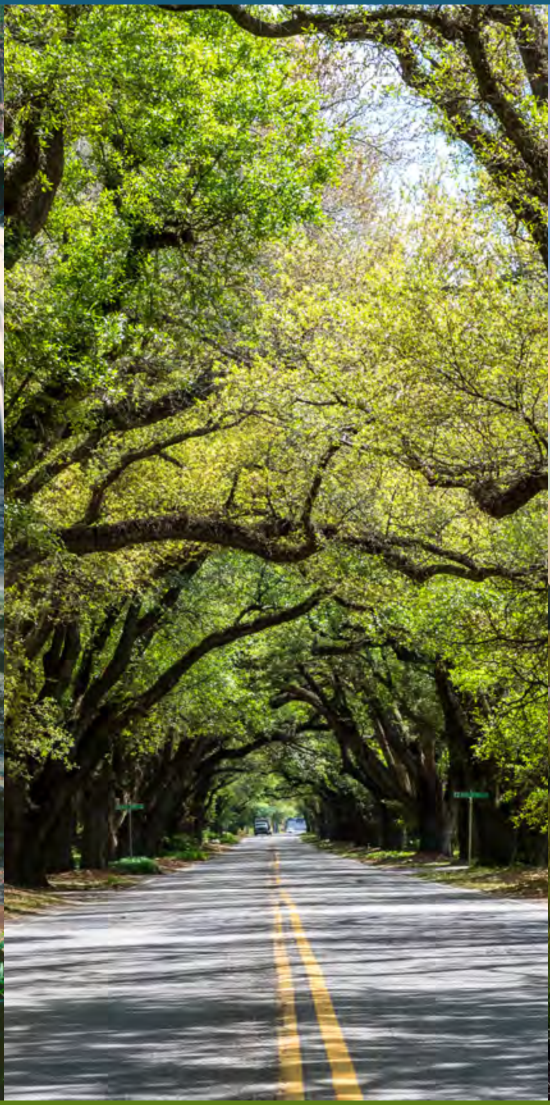
SOUTH CAROLINA

Strategic Statewide Resilience and Risk Reduction Plan


SCOR South Carolina Office of Resilience

JUNE 2023

Henry McMaster
Governor

June 23, 2023

Dear Friends,

The South Carolina Office of Resilience has completed the first ever Strategic Statewide Resilience and Risk Reduction Plan for the State of South Carolina.

Building on the 2019 recommendations of the Floodwater Commission, the General Assembly statutorily commissioned the state's first resilience plan, which is intended to serve as a framework to guide state investment in flood mitigation projects and the adoption of programs and policies to protect the people and property of South Carolina from the damage and destruction of extreme weather events.

South Carolina faces many new challenges. We are experiencing changes in the intensity of our rainfall events. Sea levels are rising, putting pressure on our coastal communities. Our economic and population growth has led to increased pressure on our land resources.

This places our state's culturally and environmentally significant structures, monuments, lands, islands, and waters at risk to be lost to over-development, mismanagement, flooding, erosion, or storm damage. We must preserve and protect our history, our culture, and our environment, and the public's access to them, before they are lost forever.

We must take actions that increase our ability to anticipate, absorb, recover, and thrive as we face these environmental changes and natural hazards. Our communities, economies and ecosystems are complementary, intertwined, and inseparable – each dependent on the other. To strengthen one is to strengthen the other. By taking a holistic view of our state's current and future vulnerability to natural disasters we can begin to make wise investments into South Carolina's communities, economies, and ecosystems.

This is our moment to act — while we still can. The release of the initial Strategic Statewide Resilience and Risk Reduction Plan is the first step in this process.

Yours very truly,

Henry McMaster

State House • 1100 Gervais Street • Columbia, South Carolina 29201 • Telephone: 803-734-2100

SOUTH CAROLINA
OFFICE OF
RESILIENCE

Strategic Statewide Resilience and Risk Reduction Plan
June 2023

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The Resilience Planning Team would like to thank the entire SCOR staff for their support of and contributions to the planning process.

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EXECUTIVE SUMMARY

PURPOSE

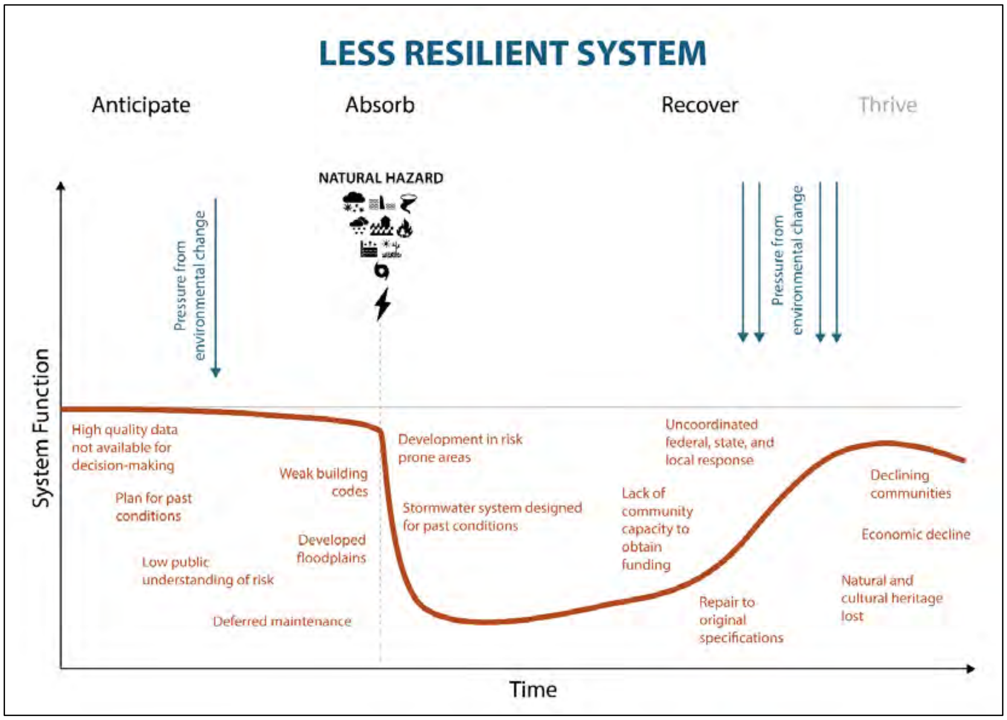
Impacts from three presidentially declared disasters in less than four years led, in part, to the creation of the South Carolina Office of Resilience. The South Carolina Office of Resilience (SCOR) exists to increase resilience to disasters and reduce or eliminate the long-term risk of loss of life, damage to and loss of property, and suffering and hardship, by lessening the impact of future disasters. The Disaster Relief and Resilience Act directs SCOR to develop, implement and maintain the Strategic Statewide Resilience and Risk Reduction Plan (Resilience Plan). The Resilience Plan is intended to serve as a framework to guide state investment in flood mitigation projects and the adoption of programs and policies to protect the people and property of South Carolina from the damage and destruction of extreme weather events (S.C. Code Ann. § 48-62-30 et seq.).

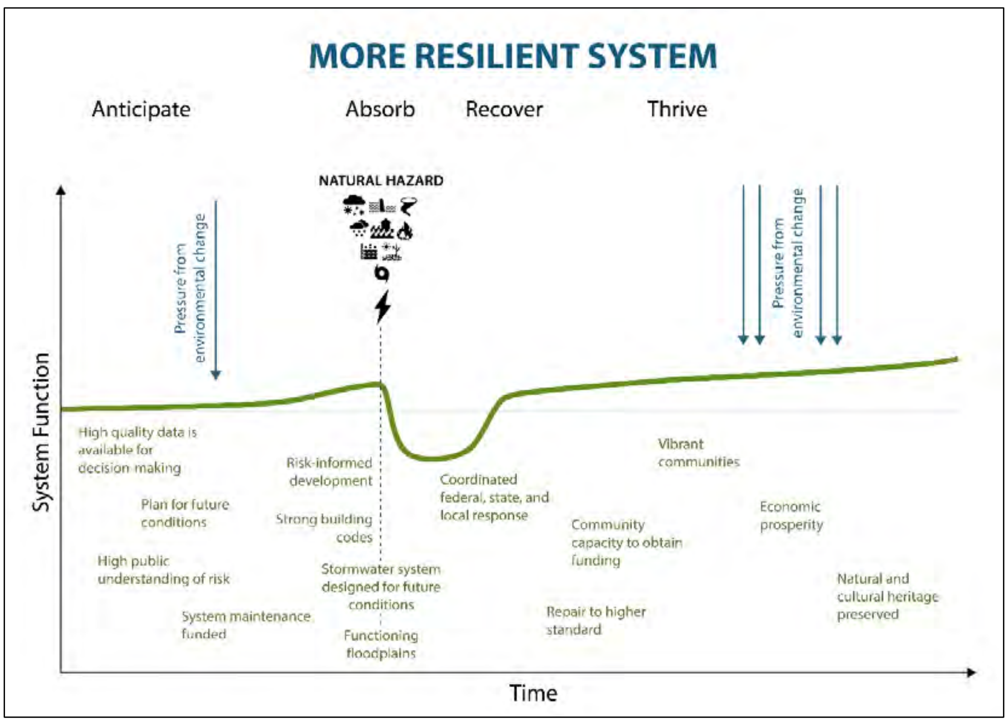
DEFINING RESILIENCE

Resilience is a complex term, capturing multiple theories and concepts depending on who is giving the definition. Working with the Advisory Committee, SCOR has adopted the following definition of resilience, guiding our work on this plan:

The ability of communities, economies, and ecosystems within South Carolina to anticipate, absorb, recover, and thrive when presented with environmental change and natural hazards.

The figures on the following page compare the difference in system function over time for a more resilient system and a less resilient system when faced with environmental changes and natural hazards.


LESS RESILIENT SYSTEM
Anticipate
Absorb
Recover
Thrive
NATURAL HAZARD
Pressure from environmental change
Pressure from environmental change
System Function
High quality data not available for decision-making
Plan for past conditions
Low public understanding of risk
Deferred maintenance
Weak building codes
Developed floodplains
Development in risk prone areas
Stormwater system designed for past conditions
Uncoordinated federal, state, and local response
Lack of community capacity to obtain funding
Repair to original specifications
Declining communities
Economic decline
Natural and cultural heritage lost
Time


MORE RESILIENT SYSTEM
Anticipate
Absorb
Recover
Thrive
NATURAL HAZARD
Pressure from environmental change
Pressure from environmental change
System Function
High quality data is available for decision making
Plan for future conditions
High public understanding of risk
System maintenance funded
Risk-informed development
Strong building codes
Stormwater system designed for future conditions
Functioning floodplains
Coordinated federal, state, and local response
Community capacity to obtain funding
Repair to higher standard
Vibrant communities
Economic prosperity
Natural and cultural heritage preserved
Time

KEY FINDINGS

NATURAL SYSTEM

- South Carolina’s hydrological footprint consist of eight major river basins: Broad, Catawba, Edisto, Pee Dee, Salkehatchie, Saluda, Santee, and Savannah. The hydrologic footprint extends beyond state boundaries, and includes those basins shared with neighboring states.

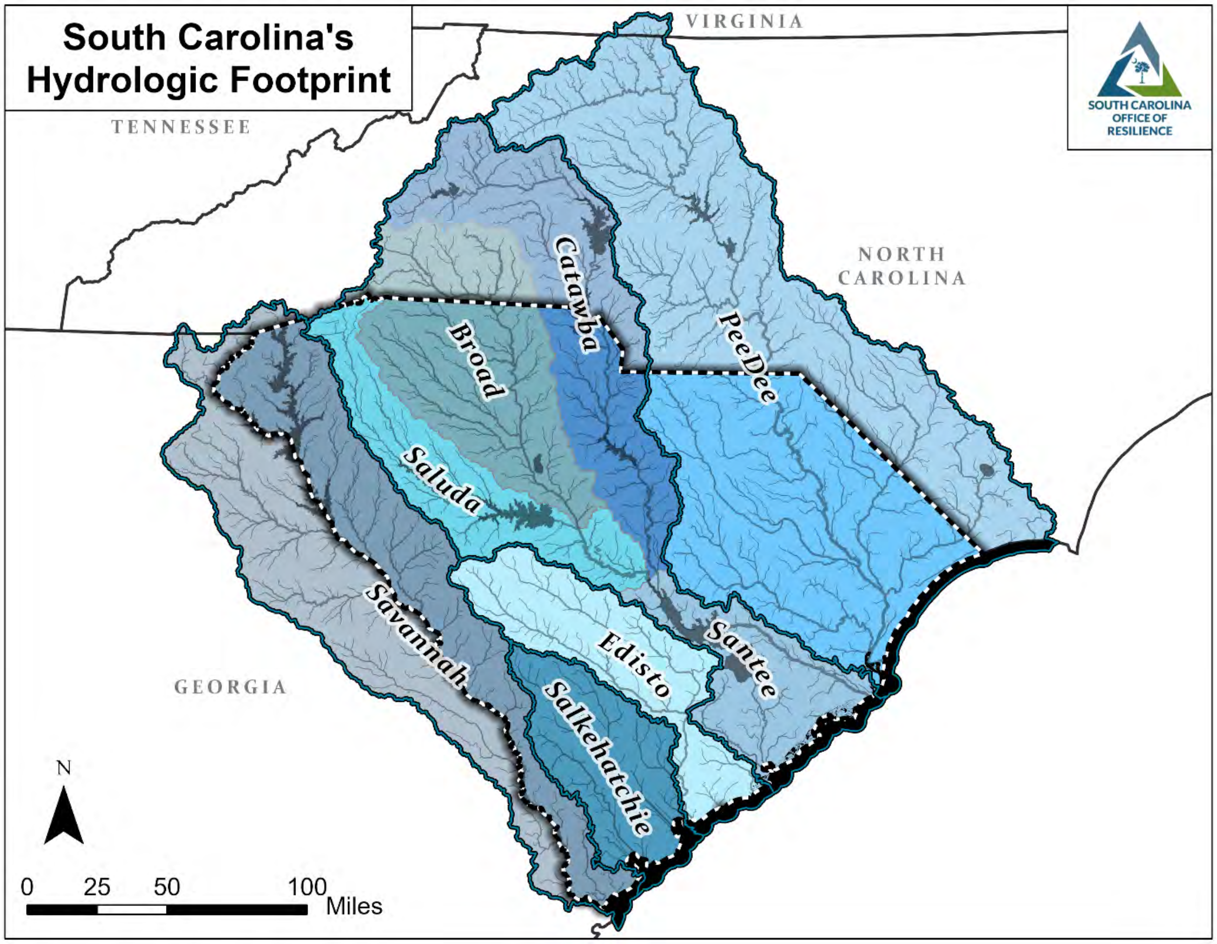
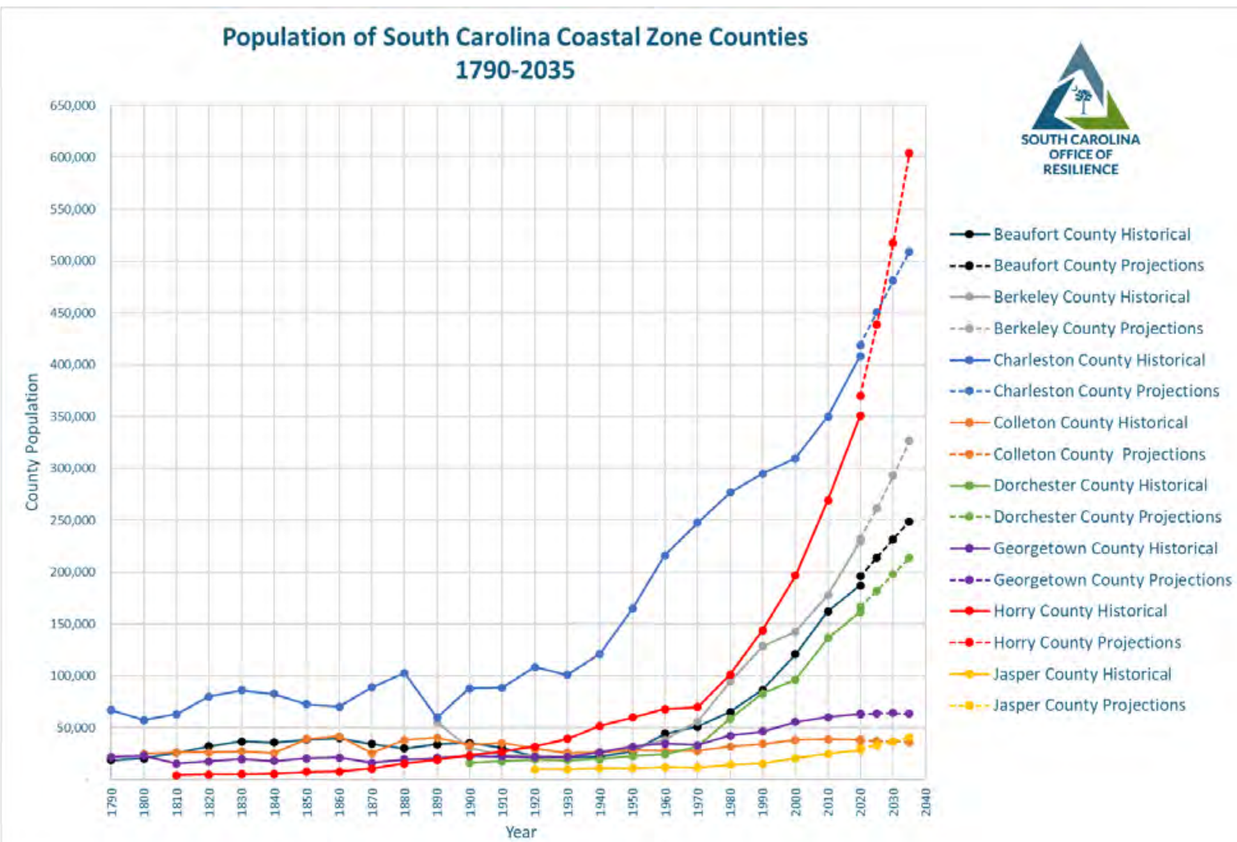


Figure 3: South Carolina's Hydrological Footprint

- There are eight major aquifers that are recharged by surface water that falls on permeable surfaces like the Sandhill region of South Carolina. The deeper aquifers are used for larger withdrawers, while the surficial aquifer is mostly used for minor withdrawers like private drinking water supply and smaller irrigation operations.
- Septic systems can be impacted by changes in the water table elevation caused by increased precipitation and/or sea level rise.

POPULATION & LAND USE

- South Carolina's population has increased to over 5.1 million people from an estimated 2.5 million people in 1970.
- Population growth is expected to continue with the population reaching 6.2 million people by 2035.
- Changing land uses can put new development areas and existing areas at an increased risk for natural hazards. Developed areas can experience flooding as natural systems are changed into developed areas with non-permeable surfaces. Developed settings decrease the storage capacity to the system and discharge water faster into the waterways. Meanwhile, changes in land uses at the wildland-urban interface can increase wildfire risk.
- The explosive population growth in South Carolina is regionally disproportionate. Population growth has centered around coastal counties and urban areas. Many rural areas, especially along the I-95 corridor, are experiencing population decline.



TEMPERATURE TRENDS

- Since 1895, average annual temperature has increased by approximately 1°F, lower than the average global increase of approximately 2°F. However, the rise during the past 60 years has matched or exceeded global increases, and the past 30 years have been warmer than any other consecutive 30-year period.

- The instrumental temperature record includes considerable year-to-year and decade-to-decade variability.
- Most stations exhibit statistically significant increases in a) maximum temperature in winter, spring, and summer, and b) minimum temperature in summer. While the state has had temperature increases in the past sixty years, few stations exhibit maximum temperature trends during fall, or minimum temperature trends during winter, spring, or fall when considering records from the beginning of the early 20th century.
- Climate models project South Carolina temperature increases of 5° to 10°F by the year 2100, depending on future greenhouse gas emissions.

PRECIPITATION TRENDS

- Precipitation has varied greatly on a yearly and decadal basis.
- Summer precipitation has decreased and the number of precipitation days in fall has increased; overall, few other statistically significant trends are found for seasonal or annual total precipitation.
- There are relatively few statistically significant long-term trends in heavy precipitation. However, recent heavy precipitation events affecting the coastal regions and the Pee Dee River Basin (2015, 2016, 2018) match expectations of a warmer world with higher evaporation rates and atmospheric moisture.
- Drought has periodically affected all parts of the state. The historical record reveals interannual and interdecadal variability, but no statistical trend. Rising temperatures in the 21st century will likely exacerbate agricultural and hydrologic drought.

STORM EVENTS

- South Carolina’s geographic position makes it vulnerable to tropical cyclones. The impact of tropical storms and hurricanes affecting the state have fluctuated greatly across years and decades. Their frequency and intensity have been influenced by large-scale conditions including sea-surface temperature and wind shear.
- Future scenarios are mixed with respect to the frequency of storms, but more consistently project greater intensity of wind and precipitation for those storms that do occur.

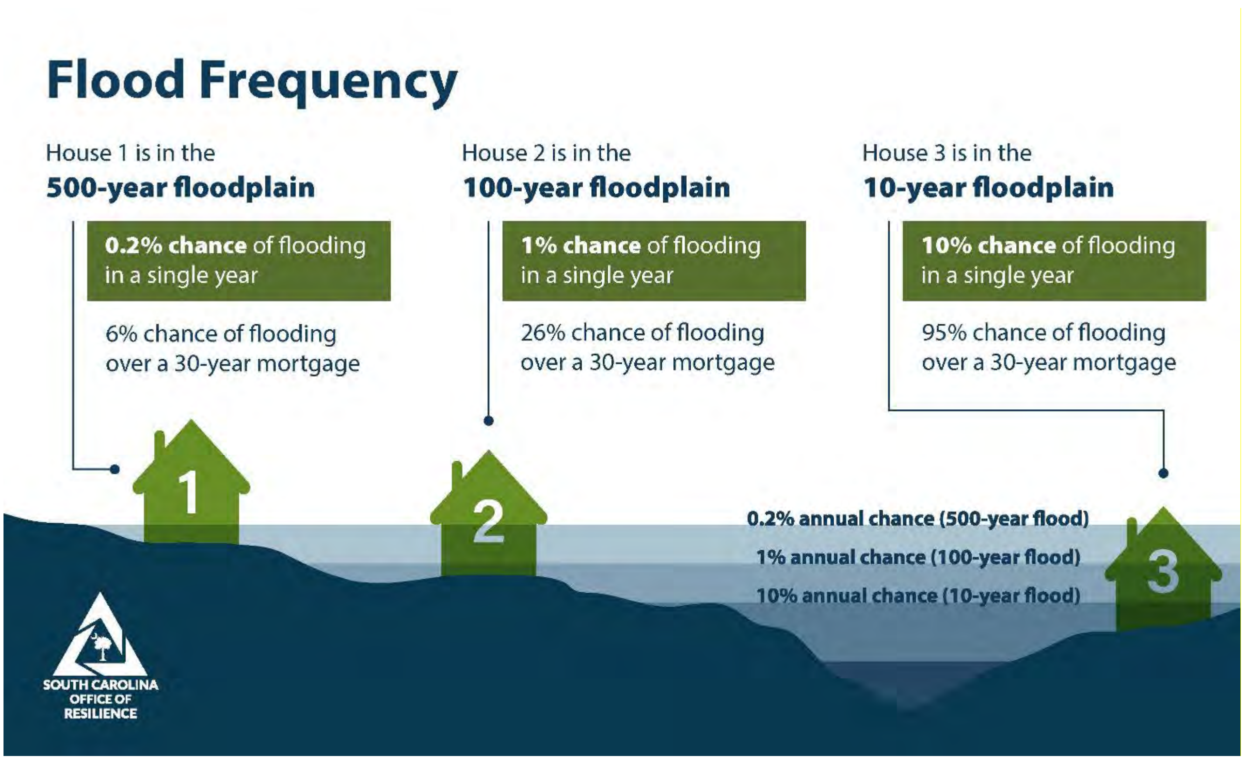
COASTAL IMPACTS

- South Carolina’s coast is low-lying and vulnerable to sea level rise. Sea levels have already risen by approximately 1 foot from 1899 levels and will further rise by approximately 1 foot by 2050. Projections for sea level rise range from 2 to 16 feet by 2150.
- Sea surface temperature increases off the Carolinas are statistically significant, and projected increases of 7 to 9 °F by 2100 would be among the highest nationally.
- Ocean acidification is currently stressing marine organisms and is projected to accelerate.

- Beyond sea level rise, South Carolina is likely to experience compound changes (a combination of impacts that could be larger than each individually) in our coastal and marine waters including sea surface temperature, ocean acidification, salinity, deoxygenation, and potential disruptions to the Gulf Stream.
- Physical and chemical changes may combine to create harmful impacts for marine ecosystems and coastal economies in South Carolina.

FLOOD RISK & VULNERABILITY

- Flooding in South Carolina is caused by prolonged rain events, short intense rain, overflowing rivers, dam or levee failure, storm surge, and tidal process. Flooding can be broken into three types: river flooding (fluvial), overland flooding (pluvial), and coastal flooding.
- Estimates of flood frequency are based on historical record and do not account for changes in climate and landscape conditions.



- Existing rainfall intensity, duration, and frequency (IDF) curves from NOAA Atlas 14 are based on the concept of stationarity, the idea that past conditions are predictive of the future. Changing rainfall patterns and failure to use the most up-to-date data could lead to underestimating the likelihood of damaging rain events.
- SCOR determined that the intermediate to intermediate-high sea level rise scenario should be considered in the development of South Carolina's Statewide Resilience Plan.
- Projected sea level rise will lead to increased coastal flooding in low lying areas.

- Land subsidence is likely contributing to relative sea level rise in many coastal areas.
- Since 2015, all 652 high and significant hazard dams in the state have been assessed, and the state has invested significant resources in the State's dam safety program.
- Dam failure can lead to flooding downstream. Additionally, there is the potential for mobilization of contaminated sediments that may be trapped behind the dam.
- FEMA flood mapping does not currently capture the full risk of flooding. Supplemental tools such as the First Street Foundation Flood Hazard Layers should be utilized for a more complete understanding of flood risk under both current and future conditions.
- Using the First Street Foundation Flood Hazard Layers and other publicly available datasets, SCOR assessed and mapped the vulnerability of various facilities.

WILDFIRE

- Wildfires are common occurrences in South Carolina and are defined by the South Carolina Forestry Commission as any forest fire, brush fire, grassfire, or any outdoor fire that is not controlled or supervised.
- On average, approximately 1,400 wildfires burn nearly 11,000 acres in South Carolina each year (SC Forestry Commission (SCFC), 2021).

DROUGHT

- In the last 21 years, South Carolina has experienced three major droughts.
- The State Water Plan under development at SCDNR aims to understand water supply versus water demand, including the impacts of drought on the water resources in the State.

HEAT

- Heat is the most dangerous of the weather related hazards in recent decades (National Weather Service, 2022).
- Historic analysis documents maximum summer temperature increases across the State.
- Portions of the state are projected to experience up to 50 more days a year with temperatures above 95 °F by the end of the century.
- Future temperature increases and more frequent and intense heat waves will likely cause the Southeast to experience a disproportionate health burden.

SEVERE THUNDERSTORMS

- Thunderstorms occur frequently in South Carolina, and severe storms have the potential to produce damage-causing hail, lightning, and high winds.
- Tornadoes are a facet of severe thunderstorms as well.
- In South Carolina, extreme winds are the most reported hazard to the National Centers for Environmental Information (NCEI).

TROPICAL SYSTEMS AND HURRICANES

- While hurricanes are considered low frequency but high consequence events.
- South Carolina ranks 5th (fifth) among states that experience hurricanes, behind Florida, Texas, Louisiana, and North Carolina.

TORNADOES

- There is no significant trend in tornadoes occurring in the State.
- Current climate projections predict that tornado alleys are shifting east.

WINTER WEATHER

- Damage from winter weather events has increased in the last few decades.
- These events can disrupt communications and power by trees or branches falling on suspended lines, disrupt travel plans by impairing roadways, and damage plants both for residential and agricultural purposes.

SEISMIC EVENTS

- According to the USGS, South Carolina has experienced 229 earthquakes since 2001, with 46 events larger than a magnitude 2.5. The largest event since 2001 reached a magnitude 4.1 in Parksville, SC, on November 11, 2014.
- The largest earthquake recorded in the State was the Charleston Earthquake of 1886 with an estimated magnitude of 7 to 7.6.
- Tsunamis are rare on the east coast of the U.S. and there is insufficient data to make reasonable decisions or recommendations to mitigate or plan for the impacts of a tsunami.

RECOMMENDATIONS SUMMARY

Improve Data Collection and Coordination

Establish a data coordination office to coordinate, catalog, document, and make accessible the wide range of data produced by and for the State.

Increase the density of weather stations to provide higher quality data for developing weather models, hydrologic models, drought assessments, flood forecasting and other decision-making processes.

Increase the density of permanent river gage locations to provide higher quality data for the development of better hydrologic models and to inform and improve water planning, drought assessments, flood forecasting, and flood frequency estimates.

Increase the density of tidal gauges to enable better monitoring and modeling of conditions.

Develop a statewide network to monitor surficial groundwater to better understand the impacts of sea level rise and changes in rainfall infiltration on shallow systems including septic fields.

Install extensometers along the coast to monitor vertical land movement to develop a better understanding of relative versus absolute sea level rise and improved understanding of the causes of subsidence.

Update NOAA Atlas 14 IDF curves for rainfall and incorporate into infrastructure design. Adopt NOAA Atlas 15 IDF curves when released and design based on future conditions.

Establish a group to evaluate climate information will inform decision makers on how future climate trends will likely impact the State.

Fund the collection and processing of updated LiDAR data to allow decision makers to use the most up-to-date elevation to use in computational models and in decision making.

Create a roadway elevations inventory that may be used for transportation network vulnerability analyses.

Partner with NOAA to develop a high resolution land cover dataset for the hydrological footprint of South Carolina. This allows for a more detailed catalog of the type and area coverage of various land cover types, allowing for better forecasting, planning, and modeling.

Complete a statewide sediment study to understanding of sediment budgets, including the impact of reservoirs and identify potential engineering and policy solutions to remobilize sediment in the system.

Complete the SCDNR Flood Inundation Modeling and Mapping Project to provide emergency responders and others with the information needed for evacuations, search and rescue, road closures, and other emergency response activities.

Establish a Modeling Technical Advisory Group to inventory existing models and technical capabilities, identify data gaps, make recommendations on modeling needs, and evaluate proposals for modeling improvements.

Establish a committee to examine the need for a contract with an imagery provider so that when a disaster occurs, images can be used to better assess the damage extent post-event. This can aid the ability of SCEMD, FEMA, and SCOR to identify where to focus response and recovery efforts.

Develop higher resolution population projections at the subcounty scale to inform local, county, municipality, and state planning processes.

Develop a statewide property level data standard to allow for cross jurisdictional data analysis and modeling.

Inventory and analyze zoning and land use policy statewide to understand how local jurisdictions implement zoning and the ways in which land use regulations shape a community's development and resilience.

Create and fund a cultural resources coordinator position to develop a cultural resources inventory. Such an inventory will allow for comprehensive planning that mitigates the loss of cultural resources across the State and efficient recovery.

Increase Education, Outreach, and Disclosure

Host a series of regional workshops to educate the public about the Statewide Resilience Plan.

Develop a SCOR Resilience Atlas to provide a centralized location for resilience related GIS data to aid in decision-making statewide.

Develop and maintain a resilience resource list for communities and other audiences to access information and resources that aid in decision making.

Maintain the S.C. Sea Grant Resilience Planning Archive. This archive catalogs the resilience planning efforts undertaken across the state to inform planning and project implementation and allow for cross jurisdictional coordination.

Develop a resilience training and certification program to build community capacity and aid in local implementation of statewide resilience principles.

Strengthen hazard disclosure in real estate transactions to increase the knowledge of risk and conditions by purchasers related to flooding and other natural hazards.

Develop a cultural resources training to help cultural institutions and caretakers increase the resilience of their resources and collections.

Reestablish a flood hazard signage program to increase public awareness of risk.

Coordinate Watershed-Based Resilience Planning and Projects

SCOR will coordinate with communities at the watershed level to identify risks and vulnerabilities, develop actionable flood mitigation and resilience solutions, and build community capacity by leveraging local, regional, and state partnerships.

Establish a Resilience Grant/Loan Program using the Disaster Relief and Resilience Reserve Fund to implement mitigation projects, programs and policies recommended by the Statewide Resilience Plan and watershed-based resilience planning. Recurring funds should be allocated to the Resilience Grant/Loan Program to ensure that projects, programs, and policies identified through watershed-based resilience planning are implemented in a timely manner.

Incorporate Resilience into Planning, Land Use and Other Regulatory Processes

Each state agency should conduct a resilience review based on the climate and flood risk and other hazard data presented in the vulnerability assessment and make recommendations on policy and regulatory changes that are needed to reduce vulnerabilities.

Utilizing best available data, counties and municipalities should adopt policies that restrict new development in flood prone areas whether or not they designated by FEMA as a special flood hazard area. Any new structures in flood prone areas should be designed to withstand a 1% annual flood event over the design life of the structure, considering future conditions.

Develop best management practices for communities to incorporate resilience into comprehensive plans to guide decision making regarding growth and development, public facility investments, regulation of land uses, siting of green space, and economic development initiatives.

SCOR will develop best management practices and provide principles that enable communities to develop local strategies to implement resilient policies, aligning with their comprehensive plans, through zoning and land use codes, subdivision regulations, overlay zones, floodplain management, and stormwater ordinances.

Water systems should conduct a resilience review of their water systems based on the climate and flood risk and other hazard data presented in vulnerability assessment.

New legislation should be established to regulate the alteration of isolated wetland systems to reduce the potential loss of flood mitigation and ecosystem services.

Maintain and Strengthen Building Codes

South Carolina should maintain the current update schedule for both the Residential and Commercial codes to keep up with reasonable standards of construction for public health, safety, and welfare.

The State should not make modifications to the International Residential and Commercial Codes that reduce resilience. Examples are the current reductions to the hurricane and seismic requirements in some areas.

Develop professional education programs about building codes for professions involved in construction such as contractors, architects, and engineers to ensure innovations and resilience best management practices are utilized.

Assess how an update to the 2009 Energy Code could impact the resilience of the power grid in the State. The assessment should consider both the costs of construction and operation of buildings as well as the impacts on public health, safety, and welfare.

Utilize the most conservative wind zone map when there is a question as to a property's location relative to the county level wind maps approved by the SC Building Codes Council.

Coordination is needed between Internal Organization for Standardization (ISO) and building code officials to ensure officials understand how they will be scored by the Building Code Effectiveness Grading Schedule and how to accurately complete their reports.

Incorporate Resilience into Infrastructure Design

Consider future conditions in the design of critical infrastructure. Critical infrastructure can be defined as those assets, systems, and facilities that communities rely upon for everyday health, safety and welfare and lifeline functions.

Review state and local stormwater infrastructure design standards to see if they should be modified to handle lower frequency storm events (i.e. a “50-year” storm vs “10-year” storm).

Identify and remove barriers to permitting nature-based solutions on the state and local level.

Funding sources for infrastructure maintenance should be identified prior to construction to ensure the infrastructure will function properly over the intended life of the project.

Consider the future conditions identified in the climate and vulnerability sections of this report when planning and investing in port infrastructure.

Maintain Natural Flood Protection Through Conservation

Develop a Priority Flood Mitigation Conservation Map. SCOR has used a combination of public and private datasets to better understand the landscape's role in flood mitigation across South Carolina. This data model identifies areas where floodwaters are expected, where wetlands can help absorb excess water, and those areas where water is most likely to infiltrate the ground. Protecting these areas may help attenuate the impact that future development has on flooding.

Develop a grant program for state and local governments and non-profits to complete land acquisitions that maximize flood reduction benefits, implementing the Priority Flood Mitigation Conservation Map. This program should partner with other conservation agencies such as SC Conservation Bank, South Carolina Department of Natural Resources (SCDNR), South Carolina Forestry Commission (SCFC), South Carolina Parks, Recreation, and Tourism (SCPRT), SC Department of Agriculture (SCDA), and South Carolina Department of Health and Environmental Control (DHEC).

Incorporate Resilience into Housing Recovery

Any future disaster recovery and mitigation action plans, policies and procedures developed for the State should refer to the principles of the Strategic Statewide Resilience and Risk Reduction Plan.

Manufactured housing units needing full replacement should be replaced with stick built or modular homes where possible.

Impact windows should be used when homes are repaired or replaced following a disaster, regardless of the wind zone the home is located in.

In areas that are prone to flooding, require replacement homes to have a first-floor elevation built to Base Flood Elevation (BFE) +3 feet. If this requirement would cause the home's first floor elevation to be elevated above 10ft above land surface, the home would become ineligible for replacement and would instead be offered a voluntary buyout.

Housing funds allocated to South Carolina should not be used to repair or construct homes if they are:

- A FEMA Repetitive Loss Property
- Properties in the FEMA Regulatory Floodway
- Properties Seaward of DHEC Setback Line

Establish a Voluntary Pre-Disaster Buyout Program

The Disaster Relief and Resilience Act required SCOR to develop an estimate of the current number and cost of residential properties within the State for which a buyout may be appropriate. Properties are identified and prioritized based on potential risk to flooding. The following criteria were used to develop this estimate and are proposed for the prioritization of the properties under a pre-disaster buyout program:

- Tier 1: Repetitive Loss Properties in the FEMA Regulatory Floodway & Repetitive Loss Properties Seaward of the DHEC Beachfront Setback Line
- Tier 2: Properties in the FEMA Regulatory Floodway & Properties Seaward of the DHEC Beachfront Baseline
- Tier 3: All Other Repetitive Loss Properties
- Tier 4: First Street 100 Year Event (Current) with 6+ feet of inundation
- Tier 5: First Street 100 Year Event (Future) with 6+ feet of inundation

Developing a voluntary buyout program would require a more detailed analysis and eligibility of individual properties and property owners and would be ultimately determined by the funding source and require collaboration with communities.

Identify and Maximize All Available Funding Sources For Resilience Activities

Develop a Resilience Funding Hub, a web-based portal, to collect, coordinate and disseminate information related to funding to enable coordination, collaboration and cooperation among state agencies, local and regional governments, and non-profits to obtain funding.

Develop best management practices on how communities should implement resilience practices into a range programs and projects, as required by many federal and non-federal funding sources.

Strategic Statewide Resilience and Risk Reduction Plan

1 | INTRODUCTION

OVERVIEW

The Disaster Relief and Resilience Act (2020) directs the South Carolina Office of Resilience (SCOR) to develop, implement and maintain the Strategic Statewide Resilience and Risk Reduction Plan (Resilience Plan). This plan is intended to serve as a framework to guide state investment in flood mitigation projects and the adoption of programs and policies to protect the people and property of South Carolina from the damage and destruction of extreme weather events.

CONTENTS

CONTEXT/NEED

In recent years South Carolina has experienced repetitive disasters. Beginning in 2015, portions of the state experienced three major storms within four years (2015 to 2018). These storms caused severe property damage and a total of 23 deaths in South Carolina. Water and wind-damaged homes became unlivable. Those without the means to repair their homes were either forced to live in unsafe structures, relocate with relatives, or flee the disaster area. The damage continued to be felt by the local economy as businesses lost customers and local government tax revenues diminished. This strained the fabric of impacted communities – some of which experienced damage from all three storms. The following is a timeline and brief description of the events.

October 2015: Portions of South Carolina were devastated by an extreme rainfall event generated from a stalled frontal boundary on the coast, which was worsened by outer circulation of Hurricane Joaquin. The resulting rainfall, with areas receiving over 20 inches of rainfall, caused significant riverine flooding and storm damage throughout large portions the state. During this event, an estimated $1.5 billion of property, infrastructure, and agricultural damage occurred, 36 regulated dams failed, and 19 fatalities occurred (National Oceanic and Atmospheric Administration, 2016).

October 2016: Hurricane Matthew entered the state near McClellanville, South Carolina, as a Category 1 Hurricane, unleashing strong winds, torrential rainfall, significant riverine flooding throughout the eastern part of the state. Wind damage from the storm damaged homes across the coastal counties of the State. Entire neighborhoods were underwater over forty miles inland, and 833,000 homes were without electricity. 400,000 people were evacuated from their homes in advance of the storm. Four South Carolina residents lost their lives, and hundreds more lost their homes.

September 2018: Hurricane Florence made landfall just north of South Carolina in Wrightsville Beach, North Carolina. While North Carolina experienced the worst of the storm, South Carolina suffered from heavy rainfall and riverine flooding. Much of the impact was caused by water flowing from North Carolina. The impacts of the hurricane and subsequent flooding is estimated to have caused $600 million in property damage, evacuation of close to 500,000 people, and major damage to 550 homes (National Oceanic and Atmospheric Association, 2021).

One storm can cause destabilizing damage, but with three in a row, communities are still struggling to recover and thrive years later. Actions need to be taken now to ensure that communities can anticipate, absorb, recover, and thrive when presented with the next storm or other natural hazard.

SOUTH CAROLINA OFFICE OF RESILIENCE

The South Carolina Office of Resilience (SCOR) exists to increase resilience to disasters and reduce or eliminate the long-term risk of loss of life, damage to and loss of property, and suffering and hardship, by lessening the impact of future disasters.

SCOR is directed to develop, implement, and maintain the Strategic Statewide Resilience and Risk Reduction Plan (Resilience Plan). This plan is intended to serve as a framework to guide state investment in flood mitigation projects and the adoption of programs and policies to protect the people and property of South Carolina from the damage and destruction of extreme weather events.

FLOODWATER COMMISSION

The DRRA states that the Resilience Plan should be developed with the principles recommended in the South Carolina Floodwater Commission Report (SC Floodwater Commission, 2019). The report was conducted by the SC Floodwater Commission, established by Governor Henry McMaster through Executive Order 2018-50, and chaired by Thomas S. Mullikin. The Commission was charged with developing short- and long-term recommendations to alleviate and mitigate flood impacts to the state with special emphasis on communities located near the coast or rivers. The Commission recommended the following principles be used as the foundation for the design and implementation of a comprehensive and integrated approach to reduce flood risk and increase resilience:

1. Flood management plans and actions should be based on watershed boundaries, recognizing that water flows and floods do not follow jurisdictional or political lines.
2. Decisions and actions should be based on high-quality, shared, and integrated hydrologic and hydrographic models that are derived from increased data collection; the data and models should be transparent and freely accessible to all stakeholders.
3. Building the capacity of local governments to develop science-based and actionable flood management plans and hazard mitigation plans should be a priority, especially for under-resourced communities. It does little good for one local jurisdiction to have high-quality plans if the upstream jurisdiction does not.
4. Success will depend on collaboration. Collaboration must take place between state agencies to bridge boundaries, as well as between state and local governments. Collaboration is essential to build trust among all stakeholders, which leads to partnerships, coordination, and more effective programs. Collaboration should also be explicitly encouraged with key federal agencies (i.e. US Army Corps of Engineers, US Geological Survey, National Oceanic and Atmospheric Administration).

5. Ongoing opportunities for public participation and education should be developed to encourage collaboration and build trust.
6. Flood management programs should recognize the beneficial functions of natural floodplains, salt marshes, beach dunes, forests, living shorelines and other natural features to reduce flood risk, as well as the co-benefits they deliver for recreation, forestry, tourism, fisheries, and wildlife. "Nature-based solutions" should be considered for inclusion in the design of flood control projects whenever possible in order to increase resilience and cost-effectiveness.
7. Post-disaster funding coming to South Carolina from congressional appropriations should be managed in a unified state plan as much as federal rules and guidelines will permit, and coordinated across the multiple sources (i.e. FEMA, HUD).

The Floodwater Commission Report also contains an appendix of "Local Floodwater and Drainage Mitigation Projects" which was compiled by the South Carolina Emergency Management Division (SCEMD) from counties and local governments (SC Floodwater Commission, 2019). Table 1.1 shows a breakdown of the identified projects by type. The largest category, by number of projects and cost, are for projects related to the upgrading of stormwater systems and other infrastructure, including increasing the capacity of culverts, pipes, and ponds. The second largest category, by number of projects and cost, are maintenance and cleaning projects, a majority of which involve cleaning debris from culverts and ditches to improve stormwater system function.

Table 1.1: Floodwater Commission Report Projects by Type

Category	Number of Projects	Percent of Projects	Cost	% of All Project Costs
System Upgrades to Infrastructure	97	43%	$ 141,375,787	46.55%
Stormwater Maintenance/Cleaning	41	18%	$ 46,047,609	15.16%
Studies/Assessments/Plans	24	11%	$ 12,720,000	4.19%
Public Education & Outreach	23	10%	$ 12,100	0.004%
Dredging/Cleaning/Improving Waterways	15	7%	$ 47,730,000	15.72%
Gages/Technology/Data Collection	16	7%	$ 3,100,483	1.02%
Buyout (Residential & Floodplain)	4	2%	$ 27,750,000	9.14%
Public Facility Relocation	3	1%	$ 3,750,000	1.23%
Beach (Nourishment, Groin & Bulkhead Repair)	3	1%	$ 21,194,000	6.98%

The Floodwater Commission outlined the above projects that provide a good idea of the needs related to resilience from the local perspective, however, these projects are just a compilation, and do not provide a comprehensive assessment of flood mitigation needs considering issues across jurisdictional boundaries or contain an analysis of their impacts to the overall system.

It is important to note that this first iteration of the Statewide Resilience Plan does not include recommendations for any specific structural mitigation projects like the ones mentioned in the Floodwater Commission Report. In order to develop statewide priority projects, in accordance with the report's principle regarding flood management plans and actions being based on watershed boundaries, after completing the statewide plan, SCOR will engage in watershed-based resilience planning to identify specific projects that will be included in the second iteration of this plan.

CREATION OF THE SC OFFICE OF RESILIENCE

The Disaster Recovery Office, established by Executive Order 2016-13, included within the Department of Administration by Executive Order 2018-59, was transferred and incorporated into SCOR by the Disaster Relief and Resilience Act (DRRA) (2020). The Office is governed by Chief Resilience Officer Ben Duncan, who was appointed by Governor Henry McMaster in March 2021, and confirmed by the Senate in April 2021. A timeline of these events is outlined in Figure 1.1.

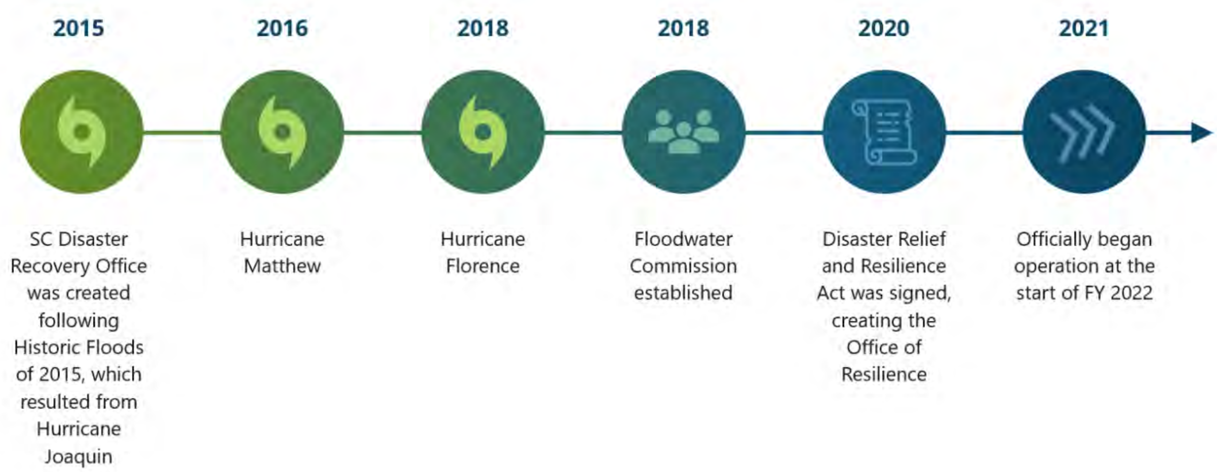


Figure 1.1: South Carolina Office of Resilience developmental timeline

CURRENT SCOR PROGRAMS

OPERATIONS DIVISION: DISASTER RECOVERY & MITIGATION

SCOR's Operations Division provides assistance to low-to-moderate income (LMI) residents and communities by way of the U.S. Department of Housing and Urban Development (HUD) Community Development Block Grants (CDBG) related to Disaster Recovery and Mitigation. Low-to-moderate income (LMI) households are defined as households that do not exceed 80% of the median income for their area, as determined by HUD. This division is currently managing four CDBG programs, three related to recovery from declared disasters (CDBG-DR), and one dedicated to mitigation (CDBG-MIT). The counties these programs operate in are seen in Table 1.2 and mapped in Figure 1.2.

Table 1.2 CBBG-DR & CDBG-MIT Program Areas

County	2015 Flood (DR)	2016 Hurricane Matthew (DR)	2018 Hurricane Florence (DR)	CDBG-MIT
Allendale		x		
Bamberg	x	x		
Barnwell		x		
Beaufort		x		
Berkeley	x	x		x
Calhoun	x	x		x
Charleston	x	x		x
Chesterfield		x	x	x
Clarendon	x	x		x
Colleton	x	x		
Darlington	x	x	x	x
Dillon		x	x	x
Dorchester	x	x		x
Fairfield	x			
Florence	x	x	x	x
Georgetown	x	x	x	x
Greenville	x			
Greenwood	x			
Hampton		x		
Horry	x	x	x	x
Jasper		x		
Kershaw	x			
Lee	x	x		x
Marion	x	x	x	x
Marlboro		x	x	x
Newberry	x			
Orangeburg	x	x		x
Spartanburg	x			
Sumter	x	x		x
Williamsburg	x	x		x

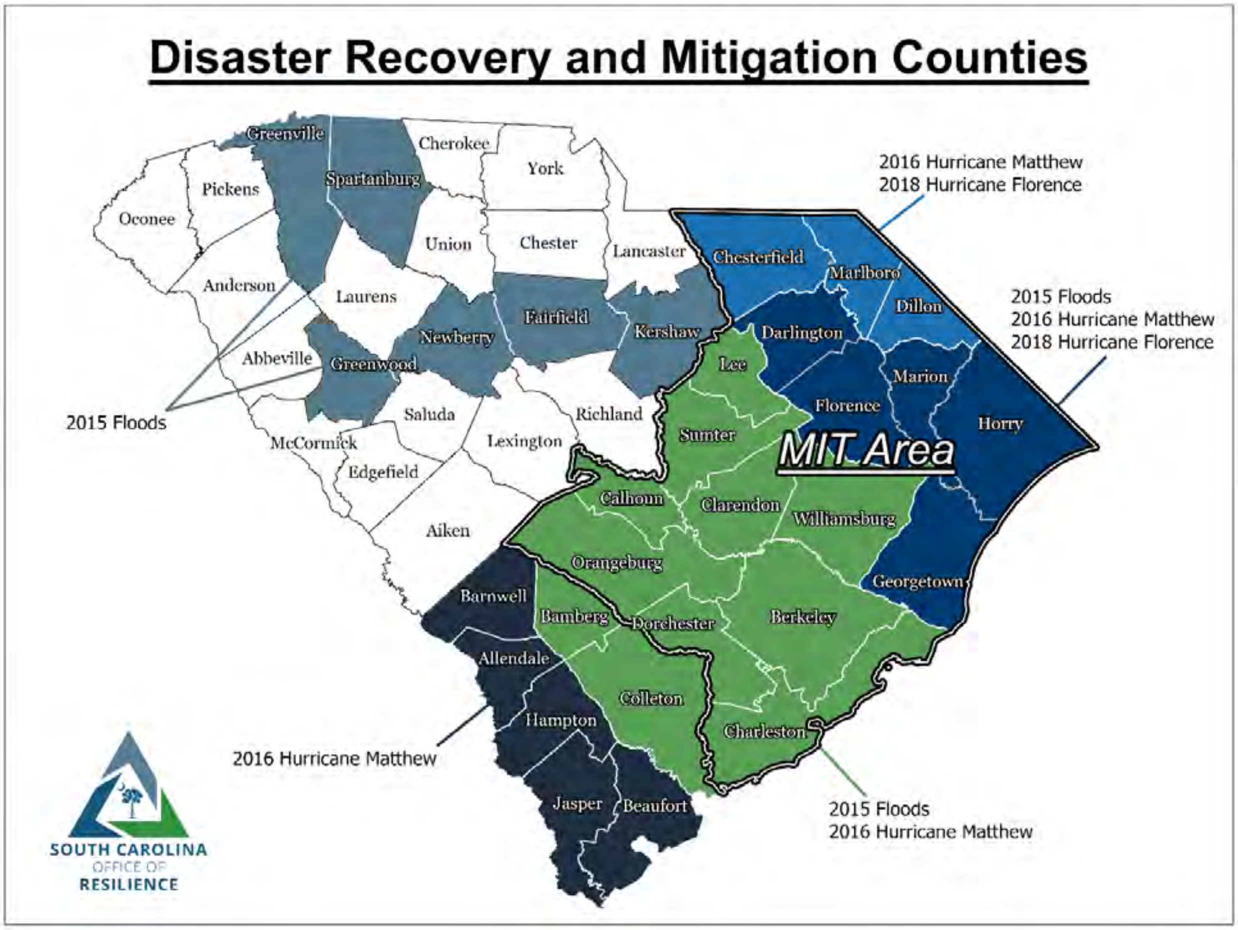


Figure 1.2: Disaster Recovery (CDBG-DR) & Mitigation (CDBG-MIT) Counties

COMMUNITY DEVELOPMENT BLOCK GRANT – DISASTER RECOVERY (CDBG-DR)

SCOR has received $293 million in U.S. Department of Housing and Urban Development (HUD) Community Development Block Grants- Disaster Recovery (CDBG-DR) funding to provide housing assistance to South Carolinians whose homes were damaged by a federally declared disaster. SCOR is currently managing three CDBG-DR programs: the 2015 severe storm (flood), Hurricane Matthew (2016) and Hurricane Florence (2018) (Table 1.3). To date, the Disaster Recovery program has rebuilt or repaired 3,252 homes for citizens whose homes were damaged by the 2015 Severe Storm, Hurricane Matthew, or Hurricane Florence (as of 6/13/2023). Construction projects in the 2015 Flood program were completed in September 2021, including repairs and replacement to a total of 1,829 homes. Approximately 98% of the citizens served under the program were earning equal to or less than 30% of the area median income. SCOR closed the 2015 CDBG-DR grant within the 6-year window established by HUD. The last home in the 2016 CDBG-DR program was completed in December 2022. The 2018 CDBG-DR grant is on track to complete its last home by the end of 2023. Additional programmatic details may be found by viewing the 2015 Severe Storm, Hurricane Matthew, and Hurricane Florence CDBG-DR Action Plans.

Table 1.3: CDBG-DR Grants Administered by SCOR

Program	Grant Authority	Grant Amount
2015 Severe Storm	HUD CDBG-DR	$126 Million
2016 Hurricane Matthew	HUD CDBG-DR	$95 Million
2018 Hurricane Florence	HUD CDBG-DR	$72 Million

PALMETTO DISASTER RECOVERY (PDR)

Palmetto Disaster Recovery (PDR) is a disaster case-management effort that identifies applicants and monitors cases as they progress through the residential recovery (CDBG-DR) program. Disaster Case Management (DCM) is a process that involves a partnership between a disaster case manager and a citizen to develop and carry out an Individualized Recovery Plan that assists eligible citizens with their disaster-caused unmet needs. Case managers connect citizens with available resources and support services and follow up to monitor progress throughout the recovery process, Case managers average 300 client contacts a week. Between all three of the above disasters, PDR has served over 2,000 cases.

DISASTER RECOVERY RESERVE CORPS

In 2022, SCOR initiated the Disaster Recovery Reserve Corps (DRRC) to increase South Carolina's readiness and greatly reduce the time it takes to provide post-disaster assistance to residents impacted by disasters. The DRRC is comprised of a statewide trained team on standby to fill positions in the Disaster Case Management department in various areas including case management, construction, operations, development, outreach, eligibility, advocacy, and other various support positions. A DRRC team will be identified in each of the 46 counties in South Carolina. DRRC members will be activated based on the location of the disaster and the specific disaster response and recovery activities the State decides to deploy.

During Hurricane Ian, DRRC members were called upon to work in a temporary status for three weeks at Federal Emergency Management Agency (FEMA) Disaster Recovery Centers in Horry, Georgetown, and Charleston counties. Since they had already received training, the DRRC members were able to deploy rapidly to connect residents to available resources. Unlike in previous disasters, this new initiative not only accelerated the delivery of services, but it also reduced the time it took for impacted residents to recover from Hurricane Ian.

COMMUNITY DEVELOPMENT BLOCK GRANT – MITIGATION (CDBG-MIT)

HUD announced the allocation of Community Development Block Grant – Mitigation (CDBG-MIT) funds on April 10, 2018, but did not grant the funds until 2020. While South Carolina was originally allocated $157,590,000, in January 2020 HUD notified the State that it would receive $4,598,000 in supplemental CDBG-MIT grant funds, bringing the total State of South Carolina CDBG-MIT allocation to $162,188,000. The Mitigation program at SCOR uses CDBG-MIT funds for mitigation activities that will increase resilience to future disasters and reduce or eliminate long-term risk of loss of life, injury, damage to and loss of property, and suffering and hardship in 17 Most Impacted and Distressed (MID) counties (Figure 1.2) through four program areas: Infrastructure, Buyouts, Funds Match, and Plans & Studies (Table 1.4). South Carolina will spend a minimum of 50% of program funds on activities that benefit the LMI population. LMI status is determined by evaluating income as a percentage of the Area Median Income (AMI) in the county in which the person lives. To date, 66% of obligated funds meet this requirement. All funded activities in the program will meet a HUD national objective related to be benefitting LMI persons or meeting urgent mitigation needs. The program must be completed no later than May 2032. Additional programmatic details may be found in the South Carolina CDBG-MIT Action Plan.

Table 1.4 CDBG-MIT Program Areas

CDBG-MIT Program Area	Allocation
Infrastructure	$100 Million
Buyouts	$37.3 Million
Funds Match	$2.7 Million
Plans & Studies	$14 Million

AMERICAN RESCUE PLAN ACT FUNDS

The South Carolina General Assembly has allocated $100 million in American Rescue Plan Act (ARPA) State and Local Fiscal Recovery Funds (SLFRF) to SCOR. The funds must be used to complete stormwater infrastructure projects and acquisitions of property in the floodplain throughout the State to lessen the impacts of future flood events. In March 2023, SCOR selected 17 projects across 12 counties to receive funding totaling $45.8 million.

DISASTER RELIEF AND RESILIENCE RESERVE FUND

SCOR is responsible for managing the Disaster Relief and Resilience Reserve Fund (Reserve Fund). These funds may be used to develop, implement, and maintain the Strategic Statewide Resilience and Risk Reduction Plan, to provide disaster relief assistance, hazard mitigation, and infrastructure improvements as set forth in the statute (S.C. Code Ann. § 48-62-50 *et seq.*). The current fund value is approximately $244 million. This includes $200 million recently added to the Reserve Fund by the 2022-2023 state budget.

SOUTH CAROLINA RESILIENCE REVOLVING FUND

The South Carolina Resilience Revolving Fund (RRF) can be used for loans and grants to eligible recipients to purchase flooded properties, including structures and land, to complete floodplain restorations. The fund was initially capitalized with $6 million by the DRRA. Eligible recipients are limited to the State, local governments (or any agency, commission, or instrumentality thereof), and land trusts accredited by the Land Trust Accreditation Commission.

RESILIENCE PLANNING PROCESS

LEGISLATIVE GUIDANCE

The Disaster Relief and Resilience Act (DRRA) directs SCOR to develop, implement and maintain the Strategic Statewide Resilience and Risk Reduction Plan (Resilience Plan) and to coordinate statewide resilience and disaster recovery efforts including coordination with federal, state, and local governmental agencies, stakeholders, and nongovernmental entities. The Resilience Plan is intended to serve as a framework to guide state investment in flood mitigation projects. Additionally, the Resilience Plan recommends programs and policies to protect the people and property of South Carolina from damage and destruction of extreme weather events. The DRRA directed that the initial version of the plan be completed by July 1, 2022. During the 2022 legislative session, the deadline was extended to July 1, 2023 by budget proviso.

The DRRA outlines the minimum provisions which must be included in the Strategic Statewide Resilience and Risk Reduction Plan. The planning process for this initial plan focused on how to meet the following required provisions most efficiently:

1. Describe known flood risks for each of the eight major watersheds of the State.
2. Examine present and potential losses associated with the occurrence of extreme weather events and other natural catastrophes, and land management practices that potentiate extreme weather events, resulting in increased flooding, wildfires, and drought conditions.
3. Identify data and information gaps that affect the capacity of state agencies and local governments to adequately evaluate and address the factors that increase flood risk and recommend strategies to overcome such gaps.
4. Develop recommendations, at appropriate scale, including sub watershed or local government levels, to decrease vulnerabilities and adverse impacts associated with flooding. In developing these recommendations, the office shall, at a minimum, consider the following:
    a. Economic impact of best available projections related to the current and future risk or extreme weather events in this State.
    b. The long-term costs of specific projects or suites of flood mitigation projects or approaches.
    c. Opportunities to prioritize the role of nature-based solutions and other methods to restore the natural function of the floodplain.
    d. Possible benefits that may be achieved beyond flood reduction.
    e. Statutory or regulatory remedies for consideration by the General Assembly.
    f. Necessary state policies or responses, including alterations to state building codes and land use management, creation of additional programs or offices and

directions for the provision of clear and coordinated services and support to reduce impacts and increase resiliency.

   g. Potential financial resources available for increasing resiliency throughout this State.

5. Estimates of the number and cost of residential properties within the State for which floodplain buyout may be appropriate.
6. A strategy for providing resources, technical assistance, and other support to local governments for flood risk reduction action.
7. Plans for integrating recommended approaches to risk reduction into existing state strategies for hazard mitigation, environmental protection, and economic opportunity and development.
8. Opportunities for stakeholder input from citizens around the State.
9. Coordination of statewide disaster recovery efforts and activities and collaboration between federal, state, and local stakeholders.
10. Technical planning assistance for state and local governmental entities.
11. Grants to institutions of higher education and other state and local governmental entities to conduct research related to resilience concerns specific to South Carolina.

PLANNING SCALE

The DRRA dictates that SCOR assess risk within the eight major SCDHEC watersheds (Figure 1.3). SCOR recognizes that floods and other natural hazards do not coincide with political boundaries, including state boundaries, and as such this plan seeks to operate by hydrological boundaries.

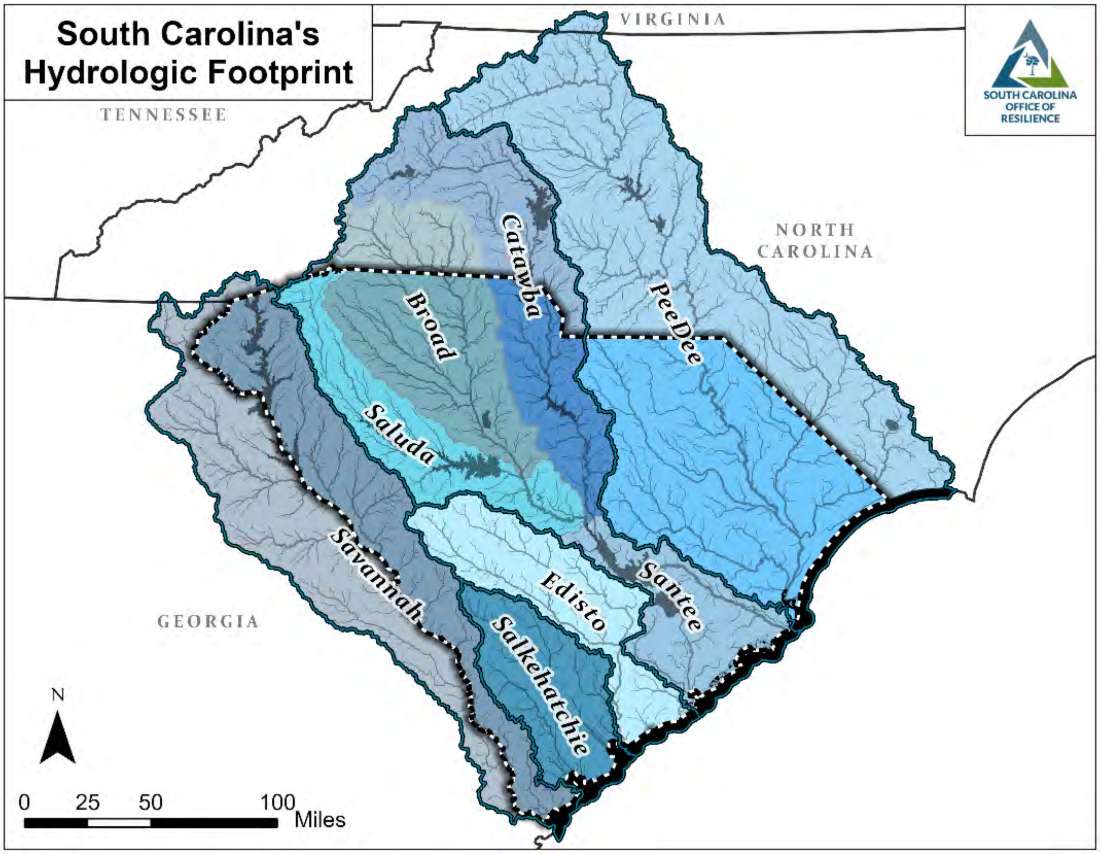


Figure 1.3: Hydrologic Footprint

DEFINING RESILIENCE

Resilience is a complex term, capturing multiple theories and concepts depending on who is giving the definition. Working with the Advisory Committee, SCOR has adopted the following definition of resilience, guiding our work on this plan:

> The ability of communities, economies, and ecosystems within South Carolina to anticipate, absorb, recover, and thrive when presented with environmental change and natural hazards.

Figure 1.4 and Figure 1.5 compare the difference in system function over time for a more resilient system and a less resilient system when face with environmental changes and natural hazards. Figure 1.5 show the more resilient system. Before an event, a resilient system is “anticipating,” heading into an event with a higher function than the less resilient system. When the event starts, the resilient system function decreases, but does not decrease as much as the less resilient system as it “absorbs’ the event. The resilient system then regains system function faster after the event ends, recovering to previous function and going beyond, reaching a level of system function higher than it had before, resulting in a “thriving” system.

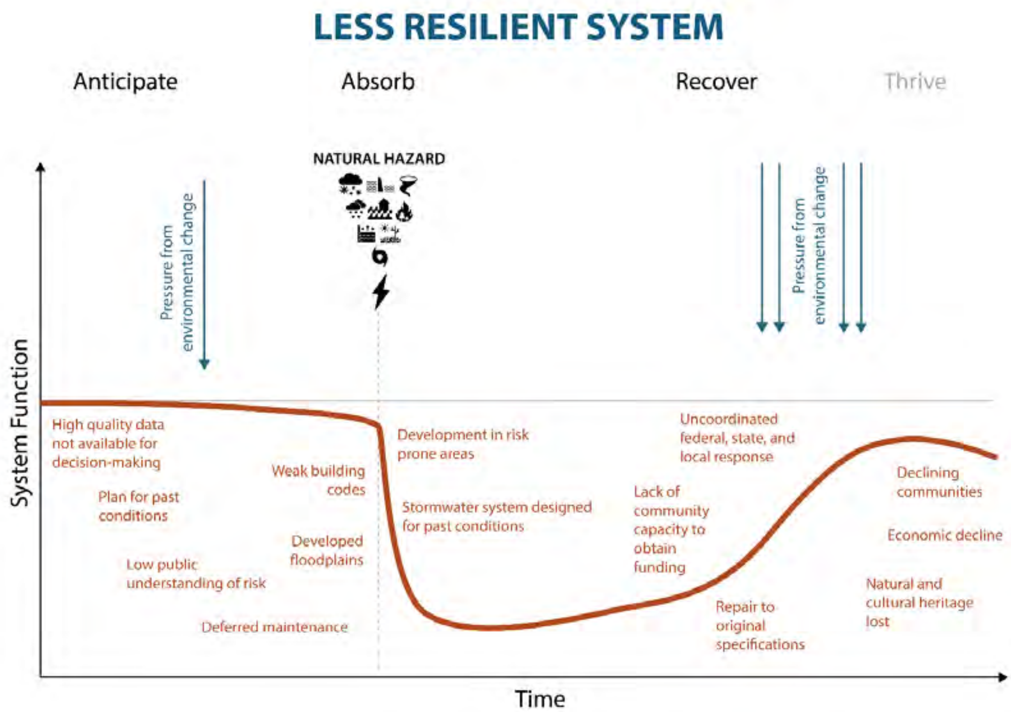


Figure 1.4: Less Resilient System Function

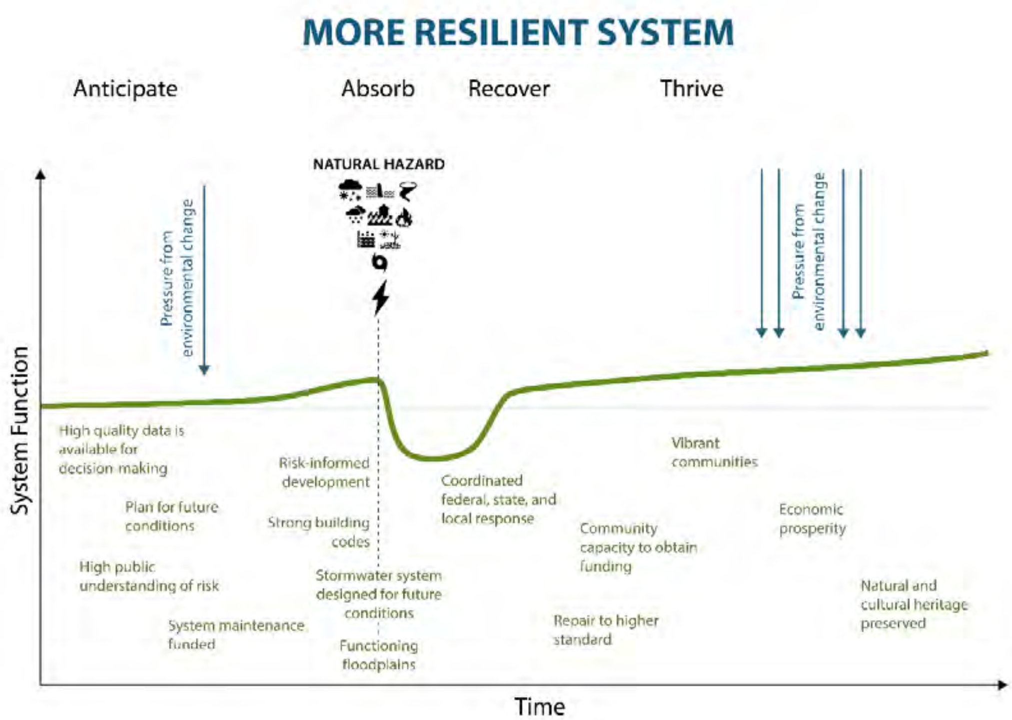


Figure 1.5: More Resilient System Function

TIMELINE

Below is the timeline of major activities completed in the planning process.

- **Advisory Committee Meetings (Fall 2021-Spring 2023):** Meetings of the legislatively created Resilience Plan Advisory Committee, made up of state agencies and other members added by SCOR to aid in the development of the plan.
- **Data Identification & Collection (Fall 2021-Spring 2022):** SCOR and partners coordinated for the identification and collection of data related to vulnerabilities and resilience from a variety of sectors.
- **Public Engagement Survey (Winter 2021-Present):** SCOR sought input from citizens around the state about their flooding experiences to inform this planning process through an online survey.
- **Subcommittee Meetings (January 2022-April 2022):** Stakeholders from a variety of sectors met to discuss available data & gaps, vulnerabilities, and recommendations on how to make their sector more resilient.
- **Virtual Office Hours and Video Q&A (Spring 2022)**: To answer questions about resilience, a web form and email address were created to allow citizens to submit questions, which were then answered in a series of short video responses. In addition to this Q&A, the Resilience team held weekly office hours, accessible by Zoom and phone, which allowed for more in-depth discussion with the public.
- **Draft Flood Vulnerability Assessment (Released Fall 2022):** A preliminary assessment of the current and future flood vulnerability of a variety of sectors in South Carolina.
- **Development of Recommendations/Strategies (Summer 2022-Spring 2023)**: Considering the data collected and vulnerabilities described, the Advisory Committee and ad hoc subcommittees worked with SCOR to determined what strategies should be recommended by the plan to decrease these vulnerabilities and make South Carolina more resilient.

COMMITTEES & WORKING GROUPS

ADVISORY COMMITTEE

To aid in the development of the Resilience Plan and coordinate efforts on a statewide level, the legislation created the Resilience Plan Advisory Committee, made up of state agencies, and directed SCOR to add members to the advisory committee as deemed necessary and proper, noting that all governmental agencies must cooperate with the Advisory Committee to fulfill its mission.

Section 48-62-40(A) of the legislation stated that the committee must be composed of the following agencies:

- **South Carolina Department of Natural Resources (SCDNR) (Robert Boyles Jr, Director):** SCDNR serves as the principal advocate for and steward of South Carolina's natural resources. The department's vision for South Carolina is an enhanced quality of life for present and future generations through improved understanding, wise use, and safe enjoyment of healthy, diverse, sustainable, and accessible natural resources (SC Department of Natural Resources, n.d.).
- **South Carolina Department of Insurance (DOI) (Michael Wise, Acting Director):** The department's mission is to protect the insurance consumers, the public interest, and the insurance marketplace by ensuring the solvency of insurers; by enforcing and implementing the insurance laws of this State; and by regulating the insurance in an efficient, courteous, responsive, fair, and equitable manner (SC Department of Insurance , n.d.).
- **South Carolina Department of Agriculture (SCDA) (Hugh Weathers, Commissioner of Agriculture):** The department promotes the growth and development of South Carolina's agriculture industry and its related businesses while assuring the safety and security of the buying public (SC Department of Agriculture, n.d.).
- **South Carolina Emergency Management Division (SCEMD) (Kim Stenson, Director):** The mission of this division is to lead the state emergency management program by supporting local authorities to minimize the loss of life and property from all-hazard events, with a vision to be an accomplished and innovate leader in emergency management that is ready, relevant, resilient, and responsive (SC Emergency Management Division , n.d.).
- **South Carolina Sea Grant Consortium (Susan Lovelace, Executive Director):** The consortium is an independent state agency whose purpose is to generate and provide science-based information on issues and opportunities to improve the social and economic well-being of our coastal residents while ensuring the optimal use and conservation of our marine coastal natural resources (South Carolina Sea Grant Consortium, n.d.).
- **South Carolina Department of Commerce (Harry M. Lightsey III, Secretary of Commerce):** From assisting with the location of new sites and buildings to offering grants for community development and infrastructure improvement, the South Carolina Department of Commerce helps grow new and existing businesses. Commerce also promotes economic opportunity for individuals and businesses through initiatives like workforce training (SC Department of Commerce, n.d.).

The legislation also states that in addition to the above, the Chief Resilience Officer may add members to the committee as deemed necessary and proper. The following organizations and agencies participated in the Advisory Committee:

- **Center of Resilience Excellence SC (CORE SC):** CORE SC is a consortium founded by the College of Charleston, the South Carolina Aquarium, and Charleston County Government. CORE SC focuses on implementing resilience best practices, feasible and deployable research and development, and economic development through innovative business strategies. CORE SC provides connections to resources and professional services to organizations and institutions who are developing solutions to resilience issues across the state (Center of Resilience Excellence South Carolina, n.d.).
- **City of Charleston Office of Resilience & Sustainability:** This office manages projects that advance the resilience of Charleston, defining resilience as the capacity of a community, business, or natural system to prevent, withstand, respond to, and recover from a disruption. Efforts to increase resilience to climate and non-climate impacts in Charleston are built on the foundation of understanding and reducing vulnerability (City of Charleston South Carolina, n.d.).
- **Municipal Association of South Carolina:** The association represents and serves the state's 271 incorporated municipalities and is dedicated to the principle of its founding members: to offer the services, programs, and tools that will give municipal officials the knowledge, experience, and tools for enabling the most efficient and effective operation of their municipalizes in the complex world of municipal government (Municipal Association of South Carolina, n.d.).
- **The Pew Charitable Trusts:** The Flood-Prepared Communities Project works to modernize flood insurance, mitigate disasters, prioritize flood ready infrastructure, and promote nature-based solutions (The Pew Charitable Trusts, n.d.).
- **South Carolina Association of Counties:** A nonprofit statewide organization that represents county government in South Carolina. It works to empower county officials through advocacy, education, and collaboration. Membership includes all 46 counties (SC Association of Counties, n.d.).
- **South Carolina Department of Archives and History (W. Eric Emerson, Director):** The mission of the Department of Archives and History is to preserve and promote the documentary and cultural heritage of the state through archival care and preservation, records management, public access, historic preservation, and education (SC Department of Archives and History, n.d.).
- **South Carolina Department of Health and Environmental Control (DHEC) (Dr. Edward Simmer, Director):** DHEC is charged with promoting and protecting the health of the public and the environment in South Carolina. The department consists of four divisions: environmental affairs, healthcare quality, public health, and operations (SC Department of Health and Environmental Control, n.d.).
- **South Carolina Department of Labor, Licensing and Regulation (LLR) (Emily Farr, Director):** The mission of the Department of Labor, Licensing and Regulation is to

promote the health, safety, and economic well-being of the public through regulation, licensing, enforcement, training, and education (SC Department of Labor, Licensing and Regulation, n.d.).

- **South Carolina Department of Parks, Recreation and Tourism (PRT) (Duane Parrish, Director):** This department is tasked with growing South Carolina's economy by fostering sustainable tourism economic development and effectively marketing our state to increase visitation and improve the quality of life for all South Carolinians. This is done by fostering and promoting the state's emerging tourism industry, protecting & promoting South Carolina state parks, and helping communities plan and develop recreational opportunities for residents (SC Department of Parks, Recreation & Tourism, n.d.).
- **South Carolina Department of Social Services (DSS) (Michael Leach, State Director):** The department serves the state by promoting the safety, permanency, and well-being of children and vulnerable adults, helping individuals achieve stability and strengthening families (SC Department of Social Services, n.d.).
- **South Carolina Department of Transportation (SCDOT) (Christy Hall, Secretary of Transportation):** SCDOT connects communities and drives our economy through the systematic planning, construction, maintenance and operation of the state highway system and the statewide intermodal transportation and freight system. It is SCDOT's vision to rebuild our transportation system over the next decade in order to provide adequate, safe and efficient transportation services for the movement of people and goods in the Palmetto state (South Carolina Department of Transportation, n.d.)
- **South Carolina Forestry Commission (SCFC) (Scott Phillips, State Forester & Executive Director):** The commission exists to protect, promote, enhance, and nurture the forest lands of South Carolina in a manner consistent with achieving the greatest good for its citizens (SC Forestry Commission, n.d.).
- **South Carolina Law Enforcement Division (SLED) (Mark Keel, Chief):** SLED provides manpower and technical assistance to law enforcement agencies and conducts investigations on behalf of the state as directed by the Governor and Attorney General (SC State Law Enforcement Division , n.d.).
- **South Carolina Office of Regulatory Staff, State Energy Office (Sara Bazemore, Director):** The State Energy Office provides a broad range of resources designed to help citizens, businesses, and public entities save energy through greater efficiency, better information, and enhanced environmental quality (State of South Carolina Office of Regulatory Staff, n.d.).
- **South Carolina Ports Authority (Barbara Melvin, President & CEO):** The South Carolina Ports Authority promotes, develops and facilitates waterborne commerce to meet the current and future needs of its customers, and for the economic benefit of the citizens

and businesses of South Carolina. SC Ports owns and operates numerous maritime terminals within the Charleston Harbor, the Port of Georgetown, Inland Port Greer and Inland Port Dillon. As a top 10 U.S. container port, SC Ports is known for efficiently run terminals, ample capacity, reliable service, and customer-centric operations (SC Ports Authority, n.d.).

- **State Housing Finance and Development Authority**: The State Housing Finance and Development Authority finances and supports affordable housing opportunities for South Carolina with a vision that all South Carolinians have the opportunity to live in safe, decent, and affordable housing. The agency provides financing through the sale of tax-exempt bonds and management of federally funded programs such as Housing Tax Credit (LIHTC), HOME Investment Partnerships (HOME) and State and National Housing Trust Funds (SC State Housing Finance and Development Authority, n.d.).
- **United States Army Corps of Engineers, Charleston District Office**: The Corps of Engineers delivers vital engineering solutions, in collaboration with partners, to secure our nation, energize the economy, and reduce disaster risk (US Army Corps of Engineers, n.d.).
- **University of South Carolina Hazards Vulnerability & Resilience Institute (HVRI):** HVRI is an interdisciplinary research and training center focused on the development of spatial analytical information, data, methods, and application for integrating hazard and climate information to advance equitable planning and management and adaptive capacity in communities (University of South Carolina, n.d.).

Table 1.5 shows the dates of the Advisory Committee meets from fall of 2021 to just before this plan was completed.

Table 1.5: Advisory Committee Meetings

August 12, 2021	March 10, 2022
September 9, 2021	April 14, 2022
September 30, 2021	May 12, 2022
October 21, 2021	July 19, 2022
November 10, 2021	October 26, 2022
December 2, 2021	January 25, 2023
January 13, 2022	April 19, 2023
February 10, 2022	June 7, 2023

SUBCOMMITTEES

To get broader statewide input on a variety of resilience related issues, six subcommittees of the Advisory Committee were created to focus on identifying data gaps, vulnerabilities, and risk reduction strategies in different sectors. Each subcommittee consists of representatives from the larger advisory committee as well as additional stakeholders from specific sectors.

- Environmental Systems Subcommittee
- Economic Systems Subcommittee
- Community Services Subcommittee
- Infrastructure Systems Subcommittee
- Building Codes and Zoning Subcommittee
- Cultural Resources Subcommittee

AD HOC COMMITTEES

Based on the work of the above subcommittees, new ad hoc committees were formed to further develop specific recommendations in identified areas. These groups focus on the following recommendation areas:

- Data Collection and Coordination
- Education, Outreach, and Property Disclosure
- Planning
- Zoning and Land Use
- Building Codes
- Community Services
- Critical Infrastructure Design
- Stormwater Design and Maintenance
- Recovery Coordination

CONSERVATION WORKING GROUP

The purpose of the workgroup is to identify conservation opportunities that would increase resilience to natural disasters in the state, prioritize areas for conservation, and identify potential funding to carry out those opportunities.

CLIMATE WORKING GROUP

SCOR worked with the SC State Climatology Office, the University of South Carolina, Carolinas Integrated Sciences and Assessments (CISA), and SC Sea Grant Consortium to develop a climate report specific to South Carolina that considers past, present, and future conditions. The resulting report can be found in Chapter 4 of this plan, Climate Trends.

MODELING TECHNICAL WORKGROUP

The Modeling Technical Workgroup has been created and tasked with inventorying existing models, identifying data gaps, making recommendations on modeling needs, and evaluating proposals for modeling improvements. SCOR is working with SCEMD, SCDNR Flood Mitigation Program, University of South Carolina, Clemson, Coastal Carolina University, Furman University, College of Charleston, NOAA, USGS, and others to better coordinate and complete the task of the workgroup.

LIMITATIONS/CONSTRAINTS

It should be noted that this initial plan was drafted in less than two years, with the first meeting of the Advisory Committee and the hiring of a Planning Director in August 2021. The timeline for completing this plan also coincided with the ongoing COVID-19 pandemic that limited SCOR's ability to engage the public in the planning process. Efforts were made to reach people electronically, and SCOR relied on partner agencies and organizations across the state to provide information through their networks.

SCOR also recognizes that this plan is not the sole authority on resilience planning. This plan builds on national, regional, state, and local work from public and private partners. S.C. Sea Grant Consortium has worked to compile a comprehensive survey of resilience-related planning efforts across South Carolina, including state agencies, counties, municipalities, non-governmental organizations, and colleges and universities. The data upon which our recommendations are based cannot guarantee exact future scenarios, and there is inherent uncertainty due to environmental and socioeconomic change. Information and recommendations in this plan need to be periodically reviewed to allow the plan to adapt to future conditions.

ACKNOWLEDGEMENTS

Below is a list of partners who participated in the above groups or in other supportive roles during the planning process. (* agency head)

Able South Carolina

- Mandy Halloran

American Flood Coalition

- Gian Tavares
- Jack Krolikowski
- Melissa Roberts*
- Tony McEwen

Audubon South Carolina

- Julia Dietz
- Nolan Schillerstrom
- Sam "Trip" King III

Beaufort County

- Juliana Smith
- Katie Herrera
- Rob Merchant

Buckeye Community Hope Foundation

- Aaron Bowman

Building Officials Association of South Carolina

- Shawn Brashear

Catawba Indian Nation (Tribal Historic Preservation Office)

- Dr. Wenonah Haire

Charleston County

- Jim Armstrong
- Kevin Limehouse (Center of Resilience Excellence SC)
- Luz Agudelo

Trident Association of Realtors

- Josh Dix

Citadel

- Scott Curtis

Citizen Center for Public Life

- Renee Chewning

City of Charleston Office of Resilience and Sustainability

- Dale Morris

Clemson University

- Cal Sawyer
- Christopher Post
- Dan Hitchcock
- Debabrata Sahoo
- Derrick Phinney
- Kim Morganello (Clemson Extension)
- Kim Roche (Warren Lasch Conservation Center)
- Jeff Allen
- Jeremy Pike
- Jon Marcoux
- Matt Smith
- Nathan Smith (Clemson Extension)
- Prakash Khedun
- Ravi Ravichandran
- Vidya Samadi

Coastal Carolina University

- Pam Martin
- Paul Gayes
- Till Hanebuth

College of Charleston

- Norman Levine

Congaree Land Trust

- Stuart White

Conservation Voters of South Carolina

- Rebecca Haynes
- Zachary Bjur

Dominion Energy

- Raymond Ammarell

Edisto Natchez Kusso Tribe of South Carolina

- Chief Andy Spell

FEMA Heritage Emergency Task Force

- Lori Foley

Francis Marion University

- Jeff Steinmetz

Furman University

- Geoffrey Habron

Gullah/Geechee Nation

- Queen Quet, Chieftess

Gullah Geechee Cultural Heritage Corridor

- Victoria Smalls

Historic Charleston Foundation

- Cashion Drolet

Individuals

- Carson Witte
- David Johnston
- Sarah Watson
- Lisa McQueen-Starling

Insurance Institute for Business & Home Safety

- Jada Charley
- Milad Shabanian

International Code Council

- Stephen Jones

Katawba Valley Land Trust

- Barry Beasley

Kershaw County

- Michael Conley

Longleaf Alliance

- Lisa Lord

Lowcountry Council of Governments

- Maleena Parkey
- Stephanie Rossi

Lowcountry Land Trust

- Ashley Demosthenes
- David Ray

Municipal Association of South Carolina

- Jenny Boulware
- Todd Glover

Muscogee Nation

- LeeAnne Wendt
- RaeLynn Butler

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Upstate Forever

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US Army Corps of Engineers

- Colt Bowles

Waccamaw Indian People

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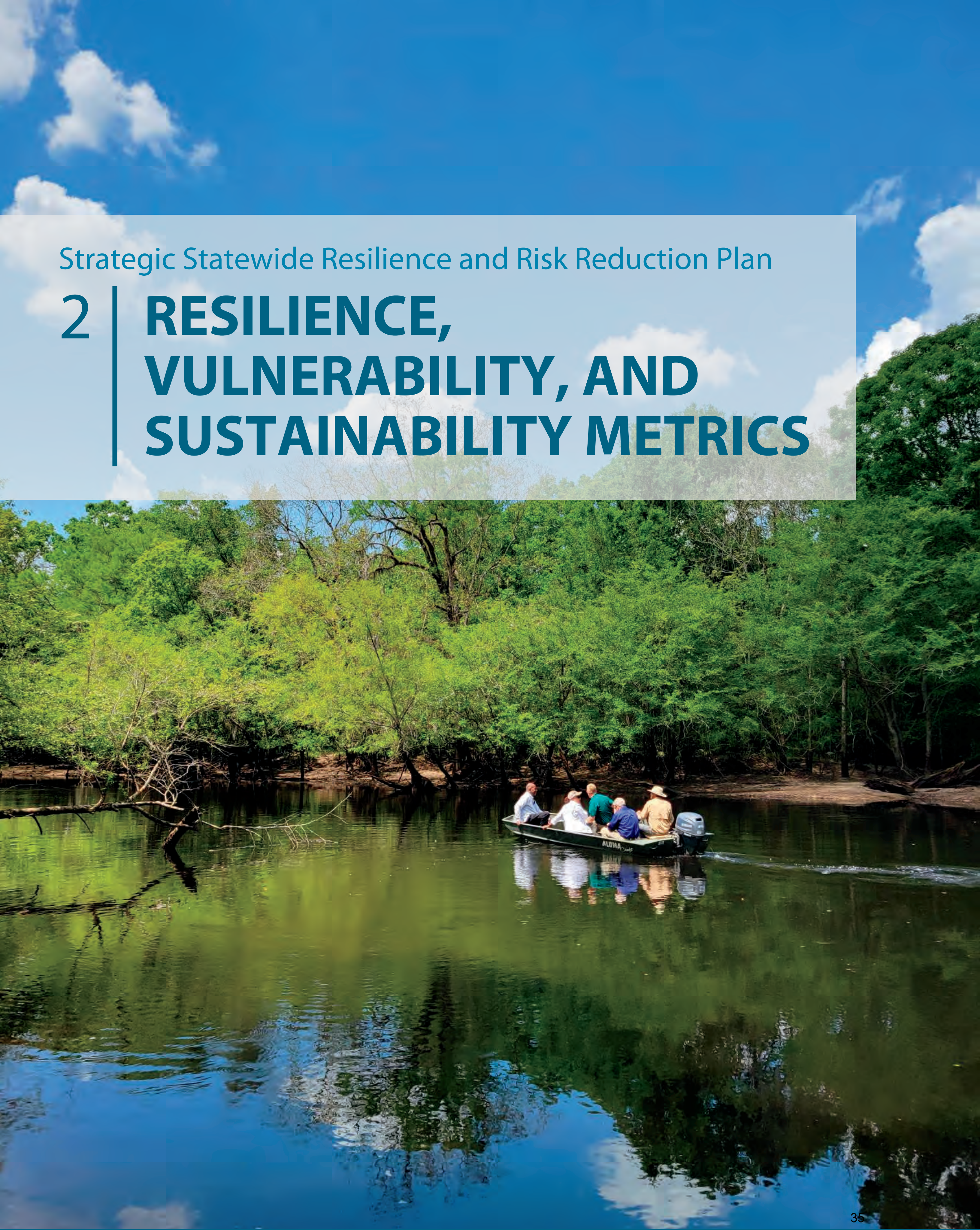
Strategic Statewide Resilience and Risk Reduction Plan

2 | RESILIENCE, VULNERABILITY, AND SUSTAINABILITY METRICS



OVERVIEW

This chapter explores the metrics used to measure resilience, vulnerability, and sustainability. The ability to measure resilience is key to ensuring that investments made are having the intended impact and maximize benefits to the communities, economies, and ecosystems of South Carolina over time. The metrics used for vulnerability and sustainability are closely related to resilience.

CONTENTS

KEY FINDINGS

- There is no dominant framework or standard for resilience measurement because communities are different in their physical, social, and built environment characteristics, disaster risk exposures, and capacities.
- SCOR has partnered with the Hazards and Vulnerability Research Institute (HVRI) at the University of South Carolina to construct two South Carolina-specific resilience metrics, one top-down and one bottom-up. The top-down metric will be used to measure the impacts of changes at the state level, highlighting those variables that are most relevant and actionable for South Carolina. The bottom-up metric will be designed specifically for local implementation within South Carolina.

RESILIENCE METRICS

SCOR partnered with the Hazards Vulnerability and Resilience Institute (HVRI) at the University of South Carolina to develop a report titled, "Evaluation of Existing Community Disaster Resilience Approaches and Tools to Support Resilience Planning Efforts" (Habets & Cutter, 2023). The report covers various resilience metrics and can be read in its entirety in Appendix C. The following are the key findings of the report:

- Vulnerability and resilience metrics are not the same as they measure different concepts.
- Top-down resilience metrics are best used for an initial filter or broad assessment of where more information on resilience and its drivers should be gathered.
- Bottom-up metrics can be employed most effectively after a top-down assessment narrows down study areas of interest.
- Bottom-up metrics can delve into specific communities to best target resilience programming and funding based on actionable information.

Building on this report, SCOR will continue to work with HVRI to develop South Carolina-specific metrics for use at the state and local level.

DEVELOPING SOUTH CAROLINA-SPECIFIC RESILIENCE METRICS

Building on the findings of the "Evaluation of Existing Community Disaster Resilience Approaches and Tools to Support Resilience Planning Efforts," SCOR has partnered with HVRI to construct two South Carolina-specific resilience metrics, one top-down and one bottom-up. The top-down metric is based on HVRI's Baseline Resilience Indicators for Communities (BRIC).

BASELINE RESILIENCE INDICATORS FOR COMMUNITIES (BRIC)

The BRIC index uses 49 variables across six broad capitals (or categories) of community disaster resilience:

- Human Well-Being/Cultural/Social: Physical attributes of populations, values, and belief systems
- Economic/Financial: Economic assets and livelihoods
- Infrastructure/Built Environment/Housing: Buildings and infrastructure
- Institutional/Governance: Access to resources and the power to influence their distribution
- Community Capacity: Social networks and connectivity among individuals and groups
- Environmental/Natural: Natural resource base and environmental conditions

BRIC is currently available at the county level and can be used to compare counties across the country to one another and to determine the specific drivers of resilience and to monitor improvements in resilience over time (Hazards Vulnerability & Resilience Institute, 2023).

DEVELOPMENT OF A SOUTH CAROLINA SPECIFIC TOP DOWN METRIC (CUSTOM BRIC)

The first of the two metrics HVRI and SCOR are developing is a custom and actionable top down resilience metric specifically for the state of South Carolina.

The metric will use the existing BRIC framework and six capitals but emphasize and add datasets that are most relevant and actionable for South Carolina, while omitting datasets that are unactionable or only useful in regional or national metrics. This assessment will allow for analysis and comparison at both the county and census tract level to better target the subjects and locations of resilience building efforts.

This metric will be used to track statewide trends after the completion of this plan and implementation of plan recommendations, informing the update of the plan and the implementation of further resilience projects, programs, and policies across the state.

DEVELOPING A COMMUNITY LEVEL RESILIENCE INDEX FOR SOUTH CAROLINA

While the top down South Carolina specific BRIC will be designed for state tracking and implementation, the custom bottom up approach in development will be designed for local implementation within South Carolina.

Measuring resilience for the purposes of resilience planning at the local level to inform the implementation of projects, programs and policies that increase resilience can be difficult. There is no single metric that can tell a community everything they need to know about an area's resilience, and top down metrics should be critically assessed before applying to a specific subject area (Jones, 2018).

In addition to the above issues of using top down metrics for local implementations, there are also gaps in the available bottom up approaches. There are several bottom up metrics that may be applicable and useful in specific areas of the state, such as coastal, rural, or post-disaster communities. HVRI and SCOR are working together to develop a tool that will allow individual communities across the State to undertake a process of looking at their resilience designed with their use in mind, to lead to actionable outcomes.

This custom tool will be refined and utilized along with community engagement through the watershed-based resilience planning process to measure baseline conditions, identify needs, and allow for the monitoring of resilience planning and implementation outcomes at the local level.

OTHER RESILIENCE RELATED CONCEPTS

VULNERABILITY & SUSTAINABILITY

While the concepts of vulnerability, sustainability and resilience are overlapping and interwoven, they are not the same, nor do they predict each other. For example, increased social vulnerability does not always indicate decreased resilience, with the two being different empirical and conceptual constructs (Cutter, Ash, & Emrich, 2014).

SOCIAL VULNERABILITY

Social vulnerability can be described as "a measure of both the sensitivity of populations to natural hazards and its ability to respond to and recovery from the impacts of hazards" (Cutter & Finch, 2008).

Social vulnerability is a product of social and place inequalities resulting in differential harm and ability to respond to different population groups. This is distinct from resilience, which encompasses the everyday qualities of a community that may enhance its ability to prepare for, respond to, and recover from hazard events (Habets & Cutter, 2023).

SOVI

The Social Vulnerability Index (SoVI®), compiled and processed by HVRI, measures the social vulnerability of counties in the United States, providing information on "where there is uneven capacity for preparedness and response and where resources might be used most effectively to reduce pre-existing vulnerability" using 29 socioeconomic variables (University of South Carolina). Total scores, percentiles, and individual scores for each component are available to allow for specific analysis about what demographics drive local vulnerability.

SVI

The CDC/ATSDR Social Vulnerability Index is a measure developed by the Centers for Disease Control and Prevention's (CDC) Agency for Toxic Substances and Disease Registry to "help emergency response planners and public health officials identify and map communities that will most likely need support before, during, and after a hazardous event on a Census tract level, ranking tracts on 15 factors in four themes: socioeconomic status, household composition, race/ethnicity/language, and housing/transportation" (Centers for Disease Control, 2020).

ENVIRONMENTAL JUSTICE (JUSTICE40)

Justice40 is an environmental justice initiative with the goal of directing 40% of climate and clean infrastructure federal investments to disadvantaged communities. In May 2021, South

Carolina legislators were the first in country to introduce a bill in response to the federal Justice40 initiative, but it did not pass during the 2021 session (UCLA Luskin Center for Innovation, 2021).

The Climate and Economic Justice Screening Tool, a new tool by the White House Council on Environmental Quality, aims to help Federal agencies identify disadvantaged communities, ensuring that the benefits of existing and new programs under the Inflation Reduction Act, Bipartisan Infrastructure Law and the American Rescue Plan flow to disadvantage communities and advance environmental justice (The White House, 2023).

COASTAL VULNERABILITY

CVI

The Coastal Vulnerability Index (CVI) proposed is an integrated coastal vulnerability assessment framework that considers both biophysical and socio-economic dimensions. the proposed CVI for coastal systems can (1) measure the degree of vulnerability where the system is exposed to biophysical hazards, and (2) measure the degree of socio-economic and ecological vulnerability of exposed places (Tanim, Goharian, & Moradkhani, 2022).

The CVI uses 5 vulnerability groups that include a total of 20 vulnerability indicators.

1. Hydroclimate: number of coastal hazard events, hurricane track density, surge height, and rainfall intensity.
2. Physical: land use, available water storage, elevation, distance from coast
3. Socio-economic: SoVI, number of historical and archeological structures, cost of fatalities
4. Ecological: species richness, shellfish harvesting, turtle
5. Shoreline: rate of shoreline change, tide range, significant wave height, coastal slope, and beachfront stability.

Two CVIs were developed using a Multi-Criteria Decision-Making method. CVI-50 uses average conditions (50th percentile weight) while CVI-90 considers extreme conditions (90th percentile weight). Coastal vulnerability was also calculated using a data-driven Probabilistic Principal Component Analysis. Maps for each of these methods are below (Figure 2.1).

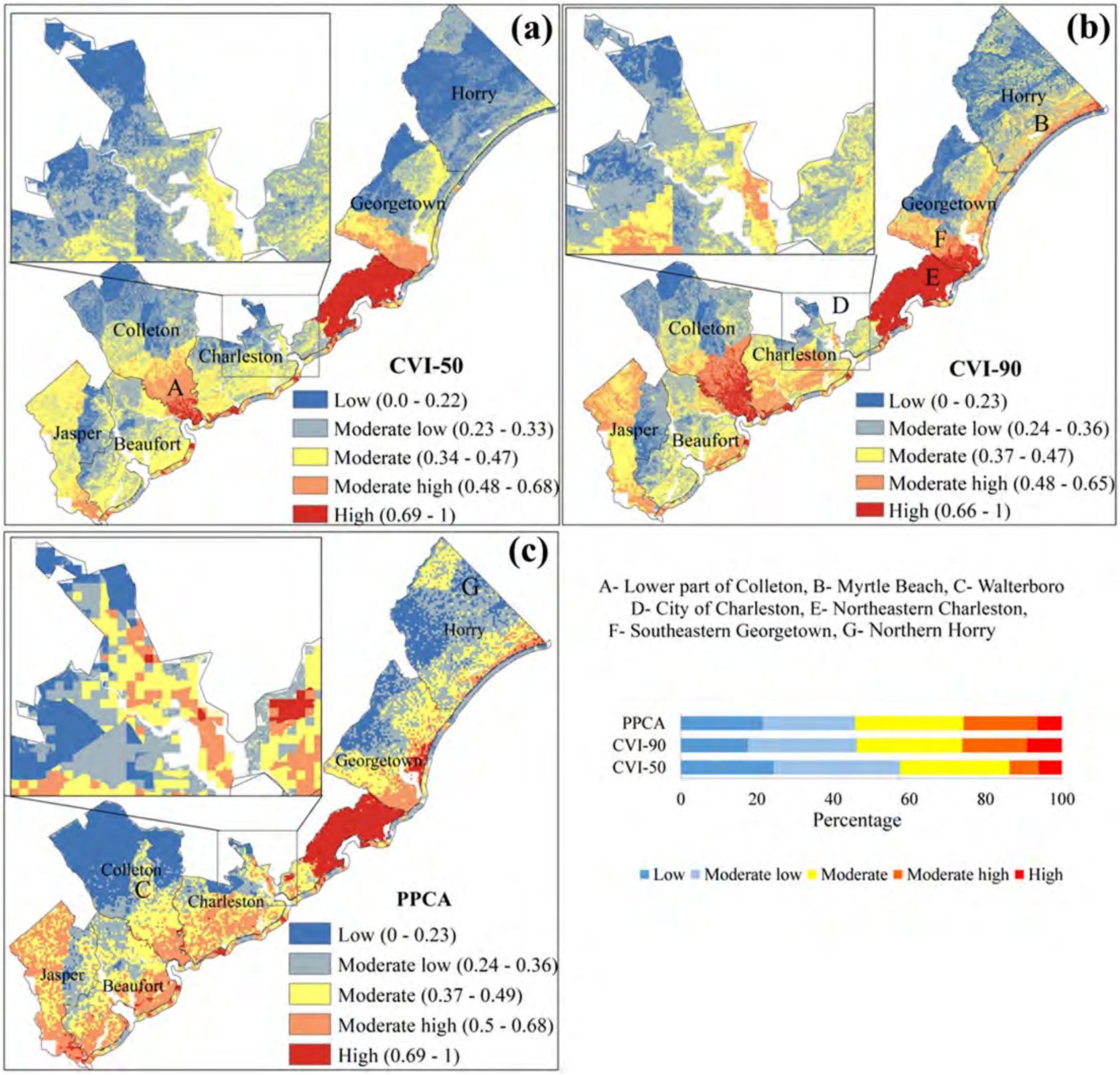


Figure 2.1: Comparison of CVI-50, CVI-90 and the Probabilistic Principal Component Analysis for the South Carolina coast

SENDAI FRAMEWORK FOR DISASTER RISK REDUCTION

The Sendai Framework advocates for the substantial reduction of disaster risk and losses in lives, livelihoods, and health and in the economic, physical, social, cultural, and environmental assets of persons, businesses, communities, and countries. It has 4 priorities:

1. Understanding disaster risk
2. Strengthening disaster risk governance to manage disaster risk
3. Investing in disaster risk reduction for resilience
4. Enhancing disaster preparedness for effecting response and to build back better in recovery, rehabilitation, and reconstruction

The framework addresses the three dimensions of disaster risk: exposure to hazards, vulnerability and capacity, and hazard's characteristics); through seven global targets and 38 indicators to measure progress towards those goals (United Nations Office for Disaster Risk Reduction, n.d.). This framework works hand in hand with the Sustainable Development Goals, with monitoring of the Sendia Framework indicators complementing the monitoring of 11 of the Sustainable Development Goals indicators (United Nations Office for Disaster Risk Reduction, n.d.).

SUSTAINABLE DEVELOPMENT GOALS

The Sustainable Development Goals is an international measure of sustainability and "connects state efforts to broader, international movements for an environmentally, socially, and economically just world, and supports an interdisciplinary approach to understanding state progress" (Lynch & Sachs, 2021). South Carolina ranks 37th nationwide on the SDG Index, with a score of 39.5. Of the 17 goals, SC scores in the areas of No Poverty, Good Health & Well-Being, Clean Water & Sanitation, and Industry/Innovation/Infrastructure are decreasing.

SCOR is participating in an effort led by Sustain SC to understand and improve South Carolina's ranking in the SDG Index. The effort includes representatives from South Carolina's business and conservation communities.

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Strategic Statewide Resilience and Risk Reduction Plan

3 | PLANNING CONDITIONS

OVERVIEW

The Disaster Relief and Resilience Act (2020) directs the South Carolina Office of Resilience (SCOR) to develop, implement and maintain the Strategic Statewide Resilience and Risk Reduction Plan (Resilience Plan). This plan is intended to serve as a framework to guide state investment in flood mitigation projects and the adoption of programs and policies to protect the people and property of South Carolina from the damage and destruction of extreme weather events. This chapter provides an overview of the current and projected future conditions that must be considered in planning for resilience, including climate, land use, population and demographic trends that influence the risk and vulnerability of South Carolina's communities, economies and ecosystems.

CONTENTS

KEY FINDINGS

- South Carolina's hydrological footprint consist of eight major river basins: Broad, Catawba, Edisto, Pee Dee, Salkehatchie, Saluda, Santee, and Savannah. The hydrologic footprint extends beyond state boundaries, and includes those basins shared with neighboring states.
- There are eight major aquifers that are recharged by surface water that falls on permeable surfaces like the Sandhill region of South Carolina. The deeper aquifers are used for larger withdrawers, while the surficial aquifer is mostly used for minor withdrawers like private drinking water supply and smaller irrigation operations.
- Septic systems can be impacted by changes in the water table elevation caused by increased precipitation and or sea level rise.
- Urban and developed areas can experience flooding as natural systems are changed into non-permeable surfaces due to the change in land coverage. Developed settings decrease the storage capacity to the system and discharges water faster into the waterways.
- Changes in land uses at the wildland-urban interface can increase wildfire risk. In short, changing land use can put new development areas and existing areas at an increased risk for natural hazards.
- South Carolina's Population has increased to over 5.1 million people from an estimated 2.5 million in 1970 people in 1970.
- Population growth is expected to continue with the population reaching 6.2 million people by 2035.
- The explosive population growth in South Carolina is regionally disproportionate. Population growth has centered around coastal counties and urban areas. Many rural areas especially along the I95 corridor are experiencing population declines.

LAND USE, POPULATION, & DEMOGRAPHIC TRENDS AND PROJECTIONS

Planning must consider the role of physical characteristics of the environment as well as the role of the built environment on risk, vulnerability and resilience.

From an environmental perspective, this section contains an overview of South Carolina's physiography, river basins, soil and land cover. Concerning land use, studies indicate that "without policies to direct new development into safer areas, the contribution of population growth to future US flood risk exceeds that of climatic changes" due to the combination of an intensified hazard and increased exposure (Wing, et al., 2022).

This section considers the population and demographic trends and projections to understand how many people are at-risk and what areas and populations are most vulnerable to environmental changes and natural hazards.

LAND ACKNOWLEDGEMENT

The South Carolina Office of Resilience would like to gratefully acknowledge and pay respect to the Indigenous inhabitants of the land on which we work and live. Since time immemorial Tribes inhabited, protected, and preserved these lands. We respect their histories and the strong cultural ties that they maintain to the land. We also gratefully acknowledge and pay respect to the Gullah/Geechee people – descendants of those enslaved and a vibrant culture currently living in South Carolina.

Table 3.1 South Carolina's Recognized Native American Indian Entities (SC Commission for Minority Affairs)

Federally Recognized Resident Tribes	State Recognized Tribes	State Recognized Groups
Catawba Indian Nation	Beaver Creek Indians	Chaloklowa Chickasaw Indian People
	Edisto Natchez-Kusso Tribe of South Carolina	Eastern Cherokee, Southern Iroquois and United Tribes of South Carolina
	Pee Dee Indian Nation of Upper South Carolina	Natchez Tribe of South Carolina
	Pee Dee Indian Tribe	Pee Dee Indian Nation of Beaver Creek
	Piedmont American Indian Association	
	The Santee Indian Organization	
	Sumter Tribe of Cheraw Indians	
	The Waccamaw Indian People	
	The Wassamasaw Tribe of Varnertown Indians	

Table 3.2

Federally Recognized Tribal Nations with Ties to South Carolina	
Absentee-Shawnee Tribe of Indians of Oklahoma	Alabama-Quassarte Tribal Town
Eastern Band of Cherokee Indians	Cherokee Nation
Kialegee Tribal Town	Eastern Shawnee Tribe of Oklahoma
Muscogee (Creek) Nation	Miccosukee Tribe of Indians of Florida
Santee Sioux Nation (Santee Sioux Tribe of the Santee Reservation of Nebraska)	Poarch Band of Creek Indians
Thlopthlocco Tribal Town	Shawnee Tribe
United Keetoowah Band of Cherokee Indians of Oklahoma	Tuscarora Nation

PHYSIOGRAPHY AND RIVER BASINS

The United States Geological Survey (USGS) and South Carolina Department of Natural Resources (SCDNR) have mandates to study and describe the geologic, geomorphic, and hydrologic setting of South Carolina. Both have extensive descriptions of the hydrology and geology in the state that can be readily retrieved from the appropriate sources.

The state has three major physiographic provinces, the Blue Ridge, Piedmont, and Coastal Plain (Figure 3.1). The Blue Ridge is a small province in the northwestern portion of the state that is identified by elevations ranging from 1,000 to 3,300 feet and high slope. The Piedmont is in the central western portion of the State and is 450 to 1,000 feet above sea level with undulating terrains, albeit lower relief than the Blue Ridge, which has less energetic riverine flow. The Fall Line is the transitional boundary for the Coastal Plain, located in the eastern portion of the State. The Coastal Plain is described by low slope, topographic relief between 0 to 450 feet above sea level.

South Carolina has eight major river basins, whose main rivers and numerous tributaries comprise of 30,000 miles of waterways that drain 20-million acres of land into the Atlantic Ocean. These major river basins are: Broad, Catawba, Edisto, Pee Dee, Salkehatchie, Saluda, Santee, and Savannah (Table 3.2). It should be noted that the hydrologic footprint extends beyond state boundaries, and includes those basins shared with neighboring states. Only three of the basins' drainage is exclusively in South Carolina, the other five drain areas within Georgia and North Carolina. In 2013, the Department of Natural Resources (DNR) published a detailed report of the river basins in South Carolina (SC Department of Natural Resources, 2013).

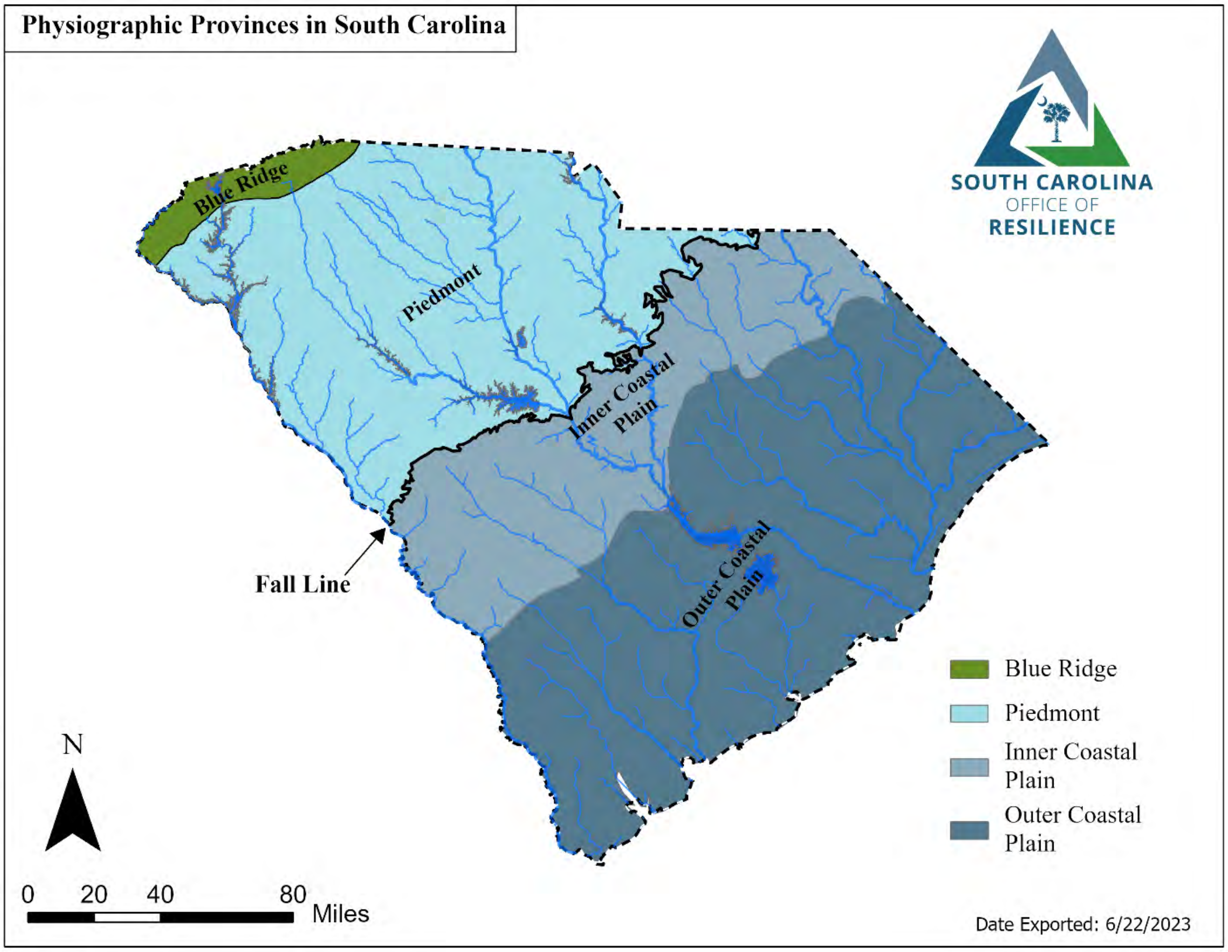

Figure 3.1: Physiographic Provinces of South Carolina (SCDNR)

RIVER BASINS

Drainage basins are the geographical extend of land where the water will flow and drain into the rivers and tributaries. Basins and watersheds are identified by hydrologic unit codes (HUC), starting with a 2-digit code that designates region down to subwatershed 12-digit HUC. At the HUC6 Basin designation, there are 4 basins in South Carolina. SCDHEC identifies 8 river basins, splitting the Santee Basin that drains the central part of the state into 4 separate subbasins (Figure 3.2)(SC Department of Natural Resources, 2013). It should be noted that the hydrologic footprint extends beyond state boundaries, and includes those basins shared with neighboring states. The eight SCDHEC basins are described by SC Department of Natural Resources (SCDNR, 2013) and are summarized below and in Table 3.3.

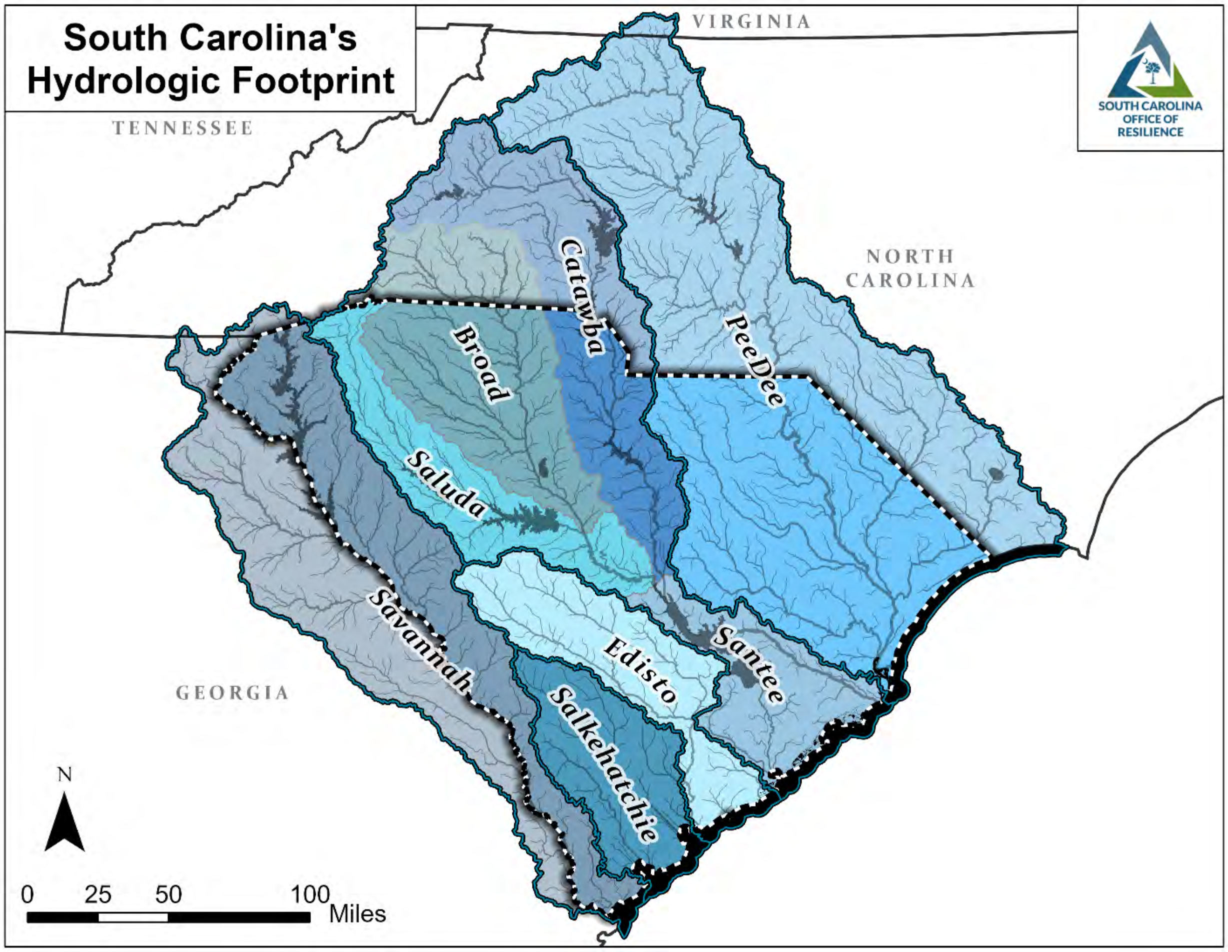

Figure 3.2: SCDHEC extended eight river basins of South Carolina, HUC 8 Basins

Table 3.3: Basin Extents as described in SCDNR (2013) river basin report.

Basin	Area (Square Mile)	Area in SC (Square Mile)	PERCENTAGE in SC	Percentage of SC covered by Basin
Broad	5,308	3,794	71.5%	12.0%
Catawba	5,612	2,323	41.4%	7.3%
Edisto	3,607	3,607	100.0%	11.4%
Pee Dee	18,868	7,854	41.6%	24.8%
Salkehatchie	3,006	3,006	100.0%	9.5%
Saluda	3,213	3,212	100.0%	10.1%
Santee	2,950	2,950	100.0%	9.3%
Savannah	10,972	4,955	45.2%	15.6%

EDISTO RIVER BASIN

The Edisto River basin is in south central South Carolina, including portions of Aiken, Bamberg, Barnwell, Berkeley, Calhoun, Charleston, Dorchester, Edgefield, Lexington, and Saluda Counties, and most of Colleton and Orangeburg Counties. The Edisto River basin is approximately 3,607 square miles and is wholly in South Carolina, covering about 11.4 percent of South Carolina (Table 3.3).

The Edisto River basin contains four major tributary streams: South Fork Edisto River, North Fork Edisto River, Edisto River, and Four Hole Swamp (University of South Carolina, 2022). The Edisto River basin reaches inland into the Coastal Plain region via the North Fork and South Fork. Four Hole Swamp is a blackwater river in the coastal zone and is a braided river system where the main channel is poorly defined. The low-lying nature of the Edisto River basin means that much of the basin is swamplands and becomes tidally influenced near the coast. The North Fork and South Fork of the Edisto River is primarily fed by groundwater discharge in the upper Coastal Plain region. This allows for consistent flows in drought times, as seen in 2011-2013.

PEE DEE RIVER BASIN

The Pee Dee River basin extends from a small section of Virginia, through North Carolina, enters South Carolina in the Northeast section of the state near the coastal plains and discharges into the Atlantic Ocean in Winyah Bay near Georgetown, SC and covers approximately 18,868 square miles (Table 3.3). In South Carolina, the Pee Dee Basin covers 7,854 square miles, or 24.8 percent of the state (Table 3.3), making it the largest basin in the State. The basin includes all or parts of 14 counties: Chesterfield, Clarendon, Darlington, Dillon, Florence, Georgetown, Horry, Kershaw, Lancaster, Lee, Marlboro, Marion, Sumter, and Williamsburg Counties (University of South Carolina, 2022).

The Pee Dee River is the main river in the basin with major tributaries including the Little Pee Dee and Lynches Rivers. The majority of the basin (48.4 percent) is in North Carolina. In North Carolina, the Pee Dee River has six reservoirs with the last, Blewett Falls Lake, being near the South Carolina state border. In South Carolina, the Pee Dee River basin is free flowing and has four main tributaries: the Black, Little Pee Dee, Lynches, and Waccamaw Rivers.

The Black River is the southernmost river in the basin. It is a coastal river is bordered with extensive swamplands. Pocotaligo River, Scape Ore Swamp, Pudding Swamp, and Black Mingo Creek are the tributaries that feed into the Black River and have poorly defined and meandering stream channels. The Black River outlets directly into the Winyah Bay.

The Little Pee Dee River and a major tributary, the Lumber River, have their headwaters in the Sandhills region of North Carolina. The Lumber River runs north to south and passes through Nichols, SC, which has experienced devastating flooding in the last few years and converges with the Little Pee Dee River soon after. The Little Pee Dee River flows through Dillion and Marion Counties and after the convergence with the Lumber River, flows through Horry County through Galivants Ferry and Aynor. The Little Pee Dee River converges with the Great Pee Dee at the border of Georgetown, Horry, and Marion counties.

The Lynches River system extends inland through Kershaw, Lee, Darlington, and Florence before converging with the Great Pee Dee River. The tributaries include the Little Lynches River, Bay Swamp, Lake Swamp, and Sparrow Swamp.

The Waccamaw River is the major coastal river in the Pee Dee River basin. The headwaters are in North Carolina at Lake Waccamaw and flows southward across Horry County, converging with the Intercoastal Waterway and Sampit River before emptying into Winyah Bay.

SALKEHATCHIE RIVER BASIN

The Salkehatchie River basin consist of the Salkehatchie, Little Salkehatchie, Coosawhatchie, and Ashepoo Rivers. It is wholly contained within South Carolina and is approximately 3,006 square miles in area, covering about 9.5 percent of the South Carolina (Table 3.3). It includes parts of Aiken, Allendale, Bamberg, Barnwell, Beaufort, Colleton, Hampton, and Jasper Counties (University of South Carolina, 2022).

The Salkehatchie and Little Salkehatchie Rivers drain the tidally influenced Combahee River, while the Coosawhatchie River drains into the tidally influenced Broad River. The basin discharges into a tidal saltwater river that also receives drainage from surrounding marshlands and estuarine waters around St. Helena Sound and Port Royal Sound.

SANTEE RIVER BASIN

As noted above, DHEC splits the Santee Basin that drains the middle portion of the state into 4 separate subbasins, identifying the 4 sub-basins that flow into it: The Broad, Catawba, Lower Santee and Saluda. This basin flows from the mountains at the boarder of South Carolina and North Carolina all the way to the ocean in Charleston, SC. The waterways change dramatically across the basin from high energy mountain streams and rivers to broad braided channels in the marsh system at the coast. The sub-basins are described individually below.

BROAD RIVER BASIN

The Broad River basin is 5,308 square miles, with 3,794 square miles of it in South Carolina (Table 3.3) (University of South Carolina, 2022). It is in the northwestern part of the state sharing a section of the NC border. The Broad River's headwaters are in North Carolina and then flows into South Carolina where three major tributaries, the Pacolet, Tyger, and Enoree Rivers, converge into the main stem. Areas within Columbia, Gaffney, Greer, Spartanburg, Union, Winnsboro, and York are included within the basin. There are three reservoirs in the basin: Lake Monticello, Parr Shoals Reservoir, and Lake William C. Bowen.

CATAWBA RIVER BASIN

The Catawba basin has an orientation roughly North – South and matches the course of the Catawba-Wateree River from the North Carolina border south to the confluence with the Congaree River near Columbia, SC. The basin has an area of approximately 5,612 square miles, with 2,323 square miles or 41.4 percent in the state of South Carolina and is 7.3 percent of the State's total area (Table 3.3) (University of South Carolina, 2022).

The Catawba and Wateree rivers are the major hydrologic features in the basin with several smaller tributaries that feed into these two rivers. The Catawba River's headwater and a majority of the river's watershed (58.6 percent) is in North Carolina. In the upper reaches, the tributaries include: Fishing Creek, Rocky Creek, Big Wateree Creek, Sugar Creek, and Cane Creek. The Catawba River flows into the Lake Wateree in Kershaw, Fairfield, and Lancaster counties. At the outlet of Lake Wateree, the Catawba River's name changes to the Wateree River. Below Lake Wateree, tributaries along Wateree River include: Spears Creek, Colonels Creek, and Swift Creek.

Within the Catawba River Basin, there are eleven hydroelectric reservoirs, six in North Carolina and five in South Carolina. All eleven reservoirs are owned and operated by Duke Energy. Due to this, the flow of the Catawba – Wateree River's is regulated and managed through releases and holding water.

LOWER SANTEE

The Lower Santee River basin is one of the smaller basins in South Carolina, covering only 2,950 square miles, about 9.3 percent of South Carolina (Table 3.3), covering portions of Berkeley, Calhoun, Charleston, Clarendon, Dorchester, Georgetown, Orangeburg, Sumter, and Williamsburg counties (University of South Carolina, 2022). The upper portion of the basin is formed at the confluence of the Congaree and Wateree Rivers that then flow into Lake Marion and subsequently Lake Moultrie. Lake Marion and Lake Moultrie are both dam controlled, and discharges are maintained by Santee Cooper. Lake Moultrie is connected to the ocean by the Santee River and the Cooper River.

The Santee River flows oceanward along the northern boundary of the basin. The river splits into the North Santee River and the South Santee River about 10 miles from the coast and run parallel until they meet at Santee Bay at the Atlantic Ocean. Tidal impacts are measured on the Santee as far up as Jamestown, SC USGS Station 02171700 prior to splitting into the

North and South Santee. The outlet at Santee Bay and South Santee River is bordered by Winyah Bay to the north, the outlet of the Pee Dee basin, and Bulls Bay and surrounding marshes to the south.

The Tailrace Canal connects Lake Moultrie with the West Branch Cooper River. The Cooper River flows into the majority of the coastal portion of the basin and connects with the Ashley and Wando Rivers meeting the ocean at the Charleston Harbor. This section is tidally influenced and has a complex system of marshes and tidal creeks at the Atlantic Ocean.

SALUDA RIVER BASIN

The Saluda River basin is in the western-central portion of the state. It is wholly within South Carolina and covers 3,212 square miles and 10.1 percent of South Carolina (Table 3.3). It originates in the Blue Ridge and Piedmont portion of South Carolina and flows northwest to southeast where it terminates at the convergence of the Catawba basin and it converts into the Santee River basin. The Saluda River Basin passes through Abbeville, Aiken, Anderson, Calhoun, Edgefield, Greenville, Greenwood, Lexington, Laurens, Newberry, Pickens, Richland, and Saluda Counties (University of South Carolina, 2022).

The northwestern part of the basin flows into Lake Greenwood and then Lake Murray with the tributaries of the Bush, Little, Little Saluda, Rabon and Reedy River feeding into the Saluda River as it passes through these reservoirs. Below Lake Murray, the Saluda converges with the Broad River and shortly forms into the Congaree River in Columbia. Along with these large rivers, Cedar Creek, Congaree Creek, Gills Creek, and Toms Creek feed into the Congaree River before its outlets into Lake Marion in the Santee River basin.

SAVANNAH RIVER BASIN

The Savannah River basin follows the Savannah River that is the western border with Georgia. The basin is 10,972 square miles, with 15.6 percent, or 4,955 square miles (Table 3.3), in South Carolina. It passes though Abbeville, Anderson, Beaufort, Edgefield, Greenwood, Pickens, Saluda, Aiken, Allendale, Barnwell, Hampton, Jasper, McCormick and Oconee Counties (University of South Carolina, 2022).

The Savannah River is the main river in the basin and is fed by Chattooga River, Twelve Mile Creek, Rocky River, Little River, Stevens Creek, Horse Creek, Upper Three Runs Creek, and Lower Three Runs Creek on the South Carolina side. The Savannah River has six large reservoirs for hydroelectric power that control discharges throughout the basin.

GROUNDWATER

Groundwater is a resource that is used across South Carolina for private and public drinking water, irrigation, power supply, and other industrial sectors. Although there are groundwater resources throughout the state, the upstate region is mostly crystalline rock and groundwater moves very slowly. Moving towards the coast, the coastal plain of the state is where the majority of the groundwater resources are available. There are eight major aquifers (Figure 3.3) that are managed and monitored by DHEC and SCDNR. The aquifers are recharged by surface water that falls on permeable surfaces like the Sandhill region of South Carolina. The deeper aquifers are used for larger withdrawers, while the surficial aquifer is mostly used for minor withdrawers such as private drinking water supply and smaller irrigation operations. The surficial aquifer can be more easily impacted by contamination due to the unconfined nature and influence from surface water, river stage, and tides (Gellici & Lautier, 2010).

Septic systems are often placed above the surficial aquifer and rely on the natural processes to treat and dispose of wastewater. When groundwater levels are high, it can affect the proper functioning of the septic system. High groundwater levels also can cause septic tanks and drain fields to become saturated, which can lead to backups and overflows of untreated wastewater. The soil surrounding the septic system becomes less effective at treating the wastewater, which can result in the discharge of pollutants and harmful pathogens into the environment. Coastal communities must also consider the tidal processes and how saltwater will additionally impact the septic systems. North Carolina Sea Grant has funded a series of studies to investigate how septic tanks in the coastal areas are impacted and included South Carolina communities like Folly Beach. South Carolina Sea Grant has also been working with Beaufort County to identify how local sea level rise is impacting their communities including the groundwater impacts on septic tanks that have been flooding. It is important to properly design and maintain septic systems, considering the local groundwater conditions. It is also important to regularly monitor the groundwater levels around the septic system and take necessary steps to prevent backups and overflows.

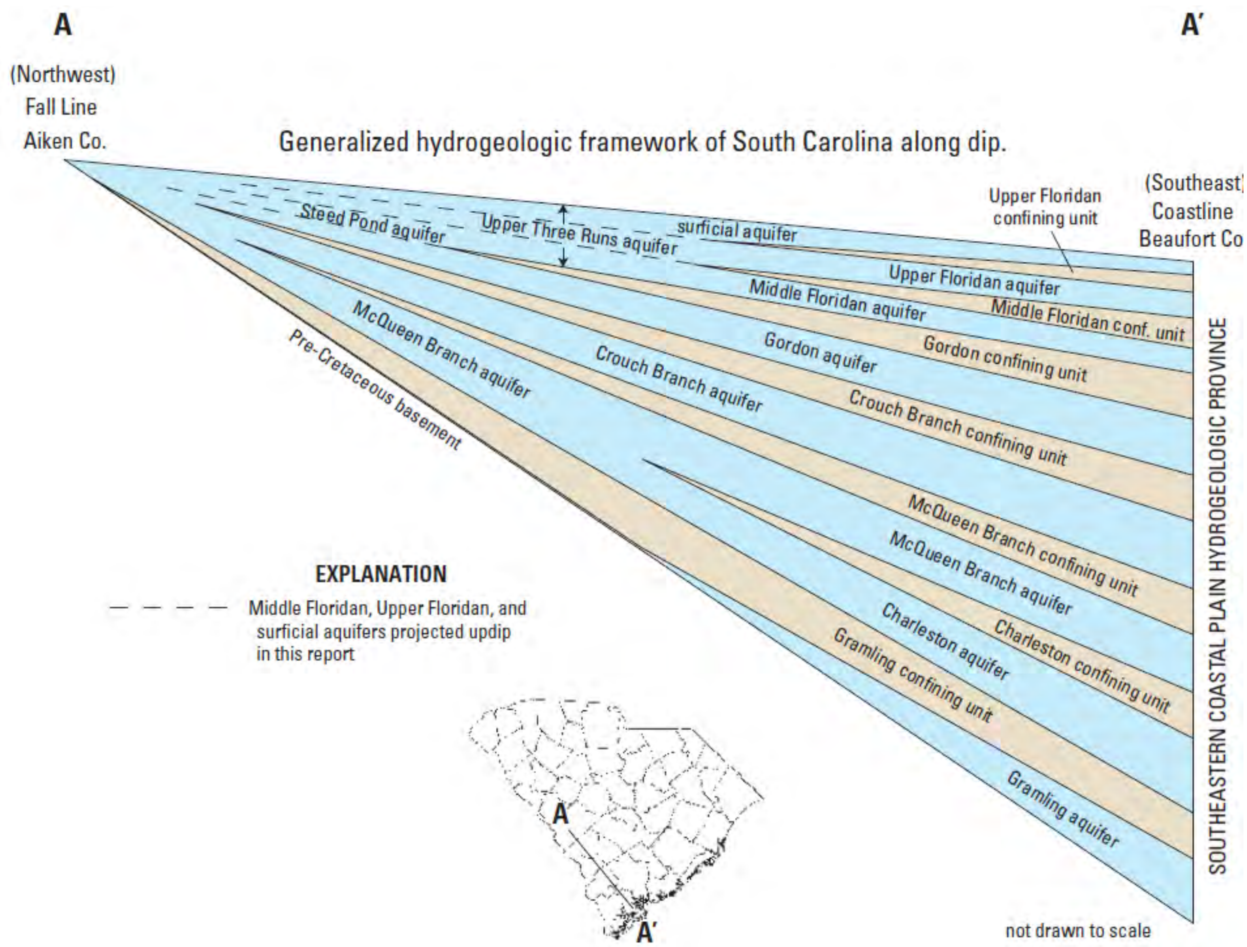

Figure 3.3 Groundwater aquifers of South Carolina (Gellici & Lautier, 2010)

SOILS

The hydrologic soil group is used to describe how four different soil types transmit water through the soils. Soils are classified based on the components that makes up the material, including rock sediment and organic material. Organic material is often from the vegetation that grows, roots, or falls onto the ground and then decomposes and incorporates into the ground. The sediment components are comprised of eroded lithified rock that is classified into sizes as described by Wentworth (1922). In simple terms, the larger the grain size and voids between grains, the easier water will flow between the grains of sediment.

The four hydrologic soil groups are a continuum of the hydraulic conductivity labeled A-D (Natural Resources Conservation Service, 2009). Soil Group A have a high potential to absorb water and consist of 90 percent sand and gravel and 10 percent silts and clay. Group B soils also have relatively high transmissibility of water and consist of 50-90 percent sands and gravels and the other component being silts and clays. Group C contains 20-40 percent clay and less than 50 percent sand, with silty loams, sandy clay loam, clay loams; creating a moderately high runoff potential. Lastly, Group D soils contain greater than 40 percent clay and less than 50 percent sands.

South Carolina contains all four soils within the hydrologic boundaries (Figure 3.4). Group B and Group D soils are the most prevalent within the state. Group B and C soils are found mostly in the Upstate above the Fall Line covering 34.6 percent and 13.9 percent of the state respectively. Group A soils cover approximately 12.8 percent and are found primarily in the Midlands in the Sand Hill region of South Carolina.

Knowing how the soils behave prior to flooding occurring allows for better planning and design. Group A soils are the best soils for allowing water to infiltrate into the ground, slowing and capturing potential floodwaters from storms. These areas are also associated with groundwater recharge zones that supply water to much of the Lowcountry across the state. The Lowcountry and small areas in the Upstate are mostly Group D soils and cover 38.7 percent of the state. Hydraulically saturated soils are placed in Group D independently of their composition.

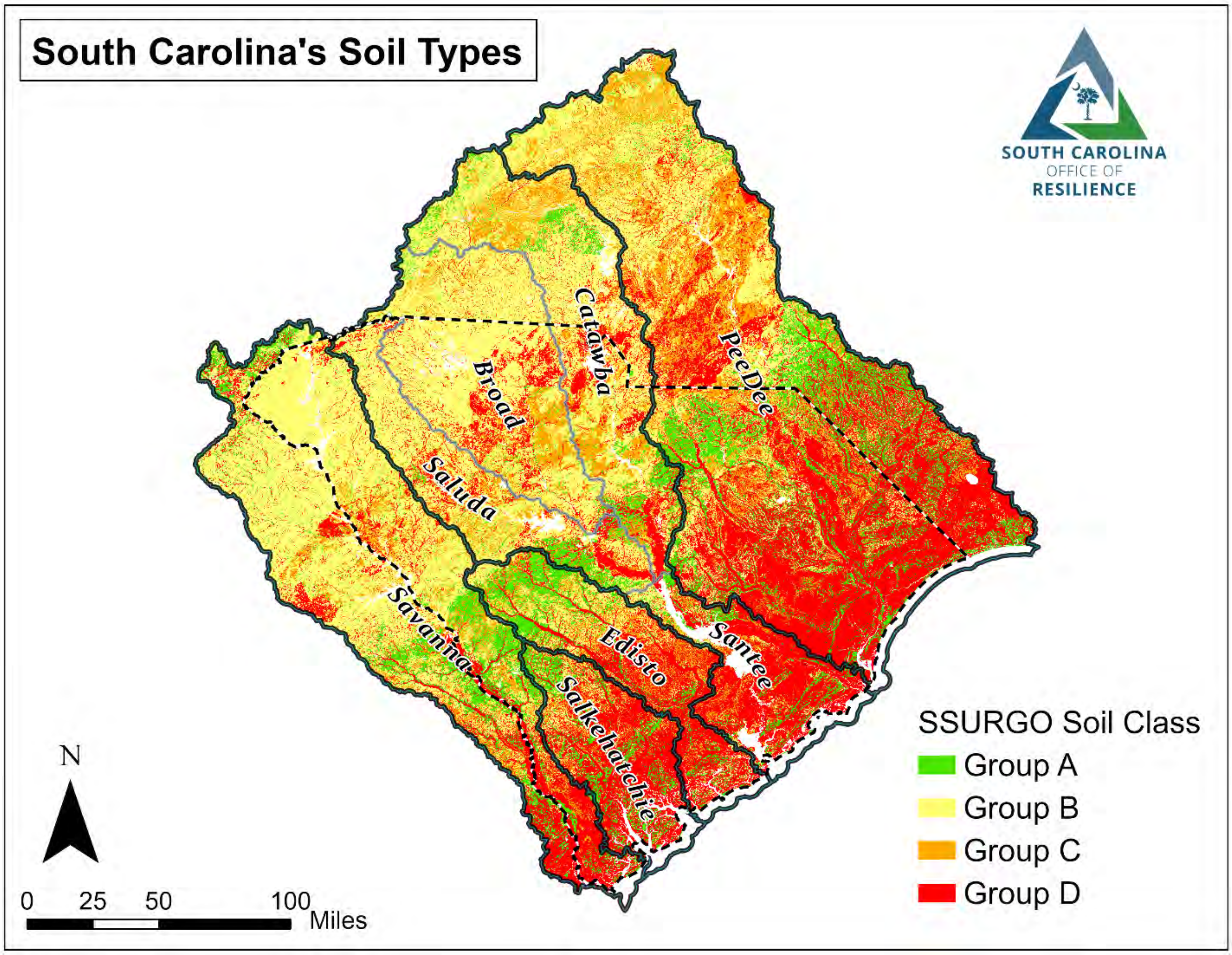

Figure 3.4: Hydraulic soil groups location in South Carolina.
***Group D soils include saturated soils (Group A-D, B-D, C-D) due to the inability to further drain water.**

LAND COVER/DEVELOPMENT

Along with the soils, land use also strongly influences where floodwaters flow. In natural, undeveloped areas like forest, wetlands, and grasslands, water is absorbed by the soils until saturation is reached and then overland flow of the waters occurs into waterways such as rivers and streams. Trees, shrubbery, and grasses slow the overland flows that eventually flows into the rivers, streams, and waterways.

When these ecosystems are altered or changed (e.g., tree removal, imcreased impervious surfaces), the capacity to store rainfall changes as well (Konrad, 2003). Urban and developed areas experience an increase in flooding as natural systems are changed into non-permeable surfaces. In South Carolina, roughly 23.2 percent of the land cover is wetlands and 46.2 percent is undeveloped forest, shrub, or grasslands, 15.4 percent is agriculture, and 11.5 percent is developed, as seen in Table 3.4 and Figure 3.5 (US Geological Survey, 2019). As urbanization continues, pluvial flooding will most likely increase, especially in areas with high topographic relief where water will flow quickly across steep surfaces with low porosity. In low lying regions of the state, Lowcountry and Pee Dee, the topographic relief is lower, water slows and fluvial flooding becomes more of an issue. The effects of urbanization result in a faster flow of runoff into waterways with less filtration and storage capacity.

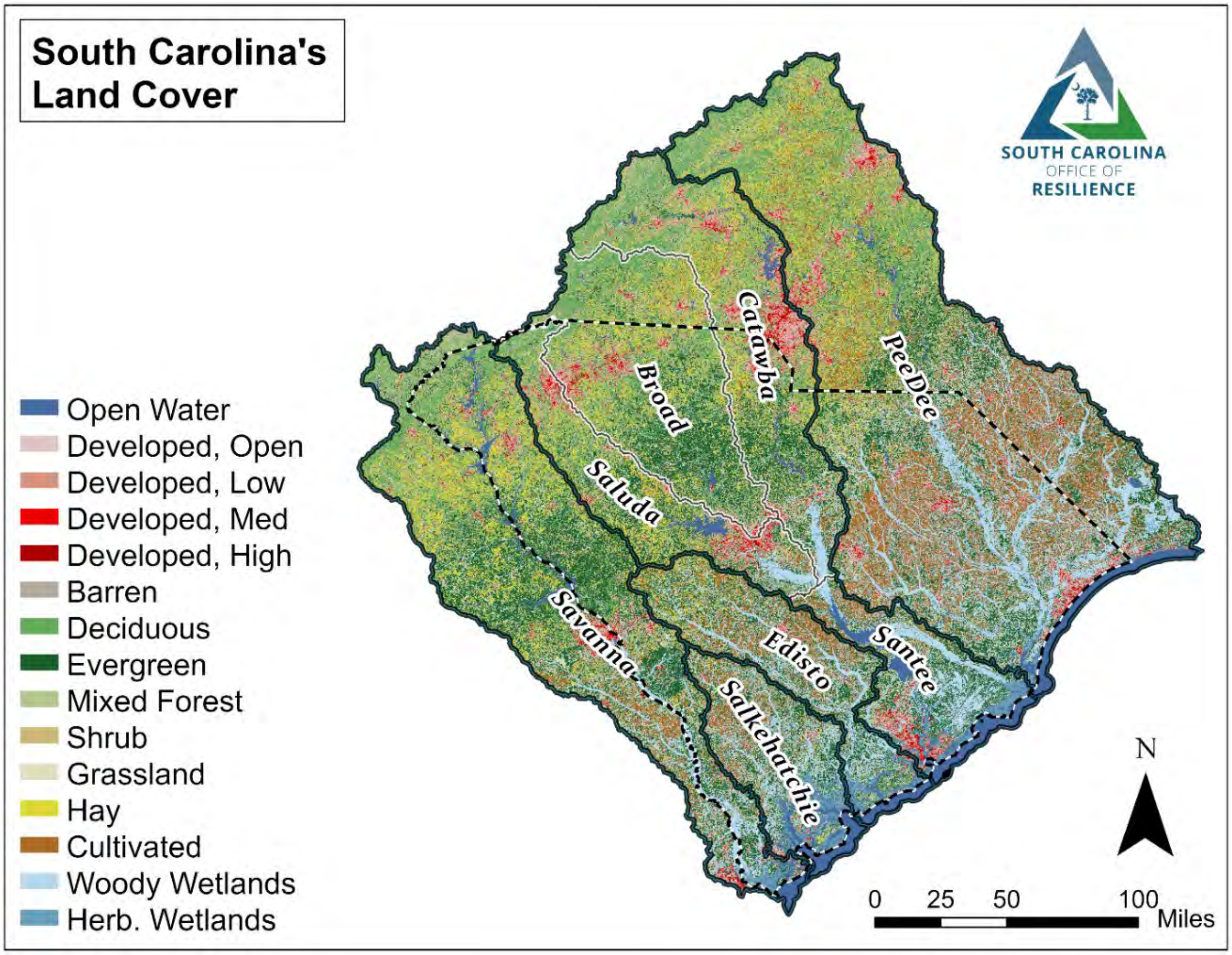

Figure 3.5: Land Cover in South Carolina (US Geological Survey, 2019)

Table 3.4: Percentage of land coverage by National Land Cover Dataset category in South Carolina (US Geological Survey, 2019)

NLCD Land Cover	Percent Area Coverage in SC (2019)
Open Water	3.5%
Developed, Open Space	6.0%
Developed, Low Intensity	3.5%
Developed, Medium Intensity	1.5%
Developed, High Intensity	0.5%
Barren Land	0.2%
Deciduous Forest	8.0%
Evergreen Forest	24.0%
Mixed Forest	5.6%
Shrub/Scrub	4.3%
Herbaceous	4.2%
Hay/Pasture	6.4%
Cultivated Crops	9.0%
Woody Wetlands	19.8%
Emergent Herbaceous Wetlands	3.4%

Land use changes are driven by development associated with population growth. Population growth, when coupled with unsustainable growth patterns, can lead to urban sprawl drasticially increasing impervious surface. Increased impervious surface decreases the storage capacity to the system and discharges water faster into the waterways (Konrad, 2003). Changes in land uses at the wildland-urban interface can increase wildfire risk. In short, changing land use can put new development areas and existing areas at an increased risk for natural hazards.

Table 3.5: Percentage of developed land cover change by National Land Cover Dataset category in South Carolina

BASIN	PERCENT DEVELOPED 2001	PERCENT DEVELOPED 2019
Broad	13%	14%
Catawba	18%	20%
Saluda	14%	16%
Santee	14%	16%
Edisto	7%	7%
Pee Dee	11%	12%
Salkehatchie	7%	7%
Savannah	9%	10%

POPULATION TRENDS AND PROJECTIONS

While South Carolina has always been subject to natural hazard events such as hurricanes and floods due to natural processes, the impact of these events has increased due to the growth of populations located in the path of these events.

STATEWIDE TRENDS

Since the first United States Census in 1790, the population of South Carolina has steadily increased from 249,073 to over 5.1 million (2020) (Figure 3.6). Growth was gradual through the first half of the 19th century. By 1890, the state had surpassed 1 million residents. This growth intensified and spread northwest across the state during the 20th century. By 1970, the state population was estimated around 2.5 million, and over the next fifty years, this number doubled to over 5 million in 2020. Between 2010 and 2020 alone, SC's population grew 10.7%, compared to a 7.4% nationwide increase, making South Carolina the 10th fastest-growing state in the nation (U.S. Census Bureau, 2021). This growth continued during the COVID-19 pandemic. While many states saw decreases in population, SC saw a 1.4% increase in population between April 1, 2020 and July 1, 2021, the 5th highest in the nation (US Census Bureau, 2021).

According to the South Carolina Revenue and Fiscal Affairs Office, this increasing trend is expected to continue, at least through 2035 (2019). Using Census numbers, along with vital records and migration data, the office predicts that the statewide population will reach over 6.2 million in 2035 (Figure 3.6). This has important implications for planning for resilience.

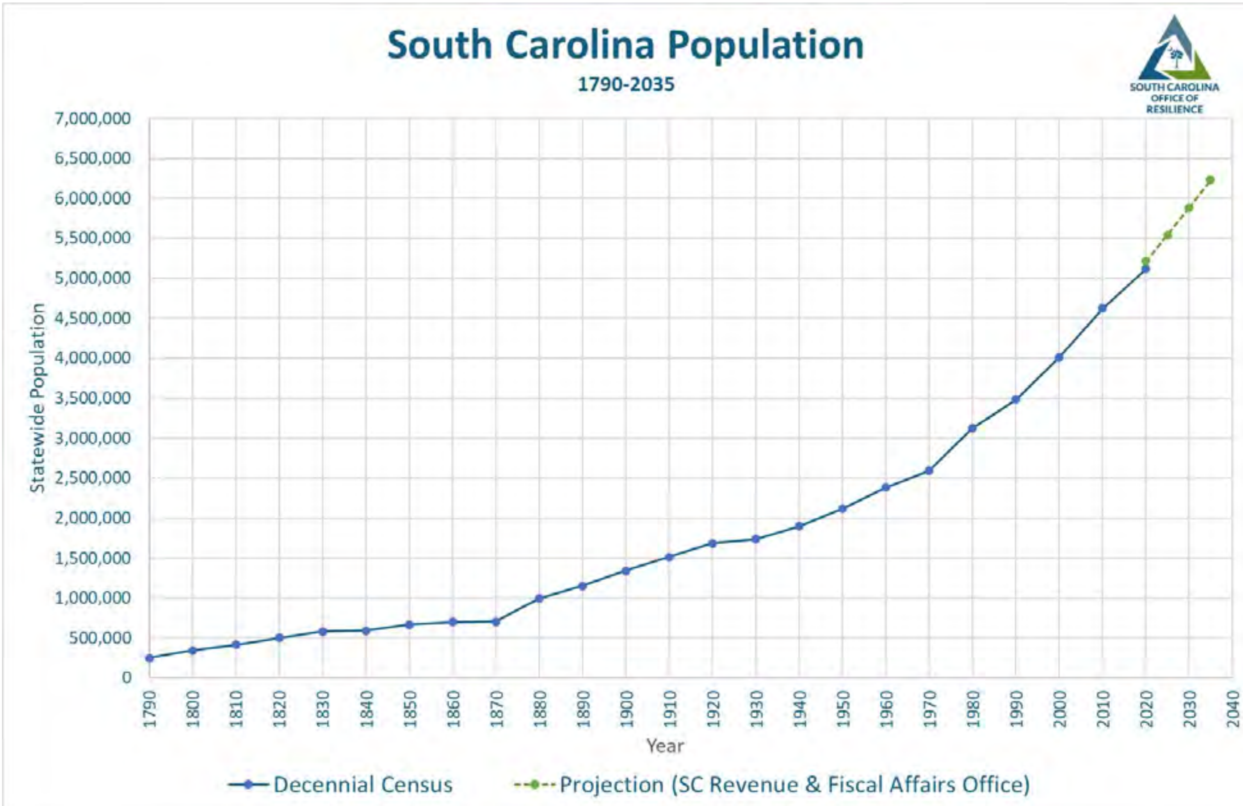

Figure 3.6 South Carolina population (with projections)

RECENT TRENDS IN COUNTY POPULATION

While the overall population of South Carolina is increasing, some counties are seeing explosive growth while others are seeing a steady decline. Knowing where populations are growing and the regional vulnerability to that population is key to keeping the residents of our state informed of the risk and safe from natural hazards. Identifying the location and hazards for growing regions will allow for resilient development and public services to be planned instead of reacting to events. Figure 3.7 shows this trend occurring in the past decade (U.S. Census Bureau, 2021), while Figure 3.8 shows that these trends are projected to continue through 2035 (SC Revenue and Fiscal Affairs Office, 2019). Coastal counties, as well as York and Lancaster Counties, due to the growth of the Charlotte metro area, are expected to see significant growth continue. Meanwhile, Pee Dee & Midlands counties such as Allendale, Bamburg, Williamsburg, Lee, and Marlboro are expected to see dramatic decreases in population.

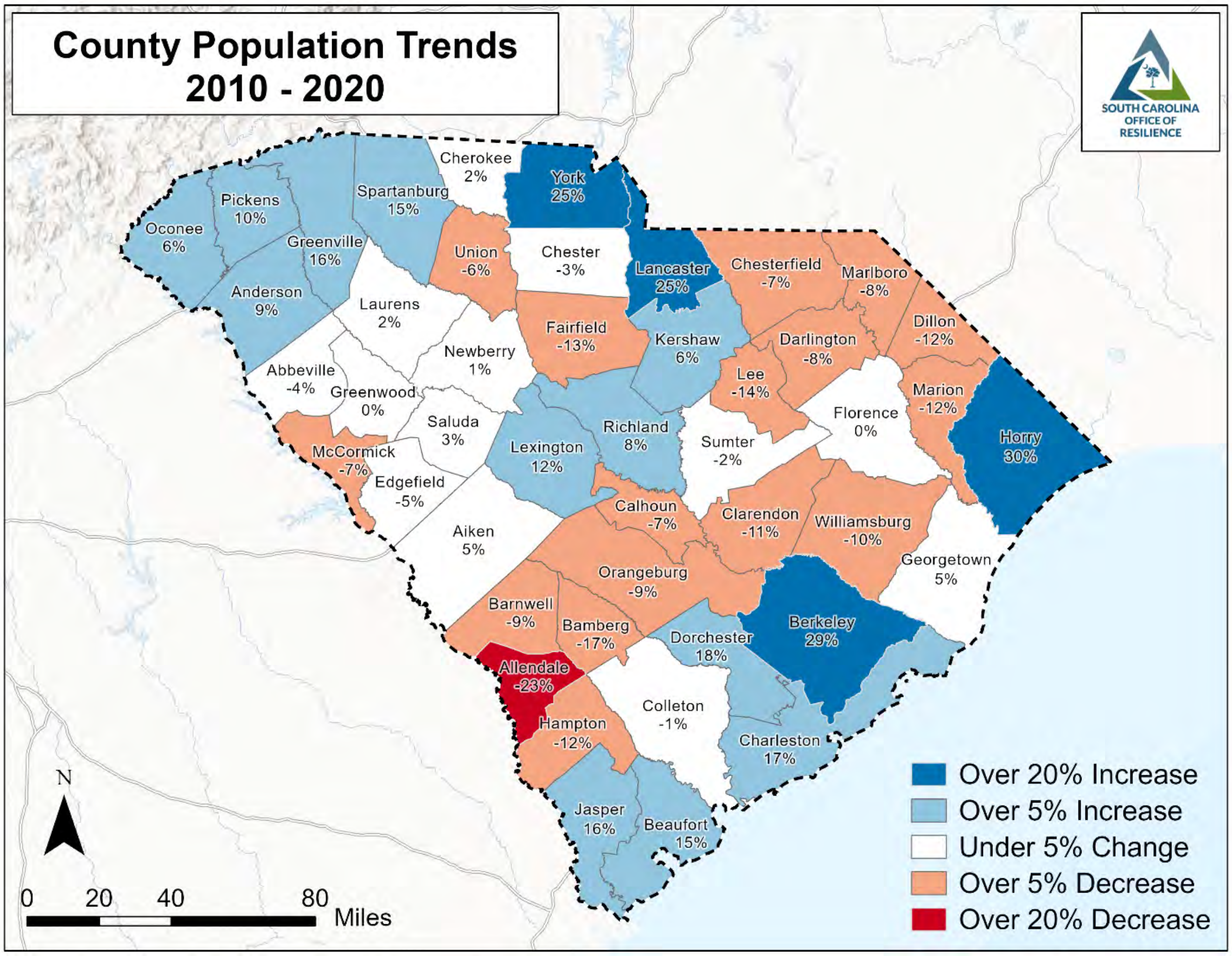

Figure 3.7: Population trends for South Carolina from 2010-2020

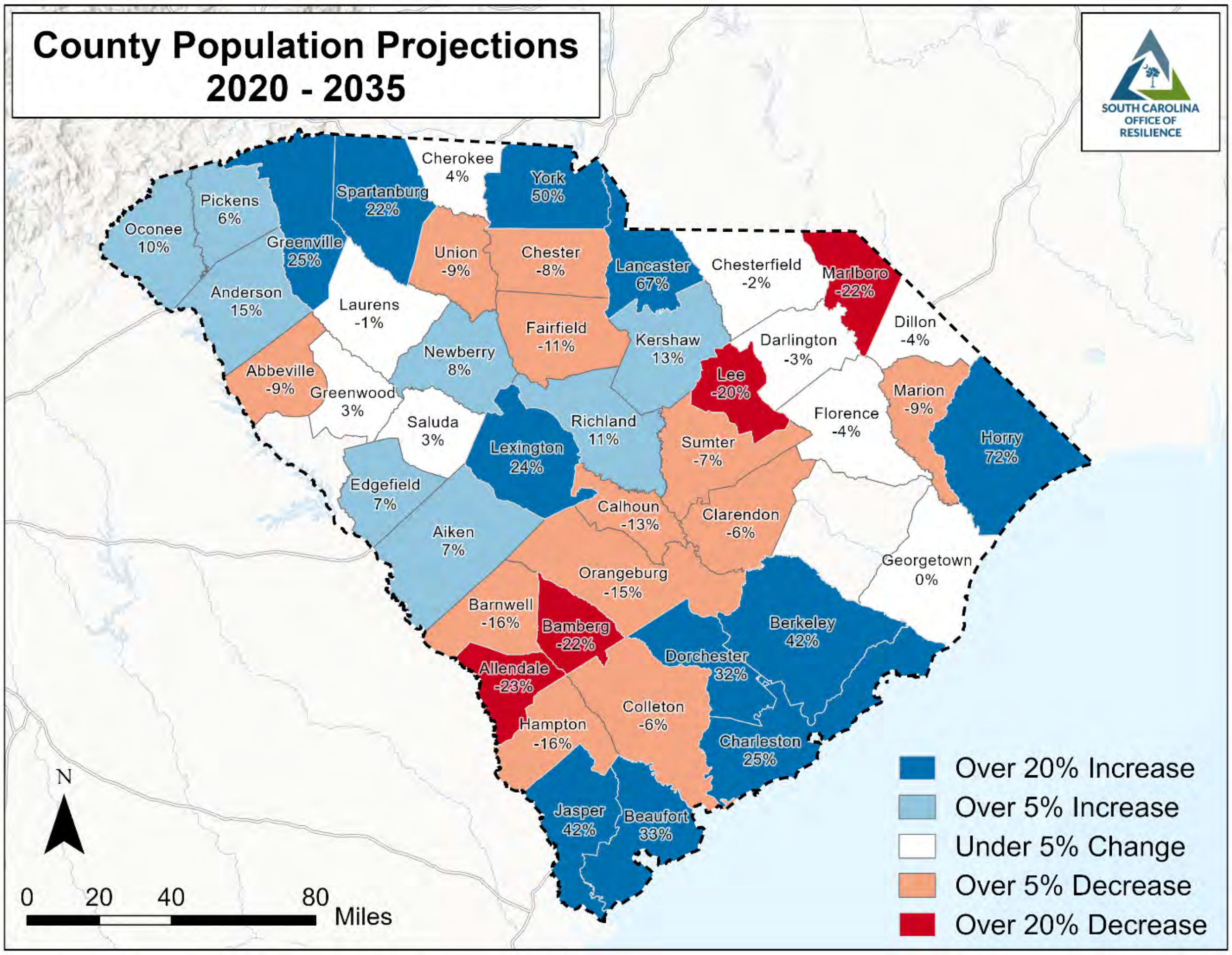

Figure 3.8: Population projections for South Carolina from 2020-2035

REGIONAL POPULATION TRENDS

Population growth in the State is also regionally disproportionate. South Carolina can be separated into four regions: the Lowcountry and Pee Dee along the coast, and the Midlands and Upstate. Figure 3.9 shows the counties that make up each region. For this analysis, the following counties were included in each region:

1) **Lowcountry:** Allendale, Bamburg, Beaufort, Berkeley, Calhoun, Charleston, Colleton, Dorchester, Hampton, Jasper, and Orangeburg
2) **Pee Dee:** Chesterfield, Marlboro, Dillon, Marion, Horry, Darlington, Florence, Georgetown, Williamsburg, Clarendon, Sumter, Lee
3) **Midlands:** Barnwell, Aiken, Edgefield, Saluda, Lexington, Newberry, Fairfield, Richland, Kershaw, Lancaster, Chester, York
4) **Upstate:** Oconee, Pickens, Greenville, Spartanburg, Cherokee, Union, Laurens, Greenwood, McCormick, Abbeville, Anderson

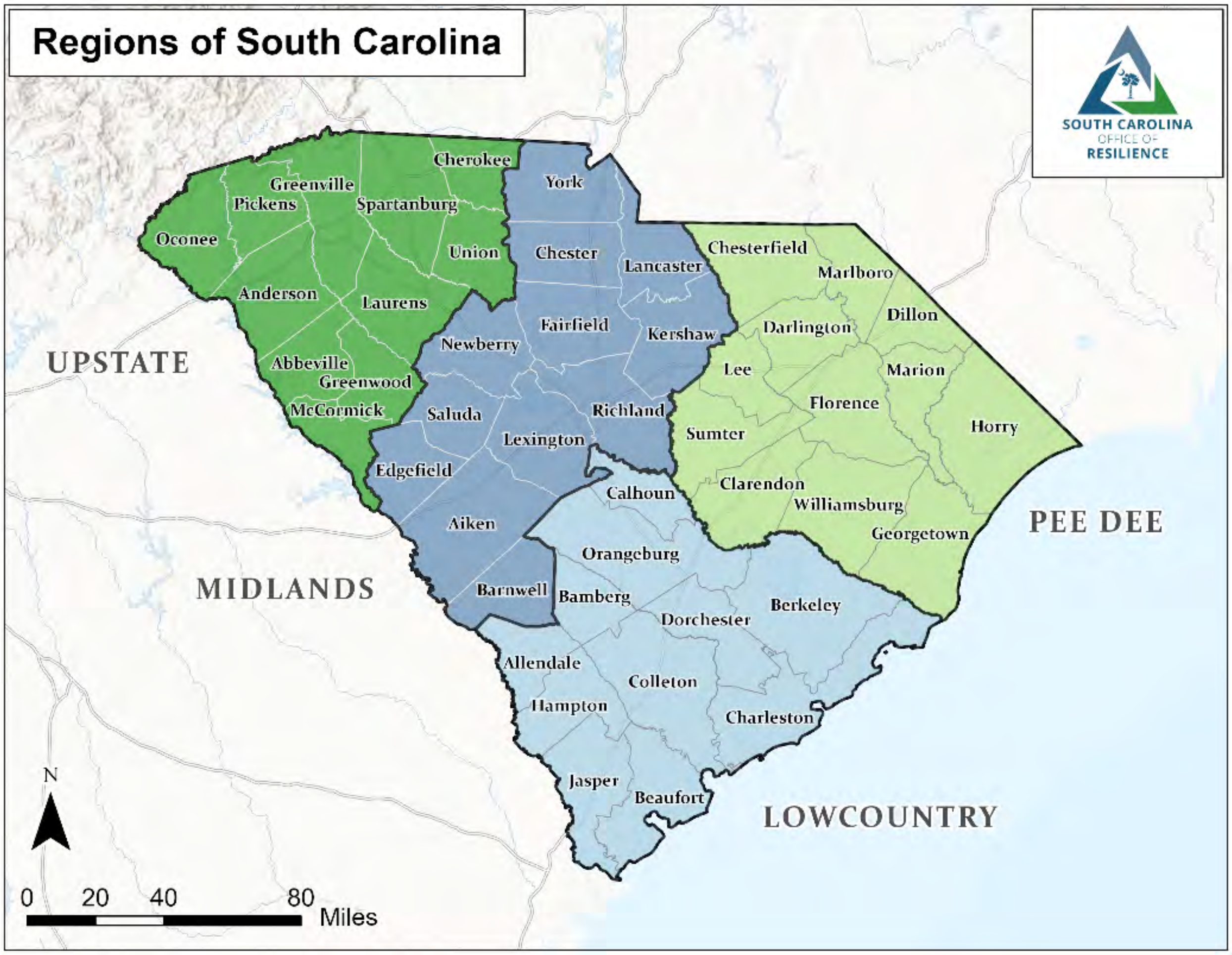

Figure 3.9: SC Regions

In recent years, the state population has shifted across these regions. In 2000, the Upstate and Midlands regions made up a higher percentage of the state population than the coastal regions, with the Lowcountry containing only 16% of the state's population (SC Revenue and Fiscal Affairs Office, 2019). However, by 2035, the Lowcountry is expected to grow to make up 24% of the state population, with other regions making up less of the state population.

UPSTATE COUNTY TRENDS

Many counties of the Upstate have seen rapid growth, especially since the 1990s, and are expected to see this growth accelerate in the next 15 years (Figure 3.10). Greenville is the region's most populous county, with Spartanburg, Anderson, and Pickens also seeing sustained growth. Meanwhile, other counties, such as McCormick, Abbeville and Union are expected to see their populations remain the same, as they have over the past few decades.

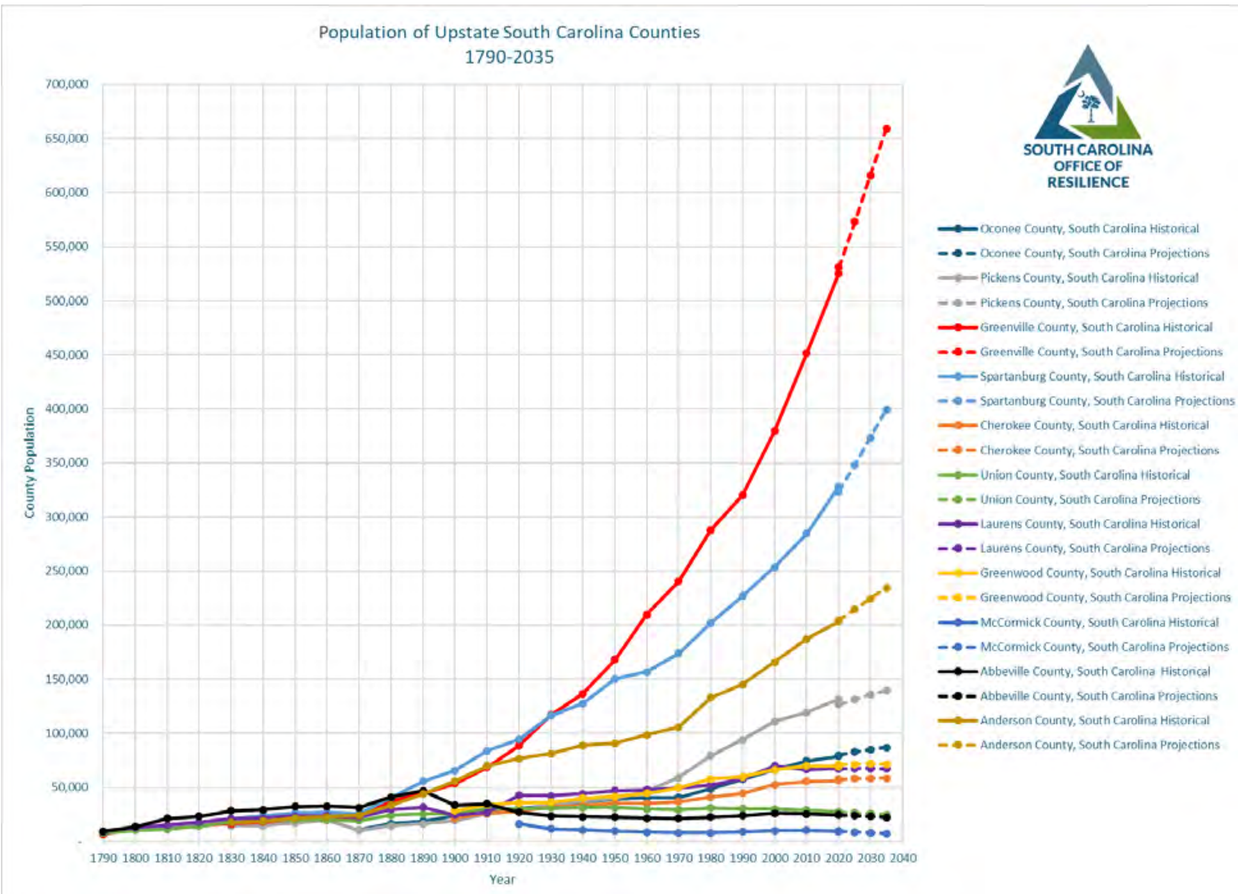

Figure 3.10: Upstate Population, 1790-2035

MIDLANDS COUNTY TRENDS

Population growth in the Midlands has been less linear than the Upstate, but similarly, there are several counties that stand out for their recent growth. Figure 3.11 illustrates significant growth in Richland, York, Lexington and Lancaster counties. Particularly of note is that in the next 15 years, York's population is set to steeply increase, surpassing Lexington to become the region's second most populous county. Other counties, such as Edgefield, Fairfield and Saluda, are expected to see stagnated growth or begin to see a decline in population.

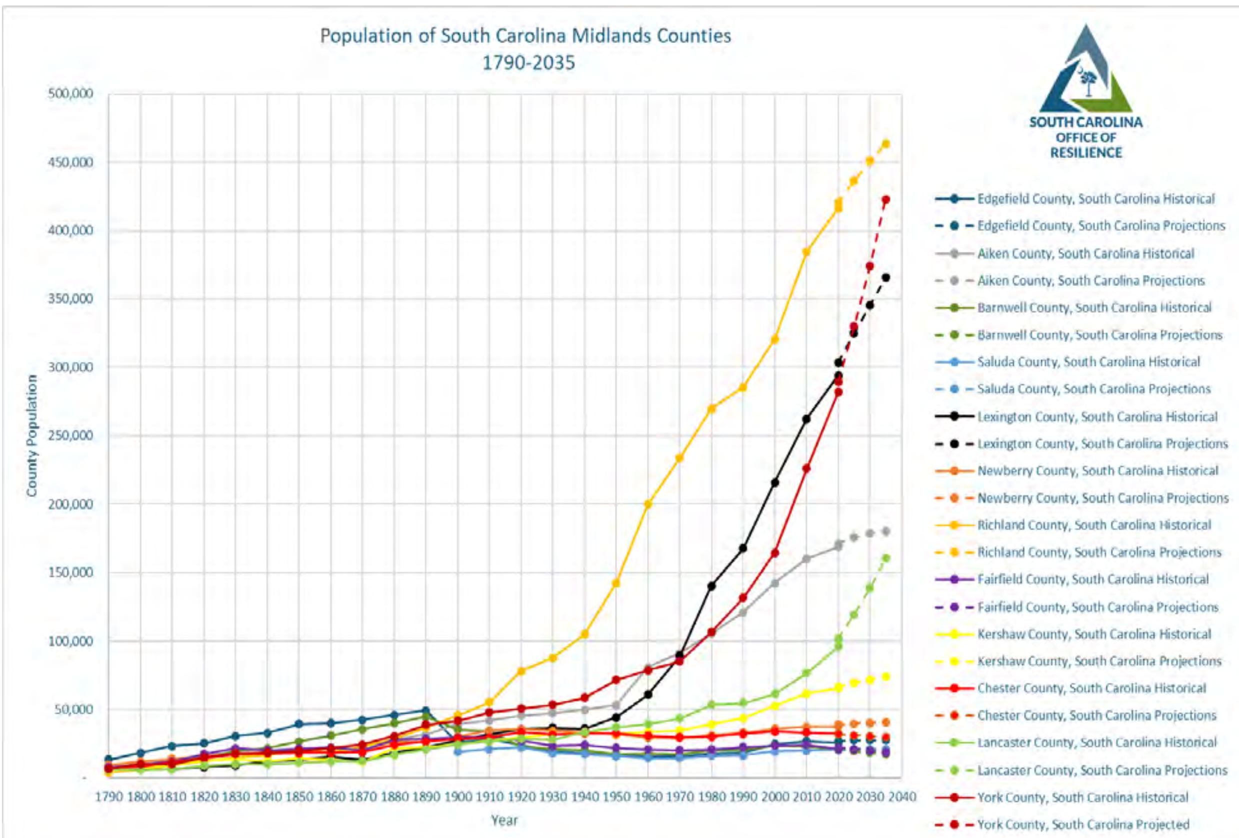

Figure 3.11: Midlands Population, 1790-2035

PEE DEE COUNTY TRENDS

Unlike other regions, the Pee Dee only has one county experiencing rapid growth, Horry County (Figure 3.12). In the 1980's, Horry surpassed Florence as the region's most populous county and has since seen dramatic growth. Other counties in the region, such as Darlington and Sumter, are expected to see their populations begin to decrease.

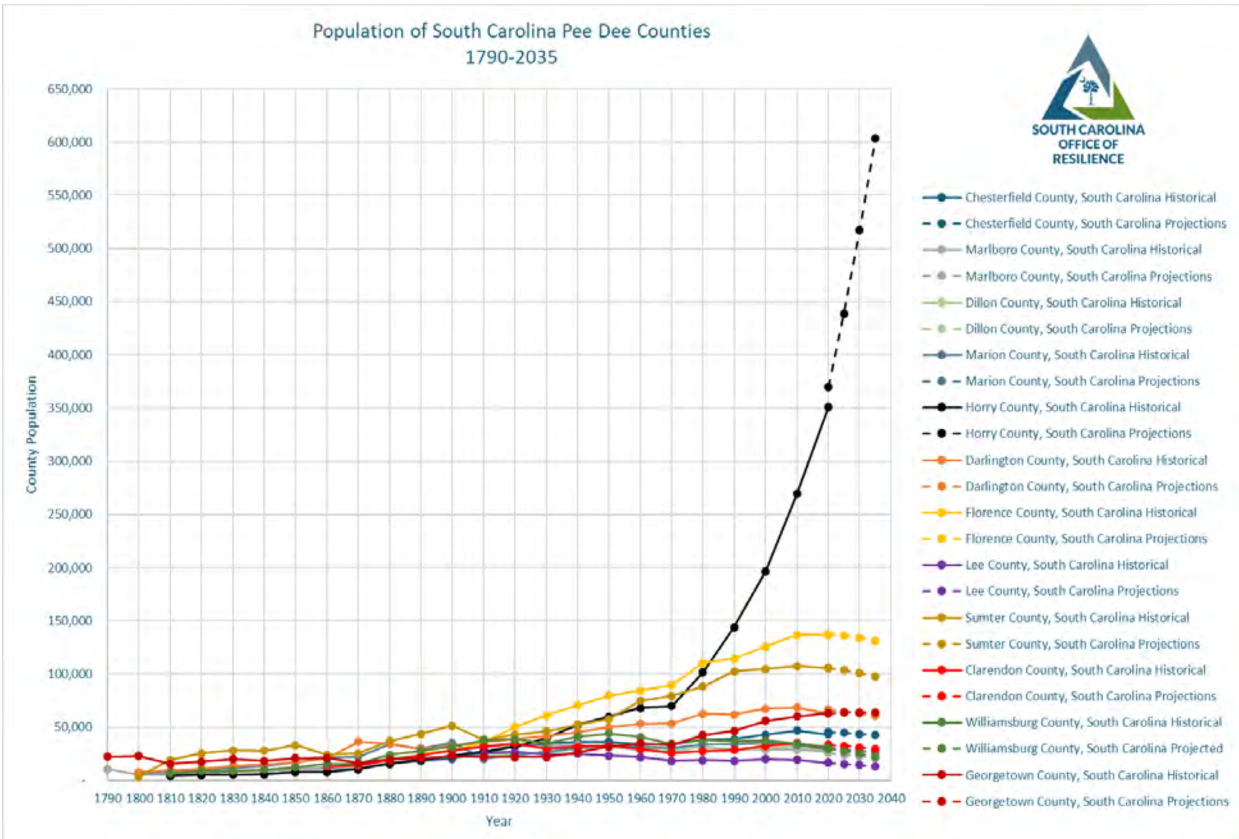

Figure 3.12: Pee Dee Population, 1790-2035

LOWCOUNTRY COUNTY TRENDS

Charleston County is seeing dramatic growth and is expected to see the population hit half a million people by 2035 (Figure 3.13). Charleston is not alone in seeing growth, Berkeley, Dorchester, and Beaufort counties are also seeing continued steep growth. Also of note is that Orangeburg County is expected to see a noticeable decrease in its population.

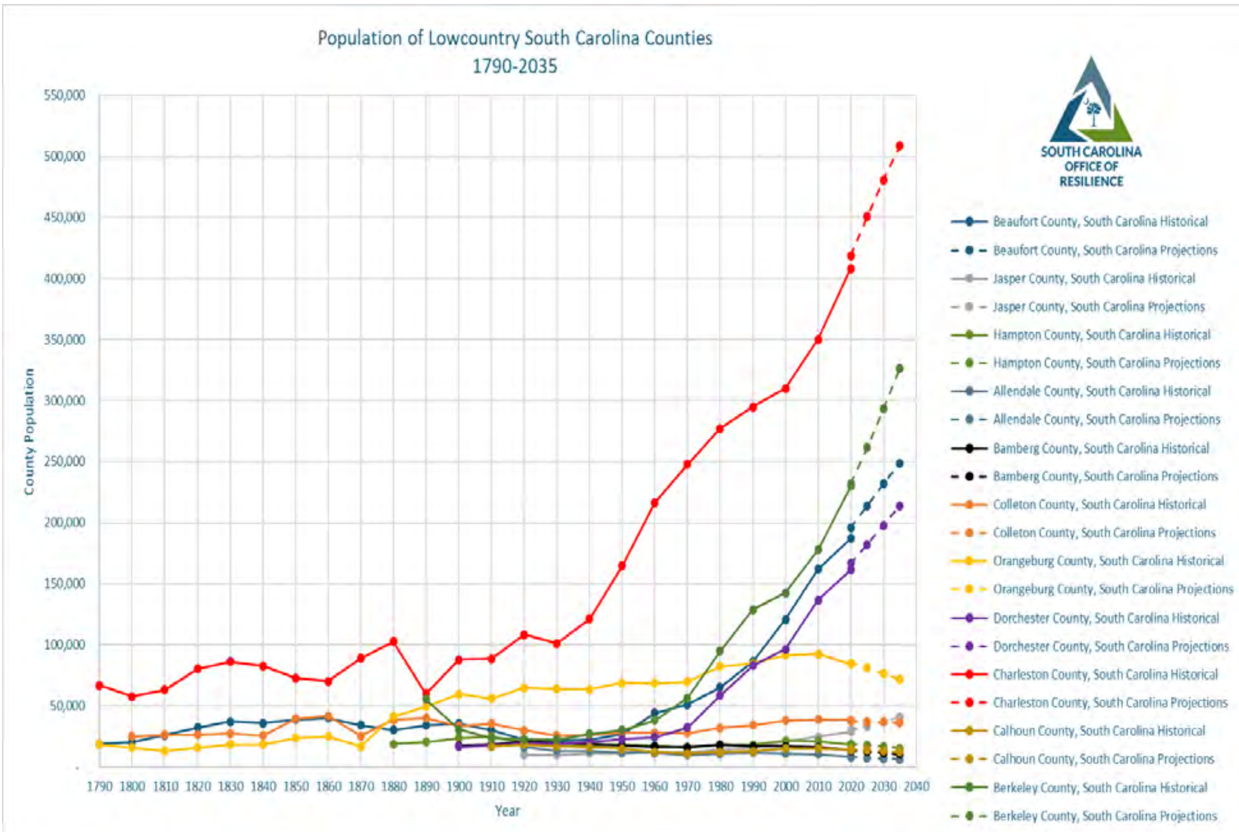

Figure 3.13: Lowcountry Population, 1790-2035

COASTAL POPULATION TRENDS

In considering population growth's role in resilience, it is important to consider population trends in the counties historically most vulnerable to tropical storms and increased flooding due to sea level rise, those counties in the coastal zone: Beaufort, Berkeley, Charleston, Colleton, Dorchester, Georgetown, Horry & Jasper (Figure 3.14).

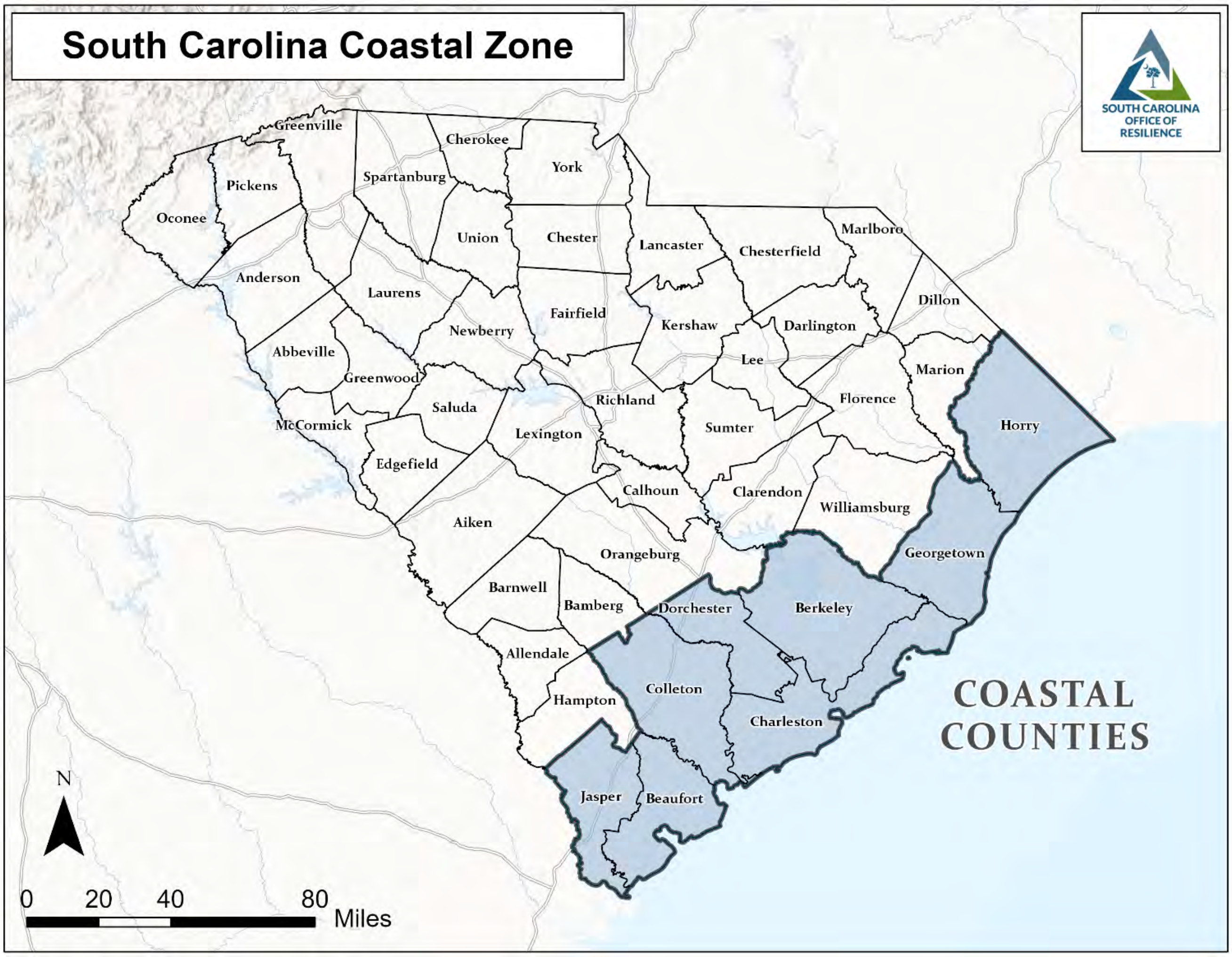

Figure 3.14: Coastal Zone Counties

Population growth in these counties has the potential to put more people in low-lying, vulnerable locations, exposed to coastal flooding and tropical storms. Figure 3.15 shows the share of the state's population living in these counties starting in 1790 and projected through 2035. In 1790, 43% of the state's population lived in these eight coastal counties. This is no surprise, as much of the population was still centered around the original colonial settlements such as Charleston, sustained by strong economic drivers such as the rice industry. As the cotton industry boomed in the upstate, the coastal zone's share of the statewide population decreased to just 15%. However, commercial and tourism growth along the coast has once again caused the share of the state's population living in the coastal zone to increase to nearly 30% (U.S. Census Bureau, 2021). This increasing trend is projected to continue to 32% by 2035, a level not seen since 1820 (SC Revenue and Fiscal Affairs Office, 2019). However, unlike in the 1820s, this time, 32% of the state's population will be over a million people.

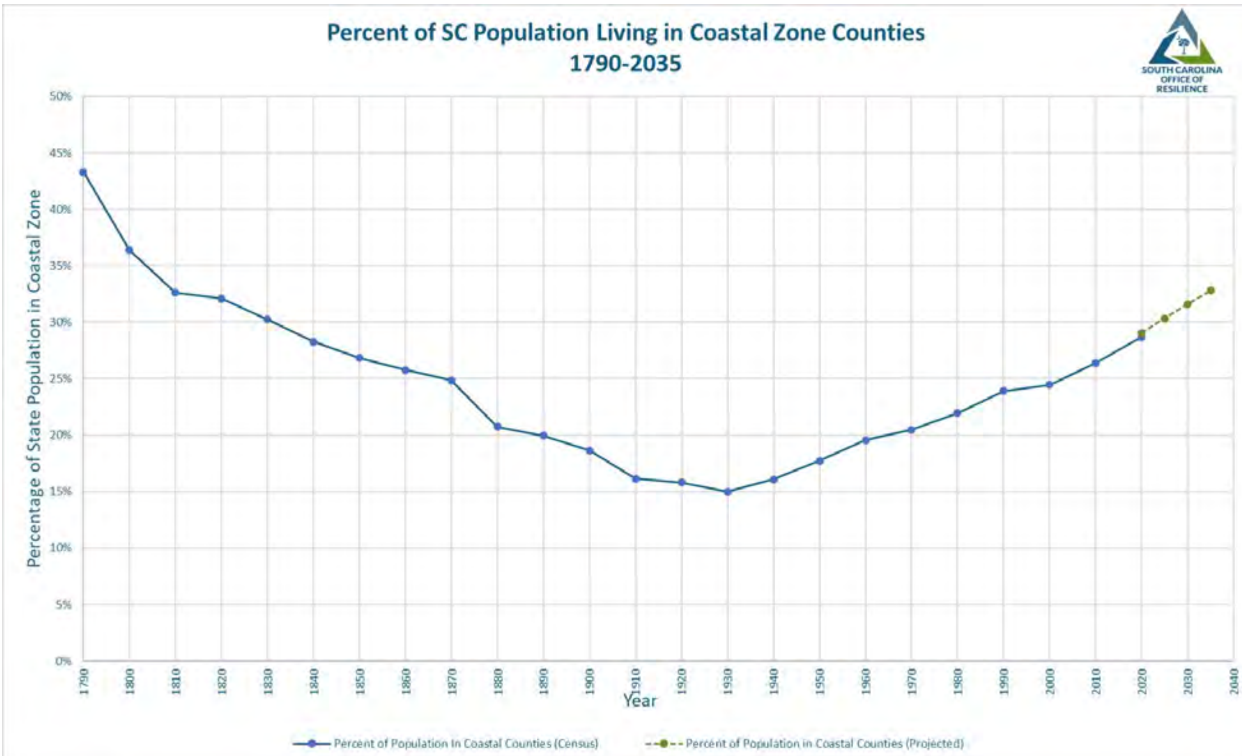

Figure 3.15: Percent of South Carolina Population living in the coastal zone counties 1790-2035 (SC Revenue and Fiscal Affairs Office, 2019; US Census Bureau, 2021)

Figure 3.16 provides a closer look at the population trend in each coastal zone county. Generally, most coastal counties have experienced continual growth since 1790, with some, such as Horry and Charleston County, seeing exponential growth starting in the mid-twentieth century. In looking at the projected growth between 2020 and 2035, Horry County stands out, with expected growth from around 350,000 people to over 600,000 people, surpassing Charleston County, which has historically been the most populous county along the South Carolina coast. The only coastal county expected to see its population decrease in the next 15 years is Colleton (SC Revenue and Fiscal Affairs Office, 2019).

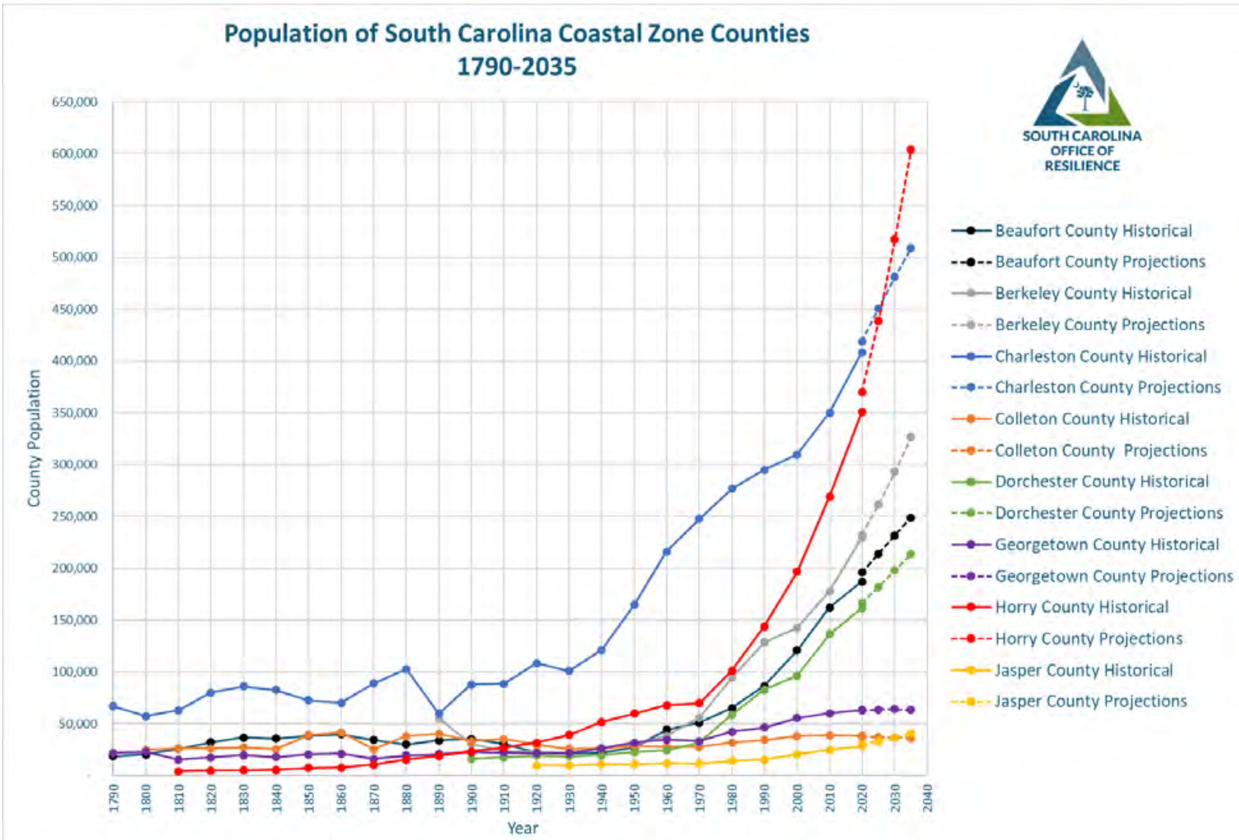

Figure 3.16: Population trends for the coastal zone counties in South Carolina 1790-2035

RURAL V. URBAN POPULATION

Historically, the state has had a mostly rural population, however a recent analysis of 2020 Census data shows that since 2010, South Carolina's rural population has decreased by 2.9% and its urban population has increased by 15.6% (Henderson, 2021). Disasters can result in rural areas further losing their already dwindling population. Studies indicate that "those settlements with populations under 2,500 were nearly three times as likely to experience population losses above 33%, while those exceeding 2,500 residents were over twice as likely to experience population growth during the decade of their destruction." While all communities are different, the article finds rural communities are more likely to lose population if they have already lost essential community components like schools (through consolidation, for instance), grocery stores, and gas stations (Cross, 2014). This supports the idea that "resilience in urban areas is primarily driven by economic capital, whereas community capital is the most important driver of disaster resilience in rural areas" (Cutter, Ash, & Emrich, 2016).

Figure 3.17 shows the U.S. Census Bureau's urban-rural classification, with urban areas representing densely population areas, encompassing residential, commercial and other non-residential urban land uses. This classification is delineated after each decennial census. According to the Bureau, "for the 2020 Census, an urban area will comprise a densely settled core of census blocks that meet minimum housing unit density and/or population density requirements. This includes adjacent territory containing non-residential urban land uses. To qualify as an urban area, the territory identified according to criteria must encompass at least 2,000 housing units or have a population of at least 5,000" (US Census Bureau, 2020).

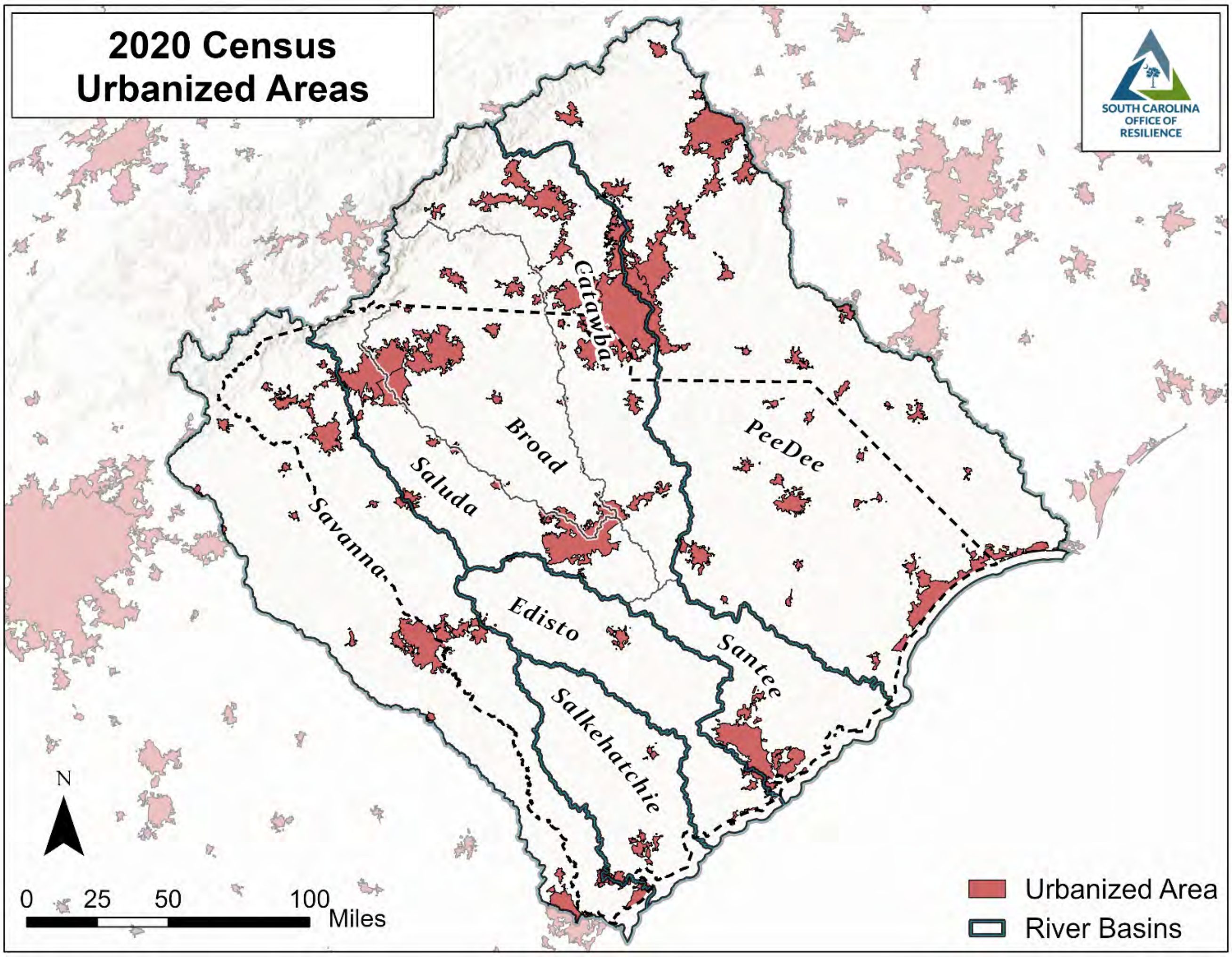

Figure 3.17 2020 Census Urbanized Areas

DEMOGRAPHICS

SOCIAL VULNERABILITY

The sensitivity of this population to natural hazards and its ability to respond to and recover from the impacts of hazards can be described by measuring social vulnerability (Cutter & Finch, 2008). The Social Vulnerability Index (SoVI®), compiled and processed by the Hazards Vulnerability and Resilience Institute at the University of South Carolina (HVRI), measures the social vulnerability of counties in the United States, providing information on "where there is uneven capacity for preparedness and response and where resources might be used most effectively to reduce pre-existing vulnerability" using 29 socioeconomic variables (University of South Carolina, 2022). More information on measuring social vulnerability and its relationship to resilience can be found in Chapter 2.

WEALTH/INCOME

Income is one of the most important determinants of disaster recovery and resilience. Those with lower incomes have less resources to prepare for and recover from a disaster. As seen in Table 5, South Carolina's median income is lower than the national average but has been steadily increasing.

The U.S. Census Bureau calculates the percentage of the population living below the poverty level using income thresholds that vary based on the size of a family and its composition. According to the U.S. Census Bureau ACS 5-year estimates (U.S. Census Bureau, 2020), South Carolina's poverty rate is 14.7%, higher than the national figure of 12.8%. However, there are areas of more concentrated poverty in South Carolina. The following counties have more than 25% of their population below the poverty level: Dillon (30.2%), Marlboro (29.4%), Allendale (28%), Barnwell (27.8%), Williamsburg (26.1%), Lee (25.7%). Table 3.5 below shows median household income and the percentage of population below the poverty level by county.

Table 3.6: Median Household Income and Poverty by County

County	Median Household Income (2020 5-yr)	% Pop Below Poverty Level (2020 5-yr)
United States	**$64,994**	**12.8%**
South Carolina	**$54,864**	**14.7%**
Abbeville	$43,090	17.7%
Aiken	$53,385	13.8%
Allendale	$26,074	28.0%
Anderson	$53,598	13.6%
Bamberg	$42,830	21.0%
Barnwell	$37,572	27.8%
Beaufort	$71,430	9.3%
Berkeley	$65,443	11.9%
Calhoun	$49,844	19.0%
Charleston	$67,182	12.8%
Cherokee	$37,787	17.9%
Chester	$43,985	18.5%
Chesterfield	$41,937	21.2%
Clarendon	$43,881	21.7%
Colleton	$36,748	19.9%
Darlington	$37,141	21.2%
Dillon	$36,429	30.2%
Dorchester	$63,501	12.0%
Edgefield	$52,491	15.2%
Fairfield	$43,861	18.5%
Florence	$49,645	17.4%
Georgetown	$52,488	16.1%
Greenville	$62,422	11.2%
Greenwood	$41,081	19.4%
Hampton	$38,178	17.9%
Horry	$51,570	14.3%
Jasper	$45,924	19.1%
Kershaw	$53,980	15.3%
Lancaster	$65,421	13.2%
Laurens	$44,374	20.4%
Lee	$32,851	25.7%
Lexington	$62,740	11.8%
McCormick	$47,402	15.3%
Marion	$30,791	22.9%
Marlboro	$31,528	29.4%
Newberry	$46,038	17.5%

Oconee	$49,691	15.3%
Orangeburg	$36,802	23.1%
Pickens	$51,032	16.4%
Richland	$54,441	16.5%
Saluda	$43,410	18.4%
Spartanburg	$53,757	14.4%
Sumter	$46,570	18.1%
Union	$41,117	19.9%
Williamsburg	$35,681	26.1%
York	$68,555	9.5%

Source: US Census Bureau 2020 ACS 5-Year Estimates Subject Tables

RACE & ETHNICITY

While the age makeup of the state population is changing, racial diversity has not changed much in recent years. While the state has a larger African American population when compared to the nation as a whole, South Carolina has relatively small populations of other racial groups (Table 3.6). Ethnically, South Carolina is 93.1% non-Hispanic and 6.9% Hispanic.

Table 3.7: Population distribution by race and ethnicity (U.S. Census Bureau, 2021)

	South Carolina	United States
White Alone	63.4%	61.6%
Black or African American Alone	25.0%	12.4%
Asian Alone	1.8%	6%
American Indian & Alaska Native Alone	0.5%	1.1%
Native Hawaiian & Other Pacific Islander alone	0.1%	0.2%
Some Other Race Alone	3.5%	8.4%
Two or More Races	5.8%	10.2%

ENGLISH LANGUAGE ABILITY

Language ability is another characteristic that can make people more vulnerable. Much of the traditional public communication about risk and disaster warnings are given in English only, leading to little-to-no understanding by non-English speakers, or misunderstanding by those with limited English language proficiency. Table 3.8 shows what language people speak at home. Compared to nation as a whole, South Carolina has fewer people who speak a language other than English at home, but that does not diminish the need for multi-language communication. This is particularly important in those counties that have a significantly higher percentage of residents who speak a language other than English at home. For example, in Jasper, 13.8% of those over five years of age speak a language other than English at home (U.S. Census Bureau, 2020).

Table 3.8: Language Spoken at Home, population 5 years and older US Census Bureau 2020 Five-Year Estimates)

	South Carolina	United States
Speak only English	92.6%	78.5%
Speaks Spanish	4.6%	13.2%
Speaks some other language	2.8%	8.3%

AGE

Age is an important factor of individual resilience. From a health and safety standpoint, older adults are more likely to be isolated and have conditions, limitations, and disabilities that make it harder for them to prepare for and recover from disasters (Shih, et al., 2018). Similarly, there are special considerations for young dependent children as well.

When compared to the 2010 Census, the 2020 Census shows that South Carolina's population is getting older. In 2010, 23.4% of residents were under the age of 18, while in 2020, only 21.6% of residents were under 18. In the same period, the state saw a 13.2% increase in the adult population. This is consistent with national trends, showing the nation's young population (under 18) decreasing 1.4% in the last decade while there has been a 10.1% increase in the adult population (U.S. Census Bureau, 2021).

According to the South Carolina Department on Aging (SCDOA), the senior population is expected to double by 2030 to 1.8 million. Additionally, SCDOA reports that 11.5% of our state's seniors live in poverty, with about a third living only on their Social Security income (South Carolina Department on Aging, n.d.).

EMPLOYMENT

Those that are unemployed generally have limited financial resources to recover from a disaster, and many also do not have benefit plans or insurance that would otherwise provide income and healthcare assistance in the case of injury or death (Edgemon, et al., 2020).

The sectors in which employment is concentrated is also important to measuring resilience. Diversified industry and employment in an area allows the overall economy to recover even if certain areas take are adversely impacted.

Table 3.9 below shows how South Carolina's major industries by employment (U.S. Census Bureau, 2020).

Table 3.9: Employment by Industry (U.S. Census Bureau, 2020)

	South Carolina	United States
Agriculture, forestry, fishing and hunting, and mining	0.9%	1.7%
Construction	6.9%	6.7%
Manufacturing	13.4%	10.0%
Wholesale Trade	2.4%	2.5%
Retail Trade	11.8%	11.0%
Transportation & Warehousing, and Utilities	5.3%	5.5%
Information	1.5%	2.0%
Finance & Insurance, real estate & rental & leasing	5.7%	6.6%
Professional, scientific, & management & administrative and waste management services	10.5%	11.7%
Educational services & health care & social assistance	22.1%	23.3%
Arts, entertainment, recreation, accommodation & food services	10.0%	9.4%
Other services, except public administration	5.1%	4.8%
Public administration	4.5%	4.7%

SPECIAL NEEDS POPULATIONS

According to the U.S. Census Bureau, 14.5% of the total civilian noninstitutionalized population of SC has a disability. The U.S. Census Bureau define that a disability “exists where the interaction between individuals; their physical, emotional, and mental health, and their physical and social environment results in limitations of activities and restrictions to full participation at school, at work, at home, or in the community.” The figure represents those with serious difficulty with four basic areas of functioning: hearing, vision, cognition, and ambulation (U.S. Census Bureau, 2019). The disability rates in several South Carolina counties are much higher than the state average; For example, in Allendale approximately 27% of the population has a disability (U.S. Census Bureau, 2020).

HEALTH INSURANCE

According to the U.S. Census Bureau, 89.5% of the state civilian population has health insurance coverage. This is slightly lower than the national percentage (91.2%). Health insurance coverage can be vastly different across groups based on age, race, ethnicity, and employment status. Due to government programs such as Medicare and Medicaid, over 95% of children under 19 and 95% of seniors over 65 in South Carolina have health insurance coverage. The age group with the lowest percentage insured is 26-34 (80.4%). Coverage is also vastly different across racial groups. In South Carolina, this is most notable between the "White alone, not Hispanic or Latino", which has an insured rate of 91.6%, and the "Hispanic or Latino of any race" group, with 71.4% insured. One of the largest factors that can influence whether a person has health insurance is their employment status. For the population considered in the labor force, only 60.3% of the unemployed have health insurance (U.S. Census Bureau, 2020).

EDUCATIONAL ATTAINMENT

Educational attainment has an impact on outreach and risk communication as well. It is important to ensure that warnings and other informative materials can be understood by all education levels. After a disaster, assistance processes should be clear and easy to navigate. Table 3.10 shows statewide educational attainment (U.S. Census Bureau, 2020).

Table 3.10 US Census 2020 ACS Five-Year Estimates Educational Attainment (population 25 and over)

	South Carolina	United States
Less than 9th Grade	3.7%	4.9%
9-12th grade, no diploma	8.0%	6.6%
High School Graduate	28.9%	26.7%
Some College, no degree	20.6%	20.3%
Associate's degree	9.9%	8.6%
Bachelor's degree	18.2%	20.2%
Graduate or professional degree	10.8%	12.7%

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Strategic Statewide Resilience and Risk Reduction Plan

4 | CLIMATE TRENDS

OVERVIEW

This section was developed in partnership with the University of South Carolina, South Carolina State Climatology Office, and South Carolina Sea Grant Consortium. The chapter includes background information regarding the drivers of global climate trends and climate variability, long-term changes in South Carolina's instrumental record, and projected future changes in the state.

CONTENTS

KEY FINDINGS

TEMPERATURE

- Since 1895, South Carolina's average annual temperature has increased by approximately 1°F, lower than the average global increase of approximately 2°F. However, the rise during the past 60 years has matched or exceeded global increases and the past 30 years have been warmer than any other consecutive 30-year period.
- The instrumental temperature record includes considerable year-to-year and decade-to-decade variability.
- Most stations exhibit statistically significant increases in a) maximum temperature in winter, spring, and summer, and b) minimum temperature in summer. While the state has had temperature increases in the past sixty years, few stations exhibit maximum temperature trends during fall, or minimum temperature trends during winter, spring, or fall when considering records from the beginning of the early 20th century.
- Climate models project South Carolina temperature increases of 5° to 10°F by the year 2100, depending on future greenhouse gas emissions.

PRECIPITATION

- South Carolina's precipitation has varied greatly on a yearly and decadal basis.
- Summer precipitation has decreased and the number of precipitation days in fall has increased; overall, few other statistically significant trends are found for seasonal or annual total precipitation.
- There are relatively few statistically significant long-term trends in heavy precipitation. However, recent heavy precipitation events affecting the coastal regions and the Pee Dee River Basin (2015, 2016, 2018) match expectations of a warmer world with higher evaporation rates and atmospheric moisture.
- Drought has periodically affected all parts of the state. The historical record reveals considerable interannual and interdecadal variability, but no statistical trend. Rising temperatures in the 21st century will likely exacerbate agricultural and hydrologic drought.

TROPICAL CYCLONES

- South Carolina's geographic position makes it vulnerable to tropical cyclones. The impact of tropical storms and hurricanes affecting the state have fluctuated greatly across years and decades.
- Their frequency and intensity have been influenced by large-scale conditions including sea-surface temperature and wind shear.
- Future scenarios are mixed with respect to the frequency of storms, but consistently project greater intensity of wind and precipitation for those storms that do occur.

MARINE CLIMATE IMPACTS

- South Carolina’s coast is low-lying and vulnerable to sea level rise. Sea levels have already risen by approximately 1 foot and will further rise by approximately 1 foot by 2050. Projections for sea level rise by 2150 range from 2 to 16 feet.
- Sea surface temperature increases off the Carolinas are statistically significant, and projected increases of 7 to 9 °F by 2100 would be among the highest nationally.
- Ocean acidification is currently stressing marine organisms and is projected to accelerate.
- Beyond sea level rise, South Carolina will experience compound changes (a combination of impacts that could be larger than each individually) in our coastal and marine waters including sea surface temperature, ocean acidification, salinity, deoxygenation, and potential disruptions to the Gulf Stream.
- Physical and chemical changes are expected to create harmful impacts for marine ecosystems and coastal economies in South Carolina.

OBSERVATIONS AND PROJECTIONS FOR SOUTH CAROLINA'S CLIMATE

GLOBAL CLIMATE

Global, regional, and local climate varies through time and is influenced by many factors. Changes in solar output, Earth's orbital cycles, volcanic eruptions, and feedbacks within the climate system are often considered "natural" causes of changes to climate. By contrast, "anthropogenic" factors include those resulting from human activities, such as the emissions of greenhouse gases. Today, both natural and anthropogenic factors affect Earth's climate across all scales – both spatial and temporal. In the absence of any changes, the earth-atmosphere system will maintain a radiation balance by which absorbed solar radiation is matched by outgoing infrared radiation (Figure 4.1). Climate scientists often use the concept of radiative forcing to quantify changes to this balance. It is possible, for example, to estimate how solar cycles, changes to Earth's axial tilt, emission of aerosols from volcanic eruptions or industrial activity, cloud type and distribution, or land use changes alter the solar radiation absorbed at Earth's surface, or how changing greenhouse gas concentrations affect the rate of radiation loss to space. The increase of greenhouse gas concentrations since the industrial revolution has slowed this latter rate such that absorbed solar radiation exceeds outgoing radiation in the lower atmosphere, causing a radiation imbalance (Loeb et al., 2021). This is an example of what is called positive radiative forcing – a net increase in available energy that alters the radiative balance. The climate system adjusts to a new radiative balance by warming the surface and lower atmosphere, which, in turn, causes greater emission of energy to space.

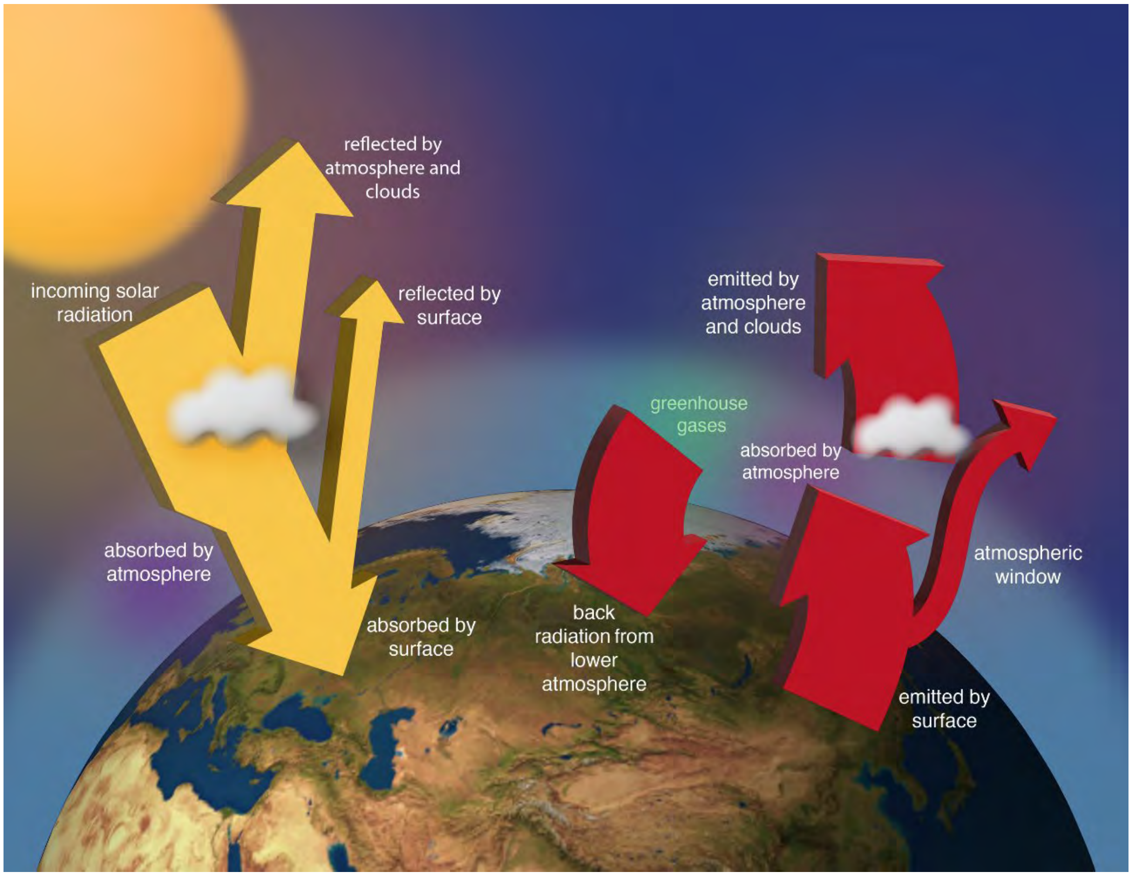

Figure 4.1: Earth's radiation budget

How much have greenhouse gases altered the radiation balance during the industrial period, and what has been the resulting climate response? Global carbon dioxide (CO_2) concentrations sampled from ice cores reveal atmospheric levels of approximately 280 parts per million (ppm) in the preindustrial period (pre-1750). Direct measurements since 1958 indicate an increase from 315 ppm to more than 415 ppm in 2022 (National Oceanic and Atmospheric Administration [NOAA], 2022b). Other greenhouse gases such as methane, nitrous oxide, and fluorinated gases have also risen during this period. The positive radiative forcing caused by these well-mixed greenhouse gas increases is large compared to other natural factors. When considering all the major factors altering Earth's radiation budget since 1850, it is estimated that human activity has caused a net global effective radiative forcing of approximately 2.75 Watts per square meter (Wm^{-2}; Smith et al., 2020). Climate models simulate a global temperature response to changes in natural and anthropogenic forcing since 1850 of approximately 2°F, consistent with the observed temperature increase (Figure 4.2). Climate simulations that exclude this human influence fail to capture the observed temperature increase of the last 60 years.

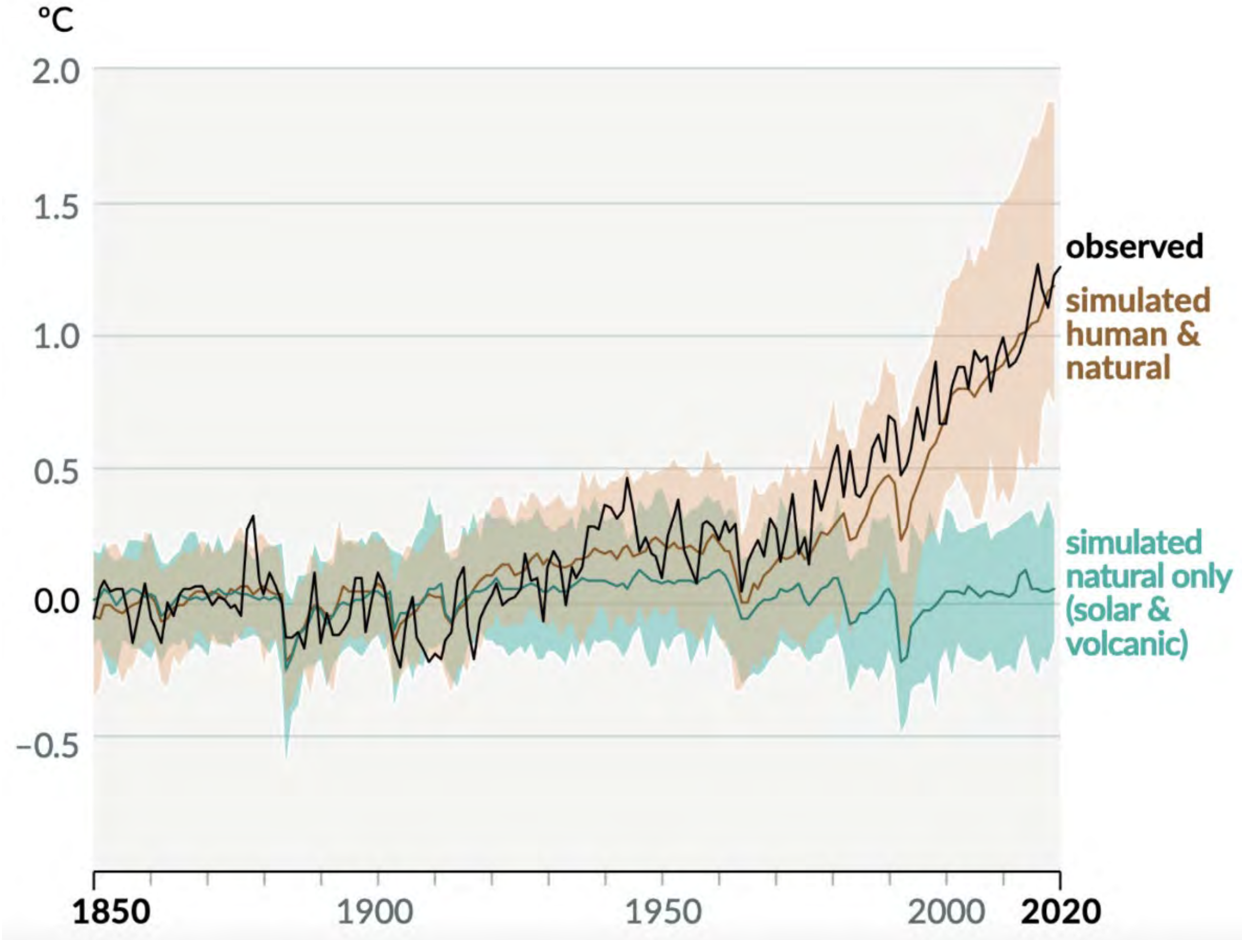

Figure 4.2: Climate model simulated temperature with and without anthropogenic forcing plotted against observed temperature

(Source: IPCC, 2021).

DATA AND METHODS

The temperature record at a given place reflects global as well as local factors; detecting trends requires consistent, long-term monitoring. In South Carolina an observation network established in the late 1800s provides a rich data set to examine historic variability and trends. These data are part of the Global Historical Climatology Network-Daily (GHCN-Daily) quality-controlled dataset with long, reliable records (Menne et al., 2012). GHCN-Daily data provide the basis for aggregated data at the state and climate division level (Vose et al., 2014) and provide the foundation for analysis of temperature and precipitation trends in South Carolina. The National Centers for Environmental Information (NCEI) maintain these data sets and make them freely available. Some analysis is done using fifteen stations from the network. These were selected based on station length, completeness, and spatial distribution and in consultation with the South Carolina State Climatology Office. Most of these stations were used in a brief 2022 state-level climate summary conducted by NCEI (Kunkel et al., 2022). A Mann-Kendall Trend Test was used to determine whether significant trends exist in the temperature and precipitation records of the fifteen select stations using records from approximately 1900 to 2020. Sen's slope was used to determine a linear rate of temperature and precipitation change.

The degree of future changes in global temperature is dependent on greenhouse gases already emitted and those that will be emitted in future decades. Since future greenhouse gas emissions depend on unknown future energy technology and policies, different emission scenarios are typically considered. In this chapter we will refer to two commonly-used scenarios – as a “lower emissions” scenario (RCP4.5) and a “higher emissions” scenario (RCP8.5). These representative concentration pathways (RCPs) are linked to specific stabilized end-of-century radiative forcing of 4.5 and 8.5 Watts per square meter respectively (Moss et al., 2010). Recalling that the radiative forcing from 1850 to 2020 is approximately 2.75 Wm^{-2}, these values represent an additional 1.75 and 5.75 Wm^{-2} by 2100. To provide context, by 2100 the lower emissions (RCP4.5) scenario would lead to a CO_2 concentration of approximately 550 ppm (about double the pre-industrial value), and the higher emissions (RCP8.5) scenario would result in CO_2 concentration of about 900 ppm (more than triple the pre-industrial value). The higher emissions scenario used here would lead to an end-of-century forcing that is two to three times higher than that witnessed thus far.

The two emissions scenarios serve as inputs to global climate models that simulate Earth’s climate response. As seen in Figure 4.2 these models capture well the global temperature trends during historical periods. At a state level, it is important to consider more than one climate model, since they collectively produce a range of plausible changes at this scale. For this study, output from all models was considered in the Fifth Coupled Model Intercomparison Project (CMIP5; Taylor et al., 2012). Of these, closer consideration was given to output from nine climate models and, when available, an average from an ensemble of all models. The nine-member subset was selected largely based on model performance in the southeastern United States (Engström & Keellings, 2018; Keellings, 2016; Rupp, 2016). From this, “bookends” that capture a wide range of warm, cool, wet, and dry projections for the 21st century were selected. This methodology accounts for the variability and uncertainty associated with state-level projections. Since most GCMs produce output at coarse (50-125 mile) grid cells, state, and regional studies commonly use “downscaled” data sets for future climate scenarios. Statistically downscaled data from CMIP5 provided by the Localized Constructed Analogs (LOCA; Pierce et al., 2014) data set were used for this assessment. LOCA has several advantages for use in this state-level assessment: it was also used in the Fourth National Climate Assessment (Hayhoe et al., 2017) and corrects for regional bias by comparing simulations against observations during the historic period and adjusting output to match general statistical properties. In the examples shown below, climate model output from LOCA was produced using historic greenhouse emissions, 1950-2005, and projected emissions 2005-2100 according to the lower (RCP 4.5) and higher (RCP 8.5) emissions scenarios.

SOUTH CAROLINA TEMPERATURE

OBSERVED TEMPERATURE

Statewide average data provide a snapshot of general temperature trends for the past 125 years (Figure 4.3). The state experienced a relatively warm period from the mid- 1920s to the mid-1950s, a cooler period during the next three decades, and an increase since the early 1980s. Average temperature during the past 30 years is warmer than any other consecutive 30-year period in the record. The state’s average annual temperature increased by approximately 0.9°F per century. These increases are slightly lower for annual maximum temperature (approximately 0.8°F per century) and slightly higher for annual minimum temperature (approximately 1.0°F per century). South Carolina’s average annual temperature pattern is typical of the broader southeastern United States during the last 125 years.

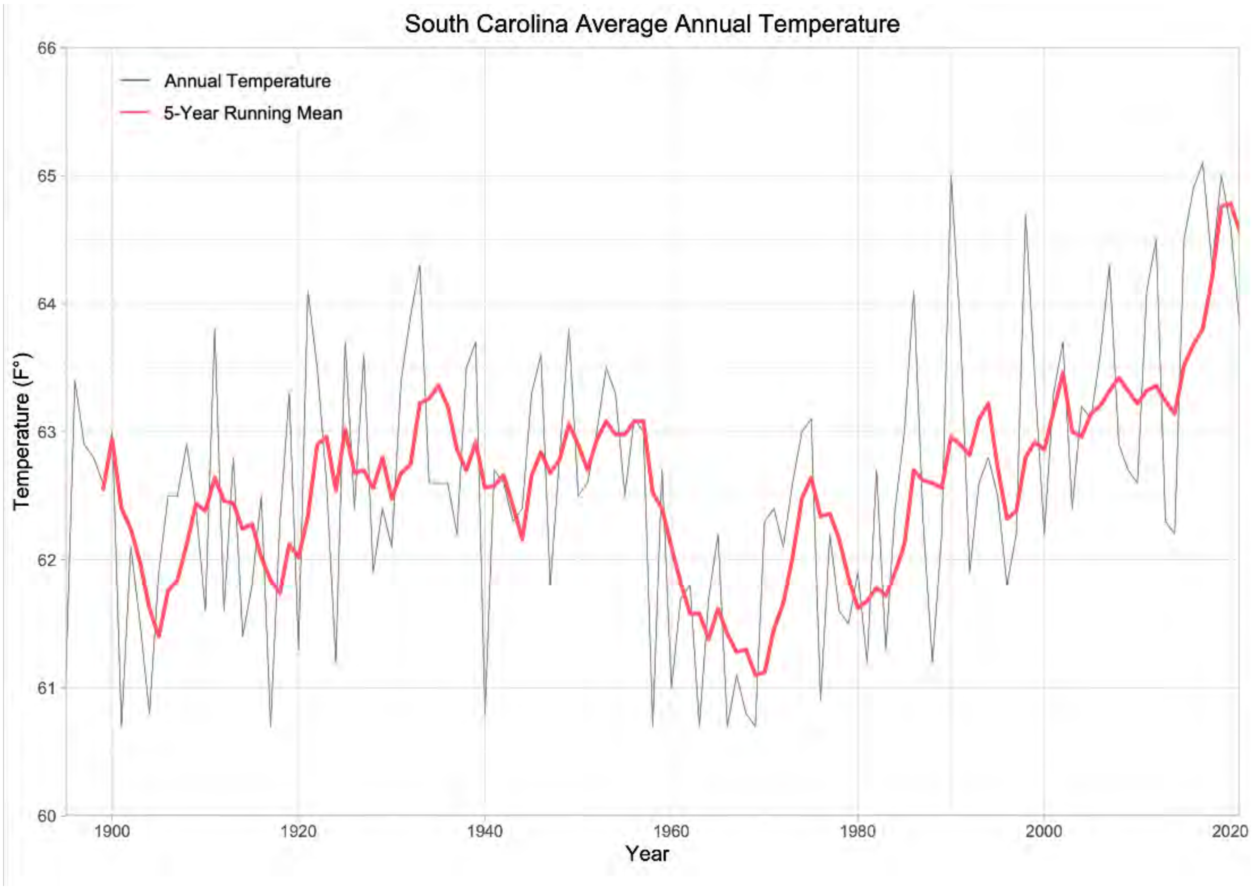

Figure 4.3: South Carolina average annual temperature

Additional comparison with global and national (lower 48 states) patterns reveals at least two key points (Figure 4.4). First, interannual and interdecadal variability is typically higher at an individual state level than at national or global scales. This is because atmospheric and ocean circulation patterns smooth trends much more at global than regional scales. Second, while South Carolina's average rate of temperature rise from 1895 to 2020 is lower than the average global rate, the 3°F increase in the most recent fifty years is comparable to or even higher than the global average increase.

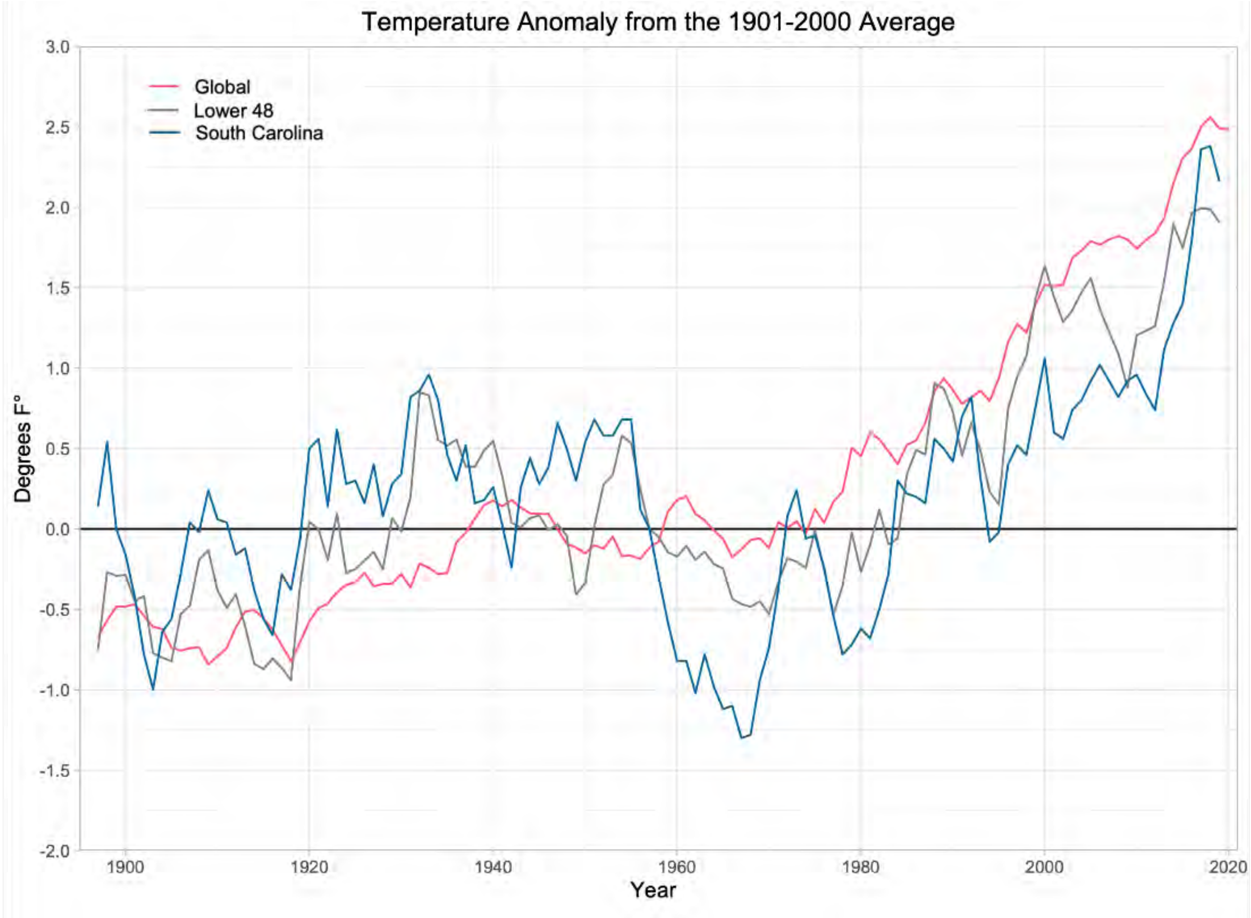

Figure 4.4: Global, Contiguous United States, and South Carolina average temperature anomalies from 20th century mean

A selection of South Carolina's most complete GHCN-Daily stations allows for identification of statistically significant temperature trends by season. Like the South Carolina versus global temperature anomalies (Figure 4.4), individual stations often experience higher year-to-year and decade-to-decade variability than spatially averaged data.

Because of this, detecting a statistically significant trend for the entire period requires large changes through time. Many stations do not show such changes, but there are some examples where the changes are dramatic enough to reveal a clear, statistically significant signal. For example, eight of the fifteen long-term and most reliable stations have experienced significant spring maximum temperature increases (Figure 4.4). Five of the stations show significant summer maximum temperature increases at a 99% confidence level (Figure 4.5). Winter maximum temperature increased at all but two stations; it was statistically significant at seven of the fifteen stations (Figure 4.6).

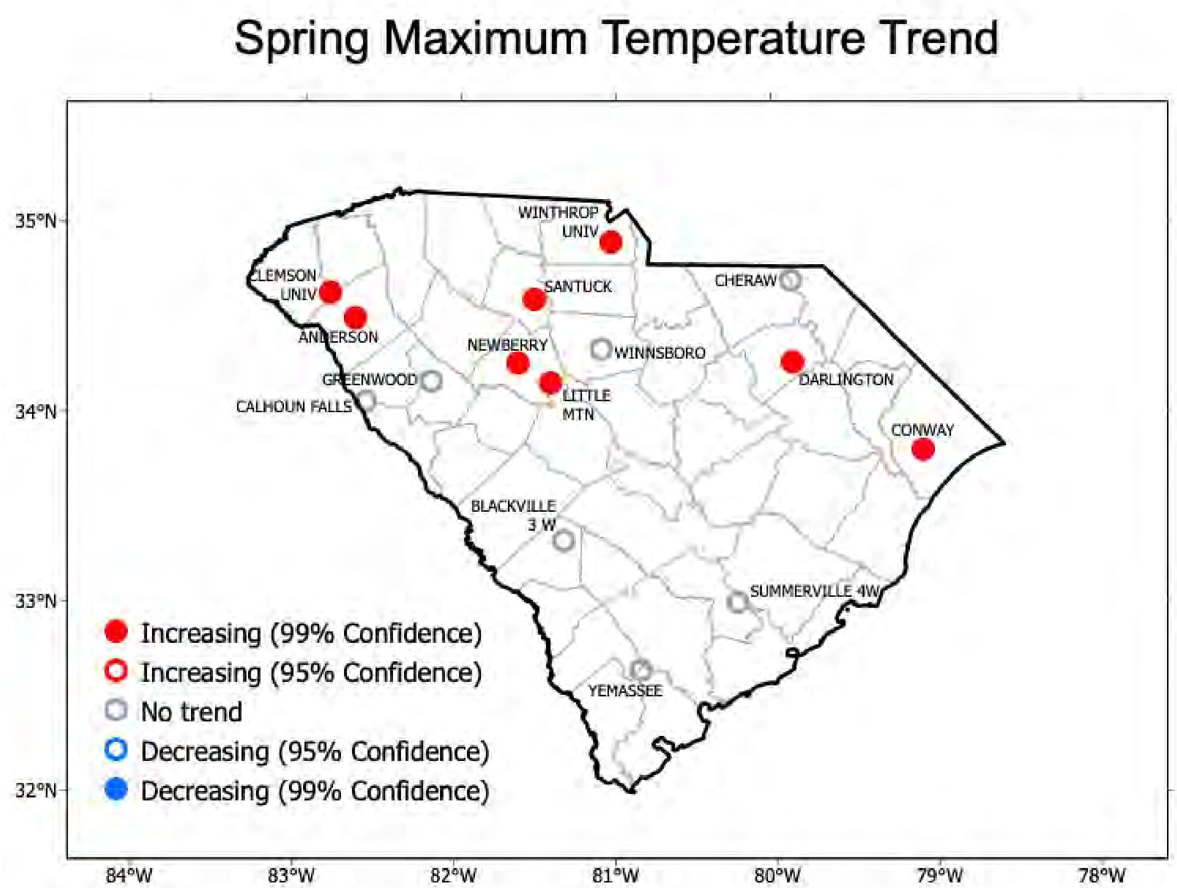

Figure 4.4: Spring maximum temperature trend, 1900-2020

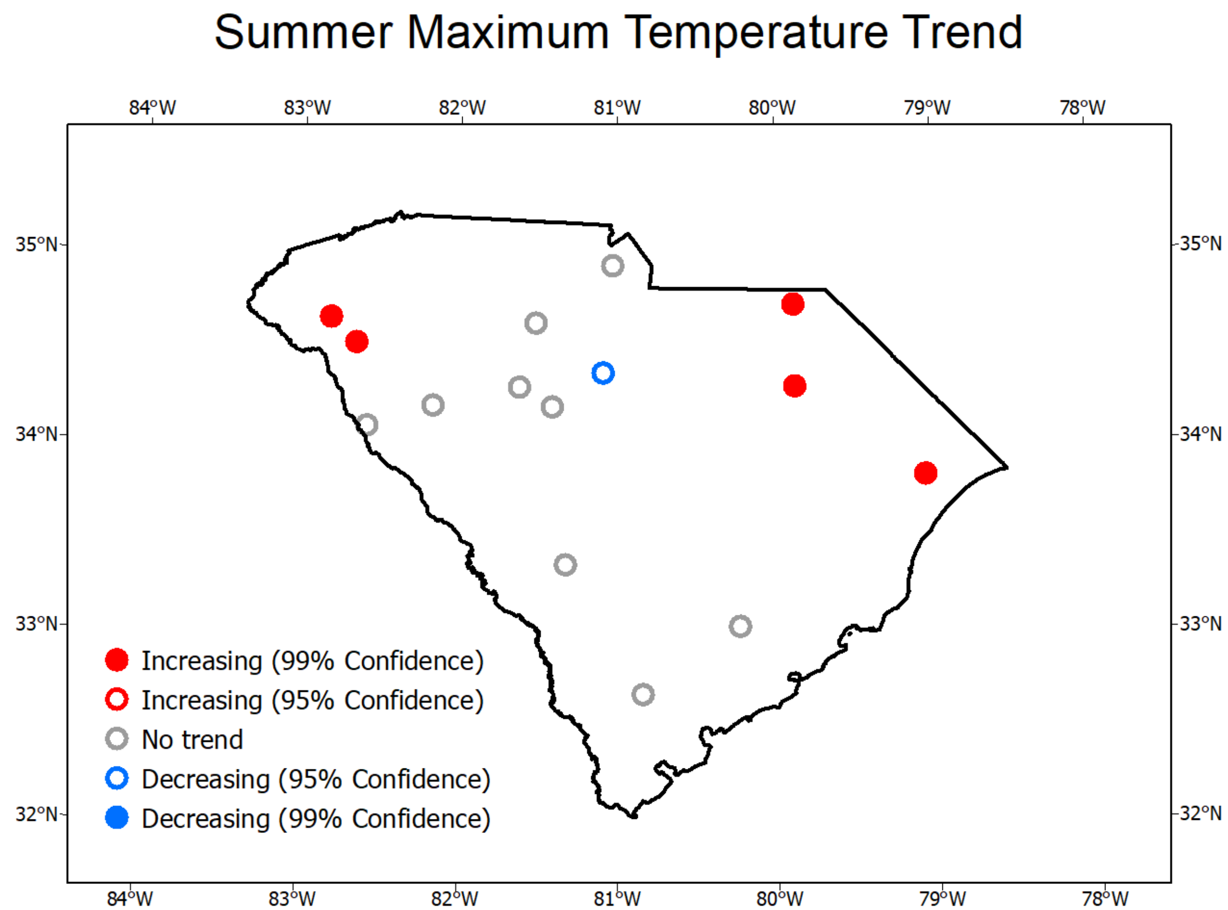

Figure 4.5: Summer maximum temperature trend, 1900-2020

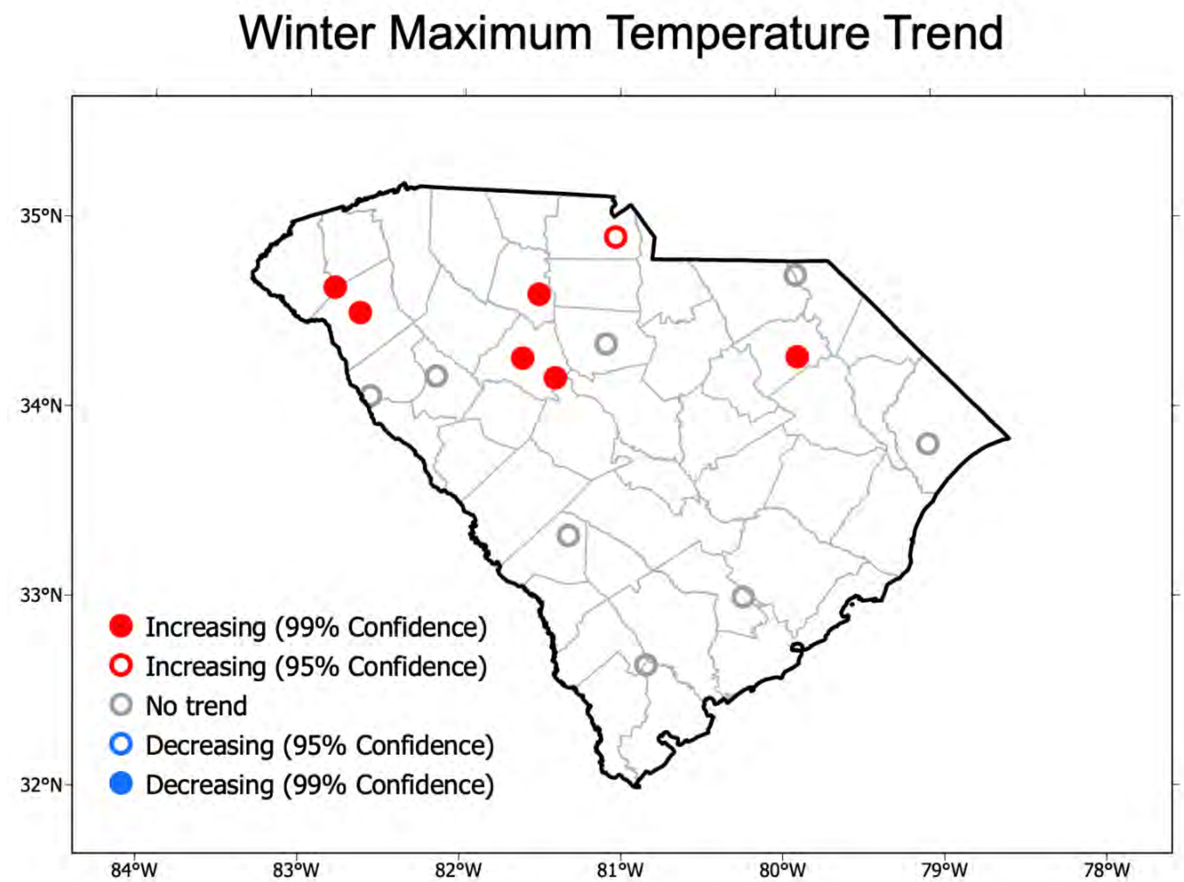

Figure 4.6: Winter maximum temperature trend, 1900-2020

Summer minimum temperature increases occurred at ten stations, nine of which were statistically significant (Figure 4.7). Two stations had decreasing trends, significant at the 99% confidence level.

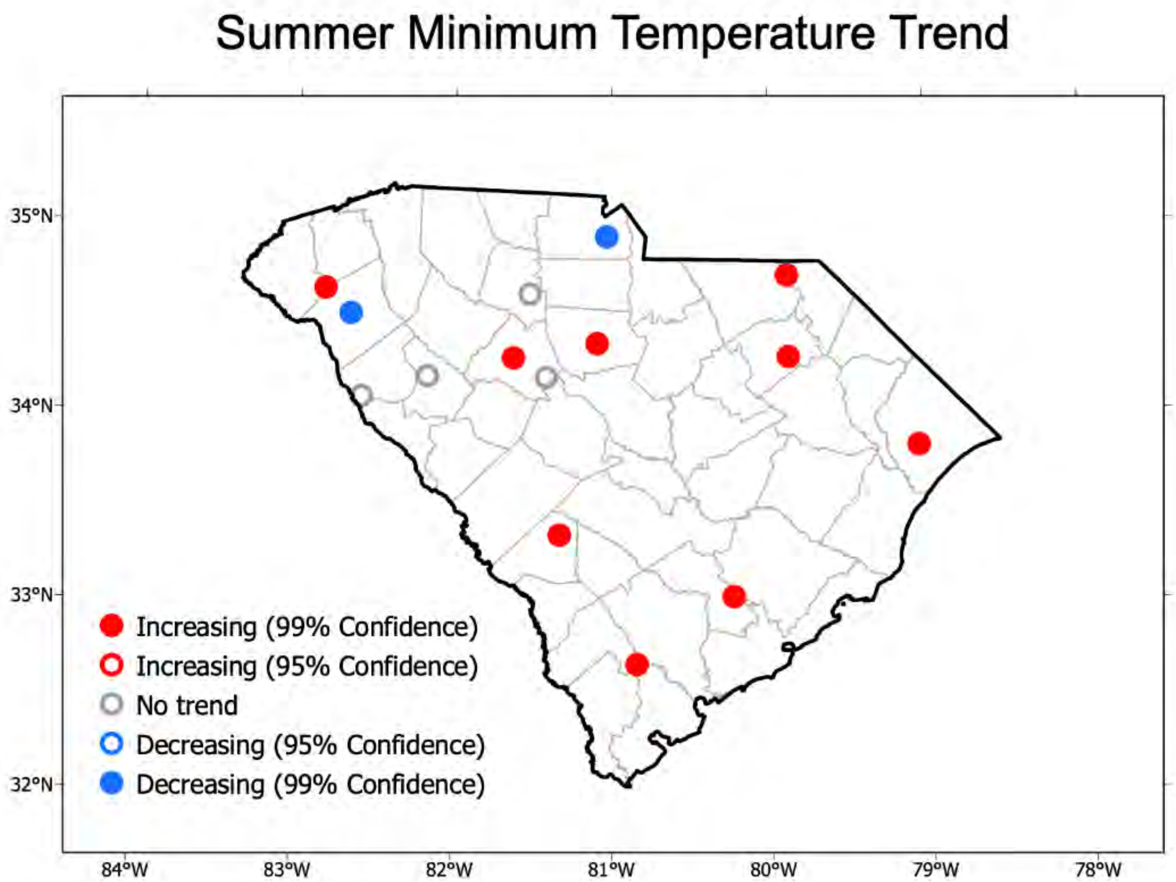

Figure 4.7: Summer minimum temperature trend, 1900-2020

Temperature plots from Little Mountain illustrate how dramatic the changes must be for trends to be statistically significant given the high interannual and interdecadal variability in South Carolina temperature records (Figure 4.8). The bars in the graph show departures from the 1901-1960 spring temperature average, also called anomalies. Note that, despite the strong year to year variability, warmer than average temperatures are more frequent in recent decades, with cooler than average temperatures less common.

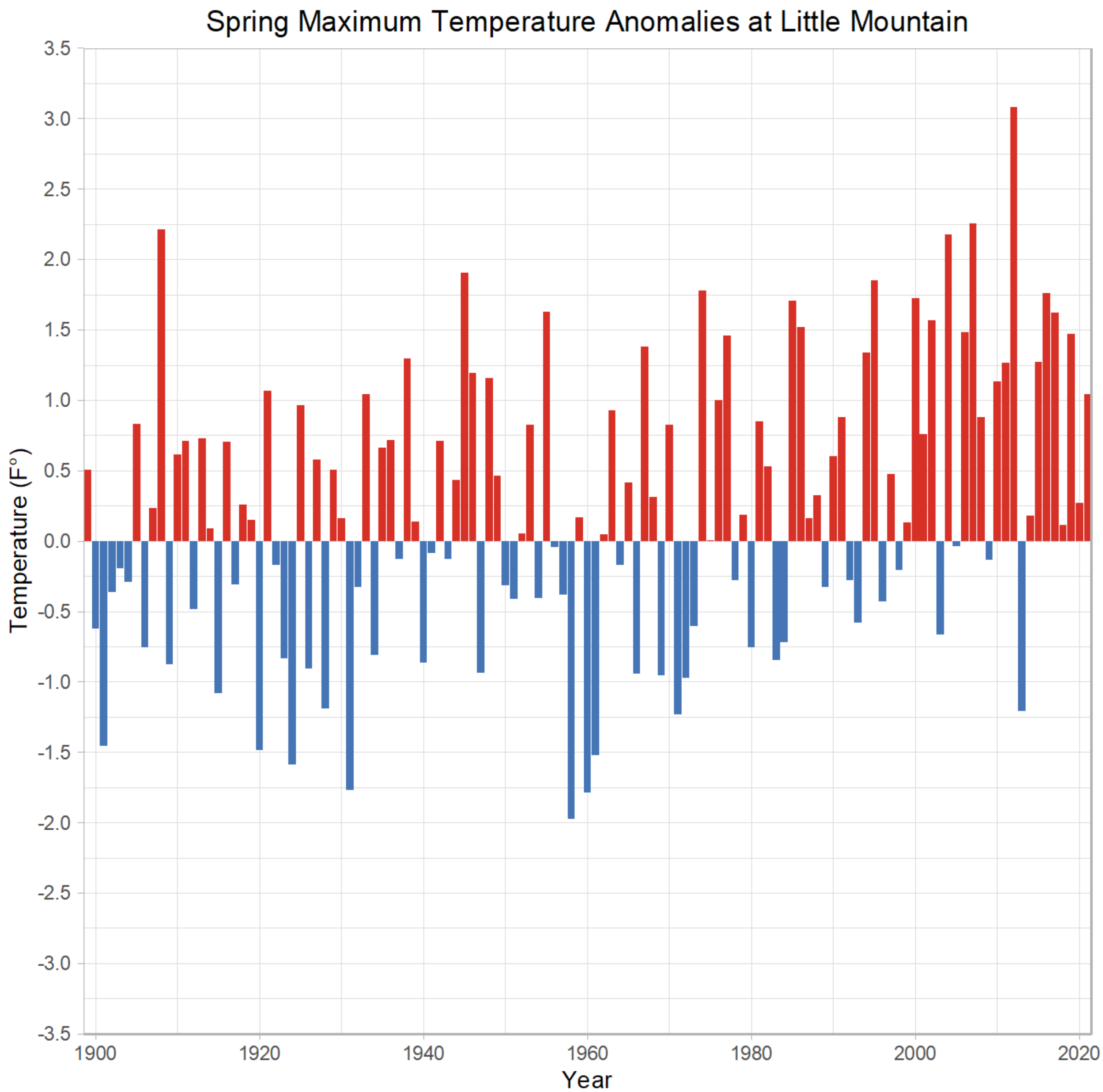

Figure 4.8: 1900-2020 Little Mountain, South Carolina Spring maximum temperature anomalies (from 1900-1960 average)

FUTURE TEMPERATURE PROJECTIONS

Climate model simulations capture the average temperature increase seen in South Carolina from 1950 to the early 2000s (Figure 4.9). In the lower emissions scenario, the ensemble average of all models projects an additional increase of 4°F from the 1991-2020 average by 2100; it ranges from an increase of approximately 3°F in a cooler model to 5°F in a warmer model (Figure 4.10). It is important to note that this lower emissions scenario assumes decreasing greenhouse gas emissions in the next decade and leveling CO_2 concentrations below 450 ppm by the end of the century. By contrast, the high emissions scenario leads to a much greater temperature increase – projected at 6°F, 8°F, and 10°F during the 21st century for the cooler model, ensemble average, and warmer model respectively (Figure 4.11).

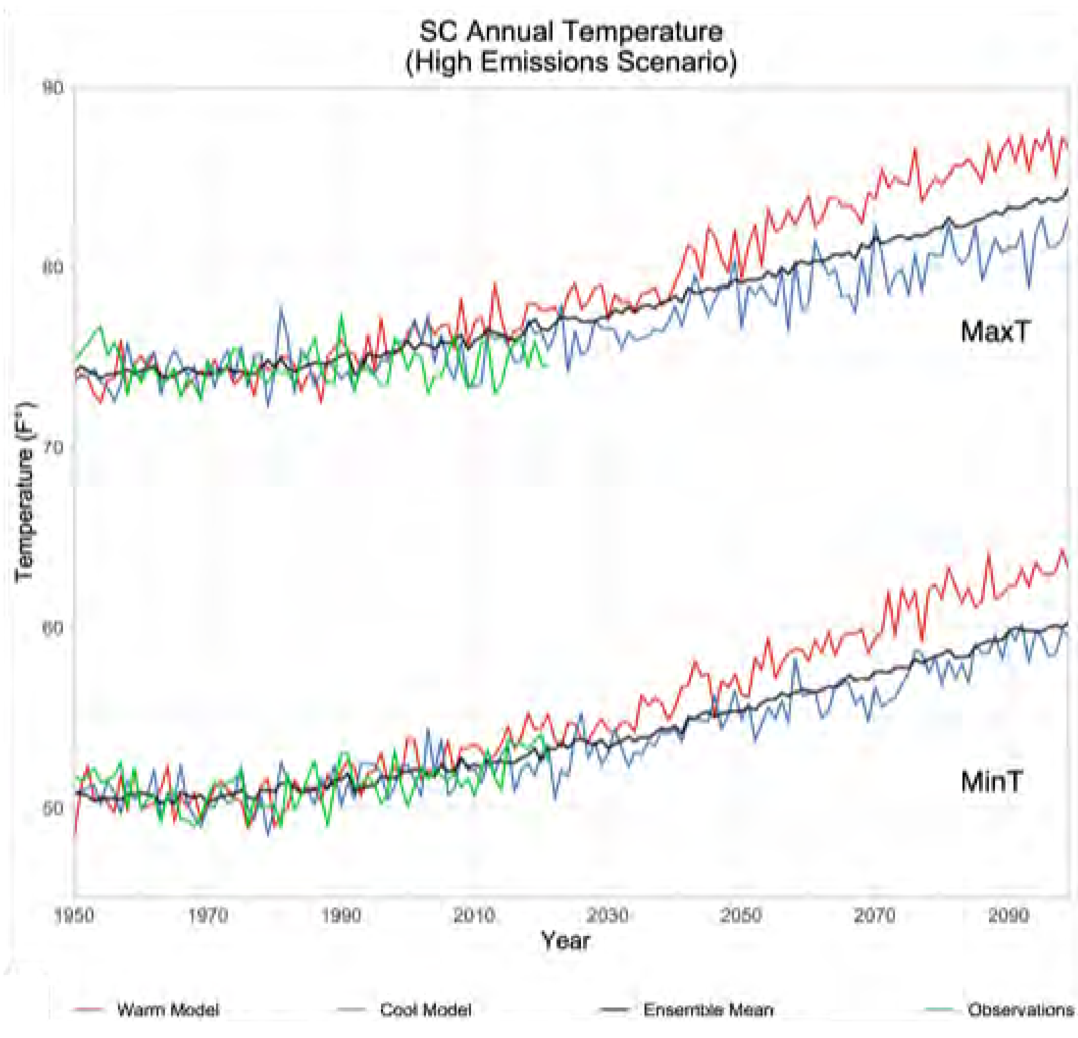

Figure 4.9: Modeled vs. observed annual, state-averaged

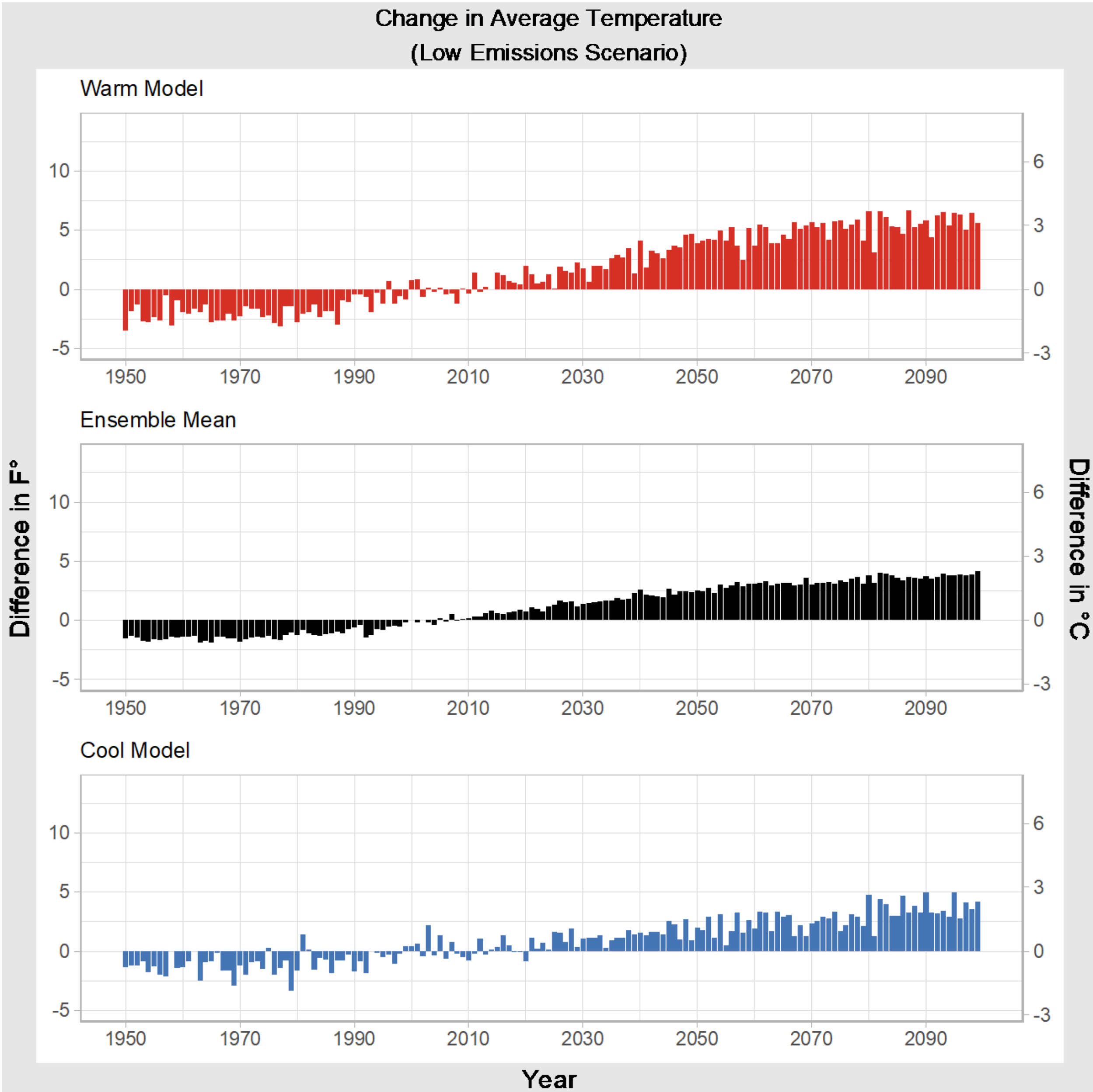

Figure 4.10: Model simulated average temperature for South Carolina. Projections are measured as departures (anomalies) from the 1991-2020 mean (RCP 4.5 emissions scenario)

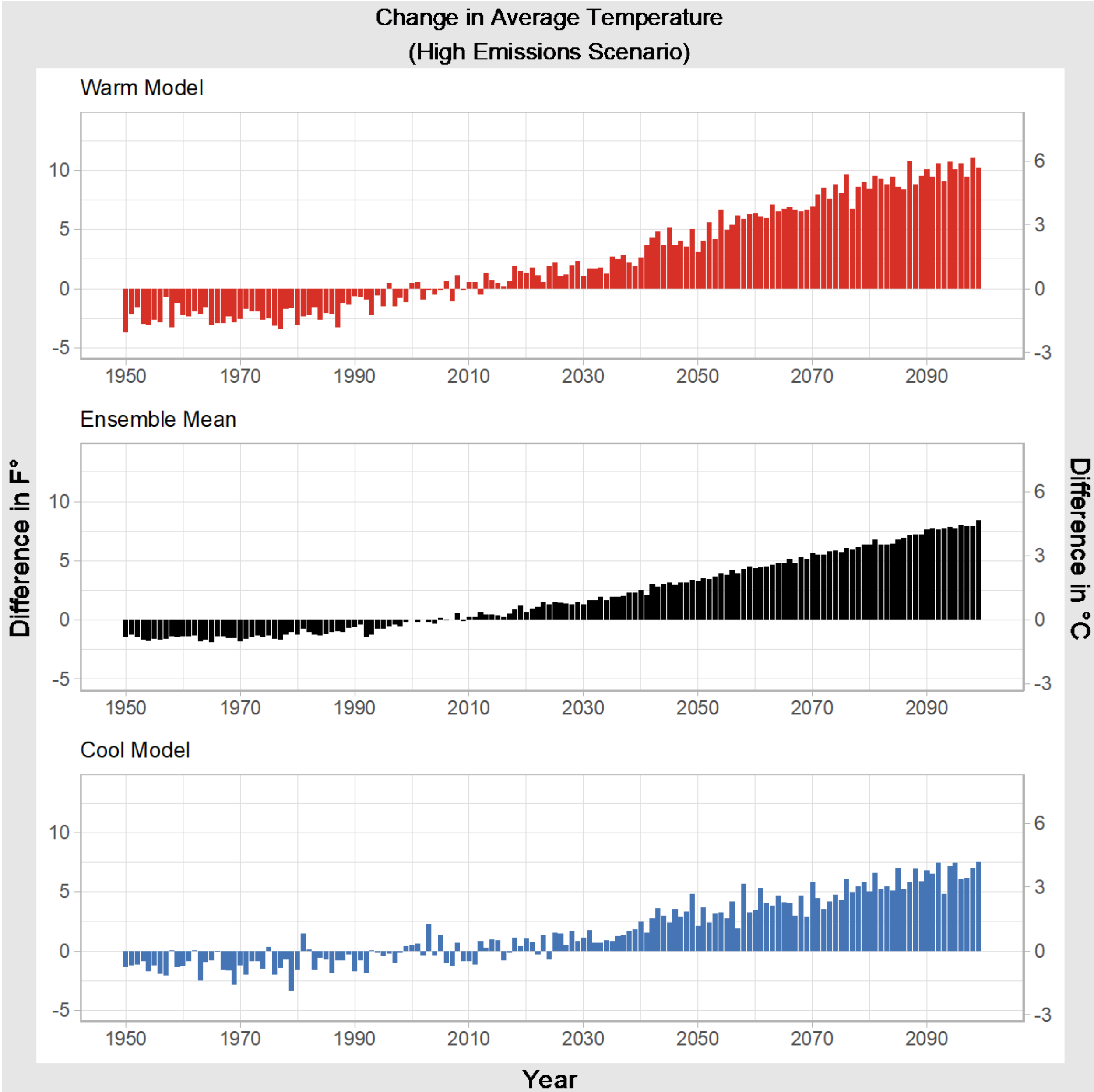

Figure 4.11: Same as Figure 11, but for the high emissions scenario (RCP 8.5)

Projected changes in temperature extremes also vary by emissions scenario and individual model. By the end of the century, the number of days in which state averaged maximum temperature would exceed 95°F doubles in the lower emissions scenario, using output from a cooler model. In the higher emissions scenario with a warmer model, the number increases five-fold. Projections from a model ensemble average show changes in hot days across space and contrasts between emissions scenarios (Figure 4.12 and Figure 4.13). Such increases would likely have ecological impacts, as well as implications for human health and cooling costs during the warm season. Warm nights, as measured by state averaged minimum temperature above 75°F, also increase in future scenarios, from double to six times the number of days per year, depending on emissions scenario and model (Figure 4.14). Meanwhile, cold extremes, in this case defined by number of days in which the statewide average minimum temperature is cooler than 32°F, drop by half in the high emissions scenario by 2100 (Figure 4.15).

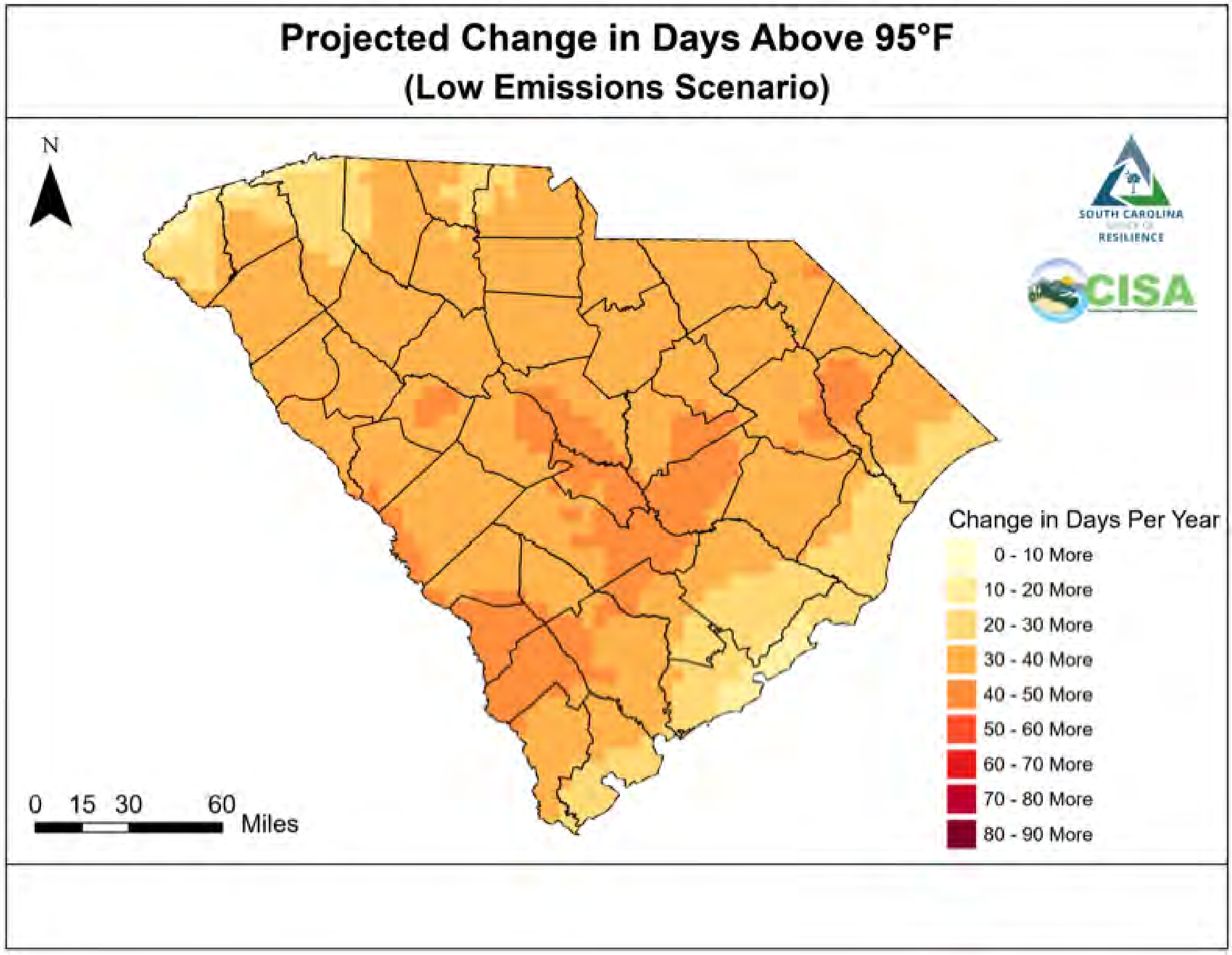

Figure 4.12: Projected increase in the number of days per year with maximum temperature above 95F (RCP 4.5 emissions scenario)

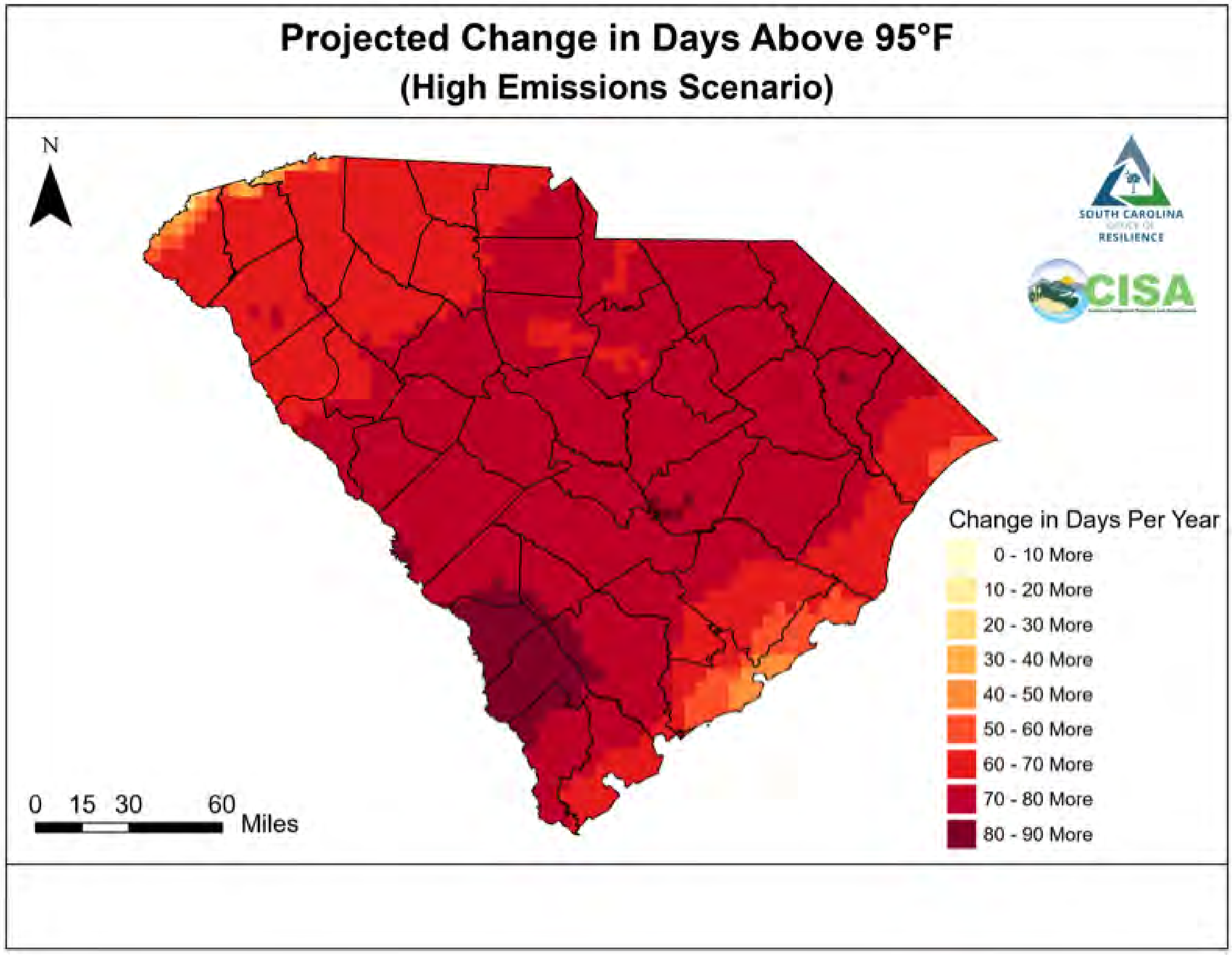

Figure 4.13: Projected increase in the number of days per year with maximum temperature above 95F (RCP 8.5 emissions)

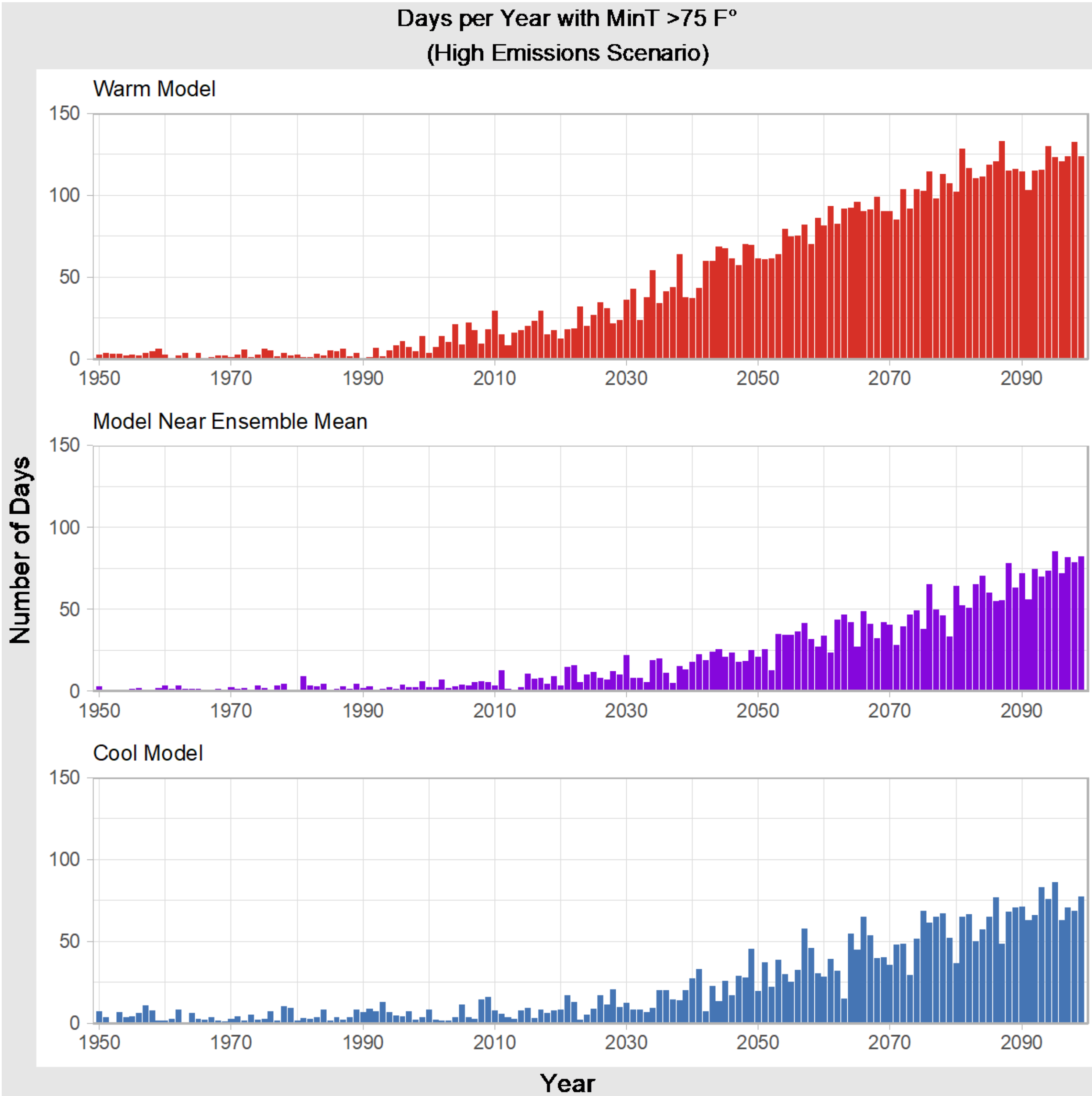

Figure 4.14: Projected number of days per year with maximum temperature above 75F (RCP 8.5 emissions scenario)

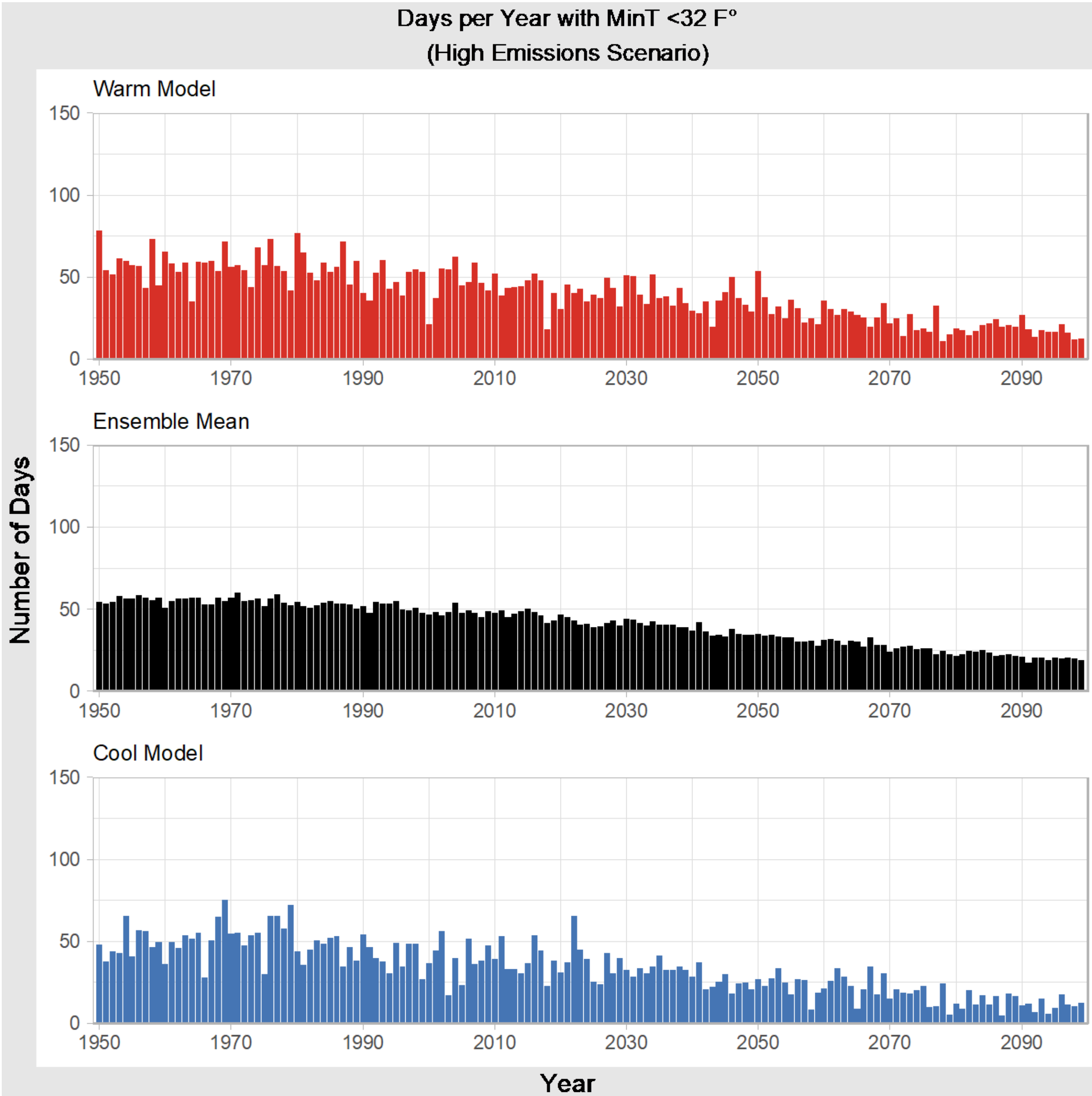

Figure 4.15: Projected number of days per year with minimum temperature below 32F (RCP 8.5 emissions scenario)

SOUTH CAROLINA PRECIPITATION

OBSERVED PRECIPITATION

South Carolina's precipitation varies across years and decades (Figure 4.16), influenced by the paths and frequency of extratropical cyclones and tropical cyclones, the position of the sub-tropical high, and sea-surface temperatures in the Gulf of Mexico and Atlantic (Curtis, 2008; Diem, 2006; Labosier & Quiring, 2013; Qian et al., 2021; Rickenbach et al., 2015). Consequently, there are few statistically significant trends in the annual or seasonal precipitation record. One exception is summer (June, July, August total) precipitation which has decreased at all long-term stations and is statistically significant at two-thirds of these stations, mostly those away from the coast (Figure 4.17).

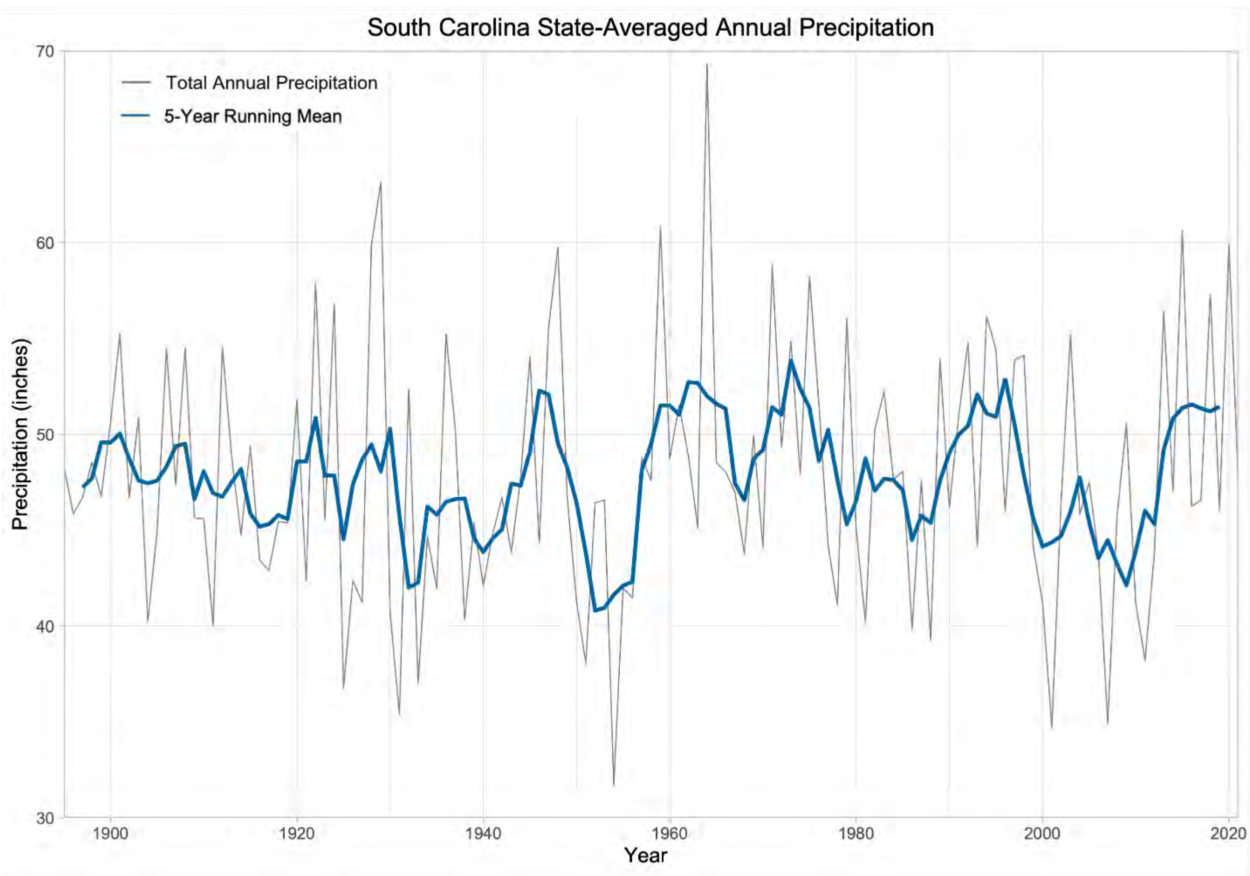

Figure 4.16: State-averaged total annual precipitation

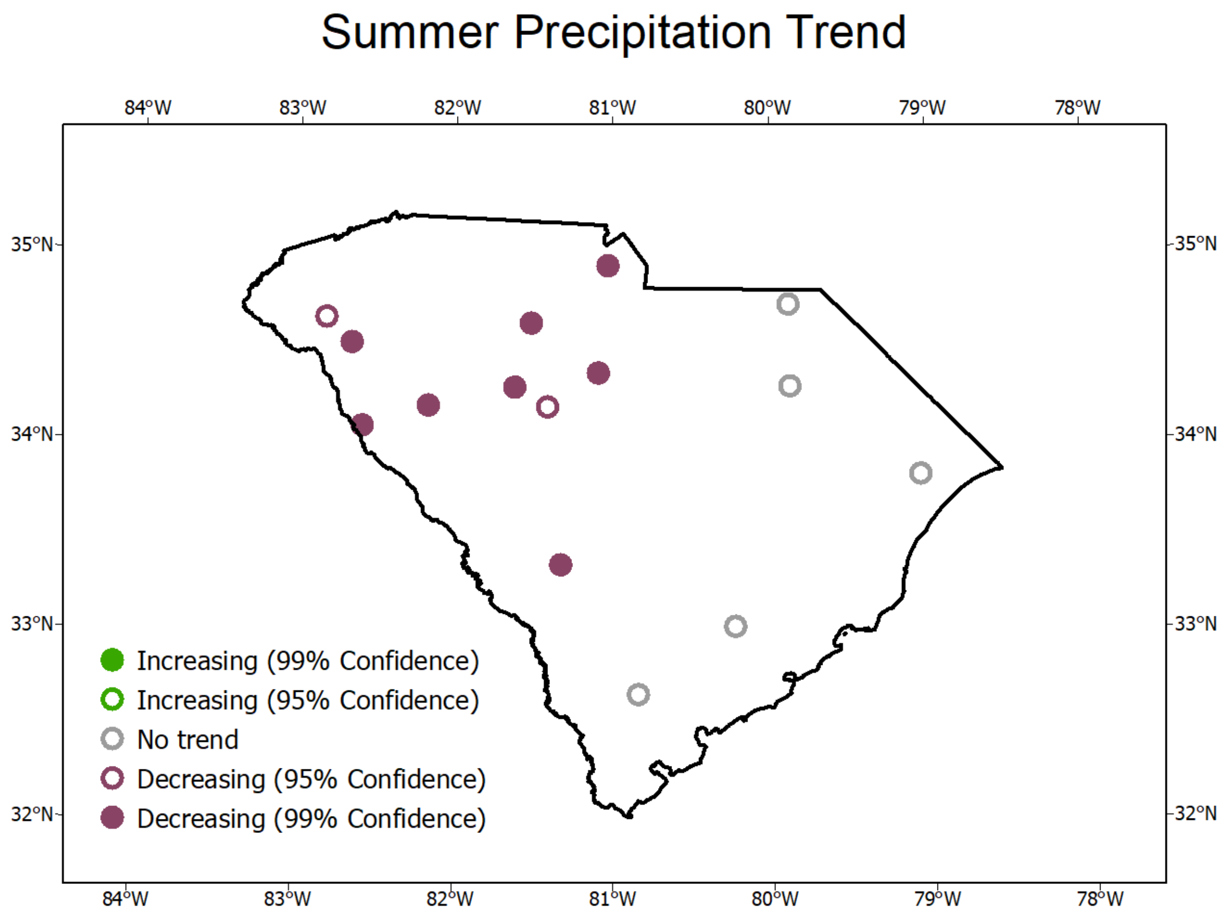

Figure 4.17: Summer precipitation trend, 1900-2020

Data from the Santuck station illustrate the statistically significant decrease of total summer precipitation found at many South Carolina stations (Figure 4.18). The bars in this time series represent the difference of each summer's precipitation from the 1901- 1960 average. The Santuck example also shows the considerable variability of precipitation from year to year and decade to decade, common to all South Carolina stations. It is large enough at many stations that long-term monthly or seasonal precipitation changes do not have statistically significant trends relative to this interannual and interdecadal variability. Three exceptions include a decrease in February and an increase in November precipitation totals at all long-term stations (statistically significant at 60-70% of them), and an increase in rain days during fall at most South Carolina stations.

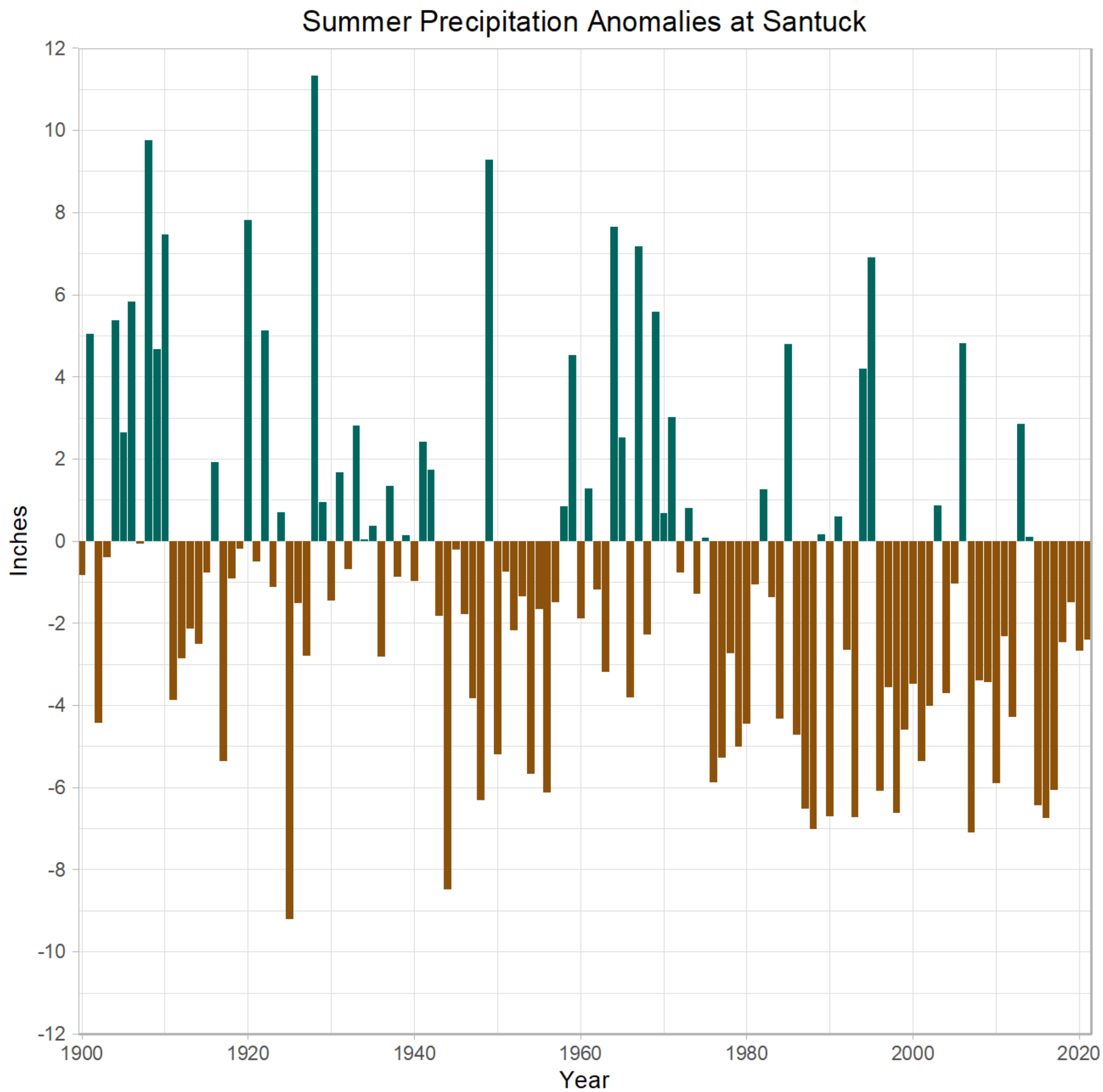

Figure 4.18: Santuck, SC summer precipitation anomalies from 1901-1960 mean

FUTURE PRECIPITATION PROJECTIONS

Most future precipitation projections show modest increases through the 21st century (Figure 4.20). There is a range among even those models with the best performance in the southeastern US during the historic period. One wetter model shows an average increase of about 10% with annual swings exceeding 40% of current average conditions. A drier model shows decreases of 10% and annual swings of 40% lower than current average conditions. The ensemble mean shows state-averaged precipitation increases of 5-10%. It is important to note that even if South Carolina's precipitation increases in the future, some of this increase would be offset by higher evaporation rates caused by warming. Under those conditions it is possible for precipitation to increase, but moisture availability in soils and watersheds to decrease because of higher evaporation rates. Moisture availability also depends on the nature of precipitation changes. If delivered in shorter, more intense bursts, precipitation runoff could increase, limiting soil moisture gains and increasing the risk of flooding.

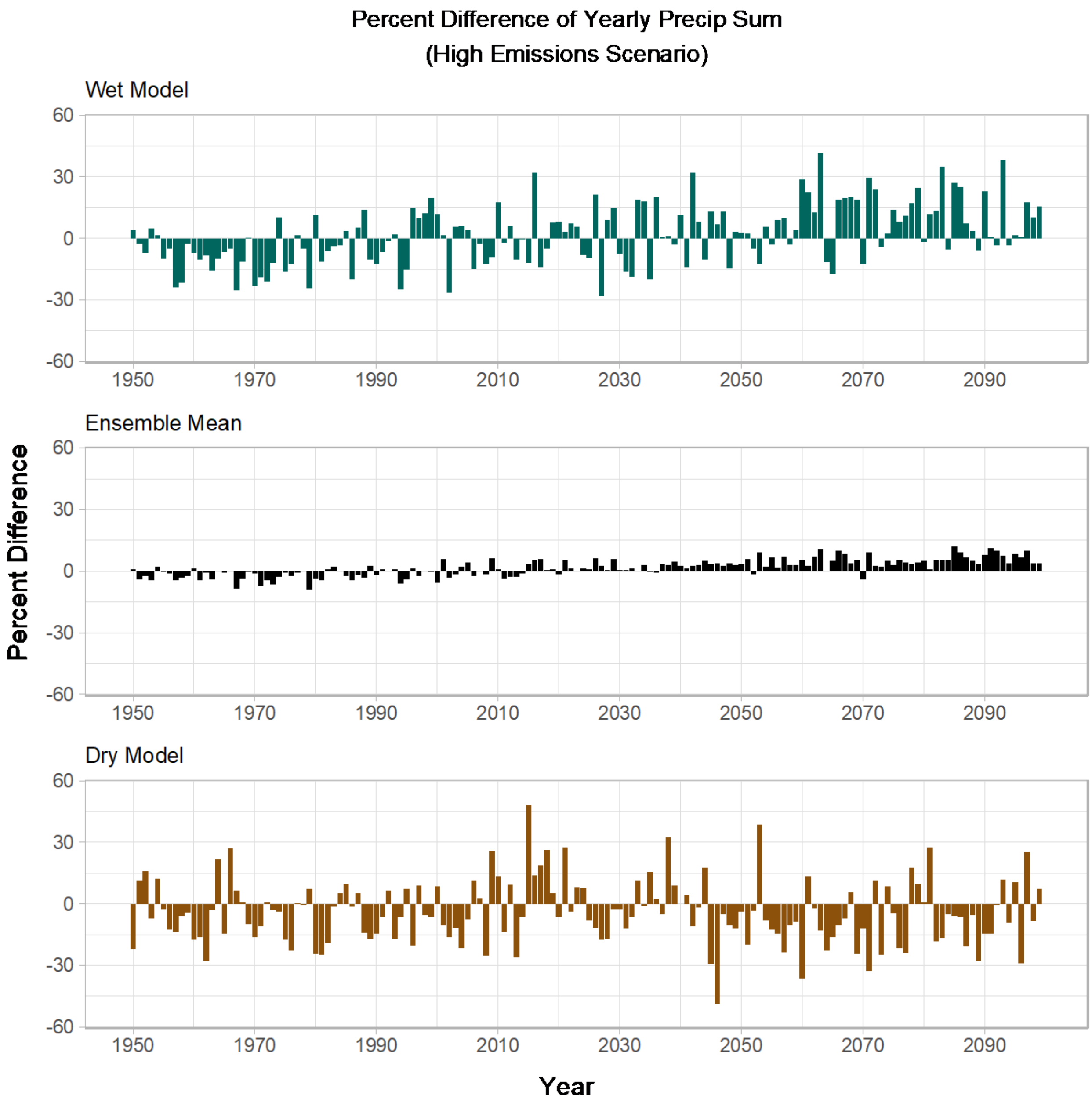

Figure 4.19 Model projected annual precipitation as percentage greater or less than 1991-2020 mean.

PRECIPITATION EXTREMES

Precipitation extremes potentially pose even greater social risks than changes in monthly, seasonal, or annual averages. South Carolina experiences many heavy precipitation events fueled by moisture delivery from the Gulf of Mexico and Atlantic, as well as lift from thunderstorms, tropical cyclones, and fronts. Changes in moisture supply or storm patterns can alter the frequency of heavy precipitation events and the intensity, or rate, at which precipitation falls during these events.

Analysis of South Carolina precipitation extremes reveals three fundamental points. First, most measures of heavy precipitation have large interannual and interdecadal variability, even greater than that seen in monthly, seasonal, or annual total precipitation. Second, while heavy precipitation has increased since the mid-1900s at many southeastern US stations (Easterling et al., 2017; Powell & Keim, 2015), the picture is less consistent in South Carolina, where most stations do not exhibit significant long term trends (Moraglia et al., 2022). Few stations in South Carolina, for example, have significant changes in the 1-day precipitation amounts expected with 50%, 10%, or 1% probability in any given year (often called 2-, 10-, and 100-year events, respectively).

The large interannual and interdecadal variability, combined with the infrequency of extreme precipitation events, makes finding statistically significant long-term trends difficult. Third, despite the lack of long term trends, extreme events during the past decade (including 2015, 2016, and 2018) are among the highest in the historic record and have resulted in extensive property damage and loss of life.

One South Carolina station that does show a long term, statistically significant increase in heavy precipitation is Conway. Analysis of 50-year periods for the station clearly shows how big events in recent decades have affected 1-day precipitation probabilities. For a given precipitation depth there is a higher probability of occurrence when considering 50-year periods after 1950 versus those earlier in the 20th century (Figure 4.20). For example, a 5-inch rainfall event has a one-in-ten chance of occurring in any given year (the so-called 10-year event) when using 1930-1979 precipitation data, but a one-in-five chance of occurring (a 5-year event) using 1970-2019 data. This has implications for infrastructure designed and built decades ago.

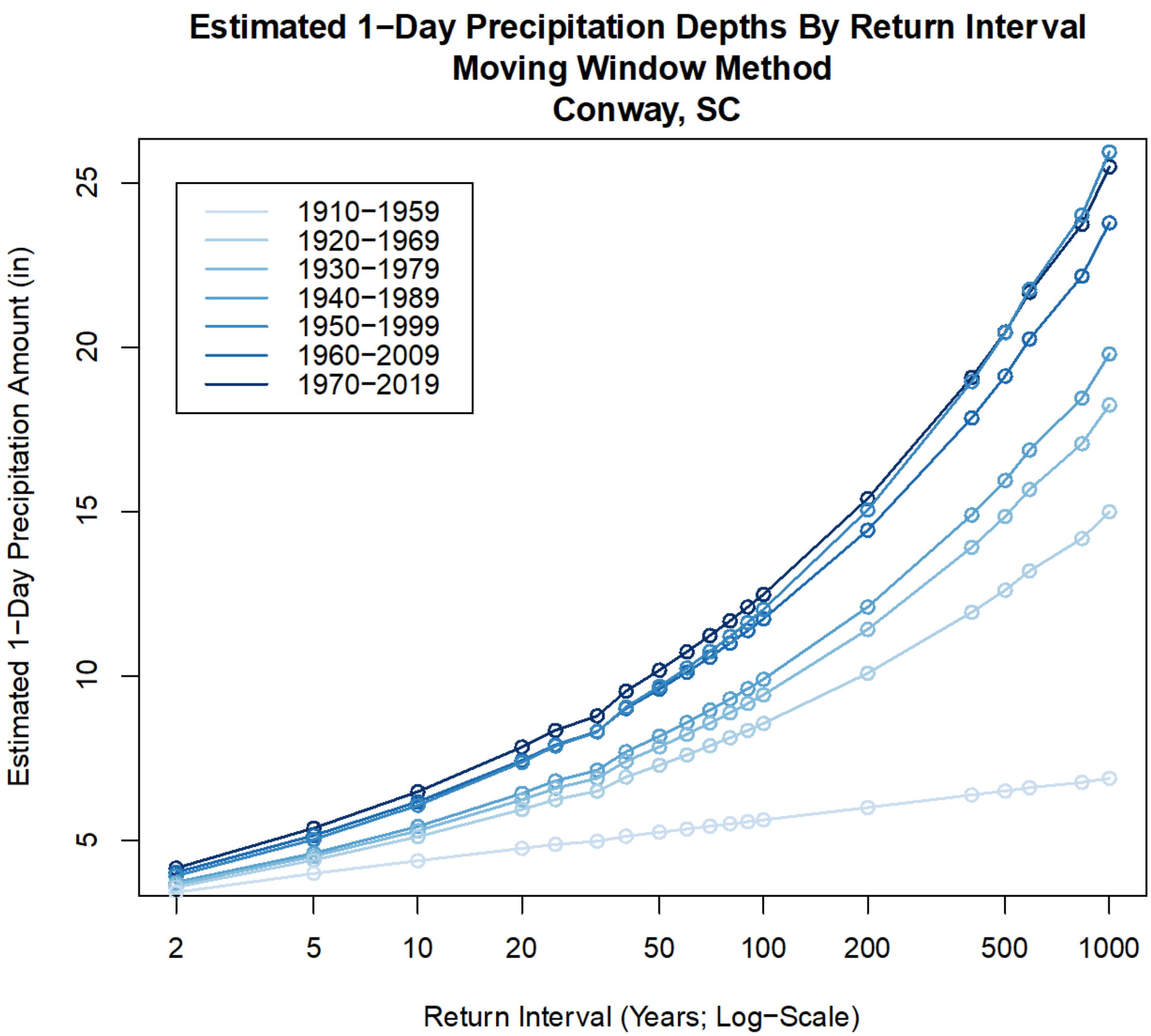

Figure 4.20: Average recurrence interval of 1-day precipitation depths calculated for separate 50-year periods. Shading is lightest for earliest period (1910-1959) and darkest for most recent period (1970-2019).

In Conway's case, there is a need to understand how recent events altered the precipitation probability of the full record. Specifically, how do probabilities of 1-day precipitation maxima during the period 1910-2000 (used in the widely-referenced Atlas-14) differ from those using data from 1910-2020? Such differences, it turns out, are relatively modest (Figure 4.21). The likely reason is that the 1910-2000 record includes 11.35 inches of precipitation from 1999's Hurricane Floyd, which already shifted the tails of the distribution. Large shifts in probability require unprecedented events, and big events after 1999 have not yielded higher 1-day precipitation at Conway. Because heavy rainfall frequently occurs for only short durations across small areas, it is often undetected, particularly by the few weather stations with the long, consistent records necessary for evaluating change. Even fewer stations measure hourly precipitation, which may be more important for capturing intensity as highest hourly precipitation can contribute more than 40% of a day's total (Barbero et al., 2019). A recent study of 1960-2015 trends in hourly precipitation at National Weather Service stations in Greenville, Columbia, and Charleston, as well as Wilmington and Charlotte, NC, and Savannah and Augusta, GA (Brown et al., 2019), found significant shortening of storm duration at all stations (90% confidence) and increasing hourly totals at Charleston (95% confidence), and Savannah, Charlotte, and Wilmington (90% confidence). By contrast, the frequency of events exceeding the station-specific average hourly accumulation dropped significantly at three stations — Greenville, Columbia, and Savannah (90% confidence). These mixed results warrant more investigation of sub-daily precipitation records.

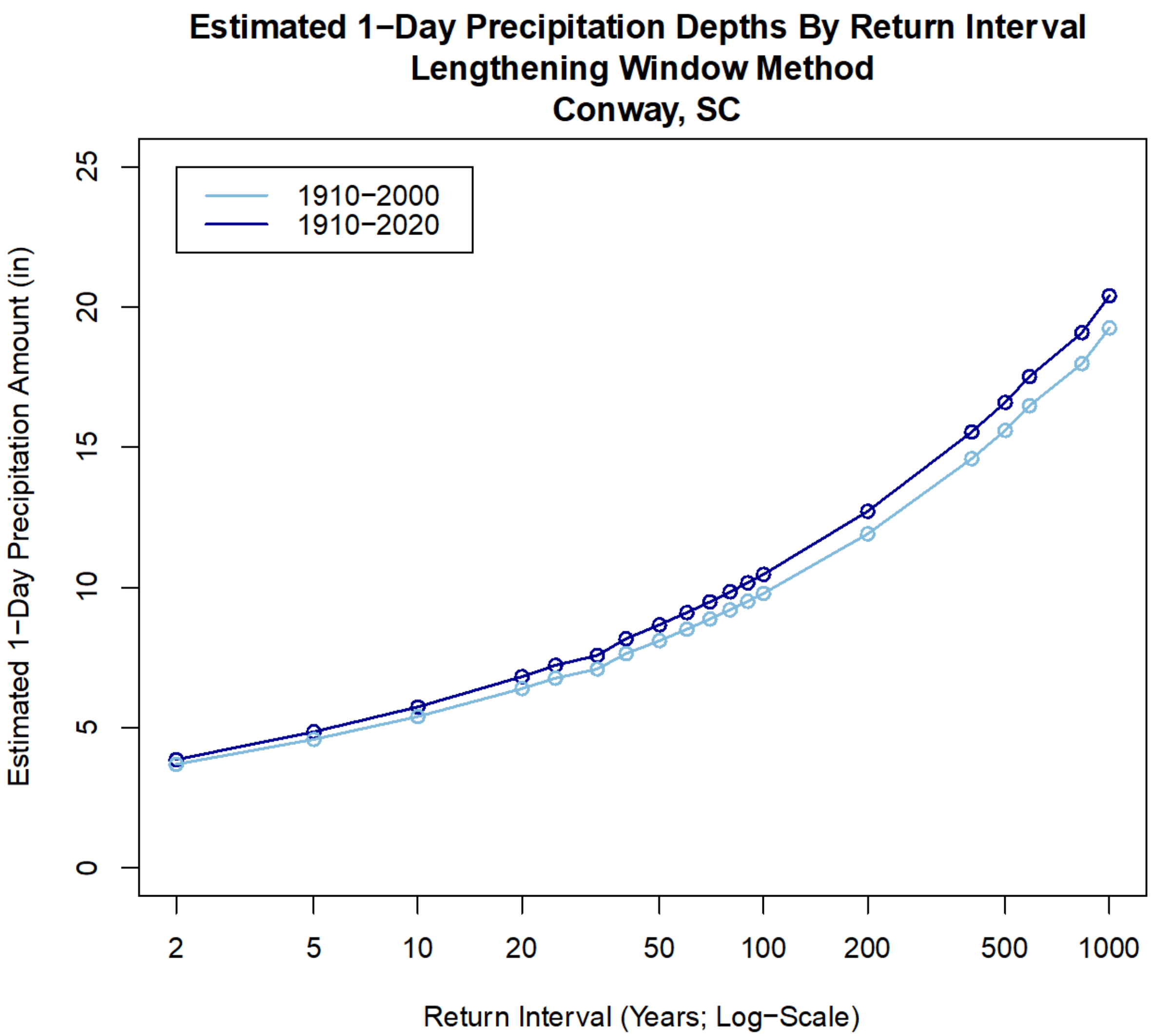

Figure 4.21: Average recurrence interval of 1-day precipitation depths calculated separately for 1910-2000, and for 1910-2020.

Changes in global climate could alter moisture availability and storm systems in ways that affect precipitation intensity. Globally, water vapor increases by approximately 7% for each 1.8°F (1°C) temperature increase (Trenberth et al., 2003). While this relationship does not translate directly to heavier precipitation events, research has documented connections between moisture availability and increases in observed and modeled precipitation intensity at global, continental, and regional scales (Fischer & Knutti, 2016; Forestieri et al., 2018; Grabowski & Prein, 2019; Huang et al., 2017; Kunkel et al., 2020a; Lehmann et al., 2015; O'Gorman & Schneider, 2009; Tabari, 2020). Heavy precipitation events in the southeastern US are strongly driven by precipitable water availability (Kunkel et al., 2020b; Kunkel et al., 2020c). As temperature increases cause higher evaporation rates from the Gulf and Atlantic, delivery of precipitable water to South Carolina should increase in the 21st century. Only significant changes in storm frequency and dynamics would curtail heavier precipitation in the future. Projections from climate models show consistent increases in atmospheric moisture delivery to the Southeast with consequent increases in heavy precipitation at daily to hourly scales (Easterling et al., 2017; Prein et al., 2017).

Current climate models generate plausible global scenarios, but their ability to project daily or hourly precipitation for a specific region is limited. Recent application of statistical methods and high resolution climate models has helped to quantify the degree to which individual heavy precipitation events can be blamed on global scale climate trends. Examples of such attribution studies exist for a heavy rainfall event due to a stationary low-pressure system near Louisiana (van der Wiel et al., 2017) and for tropical cyclones, including Hurricane Harvey (Patricola and Wehner, 2018; Risser and Wehner, 2018; van Oldenborgh et al., 2017). While many uncertainties remain, new initiatives for more detailed precipitation monitoring and for climate modeling that incorporates convective cloud dynamics should further improve our understanding of how global scale climate trends can affect heavy, short duration rainfall (Blenkinsop et al., 2018; Fowler et al., 2021).

The recent record of heavy precipitation in the Carolinas provides a tangible example of precipitation extremes, their spatial extent, and the potential for loss of life and property. Precipitation in October 2015, October 2016, and September 2018 produced record rainfall in large parts of eastern and central South Carolina, demonstrating how rare events can happen in quick succession — a compounding hazard that produced repetitive losses across the Pee Dee Basin. In just a few years, events with a 1% annual probability or less occurred multiple times in some locations (Figure 4.22). As reported elsewhere (Jalowska et al., 2021), the three extraordinary events are at the high end of future projections for precipitation intensity. Similar repetitive events have affected North Carolina during the past two decades (Paerl et al., 2019). These events are consistent with expectations of a warmer world with higher evaporation rates and atmospheric moisture and provide tangible examples of the state's vulnerability to heavy precipitation.

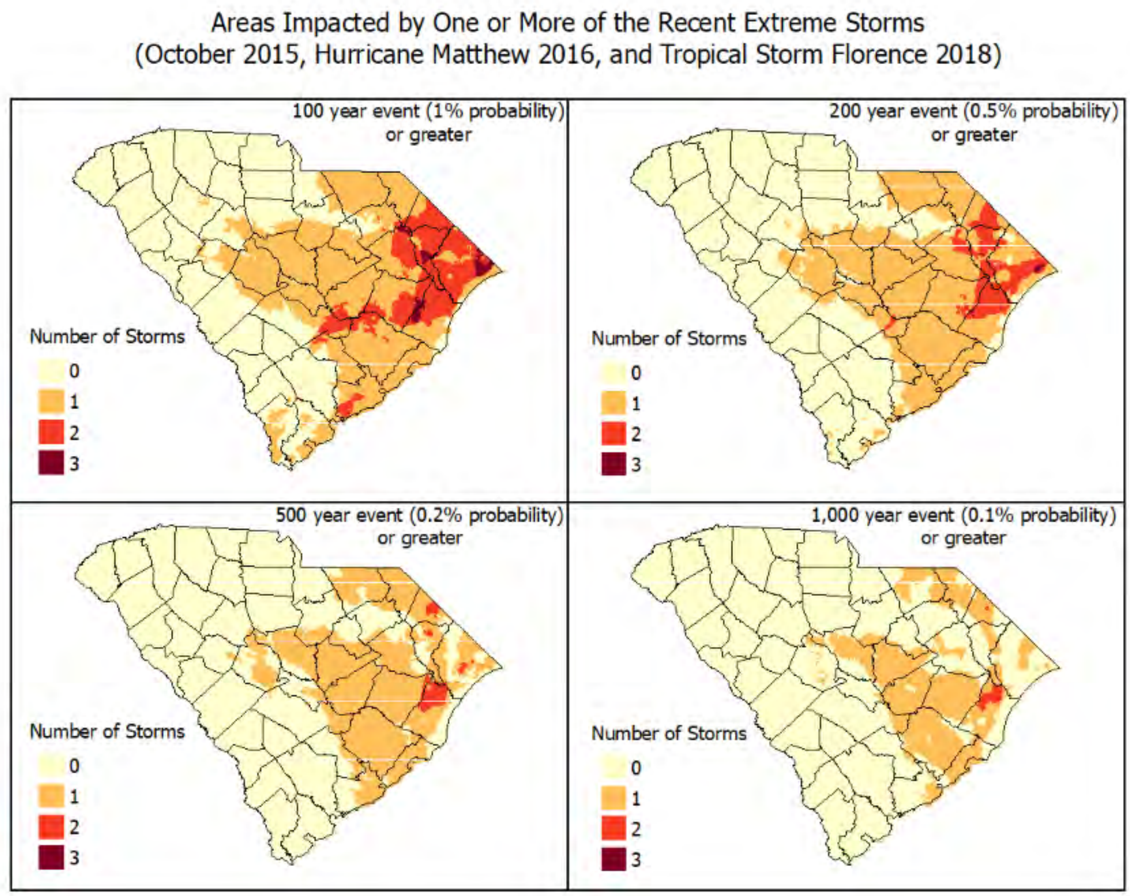

Figure 4.22: Areas experiencing 100-, 200-, 500-, and 1000-year rainfall events due to one or more of the recent extreme storms. (Data provided by SC Department of Natural Resources.)

Aside from observed or modelled changes in precipitation intensity, changes to the surface on which precipitation falls can alter the impacts of heavy rainfall events. Most of South Carolina has experienced increases in impervious surfaces in recent decades, a trend that is likely to continue through the 21st century (Terando et al., 2014). For example, urbanization around Charleston has resulted in land use and land cover change five times larger than the rate of population growth since 1990 (Allen & Lu, 2003). This land use change accelerates the delivery of water to rivers, lakes, and wetlands, increasing the likelihood that a given amount of precipitation will lead to flooding.

DROUGHT

South Carolina has endured extensive periods of meteorological, agricultural, and hydrologic drought as well as anomalously wet periods. The Standardized Precipitation Index (SPI) measures the intensity of wet or dry spells by comparing a fixed period against all such periods in the historic record. Historic records of this meteorological drought index show regular cycles of wet and dry periods during the past 125 years. By incorporating estimates of evapotranspiration, infiltration, and runoff, however, the Palmer Hydrological Drought Index (PHDI) provides a more complete measure of moisture deficit and surplus and is more commonly used when considering impacts on water resources (Figure 4.23). Both measures qualitatively show interannual and interdecadal variability in dry and wet periods, but no obvious historical trends in either. This echoes other recent research showing little statistically significant evidence for changing drought length or intensity in North Carolina (Soulé, 2022). South Carolina has also historically experienced rapid drought onset (i.e., "flash droughts"), and considerable variability across the state (Figure 4.24).

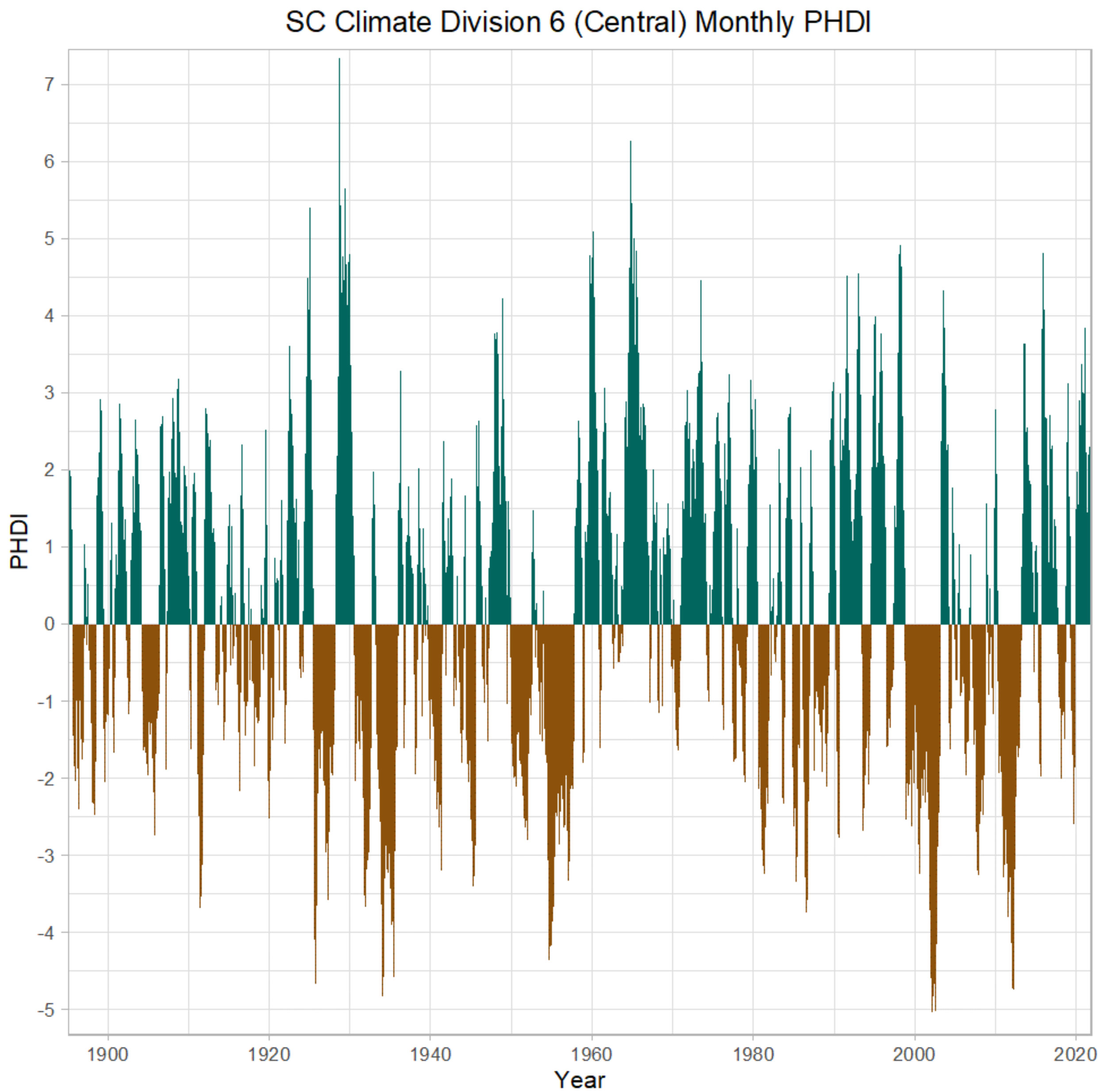

Figure 4.23: Palmer Hydrological Drought Index 1895-2020.

The 3-month SPI for November 2016 across North Carolina and South Carolina is represented in Figure 4.24. The legend shows areas of the index that indicate dry or wet conditions. The visual pattern is a swath of extremely dry areas in the western regions of the Carolinas and a swath of extremely wet areas on the Coastal Plain of the Carolinas. In the area between these two swaths, conditions are near normal.

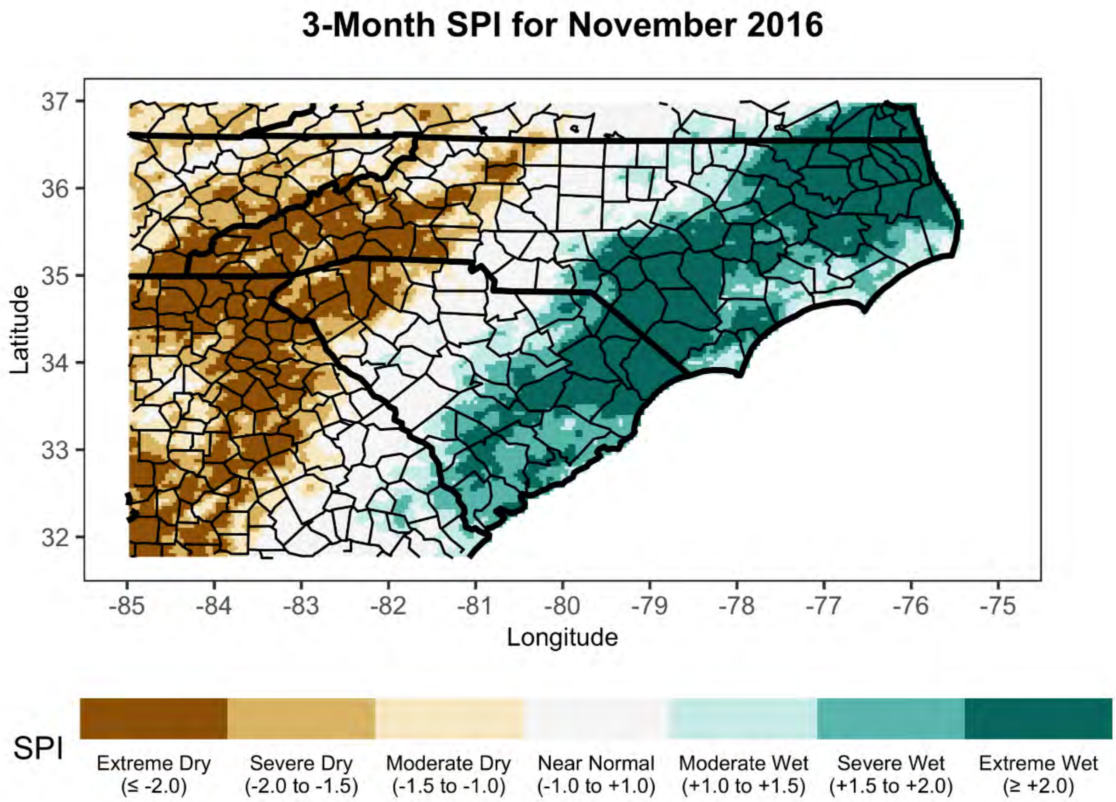

Figure 4.24: Variability of Drought across South Carolina (Fall 2016)

Projections of future meteorological drought in the state are mixed. Some recent work suggests very modest changes in projected consecutive dry days during the warm season and spatially mixed changes during the cool season (Keellings & Engström, 2019). More generally in the literature, there is relatively low confidence in human influence on meteorological drought because of uncertainties in precipitation projections. There is medium confidence that changes in the global climate could exacerbate agricultural and ecological drought, reflecting greater consensus on temperature increases that cause more evaporation from waterways and soil (Arias et al., 2021).

Projections of drought measures that incorporate an evaporation component show a trend towards drier conditions in the Southeast (Ahmadalipour et al., 2017).

TROPICAL CYCLONES

OBSERVED VARIABILITY

South Carolina’s geographic position lends itself to periodic influences of tropical cyclones (i.e., tropical storms and hurricanes; Figure 4.25). Warm waters in the tropical Atlantic foster the development of these storms, that typically travel from east to west in the tropical trade wind belt. The Bermuda High pressure system in the subtropical Atlantic steers these storms when they drift north, sometimes towards South Carolina, bringing high winds, storm surge, and heavy precipitation. Some of these storms make direct strikes on the state from the Atlantic, others strike nearby states or brush the coast, still others enter as “backdoor” storms moving north from the Gulf of Mexico and ultimately affect South Carolina.

Tropical cyclone activity varies greatly from year to year and decade to decade, across the Atlantic Basin and the Gulf of Mexico. Activity depends on many variables, particularly sea surface temperature and wind shear across tropical and subtropical waters. In addition, conditions in the tropical Pacific (associated with El Niño/La Niña cycles) and thunderstorm activity in West Africa both influence the formation and development of Atlantic hurricanes.

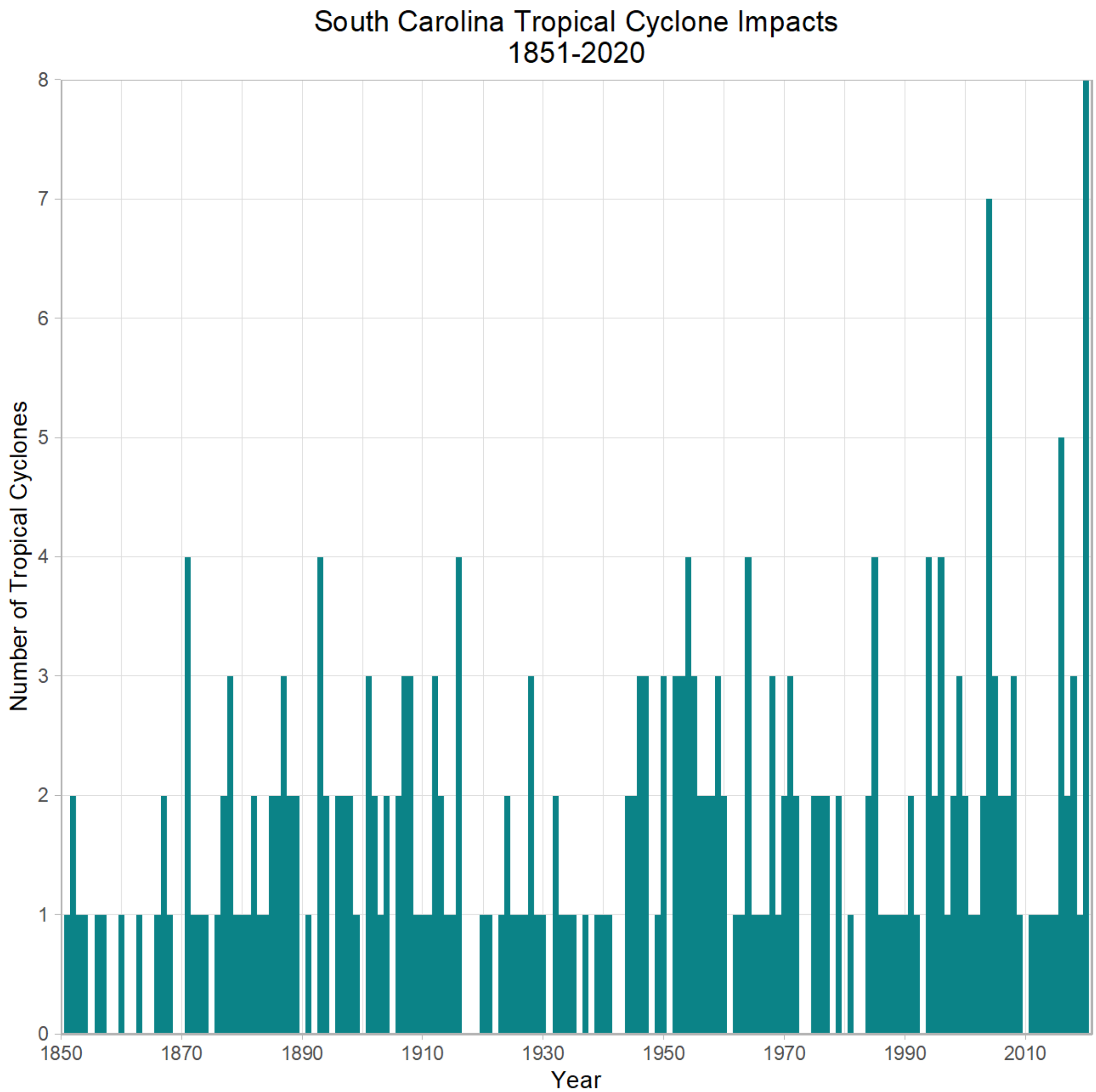

Figure 4.25: Tropical Cyclones affecting South Carolina, 1851-2020

FUTURE TROPICAL CYCLONE PROJECTIONS

Global climate trends could affect tropical cyclone frequency, intensity, and associated precipitation. Evidence for historic and projected changes come from observational analysis and climate model simulations, respectively. The observational record provides scant evidence for statistically significant changes in the number of North Atlantic hurricanes, though such investigations are hampered by a relatively short observational record (particularly over oceans), and high natural interannual and interdecadal variability. Likewise, future projections for 21st century North Atlantic hurricane frequency are mixed. While some modeling studies have indicated the possibility for fewer tropical cyclones (Mallard et al., 2013), others have shown no significant changes (Jing et al., 2021), or little basis for such decreases (Emanuel, 2021). Moreover, a panel of hurricane experts have expressed low to medium confidence in projections indicating a future decrease in the number of events (Knutson et al., 2020). The necessary conditions for hurricane formation are well known, but a more complete understanding of actual hurricane genesis is required for consistent and reliable estimates of future frequency (Sobel et al., 2021).

By contrast, observations and models show more consistency regarding recent and projected changes in hurricane intensity (Wu et al., 2022). Estimates during the satellite era (since 1979) show that category 3 and higher storms have increased in number by 8% per decade (Kossin et al., 2020). Models consistently link increasing tropical cyclone intensity to a warmer world where increasing sea surface temperatures provide more energy to the storm through increased condensation within its cumulonimbus and cumulus clouds (Emanuel, 2021; Jing & Lin, 2020; Lackman, 2015). Some future scenarios show decreased vertical wind shear near the southeastern US coast which could foster more formation and intensification of tropical cyclones (Ting et al., 2019; Vecchi & Soden, 2007). Models have also been used to estimate the effects of specific environmental changes on hurricane strength. For example, Hurricane Matthew was simulated with end-of-century-projected sea surface temperatures resulting in lower central pressure and consequent wind speed increases of 20 miles per hour (Jisan et al., 2018). There is further evidence that increased sea surface temperature has and will contribute to more rapid intensification of storms close to landfall (Emanuel, 2017).

Observations and models similarly provide a picture of increased precipitation associated with tropical cyclones (Stansfield et al., 2020). North Atlantic sea surface temperature increases of 0.75 to 1.6°F since 1850 have led to increased extreme 3-hourly rainfall rates and 3-day total precipitation of 10% and 5%, respectively, for tropical cyclone strength storms with wind speeds reaching 42 mph, and even higher for hurricane strength (74mph) storms (Reed et al., 2022). Models that incorporate convection show significantly enhanced precipitation rates and totals for simulations of Hurricanes Katrina, Irma, Maria, and Florence (Patricola & Wehner, 2018; Reed et al., 2020).

Finally, it is important to consider the impacts of compounding factors. Future changes in wind and consequent storm surge, atmospheric moisture increase and precipitation intensity, forward speed of tropical cyclones, and sea level rise could amplify impacts (Gori et al., 2022).

SEA LEVEL RISE

Globally, sea level rise has three main drivers — melting ice, warming ocean waters, and changes to water use on land. Melted ice adds water that was previously trapped in ice sheets and glaciers, water expands as it warms, and human uses of water either adds to (e.g., water previously trapped in an underground aquifer is taken out and used) or removes (e.g., a dam that slows the flow of a river into the ocean) water flowing into the ocean. Regionally, sea level rise can also be affected by ocean circulation and changes in land elevation.

Measurements at tidal gauges provide direct evidence for sea level rise in South Carolina and around the world. For example, the tide gauge station in Charleston at the Cooper River has recorded data since September 13, 1899, showing a 1.1-foot rise during the past 100 years; the increase has accelerated since 2000 (NOAA, 2022c). In the past three decades satellites have supplemented gauge measurements with continuous monitoring of global sea level.

Based on current greenhouse gas concentrations, sea levels in South Carolina will rise an additional 10 to 14 inches by 2050 (Sweet et al., 2022). While the core mechanics of sea level rise are not debated, projections of it beyond 2050 vary because scientists continually improve understanding of complex interactions between multiple systems (ocean, land, and ice) and because of uncertainty associated with future emissions and the timing of certain physical processes, especially abrupt changes like when an ice sheet collapses. By 2150, it is almost certain to see approximately 2 feet of sea level rise, and likely to see 3.5 to 7 feet if greenhouse gas emissions do not rapidly decrease (Figure 4.26; Sweet et al., 2022).

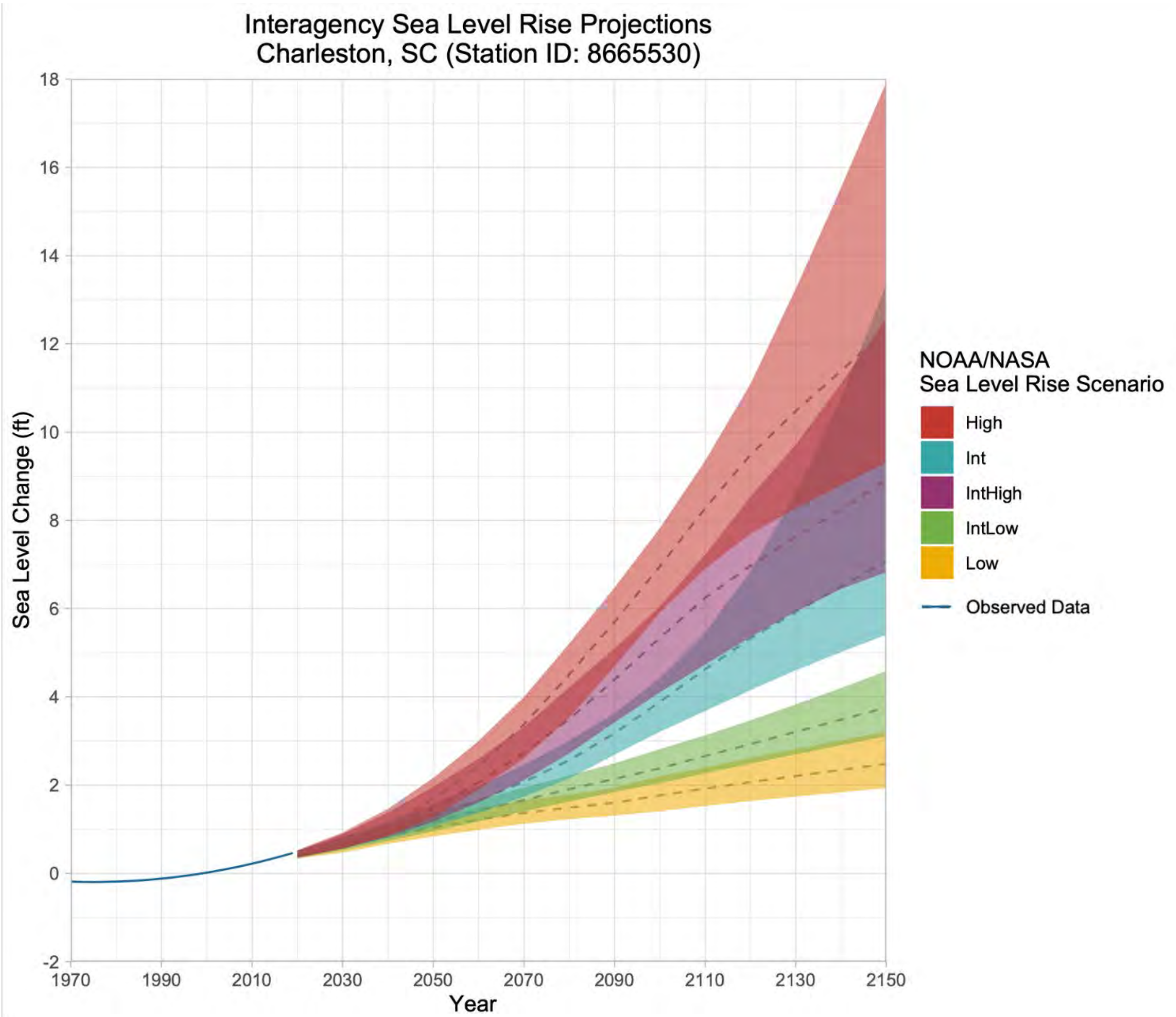

Figure 4.26: Sea level change projections at Charleston (Adapted from Sweet et al., 2022).

INCREASING FREQUENCY OF COASTAL FLOOD EXTREMES

Sea level rise can combine with storm surges, tides, or heavy rainfall to produce compound flood events (Figure 4.27; NOAA, 2022a, 2022c). Minor recurrent events cause disruptions and delays, while an additional 2 to 3 feet cause additional impacts, including damage to homes and businesses. These are sometimes referred to as extreme (sea level) events. In Charleston, extreme events are projected to occur 20 times as often by 2050 (Sweet et al., 2022).

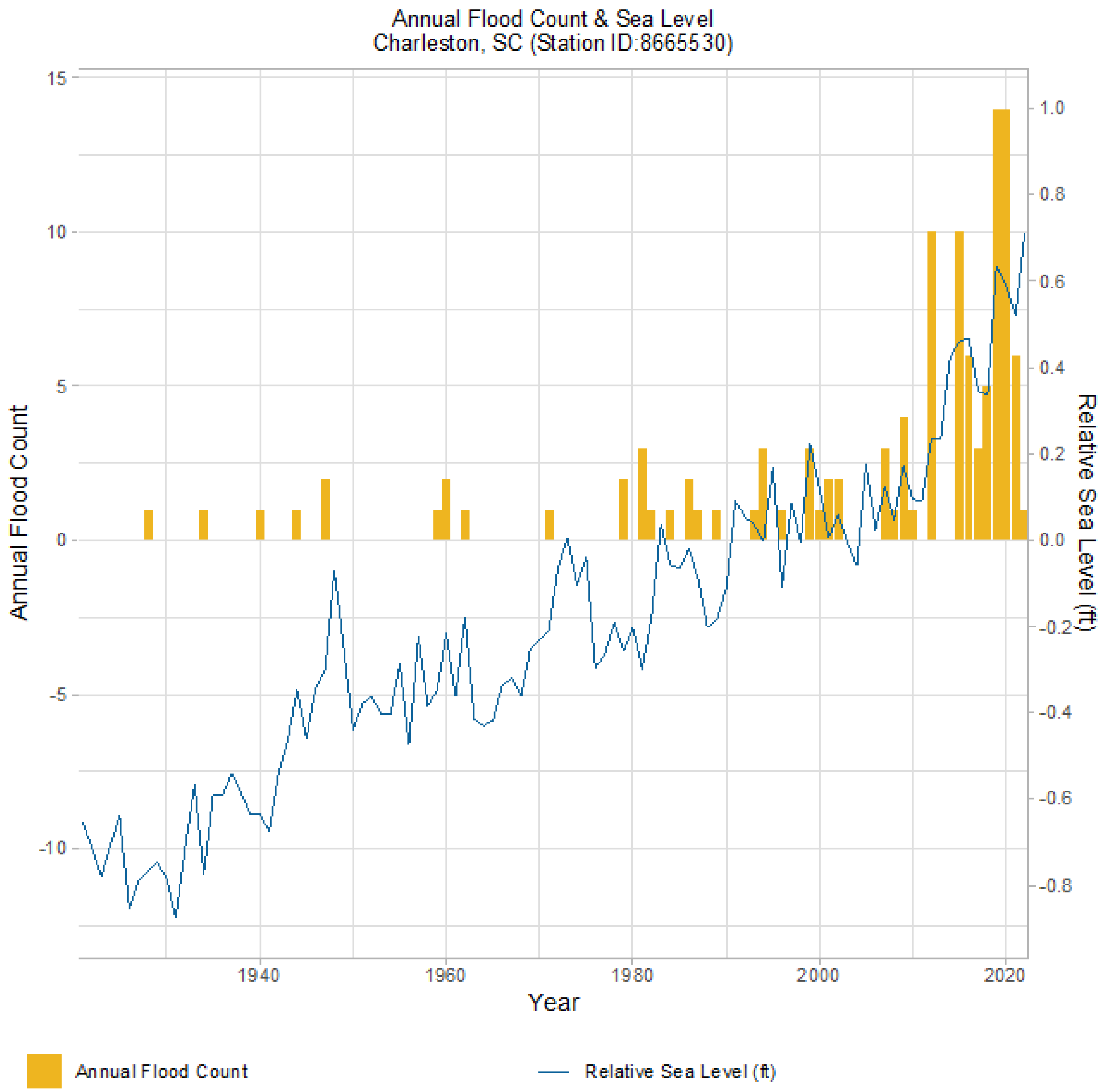

Figure 4.27: Annual Flood Count and Sea Level at Charleston Gauge. Sea level is relative to the current National Tidal Datum Epoch, 1983-2001.

OCEAN WARMING

The overwhelming majority (approximately 90%) of the warming from greenhouse gases has been absorbed by the ocean, which has warmed by about 1.6°F this century (Fox-Kemper et al., 2021). The global oceans cover approximately 71% of the Earth's surface area, and water is a highly efficient absorber of heat compared to the atmosphere. Most of the increase in sea surface temperature has been in the past 50 years, and current rates of ocean heat content increase are the highest in over 10,000 years (Fox-Kemper et al., 2021). Waters off the southeastern US coast have warmed slightly faster than the global average due to proximity to the Gulf Stream, which draws from a warming tropical Atlantic (Fox-Kemper et al., 2021). Projections from the most recent generation of (CMIP6) climate models indicate a hotspot off the U.S. Atlantic coastline, with an increase of approximately 7 to 9°F by 2100 (Table 4.1: MIP6 ensemble, Eastern North America Oceanic Region. Values in table are median projections, values in parenthetical are 5th and 95th percentiles, respectively. Future projections are in reference to baseline data from 1850 – 1900 (IPCC, 2022).Table 4.1; Intergovernmental Panel on Climate Change [IPCC], 2022; Ranasinghe et al., 2021). Coastal waters will warm faster than deep water, an effect of the gentle continental shelf slope and shallower water depths.

Warming ocean waters worsen other climate impacts, such as increasing the intensity of tropical hurricanes moving over them, as well as negatively affecting marine wildlife (Bindoff et al., 2019; Seneviratne et al., 2021). In addition to an increase in mean ocean temperature, temperatures can further spike within shorter periods; this is called a marine heatwave. If changes in global temperature exceed 3.6°F (2°C), the southeast U.S. Atlantic coast is projected to experience severe marine impacts, with marine heatwaves 20 times more often than present (Ranasinghe et al., 2021). NOAA is combining climate models with oceanographic station data to forecast marine heatwaves in our region up to 12 months in advance (Jacox et al., 2022).

OCEAN ACIDIFICATION

About a quarter (approximately 20 to 30%) of CO_2 emissions enter the ocean; there is robust evidence that this uptake has caused ocean acidification (Canadell et al., 2021). At the regional level, ocean acidification is additionally affected by biological processes and runoff from land (Canadell et al., 2021). The surface ocean pH (a measure of acidity / alkalinity) has decreased at a rate of 0.017 to 0.027 units per decade since the late 1980s (indicating greater acidity), and estimates place the total pH decrease from human activities around 0.1 (Canadell et al., 2021; Tanhua et al., 2015). Since pH is a logarithmic scale, a decline from 8.2 to 8.1 represents a 26% increase in acidity. The rate of ocean acidification is predicted to accelerate in the southeast region in the next 20 to 30 years, and projections of ocean acidification off the eastern coast of the U.S. under a high emissions scenario would approach pH levels not seen in the past 65 million years by the end of the century (Table 4.1; Canadell et al., 2021).

Table 4.1: MIP6 ensemble, Eastern North America Oceanic Region. Values in table are median projections, values in parenthetical are 5th and 95th percentiles, respectively. Future projections are in reference to baseline data from 1850 – 1900 (IPCC, 2022).

Variable	RCP 4.5 (2081 – 2100)	RCP 8.5 (2081 – 2100)
Sea Surface Temperature	+ 4.7°F (2.7 | 6.7)	+ 7.6°F (4.7 | 9.7)
pH at Surface	- 0.3 (-0.3 | -0.2)	- 0.5 (-0.5 | -0.4)

INCREASED SALINITY

The Atlantic has become saltier in the past 60 years, due to change in evaporation/precipitation balances over the ocean surface (Fox-Kemper et al., 2021). The link between anthropogenic CO_2 and salinity changes is robust (Eyring et al., 2021).

Observed changes off the Carolinas coast are highly significant when analyzed alongside climate model projections (Friedman et al., 2017).

DECREASED DISSOLVED OXYGEN

Ocean heating can reduce mixing and inhibit the process by which gasses dissolve in water. In the past 50 years, dissolved oxygen has decreased in the ocean's upper 1000 meters by 0.5 to 3.3% (Canadell et al., 2021). The link between anthropogenic CO_2 and changes in dissolved oxygen is highly robust (Canadell et al., 2021; Garcia-Soto et al., 2021). Deoxygenation serves as an indicator of changing ocean climate conditions with implications for biological habitats; it is projected to accelerate globally (Canadell et al., 2021).

CHANGING OCEAN CURRENTS

The Atlantic Meridional Overturning Circulation (a series of interconnected ocean currents, including the Gulf Stream) has slowed during the past 20 years and scientists are uncertain whether it could collapse under a high emissions scenario (Fox-Kemper et al., 2021). A combination of changes in water temperature and salinity, strongly affected by melting ice in Greenland, has affected the rate of deep water formation which drives this system of currents (Fox-Kemper et al., 2021). Climate models have underestimated observed rates of slowing, and scientists are actively researching the potential of a larger slowing or collapse (Fox-Kemper et al., 2021).

Significant decreases in the Gulf Stream would further increase sea levels along the southeast US coast.

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Strategic Statewide Resilience and Risk Reduction Plan

5 | FLOOD RISK AND VULNERABILITY ASSESSMENT

OVERVIEW

This chapter furthers the ability of organizations across the state to anticipate, by identifying current and future flood vulnerabilities. The data identification, collection and coordination of this chapter was done through subcommittees of the Statewide Resilience Plan Advisory Committee.

CHAPTER CONTENTS

KEY FINDINGS

- Flooding in South Carolina is caused by prolonged rain events, short intense rain, overflowing rivers, dam or levee failure, storm surge, and tidal process. Flooding can be broken into three types: river flooding (fluvial), overland flooding (pluvial), and coastal flooding
- Existing estimates of flood frequency are based on historical record and do not account for changes in climate and landscape conditions.
- Existing rainfall intensity, duration, and frequency (IDF) curves from NOAA Atlas 14 are based on the concept of stationarity, the idea that past conditions are predictive of the future. Changing rainfall patterns and a failure to use the most up-to-date data could lead to underestimating likelihood of damaging rain events
- SCOR determined that the intermediate to intermediate-high sea level rise scenario should be considered in the development of the Statewide Resilience Plan.
- Projected sea level rise will lead to increased coastal flooding in low lying areas.
- Land Subsidence is likely contributing to relative sea level rise in many coastal areas.
- Since 2015, all 652 high- and significant-hazard dams in the state have been assessed and the state has invested significant resources in the state's dam safety program.
- Dam failure can lead to flooding downstream. Additionally, there is the potential for mobilization of contaminated sediments that may be trapped behind the dam.
- FEMA flood mapping does not currently capture the full risk of flooding. Supplemental tools such as the First Street Foundation Flood Hazard Layer should be utilized for a more complete understanding of flood risk under both current and under future conditions.
- Using the First Street Foundation Flood Hazard Layer and other publicly available datasets, SCOR assessed and mapped the vulnerability of various facilities

FLOODING

In South Carolina, the causes of flooding include prolonged rain events, short intense rain, overflowing rivers, dam or levee failure storm surge and tidal process. Flooding can be broken into three types: river flooding (fluvial), overland flooding (pluvial), and coastal flooding.

FLOOD FREQUENCY

Flooding is often described by its flood frequency, which can be challenging for those who do not frequently deal with flooding and hydrological data to understand. Often, floods are described by the occurrence intervals of “10-year”, “100-year”, “500-year”, and “1,000-year” events. This does not mean that the event will only happen once every “100 years”, but actually describes the statistical probability of flooding of that magnitude, which may occur more frequently than once every 100 years. The current solution put forth by hydrologist, engineers, emergency managers, and others is to describe flooding based on annual probability. The recurrence interval for a 1 in “100-year” flood event means that it has 1% chance of occurring or being exceeded any given year and is therefore described as 1% annual chance of occurrence (Table 5.1). Consider the analogy of rolling a 6-sided dice. On any given roll, there is a 1 in 6 chance that the dice would rest with a 6 face up, but that does not mean every sixth roll would be land on the 6. An important note, a home in the “100-year” floodplain, based on probability, has at least a 26% chance of having a 1-percent annual exceedance probability (“100-year” flood) event over the life of a 30-year mortgage (Figure 5.1) (Holmes & Dinicola, 2010)

Table 5.1: Flood recurrence interval to annual chance

Recurrence Interval	Percent Annual Chance
2-year	50%
10-year	10%
25-year	4%
50-year	2%
100-year	1%
500-year	0.2%
1000-year	0.1%

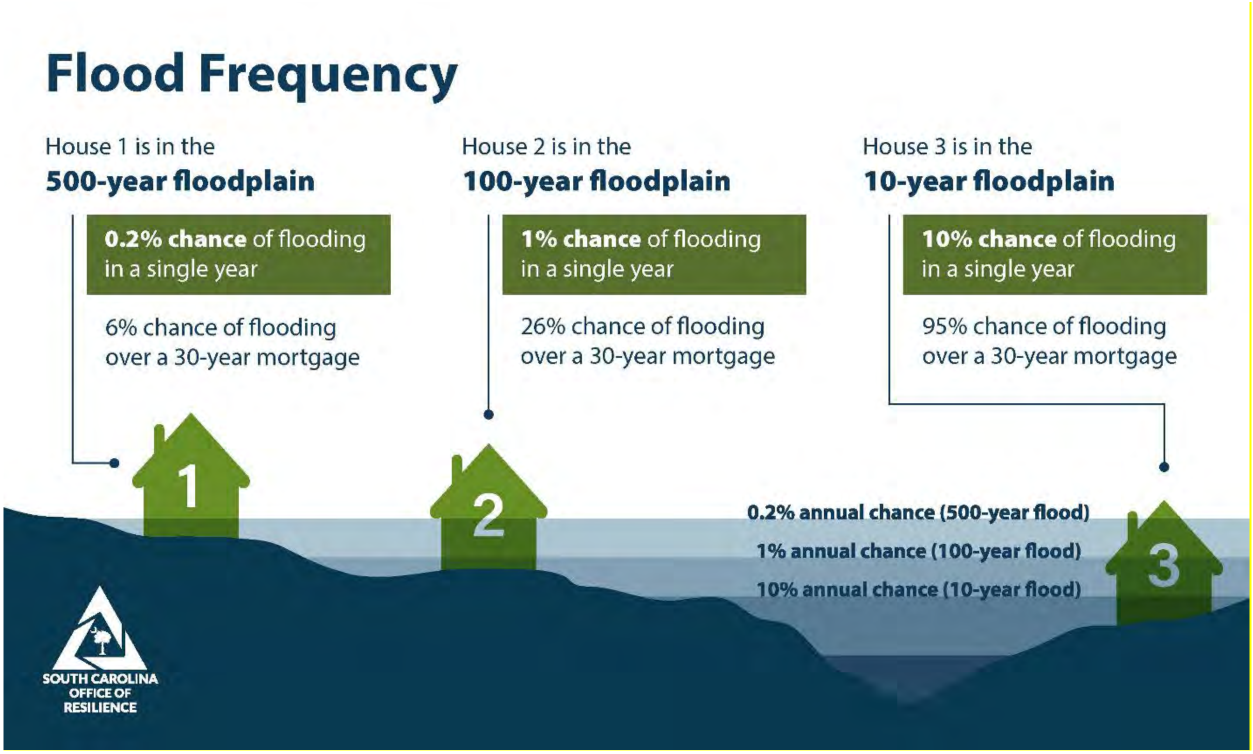

Figure 5.1: Flood Frequency (adapted from Soil & Water Conservation Districts of Montana)

Flood frequency intervals are calculated based on streamflow and stage measurements collected at a stream gage, often a USGS River Gage. The longer the period of record, the better set of data for calculating flood frequency. It is important to have accurate, long-term data to best identify the potential flood hazard at the point of measurement and estimate the potential impact to the surrounding communities

RIVERINE (FLUVIAL)

Fluvial, or river, floods occur when the water level of the river overtops its banks or natural levees (Figure 5.2). Riverine flooding can be devastating because the precipitation needed to cause the flooding does not have to fall where the flooding occurs. In addition to localized areas that may experience flooding immediately after it has rained, peak river flooding frequently occurs a few days after a rainstorm. Since 2000, over 195 riverine floods have been reported in South Carolina to the National Centers for Environmental Information database by local emergency managers, news reporters, and emergency responders (National Oceanic and Atmospheric Association, 2023).

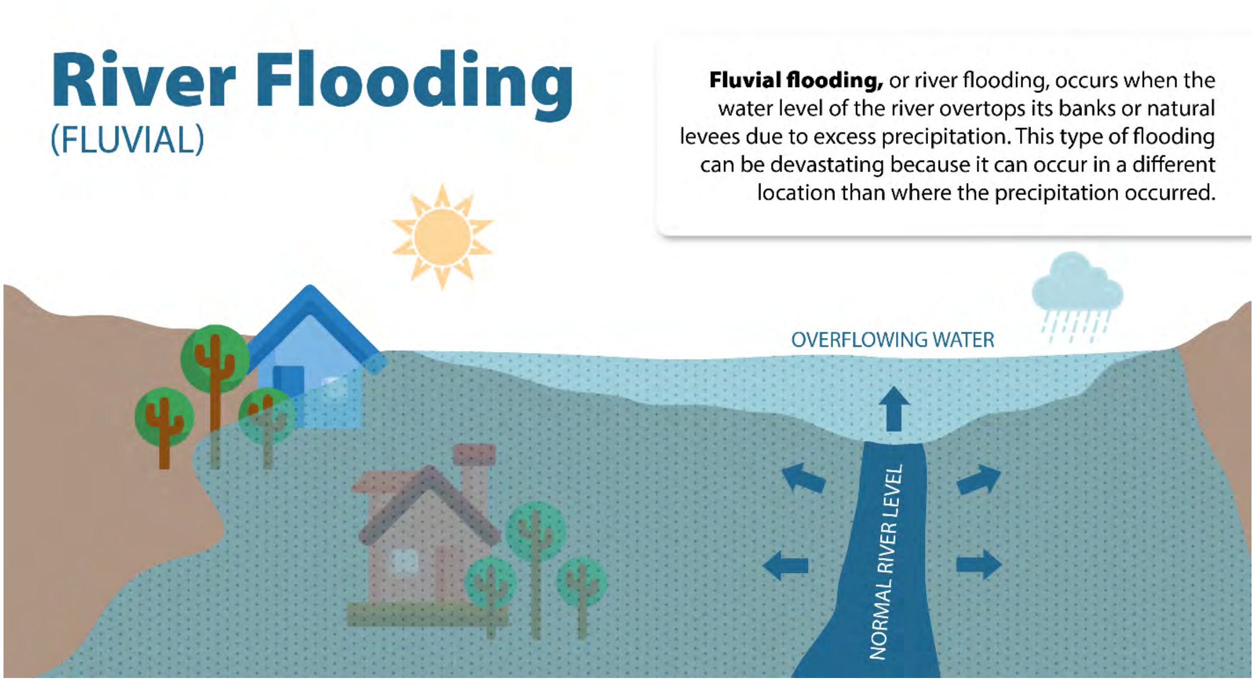

Figure 5.2: Fluvial Flooding (SCOR)

PLUVIAL FLOODING

Pluvial flooding occurs when an extreme rainfall event creates a flood independent of an overflowing water body (Figure 5.3). Pluvial flooding occurs when there is inadequate drainage for the amount of rainfall that falls in a given area (Rosenzweig, et al., 2018). Pluvial flooding can be split into two different categories: flash flooding and surface water flooding.

Flash floods are defined by the National Weather Service as:

> "A flood caused by heavy or excessive rainfall in a short period of time, generally less than 6 hours. Flash floods are usually characterized by raging torrents after heavy rains that rip through riverbeds, urban streets, or mountain canyons sweeping everything before them. They can occur within minutes or a few hours of excessive rainfall. They can also occur even if no rain has fallen, for instance after a levee or dam has failed, or after a sudden release of water by a debris or ice jam" (National Weather Service (NWS), n.d.).

Rainfall flows over the surface of the landscape as it moves toward the established drainage system but when the amount of rain is higher than the capacity of the drainage system to drain the water, the water floods at points where the flow is restrained.

Surface water floods are specifically associated with urban environments and occur when there is insufficient drainage and the water discharges into the streets or surrounding structures (National Oceanic and Atmospheric Association (NOAA), 2021). Urbanization has been linked to an increase in flash flooding due to the increase in impermeable surfaces (Konrad, 2003). In South Carolina since 2000, there have been 440 flash flood events as recorded in NOAA's Storm Event Database (National Oceanic and Atmospheric Association, 2023)

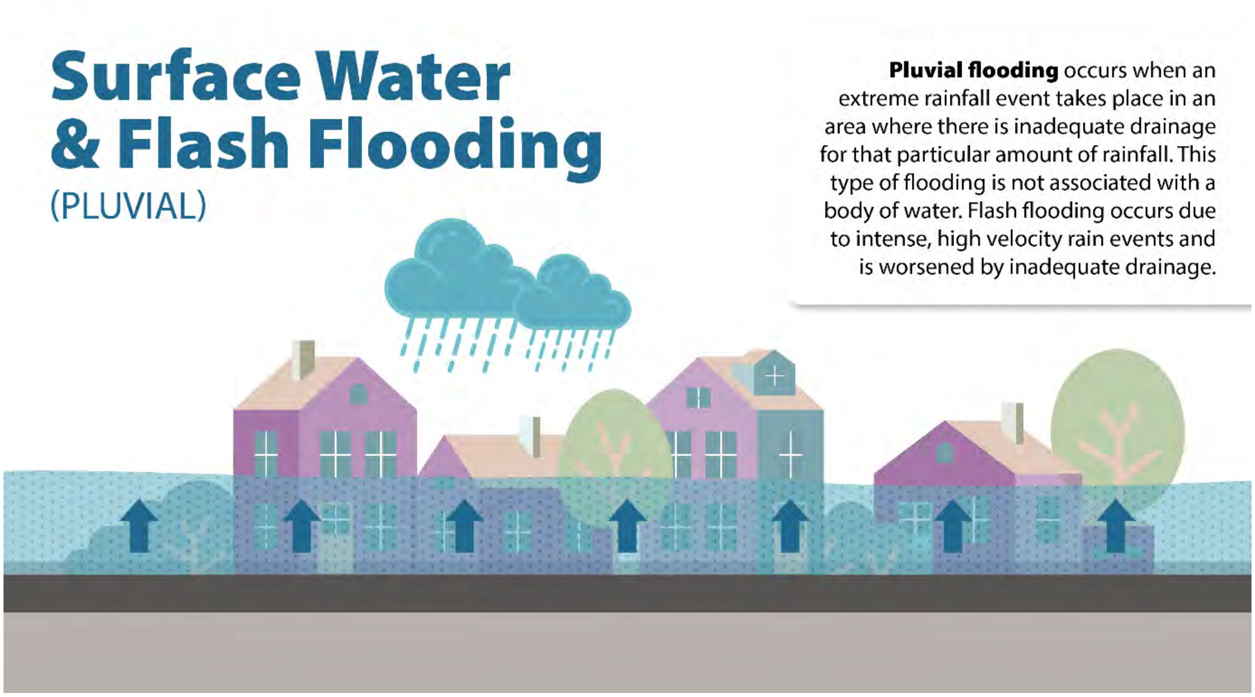

Figure 5.3: Pluvial Flooding (SCOR)

COASTAL FLOODING

The coastal system is complex and impacted by the interactions of inland flooding and marine processes. Coastal flooding can be caused by storm surge, high tides, compound flooding, and sea level rise. Onshore winds and the gravitational pulls of the moon and sun on the earth can also amplify coastal flooding events.

STORM SURGE

For coastal communities, storm surge flooding is often the greatest hazard during a hurricane and can be defined as a rise of water generated by a storm that is higher than the normal tides (Figure 5.4). A hurricane's strong winds and low barometric pressure drive the storm surge. Wind-driven storm surge is the main component of surge and is produced by water being pushed toward the shore by the force of the winds moving cyclonically around the storm. The strong winds of hurricanes rotate around its center while converging toward the center. The convergence creates a mound of seawater. As a hurricane approaches a coastline, the mound causes rising water levels. As it moves toward land, strong winds also push seawater ashore to the right of its track with respect to its forward motion, causing the highest storm surge to affect areas just to the right of a hurricane's eye as it moves ashore.

The component caused by low pressure is small compared to the wind's contribution, about five percent of the total. Water bulges upward in areas of low pressure, and the bulge becomes more pronounced as pressures drop.

When the storm surge impacts land, it pushes water up waterways, into infrastructure, and over land, appearing as a temporary increase in sea level. The rise can be rapid, sometimes like a tsunami (National Hurricane Center, 2023). Since storm surge is independent of tides and waves, the flooding it causes can be additive in its risk and brings destructive wave action to areas not normally affected.

The 1989 landfall of Hurricane Hugo caused 13 impact fatalities (mostly drownings) and $8 to $10 billion in damages (National Oceanic and Atmospheric Association (NOAA), 1989; National Oceanic and Atmospheric Association, 2023). Since Hugo, there has been a significant federal, state, and local investment in many coastal management policies (such as mandatory evacuation orders) and projects (such as beachfront flood mitigation) (SC Department of Health and Environmental Control (DHEC), 2022). For example, over 60 million cubic yards of sand have been placed along South Carolina beaches and dunes over the last several decades

(Elko, et al., 2021). Such large-scale beach and dune restoration projects may have reduced flood risk along the South Carolina beachfront (Kana & Barrineau, 2021).

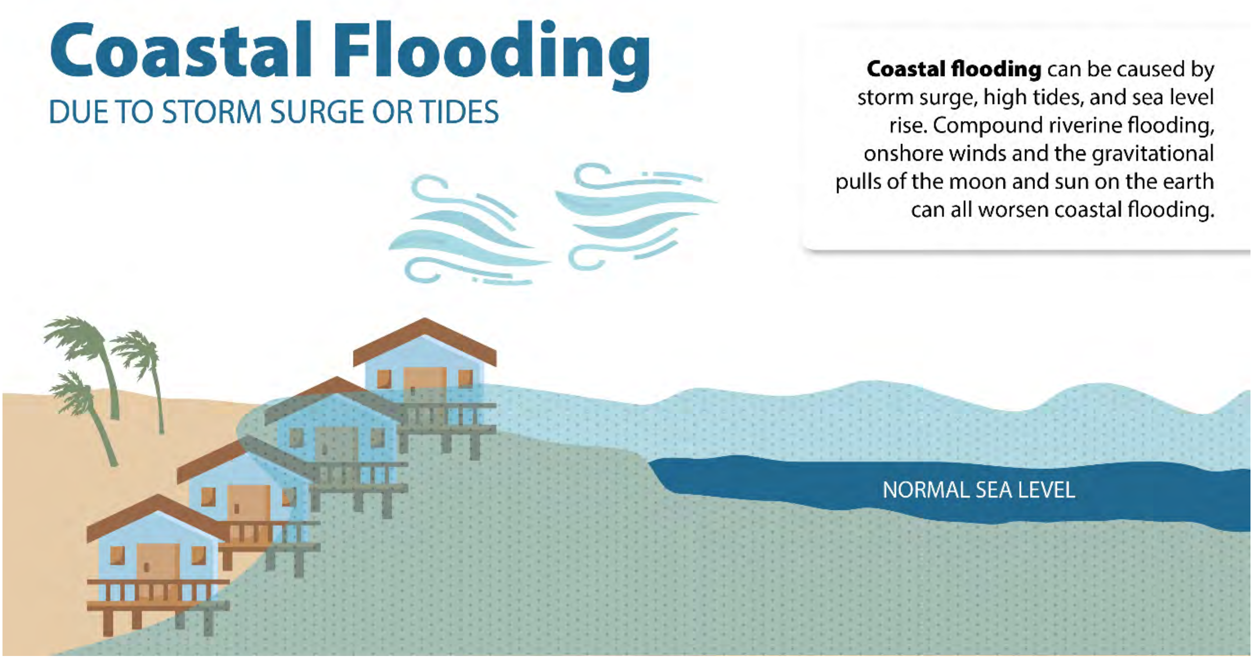

Figure 5.4: Coastal Flooding (SCOR)

TIDAL FLOODING

While coastal flooding caused by large events such as tropical storm surge receive a lot of attention, small, sustained changes in the system can be equally disruptive. For example, tidal flooding is low level inundation that disrupts daily activities, associated with high tides (Moftakhari, AghaKouchak, Sanders, Allaire, & Matthew, 2018). In low lying coastal areas, major damage is often associated with high tide flooding. High tide flooding has increased in the U.S. by about 50% in the last 20 years (National Oceanic and Atmospheric Association (NOAA), 2021).

When the moon is in alignment with the earth and sun during the full or new moon, it has a greater gravitational effect on the tides. The moon's orbit around the earth is elliptical with the furthest point of the ellipse called apogee and nearest point perigee. Spring tides occur when the moon orbit is in perigee or apogee (Figure 4). As the Earth rotates around the sun, the moon's orbit changes in reference to the sun (Espenak & Meeus, 2006). When perigee occurs with the full or new Moon, about 6-8 times a year, higher than average spring tides flooding can occur (National Oceanic and Atmospheric Association, 2021). These perigean spring tides, commonly referred to as "king tides" or "spring tides", along with the increase of sea level, have started to regularly flood coastal roads and marsh front shorelines that have not historically.

As sea level continues to increase along the South Carolina coastline (described in more detail in the next section), everyday occurrences such as high tides and coastal winds can cause flooding events. High tide flooding along estuarine or marsh front shorelines has increased due to the low-lying nature of the South Carolina coastline and increased development of coastal communities. Along with estuarine flooding events, higher tides also impact our beaches and dunes and may be causing additional erosion in these environments.

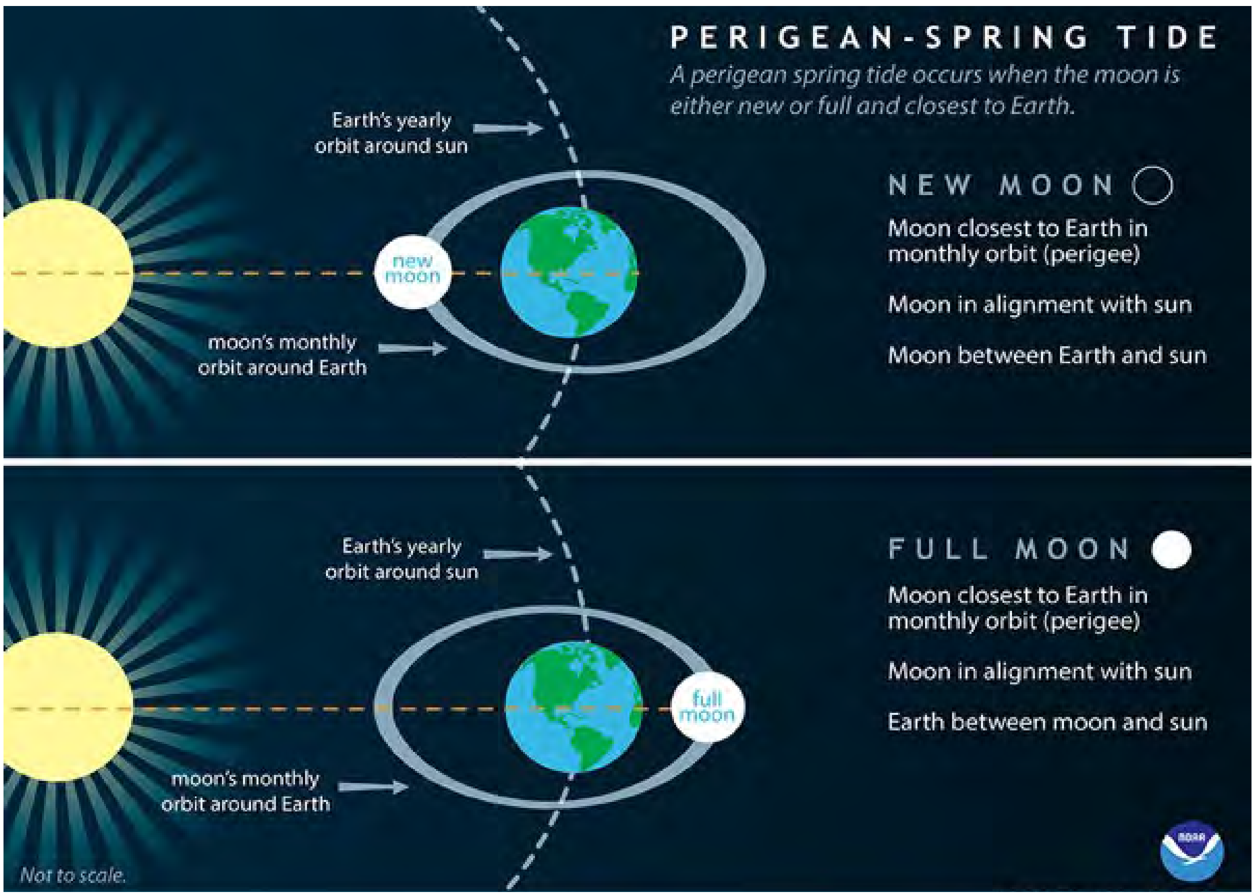

Figure 5.5: The moon's position within its orbit strongly influences gravitational pull on the Earth's tides (NOAA, 2021).

COMPOUND FLOODING

Compound flooding occurs when extreme tides, storm surge, pluvial or fluvial flooding combine in coastal areas (Wahl, 2017; Bevacqua, et al., 2020). Within coastal systems, flooding is rarely caused by a single driver (Wahl, 2017). The low-lying nature of South Carolina's coastlines means that flooding often compounds. This also makes cataloging the cause of impacts to a specific type of flooding difficult. In the National Center for Environmental Information database, storm surge and tides are not credited with any damage nor injury or deaths

(National Oceanic and Atmospheric Association, 2023). This may be because when recent storm surge has occurred, there has also been pluvial or fluvial flooding reported to the National Centers for Environmental Information (NCEI) database (National Oceanic and Atmospheric Association, 2023).

SEA LEVEL RISE

Climate model experts have developed a range of plausible future sea level rise scenarios, ranging from extreme, high, intermediate-high, intermediate, intermediate-low, and low (Figure 5.6). Sea level rise is not a new concept and has been observed in South Carolina with Charleston Harbor tidal gage since 1920, cataloging a rise of 10.9 inches since 1950 (South Carolina's Sea Level is Rising, 2022). Sweet et al. (2022) at NOAA project that sea level will continue to rise and have described six difference scenarios, extrapolation from observed tidal gages, low, intermediate-low, intermediate, intermediate-high, and high. The extrapolated observed tidal gage or present trajectory scenario calculates median sea level rise to be 16.14 inches (0.41 meters) by 2050, which falls between the intermediate (14.17 inches or 0.36 meters) and intermediate-high (16.93 inches or 0.43 meters) (Figure 5.6) (Sweet, et al., 2022). These scenarios support planning and decision-making in light of uncertainties regarding sea level rise risk. Higher-end projections represent scenarios in which South Carolina’s sea level rises precipitously while lower-end projections showcase more conservative sea level increases. Long-term planning, however, must consider a broad range of possible outcomes, including high-consequence, low-probability events.

Following discussions with the Statewide Resilience Plan Advisory Committee, SCOR determined that the intermediate to intermediate-high scenario should be considered in the development of the Statewide Resilience Plan. While the intermediate to intermediate-high scenario should be considered for future projects, SCOR recognizes the need to ensure a balanced approached to resilience that considers economic and environmental needs. Therefore, project-specific factors, such as the consequences of failure, current and future economic feasibility, and environmental impacts, may warrant the use of higher or lower projections. SCOR worked with scientists at University of South Carolina, SCDNR Climatology Office, and Carolinas Integrated Sciences and Assessments (CISA) to generate a report that includes an analysis of South Carolina’s observed climate record, translation of model output into future state-level climate projections, and synthesis of relevant peer-reviewed research. The findings of this report can be found in Chapter 4.

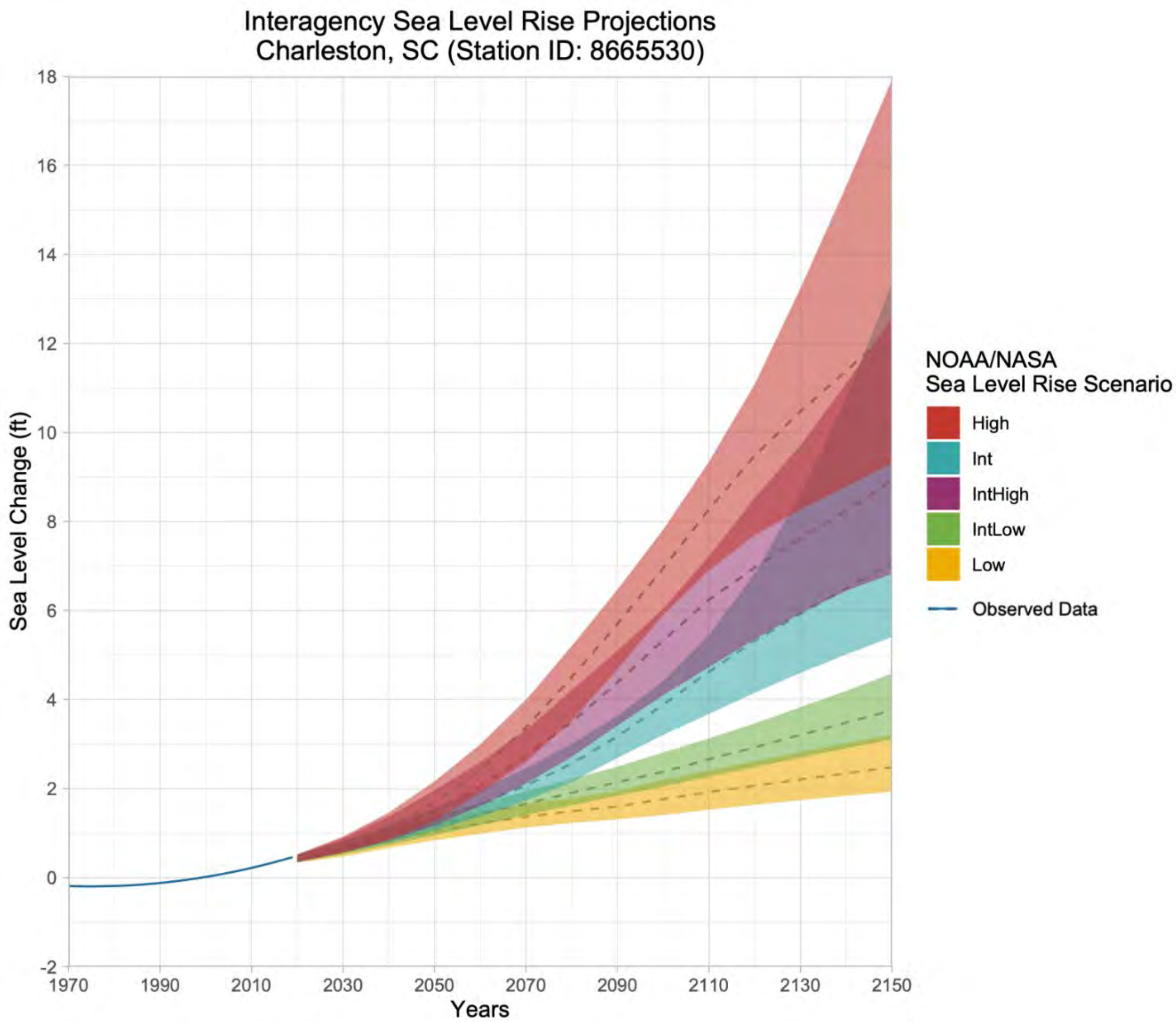

Figure 5.6: Sea level rise projections for Southeastern United States from NOAA's recent report (Sweet, et al., 2022). Edited from Sweet et al. (2022) Figure 2.3.

According to historical data at the Charleston Harbor gauge, "major" (8+ ft) flood events as well as the overall number of flood days have increased from 1970 to 2021 (Figure 5.7 and Figure 5.8) (National Weather Service (NWS), 2022). In fact, half of the top heights at the Charleston gauge have occurred since 2016, coinciding with tropical systems. However, as seen in the figures below, flood days are not limited to tropical system events. Most of the flooding days are a result of tidal flooding.

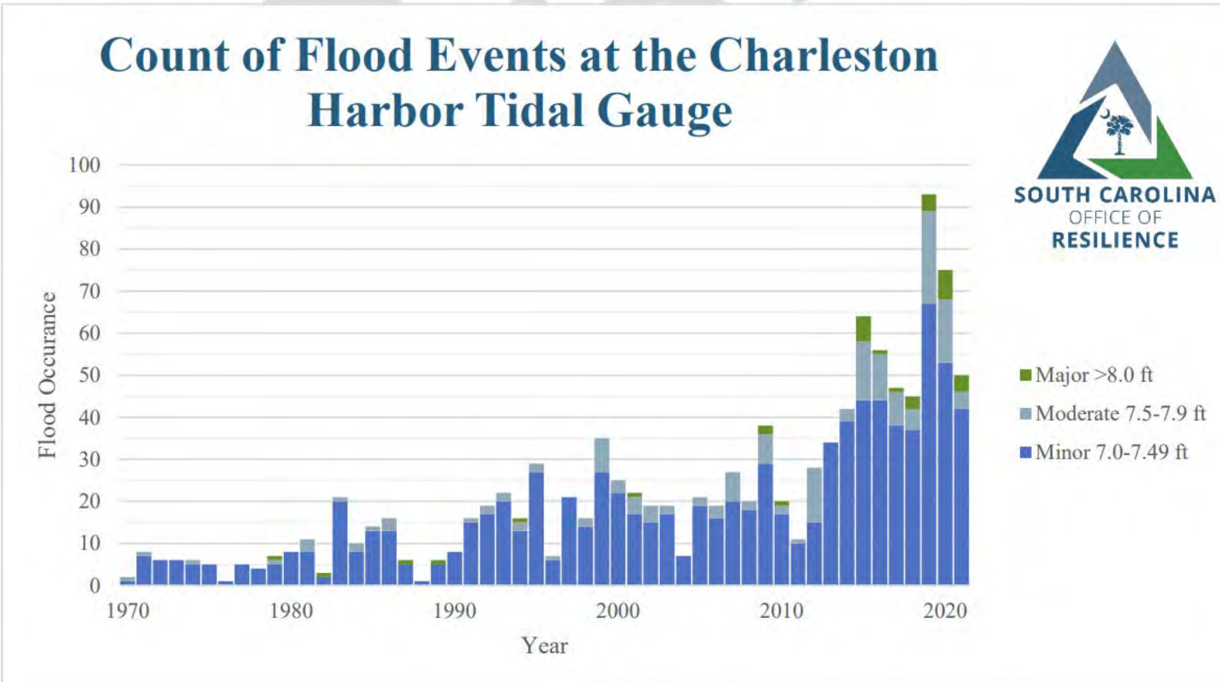

Figure 5.7: Number of flood events at Charleston Harbor gauge (National Weather Service (NWS), 2022).

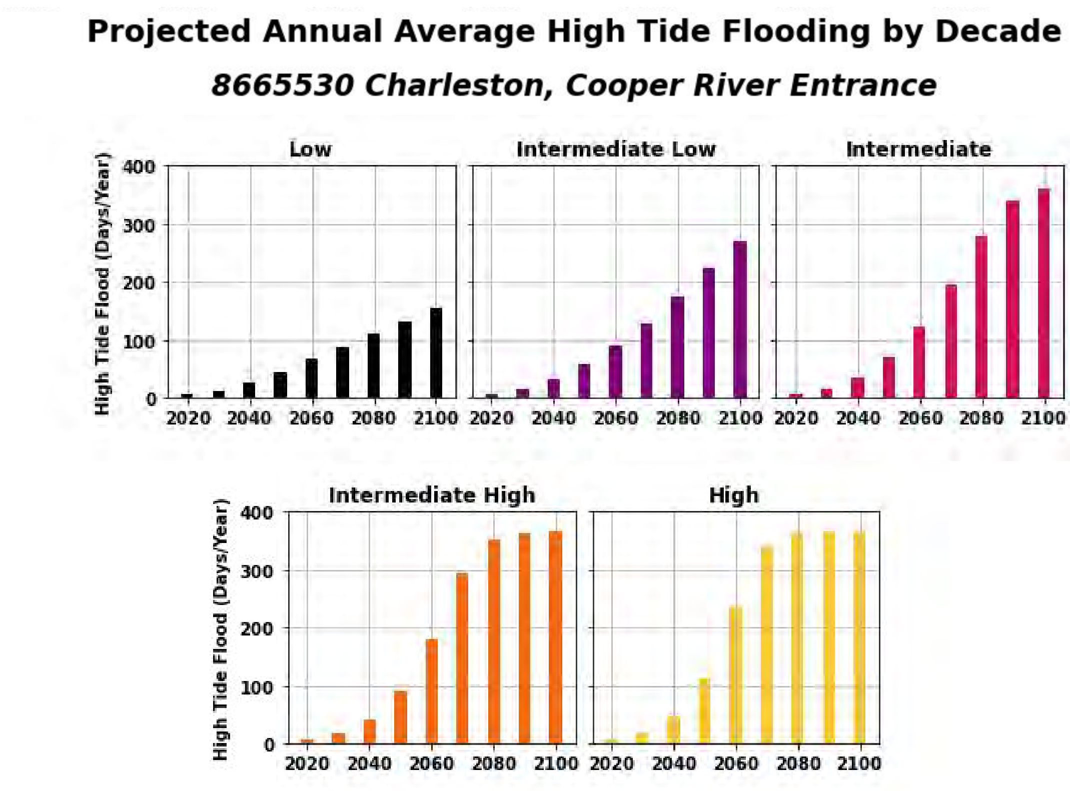

Figure 5.8: Total number of flood days at Charleston Harbor gauge, edited from (National Oceanic and Atmospheric Association, 2022)

Figure 8 combines the historical tidal floods in Charleston and pairs it with projected figures based on higher and lower emission pathways. Current projections have tidal flooding in Charleston doubling to over 100 days a year by 2040 and up to 350 flooding days by 2100.

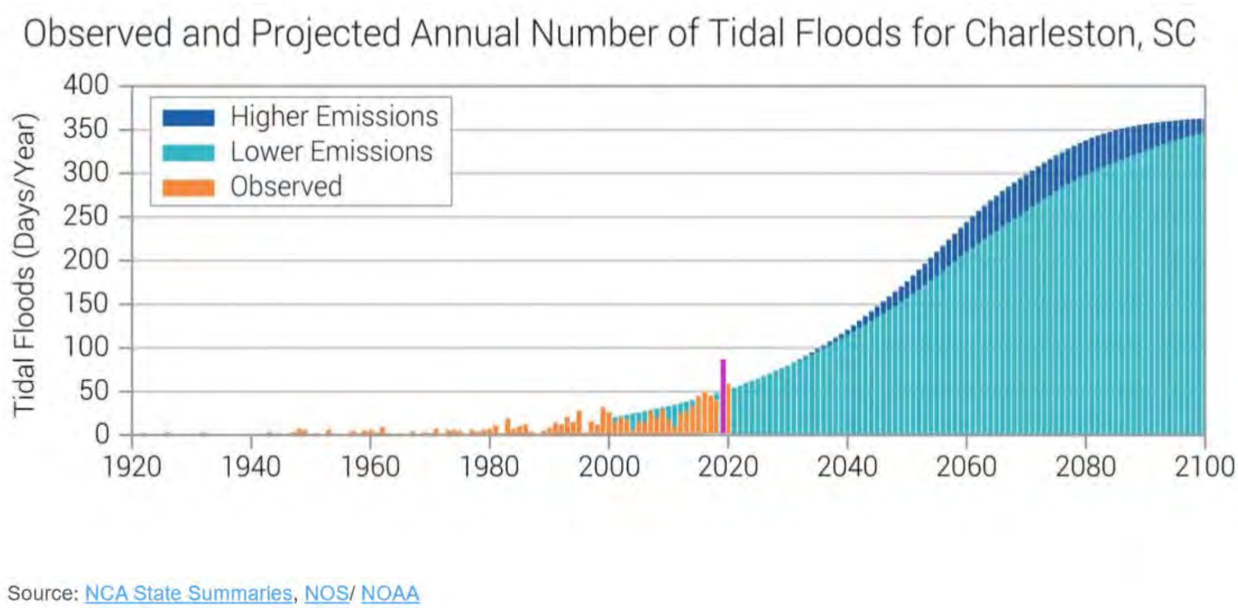

Figure 5.9: Observed and projected annual number of tidal floods for Charleston, SC (NCA State Summaries, NOS/NOAA)

In addition to the general flood risk from sea level rise, the projected trend will have wider reaching community effects, including erosion, a higher groundwater table, saltwater intrusion, corrosion of underground infrastructure, and the migration of salt marshes. One consequence of sea level rise is the impact to groundwater resources. The surficial, or unconfined, aquifer in the coastal region interacts directly with the sea water through tidal pumping through the unconsolidated sandy sediment that makes up the coastal areas in South Carolina. As sea level rises, the saltier ocean water layers under the fresh ground water due to density differences and as tides fluctuate, the water table will rise with the rising tide (Bowes et al., 2019; Cooper, 1964; Hoover et al., 2017; Plane, Hill, & May, 2019; Rotzoll & Fletcher, 2013). The rising of the water table also has detriments to pluvial flooding events due to the decreasing ability of the ground to absorb rainwater during a rain event. A secondary, non-flooding hazard associated with sea level rise is an increase in saltwater intrusion into coastal aquifers. Saltwater intrusion is not new to South Carolina and impacts many coastal drinking water sources. According to the USGS Report 2009 –5251, saltwater intrusion in Hilton Head Island has been observed since the 1970s and is described and modeled in the report (Payne, 2010).

LAND SUBSIDENCE

Land subsidence is the gradual sinking or settling of the land surface due to a variety of factors such as natural geologic processes, compaction, and groundwater pumping. When it occurs in coastal communities, it can have severe impacts on the surrounding environment and human populations. One of the primary impacts of land subsidence on coastal communities is increased vulnerability to flooding and storm surges. As the land sinks, sea levels effectively rise, exacerbating the risk of coastal inundation during extreme weather events.

In South Carolina, land subsidence is currently measured using InSAR satellite by the USGS in its most recent release of data (Barnard, et al., 2023). Coastal South Carolina has an estimated subsidence rate of approximately 0.15 cm per year (cm/yr) or 0.059 inches per year (in/yr). The average is not distributed equally across the coastal area (Figure 5.10). The coastline can experience up to 0.75 cm/yr (0.3 in/yr) of subsidence, with the Charleston area experiencing anywhere from 0.46-0.25 cm/yr (0.18-0.1 in/yr) (Figure 5.10). While InSAR data can be useful for examining land subsidence, the potential for error in remote measurements necessitates the need for direct instrumentation. At least three extensometers, which are used to measure vertical land movement, are needed along the coast to monitor and measure land subsidence. These extensometers should extend through the full sediment stack so that the causes of land subsidence can be determined. Causes may include excessive groundwater extraction, surficial weighting, or natural processes.

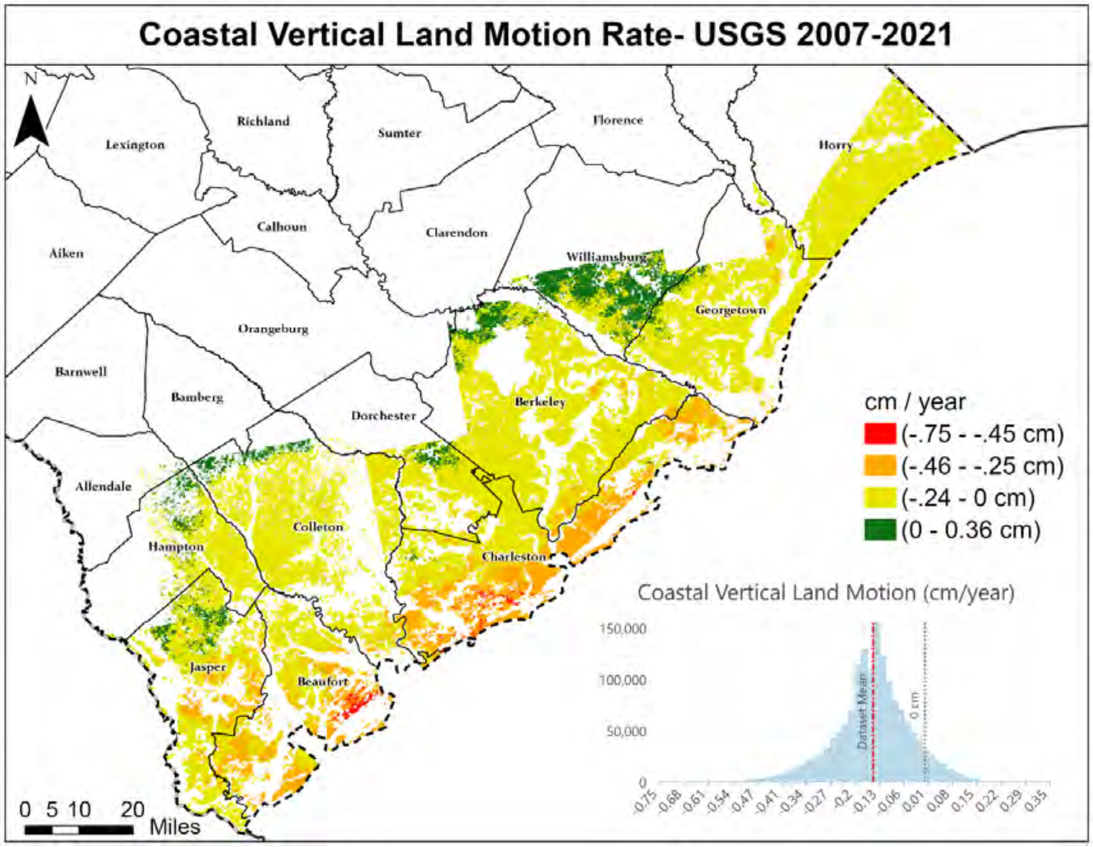

Figure 5.10: Land subsidence in coastal South Carolina (Barnard, et al., 2023)

DAM FAILURE

The South Carolina Dams and Reservoirs Safety Act charges DHEC with administration of a program to protect citizens' health, safety, and welfare by reducing the risk of failure of dams. Dams are regulated based on the height and/or amount of water impounded by the structure according to the following criteria:

- Measures 25 feet in height from the invert of the receiving stream or natural ground
- Capable of impounding 50-acre feet or more
- Smaller than either of the criteria above but failure of the dam would likely result in loss of human life, regardless of size

Dams regulated by DHEC are classified based on the hazard brought about to life and property should the dam fail. Hazard classifications are high hazard, significant hazard, and low hazard (Table 5.2).

Table 5.2: Dam Hazard Classifications (DHEC)

Hazard Classification	Classification Description
High Hazard (Class I)	Dam failure would likely result in loss of life or serious damage to home(s), industrial and commercial facilities, important public utilities, main highway(s) or railroads
Significant Hazard (Class II)	Dam failure wouldn't likely result in loss of life but may damage home(s) industrial and commercial facilities, secondary highway(s) or railroad(s) or interrupt the service of relatively important public utilities.
Low Hazard (Class III)	Dam failure may cause minimal property damage to others. Loss of life is not expected.

The regulations promulgated under authority of the act specify the process of obtaining permits for the construction of new dams and for the alteration, repair, or removal of existing dams.

The regulations outline the procedures for inspection of regulated dams and issuance of maintenance/repair orders, as well as emergency orders in situations where there is imminent risk of dam failure which may impact life or property. Dam owners are responsible for maintenance of the structural integrity of their dams.

In 2015, 51 dams failed in the Midlands, Pee Dee and Lowcountry due to the historic rainfall and subsequent flooding associated with Hurricane Joaquin (SC Department of Health and Environmental Control , n.d.). Since 2015, all 652 high and significant hazard dams in the state have been assessed and the state has invested significant resources in the state's dam safety program (SC Department of Health and Environmental Control , n.d.). In 2018, the SC General Assembly directed DHEC to focus the resources of the Dams and Reservoirs Safety Program on regulating the state's high and significant hazard dams only and reclassifying dams when the failure or improper operation of a dam will likely result in loss of human life (2018 Joint Resolution 231 (S.1190)). Considerable efforts and resources have been directed to activities to mitigate the risk of dam failure, and the resultant flooding that would ensue. These include:

- Development of an Emergency Action Plan (EAP) template to guide the actions of owners during a potential dam failure
- Increased staffing to ensure that dams are properly classified and inspected in accordance with the regulations
- Development of dam breach models for most regulated dams to assess potential impacts of dam failure. These are available on a dedicated agency web application.
- Procurement of communications tools, currently ReadyOps, to communicate with dam owners during extreme events

- Development of Screening Level Risk Analysis for High Hazard Dams to gain a more thorough understanding of the risk of dam failure
- Expansion of training and owner outreach initiatives to further the understanding of the responsibility dam owners play in maintaining their dam in a safe condition
- Coordination with SCEMD to include a “Dams Annex” in the South Carolina Hazard Mitigation Plan

HISTORICAL FLOOD IMPACTS

Flooding has the potential to cause major damage to the communities, economies, and ecosystems of South Carolina. South Carolina has 8 major watershed basins and hundreds of sub-basins, along with 2,876 statute miles of shoreline and 30,000 miles of rivers and streams (SC Department of Natural Resources, 2020; National Oceanic and Atmospheric Association, 2016).

As of December 31, 2021, South Carolina ranks 5th in the nation for the number of National Flood Insurance Program (NFIP) policies, with 202,098 in effect (Federal Emergency Management Agency, 2021).

According to the National Oceanic and Atmospheric Administration (NOAA) National Centers for Environmental Information (NCEI) Storm Event Database, there have been 807 reported flood events in South Carolina since 2000 (Table 5.3) (National Oceanic and Atmospheric Association, 2023).

Table 5.3: Flooding synopsis in South Carolina by type, 2000-2022 (National Oceanic and Atmospheric Association, 2023).

Event Type	Event type Count
Coastal Flood	60
Flash Flood	491
Flood	197
Hurricane / Tropical Storm / Storm Surge / Tide	59
Total	**807**

RECENT STORM EVENTS

Since 2015, there have been multiple major natural disasters that have caused flooding in South Carolina. These storms caused debilitating damage throughout large sections of South Carolina. Water and wind damage from these events caused homes to become unlivable. Those without the means to repair their homes were either forced to live in unsafe structures, relocate with relatives, or flee the disaster area. The damage continued to be felt by the local economy as businesses lost customers and local government tax revenues diminished. Some communities experienced damage from all three storms and are still struggling to recover and thrive years later. More detailed descriptions of these events as well as other historic floods impacting South Carolina can be found in SCDNR’s SC Keystone Riverine Flooding Events report.

OCTOBER 2015 (EXTREME RAIN EVENT/ HURRICANE JOAQUIN)

There was historic precipitation across the state from October 1st- 5th, 2015 associated with Hurricane Joaquin. As described by SCDNR Climatology Office, in late September and early October in 2015, Joaquin temporarily stalled off the coast of South Carolina due to a cold front crossing the state and a high-pressure system to the north (SC Department of Natural Resources, 2015). The interaction of these systems caused a large-scale flow of moist air over the Carolinas and record amounts of rain, with some areas receiving greater than 26 inches over the first week of October (SC Department of Natural Resources, 2015). The rain caused historic flooding across large portions the state, specifically in the midlands and coastal areas. During this event, an estimated $1.5 billion of property, infrastructure, and agricultural damage occurred, 51 regulated dams failed (South Carolina Department of Health and Environmental Control, 2016), and 19 fatalities occurred (National Oceanic and Atmospheric Association, 2016). A more detailed report of this event by SCDNR Climatology Office can be found on their website.

OCTOBER 2016 (HURRICANE MATTHEW)

Hurricane Matthew made landfall near McClellanville, a small fishing community in Charleston County, as a category one hurricane on October 8, 2016. Hurricane Matthew moved slowly across the Carolinas coastline. More than 15 inches of rain occurred in northeastern South Carolina over a 12-hour period. This caused significant flash and riverine flooding in the Pee Dee River Basin and northeastern portion of South Carolina. The peak stage on the Little Pee Dee River at Galivant's Ferry, USGS Gage 02135000, was 17.1 ft, where major flood stage is 12 ft. The Waccamaw River, USGS Gage 02110704, crested at 17.9 ft, both breaking records set in 1928 from the Okeechobee Hurricane (Weaver, 2016). At the Conway Marina USGS river gage, the major flood stage is 14 feet (United States Geological Survey (USGS), 2023). Major flood stage is defined by NWS as extensive impact to structures, roads, homes, and evacuation may be required. This level of flooding is correlated with the "50" to "100-year" recurrence intervals (National Weather Service (NWS), 2023).

There was significant flooding at the junction of the Lumber and Little Pee Dee Rivers and the surrounding area. During Hurricane Matthew, large amounts of water drained through these rivers and at the convergence and caused significant flooding in the area, including the Town of Nichols. Although not directly in the path of Hurricane Matthew, the town lost 261 homes and almost 150 residents were rescued (Adcox, 2016; Edwards, 2020). A more detailed report of this event by SCDNR Climatology Office can be found on their website.

SEPTEMBER 2018 (HURRICANE FLORENCE)

Hurricane Florence made landfall near Wrightsville Beach, NC, on September 14th, 2018, resulting in significant storm surge and historic rainfall in both North and South Carolina. More than 26 inches of rain fell in Loris, SC, setting a rainfall record (Stewart & Berg, 2019). Riverine flooding occurred in Chesterfield, Darlington, Dillon, Georgetown, Horry, and Marion Counties in South Carolina. In Conway, the Waccamaw River crested at 22.1 ft and flooded close to 1,000 homes and businesses (National Weather Service, 2018). The impacts of the hurricane and subsequent flooding is estimated to have caused $600 million in property damage, evacuation of close to 500,000 people, and major damage to 550 homes (National Oceanic and Atmospheric Association, 2023).

UNDERSTANDING FLOOD RISK & VULNERABILITY

In the first portion of this chapter, we discuss the common monitoring, data, and modeling tools that can be used to assess risk and vulnerability. Then, this chapter provides an assessment of potential losses across the state by combining hazard data with statewide datasets of assets and facilities. In addition, this chapter looks at the intersection of flood hazard exposure and the social factors that influence vulnerability.

ENVIRONMENTAL MONITORING AND DATA

To best assess flood risk and vulnerability, an extensive network of environmental monitoring datasets is needed. Relevant to this planning process has been scientific or modeling data from the following sources: federal agencies (NOAA, USGS, NWS), state agencies (SCDNR, DHEC, SCDOT, and S.C. Sea Grant Consortium), academia, community interest groups, and non-profits. Environmental data is generally widely available and most data owners or managers have website portals that allows access to data such as tide levels (NOAA and SECOORA), land use (NOAA), water quantity (USGS). However, some environmental datasets are not as easy to access or query in order to find data, data descriptions, or data managers.

UGSG RIVER GAGES

In South Carolina, the USGS river gage network is used to monitor river stage (height) and discharge and is the standard used for decision making and environmental monitoring. River gages are needed to monitor the volume of water in the system to aid in water resource management, flood management, ecological monitoring, aid in infrastructure planning and design, and monitor changes to the system through time. South Carolina has roughly 159 USGS river gages throughout the state (Figure 5.11). SCDNR recently received funding to install 30 additional gages. In South Carolina, many agencies, industries, power suppliers, agricultural users, scientists, and communities use the USGS river monitoring network and contribute funding to maintain and operate gages. There are also endeavors to identify more cost effective methods and pilot new technologies to monitor water quantity and quality such as the Intelligent River Project on the Savannah River.

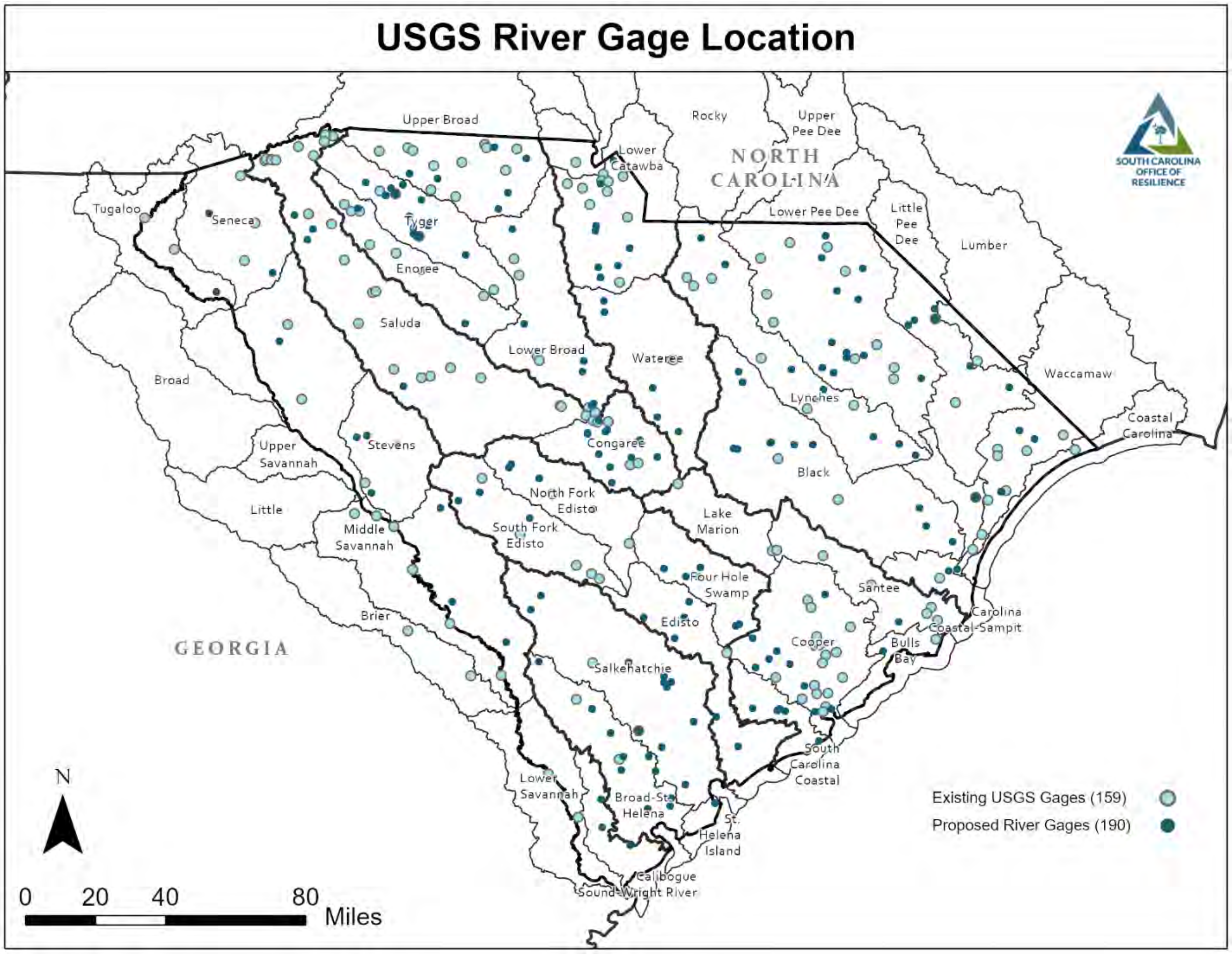

Figure 5.11: USGS river gages and proposed new water level gages in South Carolina

TIDAL GAUGE

There are currently two NOAA Center for Operational Oceanographic Products and Services (CO-OPS) tidal gauges in South Carolina, in Charleston and Myrtle Beach, and one in Savannah, Georgia (Figure 5.12). Similar to USGS river gages, the NOAA CO-OPS stations provide robust high accuracy data and require routine maintenance. These data produced by these monitoring stations inform modeling, monitor sea level trends, and support navigation. New technologies have allowed for lower cost sensors to supplement the NOAA CO-OPS program. These sensors allow communities to monitor tidal levels and provide local level decision makers with additional observations. For example, 18 Hohonu monitoring stations have been installed in South Carolina (Figure 5.12) through a Southeast Coastal Ocean Observing Regional Association (SECOORA) funded project to bring these low cost sensors to communities through the Southeast.

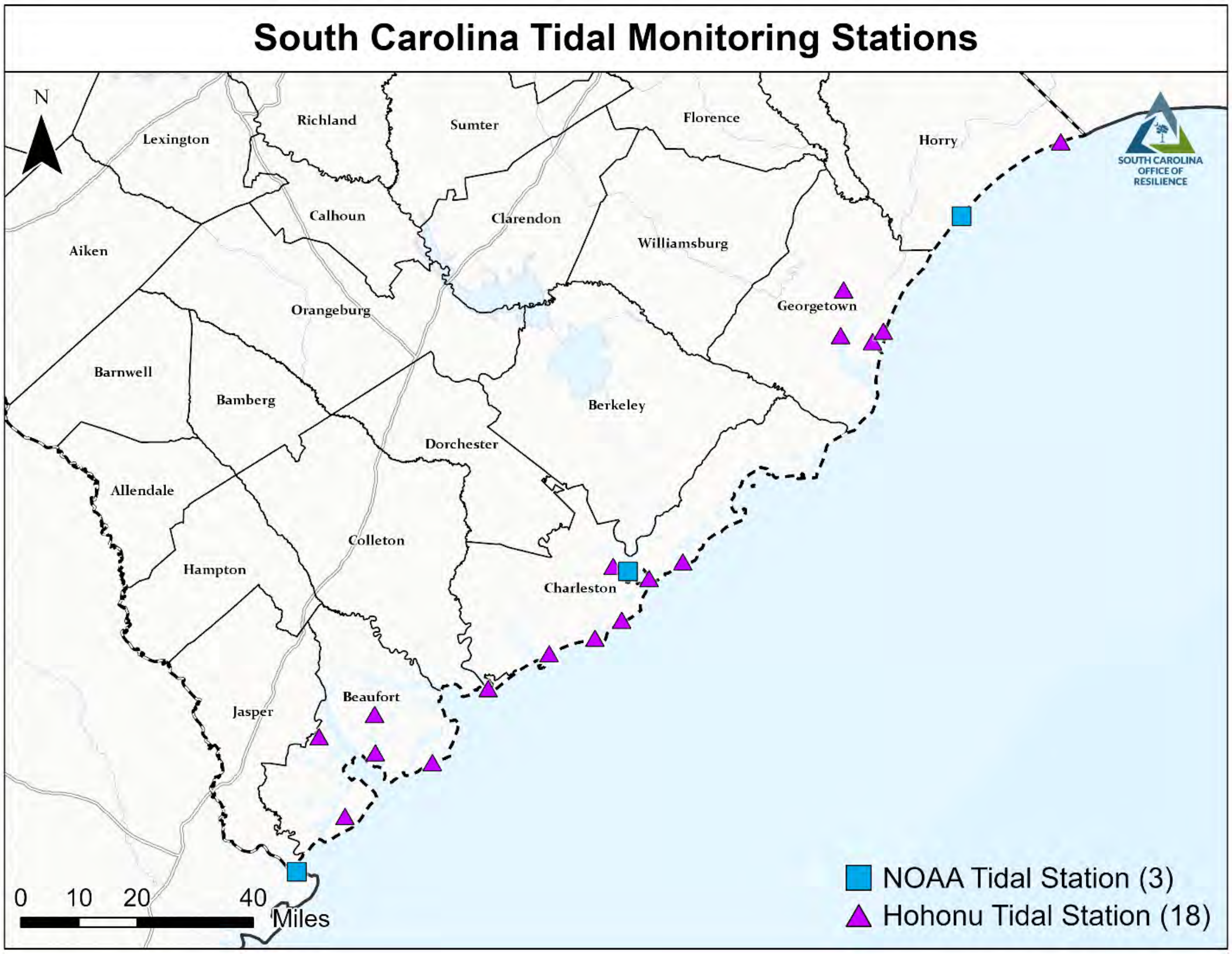

Figure 5.12: NOAA CO-OP and Hohonu Tidal Station Locations Throughout South Carolina

WEATHER STATIONS

The South Carolina State Climatology Office and the National Weather Service Forecast Offices serving South Carolina use several different weather monitoring networks, including the Cooperative Observer Program (COOP), the Remote Automated Weather Stations (RAWS), the Automated Surface Observing Systems (ASOS), and the Automated Weather Observing System (AWOS). These networks monitor and provide data regarding air temperature, precipitation, soil temperature, evaporation, and snow fall. The existing stations utilized by these networks provide an incomplete coverage of South Carolina.

MODELING AND COMPUTATIONAL TOOLS IN SOUTH CAROLINA

Computer models are useful tools that simplify and represent a complex system. With advancements in computer technology, models have increased in accuracy and speed, but have yet to account for every variable that influences a system. Models are built to answer specific questions and are not always useful to guide decision makers on those questions that are outside the original intent of the model. In many cases, several models are consulted depending on the needs of decision makers. The following section reviews a few of the models currently used in South Carolina:

Table 5.4: Existing Models, Data Processing and Managing, and Decision-making tools

Software / Tool Name	Source	Focus
SCDNR Floodplain Inundation Modeling and Mapping Initiative (in development)	SCDNR	Vulnerability Assessment Emergency Management
HEC-RAS 2D (Hydrologic Engineering Center's River Analysis System)	US Army Corps of Engineers	Steady and Unsteady River Hydraulic Calculations
CHEOPS (Computer Hydro-Electric Operations and Planning Software)	HDR, Inc	Hydroelectric Systems
Storm Water Management Model (SWMM)	EPA	Drainage system modeling
NOAA Atlas 14	NOAA	Precipitation Frequency Estimates Infrastructure Design
Bridge Watch	SC DOT	Bridge Monitoring & Alerts
First Street Flood Model	First Street Foundation	Property Level Statistics Current & Future Hazards

SCDNR FLOOD INUNDATION MODELING AND MAPPING INITIATIVE

Since 2016, SCDNR has been tasked with assisting with search and rescue through the production of inundation maps for specific storm events. These maps cover about 25% of the state and are available to be updated as needed.

Through the support of Hazard Mitigation Grant Program funding, the SC Flood IMPACT website was developed to provide inundation information to the public and emergency officials. Currently, three HUC 8 watersheds within the greater Pee Dee watershed are live on the websiteThe rest of the Pee Dee Watershed and a portion of the Santee Watershed are currently under development.

HEC-RAS 2D

The US Army Corps of Engineers (USACE) developed the Hydrologic Engineering Center's River Analysis System (HEC-RAS) to perform one-dimensional steady flow and one and two dimensional unsteady flow calculations, sediment transport / mobile bed computations, and water temperature / water quality modeling (US Army Crops of Engineers, 2022). SCDOT uses HEC-RAS to:

- Design bridges and culverts
- Verify water elevations
- Calibrate of existing models
- Analyze existing structure capacity

CHEOPS

The Computer Hydro-Electric Operations and Planning Software (CHEOPS) was developed by HDR, IncThe model simulates the physical changes and operational constraints of hydroelectric systems. It is used by the Catawba-Wateree River Basin Council and Duke Energy to manage reservoirs and dams (HDR, 2014).

SWMM

EPA's Storm Water Management Model (SWMM) is used for planning, analysis, and design related to stormwater runoff, combined and sanitary sewers, and other drainage systems. It can be used to predict runoff quantity and quality from drainage systems. SWMM was developed to help support local, state, and national stormwater management objectives to reduce runoff through infiltration and retention and help to reduce discharges that cause impairment of waterbodies (Environmental Protection Agency, 2022).

NOAA ATLAS 14

The NOAA Atlas 14 is a precipitation frequency estimation of 5-minutes through 60-day durations at average recurrence intervals of 1-year through 1,000-year (Bonnin, et al., 2006). This allows the calculation and representation of rain amounts at particular locations and for given durations. These curves are used by agencies and stakeholders to design infrastructure, environmental management, stormwater management, hydrologic studies, floodplain and watershed management, and many others. In South Carolina, the Atlas 14 curves were lasted updated in 2006 utilizing data ending in the year 2000 (Bonnin, et al., 2006)

SCOR, the SC Department of Transportation (SCDOT) and SC Department of Natural Resources (SCDNR) have agreed provide funding to include South Carolina in the update of the National Oceanic and Atmospheric Administration (NOAA) Atlas 14 Rainfall Intensity- Duration – Frequency (IDF) Curve Numbers for the Mid-Atlantic region. Once completed, the updated IDF Curve numbers for SC will include data gathered after 2000 and allow for a better understanding of the probability of rain events. In addition to updating curve numbers with more recent historical data, IDF Curve numbers that use downscaled global climate projections have been proposed by NOAA as Atlas 15. The first volume of Atlas 15 will address nonstationarity to the present day, while the second volume will include forward-looking projections. Once released, the updated Atlas 14/15 numbers should be used to update regulation and guidance utilized for planning and design.

BRIDGEWATCH

BridgeWatch is a web-based monitoring software that allows SCDOT to predict, identify, prepare for, manage, and record potentially destructive environmental events. BridgeWatch is an application that centralizes and makes accessible all database and site information through an interactive web interface. This application allows SCDOT to efficiently perform the following activities.

- Maintain Plan of Action and flood monitoring data for Federal Highway Administration (FHWA) compliance
- Monitor bridges over water and floodplains for rainfall and flow thresholds using radar and gage adjusted radar rainfall data, USGS gages, NWS rainfall predictions, and SLOSH (Sea, Lake, and Overland Surges from Hurricanes) and ADCRIC (Advanced Circulation) tidal surge predictions modeling programs
- Continuously monitor bridges for seismic events using USGS data
- Analyze threshold alerts sent to SCDOT personnel for rainfall, riverine, tidal, and seismic events
- Access real-time graphical display of geographic data, an inventory of structures being monitored, and the list of those structures experiencing their respective critical event
- Prepare a watch list of structures identified for action according to user-defined protocols

FIRST STREET FOUNDATION FLOOD HAZARD LAYERS (VERSION 2.0)

First Street Foundation describes itself as:

> "A non-profit research and technology group dedicated to quantifying and communicating those risks by incorporating world class modeling techniques and analysis with the most up to date science available in order to simply, and effectively, inform Americans of their risk today and into the future from all environmental changes" (First Street Foundation, 2022).

The foundation produces high resolution flood maps by modeling three main flood types (fluvial, pluvial, and coastal) in different modeling software with 3-meter digital elevation models (DEM) and then combining the flood type models into a single coverage of flooding for each scenario. The modeling software used is Fathom-US for fluvial, a proprietary model for pluvial that integrates the high-resolution DEMs with the NOAA Atlas 14 curves, while coastal flooding is modeled in multiple software packages (GeoCLAW, ADCIRC, and SWAN) due to the complexity of coastal modeling. The Flood Hazard Layers, V2.0, model conditions 30-years into the future. These are then historically validated to corroborate the models based on past events.

Property level statistics allow for an estimated flood inundation level for various modeled scenarios. To model future climate scenarios, First Street identified that the IPCC RCP 4.5 carbon emission scenario is the median projection for future change. To calculate the property value, First Street uses ComeHome by HouseCanary's AVM (Automated Valuation Model), paired with parcel & building characteristic data from such platforms as Lightbox.

As with any model, there is inherent error due to the limited data available. South Carolina does not keep a complete dataset of parcel statistics at the state level; this data is maintained by counties and municipalities and held in a non-standardized format. Given the national scale of the model, it is a good screening tool, but site-specific modeling is likely needed for answering specific critical questions at more localized scales.

SOCIAL VULNERABILITY & FLOOD RISK

The Social Vulnerability Index (SoVI®), compiled and processed by the Hazards Vulnerability and Resilience Institute at the University of South Carolina (HVRI), measures the social vulnerability of counties in the United States, providing information on "where there is uneven capacity for preparedness and response and where resources might be used most effectively to reduce pre-existing vulnerability" using 29 socioeconomic variables (University of South Carolina, 2022). Total scores, percentiles, and individual scores for each component are available to allow for specific analysis about what demographics drive local vulnerability.

SoVI® overlaid with the 2022 1% annual flood event, as shown by the First Street Foundation model, is shown in Figure 5.13. Appendix D provides these maps by counties to identify areas with high social and physical vulnerability to flooding, while Appendix E contains county level maps for the 2022 1% annual flood event as shown by the First Street Foundation model without the social vulnerability overlay.

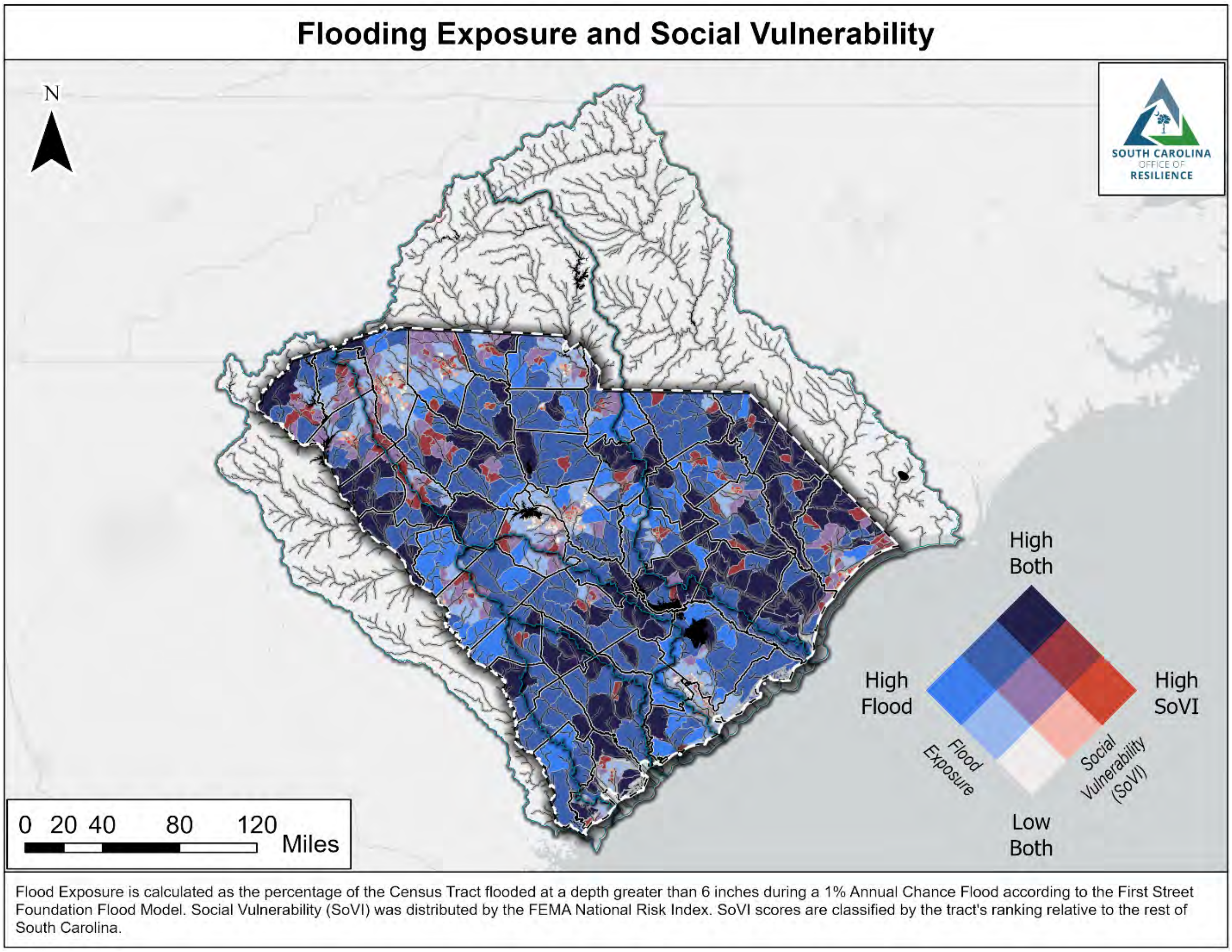

Figure 5.13: Flooding Exposure and Social Vulnerability. Flood data provided by the First Street Foundation Hazard Layers, V2.0.

VULNERABILITY BY SECTOR

DATA SOURCES

FLOOD DATA

First Street Foundation provides parcel level statistics that identify registered parcels across the state. If the parcel has a building on it, the first-floor elevation is used to determine flood inundation, and if not, the point of inundation evaluation is at the geometric center of the parcel. In the following analysis, parcel and property is used interchangeably. This data allows SCOR to not only identify properties that may currently flood, but also plan for potential flooding under various scenarios in the future. In assessing flood vulnerability, the First Street Foundation's flood maps pair well with the FEMA floodplain maps. When comparing the "100-year" flood maps, the First Street Foundation's high-resolution floodplain maps complement and provide additional coverage in areas that have historically reported flooding but which have not been represented or are underrepresented by the FEMA maps. The First Street Foundation's model served as the basis for quantifying the vulnerability of the assets below to flooding. The First Street Foundation's 2022 and 2052 1% annual chance flooding event models were overlaid with data sets obtained from state partners and public sources

SECTOR DATASETS

The data identification, collection, and coordination of this chapter was completed in coordination with the subcommittees of the Strategic Statewide Risk Reduction and Resilience Plan Advisory Committee. Identified and collected point datasets were overlaid with hazard risk data below to determine the physical vulnerability to each sector/facility type. While many of the facilities are point locations (such as storage tanks or individual buildings such as fire stations), a point analysis is limited in that it simplifies the full extent of an asset or facility at a location. Table 5.5 summarizes the flood vulnerability point analysis. Locations for each sector are overlaid with flood inundation model data. The table summarizes the count of facilities with estimated flood depth of none, 6 to 12 inches, 1 to 2 feet, 2 to 3 feet, and greater than 3 feet under both current and future conditions. Sector specific maps are expanded upon later in this chapter. This broad view of how flooding puts South Carolina at risk is useful for planning purposes, but more specific analysis would be needed to comprehensively assess risk level at a specific facility, building, or campus.

Table 5.5: Summary Table of point count by inundation levels for each by sector.

Vulnerability by Sector		Flood Inundation Depths					
	Year	0 ft	6 inches	1 foot	2 feet	3 feet	> 3 feet
Residential							
Mobile Homes	2022	1,493	1	36	37	10	9
Mobile Homes	2052	1,487	1	29	40	10	19
Water Supply							
Surface Water Intakes	2022	57	1	1	1	2	25
Surface Water Intakes	2052	57	1	0	2	1	26
Groundwater Intakes	2022	688	1	30	23	17	56
Groundwater Intakes	2052	679	3	32	24	6	71
Hazardous Waste Locations							
NPDES Sewer System Discharge	2022	106	2	12	21	16	78
NPDES Sewer System Discharge	2052	102	4	10	16	16	93
Dry cleaners	2022	406	0	8	9	5	14
Dry cleaners	2052	396	2	11	13	1	19
Mines	2022	1,015	5	38	49	27	94
Mines	2052	1,002	5	35	56	28	102
Solid Waste Landfills	2022	105	0	1	2	1	2
Solid Waste Landfills	2052	105	0	1	2	1	2
Solid Waste Facilities	2022	1,199	2	43	42	21	67
Solid Waste Facilities	2052	1,183	2	40	45	25	79
Site Assessment, Remediation, and Revitalization Facilities	2022	5,529	15	46	86	44	139
Site Assessment, Remediation, and Revitalization Facilities	2052	8,482	14	53	92	46	172
Hazmat Treatment, Storage, and Disposal Facilities	2022	40	0	4	4	1	2
Hazmat Treatment, Storage, and Disposal Facilities	2052	39	0	4	3	1	4
Underground Storage Tanks Sites	2022	16,099	31	301	381	202	400
Underground Storage Tanks Sites	2052	15,856	38	344	401	215	560
Community Services							
Local Law Enforcement Offices	2022	308	0	4	6	3	6
Local Law Enforcement Offices	2052	308	0	4	3	3	9

Detention Centers	2022	81	0	1	0	0	2
Detention Centers	2052	79	1	2	0	0	2
Fire Stations	2022	1,080	2	7	16	11	18
Fire Stations	2052	1,064	2	14	13	8	33
EMS Station	2022	522	0	7	10	6	12
EMS Station	2052	511	0	10	11	7	18
K-12 Education							
Public Schools	2022	1,237	0	10	18	5	8
Public Schools	2052	1,229	1	5	15	8	20
Private Schools	2022	269	0	4	4	5	9
Private Schools	2052	267	0	2	4	1	17
Higher Education							
College and Universities	2022	99	0	1	4	0	1
College and Universities	2052	97	1	1	2	1	3
Health and Human Services							
Public Health Facilities	2022	2,461	0	43	51	18	39
Public Health Facilities	2052	2,426	5	43	59	27	52
Hospitals	2022	105	1	2	0	0	4
Hospitals	2052	104	0	1	0	2	5
Nursing Homes	2022	197	0	0	0	1	3
Nursing Homes	2052	194	0	0	3	1	3
Mental Health Offices	2022	75	0	2	0	0	2
Mental Health Offices	2052	75	0	2	0	0	2
Dialysis Centers	2022	159	0	1	2	0	1
Dialysis Centers	2052	156	0	3	3	0	1
Pharmacies	2022	986	1	16	15	7	23
Pharmacies	2052	971	2	18	18	12	27
Dept. of Health and Human Services	2022	84	0	0	1	2	0
Dept. of Health and Human Services	2052	82	0	2	1	1	1
Childcare Facilities	2022	2,048	2	23	55	23	27
Childcare Facilities	2052	2,025	3	29	48	25	48
Veterans' Affairs	2022	23	0	0	0	0	1
Veterans' Affairs	2052	23	0	0	0	0	1
Places of Worship	2022	5,432	4	160	139	97	77
Places of Worship	2052	5,361	9	171	146	96	126
Infrastructure							
Aviation Facilities (2022)	2022	180	0	3	5	2	6
Aviation Facilities	2052	180	0	3	5	1	7
Power Plants	2022	201	0	4	3	5	9
Power Plants	2052	200	0	5	2	6	9

Substations	2022	2,323	5	56	68	36	88
Substations	2052	2,289	5	66	72	37	107
Economic							
Public Refrigerated Warehouses	2022	8	0	0	0	0	0
Public Refrigerated Warehouses	2052	8	0	0	0	0	0
Manufacturing Accounts	2022	3,378	2	67	85	44	88
Manufacturing Accounts	2052	3,335	3	73	76	49	128
Industrial Buildings	2022	220	0	7	6	0	1
Industrial Buildings	2052	220	0	5	7	1	1
Industrial Sites	2022	474	0	16	27	12	60
Industrial Sites	2052	469	0	21	24	12	63

NATURAL SYSTEMS VULNERABILITY

South Carolina is rich in natural resources. The forests, rivers, lakes, beaches, marshes, mountains, and natural environments are critical resource to South Carolina's communities and economies. The landscapes of South Carolina are used by locals and visitors for recreation, hunting, fishing, and farming. South Carolina's economic drivers rely on these natural resources as a foundation. Coastal communities rely on the beaches and marshlands to draw tourists and for recreational and commercial harvesting of fish and oysters. Farmers rely on the soils and waters to grow crops and trees throughout the State.

These natural systems also provide hazard mitigation and protection benefits to the State. Marshes and beaches absorb storm surge, wetlands and soils absorb stormwaters and hold it in storage until the water can naturally drain into the rivers or groundwater systems. The vulnerabilities of South Carolina's natural systems have been assessed in order to protect the natural and economic value of these resources to the peoples of the State.

FORESTRY

South Carolina has approximately 12.8 million acres of forestland, 87% of which are privately owned (SC Forestry Commission, 2021). Forestry is the second largest manufacturing industry sector and provides approximately $23.2 billion to the State's economy each year (South Carolina Forestry Commission, 2022).

The South Carolina Forestry Commission (SCFC), established in 1927, is charged with protecting and managing the State's forests. Forests have additional economic, ecological, and aesthetic value as natural and recreational areas. Environmental change and natural hazards threaten forests with loss of overall productivity.

Forestland acts as a sponge, absorbing rainfall and then releasing it gradually. Canopy interception of rainfall is one of the primary mechanisms of reducing the amount of runoff. The forest soil absorbs the vast majority of rainfall and slowly releases it, reducing the peak flow following storm events and increasing base flow during drier periods

Depending on species, a mature tree retains 20 to 30% of annual rainfall (U.S. Department of Agriculture, 2020). Healthy forests help slow runoff from rain events in steep terrain, insulating creeks from scouring of the creek banks and beds. They ensure stable hydrology, low sedimentation rates, stable channels, moderate water temperatures (through shading), and woody debris for in-stream habitat.

The main impact from flooding on forest management is infrastructure damage, such as destruction of stream crossings on forest roads. Newly planted tree seedlings occasionally succumb to flooding, but forest stands beyond seedlings should survive short term flooding if they are not submerged for more than 7 to 10 days (SC Forestry Commission, 2015).

NATIVE PLANTS

Flooding can be exacerbated or mitigated by the type of vegetation that exists on a landscapeIn general, native plant species are more resilient and provide significantly more stormwater mitigation capacity. Turf grass roots are short and dense, resulting in sheeting water as storm water runs off instead of absorbing rainfall to allow infiltration back into the ground / aquifer (Selbig, 2010). Native grasses and plants slow down stormwater, their longer and more extensive root systems both absorb more water and create pathways for rainfall to infiltrate into the soil, and ultimately allowing for more ground water recharge and resulting in less erosion (WeConservePA, 2017). Utilizing native plants in flood prone areas allow for ground water infiltration as well as evapotranspiration during the growing season, reducing flood water and standing water more quickly (Davis & Scaroni, 2020).

Native plants have a multitude of co-benefitsNative bird and wildlife species are more likely to be able to use native plants for habitat and they are adapted to growing conditions, climate, and soils in South Carolina, making them low maintenance and saving resources related to mowing, fertilizers, pesticides, and irrigation (SC Native Plant Society, 2023)The long root systems of native grasses cause them to be more resilient both in regrowth and carbon storage in the instance of fires (Kerlin, 2018)Using native plants to divert and retain stormwater runoff allows for filtration and removal of pollutants (Massachusetts Office of Coastal Zone Management, 2023). Riparian buffers along water ways and retention ponds absorb more pollutants and excess nutrients and help to hasten water absorption and decrease runoff through evapotranspiration.

Clemson Extension maintains the Carolina Yards Plant Database containing nearly 300 plants suited to growing in South Carolina as well as several resources to guide landowners on strategies to use native plants to mitigate flooding, including rain gardensAdditionally, SCDNR has established Solar Habitat Guidelines to promote the use of native plants on solar developments, which provide benefits to pollinators and therefore neighboring agriculture, as well as flood mitigation.

BEACHES AND OCEANFRONT

South Carolina’s coastline measures 187 miles containing 98 miles of developed beaches (including public parks) and 89 miles of wilderness areas with limited public access. It should be noted that this figure does not include tidal shoreline, which totals 2,876 miles. The beach/dune system provides the basis for approximately two-thirds of South Carolina's annual tourism industry revenue (South Carolina Code Ann. § 48-39-250 *et seq.*, 2019), which is about $18 billion annually (SC Department of Parks, Recreation and Tourism, 2022). These systems also serve as a front line of defense to beachfront residents and businesses from wind, waves, and storm surge

The main risk from flooding to South Carolina beaches is exacerbated erosion due to sea level riseAs noted in the Coastal Flooding section above, beach and dune restoration (also known as nourishment) has reduced flood risk along much of the developed coastline but requires dedicated funding and planning to sustain. In policy, the Beachfront Management Reform Act of 2018 adopted a state policy of beach preservation. The Office of Coastal Resource Management of DHEC recently convened The South Carolina Beach Preservation Stakeholder Workgroup to make recommendations on how to implement the state policy. SCOR participated in this workgroup. The recommendations are as follows:

> Recommendation 1: Definition of Beach Preservation: The Workgroup recommends that the term "Beach Preservation" be defined as: "maintaining the natural processes and functionality and benefits of the beaches and the beach/dune system critical areas to support storm protection, habitat, tourism, public access, recreation opportunities, and aesthetics."
>
> Recommendation 2: Establish a Beach Nourishment Technical Advisory Committee: The Workgroup recommends that a technical advisory committee be established to further investigate beach nourishment project specifications, including: Sand quality, Timing windows, Dredge type, Project footprint and borrow area flexibility, Long-term monitoring, Downdrift impact analysis, Bond requirement, Impacts to flora/fauna at beach and borrow sites (beach, benthic, threatened & endangered species).
>
> Recommendation 3: Establish A Pilot Project Ad Hoc Technical Advisory Committee: The Workgroup recommends establishing an Ad Hoc Technical Advisory Committee to evaluate pilot project study proposals, provide written comments and recommendations on project standards and success criteria, and evaluate the findings of such studies. Appointed by DHEC OCRM based on recommendations from stakeholders, this 7-member committee would be comprised of unbiased technical and scientific coastal experts from academia, state and federal resource agencies, coastal engineers, and other subject matter experts. The review and approval process should be rigorous and thorough.
>
> Recommendation 4: Enhance the Pilot Project Authorization Process: The Workgroup recommends that pilot project applications undergo a formal, prescribed process similar to other activities within the State's critical area. This process would include internal and committee review, an opportunity for public comment, resource agency coordination, and an appeals process. The Workgroup recommends that process requirements include detailed study design, timeline, monitoring, demonstration of how the project will

address the erosional issue, criteria for success, bonding for removal and restoration, and no material harm to the beach environment, flora, or fauna.

Recommendation 5: Modify Pilot Project Statutory Language: The Workgroup recommends that the statutory language under S.C. Code Ann. § 48-39-320(C), *et seq.*, be amended to remove the wording: “Notwithstanding any other provision of law contained in this chapter” and include language in the statute to ensure that pilot projects do not cause material harm to the beach environment, flora, or fauna. The Workgroup also recommends revising the language from ‘the board, or the Office of Ocean and Coastal Resource Management’ to “the Department”.

SALT MARSHES

South Carolina is home to roughly 350,000 acres of saltmarsh, much of which is at risk from sea level rise and lack of management. Some sources estimate that 50% of the original salt marsh habitat in the U.S. has been lost due to human influence over the last century (Kennish, 2001)Globally, it is estimated that 85% of oyster reefs have been lost, with those remaining in poor condition (Beck, et al., 2011). Salt marshes provide essential habitat, wave attenuation, and water filtration. They provide a vital refuge, food supply and breeding grounds for fish, birds, and other wildlife, as well as a unique open space in a dense urban environmentThe associated estuaries are habitat for shellfish and are nursery habitat for juvenile fish species, many of which are economically important to the State. South Carolina marshes provide public and commercial fishing/oystering opportunities, as well as other recreational opportunities such as boating and bird watchingRecreational fishing is a $686 million annual industry (US Fish and Wildlife Service, 2014) in South Carolina. In 2012, commercial fishermen in South Carolina landed 12.3 million pounds of finfish (2.4 million pounds) and shellfish (9.9 million pounds), earning $24 million in landing revenue (National Marine Fisheries Service, 2014). To promote better management, the South Atlantic Salt Marsh Initiative (SASMI) brings together local, state, and federal partners along with community stakeholders to better manage marshes along the Atlantic Ocean from Florida to North Carolina. The SASMI Plan, published in 2023, lays out the framework to improve management and planning for future impacts to the approximately 1 million-acres of marsh along the South Atlantic coastline.

Salt marshes provide services for the State by reducing wave energy, absorbing flooding, and filtering debris and pollutants from the water. Despite decades of regulatory protection, salt marshes continue to be threatened by poor water quality, rising sea levels, encroaching development, illicit dumping, and erosion from boat wakes and flood events. This leaves marshes without adequate room for natural migration. Programs to restore the marsh (e.g., living shorelines) and oyster reefs have had success in increasing resilience along the coast. Figure 5.14 to Figure 5.16 show the projected marsh migration by 2050. Figure 5.17 to Figure 5.19 show projected marsh migration by 2100.

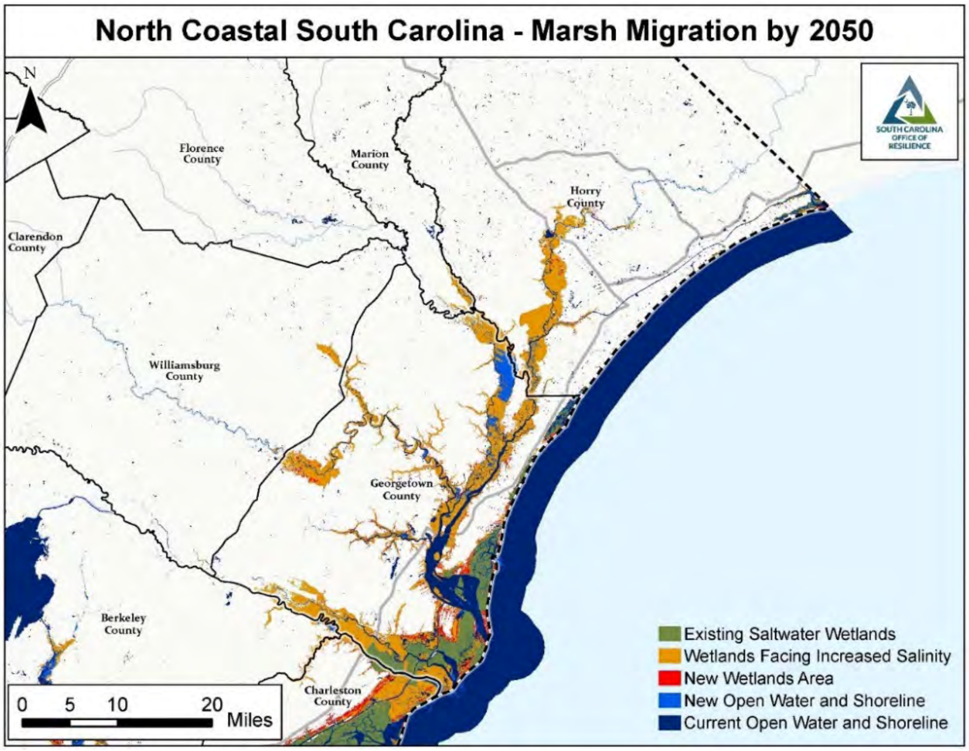

Figure 5.14: Marsh Migration by 2050 in the North Coastal Area of South Carolina

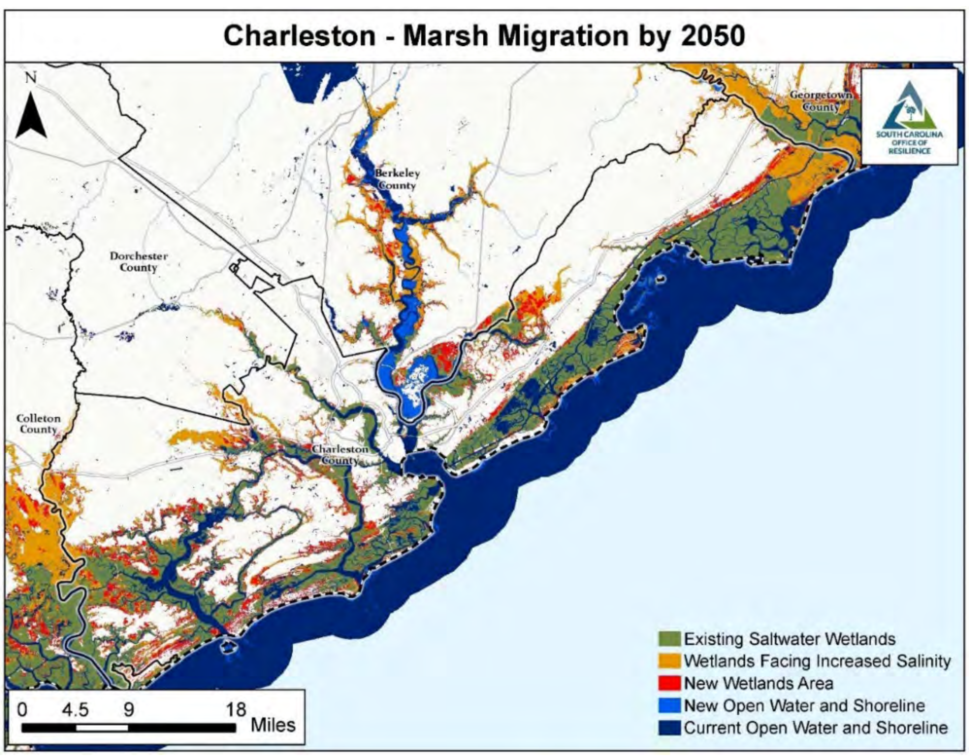

Figure 5.15: Marsh Migration by 2050 in the Charleston Area

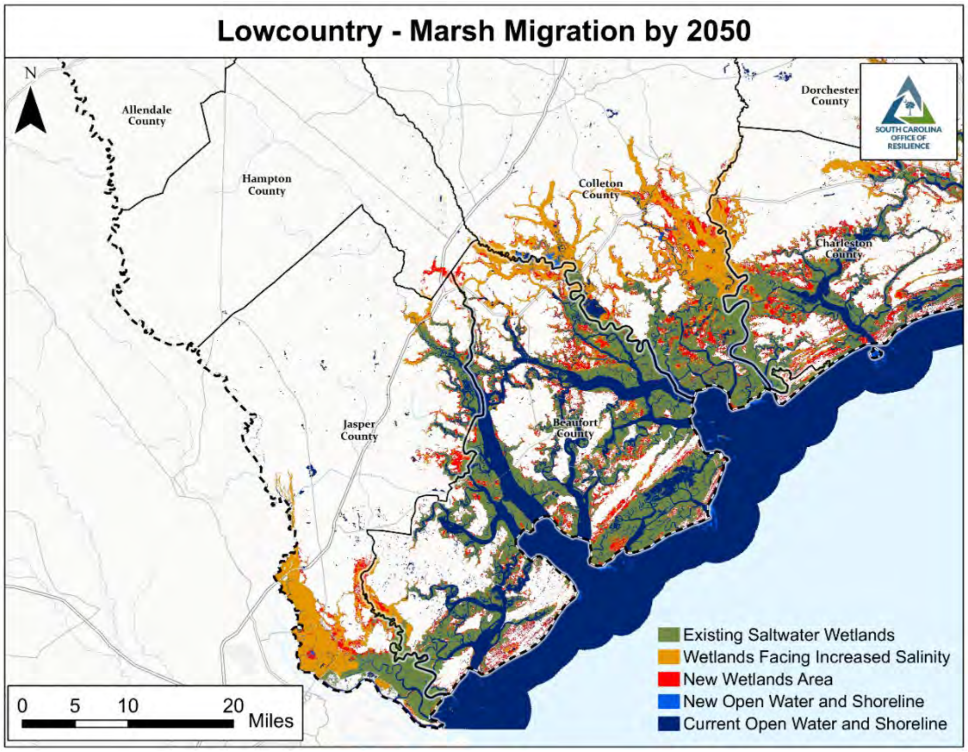

Figure 5.16: Marsh Migration by 2050 in the Lowcountry Area

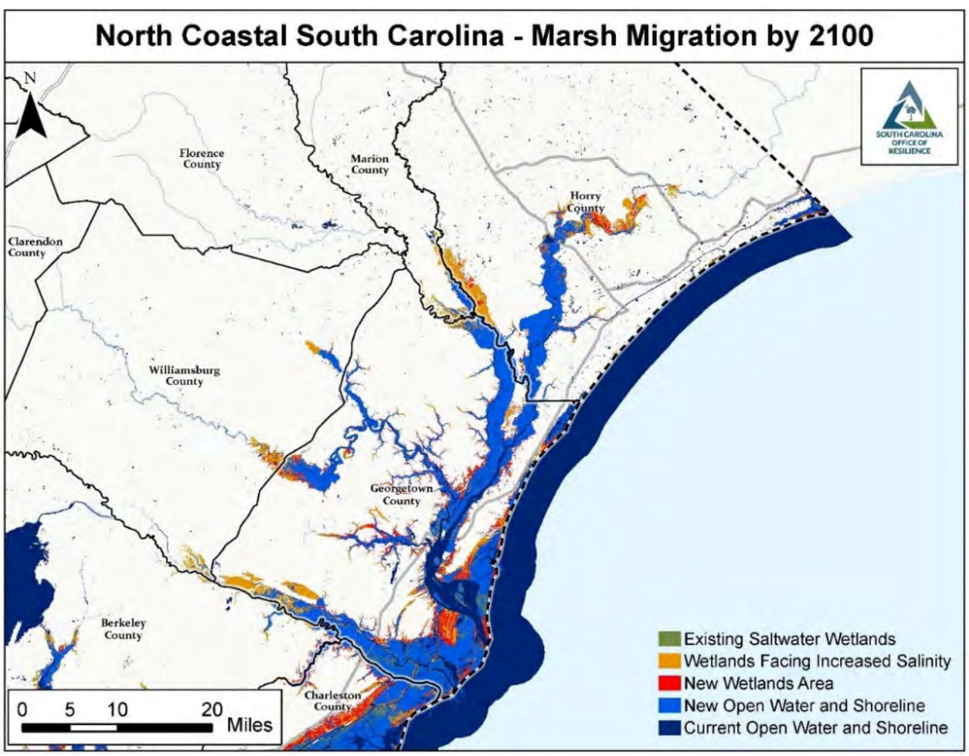

Figure 5.17: Marsh Migration by 2100 in the North Coastal Area of South Carolina

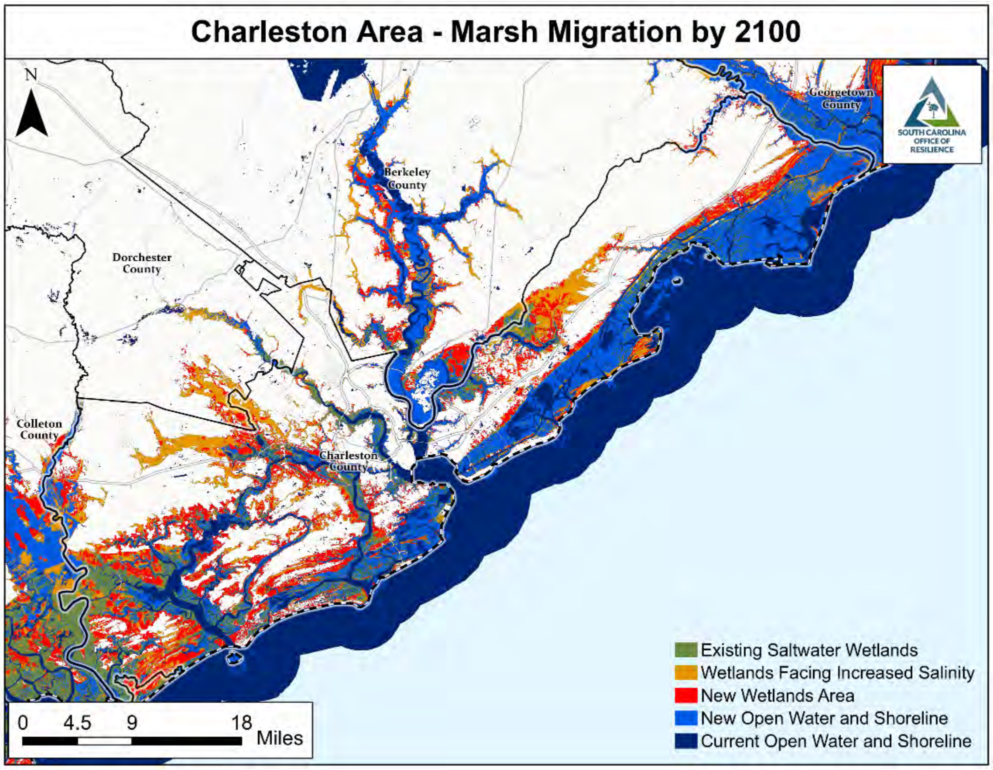

Figure 5.18: Marsh Migration by 2100 in the Charleston Area

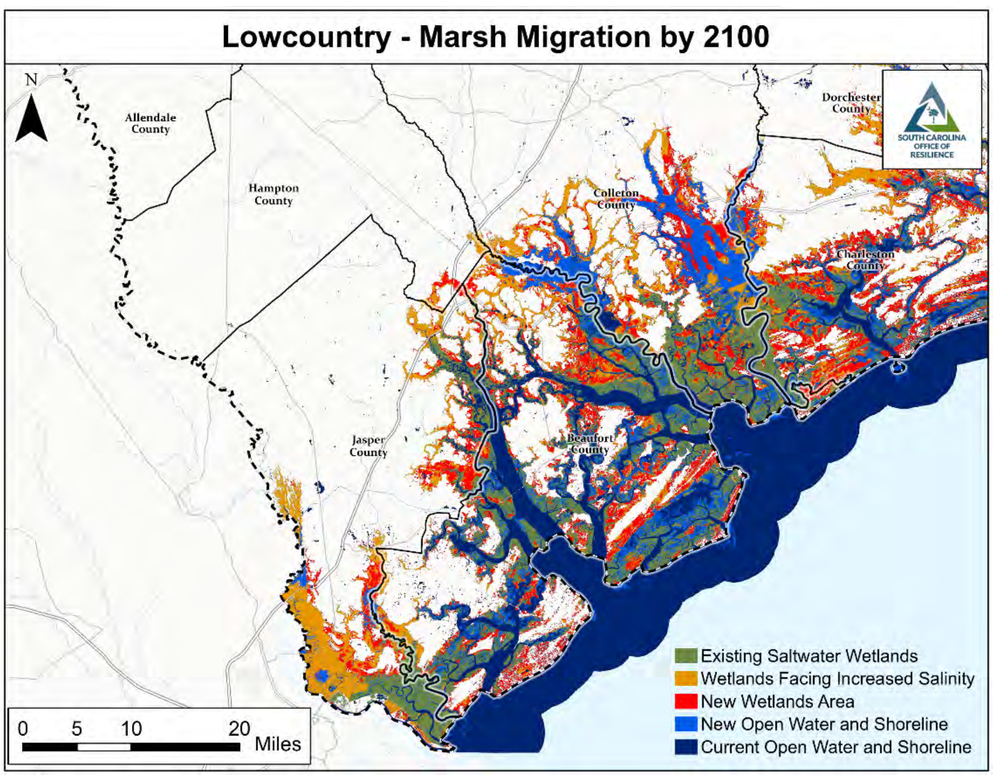

Figure 5.19: Marsh Migration by 2100 in the Lowcountry

WILDLIFE

THREATENED AND ENDANGERED SPECIES

Numerous state and federally Threatened and Endangered species, as well as species tracked in South Carolina's State Wildlife Action Plan (SWAP), depend on South Carolina's habitats for survival and recovery. The SWAP also focuses on priority species in 14 taxonomic groups, identifying 825 species of flora and fauna to include on the State's List of Species with the Greatest Conservation Need.

The plan notes several coastal, freshwater and land species and habitats that may be impacted by flooding. One of the major threats to species noted in the plan is the increase in impervious surfaces contributing to increased runoff. Runoff carries silt, chemicals, and nutrients into water and wetlands that can be lethal to aquatic life.

Along the coast, birds and sea turtles are particularly vulnerable. Least Tern and Wilson's Plovers are both beach-nesting species that are State Threatened. Red Knot and Piping Plover are federally Threatened and Endangered species that rely on South Carolina beaches as critical habitat throughout their life cycle (SC Department of Natural Resources, 2020). Loggerhead Sea Turtles commonly nest on South Carolina's beaches and rely on enough dune space to get beyond the high tide mark to deposit their eggs. The recently listed Black Rail has seen greater than 90% population decline since the 1990s due to sea level rise and its associated nest flooding (ACJV, 2020). In a recent study, 20,000 Whimbrel, almost 50% of the eastern population, were found to congregate on Deveaux Bank during spring migration (Weidensaul, 2021). Tidal marshes are vitally important feeding grounds for these species who breed in the Arctic tundra. Other shorebird species use Deveaux and other barrier islands for breeding. Dredge material has been put to good use building back up islands (i.e. Crab Bank Seabird Sanctuary in Charleston County) used by nesting shorebirds like Brown Pelicans, Black Skimmers, American Oystercatchers, and many more (SCDNR 2023). Marshes also support Seaside Sparrows, and moving further into the maritime forest community, Painted Buntings, Hummock Island Crayfish, and Diamondback Rattlesnakes find refuge (SCDNR, 2015). All of these species are Species of Greatest Conservation Need in South Carolina's SWAP. Protection of the State's beaches, marshes, maritime forests, and barrier islands is critical for the survival of multiple species of conservation concern and the buffering capacity of these landscapes (SCDNR, 2015).

In addition to these coastal vulnerabilities, the SWAP highlights threats to species statewide. The plan highlights the role increased impervious surface plays in increased flooding as well as the associated degradation and loss of habitat.

FEMA's Flood Risk and Endangered Species Habitat (FRESH) Mapping Tool, created in collaboration with the U.S. Fish and Wildlife Service and the National Marine Fisheries Service, allows the user to visualize the ranges and critical habitats of species listed as threatened and endangered under the Endangered Species Act (Federal Emergency Management Agency (FEMA), 2022)

INVASIVE SPECIES

While threatened and endangered species are at additional risk due to flooding, several invasive species have been found to exacerbate flooding in addition to their negative impacts on people and ecosystems. Ineffective marsh protection and/or management, for example, can lead to the damage or destruction of native species that would otherwise provide important ecological benefits (from food sources to structural support to protect against flooding and storms), and the subsequent possible introduction or promotion of invasive species. Many invasive species become introduced into new habitats as a direct result of flooding either through movements to avoid the floodwaters or by being carried by the floodwaters.

Phragmites: can invade freshwater marshes, outcompeting native vegetation and changing the organic composition of the ground cover. A once open marsh system may become too thick for birds and other wildlife to utilize effectively (K. Bradley, SCDNR Botanist, personal communication 2022). Other species include Chinese Tallow (Triadica Sebifera) which can damage wetlands by out-competing native plants, shading them out, and changing the hydrology of the wetland during the growing season (K. Brdaley. SCDNR Botanist, personal communication 2023).

Feral hogs: can trample cordgrass as they forage for ribbed mussels, disrupting the mutualistic relationship between the bivalve and the grass as well as damaging the marsh ecosystem (Hensel, et al., 2021). Feral swine routinely undermine the integrity of dikes and levees leading to costly repairs. Some repairs have been estimated in excess of $100,000 to replace a single water gate (N. Myers, USDA APHIS WS SC State Director, personal communication 2022). In inland areas, feral hogs can foul waterways with their wallows, spread disease, and destroy sensitive habitats. They are omnivorous and consume plant and animal matter, including rare and declining species of conservation concern (West, Cooper, & Armstrong, 2009).

Invasive zebra mussels (Dreissena polymorpha): have been known to block power intake pipes at power plants and water treatment facilities (Rosaen, Grover, & Spencer, 2016). In South Carolina, there is the potential for impact on storm water drainage pipe systems.

WILDLIFE VIEWING, HUNTING & FISHING

Wildlife and their associated habitat contribute to a significant portion of the state's economy. Fishing, hunting, and wildlife viewing are culturally important to South Carolina and contribute to almost $3 billion in economic value to South Carolina based on a 2017 study (Willis & Straka, 2017). Both local citizens and visitors come to South Carolina to experience natural places. More data can be found in the most recent report on SC's Ocean Economy (S.C. Sea Grant Consortium, 2020)

Hunting of many species is popular in the State and is particularly important to the state's economyThe hunting of deer, alligator, turkey, fur harvesting, small game, feral hog, coyote, armadillo, migratory birds, dove and waterfowls are regulated in the State, with SCDNR enforcing seasons, limits and methods of hunting statewide (SC Department of Natural Resources, 2020) SCDNR publishes harvest reports, which identify the number of over 20 species of waterfowl and migratory birds taken (South Carolina Department of Natural Resources, 2022). A 2001 report estimated $38 million was spent in the State by over 70,000 hunters on migratory bird hunting (International Association of Fish and Wildlife Agencies, 2002).

Coastal impoundments are managed wetlands that were former rice fields or built for protection of the coast from subsidence, high water levels, and high salinity. Although of anthropogenic origin, these impoundments have been a fixture on the landscape long enough to serve valuable ecosystem functions, including supporting wildlife and buffering the coast (Green, Carloss, Rader, & Brasher, n.d.). These areas are highly productive waterfowl and wading bird habitat and support a myriad of other wildlife species. Water levels are managed using gates and other water-control structures and pumps which replicate natural cycles. Some of these freshwater impoundments are threatened by sea level rise and storm surges that breach dikes and cause saltwater intrusion.

Recreation, competition, and commercial fishing are important across the State. Lakes and rivers are home to bass, bream, trout, and other species. The State's major marine fisheries are shrimp, shellfish, crabs, and offshore finish. Many more species are not harvested but are of importance to the ecological food chain, some of which are of conservation concern and listed in the SWAP. During flood events, fish populations can be impacted by the degradation of water quality with the increase of turbidity and runoff from surrounding land (bacteria, fertilizers and other nutrients, heavy metals, hazardous material, auto fluids, trash, and many others) (Clemson, 2022). With the influx of pollutants like nutrients and fertilizers, algal blooms can occur and cause fish kills when the algae growth consumes the oxygen in the water column, thus decreasing the available oxygen that other organisms need to live (Florida Fish and Wildlife

Conservation Commission, 2022). An additional source of oxygen demand placed on aquatic systems during and following flood events is the organic detritus that enters aquatic systems during and following flood eventsAs these materials break down, oxygen can be depleted, stressing aquatic organisms sometimes to the point of mortality

An even greater concern associated with flooding of small impoundments or ponds is the introduction of non-native species into public waters. During flood events, smaller water bodies, like ponds, that are normally isolated from other water bodies can overflow and allow for stocked fish to escape into nearby streams and rivers. Or a reciprocal problem may also occur, where invasive or other fish species that are not a part of the pond management plan may be introduced (Clemson, 2022)

COMMERCIAL & RESIDENTIAL PROPERTIES

The First Street Foundation parcel level data, described above, was paired with the estimated flood inundation levels associated with medium “100-year” flood event to assess the vulnerability of properties in the 2022 and 2052 scenarios. Although the chances of having a “100-year” (1% chance) flood event may seem small, they are significant when considering how risk accumulates over time. For example, a home at risk from flooding during a 1% annual flood event would have at least a 26% chance of flooding over the 30-year timeframe of the average mortgage. The figures below show the count and percentage of parcels, by HUC10 watershed, inundated greater than 6 inches, 1 foot, 2 feet, 3 feet and 6 feet in the 2022 (Table 5.6, Figure 5.20 through Figure 5.29) and 2052 (Table 5.6, Figure 5.30 through Figure 5.39) 1% annual chance flooding events. The flood damage associated with different inundation intervals are described by Risk Factor, a product of First Street Foundation, and presented in Table 5.7 (Risk Factor, 2022).

Table 5.6: Potential damage by flood inundation intervals (Risk Factor, 2022).

Flood Inundation Potential Damage		
	Interior (First Floor)	Exterior
>6 inches	Drywall, insulation, wallpaper, floors, carpets, appliances	Yard plants, root rot, standing water and bug attraction like mosquitoes, and vehicles exhaust could be under water and cause stalling
>1 foot	Electrical outlets 12-16 inch above floor and HVAC systems	Cars can float
>2 feet	Large appliances	Trucks can float
>3 feet	Building foundation and framework, severe damage	Lasting damage to water wells, sewage, plumbing, and septic tanks
>6 feet	Assumed total loss	Assumed total loss

Table 5.7: Number of noncommercial parcels estimated to see greater than 6 inches and greater than 6 feet of inundation in 1% annual chance flood event in 2022 and 2052 statewide. First Street Foundation identifies 2,334,328 parcels in South Carolina currently with their dataset.

Count of Potentially Inundated Parcels					
Year	>6 inches	>1 foot	>2 feet	>3 feet	>6 feet
2022	305,332	234,729	154,867	108,401	43,129
2052	340,038	276,459	187,066	141,040	63,546

2022 VULNERABLE PARCELS

An estimated count of properties impacted by 1% annual chance flooding event by county are listed in Table 5.8.

Table 5.8

County Name	2022					
	Above 0 Inches	Above 6 Inches	Above 1 Foot	Above 2 Feet	Above 3 Feet	Above 6 Feet
Abbeville	756	741	655	450	325	114
Aiken	6,772	6,758	5,635	3,336	2,001	695
Allendale	924	923	677	201	75	12
Anderson	5,045	5,017	4,288	2,645	1,691	534
Bamberg	1,565	1,551	1,119	350	130	3
Barnwell	984	984	737	307	115	8
Beaufort	44,834	43,830	39,173	30,828	24,020	10,924
Berkeley	9,044	8,838	5,730	2,348	1,170	143
Calhoun	1,355	1,343	1,011	534	304	83
Charleston	59,054	57,361	49,124	35,713	26,986	10,427
Cherokee	1,289	1,288	1,153	825	584	221
Chester	1,107	1,101	938	619	415	172
Chesterfield	1,817	1,816	1,469	787	426	129
Clarendon	3,357	3,334	2,011	541	206	12
Colleton	6,088	5,977	5,011	3,960	2,548	1,134
Darlington	4,744	4,705	3,227	1,038	392	41
Dillon	1,650	1,642	1,024	287	87	7
Dorchester	5,513	5,440	3,559	1,530	759	42
Edgefield	1,168	1,166	984	615	382	112
Fairfield	1,690	1,653	1,498	1,159	871	396
Florence	6,824	6,758	3,960	1,016	431	53
Georgetown	14,838	14,536	12,563	9,832	8,345	5,329
Greenville	15,311	15,232	13,174	8,783	5,756	1,832
Greenwood	2,185	2,118	1,806	1,127	644	162
Hampton	1,463	1,454	966	274	97	5
Horry	36,922	35,020	24,648	14,823	10,737	4,106
Jasper	2,993	2,917	1,953	1,185	948	486
Kershaw	2,699	2,654	2,132	1,197	789	350
Lancaster	2,199	2,167	1,859	1,215	765	232
Laurens	2,350	2,264	1,977	1,386	934	284
Lee	1,428	1,412	950	296	126	8
Lexington	6,979	6,843	5,447	2,876	1,565	374

Marion	2,742	2,687	1,686	509	233	33
Marlboro	2,427	2,369	1,665	657	214	18
McCormick	497	490	407	234	131	34
Newberry	1,802	1,709	1,434	880	549	154
Oconee	3,494	3,440	3,117	2,366	1,740	727
Orangeburg	6,066	6,019	3,981	1,367	534	72
Pickens	3,830	3,816	3,445	2,535	1,798	769
Richland	10,329	10,296	8,150	3,813	1,895	456
Saluda	1,264	1,206	983	551	303	53
Spartanburg	7,964	7,876	6,634	4,234	2,672	802
Sumter	6,105	6,062	3,849	1,142	538	67
Union	848	845	767	589	441	155
Williamsburg	4,931	4,809	2,853	820	421	57
York	5,727	5,651	5,002	3,646	2,711	1,419
Total	**312,973**	**306,118**	**244,431**	**155,426**	**108,804**	**43,246**

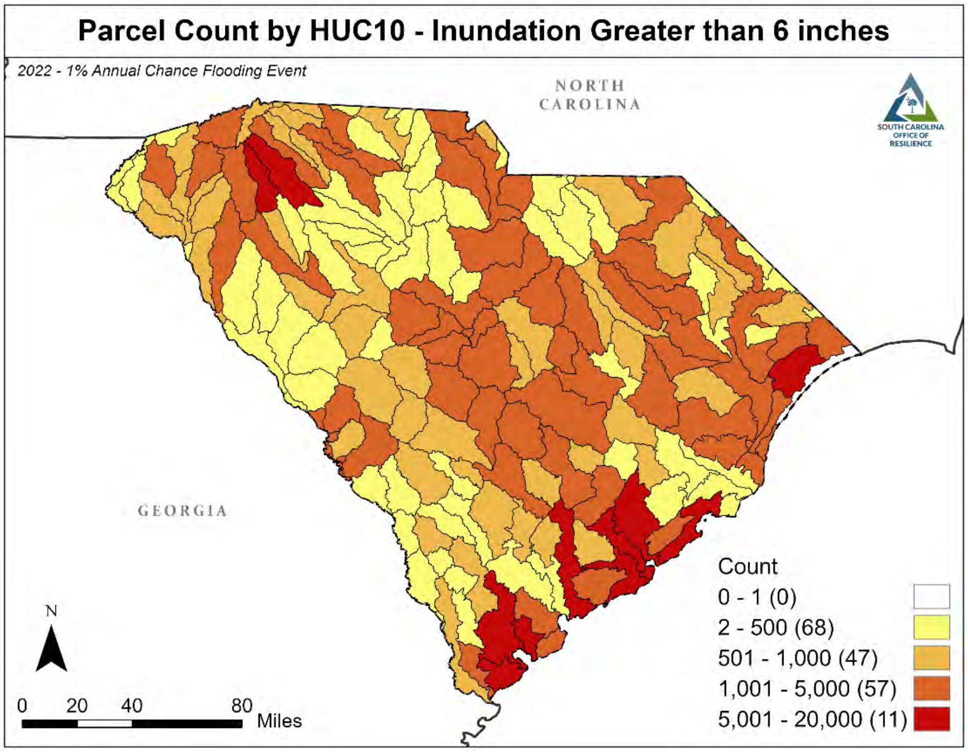

Figure 5.20: Count of parcels by HUC10 estimated to be inundated greater than 6 inches in the 2022 1% annual chance flooding event. Flood risk data provided by the First Street Foundation Flood Risk Statistics, V2.0.

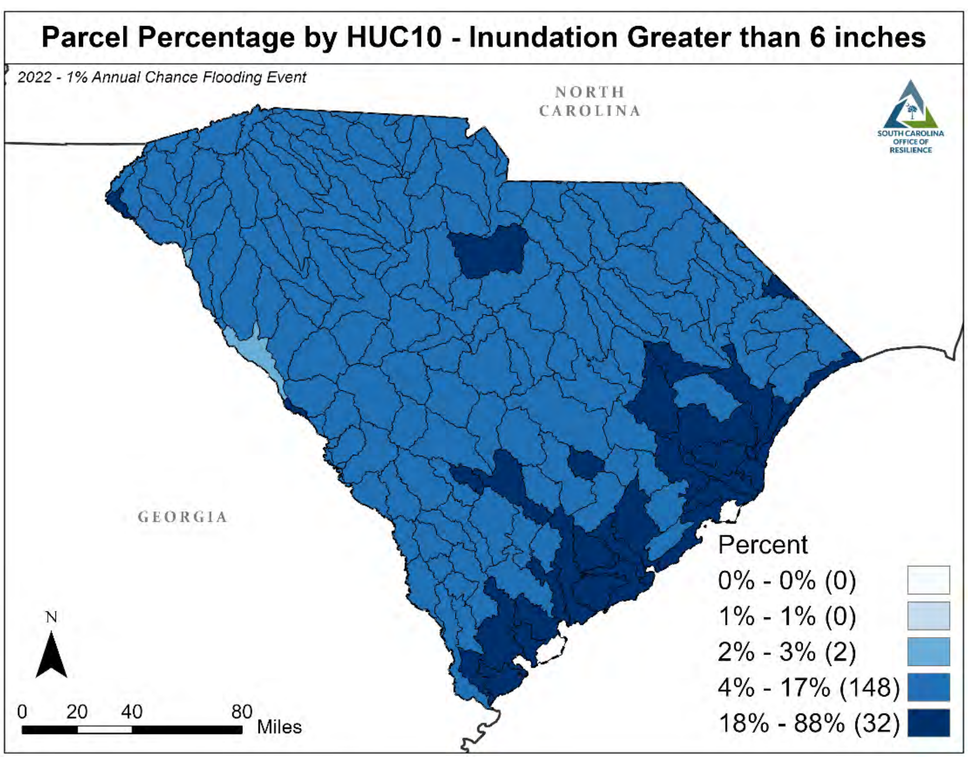

Figure 5.21: Percentage of parcels by HUC10 estimated to be inundated greater than 6 inches in the 2022 1% annual chance flooding event. Flood risk data provided by the First Street Foundation Flood Risk Statistics, V2.0.

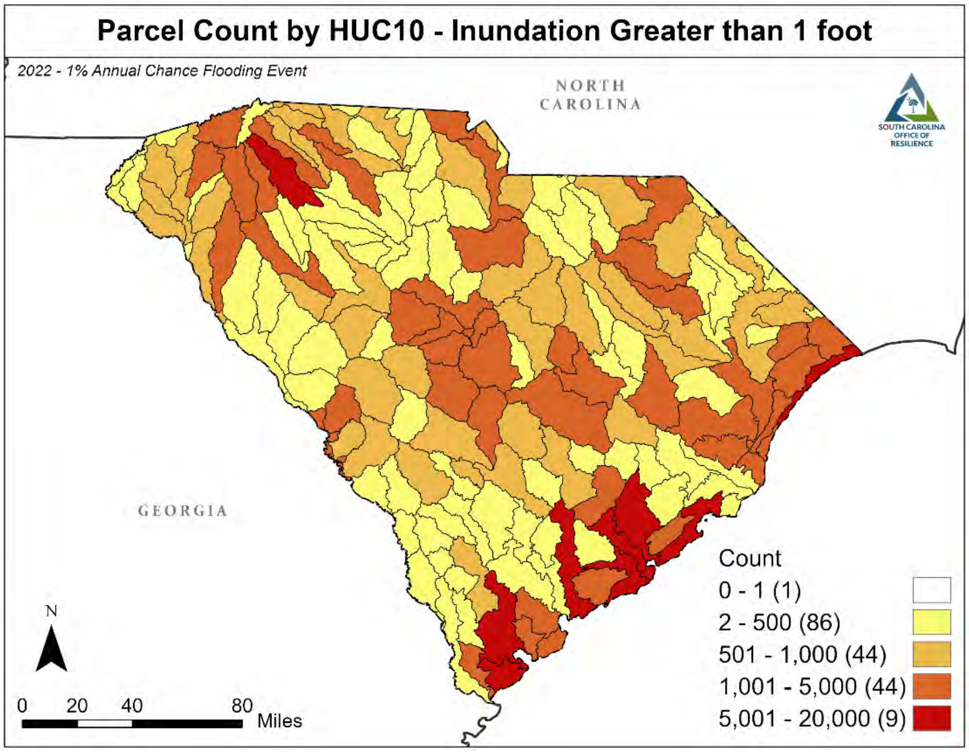

Figure 5.22: Count of parcels by HUC10 estimated to be inundated greater than 1 foot in the 2022 1% annual chance flooding event. Flood risk data provided by the First Street Foundation Flood Risk Statistics, V2.0.

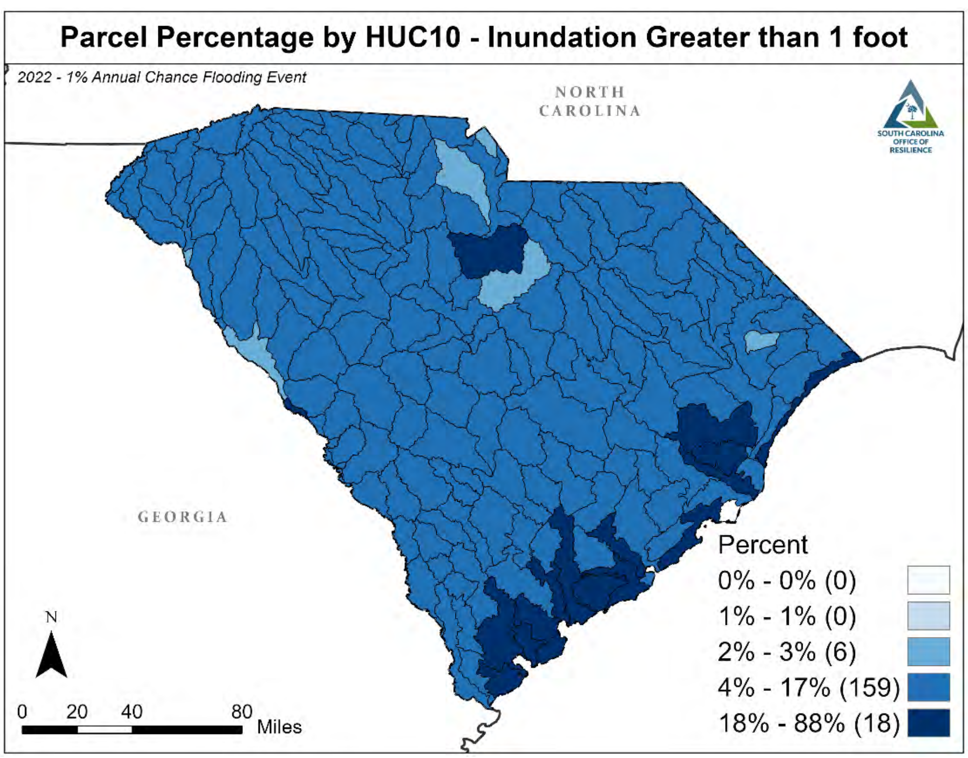

Figure 5.23: Percent of parcels by HUC10 estimated to be inundated greater than 1 foot in the 2022 1% annual chance flooding event. Flood risk data provided by the First Street Foundation Flood Risk Statistics, V2.0.

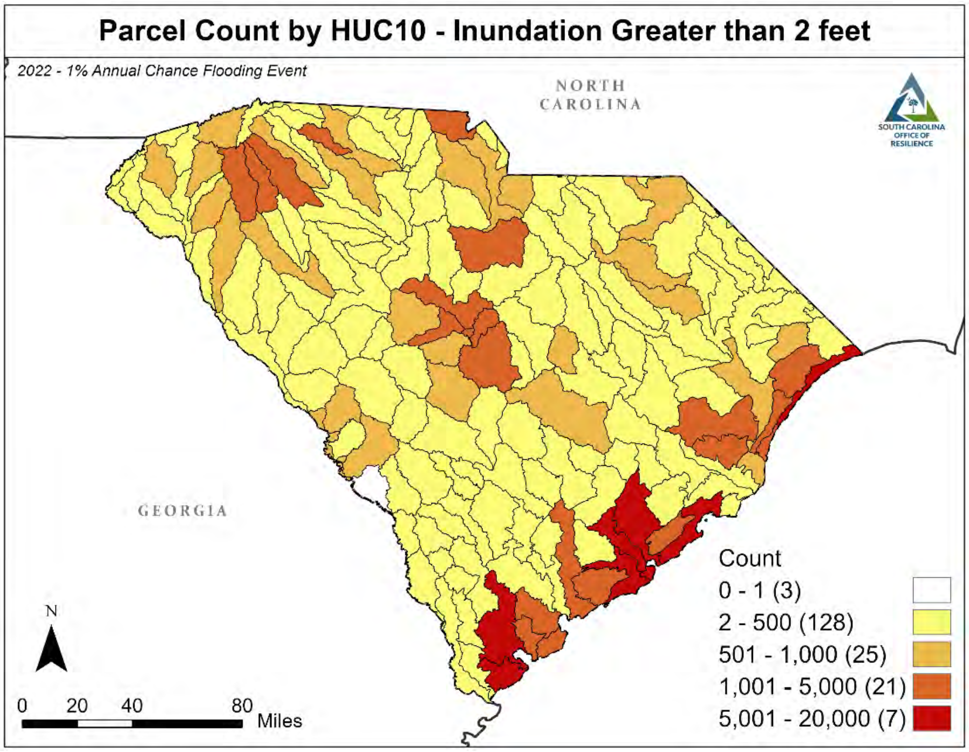

Figure 5.24: Count of parcels by HUC10 estimated to be inundated greater than 2 feet in the 2022 1% annual chance flooding event. Flood risk data provided by the First Street Foundation Flood Risk Statistics, V2.0.

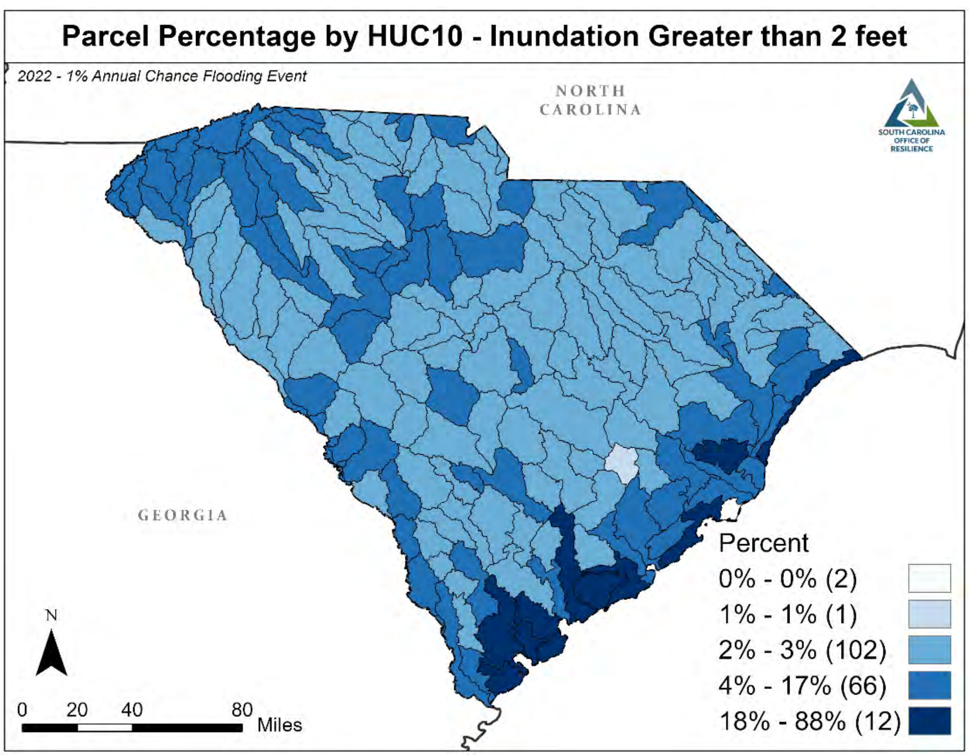

Figure 5.25: Percent of parcels by HUC10 estimated to be inundated greater than 2 feet in the 2022 1% annual chance flooding event. Flood risk data provided by the First Street Foundation Flood Risk Statistics, V2.0.

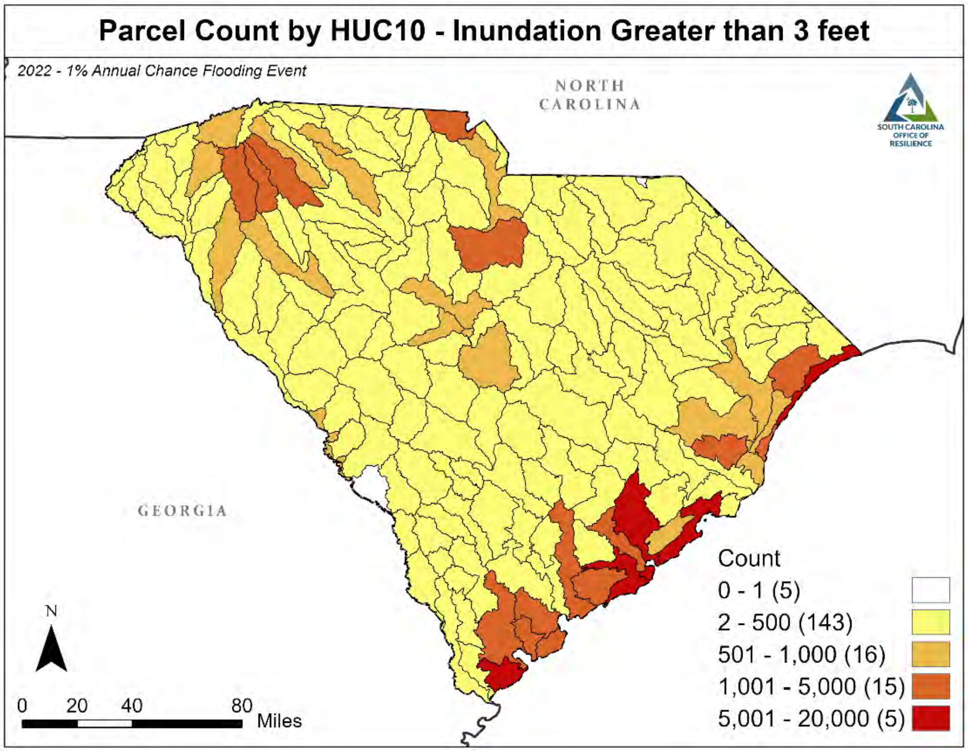

Figure 5.26: Count of parcels by HUC10 estimated to be inundated greater than 3 feet in the 2022 1% annual chance flooding event. Flood risk data provided by the First Street Foundation Flood Risk Statistics, V2.0.

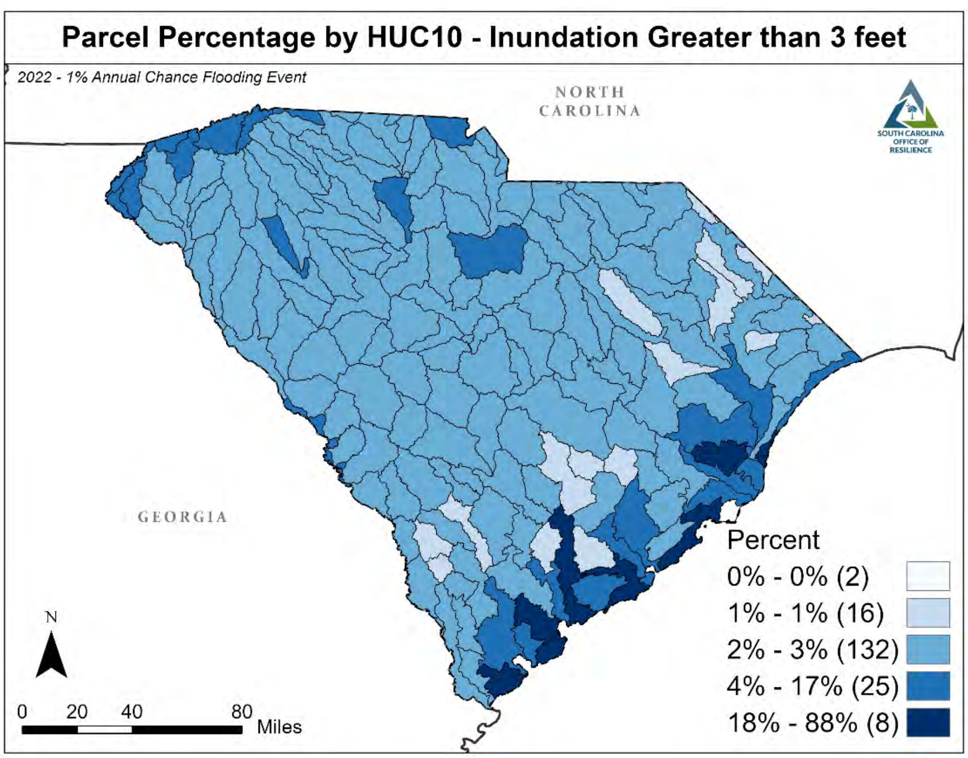

Figure 5.27: Percent of parcels by HUC10 estimated to be inundated greater than 3 feet in the 2022 1% annual chance flooding event. Flood risk data provided by the First Street Foundation Flood Risk Statistics, V2.0.

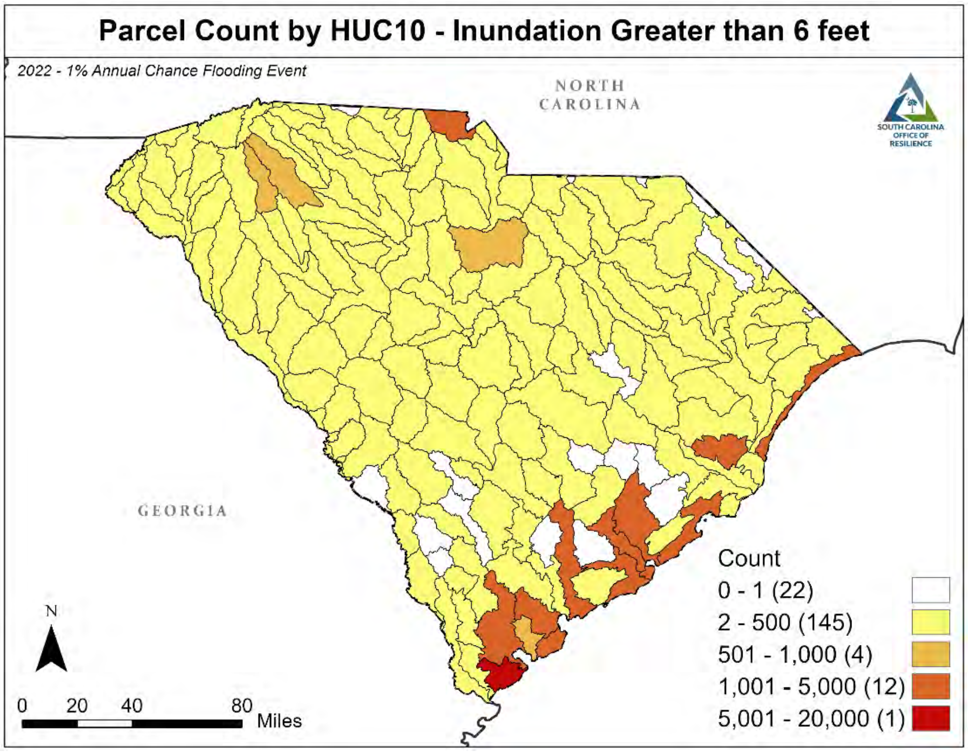

Figure 5.28: Count of parcels by HUC10 estimated to be inundated greater than 6 feet in the 2022 1% annual chance flooding event. Flood risk data provided by the First Street Foundation Flood Risk Statistics, V2.0.

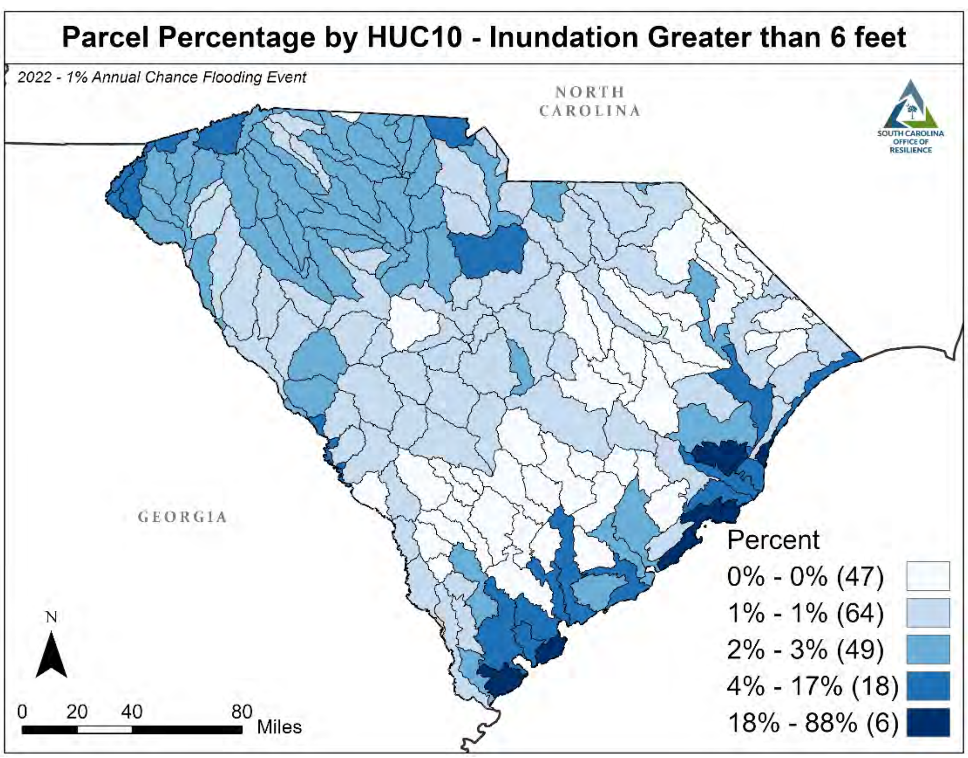

Figure 5.29: Percent of parcels by HUC10 estimated to be inundated greater than 6 feet in the 2022 1% annual chance flooding event. Flood risk data provided by the First Street Foundation Flood Risk Statistics, V2.0.

2052 VULNERABLE PARCELS

An estimated count of properties impacted by 1% annual chance flooding event by county are listed in Table 5.9.

Table 5.9

County Name	2052					
	Above 0 Inches	Above 6 Inches	Above 1 Foot	Above 2 Feet	Above 3 Feet	Above 6 Feet
Abbeville	788	776	679	472	336	121
Aiken	7,137	7,132	5,962	3,532	2,148	776
Allendale	998	998	755	238	93	15
Anderson	5,289	5,261	4,492	2,788	1,783	568
Bamberg	1,678	1,663	1,245	406	149	4
Barnwell	1,049	1,049	796	354	131	10
Beaufort	49,968	49,201	45,195	38,051	33,163	16,956
Berkeley	10,903	10,665	7,247	3,544	2,085	417
Calhoun	1,403	1,389	1,054	565	325	94
Charleston	71,545	69,446	61,646	50,201	41,716	19,840
Cherokee	1,346	1,346	1,213	865	617	234
Chester	1,149	1,145	973	637	433	180
Chesterfield	1,894	1,890	1,525	824	463	142
Clarendon	3,635	3,615	2,215	599	236	14
Colleton	6,349	6,281	5,220	4,251	3,708	1,422
Darlington	5,111	5,076	3,530	1,154	452	46
Dillon	1,774	1,762	1,116	315	100	8
Dorchester	6,098	6,039	3,990	1,803	923	70
Edgefield	1,218	1,217	1,039	648	403	126
Fairfield	1,769	1,728	1,588	1,276	965	502
Florence	7,474	7,402	4,369	1,119	480	58
Georgetown	16,177	15,835	13,782	10,969	9,378	6,190
Greenville	16,242	16,156	13,981	9,324	6,138	1,965
Greenwood	2,338	2,260	1,951	1,217	701	183
Hampton	1,594	1,590	1,056	319	126	8
Horry	41,283	39,395	28,197	18,209	13,650	6,479
Jasper	3,491	3,432	2,356	1,539	1,188	717
Kershaw	2,894	2,854	2,285	1,275	860	374
Lancaster	2,283	2,258	1,942	1,284	794	251
Laurens	2,426	2,343	2,066	1,441	981	306
Lee	1,505	1,486	1,029	318	137	10
Lexington	7,555	7,397	5,872	3,123	1,696	423
Marion	2,941	2,887	1,846	577	269	43

Marlboro	2,530	2,472	1,752	707	242	23
McCormick	535	525	435	259	144	38
Newberry	1,963	1,855	1,553	956	585	159
Oconee	3,626	3,576	3,247	2,468	1,813	757
Orangeburg	6,471	6,427	4,306	1,491	632	86
Pickens	4,022	4,007	3,607	2,679	1,868	800
Richland	11,149	11,097	8,776	4,180	2,086	506
Saluda	1,323	1,260	1,032	614	333	56
Spartanburg	8,350	8,263	6,955	4,445	2,800	856
Sumter	6,526	6,476	4,167	1,244	591	71
Union	876	874	797	607	458	171
Williamsburg	5,227	5,117	3,093	896	458	69
York	6,059	5,978	5,292	3,899	2,948	1,618
Total	**347,961**	**340,901**	**277,224**	**187,682**	**141,585**	**63,762**

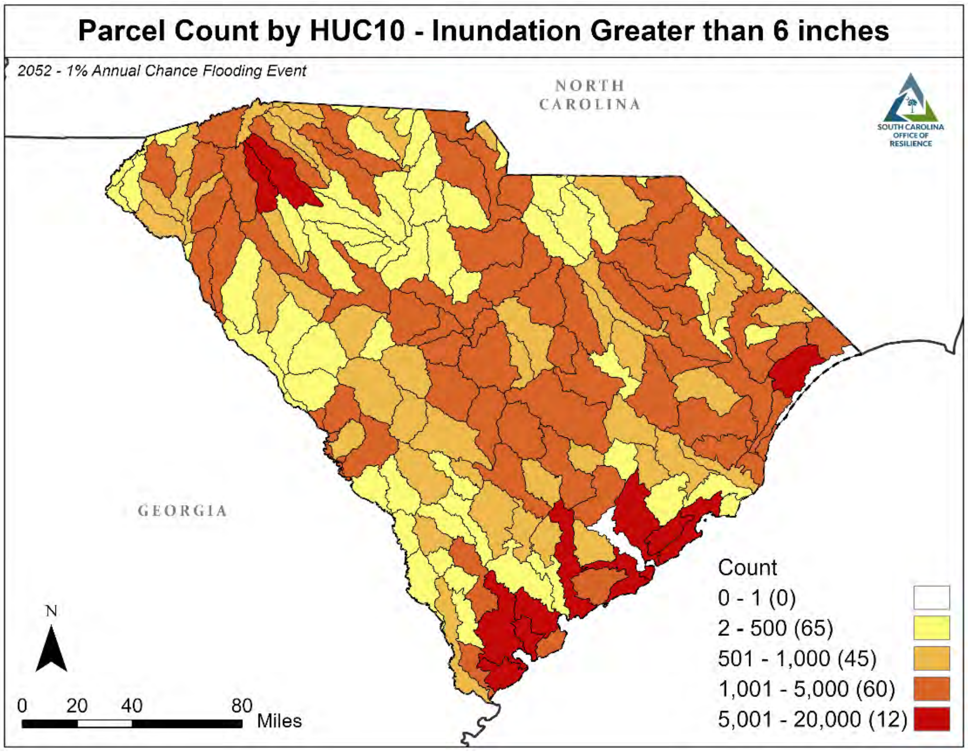

Figure 5.30: Count of parcels by HUC10 estimated to be inundated greater than 6 inches in the 2052 1% annual chance flooding event. Flood risk data provided by the First Street Foundation Flood Risk Statistics, V2.0.

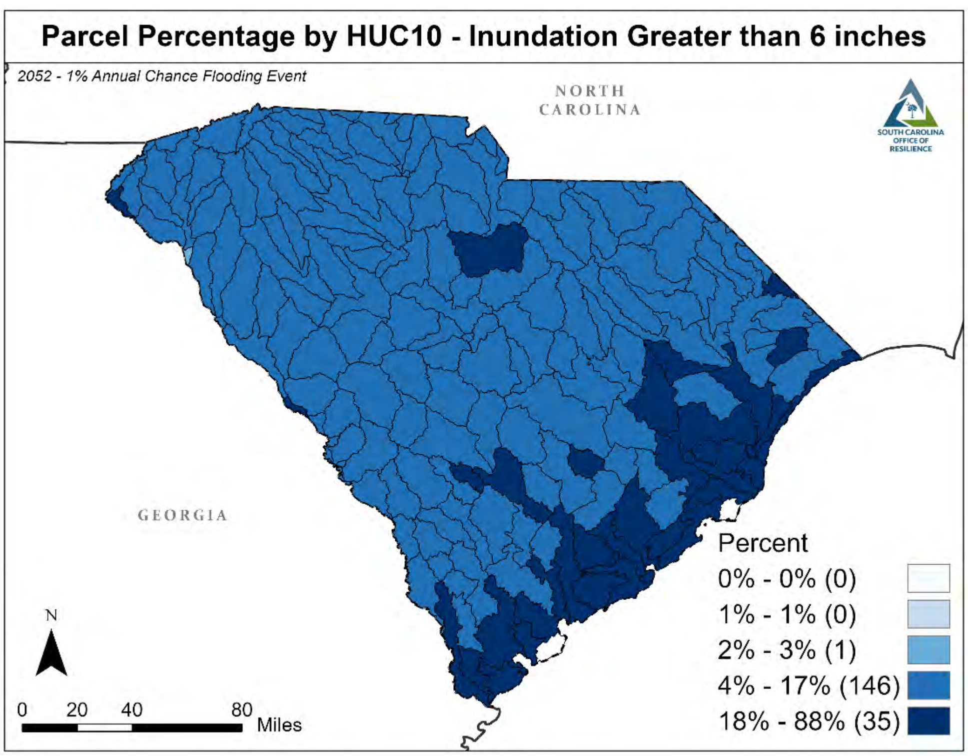

Figure 5.31: Percent of parcels by HUC10 estimated to be inundated greater than 6 inches in the 2052 1% annual chance flooding event. Flood risk data provided by the First Street Foundation Flood Risk Statistics, V2.0.

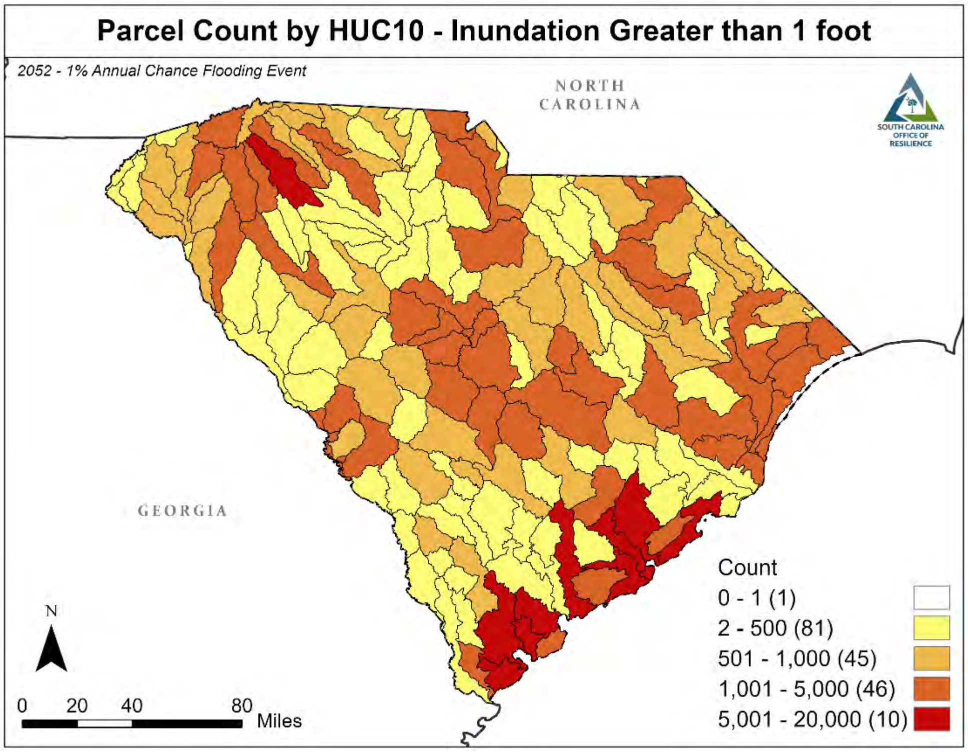

Figure 5.32: Count of parcels by HUC10 estimated to be inundated greater than 1 foot in the 2052 1% annual chance flooding event. Flood risk data provided by the First Street Foundation Flood Risk Statistics, V2.0.

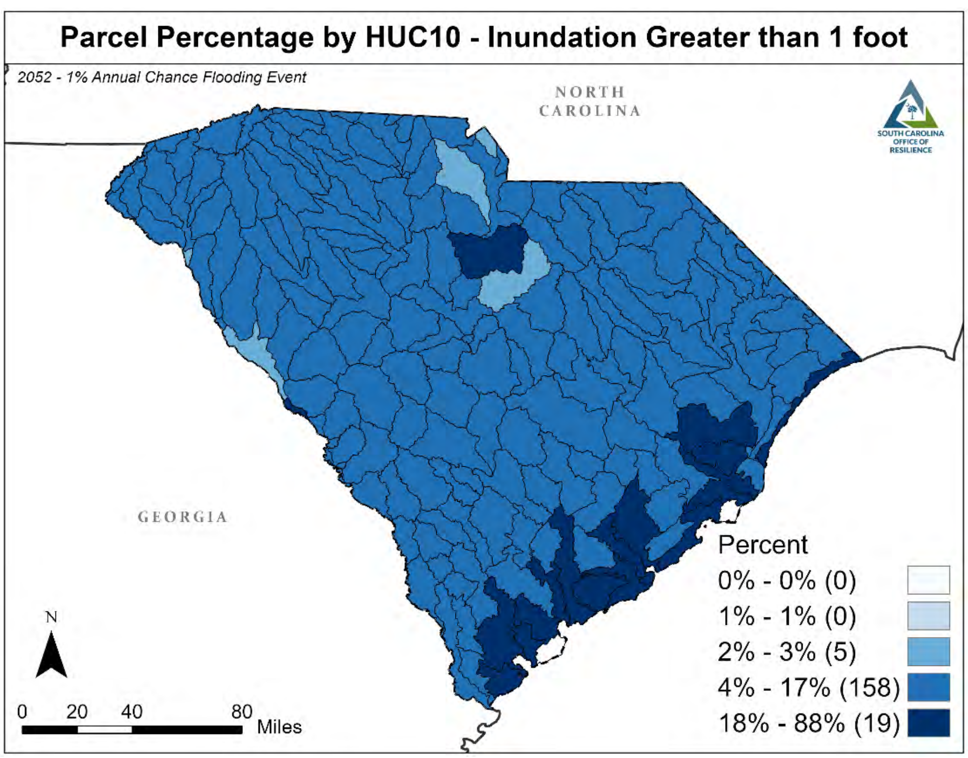

Figure 5.33: Percent of parcels by HUC10 estimated to be inundated greater than 1 foot in the 2052 1% annual chance flooding event. Flood risk data provided by the First Street Foundation Flood Risk Statistics, V2.0.

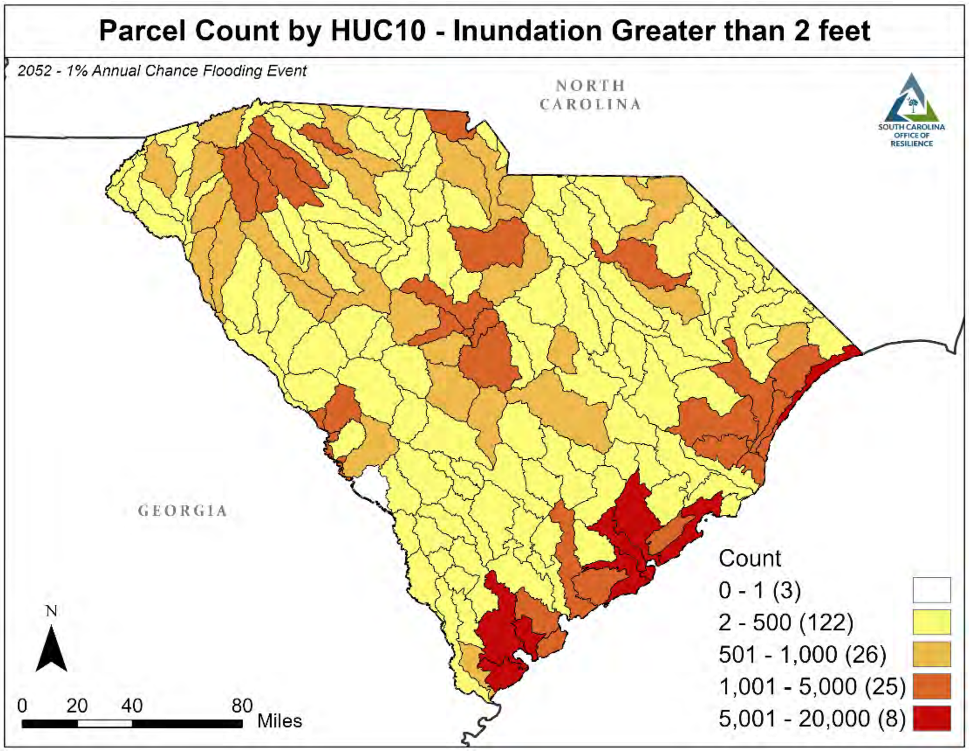

Figure 5.34: Count of parcels by HUC10 estimated to be inundated greater than 2 feet in the 2052 1% annual chance flooding event. Flood risk data provided by the First Street Foundation Flood Risk Statistics, V2.0.

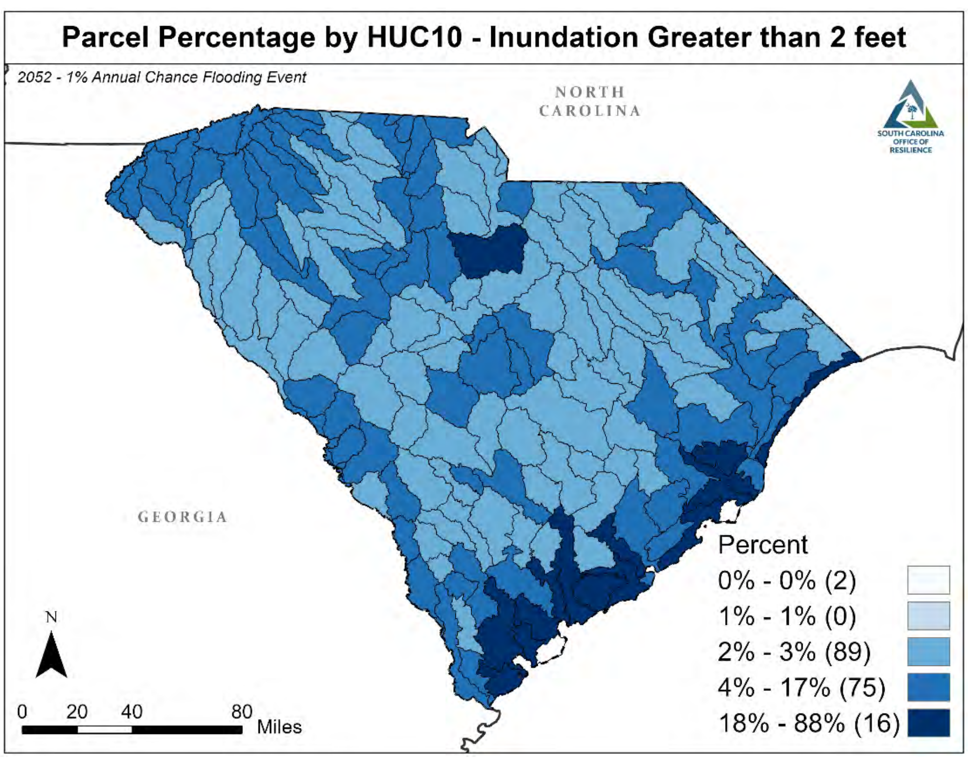

Figure 5.35: Percent of parcels by HUC10 estimated to be inundated greater than 2 feet in the 2052 1% annual chance flooding event. Flood risk data provided by the First Street Foundation Flood Risk Statistics, V2.0.

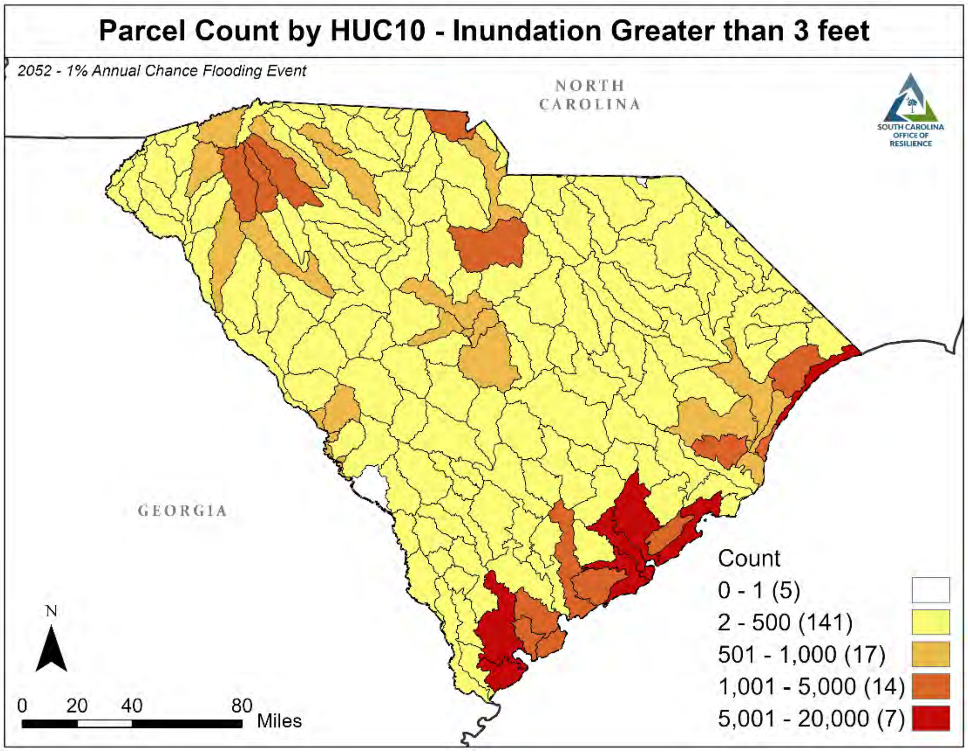

Figure 5.36: Count of parcels by HUC10 estimated to be inundated greater than 3 feet in the 2052 1% annual chance flooding event. Flood risk data provided by the First Street Foundation Flood Risk Statistics, V2.0.

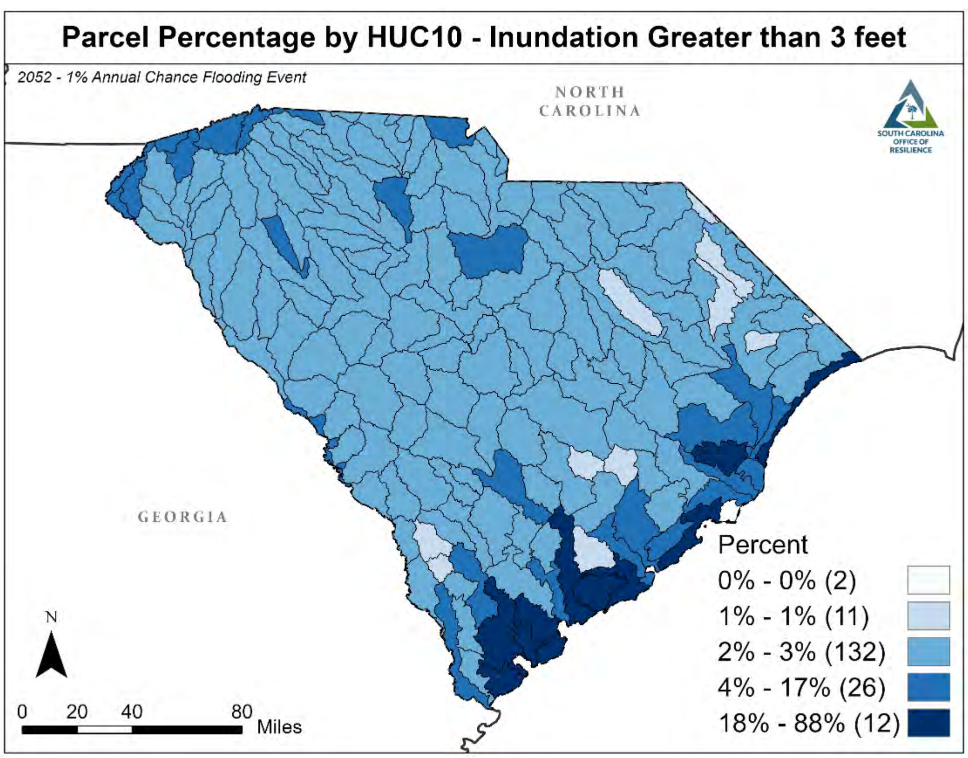

Figure 5.37: Percent of parcels by HUC10 estimated to be inundated greater than 3 feet in the 2052 1% annual chance flooding event. Flood risk data provided by the First Street Foundation Flood Risk Statistics, V2.0.

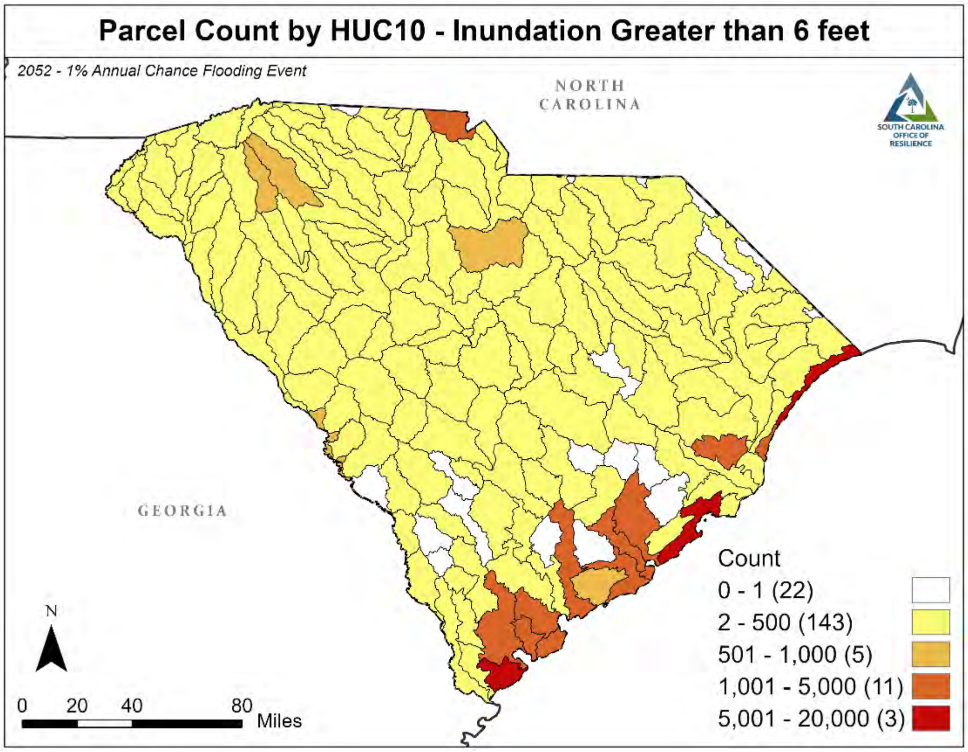

Figure 5.38: Count of parcels by HUC10 estimated to be inundated greater than 6 feet in the 2052 1% annual chance flooding event. Flood risk data provided by the First Street Foundation Flood Risk Statistics, V2.0.

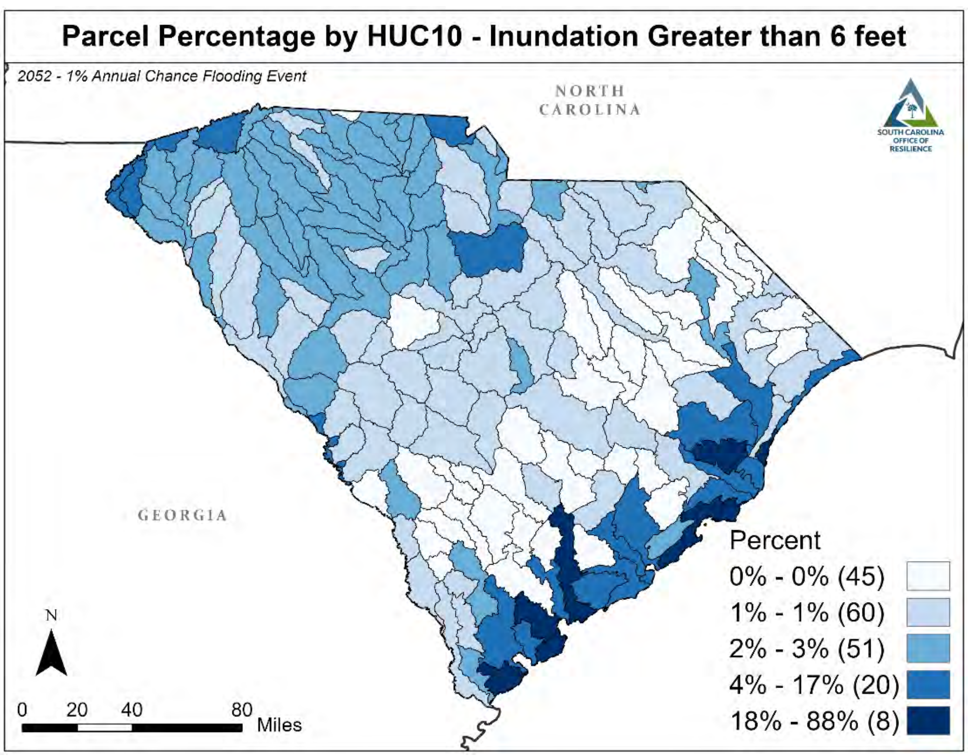

Figure 5.39: Percent of parcels by HUC10 estimated to be inundated greater than 6 feet in the 2052 1% annual chance flooding event. Flood risk data provided by the First Street Foundation Flood Risk Statistics, V2.0.

BUILDING CODES

To better understand the vulnerability of the buildings on these properties, the strength of South Carolina's building codes and enforcement was investigated. FEMA Region 4's 2021 Building Code Adoption Tracking Fact Sheet gives South Carolina a grade of 91.5% but states that the State is "not fully resistant because some jurisdictions with high flood risk do not participate in the NFIP" (Federal Emergency Management Agency, 2021).

The Building Code Effectiveness Grading Schedule is designed to assess building codes and their enforcement, with an emphasis on requirements designed to mitigate natural hazard losses. This grading scale can be used to lower insurance costs, which produces an incentive to rigorously enforce codes. With a raw score up to 100, and a possible rating class between 1 (exemplary commitment of building code enforcement) and 10, South Carolina has an average score of 4 for both the residential and commercial code (Figure 5.40). The residential classification addresses building code adoption and enforcement for 1- and 2-family dwellings. The commercial classification is for all other buildings. Community officials can get their local scores by emailing BCEGS_info@verisk.com (Insurance Services Office).

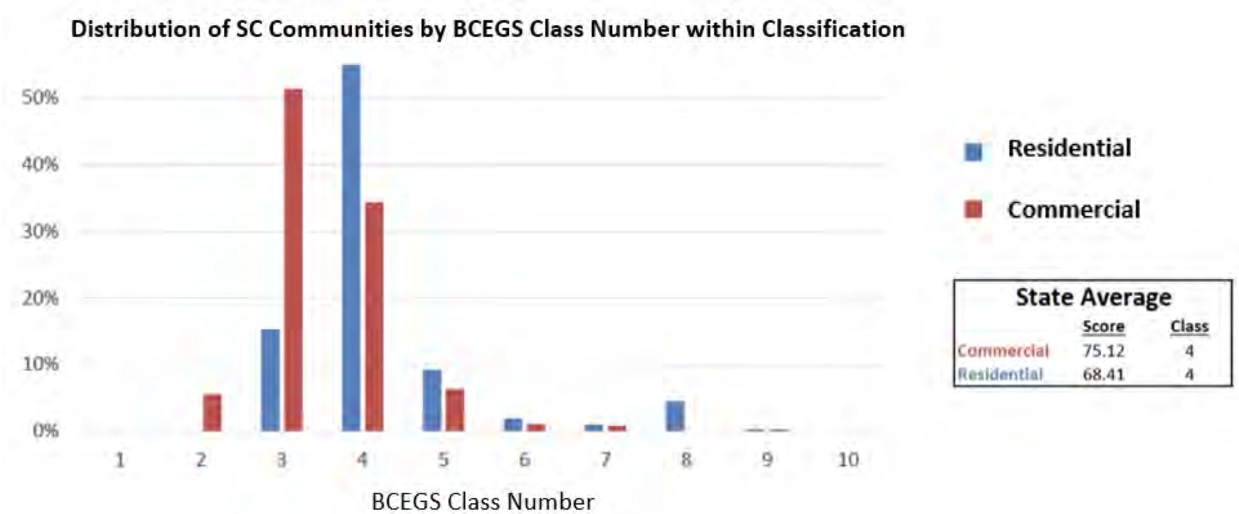

Figure 5.40: Average BCEGS Score for South Carolina (Insurance Services Office)

MOBILE HOMES

Mobile homes are considered one of the most vulnerable residential building types. The mobile or manufactured homes built today must meet the same general requirements as stick built or conventional housing. The vulnerability of these homes can depend on their age and anchoring. These homes can be used with or without a permanent foundation but should be elevated and anchored to a permanent foundation to resist flooding, collapse, or lateral movement (Federal Emergency Management Agency, 2020).

The vulnerability of mobile homes, and the recovery of those who live there, is complicated by arrangements where many residents own their individual homes but rent the land underneath (Rumbach, Sullivan, & Makarewicz, 2020). This often occurs in mobile home parks. While there is no statewide database of mobile homes, the Department of Homeland Security (DHS) maintains a database of mobile home parks, which represent communities where these homes are concentrated. The figures below quantify the number of mobile home parks impacted by the 2022 (Figure 5.41) and 2052 (Figure 5.42) 1% annual chance flood events.

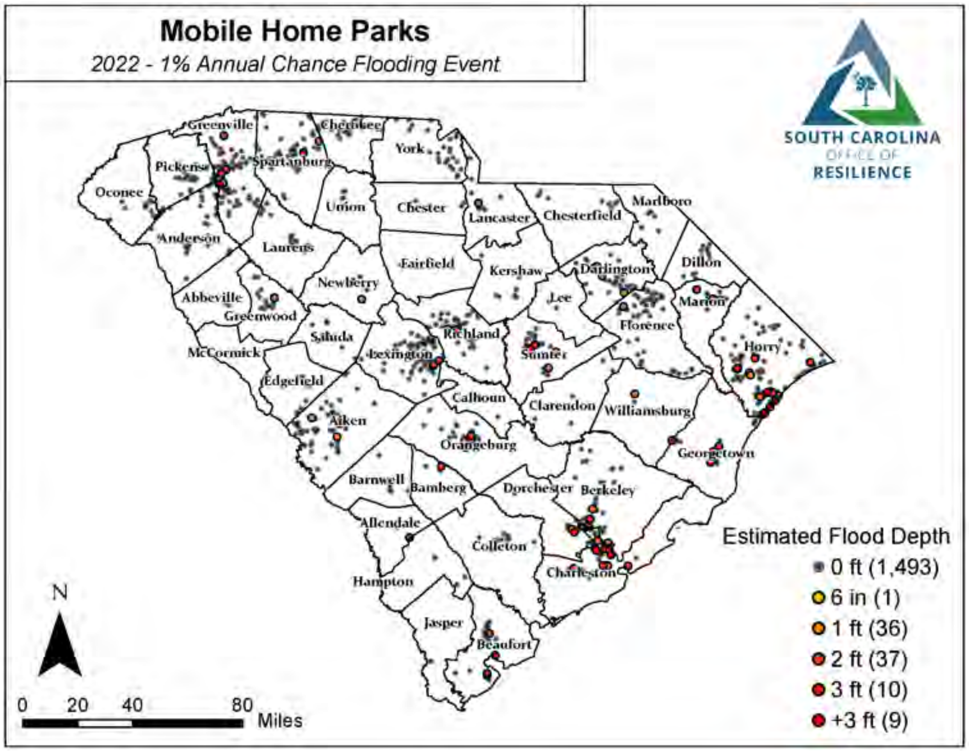

Figure 5.41: Estimated flooding of mobile home parks in the 2022 1% annual chance flooding event (Department of Homeland Security). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

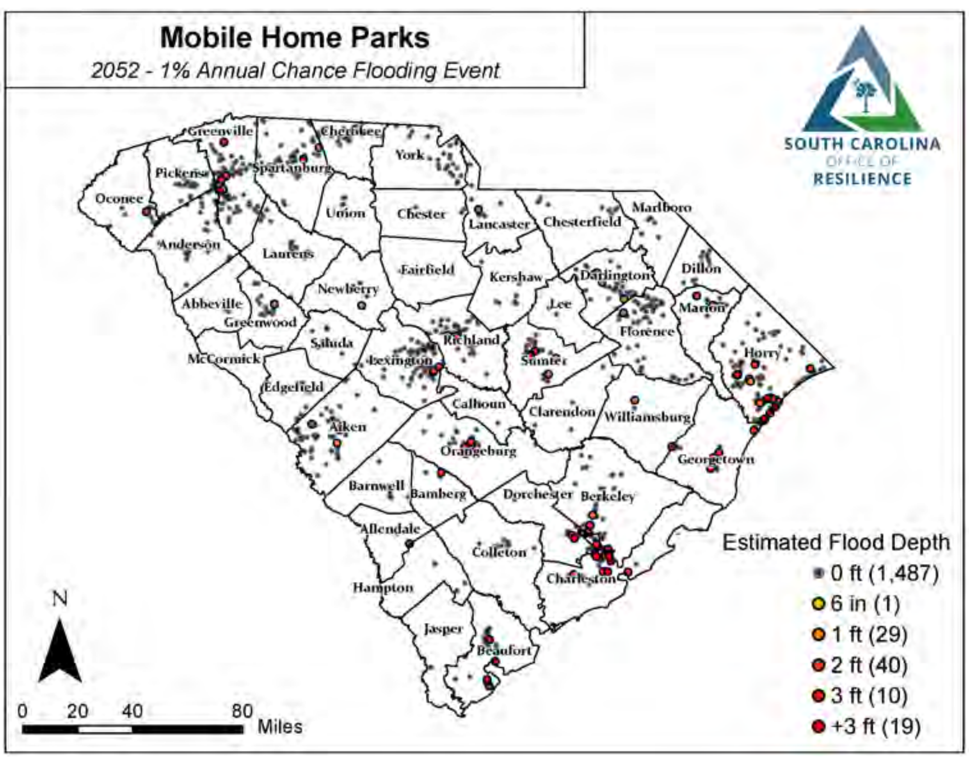

Figure 5.42: Estimated flooding of mobile home parks in the 2052 1% annual chance flooding event (Department of Homeland Security). Flood data provided by the First Street Foundation Hazard Layers, V2.0

COMMERCIAL LOSSES

First Street Foundation applies their flood model to business locations and estimates the average time in days loss of productivity and the loss in dollars (First Street Foundation, 2021). Estimated loss in time and dollars are closely linked to the type of business and the size and characteristics of the building being used. This data is provided by a third party, Lightbox (First Street Foundation, 2021). Once the building characteristics and commercial type of the business is determined, estimated cost for building restoration, time loss, and revenue loss is calculated based on reported estimates to the Bureau of Economic Analysis in 2020 and then adjusted for region and time (First Street Foundation, 2021).

Table 5.10 summarizes the commercial loss by inundation level for a 1% annual chance flood event in 2022 and 2052 including the count of inundated commercial properties and loss in days and financial loss.

Table 5.10: Statewide summary of commercial loss by inundation level for a 1% annual chance flood event in 2022 & 2052

Count of Potentially Inundated Commercial Parcels						
	2022			2052		
	Count	Total Loss ($)	Avg Days Loss	Count	Total Loss ($)	Avg Days Loss
>6 inches	8,838	1,869,247,287	68	10,707	2,342,389,629	75
>1 foot	6,801	1,725,887,130	78	8,536	2,195,073,643	85
>2 feet	4,304	1,355,536,642	99	6,089	1,869,013,394	102
>3 feet	2,884	1,069,844,028	113	4,448	1,583,387,349	113
>6 feet	1,312	540,956,282	142	2,012	852,832,771	140

2022 COMMERCIAL AVERAGE ANNUAL LOSS

Table 5.11 summarizes the commercial loss by inundation level for a 1% annual chance flood event in 2021. Charleston County has the highest estimated impact with a potential of 4,000 commercial properties being impacted, with an approximate $660 million being lost from a 1% annual chance of flooding. Coastal counties, Beaufort, Charleston, Georgetown, and Horry are modeled to be the most impacted. Other counties with a high estimation of impact include Aiken, Dorchester, Florence, Greenville, Richland, and Spartanburg each having over 200 commercial properties with estimated flooding impact in a 1% annual chance event. All counties in South Carolina can be impacted by 1% annual chance of flood event, with a statewide average of 87 days of commercial downtime due to flooding and recovery and an estimated impact of $4,500,000,000 and an average economic loss of $393,021 per facility

Table 5.11: County summary for commercial parcels potentially inundated by a 1% flood event 2022.

County	Count	Count Any Inundation	Percent	Total Loss ($)	Average Downtime (Days)
Abbeville	1	-	0%	-	-
Aiken	5,961	365	6%	48,382,254	74
Allendale	206	10	5%	344,864	49
Anderson	4,188	157	4%	31,274,623	82
Bamberg	361	53	15%	1,673,037	47
Barnwell	451	24	5%	1,033,208	49
Beaufort	2,097	893	43%	360,815,317	97
Berkeley	1,735	146	8%	82,807,791	56
Charleston	11,186	4,010	36%	660,047,306	89
Cherokee	964	26	3%	2,139,694	118
Chester	608	22	4%	1,238,213	77
Chesterfield	1,043	27	3%	1,126,099	51
Clarendon	318	36	11%	15,561,262	44
Colleton	748	71	9%	14,251,803	104
Darlington	1,398	164	12%	16,387,504	50
Dillon	682	46	7%	1,548,884	45
Dorchester	3,890	377	10%	73,232,108	50
Fairfield	419	11	3%	630,314	92
Florence	3,007	229	8%	33,102,586	47
Georgetown	1,733	909	52%	232,631,159	195
Greenville	8,096	544	7%	50,515,530	98
Greenwood	1,857	53	3%	18,924,072	81
Hampton	432	18	4%	526,246	40
Horry	5,903	930	16%	265,051,199	55
Jasper	608	62	10%	2,004,537	67
Kershaw	867	44	5%	12,863,064	61
Lancaster	1,401	53	4%	26,247,813	75
Laurens	1,301	66	5%	4,345,907	108
Lee	1	1	100%	837,716	100
Lexington	4,332	189	4%	10,280,593	69
Marion	815	65	8%	2,070,790	50
Newberry	765	28	4%	5,202,465	70
Oconee	1,202	39	3%	2,608,103	111
Orangeburg	2,629	295	11%	45,517,805	51
Pickens	1,990	138	7%	65,598,562	107
Richland	6,755	478	7%	407,301,810	70
Spartanburg	5,472	270	5%	211,740,209	74

Sumter	2,653	284	11%	16,911,760	47
Union	695	21	3%	1,244,227	122
Williamsburg	827	150	18%	1,648,110,665	52
York	3,384	86	3%	100,971,614	62
Total	92,981	11,390	12%	4,477,102,712	87

Figure 5.43 shows the commercial properties estimated to be impacted by the 2022 1% annual flood event. Figure 5.44 shows the estimated count of commercial facilities inundated by 1% annual chance flood event in First Street Foundation Flood Model Scenario mid-2021 in each HUC10 in South Carolina. Figure 5.45 then shows the estimated total dollars loss, by HUC10, of commercial facilities inundated by 1% annual chance flood event in First Street Foundation Flood Model Scenario mid-2022.

According to the First Street Foundation, there are 92,988 commercial parcels in South Carolina and of those, 11,395 are modeled to be impacted. Charleston County has the highest estimated impact with a potential of 3,600 commercial properties being impacted, with over $1 billion being lost from a 1% annual chance of flooding. Coastal counties, Beaufort, Charleston, Georgetown, and Horry are modeled to be the most impacted. Other counties with a high estimation of impact include Aiken, Dorchester, Florence, Greenville, Richland, and Spartanburg each having over 200 commercial properties with estimated flooding impact in a 1% annual chance event. All counties in South Carolina can be impacted by 1% annual chance of flood event, with a statewide average loss of 67 days to the impacted parcels and an estimated average economic loss of $393,021 per impacted commercial parcel.

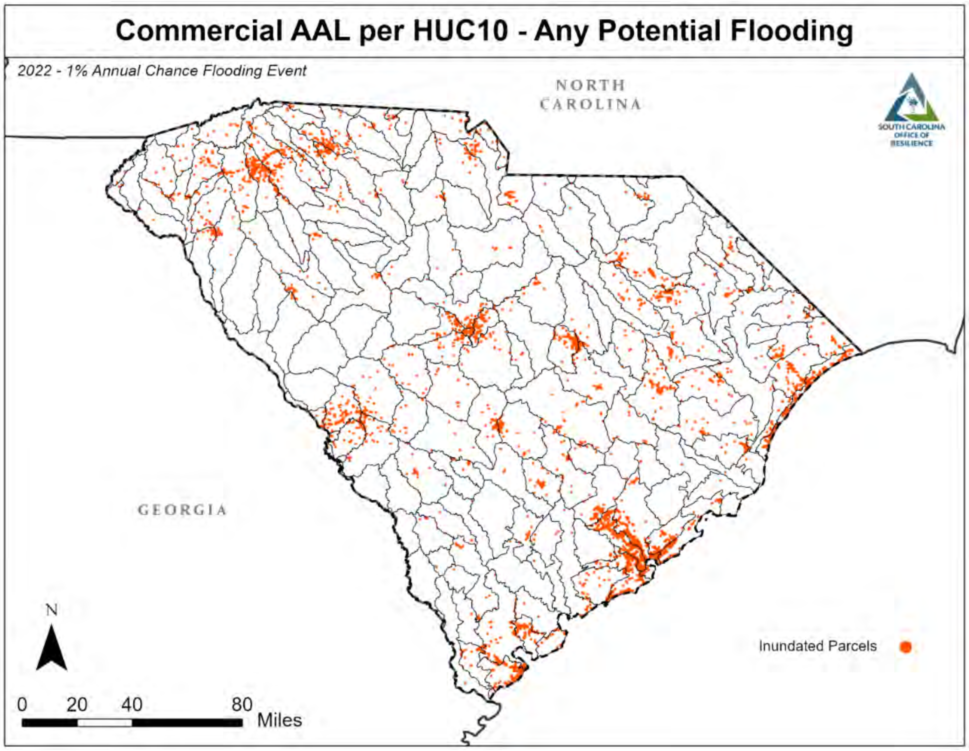

Figure 5.43: Estimated commercial properties with inundation by the 2022 1% annual chance flood event. Flood data provided by the First Street Foundation Flood Risk Statistics, V2.0.

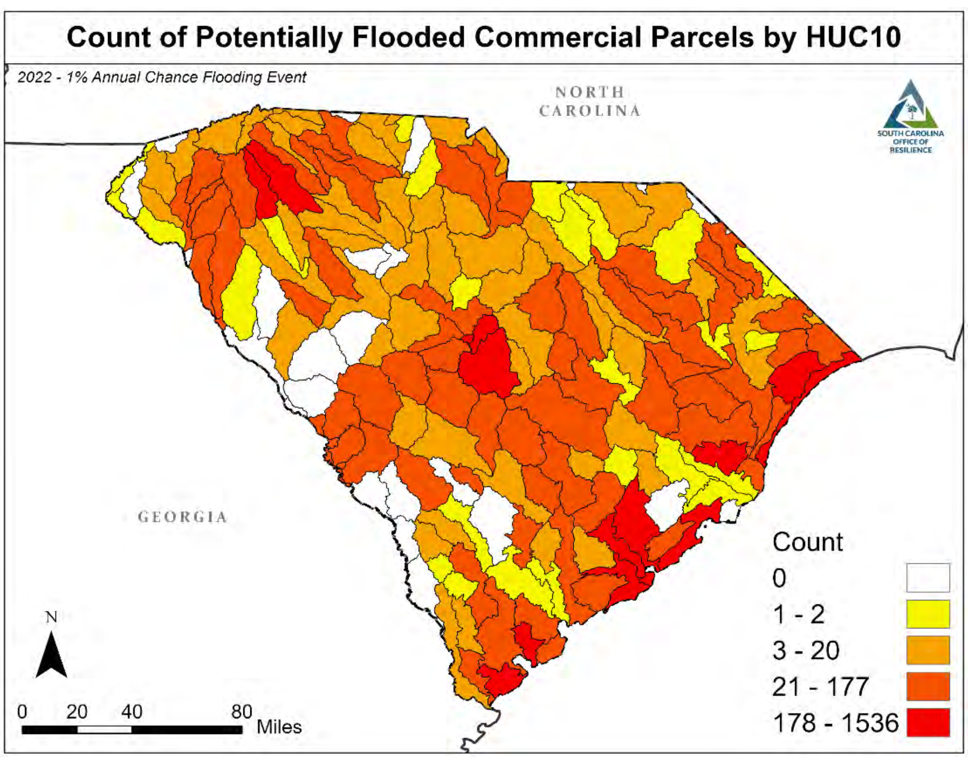

Figure 5.44: Estimated count of commercial facilities inundated by 1% annual chance flood event in First Street Foundation Flood Model Scenario mid-2022 in each HUC10 in South Carolina. Flood data provided by the First Street Foundation Flood Risk Statistics, V2.0.

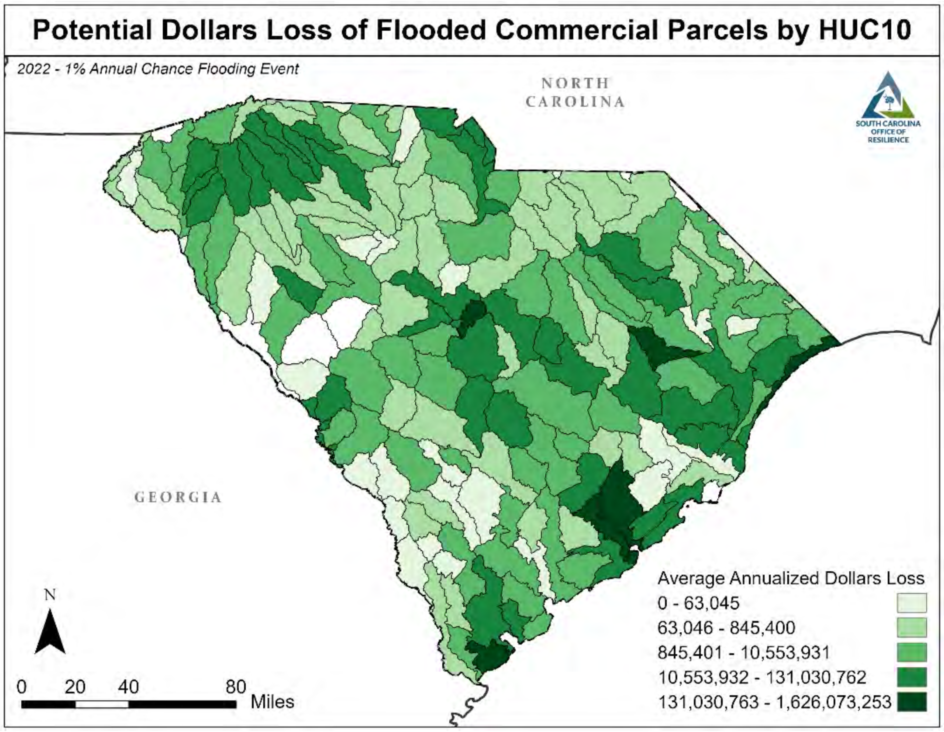

Figure 5.45: Estimated total dollar loss, by HUC10, of commercial facilities inundated by 1% annual chance flood event in First Street Foundation Flood Model Scenario mid-2022. Flood data provided by the First Street Foundation Flood Risk Statistics, V2.0.

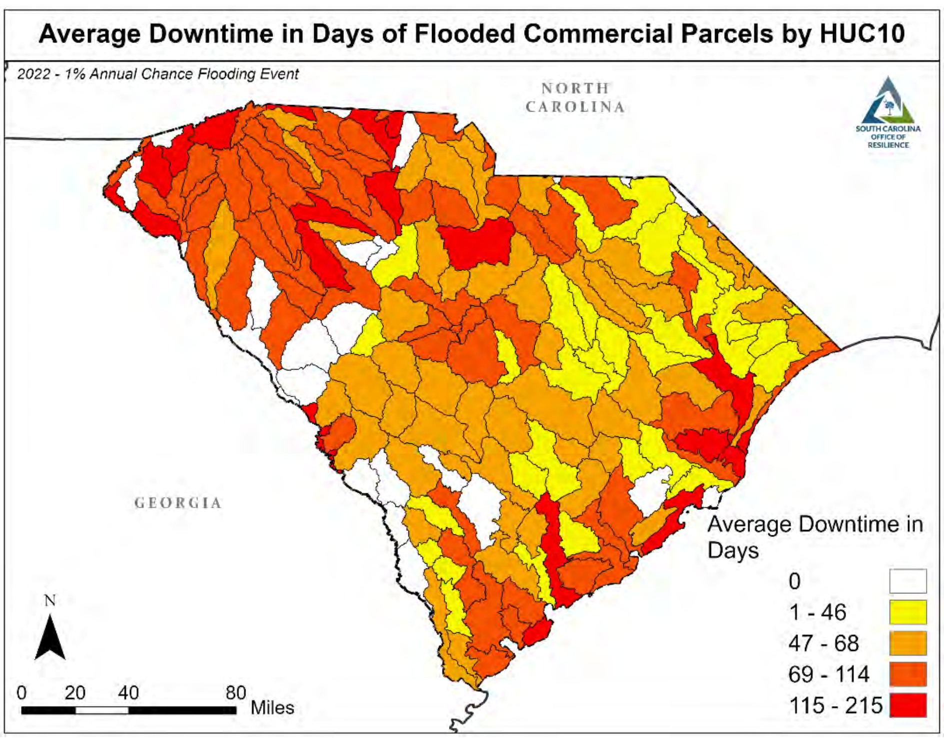

Figure 5.46: Estimated average days loss to flooding and reconstruction, by HUC10, of commercial facilities inundated by 1% annual chance flood event in First Street Foundation Flood Model Scenario mid-2022. Flood data provided by the First Street Foundation Flood Risk Statistics, V2.0.

2052 COMMERCIAL AVERAGE ANNUAL LOSS

Table 5.12 summarizes the commercial loss by inundation level for a 1% annual chance flood event in 2052.

Table 5.12: County summary for commercial parcels potentially inundated by a 1% flood event 2052.

County	Count	Count Any Inundation	Percent	Total Loss ($)	Average Downtime (Days)
Abbeville	1	-	0%	-	-
Aiken	5,961	384	6%	50,842,855	75
Allendale	206	10	5%	374,456	51
Anderson	4,188	168	4%	33,285,768	82
Bamberg	361	55	15%	1,838,997	49
Barnwell	451	27	6%	1,197,996	50
Beaufort	2,097	1,044	50%	441,904,141	110
Berkeley	1,735	198	11%	161,958,451	58
Charleston	11,186	4,976	44%	919,489,031	112
Cherokee	964	33	3%	2,462,623	110
Chester	608	22	4%	1,253,349	79
Chesterfield	1,043	31	3%	1,269,027	50
Clarendon	318	41	13%	16,695,282	44
Colleton	748	77	10%	16,950,125	116
Darlington	1,398	176	13%	17,544,018	51
Dillon	682	50	7%	1,695,694	45
Dorchester	3,890	424	11%	81,316,141	50
Fairfield	419	15	4%	988,504	82
Florence	3,007	255	8%	36,630,788	47
Georgetown	1,733	980	57%	286,038,298	206
Greenville	8,096	570	7%	53,509,800	98
Greenwood	1,857	55	3%	19,282,671	82
Hampton	432	21	5%	641,316	41
Horry	5,903	1,034	18%	332,090,277	59
Jasper	608	82	13%	2,959,060	70
Kershaw	867	50	6%	14,179,801	61
Lancaster	1,401	58	4%	28,743,124	75
Laurens	1,301	71	5%	4,748,178	107
Lee	1	1	100%	865,776	101
Lexington	4,332	216	5%	11,725,186	68
Marion	815	73	9%	2,332,843	50
Newberry	765	30	4%	5,494,845	70
Oconee	1,202	39	3%	2,713,467	113

Orangeburg	2,629	316	12%	51,199,259	52
Pickens	1,990	143	7%	67,118,840	107
Richland	6,755	516	8%	438,894,712	70
Spartanburg	5,472	291	5%	224,174,209	74
Sumter	2,653	306	12%	19,208,180	48
Union	695	26	4%	1,475,201	123
Williamsburg	827	160	19%	1,672,451,485	53
York	3,384	93	3%	124,015,230	61
Total	92,981	13,117	14%	5,151,559,002	87

CRITICAL INFRASTRUCTURE

While the natural systems above are in many ways naturally resilient, many of our vulnerabilities to hazards come at the intersection of critical infrastructure and environmental change and natural hazards. This section includes the vulnerability of systems that are essential to human health, safety, and welfare including the need to maintain a clean water supply and protection against harmful substances, materials, and waste.

ROADS & BRIDGES

In South Carolina there are over 60,000 public road miles. SCDOT maintains over 41,000 miles of those roadways as well as more than 8,400 bridges, with the fourth largest state-maintained highway system in the nation (SC Department of Transportation, 2022). In many ways, the vulnerability of roads and bridges determines much of the vulnerability of all sectors listed in this chapter. All the facilities listed here require access. Additionally, roads and bridges are essential to evacuation and response, and for the delivery of longer-term recovery resources.

The impacts of floods to roads and bridges include direct damages to the roadway and barriers to access, as well as indirect impacts due to ongoing repairs and re-routing that impacts communities and economies. In South Carolina’s coastal areas, hundreds of miles of roads are at risk of high-tide flooding. As the number of high-tide flooding days increase with sea level rise, the miles impacted will also increase.

Currently, there is no statewide road elevation data set. SCEMD, in conjunction with Clemson University, is working to develop a dataset that may be used for vulnerability analysis. A test version of this analysis was completed for Dillon County (Figure 5.45).

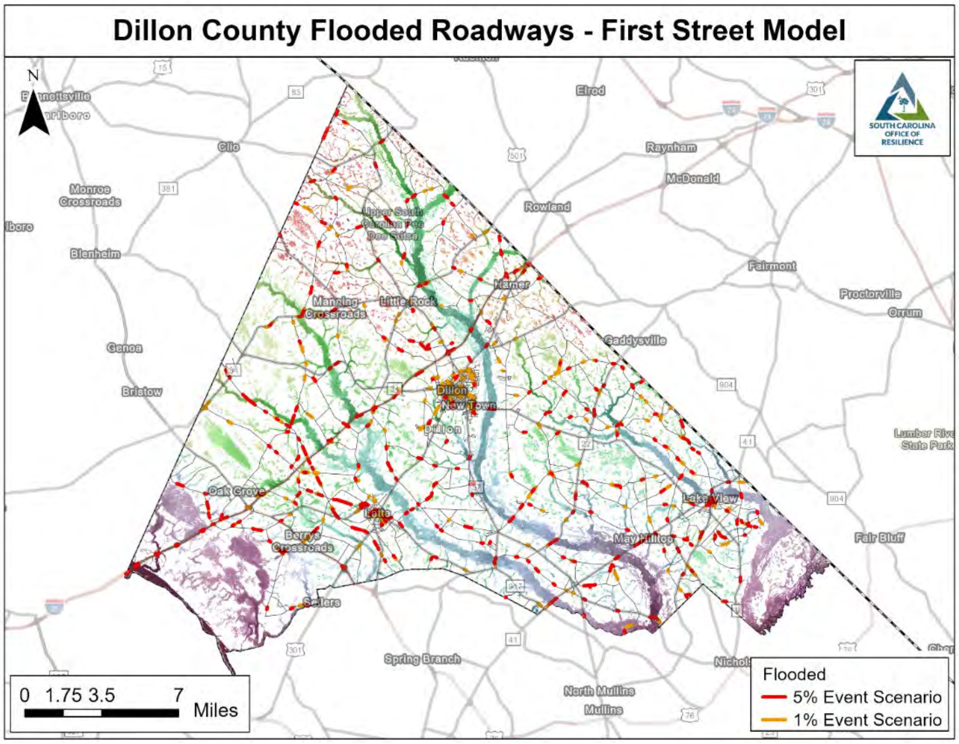

Figure 5.47: Analysis of locations where the roadway centerline elevation is lower than the elevation of a modelled flood scenario. Roadway elevations are provided by Clemson University, and flood data is provided by the First Street Foundation's Flood Hazard Layers, V2.0.

AVIATION FACILITIES

There are 51 public general aviation and six commercial airports across the state. These airports employ 122,759 people, with an annual payroll of $4.8 billion. Additionally, they generate $16.3 billion in annual economic activity. This figure includes the economic impact of Boeing, which has a large presence in Charleston, the location of final assembly for the Boeing 787 Dreamliner (South Carolina Aeronautics Commission, 2018).

The maps below show the vulnerability of these aviation facilities to flooding in the 2022 (Figure 5.48) and 2052 (Figure 5.49) 1% annual chance flood event.

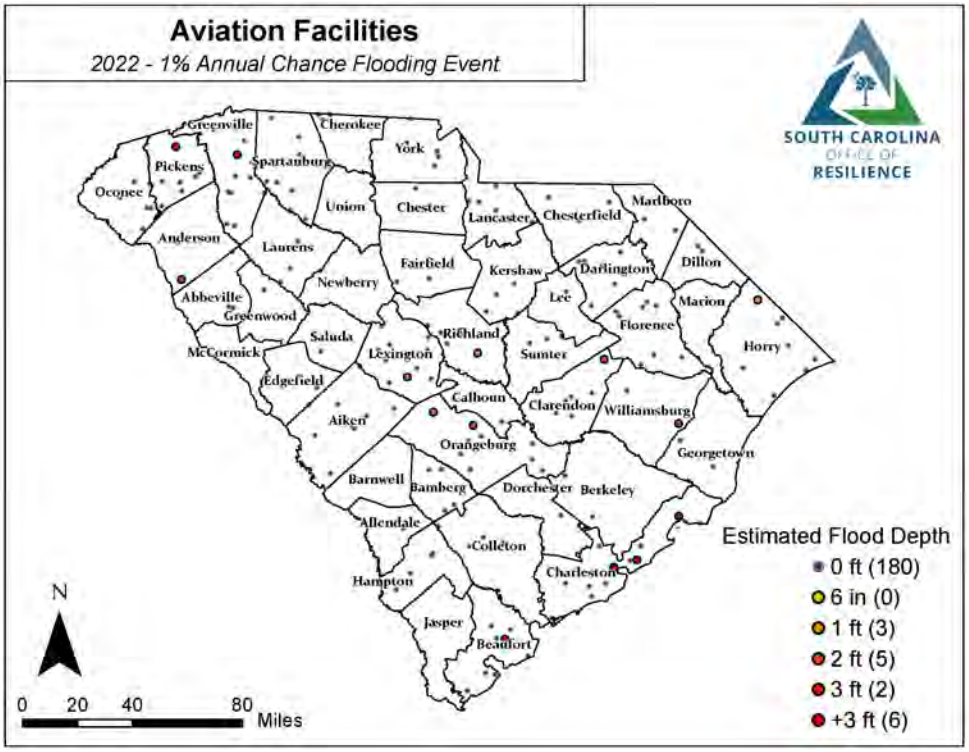

Figure 5.48: Estimated flooding of aviation facilities in the 2022 1% annual chance flooding event (Department of Homeland Security). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

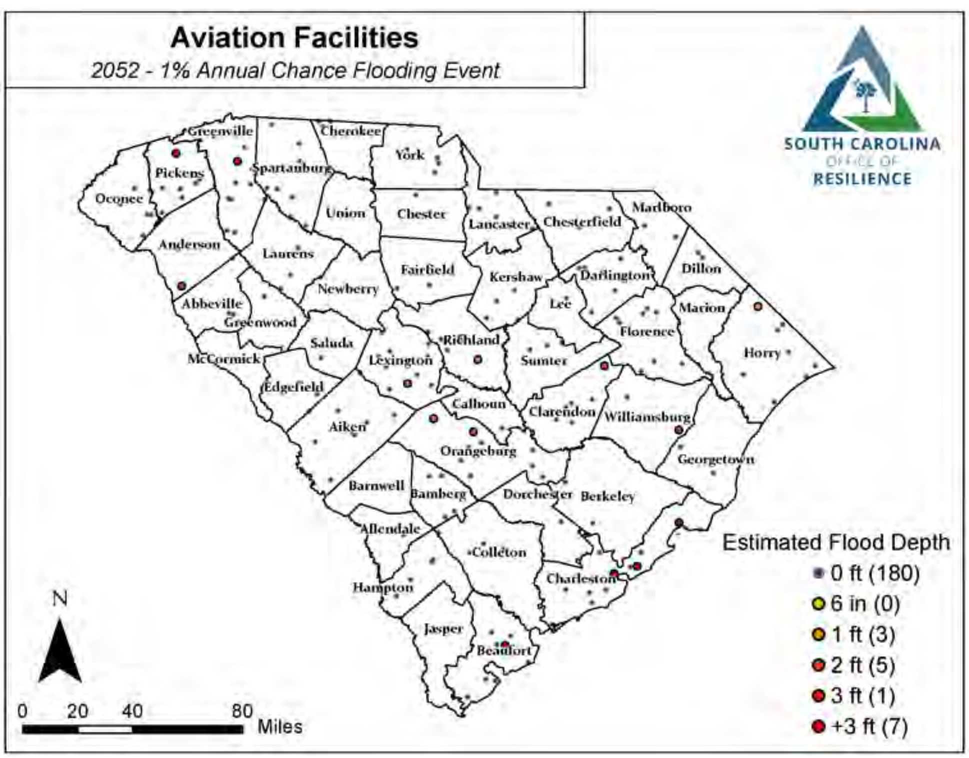

Figure 5.49: Estimated flooding of aviation facilities in the 2052 1% annual chance flooding event (Department of Homeland Security). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

PORTS

South Carolina Ports Authority (SCPA) owns and operates the Port of Charleston, Port of Georgetown, Inland Port Greer, and Inland Port Dillon, ensuring the efficient movement of cargo between South Carolina and global markets, generating a $63.4 billion economic impact in South Carolina each year (SC Ports Authority, n.d.).

Sea level rise poses risk to ports across the United States because mitigation measures are capital intensive. Ports plan for sea level rise contingencies, but the effects of storm surges and flooding could extend to complementary supply chain infrastructure on the landside and transportation sector. In the event of a massive hurricane or other disaster that leaves roads impassable. Ports would likely be a vital resource for delivery of supplies and movement of goods. Interruption of supply chain can be disastrous. Port equipment could be damaged along with cargo. Hurricanes could cause shipping channels and berths to shoal in from increased sediment load.

Historically, South Carolina’s wharves have progressively been elevated, and sea level rise is factored into Ports Authority’s design. However, older terminals have much older wharf structures that are more vulnerable to storm surge and sea level rise.

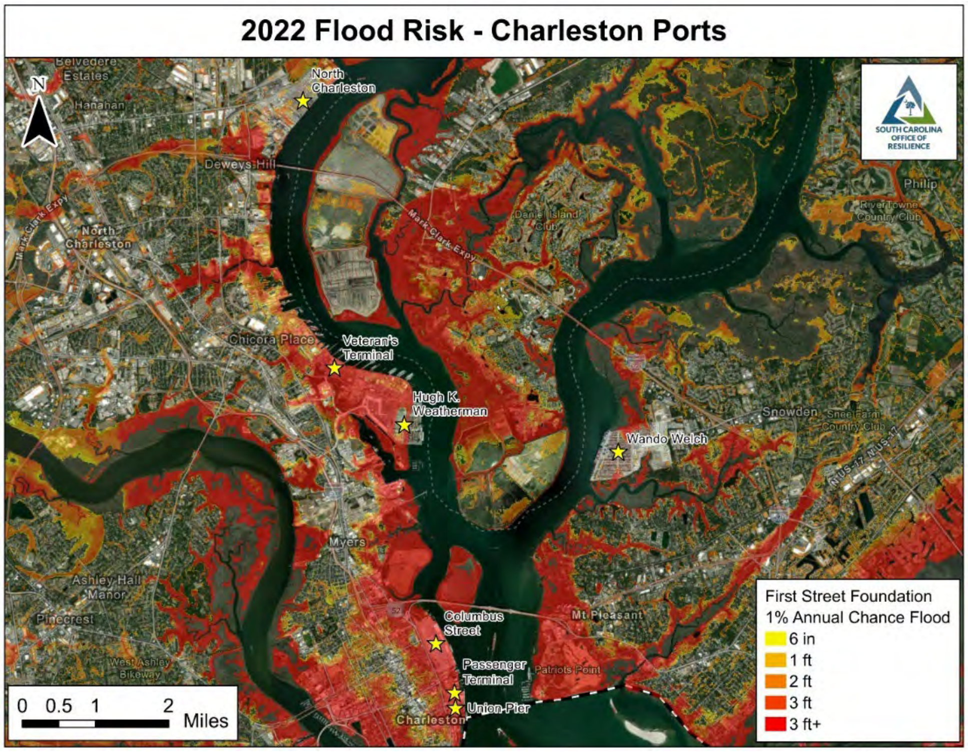

Figure 5.50: Estimated flooding of the Charleston Ports in the 2022 1% annual chance flooding event

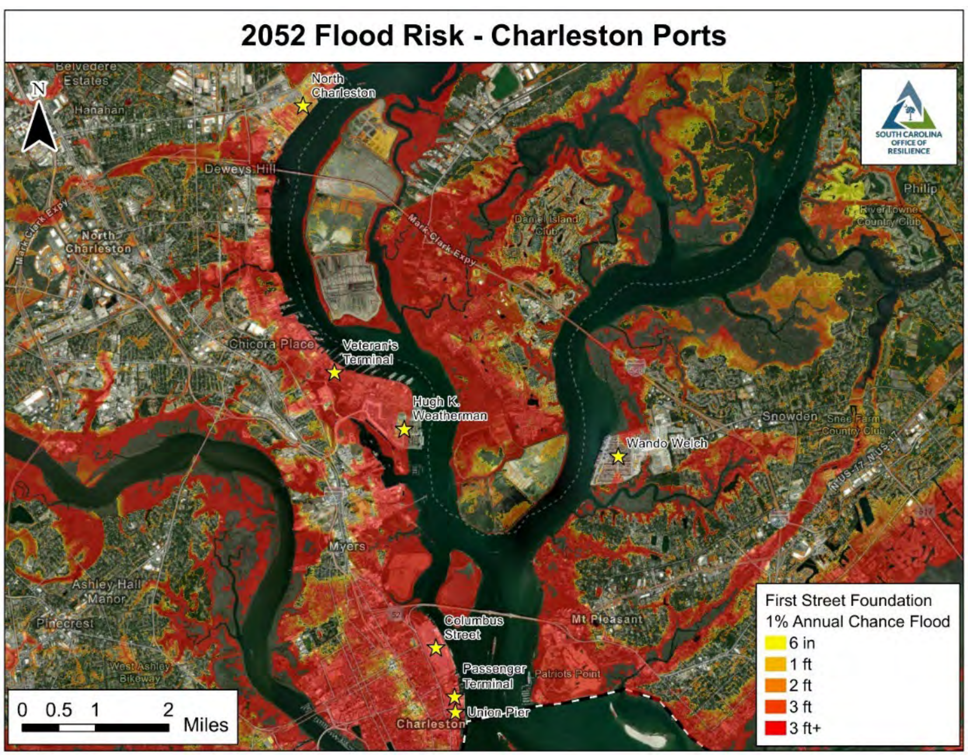

Figure 5.51: Figure 107: Estimated flooding of the Charleston Ports in the 2052 1% annual chance flooding event

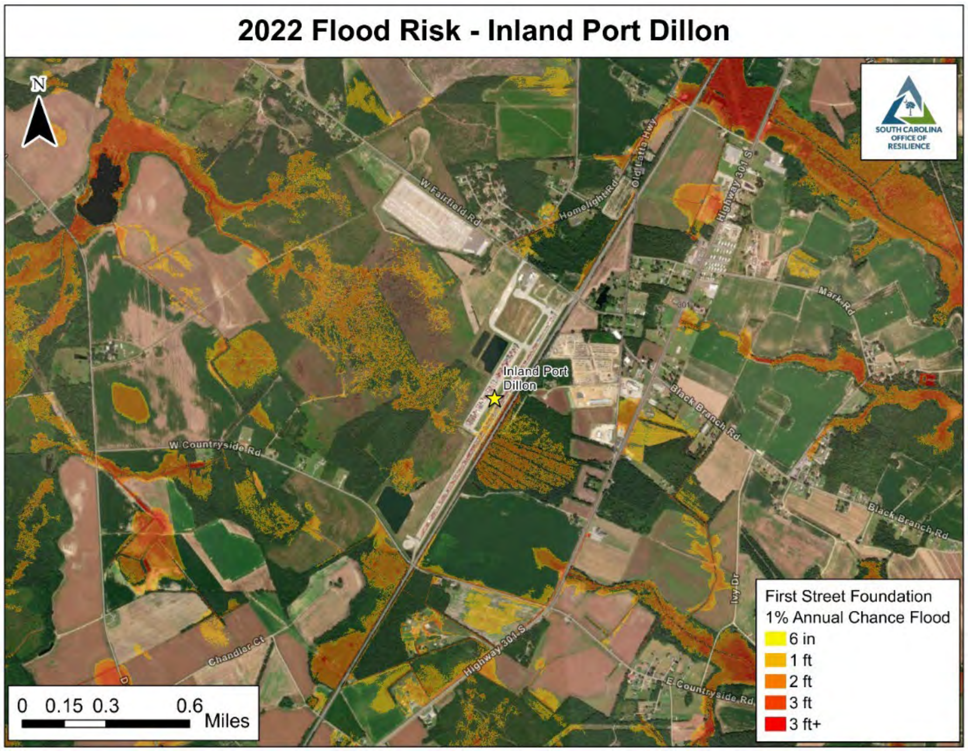

Figure 5.52: Estimated flooding of Inland Port Dillon in the 2022 1% annual chance flooding event

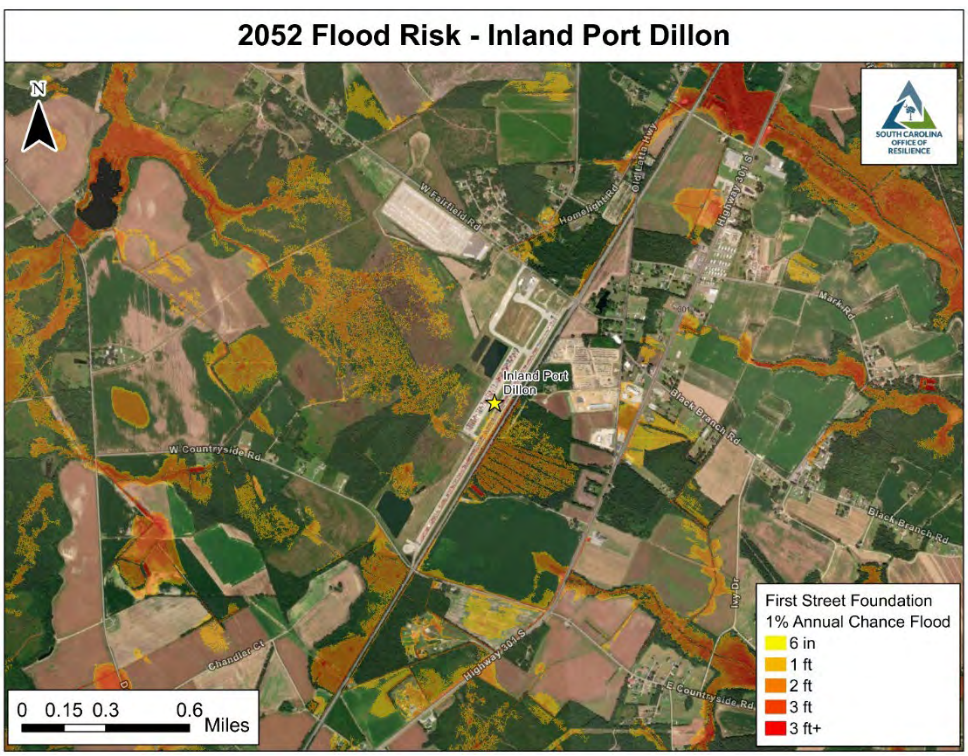

Figure 5.53: Estimated flooding of Inland Port Dillon in the 2052 1% annual chance flooding event

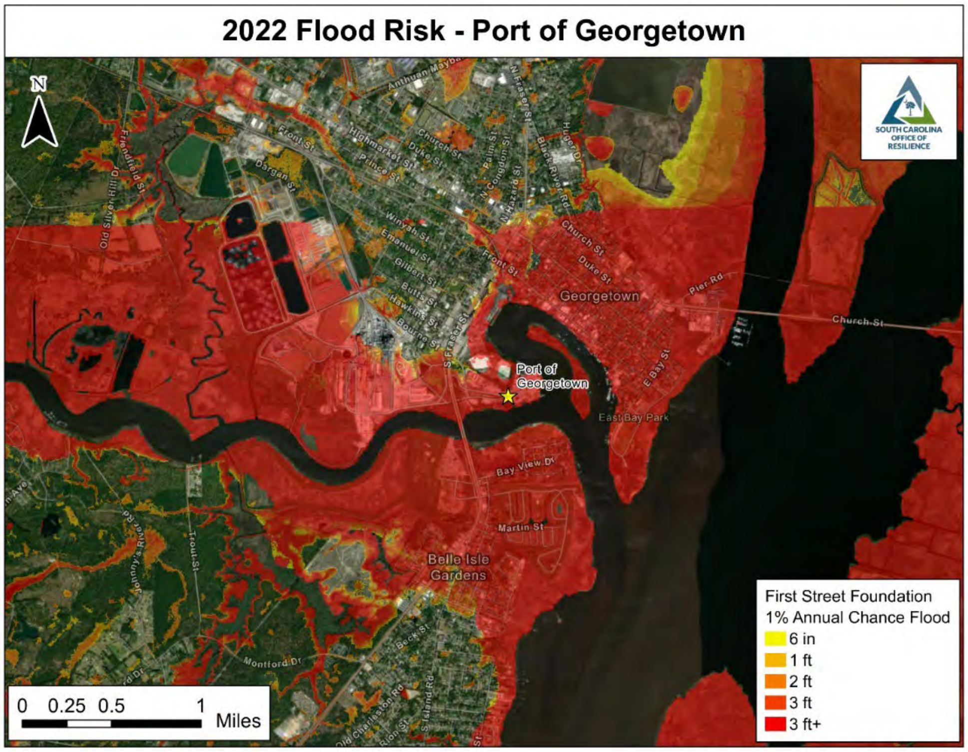

Figure 5.54: Estimated flooding of the Port of Georgetown in the 2022 1% annual chance flooding event

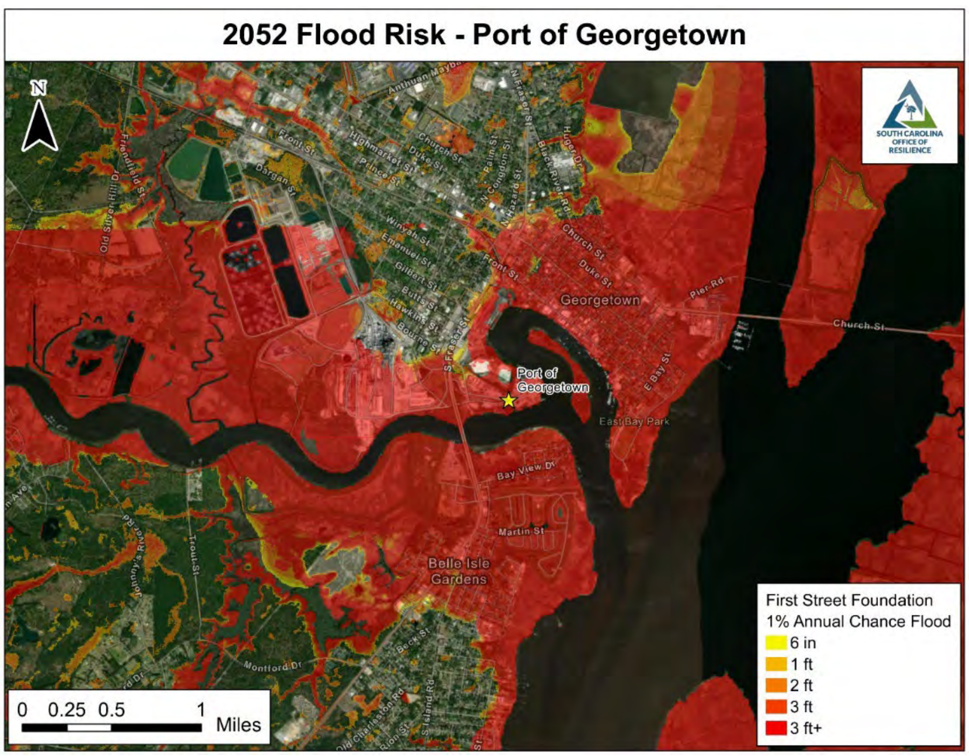

Figure 5.55:Estimated flooding of the Port of Georgetown in the 2052 1% annual chance flooding event

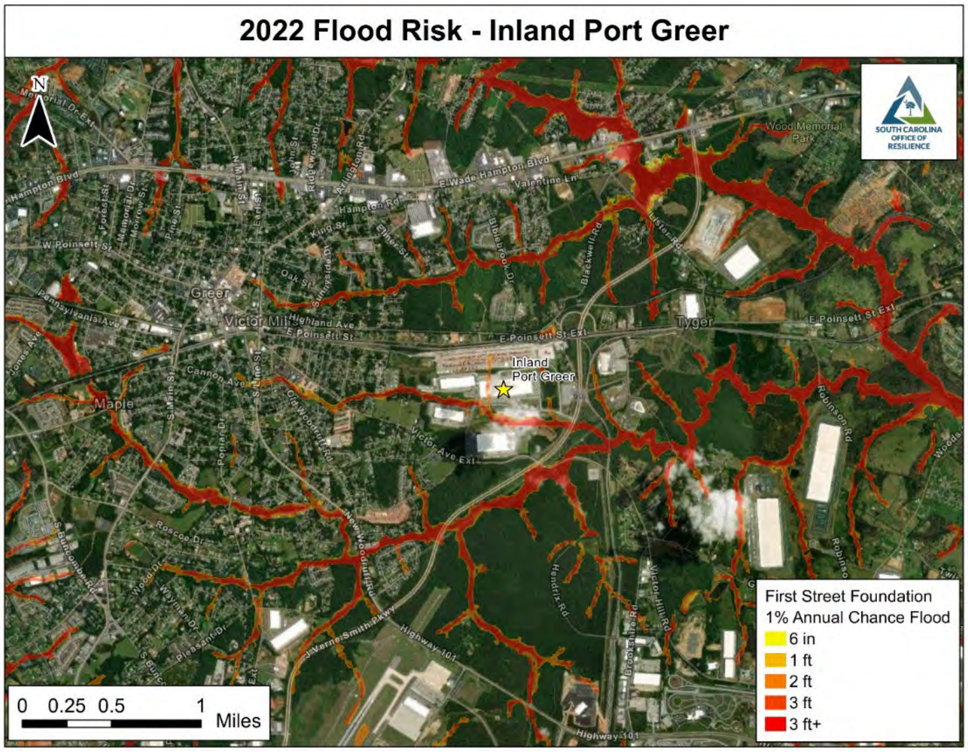

Figure 5.56: Estimated flooding of Inland Port Greer in the 2022 1% annual chance flooding event

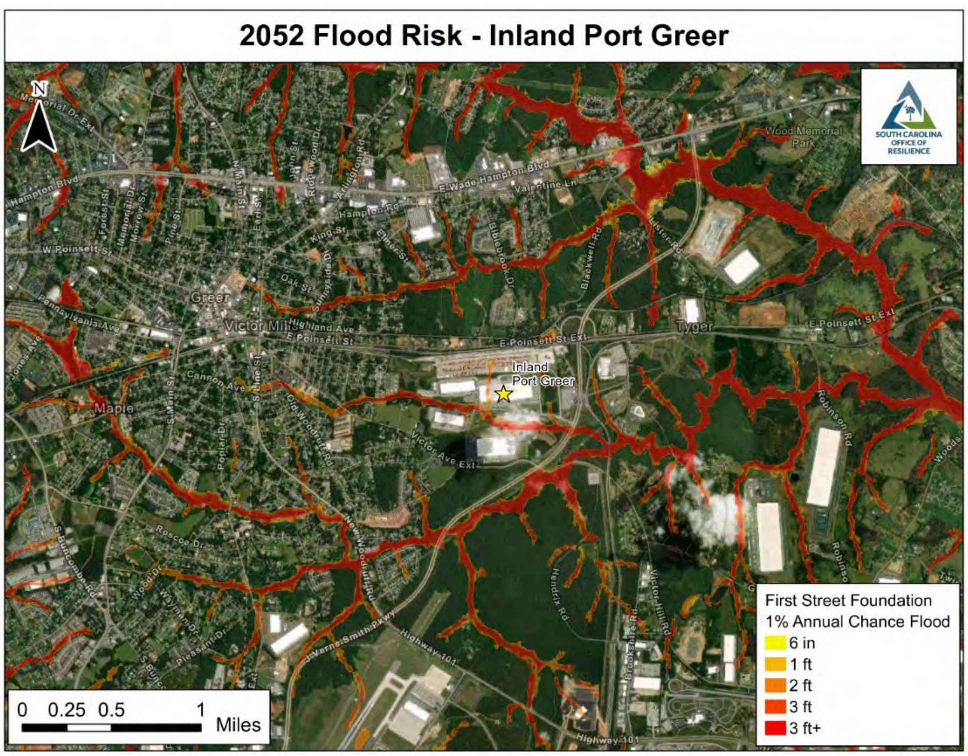

Figure 5.57: Estimated flooding of Inland Port Greer in the 2052 1% annual chance flooding event

RAIL

Rail freight is essential to the state's economy by providing efficient transportation of raw materials and goods for industries and businesses located here, as well as a distribution channel for products exported to other states and countries. Rail services are provided by 11 railroads, including two Class I railroads (CSXT and Norfolk Southern). Palmetto Railways, a branch of the South Carolina Department of Commerce, operates four railroad subdivisions. Additionally, Amtrak provides passenger service in South Carolina, with four Amtrak services passing through 11 stations in the State (SC Department of Transportation, 2020)

Currently, there is not a publicly available statewide dataset of railways with elevations on which to base a mapping analysis of flood risk.

ELECTRIC POWER GENERATION AND DISTRIBUTION

Electric generation and distribution require a complex system of power plants, substations, transmission lines, and other critical infrastructure that make up the power grid (Kern & Miranda, 2021). This section considers the impacts of hazards through the mapping of electric generation (power plants) and distribution (substations) facilities. Power generation includes hydroelectric dams, fossil fuel, nuclear, solar, wind, geothermal, and biomass (Department of Homeland Security, 2022)Power distribution includes electric power substation facilities and equipment that switch, transform, or regulate electric power at voltages equal to, or greater than, 69 kilovolts. This permits export onto the wider state grid and for distribution into homes and businesses (Department of Homeland Security).

Electric power systems are particularly vulnerable to flooding. The maps below show the vulnerability of power plants to flooding in the 2022 (Figure 5.58) and 2052 (Figure 5.59) 1% annual chance flood event.

The vulnerability of substations to flooding in the 2022 (Figure 5.60) and 2052 (Figure 5.61) 1% annual chance flood event. Repairing flooded substations can take much longer than repairing distribution lines because of the time needed to allow waters to recede (Kern & Miranda, 2021).

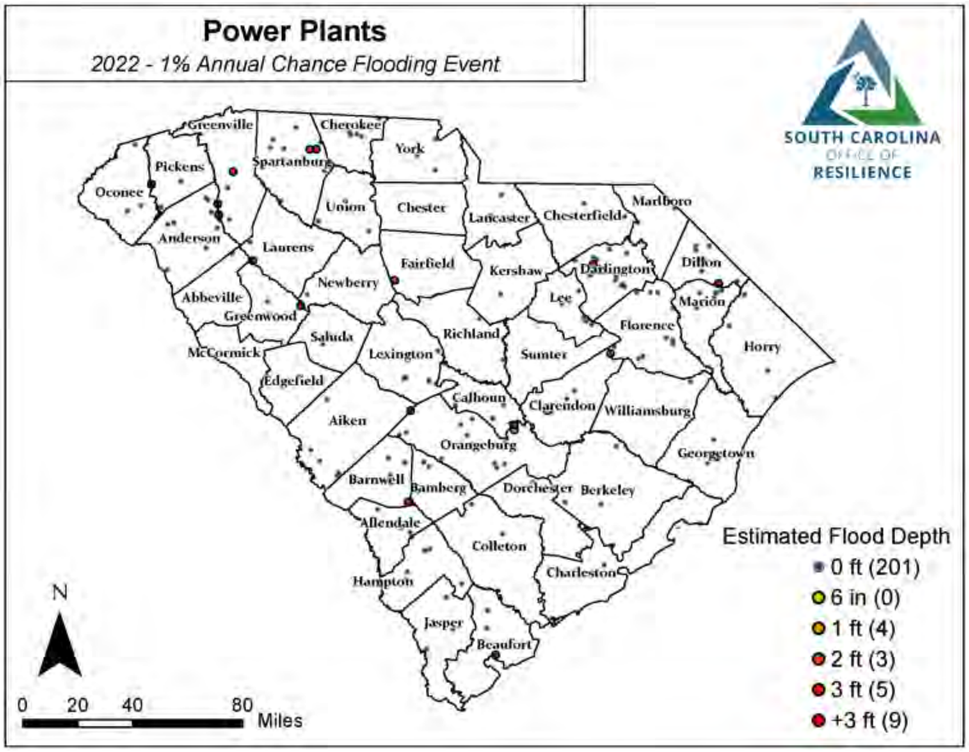

Figure 5.58: Estimated flooding of power plants in the 2022 1% annual chance flooding event (Department of Homeland Security). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

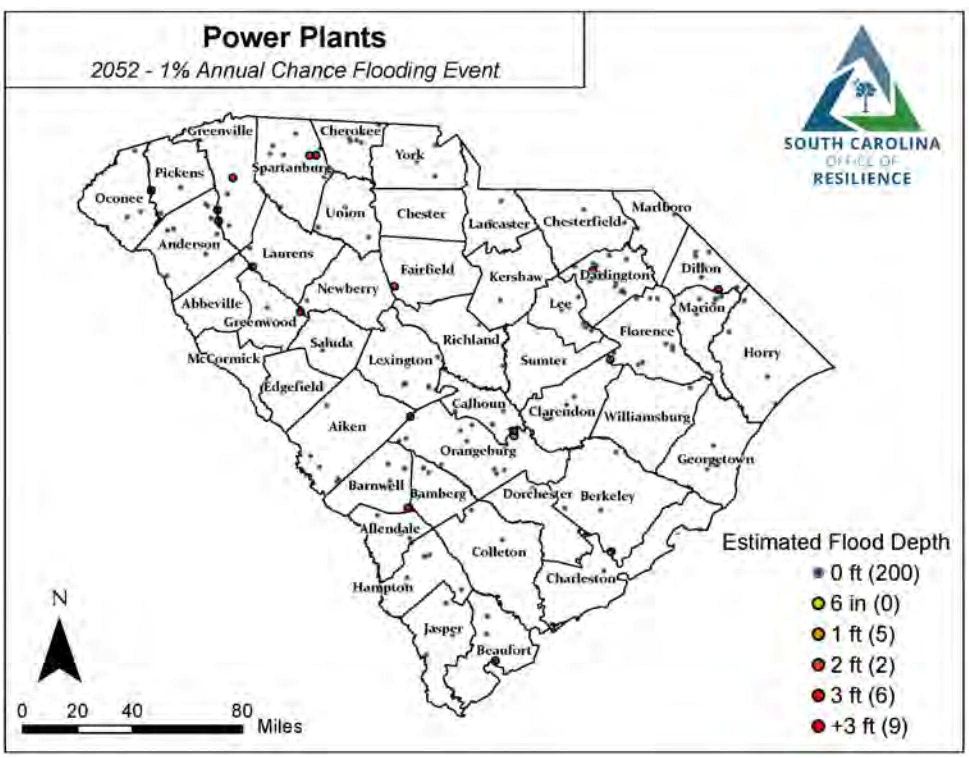

Figure 5.59: Estimated flooding of power plants in the 2052 1% annual chance flooding event (Department of Homeland Security). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

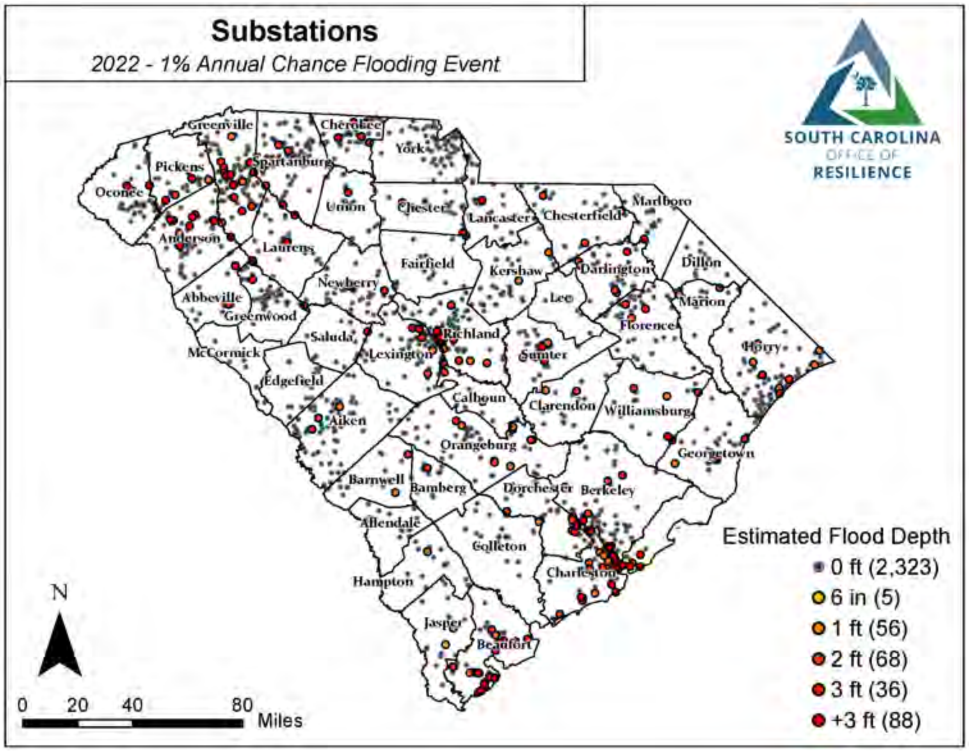

Figure 5.60: Estimated flooding of power substations in the 2022 1% annual chance flooding event (Department of Homeland Security). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

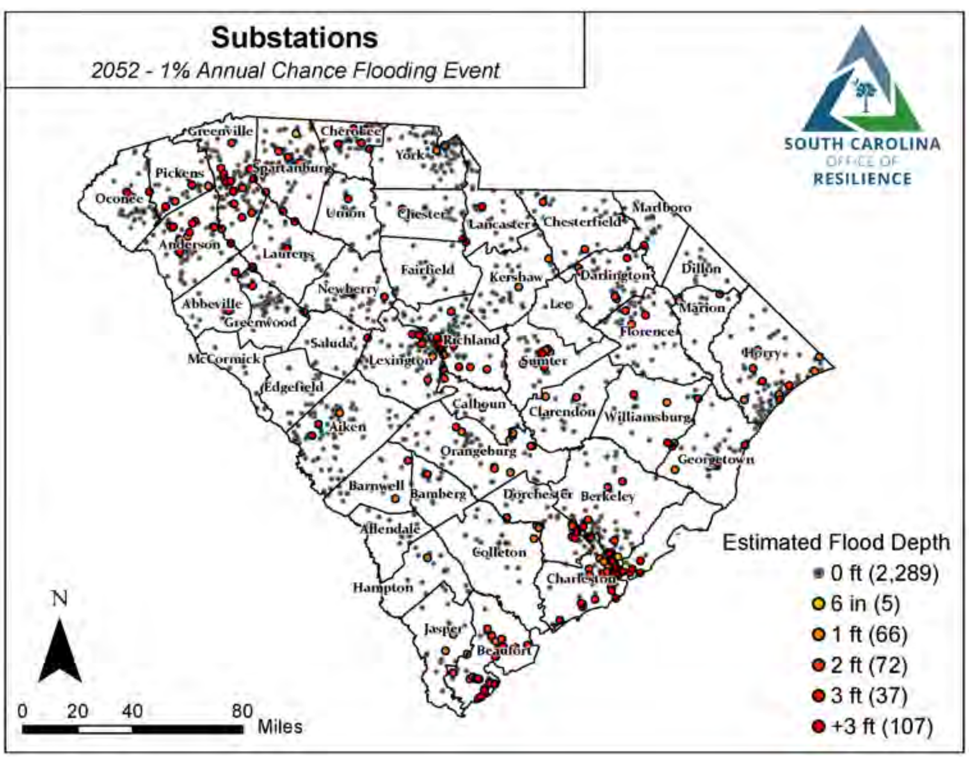

Figure 5.61: Estimated flooding of power substations in the 2052 1% annual chance flooding event (Department of Homeland Security). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

INTERNET AND BROADBAND

Flooding can have a significant impact on internet cables, especially those that are underground or located near bodies of water. When flooding occurs, water can seep into the protective casing surrounding the cables and cause damage to the wires inside. This can lead to electrical shorts, corrosion, and even complete failure of the cables. Furthermore, if the water level rises above ground level, it can also damage above ground cables, which can disrupt internet and other communication services. Flooding can also cause physical damage to the infrastructure that supports internet cables, such as poles and equipment boxes. This damage can lead to service disruptions and potentially lengthy repair times.

Broadband infrastructure is difficult to capture on a statewide basis, as this data is often either not publicly available, incomplete, disorganized, outdated, not digitized, or held in disparate formats (National Telecommunications and Information Administration, 2022). Without a centralized asset map held at the state or local level, it is difficult to assess how specific assets and infrastructure supporting South Carolina's broadband network are vulnerable to flooding or other hazards. SCOR will work with the South Carolina Broadband Office on identifying vulnerabilities and developing resilience strategies.

WATER SUPPLY

The state's freshwater resources sustain human life as well as support the state's economy for everything from agriculture to industry and power generation. Increasing population and development impact water demand. South Carolina DHEC Bureau of Water maintains an extensive dataset that includes the location of water suppliers in the State. Public water suppliers retrieve the water from surface water and groundwater. Surface water intakes can be fixed pipes or soft hoses in the water source with the pump station nearby, with larger municipalities using canals to divert water or locating their intakes on reservoirs to ensure a stable water source. Water supply groundwater wells are more likely to be found in the coastal plain of South Carolina due to access to availability of productive aquifers. Pump station and well locations are reported to SCDHEC during the permitting and registration process.

An example of how flooding can impact water supplies is the breaching of the Columbia Canal in the 2015 flooding event. The Columbia Canal originally opened in 1824 as a transportation alternative to the railroads to connect the upstate to the port in Charleston. Additions of water supply and power came in the later 19th and early 20th century (Marsh, 2015). During the historic 2015 flooding in Columbia, a 60-foot wide breach occurred, emptying into the Congaree River, compromising the primary water supply to the roughly 400,000 people (Underwood, 2021; Marsh, 2015). The City of Columbia, Columbia Water, and FEMA began repairs of the canal, with agreements announced in 2020 and the construction starting in 2022 (Columbia Water, 2022; Underwood, 2021).

The figures below illustrate the number of public water supply facilities vulnerable to flooding in the 2022 (Figure 5.62) and 2052 (Figure 5.63) 1% annual chance flood events.

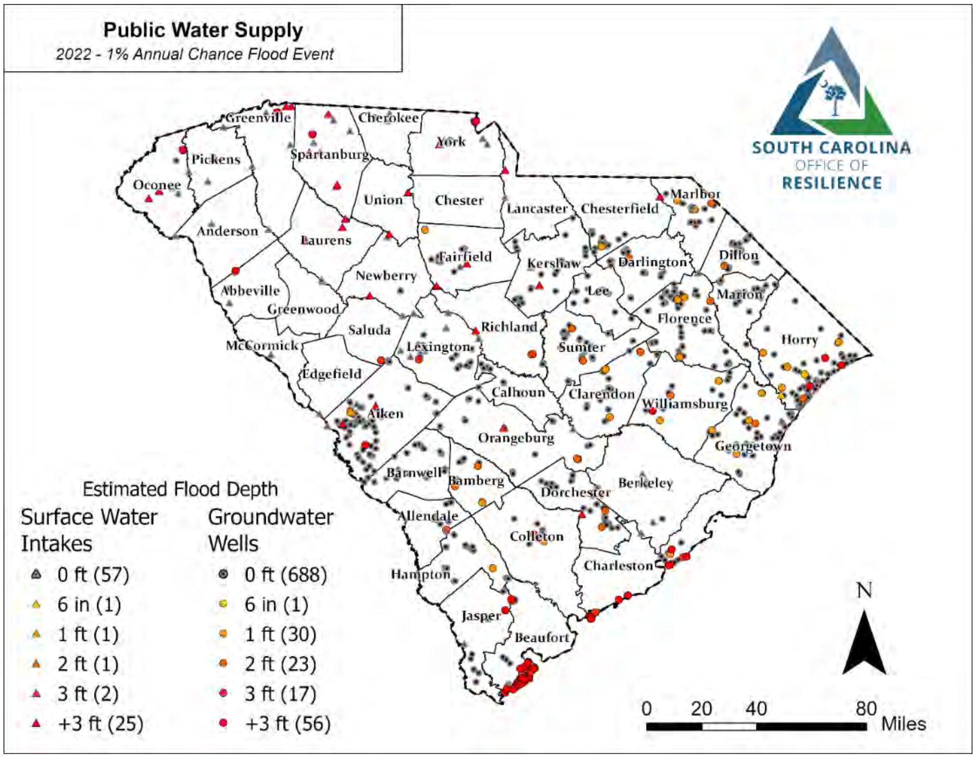

Figure 5.62: Estimated flooding of Public Water Supply in the 2022 1% annual chance flooding event (DHEC). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

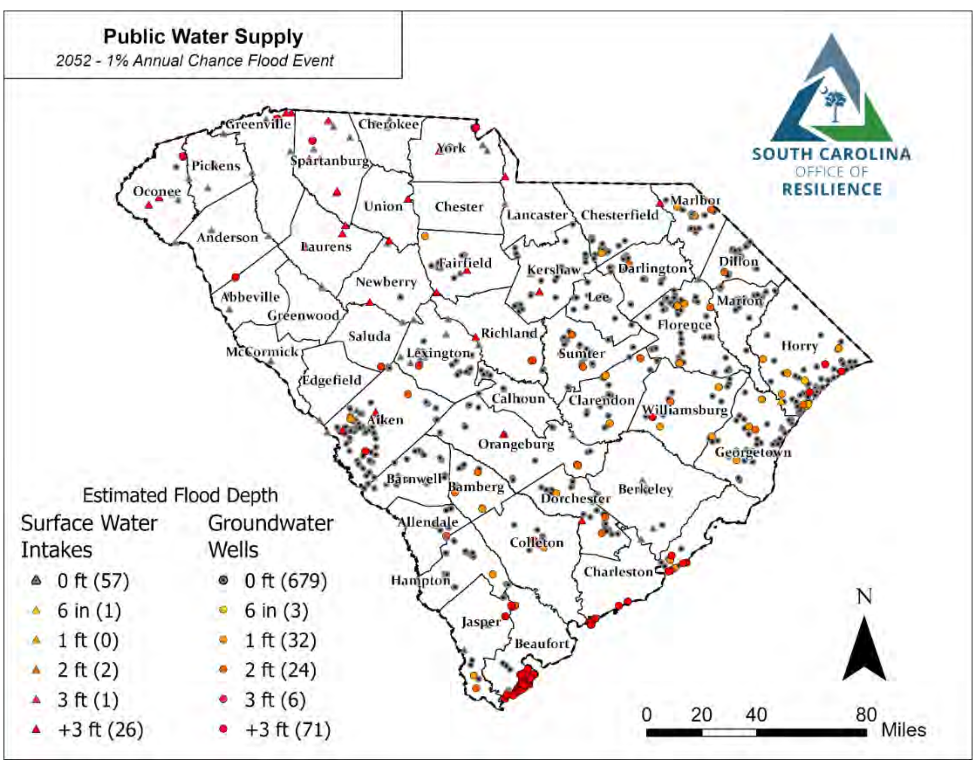

Figure 5.63: Estimated flooding of Public Water Supply in the 2052 1% annual chance flooding event (DHEC). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

HAZARDOUS WASTE LOCATIONS

During flood events hazardous materials may be mobilized and cause impacts to downstream properties. By identifying facilities at potential risk from flooding, communities can better plan for potential impacts. Understanding which facilities may be at risk also allows for closer examination of onsite practices to mitigate potential off-site releases

SEWER SYSTEM DISCHARGE

It is essential to maintain sewage system function to protect human and environmental health, safety, and welfare. Both on-site septic systems and sewer systems are vulnerable to hazards.

The National Pollutant Discharge Elimination System (NPDES), administered by DHEC, regulates potential discharge of pollutants into the waters across the nation and in South Carolina. Using the system user type in the NPDES permits, supplied by DHEC, the location of the discharge pipe can be used as a proxy for the potential vulnerability of the facility discharging the sewage.

The figures below illustrate the number of sewer system discharges vulnerable in the 2022 (Figure 5.64) and 2052 (Figure 5.65) 1% annual chance flood events. Wastewater systems in coastal areas are vulnerable to infrastructure damage and disruption resulting in public health issues from heavy rainfall events, high-tide flooding, and sea level rise.

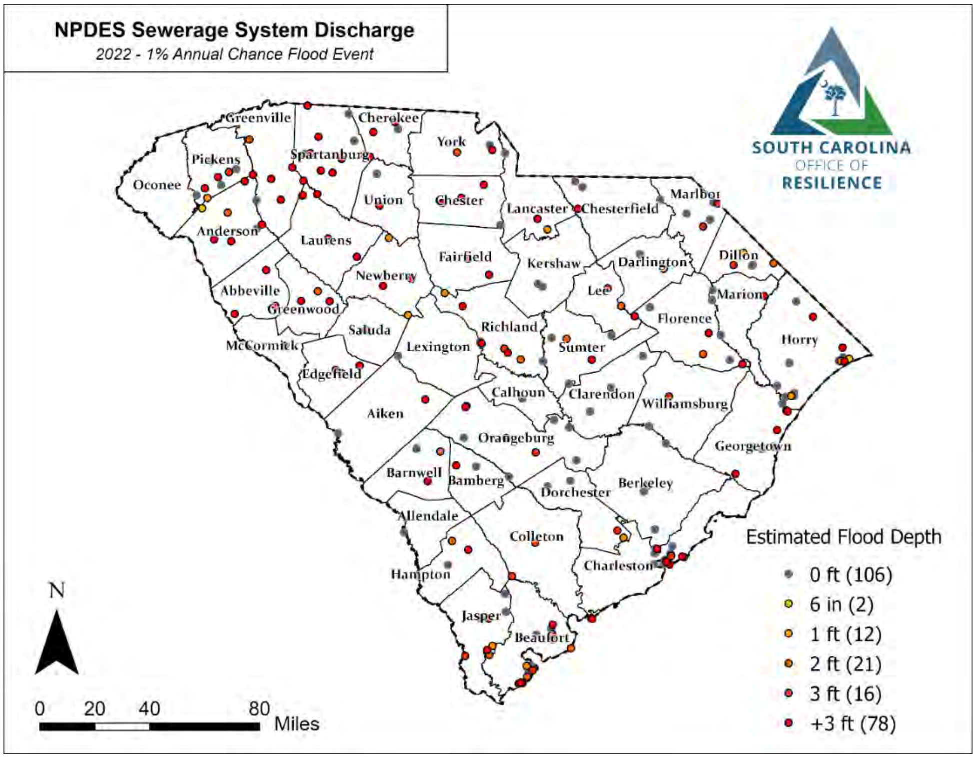

Figure 5.64: Estimated flooding of NPDES sewerage system discharge in the 2022 1% annual chance flooding event (DHEC). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

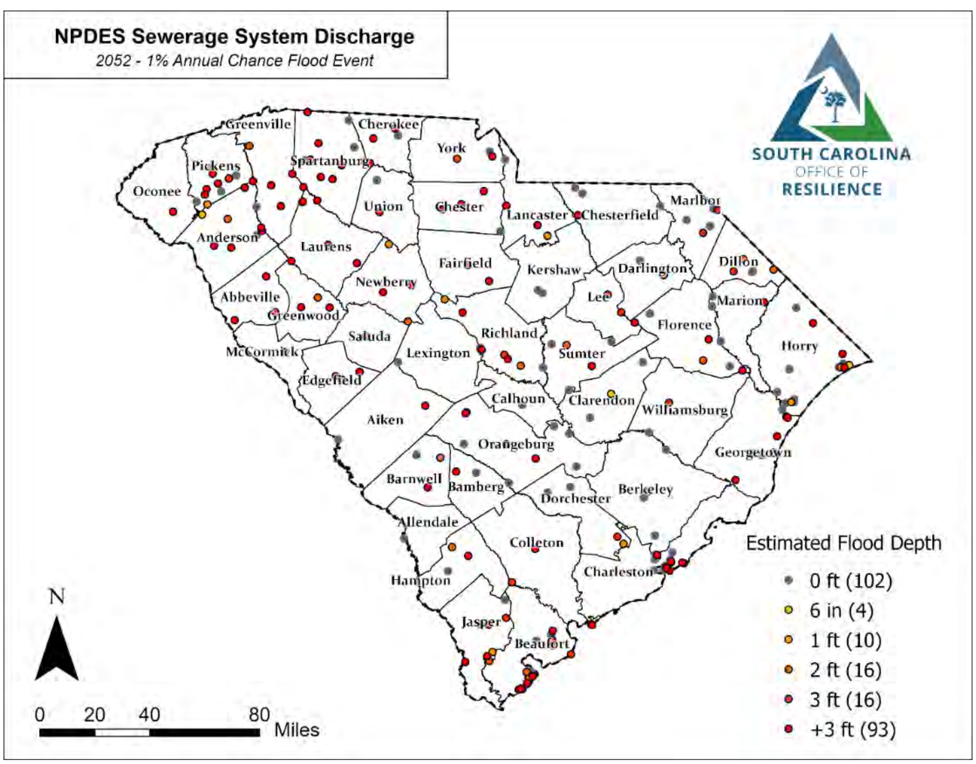

Figure 5.65: Estimated flooding of NPDES sewerage system discharge in the 2052 1% annual chance flooding event (DHEC). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

DRY CLEANERS

Dry cleaners are included in the South Carolina Hazardous Waste Management Act, which defines a dry cleaning facility as a professional commercial establishment for the purpose of cleaning clothing or other fabrics utilizing a process that involves the use of dry cleaning solvent, which can contaminate water or soil if released. Despite containment measures, many small solvent releases occur during normal operations. State environmental regulatory standards only allow a few parts per billion of the solvent to be present in the ground or groundwater under a facility (SC Department of Health and Environmental Control, n.d.).

Contamination has the potential to be even more widespread if solvent comes in contact with flood water. The figures below illustrate the number of dry cleaners vulnerable in the 2022 (Figure 5.66) and 2052 (Figure 5.67) 1% annual chance flooding event.

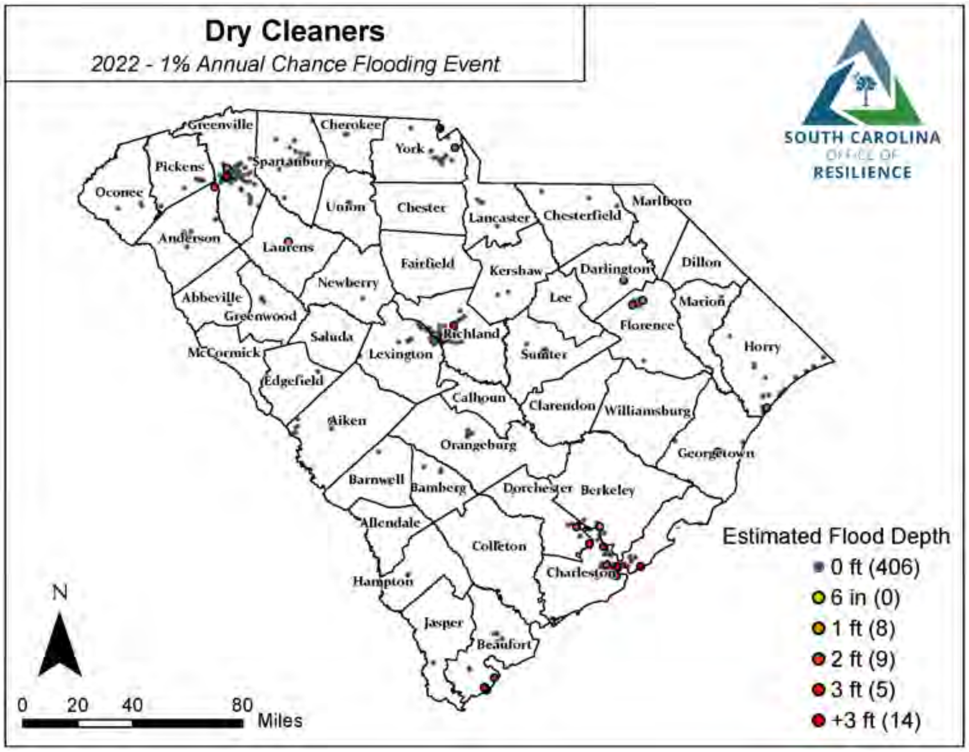

Figure 5.66: Estimated flooding of dry cleaners in the 2022 1% annual chance flooding event (DHEC). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

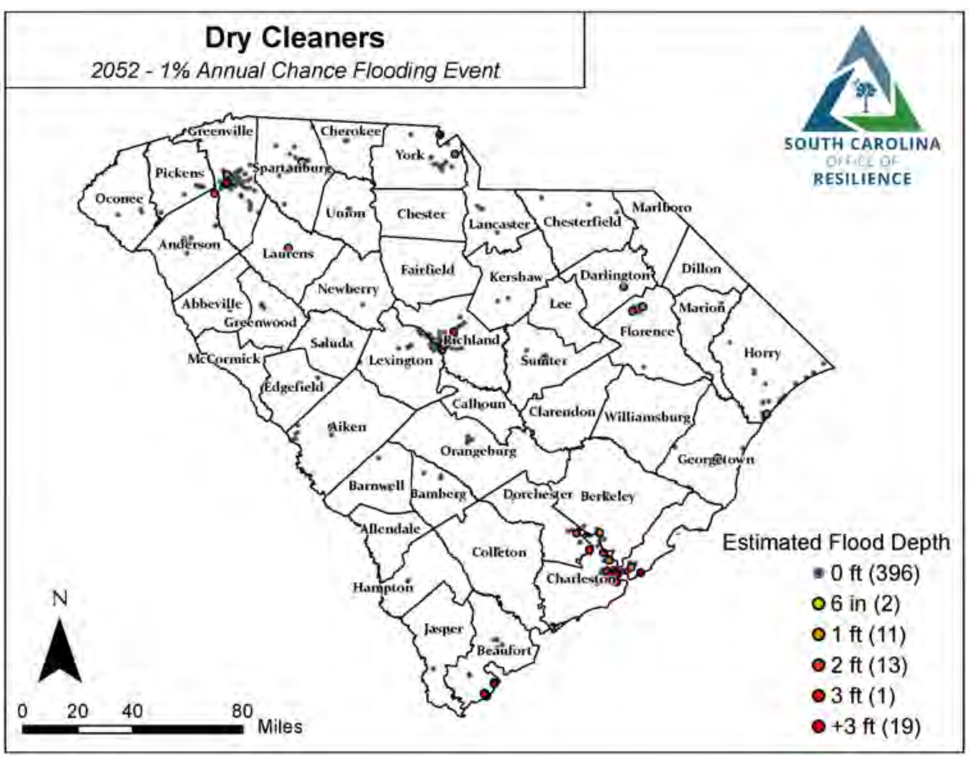

Figure 5.67: Estimated flooding of dry cleaners in the 2052 1% annual chance flooding event (DHEC). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

MINES

Approximately 500 mines are actively operating with DHEC permits. Mines are regulated through the SC Mining Act (1974). There are several types of surface mining done in the State including open pit mining of granite, strip mines for sand, clay and gravel, and sand dredging from river bottoms (South Carolina Department of Health and Environmental Control, n.d.).

DHEC Regulation 89-10 through 89-350 states that all overburden and spoil shall be placed so as not to result in deposits of sediment in streams, lakes or on adjacent property and that permanent overburden piles shall not be placed in or infringe on natural drainageways of floodways, and that temporary piles should not be placed there unless proper designs are utilized (SC Department of Natural Resources, 2003). The figures below show the number of mines vulnerable under the First Street Foundation's current (2022) and future (2052) scenario outside of these regulated areas (Figure 5.68 and Figure 5.69).

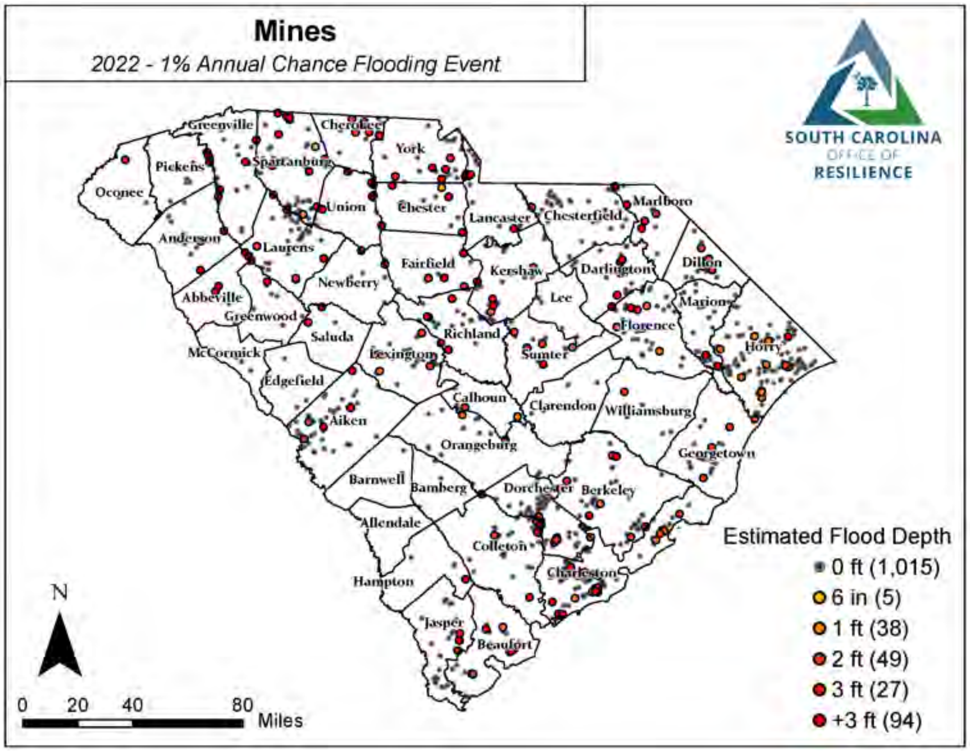

Figure 5.68: Estimated flooding of mines in the 2022 1% annual chance flooding event (DHEC). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

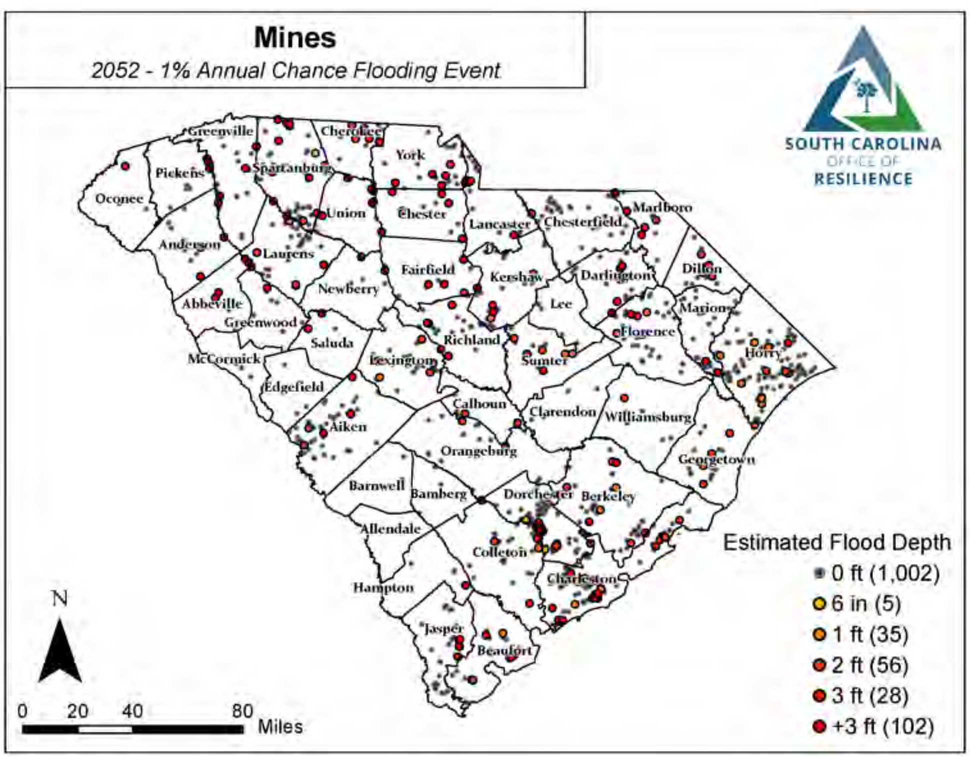

Figure 5.69: Estimated flooding of mines in the 2052 1% annual chance flooding event (DHEC). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

SOLID WASTE FACILITIES

The South Carolina Solid Waste Policy and Management Act defines a solid waste facility as all contiguous land, structures, other appurtenances, and improvements on the land used for treating, storing, or disposing of solid waste. A facility may consist of several treatment, storage, or disposal operational units such as landfills, surface impoundments, or a combination.

Washout of solid waste and leachate by floodwater poses a hazard to human health and the environment. The South Carolina Solid Waste Policy and Management Act states that landfills shall not be located in the one hundred year floodplain unless it can be demonstrated “that engineering measures have been incorporated into the landfill design to ensure the landfill will not restrict flow of the one hundred year base flood, reduce the temporary water storage capacity of the flood plain, or result in the washout of solid waste”. Figure 5.70 and Figure 5.71 show the number of solid waste landfills vulnerable in 2022 and 2052 1% annual chance flooding event while Figure 5.72 and Figure 5.73 show the vulnerability of all solid waste facilities.

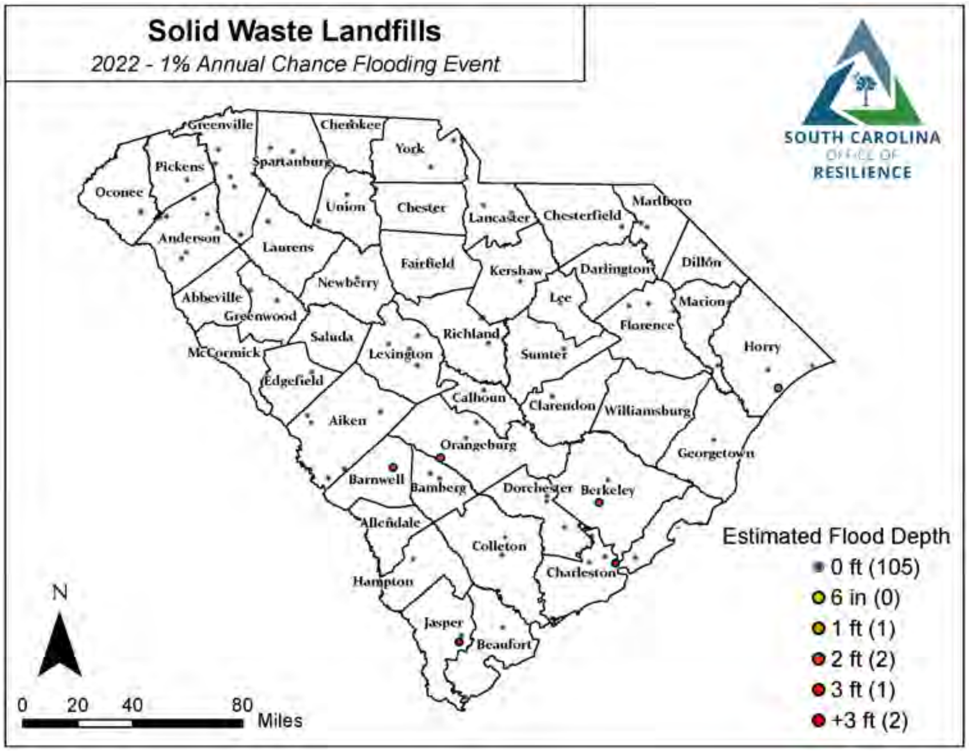

Figure 5.70: Estimated flooding of solid waste landfills in the 2022 1% annual chance flooding event (Department of Homeland Security). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

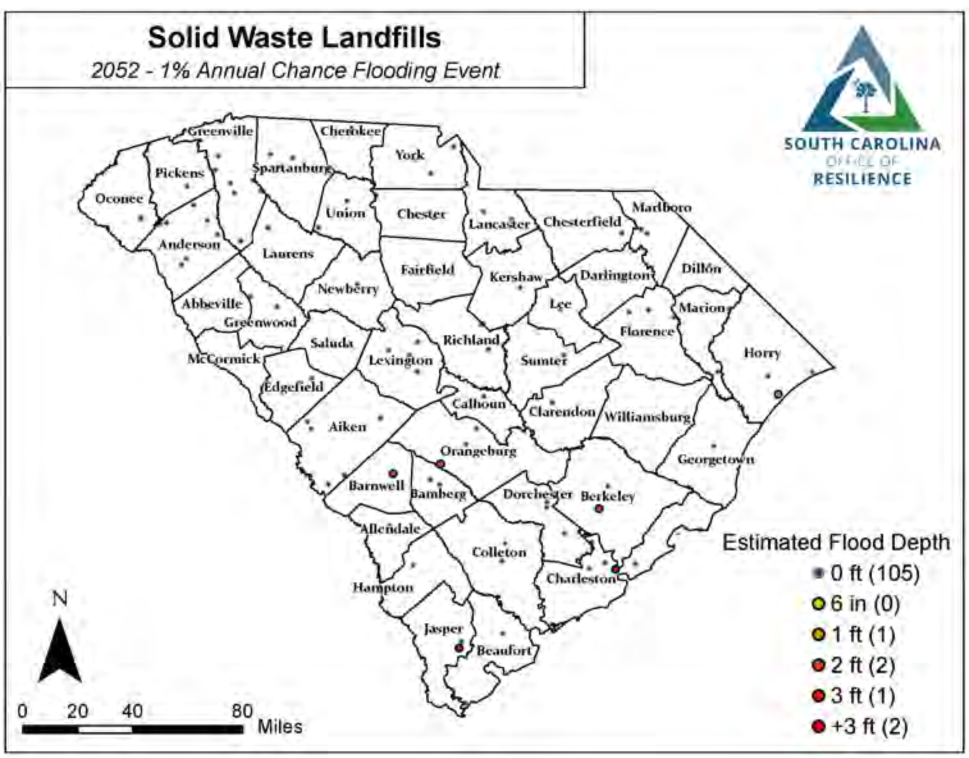

Figure 5.71: Estimated flooding of solid waste landfills in the 2052 1% annual chance flooding event (Department of Homeland Security). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

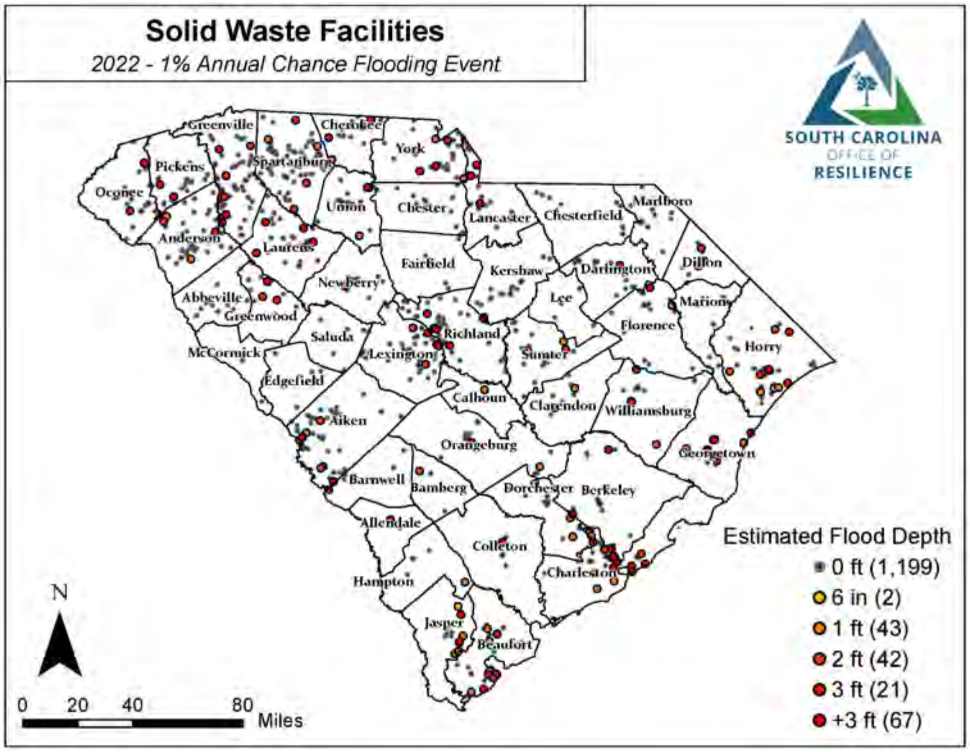

Figure 5.72: Estimated flooding of solid waste facilities in the 2022 1% annual chance flooding event (DHEC). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

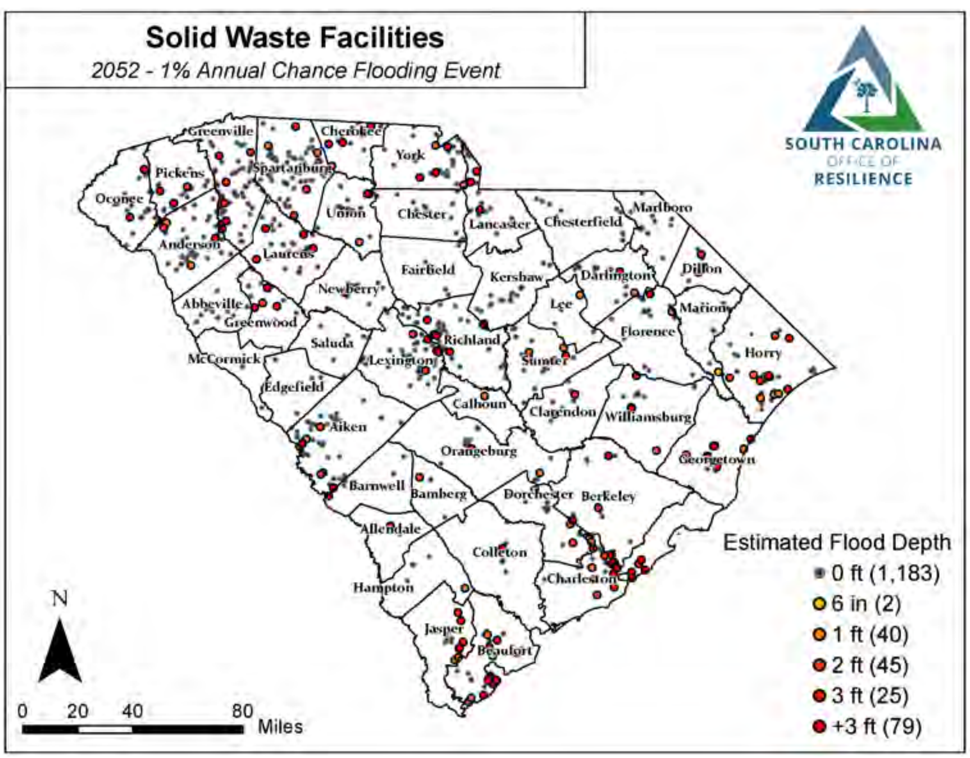

Figure 5.73: Estimated flooding of solid waste facilities in the 2052 1% annual chance flooding event (DHEC). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

SITE ASSESSMENT, REMEDIATION AND REVITALIZATION (SARR)

DHEC's Site Assessment, Remediation and Revitalization (SARR) Division manages the evaluation and restoration of sites where hazardous waste has polluted the environment. These sites include Brownfields, Superfund, and State Voluntary Cleanup locations. According to preliminary data from DHEC, there are over 5,800 sites across the state. Locations are not displayed at the request of DHEC.

Table 5.13 shows the estimated flood depth of these sites under both the 2022 and 2052 1% annual chance flooding event.

Table 5.13: Estimated flooding of DHEC Site Assessment, Remediation and Revitalization sites in the 2022 & 2052 1% annual chance flooding event (DHEC). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

Estimated Flood Depth	2022 1% Annual Flooding Event Number of Sites	2052 1% Annual Flooding Event Number of Sites
0 ft	5529	5482
6 inches	15	14
1 ft	46	53
2 ft	86	92
3 ft	44	46
+3 ft	139	172

HAZMAT TREATMENT, STORAGE AND DISPOSAL

DHEC permits active hazmat treatment, storage, and disposal facilities as authorized by the Federal Resource Conservation and Recovery Act, which established a process for treating, transporting, storing, and disposing of hazardous waste (SC Department of Health and Environmental Control, n.d.).

The figures below show the number of these facilities vulnerable in the 2022 (Figure 5.74) and 2052 (Figure 5.75) 1% annual chance flooding event.

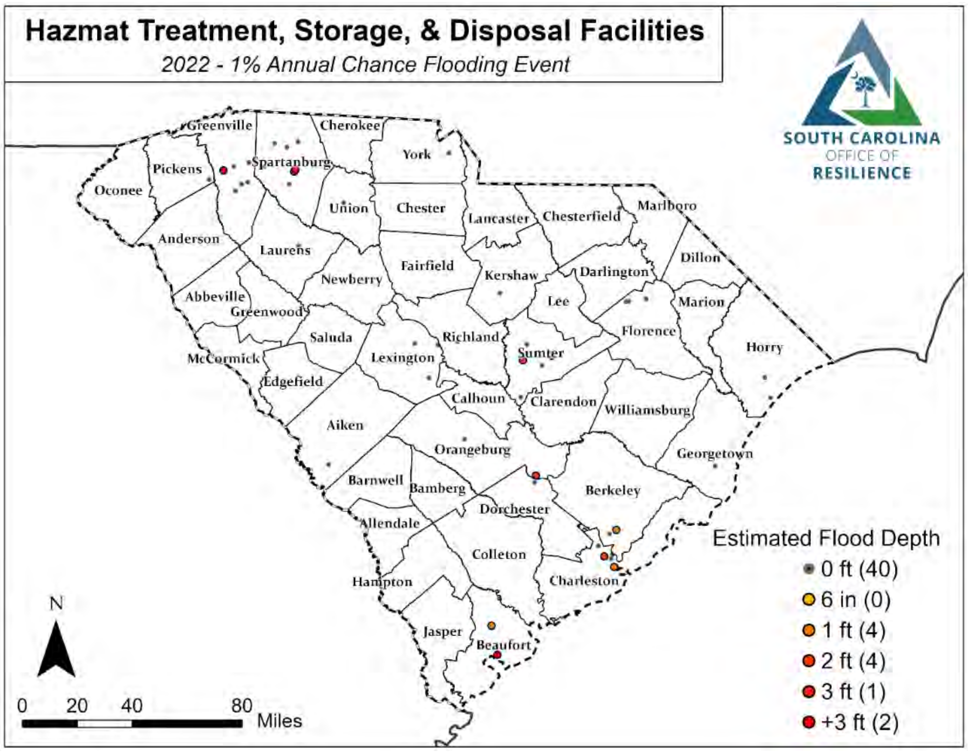

Figure 5.74: Estimated flooding of Hazmat Treatment, Storage and Disposal Facilities in the 2022 1% annual chance flooding event (DHEC). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

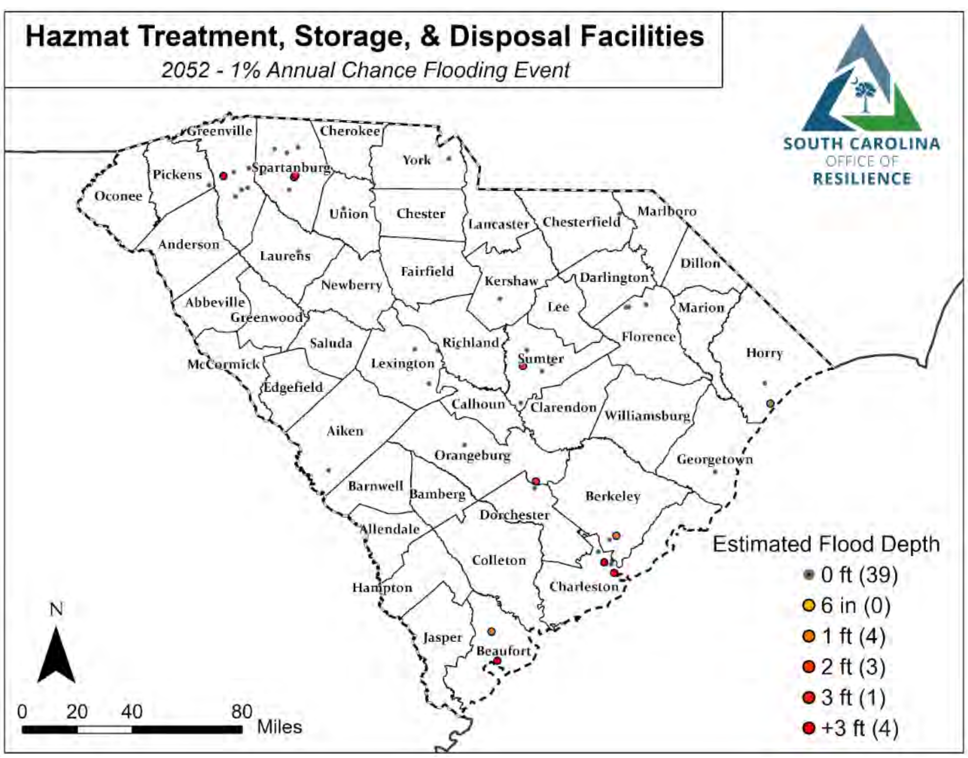

Figure 5.75: Estimated flooding of Hazmat Treatment, Storage and Disposal Facilities in the 2052 1% annual chance flooding event (DHEC). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

UNDERGROUND STORAGE TANKS (UST)

Underground storage tanks are used across the State to store vital fuel but pose a risk if not properly contained. Regulation 61-92, Underground Storage Tank Control Regulations, defines underground storage tanks as any single or combination of tanks, including underground pipes connected to it, which is used to contain an accumulation of regulated substance, and the volume of which is ten percent or more beneath the surface of the ground.

The EPA Underground Storage Tank Flood Guide describes the effects flooding can have on underground storage tanks such as buoyancy, erosion and scour, and product displacement. The guide outlines actions to decrease risks to the system and environment. Preliminary data from DHEC shows over 17,000 underground storage tanks across the State, with Table 5.10 showing the estimated flood depths under both the 2022 and 2052 1% annual chance flooding event. Locations not displayed at the request of DHEC

Table 5.14: Estimated flooding of Underground Storage Tanks in the 2022 & 2052 1% annual chance flooding event (DHEC). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

Estimated Flood Depth	2022 1% Annual Flooding Event Number of Sites	2052 1% Annual Flooding Event Number of Sites
0 ft	16,099	15,856
6 inches	31	38
1 ft	301	344
2 ft	381	401
3 ft	202	215
+3 ft	400	560

OTHER IDENTIFIED AND UNIDENTIFIED HAZARDOUS WASTE

In addition to those identified hazardous waste sites analyzed above, there are many other sites that contain known and unknown contaminants that may be at risk to spreading during a flood event. Examples of this include hazardous waste found in marine debris such as ships as well as hazardous materials found in sediment behind dams, that if compromised, can leach into water bodies or floodwaters. Below are examples of locations with identified hazardous materials. There is a need to study sites with known or potential contaminants to understand the risk of contamination with flooding.

DAMS/SEDIMENT (LAKE CONESTEE)

Dams are structures built across rivers or streams to control and manage water flow. One of the significant effects of dams is their ability to interrupt the natural flow of sediments downstream. The slowing of water in the river allows for sediments and contaminants from upstream to fall out of suspension. Contaminants from upstream activities such as industry, agriculture, and other development often accumulate in the sediment trapped behind dams.

An example of this issue is the dam at Lake Conestee. The dam is located on the main stem of the Reedy River in Greenville County. It is a stone masonry dam constructed in the late 1880s to power Conestee Mill. This dam is now in deteriorating condition, and many harmful materials have been found in the sediment behind itWhile the dam breaking or being otherwise compromised would not cause a catastrophic level of flooding, such an event would release the wide range of contaminants down the system. The dam is classified as Significant Hazard Potential as it has been determined that failure would cause drinking water interruption based on drinking water intakes downstream, including Lake Greenwood. There is a need to stabilize the structure and the contaminants behind the dam (SCDHEC , 2023).

USS YORKTOWN

In 2022, the Governor signed Executive Order No. 2022-20, directing the SC Office of Resilience to address the potential environmental hazards associated with the USS Yorktown, directing SCOR to study, and obtain approval and funding for to perform any necessary and appropriate activities identified or recommended by the study to address legacy contaminants currently contained within the USS Yorktown. The study directed by the Executive Order is currently underway.

In 1975, the U.S. Navy donated the World War II Essex-class aircraft carrier USS Yorktown to the state of South Carolina to become a museum ship at Patriots Point in Charleston Harbor. Executive Order 2022-20 directed the SCOR to begin the process of removing hundreds of thousands of gallons of toxic pollutants from the USS Yorktown by commissioning an updated cost study for the project. This project is aimed at protecting the Charleston Harbor and the surrounding area from hazardous materials with the potential to harm the economy, natural resources, and communities.

At the time of the USS Yorktown's deactivation, the extensive procedures prescribed by the Navy today, S9086-BS-STM010 [0910-LP-104-3949, rev 3] were not in place. Consequently, the USS Yorktown still contains significant quantities of potentially hazardous materials. The USS Yorktown environmental assessment project involves the identification of all contaminants and design of a mitigation plan for the estimated 100,000 gallons of fuel in approximately 129 tanks and compartments. In many of the compartments, the fuel is combined with water. There is an estimated 1.75 million gallons of contaminated water. In addition, 3,000 gallons of hydraulic and lubricating oils have been identified throughout the ship. Other known contaminants on the vessel include, but may not be limited to, the polychlorinated biphenyls (PCBs) in some of the hydraulic fluids, lubricating oils, caulks, greases, electrical wiring, and in a large portion of the wooden flight deck.

The USS Yorktown is currently moored in the Charleston harbor with the keel buried to a depth of approximately 28 feet in soft bottom silt. Above the silt line, there is open water on the port side and tidal marsh on the starboard side that allow the ship's hull to be subjected to tidal ebb and flow. Localized areas of the ship's hull, particularly in the tidal splash zone, have experienced extensive corrosion with significant through hull penetration. It is anticipated that the USS Yorktown will require significant repairs for it to remain a viable museum for the foreseeable future.

CULTURAL RESOURCES

South Carolina's history is rich with the diversity of traditional communities, including many tribal nations, that trace their roots to the landscape. While the Catawba Indian Nation is the only federally recognized resident tribe in South Carolina, many sovereign tribal nations were forcibly removed from South Carolina and still maintain strong cultural ties to the landscape

The State currently recognizes nine tribes and four tribal groups (South Carolina Commission for Minority Affairs, 2022). State recognized tribes include: Beaver Creek Indians, Edisto Natchez-Kusso Tribe of South Carolina, Pee Dee Indian Nation of Upper South Carolina, Pee Dee Indian Tribe, Piedmont American Indian Association, The Santee Indian Organization, Sumter Tribe of Cheraw Indians, The Waccamaw Indian People, The Wassamasaw Tribe of Varnertown Indians. State recognized tribal groups include: Chaloklowa Chickasaw Indian People, Eastern Cherokee, Southern Iroquois and United Tribes of South Carolina, Natchez Tribe of South Carolina, Pee Dee Indian Nation of Beaver Creek.

Federally recognized tribal nations with ties to South Carolina include: Absentee-Shawnee Tribe of Indians of Oklahoma, Alabama-Quassarte Tribal Town, Catawba Nation, Cherokee Nation, Eastern Band of Cherokee Indians, Eastern Shawnee Tribe of Oklahoma, Kialegee Tribal Town, Miccosukee Tribe of Indians of Florida, Muscogee Nation, Poarch Band of Creek Indians, Santee Sioux Nation (Santee Sioux Tribe of the Santee Reservation of Nebraska), Shawnee Tribe, Thlopthlocco Tribal Town, Tuscarora Nation, United Keetoowah Band of Cherokee Indians of Oklahoma.

Additionally, the Gullah/Geechee warrant special consideration given their national cultural significance and ties to the Lowcountry's environmental and cultural landscape (National Park Service, 2005).

These historically marginalized communities have been overlooked as key stakeholders in the region's ability to absorb and recover from environmental change and natural hazards. Cultural assets – archives, libraries, museums, historic buildings, archeological sites, historic neighborhoods and communities, and cultural landscapes – throughout South Carolina have a vested interest in the state's resilience efforts. Cultural custodians and representatives can offer critical insight to the specific threats experienced in their communities and provide valuable historic context for land and resource use important for resilience planning solutions (National Park Service, 2005).

Intangible cultural heritage such as oral traditions, performing arts, social practices, rituals, festive events, knowledge, and practices (UNESCO, 2022) also deserve special consideration and are often tied to a physical place (Feary, 2015).

Cultural resources are increasingly threatened both by development and by climate driven impacts, especially in coastal zones (Dawson, Hambly, Kelley, Lees, & Miller, 2020). On the southeastern Atlantic Seaboard, nearly 20,000 known archaeological sites are at risk of damage or destruction due to forces related to sea level rise (Anderson, et al., 2017). Assuming current projections hold, and the sea level rises approximately one meter by the end of the century, a total of 19,676 currently recorded archaeological sites will be submerged. Since survey coverage is incomplete, the numbers of actual sites impacted will be much higher (Anderson, et al., 2017). Many additional archaeological sites will be lost before they are discovered due to the current methodologies of archeological survey. These sites are damaged most severely by the persistent wave and tidal energies generating erosion that precedes permanent sea level rise.

Additionally, portions of the southeastern coastline are experiencing sea level rise at rates three times the global average (Valle-Levinson, Dutton, & Martin, 2017). The ways in which we are addressing the impacts of climate to cultural heritage in the United States is a patchwork of partial solutions driven largely by state budgets and to a lesser extent by federal support for specific weather events for which funding often comes years later (Beavers, et al, 2016; Newland, et al, 2017). Furthermore, siloed cultural resource management practices operating within state borders have led to divergent and imperfect responses to environmental changes and natural hazards. Currently, no laws associated with resilience and mitigation provide funding for cultural resources that are increasingly threatened by environmental processes.

Federal, state, and local laws and regulations define what typically makes a cultural resource or historic property “significant”. For example, for buildings, structures, sites, objects, and districts, their inclusion in the National Register of Historic Places (NRHP), or a determination of eligibility for inclusion in the NRHP can make them significant. This is different however from how resources are designated at the local level, which are less quantifiable due to the number of entities involved or due to their sensitive nature.

South Carolina has over 1,600 listings in the National Register of Historic Places including 199 historic districts. Since one listing can include multiple buildings and sites, it is estimated 12,000 to 15,000 properties are included in the National Register. Charleston County has the most listings followed by Richland, Greenville, Beaufort, Spartanburg, Lexington, York, and Darlington Counties.

In addition to these NRHP listings, 76 South Carolina properties are recognized as National Historic Landmarks (NHLs), including four historic districts - Beaufort, Charleston, Graniteville in Aiken County, and Penn School on St. Helena Island. Of the NHLs, 42 are in Charleston County, including the USS Yorktown, and the remainder are scattered across the state.

Over 83,000 above-ground historic and architectural resources have been recorded by surveys of historic properties since the early 1970s. An average of 1,800 properties are added annually to the Statewide Survey collection that is maintained by the SC Department of Archives and History (SCDAH). Additionally, nearly 37,000 archaeological sites are in the state archaeological site files maintained by the SC Institute for Archaeology and Anthropology (SCIAA). Over the past decade, almost 700 new sites were added to the inventory annually, primarily through cultural resources surveys to comply with federal and state laws. Counties with the most recorded sites include Beaufort, Berkeley, Charleston, and McCormick, each with over 2,000 sites.

Regarding tangible collections, heritage custodians are overburdened and focused on triage and mitigating active instances of damage and loss rather than planning for the long-term needs of collections. According to the 2014 Heritage Health Information Survey (HHIS) conducted by the Institute of Museum and Library Services (IMLS), 76% of organizations do not have both a written institutional emergency plan and staff trained to carry that plan out - a statistic that was unimproved from the 2004 HHIS (Institute of Museum and Library Services, 2019). As a result, time and resources are directed to mitigating internal impacts on collections such as improper packaging and storage, obsolete and out of date equipment, water damage, and pest infestations rather than looking toward future impacts. The potential impact of future climate conditions on tangible collections has not been thoroughly investigated beyond the monetary impact of rising temperatures, humidity, and natural weather events on collection storage environments and the acknowledgement that most collections are greatly unprepared to respond to any emergency (International Institute for Conservation of Historic and Artistic Work, 2008).

Of primary concern is the lack of up-to-date documentation and assessments of State cultural assets. Over half of collecting organizations nationally have not completed a condition assessment of their collection, and nearly all do not regularly assess the entire collection (Institute of Museum and Library Services, 2019). Furthermore, volunteer-run sites and assets not listed on official registers will easily slip through the cracks. The level of preparedness was demonstrably worse for small collections compared to large ones with greater resources at their disposal.

The cultural heritage sector in South Carolina is largely unprepared to absorb adverse impacts, let alone adapt, thrive, or demonstrate resilience at this time. A long-term, sustainable investment in funding, time, and people (e.g., cultural resource managers, community members, members of sovereign tribal nations) is required to allow the cultural resources sector to become resilient.

ArchSite, the South Carolina Institute for Archeology and Anthropology (SCIAA) and the South Carolina Department of Archives and History's (SCDAH) online cultural resources information system, is used in the maps below to show physical vulnerability to properties that are individually listed in the NRHP or historic structures that have been determined eligible for listing in the NRHP. In the following maps, this data is not represented by individual points to protect the security of the properties while allowing for statewide analysis. Figures 5.76 through 5.79 display the number of sites or structures at the HUC-10 level that will be impacted by a 1% annual chance flooding event.

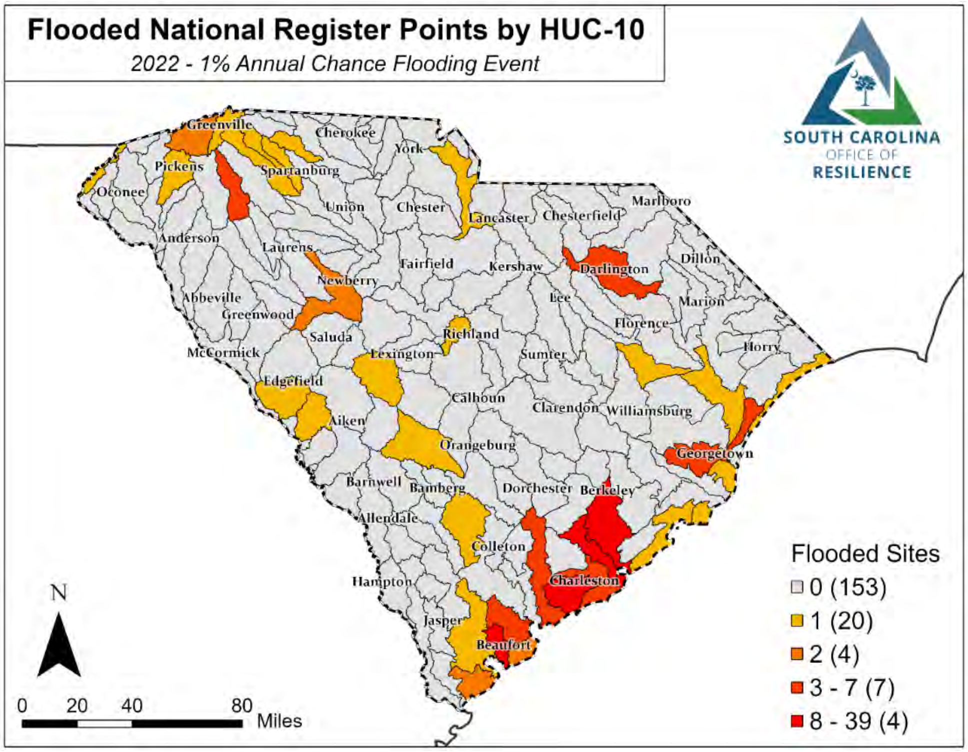

Figure 5.76: Estimated flooding of National Register Locations in the 2022 1% annual chance flooding event by local watershed (HUC-10) (ArchSite). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

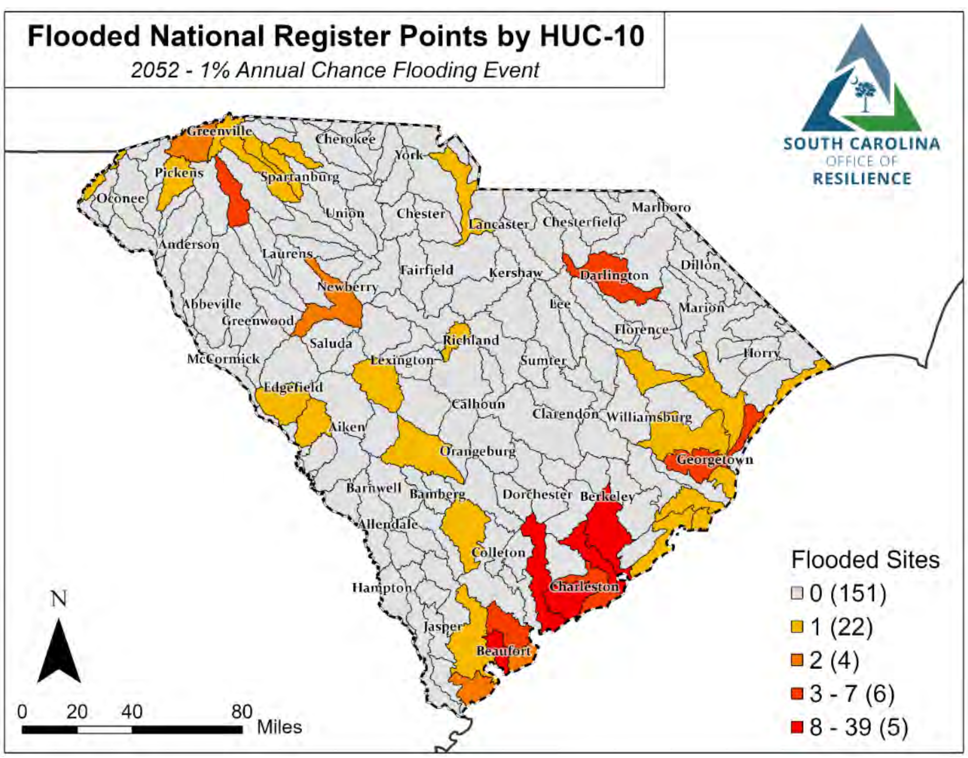

Figure 5.77: Estimated flooding of National Register Locations in the 2052 1% annual chance flooding event by local watershed (HUC-10) (ArchSite). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

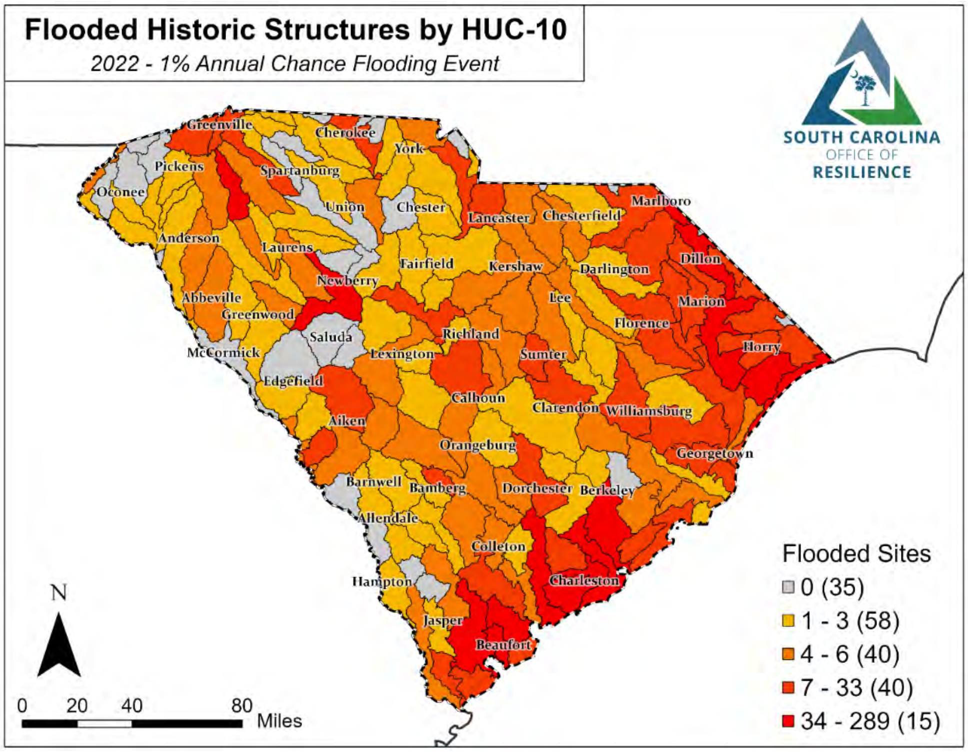

Figure 5.78: Estimated flooding of Historic Structures in the 2022 1% annual chance flooding event by local watershed (HUC-10)(ArchSite). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

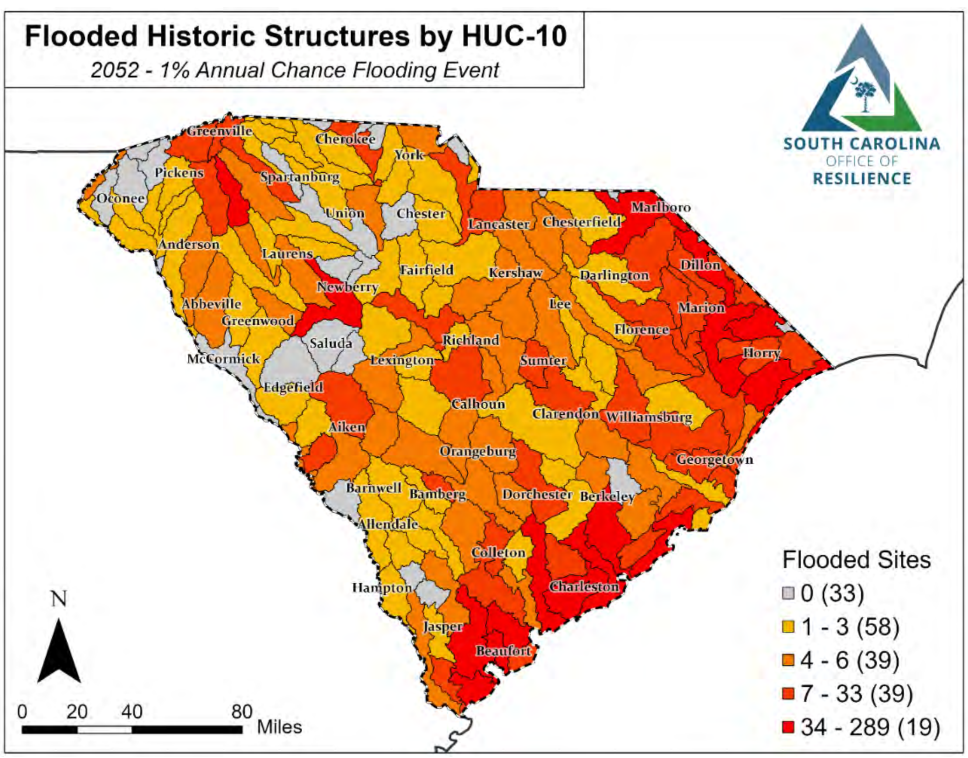

Figure 5.79: Estimated flooding of Historical Structures in the 2052 1% annual chance flooding event by local watershed (HUC-10) (ArchSite). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

COMMUNITY SERVICES

Community services are essential to maintaining the health, safety and welfare of people, economies, and ecosystems through environmental changes and natural hazards.

MILITARY

South Carolina's military community provides critical strategic value to our nation's defense and has a significant presence in our State. The State's location on the East Coast is advantageous for deployment to the Middle East, South and Central America, Africa, and Europe, as well as to Military Operating Areas (MOAs) offshore. Each base supports multiple defense missions that contribute to defense readiness, training, and homeland security (SC Department of Veterans' Affairs, n.d.). Therefore, understanding base exposure as well as access routes to the bases, is important to addressing military readiness.

Figure 5.80: South Carolina Military Installations

Figure 5.81 and Figure 5.82 below display the current and future flood risk to military bases in the Midlands region using the First Street Foundation’s hazard layers for a 1% annual chance flood event.

Figure 5.83 and Figure 5.84 below display the current and future flood risk to military bases in the Beaufort area using the First Street Foundation’s hazard layers for a 1% annual chance flood event.

Figure 5.85 and Figure 5.86 below display the current and future flood risk to military bases in the Charleston area using the First Street Foundation’s hazard layers for a 1% annual chance flood event.

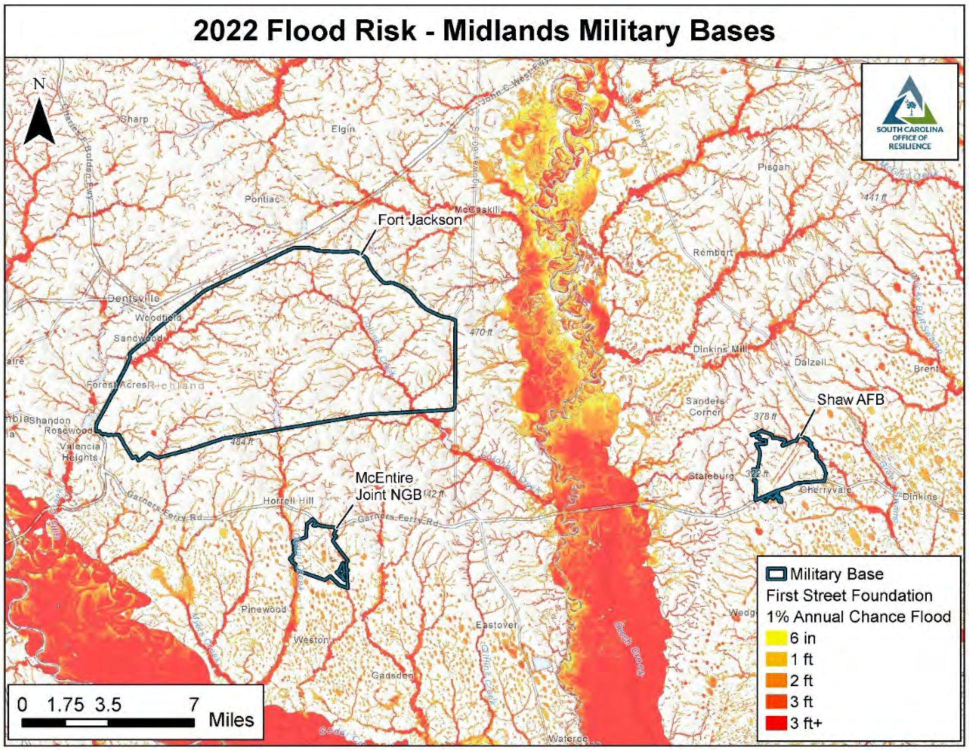

Figure 5.81: Estimated flooding of Military Installations in the Midlands, Fort Jackson, Shaw AFB, and McEntire Joint NGB, in the 2022 1% annual chance flooding event. Flood data provided by the First Street Foundation Hazard Layers, V2.0.

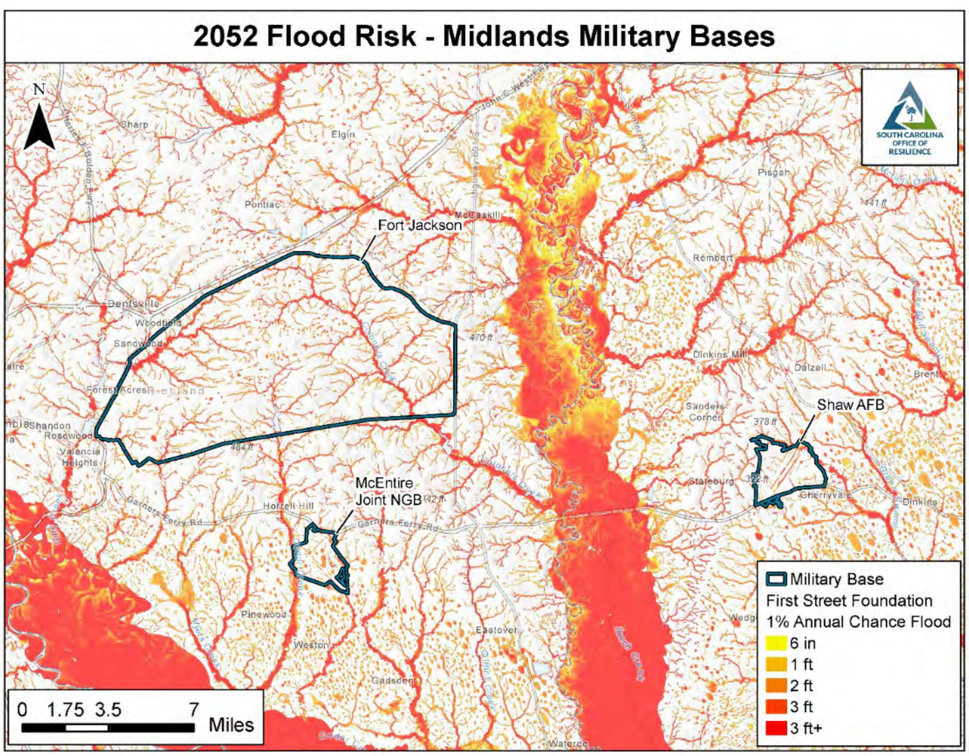

Figure 5.82: Estimated flooding of Military Installations in the Midlands, Fort Jackson, Shaw AFB, and McEntire Joint NGB, in the 2052 1% annual chance flooding event. Flood data provided by the First Street Foundation Hazard Layers, V2.0.

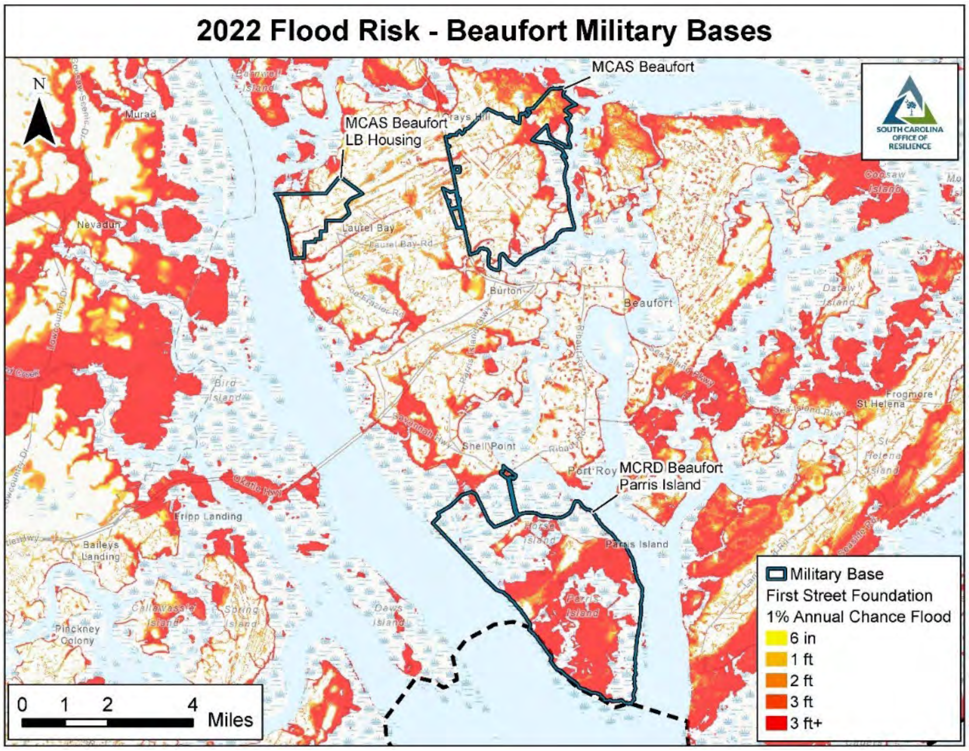

Figure 5.83: Estimated flooding of Military Installations in the Beaufort County: MCAS Beaufort, MCAS Beaufort LB Housing, and MCRD Beaufort Parris Island, in the 2022 1% annual chance flooding event. Flood data provided by the First Street Foundation Hazard Layers, V2.0.

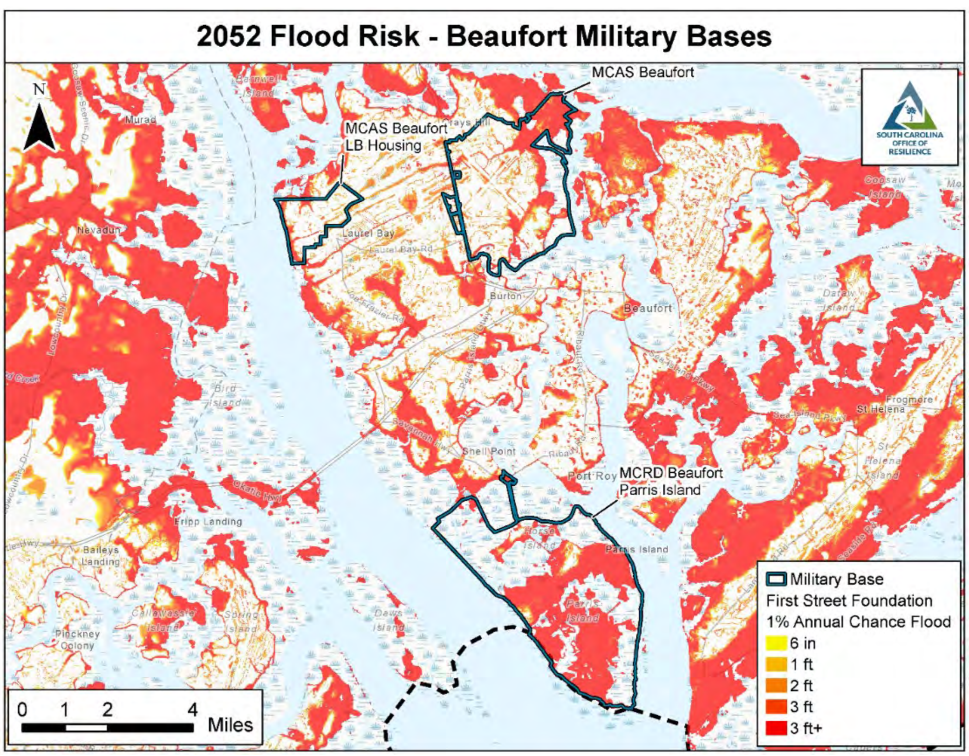

Figure 5.84: Estimated flooding of Military Installations in the Beaufort County: MCAS Beaufort, MCAS Beaufort LB Housing, and MCRD Beaufort Parris Island, in the 2052 1% annual chance flooding event. Flood data provided by the First Street Foundation Hazard Layers, V2.0.

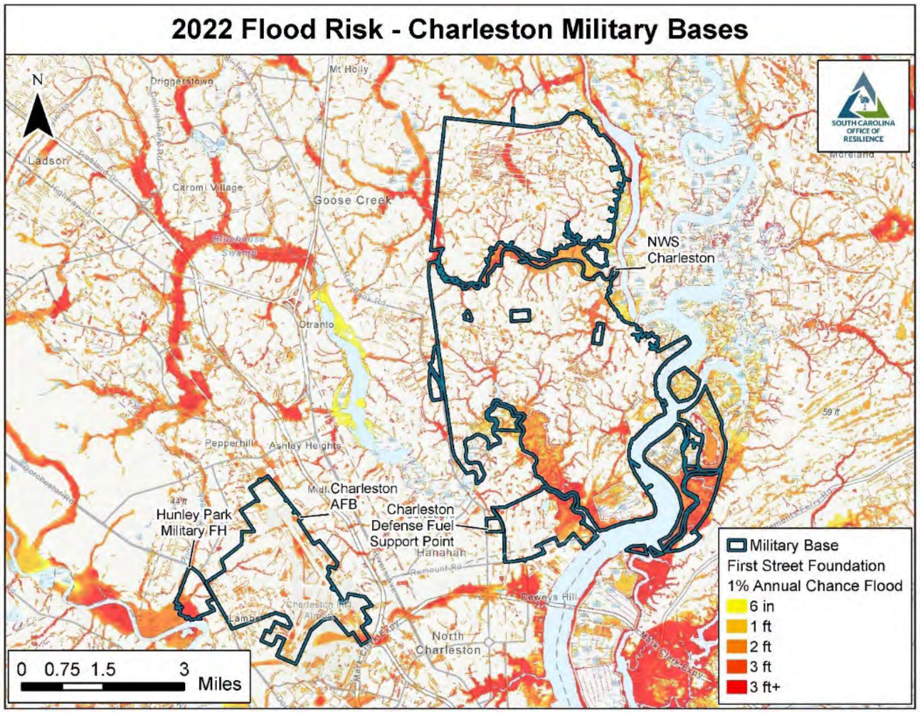

Figure 5.85: Estimated flooding of Military Installations in the Charleston County: NWS Charleston, Charleston Defense Fuel Support Point, Charleston AFB, and Hunley Park Military FH, in the 2022 1% annual chance flooding event. Flood data provided by the First Street Foundation Hazard Layers, V2.0.

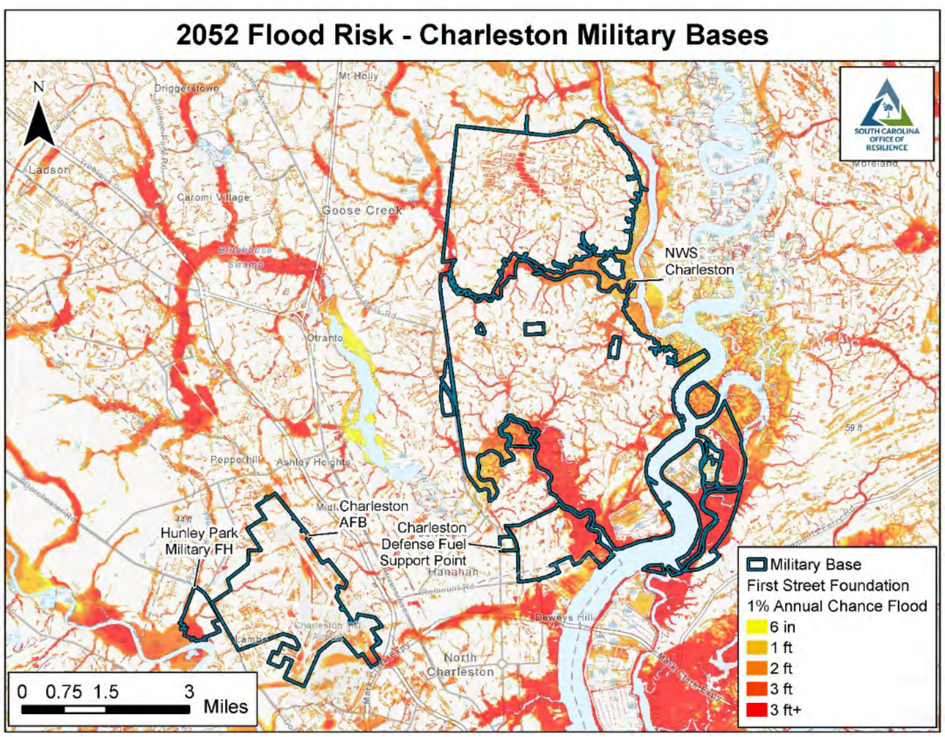

Figure 5.86: Estimated flooding of Military Installations in the Charleston County: NWS Charleston, Charleston Defense Fuel Support Point, Charleston AFB, and Hunley Park Military FH, in the 2052 1% annual chance flooding event. Flood data provided by the First Street Foundation Hazard Layers, V2.0.

PUBLIC SAFETY

STATE LEVEL LAW ENFORCEMENT

State level law enforcement in South Carolina is split across several agencies. The Department of Public Safety and the State Law Enforcement Division (SLED) act in coordination with local and federal entities. Services provided include crime investigation, emergency response, intelligence gathering, protective services, and highway patrol. In times of emergency, personnel and resources are deployed preemptively to provide support functions to the afflicted areas.

The SC Criminal Justice Academy (SCCJA) is responsible for all mandated basic law enforcement, detention, and telecommunications training in South Carolina. The Academy provides full training continuity to every law enforcement officer in the state (includes over 300 law enforcement agencies). In addition, the SCCJA serves as a housing and operational staging point during emergencies for agencies such as FEMA, National Guard, Emergency Rescue Teams, and deployment teams.

The South Carolina Department of Probation, Parole and Pardon Services (PPP) is an accredited law enforcement agency that is charged with the community supervision of offenders placed on probation by the court and paroled by the State Board of Paroles and Pardons. The Department is committed to the use of innovative, cost effective strategies proven to reduce new crime and new victimization in South Carolina. PPP is currently divided into 5 Regions and has offices in all 46 counties. PPP provides assistance and staffing for Emergency Support Function-13 security missions, hurricane evacuations, and other natural disaster assistance when called upon.

LOCAL LAW ENFORCEMENT

While the above state agencies support local law enforcement agencies, initial response depends on county, city, and town law enforcement agencies.

The figures below illustrate the number of local law enforcement facilities vulnerable in the 2022 (Figure 5.87) and 2052 (Figure 5.88) 1% annual chance flood events.

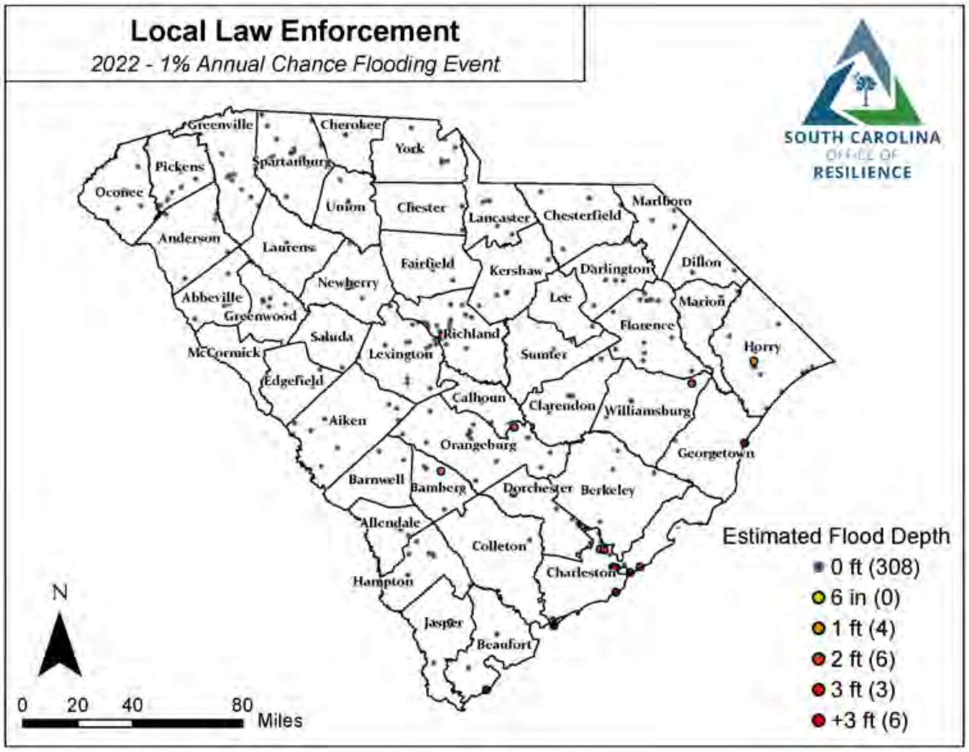

Figure 5.87: Estimated flooding of local law enforcement agencies in the 2022 1% annual chance flooding event (SLED). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

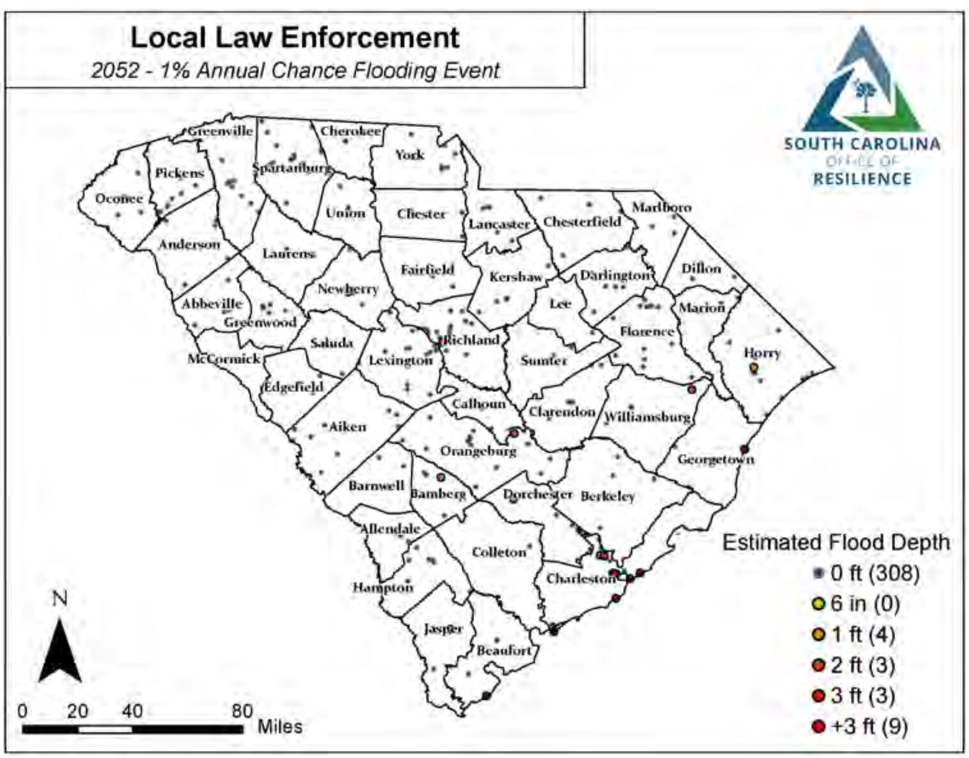

Figure 5.88: Estimated flooding of local law enforcement agencies in the 2022 1% annual chance flooding event (SLED). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

DETENTION CENTERS

SLED identifies 84 detention centers across the state, which includes county, state federal, and juvenile facilities.

One of the most studied and pressing issues that these detention centers and the SC Department of Corrections face during flooding events is the need to evacuate large numbers of people from the facilities. The figures below illustrate the vulnerability of these centers in the 2022 (Figure 5.89) and 2052 (Figure 5.90) 1% annual chance flood events.

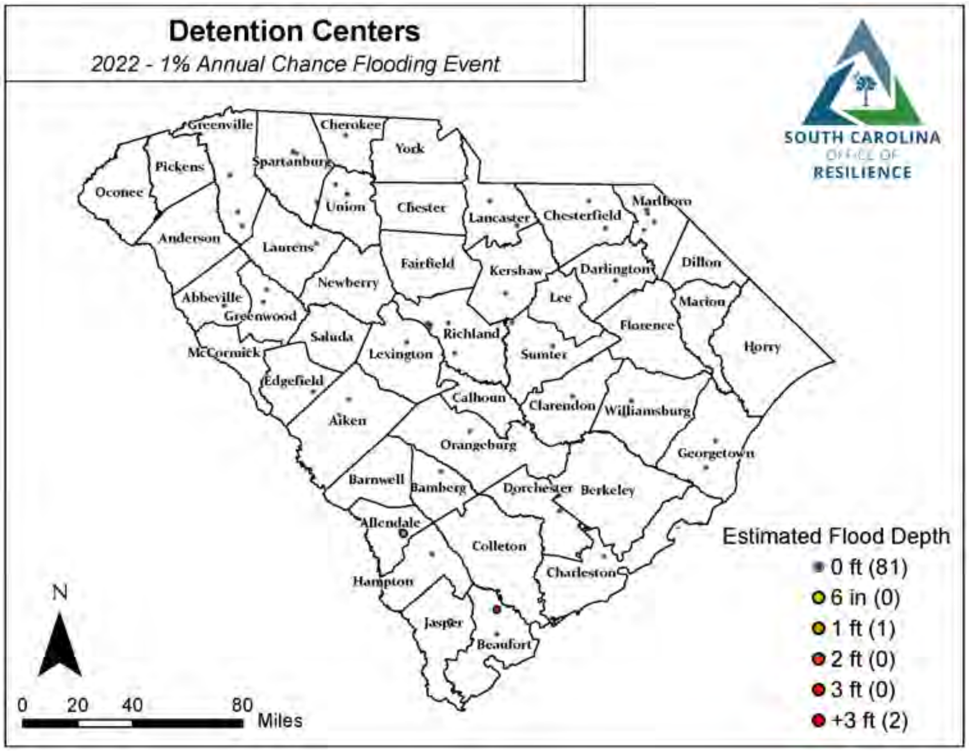

Figure 5.89: Estimated flooding of detention centers in the 2022 1% annual chance flooding event (SLED). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

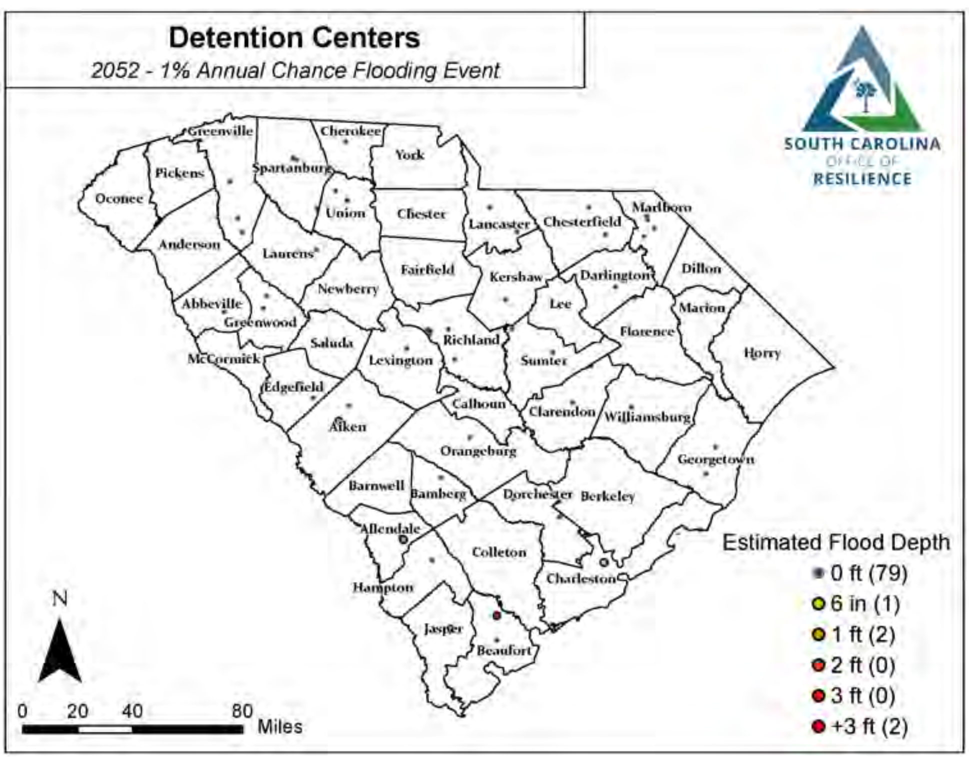

Figure 5.90: Estimated flooding of detention centers in the 2052 1% annual chance flooding event (SLED). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

FIRE STATIONS

Fire stations provide response to a variety of incidents, disasters, and situations. The public relies heavily on first responders during daily emergencies, and even more during disasters, when there is an even greater need for assistance.

Flooding can create dangerous barriers for fire personnel to get to the needed locations. The figures below illustrate the vulnerability of these stations in the 2022 (Figure 5.91) and 2052 (Figure 5.92) 1% annual chance flood events. The data points include manned fire stations and buildings from which a fire response occurs, such as volunteer fire department buildings, and includes both private and governmental entities.

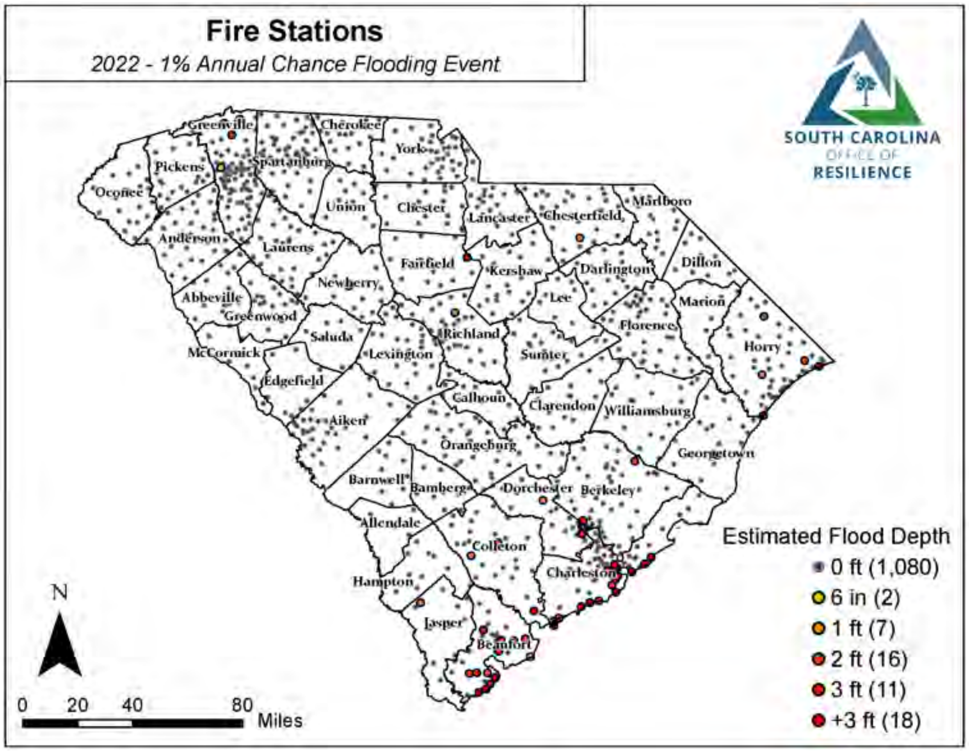

Figure 5.91: Estimated flooding of fire stations in the 2022 1% annual chance flooding event (Department of Homeland Security). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

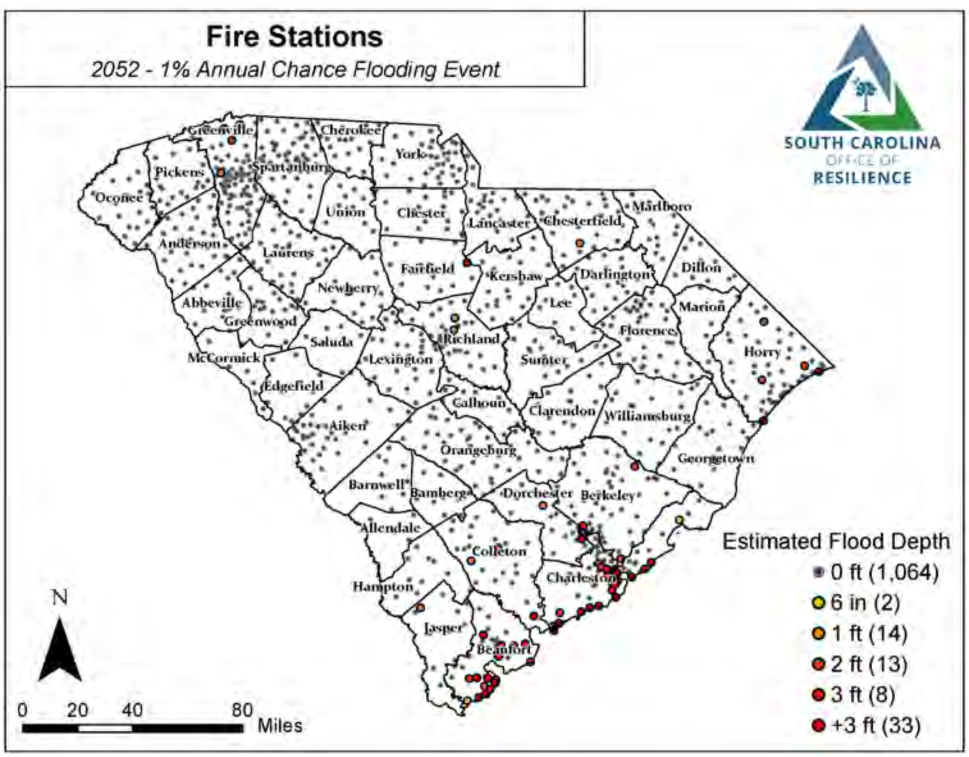

Figure 5.92: Estimated flooding of fire stations in the 2052 1% annual chance flooding event (Department of Homeland Security). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

EMERGENCY MEDICAL SERVICES (EMS)

Like fire stations, EMS stations and personnel are needed daily, but in increased demand leading up to, during, and after a disaster. There are an increased number of calls to respond to, and more barriers to arriving on the scene.

The figures below illustrate the vulnerability of these stations in the 2022 (Figure 5.93) and 2052 (Figure 5.94) 1% annual chance flood events on these stations.

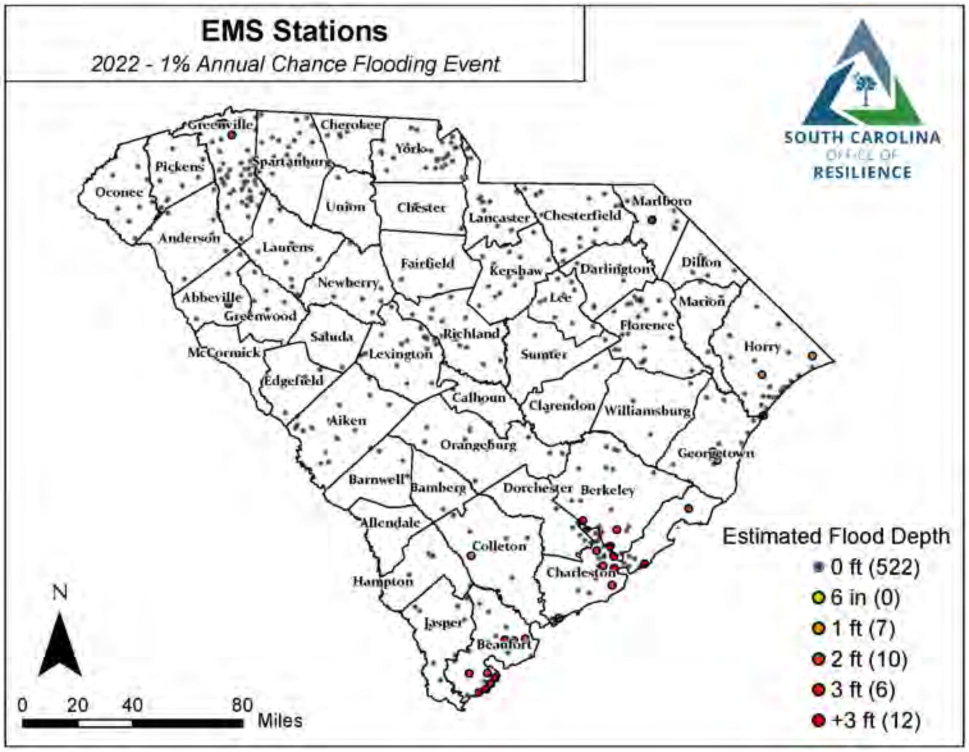

Figure 5.93: Estimated flooding of EMS stations in the 2022 1% annual chance flooding event (Department of Homeland Security). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

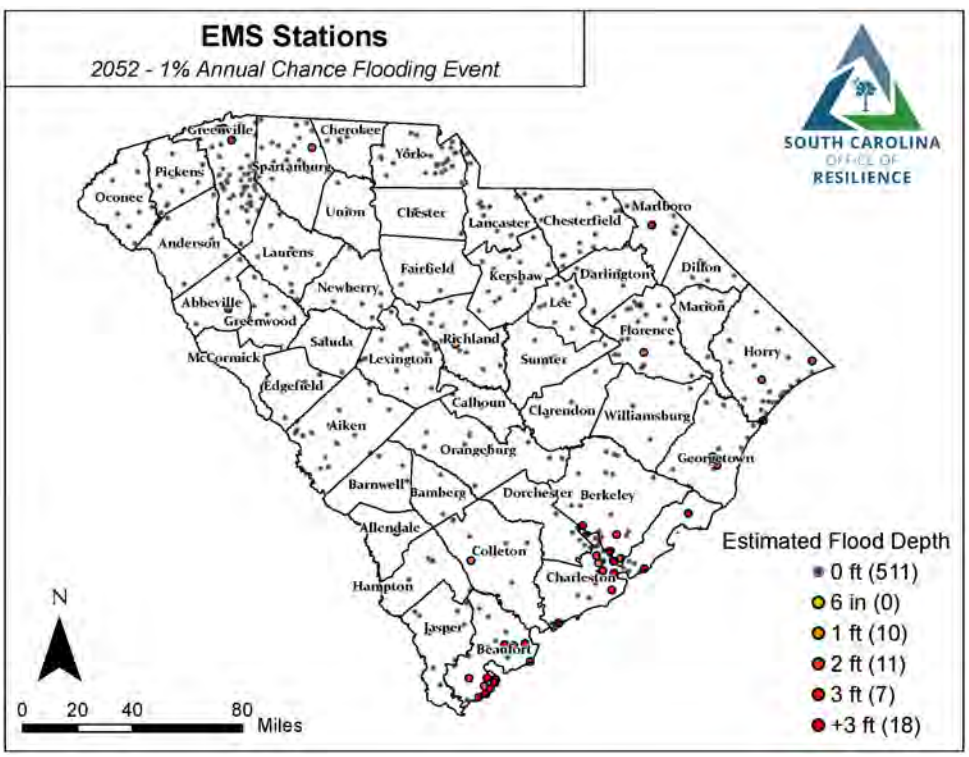

Figure 5.94: Estimated flooding of EMS stations in the 2052 1% annual chance flooding event (Department of Homeland Security). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

EDUCATION

In addition to the initial impact of an event on school buildings, hazard events have the potential to force schools to close for long periods of time, disrupting student learning.

K-12 EDUCATION

According to the South Carolina Department of Education's Active Student Headcounts, there are 777,111 students enrolled in South Carolina public schools (SC Department of Education, 2022). The damage public schools face due to natural hazards is compounded by their age and condition, and not being built to withstand such hazards (The Pew Charitable Trusts, 2017). While the maps below illustrate the vulnerability of public K-12 schools in the 2022 (Figure 5.95) and 2052 (Figure 5.96) 1% annual chance flood events, they do not consider these factors. Additionally, there are nearly 300 private K-12 schools across the state, shown in Figure 5.97 and Figure 5.98.

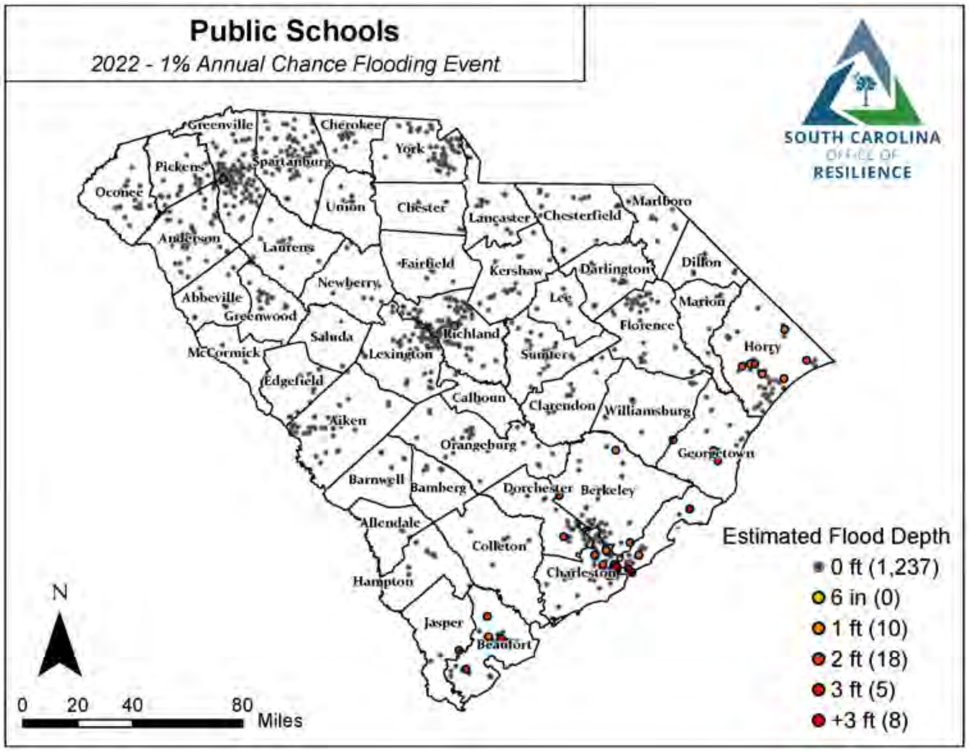

Figure 5.95: Estimated flooding of public schools in the 2022 1% annual chance flooding event (Department of Homeland Security). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

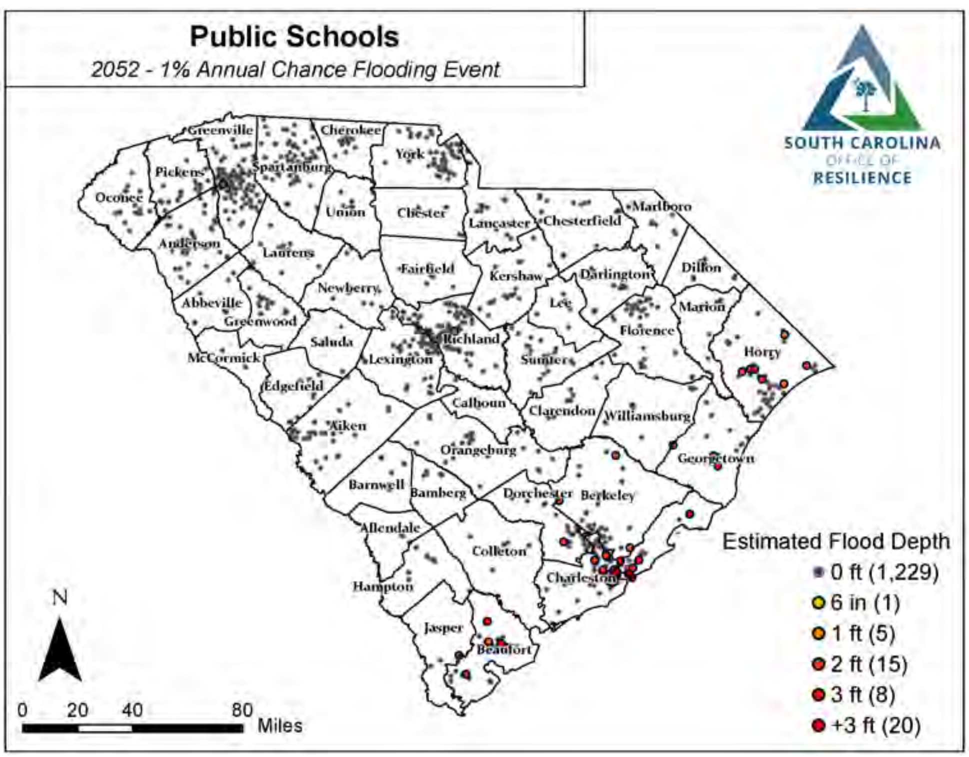

Figure 5.96: Estimated flooding of public schools in the 2052 1% annual chance flooding event (Department of Homeland Security). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

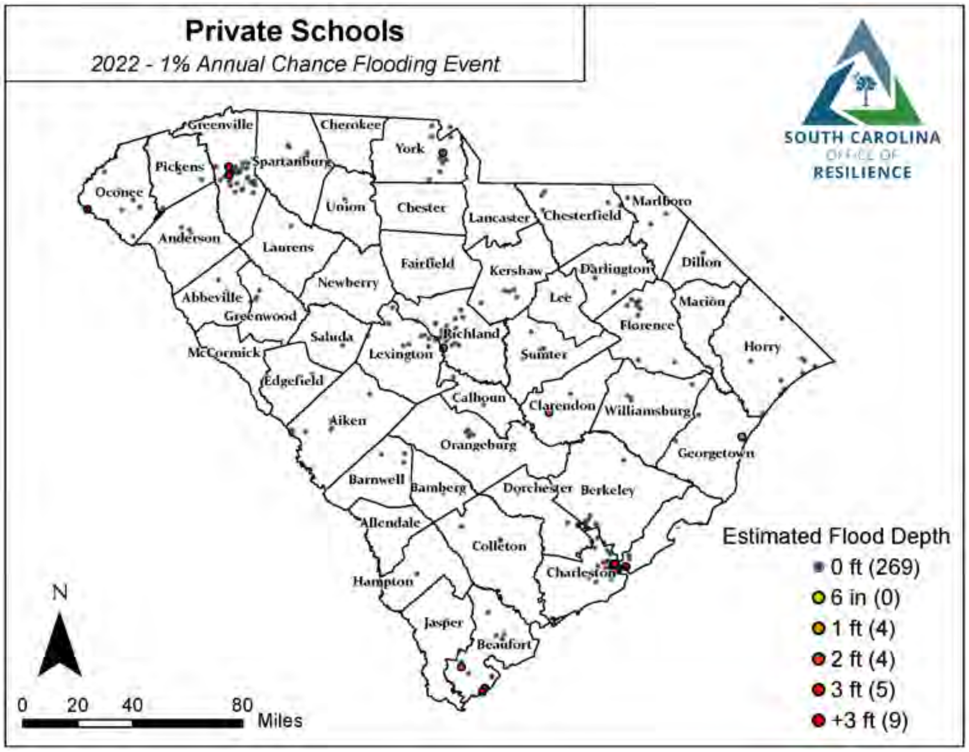

Figure 5.97: Estimated flooding of private schools in the 2022 1% annual chance flooding event (Department of Homeland Security). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

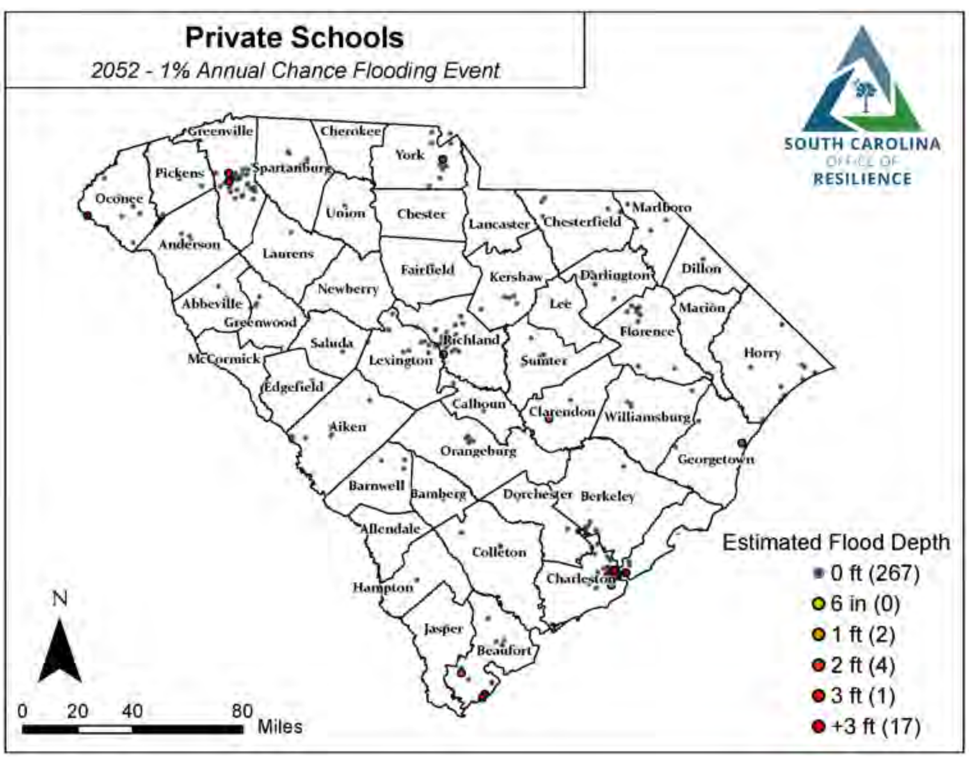

Figure 5.98: Estimated flooding of private schools in the 2052 1% annual chance flooding event (Department of Homeland Security). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

HIGHER EDUCATION

There are 33 public colleges and universities as well as 25 independent institutions in South Carolina. In Fall 2020, these institutions enrolled 229,781 students, 69.8% of which were full-time students. In the previous school year (2019-2020), these institutions awarded 52,670 degrees, 49.4% of which were bachelor's degrees. This is a 14.5% increase over total degrees awarded in the 2010-2011 school year. From an economic perspective, public and private institutions employ nearly 16,000 faculty members, 48% full-time (SC Commission on Higher Education, 2021).

In terms of physical vulnerability, public institutions alone have a building footprint of over 36 million square feet of usable space across the state, 28% of which is instructional space. 10% of all public campus buildings are over 99 years old, while over 40% of buildings are over 50 years old.

The figures below illustrate the vulnerability of 2-year and 4-year public and private institutions to the 2022 (Figure 5.99) and 2052 (Figure 5.100) 1% annual chance flood events. This data set does not include online colleges

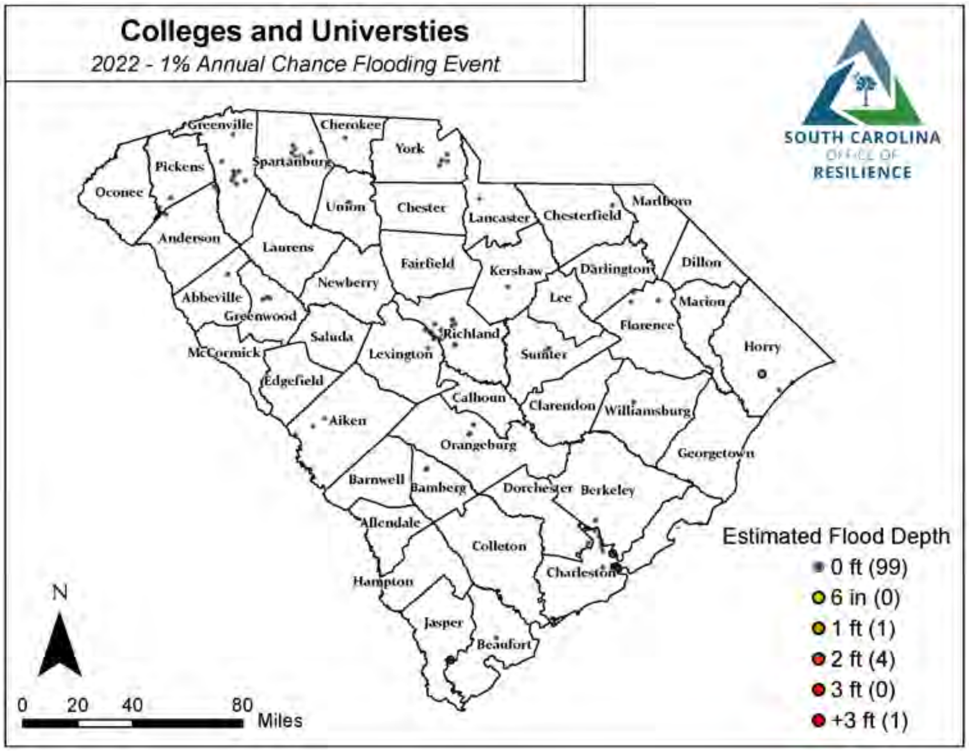

Figure 5.99: Estimated flooding of colleges and universities in the 2022 1% annual chance flooding event (Department of Homeland Security). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

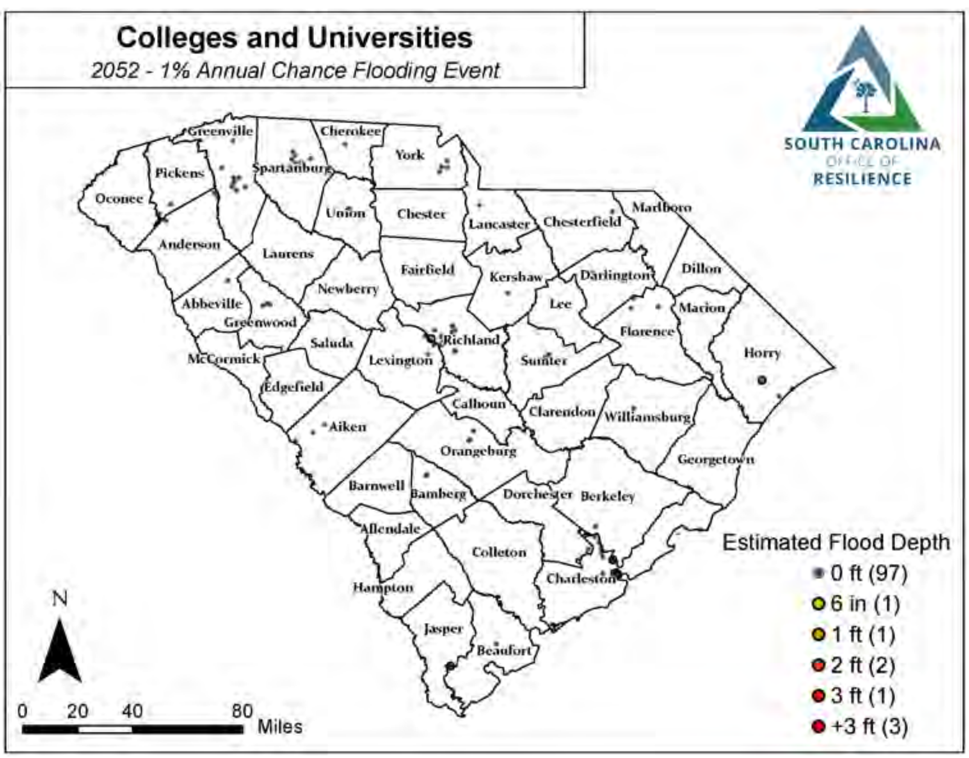

Figure 5.100: Estimated flooding of colleges and universities in the 2052 1% annual chance flooding event (Department of Homeland Security). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

PUBLIC HEALTH

Environmental change and natural hazards can impact those with existing illnesses as well as cause outbreaks of vector-borne diseases due to the presence of mosquitoes and the growth of pathogens in flood waters, for example, which can in turn affect things like food supply, water quality and other factors negatively impacting public health.

PUBLIC HEALTH FACILITIES

DHEC’s Bureau of Health Facility Licensing (BHFL) regulates health care facilities and providers, enforcing standards, inspections, and licenses for nursing homes, hospices, home health agencies, ambulatory surgical centers, adult day cares, and renal dialysis centers that provide essential health services.

Those facilities are included in Figure 5.101 and Figure 5.102 below.

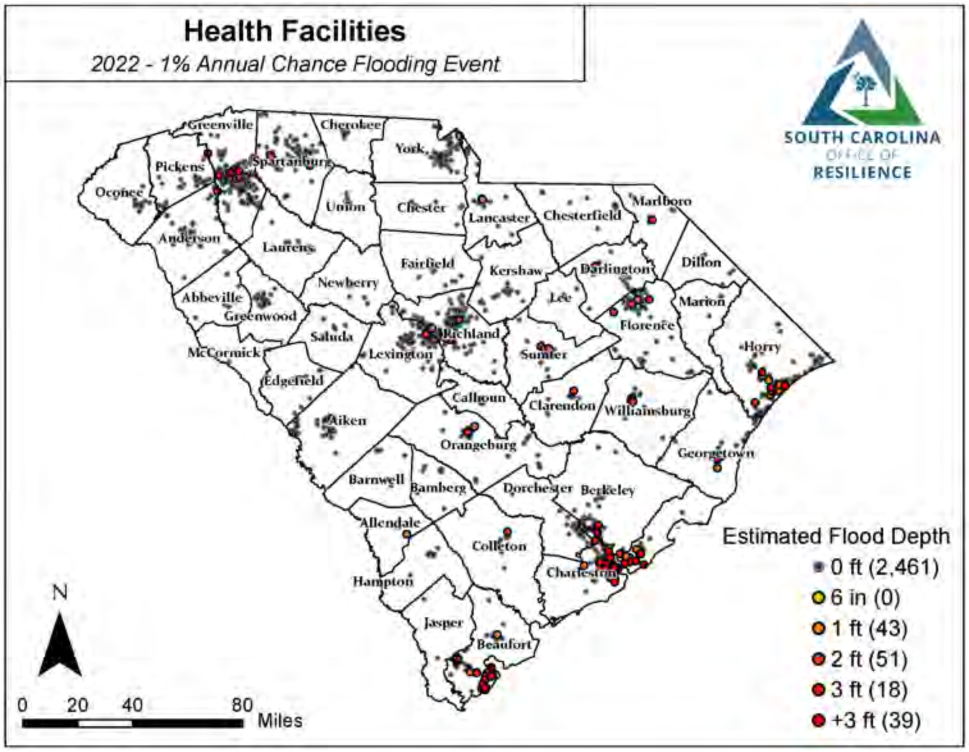

Figure 5.101: Estimated flooding of health facilities in the 2022 1% annual chance flooding event (DHEC). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

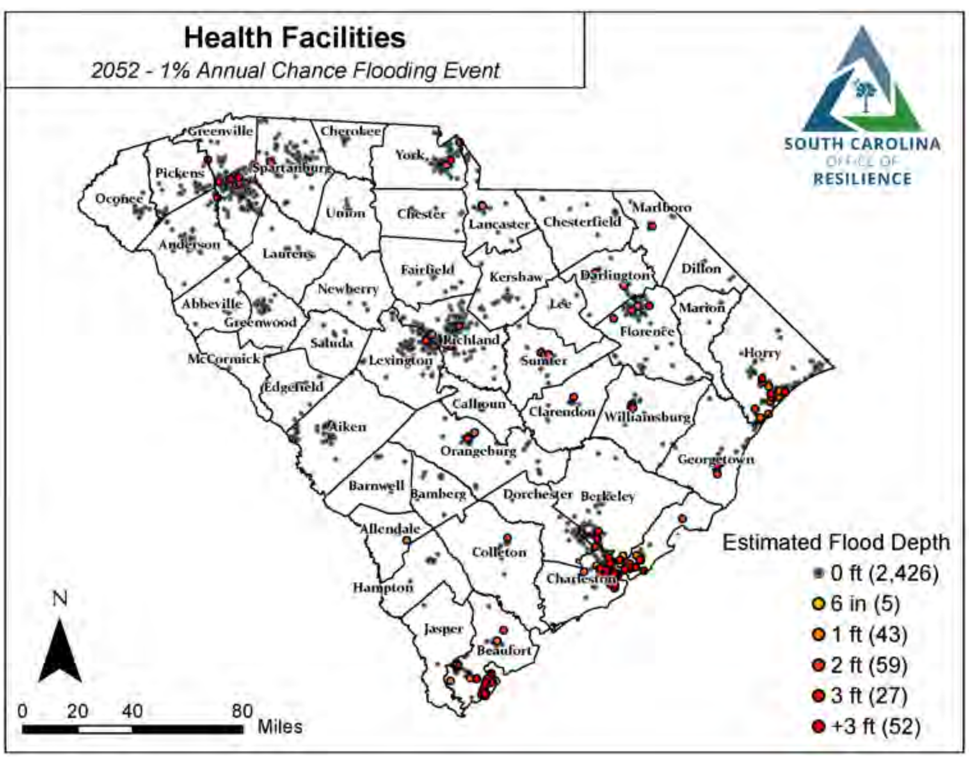

Figure 5.102: Estimated flooding of health facilities in the 2052 1% annual chance flooding event (Department of Homeland Security). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

HOSPITALS

Across the state, there are over 100 hospitals. In addition to the physical vulnerabilities of these facilities, environmental changes and natural hazards can increase the demand for medical care, as a result of immediate injuries from natural hazards or cascading impacts. Hospitals can experience increased demand and continue to be essential leading up to, during, and in the short and long term after an event. In the time leading up to an event, especially in the case of evacuations, there can be increased traffic accidents. During and immediately after an event, those who cannot or do not leave may be trapped and in need of medical care. Road detours and closures before and during an event can limit access to hospitals for both patients and staff. Demand for medical care may intensify as event effects linger. A common issue is carbon-monoxide poisoning related to the use of gas-powered generators (SC Sea Grant Consortium, 2019).

The figures below illustrate the vulnerability of hospitals in the 2022 (Figure 5.103) and 2052 (Figure 5.104) 1% annual chance flood events.

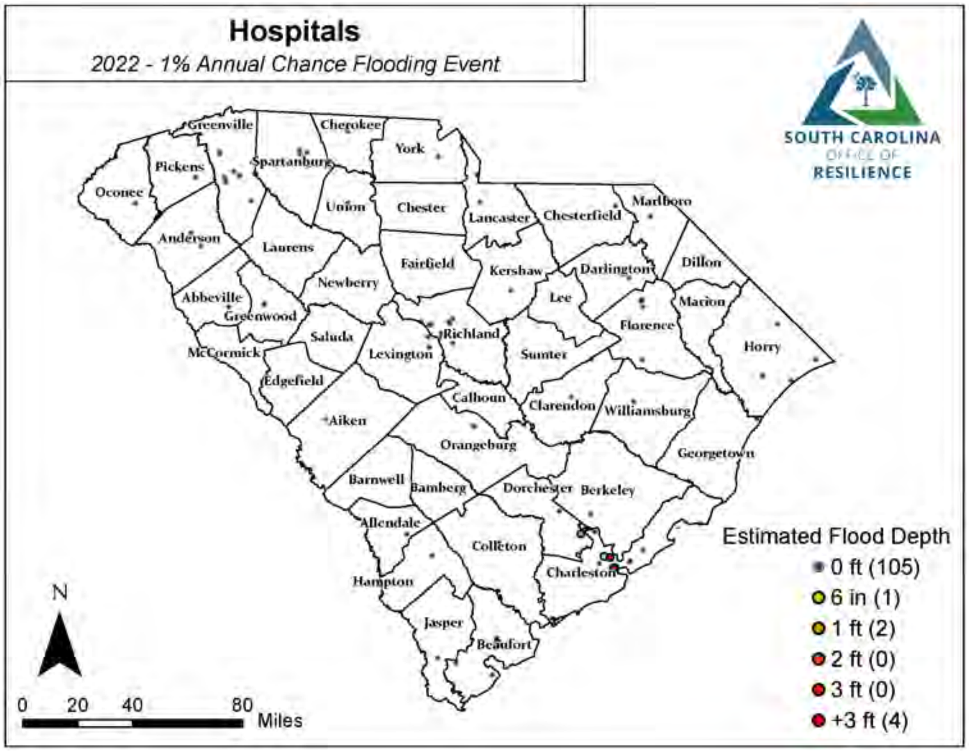

Figure 5.103: Estimated flooding of hospitals in the 2022 1% annual chance flooding event (Department of Homeland Security). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

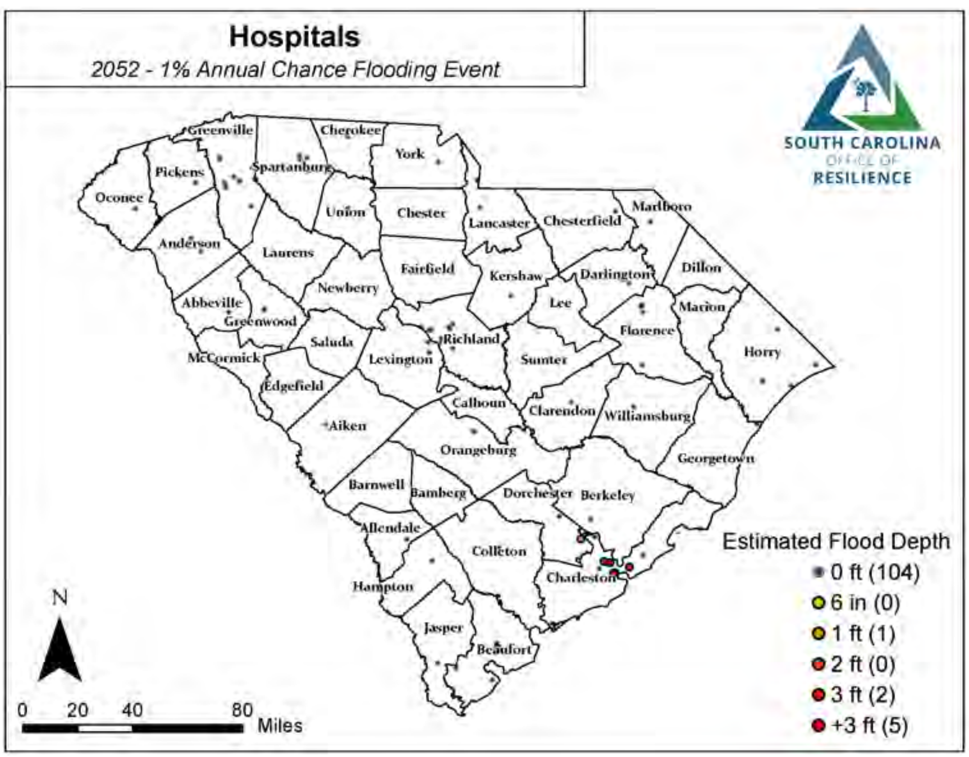

Figure 5.104: Estimated Flooding of hospitals in the 2052 1% annual chance flooding event (Department of Homeland Security). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

NURSING HOMES

Nursing homes have similar vulnerabilities to hospitals when it comes to providing medical care. Due to the residential nature of these facilities, there is the potential for long term impacts, if the event requires residents to find other homes to live in and results in the loss of personal belongings.

The figures below illustrate the vulnerability of these facilities to the 2022 (Figure 5.105) and 2052 (Figure 5.106) 1% annual chance flood events. This database from DHS includes facilities that house older adults and assisted care facilities.

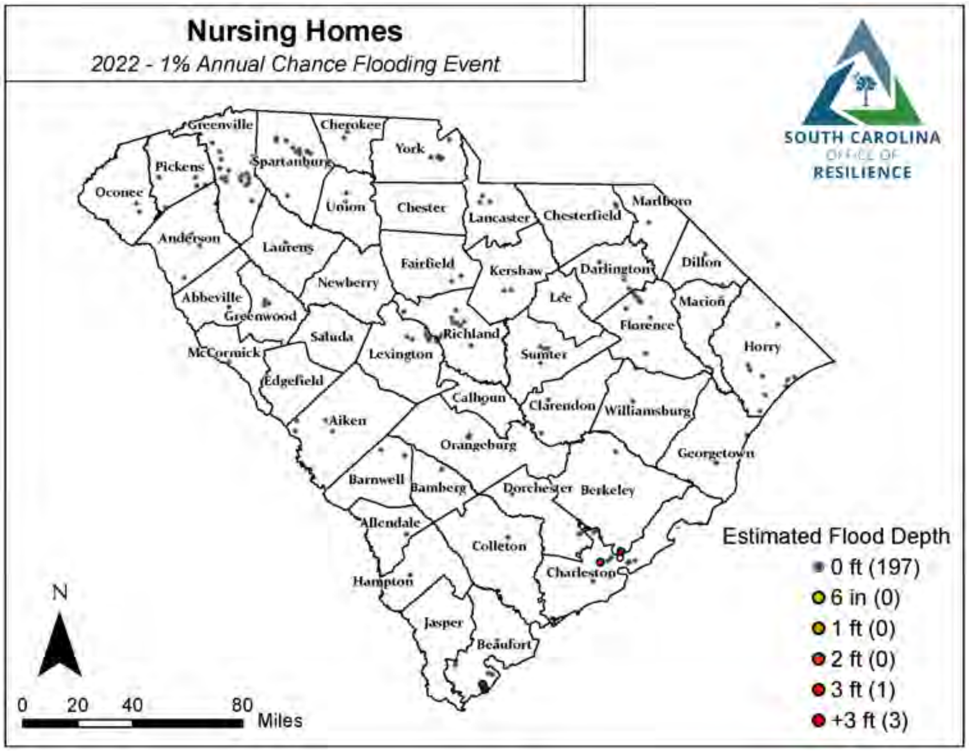

Figure 5.105: Estimated flooding of nursing homes in the 2022 1% annual chance flooding event (Department of Homeland Security). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

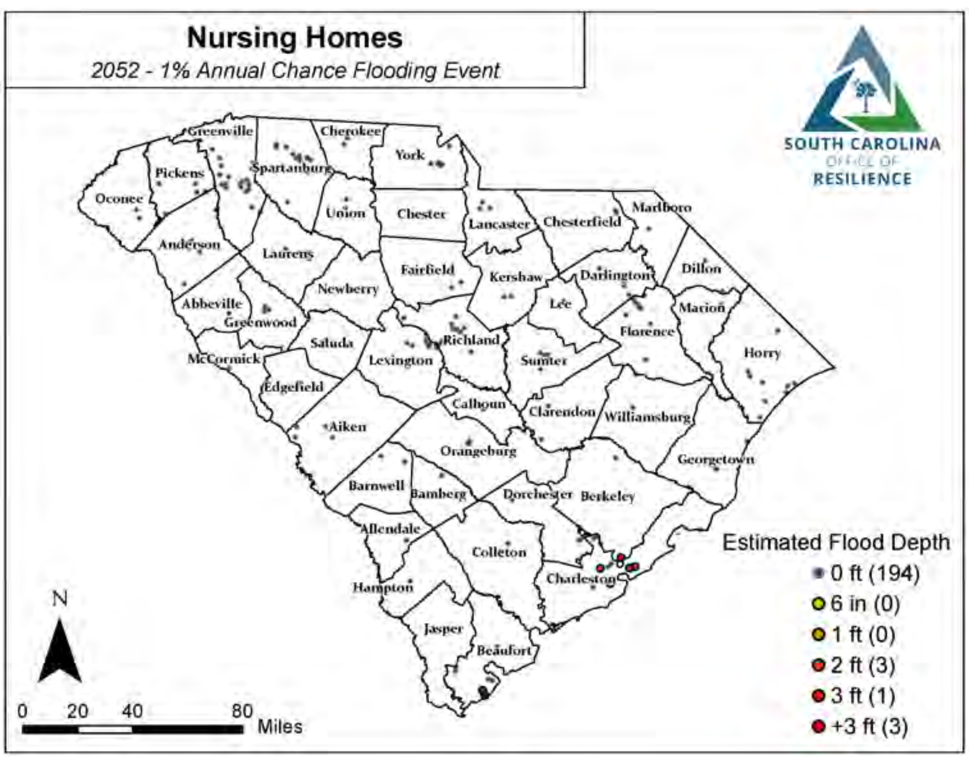

Figure 5.106: Estimated flooding of nursing homes in the 2052 1% annual chance flooding event (Department of Homeland Security). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

MENTAL HEALTH FACILITIES

Experiencing environmental change and natural hazards can be stressful, and for some people, they may result in serious mental health consequences and make access to care for ongoing conditions more difficult. According to the South Carolina Behavioral Health 2021 Progress Report, nearly a fifth of South Carolinians live with mental illness, with 18.3% reporting a diagnosable mental, behavioral, or mental disorder in 2018 as reported by Mental Health America (South Carolina Institute of Medicine & Public Health, 2021).

There are 79 offices operated by the South Carolina Department of Mental Health (DMH), helping individuals with addiction, Anxiety, Attention Deficit Disorder (ADD), behavioral problems, Bipolar Disorder, Depression, Oppositional Defiant Disorder (ODD), suicide risk, thought disorders, and trauma. This includes 3 hospitals, 4 nursing homes, 16 Community Mental Health Centers, and 43 Mental Health Clinics. The vulnerability of these programs is not isolated to the physical facilities but incorporates the mental health professionals and the patient's access to these locations. Events may create accessibility issues, as well as serve as a traumatic event, spurring the need for more mental healthcare in its wake.

The figures below illustrate the vulnerability of these offices to the 2022 (Figure 5.107) and 2052 (Figure 5.108) 1% annual chance flood event.

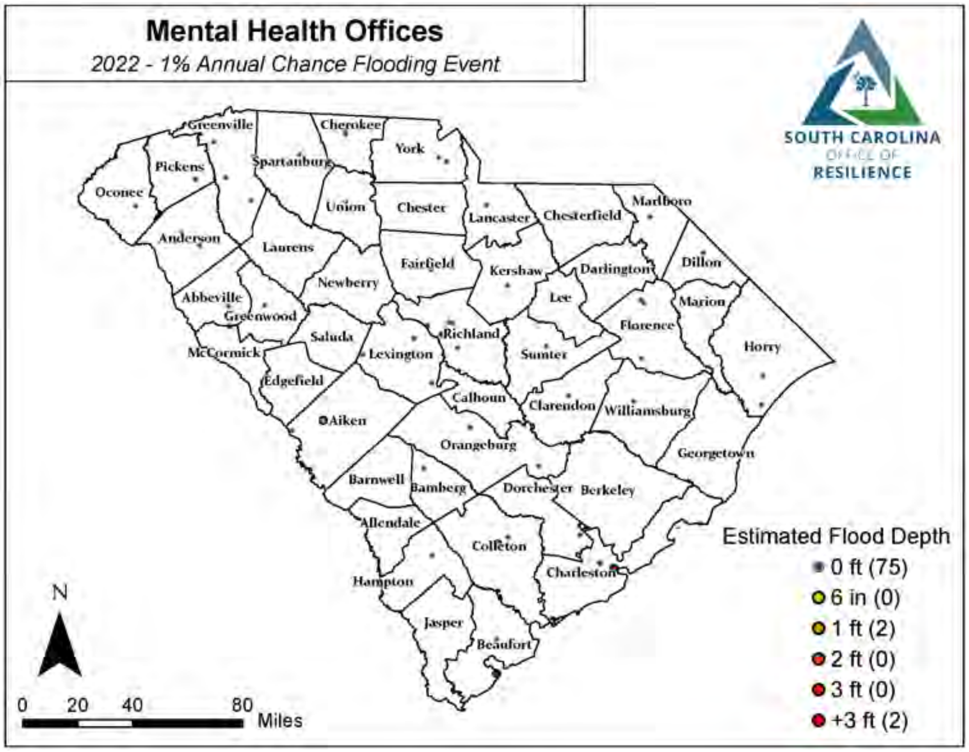

Figure 5.107: Estimated flooding of mental health offices in the 2022 1% annual chance flooding event (DMH). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

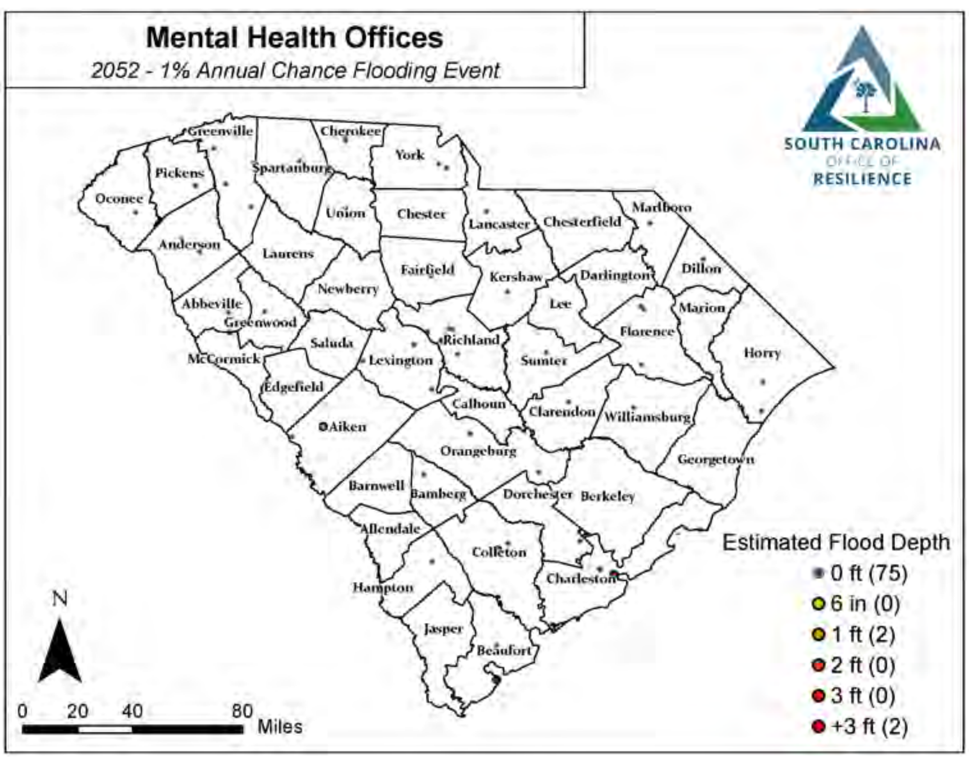

Figure 5.108: Estimated flooding of mental health offices in the 2052 1% annual chance flooding event (DMH). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

DIALYSIS CLINICS

Flooding has the potential to place large numbers of patients treated with maintenance dialysis or individuals with a recent onset of acute kidney injury at risk due to lack of access to dialysis care. Dialysis treatment requires specialized equipment, power, and high-quality water, all of which may be compromised during a hazard event. Dialysis clinics may close ahead of or in response to an event. Even if clinics are able to operate, access can be limited after an event, leading to increased demand at accessible clinics (Lempert & Kopp, 2013).

The figures below illustrate the estimated flooding of these centers by the 2022 (Figure 5.109) and 2052 (Figure 5.110) 1% annual chance flood events on these facilities.

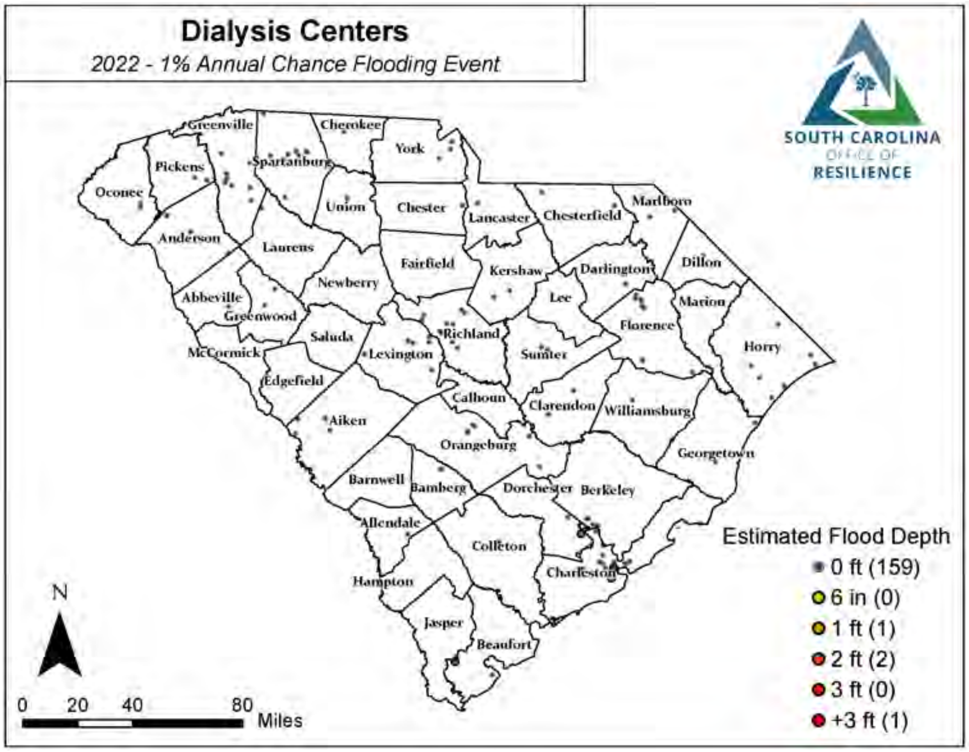

Figure 5.109: Estimated flooding of dialysis centers in the 2022 1% annual chance flooding event (Department of Homeland Security). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

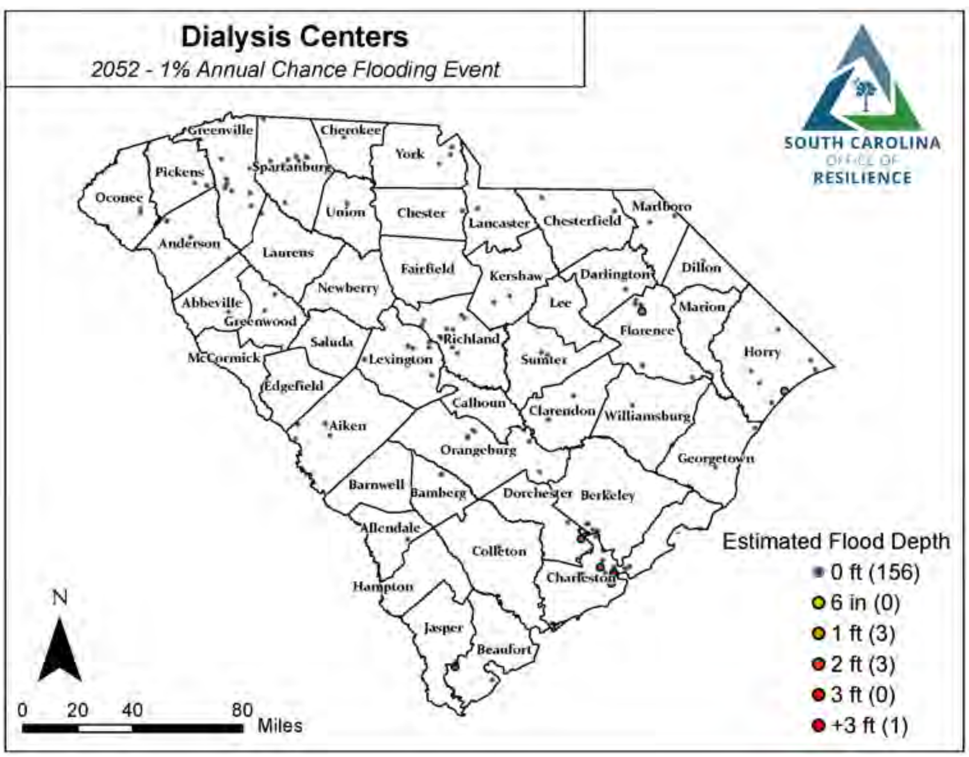

Figure 5.110: Estimated flooding of dialysis centers in the 2052 1% annual chance flooding event (Department of Homeland Security). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

PHARMACIES

People need access to their prescription medication to maintain continuity of care leading up to, during, and after an event. Approximately half of all Americans live with a chronic disease that requires prescription medications. Evacuations and preparation can increase demand for pharmacy services and medication doses. After an event, pharmacies may be closed for extended periods of time or have supply chain issues. A study of Hurricane Florence found that pharmacy function along the North Carolina and South Carolina coast was “suboptimal” (Sharpe & Clennon, 2020).

The figures below illustrate the estimated flooding of pharmacies in 2022 (Figure 5.111) and 2052 (Figure 5.112) 1% annual chance flooding event.

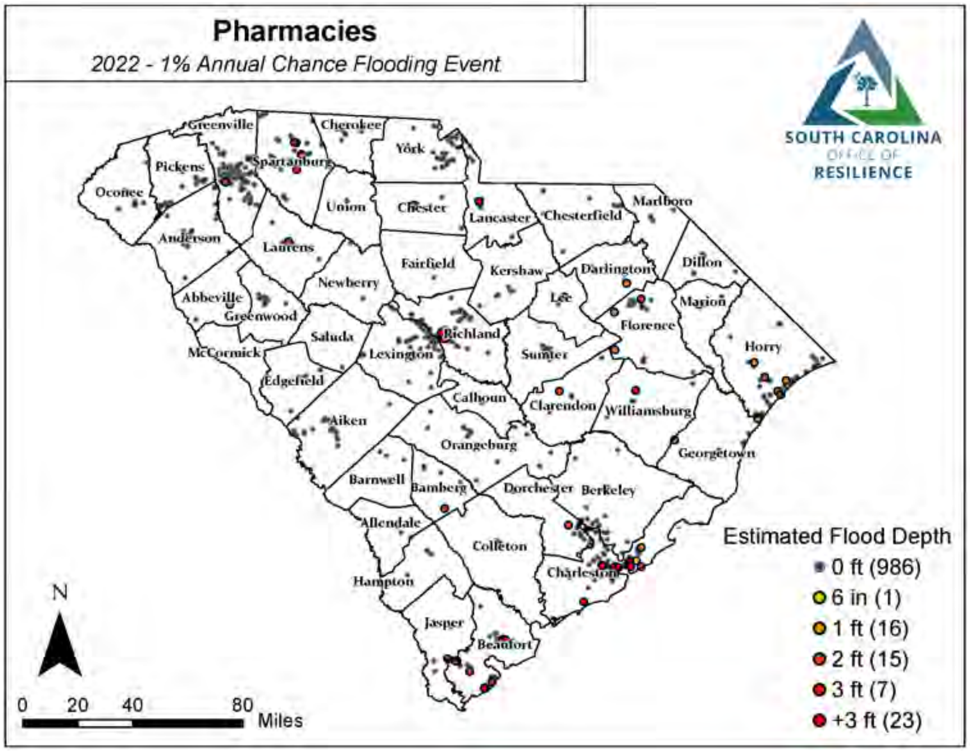

Figure 5.111: Estimated flooding of pharmacies in the 2022 1% annual chance flooding event (Department of Homeland Security). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

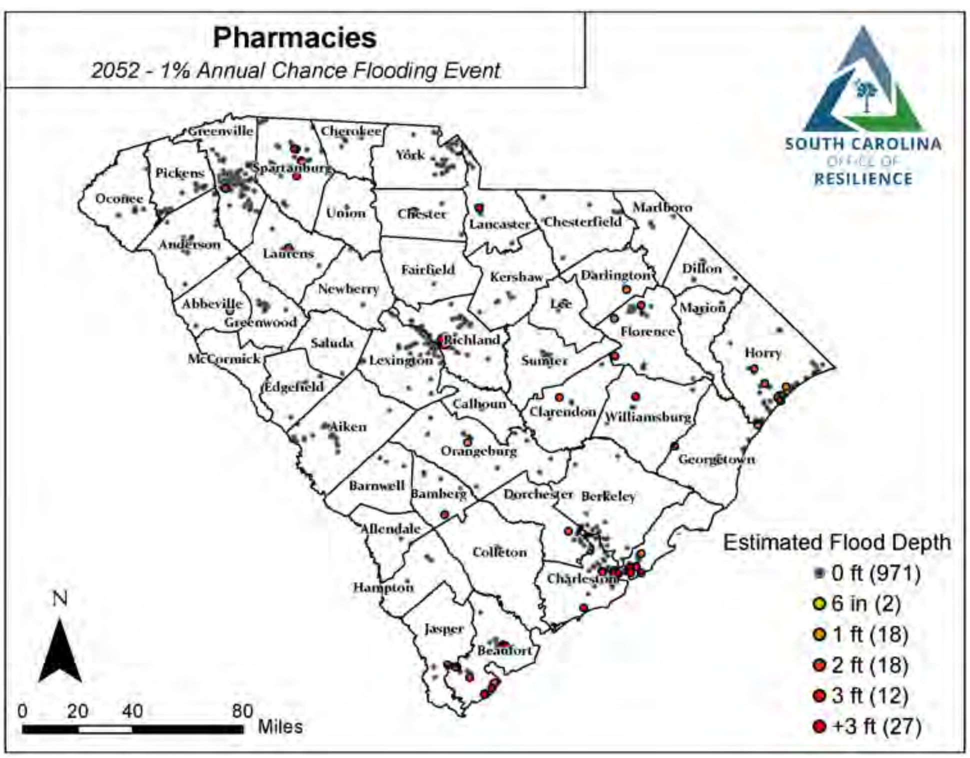

Figure 5.112: Estimated flooding of pharmacies in the 2052 1% annual chance flooding event (Department of Homeland Security). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

TELEHEALTH

Telehealth services gained momentum during the COVID-19 pandemic, with authorizations for the use of federal funds to expand telehealth. The SC Telehealth Alliance Strategic Plan seeks to continue this expansion; however, a potential barrier is the lack of broadband service across the State. Nearly 435,000 people across the state either have no internet service provider available or have internet service that is not capable of person-to-person telehealth visits (South Carolina Telehealth Alliance, 2022). Additionally, as noted in this chapter, flooding can have a significant impact on internet cables, especially those that are underground or located near bodies of water causing disruption of services.

HEALTH AND HUMAN SERVICES

The SC Department of Health and Human Services (DHHS) administers a variety of health related service programs. This includes Medicaid, Community Long Term Care, Telehealth, and BabyNet.

> Medicaid: Medicaid supports 1 in 4 South Carolinians. The program serves to expand medical coverage to those with certain income thresholds as well as pregnant women and newborns, the elderly, the blind, the disabled, and those who may be in a nursing home or hospital for extended periods of time. DHHS maintains offices in every county that serve as enrollment centers for Medicaid.
>
> Community Long Term Care (CLTC): CLTC provides in-home services to Medicaid-eligible people wish to remain in their home but need special services. CLTC services are available for persons aged 18 years or older who are unable to perform activities of daily living such as bathing, dressing, and toileting due to illness or disability. In order to meet the qualifications to enroll into the Community Choices waiver the individual must meet the same level of care that is needed to enter a nursing facility (SC Department of Health and Human Services, n.d.). There are 14 CLTC enrollment offices throughout the state, but the major vulnerability lies with connecting health providers with those residents who depend on them, as well as making sure that the patient's residence is safe in times of flooding.
>
> BabyNet: The BabyNet program connects children and youths with developmental delays or disabilities to care programs for early intervention, special education, and related programs. There are 14 offices throughout the state where children can be referred and enrolled to the program.

The maps below show the vulnerability of these offices to flooding in the 2022 (Figure 5.113) and 2052 (Figure 5.114) 1% annual chance flood event

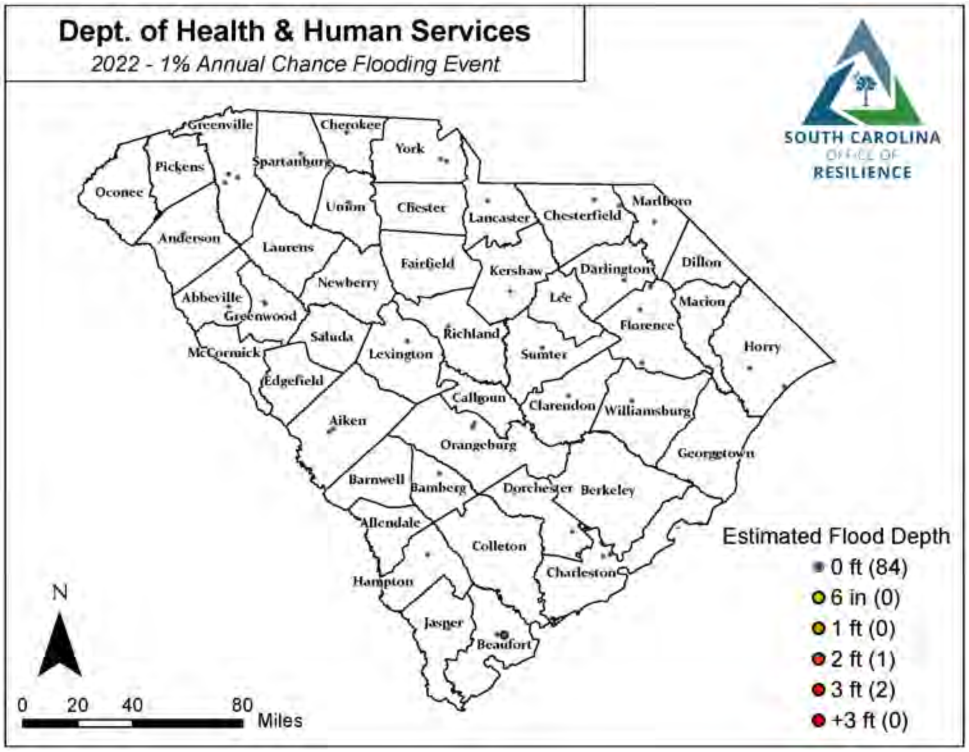

Figure 5.113: Estimated flooding of Department of Health and Human Services' offices in the 2022 1% annual chance flooding event (DHHS). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

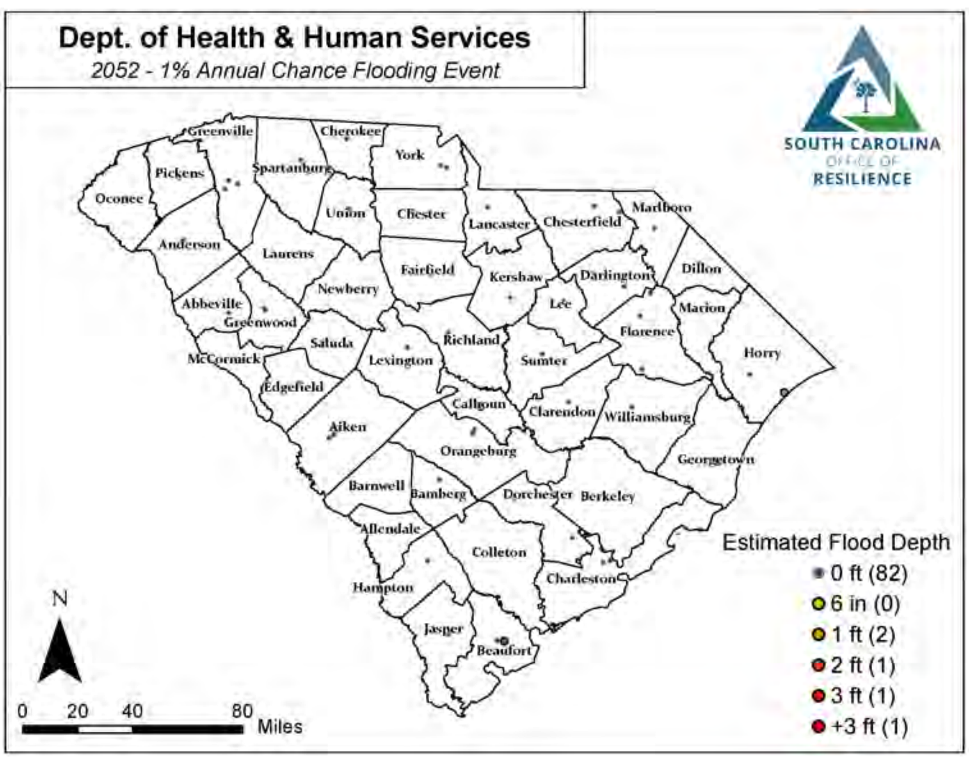

Figure 5.114: Estimated flooding of Department of Health and Human Services' offices in the 2052 1% annual chance flooding event (DHHS). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

SOCIAL SERVICES

The South Carolina Department of Social Services (DSS) hosts a diverse array of programs including Child Protective Services (CPS), foster care / adoption, Temporary Assistance for Needy Families (TANF), Supplemental Nutrition Assistance Program (SNAP), work programs, early care and education, adult advocacy, and child support services. These programs directly impact 1 in 6 South Carolinians. Regarding flooding, DSS operates Disaster Supplemental Nutritional Program (D-SNAP) and maintains evacuation plans for all of its licensed facilities. Similar to other community services the vulnerability is not held completely by the physical locations, it lies with the access of providers and constituents to the services they rely on.

The maps below show the vulnerability of childcare facilities licensed by DSS to flooding in the 2022 (Figure 5.115) and 2052 (Figure 5.116) 1% annual chance flood event

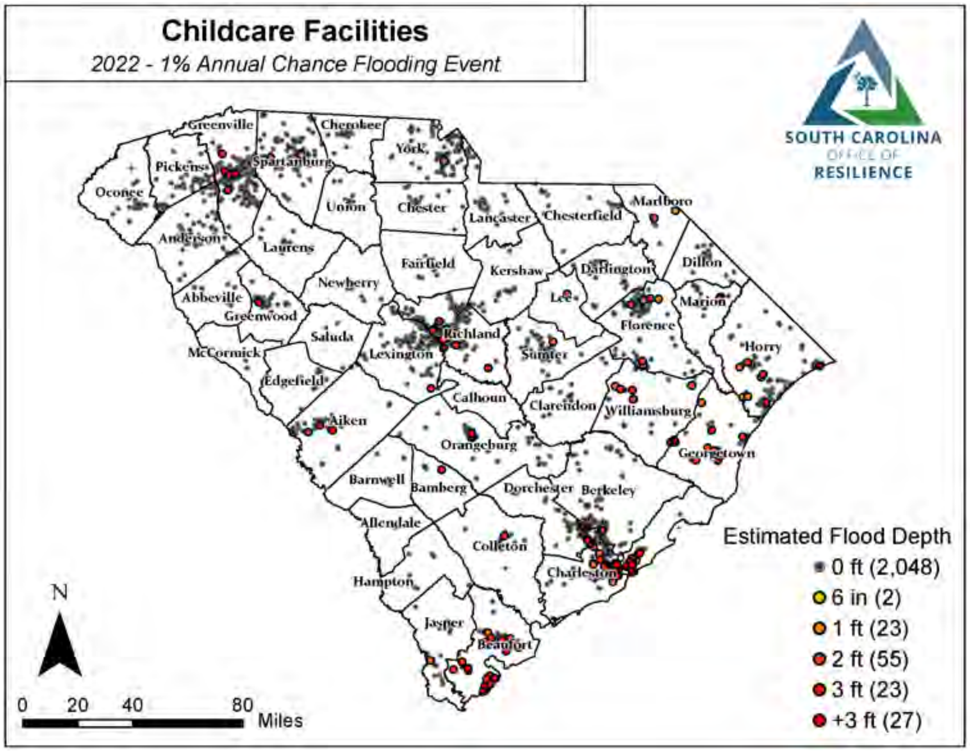

Figure 5.115: Estimated flooding Childcare Facilities in the 2022 1% annual chance flooding event (DSS). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

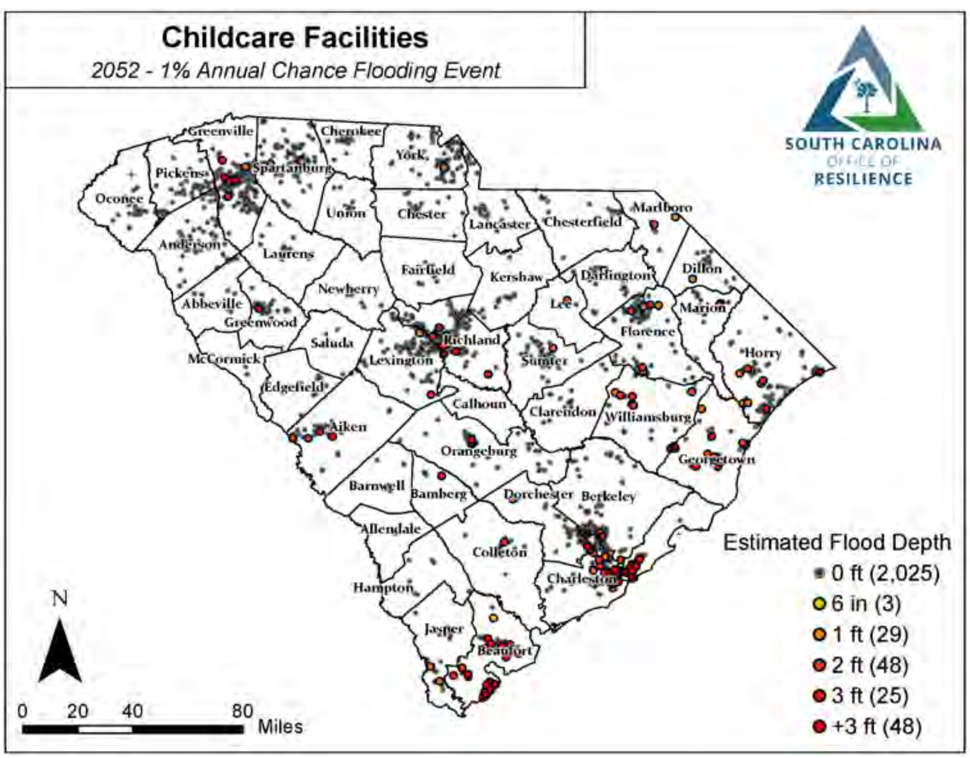

Figure 5.116: Estimated flooding Childcare Facilities in the 2052 1% annual chance flooding event (DSS). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

VETERANS’ AFFAIRS

The South Carolina Department of Veterans’ Affairs (DVA) coordinates county level Veterans’ Affairs offices where veterans can access benefits. The DVA assists veterans with employment, healthcare, suicide prevention, and education.

The maps below show the vulnerability of DVA facilities to flooding in the 2022 (Figure 5.117) and 2052 (Figure 5.118) 1% annual chance flood event

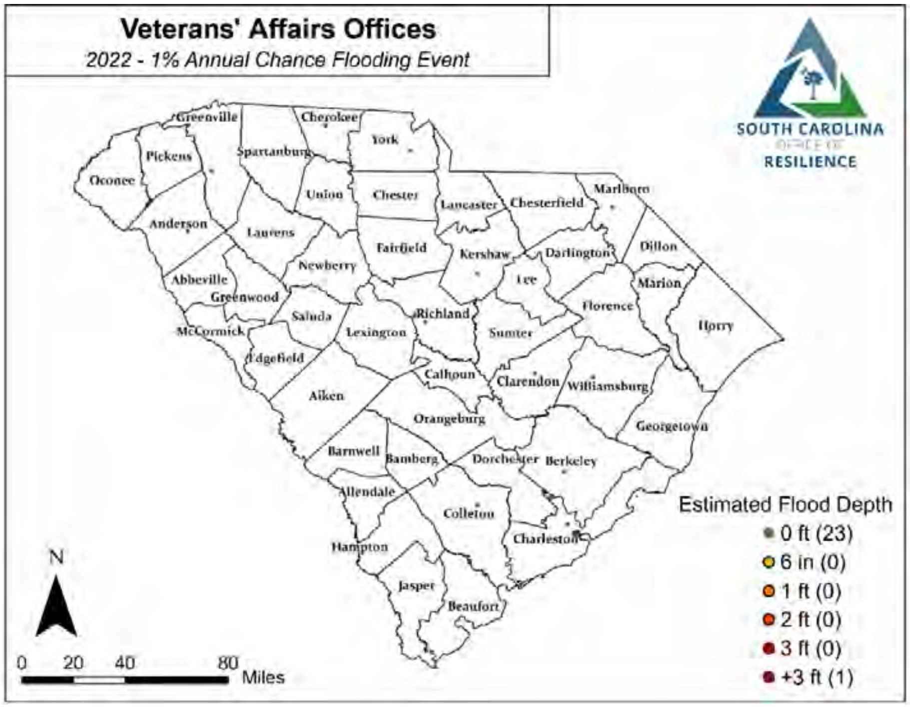

Figure 5.117: Estimated flooding of Veterans' Affairs facilities in the 2022 1% annual chance flooding event (DVA). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

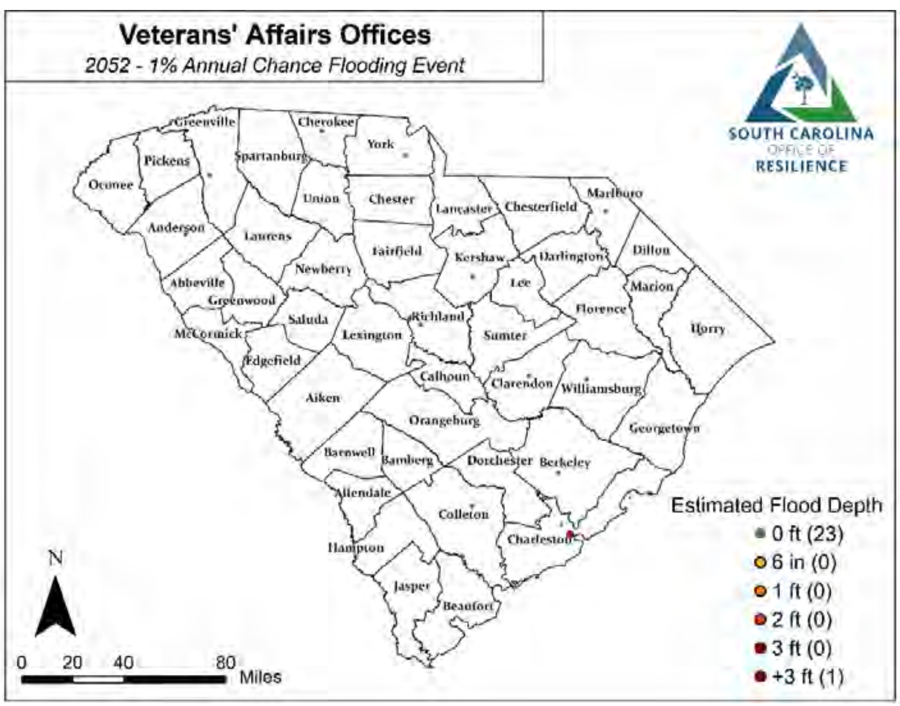

Figure 5.118: Estimated flooding of Veterans Affairs facilities in the 2052 1% annual chance flooding event (DVA). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

PLACES OF WORSHIP

There are nearly 6,000 places of worship across the State. After a disaster, these places provide essential support such as the collection, storing and distribution of supplies, shelter, and other community needs

The maps below show the vulnerability of places of worship to flooding in the 2022 (Figure 5.119) and 2052 (Figure 5.120) 1% annual chance flood event

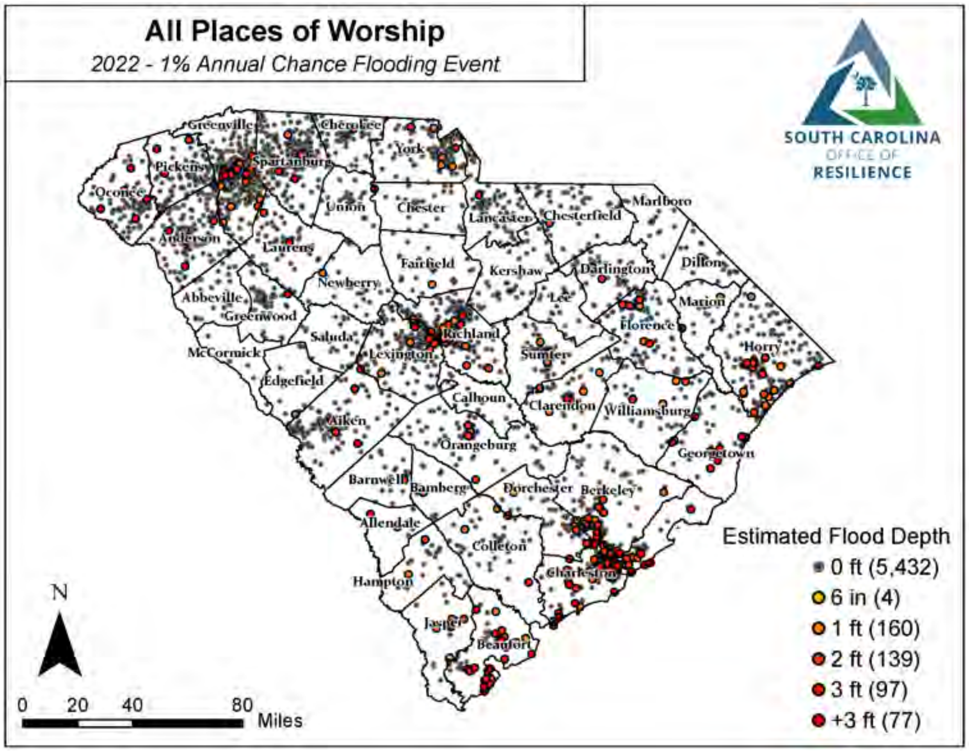

Figure 5.119: Estimated flooding of places of worship in the 2022 1% annual chance flooding event (Department of Homeland Security). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

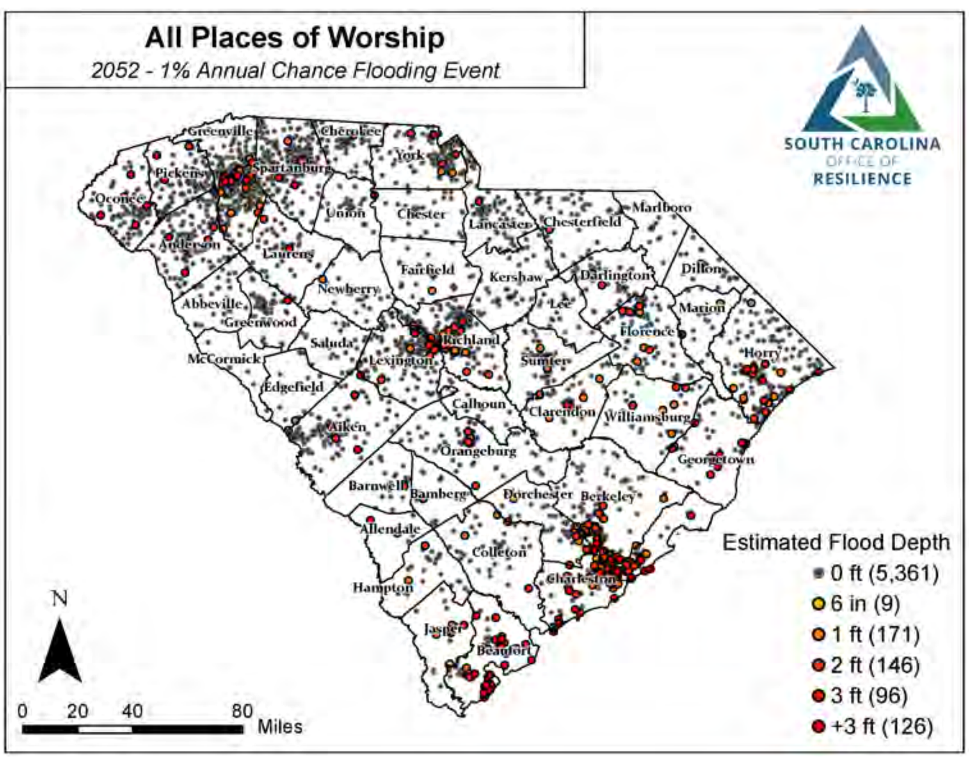

Figure 5.120: Estimated flooding of places of worship in the 2052 1% annual chance flooding event (Department of Homeland Security). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

ECONOMIC SYSTEMS

AGRICULTURE

According to the SC Department of Agriculture, there are nearly 25,000 farms and 4.7 million acres of farmland in South Carolina. Agribusiness (agriculture & forestry) accounts for 246,957 jobs and $46.2 billion in annual economic impact. The top 10 agricultural commodities are: broilers, turkeys, corn, cattle/calves, soybeans, cotton, chicken eggs, peanuts, floriculture, and tobacco (SC Department of Agriculture, 2017). Agriculture relies on weather, climate, and water availability, all of which are easily impacted by environmental change and natural hazards (United States Environmental Protection Agency (EPA), 2022).

Flooding has a history of destroying a variety of crops in South Carolina. A study on the 2015 flood estimated losses in the field and from prevented planting totaling over $375 million (SC Department of Agriculture, 2015). Flooding also impacts the processing, transportation, and sales of agricultural products vital to the State's economy.

Using the USDA Cropland Data Layer, croplands are identified through the use of remote sensing techniques such as satellite imagery. The Cropland Data Layer identifies crop extent and probable type in a 30m resolution across the country and is accessible through the USDA CropScape webtool (Han, et al., 2012). From the Cropland Data Layer dataset, the majority of croplands in South Carolina are located in the Coastal Plain, although there is agricultural land statewide (Figure 5.121). Figure 5.122 indicates that, according to the First Street Foundation's model, the majority of potentially inundated crops are also located in the Coastal Plain.

The Cropland Data Layer also delineates the potential crop type being grown. Table 5.15 shows the percent of cropland potentially inundated by a 1% annual chance event ("100-year" event) for 2022 and future projected 2052. Rice has the highest exposure to flooding, 72.4% for 2022 and 74.1% for 2052, due to the low-lying nature and requirement of flooding the crop. The percentage of total crop area at risk to flooding in 2022 and 2052 is shown in Table 5.16 and Table 5.17.

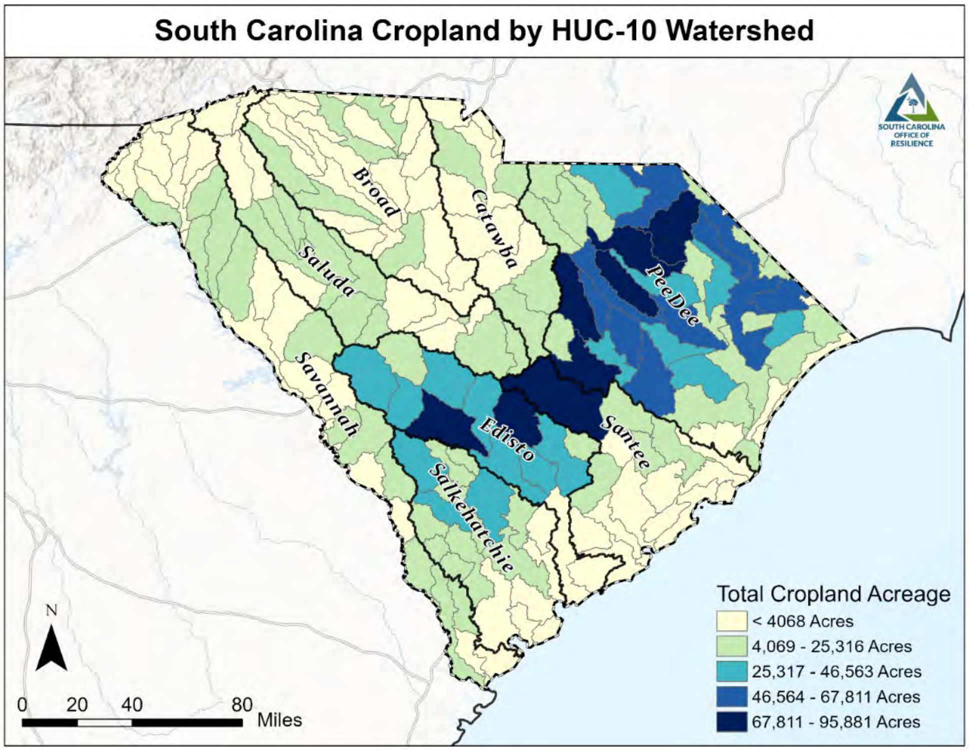

Figure 5.121: Cropland coverage by HUC10 as listed in the USDA Cropland Data Layer

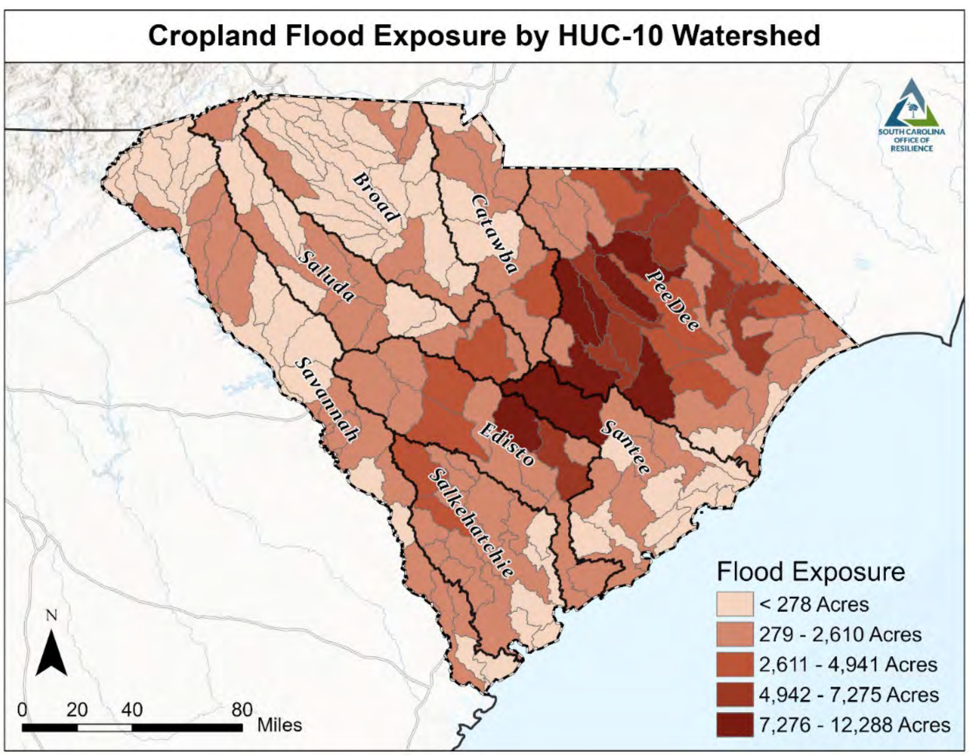

Figure 5.122: Cropland Exposure to any inundation during a 1% annual chance of flood by HUC10 as listed in the USDA Cropland Data Layer

Table 5.15: 1% annual chance of total crop area flooding over 6 inches of inundation in 2022 and 2052 Hazard Layer 2.0 model by crop type in the USDA Cropland Data Layer

Crop Type	2022	2052
Alfalfa	5.2%	5.4%
Apples	4.6%	4.6%
Barley	2.9%	2.9%
Barley/Soybeans	4.4%	4.6%
Blueberries	24.8%	26.1%
Cabbage	11.6%	12.3%
Cantaloupes	6.3%	6.6%
Clover/Wildflowers	7.3%	7.4%
Corn	12.4%	13.3%
Corn/Soybeans	6.9%	7.4%
Cotton	7.9%	8.4%
Cucumbers	10.2%	10.9%
Dry Beans	4.8%	5.4%
Fallow/Idle Cropland	7.4%	8.0%
Grapes	4.7%	5.0%
Greens	9.4%	10.1%
Millet	7.6%	8.0%
Non-Alfalfa Hay	7.4%	7.9%
Oats	6.5%	7.0%
Oats/Corn	10.6%	11.3%
Onions	0.0%	0.0%
Other Crops	6.1%	6.6%
Other Tree Crops	4.8%	5.1%
Peaches	5.5%	5.7%
Peanuts	7.2%	7.9%
Peas	10.8%	11.8%
Pecans	10.4%	10.8%
Peppers	4.4%	4.7%
Potatoes	11.6%	12.2%
Pumpkins	18.5%	18.6%
Rice	72.3%	74.1%
Rye	6.9%	7.2%
Sod/Grass Seed	9.3%	10.1%
Sorghum	6.6%	7.1%
Soybeans	10.5%	11.3%
Soybeans/Oats	6.9%	7.4%

Squash	4.6%	4.8%
Strawberries	6.5%	6.6%
Sunflower	9.7%	10.2%
Sweet Corn	12.2%	13.3%
Sweet Potatoes	8.2%	9.0%
Switchgrass	3.6%	3.6%
Tobacco	6.4%	6.8%
Tomatoes	8.8%	9.4%
Triticale	3.4%	3.5%
Triticale/Corn	11.6%	11.9%
Watermelons	5.8%	6.1%
Winter Wheat	12.2%	12.7%
Winter Wheat/Corn	6.1%	6.3%
Winter Wheat/Cotton	6.4%	6.7%
Winter Wheat/Sorghum	4.3%	4.5%
Winter Wheat/Soybeans	10.1%	10.8%

Table 5.16: 2022 – 1% Annual Chance of flooding by inundation levels, not cumulative

Crop Type	0 feet	6 Inches	1 Foot	2 Foot	3 Foot	Over 3 Ft
Alfalfa	94.78%	0.00%	1.06%	1.69%	1.22%	1.25%
Apples	95.36%	0.00%	0.49%	1.64%	0.97%	1.53%
Barley	97.07%	0.00%	0.79%	1.32%	0.42%	0.40%
Barley/Soybeans	95.57%	0.20%	1.48%	1.12%	0.58%	1.06%
Blueberries	75.16%	0.44%	8.85%	7.04%	2.21%	6.30%
Cabbage	88.38%	0.00%	7.56%	3.86%	0.20%	0.00%
Cantaloupes	93.75%	0.00%	2.36%	2.88%	0.75%	0.27%
Clover/Wildflowers	92.65%	0.00%	4.89%	2.39%	0.07%	0.00%
Corn	87.56%	0.25%	5.07%	4.58%	1.16%	1.39%
Corn/Soybeans	93.09%	0.01%	3.52%	2.99%	0.28%	0.12%
Cotton	92.11%	0.12%	3.56%	3.12%	0.62%	0.46%
Cucumbers	89.77%	0.00%	4.87%	4.71%	0.48%	0.17%
Dry Beans	95.22%	0.00%	2.40%	1.98%	0.29%	0.11%
Fallow/Idle Cropland	92.64%	0.07%	3.13%	2.81%	0.70%	0.65%
Grapes	95.28%	0.07%	1.69%	1.70%	0.89%	0.36%
Greens	90.58%	0.05%	5.42%	3.42%	0.30%	0.23%
Millet	92.43%	0.03%	2.34%	2.26%	0.90%	2.04%
Non-Alfalfa Hay	92.56%	0.11%	2.34%	2.66%	0.98%	1.35%
Oats	93.52%	0.09%	2.32%	2.26%	0.68%	1.12%
Oats/Corn	89.36%	0.01%	3.84%	4.47%	1.19%	1.13%
Onions	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%

Other Crops	93.86%	0.01%	2.66%	2.45%	0.53%	0.48%
Other Tree Crops	95.24%	0.00%	1.72%	3.04%	0.00%	0.00%
Peaches	94.55%	0.01%	1.87%	2.18%	0.76%	0.63%
Peanuts	92.76%	0.08%	3.04%	2.90%	0.68%	0.54%
Peas	89.21%	0.13%	5.57%	3.94%	0.60%	0.55%
Pecans	89.57%	0.06%	2.85%	3.95%	1.45%	2.12%
Peppers	95.57%	0.00%	1.53%	1.78%	0.51%	0.60%
Potatoes	88.43%	0.01%	3.89%	4.34%	1.80%	1.54%
Pumpkins	81.52%	0.00%	0.38%	18.10%	0.00%	0.00%
Rice	27.70%	3.92%	23.57%	43.17%	0.59%	1.05%
Rye	93.08%	0.04%	1.60%	2.17%	0.97%	2.14%
Sod/Grass Seed	90.70%	0.08%	4.67%	3.28%	0.72%	0.55%
Sorghum	93.37%	0.07%	2.52%	2.42%	0.70%	0.92%
Soybeans	89.48%	0.23%	4.82%	3.83%	0.80%	0.85%
Soybeans/Oats	93.12%	0.09%	3.53%	2.32%	0.55%	0.39%
Squash	95.39%	0.00%	2.78%	1.68%	0.07%	0.07%
Strawberries	93.49%	0.02%	1.51%	1.20%	2.63%	1.16%
Sunflower	90.34%	0.01%	3.58%	3.42%	1.37%	1.28%
Sweet Corn	87.83%	0.04%	6.11%	4.56%	0.60%	0.87%
Sweet Potatoes	91.76%	0.03%	3.09%	3.74%	0.84%	0.54%
Switchgrass	96.41%	0.00%	0.77%	0.85%	1.76%	0.21%
Tobacco	93.60%	0.00%	2.57%	3.57%	0.19%	0.07%
Tomatoes	91.18%	0.02%	3.26%	2.94%	1.02%	1.60%
Triticale	96.63%	0.00%	0.96%	1.13%	0.51%	0.77%
Triticale/Corn	88.38%	0.00%	4.71%	5.54%	1.36%	0.00%
Watermelons	94.23%	0.00%	2.26%	2.47%	0.82%	0.22%
Winter Wheat	87.83%	0.40%	2.59%	3.14%	1.61%	4.43%
Winter Wheat/Corn	93.94%	0.07%	1.16%	1.28%	1.16%	2.40%
Winter Wheat/Cotton	93.61%	0.00%	3.01%	2.37%	0.51%	0.50%
Winter Wheat/Sorghum	95.66%	0.08%	1.18%	1.39%	0.68%	1.00%
Winter Wheat/Soybeans	89.87%	0.19%	4.01%	3.59%	1.06%	1.27%

Table 5.17: 2052 – 1% Annual Chance of flooding by inundation levels, not cumulative

Crop Type	0 feet	6 Inches	1 Foot	2 Foot	3 Foot	Over 3 Ft
Alfalfa	94.63%	0.00%	1.13%	1.65%	1.21%	1.37%
Apples	95.38%	0.00%	0.46%	1.66%	0.85%	1.66%
Barley	97.05%	0.01%	0.79%	1.16%	0.58%	0.41%
Barley/Soybeans	95.44%	0.17%	1.40%	1.19%	0.60%	1.19%
Blueberries	73.86%	0.43%	6.51%	9.66%	2.48%	7.06%
Cabbage	87.67%	0.00%	7.44%	4.46%	0.43%	0.00%
Cantaloupes	93.41%	0.00%	2.41%	3.11%	0.80%	0.28%
Clover/Wildflowers	92.62%	0.00%	4.81%	2.49%	0.07%	0.00%
Corn	86.70%	0.25%	5.30%	4.94%	1.24%	1.58%
Corn/Soybeans	92.63%	0.00%	3.69%	3.25%	0.30%	0.13%
Cotton	91.56%	0.11%	3.74%	3.39%	0.69%	0.52%
Cucumbers	89.06%	0.00%	5.07%	5.12%	0.57%	0.18%
Dry Beans	94.65%	0.00%	2.43%	2.44%	0.31%	0.17%
Fallow/Idle Cropland	92.01%	0.06%	3.30%	3.12%	0.76%	0.75%
Grapes	95.02%	0.04%	1.84%	1.79%	0.91%	0.40%
Greens	89.85%	0.01%	5.66%	3.88%	0.34%	0.25%
Millet	92.00%	0.03%	2.44%	2.44%	0.94%	2.15%
Non Alfalfa Hay	92.13%	0.10%	2.44%	2.81%	1.04%	1.48%
Oats	93.04%	0.15%	2.42%	2.42%	0.70%	1.27%
Oats/Corn	88.72%	0.02%	3.95%	4.73%	1.22%	1.36%
Onions	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Other Crops	93.40%	0.07%	2.84%	2.61%	0.57%	0.51%
Other Tree Crops	94.93%	0.00%	1.82%	3.25%	0.00%	0.00%
Peaches	94.26%	0.01%	1.95%	2.29%	0.81%	0.68%
Peanuts	92.11%	0.09%	3.15%	3.02%	0.72%	0.91%
Peas	88.24%	0.08%	5.95%	4.41%	0.71%	0.60%
Pecans	89.19%	0.04%	2.80%	4.06%	1.63%	2.28%
Peppers	95.33%	0.00%	1.59%	1.86%	0.58%	0.63%
Potatoes	87.81%	0.01%	4.15%	4.49%	1.88%	1.66%
Pumpkins	81.44%	0.00%	0.46%	18.10%	0.00%	0.00%
Rice	25.91%	2.58%	6.86%	62.57%	0.91%	1.17%
Rye	92.82%	0.05%	1.64%	2.27%	0.98%	2.24%
Sod/Grass Seed	89.87%	0.07%	4.99%	3.58%	0.82%	0.67%
Sorghum	92.93%	0.06%	2.69%	2.56%	0.71%	1.05%
Soybeans	88.66%	0.24%	5.09%	4.18%	0.86%	0.96%
Soybeans/Oats	92.55%	0.04%	3.83%	2.53%	0.60%	0.44%
Squash	95.22%	0.00%	2.66%	1.97%	0.07%	0.08%
Strawberries	93.43%	0.01%	1.38%	1.31%	2.63%	1.25%

Sunflower	89.78%	0.04%	3.87%	3.58%	1.39%	1.34%
Sweet Corn	86.71%	0.05%	6.82%	4.87%	0.65%	0.90%
Sweet Potatoes	91.04%	0.02%	3.29%	4.10%	0.93%	0.62%
Switchgrass	96.41%	0.00%	0.63%	0.99%	1.69%	0.28%
Tobacco	93.18%	0.00%	2.66%	3.86%	0.20%	0.09%
Tomatoes	90.65%	0.05%	3.42%	3.14%	1.01%	1.73%
Triticale	96.51%	0.00%	0.98%	1.16%	0.48%	0.87%
Triticale/Corn	88.12%	0.00%	4.84%	5.46%	1.58%	0.00%
Watermelons	93.93%	0.00%	2.26%	2.64%	0.89%	0.28%
Winter Wheat	87.28%	0.35%	2.64%	3.28%	1.68%	4.77%
Winter Wheat/Corn	93.75%	0.06%	1.21%	1.31%	1.06%	2.61%
Winter Wheat/Cotton	93.31%	0.01%	3.07%	2.55%	0.55%	0.51%
Winter Wheat/Sorghum	95.47%	0.09%	1.24%	1.41%	0.71%	1.07%
Winter Wheat/Soybeans	89.20%	0.18%	4.23%	3.87%	1.13%	1.39%

FOOD SYSTEMS

DHEC's GIS Hub includes a SC Food Desert Map to help partner agencies identify underserved areas to develop strategies to increase access to healthy food. Healthy food can be hard to obtain immediately before, during, and after hazardous events.

Public refrigerated warehouses support this food system by storing perishable food. These temperature controlled storage facilities can also house medication, plants, and flowers. Additionally, there are cultural resources and other fragile items that may need to be kept in a climate controlled setting.

The maps below show the vulnerability of these refrigerated warehouses to flooding in the 2022 (Figure 5.123) and 2052 (Figure 5.124) 1% annual chance flood event.

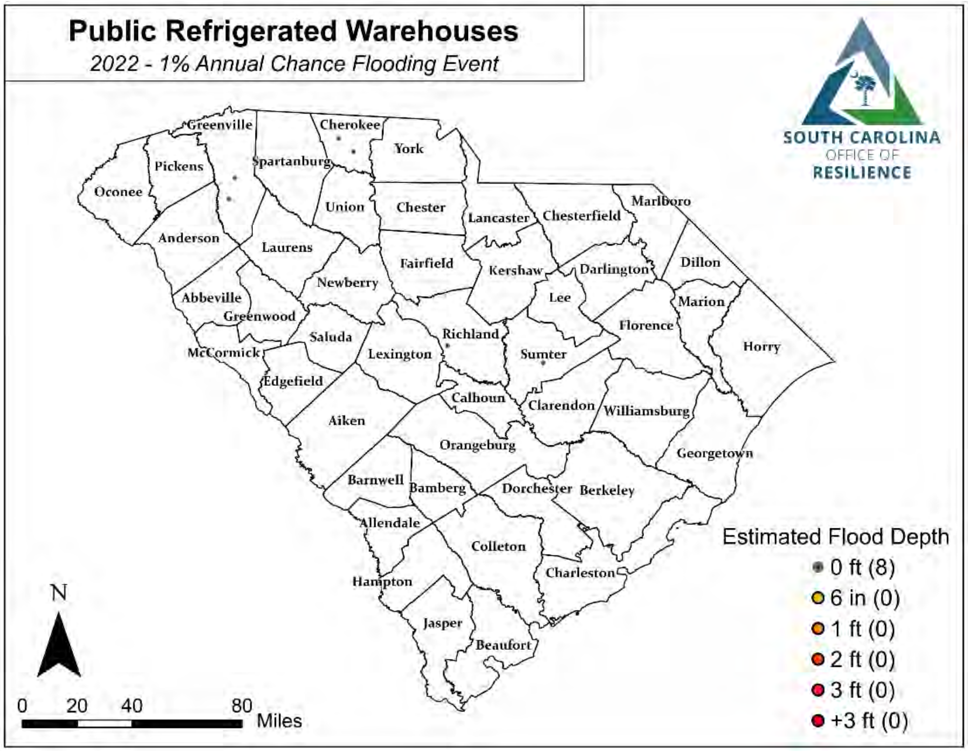

Figure 5.123: Estimated flooding of public refrigerated warehouses in the 2022 1% annual chance flooding event (Department of Homeland Security). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

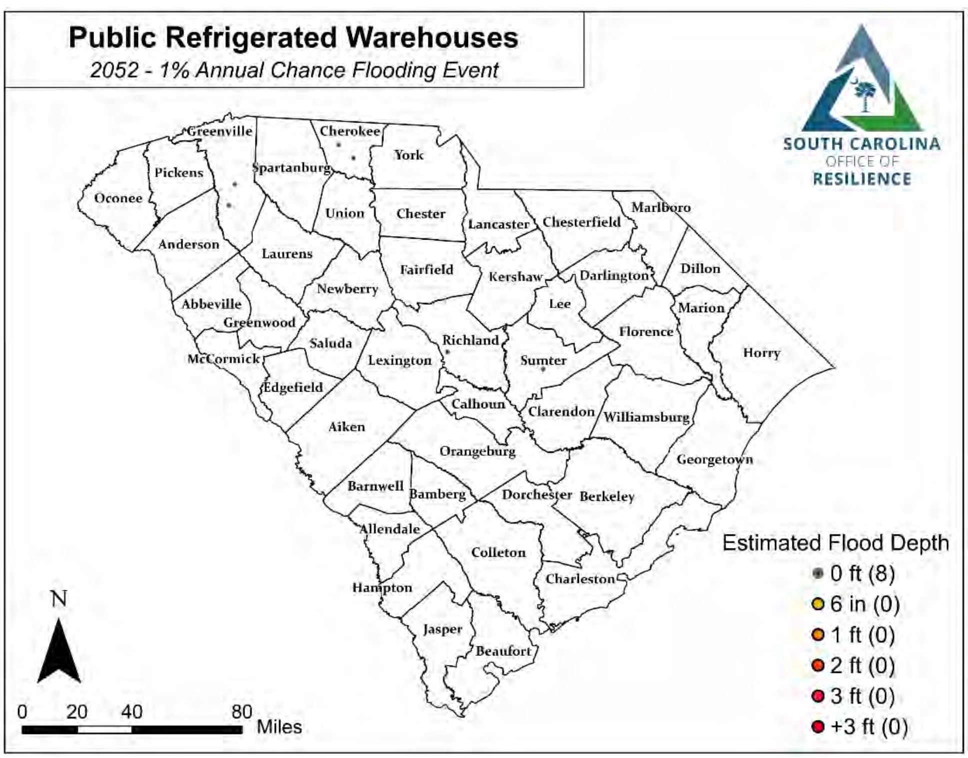

Figure 5.124: Estimated flooding of public refrigerated warehouses in the 2052 1% annual chance flooding event (Department of Homeland Security). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

MANUFACTURING

Manufacturing accounts for 12% of the employment in the state. Businesses in South Carolina manufacture a wide range of products including automobiles, appliances, boats, and aircraft (SC Department of Commerce, 2020).

The maps below show the estimated flooding of these manufacturing facilities in the 2022 (Figure 5.125) and 2052 (Figure 5.126) 1% annual chance flood event.

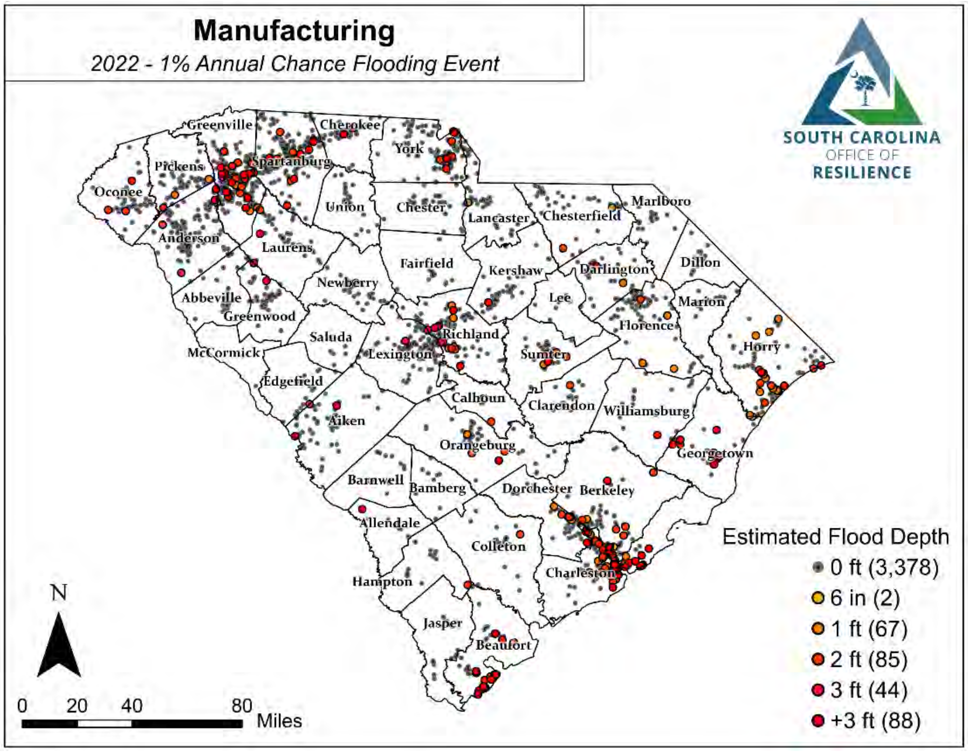

Figure 5.125: Estimated flooding of manufacturing facilities in the 2022 1% annual chance flooding event (SC Department of Commerce). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

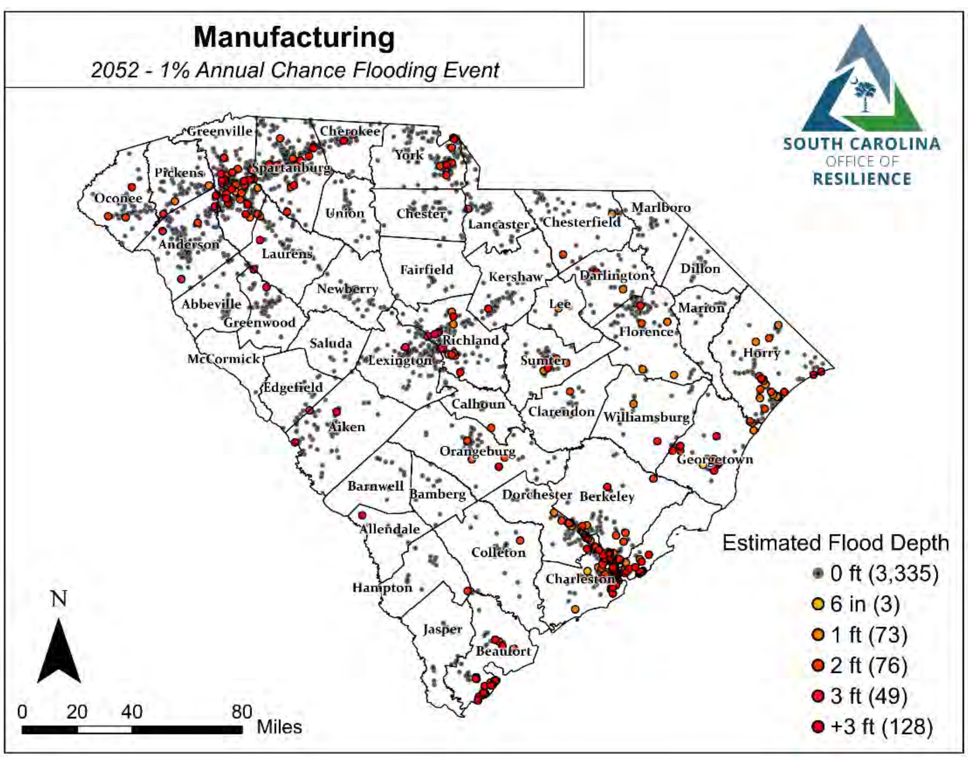

Figure 5.126: Estimated flooding of manufacturing facilities in the 2052 1% annual chance flooding event (SC Department of Commerce). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

INDUSTRIAL SITES AND BUILDINGS

According to the South Carolina Department of Commerce, there are over 230 industrial buildings across the state. Additionally, there are designated industrial sites, that can help us predict where we are likely to see industrial buildings constructed in the future.

The first maps below show the estimated flooding of these buildings in the 2022 (Figure 5.127) and 2052 (Figure 5.128) 1% annual chance flood event, while Figure 5.129 and Figure 5.130 show the industrial sites.

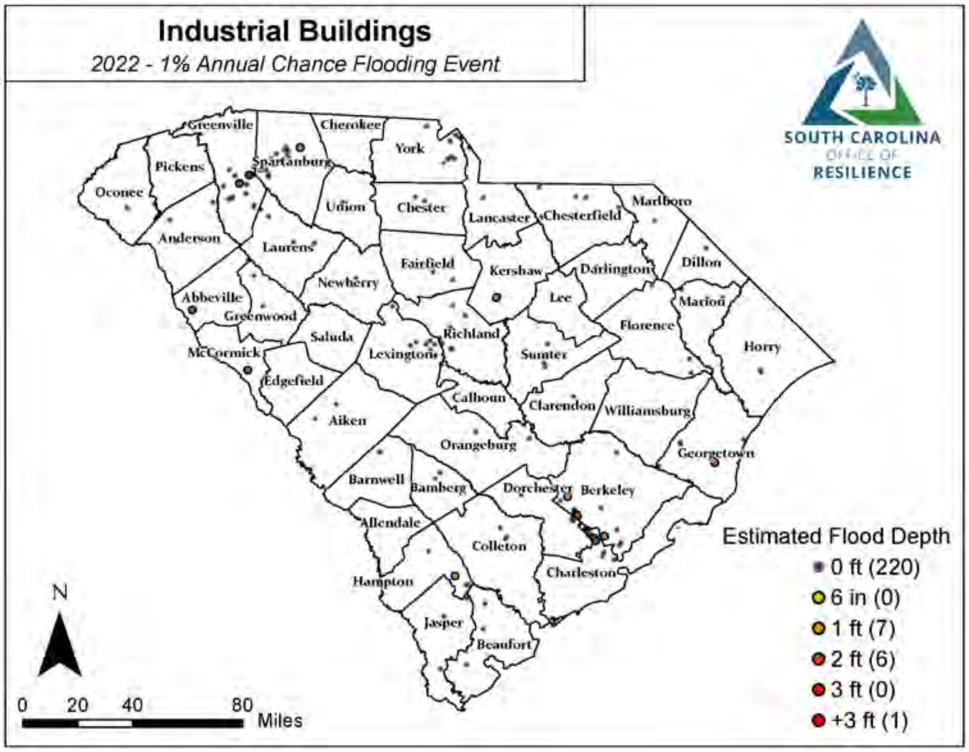

Figure 5.127: Estimated flooding of commerce industrial buildings in the 2022 1% annual chance flooding event (SC Department of Commerce). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

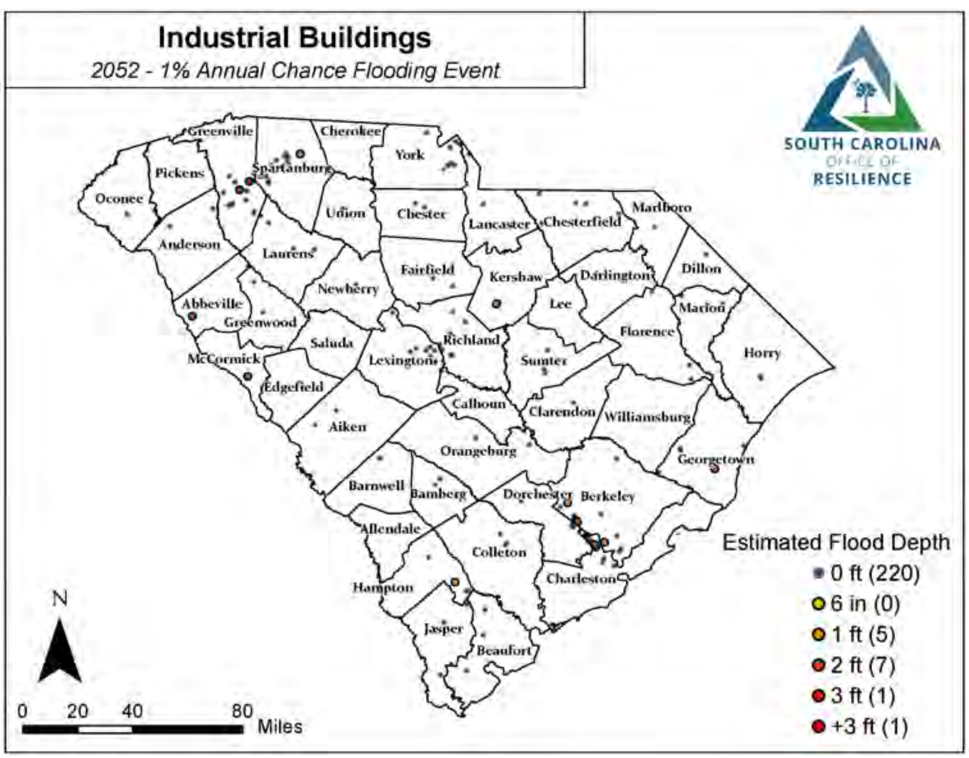

Figure 5.128: Estimated flooding of commerce industrial buildings in the 2052 1% annual chance flooding event (SC Department of Commerce). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

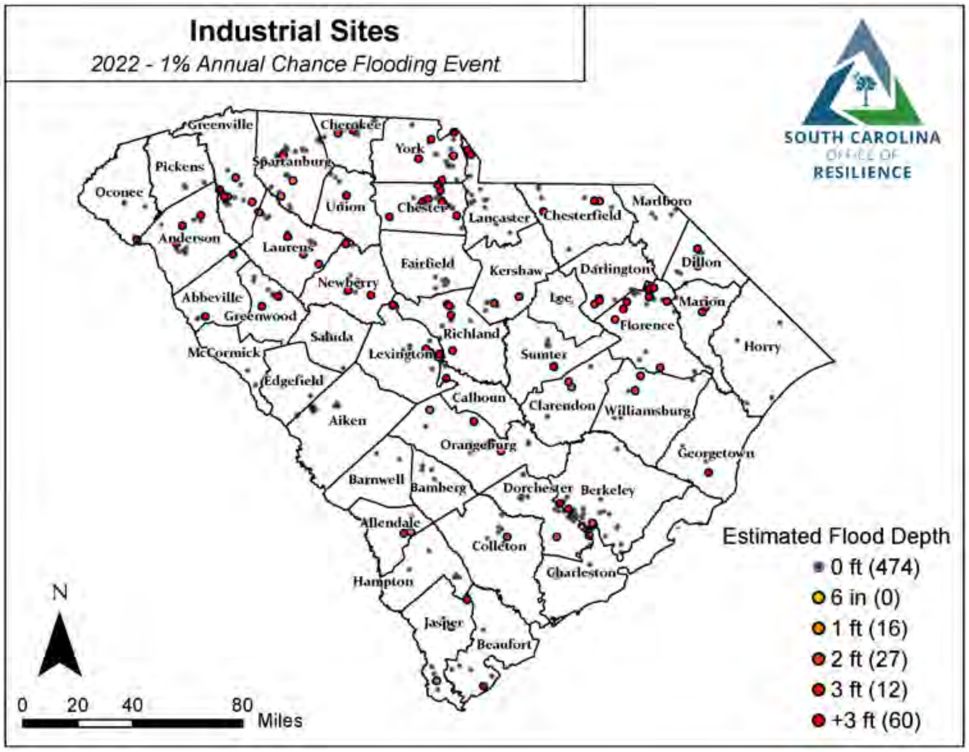

Figure 5.129: Estimated flooding of industrial sites in the 2022 1% annual chance flooding event (SC Department of Commerce). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

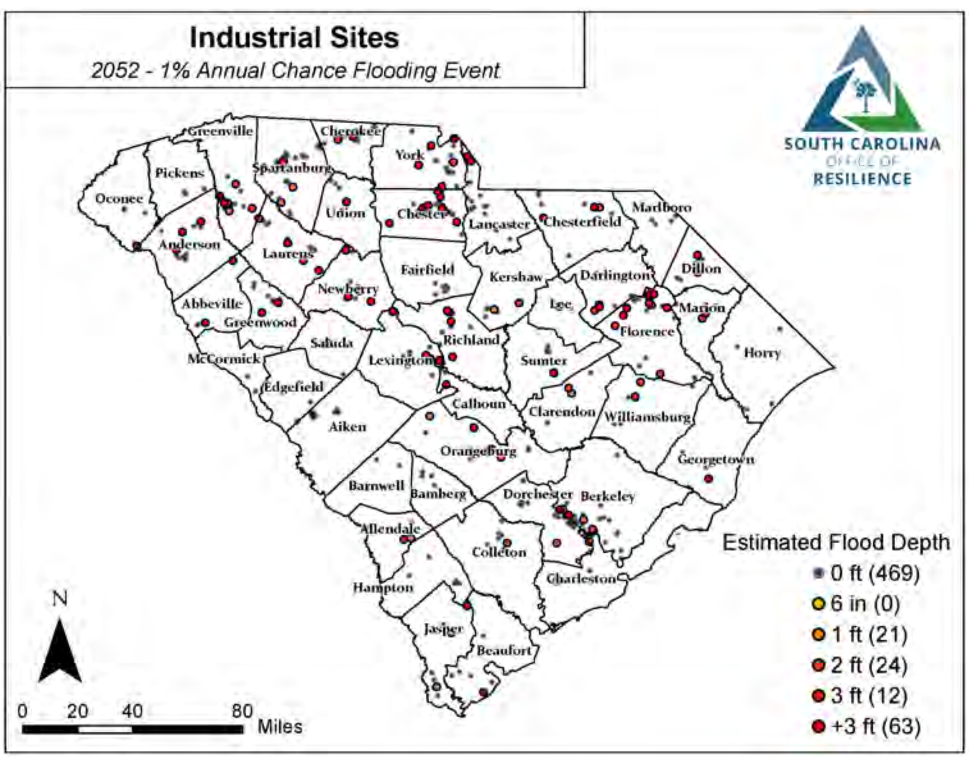

Figure 5.130: Estimated flooding of industrial sites in the 2052 1% annual chance flooding event (SC Department of Commerce. Flood data provided by the First Street Foundation Hazard Layers, V2.0.

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Strategic Statewide Resilience and Risk Reduction Plan

6 | OTHER HAZARDS

OVERVIEW

This chapter furthers the ability of organizations across the state to anticipate by identifying wildfire, drought, heat, seismic, severe thunderstorms, wind, and winter weather hazards. While the initial version of this plan focuses on flooding, S.C. Code Ann. § 48-62-10 *et seq.*, also directs SCOR to identify potential losses that could occur as a result of severe weather events and other natural catastrophes that impact South Carolina. This chapter is a brief overview of these hazards utilizing a few key resources. South Carolina's vulnerability to other hazards will be analyzed in future iterations of this plan, as appropriate datasets are identified or developed.

A historical analysis of the various hazards that impact South Carolina is one part of the SCEMD State Hazard Mitigation Plan that was last published in 2018; an updated iteration of that plan is scheduled to be published in 2023. These plans include a comprehensive discussion of historic events' geographic extent, and economic and human impacts.

CONTENTS

KEY FINDINGS

- There is a risk for increased impacts as more people and property are located in the path of hazards.

WILDFIRE

- Wildfires are common occurrences in South Carolina and are defined by the South Carolina Forestry Commission as any forest fire, brush fire, grassfire, or any outdoor fire that is not controlled or supervised.
- On average, approximately 1,400 wildfires burn nearly 11,000 acres in South Carolina each year (SC Forestry Commission (SCFC), 2021).

DROUGHT

- In the last 21 years, South Carolina has experienced three major droughts.
- The State Water Plan under development at SCDNR aims to understand water supply versus water demand, including the impacts of drought on the water resources in the State.

HEAT

- Heat is the most dangerous of the weather related hazards in recent decades (National Weather Service, 2022).
- Historic analysis documents maximum summer temperature increases across the State.
- Portions of the state are projected to experience up to 50 more days a year with temperatures above 95 °F by the end of the century.
- Future temperature increases and more frequent and intense heat waves will likely cause the Southeast to experience a disproportionate health burden.

SEVERE THUNDERSTORMS

- Thunderstorms occur frequently in South Carolina, and severe storms have the potential to produce damage-causing hail, lightning, and high winds.
- Tornadoes are a facet of severe thunderstorms as well.
- In South Carolina, extreme winds are the most reported hazard to the National Centers for Environmental Information (NCEI).

TROPICAL SYSTEMS AND HURRICANES

- While hurricanes are considered low frequency but high consequence events.
- South Carolina ranks 5th (fifth) among states that experience hurricanes, behind Florida, Texas, Louisiana, and North Carolina.

TORNADOES

- There is no significant trend in tornadoes occurring in the State.
- Current climate projections predict that tornado alleys are shifting east.

WINTER WEATHER

- Damage from winter weather events has increased in the last few decades.
- These events can disrupt communications and power by trees or branches falling on suspended lines, disrupt travel plans by impairing roadways, and damage plants both for residential and agricultural purposes.

SEISMIC EVENTS

- According to the USGS, South Carolina has experienced 229 earthquakes since 2001, with 46 events larger than a magnitude 2.5. The largest event since 2001 reached a magnitude 4.1 in Parksville, SC, on November 11, 2014.
- The largest earthquake recorded in the State was the Charleston Earthquake of 1886 with an estimated magnitude of 7 to 7.6.
- Tsunamis are rare on the east coast of the U.S. and there is insufficient data to make reasonable decisions or recommendations to mitigate or plan for the impacts of a tsunami.

INFORMATION USED IN THIS CHAPTER

This chapter uses state, federal, and local data sources to give a brief overview of the State's vulnerabilities to hazards other than flood, which is described in its own chapter. Local and state specific data are prioritized when available, and they are supplemented by FEMA's National Risk Index (NRI), which gives a brief overview of nationwide vulnerabilities to various hazards. The NRI interactive map database allows users to identify potential impacts that may occur to populations and economies at the Census tract level. The Index provides a Risk Index Rating for each hazard based on previous hazard specific economic losses to represent a community's relative risk from "Very High" to "Very Low" when compared with communities across the United States, and is calculated using Equation 6.1. The equation includes the variables for Expected Annual Loss, the average economic loss in dollars resulting from each hazard each year, Social Vulnerability using based around the Social Vulnerability Index (SVI), and Community Resilience based on HVRI's BRIC indicators (Zuzak, et al., 2023).

Equation 6.1 FEMA Risk Index Equation (Zuzak, et al., 2023)

$$Risk\ Index = Expected\ Annual\ Loss\ x\ \frac{Social\ Vulnerability}{Community\ Resilience}$$

Table 6.1 FEMA Risk Index nomenclature breaks by percentiles (Zuzak, et al., 2023)

Risk Index	Percentile
Very High	80th to 100th percentiles
Relatively High	60th to 80th percentiles
Relatively Moderate	40th to 60th percentiles
Relatively Low	20th to 40th percentiles
Very Low	0th to 20th percentiles

WILDFIRE

Wildfires are common occurrences in South Carolina and are defined by the South Carolina Forestry Commission as any forest fire, brush fire, grassfire, or outdoor fire that is not controlled or supervised. On average, approximately 1,400 wildfires burn nearly 11,000 acres in South Carolina each year (SC Forestry Commission (SCFC), 2021).

Common ignitors of wildfires are debris burning (35-45%), woods arson (25-30%), equipment use (5%), smoking (3-4%), lightning (2%), campfires (1-3%), intentional fires, railroad (1-2%), children (3-5%), and miscellaneous (4-6%). In November 2016, a large wildfire started in Table Rock State Park from an escaped campfire. This fire occurred during an ongoing drought and grew to 10,623 acres before it became under control (SC Forestry Commission (SCFC), 2022).

Although wildfires can start any time there is a spark and enough fuel to drive it, they are exacerbated by periods of drought and excessive heat that can increase the amount of fire prone brush within an area. The South Carolina Forestry Commission, along with the other 12 states in USDA Forest Service Region 8, have used the LANDFIRE model, funded by the U.S. Department of Agriculture Forest Service, to develop the Southern Wildfire Risk Assessment Portal (SouthWRAP). South Carolina’s vulnerability to wildfires can be estimated using SouthWRAP for regional scale assessments.

WILDFIRE BURN PROBABILITY

SouthWRAP provides access to the LANDFIRE model with layers used by decision makers, including the Burn Probability and Wildland Urban Interface Risk Index.

Burn Probability represents how communities are interspersed with wildfire fuels, and the expected human structural impacts if a fire occurs. Wildfire Burn Probability, displayed in Figure 6.1, is interpreted as the actuarial likelihood that an area will burn in a wildfire and is the result of analysis of landscape conditions, weather patterns, ignition patterns, and regional fire management practices. This analysis does not incorporate the built environment or assess the impact of wildfire.

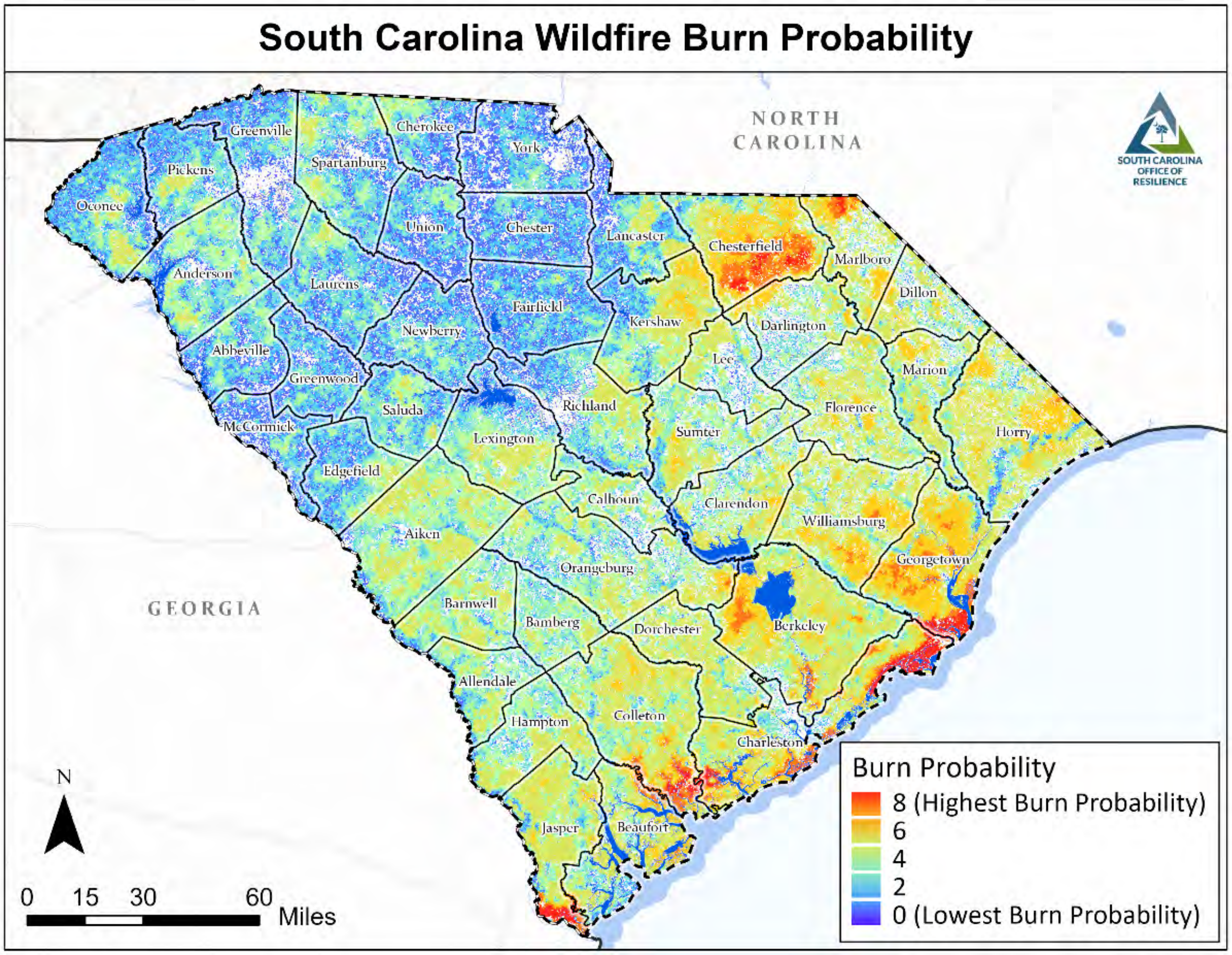

Figure 6.1 South Carolina Wildfire Burn Probability

WILDFIRE VULNERABILITY BY SECTOR

SECTOR DATASETS

The data identification and collection for this chapter was completed in coordination with the subcommittees of the Strategy Statewide Risk Reduction and Resilience Plan Advisory Committee. Identified and collected point datasets were overlaid with hazard risk data below to determine the physical vulnerability of each sector/facility type. While many of the facilities are point locations (such as storage tanks or individual buildings such as fire stations), a point analysis is limited in that it simplifies the full extent of an asset or facility at a location. The point analysis is overlayed with the SouthWRAP Burn Probability to assess the potential impacts. This analysis's simplicity enables a broad view of how wildfire puts South Carolina at risk. It is a starting point, but more specific analysis would be needed to assess risk levels more comprehensively at a particular facility, building, or campus.

BUSINESSES

Businesses identified in the ESRI Business Analyst database are used for the wildfire point analysis. Most of the business are outside of the Estimated Burn Probability (Figure 6.2).

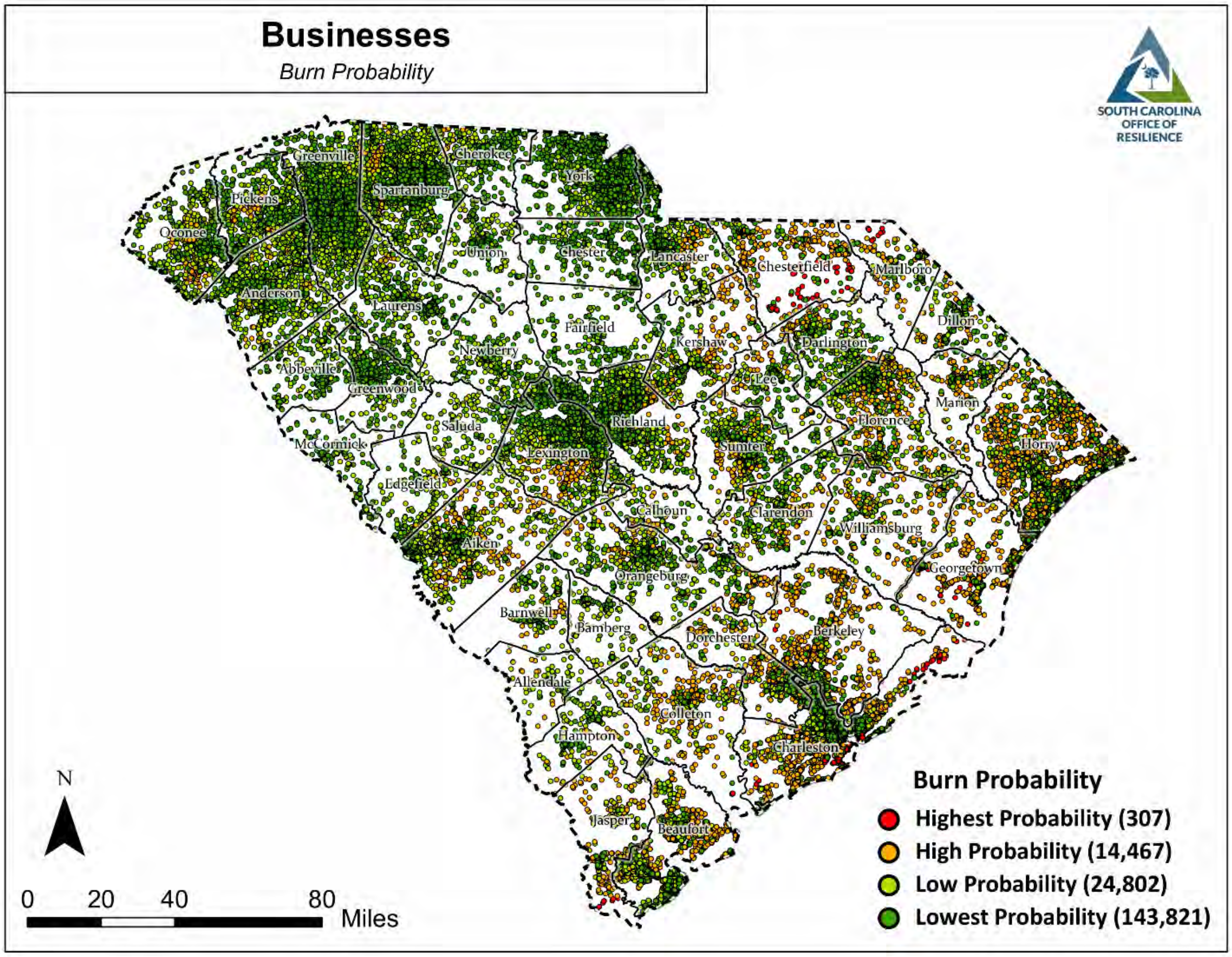

Figure 6.2: Estimated Burn Probability on businesses (ESRI). Wildfire data provided by SouthWRAP

HAZARDOUS WASTE LOCATIONS

DRY CLEANERS

Dry cleaners are included in the South Carolina Hazardous Waste Management Act, which defines a dry cleaning facility as a professional commercial establishment for the purpose of cleaning clothing or other fabrics utilizing a process that involves the use of dry cleaning solvent, which can cause additional impacts during hazard events. Figure 6.3 identifies dry cleaners that fall within the burn probability areas.

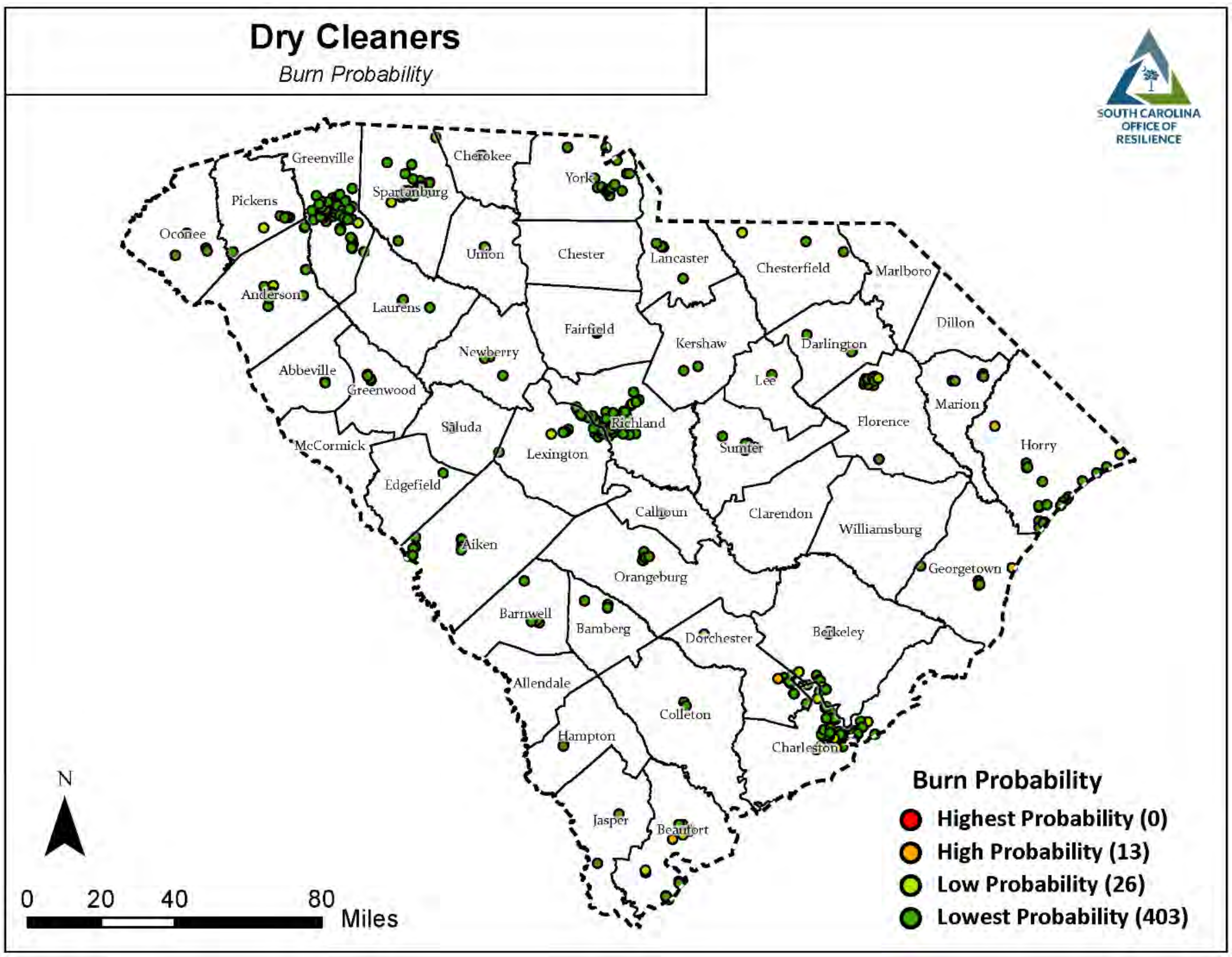

Figure 6.3: Estimated Burn Probability on dry cleaners (DHEC). Wildfire data provided by SouthWRAP.

MINES

About 500 mines are actively operating, with permits through DHEC, following the SC Mining Act (1974). Several types of surface mining are done in the state, including open pit mining of granite, strip mines for sand, clay and gravel, and sand dredging from river bottoms (South Carolina Department of Health and Environmental Control, n.d.). Figure 6.4 shows the mines in relation to burn probability areas.

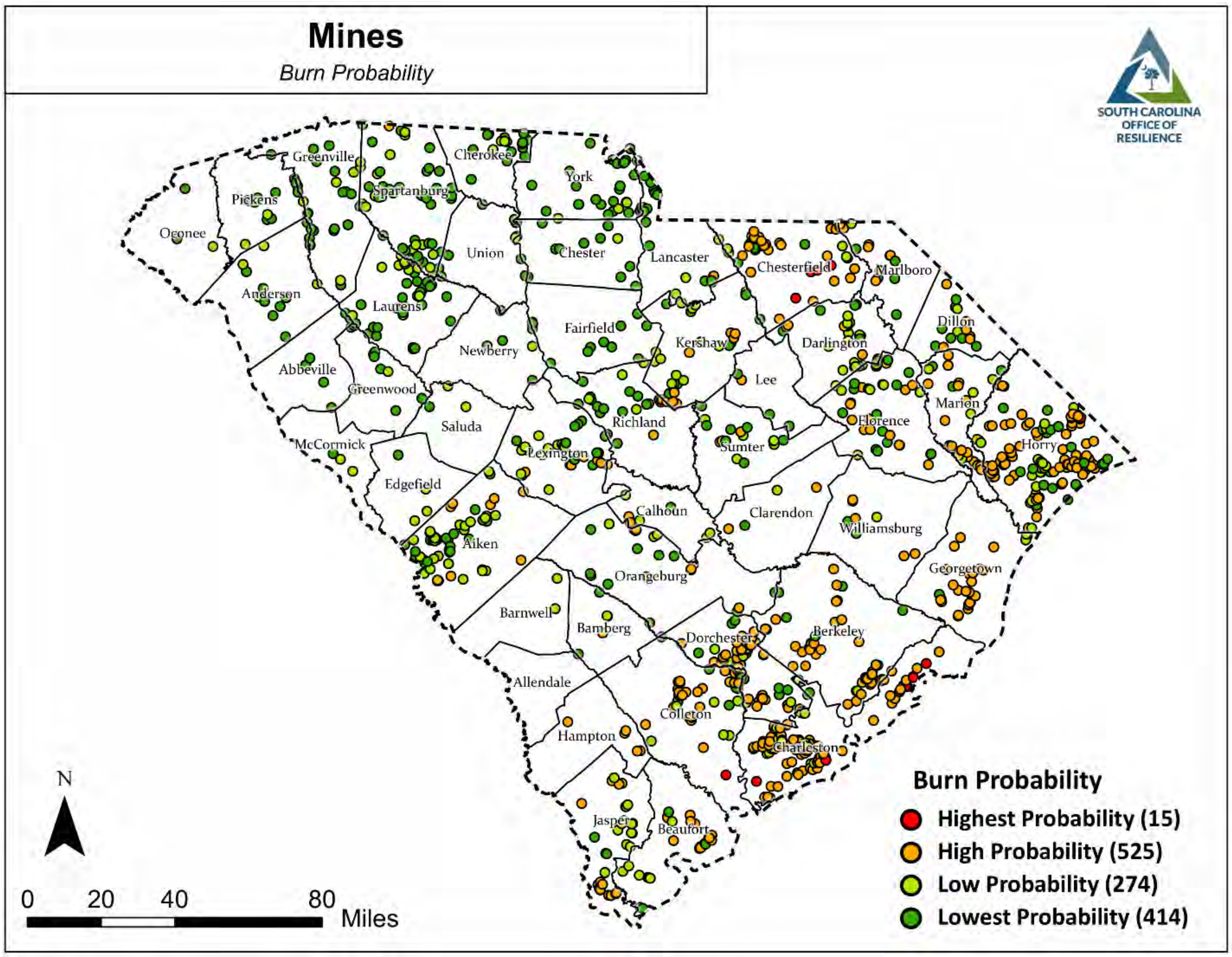

Figure 6.4: Estimated Burn Probability on mines (DHEC). Wildfire data provided by SouthWRAP.

SOLID WASTE

The South Carolina Solid Waste Policy and Management Act defines a solid waste facility as all contiguous land, structures, other appurtenances, and improvements on the land used for treating, storing, or disposing of solid waste. A facility may consist of several treatment, storage, or disposal operational units such as landfills, surface impoundments, or a combination. Figure 6.5 shows landfills in relation to burn probability areas, where Figure 6.6 is all solid waste facilities in relation to burn probability areas.

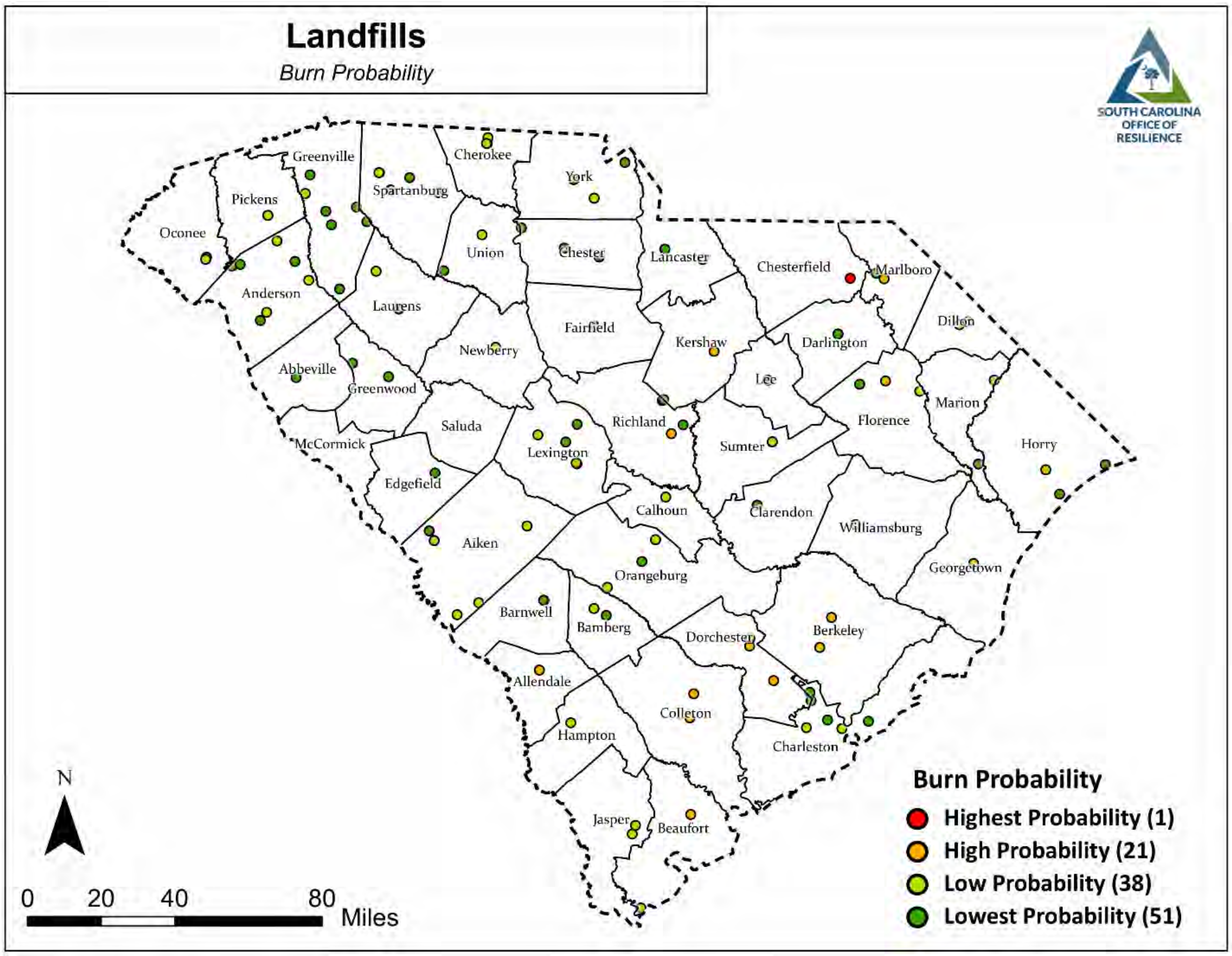

Figure 6.5: Estimated Burn Probability of solid waste facilities (Department of Homeland Security). Wildfire data provided by SouthWRAP

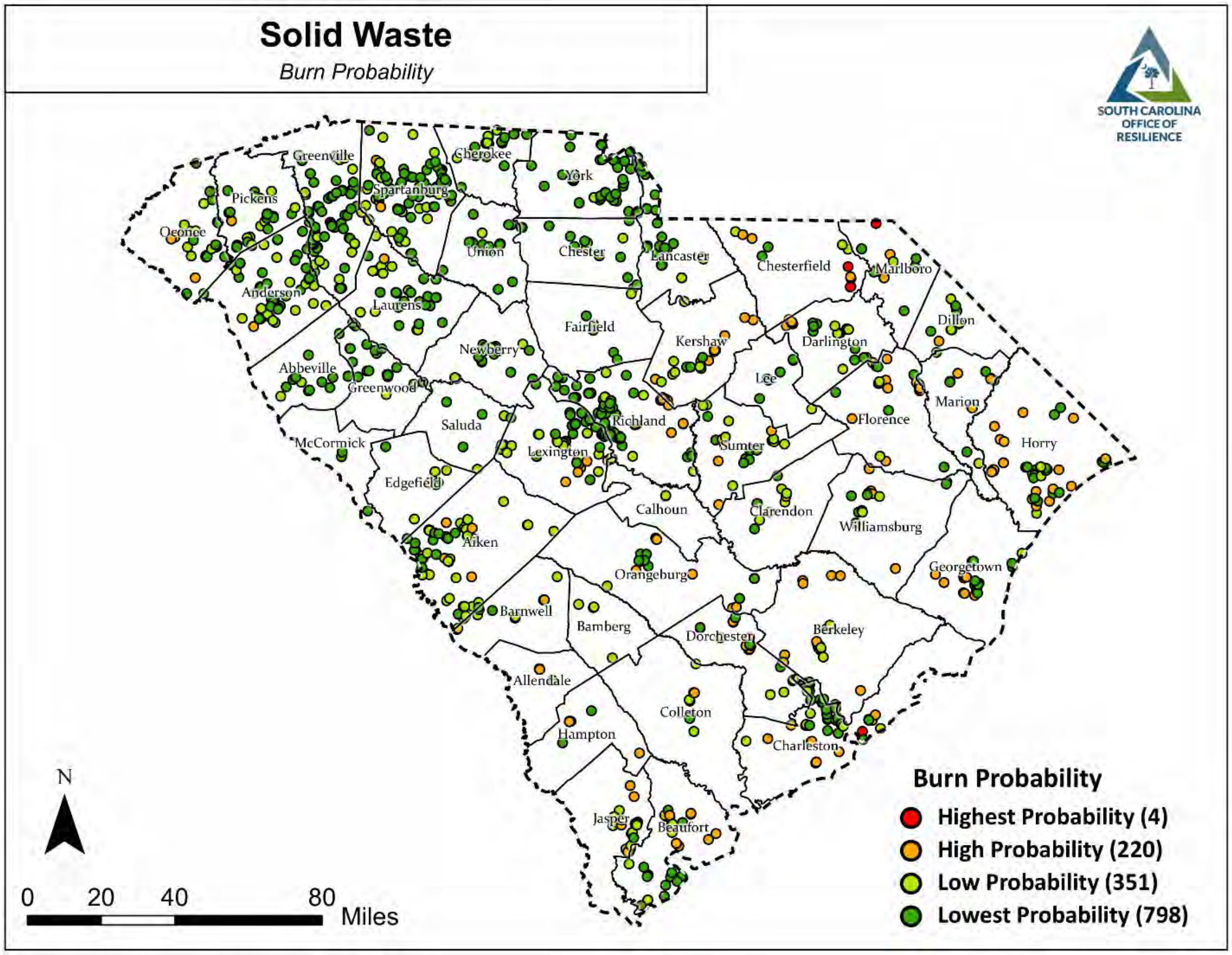

Figure 6.6: Estimated Burn Probability of solid waste facilities (DHEC). Wildfire data provided by SouthWRAP

HAZARDOUS MATERIALS TREATMENT, STORAGE AND DISPOSAL

DHEC permits active hazardous materials treatment, storage and disposal facilities as authorized by the Federal Resource Conservation and Recovery Act, which established a process for treating, transporting, storing and disposing of hazardous waste (SC Department of Health and Environmental Control, n.d.). Figure 6.7 shows the burn probability risk to hazardous materials treatment, storage, and disposal facilities in South Carolina.

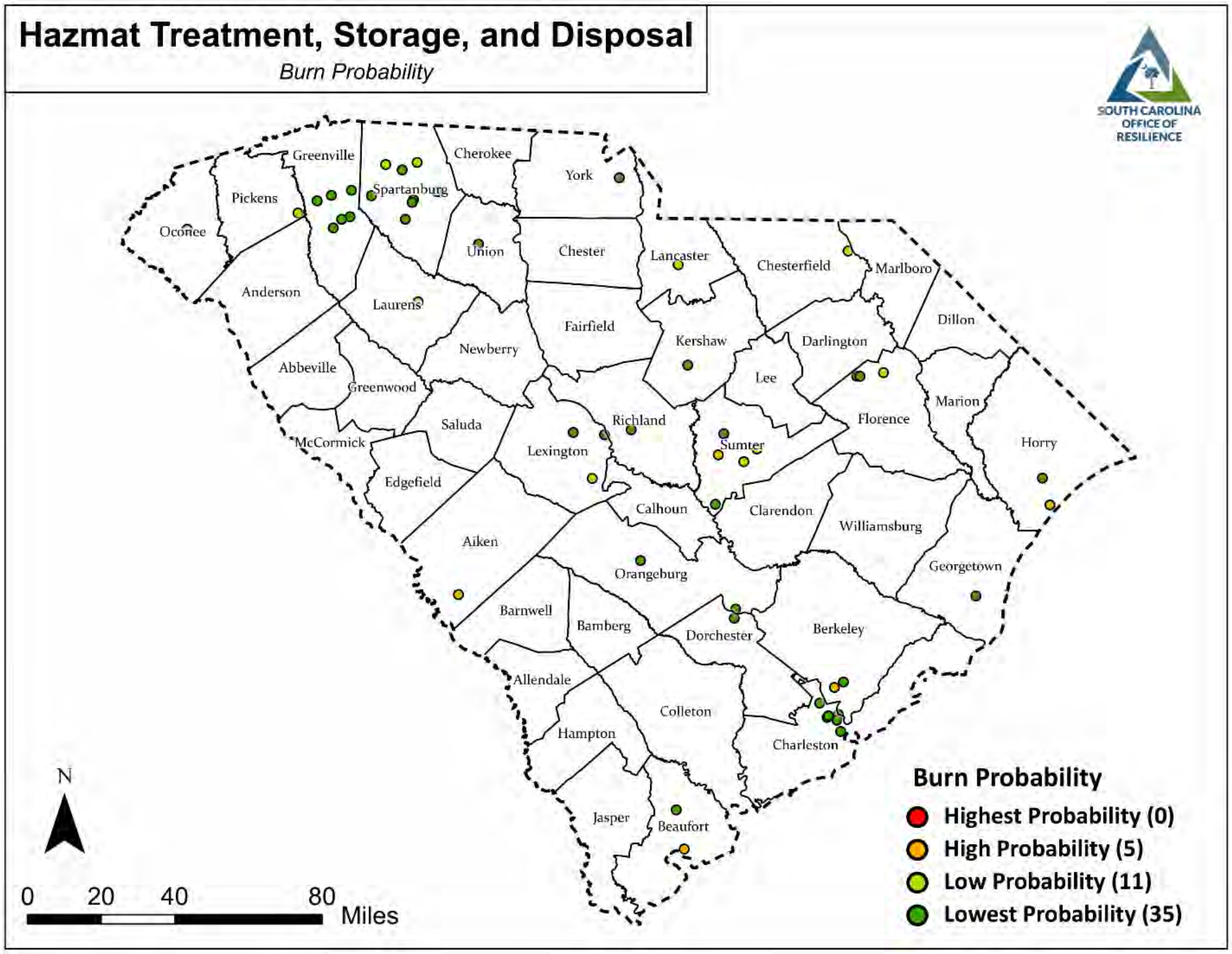

Figure 6.7: Estimated Burn Probability of Hazmat Treatment, Storage and Disposal Facilities (DHEC). Wildfire data provided by SouthWRAP

CULTURAL RESOURCES

South Carolina's history is rich with the diversity of traditional communities that trace their roots to the landscape.

Figure 6.8 represents the number of points from National Register Locations with a Burn Probability of 5 or higher by census tract. South Carolina has over 1,600 listings in the National Register of Historic Places including 199 historic districts. Since one listing can include multiple buildings and sites, it is estimated that 12,000 to 15,000 properties are included in the National Register.

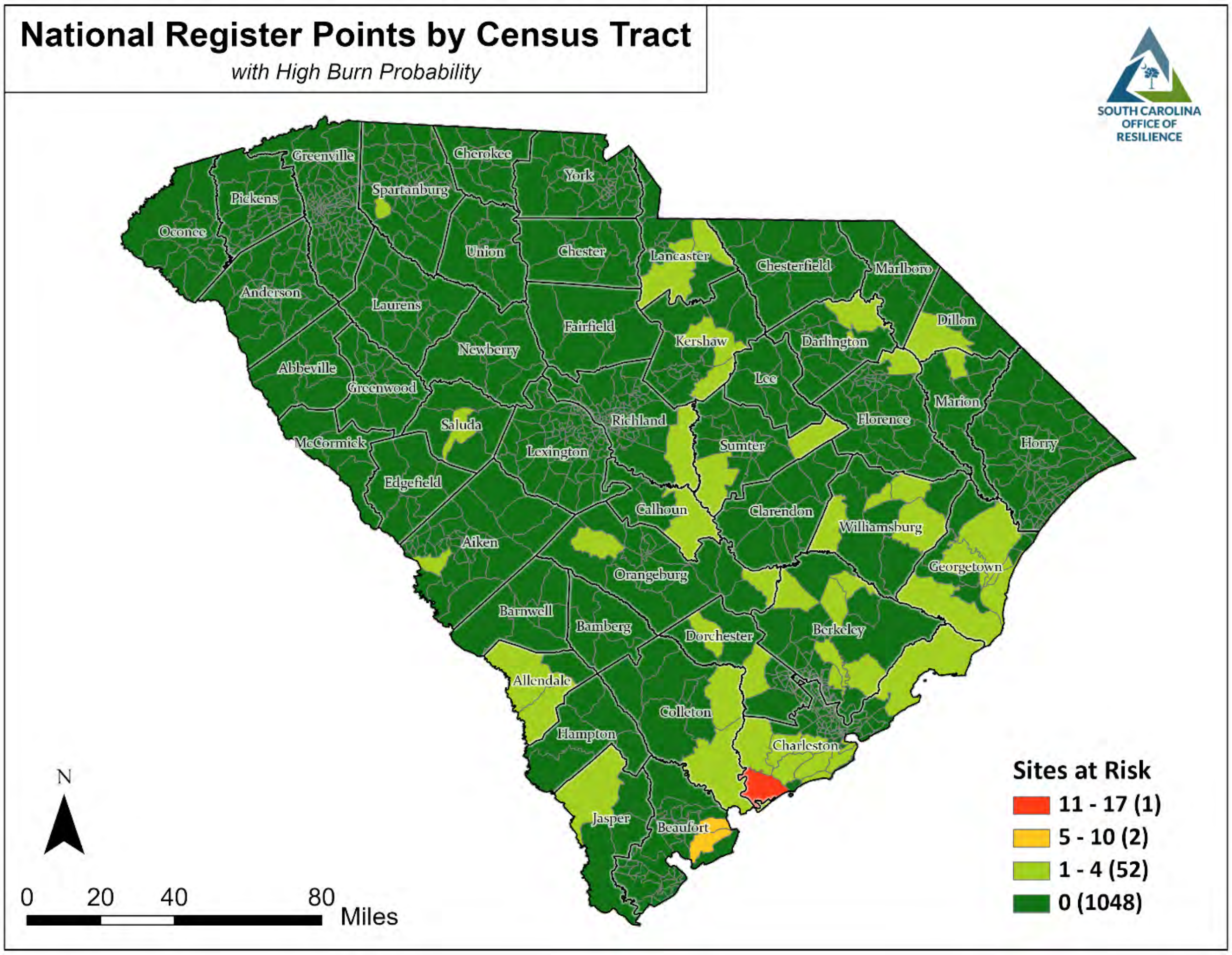

Figure 6.8: National Register Locations with a Burn Probability of 5 or higher by census tract (ArchSite). Wildfire data provided by SouthWRAP

Figure 6.9 shows the historic structures in the National Register with a Burn Probability of 5 or higher by census tract. Over 83,000 properties have been recorded by surveys of historic properties since the early 1970s. Over the past decade an average of 1,800 properties were added annually to the Statewide Survey collection that is maintained by the SC Department of Archives and History (SCDAH).

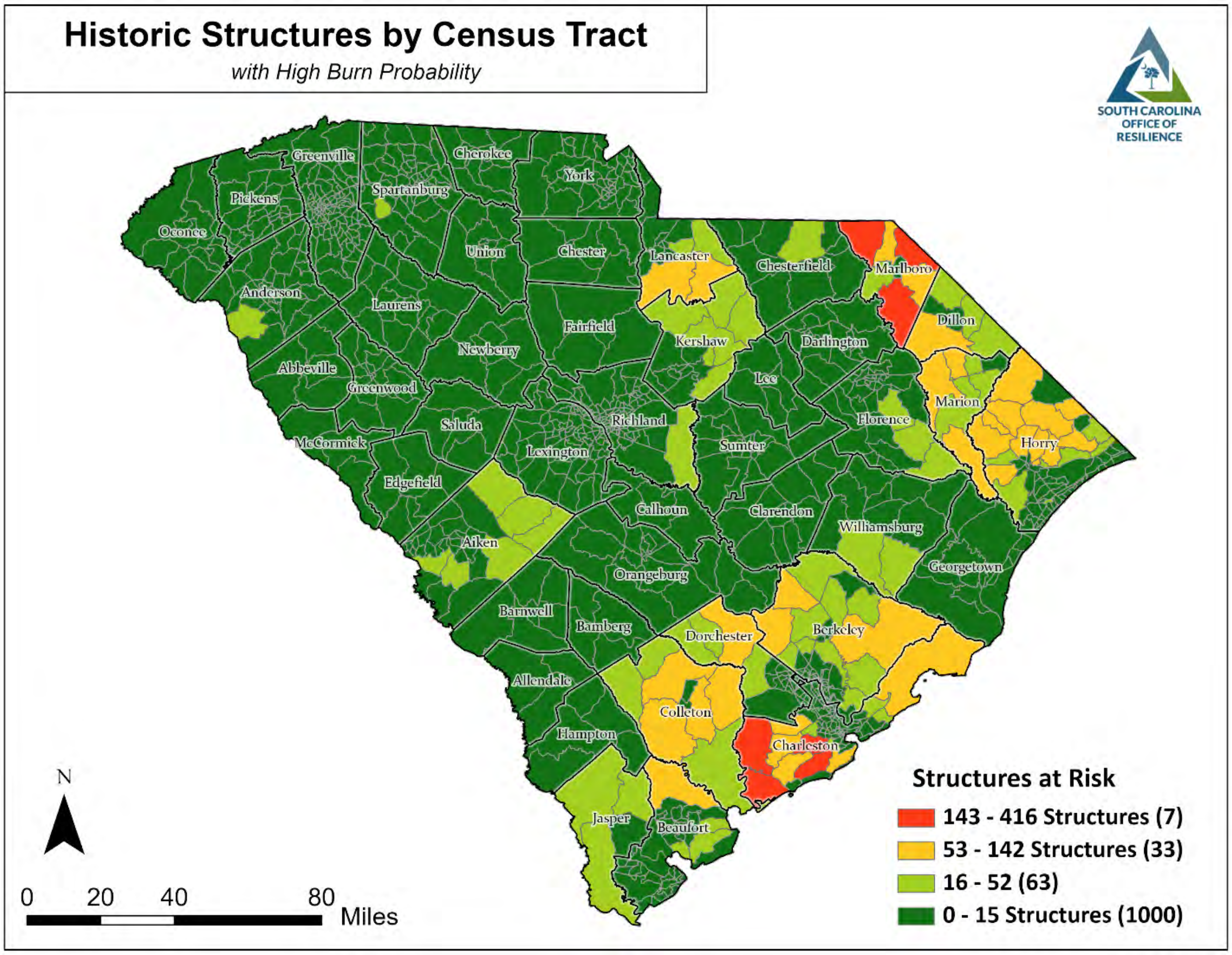

Figure 6.9: Historic Structures with a Burn Probability of 5 or Higher by census tract (ArchSite). Wildfire data provided by SouthWRAP

COMMUNITY SERVICES

Community services are essential to maintaining the health, safety and welfare of people, economies and ecosystems through environmental changes and natural hazards.

MILITARY

South Carolina's military community provides critical strategic value to our nation's defense. Our location on the East Coast is advantageous for deployment to the Middle East, South and Central America, Africa, and Europe, as well as to Military Operating Areas (MOAs) offshore. Each base (Figure 6.10) supports multiple defense missions that contribute to defense readiness, training, and homeland security (SC Department of Veterans' Affairs, n.d.). Figures 6.11 to Figure 6.14 identify the burn probability of many of the military installations across South Carolina.

Figure 6.10: South Carolina Military Installations

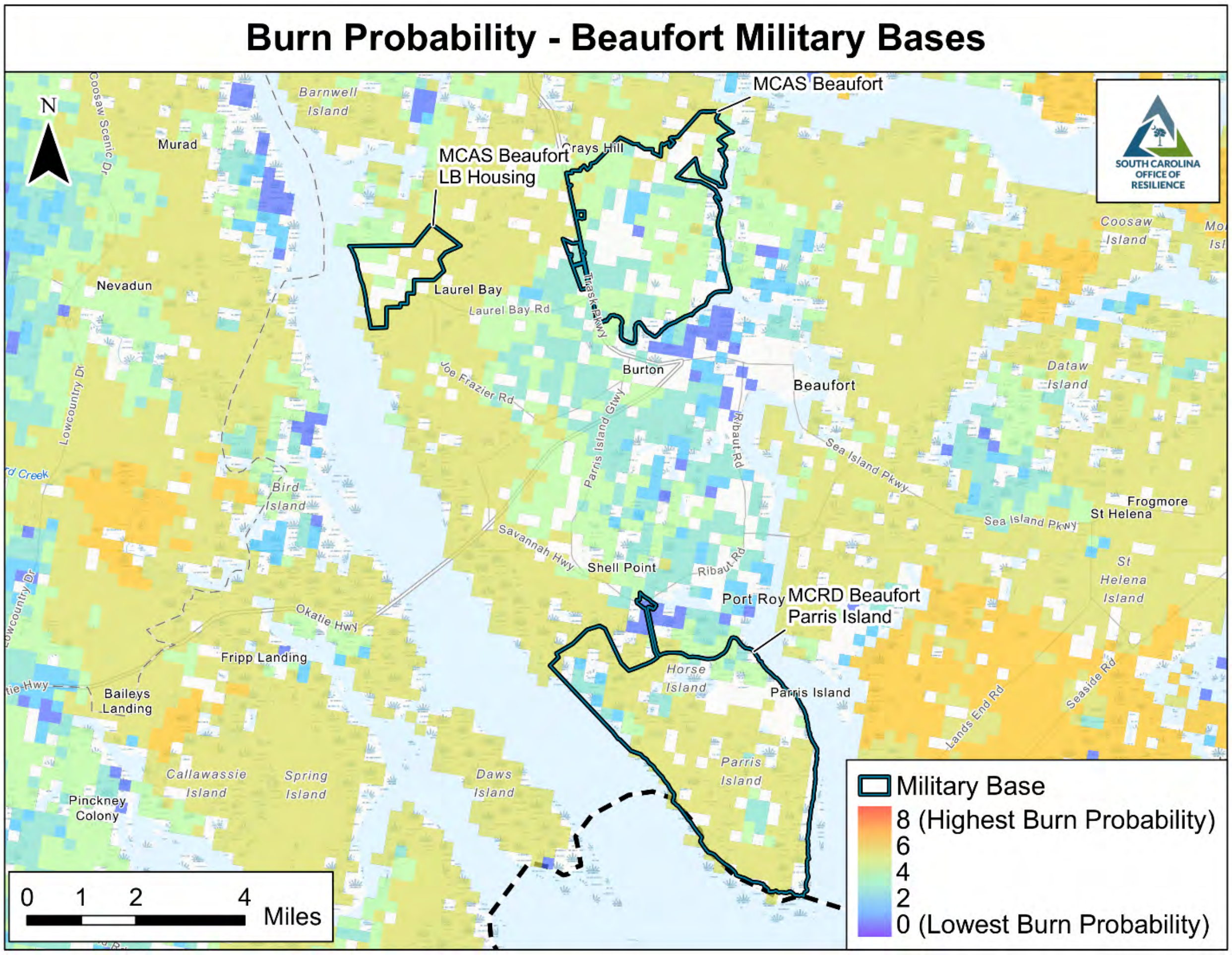

Figure 6.11: Estimated Burn Probability of Military Installations in the Beaufort County: MCAS Beaufort, MCAS Beaufort LB Housing, and MCRD Beaufort Parris Island. Wildfire data provided by SouthWRAP

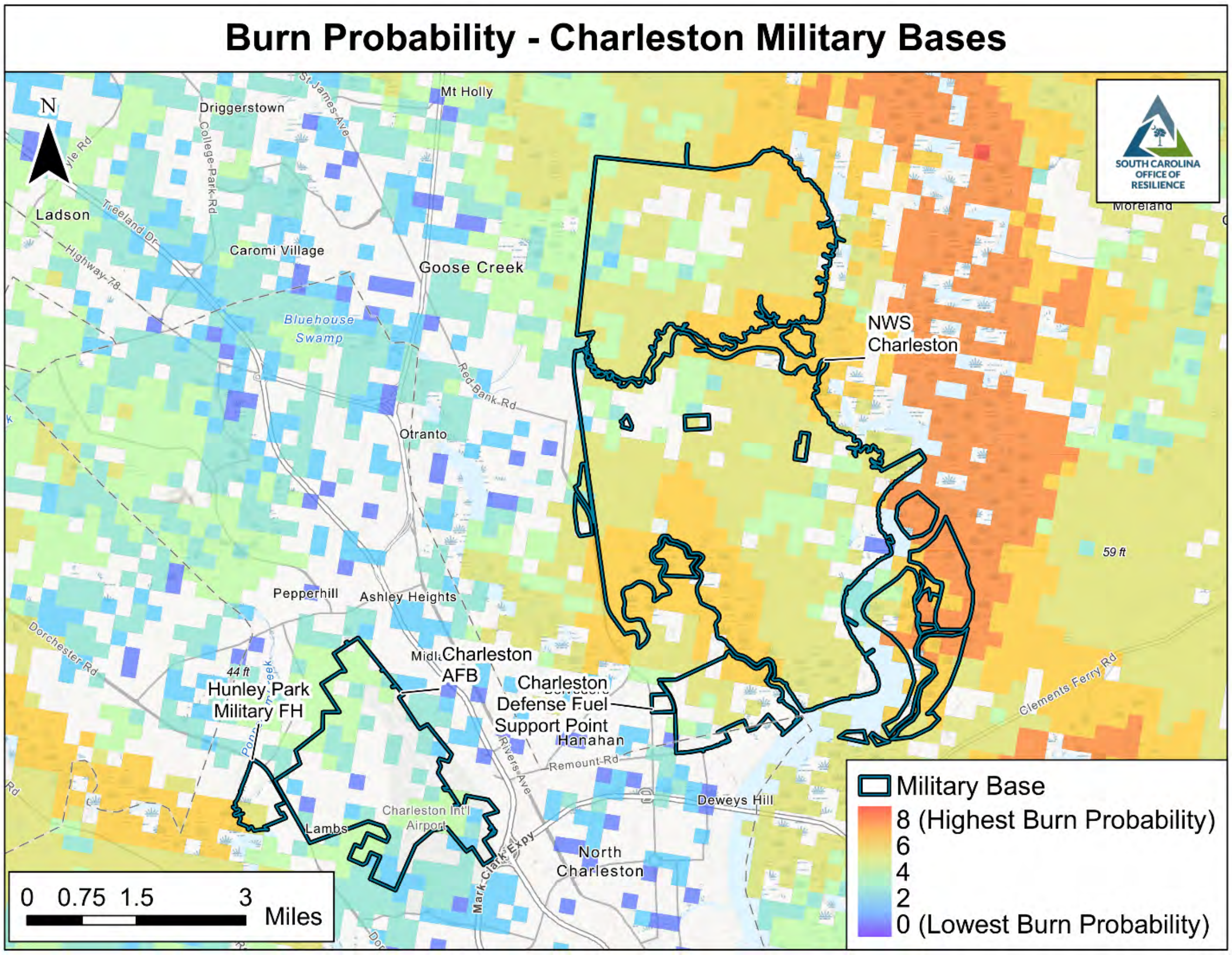

Figure 6.12: Estimated Burn Probability of Military Installations in the Charleston County: NWS Charleston, Charleston Defense Fuel Support Point, Charleston AFB, and Hunley Park Military FH. Wildfire data provided by SouthWRAP

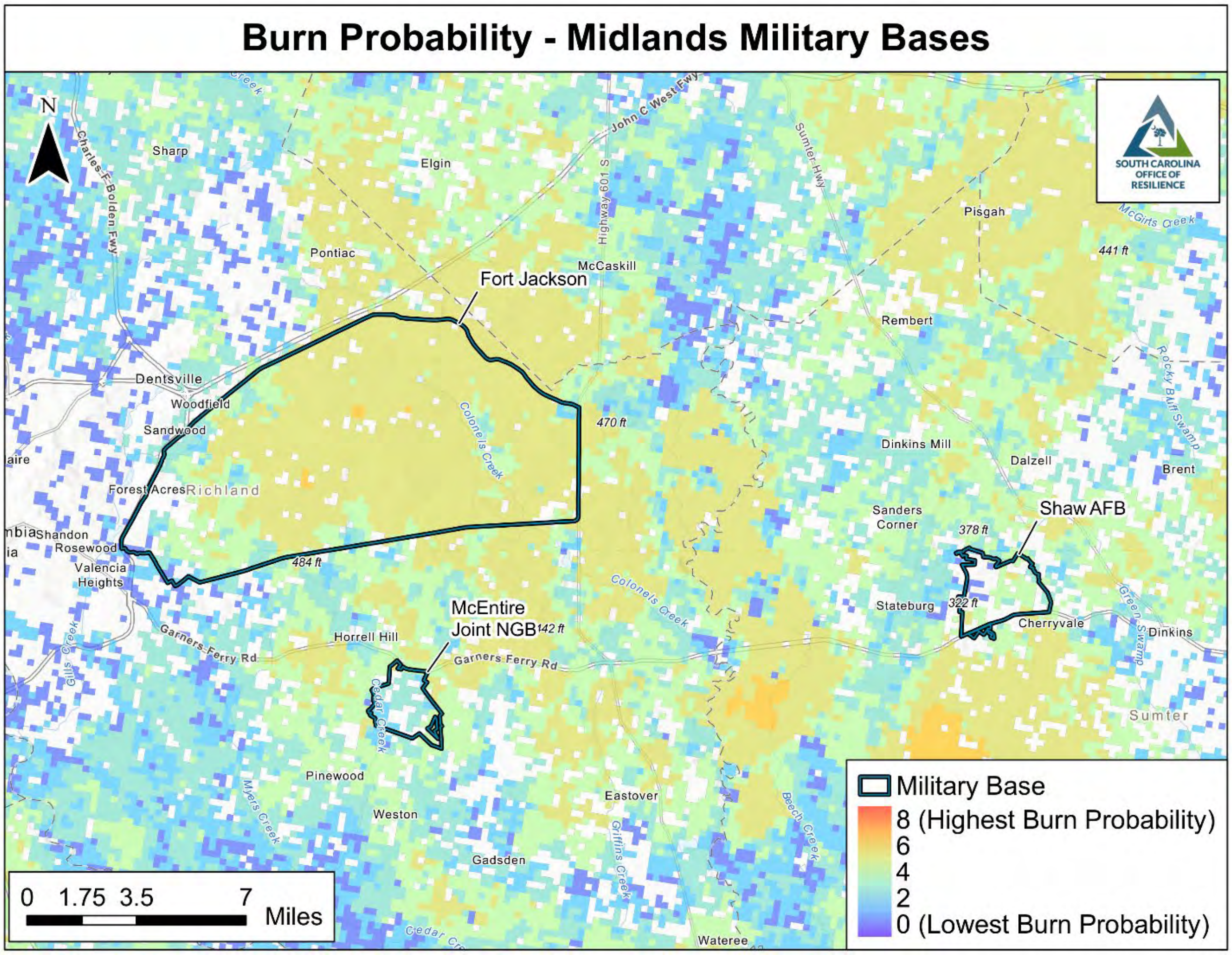

Figure 6.13: Estimated Burn Probability of Military Installations in the Midlands, Fort Jackson, Shaw AFB, and McEntire Joint NGB. Wildfire data provided by SouthWRAP

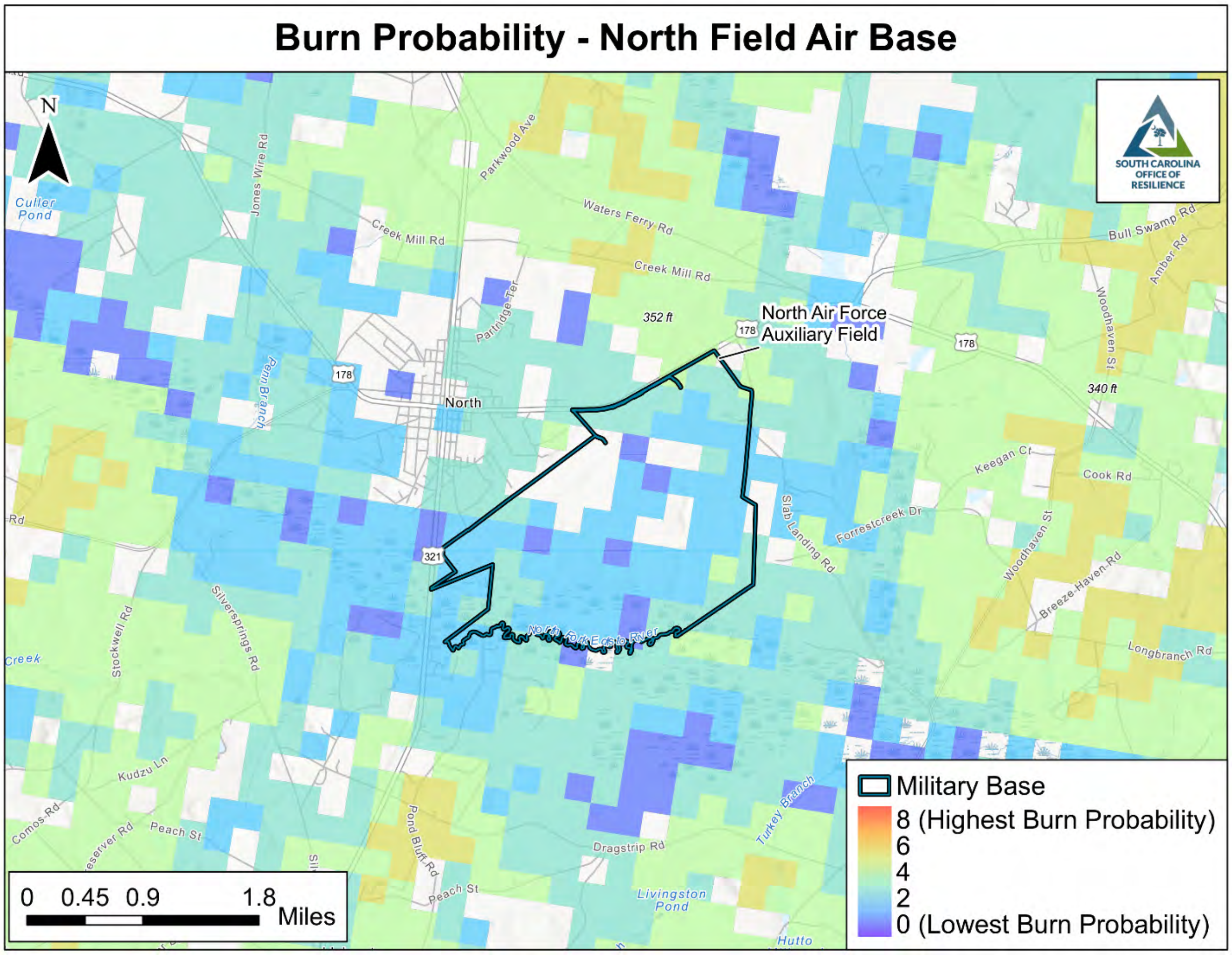

Figure 6.14: Estimated Burn Probability of North Field Air Base in Orangeburg County. Wildfire data provided by SouthWRAP

PUBLIC SAFETY

STATE LEVEL

State level law enforcement in South Carolina is split across several agencies. The Department of Public Safety and the State Law Enforcement Division (SLED) act in coordination with local and federal entities. Services provided include crime investigation, emergency response, intelligence gathering, protective services, and highway patrol. In times of emergency, personnel and resources are deployed preemptively to provide support functions to the afflicted areas.

The South Carolina Forestry Commission has 48 commissioned, class 1 law enforcement officers that conduct origin and cause investigations on every wildfire the SCFC responds to and assists other state and local agencies with origin and cause needs. SCFC has 4 full-time investigators that focus on complex arson causes and other issues, like timber theft.

LOCAL LAW ENFORCEMENT

While the above state agencies support local law enforcement agencies, the initial response depends on county, city, and town law enforcement agencies. Figure 6.15 shows the potential risk to law enforcement offices across the state.

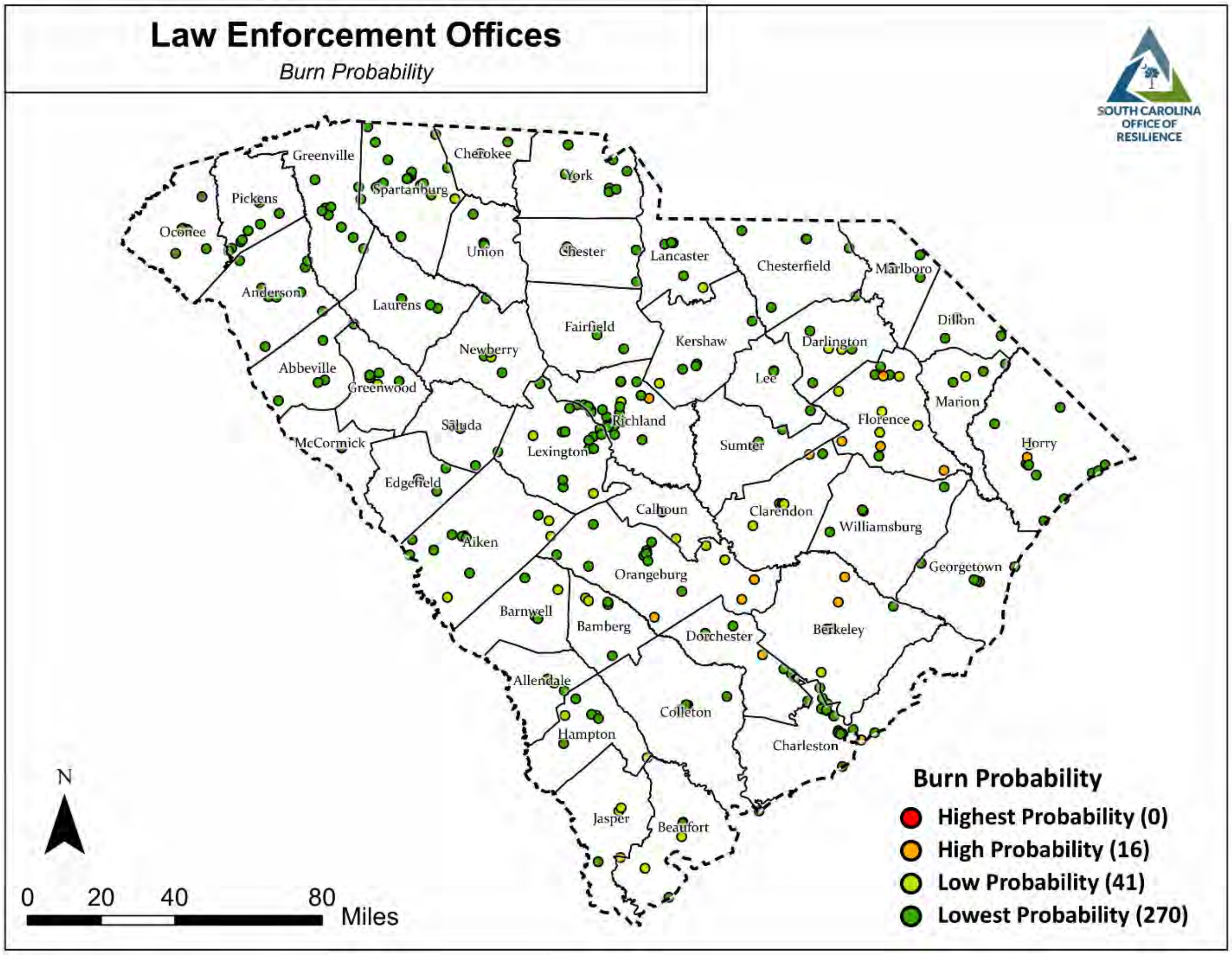

Figure 6.15: Estimated Burn Probability of local law enforcement agencies (SLED). Wildfire data provided by SouthWRAP

DETENTION CENTERS

SLED identifies 84 detention centers across the state, which includes county, state, federal, and juvenile facilities. Figure 6.16 shows the potential risk to detention centers across the state.

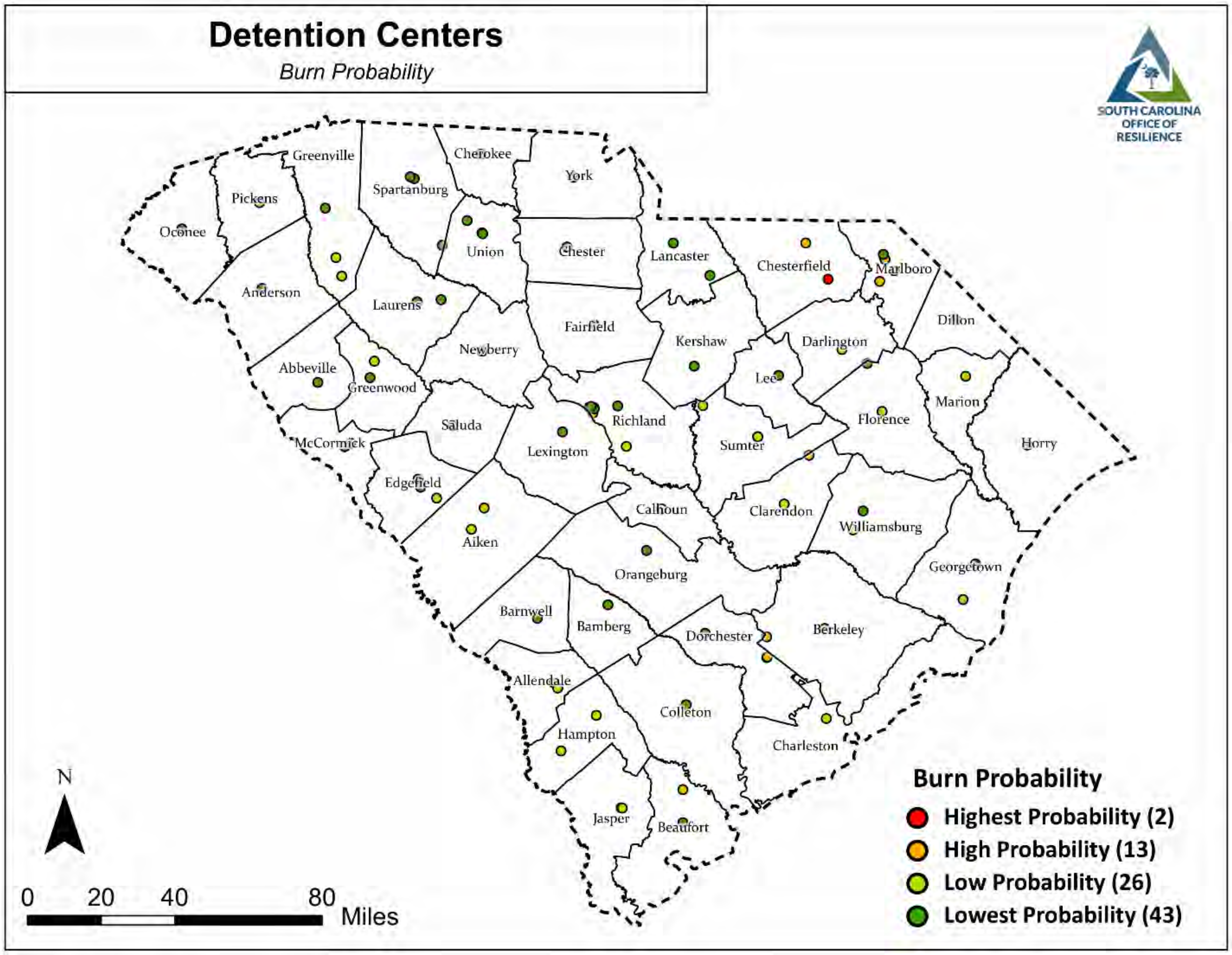

Figure 6.16: Estimated Burn Probability of detention centers (SLED). Wildfire data provided by SouthWRAP

FIRE STATIONS

Fire stations provide response to a variety of incidents, disasters, and situations. The public relies heavily on first responders during daily emergencies, and even more during disasters when there is a greater need for assistance. Figure 6.17 shows the burn probability for fire stations across the state. The data points include manned fire stations and buildings from which a fire response occurs, such as volunteer fire department buildings, and includes both private and governmental entities.

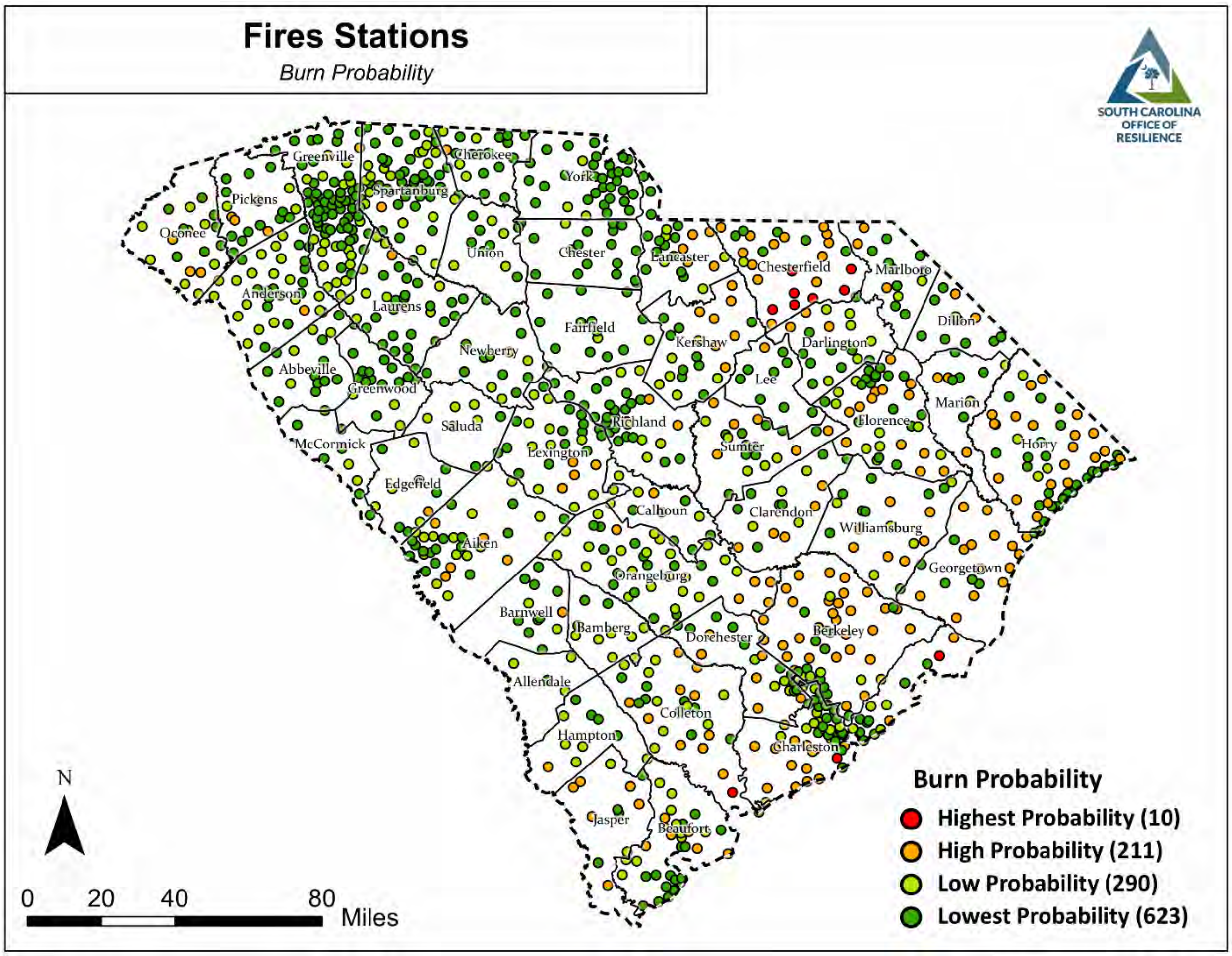

Figure 6.17: Estimated Burn Probability of fire stations (Department of Homeland Security). Wildfire data provided by SouthWRAP

EMS

Like fire stations, EMS stations and personnel are needed daily, but are in increased demand leading up to, during, and after a disaster. There are an increased number of calls to respond to and more barriers to arriving on the scene. Similar to fire stations, EMS stations are placed where they can service the most people and as the population grows, new staging sites are added. Figure 6.18 shows the burn probability for EMS stations across the State.

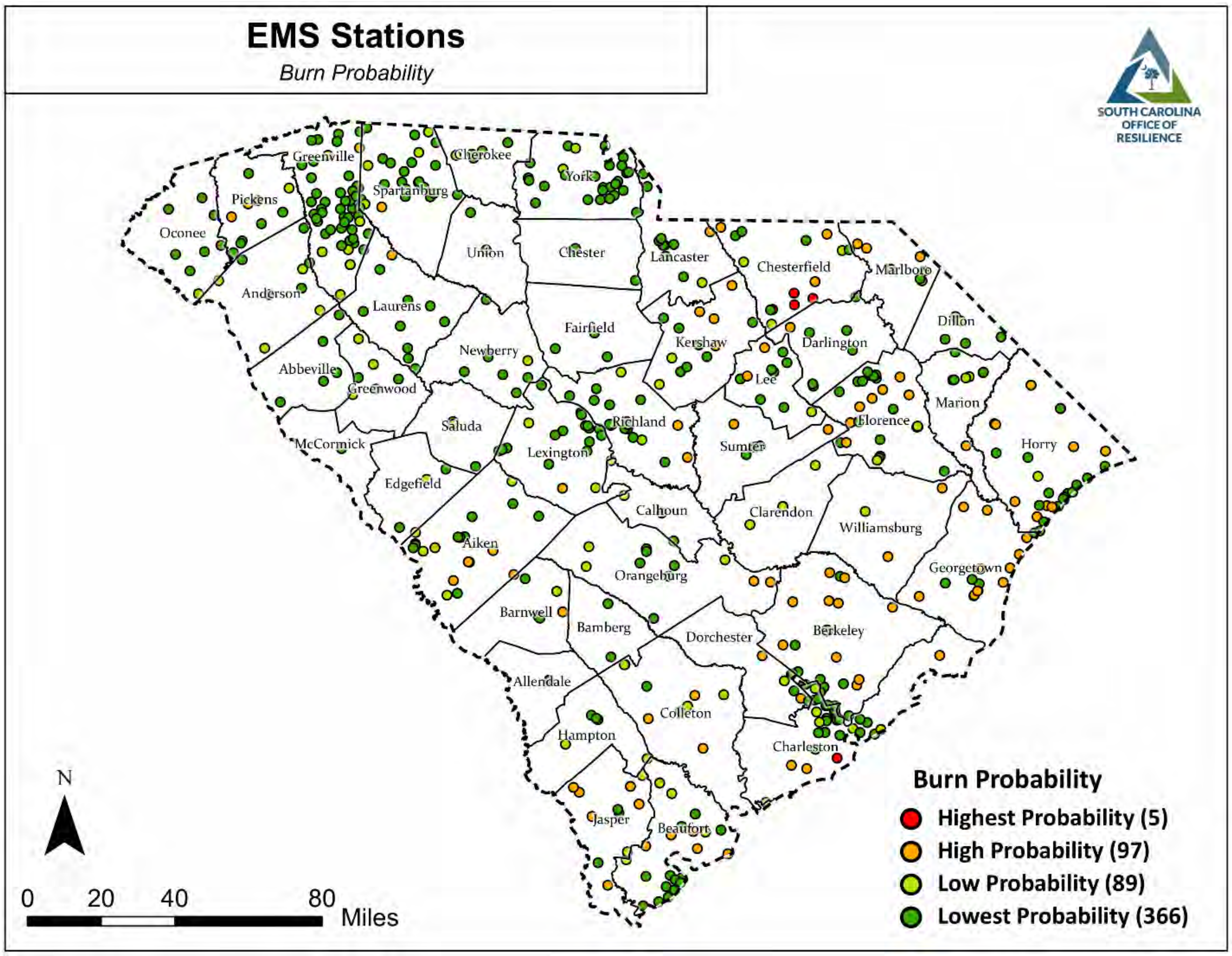

Figure 6.18: Estimated Burn Probability of EMS stations (Department of Homeland Security). Wildfire data provided by SouthWRAP

EDUCATION

In addition to the initial impact of an event on schools, hazard events have the potential to force schools to close for long periods of time, disrupting student learning.

K-12 EDUCATION

According to the South Carolina Department of Education's Active Student Headcounts, there are 777,111 students enrolled in South Carolina public schools (SC Department of Education, 2022). It has been found that the damage public schools face due to natural hazards is compounded by their age and condition (The Pew Charitable Trusts, 2017). These factors are not variables in the assessment for burn probability used to identify the public schools at potential risk in Figure 6.19 and the private schools in Figure 6.20.

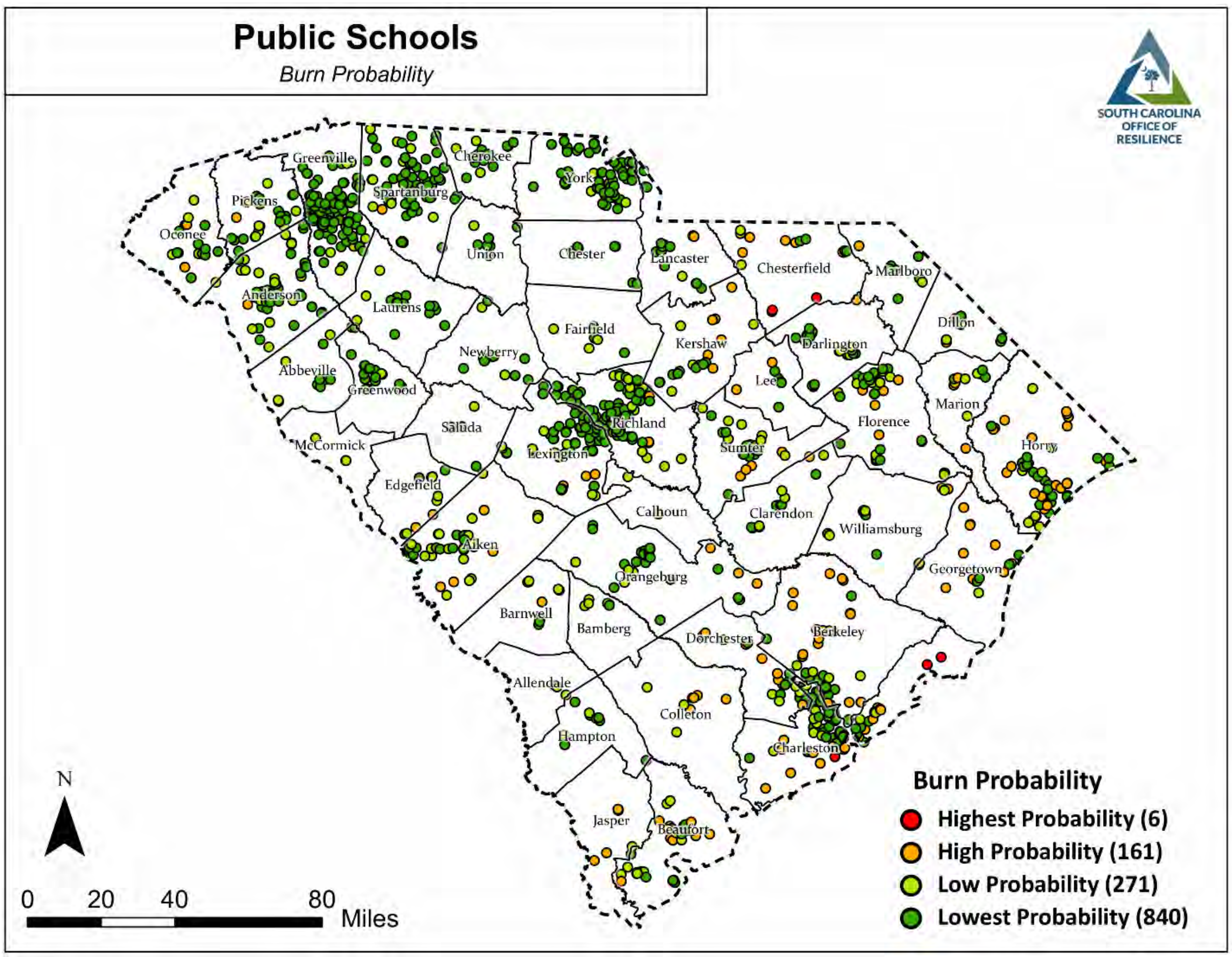

Figure 6.19: Estimated Burn Probability of public schools (Department of Homeland Security). Wildfire data provided by SouthWRAP.

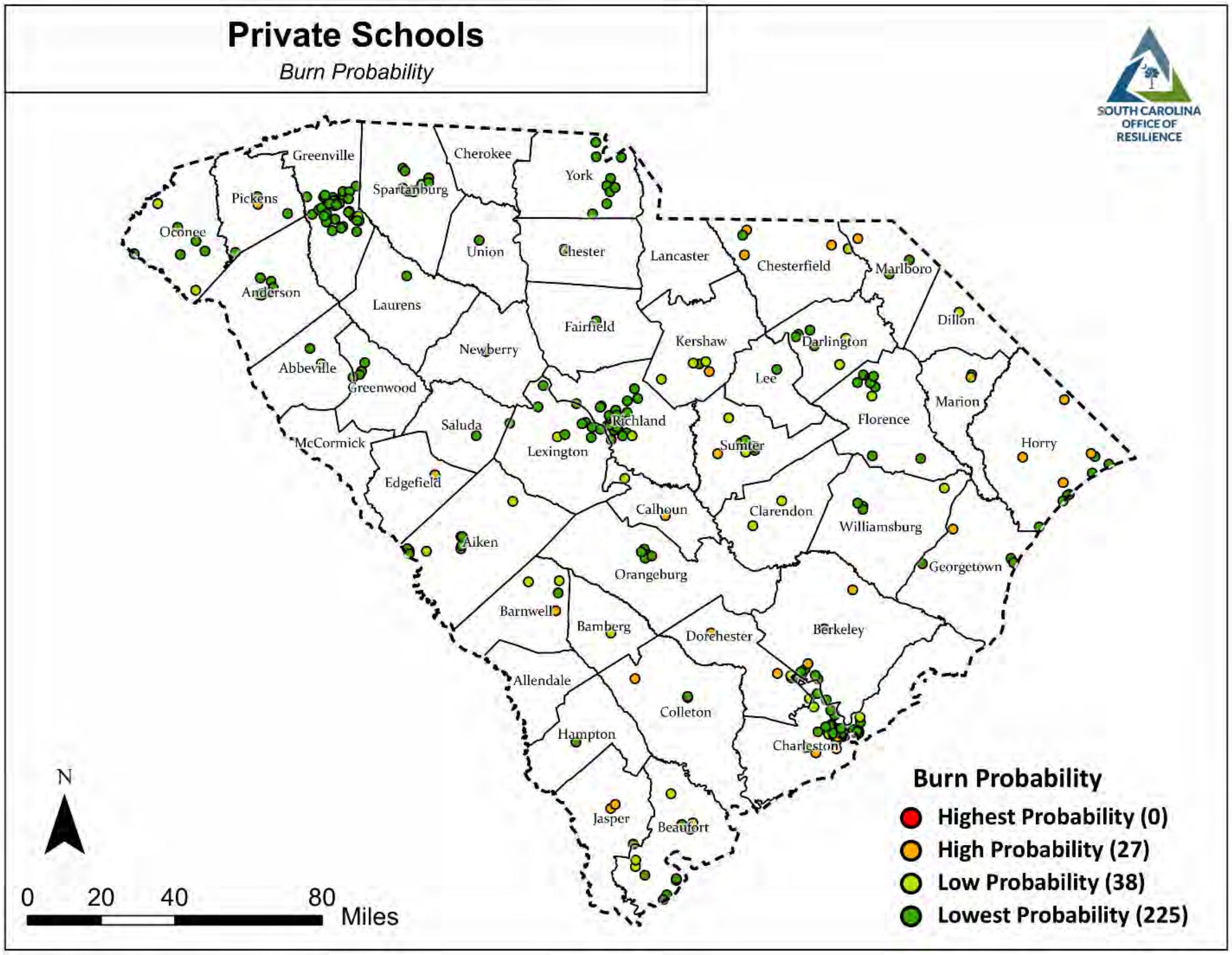

Figure 6.20: Estimated Burn Probability of private schools (Department of Homeland Security). Wildfire data provided by SouthWRAP.

HIGHER EDUCATION

There are 33 public colleges and universities as well as 25 independent institutions in South Carolina. In the Fall of 2020, these institutions enrolled 229,781 students, 69.8% of which were full-time students. In the previous school year (2019-2020), these institutions awarded 52,670 degrees, 49.4% of which were bachelor's degrees. This is a 14.5% increase over the total degrees awarded in the 2010-2011 school year. From an economic perspective, public and private institutions employ nearly 16,000 faculty members, and 48% are full-time (SC Commission on Higher Education, 2021).

In terms of physical vulnerability, public institutions alone have a building footprint of over 36 million square feet of usable space across the state, 28% of which is instructional space. 40% of buildings are over 50 years old while 10% of all public campus buildings are over 99 years old.

Figure 6.21 shows the burn probability of the post-secondary education schools. Higher education tends to have large campuses that can be distributed across towns and satellite campuses. The point analysis does not represent the total wildfire risk to a whole campus and just a single point at the campus.

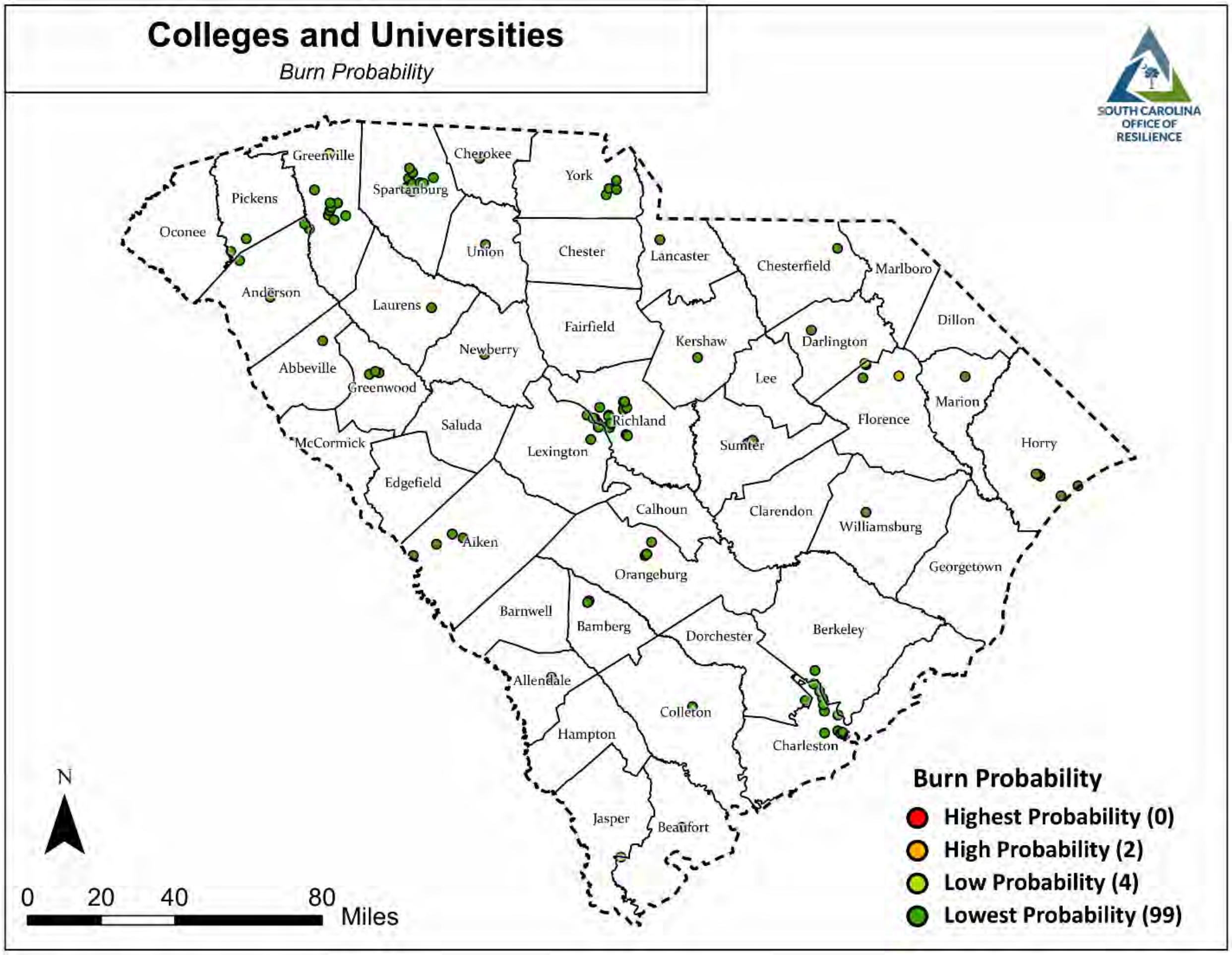

Figure 6.21: Estimated Burn Probability of colleges and universities (Department of Homeland Security). Wildfire data provided by SouthWRAP.

PUBLIC HEALTH

Wildfires can have large impacts on public health. The maps below show the physical burn probability of public health facilities. In addition to the risk of facilities burning, smoke associated with fire is of particular concern to public health. Wildfires can occur at any time, and the worst air quality impacts often happen when atmospheric conditions keep smoke low and blow it into developed areas or over roadways, creating hazardous air quality for public health or unsafe driving conditions where accidents may occur. Wildfire smoke can travel very long distances and cause impacts to sensitive populations. As more wildfires occur in the wildland urban interface, there have been increased smoke impacts on the population. These impacts can even be seen with controlled, prescribed fires, like those conducted by the SCFC. SCFC works with DHEC to implement South Carolina's Smoke Management Guidelines to encourage prescribed burns for forestry, wildlife, and agriculture purposes to be conducted on days when the atmospheric conditions allow smoke to dissipate and minimize smoke impacts, thereby allowing land managers to choose to burn when smoke will not create avoidable public health issues.

PUBLIC HEALTH FACILITIES

DHEC’s Bureau of Health Facility Licensing (BHFL) regulates health care facilities and providers, enforcing standards, inspections, and licenses for nursing homes, hospices, home health agencies, ambulatory surgical centers, adult day cares, and renal dialysis centers that provide essential health services. Figure 6.22 shows the burn probability for health facilities.

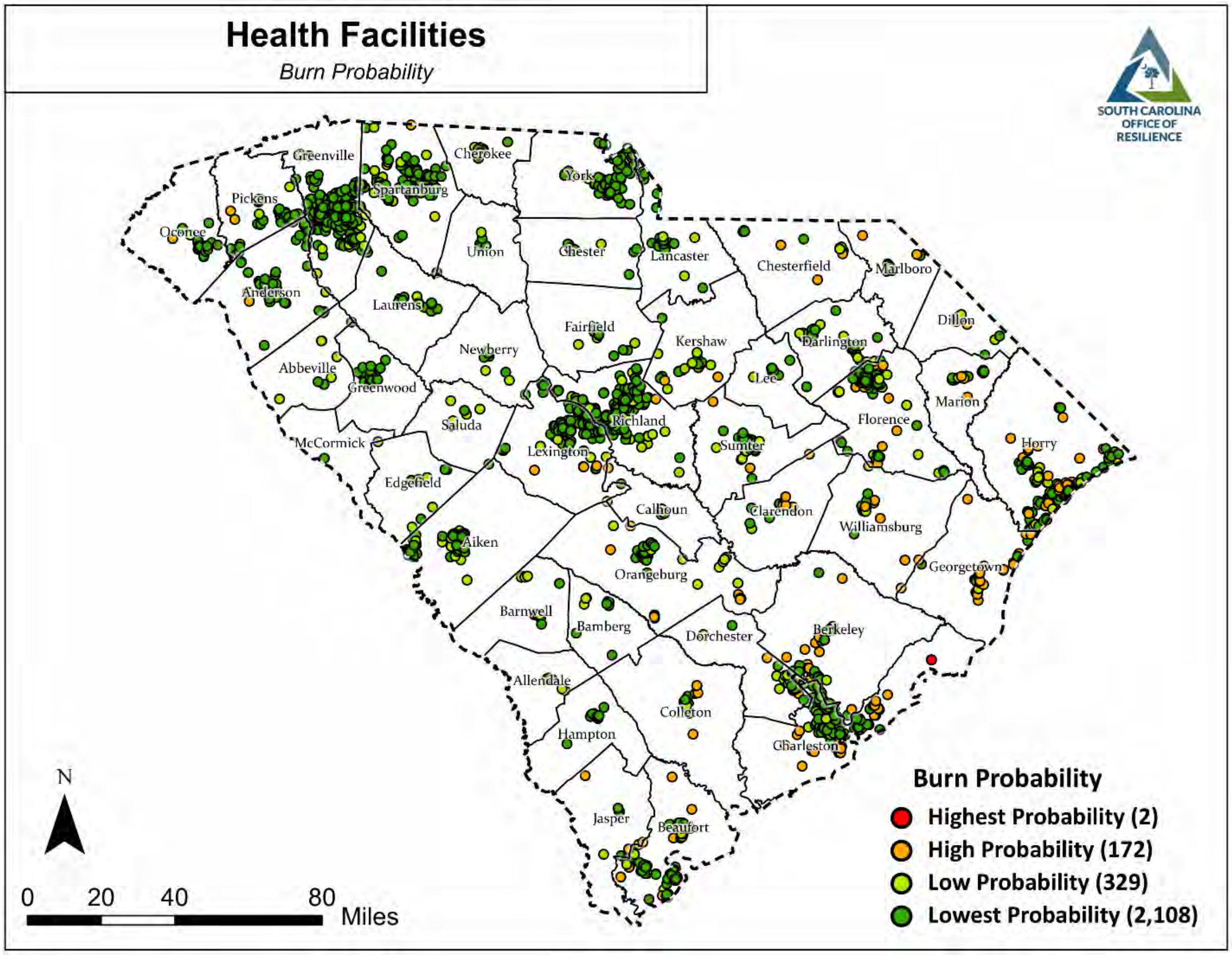

Figure 6.22: Estimated Burn Probability of health facilities (DHEC). Wildfire data provided by SouthWRAP.

HOSPITALS

The State has over 100 hospitals. In addition to the physical vulnerabilities of these facilities, environmental changes and natural hazards can increase the demand for medical care. Hospitals can experience increased demand and continue to be essential leading up to, during, and in the short and long term after an event. In the time leading up to an event, especially in the case of evacuations, there can be increased traffic accidents. During and immediately after an event, those who cannot or do not leave may be trapped and in need of medical care. Road detours and closures before and during an event can limit hospital access for patients and staff. Figure 6.23 shows the burn probability for hospitals.

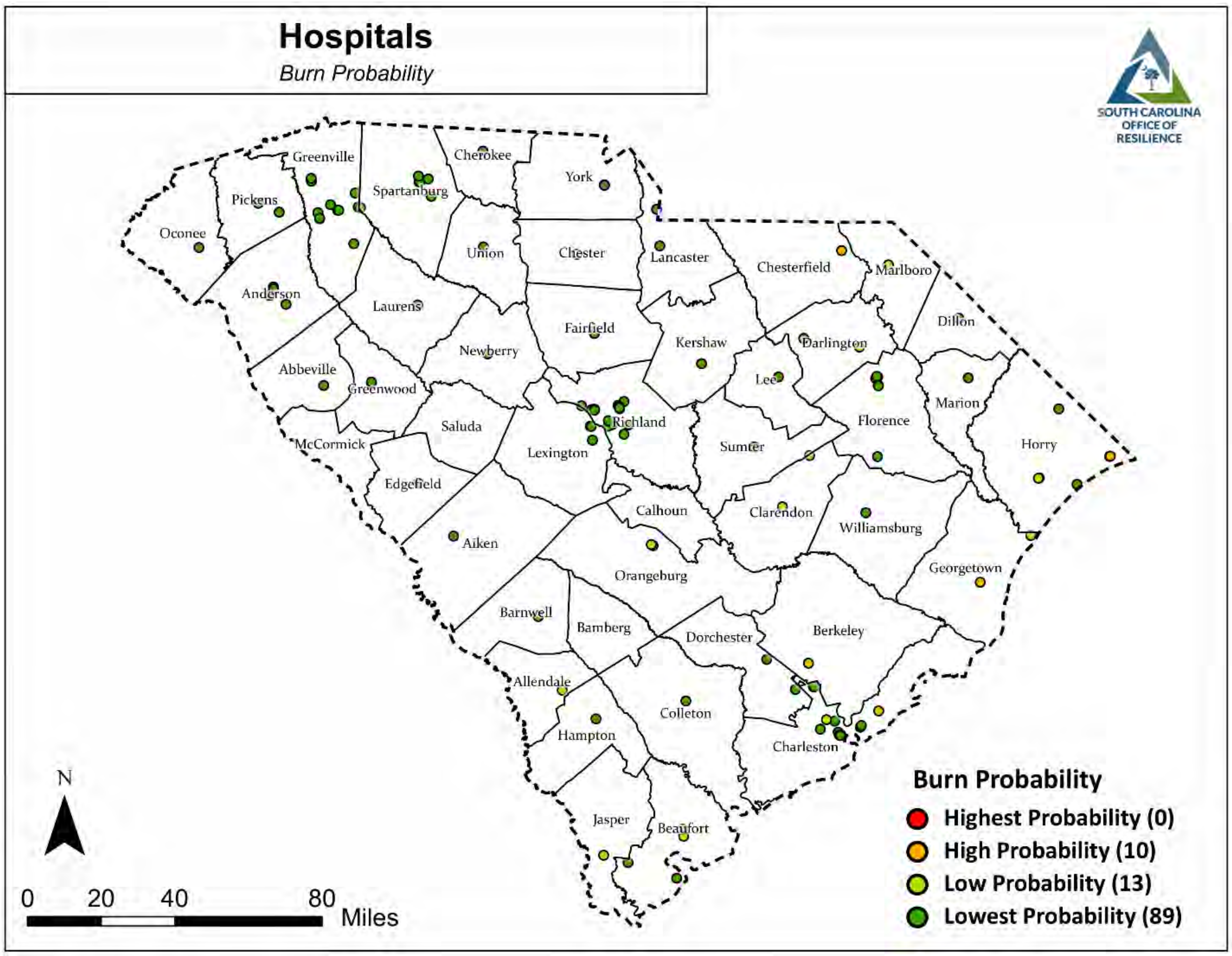

Figure 6.23: Estimated Burn Probability of hospitals (Department of Homeland Security). Wildfire data provided by SouthWRAP.

NURSING HOMES

Nursing homes have similar vulnerabilities to hospitals when it comes to providing medical care. The residential nature of these facilities has the potential to impact their residents in the long term, requiring them to find other homes to live in and the loss of personal belongings. Figure 6.24 shows the burn probability for nursing homes.

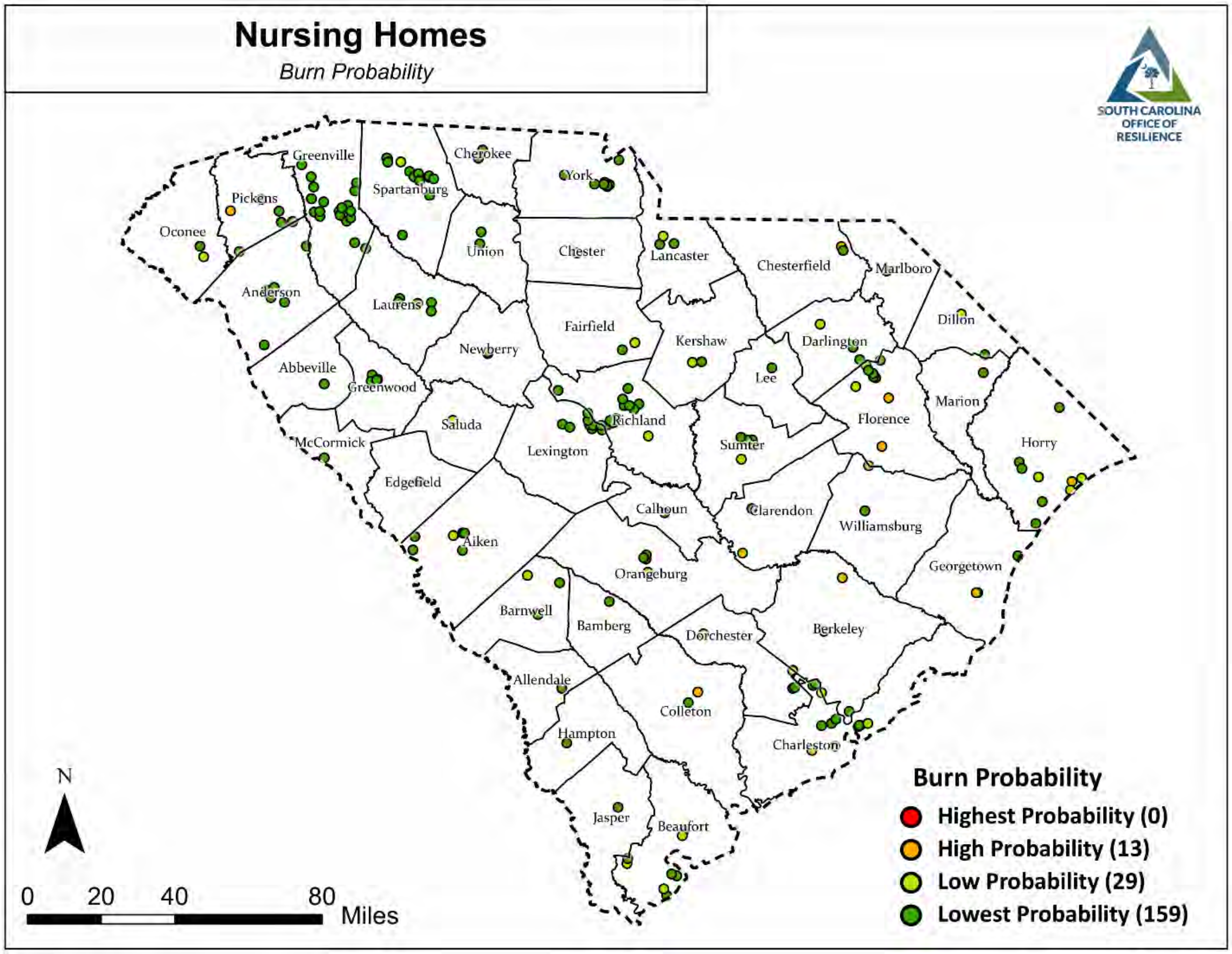

Figure 6.24: Estimated Burn Probability of nursing homes (Department of Homeland Security). Wildfire data provided by SouthWRAP.

MENTAL HEALTH FACILITIES

Experiencing environmental change and natural hazards can be stressful, and for some people, they may result in serious mental health consequences and make access to care for ongoing conditions more difficult. According to the South Carolina Behavioral Health 2021 Progress Report, nearly a fifth of South Carolinians live with mental illness, with 18.3% reporting a diagnosable mental, behavioral, or mental disorder in 2018 as reported by Mental Health America (South Carolina Institute of Medicine & Public Health, 2021).

There are 79 facilities operated by the South Carolina Department of Mental Health (DMH), helping individuals with addiction, Anxiety, Attention Deficit Disorder (ADD), behavioral problems, Bipolar Disorder, Depression, Oppositional Defiant Disorder (ODD), suicide risk, thought disorders, and trauma. This includes three hospitals, four nursing homes, 16 Community Mental Health Centers, and 43 Mental Health Clinics. The vulnerability of these programs is not isolated to the physical facilities but incorporates the mental health professionals' and the patients' access to these locations. Events may create accessibility issues and serve as traumatic events, spurring the need for more mental healthcare in its wake. Figure 6.25 shows the burn probability for DMH offices.

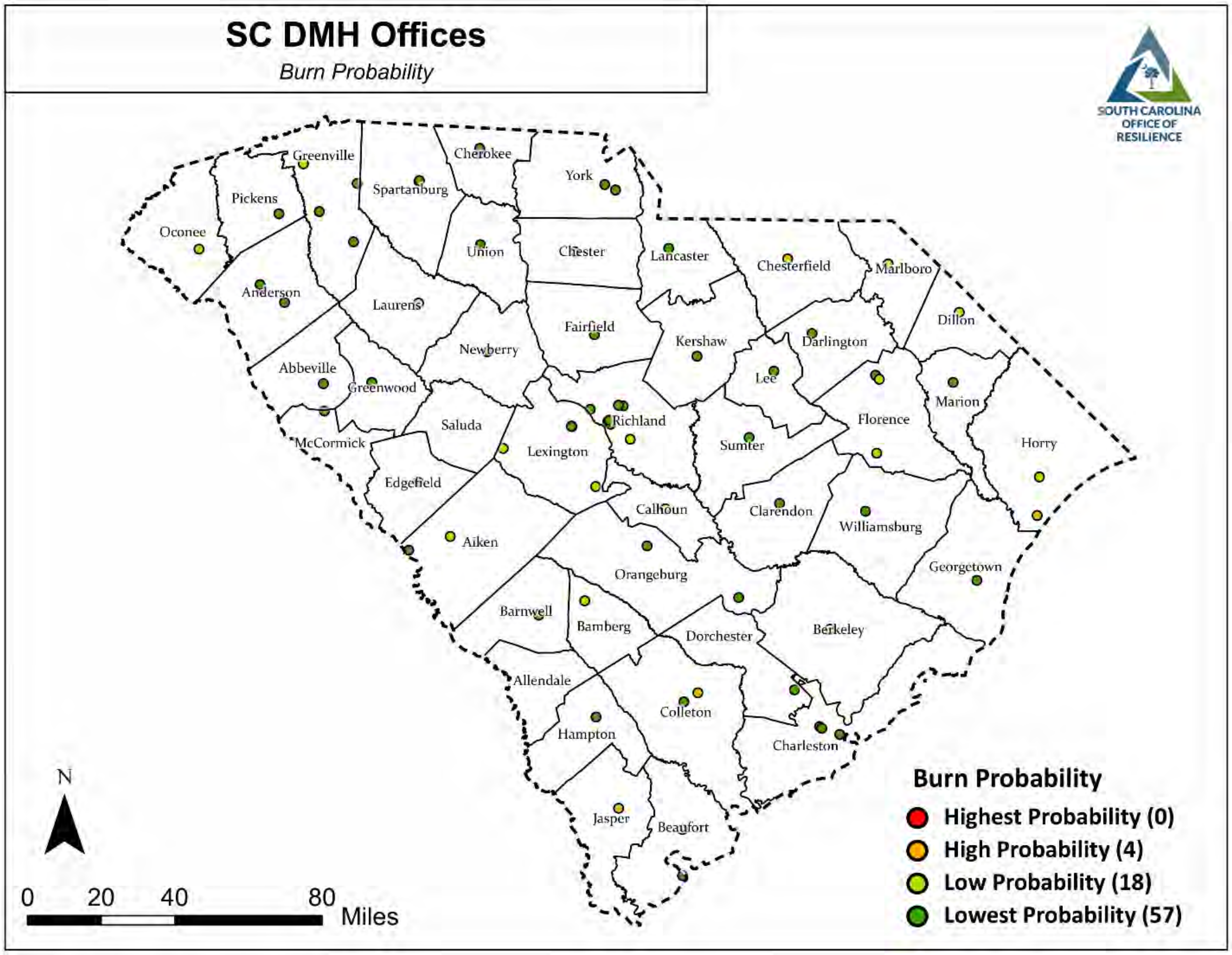

Figure 6.25: Estimated Burn Probability of the South Carolina Department of Mental Health (DHM). Wildfire data provided by SouthWRAP.

DIALYSIS CLINICS

Wildfire can place large numbers of patients treated with maintenance dialysis or individuals with a recent onset of acute kidney injury at risk due to lack of access to dialysis care. Dialysis treatment requires specialized equipment, power, and high-quality water, which may be compromised during a hazardous event. Dialysis clinics may close ahead of or in response to an event. Even if clinics are able to operate, access can be limited after an event, leading to increased demand for accessible clinics (Lempert & Kopp, 2013). Figure 6.26 shows the burn probability for dialysis centers.

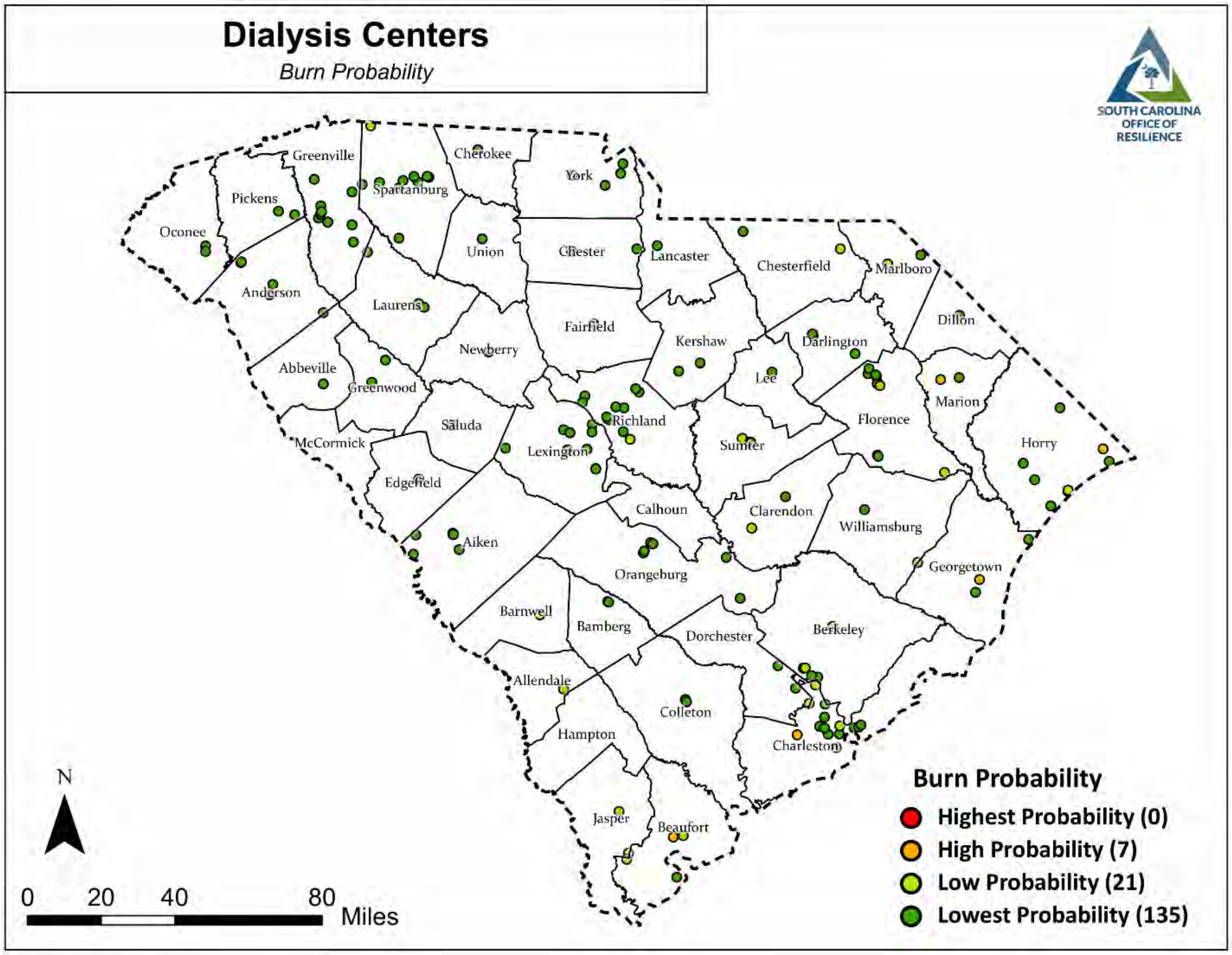

Figure 6.26: Estimated Burn Probability of dialysis centers (Department of Homeland Security). Wildfire data provided by SouthWRAP.

PHARMACIES

People need access to their prescription medication to maintain continuity of care leading up to, during, and after an event. Approximately half of all Americans live with a chronic disease that requires prescription medications. Evacuations and preparation can increase demand for pharmacy services and medication doses. After an event, pharmacies may be closed for extended periods of time or have supply chain issues. Figure 6.27 shows the burn probability for pharmacies.

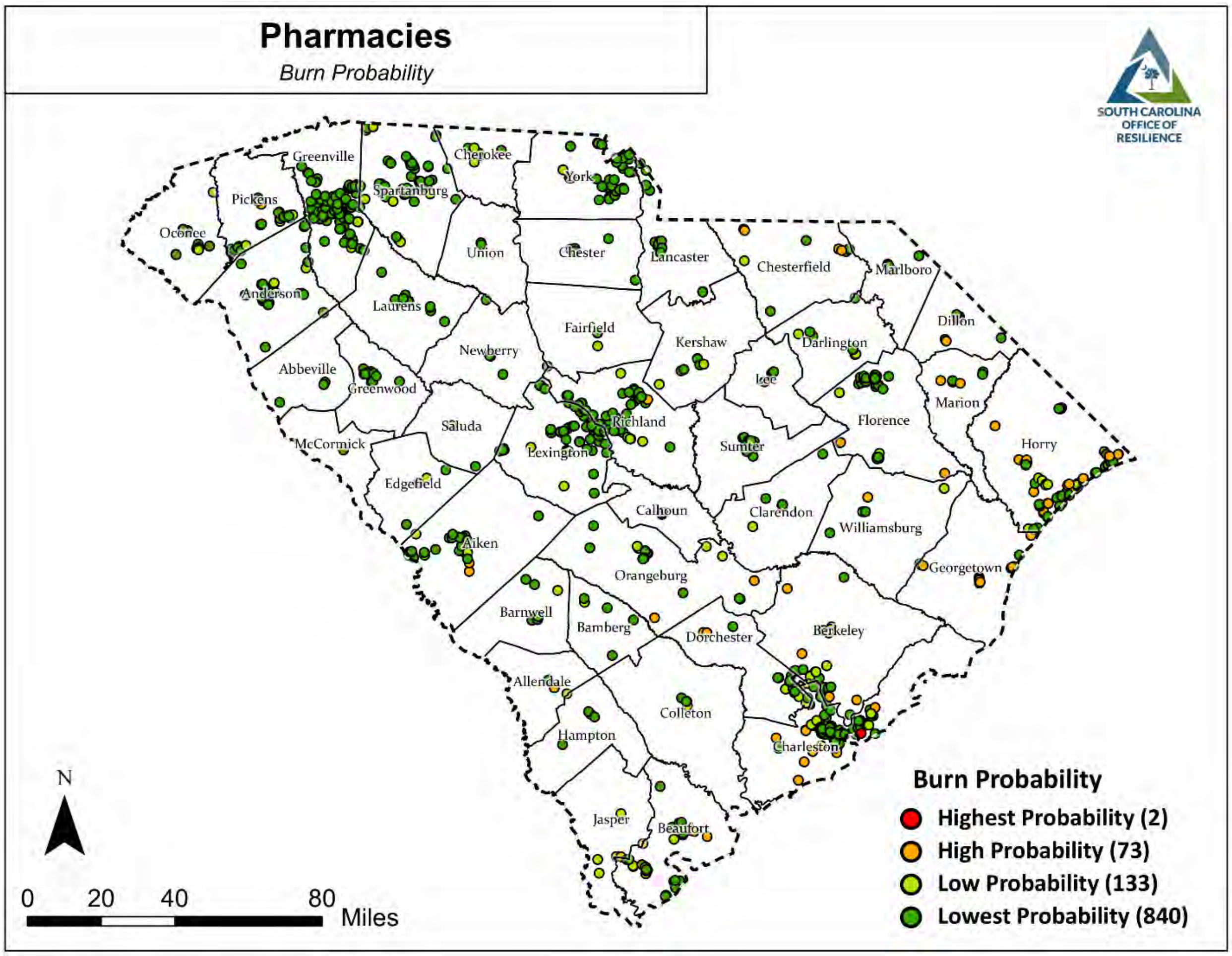

Figure 6.27: Estimated Burn Probability of pharmacies (Department of Homeland Security). Wildfire data provided by SouthWRAP.

HEALTH AND HUMAN SERVICES

The SC Department of Health and Human Services administers a variety of programs related to health-related services. The largest of which is Medicaid, but also includes Community Long Term Care, Telehealth, and BabyNet. The Department maintains offices in counties across the state to administer these programs. Figure 6.28 shows the burn probability for DHHS offices in South Carolina.

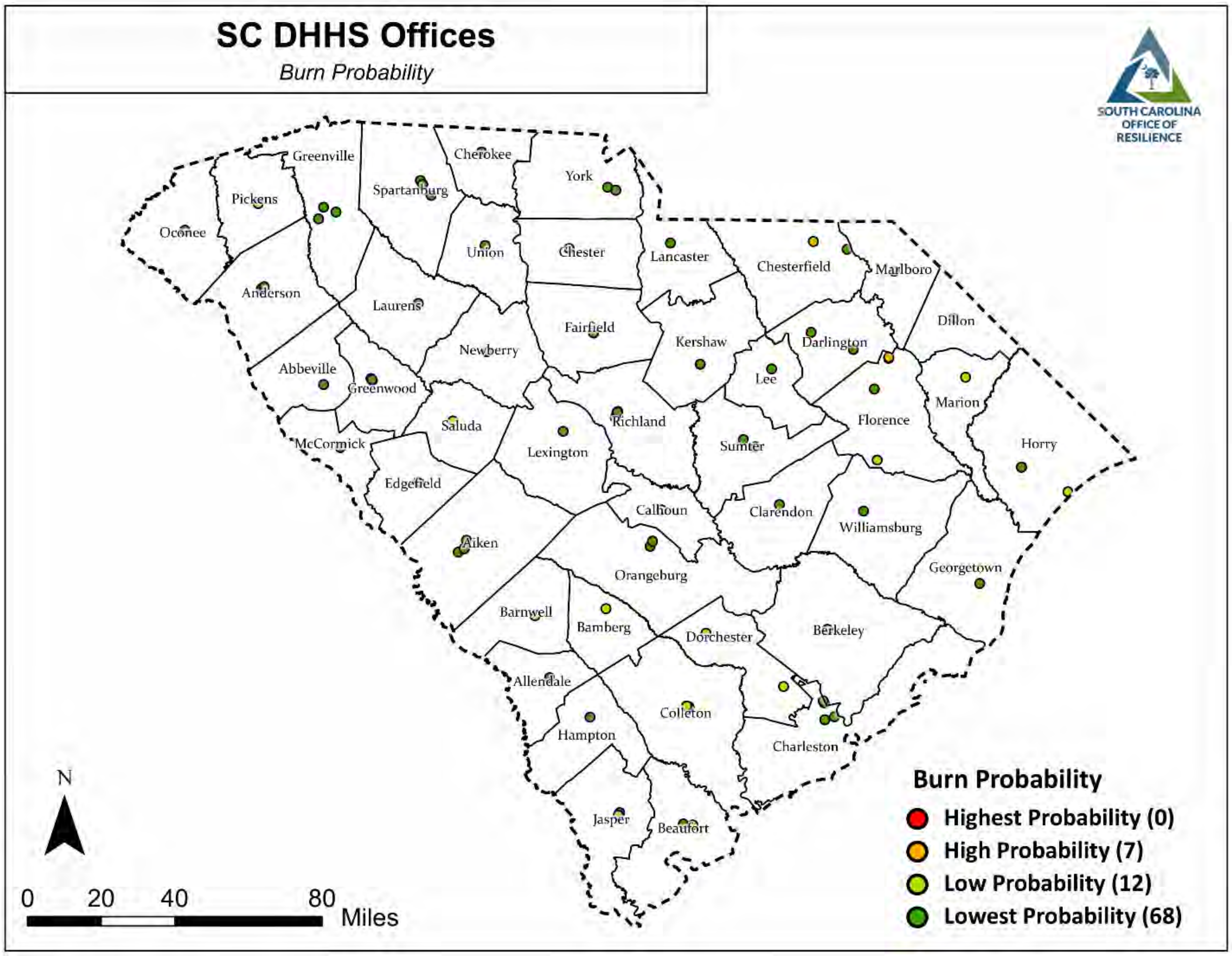

Figure 6.28: Estimated Burn Probability of South Carolina Department of Health and Human Services offices (DHHS). Wildfire data provided by SouthWRAP.

SOCIAL SERVICES

The South Carolina Department of Social Services (DSS) hosts an array of programs including Child Protective Services (CPS), foster care / adoption, Temporary Assistance for Needy Families (TANF), Supplemental Nutrition Assistance Program (SNAP), work programs, early care and education, adult advocacy, and child support services. These programs directly impact 1 in 6 South Carolinians. DSS operates Disaster Supplemental Nutritional Program (D-SNAP) and maintains evacuation plans for its licensed facilities. Similar to other community services the vulnerability is not held completely by the physical locations; it lies with the access of providers and constituents to the services they rely on. Figure 6.29 shows the burn probability for childcare facilities.

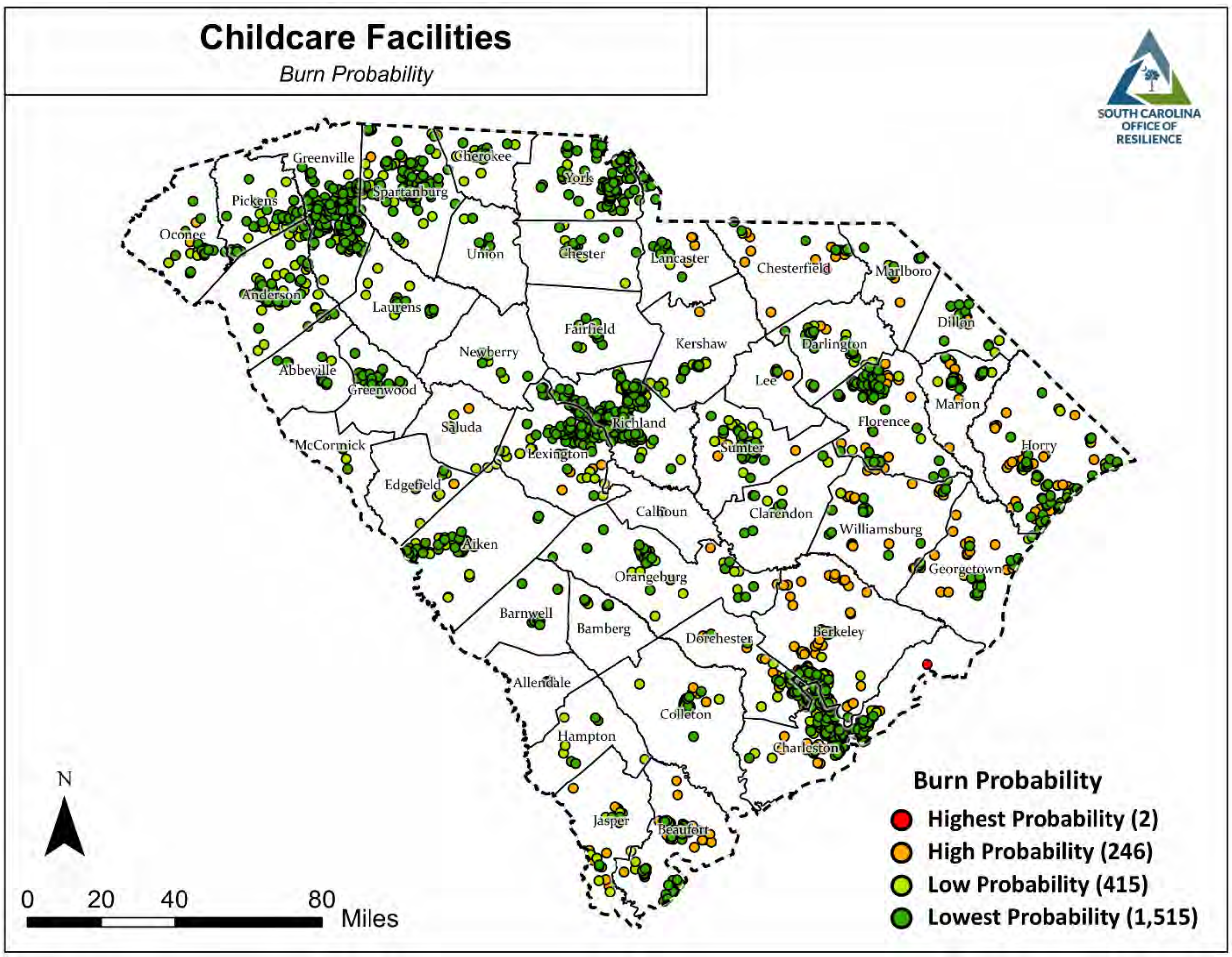

Figure 6.29: Estimated Burn Probability of childcare facilities (DSS). Wildfire data provided by SouthWRAP.

VETERANS' AFFAIRS

The South Carolina Department of Veterans' Affairs (DVA) coordinates county level offices and places in the community where veterans can access benefits. The DVA assists veterans with employment, healthcare, suicide prevention, and education. Figure 6.30 shows the burn probability for DVA offices.

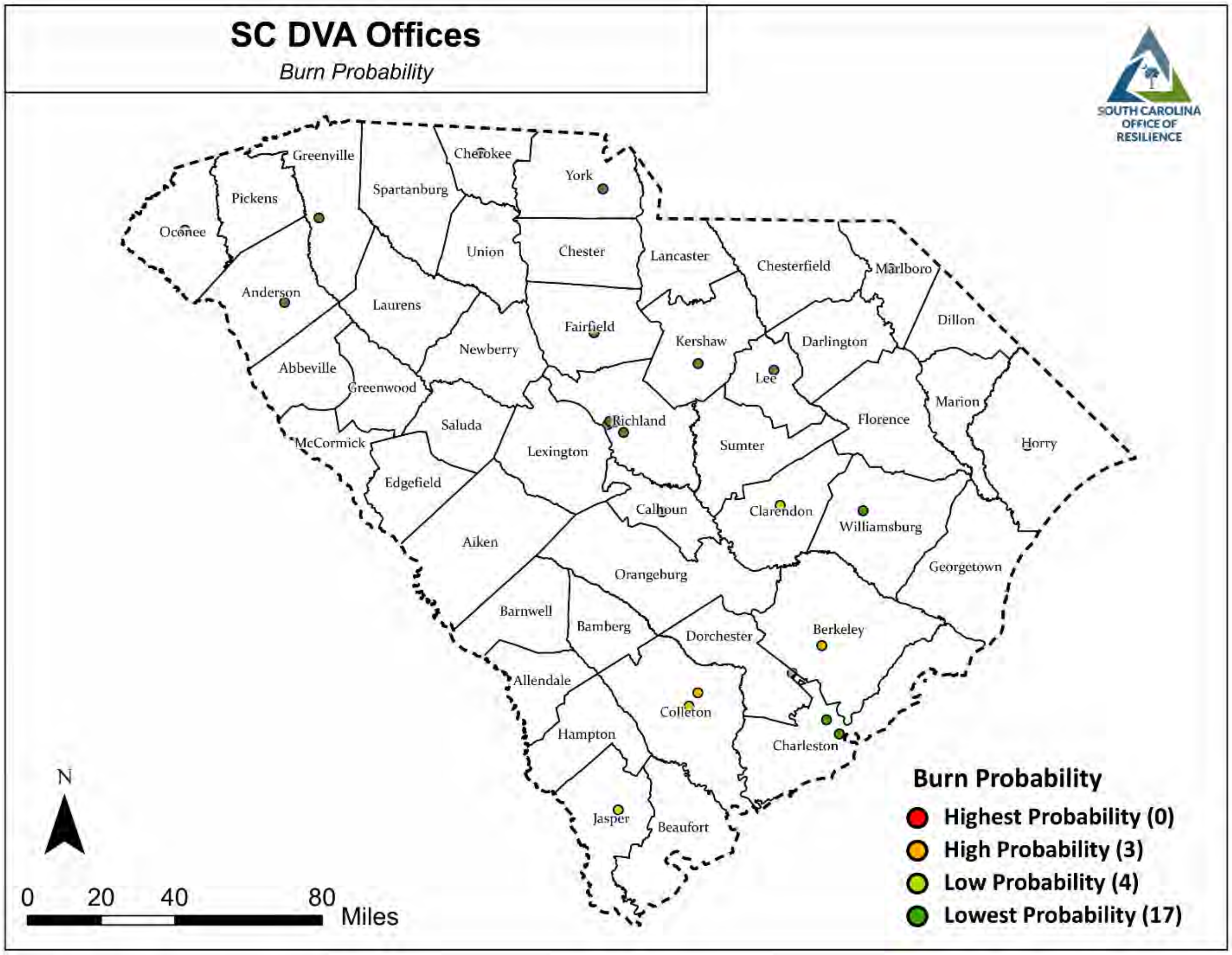

Figure 6.30: Estimated Burn Probability of South Carolina Department of Veteran's Affairs offices (DVA). Wildfire data provided by SouthWRAP.

PLACES OF WORSHIP

There are nearly 6,000 places of worship across the State. After a disaster, these places and their communities provide essential support such as collecting, storing, and distributing supplies, acting as a shelter, and supporting other community needs. Figure 6.31 shows the burn probability for places of worship.

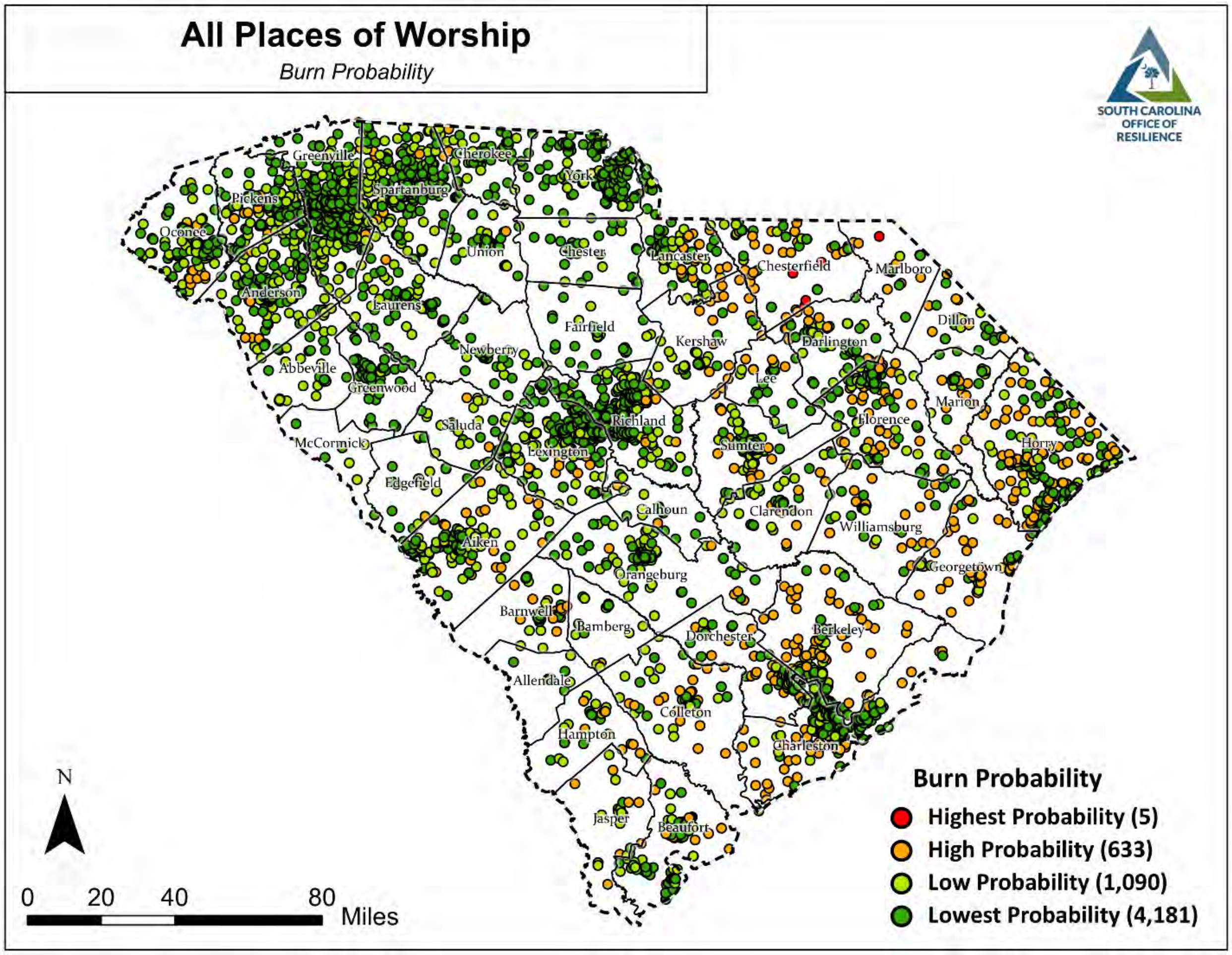

Figure 6.31: Estimated Burn Probability of places of worship (Department of Homeland Security). Wildfire data provided by SouthWRAP.

INFRASTRUCTURE

ROADS & BRIDGES

In South Carolina there are over 60,000 public road miles. SCDOT maintains over 41,000 miles of those roadways as well as more than 8,400 bridges, with the fourth largest state-maintained highway system in the nation (SC Department of Transportation, 2022). Impacts from wildfires could shut down roads and bridges. In many ways, the vulnerability of roads and bridges determines much of the vulnerability of all sectors listed in this chapter. All the facilities listed here require access. Additionally, roads and bridges are essential to evacuation and response, and for delivering longer term recovery resources. Figure 6.32 illustrates the burn probability of the State's highways.

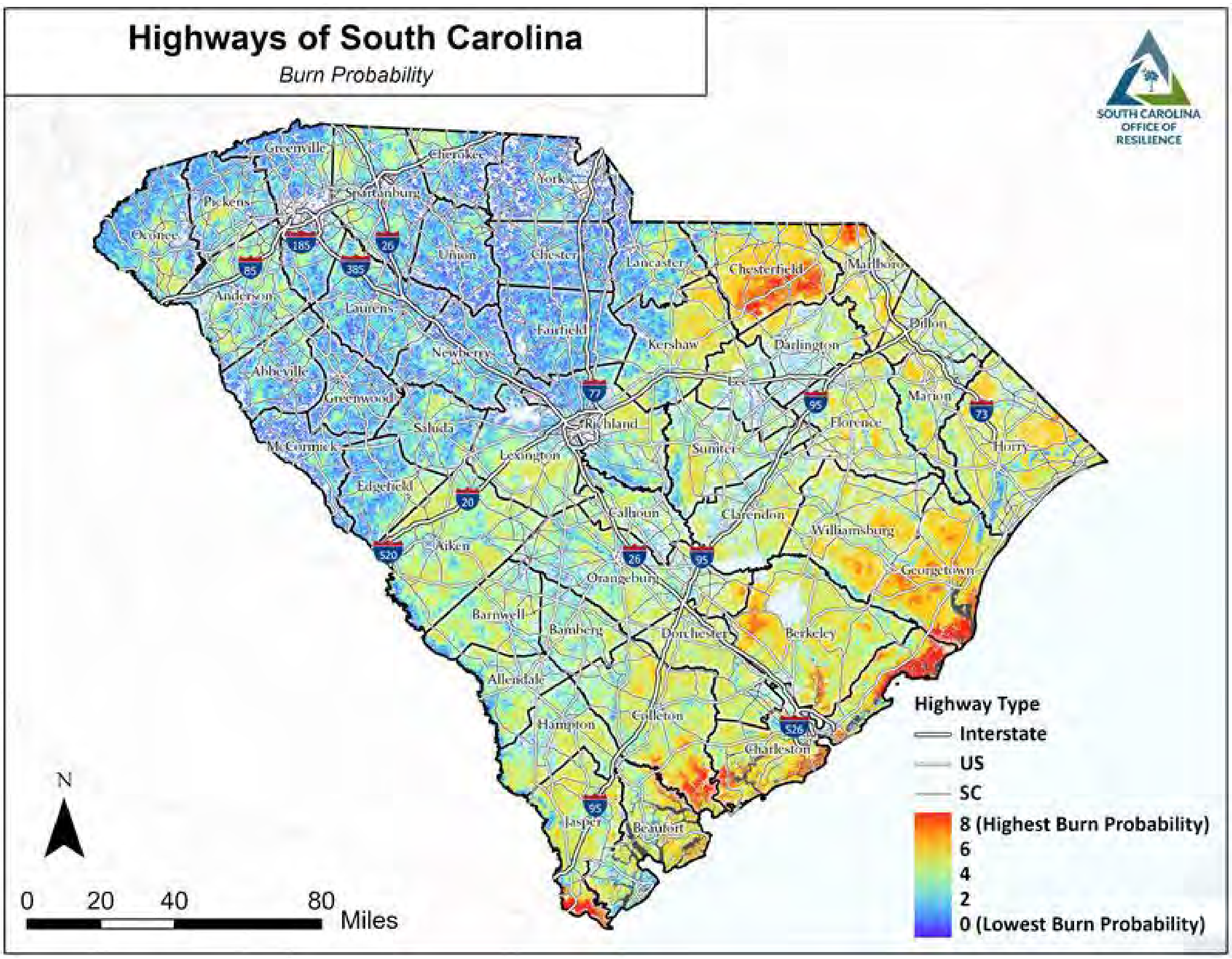

Figure 6.32: Estimated Burn Probability of highways

AIR FACILITIES

There are 51 public general aviation and six commercial airports across the state. These airports employ 122,759 people, with an annual payroll of $4.8 billion. Additionally, they generate $16.3 billion in annual economic activity. This includes the economic impact of Boeing, which has a large presence in Charleston, and the location of the final assembly for the Boeing 787 Dreamliner (South Carolina Aeronautics Commission, 2018). Figure 6.32 shows the burn probability for airports and aviation facilities.

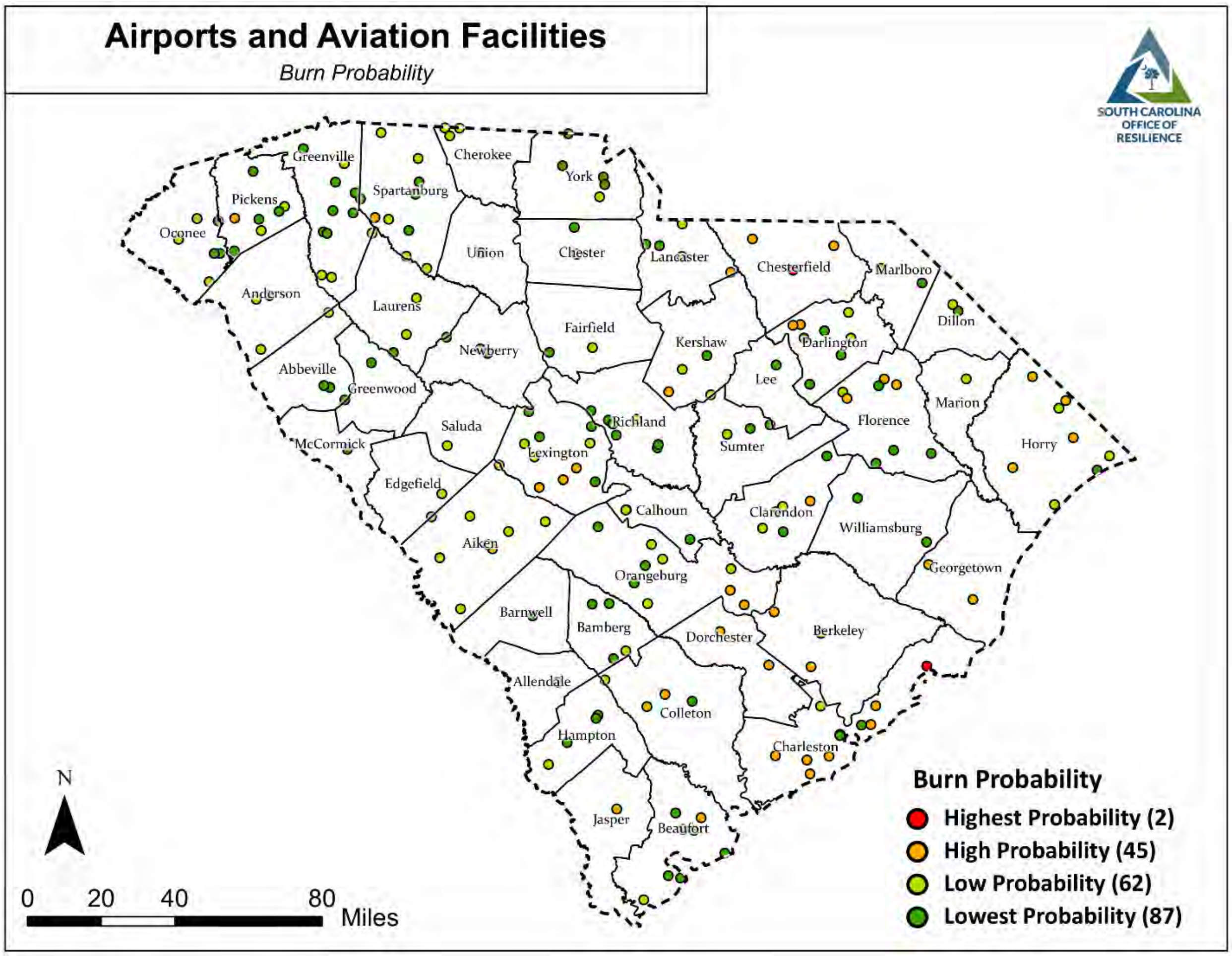

Figure 6.33: Estimated Burn Probability of airports and aviation facilities (Department of Homeland Security). Wildfire data provided by SouthWRAP.

ELECTRIC POWER GENERATION AND DISTRIBUTION

Electric generation and distribution require a complex system of power plants, substations, transmission lines, and other critical infrastructure that comprise the power grid (Kern & Miranda, 2021). This section considers the impacts of hazards through mapping electric generation (power plants) and distribution (substations) facilities.

Power generation includes hydroelectric dams, fossil fuel, nuclear, solar, wind, geothermal, and biomass (Department of Homeland Security). Electric power substation facilities and equipment allow for export onto the wider state grid and for distribution into homes and businesses (Department of Homeland Security). Figure 6.34 shows the burn probability for power plants and Figure 6.35 shows the burn probability for substations.

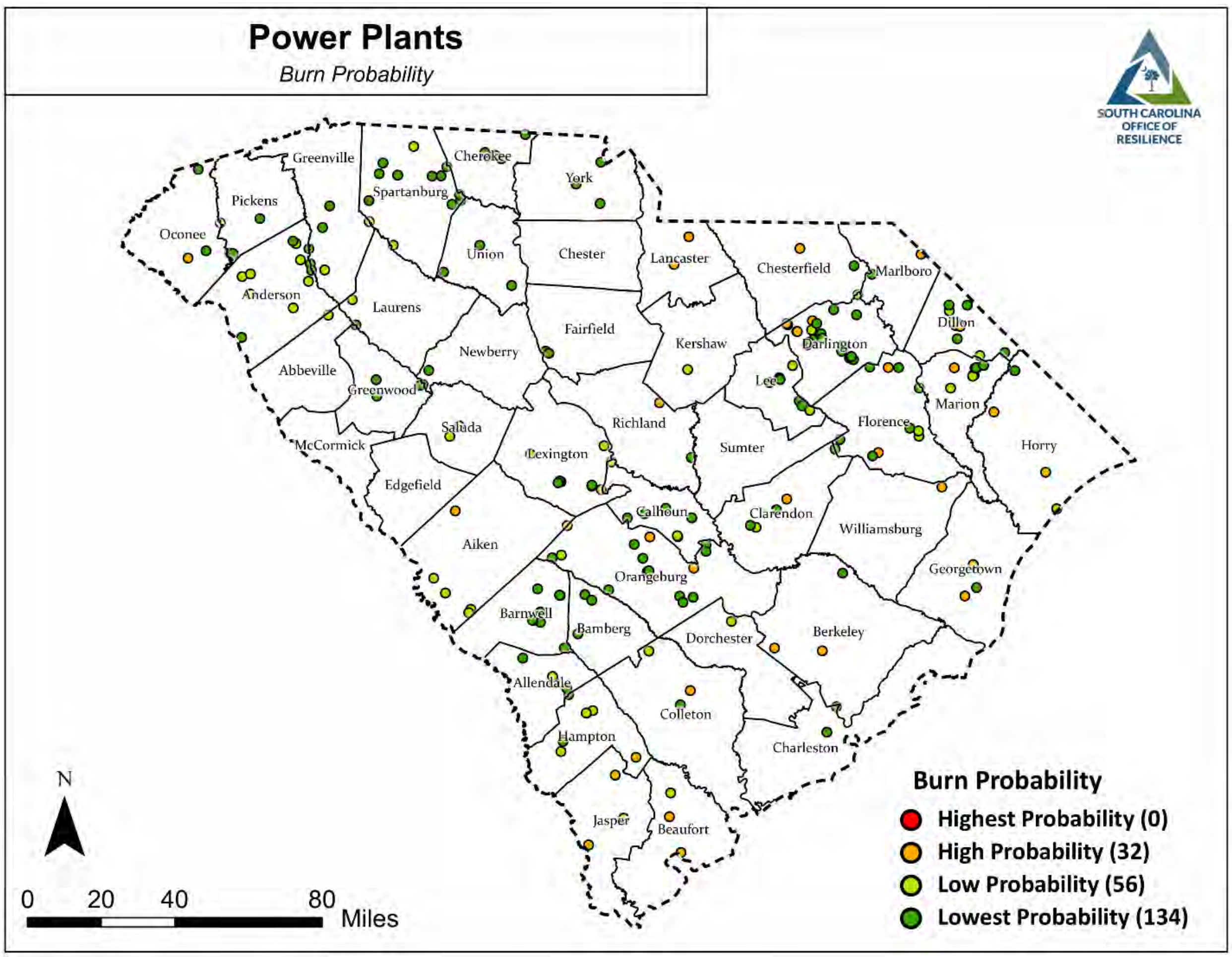

Figure 6.34: Estimated Burn Probability of power plants (Department of Homeland Security). Wildfire data provided by SouthWRAP.

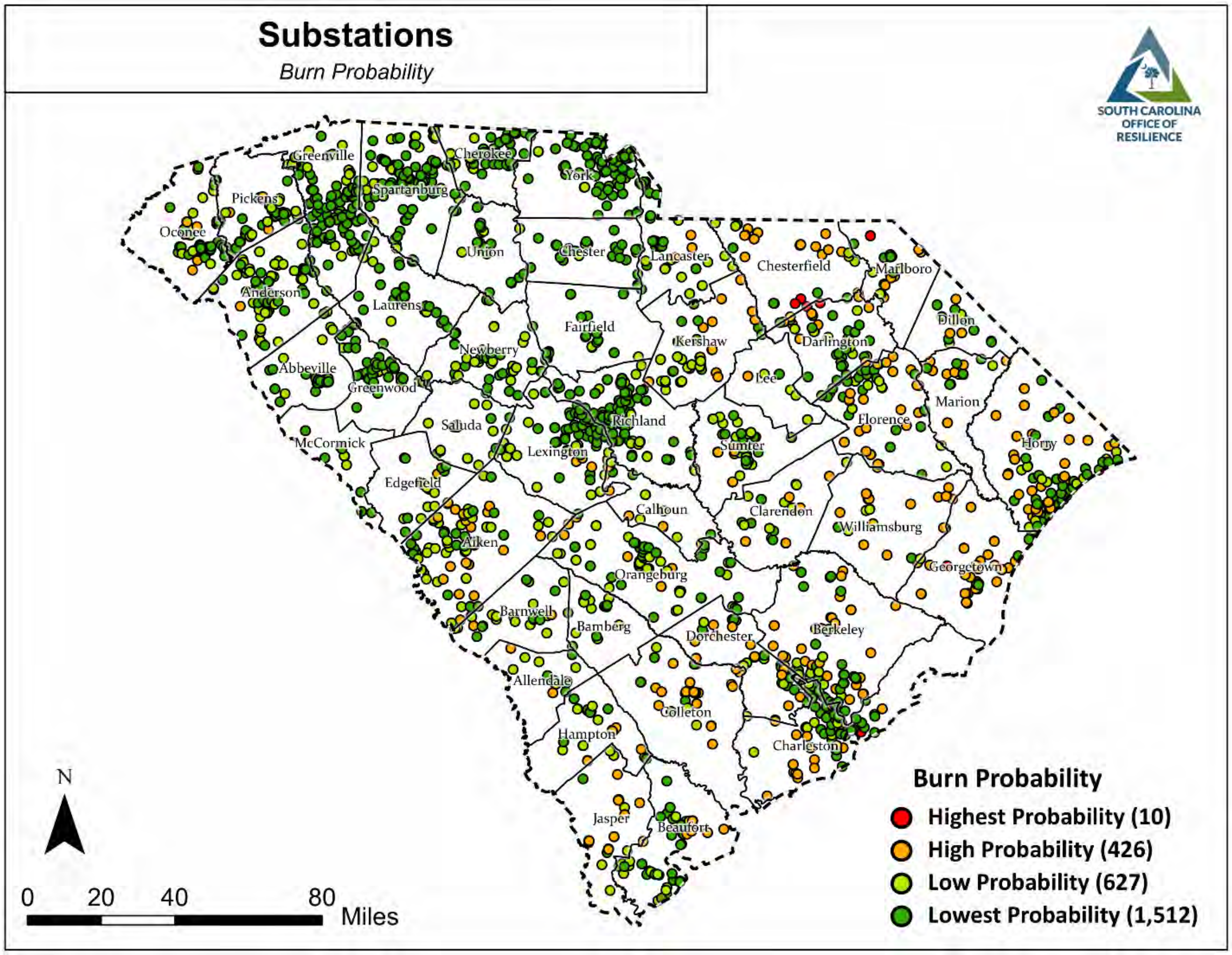

Figure 6.35: Estimated Burn Probability of power substations (Department of Homeland Security). Wildfire data provided by SouthWRAP.

INTERNET AND COMMUNICATIONS

Internet and communications connectivity are an essential part of life for most Americans. The connectivity of the internet is used for education, business, shopping, social interactions, and healthcare. Connectivity allows those that live in rural areas to access to healthcare specialists, work remotely, market their goods and services, and access services that are not available locally. There have been large investments in connecting rural communities with broadband high speed internet. The South Carolina Office of Regulatory Staff, State Broadband Office coordinates and manages the hundreds of millions of dollars that have been made available through the American Rescue Plan Act (ARPA), the Investment in Infrastructure and Jobs Act (IIJA), and several other state and federal funding sources. The following figures show the burn probability for cellular towers (Figure 6.36), land mobile broadcast towers (Figure 6.37), and paging transmission towers (Figure 6.38).

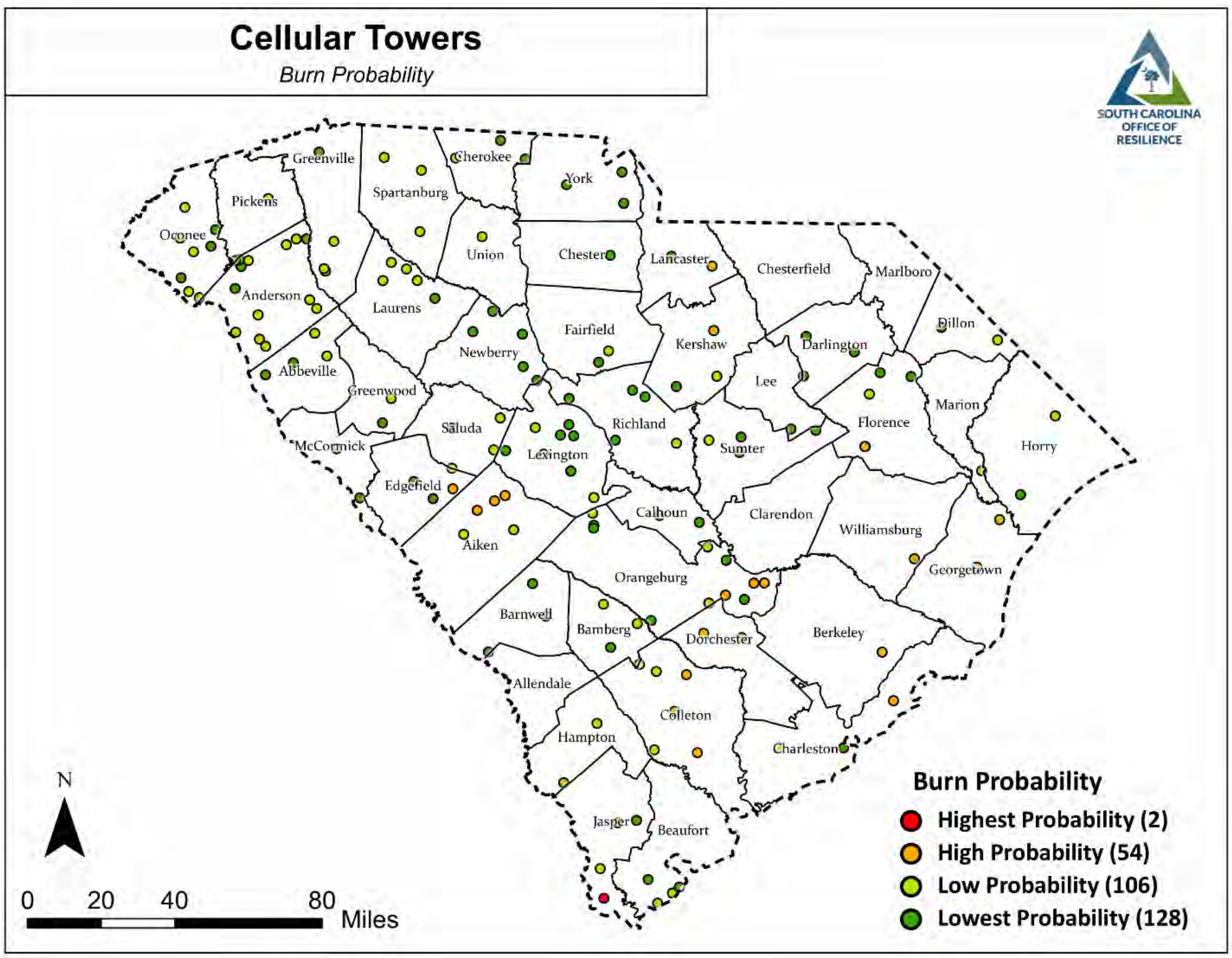

Figure 6.36: Estimated Burn Probability of cellular towers (Department of Homeland Security). Wildfire data provided by SouthWRAP.

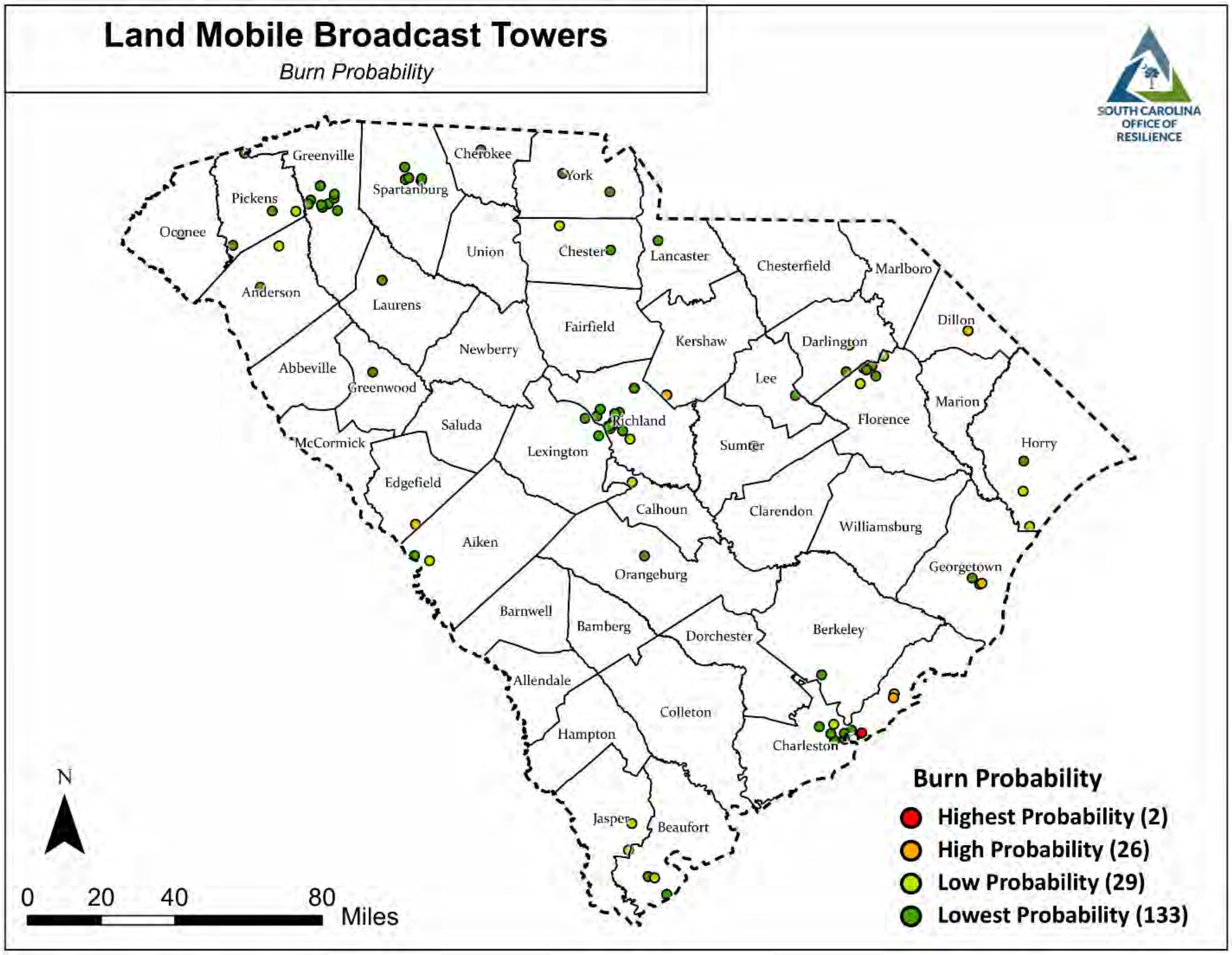

Figure 6.37: Estimated Burn Probability of land mobile broadcast towers (Department of Homeland Security). Wildfire data provided by SouthWRAP.

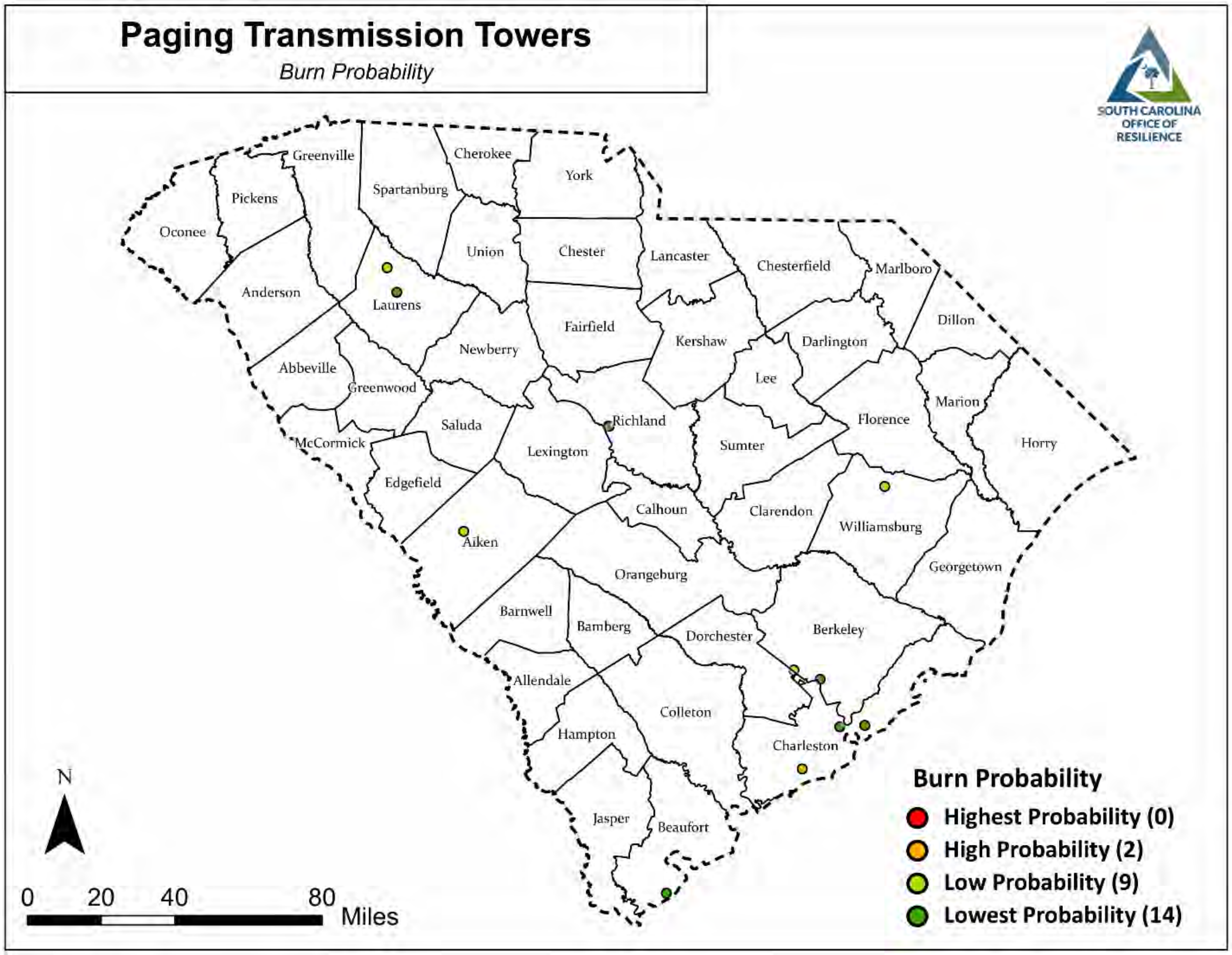

Figure 6.38: Estimated Burn Probability of paging transmission towers (Department of Homeland Security). Wildfire data provided by SouthWRAP.

FOOD SYSTEMS

DHEC's GIS Hub includes a SC Food Desert Map to help partner agencies identify underserved areas to develop strategies to increase access to healthy food. Healthy food can be even harder to obtain before, during, and after hazardous events.

Public refrigerated warehouses support this food system by storing perishable food. These temperature controlled storage facilities can also serve as other types of products such as medication, plants, and flowers. Additionally, there are cultural resources and other fragile items that may need to be kept in a facility with a specific constant temperature. Figure 6.39 shows the burn probability for public refrigerated warehouses.

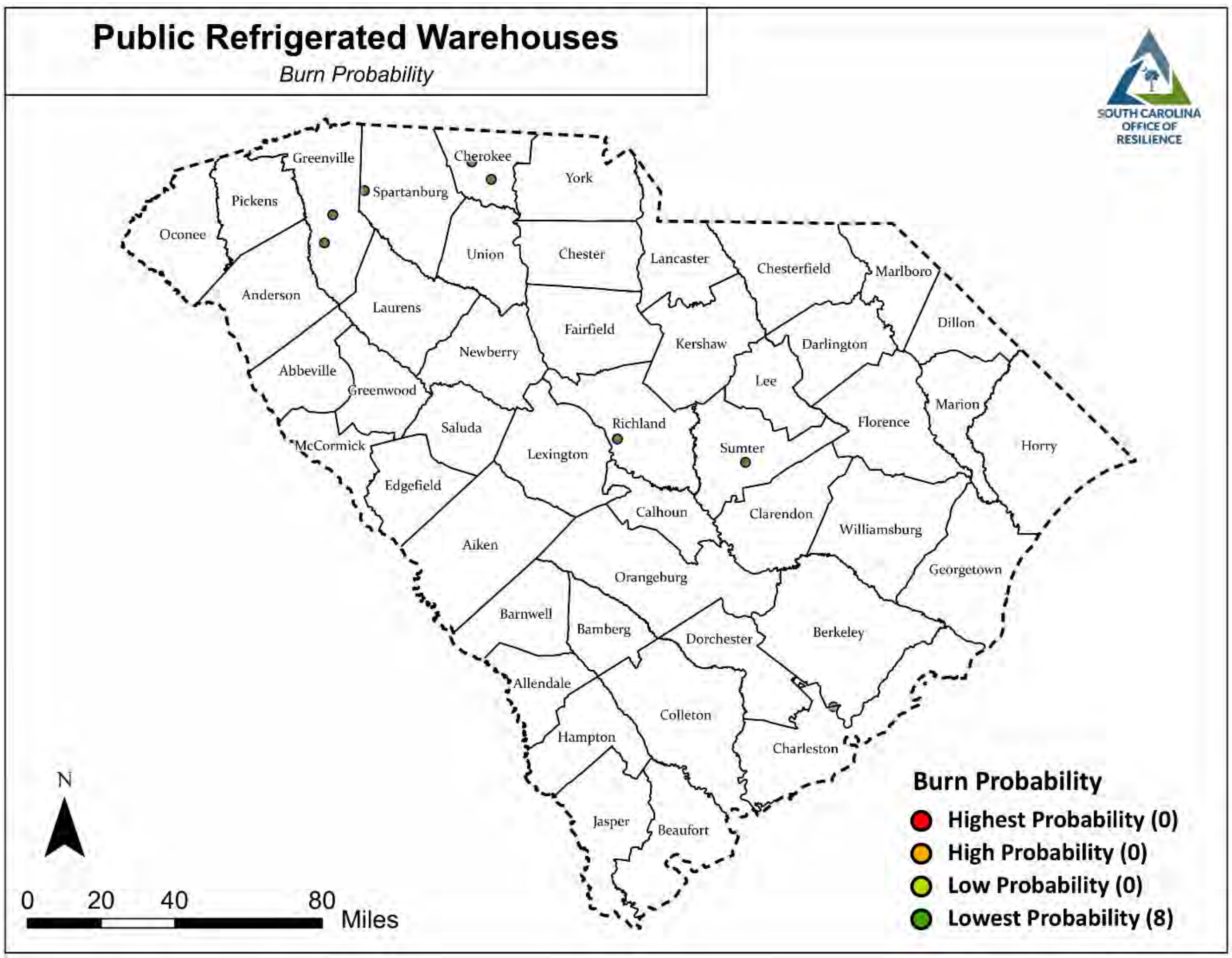

Figure 6.39: Estimated Burn Probability of public refrigerated warehouses (Department of Homeland Security). Wildfire data provided by SouthWRAP.

MANUFACTURING

Manufacturing accounts for 12% of the employment in the State. Businesses in South Carolina manufacture automobiles, appliances, boats, and aircraft (SC Department of Commerce, 2020). Figure 6.40 shows the burn probability for manufacturing facilities.

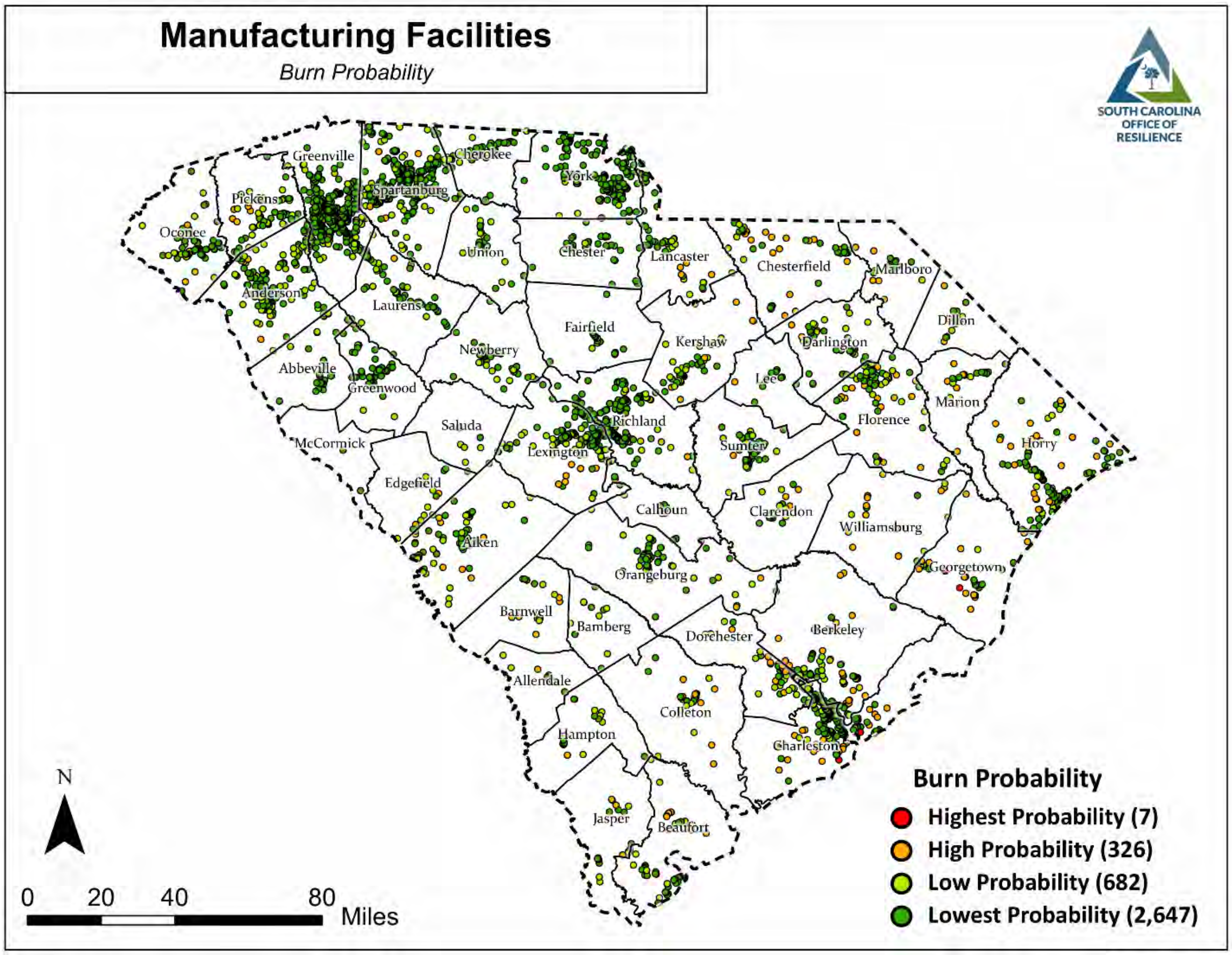

Figure 6.40: Estimated Burn Probability of manufacturing facilities (SC Department of Commerce). Wildfire data provided by SouthWRAP.

INDUSTRIAL SITES AND BUILDINGS

According to the South Carolina Department of Commerce, there are over 230 industrial buildings across the state. Additionally, there are designated industrial sites, that can help determine where industrial buildings are likely to be constructed. Figure 6.41 shows the burn probability for industrial buildings. Figure 6.42 shows the burn probability for industrial sites.

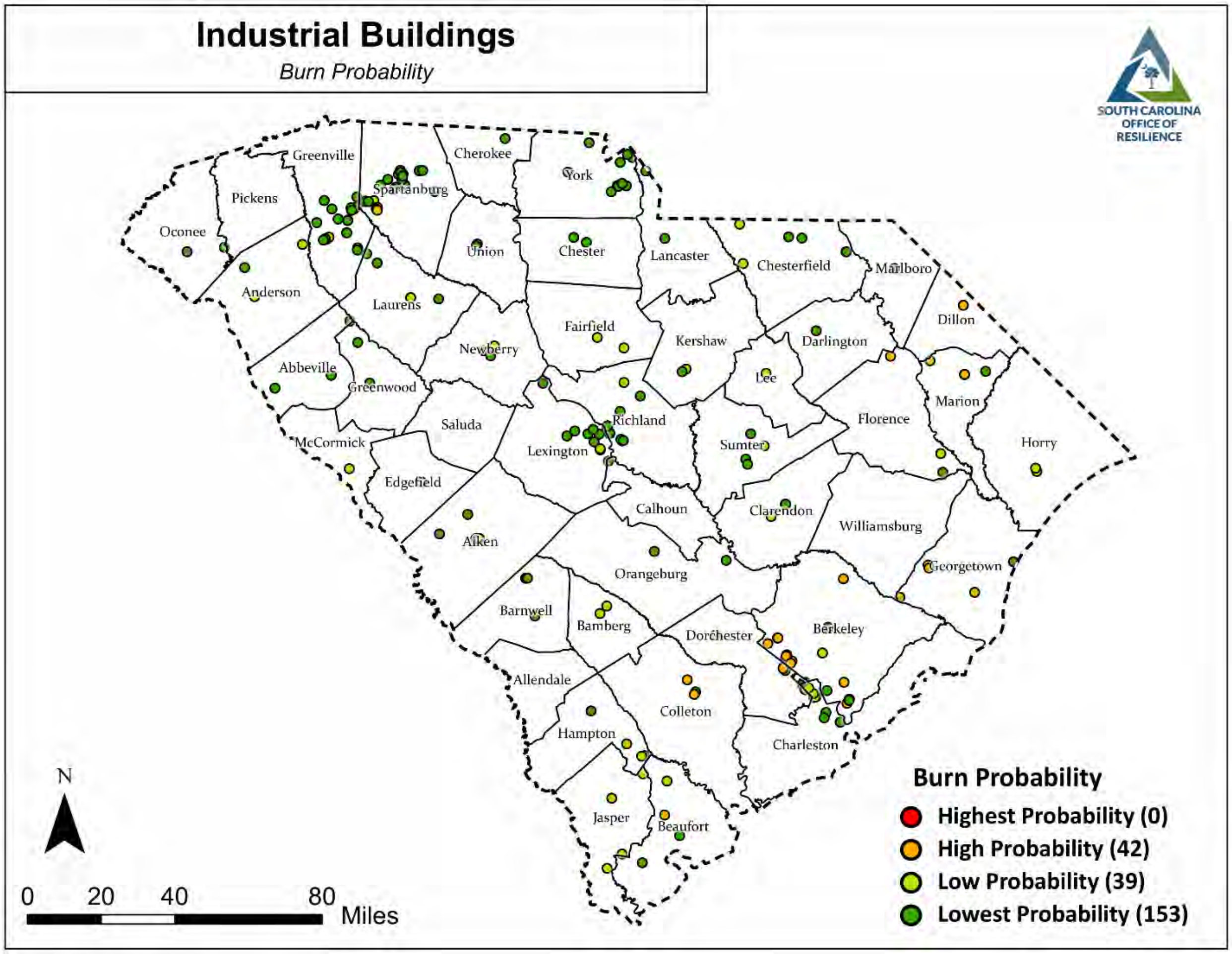

Figure 6.41: Estimated Burn Probability of industrial buildings (SC Department of Commerce). Wildfire data provided by SouthWRAP.

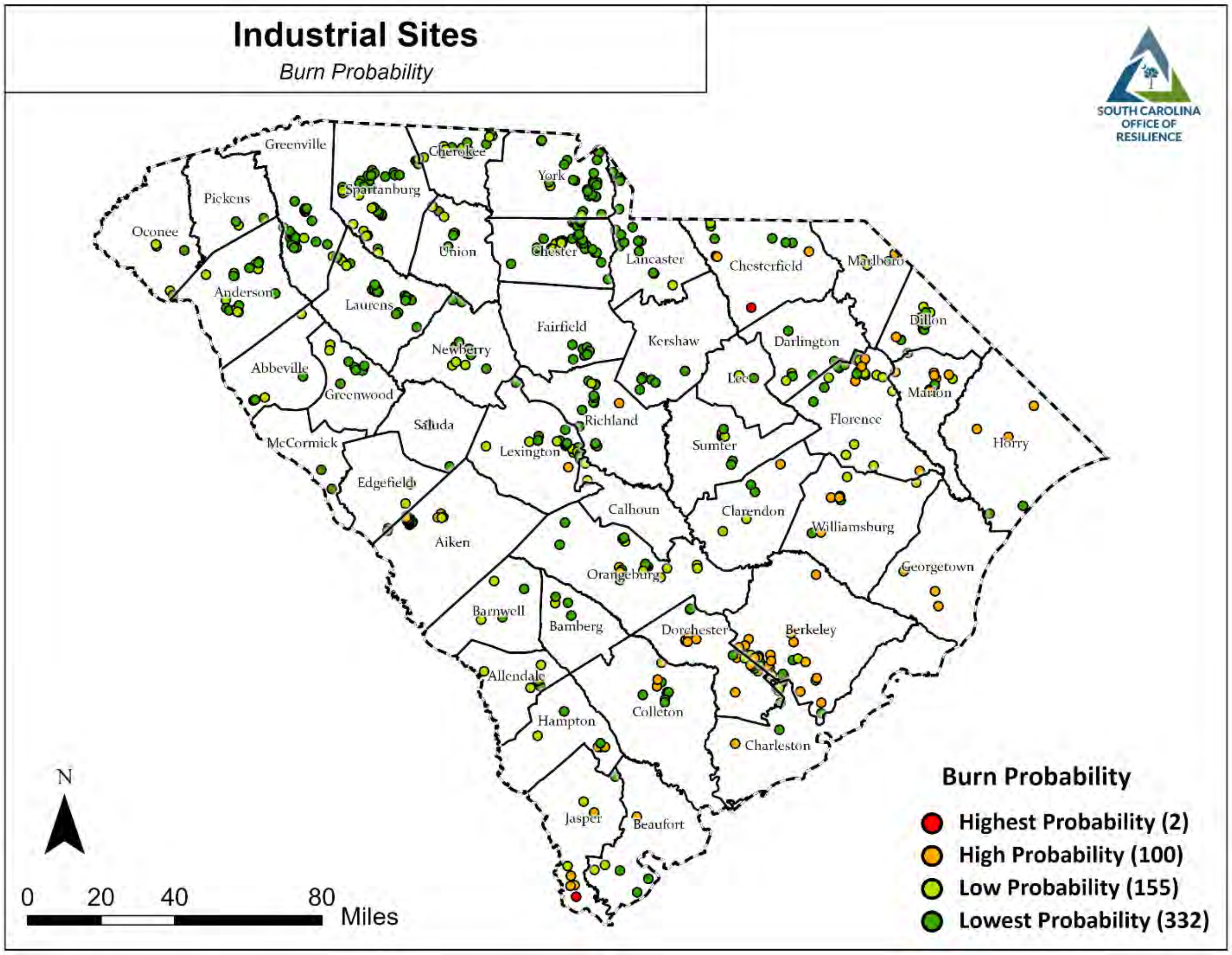

Figure 6.42: Estimated Burn Probability of industrial sites (SC Department of Commerce). Wildfire data provided by SouthWRAP.

OTHER WILDFIRE METRICS

Forest, timberlands, and agriculture lands cover roughly 13.6 million acres of South Carolina and wildfires are common occurrences. On average, approximately 1,400 wildfires burn nearly 11,000 acres in South Carolina each year (SC Forestry Commission (SCFC), 2021). Large tracts of forest and increasing population imply the potential increase in wildfire exposure and impacts on communities in South Carolina. There are two additional tools SCOR used to identify the potential risk of wildfires in South Carolina: the SouthWRAP WUI Risk Index and the FEMA National Risk Index.

WILDLAND URBAN INTERFACE (WUI)

The Wildland Urban Interface (WUI) Risk Index layer is a rating of the potential impact of a wildfire on people and their homes. The key input, WUI, reflects housing density (houses per acre) consistent with Federal Register National standards. The location of people living in the Wildland Urban Interface and rural areas is key information for defining potential wildfire impacts on people and homes.

Urban wildfires nationwide have been on the rise, primarily due to the pattern of human development near wildlands. The Wildland Urban Interface (WUI) is the measure of interspersion between residential areas and areas with natural wildfire fuels. This intermingling of human structures and wildlands identifies areas where wildfire carries increased potential to have a direct impact on communities. It is important to note that the WUI does not assess the severity of wildfire impacts, just the exposure to potential impacts. A high WUI score indicates an area where human structures and natural fuels exist closely together. A low WUI score indicates that the area either has just a few structures near natural fuels (rural areas), or that there is little natural fuel near community structures (urban cores).

To better target where communities are the most vulnerable to severe wildfire impacts, the WUI has been augmented with fire severity models in the Wildland Urban Interface Risk Index (WUI Risk Index) as seen in Figure 6.43. Areas identified as having a high WUI Risk Index indicate both a high WUI score and more intense wildfire and are expected to have the most severe impacts if a wildfire does occur. The WUI Risk Index is derived using a Response Function modeling approach. Response functions assign a net change in the value to a resource or asset based on susceptibility to fire at different intensity levels, such as flame length (Southern Group of State Foresters, 2023). The WUI Risk Index range of values is from 1 (least impact) to 9 (greatest impact).

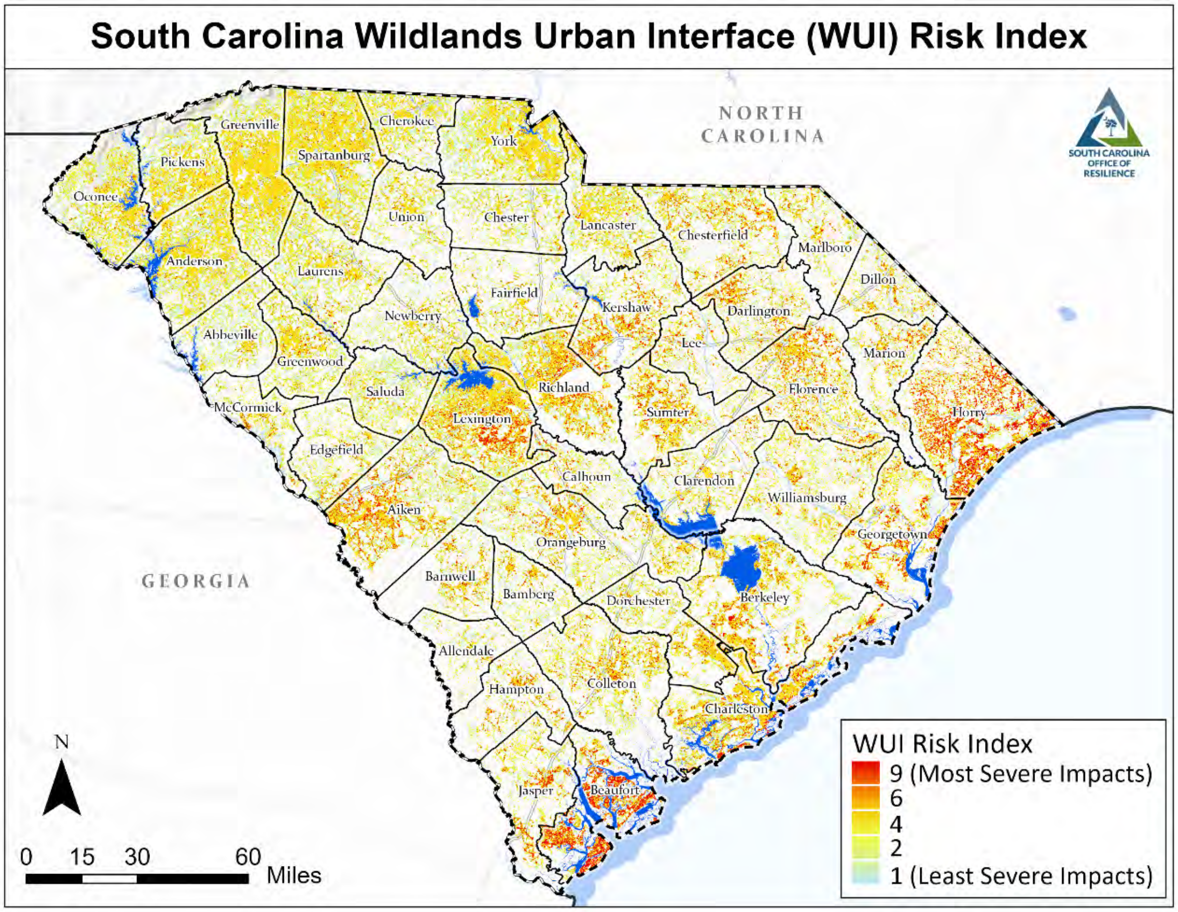

Figure 6.43: SC Wildlands Urban Interface Risk Index

NATIONAL RISK INDEX

In the National Risk Index, a Wildfire Risk Index Rating, shown in Figure 6.44, represents a community's relative risk compared to the rest of the United States. The majority of the state is low to moderate risk according to FEMA which corresponds well with the SouthWRAP Burn Probability (Figure 6.1) and WUI Risk Index (Figure 6.43).

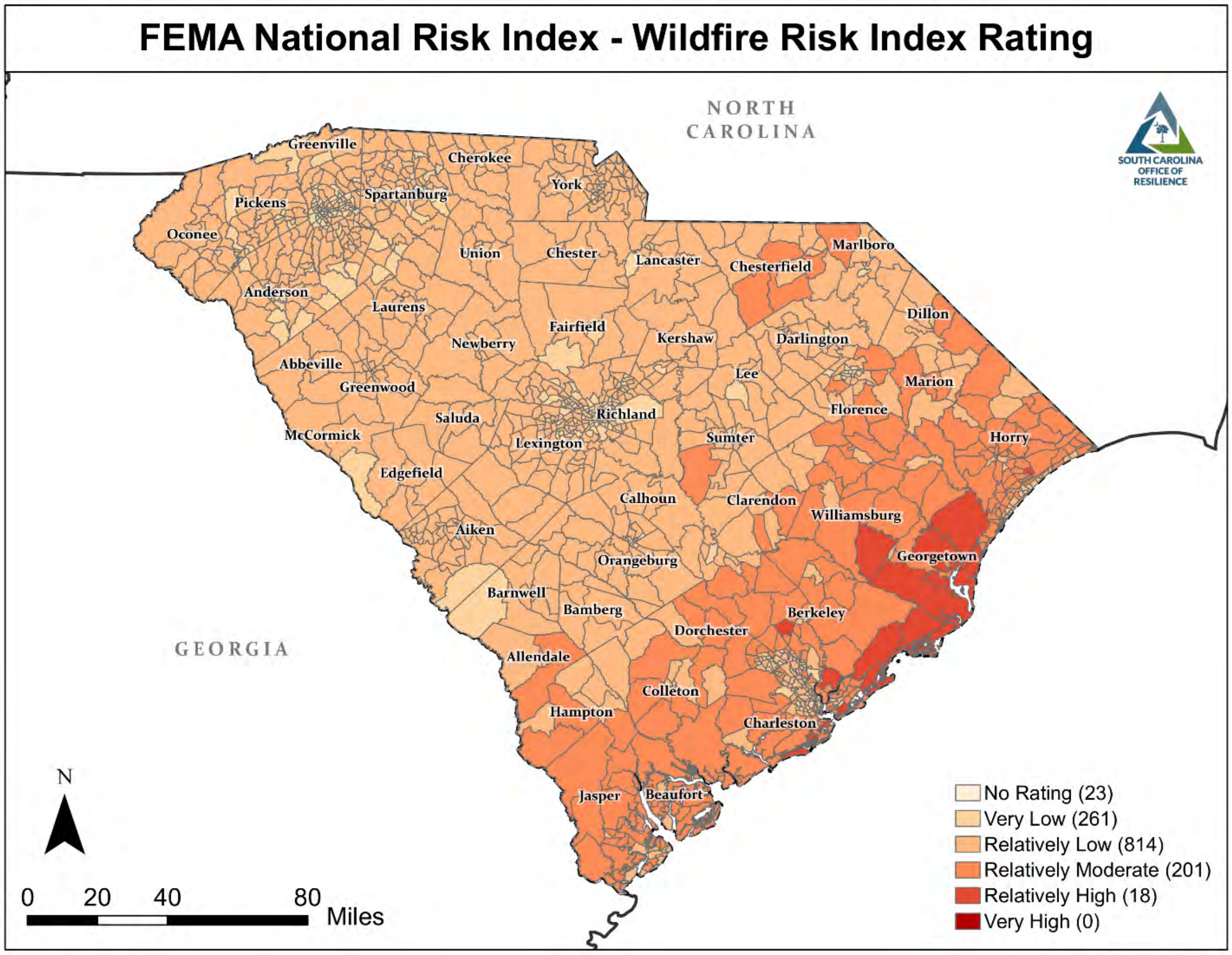

Figure 6.44: FEMA Hazard Risk Index Rating for wildfires in South Carolina by Census Tract.

DROUGHT

DROUGHT INDICATORS

Drought results from less than normal precipitation over an extended period, often resulting in a water shortage for some activity, sector, or the environment. In contrast to other environmental hazards, droughts typically develop slowly over weeks, months, or years. Three main categories physically define drought: meteorological, agricultural, and hydrological. These categories help determine the economic, ecological, and societal impacts of droughts in communities. Drought impacts most of the industries in the State, but agriculture, forest, and water supply are very susceptible to drought.

The South Carolina Drought Response Committee (DRC) is the major drought monitoring and decision making entity for the state. It is comprised of five state agencies and 48 local members and is chaired and supported by the SC Department of Natural Resources and the SC State Climatology Office. The 48 local members are comprised of different stakeholder groups to ensure robust sectoral input for drought monitoring and response.

While the DRC is a statewide entity, the state has four drought management areas (DMAs) that generally follow the four major river basins, but are fitted to the counties, as drought status in South Carolina is declared at the county level. This approach allows for smaller scale (county) drought conditions while also considering the geographical relationship of water supplies from the top to the bottom of the water basin. Figure 6.45 below shows the four DMAs. Each of the DMAs has 12 local representatives, providing equal local-level and sectoral representation for all the DMAs.

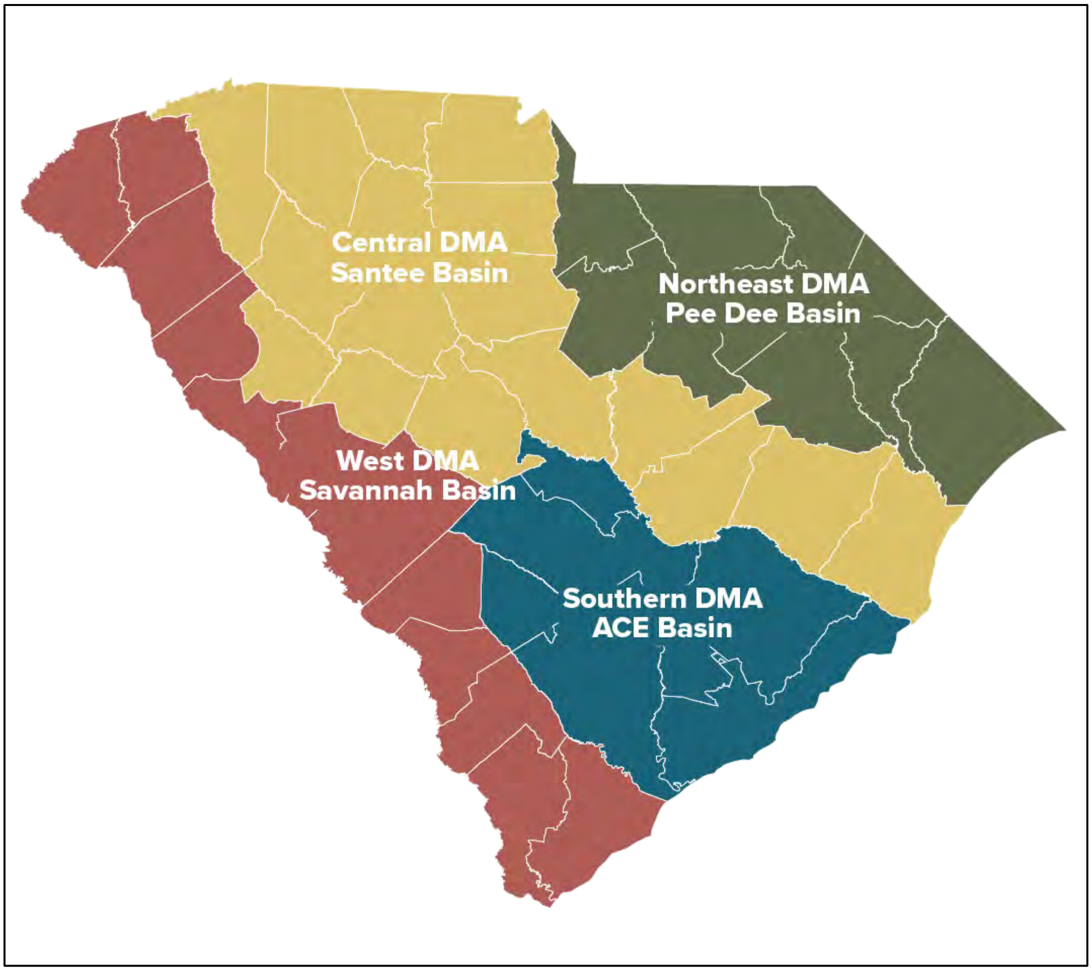

Figure 6.45: South Carolina Drought Management Areas (DMAs) (SC State Climatology Office)

The Drought Regulations of the South Carolina Drought Response Act outlines the process and procedures for the DRC. The DRC continually monitors conditions and convenes a meeting when conditions warrant a discussion for potential response. The DRC uses seven different drought indicators to monitor conditions. Five of these are indices (Palmer Drought Severity Index (PDSI), Crop Moisture Index (CMI), Keetch-Byram Drought Index (KBDI), Standardized Precipitation Index (SPI), the US Drought Monitor (USDM) and two are hydrologic values for groundwater and surface water. The use of multiple indicators allows for a comprehensive approach for monitoring drought conditions across multiple sectors, as no one indicator or indicator type can accurately depict drought severity for all sectors.

When the DRC meets, it votes on the status of each county. The status depends on the indicators, along with state-agency and local-level reports. Based on the indicators and reports, each county can be classified in either “normal,” “incipient,” “moderate,” “severe,” or "extreme" conditions. Generally, a county can only change by one category per DRC meeting. When a county is classified in "moderate" conditions or worse, the DRC will decide what non-essential water curtailment needs to be made at the local level to help conserve water. All local public water suppliers in the state must have a local drought management plan and ordinance to respond to and manage drought periods. The Governor may call for further water conservation than the DRC's recommendations or call for mandatory water conservation. If drought conditions become so extreme, beyond the scope of the DRC, the State's Emergency Operations Plan (Appendix 10) goes into effect for drought response. Fortunately, there has not been a drought so extreme in South Carolina that Appendix 10 of the State's EOP plan has been enacted.

As discussed in Chapter 4 of this document, future droughts have mixed projections. While increased temperatures have the ability to accelerate the hydrologic cycle, leading to increases to both precipitation and evapotranspiration, it is difficult to determine how this will lead to changes in water availability. Although South Carolina is expected to see more rain overall, precipitation may come in the form of more intense events, leading to less "water recharge" events for soils. In conjunction, increased temperatures have the ability to increase evapotranspiration. These changes may allow for increased drought impacts to agriculture and ecology. However, a change in rain fall delivery, increased temperatures and evapotranspiration, and population growth all have the ability to affect the current balance between water supply and water demand for municipalities, providing a potential for more drought impacts to public water suppiers (Carter, et al., 2018).

NATIONAL RISK INDEX

The National Risk Index's Drought Risk Index Rating, shown in Figure 6.46, represents a community's relative risk when compared to the rest of the United States. The Risk Index highlights areas that have large agriculture concentrations as the risk to the damage to buildings is low in the case of a drought.

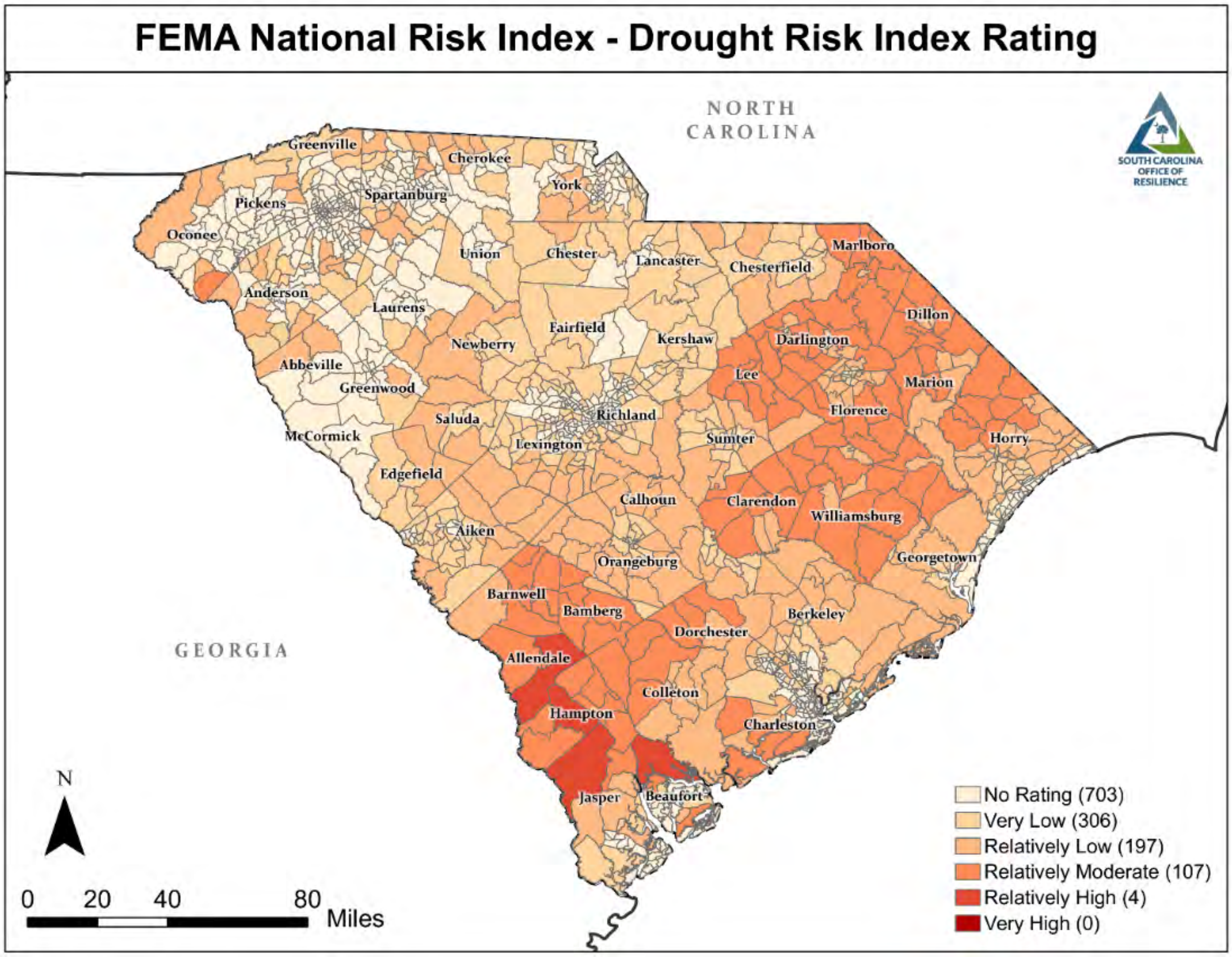

Figure 6.46: FEMA Hazard Risk Index Rating for droughts in South Carolina by Census Tract.

HEAT

Excessive heat events occur whenever the heat index values meet or exceed established excessive heat warning thresholds established by local or regional managers. Extreme heat is influenced by humidity, where the muggy conditions can exacerbate the temperature and make it feel hotter than it is (Centers for Disease Control and Prevention, 2019). Recent evidence suggests that humans have a physical heat tolerance limit at a wet bulb temperature of 95 °F. Above this threshold of heat and humidity, the human body can no longer cool through perspiration (Sarofim, et al., 2016), although adverse health effects and declined ability to perform tasks can be experienced at much lower temperatures (Heal & Park, 2016). Higher heat index values add stress to individuals with preexisting health issues like the elderly, obese, those with mental illness, those with heart disease, and other chronic diseases (Centers for Disease Control and Prevention, 2019).

STATEWIDE HEAT RISK ASSESSMENT

Heat has been one of the most dangerous weather-related hazards in recent decades (National Weather Service, 2022). Historic analysis indicates maximum summer temperature increases across the state, as documented in Chapter 4. Urban areas within the State have experienced significant increasing trends, exceeding the national average for heatwave timing, frequency, and intensity (Habeeb, Vargo, & Stone, 2015). These trends are likely to accelerate, as are increasing overnight low temperatures, compounding the impacts of urban heat islands. Chapter 4 of this report identifies that by the end of the century the average number of days above 95 °F will increase by up to 50 days per year (Figure 6.47).

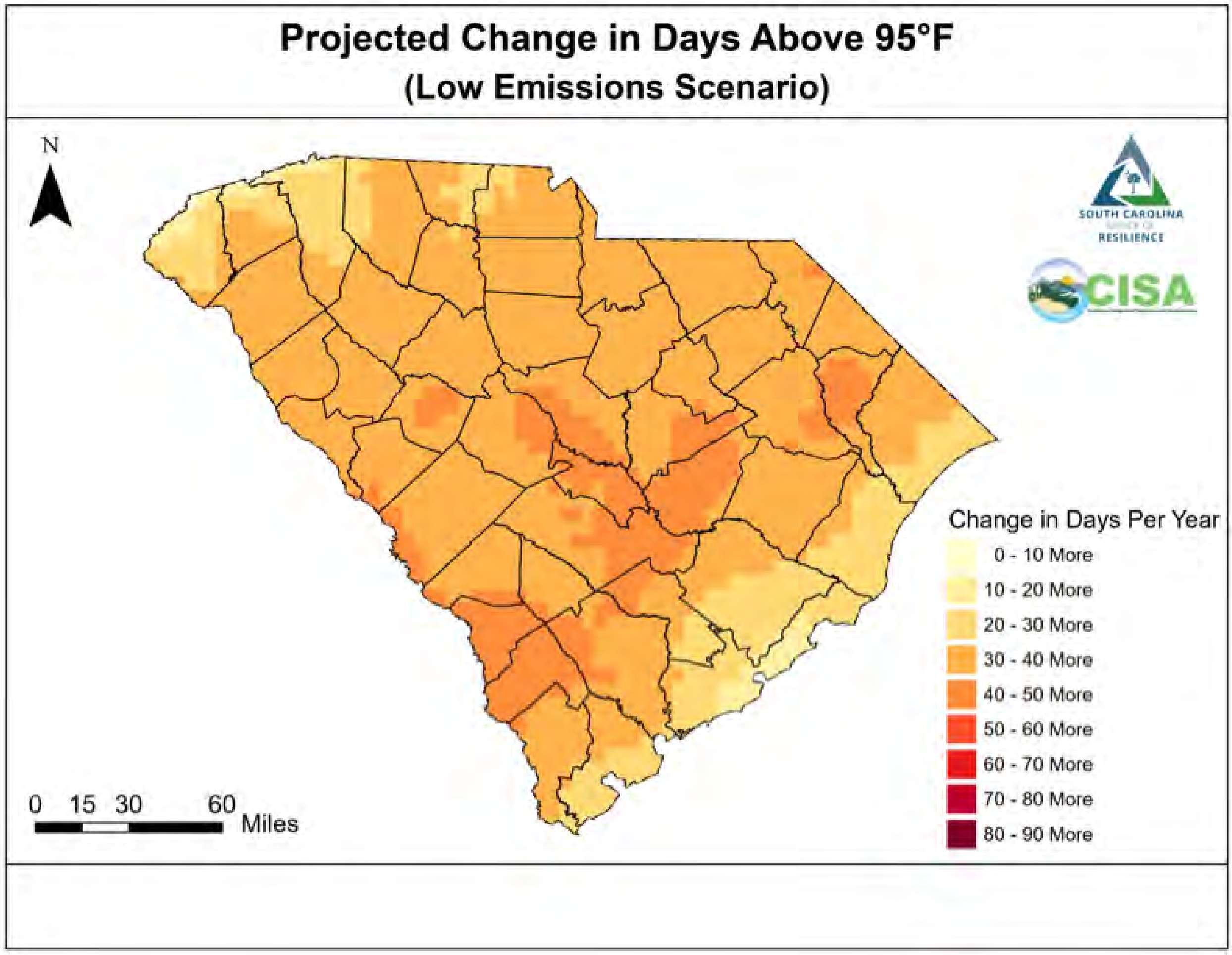

Figure 6.47: Projected increase in the average number of days per year with maximum temperature above 95F by 2100 (RCP 4.5 emissions scenario)

Infants, children, and older populations (<65 years and especially <85 years), pregnant women, people working outside and those wearing additional personal protective equipment, as well as those with or recovering from COVID-19, or with other preexisting conditions are at greater risk (Global Heat Health Information Network, 2022). Football players are another specific risk population. They have been found to be 11 times more likely than other athletes to experience a heat-related illness are particularly at risk due to their summer practice season, protective equipment, and tendency to have higher body mass index values compared with other athletes (Kerr, Casa, Marshall, & Comstock, 2013).

A wide range of health conditions are exacerbated by high ambient heat conditions as well as heatwaves. These illnesses include cardiovascular, respiratory, and renal illnesses; diabetes; hyperthermia; mental health issues; and pregnancy (Ye, et al., 2012). South Carolina has among the higher percentages nationally of adult population with these heat sensitive illnesses (Table 6.3). South Carolina was 5th among a geographically diverse group of 20 US states studied for heat stress illness hospitalizations (2001-2010) with Colleton, Darlington, Florence, and Marion Counties reporting the highest rates in the state (Choudhary & Vaidyanathan, 2014). Research in North Carolina highlighted the increased odds of pregestational births associated with days of high temperatures but less than heatwave conditions (Ward, et al., 2019).

Table 6.2: Rates of Climate Sensitive illnesses negatively Affected by high ambient heat levels in South Carolina 2021 (Source: America's Health Rankings)

	National Ranking (1 best- 50 lowest)	Percentage of adults
Access to Care – Annual	44	NA
Asthma	22	9.4
Cardiovascular Diseases	45	11.1
Chronic Kidney Diseases	43	3.7
Chronic Obstructive Pulmonary Disease	38	8.1
Diabetes	45	13.6
Obesity	40	36.2

Future temperature increases and more frequent and intense heat waves will likely cause the Southeast to experience a disproportionate health burden (Smith, Zaitchik, & Gohlke, 2013; Vose, Easterling, Kunkel, LeGrande, & Wehner, 2017). A few studies provide an indication of the anticipated increased heat stress using some assumptions, often historically based temperature- mortality relationships, to reduce the uncertainty. The difficulty in projecting heat health impacts reflects the complexity of the social, behavioral, and physiological processes shaping exposures, preexisting conditions, and access to health care, in addition to the challenge of projecting climate extremes.

Schwartz et al. (2015) used two different climate models (GFDL- CM3 and MIROC5) and historical temperature-mortality relationships in projecting premature heat-related deaths for 209 US cities including 5 in South Carolina. The range of rising mortality rates shown in Table 6.4 does not include any assumptions about adaptive actions that could reduce impacts (Schwartz, et al., 2015).

Modelling of extreme-temperature related mortality in Charlotte, North Carolina calculated an increase of 2.74 and 6.34 deaths/100,000 under 3.6°F (2.0°C) and 7.2°F (4.0°C) scenarios, respectively (Environmental Protection Agancy (EPA) , 2021). Another research team considered the risk of kidney stone disease and kidney stone presentations in South Carolina beginning with past relationships to temperature and projecting how that relationship would change under two climate scenarios, one warmer (RCP 4.5) and one much warmer (RCP 8.5) (Kaufman, et al., 2022). Based on this analysis, by 2085–2089 (vs. 2010–2014), the estimated total statewide kidney stone presentations attributable to heat are projected to increase by 2.2% under RCP 4.5 and 3.9% under RCP 8.5 with related total excess costs of approximately $57 million and approximately $99 million, respectively (Kaufman, et al., 2022).

Table 6.3: Projected excess heat deaths in South Carolina cities

Projected excess heat deaths (mean ± 1 Standard Deviation) GFDL- CM3 model Heat Deaths (April to September)					
	Population	**1990**	**2030**	**2050**	**2100**
Charleston	345,379	14.95 ± 4.96	31.45 ± 7.98	36.59 ± 6.94	53.84 ± 6.02
Columbia	639,401	21.22 ± 12.26	53.8 ± 16.35	63.42 ± 14.4	98.95 ± 14.38
Greenville	439,607	10.68 ± 17.9	37.53 ± 12.7	45.33 ± 12.18	75.85 ± 14.75
Myrtle Beach	254,638	10.59 ± 5.43	26.32 ± 6.94	31.19 ± 6.33	48.59 ± 6.31
Spartanburg	290,717	1.47 ± 8.4	19.53 ± 9.13	25.15 ± 9.05	48.36 ± 11.47
Projected excess heat deaths (mean ± 1 Standard Deviation) MIROC5 model Heat Deaths (April to September)					
	Population	**1990**	**2030**	**2050**	**2100**
Charleston	345,379	14.95 ± 4.96	23.65 ± 4.81	27.82 ± 5.55	45.1 ± 4.59
Columbia	639,401	21.22 ± 12.26	39.69 ± 10.16	48.28 ± 10.96	80.3 ± 9.21
Greenville	439,607	10.68 ± 17.9	24 ± 7.82	29.48 ± 7.8	51.13 ± 7.4
Myrtle Beach	254,638	10.59 ± 5.43	16.85 ± 4.39	20.23 ± 4.83	36.23 ± 4.86
Spartanburg	290,717	1.47 ± 8.4	9.88 ± 5.35	13.63 ± 5.63	29.31 ± 5.53

HEAT WAVE

Heat waves are defined as two or more days of unusually hot weather (outside of the historical averages) (National Oceanic and Atmospheric Administration (NOAA) , 2023).

In the National Risk Index, a Heat Wave Risk Index Rating, shown in Figure 6.48, represents the potential impact to people, buildings, and agricultural value when compared to the rest of the United States. For the index, FEMA defines a heat wave as a period of abnormally and uncomfortably hot and unusually humid weather typically lasting two or more days with temperatures outside the historical averages for a given area. According to FEMA, “no rating” indicates that the Risk Index score cannot be calculated for that community.

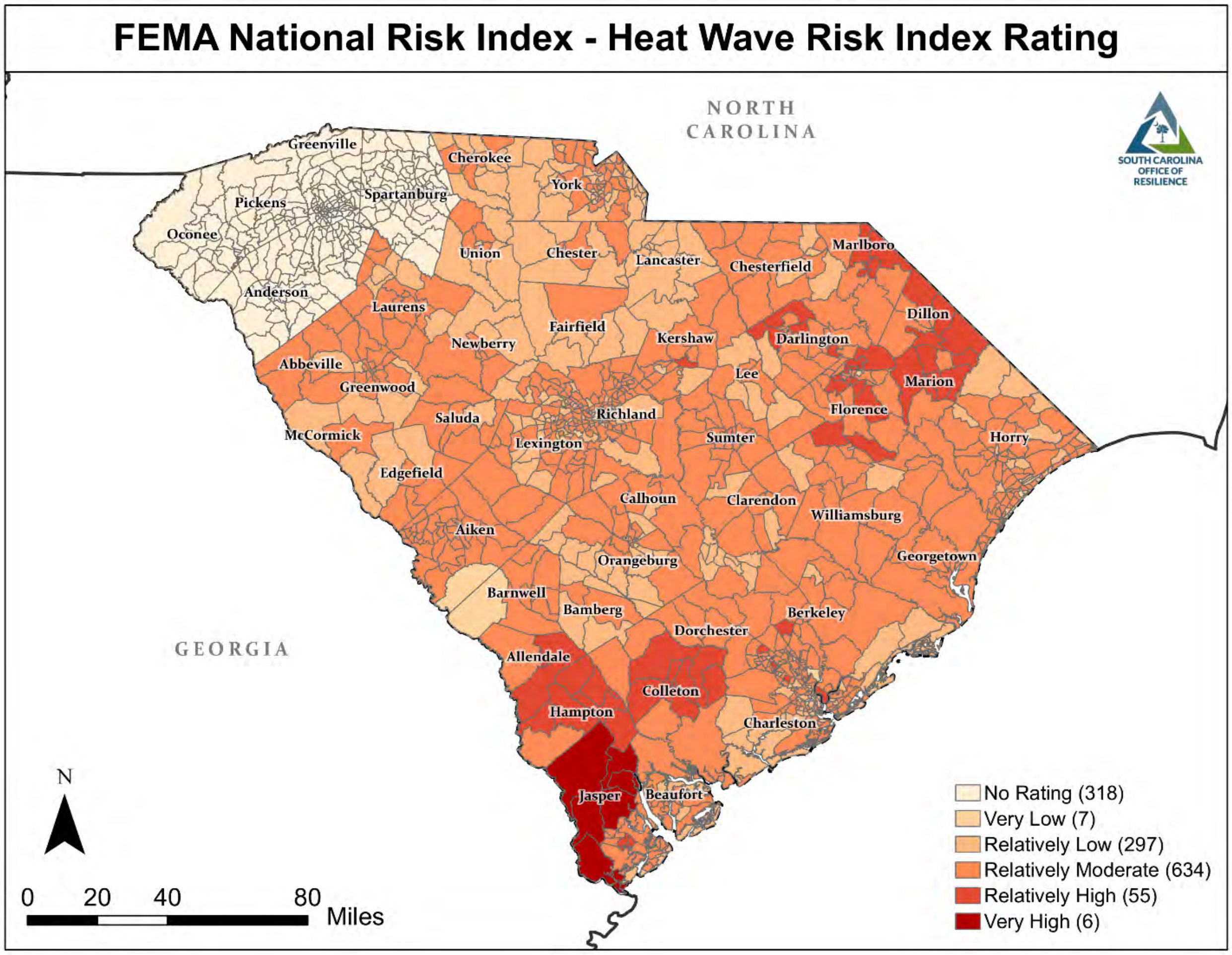

Figure 6.48: FEMA Hazard Risk Index Rating for heat waves in South Carolina by Census Tract.

URBAN HEAT ISLANDS

The City of Charleston (Figure 6.49), Richland County, and the City of Columbia (Figure 6.50) have participated in a national urban heat island mapping initiative funded through a NOAA and National Integrated Heat Health Information System (NIHHIS) grant program called HeatWatch. A heat island is an area that is hotter than the area around it. This is often associated with urban areas where infrastructure and buildings absorb more heat than forests, grasses, and bodies of water. HeatWatch is a national effort to record the heat index throughout participating cities on a single day, to see how the heat index varies from one area of a city to the next. This program results in detailed maps of heat islands using sensors that record temperature and humidity (City of Charleston, SC, n.d.). This mapping is vital to understand heat vulnerability and provides data to direct actions to reduce those vulnerabilities (City of Columbia, SC, n.d.). Below are maps from these initiatives.

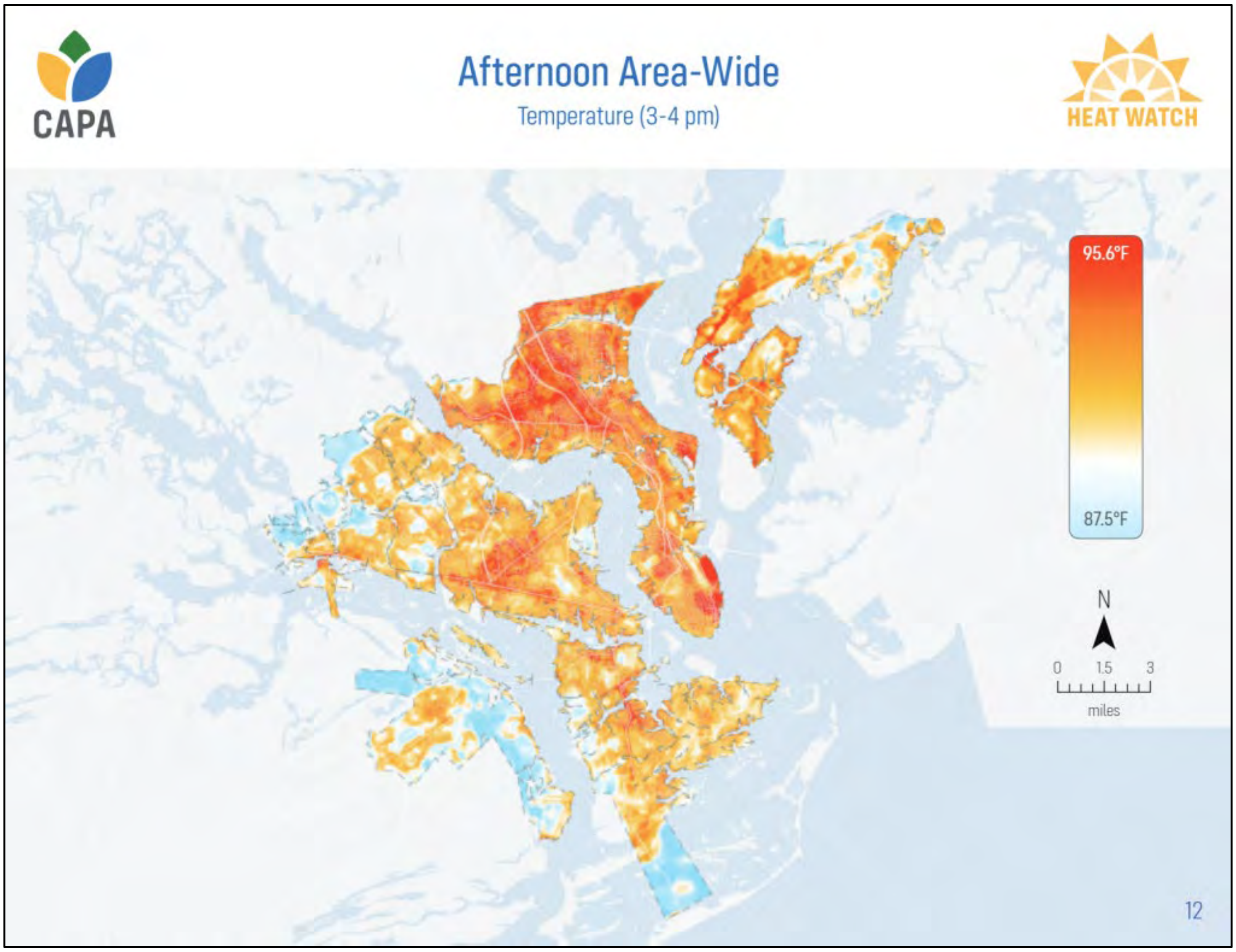

Figure 6.49: Charleston HeatWatch Afternoon Area-Wide Temperature (CAPA Strategies, 2021)

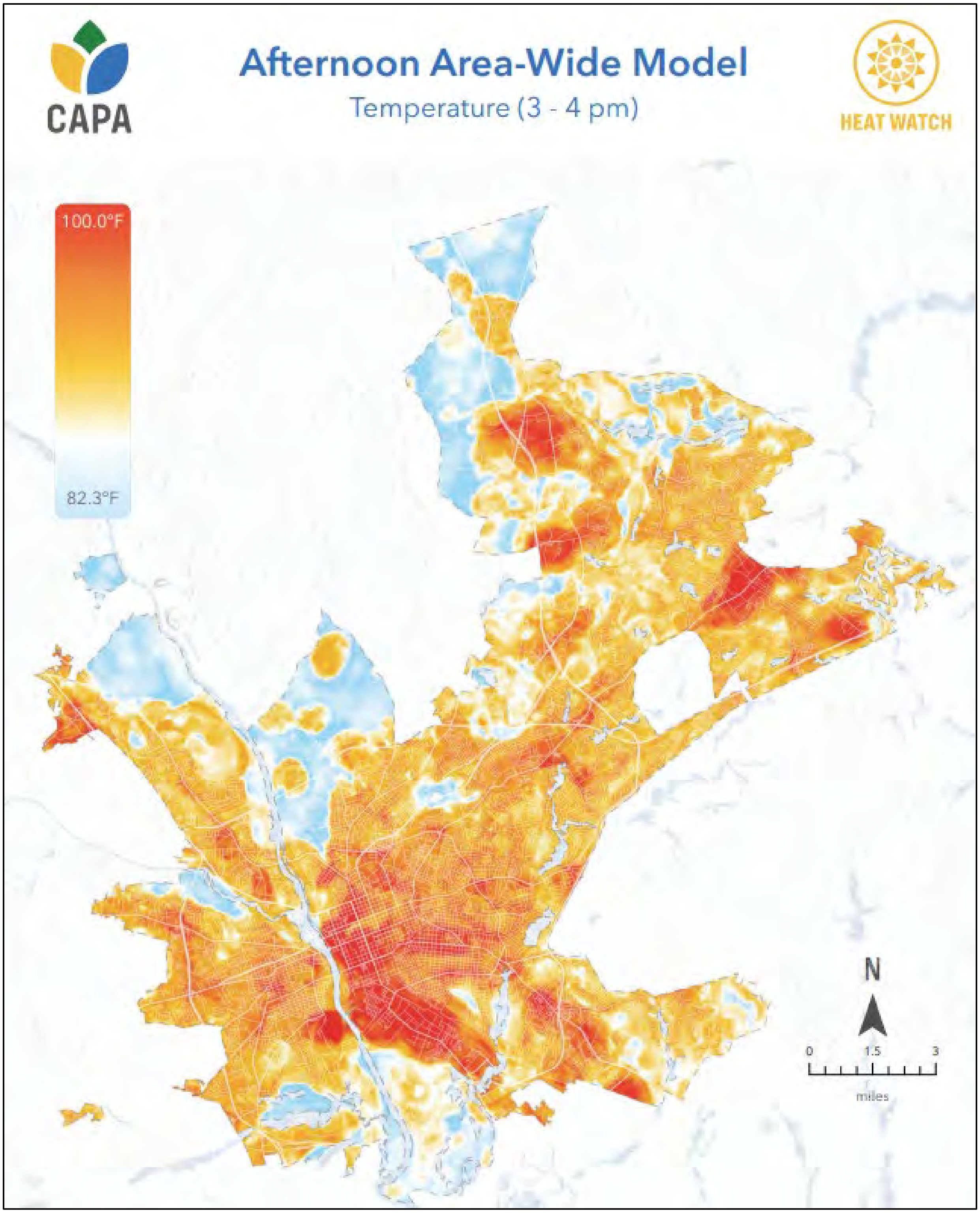

Figure 6.50: Columbia HeatWatch Afternoon Area-Wide Model Temperature (CAPA Strategies, 2022)

SEVERE THUNDERSTORMS

Thunderstorms occur frequently in South Carolina, with the state experiencing on average 45 to 72 thunderstorm days per year (National Oceanic and Atmospheric Administration, 2023). When severe, thunderstorms have the potential to produce damage-causing hail, lightning, high winds, and tornadoes.

Since 2001, there have been 1,661 severe thunderstorm events in South Carolina. Two particularly destructive storms in 2008 and 2014 occurred that caused 7.5 million and 8.5 million dollars of damage respectively (National Center for Environmental Information, 2021). In 2008, several supercell thunderstorms affected the southern part of Upstate South Carolina that caused very large hail stones along with destructive tornadoes. The 2014 storm was very similar in that it was a collection of thunderstorms that developed in the Piedmont region and moved slowly across the Upstate.

HAIL

Hail is precipitation in the form balls or lumps, consisting of concentric layers of ice, formed in cumulonimbus clouds. It forms when updrafts within a thunderstorm force liquid water upward into subfreezing air, where they collide and combine with supercooled droplets. Eventually, the hailstone becomes too heavy to be supported by updrafts within the storm, and it falls to the ground.

LIGHTNING

Lightning is another thunderstorm hazard. It is the sudden visible flash of energy and light caused by an electrical discharge from within the storm. The movement of rain and ice creates an electric charge, with the negative charges forming at the bottom of the cloud and positive charges toward the top. Positive charges build upon the ground underneath the cloud; lightning is the resultant discharge when the two charges connect. According to the most recent Annual Lightning Report, over 2.9 million lightning, in-cloud and cloud to ground, flashes and strikes were observed across South Carolina in 2022 (Vaisala, 2022).

The National Risk Index, shown in Figure 6.51 through Figure 6.53 below, represent the potential risk of lightning.

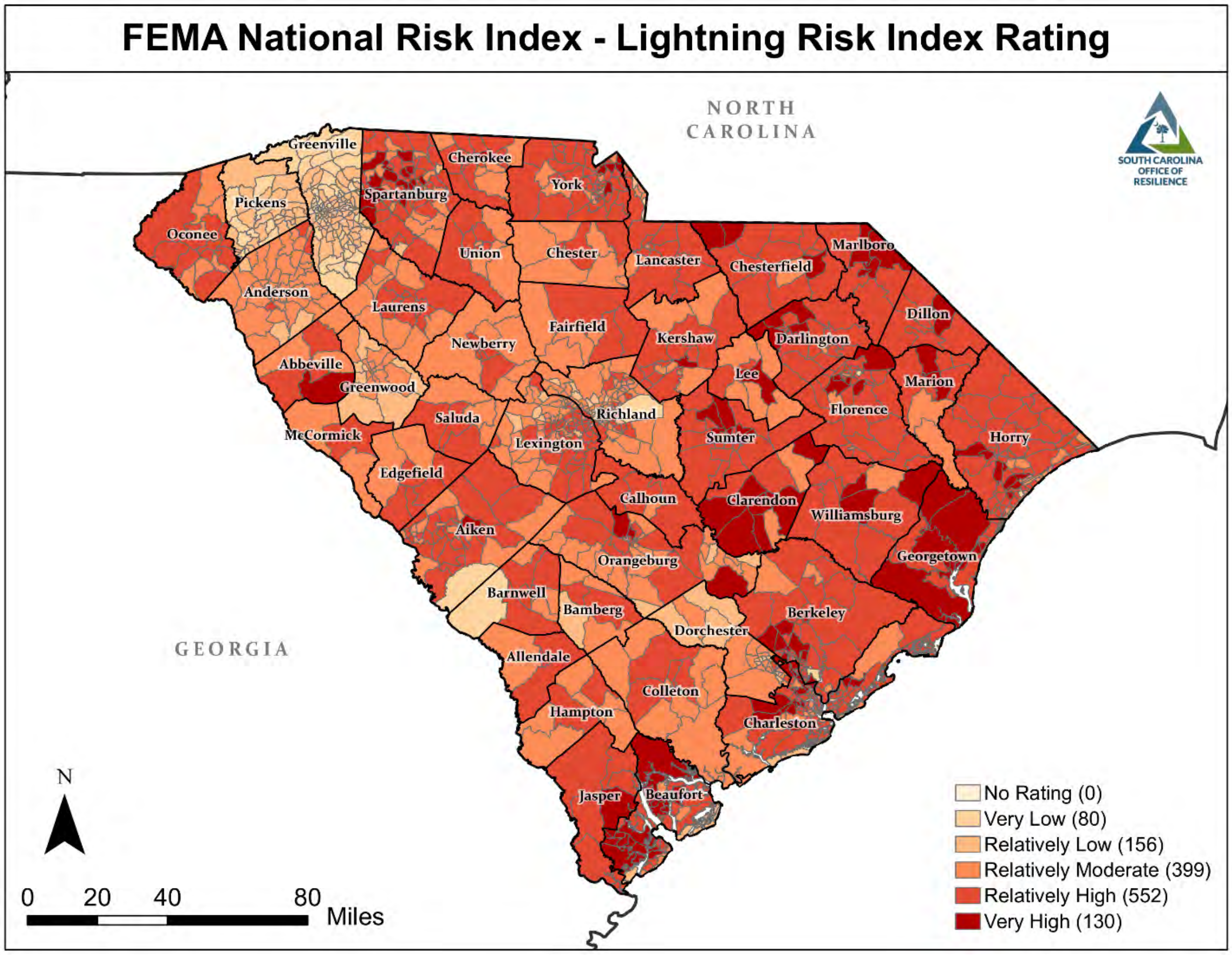

Figure 6.51: Lightning Risk Index Rating

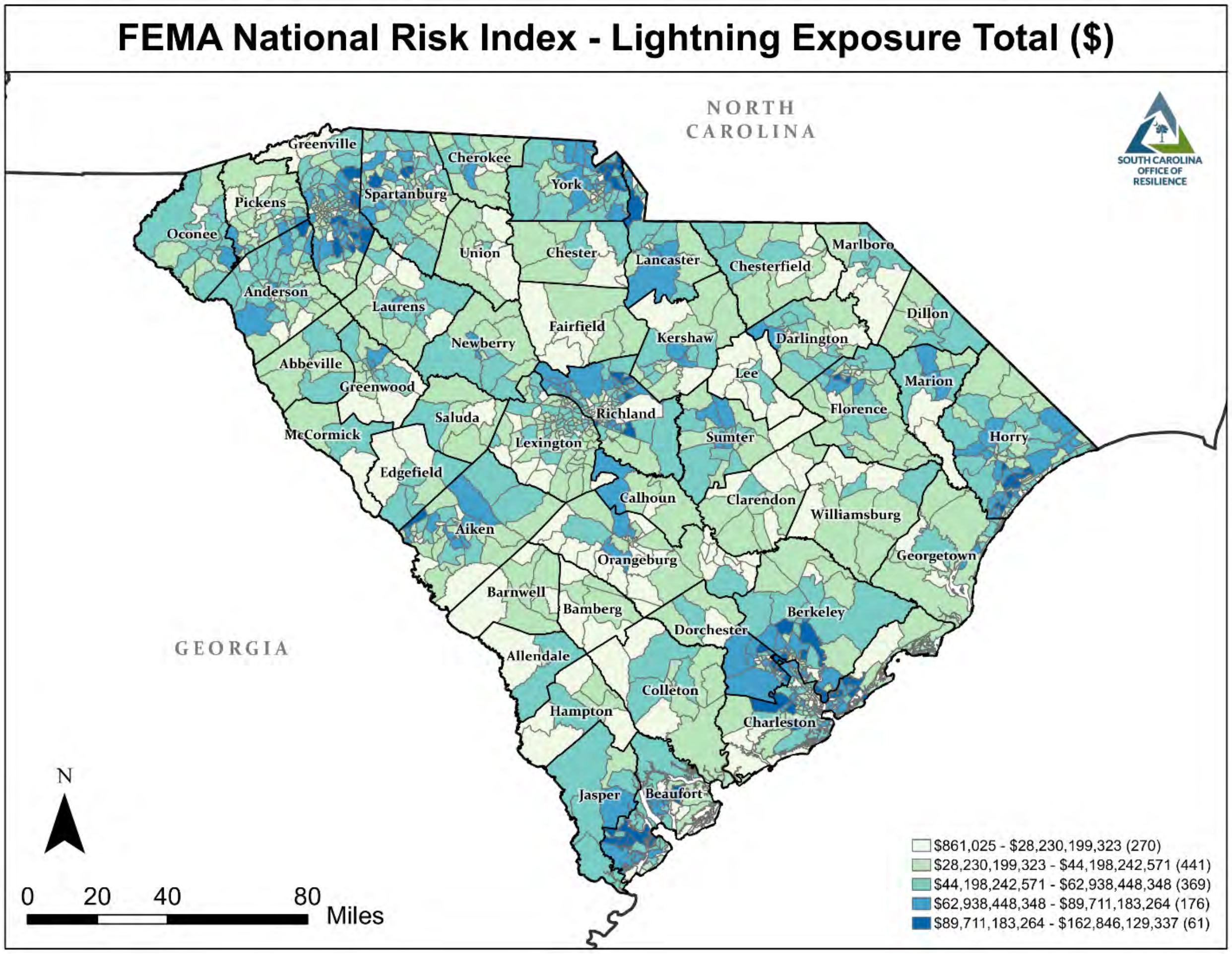

Figure 6.52: Total Lightening Exposure Cost

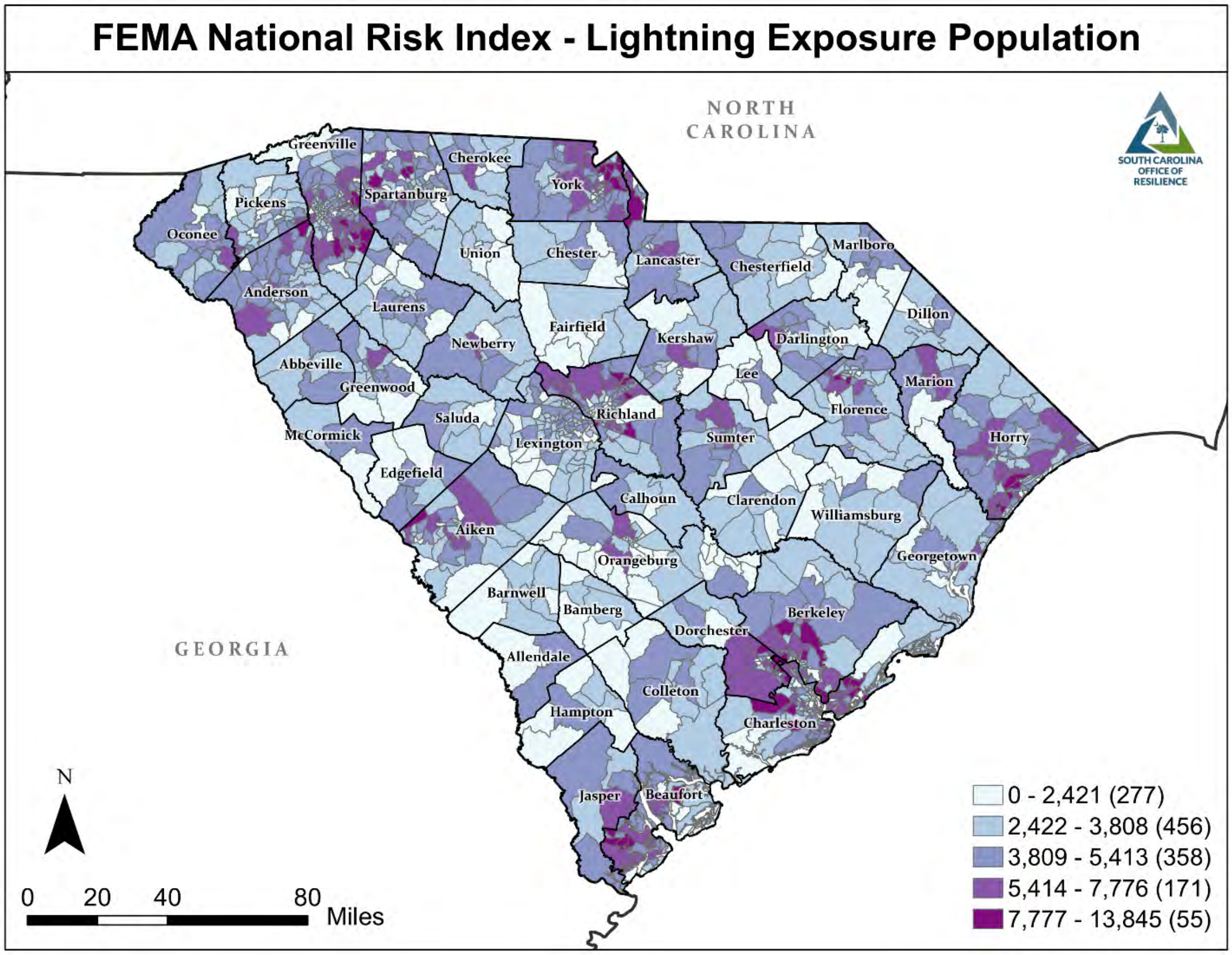

Figure 6.53: Lightning Exposure to Population

DAMAGING WINDS

Strong winds are winds greater than 50 mph and are generally produced by thunderstorms but can be caused by various processes. Straight-line winds are a term used to define non-rotational thunderstorm winds, unlike tornadoes (National Weather Service, n.d.). Downbursts are thunderstorm winds driven by falling precipitation that can exceed 100 mph. Derechos are long-lived and damaging thunderstorms, whose winds can extend away from the thunderstorm (National Weather Service, n.d.). In South Carolina, extreme winds are the most reported hazard to NCEI in the last 20 years with 3,112 unique events reported that have caused 26 deaths, 110 injuries, and close to $70 million in damages (National Center for Environmental Information, 2021).

The National Risk Index's Strong Winds Risk Index Rating, shown in Figure 6.54, represents the potential impact to people, buildings, and agricultural value when compared to the rest of the United States.

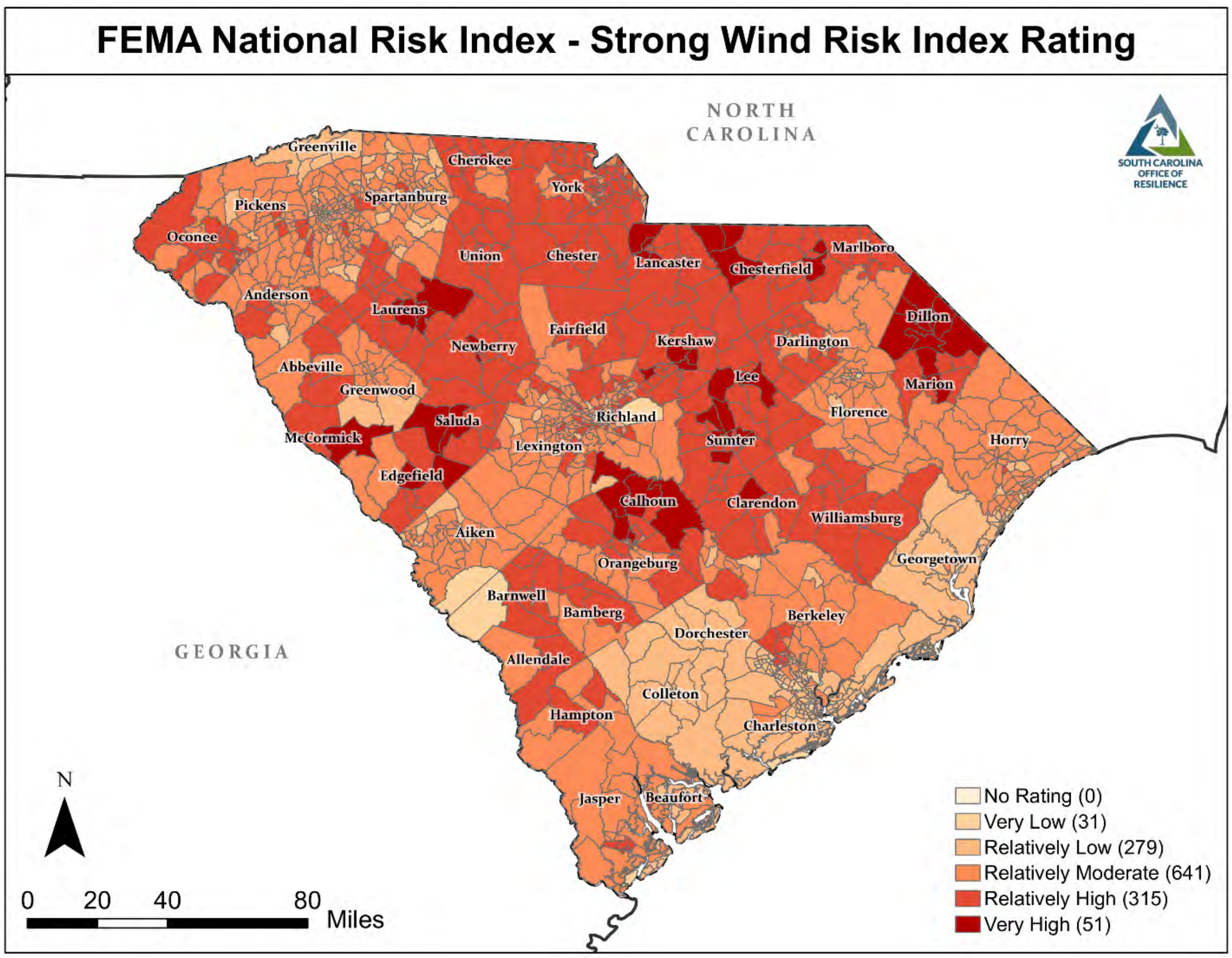

Figure 6.54: FEMA Hazard Risk Index Rating for strong winds in South Carolina by Census Tract.

TROPICAL SYSTEMS AND HURRICANES

While hurricanes are considered, “low frequency/high consequence events,” South Carolina is 5th (fifth) in the ranking of states where hurricanes hit the most, behind Florida, Texas, Louisiana and North Carolina (State Climatology Office, HURDAT Re-analysis noaa.gov).

Based on a period of record from 1851 to 2022, the state has roughly an 80% chance of being impacted by a tropical cyclone each year. Since 1851, South Carolina has been impacted by 263 tropical cyclones: 140 of these tracked into the state, while only 44 made direct landfall. Four of these landfalls were major hurricanes, with a Saffir-Simpson Hurricane Wind Scale of Category 3 or higher. It is also important to note that while these major hurricanes are devastating, minor hurricanes and tropical storms can also have significant impacts through additional hazards, such as rainfall, tornadoes, and strong winds. The State Climatology Office at SCDNR released an update to their comprehensive report in May 2023 on tropical cyclones and their impact in South Carolina.

A tropical cyclone’s strength is classified by the Saffir Simpson Hurricane Wind Scale. Three of the strongest storms to directly impact the state since 1900 are: Hurricane Hazel (1954), Hurricane Gracie (1959), and Hurricane Hugo (1989). As described in Chapter 4, climate projections suggest more rapid intensification of storms; on the other hand, increased wind shear in the future could keep some storms from forming.

The Atlantic Tropical Cyclone season officially begins on June 1 and lasts through November 30; however, documented storms have impacted the State outside of these dates. The primary hazards from tropical cyclones are inland flooding, wind damage, tornadoes, and storm surge. The extent and severity of how these hazards affect the state are dependent on the track and landfall point of the storm, along with the size of the wind field, the forward speed of the storm, the bathymetry of the coastline, and the angle of the storm approaches the coast. The combination of these hazards causes tremendous impacts on the citizens of South Carolina and makes assessing the vulnerability to any given sector challenging to estimate.

STORM SURGE

Storm surge is the most significant coastal tropical cyclone-related hazard, posing the greatest threat to life and property along the coast. It is a rise of water generated by a storm higher than the predicted astronomical tides. The strong winds in a tropical cyclone primarily cause storm surge. As the tropical cyclone approaches land, it encounters shallower water, and the water is pushed inland. The highest surge levels at the coast typically occur to the right of the storm’s center, and the stronger, larger, and faster tropical cyclones usually produce the highest surge.

Since storm surge is independent of tides and waves, the flooding it causes can be additive in its risk and bring those tidal forces and wave actions into areas not commonly affected by storm surge. This rise in water can result in devastating flooding in coastal areas and can cause significant damage to homes, businesses, and infrastructure.

WIND

Devastating winds are the hazard most often associated with tropical cyclones. The Saffir-Simpson Hurricane Wind Scale (Table 6.6) is used to characterize potential damage to property based on the hurricane's maximum sustained wind speed.

Table 6.4: The Saffir-Simpson Hurricane Wind Scale and descriptions of estimated property damage (National Hurricane Center, 2023).

Category	Sustained Winds	Types of Damage Due to Hurricane Winds
1	74-95 mph 64-82 kt 119-153 km/h	**Very dangerous winds will produce some damage:** Well-constructed frame homes could have damage to roof, shingles, vinyl siding and gutters. Large branches of trees will snap and shallowly rooted trees may be toppled. Extensive damage to power lines and poles likely will result in power outages that could last a few to several days.
2	96-110 mph 83-95 kt 154-177 km/h	**Extremely dangerous winds will cause extensive damage:** Well-constructed frame homes could sustain major roof and siding damage. Many shallowly rooted trees will be snapped or uprooted and block numerous roads. Near-total power loss is expected with outages that could last from several days to weeks.
3 (major)	111-129 mph 96-112 kt 178-208 km/h	**Devastating damage will occur:** Well-built framed homes may incur major damage or removal of roof decking and gable ends. Many trees will be snapped or uprooted, blocking numerous roads. Electricity and water will be unavailable for several days to weeks after the storm passes.
4 (major)	130-156 mph 113-136 kt 209-251 km/h	**Catastrophic damage will occur:** Well-built framed homes can sustain severe damage with loss of most of the roof structure and/or some exterior walls. Most trees will be snapped or uprooted and power poles downed. Fallen trees and power poles will isolate residential areas. Power outages will last weeks to possibly months. Most of the area will be uninhabitable for weeks or months.
5	157 mph or higher	**Catastrophic damage will occur:** A high percentage of framed homes will be destroyed, with total roof failure and wall collapse. Fallen trees and

(major)	137 kt or higher	power poles will isolate residential areas. Power outages will last for weeks to possibly months. Most of the area will be uninhabitable for weeks or months.
	252 km/h or higher	

Tropical cyclones can devastate inland areas, even if they make landfall in locations other than the South Carolina coast. Heavy rainfall can cause flash and riverine flooding, while strong winds and tornadoes can uproot trees, damage buildings, and cause power outages. Even areas far from the coast can be affected by the aftermath of a tropical cyclone, and the damage to infrastructure can take weeks or months to repair. In the National Risk index, a Hurricane Risk Index Rating, shown in Figure 6.55, represents the potential impact to people, buildings, and agricultural value when compared to the rest of the United States.

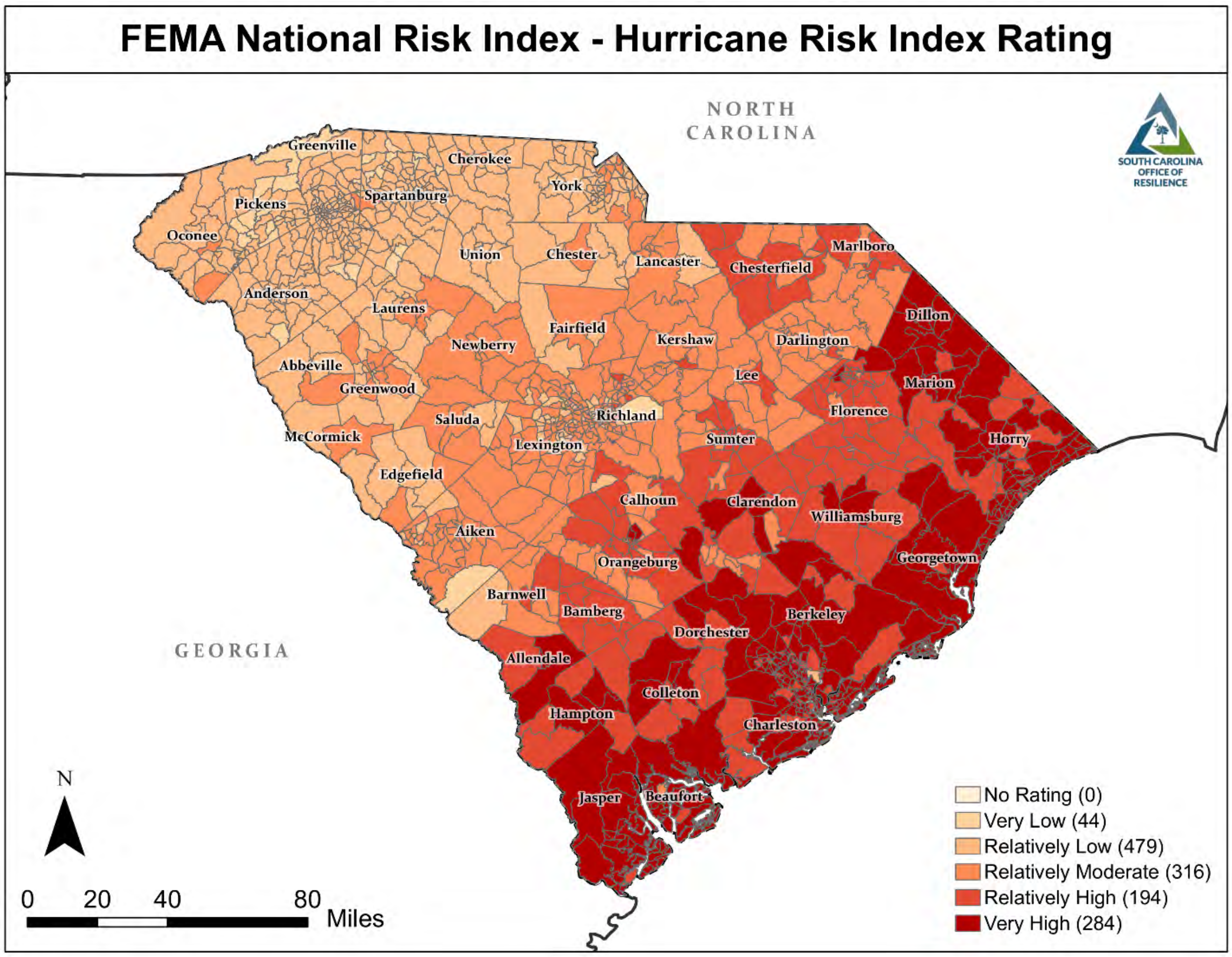

Figure 6.55: FEMA Hazard Risk Index Rating for hurricanes in South Carolina by Census Tract.

TORNADOES

South Carolina has a history of tornadoes, documented by the State Climatology Office, the National Weather Service, and NOAA's Storm Prediction Center back to 1950. Tornadoes are violently rotating air columns that descend from a thunderstorm and come in contact with the ground. The strength of a tornado is determined by the amount of damage left in its wake and is rated on the Enhanced Fujita Scale. The weakest tornadoes are rated EF-0 (estimated winds of 65 -85 mph) and the strongest are rated EF-5 (estimated winds over 200 mph). Before 2008, the original Fujita Scale rated them from F-0 to F-5, which had limitations. A count of EF/0 to E/F4 tornadoes observed yearly between 1950 and 2020 shows an increasing trend in the number of tornadoes South Carolina has seen since the early 1990s. However, this is mainly due to the advent of NEXRAD radar in 1994-1996, which allows meteorologists to better detect weaker EF/F-0 & EF/F-1 tornadoes and increasing population density.

To account for these changes in observing practices, Figure 6.56 below shows the number of E/F2 or greater tornadoes annually between 1950 and 2020. While no significant trend is shown, the state still experiences devastating impacts from these events due to increases in population and development since 1950. Additionally, as discussed in Chapter 4, current climate projections predict that tornado alleys are shifting east toward the state.

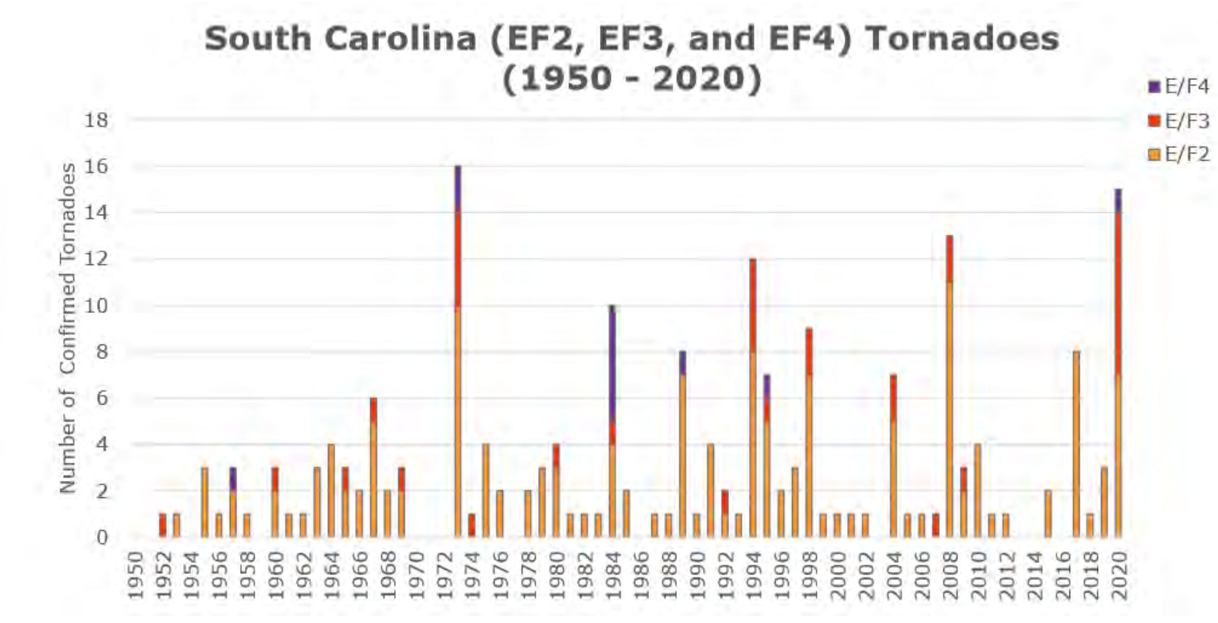

Figure 6.56: South Carolina Tornados (SC Climatology Office)

Figure 6.57 illustrates the probability of tornadoes every month, showing a peak during spring and in September. The springtime peak of tornado activity is typical for the southeastern and south-central United States, resulting from increasingly warm and humid air becoming available for storm systems crossing the region to produce intense thunderstorms. The September peak is primarily driven by tornadoes spawned by tropical cyclones affecting the state.

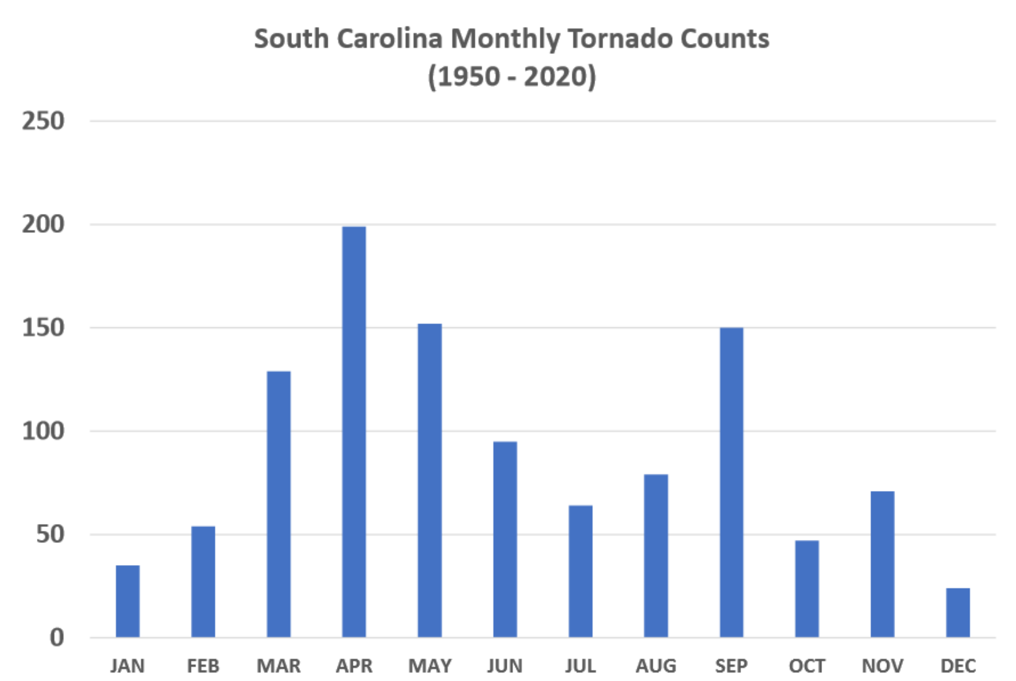

Figure 6.57: SC Monthly Tornado Counts (SC Climatology Office)

Tornadoes are a hazard that can impact anywhere in South Carolina and produce powerful winds and lift debris that can impact structures or other objects. Typically, tornadoes cause the greatest damages to non-reenforced structures or light construction buildings such as mobile homes, sheds, or residential homes. In the National Risk index, a Tornado Risk Index Rating, shown in Figure 6.58, represents the potential impact to people, buildings, and agricultural value when compared to the rest of the United States.

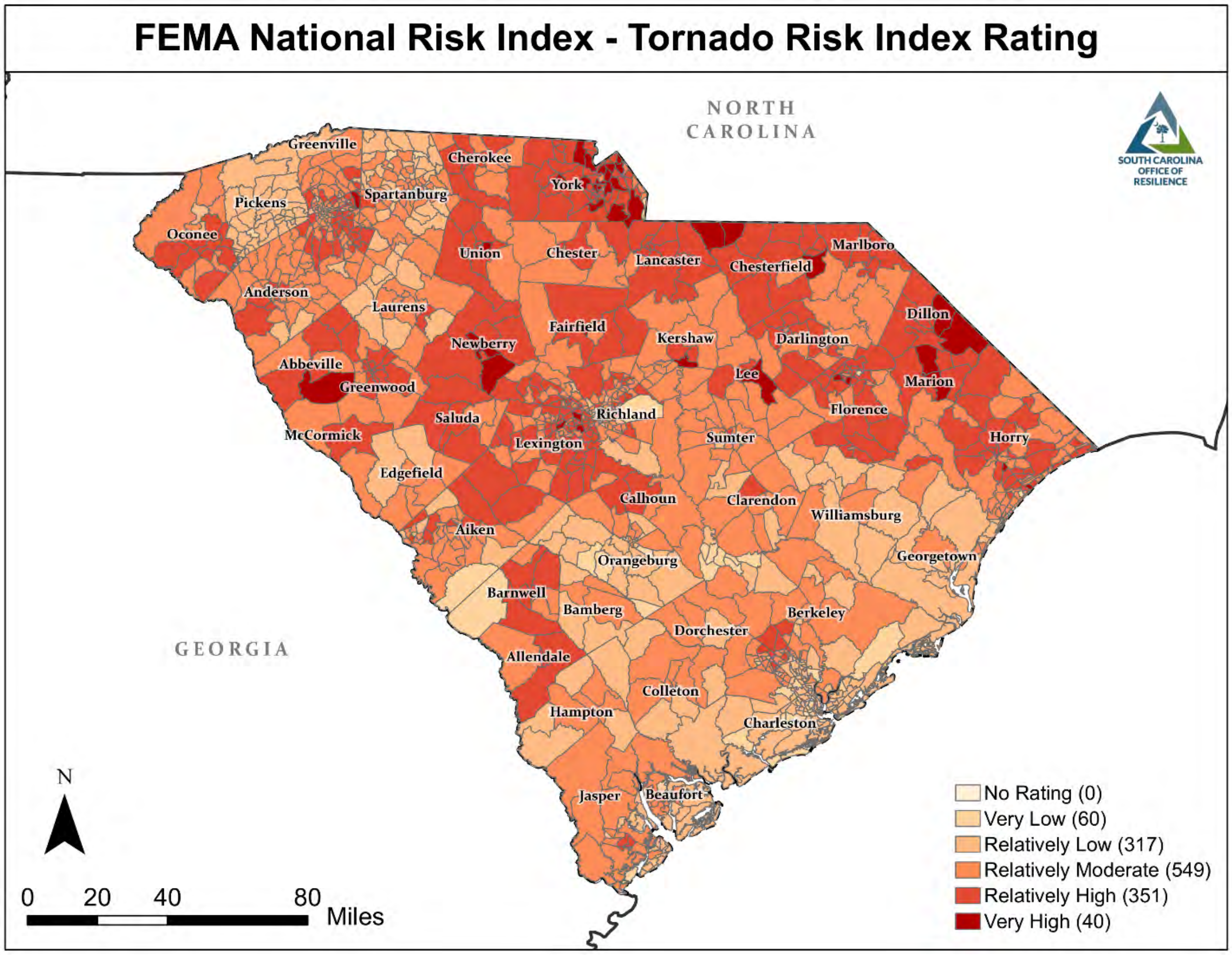

Figure 6.58: FEMA Hazard Risk Index Rating for tornadoes in South Carolina by Census Tract.

WINTER WEATHER

Extreme winter weather events in South Carolina are relatively rare but cause significant impacts across the state. A database of events since 1958 is recorded on SCDNR Climatology Office's Winter Weather webpage. Winter weather events include Blizzard, Cold/Wind Chill, Extreme Cold/Wind Chill, Frost/Freeze, Heavy Snow, Ice Storm, Sleet, and Winter Storm events. These events can disrupt communications and power as a result of trees or branches falling on suspended lines (see Energy Office Report on the Resiliency of South Carolina's Electric and Natural Gas Infrastructure Against Extreme Winter Storm Events), disrupt travel plans through impairing roadways, and damage both residential and agricultural plants.

Since 2001 there have been a total of 104 events that have caused millions of dollars in property damage and agricultural losses (National Oceanic and Atmospheric Association (NOAA), 2021). A late season freeze in April 2007 generated over $32 million in crop damages, which killed off 80 to 90% of the peach crop (National Oceanic and Atmospheric Association (NOAA), 2021).

The National Risk Index's Winter Weather Risk Index Rating, shown in Figure 6.59, represents the potential impact to people, buildings, and agricultural value when compared to the rest of the United States.

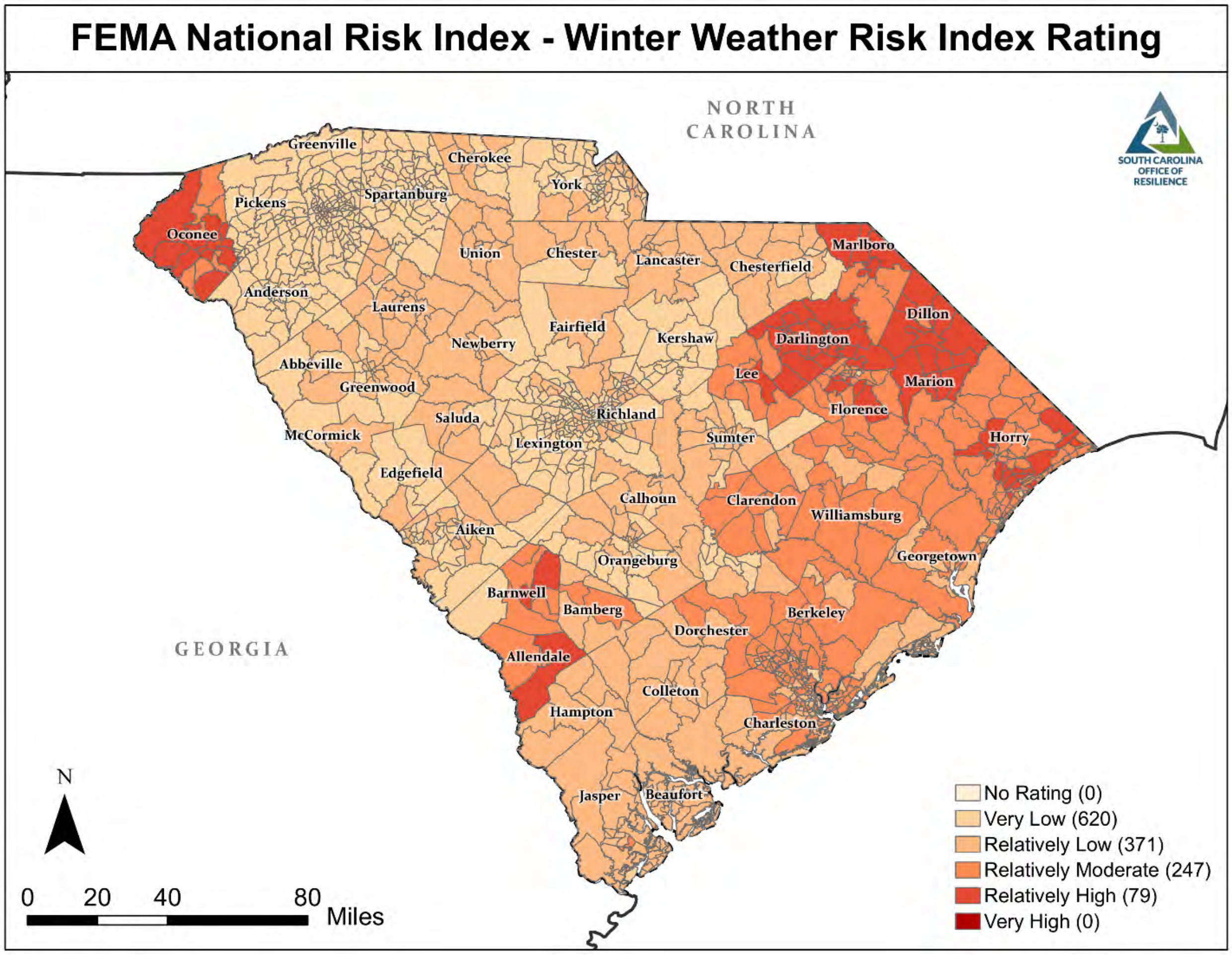

Figure 6.59: FEMA Hazard Risk Index Rating for winter weather in South Carolina by Census Tract.

SEISMIC EVENTS

EARTHQUAKES

Earthquakes occur when forces build up and are suddenly released within the earth's crust, causing blocks of earth to move as an earthquake along fault lines. There are three main types of faults: strike-slip, normal, and thrust (Figure 6.60). Strike-slip faults occur when earth's crustal plates move laterally against each other (Figure 6.60a). Normal faults occur when one block slides downward in reference to the other block due to tensional or extensional forces to the blocks (Figure 6.60b). Thrust (reverse) faults occur when one block is thrusted over another (Figure 6.60c). Most large earthquakes, greater than magnitude 5 on the Moment Magnitude Scale (Mw), occur along crustal plate boundaries, but do not exclude earthquakes in the middle of plates or along inactive boundary zones. According to the USGS, South Carolina has experienced 229 earthquakes since 2001, with 46 events larger than a magnitude 2.5 Mw. The largest event since 2001 reached a magnitude 4.1 Mw in Parksville, SC, on November 11, 2014 (Figure 6.54) (US Geological Survey (USGS), 2023).

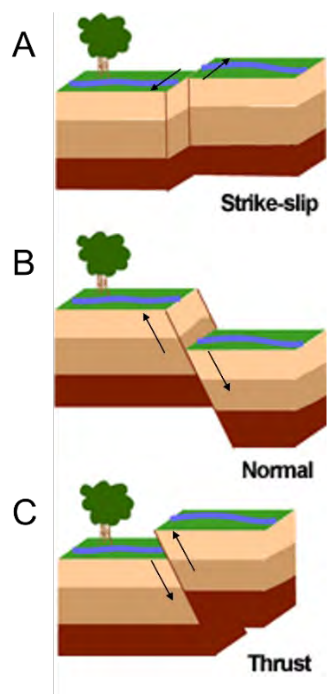

Figure 6.60: Three types of faults, black arrows represent observed motion, edited from (US Geological Survey, 2022).

The United States Geological Survey (USGS) Earthquake Hazard Program and the South Carolina Geological Survey (SCGS) monitor and calculate potential impacts from earthquakes. Intensity, location (epicenter or hypocenter), and other information is collected and housed by multiple sources including the USGS, SCGS, and academia. The University of South Carolina's School of Earth, Ocean and Environment maintains the South Carolina Seismic Network that houses nine seismic monitoring stations, six in the Charleston/Summerville area and three around the rest of the State (University of South Carolina, 2023).

Earthquake vulnerability assessment involves evaluating the potential damage and losses that could occur in a specific area as a result of an earthquake. With the available technology, earthquakes are practically impossible to predict, although historic events provide context and allow for a probabilistic estimate of future events. The USGS Earthquake Hazard Program maintains a database of historic earthquakes and calculates the probabilistic 1% annual chance of an event that is used by the FEMA National Risk index in their base calculations (Zuzak, et al., 2023). Seismic hazard analysis involves evaluating the likelihood and severity of earthquakes in a specific area. It considers factors such as the frequency of earthquakes, the location and depth of fault lines, and the geological characteristics of the region. Figure 6.61 maps the measured historic earthquakes in South Carolina between 1913 and 2022 and their magnitude (US Geological Survey (USGS), 2023).

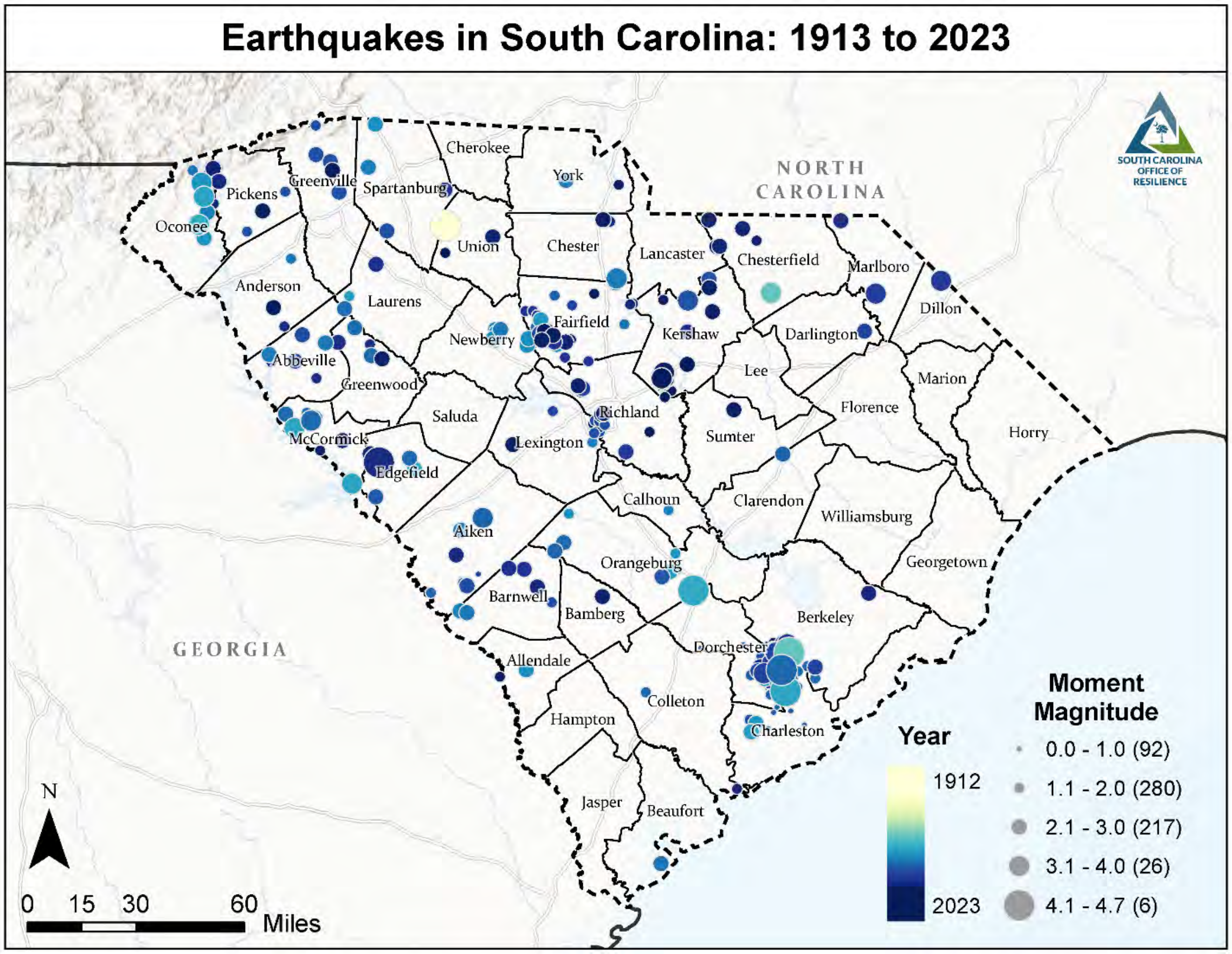

Figure 6.61: Historic Earthquakes in South Carolina (US Geological Survey (USGS), 2023)

PEAK GROUND ACCELERATION

Peak Ground Acceleration (PGA) is a primary assessment tool for communities to better mitigate and plan for a potential earthquake. PGA is the maximum acceleration a ground surface experiences during an earthquake. It is a measure of the intensity of ground shaking and is used to assess seismic hazard and design earthquake resistant structures. A broad guide is that the higher the PGA, the higher the potential damage or hazardous conditions to the community. The USGS provides data to aid in the development of building codes that include ground acceleration metrics. The SC Building Codes Council maintains the seismic design boundary maps for each county on its website and has adopted the 2015 International Residential Code for the 2021 cycle (Labor Licensing Regulation, 2023). Figure 6.62 and Figure 6.63 represent the PGA probabilities in South Carolina.

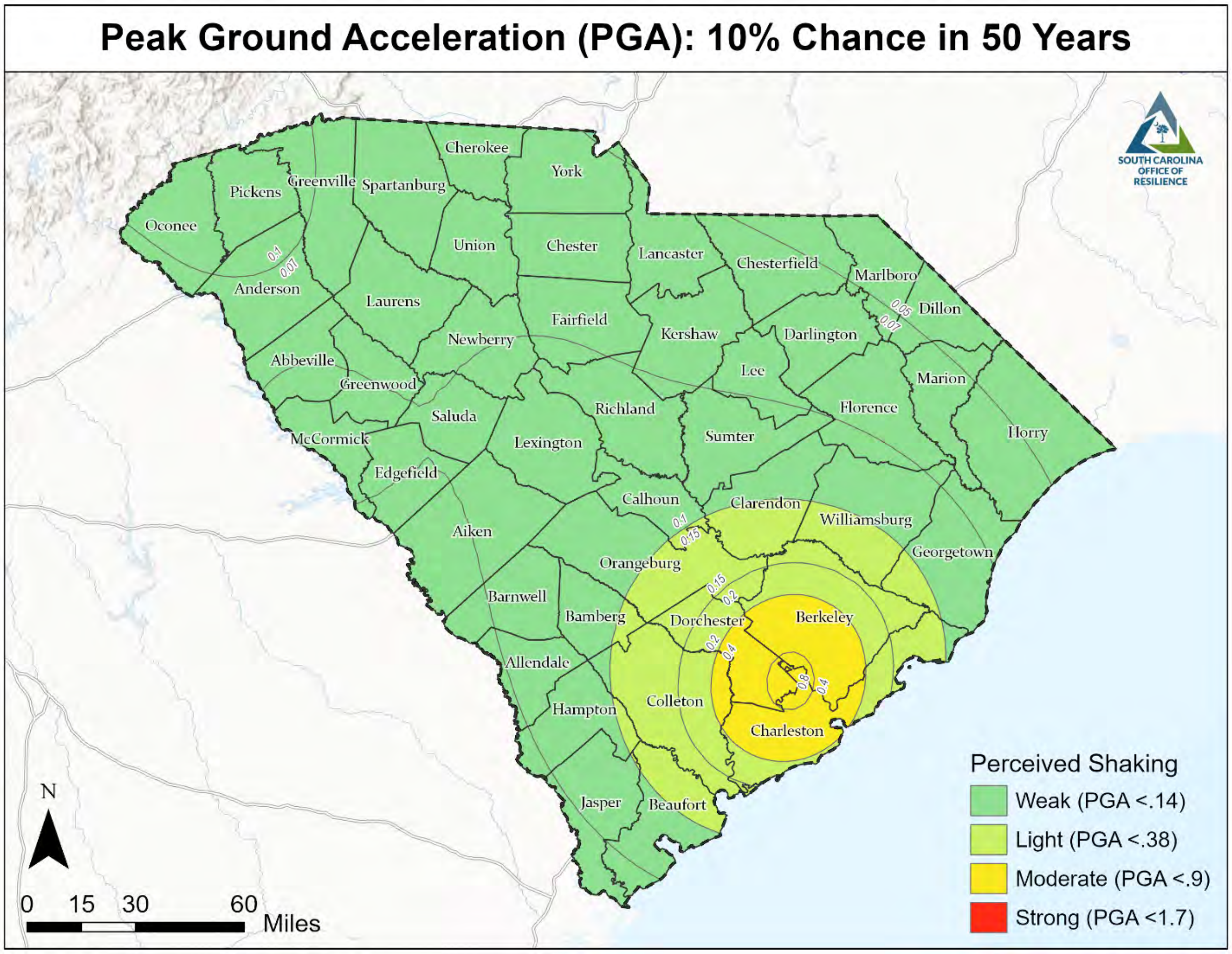

Figure 6.62: Peak Ground Acceleration (PGA) impact for SC in 10% chance in the next 50 years (U.S. Geological Survey (USGS), 2019)

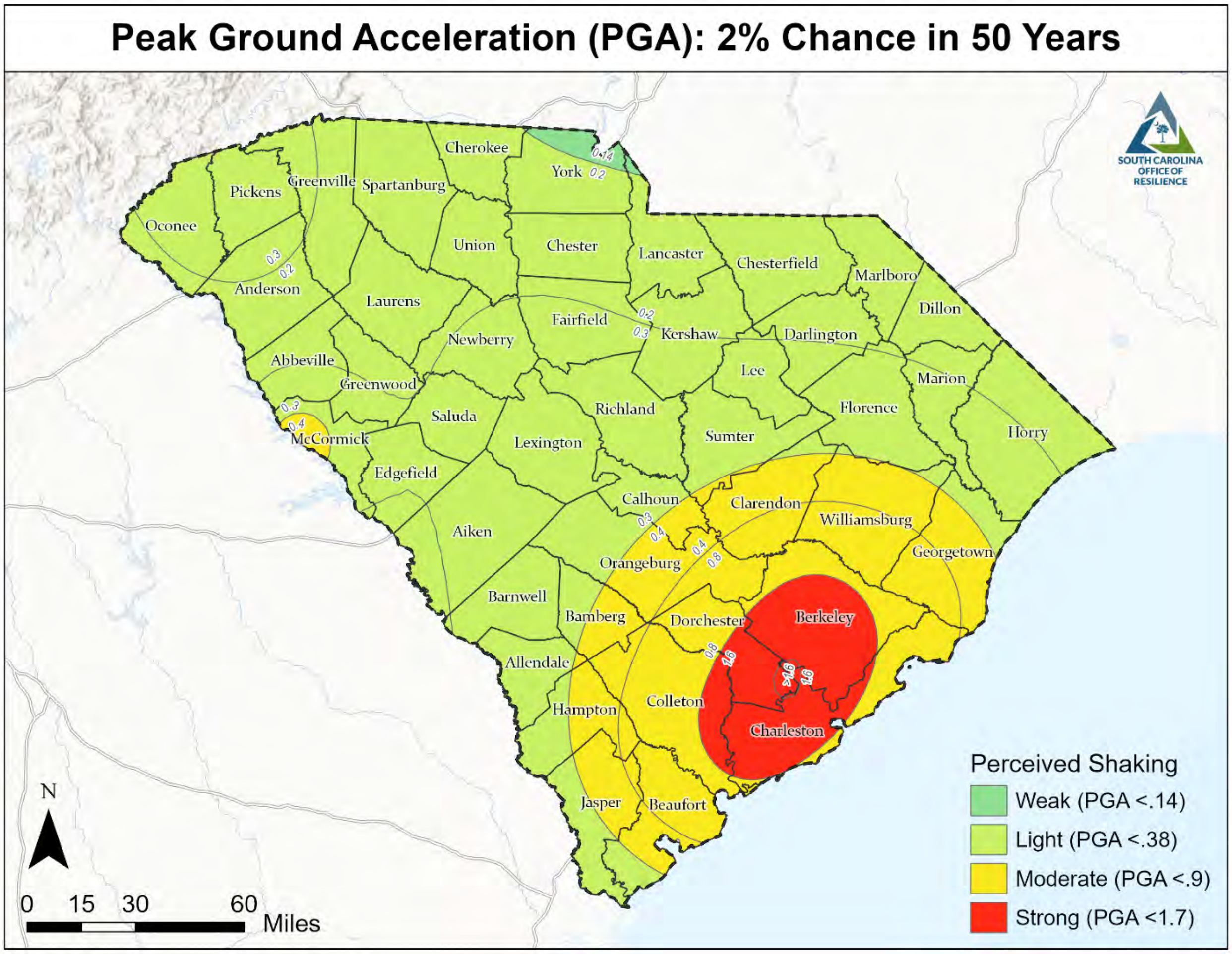

Figure 6.63: Peak Ground Acceleration (PGA) impact for SC in 10% chance in the next 50 years (U.S. Geological Survey (USGS), 2019)

GEOLOGIC HAZARDS OF THE COASTAL PLAIN

Figure 6.64 illustrates potential geologic hazards associated with earthquakes across the Coastal Plain. The unconsolidated sediments that make up the Coastal Plain of South Carolina increase the risk to the following hazards that could be cooccurring during an earthquake:

1. Karst carbonate rocks & karst carbonate sediment: Near-surface sediments with collapse potential
2. Landslide potential: Thick, cohesionless materials at steep riverbanks
3. Sinkhole potential: Mapped based on karstic features
4. Liquefaction Areas: Liquefaction is a phenomenon that occurs when soil loses its strength and stiffness due to an earthquake or other sudden change in stress conditions. When an earthquake occurs, the ground moves rapidly back and forth, causing the soil particles to rearrange and lose their contact with each other. In saturated soil, this can cause the pore water pressure to increase, which can reduce the effective stress and

cause the soil to lose its strength. As a result, the soil behaves like a liquid, rather than a solid, and can cause significant damage to buildings and infrastructure. This can lead to buildings sinking, tilting, or collapsing, and can also damage roads, bridges, and other infrastructure.

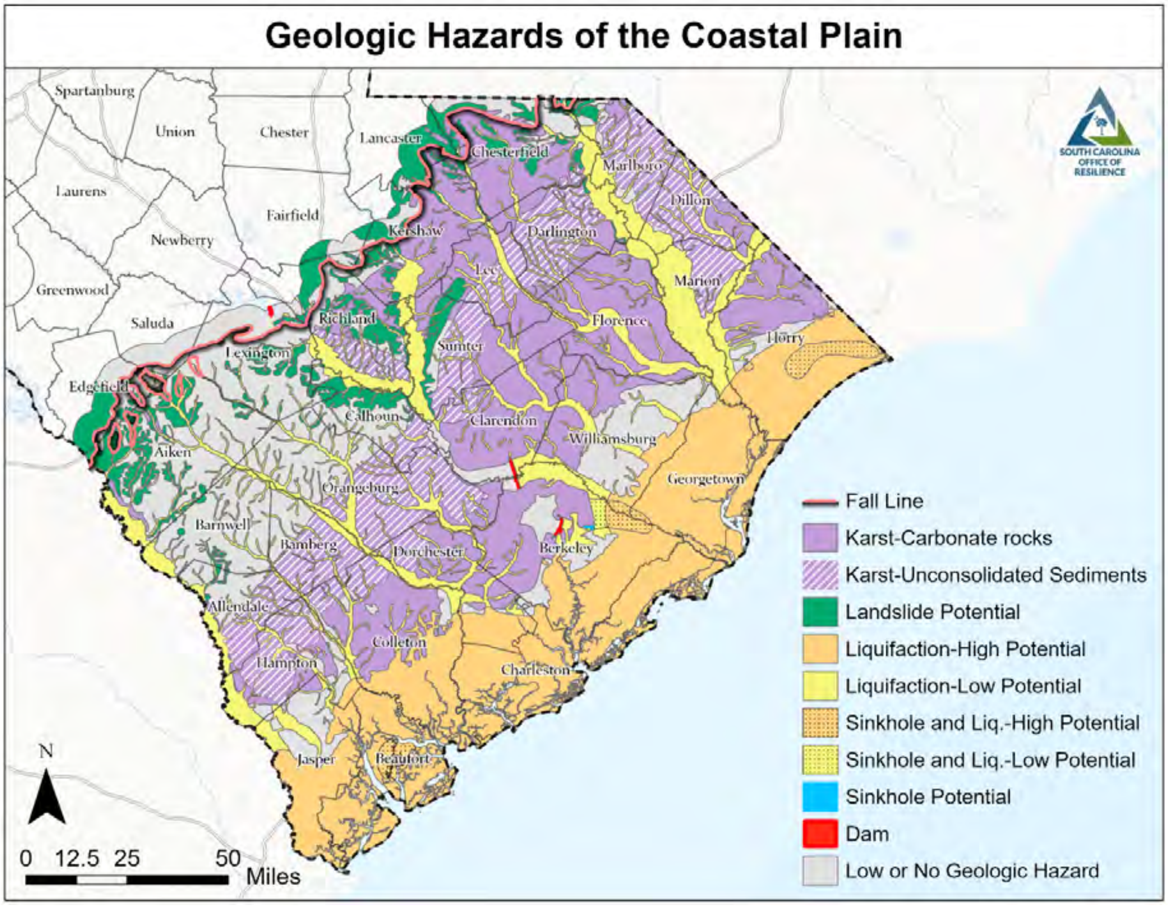

Figure 6.64: Geologic Hazards of the Coastal Plain (South Carolina Geological Survey)

FEMA NATIONAL RISK INDEX

The National Risk Index, shown in Figure 6.65, represents the potential impact from earthquakes to people, buildings, and agricultural value when compared to the rest of the United States.

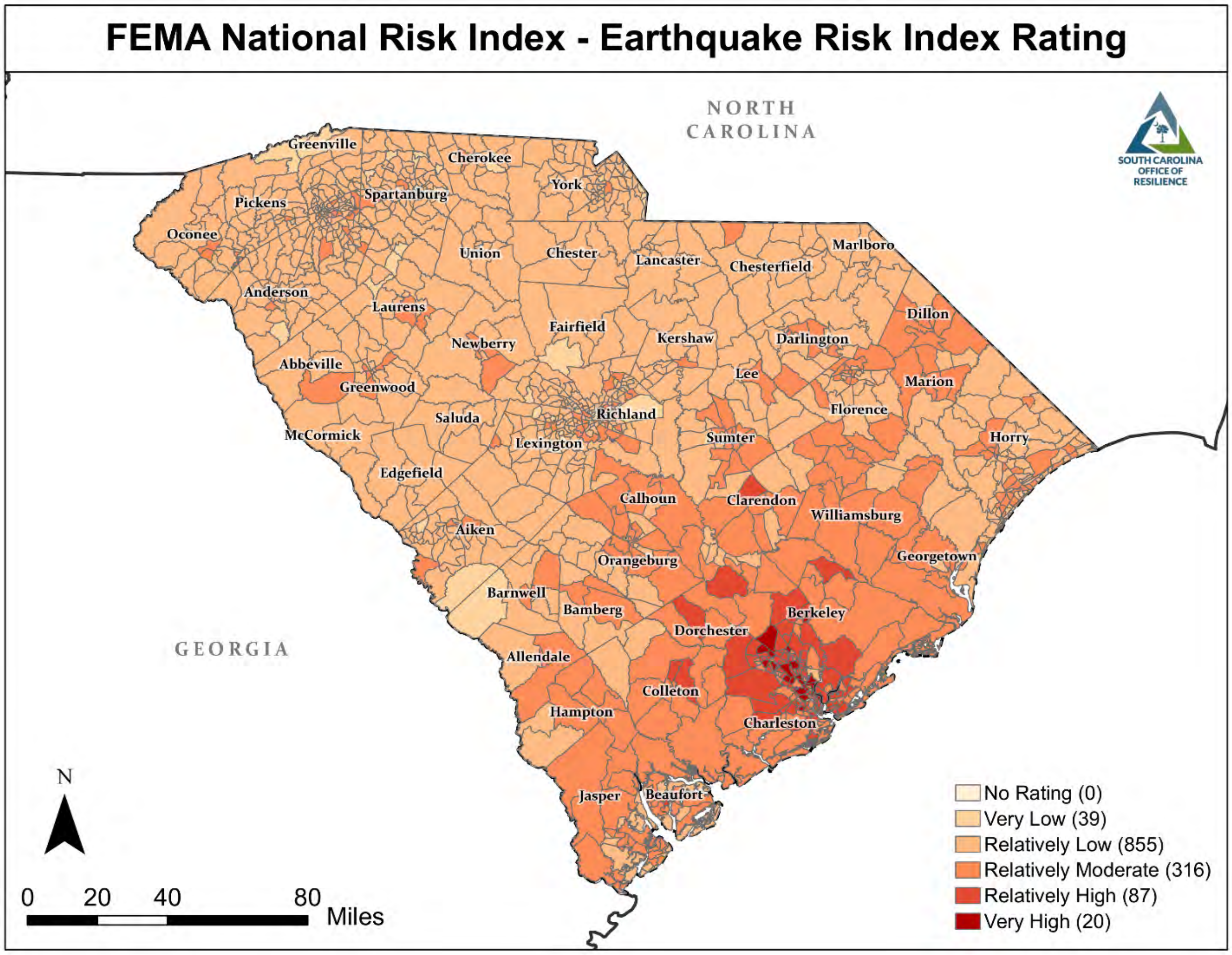

Figure 6.65: FEMA Hazard Risk Index Rating for earthquakes in South Carolina by Census Tract.

TSUNAMI

Tsunamis are relatively rare events on passive margins like the east coast of the United States. Tsunamis are large, long waves that temporarily raise local sea level and are often generated by large tectonic events such as earthquakes along megathrust fault lines. When an earthquake occurs in the ocean, the crustal plate can shift vertically, which can cause the water column above to also shift. This generates a tsunami, like the 2004 Boxing Day Tsunami that occurred in the Indian Ocean near Sumatra, Indonesia. Submarine landslides can also generate tsunamis in a similar manner. Along the continental slope, the substrate can be destabilized by an earthquake, and as the sediment moves down the slope, if the volume of sediment is large enough, it can cause a depression in the water column above it and cause a tsunami. Lastly, a meteorite impact in the ocean can also cause a tsunami. These types of events are quite rare and in South Carolina since 1950, no tsunamis have been recorded. The last major earthquake that may have generated a tsunami regionally was in 1886, centered in Charleston. A wave was detected in the Cooper River, but it is not well defined if it was a result from the earthquake or a submarine landslide (National Center for Environmental Information, 2021). There is insufficient data to make reasonable decisions or recommendations to mitigate or plan for the impacts of a tsunami.

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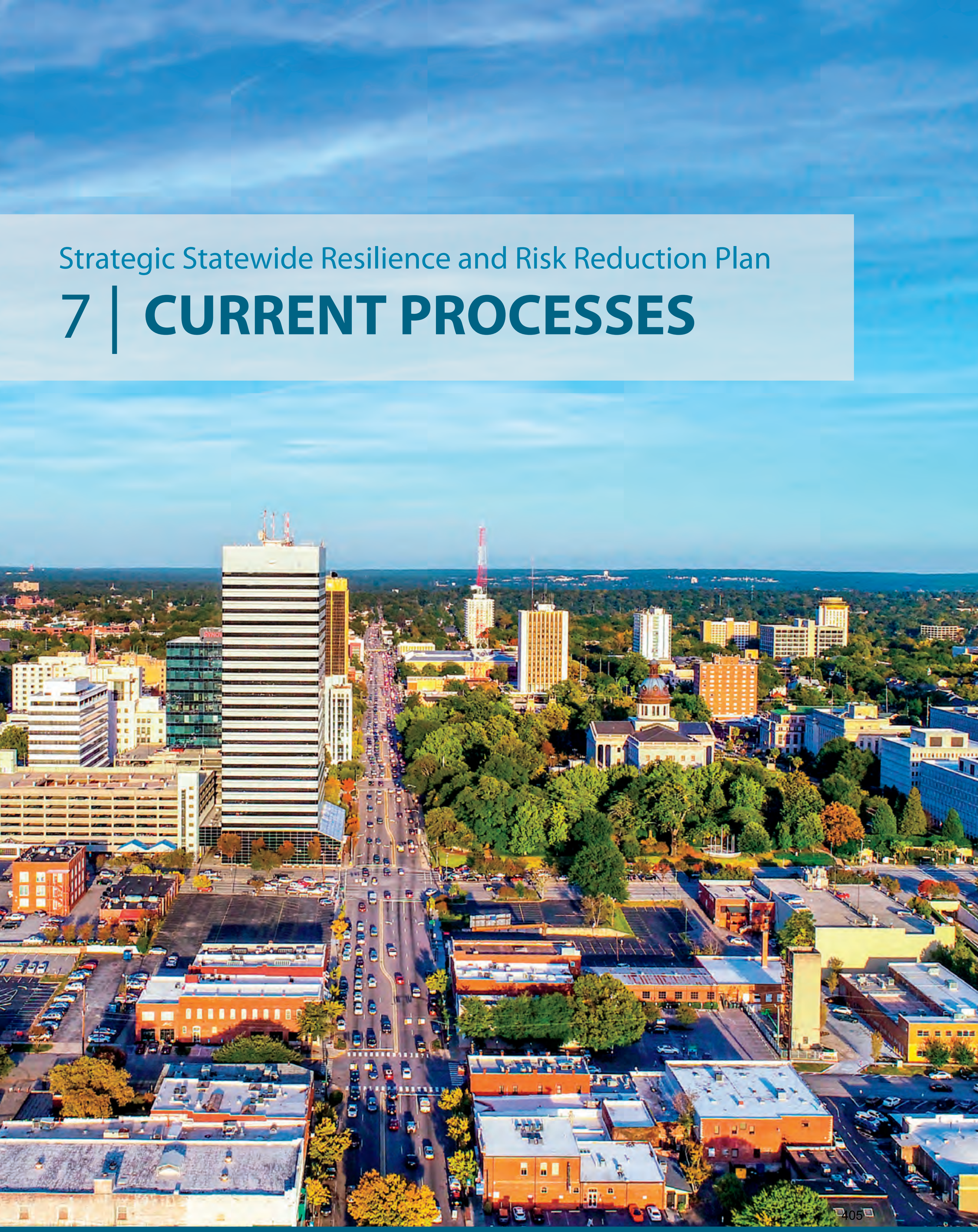
Strategic Statewide Resilience and Risk Reduction Plan

7 | CURRENT PROCESSES



OVERVIEW

The Disaster Relief and Resilience Act (2020) directs that this plan serve as a framework to guide not only investment in flood mitigation projects, but also for the adoption of program and policies to protect people and property from the damage and destruction of extreme weather events. This chapter serves to provide background on the current programs and polices related to resilience at the state and local level.

This chapter is organized into four sections corresponding to SCOR's definition of resilience: The ability of community economies and ecosystems to **anticipate**, **absorb**, **recover**, and **thrive** when faced with environmental change and natural hazards (Figure 7.1).

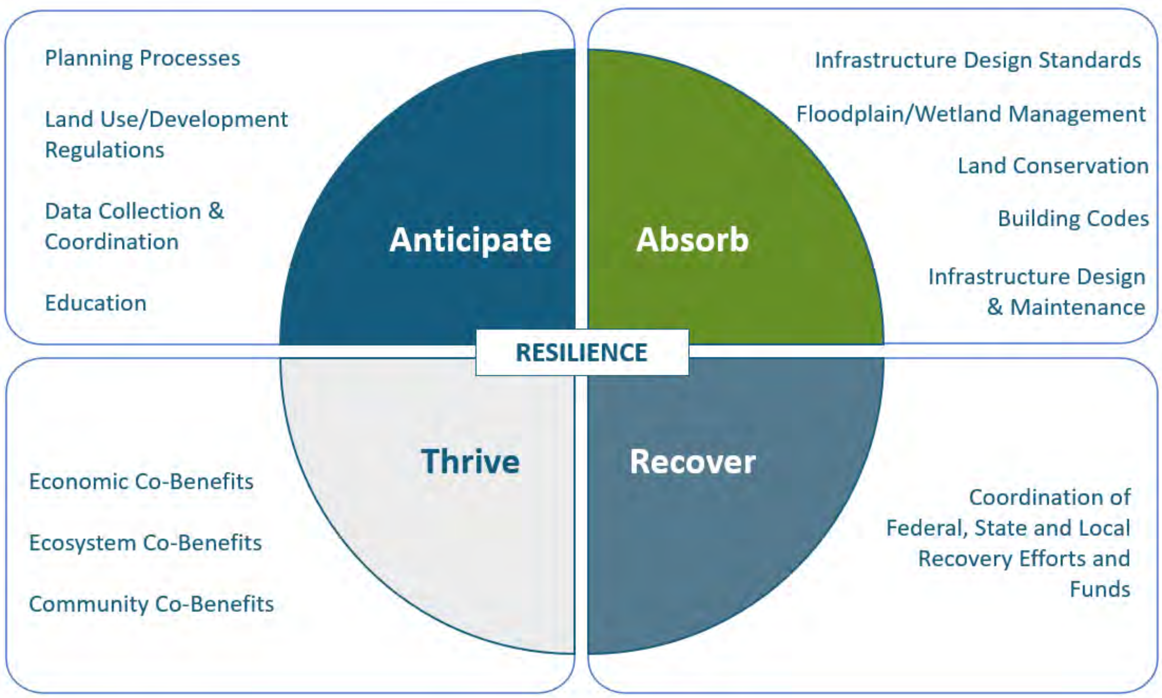


Figure 7.1: Components of Resilience

CONTENTS

KEY FINDINGS

- **Anticipate:** A variety of federal, state, and local plans and regulations impact the ability of communities, economies, and ecosystems to be resilient to natural hazards.
- **Absorb:** State, federal, and local regulations impact how well our systems are able to handle both environmental changes and natural hazards, particularly the standards to which we design our infrastructure and buildings and protect our wetlands and coastal zones.
- **Recover:** The ability of communities, economies, and ecosystems to recover is impacted by agencies, processes, and resources available at the federal, state, and non-profit level.
- **Thrive:** The investments and actions taken to improve the ability of communities, economies, and ecosystems to anticipate, absorb and recover from environment change and natural hazards will also allow the systems to work better every day and provide multiple co-benefits.

ANTICIPATE

This section focuses on the framework for state and local planning and regulations related to planning for environmental change and natural hazards and how these plans may affect the vulnerability or resilience of the state's communities, economies, and ecosystems.

LAND USE PLANNING & REGULATIONS

COMPREHENSIVE PLANS

The South Carolina Local Government Comprehensive Planning Enabling Act of 1994 (S.C. Code Ann. § 6-29-310 *et seq.*) gave local governments the authority to adopt and update comprehensive plans, create planning commission and zoning ordinances to guide development and redevelopment of the local government's area of jurisdiction. Plans developed by communities serve as a roadmap to decision making regarding growth and development, public facility investments, regulation of land uses, and economic development initiatives. Because comprehensive plans involve regulating development and design, it is an excellent place to incorporate local mitigation strategies and actions (SC Hazard Mitigation Plan, 2018).

All local government comprehensive plans, zoning and land development ordinances must conform to the Act. A planning commission is given the authorization to prepare and implement the comprehensive plan through zoning ordinances, land development and subdivision regulations, landscape ordinances, a capital improvements program, and policies and procedures.

The Act also requires the systematic preparation and re-evaluation and updating of a community's comprehensive plan, with review no less than once every five years, and an update at least every ten years. The plan must include the following elements: population, economic development, natural resources, cultural resources, community facilities, housing, land use, transportation, priority investment and resiliency.

The Act was amended by the Disaster Relief and Resilience Act to require that plans include a resiliency element that considers the impacts of flooding, high water, and natural hazards on individuals, communities, institutions, businesses, economic development, public infrastructure and facilities, and public health, safety, and welfare (S.C. Code Ann. § 6-29-510(D)(10) et seq.). This element includes an inventory of existing resiliency conditions, promotes resilient planning, design and development, and is coordinated with adjacent and relevant jurisdictions and agencies. For the purposes of this element, "adjacent and relevant jurisdictions and agencies" means those counties, municipalities, public service districts, school districts, public and private utilities, transportation agencies, and other public entities that are affected by or have planning authority over the public project. "Coordination" means written notification by the local planning commission or its staff to adjacent and relevant jurisdictions and agencies of the proposed projects and the opportunity for adjacent and relevant jurisdictions and agencies to provide comment to the planning commission or its staff concerning the proposed projects. Failure of the planning commission or its staff to identify or notify an adjacent or relevant jurisdiction or agency does not invalidate the local comprehensive plan and does not give rise to a civil cause of action. This element shall be developed in coordination with all preceding elements and integrated into the goals and strategies of each of the other plan elements.

While the recent addition to the enabling legislation requiring a resilience element will help ensure comprehensive plans address resilience related issues, the comprehensive planning process is complicated. It requires considerable coordination with adjacent and relevant jurisdictions and agencies, however, the recommendations made in these plans do not always translate into action through local regulations. This may be due to the language of the enabling legislation, which leaves room for local interpretation by not providing clear guidance on how to incorporate resilience into the comprehensive plan. Additionally, recommendations of the comprehensive plan may not reach implementation due to limited staff capacity when dealing with the administrative burden of development and zoning applications that many planning offices face. Finally, planners may not have the data they need to take broad goals found in the comprehensive plan and implement them. This could include GIS data to identify parcels for protection, as well as population and land use change projections that allow the community to consider its future needs.

LAND DEVELOPMENT REGULATIONS

Land development regulations, including subdivision regulations, establish the right of a property owner to create multiple parcels for sale or development from a larger parcel. This ability to subdivide parcels can have important implications for the resilience of communities. Subdivision regulations can be used to limit development in flood hazard areas and minimize flood risk to particular parcels proposed in a subdivision plat. The State Planning and Zoning Enabling Act of 1994 provides the authority for local government regulation of land development, including the subdivision of land. When a local government has adopted the community facilities element, the housing element, and the priority investment elements of the comprehensive plan, it may adopt land development regulations that govern subdivision and development of land, including infrastructure standards. Generally, these regulations are intended to "provide for the harmonious development" of the community to support the "health, safety, convenience, appearance, prosperity, or the general welfare" (S.C. Code Ann. § 6-29-1130(A) *et seq.*).

Land development regulations are explicitly intended to limit the risk of flooding and other natural hazards to people and property: "the regulations shall prescribe that no land development plan, including subdivision plats, will be approved unless all land intended for use as building sites can be used safely for building purposes, without danger from flood or other inundation or from other menaces to health, safety, or public welfare" (S.C. Code Ann. § 6-29-1130(A) *et seq.*).

It is important for subdivision regulations to consider both the on-site and off-site impacts of the development. Prevention or mitigation of on-site impacts will protect people and property on the subdivision site from flooding, and prevention or mitigation of off-site impacts will protect people and property downstream from the development site from increased risks of flooding.

Specific strategies for land development regulations that reduce or minimize the on-site and off-site impacts of stormwater or flooding include:

- Preservation of open space
- Preservation of wetlands and riparian areas
- Preservation of forested areas
- Infrastructure requirements for stormwater infrastructure or low impact development (LID) practices to manage stormwater
- Limiting or prohibiting the subdivision of parcels that include floodplains or flood prone areas, including cluster subdivision design to avoid development in floodplains

- Establishing a large minimum lot size for subdivisions of parcels that include floodplains or flood prone areas to ensure minimal development occurs in these areas
- Prohibiting the creation of new parcels that do not conform with other development standards, including lot dimensions and setbacks from lot lines, riparian buffers, and floodplains that may be incorporated into zoning regulations, to ensure that nonconforming or undevelopable lots are not created in floodplains or flood prone areas

ZONING REGULATIONS

Zoning regulations are an important tool for local governments to control the risks their communities face from hazards, especially exposure to flood risk. Zoning regulations can limit the types and intensity of land uses in flood hazard areas to minimize flood risk. When a local government has adopted the land use element of a comprehensive plan, the governing body may adopt a zoning ordinance. The general purpose of the zoning ordinance is to "help implement the comprehensive plan" (S.C. Code Ann. § 6-29-720, *et seq*.). The primary tools of zoning include regulation of land use, lot size, setbacks, height of structures, and density. These regulations are generally uniform across districts and apply equally to all parcels in the district. Each district is also defined on a map, so geographical distinctions can be made to regulate land use in only a particular area of the jurisdiction.

Public safety is one of the essential purposes of zoning regulations, and the Enabling Act specifically requires that "zoning ordinances must be made with reasonable consideration of the following purposes, where applicable: …to secure safety from fire, flood, and other dangers" (S.C. Code Ann. § 6-29-710(A)(7), *et seq.*). In order to protect the community from hazards, the zoning ordinance must be based on an evaluation of the risk of particular hazards in the jurisdiction generally.

Parcel level risk assessment is also necessary for effective zoning regulations. The most common geospatial dataset for evaluating flood risk in zoning ordinances is FEMA's Flood Insurance Rate Maps (FIRMs). Some zoning ordinances create an overlay district that provides special or additional standards for parcels located in the "100 year" floodplain and frequently reference the Base Flood Elevation, which is the estimated elevation of inundation during a "100 year" flood event. It should be noted that FIRMs do not completely capture an area's flood risk and additional information should be considered. Specific strategies currently found in some zoning ordinances that reduce or minimize the risk for flood hazard exposure include:

- Prohibition of certain uses in the flood hazard overlay, such as schools, daycare centers, retirement homes, and residential use.
- Requiring increased setbacks and planted or natural buffers from riparian areas.

- Requiring structures to be elevated above the base flood elevation. The distance of elevation above the BFE is commonly referred to as "freeboard."
- Prohibiting construction of new structures in the floodplain.
- Limiting the ability to perform construction on existing structures, such as renovations and additions.
- Including an amortization period that requires the removal of existing structures from the floodplain within a certain period of time.

HAZARD MITIGATION PLANNING

STATE HAZARD MITIGATION PLAN

The State Hazard Mitigation Plan serves as a guide to reducing the effects of hazards by engaging stakeholders, identifying and analyzing the state's hazards and vulnerabilities, and developing a strategy for mitigation. The plan includes the following elements:

- State Profile: An overview of the State's geography and environment, population and housing characteristics, employment and industry, land use, and historical disasters.
- Hazard and Risk Analysis: An analysis of 19 potential hazards: coastal, drought, earthquake, extreme cold, extreme heat, flood, hail, hazardous materials, infectious disease, landslide, lightning, nuclear facilities, severe thunderstorms, terrorism, tornado, tropical cyclones, wildfire, wind, winter weather.
- State Capability Assessment: Identifies state administrative, fiscal, and technical capacity as well as state agency programs that directly or indirectly relate to hazard mitigation.
- Mitigation Strategy: Includes goals and objectives of the state mitigation program and identifies mitigation measures and techniques based on the findings in the above sections.

Hazard mitigation plans must be updated every five years for state and local governments to be eligible for mitigation funding under the Robert T. Stafford Disaster Relief and Emergency Assistance Act, 42 U.S.C. 5121 *et seq*. South Carolina Emergency Management Division has been working to update the 2023 State Hazard Mitigation Plan and will adopt the plan after is reviewed by FEMA. States with Enhanced Mitigation Plans are now eligible to receive more funds under the Hazard Mitigation Grant Program following a disaster declaration. The most recent version of the State Hazard Mitigation Plan is seeking this status.

Mitigation actions in the 2018 State Hazard Mitigation Plan were organized based on 8 goals.

1. Goal 1: Policies and programs to reduce or eliminate the impacts of hazards on people and property.
2. Goal 2: Obtain resources necessary to reduce the impact of hazards on people and property.

3. Goal 3: Enhance training, education, and outreach efforts focusing on the effects of hazards, importance of mitigation, and ways to increase resiliency.
4. Goal 4: Collect and utilize data, including conducting necessary studies and analyses, to improve policymaking and identify appropriate mitigation projects.
5. Goal 5: Improve interagency coordination and planning to reduce the impact of hazards on people and property.
6. Goal 6: Enhance compliance capabilities in order to reduce the impacts of hazards on people and property.
7. Goal 7: Enhance and encourage the use of natural resource protection measures as a means to reduce the impacts of hazards on people and property.
8. Goal 8: Pursue and prioritize mitigation actions that include and benefit multiple stakeholders and geographic areas to achieve broad, comprehensive results and leverage available resources.

LOCAL HAZARD MITIGATION PLANS

Local governments are responsible for preparing and adopting a jurisdiction wide natural hazard mitigation plan as a condition of receiving project grant funds under the Hazard Mitigation Grant Program (HMGP). They also are required to review and, if necessary, update the local mitigation plan every five years from date of plan approval to continue program eligibility. FEMA's Hazard Mitigation Plan Status map shows local jurisdictions with approved plans, approvable-pending-adoption plans, and expired plans. At the writing of this report, there are several counties with expired hazard mitigation plans, while several are in development or are pending adoption.

These plans are generally completed by local emergency managers and are multi-jurisdictional. The hazard identification, risk analyses, and vulnerability assessments in local hazard mitigation plans provide estimates of potential property losses and societal impacts on a county-by-county basis throughout the state. Based on the information in these assessments, each county identifies a list of hazard mitigation measures and provides an action plan for their implementation.

DISTINCTION BETWEEN A HAZARD MITIGATION PLAN AND RESILIENCE PLAN

A hazard mitigation plan is similar to a resilience plan in that they both seek to reduce the impacts of disasters, but the Resilience Plan and the State Hazard Mitigation Plan differ in scope. While the Hazard Mitigation Plan focuses primarily on potential hazard impacts to the existing system and how those impacts may be mitigated, the Resilience Plan considers how the system itself can be altered, focusing on how our communities, economies, and ecosystems can better anticipate, absorb, recover, and thrive when presented with both environmental changes and natural hazards. This adaptive systems approach also considers the benefits of these actions in the absence of hazard events.

STATE WATER PLANNING

The South Carolina Water Resources Planning and Coordination Act (S.C. Code Ann. § 49-3-10, *et seq.*) requires SCDNR to develop a comprehensive water resources policy or water plan for the State. The third edition of SCDNR's Water Plan is continuing the work of previous plans to evaluate water usage and demands and understand the impacts of drought on the water resources in the State. The 2004 Water Plan highlighted the need for water resources to be managed at the regional level and starting in 2019, water plans are being developed in the Broad, Catawba, Edisto, Pee Dee, Saluda, and Santee watersheds, with the Savannah and Salkehatchie being split regionally into the Upper Savannah and Lower Savannah-Salkehatchie plans (South Carolina Department of Natural Resources (SCDNR), 2023).

The Edisto River Basin Plan was the first of the regional plans to be completed, and it describes the water usage, projected usage, drought management, and projected shortages. The SWAM model was used to calculate surface water usage and apply withdrawal scenarios within the basin. This allows for identification of the flow conditions in which the basin becomes water stressed.

The plan identifies that under a high demand scenario, the basin would have decreased water available at the Givhans river gage by:

- 10% under current conditions
- 40% under a proposed 2070 conditions
    - increased population, economic demand, and a hotter and drier climate (although climate projection used is not defined).

The current South Carlina Surface Water Withdrawal, Permitting Use, and Reporting Act of 2011, Title 49 Chapter 4, and SCDHEC Regulation 61-119, defines 3 types of surface water users: Existing, New, and Agriculutural. The Existing users received a permit for a minimum of 30 years for the amount of water that the intake structure is designed to withdraw, not the historic nor needed withdraw amount. New withdrawlers receive a permit for a minimum of 20 years but do have to be evaluated by reasonableness and minimum instream flow requirements. Agricultural withdrawlers only have to register for water use. Agricultural withwrawlers are deemed registered if the legally available amount of water at the point of withdraw has not been exceeded. Registrations do not expire.

The Edisto River Basin Plan used the SWAM model to identify the demand under a use case in which all currently permitted and registered withdrawers are allowed to withdraw the maximum allowed. This scenario identified that there would be insufficient water at 54% of the intakes and almost no water 5% of the time at the Givhans USGS river gage near the Charleston

Water Supply intake. This senario is four times the water demand modeled under the 2070 High Demand scenario implicating that the historic water use does not align with the permitted and registered volumes. While changes to the demand side were examined, changes to future climate conditions and changing rainfall patterns were not explicitly considered.

OTHER STATEWIDE PLANNING EFFORTS RELATED TO RESILIENCE

The table below outlines various other statewide or state agency led planning processes that may have connections to resilience.

Table 7.1: South Carolina statewide planning efforts

Planning Name/Type	Lead(s)	Focus	Description of Purpose
DHEC Funded Watershed Plans	DHEC (EPA)	Water quality	• Part of DHEC's Watershed Program that supports the goals of the Clean Water Act in the state's 8 major river basins. • Identify pollutants in a watershed, determine the source of pollutants, and describe what needs to be done to address each source. • Address surface water pollutants impacting source water for drinking water systems. • Once a watershed plan is in place, it becomes the guidance and framework for any water quality improvement activities in that watershed. • Having a watershed plan in place opens up additional funding opportunities for Section 319 grants to implement nonpoint source-reduction projects. • Are developed for one or more 12-digit HUCs (hydrologic unit codes) and, occasionally, a 10-digit HUC.
State Wildlife Action Plan (2015)	South Carolina Department of Natural Resources	Conserving wildlife and habitats	• Focusing on a proactive approach to conservation, the plan is a guide to address limiting factors that affect species persistence on the South Carolina landscape. Strategies and tools are discussed that can be implemented by SCDNR and its partners, with a cooperative, proactive approach. • Required elements: (1) distribution and abundance of species, (2) location and relative condition of key habitats, (3) problems that affect species, (4) conservation actions, (5) plans for monitoring and adaptive management, (6) procedures to review the plan, (7) plans of coordinating with federal, state, and local agencies, and (8) public participation.
SC Green Infrastructure Plan (2023)	South Carolina Forestry Commission	Landscape Conservation focused on interconnected natural systems (cores and corridors)	• A set of maps and strategies for South Carolina to conserve its highest value landscapes for both wildlife and people, creating a strategic green infrastructure network. • For the purposes of this plan, green infrastructure includes all the interconnected natural systems in a landscape such as intact forests, wetlands, bays, dune systems, rivers and agricultural soils that provide clean water, air quality, wildlife habitat, and food. • Note: The SC Office of Regulatory Staff has also released a separate report on the resiliency of South Carolina's electric and natural gas infrastructure against extreme winter storm events.
State Energy Plan (2018)	State Energy Office (Office of Regulatory Staff)	Energy Efficiency	• Established by SC Code 48-52-410 • A comprehensive blueprint for a reliable, resilient, clean, and affordable energy system for South Carolina residents and businesses. Specifically, the State Energy Plan is designed to maximize (to the extent practical) reliability, environmental quality, energy conservation, and energy efficiency while minimizing the cost of energy throughout the state.

FLOODPLAIN MANAGEMENT REGULATIONS

Floodplain management regulations provide a set of tools for protection from flood hazards and focuses particularly on non-structural management at the local level. Floodplain management regulations are not mandated by South Carolina law. Instead, the National Flood Insurance Program (NFIP) requires a community to adopt a floodplain management ordinance that meets federal standards in order to participate. FEMA has promulgated form floodplain management ordinances, and each state's NFIP coordinator generally develops a state specific version. The Department of Natural Resources' Flood Mitigation Program administers the NFIP for South Carolina. While the standards include many technical requirements, the minimum development standards for a compliant ordinance generally are:

- Permitting requirements to determine if a development is in a flood hazard area
- Requiring the lowest floor of a structure to be at or above the Base Flood Elevation
- Providing special standards for the foundation for manufactured housing
- Providing that the cumulative effect of a development cannot increase the base flood by more than one foot

Many features of floodplain management regulation overlap with or are integrated into a community's zoning ordinance using the strategies discussed above. Community standards that exceed the minimum NFIP requirements qualify residents for discounted flood insurance premiums.

FEMA SPECIAL FLOOD HAZARD AREAS

FEMA uses the term "Special Flood Hazard Areas" (SFHA) to identify flood hazard areas on the Flood Insurance Rate Maps (FIRM). SFHA are defined as the area that will be inundated by the flood event having a 1-percent chance of being equaled or exceeded in any given year. The 1-percent annual chance flood is also referred to as the base flood or "100 year" flood. SFHAs are labeled as Zone A, Zone AO, Zone AH, Zones A1-A30, Zone AE, Zone A99, Zone AR, Zone AR/AE, Zone AR/AO, Zone AR/A1-A30, Zone AR/A, Zone V, Zone VE, and Zones V1-V30. Moderate flood hazard areas, labeled Zone B or Zone X (shaded) are also shown on the FIRM, and are the areas between the limits of the base flood and the 0.2-percent-annual-chance (or 500-year) flood. The areas of minimal flood hazard, which are the areas outside the SFHA and higher than the elevation of the 0.2-percent-annual-chance flood, are labeled Zone C or Zone X (unshaded) (Federal Emergency Management Agency, 2020).

These FIRMs also show what is called the Base Flood Elevation (BFE). BFE is the elevation of surface water resulting from a flood that has a 1% chance of equaling or exceeding that level in any given year. The BFE is shown on the Flood Insurance Rate Map (FIRM) for zones AE, AH, A1–

A30, AR, AR/A, AR/AE, AR/A1– A30, AR/AH, AR/AO, V1–V30 and VE (Federal Emergency Management Agency, 2020).

COMMUNITY RATING SYSTEM

FEMA's Community Rating System (CRS) gives communities an incentive to adopt higher standards than the National Flood Insurance Program requires. Generally, communities adopting heightened standards will qualify for a discounted premium for flood insurance through the CRS process, providing a direct benefit to residents purchasing flood insurance that can be substantial.

In CRS participating communities, flood insurance premium rates are discounted to reflect the reduced flood risk resulting from the community's efforts that address the 3 goals of the program: (1) reduce and avoid damage to insurable property, (2) strengthen and support the insurance aspects of the National Flood Insurance Program, and (3) foster comprehensive floodplain management.

Flood insurance premium discounts in CRS communities range from 5% to 45% and are discounted in increments of 5%. A Class 10 community is not participating in the CRS and receives no discount. A Class 9 community receives a 5% discount for all policies, a Class 8 community receives a 10% discount, all the way to a Class 1 community, which receives a 45% premium discount.

Discount classifications are based on 19 credible activities, organized into four categories: (1) public information, (2) mapping and regulations, (3) flood damage reduction, and (4) warning and response. Specific activities within these categories are shown in Table 2.

Table 7.2: CRS Credible Activities (FEMA, 2021).

Public Information	Mapping & Regulations
o **Activity 310 (Elevation Certificates)** Maintaining construction certificates and making them available to the public o **Activity 320 (Map Information Service)** Providing Flood Insurance Rate Maps (FIRMS) and other map information and publicizing that service. o **Activity 340 (Hazard Disclosure)** Real estate agents' advising potential purchasers of flood-prone property about the flood hazard, and local regulations requiring disclosure of the hazard o **Activity 350 (Flood Protection Information)** Maintaining a community public library and/or website that contains flood-related information o **Activity 360 (Flood Protection Assistance)** Advising property owners and renters about how to protect buildings from flooding and publicizing that service o **Activity 370 (Flood Insurance Promotion)** Assessing flood insurance coverage in the community and implementing a plan to promote flood insurance	o **Activity 410 (Floodplain Mapping)** Developing regulatory maps for areas not mapped by FEMA or flood mapping based on future conditions, detailed topography, or other standards o **Activity 420 (Open Space Preservation)** Keeping flood-prone land free of development o **Activity 430 (Higher Regulatory Standards)** Regulations that exceed the NFIP's minimum criteria for floodplain management o **Activity 440 (Flood Data Maintenance)** Gathering and/or maintaining more accessible, useful, and/or accurate floodplain data for regulation, insurance rating, hazard disclosure, and property appraisals o **Activity 450 (Stormwater Management)** Watershed planning and regulations that prevent future development from increasing flood hazards or diminishing water quality
Flood Damage Reduction	**Warning & Response**
o **Activity 510 (Floodplain Management Planning)** Adoption of flood hazard mitigation and/or natural functions plans using the CRS planning process, and/or conducting repetitive loss area analyses o **Activity 520 (Acquisition and Relocation)** Acquiring insurable buildings and relocating them out of the floodplain, and leaving the property as open space o **Activity 530 (Flood Protection)** Protecting buildings from flood damage by floodproofing, elevation, or minor structural projects o **Activity 540 (Drainage System Maintenance)** Annual inspections of channels and retention basins, and maintenance of the drainage system's flood-carrying and storage capacity	o **Activity 610 (Flood Warning and Response)** Timely warning of flood threats and coordinating flood response activities. o **Activity 620 (Levees)** Annual levee inspection programs and plans to respond to floods caused by levee failure o **Activity 630 (Dams)** State dam safety programs and plans to respond to flooding caused by dam failure.

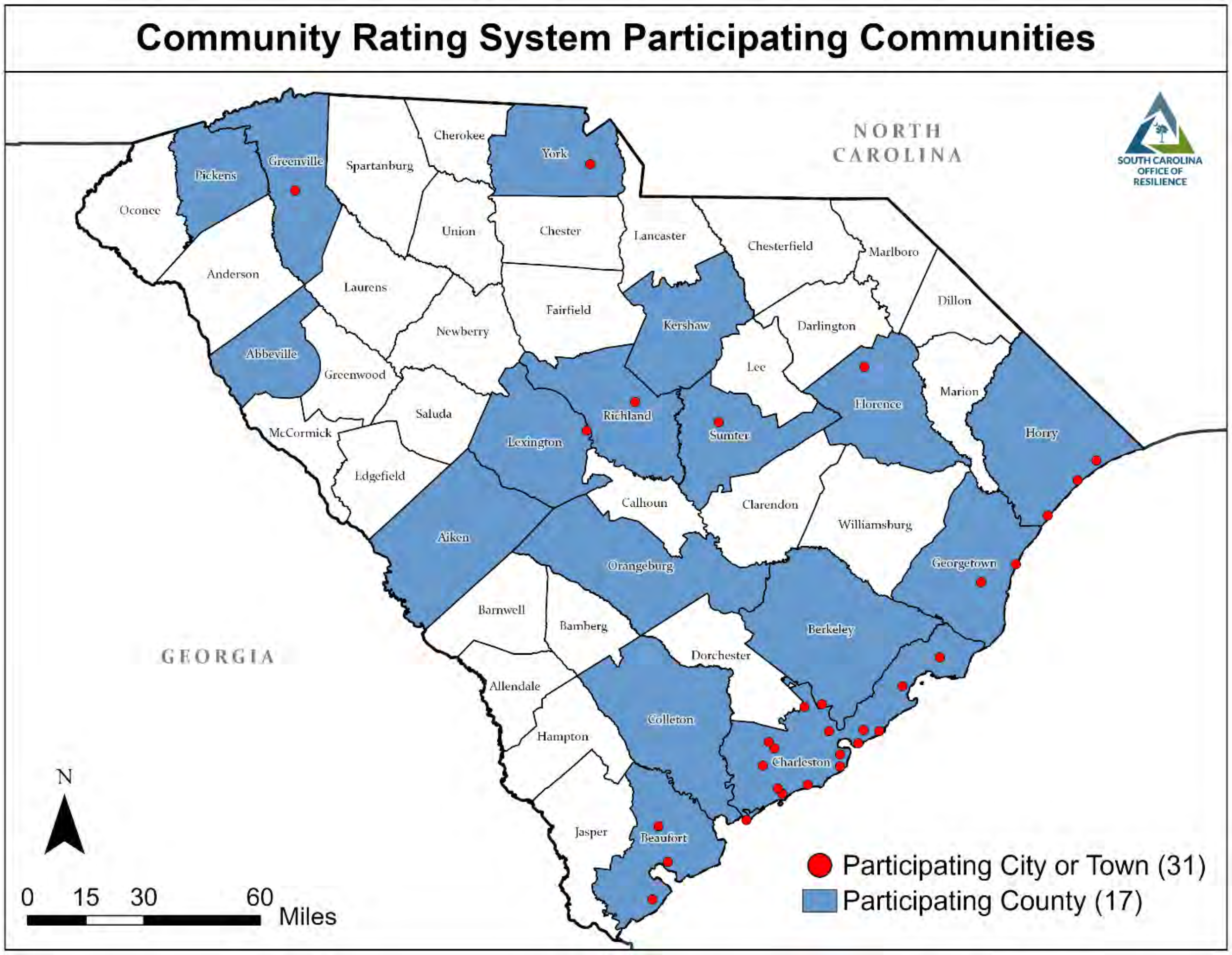


Figure 7.2 : Communities Participating in the Community Rating System (FEMA)

Table 7.3: Class and Discount Rate for CRS Participating Communities

Name	Class	% Discount
Abbeville County	9	5%
Aiken County	9	5%
Beaufort County	5	25%
Beaufort	6	20%
Hilton Head Island	5	25%
Port Royal	9	5%
Berkeley County	8	10%
Hanahan	7	15%
Charleston County	3	35%
Awendaw	6	20%
Charleston	6	20%
Folly Beach	3	35%
Hollywood	6	20%

Isle of Palms	5	25%
James Island	6	20%
Kiawah Island	5	25%
McClellanville	6	20%
Meggett	6	20%
Mount Pleasant	6	20%
North Charleston	7	15%
Ravenel	5	25%
Rockville	6	20%
Seabrook Island	5	25%
Sullivan's Island	5	25%
Colleton County	8	10%
Edisto Beach	6	20%
Florence County	9	5%
Florence	6	20%
Georgetown County	7	15%
Georgetown	7	15%
Pawleys Island	5	25%
Greenville County	7	15%
Greenville	5	25%
Horry County	7	15%
Myrtle Beach	5	25%
North Myrtle Beach	6	20%
Surfside Beach	5	25%
Kershaw County	9	5%
Lexington County	7	15%
Cayce	9	5%
Orangeburg County	9	5%
Pickens County	9	5%
Richland County	8	10%
Columbia	9	5%
Sumter County	7	15%
Sumter	7	15%
York County	8	10%
Rock Hill	7	15%

THE RESIDENTIAL PROPERTY CONDITION DISCLOSURE ACT

The Residential Property Condition Disclosure Act (S.C. Code Ann. § 27-50-10 *et seq.*) requires that an owner of residential real property (single family dwelling unit or a single transaction involving transfer of four dwelling units or less) shall provide to the purchaser a completed and signed disclosure statement prior to forming a real estate contract. This disclosure must be provided in connection with any sale, exchange, installment land sale, or lease with an option to purchase contract. This disclosure statement is not required in connection with transactions listed and exempted by S.C. Code Ann. § 27-50-30 *et seq*.

The Act states the disclosure must contain the language and be in the form promulgated by the South Carolina Real Estate Commission and outlines minimum requirements that the statement must include about the following characteristics and conditions of the property:

1. The water supply and sanitary sewage disposal system
2. The roof, chimneys, floors, foundation, basement, and other structural components and modifications of these structural components
3. The plumbing, electrical, heating, cooling, and other mechanical systems
4. Present infestation of wood-destroying insects or organisms or past infestation, the damage from which has not been repaired
5. The zoning laws, restrictive covenants, building codes, and other land-use restrictions affecting the real property, any encroachment of the real property from or to adjacent real property, and notice from a governmental agency affecting this real property
6. Presence of lead-based paint, asbestos, radon gas, methane gas, underground storage tank, hazardous material or toxic material, buried or covered, and other environmental contamination
7. Existence of a rental, rental management, vacation rental, or other lease contract in place on the property at the time of closing, and, if known, any outstanding charges owed by the tenant for gas, electric, water, sewerage, or garbage services provided to the property the tenant leases
8. Existence of a meter conservation charge, as permitted by Section 58-37-50, that applies to electricity or natural gas service to the property
9. Whether the property is subject to governance of a homeowners association

The Act also states that this disclosure statement must give the owner the option to indicate that the owner has actual knowledge of the specified characteristics or conditions, or that the owner is making no representation as to any characteristic or condition.

STATE OF SOUTH CAROLINA RESIDENTIAL PROPERTY CONDITION DISCLOSURE STATEMENT

The South Carolina Real Estate Commission recently approved an update to the Residential Property Condition Disclosure Statement effective June 1, 2023. The new form added additional questions and details regarding past flood damage, receipt of disaster assistance, repairs covered and not covered by insurance to include private or public flood insurance, and beach renourishment projects.

The form contains a series of questions, many of which have the options of “Yes”, “No” or “No Representation.” Recognizing confusion over the use of the “No Representation” option, The Real Estate Commission added the following explanation of the above choices in the new disclosure form:

- Yes: If a question is answered “Yes” or asks for a description, then owner must explain or describe the issue or attach a descriptive report from an engineer, contractor, pest control operator, expert, or public agency.
- No: If a question is answered “No” for any question, the owner is stating that owner has no actual knowledge of any problem
- No Representation: By answering “No Representation” on this disclosure statement, the owner is acknowledging that they do not have the current knowledge necessary to answer the questions with either a “Yes” or “No” response. Owner still has a duty to disclose information that is known at the time of the disclosure statement. “No Representation” should not be selected if the owner simply wishes to not disclose information or answer the question. Selecting “No Representation” does not waive liability if owner is aware or subsequently becomes aware.

A 2010 report by DHEC OCRM’s Shoreline Change Advisory Committee, Adapting to Shoreline Change, included a recommendation to update the form with a coastal hazard section which included the disclosure of: erosion control structures, shoreline change rates, dates of known emergency actions, special OCRM permits, and the presence of septic systems. Several of these recommendations were a part of the June 1, 2023, update of the form.

The report also noted that knowledge and disclosure may be limited by the availability of information. While some of this specific information is publicly available, it is not all inclusive or all in one place.

DATA

POPULATION & DEMOGRAPHIC DATA

The primary organization that provides statewide population and demographic data is the South Carolina Revenue and Fiscal Affairs Office (RFA). Their mission is to provide insightful research, analysis, and resources to facilitate informed policy decisions and administration of services. The Data Integration and Analysis Division receives, processes, distributes, and interprets health, demographic and Census data for planning, policy, and evaluation of programs.

The South Carolina Census State Data Center at RFA focuses on making U.S. Census Bureau data more accessible and provides guidance in the use of Census Bureau data products. This includes use of census socioeconomic, housing, and population data.

RFA's work with population data includes population projections out to the year 2035. This includes total population as well as population by sex and age at the county level.

GEOGRAPHIC INFORMATION

GEOGRAPHIC INFORMATION COUNCIL (GIC)

Affiliated with RFA is the State's Geographic Information Council (GIC), a collection of state agencies that voluntarily agree to share certain geographic information system (GIS) data (through Memorandums of Agreement), fund internal GIC-data management, and coordinate statewide aerial imagery collection. Participating agencies contribute $20,000 per year to maintain their GIC status. The mission of the GIC is to promote a positive collaborative geospatial mapping community between local, state, and federal agencies.

PROPERTY LEVEL INFORMATION

Property, or parcel level, data is collected and maintained at the local level. Each municipality and county maintain their own system of collecting and managing information about properties related to tax classifications, property use, value, zoning, land development regulations, and structural information.

PALMETTO EOC EMERGENCY MANAGEMENT SYSTEM

SCEMD owns and maintains the State's emergency management Common Operating Picture. Palmetto EOC is used to facilitate common situational awareness during emergency operations, track resource requests to completion, and map hazard impacts. Palmetto EOC includes both a GIS mapping component and data entry fields in an intuitive platform. Emergency management officials across the state have access to this system. This tool is available only to direct partners of SCEMD and is intended to enrich facility location data with the updated operational status of facilities, roadways, utilities, and services as an emergency event progresses. Familiarity with this system before an onset disaster allows emergency managers and responders to act efficiently.

ABSORB

This section focuses on those regulations that impact the ability of our communities, economies, and ecosystems to withstand environmental changes and natural hazards, to include the standards to which stormwater infrastructure is designed.

STORMWATER MANAGEMENT REGULATIONS

Stormwater management is essential to ensure that development does not temporarily or permanently increase the impact of precipitation on downstream owners and the overall watershed. The Stormwater Management and Sediment Reduction Act (SWMA), codified at S.C. Code Ann. § 48-14-10, *et seq.,* provides the basis for local regulations for stormwater management and site disturbance. The Stormwater Regulations adopted by DHEC recognize that stormwater runoff creates water quality and quantity problems because stormwater runoff is "a source of pollution" and "may add to existing flooding problems." Therefore, the Stormwater Regulations seek to "prevent additional water quantity and quality problems and may reduce existing problems" (S.C. Code Ann. Regs. 72-300.A). The stormwater permitting program generally is intended to implement the requirements of the National Pollutant Discharge Elimination System (NPDES) permitting program of the federal Clean Water Act (33 U.S.C. §1251 *et seq*.). DHEC administers the NPDES permitting process for the state and regulates municipal separate storm sewer systems (MS4s).

The SWMA and regulations authorize an implementing agency to oversee a permitting system for land disturbing activities. The SWMA authorizes DHEC as the implementing agency if the local government or conservation district does not receive a delegation of authority to implement the program from DHEC (S.C. Code Ann. §48-14-60, *et seq.*). DHEC's regulations include the standards that a local government must meet to receive a delegation of authority to administer the stormwater management program (S.C. Code Ann. Regs. 72-304).

The SWMA requires a permit to undertake all land disturbing activities unless the activity is exempt (S.C. Code Ann. § 48-14-30, *et seq.*). A land disturbing activity is "any use of the land by any person that results in a change in the natural cover or topography that may cause erosion and contribute to sediment and alter the quality and quantity of stormwater runoff" (S.C. Code Ann. § 48-14-20(8), *et seq.*). In the land development process, land disturbing activity commonly includes the clearing and grading of a site in preparation for the construction of infrastructure and buildings. However, the SWMA exempts several common land disturbing uses, such as agriculture and forestry (S.C. Code Ann. § 48-14-40, *et seq.*).

The SWMA and regulations and/or local government stormwater management ordinances generally seek to control the quality and quantity of stormwater runoff and prevent erosion through best management practices (BMPs). BMPs are generally actions or practices “which have been demonstrated to effectively control the quality and/or quantity of stormwater runoff and which are compatible with the planned land use.” BMPs include common solutions for stormwater, such as gutters, catch basins, and detention ponds, as well as low impact development (LID) practices which seek to mimic the natural process of water infiltration. The permit review process evaluates construction activities as well as post construction BMPs. Therefore, stormwater management plays an important role in the temporary impacts of construction but also on the long term impacts of the development on the watershed.

STORMWATER INFRASTRUCTURE DESIGN

ATLAS 14

Currently the National Oceanic and Atmospheric Administration (NOAA) Atlas 14 precipitation frequency estimates for the Mid-Atlantic Region, as discussed in Chapter 5, are used for infrastructure design, planning, and management. The Atlas is intended as the official documentation of precipitation frequency estimates and associated information in the United States. The most recent, Atlas 14, Volume 2 was updated in 2006, based on historical data up to 2000. These estimates are used in the design guidelines discussed below for DOT.

SOUTH CAROLINA DEPARTMENT OF TRANSPORTATION

SCDOT is a major designer, owner, and maintainer of stormwater infrastructure.

The following are the hydrologic analyses used and recommended by SCDOT for calculating hydraulic designs for projects based on the size of the drainage area.

A. Drainage Areas Up to 100 Acres

For drainage areas up to 100 acres, SCDOT utilizes the Rational Method. This generally applies in the design of ditches, storm drain systems, spread calculations, and small culverts, and is used to evaluate existing drainage features.

B. Drainage Areas Greater than 100 Acres to 1 Square Mile

For drainage areas greater than 100 acres and up to 1 square mile, SCDOT utilizes the Natural Resources Conservation Service (NRCS) Method. This method also applies to any calculations where rainfall volumes and devices storage are involved. Currently, SCDOT uses the South Carolina Unit hydrograph to apply the NRCS method. This is a spreadsheet developed by the University of South Carolina in consultation with NRCS and with collaboration from SCDOT. This is generally utilized in the design and evaluation of ditches, storm drain systems, erosion and sediment control devices, stormwater management basins, and small culverts.

C. Drainage Areas Greater than 1 Square Mile

For drainage areas greater than 1 square mile, SCDOT utilizes the USGS Regression Equations.

These equations are developed from the streamflow gages and do not depend on Atlas 14 rainfall depths and distribution. The regression equations are updated every 10 years by USGS in partnership with GDOT, NCDOT, and SCDOT and are utilized in the design and evaluation of bridges and large culverts.

While the above calculations are based on the size of the project drainage area, the capacity of draining facilities, determined by the design storm, is also determined by the project's structural classification and structure type. Below are the Design Storms for Various Drainage Facilities recommended by SCDOT.

Table 7.4: SCDOT Recommended Design Storms for Various Drainage Facilities

Recommended Design Storms for Various Drainage Facilities					
	Design AEP (Annual Exceedance Probability)				
Functional classification and structure type	**50% (2-yr)**	**10% (10-yr)**	**4% (25-yr)**	**2% (50-yr)**	**1% (100-yr)**
Primary Roads and Interstates					
Culverts				X	
Bridges				X	
Scour at Bridges					X
Secondary Roads					
Culverts			X		
Bridges			X		
Scour at Bridges					X
All Roads					
Inlets, storm drain pipes, roadside ditches, and outfalls		X *			
Sag Inlets for roadways				X	
Temporary Erosion and Sediment Control Devices		X**			

Permanent Stormwater Management	X*	X**			X ***

* AEP increases for watersheds > 40 acres

** SC State Regulations

*** For Emergency Spillway Design only.

REGIONAL/LOCAL STORMWATER DESIGN STANDARDS

Local governments can further regulate stormwater standards, and often do as a part of meeting Environmental Protection Agency (EPA) permitting requirements for Municipal Storm Sewer Systems, which require a look at community goals, implementation strategies and policies.

One innovative example of multi-jurisdictional stormwater design guidelines that consider the impacts of stormwater between multiple communities is the Southern Lowcountry Stormwater Ordinance and Design Manual. This was developed by representatives from Beaufort County, Jasper County, the City of Beaufort, the Town of Bluffton, the City of Hardeeville, and the Town of Port Royal to address post-construction stormwater management in the Southern Lowcountry Region. A model stormwater ordinance provides common language and minimum management provisions for jurisdictions in this area, while the design manual provides for proper implementation of the ordinance. The manual provides a framework to 1) improve water quality through runoff reduction to the maximum extent practicable, 2) prevent downstream stream bank and channel erosion, 3) reduce downstream overbank flooding, and 4) safely pass or reduce runoff from extreme storm events. It outlines a design review and permitting process, minimum control requirements, stormwater best management practices, erosion and sediment control, enforcement, and violations (Beaufort County, South Carolina, 2020).

GREEN STORMWATER INFRASTRUCTURE DESIGN

Green stormwater infrastructure can be defined as stormwater management techniques and practices that mimic natural hydrologic functions and incorporate landscape features to store or treat runoff. Nature-based solutions incorporate the natural environment to provide multiple benefits and support resilient communities. Green infrastructure can include site specific management practices as well as watershed scale techniques such as land preservation and the restoration of wetlands and floodplains that naturally store water and reduce runoff (NOAA, 2015). Nature-based solutions can be thought of as “the sum of all our natural resources,” made up of “a strategically planned and managed network of wilderness, parks, greenways, conservation easements, and working lands with conservation value that supports native species, maintains natural ecological processes, sustains air and water resources, and contributes to health and quality of life” (Firehock, 2015). Green infrastructure contributes to a more resilient ecosystem that is better able to maintain its core functions in the face of stressors and provide redundancy to the existing grey/hardened infrastructure system.

Nature-based solutions can be implemented through construction practices (such as permeable pavement), restoration projects (restoring or simulating natural hydrology), or through policy (land conservation). They can be done on a regional scale, such as the restoration of forests, floodplains, and wetlands, or on a local scale with site specific practices such as green roofs, permeable pavement, and cisterns. Examples of nature-based solutions are:

> **Living shorelines:** A protected and stabilized shoreline that is made of natural materials such as plants, sand, or rock. Plants or other natural elements, sometimes in combination with harder shoreline structure, are used to stabilize estuarine coasts, bays, and tributaries. Additionally, they can improve water quality, promote biodiversity, reduce wave energy, and are more resilient against storms than bulkheads, which prevent natural marsh migration and may create seaward erosion (NOAA Fisheries, n.d.).
>
> **Restoration of floodplains and wetlands:** The manipulation of a former or degraded wetland's physical, chemical, or biological characteristics to return its natural functions. Floodplains and wetlands can act as natural buffers and soak up and store a significant amount of stormwater. This may include “daylighting” urban creeks and streams that were previously piped to reduce stormwater run-off (American Planning Association, 2020).
>
> **Rain gardens:** Small, shallow, sunken areas of plantings that collect stormwater runoff from roofs, streets, and sidewalks. Also known as bioretention cells, they are designed to mimic the natural ways water flows over and absorbs into land to reduce stormwater pollution.
>
> **Green roofs:** Roofs covered with growing media and vegetation that enable rainfall infiltration and evapotranspiration of stored water and prevent ponding on the roof surface (EPA, 2017).

Green streets: Designing streets to capture and filter stormwater from impervious surfaces at its source. Permeable pavement, bioswales, planter boxes, and trees are all elements that can be woven into street design, while also contributing to an enjoyable transportation experience for drivers as well as pedestrians and may spur adjacent economic development (EPA, 2017). NOAA estimates that the average cost of creating a rain garden is $5 to $16 per square foot with a maintenance cost of 2 to 41 cents per square foot including everything from design to yearly inspections and maintenance (NOAA, 2020).

Bioswales: Landscape elements that remove silt and pollution from stormwater runoff. Filled with vegetation, compost, or riprap in a swaled drainage course with gently sloped sides. Usually used around parking lots or around streets where pollution is often collected and filtrated before flowing to surface water (EPA, 2017). NOAA estimates that the average cost of construction of a bioswale is $5.50 to $24 per square foot with a maintenance cost of 6 to 21 cents per square foot (NOAA, 2020).

Constructed wetlands: Treatment systems that use natural processes involving wetland vegetation, soils, and their associated microbial assemblages to improve water quality and established desired hydraulic flow patterns (EPA, 2017).

Permeable (Pervious) pavement: Pavements that infiltrate, treat, and/or store rainfall where it falls. Materials can include pervious concrete, porous asphalt, or permeable interlocking pavers (EPA, 2017).

Native planting (Xeriscape): Using drought resistant landscaping that is native to the location.

Grey water re-use systems: Systems that capture water used in showers, washing machines, and bathroom sinks for use (for landscape and/or indoor non-potable use) in order to save water and energy. (EPA, 2017).

Cisterns: Containers for the harvesting of rainwater; often runoff from rooftops. From this container, it can be used for non-potable water uses and onsite infiltration (EPA, 2017).

Infiltration trenches: Excavations typically filled with stone to create an underground reservoir for stormwater runoff. Runoff volume gradually exfiltrates through the bottom and sides of the trench into the subsoils and over a period of time.

Downspout disconnections: Reroutes rooftop drainage pipes from draining into the storm sewer to draining into rain barrels, cisterns, or permeable areas such as lawns (EPA, 2017).

Beneficial use of dredged material: The dredging of waterbodies, ways, and harbors produces a large amount of sediment that may be relocated and used for beneficial purposes such as beach restoration, shore protection, and habitat enhancement.

Vegetative/riparian buffer requirements: Protecting riparian and floodplain areas from being destroyed or negatively impacted by development by requiring a certain distance between the water body and the developed area or requiring the placement of vegetation between the water body and the development (EPA, 2017).

Land conservation: Protecting open spaces and sensitive areas within and adjacent to urban areas, focusing on riparian areas, wetlands, and steep hillsides (EPA, 2017).

Low-impact development: Sometimes used interchangeably with green infrastructure, these are systems and practices that use or mimic natural processes that result in the infiltration, evapotranspiration, or use of stormwater in order to protect water quality and associated aquatic habitat.

In addition to handling stormwater on site, green infrastructure techniques can have wide reaching benefits. Nature-based solutions provides redundancy in the existing gray stormwater system in the case of extreme weather events. The EPA has also compiled a report on "Healthy Benefits of Green Infrastructure in Communities," which outlines co-benefits to green infrastructure including recreation, safety, reduced exposure to pollutants, and increases in adjacent property values. The EPA also notes that green infrastructure costs less than conventional gray infrastructure, provides green jobs, and reduces municipal water usage and cooling costs (EPA, 2017). Additionally, in times of rapid development, green infrastructure provides a way to increase stormwater system capacity while maintaining the quality of the landscape.

In many cases, nature-based strategies can be more cost effective than traditional alternatives. As with any solution intended to function for an extended period of time, nature-based strategies should be evaluated to ensure the maintenance and operations can be resourced for the life cycle of the solution. While the benefits can vary based on location and approach, a study from 2018 found that nature-based solutions compared favorably with traditional flood mitigation options and significantly reduced flood damages in coastal environments, with average benefit-cost ratios over 3.5 (Reguero, Beck, Bresch, Calil, & Meliane, 2018). A 2017 study on Superstorm Sandy estimates that coastal wetlands reduced flood damages in the total of $625 million (Narayan, et al., 2017).

While there is a continued need for traditional gray infrastructure and protections for communities, nature-based solutions have been found to be cost effective and low maintenance, especially on small property scales. For example, a study after Hurricanes Irene and Arthur found that waterfront property owners protected by bulkheads experienced, on average, twice the property damage costs compared to those who had implemented natural features to safeguard their shorelines (Smith, et al., 2017).

BUILDING CODES

Building codes are the primary regulatory tool to ensure that all structures are safe. Building codes ensure structural integrity, fire resistant construction, and, of course, disaster resistant construction. The South Carolina Building Codes Council adopts and modifies model building codes for South Carolina in accordance with S.C. Code Ann. § 6-9-5, *et seq*.

There are many specific codes, including the International Building Code for commercial structures and the International Residential Code for residential structures. The South Carolina Legislature has mandated that communities adopt the International Codes Council (ICC) Codes and has created the Building Codes Council to regularly review and adopt specific components, in addition to overseeing implementation and training for Building Officials (See S.C. Code Ann. § 6-8-10, *et seq*. & S.C. Code Ann. Regs. 8-100, *et seq*.).

The Council can also grant local or statewide modifications sought by local jurisdictions or professional associations. Local modifications may be given when the Council determines that the changes are required to meet local needs due to physical or climatological conditions. Along with code adoptions, the South Carolina Building Codes Council updates and approves use of wind and seismic maps. LLR’s website provides current map files for each county. To determine design loads for locations by address or coordinates, the Applied TC Hazards by Location website can be used. The Council adopted the 2021 SC Building Codes in 2021, with an effective date of January 1, 2023. As in previous years, the changes to both the residential and commercial codes are largely limited to reducing some of the requirements from the national code, as seen in the 2021 Modification Index.

Like other aspects of development regulation, the Building Codes base construction standards on FEMA’s Flood Insurance Rate Maps. The Building Codes generally require that the lowest habitable floor of a structure constructed in a flood hazard area must be elevated to a design flood elevation, which is the higher of the Base Flood Elevation (BFE) or another design flood event adopted by the community. The BFE is the estimated elevation of inundation during a

100-year flood event. A design flood elevation is a higher standard adopted by a community. The Building Codes provide for many other flood resilient construction standards, but the design elevation is by far the most important.

While the BFE is intended to protect against the risk of flood hazard exposure, there are significant limitations to the protections it provides. It is important to note that BFE is only intended to ensure that a 100-year flood event will not reach the lowest floor of a structure. Therefore, any electrical, mechanical, insulation, foundation, or other construction materials below the lowest floor could be significantly damaged by a 100-year flood. In addition, the BFE only measures the estimated risk to a structure in one year. Over the life of a structure, the actual risk may be much higher. For example, the risk of a 100-year flood event at a particular location over an estimated 30-year lifespan of a building exceeds 25%. Finally, the flood risks change over time. Increases in upstream development and changes in climate patterns can increase the risk of a particular flood event above the original design flood elevation of a structure, placing it in harm’s way long after it was constructed.

FEMA’s 2023 Building Code Adoption Tracking Fact Sheet gives South Carolina a 50.9% score for adoption of hazard-resistant building codes, indicating “moderate resistance.” The state adopts the most recent IBC and IRC, however the “state weakens hurricane resilience by using alternative hurricane maps with less conservative wind contour lines in seven counties (Figure 7.4), and less conservative seismic maps in eleven counties (Figure 7.5) (FEMA, 2023).

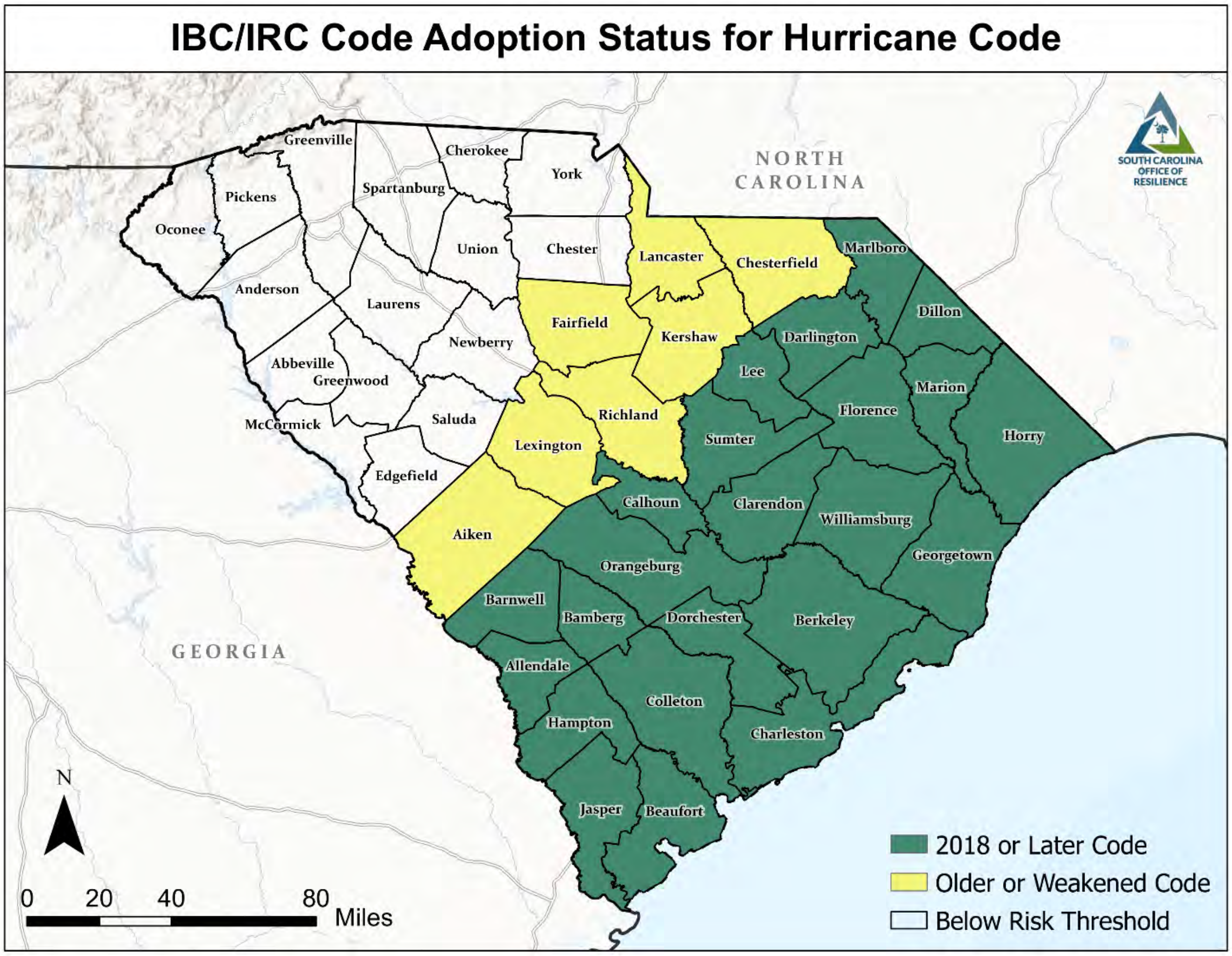


Figure 7.3: IBC/IRC Code adoption statude for hurricane code

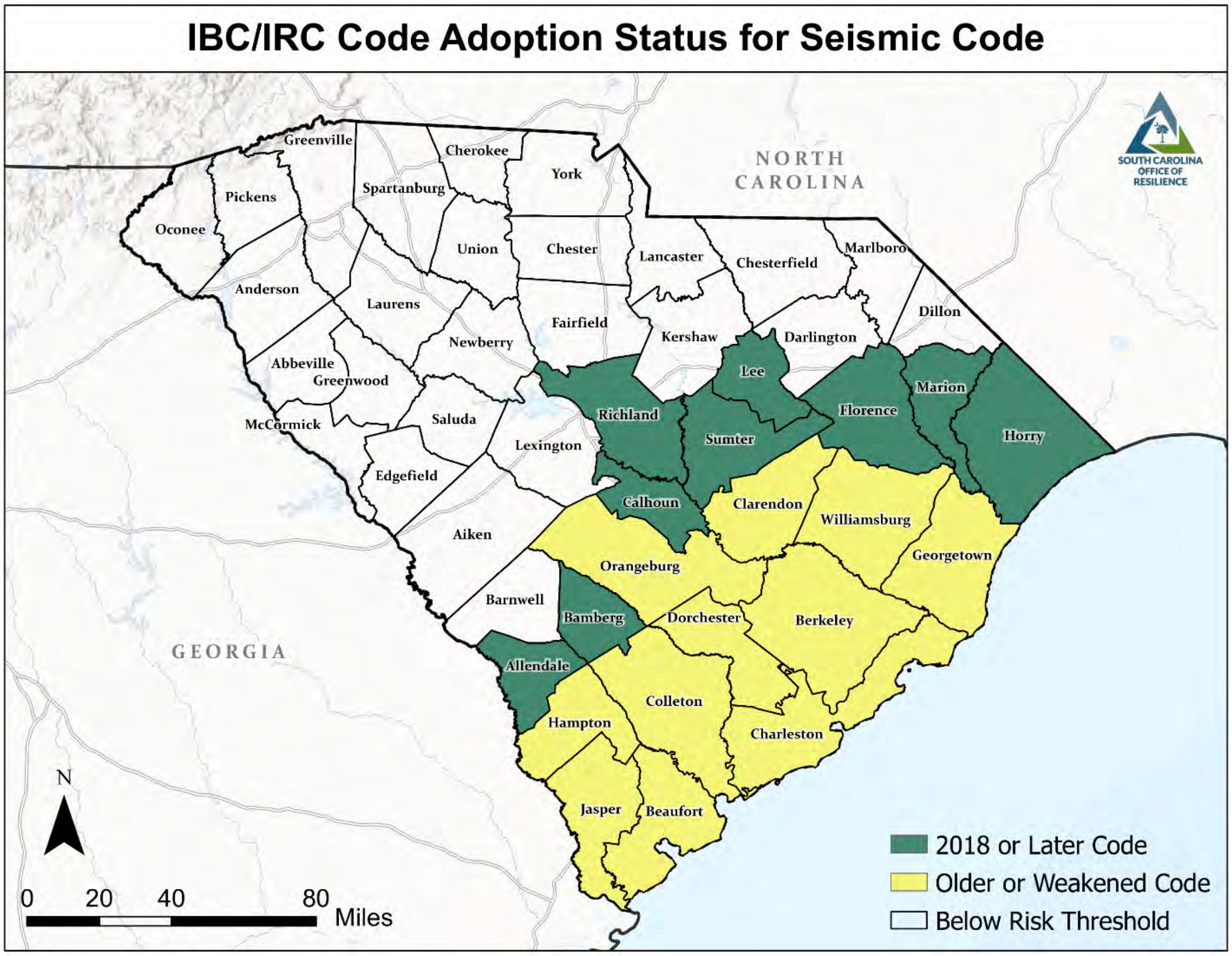


Figure 7.4: IBC/IRC Code adoption statude for seismic code

COASTAL ZONE MANAGEMENT

Due to its location along the Atlantic Coast, South Carolina faces a unique risk of coastal storms and exposure to changes in sea level. The State Legislature has adopted the Coastal Tidelands and Wetlands Act (CTWA) (S.C. Code Ann. § 6-8-10, *et seq*.) to balance the development and conservation of coastal resources and to implement the Federal Coastal Zone Management Act of 1972. The Act authorizes DHEC's Office of Ocean and Coastal Resources Management (OCRM) to oversee the program in the State's eight coastal counties. Therefore, additional development restrictions may apply in these locations, especially for sensitive areas such as tidal lands, dunes, beaches, and coastal waters. In particular, OCRM has adopted baseline and setback lines for beachfront development under the Act.

PROTECTION OF WETLANDS

Section 404 of the Federal Clean Water Act (CWA) (33 U.S.C. § 1344) requires a permit from the U.S. Army Corps of Engineers before engaging in development activity that affects a wetland. South Carolina's landscape includes many wetlands, especially in coastal areas. The Section 404 program seeks to avoid or minimize the impacts of development on wetlands because they are important in the natural process of stormwater infiltration and downstream discharge. While state and local governments do not have a significant role to play in wetlands permitting under Section 404, many local governments require setbacks from wetlands as part of their land use and development ordinances to support the goals of resilience and flood hazard mitigation.

The Clean Water Act identifies the navigable waters and adjacent wetlands within the environmental regulations. The 2023 Supreme Court decision in Sackett v. Environmental Protection Agency limits the CWA wetlands authority to include only wetlands that have a continuous surface water connection with a larger body of water. This decision clarifies that wetlands not continuously connected to a surface body of water, such as isolated wetlands, are not covered under the CWA regulatory authority. In South Carolina, there are many such isolated wetlands that provide many important ecological functions, such as providing habitat, filtering pollutants, and mitigating flood risks. The types of isolated wetlands across South Carolina include Carolina Bays, (which are unique to North Carolina and South Carolina), depression meadows, high ponds, limestone sinks, cypress wetlands, pond pine flatwoods, pocosins, and oxbow lakes. In 1999, SCDNR estimated that 28% of isolated wetlands have been lost to development and changes in the landscape (SC Department of Natural Resources (SCDNR), 1999).

The South Carolina Legislature created the Isolated Wetlands and Carolina Bays Task Force in 2012 as Act No. 198. This task force identifies that there are approximately 400,000 acres of isolated wetlands in South Carolina with only 100,000 acres outside of the coastal counties. SCOR completed a preliminary mapping exercise using the National Wetlands Inventory and the National Hydrography Dataset's water flowlines to visualize the distribution of these isolated wetlands in Figure 7.7.

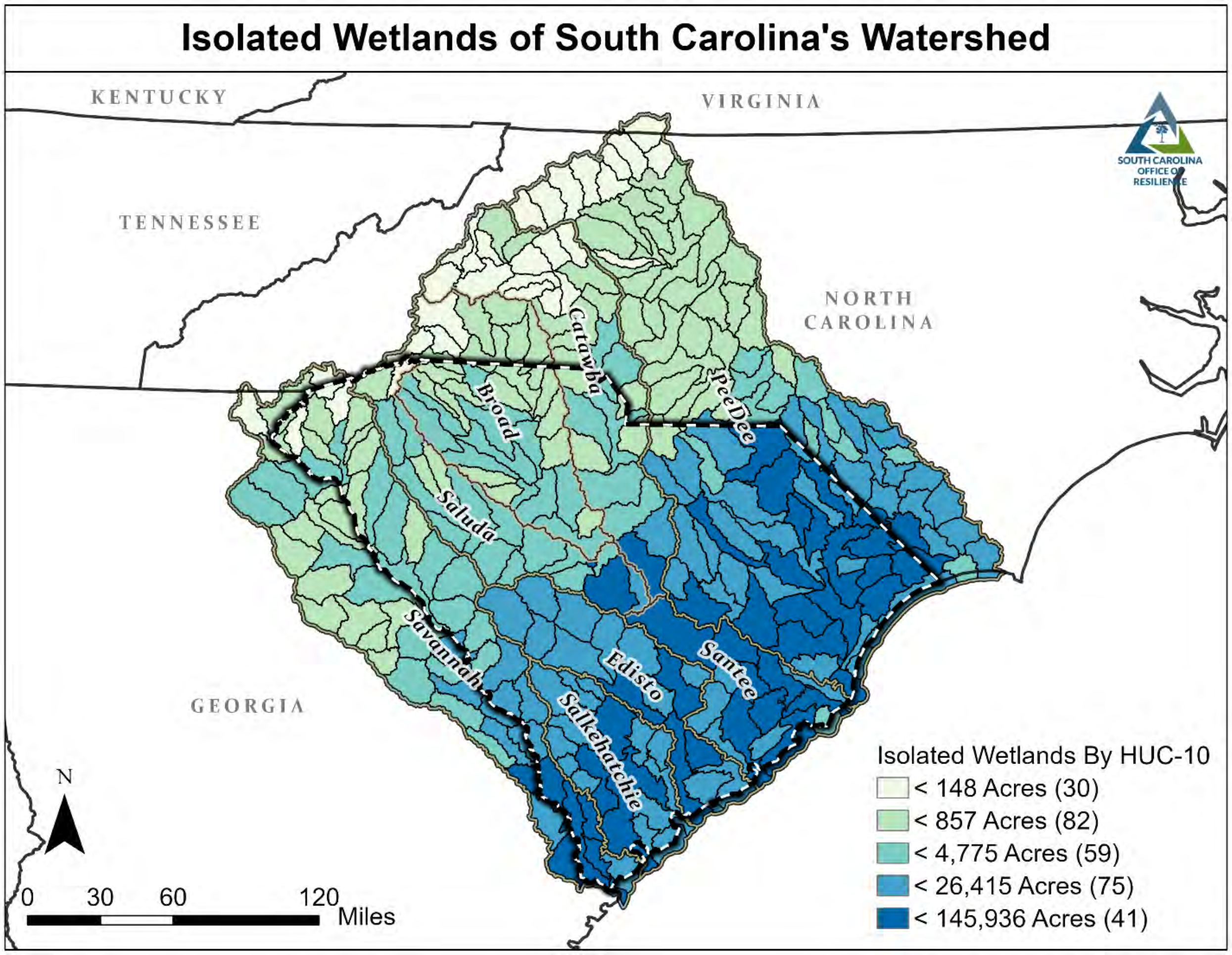


Figure 5.7 Preliminary Visualization of Isolated Wetlands in South Carolina

The task force highlights the uniqueness of Carolina Bays and their ecological and historical importance to the State. The loss of Carolina Bays will negatively impact the habitat for rare plant species and other organisms, relief from flooding, and water quality. Recommendations from the Task Force include the preservation and restoration of Carolina Bays, along with mapping and inventorying the bays.

Due to the recognized importance of isolated wetlands, continued efforts should prioritize the inventorying, mapping, and protection of these wetlands for the economic, ecosystem, water quality, and flood mitigation purposes for the citizens of South Carolina.

RECOVER

The Recover section focuses on how disaster recovery is currently managed, considering the role of federal agencies as well as the role of state agencies such as SCEMD and SCOR.

NATIONAL DISASTER RESPONSE & RECOVERY FRAMEWORK

RECOVERY CONTINUUM

The recovery process can be described as a continuum, or sequence of interdependent and often concurrent activities that progressively advance a community toward its planned recovery outcome. Figure 7.6 illustrates FEMA's Recovery Continuum, from pre-incident preparedness, or planning for recovery, through short-term, intermediate, and long-term recovery (U.S. Department of Homeland Security, 2016).

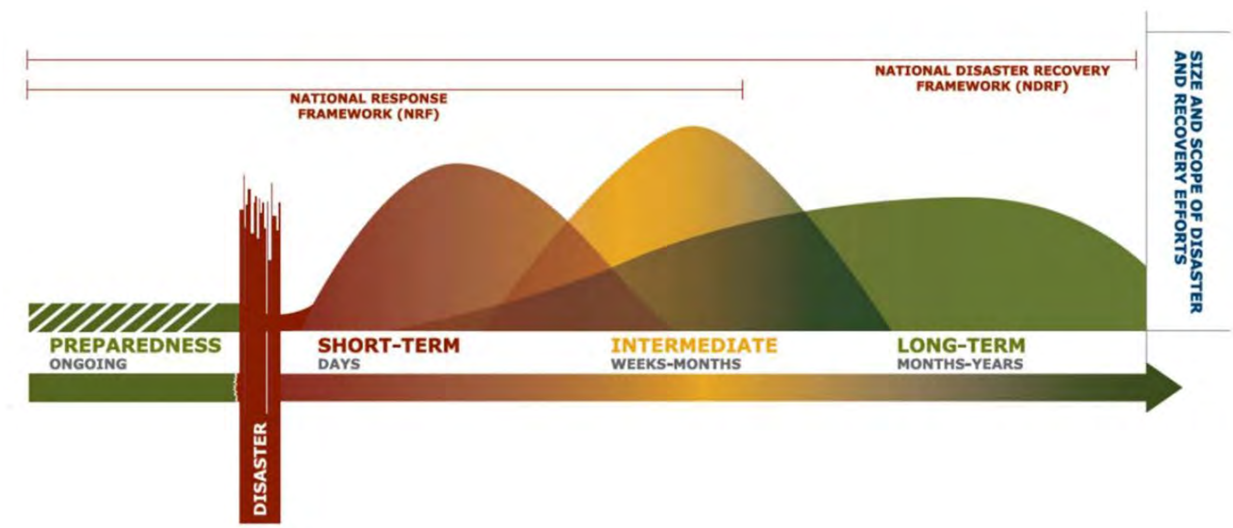


Figure 7.6: Recovery Continuum

NATIONAL RESPONSE FRAMEWORK

The National Response Framework focuses on recovery from disasters, as opposed to short term response activities such as life sustaining, property protection, and other measures intended to neutralize an immediate threat. It is important to note that these activities influence recovery activities (U.S. Department of Homeland Security, 2016).

The National Incident Management System guides all levels of government and the non-profit and private sectors in managing and responding to events, covering three main components: (1) resource management, (2) command and coordination, and (3) communications and information management.

NATIONAL DISASTER RECOVERY FRAMEWORK

The "Resilience and Sustainability" section of the National Disaster Recovery Framework addresses the role of recovery in resilience in the following ways:

- Pre- and post-disaster recovery activities offer unique opportunities to reduce current and future risk and contribute to a more sustainable community.
- Disaster Recovery efforts can be leveraged to implement solutions that will increase community resilience in the economic, housing, natural and cultural resources, infrastructure, health and social services, and government sectors.
- Communities can capitalize on opportunities during rebuilding to support their sustainability and livability goals such as laying foundations for future growth; making smart energy choices; improving economic competitiveness; expanding energy efficient and accessible housing choices; and enhancing healthy, safe, and walkable neighborhoods (rural, urban, or suburban). The process of pre-disaster planning can help build capacity and increase resilience and sustainability by taking a deliberate look at physical, continuity of operations, environmental, and societal risks, and opportunities prior to an incident (U.S. Department of Homeland Security, 2016).

RECOVERY SUPPORT FUNCTIONS (RSF)

The purpose of the Federal Recovery Support Functions is to support local, regional/metropolitan, state, tribal, and territorial governments in recovery. FEMA facilitates inter-RSF coordination at the national level. Each RSF member agency contributes subject matter expertise, authority, and resources. Federal RSFs provide a forum for interagency coordination, information sharing, exchange of efficient and effective practices, and support of improved recovery outcomes for communities. RSFs develop guidance and standard operating procedures for rapid activation of their capabilities to support community recovery. Each RSF identifies relevant statutory and/or regulatory programs, potential capabilities, and/or limiting factors pertaining to recovery support for their functional area of assistance. Each RSF has a designated coordinating agency. The six RSFs and their primary agencies are listed below (U.S. Department of Homeland Security, 2016).

1. Community Planning and Capacity Building (Department of Homeland Security/FEMA)
2. Economic Recovery (Department of Commerce)
3. Health and Social Services (Department of Health and Human Services)
4. Housing (Department of Housing and Urban Development)
5. Infrastructure Systems (U.S. Army Corps of Engineers)
6. Natural and Cultural Resources (Department of the Interior)

STATE COORDINATION OF RECOVERY

State governments are the tie between the national framework and resources above and communities in recovery, providing essential leadership, support, and additional capacity.

SCEMD'S ROLE IN RESPONSE AND RECOVERY

SCEMD's South Carolina Emergency Operations Plan establishes a framework for how state agencies should conduct all-hazards emergency response and recovery and coordinate with other governmental entities across the state.

The State has established Emergency Support Functions with State agencies and other organizations to support recovery and response operations in conjunction with the National Response Framework described above (SC Emergency Management Division).

Table 7.5: Emergency Support Functions & Coordinating State Agencies

ESF	Title	Coordinating State Agency
1	Transportation	Department of Transportation
2	Communications	Department of Administration, Division of Technology Operations
3	Public Works and Engineering	SC National Guard
4	Firefighting	Forestry Commission (wildland fires) Department of Labor, Licensing and Regulation; Division of Fire and Life Safety (structural fires)
5	Emergency Management	Emergency Management Division
6	Mass Care	Department of Social Services
7	Finance and Administration	Emergency Management Division
8	Health and Medical Services	Department of Health and Environment Control
9	Search and Rescue	Department of Labor, Licensing, and Regulation; Division of Fire and Life Safety
10	Environmental and Hazardous Material Operations	Department of Health and Environmental Control
11	Food Services	Department of Social Services

12	Energy	Office of Regulatory Staff
13	Law Enforcement	Law Enforcement Division
14	Initial Recovery and Mitigation	Emergency Management Division
15	Public Information	Emergency Management Division
16	Emergency Traffic Management	Department of Public Safety
17	Agriculture and Animals	Clemson University Livestock Poultry Health
18	Donated Goods and Volunteer Services	Department of Administration, General Services Division
19	Military Support	SC National Guard
24	Business and Industry	Department of Commerce

The South Carolina Emergency Management Division operates on a system of Operational Condition Levels, also known as OPCONS. This numerical scale is how SCEMD, the State Emergency Response Team, and counties coordinate, prepare, and respond to major emergencies. The levels are designed to simplify the steps agencies take in order to fully activate emergency resources. The three OPCONs and their definitions are compatible with the majority of state and federal emergency management organizations nationwide, making the State's processes and procedures easier to understand for teams deploying into South Carolina during a disaster (South Carolina Emergency Management Division, n.d.).

SCOR'S ROLE IN RECOVERY

While SCEMD is responsible for disaster response and initial recovery, SCOR began as the Disaster Recovery Office, with a focus on long-term housing recovery, managing CDBG-DR funds while EMD coordinates FEMA Individual and Public Assistance programs. To date, the Disaster Recovery program has rebuilt or repaired more than 3,300 homes for citizens whose homes were damaged by the 2015 Flood, Hurricane Matthew, or Hurricane Florence. On September 24, 2021, the office completed construction projects in the 2015 Flood program, which repaired or replaced a total of 1,829 homes, with 98% of the citizens served earning 30% or below the area median income. The last home in the 2016 Hurricane Matthew program was completed in December 2022. Both programs have exclusively served low-to-moderate income citizens. More programmatic details may be found by viewing the 2015 Severe Storm, Hurricane Matthew, and Hurricane Florence CDBG-DR Action Plans.

DISASTER CASE MANAGEMENT (PALMETTO DISASTER RECOVERY)

Palmetto Disaster Recovery (PDR) is a disaster case management effort that identifies applicants and monitors cases as they progress through the residential recovery (CDBG-DR) program. Disaster Case Management (DCM) is a process that involves a partnership between a disaster case manager and a citizen to develop and carry out an Individualized Recovery Plan that assists eligible citizens with their disaster-caused unmet needs. Case managers connect citizens with available resources and support services and follow up to monitor progress throughout the recovery process. Case managers average 300 client contacts per week. To date, PDR has served over 2,000 cases.

DISASTER RECOVERY RESERVE CORPS

In 2022, SCOR initiated the Disaster Recovery Reserve Corps (DRRC) to increase South Carolina's readiness and greatly reduce the time it takes to provide post-disaster assistance to residents impacted by disasters. The DRRC is comprised of a trained team on standby to fill positions in the Disaster Case Management department in various areas including case management, construction, operations, development, outreach, eligibility, and advocacy. A Reserve Corps team will be identified in each of the 46 counties in South Carolina. Corps members will be activated based on the location of the disaster and the specific disaster response and recovery activities the State decides to deploy.

During Hurricane Ian (2022), reservists were called upon to work in a temporary status for three weeks at Federal Emergency Management Agency (FEMA) Disaster Recovery Centers in Horry, Georgetown, and Charleston counties. The DRRC was able to be deployed rapidly to connect with survivors, linking them to available resources. Unlike in previous disasters, this new initiative accelerated the placement of trained recovery specialists in the field to deliver immediate disaster recovery services.

COMPLICATING FACTORS FOR RECOVERY

HEIRS' PROPERTY

Heirs' property is family owned land that is jointly owned by descendants of the deceased person, whose estate did not clear probate (U.S. Department of Agriculture, 2023). When all heirs cannot be identified and/or contacted, or if all heirs do not agree with a disaster recovery housing solution offered, it is unlikely that the project can proceed. SCOR has developed a process to assist these owners with the disaster recovery process.

South Carolina's CDBG-DR housing recovery program policy, as dictated by federal law and regulations, requires at least one resident applicant to demonstrate an ownership interest in part or in whole in the property, and to have resided in the property at the time of the storm. Applicants submit a deed to the property demonstrating ownership along with county property tax receipts and/or tax bills to satisfy the proof of ownership requirement. The program searches county online tax documents to confirm the county identified owner. Where the applicant is not listed on a deed or listed as group owner (et al.) and/or the county records reflect the property is a deceased owner's estate (John Doe, EST), the applicant will be asked to provide further information regarding his/her ownership interest.

A SCOR developed heirs' property questionnaire is then prepared by the intake office to assist the applicant with identifying all heirs of the deceased property owner. A family tree is constructed, and all living heirs determined. Additional information identifying heirs is also requested. Information includes obituaries, funeral programs, family bibles listing familial ties, and any other document with identifying family information. The applicant must sign an affidavit attesting to the validity of the heirs' property questionnaire. A third-party, who is not an heir, is also asked to review the questionnaire and attest to its validity. Once identified, all heirs are contacted and asked to voluntarily sign the contract for the disaster recovery reconstruction of the home, or the family is referred to a free or reduced cost legal resource to execute quit-claim deeds conveying the property to applicant.

If all heirs cannot be identified and/or contacted, or if all heirs do not agree with the disaster recovery housing solution offered, it is unlikely that the project can proceed. A referral to South Carolina Legal Services or the Center for Heirs' Property Preservation will be made to assist the family in resolving legal ownership. However, where deplorable housing conditions exist, thereby creating a threat to the health and safety of the applicant and his/her family, the case is immediately reviewed, and the housing recovery solution may be authorized to proceed by the Chief Resilience Officer. All efforts to identify and contact the heirs are documented in the SCOR system of record. All locatable heirs are required to sign off on the recovery project and the house is reconstructed/replaced based upon applicant's ownership interest in the property.

If the property is heirs' property and the disaster recovery housing solution is a rehabilitation of the structure, the damage assessment will be reviewed to determine if the project is in jeopardy of changing from a rehabilitation to a reconstruction project. SCOR will proceed with a rehabilitation project using the applicant's ownership interest in the property, because under this project process, the asset/home is not demolished but improved. If based upon the damage assessment, the project is likely to change from a rehabilitation to reconstruction, then the above heirs' property questionnaire process is followed prior to any rehabilitation of the home.

PROOF OF OWNERSHIP FOR MANUFACTURED HOUSING UNITS (MHU)

In South Carolina, Mobile Housing Units (MHU) are treated as personal property and subject to titling requirements from the Department of Motor Vehicles (DMV). If an applicant cannot produce a title to the MHU, then SCOR conducts a search of the DMV title records to determine who holds title. If the applicant cannot demonstrate title ownership or show a valid ownership interest that can be "cured", then the applicant is ineligible.

In cases in which the applicant has an ownership in MHU, but not the land upon which it sits, a SCOR produced MHU Land Ownership Authorization Form is used to authorize a MHU rehabilitation/replacement on the property.

NON-PROFIT PARTNERS IN RECOVERY

VOLUNTARY ORGANIZATIONS ACTIVE IN DISASTER (VOADS)

South Carolina Voluntary Organizations Active in Disaster or SCVOAD is an affiliate of National Voluntary Organizations Active in Disaster (NVOAD). A VOAD is an association of organizations that promote cooperation, communication, coordination, and collaboration and work to foster more effective delivery of services to communities affected by disaster.

The membership of South Carolina VOAD consists of both locally based organizations and local representatives of national organizations. The mission of VOAD is to strengthen the capabilities of organizations by working together to respond to communities affected by disaster in South Carolina.

SCVOAD member organizations cover a broad range of missions and technical expertise and include several active regional Long Term Recovery Groups (South Carolina Voluntary Organizations Active in Disaster (SCVOAD), n.d.).

UNITED WAY'S SC 211 SERVICES

The United Way Association of South Carolina facilitates SC 211 Services, which is an FCC regulated phone number similar to 911 or 411. However, instead of connecting to appropriate emergency services, SC 211 Services provides information and referrals to callers regarding a multitude of health and human services across the state. This free and confidential resource uses a rich network of over 3,000 local, state, regional, and national resources to guide callers to appropriate agencies or programs for food resources, housing and utilities, clothing needs, transportation, legal aid, education, employment, income support, mental health and substance abuse, health care, and disaster services.

THRIVE

The investments and actions taken to improve the ability of communities, economies, and ecosystems to anticipate, absorb, and recover from environment change and natural hazards will also allow systems to function better every day and provide multiple co-benefits.

COMMUNITY CO-BENEFITS

Disaster resilience efforts can provide a wide range of benefits to the community beyond the risk reduction. A few examples include the following:

- Green infrastructure projects often result in community green spaces and recreational areas that improve quality of life for the communities around these projects.
- Better data collection and coordination at the local and state level can improve the quality of services these government provide to citizens on a daily basis and improve community decision making.
- Improved infrastructure function not only helps communities in time of large events and disasters, but also in the day-to-day activities.

ECONOMIC CO-BENEFITS

It is easy to see that increasing resilience will result in reduced disaster damages. Likewise, there are additional economic co-benefits for increasing resilience, including the following:

- Job creation
- Building resilience into economic systems and sectors will build resilience to financial highs and lows.

ECOSYSTEM CO-BENEFITS

Ecosystem function and services can also be improved through resilience efforts. Resilience programs, policies, and projects can lead to:

- Habitat protection
- Improved water quality
- Improved soil quality
- Carbon sequestration

This can be most clearly seen through conservation efforts. There are many existing conservation efforts underway, from state organizations such as the Department of Natural Resources, South Carolina Conservation Bank, South Carolina Forestry Commission, and South Carolina Department of Parks, Recreation and Tourism, as well as a large number of non-profits. Each of these conservation programs have different goals, but many share priority conservation areas. For example, the South Carolina Office of Resilience has identified priority flood mitigation areas for conservation that overlap with priority areas identified by other conservation groups for species and habitat protection.

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Strategic Statewide Resilience and Risk Reduction Plan

8 | FUNDING

CHAPTER OVERVIEW

The Disaster Relief and Resilience Act (DRRA) states that this plan shall serve as a framework to guide state investment in planning, projects, programs, and policies to protect the people and property of South Carolina from the damage and destruction of extreme weather events.

SCOR recognizes that coordinating and obtaining grant funds will further resilience efforts statewide and locally. To that end, this plan includes a strategy for providing resources, technical assistance, and other support to local government for resilience efforts.

SCOR's goal is to obtain funding to implement statewide resilience and also support other state agencies, local and regional governments, communities, tribal nations, traditional communities, and nonprofits in obtaining funding to create a more resilient South Carolina. This requires coordination, collaboration, and cooperation between governments, agencies, and other organizations.

This chapter includes:

- A brief description of major sources of funding for resilience available at the federal and state level, with a focus on grant funding, recognizing that resilience is a broad topic that touches several sources of funding.
- A description of how funds related to resilience are currently managed in South Carolina.
- A description of how SCOR can enable the implementation of resilience to take advantage of the recent influx of federal grant funding.

This chapter, and the challenges identified here, inform the recommendations related to funding proposed in Chapter 9 of this plan. These recommendations build the multi-faceted strategy to provide resources, including funding, technical assistance, and other support to local governments for programs and policies.

CHAPTER CONTENTS

FUNDING RESILIENCE

Resilience covers a wide range of issues related to the interaction of natural and human systems, and as such, can connect to various funding sources. The South Carolina Office of Resilience defines resilience as the ability of communities, economies, and ecosystems to anticipate, absorb, recover, and thrive when presented with environmental change and natural hazards. Under this definition of resilience, projects could be potentially funded by a multitude of sources. Government agencies, as well as some private foundations, offer funding to a wide range of recipients including but not limited to States, regional, local, tribal and territorial governments, community organizations, and neighborhood groups. Therefore, there is a need for coordination, collaboration, and cooperation amongst applicants and recipients of funding.

FUNDING AND THE DISASTER RELIEF AND RESILIENCE ACT

STATE INVESTMENT

The DRRA states that this Strategic Statewide Resilience and Risk Reduction Plan is intended to serve as a framework to guide state investment in projects, programs, and policies to protect the people and property of South Carolina from the damage and destruction of extreme weather events. The Act specifically requires this plan to identify potential financial resources available for increasing resilience across the state.

COORDINATION OF STATEWIDE RESILIENCE EFFORTS

The DRRA states that the Office of Resilience shall coordinate statewide resilience and disaster recovery efforts, including coordination with federal, state, and local governmental agencies, stakeholders, and nongovernmental entities. As part of this coordination role, this plan must include a strategy for providing resources, technical assistance, and other support to local governments for flood risk reduction action.

Figure 8.1 outlines how several of the sources of the federal funding decribed below flow through federal and state goverments. This highlights the importance of coordination between state agencies in order to optimize federal funding for resilience in South Carolina. Brief descriptions of several federal programs are below. For more information, please see program websites for the most up to date information about eligible applicants, timelines, and available funding. Several different South Carolina state agencies manage federal grant programs related to resilience (Figure 8.1). This distributive nature of funding flows highlights the importance of coordination between state agencies in order to optimize federal funding for resilience in South Carolina.

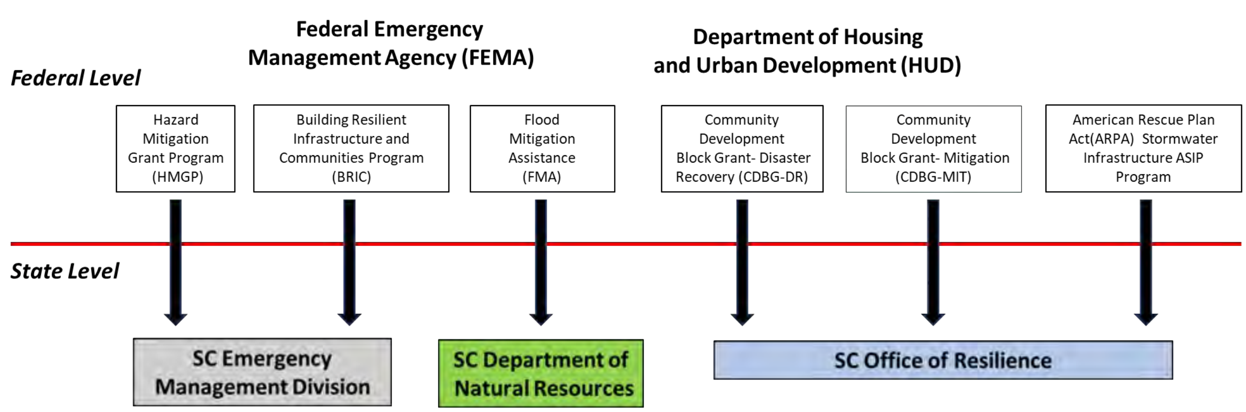

Figure 8.2: An example of how Federal funding reaches state agencies.

FUNDING SOURCES FOR RESILIENCE CREATED IN THE DISASTER RELIEF AND RESILIENCE ACT

The Disaster Relief and Resilience Act established the Office of Resilience, directed the development of the Resilience Plan, and created two funds for resilience activities as outlined in the Act.

RESERVE FUND

The Act created the Disaster Relief and Resilience Reserve Fund. These funds may be used for:

1. Development, implementation, and maintenance the Strategic Statewide Resilience and Risk Reduction Plan
   The Statewide Resilience Plan shall serve as a framework to guide state investment in flood mitigation projects and the adoption of programs and policies to protect the people and property of South Carolina from the damage and destruction of extreme weather events.
2. Disaster Relief Assistance
   Following a federally declared disaster, the fund may make available immediate disaster relief assistance to aid resilient rebuilding in affected communities with significant unmet needs. Activities completed using disaster relief assistance from the fund shall account for future risks and hazard exposure in order to rebuild in a manner that will reduce the exposure of the community to future hazards and reduce future losses, consistent with the Statewide Resilience Plan. The current statutory authority does not provide for relief and recovery activities in response to a gubernatorially declared disaster.
3. Hazard Mitigation and Infrastructure Improvements
   The Fund will support resilient hazard mitigation activities through loans and grants with the goal of removing residents from hazard areas, safeguarding property, and restoring the natural function of the floodplain. Priority must be given to projects identified in the Statewide Resilience Plan or local hazard mitigation plans.

In order to qualify for funds, eligible recipients must apply to the South Carolina Office of Resilience and meet all criteria set forth by the Disaster Relief and Resilience Act and the Office. In approving financial assistance for hazard mitigation and infrastructure improvement projects, the Office of Resilience shall ensure that selected projects comply with requirements of the National Flood Insurance Program, or any more stringent requirements adopted by a local government. Priority will be given to projects which offer enhanced protection from future flood events, or which utilize or incorporate natural features to achieve protections. Funds may not be used for projects which, rather than lowering risks overall, increase the flood vulnerabilities of neighboring areas.

REVOLVING FUND

The Act created the South Carolina Resilience Revolving Fund. This fund offers low interest loans to eligible entities in South Carolina to carry out buyout programs for properties that have experienced repetitive flood loss or to complete floodplain restoration projects. Eligible applicants are any state agency, commission, or local government, or land trusts accredited by the Land Trust Accreditation Commission.

Priority will be given to projects which:

- Buyout blocks or groups of homes (avoiding the "checkerboard" effect)
- Buyout single family primary residences and multifamily residences
- Use the Revolving Loan funds to leverage additional funding sources
- Serve low to moderate income households earning less than 125% of the median household income in the eligible recipient's area
- Implement activities consistent with the goals and priorities of the Statewide Resilience Plan

Loans will have a low interest rate no higher than 40% of the market interest rate defined by the ten year United States Treasury Yield Curve (TYC). Implementing beneficial flood mitigation practices can earn loan awardees an additional financial incentive. Awardees may qualify to have up to 25% of their loan converted into a grant not requiring repayment. The amount is determined at the time the loan is closed.

No loans or grants will be provided for activities that involve homes built after July 1, 2020, and/or the use of eminent domain.

FEDERAL SOURCES OF FUNDING

FEDERAL DISASTER RECOVERY FUNDING PROGRAMS

DISASTER DECLARATION

The Robert T. Stafford Disaster Relief and Emergency Assistance Act (Stafford Act) authorizes the President to provide Federal assistance when the magnitude of an incident or threat of an incident exceeds the affected state, local, tribal or territorial government's capability to respond or recover. A declaration establishes the following: types of assistance, federal cost share, type of incident, incident period, and designated areas (FEMA, 2021).

FEDERAL EMERGENCY MANAGEMENT AGENCY

FEMA provides recovery assistance through Public Assistance (PA) and Individual Assistance (IA).

PUBLIC ASSISTANCE

Public Assistance (PA) is FEMA's largest grant program providing funds to assist communities responding to and recovering from major disasters or emergencies declared by the President (FEMA, 2019). PA supports states, territories, tribes, local governments, and private nonprofit organizations to repair damage to public property and can include debris removal and emergency protective measures in the short term, and permanent work on roads and bridges, water control facilitates, public buildings and contents, public utilities, and parks, recreational and other facilities (FEMA, 2021). FEMA will provide a reimbursement grant of at least 75% of eligible costs, with the state and local governments sharing the remaining 25%. Eligible public entities include state governments, local governments and any other political subdivision of the state, recognized tribes and U.S. territories. Certain private nonprofits such as schools, utility companies, irrigation systems, emergency, medical, and rehabilitation operations, houses of worship and temporary or permanent custodial-care facilities are potentially eligible to get assistance (FEMA, 2020). For more information on PA programs, see the Public Assistance Program and Policy Guide.

INDIVIDUAL ASSISTANCE (IA)

FEMA provides Individual Assistance (IA) to eligible individuals and households who have sustained losses as a direct result of a disaster that receives a federal disaster declaration. Homeowners and renters in designated counties who sustained damage to their homes, personal property, businesses or business inventory may apply for assistance. This assistance can help pay for things like temporary housing, emergency home repairs, uninsured and underinsured personal property losses, as well as medical, dental and funeral expenses, together with other serious disaster-related expenses.

DEPARTMENT OF HOUSING AND URBAN DEVELOPMENT (HUD)

COMMUNITY DEVELOPMENT BLOCK GRANT DISASTER RECOVERY (CDBG-DR)

HUD provides flexible Community Development Block Grant Disaster Recovery (CDBG-DR) funds to help cities, counties and states recover from Presidentially declared disasters (U.S. Department of Housing and Urban Development (HUD), 2023). In response to extraordinary impacts from disasters, Congress can appropriate additional funding to the CDBG-DR program. Unlike other recovery assistance programs administered by FEMA and the U.S. Small Business Administration (SBA), CDBG-DR assistance is not permanently authorized. After Congress appropriates funding to the CDBG-DR program, HUD formally announces the CDBG-DR awards and publishes rules for the awards in a Federal Register notice. States and local governments can administer the CDBG-DR grant program directly or distribute funds to subrecipients or subgrantees (U.S. Department of Housing and Urban Development, 2023).

CDBG-DR funds can only be spent to meet the recovery needs caused by the disaster(s) specifically stated in the appropriation. Typically, appropriations further limit use of funds to the “most impacted and distressed” areas resulting from a major disaster. HUD uses damage estimates and other available data to determine the eligible grantees, geographical areas to be served or prioritized, and allocation amounts. Eligible disasters and any geographic restrictions are identified in the Federal Register Notice that governs the use of funds (U.S. Department of Housing and Urban Development, 2023).

As outlined in Chapter 1, the South Carolina Office of Resilience has been a grantee for three CDBG-DR programs, receiving $293 million to provide housing assistance to South Carolinians whose homes were damaged by Presidentially declared disasters. Additionally, Richland County, Lexington County and the City of Columbia received CDBG-DR funds directly after the 2015 flood event (Richland County, 2023).

SMALL BUSINESS ADMINISTRATION DISASTER LOANS

The U.S. Small Business Administration (SBA) offers low-interest disaster loans to businesses of all sizes, nonprofits, homeowners and renters. These disaster loans are the primary source of federal long term disaster recovery funds for damages that are not covered by insurance or other compensation.

FEDERAL HAZARD MITIGATION FUNDING PROGRAMS

In addition to the disaster recovery programs described above FEMA and HUD also have grant programs focused on hazard mitigation and resilience. However, the funding for many of these programs is still tied back to a previous disaster.

FEMA

The Federal Emergency Management Agency (FEMA) has several Hazard Mitigation Assistance (HMA) programs that provide funding for eligible activities that reduce or eliminate long-term risk to people and property from future disasters. States, local, tribal and territorial governments may apply to these programs (Federal Emergency Management Agency, 2023).

BUILDING RESILIENT INFRASTRUCTURE AND COMMUNITIES (BRIC)

Building Resilient Infrastructure and Communities (BRIC) is a competitive annual grant program focusing on the implementation of hazard mitigation projects that reduce the risks from disasters and natural hazards. While the program is focused on proactive investment as opposed to reactive disaster spending, FEMA can provide annual BRIC funding in an amount equal to up to 6% of its total disaster response costs for the previous year (Federal Emergency Management Agency, 2023). BRIC funding is distributed via national competition and set-aside funding for each state and eligible tribal government.

BRIC funds may be used for: (1) capability and capacity building activities, (2) mitigation planning activities, and (3) mitigation projects. BRIC encourages public infrastructure projects, projects incorporating nature-based solutions, and the adoption and enforcement of modern building codes.

Local governments, state agencies, special purpose districts, and tribal governments are eligible applicants. To qualify for funding, these entities must have adopted a FEMA approved hazard mitigation plan.

SC Emergency Management Division (SCEMD) administers BRIC funding in South Carolina. Eligible sub applicants must notify SCEMD with an intent to apply and work with SCEMD Mitigation staff to develop and submit a project application into FEMA’s system.

In addition to providing funding, the BRIC program offers non-financial Direct Technical Assistance that can provide planning and project development support (Federal Emergency Management Agency, 2023).

HAZARD MITIGATION GRANT PROGRAM (HMGP)

The Hazard Mitigation Grant Program (HMGP) is a FEMA grant program managed at the state level by SCEMD. The goal of the HMGP is to reduce the risk of loss of life and property from future hazard occurrences.

HMGP funding is made available after a federally declared major disaster, but applicants do not need to have sustained disaster-related damage to apply. FEMA provides HMGP funding equal to 15% of total estimated federal assistance for the disaster, with a sliding scale for disasters with more than $2 billion in estimated assistance.

HMGP funding priorities are set by the State for each disaster. To qualify for funding, projects must provide a long term solution for the community, demonstrate cost effectiveness, and comply with program regulations and the FEMA Hazard Mitigation Assistance Program and Policy Guide.

Local governments, state agencies, tribal governments, and certain non-profits are eligible applicants. To qualify for funding, these entities must have participated in and adopted a FEMA approved hazard mitigation plan.

FLOOD MITIGATION ASSISTANCE (FMA)

The Flood Mitigation Assistance (FMA) Program is a FEMA grant that is managed at the state level by the SC Department of Natural Resources (SCDNR).

The goal of this grant program is to reduce flooding of National Flood Insurance Program (NFIP) insured properties through mitigation, thereby reducing flood insurance claims. FMA is funded by the National Flood Insurance Fund.

This grant program offers federal mitigation assistance to update the flood mitigation portion of hazard mitigation plans. The program also funds projects to protect against flooding, assisting states and communities in implementing measures to reduce or eliminate the long-term risk of flood damage to buildings, manufactured homes, and other structures insurable under the National Flood Insurance Program (NFIP).

FMA has 3 program priorities:

1. Localized Flood Risk Reduction Projects: Includes floodwater storage and diversion, stormwater management, floodplain restoration and protection, green and gray infrastructure, and nature-based solutions.
2. Individual Flood Mitigation Projects: Includes property acquisition, elevation, floodproofing, retrofitting, and mitigation reconstruction.
3. Capability and Capacity Building Activities: Includes multi-hazard mitigation plans, technical assistance to states, and project scoping.

Local governments, state agencies, and tribal governments are eligible applicants.

HUD

COMMUNITY DEVELOPMENT BLOCK GRANT MITIGATION (CDBG-MIT)

Community Development Block Grant Mitigation (CDBG-MIT) funds provide an opportunity for eligible grantees who have been impacted by recent disasters to carry out strategic and high impact activities to mitigate disaster risk and reduce future losses (U.S. Department of Housing and Urban Development, 2023). In February 2018, Congress appropriated $12 billion dollars in CDBG funds specifically for mitigation activities for qualifying disasters in 2015, 2016, and 2017. In January 2020, HUD allocated an additional $3.9 billion, bringing the amount available for mitigation to nearly $16 billion (U.S. Department of Housing and Urban Development, 2023).

For the purposes of this funding, mitigation activities are defined as activities that increase resilience to disasters and reduce or eliminate the long-term risk of loss of life, injury, damage to and loss of property, and suffering and hardship by lessening the impact of future disasters (U.S. Department of Housing and Urban Development, 2023).

As outlined in Chapter 1, the South Carolina Office of Resilience is currently administering $162 million in CDBG-MIT funds covering 17 of the most impacted and distressed counties.

HUD also made CDBG-MIT funds available to the City of Columbia and Richland County. More information about these programs and how the funding has been used can be found on their websites.

Future mitigation efforts will now be a set aside in CDBG-DR funds. The Disaster Relief Supplemental Appropriations Act of 2021 requires HUD to set aside 15% of disaster recovery grants for disaster mitigation activities in any allocation of CDBG-DR funds. In the CDBG-DR Action Plan, grantees must identify how they will use the set aside for mitigation activities that address current and future risks (U.S. Department of Housing and Urban Development).

NEW FEDERAL FUNDING PROGRAMS RELATED TO RESILIENCE

An influx of federal money directly and indirectly tied to resilience is being made available to state agencies, local and regional governments, communities, tribal nations, and nonprofits. This funding includes increases to existing programs and the introduction of additional competitive grant opportunities authorized through legislation such as the Bipartisan Infrastructure Law and the Inflation Reduction Act.

Grants.gov is a searchable database of many federal grant opportunities. It also provides information on how to apply for grants and the grant making process.

BIPARTISAN INFRASTRUCTURE LAW

The Infrastructure Investment and Jobs Act (IIJA), also known as the Bipartisan Infrastructure Law, was signed in 2021 and contains many new programs related to resilience. Funding through these new programs is appropriated to States based on formulas and through a series of new and supplemented federal grant programs. The programs include funding for priorities such as transportation infrastructure, climate, energy, and broadband, with an emphasis on resilience and environmental justice.

In 2022, the White House released a guidebook to the Bipartisan Infrastructure Law that includes a section specifically on resilience, although resilience is mentioned through the guidebook. The guidebook identifies that the Act provides a $50 billion investment to protect against droughts, heat, floods, wildfires, and cyber threats, as well as a major investment in weatherization, calling the Act, “the largest investment in the resilience of physical and natural systems in American history” (The White House, 2022). The guidebook highlights several specific funding programs at agencies across the federal government and encourages communities to explore existing resources within FEMA and HUD, which have been described above.

The Act provided additional funding to existing resilience programs such as the National Coastal Resilience Program (NFWF) and Transformational Habitat Restoration and Coastal Resilience Grant Programs (NOAA).

INFLATION REDUCTION ACT

The Inflation Reduction Act was signed into law in August 2022. Building on similar themes as the Bipartisan Infrastructure Law, the Act adds new funding to mitigate the effects of environmental change and nature hazards with a focus on nature-based solutions and providing financial and technical assistance to vulnerable communities including Tribes. The Inflation Reduction Act Guidebook overviews major funding themes, which include those listed below (The White House, 2022).

- Harnessing Nature Nature-Based Solutions and Climate-Smart Agriculture to Deliver Economic, Climate, and Resilience Benefits
- Increasing the Resilience of Our Communities
- Preserving and Protecting the Nation’s Lands and Waters for Climate Mitigation and Resilience

Additionally, the Inflation Reduction Act creates a $3 billion Environmental and Climate Justice Block Grant Program to provide grants and technical assistance to community based organizations to improve community resilience to climate impacts, including extreme heat and wildfire, among other funded activities. The law also gives $1 billion to the Department of Housing and Urban Development for the Green and Resilient Retrofit Program to make America's affordable housing stock more energy efficient and resilient to extreme weather events.

ADDITIONAL STATE FUNDING RELATED TO RESILIENCE

SAFE HOME PROGRAM

The South Carolina Safe Home Program, administered by the South Carolina Department of Insurance, provides matching and non-matching grant funds to help coastal property owners retrofit their homes to make them more resistant to hurricane and high wind damage. The funds provided by this program are for the sole purpose of retrofitting owner occupied, single family homes. Safe Home funds may not be used for remodeling, home repair, or new construction. Eligible retrofits include:

- Bracing gable ends
- Exterior doors (including garage doors)
- Opening protection (window replacement, hurricane shutters)
- Roof-to-wall connectors
- Roof covering
- Roof deck attachment
- Secondary water barrier
- Repair or replacement of manufactured home piers, anchors, and tie-down straps
- Issues associated with weak trusses, studs, and structural components

These retrofitted or strengthened homes are less vulnerable to the effects of severe storms, thereby making the hurricane and high-wind damage less likely and less severe. The Safe Home Program has partnered with the IBHS Fortified Program to provide participating homeowners with the possibility of achieving dual designations when mitigation work is performed on the roof of their homes, providing additional insurance benefits.

The program receives a limited annual allocation from the state legislature under the Omnibus Coastal Property Insurance Reform Act of 2007. Applications are received on a first come, first serve basis. Grants are based on family size and adjusted gross household income when compared to county and/or state median family income, whichever is higher. The maximum grant is $5,000. The application period generally begins on July 1st with rolling applications and awards until funds are depleted. However, it should be noted that these funds are exhausted quickly when the application opens each year. To date, the program has awarded more than 7,291 grants totaling more than $32.8 million to coastal residents.

RURAL INFRASTRUCTURE AUTHORITY (RIA)

The Rural Infrastructure Authority (RIA) offers grants to assist in the development of reliable infrastructure statewide and increase capacity for economic growth. Financial assistance is made available during two competitive funding rounds annually. Applications are reviewed on a comparative basis with consideration of the relative need, feasibility, and impact of each project. Funding decisions are made by the RIA's Board of Directors. RIA staff can provide technical assistance to help communities apply for funding to address critical infrastructure needs.

LOCAL CAPACITY CHALLENGES

SCOR's work on the Resilience Plan and CDBG-DR and MIT programs has identified barriers to resilience and restoration planning and implementation on a community scale. These barriers include a lack of capacity, resources, and funding, especially among the most underserved and vulnerable communities. Many communities would like to implement resilience projects in their communities, but they may not have the resources to plan and develop projects that meet grant funding requirements. Overcoming this barrier will require added capacity at the local level and technical assistance from the state and federal government.

Another significant barrier is the non-federal cost share requirement of many competitive grant programs. Many communities struggle to provide the non-federal cost share, which for many programs is between 10 to 25% of the total project cost.

The Justice40 Initiative, established by Executive Order 14008, is part of the effort to overcome some of these barriers in capacity and serve the most vulnerable communities. The environmental justice initiative has a goal of directing 40% of climate and clean infrastructure federal investments to disadvantaged, frontline communities with longstanding, critical environmental needs.

OPPORTUNITIES

The Office of Resilience has identified several opportunities to support the implementation of resilience utilizing the recent influx of federal grant funding.

SCOR has developed five lines of effort to support this process for projects that are consistent with the Statewide Resilience Plan.

> Applicant: SCOR applies for and receives grants as the applicant or lead. This process includes SCOR identifying a funding source, determining appropriate partners, and applying for and managing the project.
>
> Partner (Co-Lead): SCOR or another organization identifies a funding source and works with partners as co-leads to apply for and manage a project.
>
> Technical Assistance: SCOR provides technical assistance by identifying funding sources and providing guidance on grant proposals.
>
> Letter of Support: SCOR provides letters of support for grant proposals that are consistent with the Office's mission and in line with the principles of the Statewide Resilience Plan.
>
> Coordination: SCOR coordinates with the various resilience related projects being funded to decrease duplication of effort for the organizations and the communities these projects are engaging and share best practices.

At the time of publishing, the South Carolina Office of Resilience is actively engaged in seeking funding and supporting other organizations seeking funding for resilience related projects. SCOR will maintain a webpage to track funding available and received by SCOR and other partners.

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Strategic Statewide Resilience and Risk Reduction Plan

9 | RECOMMENDATIONS

OVERVIEW

The following recommendations are intended to improve the ability of communities, economies, and ecosystems within South Carolina to anticipate, absorb, recover, and thrive when presented with environmental change and natural hazards. Additionally, these serve as a framework to guide state investment in flood mitigation projects and the adoption of programs and policies to protect the people and property of South Carolina from the damage and destruction of extreme weather events. Implementation of these recommendations will require action at the local, state, and federal levels of government as well as participation of the private and non-profit sectors.

The process of implementation will allow for development of coordinated resilience efforts and the identification of projects that maximize the benefit to South Carolinians while minimizing the risk of failure to adjust appropriately to current and future conditions.

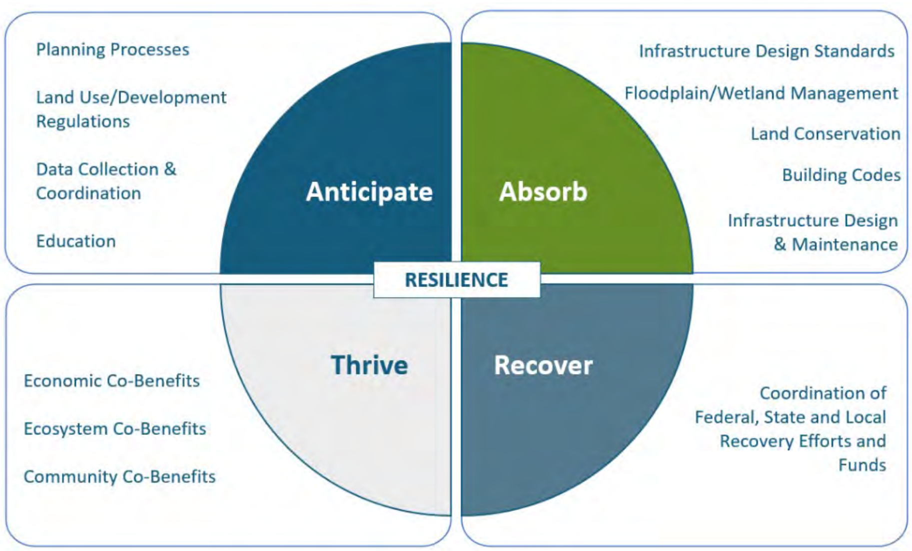

Figure 9.1

The Disaster Relief and Resilience Act directs SCOR to consider the long-term costs of the plan's recommendations. When available, estimates of the cost to implement each recommendation is provided. The costs provided are estimates only, based on information available at the time this plan was written, and should be further investigated.

The involved parties listed may not be comprehensive and additional stakeholders will likely need to be engaged for implementation.

In order to adapt to changes in conditions and to incorporate new information, these recommendations should be reviewed periodically.

Many of the recommendations provided here have multiple co-benefits that may be achieved beyond reduction of vulnerabilities to flooding or other hazards.

CONTENTS

IMPROVE DATA COLLECTION & COORDINATION

The resilience planning process returned a wealth of datasets maintained by various state, local, and federal entities, but also illustrated the need for strategic efforts to enhance the state's data resources. Current processes related to the State's data can be found in Chapter 7 (Current Processes). Investments in information infrastructure can promote efficient and cost-effective decision making through:

- Providing a better understanding of what data exists, who manages it, who can access it, and how it may be applied across sectors
- Decreasing duplication of effort related to data acquisition, analysis, and data management
- Connecting decision makers to accurate and up-to-date and sources of relevant information
- Reducing project development costs and barriers for project implementation
- Enhancing geospatial understanding and data visualization for current and future programs
- Ensuring equitable coverage across the state to provide needed tools for the most vulnerable

Effective implementation of these recommendations will require engagement with communities to understand local contexts, needs, and vulnerabilities. These recommendations will guide the State and its stakeholders into the future with confidence that policies and programs are well informed.

CREATE A DATA COORDINATION OFFICE

Results: The creation of a Data Coordination Office will result in improved data collection, management, and utilization for data for decision making statewide.

A Data Coordination Office is needed to coordinate, catalog, document, and make accessible the wide range of data produced by and for the state. This data includes (but is not limited to) programmatic, quantitative, geographic (GIS), and financial data at the state and local levels. Coordination will allow for data integration across platforms and agencies. When this data is cataloged and coordinated effectively, existing programs can target resources more efficiently, agencies can more easily pursue novel funding opportunities, and state-derived data can enhance accountability reporting schemes that otherwise rely on non-official sources.

This office would work closely with state-level agencies and local partners for a reciprocal exchange of knowledge, providing technical assistance as necessary to help partners understand, access, and use data for planning, project implementation, and grant writing. Based on this essential collaboration from various levels, this office should establish standards for state data acquisitions and management, as well as best management practices to facilitate data accessibility.

A statewide study should be completed to determine the most efficient means of creating and running the Data Coordination Office.

Many of the subsequent recommendations could be coordinated or managed by this office.

Time Frame: 1-5 years

Involved Parties: All State Agencies

Estimated Costs: $250,000

Funding Source: State Appropriations

INCREASE THE DENSITY OF WEATHER STATIONS

Results: Placement of additional weather stations will provide greater precision in developing weather models, hydrologic models, drought assessments, flood forecasting and other decision-making processes.

Weather monitoring is essential to decision making before, during, and after an event. SCOR will coordinate a committee to determine specific station needs, locations, and specific costs and funding. This committee will require coordination with the State Climatology Office, National Weather Service, academia, and USGS to ensure efficient deployment and data management of additional stations. These may include the use of low-cost sensors to supplement data from benchmark stations and the identification and addressing of gaps in rain gauge coverage for shorter duration rainfall events (i.e. 1-hour precipitation data).

Time Frame: 1-5 years

Involved Parties: Academia, EMD, NWS, SCDNR, USGS

Estimated Costs: $1.5 million upfront cost (one benchmark station per county)**,** $500,000 per year operations cost (5 positions [1 data quality analyst, 3 field techs, program director] for operations and maintenance of the network)

Funding Source: To be determined for installation; state recurring funds required for operation.

INCREASE THE DENSITY OF RIVER GAGES

Results: New gages will be used to develop better hydrologic models and to inform and improve water planning, drought assessments, flood forecasting, and flood frequency estimates.

Additional river gages are needed, providing for better data distribution across the State. SCOR will coordinate a committee to determine specific gage needs, including specific locations, costs, and funding mechanisms. This will include coordination between state agencies such as SCDNR, DHEC, SCDOT, and SCOR, academia, and federal agencies (USGS) to ensure that efficient deployment and data management of additional gages, which may include combination stations for additional purposes such as river gages, as well as the use of low-cost sensors to supplement data from benchmark gages.

SCDNR has identified 256 potential gage sites needed to inform drought monitoring, bridge scouring, flood mitigation, water usage, and permitting. A USGS river gage that monitors stage and discharge currently costs $15,800 per year, and a gage that monitors stage, discharge, and velocity currently costs $24,950 per year. Each USGS gage also has an installation fee, which is waived if the gage has more than 5 years of funding commitment. SCDNR recently received $470,000 that will cover a minimum of 30 gages. It would require an additional $3,575,000 per year to install gages that monitor stage and discharge; an additional $5,920,000 per year would be needed to install and operate gages that monitor stage, discharge, and velocity. Low-cost optical sensors may be considered to fill data gaps between USGS gage locations.

Time Frame: 1-5 years

Involved Parties: Academia, DHEC, EMD, NWS, SCDNR, SCDOT, SCOR, USGS

Estimated Costs: $5,920,000 per year (to fill all identified data gaps)

Funding Source: To be determined for installation; state recurring funds required for operation

INCREASE THE DENSITY OF TIDAL GAUGES

Results: Increasing the density of tidal gauges will enable better monitoring and modeling of conditions.

Additional tidal gauges are needed to monitor conditions along the coast. South Carolina currently has direct measurement gauges in Charleston and Myrtle Beach, while tides for the rest of the state are calculated. Due to the increase in tidal flooding and the complex nature of the South Carolina coastline, increasing monitoring through gauges will provide a more accurate representation of the water levels in the coastal environments. SCOR will coordinate a committee that will work to determine specific gauge needs, including specific locations, costs, and funding mechanisms. This committee will include SCDNR, NOAA, OCRM and academia to coordinate efficient deployment and data management of additional gauges. These additional gauges may include combination stations for additional purposes such as river gages, and low-cost optical sensors to supplement data from benchmark gauges.

Time Frame: 1-5 years

Involved Parties: Academia, NOAA, OCRM, SCDNR, USGS, SCEMD, SECOORA

Estimated Costs: To be determined, $3,000 per low-cost optical sensor

Funding Source: To be determined for installation; South Carolina Legislative Appropriation recurring funds required for operation

DEVELOP A STATEWIDE NETWORK TO MONITOR SURFICIAL GROUNDWATER

Results: Developing a statewide network to monitor surficial groundwater will provide a better understanding of the impacts of sea level rise and changes in rainfall infiltration on shallow systems including septic fields.

Monitoring of surficial groundwater should be continued and expanded. In coastal zones, sea level rise can cause the water table to rise, leading to flooding from soil saturation and tidal fluctuation, especially in low-lying areas. Additionally, sea level rise is increasing the salinity of coastal groundwater through saltwater intrusion, which puts infrastructure at risk of deterioration and can cause water quality and septic issues. Statewide, surficial groundwater can be impacted by changes in precipitation rates, land cover, and compaction of sediment.

The surficial aquifer monitoring wells in the SCDNR Groundwater Monitoring Network are primarily used for drought monitoring. In 2018, SCDNR and USGS added more wells in the surficial aquifer, but a baseline is still being established. SCOR, SCDNR, and many counties and municipalities recognize the importance of monitoring the surficial aquifer as sea level changes and saltwater intrusion occurs, impacting septic tanks and causing soil saturation that can exacerbate flooding impacts.

Time Frame: 1-5 years

Involved Parties: SCDHEC, SCDNR, USGS

Estimated Costs: To be determined, approximately $6,000 for installation per 30-40 foot well, $820 per well for instrumentation, plus ongoing monitoring costs

Funding Source: To be determined for installation; South Carolina Legislative Appropriation recurring funds required for operation.

INSTALL THREE EXTENSOMETERS & MONITOR LAND SUBSIDENCE

Results: Install three extensometers to monitor vertical land movement to develop a better understanding of relative versus absolute sea level rise and improved understanding of the causes of subsidence.

At least three extensometers are needed along the coast to monitor and measure land subsidence. These extensometers should extend through the full sediment stack so that the causes of land subsidence can be determined. Causes may include excessive groundwater extraction, surficial weighting, or natural processes.

Currently there are no extensometers in South Carolina. One extensometer should be paired with USGS Groundwater Monitoring Well CHN14. The second should be placed in the Andrews/Georgetown area, and the third located in the Lowcountry near Beaufort, paired with a groundwater monitoring cluster. Additional funding and resources should be provided for remote sensing technology such as Interferometric Synthetic Aperture Radar (InSAR), allowing for more widespread monitoring in the coastal area.

Time Frame: 1-5 years

Involved Parties: SC Geodetic Survey, SC Geological Survey (SCDNR), USGS

Estimated Costs: $6M (installation of 3) and operating costs

Funding Source: To be determined for installation; South Carolina Legislative Appropriation recurring funds required for operation.

INCORPORATE UPDATED ATLAS 14/15 INTO INFRASTRUCTURE DESIGN

Results: Updating Atlas 14 will allow for the incorporation of more recent precipitation patterns into infrastructure design. The upcoming Atlas 15 will account for non-stationarity and the potential increase in extreme weather events anticipated in the coming decades. Having forward-looking precipitation frequency estimates will enable infrastructure investments to build long-term resilience into system designs.

SCOR, the SC Department of Transportation (SCDOT), and SC Department of Natural Resources (SCDNR) have agreed to provide funding to include South Carolina in the update of the National Oceanic and Atmospheric Administration (NOAA) Atlas 14 precipitation frequency estimates for the Mid-Atlantic Region. Once completed, the updated estimates for SC will include data gathered after the year 2000, allowing for a better understanding of the probability of rain events.

In addition to updating precipitation frequency estimates with more recent historical data, NOAA has been authorized to develop estimates that use downscaled global climate projections to be published as Atlas 15. Once released, the updated Atlas 14 and Atlas 15 numbers should be used to revise regulations and guidance utilized for planning and design.

In the interim, projects should at a minimum consider the high-end estimate of the currently published Atlas 14 numbers and plan for future climate conditions over the intended design life. SCOR recognizes the need to ensure a balanced approach to resilience that considers economic and environmental needs. Therefore, project-specific factors, such as the consequences of failure, current and future economic feasibility, and environmental impacts may warrant the use of higher or lower projections.

Time Frame: Updated Atlas 14 expected to be released in 2025. Atlas 15 expected to be released in 2026.

Involved Parties: NOAA, Federal Highway Administration (FHWA), SCDNR, SCDOT, SCOR

Estimated Costs: $308,000

Funding Source: SCOR ($185,000), SCDOT ($103,000), SCDNR ($20,000)

ESTABLISH A GROUP TO EVALUATE CLIMATE INFORMATION

Results: Establishing a group to evaluate climate information will inform decision makers on how future climate trends will likely impact the State.

To anticipate future climate-driven hazards, as well as future changes to sea level, the creation of a group to evaluate emerging climate information is needed. International organizations periodically release reports on the status of global climate and future projections. The Global Change Research Act of 1990 also mandates a national report every four years that includes climate assessments. Considering these global and national reports, the group will advise the State on how future climate trends are likely to impact South Carolina specifically and how these trends are likely to impact the State’s vulnerability to natural hazards. The group should be coordinated by the SCDNR State Climatology Office and include representatives from SCOR, S.C. Sea Grant Consortium, academia, and others. The Council should coordinate with Modeling Technical Advisory Groups.

Time Frame: 1-5 years

Involved Parties: Academia, SCDNR State Climatology Office (lead), SCOR, S.C. Sea Grant Consortium

Estimated Costs: $100,000 per year

Funding Source: To be determined

COLLECT LIDAR DATA STATEWIDE ON A REGULAR BASIS

Results: Cyclical updated LiDAR will allow decision makers to use the most up-to-date elevation data to use in computational models and in decision making.

Light Detection and Ranging (LiDAR) is a fundamental dataset used in urban, environmental, transportation, and emergency planning, as well as scientific research, and various types of modeling. Several recent flights for LiDAR in the last five years, including a county-led flight in 2020 and flights done by SCDNR's Flood Mitigation Program, have resulted in improved statewide coverage. However, not all this data is easily accessible for use. Where federal money was used for the flights, the data is customarily hosted for public download; however, several county flights are not available as they were not federally funded.

Recently, House Bill H. 3055 came into effect, mandating that the South Carolina Geological Survey Unit conduct LiDAR collection for the State on a 7-year cycle, provided that the necessary funding is appropriated. It is estimated that this effort would require $2.5M per year for collection, a dedicated full-time employee (FTE) to manage LiDAR data acquisition, data storage and processing, and robust information technology (IT) infrastructure to handle the volume of data. Integrating this effort with the proposed Data Coordination Office could improve efficiency.

The LiDAR program manager should work with local, state, and federal partners for funding and cost-sharing opportunities.

A committee should be convened to determine the appropriate collection specifications, designate priority areas of the state, and determine essential LiDAR derivatives to be produced.

Time Frame: 1-5 Year

Involved Parties: NOAA, SC Geological Survey, SCDNR, SCOR, USGS

Estimated Costs: $2.5 million per year

Funding Source: South Carolina Legislative Appropriation

CREATE A ROADWAY ELEVATIONS INVENTORY

Results: Creation of a roadway elevations inventory will improve understanding of the State's roadways' vulnerability to flooding.

Currently, there is no statewide road elevation data set. SCEMD, in conjunction with Clemson University, is working to develop a dataset that may be used for a vulnerability analysis; however, this project does not cover the entire state's roads.

Time Frame: Current, 1-5 years

Involved Parties: SCOR, SCEMD, Clemson University, SCDOT

Estimated Costs: To be determined

Funding Source: To be determined

OBTAIN HIGHER RESOLUTION LAND COVER DATA

Results: Obtaining one-meter resolution land cover data would allow for a more detailed catalog of the type and area coverage of various land cover types, allowing for better forecasting, planning, and modeling. SCOR will also use this data to improve the mapping of Prioritized Flood Mitigation Areas for Conservation by supporting the mapping and modeling of marsh migration and infiltration areas.

NOAA is developing a high-resolution land cover product, the Coastal Change Analysis Program (C-CAP) High-Resolution Land Cover and Change dataset. The resolution of this product is 1 to 5 meters, compared to the USGS's National Land Cover Dataset's (NLCD) 30-meter resolution, allowing for a more precise understanding of the state's landscape. Currently, C-CAP is being produced for NOAA's coastal areas. There is the potential for the dataset to encompass all of South Carolina's hydrological footprint with state-based funding and the use of our State's high-resolution imagery. NOAA estimates the cost of this expansion at $1,500,000. This information would serve as a key input to hazard modeling. Higher-resolution data will be used by various stakeholders. Integrating this effort with the proposed Data Coordination Office could improve efficiency.

Time Frame: 1-5 Years

Involved Parties: EPA, NOAA, SCDNR, SCOR, USGS

Estimated Costs: $1,500,000, with updates in 3–5-year increments. Subsequent updates would be at a lower cost according to NOAA.

Funding Source: $425,000 from EPA Climate Pollution Reduction Grant (proposed), Balance TBD

COMPLETE A STATEWIDE SEDIMENT STUDY

Results: A sediment study would improve our understanding of the sediment budgets, including the impact of reservoirs and identify potential engineering and policy solutions to remobilize sediment in the system.

The study should examine the potential contaminants that may be deposited with the sediment to determine if there is a risk of remobilization through planned activities or flooding events. Additionally, this study should include investigation into the beneficial use of dredge materials to keep sediment in the system.

Time Frame: To be determined

Involved Parties: Academia, DHEC, SCDNR, SCOR, US Army Corps of Engineers, reservoir owners/operators

Estimated Costs: To be determined

Funding Source: To be determined

COMPLETE THE STATEWIDE FLOOD INUNDATION MODELING AND MAPPING

Results: The SCDNR Flood Inundation Modeling and Mapping Project will provide emergency responders and others with the information needed for evacuations, search and rescue, road closures, and other emergency response activities.

The SCDNR Flood Mitigation Program was tasked with assisting with search and rescue through the production of inundation mapping for the resulting flooding from Hurricane Matthew in 2016. In 2018, the Flood Mitigation Program provided a prediction one week prior to Hurricane Florence making landfall and updated the information through the resulting flooding. The response to these events along with others since 2015 resulted in the development of the SC Flood IMPACT website (scfloodimpact.com) that provides inundation information to the public and emergency officials. Currently, SCDNR has developed or has under development the Pee Dee Watershed and a portion of the Santee Watershed. Funding for additional watersheds has been applied for through FEMA's Hazard Mitigation Grant Program (HMGP).

Time Frame: Current, 1-5 years

Involved Parties: SCDNR

Estimated Costs: $4,500,000 to finish the state and approximately $425,000 annually to maintain and update data.

Funding Source: State Funds, HMGP

COORDINATE MODELING EFFORTS STATEWIDE

Results: Coordinating modeling efforts statewide will improve data modeling of hazard vulnerabilities and reduce duplication of efforts.

A Modeling Technical Advisory Group has been created and tasked with inventorying existing models and technical capabilities, identifying data gaps, making recommendations on modeling needs, and evaluating proposals for modeling improvements, with a focus on flood inundation, hydrologic and hydraulic, and storm models. The need for collaboration across municipalities, state agencies, federal agencies, and academia has become evident as the need for computational models becomes more commonplace and efficient. By engaging with academia and the technical community, local communities and state agencies can be more efficient with their resources by having a publicly accessible catalog of existing models and having a better starting point to answer the question at hand.

The first meeting of this group was on August 2nd, 2022. The group should coordinate across political boundaries and include representation from North Carolina and Georgia as appropriate. The group may also coordinate with the National Weather Service on the National Flood Inundation Model, estimated to be available in 2023, with a national map produced by 2027.

Once completed, the inventory of models would be made publicly available with contact information for the entities responsible for model development to enable state and local government agencies to access existing models specific to planning, project design, and grant-writing goals.

SCOR should create a position to coordinate this group and act as a point of contact for interested parties.

Time Frame: Current, 1-5 years

Involved Parties: Academia, County & Municipal Governments, DHEC, EMD, NOAA, NWS, SCDNR, SCDOT, SCOR, USGS

Estimated Costs: $150,000 per year

Funding Source: To be determined

ASSESS THE NEED FOR ADDITIONAL POST DISASTER IMAGERY

Results: The collection of post disaster imagery can be used to better assess the damage extent post event. This can aid SCEMD, FEMA, and SCOR to identify where to focus response and recovery efforts.

A committee should be formed to assess the need for post event imagery to improve the efficiency and accuracy of completing disaster damage assessments to guide community recovery efforts. This can be accomplished via multiple platforms, including airplanes, satellites, and drone surveys, with each platform having its own advantages and disadvantages. There are existing frameworks for airplane and satellite collection efforts, but these require formal partnerships and contracts. The committee could designate the appropriate collection platform for specific disaster events, establish partnership contracts, and determine the event threshold needed to invoke these collection activities. For flood events, acquisition of imagery timed to capture maximum flood extents should be prioritized. This information would help support both recovery and mitigation efforts undertaken post-event and fill gaps when existing thresholds for imagery collection are not met. Integrating this effort with the proposed Data Coordination Office could improve efficiency.

Time Frame: 1-5 Year

Involved Parties: EMD, FEMA

Estimated Costs: To be determined

Funding Source: To be determined

DEVELOP HIGHER RESOLUTION POPULATION PROJECTIONS

Results: Higher resolution projections related to population movement, growth, and reduction would inform local, county, municipality, and state planning processes.

Resources should be allocated to allow the department to produce detailed, downscaled population and demographic projections based on data collected from the U.S. Census Bureau and to include new projections related to land use and development pressure. This information would be used to inform local decision making. While projections are currently available at the county level, it is critical to understand where, why, and how population change is occurring within a county to identify threats to natural systems caused by growth as well as threats to social vulnerability brought by population growth and decline. It can also inform infrastructure decisions, support smart planning on where to extend services and put in infrastructure, and minimize the loss of lands important for natural flood mitigation to keep populations away from hazard areas.

Time Frame: 1-5 Years

Involved Parties: Academia, Counties,

Estimated Costs: To be determined

Funding Source: To be determined

DEVELOP A STATEWIDE PROPERTY LEVEL DATA STANDARD

Results: Developing a statewide property level data standard will improve data collection and coordination and enable better monitoring and modeling.

Property level data is currently collected and managed at the local level. SCOR recommends development of a standardized schema of what data should be collected for each property and providing best management practices to local governments on data management. This data should be organized in a central database to improve resilience planning. Damage statistics would be improved as a result of additional data collection and sharing of property level data.

Data to collect would include address, tax use description, number of structures, primary structure's year of construction, first (finished) floor elevation, parcel value, structure value, construction type, owner type, owner name, subdivision name, parcel data source, and parcel data date.

Time Frame: 1-5 years

Involved Parties: County & Municipal Governments, SCEMD

Estimated Costs: To be determined

Funding Source: To be determined

INVENTORY & ANALYZE CURRENT ZONING AND LAND USE POLICY STATEWIDE (ZONING ATLAS)

Results: Inventorying and analyzing zoning and land use policy statewide will help decision makers better understand how local jurisdictions implement zoning and the ways in which land use regulations shape a community's development and resilience.

As with other data collected on the local level, existing zoning maps and ordinances are decentralized and inconsistent, making statewide comparison and understanding of zoning's role difficult. A zoning atlas will make comparisons of jurisdictions possible, open up research opportunities to explore the impacts of land use regulations on resilience, strengthen city and regional plans, better inform stakeholders, and update zoning and land use regulation to better align with risk and vulnerability, decreasing development in flood-prone locations and encouraging smart growth in lower-risk areas. In addition to the geospatial analysis, this process would include an analysis of existing zoning ordinances and classifications across the state to determine similarities between communities and determine if classifications can be collated for statewide comparison. In areas that are not zoned, this analysis will also look at other land development regulations such as setbacks, minimum lot sizes, and floodplain ordinances.

The National Zoning Atlas process for How to Make a Zoning Atlas, already being used in other states, may provide guidance to this end. This analysis could be supported through the statewide watershed-based resilience planning process.

Time Frame: Current

Involved Parties: SCAPA, SCOR

Estimated Costs: To be determined

Funding Source: To be determined

CREATE A CULTURAL RESOURCES RESILIENCE COORDINATOR POSITION TO DEVELOP A CULTURAL RESOURCES INVENTORY

Results: Improved data management and coordination of disaster preparedness and recovery activities and resilience efforts for the State's cultural resources. Allows for comprehensive planning that mitigates the potential loss of cultural resources across the State and promotes efficient recovery and resilience efforts.

A Cultural Resources Resilience Coordinator position should be created to coordinate and conduct a Statewide Cultural Resources Inventory to begin understanding the vulnerabilities cultural resources face to natural hazards. This coordinator will also manage education and training associated with cultural heritage such as disaster preparedness and recovery workshops for cultural heritage stewards (e.g., archives, libraries, and museum employees and volunteers) and community members.

A cultural resources inventory should catalog the institutions and organizations that manage the State's cultural, historic, and artistic collections so that their vulnerability to flooding and other hazards can be assessed. This inventory will also assist in creating a network of historical and cultural resource conservationists, which will serve as a platform for annual training and outreach, building upon the information held by FEMA's Heritage Emergency National Task Force (HENTF) to aid in local coordination.

Additional cultural resources survey and inventory should be conducted for known and potential cultural resources (e.g., archaeological sites, cemeteries, buildings/structures, cultural landscapes, and traditional communities) across the State's coastal counties and at-risk watersheds. This survey and inventory should include qualitative and quantitative data on the impacts cultural resources are experiencing and assess their vulnerability to flooding and other hazards. Such data would allow for pre-disaster mitigation and response. A subsequent monitoring program for at-risk cultural resources should be established. Similarly, the State should focus on mapping the extent and locations of traditional cultural places and communities. This needs to be an ethnographic endeavor, capturing oral histories and perspectives of the people who give South Carolina its rich and diverse cultural landscape.

These inventories will support the South Carolina Emergency Management Division's Natural and Cultural Resources (NCR) Recovery Support Function (RSF) Annex by helping emergency managers know what cultural resources are at risk when an event is on the horizon, as well as coordinating subsequent recovery and response.

Time Frame: 1-5 years

Involved Parties: SCOR, SCDNR Heritage Trust, SC PRT, SC Department of Archives and History/State Historic Preservation Office, SC Institute for Archaeology and Anthropology, SC State Library, Gullah/Geechee Nation, Gullah/Geechee Sea Island Coalition, Gullah Geechee Cultural Heritage Corridor NHA, Lowcountry Alliance for Response, SC African American Heritage Commission, SC Battleground Preservation Trust, Preservation South Carolina, SC Commission for Minority Affairs, SC Council of Chiefs, Tribal Nations, Confederation of SC Local Historical Societies, SC Federation of Museums, Palmetto Archives, Libraries, and Museums Council on Preservation, other cultural institutions, federal partners.

Estimated Costs: $100,000-$200,000 per year

Funding Source: To be determined

EDUCATION, OUTREACH & DISCLOSURE

The following recommendations focus on education and outreach to a variety of audiences. The recommendations include the development of tools and processes to engage and educate individual citizens, government organizations, and other stakeholders on resilience related topics. The disclosure recommendation specifically focuses on the disclosing of flood related information during real estate transactions.

STATEWIDE RESILIENCE PLAN REGIONAL WORKSHOPS

Results: Hosting Statewide Resilience Plan regional workshops will educate the public on the information included in the Resilience Plan.

Following the release of this plan, SCOR will hold regional workshops to present information in this plan to a variety of stakeholders.

Time Frame: 0-1 year

Involved Parties: SCOR, Planning Advisory Members

Estimated Costs: <$10,000

Funding Source: Reserve Fund

DEVELOP THE SCOR RESILIENCE ATLAS

Results: Development of the SCOR Resilience Atlas will provide a centralized location for resilience related GIS data to aid in decision-making statewide.

To present and share data analyzed as part of SCOR's Vulnerability Assessment and visualize other relevant data for use by multiple stakeholders and decision makers, SCOR will develop a comprehensive and easy-to-use mapping tool to be known as the SCOR Resilience Atlas that will function similarly to the SC DHEC Watershed Atlas. SCOR will work to consolidate existing tools such as the Water Resources Registry and the SC Green Infrastructure Plan Hub Site. Additional data layers from federal, state, local, and private sources may be added to increase local insight and context. An accompanying training or tutorial will help users navigate this tool. To ensure the tool is useful and easy to use, SCOR will collect feedback from representative end users during the Atlas development process.

Time Frame: Current, 1-5 years

Involved Parties: SCOR

Estimated Costs: $150,000 per year

Funding Source: Proposed SCOR budget

DEVELOP A RESILIENCE RESOURCE LIST

Results: The Resilience Resource List will provide a centralized location for communities and other identified audiences to access decision-relevant information and resources.

The South Carolina Office of Resilience will continue to refine and organize the resources found on the Resilience Resources webpage. This list will contain vetted resources that are most needed and relevant to South Carolina.

Time Frame: Resource list currently exists but needs further development and update.

Involved Parties: SCOR will solicit feedback on currently listed tools and resources and ensure these resources are easily accessible on the SCOR website and shared more broadly.

Estimated Costs: $100,000 per year

Funding Source: Proposed SCOR budget

MAINTAIN THE S.C. SEA GRANT CONSORTIUM RESILIENCE PLANNING ARCHIVE

Results: An easy-to-use database cataloging the resilience planning efforts undertaken across the states will inform planning and implementation of projects and allow for cross jurisdictional coordination.

The S.C. Sea Grant Consortium has compiled a comprehensive survey of resilience planning efforts across South Carolina, including state agencies, counties, municipalities, non-governmental organizations, colleges and universities, and private companies. The archive allows for keyword and publication type searches, as well as a place for reports and plans to be submitted. Funding and staffing should be dedicated to maintain this archive as resilience-related planning across the State continues to grow and existing plans are updated. Additional tools and components of the archive may continue to develop including additional sorting categories and integration of regional plans with a South Carolina component, as well as a method to highlight newly included materials or view plans spatially, which would improve statewide and watershed-based coordination.

Time Frame: Currently in place

Involved Parties: SCOR, S.C. Sea Grant Consortium (lead)

Estimated Costs: $20,000 per year

Funding Source: South Carolina Sea Grant Consortium

DEVELOP A RESILIENCE TRAINING/CERTIFICATION PROGRAM

Results: Developing a resilience training and certification program to build community capacity and facilitate local implementation of statewide resilience principles.

SCOR and partners will develop a curriculum of training related to resilience. These trainings will utilize existing training series and sector group meetings and be developed with partners with extensive experience in hosting trainings. This may include but is not limited to groups such as the Municipal Association, SC Association of Counties, Councils of Governments, and other groups depending on the intended audience. Audiences may include local government officials and staff, property owners, citizens, the real estate industry, and others. In addition to providing content, these trainings should incorporate case stories, highlighting successes and challenges, that show the impact of resilience work. To make these trainings most successful, goals, topics, and target audiences will be defined using a needs assessment, and based on that, the best avenues of delivery and content will be developed for different audiences.

Time Frame: Ongoing

Involved Parties: Professional CE/credit organizations, SCOR, LLR, Clemson Extension, S.C. Sea Grant Consortium, DNR Coastal Training Program

Estimated Costs: $150,000 per year

Funding Source: Proposed SCOR budget

DEVELOP A CULTURAL RESOURCES TRAINING FOR DISASTER PLANNING AND RECOVERY

Results: Developing and implementing a cultural resources training will increase the preparedness and reduce the vulnerability of cultural institutions and resources.

The training can include templates that small and independent cultural institutions can use to develop disaster preparedness and recovery plans. Continued dialogue between cultural institutions at all levels of the state and using an adaptive management framework will encourage diverse and creative solutions to resource preservation and conservation challenges. Additional training should target the public so they can be prepared to care for family collections and heirlooms. This recommendation builds on the vulnerability to cultural resources discussed in Chapter 5 (Flood Risk & Vulnerability).

Time Frame: 1-5 years

Involved Parties: SCOR, SCDNR Heritage Trust, SC Department of Archives and History/State Historic Preservation Office, SCEMD, SC PRT, Gullah Geechee Cultural Heritage Corridor NHA, SC African American Heritage Commission, Lowcountry Alliance for Response, Gullah/Geechee Sea Island Coalition, SC Institute for Archaeology and Anthropology, SC State Library, Confederation of SC Local Historical Societies, SC Federation of Museums, Palmetto Archives, Libraries, and Museums Council on Preservation, Other Cultural Institutions, Federal partners

Estimated Costs: To be determined

Funding Source: To be determined

REESTABLISH A FLOOD HAZARD SIGNAGE PROGRAM

Results: Reestablishment of a flood hazard signage program will increase public awareness of flood risks and vulnerabilities, as part of a comprehensive flood hazard education program.

In the past, the Water Resources Commission and SCDNR worked on a floodplain and storm surge signage program. Restarting such a program should be considered, but should be carefully planned, with a defined purpose and strategic locations along with careful considerations of positive and negative implications.

Time Frame: 1-5 years

Involved Parties: County & Municipal Governments, NWS, SCDNR, SCOR, SCEMD

Estimated Costs: To be determined

Funding Source: To be determined

STRENGTHEN HAZARD DISCLOSURE IN REAL ESTATE TRANSACTIONS

Results: Strengthening hazard disclosure in real estate transactions will provide purchasers a more complete knowledge of risk and conditions related to flooding and other natural hazards.

The South Carolina Residential Property Condition Disclosure Act currently requires some level of flood risk disclosure in property sales (see Chapter 7: Current Processes), but efforts should be made to strengthen disclosure procedures in real estate transactions. Recent additions to the SC Residential Property Condition Disclosure Statement have strengthened flood disclosure, but additional edits are needed. While there has been some clarification on the use of “no representation” on the form, which is called for in statute, the presence of this choice in the form has been identified as a potential barrier to accurate disclosure of hazard related information.

Additionally, there are several items found in the form that are not specifically mentioned in the current statute. Therefore, this recommendation considers two points: what should be in the form, and how to get these provisions written into the statute.

In addition to flood risk, there are needed additions regarding coastal issues, and the dynamics of coastal vulnerability. While some of these changes were made in the June 1, 2023 update, it is important to note that some of this information is publicly available but is not all inclusive or all in one place. Therefore, there is a need for a tool such as a website where an address could be entered and returns and a list of all publicly available data about a property, such as any permits and flood zone designations associated with it. The group discussed Louisiana's disclosure form as a useful example for edits to South Carolina's disclosure form.

Time Frame: Current, 1-5 years

Involved Parties: Legislature (Amendment of Residential Property Condition Disclosure Act), South Carolina Real Estate Commission (S.C. Residential Property Condition Disclosure Statement), DHEC OCRM

Estimated Costs: N/A

Funding Source: N/A

WATERSHED-BASED RESILIENCE PLANNING & PROJECTS

In addition to the development, implementation, and maintenance of the Statewide Resilience Plan, the Disaster Relief and Resilience Act charged SCOR with providing technical planning assistance for state and local governmental entities. The Act specifies that the plan should include a strategy for providing resources, technical assistance, and other support to local governments for flood risk reduction efforts.

This recommendation focuses on resilience planning on the watershed scale that will enable the development, implementation, and coordination of resilience projects, programs, and policies on the local level.

The watershed planning process will also provide opportunities for stakeholder input from citizens around the state that will be incorporated into the second edition of the Statewide Resilience Plan. Through this process, data and information gaps that affect the capacity of state agencies or local governments to adequately evaluate and address the factors that increase flood risk may be identified and recommendations for strategies to reduce flood risk will be developed.

SCOR WATERSHED-BASED RESILIENCE PLANNING PROCESS

Results: The watershed-based resilience planning process will result in prioritized projects and strategies, supported by data and community input, that will increase community and watershed resilience and build community capacity to access funding for the implementation of projects.

SCOR will coordinate with communities at the watershed level to identify risk and vulnerability, develop actionable flood mitigation and resilience solutions, and build community capacity by leveraging local, regional, and state partnerships. By considering the principles and data in the Statewide Resilience Plan, and pairing them with local needs assessments, this process will allow for the implementation of projects that meet local needs and consider the impact of potential projects on the larger watershed. The process will enable communities across the watershed to leverage their capacity to access the increase in federal funding that is available to deliver a pipeline of prioritized projects throughout the watershed that do not cause adverse upstream or downstream effects.

Each of the state's eight major watersheds should have a full-time coordinator, who can support local governments to ensure comparable data is collected across and within watersheds, coordinate cross-jurisdictional projects, and serve as the liaison between local communities, SCOR, and other statewide planning efforts.

As part of this process, communities statewide will receive technical assistance to complete the following tasks, resulting in actionable watershed-based resilience plans for each of the State's major river basins.

- Information Gathering, Planning & Community Engagement
  - Collect and organize available information for the watershed
  - Engage the community to identify vulnerabilities and resilience priorities
  - Inventory existing plans
  - Identify and work to fill data gaps
- Community Risk, Vulnerability & Resilience Reports
  - Identify community risks and vulnerabilities
  - Complete top-down (data-driven) and bottom-up (community-driven) resilience assessments
- Recommendations to Improve Watershed-Based Resilience
  - Identify and prioritize projects at local and regional scale
  - Make policy and planning recommendations

The result of this process will be a cohesive watershed-based resilience plan that outlines watershed risk and vulnerability and prioritizes projects and policies for implementation that increase the resilience of the watershed, considering both upstream and downstream impacts.

This process will enable many other recommendations proposed in this chapter, as well as enable communities to meet the new comprehensive planning requirement, develop best management practices, and integrate resilience across multiple planning and implementation processes.

Time Frame: Current, 1-5 years

Involved Parties: SCOR, state agencies, local government, regional governments, citizens, and interest groups.

Estimated Costs: $5,000,000 to complete initial plans for each of the eight basins

Funding Source: To be determined; SCOR has received funding from the National Fish and Wildlife Foundation (NFWF) to complete this process in the Salkehatchie River Basin. SCOR has applied to other grant programs to implement this approach in other watersheds across the State. The Disaster Relief and Resilience Reserve Fund can also be used to complete this process statewide.

ESTABLISH A RESILIENCE GRANT/LOAN PROGRAM UNDER THE DISASTER RELIEF AND RESILIENCE RESERVE FUND (RESERVE FUND) TO IMPLEMENT RECOMMENDATIONS OF THE STATEWIDE RESILIENCE PLAN AND WATERSHED-BASED RESILIENCE PLANNING

Result: A Resilience Grant/Loan Program will enable the implementation of mitigation projects, programs, and policies identified in the statewide resilience plan and watershed-based resilience planning process.

Establishing a Resilience Grant/Loan Program using the Reserve Fund will make funds available to implement projects, programs, and policies identified through watershed-based resilience planning. Projects may be traditional "gray" infrastructure projects such as stormwater systems or flood control structures or "green" infrastructure such as nature based and conservation projects.

Recurring funds should be allocated to the Resilience Grant/Loan Program to ensure that projects, programs, and policies identified through watershed-based resilience planning are implemented in a timely manner.

Time Frame: 1-5 years

Involved Parties: SCOR

Estimated Costs: To be determined

Funding Source: Disaster Relief and Resilience Reserve Fund

INCORPORATE RESILIENCE INTO PLANNING & LAND USE, AND OTHER REGULATORY PROCESSES

The Disaster Relief and Resilience Act calls for recommendations related to land use management, technical planning assistance for state and local government, and integration of recommended approaches into existing state strategies. The Act amended Section 6-29-51(D) by requiring a resilience element in local comprehensive plans (discussed in Chapter 7: Current Processes).

These recommendations not only address the comprehensive plan, but other facets of local planning and the implementation of those plans that occur through zoning and land use policies and procedures.

These recommendations also consider the other types of planning processes occurring across the State (covered in Chapter 7: Current Processes) including hazard mitigation plans and other state planning efforts that relate to resilience, such as drought planning.

In line with the above recommendations related to data, there are several existing data gaps that hinder the ability of local communities to integrate resilience into their land use planning, programs and policies that need to be addressed to improve these planning processes.

COMPLETE STATE AGENCY RESILIENCE REVIEWS

Results: State agency resilience reviews will provide policy and regulatory recommendations to ensure that current and future vulnerabilities are considered across state government.

Section 48-62-40 of the Disaster Relief and Resilience Act sets up the Statewide Resilience Plan Advisory Committee, composed of select state agencies for the development of the plan (see Chapter 1: Introduction). Implementation of the plan will require a whole-of-government approach. Every state agency should designate a resilience liaison to assist with interagency coordination and implementation of the Resilience Plan.

Each agency should conduct a resilience review based on the climate and flood risk and other hazard data presented in this report's vulnerability assessment and make recommendations on policy and regulatory changes that are needed to reduce vulnerabilities. Recommendations on policy and regulatory changes should be submitted to SCOR for inclusion in the second edition of the Strategic Statewide Resilience and Risk Reduction Plan.

Time Frame: 5 years

Involved Parties: All State Agencies

Estimated Costs: To be determined

Funding Source: Each agency should identify resource needs for inclusion in budget requests.

INCREASE REGULATION OF DEVELOPMENT IN FLOOD PRONE AREAS

Results: Increasing regulation of development in flood prone areas will reduce future vulnerabilities and reduce the risk of loss of life and property.

Utilizing best available data, counties and municipalities should adopt policies that restrict new development in flood prone areas, whether or not they are designated by FEMA as a special flood hazard area (described in Chapter 7: Current Processes). Any new structures in flood prone areas should be designed to withstand a 1% flood event over the design life of the structure, considering changes in future conditions.

Time Frame: Current

Involved Parties: Counties, Municipalities

Estimated Costs: To be determined

Funding Source: To be determined

DEVELOP BEST MANAGEMENT PRACTICES FOR COMMUNITIES TO INCORPORATE RESILIENCE INTO COMPREHENSIVE PLANS

Results: Developing best management practices for resilience in comprehensive plans will increase the ability of communities to anticipate, absorb, recover and thrive when presented with environmental changes and natural hazards.

A comprehensive plan is the primary long-range plan adopted by the governing body of a jurisdiction that guides the development of the community and serves as a roadmap to decision making regarding growth and development, public facility investments, regulation of land uses, siting of green space, and economic development initiatives (see Chapter 7: Current Processes). The South Carolina Local Government Comprehensive Planning Enabling Act of 1994 (S.C. Code Ann. § 6-29-310 *et seq*.), which was updated in 2020 by Disaster Relief and Resilience Act, now requires a resiliency element that considers the impact of flooding, high water, and natural hazards on individuals, communities, institutions, businesses, economic development, public infrastructure and facilities, and public health, safety, and welfare.

While resiliency is its own element in a comprehensive plan, vulnerabilities and opportunities for implementation are present in all the plan's elements, and as such the resiliency element should be drafted with that in mind.

SCOR has developed a one-pager, available to the public on the SCOR website, to present the legislative requirements mentioned above (Appendix F).

Beyond best practices, model ordinances that support implementation of the plan through zoning, land use and development regulations may be beneficial in addition to creating funding incentives for communities to develop and implement resilience plans. This analysis will be supported through the statewide watershed-based resilience planning process.

Time Frame: Current

Involved Parties: County, Municipal & Regional (COG) governments, SCAPA, SCOR

Estimated Costs: To be determined

Funding Source: To be determined

PROMOTE RESILIENT DEVELOPMENT THROUGH LOCAL ZONING, LAND USE AND DEVELOPMENT REGULATIONS

Results: Implementation of zoning and land use regulations that incorporate resilience will increase the ability of communities to anticipate, absorb, recover and thrive when presented with environment change and natural hazards.

SCOR will develop best management practices and provide principles that enable communities to develop local strategies to implement resilient policies, aligning with their comprehensive plans, through zoning and land use codes, subdivision regulations, overlay zones, floodplain management, and stormwater ordinances or other tools as described in the Land Development Regulation section of Chapter 7: Current Processes). Since there are large parts of the state that are not currently zoned, these practices will also need to focus on the role of other land-use policies and practices, including but not limited to: cluster development, overlay districts, impervious surface regulations, annexations, closing loop-holes, density bonuses, nature based solutions and conservation, as well as the land development permitting process. These best management practices will provide a flexible toolkit for communities across the state, drawing on examples and lessons learned from communities within South Carolina, such as Charleston's elevation-based zoning and nationwide, such as Norfolk, Virginia's Resilience Quotient.

Time Frame: 1-5 years

Involved Parties: SCAPA, SCOR

Estimated Costs: $100,000 per year

Funding Source: To be determined

WATER SYSTEMS SHOULD INCORPORATE RESILIENCE INTO LONG-RANGE PLANNING

Results: Incorporating resilience into water system planning will ensure that water systems are prepared for future conditions.

Water systems should conduct a resilience review of their water systems based on the climate and flood risk and other hazard data presented in this report's vulnerability assessment. Plans should consider changes in water availability and development patterns. Water systems should coordinate with SCDNR State Climatology Office to update drought response plans. Water systems should plan for redundancies in operations such as the conjunctive use of surface and groundwater to meet long term demand under changing conditions.

Time Frame: Ongoing

Involved Parties: SCDNR, SHEC Office of Rural Water (ORW), Water Systems

Estimated Costs: To be determined

Funding Source: To be determined

DEVELOP LAWS AND REGULATIONS FOR THE PROTECTION OF ISOLATED WETLANDS

Results: Conserving and protecting isolated wetlands will maintain the current level of flood mitigation and ecosystem services.

The May 25, 2023, U.S. Supreme Court decision in *Sackett v. Environmental Protection Agency*, 598 U.S. ___held that only wetlands that are connected to other surface waters are regulated under Section 404 of the Clean Water Act. It states EPA Clean Water Act regulated wetlands are limited to only those areas that have a "...continuous surface water connection with a larger body of water." The decision puts some of South Carolina's unique isolated wetlands features such as Carolina Bays at risk of unregulated development. There is currently no state-level legislation to protect isolated wetlands. Isolated wetlands, such as Carolina Bays, offer habitat and flood mitigation in South Carolina. A majority are in the coastal zone where populations are increasing and therefore at an increased risk of loss to development. New state legislation should be enacted to regulate the alteration of these unique systems to reduce the potential loss of function.

Time Frame: 1-5 years

Involved Parties: SC Legislature

Estimated Costs: N/A

Funding Source: N/A

MAINTAIN AND STRENGTHEN BUILDING CODES

The Disaster Relief and Resilience Act requires SCOR to consider alterations to state building codes. In South Carolina, building codes are adopted at the state level, with a modification and adoption process that follows a regular schedule. This process is outlined in Chapter 7: Current Processes, under the Absorb section. The following recommendations consider the Residential, Commercial and Energy Codes.

MAINTAIN UPDATED BUILDING CODES

Results: Maintaining the current building code update schedule will ensure our codes incorporate the latest information and best practices to increase resilience.

South Carolina has an on-schedule code modification and adoption process following the update of the International Code, which is updated every three years. South Carolina should maintain this schedule for both the Residential and Commercial codes to keep up with reasonable standards of construction for public health, safety, and welfare.

Time Frame: Ongoing

Involved Parties: Building Codes Council, International Codes Council (ICC), SC Department of Insurance, SC Department of Labor, Licensing, and Regulation (LLR)

Estimated Costs: To be determined

Funding Source: To be determined

REDUCE MODIFICATIONS TO BUILDING CODES THAT REDUCE HAZARD RESILIENCE

Results: Reducing modifications to the International Codes will ensure our codes incorporate the latest information and best practices to increase resilience.

South Carolina currently modifies the International Codes, including requirements related to hurricane and seismic maps. The State should not make modifications to the International Codes that reduce resilience. For more information on this, please see the Current Processes chapter, which includes maps of the areas identified by FEMA as having a weakened code.

Time Frame: Ongoing

Involved Parties: Building Codes Council, ICC, SC LLR

Estimated Costs: To be determined

Funding Source: To be determined

DEVELOP PROFESSIONAL EDUCATION PROGRAMS RELATED TO BUILDING CODES

Results: Development of professional education program related to building codes will ensure that practitioners are trained on the most up-to-date practices and technologies to increase resilience.

Innovations are being made on a regular basis to increase resilience as it applies to planning, design, and construction. However, these innovations are only put into practice if professionals are kept up to date on the latest technology, products, and methods.

South Carolina requires licensing of general contractors, mechanical contractors, residential builders, and residential specialty trade contractors, but does not mandate continuing education for renewal of licenses in any category. SCOR recommends LLR develop continuing education opportunities to ensure that contractors can remain current on using new materials and techniques and investigate whether a continuing education requirement is needed.

Architecture school curriculums currently provide limited education to students on building codes. Clemson University's School of Architecture is the only National Architectural Accrediting Board accredited program in South Carolina. Courses on building codes, that are important to consider in design, should be built into their curriculum. Such education should be supported through the continuing education requirements pursuant to SC Code of Regulations, §11-8.1 as well. Additionally, code education should be built into the professional development curriculum for engineers, as pursuant to SC Code §49-600.

Time Frame: 1-5 years

Involved Parties: Accreditation and Licensing Organizations, Building Officials Association of South Carolina, Education Providers, IBHS, South Carolina Association for Hazard Mitigation

Estimated Costs: To be determined

Funding Source: To be determined

EVALUATE ENERGY CODE STANDARDS

Results: An evaluation of energy code standards will allow for a more complete understanding of how utilization of the 2009 Energy Code impacts the resilience of the electric grid.

The SC Energy Standard Act adopts the 2009 edition of the International Energy Conservation Code as the Energy Standard with which all new and renovated buildings and additions constructed within the state must comply. This code is not part of the normal code adoption process, and future versions must be adopted by statutory amendment. While SC is still using the 2009 edition, the ICC has released several updates to the International Energy Conservation Code, most recently in 2021.

Steps should be taken to assess the impacts that updating the state's energy standard to a newer code might have. This assessment should include how an update the code could impact the resilience of the power grid in the state and consider both the costs of construction and operation of buildings as well as the impacts on public health, safety, and welfare.

Time Frame: 1-5 years

Involved Parties: South Carolina Department of Commerce, South Carolina Energy Office

Estimated Costs: To be determined

Funding Source: To be determined

UTILIZE MOST CONSERVATIVE WIND ZONE MAP

Results: Utilization of the most conservative wind zone map will ensure that structures can withstand projected wind speeds.

The SC Building Codes Council approved county level wind maps for the 2021 code cycle based on the 2015 International Residential Code. These maps determine the boundaries for wind design in South Carolina for single- and two-family dwellings.

In cases where there is a question of which side of the wind boundary a property is on, the higher of the two requirements should be used.

Time Frame: 1-5 years

Involved Parties: Building Codes Council

Estimated Costs: To be determined

Funding Source: To be determined

CLARIFY SCORING CRITERIA FOR ISO PROCESS

Results: Clarifying the scoring criteria for the Building Code Effectiveness Grading Schedule will allow building officials to adopt best practices to improve their scores.

Building code officials need more guidance on how to fill out the reports and more education on how they will be scored. Coordination is needed between ISO and building code officials to ensure officials understand how they will be scored and how to accurately complete their reports. Support and coordination are also needed to ensure officials understand where they may have lost points so that they can take actions to improve their score.

Time Frame: 1-5 years

Involved Parties: Building Officials Across the State, Building Officials Association of South Carolina, ISO, SCEMD

Estimated Costs: To be determined

Funding Source: To be determined

INCORPORATE RESILIENCE INTO INFRASTRUCTURE DESIGN, CONSTRUCTION, AND MAINTENANCE

Infrastructure, especially stormwater infrastructure, is a major component of flood mitigation and resilience. The following recommendations focus on infrastructure design, with a focus on stormwater and critical infrastructure.

These recommendations should be used for infrastructure projects.

CONSIDER FUTURE CONDITIONS FOR CRITICAL INFRASTRUCTURE DESIGN

Results: Designing and building critical infrastructure considering future conditions ensures that infrastructure will be able to withstand hazards they are likely to encounter during their design life.

Critical infrastructure can be defined as those assets, systems, and facilities that communities rely upon for everyday health, safety and welfare and lifeline functions. This can include anything from transportation systems to facilities that provide clean water and electricity to communities. The benefits of diversification of assets such as multi-modal transportation system design, conjunctive use of surface and groundwater, and a distributed electrical grid should be considered. SCOR recognizes the need to ensure a balanced approach to resilience that considers economic and environmental needs. Therefore, for the design of critical infrastructure, project-specific factors, such as the consequences of failure, current and future economic feasibility, and environmental impacts may warrant the use of higher or lower design standards.

To understand said future conditions, SCOR worked with SCDNR State Climatology Office, S.C. Sea Grant, and the University of South Carolina's Carolinas Integrated Sciences and Assessments (CISA) program to generate a report that includes an analysis of South Carolina's observed climate record, translation of model output into future state-level climate projections, and synthesis of relevant peer-reviewed research.

Time Frame: Ongoing

Involved Parties: All levels of government

Estimated Costs: To be determined

Funding Source: To be determined

REVIEW OF STORMWATER INFRASTRUCTURE DESIGN REGULATIONS

Results: Reviewing and updating stormwater infrastructure design regulations will ensure that infrastructure will be able to withstand hazards they are likely to encounter during their design life.

Current stormwater infrastructure design is a result of federal, state and local regulations. This is discussed in Chapter 7: Current Processes.

Much of the stormwater infrastructure statewide uses a 10-year, 24-hour storm event per the State of South Carolina Regulation 72-300 through 72-316: Standards for Stormwater Management and Sediment Reduction. A regulatory review identifying project-specific factors, such as the consequences of failure, current and future economic feasibility, and environmental impacts should be conducted. Based on the outcome, higher design standards may be warranted.

South Carolina Code Annotated §48-14-40 provides provisions for certain land-disturbing activities to be exempt from the provisions of the Act. These include most agricultural activities, as well as mining, and the construction of individual single-family residences. These exemptions should be reviewed to gain a greater understanding of their potential impacts.

While the above Act and regulations provide minimum standards, guidelines, and criteria, local governments are responsible for implementing local stormwater management programs and may establish stormwater utilities. A comprehensive inventory of existing stormwater regulations across local governments is needed.

An analysis of the current implementation of watershed master plans under §48-14-130 of The Stormwater Management and Sediment Reduction Act should also be conducted.

Long-term cost of natural infrastructure can be lower than gray infrastructure, even if the up front is higher. There are also other benefits to natural infrastructure that can support outdoor recreation/habitat, etc. State and local regulation and planning should identify and remove barriers to permitting nature-based solutions.

Time Frame: Ongoing

Involved Parties: DHEC, Local Governments, MS4s, and Stormwater Utilities

Estimated Costs: To be determined

Funding Source: To be determined

IDENTIFY FUNDING SOURCE FOR MAINTENANCE OF INFRASTRUCTURE PROJECTS

Results: Identifying funding sources for maintenance of infrastructure projects prior to construction will ensure that they function properly over the intended life of the project.

SCOR has identified, through conversations with state and local government agencies and community stakeholders have identified lack of maintenance as a major cause of failure of infrastructure. Current federal, state, and local funding sources often do not allow for maintenance costs, therefore funding sources for infrastructure maintenance should be identified.

Time Frame: Ongoing

Involved Parties: Entities responsible for infrastructure

Estimated Cost: To be determined

Funding Source: To be determined

INCORPORATE RESILIENCE INTO PORT INFRASTRUCTURE PLANNING

Results: Incorporating resilience into port infrastructure planning will ensure that the port is able to anticipate, absorb, recover, and thrive when presented with environmental change and natural hazards.

Port infrastructure is a critical asset during the disaster recovery period. The future conditions identified in the climate and vulnerability sections of this report should be considered in planning and port infrastructure investments. When identified, investments that increase the resilience of the port infrastructure and operations should be prioritized.

Time Frame: Ongoing

Involved Parties: SC Ports Authority

Estimated Costs: TBD

Funding Source: TBD

MAINTAIN NATURAL PROTECTION THROUGH CONSERVATION

DEVELOP A PRIORITY FLOOD MITIGATION CONSERVATION MAP

Results: Development of a priority flood mitigation conservation map will allow the state to maximize flood protection from conservation dollars spent.

The landscape is the first line of defense for flood hazard mitigation as undeveloped lands provide the essential ecosystem services of water infiltration and stormwater conveyance.

SCOR has used a combination of public and private datasets to better understand the landscape's role in flood mitigation across South Carolina. This data model is targeted at identifying areas where floodwaters are expected, where wetlands can help absorb excess water, and those areas where water is most likely to infiltrate the ground as opposed to creating excess runoff. Protecting these areas may help attenuate the impact that future development has on South Carolina's population. Alternatively, developing these areas could amplify upstream and downstream communities' flooding risks. An in-depth methodology and maps are available in Appendix G.

SCOR will promote the use of this model with partner agencies when evaluating potential land acquisitions as well as use this as a tool to demonstrate to communities the landscape's role in flooding. SCOR will also work to ensure local governments are aware of the availability of the model for the development of comprehensive plans and zoning and land use decision making. Conservation layers will also be available in the coming Resilience Atlas.

Time Frame: Ongoing

Involved Parties: SCOR, SC Conservation Bank, SCDNR, South Carolina Forestry Commission (SCFC), South Carolina Parks, Recreation, and Tourism (SCPRT), local governments, land trusts

Estimated Costs: N/A

Funding Source: N/A

DEVELOP A GRANT PROGRAM TO COMPLETE LAND ACQUISITIONS THAT MAXIMIZE FLOOD REDUCTION BENEFITS

Results: Development of a grant program allows for implementation of the Priority Flood Mitigation Conservation Map.

Pending funding availability from state or federal sources, SCOR will establish a grant program for state and local governments and non-profits to acquire properties so that natural flood reductions benefits can be maintained. Potential criteria for grant awards may include:

- Property's location relative to SCOR's Conservation Priority Areas.
- If the property is currently available for purchase.
- If the property meets requirements set forth by the funding source and/or authorizing act.
- Whether there is an identified entity willing and able to hold the land in a way that preserves or enhances the property's long-term flood mitigation characteristics and maintains public access.
- If the property provides conservation values beyond flood mitigation, such as those areas identified by the SC Conservation Bank.
- Priority will be given to properties that face development pressure or land use change that would reduce the flood mitigation characteristics.
- Priority will be given to those areas that have unique landforms or critical habitats, or offer cultural significance.
- Priority will be given to projects that leverage funds from additional state and external sources.
- If the property provides co-benefits identified by federal, state or local partners.

Time Frame: Ongoing

Involved Parties: SCOR, SC Conservation Bank, SCDNR, SCFC, SCPRT, DHEC, SC Department of Agriculture, local governments

Estimated Costs: To be determined

Funding Source: Disaster Relief and Resilience Reserve Fund, other state and federal funds

INCORPORATE RESILIENCE INTO HOUSING RECOVERY

Any future disaster recovery and mitigation action plans, policies, and procedures developed for the State should refer to the principles of the Strategic Statewide Resilience and Risk Reduction Plan. Additionally, the recommendations below will increase the resilience of housing to future disasters. These recommendations are informed by the Recover section of Chapter 7 of this plan, Current Processes, which outlines how federal disaster recovery assistance flows to the state and communities and is managed at the state level.

REDUCE USE OF MANUFACTURED HOUSING UNITS

Results: Replacement of manufactured homes with stick built or modular homes will increase the ability of the housing stock to absorb the impacts of future natural hazards.

Housing recovery plans should state that, where possible, manufactured housing units needing full replacement should be replaced with stick built or modular homes. Exceptions can be made when it is not possible or practical to replace a manufactured home with a stick built or modular home.

Time Frame: Ongoing

Involved Parties: SCOR

Estimated Costs: To be determined

Funding Source: State and federal disaster recovery funds

UTILIZE WIND/IMPACT WINDOWS

Results: Using wind/impact windows will increase the ability of the housing stock to absorb the impacts of future natural hazards.

Impact windows should be used when homes are repaired or replaced following a disaster, regardless of the wind zone the home is located in. Exceptions can be made to meet federal, state, or local requirements.

Time Frame: Ongoing

Involved Parties: SCOR

Estimated Costs: To be determined

Funding Source: State and federal disaster recovery funds

INCREASE HOUSING ELEVATION STANDARDS

Results: Increasing housing elevation standards will reduce structures' exposure to flood waters.

In areas that are prone to flooding, require replacement homes to have a first-floor elevation built to Base Flood Elevation (BFE) +3 feet. If this requirement would cause the home's first floor elevation to be elevated above 10 feet above land surface, the home would be recommended for replacement and would instead be offered a voluntary buyout. The property would then have a building restriction attached to the deed thereby preventing future development.

Time Frame: Ongoing

Involved Parties: SCOR

Estimated Costs: To be determined

Funding Source: State and federal disaster recovery funds

RESTRICT USE OF DISASTER RECOVERY FUNDS FOR REPAIR OR REPLACEMENT OF HOMES IN FLOOD PRONE AREAS

Results: Restricting the use of disaster recovery funds for the repair or replacement of homes in flood prone areas will reduce the risk of future losses.

Housing funds allocated to South Carolina should not be used to repair or construct homes if they are:

- A FEMA Repetitive Loss Property
- Properties in the FEMA Regulatory Floodway
- Properties seaward of DHEC-OCRM Setback Line

Time Frame: Ongoing

Involved Parties: SCOR

Estimated Costs: To be determined

Funding Source: State and federal disaster recovery funds

ESTABLISH A VOLUNTARY PRE-DISASTER BUYOUT PROGRAM

Results: Establishment of a voluntary pre-disaster buyout program will allow the state to be proactive rather than reactive to reduce the risk of future losses.

The Disaster Relief and Resilience Act requires SCOR to develop an estimate of the current number and cost of residential properties within the State for which a buyout may be appropriate. The following criteria were used to develop this estimate and are proposed for the prioritization of the properties under a pre-disaster buyout program:

- Tier 1: Repetitive Loss Properties in the FEMA Regulatory Floodway & Repetitive Loss Properties Seaward of the DHEC Beachfront Setback Line
- Tier 2: Properties in the FEMA Regulatory Floodway & Properties Seaward of the DHEC Beachfront Baseline
- Tier 3: All Other Repetitive Loss Properties
- Tier 4: First Street "100-Year" Event (Current) with 6+ feet of inundation
- Tier 5: First Street "100-Year" Event (Future) with 6+ feet of inundation

Additional details of SCOR's estimate can be found in Appendix H.

Developing a voluntary buyout program would require a more detailed analysis and eligibility of individual properties and property owners and would be ultimately determined by the funding source and require collaboration with communities.

Time Frame: Ongoing

Involved Parties: SCOR, participating communities

Estimated Costs: To be determined

Funding Source: To be determined

IDENTIFY AND MAXIMIZE ALL AVAILABLE FUNDING SOURCES FOR RESILIENCE ACTIVITIES

SCOR seeks to maximize federal and non-federal funding to South Carolina to implement resilience planning, projects, programs, and policies. This will require coordination, collaboration, and cooperation among state agencies, local and regional governments, non-profits, special purpose districts, and tribal governments.

As noted throughout this plan, resilience covers a wide range of natural and human systems, requiring coordination between stakeholders that have not traditionally worked together.

Collaboration is essential as federal and non-federal sources require recipients to incorporate resilience practices into their projects. Coordination requires the sharing of information and alignment of efforts to encourage organizations to work outside their traditional boundaries, reduce duplication of effort, and maximize benefits. SCOR will operate as a resilience hub to advance resilience initiatives while coordinating with other groups to increase resilience statewide.

More information about funding related to resilience, including sources and current processes specific to the State and SCOR can be found in Chapter 8: Funding.

DEVELOP A RESILIENCE FUNDING HUB

Results: Developing a resilience funding hub will enable coordination, collaboration, and cooperation among state agencies, local and regional governments, non-profits, special purpose districts, and tribal governments seeking resilience funding.

Coordinating and obtaining grant funds will further resilience efforts statewide and locally. SCOR recognizes the challenge that many local governments may have in seeking, applying for, and managing funds.

SCOR seeks to support communities by creating the Resilience Funding Hub to collect, coordinate and disseminate information related to funding. The hub, maintained as a web-based portal by SCOR, will provide a better understanding of aspects of funding opportunities. In addition, the hub can be used to highlight how funding sources were utilized for successful resilience projects.

Coordination, collaboration, and cooperation among state agencies is a continued need to implement resilience-related projects, programs, and policies. This coordination should continue to occur with an emphasis on funding coordination including what agencies are pursuing what funding and share opportunities and discuss partnering on them. This coordination would require a staff person at SCOR who interfaces with all state agencies on how to ensure resilience is addressed and implemented.

Time Frame: Ongoing

Involved Parties: SCOR, All relevant state and local agencies

Estimated Costs: $150,000 per year

Funding Source: To be determined

DEVELOP BEST MANAGEMENT PRACTICES FOR COMMUNITIES TO INCORPORATE RESILIENCE INTO FUNDING PROGRAMS AND PROJECTS

Results: Developing best management practices will enable communities to incorporate resilient practices in a range of programs and projects.

Many federal and non-federal funding sources require that grant applications and projects incorporate resilient practices. SCOR will develop best management practices on how communities can incorporate resilience into programs and projects. Best management practices will be made available through SCOR's Resilience Hub.

Time Frame: 1-5 years

Involved Parties: SCOR

Estimated Costs: To be determined

Funding Source: To be determined

APPENDIX A:
DISASTER RELIEF AND RESILIENCE ACT

South Carolina General Assembly
123rd Session, 2019-2020

A163, R153, S259

STATUS INFORMATION

General Bill
Sponsors: Senators Goldfinch, Campsen, Kimpson, Senn and Campbell
Document Path: l:\council\bills\rt\17500cz19.docx
Companion/Similar bill(s): 3083

Introduced in the Senate on January 8, 2019
Introduced in the House on March 21, 2019
Last Amended on September 23, 2020
Passed by the General Assembly on September 23, 2020
Governor's Action: September 29, 2020, Signed

Summary: SC Resilience Revolving Fund Act

HISTORY OF LEGISLATIVE ACTIONS

Date	Body	Action Description with journal page number
12/12/2018	Senate	Prefiled
12/12/2018	Senate	Referred to Committee on **Agriculture and Natural Resources**
1/8/2019	Senate	Introduced and read first time (Senate Journal-page 156)
1/8/2019	Senate	Referred to Committee on **Agriculture and Natural Resources** (Senate Journal-page 156)
3/5/2019	Senate	Committee report: Favorable with amendment **Agriculture and Natural Resources** (Senate Journal-page 15)
3/6/2019		Scrivener's error corrected
3/19/2019	Senate	Committee Amendment Adopted (Senate Journal-page 17)
3/19/2019	Senate	Amended (Senate Journal-page 17)
3/19/2019	Senate	Read second time (Senate Journal-page 17)
3/19/2019	Senate	Roll call Ayes-44 Nays-1
3/20/2019		Scrivener's error corrected
3/20/2019	Senate	Read third time and sent to House (Senate Journal-page 14)
3/21/2019	House	Introduced and read first time (House Journal-page 4)
3/21/2019	House	Referred to Committee on **Labor, Commerce and Industry** (House Journal-page 4)
3/27/2019	House	Recalled from Committee on **Labor, Commerce and Industry** (House Journal-page 24)
3/27/2019	House	Committed to Committee on **Ways and Means** (House Journal-page 24)
9/15/2020	House	Committee report: Favorable with amendment **Ways and Means** (House Journal-page 64)
9/22/2020	House	Requests for debate-Rep(s). Hill, Thayer, Calhoon, White, Toole, Wooten, Caskey, Martin, Hixon, Magnuson, Burns, Haddon, Trantham, and Ott (House Journal-page 30)
9/22/2020	House	Requests for debate removed-Rep(s). Ott, Thayer, Calhoon, Caskey, Wooten, Martin, Hixon, Trantham, Burns, and Haddon (House Journal-page 57)
9/22/2020	House	Amended (House Journal-page 57)
9/23/2020	Senate	Free conference powers granted
9/22/2020	House	Read second time (House Journal-page 57)
9/22/2020	House	Roll call Yeas-65 Nays-35 (House Journal-page 57)

9/23/2020		Scrivener's error corrected
9/23/2020	House	Read third time and returned to Senate with amendments (House Journal-page 7)
9/23/2020	Senate	Non-concurrence in House amendment (Senate Journal-page 110)
9/23/2020	Senate	Roll call Ayes-0 Nays-42 (Senate Journal-page 110)
9/23/2020	House	House insists upon amendment and conference committee appointed Reps. GM Smith, Crawford, and Stavrinakis (House Journal-page 66)
9/23/2020	Senate	Conference committee appointed Goldfinch, Climer, Sabb (Senate Journal-page 112)
9/23/2020	House	Free conference powers granted (House Journal-page 85)
9/23/2020	House	Free conference committee appointed GM Smith, Crawford, and Stavrinakis (House Journal-page 65)
9/23/2020	House	Free conference report adopted (House Journal-page 87)
9/23/2020	Senate	Free conference powers granted (Senate Journal-page 112)
9/23/2020	Senate	Free conference committee appointed Goldfinch, Climer, Sabb (Senate Journal-page 112)
9/23/2020	Senate	Free conference report received and adopted (Senate Journal-page 112)
9/23/2020	Senate	Roll call Ayes-41 Nays-0 (Senate Journal-page 112)
9/23/2020	Senate	Ordered enrolled for ratification (Senate Journal-page 129)
9/25/2020		Ratified R 153
9/29/2020		Signed By Governor
10/7/2020		Effective date 09/29/20
10/7/2020		Act No. 163

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VERSIONS OF THIS BILL

12/12/2018
3/5/2019
3/6/2019
3/19/2019
3/20/2019
9/15/2020
9/22/2020
9/23/2020
9/23/2020-A

(A163, R153, S259)

AN ACT TO AMEND THE CODE OF LAWS OF SOUTH CAROLINA, 1976, BY ADDING CHAPTER 62 TO TITLE 48 SO AS TO ESTABLISH THE SOUTH CAROLINA OFFICE OF RESILIENCE, TO DEVELOP, IMPLEMENT, AND MAINTAIN A STATEWIDE RESILIENCE PLAN AND TO COORDINATE STATEWIDE RESILIENCE AND DISASTER RECOVERY EFFORTS, TO PROVIDE THAT A CHIEF RESILIENCE OFFICER SHALL GOVERN THE OFFICE, TO ESTABLISH THE STATEWIDE RESILIENCE PLAN ADVISORY COMMITTEE, TO TRANSFER THE SOUTH CAROLINA DISASTER RECOVERY OFFICE TO THE SOUTH CAROLINA OFFICE OF RESILIENCE, AND TO CREATE THE DISASTER RELIEF AND RESILIENCE RESERVE FUND TO FUND THE STATEWIDE RESILIENCE PLAN, DISASTER RELIEF ASSISTANCE, AND HAZARD MITIGATION AND INFRASTRUCTURE IMPROVEMENTS, TO ESTABLISH THE SOUTH CAROLINA RESILIENCE REVOLVING FUND TO PROVIDE LOW INTEREST LOANS TO PERFORM FLOODED-HOME BUYOUTS AND FLOODPLAIN RESTORATION; AND TO AMEND SECTION 6-29-510, RELATING TO COMPREHENSIVE PLANS OF LOCAL PLANNING COMMISSIONS, SO AS TO REQUIRE LOCAL COMPREHENSIVE PLANS TO INCLUDE A RESILIENCE ELEMENT.

Be it enacted by the General Assembly of the State of South Carolina:

Office of Resilience, Resilience Revolving Fund created

SECTION 1. A.Title 48 of the 1976 Code is amended by adding:

“CHAPTER 62

Disaster Relief and Resilience Act

Article 1

South Carolina Office of Resilience

Section 48-62-10. As used in this article:
(1) ‘Fund’ means the Disaster Relief and Resilience Reserve Fund.

(2) 'Office' means the South Carolina Office of Resilience.

Section 48-62-20. (A) There is created the South Carolina Office of Resilience. The office shall develop, implement, and maintain the Statewide Resilience Plan and shall coordinate statewide resilience and disaster recovery efforts, including coordination with federal, state, and local governmental agencies, stakeholders, and nongovernmental entities.

(B) Additionally, the South Carolina Disaster Recovery Office as established by Executive Order 2016-13 and included within the South Carolina Department of Administration by Executive Order 2018-59 is transferred to, and incorporated into, the South Carolina Office of Resilience.

(C) The office shall be governed by a Chief Resilience Officer who shall be appointed by the Governor, with the advice and consent of the Senate. The Chief Resilience Officer shall serve at the pleasure of the Governor.

Section 48-62-30. To coordinate and strengthen efforts to reduce losses from future disasters across the State, the office shall develop, implement, and maintain a strategic Statewide Resilience Plan, which must include, but is not limited to:

(1) development and implementation of a Strategic Statewide Resilience and Risk Reduction Plan, which shall be developed in accordance with the principles recommended in the South Carolina Floodwater Commission Report and shall serve as framework to guide state investment in flood mitigation projects and the adoption of programs and policies to protect the people and property of South Carolina from the damage and destruction of extreme weather events. This plan shall be reviewed and revised at appropriate intervals determined by the Chief Resilience Officer and advisory agencies to assure that it continues to serve the health, safety, and welfare of the citizens of South Carolina over time. An initial version of this plan shall be completed by July 1, 2022, and shall, at minimum, include provisions that:

(a) describe known flood risks for each of the eight major watersheds of the State, as delineated in the Department of Health and Environmental Control's South Carolina Watershed Atlas;

(b) for each major watershed, examine present and potential losses associated with the occurrence of extreme weather events and other natural catastrophes in this State, and land management practices that potentiate extreme weather events, resulting in increased flooding, wildfires, and drought conditions;

(c) for each major watershed, identify data and information gaps that affect the capacity of state agencies or local governments to adequately evaluate and address the factors that increase flood risk, and recommend strategies to overcome such gaps;

(d) develop recommendations, at appropriate scale, including subwatershed or local governmental levels, to decrease vulnerabilities and adverse impacts associated with flooding. In developing these recommendations, the office shall, at a minimum, consider the following:

(i) the economic impact of best available projections related to the current and future risk of extreme weather events in this State including, but not limited to, the impact on forestry, agriculture, water, and other natural resources, food systems, zoning, wildlife, hunting, infrastructure, economic productivity and security, education, and public health;

(ii) the long-term costs, including ongoing operation and maintenance costs of specific projects or suites of flood mitigation projects and approaches;

(iii) opportunities to prioritize the role of nature-based solutions and other methods to restore the natural function of the floodplain;

(iv) possible cobenefits that may be achieved beyond flood reduction including, but not limited to, enhanced water supply, improvements in water quality, tourism and recreational opportunities, or protection of wildlife and aquatic resources;

(v) statutory or regulatory remedies for consideration by the General Assembly;

(vi) necessary state policies or responses, including alterations to state building codes and land use management, creation of additional programs or offices and directions for the provision of clear and coordinated services and support to reduce the impact of natural catastrophes and extreme weather events and increase resiliency in this State; and

(vii) potential financial resources available for increasing resiliency throughout the State;

(e) estimates of the number and cost of residential properties within the State for which a floodplain buyout may be appropriate;

(f) a strategy for providing resources, technical assistance, and other support to local governments for flood risk reduction action;

(g) plans for integrating recommended approaches to risk reduction into existing state strategies for hazard mitigation, environmental protection, and economic opportunity and development;

(h) opportunities for stakeholder input from citizens around the State;

(2) coordination of statewide disaster recovery efforts and activities and collaboration between federal, state, and local stakeholders;

(3) technical planning assistance for state and local governmental entities; and

(4) grants to institutions of higher education and other state and local governmental entities to conduct research related to resilience concerns specific to South Carolina.

Section 48-62-40. (A) To aid in the development of the Statewide Resilience Plan, there is created the Statewide Resilience Plan Advisory Committee. The committee must be composed of:

(1) the Director of the Department of Natural Resources, or his designee;

(2) the Director of the Department of Insurance, or his designee;

(3) a representative of the South Carolina Disaster Recovery Office appointed by the Chief Resilience Officer;

(4) the Commissioner of Agriculture, or his designee;

(5) the Director of the South Carolina Emergency Management Division, or his designee;

(6) the Executive Director of the Sea Grant Consortium, or his designee; and

(7) the Secretary of the Department of Commerce, or his designee.

(B) In addition to the members set forth in subsection (A), the Chief Resilience Office may add members to the advisory board as he deems necessary and proper. All governmental agencies must cooperate with the advisory board to fulfill its mission.

Section 48-62-50. There is created in the State Treasury the Disaster Relief and Resilience Reserve Fund, which shall be separate and distinct from the general fund and all other reserve funds. Funds appropriated to the fund only may be used to develop, implement, and maintain the Statewide Resilience Plan, and for disaster relief assistance, hazard mitigation, and infrastructure improvements as set forth in this article. Interest accrued by the fund must remain in the fund and unexpended funds must be retained and carried forward to be used for the same purposes.

Section 48-62-60. (A) Following a federally declared disaster, the Disaster Relief and Resilience Reserve Fund may make available immediate disaster relief assistance to aid resilient rebuilding in affected communities with significant unmet needs. For purposes of this section, disaster relief assistance includes, but is not limited to:

(1) financial assistance to state and local governmental entities to provide the nonfederal share for federal disaster assistance programs;

(2) infrastructure repairs for homeowners and communities that are not eligible for Community Development Block Grant - Disaster Recovery and other federal funding assistance;

(3) loans and grants to local governments in disaster areas that need immediate cash flow assistance;

(4) grants to governmental entities and organizations exempt from federal income tax under Section 501(c)(3) of the Internal Revenue Code to repair or replace infrastructure or equipment damaged as a result of a natural disaster; and

(5) financial assistance for verifiable losses of agricultural commodities due to a natural disaster.

(B) Activities completed using disaster relief assistance from the fund shall account for future risks and hazard exposure in order to rebuild in a manner that will reduce the exposure of the community to future hazards and reduce future losses, consistent with the implementation of the Statewide Resilience Plan.

(C) In order to qualify for disaster relief assistance, eligible fund recipients must apply to the office and meet all criteria set forth by the office.

Section 48-62-70. (A) To satisfy the purposes of removing residents from hazard areas, safeguarding property, and restoring the natural function of the floodplain, the Disaster Relief and Resilience Reserve Fund may be allocated to enable hazard mitigation and infrastructure improvements through loans and through a competitive grant process administered by the office. For purposes of this section, hazard mitigation and infrastructure improvements include, but are not limited to:

(1) mitigation buyouts, relocations, and buyout assistance for homes, including multifamily units, not covered by the Hazard Mitigation Grant Program;

(2) gap funding related to buyouts in order to move residents out of floodplain hazard areas and restore or enhance the natural flood-mitigation capacity of functioning floodplains;

(3) assistance to low- and moderate-income homeowners to help lower flood risk through flood insurance, structural and nonstructural mitigation projects, or other means;

(4) loans and grants to state and local governmental entities for hazard mitigation and infrastructure improvement projects; and

(5) approved mitigation projects identified in local post-disaster recovery plans created and adopted prior to a disaster.

(B) Upon its creation, funding priority must be given to projects identified by the Statewide Resilience Plan or local hazard mitigation plans.

(C) In approving financial assistance for hazard mitigation and infrastructure improvement projects, the office shall ensure that selected projects are in compliance with requirements of the National Flood Insurance Program or any more stringent requirements adopted by a local government and shall give priority to projects which offer enhanced protection from future flood events or which utilize or incorporate natural features to achieve protections. Funds may not be used for projects which, rather than lowering risks overall, increase the flood vulnerabilities of neighboring areas.

(D) In order to qualify for hazard mitigation and infrastructure improvement grants and loans, eligible fund recipients must apply to the office and meet all criteria set forth by the office.

Article 3

South Carolina Resilience Revolving Fund

Section 48-62-310. As used in this article:

(1) 'Authority' means the South Carolina Disaster Recovery Office within the South Carolina Office of Resilience.

(2) 'Conservation easement' means an interest in real property as defined in Chapter 8, Title 27, the South Carolina Conservation Easement Act of 1991.

(3) 'Eligible fund recipient' means:

(a) the State of South Carolina and any agency, commission, or instrumentality of the State;

(b) local governments of the State and any agency, commission, or instrumentality of the local government; and

(c) land trusts operating within the State accredited by the Land Trust Accreditation Commission, an independent program of the Land Trust Alliance that provides independent verification that land trusts meet the high standards of land conservation, stewardship, and nonprofit management in the nationally recognized Land Trust Standards and Practices.

(4) 'Floodplain restoration' means any activity undertaken to reestablish the hydrology and ecology of the floodplain to its natural state.

(5) 'Fund' means the South Carolina Resilience Revolving Fund.

(6) 'Loan' means a loan from the authority to an eligible fund recipient for the purpose of financing all or a portion of the cost of a project.

(7) 'Loan agreement' means a written agreement between the authority and a project sponsor with respect to a loan.

(8) 'Loan obligation' means a bond, note, or other evidence of obligation issued by a project sponsor to evidence its indebtedness under a loan agreement with respect to a loan.

(9) 'Local government' means any county, city, town, municipal corporation, authority, district, commission, or political subdivision created by the General Assembly or established pursuant to the laws of this State.

(10) 'Multifamily residence' means a building with multiple separate residential housing units.

(11) 'Office' means the South Carolina Office of Resilience.

(12) 'Primary single-family residence' means a single detached dwelling that is occupied as the main home by the owners for the majority of the year.

(13) 'Proposed project' means a plan submitted to the authority by an eligible fund recipient for the use of loan funds.

(14) 'Repetitive loss' means a residence that sustained two or more incidents of weather-related flooding causing damages over one thousand dollars each within a period of ten consecutive years.

(15) 'Restrictive covenant' means a recorded covenant that imposes activity and use limitations on real property.

Section 48-62-320. There is created the South Carolina Resilience Revolving Fund. The fund is governed by the authority. The authority is a public instrumentality of this State, and the exercise by it of a power conferred in this article is the performance of an essential public function. The Director and staff of the South Carolina Disaster Recovery Office comprise the authority, under the supervision and review of the Chief Resilience Officer and the Governor.

Section 48-62-330. (A) With regard to the fund, the authority is authorized to:

(1) make and service below-market interest rate loans and grants as financial incentives to eligible fund recipients meeting the criteria of Section 48-62-50 for the purchase of flooded properties and land to complete floodplain restorations, so long as the loans advance the purposes of this article and meet applicable criteria;

(2) enter into loan agreements and accept and enforce loan obligations, so long as the loans advance the purposes of this article and meet applicable criteria;

(3) receive and collect the inflow of payments on loan amounts;

(4) apply for and receive additional funding for the fund from federal, state, private, and other sources;

(5) receive charitable contributions and donations to the fund;

(6) receive contributions to the fund in satisfaction of any public or private obligation for flooding mitigation, whether such obligation arises out of law, equity, contract, regulation, administrative proceeding, or judicial proceeding. Such contributions must be used as provided for in this article;

(7) make and execute contracts and all other instruments and agreements necessary or convenient for the performance of its duties and the exercise of its powers and functions;

(8) establish policies and procedures for the making and administration of loans, fiscal controls, and accounting procedures to ensure proper accounting and reporting; and

(9) exercise its discretion in determining what portion of funds must be disbursed and awarded in any particular year and what portion of funds shall remain in the fund from one fiscal year to the next. Sums within the fund must be invested or deposited into interest-bearing instruments or accounts, and the accrued interest must be credited to the fund.

(B) To carry out these functions, the authority shall:

(1) operate a program in order to implement the purposes of this article;

(2) receive final approval from the State Fiscal Accountability Authority for fund disbursements prior to the issuance of a loan;

(3) develop additional guidelines and prescribe procedures, consistent with the criteria and purposes of this article;

(4) submit an annual report to the Governor, Lieutenant Governor, State Treasurer, and General Assembly that:

(a) accounts for fund receipts and disbursements;

(b) briefly describes applications submitted to the fund and, in greater detail, describes grants and loans that were approved or funded during the current year and the public benefits, including increased flood retention resulting from such grants and loans;

(c) describes recipients of fund loans and grant monies; and

(d) sets forth a list and description of all loans and grants approved and all acquisitions of homes and lands obtained since the fund's inception; and

(5) have an annual audit of the fund conducted by outside independent certified public accountants and submitted to the Governor, Lieutenant Governor, State Treasurer, and General Assembly. The accounting of fund receipts and expenditures required above must be part of this annual audit.

Section 48-62-340. (A) In the issuing of loans, the authority must:

(1) prioritize the buyout of blocks or groups of homes rather than individual homes so that no more than fifteen percent of funds disbursed in a fiscal year go toward individual home buyouts;

(2) prioritize buyouts of single-family primary residences and multifamily residences;

(3) consider the availability of additional funding sources leveraged by a project;

(4) prevent the use of the fund for homes built after July 1, 2020;

(5) prevent the use of the fund for proposed projects that involve the use of eminent domain; and

(6) prioritize the use of the fund for low- and moderate -income households making less than one hundred twenty-five percent of the median household income in the jurisdiction of the eligible fund recipient.

(B) The authority must issue loans using the following criteria and conditions:

(1) offer a funding package of grants and loans for a particular project that carries an overall effective interest rate equivalent to no higher than forty percent of the market interest rate as defined by the ten-year United States Treasury Yield Curve;

(2) make a portion of each loan available as a grant not requiring payment as a financial incentive to reduce the loan amount, that portion being no greater than twenty-five percent and no less than five percent of the total project disbursement, to incrementally reward those eligible fund recipients that execute beneficial flood mitigation practices. To qualify for a grant, eligible fund recipients must execute one or more of the following beneficial flood mitigation practices:

(a) ensuring residents relocate outside of the floodplain;

(b) aiding residents in relocating outside of the floodplain and within the tax base;

(c) aiding residents in relocating outside of the floodplain within an area designated as an opportunity zone;

(d) conducting floodplain restoration after the property is converted to open space to reestablish the full water storing benefits of the floodplain;

(e) completing a buyout of an area larger than ten acres; and

(f) other activities as deemed appropriate by the authority so long as they contribute to flood resilience in the community of the buyout;

(3) require that acquired properties are returned to open space and that all future development on the parcel is prohibited in perpetuity through easement or restrictive covenant; and

(4) prohibit the use of more than five hundred thousand dollars for each housing unit receiving loan funds.

(C) Eligible fund recipients may apply for loans from the fund to complete:

(1) buyouts of repetitive loss properties;

(2) buyouts of repetitive loss properties with land intended for floodplain restoration; and

(3) floodplain restoration in connection with buyouts funded through other mechanisms.

(D) In order to qualify for a loan, eligible fund recipients must apply to the authority and, at a minimum, meet the following criteria:

(1) for buyouts of repetitive loss properties:

(a) identify specific properties included in the proposed project;

(b) demonstrate how the properties qualify as repetitive loss properties;

(c) identify a plan and timeline for returning the property to open space within six months following the completion of the buyout and holding an easement or restrictive covenant on the land in perpetuity;

(d) complete an economic assessment to show the costs and benefits of the project; and

(e) identify any beneficial flood mitigation practices planned for the project;

(2) for buyouts of repetitive loss properties with land intended for floodplain restoration:

(a) identify specific properties included in the proposed project;

(b) demonstrate how the properties qualify as repetitive loss properties;

(c) identify a plan and timeline for returning the property to open space within six months following the completion of the buyout and holding an easement or restrictive covenant on the land in perpetuity;

(d) complete an economic assessment to show the costs and benefits of the project;

(e) submit a plan for conducting floodplain restoration; and

(f) identify any additional beneficial flood mitigation practices planned for the project;

(3) for other floodplain restoration:

(a) submit a plan and timeline for conducting floodplain restoration;

(b) identify a plan and timeline for holding an easement or restrictive covenant on the land in perpetuity;

(c) complete an economic assessment to show the costs and benefits of the project; and

(d) identify any additional beneficial flood mitigation practices planned for the project; and

(4) any additional criteria required by external grants contributing to the fund.

(E) Financial criteria also must be met pursuant to the standards set by the authority. The authority may require additional criteria and exercise discretion in issuing loans.

Section 48-62-350. (A) The fund must be held and administered by the authority in accordance with the provisions of this article and policies, rules, regulations, directives, and agreements as may be promulgated or entered into by the authority pursuant to this article. Earnings on balances in the fund must be credited to the fund. Amounts remaining in the fund at the end of the fiscal year accrue only to the credit of the fund. Amounts in the fund must be available in perpetuity for the purpose of providing financial assistance in accordance with the provisions of this article.

(B) The authority is authorized to deposit the following into the fund:

(1) federal capitalization grants, awards, or other federal assistance received by the office for the purposes of the fund;

(2) funds appropriated by the General Assembly for deposit to the fund;

(3) payments received from a recipient in repayment of a loan;

(4) interest or other income earned on the investment of monies in the fund; and

(5) additional monies made available from public or private sources for the purposes of which the fund has been established.

(C) Monies in the fund only may be used to:

(1) make loans to eligible fund recipients in accordance with the provisions of this article;

(2) earn interest on fund accounts; and

(3) provide for the program administration and project management activities of the fund.

(D) The authority may establish accounts and subaccounts within the fund as considered desirable to effectuate the purposes of this article.

Section 48-62-360. In addition to appropriations made by the General Assembly, the office shall seek out additional sources of funding to sustain the fund, including federal dollars from the Department of Housing and Urban Development Community Development Block Grant-Disaster Recovery appropriations. Additional appropriations to the fund may be requested from the General Assembly so as to expand the capabilities of the fund.

Section 48-62-370. The office may:

(1) promulgate regulations to effectuate the provisions of this article;

(2) establish an operational structure within its authority to administer the fund;

(3) develop priority systems that ensure consistency with the provisions of this article;

(4) prepare annual plans in accordance with this article;

(5) receive monies from the fund for program administration and project management activities of the fund; and

(6) hire staff and employ agents, advisers, consultants, and other employees, including attorneys, financial advisers, engineers, and other technical advisers, and public accountants and determine their duties and compensation.

Section 48-62-380. The provisions of this article must be liberally construed to the end that its beneficial purposes may be effectuated. No proceeding, notice, or approval is required for loan obligations by a project sponsor or instruments or the security for the loan obligation, except as provided in this article. If the provisions of this article are inconsistent with the provisions of any other law, whether general, special, or local, then the provisions of this article are controlling."

B. (A) As set forth in Section 48-62-20(B), the South Carolina Disaster Recovery Office as established by Executive Order 2016-13 and included within the South Carolina Department of Administration by Executive Order 2018-59 is transferred to, and incorporated into, the South Carolina Office of Resilience.

(B) The South Carolina Disaster Recovery Office, and to the extent necessary, the South Carolina Department of Administration, shall take all necessary actions to accomplish this transfer in accordance with any state and federal laws and regulations.

(C) The employees, authorized appropriations, and assets and liabilities of the South Carolina Disaster Recovery Office also are transferred to and become part of the South Carolina Office of Resilience.

(D) On the effective date of this act, all classified or unclassified personnel employed by the South Carolina Disaster Recovery Office, either by contract or by employment at will, and all permanent or temporary grant employees become employees of the South Carolina Office of Resilience, with the same compensation, classification, and grade level, as applicable.

(E) Any rules or regulations which have been promulgated by the South Carolina Disaster Recovery Office and any applicable contracts entered into by the South Carolina Disaster Recovery Office are continued in full force and effect.

Local comprehensive plan, resiliency element required

SECTION 2. Section 6-29-510(D) of the 1976 Code is amended by adding an appropriately numbered item at the end to read:

"( ) a resiliency element that considers the impacts of flooding, high water, and natural hazards on individuals, communities, institutions, businesses, economic development, public infrastructure and facilities, and public health, safety and welfare. This element includes an inventory of existing resiliency conditions, promotes resilient planning, design and development, and is coordinated with adjacent and relevant jurisdictions and agencies. For the purposes of this item, 'adjacent and relevant jurisdictions and agencies' means those counties, municipalities, public service districts, school districts, public and private utilities, transportation agencies, and other public entities that are affected by or have planning authority over the public project. For the purposes of this item, 'coordination' means written notification by the local planning commission or its staff to adjacent and relevant jurisdictions and agencies of the proposed projects and the opportunity for adjacent and relevant jurisdictions and agencies to provide comment to the planning commission or its staff concerning the proposed projects. Failure of the planning commission or its staff to identify or notify an adjacent or relevant jurisdiction or agency does not invalidate the local comprehensive plan and does not give rise to a civil cause of action. This element shall be developed in coordination with all preceding elements and integrated into the goals and strategies of each of the other plan elements."

Time effective

SECTION 3. This act takes effect upon approval by the Governor.

Ratified the 25th day of September, 2020.

Approved the 29th day of September, 2020.

Appendix 18

APPENDIX B:
ACRONYM LIST

Acronym	Meaning
ACE Basin	Ashepoo, Combahee, Edisto Basin
AEP	Annual Exceedance Probability
AMI	Area Median Income
ARPA	American Rescue Plan Act
ATC	Applied Technology Council
BHFL	Bureau of Health Facility Licensing
BMP	Best Management Practices
BRIC	Building Resilient Infrastructure and Communities
BRIC	Baseline Resilience Indicators for Communities
CDBG-DR	Community Development Block Grant – Disaster Recovery
CDBG-MIT	Community Development Block Grant – Mitigation
CHEOPS	Computer Hydro-Electric Operations and Planning Software
CISA	Carolinas Integrated Sciences and Assessments
CLTC	Community Long Term Care
CMI	Crop Moisture Index
CMIP5	Coupled Model Intercomparison Project Phase 5
CMIP6	Coupled Model Intercomparison Project Phase 6
CO_2	Carbon Dioxide
COG	Council of Governments
CORE SC	Center of Resilience Excellence SC
CPS	Child Protective Services
DCM	Disaster Case Management
DEM	Digital Elevation Model
DHHS	Department if Health and Human Safety
DHS	Department of Homeland Security
DR	Disaster Recovery
DRRA	Disaster Relief and Resilience Act
DRRA	Disaster Relief and Resilience Act
DRRC	Disaster Recovery Reserve Corps
DRRRF	Disaster Relief and Resilience Reserve Fund
D-SNAP	Disaster Supplemental Nutrition Assistance Program
EAP	Emergency Action Plan
EPA	Environmental Protection Agency
FEMA	Federal Emergency Management Agency
FHWA	Federal Highway Administration
FIRM	Flood Insurance Rate Map
FMA	Flood Mitigation Assistance
FRESH	Flood Risk and Endangered Species Habitat
FTE	Full-Time Equivalent
GHCN	Global Historic Climatology Network
GIS	Geographic Information System

HEC-RAS	Hydrologic Engineering Center's River Analysis System
HENTF	Heritage Emergency National Task Force
HHIS	Heritage Health Information Survey
HMGP	Hazard Mitigation Grant Program
HUD	US Department of Housing and Urban Development
HVRI	University of South Carolina Hazards Vulnerability & Resilience Institute
IA	Individual Assistance
IBHS	Insurance Institute for Business & Home Safety
IDF	Intensity-Duration-Frequency
IIJA	Infrastructure Investment and Jobs Act
IMLS	Institute of Museum and Library Services
InSAR	Interferometric Synthetic Aperture Radar
IPCC	International Panel on Climate Change
IT	Information Technology
KBDI	Keetch-Byram Drought Index
LID	Low Impact Development
LiDAR	Light Detection and Ranging
LIHTC	Low-Income Housing Tax Credit
LMI	Low-to-Moderate Income
LOCA	Localized Constructed Analogs
MEP	Maximum Extent Practicable
MOA	Military Operating Areas
MS4	Municipal Separate Storm Sewer Systems
NCA	National Climate Assessment
NCEI	National Centers for Environmental Information
NCR	Natural and Cultural Resources
NERR	National Estuarine Research Reserve
NFIP	National Flood Insurance Program
NFWF	National Fish and Wildlife Foundation
NHL	National Historical Landmark
NLCD	National Landcover Dataset
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NWS	National Weather Service
PA	Public Assistance
PDR	Palmetto Disaster Recovery
PDSI	Palmer Drought Severity Index
PGA	Peak Ground Acceleration
RBC	River Basin Council
RCP	Representative Concentration Pathway
RFA	Revenue and Fiscal Affairs
RRF	Resilience Revolving Fund

RSF	Recovery Support Function
SARR	Site Assessment, Remediation, and Revitalization
SASMI	South Atlantic Salt Marsh Initiative
SBA	US Small Business Administration
SC DNR	South Carolina Department of Natural Resources
SC DOI	South Carolina Department of Insurance
SC DOT	South Carolina Department of Transportation
SC DSS	South Carolina Department of Social Services
SC LLR	South Carolina Department of Labor, Licensing, and Regulation
SC ORS	South Carolina Office of Regulatory Staff
SC PPP	South Carolina Department of Probation, Parole, and Pardon Services
SC PRT	South Carolina Department of Parks, Recreation & Tourism
SCAPA	South Carolina Chapter of the American Planning Association
SCDA	South Carolina Department of Agriculture
SCDAH	South Carolina Department of Archives and History
SCDHEC	South Carolina Department of Health & Environmental Control
SCDOA	South Carolina Department On Aging
SCDVA	South Carolina Department of Veteran's Affairs
SCEMD	South Carolina Emergency Management Division
SCFC	SC Forestry Commission
SCGIC	South Carolina Geographic Information Council
SCIAA	South Carolina Institute for Archeology and Anthropology
SCJIA	South Carolina Criminal Justice Academy
SCOR	South Carolina Office of Resilience
SECCORA	Southeast Coastal Ocean Observing Regional Association
SFHA	Special Flood Hazard Area
SHPO	State Historic Preservation Office
SLED	South Carolina Law Enforcement Division
SLFRF	State and Local Fiscal Recovery Funds
SNAP	Supplemental Nutrition Assistance Program
SouthWRAP	Southern Wildfire Risk Assessment Portal
SoVI®	HVRI Social Vulnerability Index®
SPI	Standardized Precipitation Index
SSRRRP	Strategic Statewide Resilience and Risk Reduction Plan (Statewide Resilience Plan)
SVI	CDC Social Vulnerability Index
SWAM	Surface Water Allocation Model
SWMM	Storm Water Management Model
TANF	Temporary Assistance for Needy Families
TSD	Treatment, Storage, and Disposal
TYC	Treasury Yield Curve
UGLG	Units of General Local Government
USACE	U.S. Army Corps of Engineers

USDM	US Drought Monitor
USGS	United States Geological Survey
UST	Underground Storage Tank
WUI	Wildland Urban Interface

APPENDIX C:
HVRI REPORT

Hazards Vulnerability & Resilience Institute
UNIVERSITY OF SOUTH CAROLINA

Evaluation of Existing Community Disaster Resilience Approaches and Tools to Support Resilience Planning Efforts

Summary:

- Vulnerability and resilience metrics are not the same as they measure different concepts.
- Top-down resilience metrics are best used for an initial filter or broad assessment of where more information on resilience and its drivers should be gathered.
- Bottom-up metrics can be employed most effectively after a top-down assessment narrows down study areas of interest.
- Bottom-up metrics can delve into specific communities to best target resilience programming and funding based on actionable information.

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Report for the South Carolina Office of Resilience
May 19, 2023

Introduction

The term resilience has been around for centuries with multiple, intertwined meanings stretching from the mechanical and natural sciences to engineering, medicine, and to the humanities and social sciences (Alexander 2013). Resilience has been used for decades as an approach to examining the ability of a system or an entity such as a building to withstand a shock, cope with or absorb changes, and adapt to such changes to bounce back and regain prior functions. In the context of disaster risk reduction, resilience was initially applied to ecosystems (Holling 1973) and performance-based engineered structures including lifelines (Bruneau et al. 2003. Resilience was not really introduced into hazards or disaster planning until the mid-1990s as an approach for describing the capacity of communities to resist or recover from a disaster shock (Emrich and Tobin 2018). In this context, resilience was used to describe the multi-dimensional scale, time, and place-dependent interactions between preparedness, recovery, and adaptation in response to shocks to communities. Rather than focusing on reducing the vulnerability in places, the focus shifted to positive actions that communities could take to not only improve their capacities to withstand the impacts of disaster risks but also to bounce forward in its aftermath, not simply returning to what was there before.

In 2012, the National Academies published their seminal report, *Disaster Resilience: A National Imperative,* to address the obstacles related to increasing the nation's resilience, describe the state of knowledge about hazards resilience including baselines and performance metrics, and provide guidance on needed approaches to elevate resilience as a common goal. The study began by defining resilience as "the ability to prepare and plan for, absorb, recovery from, or more successfully adapt to actual or potential adverse events" (NRC 2012: 16). In the intervening decade, the application of disaster resilience to raise awareness about disaster risk reduction, stimulate communities to engage in and promote resilience actions has produced significant advancements in resilience planning in all sectors (Walton et al. 2021). Many communities and states now have a Chief Resilience Officer or a resilience office, resilience is incorporated into risk mitigation planning at all levels, and in South Carolina, resilience is now a required element in comprehensive plans (S.C. Code § 6-29-510).

While there is enormous enthusiasm for the idea and concept of disaster resilience, resilience measurement science and practice still are not mature enough to determine which approach works best in theory, or more importantly in practice (NASEM 2019). The purpose of this white paper is to provide a critical evaluation of the current metrics and approaches used in disaster/ hazard resilience including a comparison of their relative weaknesses and strengths to help inform South Carolina's strategic statewide resilience and risk reduction planning effort.

Metrics for Disaster Resilience

There is no dominant framework or standard for resilience measurement (Cutter 2016a) because communities are different in their physical, social, and built environment characteristics, disaster risk exposures, and capacities. By measurement, we mean the action of assessing a place (or event) using a standard approach to compare the place over time, after changes in conditions, or with other places (NASEM 2019). There are a multitude of activities and frameworks for measuring resilience, which generally focus on the inherent resilience of a community – the pre-existing resilience a community has at a particular point in time (Asadzadeh et al. 2017). Each approach requires choices on resilience definitions, input data (quantitative, qualitative), study area, and the hazards considered (Parker 2020). Individually and collectively such choices influence the complexity of the metric and its lack of transference of the approach from one place to another, or from one-time timeframe to another.

What are resilient communities?

Resilience can be a measurable outcome, a process, or some combination of the two. Common elements in resilience frameworks focus on assets (the restoration of the physical infrastructure) to achieve an outcome after an event (static conditions), or on social processes that improve social and institutional capacities through social learning (dynamic processes). In some instances, both asset and capacity approaches are used to define community resilience. However, inherent in that conversation are the questions of resilience to what? And resilience for whom? (Cutter 2016b; Meerow and Newell 2019). These basic conceptual differences (assets vs. capacities; to what vs. for whom; and static vs. dynamic processes) influence the various measurement approaches and resulting outputs.

South Carolina defines resilience in its introduction to the draft Strategic Statewide Resilience and Risk Reduction Plan as “the ability of communities, economies, and ecosystems within South Carolina to anticipate, absorb, recover and thrive when presented with environmental change and natural hazards” (SCOR 2023, 14). In this respect, the state has taken a combination of the assets and capacities perspective in its definition.

Most measurement schemas take a broad holistic view suggesting that communities contain many different dimensions of resilience that are interdependent and connected. These inherent dimensions are often referred to as capitals (environmental, economic/financial, cultural, social, and infrastructure), and the capitals approach provides the general conceptual model for many of the measurement approaches (Tierney 2019). Other schemas focus on the disaster cycle (e.g., recovery, preparedness) and concentrate on how social and cultural systems recover post-event (Clarke and Mayer 2017) or measure resilience as the length of time for infrastructure (or lifeline) restoration (in hours or days) after a major earthquake (Poland 2009). Other approaches may be more localized in context such as the resilience of cities (Bozza et al. 2017; McPhearson et al. 2015) or rural areas (Cox and Hamlen 2015) or focused on a particular hazard or acute stressor such as flooding (van de Lindt et al. 2020). Even resilience metrics that approach the concept from the same framework can make different decisions in the variable selection and methodology, resulting in different resilience measures and findings (Jones 2018).

How is it measured?

Common elements in community resilience measurement schemas include information on the physical attributes and assets of an area combined with social and institutional capacities. Such measurements are normally static snapshots of a particular time or context to be compared to other indicators such as sustainable development goals (SDGs), vulnerability indices, environmental justice metrics like EJ-40, or identified response needs within a community (e.g., FEMA lifelines). *Resilience metrics do not measure sustainability, FEMA lifeline performance, vulnerability, or environmental justice* (See Box 1). Resilience assessments determine prevailing conditions or baselines of existing resilience in communities. These baselines provide the foundation for future assessments (generally employing the same methodology) that can be compared to monitor progress over time. However, limitations in input data render many of the current tools or techniques not directly actionable or changeable. For example, variables that are difficult to measure, operate over longer time scales before a change occurs, or are outliers are often ignored. Instead, assessments use more available indicators as proxies arguing they still may have some importance in community resilience (Cardoni et al. 2021; Carvalhaes et al. 2022).

Box 1: Vulnerability and Resilience

Social vulnerability is a product of social and place inequalities resulting in differential harm and ability to respond to different population groups (Cutter 2003). It is generally a measure of exposure to and degree of harm that a community may face. Community resilience, on the other hand, encompasses the everyday qualities of a community that may enhance its ability to prepare for, respond to, and recover from hazard events (Cutter et al. 2014). Their relationship can be conceptualized as a Venn diagram, with a level of overlap between the two, but still distinct differences.

Some indices that purport to measure resilience only use vulnerability indicators, such as the U.S. Census Bureau's (USCB) Community Resilience Estimates (CRE), assuming that the two are opposites (USCB 2022). However, this would mean that all places with high social vulnerability have low community resilience, which has been refuted (Derakhshan et al. 2022). Therefore, if you are measuring resilience, you are not necessarily measuring vulnerability and it is important to approach the two separately. This is the methodology adopted by the National Risk Index (NRI) and allows for the clear distinction between the two concepts while also understanding how they overlap (Zuzak et al. 2023).

There are four primary ways that researchers implement resilience measurements: 1) checklists, 2) scorecards, 3) indices that create a resilience assessment tool, and 4) mathematical/statistical models. Scorecards and checklists tend to take a qualitative or self-reported approach. They identify focal points of resilience in planning, and local business, and ask local areas to determine their presence or absence within the community (a checklist) (Sempier et al. 2010) or provide some assessment of the attribute's conditions using a scorecard (Berke et al. 2019; Malecha et al. 2021).

The most common way to measure resilience is by using multi-variate composite indices (Cutter 2016a). Resilience indices choose a variety of quantitative variables that theoretically enhance resilience and combine them to create a comparative value of resilience for a selected study area. These methods tend to be larger data aggregations and normally do not elicit participation from local stakeholders in their construction (Asadzadeh et al. 2017).

Lastly, mathematical models and more advanced models such as AI try to model the performance of infrastructure, human decision-making, and complex systems to understand the dynamic forms and processes of resilience (Yabe et al. 2022). The results or outputs of resilience measurement often are visualized through different types of mapping, charts, and dashboards which communicate multiple visualizations and offer a more holistic view of community resilience (Nguyen and Akerkar 2020).

Within each type of metric, researchers have to make decisions on how resilience is defined and how it will be measured, either subjectively (defined by the subject) or objectively (defined by theory and literature) (Jones 2018). Comparative reviews of the relative strengths and weaknesses of various resilience metrics and tools abound with critiques ranging from conceptualization, to methods, to input data (Bakkensen et al. 2017; Cai et al. 2018; Koliou et al. 2018; Johnson et al. 2020; NASEM 2019; Nguyen and Akerkar 2020; Sharifi 2016). However, these critiques also highlight room for improvement, especially in translating the science of resilience metrics to practice. Aligning top-down metrics comparable across multiple areas with more locally-based bottom-up ones that may not be comparable in other places has been the major impediment in moving community disaster resilience concepts to action (Cutter 2018).

What scale and units of measurement are used?

The choice of scale often depends on the level of decision-making addressing resilience as well as the availability of data for analysis. In more qualitative schemas, scale also depends on the type of tool used. An institution that may address resilience at a national level, like FEMA may only be interested in resilience at a state or county level, while a state or county may be able to fund specific projects and would find a zip code or census tract-level analysis more helpful. The scale of data that is available can be a large limitation for resilience measurement. Since individual-level data is unavailable, aggregated demographic data are used but this must be done with caution to avoid issues with interpretation (Chu et al. 2021).

The unit of analysis is another consideration. Units of analysis are the objects of the study—communities, watersheds, states, and countries. For communities, the unit of analysis is defined as the administrative boundary and is further defined as counties, municipal boundaries, census tracts/blocks, zip codes, or metropolitan statistical areas. Many of the data inputs on the resilience capitals come from Census information, so census tracts/blocks, zip codes, or other census-designated geographies define community boundaries instead of actual jurisdictional control. For some localized applications census-defined enumeration units are problematic where other defined areas (e.g., watersheds, flood zones, neighborhoods, land use) might have more currency for measuring community resilience.

Fit for Purpose: Top-Down versus Bottom-Up Tools

While existing tools are useful for their specific design purpose, they are often limited in their application to the specific and localized needs and investments of communities. In addition, many resilience metrics are only conceptual or have been developed for one area and have yet to be widely implemented. Resilience metrics can be described as top-down or bottom-up. While theoretically and conceptually driven and often using national datasets for consistency, top-down measurements use a single value to represent all the dimensions of resilience. Top-down schemas are more policy-oriented at national, regional, and state scales where counties are the unit of analysis. The top-down schema provides comparative analyses across large geographic areas based on aggregated data.

In contrast, bottom-up approaches, provide a rich narrative on community change and actions at very localized scales (sub-county). The use of qualitative data or experiential information is not generalizable across broader geographies. There is a need to consider "fit for purpose" in the selection of tools based on policy or local action orientation. In either case, there is a need to reflect local conditions based on actionable data yet are able to scale up beyond the local community (bottom-up) to reveal a broader pattern of resilience at larger scales, or downscaled disaggregated national or state data to reflect local variability to partially capture local assets and capacities.

A summary of commonly used and/or cited resilience indices is provided in Table 1. The methodology used in the metric as well as the conceptual structuring of resilience (capitals) are provided. Additional information including the approach, goal, positives, critiques, and a sample of included variables for each metric is included in Appendix A. General findings for top-down and bottom-up metrics as well as room for improvement are discussed below.

TABLE 1 – Summary of Indicators/Tools Described split by Top-Down or Bottom-Up approach

Indicator Name	Author(s)	Scale of Analysis	Model/ Tool	Indicator	Scorecard /Checklist	Dimensions/Capacities Identified
TOP-DOWN						
Baseline Resilience Indicators for Communities (HVRI BRIC)	Cutter et al. 2014 Derakhshan et al. 2022	County, Tract		X		Social, economic, community capital, institutional, housing/infrastructure, environmental
FEMA Community Resilience Index (FEMA CRI)	FEMA 2022	County, Census Tract		X		Population, Household, Housing, Healthcare, Economic, Connection to Community
Community Intrinsic Resilience Index (CIRI)	Gerges et al. 2022	County		X		Transportation, energy, health and socio-economic
Community Resilience Index	Sherrieb et al. 2010	County		X		Social capital, Economic development
Natural Hazard Resilience Screening Index (NaHRSI)	Summers et al. 2018	County		X		Natural environment, built environment, society, governance, and risk
PEOPLES Framework	Renschler et al. 2010 Cimarello et al. 2016	Community	X			Population and demographics, environmental and ecosystem, organized governmental services, physical infrastructures, lifestyle and community competence, economic development, social-cultural capital
BOTTOM-UP						
Coastal Communities Resilience Index (CCRI)	Sempier et al. 2021	Community			X	Critical infrastructure, transportation, community plans, mitigation measures, business plans, social systems
Communities Advancing Resilience Toolkit (CART)	Pfefferbaum et al. 2013; 2015	Community	X			Connection and caring, resources, transformative potential, disaster management, information and communication
Composite of Post-Event Well-being (COPEWELL) Model and Rubric	Links et al. 2018; Schoch-Spana et al. 2019	County; Community		X	X	Index: Pre-event community functioning; Prevention and Mitigation; Population vulnerability, inequality, and deprivation; Social capital and cohesion; event preparedness and response; external resources
Los Angeles County Community Disaster Resilience Project (LACCDR)	Eisenman et al. 2014	Community	X			Education, engagement, self-sufficiency, partnership
Rural Coastal Community Resilience (RCCR) framework	Jurjonas & Seekamp 2017; Jurjonas et al. 2020	Community			X	Livelihood dependency/diversity, poverty/prosperity, un/sustainable development, community disengagement/cohesion, rigidity/agency
Rural Resilience Index (RRI)	Cox and Hamlen 2015	Community		X		Social fabric, community resources, disaster management

Top-Down Resilience Metrics

Top-down resilience metrics are used to give a snapshot of the inherent resilience of a study region. They can be used for a comparative understanding of the resilience landscape of a study region that can lead to improved decision-making at a state or county scale. This scalability lets stakeholders understand resilience across a large area while targeting specific counties that may need additional resilience resources. Since county-level analysis aligns with existing resilience programming from the federal government, top-down indices are a good first step to using those resources in the places they are most needed.

All of the top-down approaches begin their study with a pre-determined definition and framework of resilience. According to their theoretical approaches, FEMA CRI, the PEOPLES framework, and NaSHRI conflate resilience with social vulnerability, whereas BRIC, CIRI, and the Community Resilience Index either explicitly define their approach to the relationship between resilience and vulnerability, or only include variables that are generally not used in social vulnerability measurement. For example, the Community Resilience Index only addresses social capital and economic development, and CIRI only uses 15 variables whereas BRIC widens the scope of resilience to include 49 variables within social, economic, environmental, community, institutional, and infrastructural capitals.

All top-down resilience metrics discussed here are indices created from local or national datasets except for the PEOPLES Framework which is a largely GIS-based tool. Large, publicly available datasets, while often only available at the county or census tract scale, are consistently available over time and can be used to identify broad drivers and temporal patterns of resilience. Locally sourced datasets, as used in CIRI, can be more accurate and more data related to resilience may be available Depending on the scale and datasets used, top-down resilience metrics can be quickly calculated, but some metrics rely on calculated datasets that become more time and labor-intensive such as NaHRSI and the PEOPLES Framework which require complex modeling and extensive data collection at 117 and 95 variables respectively. CIRI includes an additional equation that would model resilience after a hazard, but this can only be related to infrastructural resilience (Gerges et al. 2022). In addition to choosing variables that represent resilience, some indices strive to include actionable variables, those that can be directly impacted by governments, to help identify what changes need to be implemented to improve resilience for the target community. Of all the indices (and variables within them) listed in Table 1, none are completely actionable, but all have some and widely differing actionable variables.

An additional difficulty of top-down resilience indices is their wider application and validation of outcomes. Variables in existing resilience indices may not always be applicable to each study area or data may not be available at chosen locations or scales. Resilience is also a place-based process and variables that may do a good job quantifying inherent resilience in one area, for example on the coast of South Carolina, may be a poor choice for a variable in a mountainous land-locked state such as Colorado. Expert and stakeholder input can improve variable selection to possibly move national resilience indicators to the state and local scale, making them more operational. Quantitative metrics like indices also require statistical and external validation to make sure the measurement accurately portrays what it says it will.

Validation varies over the metrics presented, but there is work to be done overall in resilience metric testing (Koliou et al.2018).

Bottom-Up Resilience Metrics

Though bottom-up resilience metrics may not always use a resilience framework created by the study community, they are implemented at a local scale and are measurements of local, place-based community resilience. Place-based means that the indicators used as well as the people surveyed are local and account for contexts of resilience that may not be found elsewhere. These can be found in top-down resilience metrics if created in partnership with communities, but bottom-up metrics have this built into their methods from the beginning. The only index in our assessment that is truly bottom-up is the RRI, which identifies variables through stakeholder engagement and builds an index from these variables only (Cox and Hamlen 2015). In addition, since bottom-up metrics involve the community in conceptualizing and measuring resilience, they can also act as a resilience-building exercise.

Most bottom-up metrics are either community scorecards and checklists or community assessments. Checklists, such as CCRI identify a specific audience for the assessment and direct them to grade different parts of the study area on resilience qualities that generally cannot be quantitatively measured. These types of assessments are easier to implement than larger focus groups or participatory action research, but still function as both a teaching and assessment mechanism. Generally, scorecards are created through an assessment of resilience literature to identify what qualities improve the resilience of the community targeted and then administered to that community. The production of the actual assessment can be created alongside stakeholders as it is done in COPEWELL, or it can be research-based and adapted once administered similarly to how the RCCR Framework approached its scorecard.

Community assessments take many different forms. The two assessments discussed here are chosen to show the different approaches one can take in qualitatively assessing community resilience in this way. CART adopts a four-stage participatory methodology, which, while time-consuming, involves the target community through every step of the resilience assessment process and results in a plan for resilience improvement. LACCDR takes a public health approach to resilience and trains groups on resilience building for them to then take home and implement which involves a high reliance on established NGOs, improving their resilience but possibly taking away from other programming priorities. Both community assessments involve the creation of a resilience toolkit and implementation over multiple meetings and stages with ample opportunity for stakeholder feedback and revision. They are time-intensive, involving multiple different qualitative methods (i.e., interviews, surveys, focus groups, community mapping, network analysis) to determine very localized but detail-rich understandings of community resilience.

Bottom-up methods vary in approach and methodology to address resilience in a multitude of ways, but their scope normally narrows to one or two capitals of resilience to make them doable. The audience of these metrics can vary from government workers to NGOs to the public. Finding participants and drawing out actions that can improve resilience takes time and effort, not only on the researcher's behalf but also by the community that is being assessed. These limitations can make it difficult to repeat bottom-up methodologies or apply them across different parts of a larger study area.

Conclusions

There is no single resilience metric that can tell researchers and stakeholders everything they need to know about a study area's resilience. However, resilience metrics are not all created using the same approach, and they must be critically assessed before being applied to a study area (Jones 2018). Resilience is theoretically different than vulnerability, however, many resilience metrics conflate the two concepts, resulting in a measurement that is not explicitly resilience.

Top-down resilience indices involve large datasets that distill resilience down to quantitative variables that are either combined into an index or used in GIS programs that attempt to portray the systems of systems of resilience. These metrics can be used to aid in decision-making and track resilience over time but are not always actionable and require local input to accurately integrate more local measures of resilience. Also, there is still work to do to test and validate different resilience metrics (Koliou et al. 2018, Parker 2020).

Bottom-up metrics are generally limited to approaching resilience through one or two capitals due to their time- and resource-intensive nature. The interactive nature of bottom-up metrics may result in the metric acting as a resilience intervention itself and can result in specific resilience actions that are community-identified and supported. However, the time intensity of these metrics means that it is difficult to track resilience over time or to administer multiple bottom-up metrics over a larger area without substantial dedicated resources. As it stands, a combination of top-down and bottom-up approaches is necessary to both identify areas with low inherent resilience (policy-oriented) and actions that will be community-supported and effectively improve resilience.

Currently, Charleston, Lexington, Florence, and York Counties all have specific resilience chapters as parts of their comprehensive plans. They all identify hazards that directly impact the counties and key tasks or actions that must be taken to improve their resiliency to these events, but there is no evidentiary basis (e.g., direct or indirect measurement of resilience) for such actions or mechanisms for monitoring their effectiveness. A top-down resilience metric coupled with bottom-up resilience priorities can effectively target communities at the state and county level that are less resilient and guide programs and projects that local communities self-determine. This is necessary to efficiently and effectively utilize limited resilience funding for the largest impact on local community resilience.

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Appendix A: Summary of Metric Approaches and Critique

BRIC

49 Variables; hierarchical construction with internal validation

Goal: To provide a reference point for examining current inherent resilience and aid in decision-making with some actionable variables

Plus: theoretically and conceptually driven; ease of use/transparency; use of national datasets for consistency; monitor drivers and changes over time; address inequality through visualization

Minus: single value not representative of all dimensions; not ground-truthed or validated; does not measure interdependencies; internal consistency too variable; not all variables actionable; county scale (and unit of analysis) too coarse; comparative descriptive NOT absolute predictive so dependent on study area selection

Variable Examples: medical facilities (beds, physicians, psychosocial support facilities per 1,000 people); Business size; Gini coefficient; impervious surface change; mitigation cost share percentage; Social assistance services per 1,000 people

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Coastal Community Resilience Index

Checklist format with two hazard scenarios built in.

Goal: Targeted to local planners, engineers, managers, or administrators for a guided self-examination of community resilience that can also be converted into an index for comparison.

Plus: structured self-assessment; easy to apply elsewhere; easy to understand; translates into a resilience index; relatively quick to implement

Minus: not a replacement for detailed study; requires expert knowledge on wide-ranging topics; relies on hazard event scenarios; subjective language for rating “strong” social systems

Variable examples: location of critical facilities; evacuation route availability; comprehensive plan contents; early warning system; mitigation measures and activities

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CART

Four stage participatory action methodology focused on resilience perception

Goal: Provide a toolkit focused on group participation to define a community profile of resilience and plan for improved resilience

Plus: evidence-informed and supported theoretically; field-tested; participation is a resilience intervention itself; involves stakeholders in creating knowledge and solutions; intervention and implementation driven

Minus: time and labor intensive; application of assessment to new study areas difficult resulting in limited application; will not result in measurement of resilience, rather interventions

Variable examples: neighborhood infrastructure mapping; community conversations; community ecological maps; stakeholder analysis; SWOT analysis; capacity and vulnerability assessment

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CIRI

15 Variables; Hierarchical construction, with variable compared to "ideal" and weighting determined by user

Goal: To provide an inherent resilience index and post-disaster resilience that uses an "ideal" goal for each variable and with weighting that is customizable to each place where it is implemented.

Plus: Highlights infrastructural resilience; includes novel penalty system that could model limiting agents of recovery; compares score to a theoretical "perfect score"

Minus: Limited list of indicators; weighting and penalty schemas difficult to implement; definitions of variables unjustified; requires proprietary data; justification of "perfect score" arbitrary; penalty system requires more testing; index not ground-truthed; not all variables actionable

Variable examples: road area, transit performance, microgrids, hospital beds, education, creative class

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Community Resilience Index

17 Variables; hierarchical construction with internal and external validation

Goal: Measure adaptive capacity through social capital and economic development specifically

Plus: ease of use/transparency; easily visualized; monitor changes over time

Minus: limited variables; single value not representative of all dimensions of community resilience; not all variables actionable; county scale (and unit of analysis) too coarse; comparative descriptive NOT absolute predictive so dependent on study area selection; not all variables replicable

Variable examples: Gini coefficient; net gain/loss rate in business year; occupational diversity; two-parent families; net migration rate

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COPEWELL

49 Variables; System dynamics model for index; Rubric-based self-assessment

Goal: Assessment of pre-event, event, and post-event resilience characteristics through system dynamics index development and additional community assessment

Plus: Index and self-assessment based on same theoretical framework; assessment co-developed with community-level users; assessment is implementation-driven; participatory assessment acts as resilience intervention itself; index relies on national datasets; index is hazard-specific

Minus: Time-intensive; index and assessment not well connected to create holistic view of resilience; scale of index very coarse (County); application of assessment to new study areas difficult resulting in limited application; Index includes hazard exposure and vulnerability, conflating ideas of risk and resilience; not all index variables actionable

Variable examples: homes with internet service; food and water providers; insurance factors for women, Medicare enrollees, and all adults; housing stock; income inequality; affiliation with religious groups; hazard impact

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FEMA Community Resilience Index

22 Variables; Additive across all variables

Goal: Through accepted variables from the literature, create a universal resilience index

Plus: constructed from variables found across various resilience methodologies; available for download online from FEMA; incorporated into FEMA Resilience Analysis and Planning Tool (RAPT)

Minus: Overlap between vulnerability and resilience not well justified (uses social vulnerability indices in variable selection); uses all publicly available data;

Variable Examples: population without high school diploma; owner-occupied housing; number of hospitals; population below poverty level; income inequality; population change

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LACCDR

Training that includes network analysis, household survey, table-top exercise, and process evaluation/reflection

Goal: Operationalize and measure factors and strategies to increase community resilience through community coalition training

Plus: Training initiative; directly actionable; toolkit developed through stakeholder engagement; interactive method directly improves resilience as its own action; resilience improvement through established groups; public health led program (can be both plus and minus)

Minus: Time and resource-intensive; requires involved community organizations for implementation; missing factors of resilience other than social/community

Variable examples: Pre-/Post- incident wellness; preparedness education; self-sufficiency; partnerships between/within government and NGOs

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NaHRSI

117 Variables; Hierarchical construction with no internal validation

Goal: Index of basic resilience that incorporates hazard risk within the index rather than creating a separate exposure index for comparison

Plus: theoretically/conceptually driven; extensive measurement variables; can integrate hazard event for post-event resilience and recovery modeling

Minus: Includes hazard exposure and vulnerability, conflating ideas of risk and resilience; intense data management required; complicated model/equations for index construction; not validated or ground-truthed; datasets inconsistent

Variable examples: communication continuity; biodiversity; land area type; hazard exposure and loss; access to social support; structure vulnerability; condition of natural environment; labor-trade services

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PEOPLES Framework

95 Variables; GIS overlay methodology; systems of systems approach

Goal: Create a GIS tool to investigate different interactions across variables

Plus: holistic view of community resilience; geospatial focus;

Minus: requires complex modeling and extensive data collection; conflates vulnerability and resilience within population demographics dimension;

Variable examples: population demographics (age, gender, race,); water, air, soil quality; executive and administrative emergency functions, cultural facilities, lifelines (internet connections, postal, healthcare, food supply, utilities, and transportation); collective action and efficacy (conflict resolution and quality of life); financial services, CPI; employment and business services; social services

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RCCR Framework

Risk and Resilience spectrums created through local perception; Later revised to include climate justice

Goal: Understand locally perceived resilience needs in coastal rural communities

Plus: Themes designed with practical application in mind; themes assessed by community members through interviews and focus groups; focused on engaging communities in resilience conversation; stimulate capacity building dialogue; manageable tool for replication; avenue for community members to describe place-based issues and perceptions

Minus: Frames resilience and vulnerability as opposing forces influencing adaptive capacity; only pre- and post- surveys from focus groups; not generalizable to other scales; findings very localized; small group of people engaged at one time

Variable Examples (Survey): Threat of sea level rise, saltwater intrusion, and flooding; vulnerability of the same three hazards; level of preparedness to the same three hazards

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RRI

Blend of qualitative and quantitative data through Citizen engagement in generating locally relevant data through Likert-scale

Goal: While an index, this is a bottom-up tool due to the identification of the variables included occurring at the community level, creating a place-specific index

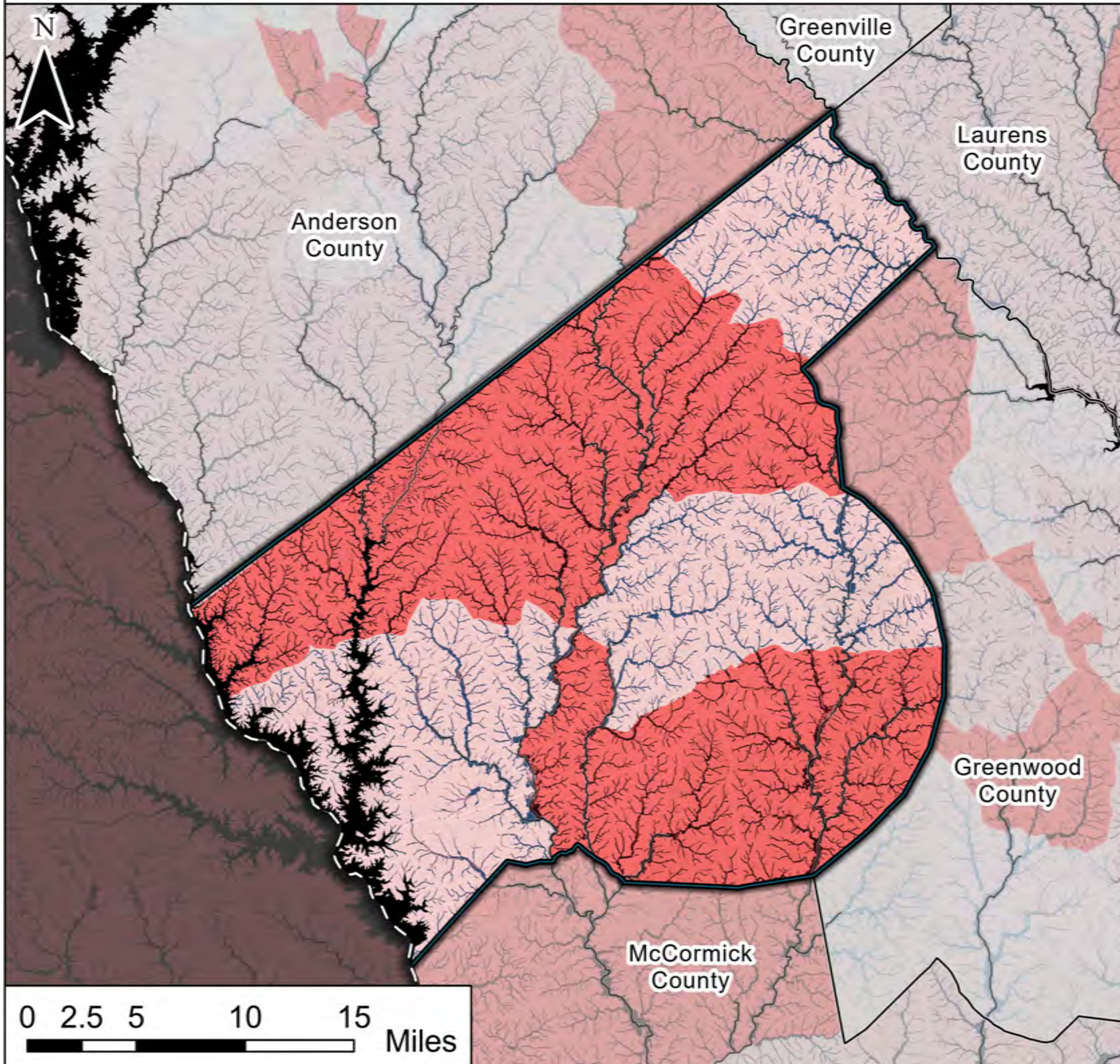
Plus: Indicators theoretically bound and iteratively chosen through local knowledge; focus on the implementation of plan to increase resilience; developed in tandem with hazard risk assessment tool

Minus: Due to local input, variables may not be widely applicable; measurement of resilience through survey method - difficult to measure over time; time and resource intensive; final product not easily interpreted; methods and variable list incomplete

Variable examples: Community wellbeing; housing and public spaces; communication options; hazard awareness; emergency operations; community engagement

APPENDIX D:
COUNTY FLOOD EXPOSURE & SOCIAL VULNERABILITY

Abbeville County
Flooding Exposure and Social Vulnerability



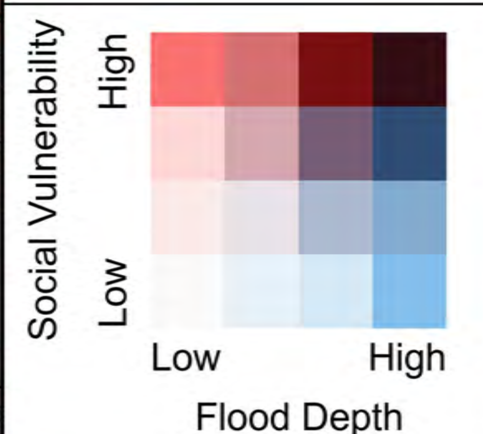
This map overlays flooding depth associated with a 1% Annual Chance Event (1 in 100 Year Flood) and Social Vulnerability (SoVI®).

Flood Depth's are produced by the First Street Foundation, and are symbolized in 4 categories;

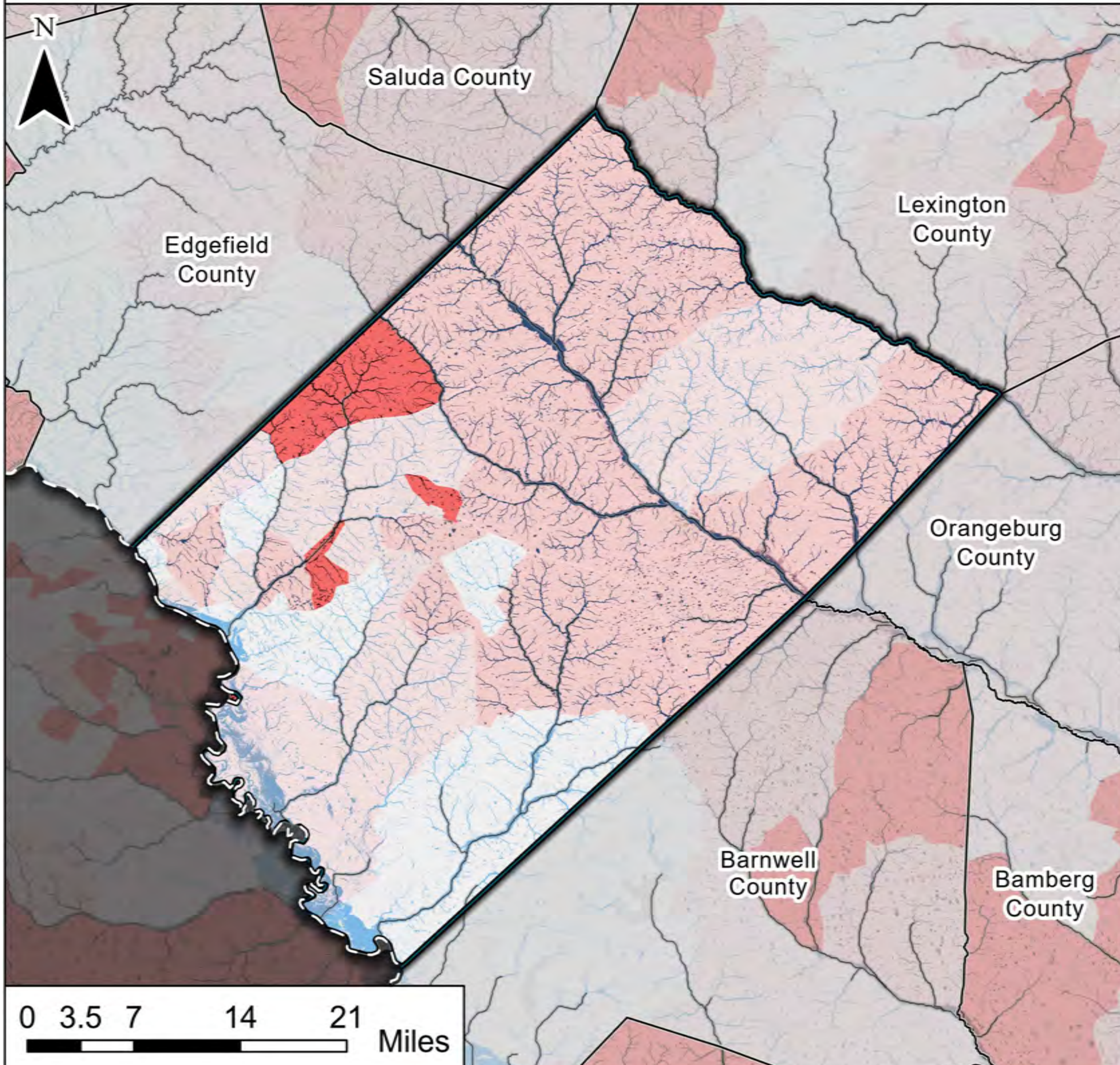
- Low - Under 1 foot
- Under 2 feet
- Under 3 feet
- High - Over 3 feet

Social Vulnerability values are taken at the Census Tract Level - State Percentile value, and provided by the National Risk Index (FEMA). This map uses 4 categories to symbolize low to high social vulnerability.

- Low - ≤25th percentile
- ≤50th percentile
- ≤75th percentile
- High - ≥75th percentile



Aiken County
Flooding Exposure and Social Vulnerability



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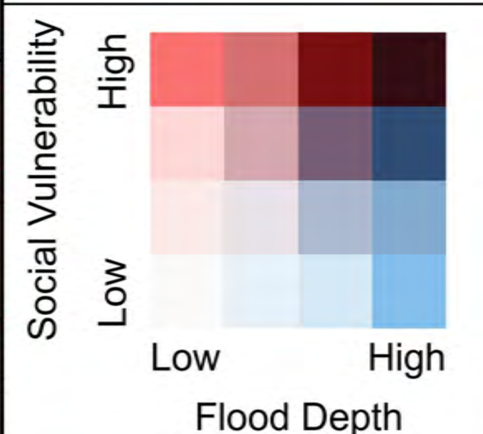
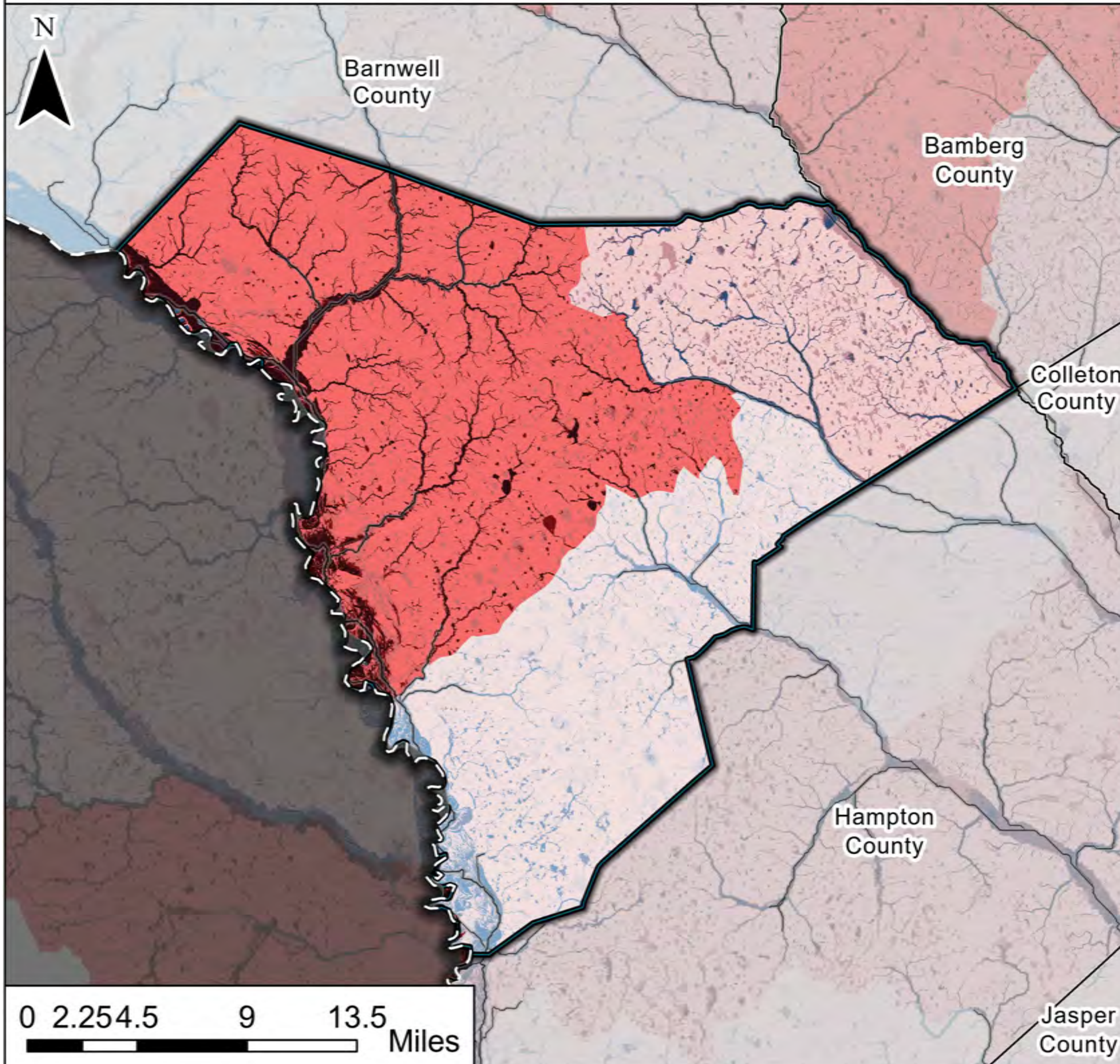


Allendale County
Flooding Exposure and Social Vulnerability



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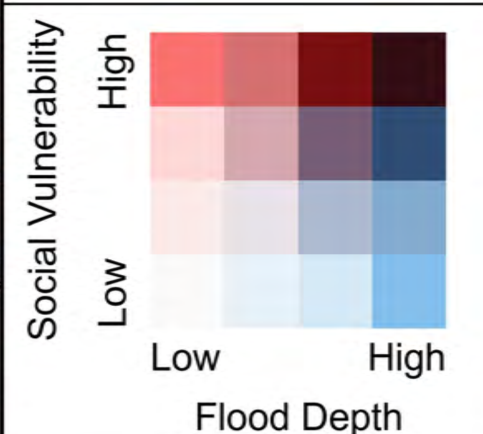
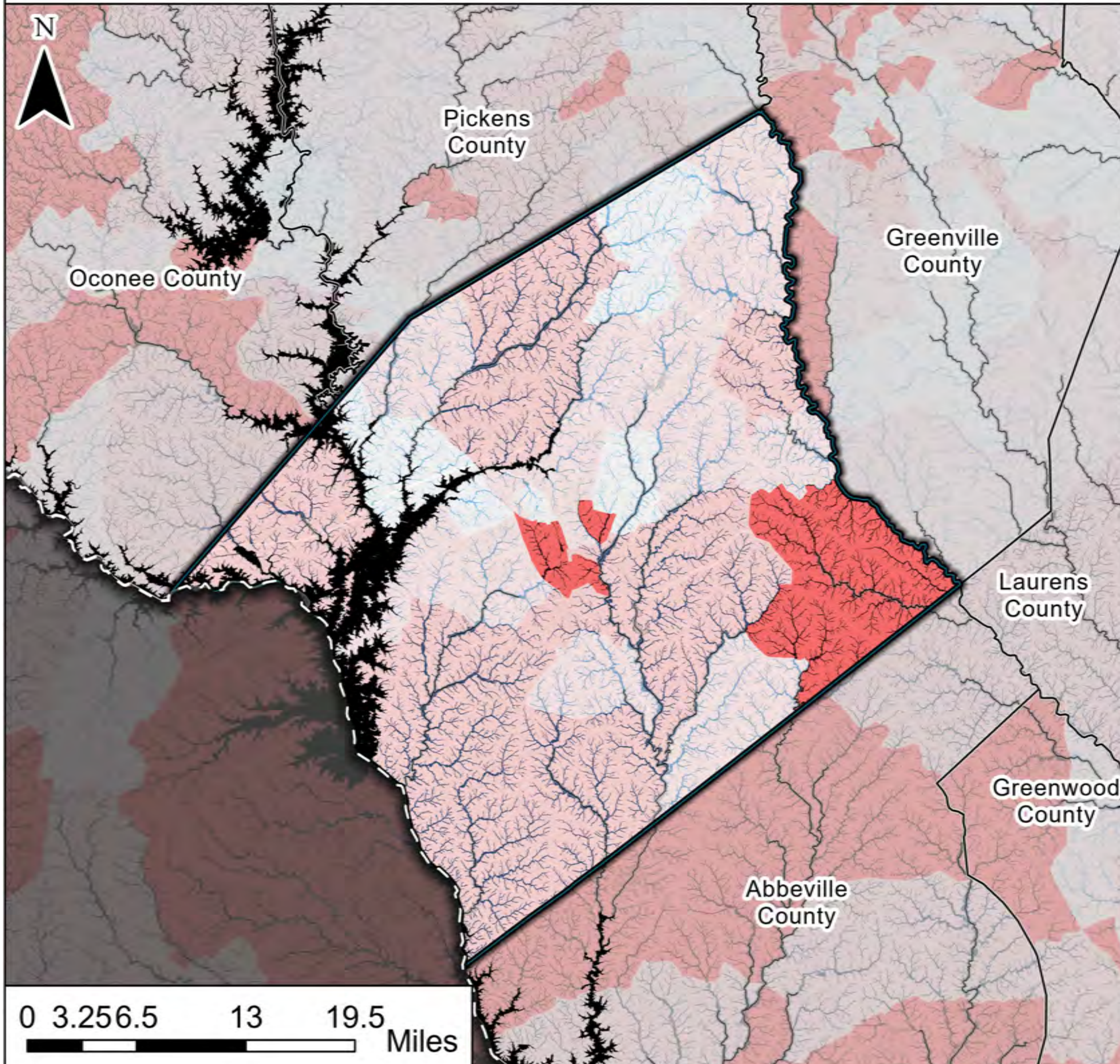


Anderson County
Flooding Exposure and Social Vulnerability



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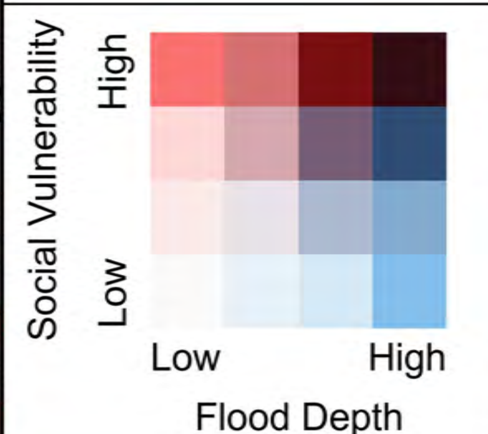
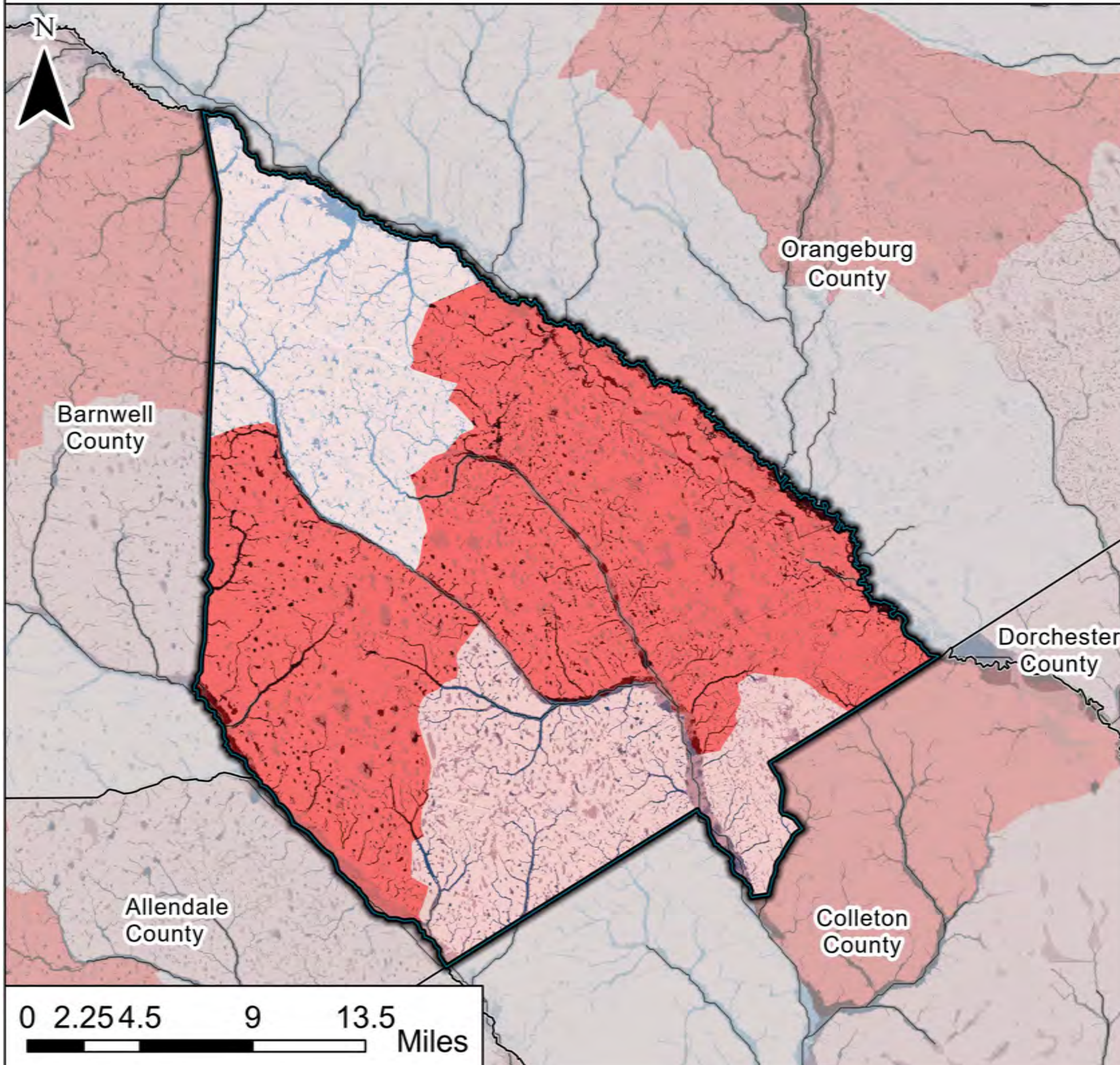


Bamberg County
Flooding Exposure and Social Vulnerability



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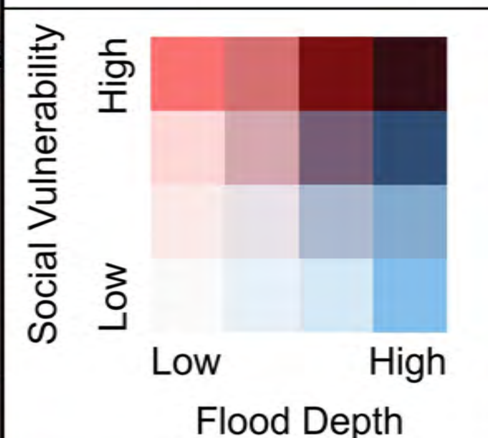
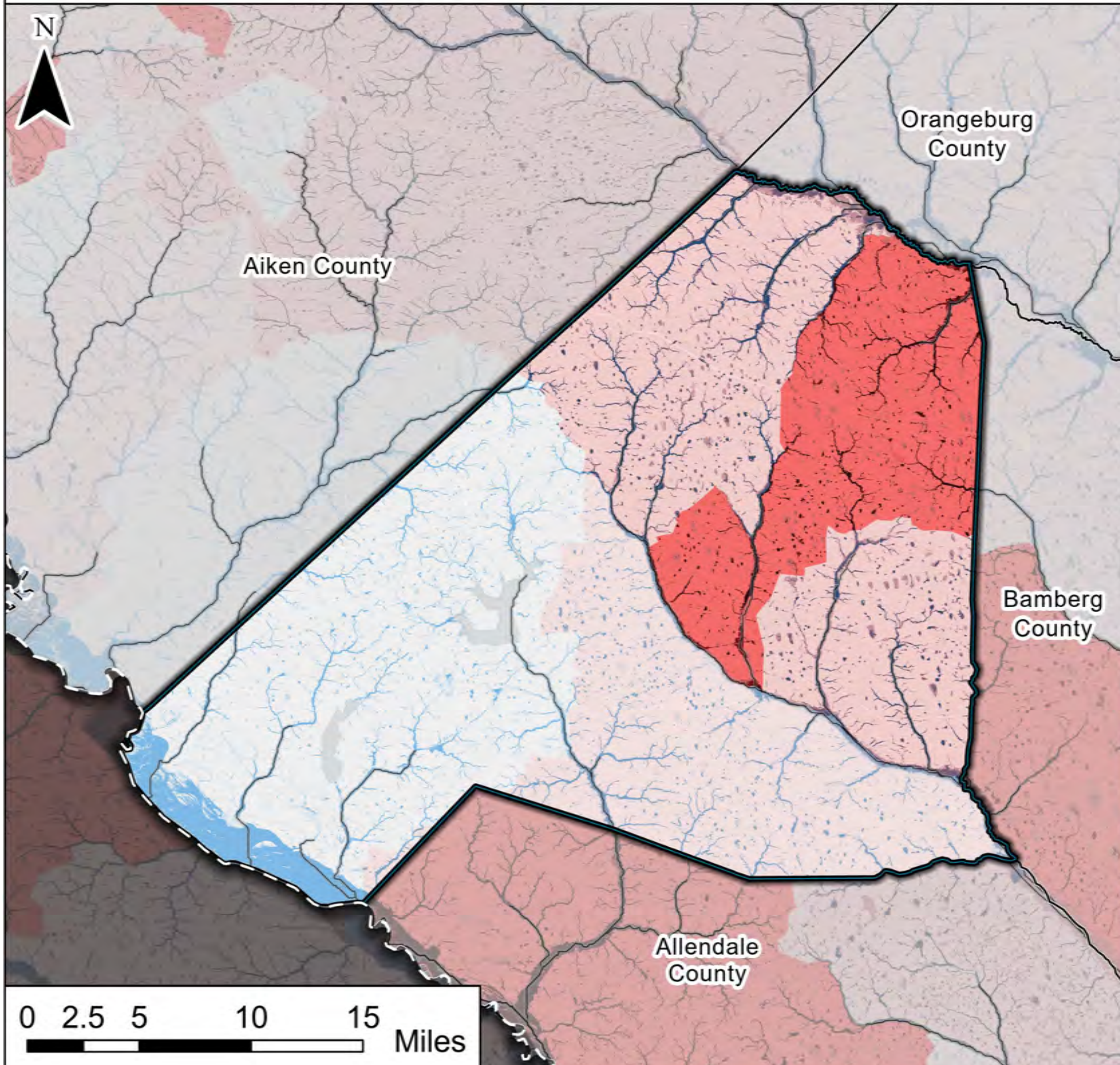


Barnwell County
Flooding Exposure and Social Vulnerability



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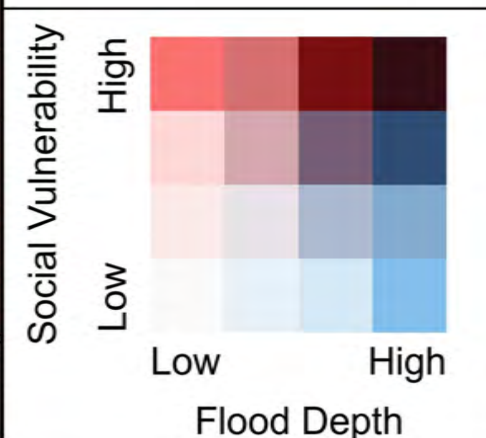
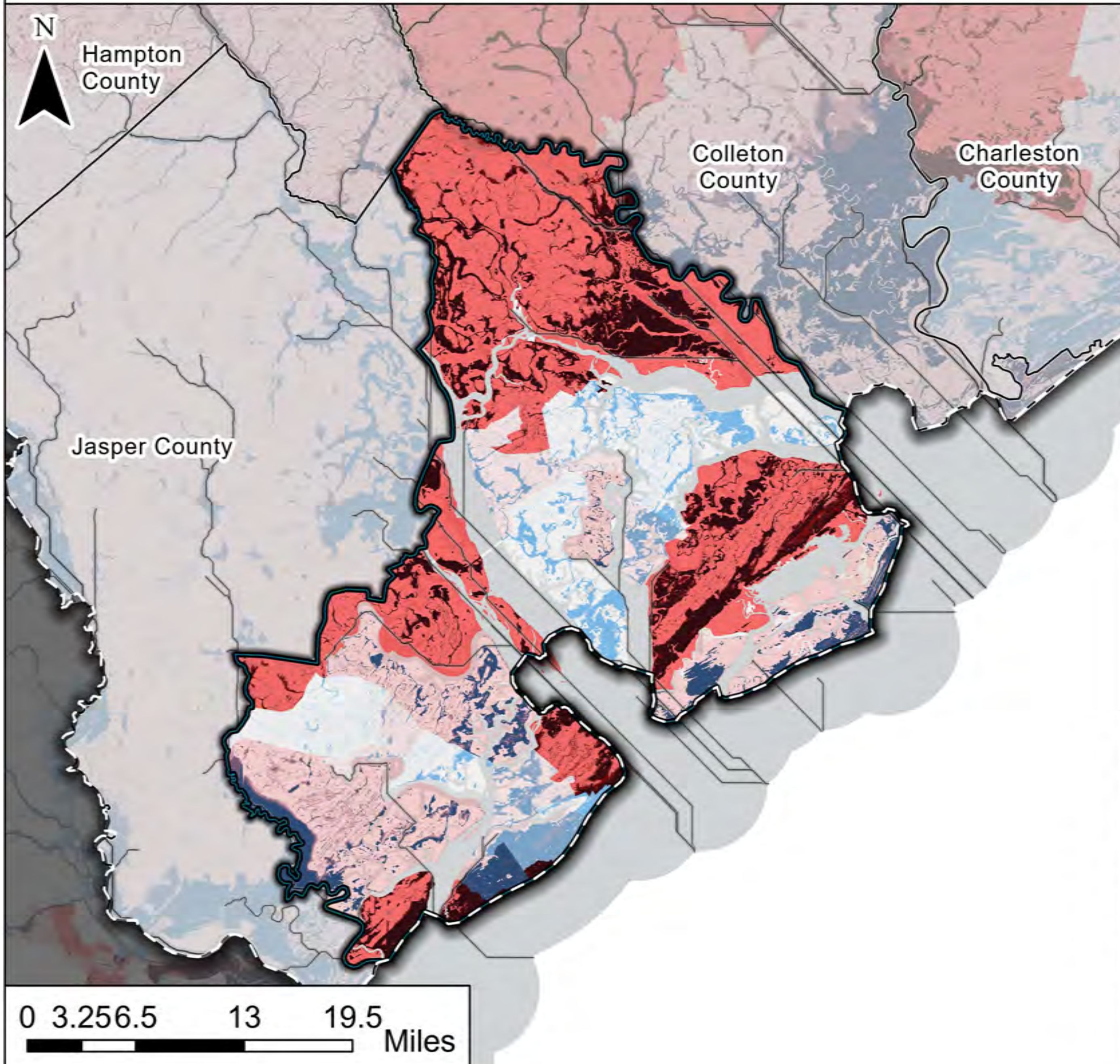


Beaufort County
Flooding Exposure and Social Vulnerability



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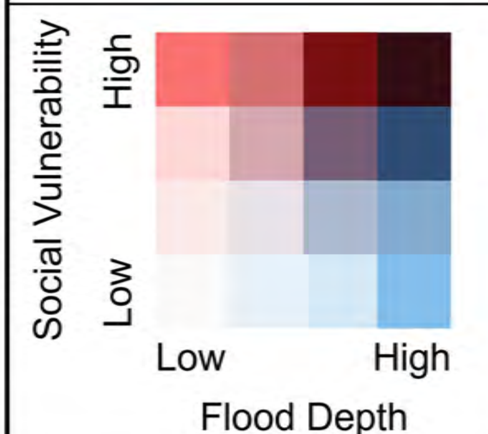
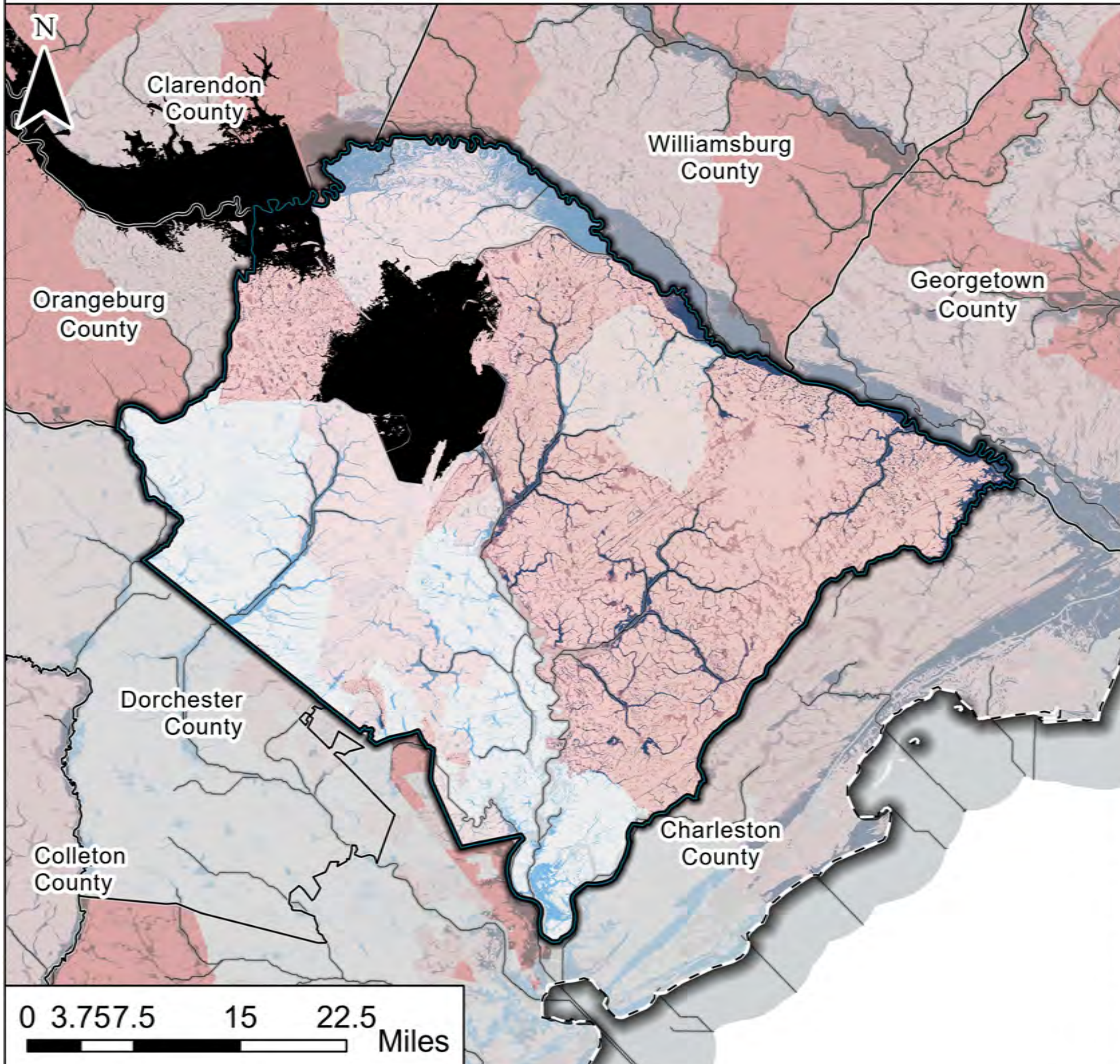


Berkeley County
Flooding Exposure and Social Vulnerability



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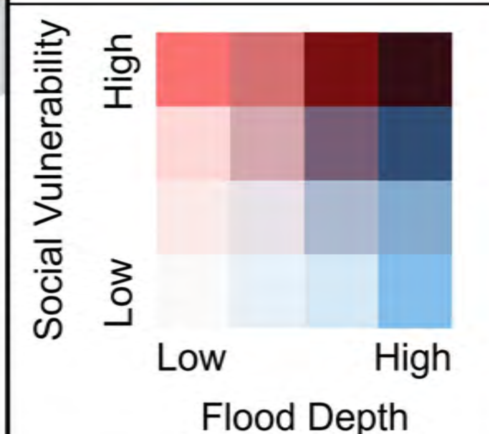
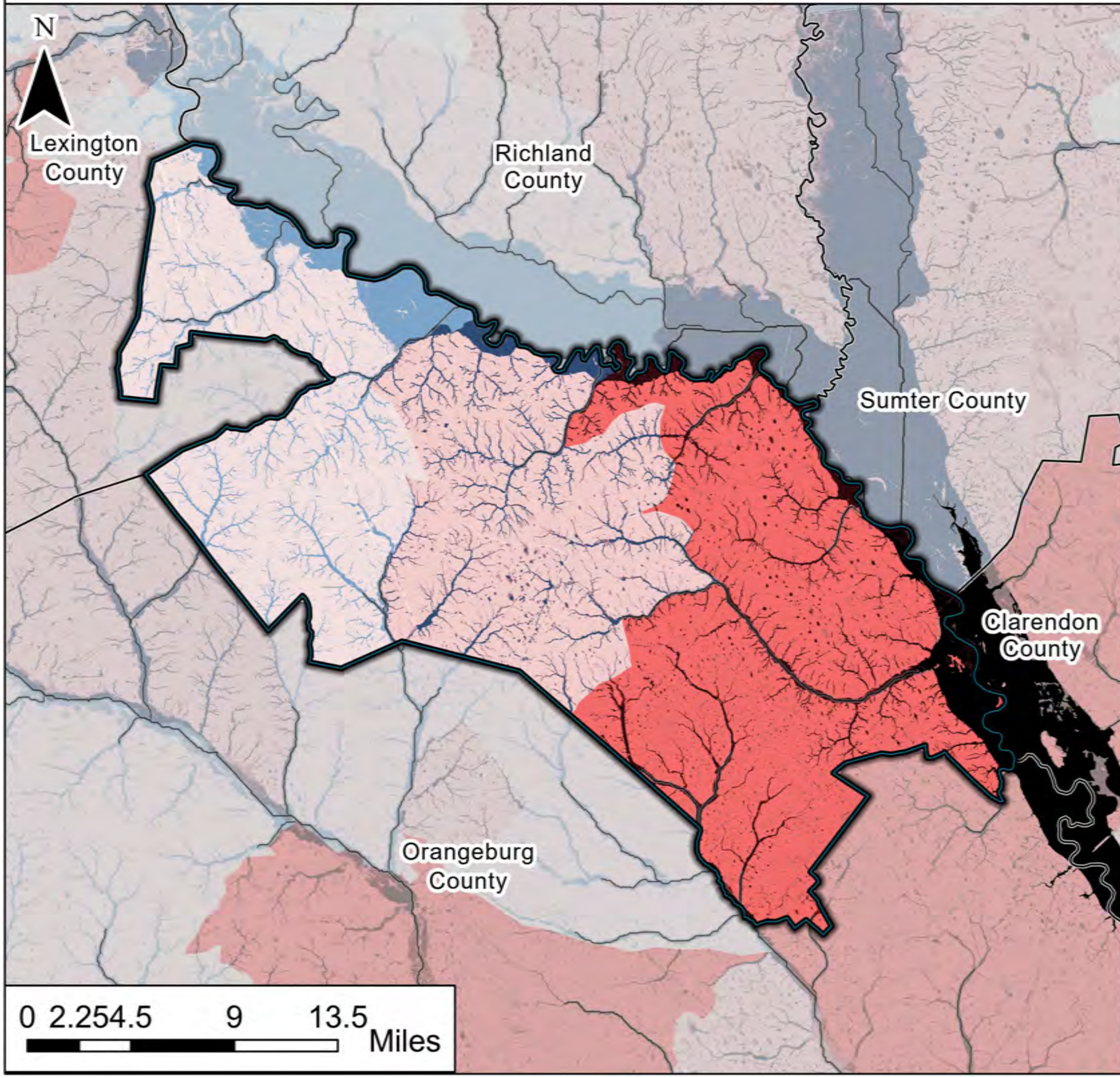


Calhoun County
Flooding Exposure and Social Vulnerability



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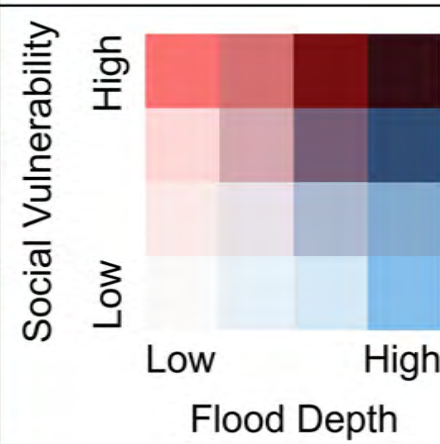
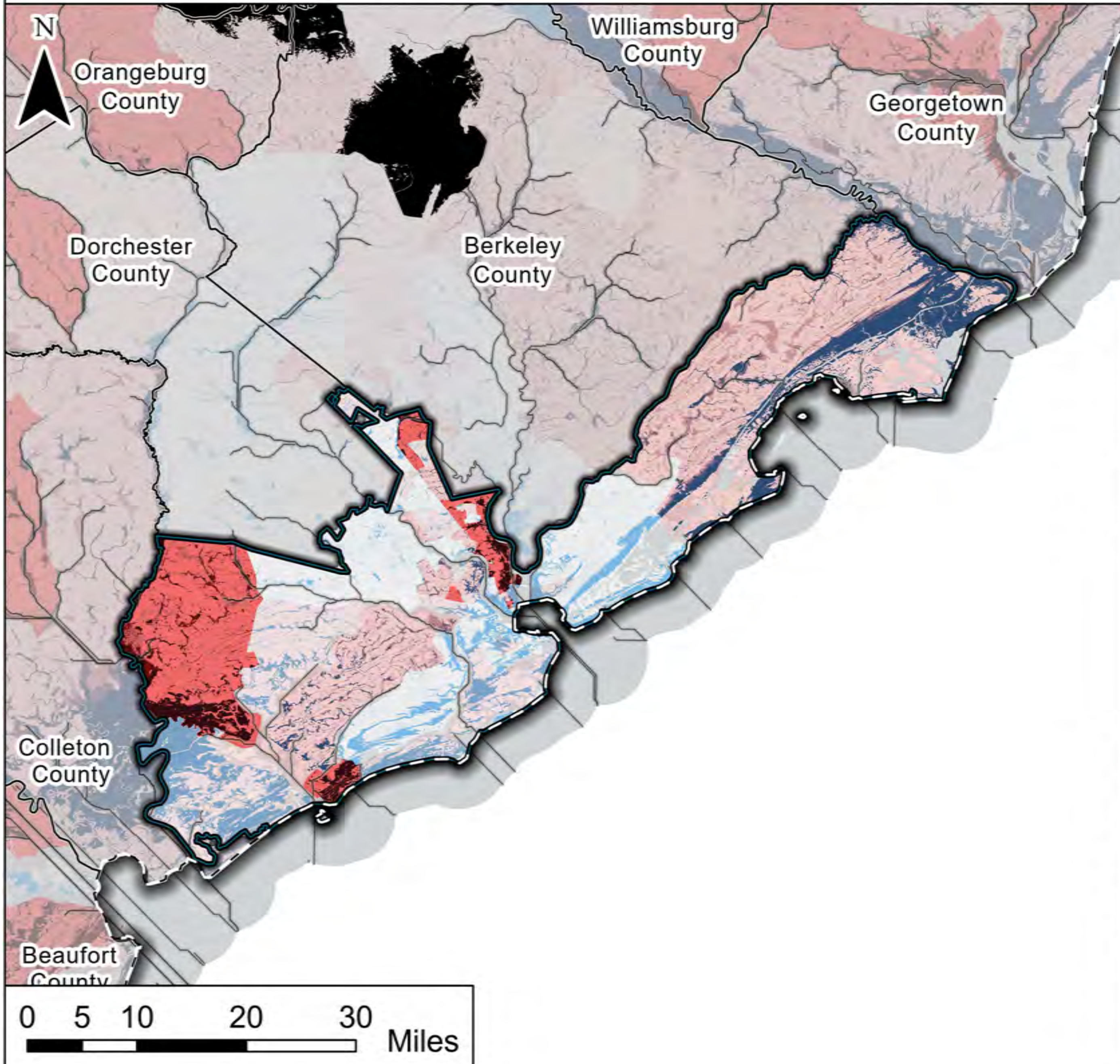


Charleston County
Flooding Exposure and Social Vulnerability



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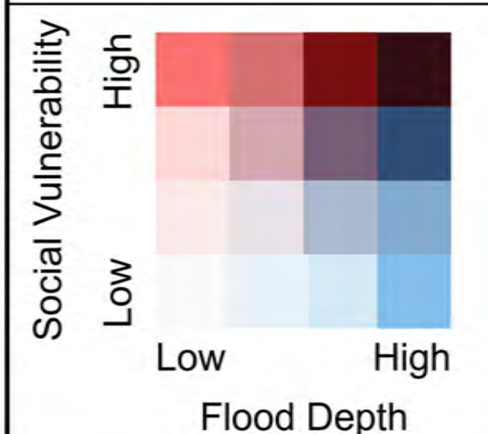
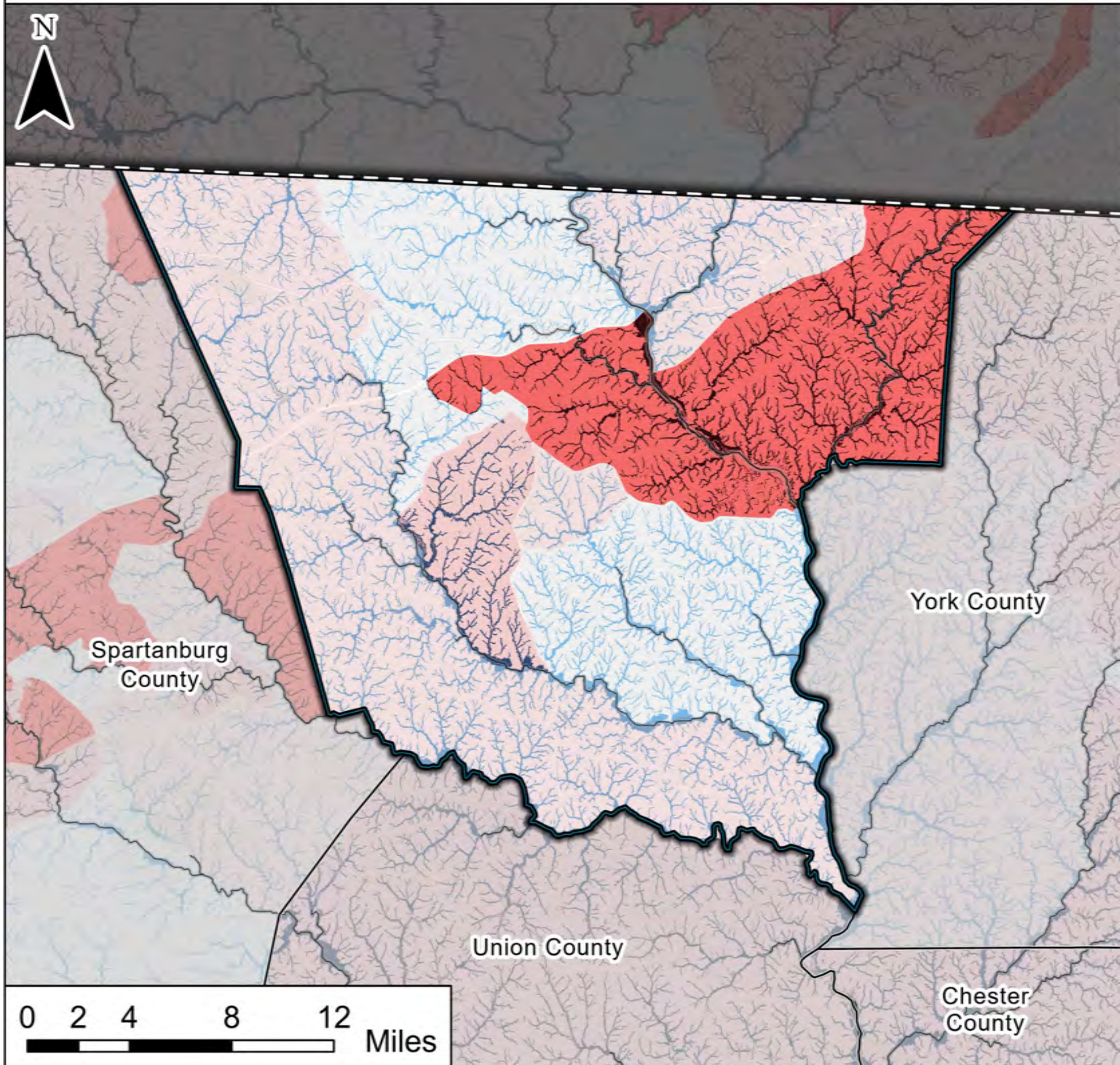


Cherokee County
Flooding Exposure and Social Vulnerability



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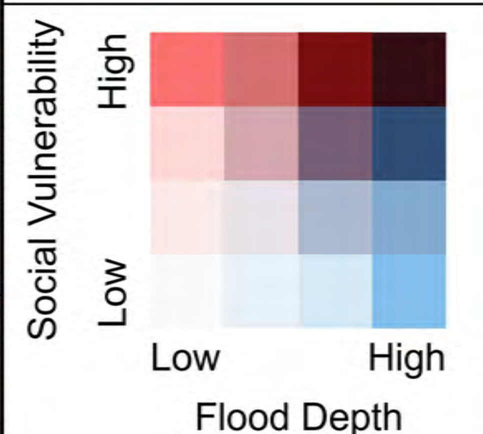
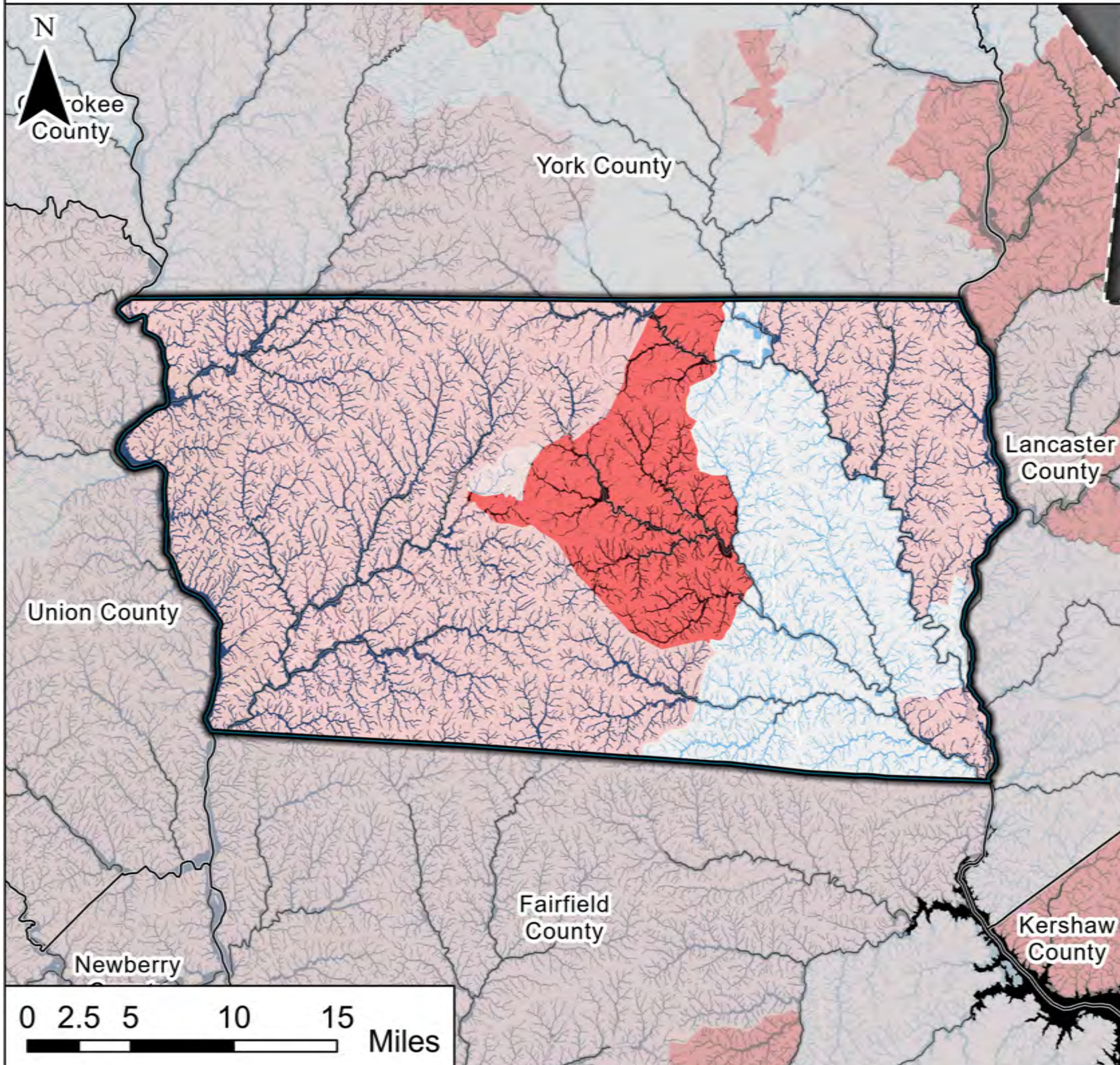


Chester County
Flooding Exposure and Social Vulnerability



This map overlays flooding depth associated with a 1% Annual Chance Event (1 in 100 Year Flood) and Social Vulnerability (SoVI®).

Flood Depth's are produced by the First Street Foundation, and are symbolized in 4 categories;

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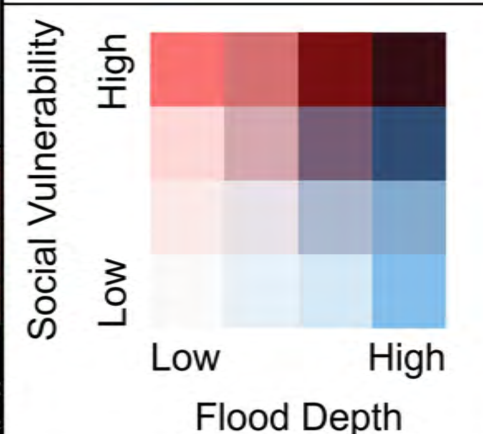
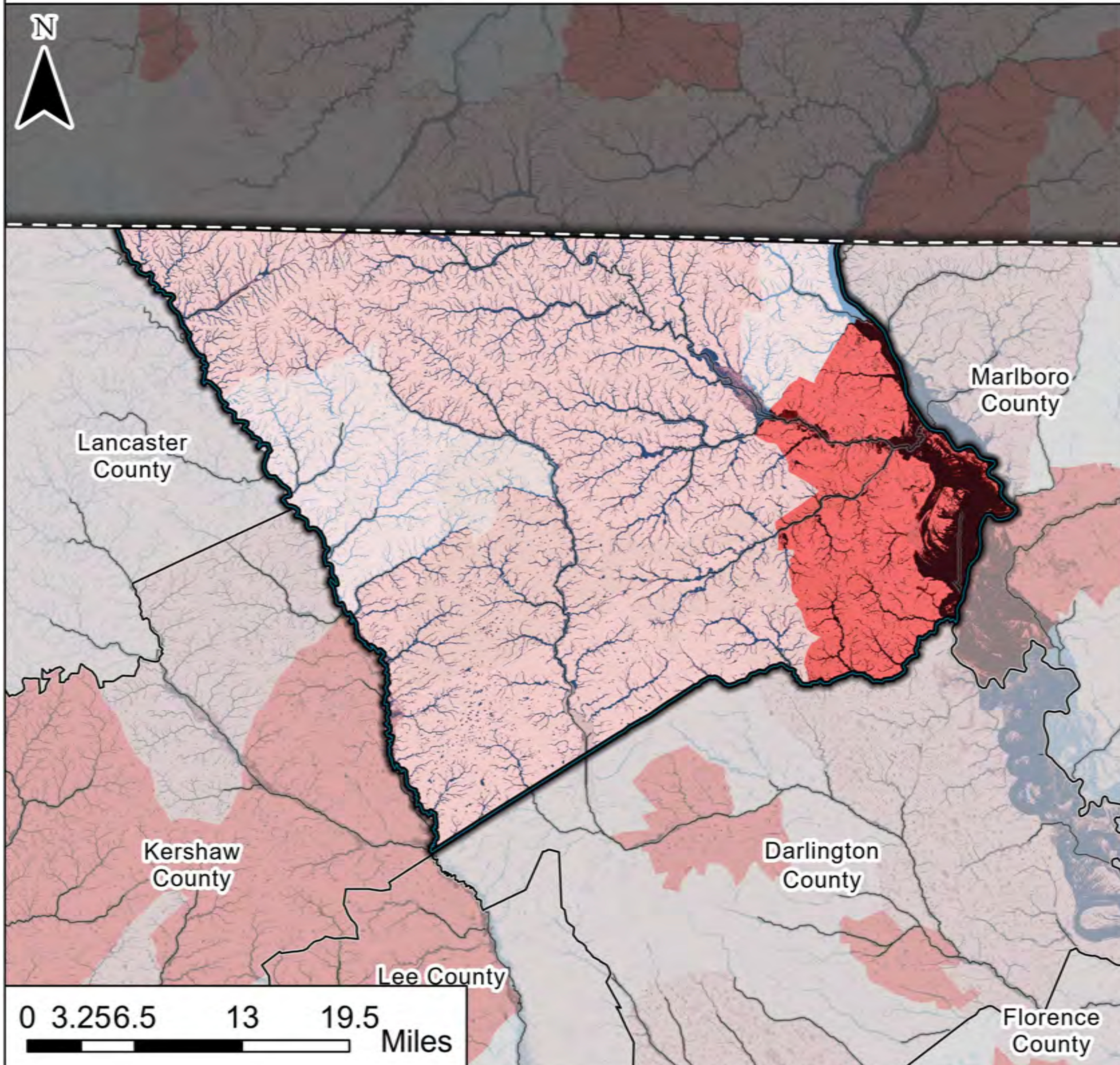


Chesterfield County
Flooding Exposure and Social Vulnerability



South Carolina Office of Resilience

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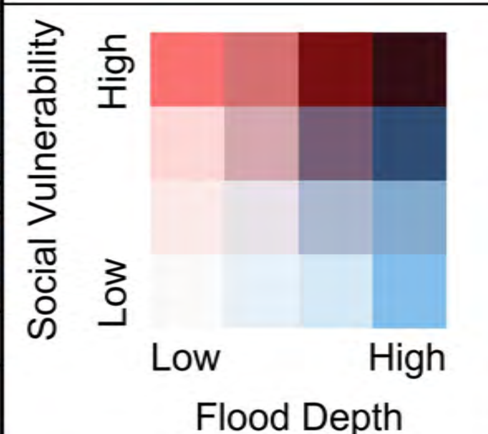
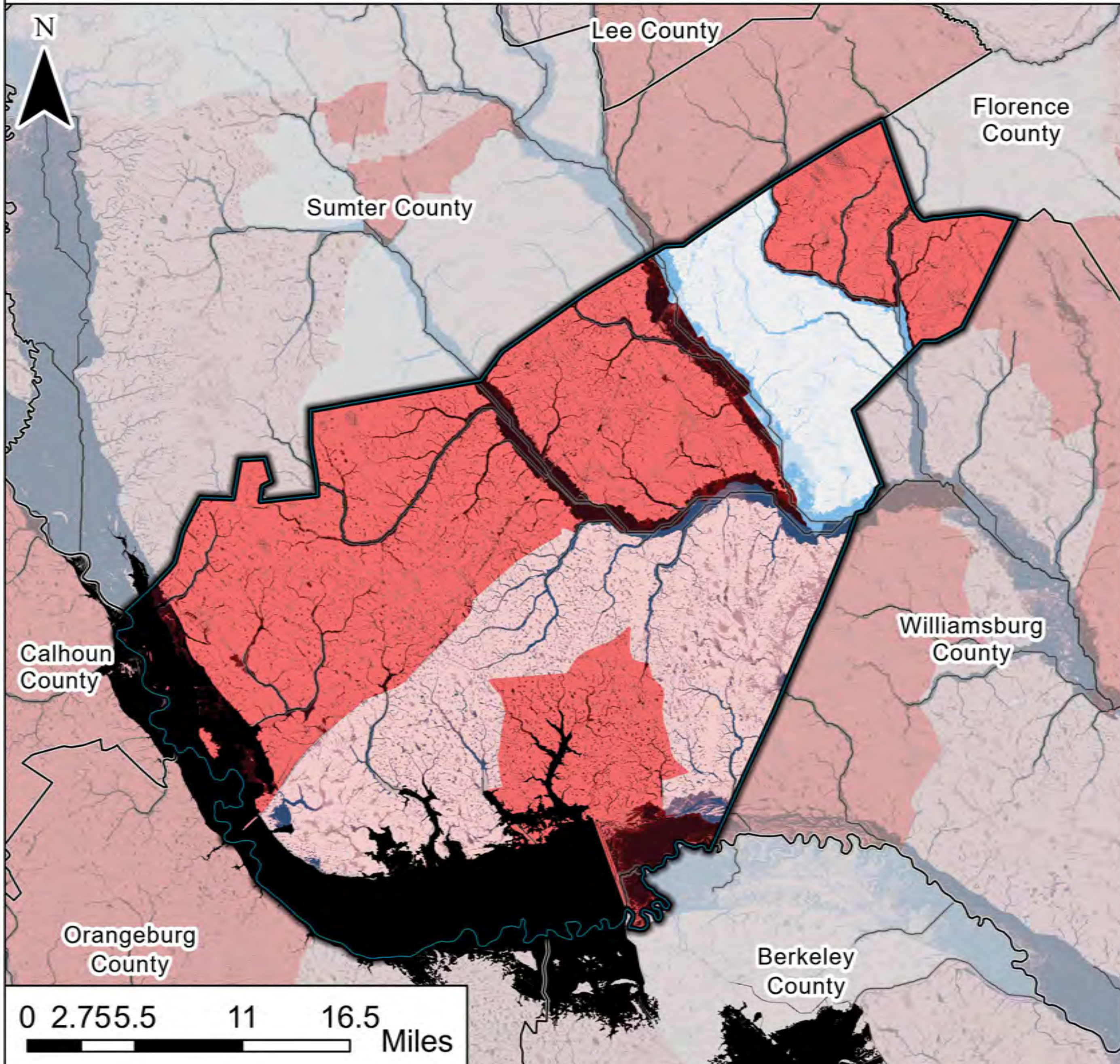


Clarendon County
Flooding Exposure and Social Vulnerability



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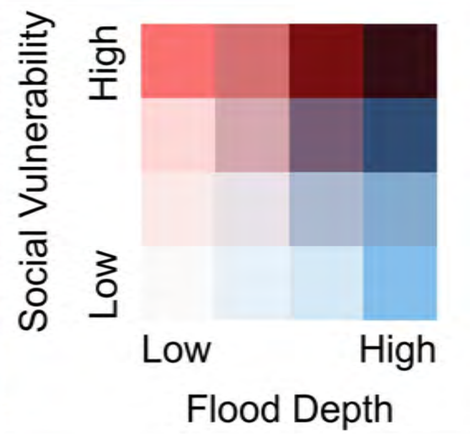
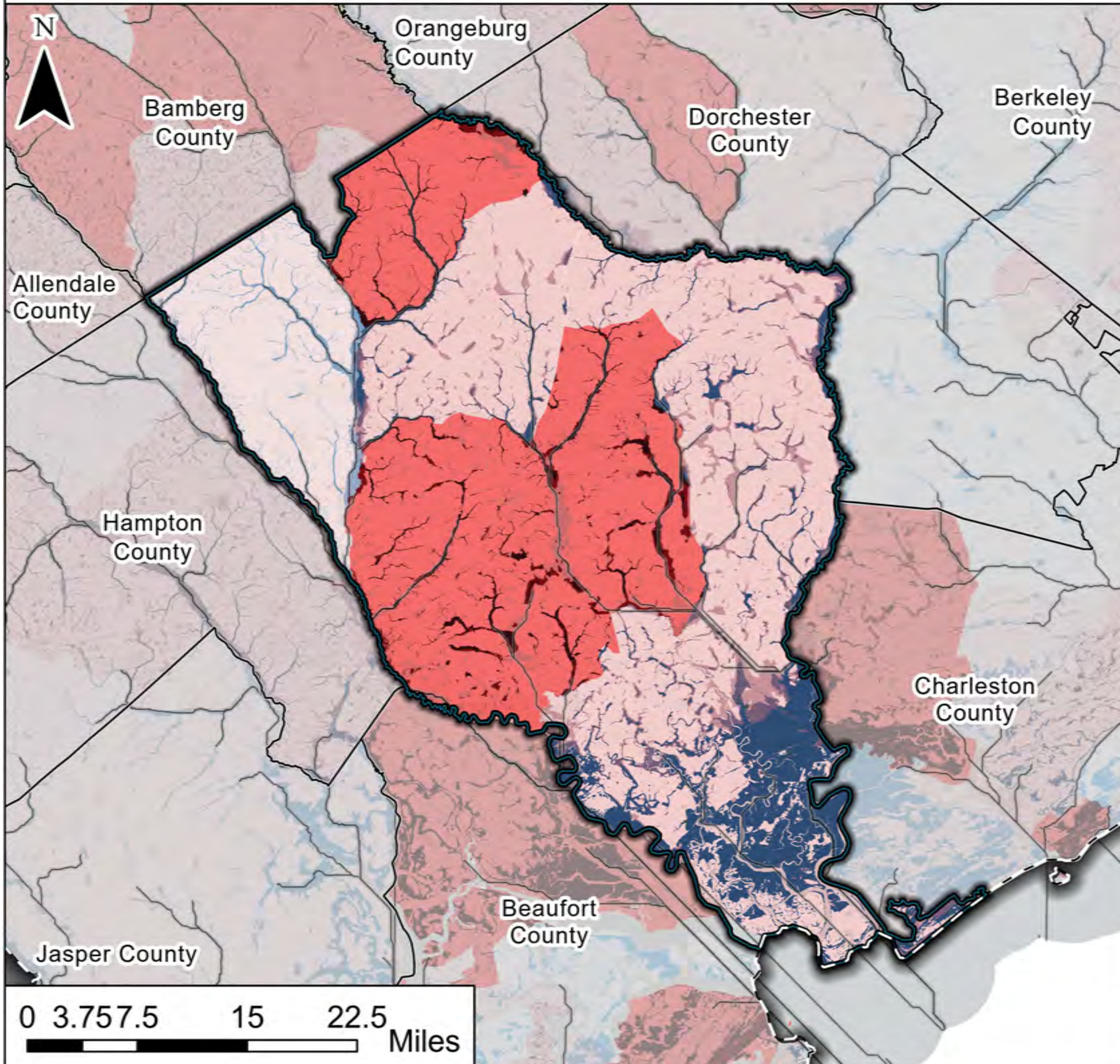


Colleton County
Flooding Exposure and Social Vulnerability



SCOR South Carolina Office of Resilience

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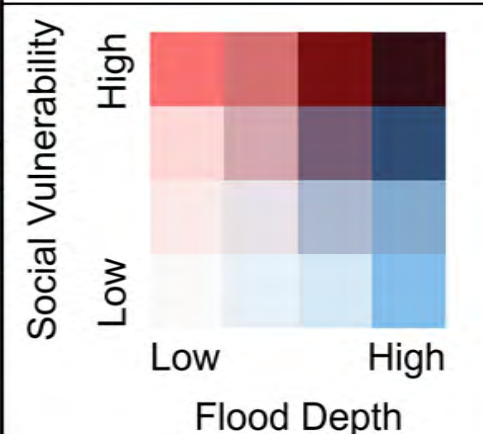
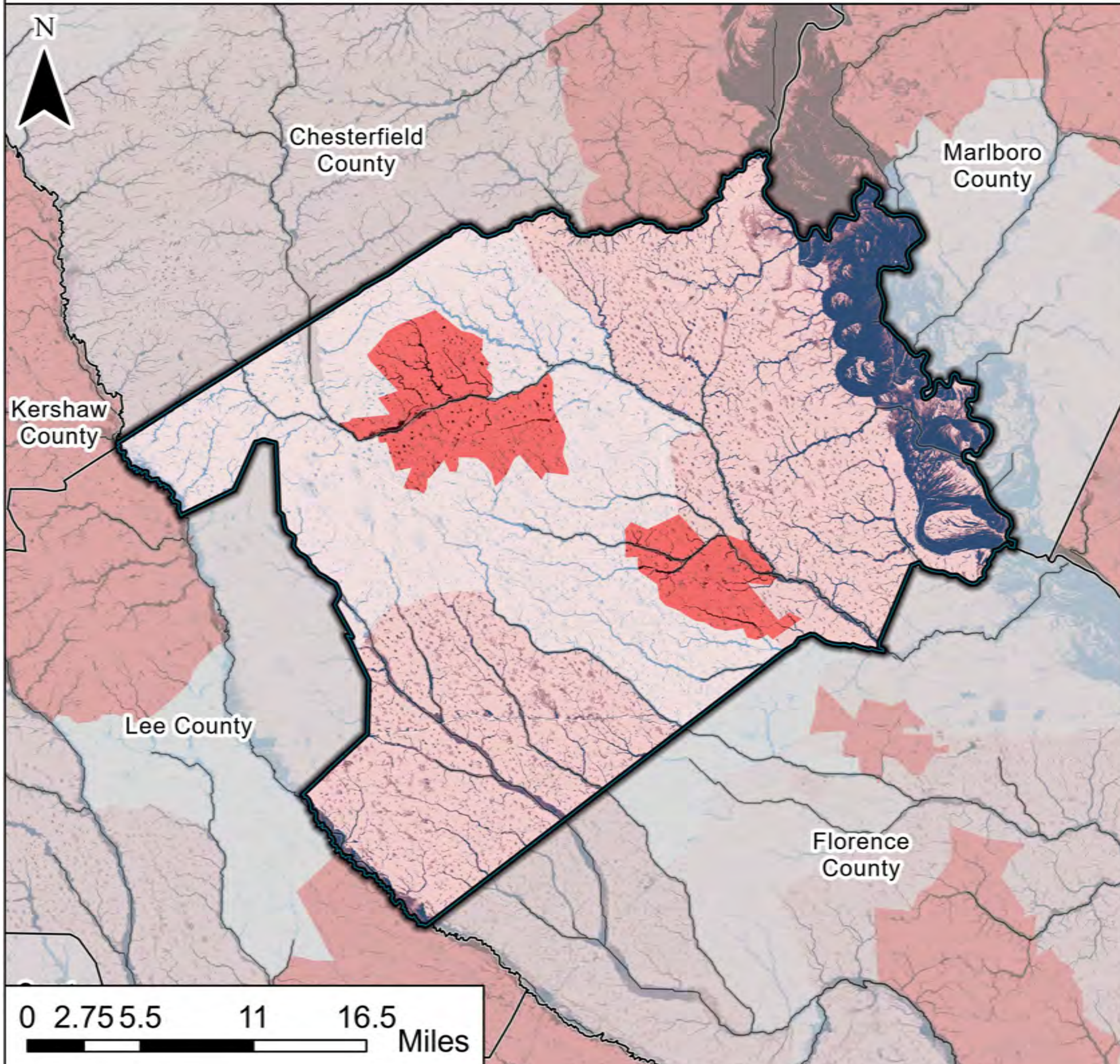


Darlington County
Flooding Exposure and Social Vulnerability



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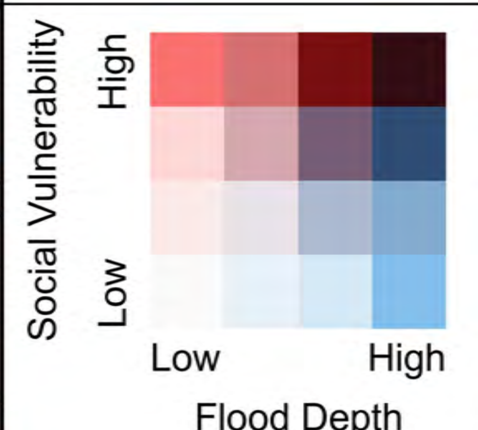
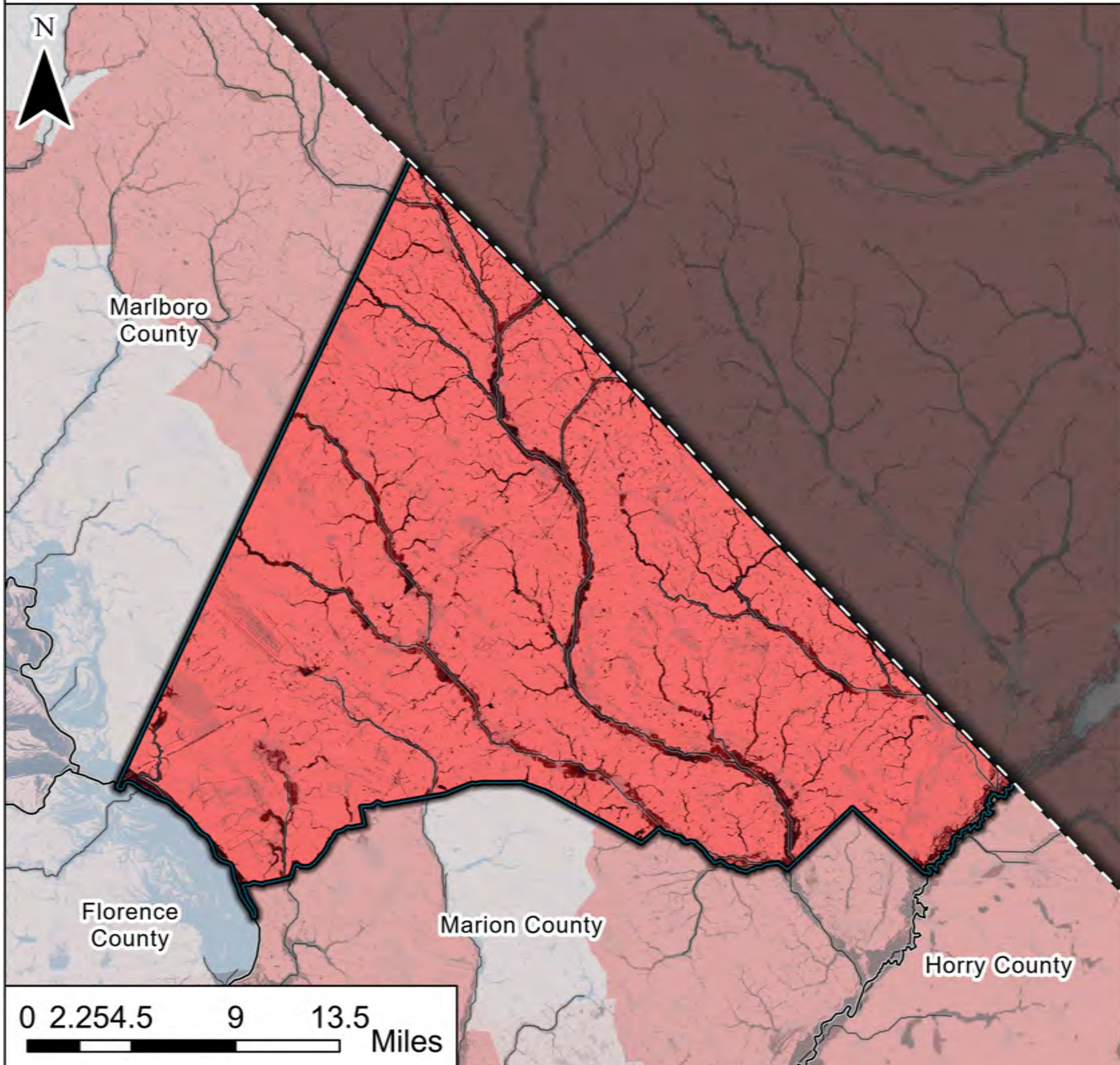


Dillon County
Flooding Exposure and Social Vulnerability



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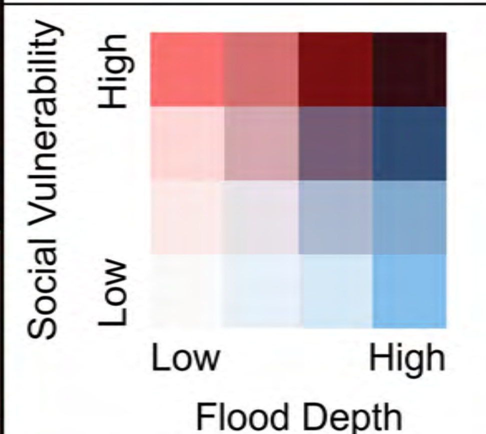
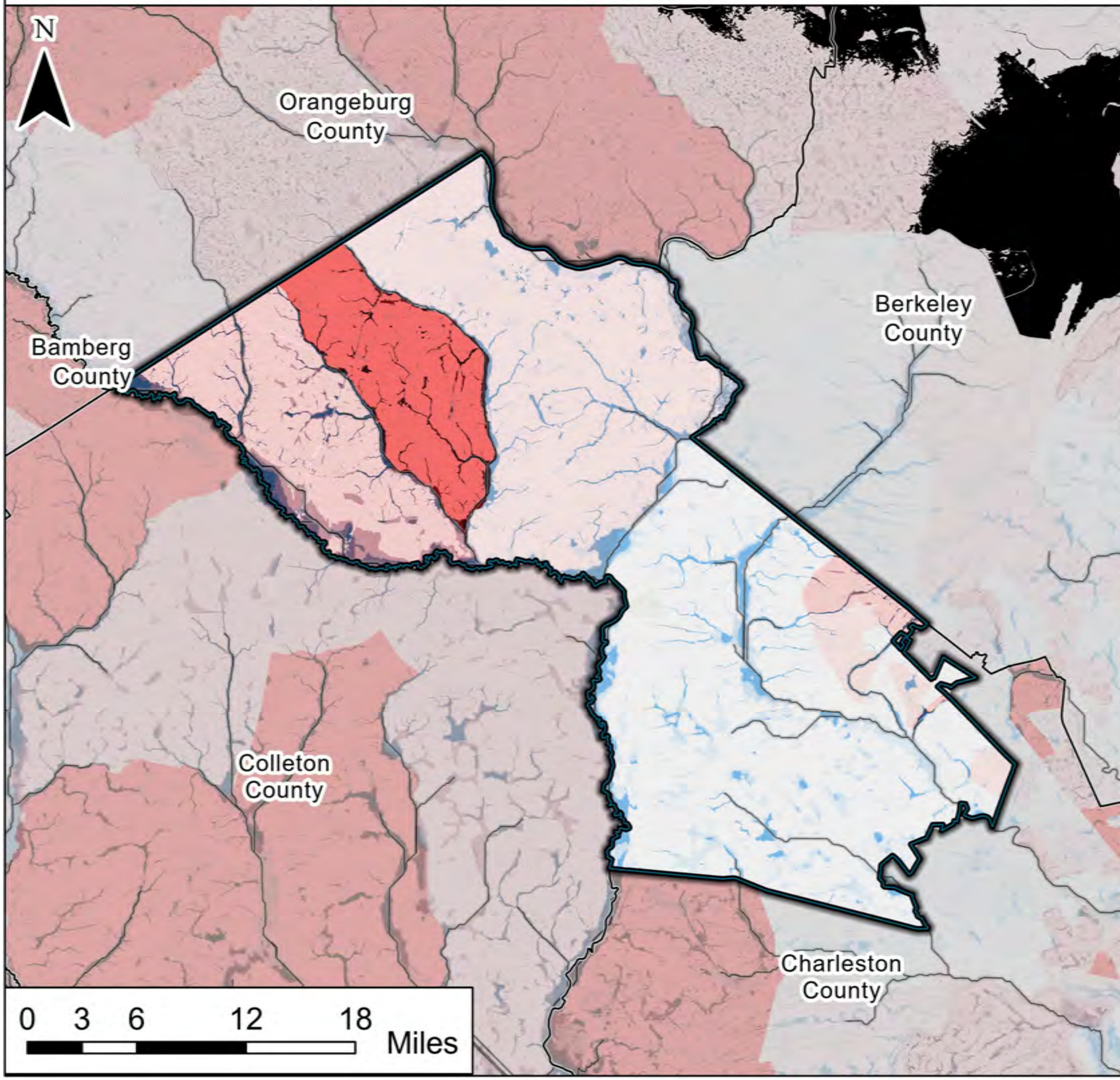


Dorchester County
Flooding Exposure and Social Vulnerability



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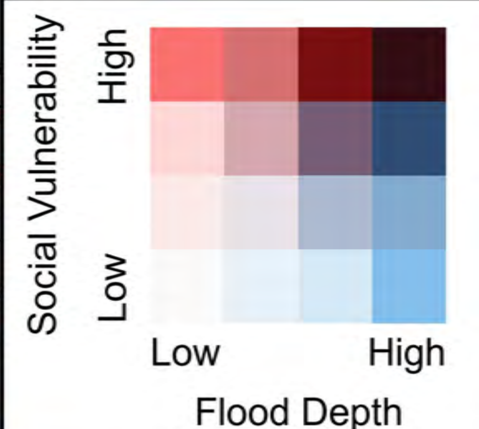
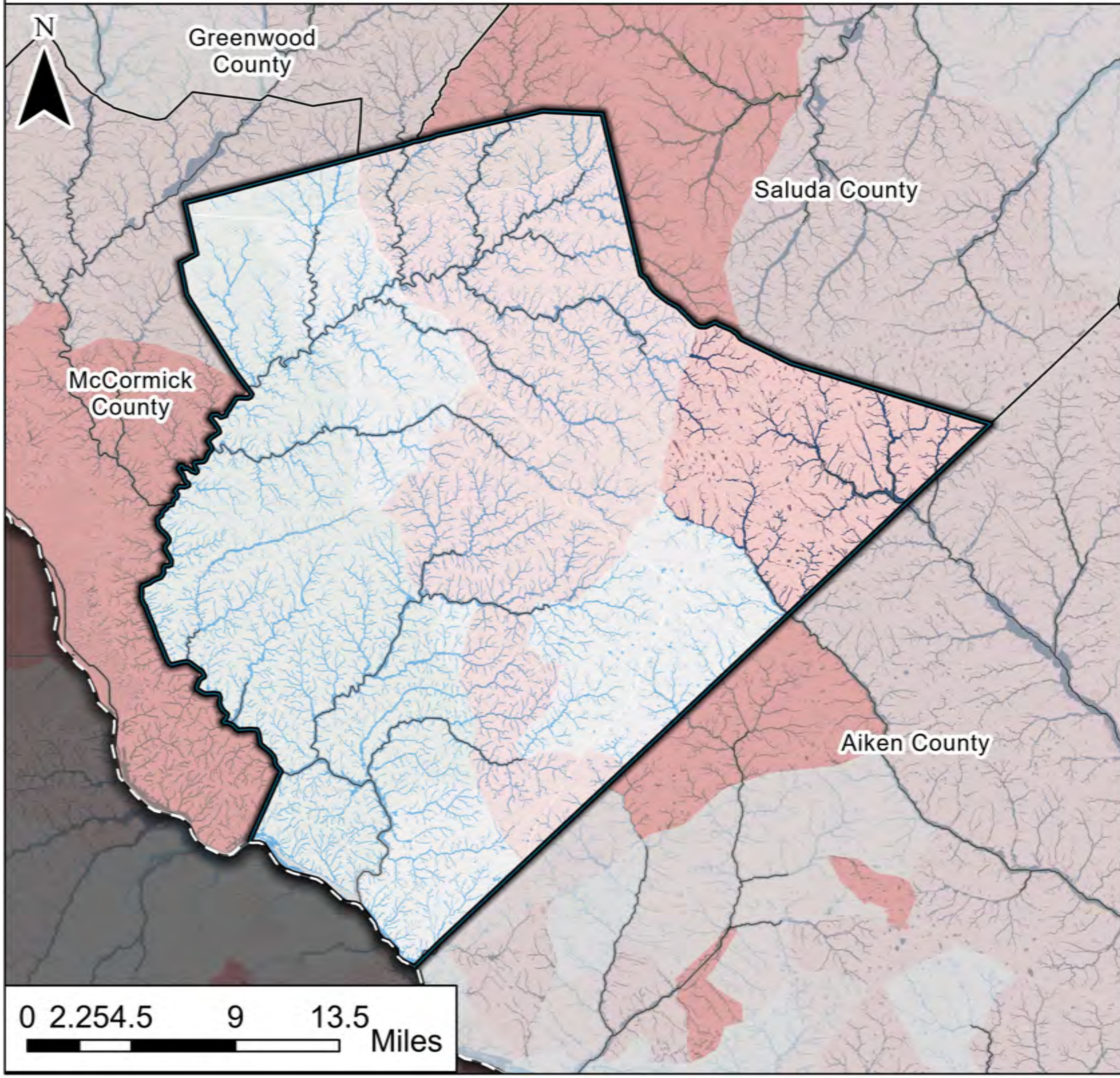


Edgefield County
Flooding Exposure and Social Vulnerability



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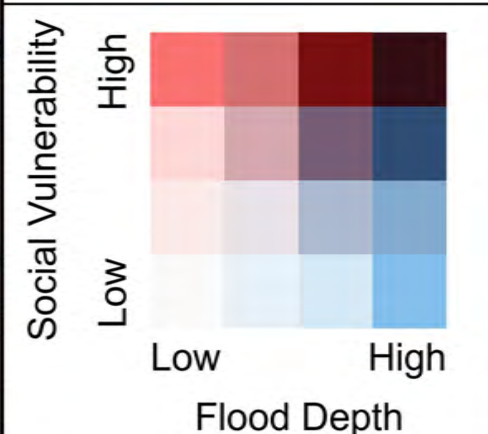
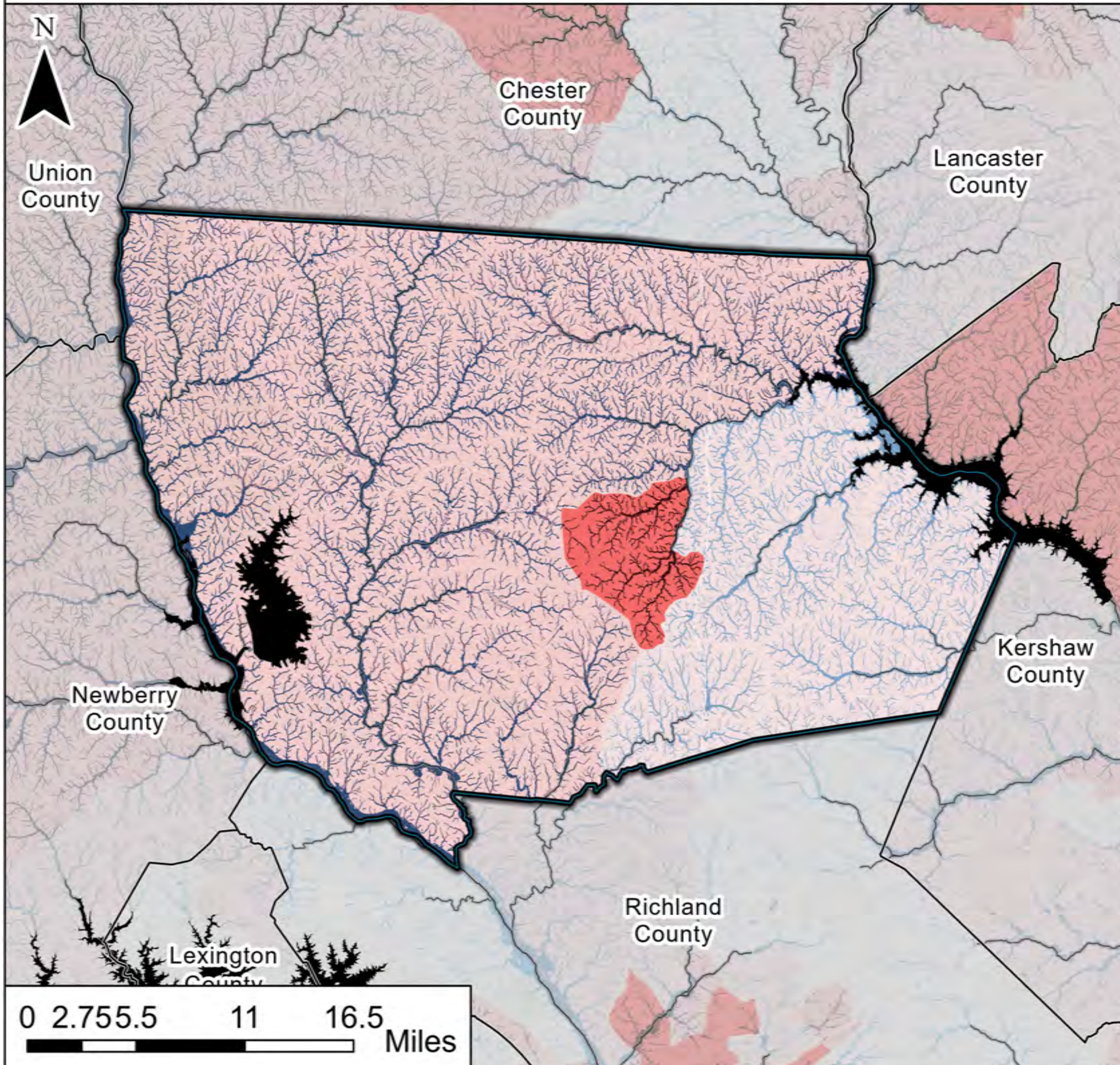


Fairfield County
Flooding Exposure and Social Vulnerability



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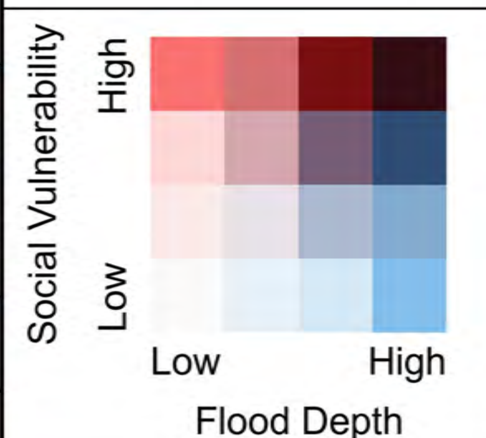
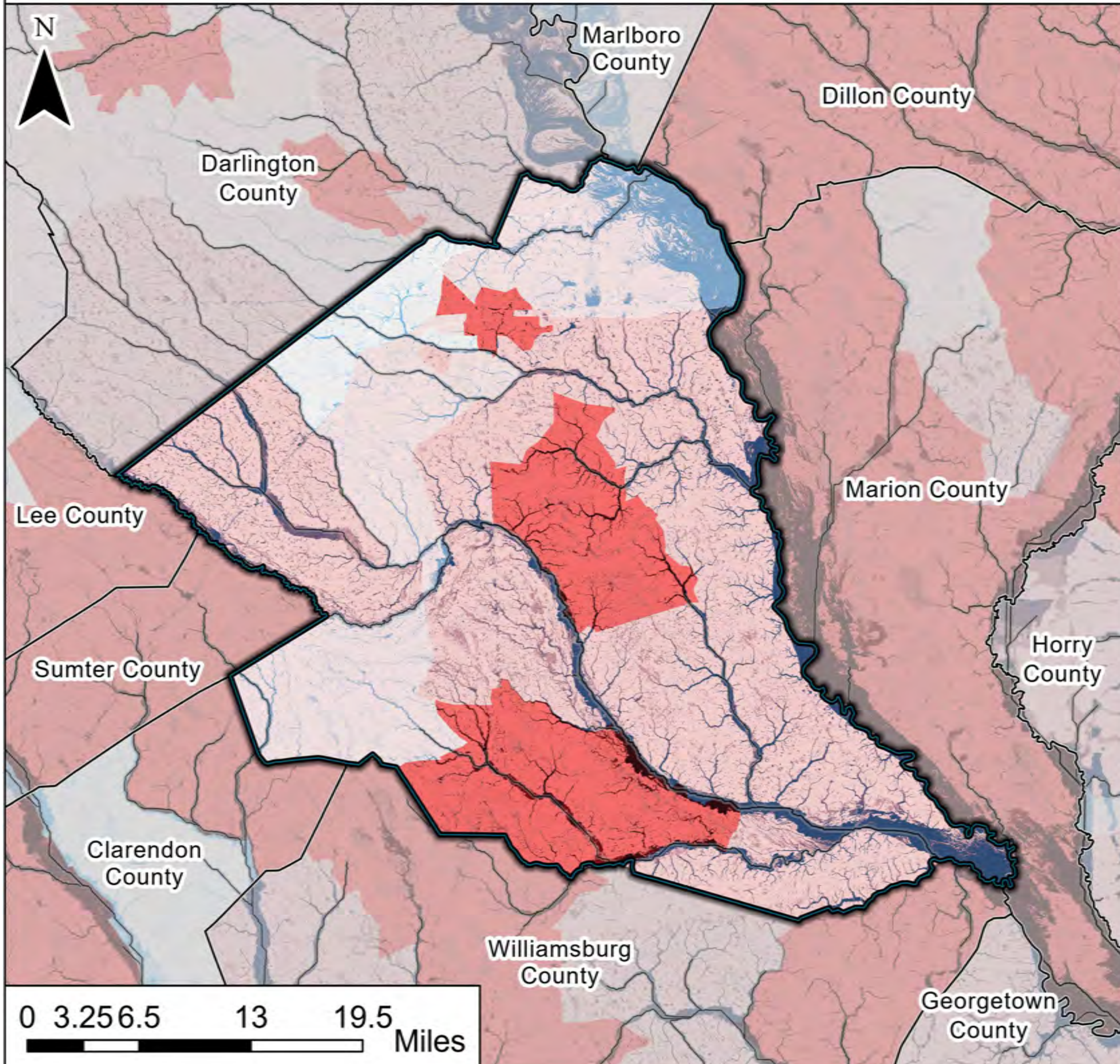


Florence County
Flooding Exposure and Social Vulnerability



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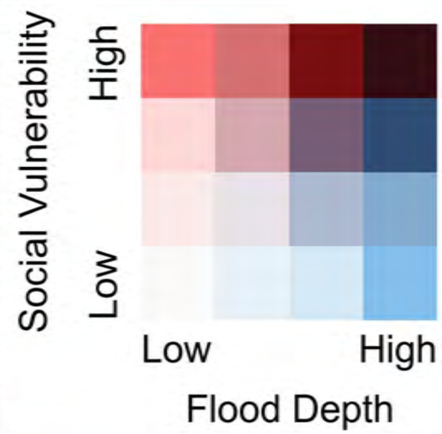
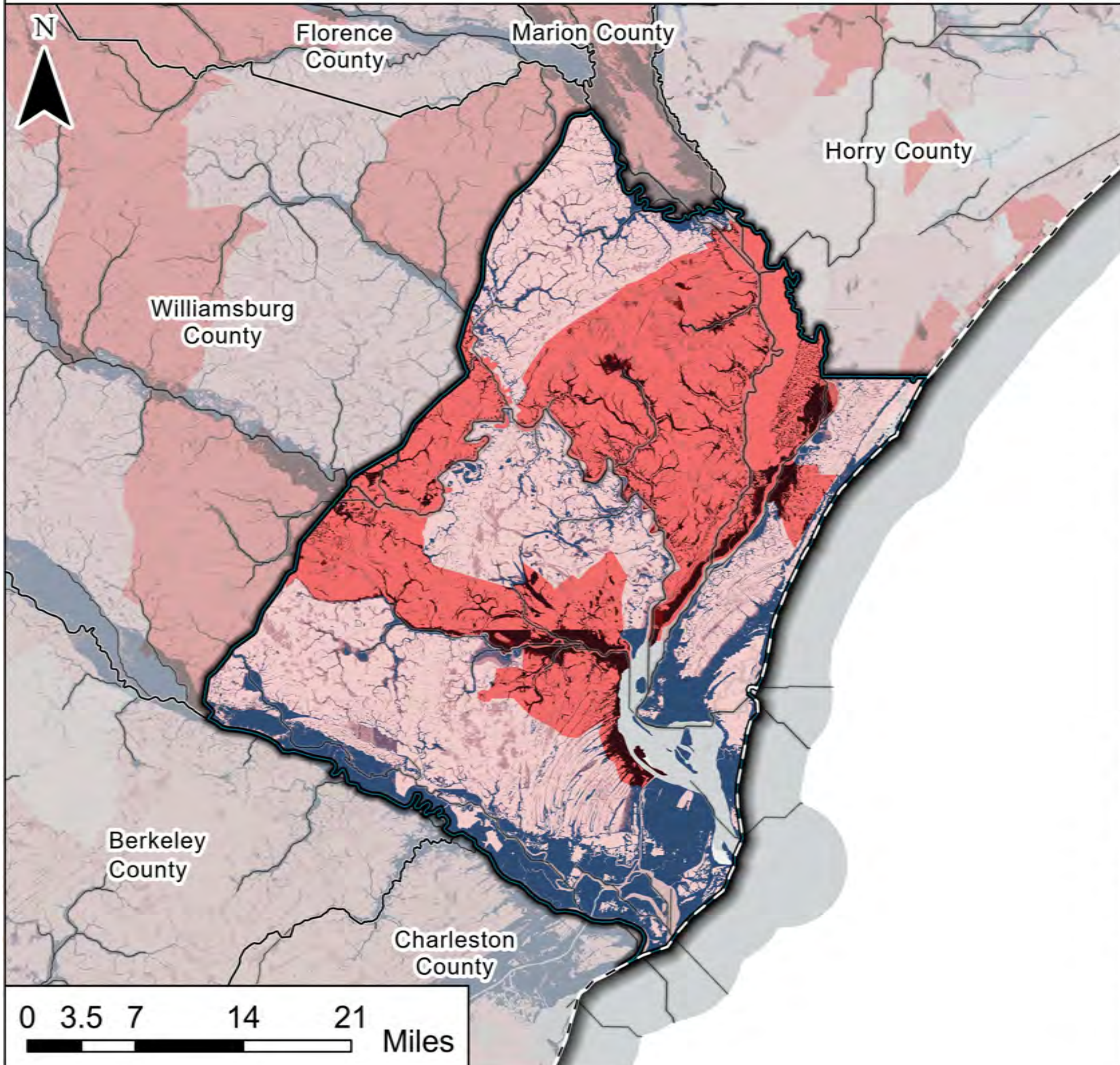


Georgetown County
Flooding Exposure and Social Vulnerability



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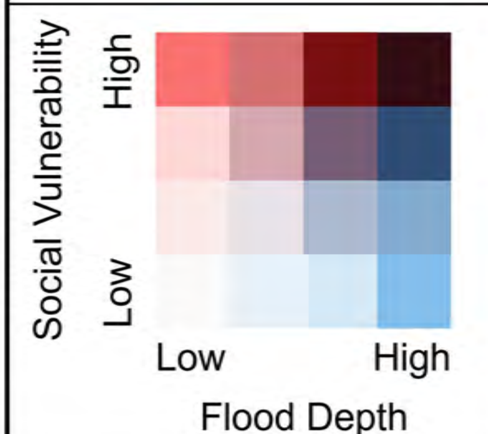
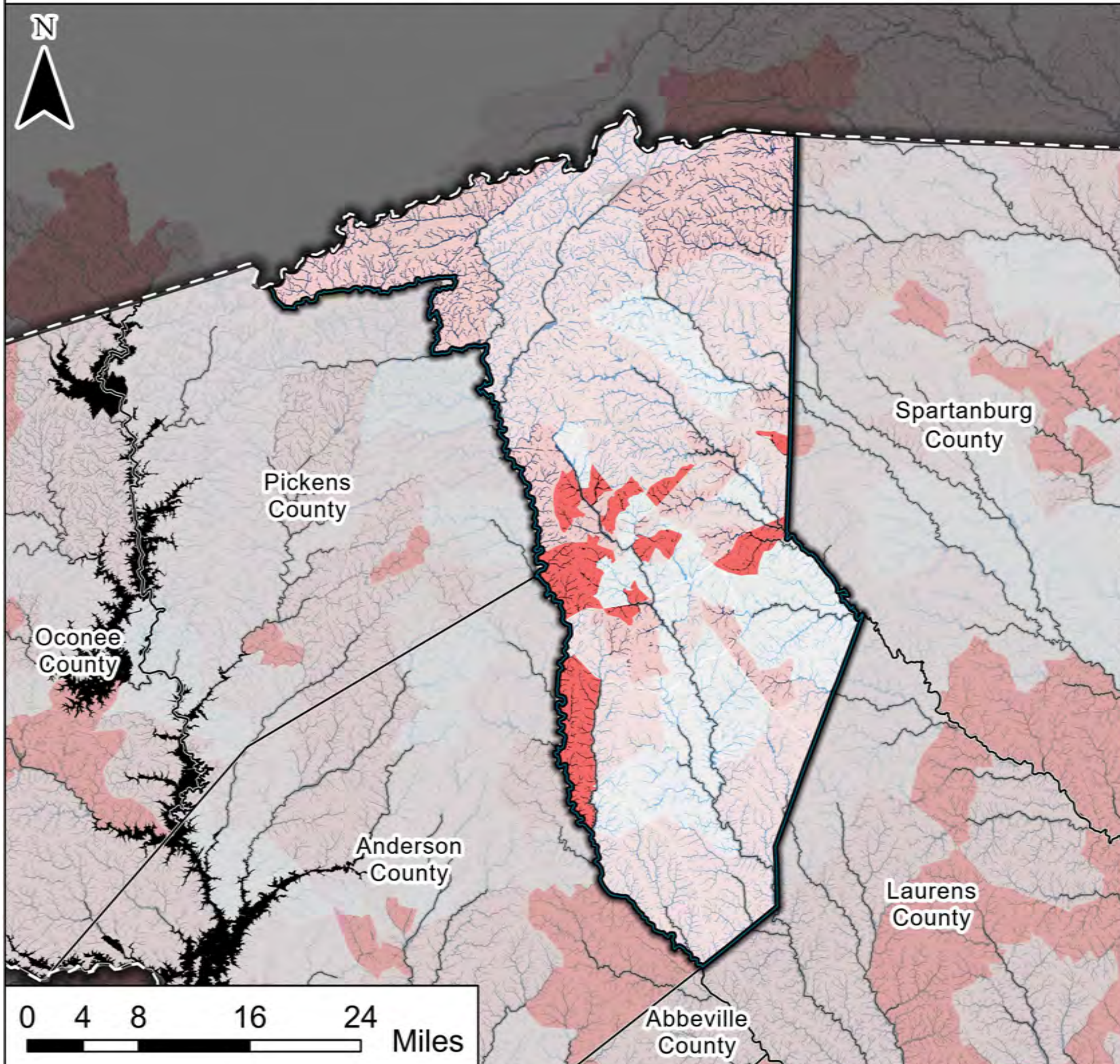


Greenville County
Flooding Exposure and Social Vulnerability



SCOR South Carolina Office of Resilience

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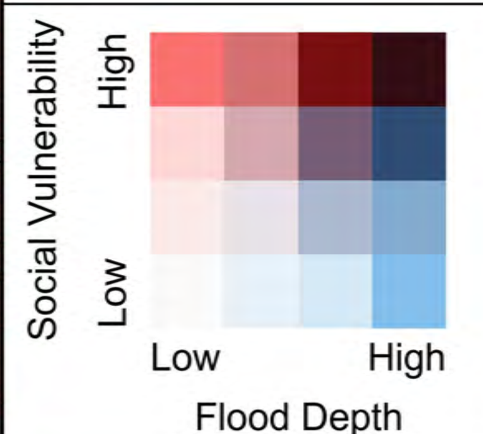
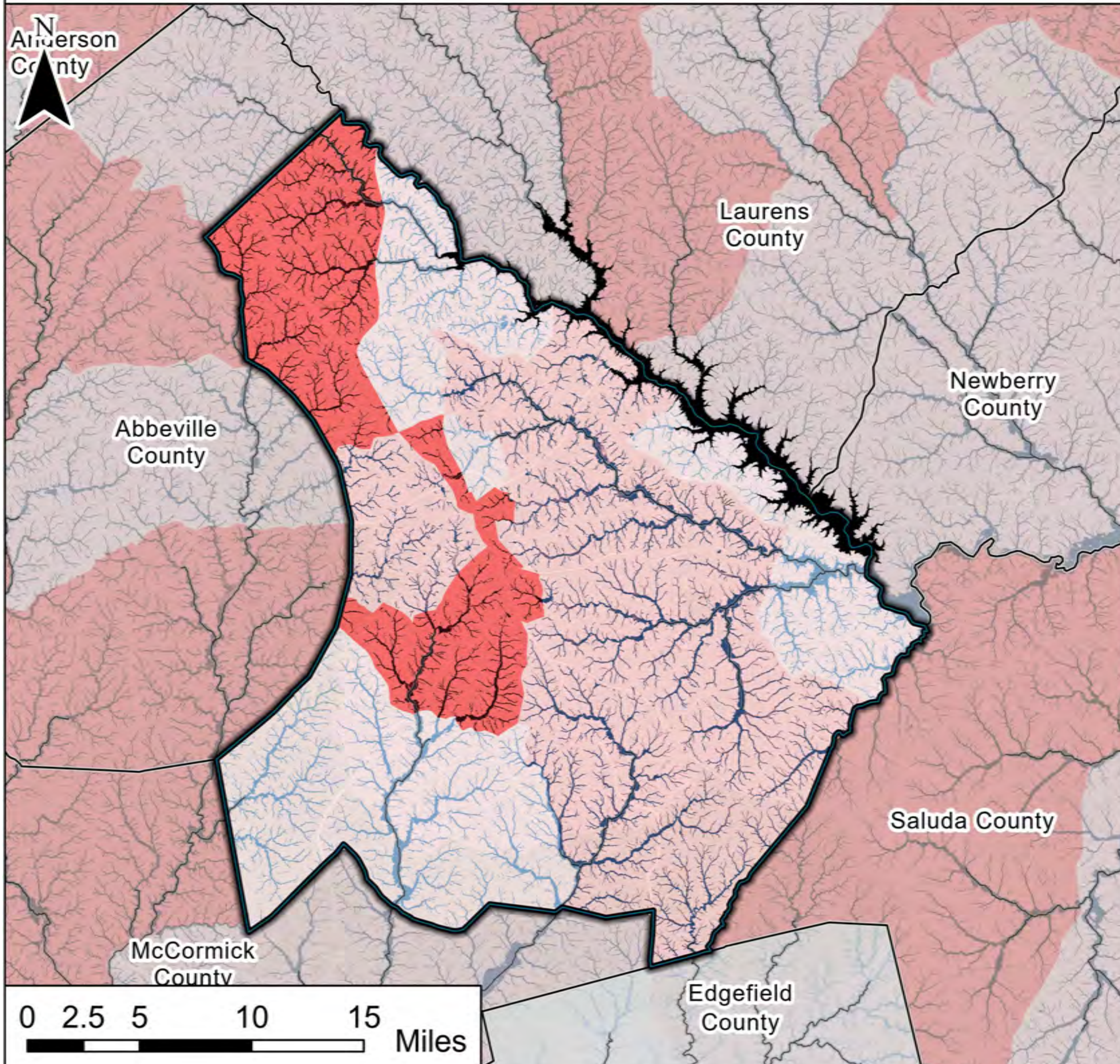


Greenwood County
Flooding Exposure and Social Vulnerability



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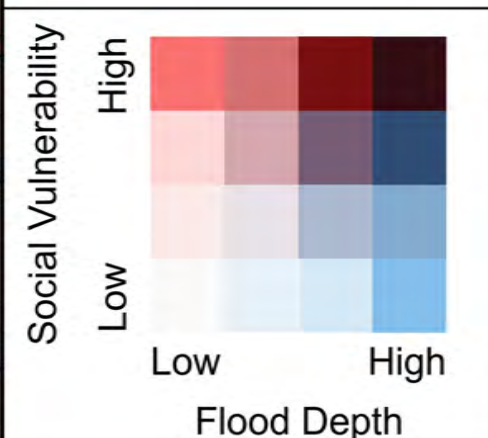
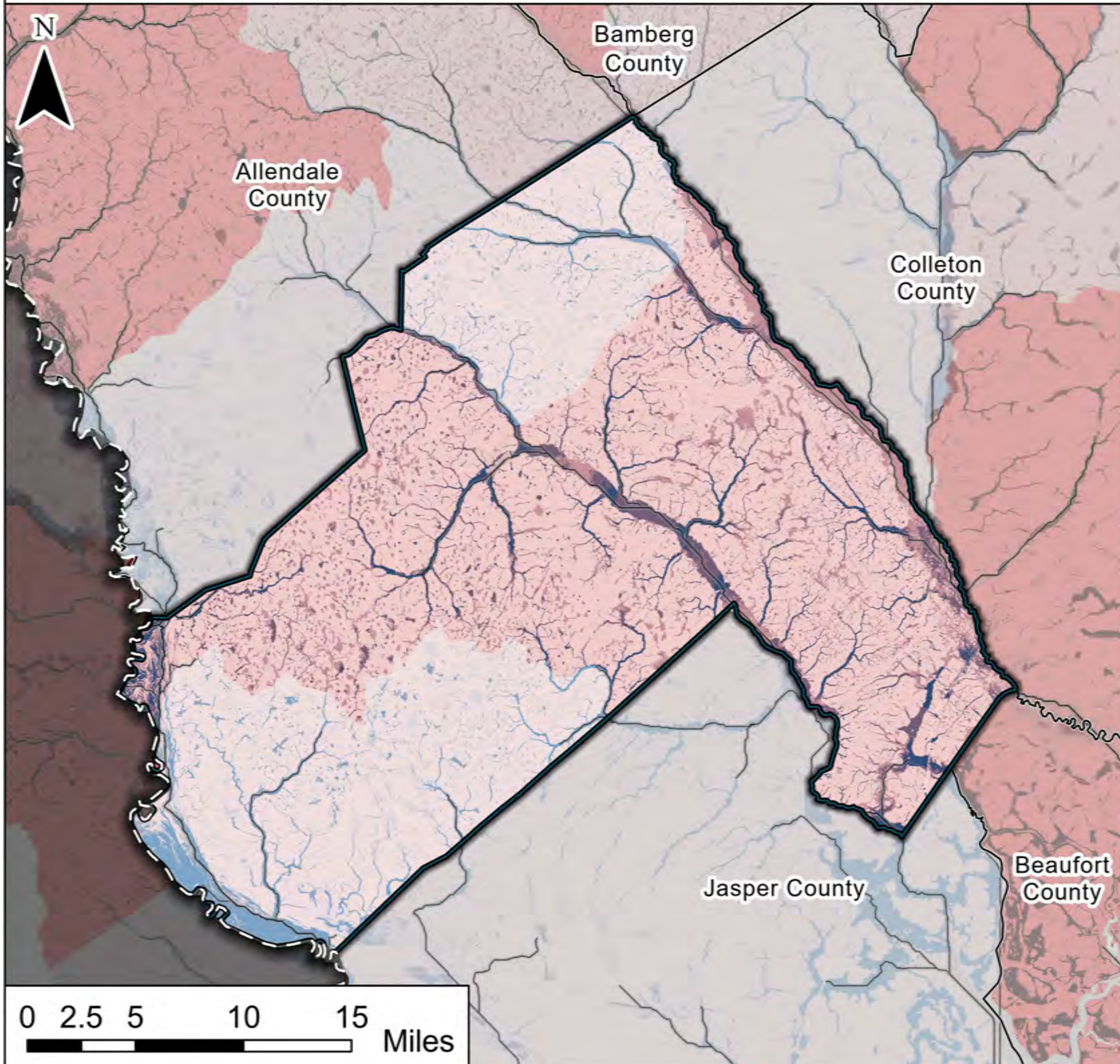


Hampton County
Flooding Exposure and Social Vulnerability



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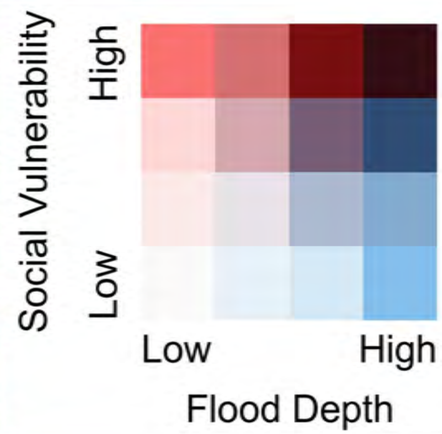
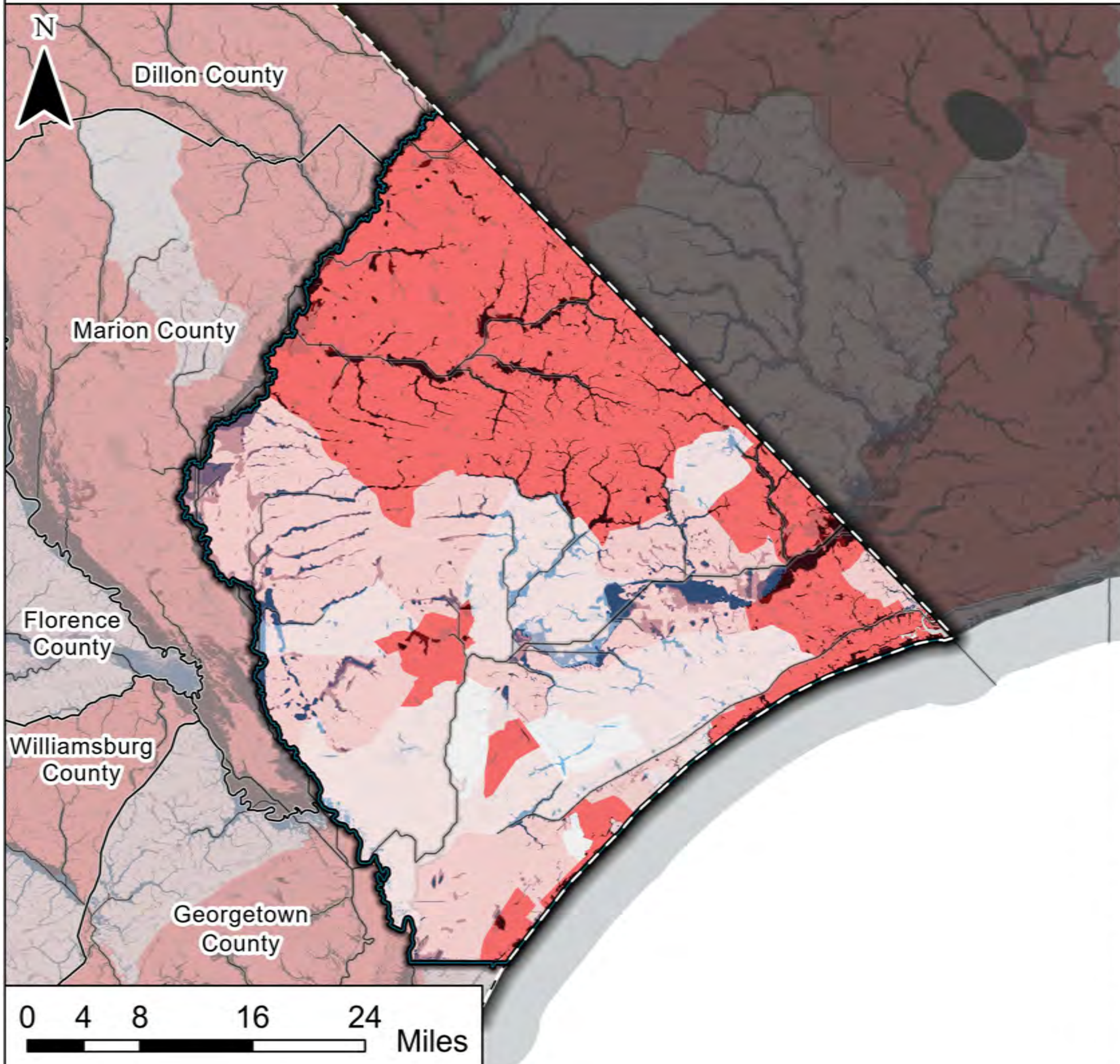


Horry County
Flooding Exposure and Social Vulnerability



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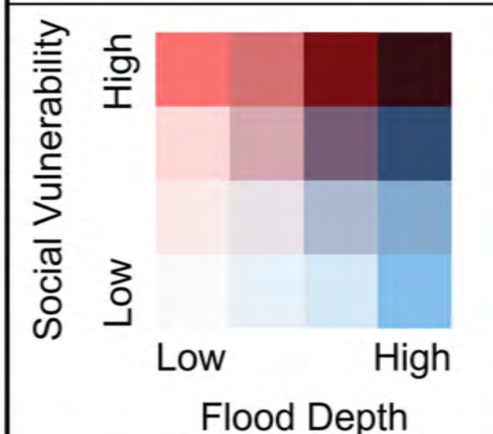
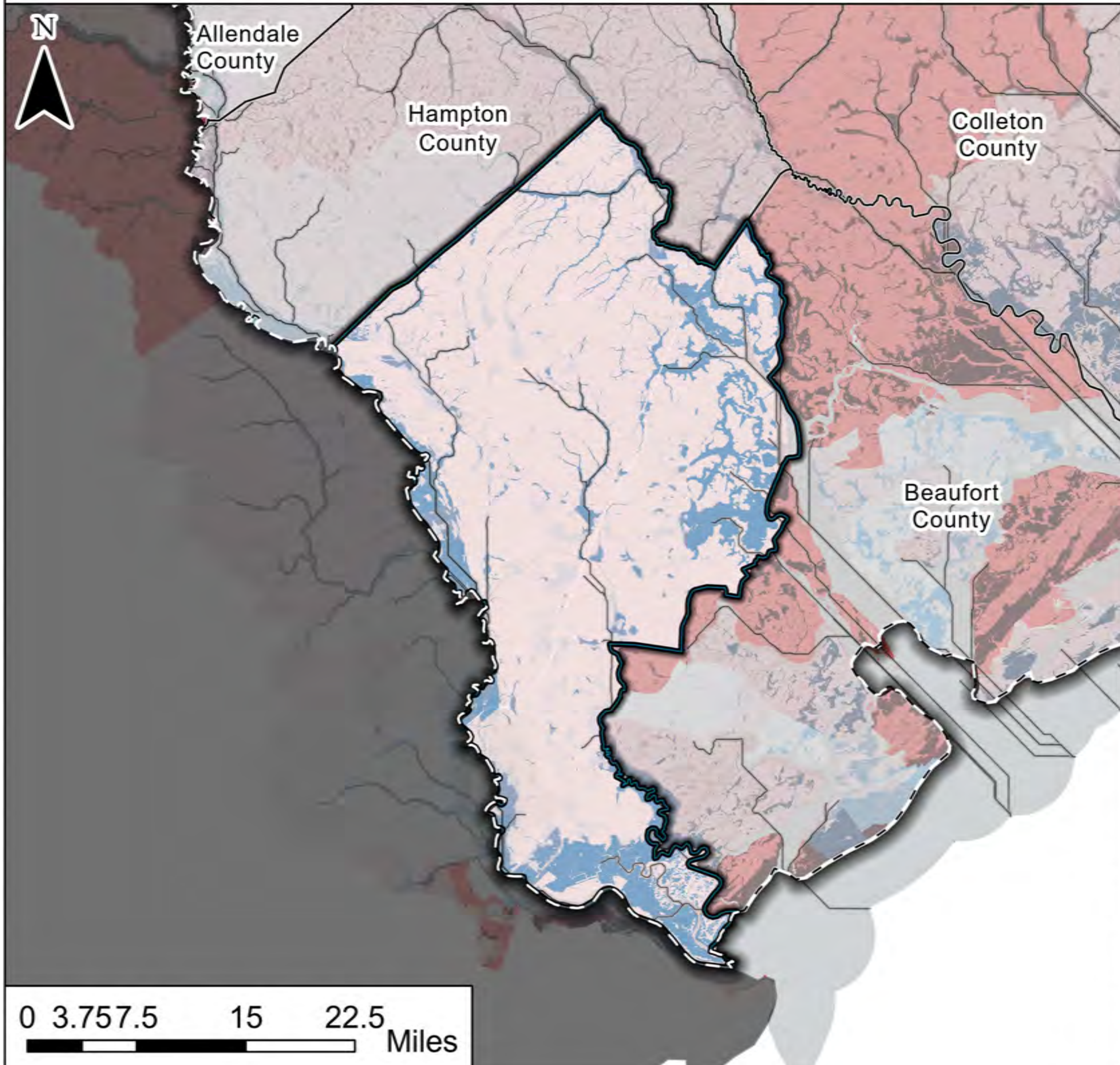


Jasper County
Flooding Exposure and Social Vulnerability



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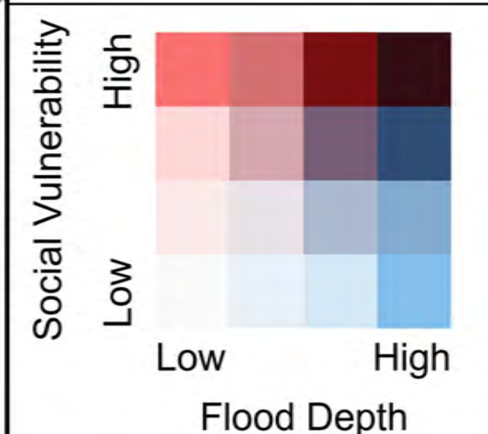
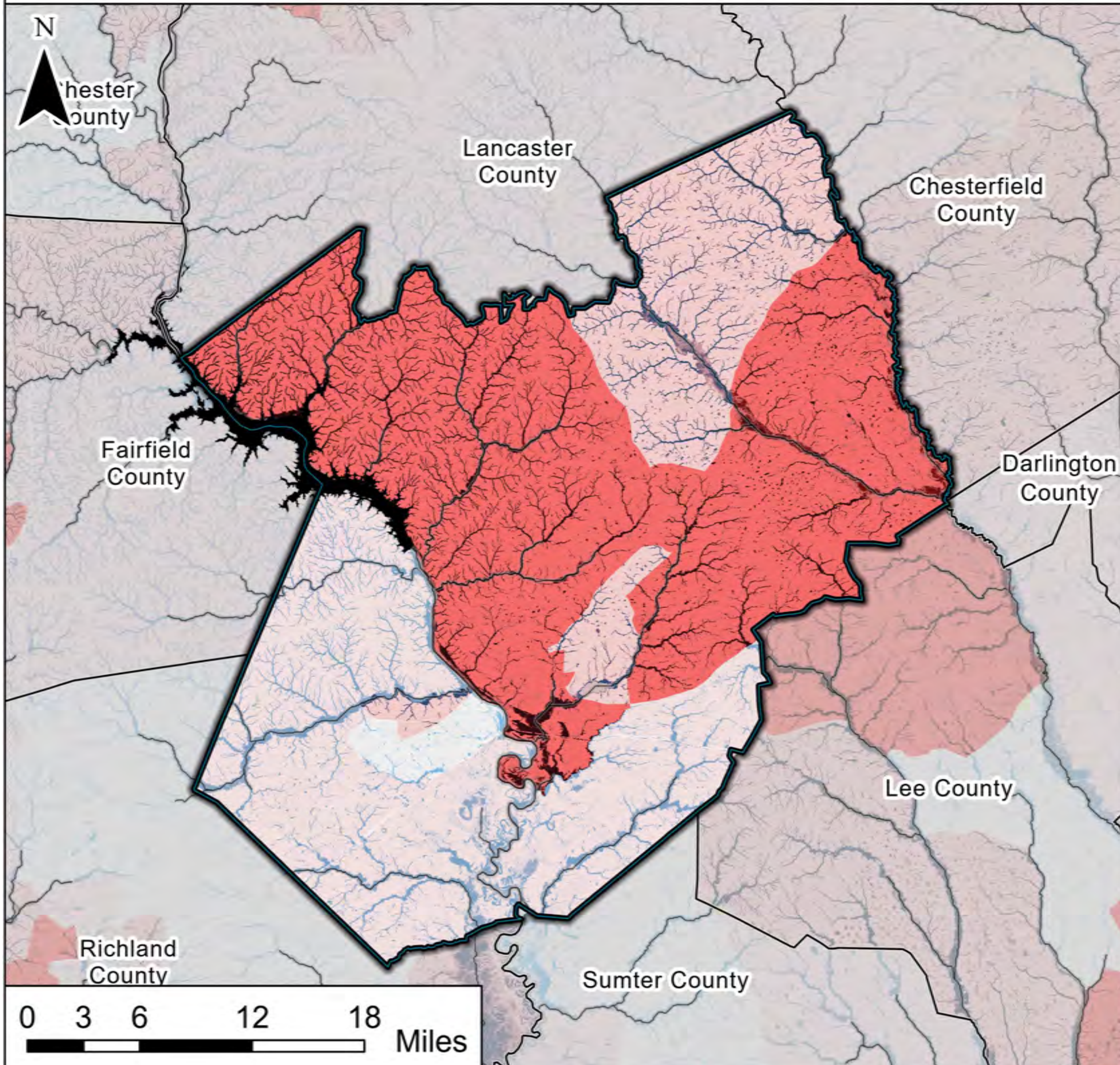


Kershaw County
Flooding Exposure and Social Vulnerability



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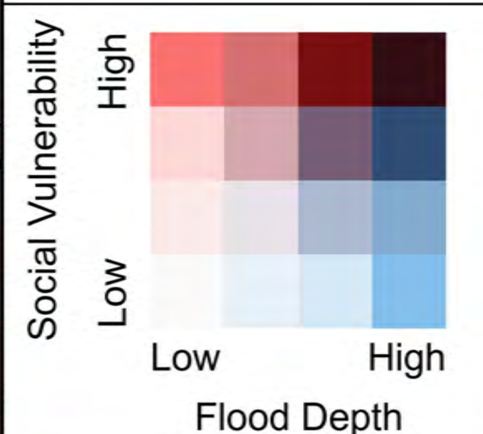
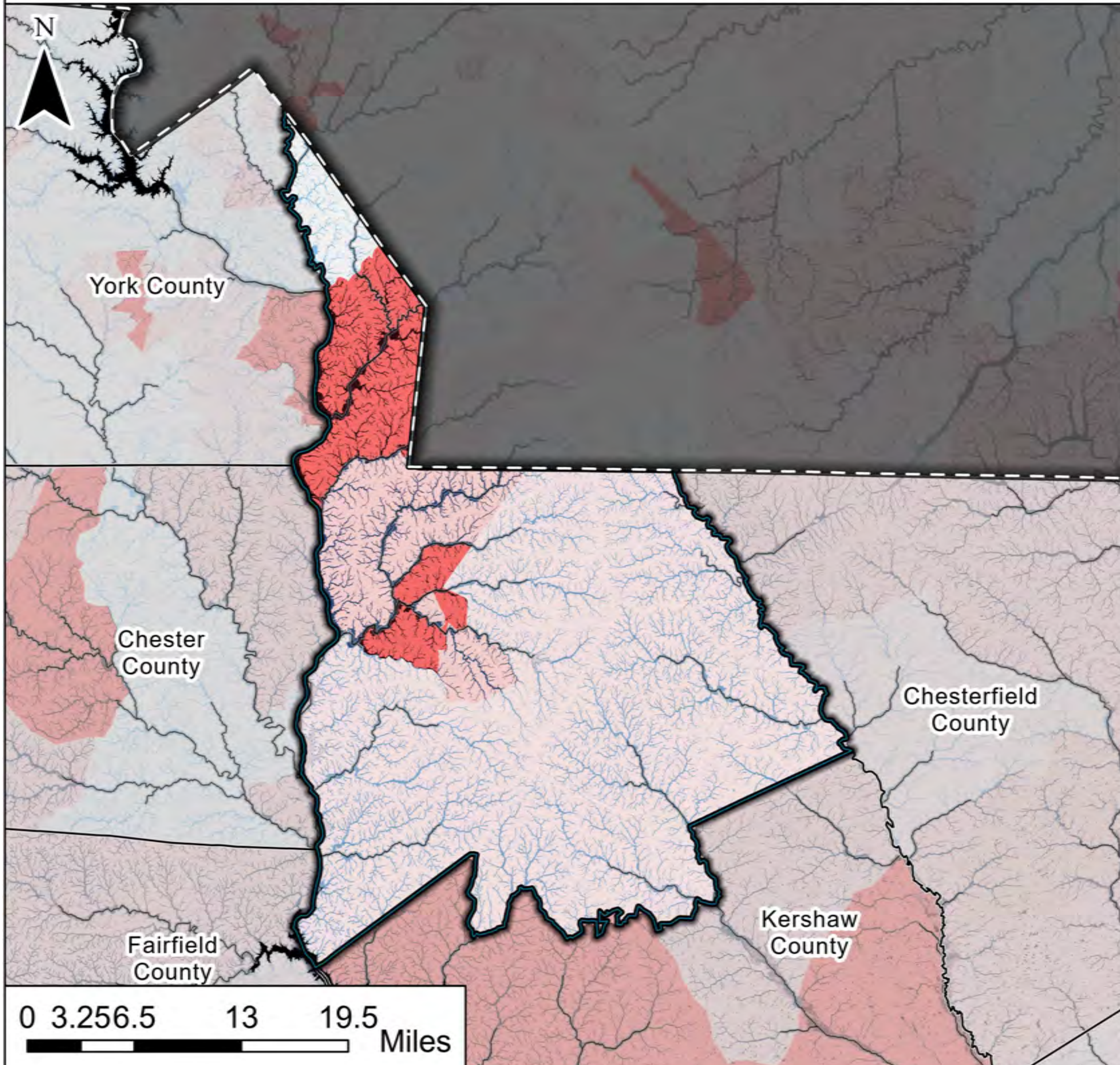


Lancaster County
Flooding Exposure and Social Vulnerability



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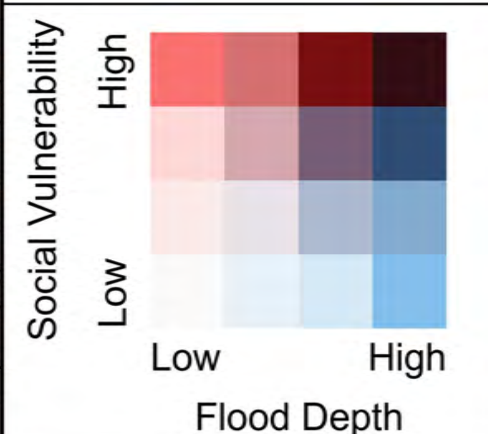
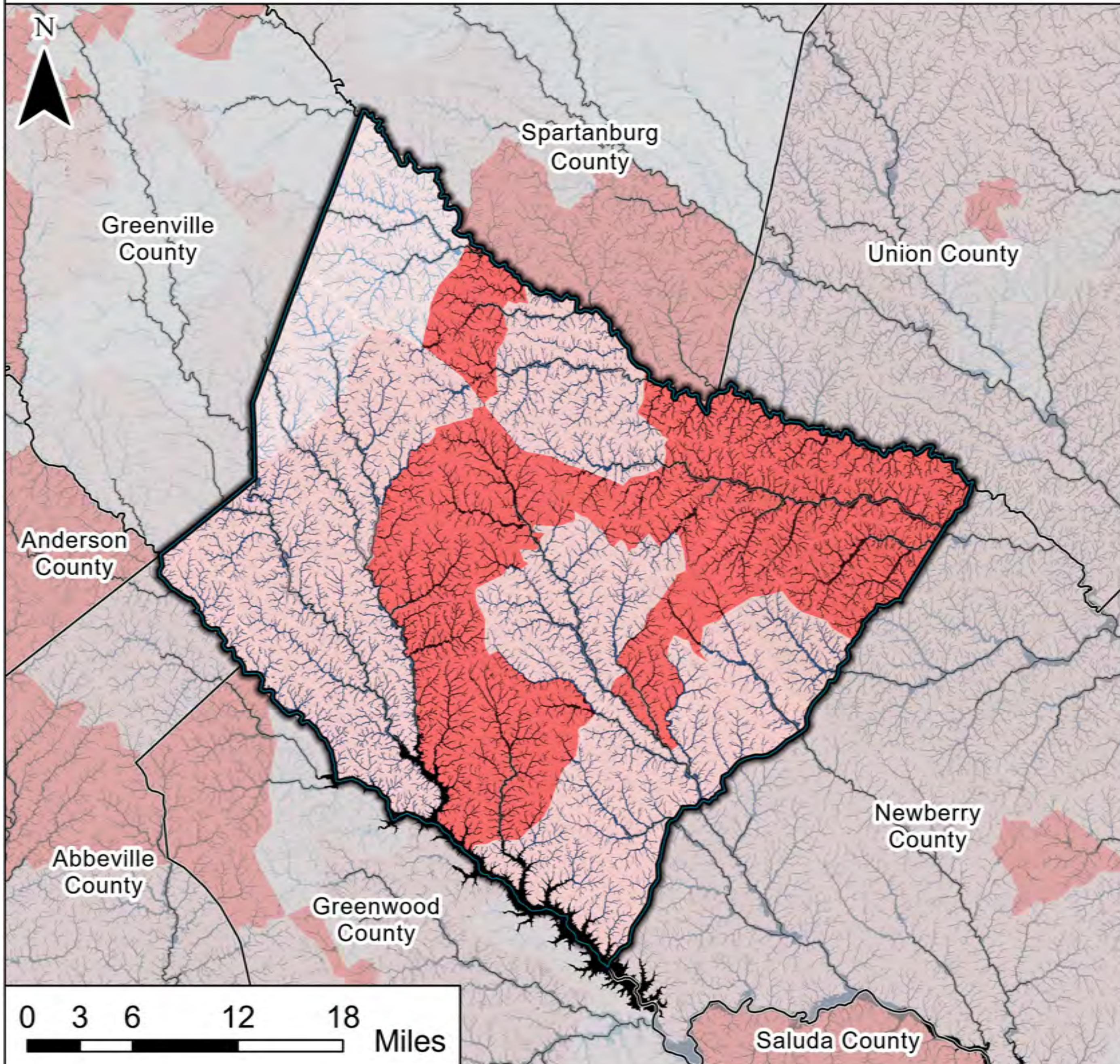


Laurens County
Flooding Exposure and Social Vulnerability



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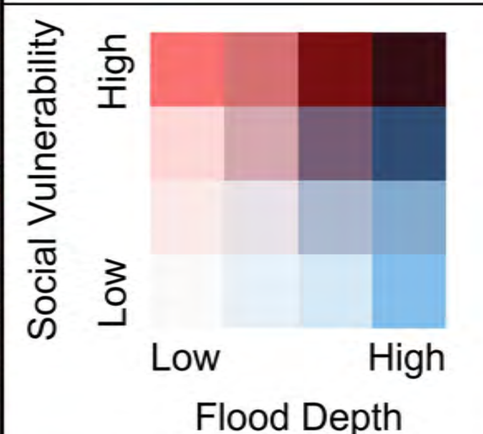
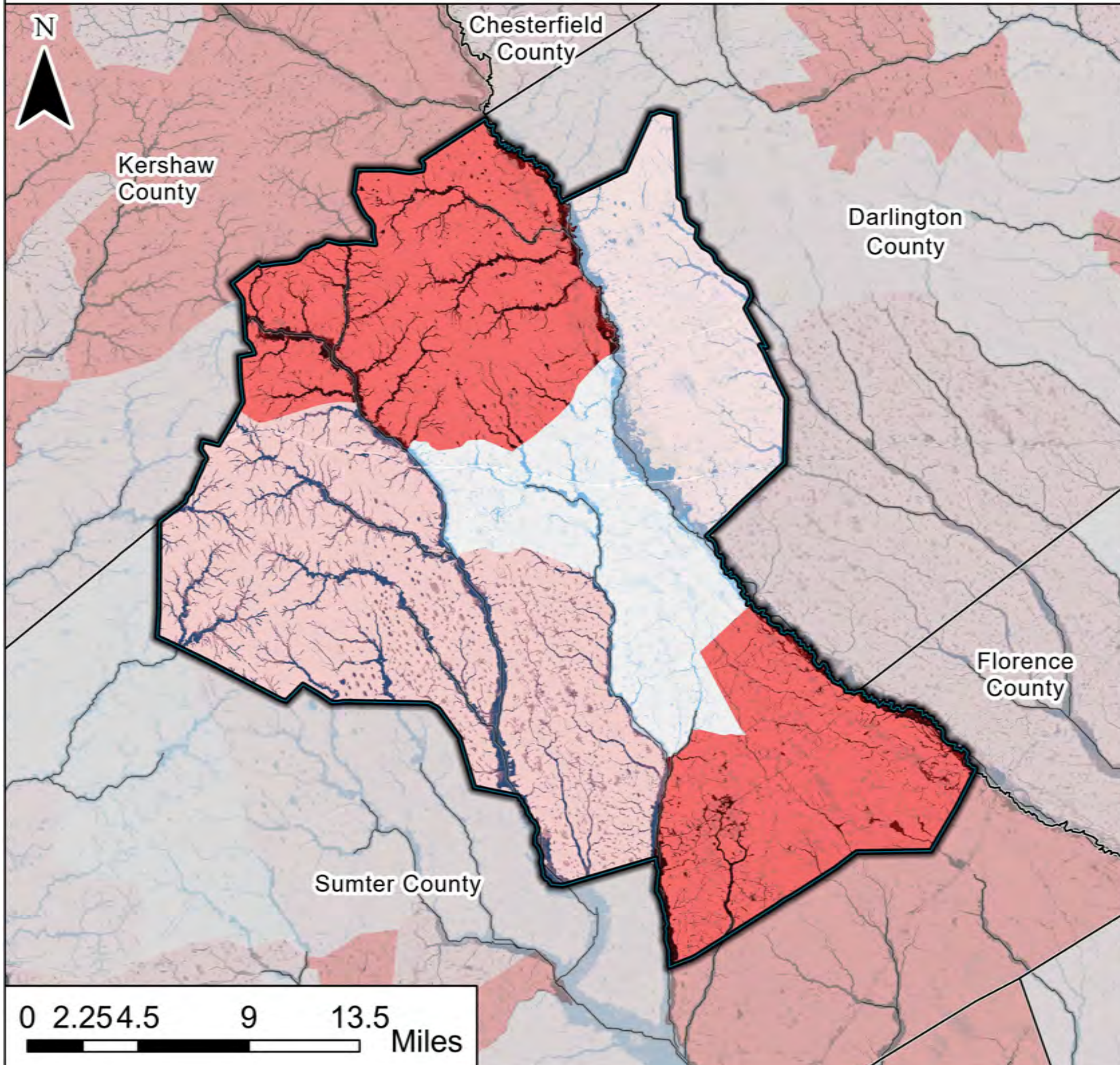


Lee County
Flooding Exposure and Social Vulnerability



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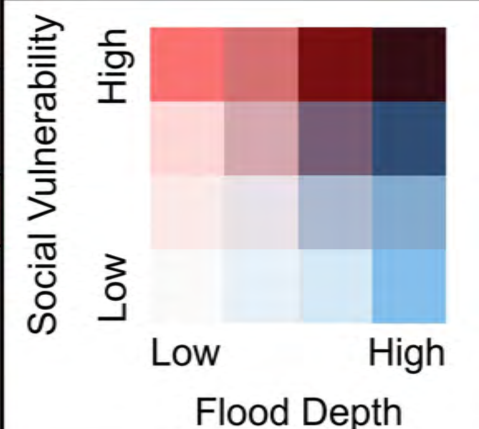
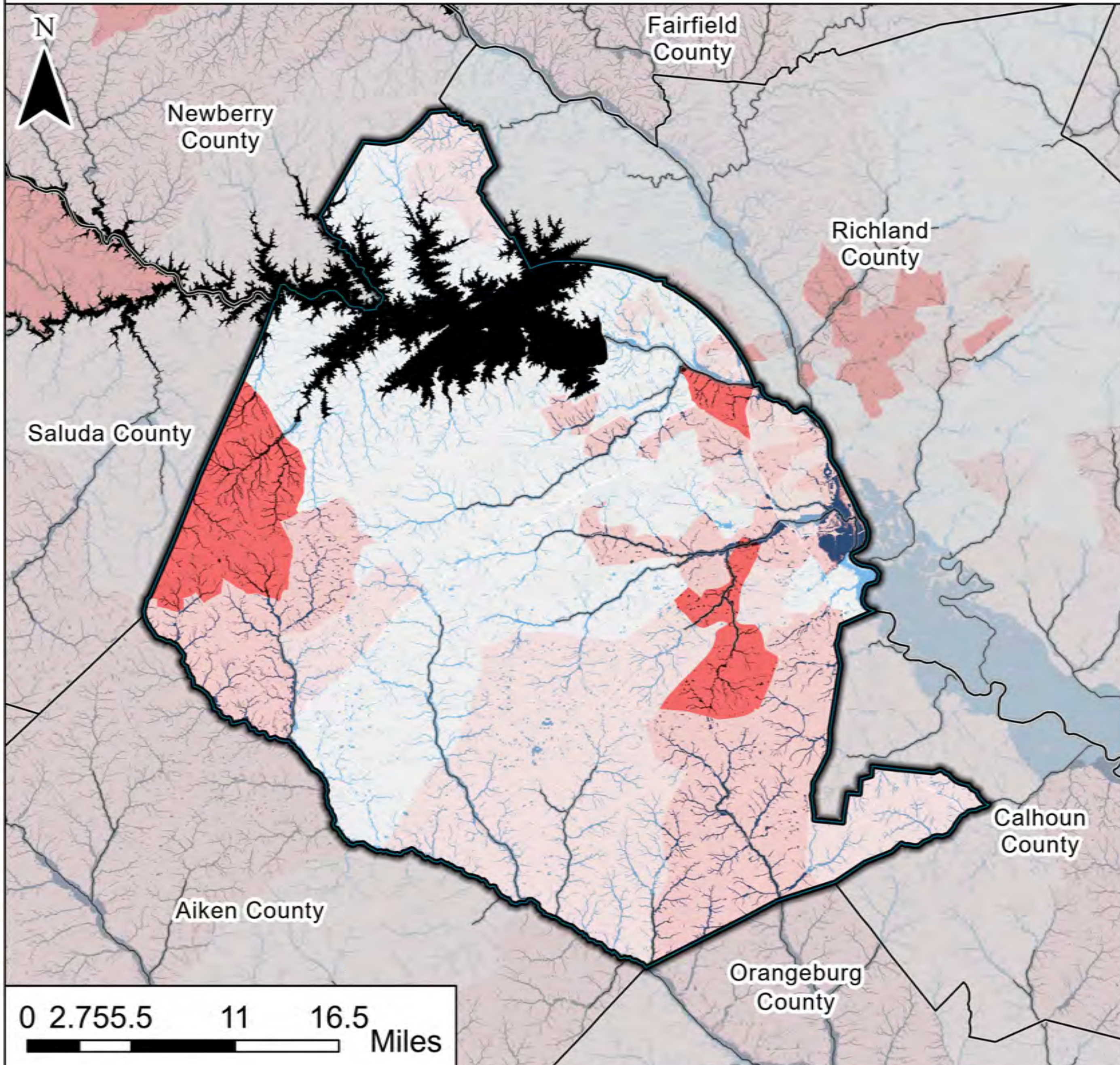


Lexington County
Flooding Exposure and Social Vulnerability



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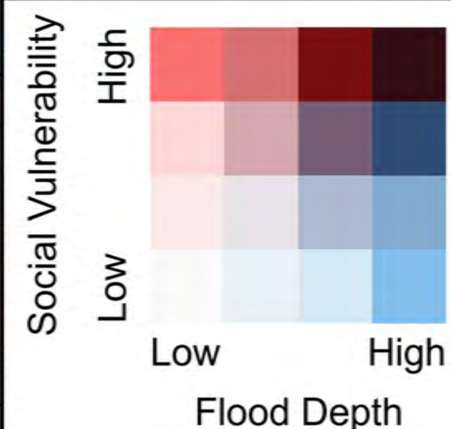
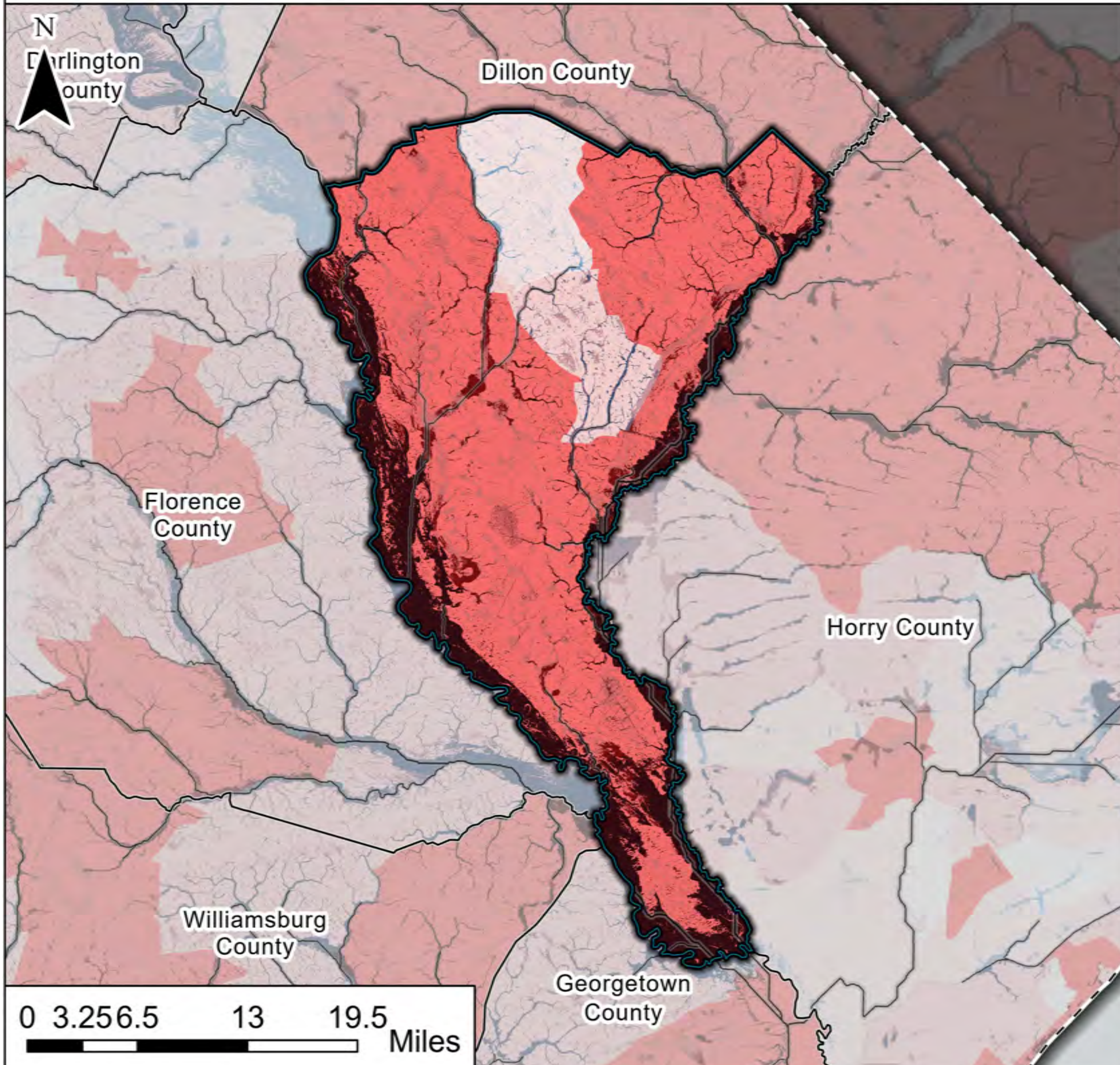


Marion County
Flooding Exposure and Social Vulnerability



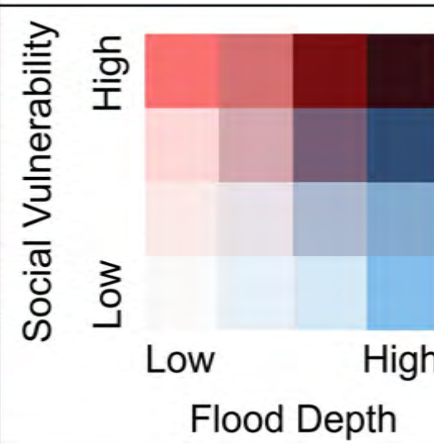
This map overlays flooding depth associated with a 1% Annual Chance Event (1 in 100 Year Flood) and Social Vulnerability (SoVI®).

Flood Depth's are produced by the First Street Foundation, and are symbolized in 4 categories;

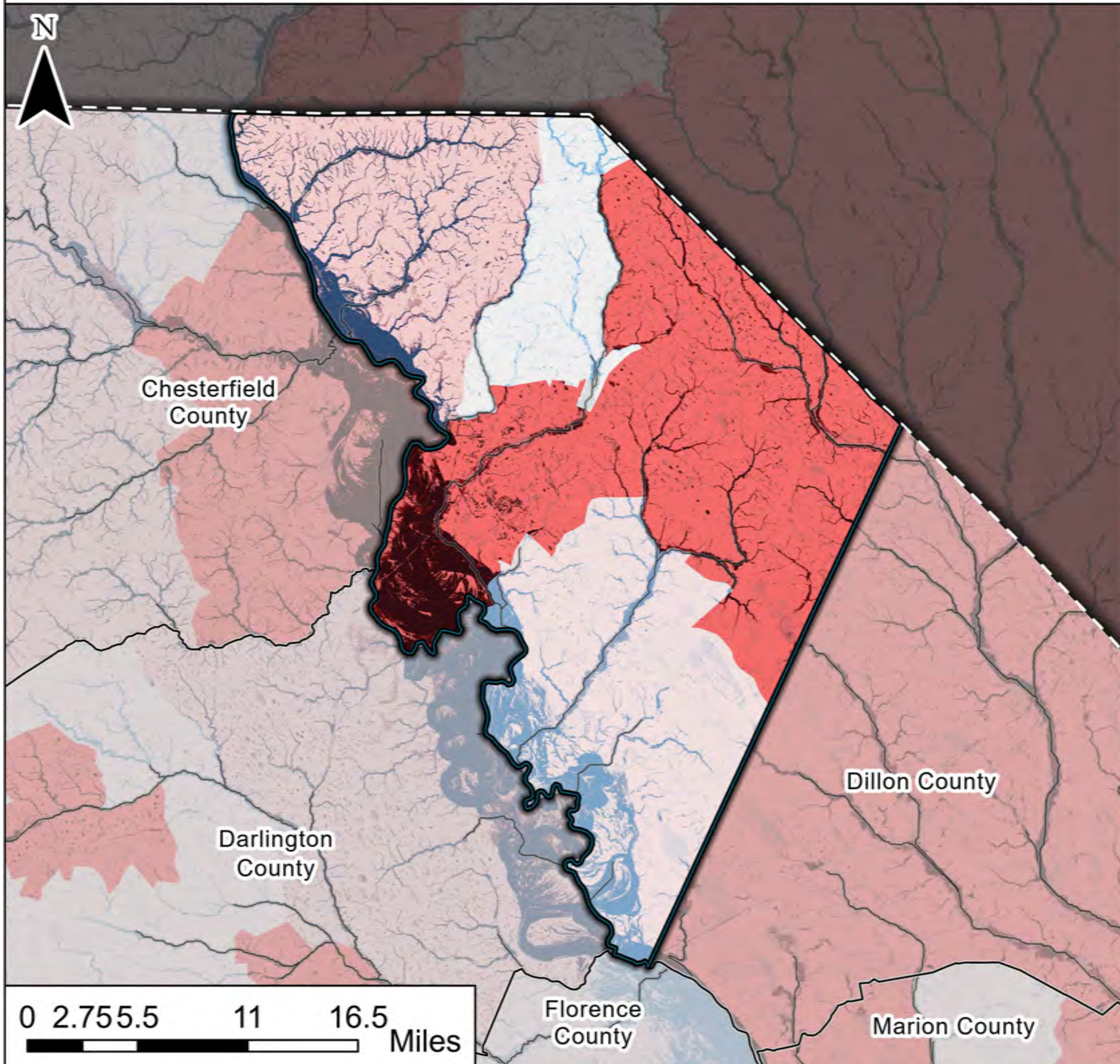
- Low - Under 1 foot
- Under 2 feet
- Under 3 feet
- High - Over 3 feet

Social Vulnerability values are taken at the Census Tract Level - State Percentile value, and provided by the National Risk Index (FEMA). This map uses 4 categories to symbolize low to high social vulnerability.

- Low - ≤25th percentile
- ≤50th percentile
- ≤75th percentile
- High - ≥75th percentile



Marlboro County
Flooding Exposure and Social Vulnerability



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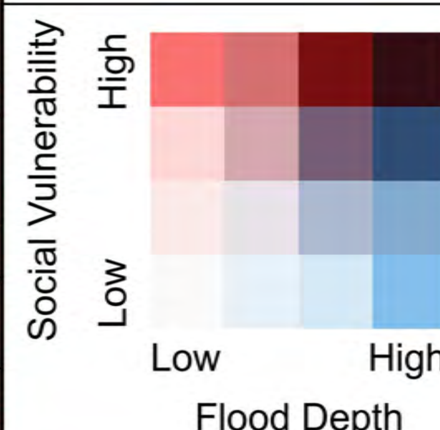
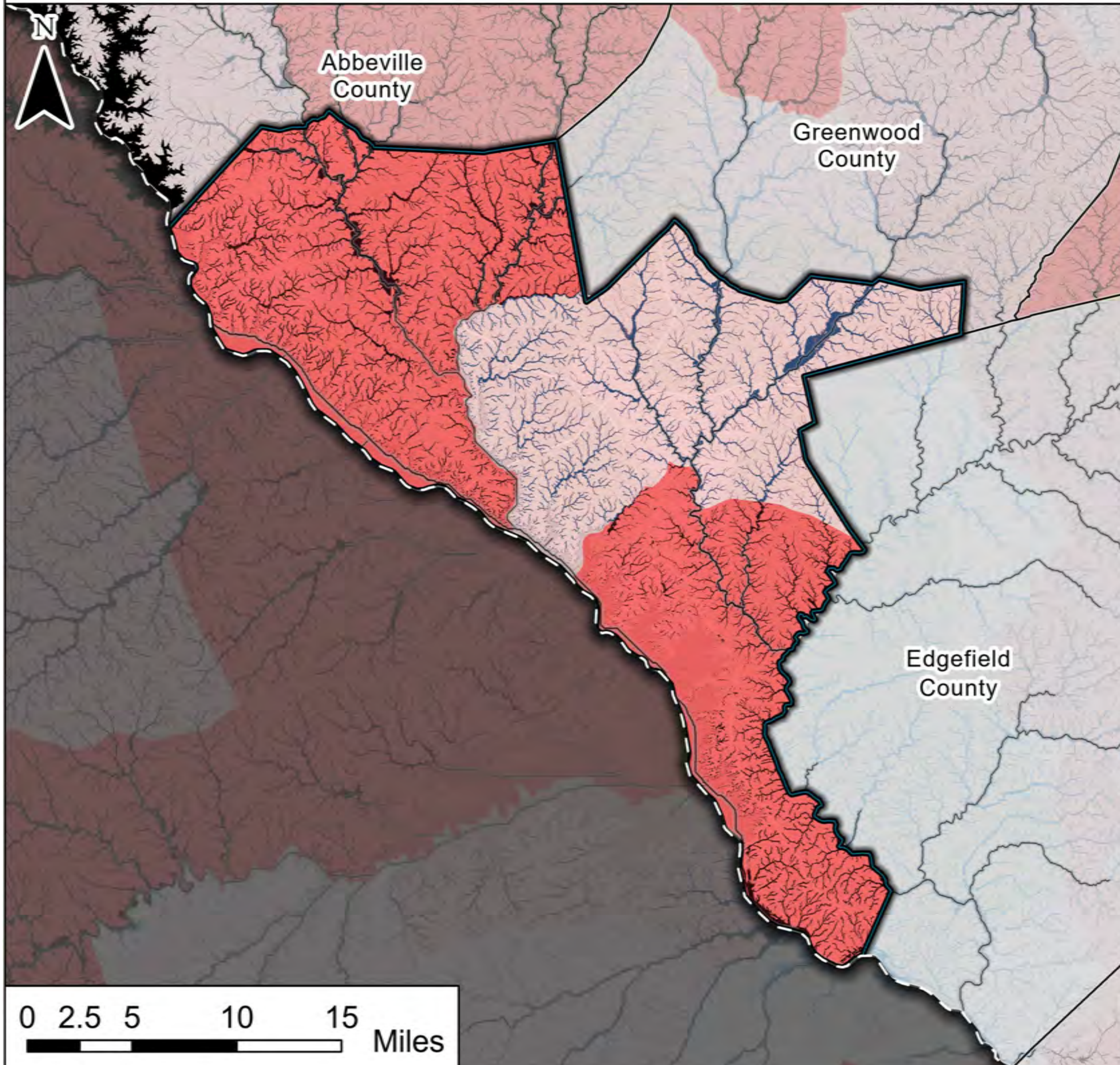


McCormick County
Flooding Exposure and Social Vulnerability



This map overlays flooding depth associated with a 1% Annual Chance Event (1 in 100 Year Flood) and Social Vulnerability (SoVI®).

Flood Depth's are produced by the First Street Foundation, and are symbolized in 4 categories;

- Low - Under 1 foot
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Social Vulnerability values are taken at the Census Tract Level - State Percentile value, and provided by the National Risk Index (FEMA). This map uses 4 categories to symbolize low to high social vulnerability.

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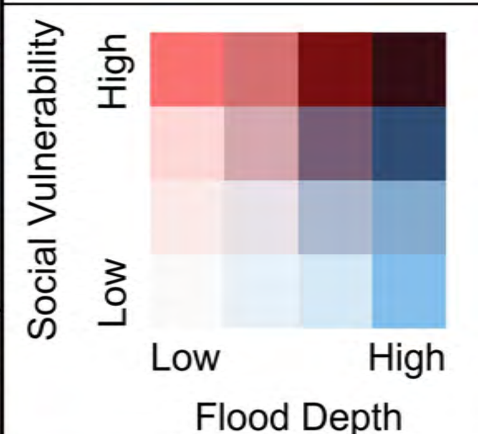
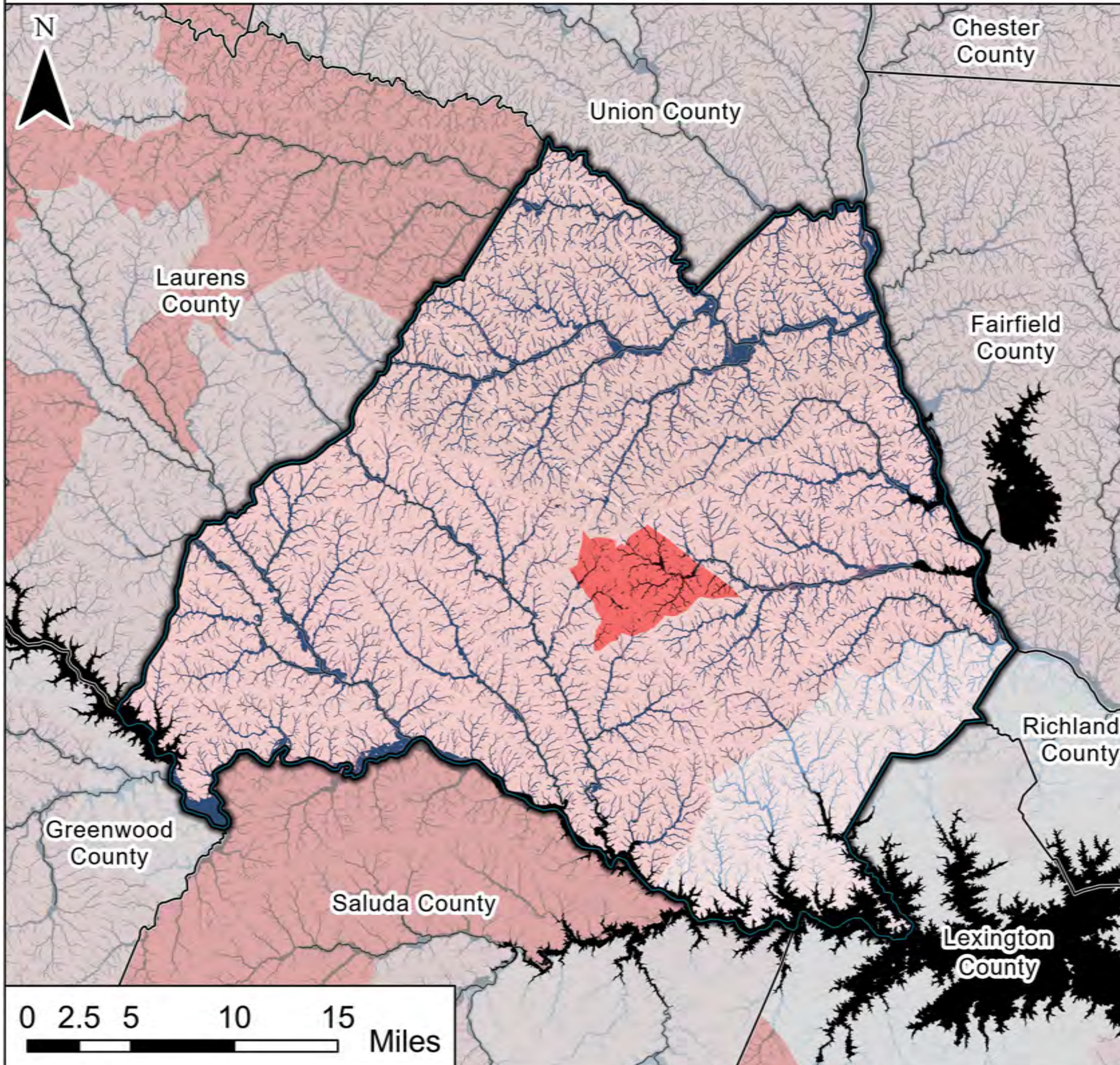


Newberry County
Flooding Exposure and Social Vulnerability



This map overlays flooding depth associated with a 1% Annual Chance Event (1 in 100 Year Flood) and Social Vulnerability (SoVI®).

Flood Depth's are produced by the First Street Foundation, and are symbolized in 4 categories;

- Low - Under 1 foot
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- Low - ≤25th percentile
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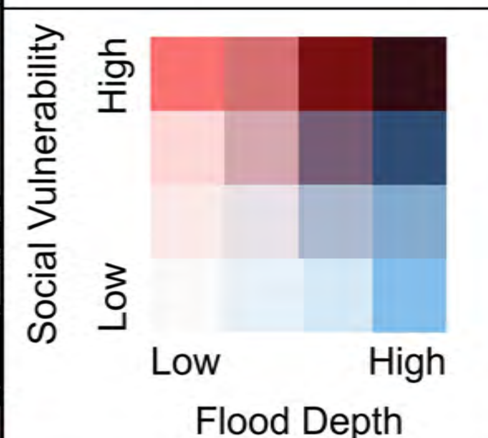
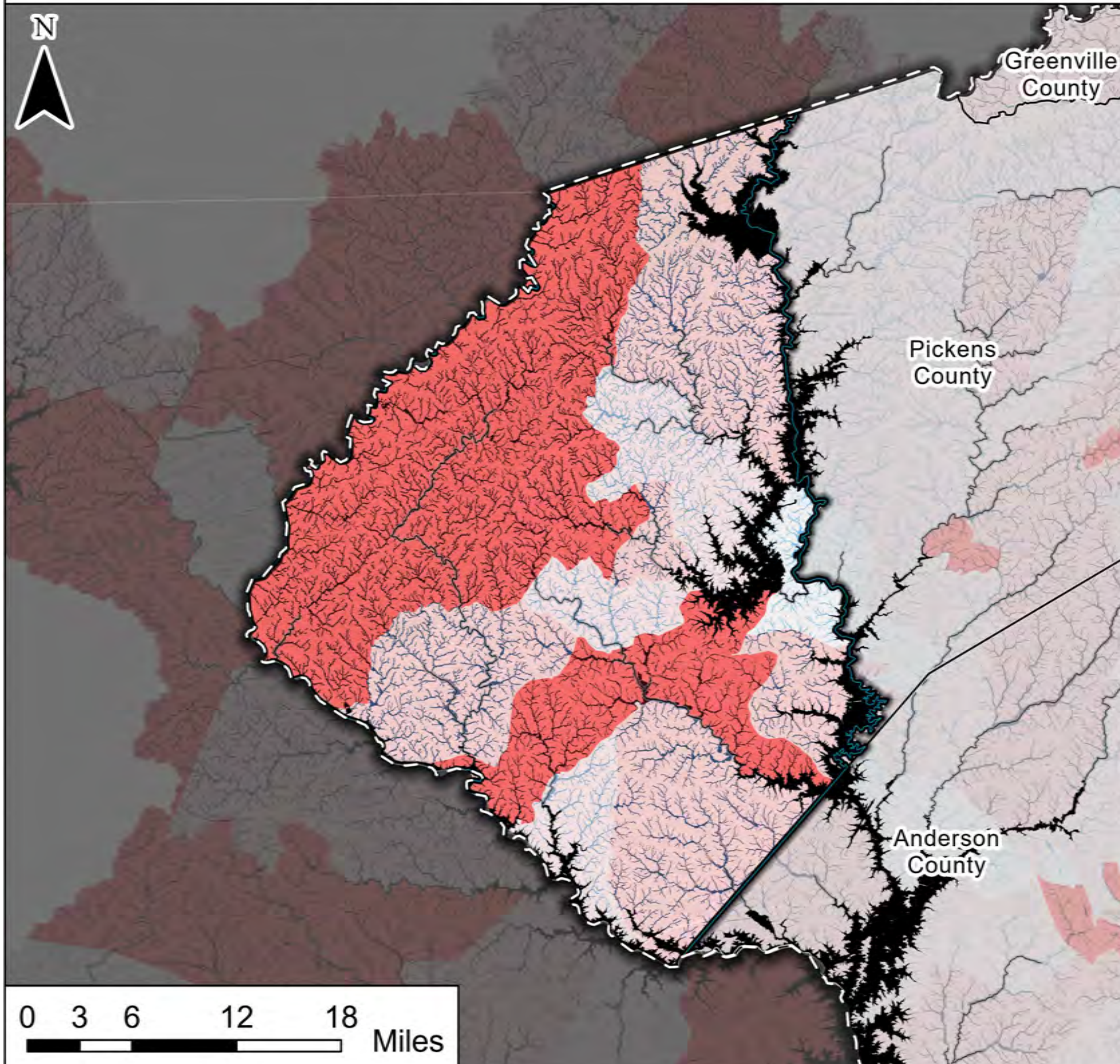


Oconee County
Flooding Exposure and Social Vulnerability



This map overlays flooding depth associated with a 1% Annual Chance Event (1 in 100 Year Flood) and Social Vulnerability (SoVI®).

Flood Depth's are produced by the First Street Foundation, and are symbolized in 4 categories;

- Low - Under 1 foot
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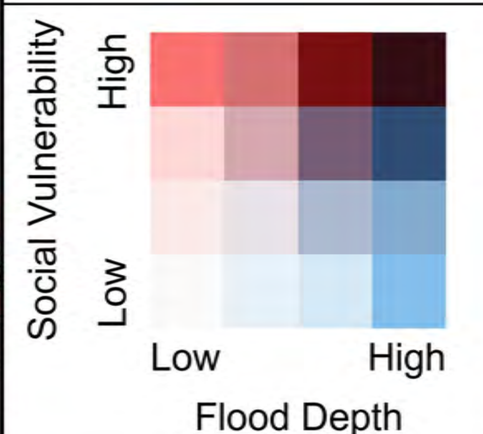
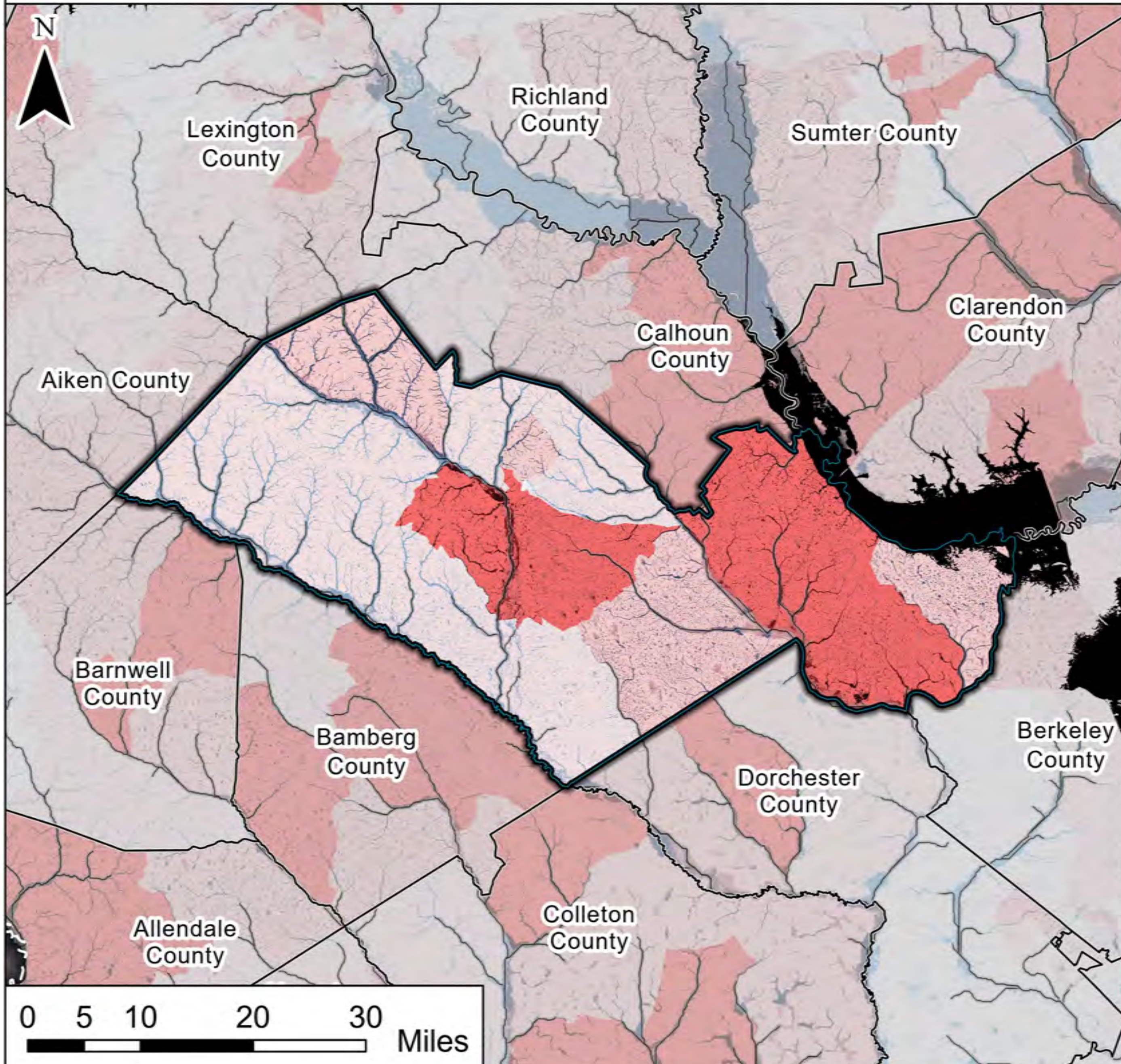


Orangeburg County
Flooding Exposure and Social Vulnerability



This map overlays flooding depth associated with a 1% Annual Chance Event (1 in 100 Year Flood) and Social Vulnerability (SoVI®).

Flood Depth's are produced by the First Street Foundation, and are symbolized in 4 categories;

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Social Vulnerability values are taken at the Census Tract Level - State Percentile value, and provided by the National Risk Index (FEMA). This map uses 4 categories to symbolize low to high social vulnerability.

- Low - ≤25th percentile
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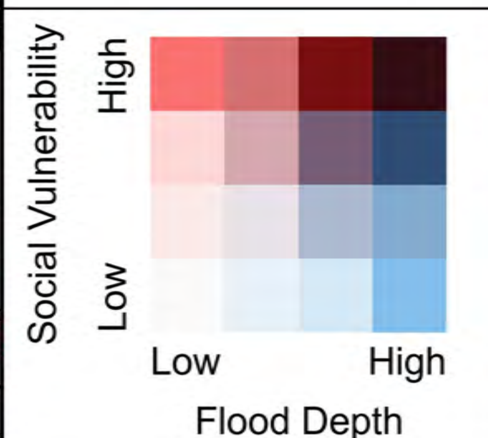
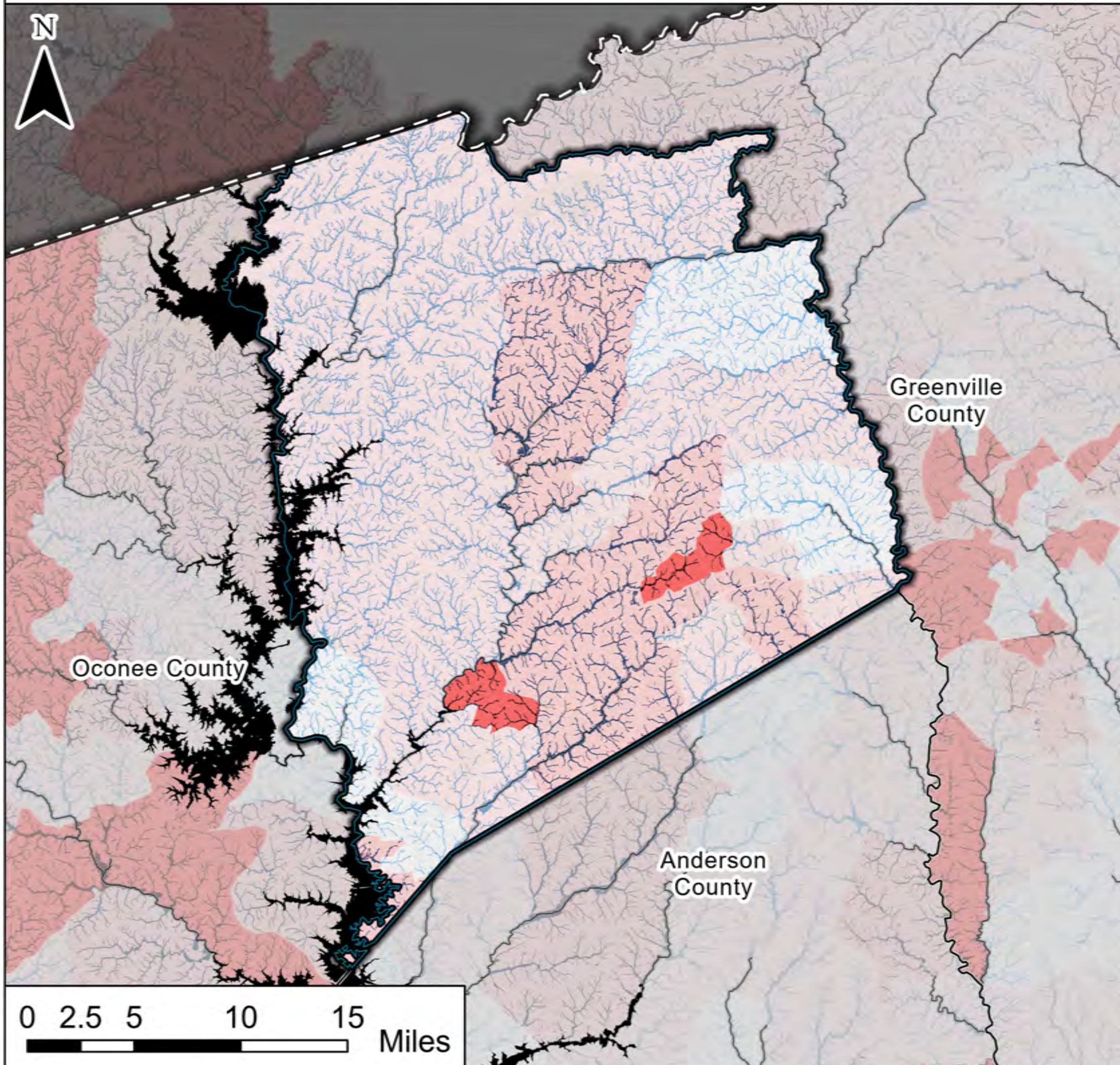
- ≤75th percentile
- High - ≥75th percentile



Pickens County
Flooding Exposure and Social Vulnerability



This map overlays flooding depth associated with a 1% Annual Chance Event (1 in 100 Year Flood) and Social Vulnerability (SoVI®).

Flood Depth's are produced by the First Street Foundation, and are symbolized in 4 categories;

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Social Vulnerability values are taken at the Census Tract Level - State Percentile value, and provided by the National Risk Index (FEMA). This map uses 4 categories to symbolize low to high social vulnerability.

- Low - ≤25th percentile
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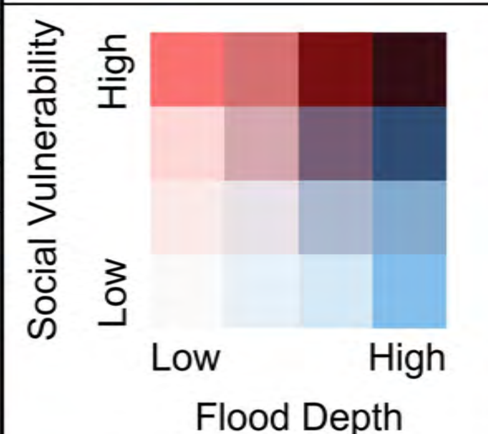
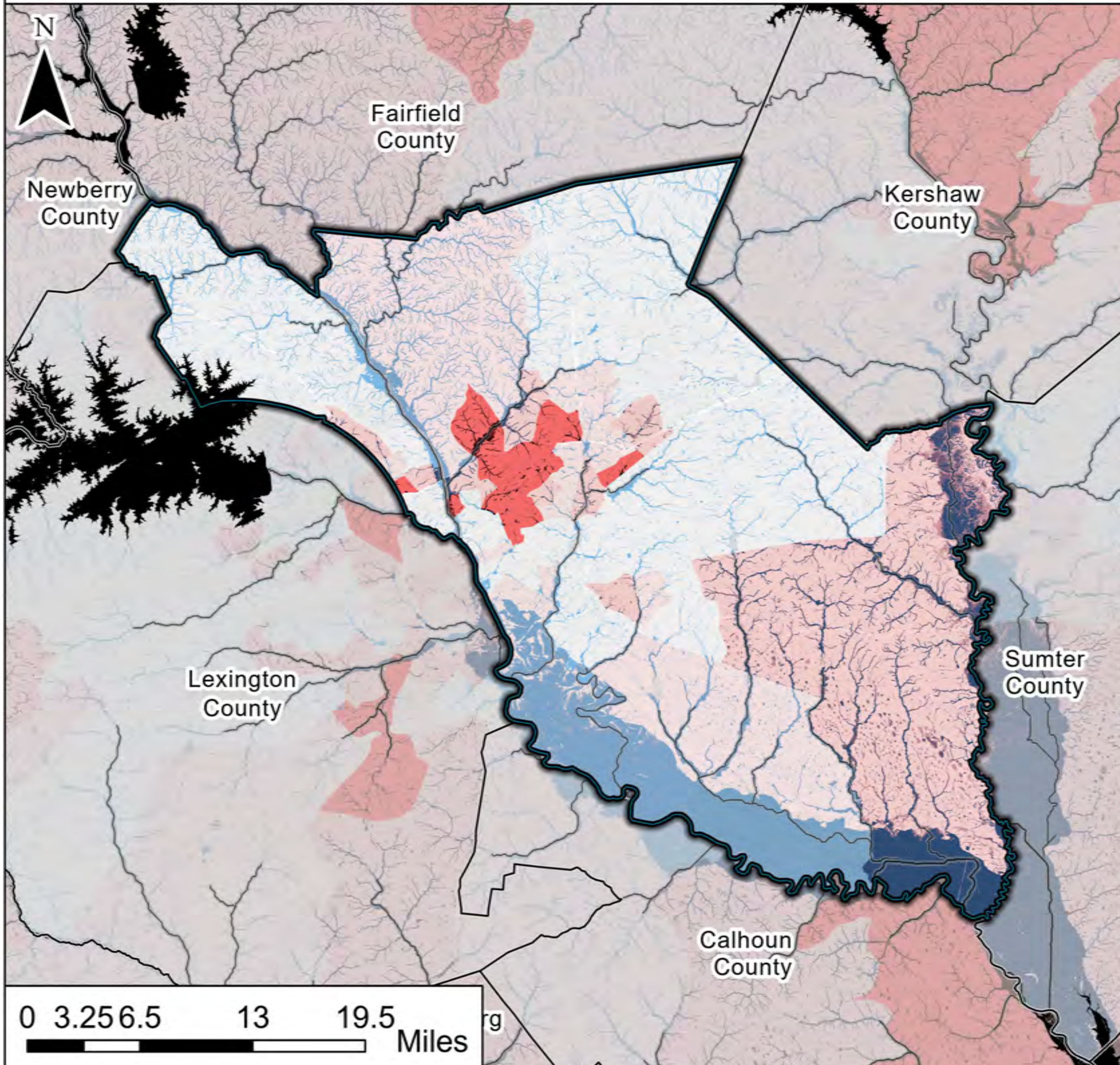
- ≤75th percentile
- High - ≥75th percentile



Richland County
Flooding Exposure and Social Vulnerability



This map overlays flooding depth associated with a 1% Annual Chance Event (1 in 100 Year Flood) and Social Vulnerability (SoVI®).

Flood Depth's are produced by the First Street Foundation, and are symbolized in 4 categories;

Low - Under 1 foot
Under 2 feet
Under 3 feet
High - Over 3 feet

Social Vulnerability values are taken at the Census Tract Level - State Percentile value, and provided by the National Risk Index (FEMA). This map uses 4 categories to symbolize low to high social vulnerability.

Low - ≤25th percentile
≤50th percentile
≤75th percentile
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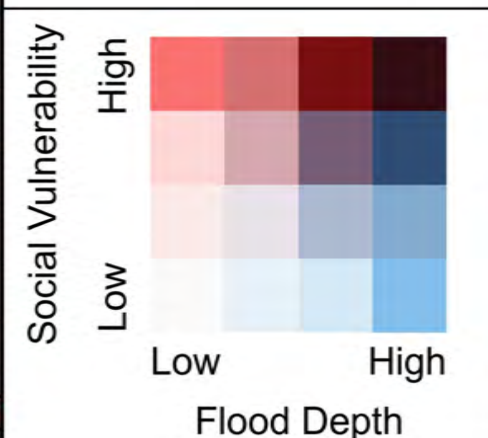
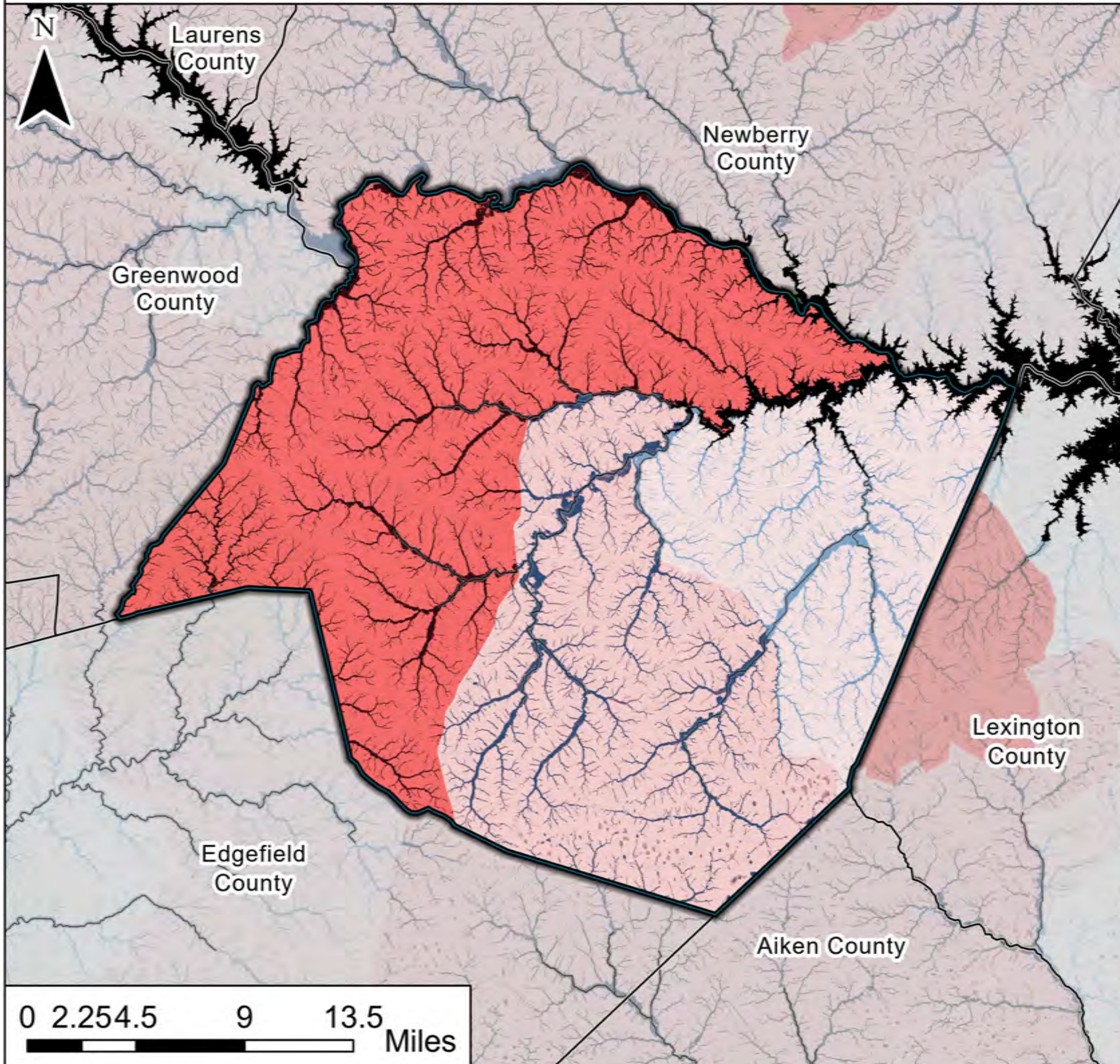


Saluda County
Flooding Exposure and Social Vulnerability



This map overlays flooding depth associated with a 1% Annual Chance Event (1 in 100 Year Flood) and Social Vulnerability (SoVI®).

Flood Depth's are produced by the First Street Foundation, and are symbolized in 4 categories;

- Low - Under 1 foot
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- Under 3 feet
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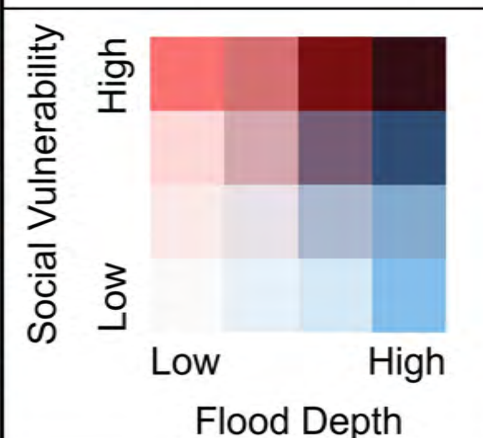
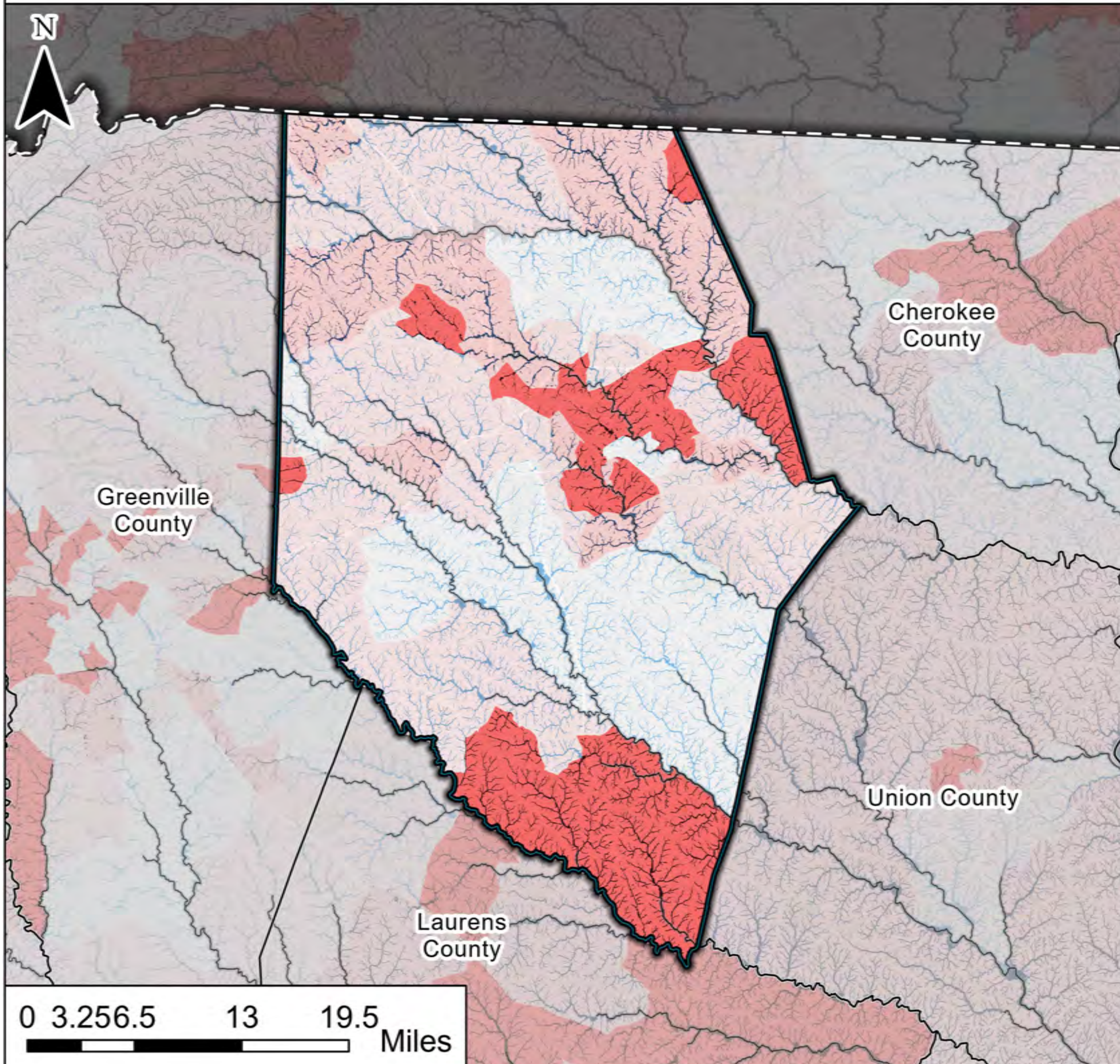


Spartanburg County
Flooding Exposure and Social Vulnerability

SCOR South Carolina Office of Resilience



This map overlays flooding depth associated with a 1% Annual Chance Event (1 in 100 Year Flood) and Social Vulnerability (SoVI®).

Flood Depth's are produced by the First Street Foundation, and are symbolized in 4 categories;

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Social Vulnerability values are taken at the Census Tract Level - State Percentile value, and provided by the National Risk Index (FEMA). This map uses 4 categories to symbolize low to high social vulnerability.

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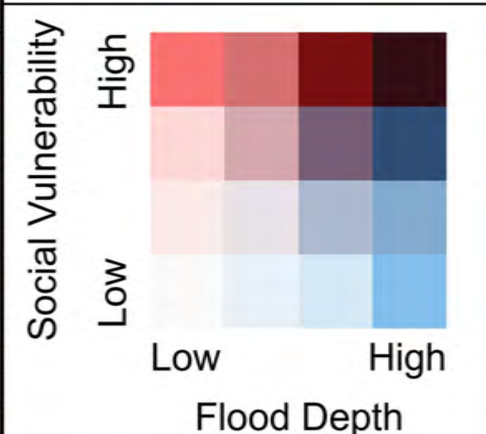
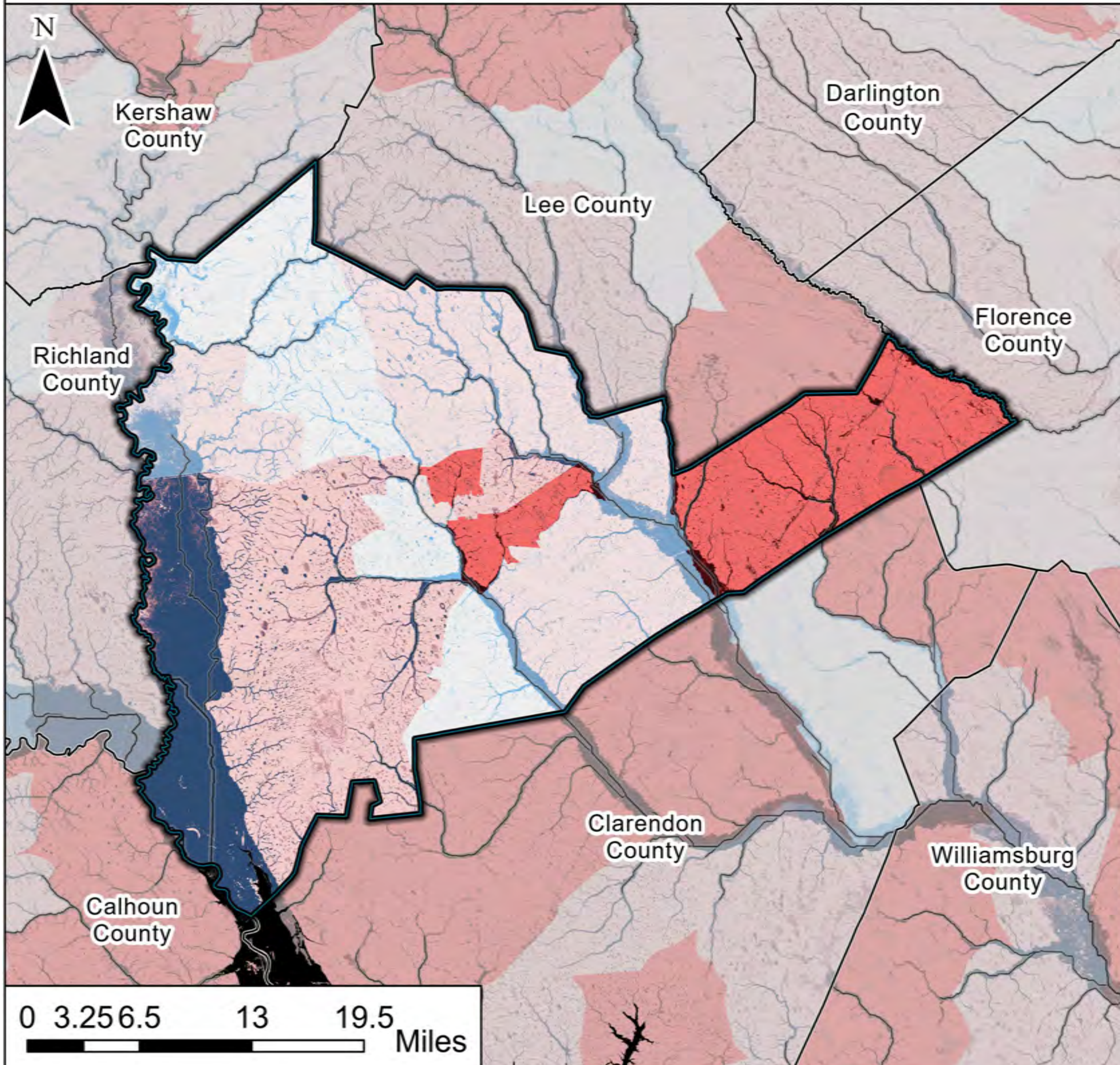


Sumter County
Flooding Exposure and Social Vulnerability



This map overlays flooding depth associated with a 1% Annual Chance Event (1 in 100 Year Flood) and Social Vulnerability (SoVI®).

Flood Depth's are produced by the First Street Foundation, and are symbolized in 4 categories;

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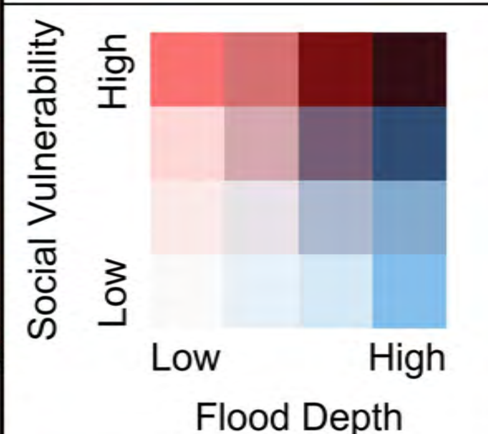
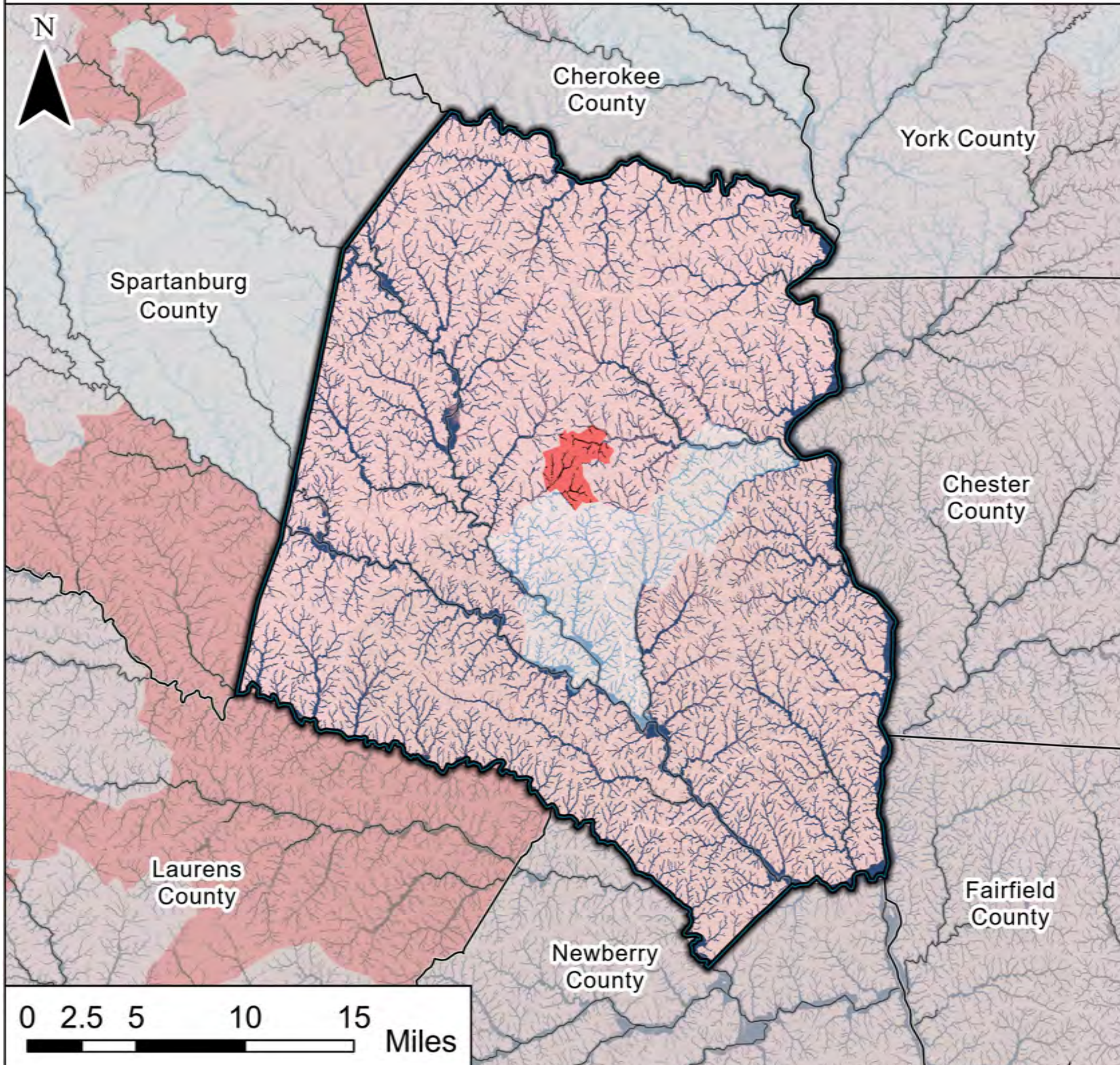


Union County
Flooding Exposure and Social Vulnerability



SCOR South Carolina Office of Resilience

This map overlays flooding depth associated with a 1% Annual Chance Event (1 in 100 Year Flood) and Social Vulnerability (SoVI®).

Flood Depth's are produced by the First Street Foundation, and are symbolized in 4 categories;

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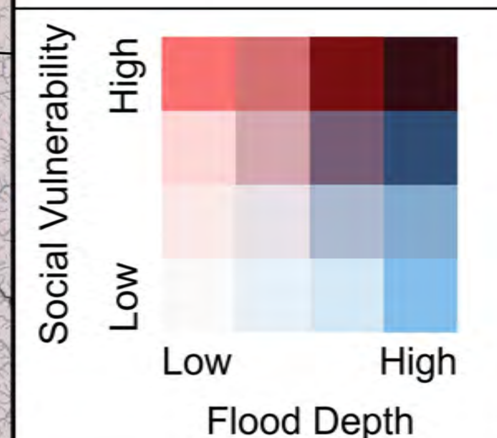
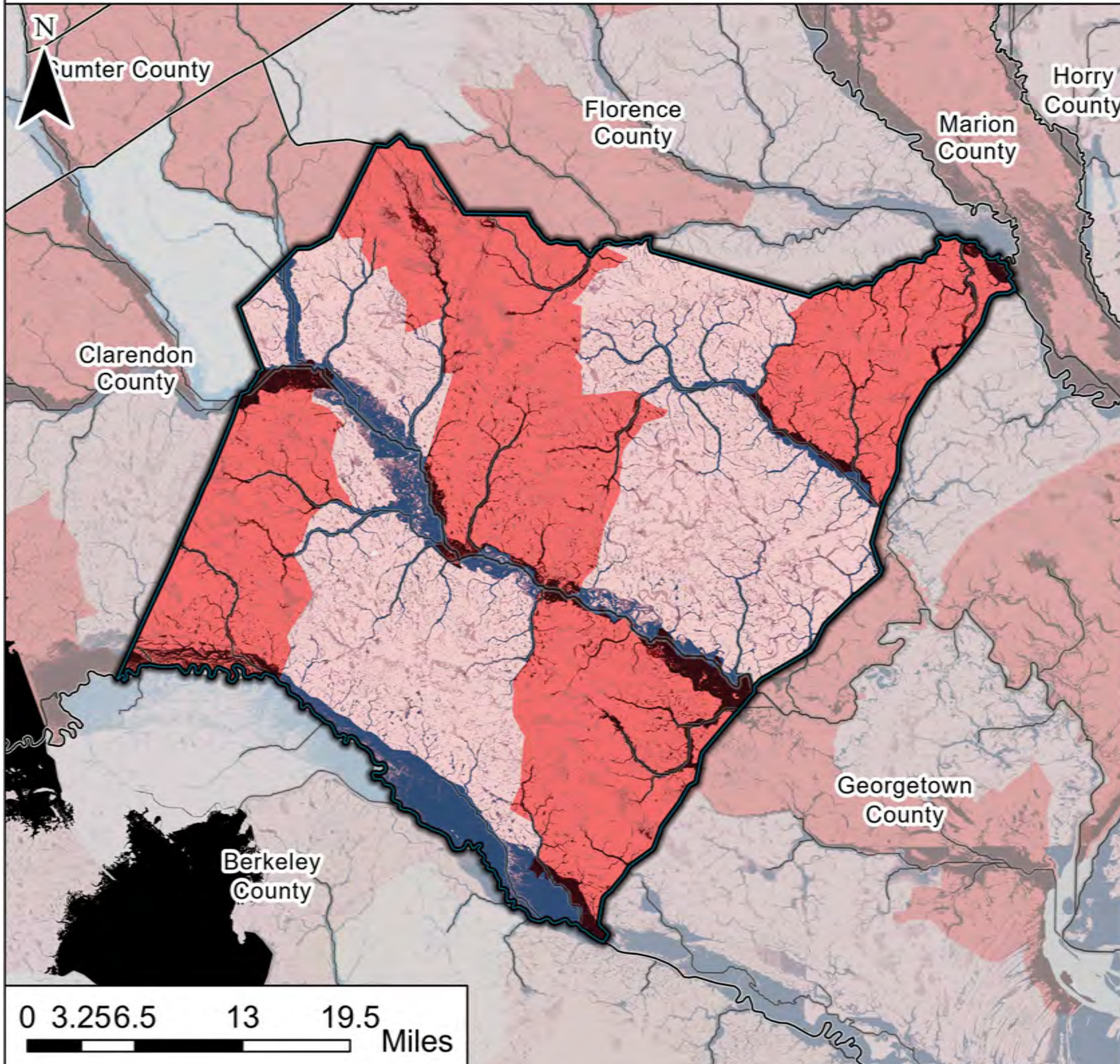


Williamsburg County
Flooding Exposure and Social Vulnerability



This map overlays flooding depth associated with a 1% Annual Chance Event (1 in 100 Year Flood) and Social Vulnerability (SoVI®).

Flood Depth's are produced by the First Street Foundation, and are symbolized in 4 categories;
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Social Vulnerability values are taken at the Census Tract Level - State Percentile value, and provided by the National Risk Index (FEMA). This map uses 4 categories to symbolize low to high social vulnerability.
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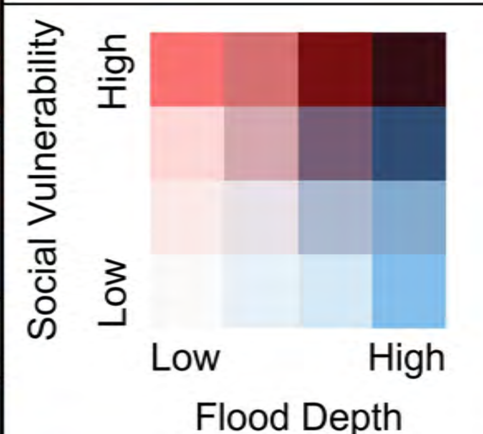
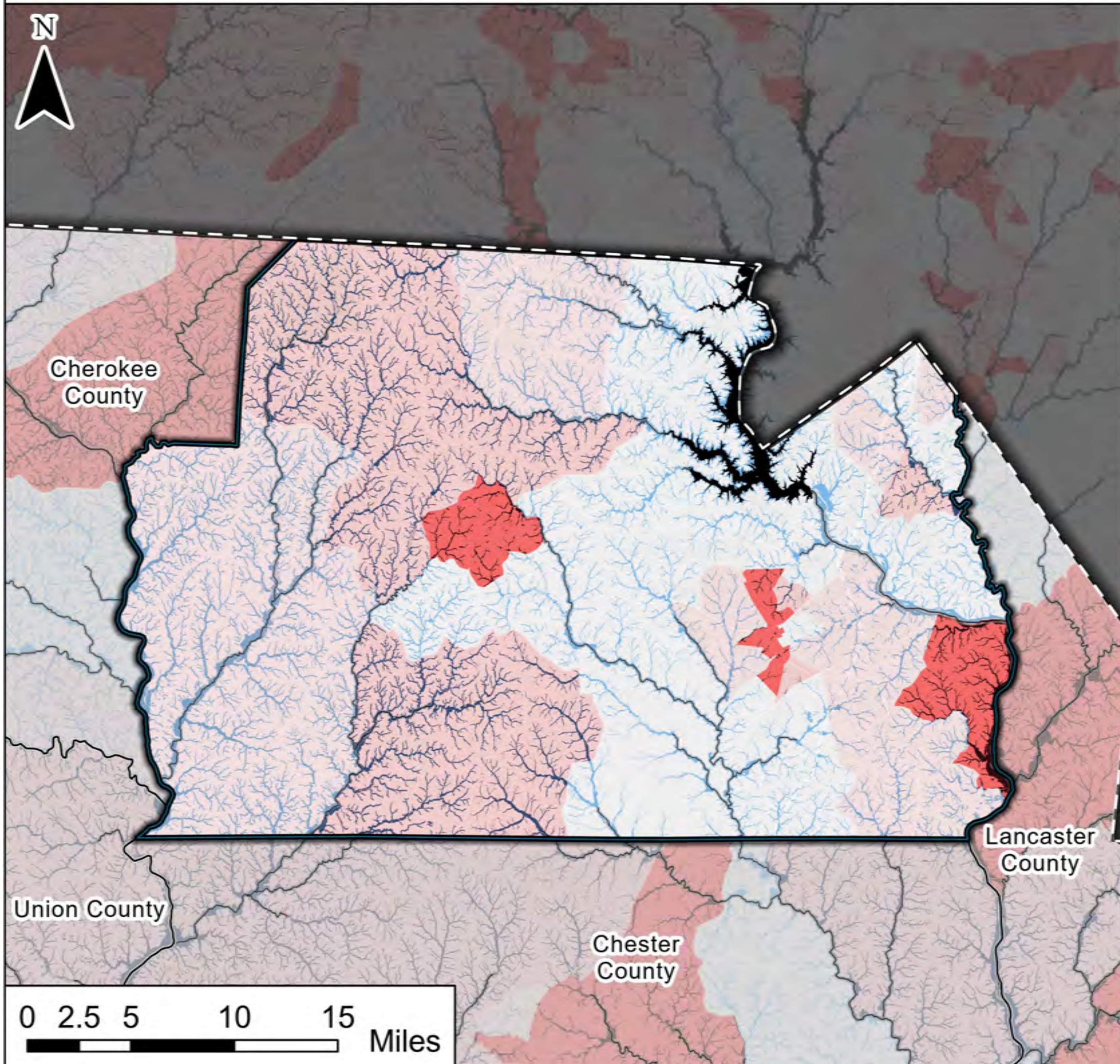


York County
Flooding Exposure and Social Vulnerability



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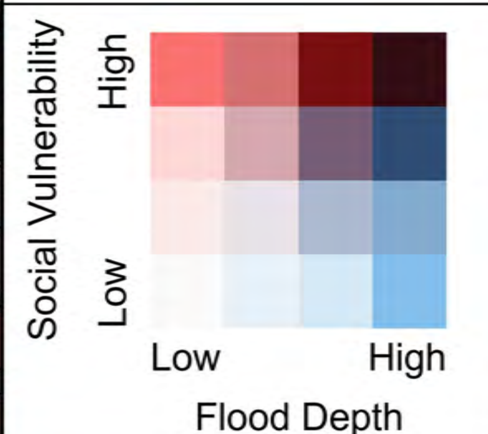
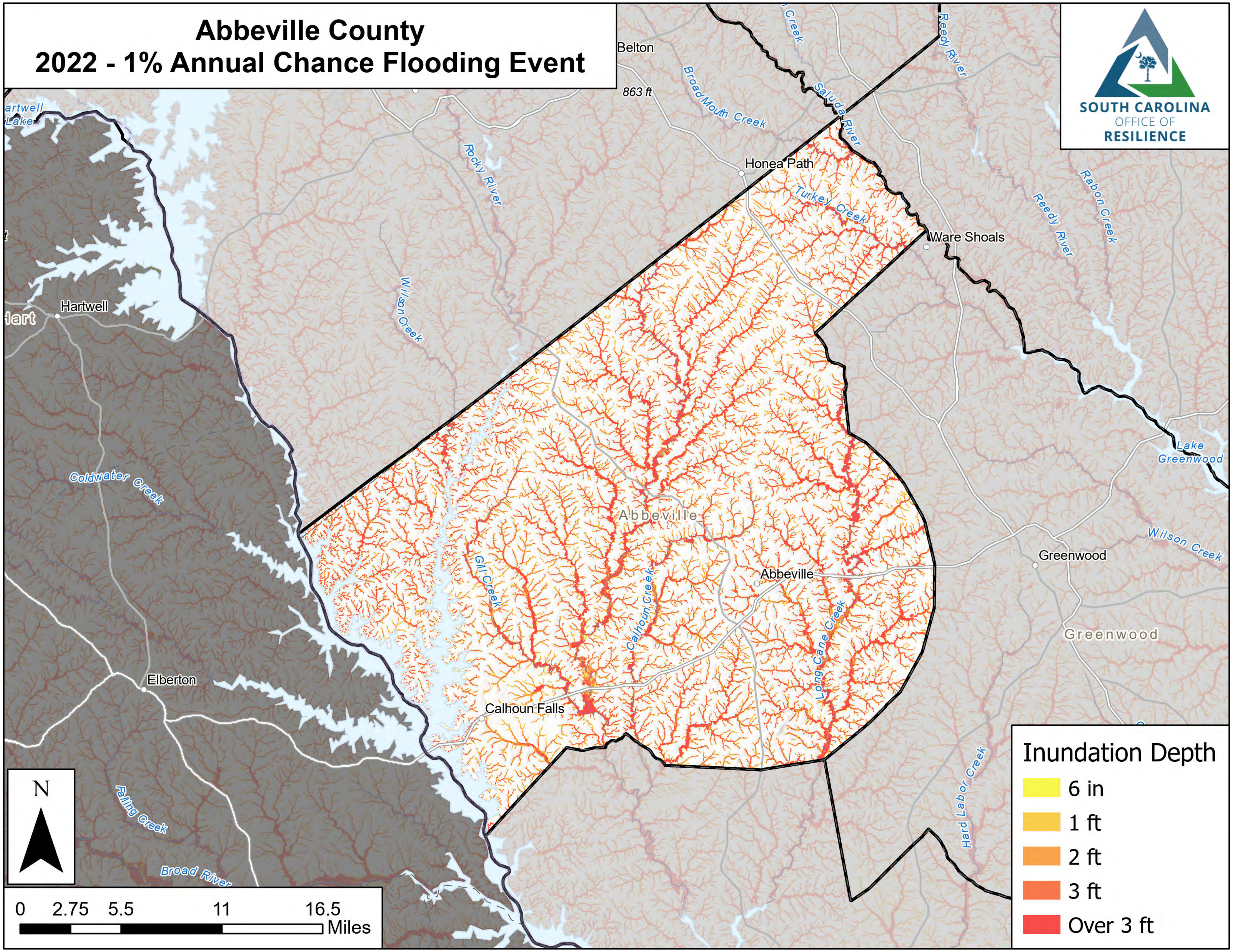
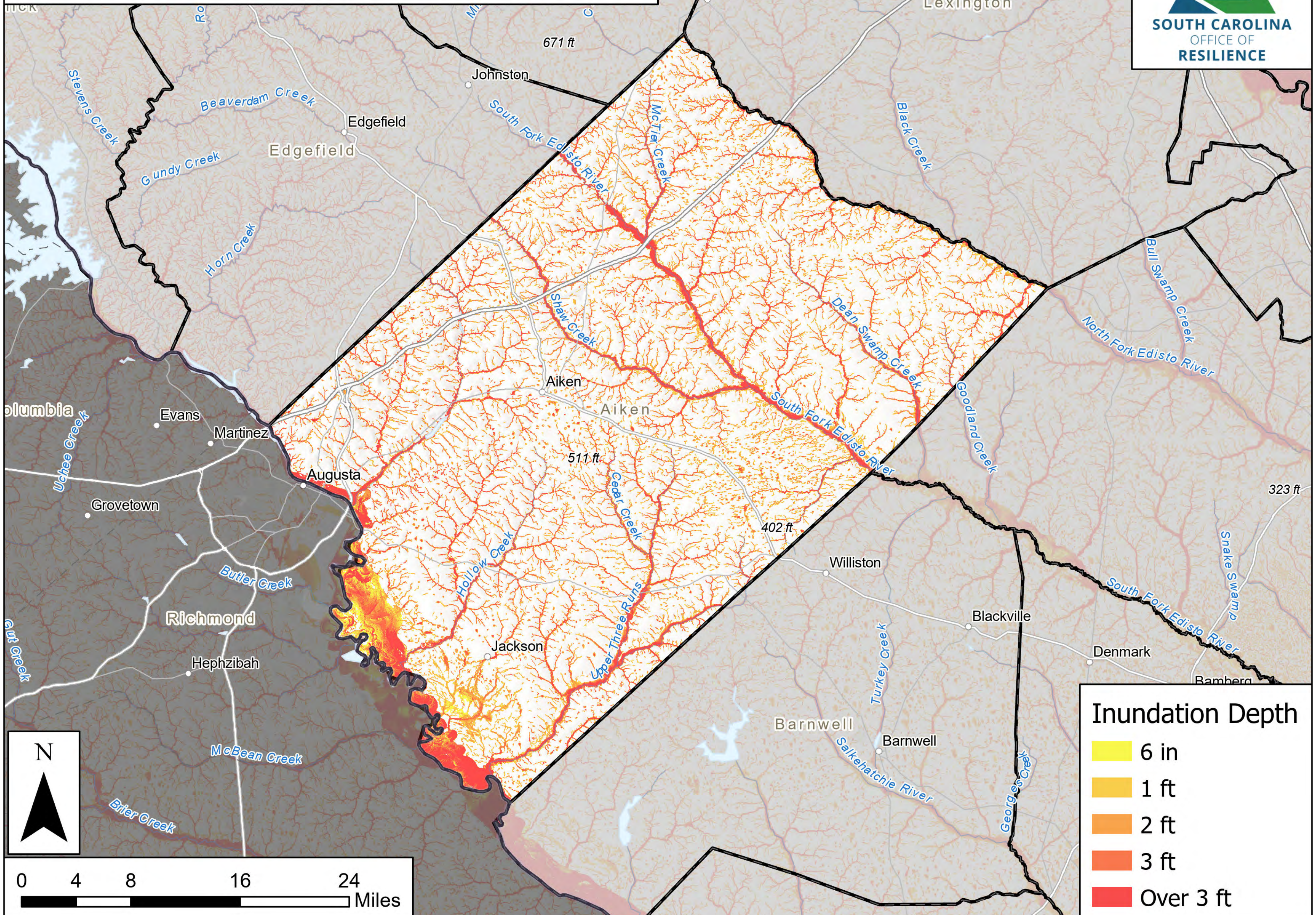


APPENDIX E:
COUNTY INUNDATION DATA FOR A 1% ANNUAL CHANCE FLOOD

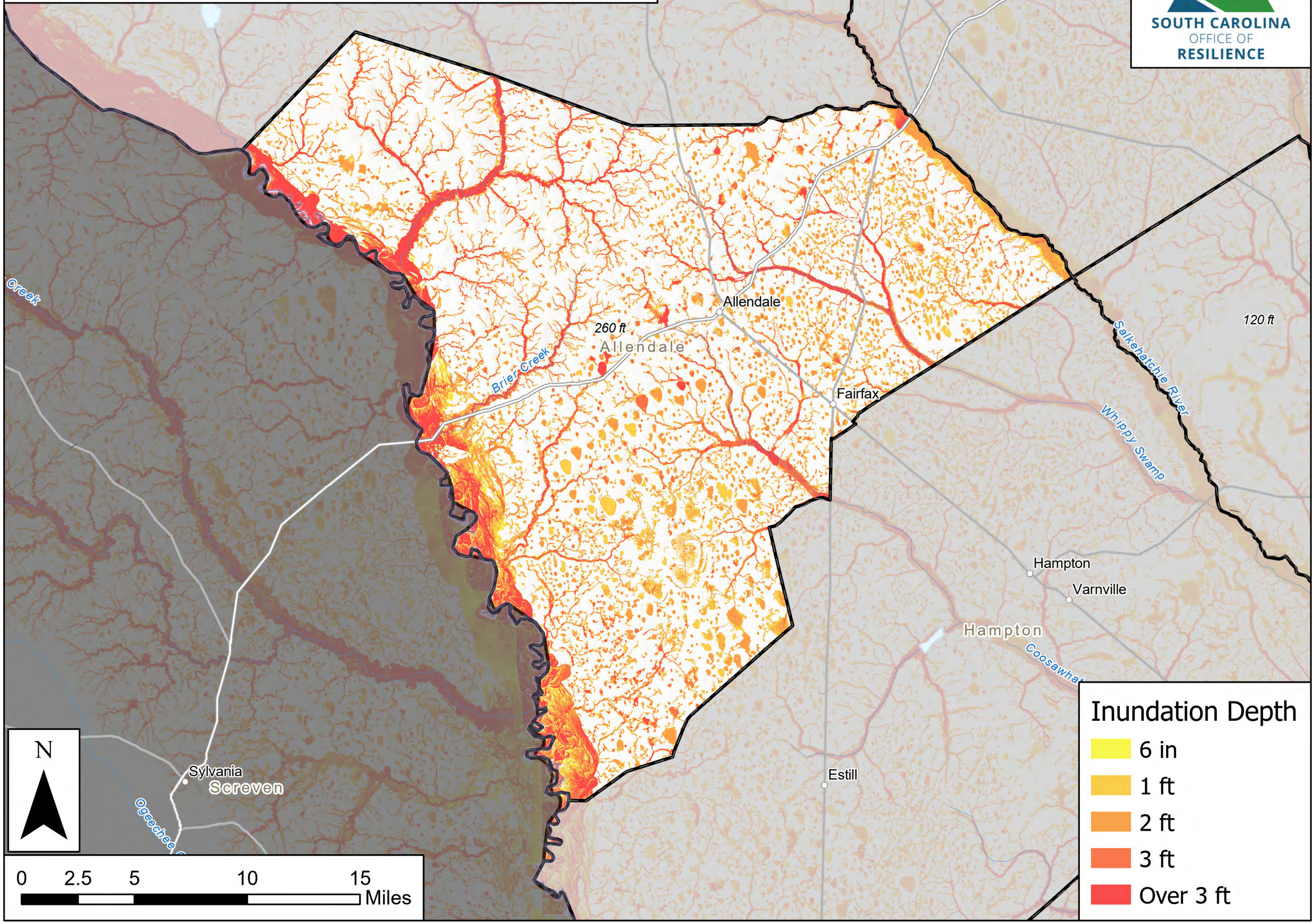
Abbeville County
2022 - 1% Annual Chance Flooding Event



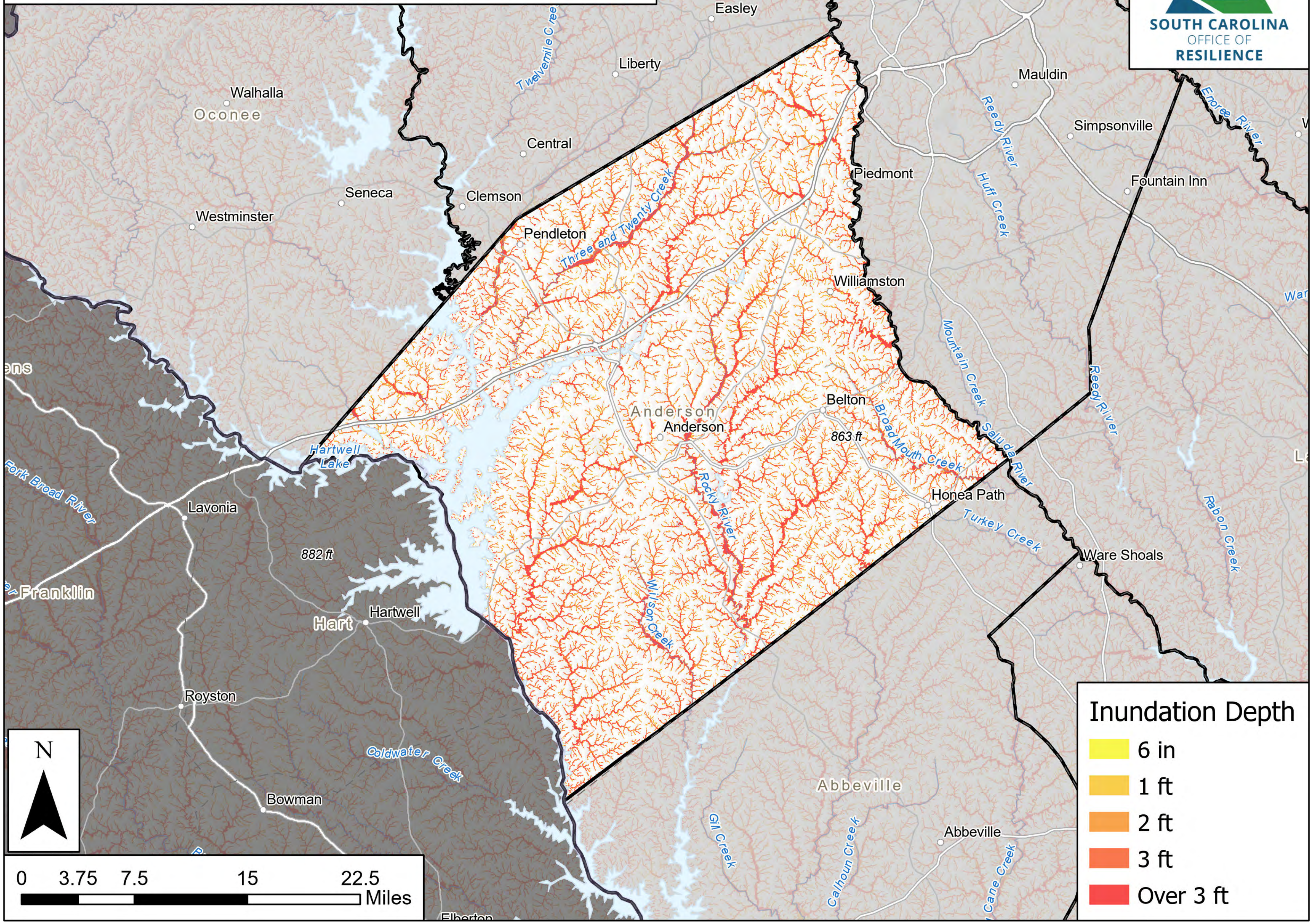
Aiken County
2022 - 1% Annual Chance Flooding Event



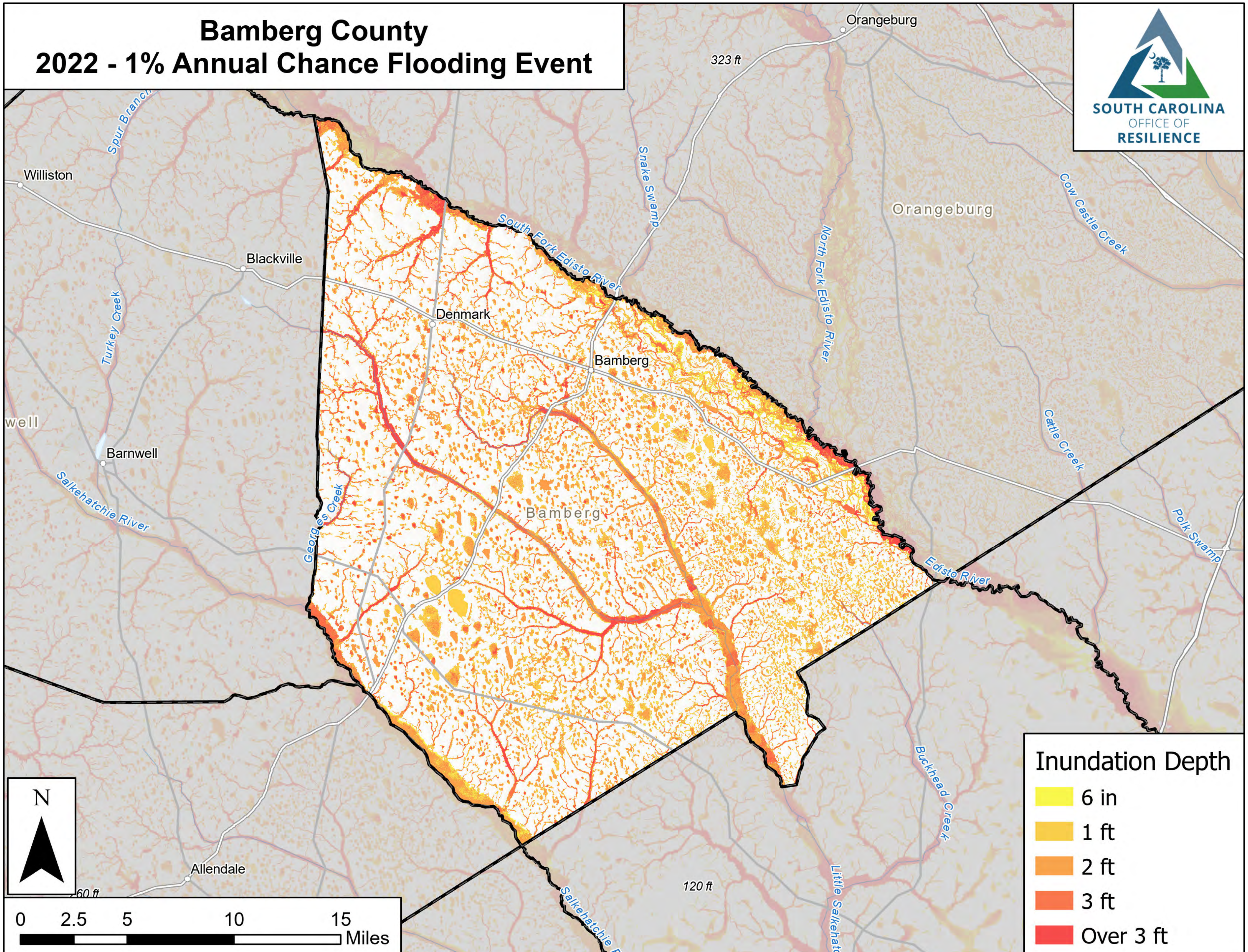
Allendale County
2022 - 1% Annual Chance Flooding Event



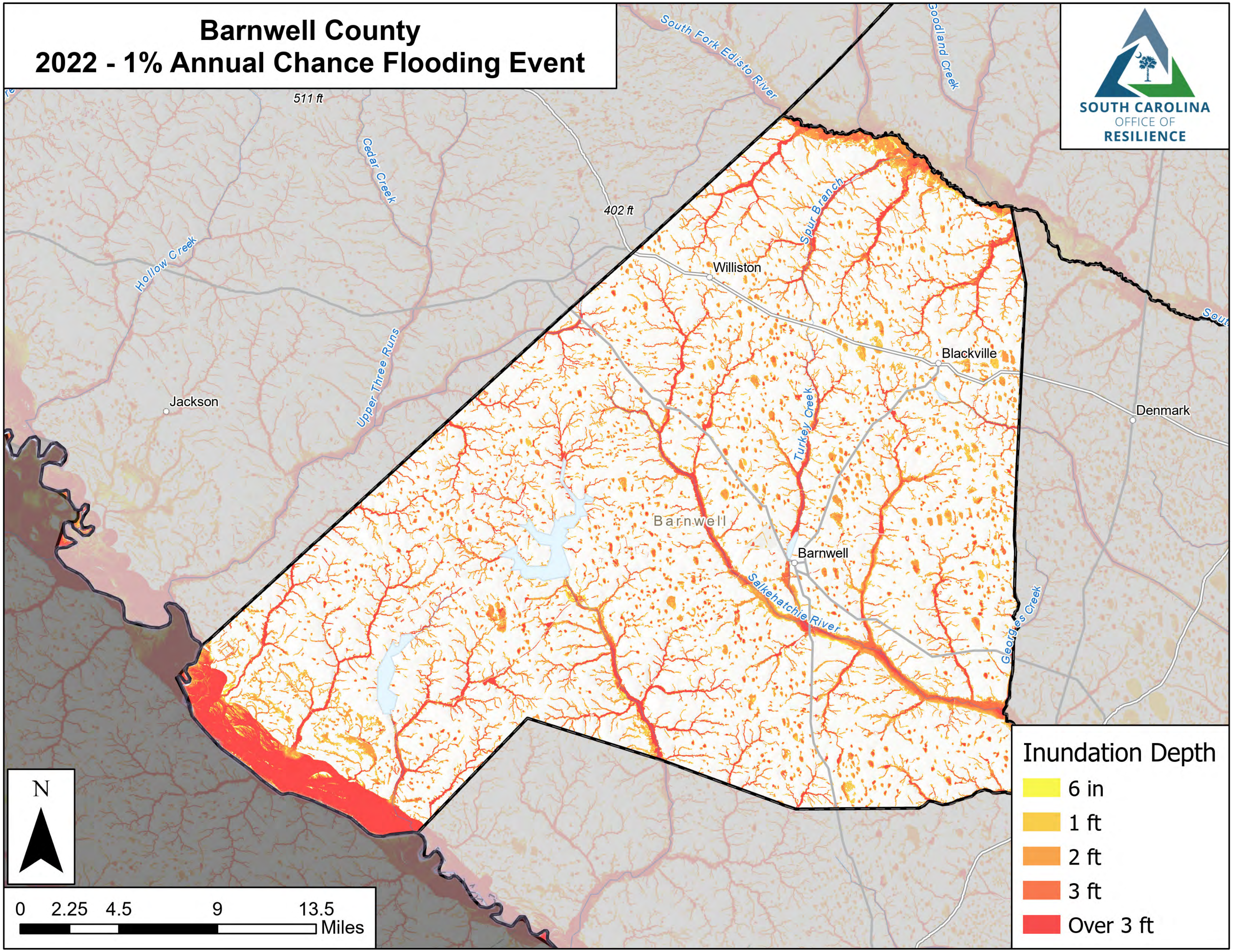
Anderson County
2022 - 1% Annual Chance Flooding Event



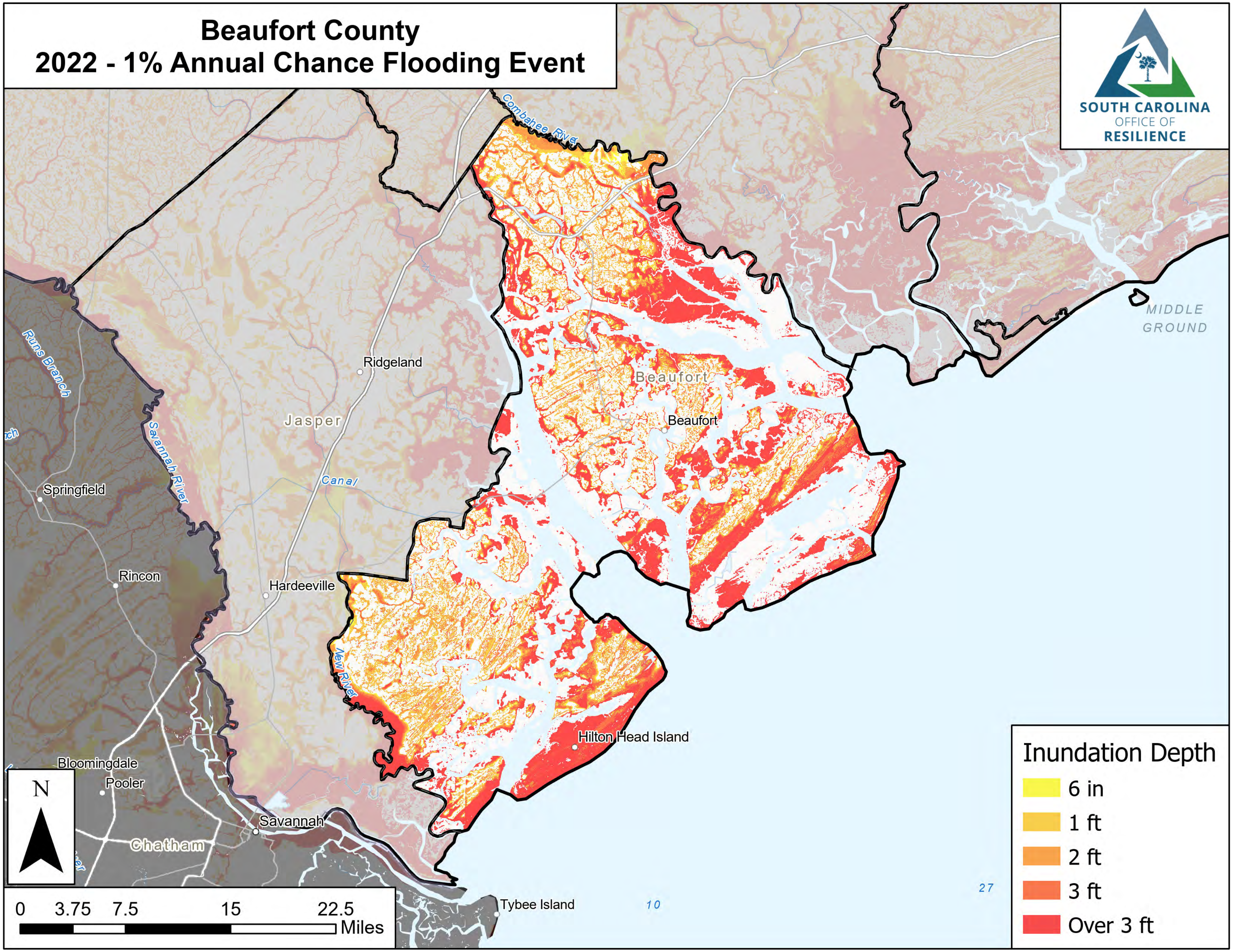
Bamberg County
2022 - 1% Annual Chance Flooding Event



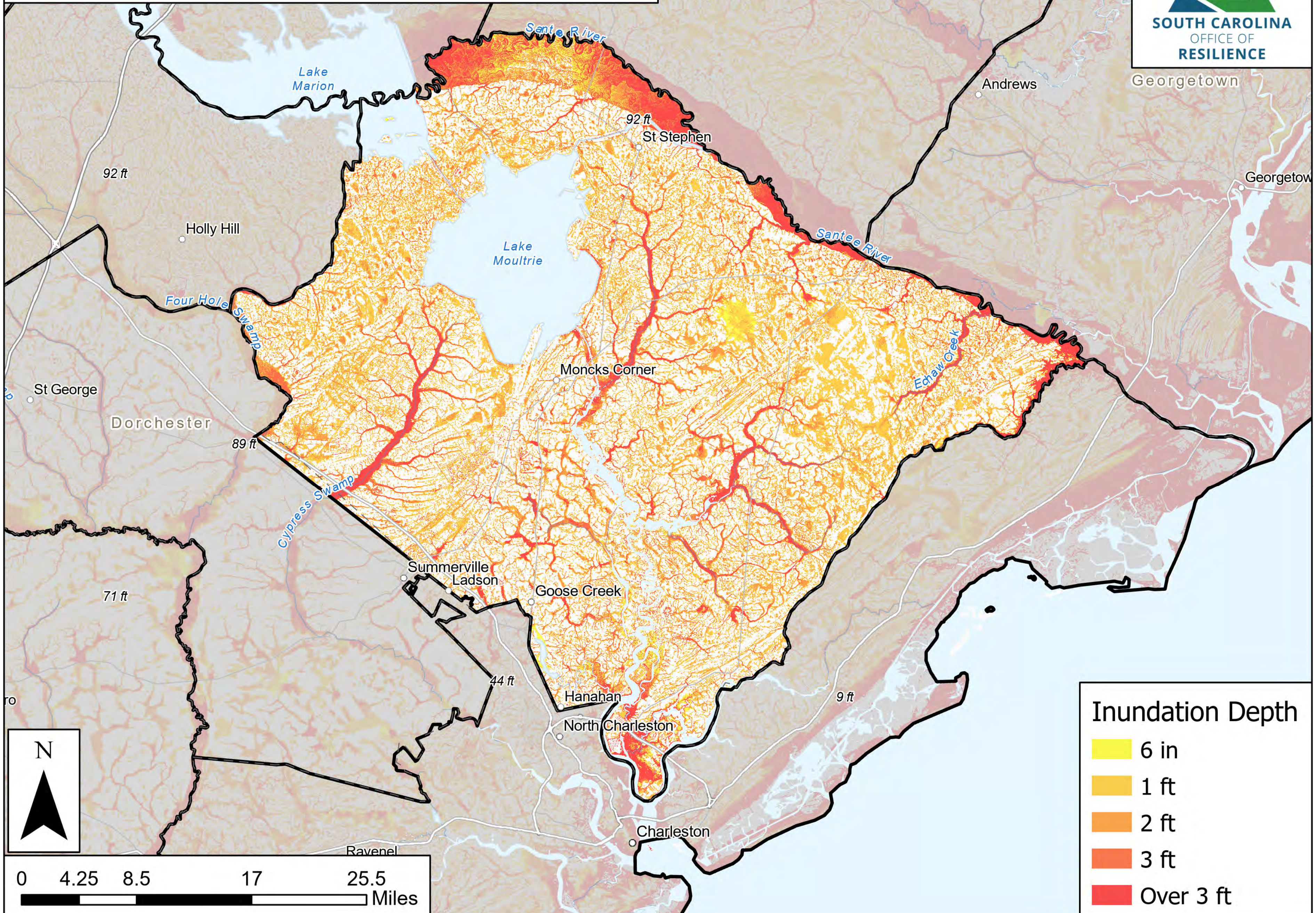
Barnwell County
2022 - 1% Annual Chance Flooding Event



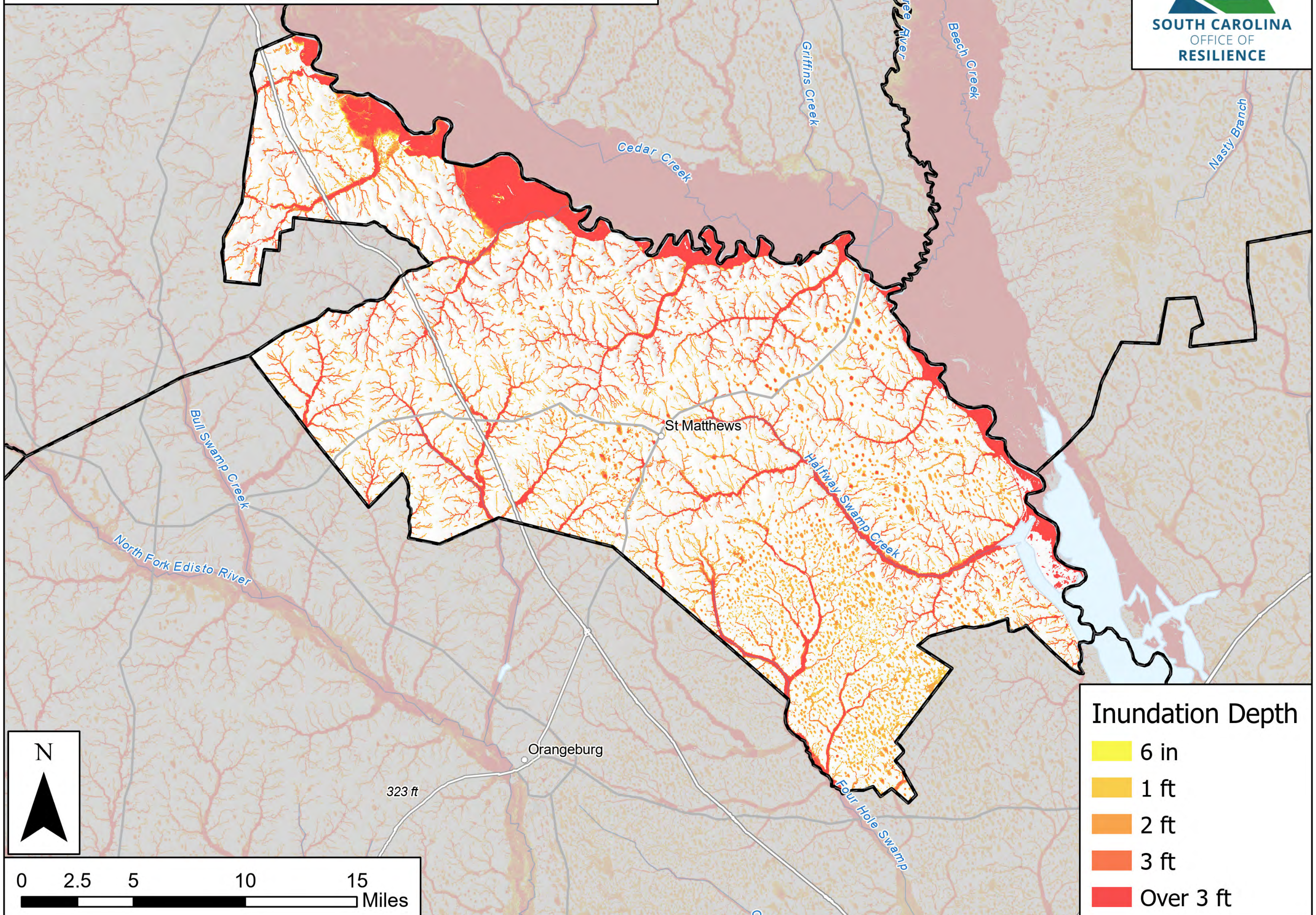
Beaufort County
2022 - 1% Annual Chance Flooding Event

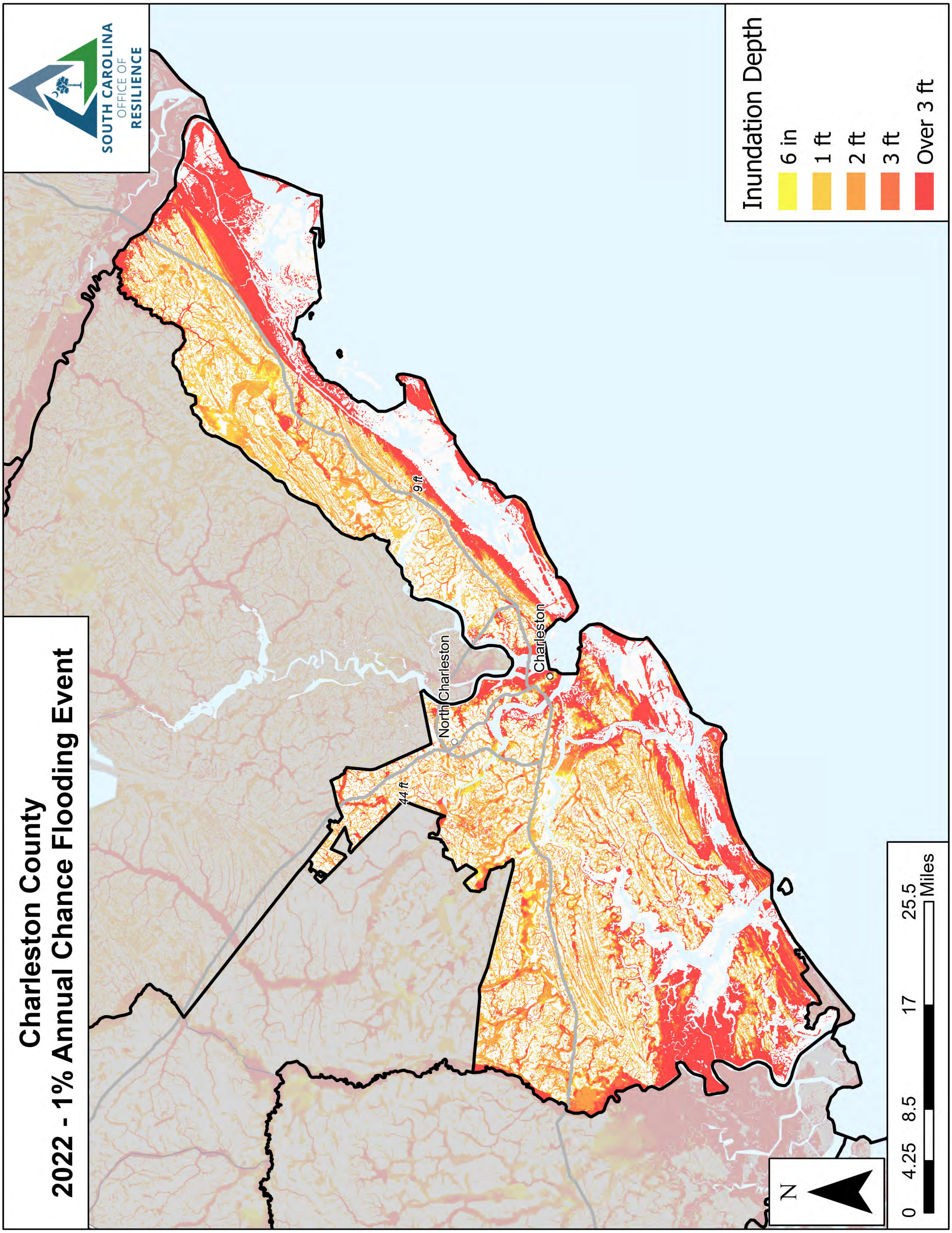


Berkeley County
2022 - 1% Annual Chance Flooding Event

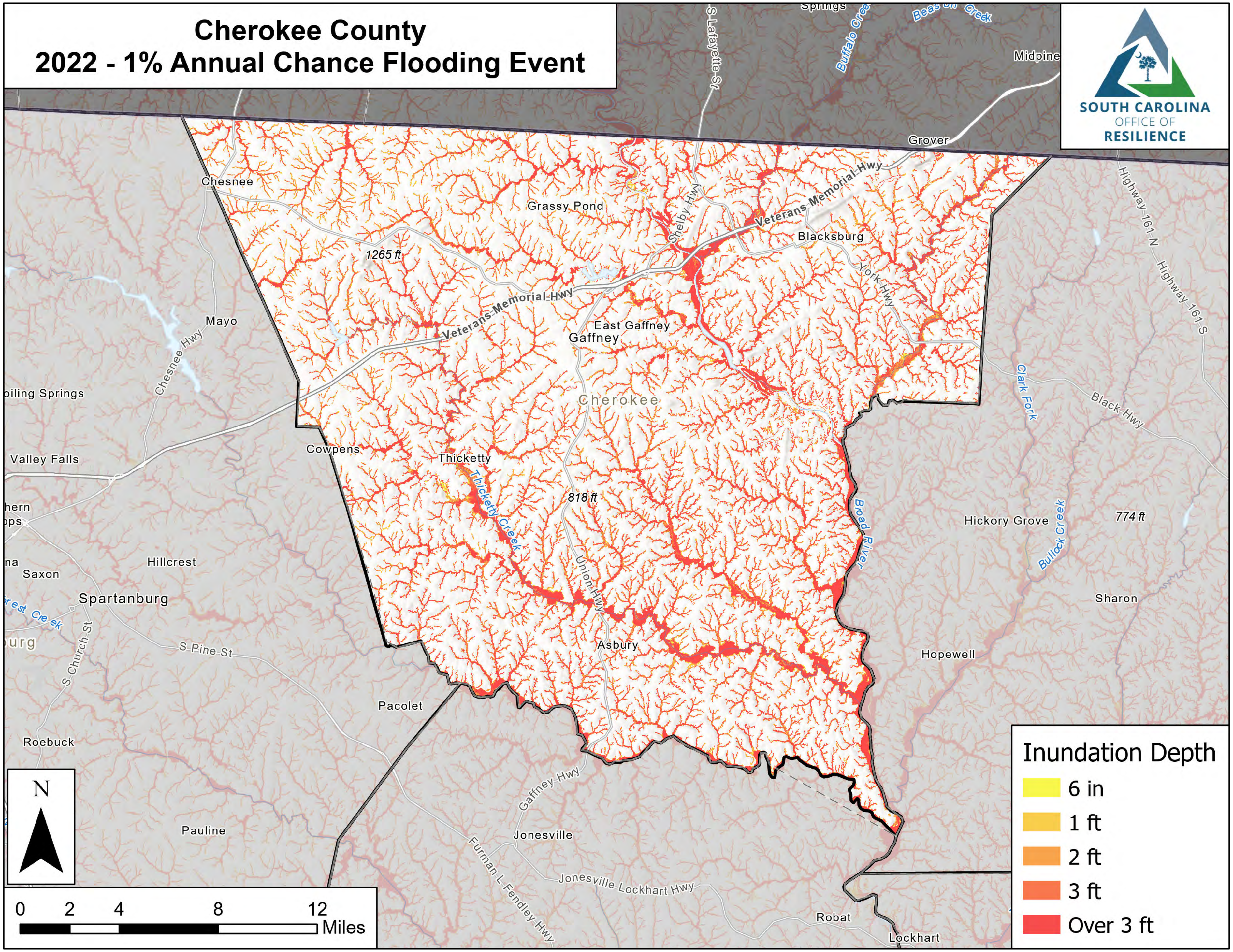


Calhoun County
2022 - 1% Annual Chance Flooding Event

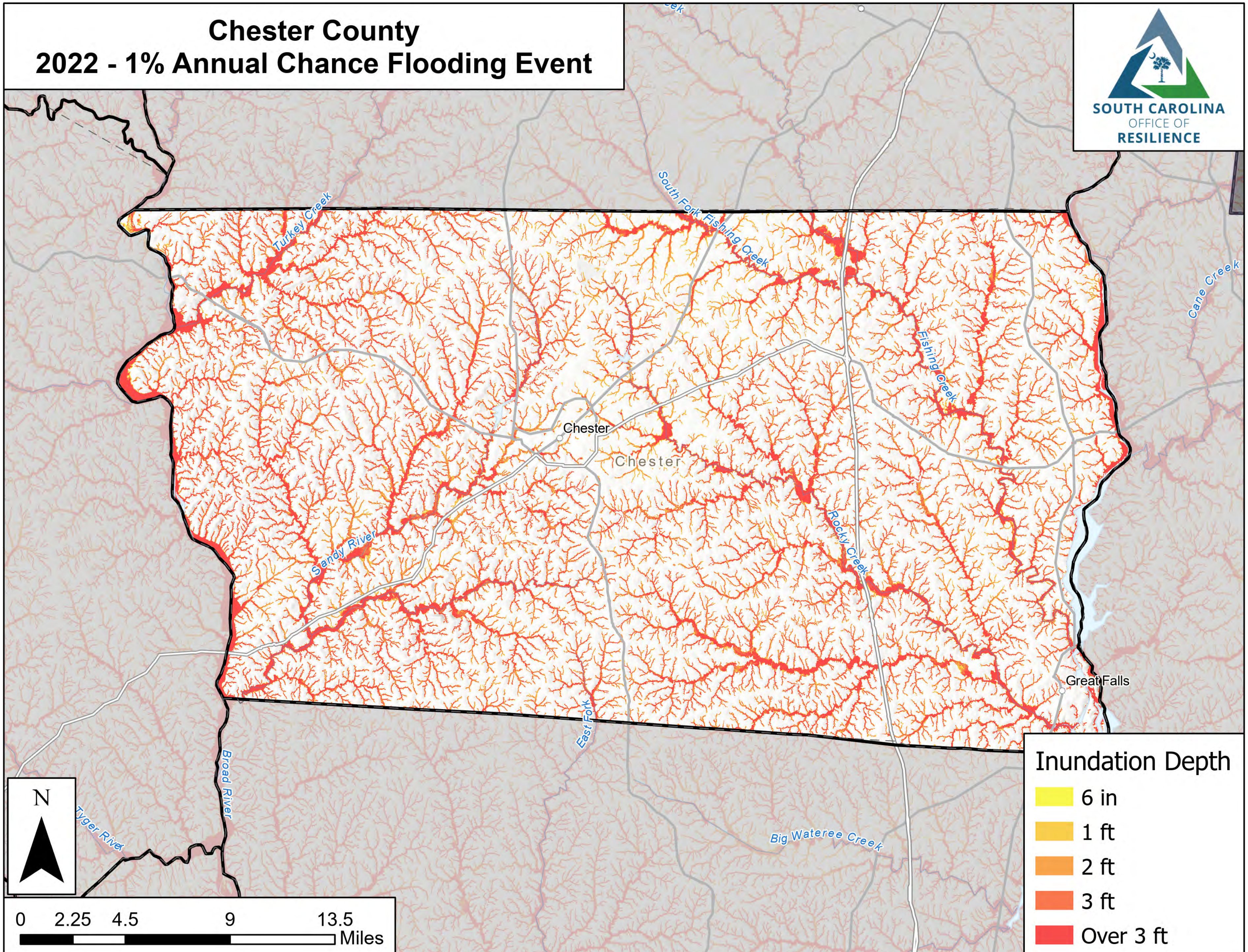



Charleston County
2022 - 1% Annual Chance Flooding Event
SOUTH CAROLINA
OFFICE OF
RESILIENCE
Inundation Depth
6 in
1 ft
2 ft
3 ft
Over 3 ft
Charleston
North Charleston
9 ft
44 ft
0 4.25 8.5 17 25.5
Miles
N

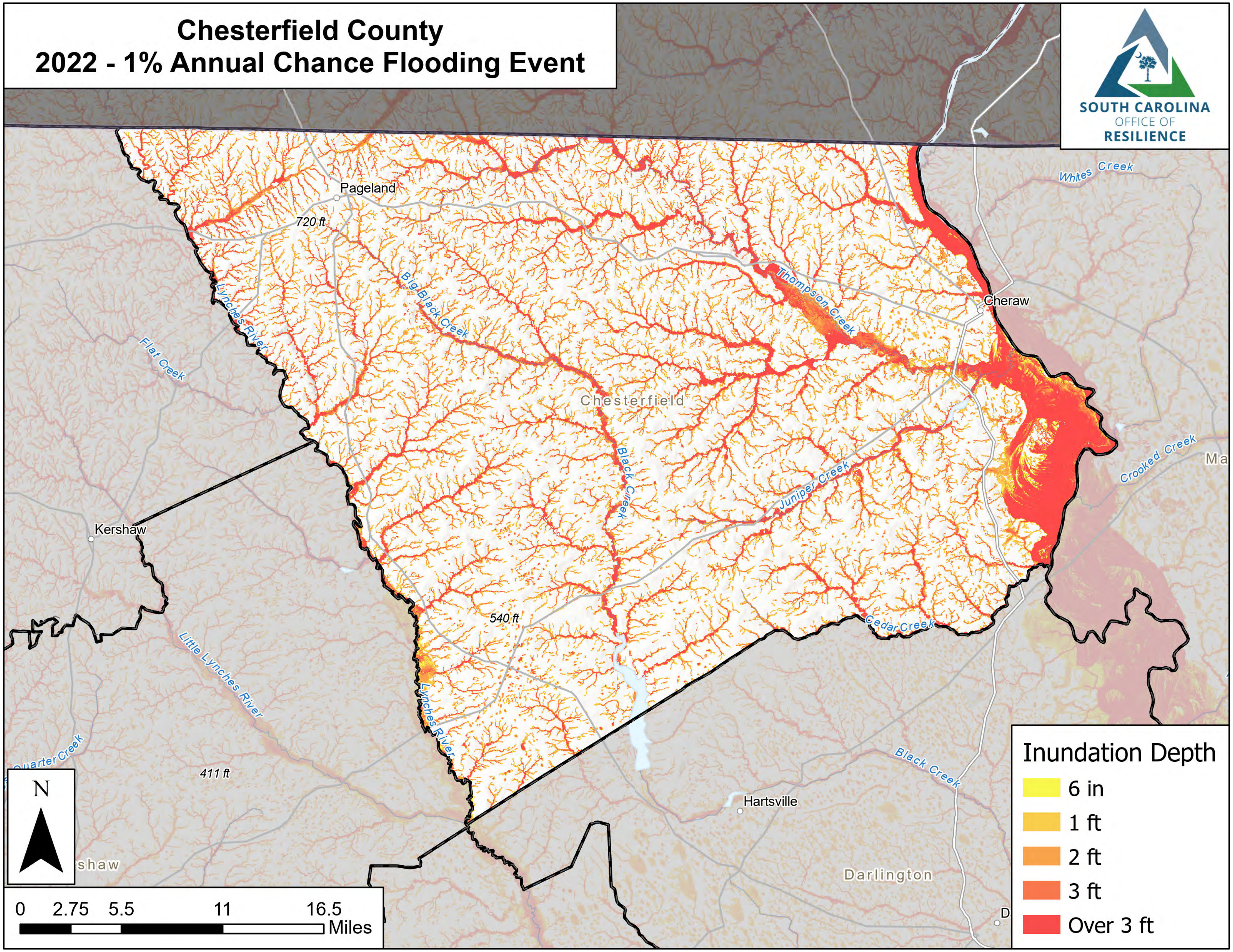
Cherokee County
2022 - 1% Annual Chance Flooding Event



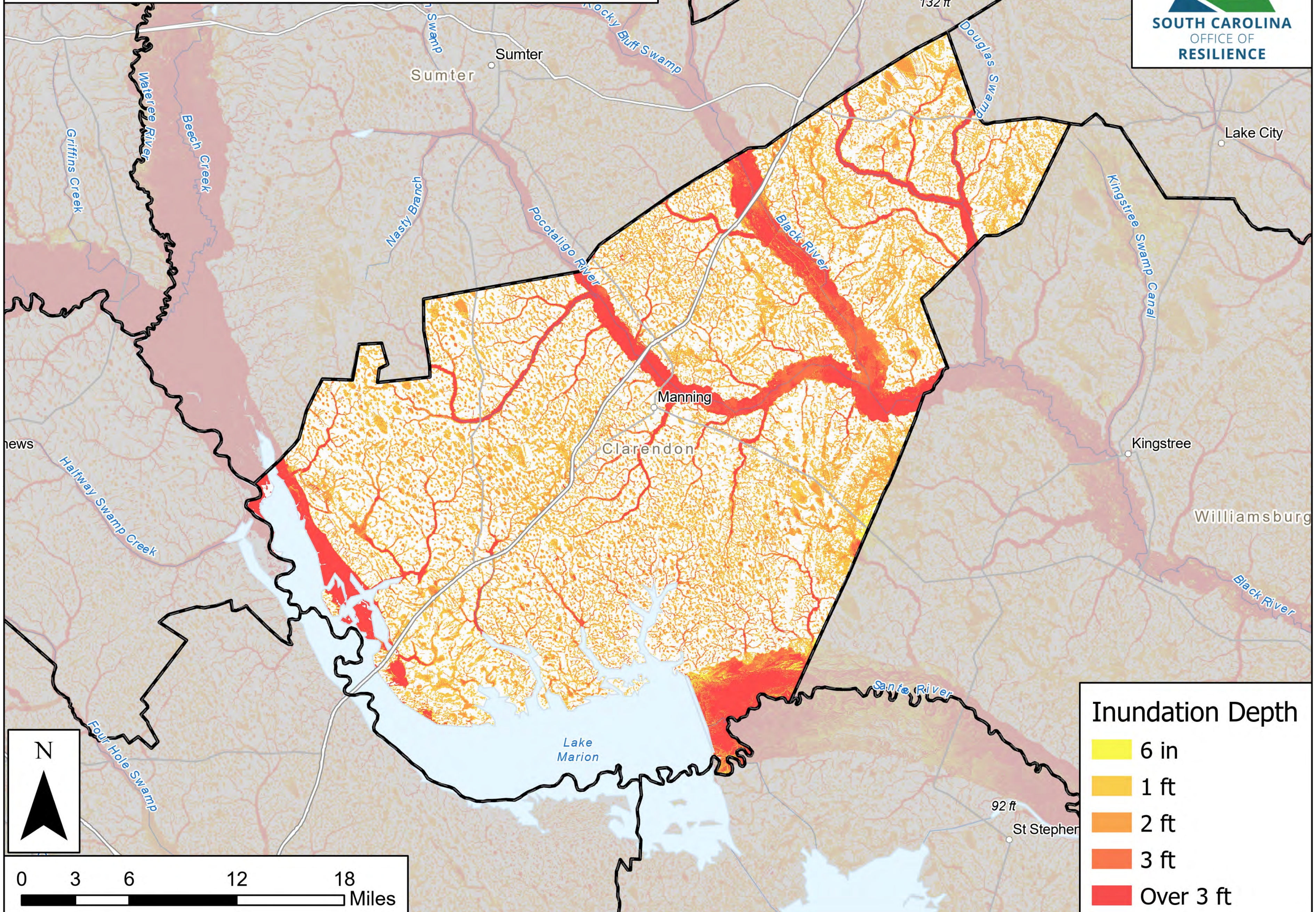
Chester County
2022 - 1% Annual Chance Flooding Event



Chesterfield County
2022 - 1% Annual Chance Flooding Event

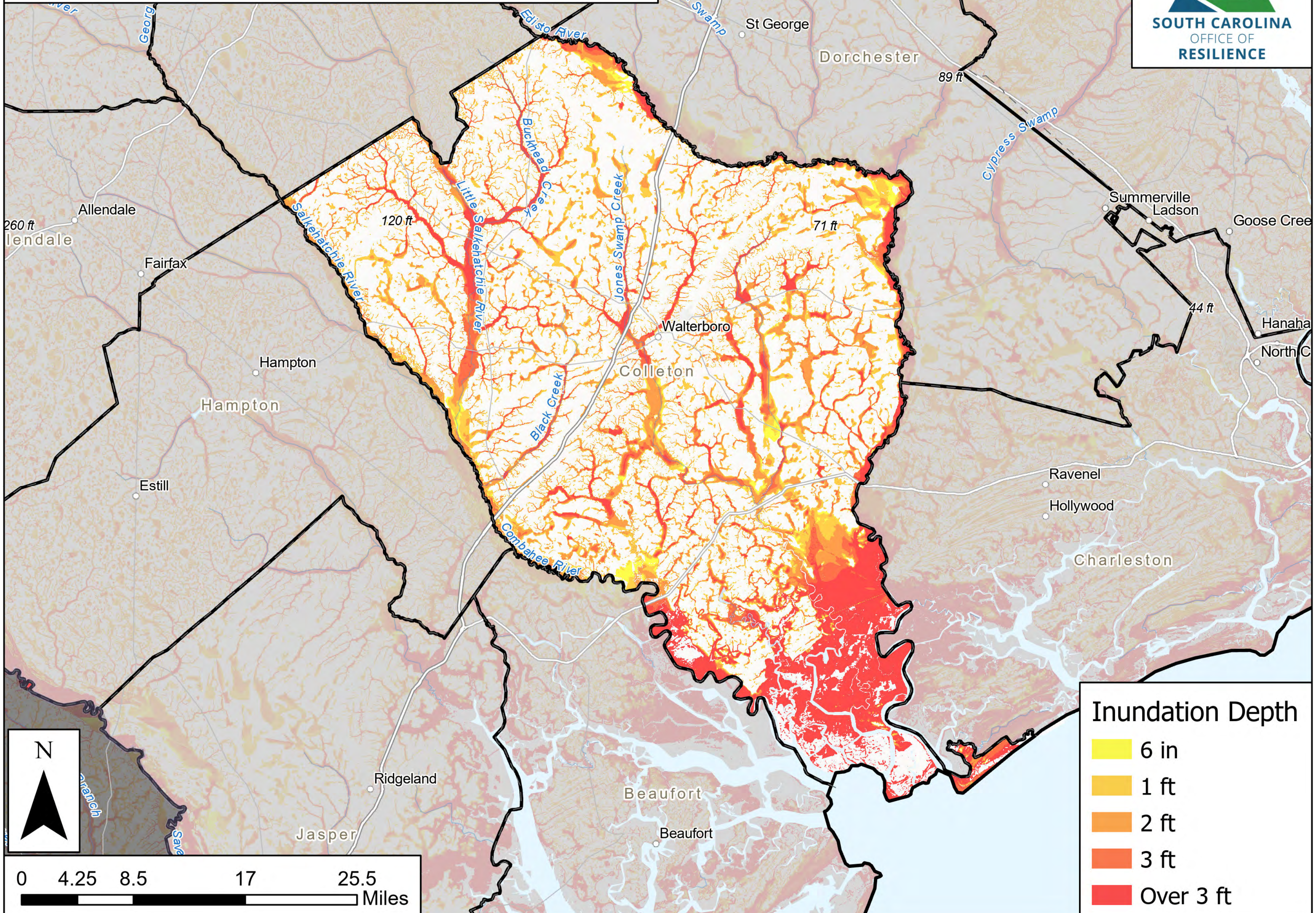


Clarendon County
2022 - 1% Annual Chance Flooding Event

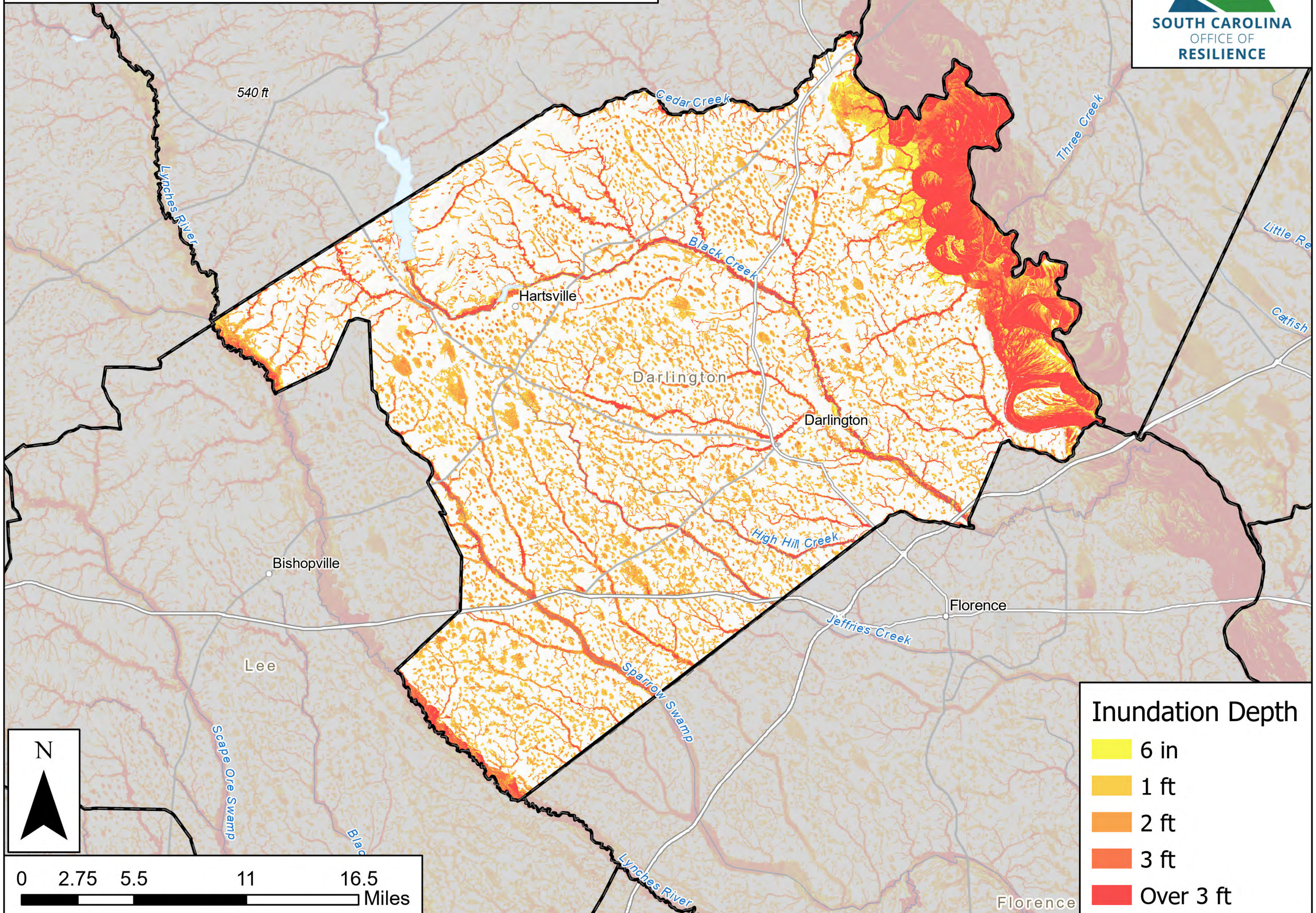


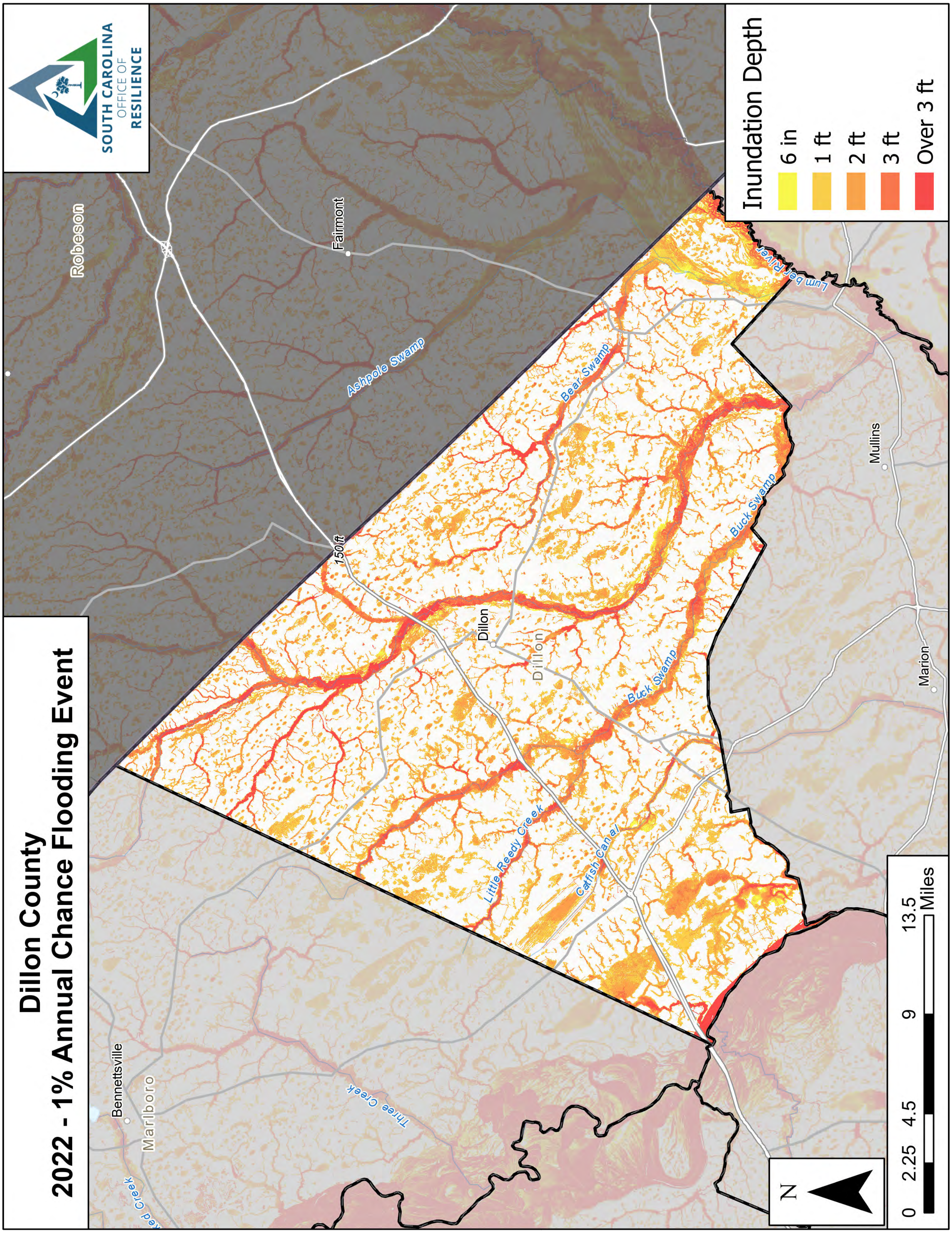
SOUTH CAROLINA OFFICE OF RESILIENCE

Colleton County
2022 - 1% Annual Chance Flooding Event

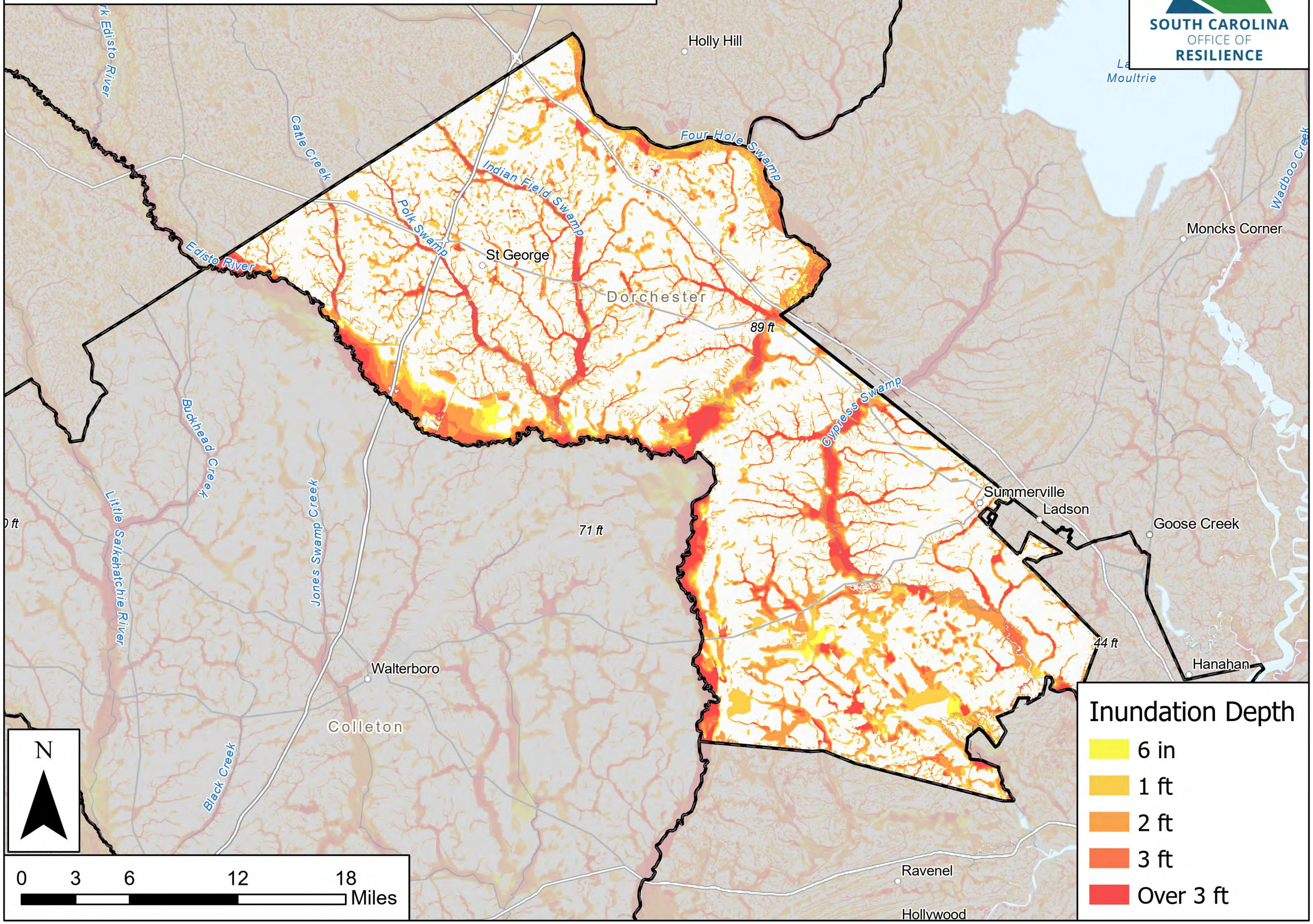


Darlington County
2022 - 1% Annual Chance Flooding Event

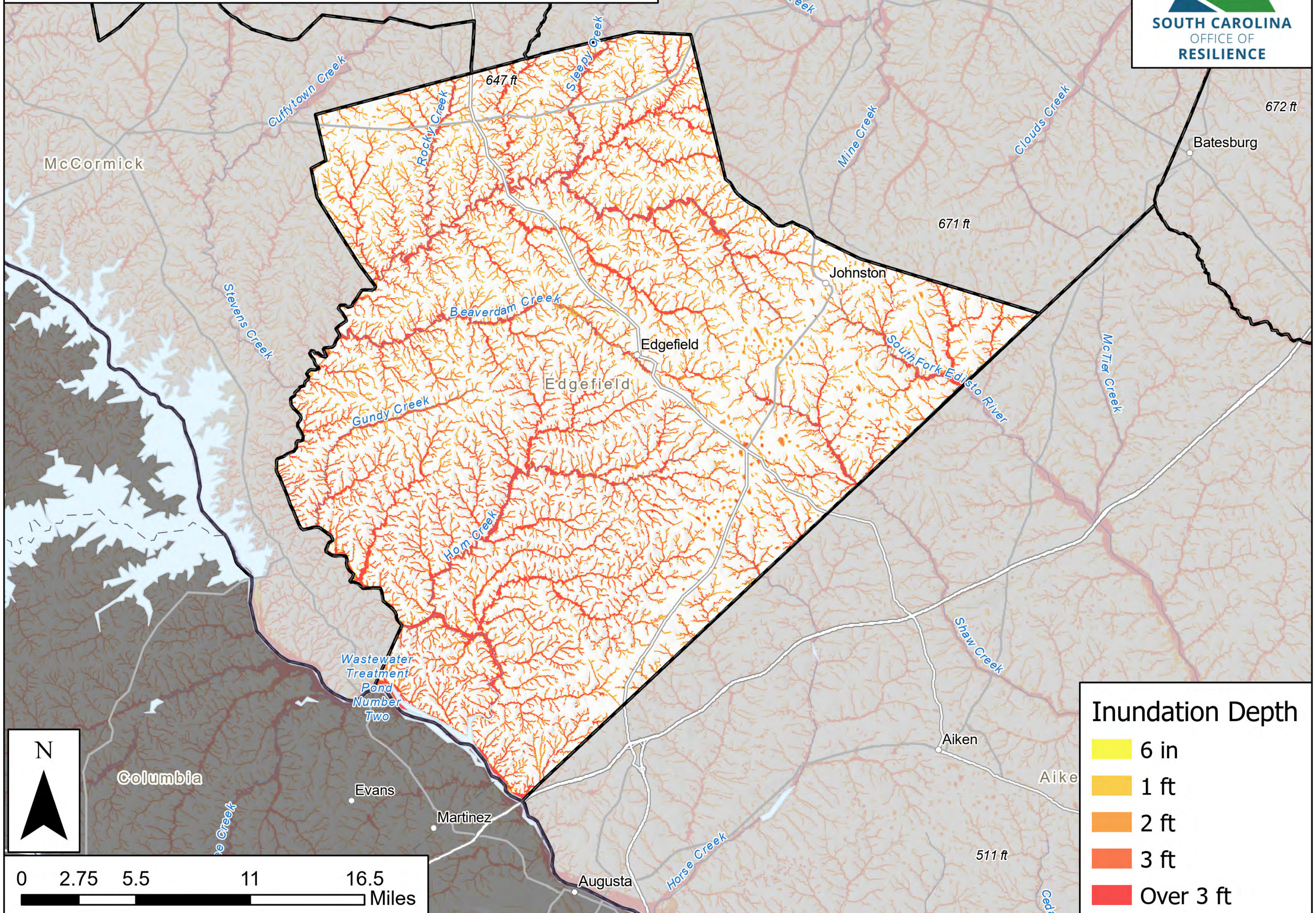



Dillon County
2022 - 1% Annual Chance Flooding Event
SOUTH CAROLINA
OFFICE OF
RESILIENCE
Inundation Depth
6 in
1 ft
2 ft
3 ft
Over 3 ft
Robeson
Fairmont
Ashpole Swamp
Bear Swamp
Lumber River
Mullins
Buck Swamp
150 ft
Dillon
Marion
Little Reedy Creek
Catfish Canal
Bennettsville
Marlboro
Three Creek
N
0
2.25
4.5
9
13.5
Miles

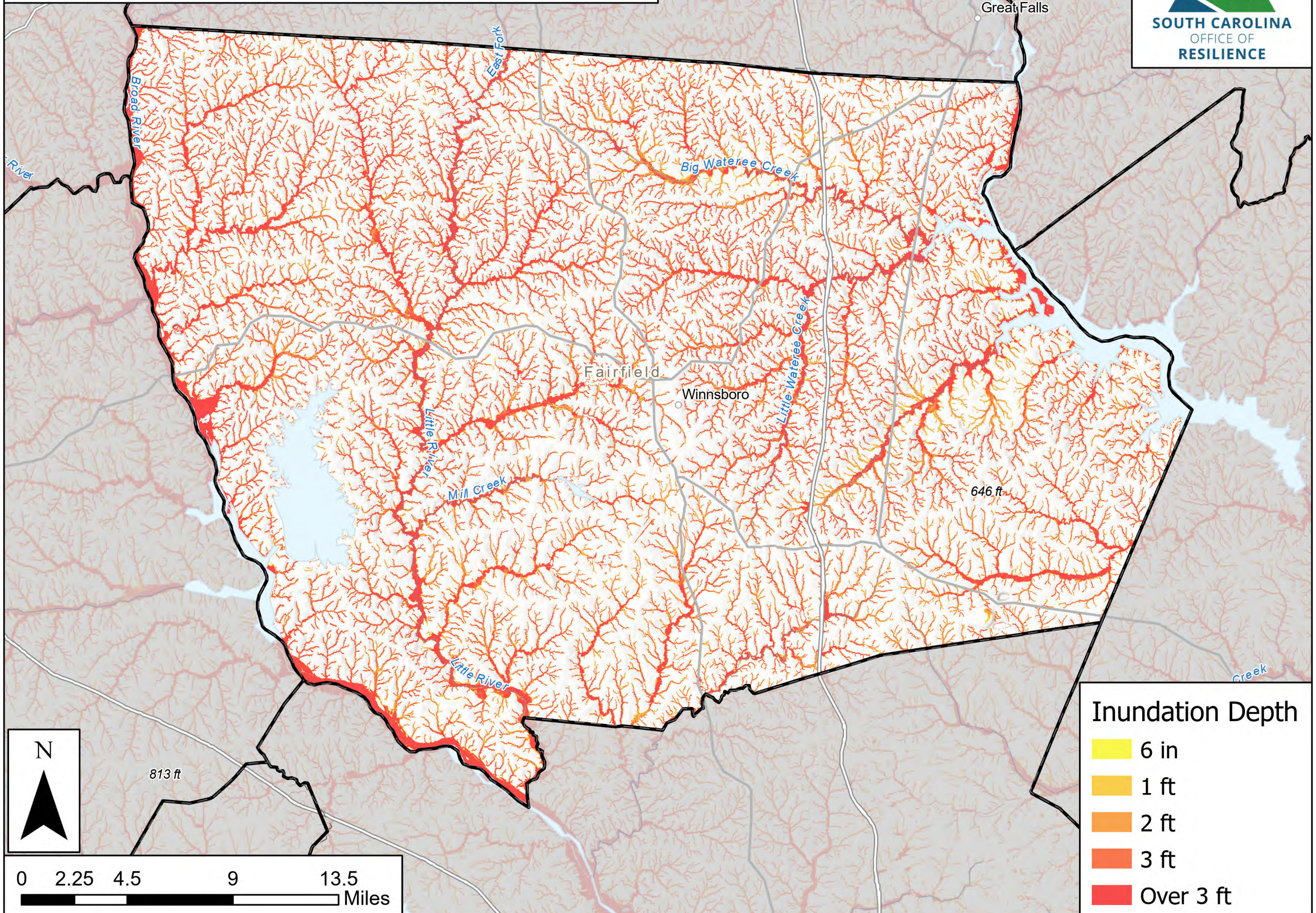
Dorchester County
2022 - 1% Annual Chance Flooding Event



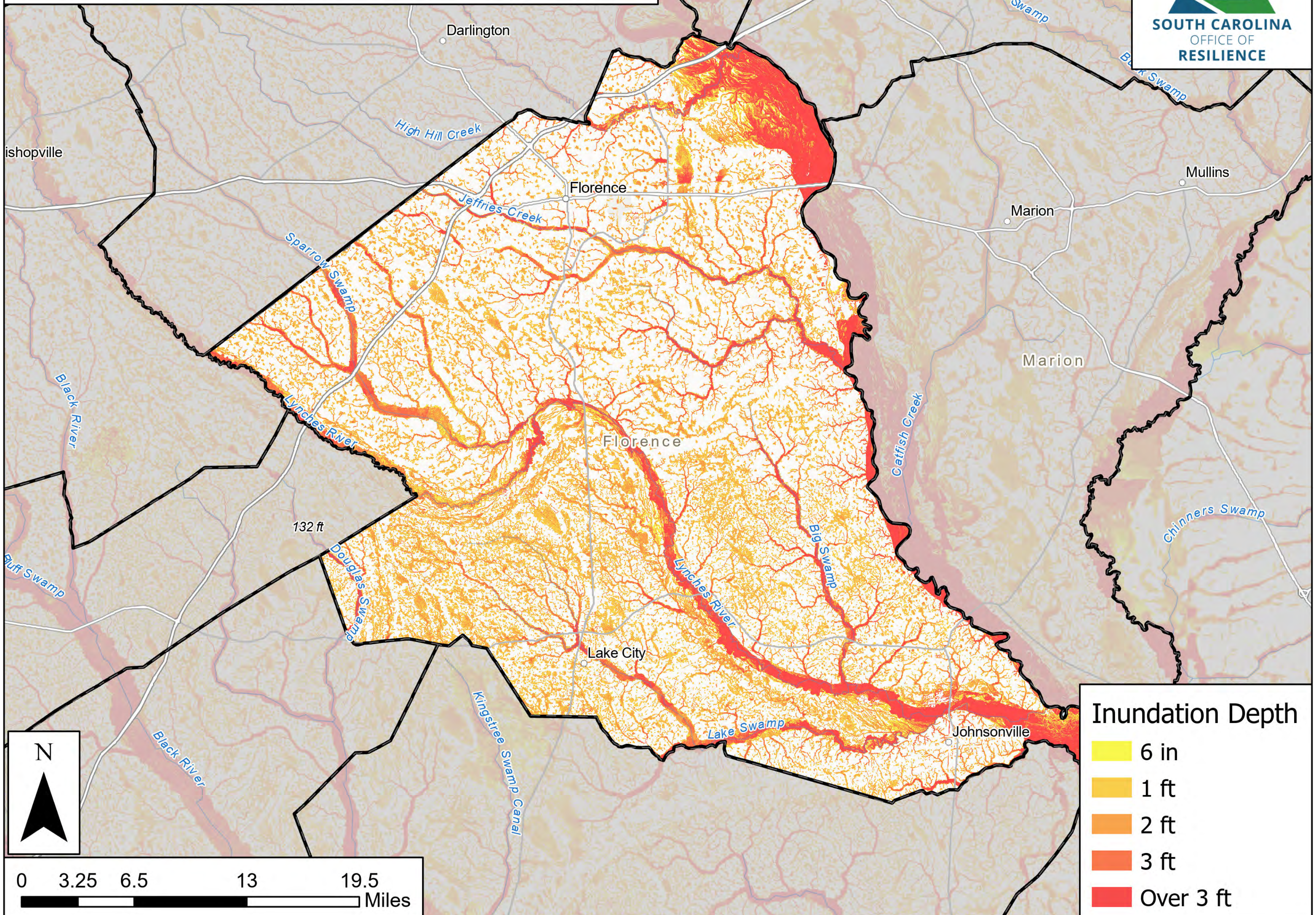
Edgefield County
2022 - 1% Annual Chance Flooding Event



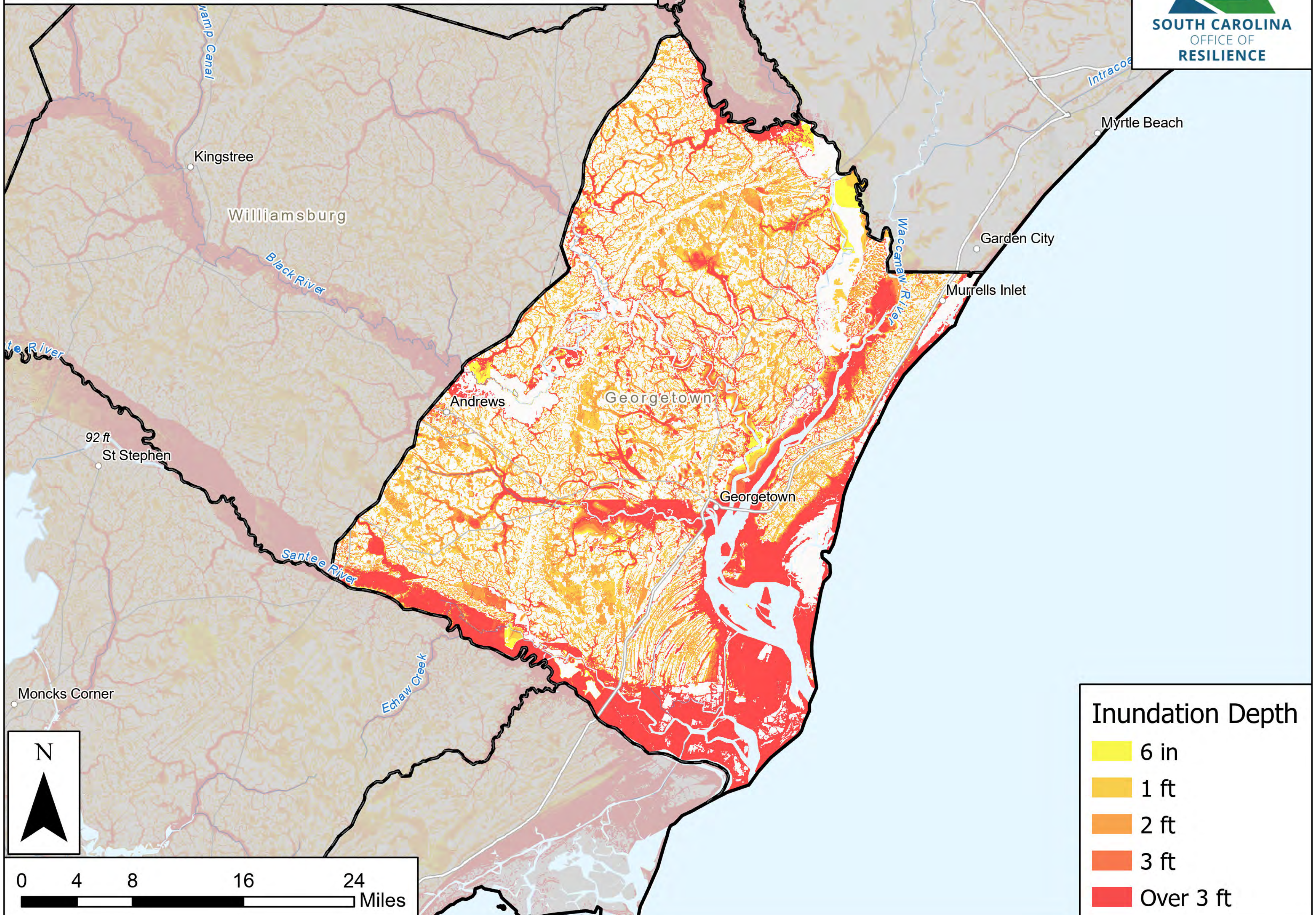
Fairfield County
2022 - 1% Annual Chance Flooding Event



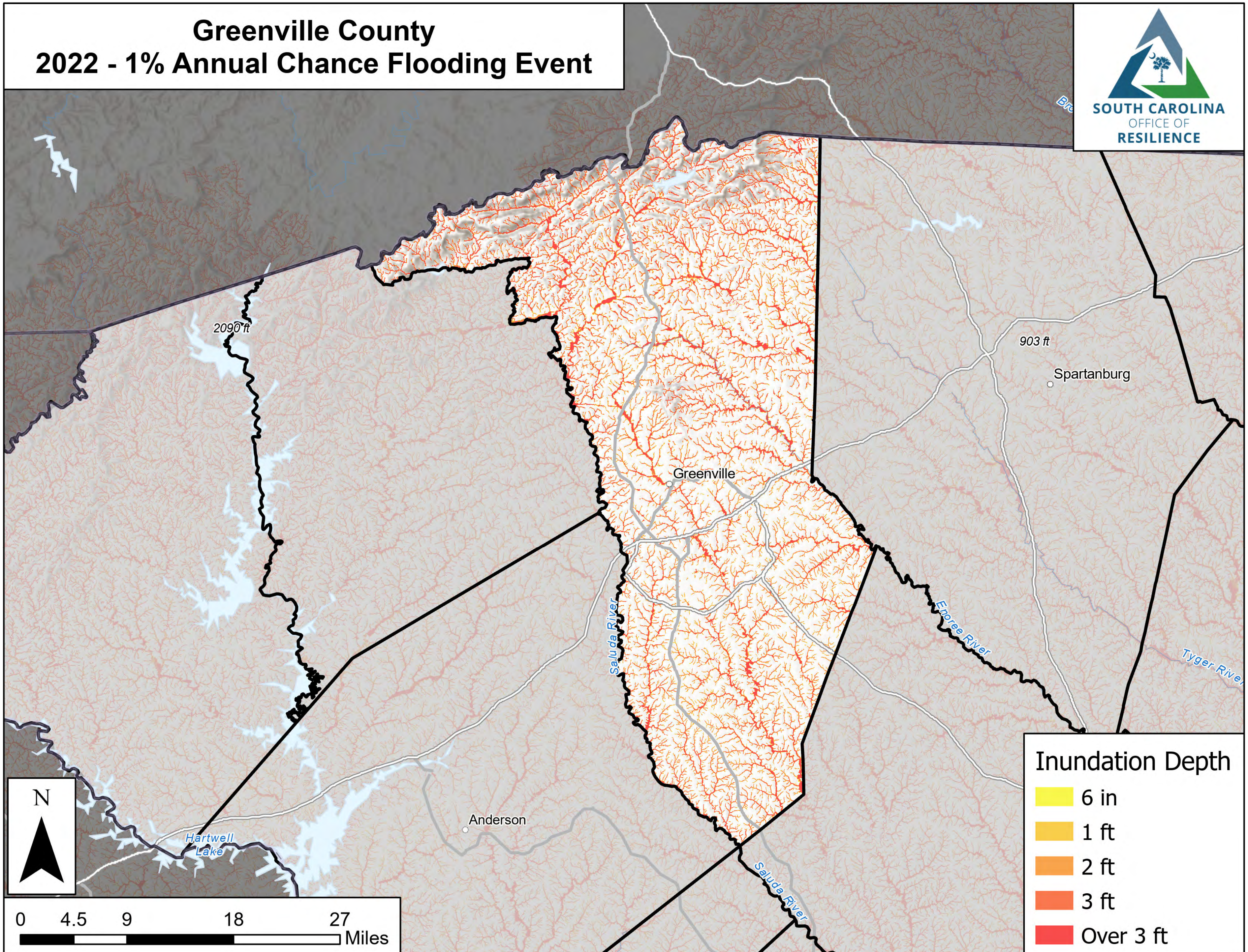
Florence County
2022 - 1% Annual Chance Flooding Event



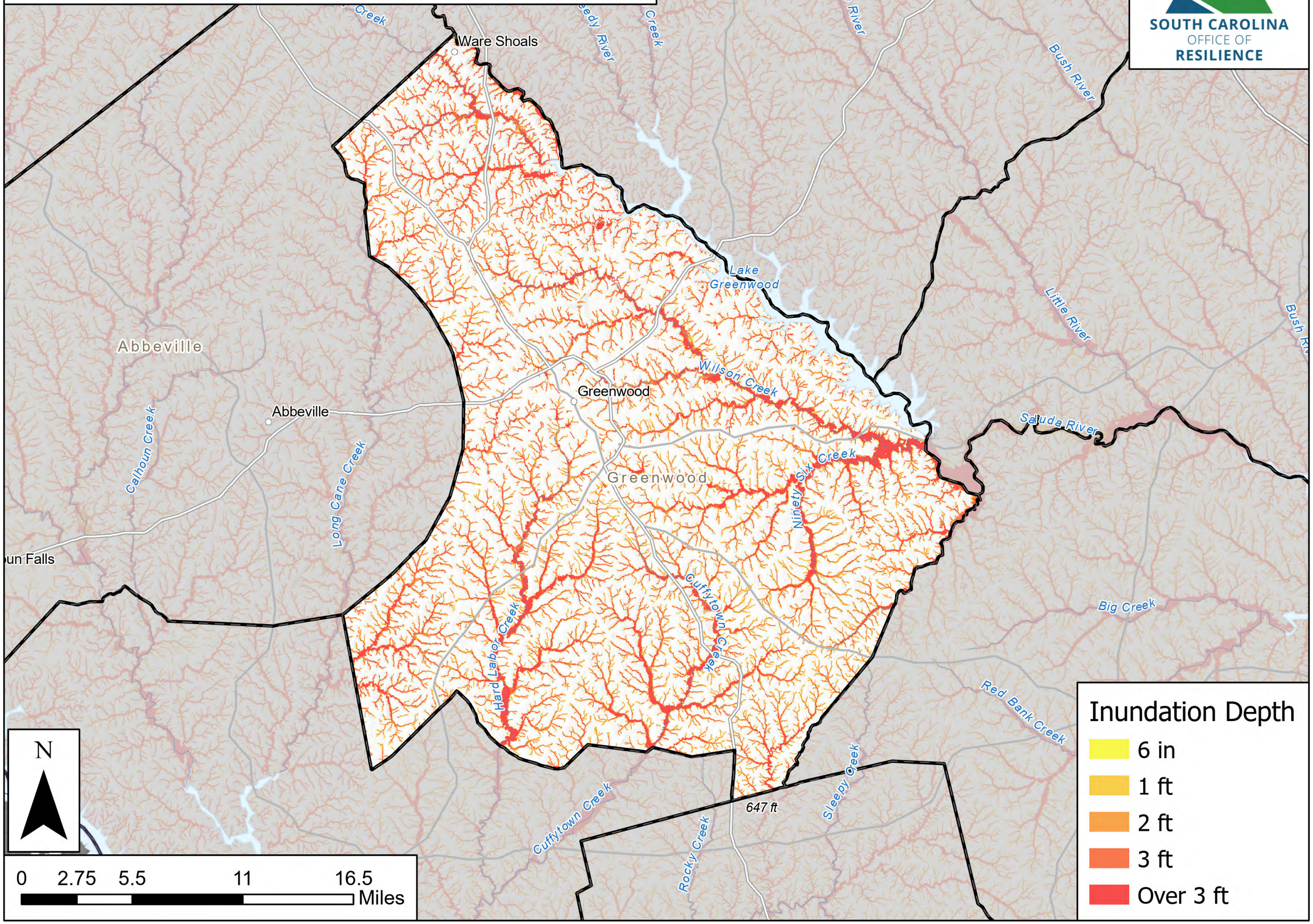
Georgetown County
2022 - 1% Annual Chance Flooding Event



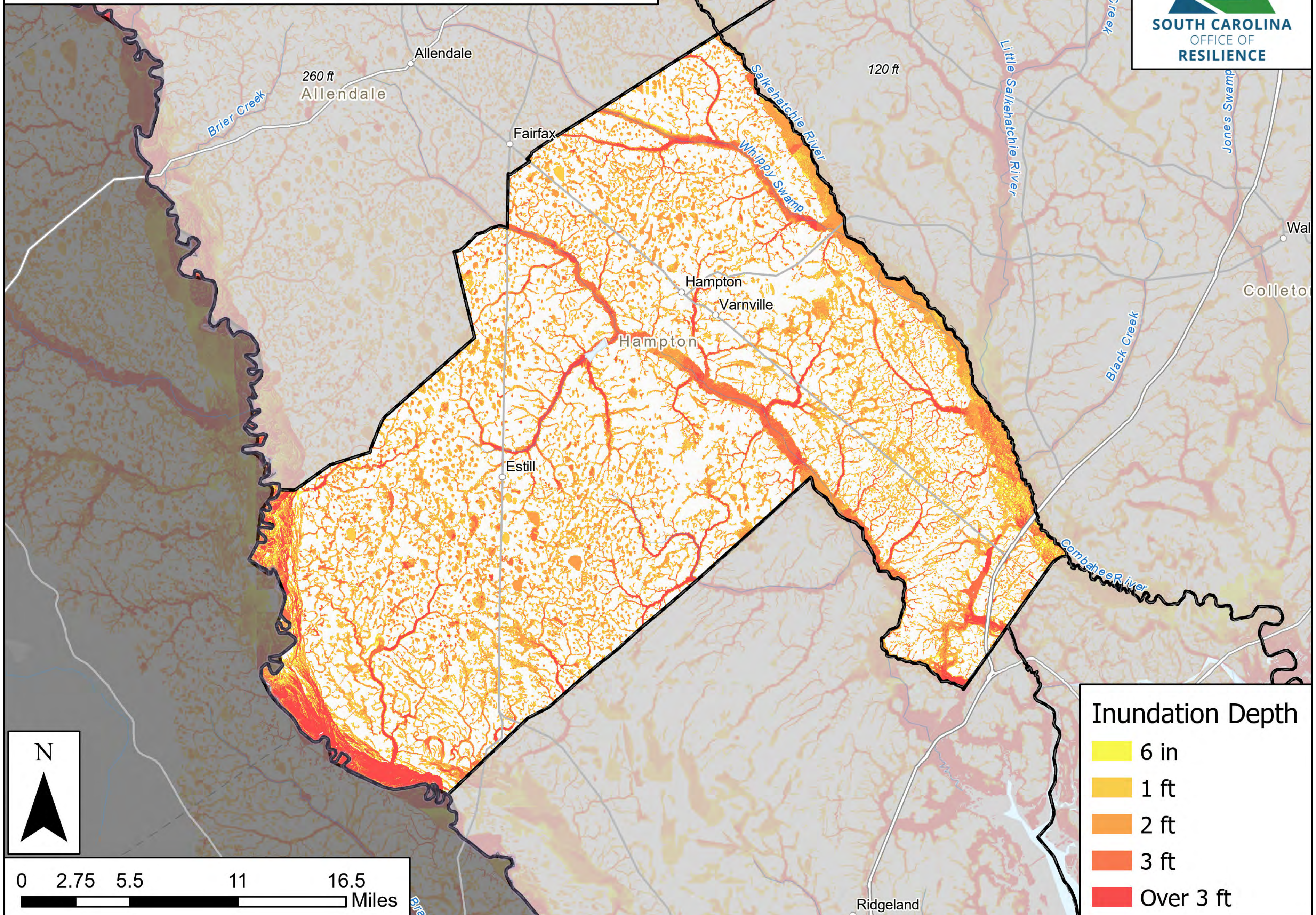
Greenville County
2022 - 1% Annual Chance Flooding Event



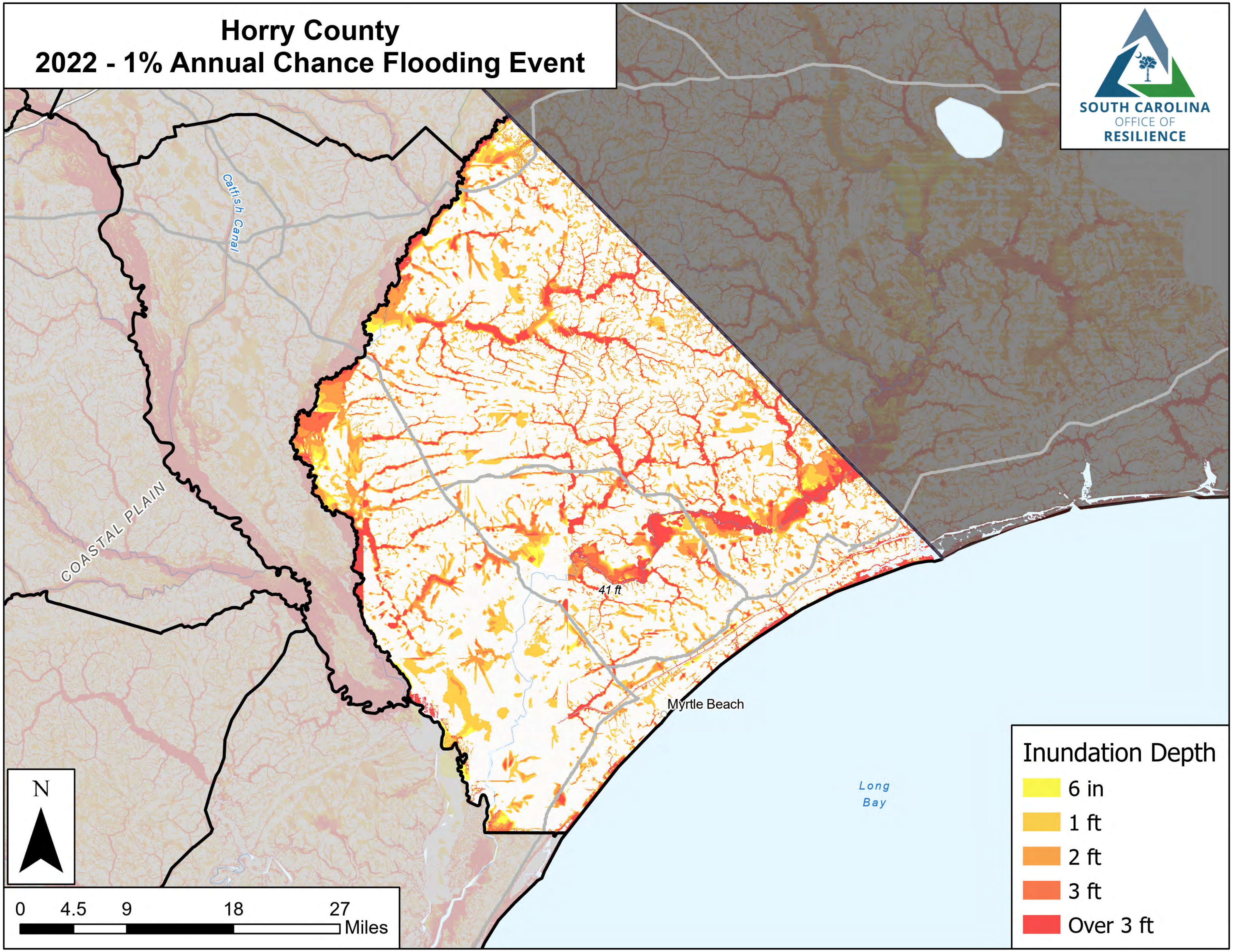
Greenwood County
2022 - 1% Annual Chance Flooding Event



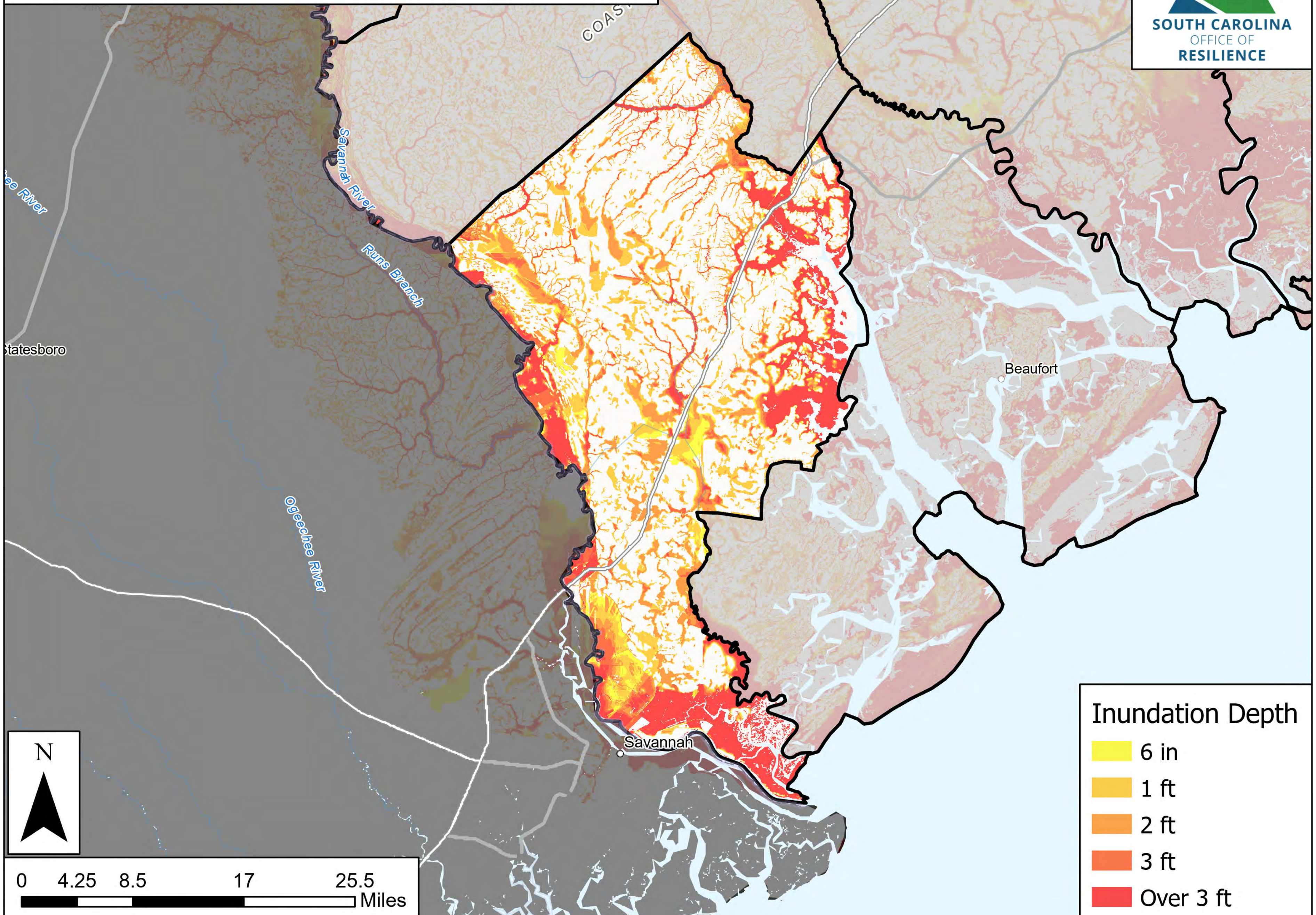
Hampton County
2022 - 1% Annual Chance Flooding Event



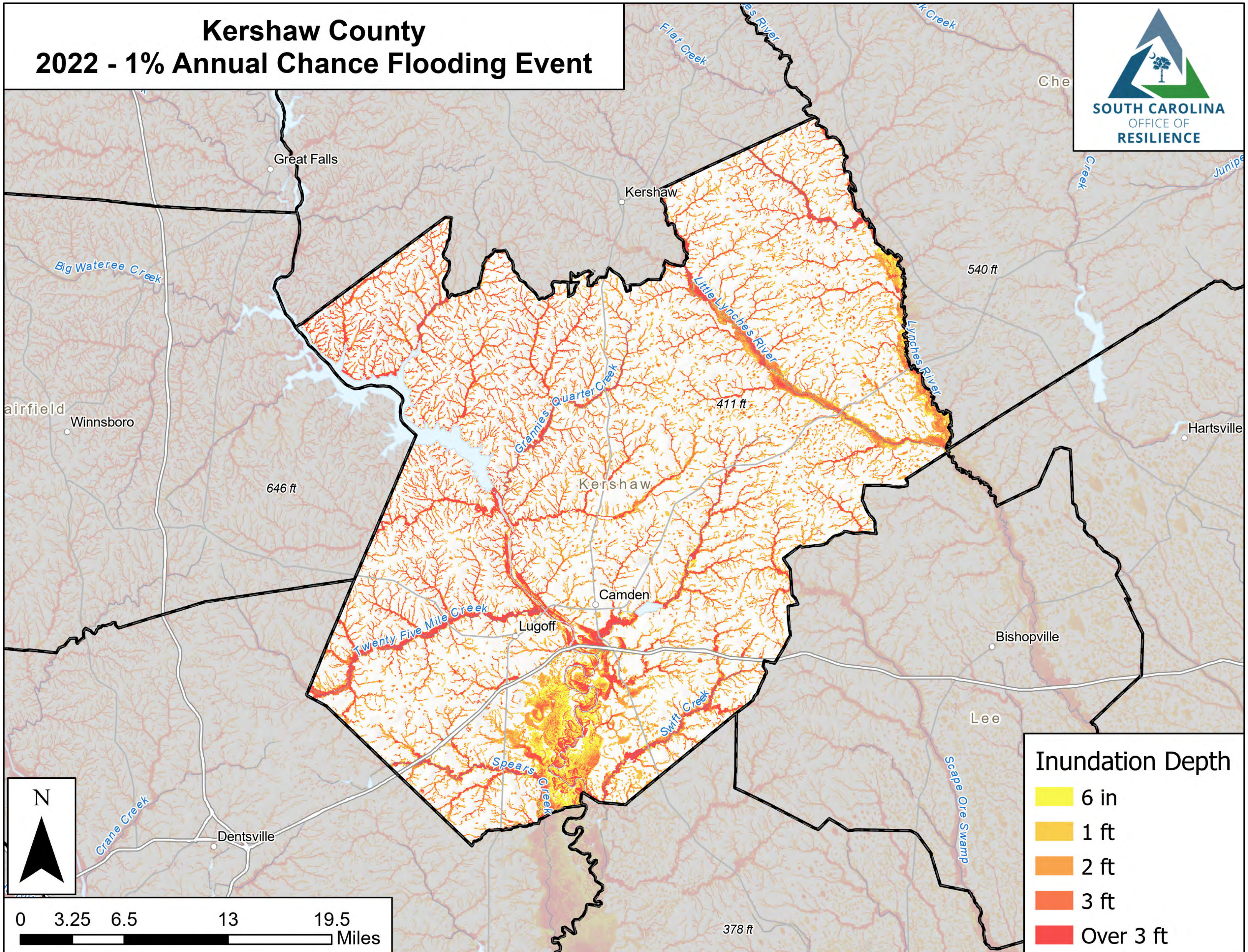
Horry County
2022 - 1% Annual Chance Flooding Event



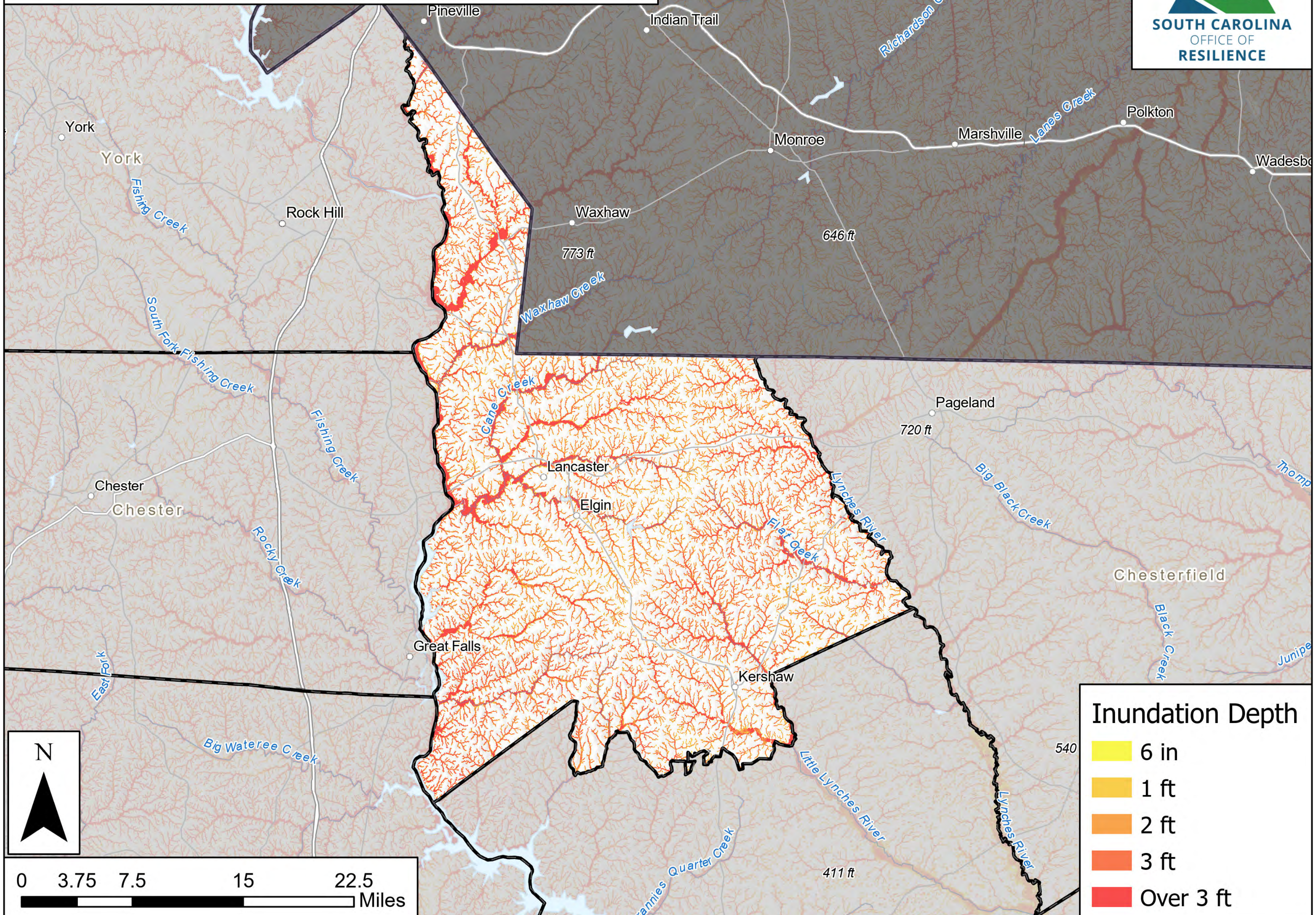
Jasper County
2022 - 1% Annual Chance Flooding Event



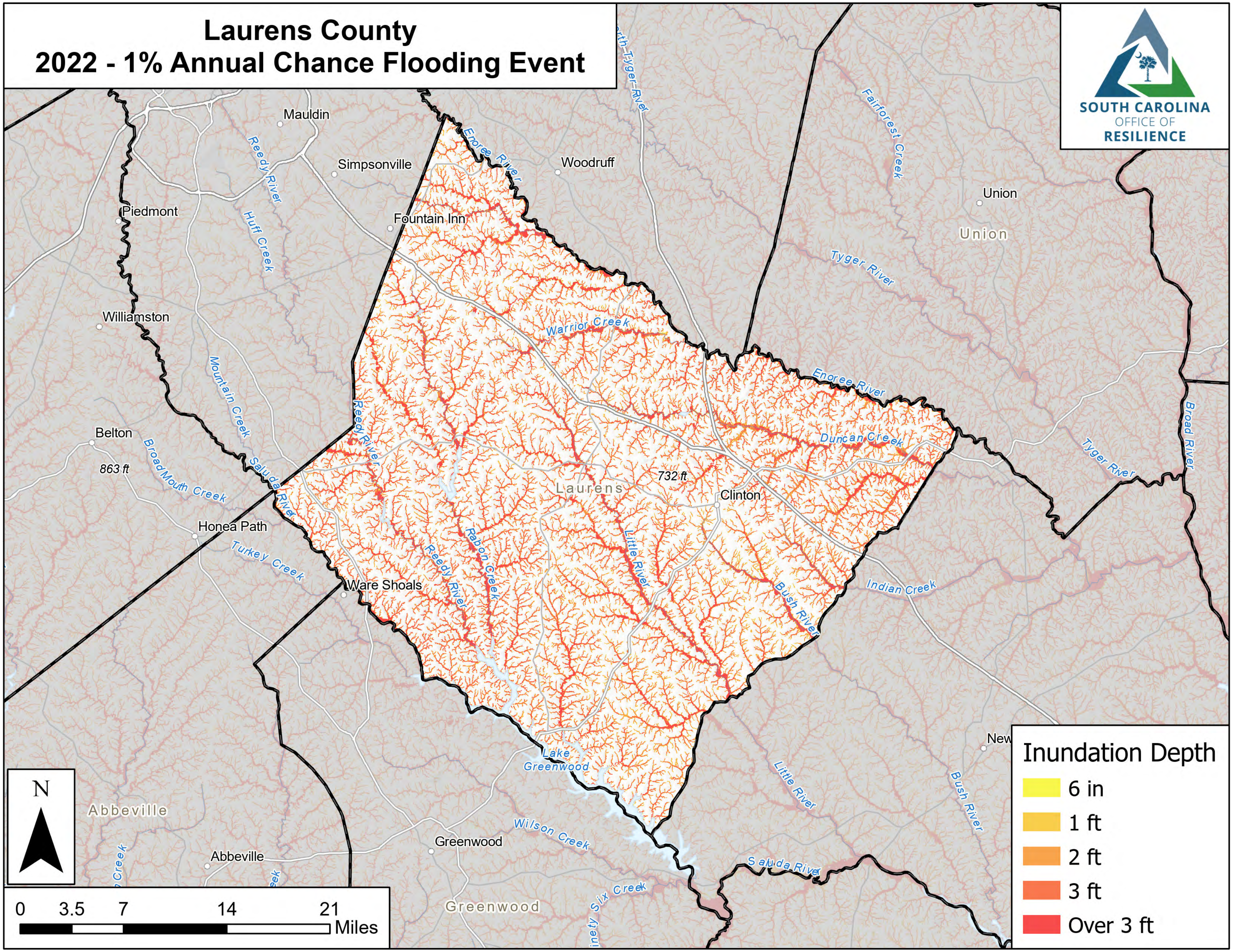
Kershaw County
2022 - 1% Annual Chance Flooding Event



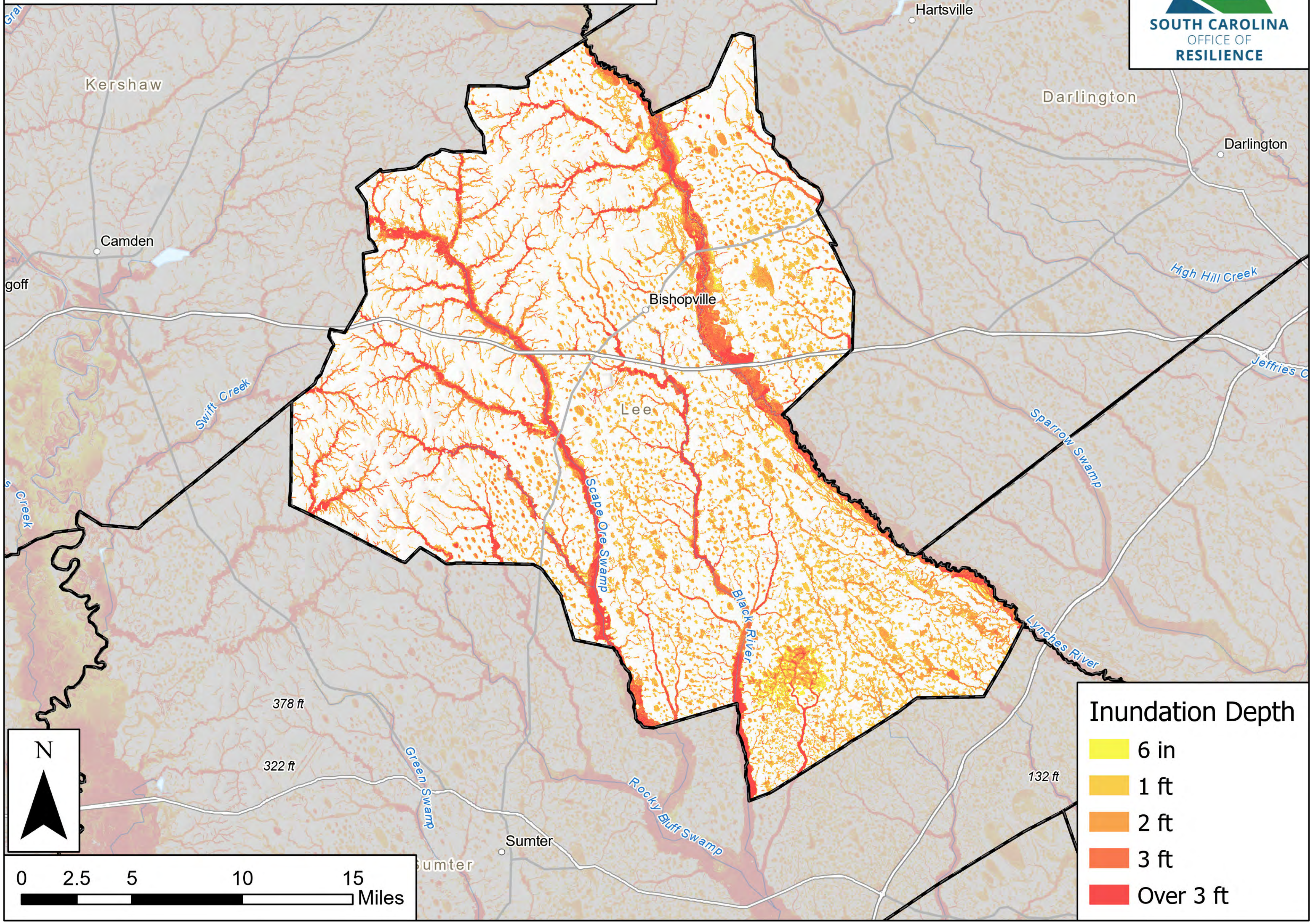
Lancaster County
2022 - 1% Annual Chance Flooding Event



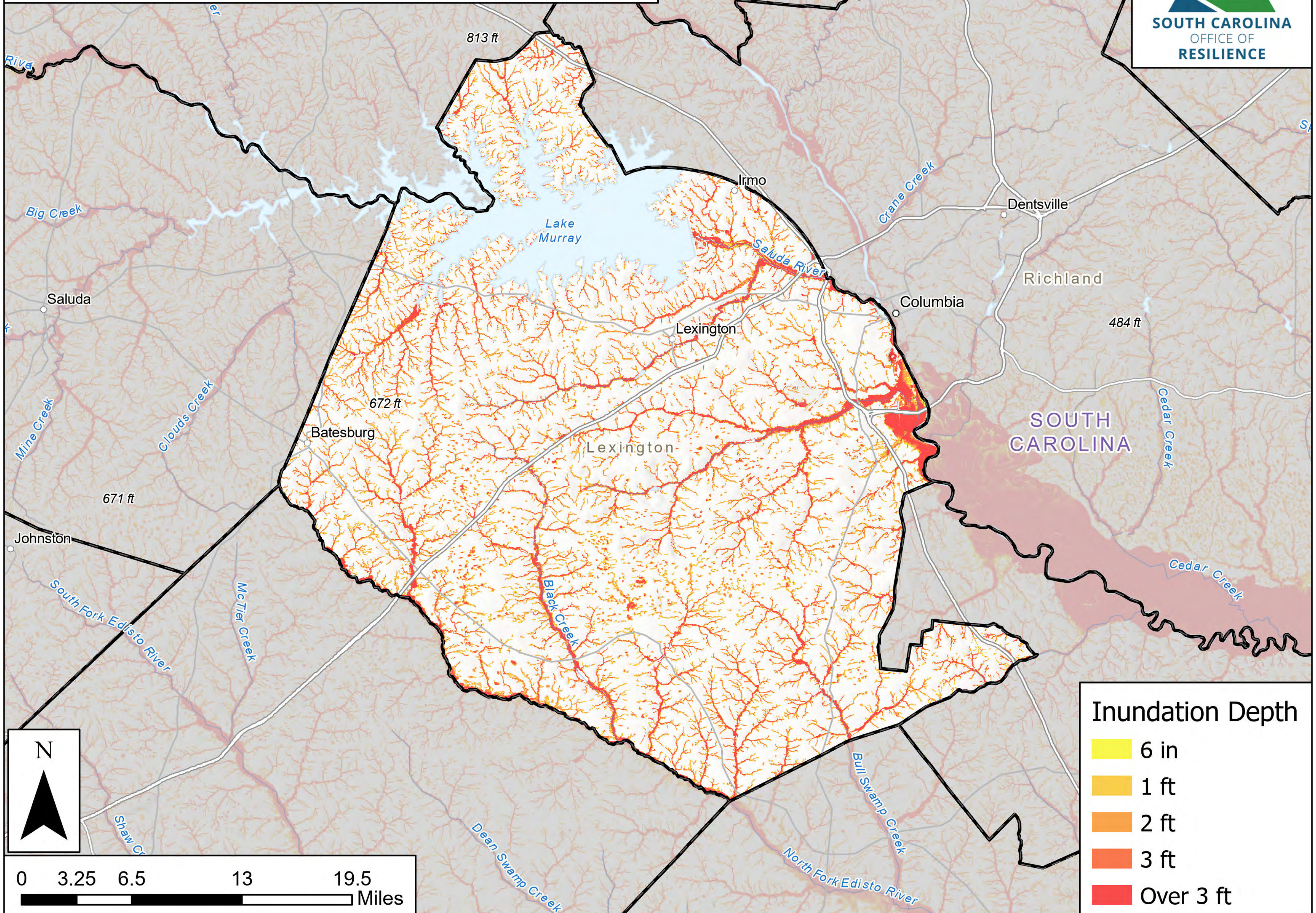
Laurens County
2022 - 1% Annual Chance Flooding Event



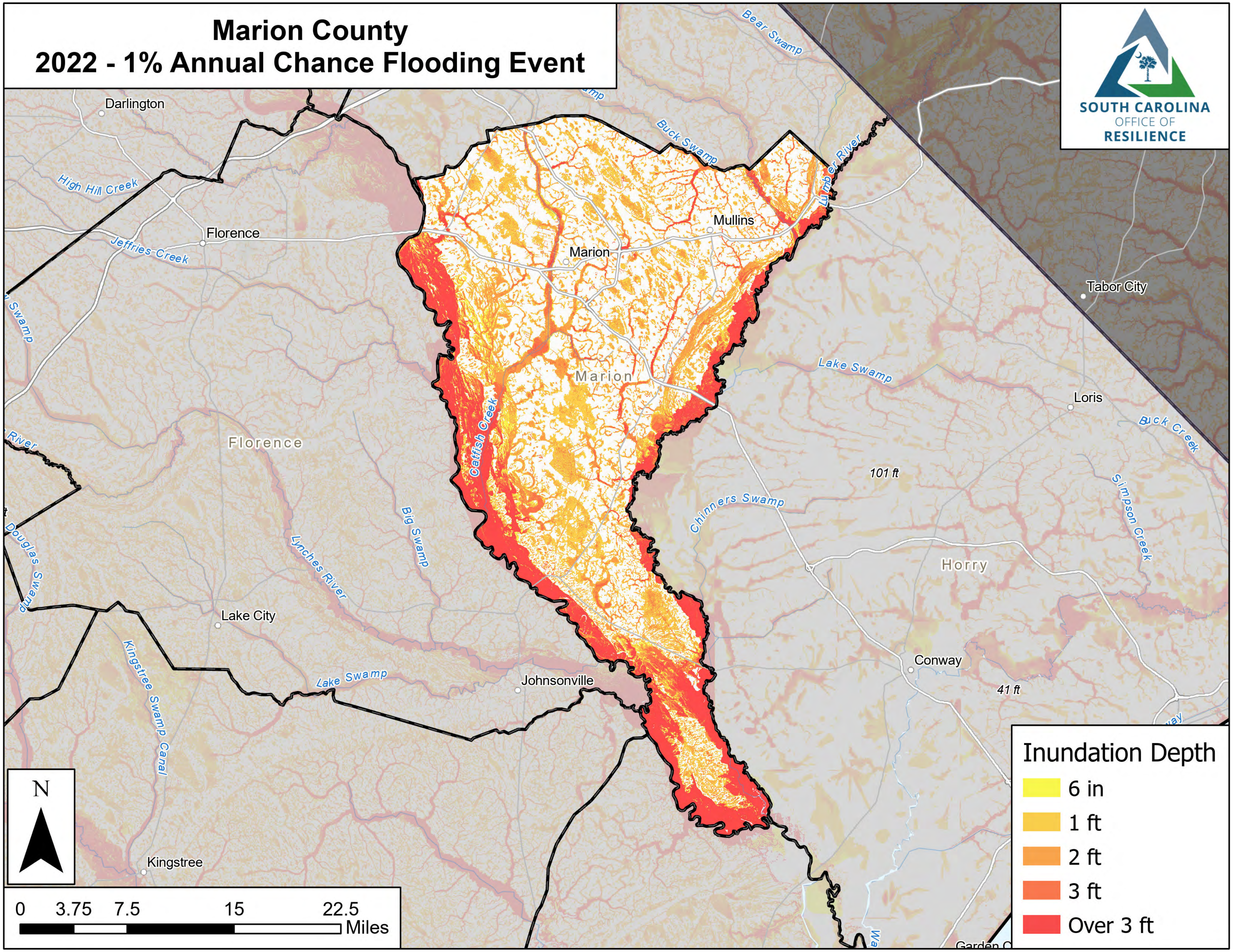
Lee County
2022 - 1% Annual Chance Flooding Event



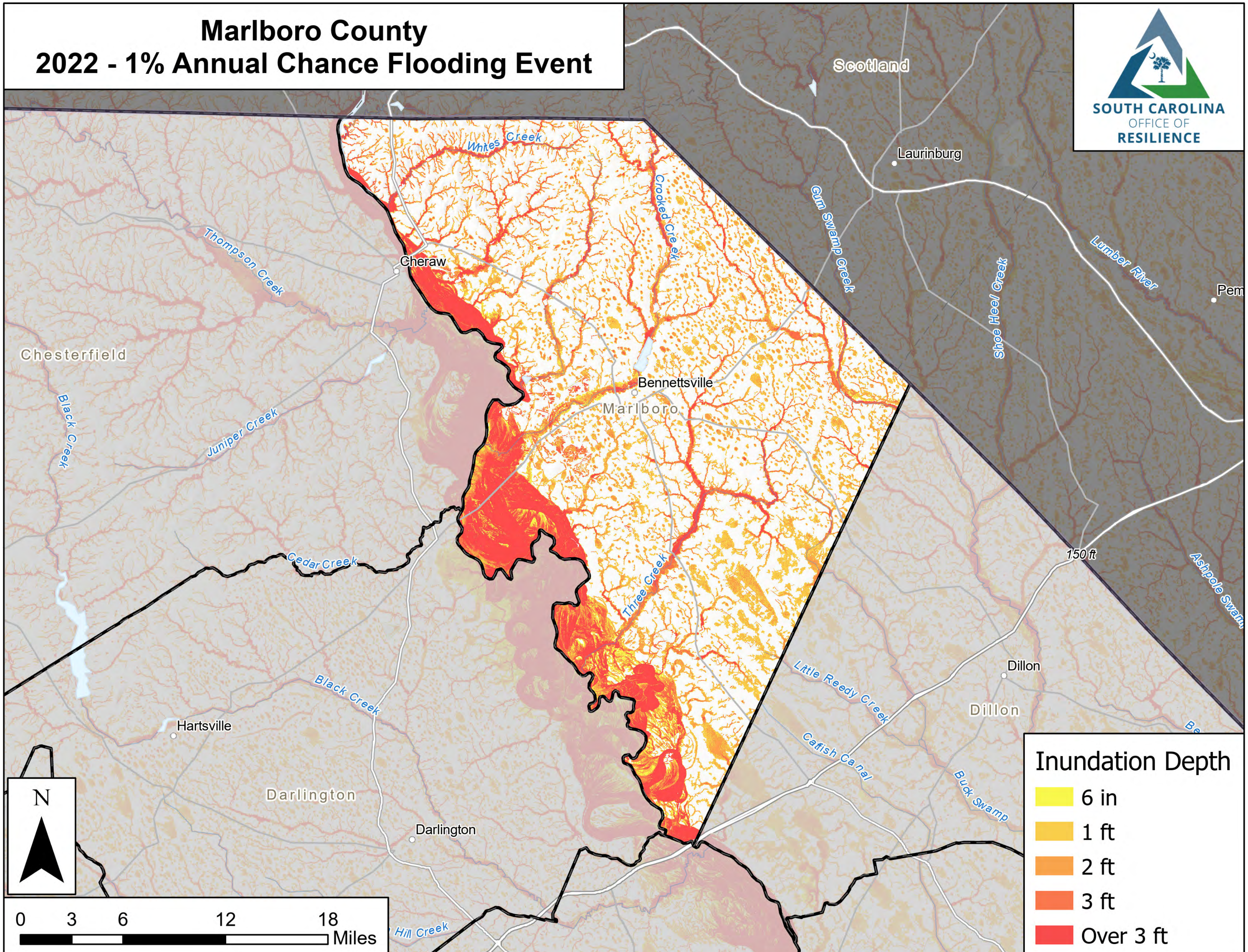
Lexington County
2022 - 1% Annual Chance Flooding Event



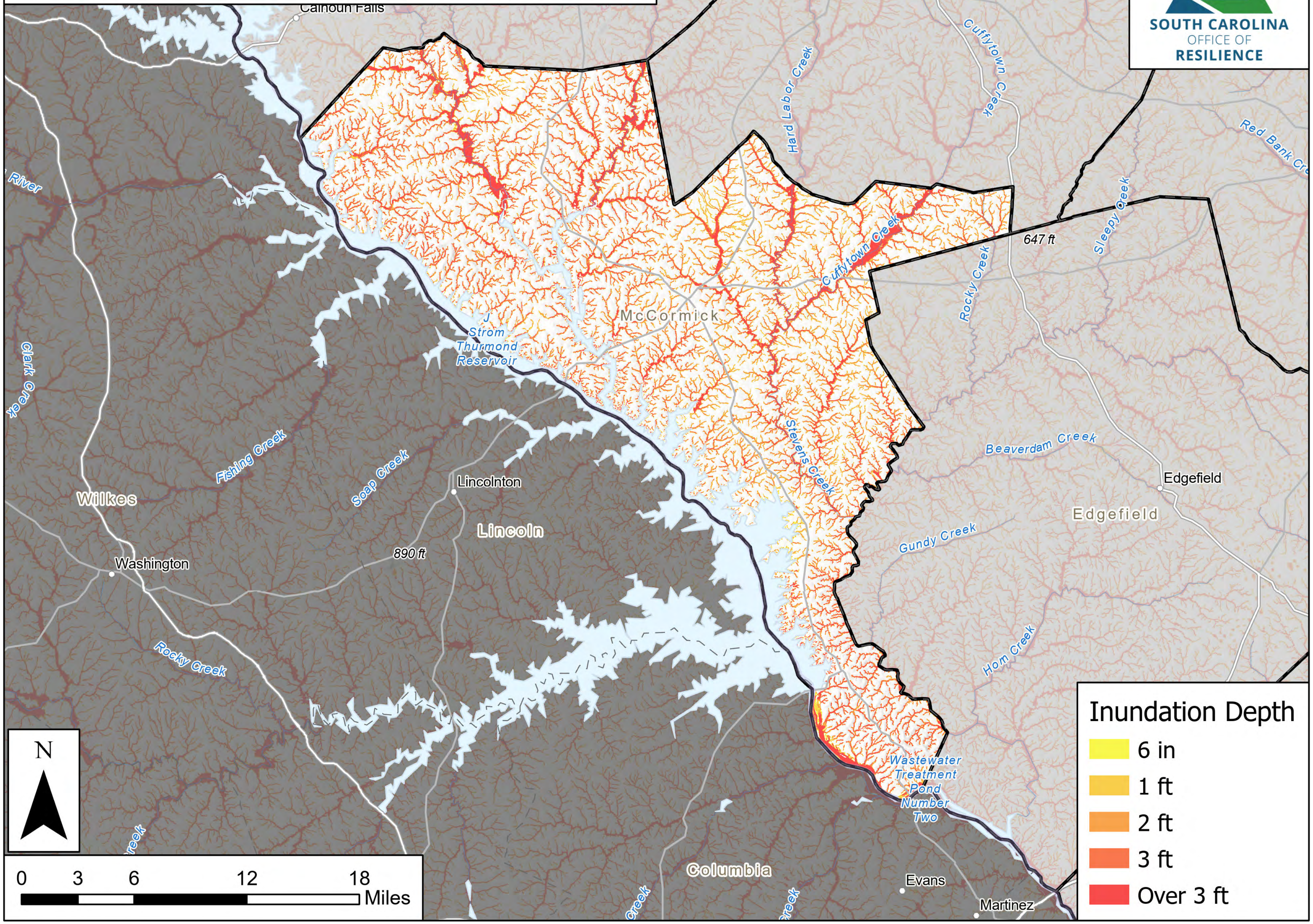
Marion County
2022 - 1% Annual Chance Flooding Event



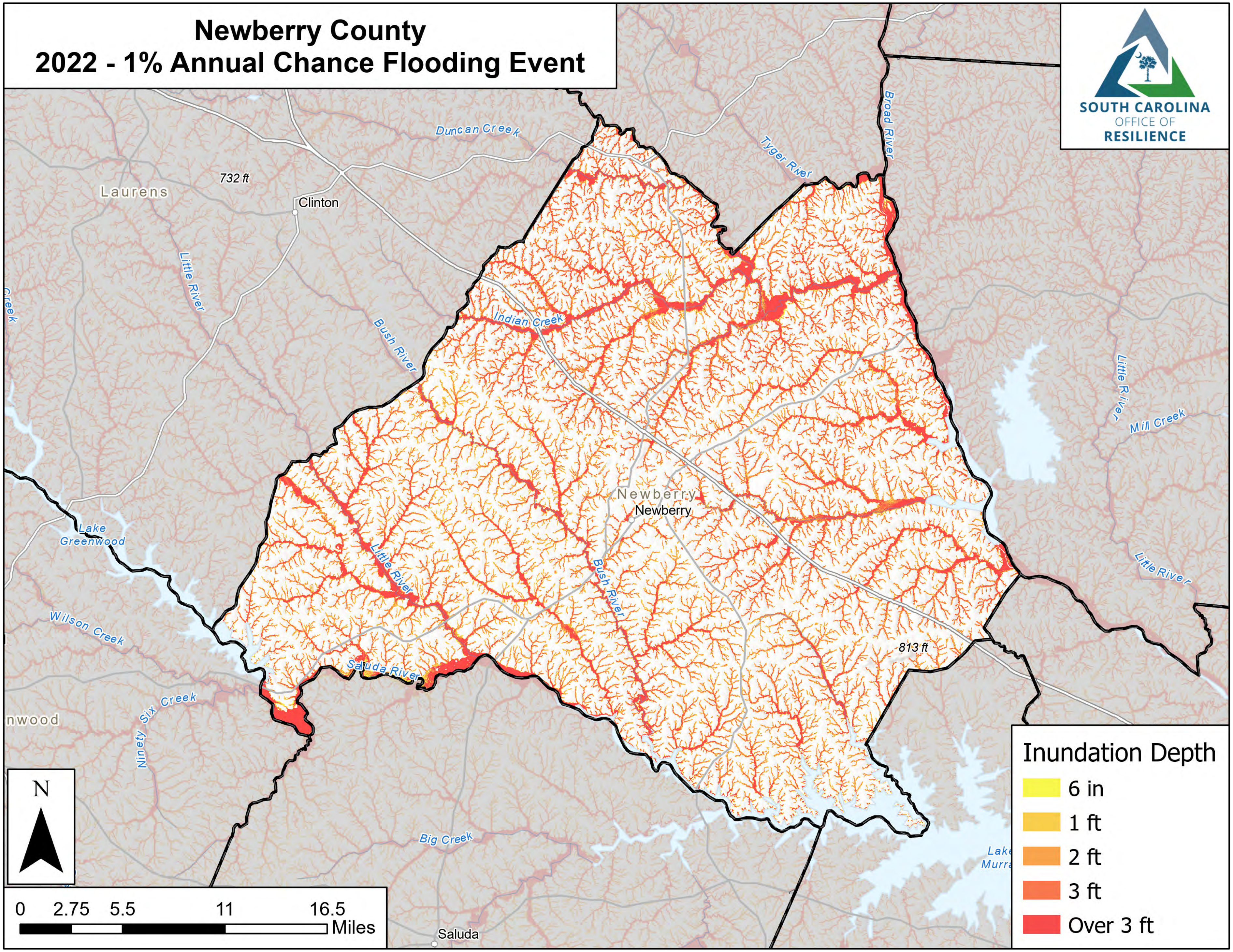
Marlboro County
2022 - 1% Annual Chance Flooding Event



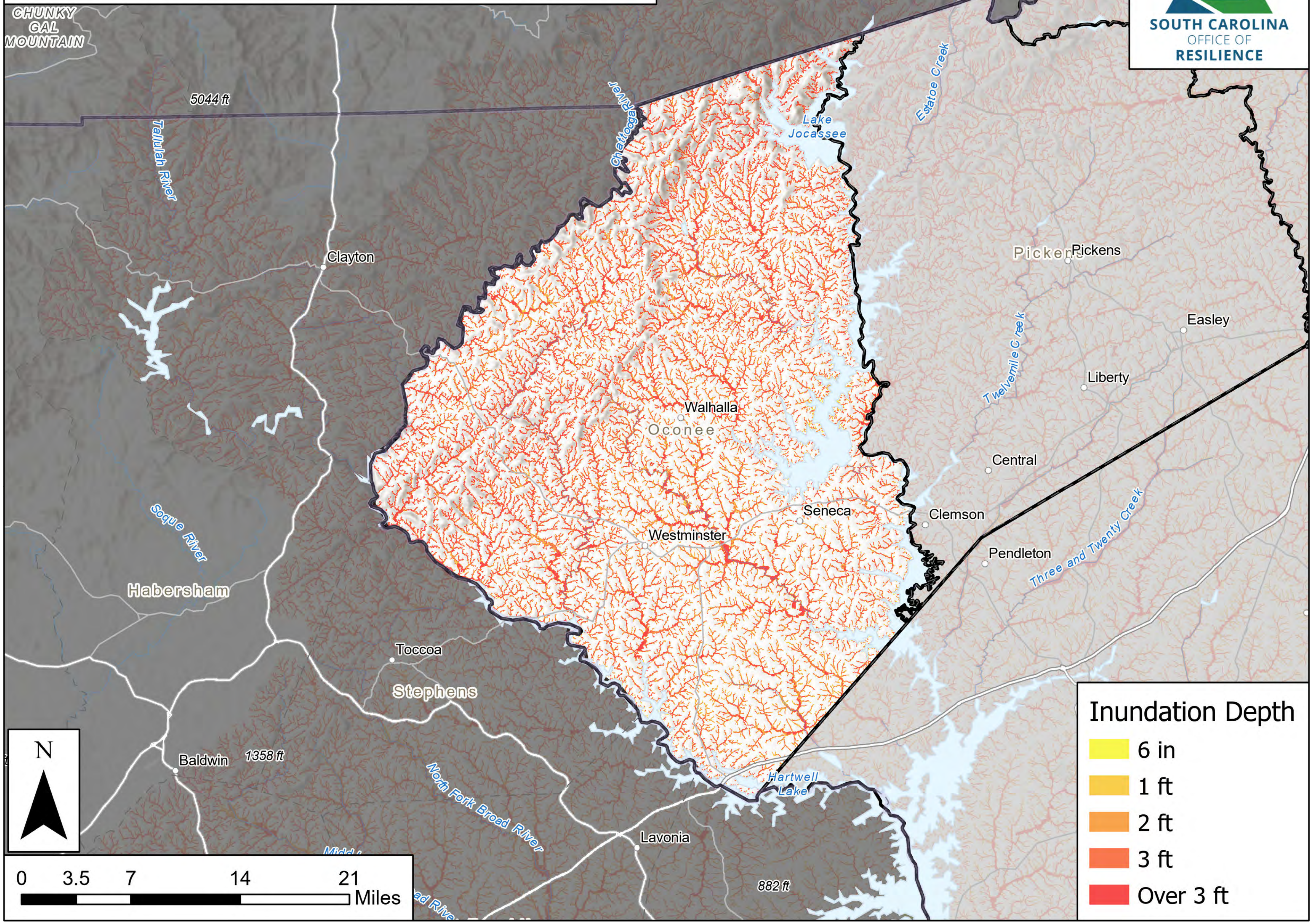
McCormick County
2022 - 1% Annual Chance Flooding Event



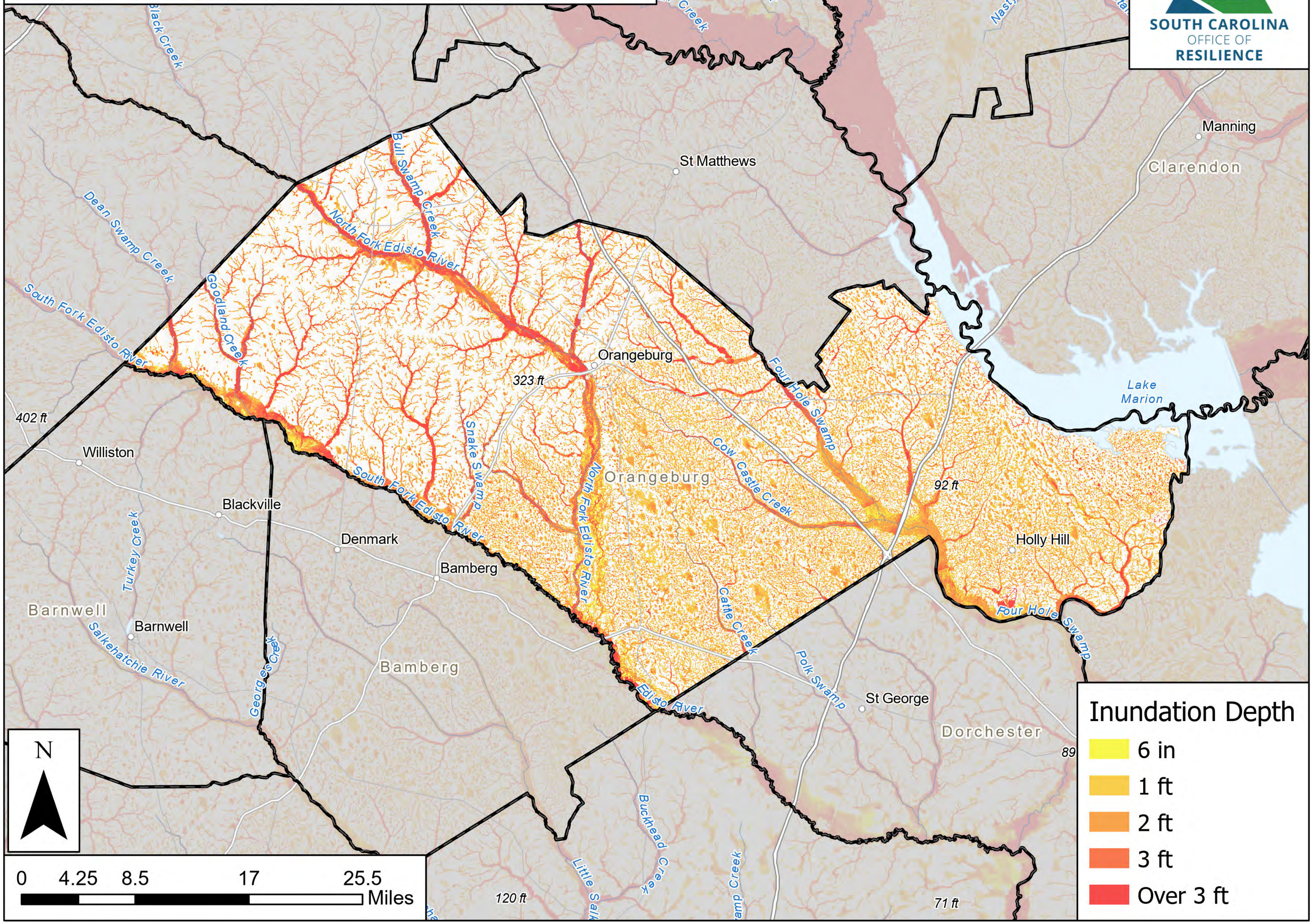
Newberry County
2022 - 1% Annual Chance Flooding Event



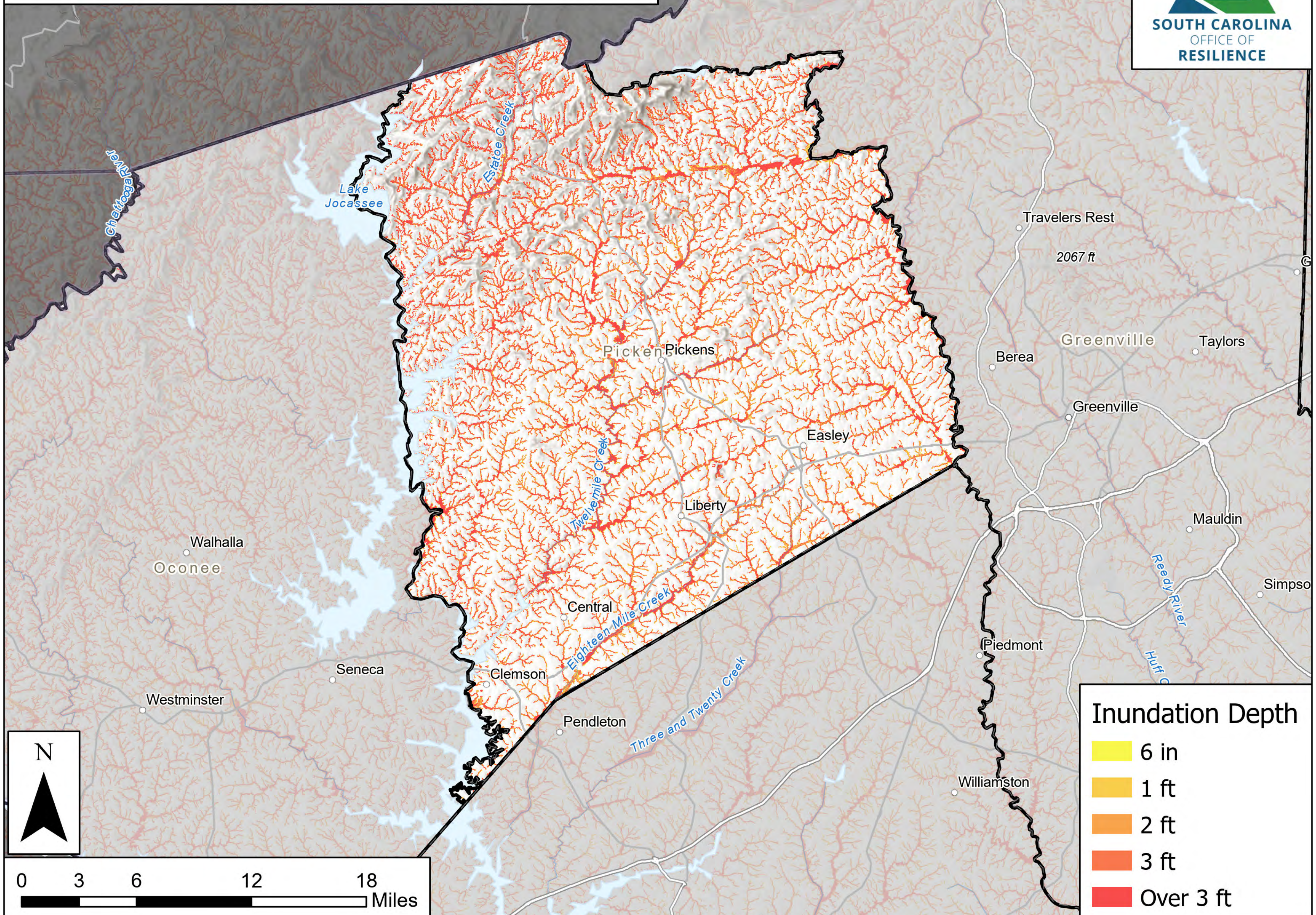
Oconee County
2022 - 1% Annual Chance Flooding Event



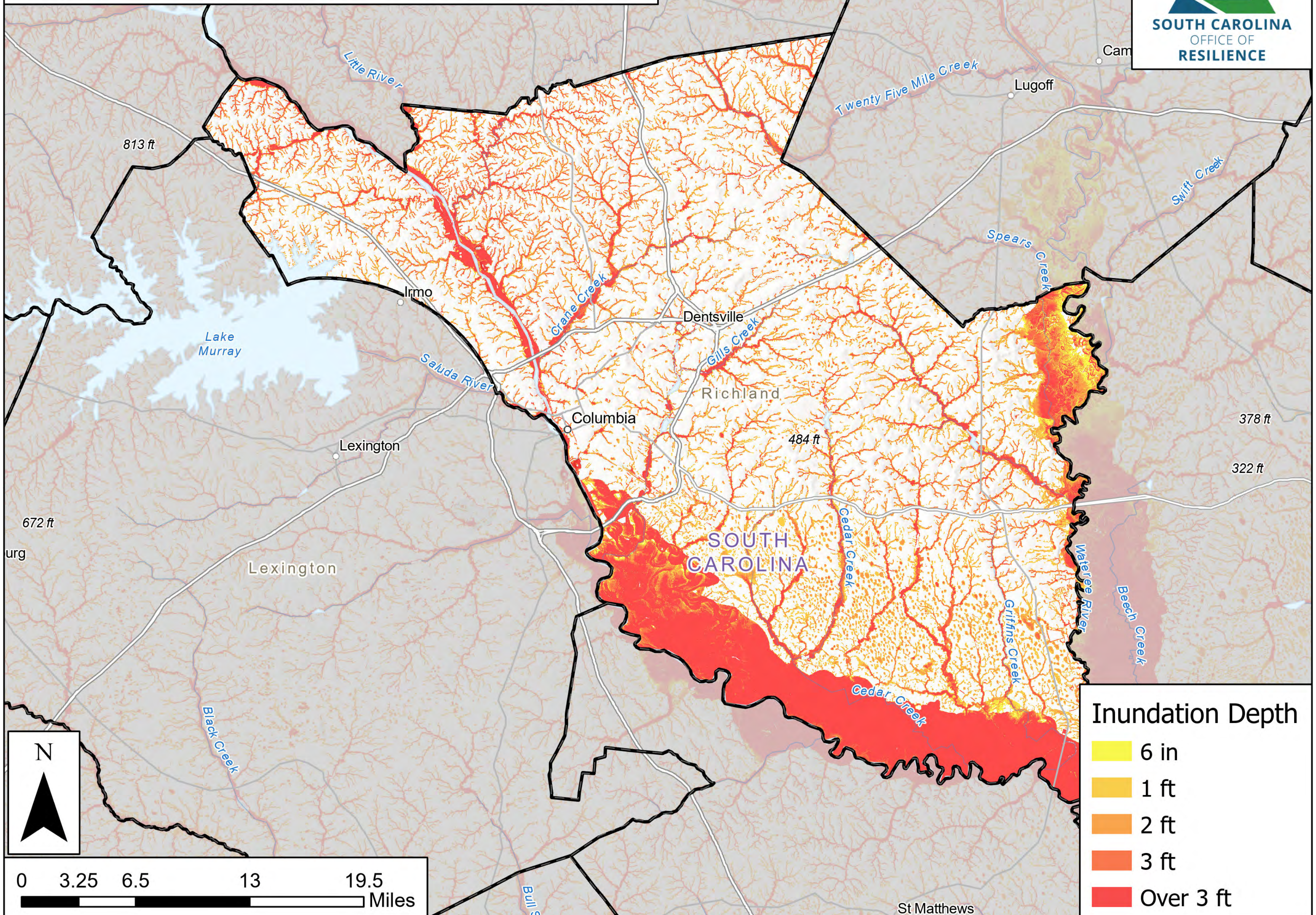
Orangeburg County
2022 - 1% Annual Chance Flooding Event



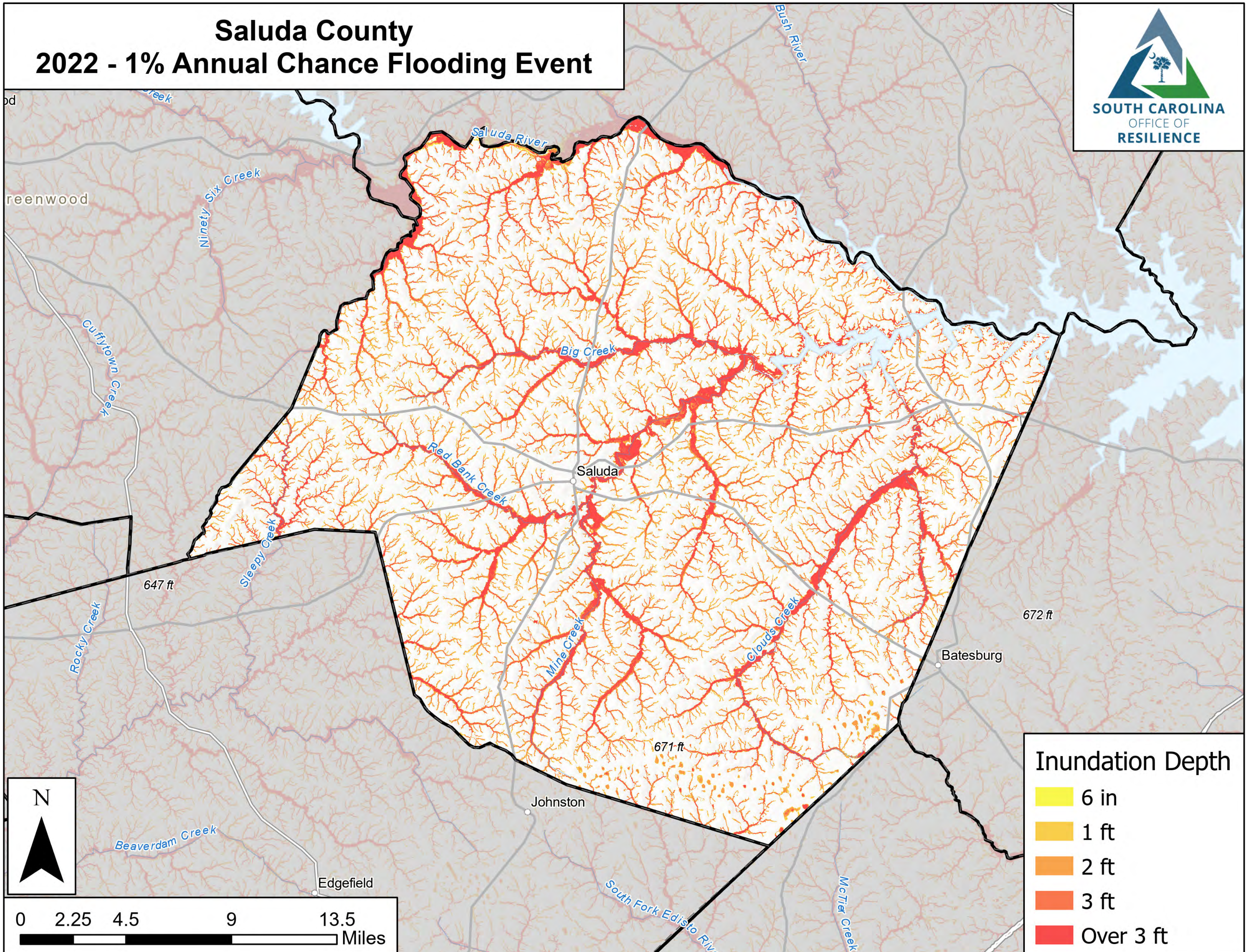
Pickens County
2022 - 1% Annual Chance Flooding Event



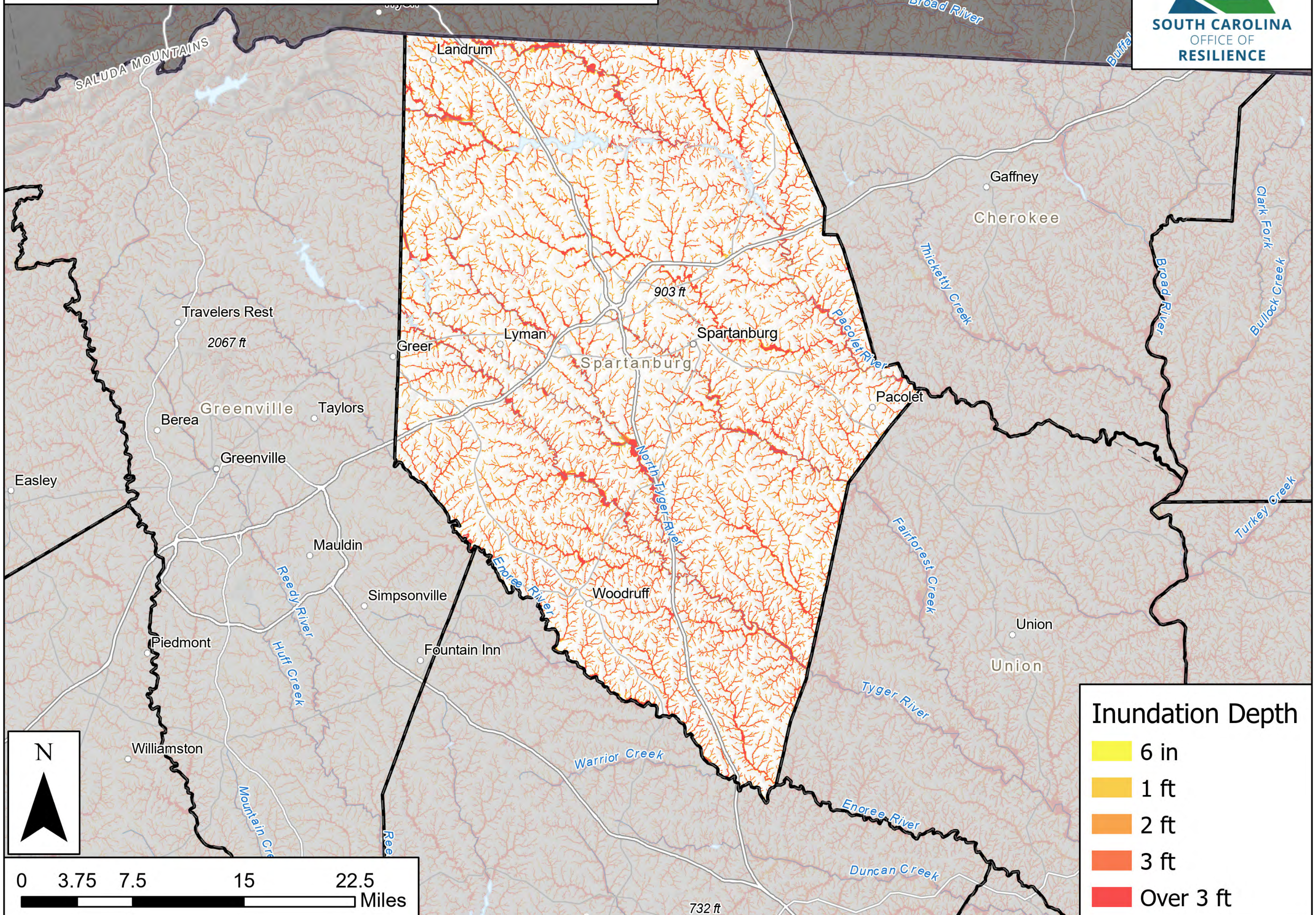
Richland County
2022 - 1% Annual Chance Flooding Event



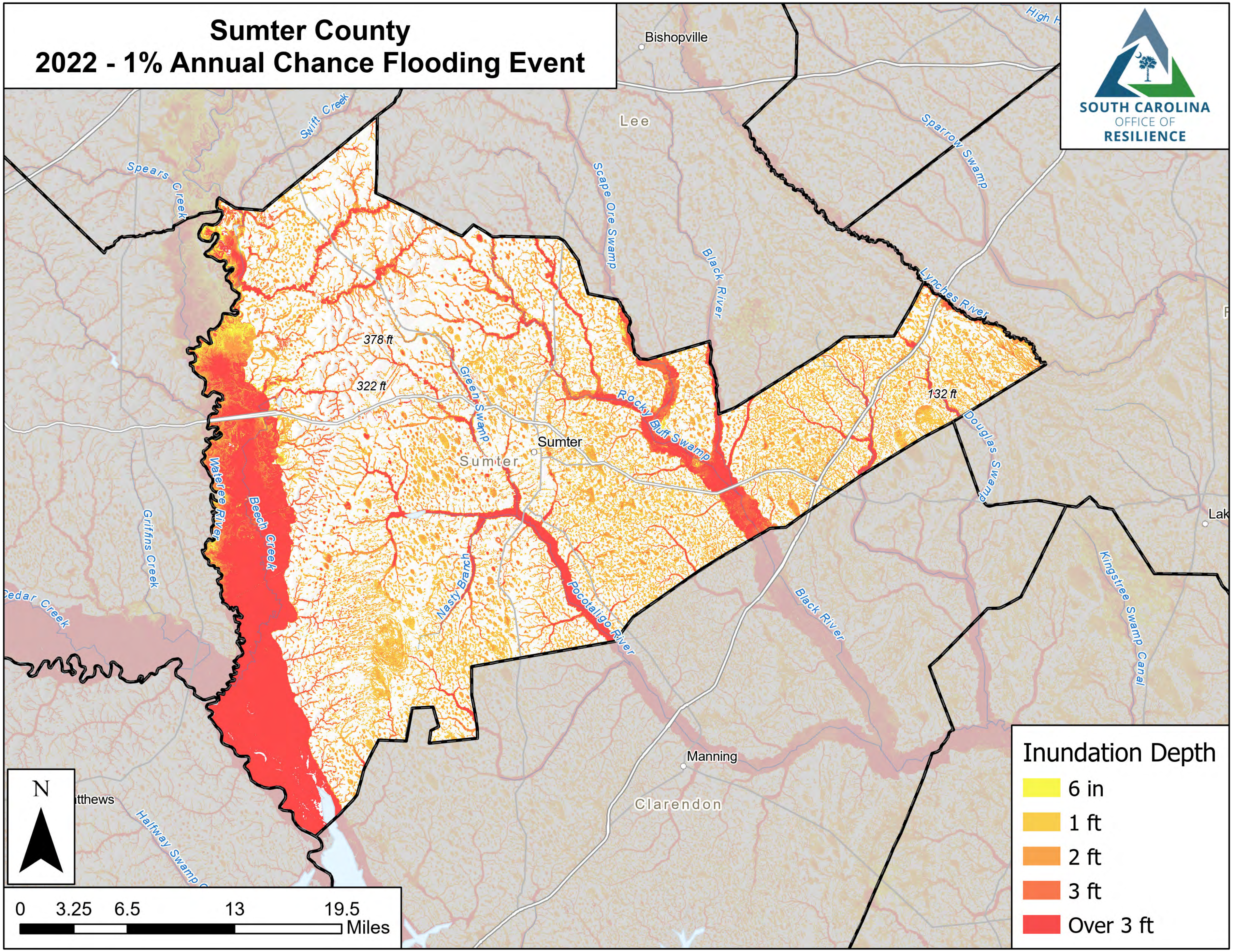
Saluda County
2022 - 1% Annual Chance Flooding Event



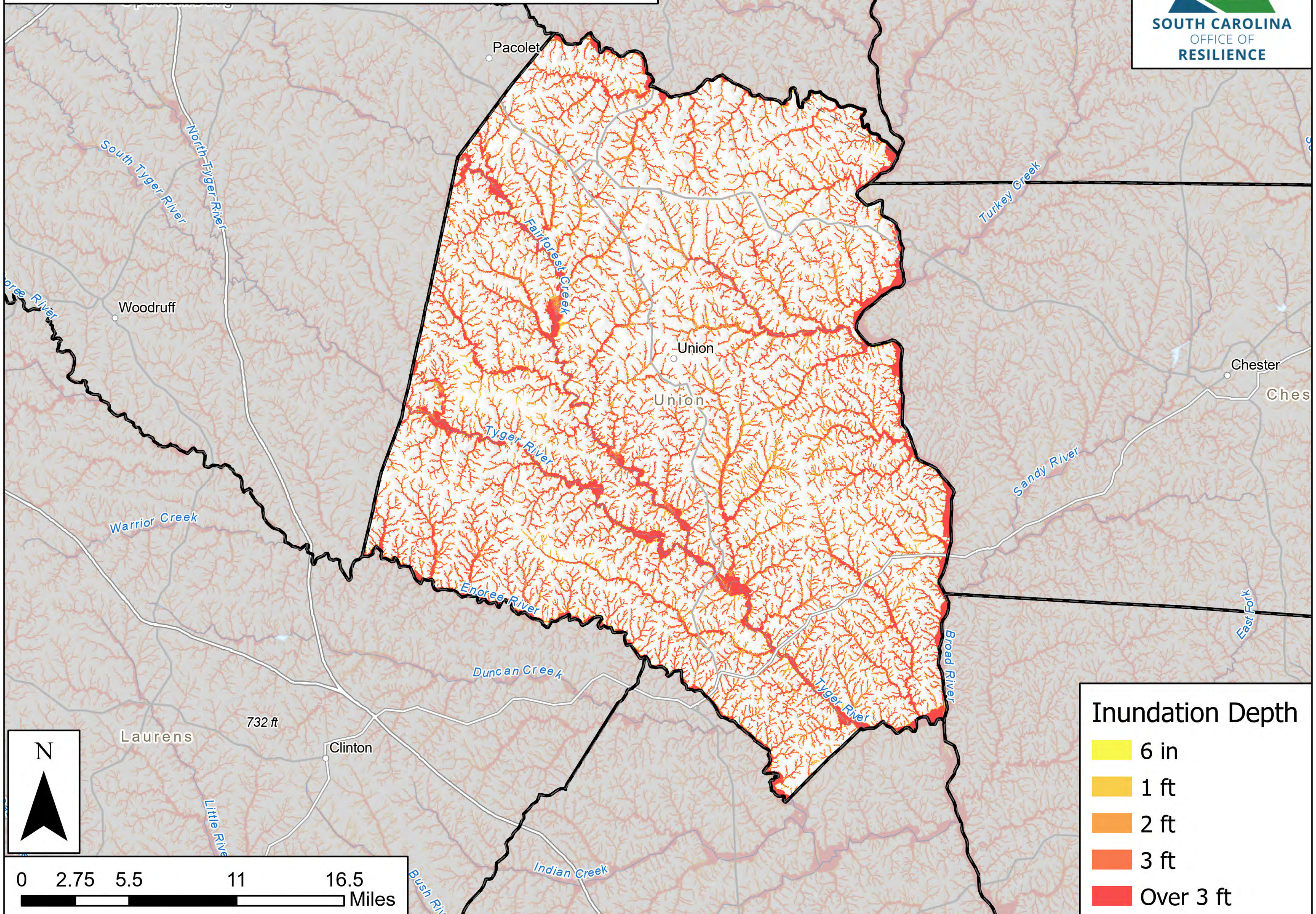
Spartanburg County
2022 - 1% Annual Chance Flooding Event



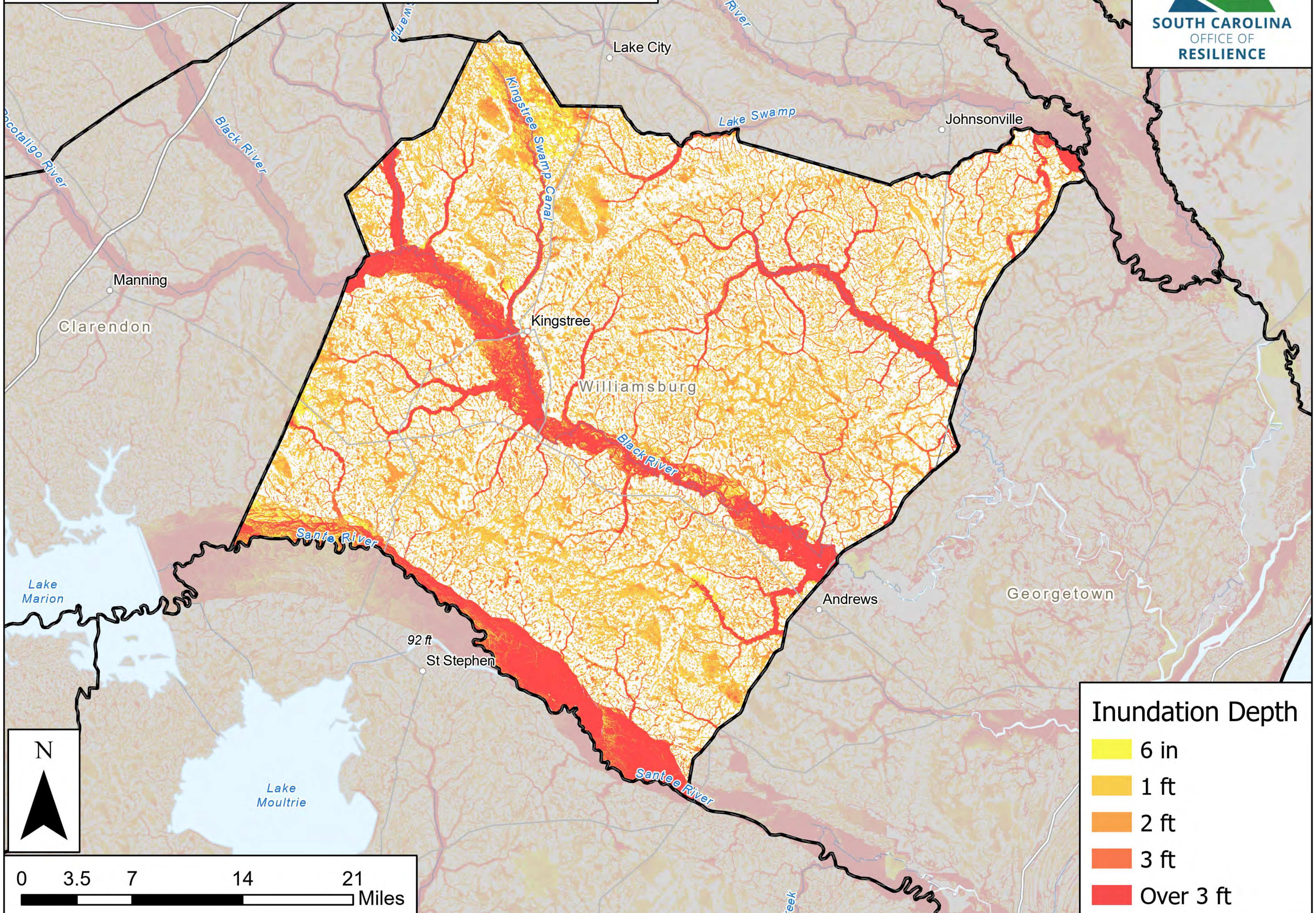
Sumter County
2022 - 1% Annual Chance Flooding Event

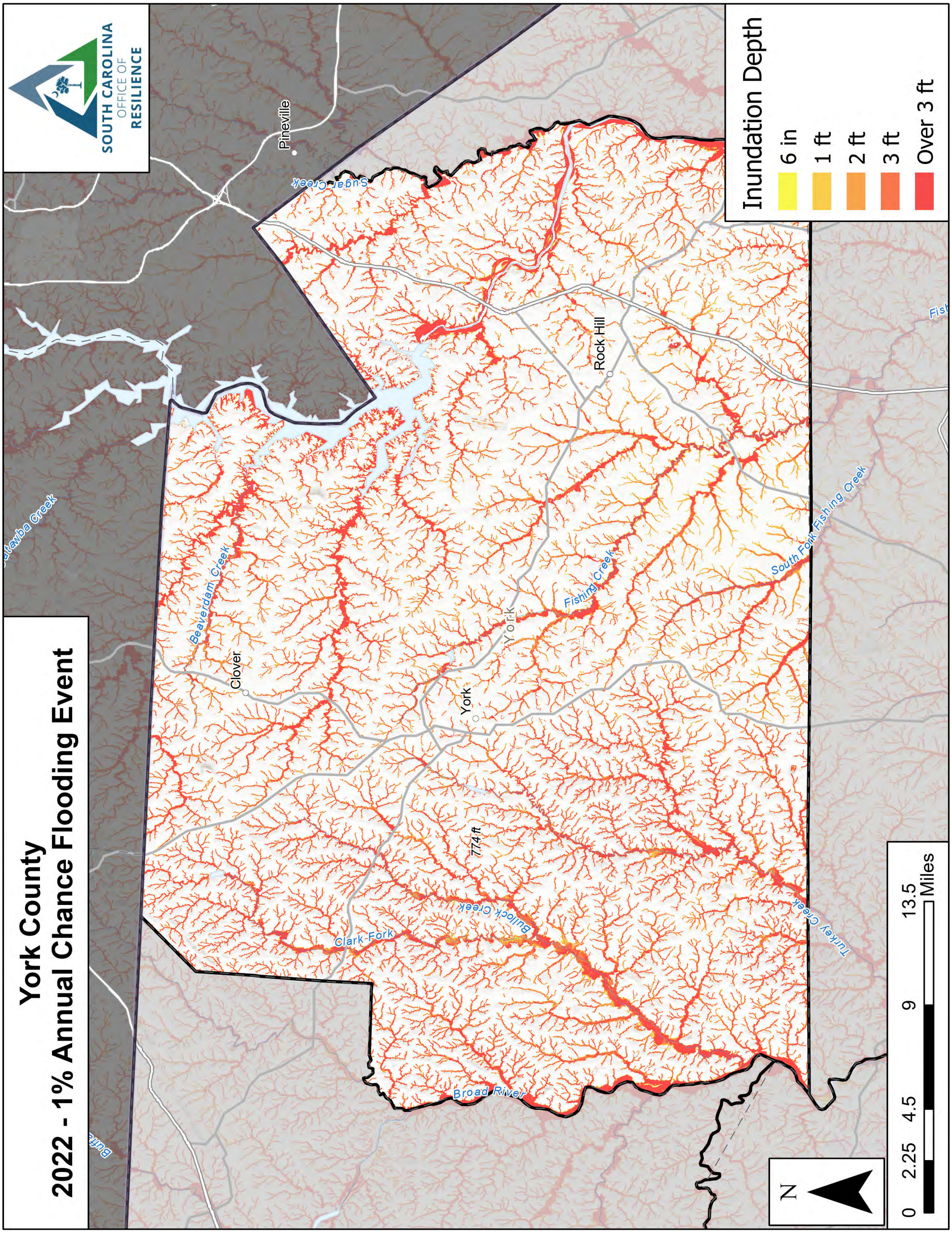


Union County
2022 - 1% Annual Chance Flooding Event



Williamsburg County
2022 - 1% Annual Chance Flooding Event




York County
2022 - 1% Annual Chance Flooding Event
SOUTH CAROLINA
OFFICE OF
RESILIENCE
Inundation Depth
6 in
1 ft
2 ft
3 ft
Over 3 ft
Pineville
Sugar Creek
Rock Hill
Catawba Creek
Beaverdam Creek
Clover
York
Fishing Creek
South Fork Fishing Creek
774 ft
Bullock Creek
Clark Fork
Turkey Creek
Broad River
N
0 2.25 4.5 9 13.5
Miles

APPENDIX F:
GUIDANCE FOR COMPREHENSIVE PLANS

Guidance for Resilience in Comprehensive Plans

January 2022

The **Comprehensive Planning Enabling Act (SC Code Section 6-29-510)** was amended by the Disaster Relief and Resilience Act to add a required resilience element. SCOR has developed a working definition of resilience (right). This working definition should be kept in mind when meeting the Section 6-29-510(D) comprehensive planning resilience requirements below:

1 A resilience element that considers the impacts of flooding, high water, and natural hazards on individuals, communities, institutions, businesses, economic development, public infrastructure and facilities, and public health, safety, and welfare

2 Planning that promotes resilient planning, design, and development

3 Element shall be developed in coordination with all preceding elements in SC Code Section 6-29-510 and integrated into the goals and strategies of each of the other plan elements

4 The local comprehensive planning entity must undertake an inventory of existing resilience conditions

The words "undertake an inventory of resilience conditions" should be taken in their plain and ordinary meaning which would involve an itemization or listing of present conditions of the things or systems that enable a community to anticipate, absorb, recover, and thrive when presented with environmental change and natural hazards. As a starting point, SCOR suggests that communities begin by looking at the 7 ***FEMA community lifelines*** *as well as* ***Baseline Resilience Indicators for Communities (BRIC)*** *which provides resilience characteristics and scores for all South Carolina counties (University of South Carolina, n.d.)*

Resilience: The ability of communities, economies, and ecosystems within South Carolina to anticipate, absorb, recover, and thrive when presented with environmental change and natural hazards.

Note: The working definition will not be finalized until the Strategic Statewide Resilience and Risk Reduction Plan is submitted to the General Assembly.

5 Planning which is coordinated with adjacent and relevant jurisdictions and agencies.

For the purposes of this item, "adjacent and relevant jurisdictions and agencies" means those counties, municipalities, public service districts, school districts, public and private utilities, transportation agencies, and other public entities that are affected by or have planning authority over the public project.

For the purposes of this item, "coordination" means written notification by the local planning commission or its staff to adjacent and relevant jurisdictions and agencies of the proposed projects and the opportunity for adjacent and relevant jurisdictions and agencies to provide comment to the planning commission or its staff concerning the proposed projects. Failure of the planning commission or its staff to identify or notify an adjacent or relevant jurisdiction or agency does not invalidate the local comprehensive plan and does not give rise to a civil cause of action.

Timeline for Implementation: While the changes took effect upon approval by the Governor on September 29, 2020, recognizing that local governments are in different stages of their Comprehensive Plan update schedule, there is currently no hard and fast deadline for when a community must have a full resilience element developed.

SCOR South Carolina Office of Resilience

Guidance for Resilience in Comprehensive Plans

January 2022

SCOR
South Carolina
Office of Resilience

Community Lifelines

lifelines@fema.dhs.gov

fema.gov/media-library/assets/documents/177222

Definition

A lifeline enables the continuous operation of **critical business** and **government functions** and is essential to **human health** and safety or **economic security.**

Purpose

- Root Cause Analysis
- Interdependencies
- Prioritization
- Ease of Communication

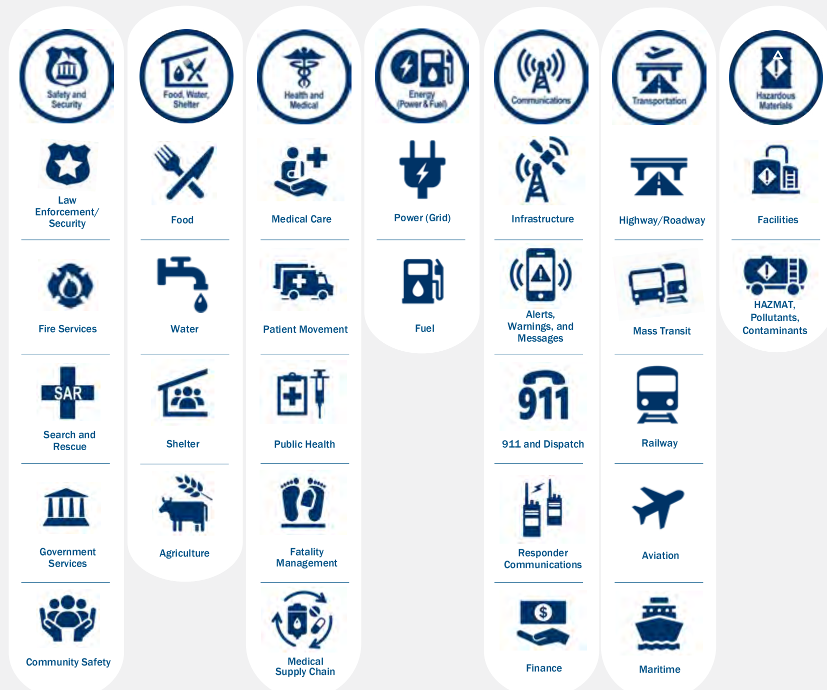
Assessing

- Status ⟶ What?
- Impact ⟶ So What?
- Actions ⟶ Now What?
- Limiting Factors ⟶ What's the Gap?

Stabilization

Occurs when basic lifeline services or capabilities are provided to survivors (may be temporary solutions requiring sustainment).

COMPONENTS of Lifelines



November 2019

APPENDIX G:
PRIORITY FLOOD MITIGATION AREAS FOR CONSERVATION

OVERVIEW

The South Carolina Office of Resilience has used a combination of public and private datasets to better understand the landscape's role in flood mitigation across South Carolina.

The methodology used to identify priority flood mitigation areas focuses on areas where flood hazards are expected, as well as wetlands that absorb excess water, as well as those areas where water is most likely to infiltrate, reducing runoff. Protecting these areas will reduce community flood risk and allow for the natural storage and conveyance functions.
This appendix includes a description of the methodology used, a process flowchart, as well as a series of maps showing the identified Priority Flood Mitigation Areas.

This appendix includes a description of the methodology used, a process flowchart, as well as a series of maps showing the identified Priority Flood Mitigation Areas.

AREA IDENTIFICATION DEVELOPMENT

STEP 1: FLOOD HAZARD AREAS

This step focusing on protecting those areas with high current and future flood risks from being developed. This part of the model incorporates the Federal Emergency Management Agency's (FEMA) 1% and 0.2% Annual Chance flood hazard areas. To ensure an appropriate focus on future flood risk, the First Street Foundation's Flood Hazard Layers (Version 2.0) were used to identify areas that would experience over 3 feet of flooding during a 0.2% Annual Chance flood scenario in 2052.

STEP 2: MARSH MIGRATION

This step focuses on protecting the future locations of marshes, which store floodwaters. NOAA's Sea Level Rise Viewer predicts a 1.5-foot rise in sea level by 2050 for South Carolina. With this predicted rise, NOAA's Marsh Migration Model predicts that by 2050, coastal marshes will naturally migrate inland if they have the space to. Conserving areas where these marshes are expected to migrate ensures that their absorptive properties are protected.

STEP 3: CURRENT WETLANDS

Similar to marshes, inland wetlands provide natural stormwater retention. Using the USGS 2019 National Land Cover Dataset, areas identified as wetlands were selected for conservation to ensure their retention properties are not threatened.

STEP 4: BEST INFILTRATION

Upland areas outside of floodplains and wetlands also directly contribute to flood mitigation by allowing water to infiltrate the soil instead of flowing downstream. This is made most obvious when permeable soils are negated by the placement of impervious surfaces such as concrete over them, leading to runoff and an increase of floodwaters downstream.

In order to identify those upland areas most suited to infiltration, SCOR has used the USGS SSURGO Soils mapping in conjunction with the USGS 2019 National Land Cover Dataset and the USDA 30-meter Digital Elevation Model to calculate runoff curve numbers according to the USDA TR-55 technical report titled Urban Hydrology for Small Watersheds. In this calculation, high runoff curves convey high runoff potential, whereas low runoff curves communicate high infiltration potential. Any high slope areas (over 7%) where soils are classified as B, C, or D were multiplied by 1.25% to further isolate where flat land allows for longer infiltration time.

With runoff curves calculated, an analysis was performed to identify the 10th percentile best infiltration areas for each local watershed. These watersheds are formed out of HUC-8 level watersheds that were modified to include their entire upstream catchment areas, accounting for any substantive drainage resets, such as regulated dams. This ensures the identification of upland areas in every watershed in South Carolina that should be prioritized for conservation for infiltration.

This process can be replicated for watersheds of any size, which allows for downscaling to smaller local watersheds depending on the project proposed.

AREAS NOT INCLUDED IN SCOR'S MODEL

DEVELOPED AREAS & OPEN WATER

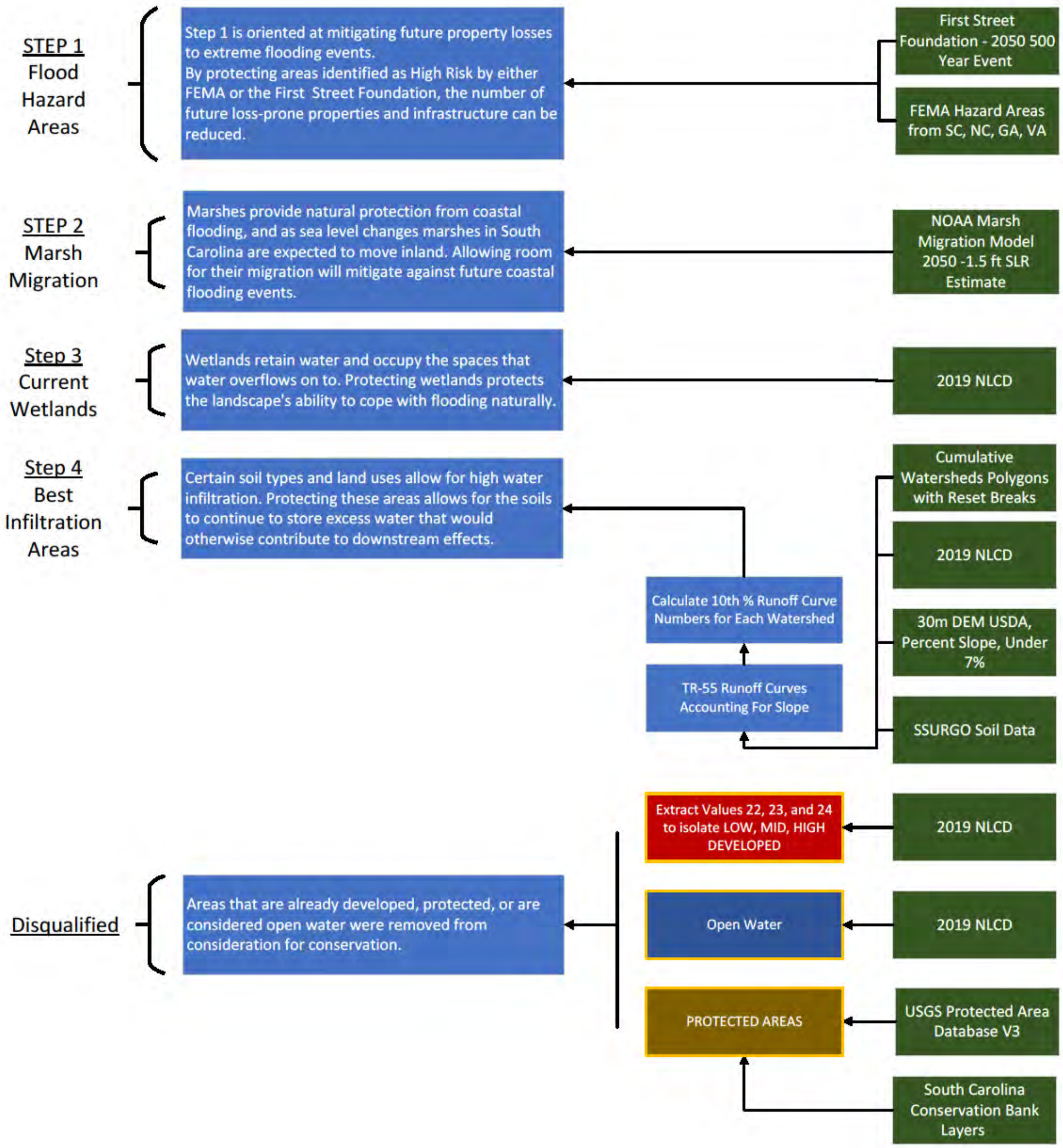
Any areas that are currently identified as open water or low, medium, or high intensity development by the 2019 National Landcover Dataset.

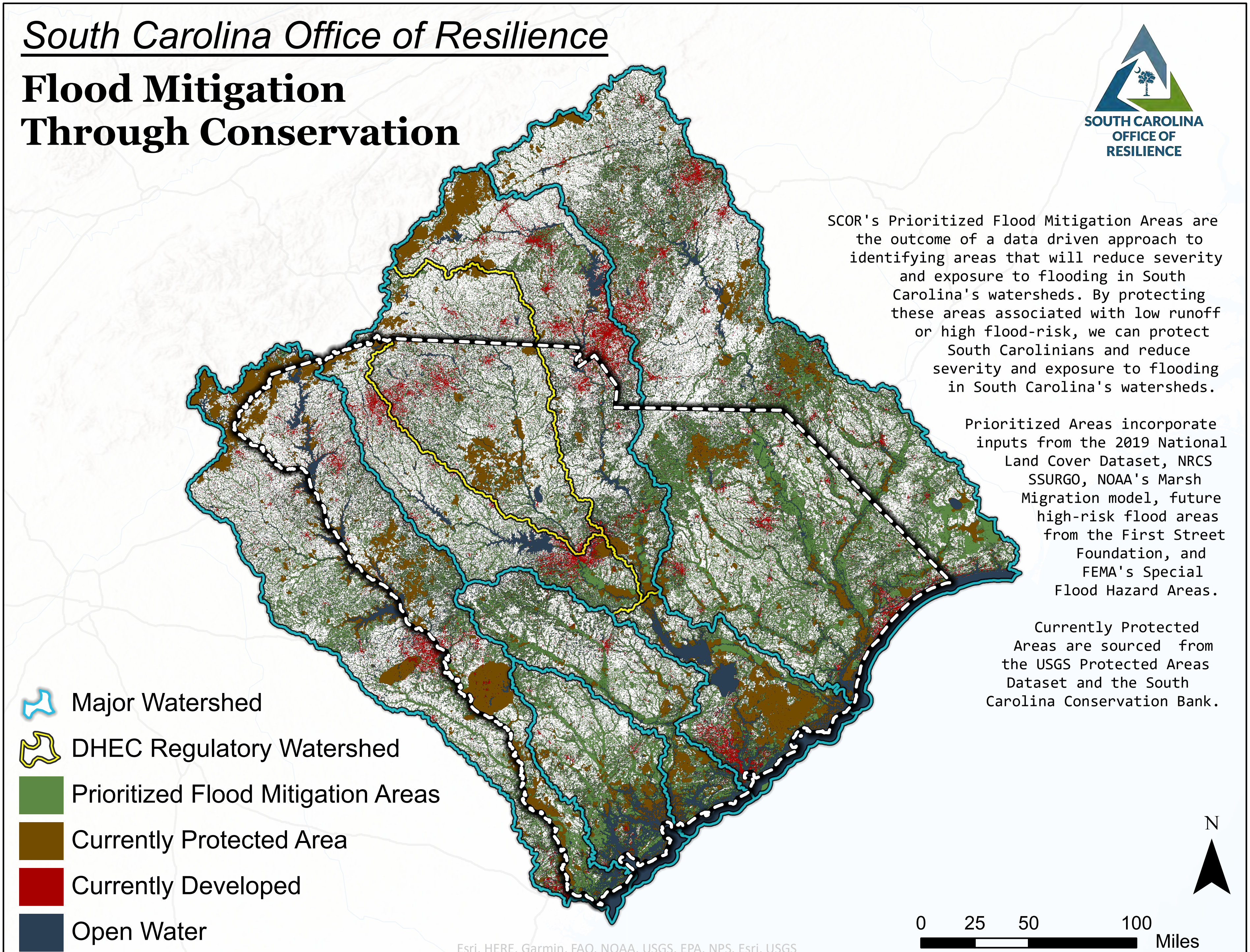
PROTECTED AREAS

Areas identified by the South Carolina Conservation Bank or the USGS Protected Area Database (Version 3) as being protected were removed from SCOR's model.

PRIORITY FLOOD MITIGATION AREAS FIGURES AND MAPS

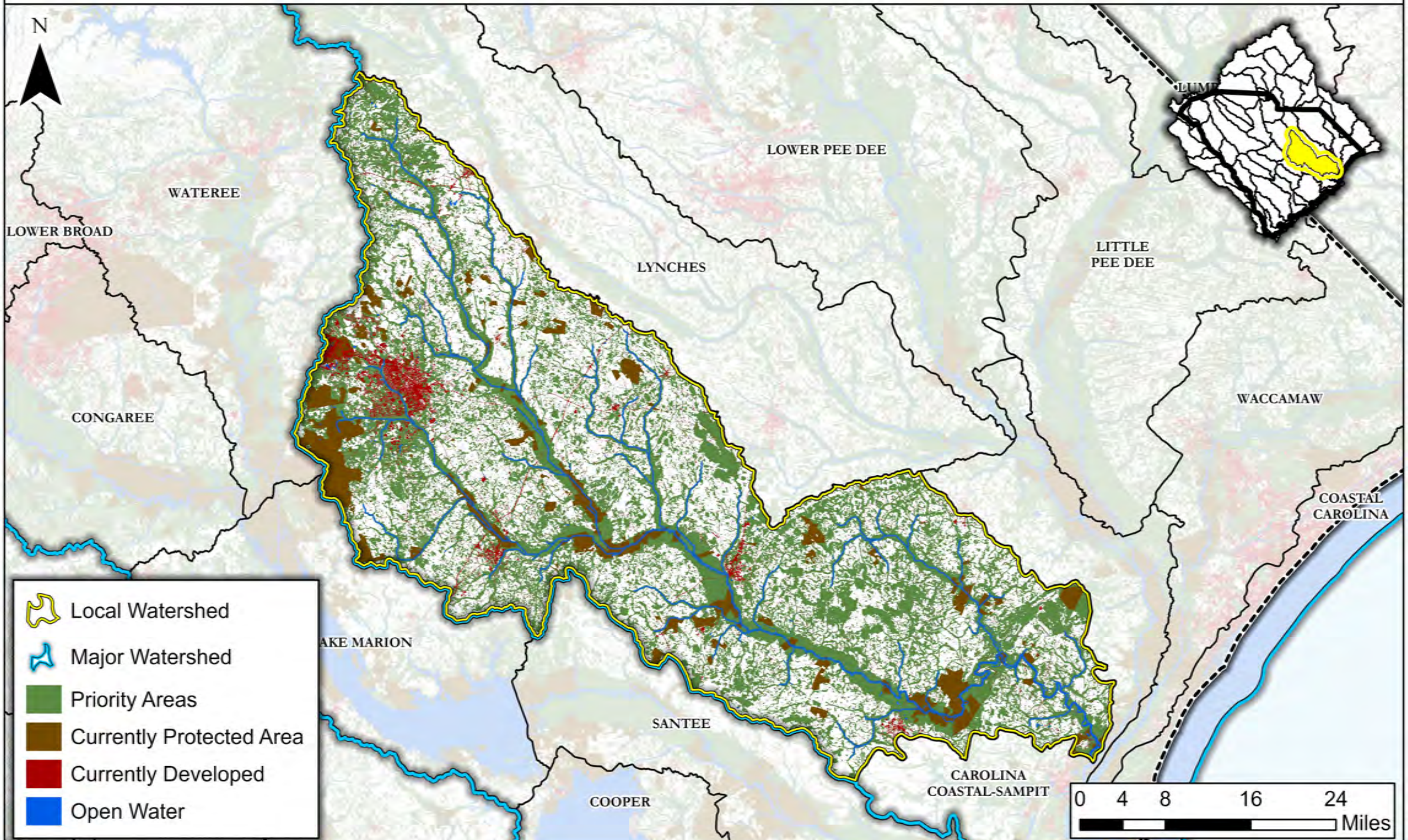
PROCESS FLOWCHART




South Carolina Office of Resilience
Flood Mitigation Through Conservation
SOUTH CAROLINA OFFICE OF RESILIENCE
SCOR's Prioritized Flood Mitigation Areas are the outcome of a data driven approach to identifying areas that will reduce severity and exposure to flooding in South Carolina's watersheds. By protecting these areas associated with low runoff or high flood-risk, we can protect South Carolinians and reduce severity and exposure to flooding in South Carolina's watersheds.
Prioritized Areas incorporate inputs from the 2019 National Land Cover Dataset, NRCS SSURGO, NOAA's Marsh Migration model, future high-risk flood areas from the First Street Foundation, and FEMA's Special Flood Hazard Areas.
Currently Protected Areas are sourced from the USGS Protected Areas Dataset and the South Carolina Conservation Bank.
Major Watershed
DHEC Regulatory Watershed
Prioritized Flood Mitigation Areas
Currently Protected Area
Currently Developed
Open Water
N
0
25
50
100
Miles
Esri, HERE, Garmin, FAO, NOAA, USGS, EPA, NPS, Esri, USGS

Prioritized Flood Mitigation Areas

Black Watershed



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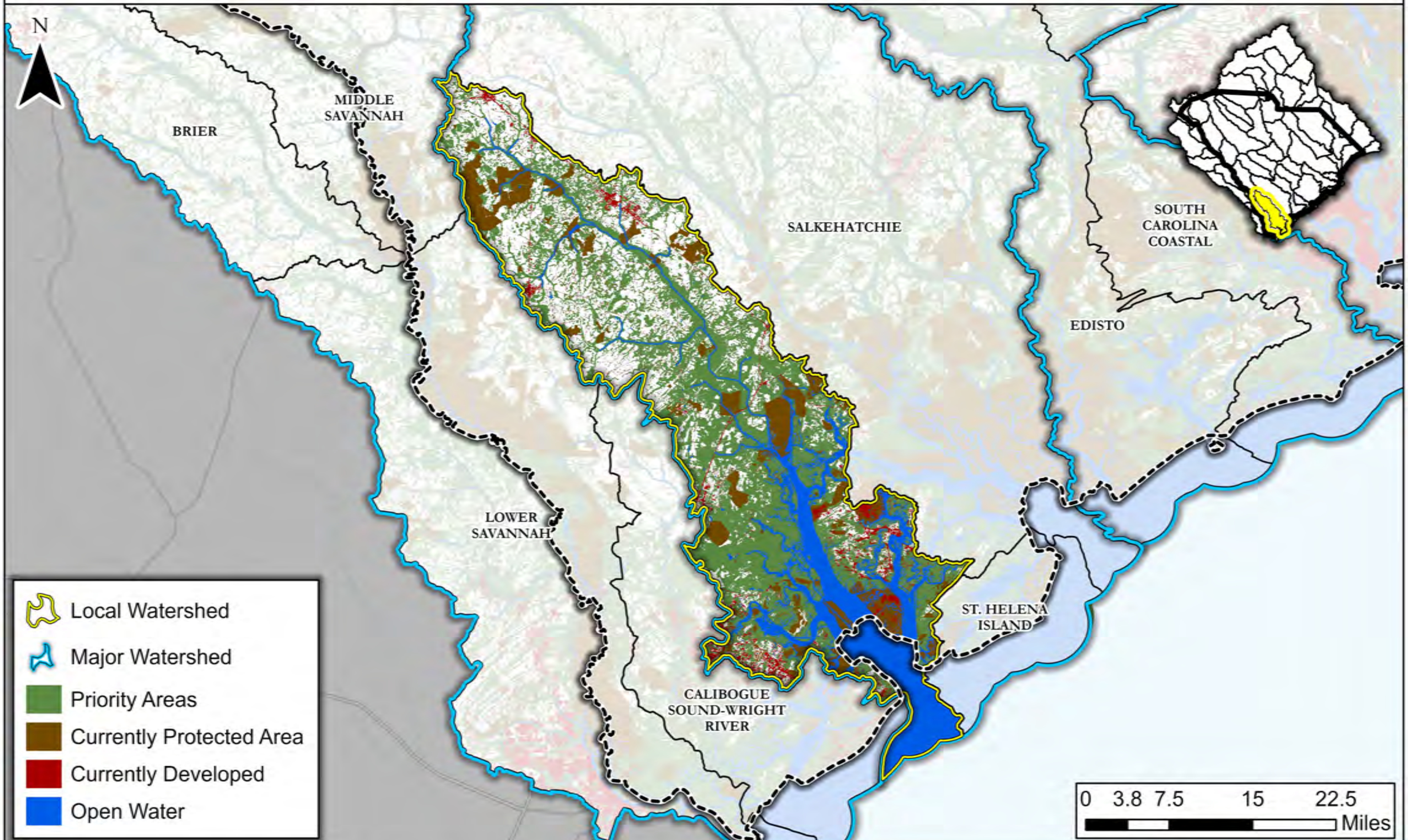
SCOR South Carolina Office of Resilience

Prioritized Flood Mitigation Areas

Broad-St. Helena Watershed



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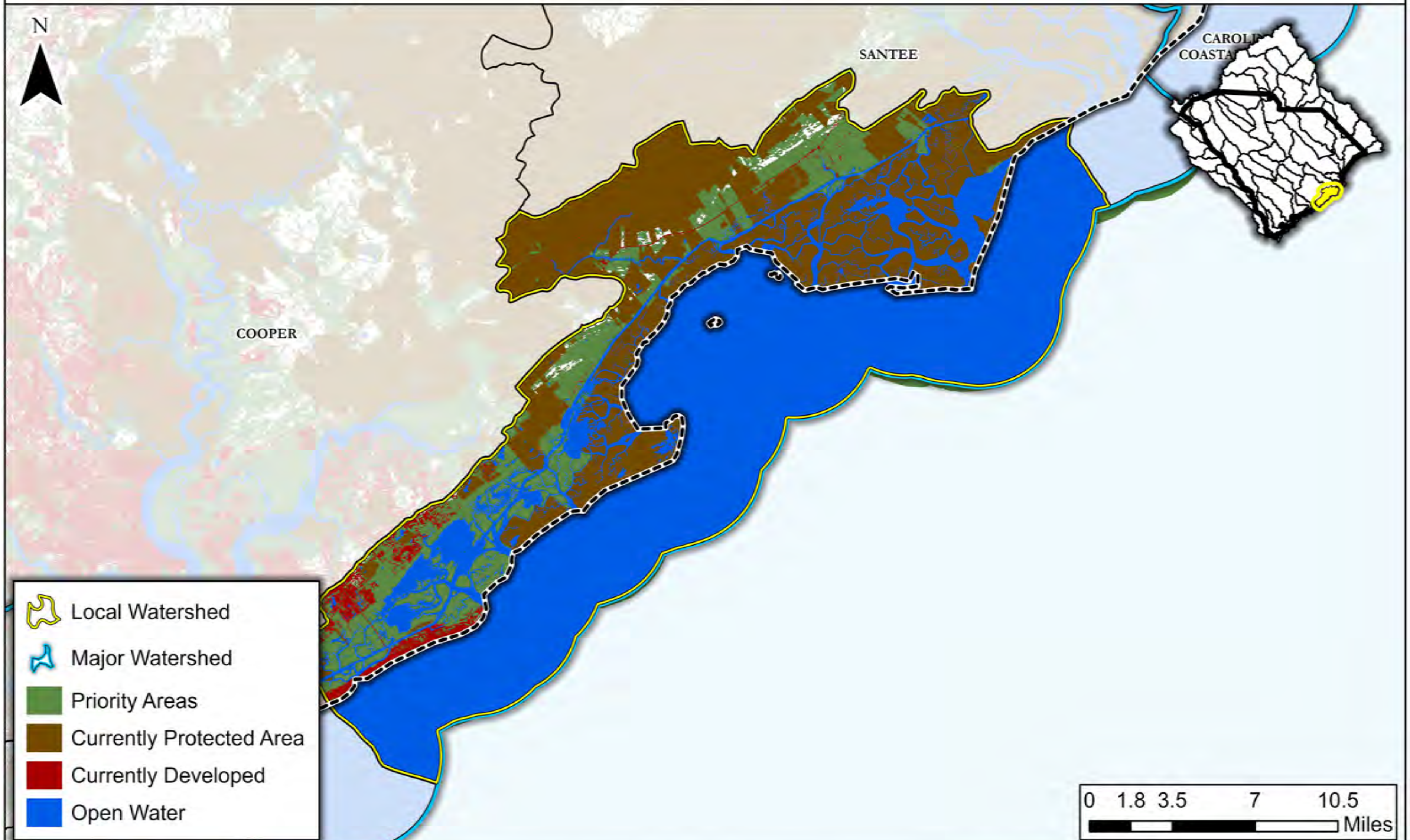
Prioritized Flood Mitigation Areas

Bulls Bay Watershed



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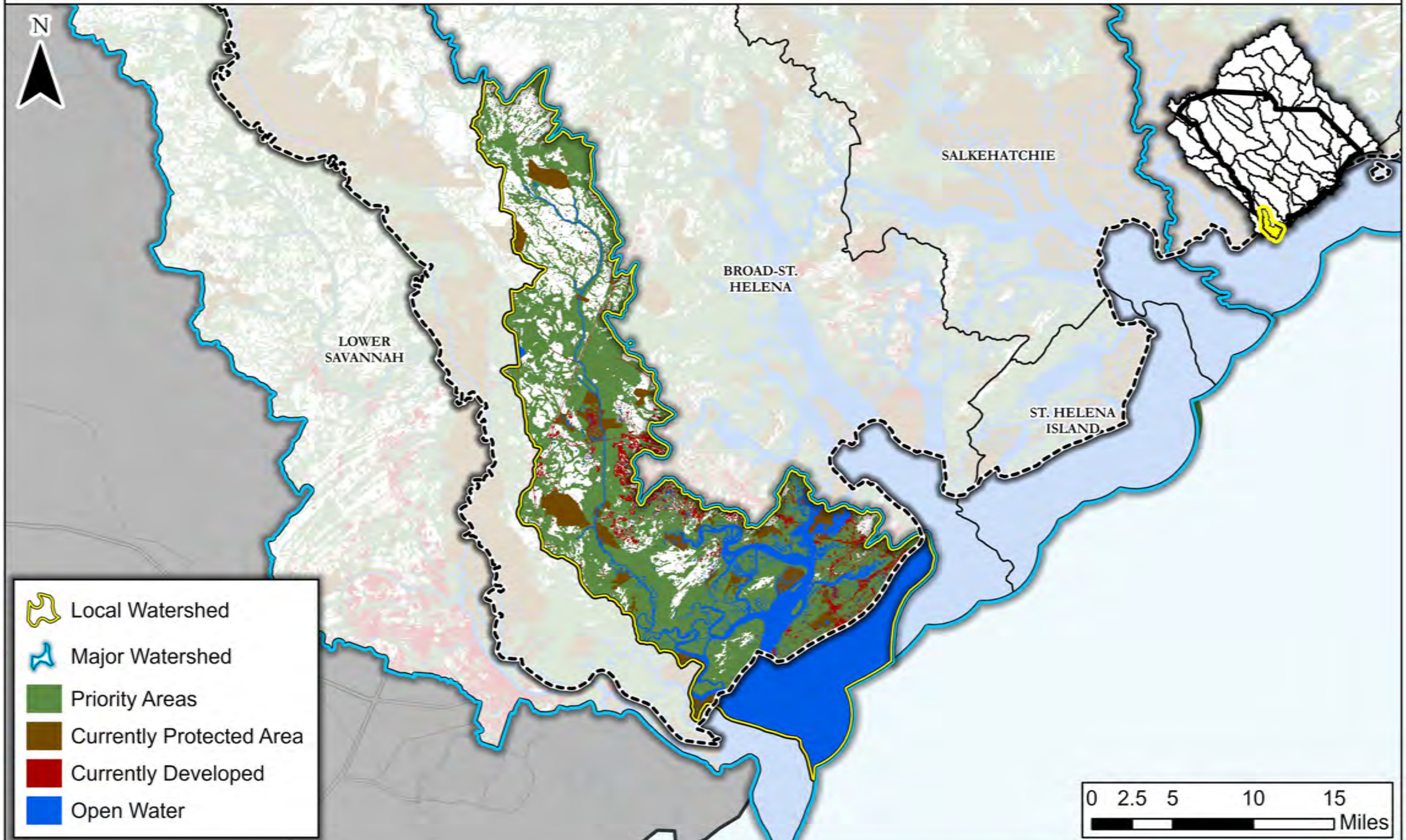
Prioritized Flood Mitigation Areas

Calibogue Sound-Wright River Watershed



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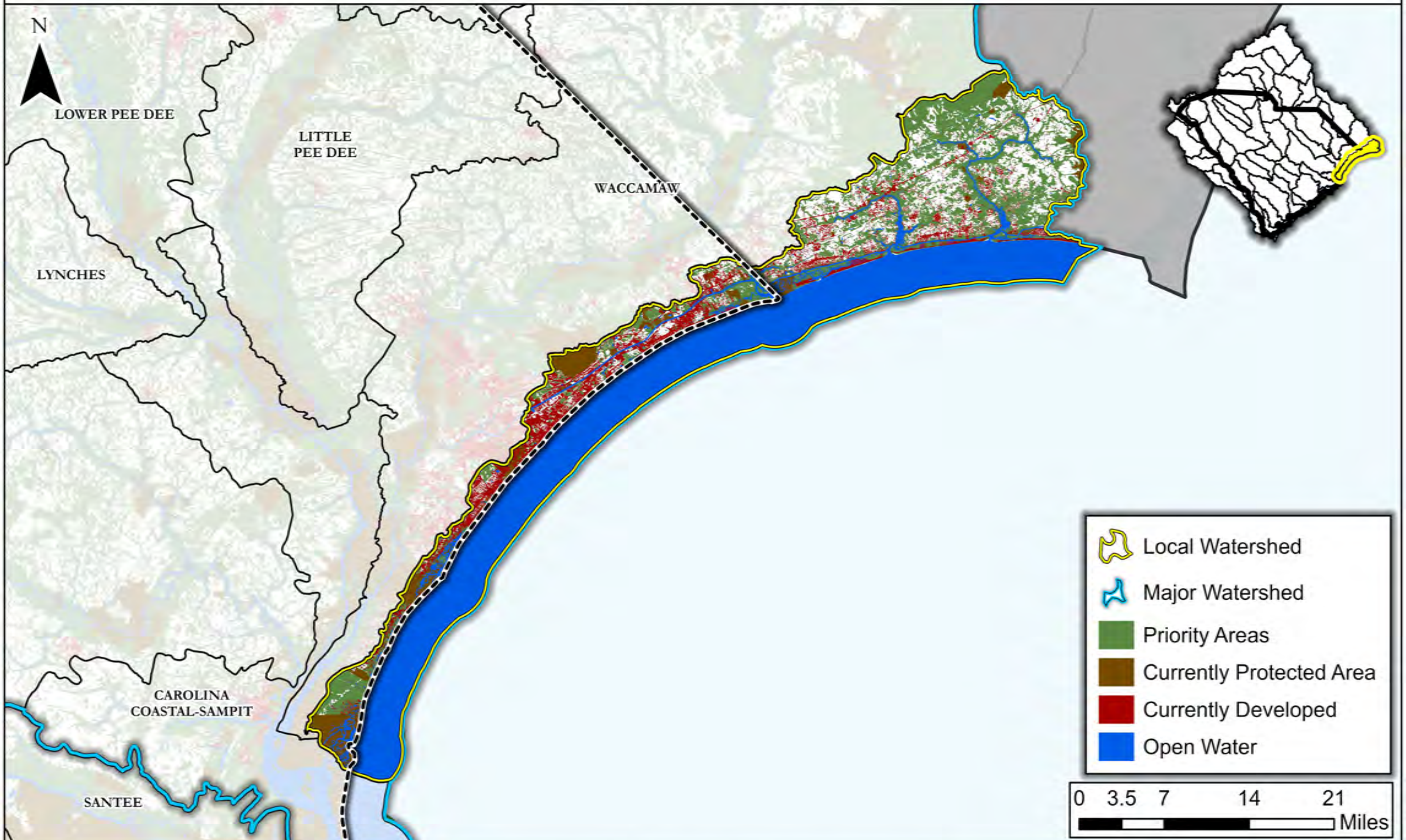
Prioritized Flood Mitigation Areas

Coastal Carolina Watershed



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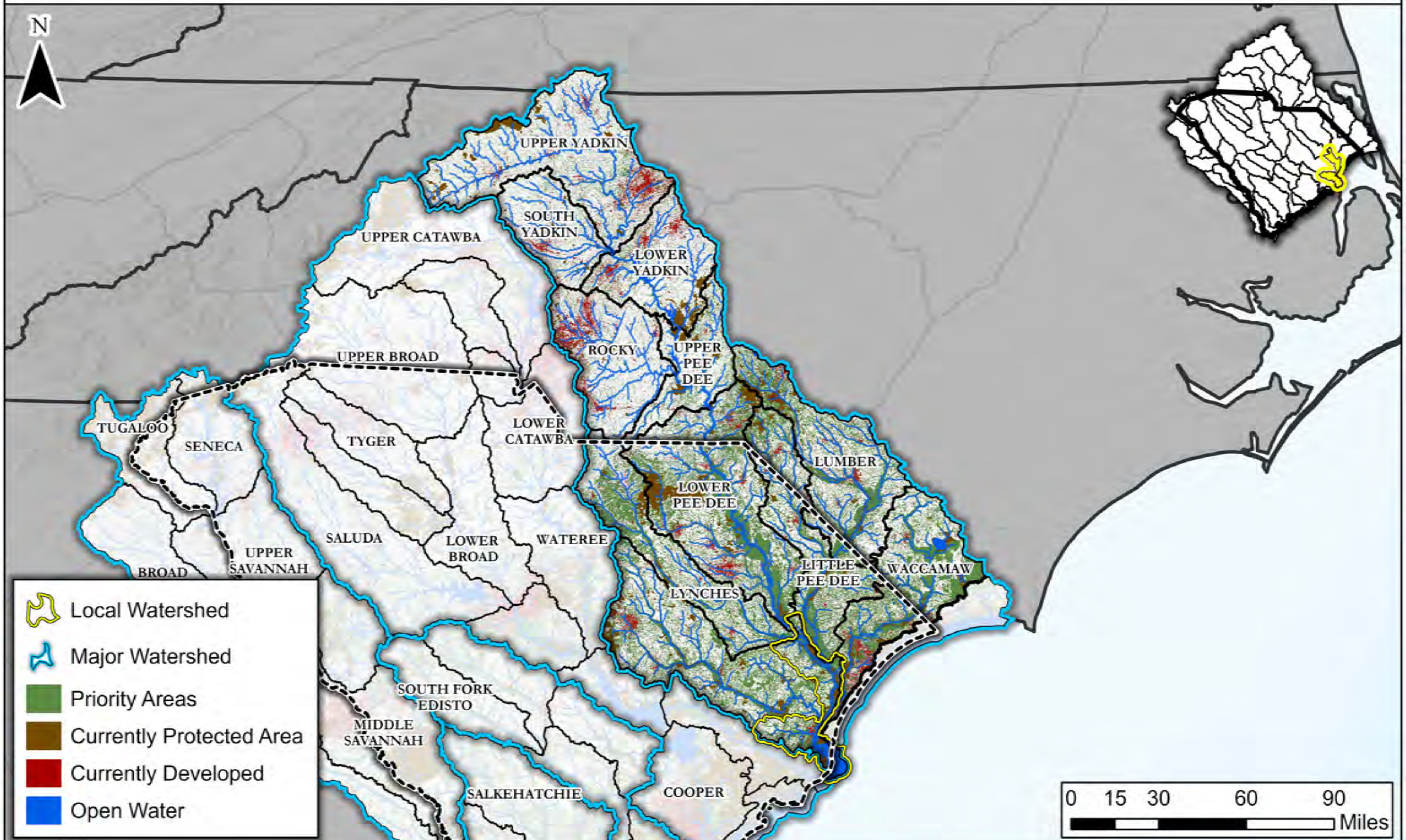
Prioritized Flood Mitigation Areas

Carolina Coastal-Sampit Watershed



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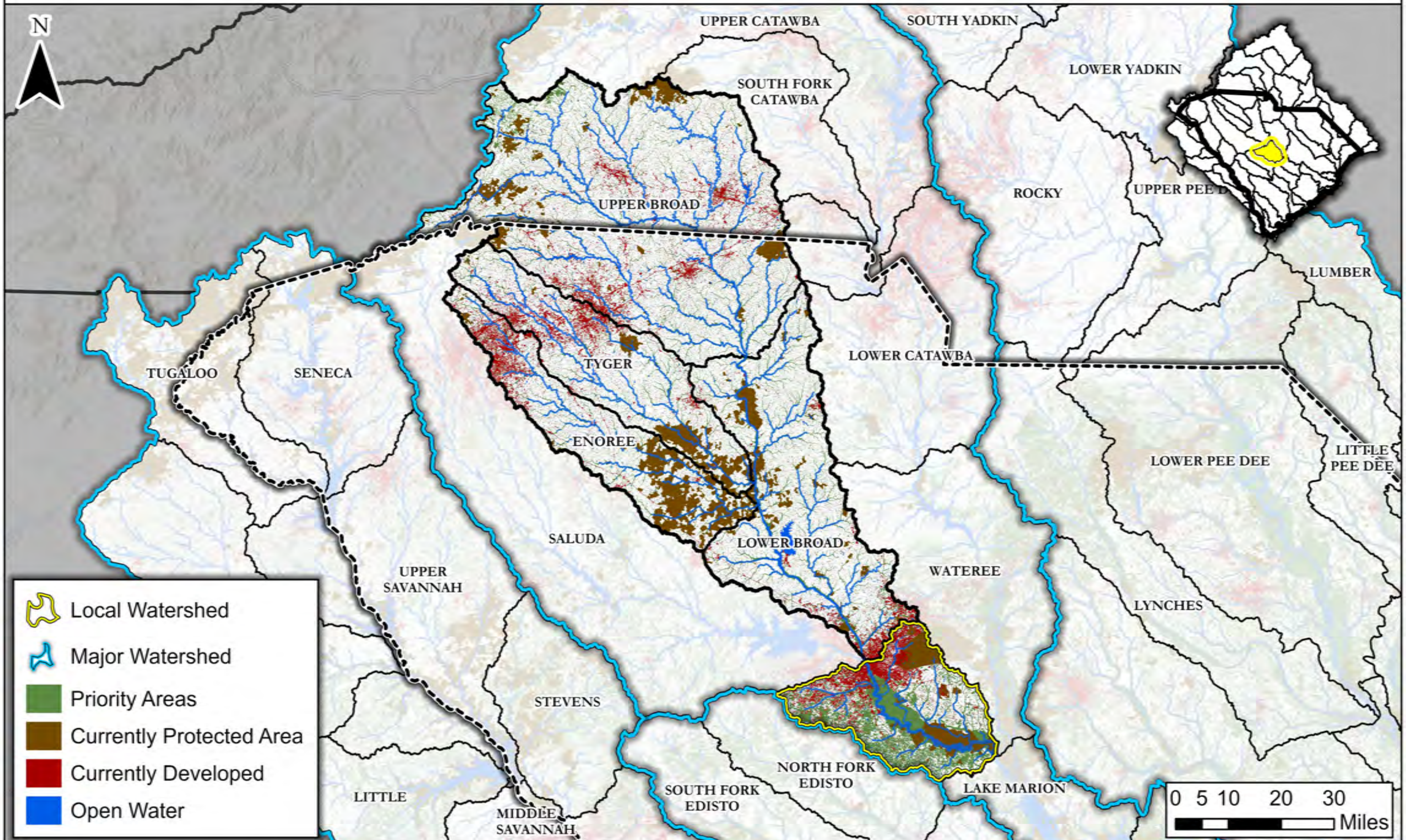
SCOR South Carolina Office of Resilience

Prioritized Flood Mitigation Areas

Congaree Watershed



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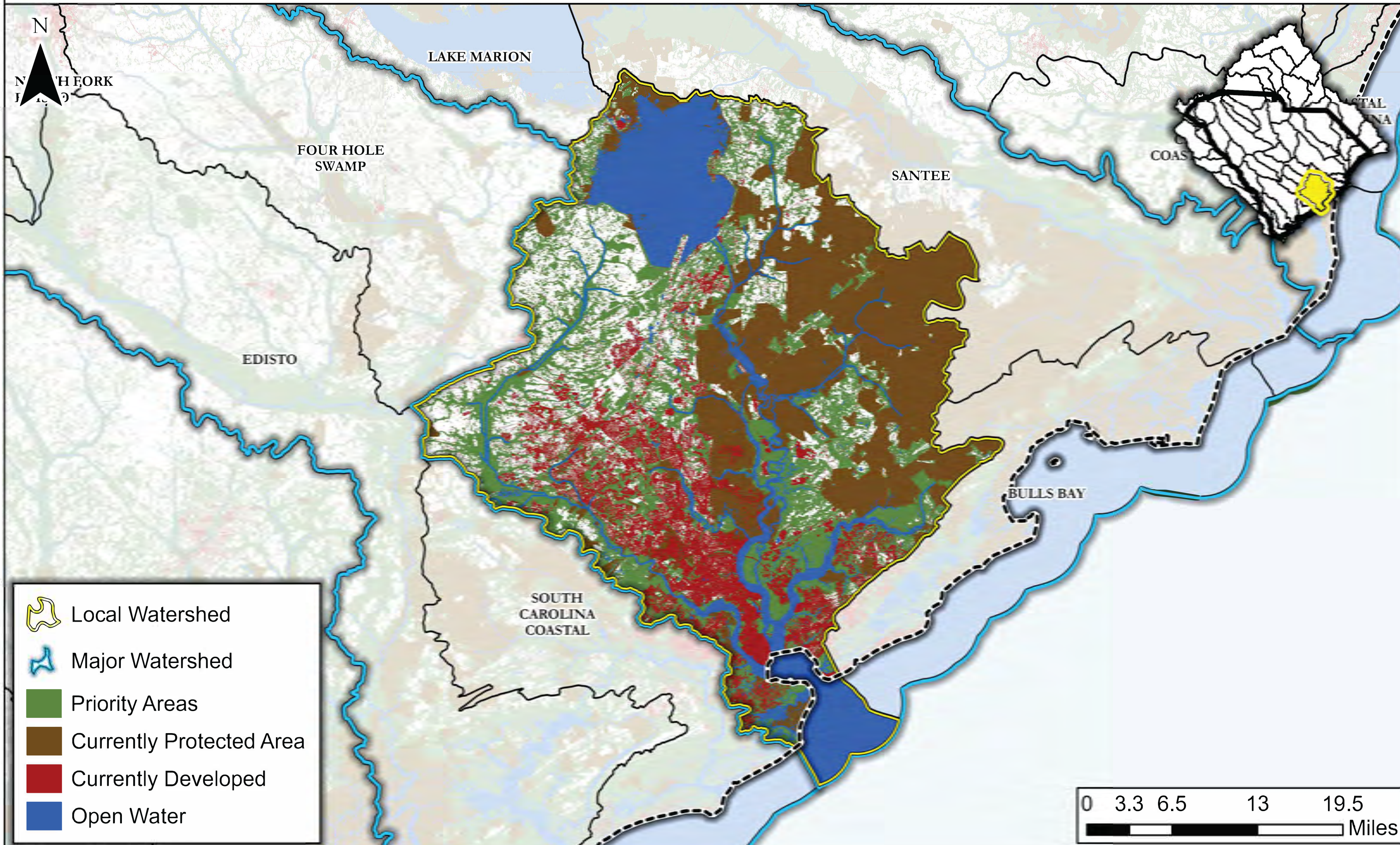
Prioritized Flood Mitigation Areas

Cooper Watershed



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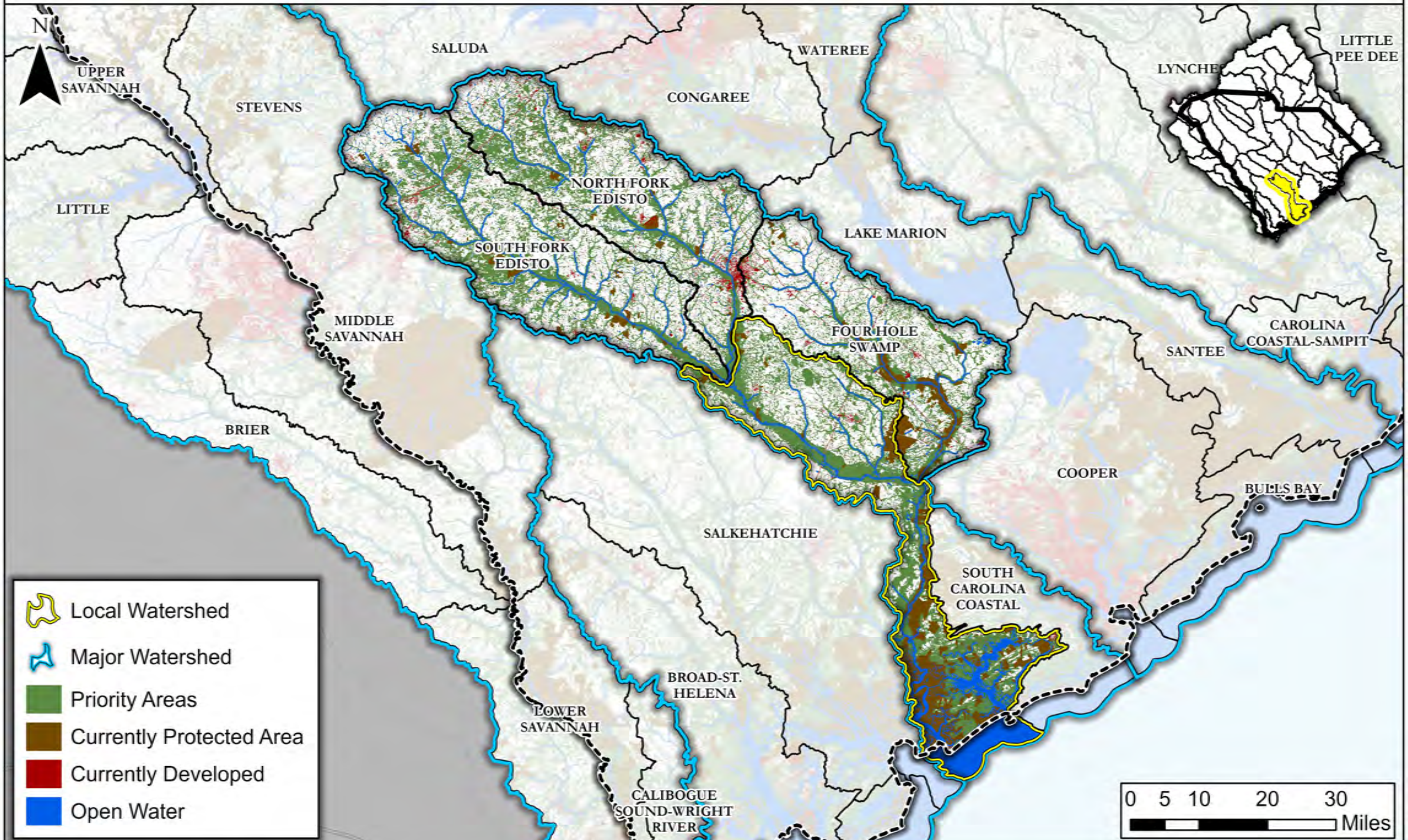
Prioritized Flood Mitigation Areas

Edisto Watershed



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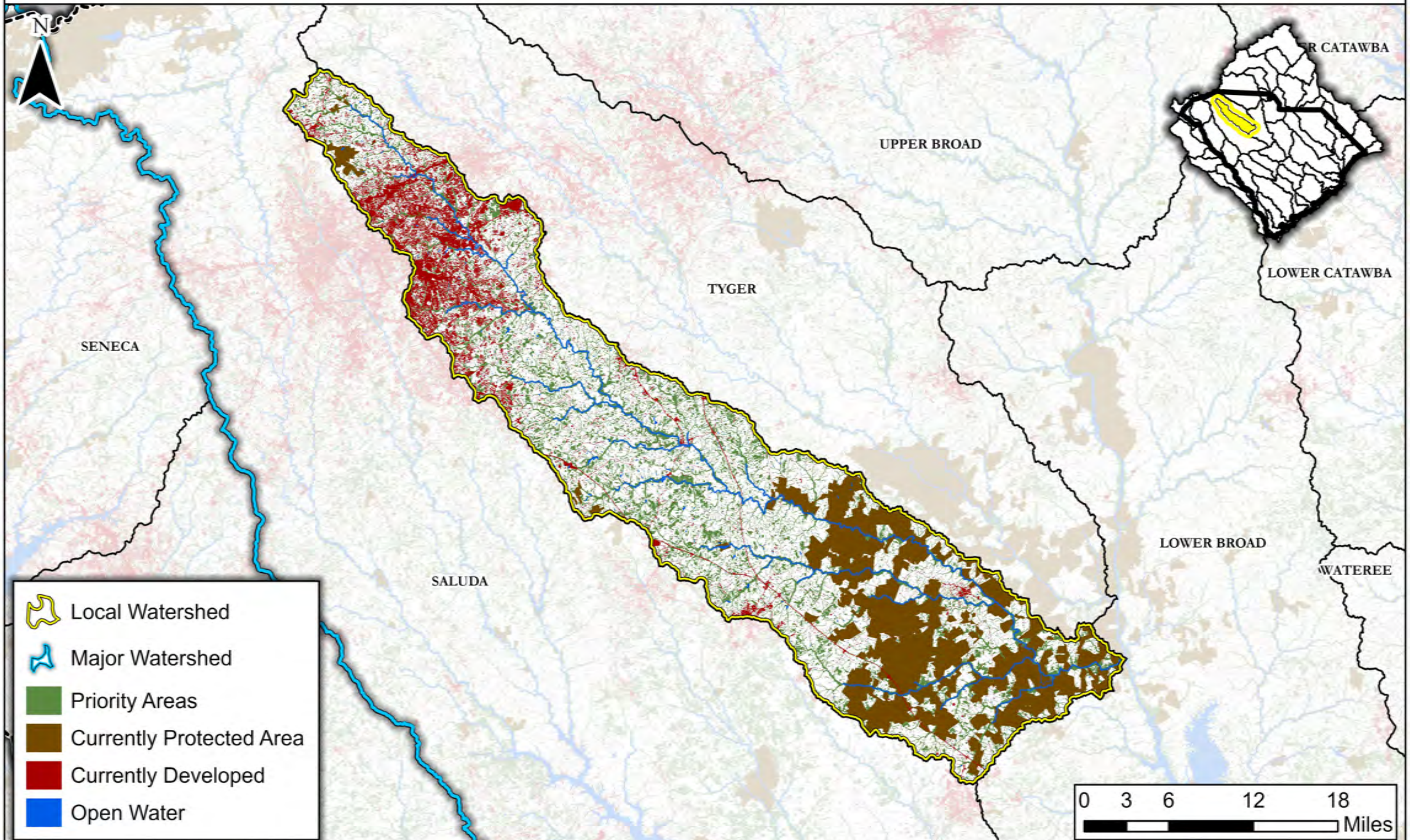
Prioritized Flood Mitigation Areas

Enoree Watershed



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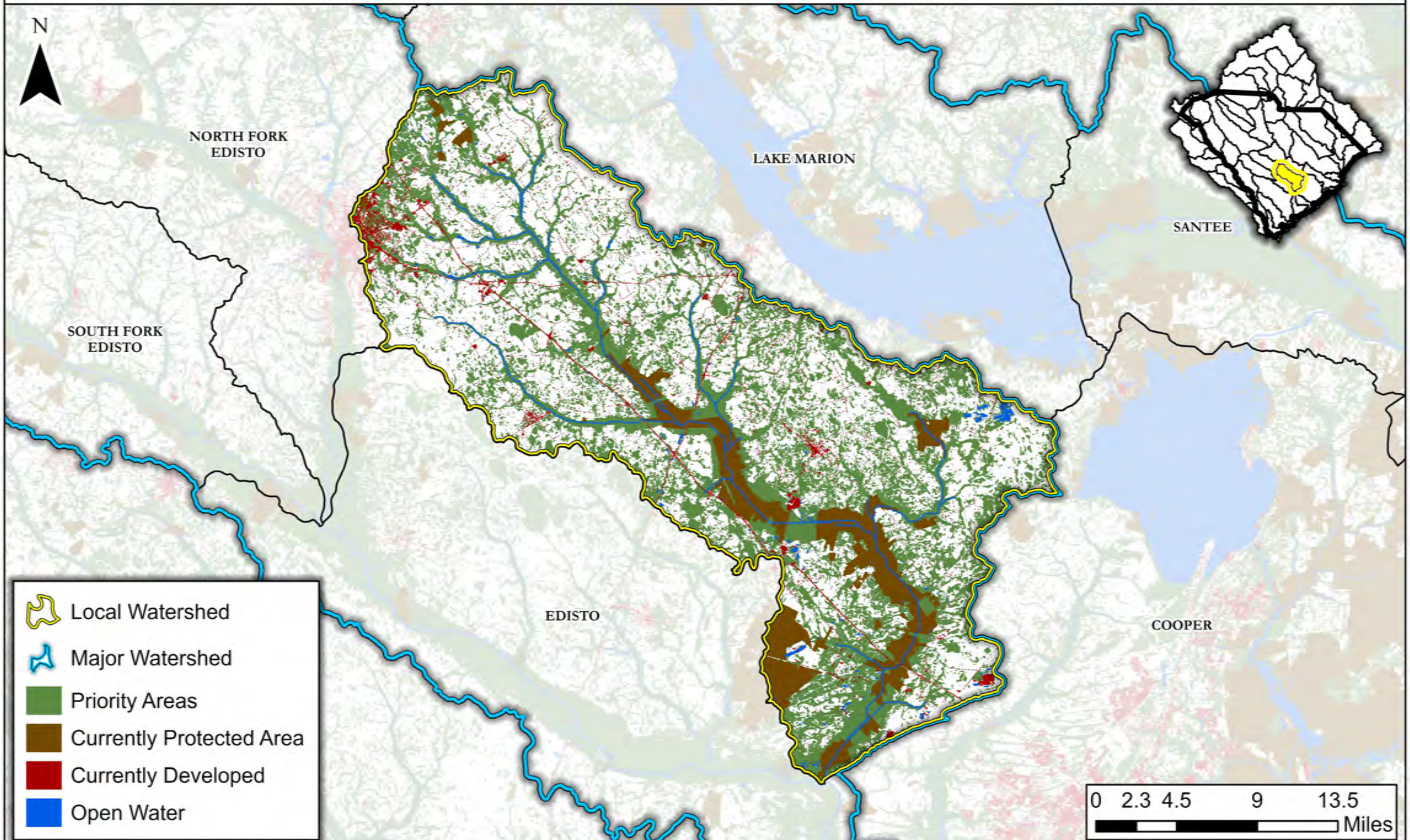
Prioritized Flood Mitigation Areas

Four Hole Swamp Watershed



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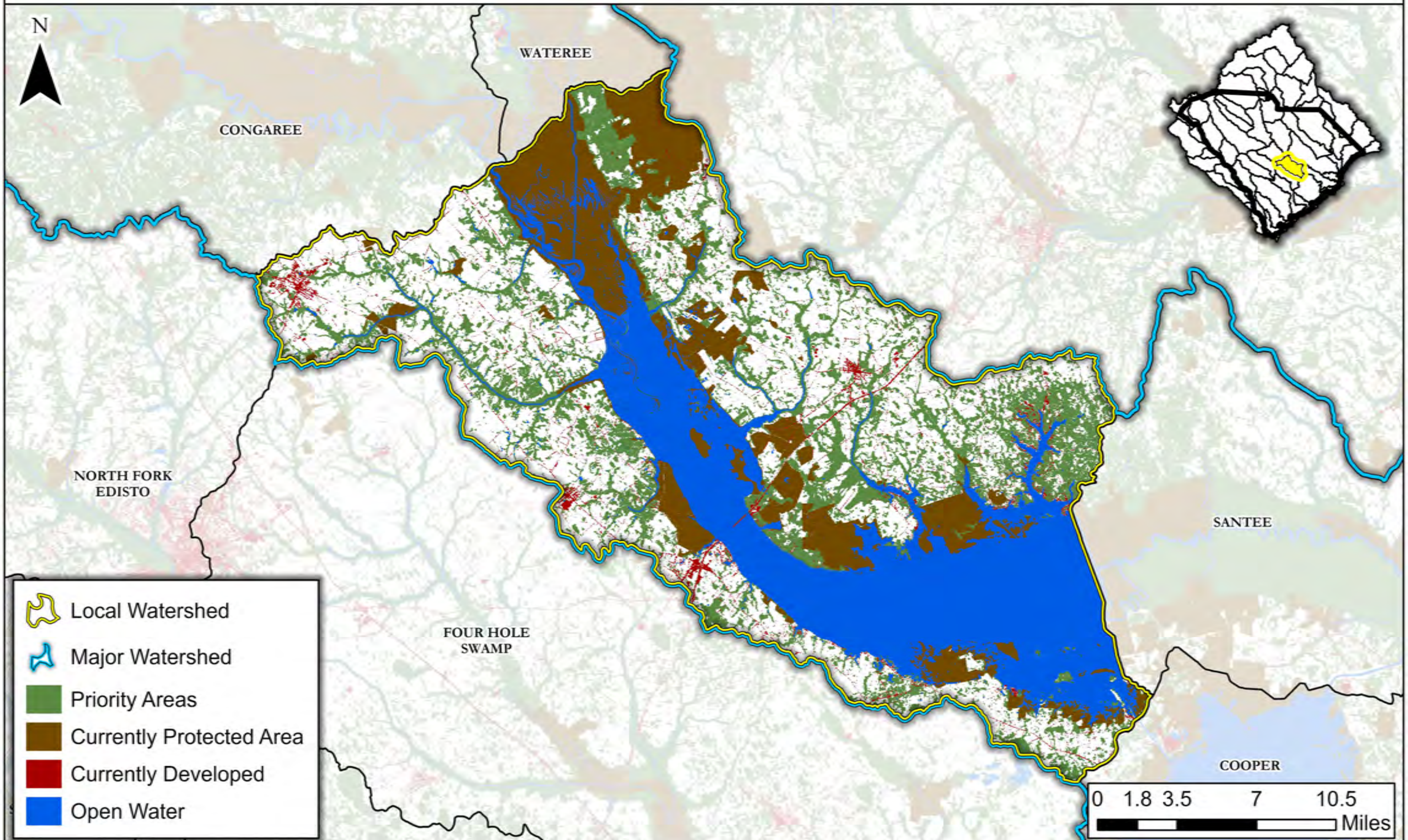
Prioritized Flood Mitigation Areas

Lake Marion Watershed



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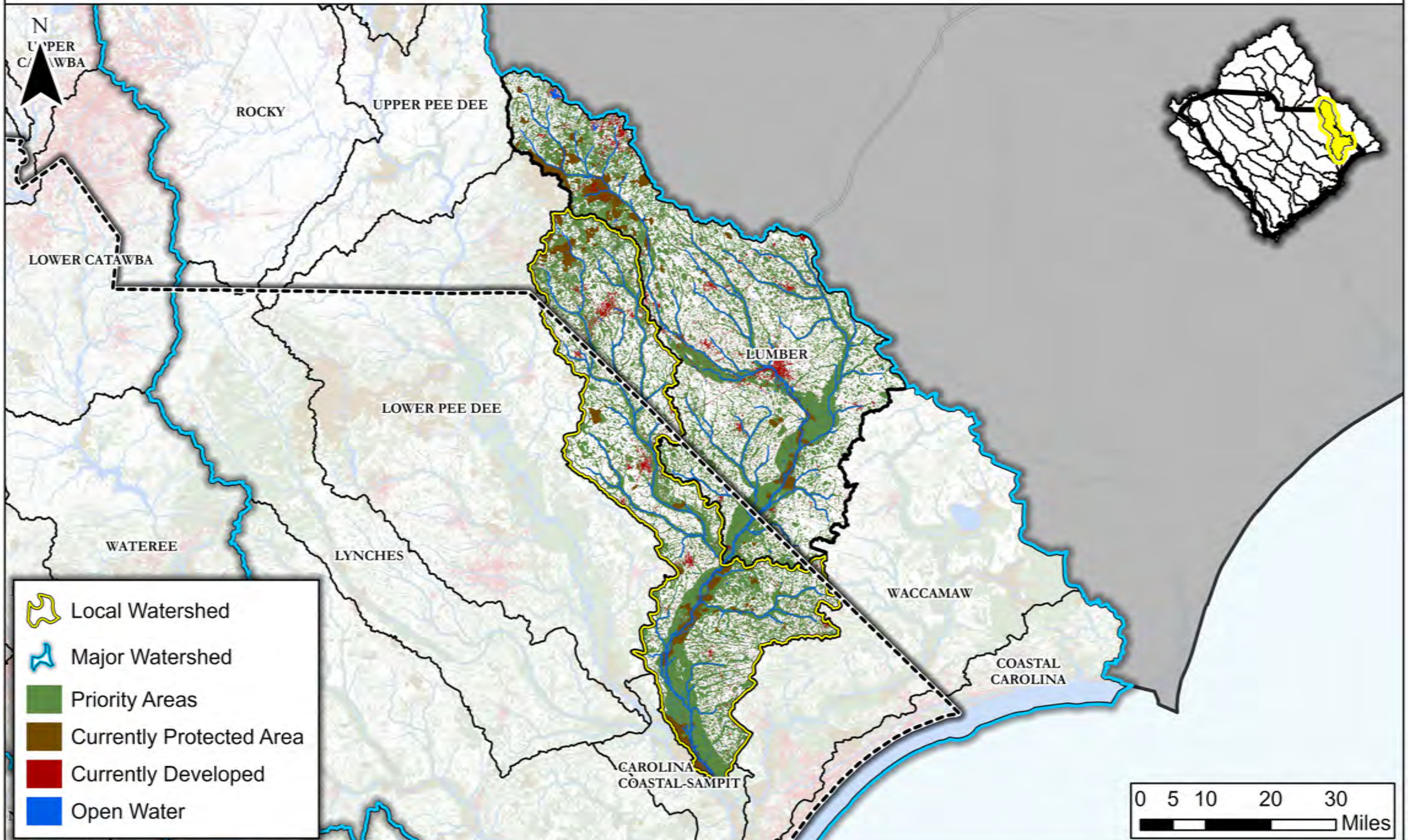
SCOR South Carolina Office of Resilience

Prioritized Flood Mitigation Areas

Little Pee Dee Watershed



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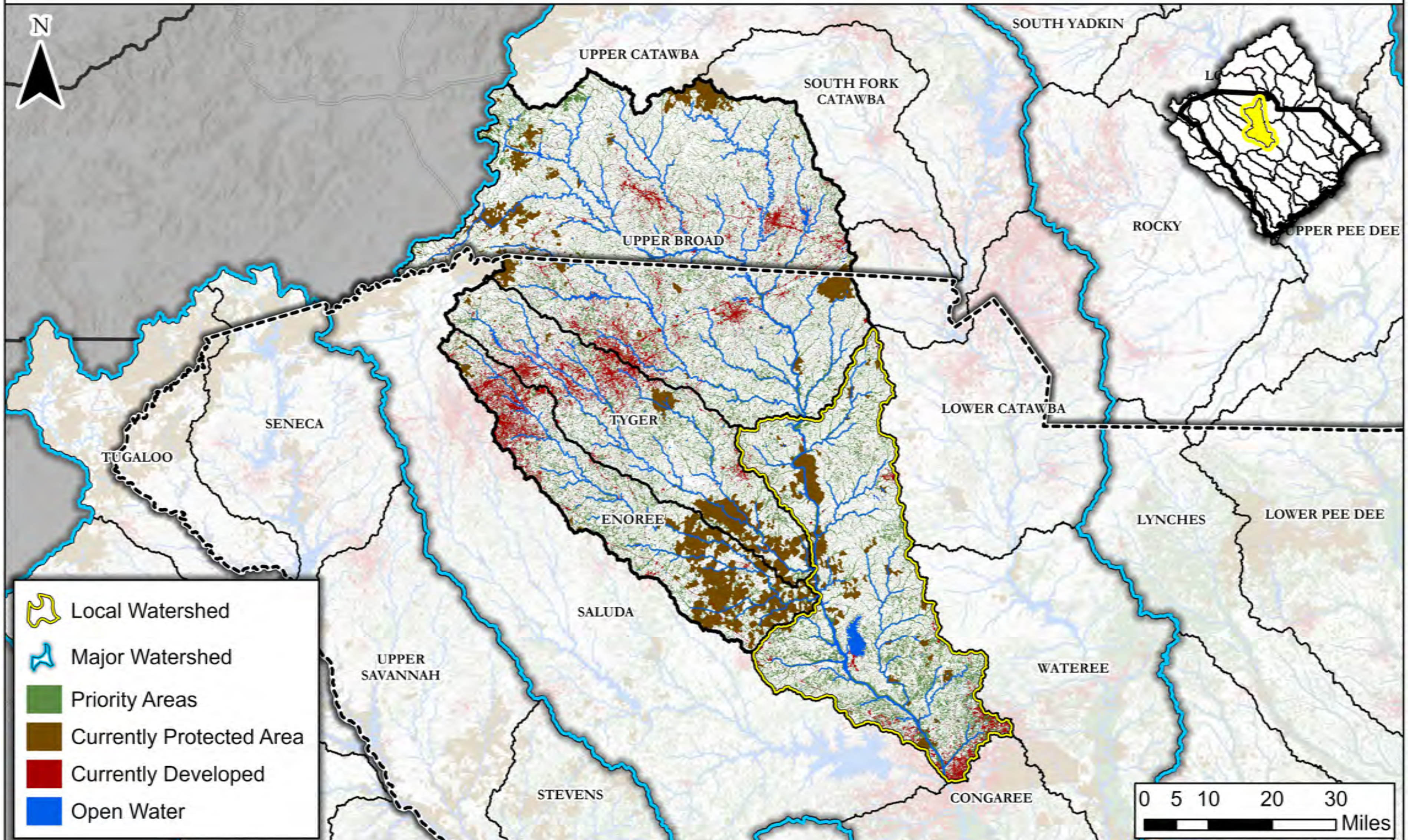
Prioritized Flood Mitigation Areas

Lower Broad Watershed



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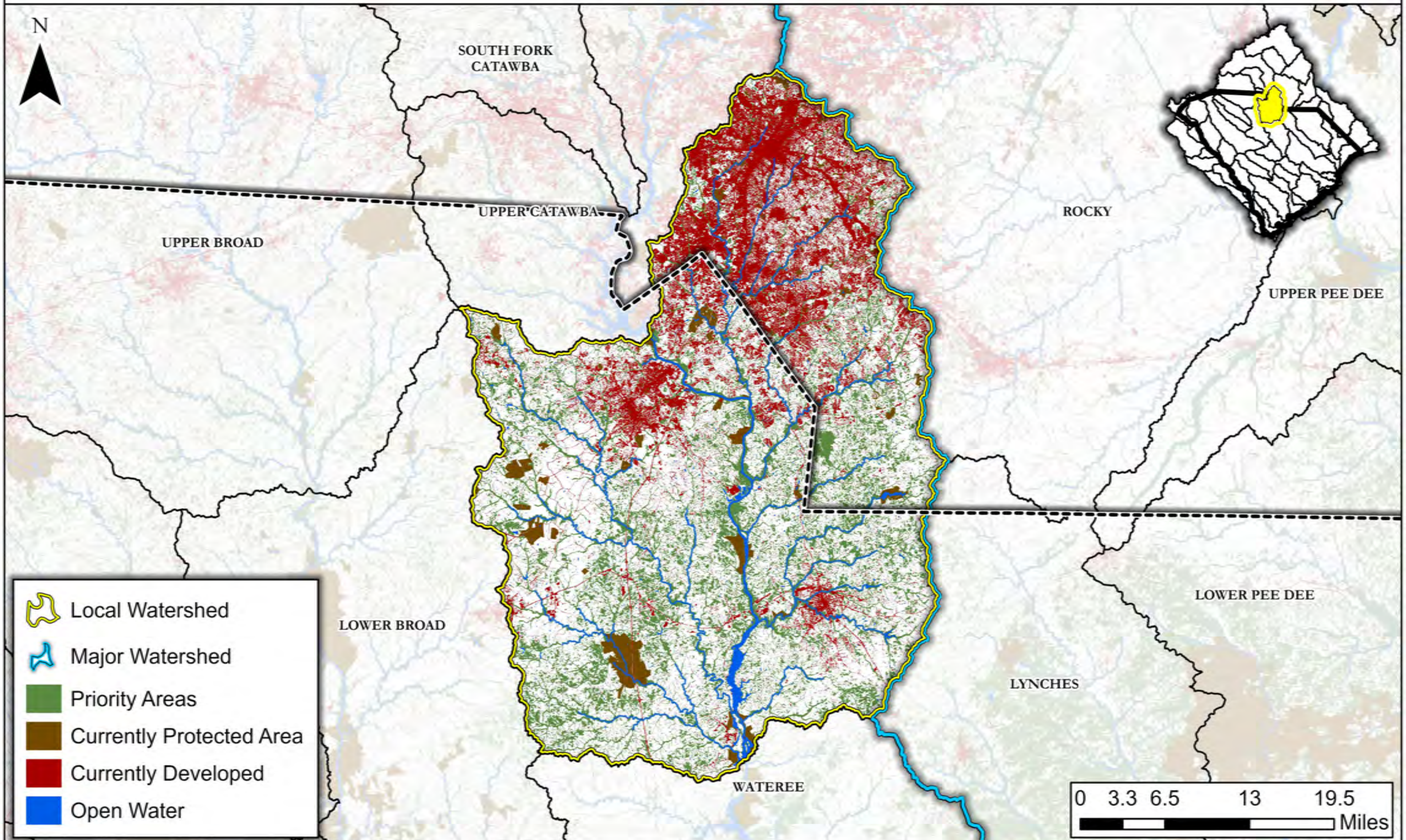
Prioritized Flood Mitigation Areas

Lower Catawba Watershed



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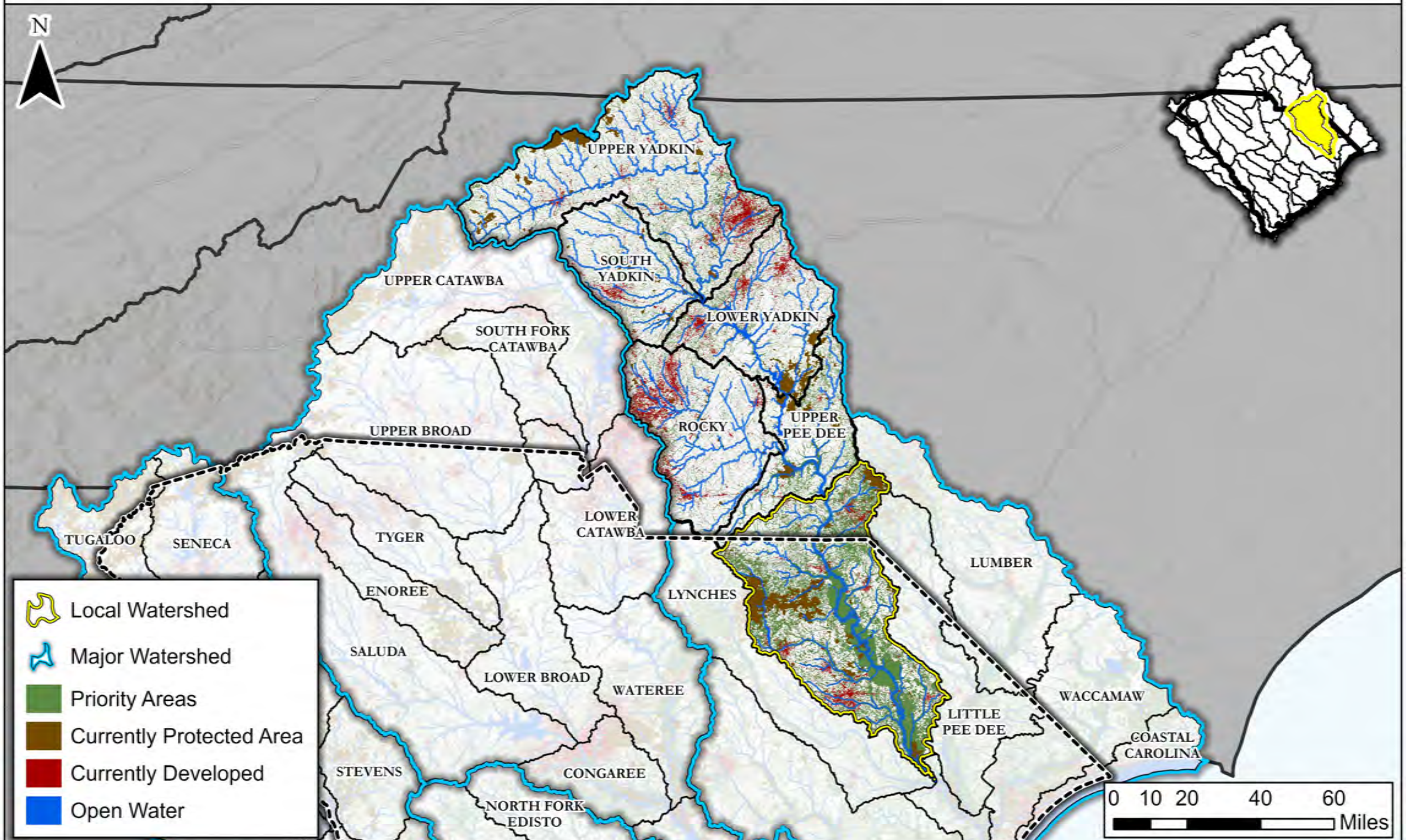
Prioritized Flood Mitigation Areas

Lower Pee Dee Watershed



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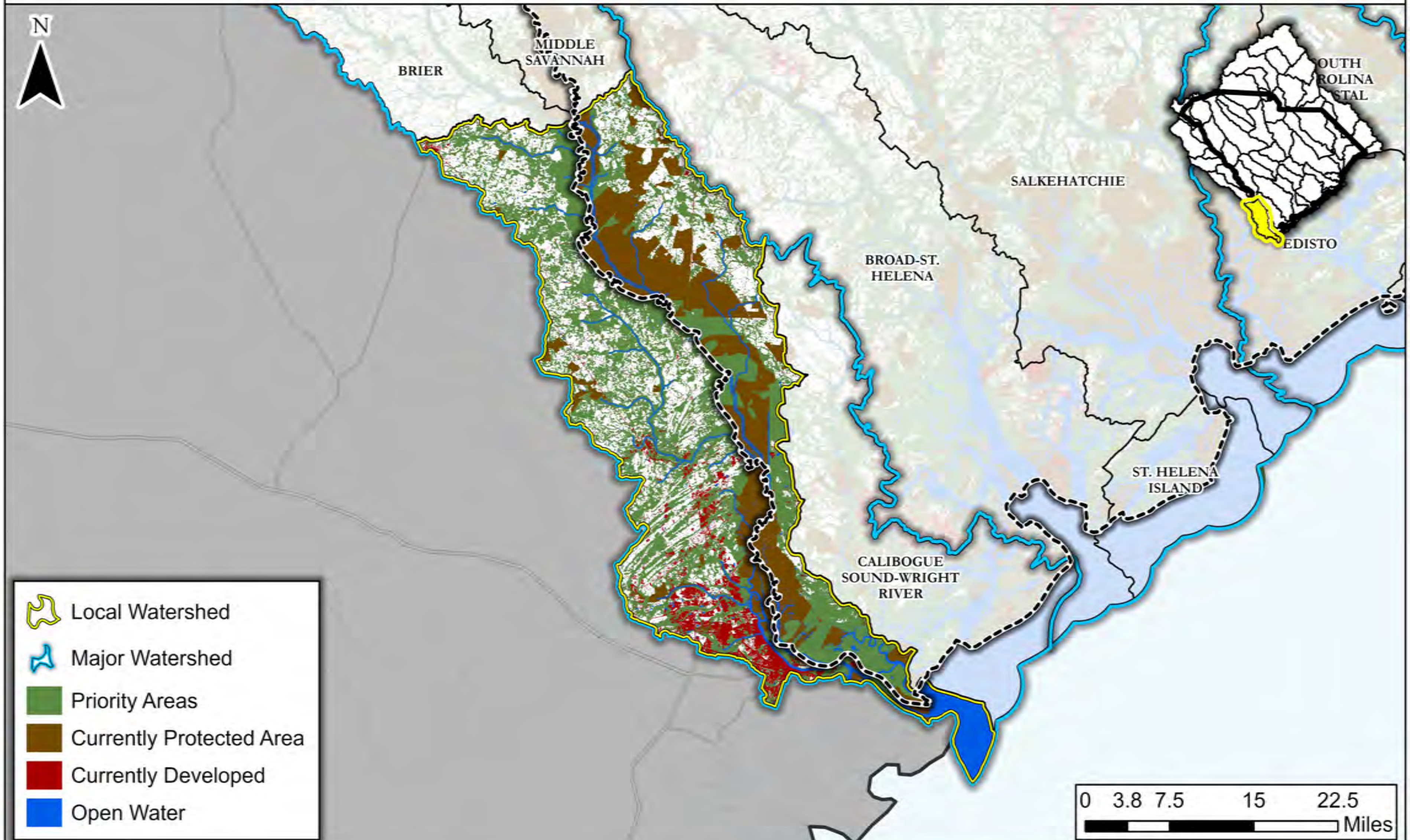
Prioritized Flood Mitigation Areas

Lower Savannah Watershed



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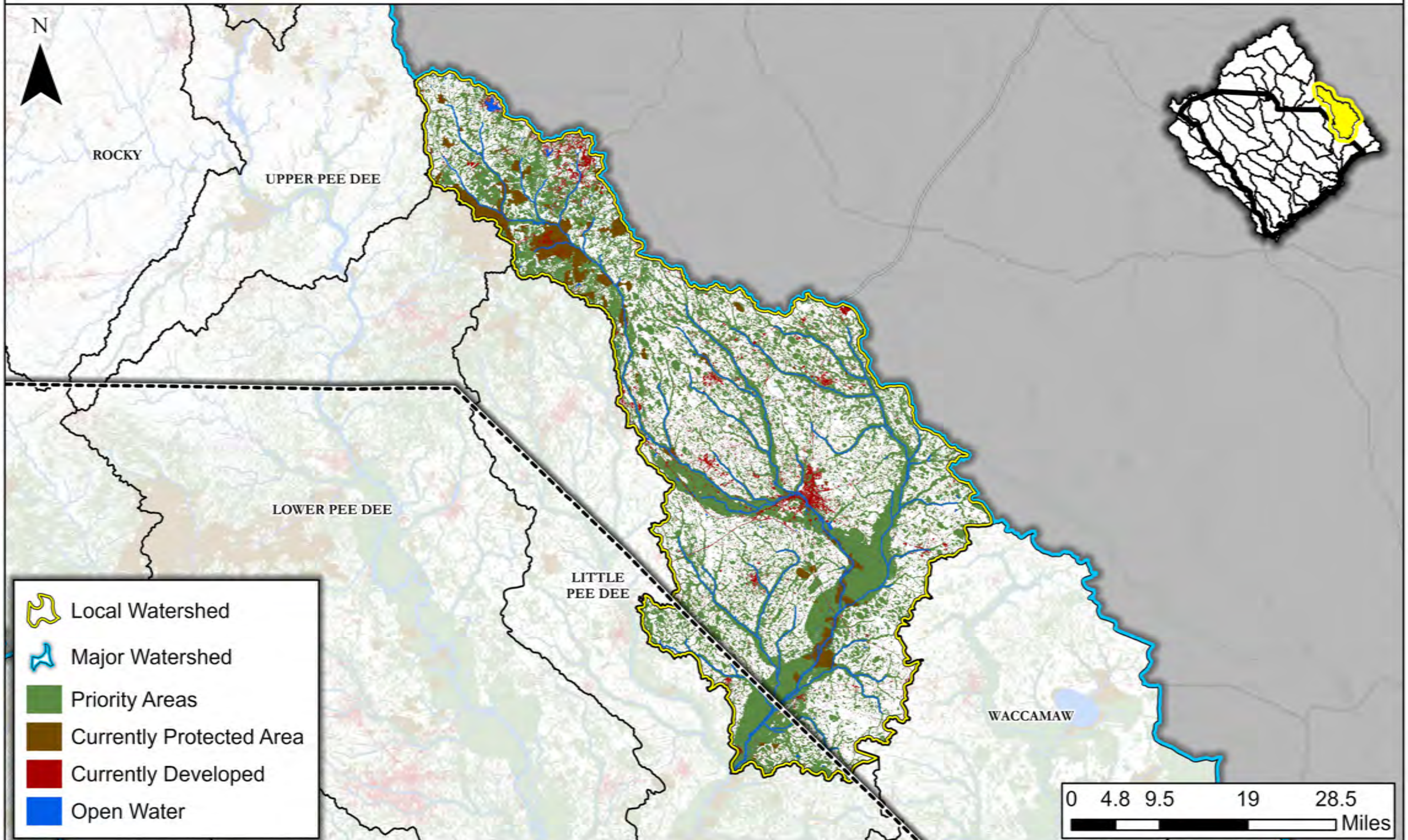
Prioritized Flood Mitigation Areas

Lumber Watershed



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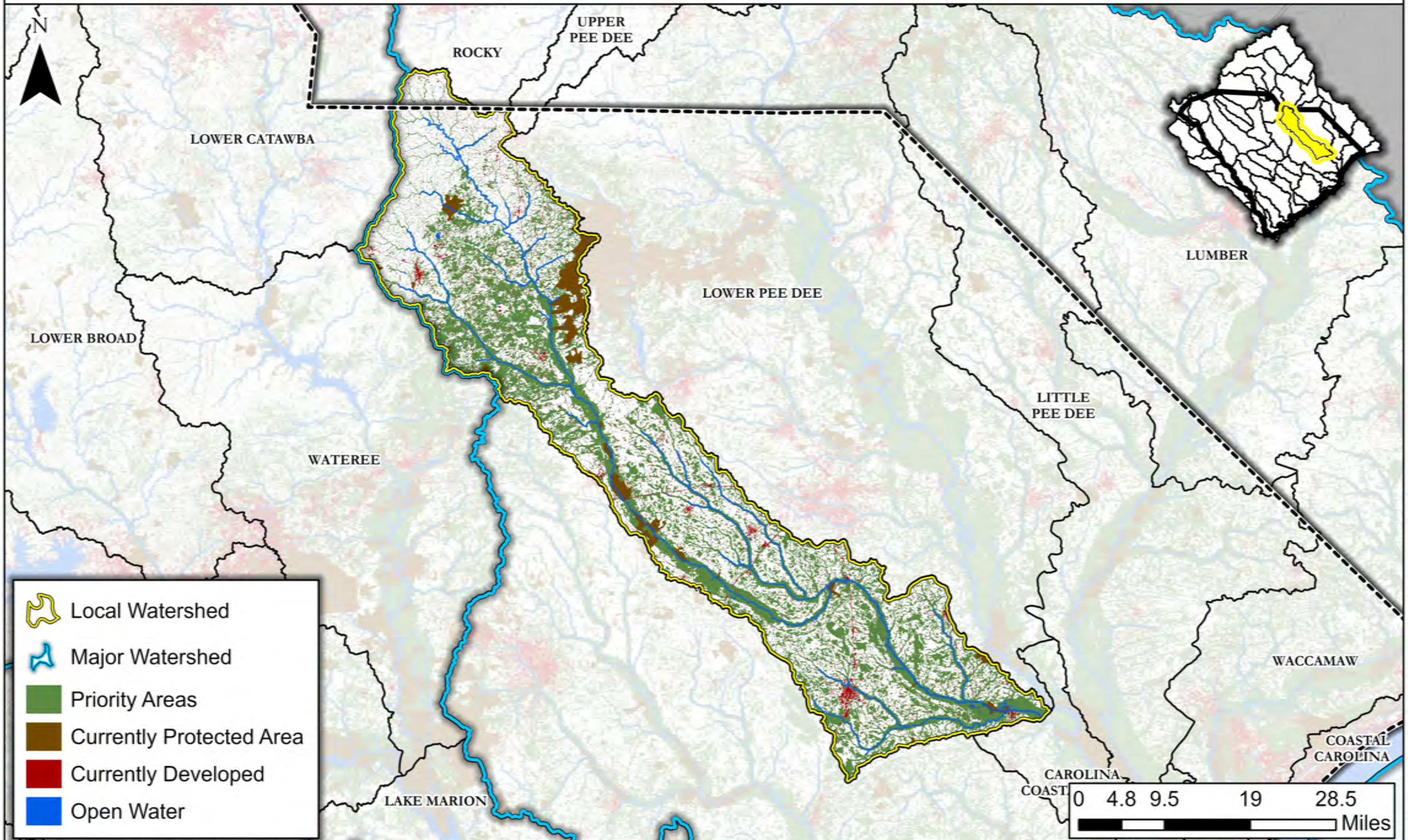
Prioritized Flood Mitigation Areas

Lynches Watershed



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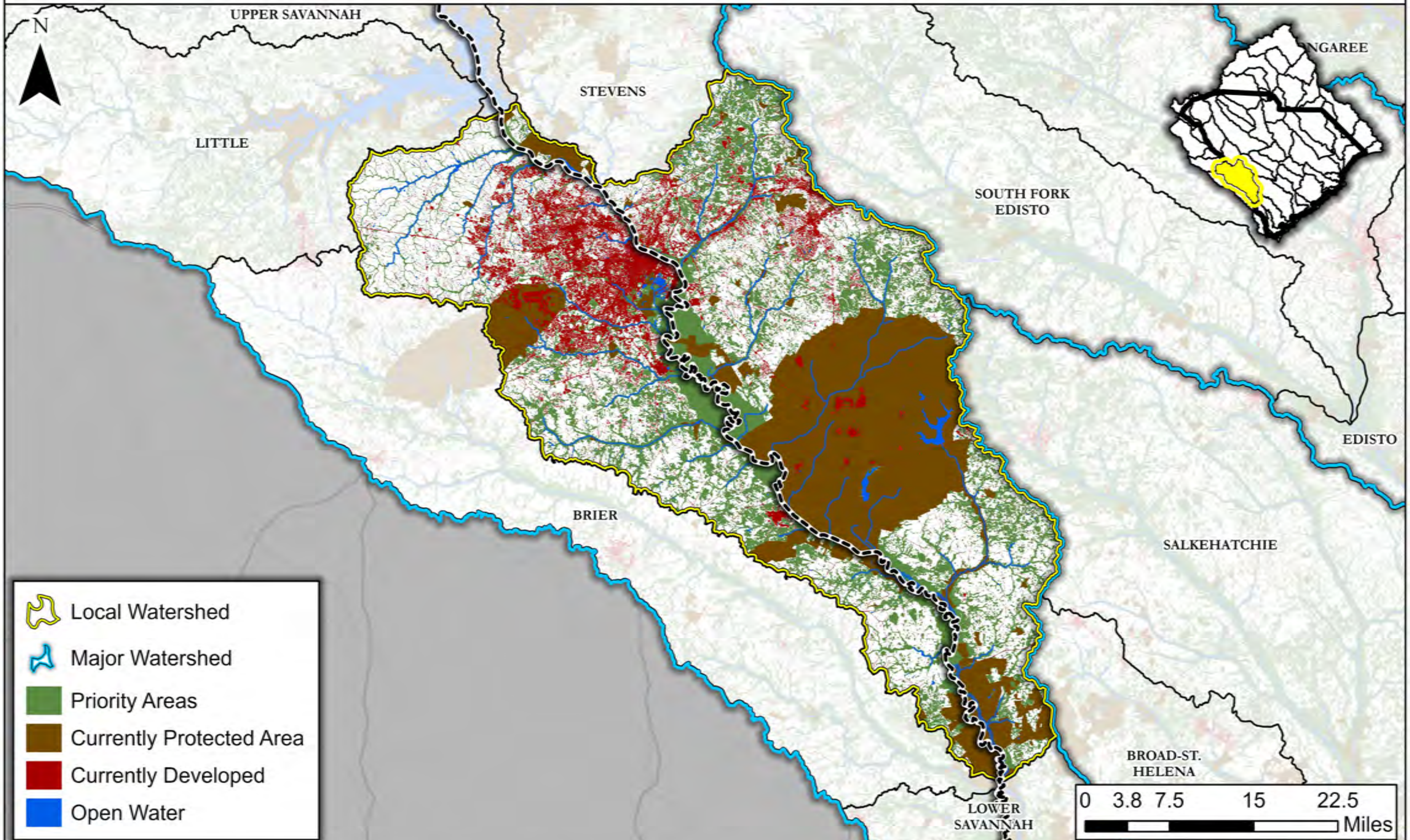
Prioritized Flood Mitigation Areas

Middle Savannah Watershed



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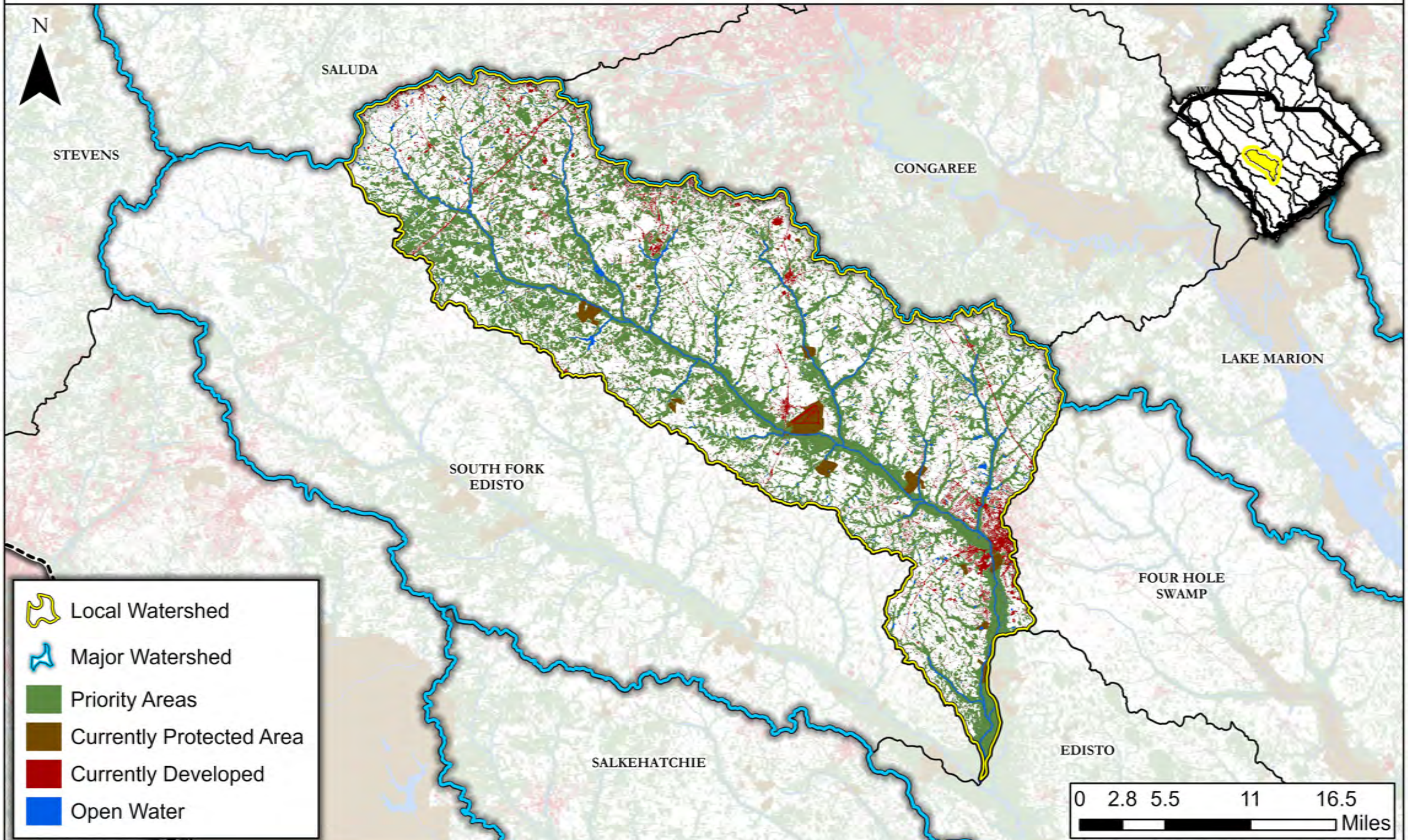
Prioritized Flood Mitigation Areas

North Fork Edisto Watershed



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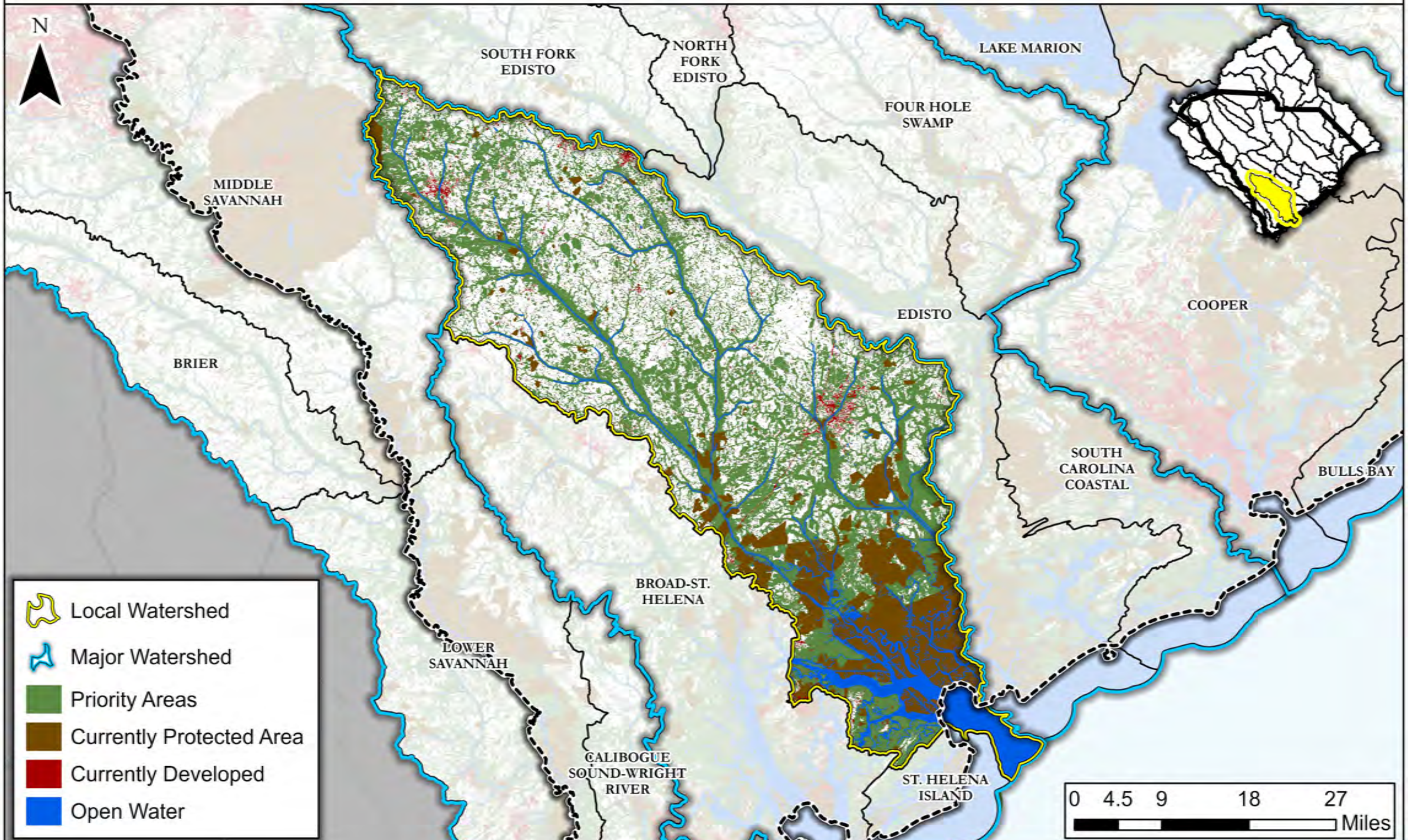
Prioritized Flood Mitigation Areas

Salkehatchie Watershed



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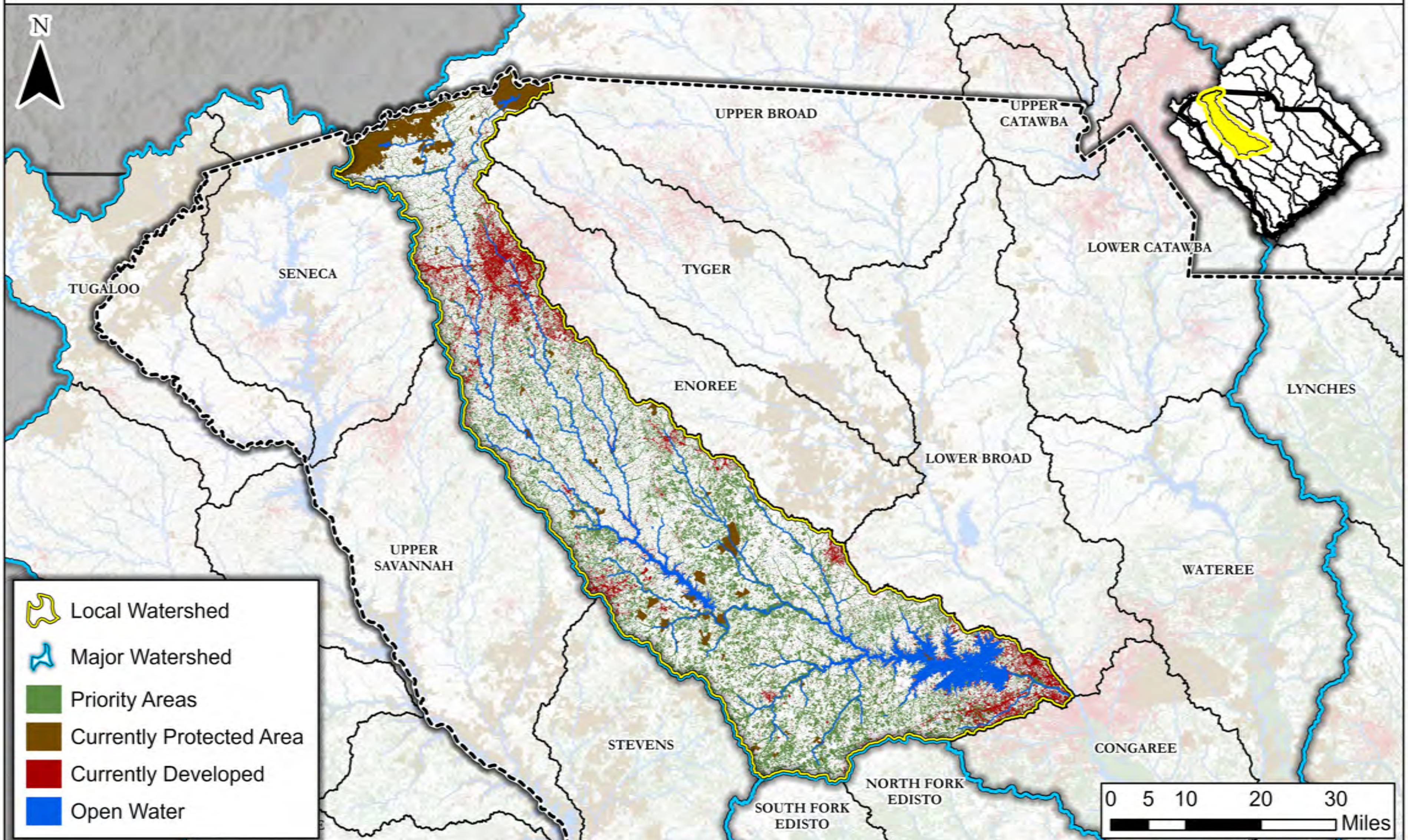
Prioritized Flood Mitigation Areas

Saluda Watershed



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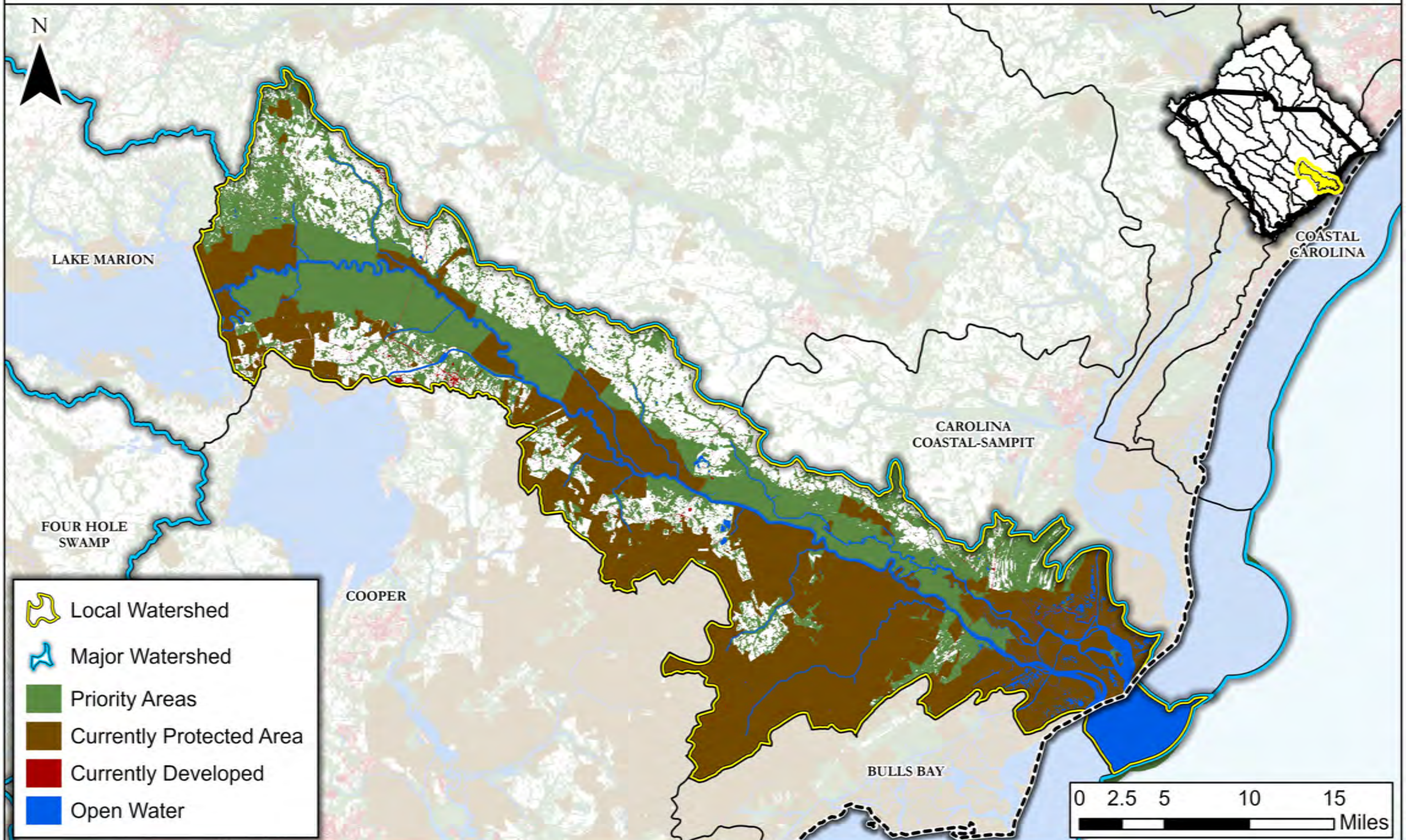
Prioritized Flood Mitigation Areas

Santee Watershed



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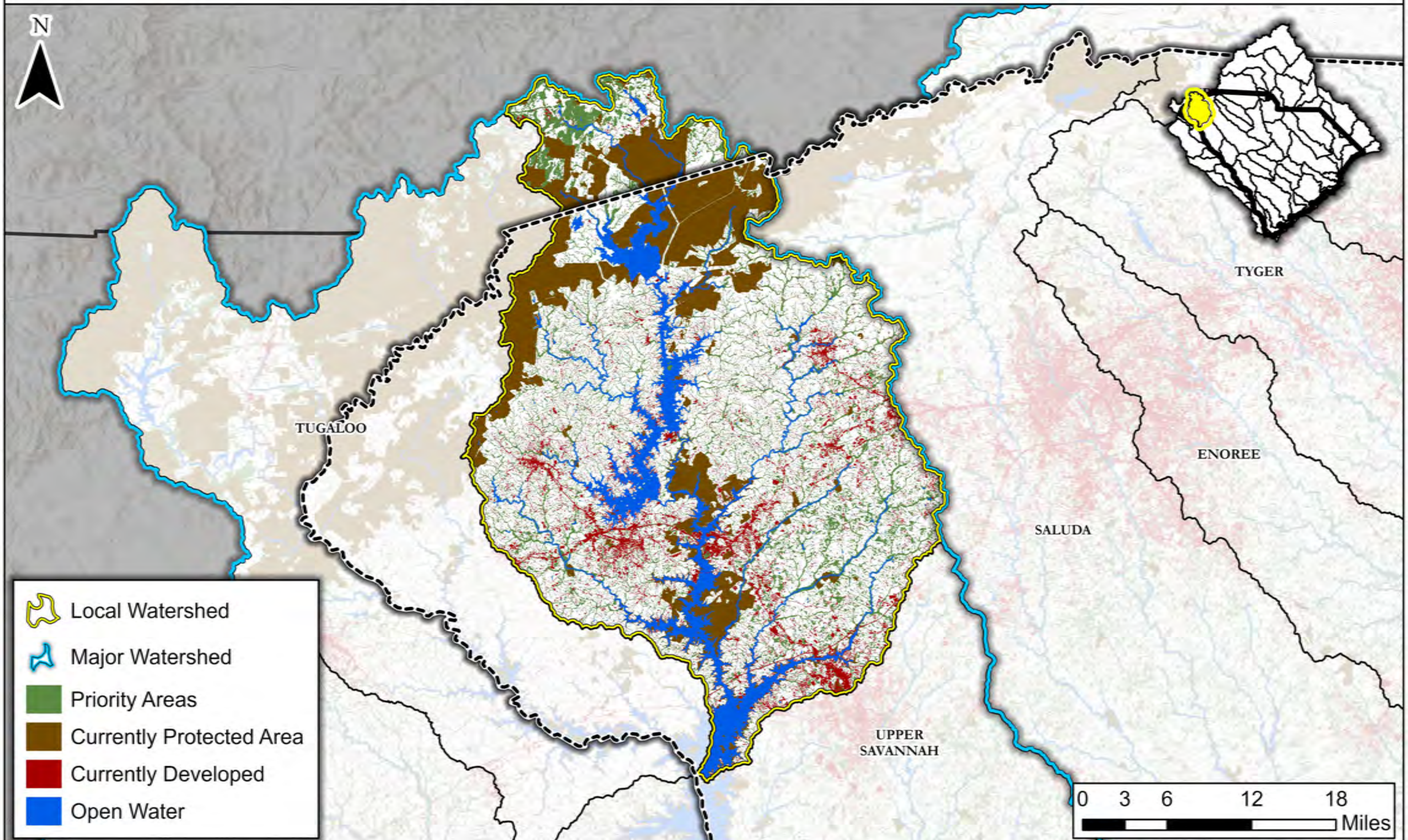
Prioritized Flood Mitigation Areas

Seneca Watershed



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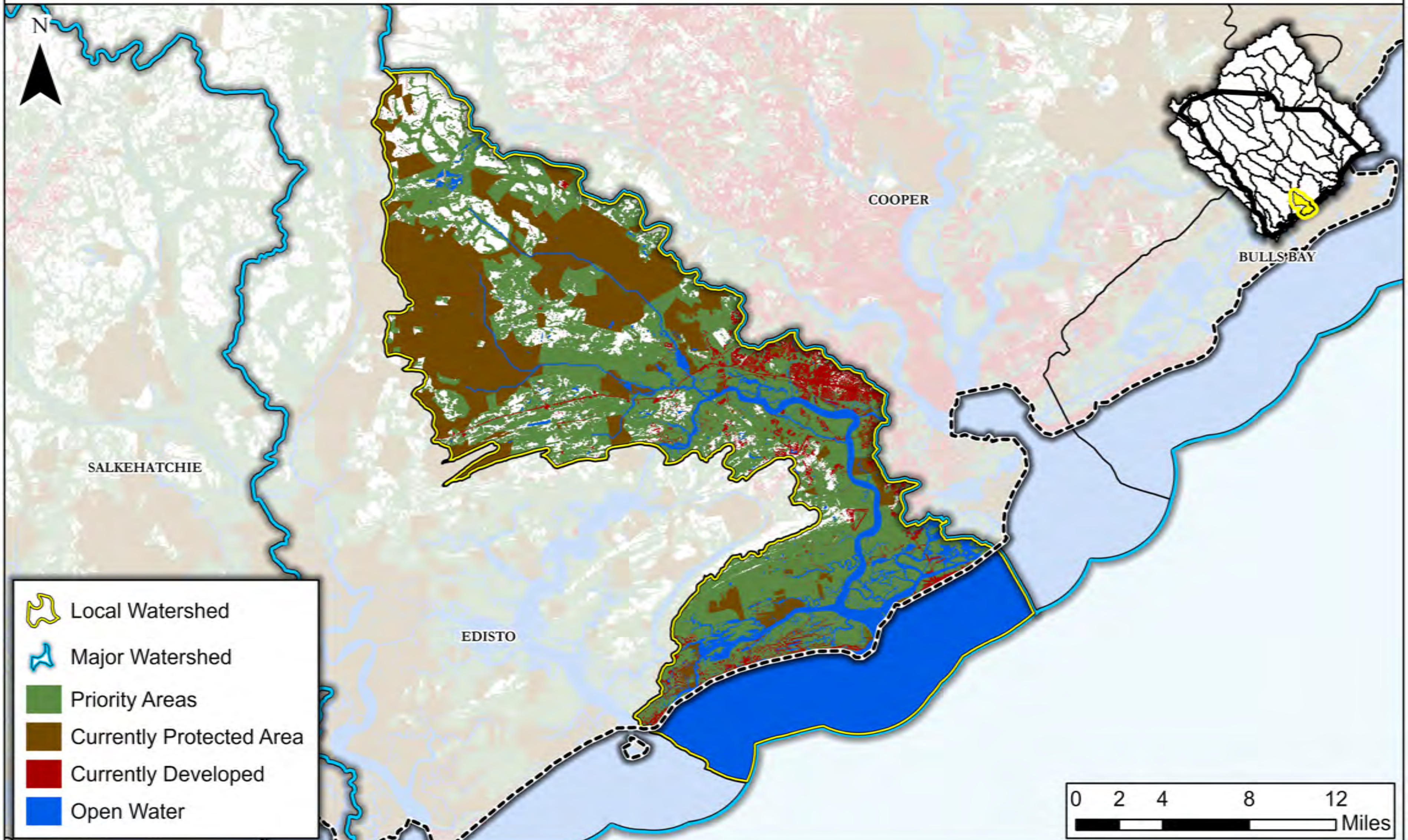
Prioritized Flood Mitigation Areas

South Carolina Coastal Watershed



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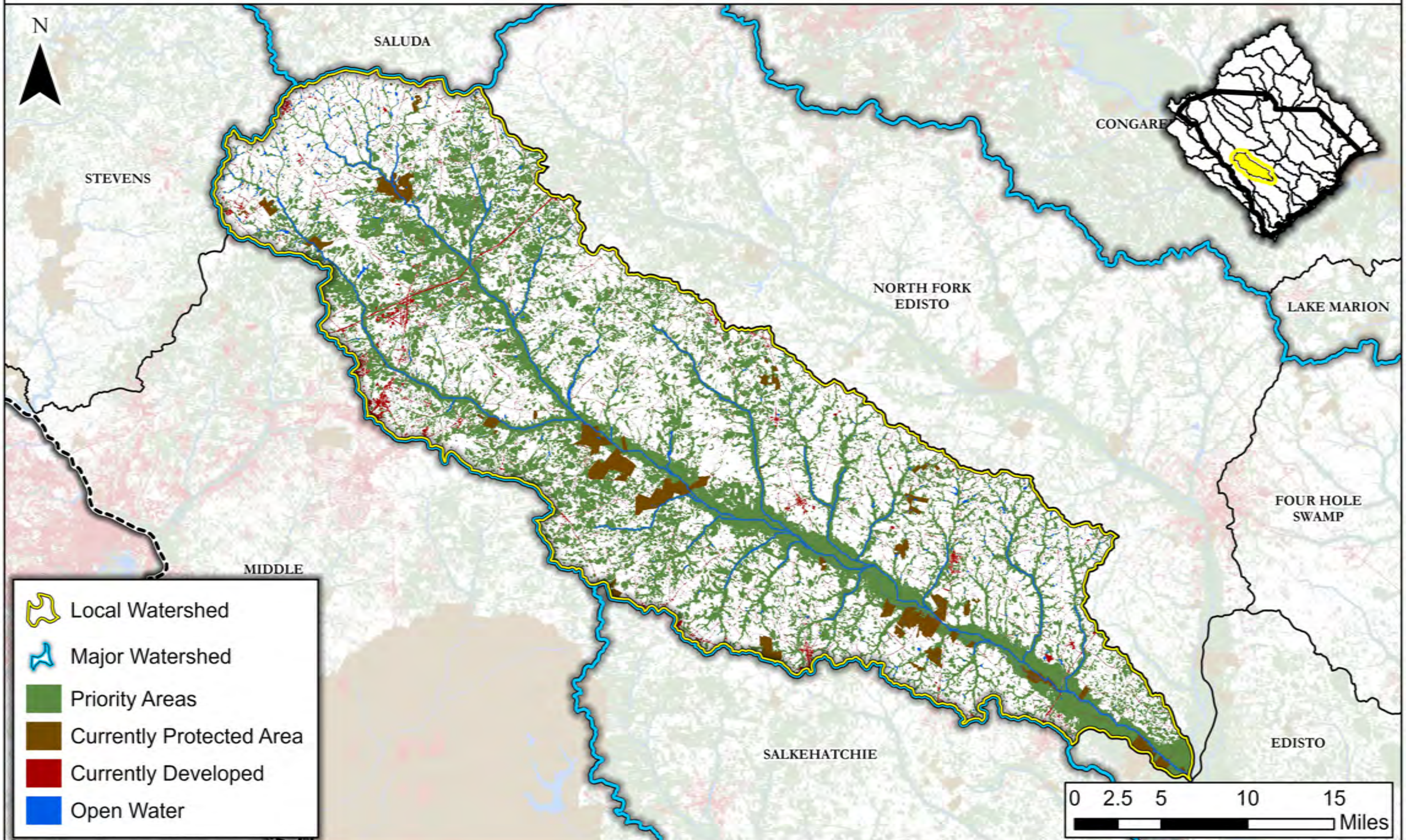
Prioritized Flood Mitigation Areas

South Fork Edisto Watershed



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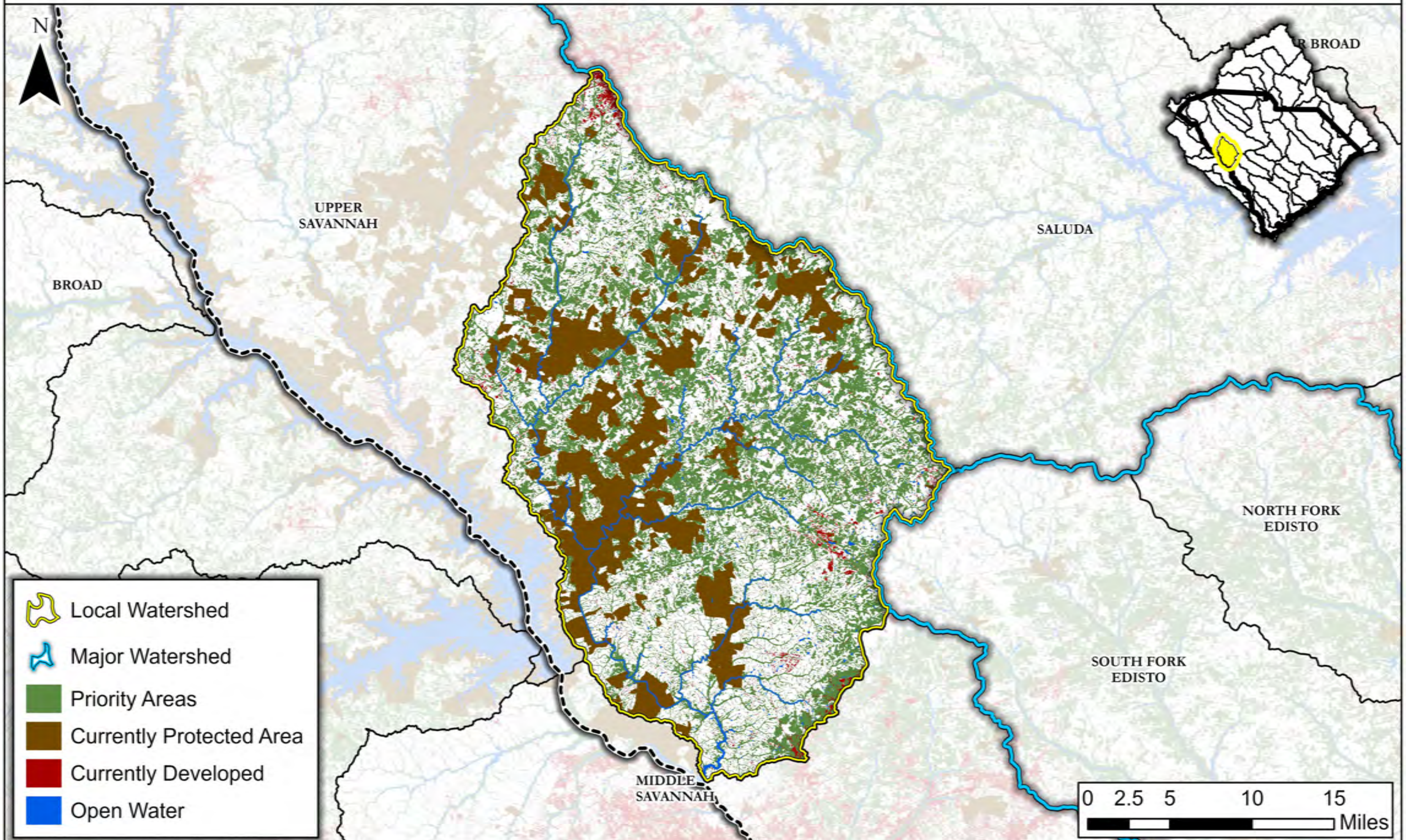
Prioritized Flood Mitigation Areas

Stevens Watershed



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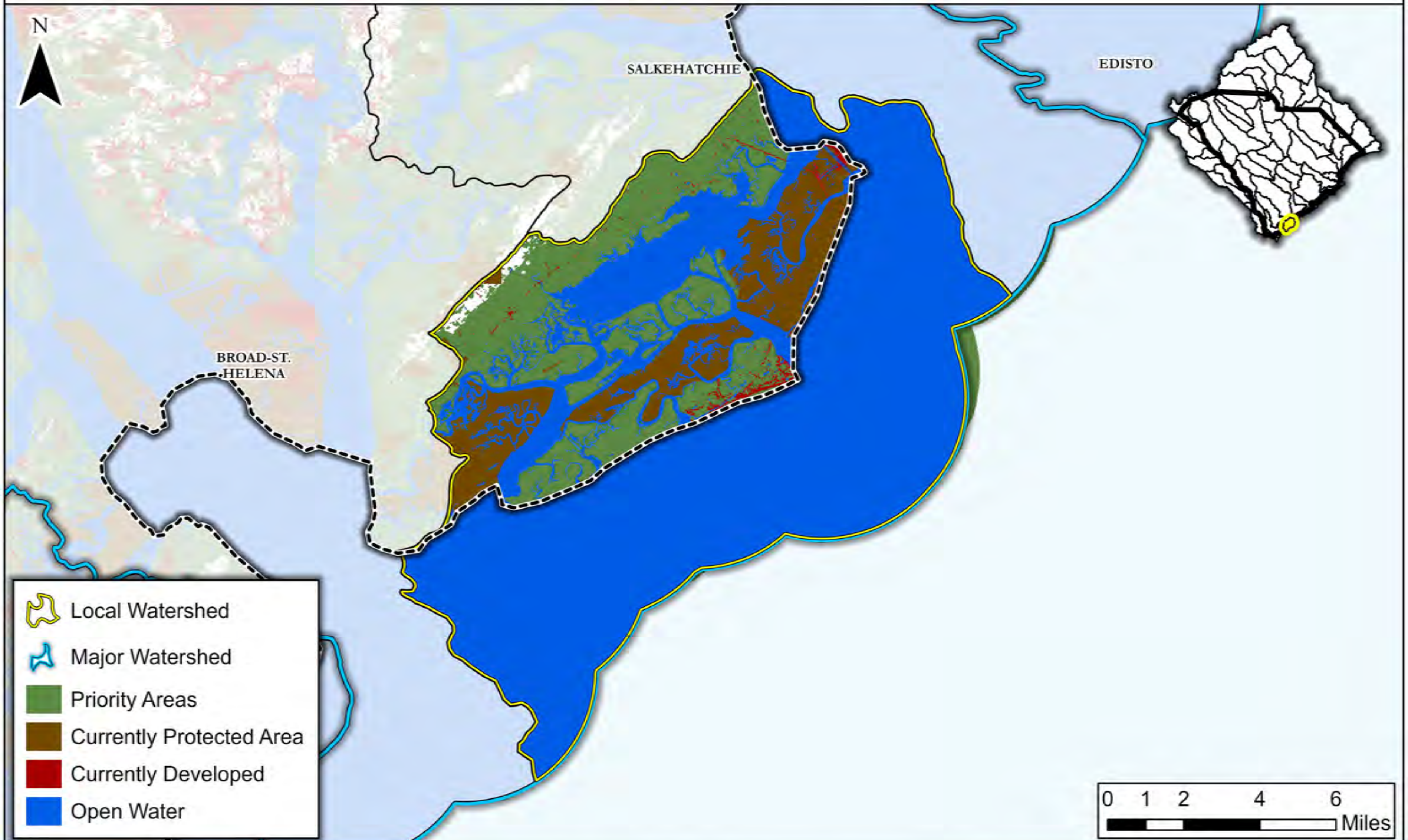
Prioritized Flood Mitigation Areas

St. Helena Island Watershed



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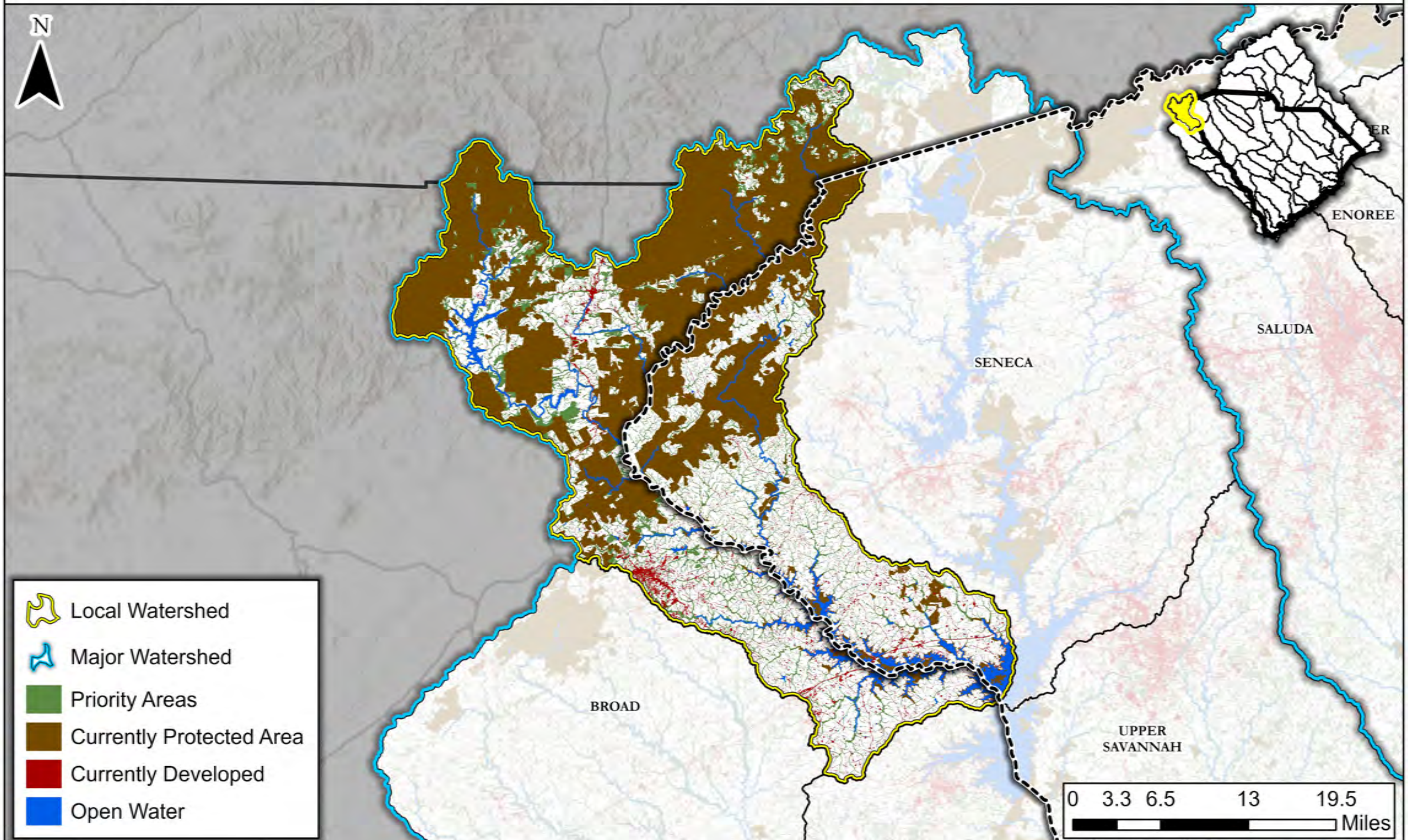
Prioritized Flood Mitigation Areas

Tugaloo Watershed



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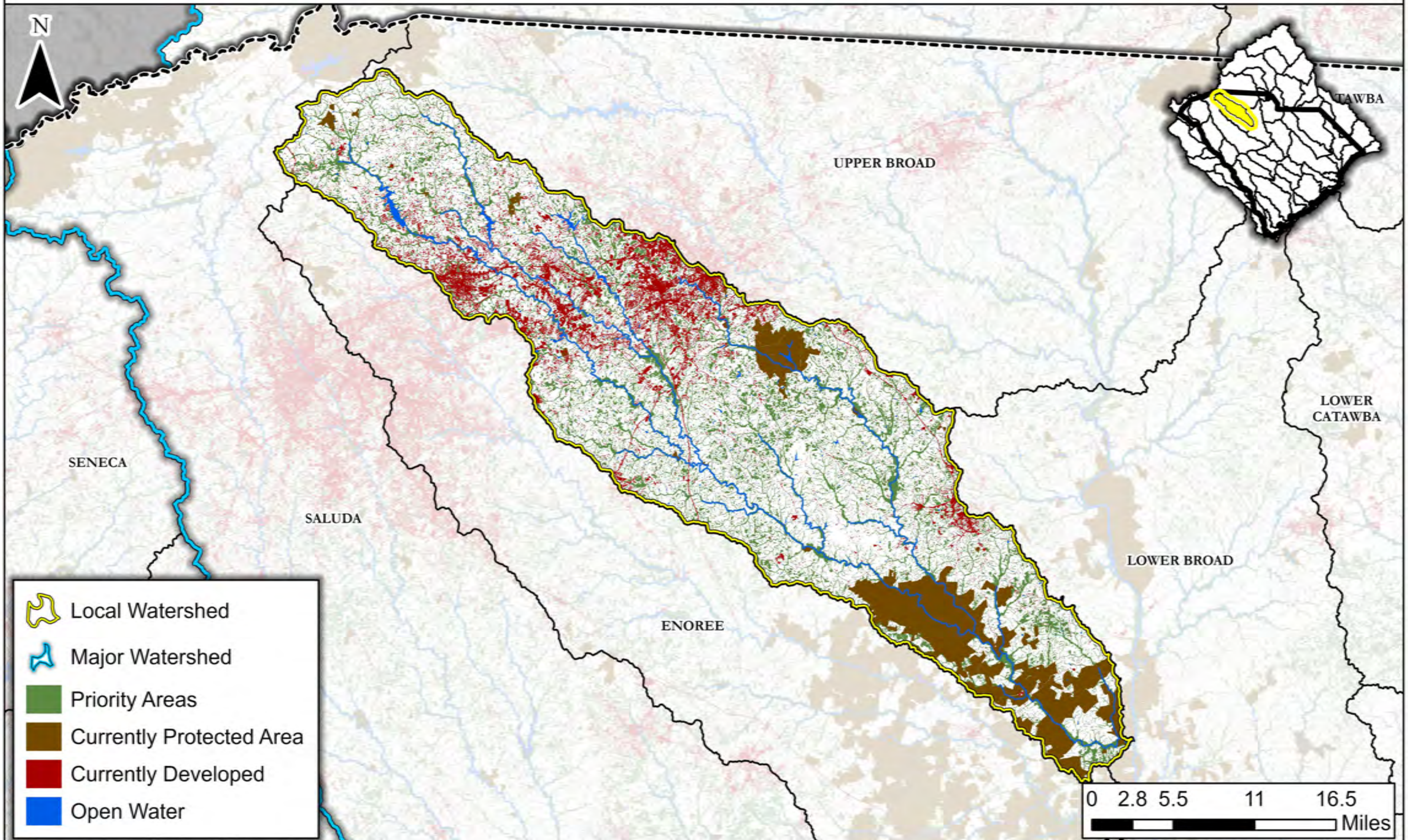
Prioritized Flood Mitigation Areas

Tyger Watershed



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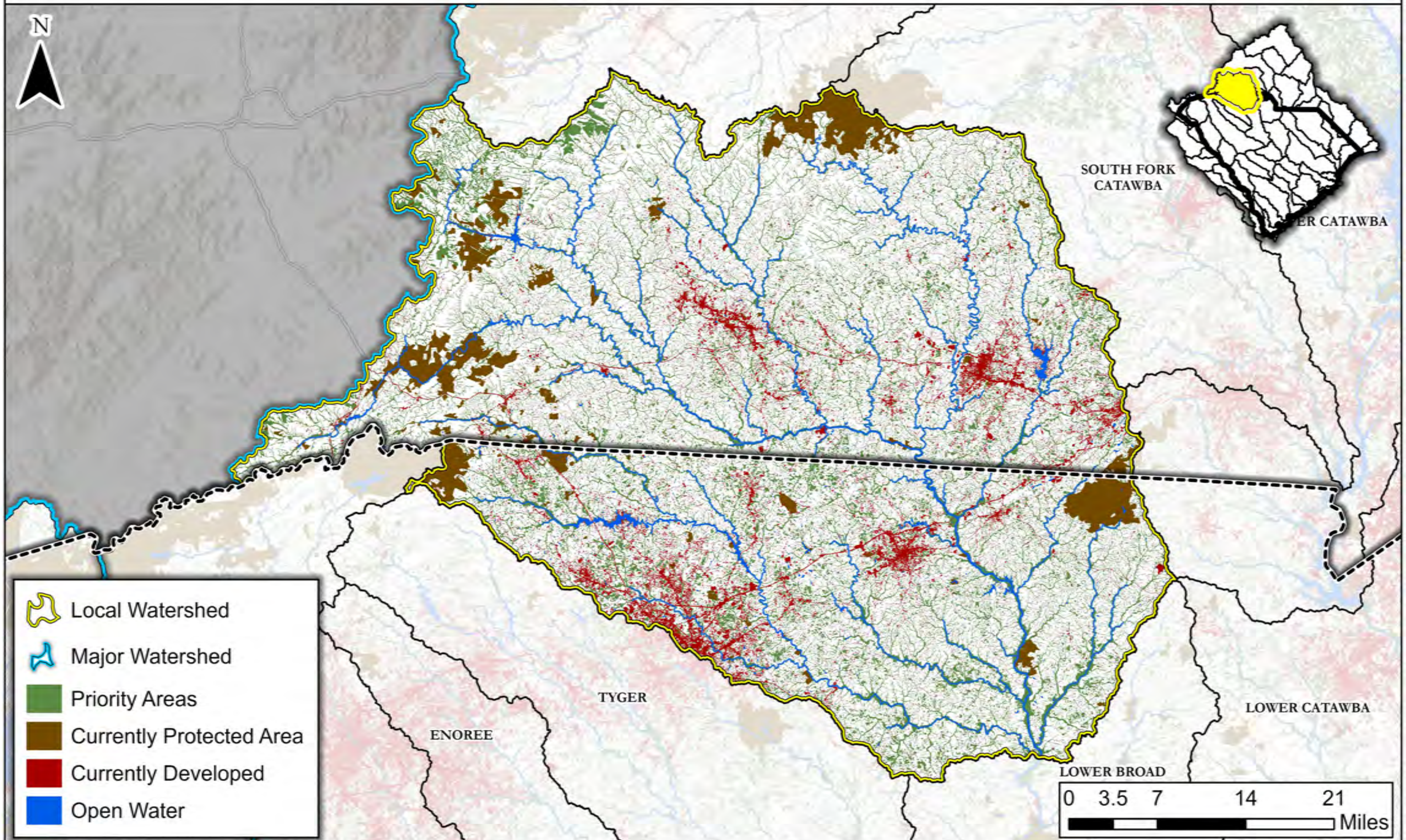
Prioritized Flood Mitigation Areas

Upper Broad Watershed



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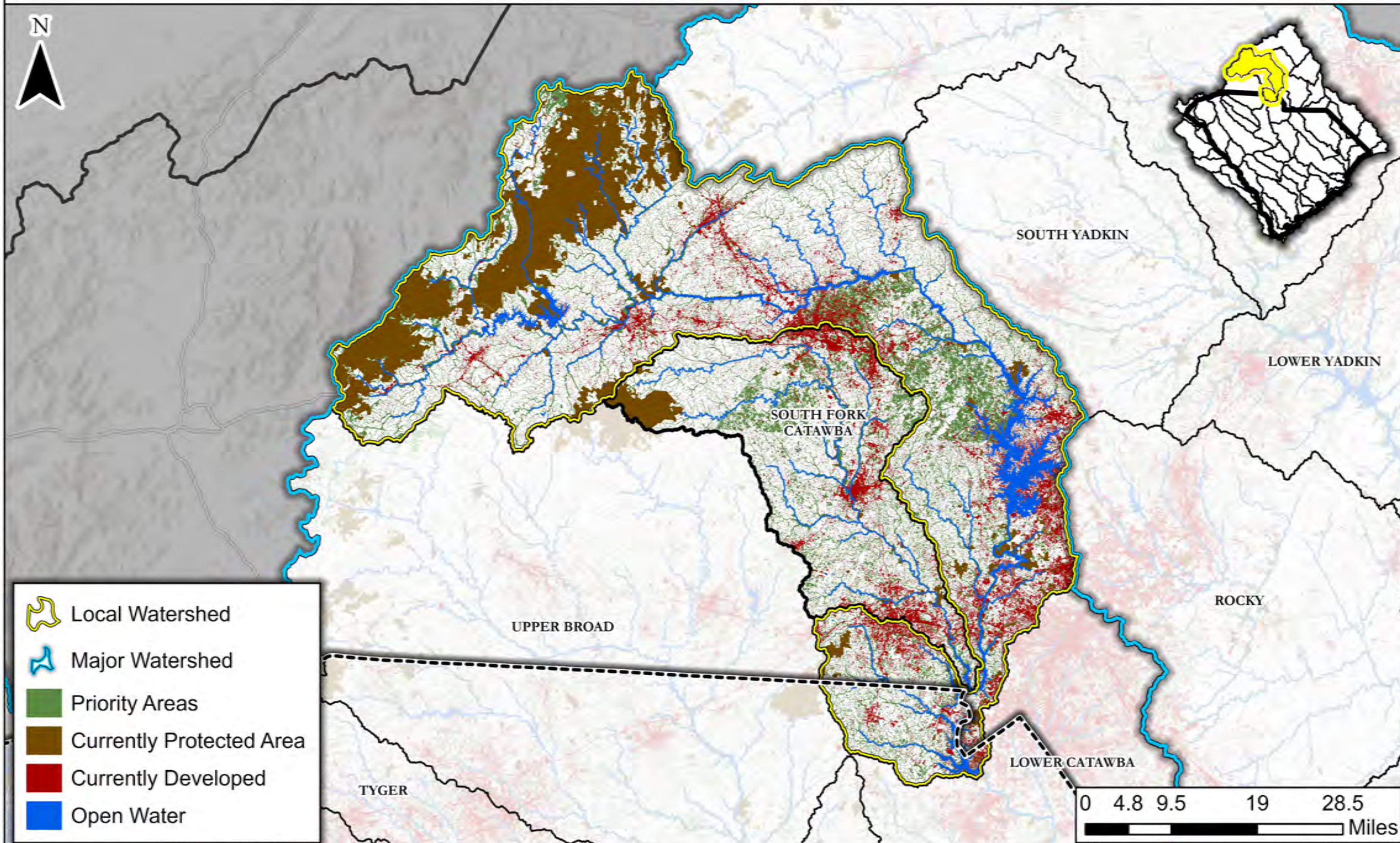
Prioritized Flood Mitigation Areas

Upper Catawba Watershed



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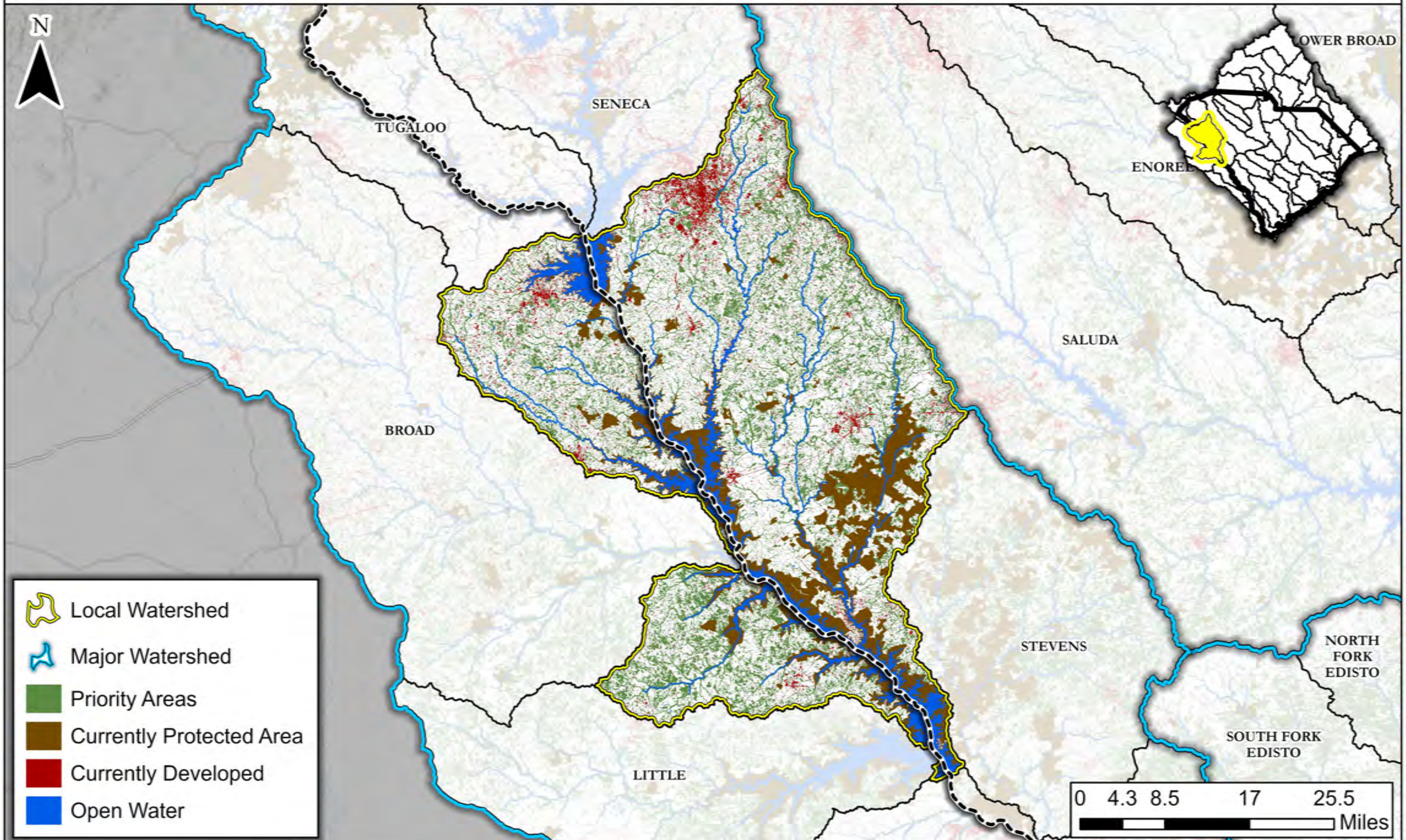
Prioritized Flood Mitigation Areas

Upper Savannah Watershed



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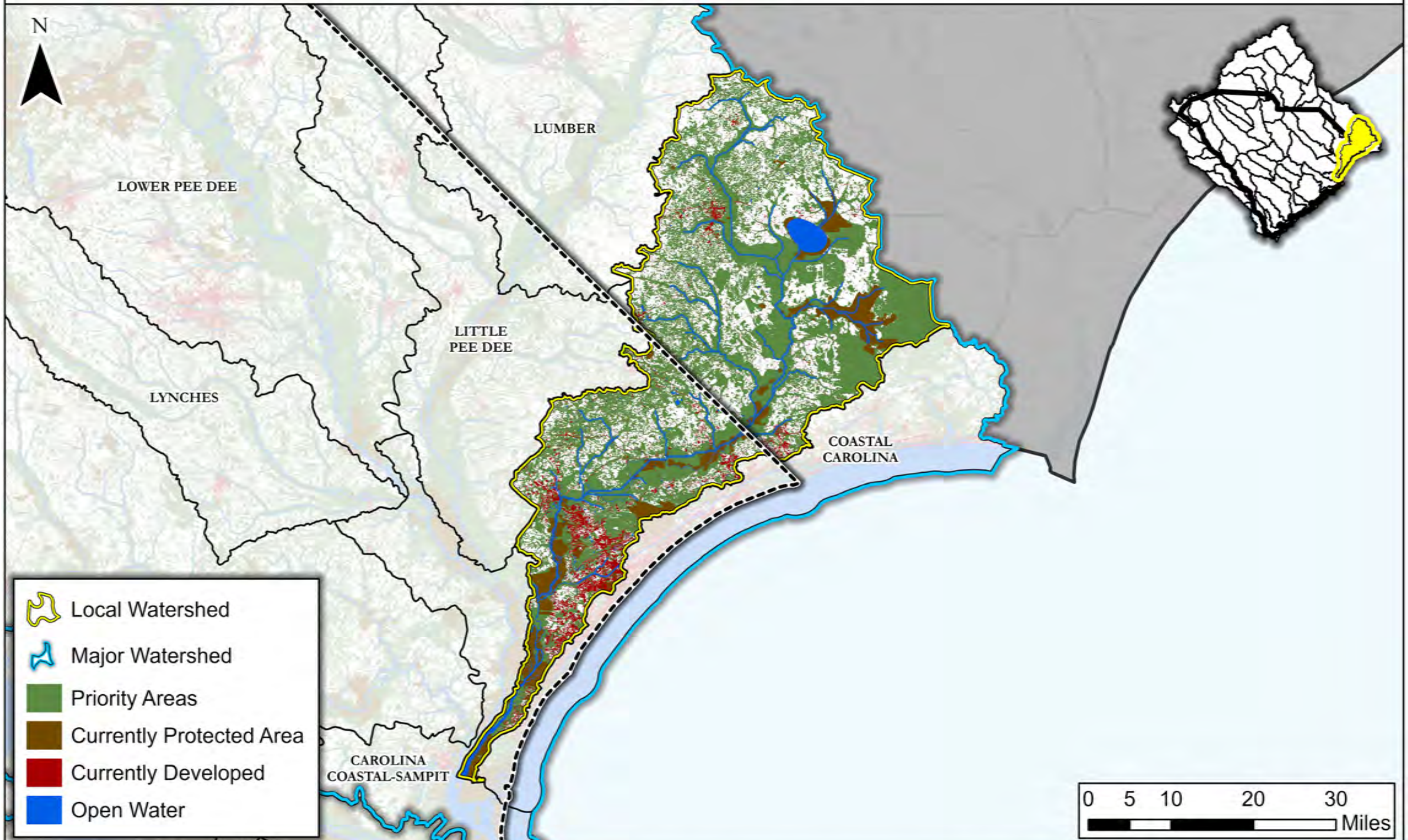
Waccamaw Watershed



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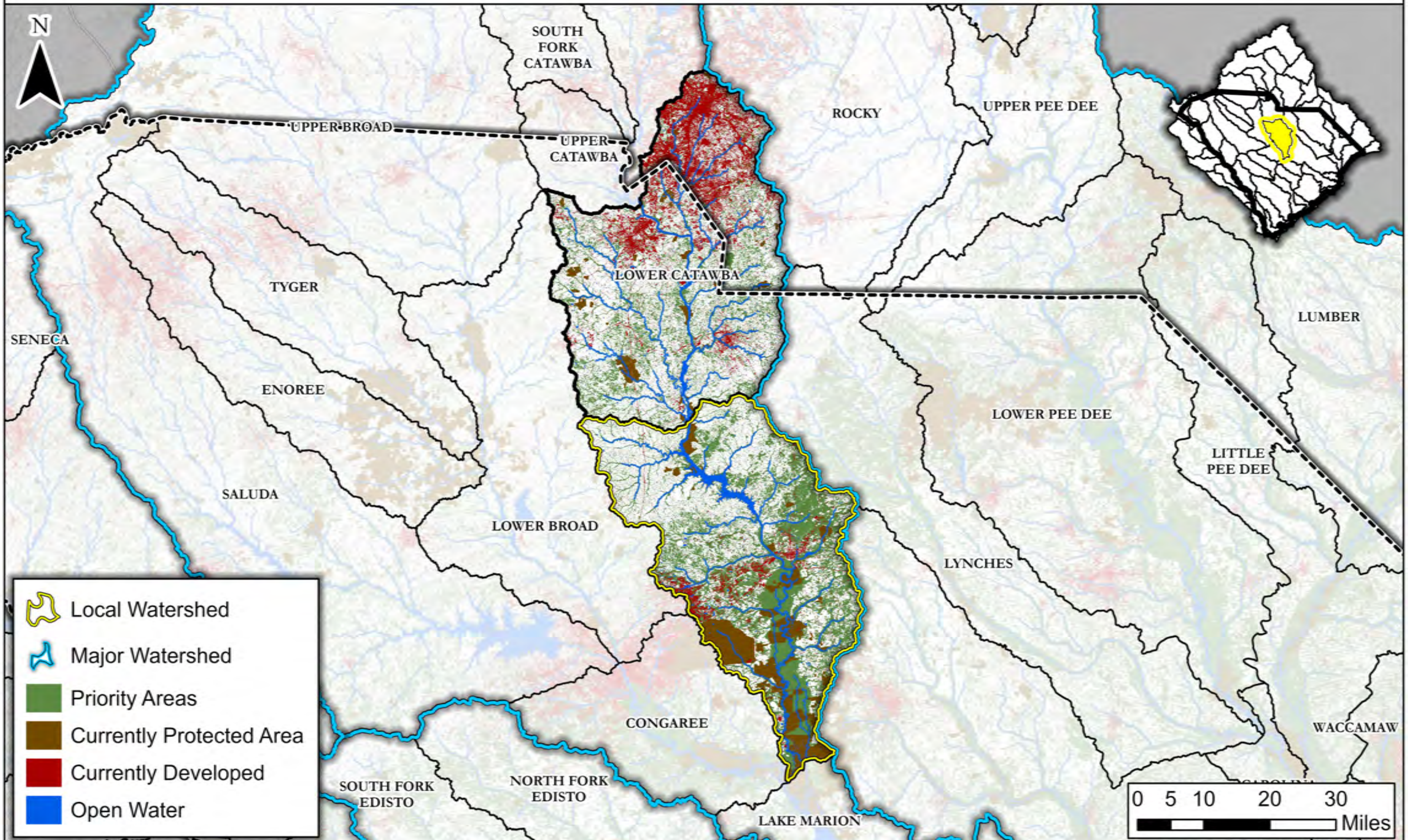
Wateree Watershed



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APPENDIX H:
BUYOUT METHODOLOGY AND SUMMARY

PROPERTY ACQUISITIONS/BUYOUT CRITERIA

The following criteria is proposed in order to develop an estimate of the number and cost of residential properties that may be appropriate for buyout across the state. Developing a buyout program would require a more detailed analysis and eligibility would ultimately be determined by the funding source and voluntary.

TIER 1:

REPETITIVE LOSS PROPERTIES IN THE FEMA REGULATORY FLOODWAY

Prioritizing repetitive loss properties in the FEMA regulatory floodway will provide relief to those homeowners who have seen repetitive damage and increase the function of the natural floodway. FEMA defines a repetitive loss structure as “any NFIP-insured structure that has had at least 2 paid flood losses of more than $1,000 each in any 10-year period since 1978” (FEMA, 2020). FEMA defines the regulatory floodway as “the channel of a river or other watercourse and the adjacent land areas that must be reserved in order to discharge the base flood without cumulatively increasing the water surface elevation more than a designated height.” Communities regulate development in these floodways to makes sure there are no increases in upstream flood elevations (FEMA, 2020). Therefore, purchasing these properties will also produce a compounding benefit downstream.

REPETITIVE LOSS PROPERTIES SEAWARD OF THE DHEC BEACHFRONT SETBACK LINE

DHEC designates the beachfront setback line landward of a designated baseline that is placed at the crest of the primary oceanfront sand dune (that is the dune immediately adjacent to the ocean). The setback line’s distance from the baseline varies along the coast and is determined by the calculated long-term annual erosion rate in that area, with a minimum setback of 20 feet.

TIER 2:

PROPERTIES IN THE FEMA REGULATORY FLOODWAY

Following properties that were both repetitively loss according to FEMA and in the floodway, Tier 2 addresses the rest of the properties in the FEMA Regulatory Floodway. It should be noted that there are streams and watercourse where FEMA has provided base flood elevations, but not designated a floodway. In these cases, communities review floodplain development on a case-by-case basis to maintain water surface elevations or may adopt a floodway if adequate information is available (FEMA, 2020). Again, floodway purchases not only protect surrounding properties, but provide downstream benefits as well.

PROPERTIES SEAWARD OF THE DHEC BEACHFRONT BASELINE

After targeting the repetitive loss properties seaward of the setback line, the next tier for coastal properties are those structures that are seaward of the DHEC baseline, which is placed at the crest of the primary oceanfront sand dune (the dune immediately adjacent to the ocean). Being seaward of this dune means these properties have little to no natural protection from coastal storms and flooding.

TIER 3:

ALL OTHER REPETITIVE LOSS PROPERTIES

Once the floodway has been addresses, Tier 3 seeks to give relief to owners of the remaining repetitive loss structures. FEMA defines a repetitive loss structure as “any NFIP-insured structure that has had at least 2 paid flood losses of more than $1,000 each in any 10-year period since 1978” (FEMA, 2020).

PROPERTIES SEAWARD OF DHEC SETBACK LINE

This tier prioritizes those properties that are seaward of the setback line but are not repetitive loss properties. Again, the setback line’s distance varies along the coast, calculated using the long-term annual erosion rate in the area, with a minimum setback of 20 feet from the baseline.

TIER 4:

FIRST STREETS 100-YEAR EVENT (2020) WITH 6+ FEET OF INUNDATION

First Street’s dataset is an ideal supplement to FEMA mapping, providing a greater resolution to identify those properties that will see six or more feet of inundation in the 100-year event. The dataset includes areas that are not included in the FEMA 100-year floodplain but have historically seen flooding. A study using NFIP-derived relative structure damages (structural damages as a percentage of building value) found that at 6 feet of flooding, the median relative damage was around 50% (Wing, Pinter, Bates, & Kousky, 2020). This value is consistent with FEMA’s substantial damage determination.

TIER 5:

FIRST STREETS 100-YEAR EVENT (2051) WITH 6+ FEET OF INUNDATION

The First Street Foundation's dataset provides flood hazard projections and modeling for 30 years in the future (2051) using low, medium, and high scenarios. This allow for the identification of properties that will be inundated by a 100-year event in 2051. Utilizing the medium scenario, Tier 4 identifies those properties with 6 feet or more of inundation as appropriate for buyout. It is important to note that many of these properties are likely already seeing flooding but are identified as having a greater likelihood or depth of flooding over the next thirty years. Additionally, a thirty-year projection relates to the length of a typical mortgage. A buyout sooner rather than later will reduce future losses and further protect the consumer from future losses.

RESULTS

An estimation of the number and value of buyouts in each Tier along with the cumulative estimates can be found in Table 1. Tiers are not cumulative, and locations are presented as HUC10 watersheds to protect the exact location of at-risk parcels.

Table 1: Properties Identified within each Tier and the estimated value of those properties

	Count of Properties in Tier	Sum of AVM ($) in Tier	Cumulative Count	Cumulative Sum of AVM ($)	Percent of Properties in SC
Tier 1	119	22,236,508	119	22,236,508	0.01%
Tier 2	3,958	810,091,503	4,077	832,328,012	0.15%
Tier 3	3,591	688,500,746	7,668	1,520,828,758	0.29%
Tier 4	40,596	8,156,752,475	48,264	9,677,581,234	1.82%
Tier 5	20,502	4,012,784,662	68,766	13,690,365,896	2.60%
Total Number of Properties in SC identified in dataset	2,645,755				

NOTES/LIMITATIONS

DATA

- The First Street dataset does not distinguish between developed and undeveloped parcels.
- The Automated Value Model (AVM) that is provided in the property level statistics is based on 2021 values and were not included in Version 2 of the First Street Flood Model due to housing market variations.
- DHEC is responsible for the management of South Carolina's beaches and beach/dune system. Using historical and present-day shoreline and beach profile information, DHEC designates a baseline and setback line along the coast. DHEC is responsible for designating and managing these lines. The lines are revised every 7-10 years as required by the South Carolina Coastal Zone Management Act, meaning that additional structures make come into this area as the lines change. The next cycle for baseline and setback line positions will begin in 2024.

CONTEXT FOR STATISTICS

- Although a total of 68,766 properties is substantial, these properties make up only about 2.6% of all properties statewide that are part of the First Street data set.
- Coastal maps are broken out by county as analyzing by HUC 8 would include areas too far inland.

ADDITIONAL CONSIDERATIONS FOR BUYOUT PROGRAM DEVELOPMENT

While the goal of this buyout estimate is to move people away from the flood hazard, it is recognized that there will be many properties that will be eligible for voluntary buyout programs based on risk, so vulnerable populations should be considered and prioritized in any buyout program. Households with the following characteristics should be eligible for buyouts:

PRIMARY RESIDENCE

The goal of this buyout criteria is to move people out of harm's way; therefore, we should move those who live in a structure full-time out first. Data for individual properties is available in tax records. By using county level Census data on the percentage of primary residences, we can predict how many structures this will remove from our buyout estimate. For eligibility purposes for individual properties, publicly available tax data may be used.

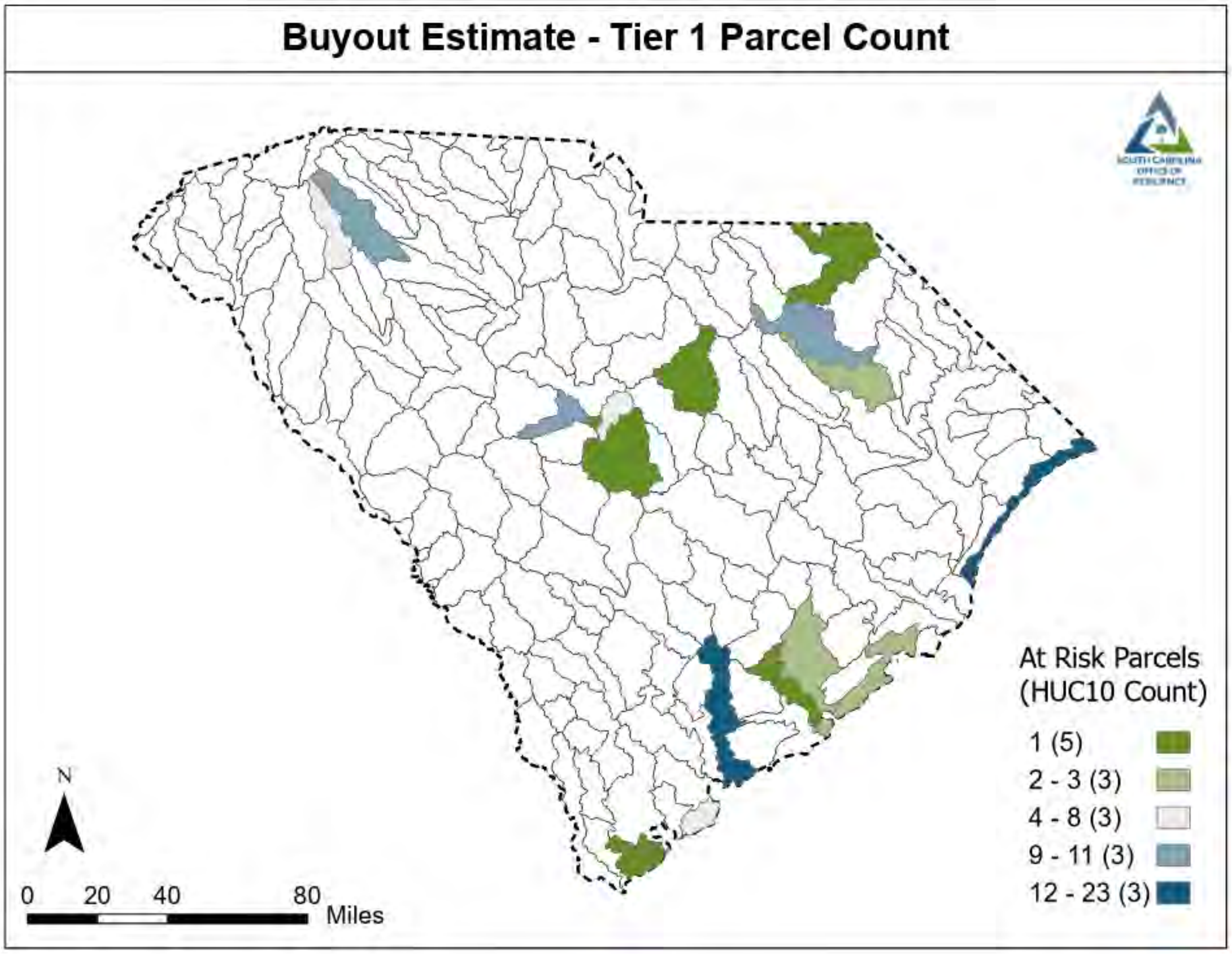
DATE OF PURCHASE

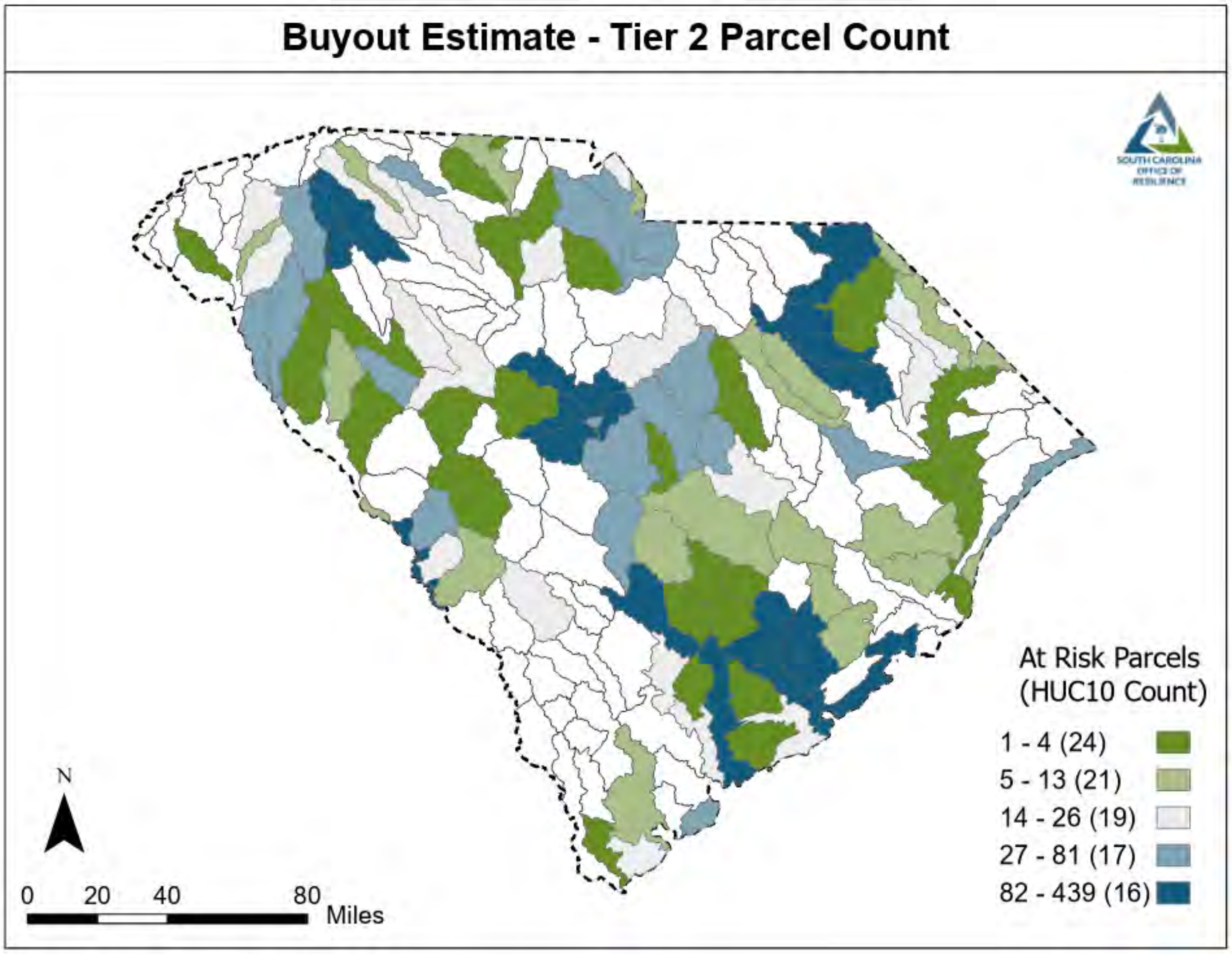
We should also prioritize those residents that purchased the property before 2020. These homeowners have likely suffered from one or more presidentially declared disasters and may have been unaware of the risk at the time of purchase. The criteria may also reduce the risk of people seeking to unfairly profit from this type of program and provides consistency with the formation of the Office of Resilience.

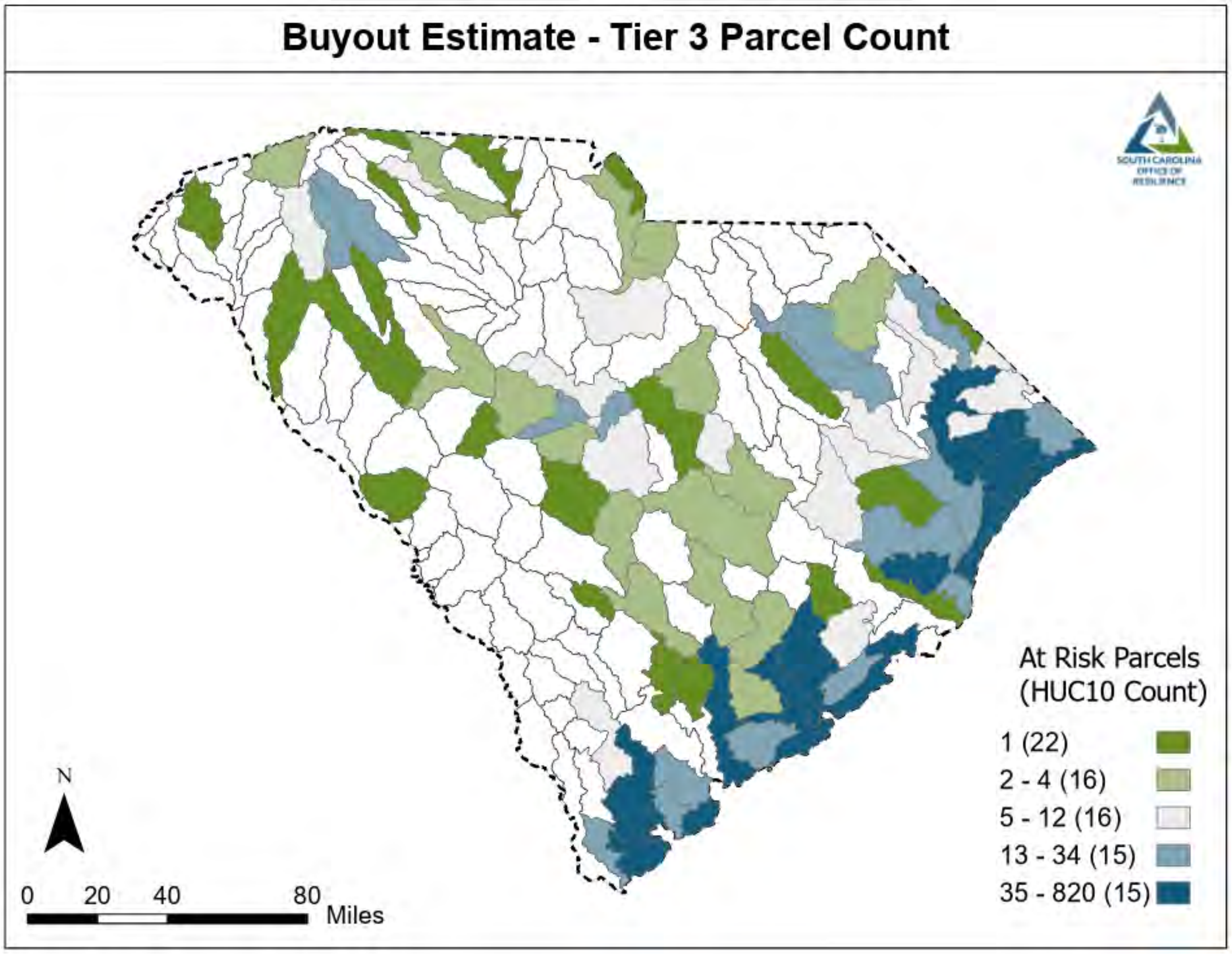
INCOME

This plan proposes that we should prioritize getting the most people out of harm's way, while helping those of middle and low-income who do not have the means to remove themselves from the hazard. Therefore, those households within the 75 percentile of the county's median income should be eligible for a buyout.

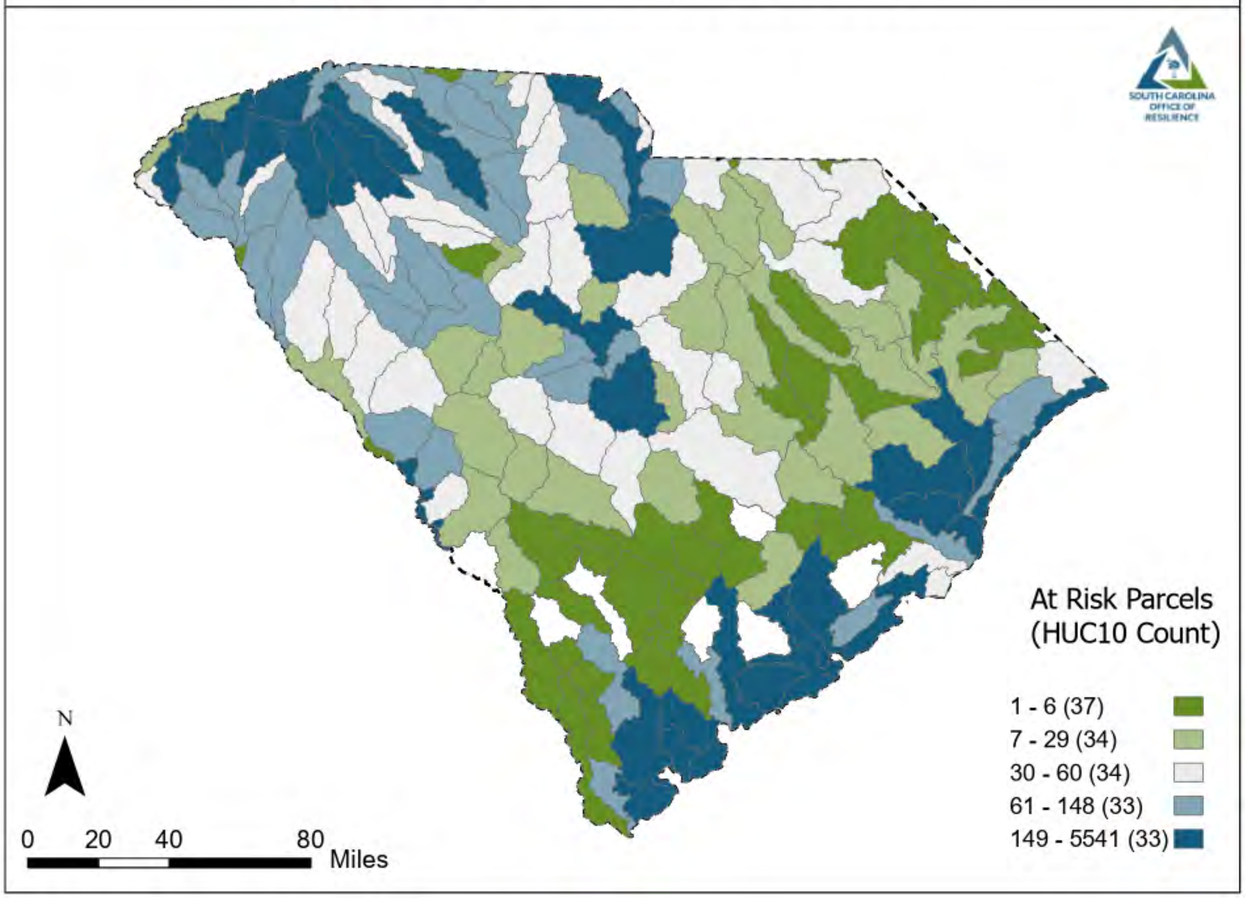
FIGURES:

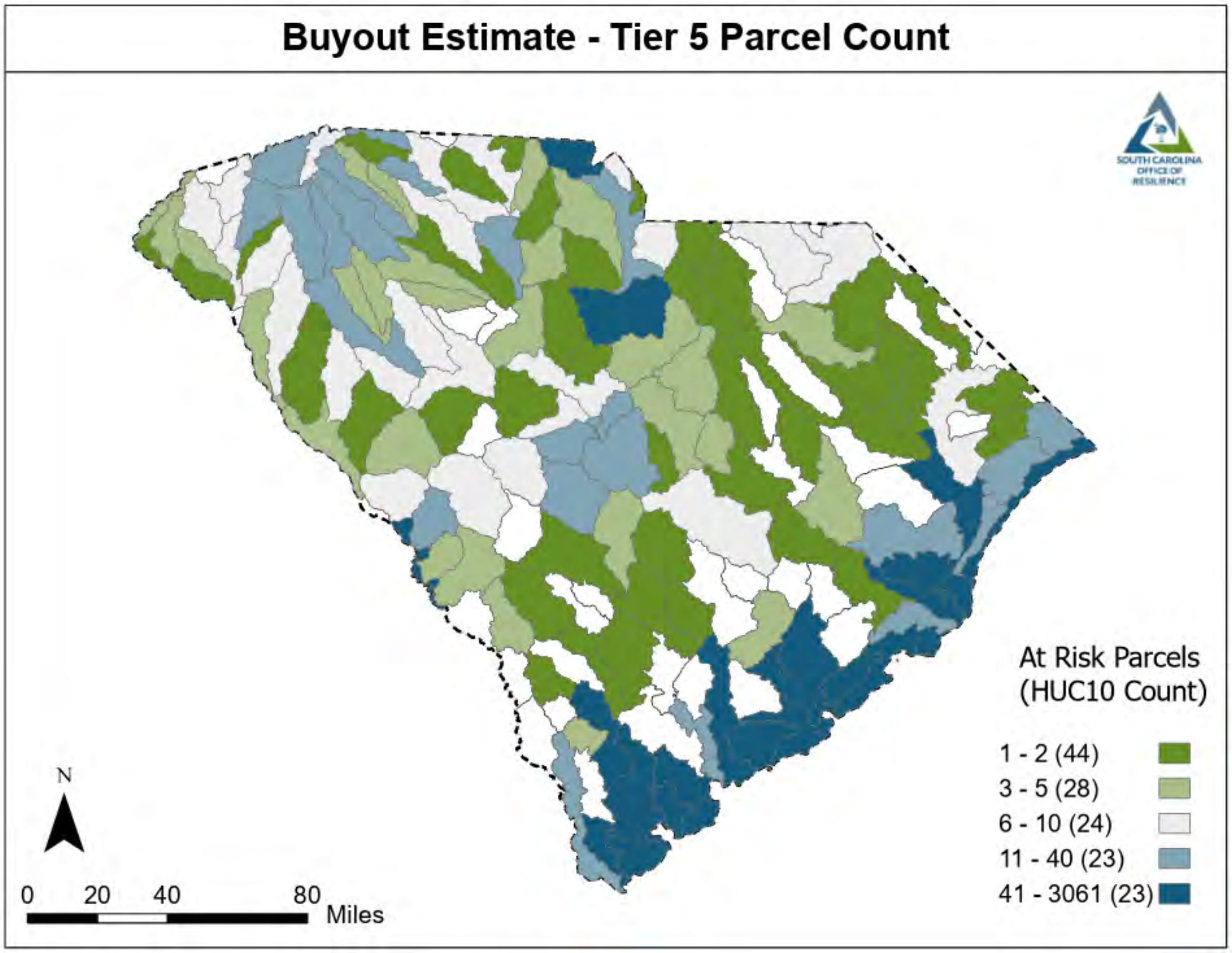

Buyout Estimate - Tier 1 Parcel Count
SOUTH CAROLINA OFFICE OF RESILIENCE
At Risk Parcels
(HUC10 Count)
1 (5)
2 - 3 (3)
4 - 8 (3)
9 - 11 (3)
12 - 23 (3)
N
0
20
40
80
Miles


Buyout Estimate - Tier 2 Parcel Count
SOUTH CAROLINA OFFICE OF RESILIENCE
At Risk Parcels (HUC10 Count)
1 - 4 (24)
5 - 13 (21)
14 - 26 (19)
27 - 81 (17)
82 - 439 (16)
N
0 20 40 80 Miles


Buyout Estimate - Tier 3 Parcel Count
At Risk Parcels
(HUC10 Count)
1 (22)
2 - 4 (16)
5 - 12 (16)
13 - 34 (15)
35 - 820 (15)
N
0 20 40 80
Miles

Buyout Estimate - Tier 4 Parcel Count





Buyout Estimate - Tier 5 Parcel Count
SOUTH CAROLINA OFFICE OF RESILIENCE
At Risk Parcels (HUC10 Count)
1 - 2 (44)
3 - 5 (28)
6 - 10 (24)
11 - 40 (23)
41 - 3061 (23)
N
0 20 40 80 Miles