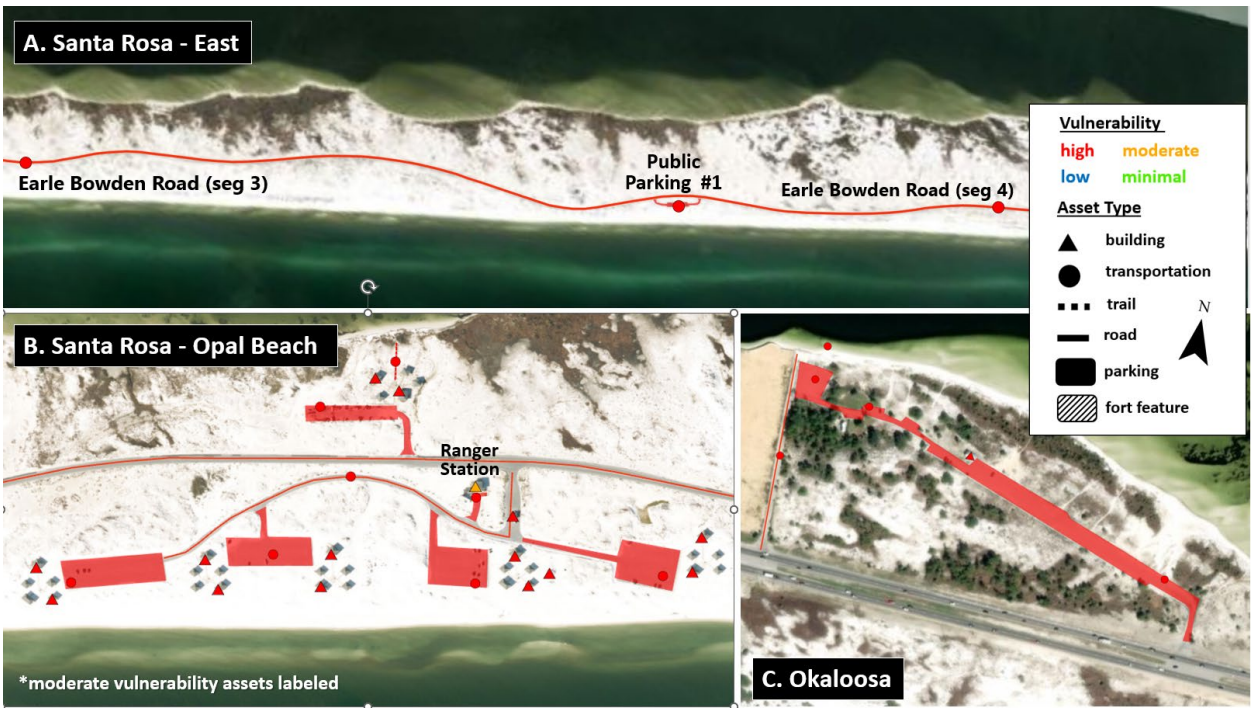

Figure 12. GUIS vulnerability results for the A) Santa Rosa - East, B) Santa Rosa - Opal Beach, and C) Okaloosa areas of the FL district. Background is 2021 ESRI world imagery. Note the direction of north.

Mississippi Vulnerability Results

Over half (54%) of the assets located in the MS district of GUIS have high vulnerability to the coastal hazards evaluated, while 27% have moderate exposure (Table 10, and Figures 13-15). Fourteen assets (17%) have low exposure, and only 2% have minimal exposure. Buildings make up the majority of the high vulnerability assets in this district. Twenty-four assets have both high exposure and high sensitivity, including Fort Massachusetts and all other assets on Ship Island, as well as Robert McGee Road in the Davis Bayou area.

Six assets in the MS district have both high vulnerability and a high API: Fort Massachusetts, Boardwalks, and Public Restroom North on Ship Island; and the Visitor Center/Headquarters and Robert McGee Culvert Bridge in the Davis Bayou area.

Table 10. Vulnerability results for the MS district of GUIS. Sum of percentages may not equal 100 due to rounding.

	High Vulnerability		Moderate Vulnerability		Low Vulnerability		Minimal Vulnerability		Total
Assets	**#**	**%**	**#**	**%**	**#**	**%**	**#**	**%**	**#**
Buildings	22	59%	3	8%	12	32%	0	0%	37
Transportation	23	49%	20	43%	2	4%	2	4%	47
All Assets	45	54%	23	27%	14	17%	2	2%	84

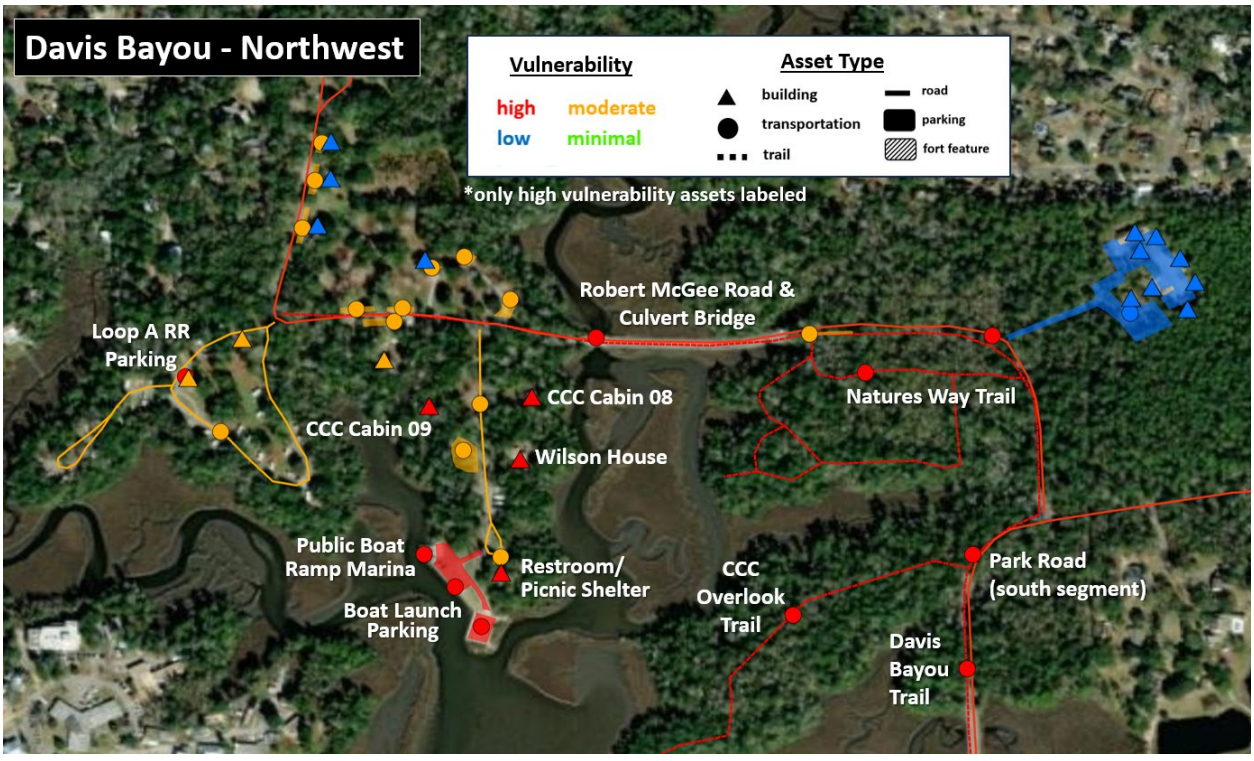

Figure 13. GUIS vulnerability results for Davis Bayou - Northwest area of the MS district. Background is 2021 ESRI world imagery. Only high vulnerability assets are labeled.

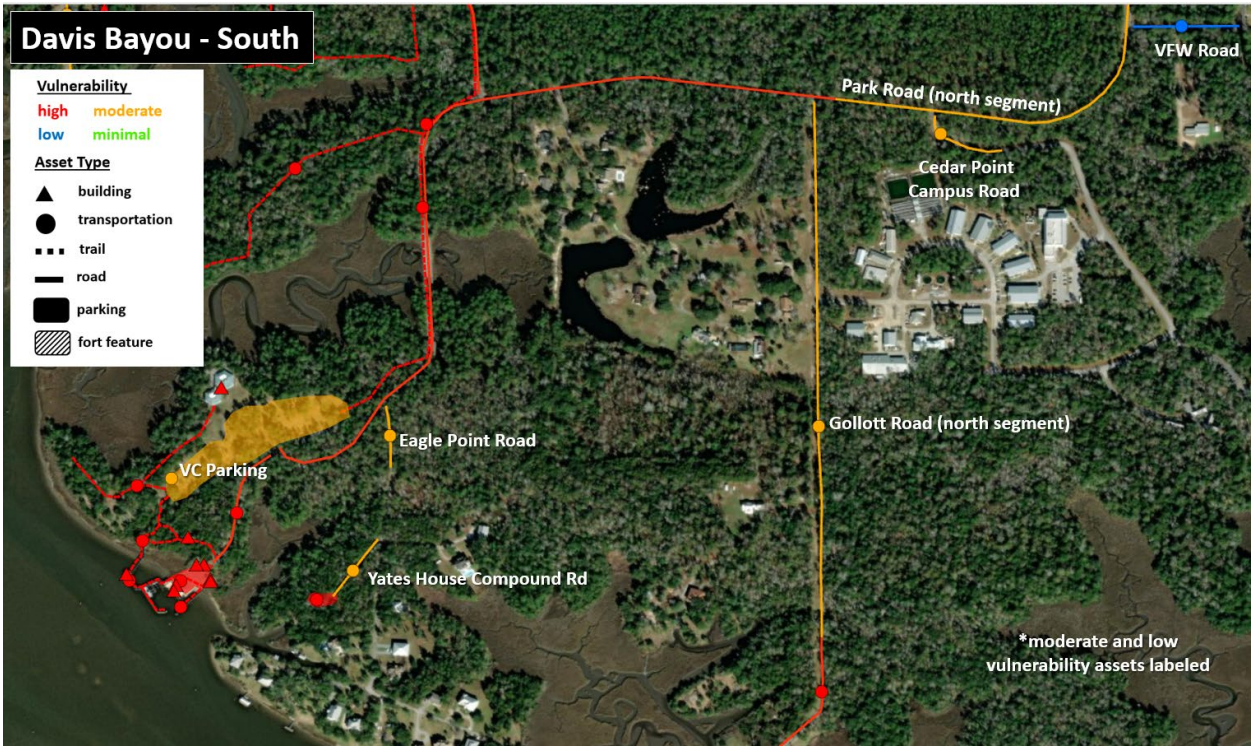

Figure 14. GUIS vulnerability results for Davis Bayou - South area of the MS district. Background is 2021 ESRI world imagery. Moderate and low vulnerability assets are labeled.

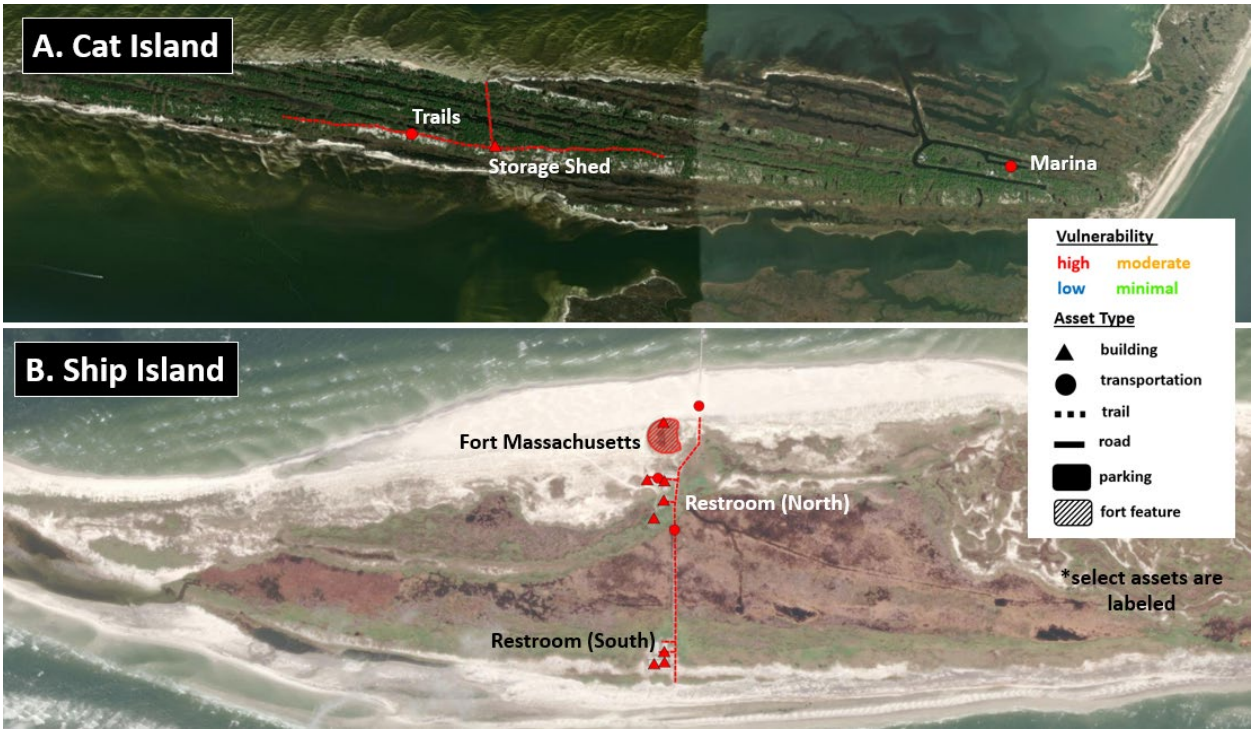

Figure 15. GUIS vulnerability results for the A) Cat Island and B) Ship Island areas of the MS district. Background is 2021 ESRI world imagery. Select assets are labeled for Ship Island (B).

GUIS Unique Considerations & Updates

FMSS assets: Peek et al. (2015) evaluated 148 buildings and 110 transportation assets, while in this updated VA, we evaluated 147 buildings and 148 transportation assets. For buildings, the change is mainly due to the inclusion of eight assets in the Pensacola Lighthouse area that were not listed in FMSS in the previous analysis, and the removal of multiple assets from FMSS within the Davis Bayou area. For transportation assets, the change is mainly due to the inclusion of trails in the updated VA.

Linear assets: Due to exposure variability, we segmented six roads at GUIS: Fort Pickens Loop Road (2 segments), Fort Pickens Road (4 segments), Johnson Beach Road (2 segments), Earle Bowden Road (4 segments), Gollott Road (2 segments), Davis Bayou Park Road (2 segments). The number of segments and segment locations were updated based on new exposure data. Robert McGee Road and Battery 234 Loop Road were not segmented in this VA.

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.

Park questionnaire: Park staff completed an updated questionnaire in 2023 for historic flooding (exposure), condition (sensitivity), and historic damage (sensitivity) to capture changes since the initial Peek et al. (2015) VA.

Flood damage potential data: Two of the counties in the GUIS area have been updated since Peek et al. (2015). FEMA published preliminary data for Escambia County in 2017, and effective data for Okaloosa County in 2021.

Shoreline change data: We used updated USGS short-term shoreline change rate data (Himmelstoss 2017; Kratzmann 2021) to create erosion buffer zones for the oceanfront shorelines of GUIS (see Peek et al. 2022 for methodology). The digital shoreline used as baseline for the buffer zones is a combination of 2022 shoreline data provided by the park (GULN 2022) and manually digitized shorelines using recent aerial imagery (2018-2021). For non-oceanfront shorelines, we used a simple 30-m proximity buffer, updated from 35 meters in the 2015 analysis to maintain the approximate 2050 timeframe.

SLR data: In the initial VA, we used the 2050 8.5 Representative Concentration Pathway (RCP) SLR projections and inundation model (0.25 m rise for GUIS) from Caffrey et al. (2018) to score this exposure indicator. In this updated VA, we used the 2100 4.5 RCP SLR projections and inundation model (0.55 m rise). These data are used as a proxy for 2050 SLR to accommodate higher SLR projections recently released by the National Oceanic and Atmospheric Administration (NOAA; see Peek et al. 2022).

Extreme event flooding data: We used storm surge models produced by NPS (Caffrey et al. 2018) in the initial VA. In this updated VA, we also used the NOAA category 3 high tide inundation model (National Storm Surge Hazard Maps - Version 3; Zachry et al. 2015).

Threshold elevation data: We incorporated elevation data (collected by the NPS Information System Services) into the Flood Damage Potential sensitivity indicator for 65 assets at GUIS (see Peek et al. 2022). These data have not changed since Peek et al. (2015).

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