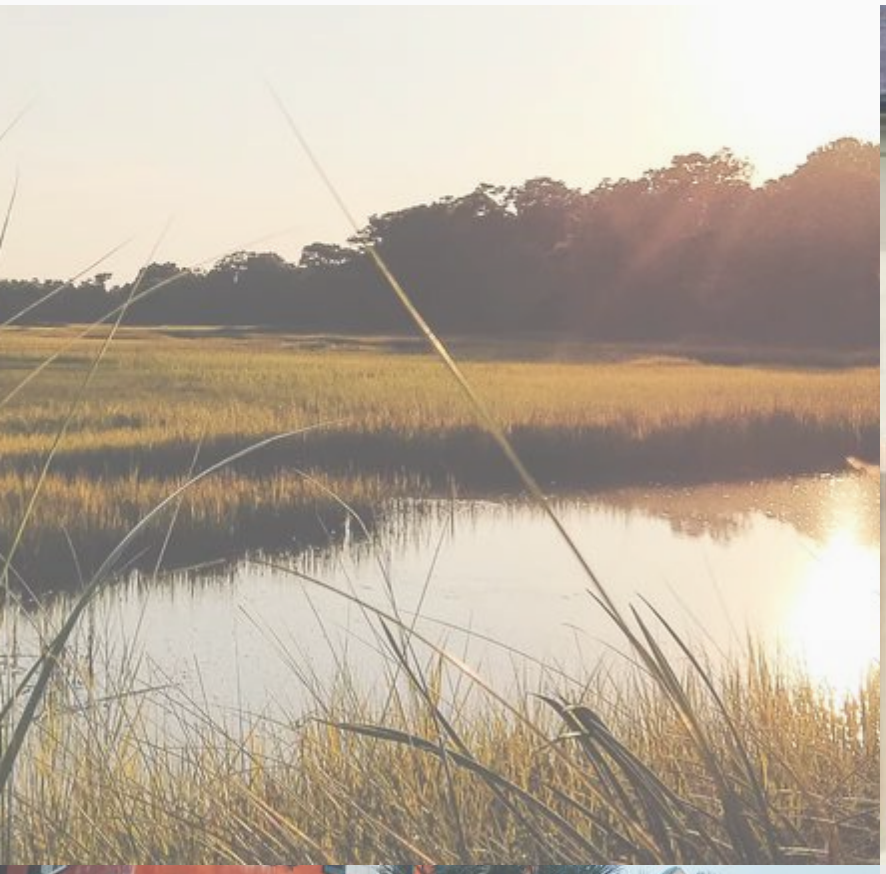
All Hazards Vulnerability and Risk Assessment









City of Charleston

November 2020

Acknowledgements

The consultant team would like to thank and recognize the city staff for their hard work and dedication throughout the course of the assessment process. The City of Charleston is a recognized leader in resilience planning throughout the southeast and that is due to their hard work and leadership. We would also like to thank the team at the College of Charleston and SC Sea Grant for their valuable input for the earthquake assessment.

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The assessment is based on the best available information for specific hazards and assets at the time the analysis was conducted. Quantitative results presented herein are based on data with inherent uncertainties and generalized assumptions; site-specific evaluations of vulnerability and risk are beyond the scope of this assessment and should be reserved for a detailed evaluation of specific adaptation measures. Values should be interpreted as indicators of relative risk among different areas within the city.

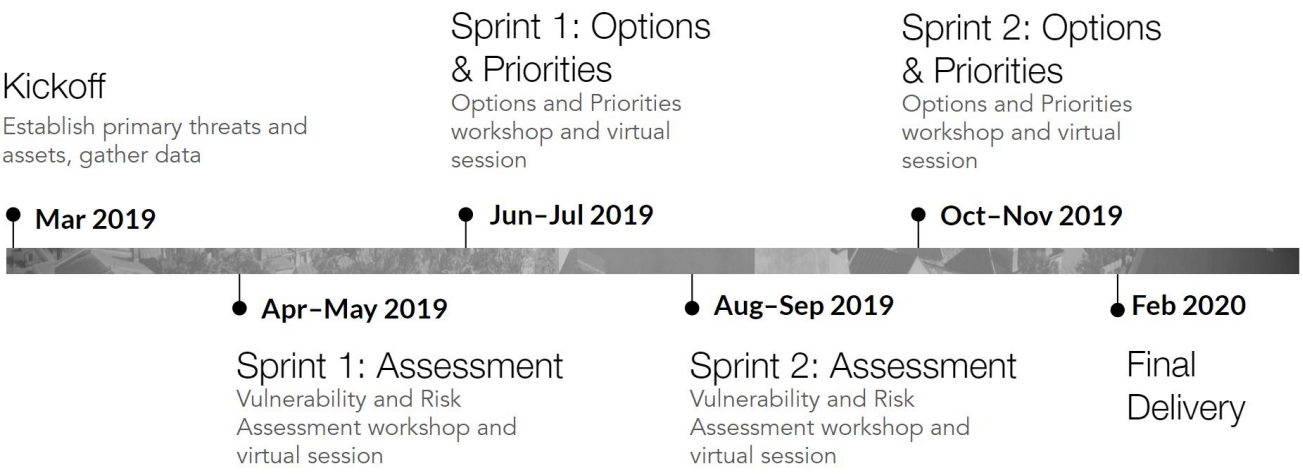
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Report authored November 12, 2020
Analysis: March, 2020 (Revision 1)

Project Team and Timeline

A project team was assembled in March 2019. The team includes a steering committee led by the Mayor's Office of Resilience and Emergency Management, which served as the coordinating staff for the planning process. The steering committee was responsible for logistical coordination, information gathering, and participation in planning needed through the process. A core team was also assembled to participate in workshops and provide input to guide the analysis. A team of consultants led by NEMAC+FernLeaf provided facilitation of the assessment process, as well as scientific analysis and technical support to support the project.

The assessment was carried out over two "sprints," consisting of a series of five in-person workshops and four virtual working sessions, that took place between April and November 2019.



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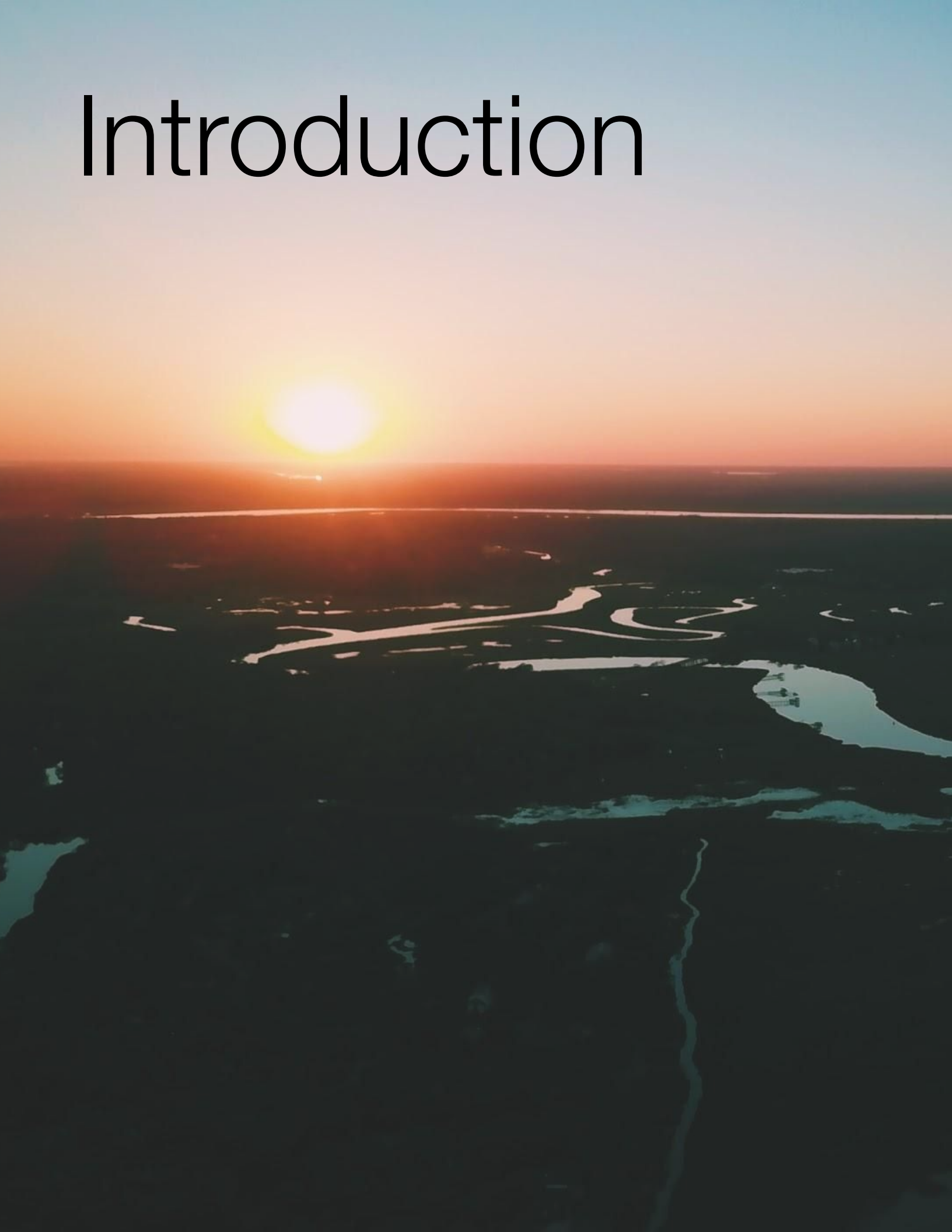
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Introduction





What is Resilience?

Resilience is defined as the capacity of a community, business, or natural system to prevent, withstand, respond to, and recover from a disruption.[1,2] In the southeast and across the nation, many local governments are recognizing the need to build resilience to increasingly frequent and/or severe extreme weather events. Changes in climate will result in existing hazards becoming more frequent and/or severe.[3,4]

Efforts to increase resilience to climate and non-climate impacts are built on the foundation of understanding—and reducing—vulnerability. *Vulnerability* is a ubiquitous term often used to describe susceptibility to harm. In the context of building resilience, a vulnerability assessment is a structured process that identifies ways in which an organization or community is susceptible to harm from existing or potential hazards.

Vulnerability assessments tend to have three main components: (1) exposure; (2) potential impact; and (3) adaptive capacity, where both physical and socioeconomic dimensions are considered. Another key concept used in a resilience assessment is the understanding of risk. Risk involves the likelihood and consequence of a hazard.

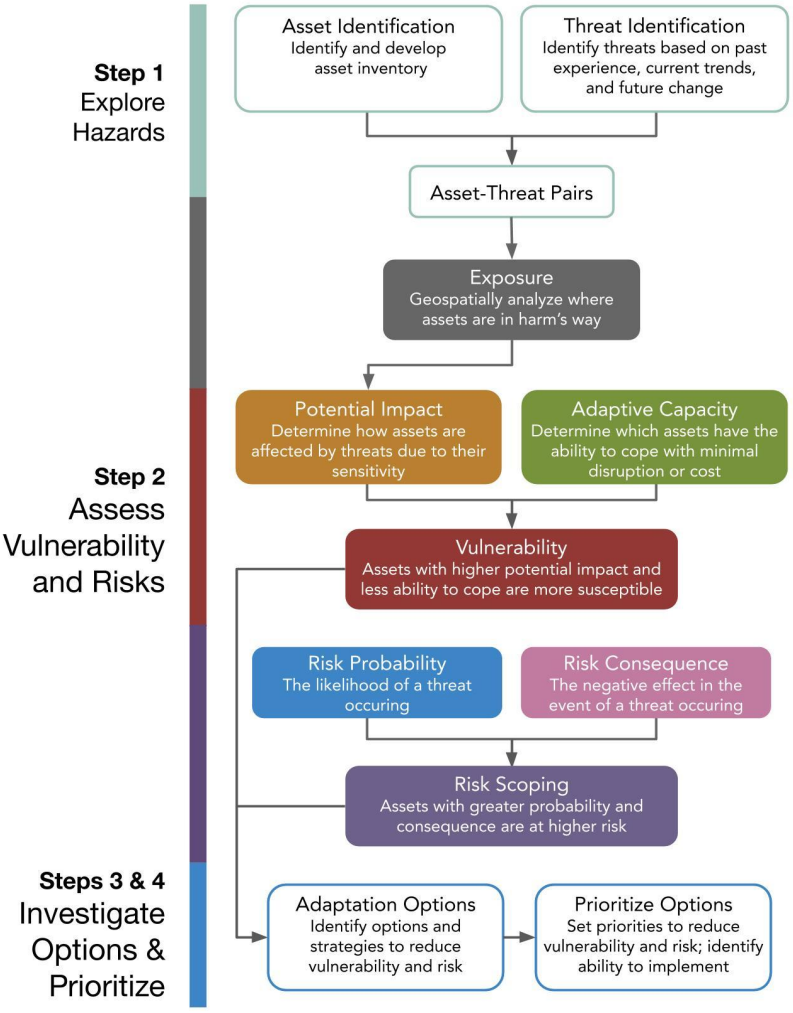
Together, the concepts of vulnerability and risk within a resilience framework can serve to inform the development of strategies to reduce the vulnerability or risk. By taking an integrated viewpoint of these concepts, efforts can focus on building resilience for the assets that are most susceptible and most likely to be impacted. This approach also complements risk-hazard mitigation activities and management practices.

Another important aspect of a resilience assessment is to recognize the iterative nature of the process. Once strategies are implemented, it is necessary to monitor their effectiveness and to update the plan.

The Steps to Resilience

The U.S. Climate Resilience Toolkit[5] provides an iterative, five-step process for communities to follow when planning for climate resilience.

This framework—known as the Steps to Resilience—is used as the foundation of this all-hazards vulnerability and risk assessment. The framework integrates the components of resilience that can be used in existing planning processes at the local level, and can be used to understand the characteristics of vulnerability and risk in a community, inform policy, and evaluate the effectiveness of strategies that are implemented.



Step One: Explore Hazards

Step One suggests that a community begin by researching its past experiences with climate and weather events and explore regional climate trends and projections to understand how assets (people, infrastructure, services, or resources) may be threatened. This is followed by identifying stressors—both climate (for climate-related hazards) and non-climate—that cause or contribute to a hazard event.

Step Two: Assess Vulnerability and Risks

Step Two begins with a vulnerability assessment. The purpose of this step is to understand how a community's assets are susceptible to hazards identified during Step One. This assessment then becomes the foundation for developing options and setting priorities to build resilience in Steps Three and Four.

As stated earlier, *vulnerability* is defined as the susceptibility of societal assets to be impacted due to both physical and social factors. To define vulnerability, the assessment examines both potential impact and adaptive capacity. This can be thought of simply as *vulnerability = potential impact – adaptive capacity.*[1,2,6]

> *Potential impact* includes evaluating sensitivity, or the degree to which exposed assets are potentially affected.
>
> *Adaptive capacity* is the ability to cope with identified impacts with minimal disruption or cost.

Vulnerability is then determined by considering both the potential impact and the adaptive capacity, with the most vulnerable having the highest potential impact and the lowest adaptive capacity.

It is also important to scope the level of risk. Risk depends on both the probability of an event happening and the consequence of that event. That is, what is the chance of a loss? It is important to note that the scoping of risk at this stage is an initial broad classification of risk that can be used to compare general probabilities and consequences of certain threats occurring.

Step Three: Investigate Options

The ultimate goal of Step Three is to have strategies and actionable options to build resilience for the assets that are most vulnerable and at risk. To be actionable, an option should have the potential of building resilience by (1) reducing exposure and potential (removing assets from harm's way), (2) increasing adaptive capacity (increasing the asset's ability to cope with impacts), or (3) supporting response and recovery. In addition, the options identified should be holistic in terms of the types of strategies that are available to local government, such as governance, land use, and infrastructure. For Charleston, these types of strategies are based on the city's Five Critical Components, which are a part of the city's Flooding and Sea Level Rise Strategy.[7]

Step Four: Prioritize and Plan

Step Three often yields a large number of options, and it can be difficult to evaluate and compare them all. Prioritization is a two-part process, the first of which involves looking at the actions that will have the most impact. The second part of the prioritization process is to recognize the resources needed to implement the identified priorities.

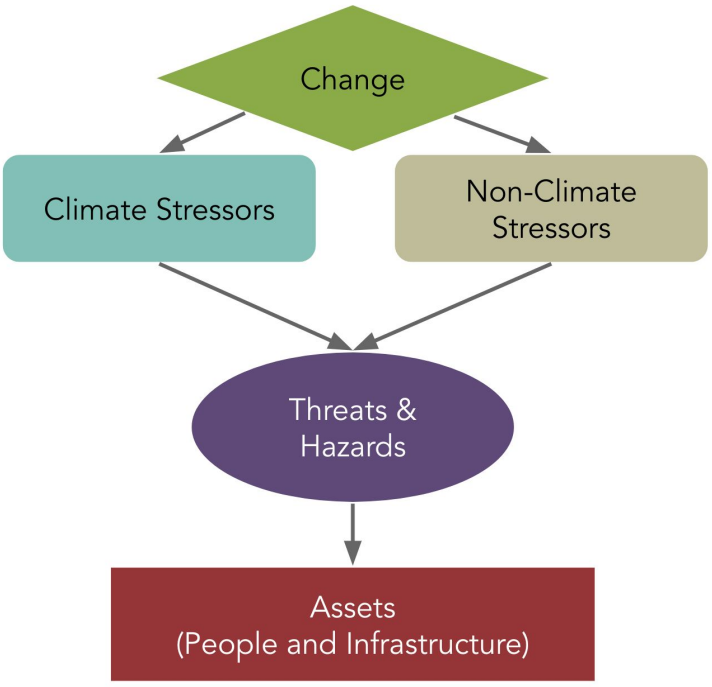
Step Five: Take Action

Step Five can be viewed as the most important, as it involves implementing a plan to build community resilience. This step can take years to fully implement, and it is critical for the community to monitor results as time passes—some of the assumptions made during the original analysis may have been faulty, or on-the-ground implementation may not have been completed. This is to be expected, and the community should be open to modifying its approach as needed and as new information becomes available.

Understanding Impacts and Future Change

One of the main challenges that communities such as Charleston face is the reality of changing conditions. Especially for climate-related impacts, it is important for communities to make informed decisions, and those impacts must be evaluated and measured in a structured way. To begin the evaluation, we ask four primary questions:

1. What are the primary hazards and drivers of changing conditions for the City of Charleston?
2. How do climate and non-climate stressors influence hazards for the city?
3. How do hazards impact the city's assets?
4. Is the city resilient to these hazards (based on past events and possible future)?



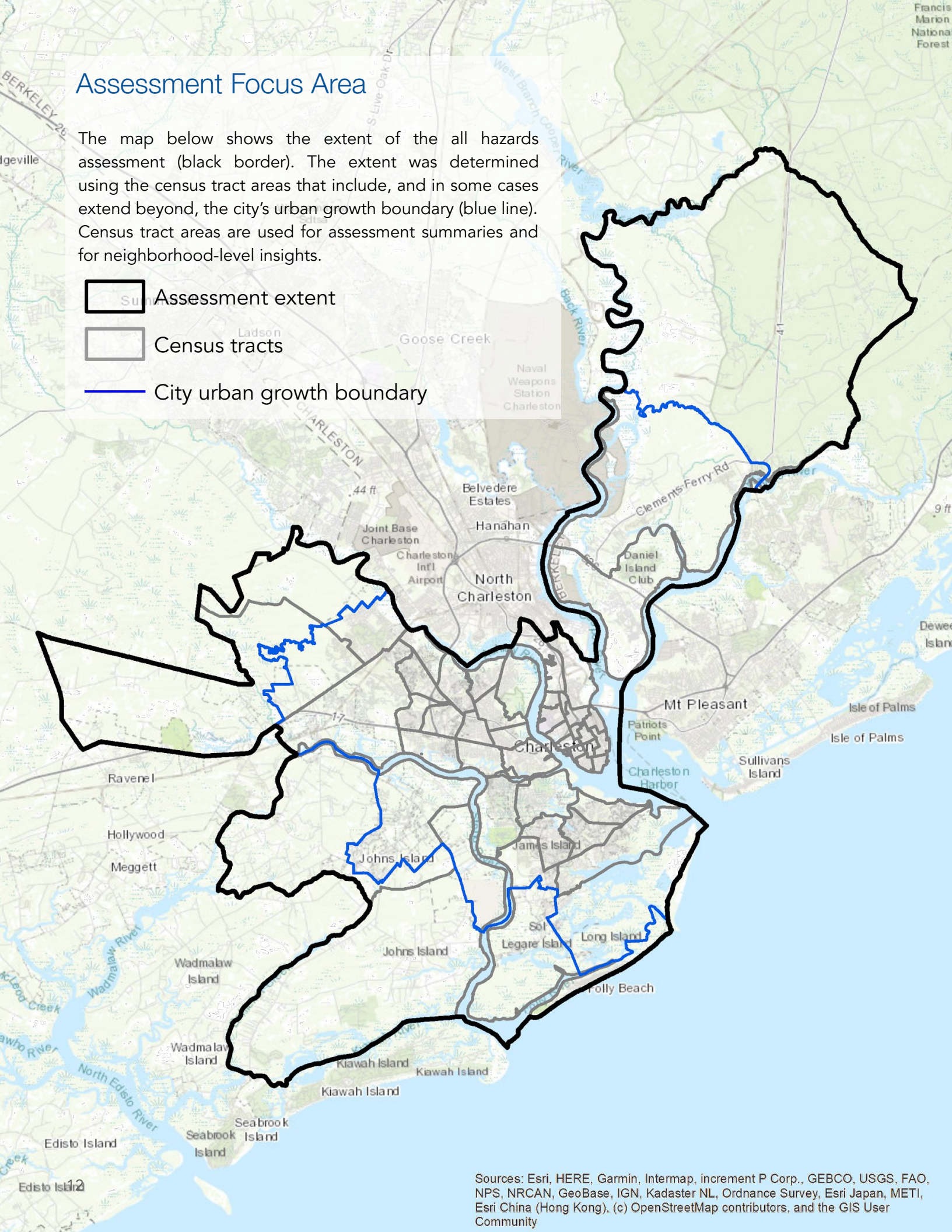
To address these questions, it's best to break the system into its basic building blocks. One way to visualize these building blocks and see how they are related to one another is called a conceptual model—a technique that can be used to explore the causal relationships between stressors, threats, and assets that are potentially affected.

This conceptual model framework (above) illustrates the relationships between climate and non-climate stressors, threats and hazards, and assets that may be affected. The arrows in the model are drawn to reflect the causal influences between these different components. This type of model can also be used to reveal strategies or actions (not shown) that have the potential to reduce vulnerability and build resilience.

As shown in the conceptual model, climate threats and hazards are the result of the interaction between climate and non-climate stressors. For example, the amount of precipitation (or lack thereof) in and of itself is not a hazard. However, extreme precipitation is a climate stressor if enough precipitation falls in a given time, or in combination with a substantial amount of impervious surface (a non-climate stressor) that can lead to the threat of flooding. In this example, future increases in either climate or non-climate stressors could result in increased frequency or severity of the flooding hazard.

Assessment Focus Area

The map below shows the extent of the all hazards assessment (black border). The extent was determined using the census tract areas that include, and in some cases extend beyond, the city's urban growth boundary (blue line). Census tract areas are used for assessment summaries and for neighborhood-level insights.

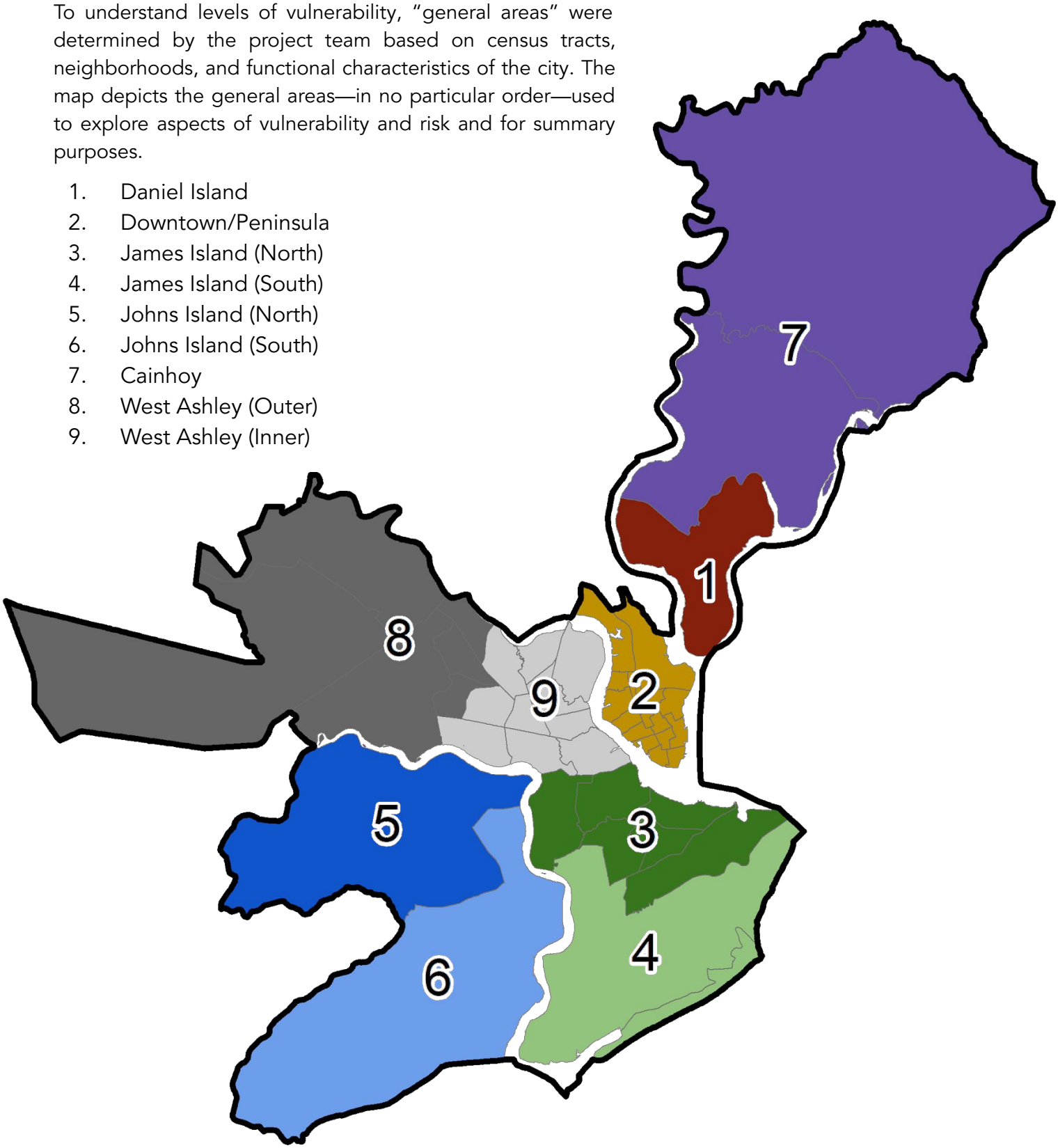


Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community

General Areas

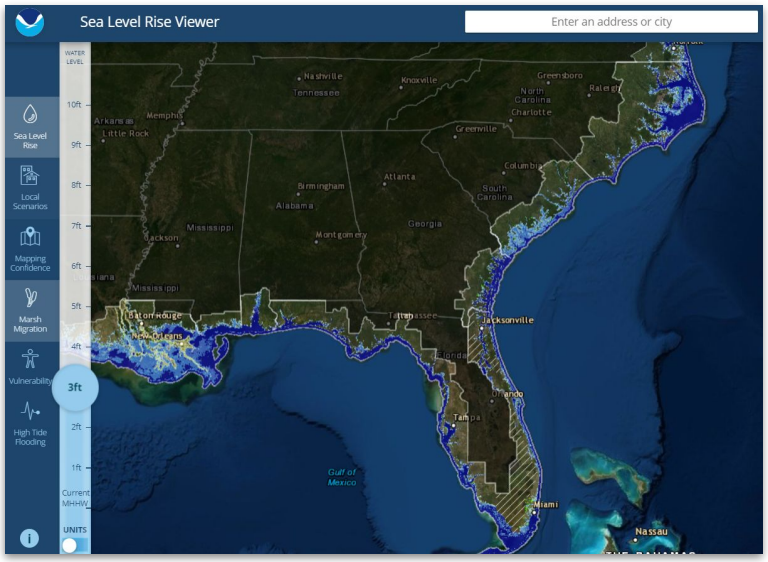
To understand levels of vulnerability, "general areas" were determined by the project team based on census tracts, neighborhoods, and functional characteristics of the city. The map depicts the general areas—in no particular order—used to explore aspects of vulnerability and risk and for summary purposes.

1. Daniel Island
2. Downtown/Peninsula
3. James Island (North)
4. James Island (South)
5. Johns Island (North)
6. Johns Island (South)
7. Cainhoy
8. West Ashley (Outer)
9. West Ashley (Inner)

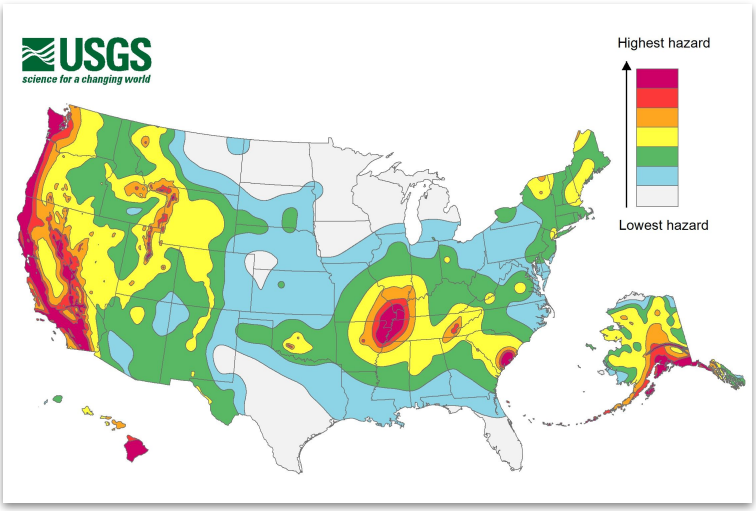


Hazards

The assessment considers eight hazards in total, including four different types of flooding. Of the eight hazards assessed, six are related to climate. The consultant team was not tasked with developing any new hazard models; therefore, the best available existing datasets were used for each hazard assessment.



Trusted sources of information and national data products, such as the NOAA Sea Level Rise Viewer (shown top right) and the USGS National Earthquake Hazard map (shown bottom right) provide invaluable information for identifying hazards at the national and regional level.[a, b] However, hazard data products must be combined with local asset information from communities in order to create actionable information, which is the role of a local-scale vulnerability assessment.



Several of the hazards selected for this assessment have impacted Charleston in the past. As discussed previously, climate-related hazards are the result of both climate and non-climate stressors.

Therefore, changing climate and non-climate stressors have the potential to cause changes in the frequency or severity of the hazards that could impact Charleston in the future.

Climate Stressors

The primary climate stressors for Charleston are:

- Heavy precipitation events
- Drought
- Tropical systems
- Sea level rise (which is both a climate stressor and a hazard)
- Temperature variability

a. The Sea Level Rise Viewer is maintained by NOAA's Office for Coastal Management, https://coast.noaa.gov/digitalcoast/tools/slr.html
b. The USGS 2018 Long-term National Seismic Hazard Map is based on the most recent USGS models for the conterminous U.S., https://www.usgs.gov/natural-hazards/earthquake-hazards/hazards

Non-Climate Stressors

Non-climate stressors are factors or conditions that contribute to the occurrence of a threat. For example, impervious surfaces are a non-climate stressor and are known to contribute to increased runoff, erosion, and flooding in urban areas, and impervious surfaces and buildings contribute to the urban heat island effect. The primary non-climate stressors for Charleston include:

- Population growth and land use conversion
- Socioeconomic disparity
- Commuting time
- Water demand

Both climate and non-climate stressors have the potential to change in the future and increase risk for Charleston. In some cases, changes to non-climate stressors can have greater influence on hazards than climate stressors.

The table below lists the hazards addressed in the assessment along with their associated climate and non-climate stressors. This inventory of hazards was based on the project team's institutional knowledge of past events, the NOAA National Centers for Environmental Information (NCEI) Storm Events Database,[8] and regional climate trends and projections from the third and fourth National Climate Assessments.[1,9] The assessment section of this report includes more detailed descriptions of each hazard considered in the assessment.

Hazards Considered in the Assessment

Data sources and additional notes are included in Appendix A.

Hazard	Climate Stressors	Non-Climate Stressors
Floodplain Inundation	Sea level rise, heavy precipitation	Impervious surfaces, land use change
Tidal Flooding (Current)	Sea level rise, heavy precipitation	Impervious surfaces, land use change
Storm Surge	Sea level rise, tropical systems	Land use change
Sea Level Rise and Future Tidal Flooding	Sea level rise	Land use change
Earthquake	N/A	Land use change
Hazardous Materials (Hazmat)	N/A	Land use change
Extreme Heat	Temperature variability	Socioeconomic vulnerability
Water Shortage	Drought, sea level rise	Water use/demand

Core Systems and Assets

In this resilience assessment process, *core systems* were defined as the tangible and intangible things that people or communities value and expect its city leaders to manage and protect. The purpose of the all-hazards assessment is to provide city leaders and staff with a resource to continuously assess and better manage its core systems and services in response to the impacts of key hazards. Therefore, defining and representing these core systems is an important aspect of the assessment.

The following core systems were identified by the project team and include the lifelines essential to the survival of the city's citizens or that are vital for the city to maintain operations and grow:

- Communities & Homes
- Utilities
- Transportation
- Public Safety
- Economy
- Health & Wellness
- Environment & Sustainability

Assets specific to the city were then identified in order to represent and assess the vulnerability of these core systems. The following list of themes and assets were used as the basis of the all-hazards assessment and for the summary of vulnerability and risk metrics. Most assets were represented using county property parcel datasets for Charleston and Berkeley Counties. Data sources for all assets are provided in Appendix A, asset maps and socioeconomic variables are provided in Appendix B.

PROPERTY & PUBLIC SERVICES

Core Systems	Assets	Total
Economy Communities & Homes	Commercial & Industrial Property Includes non-residential properties that serve businesses and organizations. They also typically support commerce, jobs, and tourism.	3,368 parcels
Communities & Homes	Residential Property Includes all single-family residences, multiple-family residences, low-income housing, apartments, manufactured houses, and mobile home parks.	61,781 parcels
Public Safety Health & Wellness	Government-Owned Property Includes all federally-, state-, county-, and city-owned properties, except for those associated with parks and recreation and critical facilities.	144 parcels
Utilities Public Safety	Critical Facilities Includes fire and police stations that aid in emergency response, some utilities, as well as other critical facilities not included in another category.	347 parcels
Communities & Homes Environment & Sustainability Health & Wellness	Parks & Cultural Property Includes parks and recreational facilities and buildings or properties that are cultural landmarks or other historic resources.	659 parcels

ROADS & MOBILITY

Core Systems	Assets
Transportation Economy Public Safety	Major Roads Includes all major and secondary roads and considers the critical access they provide for emergency services. Road connectivity and accessibility by fire/emergency services was also considered.
Transportation Public Safety	Minor Roads Includes all residential and tertiary roads. Road connectivity and accessibility by fire/emergency services was also considered.



ECONOMIC FACTORS

Core Systems	Assets	Total
Economy	Annual Sales Volume Total reported annual sales volume for individual companies and businesses.	$36B
Economy Communities & Homes	Jobs/Employees Total number of jobs or employees reported for individual companies and businesses.	217,942 jobs

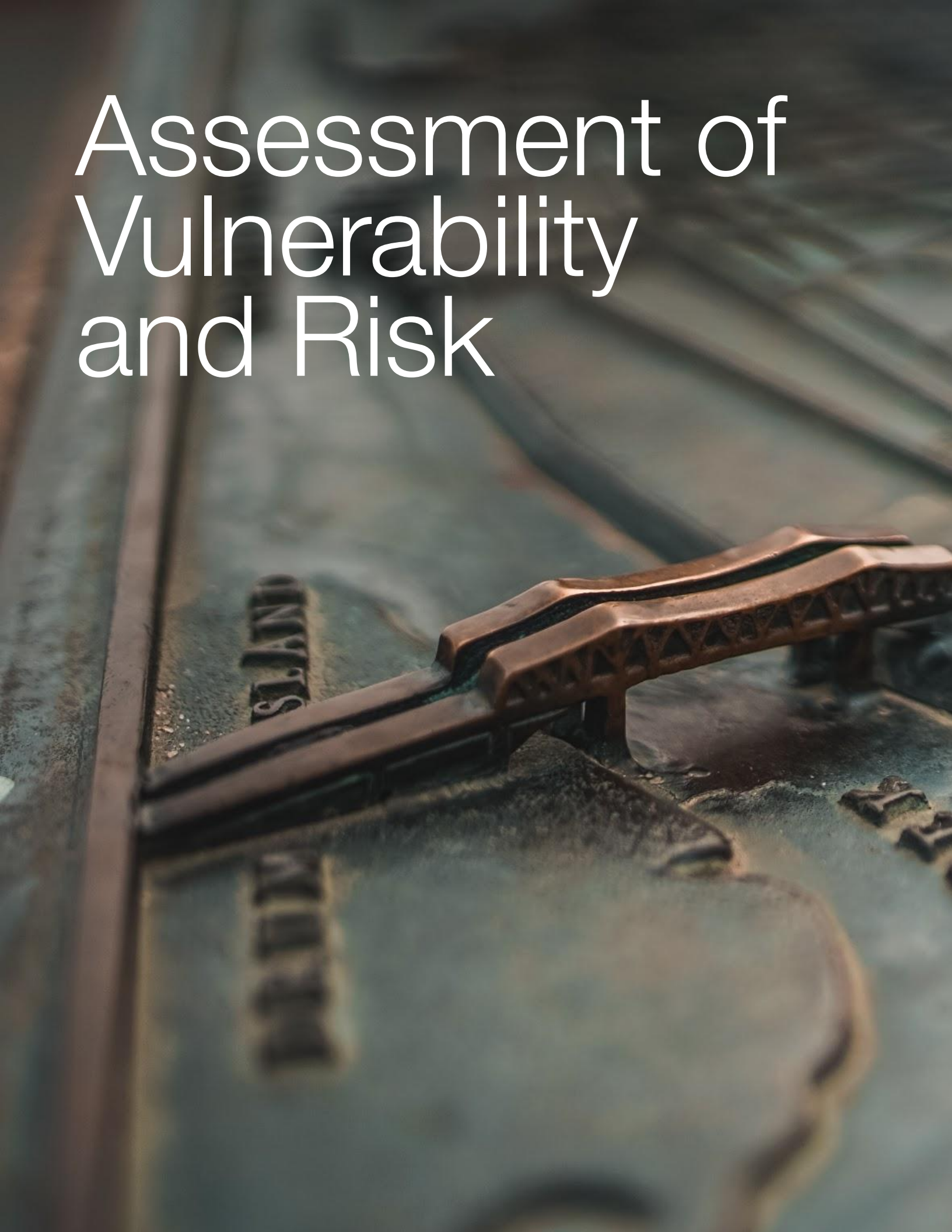


PEOPLE & SOCIOECONOMICS

Core Systems	Assets	Total
Communities & Homes	Total Population 15 socioeconomic and demographic metrics are available to examine characteristics of populations and households at the census tract level.	186,782 people
Communities & Homes	Public Housing Also part of Residential and/or Government-Owned Property, includes all identified public housing.	103 parcels
Communities & Homes Health & Wellness	SNAP Food Retailers Also part of Commercial & Industrial Property, includes all SNAP retailers identified by USDA-FNS.	122 parcels

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Assessment of Vulnerability and Risk





Vulnerability And Risk Assessment Process

The project team applied a vulnerability and risk assessment framework to every combination of hazards and assets identified. These are referred to as asset-hazard pairs and each was evaluated separately, even though some hazards may be interrelated (e.g., floodplain inundation and tidal flooding). The flowchart at right shows each component of the assessment framework and how they come together to inform both vulnerability and risk. Each of these core concepts and the resulting assessments were explored in detail during the workshops and working sessions with the project team.



For most asset-hazards pairs, the vulnerability and risk assessment components were applied at the asset scale. For example, commercial property and tidal flooding was assessed at the parcel and building level. These core concepts were applied using a data-driven technique with rulesets developed by the project team based on factors consistent with the framework concepts.

Classifications of vulnerability and risk were assigned using data attributes and spatial analysis. Most asset-hazard pairs were assessed through vulnerability and risk; however, a few hazards were assessed only through exposure (5-foot sea level rise/future tidal flooding) and vulnerability (earthquake and extreme heat). Water shortage is the only non-spatially explicit hazard addressed in the assessment.

Definitions

Exposure: The presence of assets in harm's way.
Vulnerability: The susceptibility of exposed assets based on the two core concepts: (1) potential impact—the degree to which an asset is affected due to its sensitivity; and (2) adaptive capacity—the ability the asset has to cope with a potential impact with minimal disruption or cost.
Risk: The probability (likelihood) and the consequence, or negative outcome, of a hazard occurring.

Value-Based Metrics and Insights



PROPERTY & PUBLIC SERVICES

Direct impact assessments for a range of property assets, such as commercial, residential, critical facilities, and government. Assessments consider property- and building-level characteristics and the services they provide in defining vulnerability and risk.



ROADS & MOBILITY

Road connectivity and road network assessments that consider: (1) how roads could be directly impacted (e.g., inundated by flooding); (2) roads that may not be directly impacted but could become inaccessible by emergency response; and (3) properties that could become isolated and inaccessible during hazard events.



ECONOMIC FACTORS

Assessment of two potential economic impact factors: (1) total annual sales volume; and (2) number of jobs/employees. Both of these economic factors are related to the property-based assessments to provide insight into the proportion of sales and jobs that could be affected by each hazard.



PEOPLE & SOCIOECONOMICS

A key consideration for all hazard assessments; considers overall social vulnerability using the CDC's Social Vulnerability Index (SVI).[10] The SVI is based on five themes, including socioeconomic status, minority status and language, household composition and disability, and housing and transportation. In addition to these, metrics from the property assessment were considered, including public housing and food SNAP retailers that are vulnerable and at risk.

Key Findings and Summaries

The primary goal of the assessment was to perform and present the methods and findings with transparency—which is key if the assessment is to be successfully used and integrated for resilience planning. Key findings and summaries for each hazard assessment are presented on the following pages, which include the following information:

- A brief description or definition of the hazard
- Assessment dataset(s)
- General approach and criteria
- Key findings, including (1) overall vulnerability from the perspective of each asset theme, (2) general areas in the city that are most vulnerable, and (3) supporting key findings

In addition to these summaries, more detailed and specific information about each hazard assessment is provided in the following appendices:

- *Appendix C: Analysis Technical Documentation.* Detailed technical documentation and assessment methodology.
- *Appendix D: General Area Reports.* An area-specific profile and summary table is provided for every general area of the city (nine areas total).
- *Appendix E: Asset-Hazard Pair Vulnerability and Risk Profiles.* For every property-based asset, an asset-hazard profile is provided (35 asset-hazard pairs total). Each profile includes a general description, a vulnerability and risk map, summary statistics, and assessment ruleset summaries.

Citywide Summary of Vulnerability and Risk

All areas of the city and most assets are vulnerable to hazards; however, there are differing types and levels of vulnerability in different areas of the city.

Characteristics of hazards, including the type of impact and the frequency of occurrence, should be considered when comparing vulnerability and risk metrics across different hazards. For example, impacts from tidal flooding and storm surge are inherently different.

Key Findings

- Based on the total number of assets, the highest levels of vulnerability citywide are to the hazards of floodplain inundation, storm surge, and earthquake.
- More than half (52%) of all flood-prone properties in the city have buildings that were built before any floodplain development requirements were in place.
- While properties are prone to flooding throughout the city, some areas have much higher levels of vulnerability and risk—especially for commercial property, critical facilities, and government-owned property.
- Storm surge has the potential to impact almost any area of the city. A large storm surge event could have devastating impacts to the core systems and assets that keep the city functioning.
- While fewer assets are vulnerable to current tidal flooding and hazmat hazards, they occur most frequently. Understanding the cumulative effect of hazard events is important.
- The city could face increasing risk due to several factors (both climate and non-climate), particularly sea level rise, increasing frequency and severity of heavy precipitation events, and land use conversion.
- A primary impact from sea level rise will be the increased frequency and severity of tidal flooding.
- Social vulnerability is an important consideration for all threats. Many areas that are the most vulnerable to hazards are also the most socially vulnerable.

Extreme Heat & People

Extreme heat was assessed at the census tract level for the city. This screening-level assessment found that, in the most vulnerable areas (medium to high), there are about 1,900 households with members 65 years of age or older and about 2,900 households living below the poverty line.

Water Shortage & Water Supply

There were two impacts considered for water shortage: shortage due to drought and shortage due to salinity impacts. For both, current levels of vulnerability are relatively low to moderate. However, due to changing climate conditions and sea level rise, historic conditions should not be the basis for understanding the potential for future risk from both types of impacts.

Theme and Asset	Asset Total	Floodplain Inundation	Storm Surge	Tidal Flooding	Sea Level Rise / Future Tidal Flooding		Earth-quake (Vuln)	Hazardous Materials
					3 ft + MHHW	5 ft + MHHW (Exp)		
Property & Public Services								
Commercial	3,368	2,380 (71%)	3,153 (94%)	102 (3%)	183 (5%)	715 (21%)	1,556 (46%)	1,045 (31%)
Residential	61,781	43,118 (70%)	58,915 (95%)	2,041 (3%)	4,009 (6%)	18,994 (31%)	24,328 (39%)	5,845 (9%)
Critical Facilities	347	210 (61%)	279 (80%)	27 (8%)	42 (12%)	123 (35%)	304 (88%)	124 (36%)
Government-Owned	144	104 (72%)	108 (75%)	17 (12%)	27 (19%)	69 (48%)	136 (94%)	84 (58%)
Parks and Cultural	659	406 (62%)	499 (76%)	42 (6%)	72 (11%)	255 (39%)	612 (93%)	180 (27%)
Historic	3,562	3,372 (95%)	3,378 (95%)	301 (9%)	636 (18%)	1,507 (42%)	2,894 (81%)	2,516 (71%)
Roads & Mobility								
Major Roads Inaccessible (Lane miles)	596	250 (42%) [100-yr]	496 (83%) [Cat 3]	22 (4%)	67 (11%)	149 (25%)	34 (44%) Bridges	N/A
Minor Roads Inaccessible (Lane miles)	3,007	1,775 (59%) [100-yr]	2,618 (87%) [Cat 3]	538 (18%)	753 (25%)	1,277 (42%)		
Inaccessible Property	69,153	41,346 (60%) [100-yr]	64,901 (94%) [Cat 3]	7,634 (11%)	15,128 (22%)	28,219 (41%)		
Economic Factors								
Annual Sales Volume	$14.4B	$11.8B (82%)	$13.9B (97%)	$1.9B (13%)	$2.1B (15%)	$4.4B (30%)	$10.1B (70%)	N/A
Jobs / Employees	74K	60K (81%)	71K (97%)	15K (21%)	18K (24%)	29K (40%)	50K (68%)	
People & Socioeconomics								
Overall SVI	Neighborhood areas (census tracts) with the highest overall social vulnerability are in Downtown/Peninsula, West Ashley (Inner), and Cainhoy areas (see CDC's Social Vulnerability Index in Appendix B)							
Public Housing	103	93 (90%)	102 (99%)	5 (5%)	8 (8%)	41 (40%)	N/A	N/A
SNAP Retailers	122	81 (66%)	117 (96%)	6 (5%)	12 (10%)	40 (33%)	N/A	N/A

1. Asset total column reflect citywide totals. Percentages reflect the percent of assets citywide vulnerable and at risk.
2. Inaccessible property refers to all properties regardless of type.
3. Sea Level Rise/Future Tidal Flooding 5 ft + MHHW shows exposure instead of vulnerability and risk.
4. Earthquake refers to vulnerability.
5. Economic factors report sales and employees associated with commercial property.

Floodplain Inundation

Summary of Key Findings

PROPERTY & PUBLIC SERVICES
High vulnerability and risk

Downtown/Peninsula, West Ashley (Inner), James Island (North)

The majority of vulnerable critical facilities, government-owned, and commercial assets in the city are located in the Downtown/Peninsula area.

About 70% of all residential properties in the city are highly vulnerable and at risk to flooding.

ROADS & MOBILITY
High vulnerability and risk

West Ashley (Inner and Outer), James Island (North), Downtown/ Peninsula, Johns Island (South)

Major corridors and neighborhoods have the potential for being isolated and inaccessible.

ECONOMIC FACTORS
High vulnerability and risk

Downtown/Peninsula, James Island (North), West Ashley (Inner)

About 80% of the city's annual sales volume and jobs/employees are highly vulnerable.

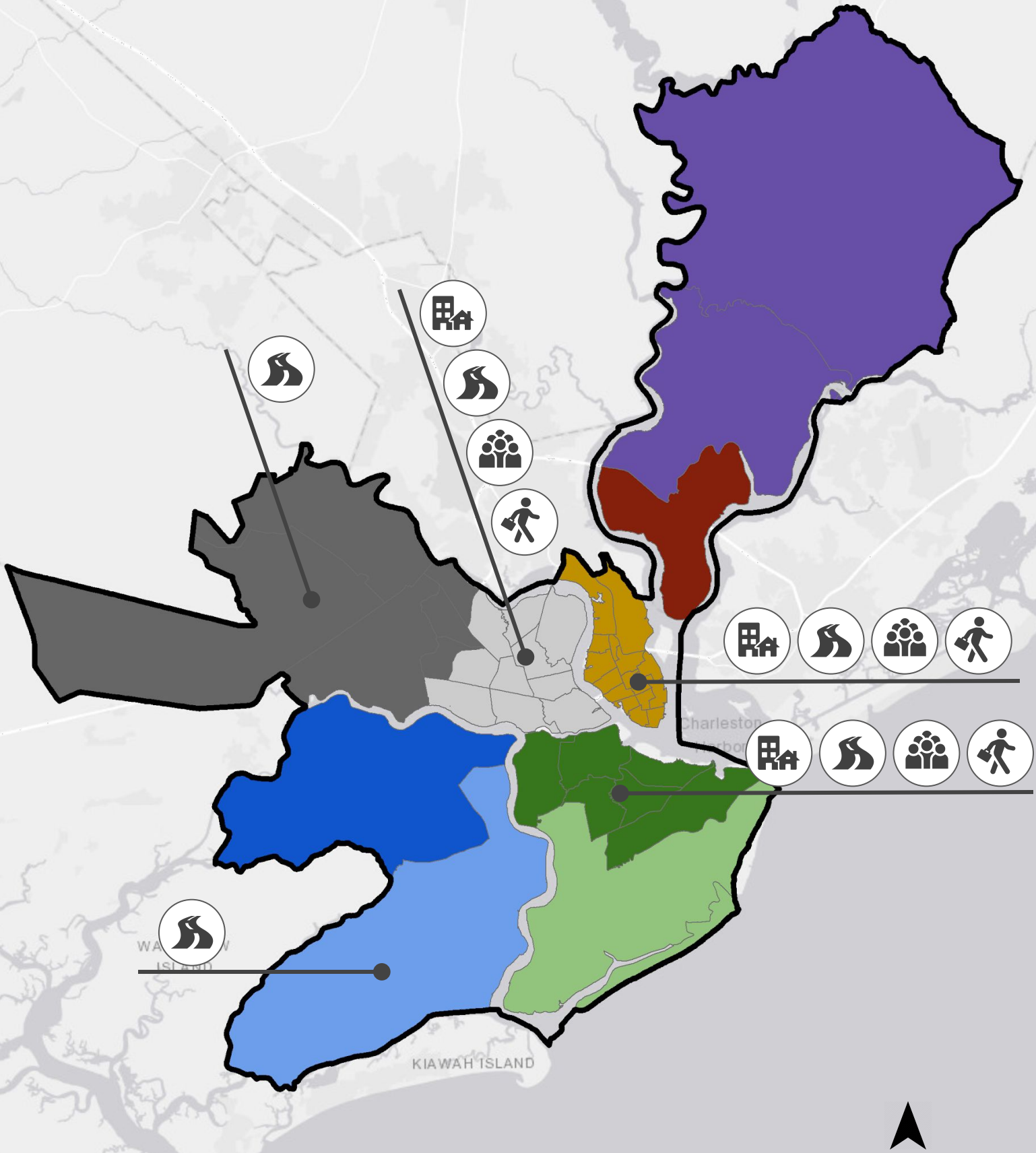
PEOPLE & SOCIOECONOMICS
High vulnerability and risk

Downtown/Peninsula, West Ashley (Inner), James Island (North)

Several areas most vulnerable to flooding are also the most socially vulnerable.

Note: The areas listed here and the map on the next page highlight areas of the city with a high proportion of citywide vulnerability and risk for each of the four asset themes. For a full account on number and proportion of assets vulnerable in every area of the city refer to Appendix D: General Area Reports and Appendix E: Asset-hazard pair vulnerability and risk profiles.

Floodplain Inundation: Areas with High Proportions of Citywide Vulnerability and Risk



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Floodplain Inundation Defined

FEMA flood zones are characterized by how likely a certain level, or extent, of flooding is likely to recur or be exceeded over a time period. For example, the terms "100-year flood" or "1-percent annual exceedance probability flood" are used to refer to a magnitude of a flood that has a greater than one percent chance of occurring or being exceeded in any given year. Put differently, a 100-year flood has a 26% chance of occurring over the course of 30 years or a 39.5% chance over the course of 50 years. In addition to the 100-year flood zones, other flood zones considered in the floodplain inundation assessments include floodway, wave action areas, and the "500-year flood" zone, or "0.2-percent annual exceedance probability flood."

In coastal areas such as Charleston, FEMA flood zones represent a combination of rainfall-induced and storm surge flooding.

Rainfall-induced flooding typically occurs when rivers, lakes, or ponds overflow their banks or when urban drainage systems are overwhelmed by the stormwater trying to enter the system due to an extended and/or an extreme rainfall event.

Storm surge refers to the flooding resulting from an abnormal rise in tide, over and above the astronomical tide, generated by a severe storm.

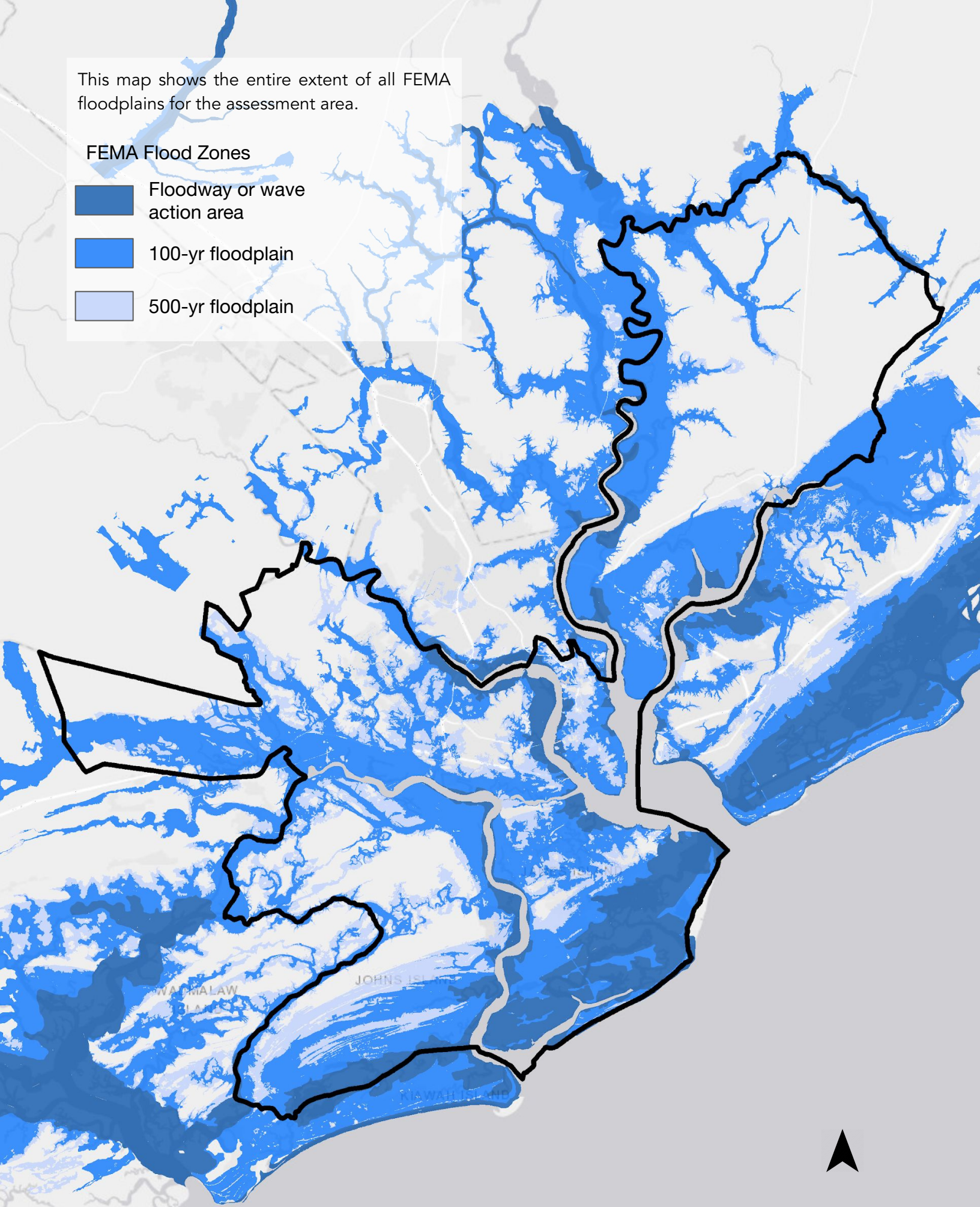
How Floodplain Inundation Was Assessed

The assessment uses the most recent floodway, wave action, 100-year floodplain, and 500-year floodplain in the Flood Insurance Rate Map (FIRM) developed by the Federal Emergency Management Agency (FEMA) to support the National Flood Insurance Program (NFIP).[11] Note that these were recently revised for Charleston County by FEMA and as of May 2019 are not yet "effective" as a Flood Insurance Rate Map.

The assessment of floodplain inundation focused on identifying assets that have greater potential impact, such as critical assets (e.g., major medical facilities) or where more people could be affected (e.g., apartment buildings). The assessment also considered how adaptive buildings are based on the year they were built and the Base Flood Elevation (BFE) requirement in place at the time they were built.

Assessment Factors

- ✓ Criticality of buildings in floodplain
- ✓ Floodplain development BFE requirements
- ✓ Likelihood of flooding (e.g., 100-year vs. 500-year flood risk)



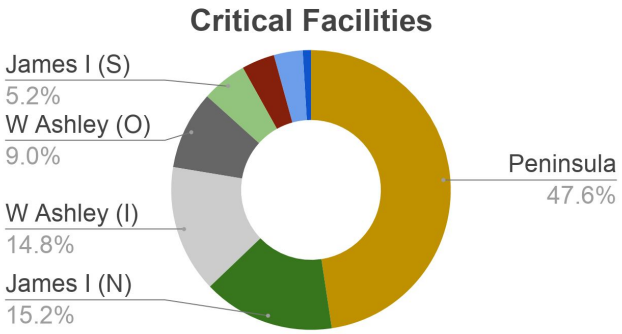
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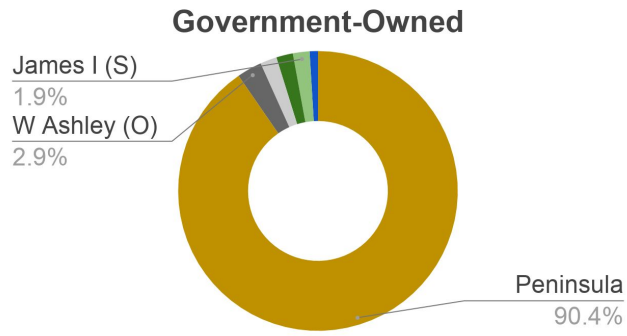
Floodplain Inundation Impacts on Property & Public Services

High Vulnerability and Risk

Most vulnerable areas: Downtown/Peninsula, West Ashley (Inner), James Island (North)

The majority of vulnerable critical facilities, government-owned, and commercial assets in the city are located in the Downtown/ Peninsula area. The graphs at right show the locations of highly vulnerable critical facilities and government-owned property proportionally by general area—about 48% of all highly vulnerable critical facilities and 90% of highly vulnerable government-owned property are in the Downtown/Peninsula area (shaded in yellow).

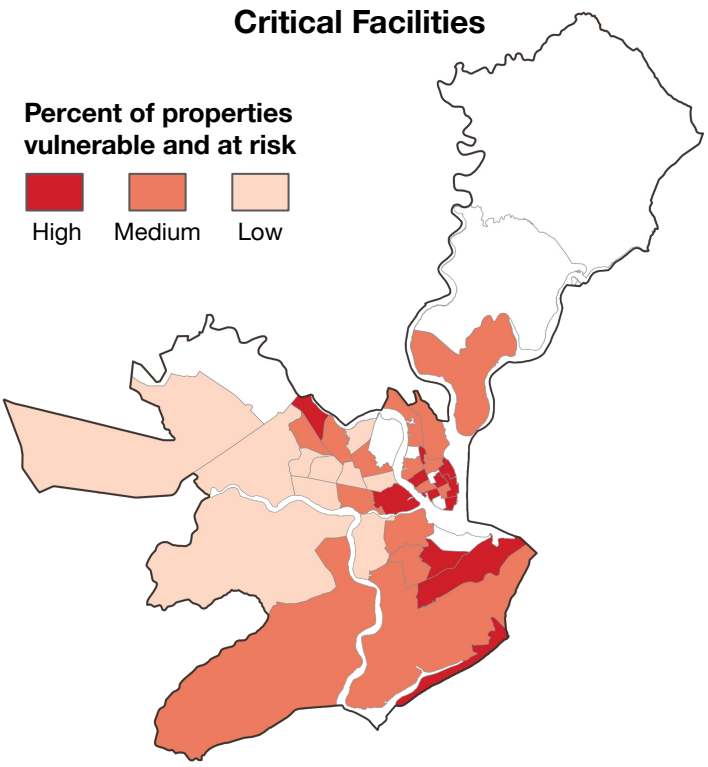




Looking at more specific types of critical facilities, important types of properties are highly vulnerable, including:

- 31 (56%) public safety properties (including fire and police)
- 78 (69%) schools and community center properties
- 58 (67%) medical facility properties
- 16 (31%) energy and utility properties

Critical facilities in the most vulnerable areas can be explored in further detail using a summary map (shown at right, from Appendix E). The map highlights areas in the city with the highest percentage of vulnerable and at-risk facilities (shaded in dark red).



About 70% of all residential properties in the city are highly vulnerable and at risk to flooding. The most vulnerable areas are about evenly shared between James Island (North), Downtown/Peninsula, and West Ashley (Inner).

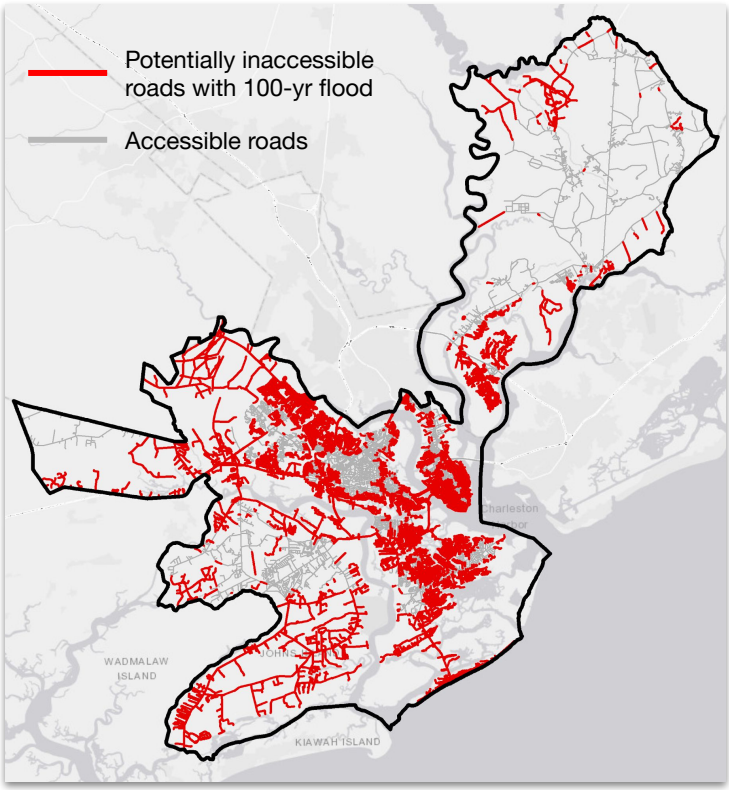
Floodplain Inundation Impacts on Roads & Mobility

High Vulnerability and Risk

Most vulnerable areas: West Ashley (Inner and Outer), James Island (North), Downtown/Peninsula, Johns Island (South)

Major corridors and neighborhoods have the potential for being isolated and inaccessible. For major roads, the vulnerable areas include West Ashley (Inner), West Ashley (Outer), and Downtown/Peninsula. These include roads that provide access to emergency response and critical services, such as hospitals. For minor roads, the most vulnerable include West Ashley (Inner and Outer), James Island (North), and Johns Island (South). The map shows all roads potentially inaccessible in a 100-year flood event.

Potentially Inaccessible Roads



Floodplain Inundation Impacts on Economic Factors

High Vulnerability and Risk

Downtown/Peninsula, James Island (North), West Ashley (Inner)

About 80% of the city's annual sales volume and jobs/employees are highly vulnerable. These numbers are based on reported sales volume and number of employees at businesses where the properties have high or medium vulnerability and risk. These include only direct impact vulnerability; excluded are the amount of sales or jobs that may be associated with indirect impacts, such as business interruption, inaccessibility, and other impacts. The majority of these are located in the Downtown/Peninsula area.

Floodplain Inundation Impacts on People & Socioeconomics

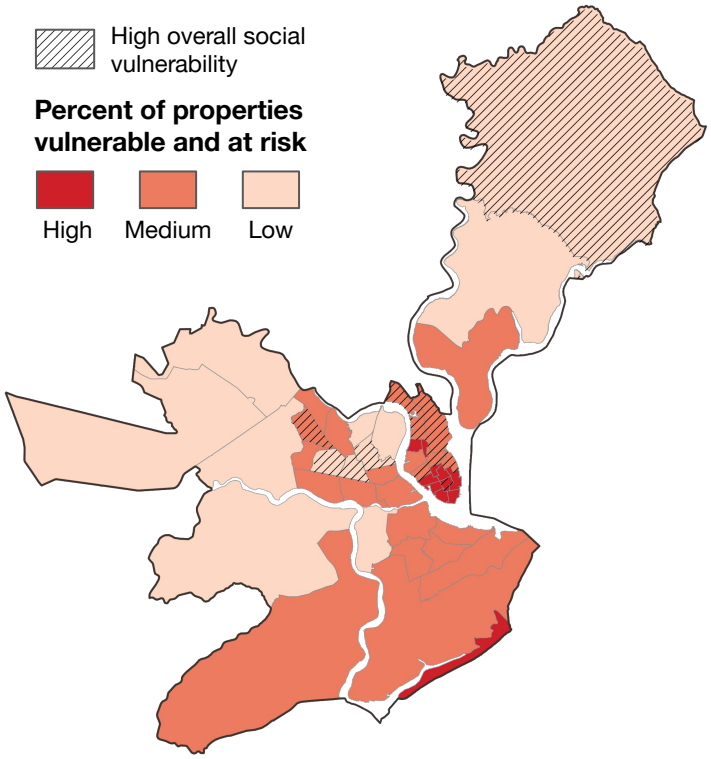
High Vulnerability and Risk

Most vulnerable areas: Downtown/Peninsula, West Ashley (Inner), James Island (North)

Several areas most vulnerable to flooding are also the most socially vulnerable. In all of the areas with at least 70% of homes vulnerable and at risk (see residential property map to the right), six have among the highest overall social vulnerability in the city; most of these are in the Downtown/Peninsula area.

Public housing properties are also proportionally more vulnerable to flooding based on the FEMA floodplains compared to other residential property in the city. The majority of SNAP retailers are also highly vulnerable to flooding in all but two areas of the city. Most of these are located in the Downtown/Peninsula and West Ashley (Inner) areas.

Residential Property



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Storm Surge

Summary of Key Findings

PROPERTY & PUBLIC SERVICES
High vulnerability and risk
Citywide

More properties are vulnerable to potential storm surge than any other type of flooding hazard. High percentages of properties are vulnerable to storm surge, including almost 90% of all residential properties in the city and at least 70% of all other property types. This does not mean that all of the vulnerable properties are likely to be impacted by a single event; rather, these properties are susceptible to a storm of a certain size on a possible track.

ROADS & MOBILITY
High vulnerability and risk
Citywide

Almost all of the city (94% of all property) is vulnerable to the loss of road access at a worst-case Category 3 storm surge level. Again, it is unlikely that all of the city would experience this level of inaccessibility from a single event; rather, these properties are vulnerable to a potential scenario at this level.

ECONOMIC FACTORS
High vulnerability and risk
Citywide

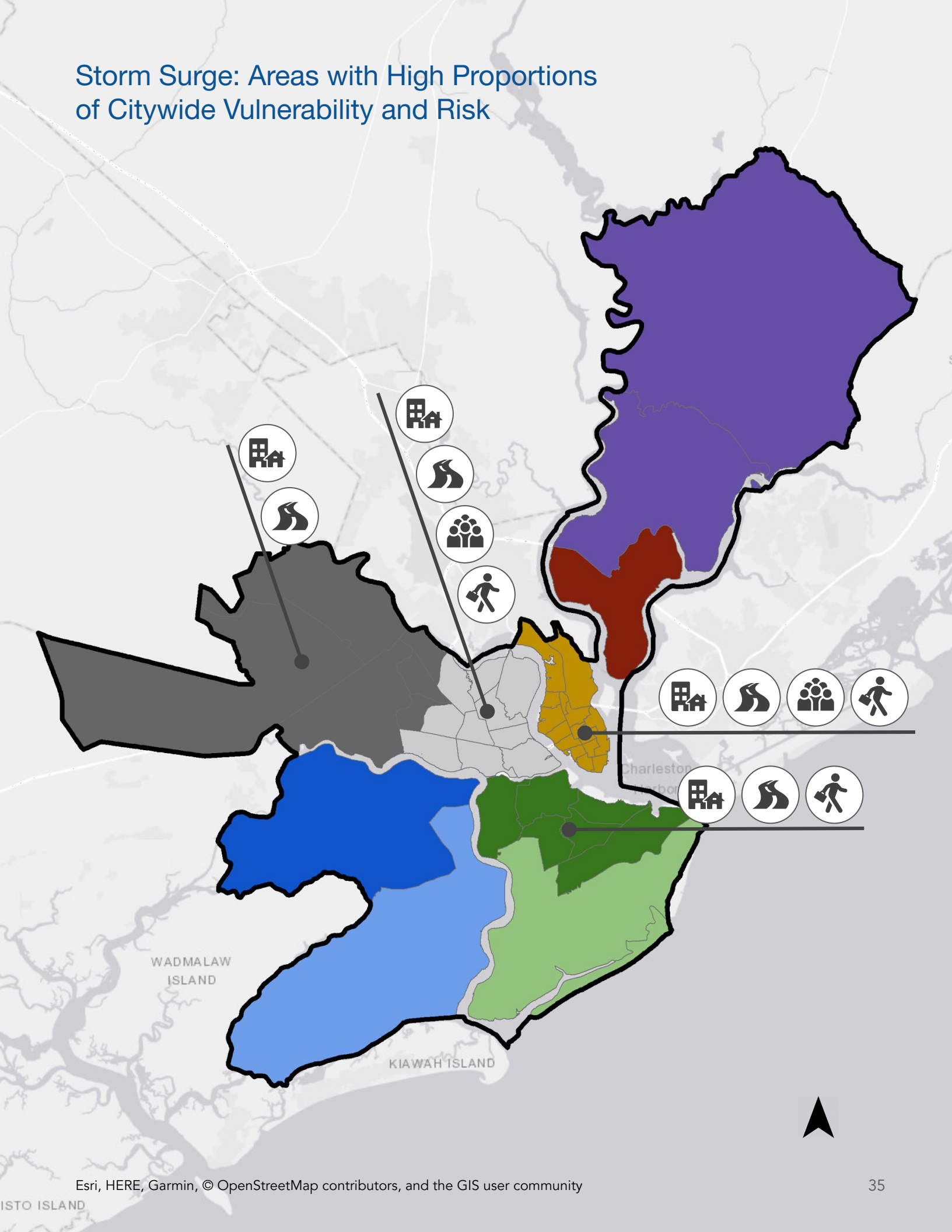
More than 90% of jobs and annual sales are associated with properties vulnerable to a worst-case Category 3 storm surge level. This does not include potential business interruption due to accessibility or other factors.

PEOPLE & SOCIOECONOMICS
High vulnerability and risk
Citywide

Populations with limited access to transportation may be more vulnerable due to fewer options for evacuation before a storm surge event. Housing and transportation vulnerability,[10] which considers households with no vehicle, is highest in the Downtown/Peninsula, West Ashley, Johns Island (North), and James Island (South) areas.

Note: The areas listed here and the map on the next page highlight areas of the city with a high proportion of citywide vulnerability and risk for each of the four asset themes. For a full account on number and proportion of assets vulnerable in every area of the city refer to Appendix D: General Area Reports and Appendix E: Asset-hazard pair vulnerability and risk profiles.

Storm Surge: Areas with High Proportions of Citywide Vulnerability and Risk



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Storm Surge Defined

Storm surges can cause deaths and extensive property loss, including erosion of beaches, damage to coastal habitats, and undermining the foundations of vital infrastructure like roads, railroads, bridges, buildings, and pipelines.[12]

The wind and air pressure from a storm pushes the water toward the shore, which causes an increase in water level above the natural tide. The height of the storm surge depends on the intensity of the storm, how fast the storm is moving, the size of the storm, the direction it's coming from, and the shape of the shoreline. A storm surge can occur during any tidal water level (e.g., at low tide, high tide, etc.). The height of the storm surge is added on top of the height of the tide; thus, a storm surge that occurs during a high tide will cause more flooding than one that occurs during a low tide. The sum of a storm surge and the astronomical tide is called a "storm tide."

Storm surge is flooding caused by an abnormal rise in tide from a severe storm (e.g., hurricane) over and above the usual, astronomical tide.

Inundation from storm surge is described in terms of height above ground level. For example, a storm surge prediction of 10 feet above ground level for a particular area means that forecasters expect 10 feet of water to cover that area.[12] The highest storm tide at Charleston Harbor occurred during Hurricane Irma at 9.9 feet above the mean lower low water (MLLW), or the average daily lower low tide.

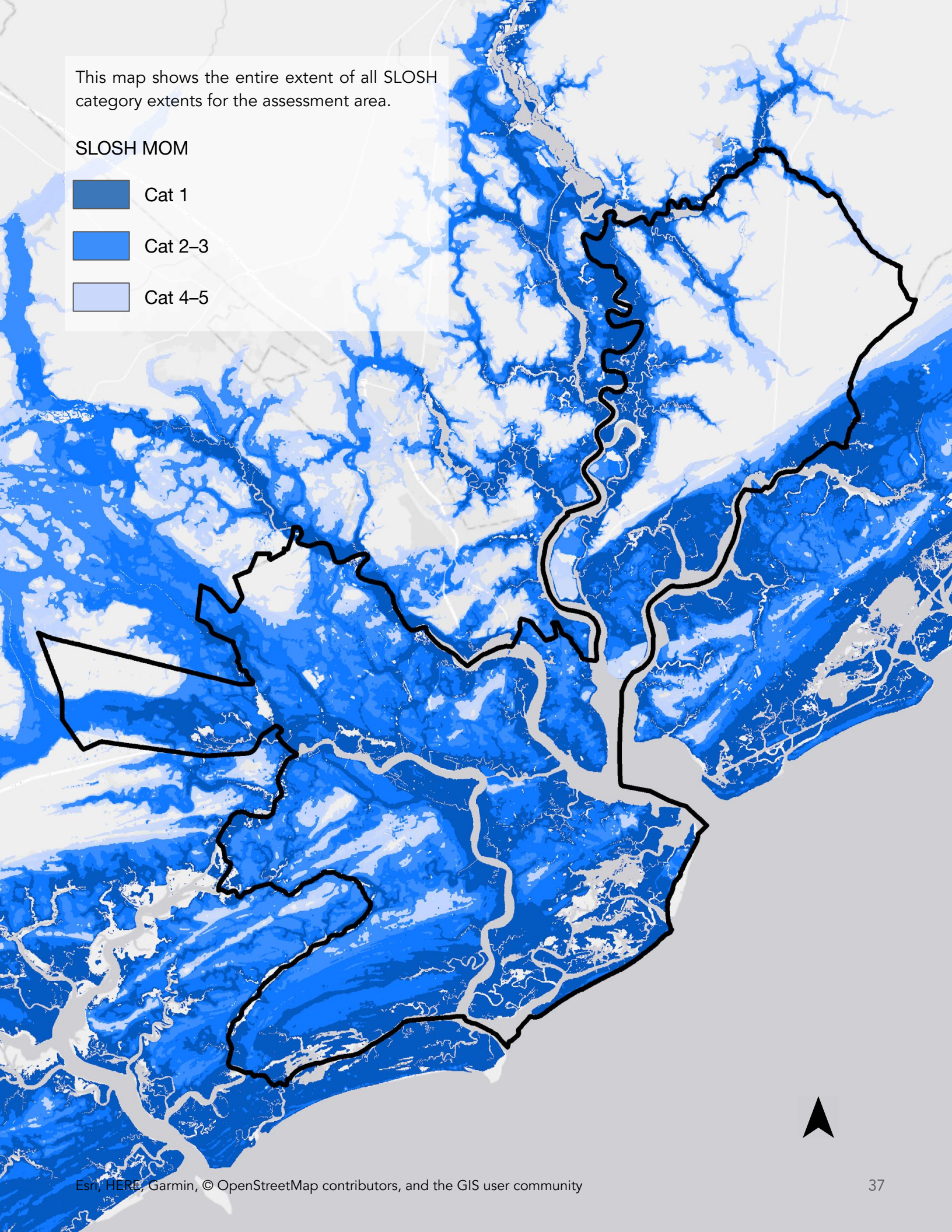
How Storm Surge Was Assessed

The assessment uses the Sea, Lake, and Overland Surge from Hurricanes (SLOSH) Maximum of the Maximum Envelopes of Water (MOM) layer developed by the NOAA National Weather Service's National Hurricane Center, with a focus on Categories 1–3, when evaluating risk.[13] This layer represents a "worst-case" scenario of flooding resulting from an "ideal" storm.

The assessment of storm surge is based on inundation extents of different storm category levels from the NOAA SLOSH model. Like other inundation hazards, vulnerability is based on assessing buildings in the inundation extents and criticality/use of the property (for potential impact), as well as the year the structures were built to determine which base flood elevation (BFE) applies to buildings on the properties (to determine adaptive capacity). This assumes that buildings with more stringent BFE requirements are more adaptive to a storm surge event. Risk scoping levels were based on storm category levels, with a Category 1 storm considered the most likely, and property values.

Assessment Factors

- ✓ Criticality of buildings in inundation extent
- ✓ Floodplain development BFE requirements
- ✓ Storm category level (Cat 1, Cat 2–3, Cat 4–5)



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Current Tidal Flooding

Summary of Key Findings

PROPERTY & PUBLIC SERVICES
Moderate vulnerability and risk

Downtown/Peninsula, West Ashley (Inner), James Island (South)

The majority of assets vulnerable to current tidal flooding are located in the Downtown/Peninsula and West Ashley areas.

ROADS & MOBILITY
High vulnerability and risk

Johns Island (South), Downtown/ Peninsula, Cainhoy, James Island (South),

Lifelines and critical areas are potentially inaccessible during current tidal flooding events. Several residential areas are potentially isolated during tidal events due to inaccessible minor or residential roads.

ECONOMIC FACTORS
High vulnerability and risk

Downtown/Peninsula, James Island (North), West Ashley (Inner)

Properties directly vulnerable to current tidal flooding contribute more than 10% of the city's annual sales volume and about 20% of the city's jobs/employees.

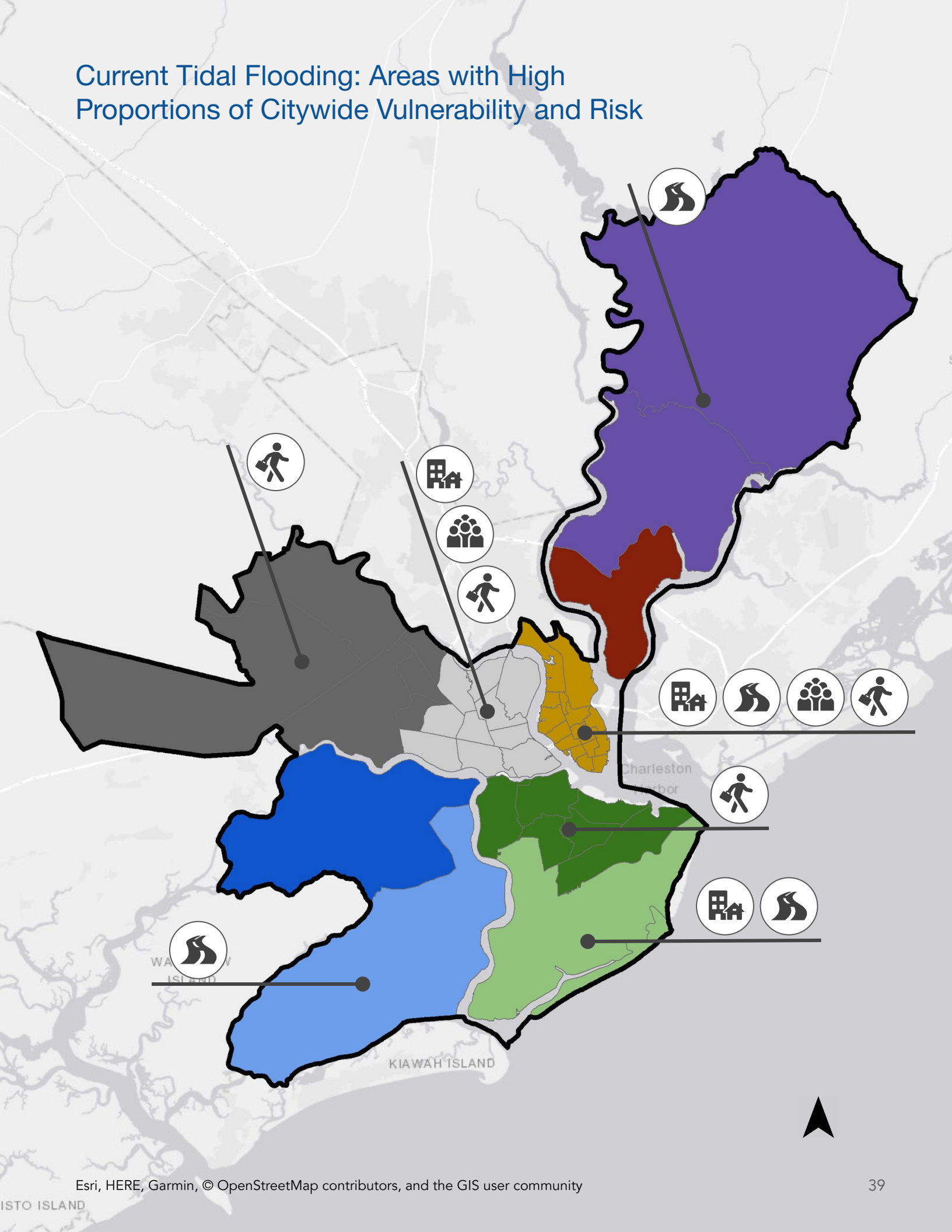
PEOPLE & SOCIOECONOMICS
Moderate vulnerability and risk

Downtown/Peninsula, West Ashley (Inner)

One of the primary impacts to socially vulnerable populations from tidal flooding is access to community services.

Note: The areas listed here and the map on the next page highlight areas of the city with a high proportion of citywide vulnerability and risk for each of the four asset themes. For a full account on number and proportion of assets vulnerable in every area of the city refer to Appendix D: General Area Reports and Appendix E: Asset-hazard pair vulnerability and risk profiles.

Current Tidal Flooding: Areas with High Proportions of Citywide Vulnerability and Risk



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Current Tidal Flooding Defined

The height of a daily tide varies seasonally and from year to year, depending on the relative position of the Earth, the sun, and the moon (i.e., astronomical factors), ocean and wind currents, and changes in ocean circulation (such as El Niño/La Niña). In addition to the height of the high tide, the degree of tidal flooding at a location is dependent upon the coastal landscape, the topography, and the coastal infrastructure (such as seawalls, storm drains, and roadways).

Tidal flooding is flooding of the low-lying land along the coastline from a high tide that is not associated with a tropical storm. Tidal flooding is also referred to as "high tide," "king tide," or "sunny day" flooding.

How Current Tidal Flooding Was Assessed

The "High Tide Flooding" layer produced by NOAA was used to assess current vulnerability and risk to high tide flooding. This layer shows areas that are currently subject to "minor" flooding from a tide elevation of 4.5 feet referenced to the North American Vertical Datum of 1988 (NAVD88) or 7.6 feet above average daily lower low tide (Mean Lower Low Water, or MLLW) at Cooper River at Charleston Harbor gage (ID: 866530).

Note that the "minor" tidal flood elevation threshold mentioned above is "derived" by NOAA using a methodology that enables consistent quantification and communication of tidal flooding impacts across the country.[14] The NOAA-derived "minor" threshold is about 7 inches higher than the "official" National Weather Service (NWS) thresholds used by the local Weather Forecast Office to issue coastal flood advisories and represents "more severe and deeper" flooding than that expected during a NWS flood "watch" for minor flooding.[14] The 2016 State of U.S. High Tide Flooding[15] reported that there were 50 minor flood days in 2016 at Charleston Harbor using the NWS "watch" advisory threshold; under the newly adopted "derived" threshold, this number drops to 9 minor flood days.[14]

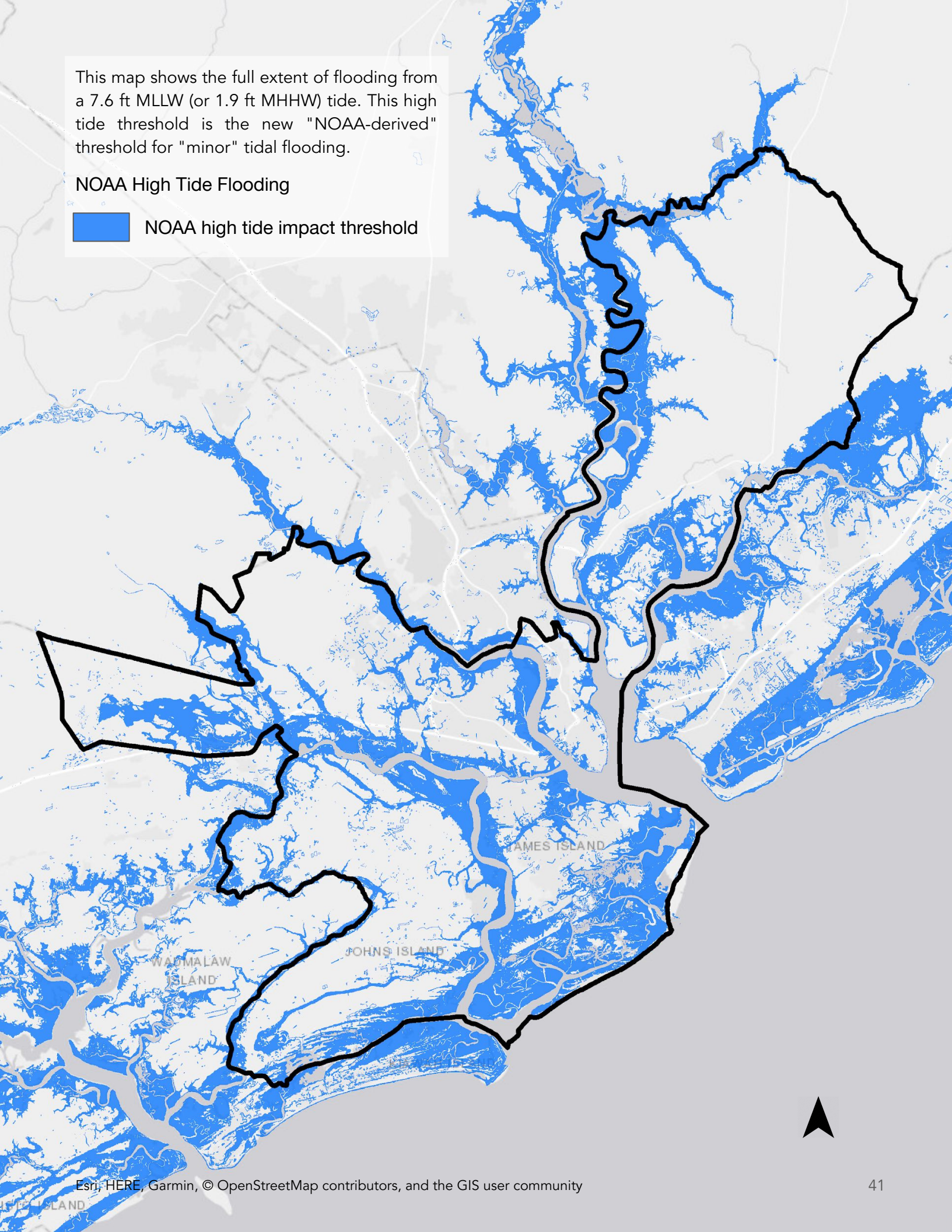
Assessment Factors

- ✓ Criticality of buildings in inundation extent
- ✓ Floodplain development BFE requirements

Tidal Flood Thresholds (feet) Cooper River at Charleston Harbor

	NOAA derived			NOAA official (NWS advisories)		
Vertical Datum	Minor*	Moderate	Major	Minor	Moderate	Major
MHHW	1.9	2.8	4.1	1.2	1.7	2.2
MLLW	7.6	8.5	9.8	7	7.5	8
NAVD88	4.5	5.4	6.7	3.9	4.4	4.8

**Threshold used in assessment*


This map shows the full extent of flooding from a 7.6 ft MLLW (or 1.9 ft MHHW) tide. This high tide threshold is the new "NOAA-derived" threshold for "minor" tidal flooding.
NOAA High Tide Flooding
NOAA high tide impact threshold
JAMES ISLAND
JOHNS ISLAND
WADMALAW ISLAND

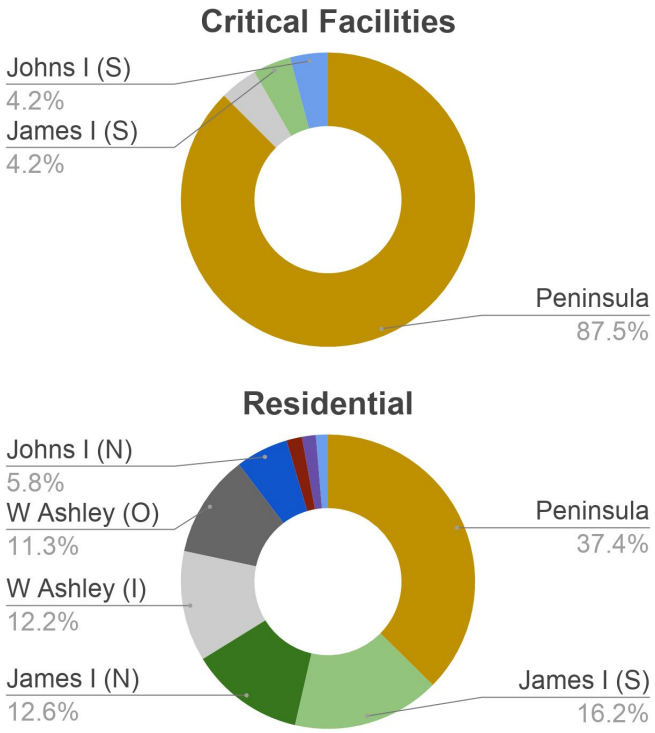
The assessment of tidal flooding focused on identifying assets that have greater potential impact to current high tide levels. Higher potential impact was considered for more critical assets (e.g., major medical facilities) or where more people could be affected (e.g., apartment buildings). Similar to the floodplain inundation assessment, the tidal flooding assessment considered how adaptive buildings are based on the year they were built and the Base Flood Elevation (BFE) requirement in place at the time they were built. Based on current tidal flooding levels, fewer properties and roads are in harm's way compared to the FEMA floodplains; however, these tidal flooding events happen more frequently (about four times per year, on average, over the last 10 years).

Current Tidal Flooding Impacts on Property & Public Services

Moderate Vulnerability and Risk

Most vulnerable areas: Downtown/Peninsula, West Ashley (Inner), James Island (North)

The majority of assets vulnerable to current tidal flooding are located in the Peninsula, James Island, and West Ashley areas. The graphs at right show the locations of highly vulnerable critical facilities and residential property proportionally by general area—about 88% of all highly vulnerable critical facilities and 37% of highly vulnerable residential property are in the Peninsula area (shaded in yellow). The general areas with the next two highest proportions for both assets are West Ashley (Inner) and James Island (North and South).



Current Tidal Flooding Impacts on Economic Factors

High Vulnerability and Risk

Downtown/Peninsula, James Island (North), West Ashley (Inner)

Properties directly vulnerable to current tidal flooding contribute more than 10% of the city's annual sales and include about 20% of the city's jobs. These numbers are based on data reported at businesses where the properties have high or medium vulnerability and risk of direct impacts. This includes only direct impact vulnerability and likely underestimates indirect impacts, such as business interruption, inaccessibility, and other impacts. The yearly cumulative impact of these events is significant. The majority of these assets and economic vulnerabilities are located in the Downtown/Peninsula and James Island (North) areas.

Current Tidal Flooding Impacts on Roads & Mobility

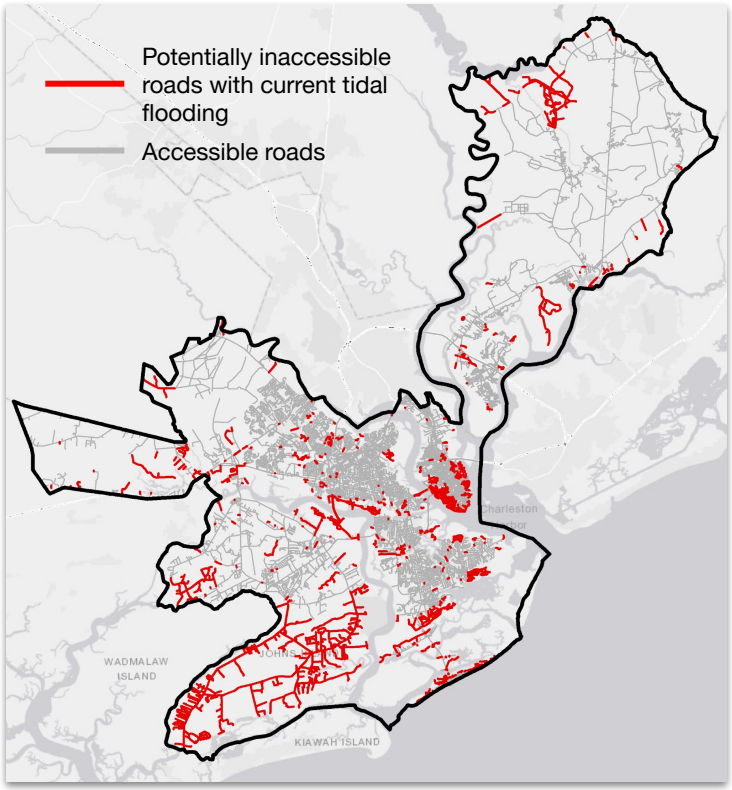
High Vulnerability and Risk

Most vulnerable areas: West Ashley (Inner and Outer), James Island (North), Downtown/Peninsula, Johns Island (South)

Lifelines and critical areas are potentially inaccessible during current tidal flooding events. Recent events have limited access to critical assets in the medical district, including access to the hospital. The assessment highlights areas where other key assets could be inaccessible, such as schools and community centers.

Several residential areas are potentially isolated during tidal events due to inaccessible minor or residential roads. These areas could be inaccessible by emergency responders during tidal flooding events, such as in Johns Island (South) where 86% of all properties could potentially be inaccessible. The map shows all roads potentially inaccessible to current tidal flooding.

Inaccessible Roads



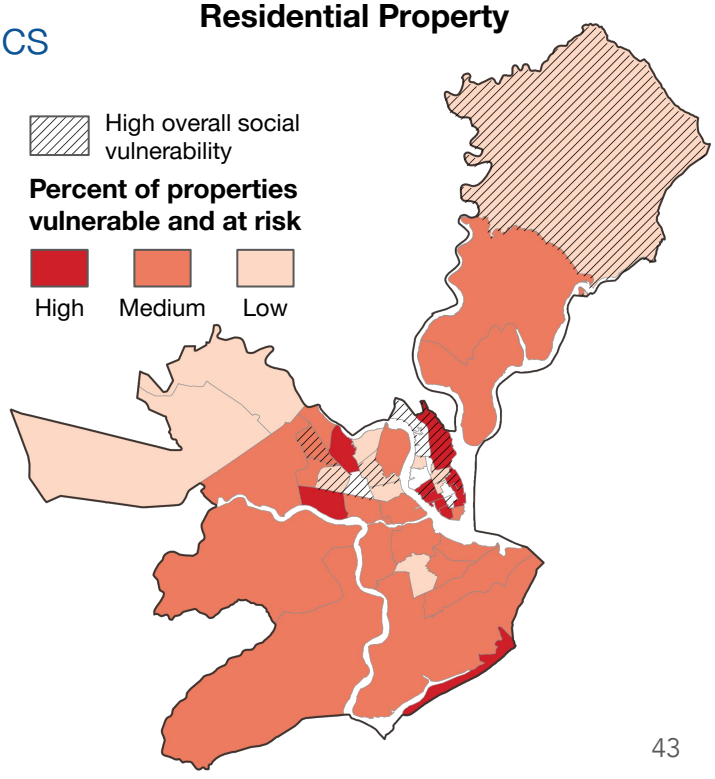
Current Tidal Flooding Impacts on People & Socioeconomics

Moderate Vulnerability and Risk

Most vulnerable areas: Downtown/Peninsula, West Ashley (Inner), James Island (North)

One of the primary impacts to socially vulnerable populations from tidal flooding is access to community services. These include schools, community services, churches, and other critical facilities. The lower west side of the Peninsula has the most residential vulnerability to tidal flooding (shown in the map). Areas in the northeast side of the Peninsula and near the medical district are also vulnerable and have higher levels of social vulnerability compared to other areas in the city.

Residential Property



Sea Level Rise and Future Tidal Flooding

Key Findings

PROPERTY & PUBLIC SERVICES

Moderate to high vulnerability and risk

Citywide

Tidal flooding will increase in severity over time. Government-owned property has the highest proportion of properties vulnerable to sea level rise and future tidal flooding. Nearly all of these properties are in the Downtown/Peninsula area, with a few in West Ashley (Inner).

All properties have potentially increasing vulnerability to sea level rise and future tidal flooding. Residential, commercial, and parks/cultural property have potentially the largest proportional increases with increasing water levels.

PEOPLE & SOCIOECONOMICS

Moderate to high vulnerability and risk

Downtown/Peninsula, West Ashley (Inner)

Several of the areas with the most vulnerable residential property are the most socially vulnerable.

ROADS & MOBILITY

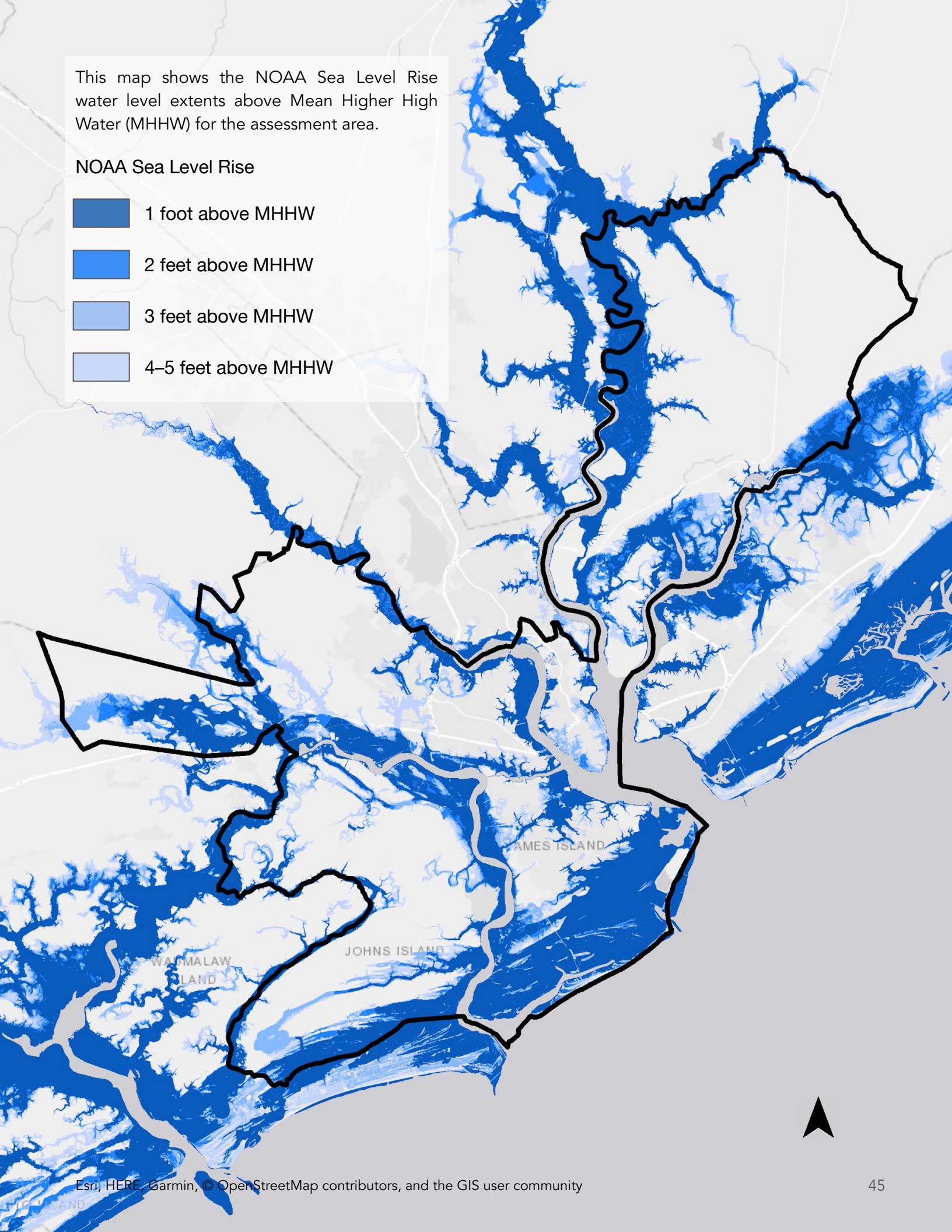
High vulnerability and risk

Downtown/Peninsula, West Ashley (Inner and Outer), Johns Island (South) James Island (North)

Areas could experience inundation from sea level rise and future tidal flooding at different rates over time. For example, in Daniel Island at 3 feet + MHHW only 12% of minor roads are inaccessible; however, at 5 feet + MHHW, 66% of minor roads are potentially inaccessible.

About 10% of major roads in the city could become inaccessible at 3 feet + MHHW. West Ashley (Outer) and Downtown/Peninsula areas have the highest number of major roads potentially inaccessible. James Island (South) has among the highest percentage of major roads potentially inaccessible.

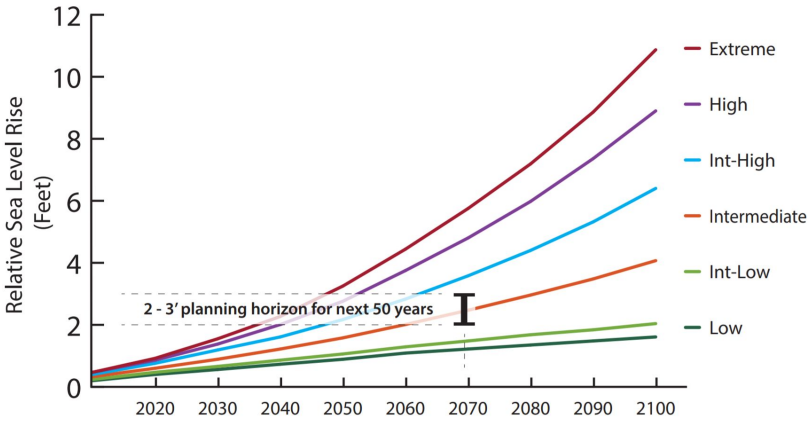
About 25% of minor roads in the city could become inaccessible at 3 feet + MHHW. Both the highest total amount and percentage of roads are in Johns Island (South).

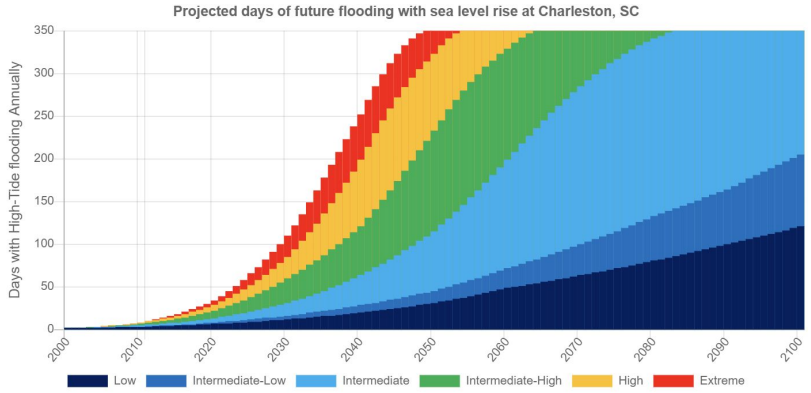

This map shows the NOAA Sea Level Rise water level extents above Mean Higher High Water (MHHW) for the assessment area.
NOAA Sea Level Rise
1 foot above MHHW
2 feet above MHHW
3 feet above MHHW
4–5 feet above MHHW
JAMES ISLAND
JOHNS ISLAND
Esri, HERE, Garmin, © OpenStreetMap contributors, and the GIS user community

Sea Level Rise and Future Tidal Flooding Defined

While the local tides vary daily, seasonally, and from year to year, the average of all measurements over a specified time period is called *mean sea level*. For Charleston, the mean sea level has risen 1.07 feet since 1921.[7]

Sea level rise is generally considered using a scenario approach. Scenarios of global mean sea level rise are translated to regional scenarios by accounting for factors such as vertical land movement or ocean circulations that affect local sea levels. The graphic on the top shows the most up-to-date sea level rise scenarios for Charleston produced by NOAA.[16] The graphic on the bottom shows the increasing *frequency* of high tide flood events (about 7.6 feet MLLW threshold) corresponding to the sea level rise scenarios in the previous figure.[16]





Relative rise of the local mean sea level over time is a persistent inundation hazard and can also increase the frequency and severity of tidal flooding.

How Sea Level Rise and Future Tidal Flooding Were Assessed

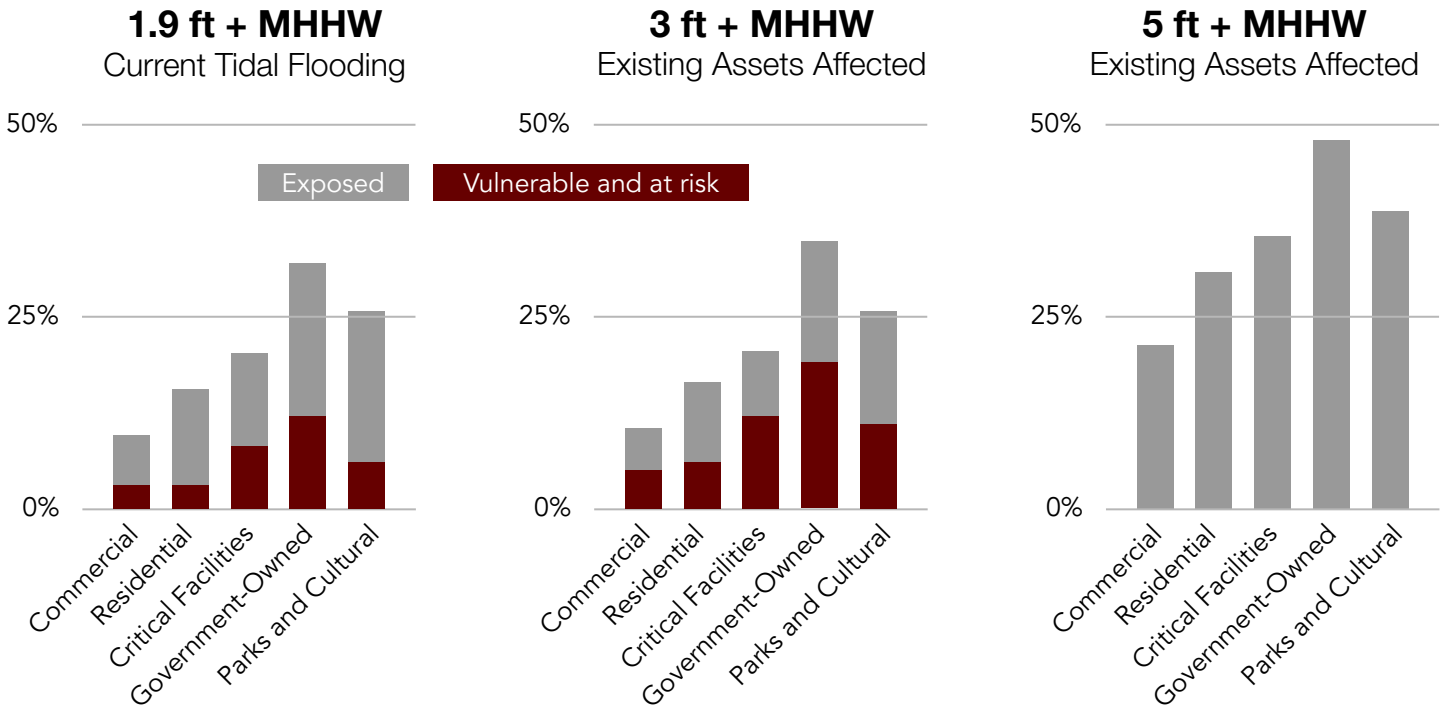
To assess the effects of relative sea level rise, sea level changes of different thresholds are mapped on top of current tidal datums—such as mean sea level, mean higher high water, etc.—to map the extent of permanent inundation. For this assessment, multiple sea level thresholds are considered to provide insight into permanent inundation: 3 feet (for vulnerability and risk) and 5 feet (for exposure). These two levels are added to the current multi-year average daily higher high tide ("MHHW"), as mapped in the NOAA Sea Level Rise Viewer.[17] The 3-foot threshold (3 feet + current MHHW) is consistent with the city's Flooding and Sea Level Rise Strategy.[7]

These extents also provide a screening-level view of the increase in *severity* (area affected) of potential future high tide flooding due to rising sea levels. In other words, the extent for a given relative sea level provides information about both potential flooding that could at first be observed several times a year as high tides, as well as about sea level rise inundation over time. Limitations to this approach should be recognized as modeling for these extents do not consider factors, such as potential shifts in future tidal ranges.

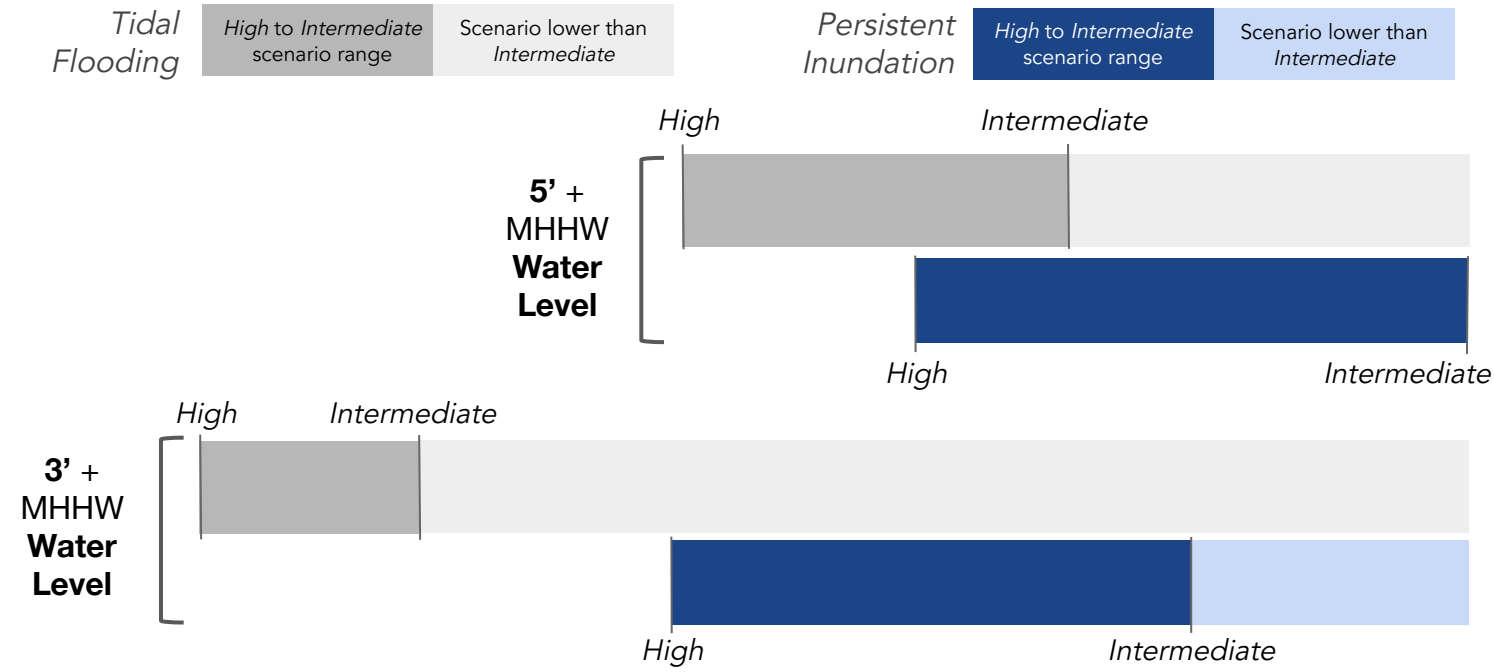
Assessment Factors

- ✓ Criticality of buildings in inundation extent
- ✓ Floodplain BFE requirement
- ✓ Sea level rise thresholds (1, 2, and 3 feet above MHHW)

Timing and Impact of Sea Level Rise and Future Tidal Flooding



Timeline of potential *future tidal flooding* and *persistent inundation* with sea level rise



Note: Scenario ranges are based on the NOAA Sea Level Rise Viewer local scenarios. Given today's high tide impact threshold is about 1.9' above MHHW, the water level of 3' + MHHW could be considered equivalent to a future high tide with about 1.1 feet sea level rise. Similarly, the water level of 5' + MHHW could be considered a future high tide with about 3.1 feet of sea level rise.

Earthquakes

Key Findings

PROPERTY & PUBLIC SERVICES
High vulnerability and risk

Most vulnerable areas: Downtown/ Peninsula, West Ashley (Inner and Outer), James Island (North)

Government-owned, parks and cultural, and critical facilities have the highest vulnerable percentage of all property types. Impacts to other types of infrastructure—including pipelines, railroad and port access, tanks and reservoirs, pumps, lift stations, wells, water and wastewater utilities, and power assets—should be assessed further.[18]

Many properties were built before modern building codes were in place. About 36% of all properties in the city contain structures built before the first building code was established in 1968. This includes about 530 historic properties that were built before the earthquake of 1886 (most of which are in the Lower Peninsula), which are especially vulnerable due to having been through a previous earthquake.

ROADS & MOBILITY
High vulnerability and risk

Citywide

About 44% of bridges in the city are highly vulnerable because they do not have seismic design considerations. Bridges designed prior to 1990 likely did not have any consideration for seismic forces, while bridges designed in the 1990s likely had a consideration for seismic forces. The first performance-based seismic design procedures were implemented in South Carolina in 2001 and were updated in 2008.[19]

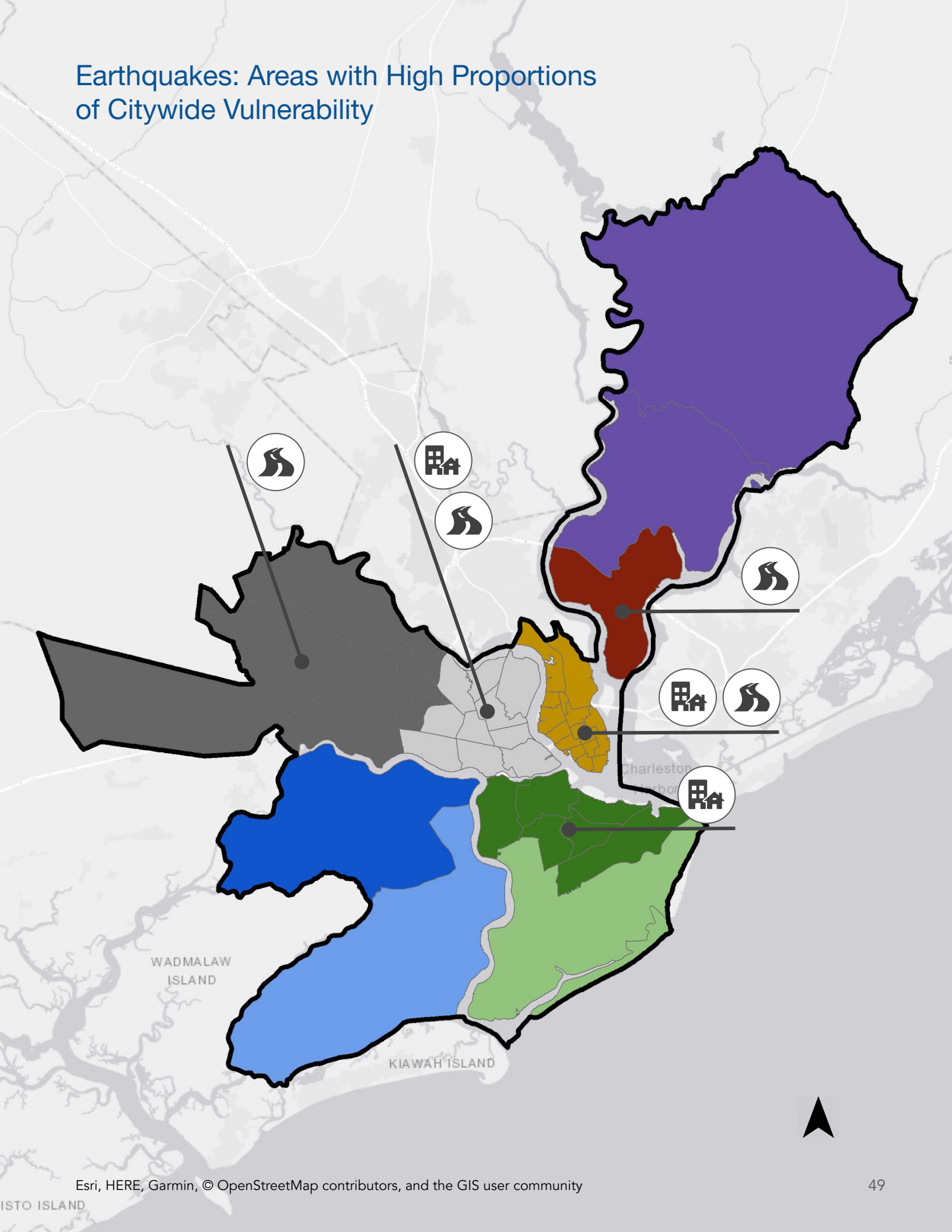
PEOPLE & SOCIOECONOMICS
High vulnerability and risk

Most vulnerable areas: Downtown/ Peninsula, West Ashley (Inner)

Populations will be most affected by lack of access to critical services and emergency response. Vulnerable populations will be most affected by the loss of services.

Note: The areas listed here and the map on the next page highlight areas of the city with a high proportion of citywide vulnerability and risk for each of the four asset themes. For a full account on number and proportion of assets vulnerable in every area of the city refer to Appendix D: General Area Reports and Appendix E: Asset-hazard pair vulnerability and risk profiles.

Earthquakes: Areas with High Proportions of Citywide Vulnerability



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Earthquakes Defined

In addition to ground shaking, earthquakes can cause liquefaction, which has the potential to damage or destroy buildings and infrastructure, trigger fires, and cause loss of life.

An earthquake is a sudden, rapid shaking of the earth due to seismic activity.

How Earthquakes Were Assessed

The National Earthquake Hazard Reduction Plan (NEHRP) site class map (part of the FEMA HAZUS 4.1 data suite) was used to assess earthquake hazard.[20] The NEHRP site class map is based on 1997 NEHRP provisions. Site classes provide a simplified measure of the potential for strong shaking in a particular area based on soil conditions (softer soils amplify the ground motion). Two site classes are present in the Charleston region: Class D (stiff soils) and Class E (soft soils). Class E areas are considered to be the high hazard areas, with less geologic stability and more susceptibility to ground shaking and seismic activity.

Assessment Factors

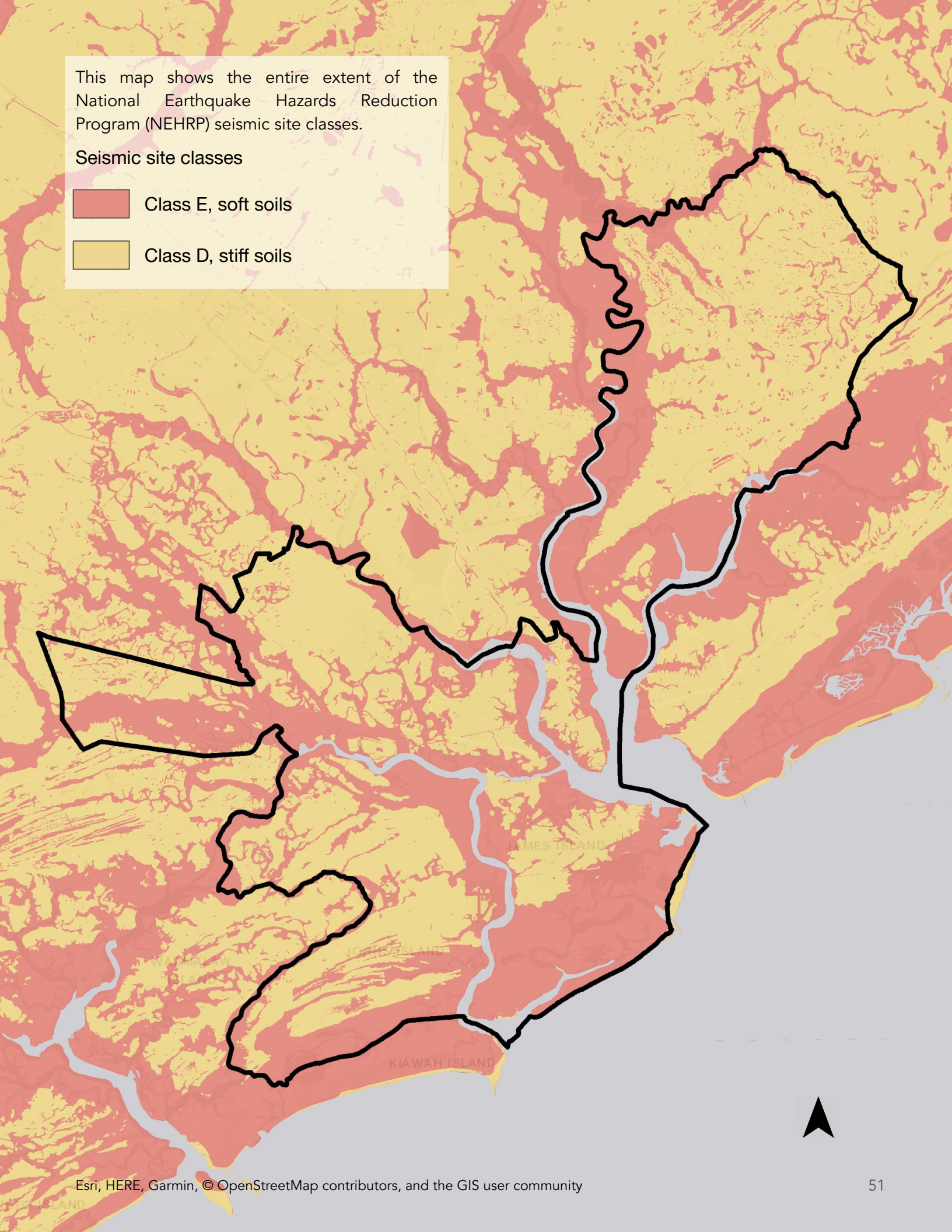
- ✓ Criticality of buildings
- ✓ Soil site classes (soft vs. stiff soils)
- ✓ Seismic building code and design standards

The assessment of property assets consider building code standards and seismic design guidelines. Key dates and considerations in the assessment include:

- 1968 as the first year that building codes were established for Charleston
- 2002 as the year when building codes for seismic guidelines were updated and building requirements were increased

Bridges were also evaluated based on a review of bridge design guidance. The review found that first performance based seismic design procedures for bridges were implemented in South Carolina in 2001 and were updated in 2008.[21] The review also found that bridges designed in the 1990's likely had some consideration for seismic forces, but industry standards were limited. Bridges designed prior to the 1990's likely did not have consideration for seismic forces.

Note that this screening-level vulnerability assessment does not examine specific earthquake scenarios or consider other seismic risk factors such as liquefaction potential, depth to the marl, or probabilities.


This map shows the entire extent of the National Earthquake Hazards Reduction Program (NEHRP) seismic site classes.
Seismic site classes
Class E, soft soils
Class D, stiff soils
JAMES ISLAND
JOHNS ISLAND
KIAWAH ISLAND
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Hazardous Materials (Hazmat)

Key Findings

PROPERTY & PUBLIC SERVICES
High vulnerability and risk

Most vulnerable areas: Downtown/ Peninsula, West Ashley (Inner and Outer)

While hazmat sites are found throughout the city, the majority of vulnerable assets are in the Downtown/Peninsula area, due to a combination of Tier II facilities and transportation corridors. Most hazmat sites are also in harm's way to other hazards, such as flooding.

PEOPLE & SOCIOECONOMICS
High vulnerability and risk

Most vulnerable areas: Downtown/ Peninsula, West Ashley (Inner)

About 71% of all hazmat locations are in the most socially vulnerable areas of the city. This is based on the number of Tier II facilities in the neighborhood areas (census tracts) that have the highest overall social vulnerability.[10]

Hazardous materials (hazmat) are chemicals or any substances that could pose a risk to human health and safety, property, or the environment.

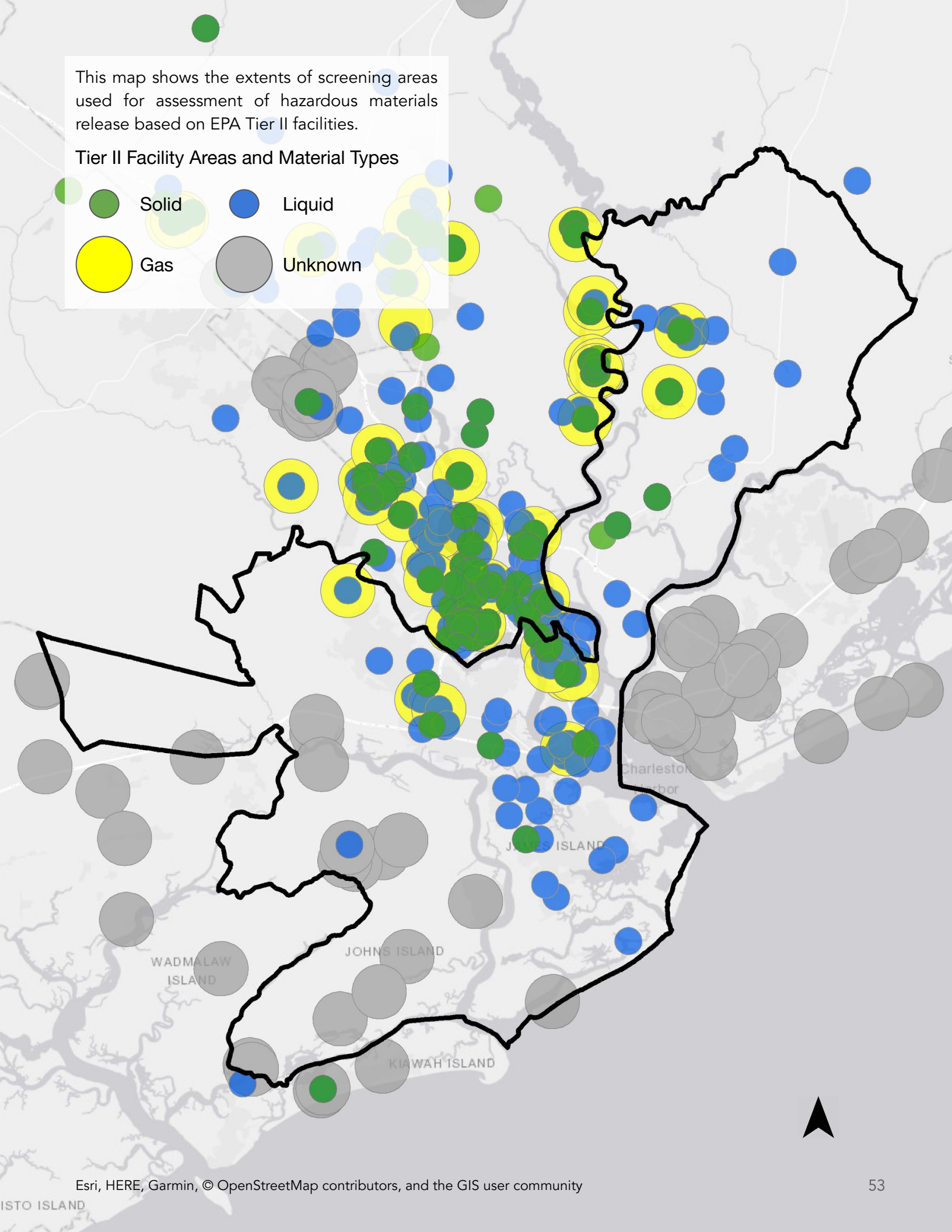
If released, hazardous materials can have different rates of dispersal, depending on the phase of material (solid, liquid, or gas). Generally, gases have higher rate of dispersal compared to solids and liquids. The phase, type, concentration, and quantity of material can also determine the hazard ratings that materials are given for health hazards, flammability hazards, and instability hazards. Each of these criteria is given a rating based on the National Fire Protection Association (NFPA) 704 standard that ranges from 0 (no hazard) to 4 (can be lethal).[22,23,24] Hazardous materials are often located where businesses or industrial facilities use chemicals as part of a manufacturing process or where the material itself may be produced or sold directly.

How Release of Hazardous Materials Was Assessed

Hazmat hazard areas for Charleston were determined by the location of U.S. Environmental Protection Agency (EPA) Tier II sites along with screening areas around their locations, the size of which were based on the phase of material and general rate of potential dispersal. Tier II facilities are part of an EPA reporting system that requires businesses and other facilities to report specific information about the on-site storage of hazardous materials.[24] Tier II reports provide information about the type and often the quantity of materials being stored. Major transportation corridors (interstates and railways) were also considered as well as other hazards, such as flooding, that could impact hazmat sites and increase risk of release.

Assessment Factors

- ✓ Proximity to hazmat sites
- ✓ Fire response drive-time
- ✓ NFPA hazard rating and number of materials in proximity
- ✓ Exposure to other hazards (flooding and earthquake)


This map shows the extents of screening areas used for assessment of hazardous materials release based on EPA Tier II facilities.
Tier II Facility Areas and Material Types
Solid
Liquid
Gas
Unknown
WADMALAW ISLAND
JOHNS ISLAND
KIAWAH ISLAND
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Extreme Heat

Key Findings

1

Areas in the Downtown/ Peninsula and West Ashley (Inner) areas are most vulnerable to extreme heat.

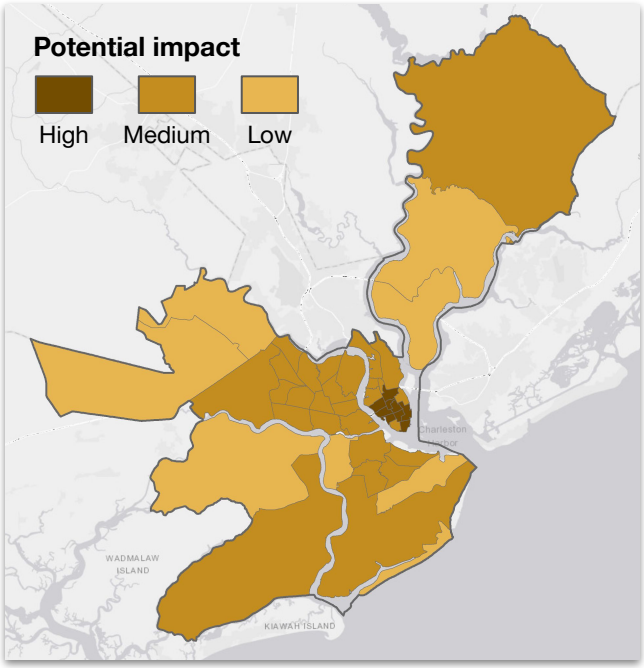
2

In the most vulnerable (medium to high) neighborhood areas, there are about 1,900 households with members 65 years of age or older and about 2,900 households living below the poverty line.

Extreme heat events are periods of excessively hot and/or humid weather that can last for multiple days. Extreme heat is a pressing public health risk, particularly for low-income and elderly communities living in developed areas with low tree canopy cover.[25]

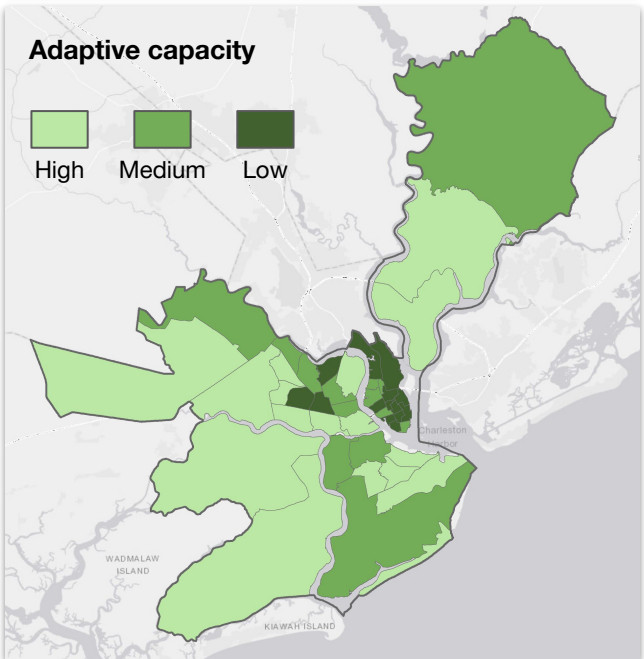
Sensitive Populations and Developed Landcover

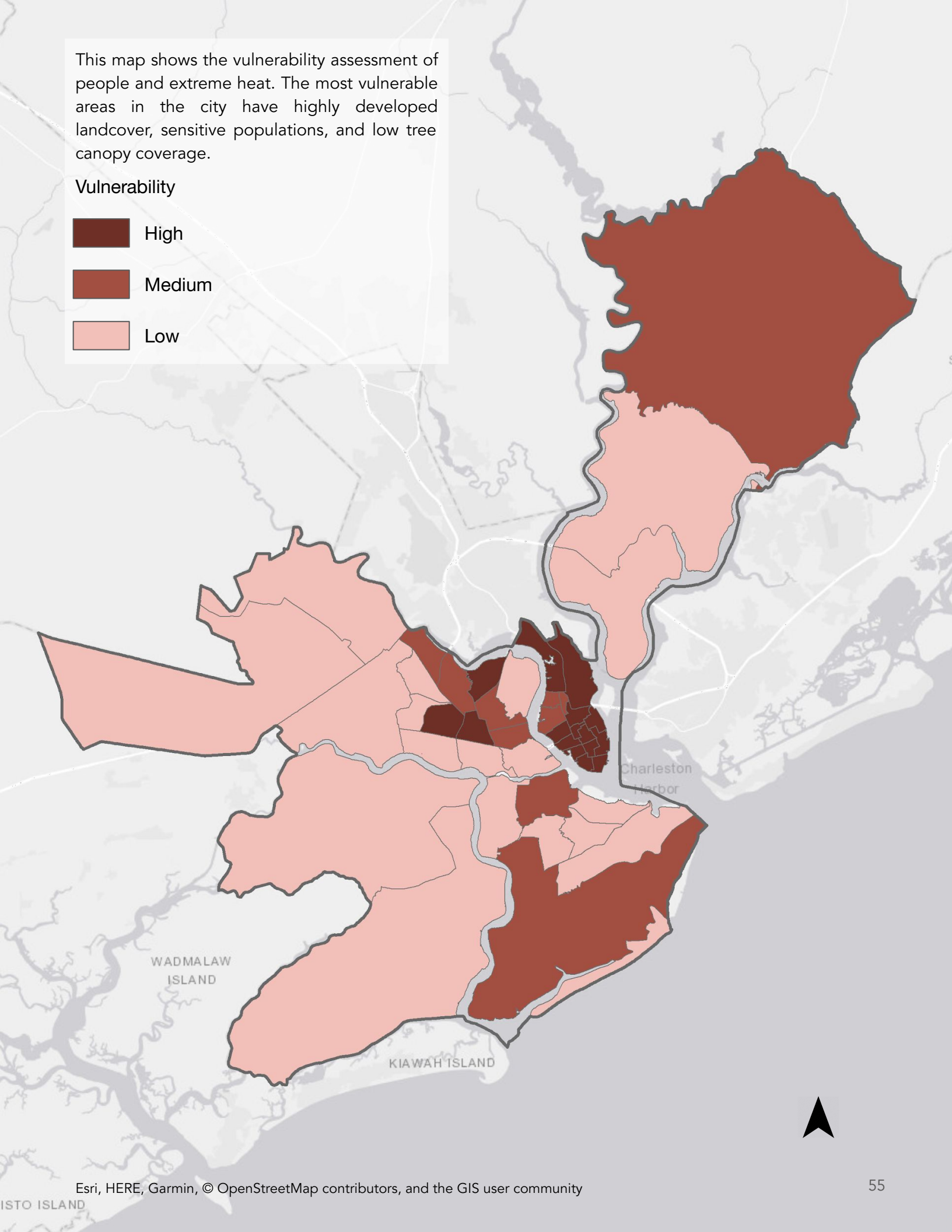
The vulnerability of residents to extreme heat considers sensitive populations. For the purpose of this assessment, families below the poverty line and households with members over 65 years of age were recognized as populations that are more sensitive to heat events. As a potential impact to those sensitive populations, areas were identified where a high percentage of those populations live in highly developed areas where impervious surfaces contribute to the urban heat island. The darker areas on the map at right show that the highest percentages of sensitive populations are located in areas with the highest levels of developed land cover.



Tree Canopy and Socioeconomic Status

The amount of tree canopy and socioeconomic status were used as measures of adaptive capacity to an extreme heat event. The darker areas on the map at right show areas that have the lowest levels of tree canopy and where residents may have less ability to cope with the effects of heat based on socioeconomic status.




This map shows the vulnerability assessment of people and extreme heat. The most vulnerable areas in the city have highly developed landcover, sensitive populations, and low tree canopy coverage.
Vulnerability
High
Medium
Low
Charleston Harbor
WADMALAW ISLAND
KIAWAH ISLAND
ISTO ISLAND
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Water Shortage

Key Findings

1

Water shortage in the City of Charleston can result from (1) a lack of freshwater due to an extended drought, or (2) salinity impacts to the Bushy Park Reservoir with brackish water moving up the Cooper River.

2

Past experience suggests that the current likelihood of severe water shortage due to drought and salinity intrusion is low. However, due to changing climate conditions and sea level rise, historic conditions should not be the only basis for understanding the potential for future risk from both types of impacts.

Shortage of water supply can cause stress to societal and natural systems.

Due to its inherently regional nature, the threat of water shortage is addressed in narrative form rather than by a spatially distinct assessment.

The Bushy Park Reservoir in the Santee River watershed is the main source of drinking water supplied to the City of Charleston by the Charleston Water System, which also regularly draws a small amount of water from the Edisto River. Water shortage in the City of Charleston can result from (1) a lack of freshwater due to an extended drought, or (2) salinity impacts to the Bushy Park Reservoir with brackish water moving up the Cooper River. These two causes do interact—salinity intrusion can occur during periods of extended drought, when releases by Santee Cooper drop significantly, or during high tides (including those resulting from tropical storms), or a combination of both drought and high-tide conditions.

Past experience suggests that the *current* likelihood of severe water shortage due to drought and salinity intrusion is low for a number of reasons. First, Bushy Park Reservoir is located at the downstream end of a large river basin (the Santee River watershed) and hence reservoir levels respond more slowly to drought. This was evident during the most recent extreme multi-year drought event that began in 2007, when even voluntary water restrictions were unnecessary. Second, while the combination of drought and high tides has been found to result in frequent salinity and tidal alerts, salinity impacts have been successfully avoided by mandatory flow release requirements based on salinity and tidal monitoring and an alert system.[27] Third, the Charleston Water System has reported the ability to dilute raw brackish water in its main source by pumping more from its intake in the Edisto River, and completely switch to the Edisto River if needed.[28]

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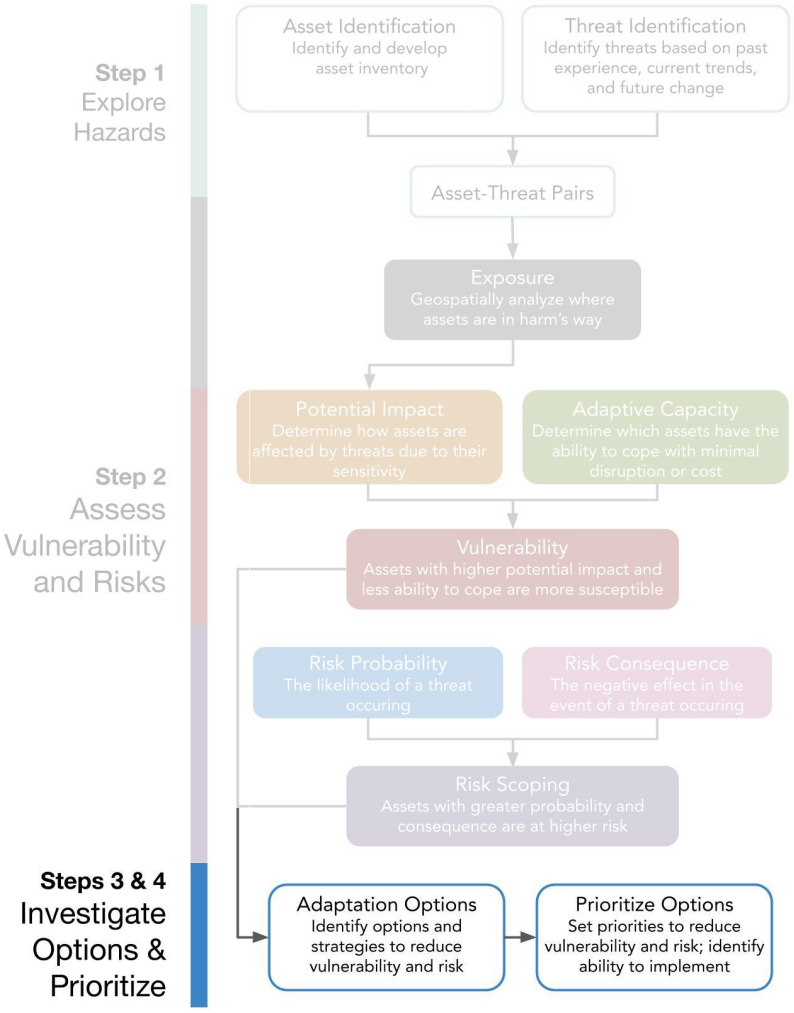
Options and Priorities




STON FIRE DEPARTMENT
2
CHARLESTON
262

Identifying Options to Reduce Vulnerability and Risk

The assessment highlights how and where the city's core systems and assets are vulnerable and at risk to a range of hazards. However, it's important to keep in mind that the Steps to Resilience process is a solutions-oriented framework. In fact, the purpose of the vulnerability and risk assessment is to provide a foundation for the development and implementation of resilience strategies and, while recognizing issues the city faces, to also recognize its opportunities. It is also important to recognize the process—from assessment of vulnerability and risk to the development of options and priorities—as an iterative one that can help guide the city through adaptation pathways and to a resilient future.



Using information from the assessment, the project team identified options and strategies to address the assets and areas determined to be most vulnerable and at risk. An option or strategy was identified as addressing vulnerability and risk by either (1) reducing exposure (removing assets from harm's way), (2) increasing adaptive capacity (increasing the asset's ability to cope with impacts), or (3) supporting preparedness, response, and recovery.

Through a series of in-person workshops and virtual work sessions, the project team consulted national and regional best practice, considered actions taken in cities comparable to Charleston, and developed custom options and strategies based on vulnerabilities that are unique to the city. Through this, nearly 100 options (including strategies and projects) were identified for building resilience.

Alignment with Critical Components

Building on the city's Flooding and Sea Level Rise Strategy,[7] staff identified options according to the Five Critical Components. By identifying strategies that meet all five, a balanced portfolio of actions can be undertaken by the city.

Highlights how hazards could exceed resource capacity to manage. Also, implementation criteria identifies type of resources needed (i.e., financial or staff capacity) to move forward with priorities.

Identifies need for policies and regulations based on current vulnerability and future risk.

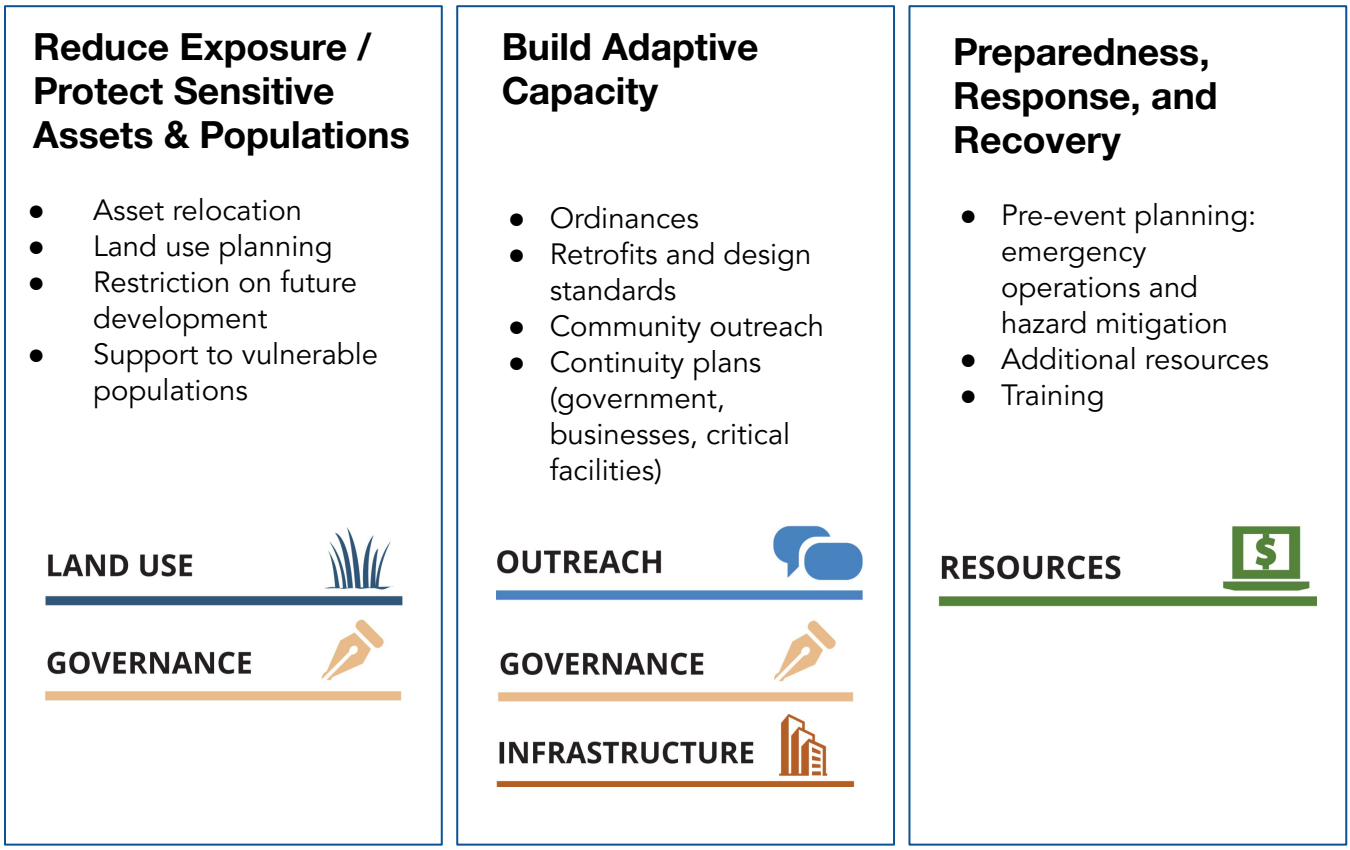
Highlights areas of current vulnerability, the potential for increasing risk, and future change. There are also opportunities in less vulnerable areas.



Identifies most vulnerable areas and systems/assets. Assessment can also be used for priority screening of new investments and performance metrics.

Highlights key issues that warrant public communication (area-specific) and identifies need for coordination with new or existing stakeholders.

With this understanding of how the assessment can inform or support the development of options and strategies to build resilience, the following are some example types of strategies that fall into different critical component categories but also address vulnerability and risk in different ways:



Ability to implement

In addition to identifying options to build resilience, criteria for the ability to implement were evaluated for each option. Four criteria were used for evaluating the ability to implement:

- Financial: Is the option financially feasible with current resources?
- Political: Does the option have current political support?
- Staff Capacity: Is there existing staff capacity available to implement?
- Socially Responsible: Is the option socially responsible? Does it help to address social equity goals in the city?

These four criteria were evaluated using a "traffic light" approach, with a "green light" being given to an option with a clear *yes*, a "yellow light" assigned for a *maybe* or for partially meeting the criteria, and a "red light" given for a clear *no*. A red light does not indicate that the option should not be considered; rather, it means that there may be significant barriers to overcome before the option can be implemented, such as the lack of financial resources or staff capacity. A detailed matrix of all options and priorities is provided in Appendix F.

Prioritization

Through the last two working sessions, city staff used information from the assessment to consider key concerns across all hazards and opportunities to build resilience and nominated priorities. From this nomination exercise, options and strategies were categorized into three tiers or priorities:

Tier 1
Strategic priorities to allocate resources needed for implementation. These actions were identified as Tier 1 because they:

- Are holistic in representing the city's Five Critical Components
- Address both near-term urgencies and long-term issues
- Recognize opportunities in preventing added future risk
- Are equitable in addressing all areas of the city while also focusing on the most vulnerable people and areas of the city

Tier 2
Important options and strategies to move forward as resources become available.

Tier 3
Supporting options and strategies that have lower priority with limited resources.

The tables on the following pages list the prioritized strategies for Tiers 1 and 2 by critical component. Each strategy is listed with its reference number (in parentheses), which can be used to reference more detail in Appendix F. The primary hazard(s) addressed for each strategy is listed, along with its "ability to implement" criteria. The ability-to-implement color shading indicates the greatest barrier identified for that strategy's ability to be implemented, including any "yellow light" or "red light" barriers. Some strategies may need additional vetting by city staff, and some may require more detailed cost estimates or further evaluation before implementation.

Tier 1 Strategies

Critical Component	Hazard	Strategy	Barriers
RESOURCES	All Flooding, Multi-Hazards	Acquire appropriate flood response assets for public safety (33)	Financial, Political
	All Flooding, Multi-Hazards	Green infrastructure incentives through zoning or fees (Peninsula-28, 69)	
	All Flooding, Multi-Hazards	Strengthen the city's Zoning Ordinance to promote Low Impact Development and more resilient development in low lying areas (47)	Political
GOVERNANCE	Floodplain Inundation	Increase additional freeboard to 2.0 feet above the Base Flood Elevation (BFE) for all new and substantially improved structures (8)	Political, Social Responsibility
	Tidal Flooding, SLR	Ensure all critical facilities, public and private, have access plans that account for SLR (11)	Financial, Staff Capacity
	Hazmat	Propose an ordinance for hazardous materials	Political
	All Flooding	Drainage improvement projects (Peninsula-20, 21, 23; WA-22)	Financial, Political, Staff Capacity
INFRASTRUCTURE	Storm Surge	U.S. Army Corps of Engineers (USACE) options (for storm surge prevention)	
	Tidal Flooding, SLR	Retrofitting city-owned facilities, public infrastructure, and critical facilities for greater than 3 feet of SLR (9,10)	Financial, Political, Staff Capacity
	All Flooding	Identify open space that could double function as water storage areas (66)	Financial
LAND USE	Tidal Flooding, SLR, Multi-Hazards	Update the city's Comp Plan for SLR and reevaluate the city's Zoning Ordinance (46)	Political
OUTREACH	All Flooding	Update current projects in the Long Range Transportation Plan based on vulnerability assessment prioritization (88)	Political, Staff Capacity

Tier 2 Strategies

Critical Component	Hazard	Strategy	Barriers
RESOURCES	All Hazards	Annually align city operational priorities to reflect the current assessment of Flooding and SLR impacts (16)	Financial, Political, Staff Capacity
	All Hazards	Seek additional staff capacity in future budget cycles (62)	Financial, Political, Staff Capacity
GOVERNANCE	All Flooding	Update current projects in the Long Range Transportation Plan based on vulnerability assessment prioritization (88)	Political, Staff Capacity
	Floodplain Inundation, Storm Surge	Seek and support new NFIP acquisition legislation for property buyouts (14)	Political, Staff Capacity
INFRASTRUCTURE	All Flooding	Maintenance initiative for existing stormwater system (58)	Financial, Staff Capacity
	All Flooding	Evaluate public housing in flood-prone areas (31)	Financial, Political, Staff Capacity
	All Flooding	Implement green infrastructure on city-owned property (27, 68)	Financial, Political, Staff Capacity
	Storm Surge, Tidal Flooding, SLR	Repair/reinforce Battery Sea Wall (Peninsula–24, 68, 69)	Financial, Political, Staff Capacity
	Tidal Flooding	Check valve program (identify opportunities) (19)	Financial, Political, Staff Capacity
	Tidal Flooding	Evaluate streets for accessibility and promote best routes (41)	Staff Capacity
LAND USE	All Flooding	Incentive-based zoning for redevelopment (WA-66)	
OUTREACH	All Flooding	Design guidelines for retrofitting/elevating historic properties (Peninsula–30)	
	All Flooding	Collaborate with partners to perform outreach to the community, particularly vulnerable populations (64)	Financial, Staff Capacity

Additional Supporting Strategies

Tier 3 Strategies

City staff identified 69 additional supporting options; see Appendix F for the full list. These supporting options fall into the following Critical Component categories:

RESOURCES 16 Strategies

GOVERNANCE 17 Strategies

INFRASTRUCTURE 19 Strategies

LAND USE 7 Strategies

OUTREACH 10 Strategies

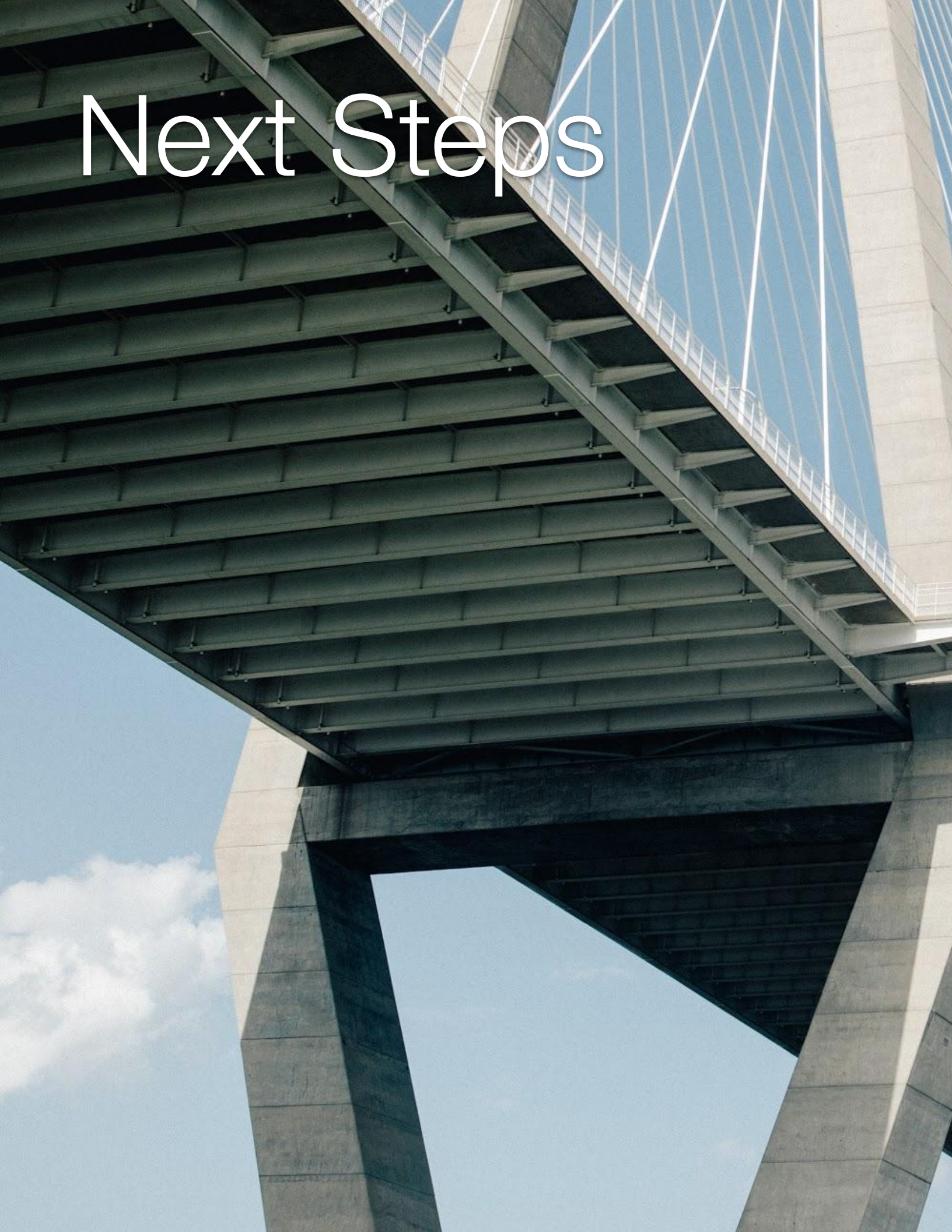
Multi-Hazard Value Strategies

The following types of strategies were also determined to be complementary in addressing vulnerabilities across most hazards. Depending on how or where they could be implemented, the following types of strategies have the potential to have value in addressing multiple issues:

- Retrofitting buildings and properties (5, 8, 30)
- Planning for the staging of response resources (57)
- Land use planning (53, 85)
- Outreach and public communication (1, 64)
- Long Range Transportation Plan (LRTP) prioritization (88)
- Pre-disaster recovery planning

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Next Steps





Integration and Use of Assessment

The ultimate goal of an assessment such as this is for it to serve as an actionable resource for city leaders and staff to be able to make informed decisions. The assessment process recognized the importance of taking a collaborative, tailored, and transparent approach to meet this goal. Three key elements of the assessment process were designed with these principles in mind:

1. Staff engagement. City staff were engaged throughout the entire assessment process, which resulted in capacity building for internal city staff. This also allowed staff to provide input and feedback throughout the process.
2. Transparency in how vulnerability and risk is defined in the assessment. Assessment rulesets are city-specific and consider local policies that help to describe the unique characteristics and vulnerabilities of the city. Appendix E contains the all asset-hazard pair assessment summaries, including a page that describes all factors used for every assessment.
3. The development of value-based insights. Using the four themes of property and public services, roads and mobility, economy, and people, the assessment considers different elements that make people, infrastructure, and services vulnerable to hazards in the city. All summary information and maps in the assessment are centered around supporting these value-based insights.

Information from the assessment has already been integrated with the Dutch Dialogues process and stormwater planning. Other planning efforts that staff have identified as opportunities for integration of the assessment include:

- the city's comprehensive planning process,
- the Army Corps of Engineers' risk management study,
- stormwater project prioritization,
- emergency management and public safety,
- transportation planning, and
- the city's hazard mitigation planning process.

For any of these planning efforts, the assessment can serve as a resource by helping those consulting it to understand key issues across the city and within neighborhoods. The assessment can also support solutions to key issues that have been identified and by highlighting what questions or considerations may need to be addressed by city departments and stakeholders.

Framework for Iteration and Adaptation Pathways

The Steps to Resilience assessment framework lays out an iterative process the city can use as a platform for ongoing resilience planning. For example, using the documented rulesets from the assessment, the city has the ability to re-evaluate its vulnerability and risk as resilience strategies are implemented or as new information becomes available.

Information from the assessment can also help to inform pathways to a resilient future. The assessment recognizes that resources are limited—which means that every issue cannot be addressed. With this, the assessment also highlights three types of risk that could help in establishing a framework to further establish the timing and sequence of resilience strategies. One approach that has been used in various communities is the Dynamic Adaptation Policy Pathways.[29] With this, it is important to stress that the ability to address future change calls for the planning and prioritization of solutions today in order to meet those challenges. In other words, the assessment highlights the fact that vulnerabilities and risk associated with future change should not be discounted, and that action should not be delayed, especially given the lead-time that may be needed for implementation. Long-term risks could also require additional stakeholders and partner coordination in order to be addressed. The three types of risk the assessment highlights include:

Near-term

Hazards: Flooding, Tidal Flooding (with current sea level rise), Release of Hazardous Materials

Near-term risks are related to events that are currently occurring with higher frequency, many of which are becoming more frequent or severe with changing conditions. This includes flooding related to heavy precipitation, tidal flooding with current sea level rise, and hazardous materials releases. Some of these are urgent issues that will involve holistic strategies to address, but with a particular focus on increasing the ability to cope with these events as they become more frequent and severe.

Long-term future change

Hazards: Sea Level Rise and Future Tidal Flooding, Extreme Heat

Future change will exacerbate current risks, with certain hazards becoming more frequent or severe with a changing climate. For some hazards, future change presents much higher levels of vulnerability, with impacts that could go well beyond what the city has experienced. These vulnerabilities are associated with sea level rise and the effect it will have on the frequency and severity of tidal flooding events, and the potential for an increased number of extreme heat events with increased temperature variability. Strategies to address these issues involve considering future risk and methods of keeping assets out of harm's way with future change.

High-impact event

Hazards: Storm Surge, Earthquake

The assessment highlights high levels of vulnerability associated with high-impact hazard events such as storm surge and earthquake. Some of these have a low or unknown probability of occurring, but could have devastating consequences if they were to occur. Strategies to address high-impact events will involve a focus on planning for response and emergency management and considering post-disaster recovery planning.

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Appendix A: Data Sources

Table 1: Hazard Data Sources

Hazard	Source	Data format
FEMA Flooding	FEMA Floodplains: ● Berkeley County, 2017 ● Charleston County, 2016	Vector features
Storm Surge	National Hurricane Center's Sea, Lake, and Overland Surge from Hurricanes (SLOSH) Maximum of the Maximum Envelopes of Water (MOM)	Raster
Tidal Flooding	NOAA Sea Level Rise Viewer "High Tide Flooding" layer	Raster
Sea level rise and future tidal flooding (3 feet and 5 feet above MHHW)	NOAA Sea Level Rise Viewer	Raster
Earthquake	Site Class Map by National Earthquake Hazard Reduction Program (NEHRP)	Vector features
Hazmat	EPA Tier II Facilities	Vector features
Extreme Heat	National Land Cover Database 2016 and City of Charleston Tree Canopy 2017 layer	Raster

Table 2: Asset and Socioeconomic Data Sources

Asset Type	Source	Data format
Property parcels	Berkeley and Charleston County Parcel Data Sets (Received Spring 2019)	Vector features
Historic properties and cultural landmarks	Charleston Historic Architecture Survey 1973 (Feiss, Wright, and City Planning), accessed via City of Charleston; National Register of Historic Sites	Vector features
Roads	Open Street Map	Linear Features
Socioeconomic Metrics	U.S Census, American Community Survey (ACS)	Vector features
Social Vulnerability Index	CDC's Social Vulnerability Index	Vector features

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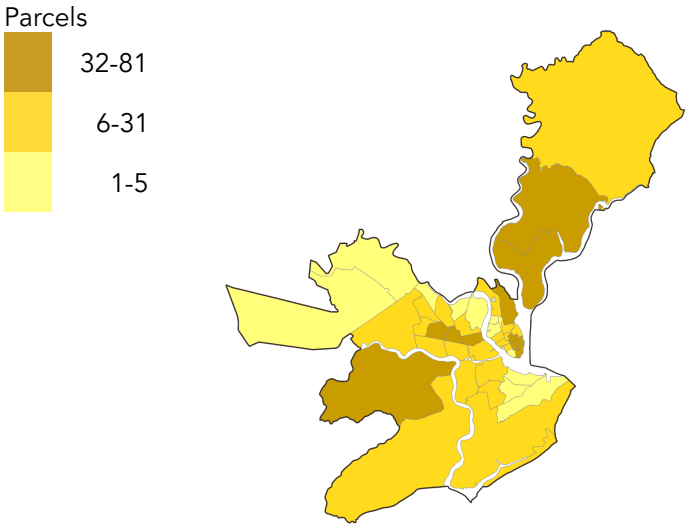
Appendix B: Asset Maps and Socioeconomic Variables

Asset Maps

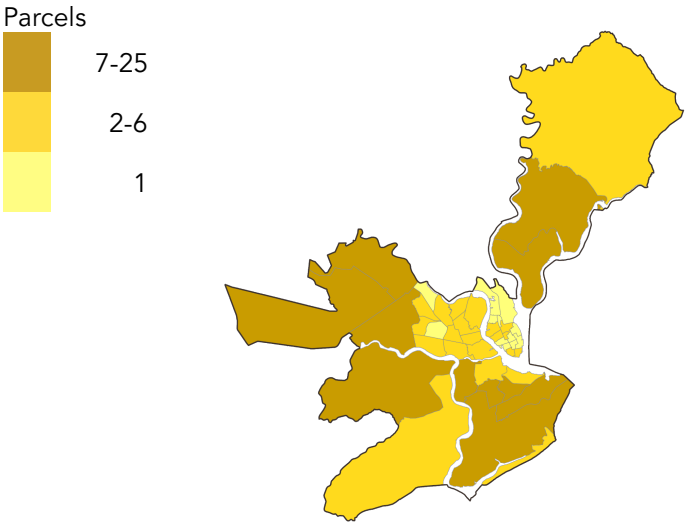
Note: In the maps below, colors indicate the total number of assets in each census tract; no adjustment has been made for differing area sizes. Darker colors in larger tracts may therefore be misleading.

Property & Public Services

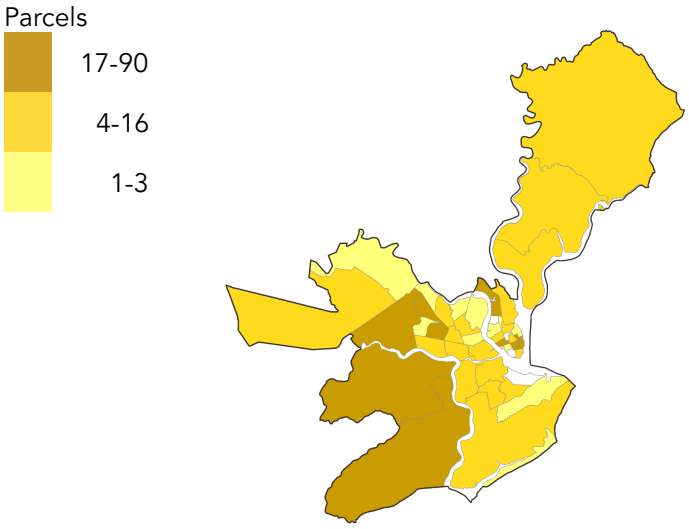
Commercial & Industrial Property



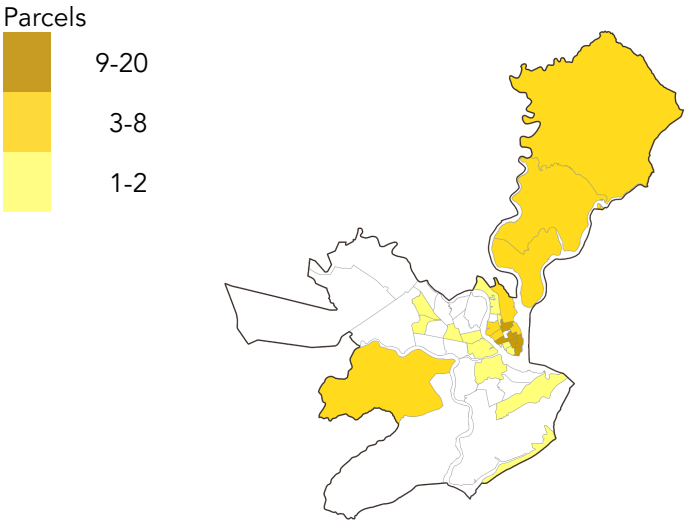
Residential Property



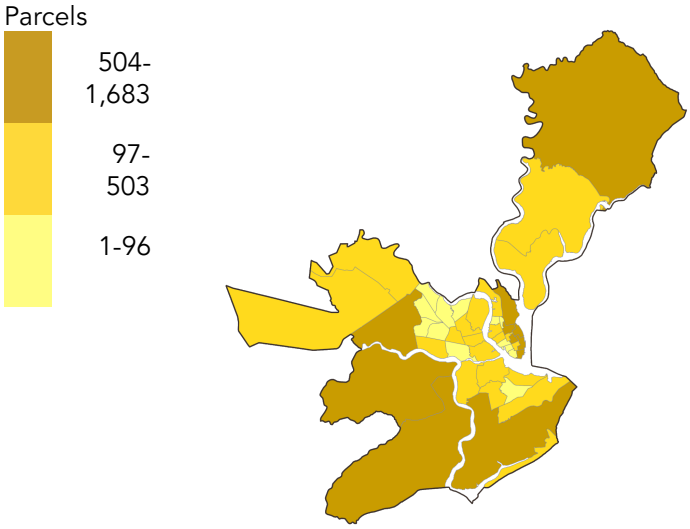
Critical Facilities



Government-Owned Property

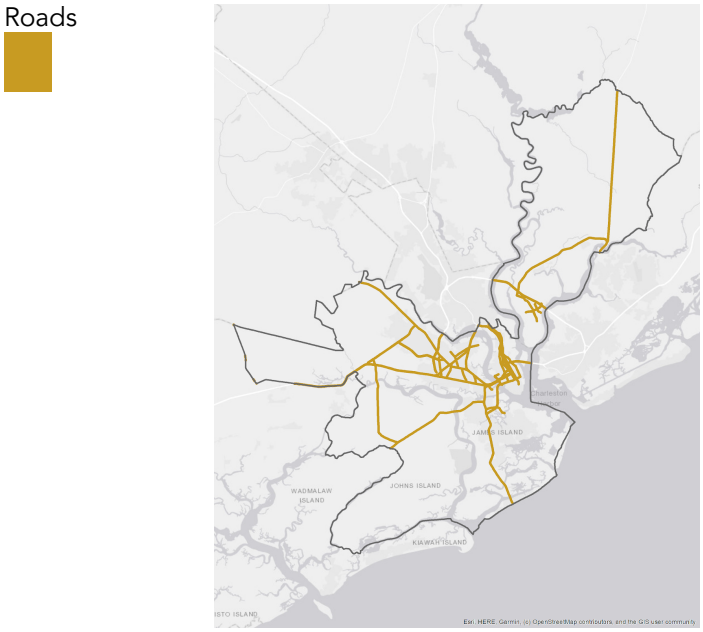


Parks & Cultural Property

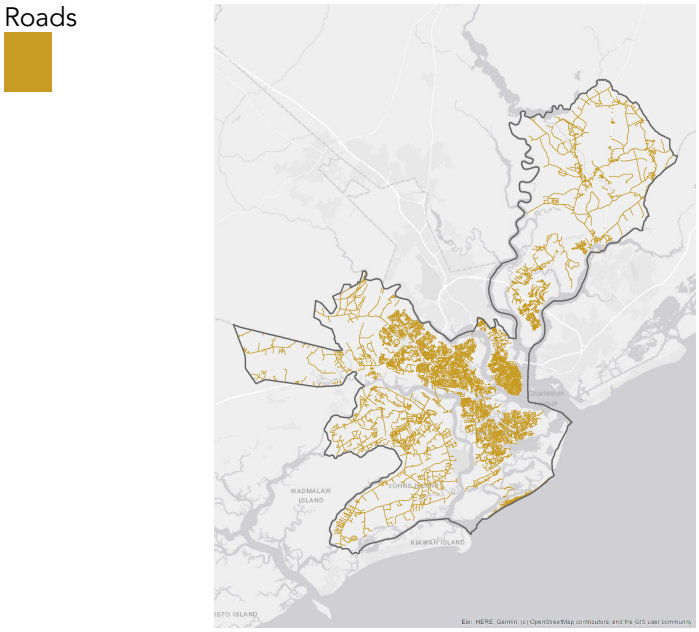


Roads & Mobility

Major Roads

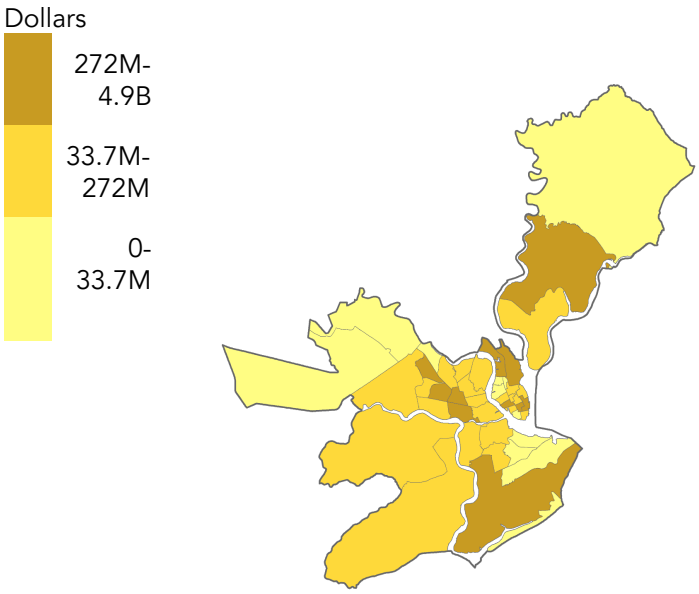


Minor Roads

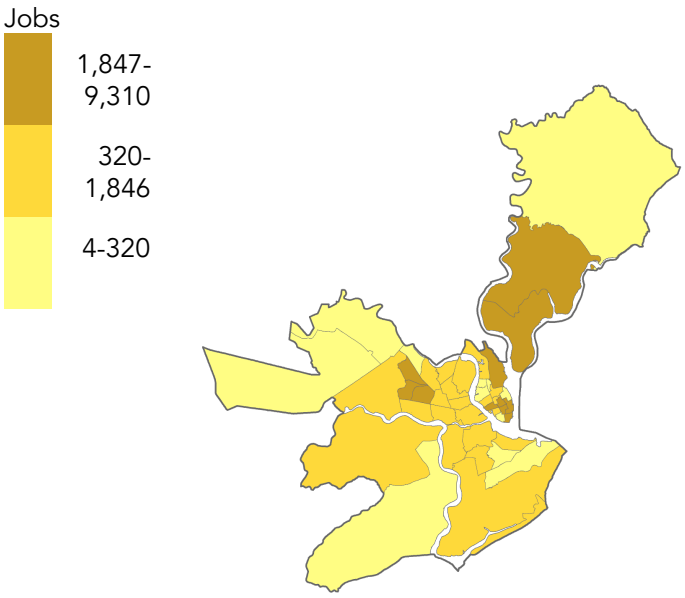


Economic

Annual Sales Volume



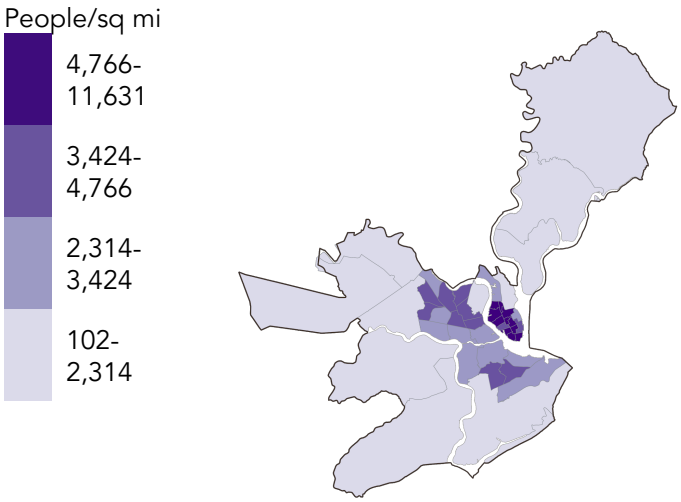
Jobs/Employees



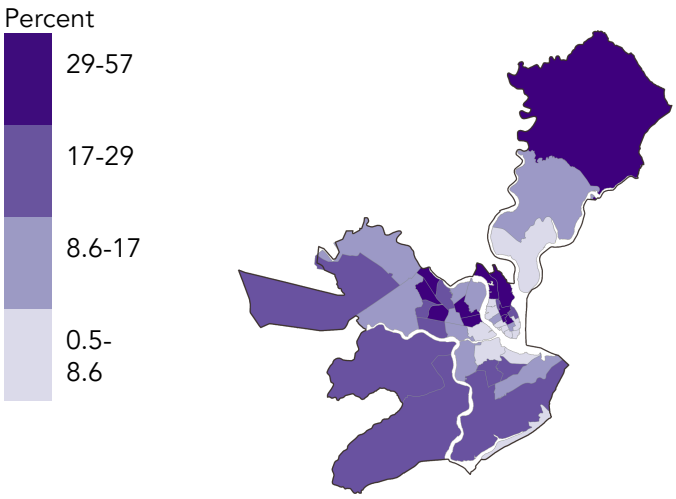
Socioeconomic Variables

The U.S. Census Bureau collects a variety of socioeconomic variables, and a number of these factors vary across Charleston.

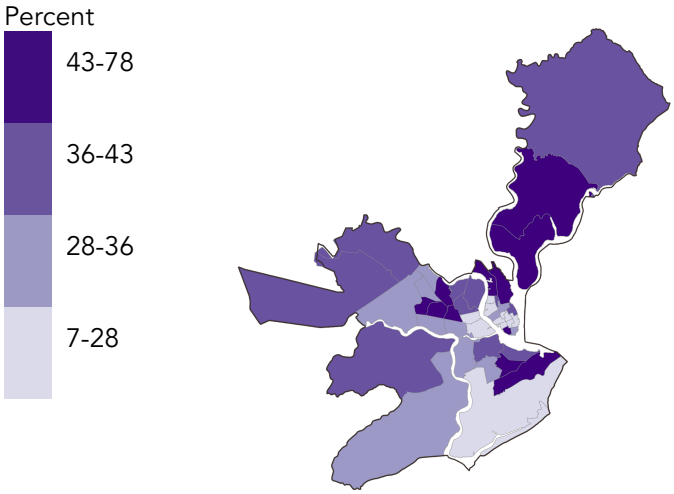
Population Density



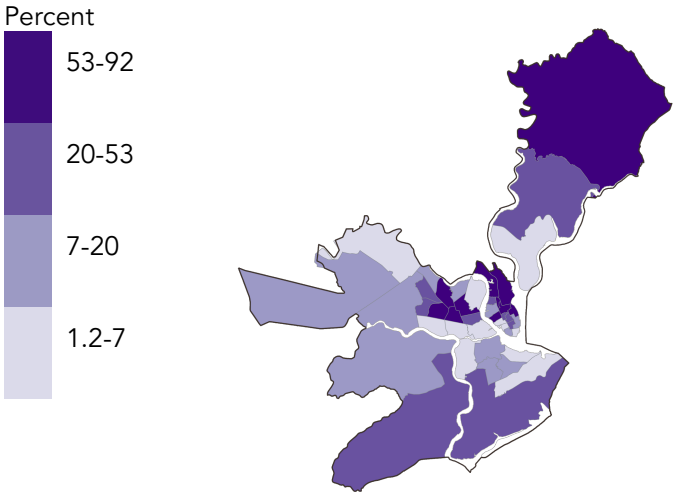
Percent of Population with Less Than a High School Diploma



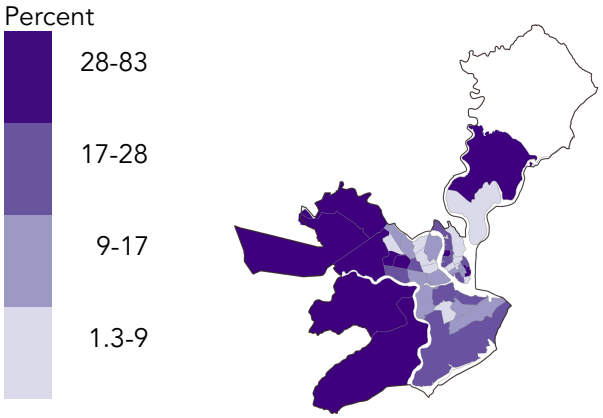
Percent of Population Younger than 18 or Older Than 64



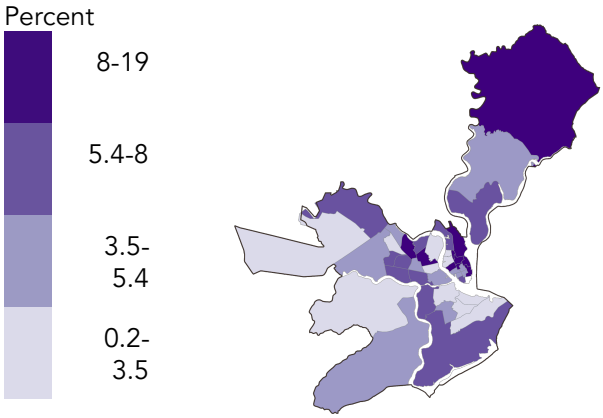
Percent African American Population



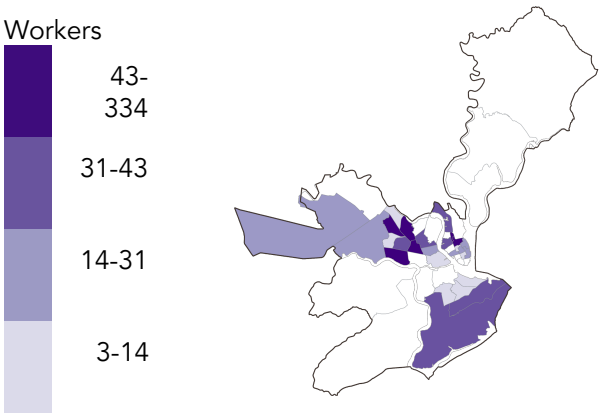
Percent Hispanic or Latino Origin Population



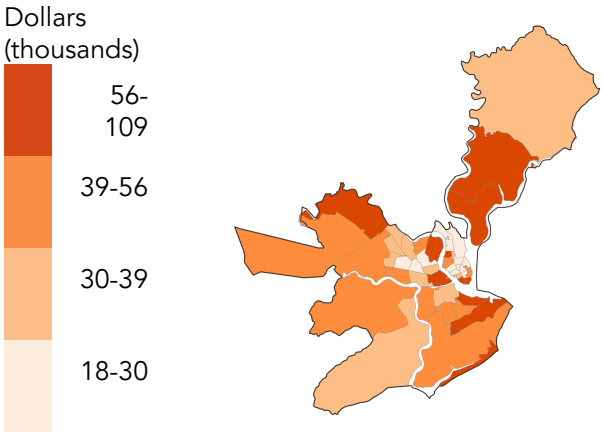
Percent of Population Age 16+ Unemployed



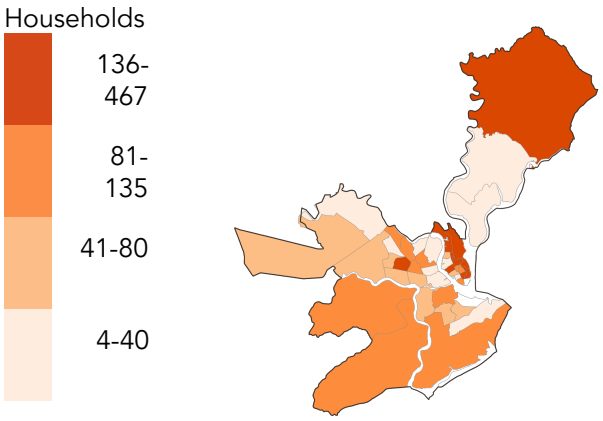
Workers Relying on Public Transportation



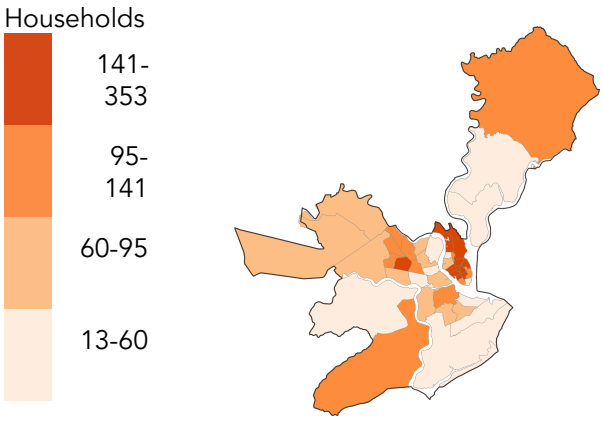
Median Household Income



Households Receiving SNAP Benefits



Households Below the Poverty Line

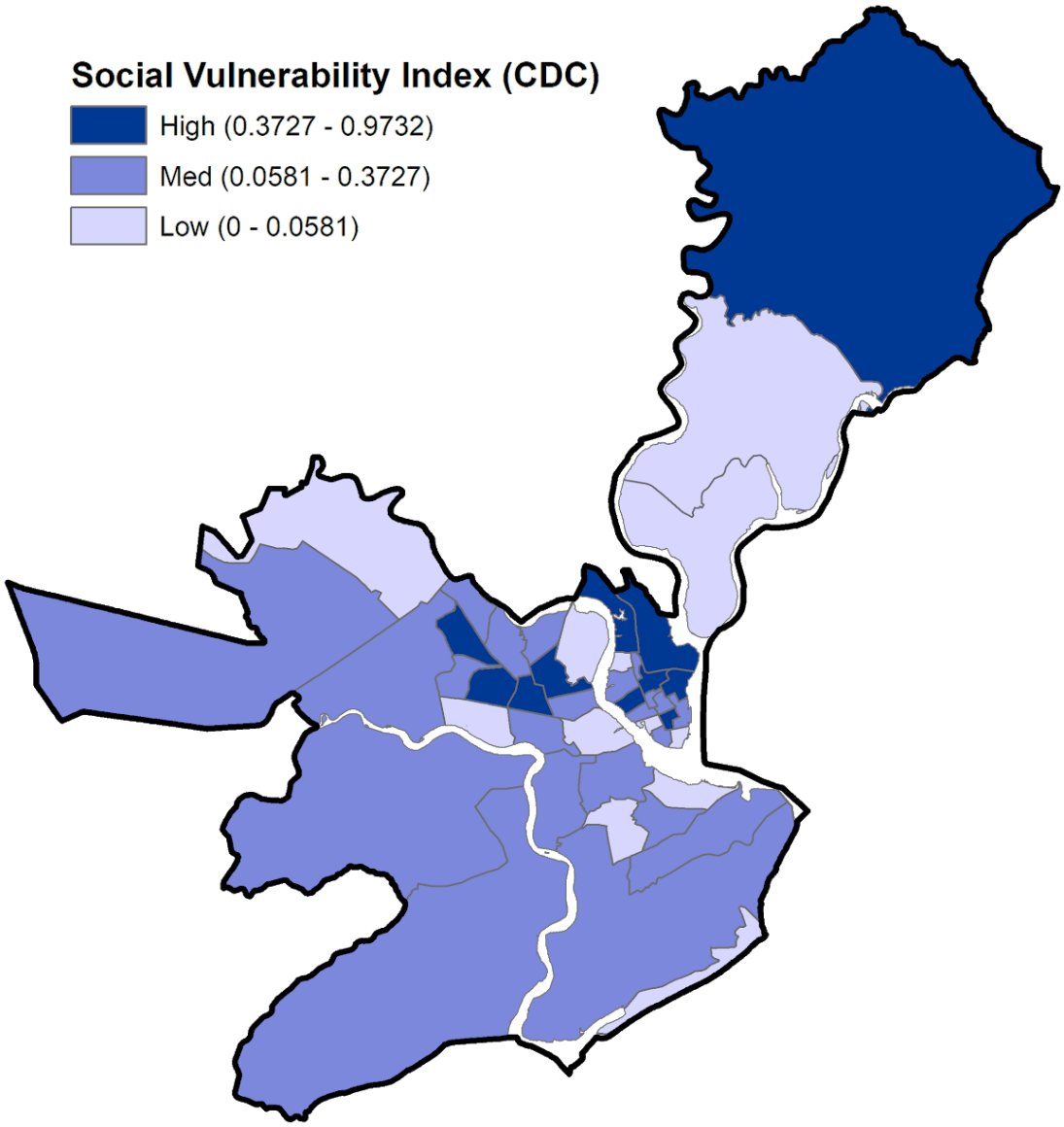


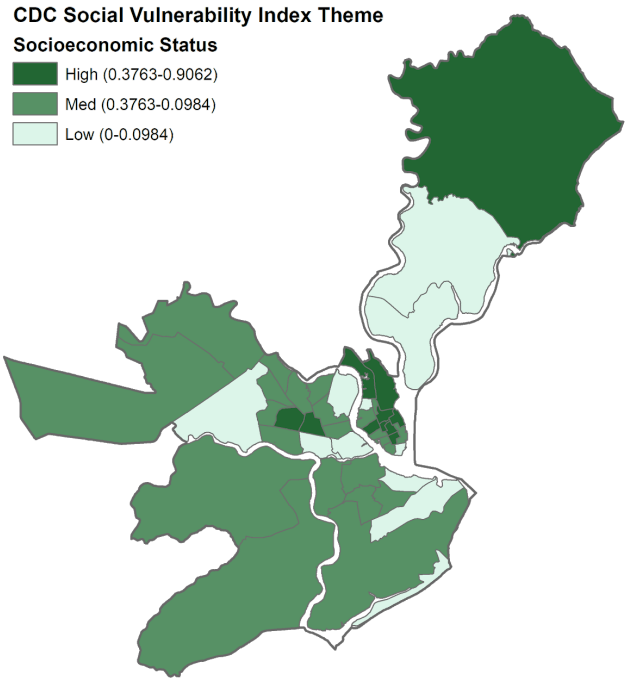
Social Vulnerability Indicators

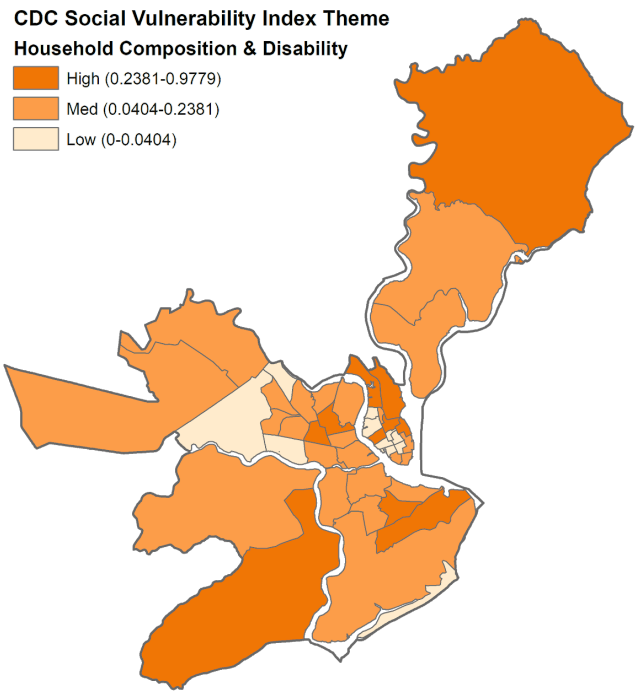
The Centers for Disease Control and Prevention (CDC) Social Vulnerability Index (SVI) was used as a general measure for levels of social vulnerability across areas of the city. The CDC SVI uses metrics from the American Community Survey (ACS) for the following themes:

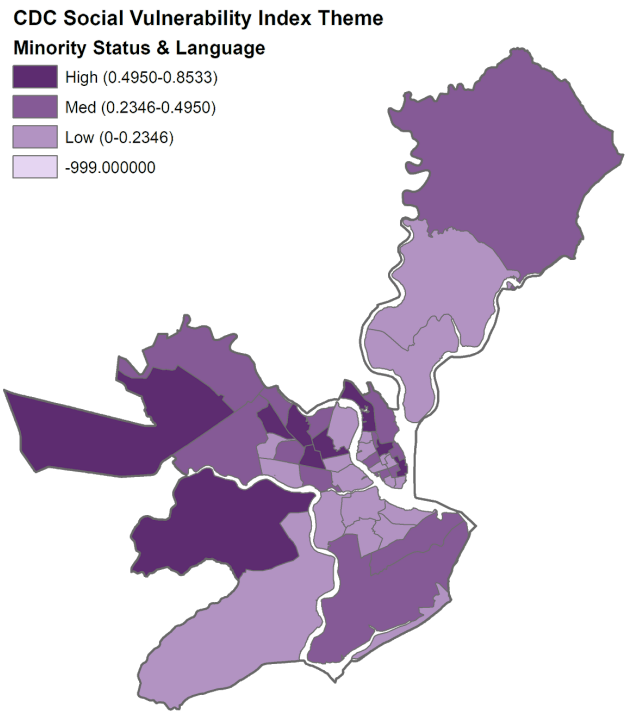
- Socioeconomic Status
- Household Composition & Disability
- Minority Status & Language
- Housing & Transportation

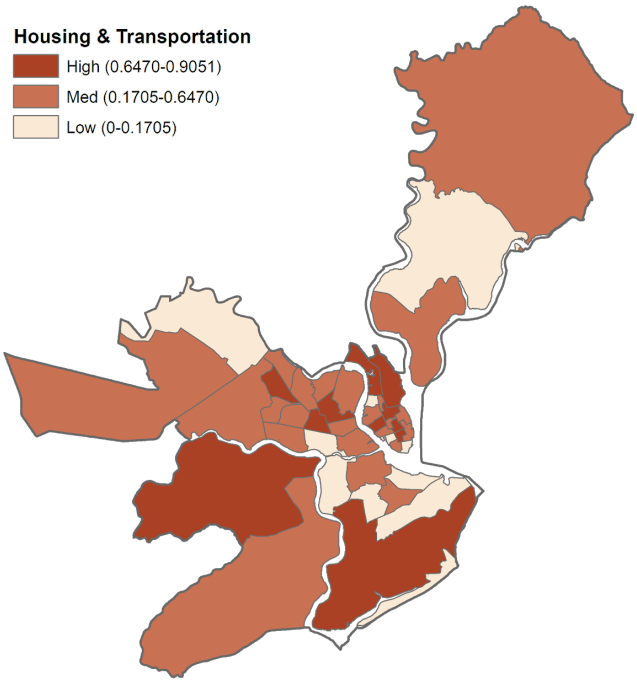
In addition to the individual themes, a single overall SVI index is produced. This overall SVI (shown below) provides a relative view of areas with the highest levels of social vulnerability, recognizing these are based on census tract aggregated statistics and that levels of vulnerability may be driven by different factors. The next pages provides a summary map of each individual SVI theme as well.




CDC Social Vulnerability Index Theme
Socioeconomic Status
High (0.3763-0.9062)
Med (0.3763-0.0984)
Low (0-0.0984)

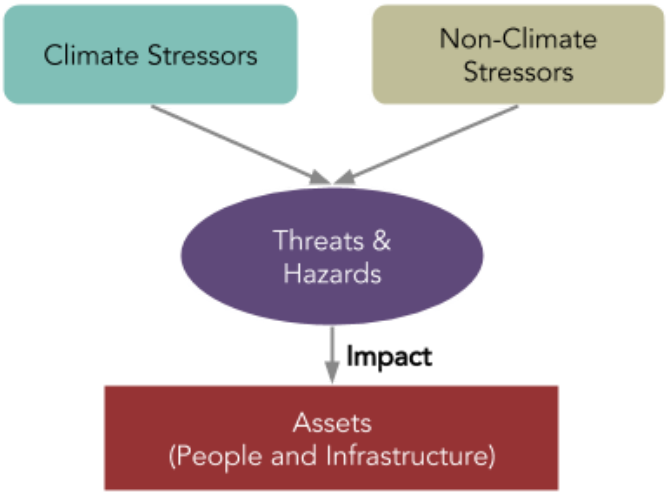

CDC Social Vulnerability Index Theme
Household Composition & Disability
High (0.2381-0.9779)
Med (0.0404-0.2381)
Low (0-0.0404)


CDC Social Vulnerability Index Theme
Minority Status & Language
High (0.4950-0.8533)
Med (0.2346-0.4950)
Low (0-0.2346)
-999.000000


Housing & Transportation
High (0.6470-0.9051)
Med (0.1705-0.6470)
Low (0-0.1705)

Appendix C: Analysis Technical Documentation

Process Overview



The U.S. Climate Resilience Toolkit defines *exposure* as "the presence of people, assets, and ecosystems in places where they could be adversely affected by hazards." For purposes of this assessment, "exposure" specifically means that an asset (e.g., a structure, parcel, or roadway) is spatially coincident with a specific hazard (e.g., flooding). For example, a warehouse located within the 500-year floodplain is considered to be "exposed."

Conceptually, the hazards to which assets are exposed are affected by both climate and non-climate stressors (shown in the diagram above). For purposes of this assessment, these hazards are presented using pre-existing hazard models, and discussion of how those hazards may change over time is presented through narrative and supporting information rather than modification of the hazard models using a variety of stressor scenarios.

The assessment was conducted in four stages:

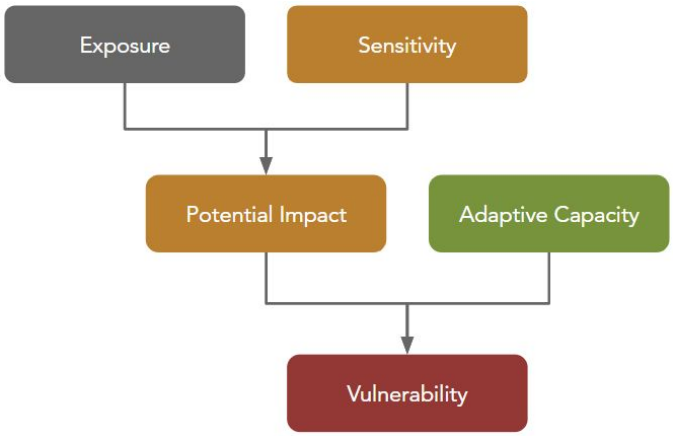
1. Asset data normalization and categorization;
2. Spatial relation of individual assets to each hazard layer;
3. Application of asset-scale vulnerability and risk rulesets; and
4. Aggregation of vulnerable and at-risk assets to census tracts.

Vulnerability and Risk Assessment

The vulnerability and risk assessment framework used multi-criteria decision analysis as well as spatial analysis in a data-driven pipeline.[1] This involved developing criteria, or rules, that were used to assign to assets specific ordinal classifications of *high*, *medium*, and *low* for each of the variables described below. The classifications were then combined using a matrix approach to determine levels of vulnerability, risk, and combined vulnerability and risk.[2]

Vulnerability

Vulnerability describes the susceptibility of exposed assets based on the two core concepts described above: (1) potential impact—the degree to which an asset is affected; and (2) adaptive capacity—the ability the asset has to cope with a potential impact.



Potential Impact

Potential impact is the degree to which an exposed asset (asset that is in harm's way) is potentially negatively affected by a climate-related threat. The level at which an exposed asset is negatively affected is also referred to as the asset's *sensitivity*. Assets that are not exposed have no potential impact; thus, they are not vulnerable, or at risk. Exposed assets were evaluated for levels of sensitivity, which were used in determining levels of potential impact.

Factors used to determine levels of potential impact were based on the asset's characteristics or on the level of impact due to service loss if the asset were to be affected.[3] For example, a property with a building structure in a flood hazard area has a higher potential impact than does a property that does not have a building in a flood hazard area.

Adaptive Capacity

Adaptive capacity considers how an asset is able to cope with a threat event or impact. An asset with adaptive capacity is able to withstand an impact with minimal disruption or loss. Measures of adaptive capacity can include physical elements, conditions, or designs in place that help an asset absorb an impact. Exposed assets were evaluated for indicators of adaptive capacity and classified accordingly.

For example, a commercial building that has flood-proofed its foundation and raised its ground floor above flood levels has more adaptive capacity than a commercial building that has not done so. As another example, a park with facilities designed to withstand flood waters without damaging its infrastructure has adaptive capacity.

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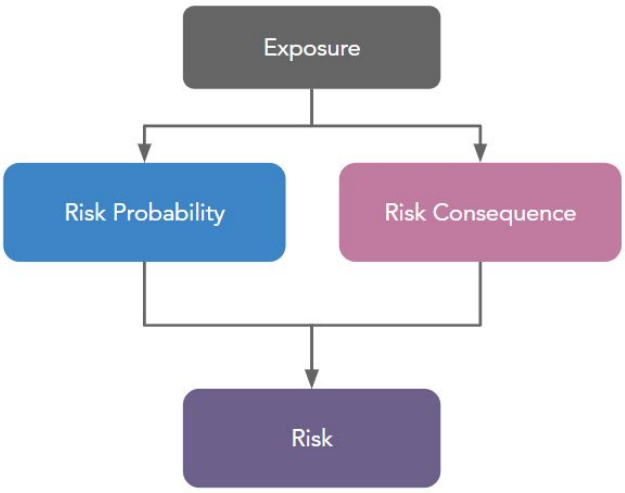
[1] Malczewski, Jacek, and Claus Rinner. *Multicriteria Decision Analysis in Geographic Information Science.* Springer-Verlag, 2015.
[2] EPA Office of Water, Climate Ready Estuaries. *Being Prepared for Climate Change: A Workbook for Developing Risk-Based Adaptation Plans.* U.S. Environmental Protection Agency, 2014. [https://www.epa.gov/sites/production/files/2014-09/documents/being_prepared_workbook_508.pdf]
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Levels of potential impact and adaptive capacity are then combined to inform vulnerability. Assets with low potential impact and high adaptive capacity are the least vulnerable. Assets with high potential impact and low adaptive capacity are the most vulnerable. For example, a business-related structure in the flood hazard zone has a "high" level of potential impact and, if it was built before 1979, it is classified as having "low" adaptive capacity. Together, they result in a "high" vulnerability classification.



Risk Scoping

Just as potential impact and adaptive capacity combine to determine vulnerability, risk probability and risk consequence combine to give us an assessment of risk scoping.

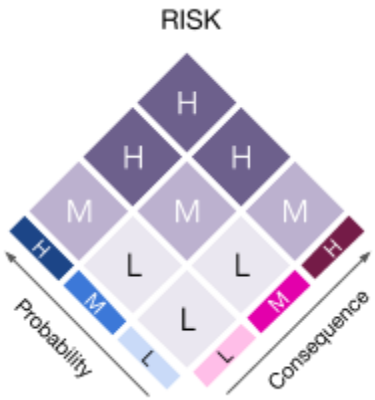


Risk Probability

Probabilities were determined for each threat using annualized likelihoods of threat occurrence or relative levels based on known risk factors. For example, for FEMA Flooding, the floodway, 100-year, and 500-year flood hazard zones were used to evaluate different probabilities of flooding for each asset.

Risk Consequence

Risk consequence refers to negative outcomes or critical thresholds that indicate varying levels of significance if a threat were to occur. For example, assets with affected structures or a higher monetary value may have a greater negative consequence than assets with no affected structures or that have a lower monetary value.



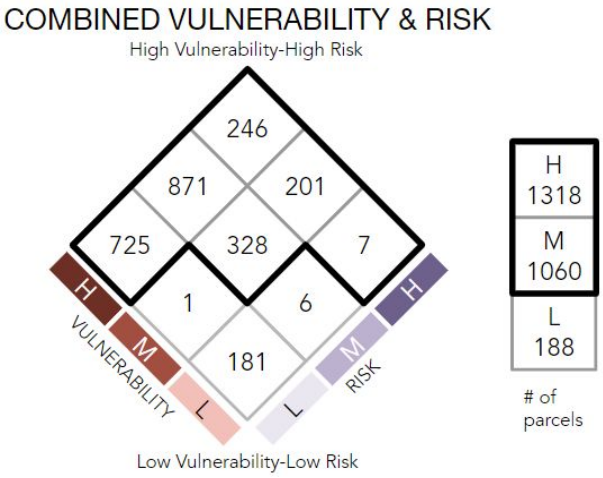
Levels of risk probability and risk consequence are then combined to inform risk scoping. For example, a parcel with an exposed high-value building in the 10-year flood hazard zone would have a high risk classification, while a parcel in the 100-year flood hazard zone without an exposed building would have a low risk classification.

It is important to note that this step is referred to as risk scoping, as no loss estimates were quantified.

Combined Vulnerability and Risk

Vulnerability considers how an asset might be impacted and its ability to cope if a given threat event were to occur, and risk considers the probability of the threat occurring and the general consequence of the threat (without considering factors that make it susceptible). Combining these concepts allows decision makers to evaluate which assets are most susceptible and most likely to be impacted, and also to consider options according to different levels of risk threshold.

The matrix shown here features the combination of vulnerability and risk for Commercial Property and FEMA Flooding. High-vulnerability and high-risk parcels are in the top-most cell. Those that have low vulnerability and low risk are in the bottom-most cell.

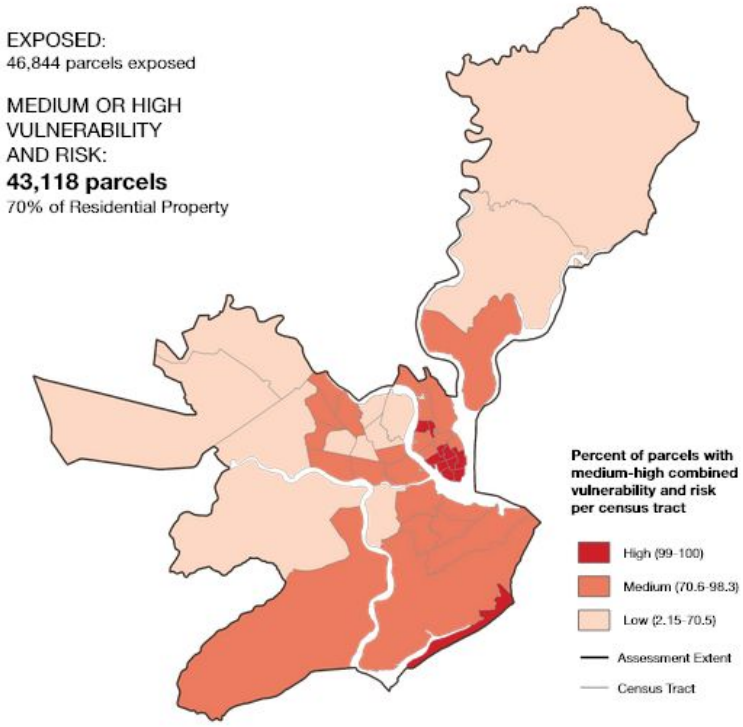


Aggregation of Vulnerability and Risk

In order to focus on the most vulnerable and risk assets, the assets with either medium or high combined vulnerability and risk are mapped at the aggregate scale. In the matrix and parcel-level map to the right, these are the cells or parcel with the two darkest shades of red.

Due to varying sizes of census tracts in the region, the *percent of assets with medium-high combined vulnerability and risk* map is used to provide a relative perspective of vulnerability within different areas in the city.

The table on the following page provides a high-level summary of the types of criteria used for each component of the vulnerability and risk assessment framework.



High-Level Summary of Assessment Ruleset Components

Hazard	Exposure	Vulnerability		Risk	
		Potential Impact	Adaptive Capacity	Probability	Consequence
FEMA Floodplains	Any FEMA flood zone (floodway, 100-yr, and 500-yr)	Criticality of asset based on type and use	Base flood elevation (BFE)	Levels of flood probability (floodway, 100-yr, 500-yr)	Property value
Tidal Flooding	NOAA high tide extent (impact threshold)	Criticality of asset based on type and use	Base flood elevation (BFE)		Property value
Storm Surge	Any storm surge category	Criticality of asset based on type and use	Base flood elevation (BFE)	Levels of Storm Category (1, 2-3, 4-5).	Property value
Sea Level Rise	NOAA 3 ft SLR	Criticality of asset based on type and use	Base flood elevation (BFE)	Levels of SLR (1, 2, 3)	Property value
Earthquakes	All areas	Criticality of asset based on type and use	Structural age using thresholds of 1970 and 2002	N/A	
HAZMAT	Any screening area (0.5 or 1 mile proximity)	Criticality of asset based on type and use	5-minute Response drive time	N/A	
Extreme Heat	All areas	Households below poverty line and 65+; developed landcover	Amount of tree canopy coverage; socioeconomic status (CDC)	N/A	
Water Shortage	All areas			N/A	

Future Assessment Considerations

Floodplain Inundation

Given the widespread nature of flooding, the City could consider taking a watershed focused approach to planning and implementing flood mitigation measures. Master planning that takes into account the cumulative effects of planned projects is necessary to implement measures that will remain effective in the coming years. This could require investing in standardized hydrologic and hydraulic modeling. Such localized modeling will have other uses as well such as, improved cost-benefit analyses of infrastructure investments.

Earthquake

The current assessment focused on property based assets and bridge infrastructure. However, many additional factors would be important to consider as part of further analysis, including but not limited to other types of infrastructure[4], such as:

- Pipelines
- Railroad and port access
- Tanks and reservoirs holding liquid
- Pumps, lift stations, and wells
- Water and wastewater utilities
- Power assets

Impacts to these different types of infrastructure can lead to a range of impacts, including:

- Potential for loss of power
- Direct hazard to employees and public safety
- Possible gas line ruptures and fires near utility assets
- Impacts to firefighting and hospitals
- Time for repairs
- Availability and cost of spare parts
- Need to provide emergency drinking water or alternate wastewater services

Hazardous Materials

The City core team identified management status as an potentially important element to consider as part of the vulnerability to hazmat. Certain types of hazmat site owners or managers will have different types of storage and capacity that could make some site more adaptive to other hazards or that may make them lower risk, such as if a facility has greater capacity for containment.

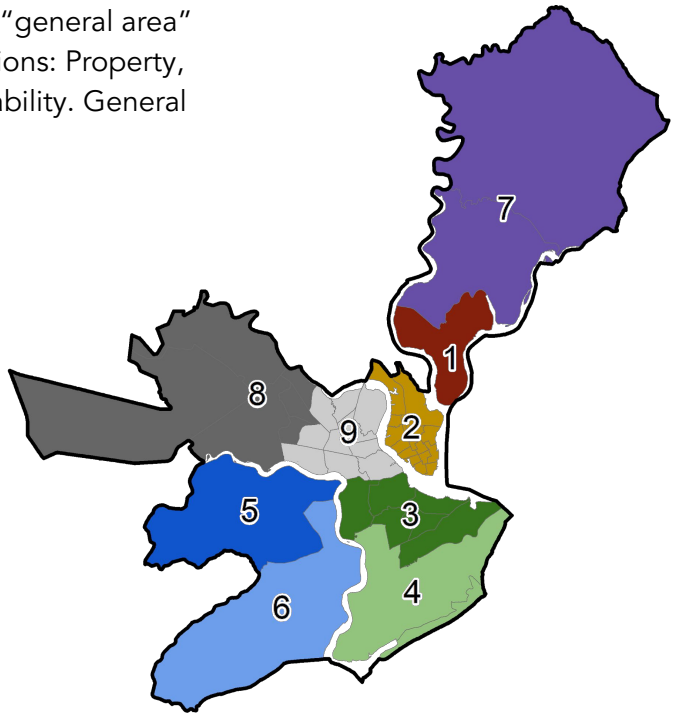
[4] EPA Earthquake Resilience Guide: https://www.epa.gov/sites/production/files/2018-02/documents/180112-earthquakeresilienceguide.pdf

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Appendix D: General Area Reports

How to read general area reports

The following pages contain summary reports for each "general area" across all threats and all assets organized into four sections: Property, Roads & Mobility, Economic Impact, and Social Vulnerability. General areas are labelled in map on right.



1. Daniel Island
2. Downtown/Peninsula
3. James Island (North)
4. James Island (South)
5. Johns Island (North)
6. Johns Island (South)
7. Cainhoy
8. West Ashley (Outer)
9. West Ashley (Inner)

The **Property** section presents assessment results of Property-based asset / threat pairs by count of assets which have been identified as *high or medium combined vulnerability risk*, *high or medium vulnerability*, or *exposed* depending on the "best" type of assessment performed for each asset / threat pair.

The **Roads & Mobility** section presents major and minor roads that are potentially isolated due to inundation-based threats in terms of "lane miles" (e.g. a road with 2 lanes, one for each direction of traffic, with a length of 1 mile is 2 lane miles). Additionally, a count of potentially isolated properties are presented where available.

The **Economic Impacts** section presents annual sales volume and employees / jobs which are attached to properties which have been identified as *high or medium combined vulnerability risk*, *high or medium vulnerability*, or *exposed* depending on the "best" type of assessment performed for each threat.

The **Social Vulnerability** section highlights themes from the Center for Disease Control and Prevention (CDC) Social Vulnerability Index (SVI) for the given area.

Additional Notes

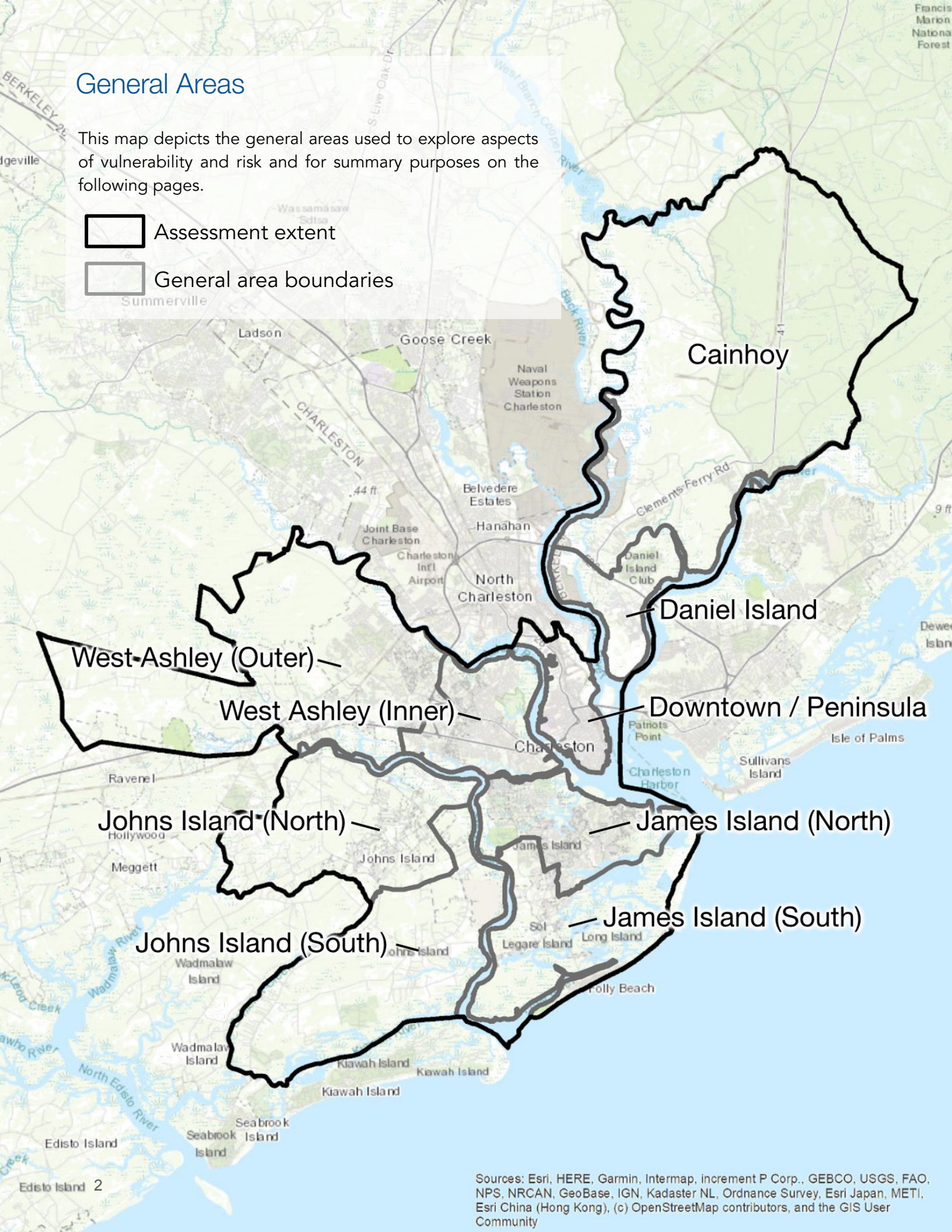
- Asset total column percentages reflect percent citywide. All other percentages reflect the percent of assets within the area that are vulnerable and at risk.
- Inaccessible property refers to all properties regardless of type.
- Roads and mobility & Floodplain Inundation reports 100-yr inundation.
- Roads and mobility & Storm Surge reports Cat 3 extent.
- Sea Level Rise/Future Tidal Flooding 5 ft reports exposure instead of vulnerability and risk.
- Earthquake and refers to vulnerability.
- Economic factors report sales and employees associated with commercial property.

General Areas

This map depicts the general areas used to explore aspects of vulnerability and risk and for summary purposes on the following pages.

Assessment extent

General area boundaries



Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community

Daniel Island Area Report

Daniel Island Theme / Asset	Asset Total [% of citywide]	FEMA Flooding	Storm Surge	Tidal Flooding	Sea Level Rise / Future Tidal Flooding		Earth-quake	Hazmat
					3 ft + MHHW	5 ft + MHHW		
Property & Public Services								
Commercial	126 [4%]	116 (92%)	116 (92%)	0 (0%)	1 (1%)	13 (10%)	36 (29%)	3 (2%)
Residential	3,720 [6%]	3,438 (92%)	3,490 (94%)	35 (1%)	114 (3%)	1,685 (45%)	714 (19%)	39 (1%)
Critical Facilities	11 [3%]	8 (73%)	9 (82%)	0 (0%)	0 (0%)	4 (36%)	8 (73%)	5 (45%)
Government-Owned	5 [3%]	1 (20%)	1 (20%)	0 (0%)	0 (0%)	5 (100%)	5 (100%)	0 (0%)
Parks and Cultural	18 [3%]	11 (61%)	11 (61%)	0 (0%)	1 (6%)	11 (61%)	16 (89%)	0 (0%)
Roads & Mobility								
Major Roads Inaccessible (Lane miles)	29 [5%]	16.2 (55%)	27.7 (94%)	3.6 (12%)	4.1 (14%)	6.3 (21%)	5 Bridges	N/A
Minor Roads Inaccessible (Lane miles)	128 [4%]	121.2 (95%)	127.7 (100%)	5.9 (5%)	15.4 (12%)	84.4 (66%)		
Inaccessible Property	4,697 [7%]	4,592 (98%)	4,691 (100%)	489 (10%)	1,330 (28%)	3,329 (71%)		
Economic								
Annual Sales Volume	225M [2%]	225M (100%)	225M (100%)	0.M (0%)	6M (3%)	35M (16%)	N/A	N/A
Jobs / Employees	2,192 [3%]	2,192 (100%)	2,192 (100%)	(0%)	20 (1%)	290 (13%)		
People & Socioeconomics								
Overall SVI	Low (area has among the lowest social vulnerability in the City)							
Public Housing	1	1 (100%)	1 (100%)	0 (0%)	0 (0%)	1 (100%)	N/A	N/A
SNAP Retailers	1	1 (100%)	1 (100%)	0 (0%)	0 (0%)	0 (0%)	N/A	N/A

Downtown/Peninsula Area Report

Downtown / Peninsula Theme / Asset	Asset Total [% of citywide]	FEMA Flooding	Storm Surge	Tidal Flooding	Sea Level Rise / Future Tidal Flooding		Earth-quake	Hazmat
					3 ft + MHHW	5 ft + MHHW		
Property & Public Services								
Commercial	1,360 [40%]	1,265 (93%)	1,326 (98%)	70 (5%)	140 (10%)	406 (30%)	833 (61%)	825 (61%)
Residential	8,741 [14%]	8,386 (96%)	8,669 (99%)	763 (9%)	1,338 (15%)	3,288 (38%)	5,546 (63%)	4,159 (48%)
Critical Facilities	115 [33%]	100 (87%)	103 (90%)	21 (18%)	32 (28%)	58 (50%)	106 (92%)	87 (76%)
Government-Owned	117 [81%]	94 (80%)	94 (80%)	17 (15%)	25 (21%)	56 (48%)	111 (95%)	83 (71%)
Parks and Cultural	293 [44%]	231 (79%)	242 (83%)	24 (8%)	41 (14%)	110 (38%)	274 (94%)	152 (52%)
Roads & Mobility								
Major Roads Inaccessible (Lane miles)	113 [19%]	39.3 (35%)	113.1 (100%)	5.1 (4%)	14.7 (13%)	23.3 (21%)	10 Bridges	N/A
Minor Roads Inaccessible (Lane miles)	307 [10%]	200.6 (65%)	306.8 (100%)	58.5 (19%)	86.9 (28%)	141.2 (46%)		
Inaccessible Property	10,651 [15%]	6,475 (61%)	10,651 (100%)	1,256 (12%)	2,466 (23%)	4,434 (42%)		
Economic								
Annual Sales Volume	8,842M [61%]	8,672M (98%)	8,841M (100%)	1,841M (21%)	2,061M (23%)	3,355M (38%)	N/A	N/A
Jobs / Employees	39,820 [54%]	39,196 (98%)	39,816 (100%)	13,533 (34%)	16,229 (41%)	21,640 (54%)		
People & Socioeconomics								
Overall SVI	High (Socioeconomic Status, Household Composition & Disability, Minority Status & Language, Housing & Transportation)							
Public Housing	58	57 (98%)	57 (98%)	5 (9%)	7 (12%)	33 (57%)	N/A	N/A
SNAP Retailers	35	34 (97%)	35 (100%)	5 (14%)	8 (23%)	14 (40%)	N/A	N/A

James Island (North) Area Report

James Island (North)	Asset Total [% of citywide]	FEMA Flooding	Storm Surge	Tidal Flooding	Sea Level Rise / Future Tidal Flooding		Earth-quake	Hazmat
Theme / Asset					3 ft + MHHW	5 ft + MHHW		
Property & Public Services								
Commercial	238 [7%]	193 (81%)	236 (99%)	5 (2%)	11 (5%)	41 (17%)	85 (36%)	10 (4%)
Residential	10,983 [18%]	9,458 (86%)	10,821 (99%)	257 (2%)	532 (5%)	3,641 (33%)	3,976 (36%)	244 (2%)
Critical Facilities	38 [11%]	32 (84%)	34 (89%)	0 (0%)	0 (0%)	11 (29%)	33 (87%)	0 (0%)
Government-Owned	2 [1%]	2 (100%)	2 (100%)	0 (0%)	0 (0%)	2 (100%)	2 (100%)	0 (0%)
Parks and Cultural	59 [9%]	38 (64%)	42 (71%)	3 (5%)	4 (7%)	35 (59%)	58 (98%)	5 (8%)
Roads & Mobility								
Major Roads Inaccessible (Lane miles)	34 [6%]	21.8 (65%)	33.6 (100%)	0.8 (2%)	4.6 (14%)	9.2 (27%)	0 Bridges	N/A
Minor Roads Inaccessible (Lane miles)	355 [12%]	263.5 (74%)	355.2 (100%)	31.0 (9%)	63.4 (18%)	153.4 (43%)		
Inaccessible Property	11,291 [16%]	7,984 (71%)	11,291 (100%)	736 (7%)	1,679 (15%)	4,683 (41%)		
Economic								
Annual Sales Volume	403M [3%]	362M (90%)	403M (100%)	0.3M (0%)	0.8M (0%)	35M (9%)	N/A	N/A
Jobs / Employees	3,891 [5%]	3,499 (90%)	3,891 (100%)	1,009 (26%)	1,040 (27%)	1,354 (35%)		
People & Socioeconomics								
Overall SVI	Low to Moderate (Household Composition & Disability)							
Public Housing	4	4 (100%)	4 (100%)	0 (0%)	0 (0%)	3 (75%)	N/A	N/A
SNAP Retailers	12	9 (75%)	12 (100%)	0 (0%)	0 (0%)	3 (25%)	N/A	N/A

James Island (South) Area Report

James Island (South) / Theme / Asset	Asset Total [% of citywide]	FEMA Flooding	Storm Surge	Tidal Flooding	Sea Level Rise / Future Tidal Flooding		Earth-quake	Hazmat
					3 ft + MHHW	5 ft + MHHW		
Property & Public Services								
Commercial	120 [4%]	106 (88%)	119 (99%)	8 (7%)	9 (8%)	61 (51%)	64 (53%)	12 (10%)
Residential	4,088 [7%]	3,559 (87%)	4,029 (99%)	331 (8%)	673 (16%)	2,374 (58%)	2,211 (54%)	214 (5%)
Critical Facilities	14 [4%]	11 (79%)	12 (86%)	1 (7%)	2 (14%)	6 (43%)	12 (86%)	3 (21%)
Government-Owned	2 [1%]	2 (100%)	2 (100%)	0 (0%)	1 (50%)	2 (100%)	2 (100%)	0 (0%)
Parks and Cultural	32 [5%]	21 (66%)	23 (72%)	3 (9%)	9 (28%)	16 (50%)	31 (97%)	3 (9%)
Roads & Mobility								
Major Roads Inaccessible (Lane miles)	24 [4%]	15.1 (64%)	23.5 (100%)	0.2 (1%)	7.6 (32%)	12.8 (54%)	0 Bridges	N/A
Minor Roads Inaccessible (Lane miles)	155 [5%]	115.0 (74%)	155.1 (100%)	43.6 (28%)	64.9 (42%)	92.6 (60%)		
Inaccessible Property	4,246 [6%]	3,420 (81%)	4,246 (100%)	1,168 (28%)	1,859 (44%)	2,846 (67%)		
Economic								
Annual Sales Volume	312M [2%]	285M (91%)	312M (100%)	3M (1%)	3M (1%)	76M (24%)	N/A	N/A
Jobs / Employees	2,032 [3%]	1,830 (90%)	2,032 (100%)	44 (2%)	44 (2%)	707 (35%)		
People & Socioeconomics								
Overall SVI	Low to Moderate (Housing & Transportation)							
Public Housing	1	1 (100%)	1 (100%)	0 (0%)	0 (0%)	0 (0%)	N/A	N/A
SNAP Retailers	5	3 (60%)	5 (100%)	1 (20%)	1 (20%)	3 (60%)	N/A	N/A

Johns Island (North) Area Report

Johns Island (North)	Asset Total [% of citywide]	FEMA Flooding	Storm Surge	Tidal Flooding	Sea Level Rise / Future Tidal Flooding		Earth-quake	Hazmat
Theme / Asset					3 ft + MHHW	5 ft + MHHW		
Property & Public Services								
Commercial	146 [4%]	15 (10%)	120 (82%)	0 (0%)	2 (1%)	5 (3%)	49 (34%)	0 (0%)
Residential	5,463 [9%]	1,631 (30%)	5,042 (92%)	118 (2%)	269 (5%)	1,195 (22%)	1,446 (26%)	2 (0%)
Critical Facilities	20 [6%]	2 (10%)	15 (75%)	0 (0%)	0 (0%)	5 (25%)	19 (95%)	0 (0%)
Government-Owned	4 [3%]	0 (0%)	2 (50%)	0 (0%)	0 (0%)	1 (25%)	4 (100%)	0 (0%)
Parks and Cultural	34 [5%]	8 (24%)	27 (79%)	1 (3%)	2 (6%)	10 (29%)	31 (91%)	0 (0%)
Roads & Mobility								
Major Roads Inaccessible (Lane miles)	39 [7%]	4.4 (11%)	23.7 (60%)	1.3 (3%)	2.1 (5%)	7.8 (20%)	0 Bridges	N/A
Minor Roads Inaccessible (Lane miles)	327 [11%]	111.9 (34%)	270.3 (83%)	53.2 (16%)	82.6 (25%)	144.3 (44%)		
Inaccessible Property	5,661 [8%]	1,249 (22%)	4,126 (73%)	540 (10%)	1,082 (19%)	1,640 (29%)		
Economic								
Annual Sales Volume	269M [2%]	51M (19%)	240M (89%)	0.M (0%)	40M (15%)	41M (15%)	N/A	N/A
Jobs / Employees	1,671 [2%]	178 (11%)	1,504 (90%)	(0%)	58 (3%)	122 (7%)		
People & Socioeconomics								
Overall SVI	Moderate (Minority Status & Language, Housing & Transportation)							
Public Housing	2	0 (0%)	2 (100%)	0 (0%)	0 (0%)	0 (0%)	N/A	N/A
SNAP Retailers	12	2 (17%)	11 (92%)	0 (0%)	0 (0%)	2 (17%)	N/A	N/A

Johns Island (South) Area Report

Johns Island (South) Theme / Asset	Asset Total [% of citywide]	FEMA Flooding	Storm Surge	Tidal Flooding	Sea Level Rise / Future Tidal Flooding		Earth-quake	Hazmat
					3 ft + MHHW	5 ft + MHHW		
Property & Public Services								
Commercial	30 [1%]	18 (60%)	28 (93%)	0 (0%)	2 (7%)	7 (23%)	15 (50%)	1 (3%)
Residential	1,476 [2%]	1,121 (76%)	1,415 (96%)	27 (2%)	119 (8%)	610 (41%)	637 (43%)	14 (1%)
Critical Facilities	15 [4%]	7 (47%)	9 (60%)	1 (7%)	1 (7%)	5 (33%)	14 (93%)	0 (0%)
Government-Owned	0 [0%]	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Parks and Cultural	29 [4%]	12 (41%)	25 (86%)	0 (0%)	0 (0%)	7 (24%)	23 (79%)	0 (0%)
Roads & Mobility								
Major Roads Inaccessible (Lane miles)	4 [1%]	4.1 (100%)	4.1 (100%)	0.0 (0%)	0.0 (0%)	4.1 (100%)	0 Bridges	N/A
Minor Roads Inaccessible (Lane miles)	217 [7%]	211.8 (97%)	217.0 (100%)	200.9 (92%)	202.3 (93%)	211.0 (97%)		
Inaccessible Property	1,545 [2%]	1,442 (93%)	1,542 (100%)	1,318 (85%)	1,345 (87%)	1,440 (93%)		
Economic								
Annual Sales Volume	55M [0%]	33M (61%)	55M (100%)	0.M (0%)	0.M (0%)	8M (14%)	N/A	N/A
Jobs / Employees	295 [0%]	235 (80%)	295 (100%)	(0%)	(0%)	49 (17%)		
People & Socioeconomics								
Overall SVI	Moderate (Household Composition & Disability)							
Public Housing	0	-	-	-	-	-	N/A	N/A
SNAP Retailers	4	3 (75%)	3 (75%)	0 (0%)	1 (25%)	2 (50%)	N/A	N/A

Cainhoy Area Report

Cainhoy Theme / Asset	Asset Total [% of citywide]	FEMA Flooding	Storm Surge	Tidal Flooding	Sea Level Rise / Future Tidal Flooding		Earth-quake	Hazmat
					3 ft + MHHW	5 ft + MHHW		
Property & Public Services								
Commercial	278 [8%]	78 (28%)	152 (55%)	3 (1%)	3 (1%)	22 (8%)	72 (26%)	10 (4%)
Residential	3,180 [5%]	705 (22%)	2,025 (64%)	31 (1%)	82 (3%)	561 (18%)	714 (22%)	88 (3%)
Critical Facilities	16 [5%]	0 (0%)	2 (13%)	0 (0%)	0 (0%)	2 (13%)	5 (31%)	2 (13%)
Government-Owned	7 [5%]	0 (0%)	0 (0%)	0 (0%)	0 (0%)	1 (14%)	7 (100%)	0 (0%)
Parks and Cultural	33 [5%]	0 (0%)	8 (24%)	0 (0%)	0 (0%)	5 (15%)	28 (85%)	2 (6%)
Roads & Mobility								
Major Roads Inaccessible (Lane miles)	98 [16%]	13.4 (14%)	46.0 (47%)	5.8 (6%)	7.7 (8%)	12.0 (12%)	0 Bridges	N/A
Minor Roads Inaccessible (Lane miles)	474 [16%]	119.3 (25%)	220.5 (47%)	71.7 (15%)	81.6 (17%)	104.9 (22%)		
Inaccessible Property	5,642 [8%]	2,050 (36%)	4,307 (76%)	1,266 (22%)	1,887 (33%)	2,332 (41%)		
Economic								
Annual Sales Volume	683M [5%]	56M (8%)	258M (38%)	0.3M (0%)	0.3M (0%)	49M (7%)	N/A	N/A
Jobs / Employees	3,408 [5%]	346 (10%)	1,499 (44%)	4 (0%)	4 (0%)	180 (5%)		
People & Socioeconomics								
Overall SVI	Moderate (Socioeconomic Status, Household Composition & Disability)							
Public Housing	0	-	-	-	-	-	N/A	N/A
SNAP Retailers	3	0 (0%)	2 (67%)	0 (0%)	0 (0%)	0 (0%)	N/A	N/A

West Ashley (Outer) Area Report

West Ashley (Outer)	Asset Total [% of citywide]	FEMA Flooding	Storm Surge	Tidal Flooding	Sea Level Rise / Future Tidal Flooding		Earth-quake	Hazmat
Theme / Asset					3 ft + MHHW	5 ft + MHHW		
Property & Public Services								
Commercial	239 [7%]	172 (72%)	234 (98%)	6 (3%)	6 (3%)	96 (40%)	112 (47%)	75 (31%)
Residential	12,600 [20%]	7,228 (57%)	12,010 (95%)	231 (2%)	280 (2%)	2,470 (20%)	2,738 (22%)	655 (5%)
Critical Facilities	44 [13%]	19 (43%)	31 (70%)	3 (7%)	3 (7%)	14 (32%)	36 (82%)	15 (34%)
Government-Owned	3 [2%]	3 (100%)	3 (100%)	0 (0%)	0 (0%)	1 (33%)	3 (100%)	1 (33%)
Parks and Cultural	66 [10%]	42 (64%)	48 (73%)	4 (6%)	6 (9%)	37 (56%)	61 (92%)	4 (6%)
Roads & Mobility								
Major Roads Inaccessible (Lane miles)	146 [25%]	107.5 (74%)	135.9 (93%)	4.3 (3%)	22.9 (16%)	64.0 (44%)	11 Bridges	N/A
Minor Roads Inaccessible (Lane miles)	626 [21%]	442.4 (71%)	583.5 (93%)	46.1 (7%)	89.9 (14%)	217.5 (35%)		
Inaccessible Property	12,927 [19%]	8,836 (68%)	12,721 (98%)	348 (3%)	1,304 (10%)	3,540 (27%)		
Economic								
Annual Sales Volume	1,097M [8%]	816M (74%)	1,097M (100%)	22M (2%)	44M (4%)	505M (46%)	N/A	N/A
Jobs / Employees	6,753 [9%]	4,863 (72%)	6,753 (100%)	363 (5%)	417 (6%)	3,292 (49%)		
People & Socioeconomics								
Overall SVI	Moderate to High (Minority Status & Language, Housing & Transportation)							
Public Housing	3	3 (100%)	3 (100%)	0 (0%)	0 (0%)	3 (100%)	N/A	N/A
SNAP Retailers	20	16 (80%)	19 (95%)	0 (0%)	0 (0%)	10 (50%)	N/A	N/A

West Ashley (Inner) Area Report

West Ashley (Inner)	Asset Total [% of citywide]	FEMA Flooding	Storm Surge	Tidal Flooding	Sea Level Rise / Future Tidal Flooding		Earth-quake	Hazmat
Theme / Asset					3 ft + MHHW	5 ft + MHHW		
Property & Public Services								
Commercial	831 [25%]	417 (50%)	822 (99%)	10 (1%)	9 (1%)	64 (8%)	290 (35%)	109 (13%)
Residential	11,530 [19%]	7,592 (66%)	11,414 (99%)	248 (2%)	602 (5%)	3,170 (27%)	6,346 (55%)	430 (4%)
Critical Facilities	74 [21%]	31 (42%)	64 (86%)	1 (1%)	4 (5%)	18 (24%)	71 (96%)	12 (16%)
Government-Owned	4 [3%]	2 (50%)	4 (100%)	0 (0%)	1 (25%)	1 (25%)	2 (50%)	0 (0%)
Parks and Cultural	95 [14%]	43 (45%)	73 (77%)	7 (7%)	9 (9%)	24 (25%)	90 (95%)	14 (15%)
Roads & Mobility								
Major Roads Inaccessible (Lane miles)	109 [18%]	29.1 (27%)	88.2 (81%)	1.4 (1%)	3.5 (3%)	9.4 (9%)	6 Bridges	N/A
Minor Roads Inaccessible (Lane miles)	417 [14%]	189.5 (45%)	382.7 (92%)	27.3 (7%)	66.2 (16%)	128.0 (31%)		
Inaccessible Property	12,493 [18%]	5,298 (42%)	11,326 (91%)	513 (4%)	2,176 (17%)	3,975 (32%)		
Economic								
Annual Sales Volume	2,548M [18%]	1,373M (54%)	2,547M (100%)	19M (1%)	18M (1%)	279M (11%)	N/A	N/A
Jobs / Employees	13,575 [18%]	7,212 (53%)	13,569 (100%)	148 (1%)	192 (1%)	1,681 (12%)		
People & Socioeconomics								
Overall SVI	High (Socioeconomic Status, Household Composition & Disability, Minority Status & Language, Housing & Transportation)							
Public Housing	34	27 (79%)	34 (100%)	0 (0%)	1 (3%)	1 (3%)	N/A	N/A
SNAP Retailers	30	12 (40%)	29 (97%)	0 (0%)	1 (3%)	6 (20%)	N/A	N/A

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Appendix E: Asset-hazard pair vulnerability and risk profiles

Every spatially-distinct asset-threat pair vulnerability and risk assessment profile is provided in this section. Each assessment profile consists of a page with a map and summary statistics, and a second page that contains a ruleset summary with a citywide matrix showing the number of assets classified for every combination of vulnerability and risk.

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Roads & Mobility 66

Asset-hazard profile guide

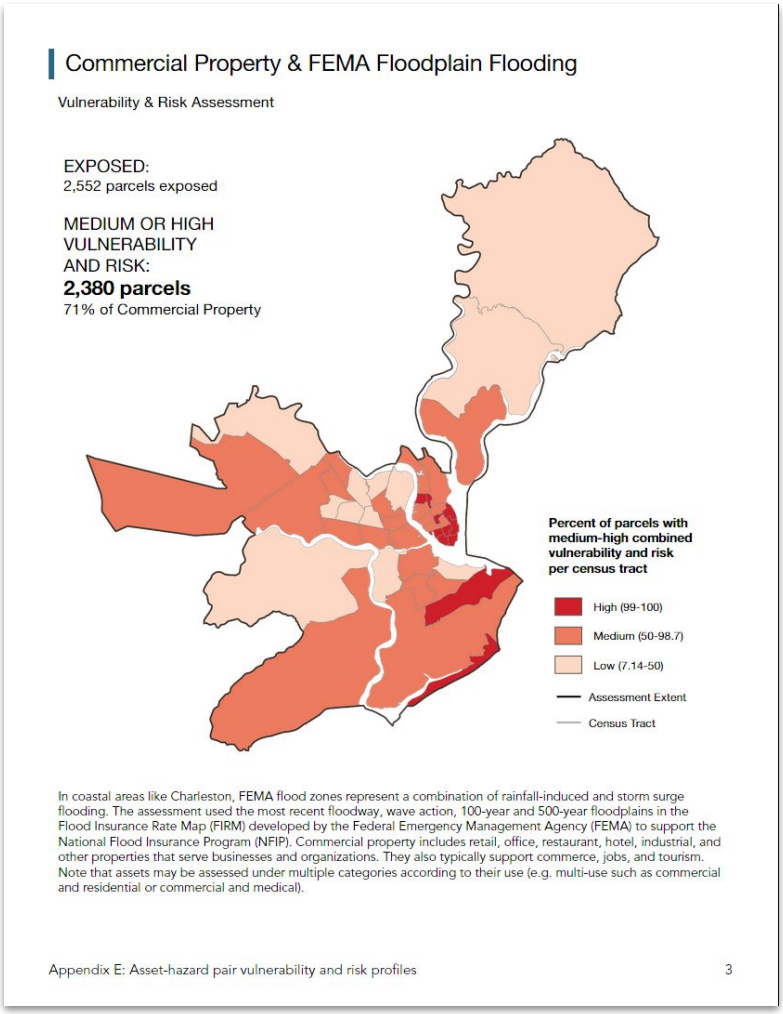
The spatially-distinct asset-threat pair vulnerability and risk assessments, or vulnerability assessments (where risk was not assessed), are presented in the following pages using consistent 2-page profiles. This guide below points out the key features of each profile.

Assessment overview / map

Asset-threat pair

Exposure
Number of assets citywide in harm's way for this threat.

Count of assets most affected
Number of assets citywide with medium or high potential impact/combined vulnerability and risk.



Assets most affected in each census tract
The high and medium vulnerability and risk parcels are aggregated within each census tract to identify the most vulnerable neighborhoods in the assessment area.

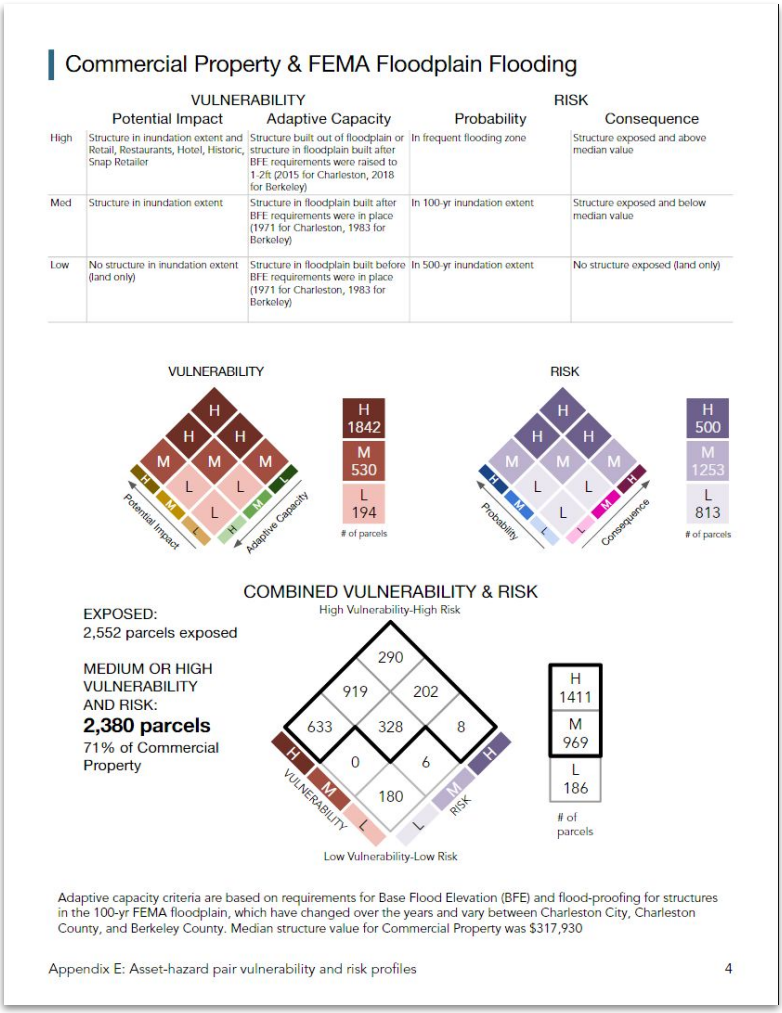
Note that the legend ranges are *per census tract*, which will vary from the "medium or high vulnerability and risk" total in the upper left.

Assessment criteria

Asset-threat pair

Assessment Criteria
Rules used to assess levels of potential impact, adaptive capacity, risk probability, and risk consequence.

Vulnerability and Risk Matrices and Charts
Matrix for each concept and a graph showing the distribution of vulnerability and risk for all exposed assets.



Commercial Property & FEMA Floodplain Flooding

	VULNERABILITY		RISK	
	Potential Impact	Adaptive Capacity	Probability	Consequence
High	Structure in inundation extent and Retail, Restaurants, Hotel, Historic, Snap Retailer	Structure built out of floodplain or structure in floodplain built after BFE requirements were raised to 1-2ft (2015 for Charleston, 2018 for Berkeley)	In frequent flooding zone	Structure exposed and above median value
Med	Structure in inundation extent	Structure in floodplain built after BFE requirements were in place (1971 for Charleston, 1983 for Berkeley)	In 100-yr inundation extent	Structure exposed and below median value
Low	No structure in inundation extent (land only)	Structure in floodplain built before BFE requirements were in place (1971 for Charleston, 1983 for Berkeley)	In 500-yr inundation extent	No structure exposed (land only)

Adaptive capacity criteria are based on requirements for Base Flood Elevation (BFE) and flood-proofing for structures in the 100-yr FEMA floodplain, which have changed over the years and vary between Charleston City, Charleston County, and Berkeley County. Median structure value for Commercial Property was $317,930

Appendix E: Asset-hazard pair vulnerability and risk profiles 4

Matrix Showing Selection of "Medium to High"
Matrix showing how concepts are combined to produce levels of combined potential impact or vulnerability and risk. Also, the number of assets that fall into each bin and the total number in medium to high. This matrix is not shown for vulnerability-only assessments.

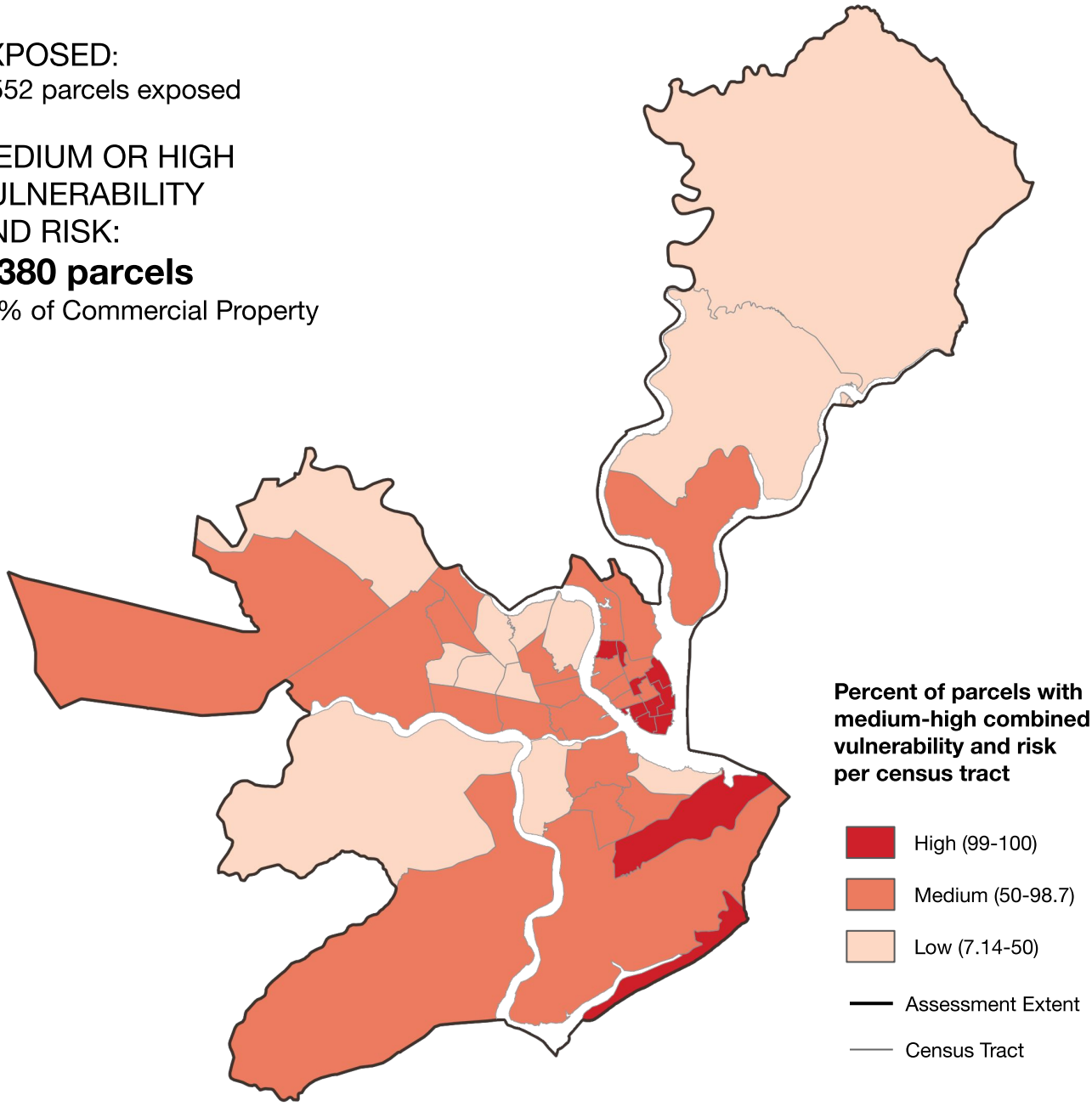
Note that the bold outline around the high and medium totals correspond to the map on the previous page.

Commercial Property & Floodplain Inundation

Vulnerability & Risk Assessment

EXPOSED:
2,552 parcels exposed

MEDIUM OR HIGH VULNERABILITY AND RISK:
2,380 parcels
71% of Commercial Property

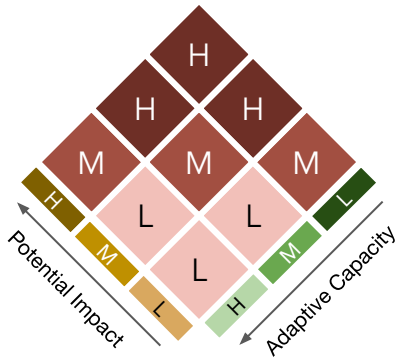


In coastal areas like Charleston, FEMA flood zones represent a combination of rainfall-induced and storm surge flooding. The assessment used the most recent floodway, wave action, 100-year and 500-year floodplains in the Flood Insurance Rate Map (FIRM) developed by the Federal Emergency Management Agency (FEMA) to support the National Flood Insurance Program (NFIP). Commercial property includes retail, office, restaurant, hotel, industrial, and other properties that serve businesses and organizations. They also typically support commerce, jobs, and tourism. Note that assets may be assessed under multiple categories according to their use (e.g. multi-use such as commercial and residential or commercial and medical).

Commercial Property & Floodplain Inundation

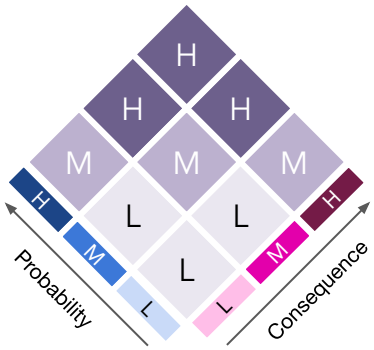
	VULNERABILITY		RISK	
	Potential Impact	Adaptive Capacity	Probability	Consequence
High	Structure in inundation extent and Retail, Restaurants, Hotel, Historic, Snap Retailer	Structure built out of floodplain or structure in floodplain built after BFE requirements were raised to 1-2ft (2015 for Charleston, 2018 for Berkeley)	In frequent flooding zone	Structure exposed and above median value
Med	Structure in inundation extent	Structure in floodplain built after BFE requirements were in place (1971 for Charleston, 1983 for Berkeley)	In 100-yr inundation extent	Structure exposed and below median value
Low	No structure in inundation extent (land only)	Structure in floodplain built before BFE requirements were in place (1971 for Charleston, 1983 for Berkeley)	In 500-yr inundation extent	No structure exposed (land only)

VULNERABILITY



H 1842
M 530
L 194
# of parcels

RISK



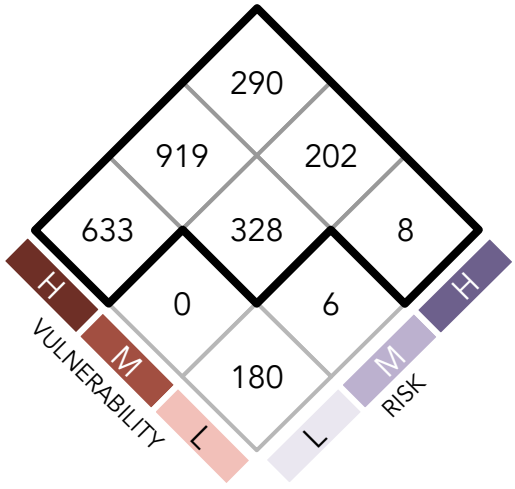
H 500
M 1253
L 813
# of parcels

COMBINED VULNERABILITY & RISK

EXPOSED:
2,552 parcels exposed

MEDIUM OR HIGH VULNERABILITY AND RISK:
2,380 parcels
71% of Commercial Property

High Vulnerability-High Risk



Low Vulnerability-Low Risk

H 1411
M 969
L 186
# of parcels

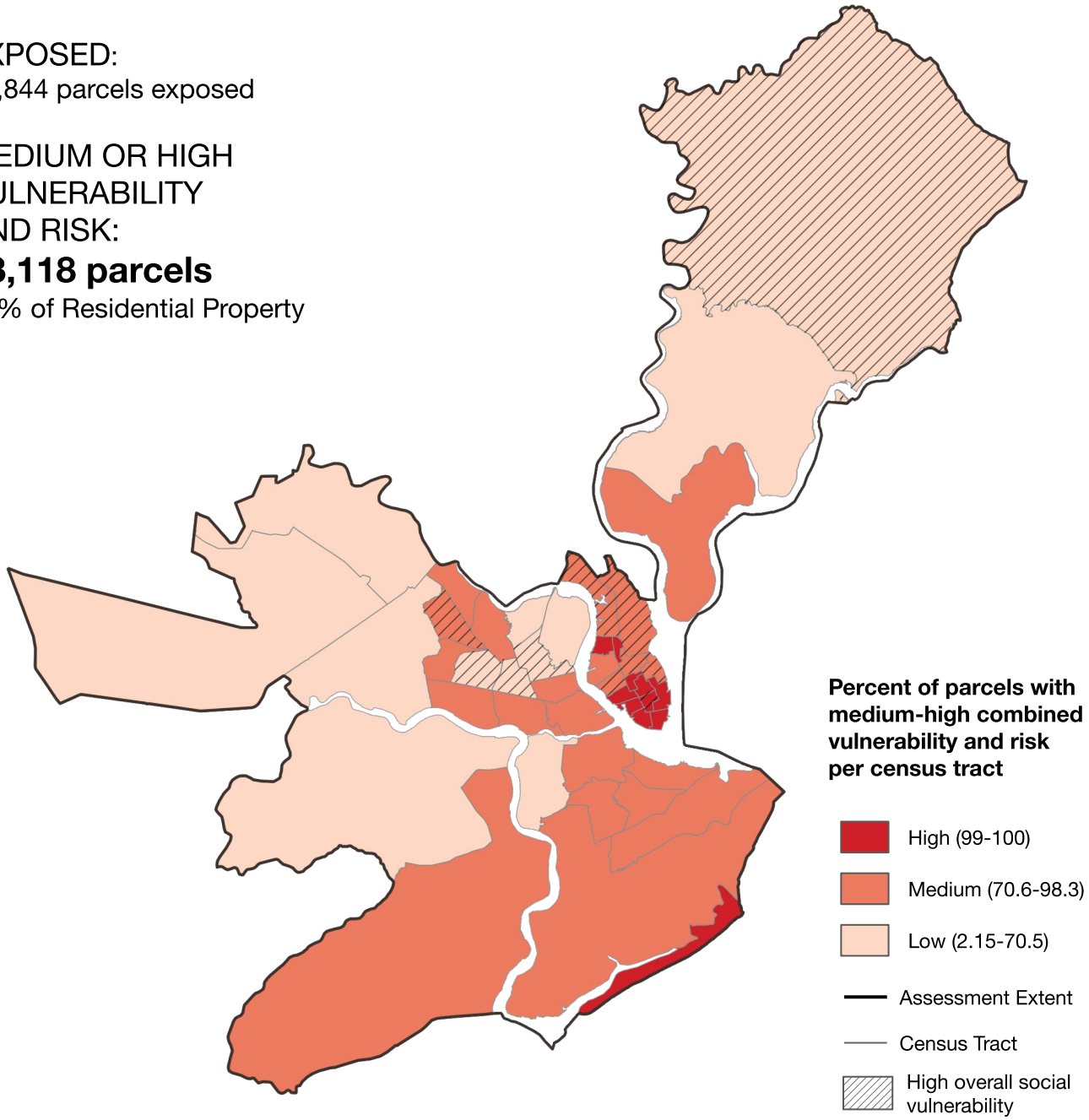
Adaptive capacity criteria are based on requirements for Base Flood Elevation (BFE) and flood-proofing for structures in the 100-yr FEMA floodplain, which have changed over the years and vary between Charleston City, Charleston County, and Berkeley County. Median structure value for Commercial Property was $317,930

Residential Property & Floodplain Inundation

Vulnerability & Risk Assessment

EXPOSED:
46,844 parcels exposed

MEDIUM OR HIGH VULNERABILITY AND RISK:
43,118 parcels
70% of Residential Property

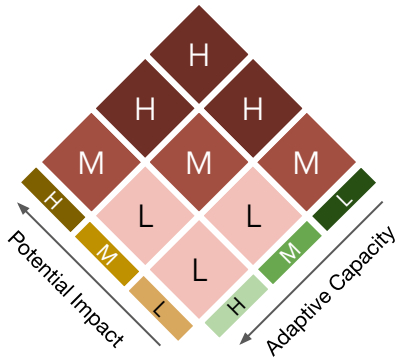


In coastal areas like Charleston, FEMA flood zones represent a combination of rainfall-induced and storm surge flooding. The assessment used the most recent floodway, wave action, 100-year and 500-year floodplains in the Flood Insurance Rate Map (FIRM) developed by the Federal Emergency Management Agency (FEMA) to support the National Flood Insurance Program (NFIP). Residential property includes all single-family residences, multiple-family residences, low-income housing, apartments, manufactured houses, and mobile home parks.

Residential Property & Floodplain Inundation

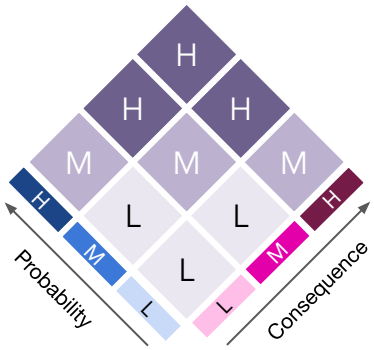
	VULNERABILITY		RISK	
	Potential Impact	Adaptive Capacity	Probability	Consequence
High	Structure in inundation extent and Multi Residence, Mobile Home, Group Home, Historic, Nursing Home, Public Housing, or {historic}	Structure built out of floodplain or structure in floodplain built after BFE requirements were raised to 1-2ft (2015 for Charleston, 2018 for Berkeley)	In frequent flooding zone	Structure exposed and above median value
Med	Structure in inundation extent	Structure in floodplain built after BFE requirements were in place (1971 for Charleston, 1983 for Berkeley)	In 100-yr inundation extent	Structure exposed and below median value
Low	No structure in inundation extent (land only)	Structure in floodplain built before BFE requirements were in place (1971 for Charleston, 1983 for Berkeley)	In 500-yr inundation extent	No structure exposed (land only)

VULNERABILITY



H 25980
M 16223
L 4688
# of parcels

RISK



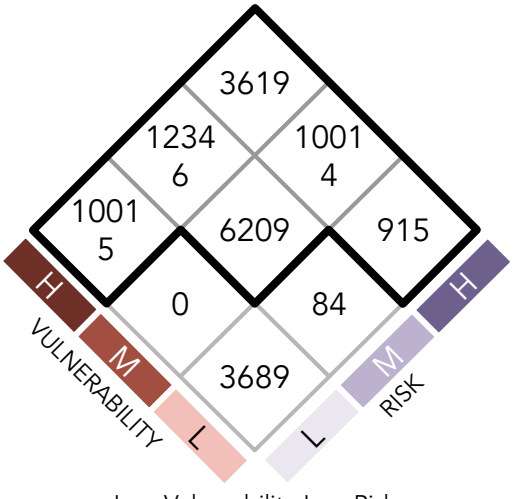
H 14548
M 18639
L 13704
# of parcels

COMBINED VULNERABILITY & RISK

EXPOSED:
46,844 parcels exposed

MEDIUM OR HIGH VULNERABILITY AND RISK:
43,118 parcels
70% of Residential Property

High Vulnerability-High Risk



H 25979
M 17139
L 3773
# of parcels

Low Vulnerability-Low Risk

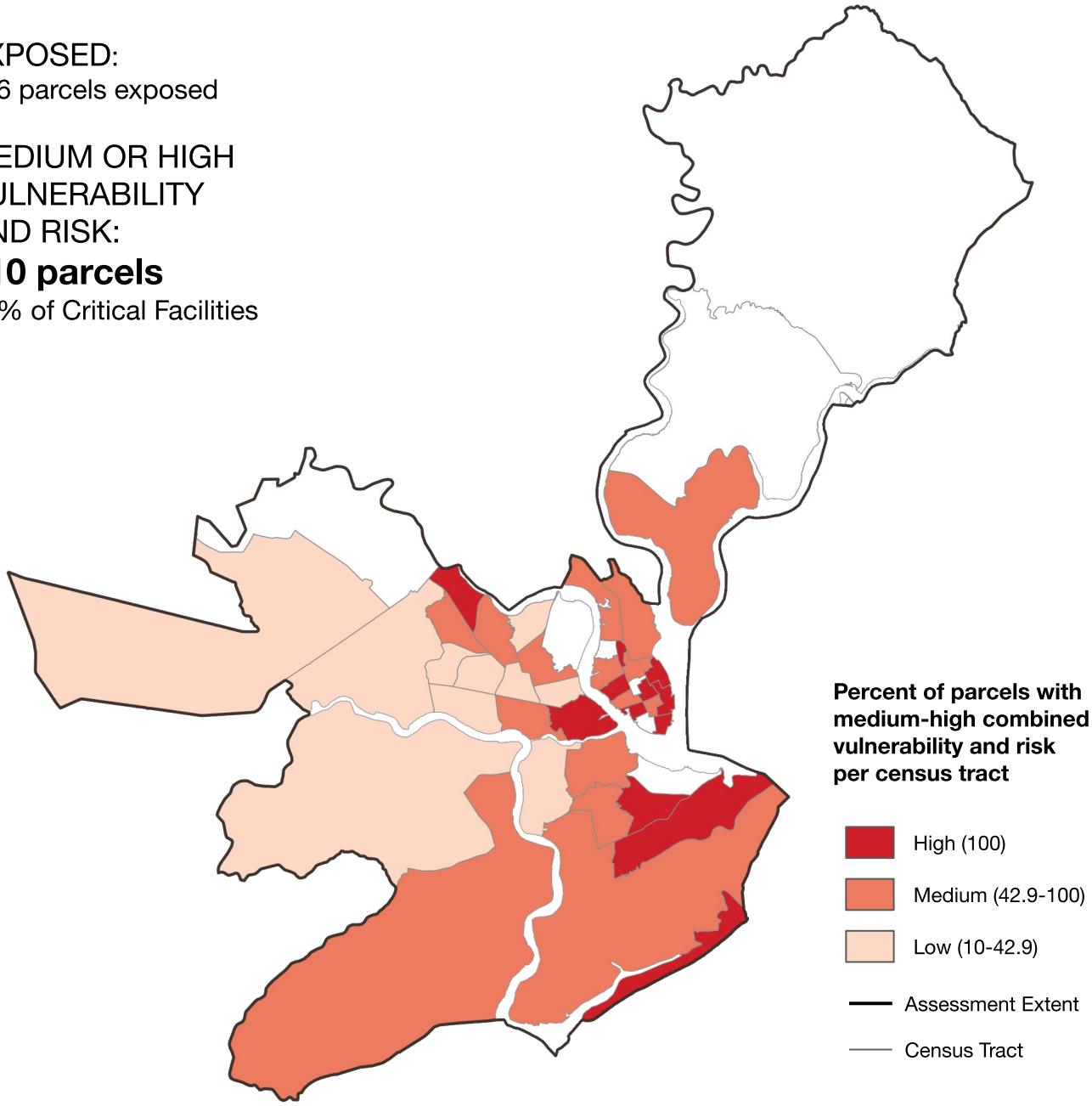
Adaptive capacity criteria are based on requirements for Base Flood Elevation (BFE) and flood-proofing for structures in the 100-yr FEMA floodplain, which have changed over the years and vary between Charleston City, Charleston County, and Berkeley County. Median structure value for Residential Property was $179,000

Critical Facilities & Floodplain Inundation

Vulnerability & Risk Assessment

EXPOSED:
266 parcels exposed

MEDIUM OR HIGH VULNERABILITY AND RISK:
210 parcels
61% of Critical Facilities

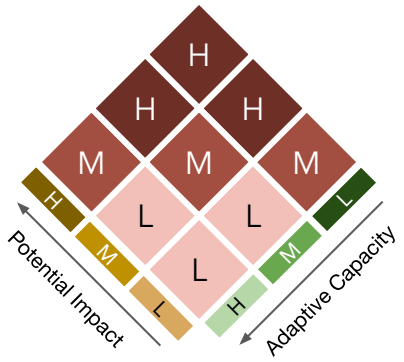


In coastal areas like Charleston, FEMA flood zones represent a combination of rainfall-induced and storm surge flooding. The assessment used the most recent floodway, wave action, 100-year and 500-year floodplains in the Flood Insurance Rate Map (FIRM) developed by the Federal Emergency Management Agency (FEMA) to support the National Flood Insurance Program (NFIP). Critical facility property includes fire and police stations that aid in emergency response, medical facilities, schools, energy and utility facilities, and transportation-related facilities.

Critical Facilities & Floodplain Inundation

	VULNERABILITY		RISK	
	Potential Impact	Adaptive Capacity	Probability	Consequence
High	Structure in inundation extent and Medical, Emergency Facilities, Schools, Historic, Medical Major	Structure built out of floodplain or structure in floodplain built after BFE requirements were raised to 1-2ft (2015 for Charleston, 2018 for Berkeley)	In frequent flooding zone	Structure exposed
Med	Structure in inundation extent	Structure in floodplain built after BFE requirements were in place (1971 for Charleston, 1983 for Berkeley)	In 100-yr inundation extent	
Low	No structure in inundation extent (land only)	Structure in floodplain built before BFE requirements were in place (1971 for Charleston, 1983 for Berkeley)	In 500-yr inundation extent	No structure exposed (land only)

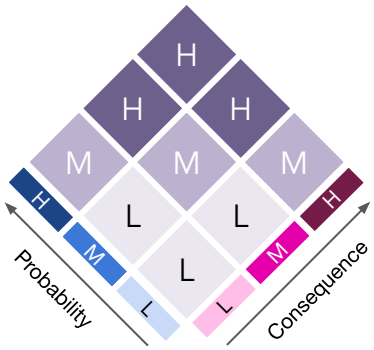
VULNERABILITY





# of parcels

RISK





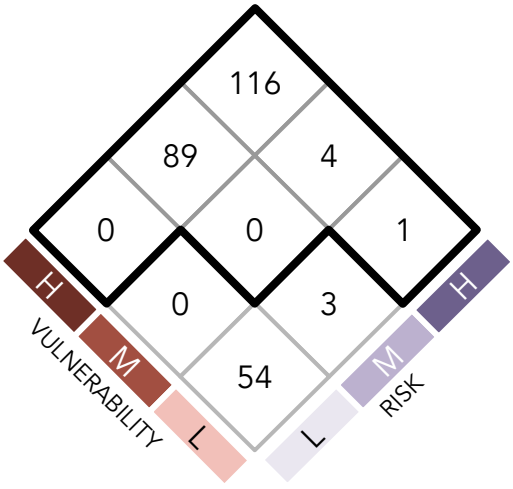
# of parcels

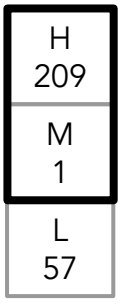
COMBINED VULNERABILITY & RISK

EXPOSED:
266 parcels exposed

MEDIUM OR HIGH VULNERABILITY AND RISK:
210 parcels
61% of Critical Facilities

High Vulnerability-High Risk





# of parcels

Low Vulnerability-Low Risk

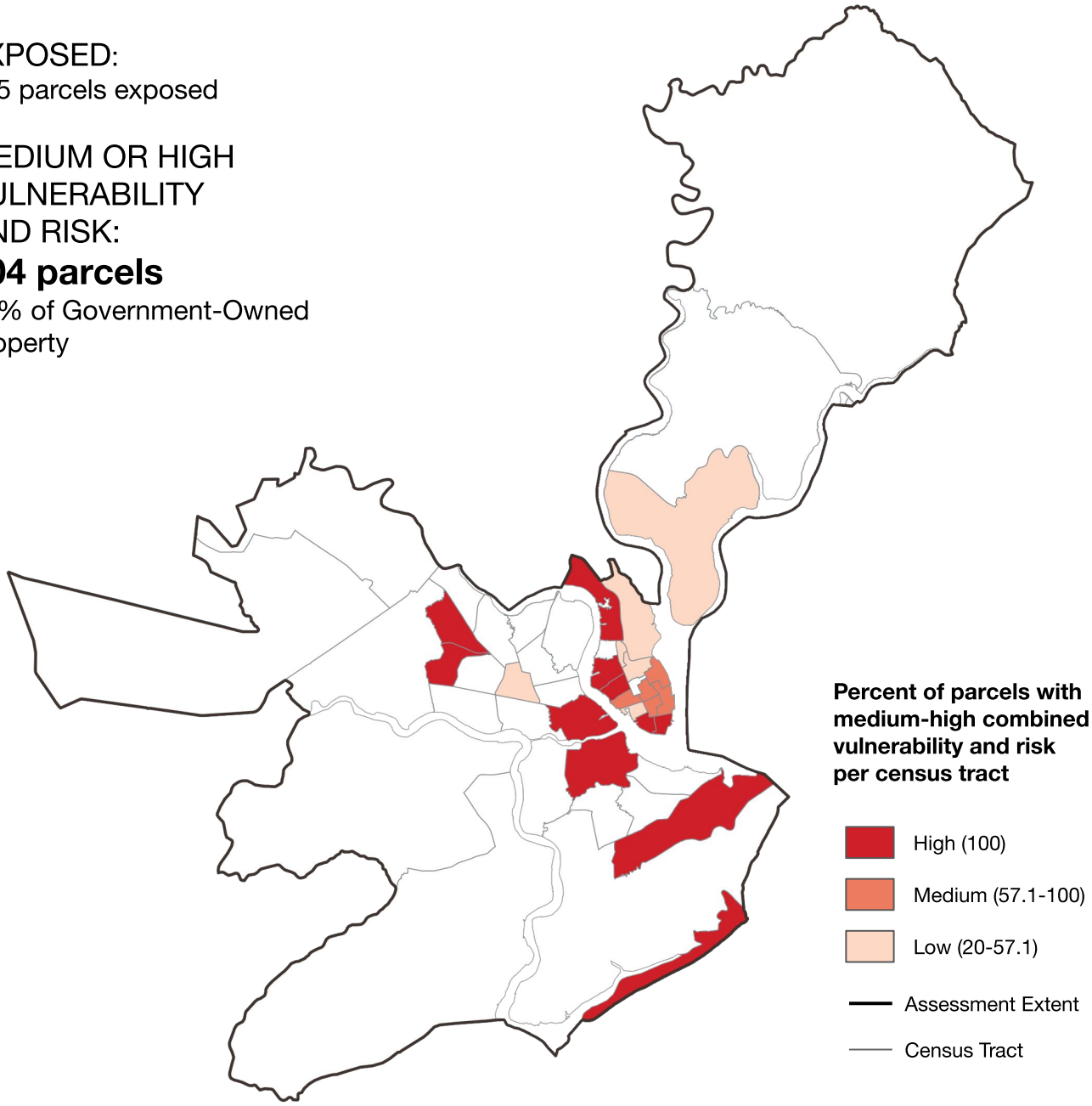
Adaptive capacity criteria are based on requirements for Base Flood Elevation (BFE) and flood-proofing for structures in the 100-yr FEMA floodplain, which have changed over the years and vary between Charleston City, Charleston County, and Berkeley County.

Government-Owned Property & Floodplain Inundation

Vulnerability & Risk Assessment

EXPOSED:
135 parcels exposed

MEDIUM OR HIGH VULNERABILITY AND RISK:
104 parcels
72% of Government-Owned Property

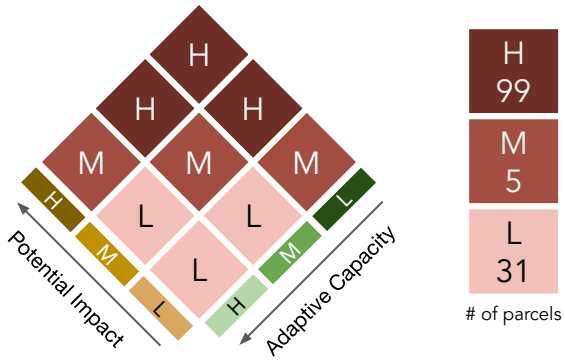


In coastal areas like Charleston, FEMA flood zones represent a combination of rainfall-induced and storm surge flooding. The assessment used the most recent floodway, wave action, 100-year and 500-year floodplains in the Flood Insurance Rate Map (FIRM) developed by the Federal Emergency Management Agency (FEMA) to support the National Flood Insurance Program (NFIP). Government-owned property includes all municipal, county, state, or federal owned properties, except for those associated with parks and recreation and critical facilities.

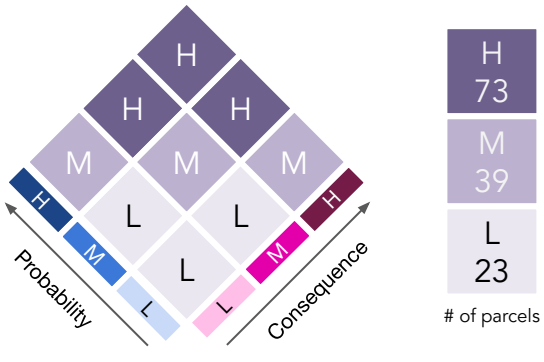
Government-Owned Property & Floodplain Inundation

	VULNERABILITY		RISK	
	Potential Impact	Adaptive Capacity	Probability	Consequence
High	Structure in inundation extent and Historic	Structure built out of floodplain or structure in floodplain built after BFE requirements were raised to 1-2ft (2015 for Charleston, 2018 for Berkeley)	In frequent flooding zone	Structure exposed
Med	Structure in inundation extent	Structure in floodplain built after BFE requirements were in place (1971 for Charleston, 1983 for Berkeley)	In 100-yr inundation extent	
Low	No structure in inundation extent (land only)	Structure in floodplain built before BFE requirements were in place (1971 for Charleston, 1983 for Berkeley)	In 500-yr inundation extent	No structure exposed (land only)

VULNERABILITY



RISK

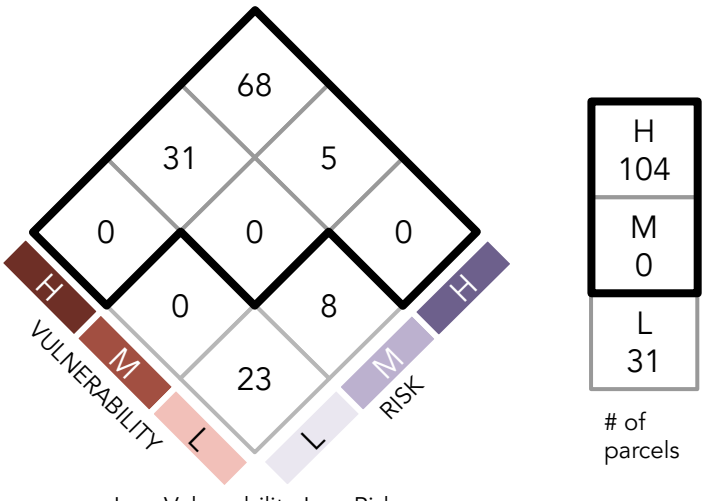


COMBINED VULNERABILITY & RISK

EXPOSED:
135 parcels exposed

MEDIUM OR HIGH VULNERABILITY AND RISK:
104 parcels
72% of Government-Owned Property

High Vulnerability-High Risk



Low Vulnerability-Low Risk

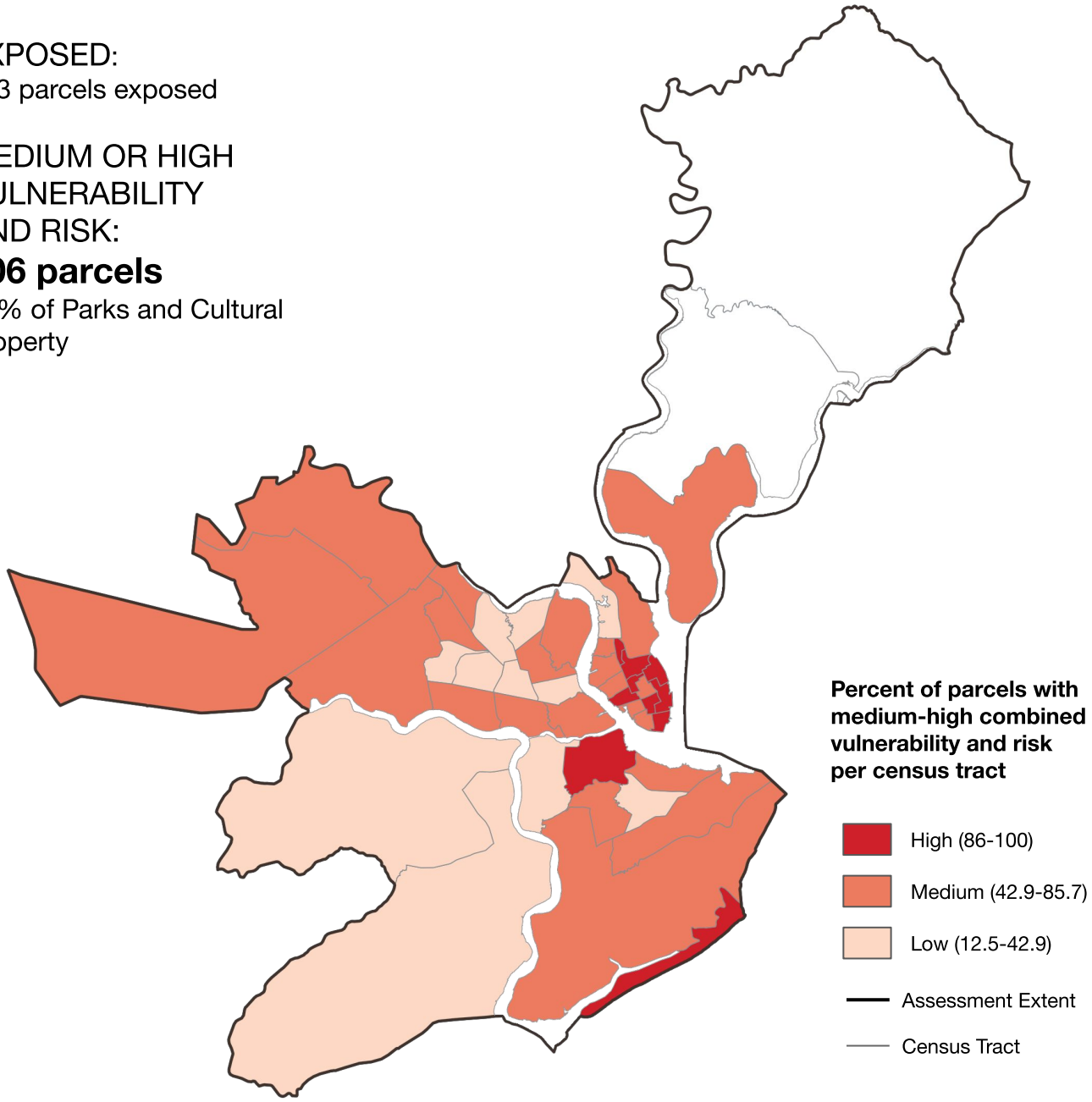
Adaptive capacity criteria are based on requirements for Base Flood Elevation (BFE) and flood-proofing for structures in the 100-yr FEMA floodplain, which have changed over the years and vary between Charleston City, Charleston County, and Berkeley County.

Parks and Cultural Property & Floodplain Inundation

Vulnerability & Risk Assessment

EXPOSED:
543 parcels exposed

MEDIUM OR HIGH VULNERABILITY AND RISK:
406 parcels
62% of Parks and Cultural Property

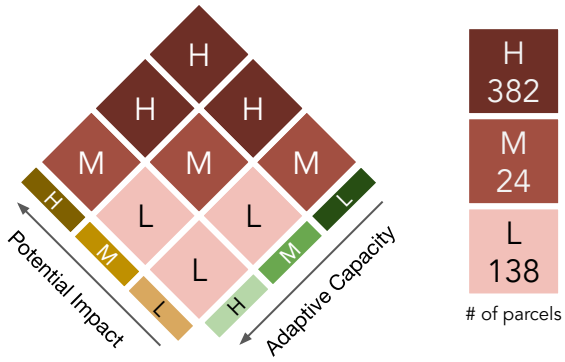


In coastal areas like Charleston, FEMA flood zones represent a combination of rainfall-induced and storm surge flooding. The assessment used the most recent floodway, wave action, 100-year and 500-year floodplains in the Flood Insurance Rate Map (FIRM) developed by the Federal Emergency Management Agency (FEMA) to support the National Flood Insurance Program (NFIP). Park properties also include greenways and other recreation property. Cultural property includes local landmarks, community or civic facilities, and property with religious significance.

Parks and Cultural Property & Floodplain Inundation

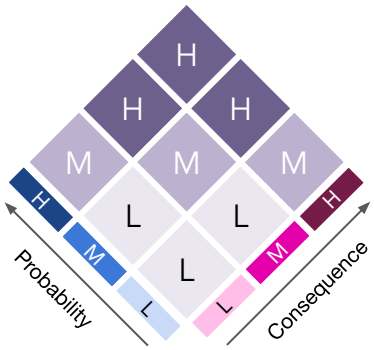
	VULNERABILITY		RISK	
	Potential Impact	Adaptive Capacity	Probability	Consequence
High	Structure in inundation extent and Historic	Structure built out of floodplain or structure in floodplain built after BFE requirements were raised to 1-2ft (2015 for Charleston, 2018 for Berkeley)	In frequent flooding zone	Structure exposed
Med	Structure in inundation extent	Structure in floodplain built after BFE requirements were in place (1971 for Charleston, 1983 for Berkeley)	In 100-yr inundation extent	
Low	No structure in inundation extent (land only)	Structure in floodplain built before BFE requirements were in place (1971 for Charleston, 1983 for Berkeley)	In 500-yr inundation extent	No structure exposed (land only)

VULNERABILITY



# of parcels

RISK





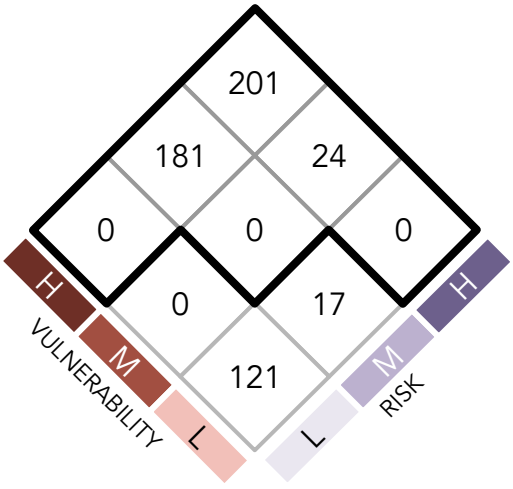
# of parcels

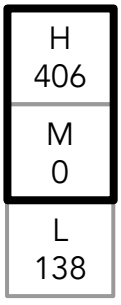
COMBINED VULNERABILITY & RISK

EXPOSED:
543 parcels exposed

MEDIUM OR HIGH VULNERABILITY AND RISK:
406 parcels
62% of Parks and Cultural Property

High Vulnerability-High Risk





# of parcels

Low Vulnerability-Low Risk

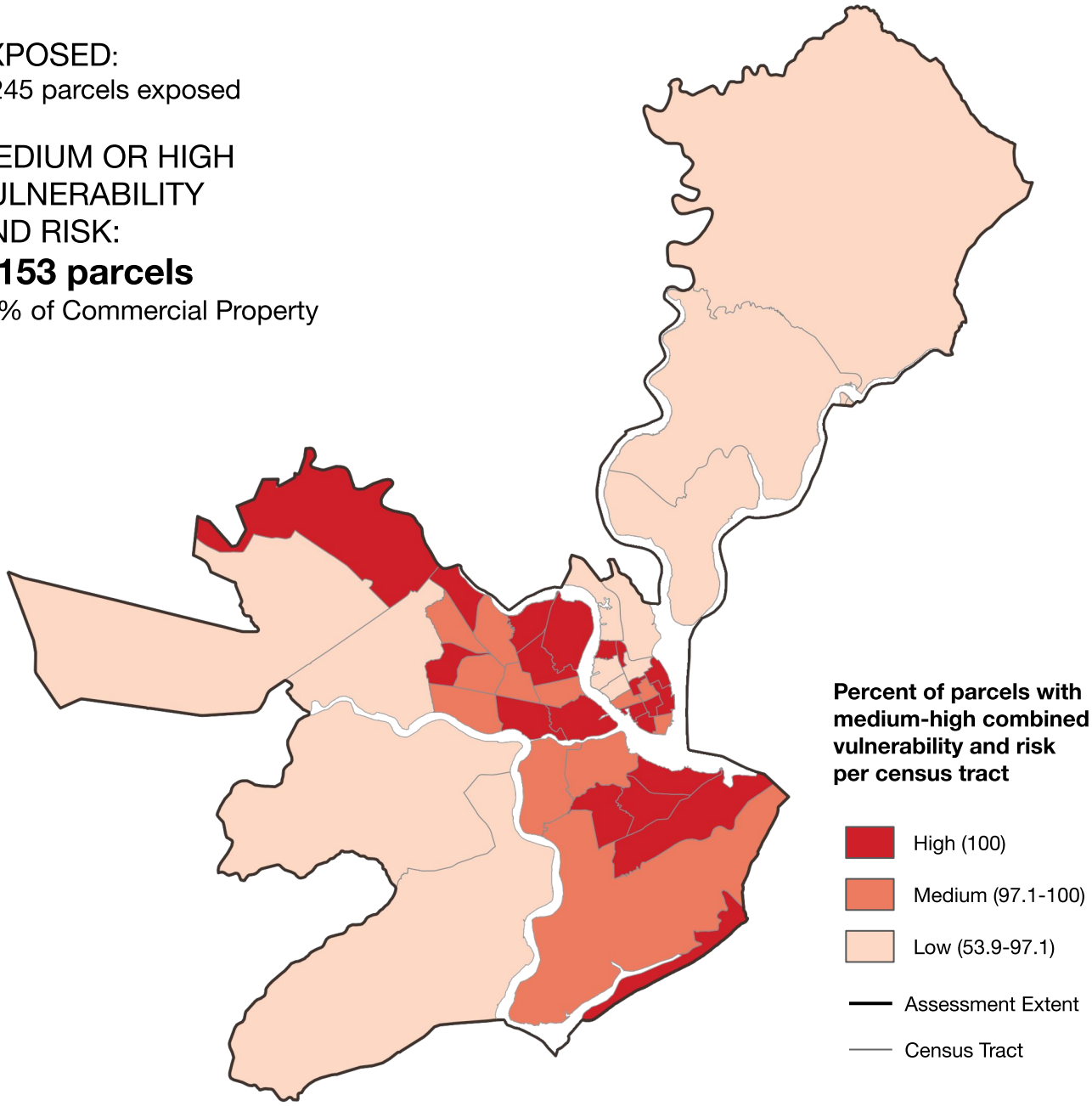
Adaptive capacity criteria are based on requirements for Base Flood Elevation (BFE) and flood-proofing for structures in the 100-yr FEMA floodplain, which have changed over the years and vary between Charleston City, Charleston County, and Berkeley County.

Commercial Property & Storm Surge

Vulnerability & Risk Assessment

EXPOSED:
3,245 parcels exposed

MEDIUM OR HIGH VULNERABILITY AND RISK:
3,153 parcels
94% of Commercial Property

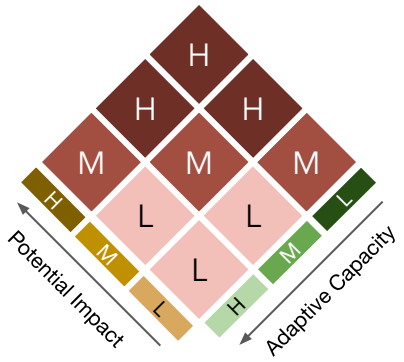


Storm surge is flooding caused by an abnormal rise in tide from a severe storm (e.g. hurricane) over and above the usual, astronomical tide. A surge forms when wind and air pressure from a storm pushes the water towards the shore which causes an increase in sea level above the natural tide. The assessment used the National Hurricane Center's SLOSH MOM storm surge layer which represents a worst-case flooding scenario for Categories 1-3. Commercial property includes retail, office, restaurant, hotel, industrial, and other properties that serve businesses and organizations. They also typically support commerce, jobs, and tourism. Note that assets may be assessed under multiple categories according to their use (e.g. multi-use such as commercial and residential or commercial and medical).

Commercial Property & Storm Surge

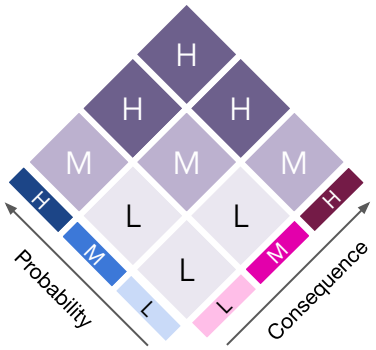
	VULNERABILITY		RISK	
	Potential Impact	Adaptive Capacity	Probability	Consequence
High	Structure in inundation extent and Retail, Restaurants, Hotel, Historic, Snap Retailer	Structure built out of floodplain or structure in floodplain built after BFE requirements were raised to 1-2ft (2015 for Charleston, 2018 for Berkeley)	Cat 1 hurricane extents	Structure exposed and above median value
Med	Structure in inundation extent	Structure in floodplain built after BFE requirements were in place (1971 for Charleston, 1983 for Berkeley)	Cat 2-3 hurricane extents	Structure exposed and below median value
Low	No structure in inundation extent (land only)	Structure in floodplain built before BFE requirements were in place (1971 for Charleston, 1983 for Berkeley)	Cat 4-5 hurricane extent	No structure exposed (land only)

VULNERABILITY





RISK



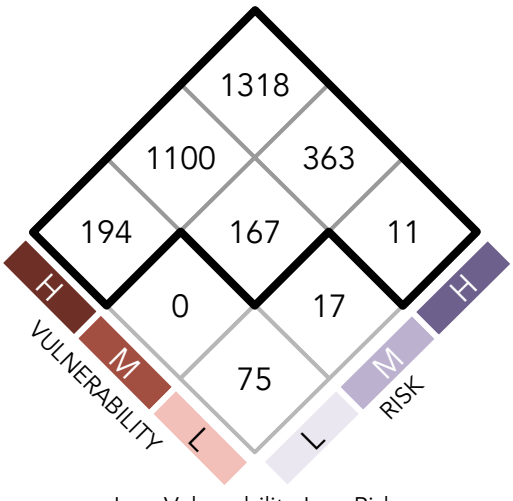


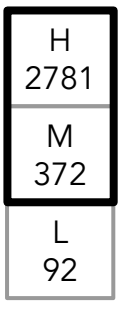
COMBINED VULNERABILITY & RISK

EXPOSED:
3,245 parcels exposed

MEDIUM OR HIGH VULNERABILITY AND RISK:
3,153 parcels
94% of Commercial Property

High Vulnerability-High Risk





Low Vulnerability-Low Risk

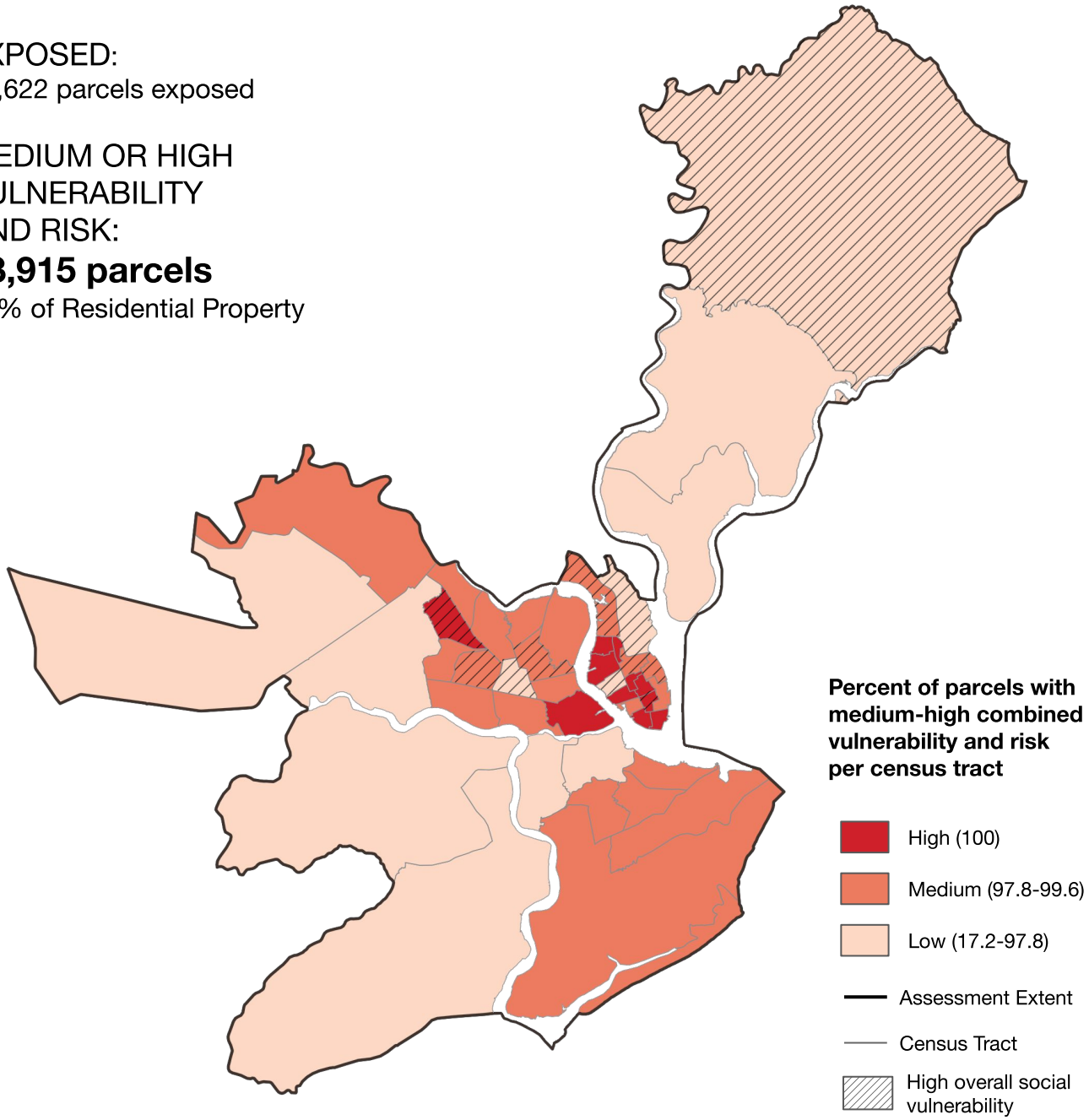
Adaptive capacity criteria are based on requirements for Base Flood Elevation (BFE) and flood-proofing for structures in the 100-yr FEMA floodplain, which have changed over the years and vary between Charleston City, Charleston County, and Berkeley County. Median structure value for Commercial Property was $317,930

Residential Property & Storm Surge

Vulnerability & Risk Assessment

EXPOSED:
60,622 parcels exposed

MEDIUM OR HIGH VULNERABILITY AND RISK:
58,915 parcels
95% of Residential Property

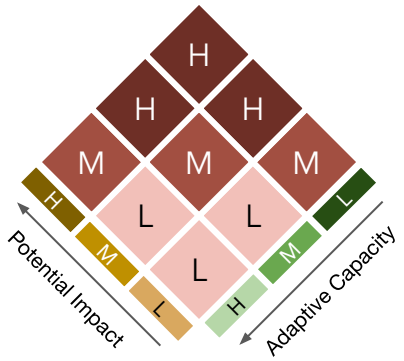


Storm surge is flooding caused by an abnormal rise in tide from a severe storm (e.g. hurricane) over and above the usual, astronomical tide. A surge forms when wind and air pressure from a storm pushes the water towards the shore which causes an increase in sea level above the natural tide. The assessment used the National Hurricane Center's SLOSH MOM storm surge layer which represents a worst-case flooding scenario for Categories 1-3. Residential property includes all single-family residences, multiple-family residences, low-income housing, apartments, manufactured houses, and mobile home parks.

Residential Property & Storm Surge

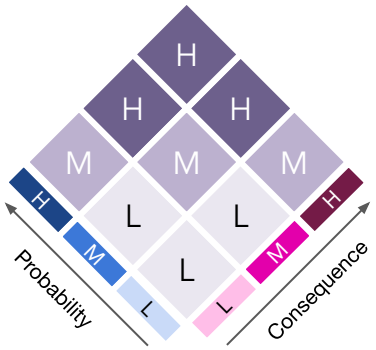
	VULNERABILITY		RISK	
	Potential Impact	Adaptive Capacity	Probability	Consequence
High	Structure in inundation extent and Multi Residence, Mobile Home, Group Home, Historic, Nursing Home, Public Housing	Structure built out of floodplain or structure in floodplain built after BFE requirements were raised to 1-2ft (2015 for Charleston, 2018 for Berkeley)	Cat 1 hurricane extents	Structure exposed and above median value
Med	Structure in inundation extent	Structure in floodplain built after BFE requirements were in place (1971 for Charleston, 1983 for Berkeley)	Cat 2-3 hurricane extents	Structure exposed and below median value
Low	No structure in inundation extent (land only)	Structure in floodplain built before BFE requirements were in place (1971 for Charleston, 1983 for Berkeley)	Cat 4-5 hurricane extent	No structure exposed (land only)

VULNERABILITY





RISK



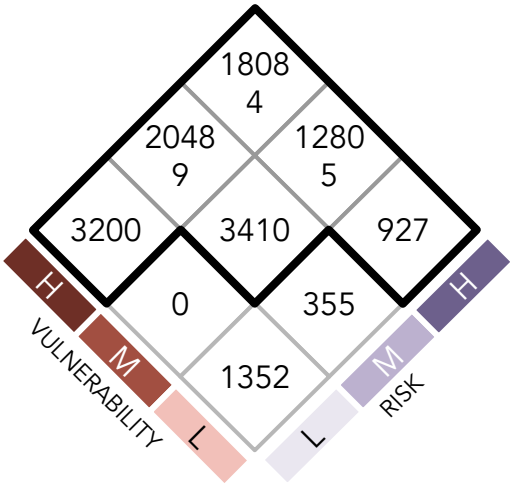


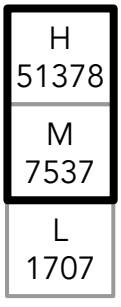
COMBINED VULNERABILITY & RISK

EXPOSED:
60,622 parcels exposed

MEDIUM OR HIGH VULNERABILITY AND RISK:
58,915 parcels
95% of Residential Property

High Vulnerability-High Risk





Low Vulnerability-Low Risk

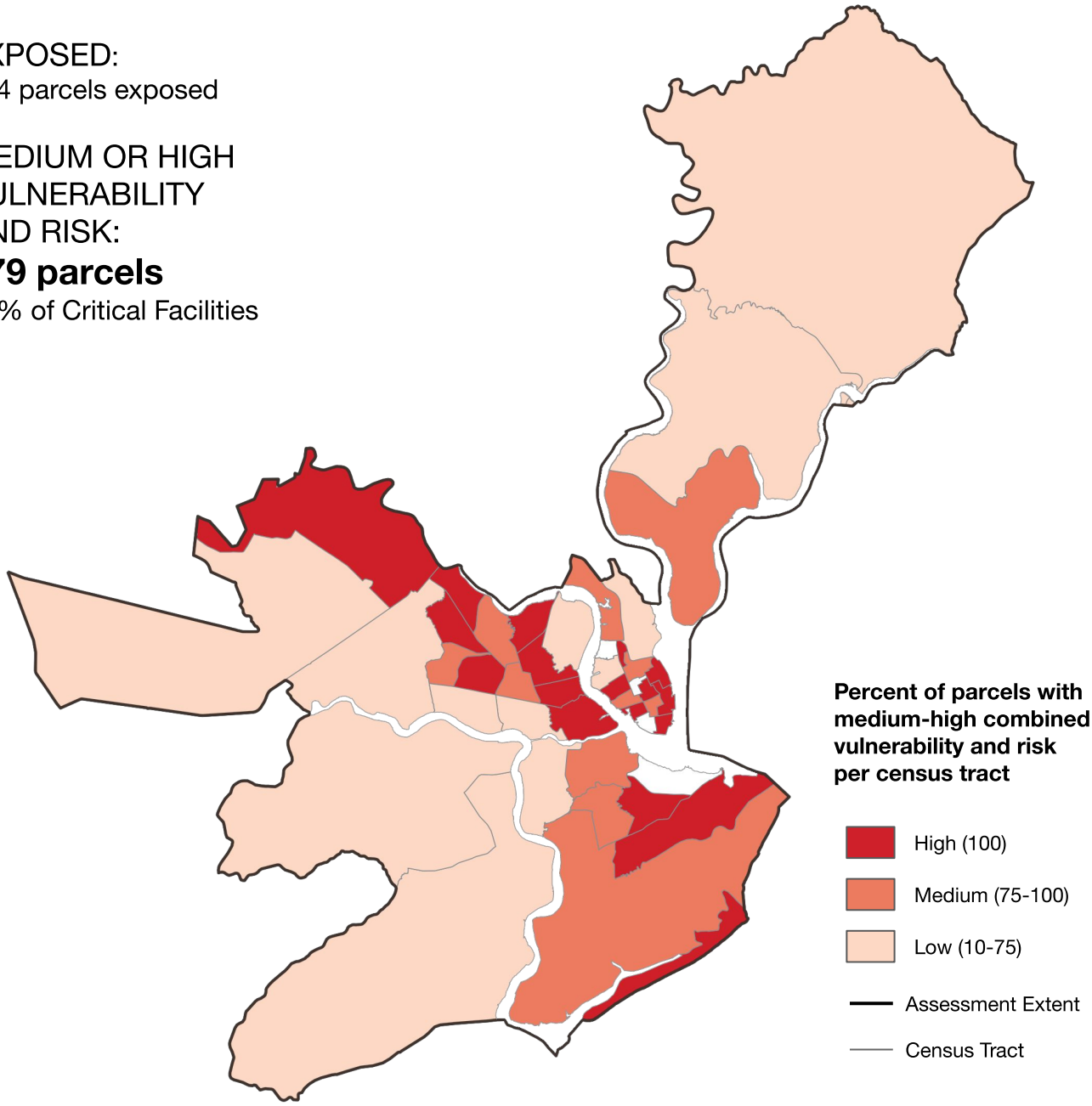
Adaptive capacity criteria are based on requirements for Base Flood Elevation (BFE) and flood-proofing for structures in the 100-yr FEMA floodplain, which have changed over the years and vary between Charleston City, Charleston County, and Berkeley County. Median structure value for Residential Property was $179,000

Critical Facilities & Storm Surge

Vulnerability & Risk Assessment

EXPOSED:
334 parcels exposed

MEDIUM OR HIGH VULNERABILITY AND RISK:
279 parcels
80% of Critical Facilities

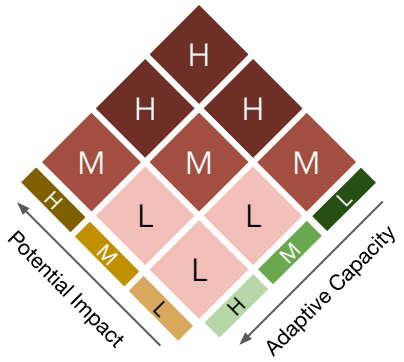


Storm surge is flooding caused by an abnormal rise in tide from a severe storm (e.g. hurricane) over and above the usual, astronomical tide. A surge forms when wind and air pressure from a storm pushes the water towards the shore which causes an increase in sea level above the natural tide. The assessment used the National Hurricane Center's SLOSH MOM storm surge layer which represents a worst-case flooding scenario for Categories 1-3. Critical facility property includes fire and police stations that aid in emergency response, medical facilities, schools, energy and utility facilities, and transportation-related facilities.

Critical Facilities & Storm Surge

	VULNERABILITY		RISK	
	Potential Impact	Adaptive Capacity	Probability	Consequence
High	Structure in inundation extent and Medical, Emergency Facilities, Schools, Historic, Medical Major	Structure built out of floodplain or structure in floodplain built after BFE requirements were raised to 1-2ft (2015 for Charleston, 2018 for Berkeley)	Cat 1 hurricane extents	Structure exposed
Med	Structure in inundation extent	Structure in floodplain built after BFE requirements were in place (1971 for Charleston, 1983 for Berkeley)	Cat 2-3 hurricane extents	
Low	No structure in inundation extent (land only)	Structure in floodplain built before BFE requirements were in place (1971 for Charleston, 1983 for Berkeley)	Cat 4-5 hurricane extent	No structure exposed (land only)

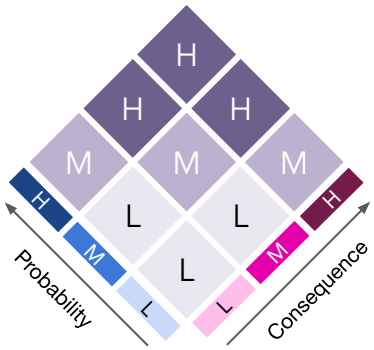
VULNERABILITY





# of parcels

RISK





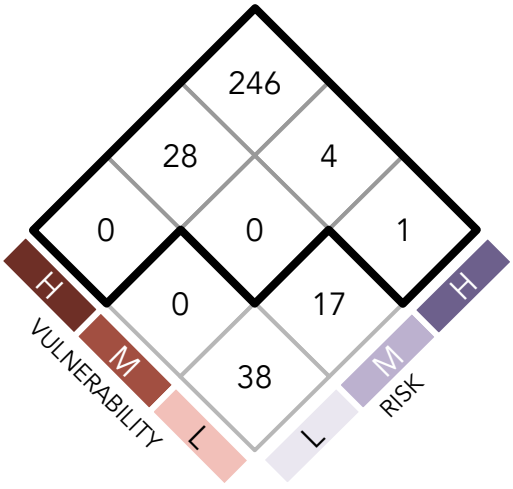
# of parcels

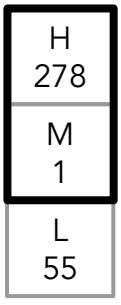
COMBINED VULNERABILITY & RISK

EXPOSED:
334 parcels exposed

MEDIUM OR HIGH VULNERABILITY AND RISK:
279 parcels
80% of Critical Facilities

High Vulnerability-High Risk





# of parcels

Low Vulnerability-Low Risk

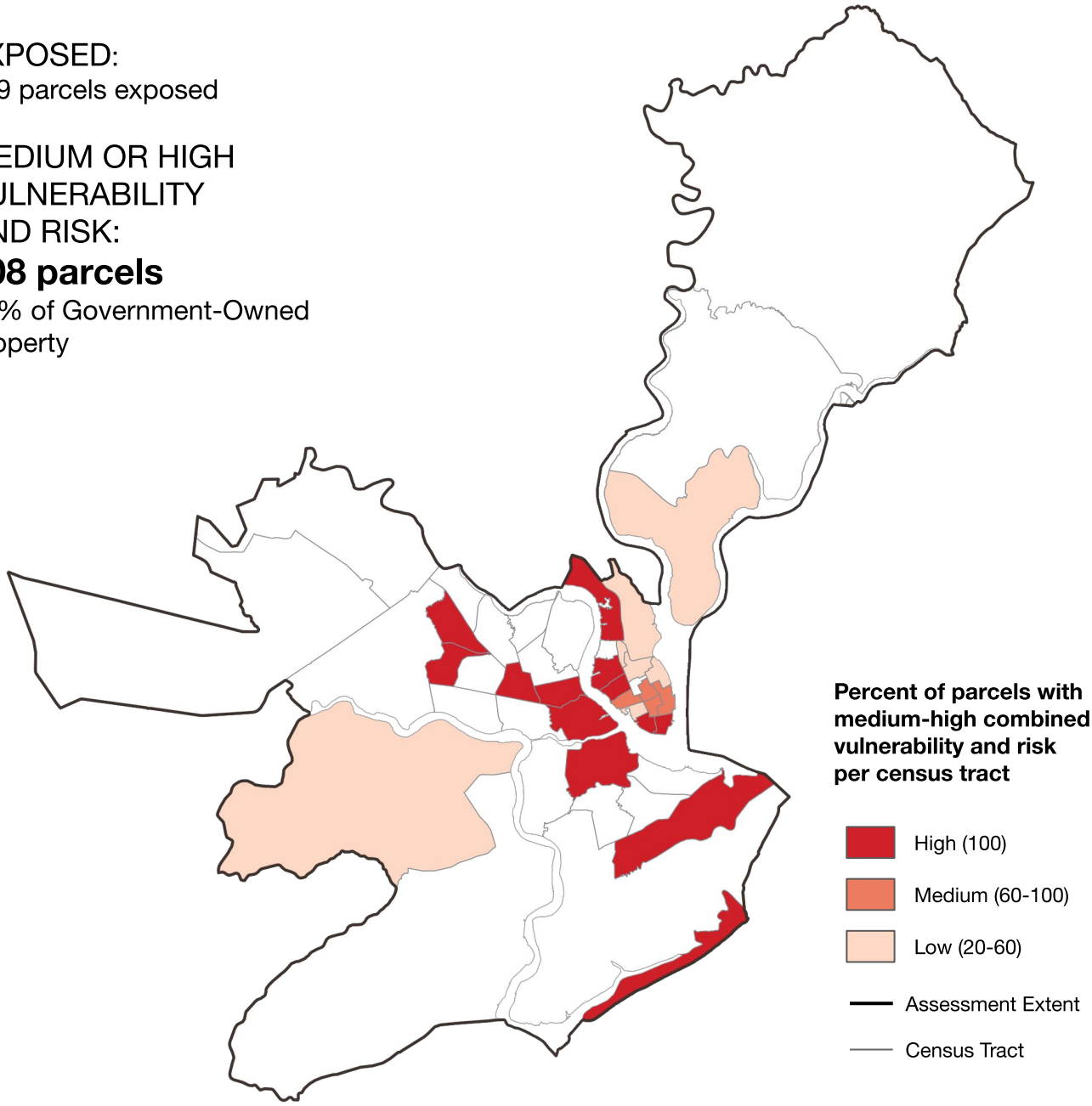
Adaptive capacity criteria are based on requirements for Base Flood Elevation (BFE) and flood-proofing for structures in the 100-yr FEMA floodplain, which have changed over the years and vary between Charleston City, Charleston County, and Berkeley County.

Government-Owned Property & Storm Surge

Vulnerability & Risk Assessment

EXPOSED:
139 parcels exposed

MEDIUM OR HIGH VULNERABILITY AND RISK:
108 parcels
75% of Government-Owned Property

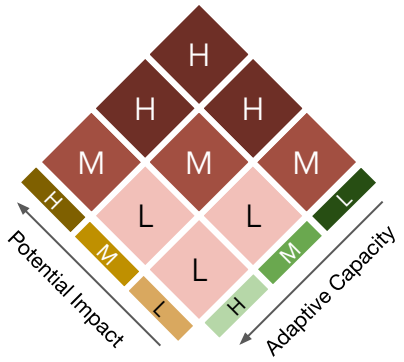


Storm surge is flooding caused by an abnormal rise in tide from a severe storm (e.g. hurricane) over and above the usual, astronomical tide. A surge forms when wind and air pressure from a storm pushes the water towards the shore which causes an increase in sea level above the natural tide. The assessment used the National Hurricane Center's SLOSH MOM storm surge layer which represents a worst-case flooding scenario for Categories 1-3. Government-owned property includes all municipal, county, state, or federal owned properties, except for those associated with parks and recreation and critical facilities.

Government-Owned Property & Storm Surge

	VULNERABILITY		RISK	
	Potential Impact	Adaptive Capacity	Probability	Consequence
High	Structure in inundation extent and Historic	Structure built out of floodplain or structure in floodplain built after BFE requirements were raised to 1-2ft (2015 for Charleston, 2018 for Berkeley)	Cat 1 hurricane extents	Structure exposed
Med	Structure in inundation extent	Structure in floodplain built after BFE requirements were in place (1971 for Charleston, 1983 for Berkeley)	Cat 2-3 hurricane extents	
Low	No structure in inundation extent (land only)	Structure in floodplain built before BFE requirements were in place (1971 for Charleston, 1983 for Berkeley)	Cat 4-5 hurricane extent	No structure exposed (land only)

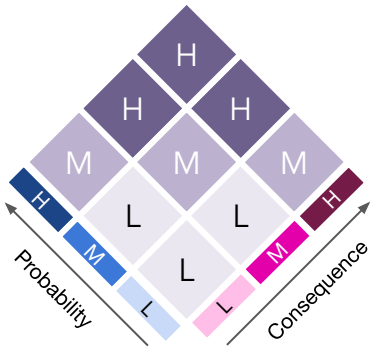
VULNERABILITY





# of parcels

RISK





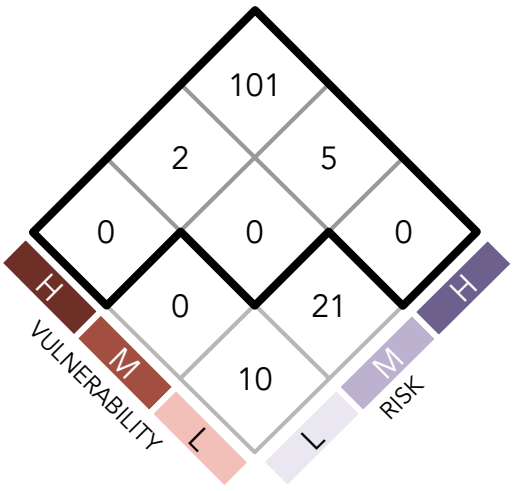
# of parcels

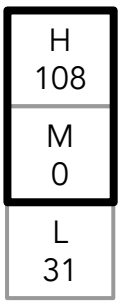
COMBINED VULNERABILITY & RISK

EXPOSED:
139 parcels exposed

MEDIUM OR HIGH VULNERABILITY AND RISK:
108 parcels
75% of Government-Owned Property

High Vulnerability-High Risk





# of parcels

Low Vulnerability-Low Risk

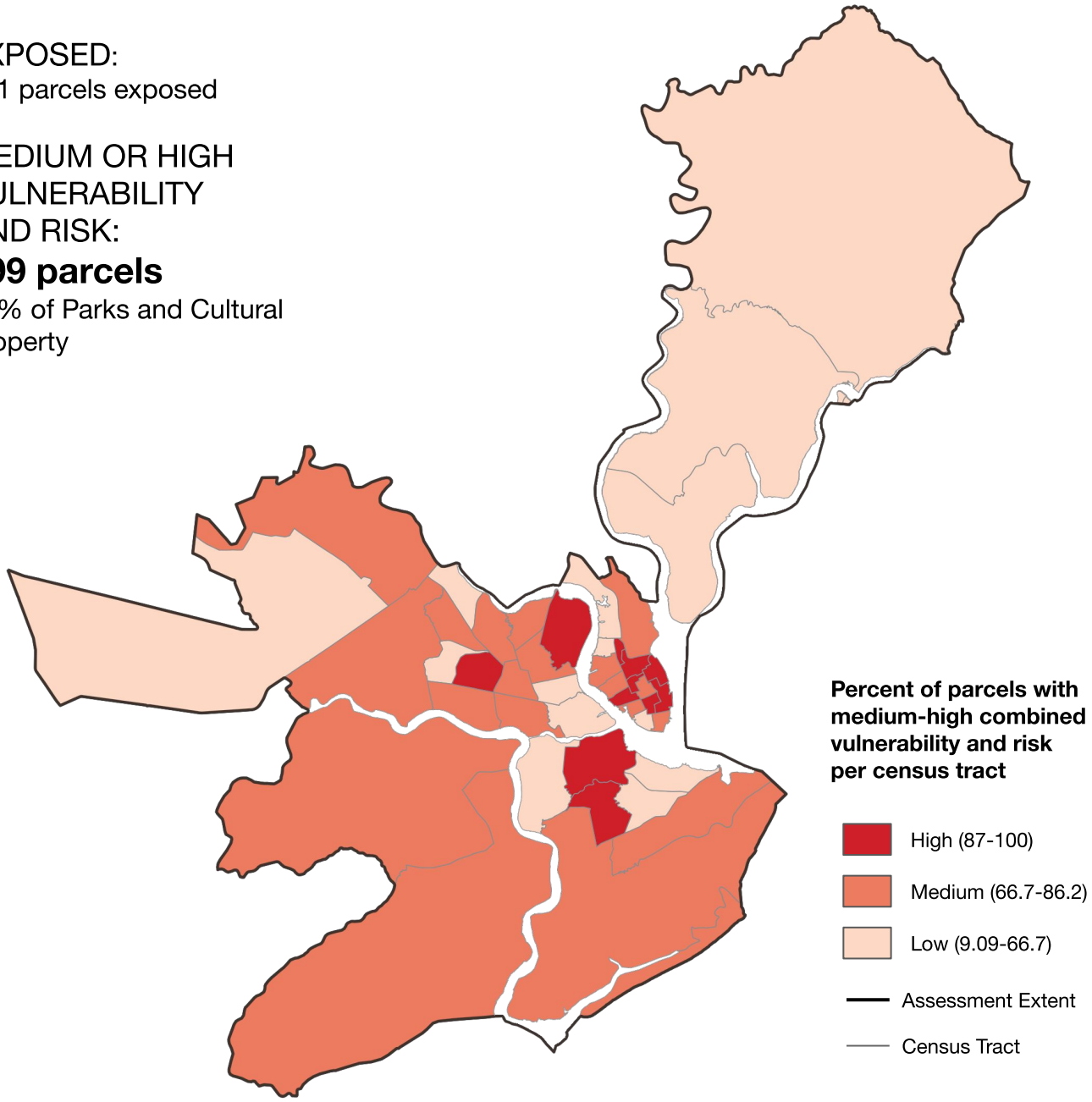
Adaptive capacity criteria are based on requirements for Base Flood Elevation (BFE) and flood-proofing for structures in the 100-yr FEMA floodplain, which have changed over the years and vary between Charleston City, Charleston County, and Berkeley County.

Parks and Cultural Property & Storm Surge

Vulnerability & Risk Assessment

EXPOSED:
641 parcels exposed

MEDIUM OR HIGH VULNERABILITY AND RISK:
499 parcels
76% of Parks and Cultural Property

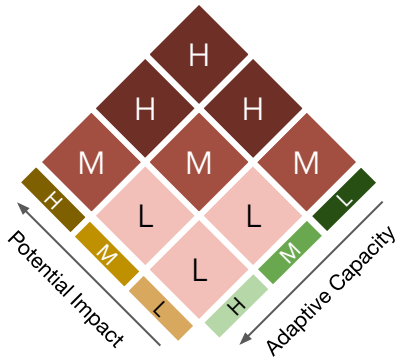


Storm surge is flooding caused by an abnormal rise in tide from a severe storm (e.g. hurricane) over and above the usual, astronomical tide. A surge forms when wind and air pressure from a storm pushes the water towards the shore which causes an increase in sea level above the natural tide. The assessment used the National Hurricane Center's SLOSH MOM storm surge layer which represents a worst-case flooding scenario for Categories 1-3. Park properties also include greenways and other recreation property. Cultural property includes local landmarks, community or civic facilities, and property with religious significance.

Parks and Cultural Property & Storm Surge

	VULNERABILITY		RISK	
	Potential Impact	Adaptive Capacity	Probability	Consequence
High	Structure in inundation extent and Historic	Structure built out of floodplain or structure in floodplain built after BFE requirements were raised to 1-2ft (2015 for Charleston, 2018 for Berkeley)	Cat 1 hurricane extents	Structure exposed
Med	Structure in inundation extent	Structure in floodplain built after BFE requirements were in place (1971 for Charleston, 1983 for Berkeley)	Cat 2-3 hurricane extents	
Low	No structure in inundation extent (land only)	Structure in floodplain built before BFE requirements were in place (1971 for Charleston, 1983 for Berkeley)	Cat 4-5 hurricane extent	No structure exposed (land only)

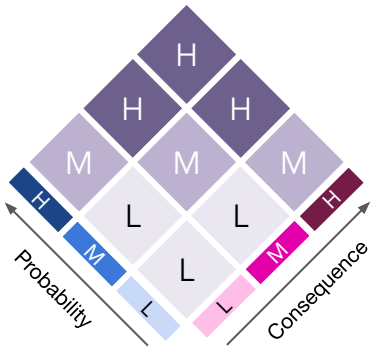
VULNERABILITY





# of parcels

RISK





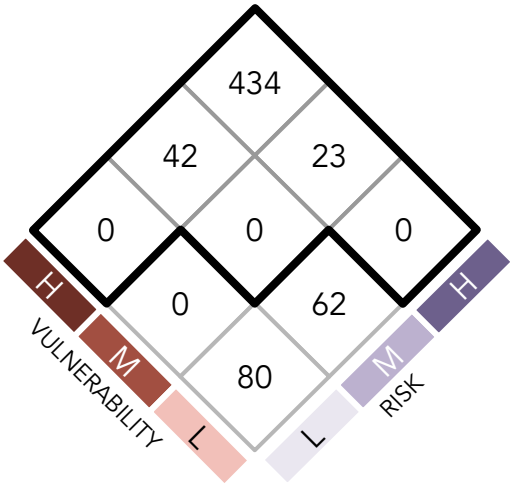
# of parcels

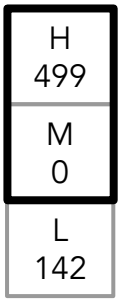
COMBINED VULNERABILITY & RISK

EXPOSED:
641 parcels exposed

MEDIUM OR HIGH VULNERABILITY AND RISK:
499 parcels
76% of Parks and Cultural Property

High Vulnerability-High Risk





# of parcels

Low Vulnerability-Low Risk

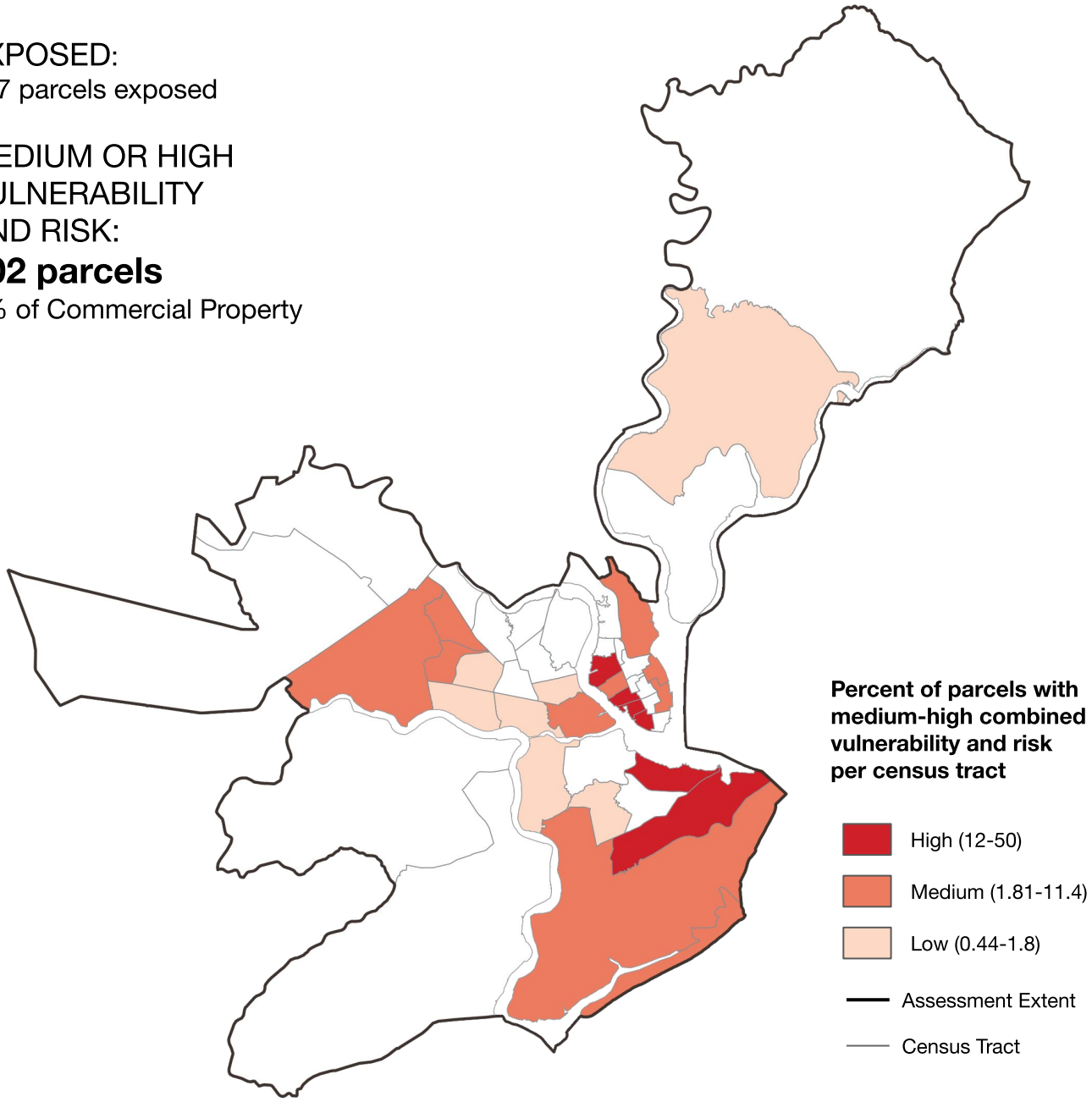
Adaptive capacity criteria are based on requirements for Base Flood Elevation (BFE) and flood-proofing for structures in the 100-yr FEMA floodplain, which have changed over the years and vary between Charleston City, Charleston County, and Berkeley County.

Commercial Property & Tidal Flooding

Vulnerability & Risk Assessment

EXPOSED:
317 parcels exposed

MEDIUM OR HIGH VULNERABILITY AND RISK:
102 parcels
3% of Commercial Property

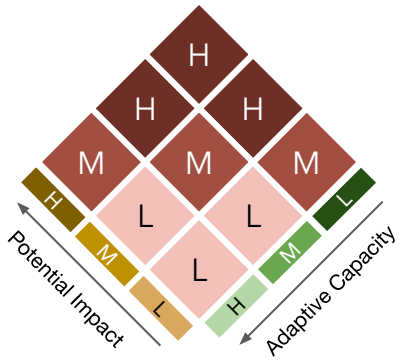


Tidal flooding is flooding of the low-lying land along the coastline from a high tide that is not associated with a tropical storm. Tidal flooding is also referred to as 'high tide', 'sunny day' and 'nuisance' flooding. The assessment used the 'High Tide Flooding' layer provided by NOAA Sea Level Rise Viewer. This layer delineates areas that are currently subject to 'minor' flooding from a tide elevation of 4.5 feet referenced to the North American Vertical Datum of 1988 (NAVD88) at Cooper River at Charleston Harbor gage (ID: 866530). Commercial property includes retail, office, restaurant, hotel, industrial, and other properties that serve businesses and organizations. They also typically support commerce, jobs, and tourism. Note that assets may be assessed under multiple categories according to their use (e.g. multi-use such as commercial and residential or commercial and medical).

Commercial Property & Tidal Flooding

	VULNERABILITY		RISK	
	Potential Impact	Adaptive Capacity	Probability	Consequence
High	Structure in inundation extent and Retail, Restaurants, Hotel, Historic, Snap Retailer	Structure built out of floodplain or structure in floodplain built after BFE requirements were raised to 1-2ft (2015 for Charleston, 2018 for Berkeley)	Within high tide flooding inundation extent	Structure exposed and above median value
Med	Structure in inundation extent	Structure in floodplain built after BFE requirements were in place (1971 for Charleston, 1983 for Berkeley)	N/A	Structure exposed and below median value
Low	No structure in inundation extent (land only)	Structure in floodplain built before BFE requirements were in place (1971 for Charleston, 1983 for Berkeley)	N/A	No structure exposed (land only)

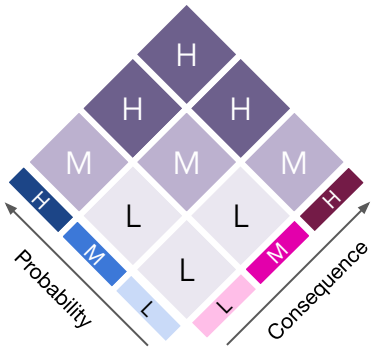
VULNERABILITY





# of parcels

RISK





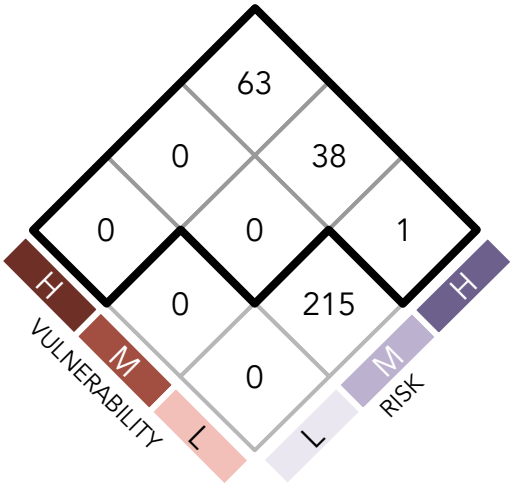
# of parcels

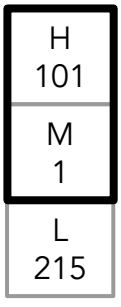
COMBINED VULNERABILITY & RISK

EXPOSED:
317 parcels exposed

MEDIUM OR HIGH VULNERABILITY AND RISK:
102 parcels
3% of Commercial Property

High Vulnerability-High Risk





# of parcels

Low Vulnerability-Low Risk

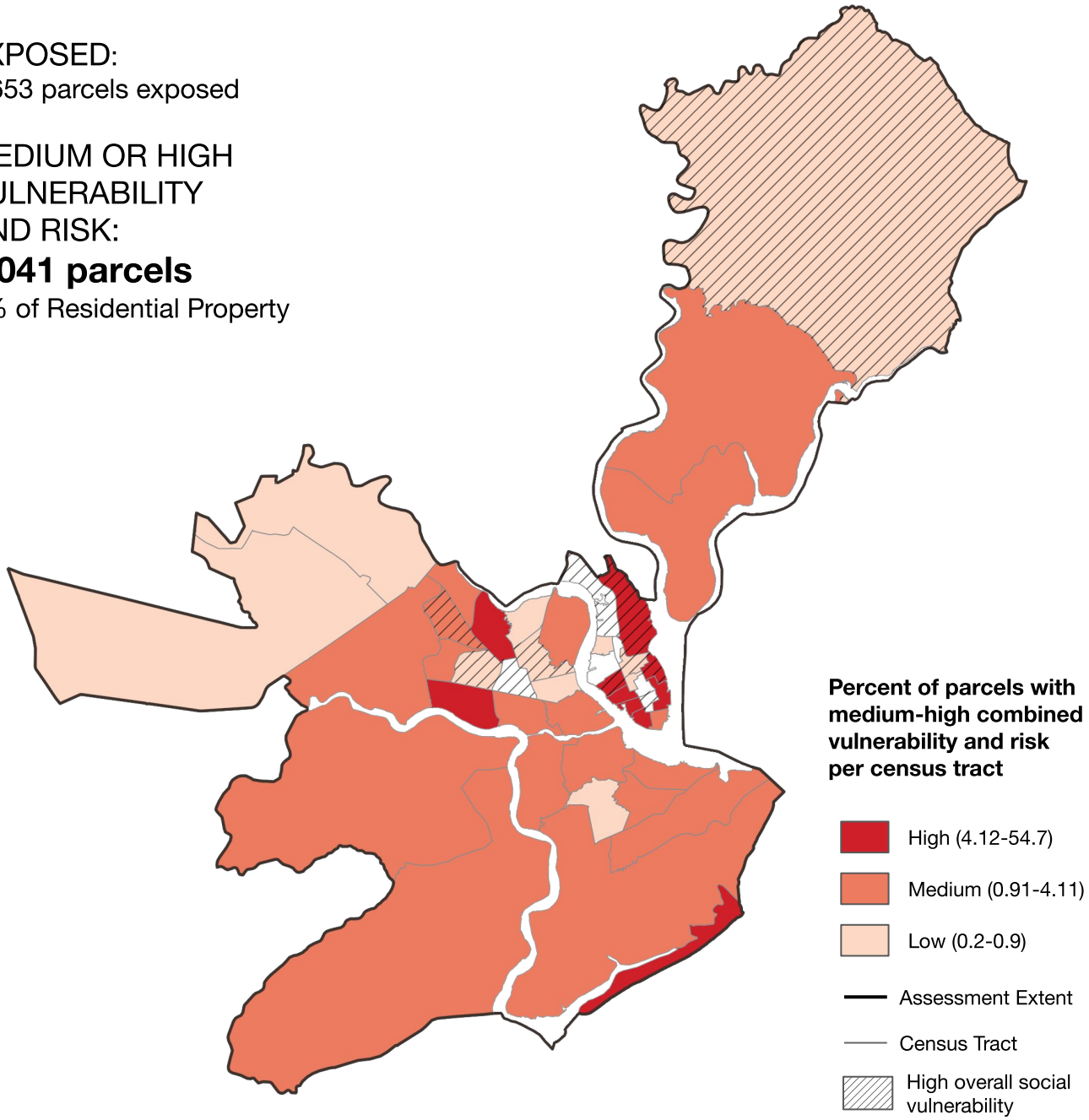
Adaptive capacity criteria are based on requirements for Base Flood Elevation (BFE) and flood-proofing for structures in the 100-yr FEMA floodplain, which have changed over the years and vary between Charleston City, Charleston County, and Berkeley County. Median structure value for Commercial Property was $317,930

Residential Property & Tidal Flooding

Vulnerability & Risk Assessment

EXPOSED:
9,653 parcels exposed

MEDIUM OR HIGH VULNERABILITY AND RISK:
2,041 parcels
3% of Residential Property

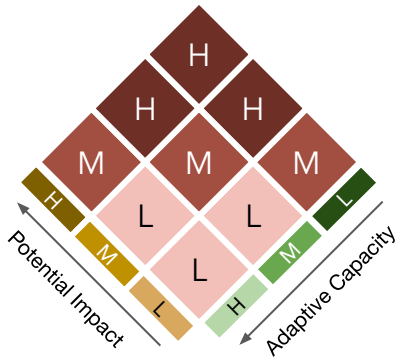


Tidal flooding is flooding of the low-lying land along the coastline from a high tide that is not associated with a tropical storm. Tidal flooding is also referred to as 'high tide', 'sunny day' and 'nuisance' flooding. The assessment used the 'High Tide Flooding' layer provided by NOAA Sea Level Rise Viewer. This layer delineates areas that are currently subject to 'minor' flooding from a tide elevation of 4.5 feet referenced to the North American Vertical Datum of 1988 (NAVD88) at Cooper River at Charleston Harbor gage (ID: 866530). Residential property includes all single-family residences, multiple-family residences, low-income housing, apartments, manufactured houses, and mobile home parks.

Residential Property & Tidal Flooding

	VULNERABILITY		RISK	
	Potential Impact	Adaptive Capacity	Probability	Consequence
High	Structure in inundation extent and Multi Residence, Mobile Home, Group Home, Historic, Nursing Home, Public Housing	Structure built out of floodplain or structure in floodplain built after BFE requirements were raised to 1-2ft (2015 for Charleston, 2018 for Berkeley)	Within high tide flooding inundation extent	Structure exposed and above median value
Med	Structure in inundation extent	Structure in floodplain built after BFE requirements were in place (1971 for Charleston, 1983 for Berkeley)	N/A	Structure exposed and below median value
Low	No structure in inundation extent (land only)	Structure in floodplain built before BFE requirements were in place (1971 for Charleston, 1983 for Berkeley)	N/A	No structure exposed (land only)

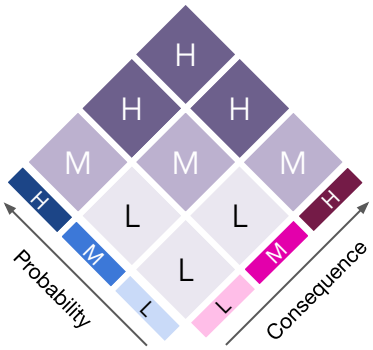
VULNERABILITY





# of parcels

RISK





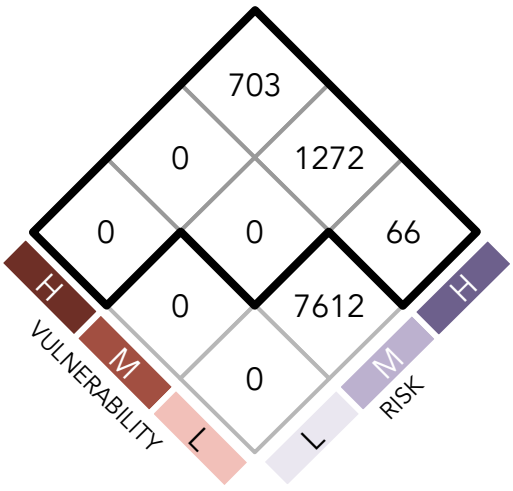
# of parcels

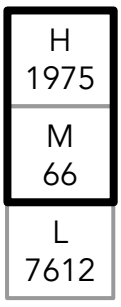
COMBINED VULNERABILITY & RISK

EXPOSED:
9,653 parcels exposed

MEDIUM OR HIGH VULNERABILITY AND RISK:
2,041 parcels
3% of Residential Property

High Vulnerability-High Risk





# of parcels

Low Vulnerability-Low Risk

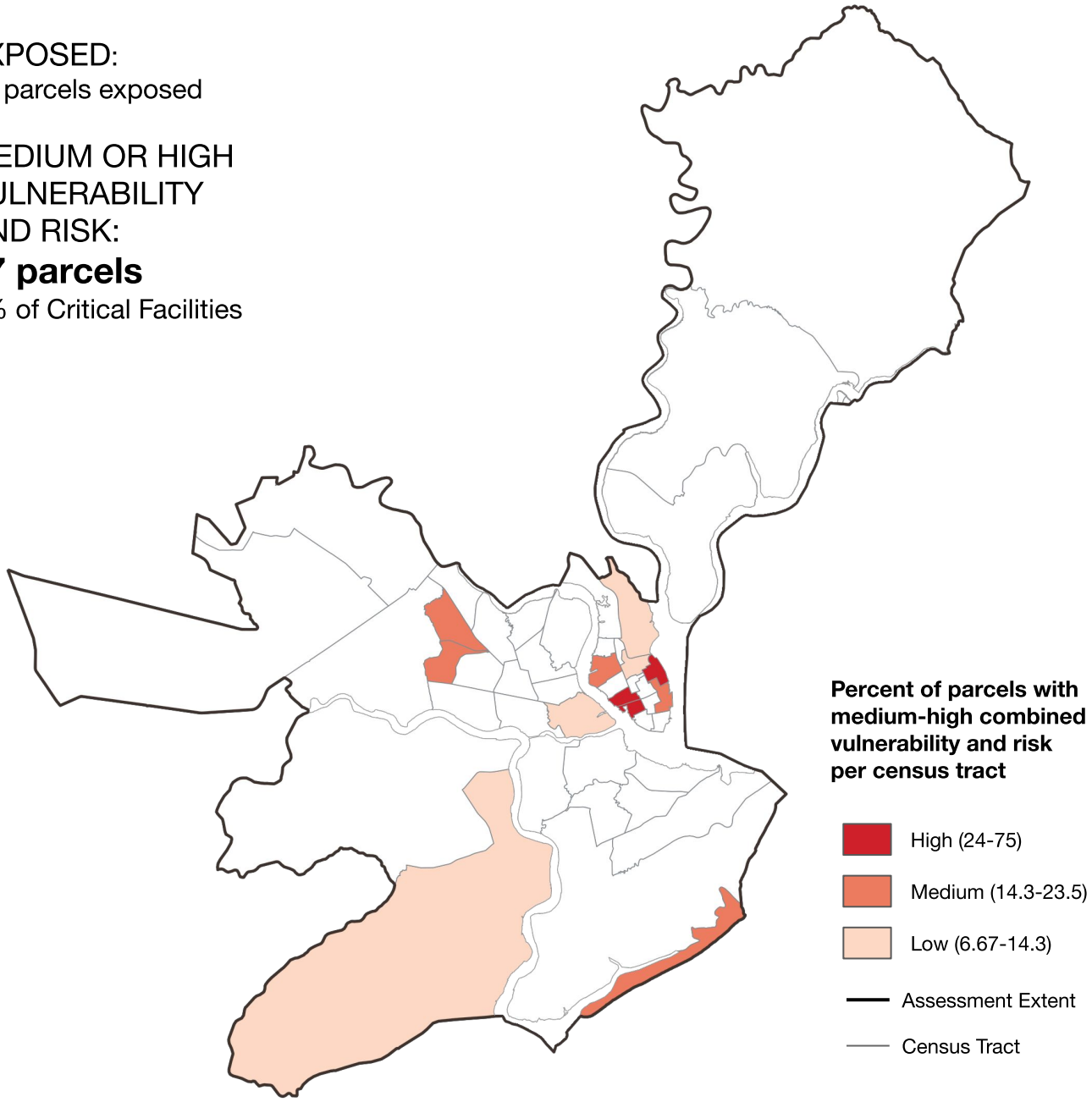
Adaptive capacity criteria are based on requirements for Base Flood Elevation (BFE) and flood-proofing for structures in the 100-yr FEMA floodplain, which have changed over the years and vary between Charleston City, Charleston County, and Berkeley County. Median structure value for Residential Property was $179,000

Critical Facilities & Tidal Flooding

Vulnerability & Risk Assessment

EXPOSED:
70 parcels exposed

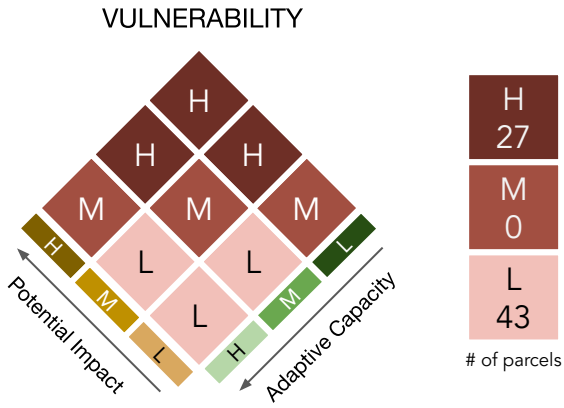
MEDIUM OR HIGH VULNERABILITY AND RISK:
27 parcels
8% of Critical Facilities

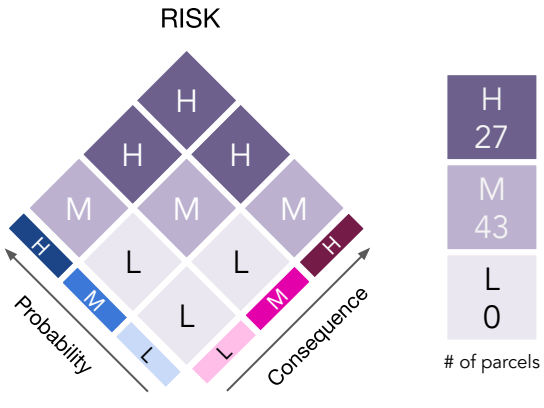


Tidal flooding is flooding of the low-lying land along the coastline from a high tide that is not associated with a tropical storm. Tidal flooding is also referred to as 'high tide', 'sunny day' and 'nuisance' flooding. The assessment used the 'High Tide Flooding' layer provided by NOAA Sea Level Rise Viewer. This layer delineates areas that are currently subject to 'minor' flooding from a tide elevation of 4.5 feet referenced to the North American Vertical Datum of 1988 (NAVD88) at Cooper River at Charleston Harbor gage (ID: 866530). Critical facility property includes fire and police stations that aid in emergency response, medical facilities, schools, energy and utility facilities, and transportation-related facilities.

Critical Facilities & Tidal Flooding

	VULNERABILITY		RISK	
	Potential Impact	Adaptive Capacity	Probability	Consequence
High	Structure in inundation extent and Medical, Emergency Facilities, Schools, Historic, Medical Major	Structure built out of floodplain or structure in floodplain built after BFE requirements were raised to 1-2ft (2015 for Charleston, 2018 for Berkeley)	Within high tide flooding inundation extent	Structure exposed
Med	Structure in inundation extent	Structure in floodplain built after BFE requirements were in place (1971 for Charleston, 1983 for Berkeley)	N/A	
Low	No structure in inundation extent (land only)	Structure in floodplain built before BFE requirements were in place (1971 for Charleston, 1983 for Berkeley)	N/A	No structure exposed (land only)

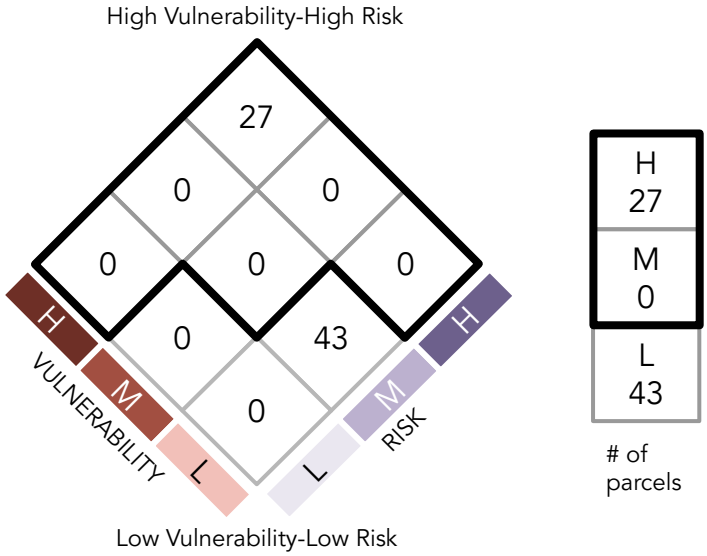




COMBINED VULNERABILITY & RISK

EXPOSED:
70 parcels exposed

MEDIUM OR HIGH VULNERABILITY AND RISK:
27 parcels
8% of Critical Facilities



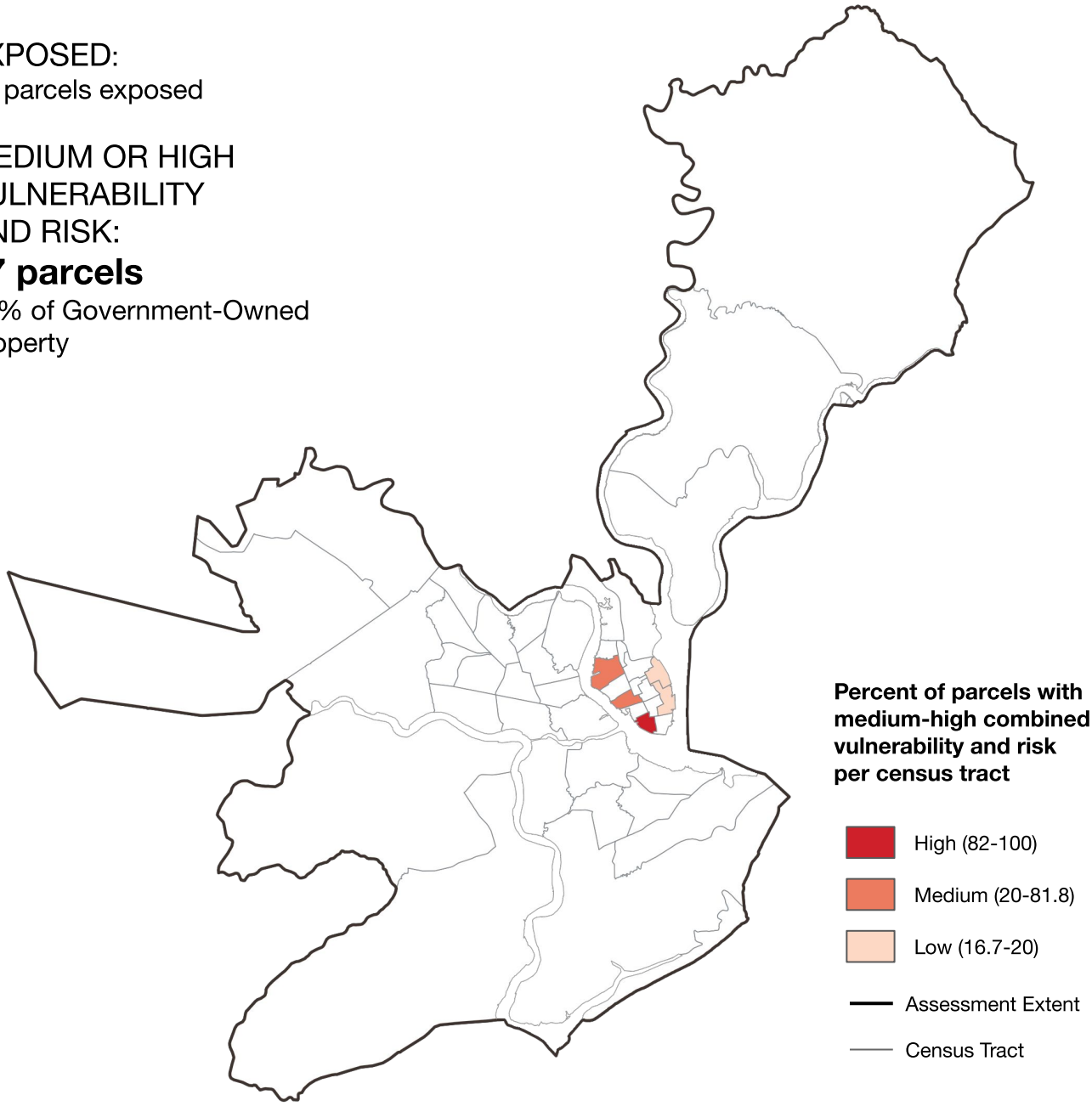
Adaptive capacity criteria are based on requirements for Base Flood Elevation (BFE) and flood-proofing for structures in the 100-yr FEMA floodplain, which have changed over the years and vary between Charleston City, Charleston County, and Berkeley County.

Government-Owned Property & Tidal Flooding

Vulnerability & Risk Assessment

EXPOSED:
46 parcels exposed

MEDIUM OR HIGH VULNERABILITY AND RISK:
17 parcels
12% of Government-Owned Property

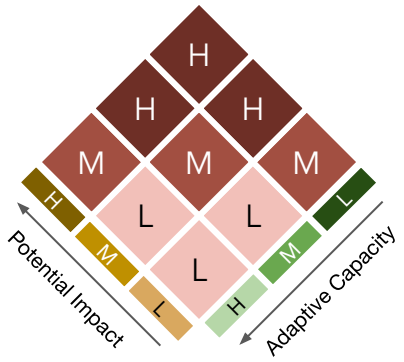


Tidal flooding is flooding of the low-lying land along the coastline from a high tide that is not associated with a tropical storm. Tidal flooding is also referred to as 'high tide', 'sunny day' and 'nuisance' flooding. The assessment used the 'High Tide Flooding' layer provided by NOAA Sea Level Rise Viewer. This layer delineates areas that are currently subject to 'minor' flooding from a tide elevation of 4.5 feet referenced to the North American Vertical Datum of 1988 (NAVD88) at Cooper River at Charleston Harbor gage (ID: 866530). Government-owned property includes all municipal, county, state, or federal owned properties, except for those associated with parks and recreation and critical facilities.

Government-Owned Property & Tidal Flooding

	VULNERABILITY		RISK	
	Potential Impact	Adaptive Capacity	Probability	Consequence
High	Structure in inundation extent and Historic	Structure built out of floodplain or structure in floodplain built after BFE requirements were raised to 1-2ft (2015 for Charleston, 2018 for Berkeley)	Within high tide flooding inundation extent	Structure exposed
Med	Structure in inundation extent	Structure in floodplain built after BFE requirements were in place (1971 for Charleston, 1983 for Berkeley)	N/A	
Low	No structure in inundation extent (land only)	Structure in floodplain built before BFE requirements were in place (1971 for Charleston, 1983 for Berkeley)	N/A	No structure exposed (land only)

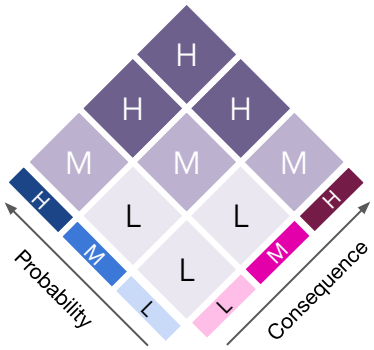
VULNERABILITY





# of parcels

RISK





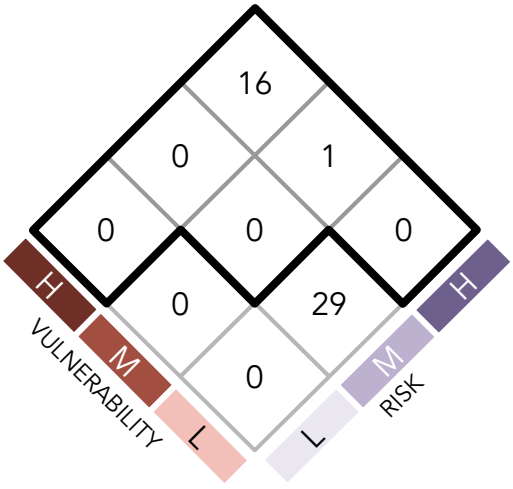
# of parcels

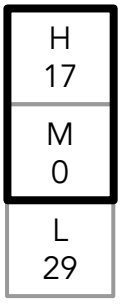
COMBINED VULNERABILITY & RISK

EXPOSED:
46 parcels exposed

MEDIUM OR HIGH VULNERABILITY AND RISK:
17 parcels
12% of Government-Owned Property

High Vulnerability-High Risk





# of parcels

Low Vulnerability-Low Risk

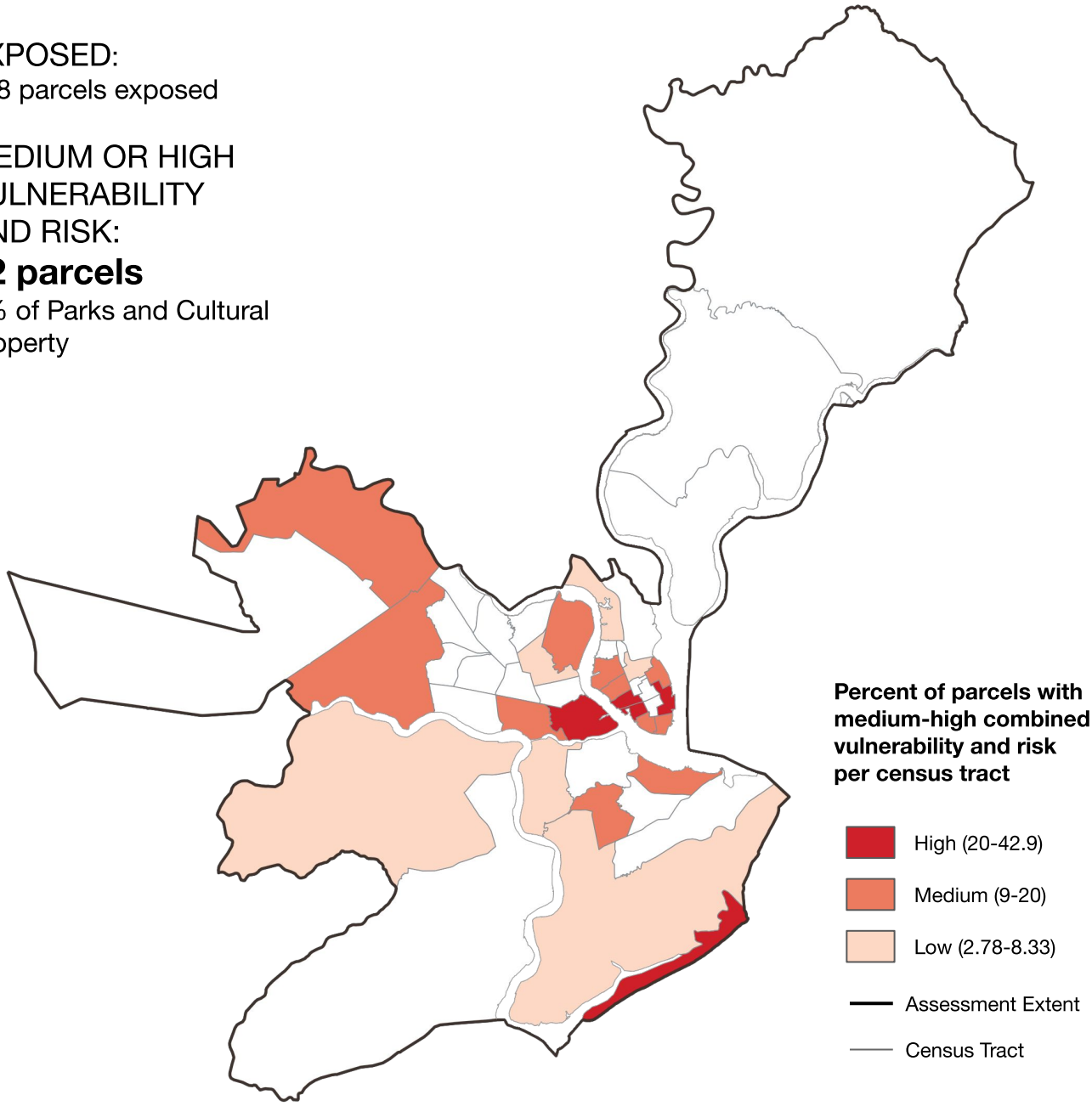
Adaptive capacity criteria are based on requirements for Base Flood Elevation (BFE) and flood-proofing for structures in the 100-yr FEMA floodplain, which have changed over the years and vary between Charleston City, Charleston County, and Berkeley County.

Parks and Cultural Property & Tidal Flooding

Vulnerability & Risk Assessment

EXPOSED:
178 parcels exposed

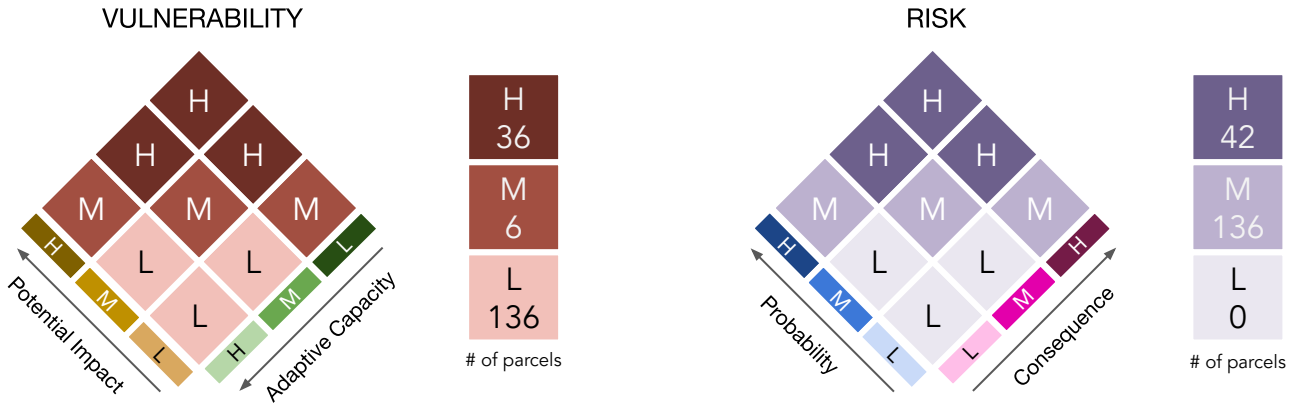
MEDIUM OR HIGH VULNERABILITY AND RISK:
42 parcels
6% of Parks and Cultural Property



Tidal flooding is flooding of the low-lying land along the coastline from a high tide that is not associated with a tropical storm. Tidal flooding is also referred to as 'high tide', 'sunny day' and 'nuisance' flooding. The assessment used the 'High Tide Flooding' layer provided by NOAA Sea Level Rise Viewer. This layer delineates areas that are currently subject to 'minor' flooding from a tide elevation of 4.5 feet referenced to the North American Vertical Datum of 1988 (NAVD88) at Cooper River at Charleston Harbor gage (ID: 866530). Park properties also include greenways and other recreation property. Cultural property includes local landmarks, community or civic facilities, and property with religious significance.

Parks and Cultural Property & Tidal Flooding

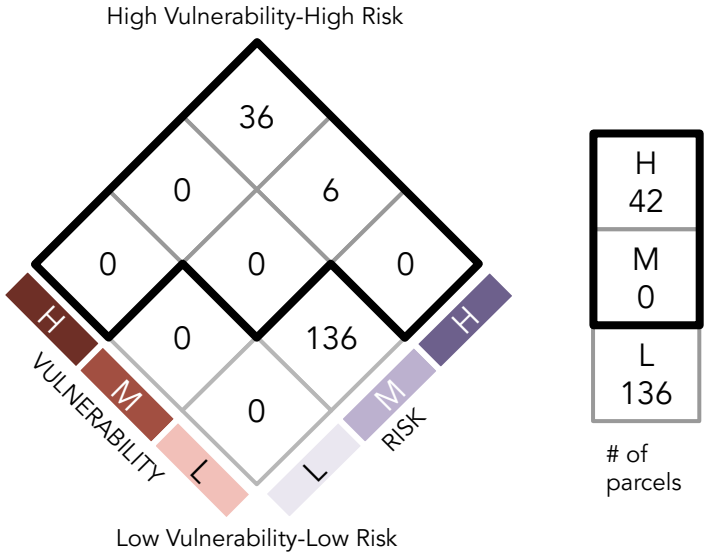
	VULNERABILITY		RISK	
	Potential Impact	Adaptive Capacity	Probability	Consequence
High	Structure in inundation extent and Historic	Structure built out of floodplain or structure in floodplain built after BFE requirements were raised to 1-2ft (2015 for Charleston, 2018 for Berkeley)	Within high tide flooding inundation extent	Structure exposed
Med	Structure in inundation extent	Structure in floodplain built after BFE requirements were in place (1971 for Charleston, 1983 for Berkeley)	N/A	
Low	No structure in inundation extent (land only)	Structure in floodplain built before BFE requirements were in place (1971 for Charleston, 1983 for Berkeley)	N/A	No structure exposed (land only)



COMBINED VULNERABILITY & RISK

EXPOSED:
178 parcels exposed

MEDIUM OR HIGH VULNERABILITY AND RISK:
42 parcels
6% of Parks and Cultural Property



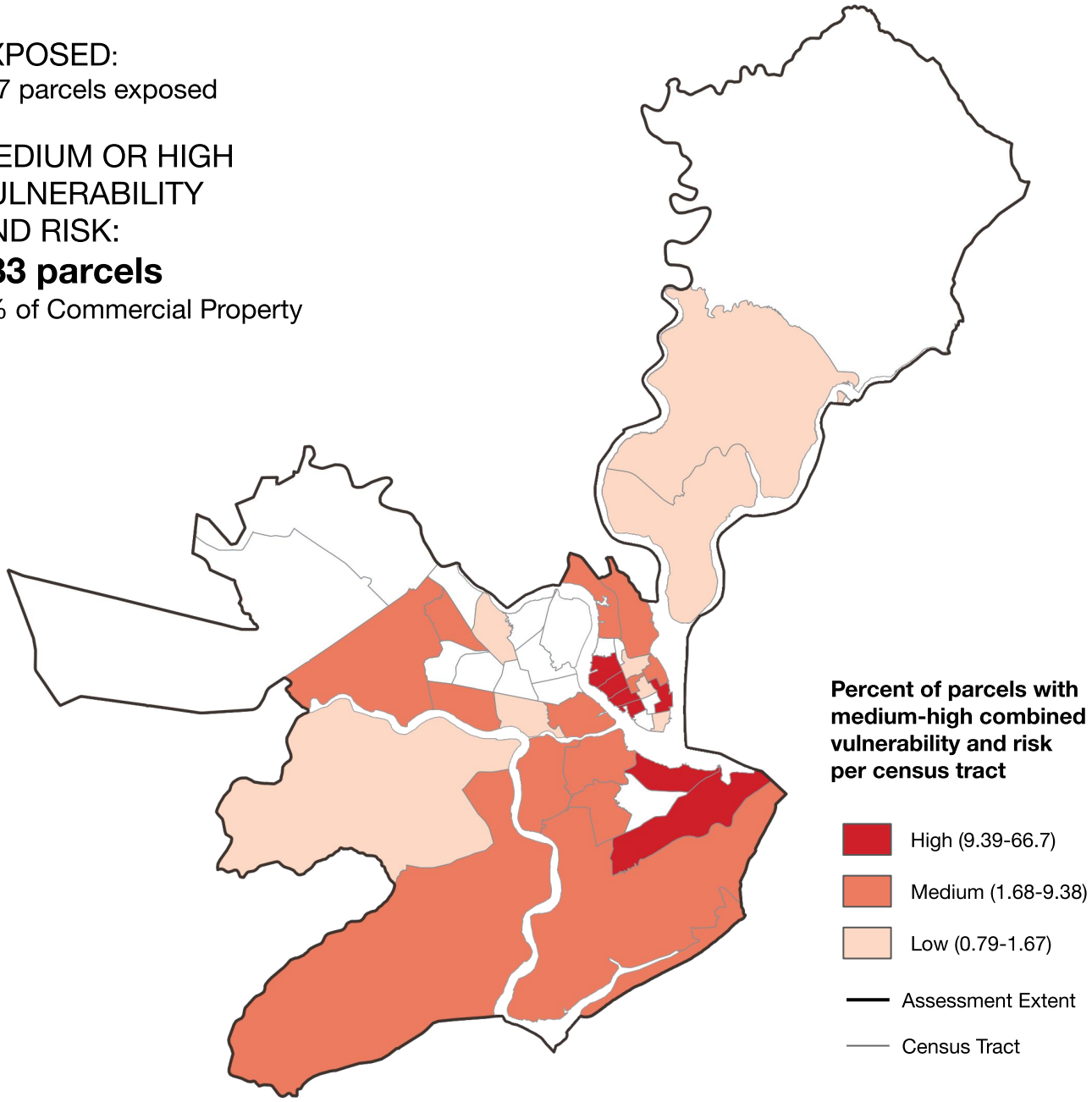
Adaptive capacity criteria are based on requirements for Base Flood Elevation (BFE) and flood-proofing for structures in the 100-yr FEMA floodplain, which have changed over the years and vary between Charleston City, Charleston County, and Berkeley County.

Commercial Property & Sea Level Rise Inundation

Vulnerability & Risk Assessment

EXPOSED:
357 parcels exposed

MEDIUM OR HIGH VULNERABILITY AND RISK:
183 parcels
5% of Commercial Property

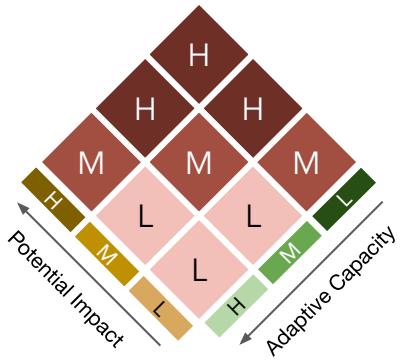


Sea level rise here refers to the relative rise of the local mean sea level over time. In alignment with the City of Charleston Flooding and Sea Level Rise strategy, this assessment used a three-foot sea level rise added to the current multi-year average daily higher high tide (MHHW+3ft). Commercial property includes retail, office, restaurant, hotel, industrial, and other properties that serve businesses and organizations. They also typically support commerce, jobs, and tourism. Note that assets may be assessed under multiple categories according to their use (e.g. multi-use such as commercial and residential or commercial and medical).

Commercial Property & Sea Level Rise Inundation

	VULNERABILITY		RISK	
	Potential Impact	Adaptive Capacity	Probability	Consequence
High	Structure in inundation extent and Retail, Restaurants, Hotel, Historic, Snap Retailer	Structure built out of floodplain or structure in floodplain built after BFE requirements were raised to 1-2ft (2015 for Charleston, 2018 for Berkeley)	Within 1ft Sea level rise inundation extent	Structure exposed and above median value
Med	Structure in inundation extent	Structure in floodplain built after BFE requirements were in place (1971 for Charleston, 1983 for Berkeley)	Within 2ft Sea level rise inundation extent	Structure exposed and below median value
Low	No structure in inundation extent (land only)	Structure in floodplain built before BFE requirements were in place (1971 for Charleston, 1983 for Berkeley)	Within 3ft Sea level rise inundation extent	No structure exposed (land only)

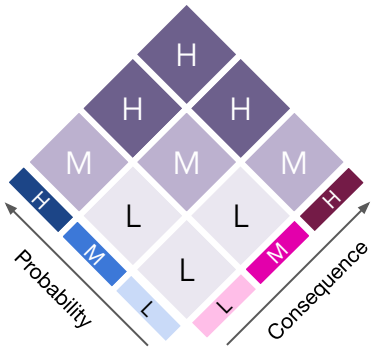
VULNERABILITY





# of parcels

RISK





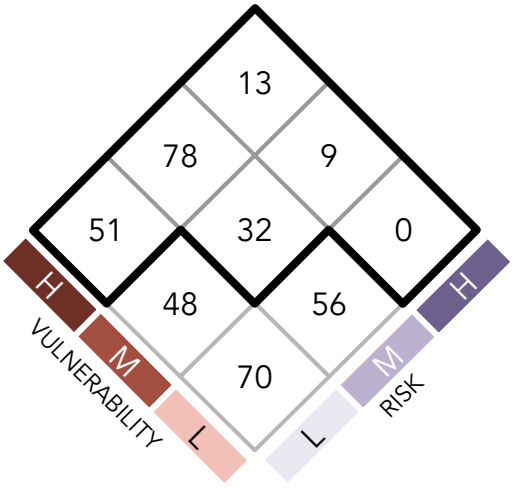
# of parcels

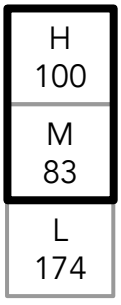
COMBINED VULNERABILITY & RISK

EXPOSED:
357 parcels exposed

MEDIUM OR HIGH VULNERABILITY AND RISK:
183 parcels
5% of Commercial Property

High Vulnerability-High Risk





# of parcels

Low Vulnerability-Low Risk

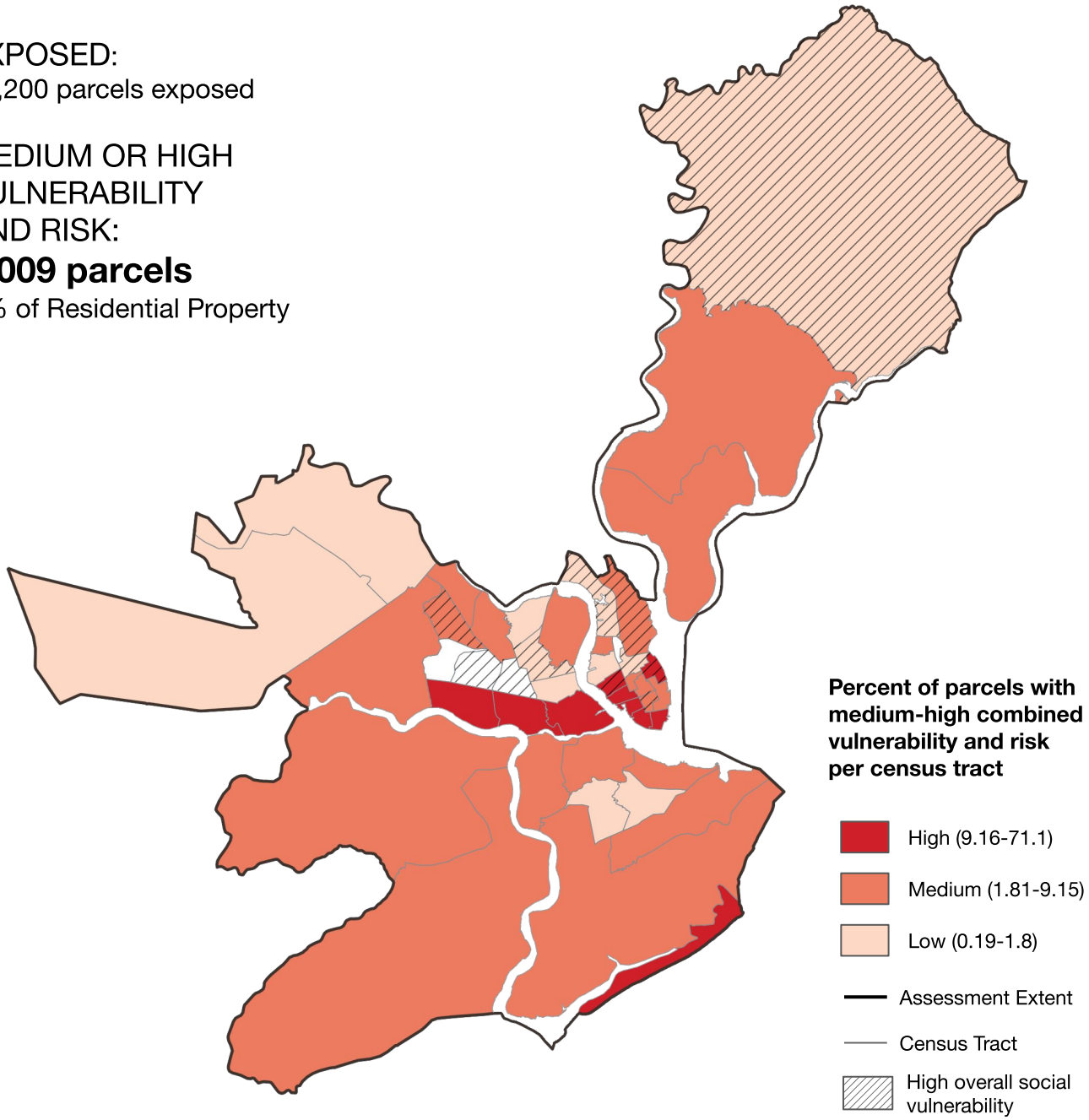
Adaptive capacity criteria are based on requirements for Base Flood Elevation (BFE) and flood-proofing for structures in the 100-yr FEMA floodplain, which have changed over the years and vary between Charleston City, Charleston County, and Berkeley County. Median structure value for Commercial Property was $317,930

Residential Property & Sea Level Rise Inundation

Vulnerability & Risk Assessment

EXPOSED:
10,200 parcels exposed

MEDIUM OR HIGH VULNERABILITY AND RISK:
4,009 parcels
6% of Residential Property

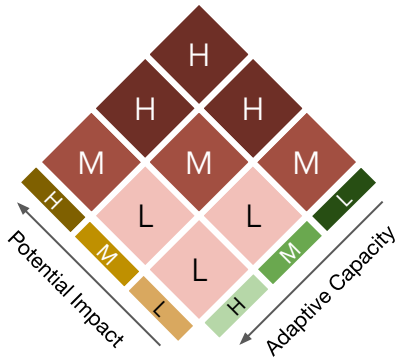


Sea level rise here refers to the relative rise of the local mean sea level over time. In alignment with the City of Charleston Flooding and Sea Level Rise strategy, this assessment used a three-foot sea level rise added to the current multi-year average daily higher high tide (MHHW+3ft). Residential property includes all single-family residences, multiple-family residences, low-income housing, apartments, manufactured houses, and mobile home parks.

Residential Property & Sea Level Rise Inundation

	VULNERABILITY		RISK	
	Potential Impact	Adaptive Capacity	Probability	Consequence
High	Structure in inundation extent and Multi Residence, Mobile Home, Group Home, Historic, Nursing Home, Public Housing	Structure built out of floodplain or structure in floodplain built after BFE requirements were raised to 1-2ft (2015 for Charleston, 2018 for Berkeley)	Within 1ft Sea level rise inundation extent	Structure exposed and above median value
Med	Structure in inundation extent	Structure in floodplain built after BFE requirements were in place (1971 for Charleston, 1983 for Berkeley)	Within 2ft Sea level rise inundation extent	Structure exposed and below median value
Low	No structure in inundation extent (land only)	Structure in floodplain built before BFE requirements were in place (1971 for Charleston, 1983 for Berkeley)	Within 3ft Sea level rise inundation extent	No structure exposed (land only)

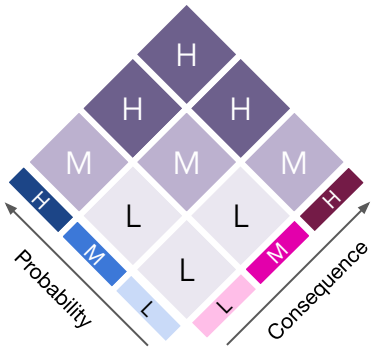
VULNERABILITY





# of parcels

RISK





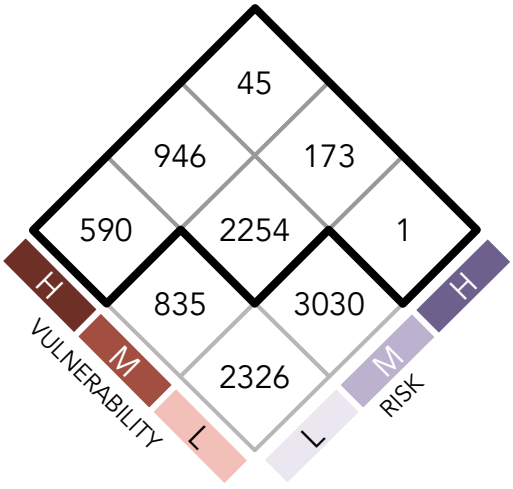
# of parcels

COMBINED VULNERABILITY & RISK

EXPOSED:
10,200 parcels exposed

MEDIUM OR HIGH VULNERABILITY AND RISK:
4,009 parcels
6% of Residential Property

High Vulnerability-High Risk





# of parcels

Low Vulnerability-Low Risk

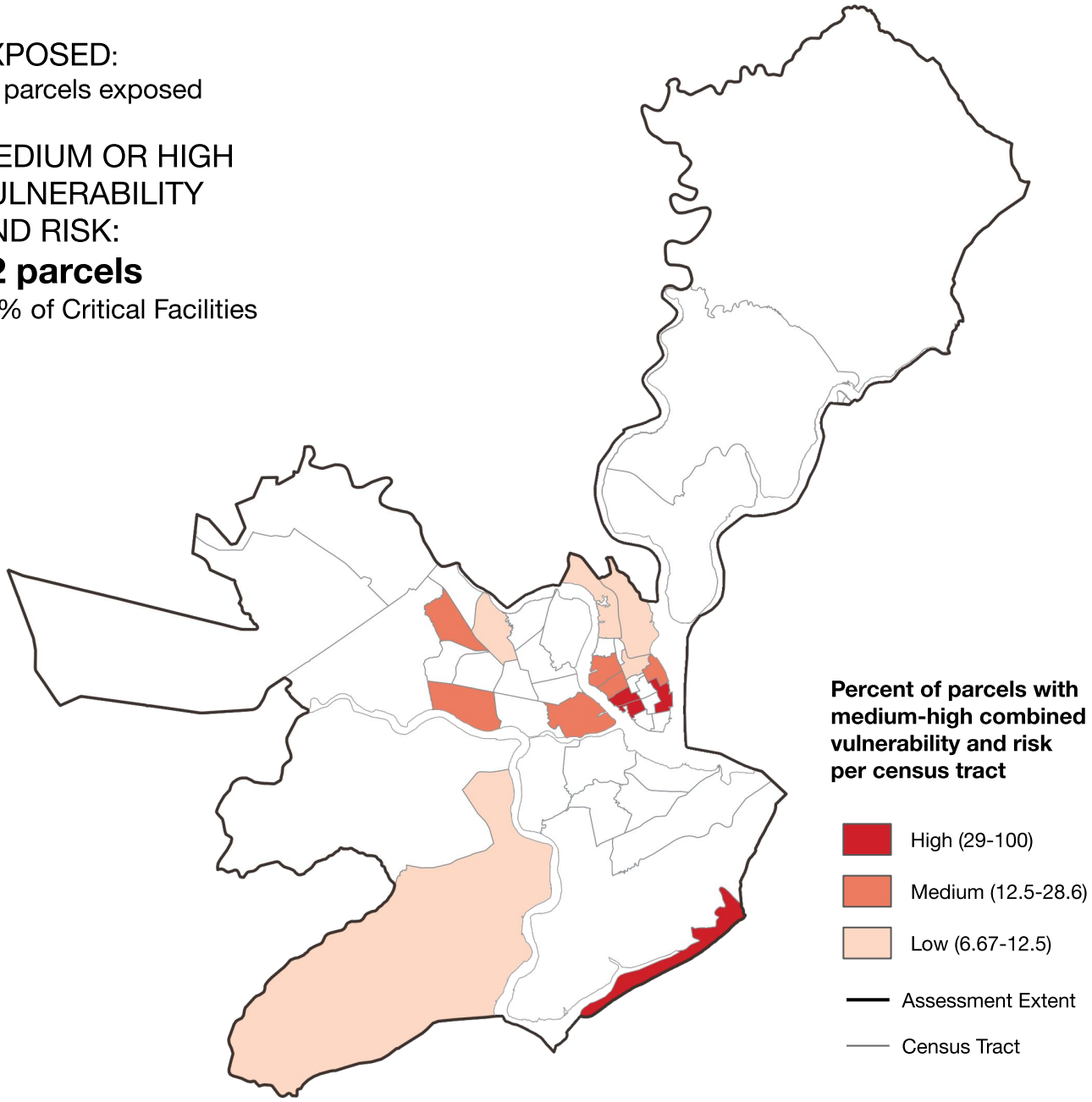
Adaptive capacity criteria are based on requirements for Base Flood Elevation (BFE) and flood-proofing for structures in the 100-yr FEMA floodplain, which have changed over the years and vary between Charleston City, Charleston County, and Berkeley County. Median structure value for Residential Property was $179,000

Critical Facilities & Sea Level Rise Inundation

Vulnerability & Risk Assessment

EXPOSED:
74 parcels exposed

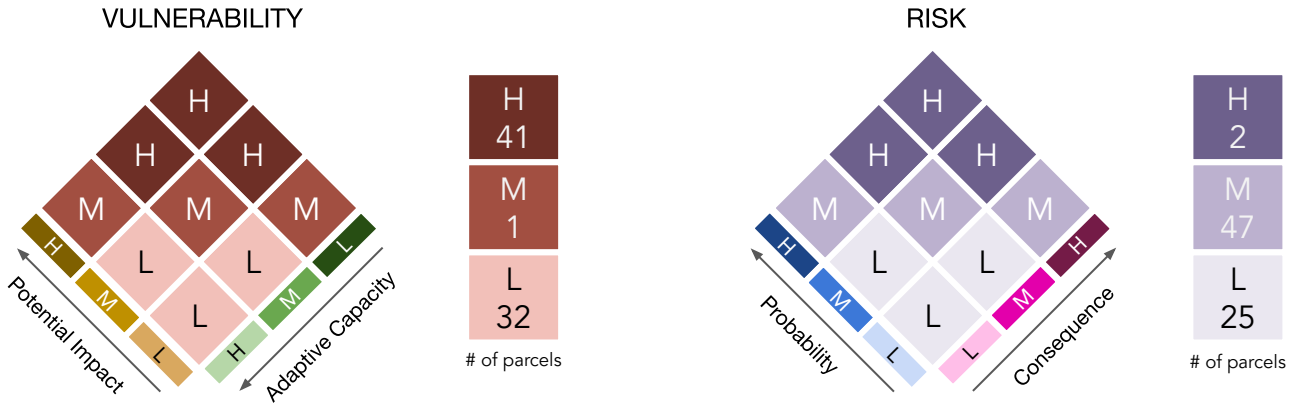
MEDIUM OR HIGH VULNERABILITY AND RISK:
42 parcels
12% of Critical Facilities



Sea level rise here refers to the relative rise of the local mean sea level over time. In alignment with the City of Charleston Flooding and Sea Level Rise strategy, this assessment used a three-foot sea level rise added to the current multi-year average daily higher high tide (MHHW+3ft). Critical facility property includes fire and police stations that aid in emergency response, medical facilities, schools, energy and utility facilities, and transportation-related facilities.

Critical Facilities & Sea Level Rise Inundation

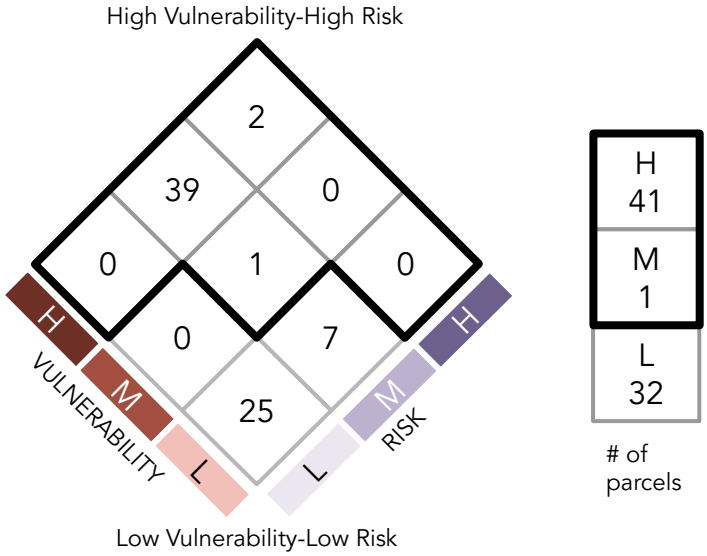
	VULNERABILITY		RISK	
	Potential Impact	Adaptive Capacity	Probability	Consequence
High	Structure in inundation extent and Medical, Emergency Facilities, Schools, Historic, Medical Major	Structure built out of floodplain or structure in floodplain built after BFE requirements were raised to 1-2ft (2015 for Charleston, 2018 for Berkeley)	Within 1ft Sea level rise inundation extent	Structure exposed
Med	Structure in inundation extent	Structure in floodplain built after BFE requirements were in place (1971 for Charleston, 1983 for Berkeley)	Within 2ft Sea level rise inundation extent	
Low	No structure in inundation extent (land only)	Structure in floodplain built before BFE requirements were in place (1971 for Charleston, 1983 for Berkeley)	Within 3ft Sea level rise inundation extent	No structure exposed (land only)



COMBINED VULNERABILITY & RISK

EXPOSED:
74 parcels exposed

MEDIUM OR HIGH VULNERABILITY AND RISK:
42 parcels
12% of Critical Facilities



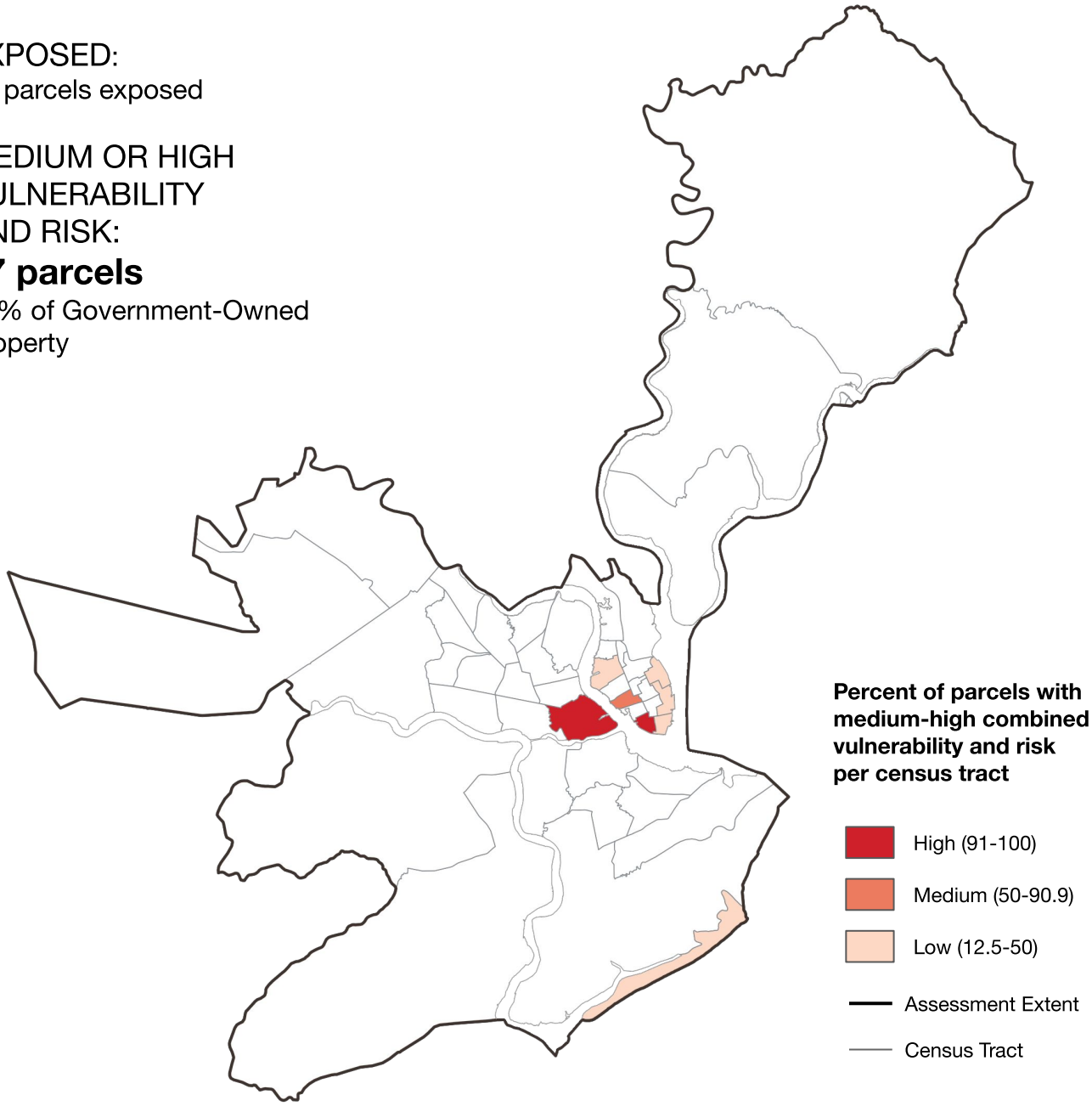
Adaptive capacity criteria are based on requirements for Base Flood Elevation (BFE) and flood-proofing for structures in the 100-yr FEMA floodplain, which have changed over the years and vary between Charleston City, Charleston County, and Berkeley County.

Government-Owned Property & Sea Level Rise Inundation

Vulnerability & Risk Assessment

EXPOSED:
50 parcels exposed

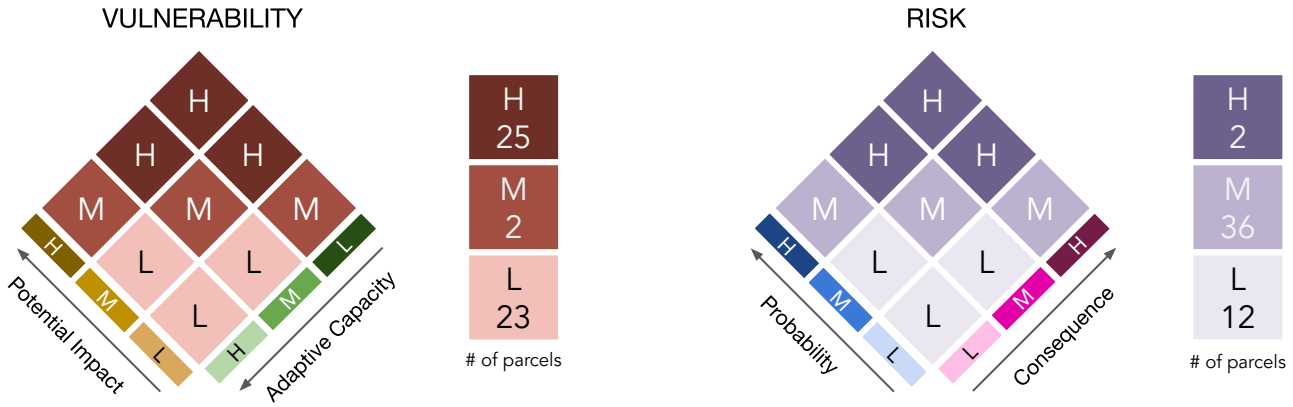
MEDIUM OR HIGH VULNERABILITY AND RISK:
27 parcels
19% of Government-Owned Property



Sea level rise here refers to the relative rise of the local mean sea level over time. In alignment with the City of Charleston Flooding and Sea Level Rise strategy, this assessment used a three-foot sea level rise added to the current multi-year average daily higher high tide (MHHW+3ft). Government-owned property includes all municipal, county, state, or federal owned properties, except for those associated with parks and recreation and critical facilities.

Government-Owned Property & Sea Level Rise Inundation

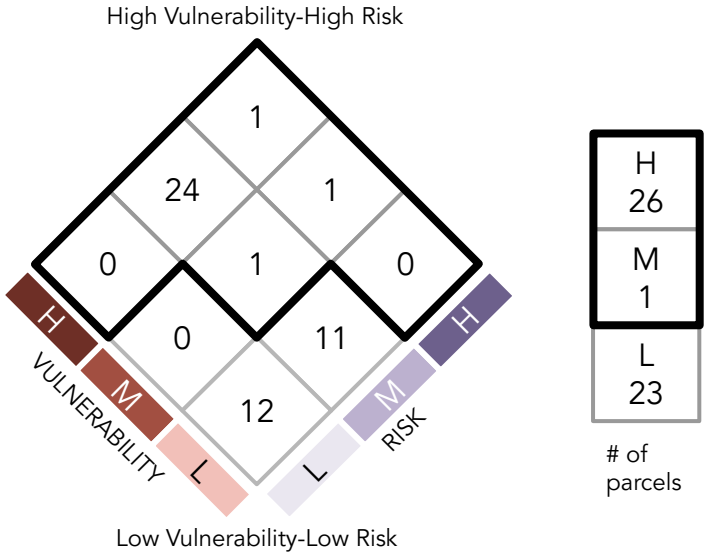
	VULNERABILITY		RISK	
	Potential Impact	Adaptive Capacity	Probability	Consequence
High	Structure in inundation extent and Historic	Structure built out of floodplain or structure in floodplain built after BFE requirements were raised to 1-2ft (2015 for Charleston, 2018 for Berkeley)	Within 1ft Sea level rise inundation extent	Structure exposed
Med	Structure in inundation extent	Structure in floodplain built after BFE requirements were in place (1971 for Charleston, 1983 for Berkeley)	Within 2ft Sea level rise inundation extent	
Low	No structure in inundation extent (land only)	Structure in floodplain built before BFE requirements were in place (1971 for Charleston, 1983 for Berkeley)	Within 3ft Sea level rise inundation extent	No structure exposed (land only)



COMBINED VULNERABILITY & RISK

EXPOSED:
50 parcels exposed

MEDIUM OR HIGH VULNERABILITY AND RISK:
27 parcels
19% of Government-Owned Property



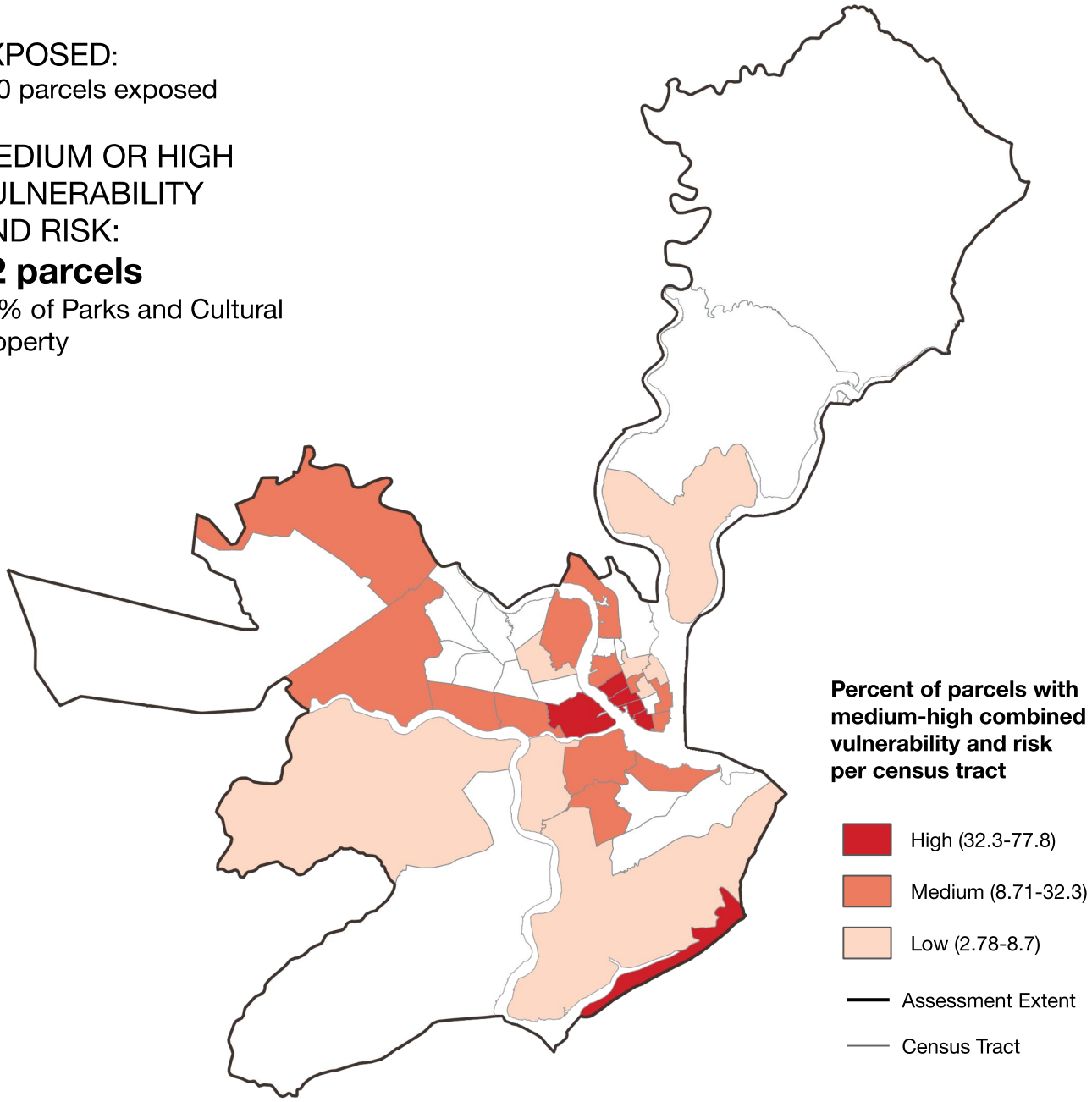
Adaptive capacity criteria are based on requirements for Base Flood Elevation (BFE) and flood-proofing for structures in the 100-yr FEMA floodplain, which have changed over the years and vary between Charleston City, Charleston County, and Berkeley County.

Parks and Cultural Property & Sea Level Rise Inundation

Vulnerability & Risk Assessment

EXPOSED:
170 parcels exposed

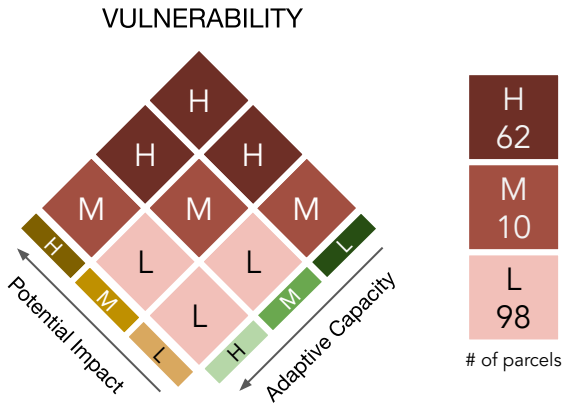
MEDIUM OR HIGH VULNERABILITY AND RISK:
72 parcels
11% of Parks and Cultural Property

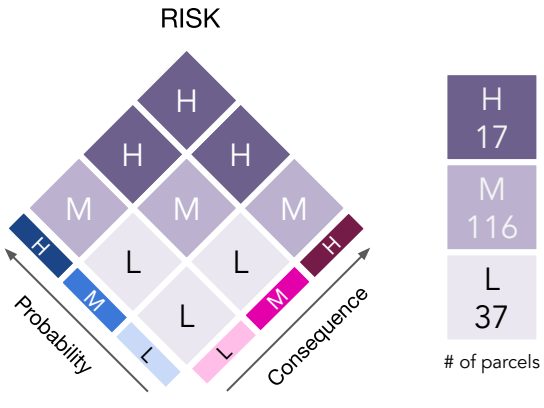


Sea level rise here refers to the relative rise of the local mean sea level over time. In alignment with the City of Charleston Flooding and Sea Level Rise strategy, this assessment used a three-foot sea level rise added to the current multi-year average daily higher high tide (MHHW+3ft). Park properties also include greenways and other recreation property. Cultural property includes local landmarks, community or civic facilities, and property with religious significance.

Parks and Cultural Property & Sea Level Rise Inundation

	VULNERABILITY		RISK	
	Potential Impact	Adaptive Capacity	Probability	Consequence
High	Structure in inundation extent and Historic	Structure built out of floodplain or structure in floodplain built after BFE requirements were raised to 1-2ft (2015 for Charleston, 2018 for Berkeley)	Within 1ft Sea level rise inundation extent	Structure exposed
Med	Structure in inundation extent	Structure in floodplain built after BFE requirements were in place (1971 for Charleston, 1983 for Berkeley)	Within 2ft Sea level rise inundation extent	
Low	No structure in inundation extent (land only)	Structure in floodplain built before BFE requirements were in place (1971 for Charleston, 1983 for Berkeley)	Within 3ft Sea level rise inundation extent	No structure exposed (land only)

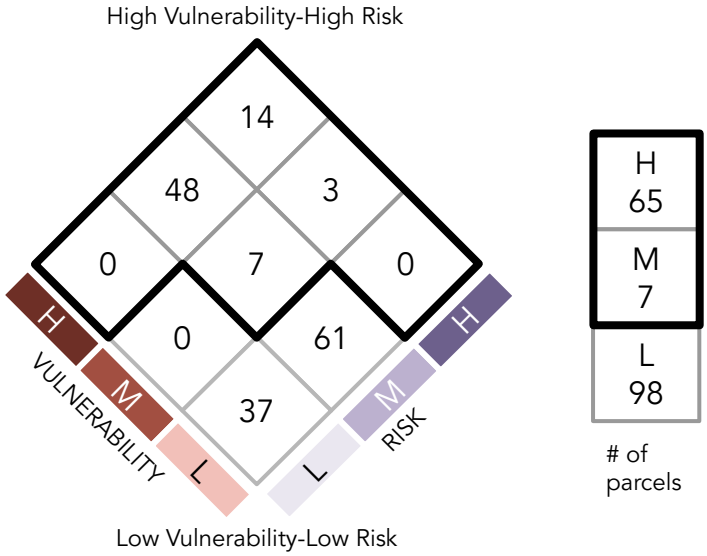




EXPOSED:
170 parcels exposed

MEDIUM OR HIGH VULNERABILITY AND RISK:
72 parcels
11% of Parks and Cultural Property

COMBINED VULNERABILITY & RISK



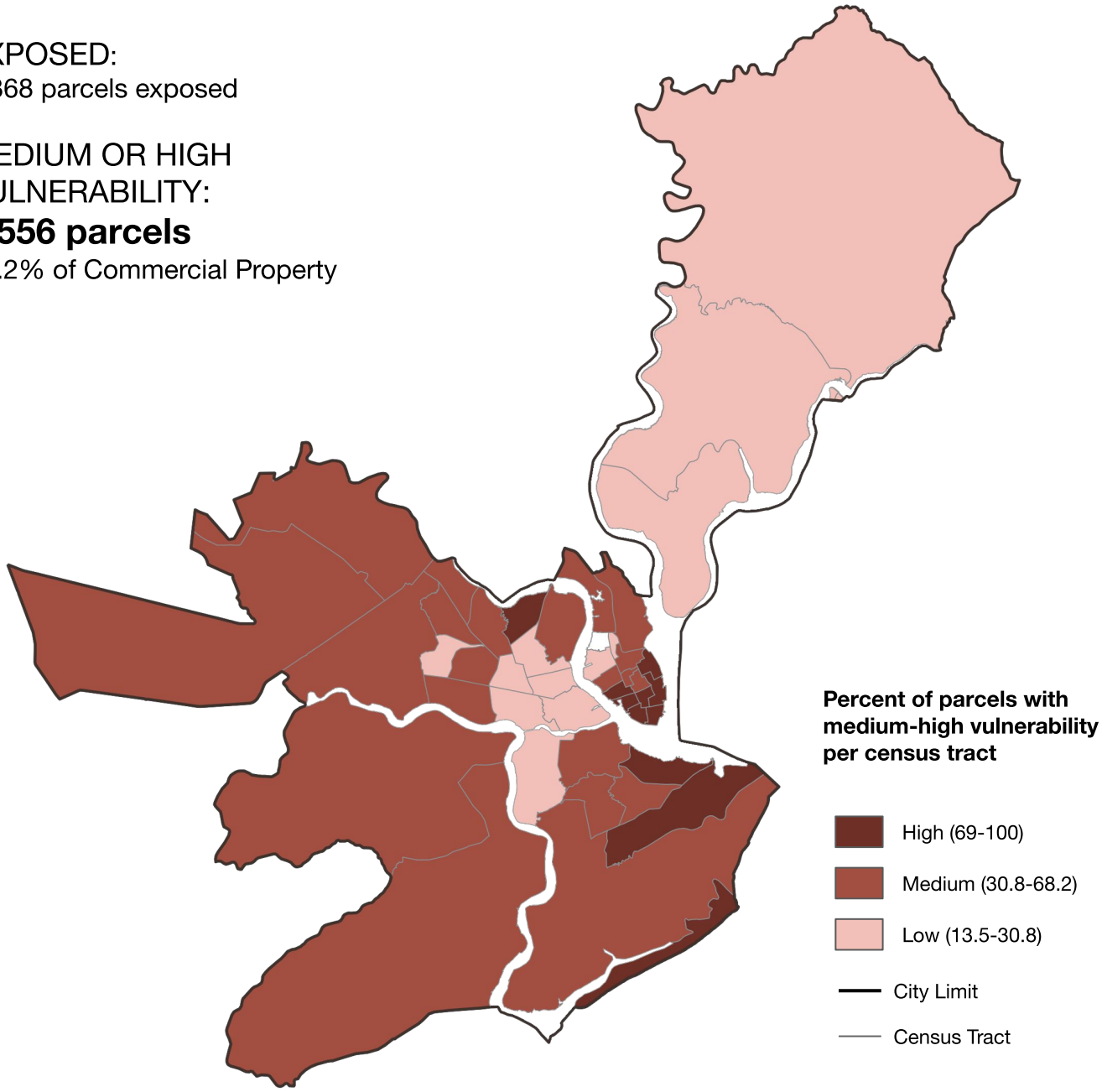
Adaptive capacity criteria are based on requirements for Base Flood Elevation (BFE) and flood-proofing for structures in the 100-yr FEMA floodplain, which have changed over the years and vary between Charleston City, Charleston County, and Berkeley County.

Commercial Property & Earthquake

Vulnerability Assessment

EXPOSED:
3,368 parcels exposed

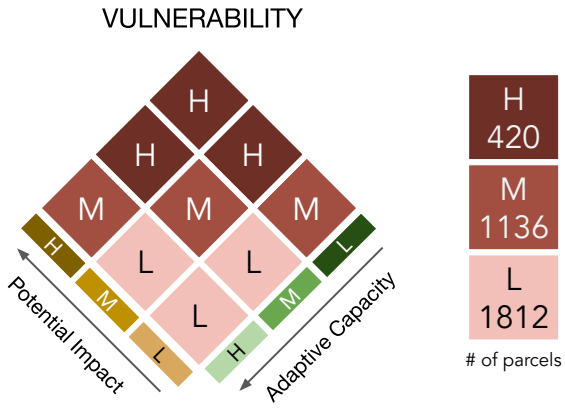
MEDIUM OR HIGH VULNERABILITY:
1,556 parcels
46.2% of Commercial Property



Sudden, rapid shaking of the earth due to seismic activity. The National Earthquake Hazard Reduction Plan (NEHRP) site class map (part of the FEMA HAZUS 4.1 data suite) was used to assess the earthquake hazard. Commercial property includes retail, office, restaurant, hotel, industrial, and other properties that serve businesses and organizations. They also typically support commerce, jobs, and tourism. Note that assets may be assessed under multiple categories according to their use (e.g. multi-use such as commercial and residential or commercial and medical).

Commercial Property & Earthquake

	VULNERABILITY	
	Potential Impact	Adaptive Capacity
High	Asset in higher susceptibility (Class E) area and Retail, Restaurants, Hotel, Historic, Snap Retailer	Structure built 2002 or after. Latest regulations apply.
Med	Asset in lower susceptibility (Class D) area and Retail, Restaurants, Hotel, Historic, Snap Retailer; or Asset in higher susceptibility (Class E) area	Structure built between 1968-2002. Some regulations apply.
Low	Asset in lower susceptibility (Class D) area	Building built before 1968 or unknown building year.



EXPOSED:
3,368 parcels exposed

MEDIUM OR HIGH VULNERABILITY:
1,556 parcels
46.2% of Commercial Property

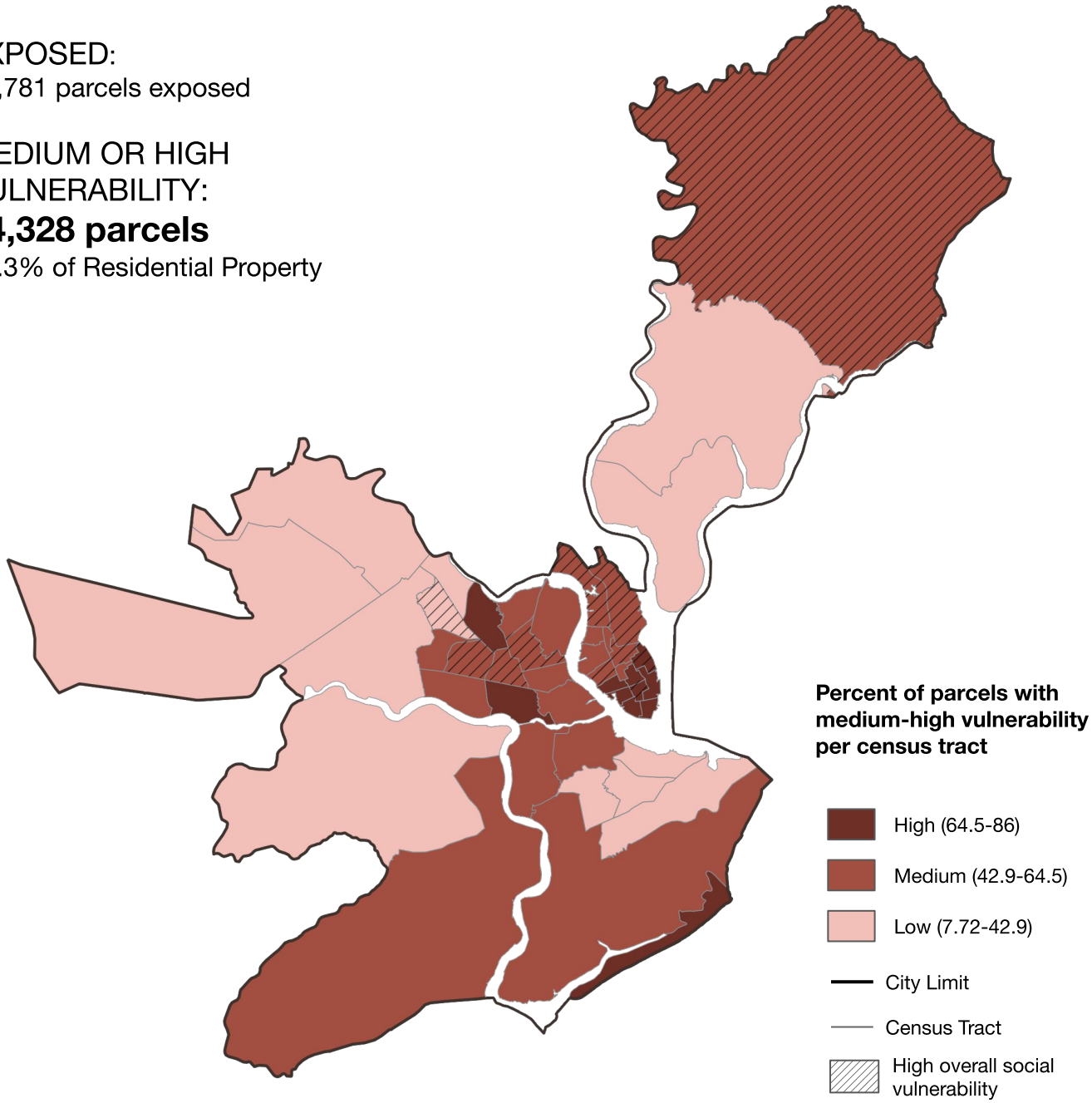
Adaptive capacity criteria are based on requirements for earthquake resistant structures

Residential Property & Earthquake

Vulnerability Assessment

EXPOSED:
61,781 parcels exposed

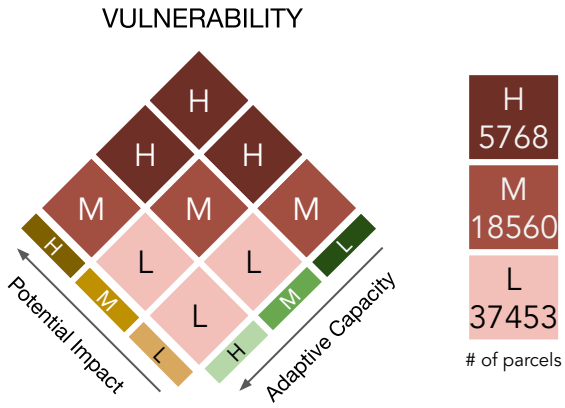
MEDIUM OR HIGH VULNERABILITY:
24,328 parcels
39.3% of Residential Property



Sudden, rapid shaking of the earth due to seismic activity. The National Earthquake Hazard Reduction Plan (NEHRP) site class map (part of the FEMA HAZUS 4.1 data suite) was used to assess the earthquake hazard. Residential property includes all single-family residences, multiple-family residences, low-income housing, apartments, manufactured houses, and mobile home parks.

Residential Property & Earthquake

	VULNERABILITY	
	Potential Impact	Adaptive Capacity
High	Structure in inundation extent and Multi Residence, Mobile Home, Group Home, Historic, Nursing Home, Public Housing, or {historic}	Structure built 2002 or after. Latest regulations apply.
Med	Structure in inundation extent	Structure built between 1968-2002. Some regulations apply.
Low	No structure in inundation extent (land only)	Building built before 1968 or unknown building year.



EXPOSED:
61,781 parcels exposed

MEDIUM OR HIGH VULNERABILITY:
24,328 parcels
39.3% of Residential Property

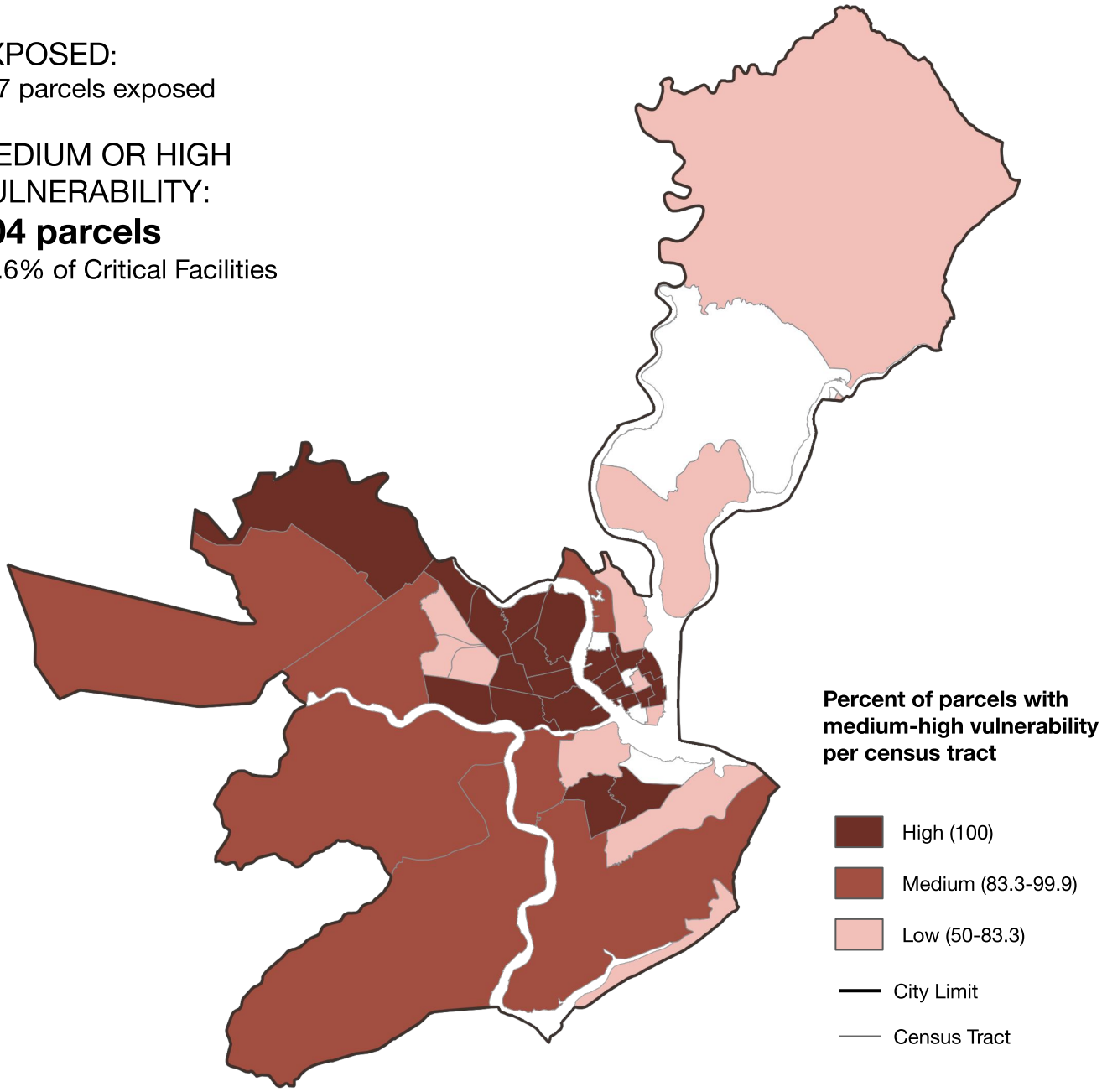
Adaptive capacity criteria are based on requirements for earthquake resistant structures

Critical Facilities & Earthquake

Vulnerability Assessment

EXPOSED:
347 parcels exposed

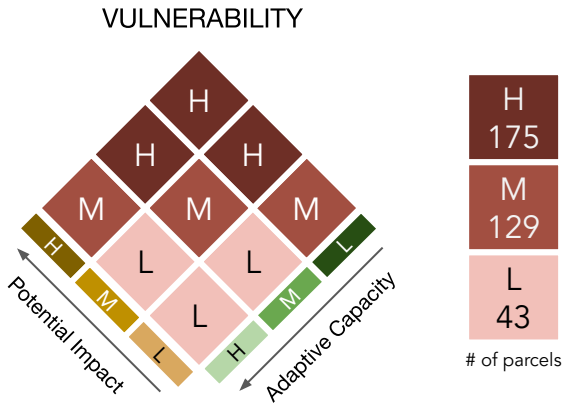
MEDIUM OR HIGH VULNERABILITY:
304 parcels
87.6% of Critical Facilities



Sudden, rapid shaking of the earth due to seismic activity. The National Earthquake Hazard Reduction Plan (NEHRP) site class map (part of the FEMA HAZUS 4.1 data suite) was used to assess the earthquake hazard. Critical facility property includes fire and police stations that aid in emergency response, medical facilities, schools, energy and utility facilities, and transportation-related facilities.

Critical Facilities & Earthquake

	VULNERABILITY	
	Potential Impact	Adaptive Capacity
High	Asset in higher susceptibility (Class E) area and Medical, Emergency Facilities, Schools, Historic, Medical Major	Structure built 2002 or after. Latest regulations apply.
Med	Asset in lower susceptibility (Class D) area and Medical, Emergency Facilities, Schools, Historic, Medical Major; or Asset in higher susceptibility (Class E) area	Structure built between 1968-2002. Some regulations apply.
Low	Asset in lower susceptibility (Class D) area	Building built before 1968 or unknown building year.



EXPOSED:
347 parcels exposed

MEDIUM OR HIGH VULNERABILITY:
304 parcels
87.6% of Critical Facilities

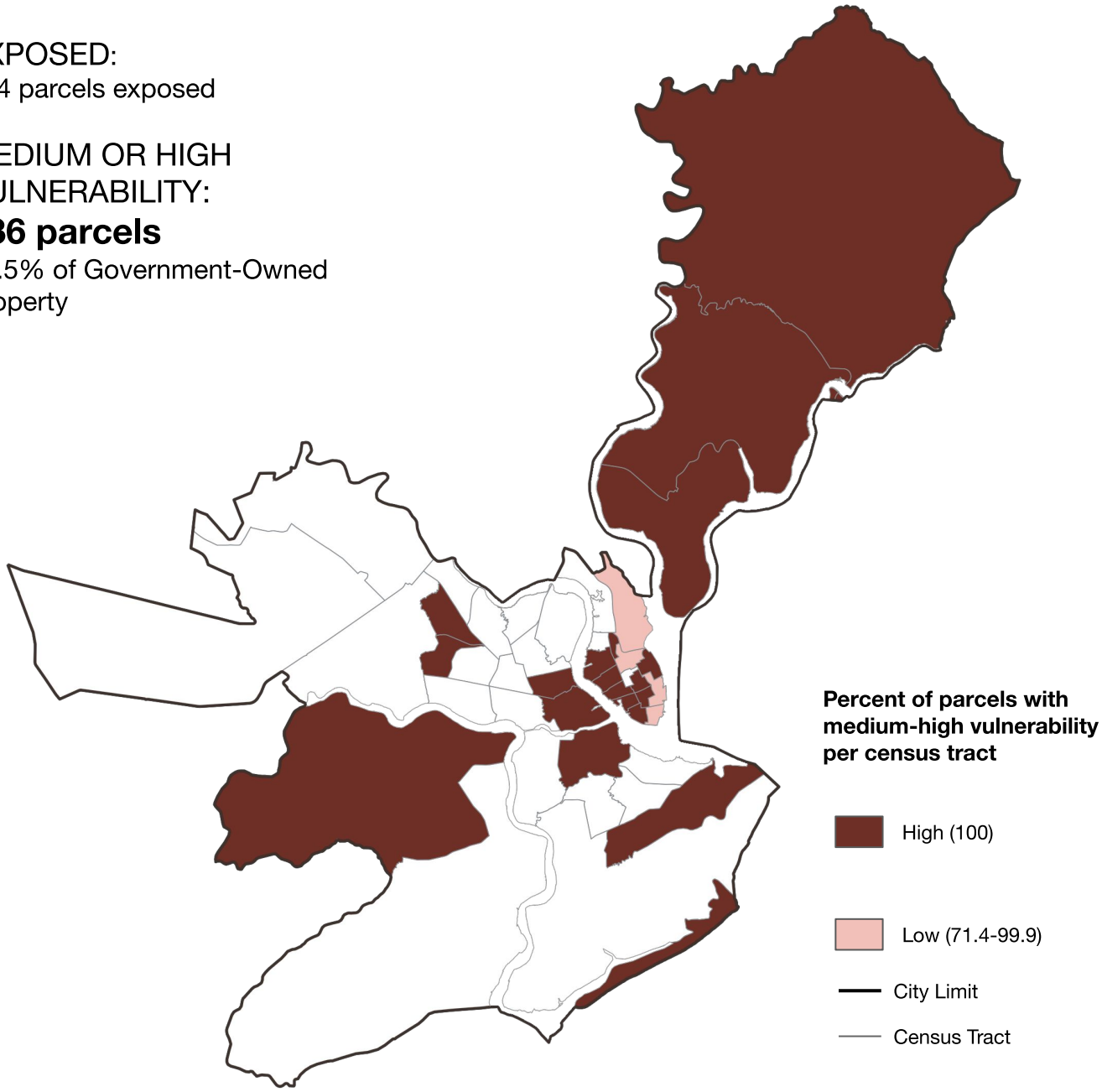
Adaptive capacity criteria are based on requirements for earthquake resistant structures

Government-Owned Property & Earthquake

Vulnerability Assessment

EXPOSED:
144 parcels exposed

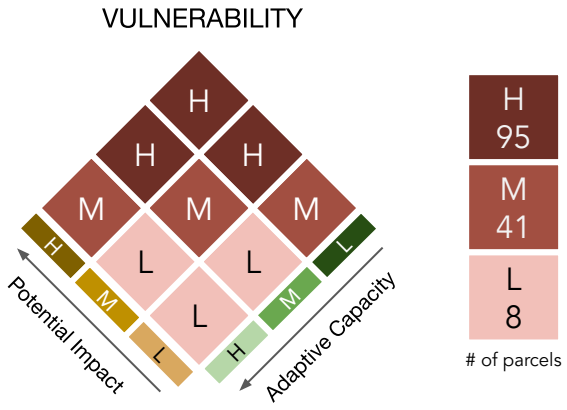
MEDIUM OR HIGH VULNERABILITY:
136 parcels
94.5% of Government-Owned Property



Sudden, rapid shaking of the earth due to seismic activity. The National Earthquake Hazard Reduction Plan (NEHRP) site class map (part of the FEMA HAZUS 4.1 data suite) was used to assess the earthquake hazard. Government-owned property includes all municipal, county, state, or federal owned properties, except for those associated with parks and recreation and critical facilities.

Government-Owned Property & Earthquake

	VULNERABILITY	
	Potential Impact	Adaptive Capacity
High	Asset in higher susceptibility (Class E) area and Historic	Structure built 2002 or after. Latest regulations apply.
Med	Asset in lower susceptibility (Class D) area and Historic; or Asset in higher susceptibility (Class E) area	Structure built between 1968-2002. Some regulations apply.
Low	Asset in lower susceptibility (Class D) area	Building built before 1968 or unknown building year.



EXPOSED:
144 parcels exposed

MEDIUM OR HIGH VULNERABILITY:
136 parcels
94.5% of Government-Owned Property

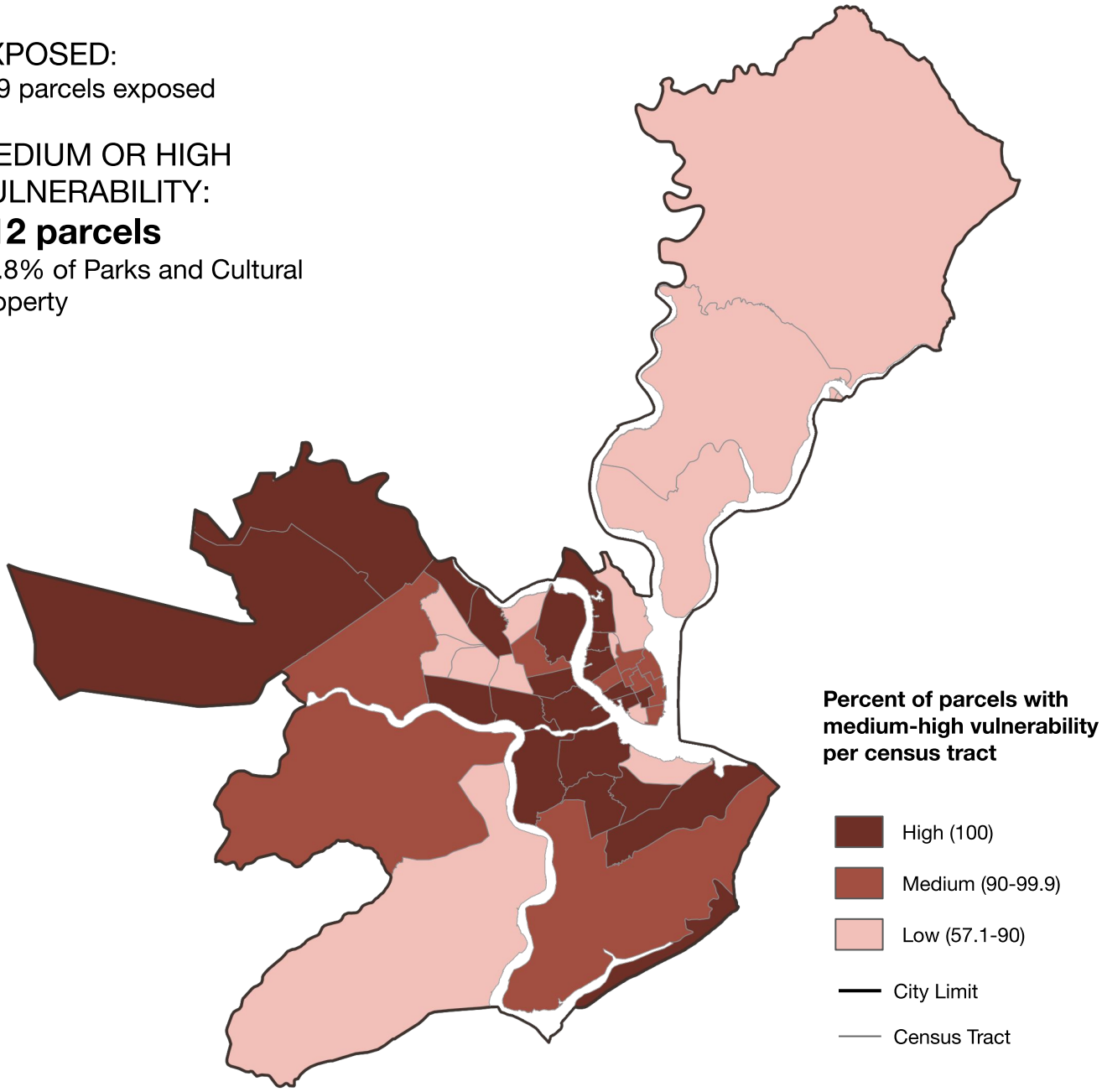
Adaptive capacity criteria are based on requirements for earthquake resistant structures

Parks and Cultural Property & Earthquake

Vulnerability Assessment

EXPOSED:
659 parcels exposed

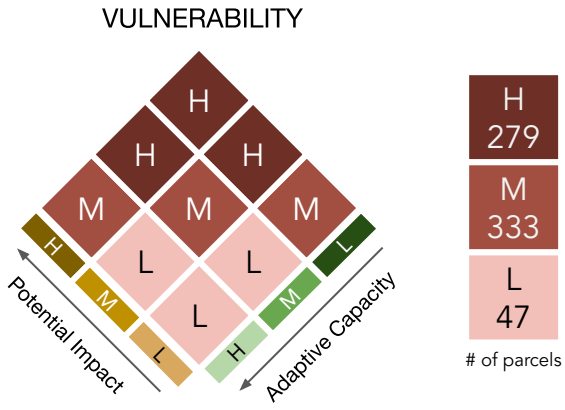
MEDIUM OR HIGH VULNERABILITY:
612 parcels
92.8% of Parks and Cultural Property



Sudden, rapid shaking of the earth due to seismic activity. The National Earthquake Hazard Reduction Plan (NEHRP) site class map (part of the FEMA HAZUS 4.1 data suite) was used to assess the earthquake hazard. Park properties also include greenways and other recreation property. Cultural property includes local landmarks, community or civic facilities, and property with religious significance.

Parks and Cultural Property & Earthquake

	VULNERABILITY	
	Potential Impact	Adaptive Capacity
High	Asset in higher susceptibility (Class E) area and Historic	Structure built 2002 or after. Latest regulations apply.
Med	Asset in lower susceptibility (Class D) area and Historic; or Asset in higher susceptibility (Class E) area	Structure built between 1968-2002. Some regulations apply.
Low	Asset in lower susceptibility (Class D) area	Building built before 1968 or unknown building year.



EXPOSED:
659 parcels exposed

MEDIUM OR HIGH VULNERABILITY:
612 parcels
92.8% of Parks and Cultural Property

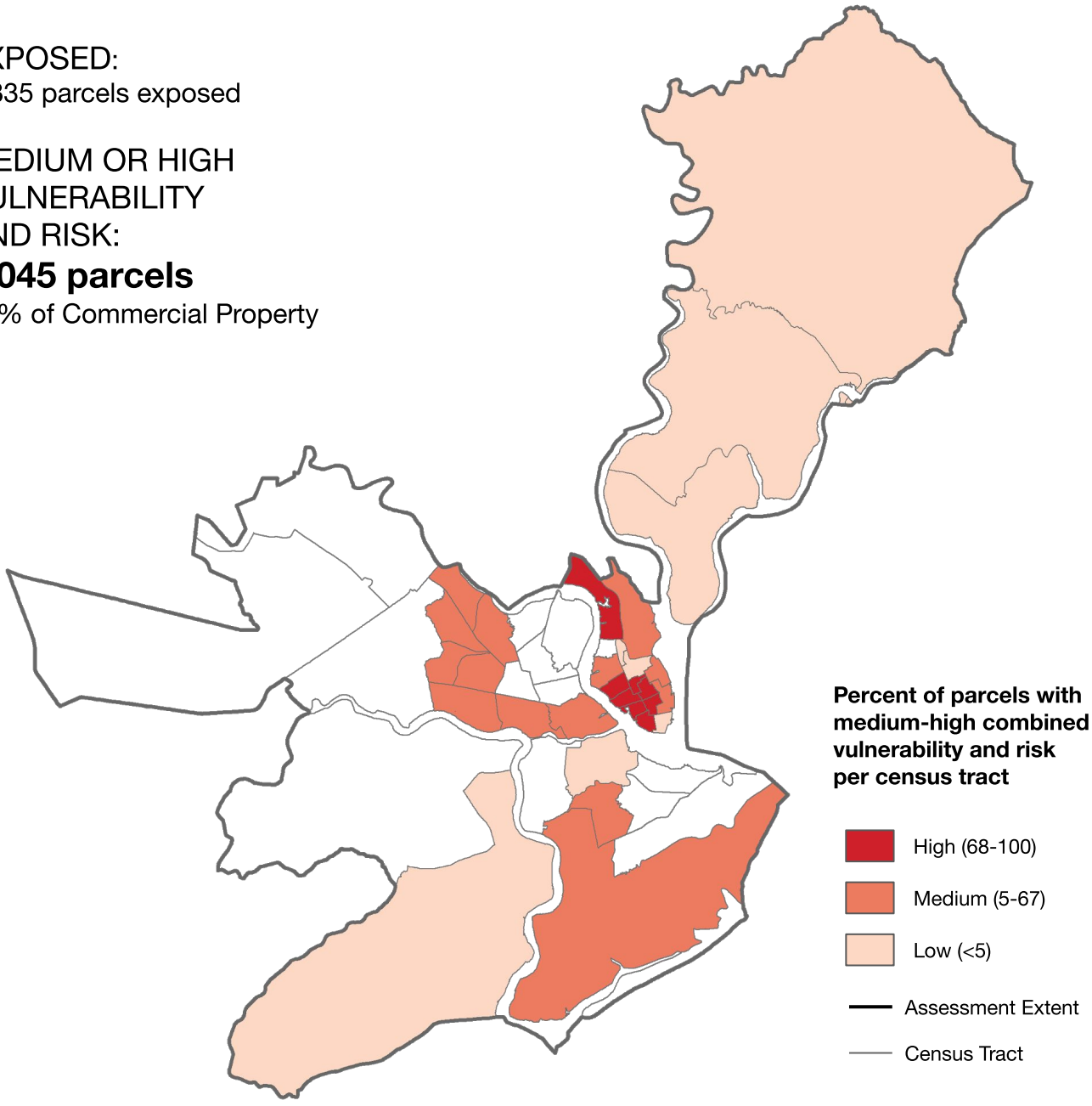
Adaptive capacity criteria are based on requirements for earthquake resistant structures

Commercial Property & Hazardous Materials

Vulnerability & Risk Assessment

EXPOSED:
2,835 parcels exposed

MEDIUM OR HIGH VULNERABILITY AND RISK:
1,045 parcels
31% of Commercial Property

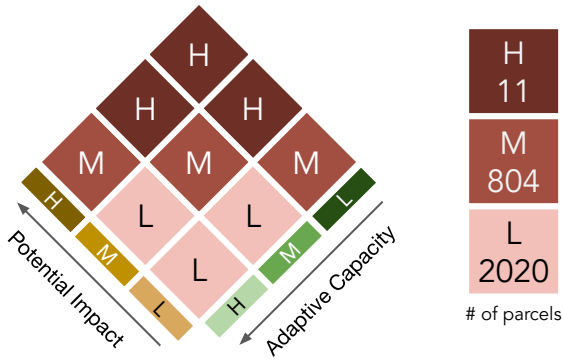


Release of hazardous materials can pose a risk to human health and safety, property, or the environment. Assets in proximity to Tier II facilities were identified as vulnerable and risk to hazardous materials. Vulnerability and risk to hazardous materials was determined by the proximity to hazmat sites, response drive-time, the number of highly hazardous materials, and hazmat site exposure to other hazards such as flooding. Commercial property includes retail, office, restaurant, hotel, industrial, and other properties that serve businesses and organizations. They also typically support commerce, jobs, and tourism. Note that assets may be assessed under multiple categories according to their use (e.g. multi-use such as commercial and residential or commercial and medical).

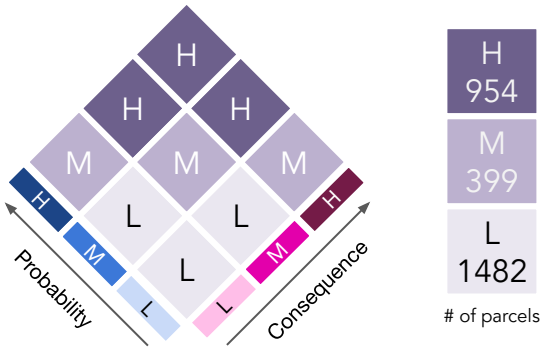
Commercial Property & Hazardous Materials

	VULNERABILITY		RISK	
	Potential Impact	Adaptive Capacity	Number of Hazardous Materials	"Other" hazard exposure
High	Property within proximity to a moderate or highly hazardous material (based on NFPA rating) and is Retail, Restaurants, Hotel, Historic, Snap Retailer	Property within 5-min response drive time from nearest fire station	Property in proximity to more than nine highly hazardous materials	Property in proximity to a hazardous material location that is exposed to between four and five "other" hazards (including floodplain inundation, storm surge, tidal flooding, earthquake, dam failure)
Med	Property within proximity to a moderate or highly hazardous material (based on NFPA rating)		Property in proximity to between four and nine highly hazardous materials	Property in proximity to a hazardous material location that is exposed to between one and three "other" hazards
Low	Property within proximity to a low hazard material (based on NFPA rating)	Property outside 5-min response drive time from nearest fire station	Property in proximity to less than four highly hazardous materials	Property in proximity to a hazardous material location that is exposed to no "other" hazards

VULNERABILITY



RISK

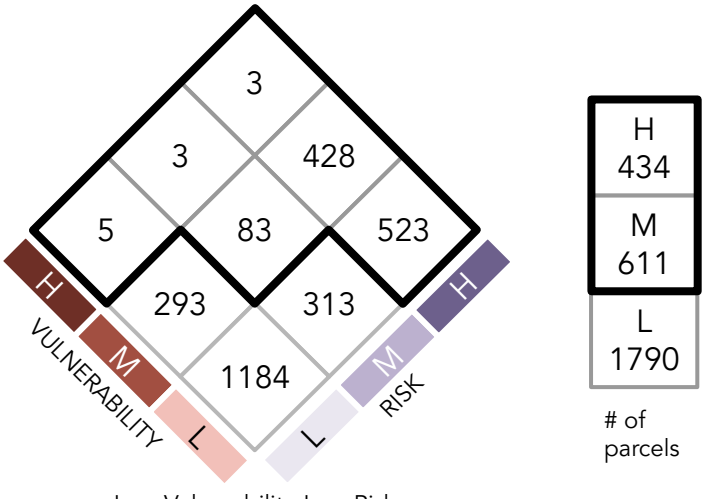


COMBINED VULNERABILITY & RISK

EXPOSED:
2,835 parcels exposed

MEDIUM OR HIGH VULNERABILITY AND RISK:
1,045 parcels
31% of Commercial Property

High Vulnerability-High Risk



Low Vulnerability-Low Risk

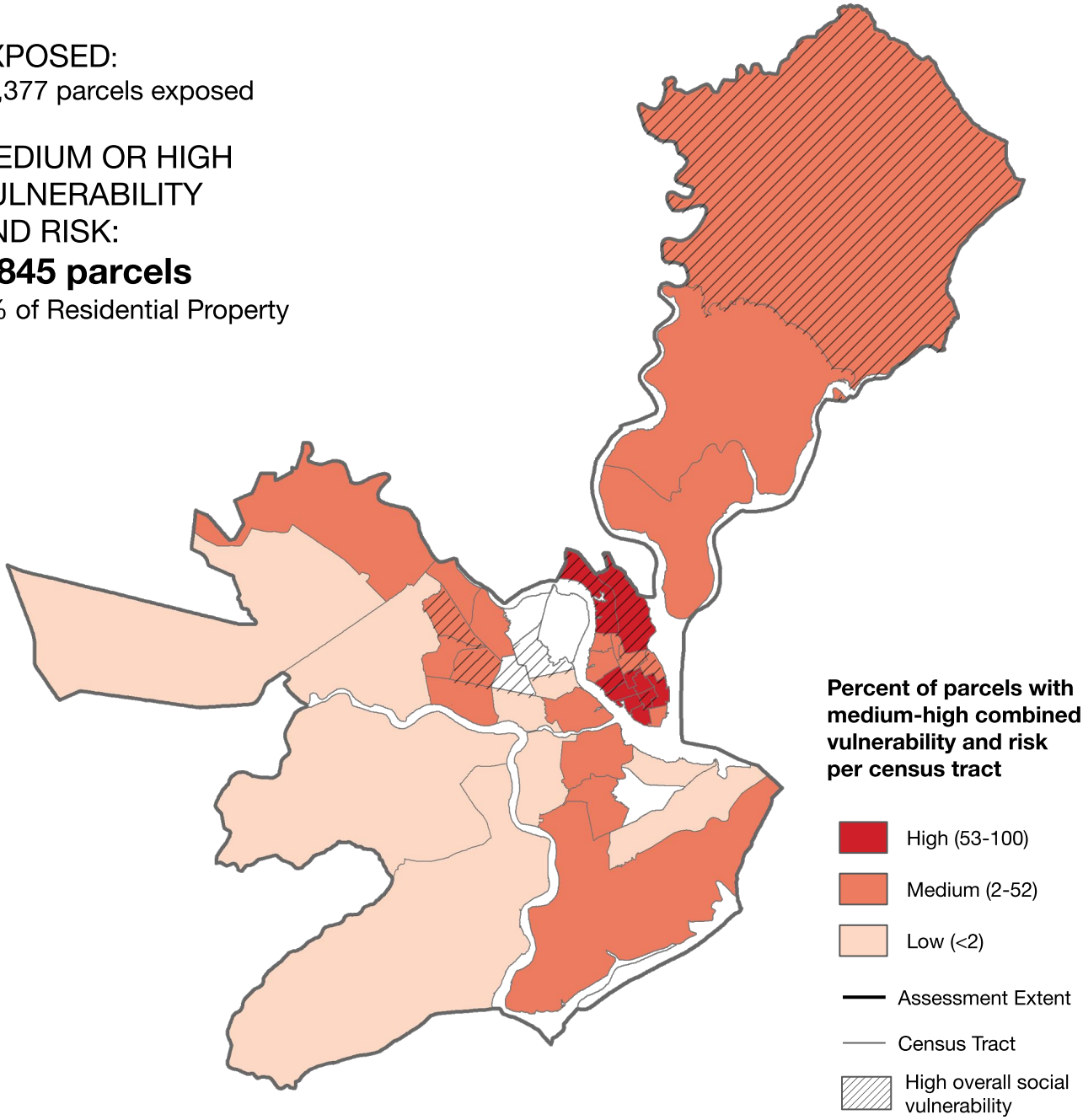
For potential impact, NFPA 704 hazard ratings were used with ratings 3 and 4 considered "highly hazardous," rating of 2 considered "moderately hazardous," and ratings 1 and 0 considered "low hazard." The "other" hazard risk factor is based on the hazardous material site property exposure to other hazards that could contribute to risk of release. For earthquake, the site exposure was based on presence of "soft soils" site class for property (see earthquake assessment for more information).

Residential Property & Hazardous Materials

Vulnerability & Risk Assessment

EXPOSED:
32,377 parcels exposed

MEDIUM OR HIGH VULNERABILITY AND RISK:
5,845 parcels
9% of Residential Property

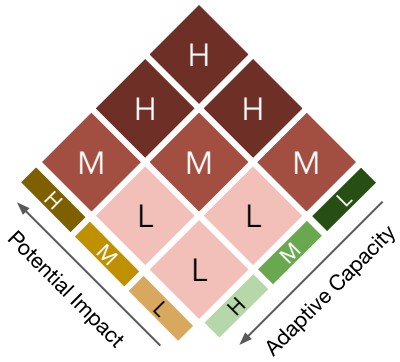


Release of hazardous materials can pose a risk to human health and safety, property, or the environment. Assets in proximity to Tier II facilities were identified as vulnerable and risk to hazardous materials. Vulnerability and risk to hazardous materials was determined by the proximity to hazmat sites, response drive-time, the number of highly hazardous materials, and hazmat site exposure to other hazards such as flooding. Residential property includes all single-family residences, multiple-family residences, low-income housing, apartments, manufactured houses, and mobile home parks.

Residential Property & Hazardous Materials

	VULNERABILITY		RISK	
	Potential Impact	Adaptive Capacity	Number of Hazardous Materials	"Other" hazard exposure
High	Property within proximity to a moderate or highly hazardous material (based on NFPA rating) and is Multi Residence, Mobile Home, Group Home, Nursing Home, and Public Housing	Property within 5-min response drive time from nearest fire station	Property in proximity to more than nine highly hazardous materials	Property in proximity to a hazardous material location that is exposed to between four and five "other" hazards (including floodplain inundation, storm surge, tidal flooding, earthquake, dam failure)
Med	Property within proximity to a moderate or highly hazardous material (based on NFPA rating) and Single Residence		Property in proximity to between four and nine highly hazardous materials	Property in proximity to a hazardous material location that is exposed to between one and three "other" hazards
Low	Property within proximity to a low hazard material (based on NFPA rating)	Property outside 5-min response drive time from nearest fire station	Property in proximity to less than four highly hazardous materials	Property in proximity to a hazardous material location that is exposed to no "other" hazards

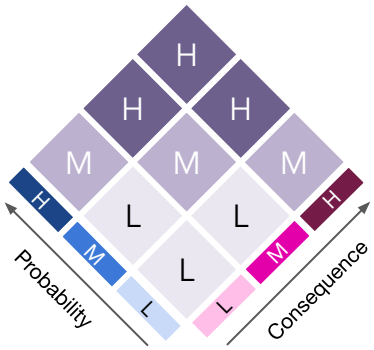
VULNERABILITY





# of parcels

RISK





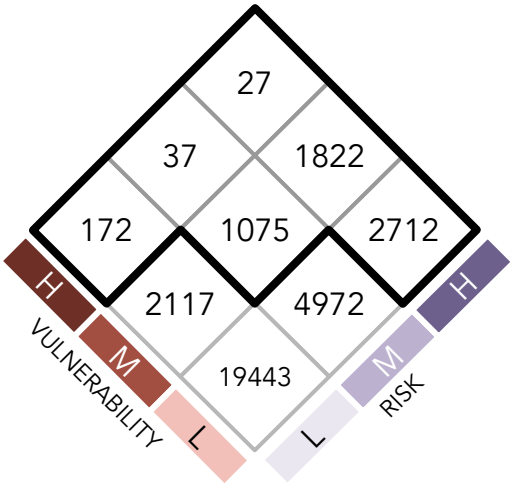
# of parcels

COMBINED VULNERABILITY & RISK

EXPOSED:
32,377 parcels exposed

MEDIUM OR HIGH VULNERABILITY AND RISK:
5,845 parcels
9% of Residential Property

High Vulnerability-High Risk





# of parcels

Low Vulnerability-Low Risk

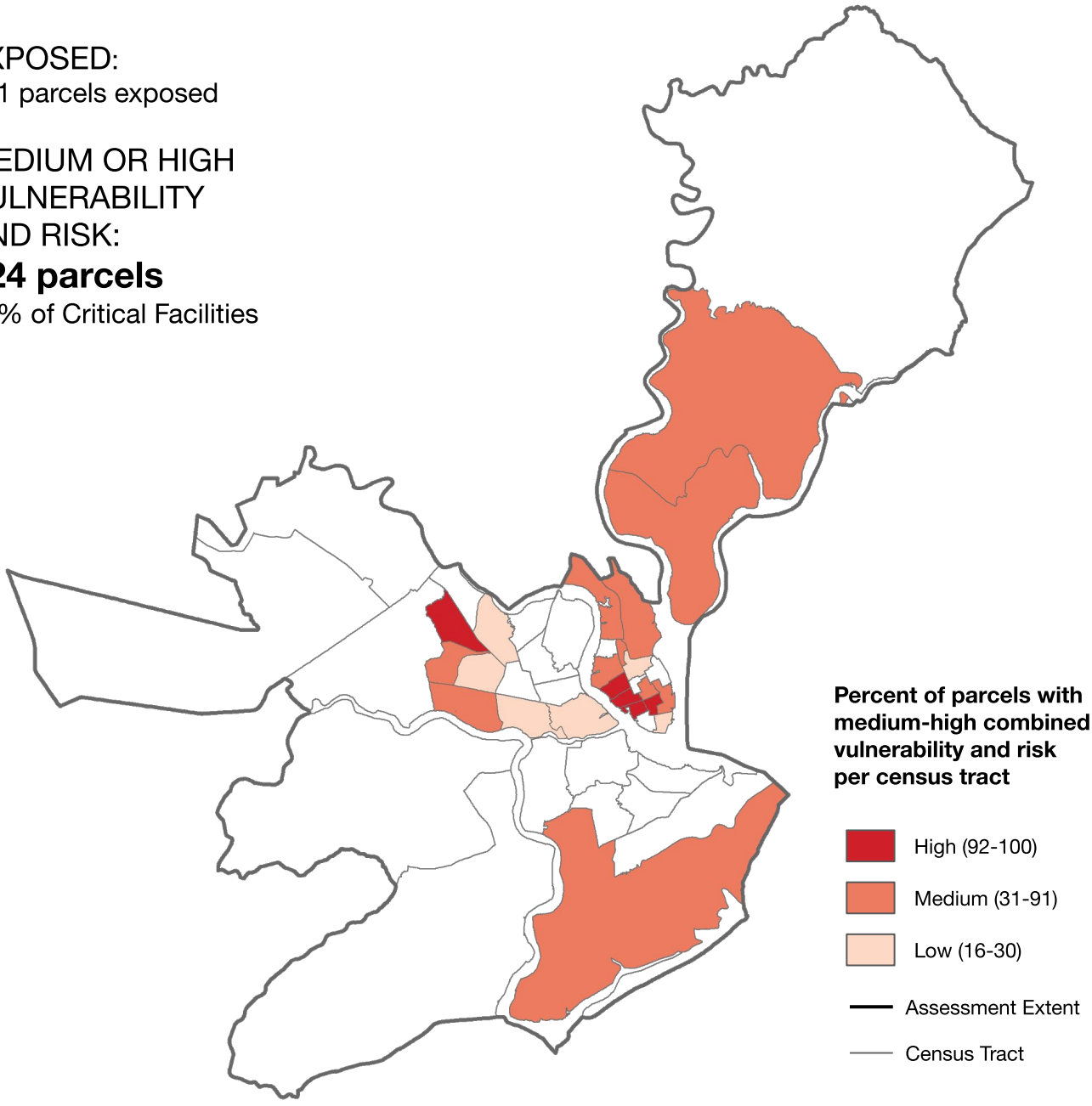
For potential impact, NFPA 704 hazard ratings were used with ratings 3 and 4 considered "highly hazardous," rating of 2 considered "moderately hazardous," and ratings 1 and 0 considered "low hazard." The "other" hazard risk factor is based on the hazardous material site property exposure to other hazards that could contribute to risk of release. For earthquake, the site exposure was based on presence of "soft soils" site class for property (see earthquake assessment for more information).

Critical Facilities & Hazardous Materials

Vulnerability & Risk Assessment

EXPOSED:
261 parcels exposed

MEDIUM OR HIGH VULNERABILITY AND RISK:
124 parcels
36% of Critical Facilities

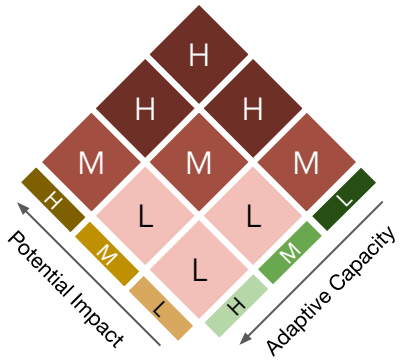


Release of hazardous materials can pose a risk to human health and safety, property, or the environment. Assets in proximity to Tier II facilities were identified as vulnerable and risk to hazardous materials. Vulnerability and risk to hazardous materials was determined by the proximity to hazmat sites, response drive-time, the number of highly hazardous materials, and hazmat site exposure to other hazards such as flooding. Critical facility property includes fire and police stations that aid in emergency response, medical facilities, schools, energy and utility facilities, and transportation-related facilities.

Critical Facilities & Hazardous Materials

	VULNERABILITY		RISK	
	Potential Impact	Adaptive Capacity	Number of Hazardous Materials	"Other" hazard exposure
High	Property within proximity to a moderate or highly hazardous material (based on NFPA rating) and is Medical, Emergency Facilities, Schools, Historic, Medical Major	Property within 5-min response drive time from nearest fire station	Property in proximity to more than nine highly hazardous materials	Property in proximity to a hazardous material location that is exposed to between four and five "other" hazards (including floodplain inundation, storm surge, tidal flooding, earthquake, dam failure)
Med	Property within proximity to a moderate or highly hazardous material (based on NFPA rating)		Property in proximity to between four and nine highly hazardous materials	Property in proximity to a hazardous material location that is exposed to between one and three "other" hazards
Low	Property within proximity to a low hazard material (based on NFPA rating)	Property outside 5-min response drive time from nearest fire station	Property in proximity to less than four highly hazardous materials	Property in proximity to a hazardous material location that is exposed to no "other" hazards

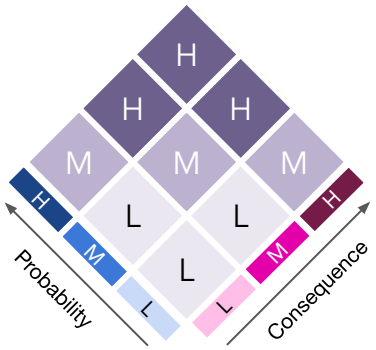
VULNERABILITY





# of parcels

RISK





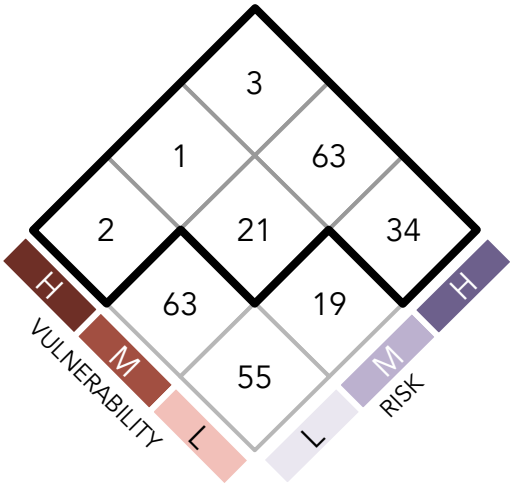
# of parcels

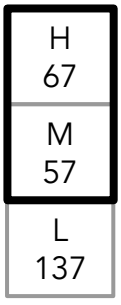
COMBINED VULNERABILITY & RISK

EXPOSED:
261 parcels exposed

MEDIUM OR HIGH VULNERABILITY AND RISK:
124 parcels
36% of Critical Facilities

High Vulnerability-High Risk





# of parcels

Low Vulnerability-Low Risk

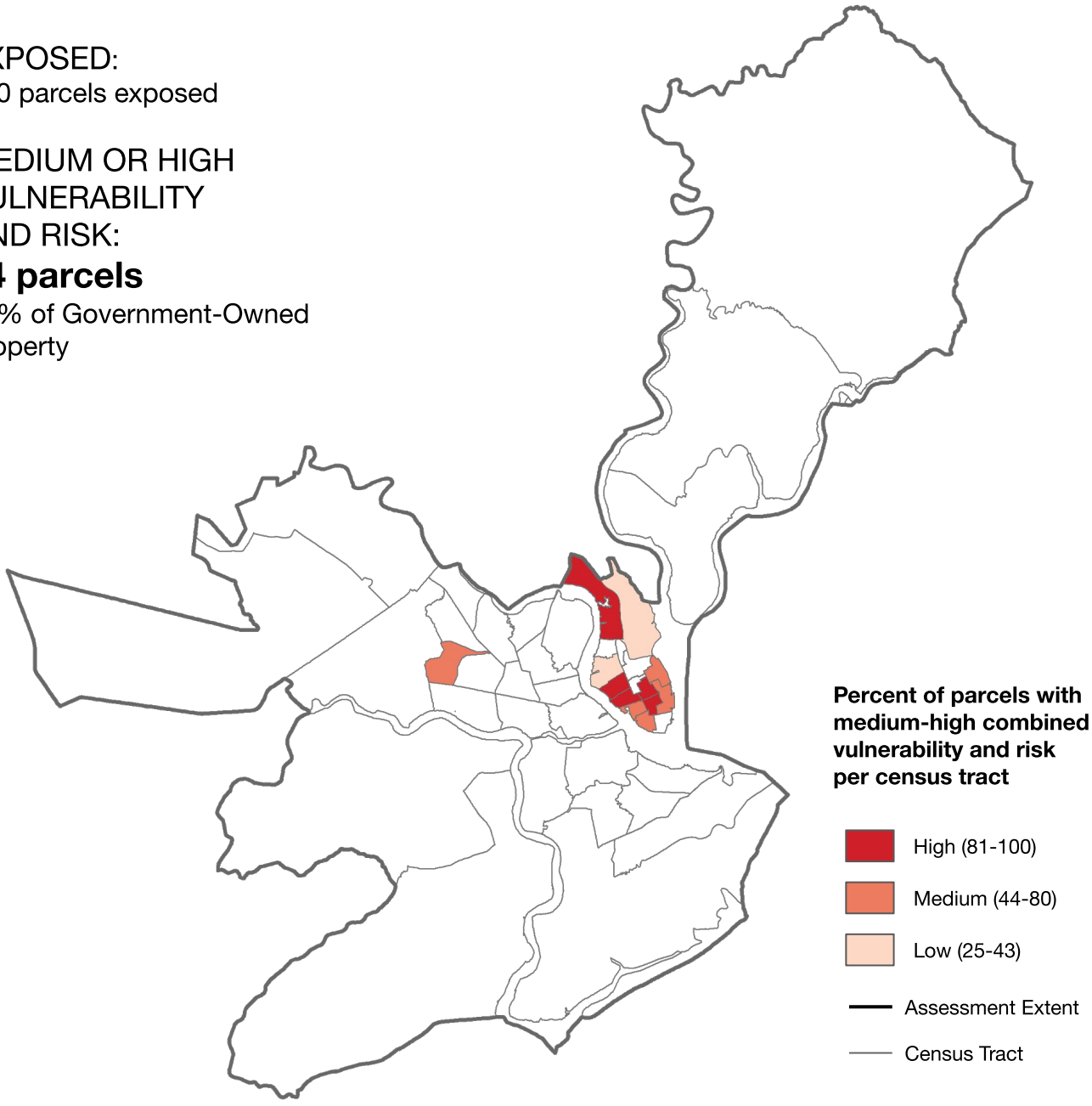
For potential impact, NFPA 704 hazard ratings were used with ratings 3 and 4 considered "highly hazardous," rating of 2 considered "moderately hazardous," and ratings 1 and 0 considered "low hazard." The "other" hazard risk factor is based on the hazardous material site property exposure to other hazards that could contribute to risk of release. For earthquake, the site exposure was based on presence of "soft soils" site class for property (see earthquake assessment for more information).

Government-Owned Property & Hazardous Materials

Vulnerability & Risk Assessment

EXPOSED:
140 parcels exposed

MEDIUM OR HIGH VULNERABILITY AND RISK:
84 parcels
58% of Government-Owned Property

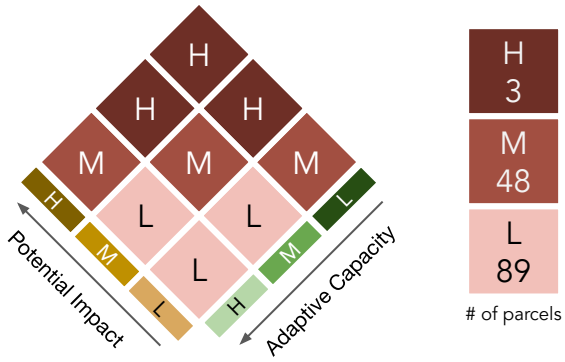


Release of hazardous materials can pose a risk to human health and safety, property, or the environment. Assets in proximity to Tier II facilities were identified as vulnerable and risk to hazardous materials. Vulnerability and risk to hazardous materials was determined by the proximity to hazmat sites, response drive-time, the number of highly hazardous materials, and hazmat site exposure to other hazards such as flooding. Government-owned property includes all municipal, county, state, or federal owned properties, except for those associated with parks and recreation and critical facilities.

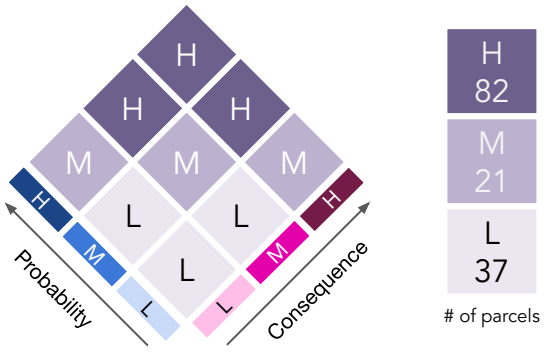
Government-Owned Property & Hazardous Materials

	VULNERABILITY		RISK	
	Potential Impact	Adaptive Capacity	Number of Hazardous Materials	"Other" hazard exposure
High	Property within proximity to a moderate or highly hazardous material (based on NFPA rating)	Property within 5-min response drive time from nearest fire station	Property in proximity to more than nine highly hazardous materials	Property in proximity to a hazardous material location that is exposed to between four and five "other" hazards (including floodplain inundation, storm surge, tidal flooding, earthquake, dam failure)
Med			Property in proximity to between four and nine highly hazardous materials	Property in proximity to a hazardous material location that is exposed to between one and three "other" hazards
Low	Property within proximity to a low hazard material (based on NFPA rating)	Property outside 5-min response drive time from nearest fire station	Property in proximity to less than four highly hazardous materials	Property in proximity to a hazardous material location that is exposed to no "other" hazards

VULNERABILITY



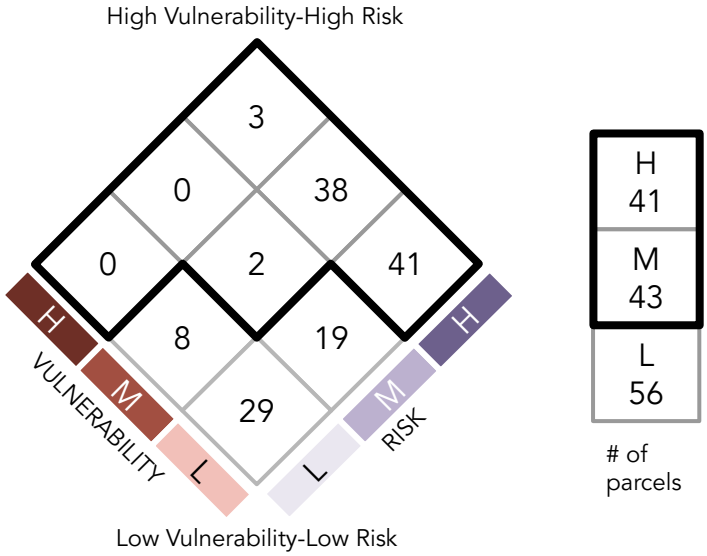
RISK



COMBINED VULNERABILITY & RISK

EXPOSED:
140 parcels exposed

MEDIUM OR HIGH VULNERABILITY AND RISK:
84 parcels
58% of Government-Owned Property



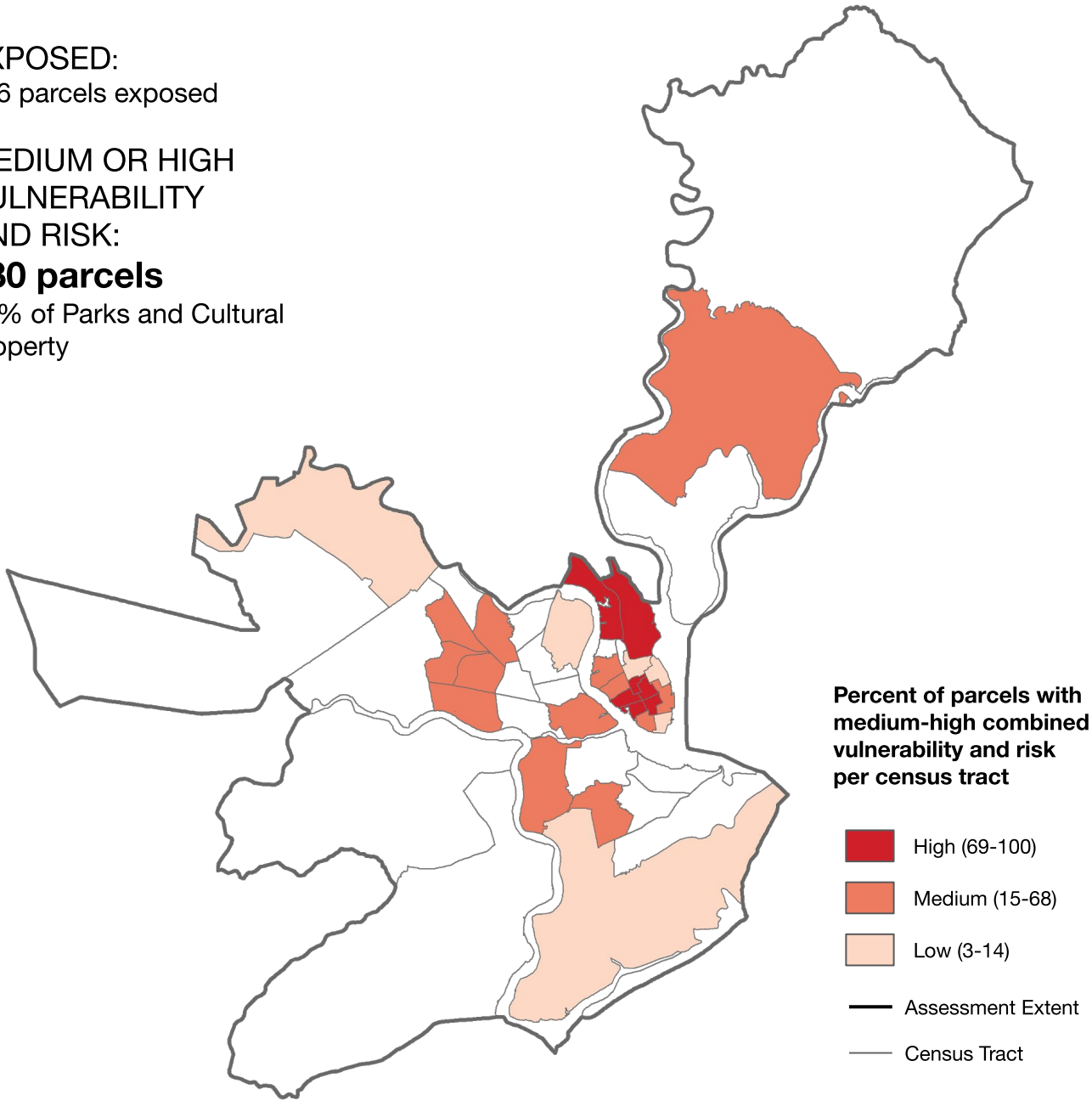
For potential impact, NFPA 704 hazard ratings were used with ratings 3 and 4 considered "highly hazardous," rating of 2 considered "moderately hazardous," and ratings 1 and 0 considered "low hazard." The "other" hazard risk factor is based on the hazardous material site property exposure to other hazards that could contribute to risk of release. For earthquake, the site exposure was based on presence of "soft soils" site class for property (see earthquake assessment for more information).

Parks and Cultural Property & Hazardous Materials

Vulnerability & Risk Assessment

EXPOSED:
486 parcels exposed

MEDIUM OR HIGH VULNERABILITY AND RISK:
180 parcels
27% of Parks and Cultural Property

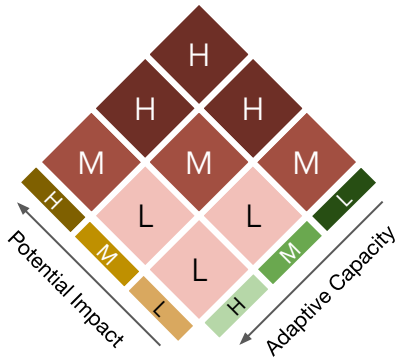


Release of hazardous materials can pose a risk to human health and safety, property, or the environment. Assets in proximity to Tier II facilities were identified as vulnerable and risk to hazardous materials. Vulnerability and risk to hazardous materials was determined by the proximity to hazmat sites, response drive-time, the number of highly hazardous materials, and hazmat site exposure to other hazards such as flooding. Park properties also include greenways and other recreation property. Cultural property includes local landmarks, community or civic facilities, and property with religious significance.

Parks and Cultural Property & Hazardous Materials

	VULNERABILITY		RISK	
	Potential Impact	Adaptive Capacity	Number of Hazardous Materials	"Other" hazard exposure
High	Property within proximity to a moderate or highly hazardous material (based on NFPA rating)	Property within 5-min response drive time from nearest fire station	Property in proximity to more than nine highly hazardous materials	Property in proximity to a hazardous material location that is exposed to between four and five "other" hazards (including floodplain inundation, storm surge, tidal flooding, earthquake, dam failure)
Med			Property in proximity to between four and nine highly hazardous materials	Property in proximity to a hazardous material location that is exposed to between one and three "other" hazards
Low	Property within proximity to a low hazard material (based on NFPA rating)	Property outside 5-min response drive time from nearest fire station	Property in proximity to less than four highly hazardous materials	Property in proximity to a hazardous material location that is exposed to no "other" hazards

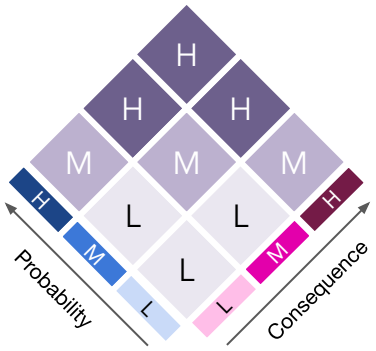
VULNERABILITY





# of parcels

RISK





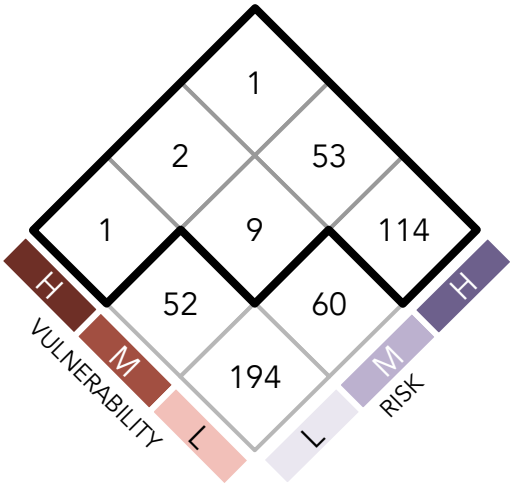
# of parcels

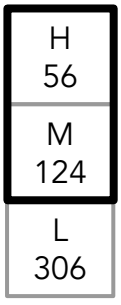
COMBINED VULNERABILITY & RISK

EXPOSED:
486 parcels exposed

MEDIUM OR HIGH VULNERABILITY AND RISK:
180 parcels
27% of Parks and Cultural Property

High Vulnerability-High Risk





# of parcels

Low Vulnerability-Low Risk

For potential impact, NFPA 704 hazard ratings were used with ratings 3 and 4 considered "highly hazardous," rating of 2 considered "moderately hazardous," and ratings 1 and 0 considered "low hazard." The "other" hazard risk factor is based on the hazardous material site property exposure to other hazards that could contribute to risk of release. For earthquake, the site exposure was based on presence of "soft soils" site class for property (see earthquake assessment for more information).

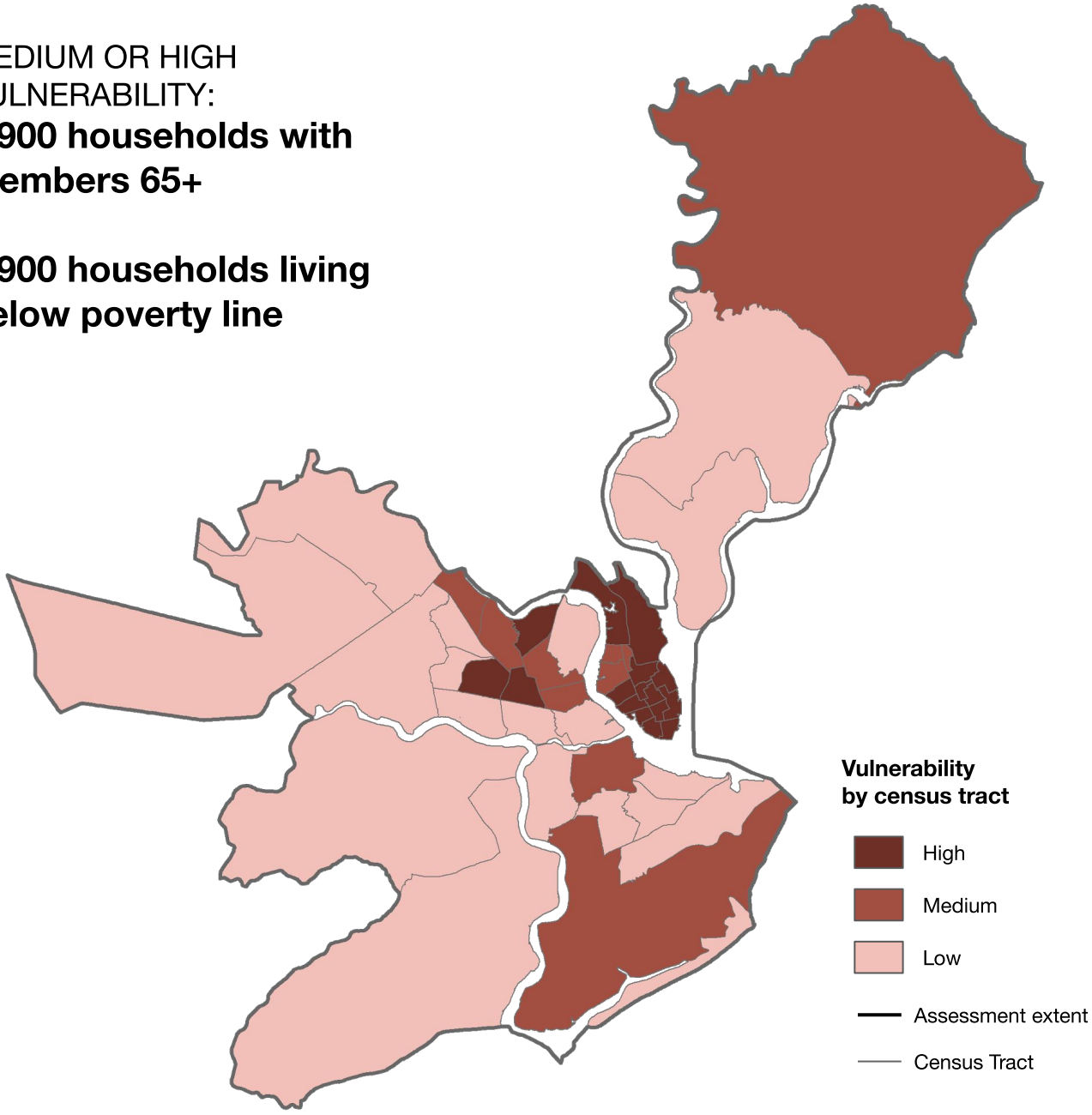
Residents & Extreme Heat

Vulnerability Assessment

MEDIUM OR HIGH VULNERABILITY:

1,900 households with members 65+

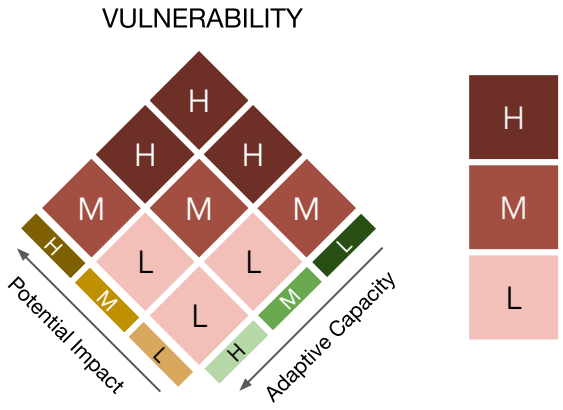
2,900 households living below poverty line



Extreme heat events are periods of excessively hot and/or humid weather that can last for multiple days. Extreme heat is a pressing public health risk, particularly for low-income and elderly communities. Socially vulnerable populations in areas with a high percentage of developed land cover and low tree canopy are more vulnerable to negative health effects related to heat stress due to the urban heat island effect. The most vulnerable areas of Charleston are shown above.

Residents & Extreme Heat

	VULNERABILITY	
	Potential Impact	Adaptive Capacity
High	Highest number of sensitive populations and high percentage of developed land cover	High amount of tree canopy coverage
Med	Lower number of sensitive populations or lower percentage of developed land cover	Moderate amount of tree canopy coverage
Low	Lower number of sensitive populations and low percentage of developed land cover	Low amount of tree canopy coverage

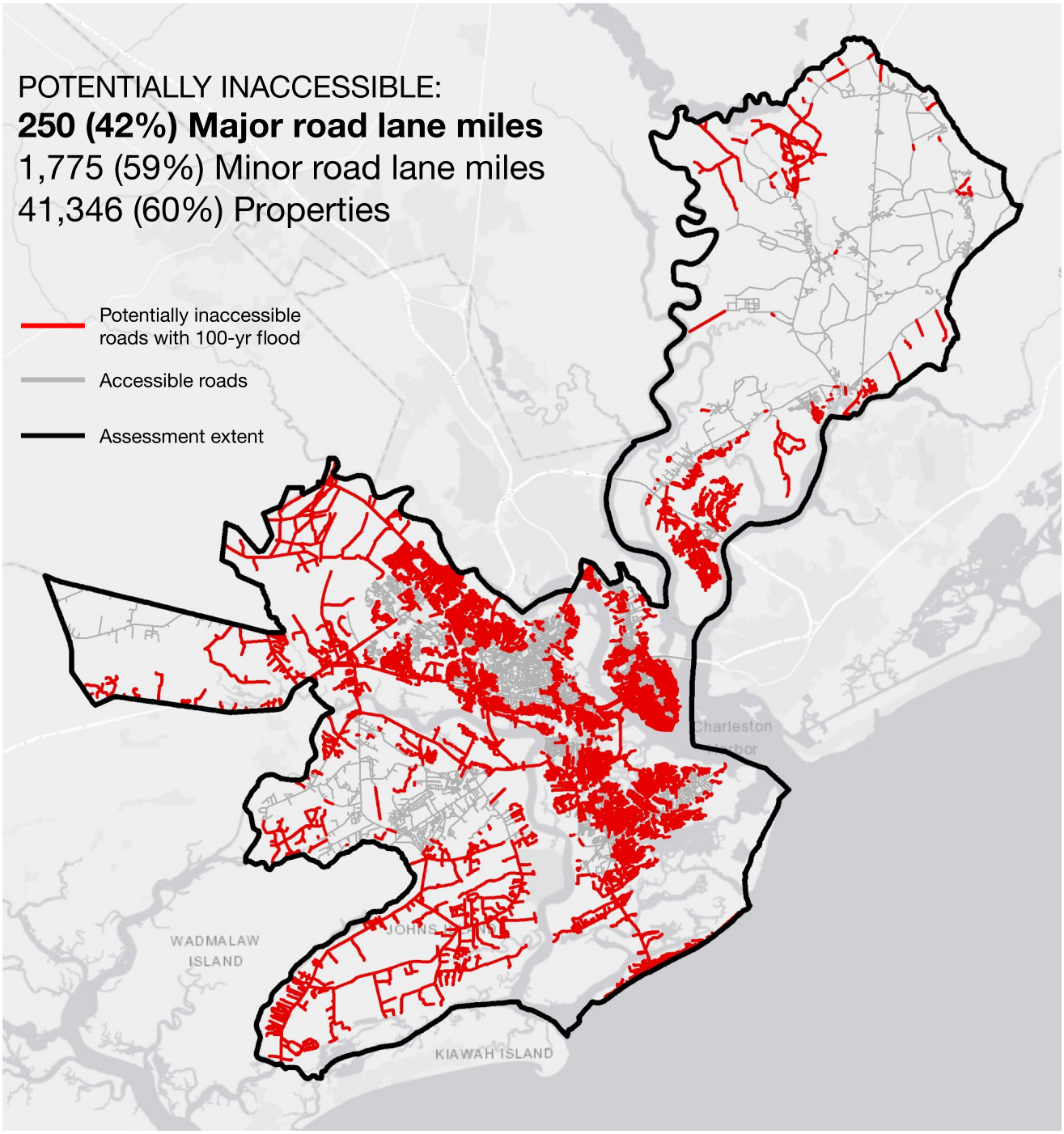


MEDIUM OR HIGH VULNERABILITY:
1,900 households with members 65+

2,900 households living below poverty line

Roads and Mobility & Floodplain Inundation

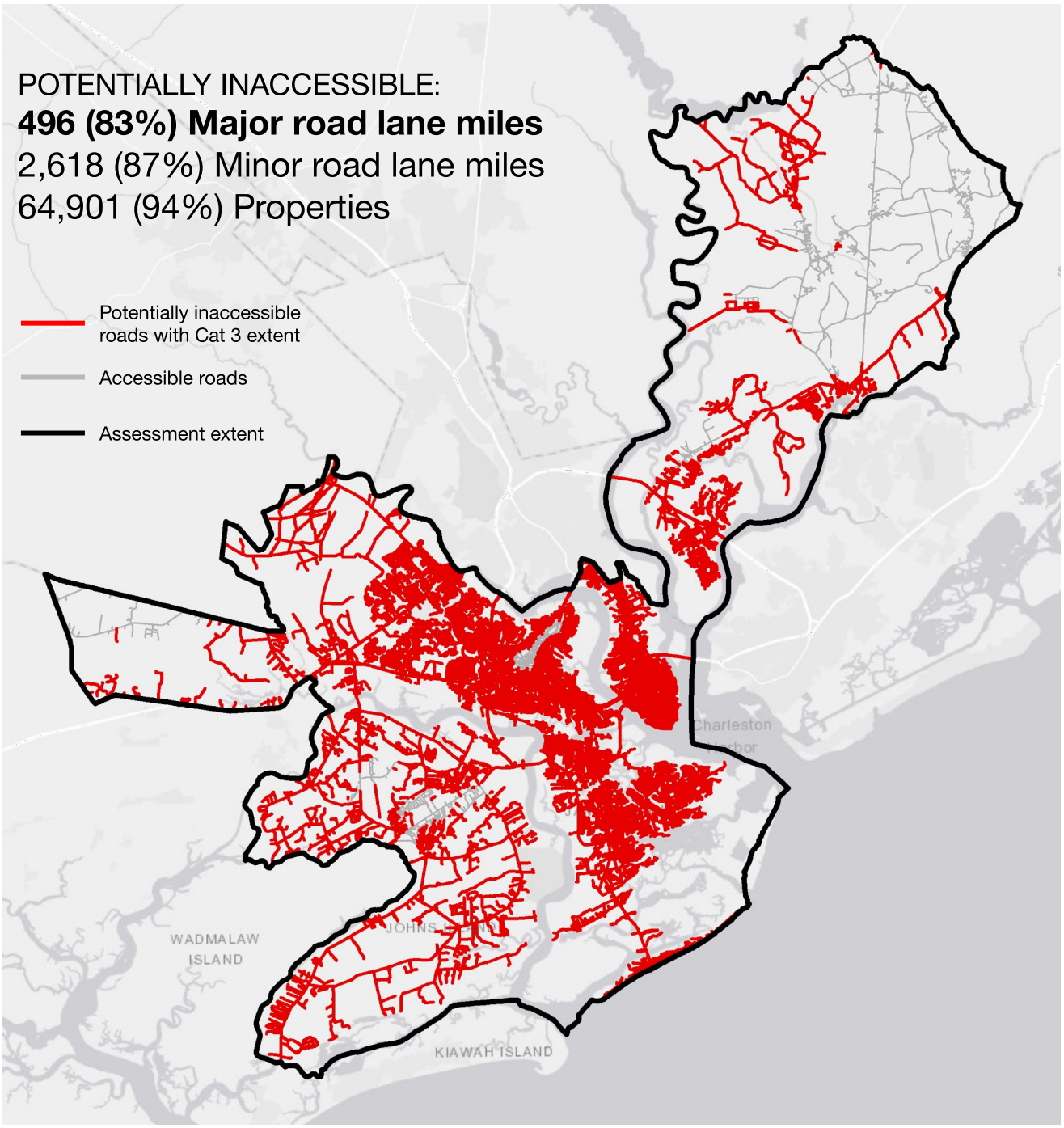
Connectivity Assessment and Potential Inaccessibility (100-yr floodplain inundation)



This road connectivity assessment identified major and minor roads that are potentially inaccessible (isolated) due to inundation-based hazards in terms of "lane miles" (e.g. a road with 2 lanes, one for each direction of traffic, with a length of 1 mile is 2 lane miles). Potential isolation is determined based on accessibility from any fire station. Additionally, potentially inaccessible properties were identified (regardless of the type of property).

Roads and Mobility & Storm Surge

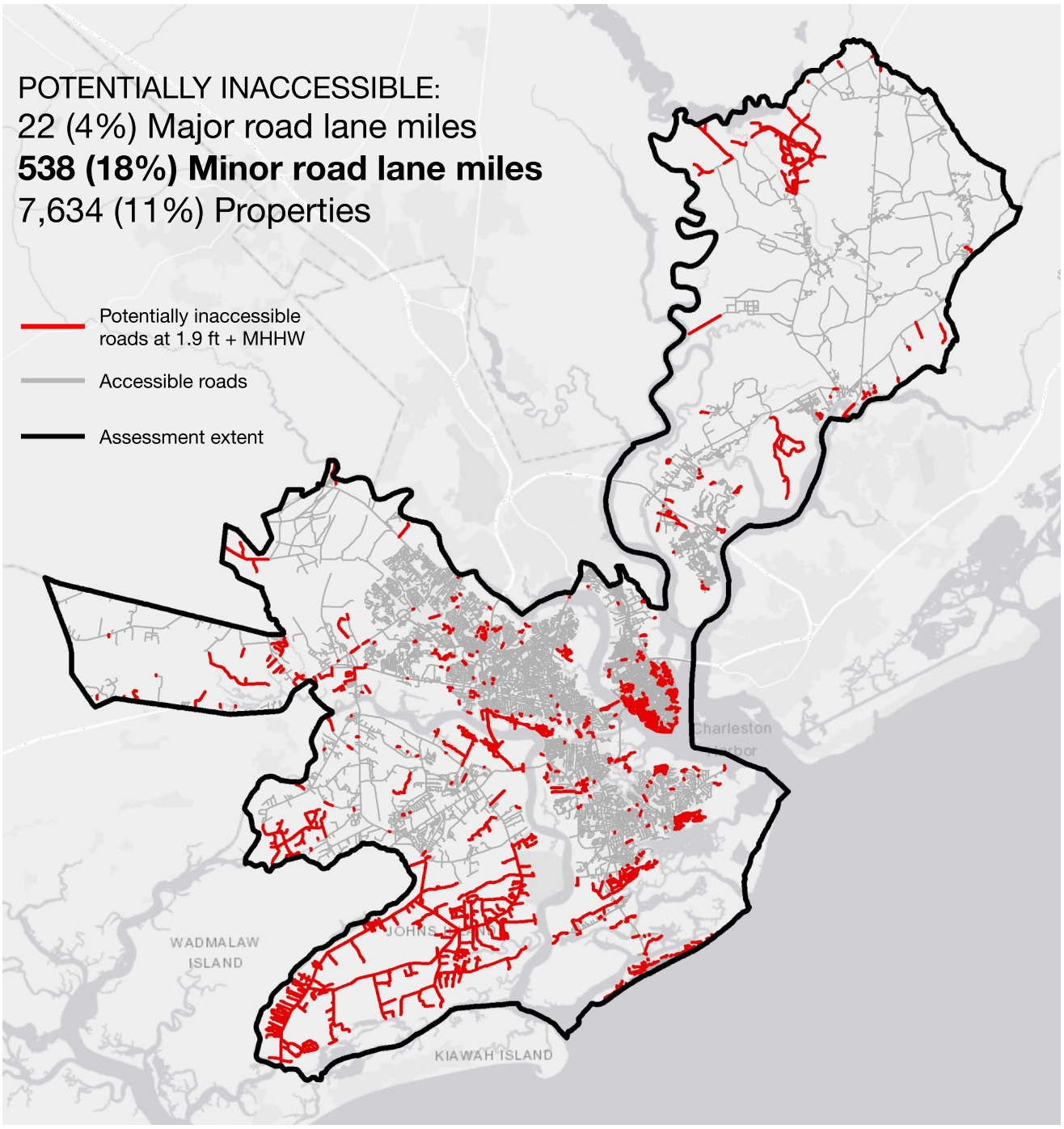
Connectivity Assessment and Potential Inaccessibility (Cat 3 inundation extent)



This road connectivity assessment identified major and minor roads that are potentially inaccessible (isolated) due to inundation-based hazards in terms of "lane miles" (e.g. a road with 2 lanes, one for each direction of traffic, with a length of 1 mile is 2 lane miles). Potential isolation is determined based on accessibility from any fire station. Additionally, potentially inaccessible properties were identified (regardless of the type of property).

Roads and Mobility & Tidal Flooding (Current)

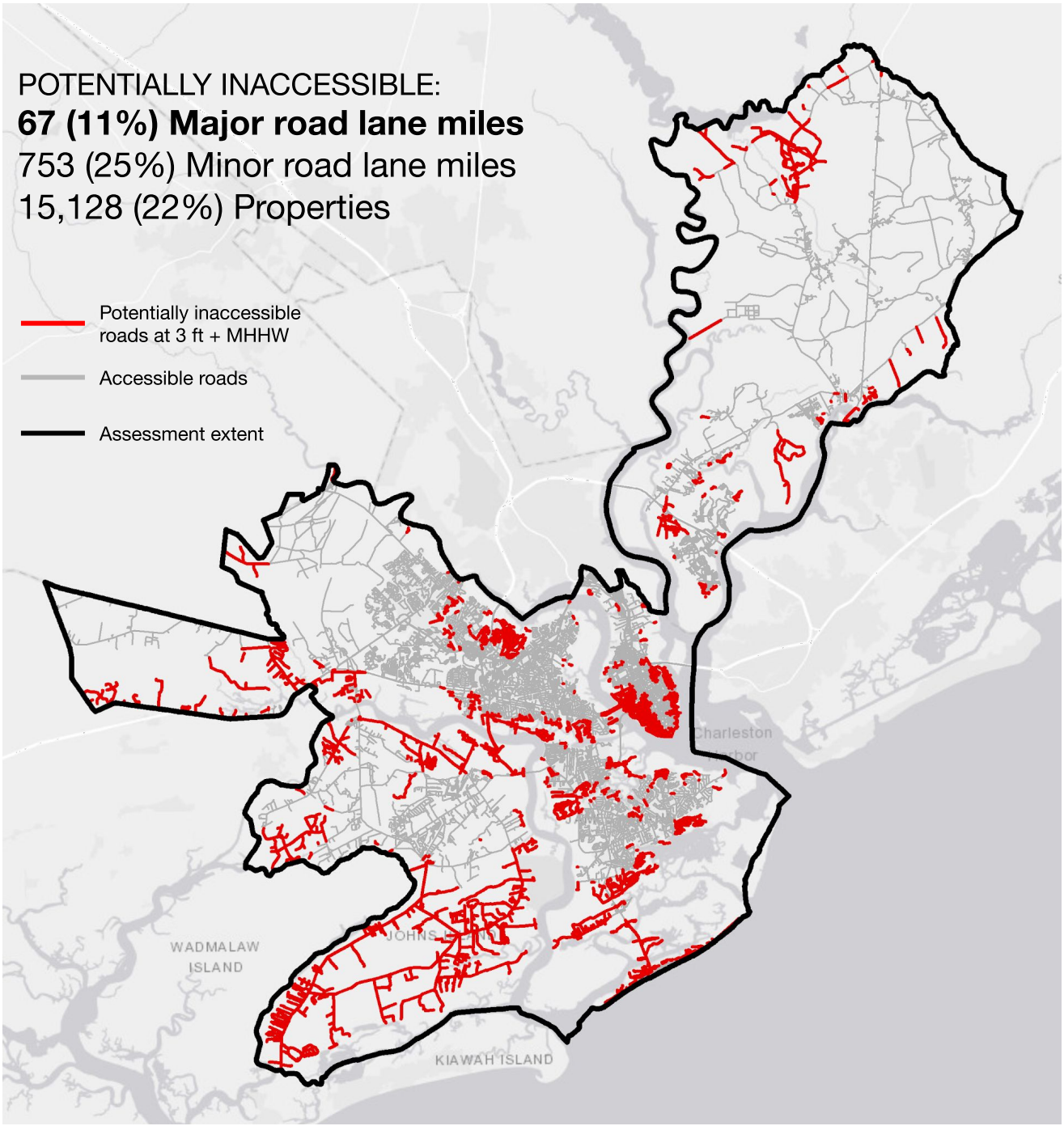
Connectivity Assessment and Potential Inaccessibility (7.6 ft + MLLW inundation extent)



This road connectivity assessment identified major and minor roads that are potentially inaccessible (isolated) due to inundation-based hazards in terms of "lane miles" (e.g. a road with 2 lanes, one for each direction of traffic, with a length of 1 mile is 2 lane miles). Potential isolation is determined based on accessibility from any fire station. Additionally, potentially inaccessible properties were identified (regardless of the type of property).

Roads and Mobility & Sea Level Rise (3 ft + MHHW)

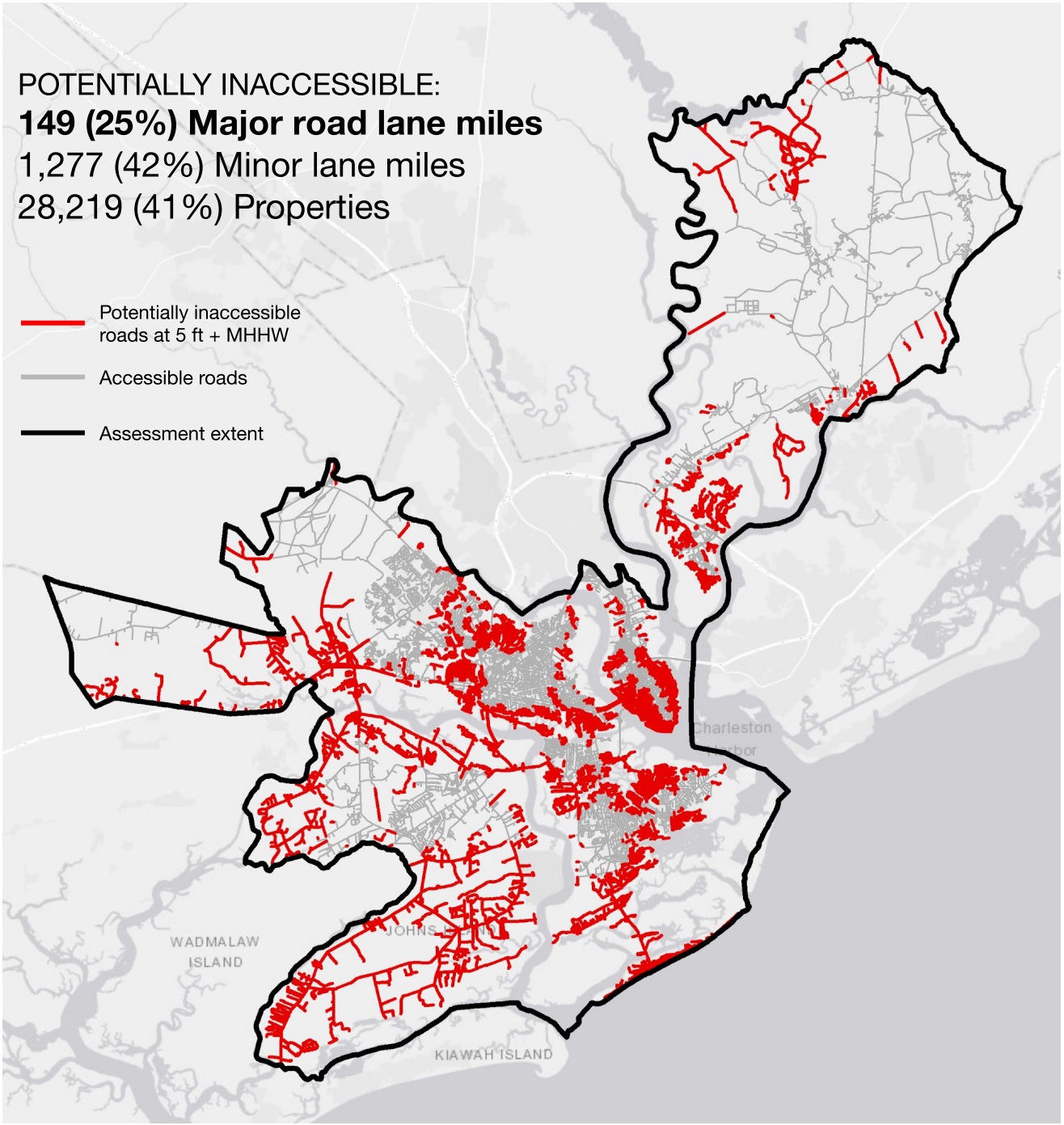
Connectivity Assessment and Potential Inaccessibility (3 ft + MHHW inundation extent)



This road connectivity assessment identified major and minor roads that are potentially inaccessible (isolated) due to inundation-based hazards in terms of "lane miles" (e.g. a road with 2 lanes, one for each direction of traffic, with a length of 1 mile is 2 lane miles). Potential isolation is determined based on accessibility from any fire station. Additionally, potentially inaccessible properties were identified (regardless of the type of property).

Roads and Mobility & Sea Level Rise (5 ft + MHHW)

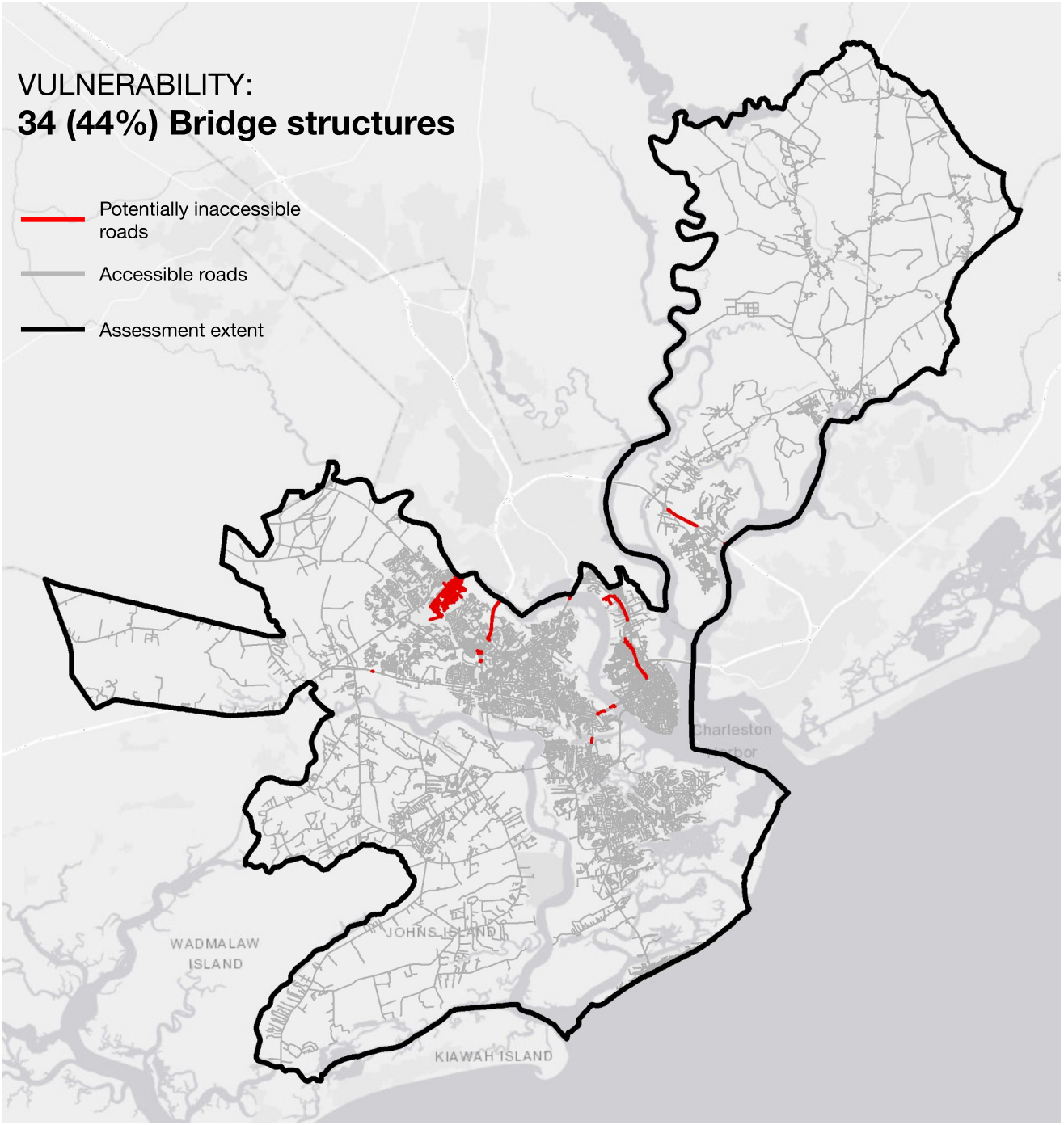
Connectivity Assessment and Potential Inaccessibility (5 ft + MHHW inundation extent)



This road connectivity assessment identified major and minor roads that are potentially inaccessible (isolated) due to inundation-based hazards in terms of "lane miles" (e.g. a road with 2 lanes, one for each direction of traffic, with a length of 1 mile is 2 lane miles). Potential isolation is determined based on accessibility from any fire station. Additionally, potentially inaccessible properties were identified (regardless of the type of property).

Bridges & Earthquake

Connectivity Assessment and Potential Inaccessibility (5 ft + MHHW inundation extent)



This road connectivity assessment identified bridges vulnerable to seismic forces based a review of bridge design guidance. Potentially inaccessibility was determined by considering 34 (44%) of the bridge structures in the city inaccessible as well as roadways underpassing the bridge structures. Potential isolation is determined based on accessibility from any fire station.

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Appendix F: Options and Priorities

The table on the following pages includes all options and priorities identified for the City of Charleston.

Component	Source	Area/ location	ID #	Threat	Initiative (Strategy or Project)	CRITERIA (3= "green light"; 2="yellow light"; 1="red light")			
						Ability to Implement (Financial)	Ability to Implement (Political)	Ability to Implement (Staff Capacity)	Socially Responsible (Equity)
Governance	Workshop 2 (Katie)	ALL	60	Flooding and SLR	Participate in future update of COG's LRTP to ensure SLR is included in the plan, making us eligible for funding in future (and include resilience as prioritization criteria)	2	2	2	3
Governance	Workshop 2 (Katie)	ALL	61	Flooding and SLR	Update current projects in LRTP based on Vulnerability Assessment prioritization? (putting priorities on projects based on road map data from VA)	3	2	1	3
Governance	Assessment Team	ALL	62	Flooding and SLR	Alternate route planning for emergency service vehicles	3	3	3	3
Governance	CHS Flooding and SLR Initiatives	ALL	14	Flooding	Aggressively seek and support new NFIP acquisiition legislation for City of Charleston pilot project.	3	1	2	2
Governance	CHS Flooding and SLR Initiatives	ALL	15	Flooding	Reduce flood insurance premiums by improving our CRS rating.	2	1	2	3

Governance	CHS Flooding and SLR Initiatives	Upper Peninsula	28	Flooding	Incentivize private property owners to implement green infrastructure through zoning.	3	3	3	3
Governance	CHS Flooding and SLR Initiatives	ALL	29	Flooding	Incentivize flood mitigation measures for more resilient construction in the floodplain, such as elevation grants.	1	1	1	2
Governance	CHS Flooding and SLR Initiatives	ALL	32	Flooding	Implement flood detection devices, alerts, warnings, and reporting systems.	2	2	1	1
Governance	CHS Flooding and SLR Initiatives	Peninsula	34	Flooding	Implement a formal City flood parking plan for flood events; public and private, including appropriate signage on streets.	2	2	1	3
Governance	CHS Flooding and SLR Initiatives	ALL	35	Flooding	Implement the City's stormwater response plan to clear inlets and outlets, including teams on stand-by, before and during events.	1	3	1	3
Governance	CHS Flooding and SLR Initiatives	ALL	47	Flooding	Strengthen the City's Zoning Ordinance to promote Low Impact Development and more resilient development in low lying areas.	3	1	2	3
Governance	CHS Flooding and SLR Initiatives	ALL	57	Flooding	Plan for and build City owned facilities for the capacity to stage resources during flood events.	1	2	1	3

Governance	CHS Flooding and SLR Initiatives	ALL	59	Flooding	Establish and nurture partnerships throughout the tri-county region to coordinate on land use and stormwater policy.	3	2	1	3
Governance	CHS Flooding and SLR Initiatives	ALL	69	Flooding	Incentivize private property owners to implement green infrastructure and stormwater BMPs through a reduced stormwater fee incentive program.	2	2	1	3
Governance	CHS Flooding and SLR Initiatives	ALL	52	Flooding and SLR	Create a City of Charleston Hazard Mitigation Plan for inclusion in County Plan.	3	3	1	3
Governance	Workshop 4	ALL	82	Hazmat	Propose an ordinance for hazardous materials				
Governance	CHS Flooding and SLR Initiatives	ALL	4	SLR and Tidal Flooding	Annually reevaluate science for appropriate SLR planning levels.	3	3	3	3
Governance	CHS Flooding and SLR Initiatives	ALL	5	SLR and Tidal Flooding	Implement building codes that support construction and retrofits more resilient to SLR.	3	2	2	2
Governance	CHS Flooding and SLR Initiatives	ALL	7	SLR and Tidal Flooding	Strengthen stormwater management regulations to take into account SLR.	2	2	1	3

Governance	CHS Flooding and SLR Initiatives	ALL	8	SLR and Tidal Flooding	Increase additional freeboard to 2.0 feet above Base Flood Elevation for all new and substantially improved structures.	3	2	3	2
Governance	CHS Flooding and SLR Initiatives	ALL	9	SLR and Tidal Flooding	Consider building or retrofitting City owned facilities for greater than 3 feet of SLR.	1	1	1	2
Governance	CHS Flooding and SLR Initiatives	ALL	10	SLR and Tidal Flooding	Consider greater than 3 feet of SLR for public infrastructure and critical facilities with longevities of greater than 50 years.	1	1	1	3
Governance	CHS Flooding and SLR Initiatives	ALL	11	SLR and Tidal Flooding	Ensure all critical facilities, public and private, have access plans that account for SLR.	2	3	2	3
Governance	CHS Flooding and SLR Initiatives	ALL	42	SLR and Tidal Flooding	Partner with Charleston County and SC Department of Transportation to establish resilient road design standards for SLR.	1	1	1	3
Infrastructure	Workshop 6	ALL	77	Dam Failure	Consider adding adaptive capacity in retrofitting				
Infrastructure	Workshop 4	ALL	75	Earthquake	Consider opportuntiies for relocating critical facilities				

Infrastructure	Workshop 5	ALL	76	Earthquake	Plan for enhanced adaptive capacity in retrofitting				
Infrastructure	Workshop 7	ALL	78	Extreme He	Tree planting to increase canopy cover				
Infrastructure	CHS Flooding and SLR Initiatives	ALL	2	Flooding	Collaborate with federal and state partners on flood protection projects.	1	3	2	3
Infrastructure	CHS Flooding and SLR Initiatives	ALL	17	Flooding	Identify coastal edges of the City ripe for flood protection and/or absorption such as seawalls, living shorelines, roadways, etc.	2	3	1	3
Infrastructure	CHS Flooding and SLR Initiatives	ALL	18	Flooding	Implement shoreline protection, natural or otherwise, to protect public infrastructure and mitigate erosion.	1	1	1	3
Infrastructure	CHS Flooding and SLR Initiatives	Peninsula	20	Flooding	Complete Spring/Fishburne Drainage Improvement Project.	2	2	3	3
Infrastructure	CHS Flooding and SLR Initiatives	Peninsula	21	Flooding	Complete Market Street Drainage Improvement Project.	2	2	2	2

Infrastructure	CHS Flooding and SLR Initiatives	Forest Acres/ West Ashley	22	Flooding	Complete Forest Acres Drainage Improvement Project.	2	3	3	3
Infrastructure	CHS Flooding and SLR Initiatives	Peninsula	23	Flooding	Complete Calhoun West Drainage Improvement Project.	1	1	1	3
Infrastructure	CHS Flooding and SLR Initiatives	ALL	27	Flooding	Implement green infrastructure strategies on City owned property.	1	2	1	2
Infrastructure	CHS Flooding and SLR Initiatives	ALL	31	Flooding	Evaluate public housing units in flood prone areas for opportunities to mitigate flooding.	1	2	1	3
Infrastructure	CHS Flooding and SLR Initiatives	ALL	51	Flooding	Evaluate critical infrastructure vulnerabilities and work with regulators to minimize gaps in services: utilities, schools, critical care, emergency buildings, etc.	1	3	1	3
Infrastructure	CHS Major Infrastructure Project	Johns Island	54	Flooding	Drainage Master Plan: "Rain on grid model" for the whole island contracted to a firm; "specific projects to follow esp. on barberry woods neighborhood	1	1	1	3
Infrastructure	CHS Major Infrastructure Project	Church Creek	55	Flooding	Interconnected Channel and Pond Routing Model to account for new dev and roadway improvements; recommended infrastructure actions part of the report (Weston and Sampson)	1	2	2	3
Infrastructure	CHS Major Infrastructure Project	Dupont/ Wappoo Watershed	56	Flooding	Inventory of drainage features	1	1	1	3
Infrastructure	CHS Flooding and SLR Initiatives	ALL	58	Flooding	Implement new maintenance initiatives to improve performance of existing stormwater systems.	2	3	2	3

Infrastructure	CHS Flooding and SLR Initiatives	ALL	68	Flooding	Implement green infrastructure strategies recommended for City owned roads.	1	2	1	3
Infrastructure	Workshop 2	ALL	72	Flooding	Consider opportunities to add multi-modal and recreational facilities to areas isolated by threats. Consider how multi-modal can be used an additional route in/out in emergency situations				
Infrastructure	Workshop 2	ALL	73	Flooding	Consider Highwater Alert Lifesaving Technology (HALT)				
Infrastructure	CHS Major Infrastructure Project	Peninsula	51	Sea Level Rise; Storm Surge	High Battery: Repair Rip-rap Damage from Hurricane Irma	3	3	3	2
Infrastructure	CHS Major Infrastructure Project	Peninsula	52	Sea Level Rise; Storm Surge	Low Battery Seawall Improvements: Repair 900 ft of seawall damaged by Hurricane Matthew	3	3	3	2
Infrastructure	CHS Flooding and SLR	ALL	72	SLR	Update City's 1984 Master Drainage Plan for SLR.	2	2	2	3
Infrastructure	CHS Flooding and SLR	ALL	41	SLR and Tidal Flooding	Evaluate streets for accessibility for various levels of service given SLR to promote best routes.	3	3	2	3
Infrastructure	CHS Flooding and SLR	Peninsula	24	SLR; Storm Surge; Tidal	Complete the repair and reinforcement of the Battery seawall. (Low Battery Project)	2	2	2	2
Infrastructure	CHS Flooding and SLR	ALL	19	Tidal Flooding	Identify opportunities for and install check valves to prevent tidal inundation.	2	2	2	3

Infrastructure	CHS Major Infrastructure Project	Peninsula	53	Tidal Flooding	Huger and King Drainage "Tidal Protection"	3	3	2	3
Land Use	Workshop 2 (Katie)	Peninsula	26	Flooding and SLR	Consider implementing an Overlay Zone for coastal resilience, i.e. marsh migration, coastal setbacks, future coastal surge protection on private property especially post any USACE project, etc.	2	1	2	3
Land Use	Workshop 2 (Katie)	West Ashley	27	Flooding and SLR	New incentive based zoning district in W.A. encouraging responsible redevelopment	3	3	3	3
Land Use	Workshop 4	ALL	79	Earthquake	Consider resilience overlay district as part of the Comprehensive Plan				
Land Use	CHS Flooding	ALL	25	Flooding	Minimize the impact to natural floodplains from future development by controling the alteration of	3	1	1	3
Land Use	CHS Flooding and SLR Initiatives	ALL	44	Flooding	Evaluate and implement tree planting and protection recommendations for private development projects.	3	2	3	3
Land Use	CHS Flooding	ALL	66	Flooding	Identify open space that could double function as water storage areas.	1	2	2	3
Land Use	CHS Flooding and SLR Initiatives	ALL	70	Flooding, Multiple Threats	Evaluate and implement tree planting recommendations in public areas.	2	3	1	3
Land Use	CHS Flooding and SLR Initiatives	ALL	55	Multiple Threats	Complete an all-hazards Vulnerability Assessment.	3	3	2	3

Land Use	CHS Flooding and SLR Initiatives	ALL	46	SLR	Update the City's Comprehensive Plan for SLR and reevaluate the City's Zoning Ordinance.	2	1	2	3
Land Use	CHS Flooding and SLR Initiatives	ALL	3	SLR; Storm Surge; Tidal Flooding	Identify opportunities to improve how City projects are designed with flooding and SLR in mind.	2	2	1	3
Outreach	Workshop 2	ALL	72	Flooding and SLR	Partner with Charleston County and the SC DOT to establish road design standards that are resilient to SLR	3	1	1	3
Outreach	Workshop 4	ALL	80	Dam Failure	Outreach and education to increase awareness				
Outreach	CHS Flooding and SLR Initiatives	ALL	1	Flooding	Continue partnerships with agencies, organizations and institutions of higher education that actively engage in resilience.	3	3	3	3
Outreach	CHS Flooding and SLR Initiatives	Peninsula	30	Flooding	Create design guidelines for retrofitting and elevating historic buildings.	3	3	3	3
Outreach	CHS Flooding and SLR Initiatives	ALL	36	Flooding	Develop a central web portal that is dedicated to all items related to flooding.	3	3	3	3
Outreach	CHS Flooding and SLR Initiatives	ALL	38	Flooding	Collect, measure, and analyze the impacts of extreme weather and coastal flood events, including information from the community.	3	3	1	3

Outreach	CHS Flooding and SLR Initiatives	ALL	45	Flooding	Conduct an annual review of SLR Strategy.	3	3	3	3
Outreach	CHS Flooding and SLR Initiatives	ALL	53	Flooding	Coordinate with neighboring jurisdictions on development activites and land use planning on a watershed level.	3	3	1	3
Outreach	CHS Flooding and SLR Initiatives	ALL	54	Flooding	Partner with FEMA to share flood maps with the community and adopt new maps.	3	3	3	3
Outreach	CHS Flooding and SLR Initiatives	ALL	56	Flooding	Utilize the RSAC and their public forum to obtain feedback and discuss action items that promote resiliency and sustainability, including mitigation strategies that reduce emissions.	3	3	3	3
Outreach	CHS Flooding and SLR Initiatives	ALL	64	Flooding	Collaborate with partners to perform outreach to the community, particularly vulnerable populations.	2	3	1	3
Outreach	CHS Flooding and SLR Initiatives	ALL	71	Flooding, Multiple Threats	Provide resources for homeowners and businesses to plant trees on private property.	3	3	1	3
Outreach		ALL			Increased outreach to community to support and encourage remote working during flooding and other measures that make economic activity and critical services less vulnerable to disruption by flooding	2	2	2	3

Resources	CHS Flooding and SLR Initiatives	ALL	16	Flooding and SLR	Annually align City operational priorities to reflect the current assessment of Flooding and SLR impacts.	2	2	1	3
Resources	CHS Flooding and SLR	ALL	26	Flooding and SLR	Identify and implement strategies to fund wetland restoration.	3	3	1	3
Resources	CHS Flooding and SLR	ALL	60	Flooding and SLR	Collaborate with and learn Dutch and other methods of managing and living with water.	2	1	3	3
Resources	CHS Flooding and SLR	ALL	61	Flooding and SLR	Create and pursue new and emerging revenue sources, both public and private, for the future.	3	3	3	3
Resources	CHS Flooding and SLR Initiatives	ALL	65	Flooding and SLR	Acquire ten new Stormwater Department positions.	3	3	3	3
Resources	CHS Flooding and SLR Initiatives	ALL	66	Flooding and SLR	Complete Dutch Dialogues Charleston.	2	1	2	3
Resources	CHS Flooding and SLR Initiatives	Peninsula	67	Flooding and SLR	Complete USACE Peninsula Flood Risk Management Study.	3	2	2	3
Resources	Workshop 2	ALL	70	Flooding and SLR	Develop local funding mechanism (i.e. gas tax or tax increment financing) to provide dollars towards non-capacity transportation projects	3	1	1	3

Resources	Assessment Team	ALL	71	Flooding and SLR	Increased capability for City staff remote working during flooding and other measures that make economic activity and critical services less vulnerable to disruption by flooding	3	2	3	3
Resources	CHS Flooding and SLR Initiatives	ALL	12	Flooding	Seek new legislation and appropriate streams of revenue to support projects.	3	3	1	3
Resources	CHS Flooding and SLR Initiatives	ALL	13	Flooding	Aggressively participate in FEMA programs to protect private property.	3	3	1	3
Resources	CHS Flooding and SLR Initiatives	ALL	33	Flooding	Acquire appropriate flood response assets for public safety.	1	2	3	3
Resources	CHS Flooding and SLR Initiatives	ALL	37	Flooding	Hire a Stormwater Program Manager consultant to assess the City's stormwater plan.	3	3	3	3
Resources	CHS Flooding and SLR Initiatives	ALL	40	Flooding	Designate a full time position for floodplain management to include managing CRS activities, education, coordinating with counties and working with citizens.	3	3	3	3
Resources	Workshop 4	ALL	81	Hazmat	Maintain and enhance expertise across all departments				
Resources	CHS Flooding and SLR Initiatives	ALL	39	Multiple Threats	Hire a Chief Resilience Officer to coordinate resilience efforts.	3	3	3	3

Resources	CHS Flooding and SLR Initiatives	ALL	62	Multiple Threats	Seek additional staff capacity in future budget cycles.	1	1	2	3
Resources	CHS Flooding and SLR Initiatives	ALL	63	Multiple Threats	Investigate additional external best practices that may transfer to Charleston.	3	3	3	3
Resources	CHS Flooding and SLR Initiatives	ALL	68	Multiple Threats	Access to ample funding to implement key infrastructure projects in pipeline, including relevant staff capacity.	1	1	2	3

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