FLOOD 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

FLOODING

In South Carolina flooding causes 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 including river flooding (fluvial), overland flooding (pluvial), and coastal flooding.

FLOOD FREQUENCY

Flooding is often described by its flood frequency and is difficult to understand for those that do not frequently interact with flood information. Often, floods are described by the occurrence intervals of 10-year, 100-year, 500-year, and 1,000-year events, but what does that mean? A 100-year event may have originally described the peak river stage (height) that happens once every 100 years, but now it currently describes the statistical probability of that flood height to occur. This can cause confusion though, in that a 100-year event can 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 recurrences interval for a 1 in 100-year flood event means that it has 1% chance of occurring any given year and is therefore described as 1% annual chance of occurrence (Table 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 the probability theory, has a 26% chance of having a 1-percent annual exceedance probability of flooding event over the life of a 30-year mortgage (Holmes & Dinicola, 2010).

Table 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%

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 the calculation for 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 1). Riverine flooding can be devastating because the rainfall or snowmelt needed to cause the flooding does not have to fall where the flooding occurs. Since 2000, over 195 riverine floods have been reported to the National Centers for Environmental Information database by local emergency managers, news reporters, and emergency responders (National Oceanic and Atmospheric Association, 2023).

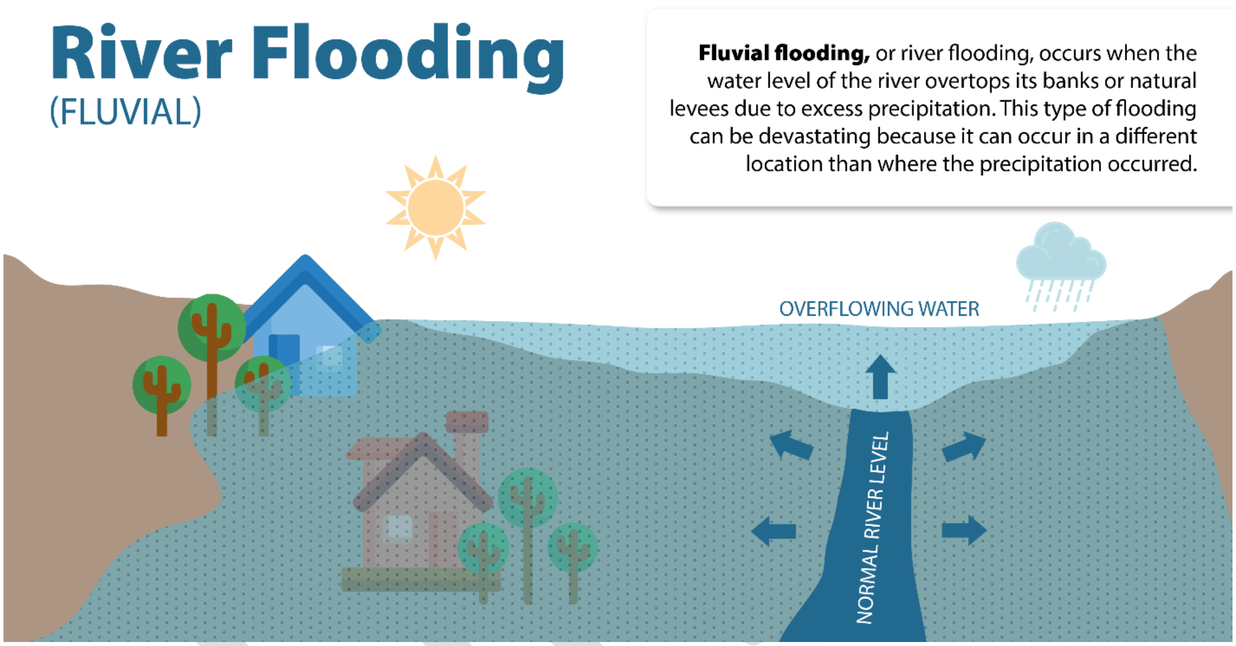


Figure 1: Fluvial Flooding (SCOR)

PLUVIAL FLOODING

Pluvial flooding occurs when an extreme rainfall event creates a flood independent of an overflowing water body (Figure 2). 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.).

Flash floods occur when rainfall flows over the surface of the landscape as it moves toward the established drainage system. When the amount of rain is higher than the capability of the drainage system to drain the water, the water floods at points where 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).

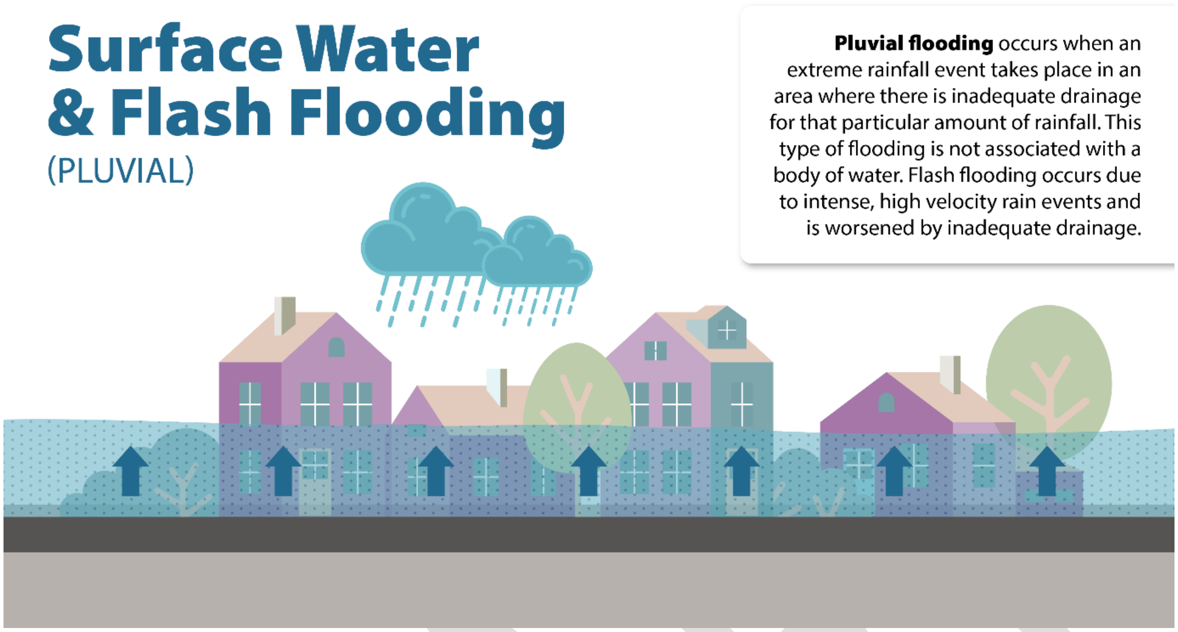


Figure 2: Pluvial Flooding (SCOR)

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

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 3). Hurricanes produce two types of storm surge: wind-driven and pressure-driven. The strong winds of hurricanes disturb the water below and as the storm moves into shallower water, the vertical circulation in the water column that is caused loses depth and can increase in elevation, much like a tsunami (National Hurricane Center, 2023). Pressure-driven storm surge is less substantial than previously believed. It is formed by the low-pressure center of a hurricane and as the air travels upward, the water is siphoned into a bulge in a balance of vertical uplift from the wind and gravity. When the storm surge impacts land, it can push water up waterways, infrastructure, and onto the land over long periods of time and appears as a temporary increase in sea level. 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 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).

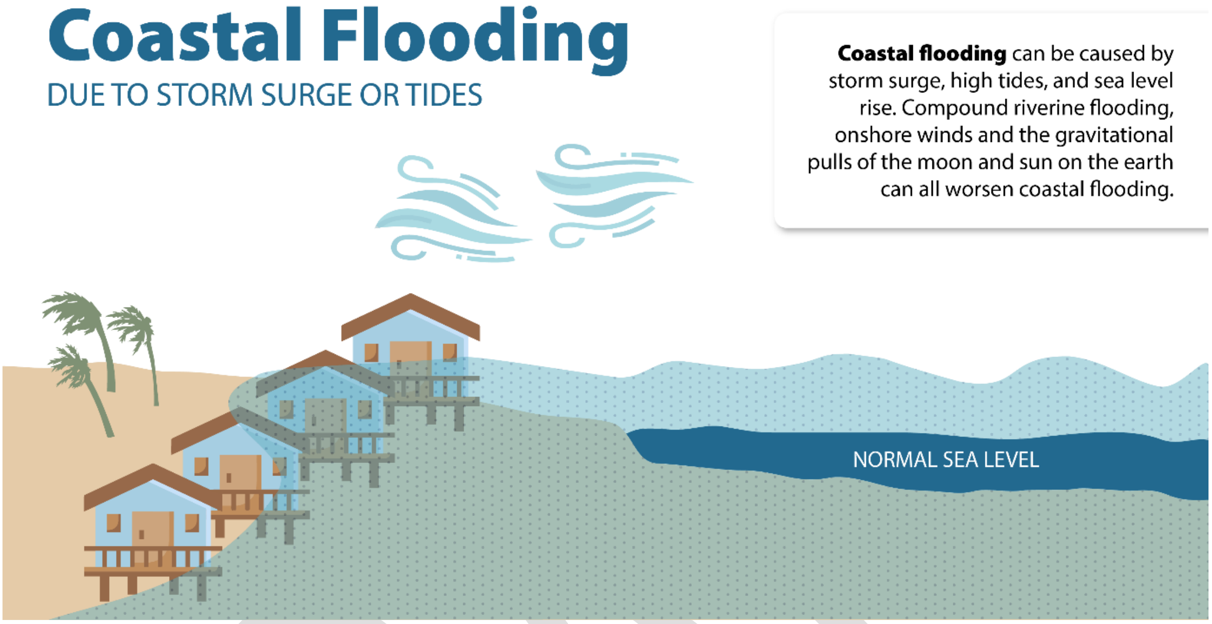


Figure 3: Coastal Flooding (SCOR)

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 equally be as 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).

Spring tides occur when the moon orbit is in perigee or apogee (Figure 4). 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. 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, has started to regularly flood coastal roads and marshfront shorelines that have not historically been flooded regularly.

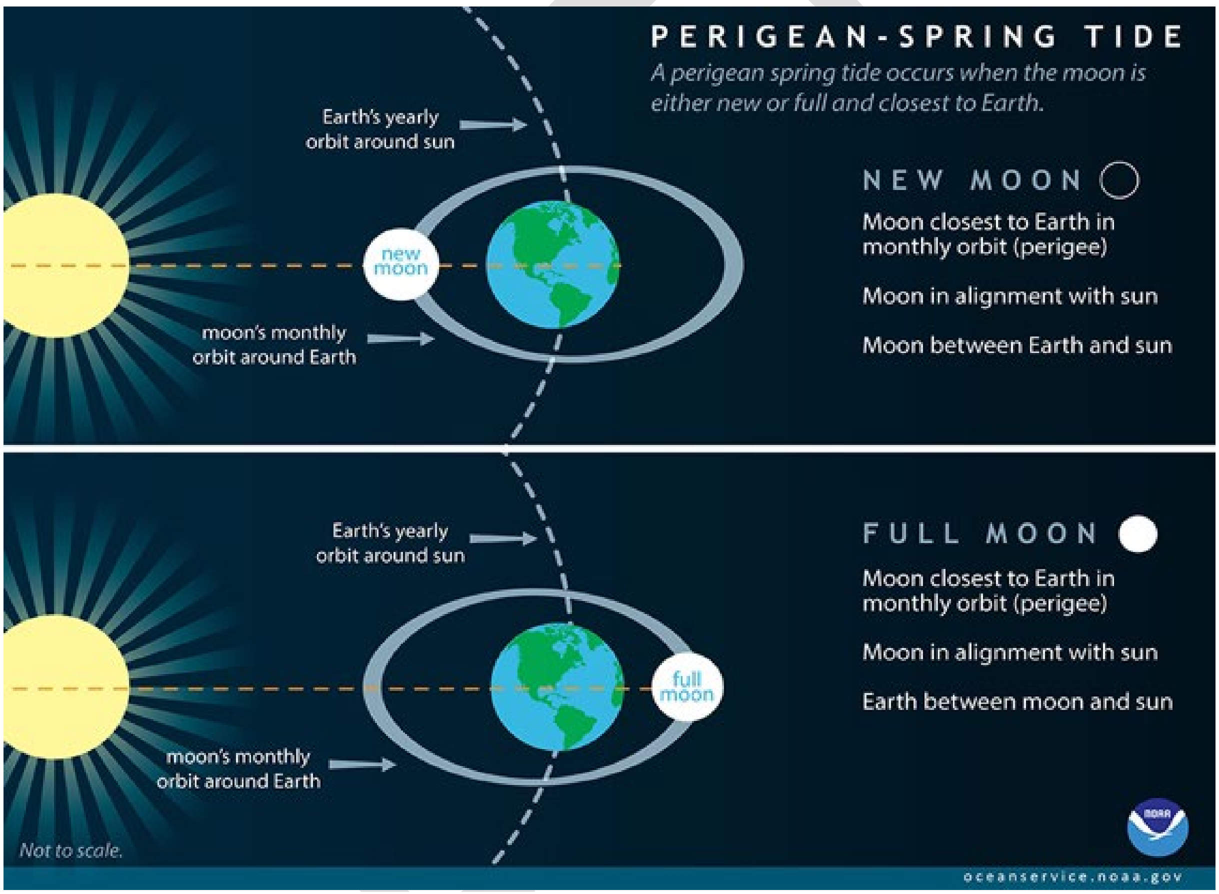


Figure 4: The moon's position within its orbit strongly influences gravitational pull on the Earth's tides (NOAA, 2021).

While coastal flooding caused by large events such as tropical storm surge receive a lot of attention, small, sustained changes in the system can equally be as 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).

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 occurrence along estuarine or marshfront 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.

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 that receives the credit in the National Centers for Environmental Information (NCEI) database (National Oceanic and Atmospheric Association, 2023). It may also be attributed at least in part to large-scale beach and dune restoration projects that have reduced flood risk along the South Carolina beachfront (Kana & Barrineau, 2021).

SEA LEVEL RISE

The compound effects of these types of flooding will only be complicated by 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). 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) (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 levels rise 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 South Carolina’s 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.

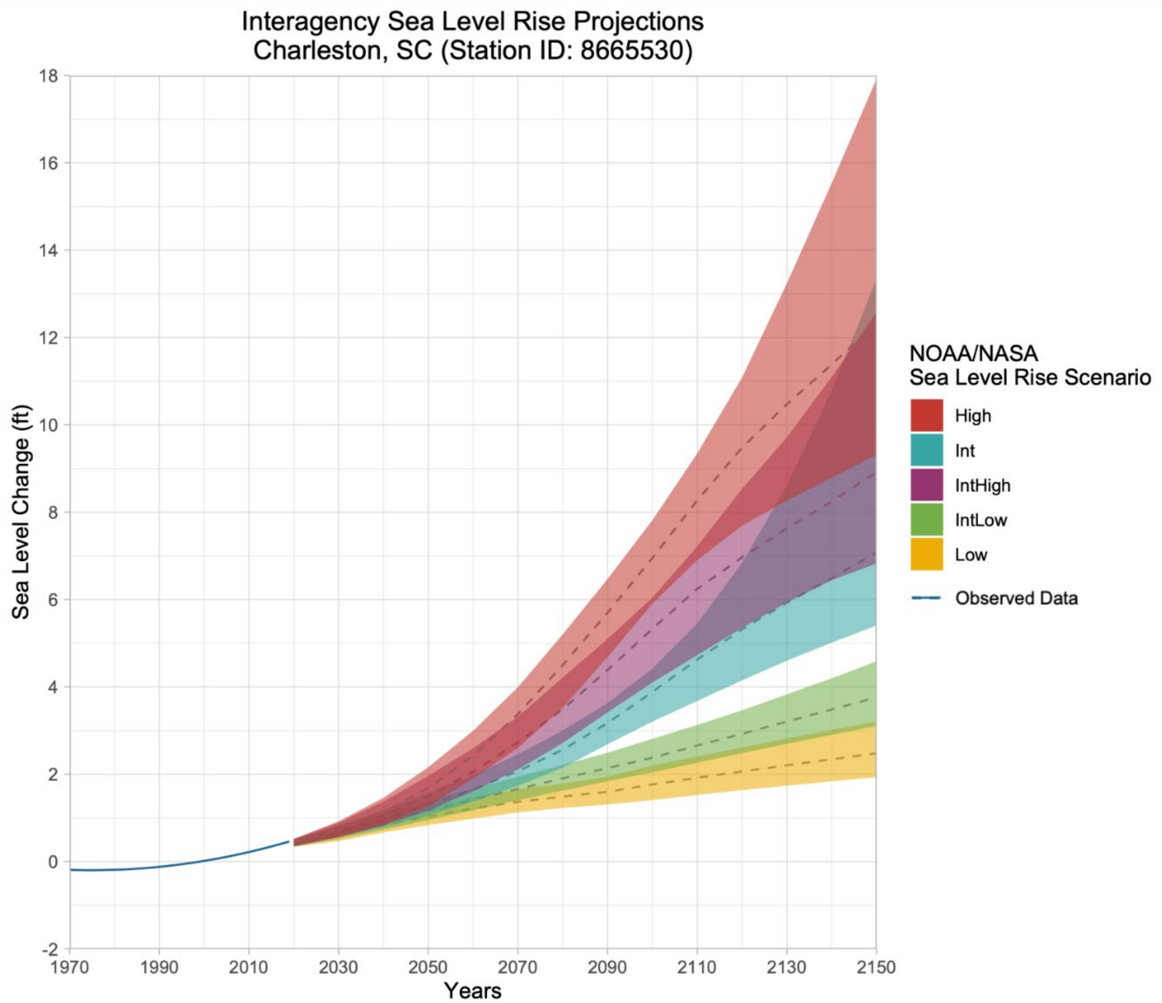


Figure 5: Sea level rise projections for Southeastern United States from NOAA's recent report (Sweet, et al., 2022). Edited from Sweet et al. (2022) Figure 2.3.

From historical records at the Charleston Harbor gauge, the total number of flood days increase has increased and an increase in "major" (8+ ft) flood events from 1970-2021 (Figure 6 and Figure 7) (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.

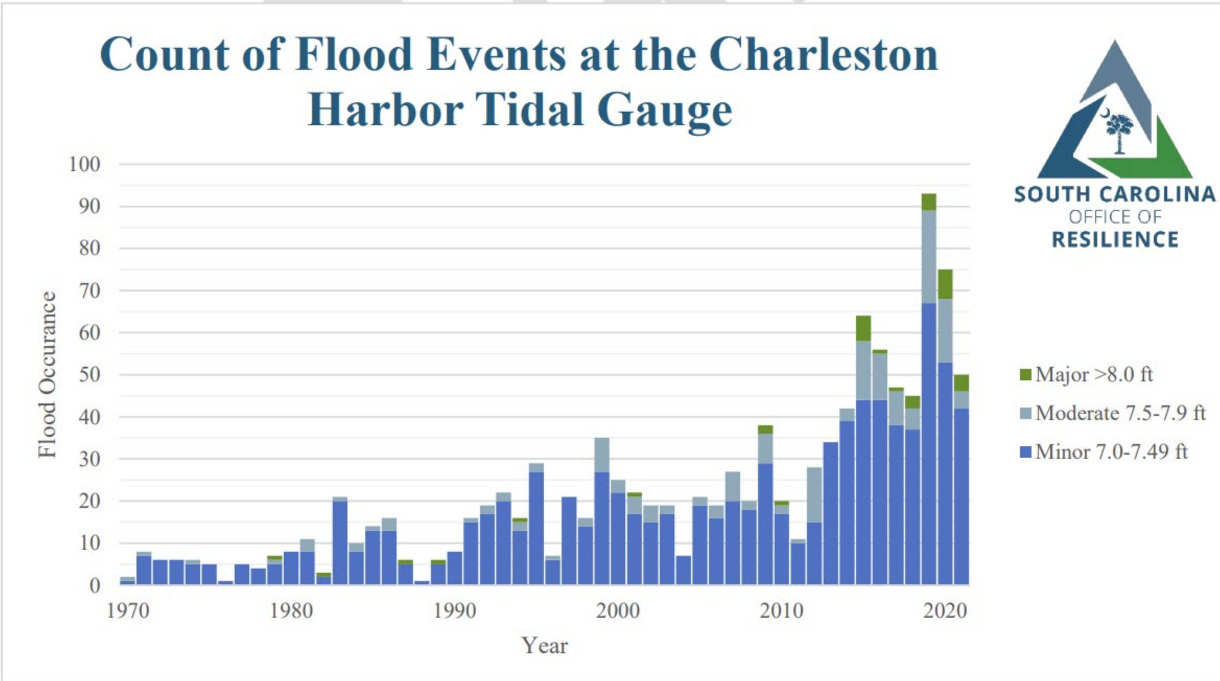


Figure 6: Number of flood events at Charleston Harbor gauge (National Weather Service (NWS), 2022).

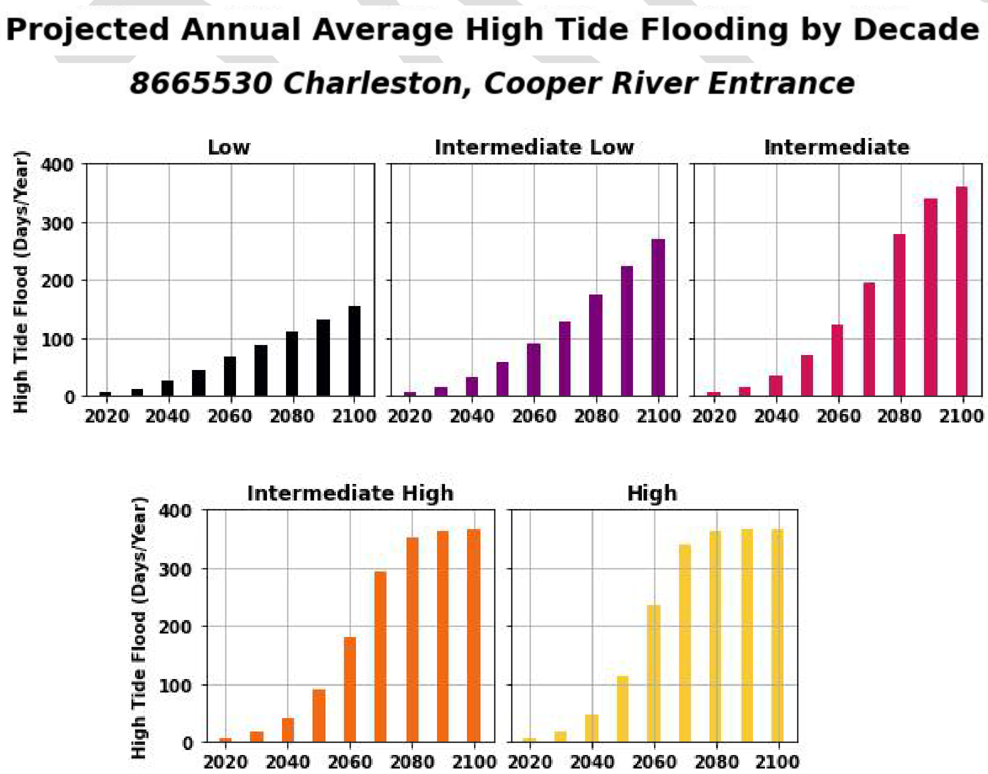
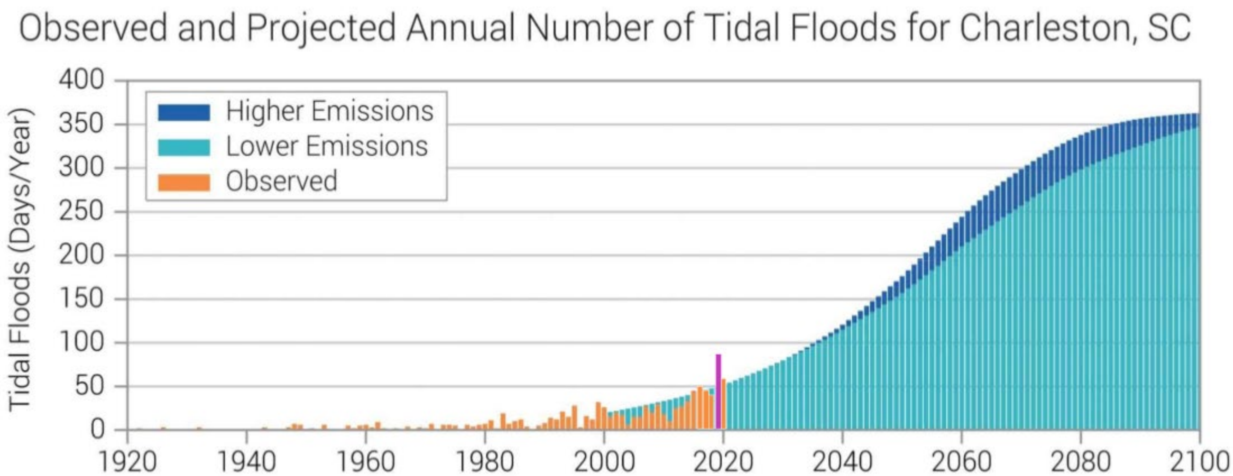


Figure 7: Total number of flood days at Charleston Harbor Gage, edited from (National Oceanic and Atmospheric Association, 2022)

Figure 8 combines the historical tidal floods in Charleston and pairs it with projected figures based on two scenarios 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.



Source: NCA State Summaries, NOS/ NOAA

Figure 8: Observed and projected annual number of tidal floods for Charleston, SC (NCA State Summaires, 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 a measured 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 9). 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 9).

The amount of subsidence is small over any given year, but over a period of time it can cause a large impact. If Charleston experiences 0.35 cm/yr (0.14 in/yr), by 2050 the land would subside 3.78 inches. The intermediate sea level rise projection is 14.17 inches by 2050, so a total potential local sea level change would be 17.95 inches. This combined effect can lead to further property damage, loss of infrastructure, and even loss of life. Land subsidence can also cause a variety of other problems for coastal communities including the loss of wetlands and other important ecosystems, which are critical for coastal protection and biodiversity.

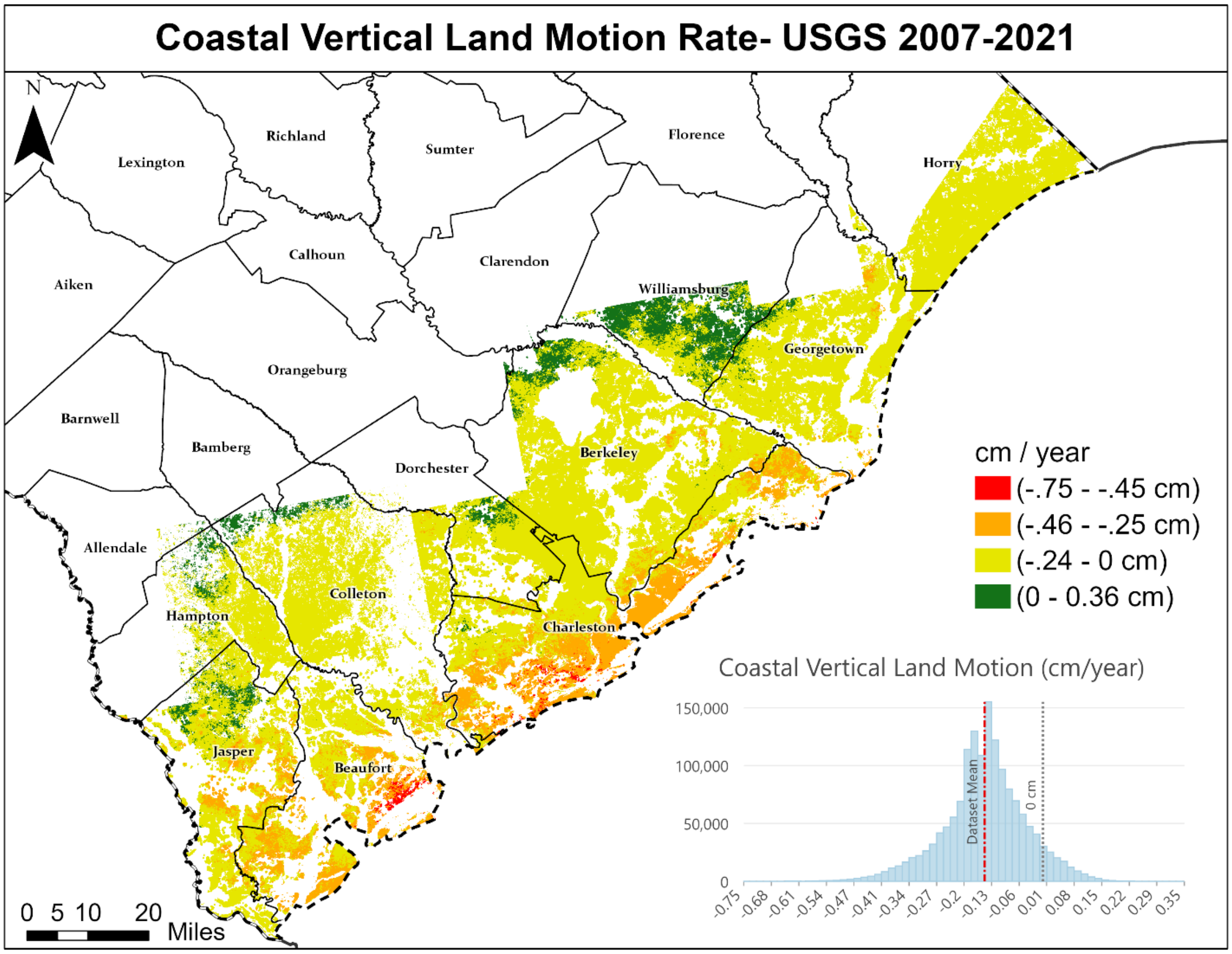


Figure 9: Land subsidence in coastal South Carolina (Barnard, et al., 2023)

DAM FAILURE

The South Carolina Dams and Reservoirs Safety Act charges the 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 the Department 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, which are defined as:

Table 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 maintain 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 caused by Hurricane Joaquin (SC Department of Health and Environmental Control (DHEC), 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 (DHEC), n.d.). In 2018, the SC General Assembly directed SCDHEC to focus the resources of the department's 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, first CodeRed and now 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 in force, 202,098, a 4.1% decrease from 2020 (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 since 2000 (National Oceanic and Atmospheric Association, 2023).

Table 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 three federally declared 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.

OCTOBER 2015 (ATMOSPHERIC RIVER/ HURRICANE JOAQUIN)

There was historic precipitation across the state from October 1st- 5th, 2015 associated with Hurricane Joaquin. As described by SC DNR 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, 36 regulated dams failed, 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 and upwards of 15 inches of rain occurred in the northeast South Carolina in close to a 12-hour period. This caused significant flash and riverine flooding in the Pee Dee River Basin and northeast South Carolina. During Hurricane Matthew, the Little Pee Dee River peak river level was at 17.1 ft at Galivant's Ferry and the Waccamaw River crested at 17.9 ft, both breaking records set in 1928 from the Okeechobee Hurricane (Weaver, 2016). Nichols, SC is located at the junction of the Little Pee Dee River and the Lumber River. During Hurricane Matthew, large amounts of water drained through these rivers and at the convergence caused significant flooding of the Town of Nichols, and 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 impacted the Carolinas on September 14th -16th and caused significant damage. Florence made landfall near Wrightsville Beach, NC and caused 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 dollars in property damage, evacuation of close to 500,000 people, and major damage to 550 homes (National Oceanic and Atmospheric Association, 2023).

DRAFT

UNDERSTANDING FLOOD VULNERABILITY

Vulnerability, as used in this analysis, is defined as the potential for loss. In the first portion of this chapter, we discuss the common monitoring, data, and modeling tools that can be used to assess vulnerability. Then, this chapter provides an assessment of potential losses across the state by combining hazard data with statewide datasets of assets and facilities.

ENVIRONMENTAL MONITORING AND DATA

In order to best assess the flow of water through the state, an extensive network of environmental monitoring datasets are needed. A wide variety of datasets applicable to South Carolina have been developed by the various federal and state agencies, community interest groups, and universities. Environmental data is widely available and most data owners or managers have website portals that allows access to data such as tide levels (NOAA and SECCORA), land use (NOAA), water quantity (USGS), and much more. Not every dataset has easy access or nor is there always searchable databases that are maintained to easily find that data, data descriptions, or data managers. The various state agencies also house datasets that are required to accomplish the missions of those agencies: SCDNR, SCDHEC, SCDOT, and Sea Grant.

MODELING AND COMPUTATIONAL TOOLS IN SOUTH CAROLINA

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

Table 4: Existing Models, Data Processing and Managing, and Decision-making tools

Software / Tool Name	Source	Focus
SCDNR Floodplain Inundation Model (in development)	DNR	Vulnerability Assessment Emergency Management
SWAM (Surface Water Allocation Model)	DNR, SCDHEC	Surface Water Availability Withdrawals, Accounting
HEC-RAS 2D (Hydrologic Engineering Center's River Analysis System)	US Army Corps of Engineers	Flow Calculations Sediment, Water Quality
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 FLOODPLAIN MODEL

Post Hurricane Matthew in 2018, DNR identified the need for a floodplain inundation model for the state. They received some funding through the FEMA Flood Mitigation Program to start the process of building a model and were able to complete a model within the Pee Dee River basin and have now modeled approximately 25% of the state. This model has been used to assess the risk of flooding and to stage SCDNR Law Enforcement and State Law Enforcement Division search and rescue personnel during flood events. Other state agencies have also used this model before and during flood events to assess vulnerabilities of their respective assets during an event, such as SCDOT. The DNR Floodplain Model can be accessed in a limited capacity on their website, SC Flood Impact, and DNR currently seeks funding to complete the model statewide.

SWAM

In 2014, DNR and DHEC awarded CDM Smith a contract to create a Surface Water Allocation Model (SWAM) for the State's eight river basins. SWAM provides the State the computational ability to quantify the surface water usage in the State's streams and rivers (SC Department of Natural Resources, 2022). The model identifies the unimpaired flow in the waterways and then subtracts out the DHEC permitted and registered withdrawers to calculate the permitted water availability (Clemson University, 2022). The model can calculate water availability over a variety of climate and water use scenarios (Westphal & Boyer, 2014). According to CDM Smith, SWAM is a water accounting tool and a what-if simulation model, but it is equally not a precipitation-runoff model, a hydraulic model, a water quality model, optimization, nor a groundwater flow model (Westphal & Boyer, 2014).

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 of bridges and culverts (time saving since we do not have to create the stream hydraulic model).
- Verification of water elevations.
- Calibration of existing models.
- Analysis of existing structures capacity.

CHEOPS

The Computer Hydro-Electric Operations and Planning Software (CHEOPS) was developed by HDR, Inc. The 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 the reservoirs and dams in that basin (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 is simply that the amount of rain, at a particular location and a given duration can be calculated and represented. 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 calculated and published in the early 2000s and was updated in 2006 (Bonnin, et al., 2006). SCOR, the SC Department of Transportation (SC DOT) and SC Department of Natural Resources (DNR) have agreed provide funding to include South Carolina in the update 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. 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. In such manner, this application allows SCDOT to efficiently perform the following activities.

- Maintain Plan of Action and flood monitoring data for 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 and ADCRIC tidal surge predictions.
- Monitor bridges for seismic events using USGS data continuously.
- 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.

All the data is available on the BridgeWatch web-based software application, which can be accessed on computers and mobile devices.

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 to get a single coverage of flooding per 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 due to the complexity of coastal modeling (GeoCLAW, ADCIRC, and SWAN). These are then historically validated to corroborate the models based on past events.

Property level statistics provide an estimated flood inundation level for various scenarios including low, medium, and high projections for flood probabilities 2-, 5-, 20-, 100-, and 500-year flood events, along with modeling the flood projections for 2022, 2037, and 2052. 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 Lightbox.

As with any model, there is inherent error by the limited data available in the state. 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 unlikely to provide the needed site-specific modeling 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.

Other measures of social vulnerability are discussed in a previous chapter of this plan, however, SoVI was utilized for the figures below, which overlay social vulnerability with flood risk.

Figure 10 shows SoVI® overlaid with the 2022 1% annual flood event as shown by the First Street model. Appendix A provides these maps by counties to identify areas with high social and physical vulnerability to flooding.

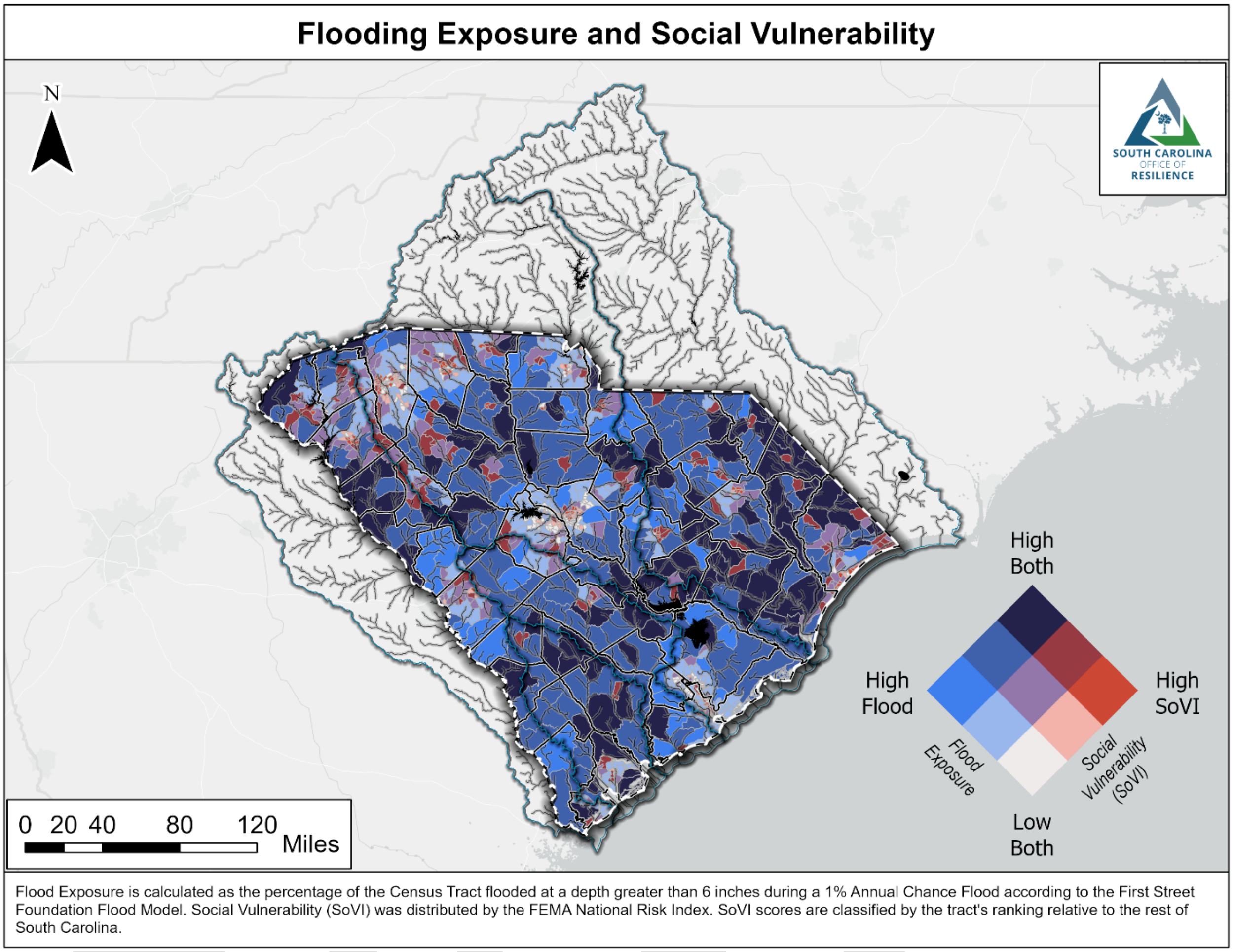


Figure 10: Flooding Exposure and Social Vulnerability. Flood data provided by the First Street Foundation Hazard Layers, V2.0.

VULNERABILITY BY SECTOR

DATA SOURCES

SECTOR DATASETS

The data identification, collection and coordination of 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 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 facilities at a location. Table 5 summarizes the flood vulnerability point analysis. Facilities location for each sector is overlaid with flood inundation model data and then the count of facilities for each sector by estimated flood depth of none, 6 – 12 inches, 1 – 2 feet, 2 – 3 feet, and greater than 3 feet. 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 more comprehensively assess risk level at a specific facility, building, or campus.

Table 5: Summary Table of point count by inundation levels for each by sector.

Vulnerability by Sector	Flood Inundation depths					
	0 ft	6 inches	1 foot	2 feet	3 feet	Greater than 3 feet
Building Codes						
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
Drycleaners (2022)	406	0	8	9	5	14
Drycleaners (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 (2032)	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						
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
Veteran's Affairs (2022)	23	0	0	0	0	1
Veteran's 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)	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

FLOOD DATA

First Street Foundation was identified as a partner to supply the data that will allow the South Carolina Office of Resilience to fulfill its mandate, providing modeled flood coverage, property level flood probability and estimated property value. 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 flood maps pair well with the FEMA floodplain maps. When comparing the 100-year flood maps, the First Street high-resolution floodplain maps matchup and provide additional coverage in areas that have historically reported flooding that is not represented or underrepresented by the FEMA maps. The First Street Foundation model described above served as the basis for quantifying the vulnerability of the assets below to flooding. The First Street 2022 and 2052 1% annual chance flooding event models were overlaid with data sets obtained from state partners and public sources.

NATURAL SYSTEMS VULNERABILITY

South Carolina is rich in natural resources. The forest, 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 the locals and visitors for recreation, hunting, fishing, and farming. Several of South Carolina's economic drivers rely on these natural resources as a foundation. Coastal communities rely on the beaches and marshlands to draw tourist 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 environments also provide hazard mitigation and protection benefits to the state as well. 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 12.9 million acres of forestland; 87% of the forests are privately owned (SC Forestry Commission, 2021). Economic impact of forestry in SC is approximately $21.2 billion annually. Forestry is the second largest manufacturing industry sector and provides approximately $21.2 billion to the State's economy each year.

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.

Trees help reduce the impact of flooding through their interception of rainfall and softening of raindrop impact. Depending on species, a mature tree retains 20 to 30 percent of annual rainfall (Forest Service, 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. Trees and other vegetation store carbon, important for reducing the impacts of climate change.

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 7-10 days (SC Forestry Commission, 2015).

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 2876 miles. The beach/dune system provides the basis for a tourism industry that generates approximately two-thirds of South Carolina's annual tourism industry revenue (South Carolina Code §48-39-250, 2019), about $17 billion annually, and also serves 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 accelerating sea level rise. As 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 is 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 SC Code of Laws Section 48-39-320(C) 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, breeding grounds and food for fish, birds, and other wildlife, as well as a unique open space in a dense urban environment. South Carolina marshes provide public and commercial fishing/oystering opportunities, as well as other recreational opportunities like boating and bird watching. Recreational fishing is a $686 million annual industry (US Fish and Wildlife Service, 2014) in our state. 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. In 2023, the SASMI Plan was published and lays out the framework to better manage and plan 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. Yet despite decades of regulatory protection, salt marshes continue to be threatened by poor water quality, rising sea levels, encroaching development, illicit dumping, and erosion without adequate room for natural migration of marshes. Figure 11 - Figure 13 show the projected marsh migration by 2050. Figure 14- Figure 16 show projected marsh migration by 2100.

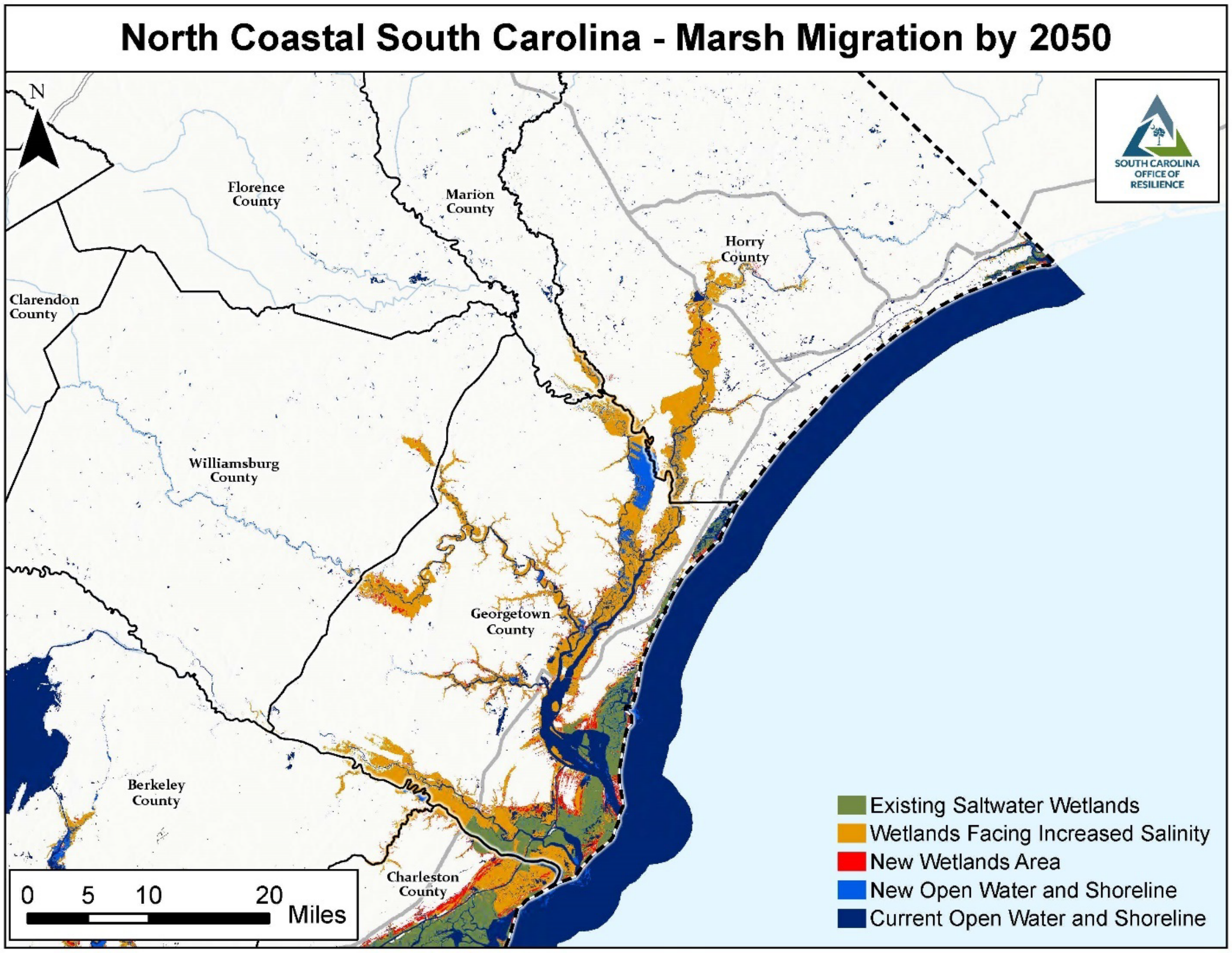


Figure 11: Marsh Migration by 2050 in the North Coastal Area of South Carolina

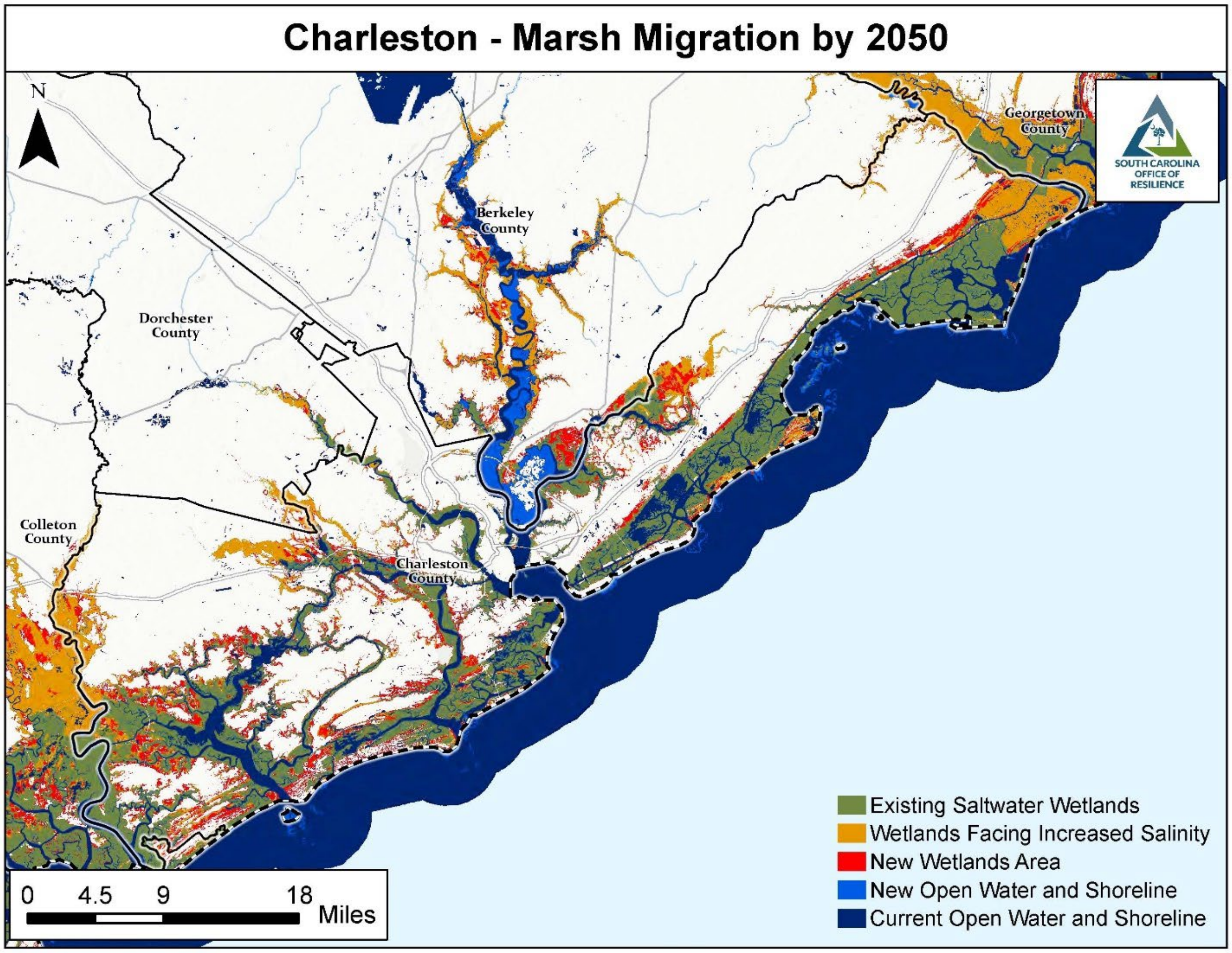


Figure 12: Marsh Migration by 2050 in the Charleston Area

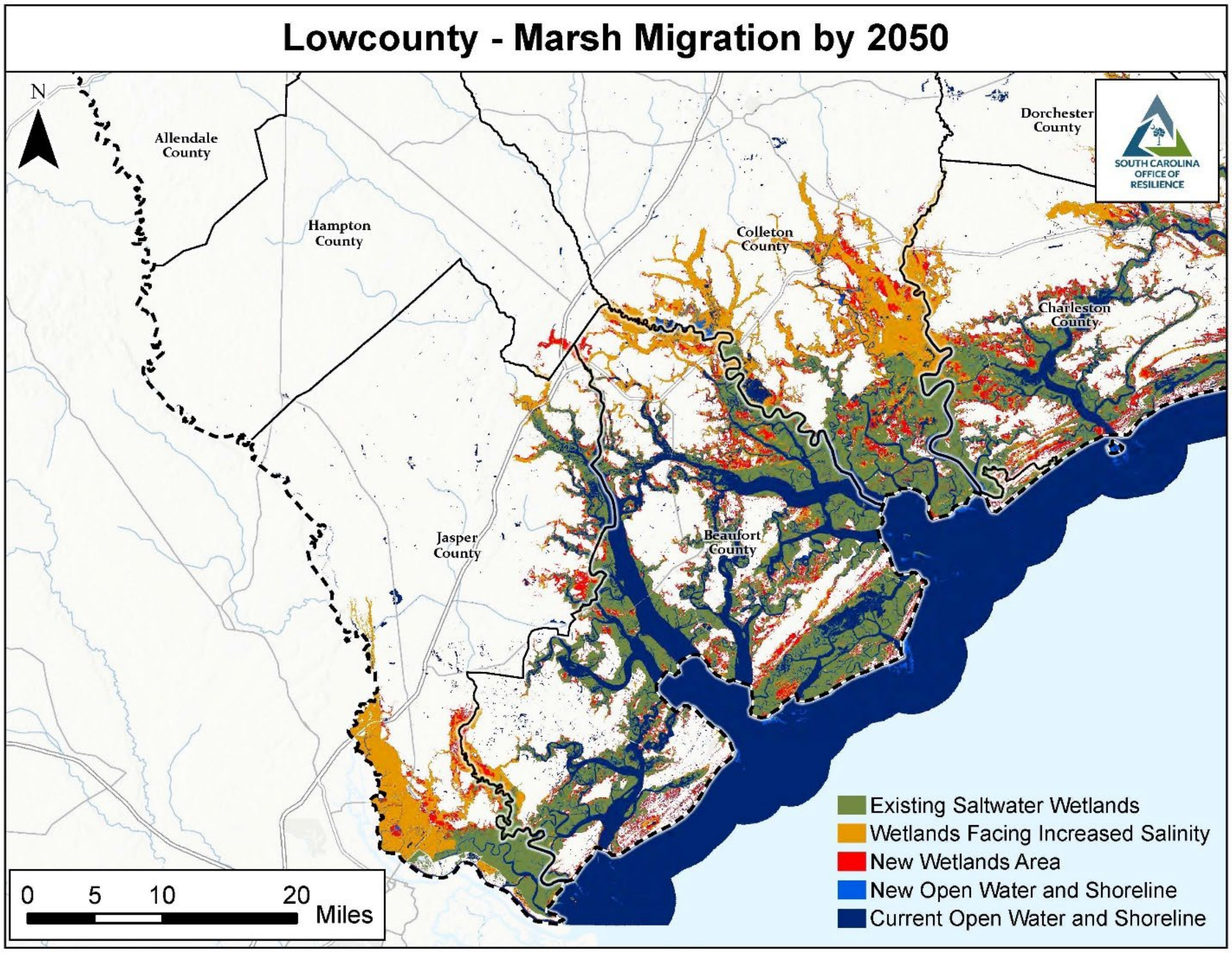


Figure 13: Marsh Migration by 2050 in the Lowcountry Area

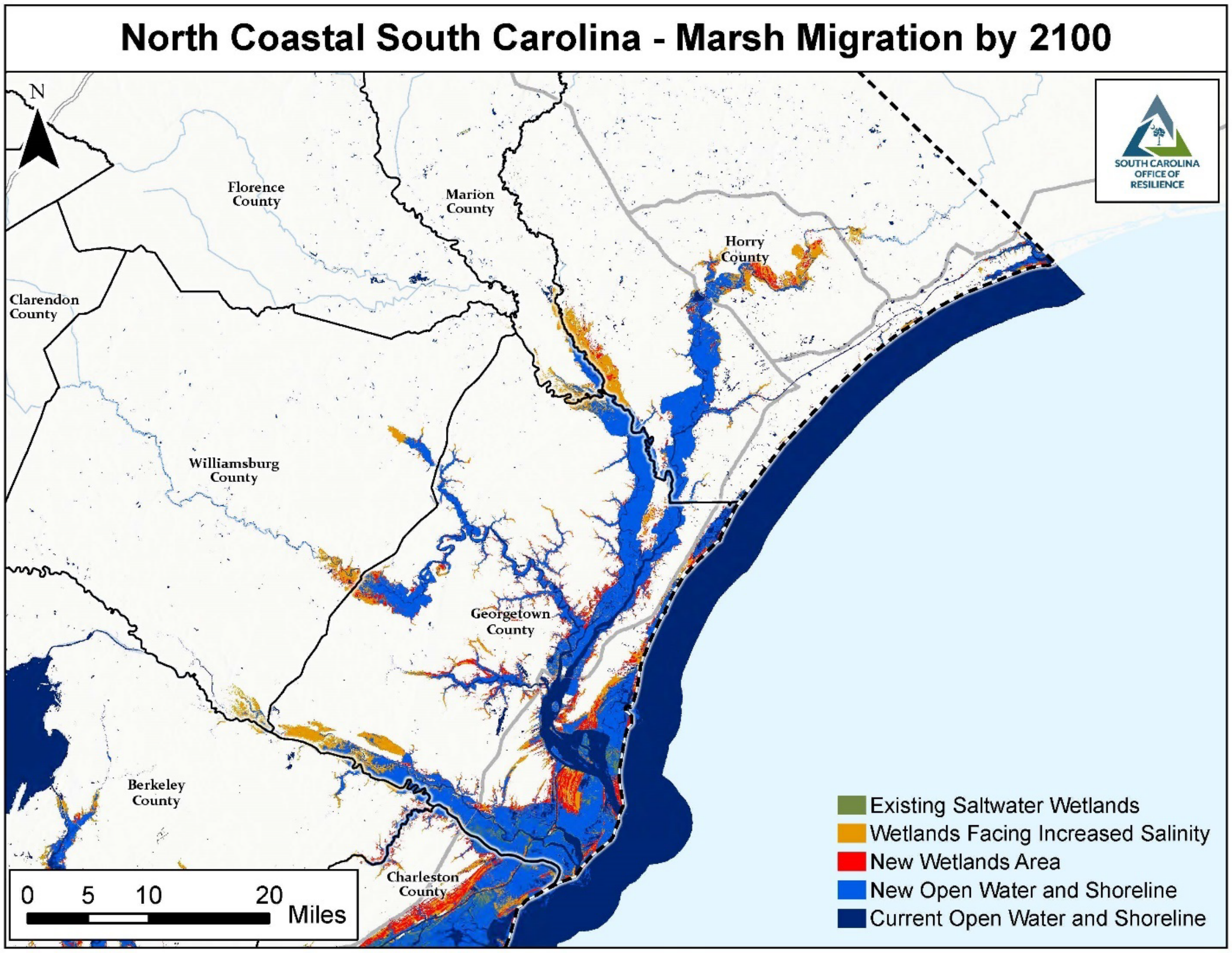


Figure 14: Marsh Migration by 2100 in the North Coastal Area of South Carolina

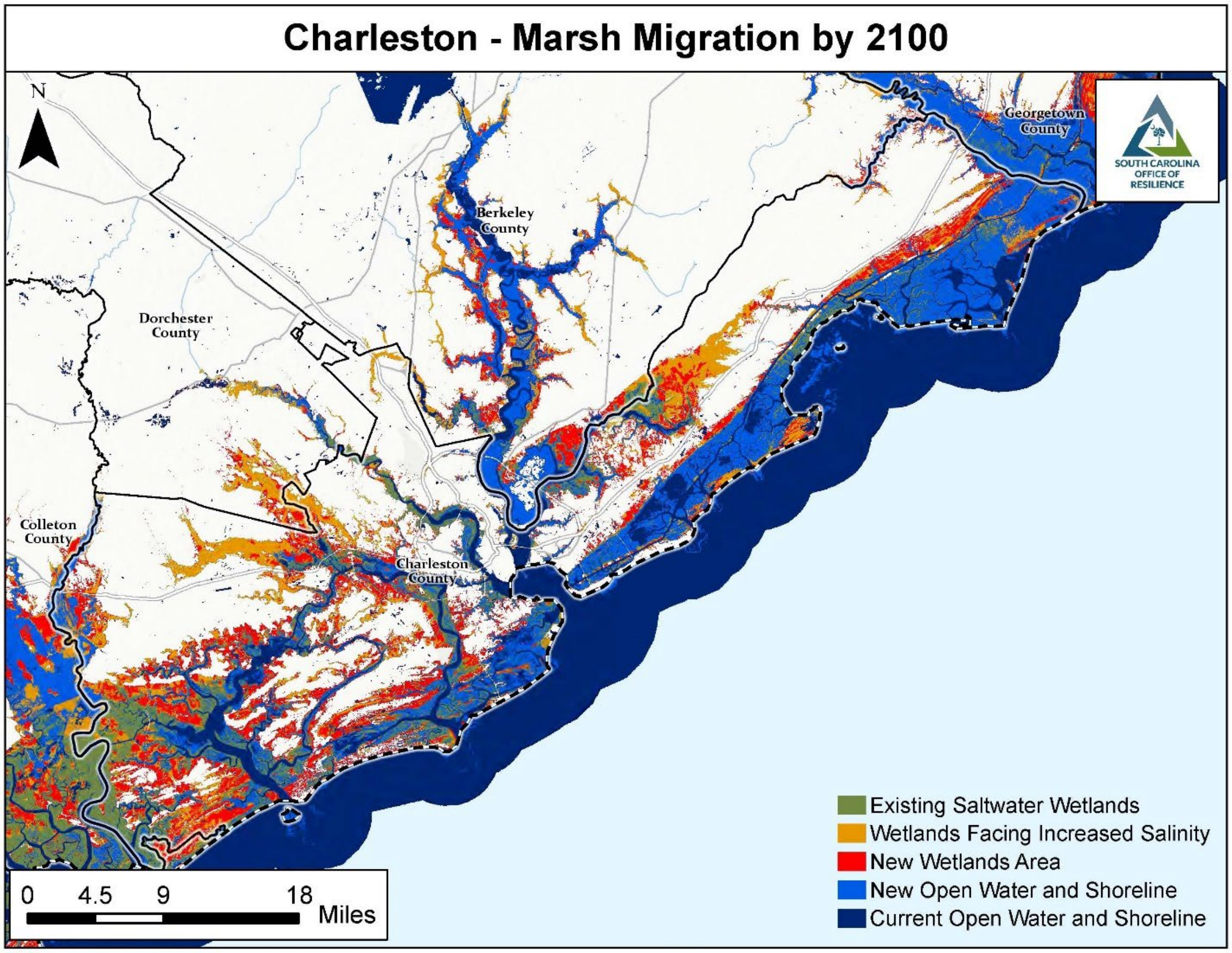


Figure 15: Marsh Migration by 2100 in the Charleston Area

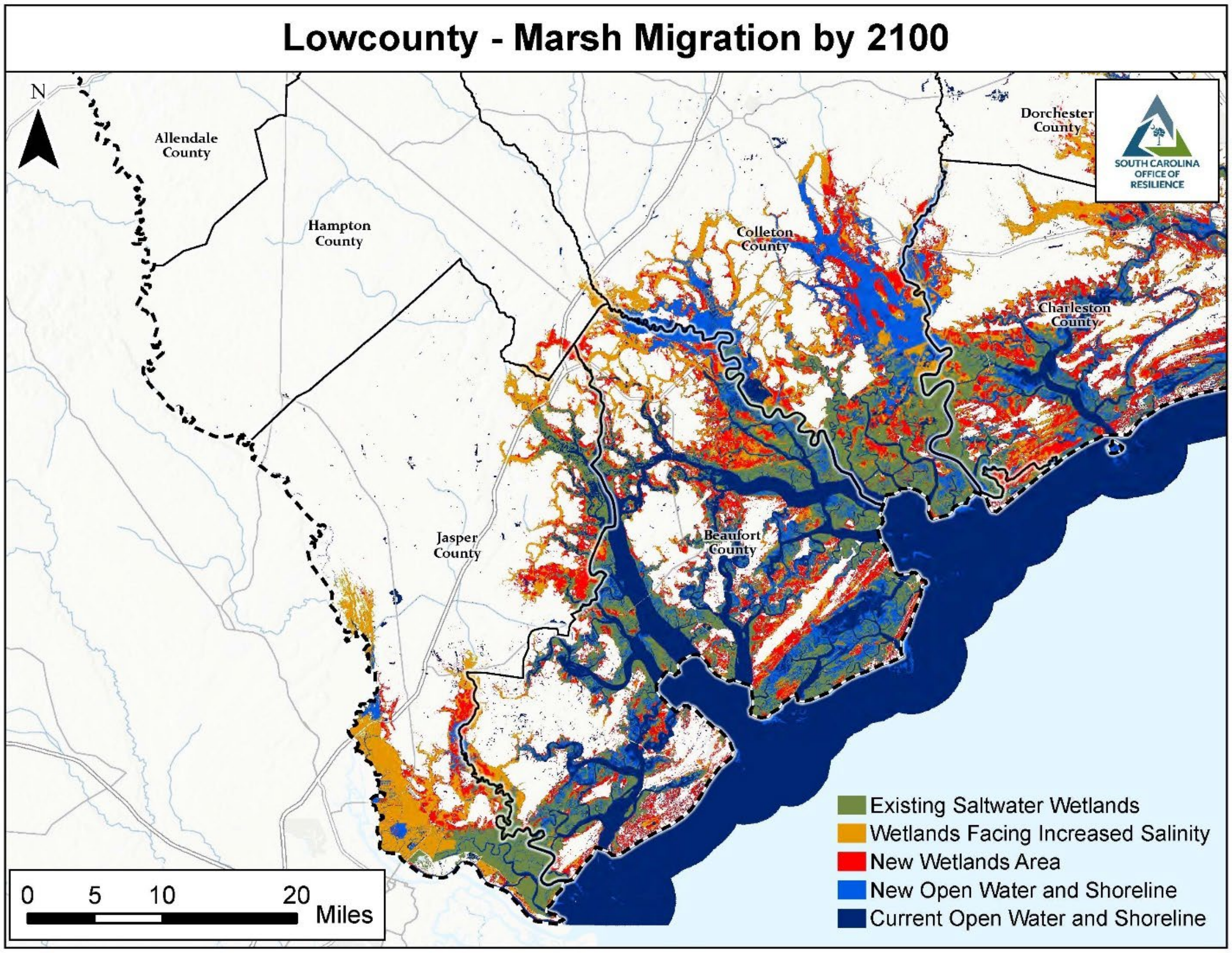


Figure 16: Marsh Migration by 2100 in the Lowcountry

WILDLIFE

THREATENED AND ENDANGERED SPECIES

Numerous state and federally Threatened/Endangered species depend on South Carolina's undeveloped land for survival and recovery. Along the coast, birds 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 & Endangered species that rely on South Carolina beaches as critical habitat throughout their life cycle (SC Department of Natural Resources, 2020). 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. In a recent study that made national headlines, 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. Protection of SC'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.

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/destruction of native species that would otherwise provide important ecological benefits (from food sources to structural support to protect against flooding/storms), and the subsequent possible introduction or promotion of invasive species. Even native species can become invasive when predator-prey relationships become disrupted. Beavers can build dams that back up water, creating flooding. Marsh periwinkle feed on intertidal cordgrass, (*Spartina alterniflora*) and are preyed on by blue crab. However, if periwinkle become overpopulated, they can degrade their own habitat which also impacts the prevalence of economically important blue crab (*Calinectes sapidus*) (SC Department of Natural Resources, 2015). 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 australis: 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).

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). Although not currently a problem in South Carolina, the potential impact they could have on storm water drainage pipe systems is obvious. Additionally, runoff volume can negatively impact the marsh ecosystem by increasing flow velocity and creating rapid salinity fluctuations (Blair, et al., 2013; Tweel, et al., 2015).

WILDLIFE VIEWING, HUNTING & FISHING

Wildlife and their associated habitat contribute to a significant portion of the state's economy. Fishing, hunting, and wildlife viewing contributes to almost $3 billion in economic value to South Carolina based on a 2017 study (Willis & Straka, 2017). This is largely due to the undeveloped wildlife habitat that our state continues to attract visitors from all over the world. 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, including deer, alligator, bear, turkey, trapping & commercial fur, small game, feral hog, coyote armadillo, migratory bird, dove and waterfowl (eRegulations, 2022). Waterfowl hunting is particularly important to the state’s economy. 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.). 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. 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. 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 SC by over 70,000 hunters on migratory bird hunting (International Association of Fish and Wildlife Agencies, 2002).Fishing, including recreation, competition and commercial fishing are also important recreationally and economically across the state.

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 (die-offs) 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 events. As these materials breakdown the result can be oxygen depletions can stress aquatic organisms sometimes to the point of mortality.

An even greater concern associated with flooding of small impoundments or ponds is the loss of what may be non-native species into public waters that can contribute to adverse impacts on native biota from the introduction of non-native often invasive species. 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 the reciprocal problem of the introduction of invasive species or other fish species that are not a part of the pond management plan (Clemson, 2022).

NATIVE PLANTS

Flooding can be exacerbated or mitigated by the type of vegetation that exists on a landscape. In general, native plant species are more resilient and provide significantly more stormwater mitigation capacity. Turf grass roots are short and dense, acting almost like impervious surfaces during rain events, 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 reabsorption 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-benefits. Native 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 storm water runoff allows for filtration and removal of pollutants, making water going back into the aquifer and drinking water reservoirs cleaner (Massachusetts Office of Coastal Zone Management, 2023). Riparian buffers along water ways and retention ponds absorbs more pollutants and excess nutrients and helps to hasten water absorption and drop levels 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 gardens. Additionally, 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.

COMMERCIAL & RESIDENTIAL PROPERTIES

The First Street Foundation parcel level data, described above, was paired with the estimated flood inundation 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, this is significant when considering how the risk accumulates over time. For example, a home at risk from flooding during a 1% annual flood event would have a 26% chance of flooding over the 30-year timeframe of the average mortgage. A parcel is a lot or tract of land that may be developed (containing structures) or non-developed. 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, Figure 17 - Figure 26) and 2052 (Table 5, Figure 27- Figure 36) 1% annual chance flooding events. Risk Factor 2.0 models that all HUC10s in South Carolina have parcels that could be flooded by at least one foot in a 100-year event under current conditions (2022 100-year event scenario). At greater inundation levels, more than 3 feet, the coastal and mountain regions have a larger portion of the parcels that could be at risk. The flood damage associated with different inundation intervals are described by Risk Factor, a product of First Street Foundation, and presented in Table 6 (Risk Factor, 2022). An estimated count of properties impacted by 1% annual chance flooding event by county are listed in Appendix B.

Table 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	

Table 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

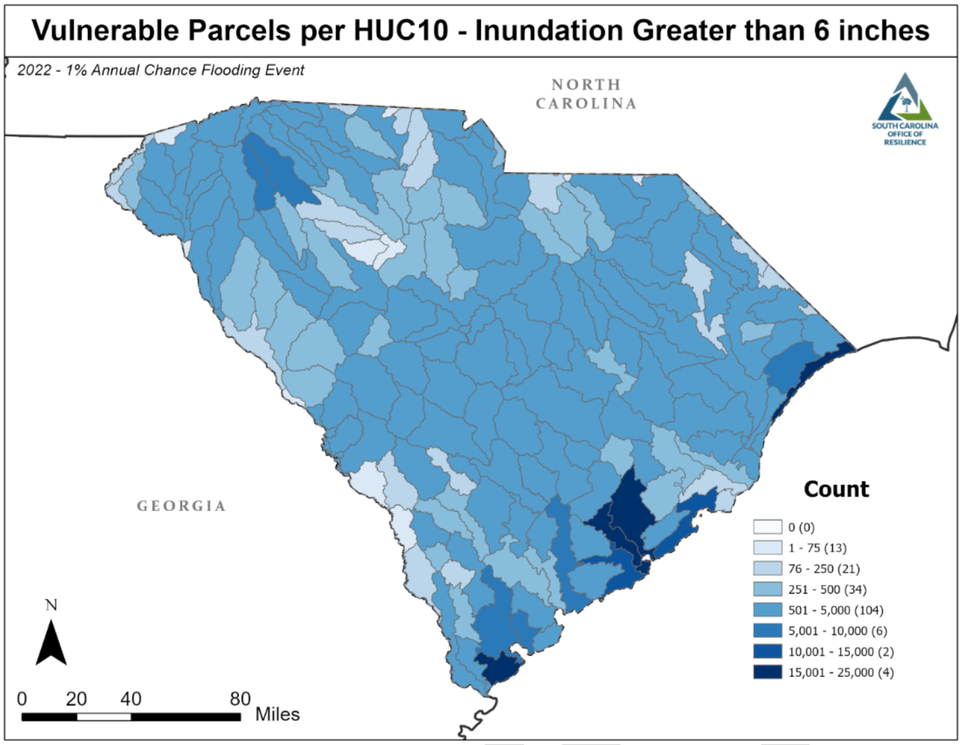


Figure 17: Count of parcels estimated to be inundated greater than 6 inches in the 2022 1% annual chance flooding event. Flood risk data provided by the First Street Foundation Flood Risk Statistics, V2.0.

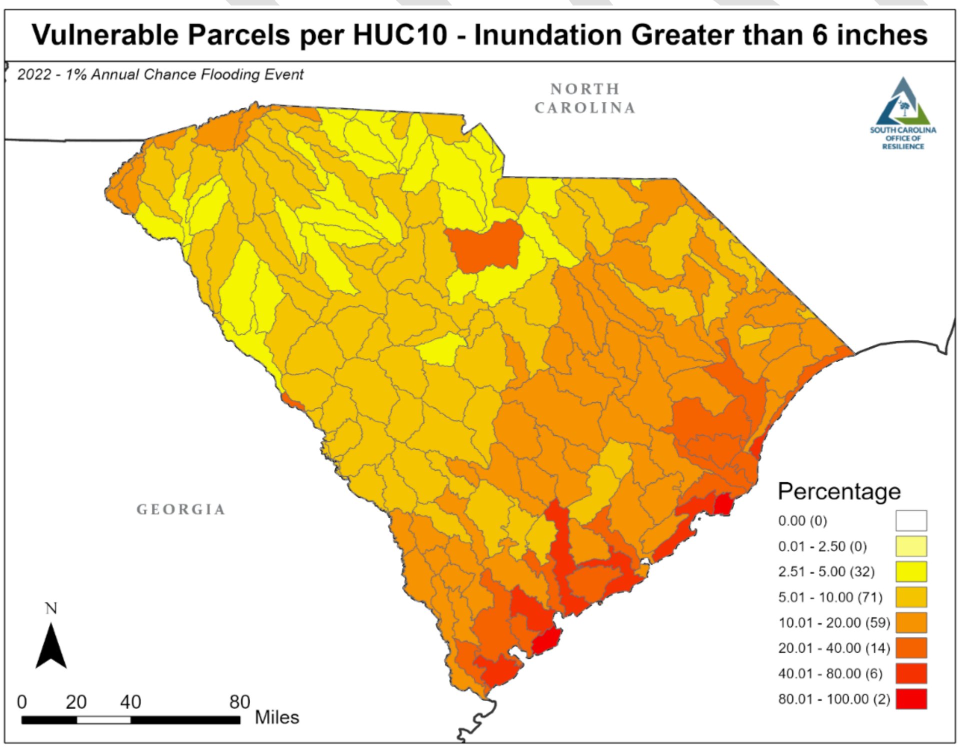


Figure 18: Percentage of parcels estimated to be inundated greater than 6 inches in the 2022 1% annual chance flooding event. Flood risk data provided by the First Street Foundation Flood Risk Statistics, V2.0.

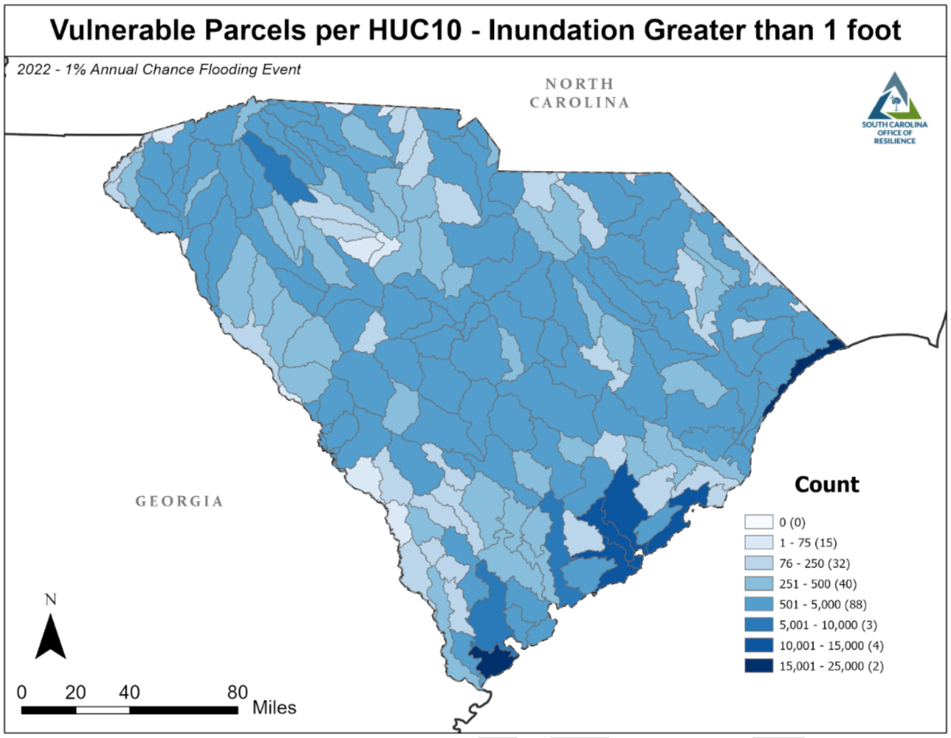


Figure 19: Count of parcels estimated to be inundated greater than 1 foot in the 2022 1% annual chance flooding event. Flood risk data provided by the First Street Foundation Flood Risk Statistics, V2.0.

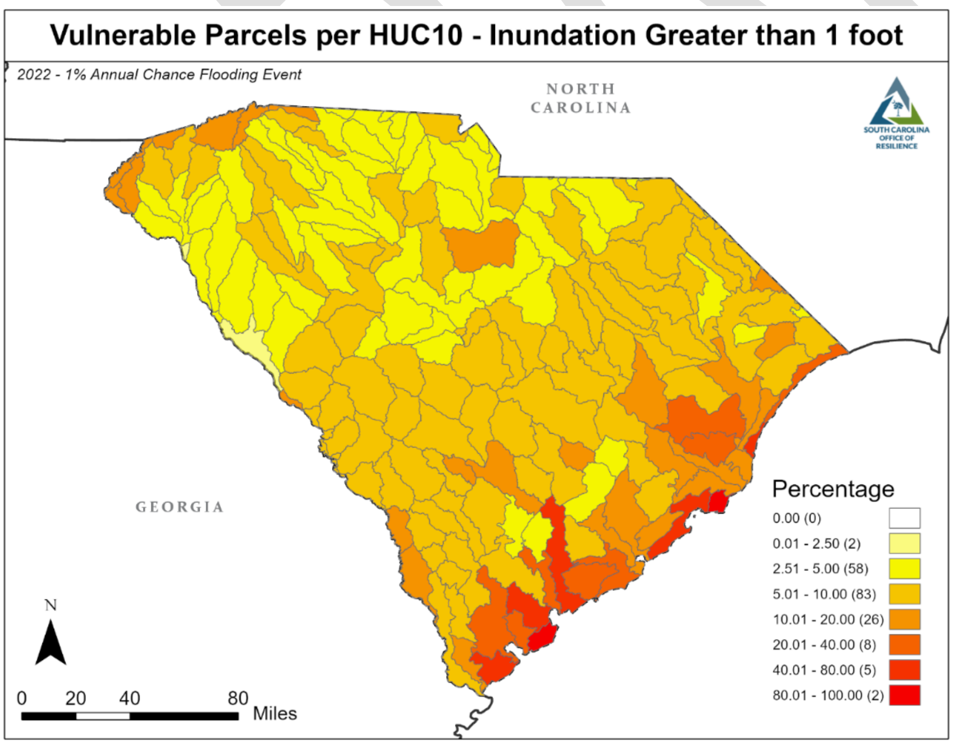


Figure 20: Percent of parcels estimated to be inundated greater than 1 foot in the 2022 1% annual chance flooding event. Flood risk data provided by the First Street Foundation Flood Risk Statistics, V2.0.

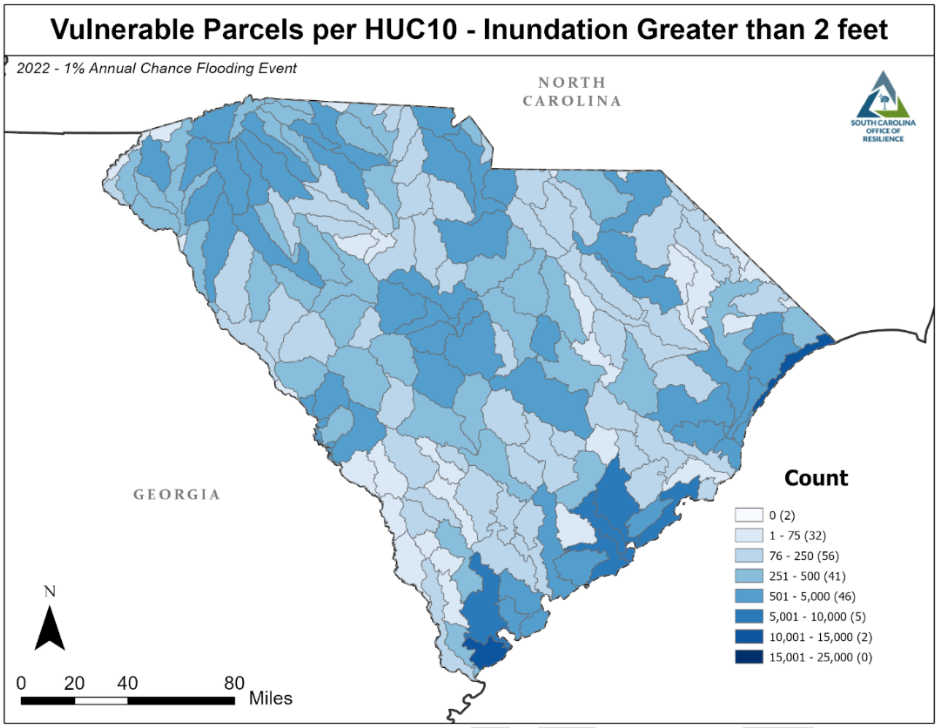


Figure 21: Count of parcels estimated to be inundated greater than 2 feet in the 2022 1% annual chance flooding event. Flood risk data provided by the First Street Foundation Flood Risk Statistics, V2.0.

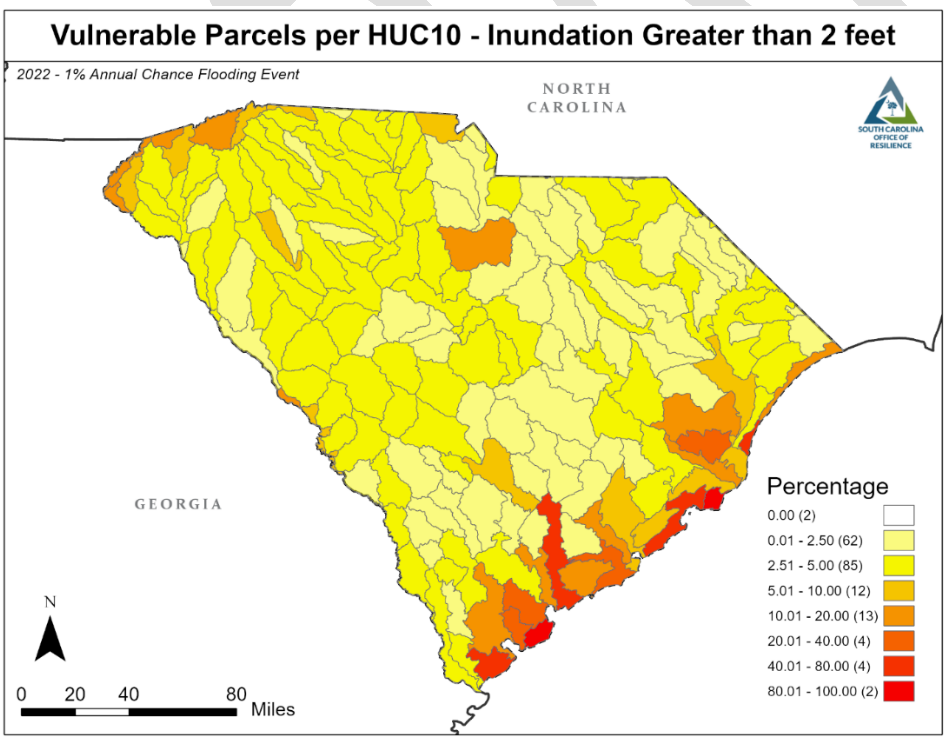


Figure 22: Percent of parcels estimated to be inundated greater than 2 feet in the 2022 1% annual chance flooding event. Flood risk data provided by the First Street Foundation Flood Risk Statistics, V2.0.

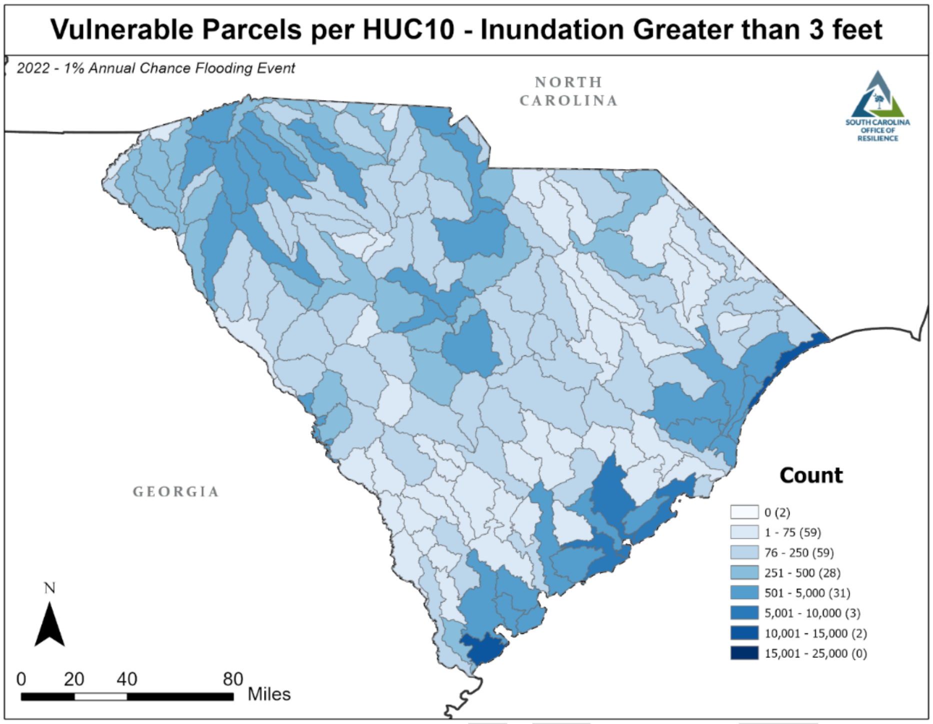


Figure 23: Count of parcels estimated to be inundated greater than 3 feet in the 2022 1% annual chance flooding event. Flood risk data provided by the First Street Foundation Flood Risk Statistics, V2.0.

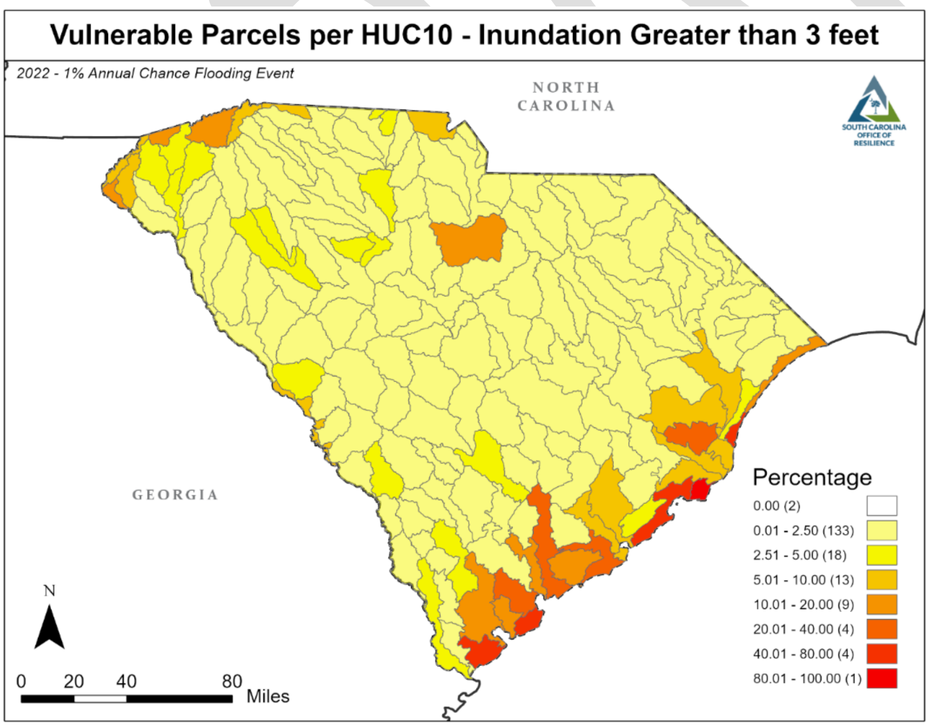


Figure 24: Percent of parcels estimated to be inundated greater than 3 feet in the 2022 1% annual chance flooding event. Flood risk data provided by the First Street Foundation Flood Risk Statistics, V2.0.

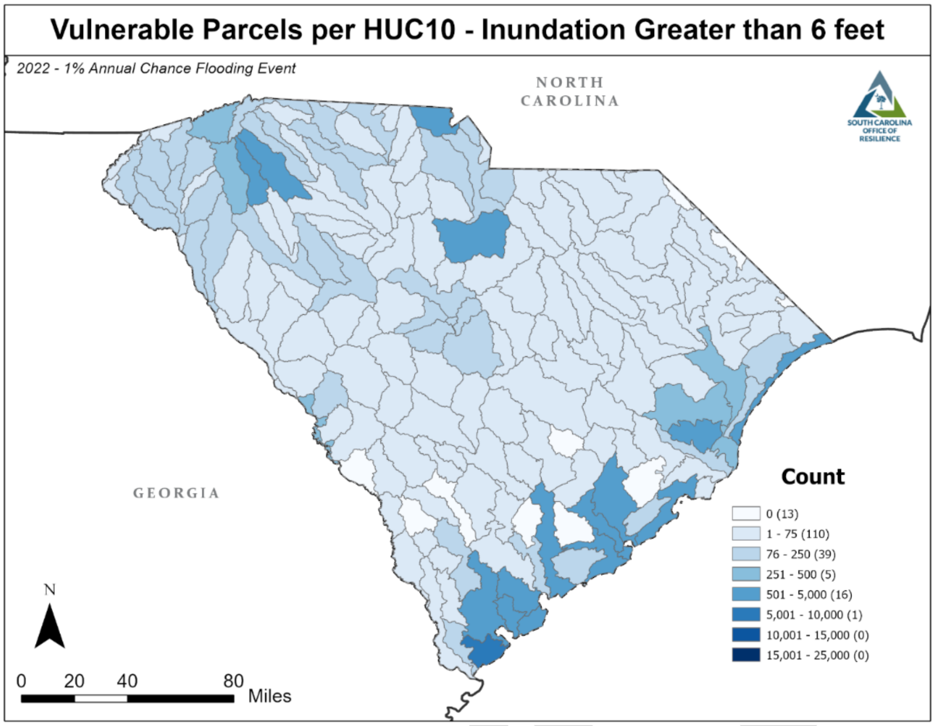


Figure 25: Count of parcels estimated to be inundated greater than 6 feet in the 2022 1% annual chance flooding event. Flood risk data provided by the First Street Foundation Flood Risk Statistics, V2.0.

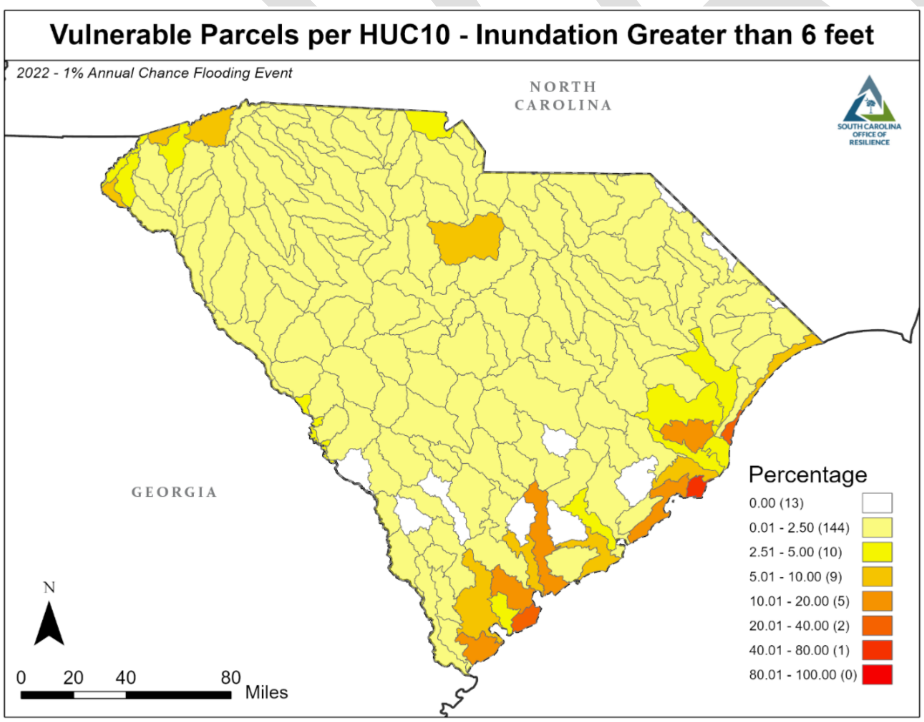


Figure 26: Percent of parcels estimated to be inundated greater than 6 feet in the 2022 1% annual chance flooding event. Flood risk data provided by the First Street Foundation Flood Risk Statistics, V2.0.

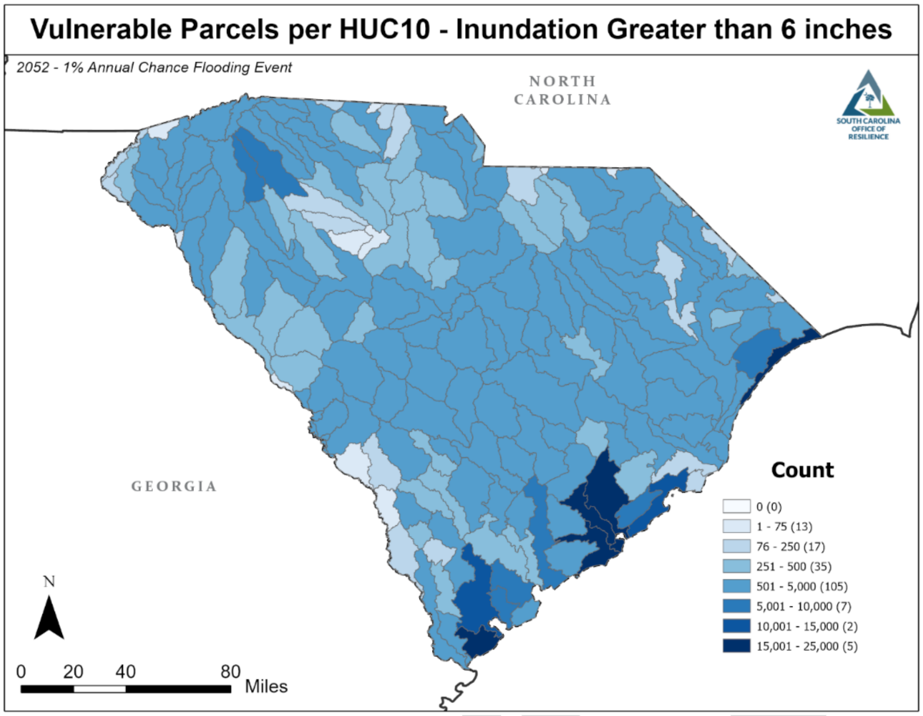


Figure 27: Count of parcels estimated to be inundated greater than 6 inches in the 2052 1% annual chance flooding event. Flood risk data provided by the First Street Foundation Flood Risk Statistics, V2.0.

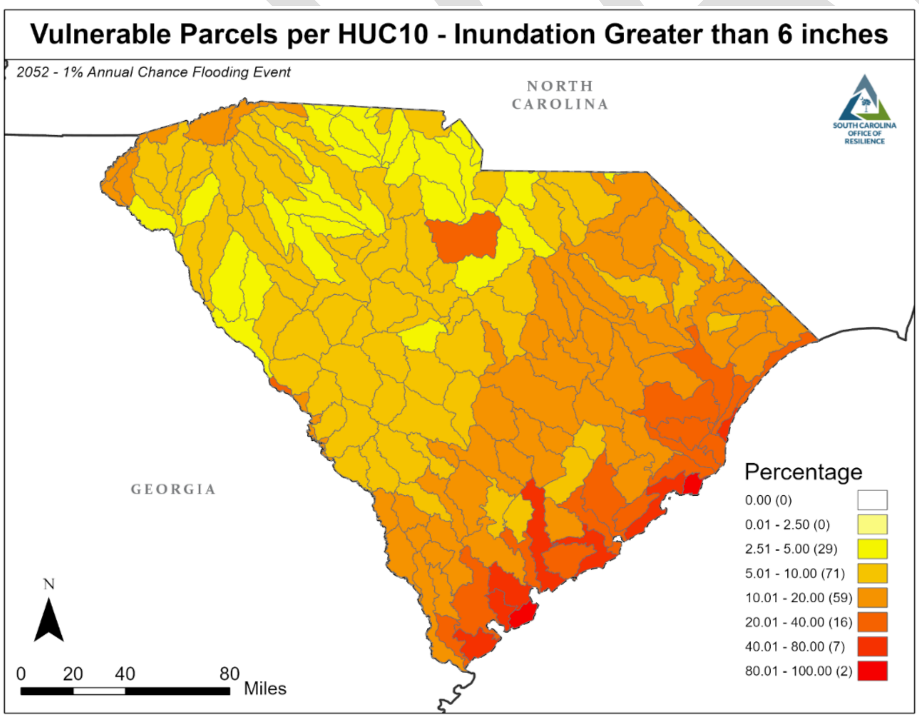


Figure 28: Percent of parcels estimated to be inundated greater than 6 inches in the 2052 1% annual chance flooding event. Flood risk data provided by the First Street Foundation Flood Risk Statistics, V2.0.

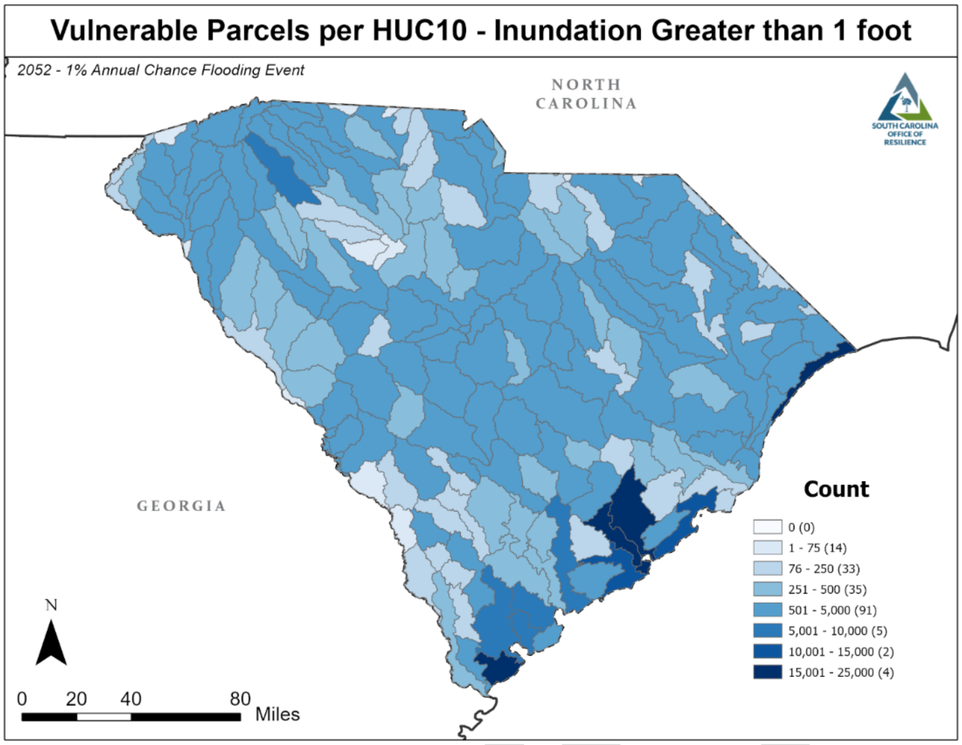


Figure 29: Count of parcels estimated to be inundated greater than 1 foot in the 2052 1% annual chance flooding event. Flood risk data provided by the First Street Foundation Flood Risk Statistics, V2.0.

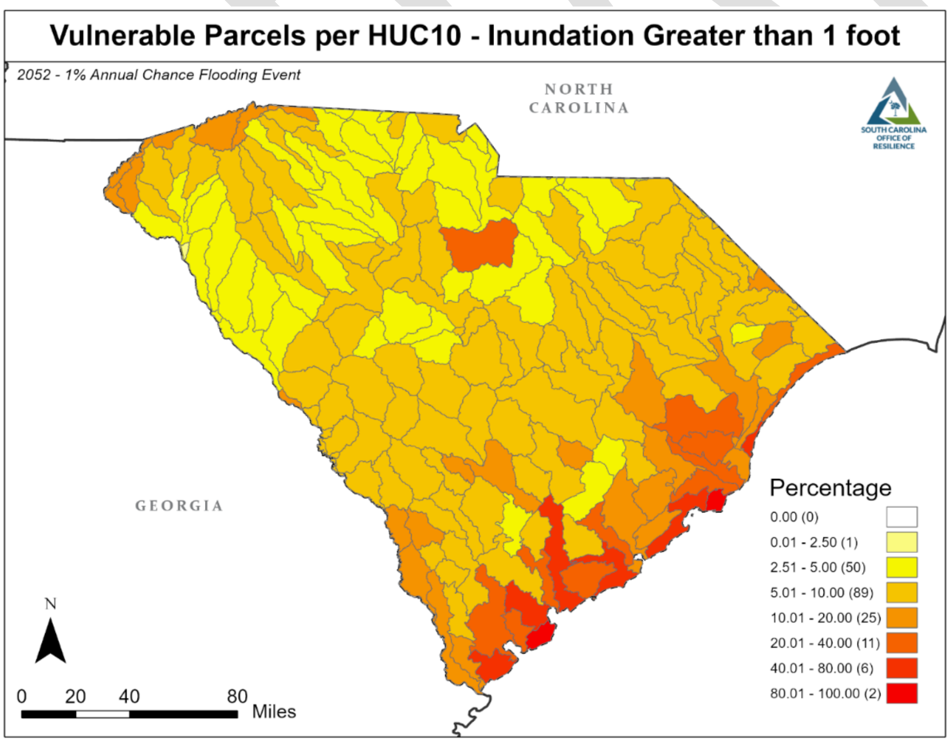


Figure 30: Percent of parcels estimated to be inundated greater than 1 foot in the 2052 1% annual chance flooding event. Flood risk data provided by the First Street Foundation Flood Risk Statistics, V2.0.

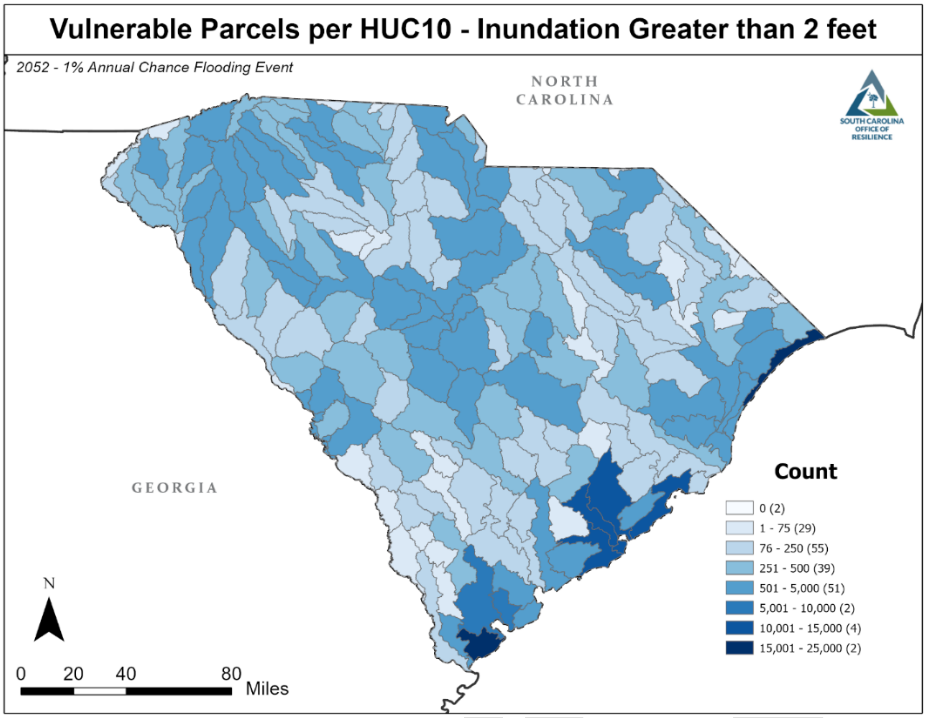


Figure 31: Count of parcels estimated to be inundated greater than 2 feet in the 2052 1% annual chance flooding event. Flood risk data provided by the First Street Foundation Flood Risk Statistics, V2.0.

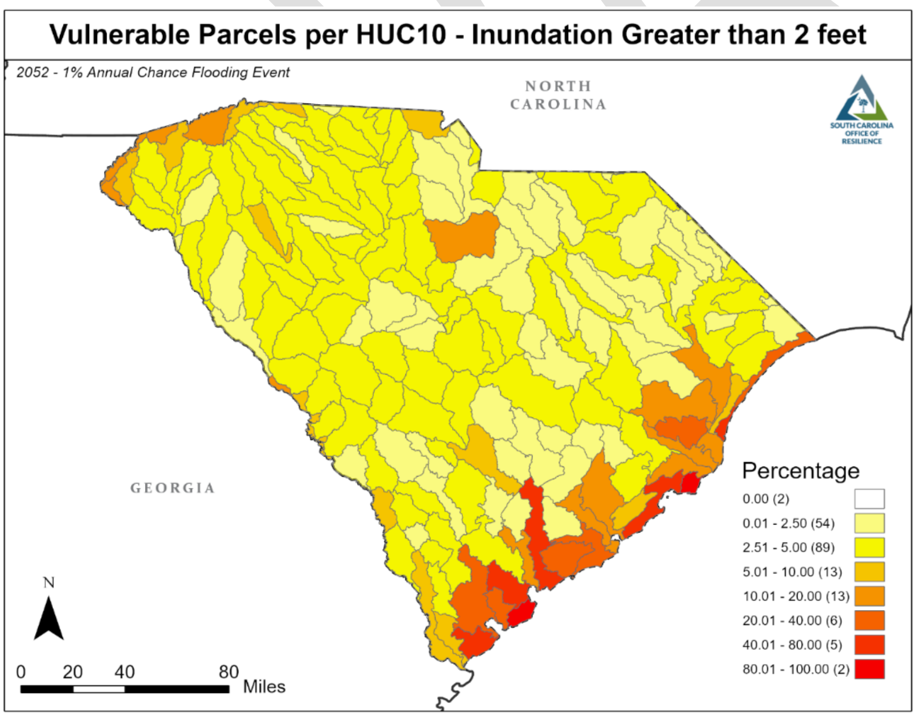


Figure 32: Percent of parcels estimated to be inundated greater than 2 feet in the 2052 1% annual chance flooding event. Flood risk data provided by the First Street Foundation Flood Risk Statistics, V2.0.

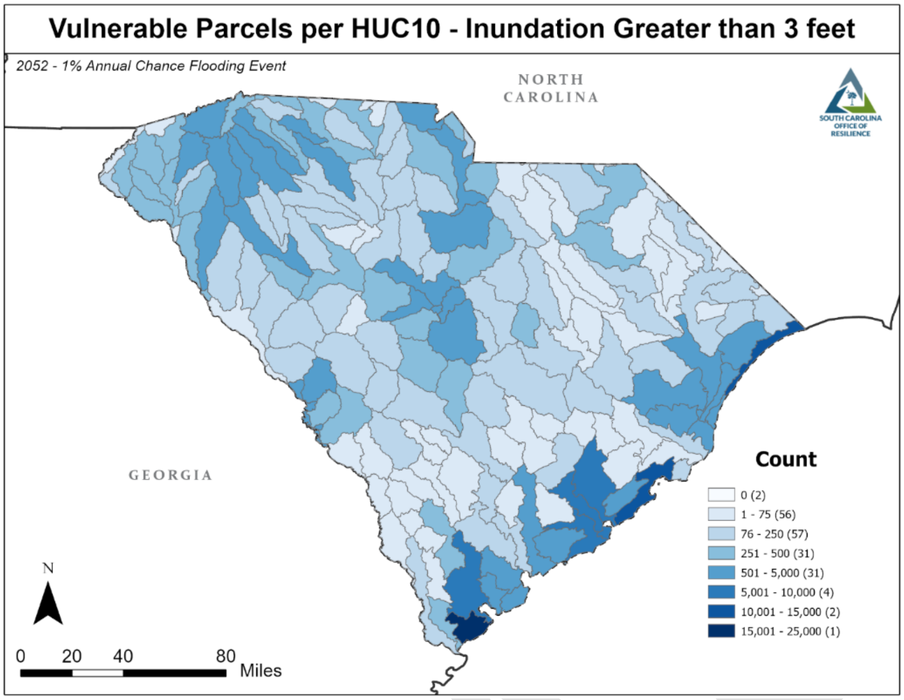


Figure 33: Count of parcels estimated to be inundated greater than 3 feet in the 2052 1% annual chance flooding event. Flood risk data provided by the First Street Foundation Flood Risk Statistics, V2.0.

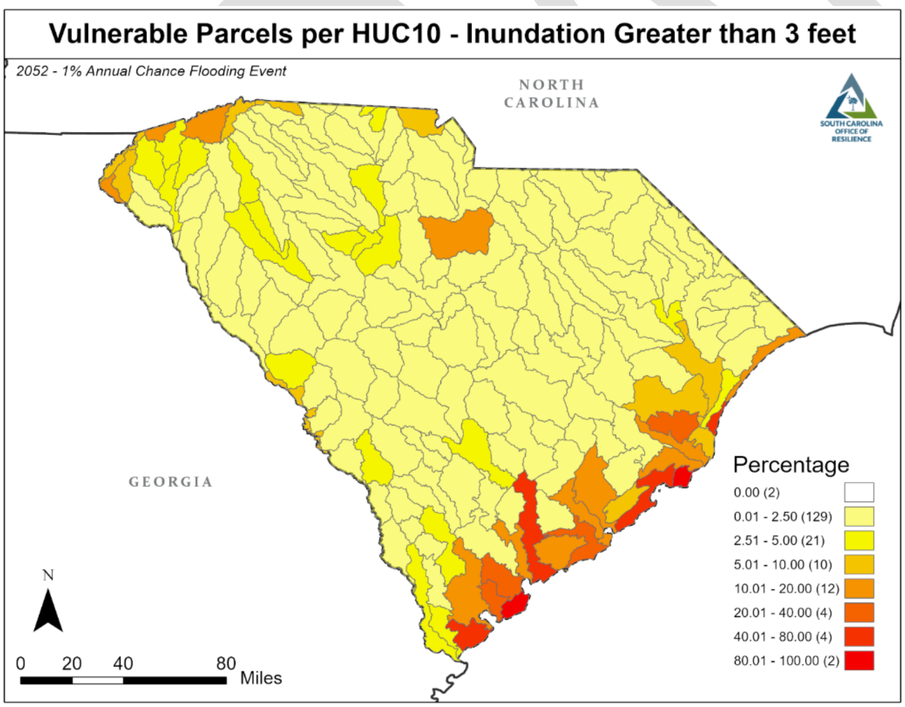


Figure 34: Percent of parcels estimated to be inundated greater than 3 feet in the 2052 1% annual chance flooding event. Flood risk data provided by the First Street Foundation Flood Risk Statistics, V2.0.

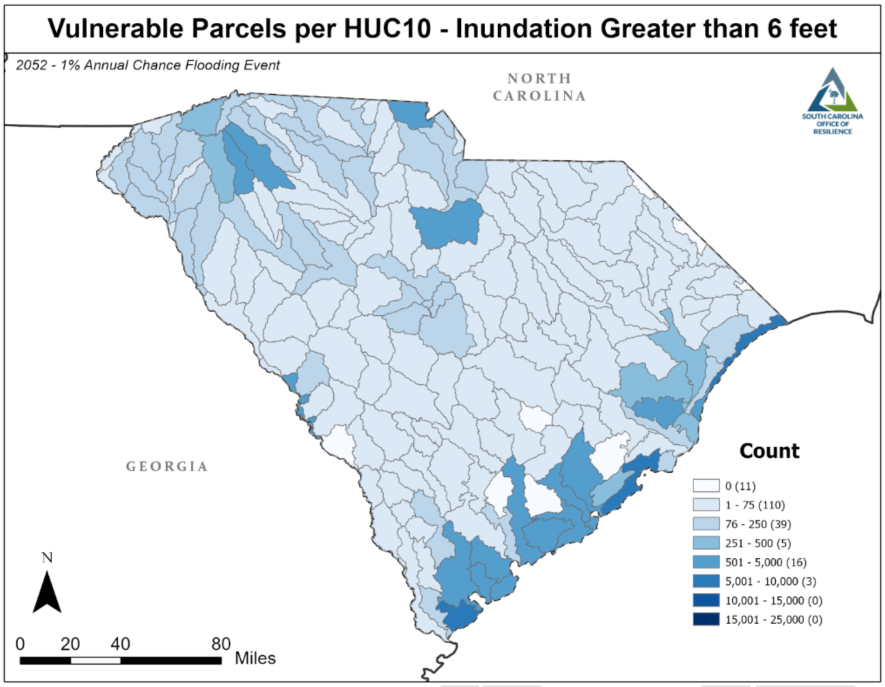


Figure 35: Count of parcels estimated to be inundated greater than 6 feet in the 2052 1% annual chance flooding event. Flood risk data provided by the First Street Foundation Flood Risk Statistics, V2.0.

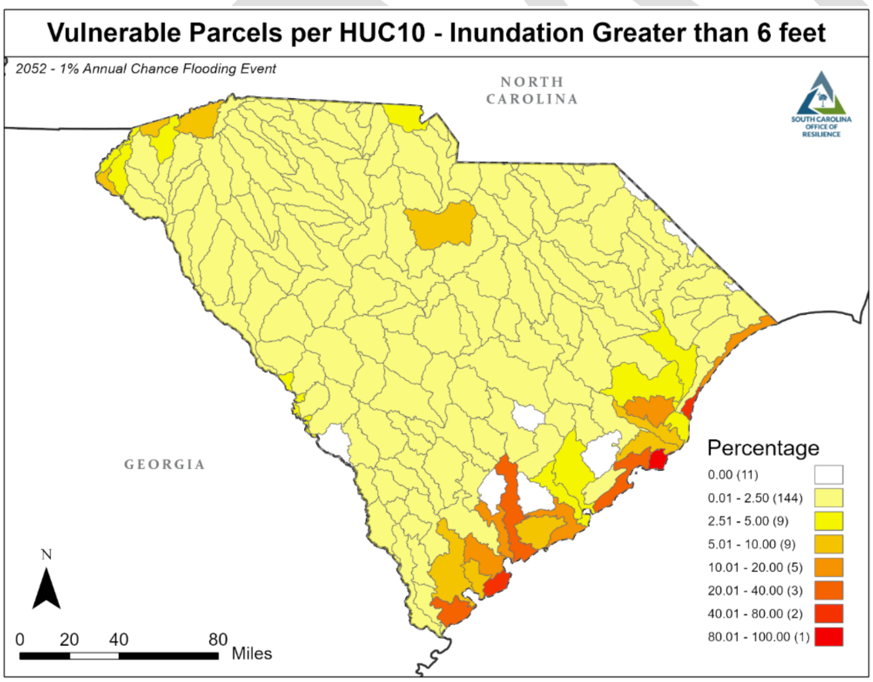


Figure 36: Percent of parcels estimated to be inundated greater than 6 feet in the 2052 1% annual chance flooding event. Flood risk data provided by the First Street Foundation Flood Risk Statistics, V2.0.

BUILDING CODES

To look at the vulnerability of the buildings on these properties, the strength of our building codes and their enforcement can be investigated. FEMA Region 4's 2021 Building Code Adoption Tracking Fact Sheet gives South Carolina a grade of 91.5%, for adopting most recent International Codes without weakening of any resilience provisions, 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 37). 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).

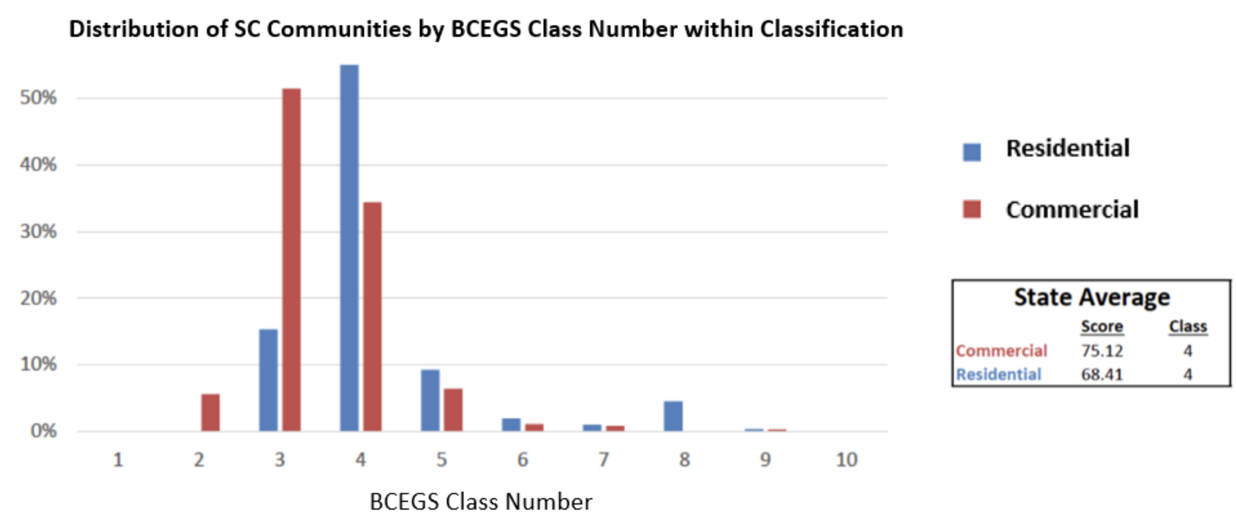


Figure 37: Average BCEGS Score for South Carolina (Insurance Services Office)

MOBILE HOMES

Mobile homes could be 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. 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 Emergnecy Management Agency, 2020). Therefore, the vulnerability of these homes can depend on their age and anchoring.

The vulnerability of mobile homes, and the recovery of those who live there, is complicated by common ownership in an arrangement 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 2020 (Figure 38) and 2050 (Figure 39) 1% annual chance flood events.

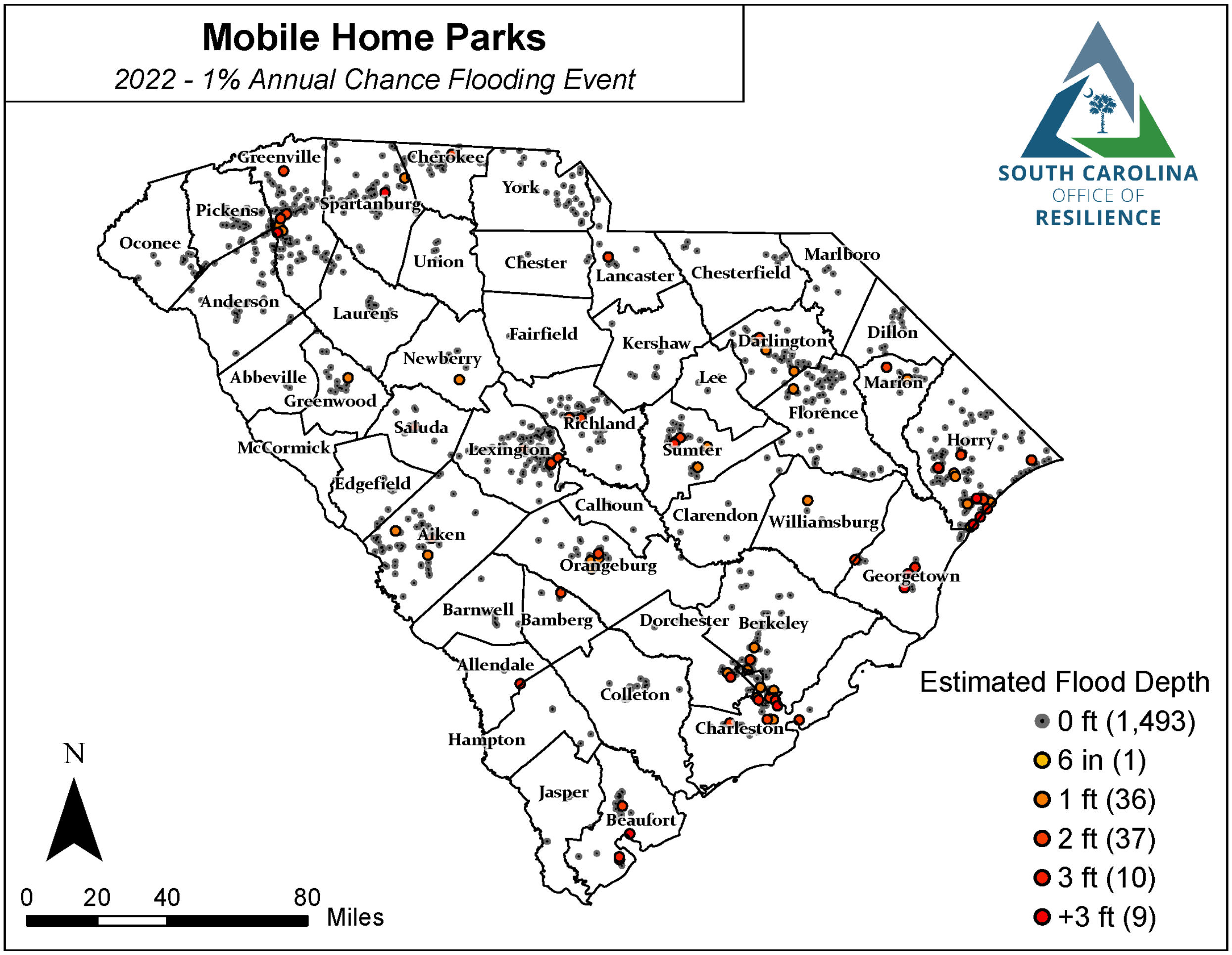


Figure 38: Estimated flooding of mobile home parks in the 2022 1% annual chance flooding event (Department of Homeland Security). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

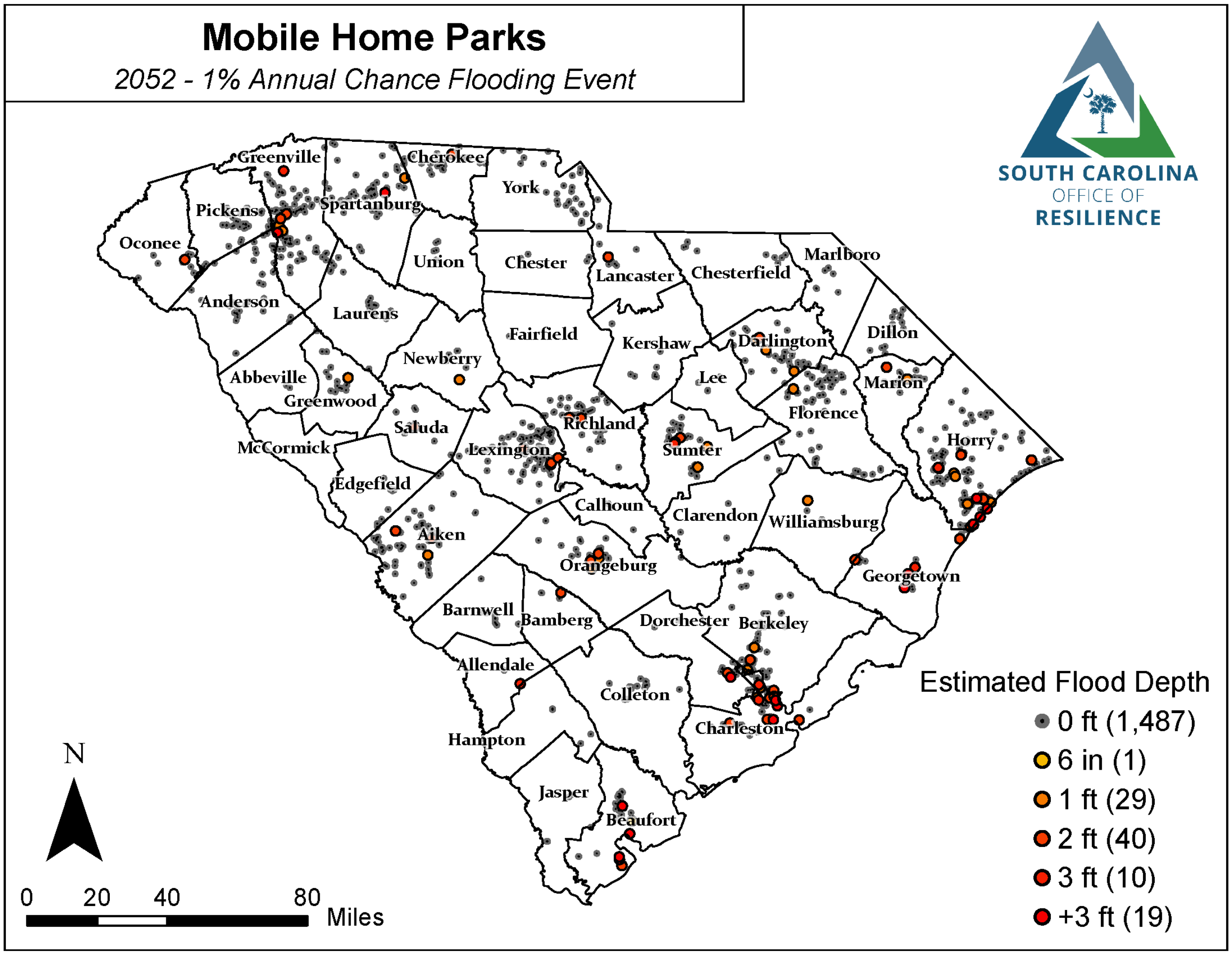


Figure 39: Estimated flooding of mobile home parks in the 2052 1% annual chance flooding event (Department of Homeland Security). Flood data provided by the First Street Foundation Hazard Layers, V2.0

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 due to loss time (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 characteristic 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 summarizes the commercial loss by inundation level for a 1% annual chance flood event in 2022 & 2052 including the count of inundated commercial properties and loss in days and financial loss.

Table 8: 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

Figure 40 shows the commercial properties estimated to be impacted by the 2022 1% annual flood event. Figure 41 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 42 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-2021.

Commercial facilities by county are outlined in Appendix B. Charleston County has the highest estimated impact with a potential of 3,600 properties and over 1 billion dollars being impacted by a 1% annual chance of flooding (Appendix B). Coastal counties, Beaufort, Charleston, Georgetown, and Horry are modeled to be the most impacted, but urban centers also see a high estimation of impact, including Aiken, Dorchester, Florence, Greenville, Richland, and Spartanburg each having over 200 commercial properties with estimated flooding impact in a 1% annual chance event (Appendix B). All counties in South Carolina can be impacted by 1%

annual chance of flood event, with a statewide average of 53 days loss to flooding and recovery and an estimated average economic loss of $200,000.

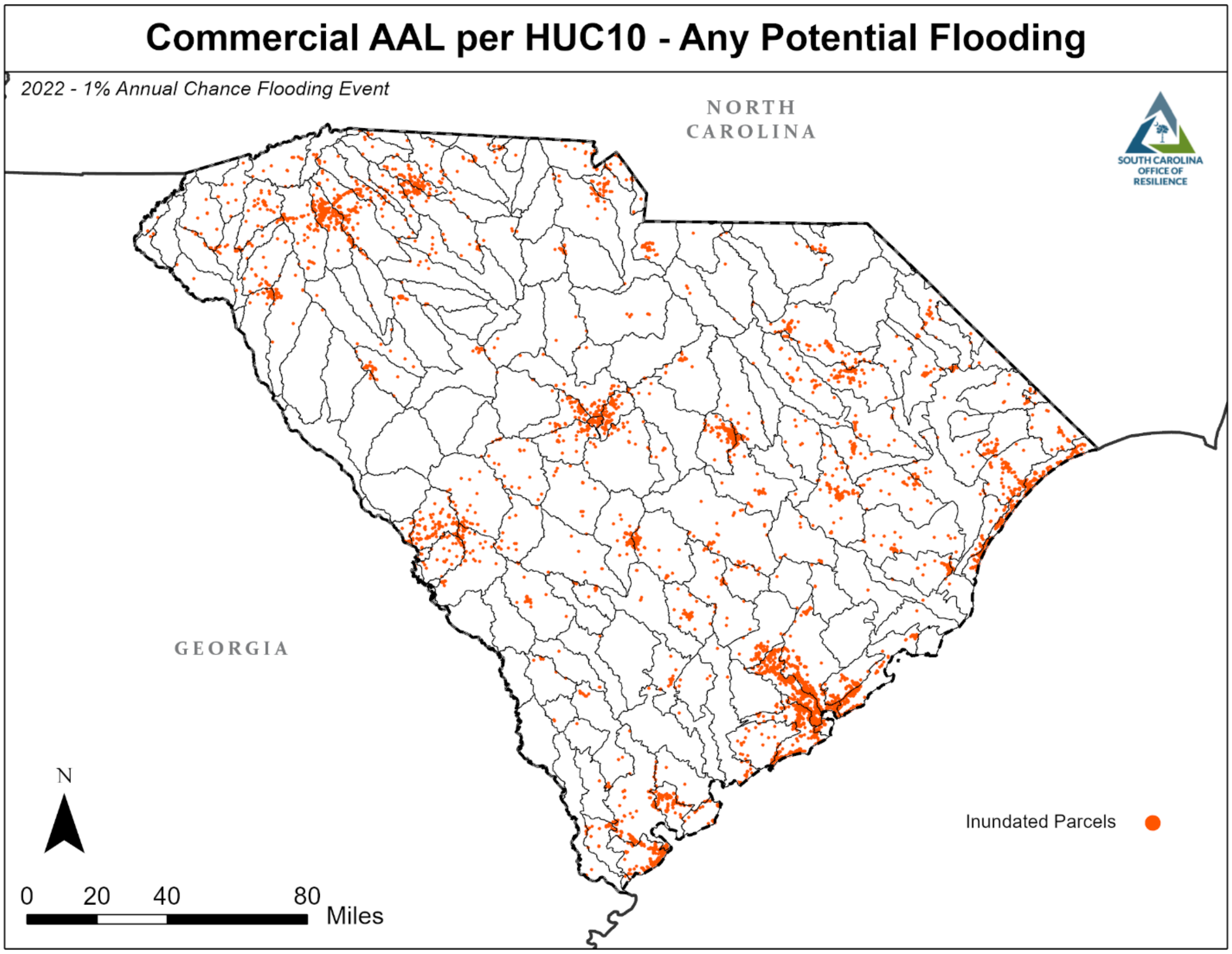


Figure 40: Estimated commercial properties with inundation by the 2022 1% annual chance flood event. Flood data provided by the First Street Foundation Flood Risk Statistics, V2.0.

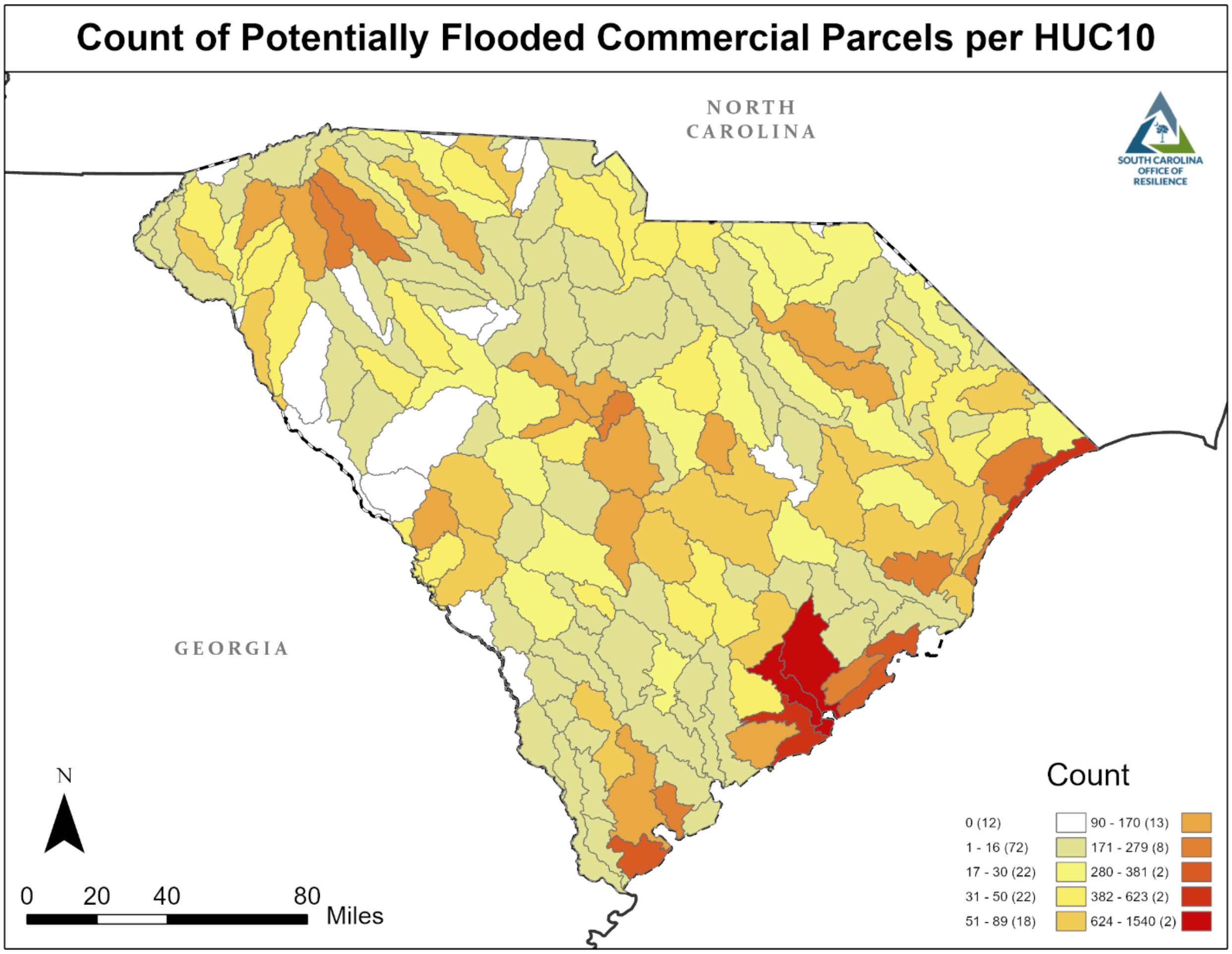


Figure 41: Estimated count of commercial facilities inundated by 1% annual chance flood event in First Street Foundation Flood Model Scenario mid-2022 in each HUC10 in South Carolina. Flood data provided by the First Street Foundation Flood Risk Statistics, V2.0.

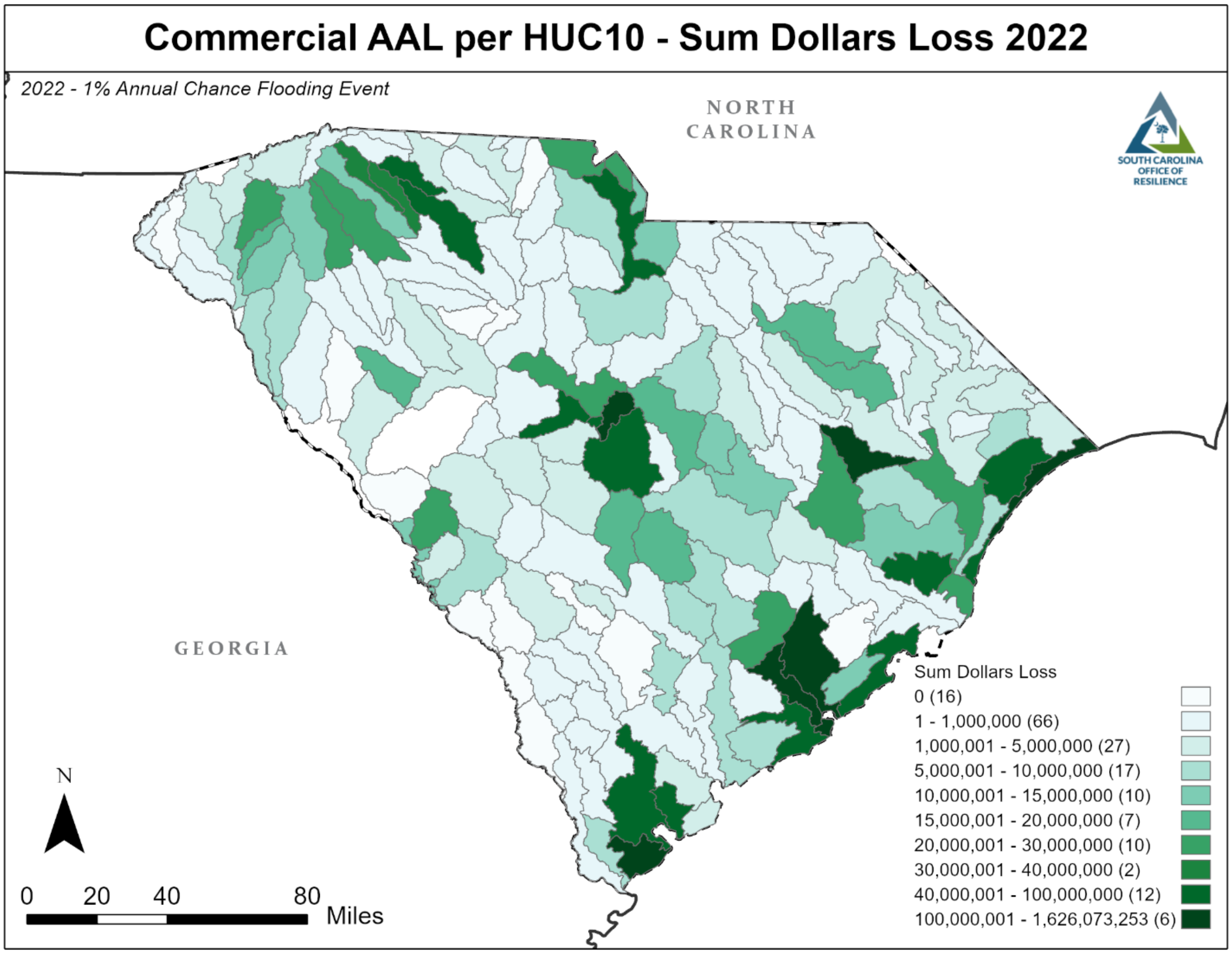


Figure 42: Estimated total dollars loss, by HUC10, of commercial facilities inundated by 1% annual chance flood event in First Street Foundation Flood Model Scenario mid-2022. Flood data provided by the First Street Foundation Flood Risk Statistics, V1.3.

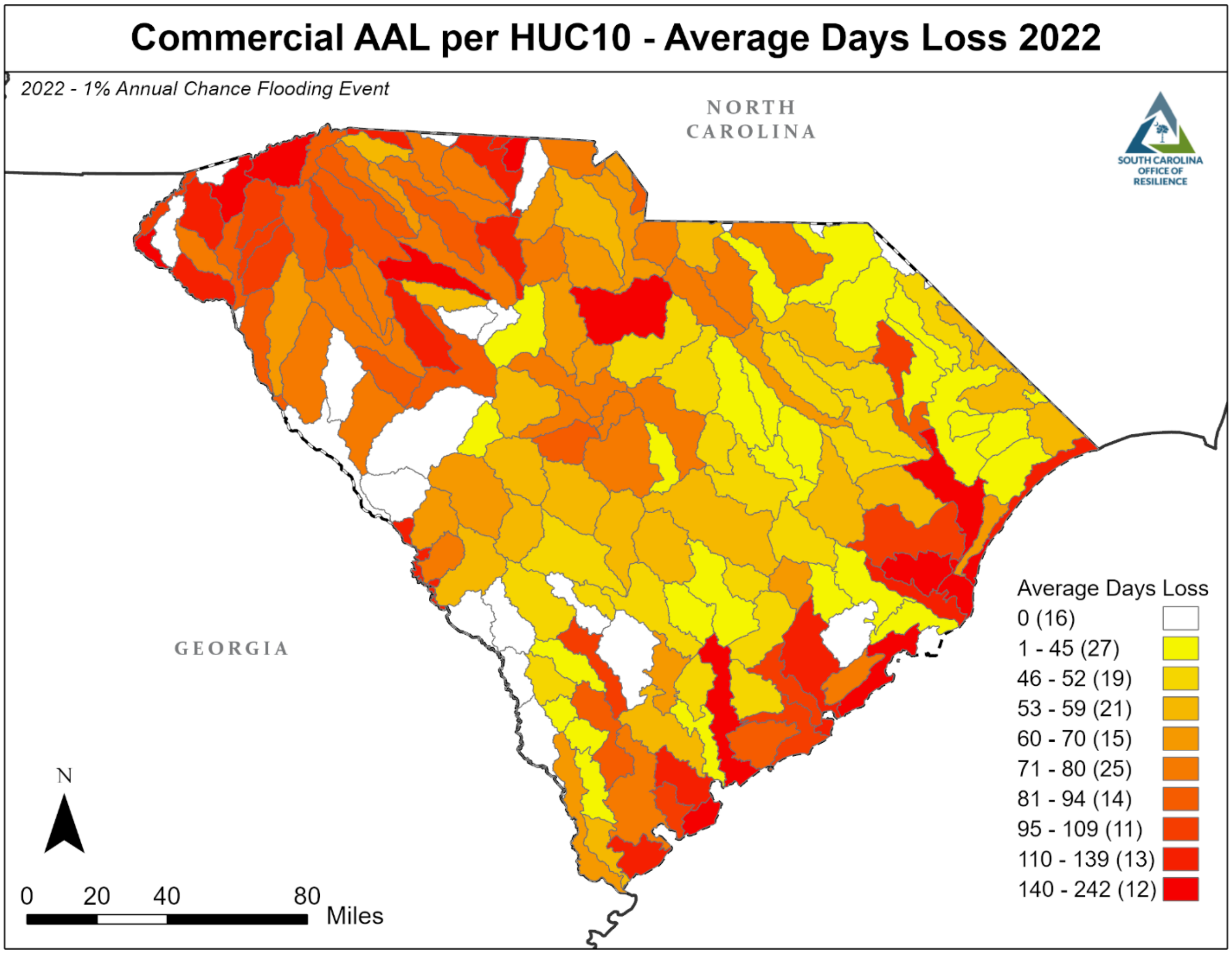


Figure 43: Estimated average days loss, by HUC10, of commercial facilities inundated by 1% annual chance flood event in First Street Foundation Flood Model Scenario mid-2022. Flood data provided by the First Street Foundation Flood Risk Statistics, V2.0.

ANTHROPOGENIC SYSTEMS VULNERABILITY

While the natural systems above are in many ways naturally resilient, many of our vulnerabilities to hazards come at the intersection of human systems and environmental change and events. This section includes the vulnerability of the human 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.

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. An increasing population and growth 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 two sources, surface water (lakes and rivers) and groundwater (via wells). 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 locate on a dam 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.

The Columbia Canal originally opened in 1824 as a transportation alternative to the railroads to connect the upstate to the port in Charleston. Later additions of water supply and power in the later 19th and early 20th century (Marsh, 2015). During the historic 2015 flooding in Columbia, a 60-foot wide breach, emptying the canal into the Congaree River, compromising the primary water supply to the roughly 400,000 people that rely on the canal for water (Underwood, 2021; Marsh, 2015). The City of Columbia, Columbia Water, and FEMA kicked off repairs of the canal, with agreements announced in 2020 and the construction stating in 2022 (Columbia Water, 2022; Underwood, 2021).

The figures below quantify the number of public water supply facilitates impacted by the 2022 (Figure 44) and 2052 (Figure 45) 1% annual chance flood events. Flooding can result in excessive runoff and pollution loading into the water supply, threatening public health, safety and welfare.

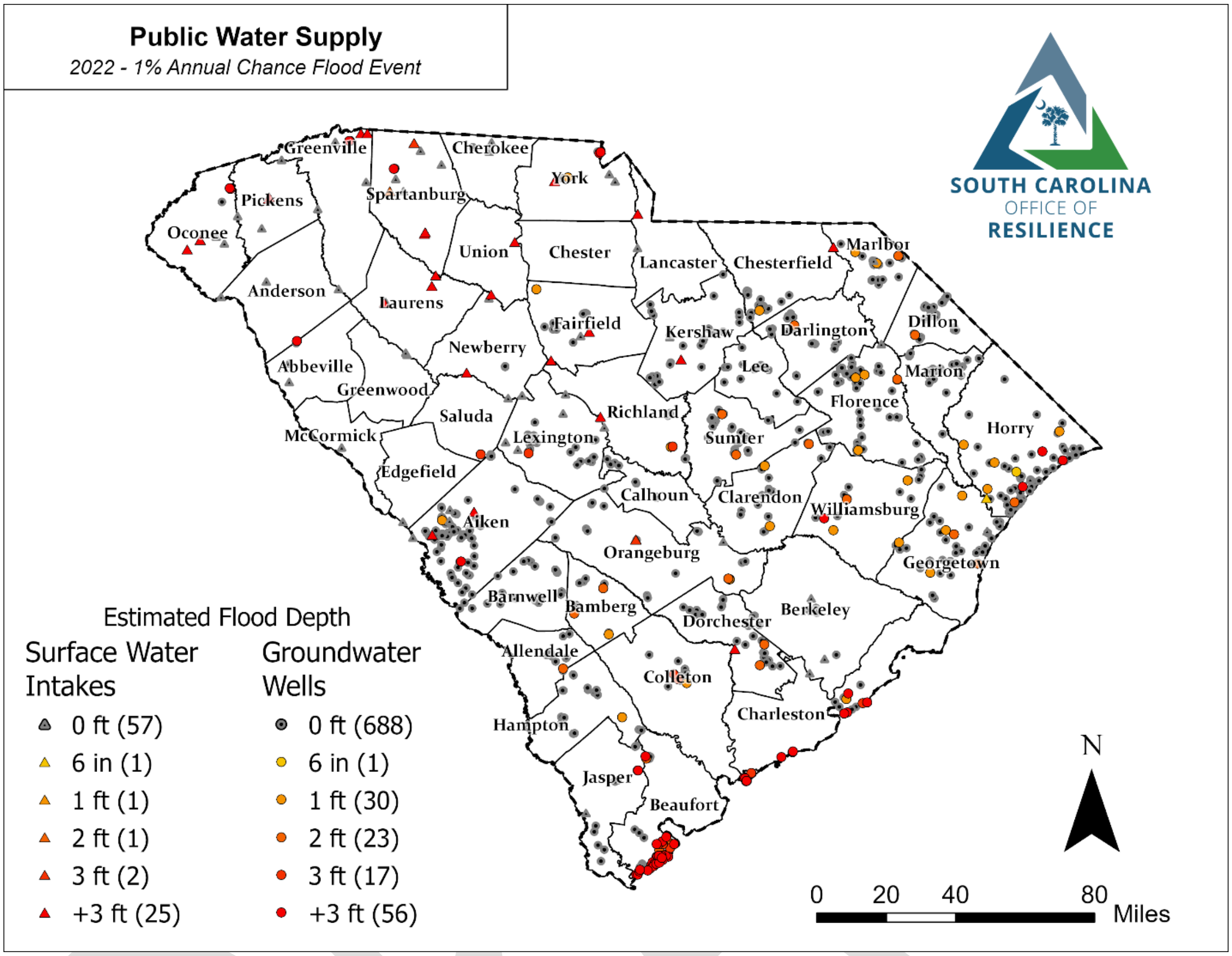


Figure 44: Estimated flooding of Public Water Supply in the 2022 1% annual chance flooding event (DHEC). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

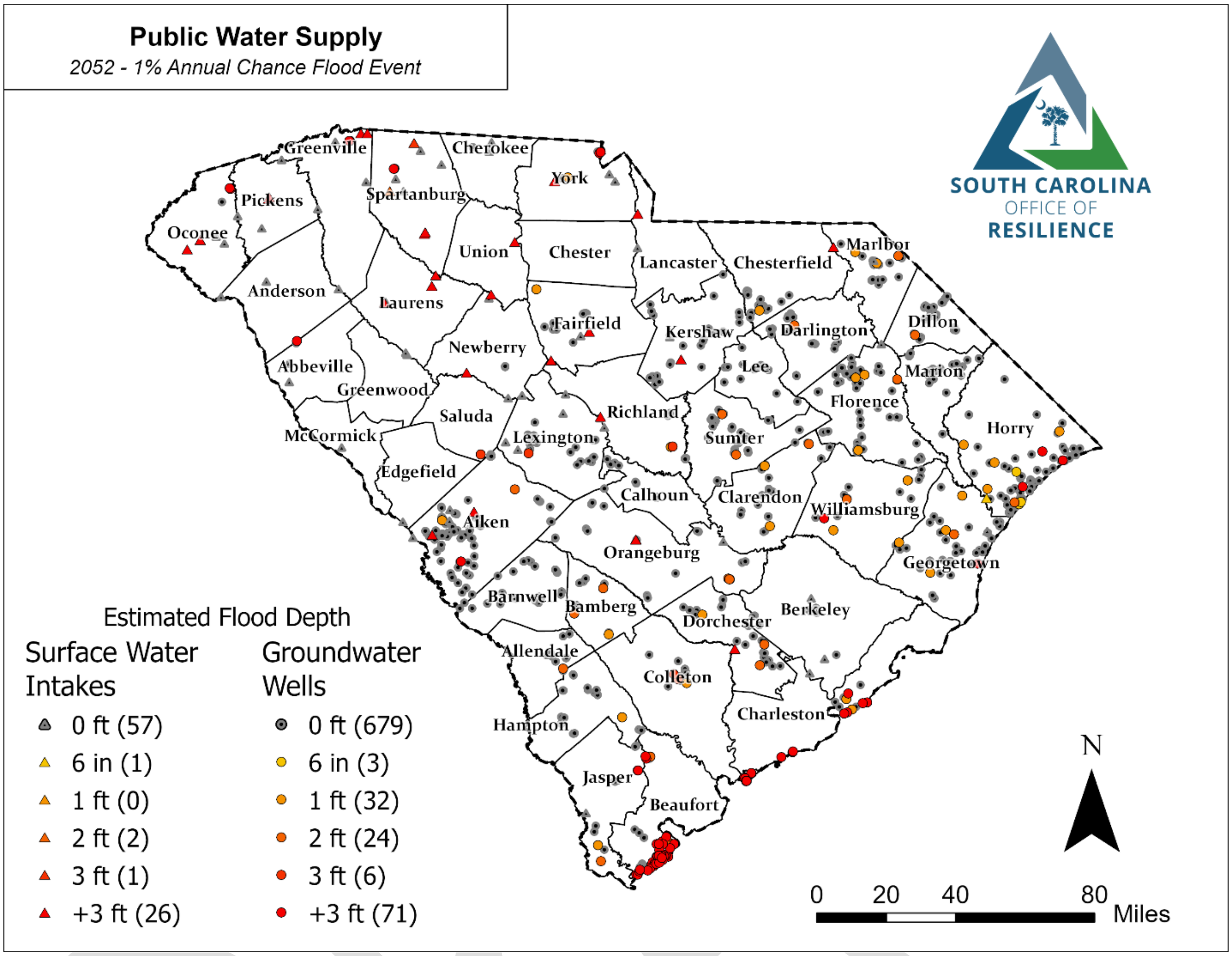


Figure 45: Estimated flooding of Public Water Supply in the 2052 1% annual chance flooding event (DHEC). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

HAZARDOUS WASTE LOCATIONS

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

SEWER SYSTEM DISCHARGE

The management of sewage is an essential utility to be maintained in the face of environmental change and natural hazards, essential to maintaining 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) regulates potential discharge of pollutants into the waters across the nation and in South Carolina, is maintained by SCDHEC. Using the sewerage system user type in the NPDES permits, supplied by SCDHEC, 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 quantify the number of sewer system discharges impacted by the 2022 (Figure 46) and 2052 (Figure 47) 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.

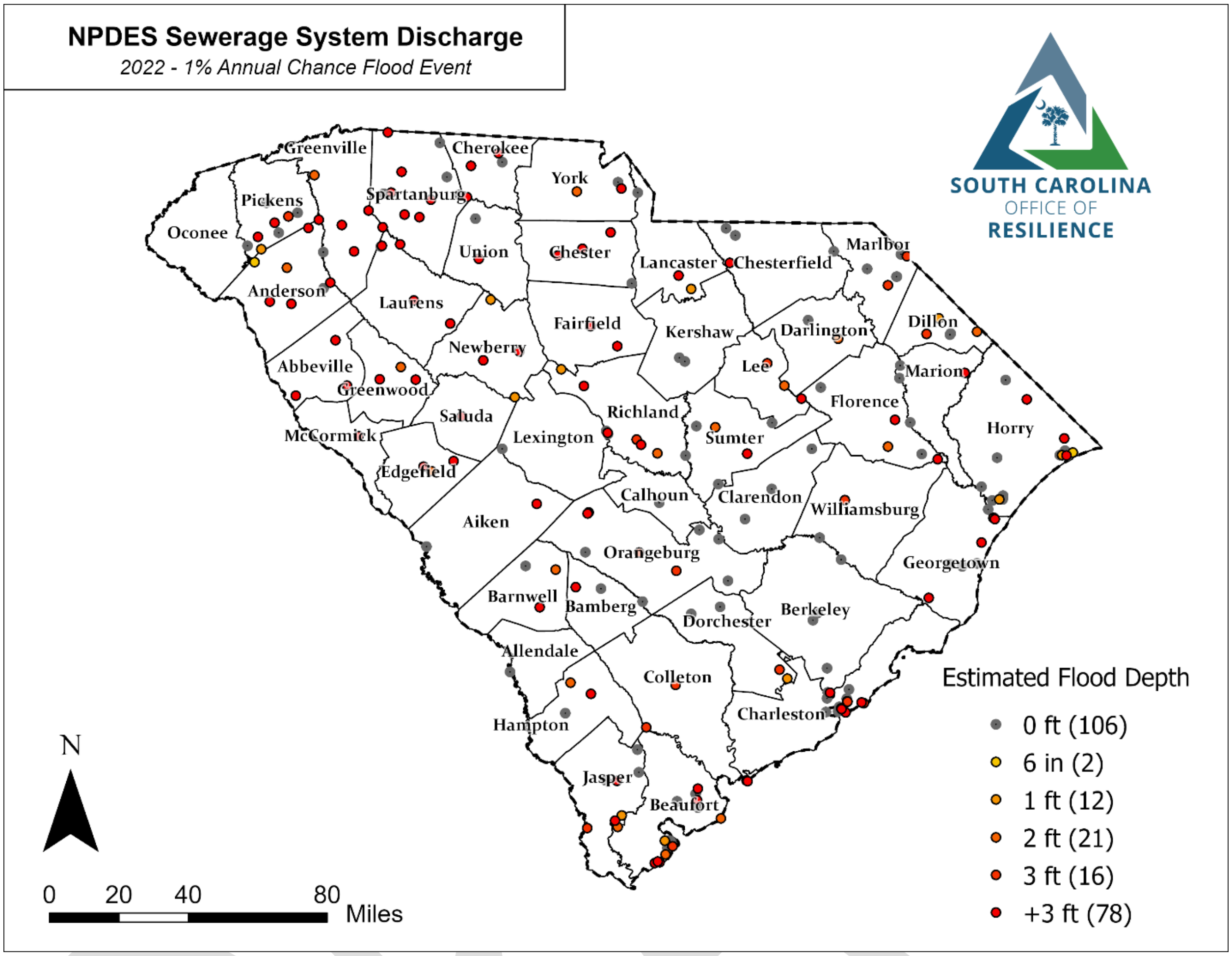


Figure 46: Estimated flooding of NPDES sewerage system discharge in the 2022 1% annual chance flooding event (DHEC). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

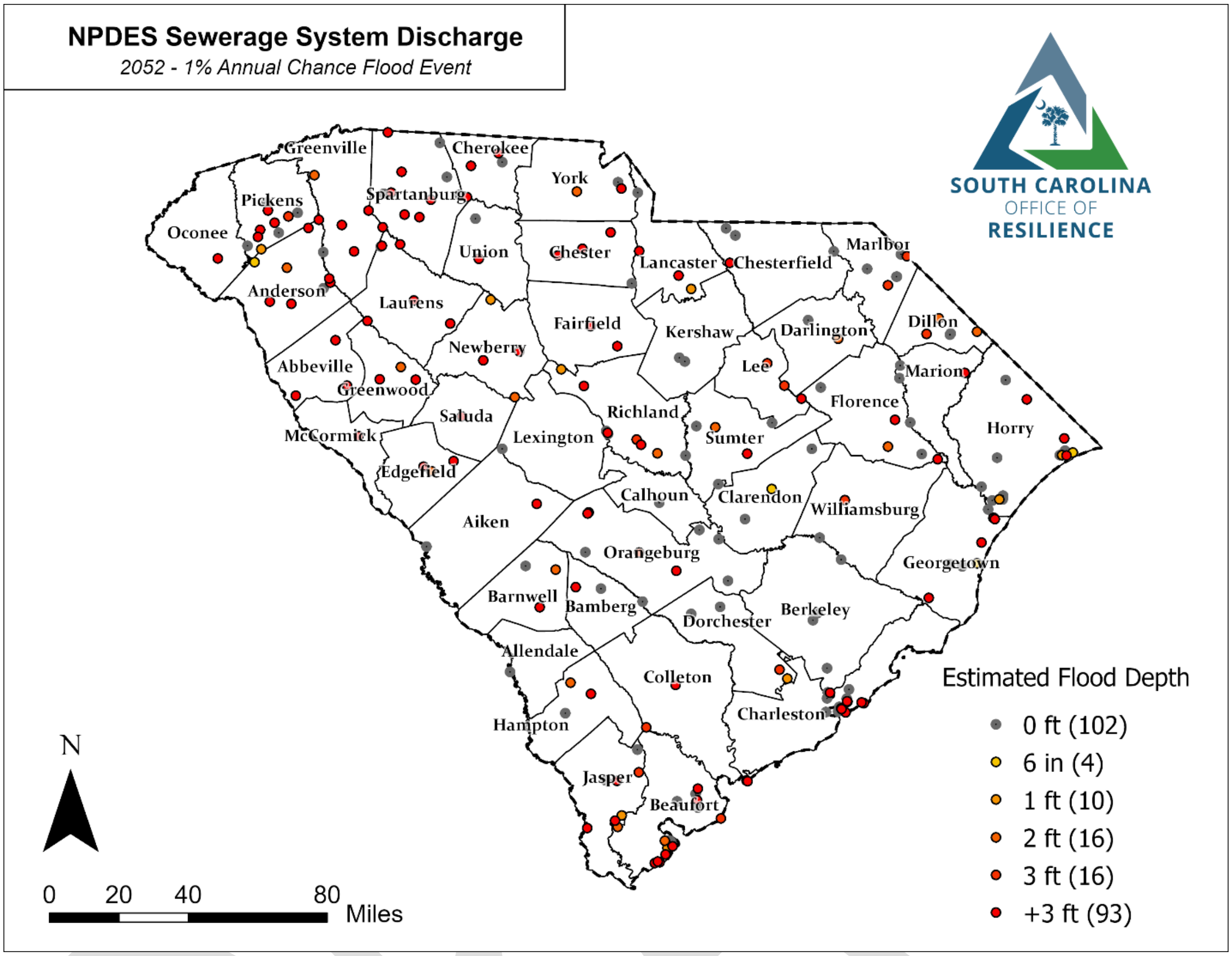


Figure 47: Estimated flooding of NPDES sewerage system discharge in the 2052 1% annual chance flooding event (DHEC). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

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. SC 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 show the estimated flooding of dry cleaners in the 2022 (Figure 48) and 2052 (Figure 49) 1% annual chance flooding event.

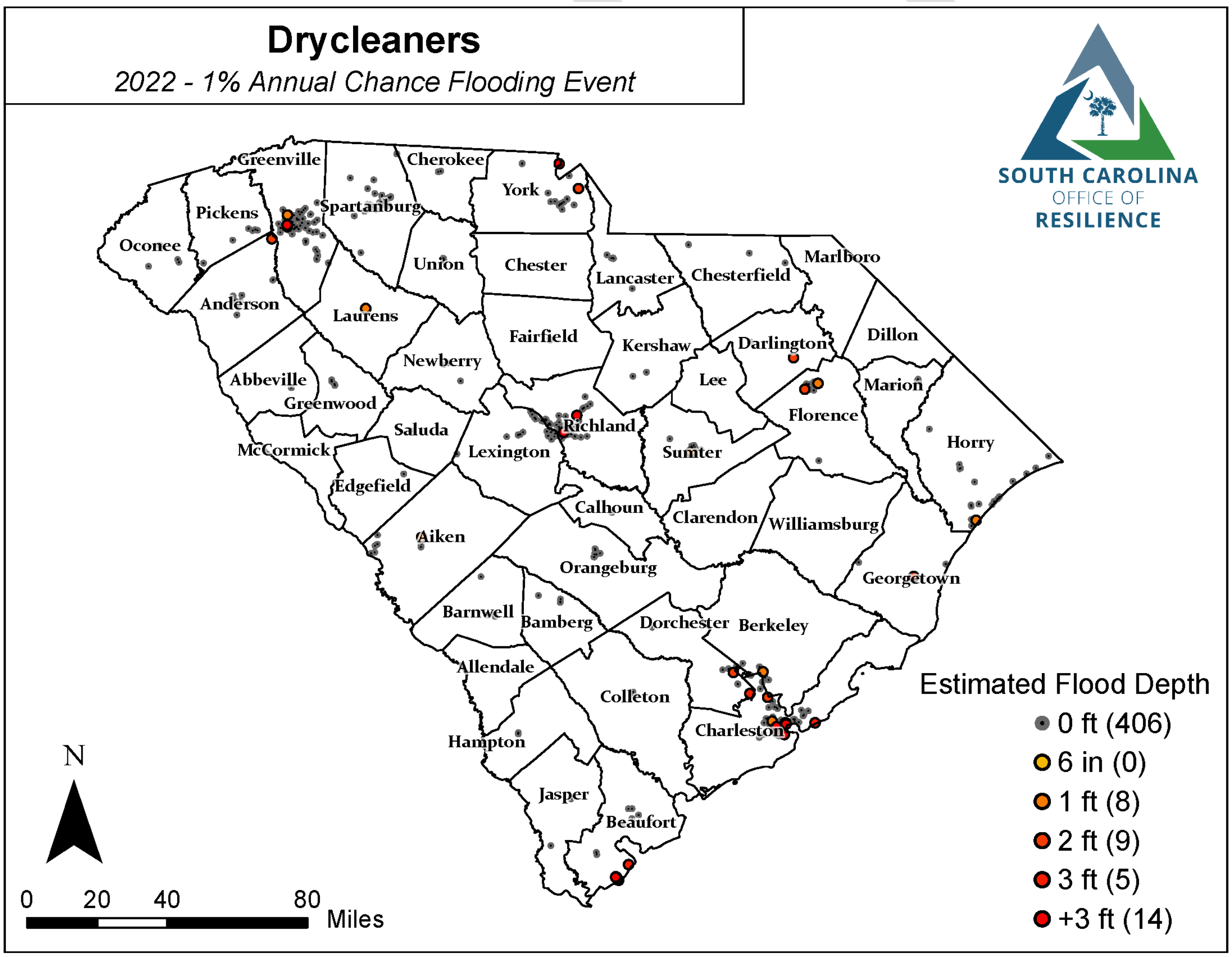


Figure 48: Estimated flooding of dry cleaners in the 2022 1% annual chance flooding event (DHEC). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

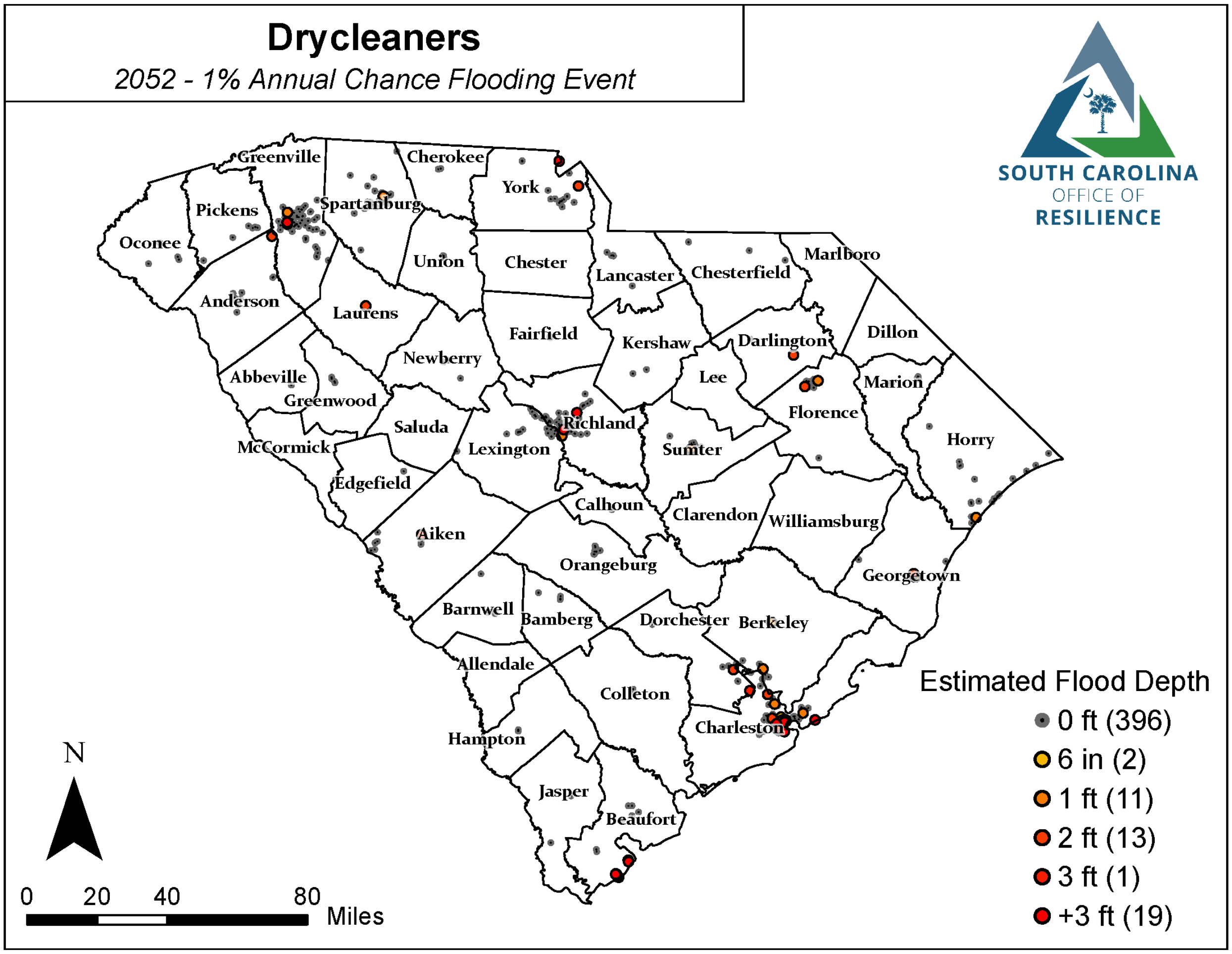


Figure 49: Estimated flooding of dry cleaners in the 2052 1% annual chance flooding event (DHEC). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

MINES

About 500 mines are actively operating, with permits through DHEC, following the [SC Mining Act](#) (1974). There are several types of surface mining done in the state including open pit mining of granite for instance, as well as 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). However, the figures below show that some mines may be impacted under the First Street current (2022) and future (2052) scenario outside of these floodways (Figure 50 and Figure 51).

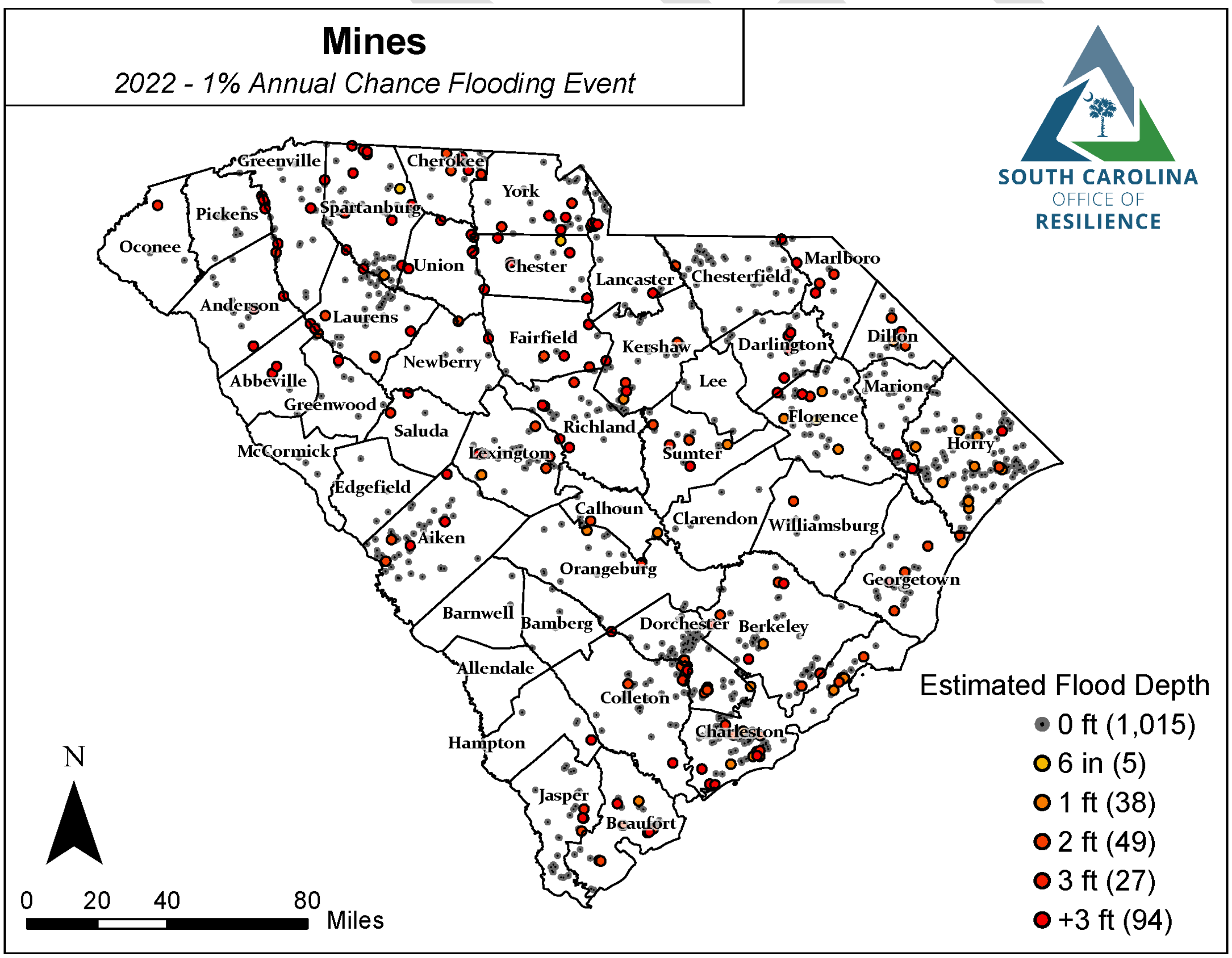


Figure 50: Estimated flooding of mines in the 2022 1% annual chance flooding event (DHEC). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

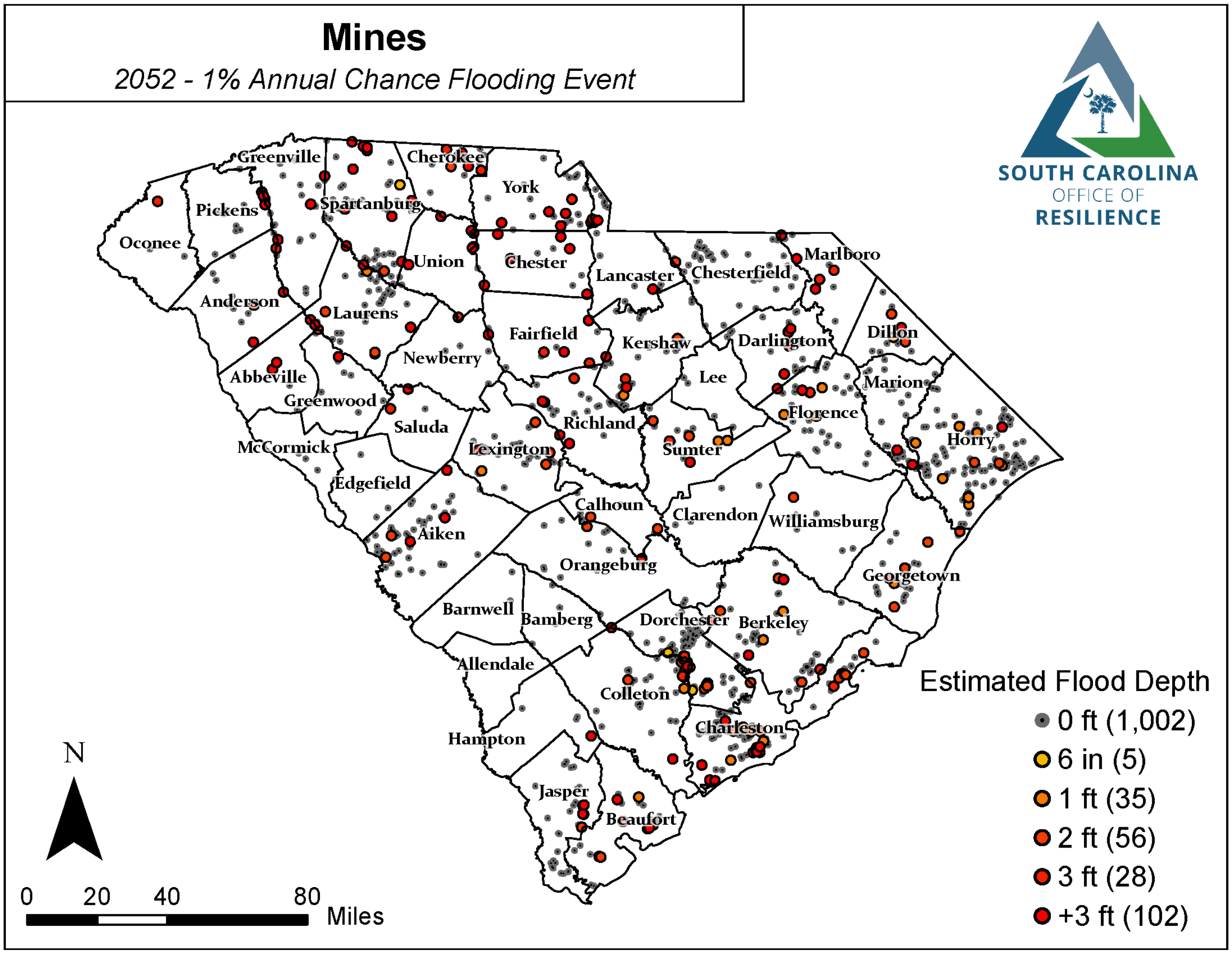


Figure 51: Estimated flooding of mines in the 2052 1% annual chance flooding event (DHEC). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

SOLID WASTE FACILITES

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 52 and Figure 53 show the estimated flooding of solid waste landfills in 2022 and 2052 1% annual chance flooding event while Figure 54 and Figure 55 show the estimated flooding of all solid waste facilities.

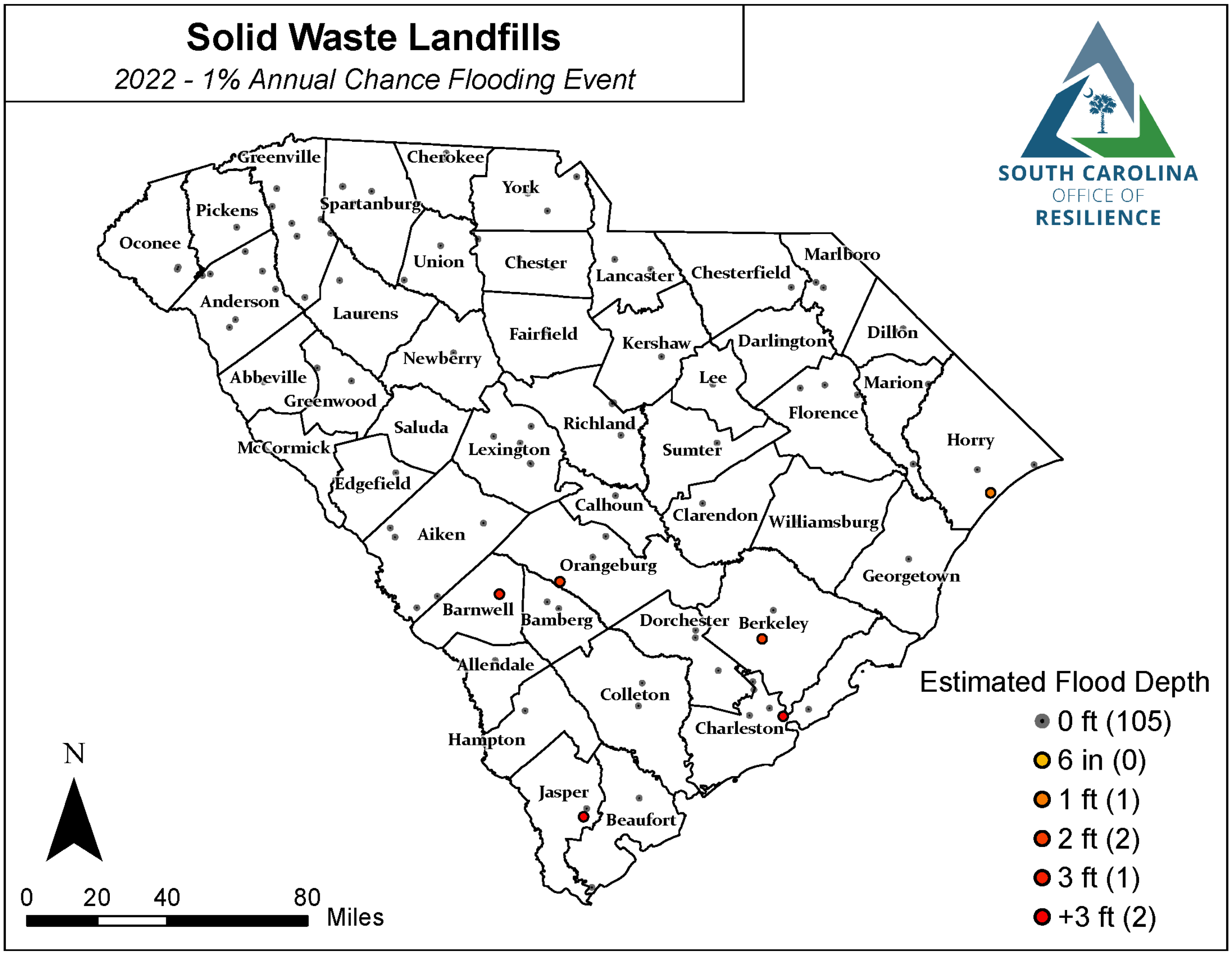


Figure 52: Estimated flooding of solid waste facilities in the 2022 1% annual chance flooding event (Department of Homeland Security). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

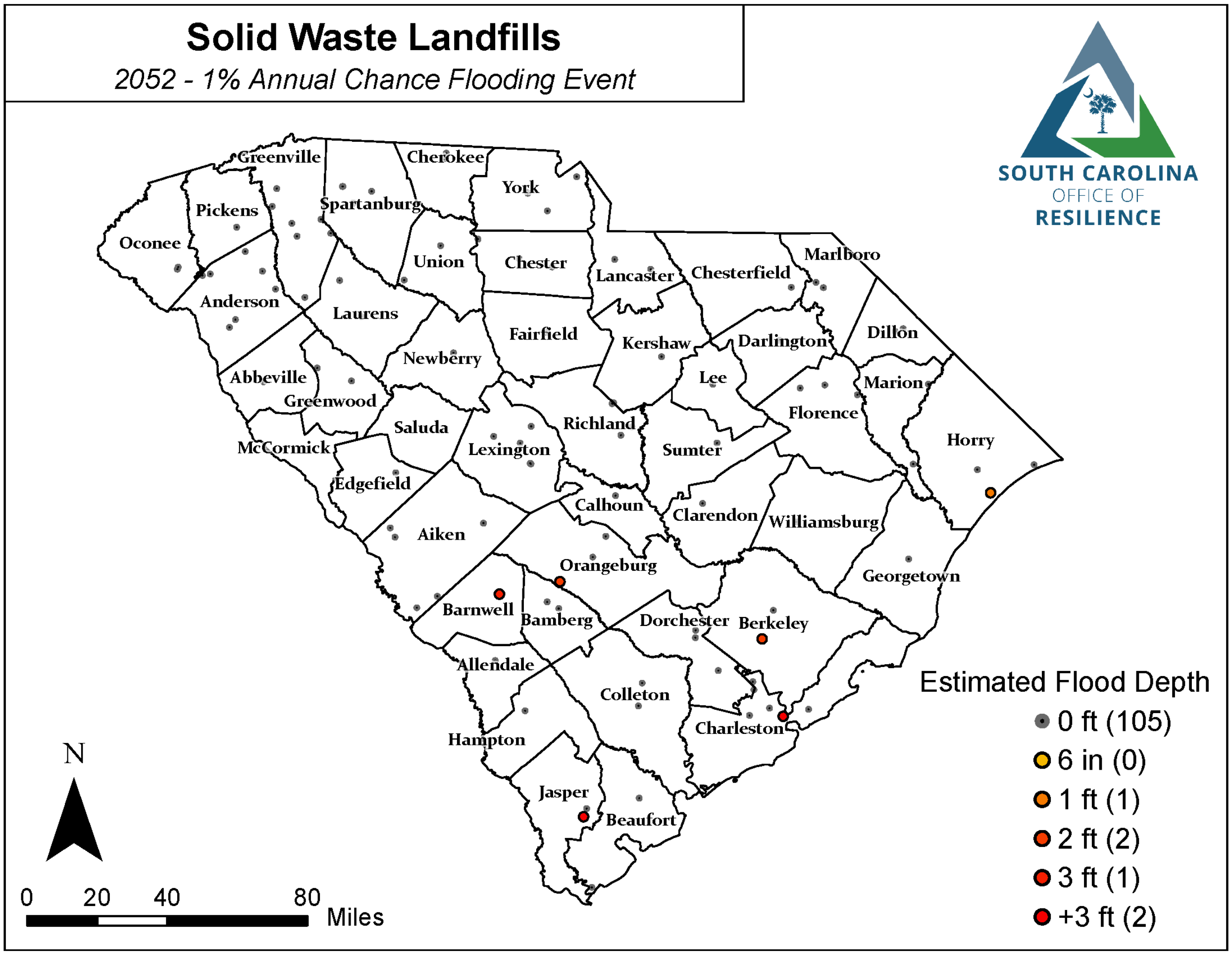


Figure 53: Estimated flooding of solid waste landfills in the 2052 1% annual chance flooding event (Department of Homeland Security). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

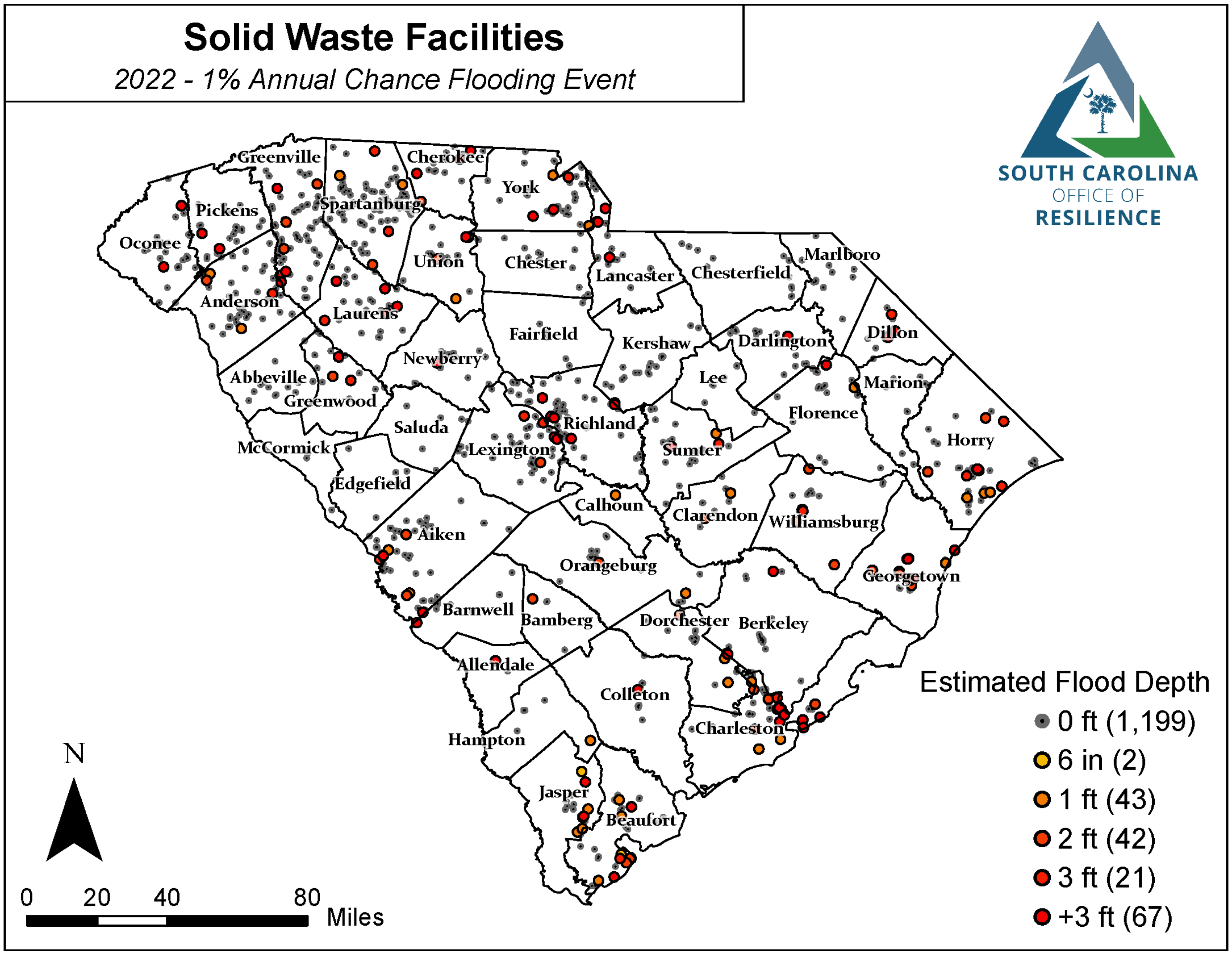


Figure 54: Estimated flooding of solid waste facilities in the 2022 1% annual chance flooding event (DHEC). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

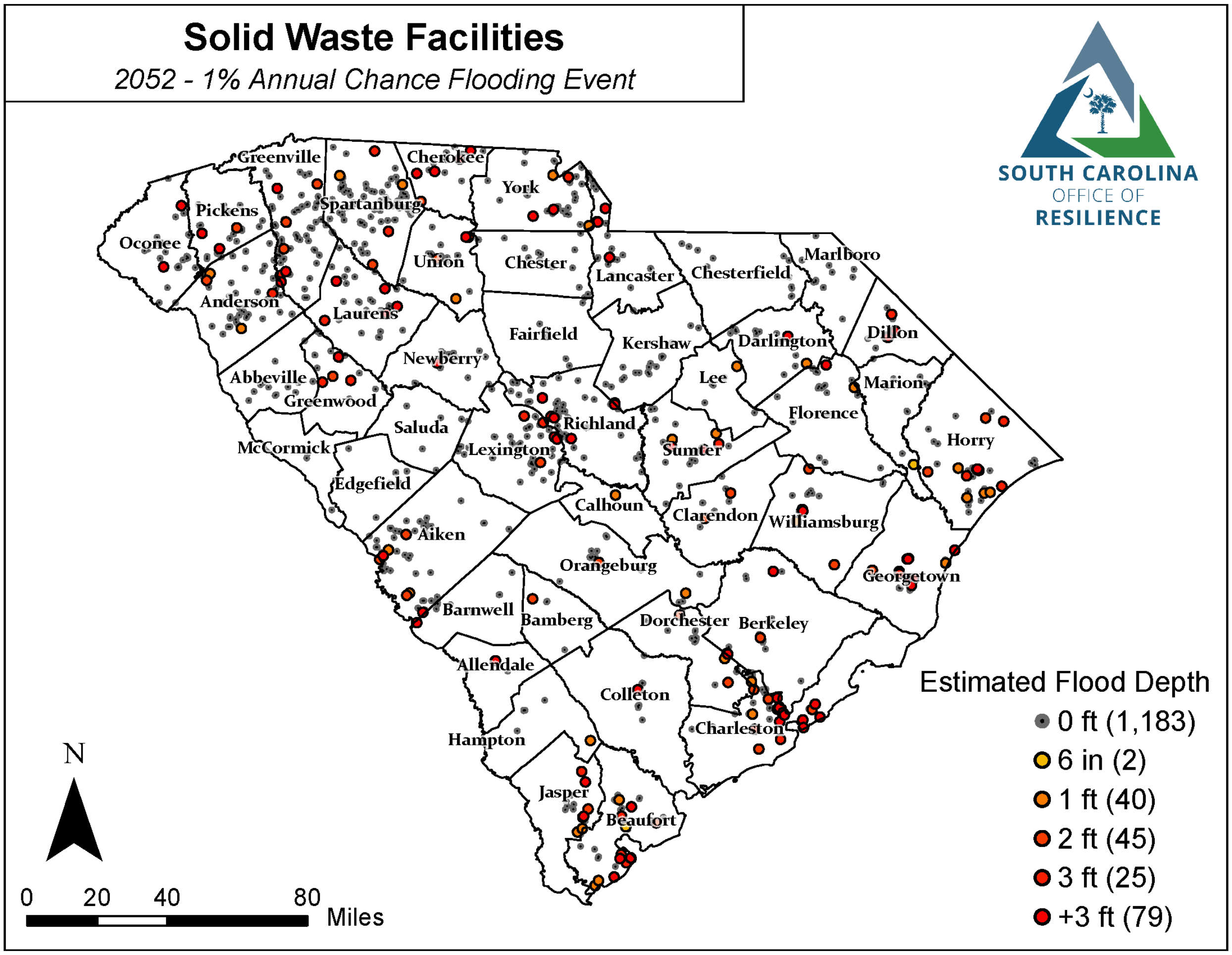


Figure 55: Estimated flooding of solid waste facilities in the 2052 1% annual chance flooding event (DHEC). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

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 5800 sites across the state. Locations not displayed at the request of DHEC.

Table 8 shows the estimated flood depth of these sites under both the 2022 and 2052 1% annual chance flooding event.

Table 9: 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 TSD (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 estimated flooding of these facilities in 2022 (Figure 56) and 2052 (Figure 57) 1% annual chance flooding event.

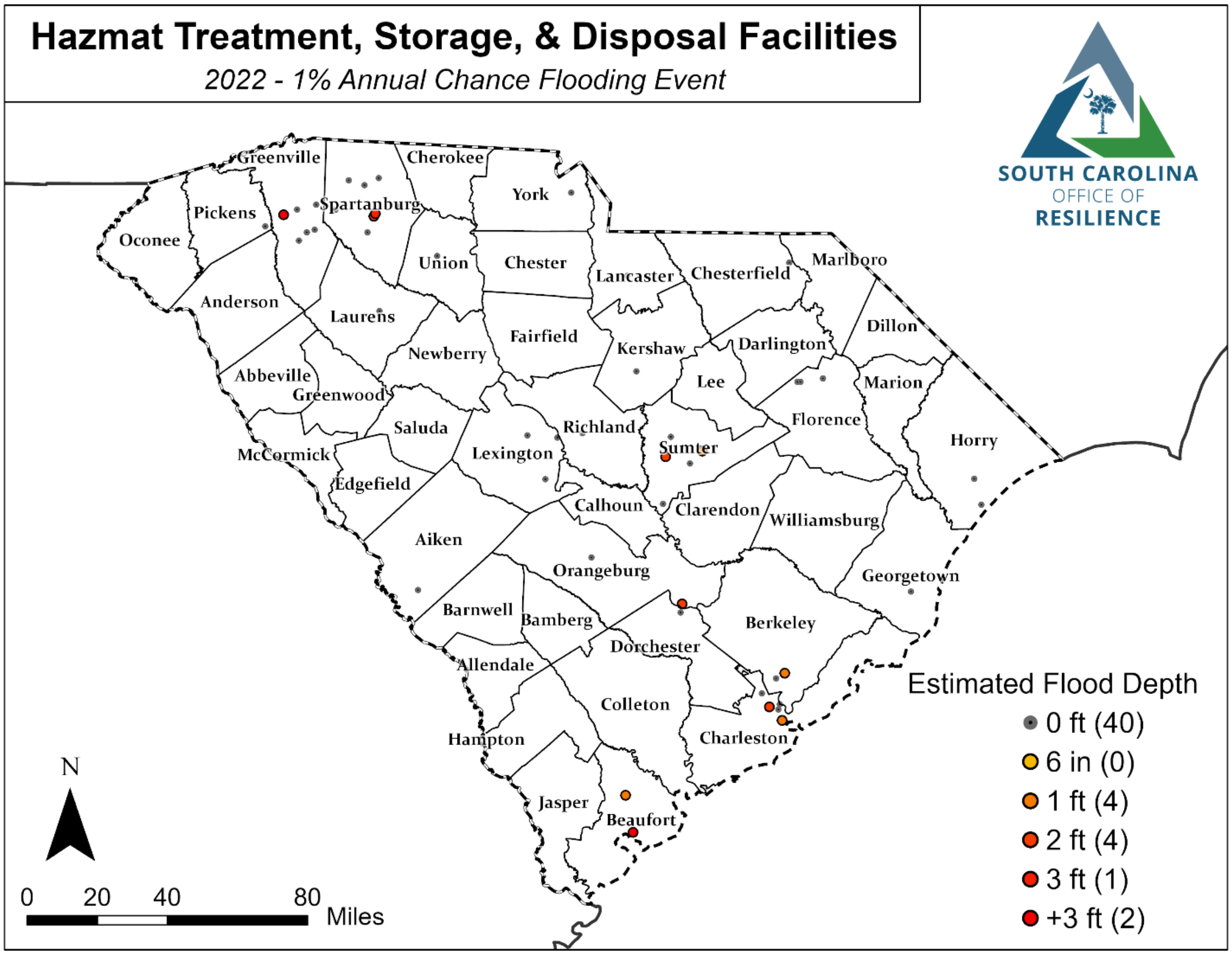


Figure 56: Estimated flooding of Hazmat Treatment, Storage and Disposal Facilities in the 2022 1% annual chance flooding event (DHEC). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

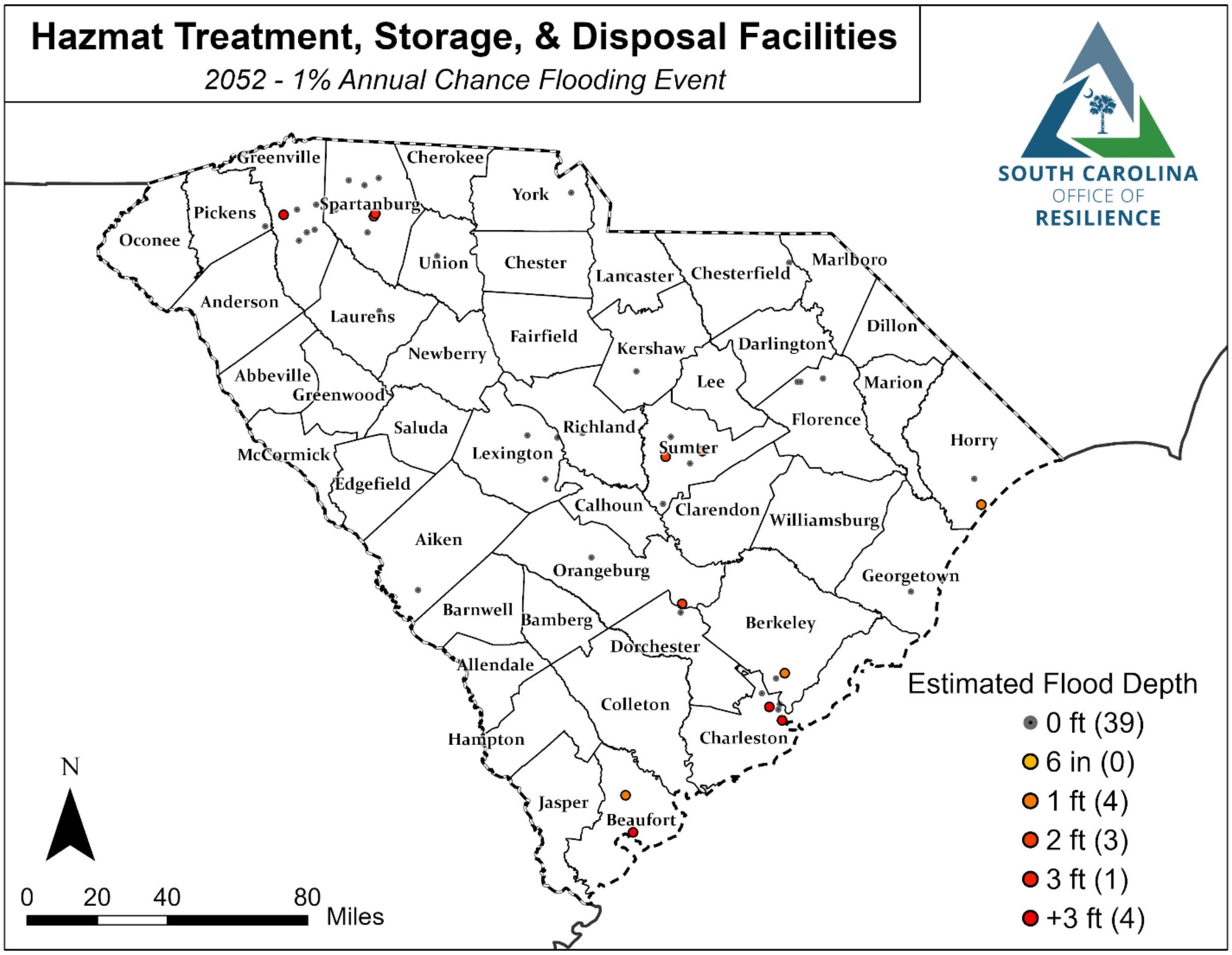


Figure 57: Estimated flooding of Hazmat Treatment, Storage and Disposal Facilities in the 2052 1% annual chance flooding event (DHEC). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

UNDERGROUND STORAGE TANKS (UST)

Underground storage tanks are used across the state to store vital fuel like gasoline but pose a risk if not properly contained. Regulation 61-92, Underground Storage Tank Control Regulations (SC DHEC), 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 buoyancy, erosion and scour, and product displacement and outlines action to decrease risks to the system and environment. Preliminary data from DHEC shows over 17,000 underground storage tanks across the state, with Table 9 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 10: 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	16099	15856
6 inches	31	38
1 ft	301	344
2 ft	381	401
3 ft	202	215
+3 ft	400	560

CULTURAL RESOURCES

South Carolina’s history is rich with the diversity of traditional communities that trace their roots to the landscape. While the Catawba Indian Nation is the only federally recognized tribe in South Carolina, the state recognizes an additional nine tribes and four recognized tribal groups (South Carolina Commission for Minority Affairs, 2022). 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 stakeholder in the region’s ability to absorb and recover from environmental change and natural hazards. Cultural assets – archives, libraries, museum, 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 help give insight into the specific threats experienced in their communities. Furthermore, they can offer critical insight to the specific threats experienced in their communities, current data on impacts as well as valuable historic context for their own community land and resource use which may offer additional resilience planning solutions. Intangible cultural resources - oral traditions, performing arts, social practices, rituals, festive events, knowledge and practices and traditional crafts - also deserve special considerations.

Unfortunately, cultural resources are increasingly threatened both by development and by climate-driven impacts, especially in coastal zones (Dawson, Hambly, Kelley, Lees, & Miller, 2020). Impacts from environmental change and natural hazards have different repercussions for cultural landscapes as a whole because of the variances in resources and their management on individual sites. Current funding mechanisms related to mitigation and resilience rely on cost benefit analysis that does not consider cultural resources.

In the Southeastern United States alone, “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 [within 200 km of the coast] will be submerged. Since survey coverage is incomplete, the numbers of actual sites impacted will be much higher” (Anderson, et al., 2012). 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.

Federal and state laws and regulations as well as local zoning ordinances 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 resources designated at the local government level under local zoning as being significant locally, or to resources that are significant to traditional communities or cultural groups, or to artifacts, records, or collections that are considered significant. The former resources are quantifiable through available inventories at the state level; the latter resources are less quantifiable due to the number of entities involved or due to their sensitive nature.

South Carolina has over 1600 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. Counties with fewer than 10 listings are Barnwell, Chesterfield, Clarendon, and Edgefield.

In addition to these national register 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 and the remainder are scattered across the state.

The number of these properties continues to grow. Over 82,000 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). Nearly 34,000 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.

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 National Register or historic structures that have been determined eligible for listing in the National Register. ArchSite contains over 37,000 properties throughout the state, 2,114 of which are currently either individually eligible or listed on the National Register of Historic Places (ArchSite). In the following maps, this data is not represented by individual points to protect the security of the site while allowing for statewide analysis.

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 any 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 State of South Carolina almost certainly has a far greater number of small- and medium- sized institutions than is represented in this survey.

Figure 58- Figure 61 display the number of sites or structures within a local watershed (at the HUC-10 level) that will be impacted by a 1% annual chance flooding event.

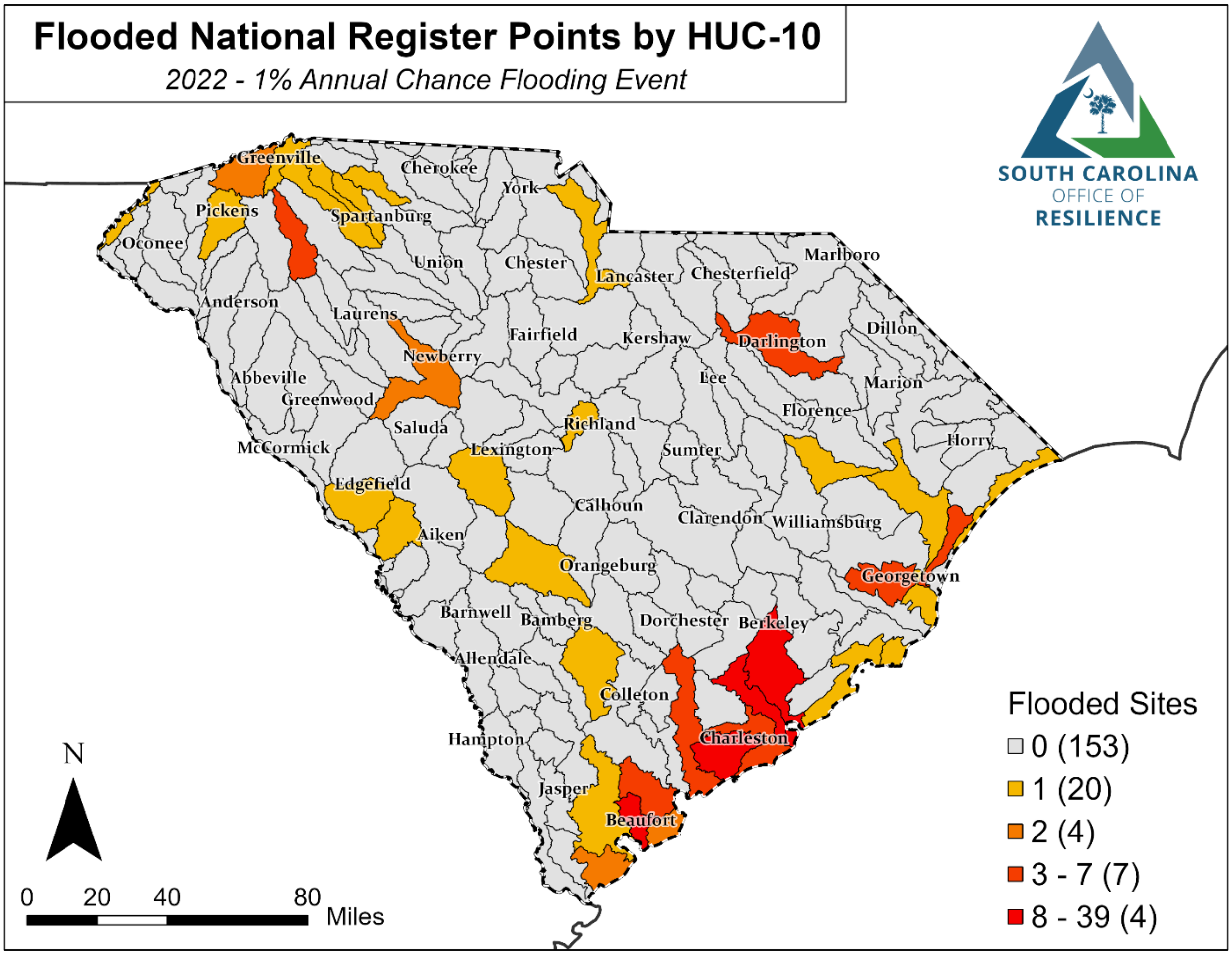


Figure 58: Estimated flooding of National Register Locations in the 2022 1% annual chance flooding event by local watershed (HUC-10) (ArchSite). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

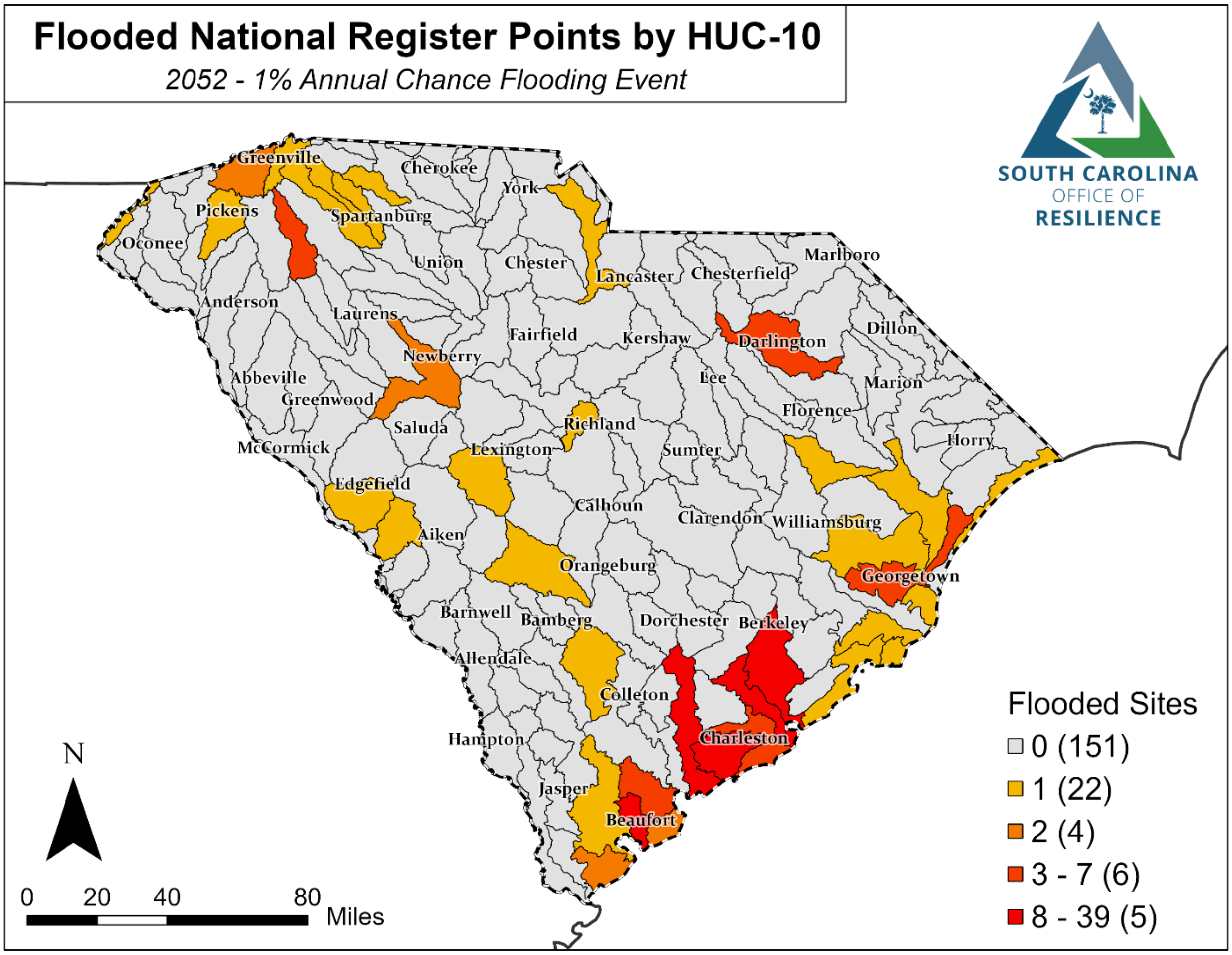


Figure 59: Estimated flooding of National Register Locations in the 2052 1% annual chance flooding event by local watershed (HUC-10) (ArchSite). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

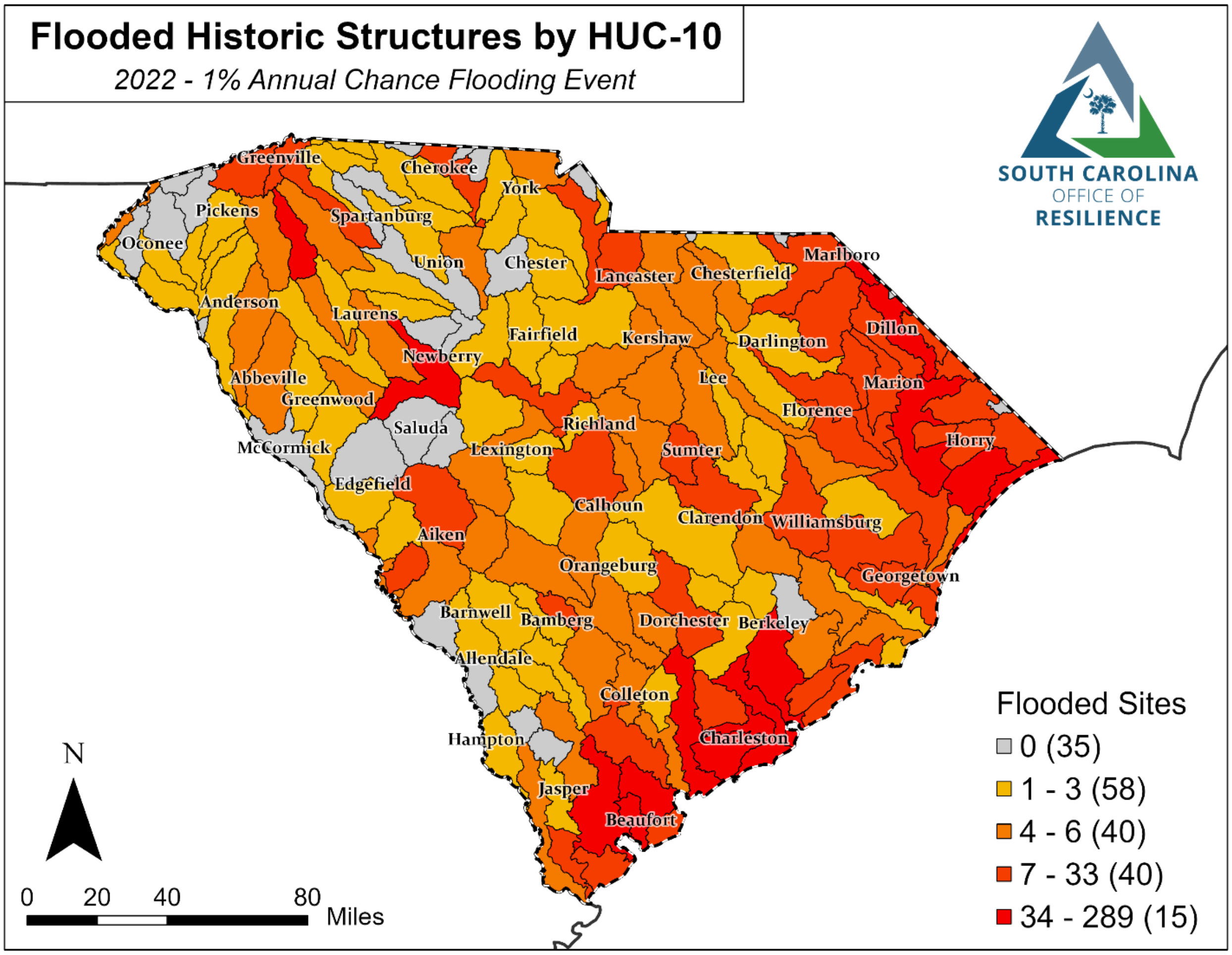


Figure 60: Estimated flooding of Historic Structures in the 2022 1% annual chance flooding event by local watershed (HUC-10)(ArchSite). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

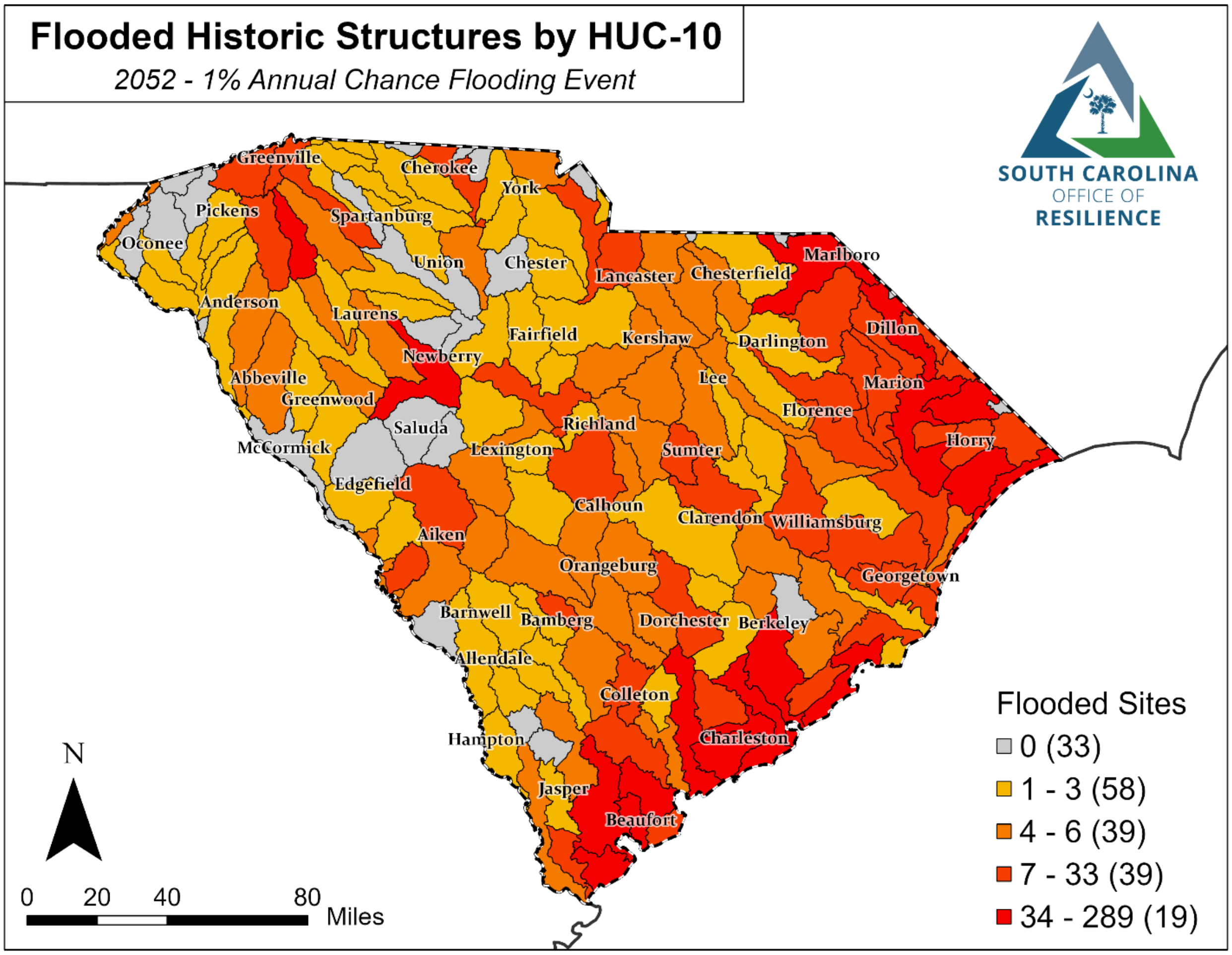


Figure 61: Estimated flooding of Historical Structures in the 2052 1% annual chance flooding event by local watershed (HUC-10) (ArchSite). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

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. All five services have a significant presence in our state, leading to synergy and mission support. 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 supports multiple defense missions that contribute to defense readiness, training and homeland security (SC Department of Veterans' Affairs, n.d.).

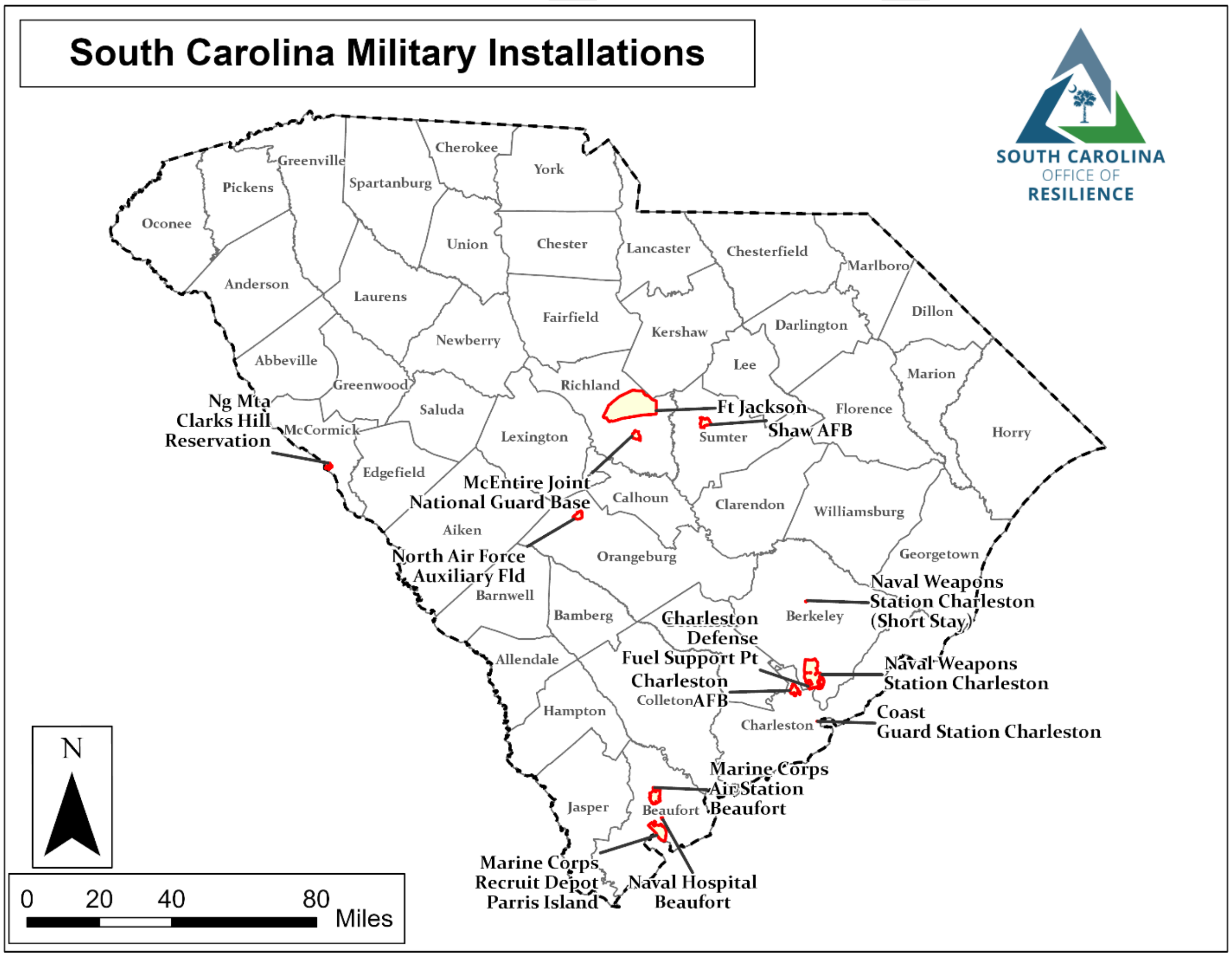


Figure 62: South Carolina Military Installations

Figure 63 and Figure 64 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.

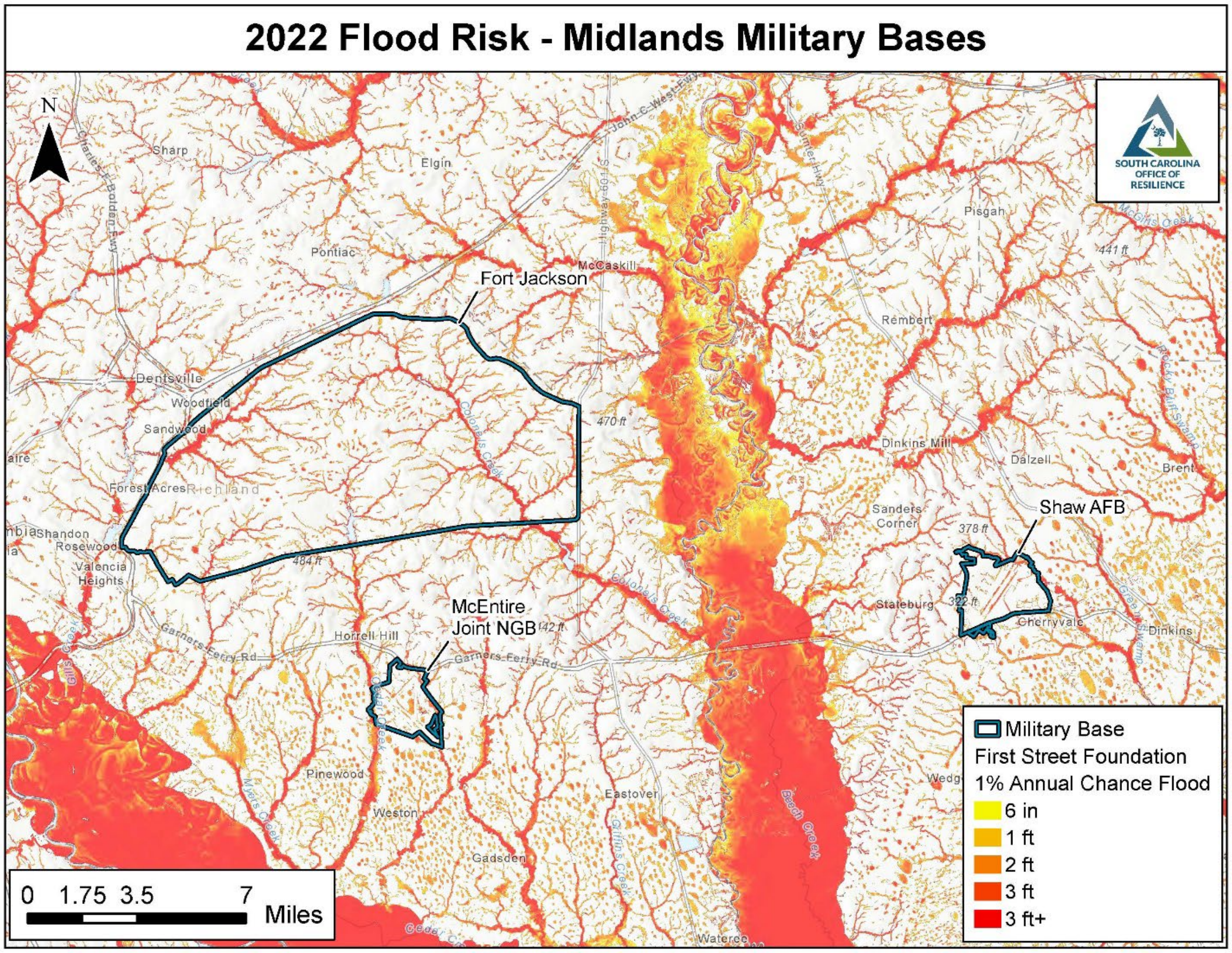


Figure 63: Estimated flooding of Military Installations in the Midlands, Fort Jackson, Shaw AFB, and McEntire Joint NGB, in the 2022 1% annual chance flooding event. Flood data provided by the First Street Foundation Hazard Layers, V2.0.

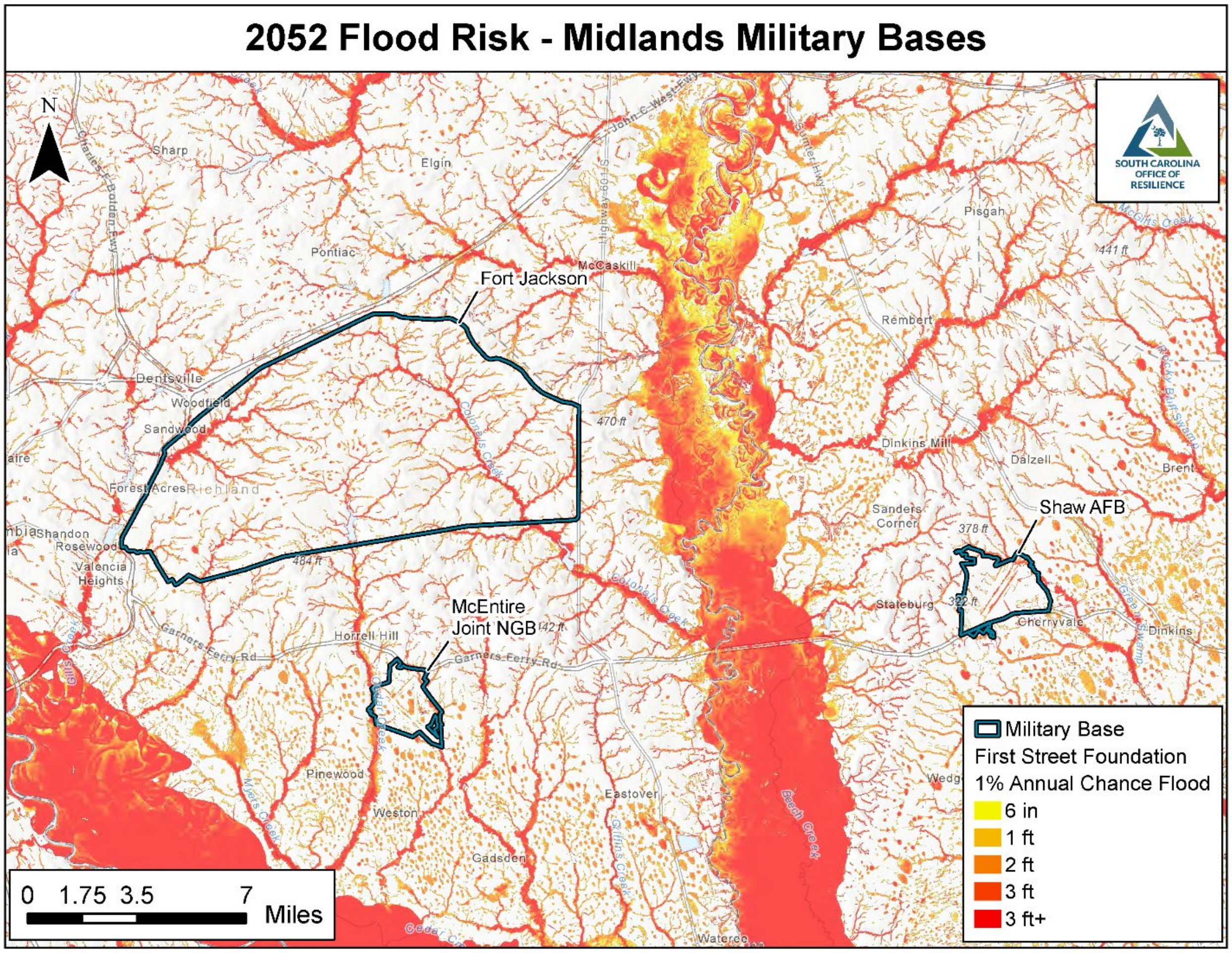


Figure 64: Estimated flooding of Military Installations in the Midlands, Fort Jackson, Shaw AFB, and McEntire Joint NGB, in the 2052 1% annual chance flooding event. Flood data provided by the First Street Foundation Hazard Layers, V2.0.

Figure 65 and Figure 66 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.

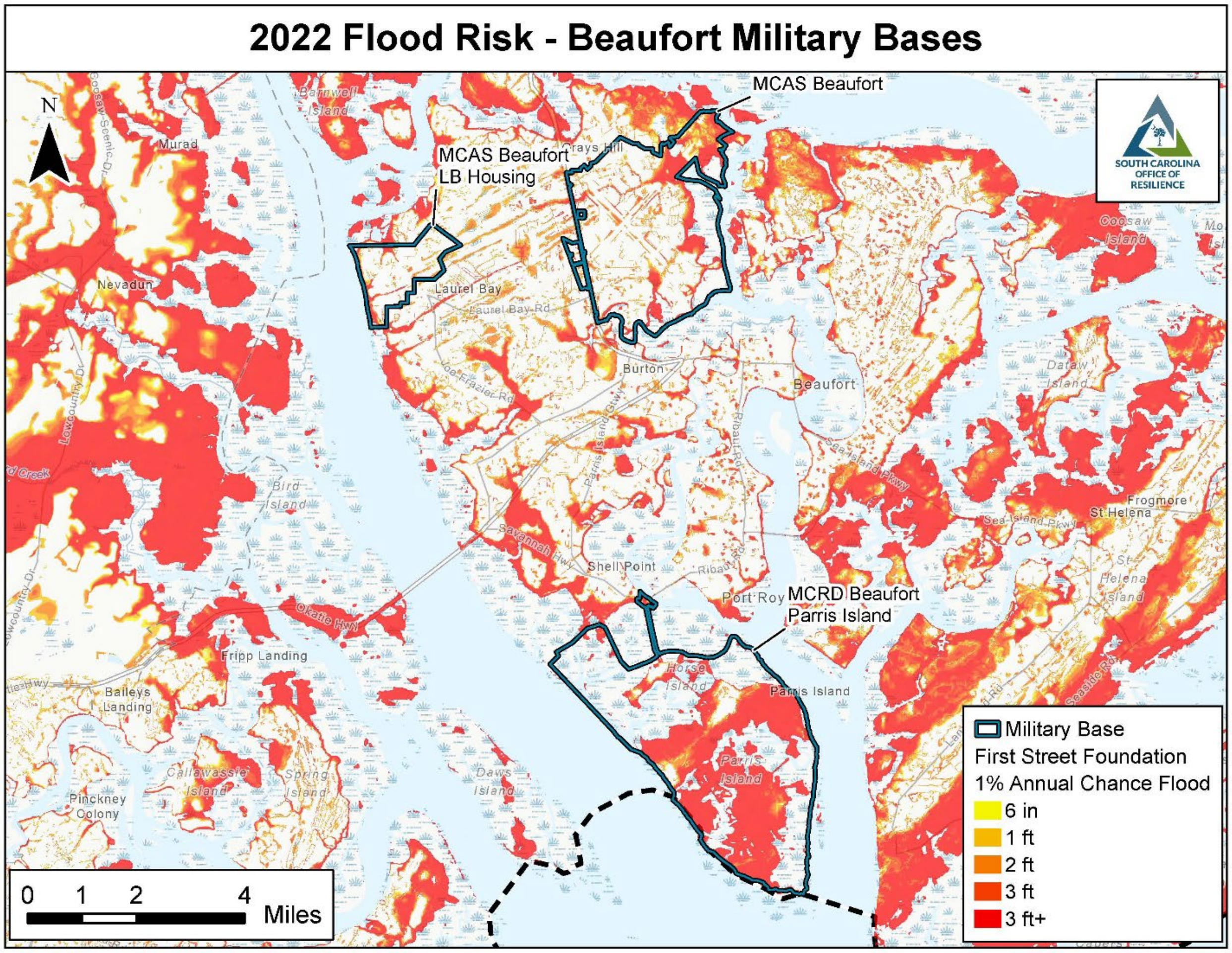


Figure 65: Estimated flooding of Military Installations in the Beaufort County: MCAS Beaufort, MCAS Beaufort LB Housing, and MCRD Beaufort Parris Island, in the 2022 1% annual chance flooding event. Flood data provided by the First Street Foundation Hazard Layers, V2.0.

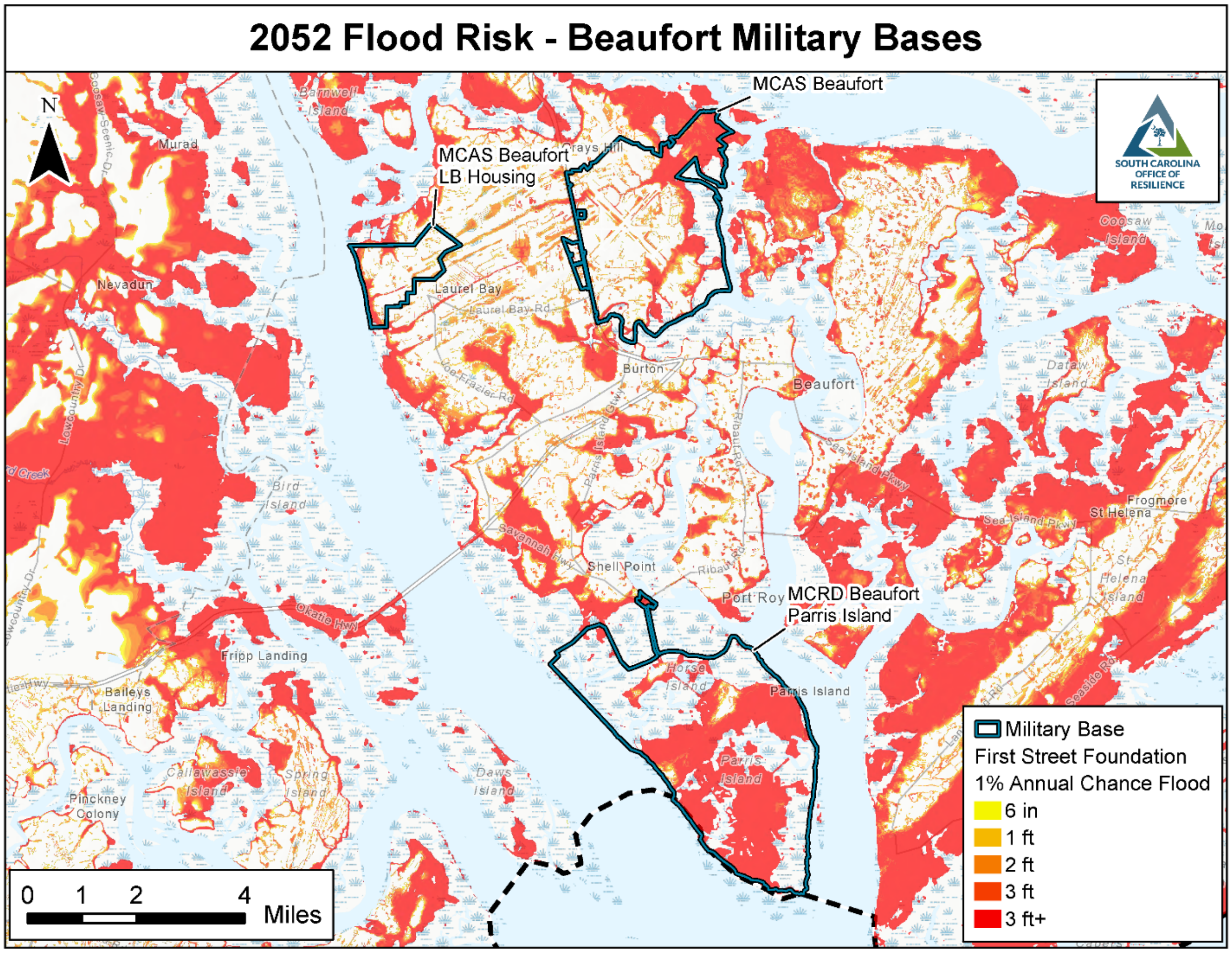


Figure 66: Estimated flooding of Military Installations in the Beaufort County: MCAS Beaufort, MCAS Beaufort LB Housing, and MCRD Beaufort Parris Island, in the 2052 1% annual chance flooding event. Flood data provided by the First Street Foundation Hazard Layers, V2.0.

Figure 67 and Figure 68 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.

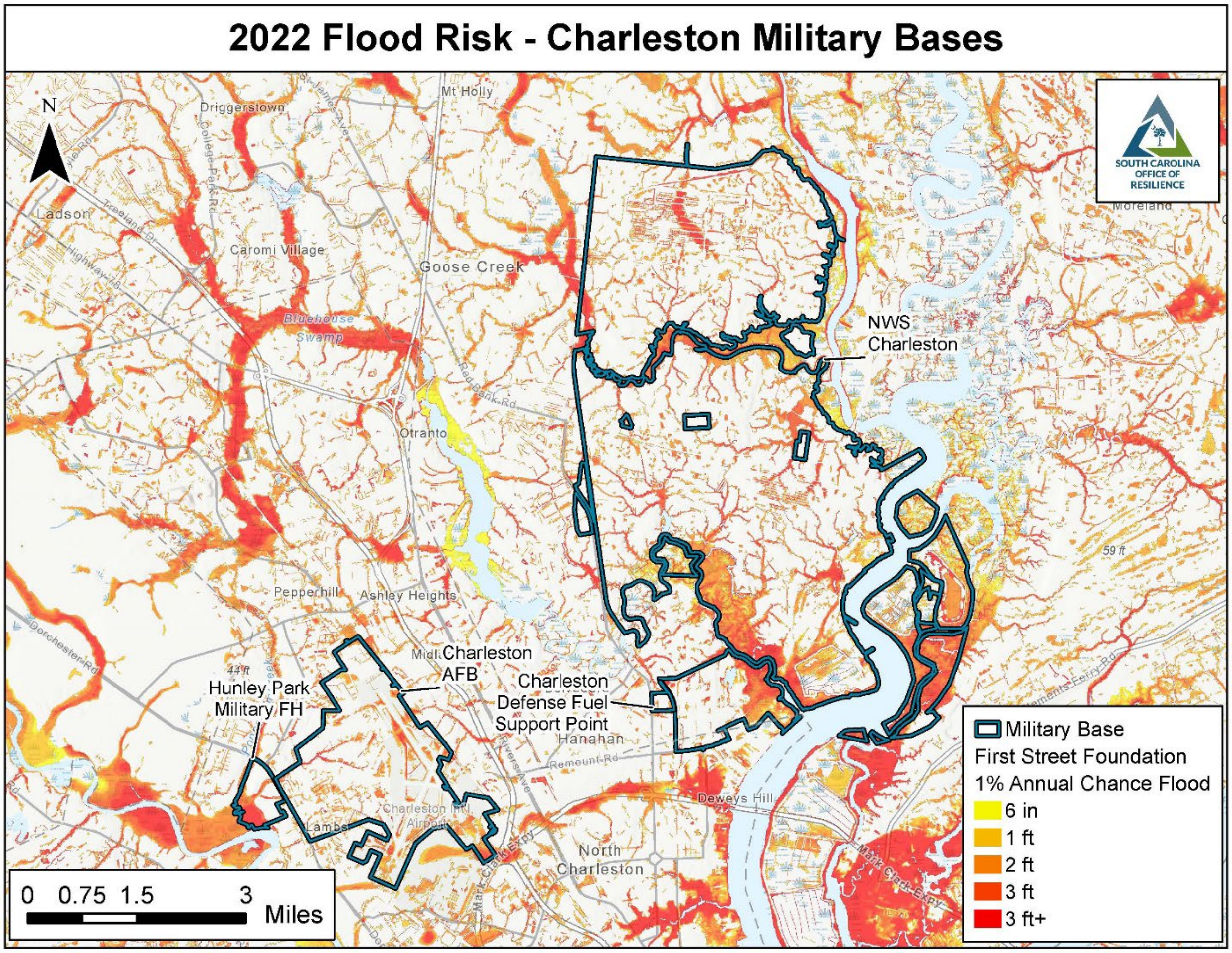


Figure 67: Estimated flooding of Military Installations in the Charleston County: NWS Charleston, Charleston Defense Fuel Support Point, Charleston AFB, and Hunley Park Military FH, in the 2022 1% annual chance flooding event. Flood data provided by the First Street Foundation Hazard Layers, V2.0.

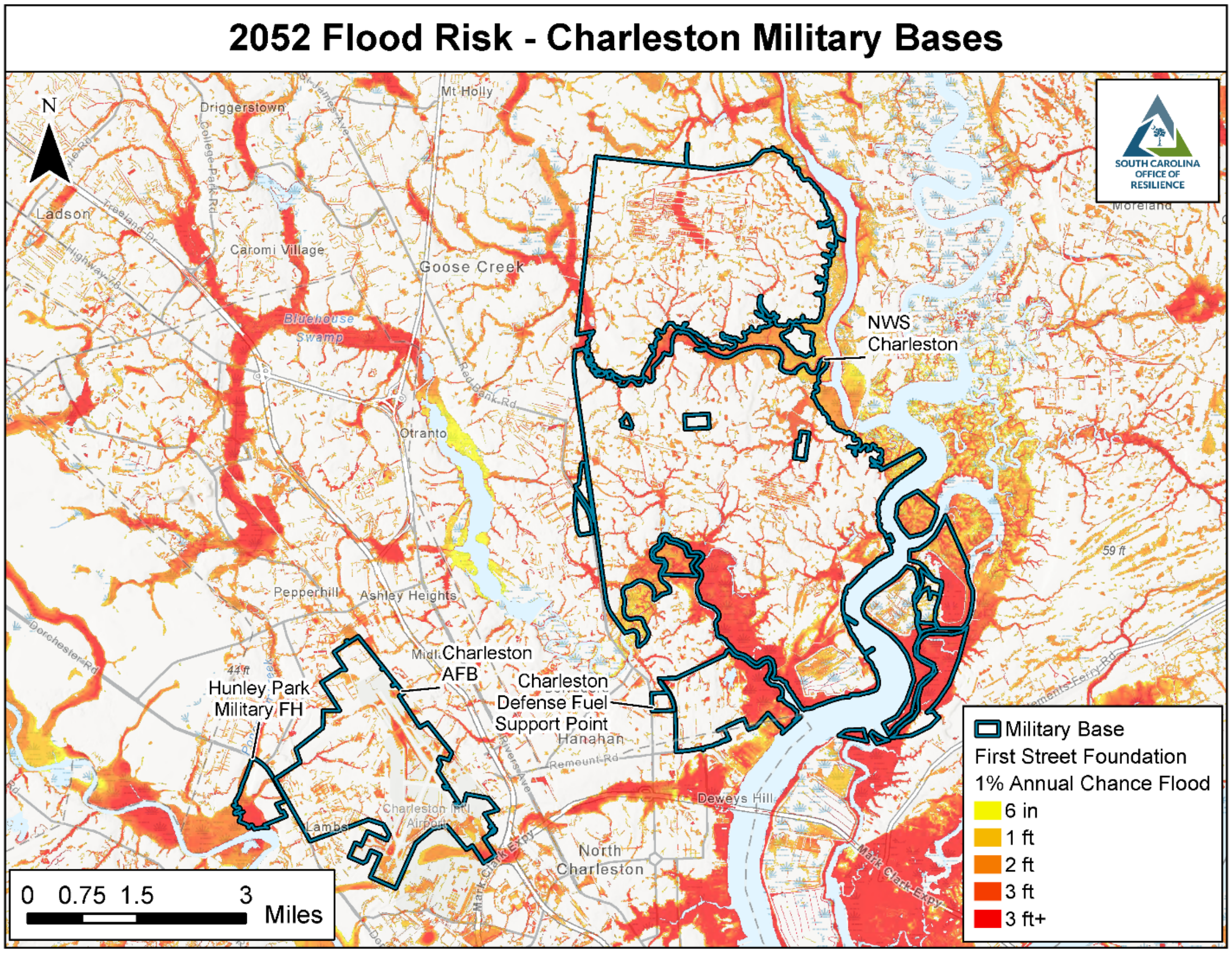


Figure 68: Estimated flooding of Military Installations in the Charleston County: NWS Charleston, Charleston Defense Fuel Support Point, Charleston AFB, and Hunley Park Military FH, in the 2052 1% annual chance flooding event. Flood data provided by the First Street Foundation Hazard Layers, V2.0.

PUBLIC SAFETY

STATE LEVEL

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. On any given day, 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, basic detention and basic telecommunications training in South Carolina. The Academy is one of the last few centralized law enforcement academies in the nation, thus providing 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 / 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 to better serve the State of South Carolina. 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 quantify the number of local law enforcement facilities impacted by the 2020 (Figure 69) and 2050 (Figure 70) 1% annual chance flood events.

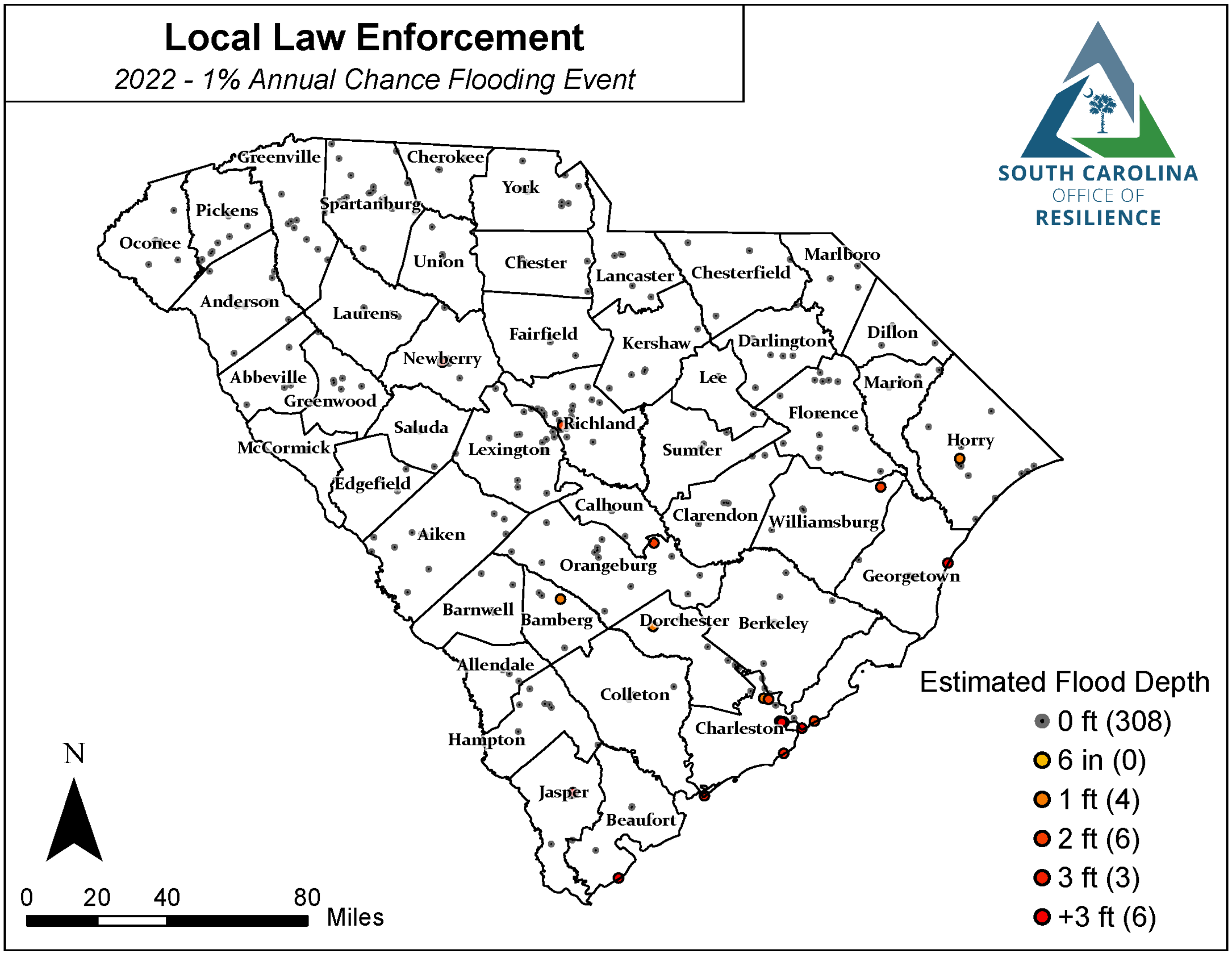


Figure 69: Estimated flooding of local law enforcement agencies in the 2022 1% annual chance flooding event (SLED). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

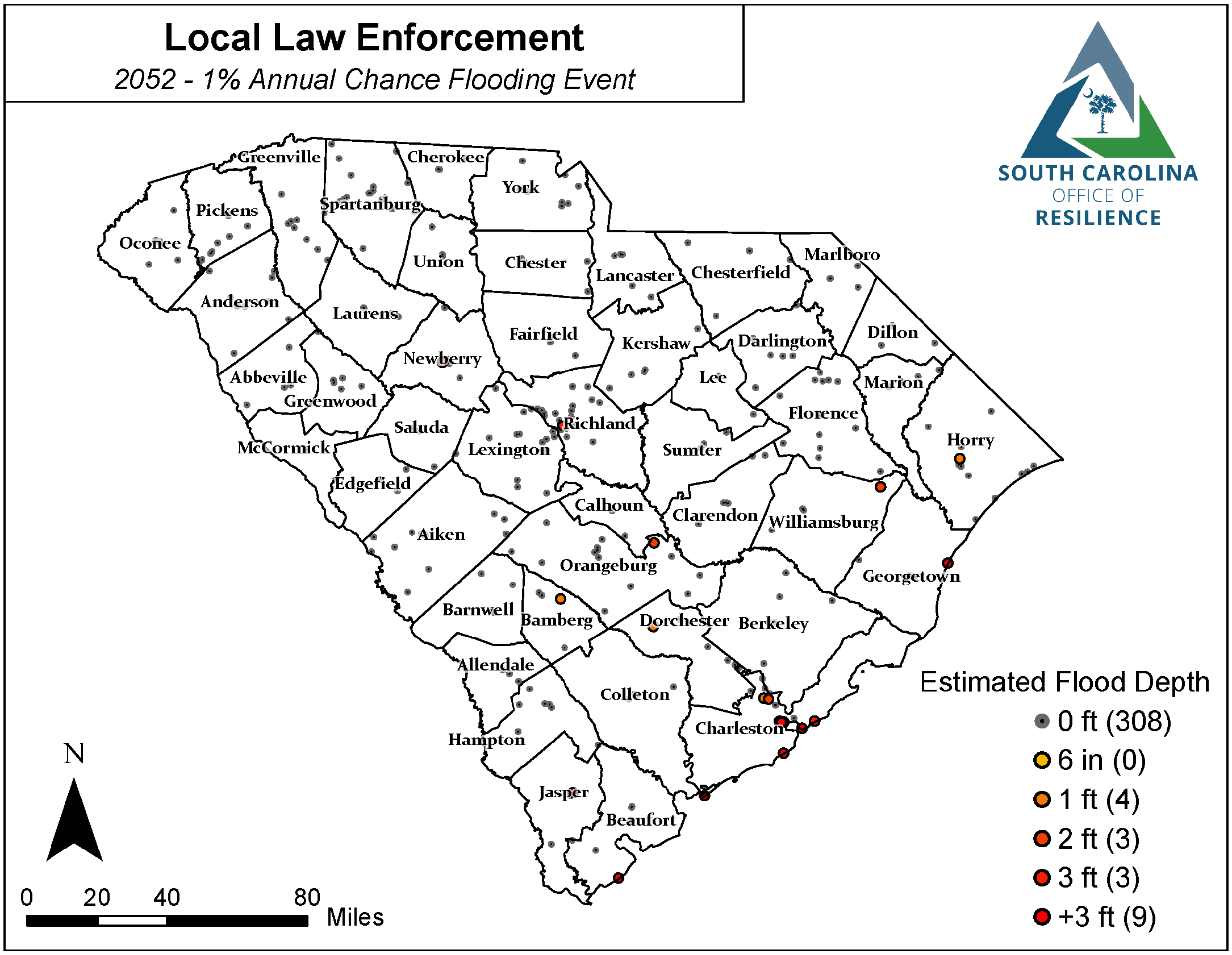


Figure 70: Estimated flooding of local law enforcement agencies in the 2022 1% annual chance flooding event (SLED). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

DETENTION CENTERS

A dataset by 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 facility. The figures below quantify the impact by the 2022 (Figure 71) and 2052 (Figure 72) 1% annual chance flood events.

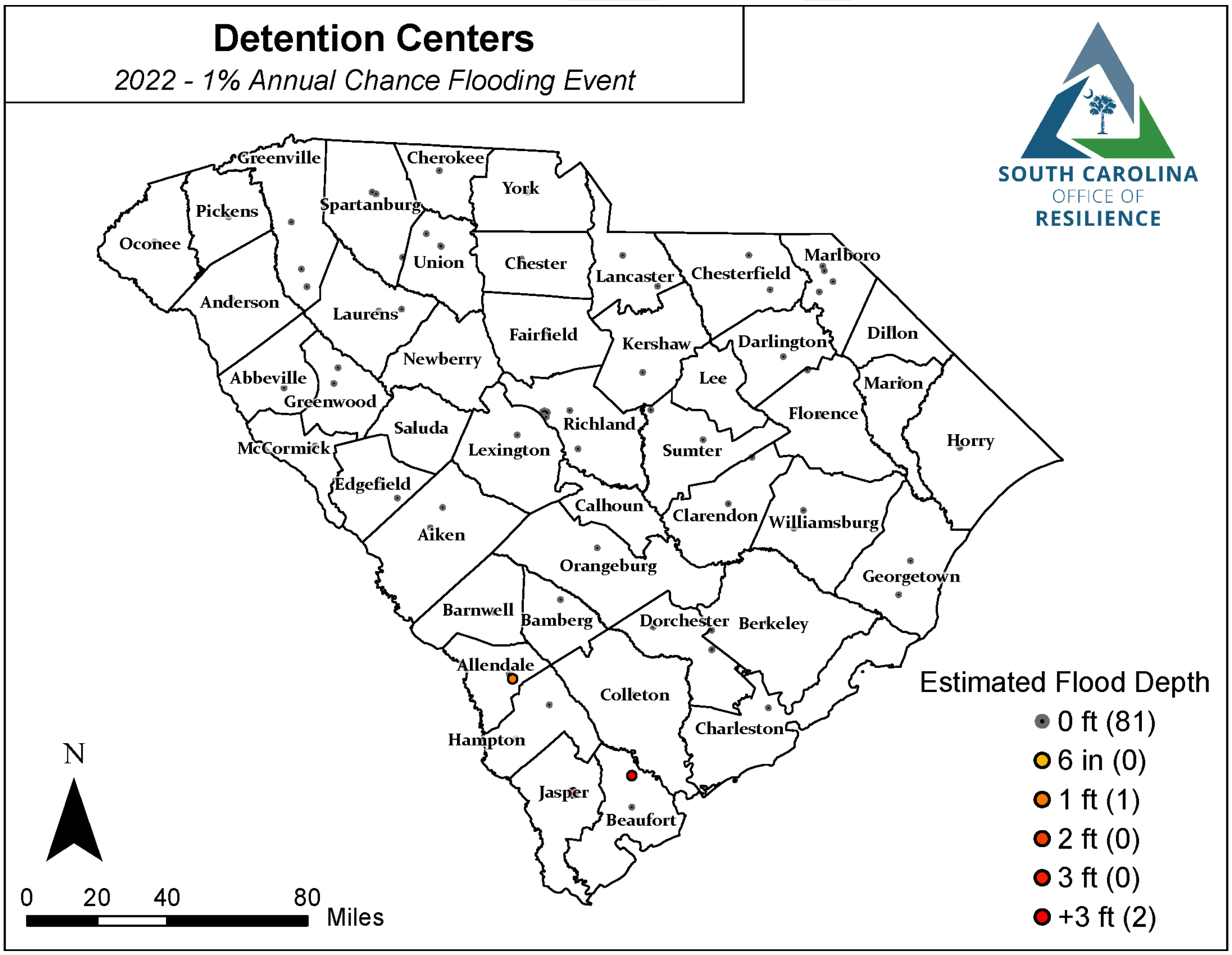


Figure 71: Estimated flooding of detention centers in the 2022 1% annual chance flooding event (SLED). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

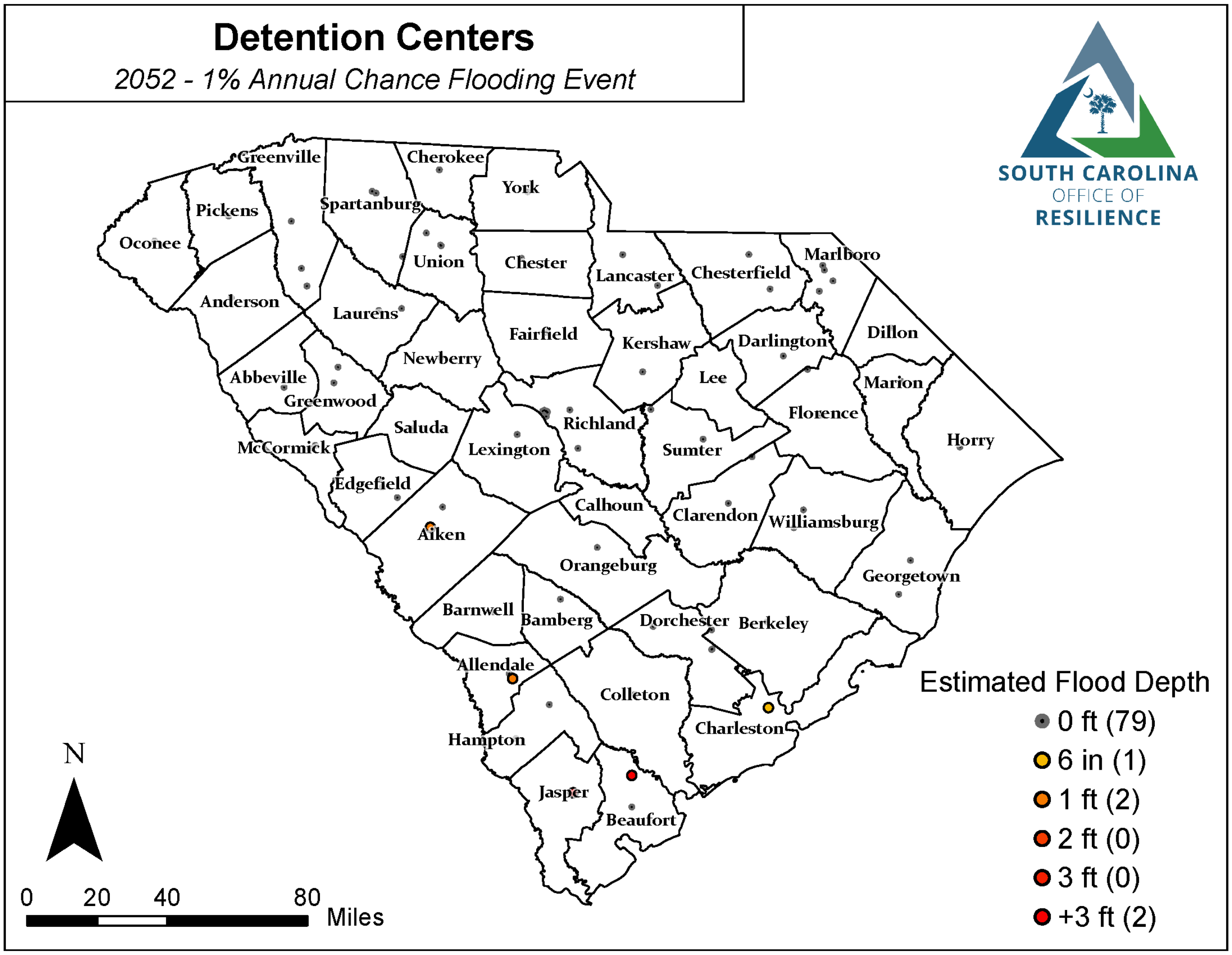


Figure 72: Estimated flooding of detention centers in the 2052 1% annual chance flooding event (SLED). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

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 quantify the potential impact of the 2022 (Figure 73) and 2052 (Figure 74) 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.

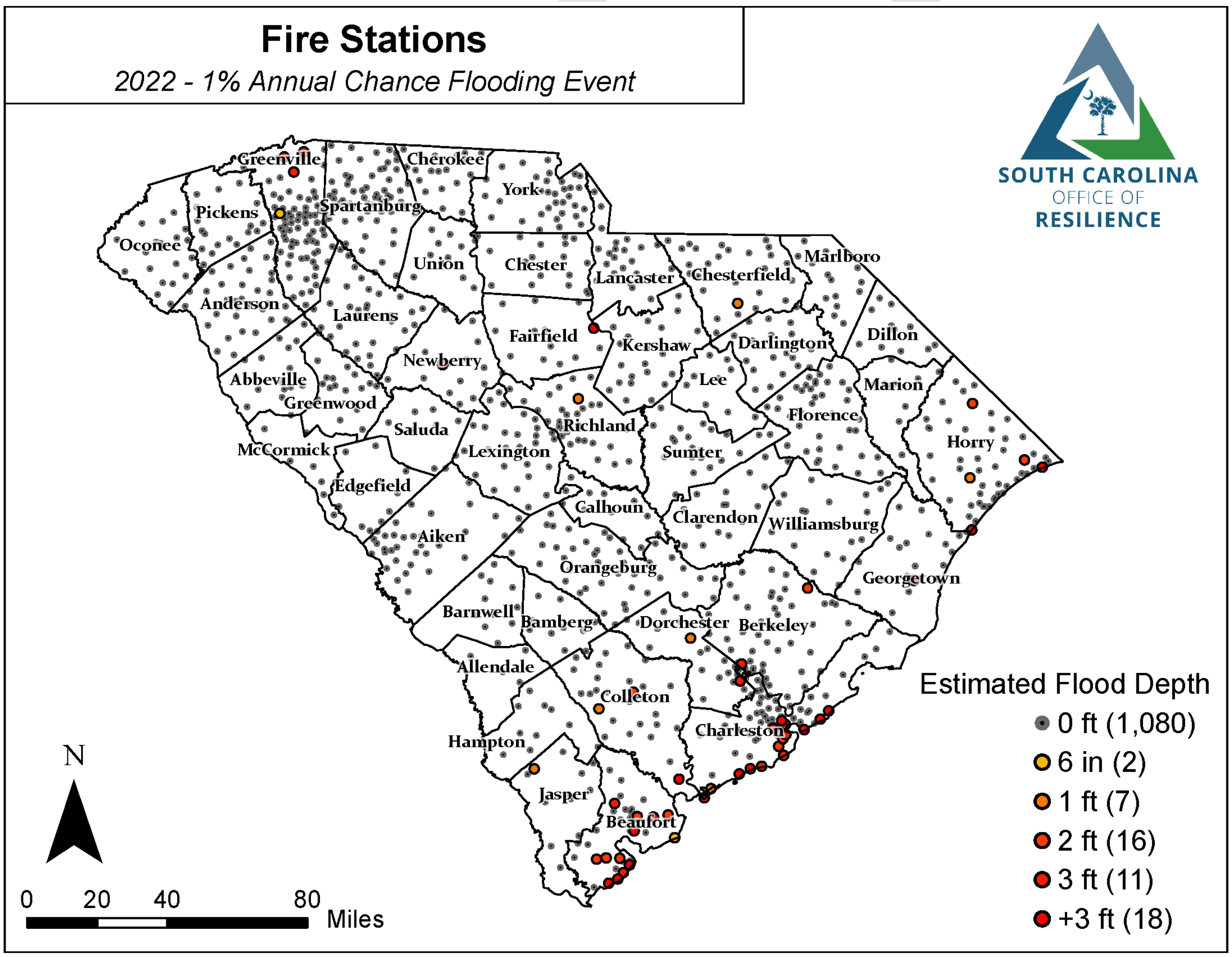


Figure 73: Estimated flooding of fire stations in the 2022 1% annual chance flooding event (Department of Homeland Security). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

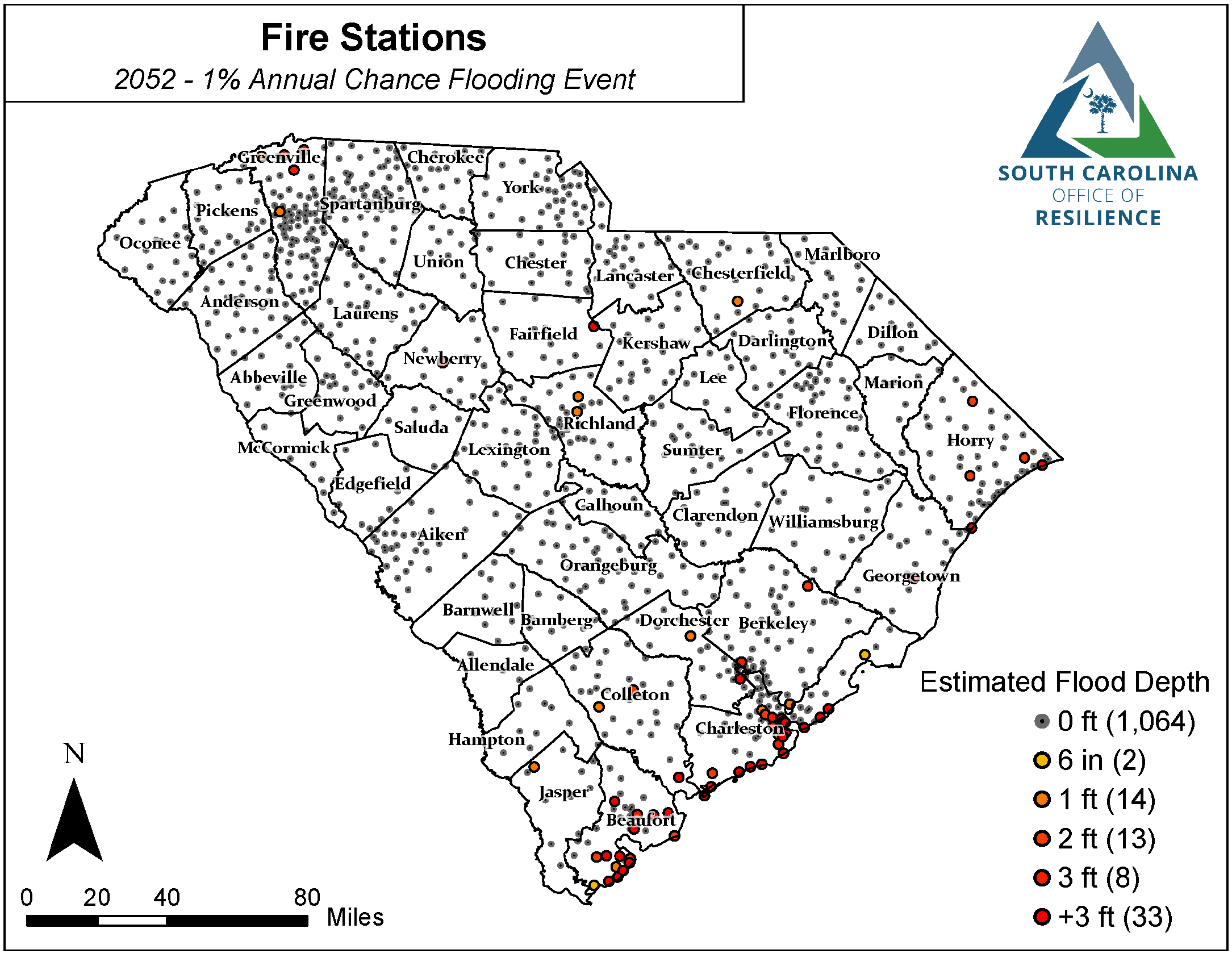


Figure 74: Estimated flooding of fire stations in the 2052 1% annual chance flooding event (Department of Homeland Security). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

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 quantify the impact by the 2020 (Figure 75) and 2050 (Figure 76) 1% annual chance flood events on these stations.

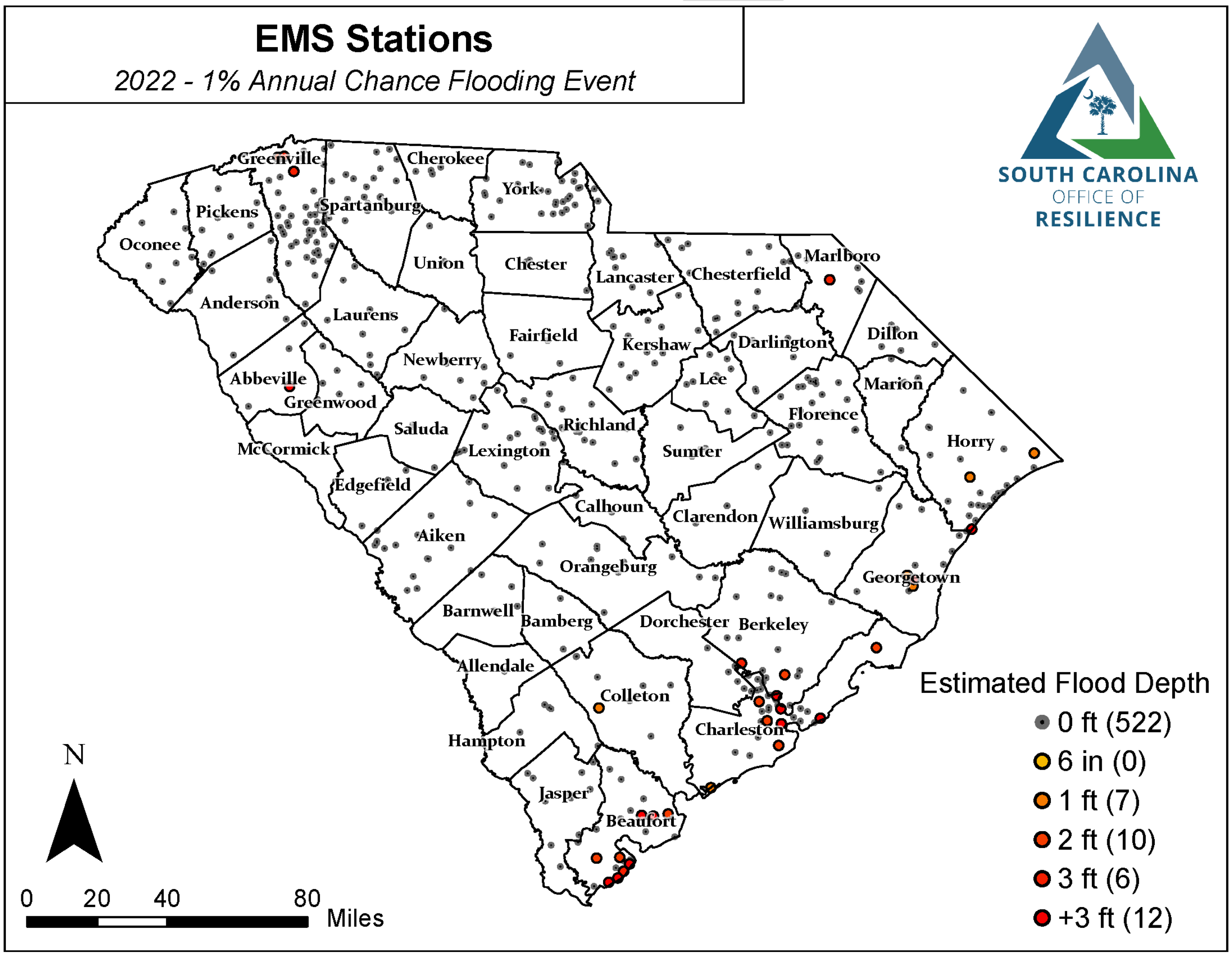


Figure 75: Estimated flooding of EMS stations in the 2022 1% annual chance flooding event (Department of Homeland Security). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

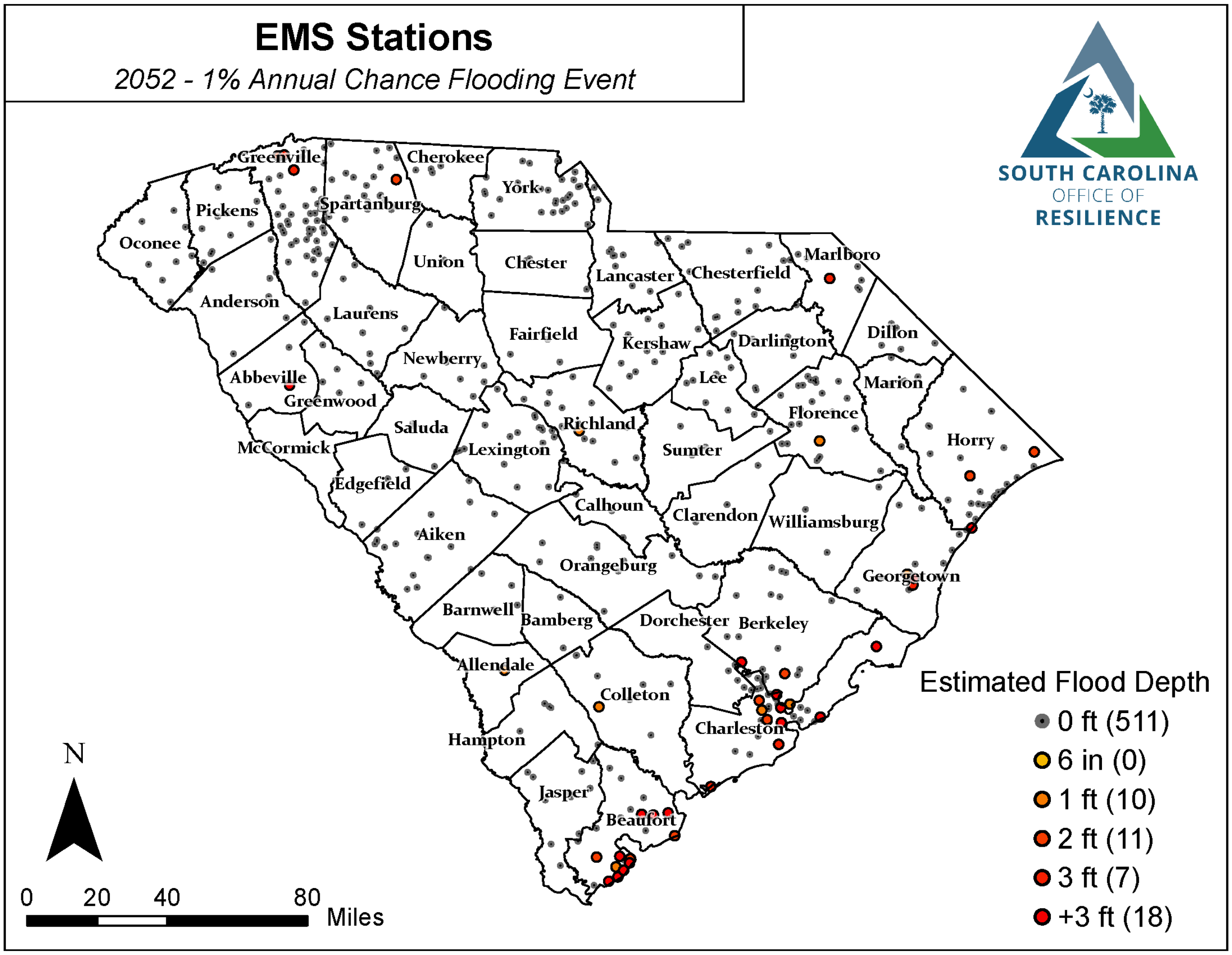


Figure 76: Estimated flooding of EMS stations in the 2052 1% annual chance flooding event (Department of Homeland Security). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

EDUCATION

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

K-12

According to the South Carolina Department of Education's Active Student Headcounts, there are 777,111 students enrolled 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, with more than half of the nation's public schools being built in the last century, and not built to withstand such hazards (The Pew Charitable Trusts, 2017).

While the maps below quantify the impact by the 2022 (Figure 77) and 2052 (Figure 78) 1% annual chance flood events, they do not consider these factors. Additionally, there are nearly 300 private K-12 schools across the state, those are shown in Figure 79 and Figure 80.

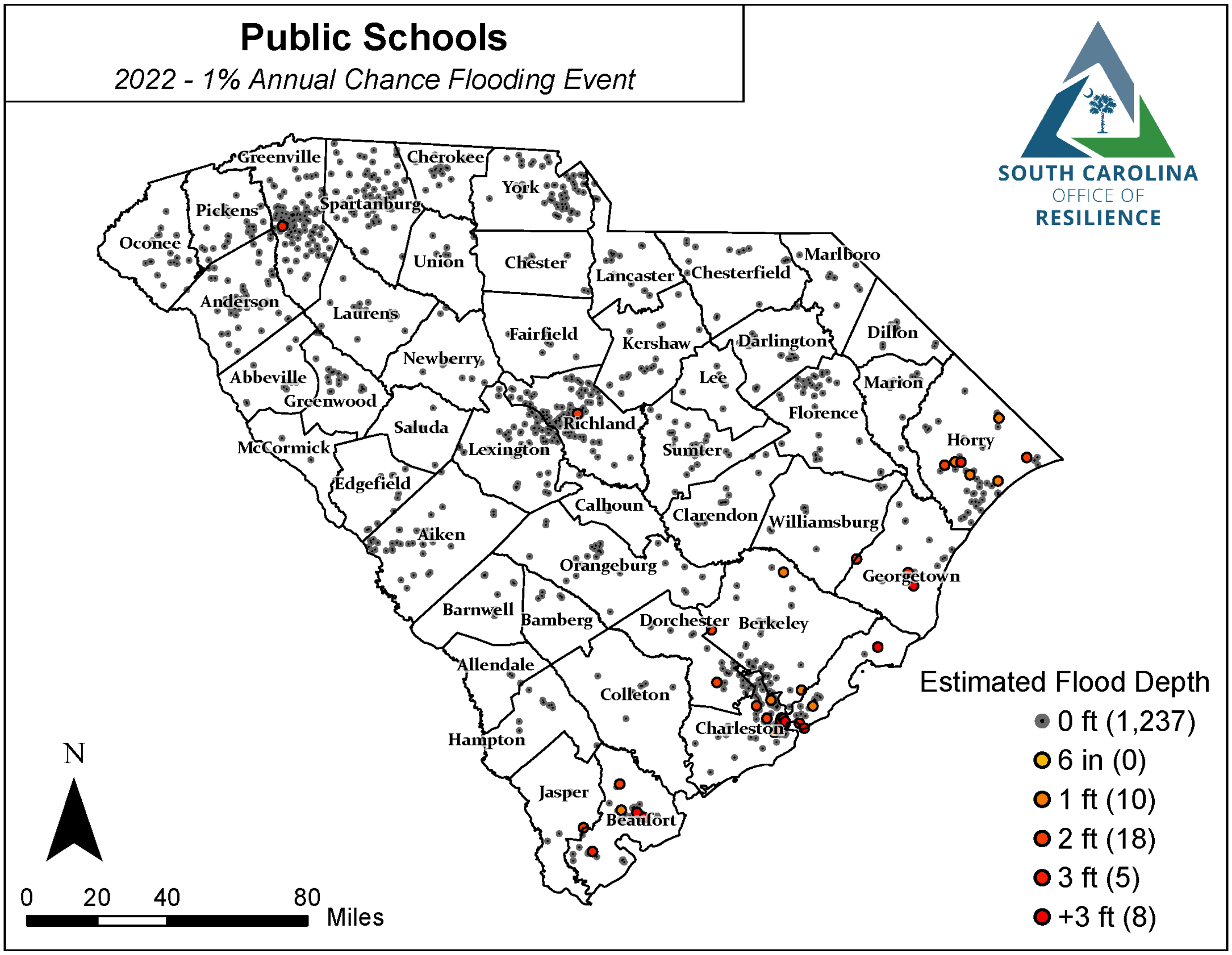


Figure 77: Estimated flooding of public schools in the 2022 1% annual chance flooding event (Department of Homeland Security). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

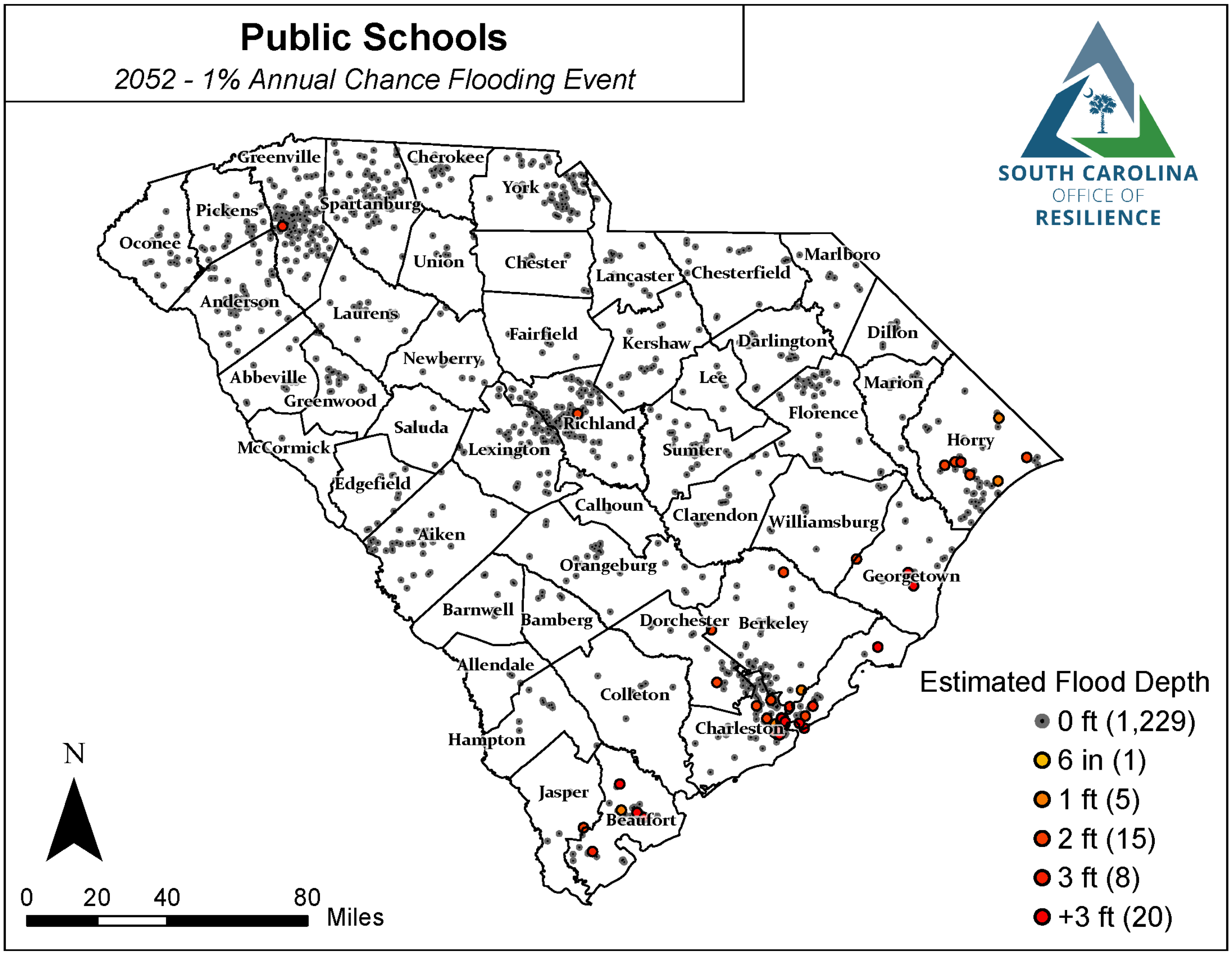


Figure 78: Estimated flooding of public schools in the 2052 1% annual chance flooding event (Department of Homeland Security). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

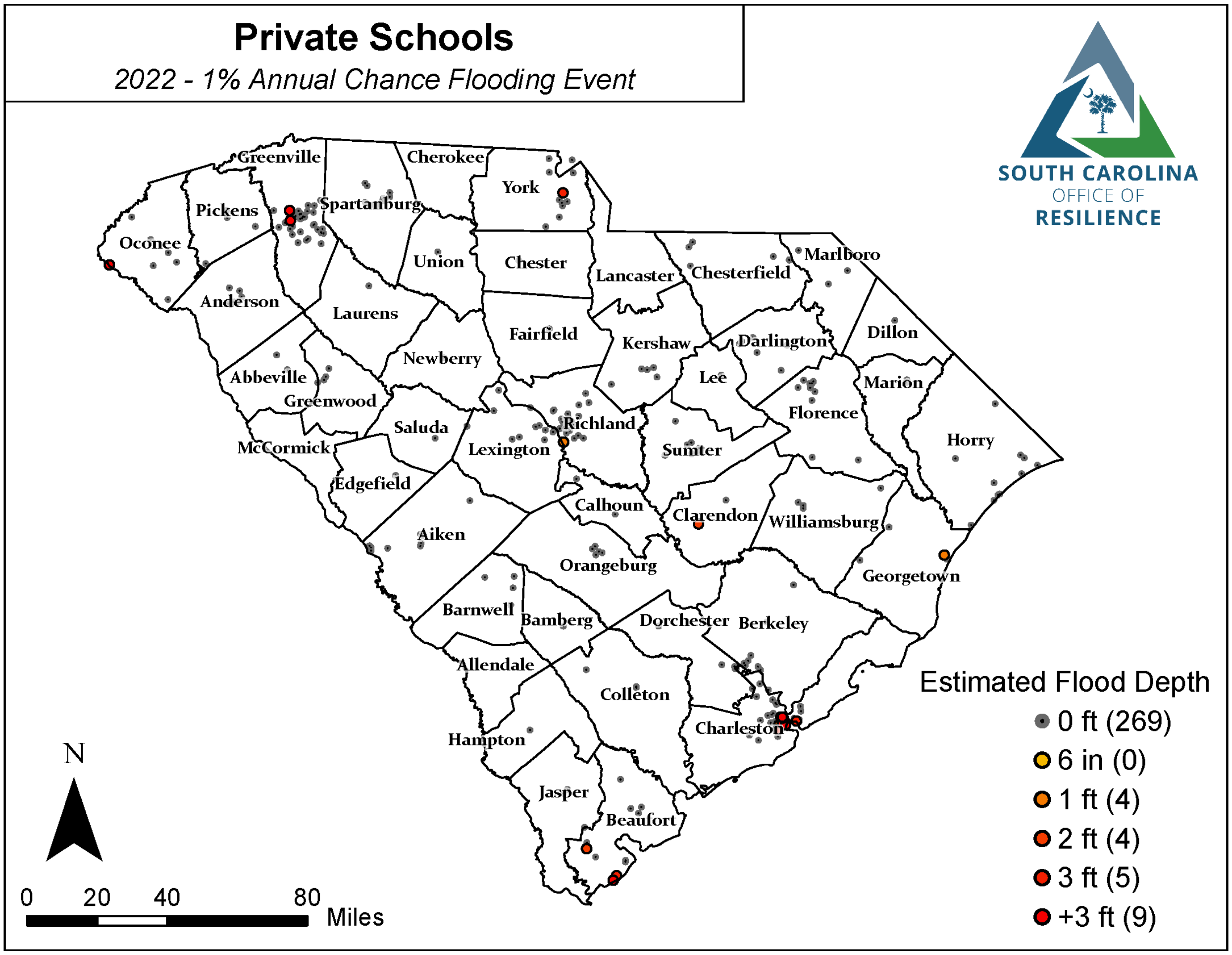


Figure 79: Estimated flooding of private schools in the 2022 1% annual chance flooding event (Department of Homeland Security). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

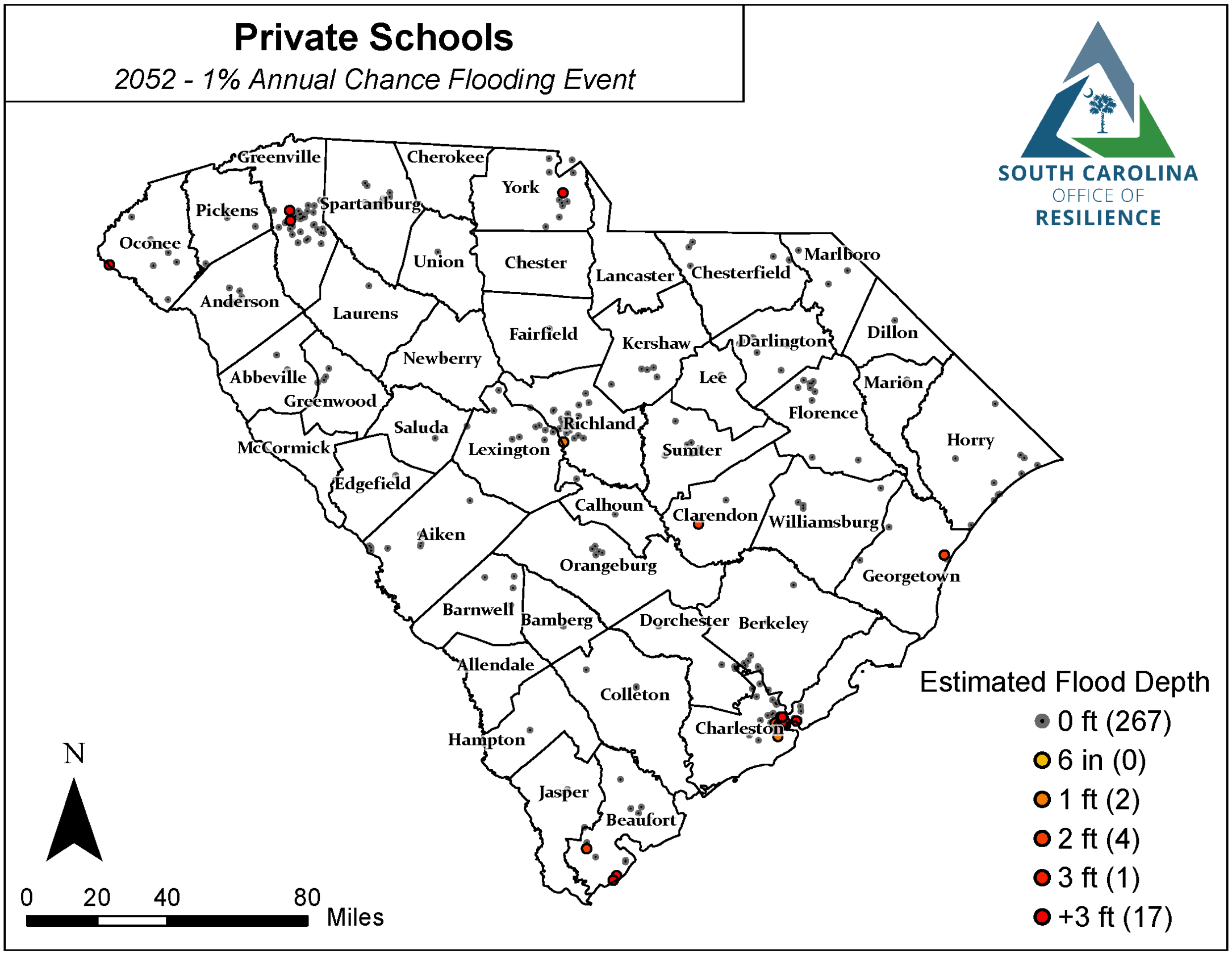


Figure 80: Estimated flooding of private schools in the 2052 1% annual chance flooding event (Department of Homeland Security). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

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. 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. From an economic perspective, public and private institutions employ nearly 16,000 faculty members, 48% full-time (SC Commission on Higher Education, 2021). Additionally, if you include other kinds of post-secondary education schools, such as cosmetology and barber schools and trade schools, the count comes to over a hundred institutions.

The figures below quantify the impact by the 2022 (Figure 81) and 2052 (Figure 82) 1% annual chance flood events on these institutions. This data set does not include online colleges.

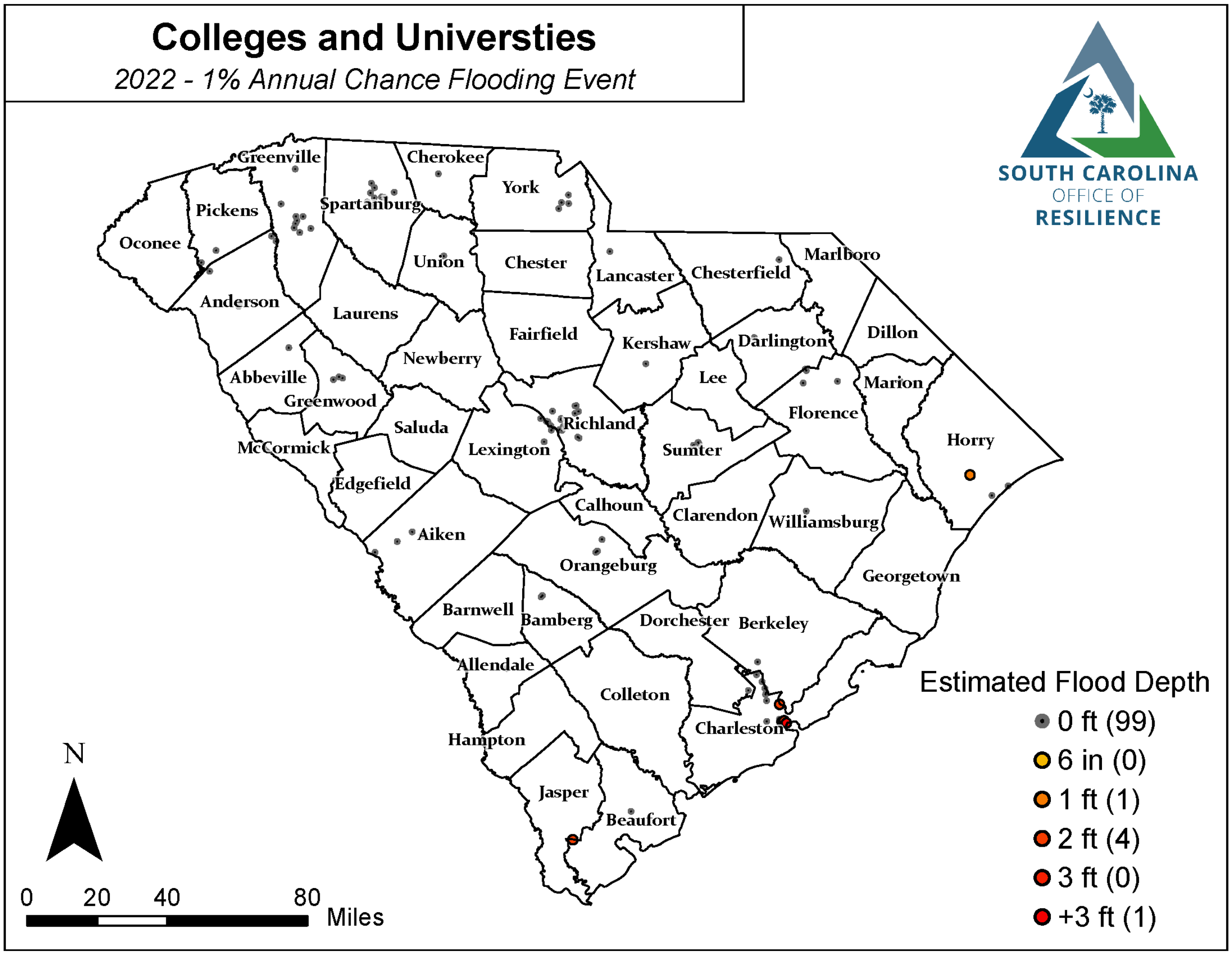


Figure 81: Estimated flooding of colleges and universities in the 2022 1% annual chance flooding event (Department of Homeland Security). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

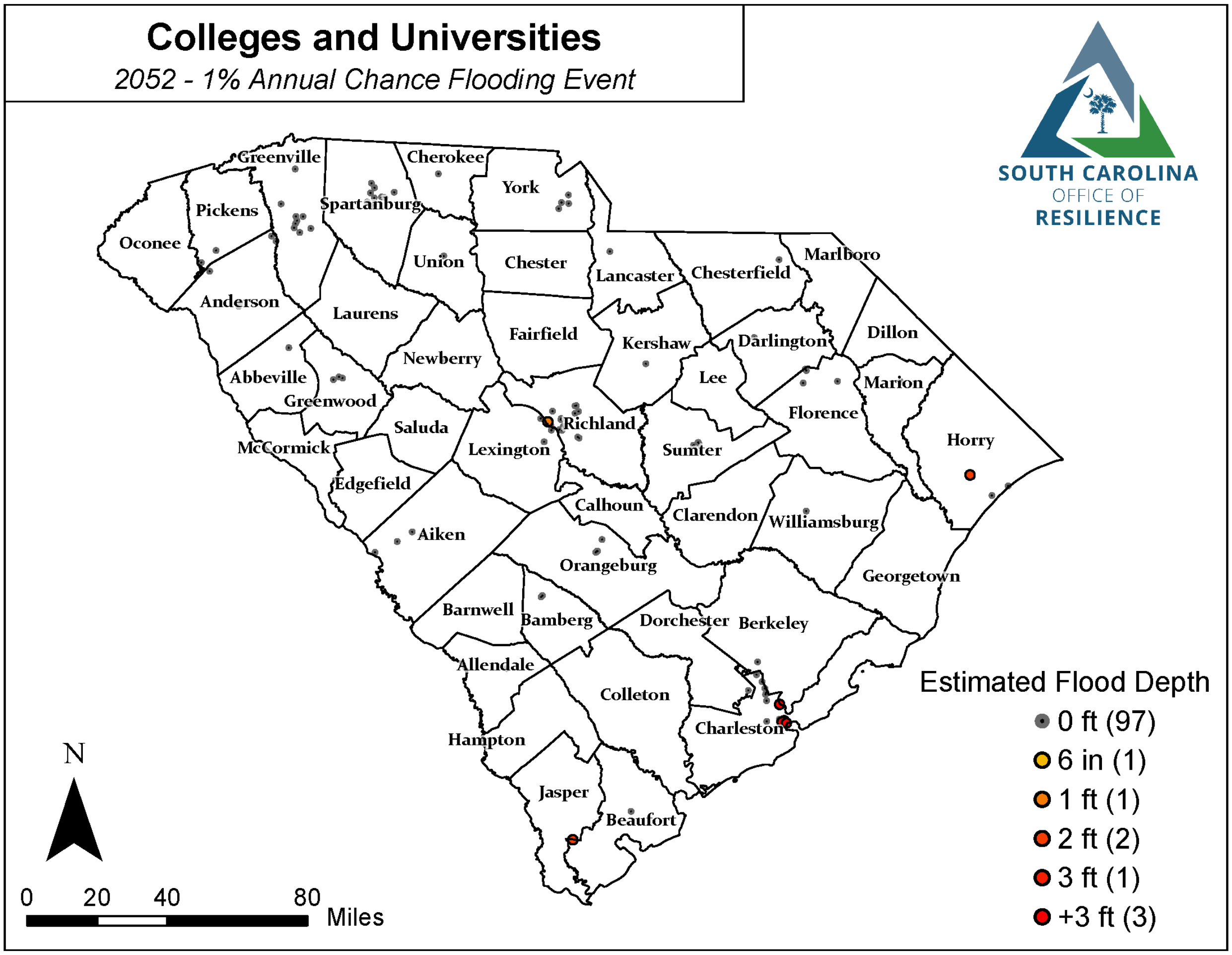


Figure 82: Estimated flooding of colleges and universities in the 2052 1% annual chance flooding event (Department of Homeland Security). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

PUBLIC HEALTH

Environmental change and natural hazards can impact those with ongoing disease as well as cause outbreaks of vector-borne diseases due to the presence of things like mosquitoes (lime disease) and the growth of pathogens in flood waters for example, which can in turn affect things like food supply, 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 83and Figure 84 below.

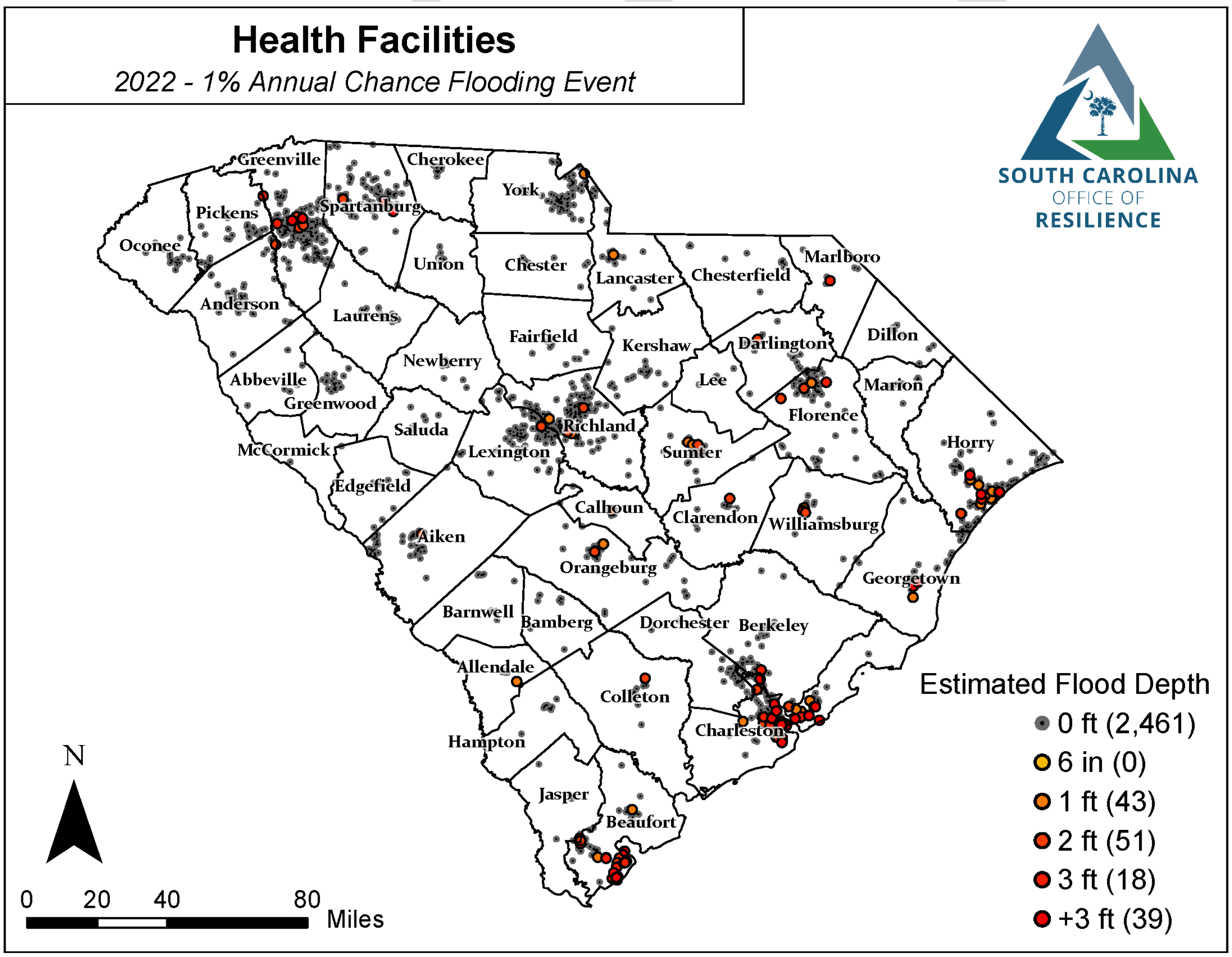


Figure 83: Estimated flooding of health facilities in the 2022 1% annual chance flooding event (DHEC). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

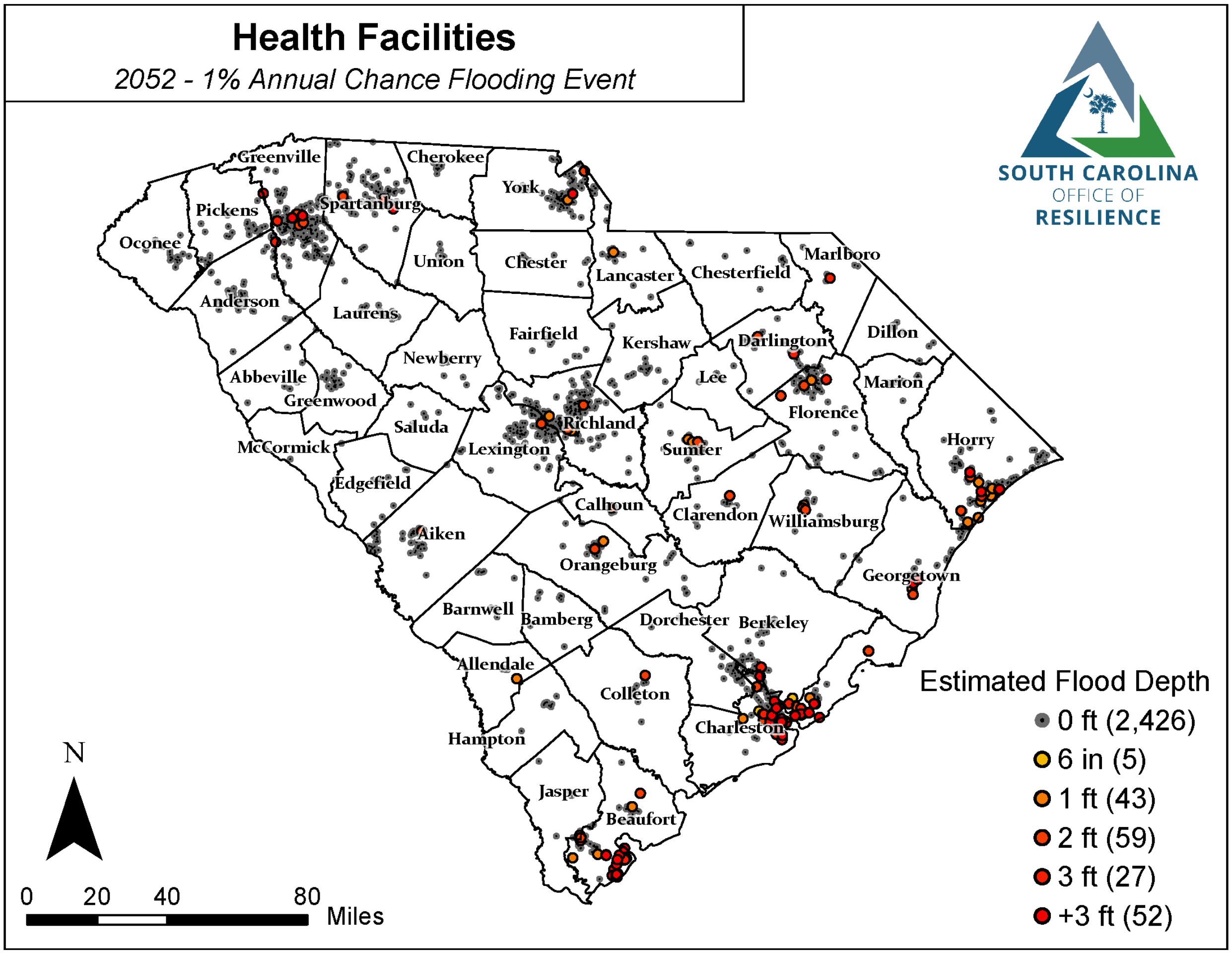


Figure 84: Estimated flooding of health facilities in the 2052 1% annual chance flooding event (Department of Homeland Security). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

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, whether from the stress of increasing temperatures or immediate injuries from natural hazards. 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. Medical conditions that require hospital 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 quantify the impact by the 2022 (Figure 85) and 2052 (Figure 86) 1% annual chance flood events on these facilities. The dataset includes everything from children, chronic disease, critical access, general acute care, long term care, military, psychiatric, rehabilitation, special and women's hospitals.

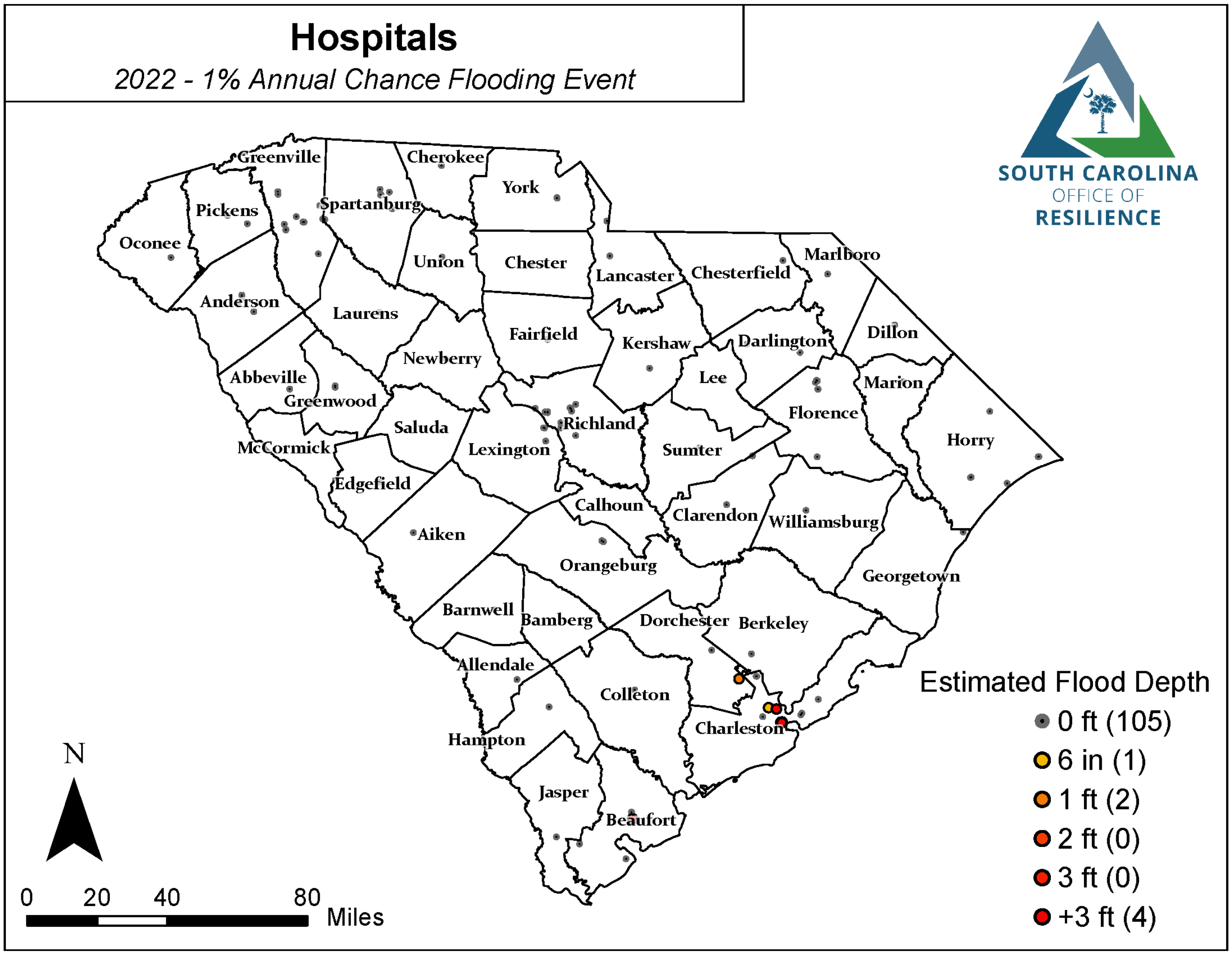


Figure 85: Estimated flooding of hospitals in the 2022 1% annual chance flooding event (Department of Homeland Security). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

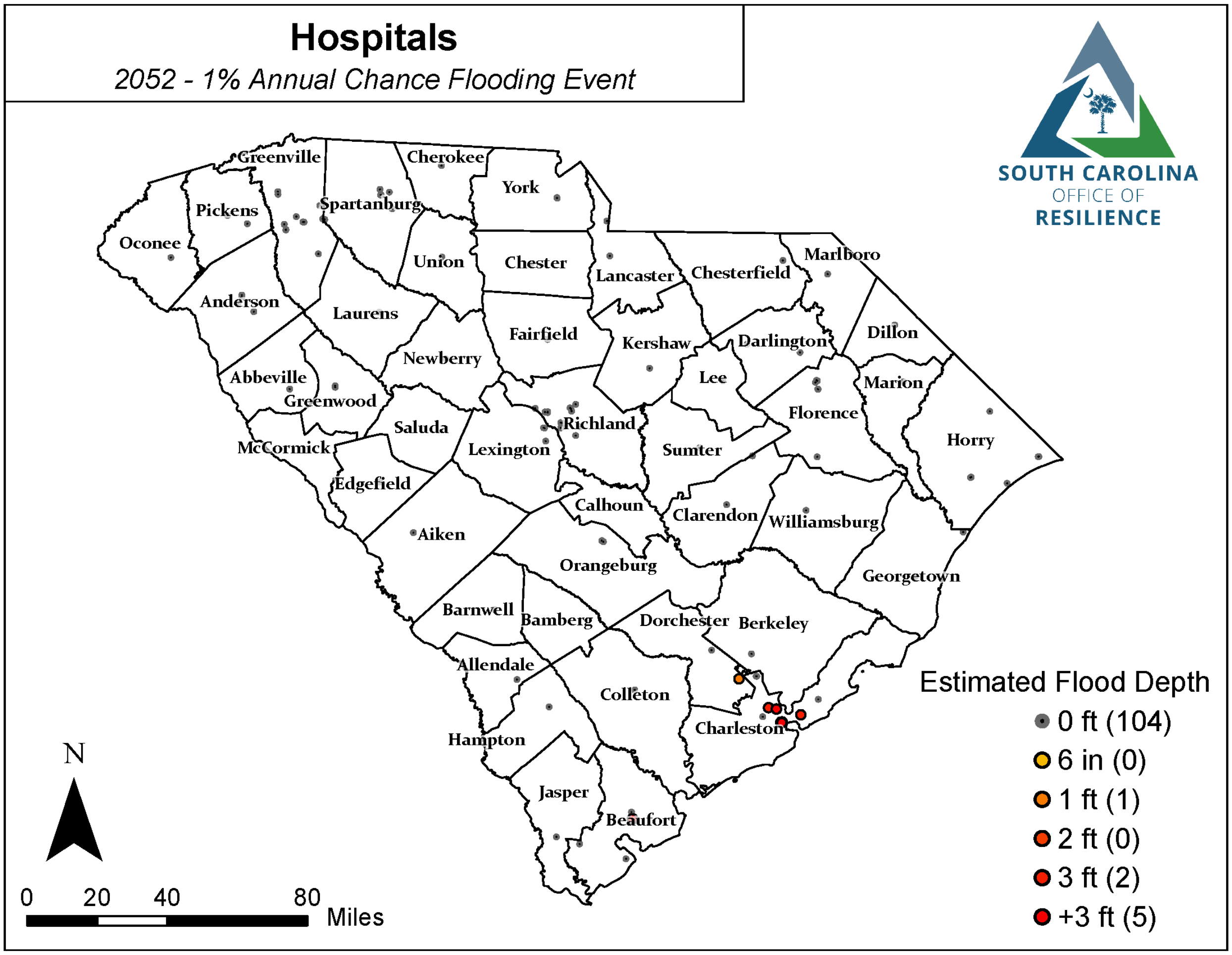


Figure 86: Estimated Flooding of hospitals in the 2052 1% annual chance flooding event (Department of Homeland Security). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

NURSING HOMES

Nursing homes have similar vulnerabilities when it comes to needed medical care of its residents, but the residential nature of these facilities have 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. This database from DHS includes facilities that house older adults and assisted care facilities.

The figures below quantify the impact by the 2022 (Figure 87) and 2052 (Figure 88) 1% annual chance flood events on these facilities.

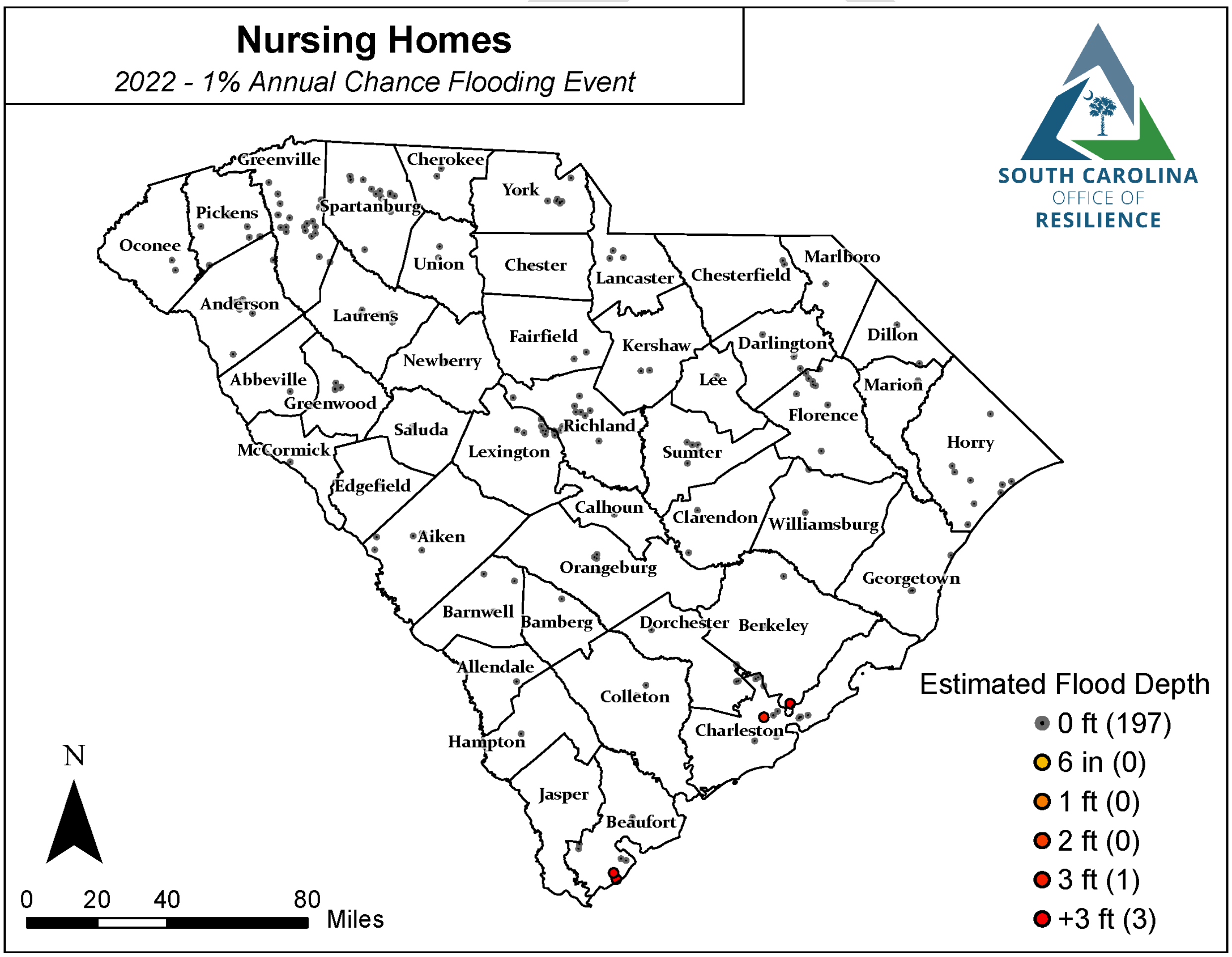


Figure 87: Estimated flooding of nursing homes in the 2022 1% annual chance flooding event (Department of Homeland Security). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

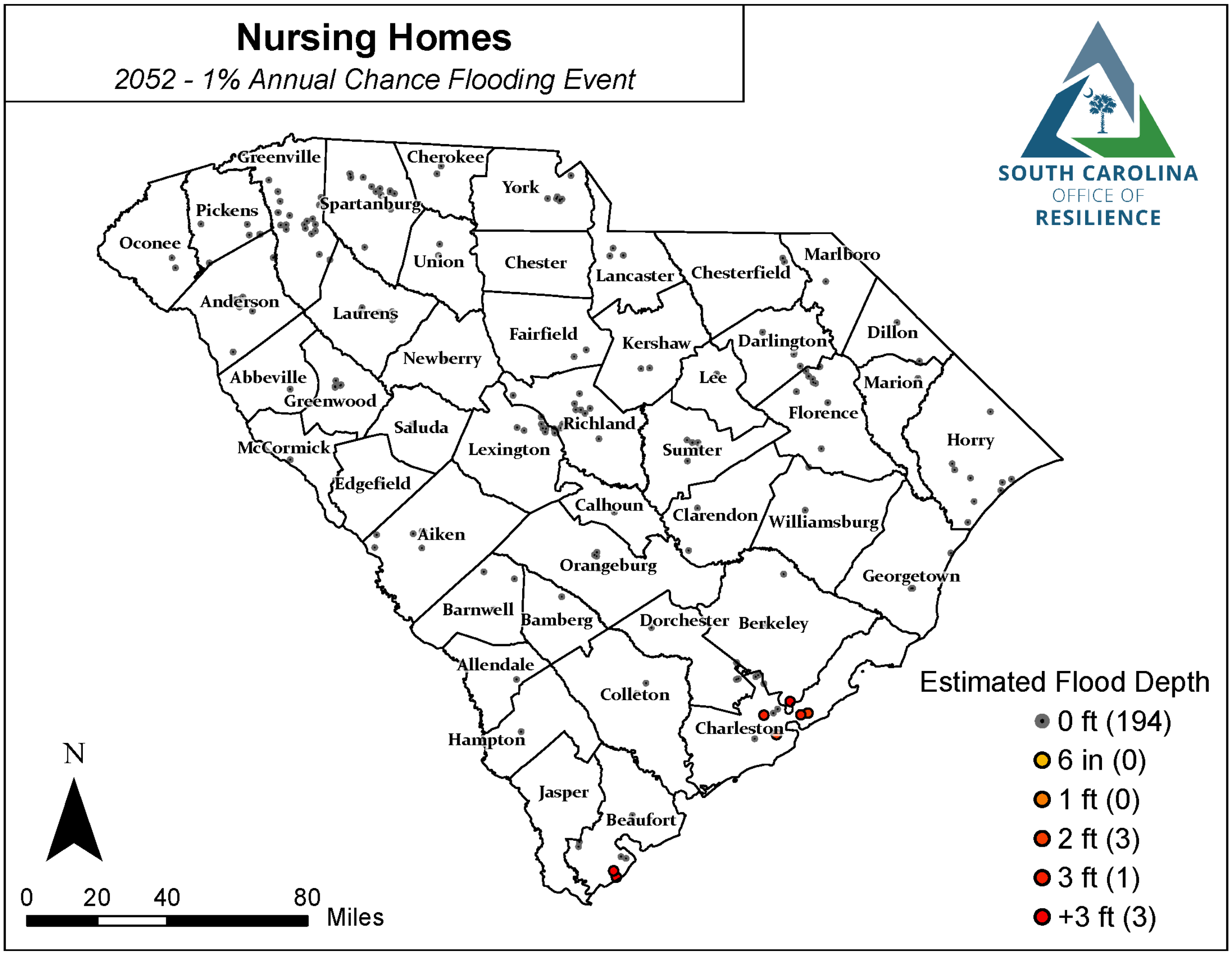


Figure 88: Estimated flooding of nursing homes in the 2052 1% annual chance flooding event (Department of Homeland Security). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

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 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 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 quantify the impact by the 2022 (Figure 89) and 2052 (Figure 90) 1% annual chance flood events on these facilities.

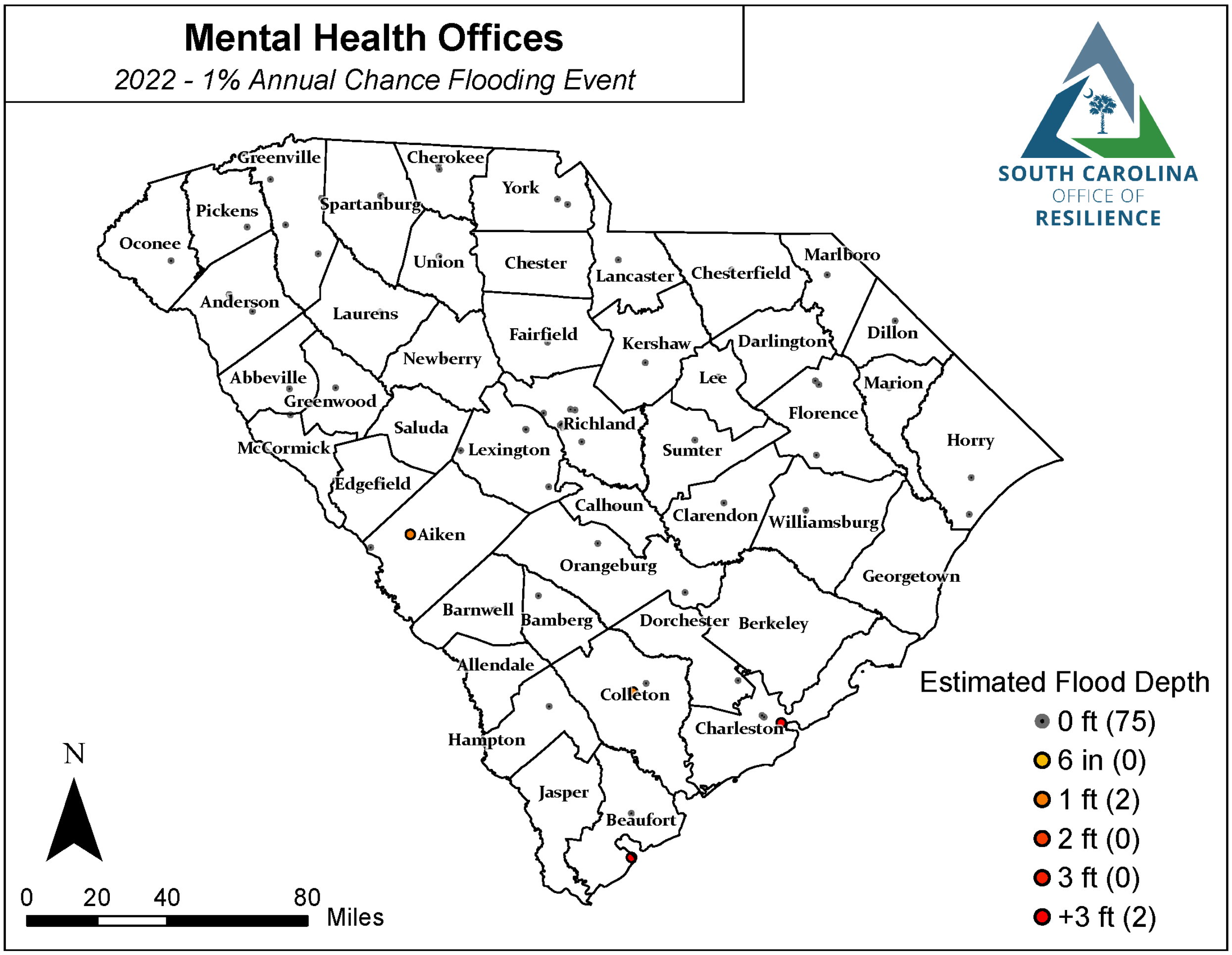


Figure 89: Estimated flooding of mental health offices in the 2022 1% annual chance flooding event (DMH). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

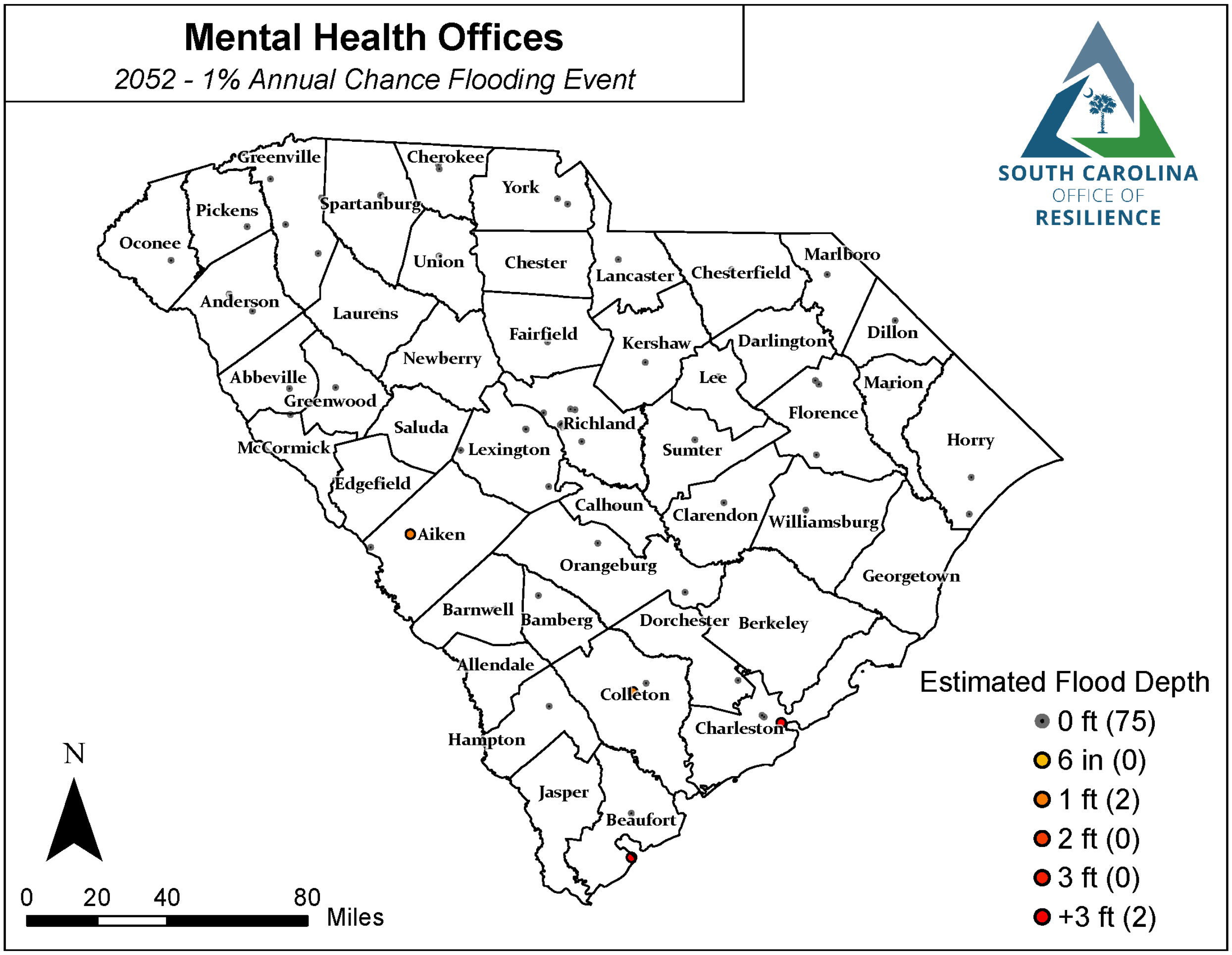


Figure 90: Estimated flooding of mental health offices in the 2052 1% annual chance flooding event (DMH). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

DIALYSIS CLINICS

A flood has the potential to become a kidney failure disaster: an event that places 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 things that 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 quantify the estimated flooding of these centers by the 2022 (Figure 91) and 2052 (Figure 92) 1% annual chance flood events on these facilities.

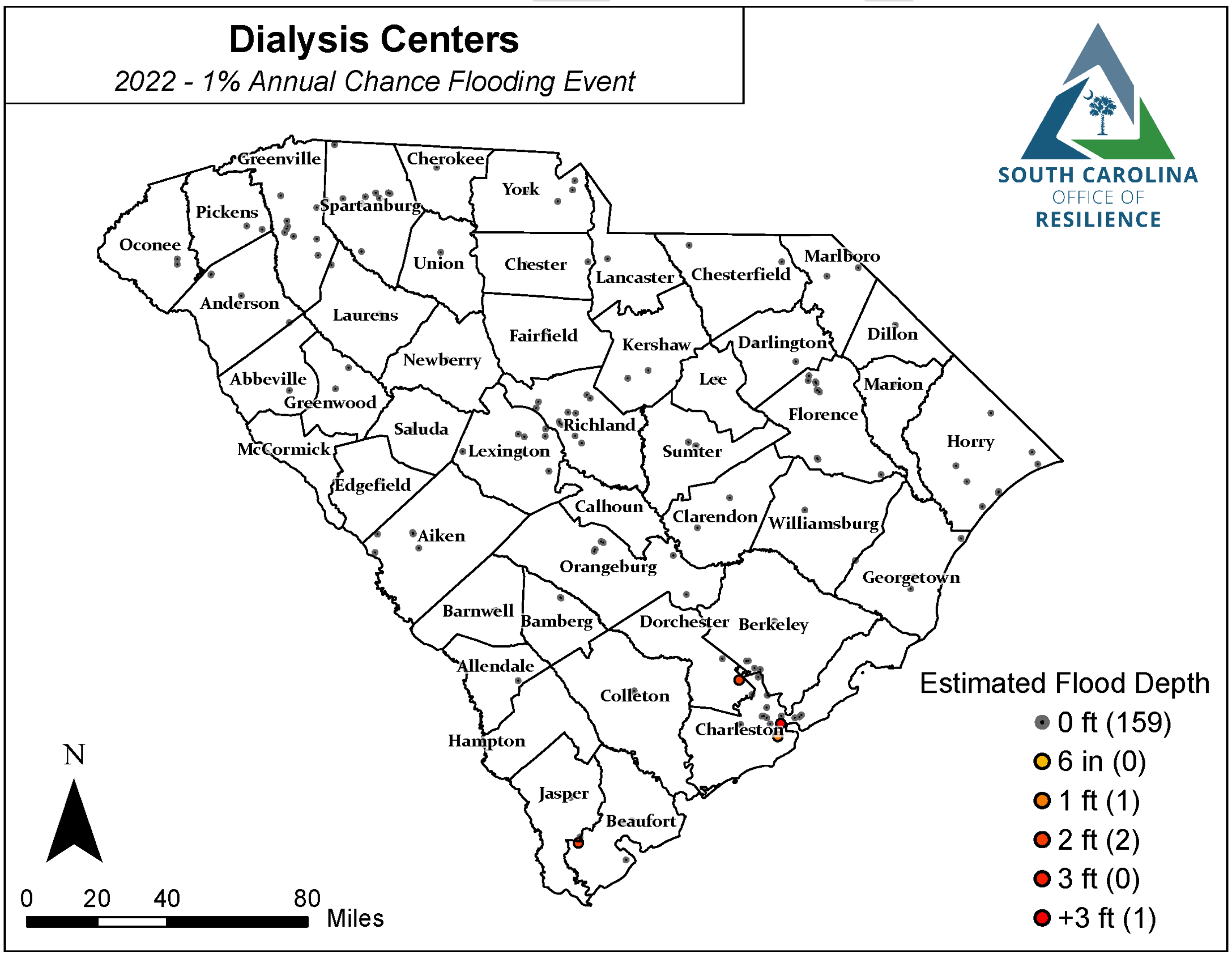


Figure 91: Estimated flooding of dialysis centers in the 2022 1% annual chance flooding event (Department of Homeland Security). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

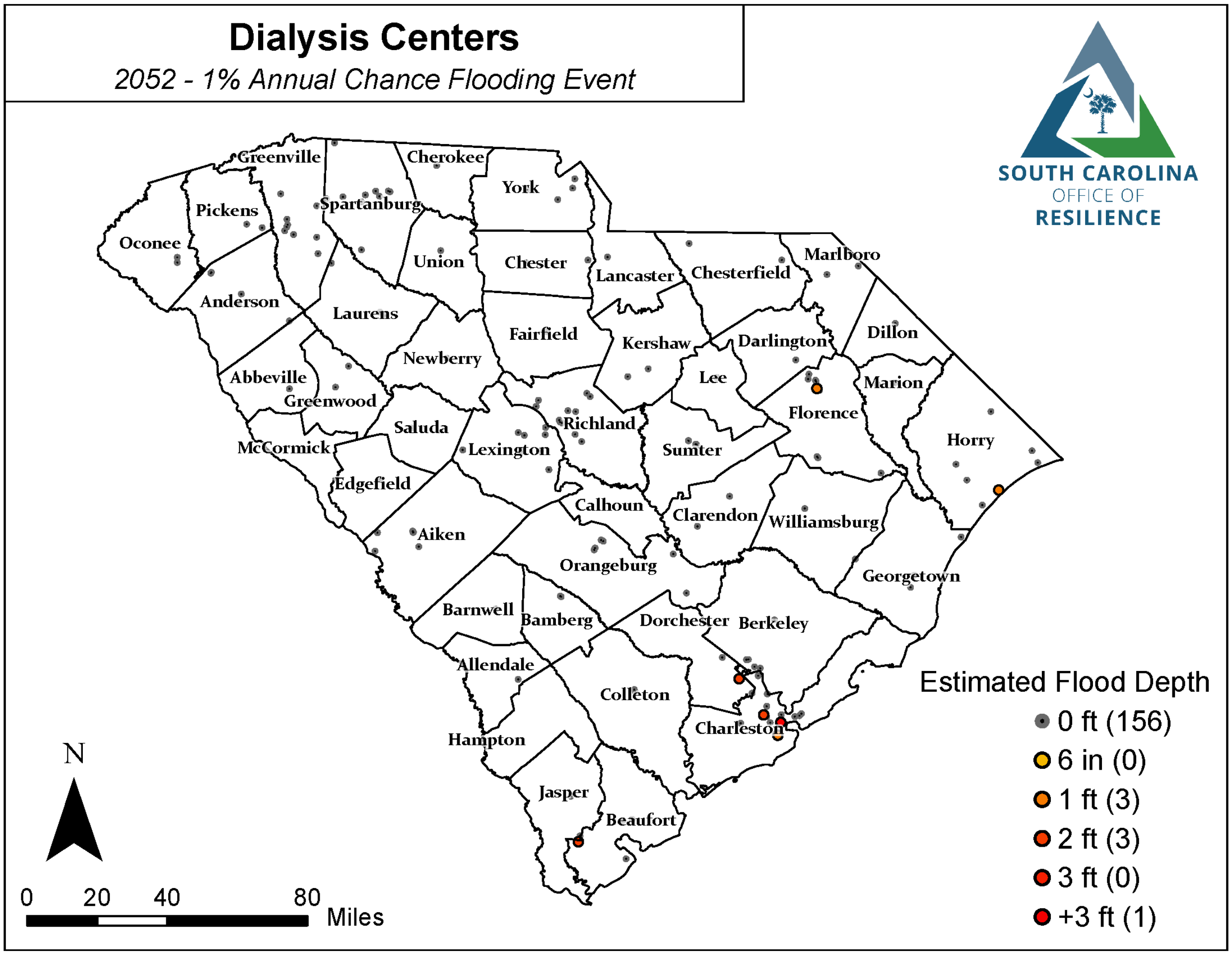


Figure 92: Estimated flooding of dialysis centers in the 2052 1% annual chance flooding event (Department of Homeland Security). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

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 show the estimated flooding of pharmacies in 2022 (Figure 93) and 2052 (Figure 94) 1% annual chance flooding event.

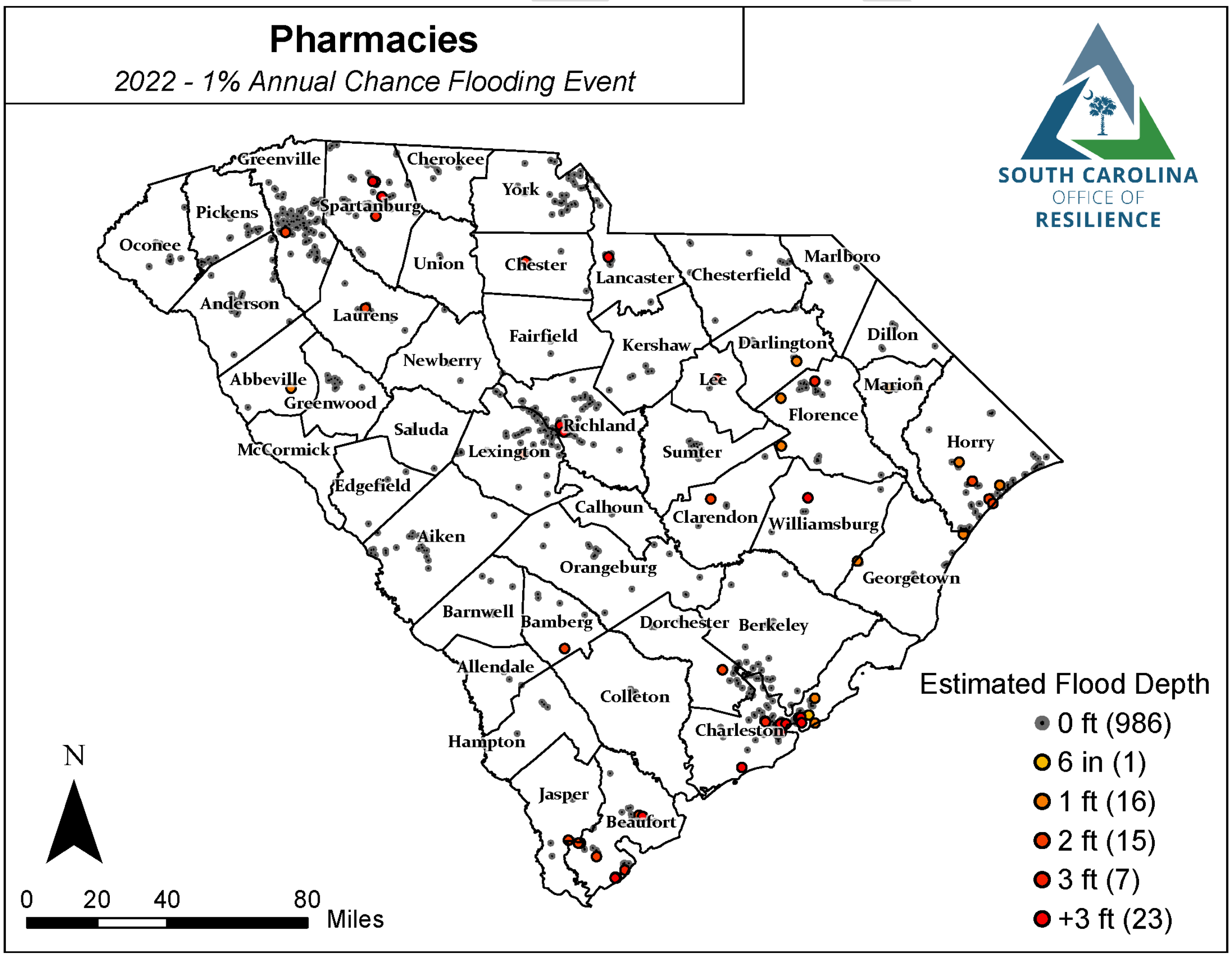


Figure 93: Estimated flooding of pharmacies in the 2022 1% annual chance flooding event (Department of Homeland Security). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

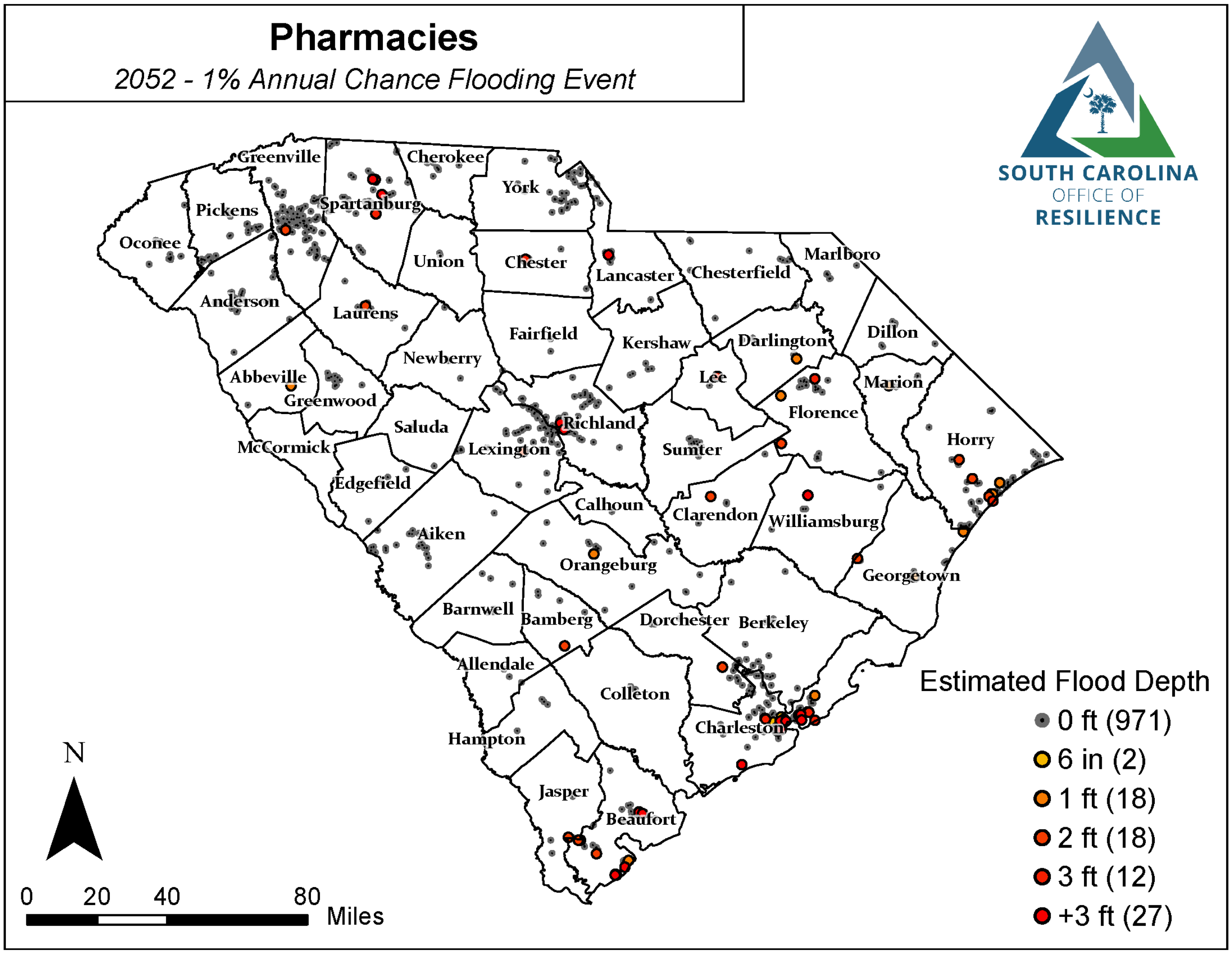


Figure 94: Estimated flooding of pharmacies in the 2052 1% annual chance flooding event (Department of Homeland Security). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

TELEHEALTH

In addition to these in-person service facilities, telehealth visits also 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). 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 administers a variety of program 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 Medicaid and other programs listed below.

Medicaid: Medicaid in South Carolina is operated by the Department of Health and Human Services (DHHS) and 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. The DHHS maintains offices in every county that serve as enrollment centers for Medicaid.

Community Long Term Care: Department of Health and Human Services (DHHS) is responsible for Community Long Term Care (CLTC) program, which provides in-home services Medicaid-eligible people to those who want to remain living at home but need special services to make that a healthy possibility. CLTC services are available for persons age 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 Department of Health and Human Services (DHHS) administers the BabyNet program, which 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 95) and 2052 (Figure 96) 1% annual chance flood event.

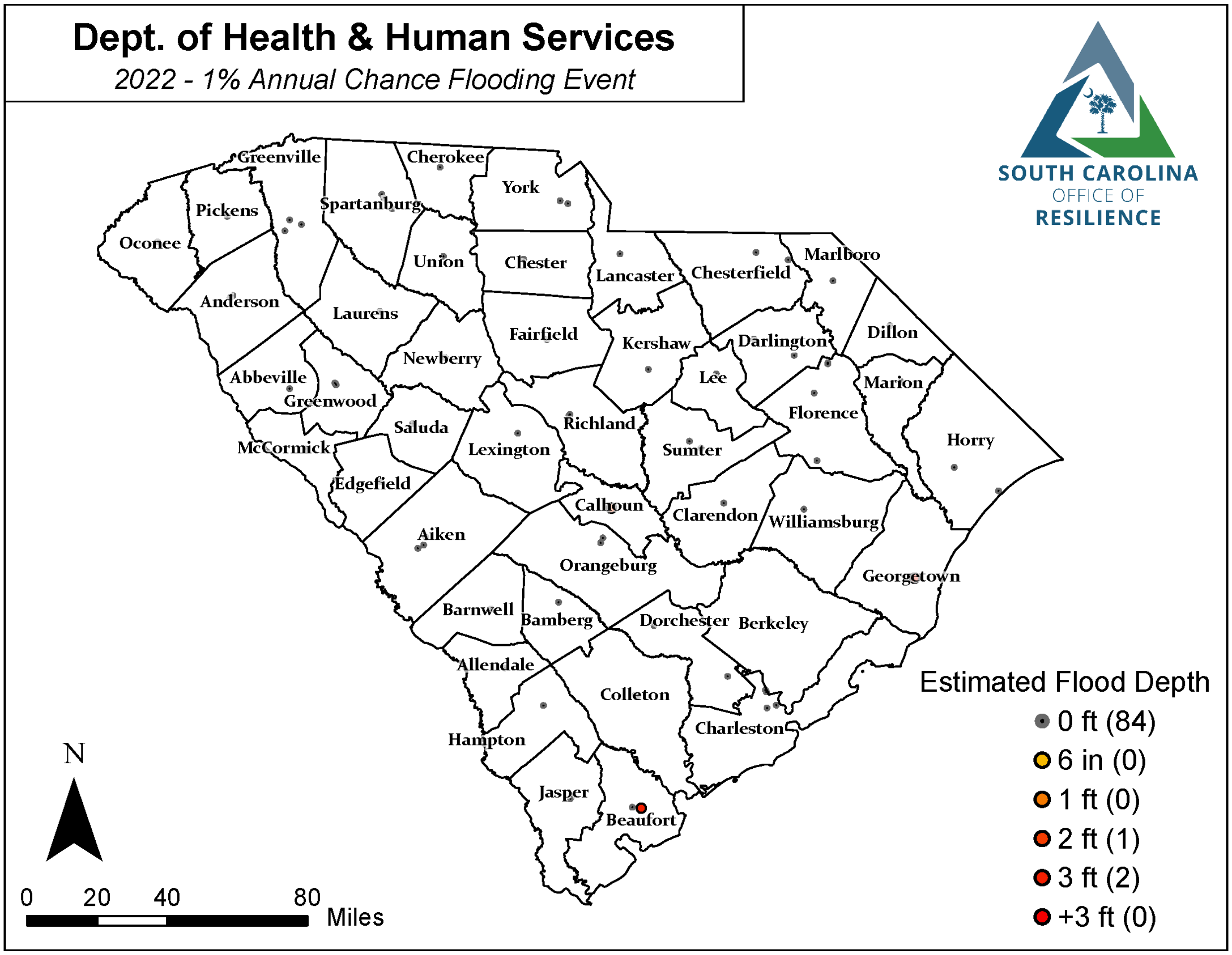


Figure 95: Estimated flooding of Department of Health and Human Services' offices in the 2022 1% annual chance flooding event (DHHS). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

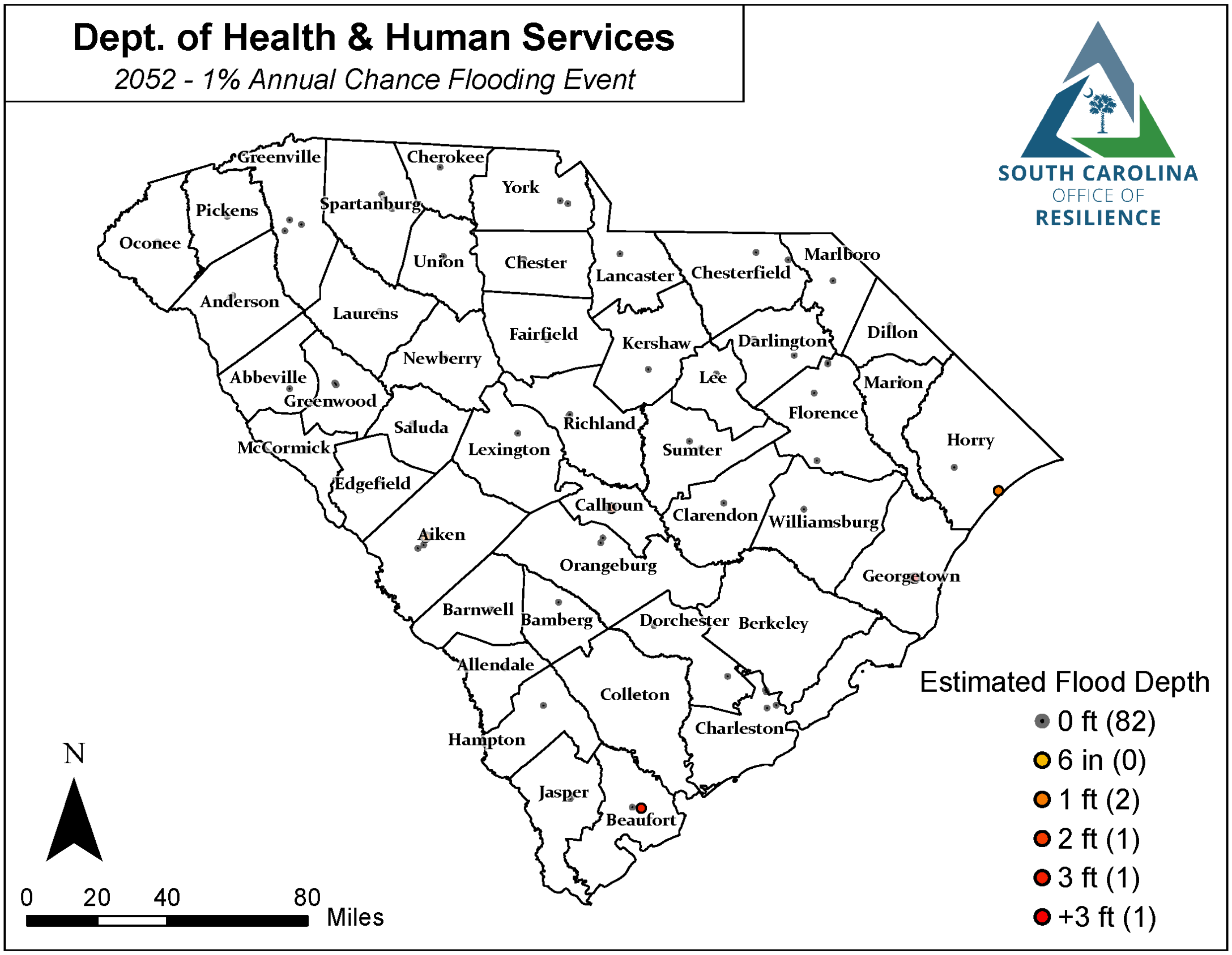


Figure 96: Estimated flooding of Department of Health and Human Services' offices in the 2052 1% annual chance flooding event (DHHS). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

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 and are based in every county in the state. 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 those childcare facilities licensed by DSS to flooding in the 2022 (Figure 97) and 2052 (Figure 98) 1% annual chance flood event.

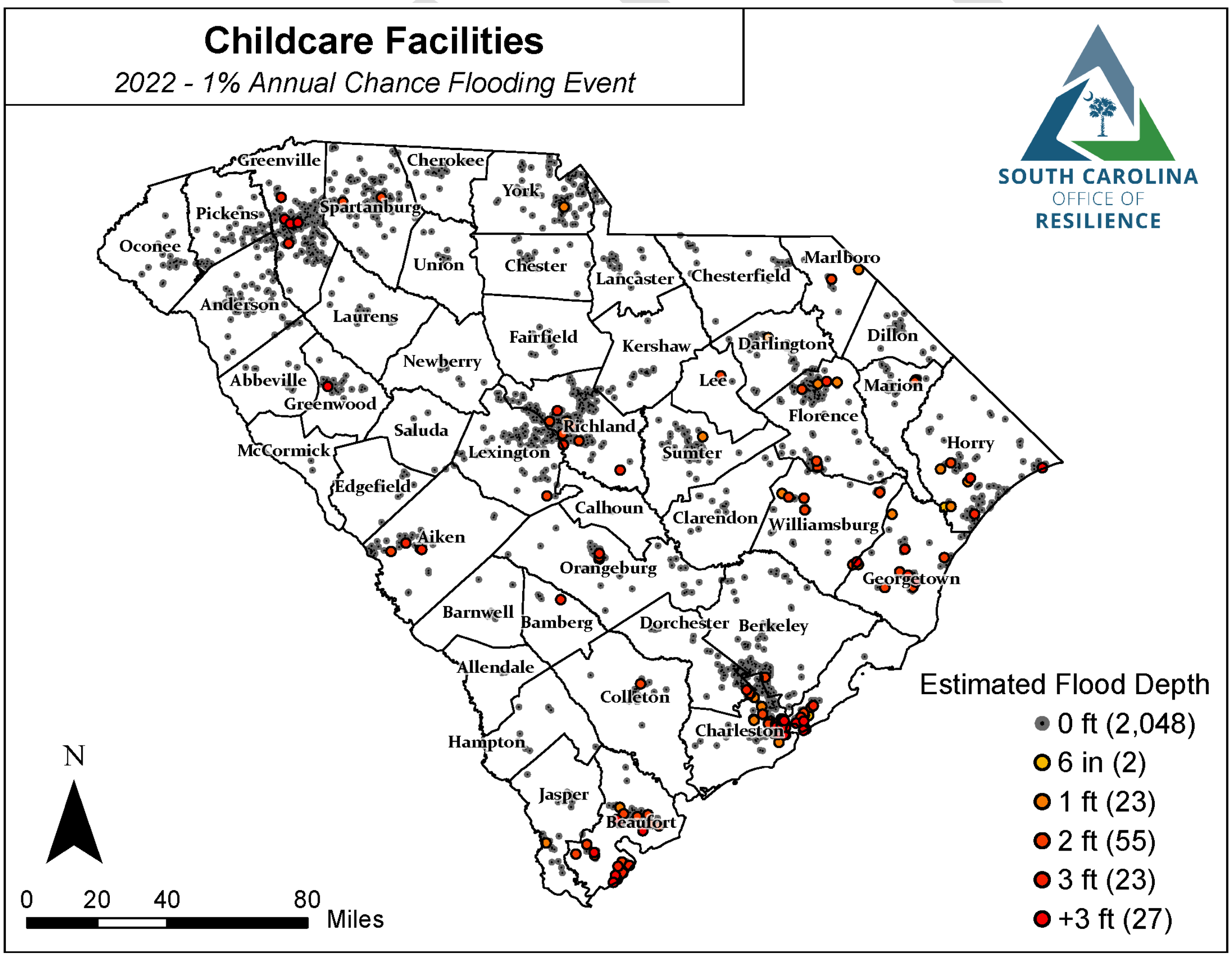


Figure 97: Estimated flooding Childcare Facilities in the 2022 1% annual chance flooding event (DSS). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

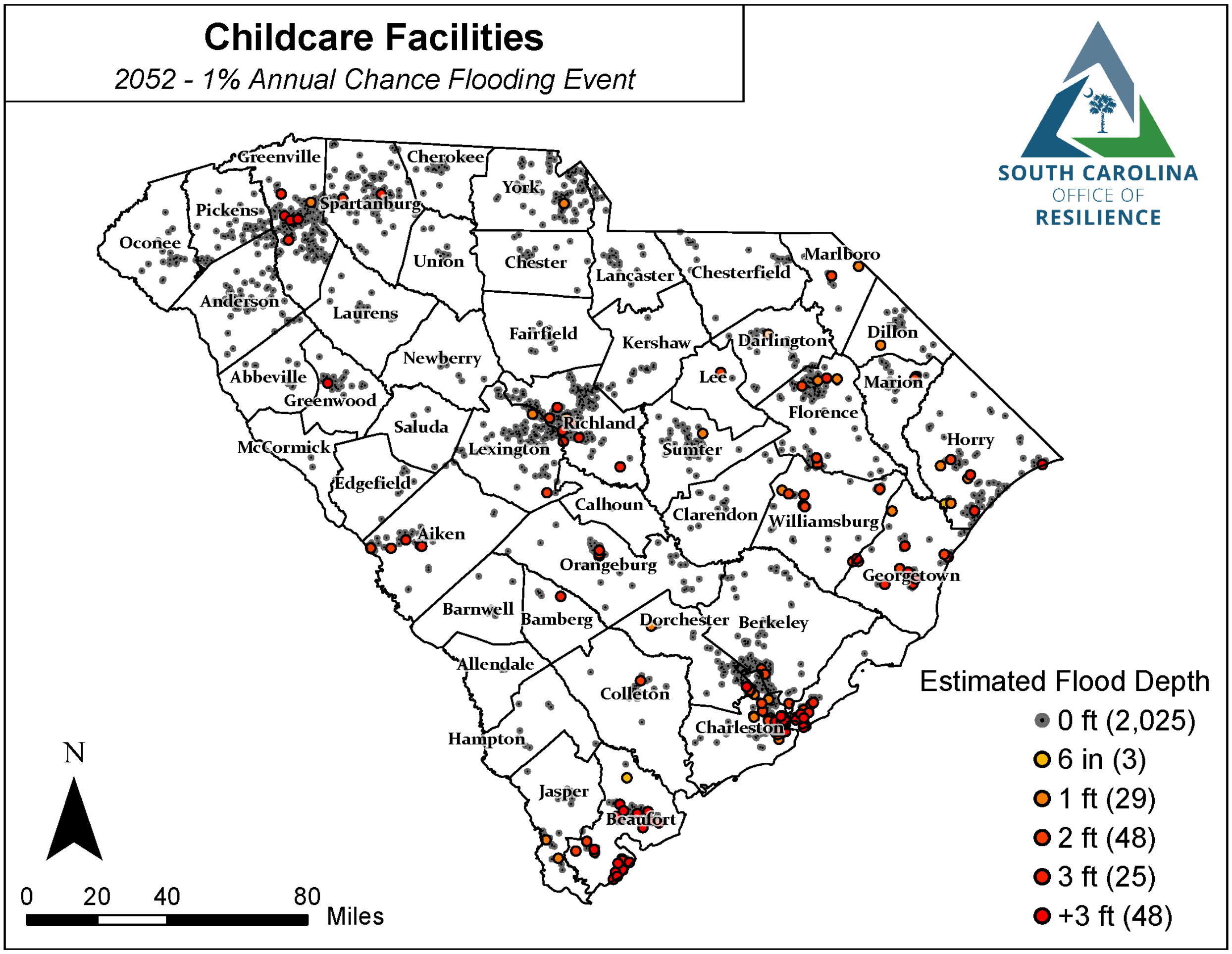


Figure 98: Estimated flooding Childcare Facilities in the 2052 1% annual chance flooding event (DSS). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

VETERAN'S AFFAIRS

The South Carolina Department of Veteran's Affairs (DVA) coordinates county level Veteran's Affairs offices, places in the community where veterans can access benefits. The DVA assists veterans with employment, healthcare, suicide prevention, and education and have facilities across the state.

The maps below show the vulnerability of these facilities to flooding in the 2022 (Figure 99) and 2052 (Figure 100) 1% annual chance flood event.

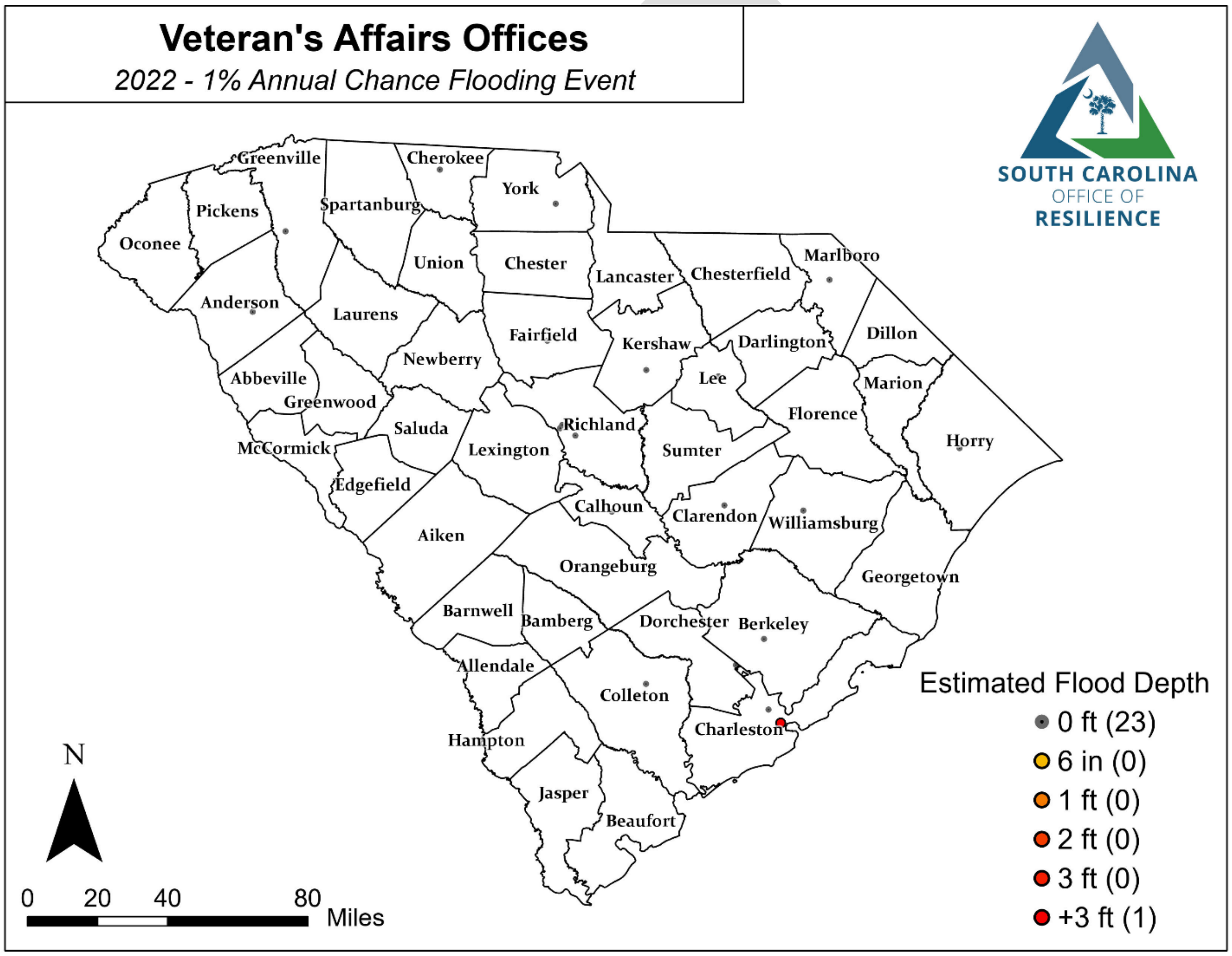


Figure 99: Estimated flooding of Veteran Affairs facilities in the 2022 1% annual chance flooding event (DVA). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

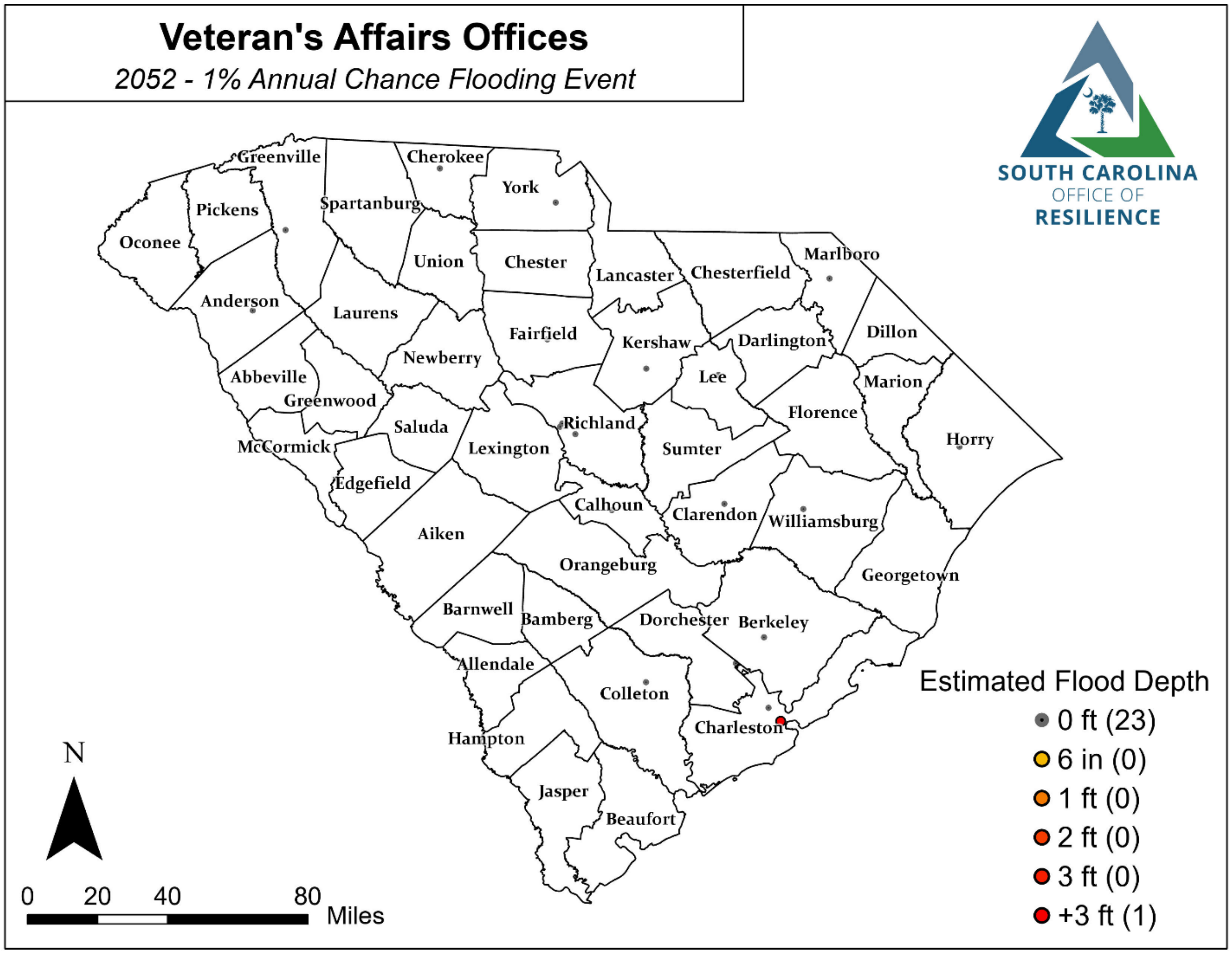


Figure 100: Estimated flooding of Veterans Affairs facilities in the 2052 1% annual chance flooding event (DVA). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

PLACES OF WORSHIP

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

The maps below show the vulnerability of these places of worship to flooding in the 2022 (Figure 101) and 2052 (Figure 102) 1% annual chance flood event.

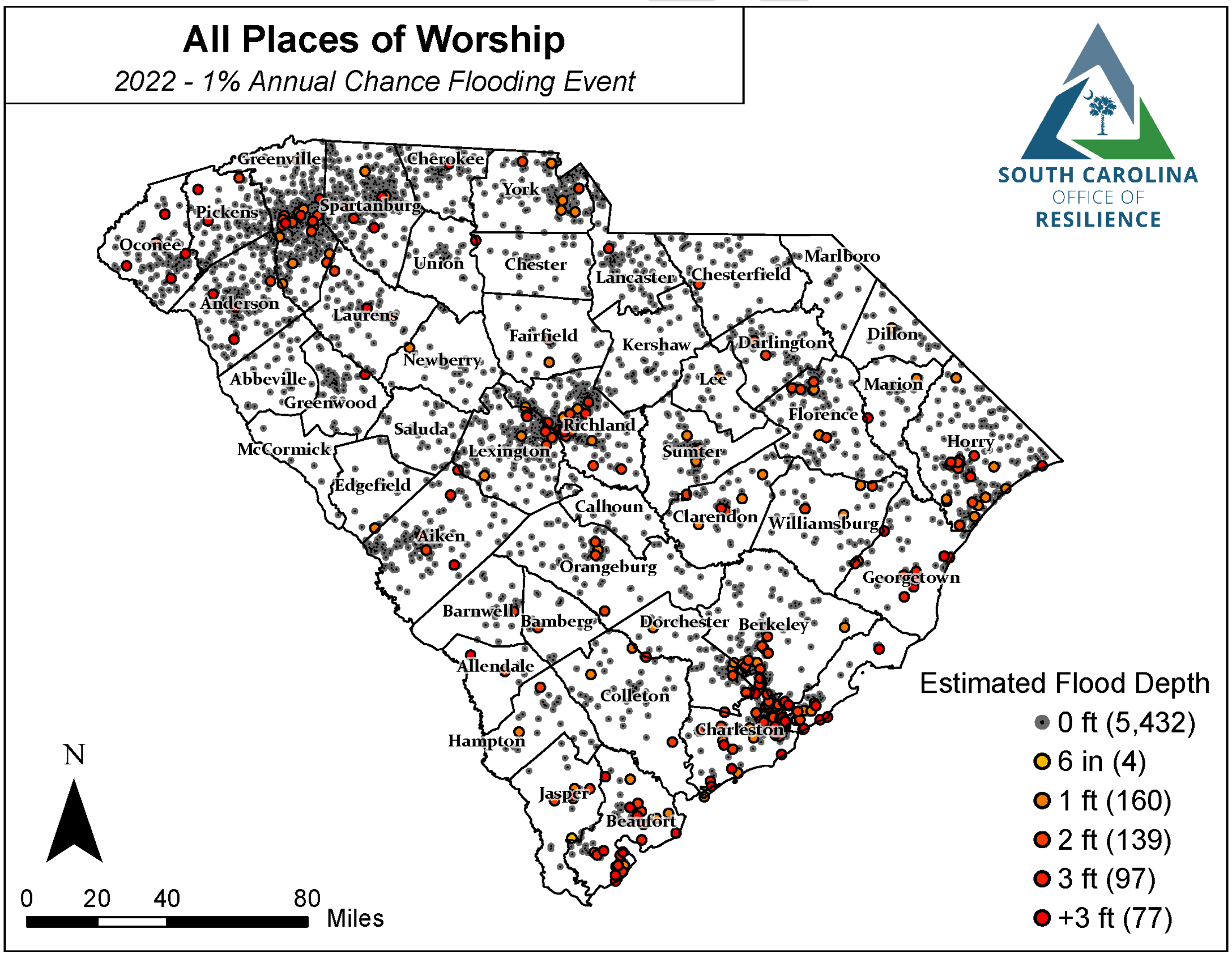


Figure 101: Estimated flooding of places of worship in the 2022 1% annual chance flooding event (Department of Homeland Security). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

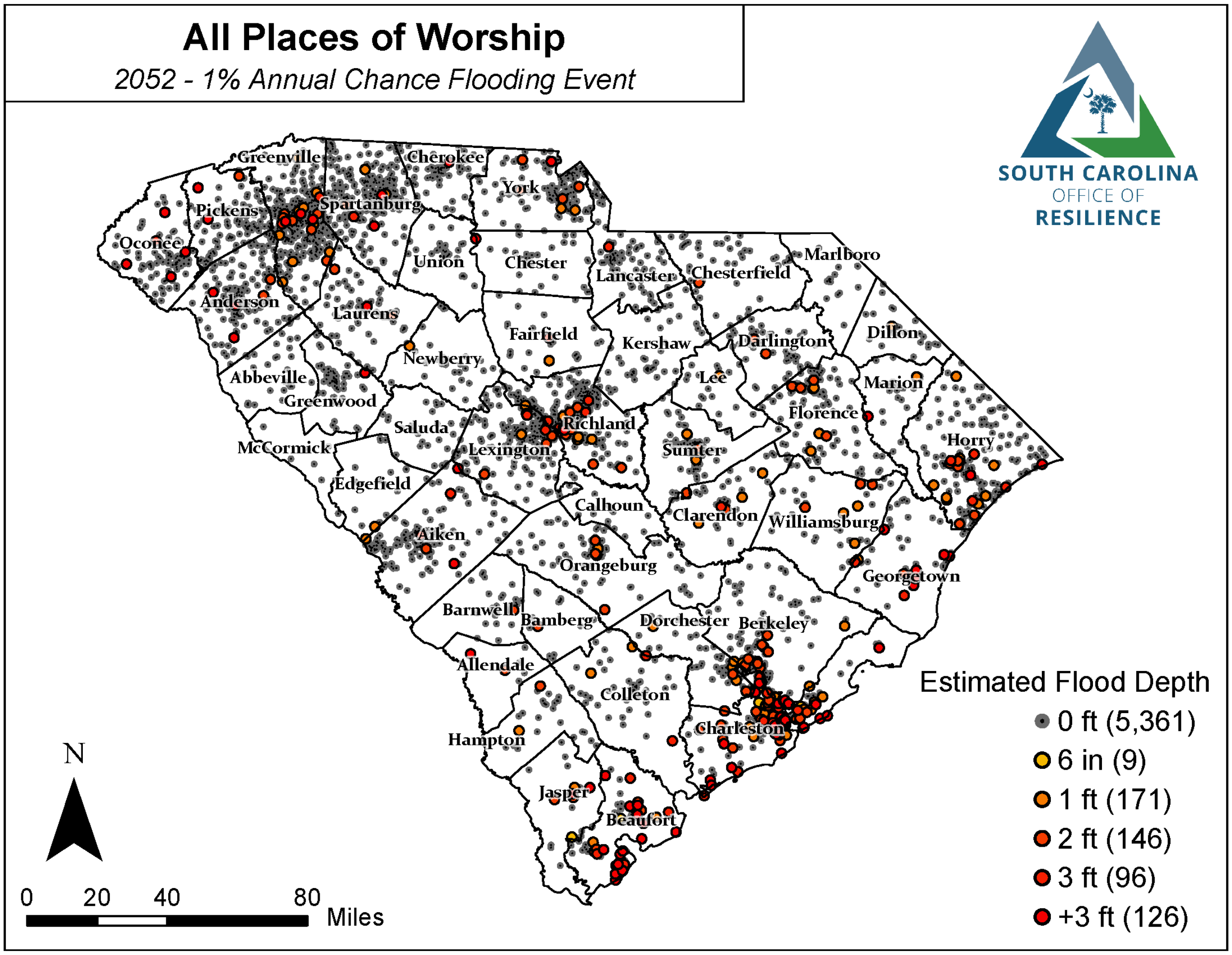


Figure 102: Estimated flooding of places of worship in the 2052 1% annual chance flooding event (Department of Homeland Security). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

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). 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 road and bridges include direct damages to the roadway and barriers to access, as well as indirect impacts due to ongoing repairs and the needs to re-routing that impacts communities and economies. In South Carolina, 627.2 miles of the state's roads are at risk of high-tide flooding. As the number of high-tide flooding days is expected to increase with future sea level rise, congestion and vehicle-hour delays will also increase. Under the intermediate high sea level rise scenario, models show an annual statewide total of 94.4 million vehicle-miles of delay resulting in $4.18 billion yearly by 2090 (Fant et al., 2021).

Currently, there is not statewide road elevation data set. EMD, in conjunction with Clemson University, is working to develop a dataset that may be used for vulnerability analysis.

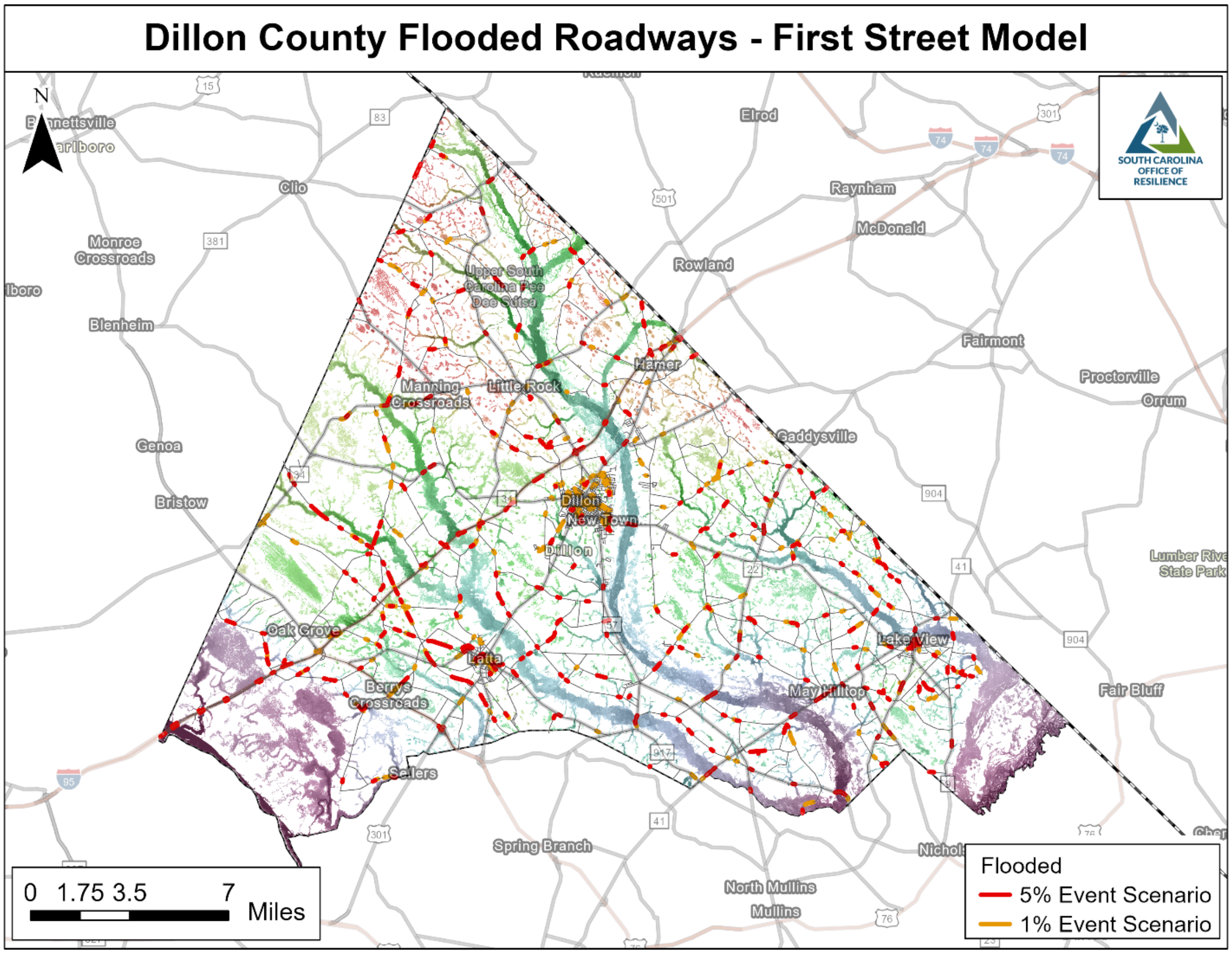


Figure 103: Analysis of where the roadway centerline elevation is lower than the elevation of a modelled flood scenario. Roadway elevations are provided by Clemson University, and flood data is provided by the First Street Foundation's Flood Hazard Layers, V2.0.

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 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 places of worship to flooding in the 2022 (Figure 103) and 2052 (Figure 104) 1% annual chance flood event.

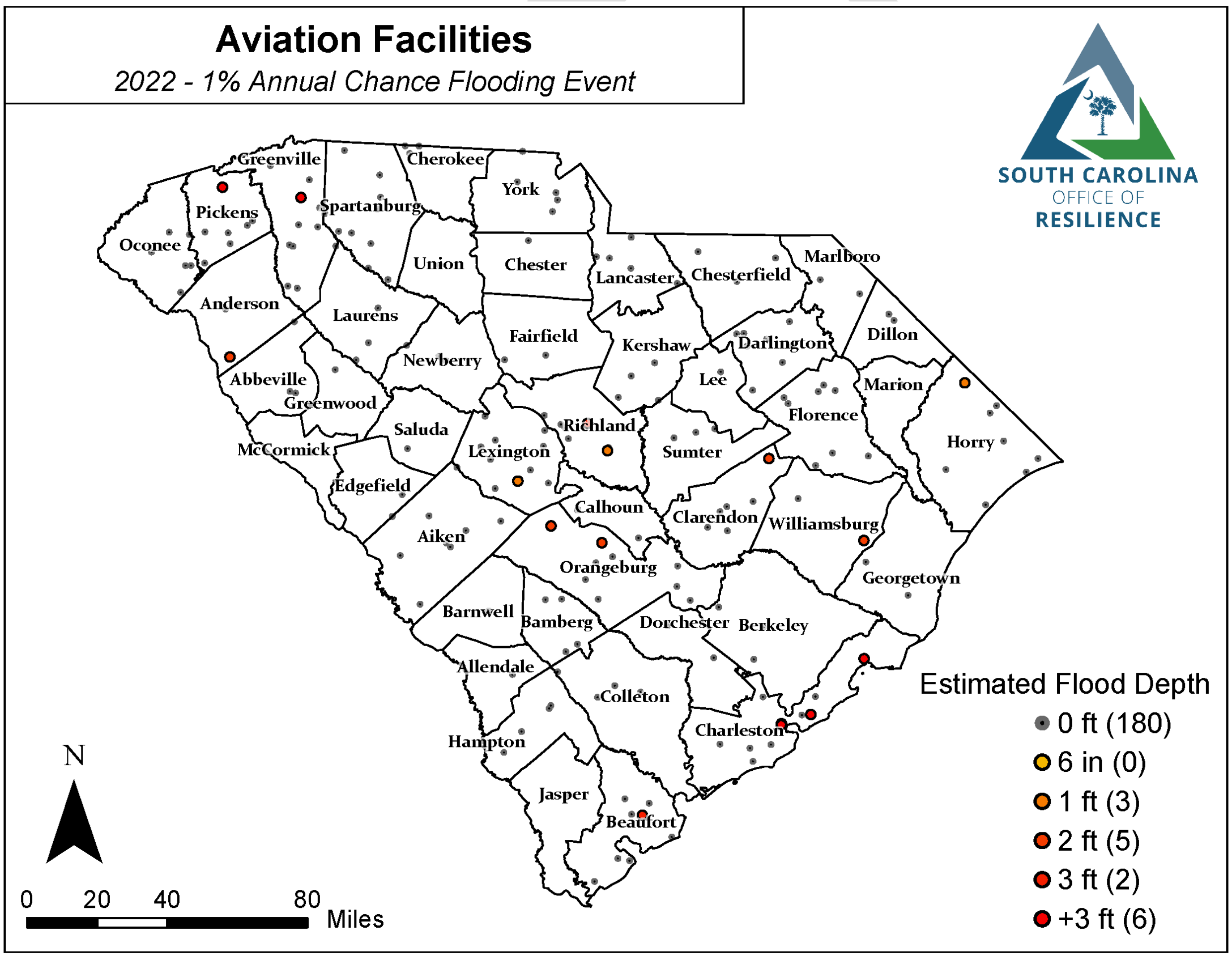


Figure 104: Estimated flooding of aviation facilities in the 2022 1% annual chance flooding event (Department of Homeland Security). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

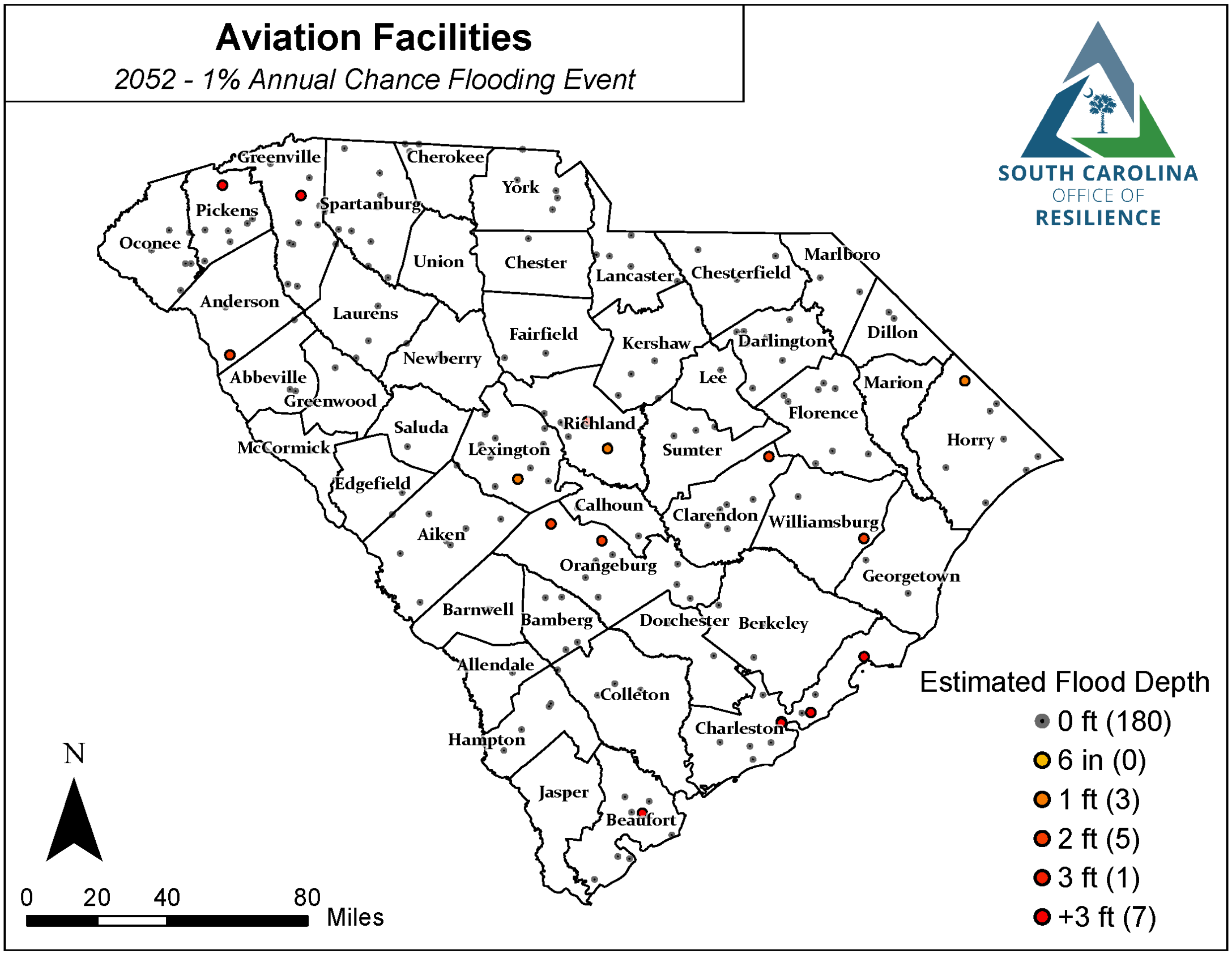


Figure 105: Estimated flooding of aviation facilities in the 2052 1% annual chance flooding event (Department of Homeland Security). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

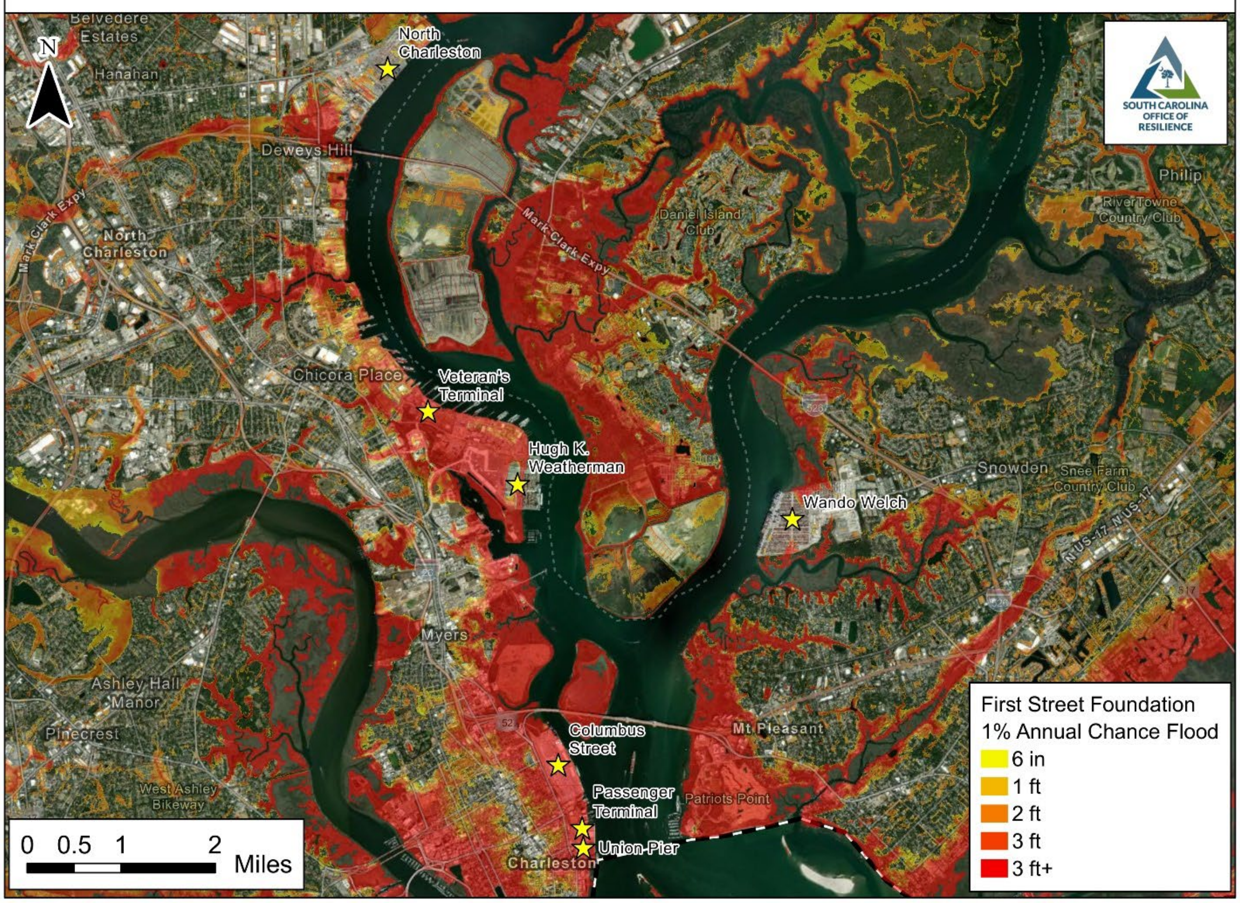
PORTS

South Carolina Ports Authority 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 on South Carolina each year (SC Ports Authority, n.d.).

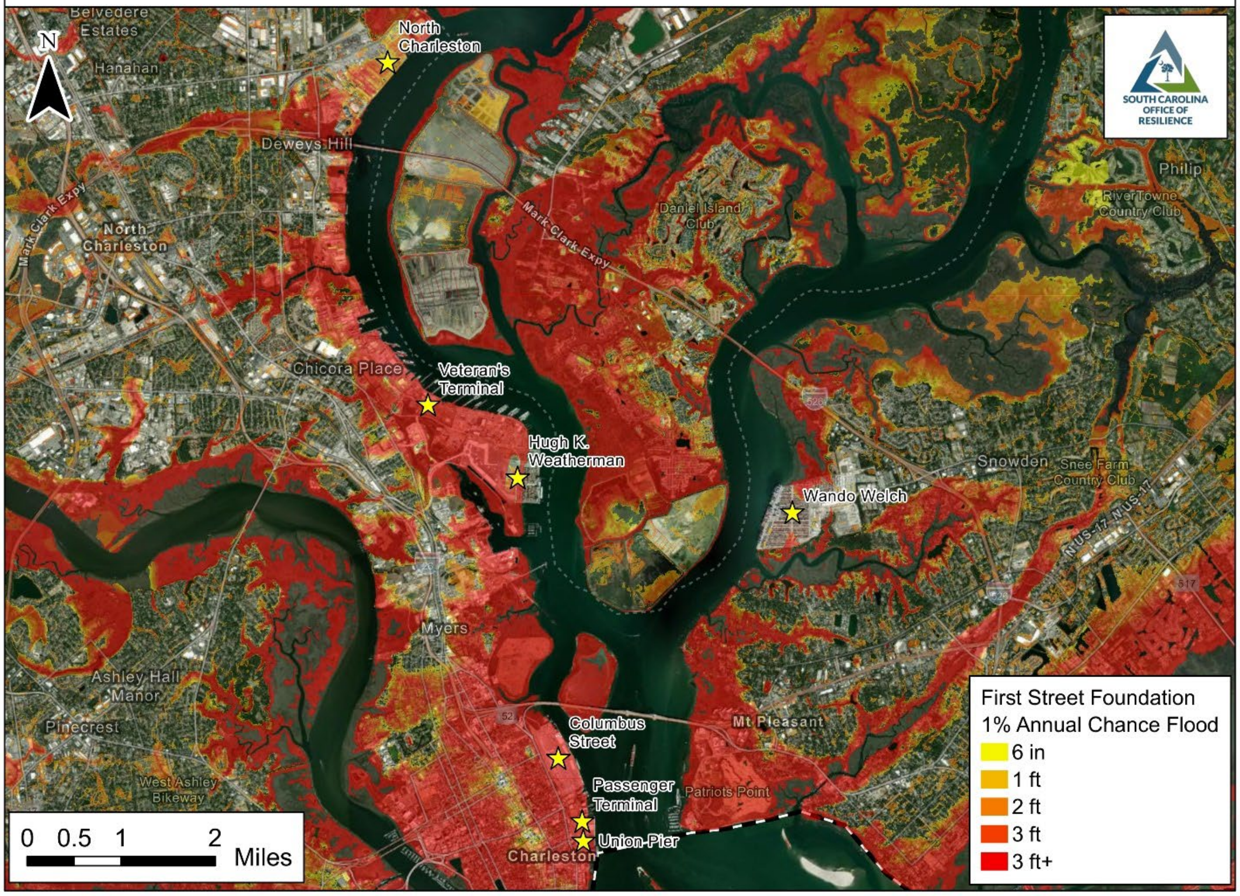
Sea level rise poses risk to ports across US because mitigation measures are capital intensive. Ports plan for sea level rise contingencies, but the effects of storm surges and flooding could extend to complementary supply chain infrastructure on the landside and transportation sector. In the event of a massive hurricane or other disaster that leaves roads impassible, 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, our wharves have gotten progressively higher in elevation, 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.

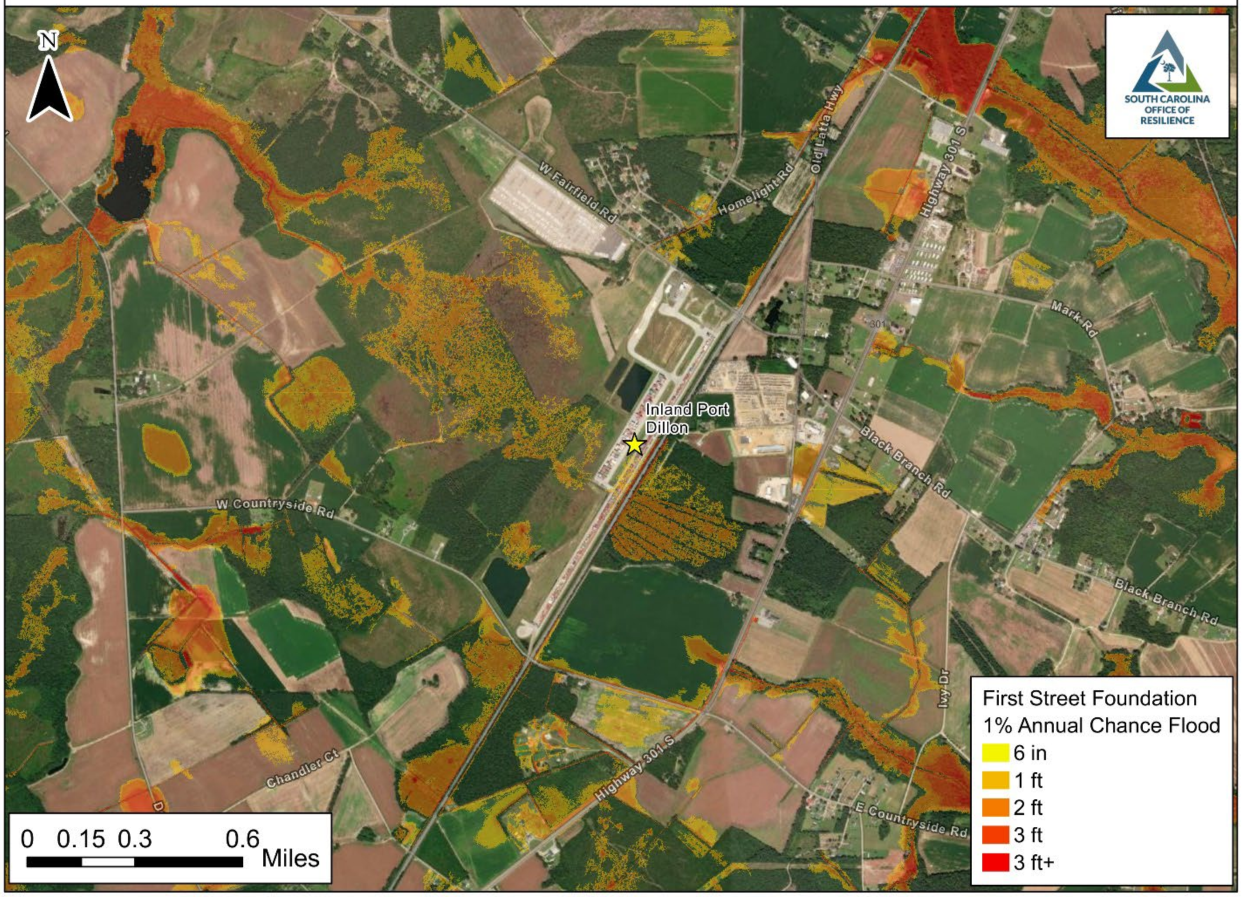
2022 Flood Risk - Charleston Ports



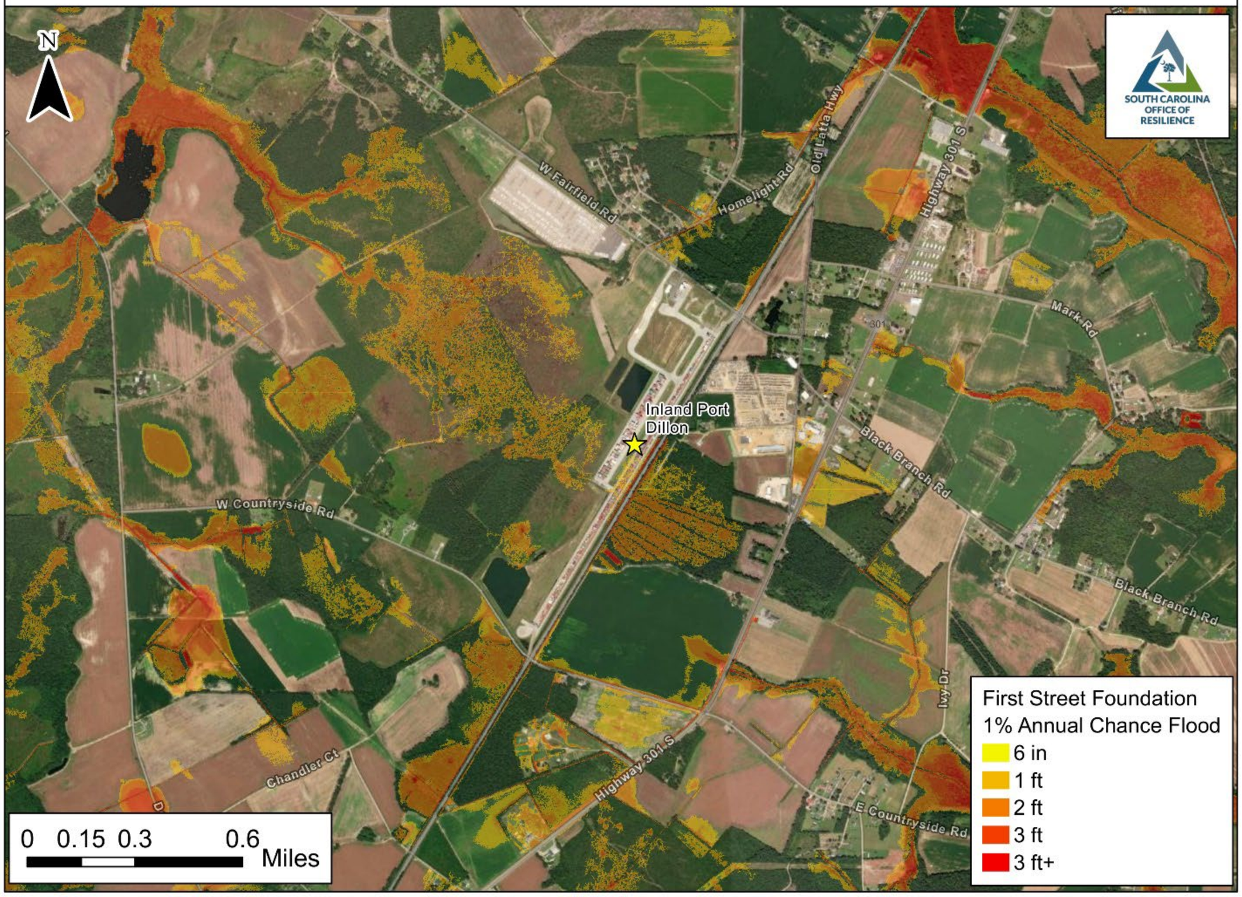
2052 Flood Risk - Charleston Ports

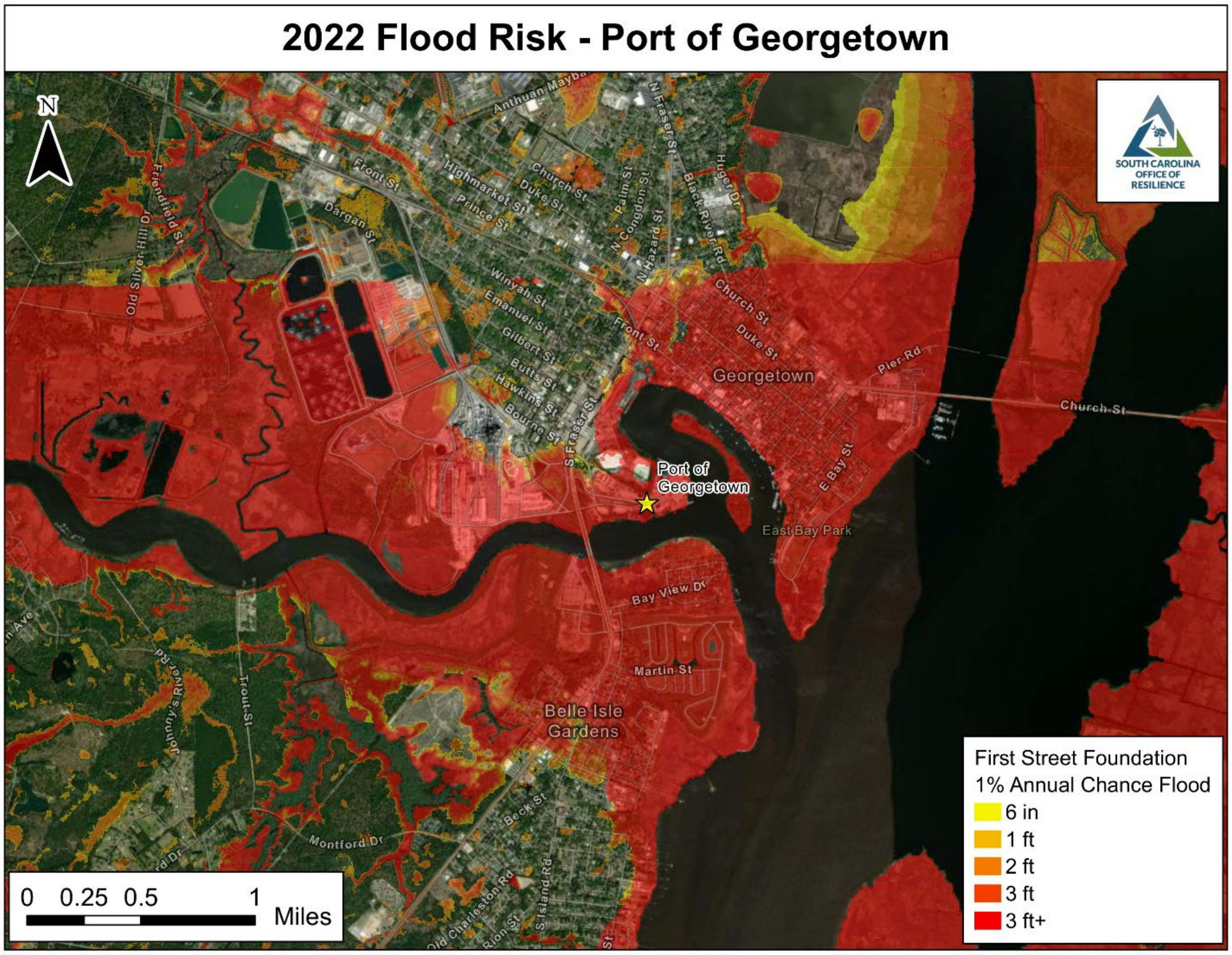


2022 Flood Risk - Inland Port Dillon

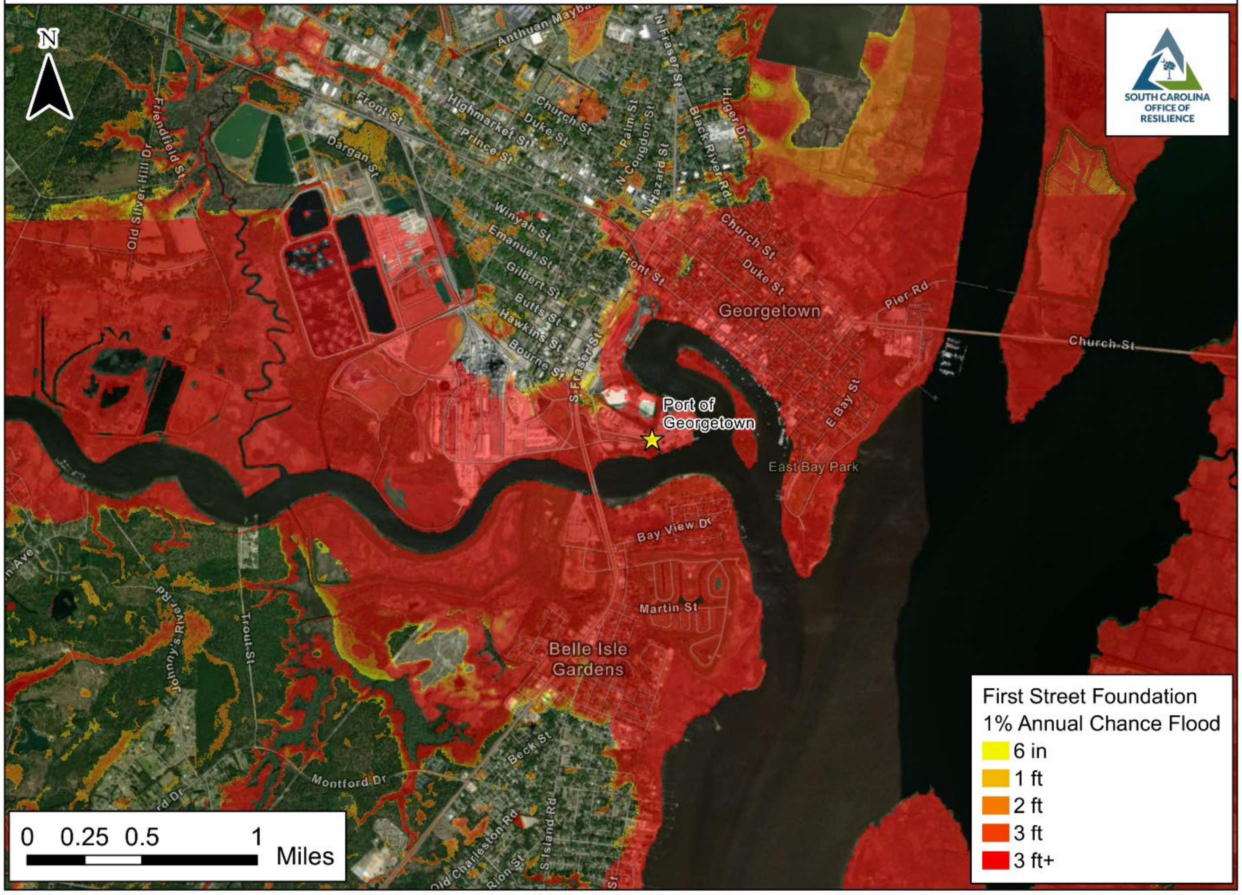


2052 Flood Risk - Inland Port Dillon

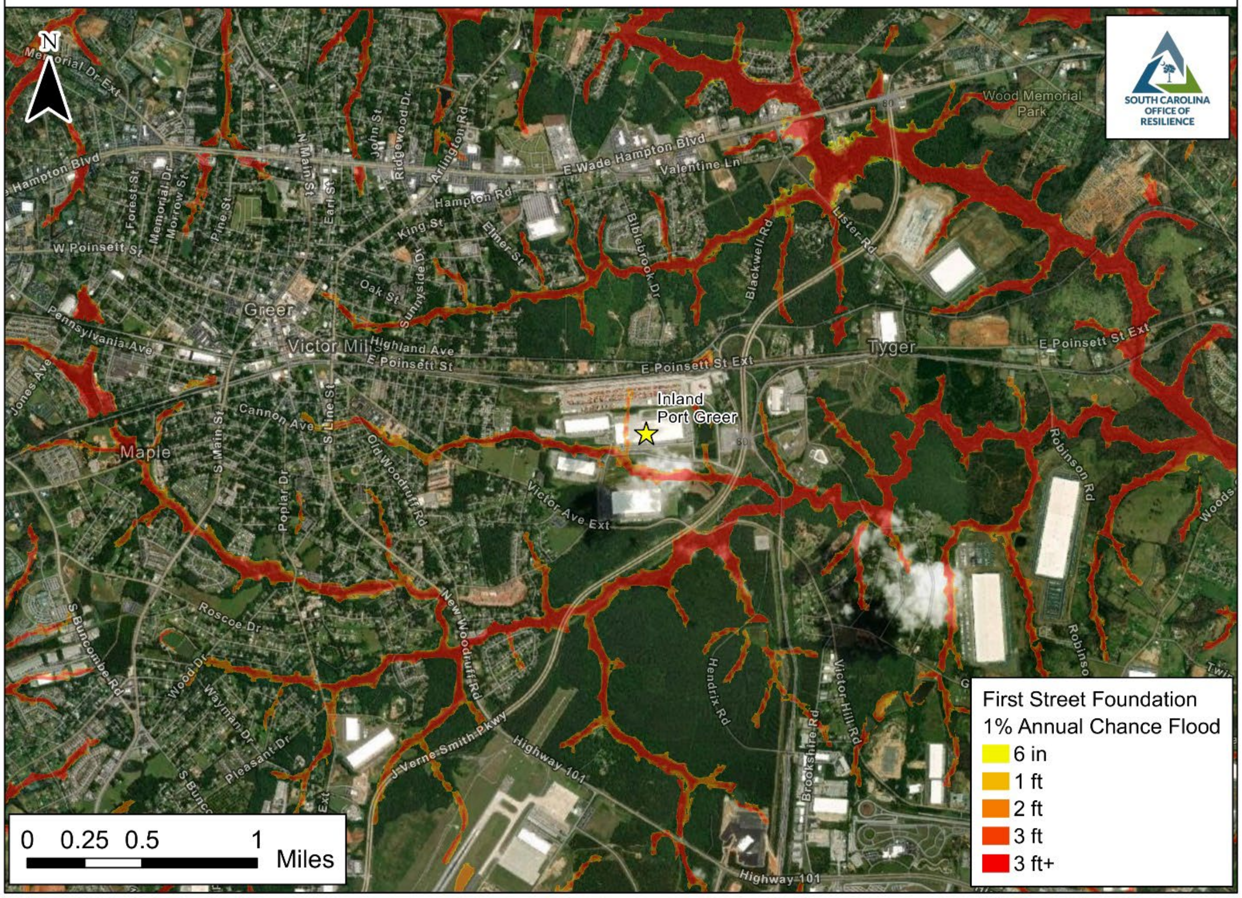



2022 Flood Risk - Port of Georgetown
SOUTH CAROLINA OFFICE OF RESILIENCE
Georgetown
Port of Georgetown
East Bay Park
Belle Isle Gardens
Front St
Highmarket St
Church St
Duke St
Prince St
Dargan St
Winyah St
Emanuel St
Gilbert St
Butts St
Hawkins St
Bourne St
S Fraser St
N Fraser St
Palm St
N Congdon St
N Hazard St
Black River Rd
Pier Rd
E Bay St
Bay View Dr
Martin St
Montford Dr
Beck St
Old Charleston Rd
S Island Rd
Rion St
Trout St
Johnny's River Rd
Old Silver Hill Dr
Friendfield St
First Street Foundation
1% Annual Chance Flood
6 in
1 ft
2 ft
3 ft
3 ft+
0 0.25 0.5 1 Miles

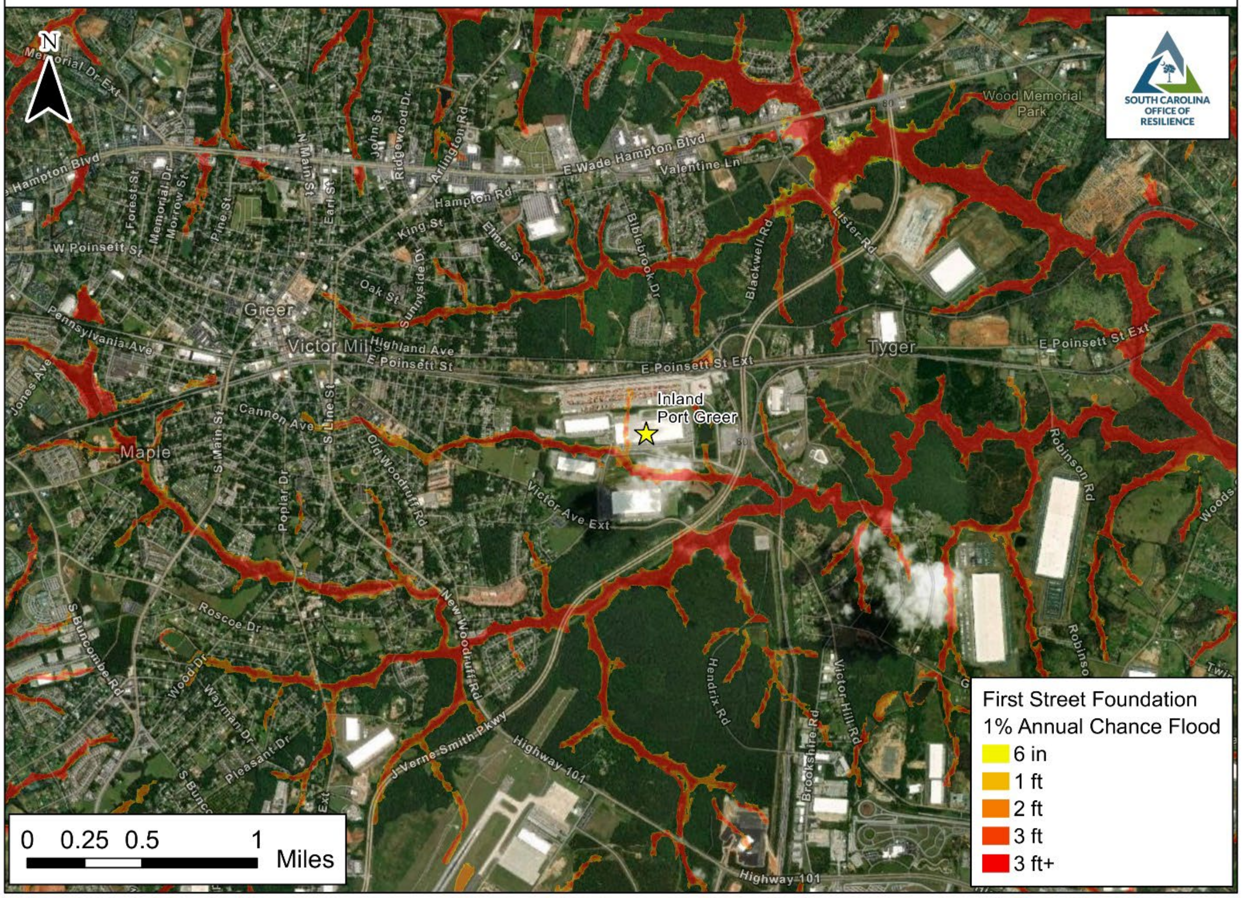
2052 Flood Risk - Port of Georgetown



2022 Flood Risk - Inland Port Greer



2052 Flood Risk - Inland Port Greer



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 the state: Silver Star – New York/Tampa/Miami via Columbia, Silver Meteor – New York/Miami via Charleston, Palmetto – New York/Savannah via Charleston, and Crescent – New York/New Orleans via Greenville, with 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 with 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). 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 105) and 2052 (Figure 106) 1% annual chance flood event.

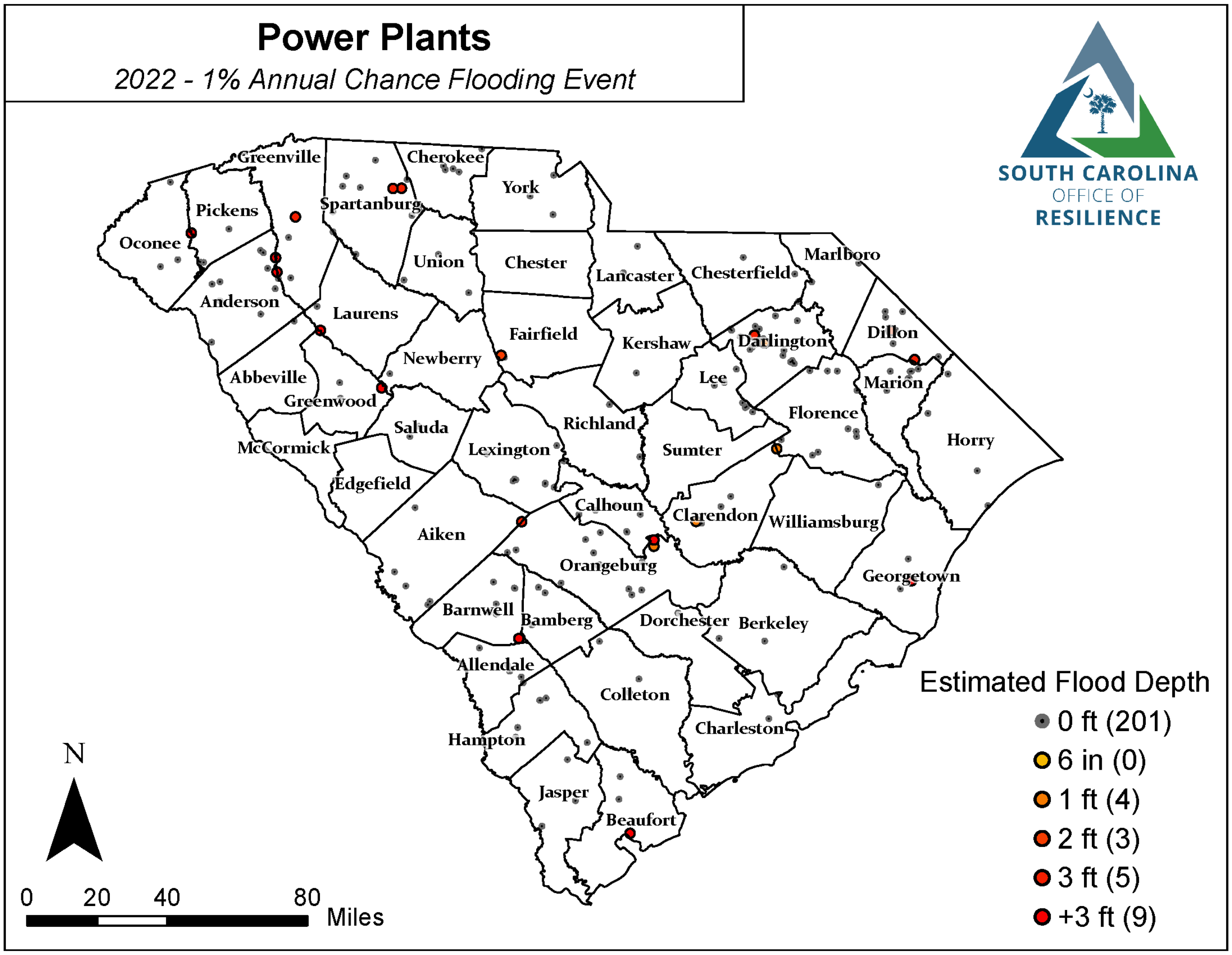


Figure 106: Estimated flooding of power plants in the 2022 1% annual chance flooding event (Department of Homeland Security). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

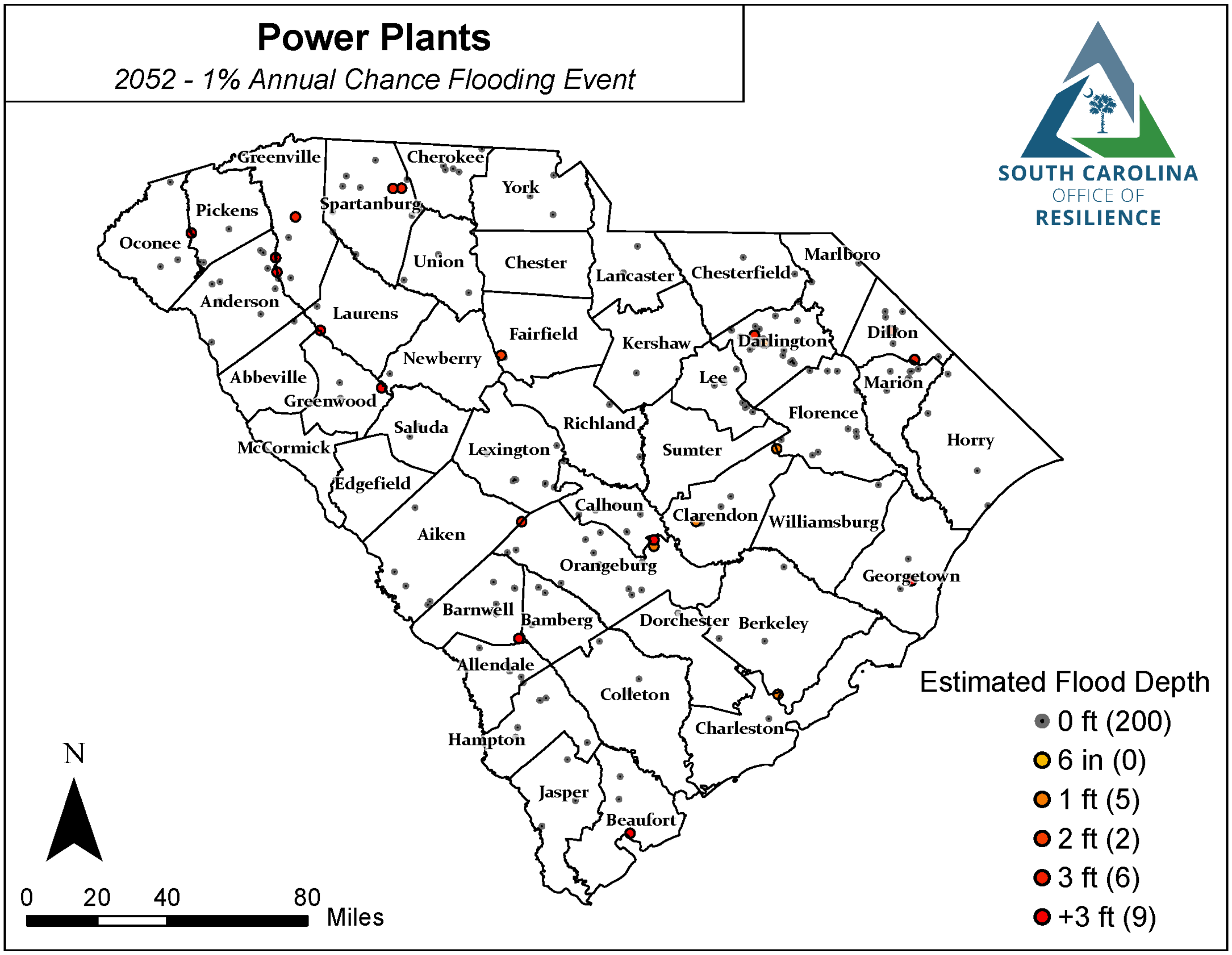


Figure 107: Estimated flooding of power plants in the 2052 1% annual chance flooding event (Department of Homeland Security). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

The maps below show the vulnerability of substations to flooding in the 2022 (Figure 107) and 2052 (Figure 108) 1% annual chance flood event. Repairing flooded substation can take much longer to repair than distribution lines because of the time needed to allow waters to recede (Kern & Miranda, 2021).

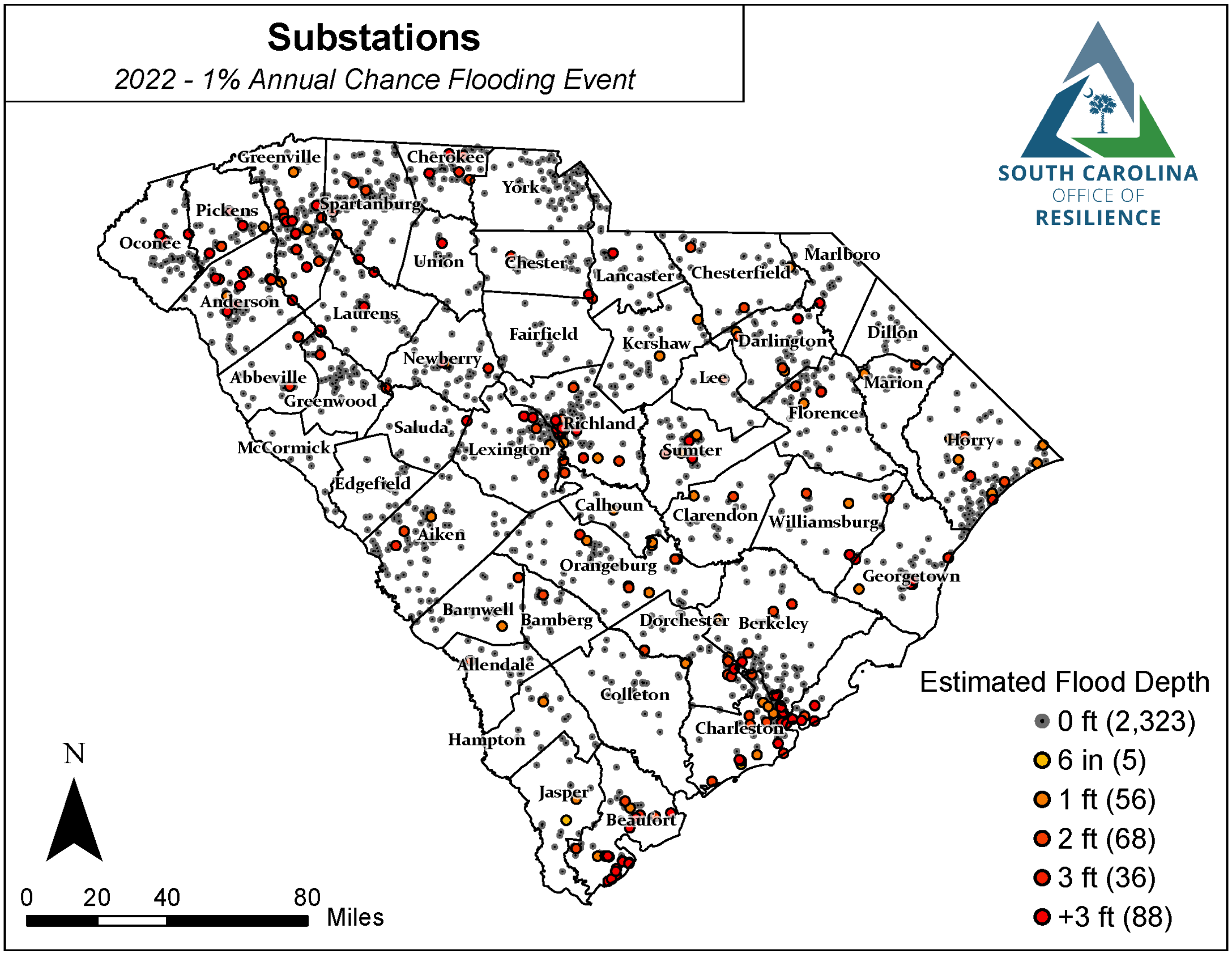


Figure 108: Estimated flooding of power substations in the 2022 1% annual chance flooding event (Department of Homeland Security). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

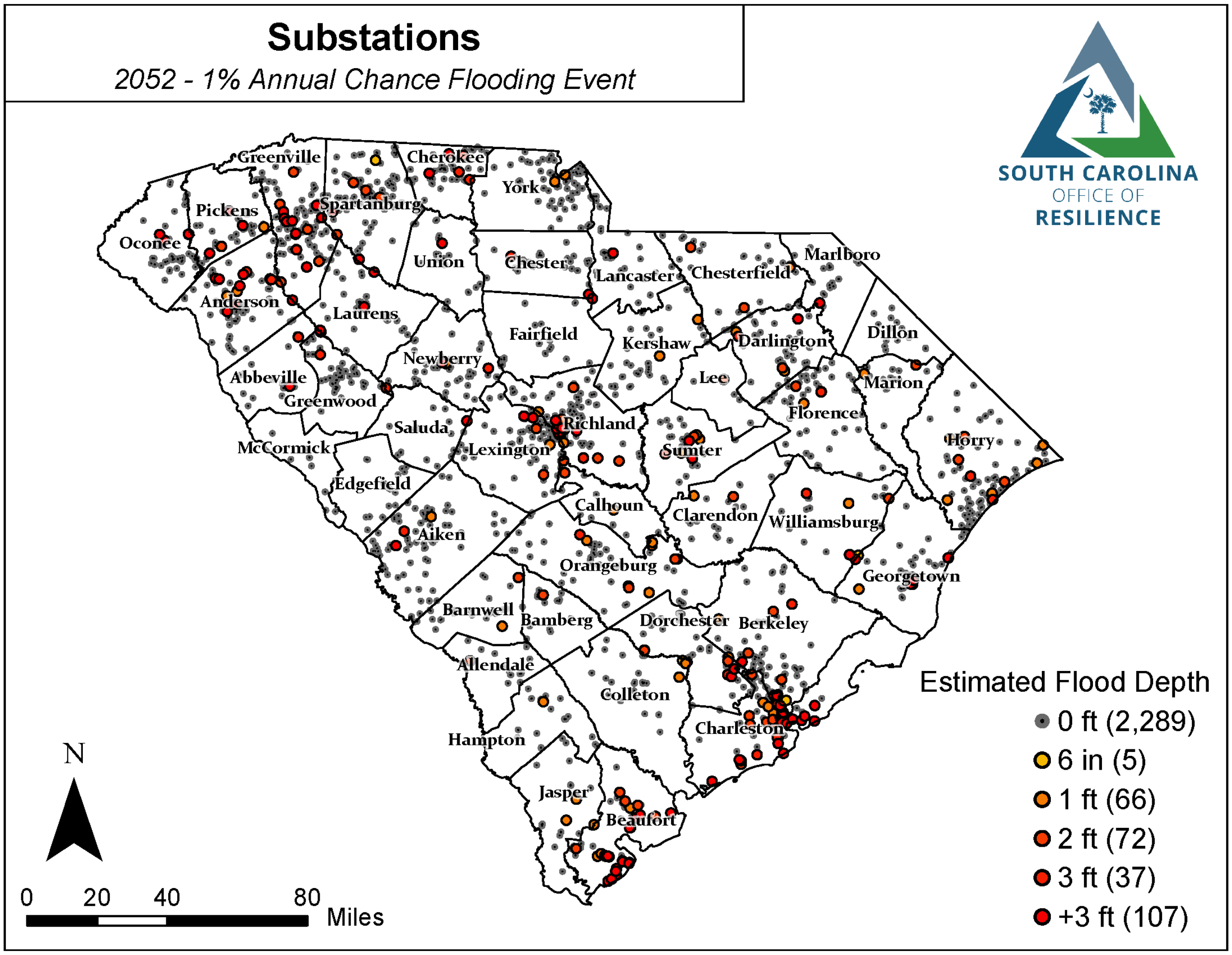


Figure 109: Estimated flooding of power substations in the 2052 1% annual chance flooding event (Department of Homeland Security). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

INTERNET AND BROADBAND

Flooding can have a significant impact on internet cables, especially those that are underground or located near bodies of water. In the next 15 years, 4,067 miles of fiber conduit will be under water and 1,101 nodes (e.g., points of presence and colocation centers) will be surrounded by water in the United States (Durairajan, Barford, & Barford, 2018). 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.

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 like satellite imagery. The Cropland Data Layer identifies crop extent and probable type in a 30m resolution across the country and accessible through the USDA CropScape webtool (Han, Yang, Di, & Mueller, 2012). From the Cropland Data Layer dataset, the majority of the croplands in South Carolina is located in the Coastal Plain portions of the state across the sandhills, although there is no HUC10 within the state that does not have any cropland (Figure 109). This concentration of agricultural lands are shore parallel and in close proximity to the coastline. Figure 110 indicates that the majority of potentially inundated crops are in the same region which may bias the results, but again, all HUC10s have flooded crops according to the First Street Foundation Hazard Layers, V2.0 flood model.

The Cropland Data Layer also delineates the potential crop type that is being grown and is listed in Table 10 with 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 risk to flooding, 72.4% 2022 and 74.1% for 2052, due to the low-lying nature and requirement of flooding the crop. The average risk of flooding for crops are 7.9%, high risk crops include blueberries (24.8%), pumpkins (18.5%), corn (12.4%), sweet corn (12.2%), and winter wheat (12.2%). Crops with the lowest risk of flooding include onions (0.0%), barley (2.9%), triticale (3.4%), and switchgrass (3.6%). For a more detailed analysis, rice crops will be removed due to the flood requirement for cultivation (Table 11 and Table 12).

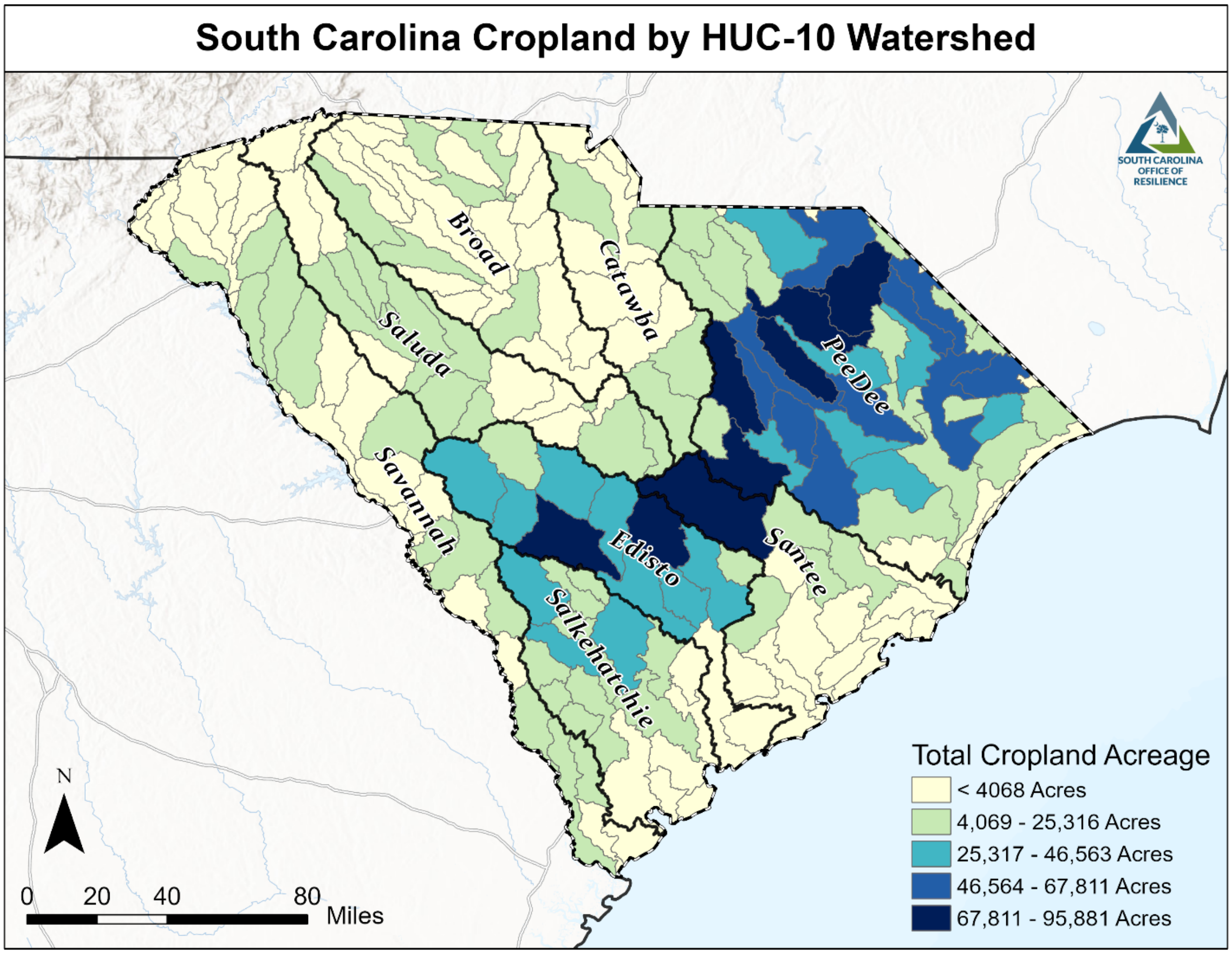


Figure 110: Cropland coverage by HUC10 as listed in the USDA Cropland Data Layer

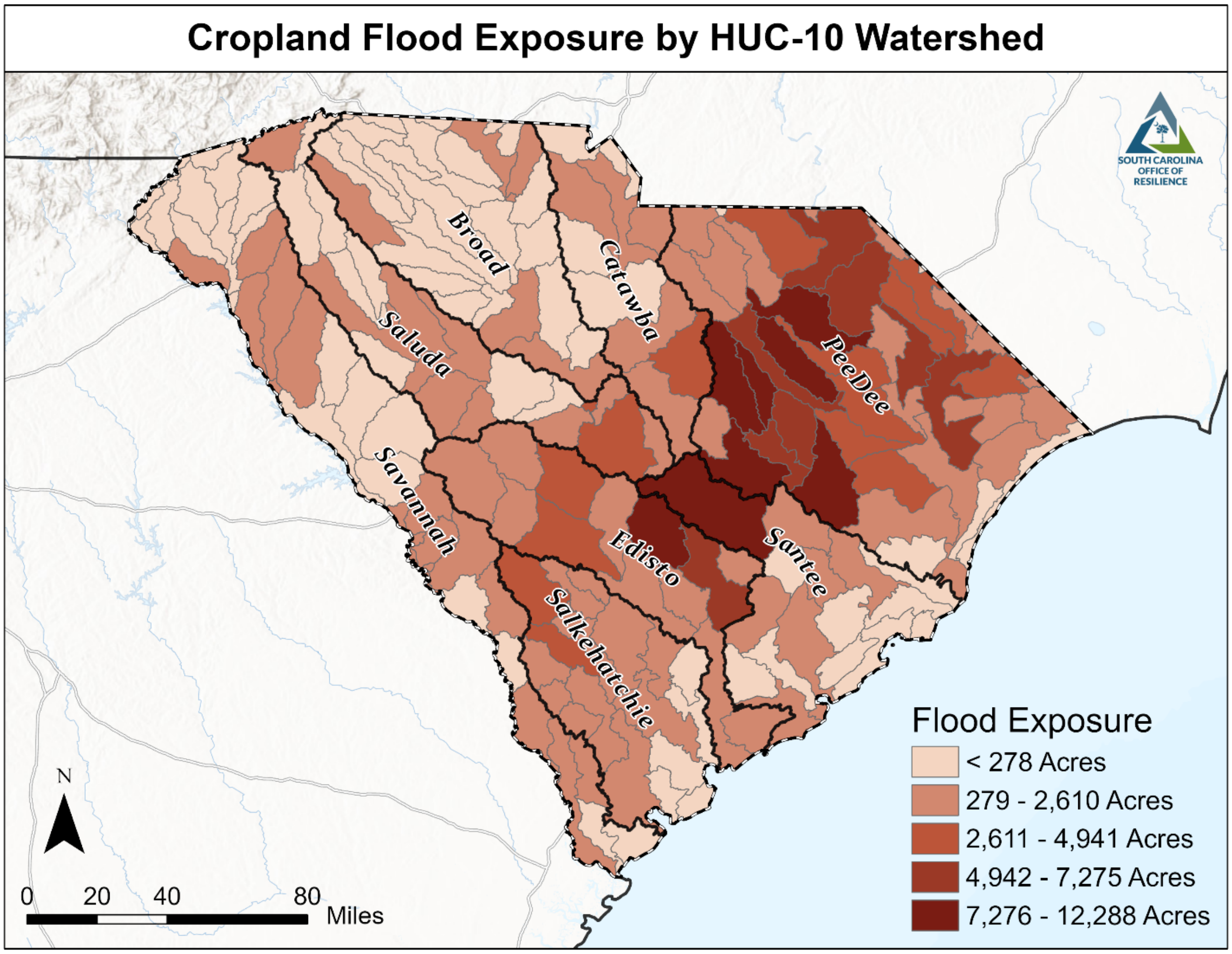


Figure 111: Cropland Exposure to any inundation during a 1% annual chance of flood by HUC10 as listed in the USDA Cropland Data Layer

Table 11: 1% annual chance of 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%
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%
Cotton	7.9%	8.4%
Cucumbers	10.2%	10.9%
Dbl Crop Barley/Soybeans	4.4%	4.6%
Dbl Crop Corn/Soybeans	6.9%	7.4%
Dbl Crop Oats/Corn	10.6%	11.3%
Dbl Crop Soybeans/Oats	6.9%	7.4%
Dbl Crop Triticale/Corn	11.6%	11.9%
Dbl Crop WinWht/Corn	6.1%	6.3%
Dbl Crop WinWht/Cotton	6.4%	6.7%
Dbl Crop WinWht/Sorghum	4.3%	4.5%
Dbl Crop WinWht/Soybeans	10.1%	10.8%
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%
Oats	6.5%	7.0%
Onions	0.0%	0.0%
Other Crops	6.1%	6.6%
Other Hay/Non Alfalfa	7.4%	7.9%
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%
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%
Watermelons	5.8%	6.1%
Winter Wheat	12.2%	12.7%

Table 12: 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%
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%
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%
Dbl Crop Barley/Soybeans	95.57%	0.20%	1.48%	1.12%	0.58%	1.06%
Dbl Crop Corn/Soybeans	93.09%	0.01%	3.52%	2.99%	0.28%	0.12%
Dbl Crop Oats/Corn	89.36%	0.01%	3.84%	4.47%	1.19%	1.13%
Dbl Crop Soybeans/Oats	93.12%	0.09%	3.53%	2.32%	0.55%	0.39%
Dbl Crop Triticale/Corn	88.38%	0.00%	4.71%	5.54%	1.36%	0.00%
Dbl Crop WinWht/Corn	93.94%	0.07%	1.16%	1.28%	1.16%	2.40%
Dbl Crop WinWht/Cotton	93.61%	0.00%	3.01%	2.37%	0.51%	0.50%
Dbl Crop WinWht/Sorghum	95.66%	0.08%	1.18%	1.39%	0.68%	1.00%
Dbl Crop WinWht/Soybeans	89.87%	0.19%	4.01%	3.59%	1.06%	1.27%
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%
Oats	93.52%	0.09%	2.32%	2.26%	0.68%	1.12%
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 Hay/Non Alfalfa	92.56%	0.11%	2.34%	2.66%	0.98%	1.35%
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%
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%
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%
All Crops Except Rice	90.42%	0.18%	3.97%	3.53%	0.89%	1.02%

Table 13: 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%
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%
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%
Dbl Crop Barley/Soybeans	95.44%	0.17%	1.40%	1.19%	0.60%	1.19%
Dbl Crop Corn/Soybeans	92.63%	0.00%	3.69%	3.25%	0.30%	0.13%
Dbl Crop Oats/Corn	88.72%	0.02%	3.95%	4.73%	1.22%	1.36%
Dbl Crop Soybeans/Oats	92.55%	0.04%	3.83%	2.53%	0.60%	0.44%
Dbl Crop Triticale/Corn	88.12%	0.00%	4.84%	5.46%	1.58%	0.00%
Dbl Crop WinWht/Corn	93.75%	0.06%	1.21%	1.31%	1.06%	2.61%
Dbl Crop WinWht/Cotton	93.31%	0.01%	3.07%	2.55%	0.55%	0.51%
Dbl Crop WinWht/Sorghum	95.47%	0.09%	1.24%	1.41%	0.71%	1.07%
Dbl Crop WinWht/Soybeans	89.20%	0.18%	4.23%	3.87%	1.13%	1.39%
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%
Oats	93.04%	0.15%	2.42%	2.42%	0.70%	1.27%
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 Hay/Non Alfalfa	92.13%	0.10%	2.44%	2.81%	1.04%	1.48%
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%
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%
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%
All Crops Except Rice	89.74%	0.17%	4.17%	3.81%	0.96%	1.15%

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.

The maps below show the vulnerability of these refrigerated warehouses to flooding in the 2022 (Figure 111) and 2052 (Figure 112) 1% annual chance flood event.

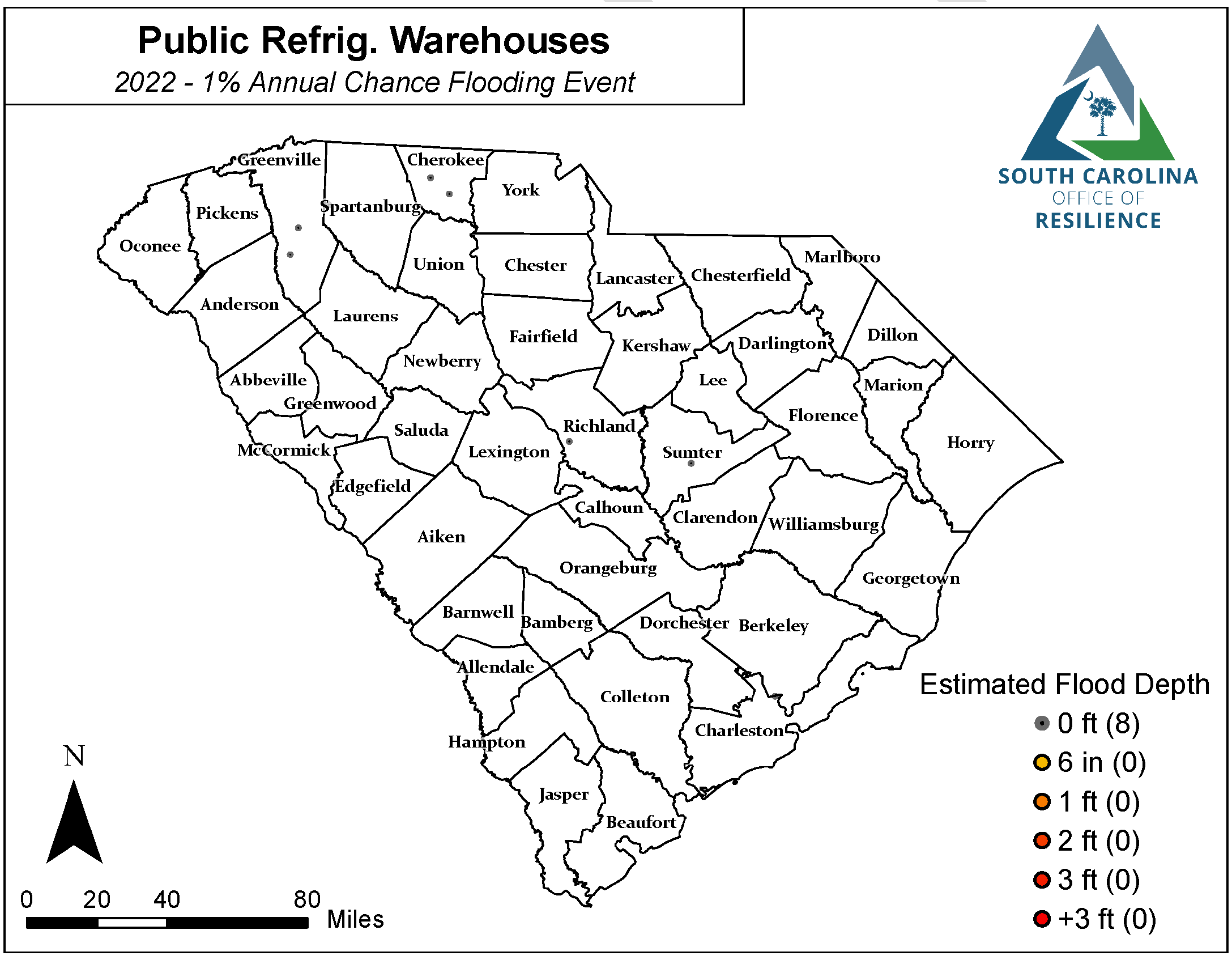


Figure 112: Estimated flooding of public refrigeration warehouses in the 2022 1% annual chance flooding event (Department of Homeland Security). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

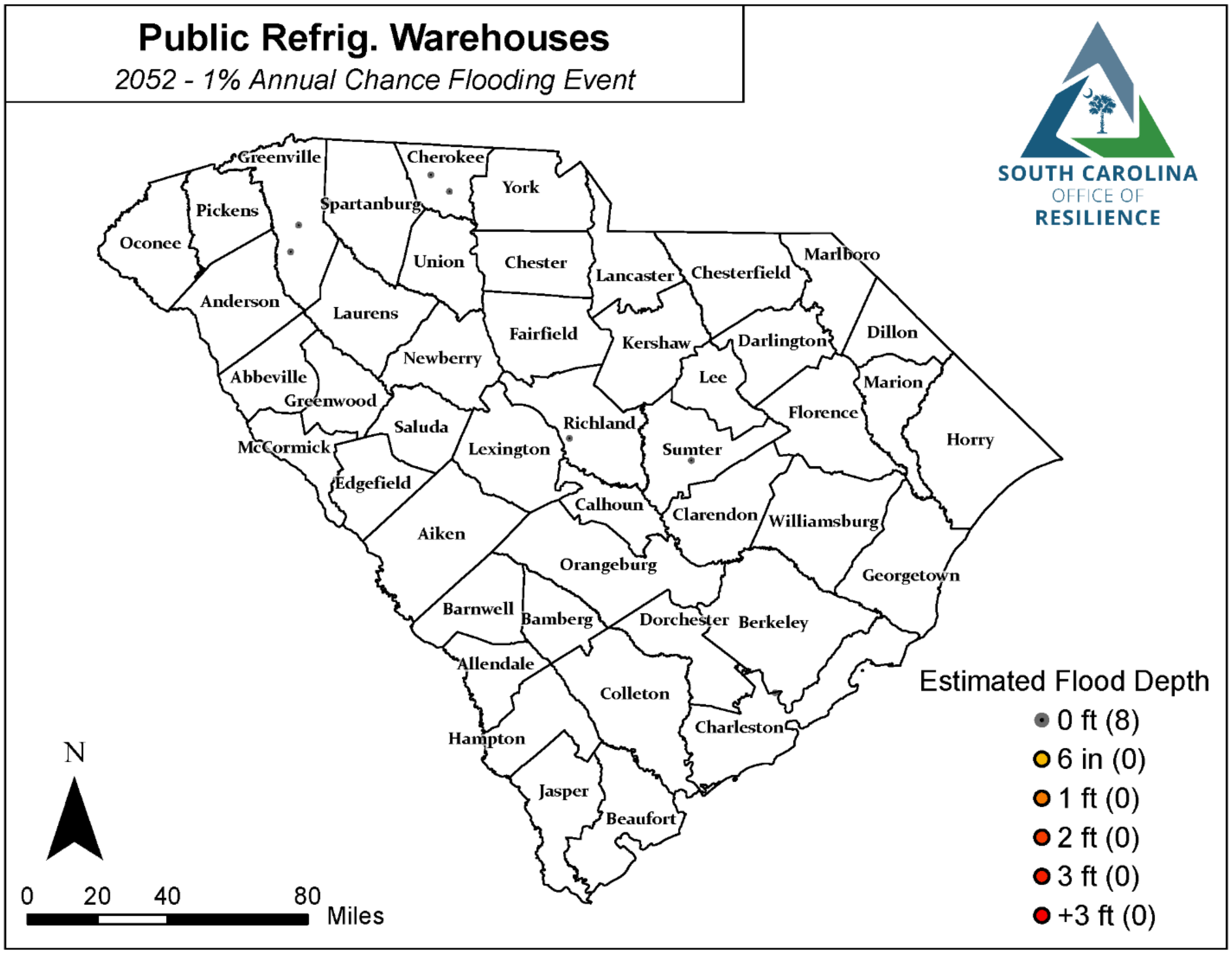


Figure 113: Estimated flooding of public refrigeration warehouses in the 2052 1% annual chance flooding event (Department of Homeland Security). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

MANUFACTURING

Manufacturing accounts for 12% of the employment in the state. There are businesses in South Carolina manufacturing everything from automobiles and appliances to boats and aircraft (SC Department of Commerce, 2020).

The maps below show the estimate flooding of these in the 2022 (Figure 113) and 2052 (Figure 114) 1% annual chance flood event.

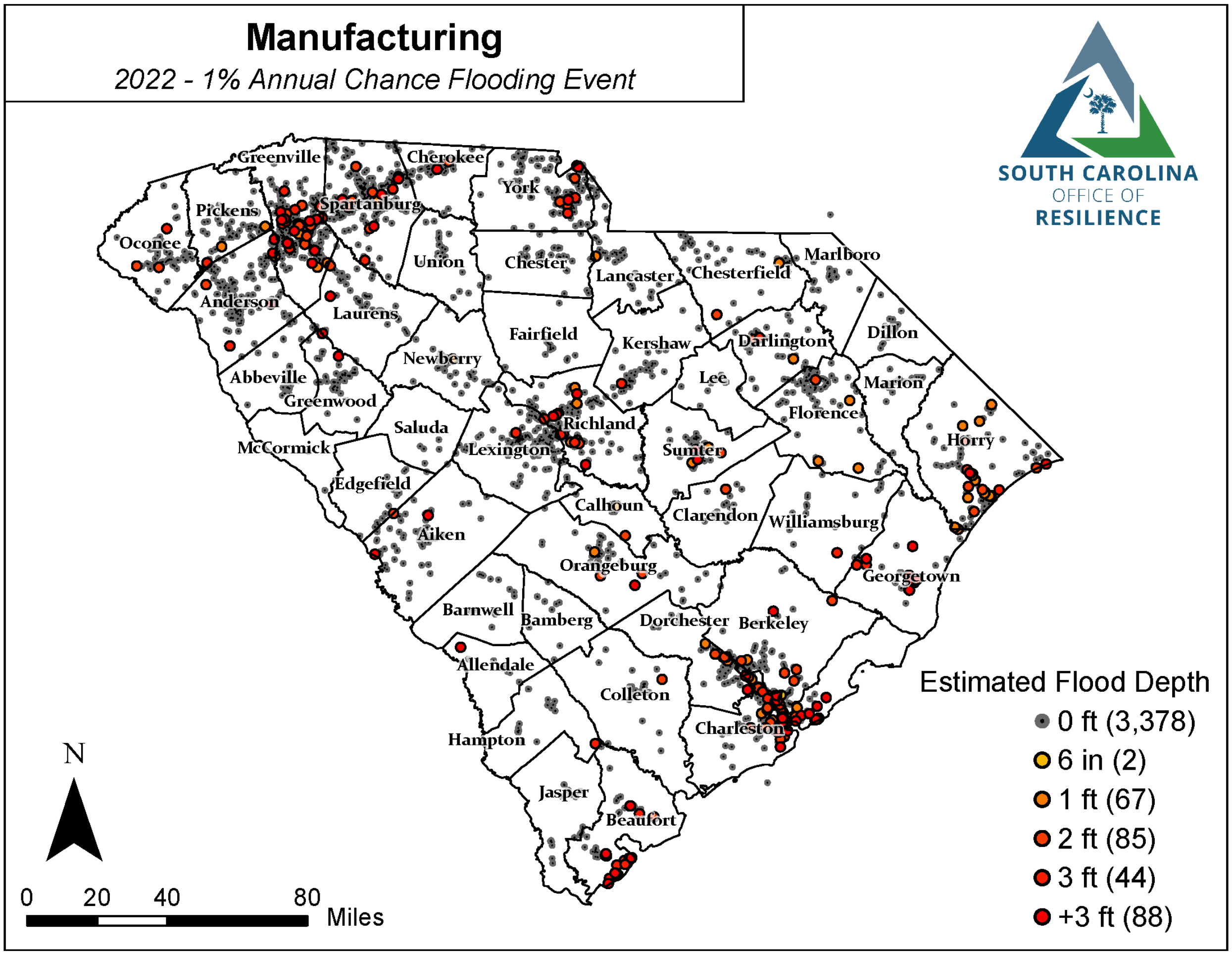


Figure 114: Estimated flooding of manufacturing facilities in the 2022 1% annual chance flooding event (SC Department of Commerce). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

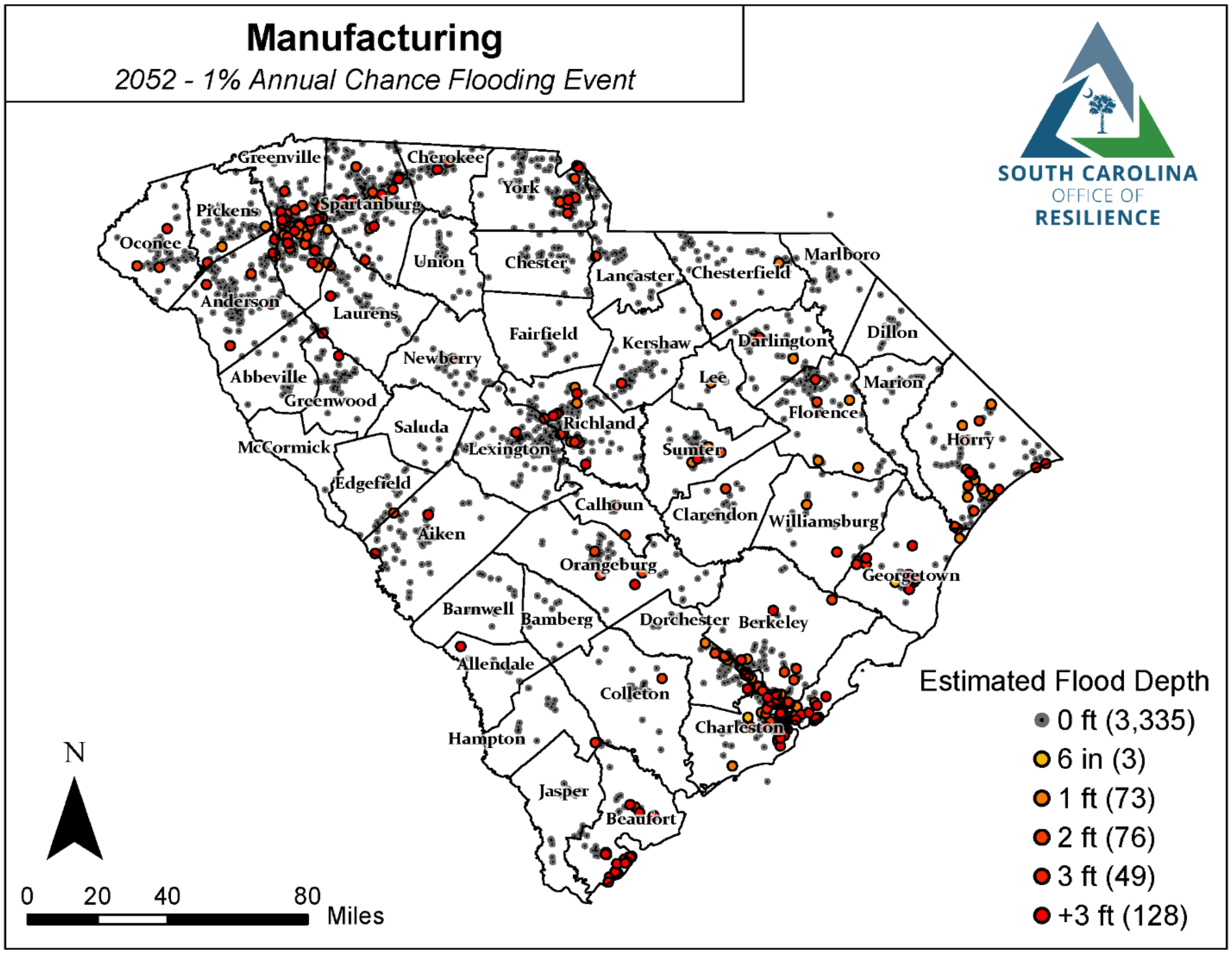


Figure 115: Estimated flooding of manufacturing facilities in the 2052 1% annual chance flooding event (SC Department of Commerce). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

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 estimate flooding of these buildings in the 2022 (Figure 115) and 2052 (Figure 116) 1% annual chance flood event, while Figure 117 and Figure 118 show the industrial sites.

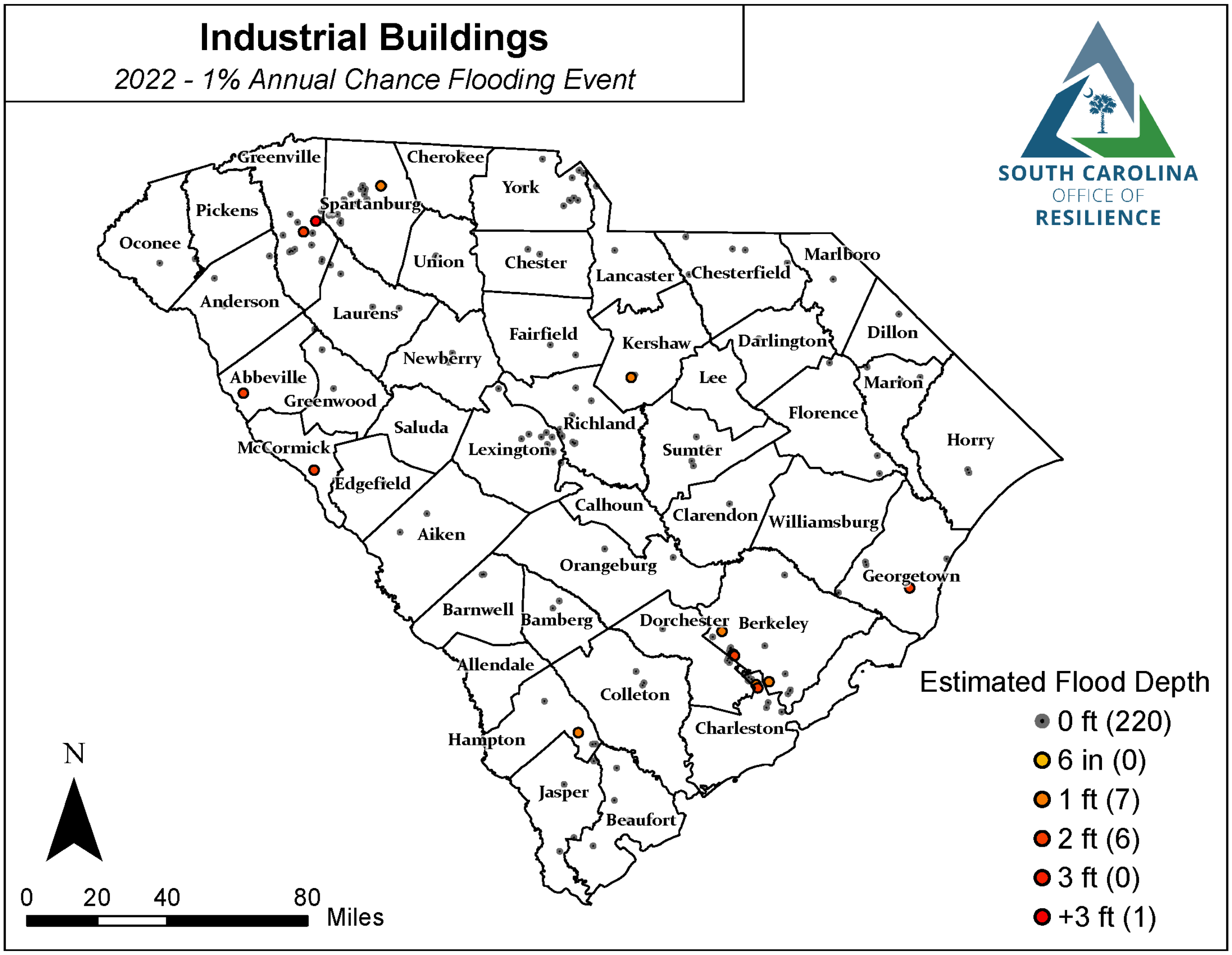


Figure 116: Estimated flooding of commerce industrial buildings in the 2022 1% annual chance flooding event (SC Department of Commerce). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

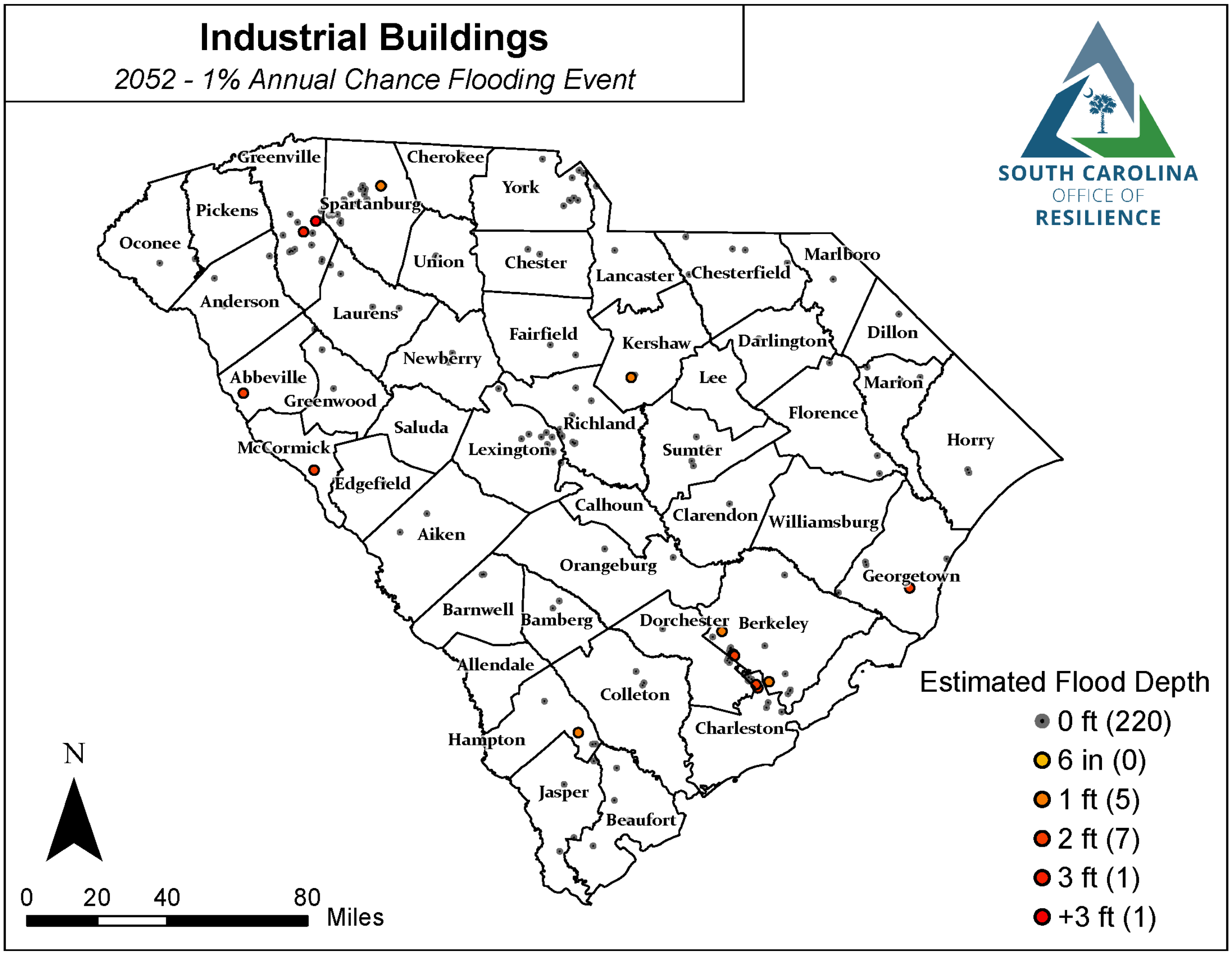


Figure 117: Estimated flooding of commerce industrial buildings in the 2052 1% annual chance flooding event (SC Department of Commerce). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

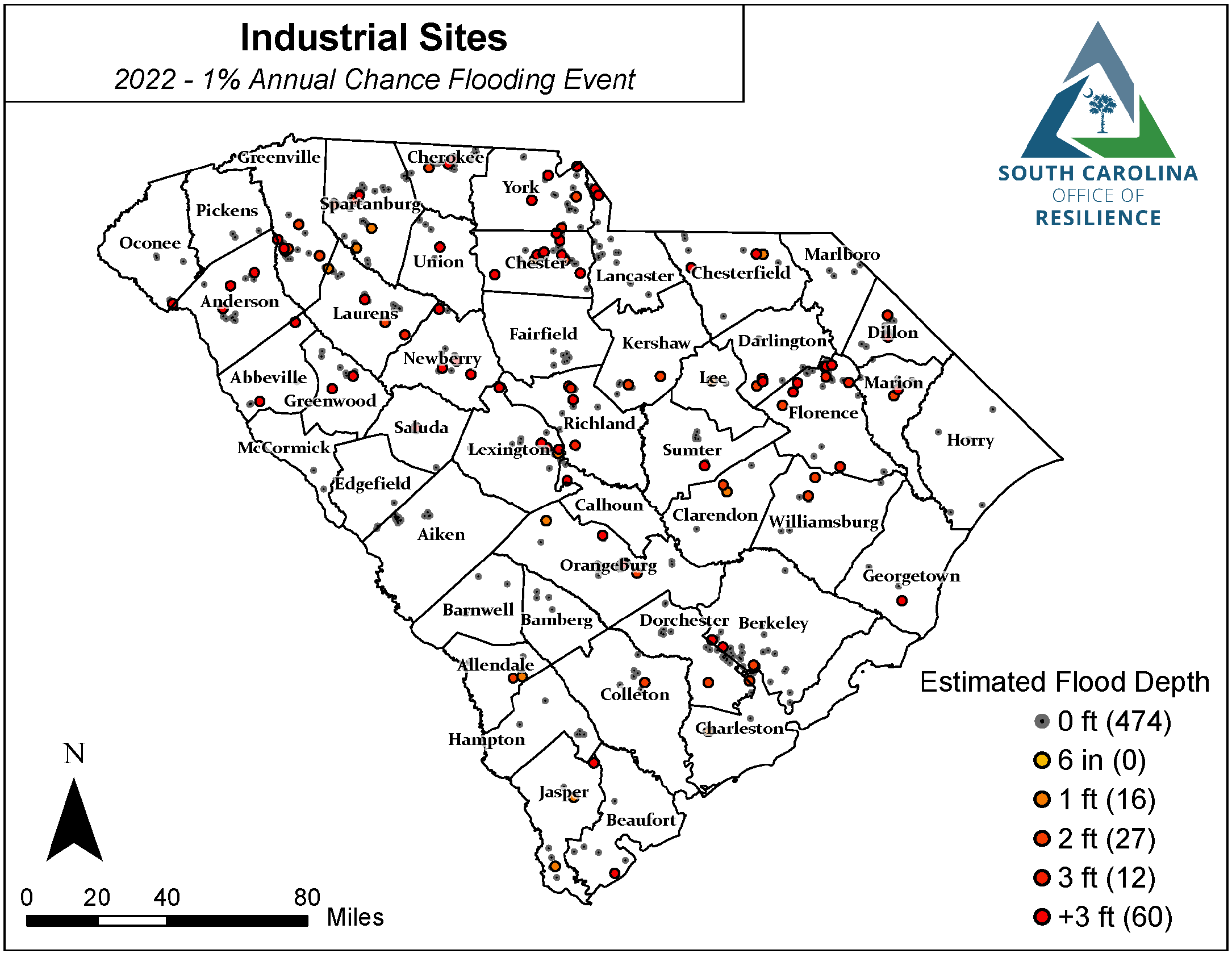


Figure 118: Estimated flooding of industrial sites in the 2022 1% annual chance flooding event (SC Department of Commerce). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

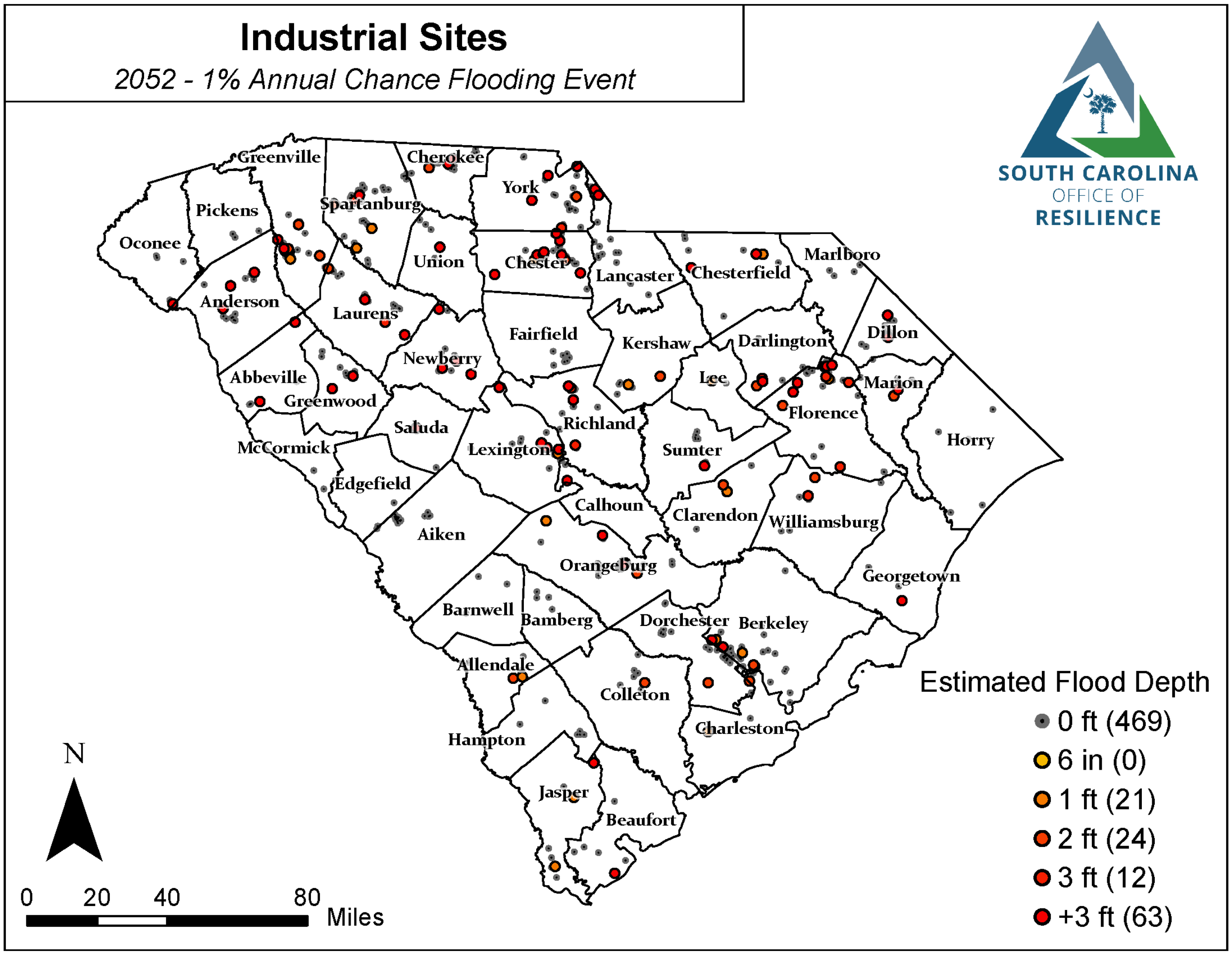


Figure 119: Estimated flooding of industrial sites in the 2052 1% annual chance flooding event (SC Department of Commerce. Flood data provided by the First Street Foundation Hazard Layers, V2.0.

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