2022

CLIMATE CHANGE AND NATURAL HAZARDS VULNERABLITY ASSESSMENT FOR THE ALBEMARLE REGION

NCORR

RISE

Regions Innovating for Strong Economies and Environment

NC DPS DEPARTMENT OF PUBLIC SAFETY

EDA U.S. ECONOMIC DEVELOPMENT ADMINISTRATION

EQUAL HOUSING OPPORTUNITY

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LAND ACKNOWLEDGEMENT

We wish to acknowledge and honor the Indigenous communities native to this region and recognize that this vulnerability assessment covers communities and structures that are built on Indigenous homelands and resources. We recognize the Chesapeake, Chowanoke, Croatan, Hatteras, Lumbee, Mattamuskeet, Moratok, Pasquotank, Perquimans, Poteskeet, Roanoke, Secotan, and Yeopim people as past, present and future caretakers of this land. We also recognize the unnamed tribes that once oversaw these lands and have since relocated or been displaced.

ALBEMARLE COMMISSION
REGION & COUNCIL OF GOVERNMENTS
Rural Planning • Senior Services & Nutrition • Workforce & Economic Development

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KITTY HAWK
MANTEO
NAGS HEAD
PLYMOUTH
ROPER
SOUTHERN SHORES
WINFALL

August 2022

Dear Residents:

Our region, encompassing Camden, Chowan, Currituck, Dare, Gates, Hyde, Pasquotank, Perquimans, Tyrrell, and Washington Counties, is known for beautiful natural landscapes and waterways. Yet, issues like rising water tables and heavier rain events are threatening these assets in many of our communities. Our very way of life has shifted in response to various changes in our regional environment. Many of these impacts can be avoided.

In light of these challenges, our goal for the Albemarle Region is to encourage actions that will strengthen our regional resilience. This work includes reducing the immediate and long-lasting risks that natural and climate disasters pose for people, property, infrastructure, and natural resources. The Albemarle Region Vulnerability Assessment uses rigorous technical analysis combined with local knowledge to outline the major gaps in our region's preparedness for future natural hazards, climate events, and their impacts. The report is the result of numerous meetings with residents, elected officials, local leaders, the North Carolina Office of Recovery and Resiliency, North Carolina Rural Center, and Tetra Tech. These findings help us identify and prioritize efforts to become more resilient. In the coming months, we will use this Assessment to develop a suite of up to 10 resilience projects for our 10-county region. The Vulnerability Assessment will also be available for any use by the public, including for the development of independent resilience efforts and grant applications.

As you read through this review of our region's susceptibility to climate impacts, I hope you will think about ways you can help increase resilience to protect your neighborhood, your community, and our beautiful region.

Sincerely,

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Executive Director

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Board Chair
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ACRONYMS

Acronym	Definition
ACS	American Community Survey
AEC	Area of Environmental Concern
ATSDR	Agency for Toxic Substances and Disease Registry
CAMA	Coastal Area Management Act
CDBG-DR	Community Development Block Grant – Disaster Recovery
CDBG-MIT	Community Development Block Grant – Mitigation
CDC	Centers for Disease Control and Prevention
COPD	Chronic obstructive pulmonary disease
COVID-19	Coronavirus-19
CRC	Coastal Resources Commission
DFIRM	FEMA Digital Flood Insurance Rate Map
ECSU	Elizabeth City State University
EDPNC	Economic Development Partnership of North Carolina
EMS	Emergency Medical Services
EOC	Emergency Operations Center
FEMA	Federal Emergency Management Agency
FIRM	Flood Insurance Rate Map
GIS	Geographic Information System
HAB	Harmful Algal Bloom
HIFLD	Homeland Infrastructure Foundation Level Data
HUD	US Department of Housing and Urban Development
HVAC	Heating, Ventilation and Air Condition Systems
IPCC	Intergovernmental Panel on Climate Change
MACU	Mid-Atlantic Christian University
MRCC	Midwestern Regional Climate Center
MRLC	Multi-Resolution Land Characteristics
NCANSMP	North Carolina Aquatic Nuisance Special Management Plan
NCDCR	North Carolina Department of Natural and Cultural Resources
NCDEQ	North Carolina Department of Environmental Quality
NCDHHS	North Carolina Department of Health and Human Services
NCDIT	North Carolina Department of Information Technology
NCDOT	North Carolina Department of Transportation
NCDPS	North Carolina Department of Public Safety
NCEM	North Carolina Emergency Management
NCFRIS	North Carolina Flood Risk Information System
NCOSBSM	North Carolina Office of State Budget & Management
NCORR	North Carolina Office of Recovery & Resiliency
NCSU	North Carolina State University
NCSHPO	North Carolina State Historic & Preservation Office

Acronym	Definition
NCTN	North Carolina Transportation Network
NCWRC	North Carolina Wildlife Resource Commission
NHA	National Hydropower Association
NJDEP	New Jersey Department of Environmental Protection
NLCD	National Land Cover Database
NOAA	National Oceanic & Atmospheric Administration
NWS	National Weather Service
NYSDOH	New York State Department of Health
ORW	Outstanding Resource Waters
RISE	Regions Innovating for Strong Economies and Environment
SFHA	Special Flood Hazard Area
SLOSH	Sea, Lakes & Overland Surges from Hurricanes
STC	Strategic Transportation Corridor
STRAHNET	Strategic Highway Network
SVI	Social Vulnerability Index
USACE	United State Army Corps of Engineers
USDA	United States Department of Agriculture
USDOT	United States Department of Transportation
USEPA	United States Environmental Protection Agency
USFWS	United States Fish and Wildlife Service
USGS	United State Geological Survey
USGCRP	United States Global Change Research Program
WCT	Wind Chill Temperature
WUI	Wildland-Urban Interface

DEFINITIONS

Vulnerability assessments involve the discussion of technical information and scientific information. While technical jargon was avoided, the following terms are defined in order to aid in the reader's understanding of the information presented in this vulnerability assessment document.

Accretion: The buildup of sediment within a certain location such as that occurring naturally across a beach/dune system (opposite of erosion) (Federal Emergency Management Agency n.d.).

Base Flood: The flood having a one percent chance of being equaled or exceeded in any given year. This is the regulatory standard also referred to as the "100-year flood." The base flood is the national standard used by the National Flood Insurance Program (NFIP) and all Federal agencies for the purposes of requiring the purchase of flood insurance and regulating new development. Base Flood Elevations (BFEs) are typically shown on Flood Insurance Rate Maps (FIRMs) (Federal Emergency Management Agency n.d.).

Mitigation: Capabilities necessary to reduce loss of life and property by lessening the impact of disasters. Mitigation capabilities include, but are not limited to, community-wide risk reduction projects; efforts to improve the resilience of critical infrastructure and key resource lifelines; risk reduction for specific vulnerabilities from natural hazards or acts of terrorism; and initiatives to reduce future risks after a disaster has occurred (Federal Emergency Management Agency n.d.).

Climate Resilience: The capacity of social, economic, and environmental systems to cope with a hazardous event or trend or disturbance, responding or reorganizing in ways that maintain their essential function, identity, and structure, while also maintaining the capacity for adaptation, learning, and transformation (Federal Emergency Management Agency n.d.).

Compound Flooding: Flooding arising from storms causing concurrent storm surge and precipitation. This compound flooding can severely affect densely populated low-lying coastal areas (nature.com 2020).

Critical Facility: A structure or other improvement that, because of its function, size, service area, or uniqueness, has the potential to cause serious bodily harm, extensive property damage, or disruption of vital socioeconomic activities if it is destroyed or damaged or if its functionality is impaired. Critical facilities include health and safety facilities, utilities, government facilities and hazardous materials facilities (CRS Community Self-Assessment n.d.).

Critical Infrastructure: Critical infrastructure includes the vast network of highways, connecting bridges and tunnels, railways, utilities and buildings necessary to maintain normalcy in daily life. Transportation, commerce, clean water and electricity all rely on these vital systems (U.S. Department of Homeland Security 2022).

Ecology: The branch of biology that deals with the relations of organisms to one another and to their physical surroundings (Merriam-Webster 2022).

Erosion: The process by which tides, strong wave action, and flood waters wear down or carry away rocks, sediment (soils, sands) along a shoreline (U.S. Climate Resilience Toolkit 2022).

Exposure: The representative value of buildings (in dollars), population (in both people and population equivalence dollars), or agriculture (in dollars) potentially exposed to a natural hazard occurrence (Federal Emergency Management Agency n.d.).

Flood Insurance Rate Map (FIRM): Official map of a community on which FEMA has delineated the Special Flood Hazard Areas (SFHAs), the Base Flood Elevations (BFEs) and the risk premium zones applicable to the community (Federal Emergency Management Agency n.d.).

Floodplain: A regulatory term used by the Federal Emergency Management Agency (FEMA) also termed the “floodway,” or “regulatory floodway,” to describe historic-based flooding. Specifically, it is the area next to a waterbody that historically experiences flooding either via tidal water or - in a riverine system - when water comes out of the banks of the main channel. FEMA generally described a floodplain as: “any land area susceptible to being inundated by flood waters from any source,” which is the broader term that can include projected, future conditions (Federal Emergency Management Agency n.d.).

Flood Zone: Flood hazard areas identified on the Flood Insurance Rate Map are identified as a Special Flood Hazard Area (SFHA). SFHA are defined as the area that will be inundated by the flood event having a 1-percent chance of being equaled or exceeded in any given year. The 1-percent annual chance flood is also referred to as the base flood or 100-year flood. SFHAs are labeled as Zone A, Zone AO, Zone AH, Zones A1-A30, Zone AE, Zone A99, Zone AR, Zone AR/AE, Zone AR/AO, Zone AR/A1-A30, Zone AR/A, Zone V, Zone VE, and Zones V1-V30. Moderate flood hazard areas, labeled Zone B or Zone X (shaded) are also shown on the FIRM, and are the areas between the limits of the base flood and the 0.2-percent-annual-chance (or 500-year) flood. The areas of minimal flood hazard, which are the areas outside the SFHA and higher than the elevation of the 0.2-percent-annual-chance flood, are labeled Zone C or Zone X (unshaded) (Federal Emergency Management Agency n.d.).

Geology: The science that deals with the earth's physical structure and substance, its history, and the processes that act on it (Merriam-Webster 2022).

Groundwater: Water that exists underground in saturated zones beneath the land surface. The upper surface of the saturated zone is called the water table (United States Geological Survey n.d.).

Hazard: A regulatory term used by FEMA to describe the potential occurrence of a natural or human-induced physical event or trend or physical impact that may cause loss of life, injury, or other health impacts, as well as damage and loss to property, infrastructure, livelihoods, service provision, ecosystems, and environmental resources (Federal Emergency Management Agency n.d.).

Hydrography: The science of surveying and charting bodies of water, such as seas, lakes, and rivers (Merriam-Webster 2022).

Hydrology: The branch of science concerned with the properties of the earth's water, and especially its movement in relation to land (Merriam-Webster 2022).

Impact: Effects on natural and human systems. Impacts generally refer to effects on lives, livelihoods, health, ecosystems, economies, societies, cultures, services, and infrastructure due to the interaction of climate changes or hazardous climate events (Federal Emergency Management Agency n.d.).

Land Use: The human use of land. It represents the economic and cultural activities (e.g., agricultural, residential, industrial, mining, and recreational uses) that are practiced at a given place (United States Environmental Protection Agency 2021).

Land Cover: The surface components of land that are physically present and visible (United States Environmental Protection Agency 2022).

Mean High Water: The average of astronomical high tides (Federal Emergency Management Agency n.d.).

Mean Return Period: The interval between events of similar size or intensity (Federal Emergency Management Agency n.d.).

Non-Potable Water: Water that has not been examined, properly treated, nor approved by appropriate authorities as being safe for consumption (Federal Emergency Management Agency n.d.).

Potable Water: Water suitable for drinking (Federal Emergency Management Agency n.d.).

Runoff: That part of the precipitation that appears in surface streams (United States Geological Survey 2019).

Sea Level Rise: The increase currently observed in the average sea level trend, which is primarily attributed to changes in ocean volume due to two factors: ice melt and thermal expansion (NOAA 2020) (NOAA 2012) .

Socially Vulnerable Populations: Populations with special needs that are especially at risk because of factors like socioeconomic status, household composition, minority status, or housing type and transportation (Agency for Toxic Substance and Disease Registry 2021).

Special Flood Hazard Area (SFHA): Areas designated by FEMA as historically having "special flood, mudflow, or flood-related erosion hazards, and shown on a Flood Hazard Boundary Map or a Flood Insurance Rate Map (Zone A, Zone AO, Zone AH, Zones A1-A30, Zone AE, Zone A99, Zone AR, Zone AR/AE, Zone AR/AO, Zone AR/A1-A30, Zone AR/A, Zone V, Zone VE, and Zones V1-V30.)" (Federal Emergency Management Agency n.d.).

Surface Water: Water sources above ground level including streams and rivers, lakes and reservoirs, and oceans (United States Geological Survey 2019).

Topography: The arrangement of the natural and artificial physical features of an area (Merriam-Webster 2022).

Water Capacity: The ability of a water system to ensure it can provide safe and reliable drinking water now and into the future (Federal Emergency Management Agency n.d.).

Watershed: The land that water flows across or through on its way to a common stream, river, or lake (United States Environmental Protection Agency n.d.).

Water Quality: A measure of the suitability of water for a particular use based on selected physical, chemical, and biological characteristics (United States Geological Survey 2018).

Wildland-Urban Interface (WUI): the zone of transition between wilderness (unoccupied land) and land developed by human activity – an area where a built environment meets or intermingles with a natural environment (Federal Emergency Management Agency n.d.).

Vulnerability: The propensity or predisposition to be adversely affected. Vulnerability encompasses a variety of concepts and elements including sensitivity or susceptibility to harm and lack of capacity to cope and adapt (Federal Emergency Management Agency n.d.)

RISE PROGRAM OVERVIEW

A. North Carolina Office of Recovery and Resiliency Overview

In the wake of Hurricane Florence in 2018, the State of North Carolina established the Office of Recovery and Resiliency (NCORR) to lead the state's efforts in rebuilding smarter and stronger. At that time, eastern North Carolina communities were still recovering from Hurricane Matthew in 2016. NCORR manages nearly a billion dollars in U.S. Department of Housing and Urban Development (HUD) funding in two grant types, Community Development Block Grant – Disaster Recovery (CDBG-DR) funds and Community Development Block Grant – Mitigation (CDBG-MIT) funds, aimed at making North Carolina communities safer and more resilient from future storms. Additional funding is provided through the State Disaster Recovery Acts of 2017 and 2018, the Storm Recovery Act of 2019, and the Economic Development Administration Disaster Supplemental Funds. NCORR manages programs statewide that include homeowner recovery, infrastructure, affordable housing, resiliency~~,~~ and strategic buyouts. To learn more about NCORR programs, visit the ReBuild.NC.Gov website. NCORR is a division of the Department of Public Safety.

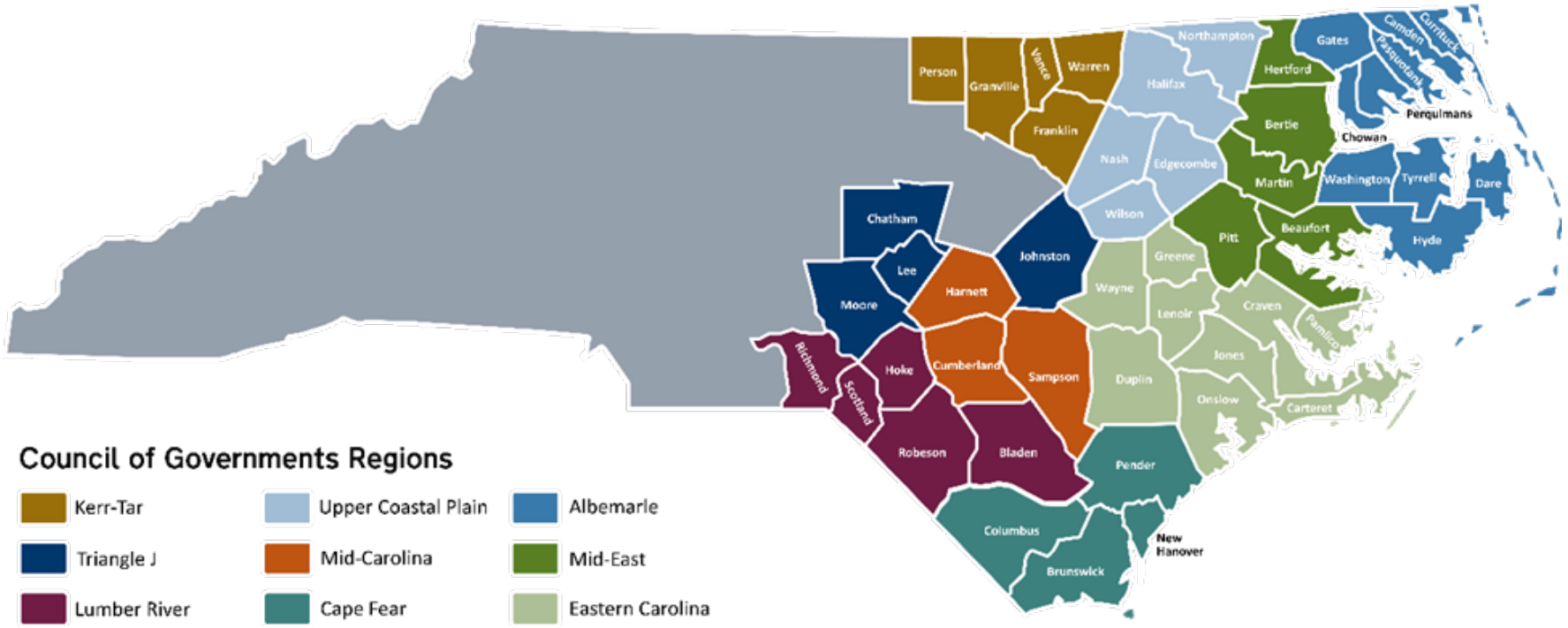
B. RISE Regional Resilience Portfolio Program Overview

Developed in partnership with North Carolina Rural Center, NCORR's Regions Innovating for Strong Economies and Environment (RISE) program supports resilience in North Carolina by:

- Facilitating the Regional Resilience Portfolio Program, which provides coaching and technical assistance to regional partners in the eastern half of the state to build multi-county vulnerability assessments, identify priority actions to reduce risk and enhance resilience in their region, and develop paths to implementation.
- Developing the North Carolina Resilient Communities Guide, a statewide resource that will provide tools, guidance and opportunities for building community resilience.
- Hosting the Homegrown Leaders program, a North Carolina Rural Center leadership training workshop, which operates in the eastern half of the state, that emphasizes resilience as a tool for community economic development.

This vulnerability assessment, which covers Camden, Chowan, Currituck, Dare, Gates, Hyde, Pasquotank, Perquimans, Tyrrell, and Washington Counties, fulfills the first deliverable of the Regional Resilience Portfolio Program for the Albemarle Region. The RISE Regional Resilience Portfolio Program covers nine areas, which align with the North Carolina Council of Government regions (Figure 1).

Figure 1. RISE Councils of Government



The second and final deliverable of each region's RISE Regional Resilience Portfolio Program will be a portfolio of 5-10 projects identified through community input and expert consultation. The portfolio document will outline funding opportunities and potential project partners to enable a clear path toward implementation for each project.

RISE is funded by the U.S. Economic Development Administration and the U.S. Department of Housing and Urban Development's Community Development Block Grant – Mitigation funds, with in-kind support from NCORR and North Carolina Rural Center. In addition, the Duke Energy Foundation committed $600,000 in grant funding to support the Regional Resilience Portfolio Program.

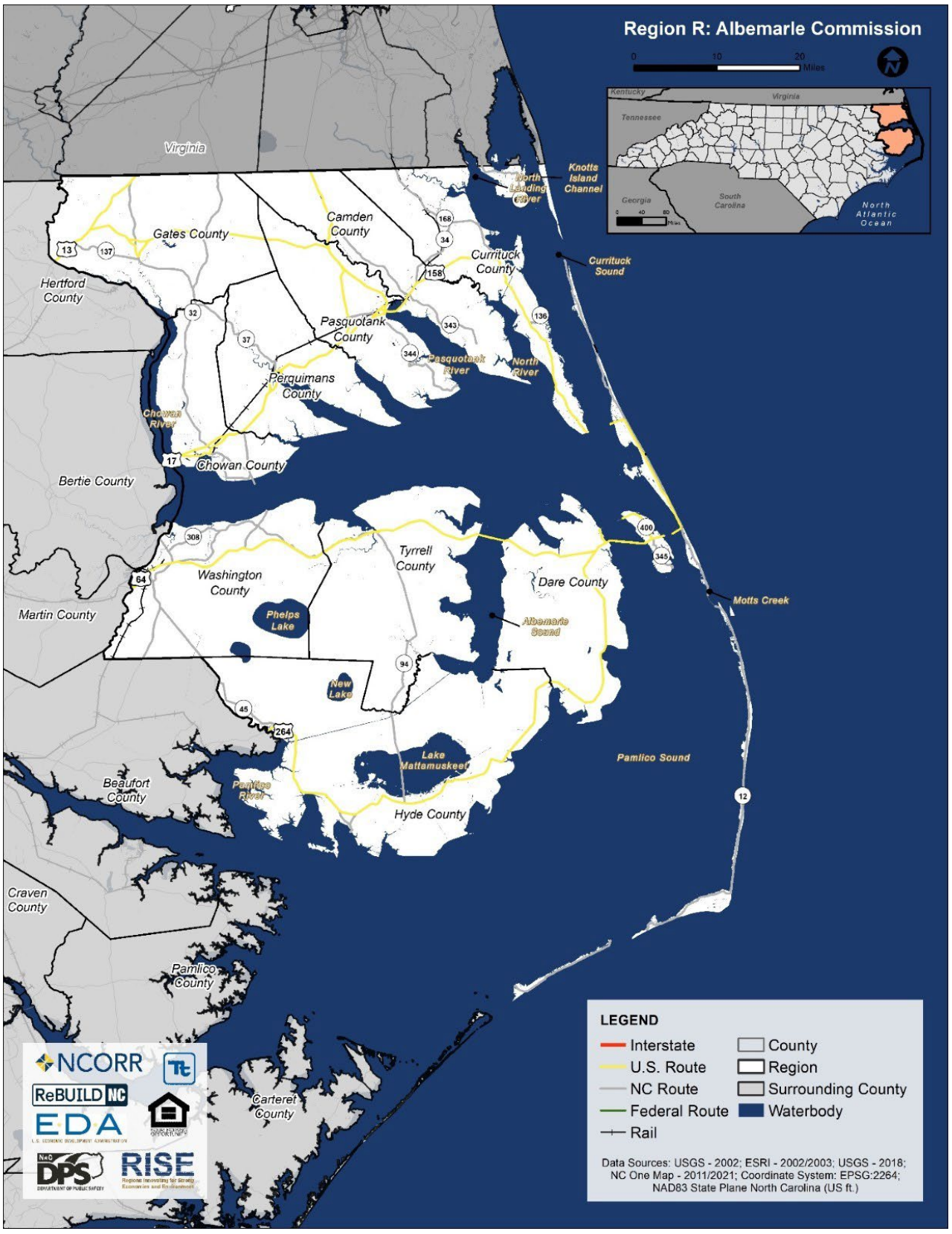
I. EXECUTIVE SUMMARY

A. The Albemarle Region

The Albemarle Region is located in the northeastern corner of North Carolina. The Region includes Camden, Chowan, Currituck, Dare, Gates, Hyde, Pasquotank, Perquimans, Tyrrell, and Washington Counties. The region is predominantly rural, with expansive wetlands and agricultural land. With a total land area of 6,222 square miles, the Albemarle Region is the largest of the 16 planning regions in the state.

Initially organized in 1969 under the direction of the U.S. Economic Development Administration, the Albemarle Commission is sanctioned as the lead regional organization for Region R (Albemarle Region) by the federal government. The Commission has been addressing regional needs since its doors opened in 1970 and has been instrumental in the development and/or enhancement of regional infrastructure; industrial recruitment business development, labor force development, travel and tourism, community reinvestment /rehabilitation, and health and human services (Albemarle Commission 2020)

Figure 2. The Albemarle Region



Regional Team

The resiliency project planning effort in the Albemarle Region is led by a Region Team comprised of an NCORR representative, the Albemarle Commission, Tetra Tech, Inc, and a facilitator. The Albemarle Commission offered project guidance, and Tetra Tech, Inc. provided technical assistance. A local leader was hired by the North Carolina Rural Center to provide facilitation support at the many stakeholder and public meetings held during the planning process.

Stakeholder Partnership

The planning effort in the Region is informed by a Stakeholder Partnership to ensure the vulnerabilities identified reflect local priorities. The Stakeholder Partnership:

- Steers the simple teer the implementation of the project by providing local input and perspective;
- Reviews project materials to ensure materials reflect local priorities and address local concerns; and
- Attends monthly meetings.

The Stakeholder Partnership represents a cross-section of local stakeholders, including representatives from all counties and sectors. Development of the Stakeholder Partnership also considered diversity in race, gender, abilities, and age.

The Stakeholder Partnership provided input on the hazards that impact the Albemarle Region, specific problem areas, and past event impacts to support this assessment.

Public Workshop

As part of a wider public engagement strategy one workshop was repeated at 3 separate times to facilitate increased attendance. Due to the continued impacts of the COVID-19 pandemic and a surge of cases in the spring of 2022, the workshops were held virtually on April 7, 8, and 9, 2022. Despite efforts to encourage attendance through offering multiple workshops on different dates and times, attendance was limited. Nonetheless, the public comments collected during these workshops provided valuable information to help inform this vulnerability assessment.

B. Summary of Findings

The sections of this vulnerability assessment report discuss:

- The Albemarle Region's population and assets at risk of natural disaster and climate-related impacts,
- Vulnerabilities identified for each of the hazards of concern, and
- Key takeaways from the vulnerability assessment that can assist in the development of regional resilience solutions.

This vulnerability assessment reviews impacts to various important characteristics of the Albemarle Region. An overall summary of the impact of natural hazards and climate change on these impacted areas is presented below:

Social Vulnerability and Equity, Health, and Safety

- The Albemarle Region is home to numerous socially vulnerable populations that are at higher risk to the impacts of natural hazards and climate change due to lack of resources or ability to respond to and recover from events.
- Numerous hazards such as hurricanes present a direct and immediate risk to life and safety. Other hazards such as drought present indirect health risks and may be more impactful to the region in the long term.
- Equitable responses to risk are needed to address rising temperatures and increasing severity and frequency of natural hazard events.

Housing, Critical Infrastructure, and Community Support Systems

- The region's housing, critical infrastructure, and community support systems have been impacted by previous natural hazard events. These impacts are likely to increase in the future as hazard events increase in frequency and intensity due to climate change.
- Upgrades and retrofits of housing, critical infrastructure, and community support systems are necessary to adjust for today's conditions and prepare for continued changes due to climate change impacts.

Economy

- The large agricultural industry in the Albemarle Region is at risk to damages from severe weather events.
- The region's tourism industry dominates the Outer Banks and is at risk from coastal hazards such as hurricanes, floods, and erosion.
- Low lying coastal areas are often used for agricultural and tourism. Sea level rise contributes to increased flooding and saltwater intrusion which threatens these areas and represents potentially permanent losses.

Natural Environmental Systems

- Climate change is already impacting natural systems in the region. For example, sea level rise is causing to saltwater intrusion, resulting in the loss of coastal forests.
- Climate change is causing rising temperatures and stronger weather events which stress natural environmental systems.
- Already stressed natural environmental systems are being impacted by invasive species, partially driven by shifting ranges of species due to rising temperatures.

Historical and Cultural Resource

- Historic structures in the Albemarle Region have higher risk to severe weather and flooding as they were not built to modern standards.
- Long-term exposure to hazards can result in degradation of historical and cultural assets.
- Cultural events can be threatened by unsafe weather conditions.

Cascading Impacts

- Numerous types of hazards are likely to occur in the same event. Hurricanes bring high winds, heavy rainfall, coastal flooding, and erosion that can result in unintended releases of chemicals and contaminants that threaten water quality.
- The occurrence of some hazards increases the likelihood of other hazards. Extreme temperature and drought result in an increased risk for wildfire events.

Summary points for each of the hazards of concern are included below.

Drought

- The area north of Elizabeth City on the Pasquotank River is reliant on surface water and is at higher risk to the impacts of severe drought.
- Droughts could pose significant risk to the region's agricultural industry.

Erosion

- Numerous areas along the Outer Banks experience erosional rates of more than two meters per year, placing oceanfront development at risk.
- Wetland migration due to sea level rise is likely to lead to significant loss of tidal wetlands in the region.

Extreme Temperature

- Due to climate change, extreme heat events are likely to become more frequent and severe in the region, while extreme cold events should become less frequent and less severe.
- Socially vulnerable populations that lack access to proper heating and cooling infrastructure are most at risk to extreme temperature health impacts.
- Droughts associated with extreme heat events could pose significant risk to the region's agricultural industry.

Flood

- The region is exposed to various types of flooding, with coastal flooding and stormwater flooding being the largest concerns.
- Forty-four percent of the region's population and twenty percent of the region's buildings are in the 1 percent annual-chance floodplain.
- Sea level rise is likely to increase the frequency and severity of coastal flooding. Flood maps do not account for sea level rise and therefore under-represent future risk. The region's rate of sea level rise (roughly 0.18 inches per year) is higher than the global average and roughly twice as fast as the southern portions of the state (NC Climate Science 2020).
- Heavy rainfall is becoming more frequent in the Albemarle Region.
- Stormwater components are not designed to handle larger rainfall and can be damaged or contribute to stormwater flooding.

Invasive Species

- While impacts from each invasive species are unique, with extensive agriculture and sensitive ecosystems, invasive species pose significant risk to the region.
- Changing conditions due to climate change and other types of habitat disruption may increase the likelihood of invasive species moving into the Albemarle Region.

Hurricane and Severe Storms

- The region experiences a variety of severe weather events including numerous secondary hazards like wind, lightning, and hail.
- These events, such as Hurricane Matthew, have led to significant damages and impacts making recovery slow, often occurring over several years.
- The frequency and severity of these events are likely to increase in the future due to climate change.

Water Quality Issues

- Hazards such as storms and floods can result in accidental spills and releases that can contaminate groundwater and surface water.
- Runoff of nutrients can cause a growing environment for harmful algal blooms, which are environmentally damaging and pose health risks for humans.
- Warming temperatures and increasing heavy precipitation increase the likelihood of harmful algal blooms.
- Rising sea levels and groundwater withdrawal contribute to saltwater intrusion in the region's coastal areas and is likely to worsen over time.
- Saltwater intrusion is leading to the abandonment of some agricultural land and may necessitate expensive treatment measures to maintain drinking water in impacted areas.

Wildfire

- Increasing frequency and severity of wildfire will lead to increased damages of natural systems and potential damages to structures
- Projected increases in wildfire risks and associated emissions can have harmful impacts on health.

II. METHODOLOGY

The following summarizes the asset inventories, methodology and tools used to support the vulnerability assessment process for the Albemarle Region.

- This 2022 vulnerability assessment was developed using best available information.
- Hazard data published between 2014 and 2022 was referenced in the vulnerability assessment.
- 2020 Decennial Census population data and 2015-2019 American Community Survey 5-year estimates were utilized.
- The risk assessment used best available building footprint and parcel data from NC OneMap.
- The critical infrastructure inventory was compiled from NC OneMap and supplemented with Homeland Infrastructure Foundation-Level Data (HIFLD).
- An updated version of Hazus (v5.1) was used to estimate potential impacts to the wind hazards.
- Best available hazard data was used as described in this methodology section.

Figure 3: Methodology for Developing the Vulnerability Assessment

A. Asset Inventories

Assets in the Albemarle Region were identified to assess potential exposure and loss associated with the hazards of concern. For this vulnerability assessment, the Albemarle Region assessed exposure vulnerability of the following types of assets: population, buildings and critical facilities/infrastructure and the environment. Some assets may be more vulnerable because of their physical characteristics or socioeconomic uses. To protect individual privacy and the security of critical facilities, information on properties assessed is presented in aggregate, without details about specific individual personal or public properties.

Population

Total population statistics from the 2020 Decennial Census Bureau and 2015-2019 American Community Survey 5-year estimates were used to estimate the exposure and potential impacts to the Albemarle Region's population. Population counts from Census tracts in the region were totaled to estimate total population. The North Carolina State 2018 Centers for Disease Control and Prevention (CDC)/Agency for Toxic Substances and Disease Registry (ATSDR) Social Vulnerability Index (CDC/ATSDR SVI) was also used to identify Census tracts within the region with an SVI ranking of 0.5001 to 0.75 and more than 0.75001. These tracts represented areas of moderate to high social vulnerability and were referenced to

assess the region's population at greatest risk to impacts. Limitations of these analyses are recognized, and thus the results are used only to provide a general estimate for planning purposes.

As discussed in Section III (Region Profile), research has shown that some populations are at greater risk from hazard events because of decreased resources or physical abilities. Vulnerable populations in the Albemarle Region included in the risk assessment are children, elderly, population below the poverty level, population with a disability, population with limited English speaking, population without a vehicle, and population commuting to work.

Buildings

The building stock inventory was updated regionwide. To develop the building inventory, data was compiled from NC OneMap, i.e., 2021/2022 State Parcels, and North Carolina Emergency Management (NCEM), i.e., 2010 State Building Footprints and 2020 State Building Footprints. The 2010 State Building Footprints with risk assessment attributes were referenced to assign attributes, i.e., year built, general occupancy class, and square footage, to the building footprints using the BLDG_ID field. Once building footprints were assigned attributes, the data was spatially joined to the 2021/2022 parcel data. The parcel data was used to fill in the gaps for building attributes. If a parcel intersected multiple building footprints, square footage was assigned based on parcel data or building footprint geometry. If the building footprint was the largest building that intersected the parcel, it was assigned the square footage from the parcel data. Otherwise, the square footage was assigned based on the area geometry of the building footprint. If a building footprint intersected multiple parcels with different occupancy classes, general occupancy classes were assigned based on the following priority: (1) residential, (2) government, (3) commercial or industrial, (4) all other general occupancy classes.

Furthermore, a mobile home inventory was updated regionwide. To develop the mobile home inventory, data was taken from the updated building stock inventory and the Homeland Infrastructure Foundation-Level Data (HIFLD), i.e., 2022 mobile home parks. Using the updated building stock inventory, mobile homes were extracted using general occupancy class attributes referenced from the 2010 state building footprint data with attributes, as well as the spatially joined 2021/2022 parcel data, i.e., PARUSECODE, PARUSEDESC, and PARUSEDSC2 fields.

Critical Infrastructure

Critical infrastructure was compiled from NC One Map, Homeland Infrastructure Foundation-Level Data (HIFLD), and United States Department of Transportation (USDOT). Critical infrastructure was categorized into eight major sectors: education facilities; facilities with impacts to public health and environmental systems; healthcare facilities; historic and cultural resource facilities; public service facilities; transportation facilities; utilities; and vulnerable population facilities. The critical infrastructure was assigned attributes such as year built, renovated year, capacity of services, and whether backup power is available (if known).

Environment

Land use land cover data was referenced in this risk assessment to analyze changes in the environment for the Albemarle Region. The 2021 Multi-Resolution Land Characteristics (MRLC) National Land Cover Database (NLCD) dataset was used to summarize land use exposure aggregated by agricultural land cover types. Additionally, the 2016 National Oceanic and Atmospheric Administration (NOAA) Marsh Migration dataset was used to illustrate the potential distribution of marsh and wetlands inundated under

the potential future sea level rise +1 foot scenario. As sea level rises, higher elevations will become more frequently inundated, allowing for marsh migration landward. At the same time, some lower-lying areas will be so often inundated that the marshes will no longer be able to thrive, becoming lost to open water.

B. Methodology

To better understand potential vulnerability and losses associated with hazards of concern, the Albemarle Region used standardized tools, combined with local, state, and federal data and expertise to conduct the risk assessment. Three different levels of analysis were used depending upon the data available for each hazard as described below.

Table 1 summarizes the type of analysis conducted by hazard of concern.

- **Historic Occurrences and Qualitative Analysis** – This analysis includes an examination of historic impacts to understand potential impacts of future events of similar size. In addition, potential impacts and losses are discussed qualitatively using best available data and professional judgement.
- **Exposure Assessment** – This analysis involves overlaying available spatial hazard layers, or hazards with defined extent and locations, with assets in GIS to determine which assets are located in the impact area of the hazard. The analysis highlights which assets are located in the hazard area and may incur future impacts.
- **Loss estimation** — The FEMA Hazus modeling software was used to estimate potential losses for the hurricane wind hazard.

Table 1. Summary of Risk Assessment Analyses

Hazard	Population	General Building Stock	Critical Facilities and Lifelines
Coastal Erosion	Q	Q	Q
Flood	E	E	E
Hurricane	E, H	E, H	E, H
Sea Level Rise and 2050 1-Percent Annual Chance Flood	E	E	E
Storm Surge	E	E	E
Urban Heat Islands	Q	Q	Q

E – Exposure analysis; H – Hazus analysis; Q – Qualitative analysis

Hazards U.S. – Multi-Hazard (Hazus)

In 1997, FEMA developed a standardized model for estimating losses caused by earthquakes, known as Hazards U.S. or Hazus. Hazus was developed in response to the need for more effective national, state, and community-level planning and the need to identify areas that face the highest risk and potential for loss. Hazus was expanded into a multi-hazard methodology, Hazus-MH, with new models for estimating potential losses from wind (hurricanes). Hazus is a Geographic Information System (GIS)-based software tool that applies engineering and scientific risk calculations, which have been developed by hazard and information technology experts, to provide defensible damage and loss estimates. These methodologies are accepted by FEMA and provide a consistent framework for assessing risk across a variety of hazards. The GIS framework also supports the evaluation of hazards and assessment of inventory and loss estimates for these hazards.

Hazus uses GIS technology to produce detailed maps and analytical reports that estimate a community's direct physical damage to building stock, critical facilities, transportation systems and utility systems. To generate this information, Hazus uses default Hazus provided data for inventory, vulnerability, and hazards; this default data can be supplemented with local data to provide a more refined analysis. Damage reports can include induced damage (inundation, fire, threats posed by hazardous materials and debris) and direct economic and social losses (casualties, shelter requirements, and economic impact) depending on the hazard and available local data. Hazus' open data architecture can be used to manage community GIS data in a central location. The use of this software also promotes consistency of data output now and in the future and standardization of data collection and storage. More information on Hazus is available at http://www.fema.gov/hazus.

In general, modeled losses were estimated in the program using probabilistic analyses were performed to develop expected/estimated distribution of losses (mean return period losses) for hurricane wind hazards. The probabilistic model generates estimated damages and losses for specified return periods (e.g., 100- and 500-year). ***Table 2*** displays the various levels of analyses that can be conducted using the Hazus software.

Table 2. Summary of Hazus Analysis Levels

Hazus Analysis Levels	
Level 1	Hazus provided hazard and inventory data with minimal outside data collection or mapping.
Level 2	Analysis involves augmenting the Hazus provided hazard and inventory data with more recent or detailed data for the study region, referred to as "local data"
Level 3	Analysis involves adjusting the built-in loss estimation models used for the hazard loss analyses. This Level is typical done in conjunction with the use of local data.

Erosion Rate

A qualitative assessment was conducted for erosion rates along the coastline of the Albemarle Region. Information from the NC Division of Coastal Management was used to assess the potential impacts to the region's assets. The information used in this assessment, which was released in 2020, identifies the 2019 average annual long-term erosion rates along North Carolina's oceanfront. The erosion rates are calculated by using the earliest and most current shorelines and shore-perpendicular transects, measuring the distance between the two shorelines at each transect, and dividing the measured distance by number of years between the two shorelines. This identifies whether accretion (i.e., beaches gain sand), erosion (i.e., beaches lose sand), or no change has occurred between the earliest and most current shorelines. The resulting information is used to update North Carolina's Ocean Hazard Construction Setback Factors and the Ocean Erodible Area of Environmental Concern (AEC).

Flood

The 1-percent and 0.2-percent chance flood events were examined to evaluate the Albemarle Region's risk and vulnerability to the riverine and coastal flood hazard areas. These flood events are generally those considered by planners and evaluated under federal programs such as the National Flood Insurance Program (NFIP).

The Albemarle Region is comprised of ten counties, t their effective FEMA Digital Flood Insurance Rate Map (DFIRM) dates are shown below:

- Camden County: December 21, 2018
- Chowan County: December 21, 2018
- Currituck County: June 19, 2020
- Dare County: June 19, 2020
- Gates County: December 21, 2018
- Hyde County: June 19, 2020
- Pasquotank County: December 21, 2018
- Perquimans County: December 21, 2018
- Tyrrell County: June 19, 2020
- Washington County: June 19, 2020

The effective FEMA Digital Flood Insurance Rate Maps (DFIRMs) were used to evaluate the region's assets risk to flood exposure.

To estimate exposure to the 1-percent and 0.2-percent annual chance flood events, the DFIRM flood boundaries were overlaid on the region's assets (building stock, critical infrastructure, and population). Building footprints and critical infrastructure that intersected the flood boundaries were totaled to estimate the total number of buildings and infrastructure located in the flood inundation areas, respectively.

To estimate the total population and vulnerable population at risk to the flood hazard, the DFIRM flood boundaries were used to extract the area of each county in the region located in the 1-percent and 0.2-percent annual chance flood events. The population at risk to flooding was calculated by obtaining the percentage of total land area within the flood hazard for each county, multiplied against the county's total population and vulnerable population types. Additionally, the analysis summarized the total number of persons living in moderate to high socially vulnerable tracts within the region located in the 1-percent and 0.2-percent annual chance flood events. The percentage of total land area of Census tracts with CDC/ASTR SVI rankings of 0.5001 to 0.75 and more than 0.75001 located in the 1-percent and 0.2-percent annual chance flood events was multiplied against the total population and vulnerable population types within these moderate to high SVI tracts. These results were summarized for each county within the region.

Hurricane

A Hazus probabilistic analysis was performed for the Albemarle Region to estimate debris generated and displacement of persons caused by the 50-year hurricane wind mean return period. The probabilistic Hazus hurricane model activates a database of thousands of potential storms that have tracks and intensities reflecting the full spectrum of Atlantic hurricanes observed since 1886 and identifies those with tracks associated with the Albemarle Region. Hazus contains data on historic hurricane events and wind speeds. It also includes surface roughness and vegetation (tree coverage) maps for the area. Surface roughness and vegetation data support the modeling of wind force across various types of land surfaces. Default demographic and building inventories in Hazus were used for the analysis. Although damages are estimated at the census tract level, results were presented at the county and regionwide level.

Sea Level Rise and 2050 1-Percent Annual Chance Flood

Sea-level rise data (in one-foot increments) available from the NOAA Office of Coastal Management (https://coast.noaa.gov/slrdata/) published in 2017 was considered and used for this analysis to understand the assets within the Albemarle Region that are at risk to impacts from the projected 2050 1-percent annual chance flood event (i.e., sea level rise +1 foot and 1-percent annual chance flood event).

Please note that the sea level rise data does not include additional storm surge due to a hurricane. Furthermore, the current Flood Insurance Rate Maps (FIRMs) also do not include the effects of sea-level rise.

Asset data (population, building stock, and critical infrastructure) were used to support an evaluation of assets at risk to future impacts from the projected 2050 1-percent annual chance flood hazard area. To determine the assets at risk, the Albemarle Region's assets were overlaid with the hazard area. Building footprints and critical infrastructure that intersected the projected 2050 1-percent annual chance flood hazard area were totaled to estimate the total number of buildings and infrastructure located in the projected flood hazard area.

To estimate the total population and vulnerable population at risk to the projected 2050 1-percent annual chance flood hazard area, the projected flood hazard area was used to extract the area of each county in the Albemarle Region located in the 2050 flood hazard area. The population at risk to the 2050 1-percent annual chance flood was calculated by obtaining the percentage of total land area within the projected flood hazard area for each county, multiplied against the county's total population and vulnerable population types. Additionally, the analysis summarized the total number of persons living in moderate to high socially vulnerable tracts within the region located in the projected 2050 1-percent annual chance of flooding. The percentage of total land area of Census tracts with CDC/ASTR SVI rankings of 0.5001 to 0.75 and more than 0.75001 located in the projected 2050 1-percent annual chance of flooding was multiplied against the total population and vulnerable population types within these moderate to high SVI tracts. These results were summarized for each county within the region.

Storm Surge

An exposure analysis was conducted using the 2014 "Sea – Lake Overland Surge from Hurricanes – SLOSH Model, which represents potential flooding from worst-case combinations of hurricane direction, forward speed, landfall point, and high astronomical tide were used to estimate exposure. Please note these inundation zones do not include riverine flooding caused by hurricane surge or inland freshwater flooding. The 2014 model, developed by the NOAA National Hurricane Center to forecast surges that occur from wind and pressure forces of hurricanes, considers only storm surge height and does not consider the effects of waves. The SLOSH spatial data includes boundaries for Category 1 through Category 4 storm surge events.

Asset data (population, building stock, and critical infrastructure) were used to support an evaluation of assets at risk to future impacts from storm surge. To determine the assets at risk, the region's assets were overlaid with each SLOSH Category 1 through 4 storm surge hazard area. Building footprints and critical infrastructure that intersected the SLOSH Category 1 through 4 storm surge hazard areas were totaled to estimate the total number of buildings and infrastructure located in each storm surge hazard area.

To estimate the total population and vulnerable population at risk to storm surge, the SLOSH Category 1 through 4 storm surge hazard areas were used to extract the area of each county in the Albemarle Region located in storm surge hazard areas. The population at risk to storm surge was calculated by obtaining the percentage of total land area within the SLOSH Category 1 through 4 storm surge hazard areas for each county, multiplied against the county's total population and vulnerable population types. Additionally, the analysis summarized the total number of persons living in moderate to high socially vulnerable tracts within the Region located in the storm surge hazard areas. The percentage of total land

area of Census tracts with CDC/ASTR SVI rankings of 0.5001 to 0.75 and more than 0.75001 located in the SLOSH Category 1 through 4 storm surge hazard areas was multiplied against the total population and vulnerable population types within these moderate to high SVI tracts. These results were summarized for each county within the region.

Urban Heat Islands

A qualitative assessment was conducted for the urban heat island (UHI) hazard. Information from the Trust for Public Land, Descarte Labs, and United States Geological Survey (USGS) was used to assess the potential impacts to the Region's assets. The Urban Heat Island Severity for U.S. cities – 2019 contains the relative heat severity for every city in the United States derived from imagery from the summers of 2018 and 2019. It shows where certain areas of cities are hotter than the average temperature for that same city. Knowing where areas of high heat are located can help plan for mitigation strategies.

Considerations for Mitigation and Next Steps

The following items are to be discussed for considerations for the next plan update to enhance the vulnerability assessment:

- Inventory Data
  - Update risk attributes of building footprints using current tax assessor data.
  - Update critical facilities with local input and locally available data sources.
- Coastal Erosion
  - Collect data on historic costs incurred to reconstruct buildings, cultural resources and/or infrastructure due to coastal erosion impacts.
- Flood
  - Conduct a Hazus loss analysis (e.g., 100-year flooding) using building footprint risk assessment attributes and updated flood data.
- Hurricanes
  - Estimate storm surge related losses using the Hazus flood model if the data is available.
  - Conduct Hazus loss analysis using user-defined facilities and critical facilities in the latest version of Hazus.
- Sea Level Rise and Projected 2050 1-Percent Annual Chance Flood Event
  - Incorporate modeled 2050 1-percent annual chance of flooding data that shows modeled extent of future flood hazard area.
- Urban Heat Islands
  - Implement locally produced data for analysis if available.

C. Data Source Summary

Table 3 summarizes the data sources used for the risk assessment for this plan.

Table 3. Risk Assessment Data Documentation

Data	Source	Date	Format
Population data	Census Bureau; American Community Survey 5-Year Estimates	2020; 2019	Digital (GIS) Format
Social Vulnerability Index	CDC/ATSDR SVI	2018	Digital (GIS) Format
Building Footprints	NCEM	2020	Digital (GIS) Format
Parcel Boundaries	NC One Map	2021/2022	Digital (GIS) Format
Critical facilities	NC OneMap; HIFLD	2011/2016/2018/2019; 2020/2021/2022	Digital (GIS) Format
2019 Land Cover	USGS/NLCD	2021	Digital (GIS) Format
Marsh Migration	NOAA	2016	Digital (GIS) Format
Erosion Rate	NC Division of Coastal Management	2020	Digital (GIS) Format
Urban Heat Island	The Trust for Public Land	2019	Digital (GIS) Format
Digitized Effective FIRM maps	NCFRIS; FEMA	2022; 2018/2020	Digital (GIS) Format
Sea Level Rise	NOAA	2017	Digital (GIS) Format
Sea-Lake Overland Surge from Hurricanes (SLOSH) Model	NOAA	2014	Digital (GIS) Format

Limitations

Loss estimates, exposure assessments, and hazard-specific vulnerability evaluations rely on the best available data and methodologies. Uncertainties are inherent in any loss estimation methodology and arise in part from incomplete scientific knowledge concerning natural hazards and their effects on the built environment. Uncertainties also result from the following:

1. Approximations and simplifications necessary to conduct such a study
2. Incomplete or dated inventory, demographic, or economic parameter data
3. The unique nature, geographic extent, and severity of each hazard
4. Mitigation measures already employed by the participating municipalities
5. The amount of advance notice residents has to prepare for a specific hazard
6. Uncertainty of climate change projections

These factors can result in a range of uncertainty in loss estimates, possibly by a factor of two or more. Therefore, potential exposure and loss estimates are approximate. These results do not predict precise results and should be used to understand relative risk. Over the long term, NCORR and the Albemarle Commission will collect additional data to collect additional data, update, and refine existing inventories to assist in estimating potential losses.

Potential economic loss is based on the present value of the general building stock utilizing best available data. Significant impacts may occur to critical facilities and infrastructure as a result of these hazards causing great economic loss. However, monetized damage estimates to critical facilities and

infrastructure, and economic impacts were not quantified as they require more detailed loss analyses. In addition, economic impacts to industry such as tourism and the real-estate market were not analyzed.

Stakeholder and Public Input

To develop the vulnerability assessment, the Regional Team engaged a diverse set of stakeholders and community members to guide the project and ensure local priorities and concerns were integrated into the effort. A literary review to establish a foundation of known hazards and impacts throughout the region was followed by a quantitative geographic information system (GIS) analysis. The literary review included an examination of local, regional and State level documentation including hazard mitigation plans, transportation plans, and post disaster assessments. The GIS analysis included an assessment of climate science, maps, and regional data and statistics.

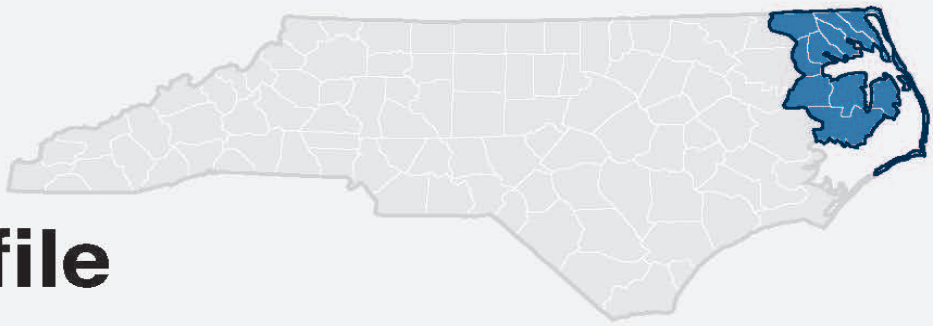
The lived experiences and knowledge of stakeholders and community members validated much of the data developed in this assessment. Stakeholders met monthly beginning in January 2022 to guide the development of the vulnerability assessment. Additionally, public input was solicited to identify vulnerabilities and challenges throughout the region. The collected data from stakeholder feedback, public comments, and GIS analysis resulted in the composition of the vulnerability assessment. Stakeholders were surveyed to identify the hazards that pose the greatest risk to the region. Respondents ranked hurricanes and coastal flooding as posing the greatest risk, followed by tornado, thunderstorms, and sea level rise. Stakeholders noted the following concerns:

- Natural disasters are impacting the region more severely today than they have in the past due the larger footprint of development, infrastructure, and population.
- The natural disasters are happening more frequently and with more severity meaning that recovery operations are not complete from one or more disasters when another one is realized.

D. Hazard Summary

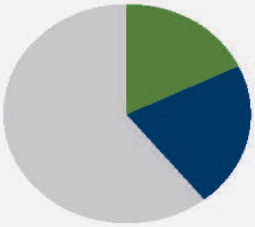
The Albemarle Region is impacted by a wide variety of natural and human-caused hazards. The Stakeholder Partnership worked with the Regional Team to identify hazards of concern that present immediate and long-term issues and include episodic events (such as hurricanes) and more gradual and incremental forms of risk (such as sea level rise). The information collected from the literature review, GIS analysis, stakeholder and community input was used to develop a list of potential hazards and their anticipated impacts for the region.

Albemarle Regional Profile



POPULATION

Total Population
171,966

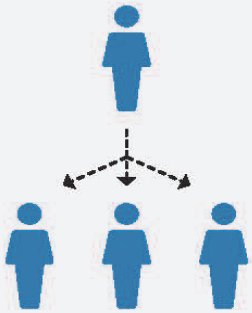


34,021
Number of Persons Under 18

34,203
Number of Persons Over 65

Regional Median Income
$51,425

State Median Income
$56,642



Regional Population Changes

Regional population did not increase nor decrease from 2010 - 2020.

Regional population is anticipated to increase 22% in the next 30 years.

HOUSING, CRITICAL INFRASTRUCTURE, AND COMMUNITY SUPPORT SERVICES

69,623
Number of Pre-FIRM houses

14.81%
Percentage of residential structures that are mobile homes

461
Critical Facilities

288
Number of Utilities

4,750
Roadway Miles

191
Rail Miles

ECONOMY

Educational services, and health care and social assistance

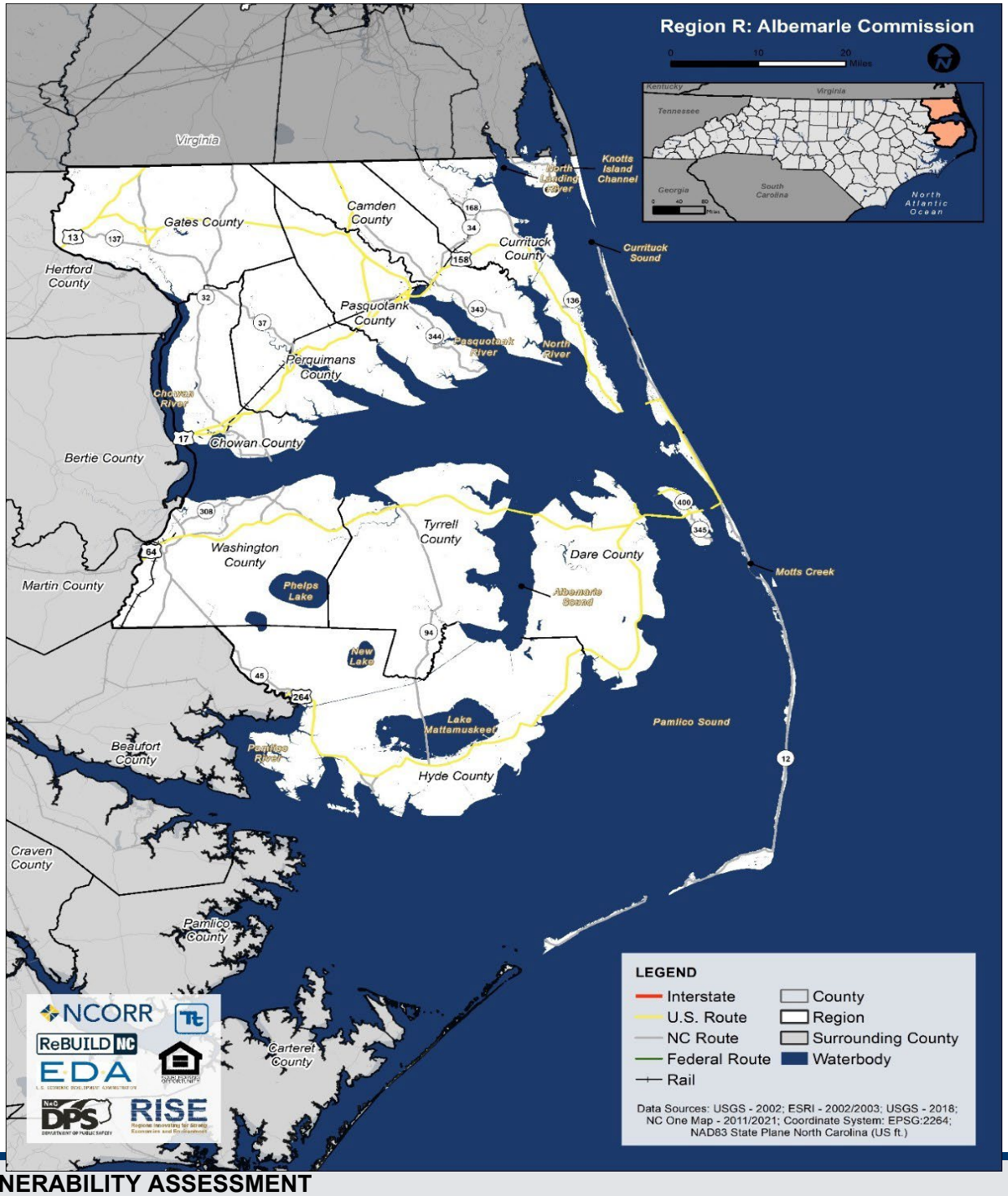
- Tourism in the region generates more than $61 million in local tax receipts and employs more than 15,490 people

- The region is home to 1,062 farms which produced a market value of products equaling $508,573,000 in 2020

III. REGIONAL PROFILE

The Albemarle Region is located in the northeastern corner of North Carolina. The region includes Camden, Chowan, Currituck, Dare, Gates, Hyde, Pasquotank, Perquimans, Tyrrell, and Washington Counties. The Albemarle Region has a total land area of 6,222 square miles, making it the largest of the 16 Council of Government regions in the state. ***Figure 4*** provides a visual of the area covered by the region.

Figure 4. The Albemarle Region



A. Physical Setting

This physical setting section presents the physical setting of the Albemarle Region, including hydrography and hydrology; watersheds; topography; geology; and ecology, climate, and land use/land cover.

Hydrography and Hydrology

The Albemarle Region is dominated by coastal waterways and includes 2,360 square miles of water as seen in ***Figure 4*** (Albemarle Commission 2018). The region includes the northeastern portion of Pamlico Sound and all of Albemarle Sound and Currituck Sound. Each sound is fed by many tidal rivers and tributaries, including the Pamlico River/Tar River (the region's southern border), the Chowan River (western border), Perquimans River, Little River, Pasquotank River, and North River (see ***Figure 4***). Changes in the physical features of the coast in northeastern North Carolina over time—in particular the closing of inlets connecting Currituck Sound to the Atlantic Ocean—have resulted in significant shifts in the sound's water flow (North Carolina Audubon 2019).

The Albemarle Region is made up of two major watersheds. The Chowan-Pasquotank River Basin is located in the northeastern section of the region. The Tar-Pamlico River Basin is located in the southern section of the region and includes the eastern and southern portions of the Outer Banks (United States Geological Survey [USGS] 2022).

Topography, Geology, and Ecology

The Albemarle Region is located in North Carolina's Coastal Plain ecoregion, which can be divided roughly into two sections: the tidewater area (lower Coastal Plain) and the interior portion (upper Coastal Plain) (North Carolina Wildlife Resource Commission [NCWRC] 2015). The Coastal Plain is largely comprised of the sediments that have eroded over time from the Appalachian Mountains and have been deposited at the coast. Coastal winds, waves, and tides have formed the narrow ribbons of the barrier islands that make up the Outer Banks.

The lower Coastal Plain in the Albemarle Region is largely flat and swampy and includes expansive coastal estuaries and the barrier islands of the Outer Banks, which border the Atlantic Ocean to the east (NCWRC 2015). These estuaries and the coastal ocean provide habitat that supports a strong commercial and recreational fishing industry. Tidal wetlands border waterways and extend well inland, with mainland brackish wetlands in many areas. Much of the land in the region cannot be developed due to the presence of wetlands (Albemarle Commission 2018). The upper Coastal Plain is made up of gently sloping elevations and is better drained than the lower Coastal Plain. The upper Coastal Plain is home to longleaf pine ecosystems and maritime forests (NCWRC 2015).

Climate

The climate conditions across the state are influenced by two major geographic features, the Atlantic Ocean to the east and the Appalachian Mountains in the western part of the state. Air over the ocean is usually more humid and experiences smaller day-to-night temperature variations than air over land. As a result, the coastal areas of the state experience more humid conditions and smaller day-to-night temperature differences (particularly when the airflow is onshore) than areas to the west. This oceanic influence on the climate diminishes as distance from the coast increases (NCICS 2020). For climate

modeling and discussions within this vulnerability assessment, the Albemarle Region is part of the Coastal Plain region of North Carolina, which includes the eastern third of the state.

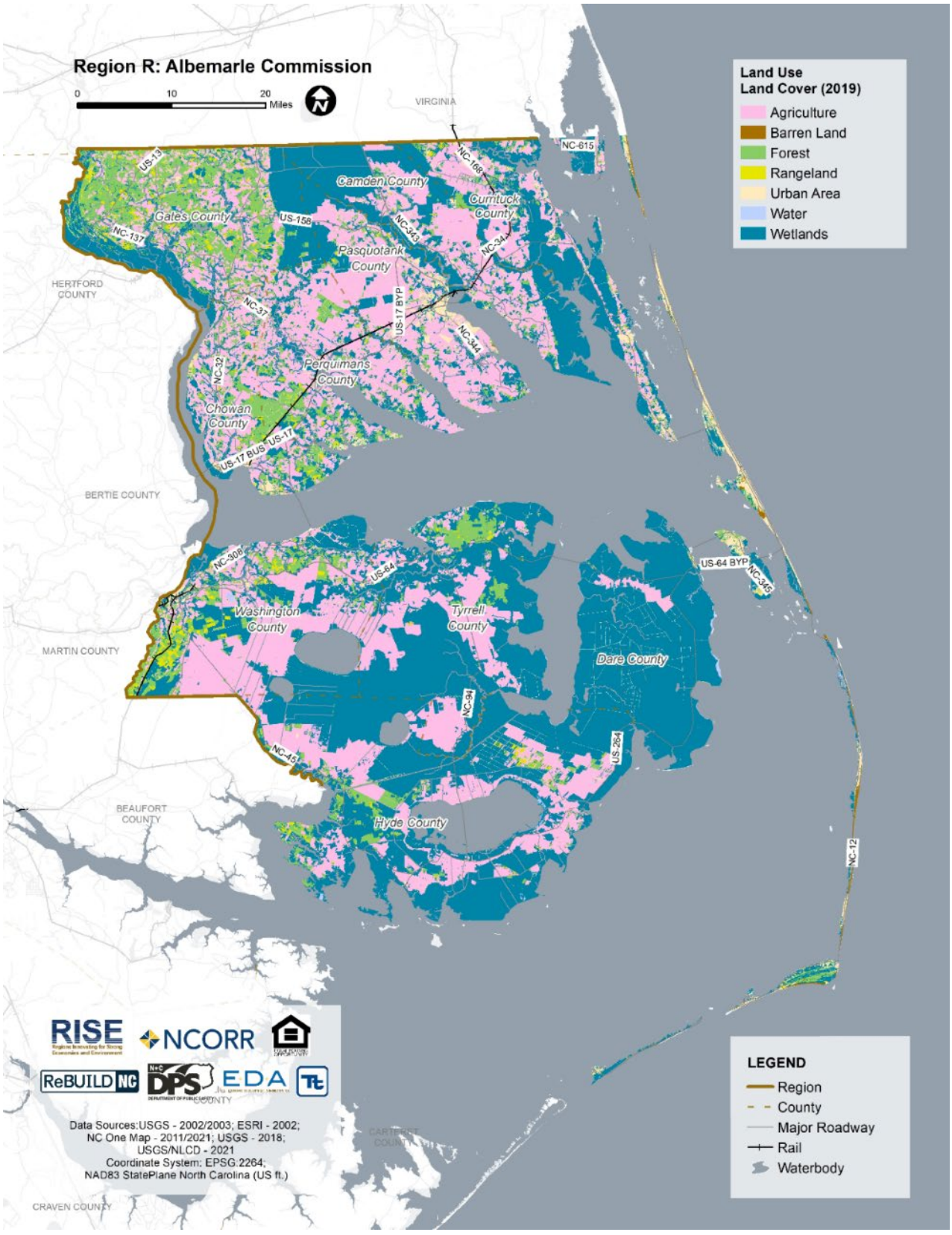
The Albemarle Region enjoys a mild, temperate climate. The heaviest monthly precipitation occurs during the summer months, tied to hurricanes, tropical storms, and thunderstorms. Average temperatures in Elizabeth City near the center of the Albemarle Region range from average low monthly temperatures (degrees Fahrenheit) in the low 40s in the winter to average high temperatures in the upper 80s in the summer (NOAA 2022). Average annual rainfall ranges from 45 to 50 inches in the northwest areas of the region to 50 to 55 inches in the southeast areas (USGS 2000). The average climate throughout the region varies slightly based on the region's large size.

Land Use, Land Cover, and Land Use Trends

The Albemarle Region is predominantly rural. The region includes the most extensive area of wetland in North Carolina and one of the largest in the country in the peninsula area of the region. These wetlands provide various ecosystem services including important flood water absorption, wave attenuation, water contaminant filtration, and nursery habitat for fish and invertebrates. Agricultural lands dominate inland areas.

This Albemarle region, with its diverse but sensitive ecological systems, its human population that is highly resource-dependent, and its proximity to the ocean, is a landscape particularly sensitive to changes in land use, land cover, and climate (North Carolina State University 2001). See Figure 5. ***Land Use Cover in the Albemarle Region*** for the current land use cover in the Albemarle Region as of 2019. Much of the land cannot be developed due to wetlands, and poor soil makes much of the region incompatible with septic system installation, which creates a dependency on local governments for water and sewer services.

Figure 5. Land Use Cover in the Albemarle Region



B. Population

Knowledge of the composition of the population, how it has changed in the past, and how it may change in the future is needed to make informed decisions. Information about population is a critical part of planning because it directly relates to needs such as housing, industry, commerce, public facilities and services, and transportation.

Population Density

Population density has a strong correlation with hazard vulnerability and loss. Urban areas tend to have larger populations and numbers of structures; therefore, these areas tend to experience greater loss during hazard events.

Table 4. Population Density in the Albemarle Region

Counties	Population Density (Person/ Sq. mile)	Total Population	Total Sq. Miles
Camden	43	10,355	241
Chowan	79	13,708	173
Currituck	107	28,100	264
Dare	95	36,915	387
Gates	30	10,478	345
Hyde	7	4,589	686
Pasquotank	178	40,568	228
Perquimans	53	13,005	247
Tyrrell	8	3,245	390
Washington	29	11,003	377
Albemarle Region	**52**	**171,966**	**3,337**

Source: Census 2010, 2020

As seen in ***Table 4***, the Albemarle Region has a population density of 52 people per square mile with vast differences in density from county to county. Pasquotank County has the highest population density with 178 people per square mile, while Hyde County has the lowest population density with 7 people per square mile.

Most of the towns in the Albemarle Region are small, with populations of less than 5,000. The largest population centers are located in the coastal communities of the Outer Banks in Dare County and Elizabeth City in Pasquotank County (population of 18,445). The relatively small population of the region (171,966) is contrasted by the large population of the Norfolk, Virginia to the north of the region (population of 238,005). Overall, the region comprises a large area where population centers are separated by distance, usually as the result of natural geographic barriers (Albemarle Commission 2018).

Population Trends

Population trends can provide a basis for making decisions on the type of mitigation approaches to consider and the locations in which these approaches should be applied. This population trend information can also be used to support planning decisions regarding future development in vulnerable areas.

As a whole, the population in the region was unchanged from 2010 to 2020. Counties in the east and northeast of the region (Camden, Currituck, and Dare) saw population growth that offset the population loss in the other counties. The most populous county (Pasquotank) saw little population change, while the two least populous counties, Hyde and Tyrrell, saw significant population loss, with 21.0 percent and 26.4 percent population decreases, respectively, as seen below in ***Table 5***.

Table 5. Population Growth in the Albemarle Region, 2010-2020

County	2010 Total Population	2020 Total Population	Percent Change, 2010-2020
Camden	9,980	10,355	3.8
Chowan	14,793	13,708	-7.3
Currituck	23,547	28,100	19.3
Dare	33,920	36,915	8.8
Gates	12,197	10,478	-14.0
Hyde	5,810	4,589	-21.0
Pasquotank	40,661	40,568	-0.2
Perquimans	13,453	13,005	-3.3
Tyrrell	4,407	3,245	-26.4
Washington	13,228	11,003	-16.8
Albemarle Region	**171,966**	**171,966**	**0**

Source: Census 2010, 2020

The North Carolina Office of State Budget and Management projects that the Albemarle Region will see population growth through 2050, with an expected increase in population of 38,271 or 22.2 percent. Overall trends in growth from the last decade are likely to continue, with significant population increases focused in Currituck (108.9 percent growth) and Dare County (33.3 percent growth) and modest growth or population loss in other counties. Areas experiencing population growth are likely to experience increased hazard exposure.

Social Vulnerability

Certain populations may experience exacerbated impacts and prolonged recovery if/when impacted by a hazard. This recovery is due to many factors, including their physical and financial ability to react or respond during a hazard. Identifying concentrations of vulnerable populations can assist communities in targeting preparedness, response, and mitigation actions. For this planning process, vulnerable populations in the Albemarle Region include children, the elderly, low-income (individuals below the poverty line), the physically or mentally disabled, and non-English speakers. A breakdown of the total vulnerable population in the Albemarle Region can be found in ***Table 6.***

Table 6. Total Vulnerable Population in the Albemarle Region

Counties	Total Vulnerable Population	Vulnerable Population Category							
		Number of Persons Over 65	Number of Persons Below 5	Number of Persons Below Poverty Level	Number of Persons With a Disability	Number of Persons Limited English Speaking	Number of Persons Without Vehicle	Number of Persons 16 and Over Commuting to Work with Public Transportation (excluding taxicab)	Number of Persons 16 and Over Commuting to Work by Walking
Camden	5,039	1,847	485	969	1,485	10	115	2	126
Chowan	9,525	3,415	639	2,207	2,337	50	636	26	215
Currituck	12,350	4,177	1,426	2,479	3,824	33	263	5	143

Counties	Total Vulnerable Population	Vulnerable Population Category							
		Number of Persons Over 65	Number of Persons Below 5	Number of Persons Below Poverty Level	Number of Persons With a Disability	Number of Persons Limited English Speaking	Number of Persons Without Vehicle	Number of Persons 16 and Over Commuting to Work with Public Transportation (excluding taxicab)	Number of Persons 16 and Over Commuting to Work by Walking
Dare	17,919	7,499	1,568	3,230	4,480	280	432	9	421
Gates	7,169	2,283	461	1,548	2,609	32	219	-	17
Hyde	3,312	1,012	253	1,125	796	69	6	7	44
Pasquotank	22,858	6,518	2,614	5,800	6,060	166	1,264	25	411
Perquimans	8,930	3,637	599	2,008	2,222	42	329	-	93
Tyrrell	2,584	819	129	749	737	4	118	6	22
Washington	9,399	2,814	551	2,612	2,553	16	761	-	92
Albemarle Region (Total)	**99,085**	**34,021**	**8,725**	**22,727**	**27,103**	**702**	**4,143**	**80**	**1,584**

Sources: American Community Survey (ACS) 2019; (US Census Bureau 2020)
Social Vulnerability Index

Age

Children are considered vulnerable because they are dependent on others to safely access resources during emergencies. Roughly five percent of the Albemarle Region population is under five years old.

The elderly are more likely to lack the physical and economic resources necessary for response to hazard events and are more likely to suffer health-related consequences, making recovery slower. Those living on their own may have more difficulty evacuating their homes. The elderly population is also more likely to live in senior care and living facilities where emergency preparedness occurs at the discretion of facility operators. The Albemarle Region has a large percentage of residents over 65 years of age with roughly 20 percent of the population over 65 years old compared to 16.7 percent for North Carolina as a whole.

Income

Of the total population, economically disadvantaged populations are more vulnerable to hazards because they are likely to evaluate their risk and make decisions based on the major economic impact to their family and may not have the funds to evacuate. Roughly 13 percent of the Albemarle Region population live below the poverty threshold, slightly lower than the percentage for North Carolina (13.6 percent). The poverty line for North Carolina in 2018 is based on the federal guidelines, which begins at $12,140 for a single person, adding $4,320 for each additional person in the household (US Census 2020).

Disability, Access and Functional Needs

The Center for Disease Control and Prevention (CDC) defines a disability as a “condition of the body or mind (impairment) that makes it more difficult for the person with the condition to do certain activities (activity limitation) and interact with the world around them (participation restrictions)” (CDC 2020). These impairments may increase the level of difficulty that individuals may face during a hazard event. Cognitive impairments may reduce an individual’s capacity to receive, process, and respond to emergency information or warnings. Individuals with a physical or sensory disability may face issues of mobility, sight, hearing, or reliance on specialized medical equipment. Roughly 16 percent of the Albemarle Region population have a known disability.

Non-English Speakers

Individuals who are not fluent or have a working proficiency in English may be vulnerable to hazard events because they may have difficulty understanding information being conveyed by disaster management authorities. Cultural differences can also add complexity to how information is received by populations with limited proficiency in English (CDC 2020). Approximately 0.5 percent of the Albemarle Region population has limited proficiency in English.

CDC Social Vulnerability Index Ranking

The CDC's Social Vulnerability Index Ranking (SVI) is a composite index that factors in socioeconomic status; household composition and disability; minority status and language; and housing type and transportation. The following figures display these factors by census tract. Socioeconomic vulnerable populations are focused in Tyrrell and Hyde County (***Figure 6***). Populations with vulnerability due to household composition and disability are spread throughout the region (***Figure 7***). Populations with vulnerability due to minority status and language are focused in Tyrell and Hyde County, with additional populations in Washington County, Perquimans County, and Pasquotank County (***Figure 8***). Populations with vulnerability due to housing type and transportation are found in Tyrrell County, the western edge of Washington County, the eastern areas of Chowan County, the eastern edge of Pasquotank County, and the eastern Outer Banks (***Figure 9***). ***Figure 10*** presents a composite of each of these mapped social vulnerability factors.

Figure 6. Census Tracts with SVI Ranking by Theme of Socioeconomic Status

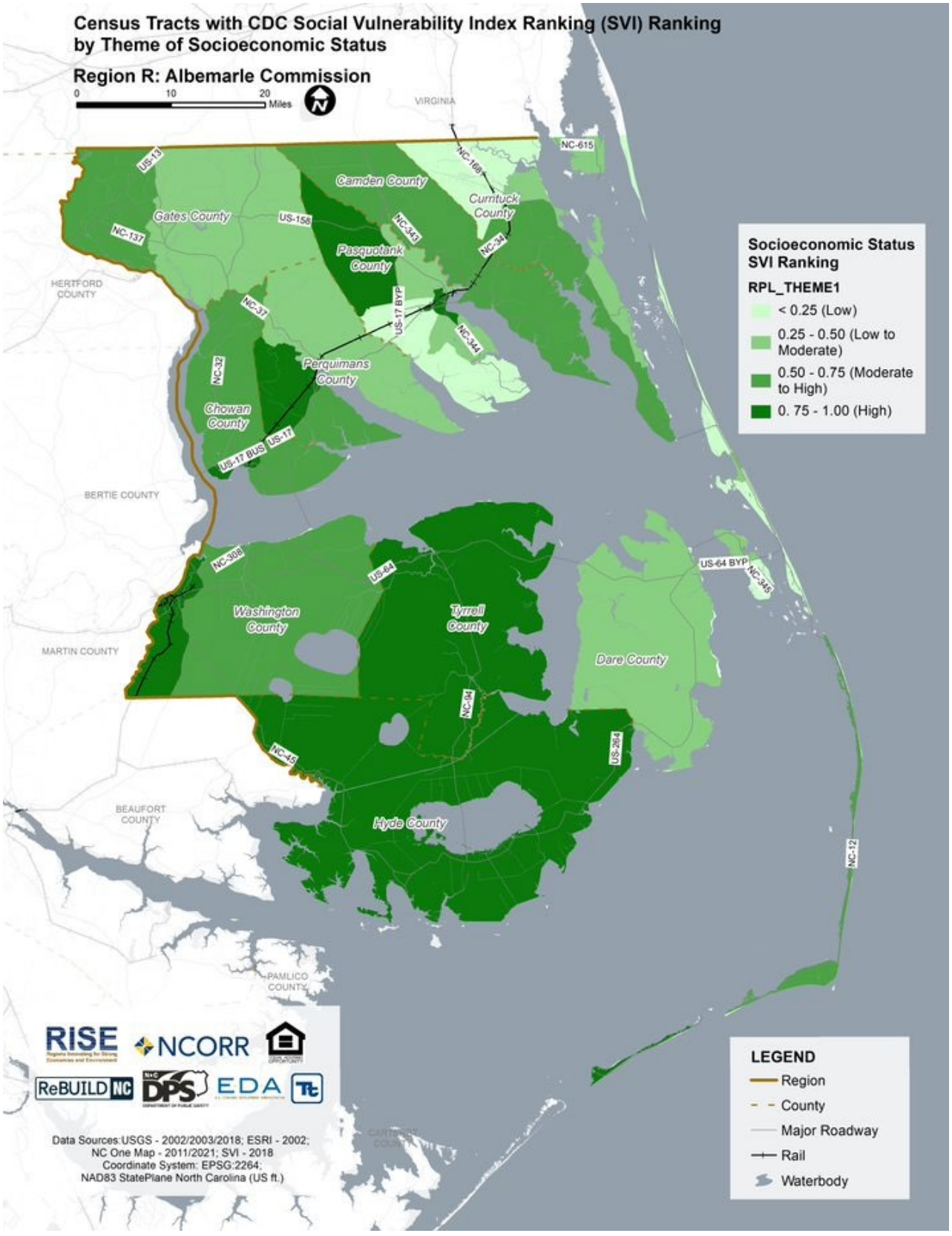


Figure 7. Census Tracts with SVI Ranking by Theme of Household Composition & Disability

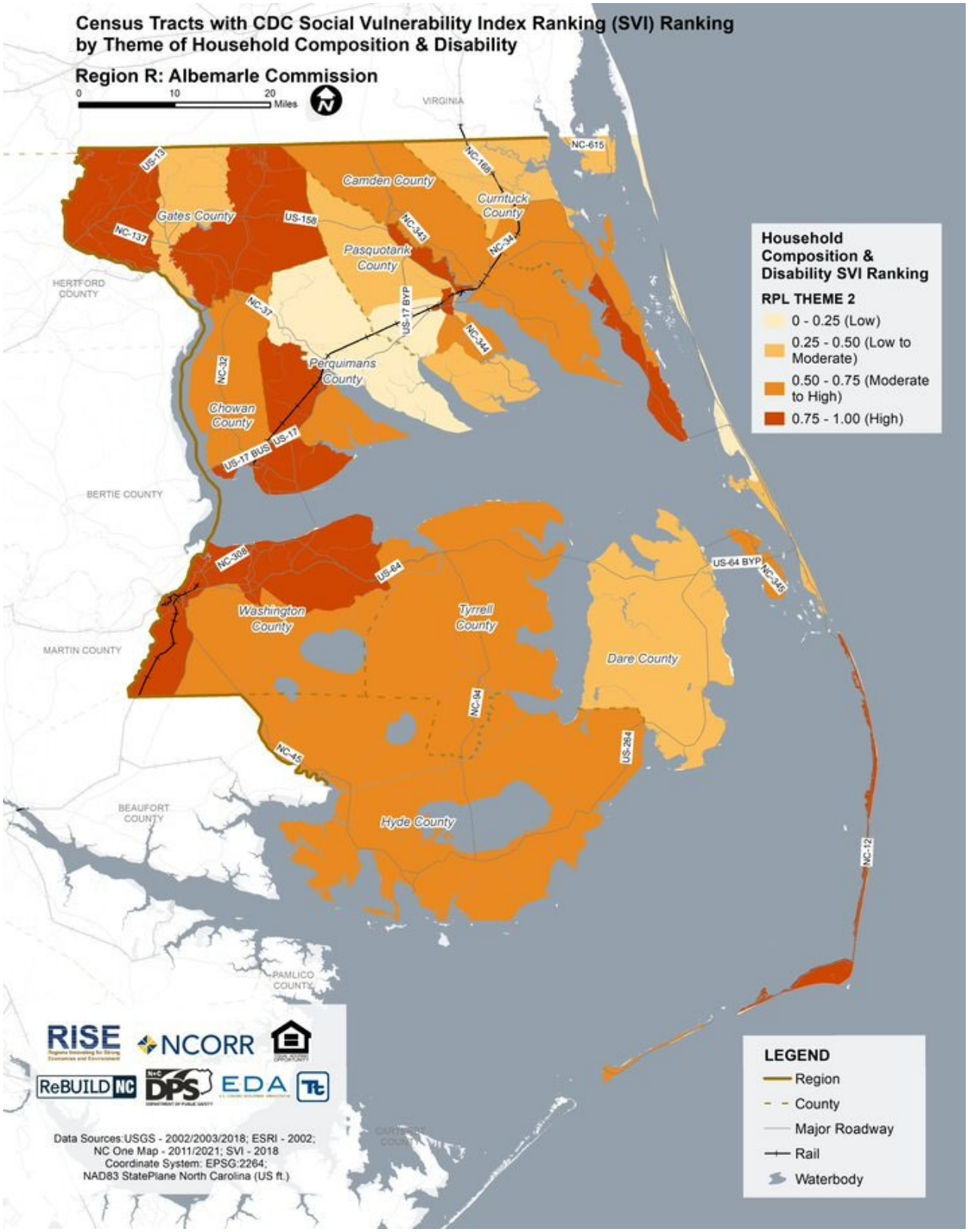


Figure 8. Census Tracts with SVI Ranking by Theme of Minority Status & Language

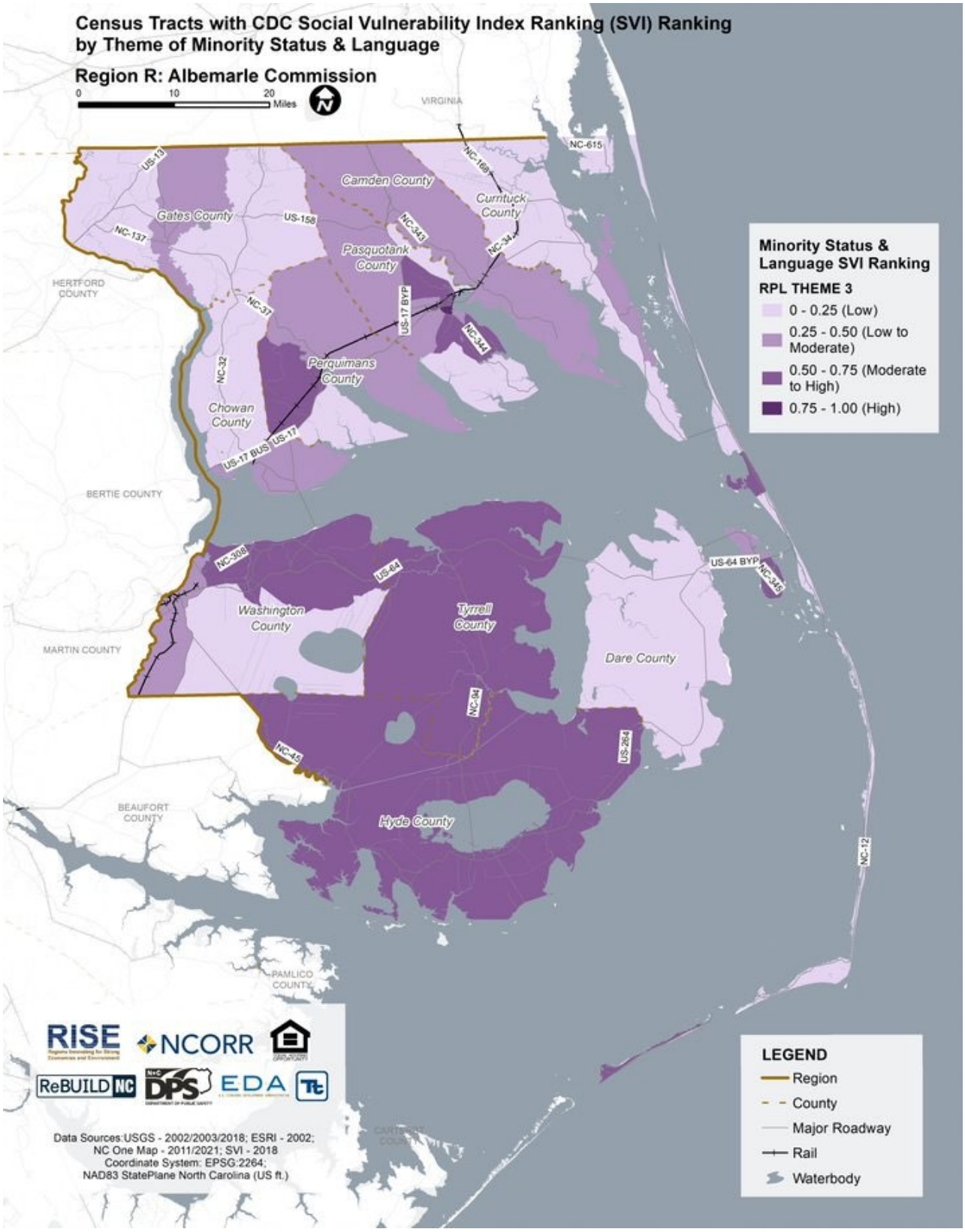


Figure 9. Census Tracts with SVI Ranking by Housing Type & Transportation

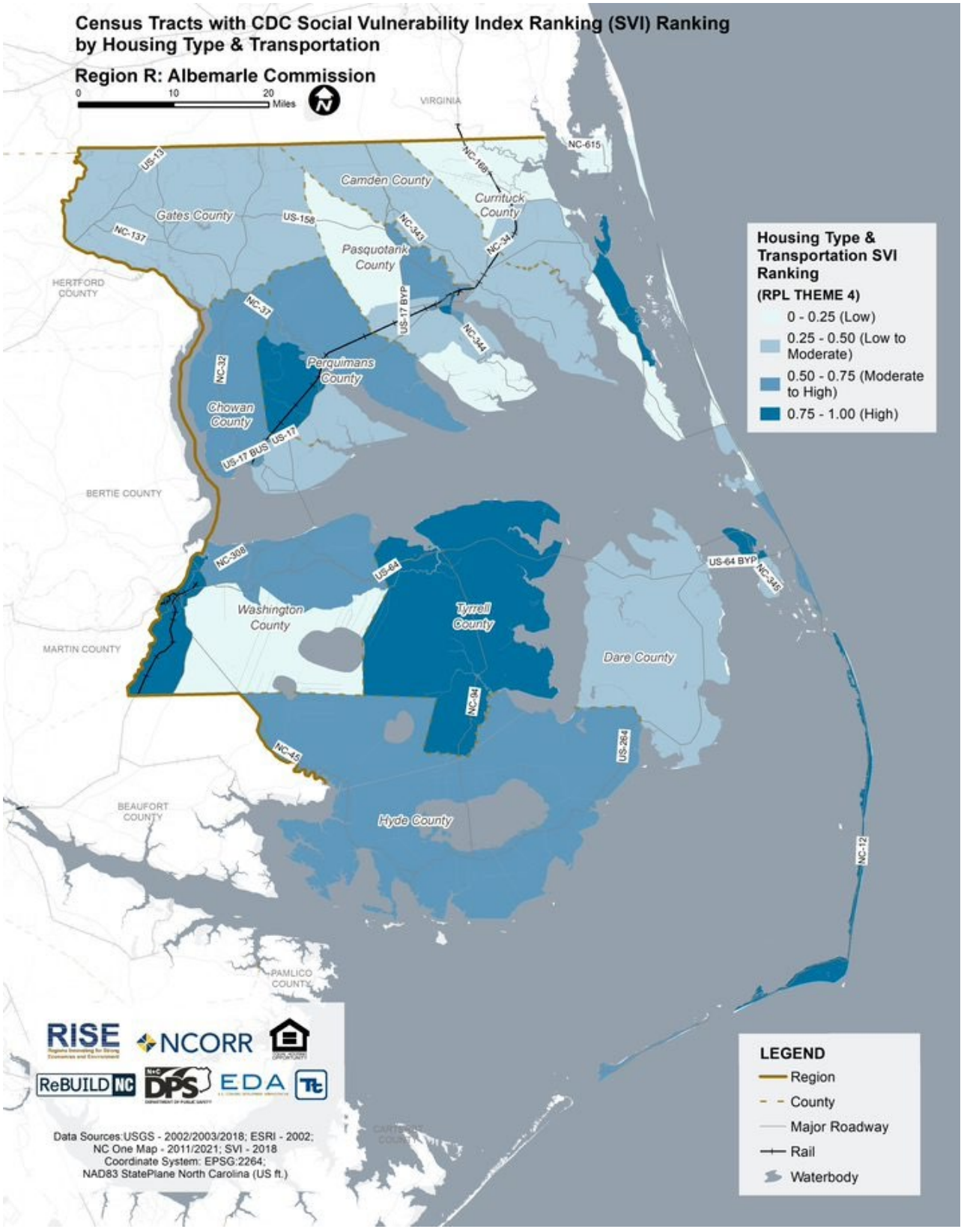
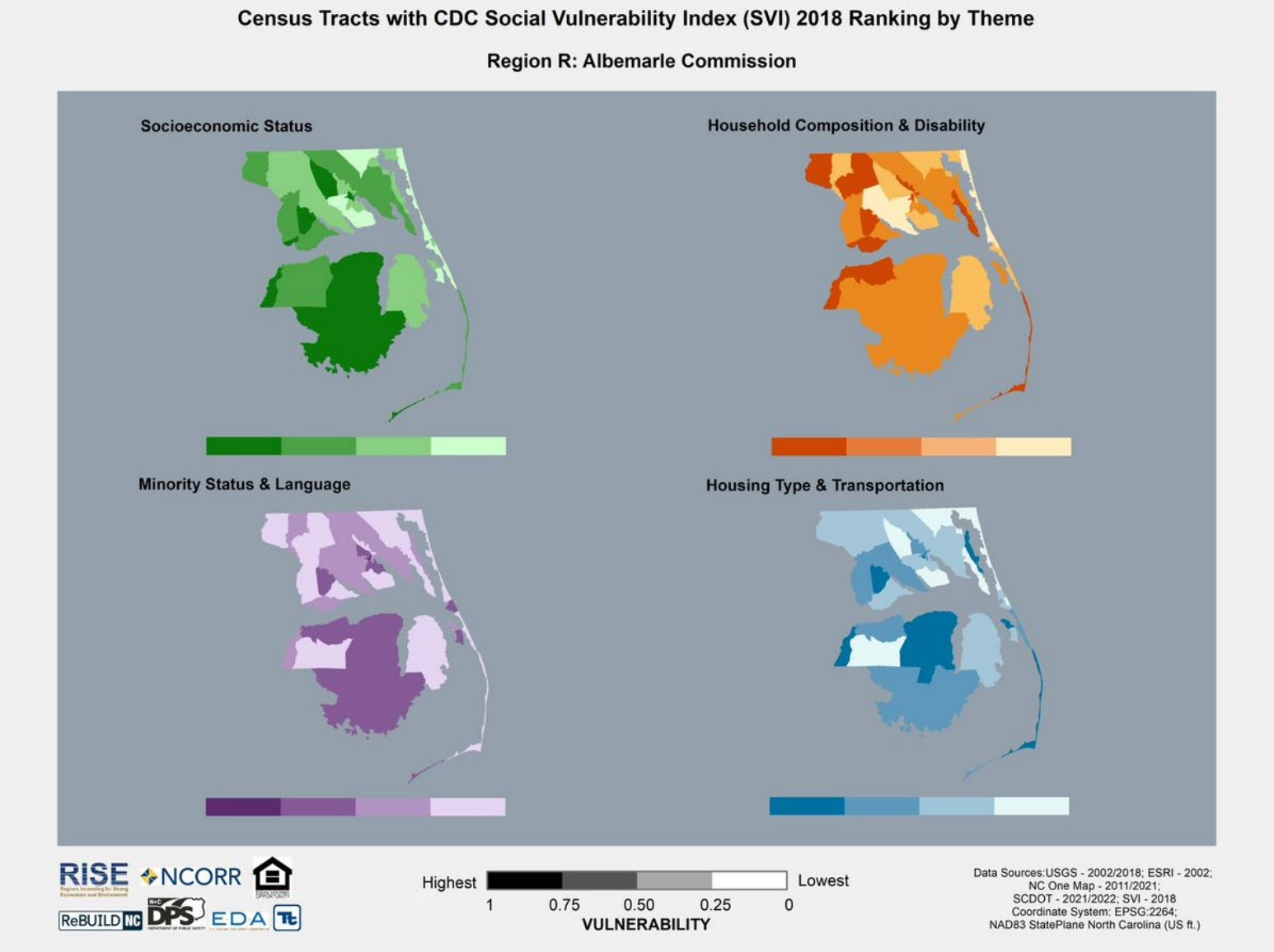


Figure 10. Census Tracts with SVI Ranking by Theme



C. Housing, Critical Infrastructure, and Community Support Services

As seen in ***Table 7***, the Albemarle Region has roughly 130,000 buildings. Residential structures comprise the majority of buildings in the Albemarle Region (85 percent). The majority of residential structures are located in Dare County (36,915 residents, 38,108 residential structures) despite the county having a lower population than Pasquotank County (40,568 residents, 22,743 residential structures). This points to the large number of secondary homes or rental properties in the Outer Banks region. Agricultural buildings make up the second-largest component of the building stock, pointing to the large role that agriculture plays in the region.

Table 7. Number of Buildings by Occupancy Type in the Albemarle Region

County	Number of Buildings by Occupancy Type in Albemarle Region							
	Occupancy Type							
	Residential	Commercial	Agricultural	Education	Religious	Government	Industrial	Vacant
Camden	5,675	209	824	26	46	108	173	167
Chowan	9,139	622	1,200	42	86	40	218	-
Currituck	20,746	1,172	580	60	83	139	206	286
Dare	38,108	2,038	59	81	124	415	219	395
Gates	7,206	287	1,925	45	127	51	53	-
Hyde	6,349	292	863	24	71	51	66	-
Pasquotank	19,601	1,381	879	108	211	223	340	-
Perquimans	9,926	376	322	33	156	211	46	-
Tyrrell	2,929	143	771	23	34	53	2	-
Washington	8,817	439	1,837	48	147	62	103	-
Albemarle Region (Total)	**128,496**	**6,959**	**9,260**	**490**	**1,085**	**1,353**	**1,426**	**848**

Sources: NC One Map 2021, 2022

Housing costs are extremely prohibitive to economic development in the Albemarle Region. Possible employers are unable to locate to the region because workforce housing is not available to support their workforce needs. This is especially true in tourism areas where a lack of affordable housing is damaging to the economies of the coastal towns (Albemarle Commission 2018).

Tourism on the coast generates jobs for the entire region. However, housing costs near these jobs force workers to commute from the inland. These long commutes detract from the value of wages. Some occupations require workers to reside near the communities they serve, such as health and safety workers that must be on call. The overall quality of life, and safety on the Outer Banks, is diminished by a lack of workforce housing (Albemarle Commission 2018).

Mobile home parks (35) and mobile homes (19,034) are a component of residential structures (14.8 percent of all residential structures). Mobile homes are more likely to be damaged than traditional residential structures due to different construction and materials. ***Table 8*** provides a breakdown of the location of mobile home communities in the region.

Table 8. Mobile Homes in the Albemarle Region

County	Total Number of Mobile Home Parks per County	Total Number of Mobile Home Buildings per County
Camden	1	611
Chowan	3	1,668
Currituck	1	3,366
Dare	9	2,948
Gates	2	1,629
Hyde	1	726
Pasquotank	10	3,519
Perquimans	3	2,226
Tyrrell	1	755
Washington	4	1,586
Albemarle Region (Total)	**35**	**19,034**

Sources: NC One Map 2021/2022; Homeland Infrastructure Foundation-Level Data (HIFLD) 2022

Critical Facilities

Critical facilities and infrastructure provide services and functions essential to a community, especially during and after a disaster. Critical facilities include essential facilities, transportation systems, utility systems, high-potential loss facilities (such as nuclear power plants, dams, and military installations), and hazardous material facilities. Transportation systems include roadways, bridges, airways, and waterways. Utility systems include potable water, wastewater, oil, natural gas, electric power facilities, and emergency communication systems. A community lifeline, a type of critical facility, enables the continuous operation of government functions and critical business and is essential to human health and safety or economic security.

More information on the breakdown of the types of essential facilities in the region can be found in **Appendix A.** To explore the location of critical facilities within the Albemarle Region, visit Albemarle Commission Region - Resilience Portfolio Web Map (arcgis.com).

Emergency Facilities

Emergency facilities include police, fire, emergency medical services (EMS), and emergency operations centers (EOC). The Albemarle Region has an interconnected network of emergency facilities and services at the county and municipal levels. In total, the region has 189 emergency facilities. These facilities serve as lifelines during and after hazards. In addition to the facilities needing to be protected, access to the facilities is important to maintain their critical services. ***Table 9*** below provides a breakdown of emergency facilities by type.

Table 9. Emergency Facilities in the Albemarle Region

Emergency Facility	Total Emergency Facilities
EMS	65
EOC	9
Fire Stations	71
Police	44
Albemarle Region (Total)	**189**

Sources: NCDCR 2022; NC One Map 2019/2020/2021; HIFLD 2016/2021/2022

Hospital and Medical Facilities

Hospitals and medical facilities provide critical medical support to the Albemarle Region. The region is home to four major hospitals and many smaller medical facilities. ***Table 10*** below provides a breakdown of health care facilities by type.

Table 10. Health Care Facilities in the Albemarle Region

Health Care Facility	Total Health Care Facilities
Hospital	4
Medical Facility	111
Pharmacy	50
Public Health Department	12
Albemarle Region (Total)	**177**

Sources: NCDCR 2022; NC One Map 2019/2020/2021; HIFLD 2016/2021/2022

Schools

The Albemarle Region hosts 82 education facilities. The majority of these are public K-12 schools. Schools often serve multiple purposes including as potential shelters and hosts of community events. ***Table 11*** below provides a breakdown of education facilities by type.

Table 11. Education Facilities in the Albemarle Region

Education Facility	Total Education Facilities
College and University	3
Private School	14
Public School	65
Albemarle Region (Total)	**82**

Sources: NCDCR 2022; NC One Map 2019/2020/2021; HIFLD 2016/2021/2022

Elizabeth City State University (ECSU) is a public, historically black college located in Elizabeth City, North Carolina. ECSU enrolls nearly 2,500 students in 37 baccalaureate programs and three masters' degree programs. ECSU is a member school of the Thurgood Marshall College Fund and a member-institution of the University of North Carolina system (Albemarle Commission 2018).

The region is also home to Mid-Atlantic Christian University (MACU). MACU is a private Christian university located in Elizabeth City. They serve more than 500 students in the region and online,

supporting 15 undergraduate degree programs and five academic completion programs (Albemarle Commission 2018).

The College of the Albemarle is one of the North Carolina Community Colleges. The main campus is located in Elizabeth City, with satellite campuses located in Barco, Edenton, and Manteo. They serve 4,500 students in the region (Albemarle Commission 2018).

Hyde, Tyrrell, and Washington Counties are served by Beaufort County Community College. The main campus is located in Washington, with satellite campuses located in Engelhard, Roper, and Columbia. They serve 2,000 students in the region. (Albemarle Commission 2018).

Shelters

Emergency shelters are a last resort option during and sometimes immediately after a natural disaster. Access to sheltering is vital to prevent loss of life during severe events. In total, the Albemarle Region has 62 emergency shelters, which may need to be used to house citizens before and after an emergency. In addition to these emergency shelters, communities may have unofficial shelters or staging locations for evacuation to official shelters. While not included in traditional sheltering counts, these unofficial sheltering locations are also critical. ***Table 12*** provides the number of emergency shelters by county in the region.

Table 12. Emergency Shelters in the Albemarle Region

County	Total Number of Emergency Shelters in the Albemarle Region
Camden	3
Chowan	7
Currituck	8
Dare	9
Gates	5
Hyde	4
Pasquotank	13
Perquimans	6
Tyrrell	1
Washington	6
Albemarle Region (Total)	**62**

Sources: NC One Map 2019/2020/2021

Senior Care and Living Facilities

The Albemarle Region is home to 19 nursing homes (North Carolina Department of Cultural Resources [NCDCR] 2022; NC One Map 2019, 2020, 2021; Homeland Infrastructure Foundation-Level Data [HIFLD] 2016, 2021, 2022). These facilities are highly vulnerable to potential impacts from disasters and knowing the location and numbers of these types of facilities will be effective in managing a response plan pre- and post-disaster.

Government Buildings

Government buildings provide the base for critical government services and exist to maintain continuity of operations. In total, the Albemarle Region has 1,353 government buildings. ***Table 13*** provides the number of government buildings by county in the region.

Table 13. Government Buildings in the Albemarle Region

County	Government
Camden	108
Chowan	40
Currituck	139
Dare	415
Gates	51
Hyde	51
Pasquotank	223
Perquimans	211
Tyrrell	53
Washington	62
Albemarle Region (Total)	**1,353**

Sources: NC One Map 2021/2022

Transportation Systems

With the Albemarle Region dominated by sounds and rivers, transportation can be difficult and involve indirect routes and sometimes ferries to move around water. This transportation movement can make evacuation or detours due to damages and hazard impacts slow and increase emergency response times. The region is home to 4,750 miles of roadway and 191 miles of rail. The region classifies 588 miles of roadway as evacuation routes (12 percent of the region's total roadway mileage). Ferries also serve an important service as critical evacuation infrastructure.

Table 14 displays the mileage of critical transportation infrastructure in the Albemarle Region.

Table 14. Total Length of Critical Transportation Infrastructure in the Albemarle Region

Total Length of Transportation Infrastructure in the Albemarle Region (Miles)				
County	**Roadway**	**Rail**	**Evacuation (Road)**	**Evacuation (Ferry)**
Camden	328	-	52	-
Chowan	350	-	17	-
Currituck	522	58	55	5
Dare	839	-	162	29
Gates	449	-	43	-
Hyde	459	-	76	56
Pasquotank	580	-	60	-
Perquimans	528	-	33	-
Tyrrell	260	-	29	-
Washington	435	133	61	-
Albemarle Region (Total)	**4,750**	**191**	**588**	**90**

Sources: North Carolina Department of Transportation (NCDOT) 2015/2020/2021
Note: Freight rail service may not be included in the Railways total

Despite being one of the largest regions in North Carolina, the Albemarle Region does not have an airport, although there are many private aircraft landing facilities. Commercial air travel into the region involves flying into airports in adjacent areas of the state or flying into Virginia and driving in. Only a few bus stations are located in the region. Transportation facilities in the region are summarized in ***Table 15*** below:

Table 15. Transportation Facilities in the Albemarle Region

Transportation Facility	Total Transportation Facilities
Aircraft Landing Facility	102
Airport	0
Bus Station	2
Highway Bridges	23

Sources: NCDCR 2022; NC One Map 2019, 2020, 2021; HIFLD 2016, 2021, 2022
Note: Military air bases are not included in the Airport total

The large water bodies that separate the region make vehicular transportation time-consuming and expensive. There is a great deal of congestion on major highway corridors, especially in and leading to tourism heavy locations such as the Outer Banks. This is especially true where the transportation system transverses large water bodies with bridges and ferries. The current transportation system has been noted to be inadequate, leading to long commute times and limiting investment by new businesses. Roadway widening, bridge replacement, and ferry upgrades have been identified as needs to increase the efficiency of the transportation system (Albemarle Commission 2018).

Efforts are underway to address some of these needs including developing a future I-87 in Chowan, Perquimans, Pasquotank, and Currituck County. The US-17 corridor is identified as a Strategic Transportation Corridor (STC) within the North Carolina Transportation Network (NCTN). The purpose of the NCTN is to preserve and maximize mobility and connectivity on a core network of multimodal transportation corridors, promoting environmental stewardship and economic prosperity. US-17 is being upgraded to interstate standards (a future I-87) to improve mobility, connectivity, and safety. Goals include:

- Connectivity: US 17 is a part of the Strategic Highway Network (STRAHNET) connecting multiple major military bases. The corridor also connects North Carolina to the South Carolina and Virginia state borders, providing the only continuous north-south route east of I-95. It provides primary access to international air service from Norfolk airports.
- Economic Prosperity: US 17 connects northeast North Carolina markets to the ports in Norfolk and workers to major employment opportunities in southeast Virginia. It serves as a major route from eastern North Carolina agricultural activities to international markets through North Carolina, Virginia, and South Carolina ports and provides primary access to critical military installations in the region, for both employment and mission-critical military activities (NCDOT 2018).

Lifeline Utility Systems

The Albemarle Region includes numerous power plants (30) and substations (57). ***Table 16*** below provides the total number of utilities in the region.

Table 16. Utilities in the Albemarle Region

Utility	Total Utilities
AM Transmission Tower	5
Cellular Tower	95
FM Transmission Tower	31
Gas Plant	1
Power Plant	30
Sewer Treatment Plant	9
Substation	57
Albemarle Region (Total)	**228**

Sources: NCDCR 2022; NC One Map 2019, 2020, 2021; HIFLD 2016, 2021, 2022

The limited capacity for wastewater treatment plants and septic systems hinders development growth in the region. Because of the high-water table and the distance between residences and businesses, the expense and environmental factors within the region impose difficulties in the expansion of existing wastewater and septic systems. Furthermore, poor soil makes much of the region incompatible for septic systems, resulting in a dependence on local governments for water and sewer services (Albemarle Commission 2018). ***Table 17*** below provides the total number of facilities with impacts to public health and environmental systems in the region.

Table 17. Facilities with Impacts to Public Health and Environmental Systems in the Albemarle Region

Facility with Impacts to Public Health and Environmental Systems	Total Facilities with Impacts to Public Health and Environmental Systems
Septage Facility	23
Solid Landfill	20
Yard Waste Facility	7
Albemarle Region (Total)	**50**

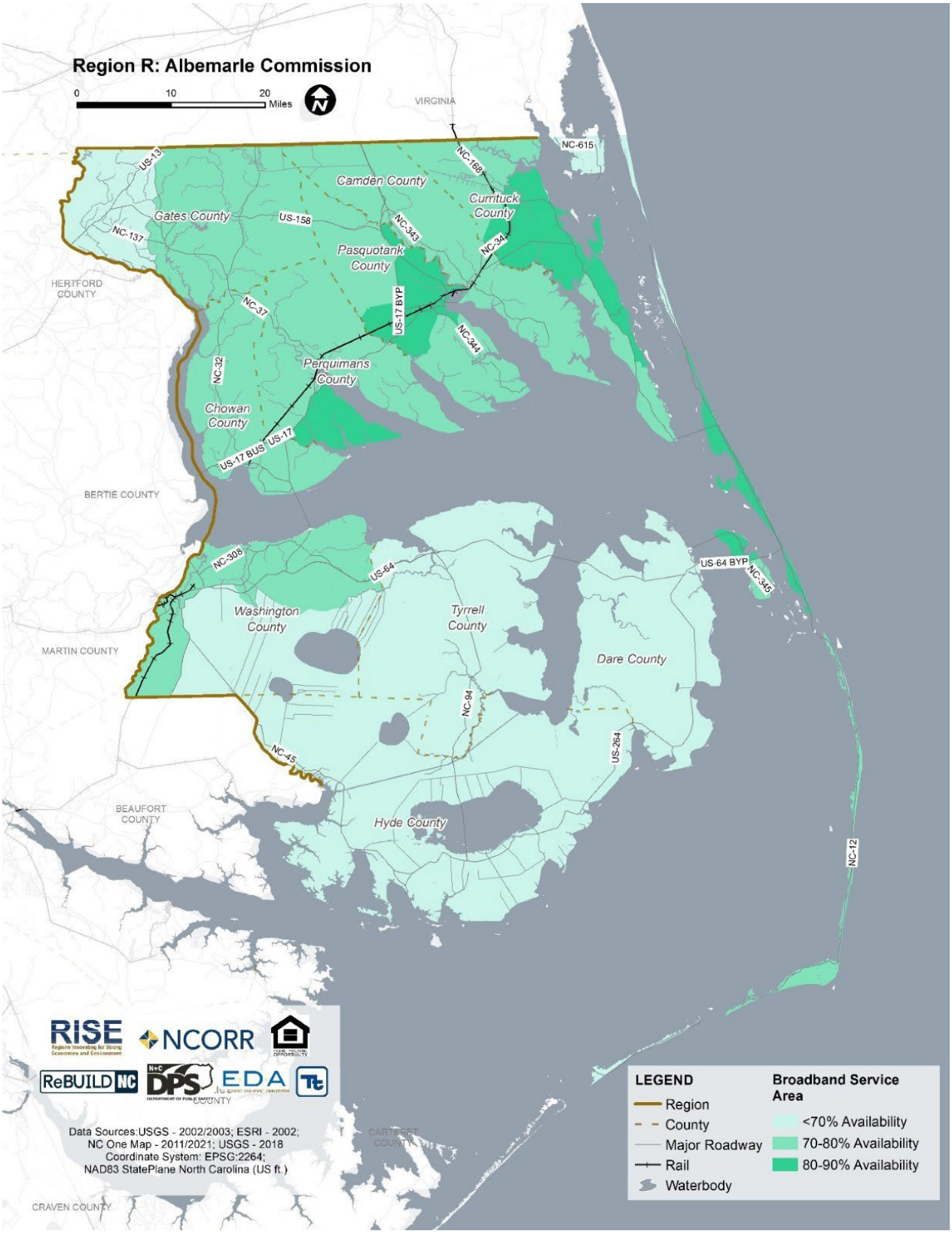
Sources: NCDCR 2022; NC One Map 2019, 2020, 2021; HIFLD 2016, 2021, 2022

There are nine county-wide, one regional, and several municipal water systems in the region. Due to a decrease in available groundwater, several local governments in the region are engaging in prolonged and expensive reverse osmosis projects (Albemarle Commission 2018).

Infrastructure deficiencies include a lack of affordable high-speed internet access. This limits the ability to work remotely and is a concern with the move to electronic textbooks for school-age children. The Albemarle Commission, in partnership with the State of North Carolina's Broadband Infrastructure Office, has undertaken a broadband demand aggregation project to attract public and private partnerships throughout the region to expand and provide this essential service to residents, businesses, and visitors throughout the region (Albemarle Commission 2018).

At least 1.1 million North Carolina households lack access to high-speed internet, cannot afford it or do not have the skills needed to take advantage of the digital economy. North Carolina plans to invest nearly $1 billion in federal American Rescue Plan funds to establish digital equity (North Carolina Department of Information Technology [NC Broadband.gov] 2022). ***Figure 11*** displays the access to broadband services in the Albemarle Region. The northern half of the region has better access than the southern half. Dare, Hyde, Tyrrell, and Washington Counties generally have less than 70 percent broadband availability. Lack of internet access limits outreach and emergency warning efficiency in the region.

Figure 11. Access to Broadband in the Albemarle Region



Other Facilities

Other facilities considered critical in the Albemarle Region include religious buildings, libraries, and historical sites and districts. The region is home to 1,085 religious buildings, 13 libraries, and 172 historical sites. Chowan and Pasquotank Counties each have historic districts that collectively cover 260 acres (North Carolina State Historic Preservation Office [NCSHPO] 2022). Historic and cultural assets are major components of a region's cultural identity and contribute to quality of life. ***Table 18*** provides the total number of historical and cultural resource facilities in the region.

Table 18. Historic and Cultural Resource Facilities in the Albemarle Region

Historic and Cultural Resource Facility	Total Historic and Cultural Resource Facilities
Historical Site	172
Library	13
Religious Facilities	1,085
Albemarle Region (Total)	1,270

Sources: NCDCR 2022; NC One Map 2019/2020/2021; HIFLD 2016/2021/2022

D. Economy

After a natural hazard, economic resiliency drives recovery. An understanding of the major employers and economic sectors in the Albemarle Region whose losses or inoperability would impact the community and its ability to receive from a disaster is essential. The major employers in the region are construction, manufacturing, retail trade, healthcare and social assistance, educational services, administrative and support, waste management, remediation services, and accommodation and food services.

Tourism and Agriculture are two of the major drivers of the region's economy. Both sectors have been impacted by hazards such as hurricanes in the past and are likely to continue to be vulnerable in the future.

Tourism

Tourism plays a large part in the state's economy. In 2020 tourism was responsible for $20 billion in direct visitor spending and 7.5 percent of total employment in the state (Economic Development Partnership of North Carolina [EDPNC] n.d.). Tourism is a major industry in the region as many of the counties border the Atlantic Ocean and the area sounds. In 2015, tourism had a $1.35 billion impact on expenditures, a regional payroll of $274 million, and employed more than 15,490 employees (NC Albemarle Commission Report 2016).

The coastal estuaries and beaches of the Albemarle Region are sought after by tourists for fishing, boating, swimming, beachgoing, and surfing. Dare County's economy specifically is supported by the tourism industry on the Outer Banks (Albemarle Commission 2018).

Tourism from the Albemarle Region generates more than $65 million in state tax receipts and $61 million in local tax receipts, saving residents more than $4,522 per resident each year (Albemarle Commission 2018).

Agriculture

Agriculture is another major industry in the region. ***Table 19*** shows the results of the most recent Census of Agriculture, completed in 2017 by the United States Department of Agriculture (USDA). Roughly

$508.5 million worth of agricultural products were sold in the region in 2017. The Region's 1,062 farms are supported by nearly 1,700 workers (USDA 2017). ***Table 20*** shows the results of the most recent Census of Agriculture, completed in 217 by the USDA to show the types of number of livestock operations in the region. ***Table 21*** shows the types of crops grown in the Albemarle Region.

Table 19. Agriculture in the Albemarle Region

County	Number of Farms	Market Value of Products Sold ($) 2012	Market Value of Products Sold ($) 2020	Total Farm Production Expenses ($) 2012	Total Farm Production Expenses ($) 2020	Total Producers (workers) *data collected for a maximum of four producers per farm
Camden	81	48,913,000	39,932,000	33,053,000	33,750,000	127
Chowan	97	70,723,000	46,585,000	51,237,000	36,240,000	151
Currituck	89	25,874,000	18,220,000	18,324,000	16,928,000	151
Dare	32	1,128,000	1,567,000	1,177,000	1,426,000	62
Gates	141	66,817,000	72,883,000	52,774,000	50,365,000	233
Hyde	138	133,411,000	117,383,000	103,107,000	94,315,000	233
Pasquotank	126	69,025,000	48,819,000	45,614,000	41,278,000	186
Perquimans	149	98,805,000	70,577,000	78,334,000	52,287,000	228
Tyrrell	68	59,551,000	43,561,000	41,156,000	26,132,000	101
Washington	141	68,365,000	49,046,000	51,112,000	42,813,000	202
Albemarle Region (Total)	**1,062**	**642,612,000**	**508,573,000**	**475,888,000**	**395,534,000**	**1,674**

Source: (USDA 2017)

Table 20. Number of Livestock Farm Operations in the Albemarle Region

County	Cattle (including calves)	Chickens	Hogs	Sheep (including lambs)	Total
Camden	709	868	12	178	1,767
Chowan	1,117	5	4	183	1,309
Currituck	243	319	1	0	563
Dare	8	0	0	28	36
Gates	439	15	14	17	485
Hyde	348	1	0	0	349
Pasquotank	598	261	822	52	1,733
Perquimans	1,130	121	1	199	1,451
Tyrrell	752	1	0	0	753
Washington	916	321	2	134	1,373
Albemarle Region (Total)	**6,260**	**1,912**	**856**	**791**	**9,819**

Source: (USDA 2017)

Table 21. Types of Crops Grown in the Albemarle Region

County	Corn	Cotton	Hay	Oats	Peanuts	Potatoes	Sorghum	Soybeans	Sweet Potatoes	Tobacco	Wheat
Camden	X	X	X	X		X	X	X			X
Chowan	X	X	X			X	X	X	X	X	X
Currituck	X		X		X	X	X			X	
Dare	X		X			X		X			
Gates	X	X	X	X	X			X	X		X
Hyde	X	X	X			X	X	X	X		X
Pasquotank	X	X				X	X	X	X		X
Perquimans	X	X	X	X	X	X	X	X			X
Tyrrell	X	X	X			X	X	X	X		X
Washington	X	X	X		X	X	X	X	X	X	X

Source: (USDA 2017)

E. Development Trends and New Development

Understanding population and development trends can assist in planning for future development and ensuring appropriate mitigation, planning, and preparedness measures are in place to protect human health and community infrastructure. Land use and development trends significantly impact exposure and vulnerability to various hazards. For example, significant development in a hazard area increases the building stock and population exposed and potentially vulnerable to that hazard.

Predicting long-term development within the Albemarle Region is difficult. However, as population growth is expected in the region, new development can be expected to meet residential and commercial needs. Population growth is expected to be focused in Currituck and Dare County, so the majority of new development will likely take place in these counties.

IV. REGION'S STRENGTHS AND CHALLENGES RELATED TO RESILIENCE

The Albemarle Region is impacted by a wide variety of natural- and human-caused hazards. The Stakeholder Partnership worked with the Regional Team to identify hazards of concern that present immediate and long-term concerns and include episodic events (such as hurricanes) and more gradual increases and incremental forms of risk (such as sea level rise).

A. Regional Climate Hazard Overview

Unlike hazard mitigation plans, which develop actions to be implemented in the near-term (usually within five years) and usually are developed on the county scale, this planning effort is meant to identify and address regional resilience issues on a longer time scale to include sudden natural disasters, such as hurricanes and floods, and long-term concerns.

For the Albemarle Region, the Stakeholder Partnership agreed to include the following hazards of concern for this vulnerability assessment:

- Erosion
- Extreme temperature
- Flood
- Invasive species
- Hurricane and severe storms
- Water quality issues

B. Significant Non-Climate Stressors

Before considering climate hazard impacts, it is important to note the current adaptive capacity of the Albemarle Region. There are various non-climate stressors in place in the Albemarle Region that increase the likelihood of negative impacts from climate related hazard events.

The Albemarle Region is home to a large socially vulnerable population. Thirteen percent of the residents of the Albemarle Region live below the poverty line. Roughly 16 percent of residents in the Albemarle Region population have a disability. Approximately 5 percent of the Albemarle Region population is under 5 years old and about 20 percent of the population is over 65 old. Residents with social vulnerabilities are at high risk for impacts during hazard events. These populations may also have limited ability to make changes to their normal behavior when threatened by a hazard and are likely to have lower capability to invest in improvements to their businesses or property to protect from hazard damages.

The Albemarle Region is likely to see long term population increases focused in Currituck County and Dare County. Each county is located on the Atlantic shoreline and is likely to see greater impacts from coastal hazards such as erosion, storm surge, and winds from coastal storms as the population and associated development increases.

The Albemarle Region has a large number of buildings constructed before modern building code requirements. Many standards within the modern building code are designed to prevent likely impacts from climate hazards such as reinforcement of walls to protect from wind damage and building elevation requirements to reduce flood risk. An older building stock is less likely to be able to withstand climate related stressors.

Like many areas across the country, current stormwater infrastructure is beginning to degrade as it reaches the end of its typical useful life. Stakeholders noted failing stormwater infrastructure was as a concern in many areas throughout the region. As stormwater infrastructure degrades, it becomes less effective and is prone to failure. This aging process is exacerbated by the increase in intense rainfall already taking place in the region.

C. Regional Strengths and Advantages in Relation to Climate Resilience

While the Albemarle Region has significant current and future risk to climate related hazards, the region benefits from a variety of resources that are in place to increase resiliency including:

- **North Carolina Office of Recovery and Resiliency (NCORR):** In the wake of Hurricane Florence in 2018, the State of North Carolina established the Office of Recovery and Resiliency to lead the state's efforts in rebuilding smarter and stronger. Additional funding is provided through the State Disaster Recovery Acts of 2017 and 2018, the Storm Recovery Act of 2019, and the Economic Development Administration Disaster Supplemental Funds. NCORR manages programs statewide that include homeowner recovery, infrastructure, affordable housing, resiliency, and strategic buyouts. To learn more about NCORR programs, visit the ReBuild.NC.Gov website. NCORR is a division of the Department of Public Safety.
- **Albemarle Commission:** The Albemarle Commission works to address regional needs and is instrumental in the development and/or enhancement of regional infrastructure; industrial recruitment business development, labor force development, travel and tourism, community reinvestment /rehabilitation, and health and human services.
- **Stakeholders:** A diverse and engaged group of stakeholders which supported this vulnerability assessment and will help to develop the portfolio of projects to increase resiliency. Stakeholders include local organizations, academia representatives, and community leaders. Many stakeholders noted prior and current participation in efforts to increase resiliency.
- **County and municipal governments:** According to comments from stakeholders, the Albemarle Region is comprised of numerous county and municipal governments that are dedicated to resiliency efforts within their jurisdictions. Several county and municipal governments are represented on the Stakeholder Partnership.

Various state and local laws exist to help reduce the impacts of current and future hazards. As an example, all counties in the Albemarle Region are subject to the rules and policies of the Coastal Resources Commission which administers the Coastal Area Management Act (CAMA). The purpose of CAMA is to protect the unique natural resources of the North Carolina coastal areas. Areas of Environmental Concern (AECs) are the foundation of the CAMA regulations. An AEC is an area of natural importance; it may be easily destroyed by erosion, flooding or it may have environmental, social, economic or aesthetic value. Generally, property is within an AEC if it is:

- In or on navigable waters;
- On marsh or coastal wetlands;
- Within 75 feet of the mean high-water line along an estuarine shoreline;
- Near the ocean beach;
- Near an inlet;
- Within 30 feet of the north high-water level of areas designated as inland fishing waters by the North Carolina Marine Fisheries Commission; or

- Within 575 feet of the mean high-water line along an ORW (Outstanding Resource Waters) shoreline.

Construction activities on properties within an AEC require CAMA permits prior to the application for flood development and building permits. This helps to restrict development in areas prone to erosion and flooding.

D. Known Investment or Planning Efforts Underway

Each county in the Albemarle Region has a hazard mitigation plan, either individually or as part of a regional effort. Hazard mitigation plans identify short term needs to protect from natural hazards and identify mitigation actions. Occasionally, the plans will also address human caused hazards. These mitigation plans are developed with the intent to implement actions within five-years, the effective period of the plan. This planning effort allows for the identification of problems, development of actions, and opportunity to carry out or revise the developed mitigation strategy on a five-year basis. Portions of the Albemarle Region are covered by:

- Outer Banks Hazard Mitigation Plan
- Albemarle Hazard Mitigation Plan
- Northeastern North Carolina Hazard Mitigation Plan

The region is also covered under the State of North Carolina Hazard Mitigation Plan.

Additional recent planning efforts that have identified pathways to resilience in the region that were reviewed for this assessment include:

- 2020 North Carolina Climate Risk Assessment and Resilience Plan (2020)
- Financial Risk of Flooding in Eastern North Carolina (2021)
- Albemarle Commission Comprehensive Regional Economic Development Strategy, 2018-2022 (2017)
- Currituck Water Quality Enhancement Study (2006)
- Hurricane Matthew Resilient Redevelopment Plan, Camden County (2017)
- Camden County Stormwater Management Report (2012)
- Camden County Transportation Plan (2014)
- Hurricane Matthew Resilient Redevelopment Plan, Chowan County (2017)
- Hurricane Matthew Resilient Redevelopment Plan, Currituck County (2017)
- Currituck 2040 Vision Plan (2019)
- Currituck County Comprehensive Transportation Plan (2012)
- Currituck Corridor Plan (1994)
- Currituck Water Quality Enhancement Study (2006)
- Currituck Parks and Recreation Master Plan (2011)
- Hurricane Matthew Resilient Redevelopment Plan, Dare County (2017)
- Hurricane Matthew Resilient Redevelopment Plan, Gates County (2017)
- Hurricane Matthew Resilient Redevelopment Plan, Hyde County (2017)
- Hurricane Matthew Resilient Redevelopment Plan, Northeast Region (2017)
- Hyde County 2012 Transportation Plan (2012)
- Hurricane Matthew Resilient Redevelopment Plan, Pasquotank County (2017)
- Hurricane Matthew Resilient Redevelopment Plan, Perquimans County (2017)

- Hurricane Matthew Resilient Redevelopment Plan, Tyrrell County (2017)
- Comprehensive Transportation Plan, Tyrell County (2012)
- Hurricane Matthew Resilient Redevelopment Plan, Washington County (2017)
- Tar River Basin Flood Analysis and Mitigation Strategy Study (2018)

Various regular maintenance activities to combat climate related hazards take place throughout the region including dredging of channels, beach nourishment, and maintenance of stormwater infrastructure while localized improvement projects such as installation of bulkheading, elevation of homes, and improvements to natural floodplain functions.

E. Recovery Processes and Challenges

The Albemarle Region has been impacted by numerous natural disasters. Each event has had unique recovery challenges. The ordeals of experiencing an event and then attempting to regroup, rebuild, and return to pre-event conditions can result in substantial mental stress (NC Department of Health and Human Services [NCDHHS] 2015). As climate change increases the frequency of damaging events, mental health struggles are likely to climb in the Albemarle Region.

Hurricane Matthew was one of the more impactful hazards the Albemarle Region has faced in recent years. As a result of widespread impacts, the Disaster Recovery Act of 2016 tasked North Carolina Emergency Management with facilitating the creation of resilient redevelopment plans for the 50 counties included in federal disaster declarations for Hurricane Matthew. Hurricane Matthew Resilient Redevelopment Plans were developed for each county in the region. These plans discussed impacts to housing, economic development, infrastructure, agriculture, and the local environments and identified strategies for resilient redevelopment.

Challenges identified in stakeholder and public meetings for the region included:

- Slow recovery time after severe hazards;
- Lack of funding to implement projects;
- Limitations in the occurrence of higher standards in local and state legislation (building codes and ordinances) to guide safer development practices;
- Increasing frequency and severity of hazard events;
- Failing stormwater systems;
- Inflow and infiltration issues of sewer lines; and
- Lack of public understanding for the full range of potential impacts from hazards.

Additional public comments were identified from a prior planning effort to develop the North Carolina Climate Risk Assessment and Resilience Plan. During that planning effort, the North Carolina Department of Environmental Quality held a northeast regional resilience workshop in Elizabeth City. Comments on recovery challenges included”

- The many long-term management challenges (stormwater drainage/impervious surface, flooding, water quality, affordable housing, septic system function, population/workforce loss, degrading habitat quality, etc.) have been exacerbated by recent historic and extreme weather such as Hurricanes Matthew and Florence and Tropical Storm Michael.
- Damages to the agriculture industry leads to increased prices for consumers.
- Socially vulnerable populations (e.g., elderly, disabled, low-income, communities of color, non-English speaking) suffer the greatest economic and public health-related impacts from both

disasters and long-term stressors and are less able to adapt to changes on their own (NCDEQ 2020).

The North Carolina State Disaster Recovery Task Force has also noted that the ability to find, build, or rehabilitate adequate affordable. housing is a massive challenge for disaster recovery (North Carolina State Disaster Recovery Task Force 2020).

F. Key Gaps in Data and Understanding

Key gaps in data and understanding that were identified during public and stakeholder meetings included:

- Lack of stormwater modeling to determine future stormwater management needs;
- Lack of combined modeling of combined rainfall and storm surge flooding events;
- Limited water quality sampling;
- Mapping of anticipated development areas; and
- Lack of understanding of risk to the military and National Guard uses of the Albemarle Region (most information unavailable due to security concerns).

V. DROUGHT

A. Hazard Description

Drought is a period characterized by long durations of below-normal precipitation. Drought conditions occur in virtually all climatic zones, yet characteristics of drought vary significantly from one region to another relative to normal precipitation within respective regions. Drought can affect agriculture, water supply, aquatic ecology, wildlife, and plant life. Drought is a temporary irregularity in typical weather patterns and differs from aridity, which reflects low rainfall within a specific region and is a permanent feature of the climate of that area. Climate change may lead to longer dry seasons and multi-year droughts, and it is likely that future droughts in their multiple forms will be more frequent and severe (NC Climate Science Report 2020).

The Albemarle Region regularly experiences periods of drought. Due to the size of the region, the severity of drought has varied across the region. From 2000–2018, Gates County experienced 11 weeks of extreme drought, while Tyrell County only experienced 1 week.

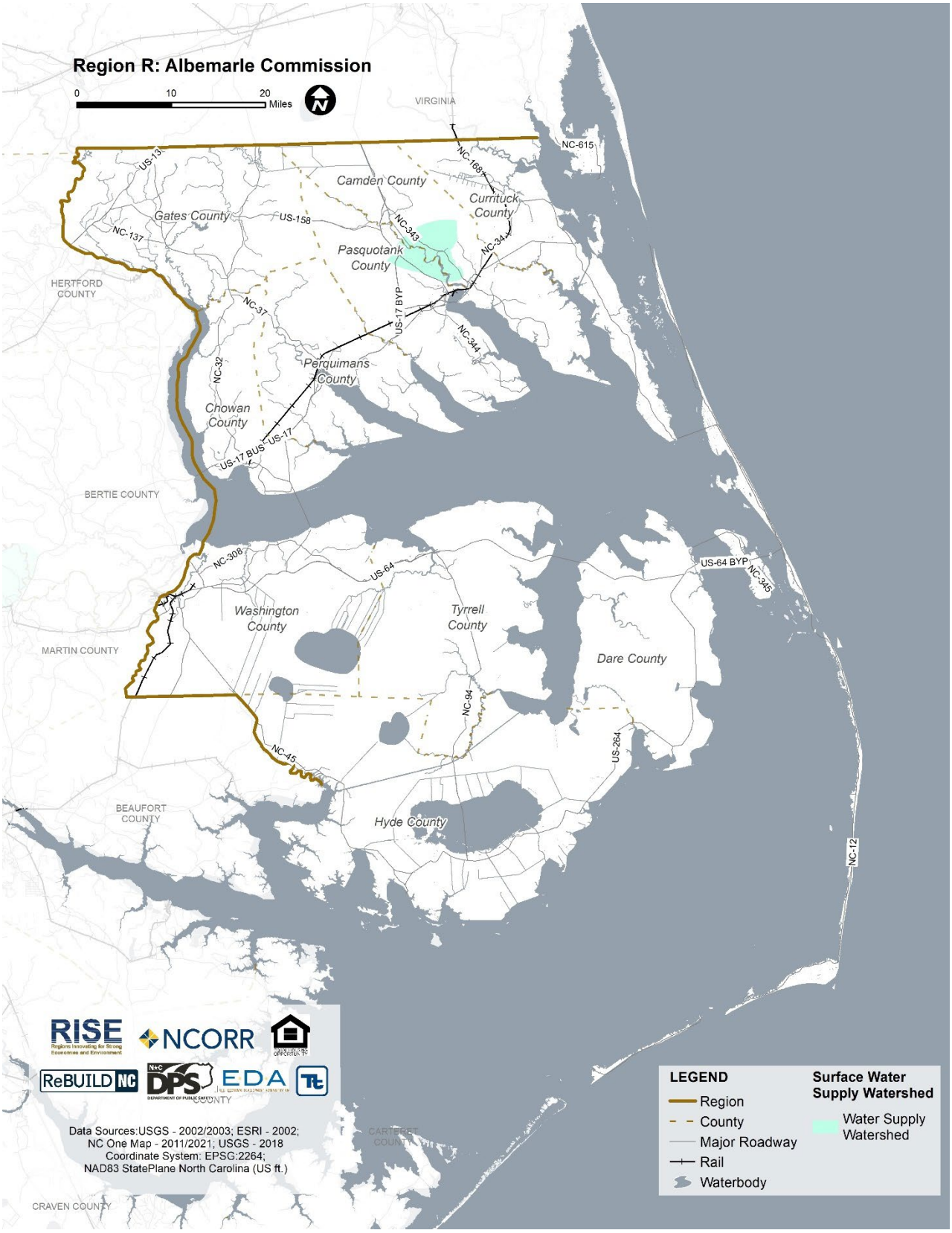
Occurrence of drought has also ranged dramatically across the region. Currituck County experienced drought 67 percent of the time from 2000–2018, while neighboring Dare County only experienced drought 32 percent of the time. Drought has resulted in impacts to agriculture and water use restrictions (Albemarle Regional HMP 2020, Northeastern North Carolina HMP 2020, Outer Banks Regional HMP 2020).

B. Location and Extent

Droughts are a natural part of the North Carolina climate. The higher frequencies of historical very hot days correspond to periods of exceptionally dry weather in the Albemarle Region (NCICS 2020). However, drought conditions can also be present in winter. Droughts can impact portions or the entirety of the Region based upon precipitation patterns.

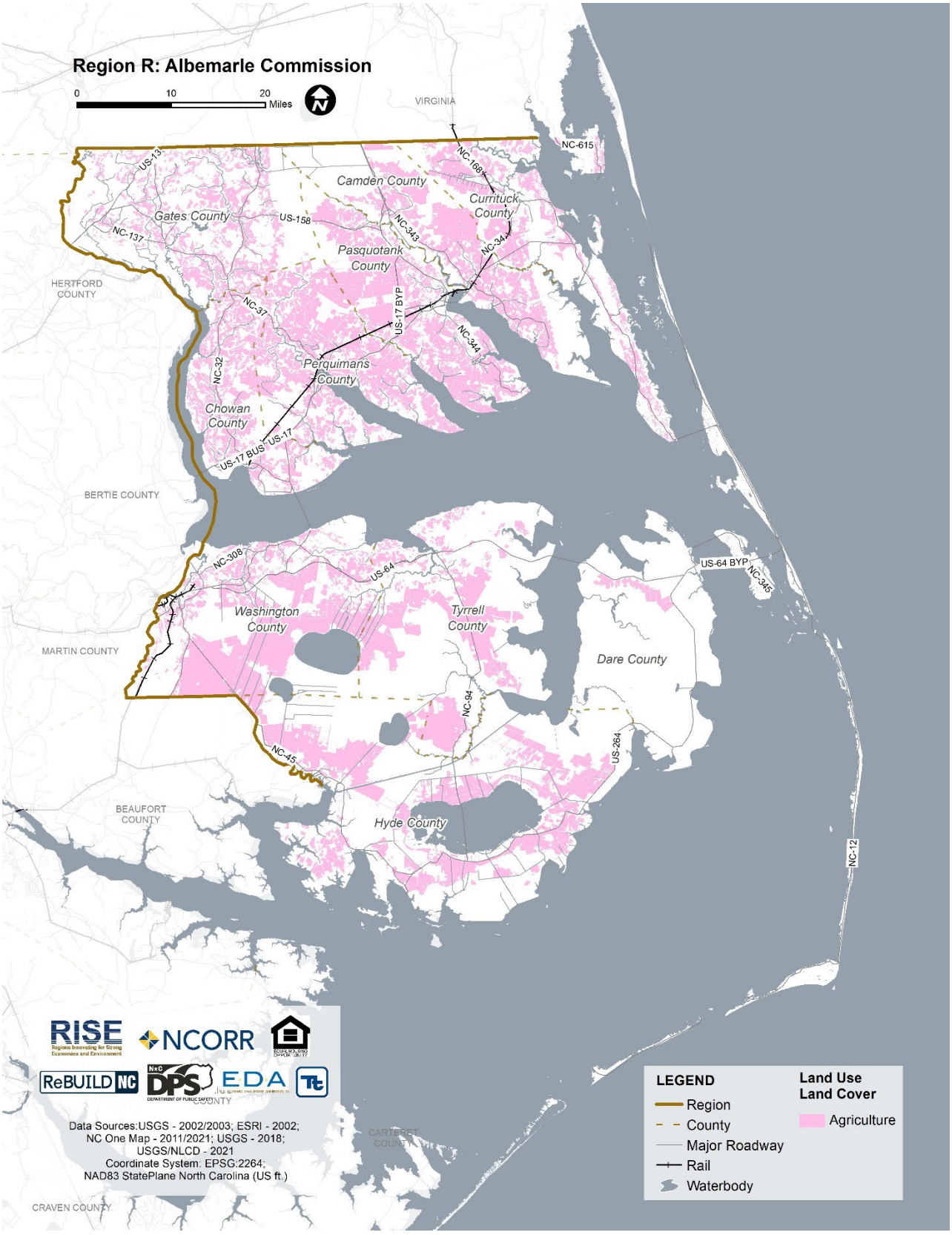
Locations that rely on surface water supply are at higher risk to the impacts of drought than those areas that rely primarily on groundwater supply. In the Albemarle Region, the locations reliant on surface water are limited to the area just north of Elizabeth City along the Pasquotank River (See ***Figure 12***).

Figure 12. Surface Water Supply Watersheds in the Albemarle Region



The Albemarle Region is home to a large agricultural industry, which is heavily reliant on existing water resources. Drought can cause a lessened crop yield; wildlife and livestock may become undernourished; land values could decrease; and ultimately, there could be a financial loss for the farmer (International Panel on Climate Change [IPCC] 2016). ***Figure 13*** displays the agricultural lands in the Albemarle Region. With the exception of Dare County, which is dominated by wetlands and barrier islands that are unsuitable for farming, agriculture is one of the dominant land uses in each county.

Figure 13. Agricultural Lands in the Albemarle Region



C. Climate Change Impacts

Climate change may increase the frequency and severity of droughts in the region. Future droughts are projected to be warmer than historical events. The warmer conditions will lead to rapid drying through increases in potential evapotranspiration. Thus, it is likely that future droughts in their multiple forms will be more frequent and severe in terms of soil moisture deficits and the impacts on rainfed agriculture and natural vegetation (NC Climate Science Report 2020). Warmer temperatures may lead to longer dry seasons and multi-year droughts (United States Department of Agriculture [USDA] 2012).

D. Impact on Social Vulnerability and Equity, Health, and Safety

The entire population of the Albemarle Region is exposed to drought. Drought conditions can cause a shortage of potable water for human consumption, both in quantity and quality. A decrease in available water may also impact power generation and availability to residents. While there are no hydroelectric dams located within the Albemarle Region, there are many hydroelectric dams in North Carolina, including several located in nearby counties, which could potentially impact the Albemarle Region (National Hydropower Association [NHA] 2022).

Public health impacts may include an increase in heat-related illnesses, waterborne illnesses, recreational risks, and limited food availability. Vulnerable populations could be particularly susceptible to impacts from droughts due to age, health conditions, and limited ability to mobilize to shelter, cooling, and medical resources. Other possible impacts to health due to drought include increased recreational risks; effects of air quality; diminished living conditions related to energy limitations (lack of power for Heating, Ventilation, and Cooling [HVAC] systems, etc.), sanitation, and hygiene; compromised food and nutrition; and increased incidence of illness and disease. Health implications of drought are numerous. Some drought-related health effects are short-term, while others can be long-term (CDC 2021).

Reduced precipitation during prolonged drought periods contribute to increased fine and coarse particulate matter in the air. Because precipitation is not regularly removing fine and coarse particulate matter, drier soil and roadways can generate more dust. Poor air quality during droughts may result in a greater number of poor air quality alert days, and have an increased impact on people with asthma, and a higher number of respiratory-related emergency department visits (NC Department of Health and Human Services [NCDHHS] 2015).

Agricultural workers are most likely to be negatively impacted financially by drought, increasing social vulnerability. Farms employ 1,674 workers in the Albemarle Region. According to the USDA, 91 percent of all farms in the Albemarle Region are family-run (USDA 2017).

E. Impact on Housing, Critical Infrastructure and Community Support Systems

While associated drought events do not cause impacts on buildings or critical infrastructure, limited water supply can put stress on critical services such as drinking water supply and water supply for firefighting.

F. Impact on Economy

A prolonged drought can have a serious economic impact on a community. One impact of drought is its impact on water supply. When drought conditions persist with little to no relief, water restrictions may be put into place by local or state governments. These restrictions may include placing limitations on when or how frequently lawns can be watered, car washing services, or any other recreational/commercial

outdoor use of water supplies. In exceptional drought conditions, the watering of lawns and crops may not be an option. If crops are not able to receive water, farmland will dry out, and crops will die. This drought impact can lead to crop shortages, which, in turn, increases the price of food (NC State University 2013).

Increased demand for water and electricity can also result in shortages and higher costs for these resources. Industries that rely on water for business could be impacted the most (e.g., landscaping businesses reducing regularity for lawn cutting). Although most businesses will still be operational, they may be impacted aesthetically. These aesthetic impacts are most significant within the recreation and tourism industry. Moreover, droughts within areas outside of the Albemarle Region could still impact the food supply and price of food for residents within the region.

Direct impacts of drought include reduced crop yield, increased fire hazard, reduced water levels, and damage to wildlife and fish habitat. The many impacts of drought can be listed as economic, environmental, or social. Direct and indirect losses include the following:

- Damage to crop quality and crop losses
- Insect infestation leading to crop and tree losses
- Plant diseases leading to loss of crops and trees
- Reduction in outdoor activities, including those related to tourism
- Increased risk of brush fires and wildfires due to dried crops, grasses, and dying trees

When a drought occurs, the agricultural industry is most at risk in terms of economic impact and damage. For example, crops may not mature, leading to a lessened crop yield; wildlife and livestock may become undernourished; land values could decrease; and ultimately there could be a financial loss for the farmer (International Panel on Climate Change [IPCC] 2016). Based on the 2017 Census of Agriculture, there were 1,062 farms in the Albemarle Region. The average farm size was 594 acres. Albemarle Region farms had a total market value of products sold of $508.5 million (USDA 2017). ***Table 22*** summarizes the agricultural components exposed to the drought hazard.

Table 22. Agriculture in the Albemarle Region

County	Number of Farms	Land in Acres	Market Value of Products Sold ($)	Total Producers (workers) *data collected for a maximum of four producers per farm
Camden	81	59,239	39,932,000	127
Chowan	97	53,528	46,585,000	151
Currituck	89	44,834	18,220,000	151
Dare	32	5,342	1,567,000	62
Gates	141	57,985	72,883,000	233
Hyde	138	124,874	117,383,000	233
Pasquotank	126	72,174	48,819,000	186
Perquimans	149	80,322	70,577,000	228
Tyrrell	68	52,946	43,561,000	101
Washington	141	79,680	49,046,000	202
Albemarle Region (Total)	**1,062**	**630,924**	**508,573,000**	**1,674**

Source: (USDA 2017)

G. Impact on Natural Environmental Systems

Drought can impact the environment because these events can trigger wildfires, increase insect infestations, and exacerbate the spread of disease (International Panel on Climate Change [IPCC] 2016). Droughts will also impact water resources relied upon by aquatic and terrestrial species. Ecologically sensitive areas, such as wetlands, can be particularly vulnerable to drought periods because they are dependent on steady water levels and soil moisture availability to sustain growth. As a result, these types of habitats can be negatively impacted after long periods of dryness (New Jersey Department of Environmental Protection [NJDEP] 2017).

Direct and indirect environmental impacts include the following:

- Insect infestation leading to crop and tree losses
- Plant diseases leading to loss of crops and trees
- Increased risk of brush fires and wildfires due to dried crops, grasses, and dying trees

H. Impact on Historical and Cultural Resources

Historical and cultural buildings are unlikely to be impacted by drought. However, outdoor cultural events and assets such as farmers markets and parks, are likely to be negatively impacted by dead or dying crops and vegetation.

I. Cascading Impacts

Droughts can cause deficits in surface and groundwater used for drinking water. Drought also has the potential to lead to water pollution due to the lack of rainwater to dilute any chemicals in water sources. Contaminated water supplies may be harmful to plants and animals. While non-point source pollution regularly moves into waterways through runoff, extended periods of dry weather can result in a buildup of non-point source pollutants that wash into waterways at a high volume after the first rainfall, causing more detrimental impacts than normal. For more information on water quality issues, refer to ***Section XI***. If water is not getting into the soils, the ground will dry up and become unstable. Unstable soils increase the risk of erosion and loss of topsoil (NC State University 2013).

Drought increases the risk of wildfire. For example, drought worsened the 2008–2009 Pocosin Lakes National Wildlife Refuge wildfire. Dry conditions allowed peat soil to burn, increasing the fire's severity and allowing the fire to spread underground (North Carolina Department of Public Safety [NCDPS] 2018). For more information on water quality issues, refer to ***Section XI***.

J. Future Changes that May Impact Regional Vulnerability to Hazard

Projected Development

Additional development increases the demand on water resources for water and wastewater utilities.

Projected Changes in Population

The North Carolina Office of State Budget & Management (NCOSBM) projects that the Albemarle Region will see population growth through 2050, with an expected increase in population of 38,271 or 22.2 percent (NCOSBM 2022). Population increases may create greater strain on water resources throughout the Albemarle Region.

K. Key Gaps in Data and Understanding

Key gaps in data and understanding that were identified during review of available scientific information and public and stakeholder meetings included:

- An analysis of the impact of drought by sub-regions would allow for better targeting of mitigation techniques.
- Drought's impact on agriculture is assessed based on drought having impacts on all sectors of the agriculture industry in the region. Better understanding of the ability of current and future agricultural practices to withstand drought conditions is needed to determine vulnerability more accurately.
- The analysis of the secondary impacts of long term drought on other sectors besides agriculture and tourism would allow for better understanding of risk.
- Analysis of anticipated future development/land use would allow for better understanding of future water needs in the region and where drought impacts are likely to be felt strongest (agriculture, landscaping, etc.).

VI. EROSION

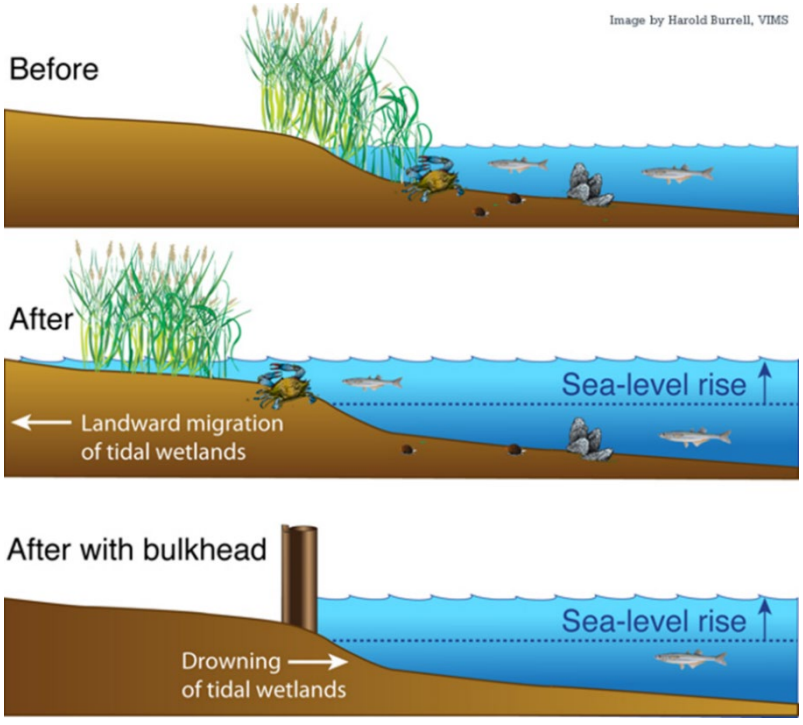
A. Hazard Description

Coastal erosion is one of the primary coastal hazards leading to loss of lives or damage to property and infrastructure in coastal areas. Many natural factors affect erosion of the shoreline, including shore and nearshore morphology, shoreline orientation, and the response of these factors to storm frequency and sea level rise. Coastal shorelines constantly change in response to wind, waves, tides, sea-level fluctuation, seasonal and climatic variations, human alteration, and other factors that influence the movement of sand and material within a shoreline system. Stronger storms and sea level rise are likely to exacerbate coastal erosion.

Erosion continually shapes the shorelines of the Albemarle Region, but large events can result in drastic changes and impacts. In the past 20 years, the most impactful erosion event to impact the region was likely Hurricane Isabel on September 17 and 18, 2003. Dare and Currituck County incurred roughly $347 million in property damage, much of which was attributed to erosion-specific damage. Highway 12 was destroyed near Rodanthe due to the ocean over-wash (NOAA NCEI 2022).

Wetlands also experience gradual and sudden erosion and are affected by the long-term impacts of sea level rise. As sea level rises, wetlands are more prone to erosion along their edges and may experience marsh migration, where low-lying marsh converts to open water and marshes slowly take over upland areas to account for changes in water elevation. This coastal erosion process may be exacerbated by flood and erosion protective structures. Marsh erosion and marsh migration have been sited within the region. ***Figure 14.*** Wetlands Migration and the Impact of Shoreline Protection below provides a representation of how seal level rise impacts wetlands migration and shoreline protection.

Figure 14. Wetlands Migration and the Impact of Shoreline Protection



Source: (Burrell, Harold 2009)

B. Location and Extent

The Albemarle Region is dominated by coastal estuaries. On the oceanfront and sandy shorelines, the region can experience gradual erosion from constant wind, wave, and tidal exposure as well as sudden erosion from large storms. Long-term and sudden erosion of the oceanfront is well documented within the region.

Long-term erosion rates throughout the Albemarle Region vary significantly because of geology and the physical nature of different locations along the shoreline. Although structural and other measures can be taken to reduce the impact or frequency of this hazard, all shorelines in the Albemarle Region are vulnerable to erosion. The properties most at risk to coastal erosion will be those located within 200 feet of the erodible shoreline and beaches.

For inland coastal shorelines, high bank shorelines can experience the loss of large volumes of material while low bank shorelines can experience severe erosion in terms of distance of retreat inland. High-bank shorelines are common in Chowan and Perquimans County. Both counties experience high erosion rates in terms of volume of material lost (Albemarle Regional HMP 2020). Tyrrell County has low bank shorelines and experiences severe erosion at times (Northeastern NC HMP 2020).

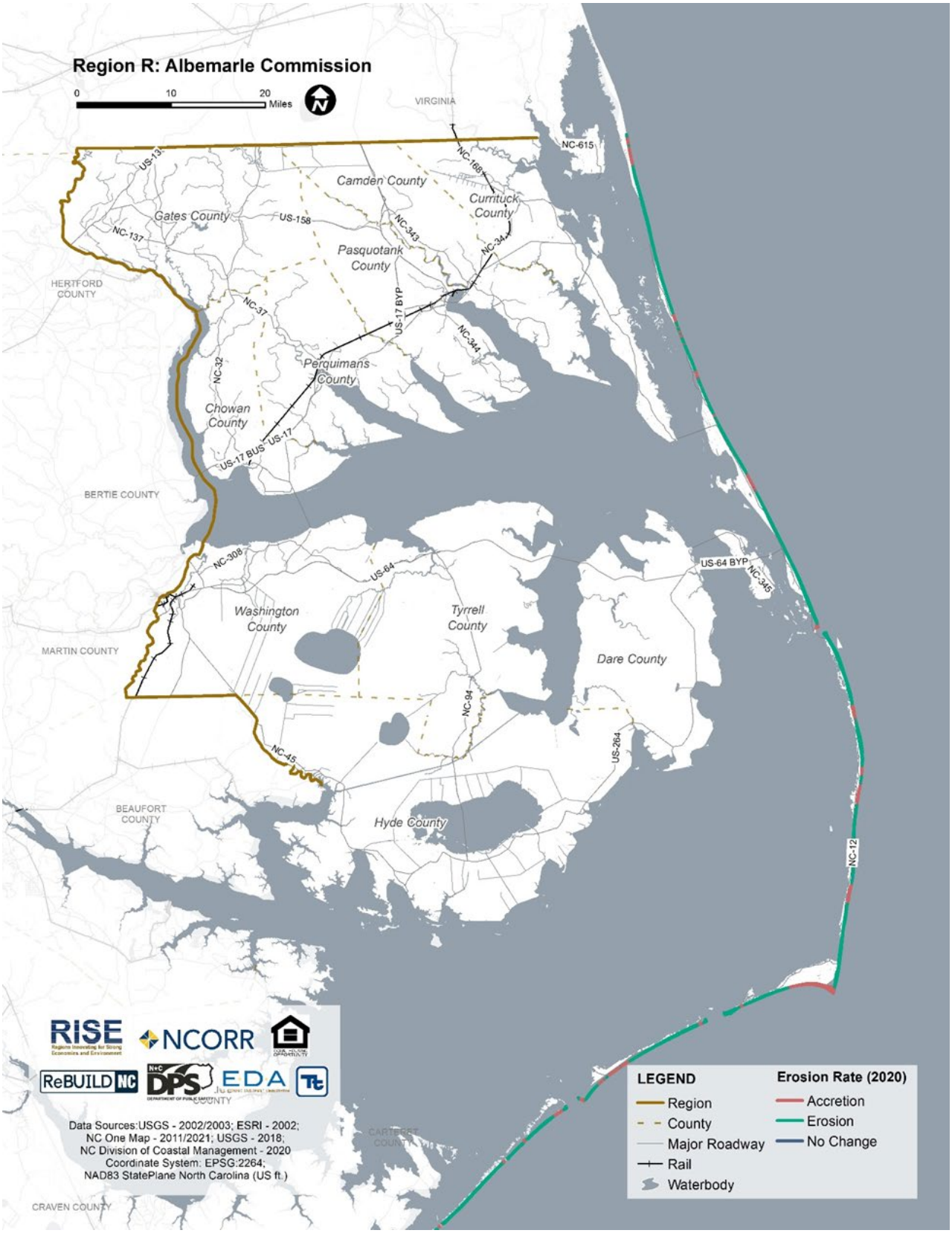
The Atlantic Ocean shorelines of the Albemarle Region are characterized by barrier islands with dune systems. Barrier islands are notably prone to large impacts from erosion. Erosion is responsible for the position and shape of most barrier islands outside of human influence. Longshore transport of eroded sediment can result in the migration of a barrier island or barrier spit, typically with one end of the island or spit lengthening due to accretion. Currituck County and Dare County include 130 miles of barrier island oceanfront shoreline, which can be impacted by wave action and littoral drift (Dare County, NC 2020). Wash overs, where wave action breaches the dune line and pushes inland, are a concern for barrier islands and occur when waves cut away the beach resulting in breaches that connect the ocean water to the bay area. These have occurred on the Outer Banks during major storms. The Albemarle Region is home to numerous shoreline structures meant to disrupt erosion along the Atlantic Ocean, Albemarle Sound, Pamlico Sound, and coastal rivers and tributaries, including groins and bulkheads.

One of the major impacts of erosion processes is the permanent breaching or creation of inlets along barrier beaches and islands. Stabilized inlets provide benefits for recreational and commercial navigation in the region. Stakeholders noted that these inlets are often impacted by shoaling caused by deposition of sediment that has been eroded from nearby beaches. This shoaling can create dangerous conditions for boaters.

The North Carolina Division of Coastal Management uses erosion rate maps and setback factors to regulate development. North Carolina's oceanfront construction setback factors are calculated using the long-term (approximately 50 years) average annual shoreline change rates for establishing oceanfront construction Setback Factors and Ocean Erodible Areas of Environmental Concern, which were initially established by the Coastal Resources Commission (CRC) under the Coastal Area Management Act (CAMA) in 1979. Oceanfront construction setback is measured landward from the first line of stable natural vegetation or a static vegetation line when applicable. Setback distance is determined by two variables: (1) the size of a structure and (2) a setback factor based on shoreline position change rates (North Carolina Department of Environmental Quality [NCDEQ] 2019).

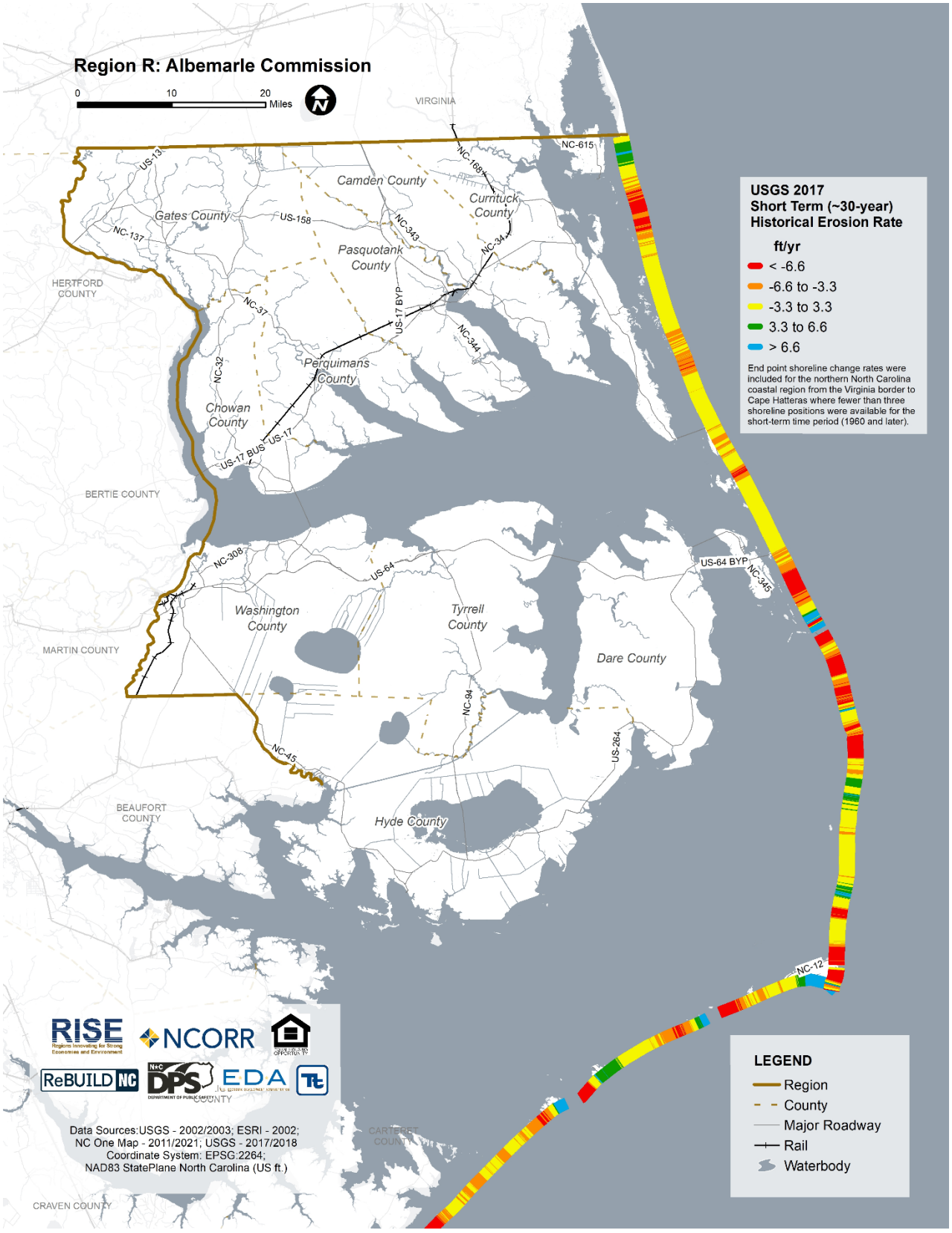
Locations that have historically experienced erosion and accretion in the Albemarle Region's Atlantic Ocean shorelines are shown in ***Figure 15***. Overall, the majority of Atlantic Ocean shorelines in the region are experiencing erosion, though small areas of accretion can be found sporadically, with one larger area just west of Cape Hatteras.

Figure 15. Erosion and Accretion on Atlantic Ocean Shorelines in the Albemarle Region



The United State Geological Survey (USGS) Coastal Change Hazards Portal hosts a short-term (30 years) change mapper, which displays the rate of average shoreline change on coastal shorelines. The Portal indicates that, over the past 30 years, the Atlantic Ocean shorelines of the Albemarle Region had various rates of shoreline change ranging from a loss of 3 meters to a gain of more than 2 meters per year. The highest erosional rates (greater than 2 meters per year) are found at Nags Head, Rodanthe, immediately north of Cape Hatteras, and areas near Hatteras Inlet. ***Figure 16*** displays short-term shoreline change rates for the Albemarle Region's Atlantic Ocean shorelines.

Figure 16. Short-Term (30-year) Shoreline Change Rates for the Albemarle Region



Recent Beach Nourishment Activities

To counteract the effects of natural erosion and prevent storms from devastating beachfront communities, numerous counties in North Carolina have worked with the federal government on beach nourishment projects. Beach nourishment is the process by which sand is brought from offshore sand sources and pumped onto a beach by a dredge. The sand is placed according to an engineered plan with specific criteria for a built beach (berm) and storm protection. Projects typically require regular maintenance and renourishment (Town of Duck 2022). Beach nourishment activities have taken place in various locations in the Albemarle Region, including Duck, Kitty Hawk, and Nags Head.

Wetlands Retreat

Although oceanfront erosion provides the most dramatic displays of coastal erosion in the Albemarle Region, coastal erosion can take place on natural shorelines bordering any coastal waterbodies. Coastal wetlands dominate areas along the inland sounds and tributaries in the Albemarle Region. Wetlands can experience episodic erosion when strong storms create enough wave energy on inland waterways to result in scouring the wetlands' edge. A long-term concern for erosion in the Albemarle Region is the gradual retreat or loss of wetlands due to marsh migration because of sea level rise.

Wetlands dominate the Albemarle Region. ***Figure 17*** shows the present day location of wetland areas in the region. ***Figure 18*** shows likely changes in wetlands distribution in 2050 with 1 foot of sea level rise. Many coastal forests are already transitioning from pine, red maple, sweetgum, and bald cypress forests to saltmarsh (Smithsonian 2021). Significant portions of Currituck County, Dare County, Hyde County, and Tyrrell County could see significant acreage in tidal wetlands convert to open water by 2050 with 1 foot of sea level rise.

Figure 17. Wetlands in the Albemarle Region, Present Day

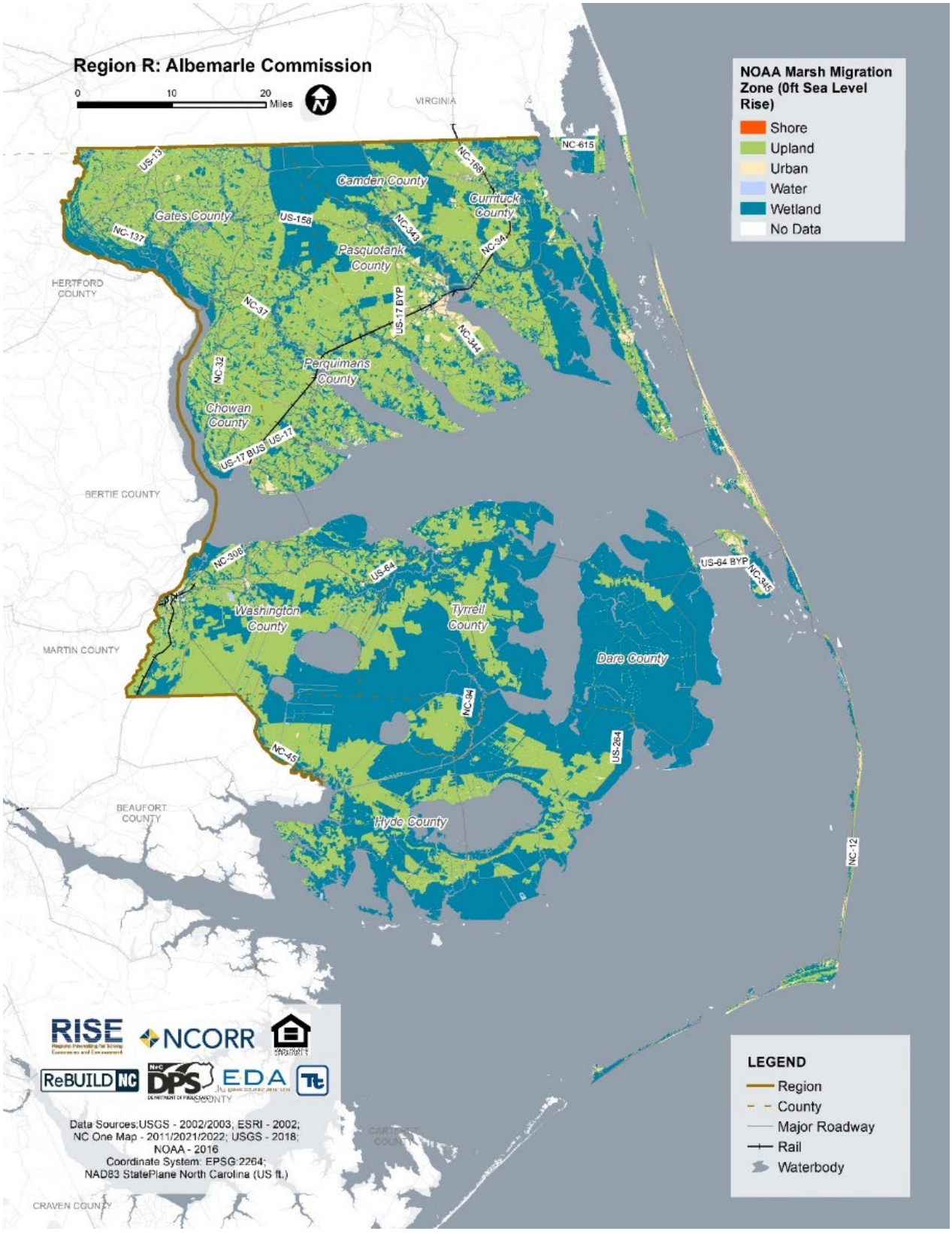
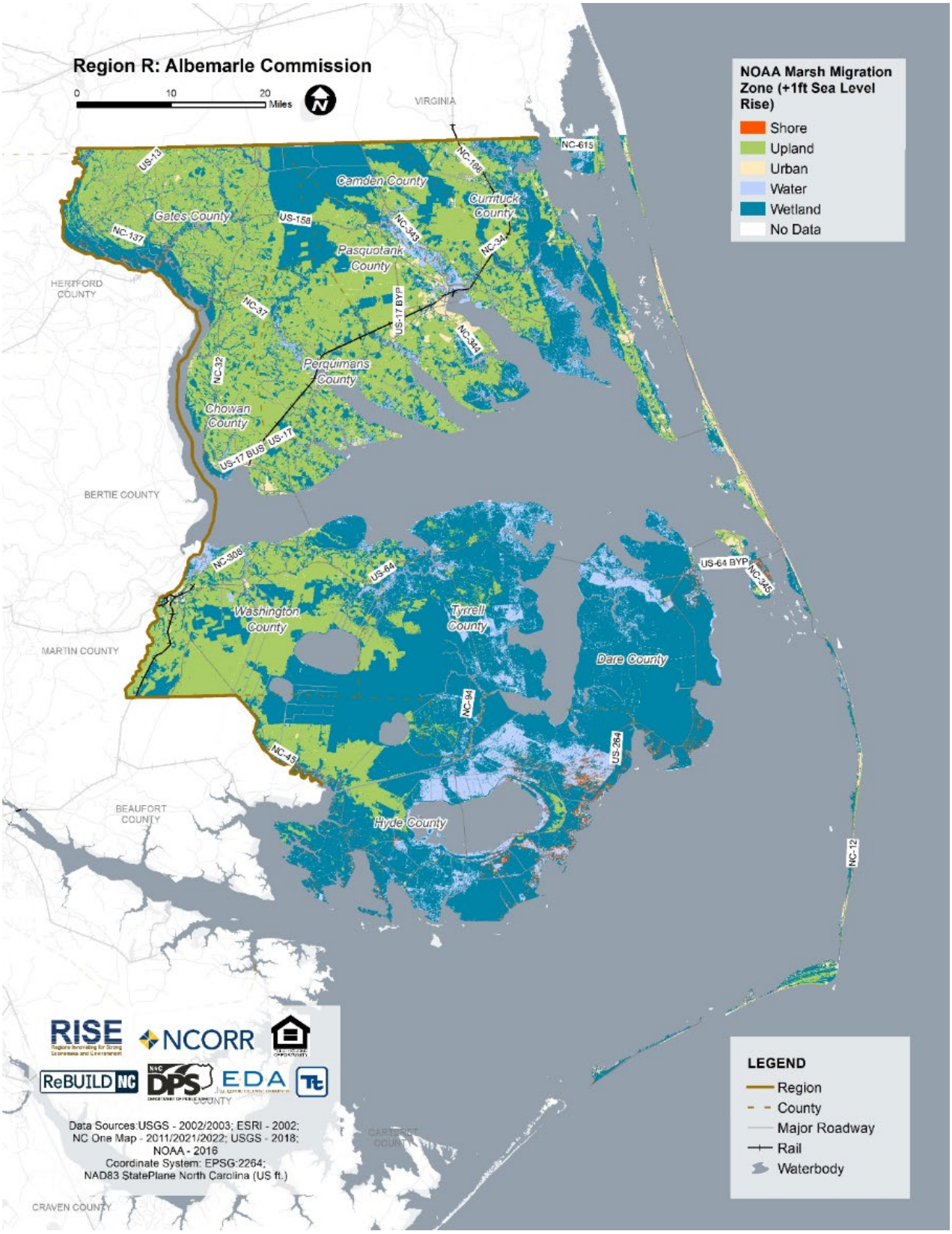


Figure 18. Anticipated Wetland Areas in the Albemarle Region in 2050 Due to 1 Foot of Sea Level Rise



To explore the location specific exposure to the erosion hazard, visit Albemarle Commission Region - Resilience Portfolio Web Map (arcgis.com).

C. Climate Change Impacts

Coastal areas may be impacted by climate change in different ways. These areas are sensitive to sea level rise, changes in the frequency and intensity of storms, increase in precipitation, and warmer ocean temperatures (US Environmental Protection Agency [USEPA] 2017). Temperatures are predicted to increase in the Albemarle Region, which lead to an increase in intensity and frequency of severe storms (NC Climate Science Report 2020). This climate change impact may increase shoreline erosion rates due to the increased frequency and severity of coastal flooding and coastal storms. The most vulnerable coastal landscapes anticipated to experience exacerbated impacts of erosion due to climate change include coastal wetlands and barrier islands.

According to the National Oceanic and Atmospheric Association (NOAA), sea level rise can amplify factors that currently contribute to coastal flooding: high tides, storm surge, high waves, and high runoff from rivers and creeks. Other secondary hazards that could occur along the coast in response to sea level rise include:

- ***Bluff and upland erosion*** – Shorelines composed of older geologic units that form headland regions of the coast will retreat landward with rising sea level. As the sea level rises, the uplands are eroded, and sandy materials are incorporated into the beach and dune systems along the shore and adjacent compartments (Gutierrez et al. 2007).
- ***Overwash, inlet processes, shoreline retreat, and barrier island narrowing*** – As sea level rise occurs, storm overwash will become more likely. Tidal inlet formation and migration will become important components of future shoreline changes. Barrier islands are subject to inlet formation by storms. If the storm surge produces channels that extend below sea level, an inlet may persist after the storm. The combination of rising sea levels and stronger storms can create the potential to accelerate shoreline retreat in many locations. Assessments of shoreline change on barrier islands have shown that barrier island narrowing has been observed on some islands over the last 100 years (Gutierrez et al. 2007).

Erosion of wetlands is closely tied to rates of sea level rise. Current sea level rise rates are exceeding marsh elevation gains, causing wetland loss. Higher rates of sea level rise will result in more rapid wetland conversion to open water and marsh migration.

D. Impact on Social Vulnerability and Equity, Health, and Safety

Coastal erosion is unlikely to have a direct impact on the health and long-term safety of vulnerable populations in the region. However, the loss of natural systems that provide protection or the weakening of protective structures by coastal erosion increases the likelihood of direct impacts by flooding which may impact them economically or their immediate safety during a natural disaster.

Social Vulnerability and Equity

Research has also shown that some human populations may experience exacerbated impacts and prolonged recovery if/when impacted. This recovery is due to many factors, including their physical and financial ability to react or respond during a hazard. Socially vulnerable populations (e.g., low-income populations, persons with disabilities, and the elderly) in the Albemarle Region may be at the greatest

risk to coastal erosion. The cost of interventions to protect properties from coastal erosion risk may financially stress lower- or middle-income residents. Relocating may be difficult because of the expenses and the availability of accessible housing or the time needed to make housing accessible. Structural improvements such as home elevations or breakwaters or bulkheading may not be possible because doing so could render the housing inaccessible (IndyStar 2019).

The population over the age of 65 is also more vulnerable and, physically, may have more difficulty evacuating during severe erosion associated with storm events. They may require extra time or outside assistance, which may not be available during a storm event.

E. Impact on Housing, Critical Infrastructure and Community Support Systems

Erosion can result in the scouring of foundations and eventual collapse if corrective measures or additional protections are not implemented. Any buildings or critical facilities located near shorelines could be impacted by coastal erosion. Those assets located near the oceanfront shoreline have a greater risk to sudden damage and loss from coastal erosion during severe coastal storms with large waves and storm surge. Assets located behind wetlands or shorelines away from the ocean are more likely to experience erosion on an incremental basis, potentially providing more time for mitigation measures to be employed.

If residents relocate away from waterfront property, the low availability and high cost of housing in coastal areas may present a challenge. However, if residents with waterfront property remain to protect their property, they may be required to make structural changes or construct bulkheads or riprap. The cost of these interventions may financially stress lower- or middle-income residents.

Critical Infrastructure

Coastal erosion can degrade the surrounding infrastructure and utility lines, depending on their location on the property. Critical services may be interrupted due to direct damage or damaged transportation corridors that connect these facilities to the community. Roads that are damaged, particularly evacuation routes, may even isolate residents and can prevent access throughout the region to many service providers needing to reach vulnerable populations. Bridges, ferries, and terminals, which may be considered major corridors for essential services and economic activity in the region, are also vulnerable to coastal erosion due to being located along shorelines.

In coastal areas, erosion can damage or result in the temporary suspension of critical infrastructure. Coastal erosion has already resulted in a major infrastructure change in the region. Due to frequent erosion and washover flooding that result in roadway closures, the North Carolina Department of Transportation (NCDOT) is completing a bypass of a section of North Carolina Route 12 by building a 2.4-mile bridge over Pamlico Sound behind the section of Pea Island National Wildlife Refuge in Dare County (NCDOT 2020).

F. Impact on Economy

Rapid coastal erosion, in association with harsh coastal storms, has the potential for financial loss in the local and regional economies. Gradual coastal erosion may also pose a financial risk. These financial risks include but are not limited to general building stock damages and associated tax loss, impacts to utilities and infrastructure, business interruption, and impacts on tourism. In areas that are directly experiencing long-term coastal erosion or are impacted by sudden severe erosion event such as a

hurricane strike, renovations of commercial and industrial buildings may be necessary, disrupting associated services.

Short-term protections, such as using sandbags or bulldozing sand to create a temporary dune or berm or to shore up a building's foundation, can also be costly. Experience in North Carolina for existing beach nourishment efforts and other states has shown that beach nourishment projects can present a feasible alternative to the loss or massive relocation of oceanfront development. Beach nourishment must meet certain criteria and have been historically funded by a federal cost share with state funding sources (North Carolina Department of Environmental Quality [NCDEQ] 2022).

Costs to protect public infrastructure are likely to rise. The previously mentioned North Carolina Route 12 bypass bridge to avoid road closures due to erosion and washover flooding has an estimated cost of $145.33 million (NCDOT 2020). The region will likely see similar infrastructure upgrades and protections enacted to protect from the erosion hazard, especially as the sea level rises.

Coastal erosion can also cause extensive damage to the region's tourism economy. Destruction caused by coastal erosion in parks, beaches, and coastal communities that rely on tourism may experience negative economic consequences should the hazard breach these areas.

The ecosystem services provided by beaches and wetlands, such as water filtration and flood protection, are of economic value since they save money that would otherwise be spent on runoff control, water treatment, and property preservation. In addition, numerous economically important products and activities depend on wetlands. Fish, shellfish, blue crabs, and shrimp – vital to North Carolina's commercial and sports fisheries – use coastal saltmarshes for habitat and food. Wetlands provide an essential link in the life cycle of 75 percent of the fish and shellfish commercially harvested in the U.S., and up to 90 percent of the recreational fish catch (USEPA 2006).

Inland freshwater wetlands also affect estuarine water quality and productivity and can also influence fisheries. Freshwater wetlands in coastal North Carolina also are used for timber production. Many wetland areas, if managed properly, can produce forest products without substantially detracting from their other wetland functions. Hunting, fishing, trapping, and ecotourism are all important to the tourist economy of many coastal counties (North Carolina Department of Environmental Quality [NCDEQ] 2022).

G. Impact on Natural Environmental Systems

The loss of beaches, dunes, wetlands, and other shoreline features would greatly reduce important ecosystem services. Wetland areas and coastal habitats are important habitat for many species and provide other environmental benefits, such as flood mitigation, and may be altered through chronic coastal flood conditions, erosion, and sea level rise.

H. Impact on Historical and Cultural Resources

Erosion can result in the need to abandon historical buildings and cultural assets. Older structures that were built at a safe distance from the shoreline may be exposed to flooding and wave damage due to steady or sudden erosion. An example of this impact is the recent demolition of six historic structures in the Cape Lookout National Seashore. Cape Lookout officials noted that unrecoverable damage occurred and, while these structures were representative of important parts of the area's history, they posed a serious threat to visitors and needed to be demolished (Charlotte Observer 2020).

I. Cascading Impacts

Since altering beach shape and coastal erosion along the Albemarle Region's shorelines could cause changes in land elevation, coastal properties are likely to become more susceptible to flooding. The Federal Emergency Management Agency (FEMA) discusses the relationship between flooding and erosion for coastal communities in the 2018 Coastal Erosion Guidance Document (FEMA 2018). For example, flood map projects for coastal communities are evaluated based on erosion assessments. Estimated flood extents may change based on the level of erosion that has occurred. For more information on flooding, refer to ***Section VIII***.

Loss of wetlands from erosion and wetlands migration increases the likelihood of water quality issues without the natural filtration provided by wetland plants. For more information on water quality issues, refer to ***Section X***.

While wetland migration inland can help to preserve wetland acreage, it comes at the expense of the habitats that wetlands will replace. A study by scientists from Duke University found that more than 10-percent of the tree cover in the Alligator National Wildlife Refuge on the Albemarle-Pamlico Peninsula became ghost forest between 1985 and 2019 (Smithsonian 2021). Ghost forests increase the risk of wildfire. For more information on wildfire, refer to ***Section VII.***

J. Future Changes that May Impact Regional Vulnerability to Hazard

Projected Development

Any areas of growth located in coastal areas could be potentially impacted by coastal erosion. Coastal Area Management Act requirements help to prevent new development in high risk erosion areas. Development in wetlands in North Carolina requires a permit from either the US Army Corps of Engineers (USACE) or the North Carolina Division of Coastal Management. This projected development reduces the likelihood of wetland services being lost due to development (NCDEQ n.d.). However, development bordering wetland areas, such as those on barrier islands, reduces available land for wetlands to retreat and increases the likelihood of wetland loss as the sea level rises.

Projected Changes in Population

The projected population growth of the Albemarle Region (22.5 percent by 2050, or 38,271 people), namely in Currituck County (108.9 percent projected growth) and Dare County (33.3 percent projected growth) is likely to result in increased exposure to natural hazards (North Carolina Office of State Budget and Management 2022). Furthermore, tourism and visitors to the region will continue to occur and likely grow, driving potential growth in the coastal communities and their amenities, exposing more persons and assets to coastal erosion-prone areas.

K. Key Gaps in Data and Understanding

Key gaps in data and understanding that were identified during review of available scientific information and public and stakeholder meetings included:

- A review of the cost-effectiveness of implemented erosion mitigation techniques including hard shoreline stabilization and beach nourishment is needed to determine the likelihood of future protections being implemented within the Albemarle Region.

- Modeling that uses sea level rise projections and future storm occurrence to project future erosional hotspots and likely location of washover and inlet breaches would allow for a more accurate vulnerability assessment and the informing of land use and development decision making.
- Riverine erosion, which involves the scouring of riverbanks by rivers, streams, and creeks, may also be a localized problem in the Albemarle Region in some locations. Riverine erosion is typically found in rivers that have a high rate of flow over changes in elevation. While the majority of the Albemarle Region's river systems have small changes in elevation as they empty into sounds, some inland stretches of rivers could experience riverine erosion. Information on the locations of any riverine erosion and riverine shorelines prone to erosion would benefit future planning efforts.
- Mapping of areas of anticipated future development in coastal areas would allow for better understanding of where future development may be at risk to erosion and prevent wetlands migration into upland areas.

VII. EXTREME TEMPERATURE

A. Hazard Description

Extreme temperature includes extreme cold and extreme heat, which can present major health concerns for those populations that lack access to heating and cooling. Extreme cold is associated with winter storms. Extreme heat is associated with drought and wildfire. The occurrence of extreme cold is likely to decrease due to climate change, while extreme heat and associated impacts are likely to increase. There is an upward trend in the number of cooling degree days (a temperature indicator related to air conditioning demand) and a downward trend in the number of heating degree days (an indicator of heating demand)—both changes are consistent with a warming climate (NCDEQ 2020).

The Albemarle Region has a long history of extreme temperature events. Six extreme heat events took place in the Albemarle Region from 1996–2022. No property damage or crop damage was noted for these events, but a heat event on July 28, 2016, with a heat index values between 105°F and 109°F resulted in the death of a 73-year-old male in Chowan County (NOAA NCEI 2022).

B. Location and Extent

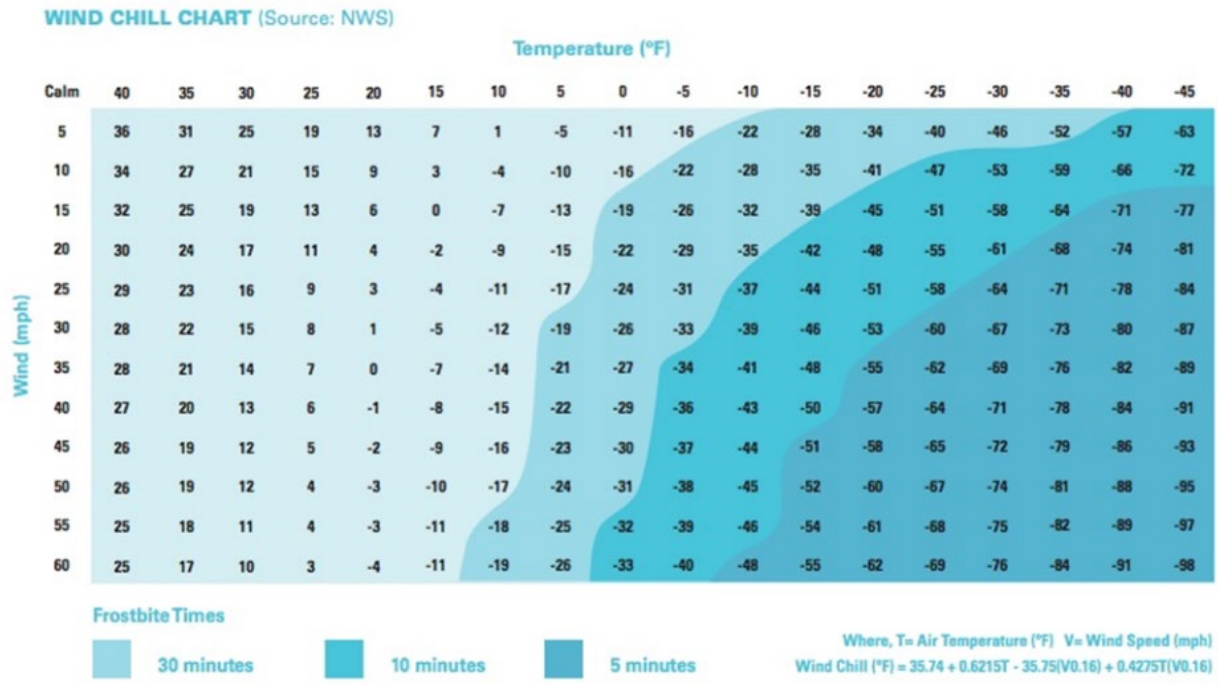
Extreme Cold

Extreme cold temperatures occur throughout most of the winter season and generally accompany most winter storms throughout the state. Outbreaks of bitterly cold Arctic air can send overnight lows well into the teens and even single digits. Across North Carolina, monthly average temperatures are the coldest in January (North Carolina State Climate Office 2022).

Occurrences of cold days (maximum temperature of 32 degrees Fahrenheit [˚F] or below) are rare in the Coastal Plain, with a long-term average of 1.4 days per year. The relatively high number of cold days in recent years were caused in part by occurrences of a winter weather pattern popularly known as the polar vortex—an area of upper-level low pressure that is nearly always present over the North and South Poles. Occasionally, the arctic vortex is displaced southward over eastern North America and becomes nearly stationary, bringing unusually cold weather to the eastern United States (NCICS 2020).

The severity of extreme cold temperatures generally is measured through the Wind Chill Temperature (WCT) Index. The WCT Index uses advances in science, technology, and computer modeling to provide an accurate, understandable, and useful formula for calculating the dangers from wind chill. For details regarding the WCT Index, refer to: http://www.nws.noaa.gov/om/winter/windchill.shtml. The WCT Index is presented in ***Figure 19***.

Figure 19. WCT Index Chart



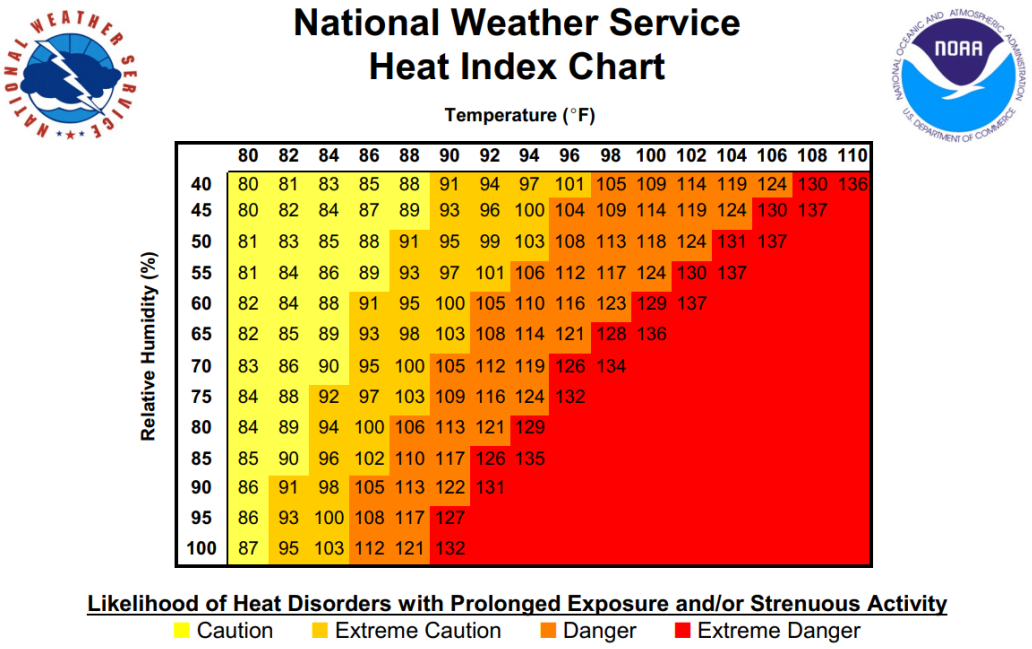
Source: NWS "Wind Chill Chart" n.d.

Extreme Heat

Extreme heat can occur anywhere within the Albemarle Region. Excessive heat incidents are widespread, even if there are localized cooler areas. In the Southeast United States, where North Carolina is located, heatwaves often occur when an area of high pressure (also called a "ridge") sits over the region for an extended period. When there is a high-pressure system in place, the Albemarle Region typically experiences clearer skies and fair weather. As the sun shines down, it warms the surface and, because high pressure in the atmosphere acts like a dome or a cap, that heat is trapped in place. When this weather pattern is in place for a few days in a row, temperatures can creep up, stay high, and lead to an extreme heat event (North Carolina State University [NCSU] n.d.).

The extent of extreme heat temperatures is measured through the Heat Index, identified in ***Figure 20.*** The National Weather Service (NWS) created the Heat Index to accurately measure apparent temperature of the air as it increases with the relative humidity. Relative humidity is the amount of moisture in the air at a certain temperature compared to what the air can hold at that temperature and is measured as a percentage or ratio of the amount of water vapor in a volume of air relative to a given temperature and the amount it can hold at that given temperature. Warm air can hold more moisture than cold air. Temperature and relative humidity are needed to determine the Heat Index. Once each value is acquired, the Heat Index is the corresponding number of both the values.

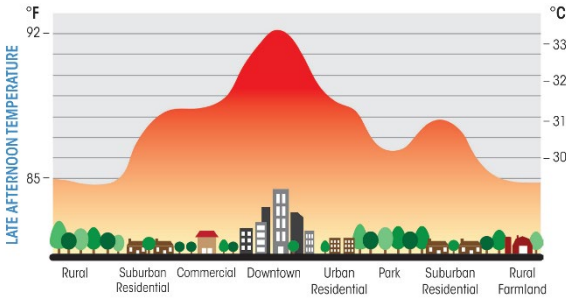
Figure 20. Heat Index Chart



Source: NWS "Heat Index Chart" n.d.

Extreme heat temperatures occur throughout the region for most of the summer season. High-pressure systems can move off the Atlantic coast and become stagnant for several days. A persistent airflow from the southwest or south affects the weather in the state. This circulation brings the very warm, often humid weather of the summer season and the mild, more pleasant temperatures during the fall, winter, and spring seasons (Midwestern Regional Climate Center [MRCC] 2020). ***Figure 21*** illustrates how rising temperatures can create an urban heat island.

Figure 21. Urban Heat Island



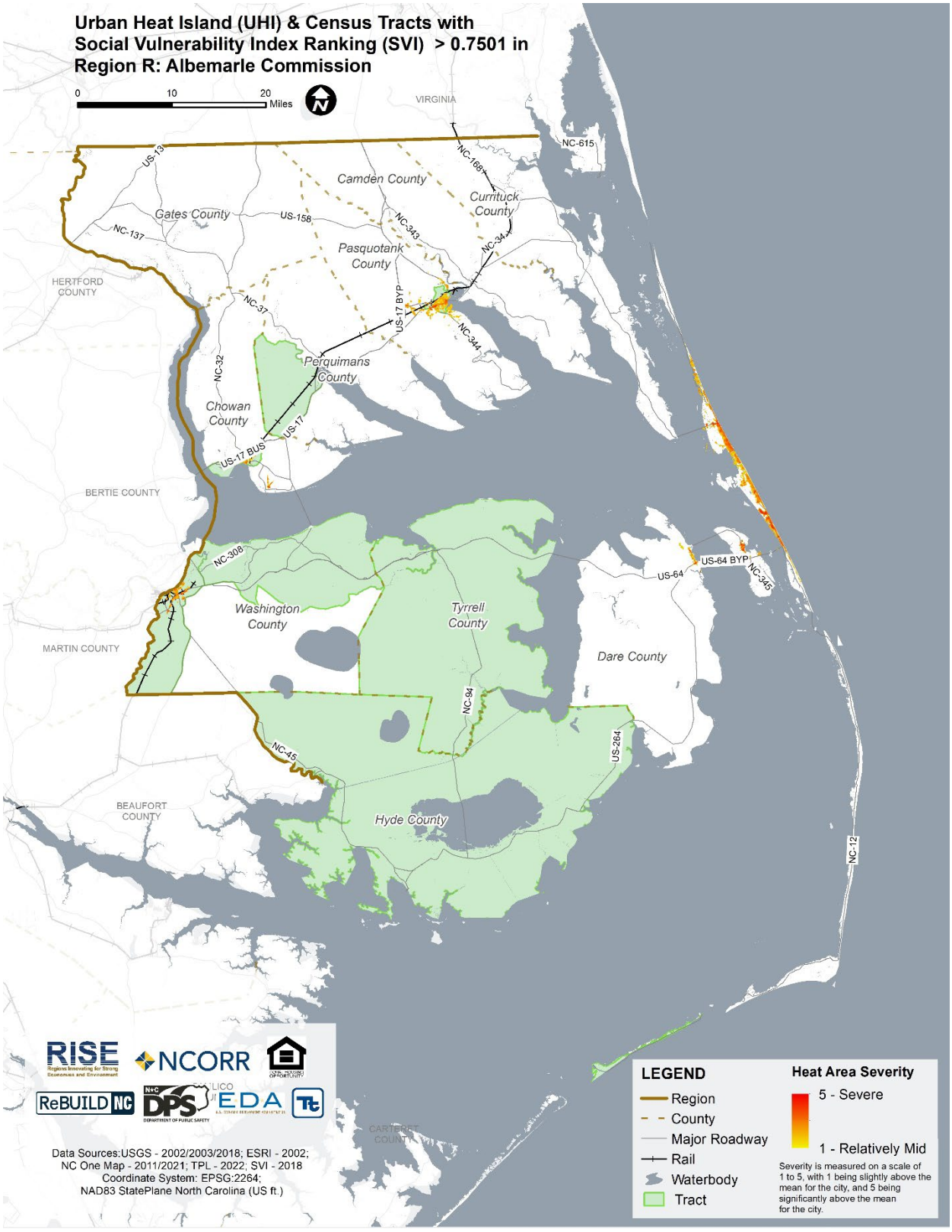
Source: Virginia Asphalt Association n.d.

On average, the North Carolina Coastal Plain region (which contains the Albemarle Region) sees about 13 very hot days per year, defined as having high temperatures at or above 95 degrees Fahrenheit, and a long-term average of about 6 very warm nights per year, defined as having low temperatures at or above 75 degrees (NCICS 2020).

Areas of dense urban development are prone to the urban heat island effect that can further raise temperatures in developed areas (Virginia Asphalt Association n.d.). Urban heat island effect can also occur in non-urban areas that have high levels of paved surfaces and buildings with little to no vegetation.

Figure 22 displays areas that are prone to urban heat island effect Areas prone to urban heat island effect and areas with a high social vulnerability. Urban heat island effect is focused in three locations in the Albemarle Region; Kill Devil Hills, Nags Head, and Manteo in Dare County; Elizabeth City in Pasquotank County; and Plymouth in Washington County. Elizabeth City and Plymouth are both contained in areas with a high social vulnerability index ranking and contain populations that are at higher risk to the impacts of extreme heat.

Figure 22. Urban Heat Island & Census Tracts with Social Vulnerability Index Ranking >0.7501 in the Albemarle Region



To explore the location specific exposure to the extreme temperature hazard, visit Albemarle Commission Region - Resilience Portfolio Web Map (arcgis.com).

C. Climate Change Impacts

Since the 1990s, annual average temperatures in the Coastal Plain have increased and remained consistently above average. Roughly 75 percent of the last 20 years have been above the long-term average temperature of about 61°F for the Coastal Plain region. The last five years have featured some of the warmest years on record. According to the International Panel on Climate Change, by the end of the century, the average temperature is projected to increase anywhere from 2°F to 10°F compared to the average temperature for 1996 to 2015.

Extreme Cold

By the end of the century, climate models project that the annual number of cold days per year will be at or close to zero. There has not been a strong trend in the number of cold nights (days with a minimum temperature of 32°F or lower) in recent years. However, by the end of the century, the number of cold nights per year is projected to decrease between 10 to 39 days under the higher scenario, compared to the 1996 to 2015 average. It is likely that the annual coldest temperature will rise over time (NCICS 2020).

Extreme Heat

The Coastal Plain region has not experienced an overall increase in the frequency of very hot days (maximum temperature of 95°F or higher) from 1970 to 2013. However, there has been an increase in the number of very warm nights (minimum temperature of 75°F or higher). Climate models project a substantial increase in the number of these very hot days and very warm nights by mid- to late-century. By the end of the century, the number of very hot days per year is projected to increase by 11 to 94 days, compared to the 1996 to 2015 average. The number of very warm nights per year is projected to increase by 14 to 87 days. The annual hottest temperature will likely increase over time (NCICS 2020).

D. Impact on Social Vulnerability and Equity, Health, and Safety

Extreme Temperature

The entire population of the Albemarle Region is exposed to extreme temperature. Extreme temperature events have potential health impacts, including injury and death. Exposure to excessive heat and extreme cold can pose several health risks to individuals.

According to the CDC, populations most at risk to extreme cold and heat include the following:

- The elderly, who are less able to withstand temperature extremes due to their age, health conditions, and limited mobility to access shelters;
- Infants and children up to 4 years of age;
- Individuals with chronic medical conditions (e.g., heart disease, high blood pressure);
- Low-income persons that cannot afford proper heating and cooling; and
- The public who may overexert during work or exercise during extreme heat or experience hypothermia during extreme cold (CDC 2021).
- Very young and older individuals have a higher risk of heat-related illness.

For the Albemarle Region, the population over 65 years of age is comprised of 34,021 people (19.8 percent of the region's population) and 8,725 are below 5 years of age (5.1 percent of the region's

population) (US Census Bureau 2020). As noted above, these populations are at risk to extreme temperatures.

Hot days influence the development of ground-level ozone, often the favoring the creation of more ozone. Ground-level ozone contributes significantly to poor air quality days, and to associated impacts on respiratory health. While increasing ground-level ozone may be a problem in the future for population centers in the Northeast and a variety of other locations in the United States, future ozone projections in North Carolina do not show an increase in risk from ground-level ozone or its health impacts (NC Department of Health and Human Services [NCDHHS] 2015).

Extreme heat can contribute to poor air quality, whereby increasing health risks among individuals with respiratory or cardiovascular disease. The impact of extreme heat is expected to be higher in underserved communities whose residents have limited means to adapt to warming temperatures, and already experience disparate respiratory and cardiovascular disease burden (NCDHHS 2015). Furthermore, the homeless and residents below the poverty level might not have access to housing or their housing could be less able to withstand extreme temperatures (e.g., homes with poor insulation and heating supply). High heat nights heavily impact those populations that lack HVAC as homes are unlikely to cool overnight during heat waves, resulting in even higher indoor temperatures on following days during heat waves. There is a total of 22,727 people (13.2 percent) living in poverty in the Albemarle Region. According to the US Census Bureau, 1,584 people in the region commute to work by walking (0.9 percent) and are more likely to have exposure to extreme temperatures (US Census Bureau 2020).

The Centers for Disease Control and Prevention (CDC) 2016 Social Vulnerability Index (SVI) ranks US Census tracts on socioeconomic status, household composition and disability, minority status and language, and housing and transportation. The Albemarle Region's overall score is 0.5516, indicating that its communities have moderate vulnerability (CDC 2016). This score indicates that while some residents would have adequate resources to respond to extreme temperatures, many not. Refer to ***Section II*** (Regional Profile) for explanations of the vulnerable populations in the Albemarle Region.

Furthermore, power outages occur more frequently during extreme cold and extreme heat. Individuals powering their homes with generators are subjected to carbon monoxide poisoning if proper ventilation procedures are not followed (CDC 2018).. And in the Albemarle region the conditions are????? And are likely to ….????

Meteorologists can accurately forecast extreme heat and cold temperature development and the severity of the associated conditions with several days of lead time, providing an opportunity for public health and other officials to notify vulnerable populations, implement short-term emergency response actions, and focus on surveillance and relief efforts for those at greatest risk. Adhering to extreme temperature warnings can significantly reduce the risk of temperature-related deaths.

For populations that lack adequate heating, ventilation, and air conditioning (HVAC) systems at their residences or during power failure that coincide with extreme temperature, warming and cooling centers/shelters can provide a lifesaving service during extreme temperature.

E. Impact on Housing, Critical Infrastructure and Community Support Systems

All buildings in the Albemarle Region (149,947 in total) are exposed to extreme temperature hazards. Elevated summer temperatures increase the energy demand for cooling and decrease the lifespan of some building materials such as roofing and siding. Losses can be associated with the overheating of

HVAC systems. Extreme cold temperatures freeze and burst pipes and increase vulnerability of home to electrical fires. Additionally, manufactured homes (mobile homes) and antiquated or poorly constructed facilities can have inadequate capabilities to withstand extreme temperatures.

Older buildings following less stringent building codes are more vulnerable to drafts during extreme cold due to cracks and leaks in the walls (IndyStar 2019). Roof damage can also occur due to excessive snowfall and extreme temperature changes. Further, structures with glass exposed to sunlight and structures exposed to heat on all four sides are more susceptible to damage, including interior damage from overheating.

All critical facilities in the Albemarle Region are exposed to extreme temperature hazards. Critical facilities experience similar issues as other buildings. It is essential that critical facilities remain operational during natural hazard events. Extreme heat can sometimes cause short periods of utility failures, commonly referred to as brownouts, due to increased usage of air conditioners and other energy-intensive appliances. Similarly, heavy snowfall and ice storms, associated with extreme cold temperature, can cause power interruption. Backup power is recommended for critical facilities and infrastructure.

On the national scale, extreme temperature often results in an increase in emergency room visits. Critical health facilities may be overwhelmed during these events. Warming and cooling centers may need to be opened during extreme temperature. These centers often are set up in existing critical facilities such as government buildings or schools, but require staffing needs that may reduce the capacity for normal operations in these facilities. These national trends are likely to impact the Albemarle Region as well.

Transportation infrastructure may experience damage from extreme temperature. This damage is particularly the case with ground transportation systems at risk of cracking, buckling, melting, or sagging due to high temperatures (U.S. Global Change Research Program 2019). This damage can cause disruptions to essential services that travel along these routes to provide services to the community. An increasing number of freeze/thaw events over winter months will also degrade roads and bridges, causing potholes and other issues. Once again, these national trends are likely to impact the Albemarle Region.

F. Impact on Economy

Extreme temperature also impacts the economy, including loss of business function and damage to and/or loss of business inventory. Business owners can be faced with increased financial burdens due to unexpected repairs caused to the building (e.g., pipes bursting), higher than normal utility bills, or business interruption due to power failure (i.e., loss of electricity or telecommunications). Disruptions in public transportation services will also impact the economy for commuters, customers, and truck drivers.

Extreme cold during the growing season can have devastating impacts on the agricultural industry through frost and freeze damage. Extreme heat can also damage crops, especially when combined with the impacts of drought. A changing climate is likely to change the growing season and could potentially change the types of appropriate crops as temperatures rise in the Albemarle Region. From 1990 to 2006, North Carolina's plant hardiness zone shifted from a majority zone 7 statewide to a majority zone 8 statewide (NC Department of Health and Human Services 2015).

G. Impact on Natural Environmental Systems

Extreme temperature can have a major impact on the environment. For example, freezing and warming weather patterns create changes in natural processes. An excess amount of snowfall and earlier warming

periods may affect natural processes such as flow within water resources (United States Geological Survey [USGS] 2019). Likewise, rain-on-snow also exacerbate runoff rates with warming winter weather. Extreme heat can have particularly negative impacts on aquatic systems, contributing to fish kills, aquatic plant die-offs, and increased likelihood of harmful algal blooms.

H. Impact on Historical and Cultural Resources

Historical and cultural buildings are impacted in the same way as other building stock by extreme temperature. Decisions to install new HVAC or climate control systems often result from concern for occupant health and comfort, the desire to make older buildings marketable, or the need to provide specialized environments for operating computers, storing artifacts, or displaying museum collections. However, applying modern standards of interior climate comfort to historic buildings has proven detrimental to historic materials and decorative finishes and some buildings do not have the space or capacity to install HVAC (US Department of the Interior 1991).

Outdoor cultural events and assets such as festivals and markets are most exposed to health impacts from extreme temperature and may require cancellation or shortened schedules.

I. Cascading Impacts

Extreme temperature can exacerbate the drought hazard, increase the potential risk of wildfires, and escalate severe storm and severe winter weather for the region. For example, extreme heat accelerates evaporation rates, drying the air and soils. Extreme heat can also dry out terrestrial species, making them more susceptible to catching fire. Extreme variation in temperatures could create ideal atmospheric conditions for severe storms or worsen the outcome of severe winter weather during freezing and thawing periods.

Extreme heat and drought can increase the withdrawal of freshwater and increase the likelihood of saltwater intrusion in coastal aquifers. Saltwater intrusion is a natural process, but it becomes an environmental problem when excessive pumping of fresh water from an aquifer changes the water pressure and intensifies the effect, drawing saltwater into new areas. When freshwater levels drop, the intrusion can proceed further inland until reaching a pumped well. For more information on saltwater intrusion, refer to ***Section X.***

Extreme temperature often contributes to poor air quality conditions. The North Carolina State Climate Office and the North Carolina Division of Air Quality have developed an Air Quality Portal for North Carolina to monitor and display air quality conditions in the state.

J. Future Changes that May Impact Regional Vulnerability to Hazard

Projected Development

Additional development increases the infrastructure that could be exposed to the extreme temperature hazard. The Albemarle Region is predominantly rural, but development that creates higher density in urbanized locations or expanded paved surfaces increases the likelihood of urban heat island impacts.

Projected Changes in Population

The North Carolina Office of State Budget & Management (NCOSBM) projects that the Albemarle Region will see population growth through 2050, with an expected increase in population of 38,271 or 22.2 percent (NCOSBM 2022). An increase in the population throughout the Albemarle Region will increase

the region's risk to extreme temperature. Population increases may create greater strain on water resources throughout the Albemarle Region.

K. Key Gaps in Data and Understanding

Key gaps in data and understanding that were identified during review of available scientific information and public and stakeholder meetings included:

- Use of projections for the Coastal Plain or Northern Coastal Plain were used as the best available data. Region specific climate change data would allow for a more specific assessment of the impacts of extreme temperature on the region.
- Recent years have seen an increase in occurrence of extreme cold. While extreme cold is likely to become less frequent and severe globally in a warming climate, there is still some scientific debate on whether changes in weather patterns in the arctic regions due to climate change could result in more frequent releases of cold air into lower latitudes (otherwise known as polar vortex events). Continued research on this subject would allow the Albemarle Region to be better informed on the likelihood of these events occurring in the future.
- Urban heat island impacts have been noted on smaller scales in more rural or suburban areas. Identification of localized urban heat island locations that are not located in urban areas would allow for better assessment of this phenomenon.
- Mapping of areas of anticipated future development would allow for better understanding of changes in exposure to extreme temperature.
- Understanding of the likely density of future development and the increase in hard surfaces and decrease in vegetation may help to identify potential sources of urban heat island effect.

VIII. FLOOD

A. Hazard Description

Flooding is one of the most visible hazards in the Albemarle Region. The region is impacted by several types of flooding, including:

- Riverine flooding from rivers, streams, and creeks overflowing banks;
- Flash flooding from heavy rainfall leading to rapid runoff;
- Urban/stormwater flooding from rainfall overwhelming stormwater systems, often from high levels of impermeable surfaces;
- Coastal flooding from high astronomical tides and storm surge; and
- Long-term increases in coastal flooding from sea level rise.

Flooding can also occur from dam failure. However, this type of flooding was reviewed and determined not to be a major concern for the Albemarle Region due to a lack of high hazard dams.

The Albemarle Region is regularly impacted by coastal flooding. From November 12–14, 2009, the remnants of Tropical Storm Ida developed into an intense Nor'easter, producing moderate to severe coastal flooding and overwash across much of the Outer Banks. Overall, 4 homes were destroyed, 61 had major damage, and 465 had minor damage. Highway 12 was severely flooded and destroyed near Rodanthe due to the ocean overwash. Damage from the coastal flooding was estimated to be $5.8 million in Dare County and $5 million in Currituck County (NOAA NCEI 2022).

Climate change is likely to result in an increase in heavy precipitation, leading to more riverine, flash, and urban/stormwater flooding. Coastal flooding is likely to increase in frequency and severity due to sea level rise. Coastal storms may also become more frequent and severe, leading to stronger storm surge.

B. Location and Extent

Floodplains

A floodplain is defined as the land adjoining the channel of a river, stream, ocean, lake, or other watercourse or water body that becomes inundated with water during a flood. The boundaries of the floodplains are altered as a result of changes in land use, the amount of impervious surface, placement of obstructing structures in floodways, changes in precipitation and runoff patterns, improvements in technology for measuring topographic features, and utilization of different hydrologic modeling techniques (Carolina Public Press n.d.).

Floodplain mapping is based on riverine and coastal flooding conditions. Future flooding conditions (from factors such as sea level rise and changes in rainfall) and urban/stormwater flooding conditions are not included in FEMA's development of floodplain mapping. As such, floodplain maps are more likely to underestimate flooding risk in many areas in the region, potentially resulting in the public also underestimating risk, limitations in building code requirements (as many are tied to floodplain zone), flood insurance requirements, and available mitigation funding (as many federal flood mitigation funding sources are restricted to locations within the Special Flood Hazard Area [SFHA]) (Carolina Public Press 2022). The SFHA is defined as the area that will be inundated, by the flooding having a 1 percent chance

of being equaled to or exceeded in any given year. ***Figure 23*** provides a listing of flood mapping terms used by FEMA.

Figure 23: FEMA Flood Map Terms

FLOOD MAP TERMS

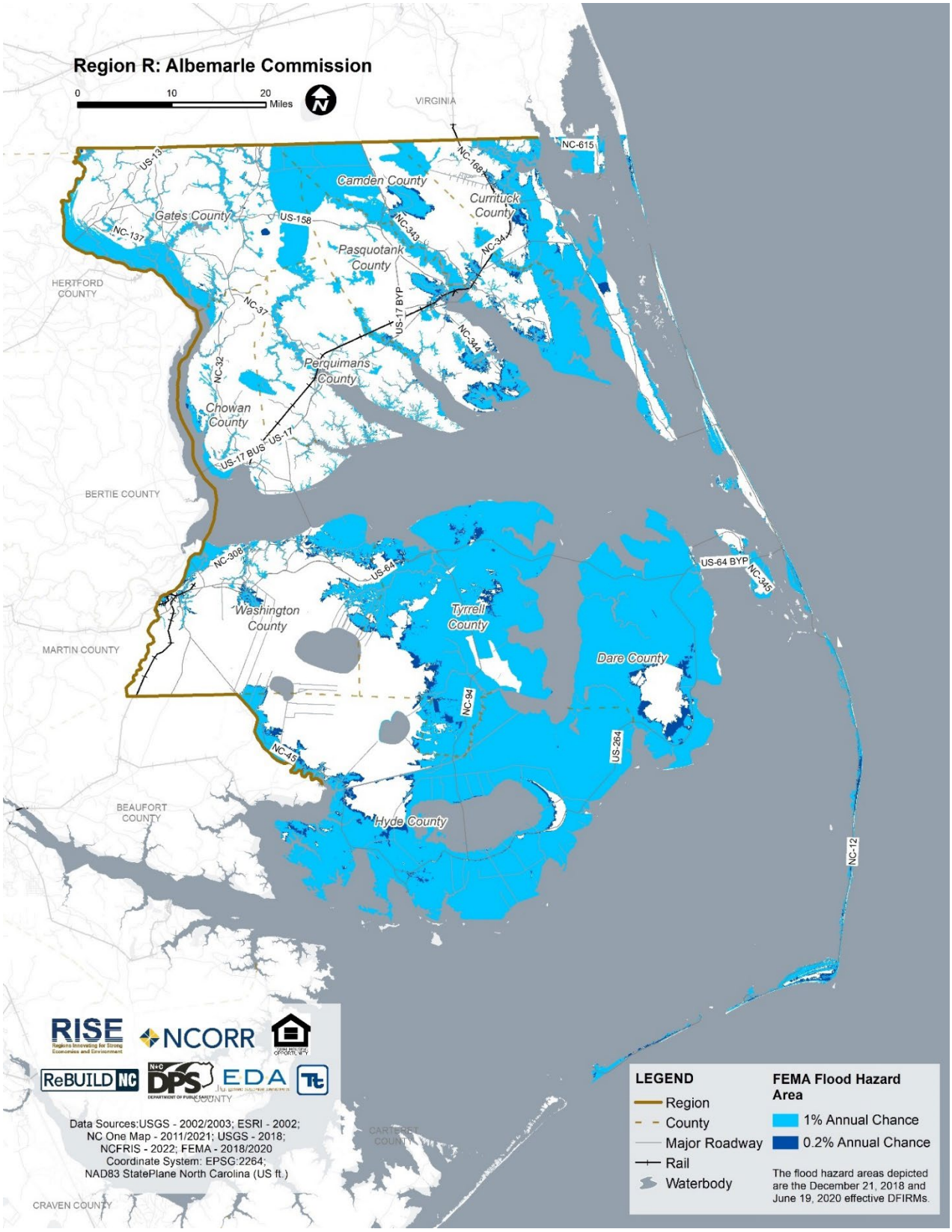
- Flood Insurance Rate Map (FIRM): Map developed by FEMA used to display the regulatory floodplain.
- 1 percent annual chance flood: Also known as the base flood or 100-year flood, this flood has a 1 in 100 chance of occurring each year. The 1 percent annual chance floodplain establishes the SFHA.
  - Special Flood Hazard Area (SFHA): The area that will be inundated by a coastal or riverine flooding having a 1 percent chance of being equaled or exceeded in any given year. Properties in this area are subject to flood insurance and building requirements.
  - The following types of flood zones are included in the 1 percent annual chance floodplain on the FIRM: Zone A, Zone AO, Zone AH, Zones A1-A30, Zone AE, Zone A99, Zone AR, Zone AR/AE, Zone AR/AO, Zone AR/A1-A30, Zone AR/A, Zone V, Zone VE, and Zones V1-V30.
- 0.2 percent annual chance flood: Also known as the 500-year flood, this is the location that 1 in 500 chance of occurring each year.
  - The following types of flood zone are included in the 0.2 percent annual chance floodplain on the FIRM: Zone B or Zone X (shaded)

Source: (FEMA 2018)

Although there is much misinformation and misunderstanding of flood zones and flooding frequencies, the 1 percent annual chance flood, base flood, and 100-year flood all are different ways of describing the same event. The 100-year flood is not a flood that will occur once every 100 years but is a flood that has a 1 percent chance of being equaled or exceeded each year. Thus, the 100-year flood could occur more than once in a relatively short period. Similarly, the 500-year flood will not occur every 500 years but is an event with a 0.2 percent chance of being equaled or exceeded each year (FEMA 2020). The 1 percent annual chance floodplain establishes the area that has flood insurance and floodplain management requirements.

In the Albemarle Region, floodplains border rivers, streams, lakes, and coastlines. The 1 percent annual-chance of flood hazard zones and 0.2 percent annual-chance flood hazard zones throughout the Albemarle Region are identified in ***Figure 24***. While each county in the region contains extensive flood hazard zones, Dare County, Tyrrell County, and southeastern Hyde County are dominated by flood hazard zones.

Figure 24. Floodplains in the Albemarle Region



Riverine Flooding

Riverine flooding can occur anywhere along the Albemarle Region's many rivers, streams, and creeks. Locations with low elevation adjacent to low-lying banks are most likely to experience riverine flooding.

Heavy Rainfall and Flash Flooding

Rainfall rates that exceed precipitation norms can be described as heavy rainfall. Extreme heavy rainfall has recently been referred to as "cloudbursts." Extreme rainfall can cause flash flooding, overwhelm stormwater systems, and contribute to heavy runoff. Heavy rainfall can take place anywhere in the Albemarle Region. Tropical systems, winter coastal storms, and slow-moving, intense thunderstorms are the typical storm systems responsible for heavy rainfall (NC Climate Science 2020). Thunderstorms usually result in localized heavy rainfall. Tropical systems can result in more broad areas of heavy rainfall, with higher rates in severe rainbands and the system's core.

Days with precipitation amounts of 3 inches or more are rare in the Coastal Plain, with slightly fewer than 1 day per year expected on average at any individual location. However, since 1995, the average number of 3-inch days has been about 35 percent above the long-term average (NC Climate Science 2020).

Flash flooding can occur anywhere throughout the Albemarle Region. Flash flooding is most likely to occur in locations surrounded by higher elevations, such as valleys and depressions.

Stormwater and Urban Flooding

Stormwater and urban flooding can occur in any location in the Albemarle Region where stormwater components are undersized or damaged. Impervious surfaces prevent water from draining into the soil and increase the amount of runoff, further adding to flooding issues. Because improvements and degradation of stormwater systems can happen at any time, there is limited ability to map these locations.

Feedback from the public and the Stakeholder Partnership noted that stormwater flooding is a major concern in most areas of Eastern North Carolina. A rising water table, stronger rainfall, and degraded stormwater infrastructure (sometimes over 50 years old) cause stormwater infrastructure deficiencies that lead to stormwater flooding.

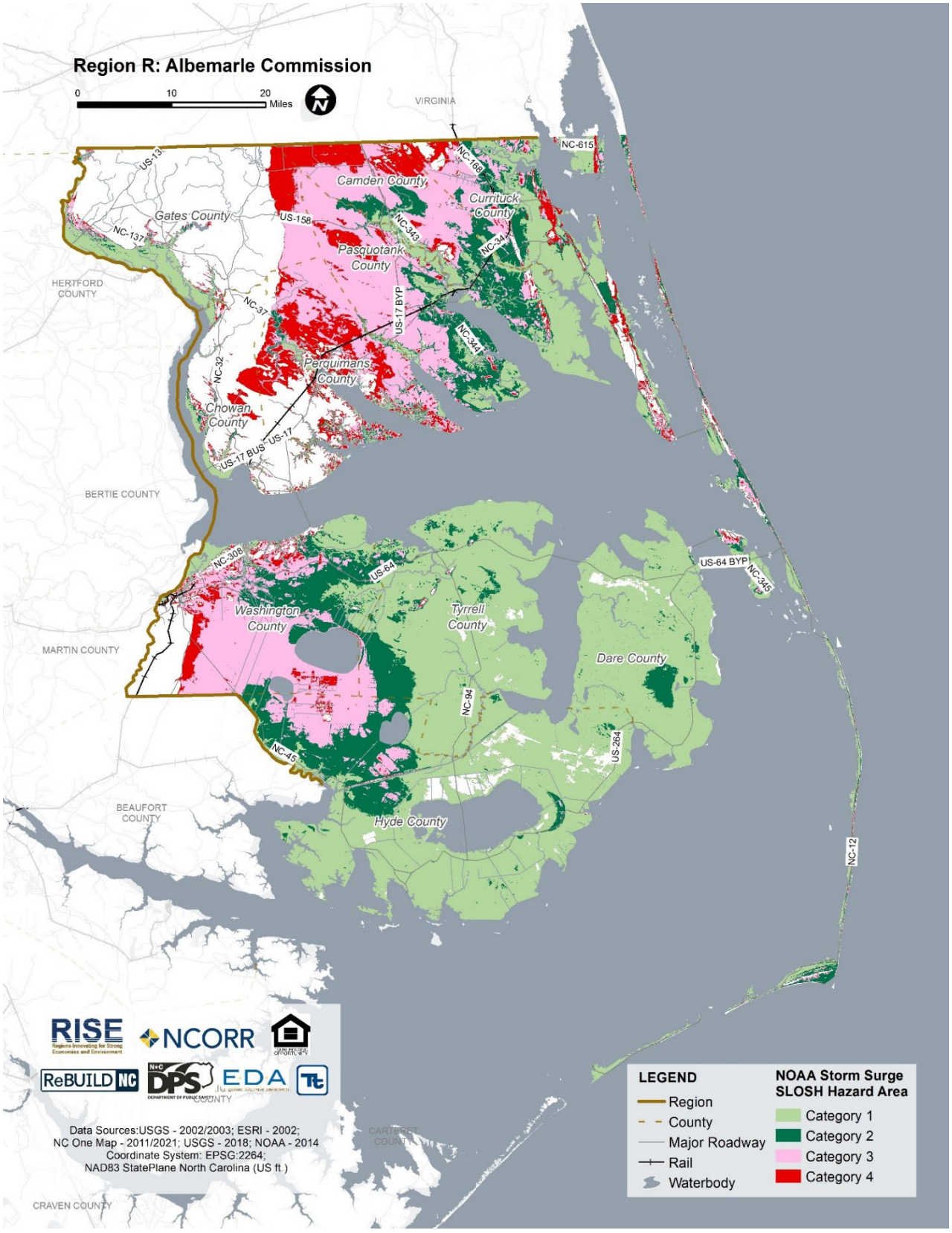
Coastal Flooding

Low-lying coastal areas in the Albemarle Region are vulnerable to coastal flooding and can be impacted during high-water, such as nor'easters and coastal storms. Certain areas along the open coast and other areas may have higher risk of experiencing structural damage caused by wave action and/or high-velocity water during the 1 percent annual-chance flood. These areas will be identified on the Flood Insurance Rate Map (FIRM) as Coastal High-Hazard Areas.

A storm surge associated with storms of longer recurrence intervals may result in higher water levels, larger waves, and an increased likelihood of dune overwash, wave damage, and possible breaching of barrier islands.

Storm surge modeling, known as SLOSH modeling (Sea, Lake, and Overland Surges from Hurricanes), computes the maximum potential storm surges based on storm movement in different directions and strengths in combination with topography, bathymetry, and tidal cycle. ***Figure 25*** illustrates the SLOSH map for the Albemarle Region. Other than Chowan County and Gates County, a severe storm surge (Category 4), has the potential to impact nearly the entire Region.

Figure 25. Storm Surge Areas in the Albemarle Region



Sea level rise

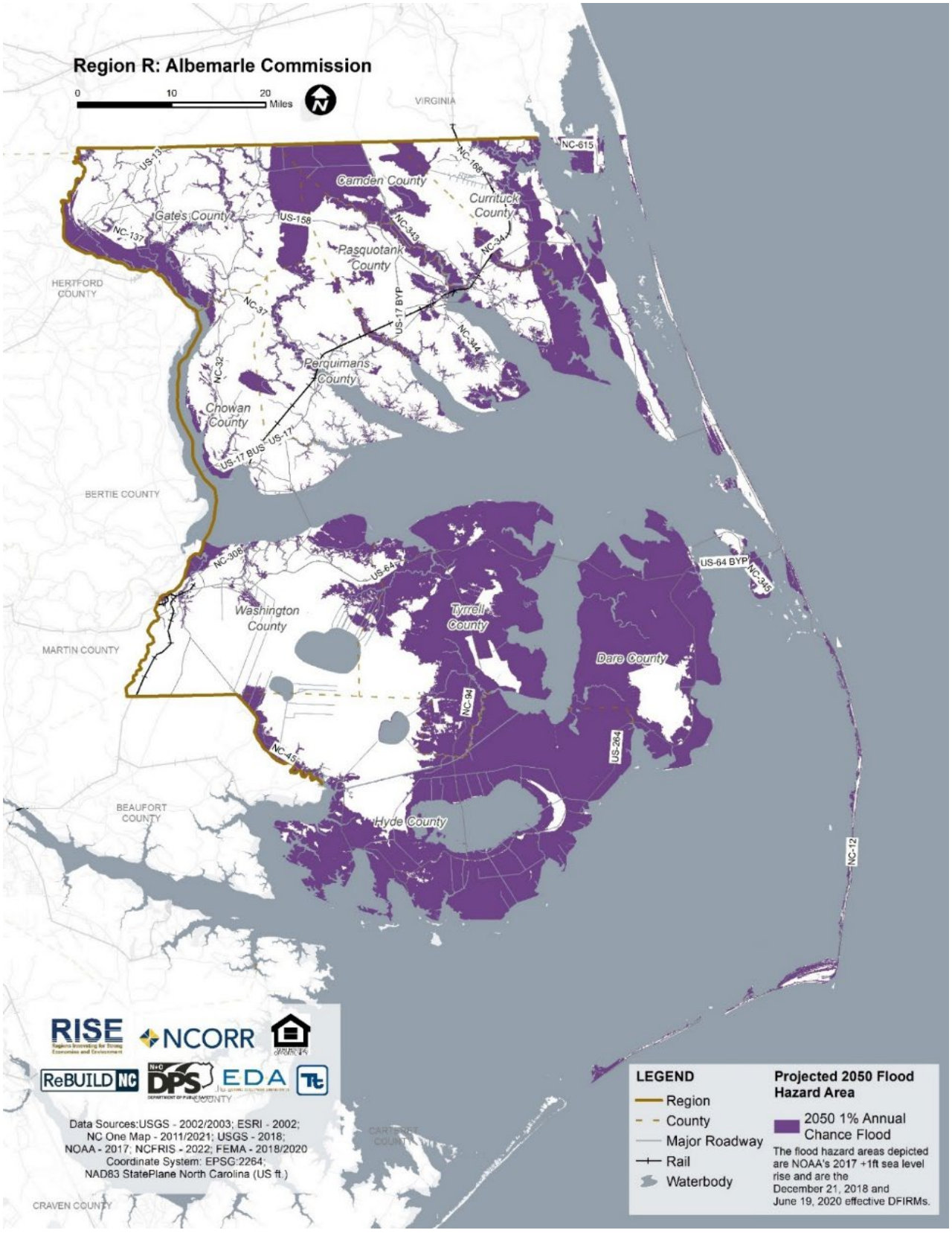
The Albemarle Region experiences ground subsidence (land sinking) of roughly 4 inches per century. Because of this “sinking” of land, the region’s rate of sea level rise (roughly 0.18 inches per year) is higher than the global average and roughly twice as fast as the southern portions of the state (NCICS 2020).

The National Oceanic and Atmospheric Administration (NOAA) has two tide gauge locations in the Albemarle Region that have long-term sea level rise data. The tide gauge in the Town of Duck has experienced a sea level rise rate of 0.18 inches per year from 1978 to 2021. The gauge at Oregon Inlet Marina has experienced a sea level rise rate of 0.21 inches per year from 1977 to 2021 (NOAA 2022).

High-tide flooding, often referred to as "nuisance" or “sunny day” flooding, is increasingly common due to years of relative sea level increases. It occurs when tides reach anywhere from 1.75 to 2 feet above the daily average high tide and start spilling onto streets or bubbling up from storm drains. As sea level rise continues, damaging floods that decades ago happened only during a storm now happen more regularly, such as during a full-moon tide or with a change in prevailing winds or currents (NOAA 2020).

As sea level rises, the starting elevation of coastal flooding will also rise. This statistic means that coastal floods are likely to reach a higher elevation and push farther inland. As a result, the mapped SFHA will likely expand. ***Figure 26*** displays the potential expansion of the SFHA with 1-foot of sea level rise, a threshold likely to be reached by 2050. Overall, the expansion of the SFHA is expected to be minor on a regional scale, but on a local scale, the changes may have significant impacts due to changes in flood insurance and building requirements for properties that are moved into the SFHA.

Figure 26. Projected Expanded SFHA in 2050 (1 foot of Sea Level Rise) in the Albemarle Region



To explore the location specific exposure to the flood hazard, visit Albemarle Commission Region - Resilience Portfolio Web Map (arcgis.com).

C. Climate Change Impacts

It is likely that the Albemarle Region will see an increase in average annual temperatures and precipitation. A warmer atmosphere means storms have the potential to be more intense (Coumou, D., S. Rahmstorf 2012) and occur more often (Gilbert, J., A.K. Betts, D.M. Rizzo, B. Beckage, and A. Bomblies 2015). Based on available studies, severe thunderstorms will likely increase in frequency in the Coastal Plain, increasing the likelihood of heavy rainfall, flash flooding, and stormwater flooding (NC Climate Science 2020).

Climate models show an overall increase in the number of extreme precipitation days in the Coastal Plain region. Based on the virtual certainty that water vapor in the atmosphere will increase as global warming occurs, it is very likely that the risk of extreme precipitation will increase everywhere in the Albemarle Region (NC Climate Science 2020), increasing the threat of flooding throughout the region.

Coastal flooding is tied to coastal storms. Temperatures are predicted to increase in the Albemarle Region, and ocean temperatures are forecast to continue to increase, which may lead to an increase in intensity and frequency of hurricanes. As temperatures increase, so will the energy in a storm system, increasing the potential for more intense tropical storms (Huang, H., J.M. Winter, E.C. Osterbert, R.M. Horton, and B. Beckage 2017), especially Category 4 and 5 storms (Melillo, J.M., T.T. Richmond, and G. Yobe 2014). It remains to be seen if other factors, such as steering currents, atmospheric sheer, and the presence of Saharan dust, will increase or decrease the risk of hurricanes in the region. Some climatologists believe that climate change may play a role in the frequency and intensity of Nor'easters. However, based on the available evidence, there is low confidence concerning future changes in the number of winter storms (NCICS 2020). For more information on severe storms, refer to ***Section IX.***

> *By the end of the century, the annual number of days with precipitation of 3 inches or more is projected to increase by up to 0.2 days (78%) under the lower scenario and 0.3 days (130%) under the higher scenario, compared to the 1996 to 2015 average (NC Climate Science 2020).*

Increases in precipitation may alter and expand the floodplain boundaries and runoff patterns, resulting in the exposure to populations, buildings, and critical facilities and infrastructure that were previously outside the floodplain. This increase in exposure would result in an increased risk to health and safety, an increase in structural losses, a diversion of additional resources to response and recovery efforts, and an increase in business closures affected by future flooding due to loss of service or access.

Sea level rise is likely to result in more severe coastal flooding and increase the number of coastal flooding days. The rate of sea level rise is largely determined by the rate of melting land ice and the thermal expansion of the oceans. As noted above, the local rate of sea level rise in the Albemarle Region is higher than the global average due to ground subsidence.

The rate of sea level rise is increasing due to climate change. According to NOAA's 2022 Sea Level Rise Technical Report, the Southeast region of the United States is very likely to see 1 foot and 2 inches of sea level rise by 2050 and 3 feet and 7 inches of sea level rise by 2100 (Sweet, W.v., and et al 2022).

D. Impact on Social Vulnerability and Equity, Health, and Safety

The impact of flooding on health and safety is dependent on several factors, including the severity of the event and whether adequate warning time is provided to residents. Exposure represents the population living in or near floodplain areas that could be impacted should a flood occur. Additionally, exposure should not be limited to only those who reside in a defined hazard zone but to everyone who may be affected by the effects of a hazard (e.g., people are at risk while traveling in flooded areas or their access to emergency services is compromised during an event). The impacts of each flooding type are described below.

Riverine and Coastal Flooding

The Flood Insurance Rate Map (FIRM) flood boundaries were used to estimate population exposure to the 1 percent- and 0.2 percent annual-chance flooding. Based on the spatial analysis, an estimated 75,735 residents live in the 1 percent annual-chance floodplain or 44.04 percent of the Albemarle Region's total population. An estimated 81,872 residents live in the 0.2 percent annual-chance floodplain or 47.61 percent of the region's total population. Dare County has the greatest number of residents living in the 1 percent annual-chance of flooding hazard area, with approximately 29,974 residents. Tyrrell County has the greatest percentage of residents living in the 1 percent annual-chance flood hazard area, with 78.74 percent of all residents located in the SFHA. ***Table 23*** summarizes the population exposed to the flood hazard by county.

Table 23. Estimated Number of Persons in the Albemarle Region Living in the 1-Percent and 0.2-Percent Annual Chance Flood Hazard Areas

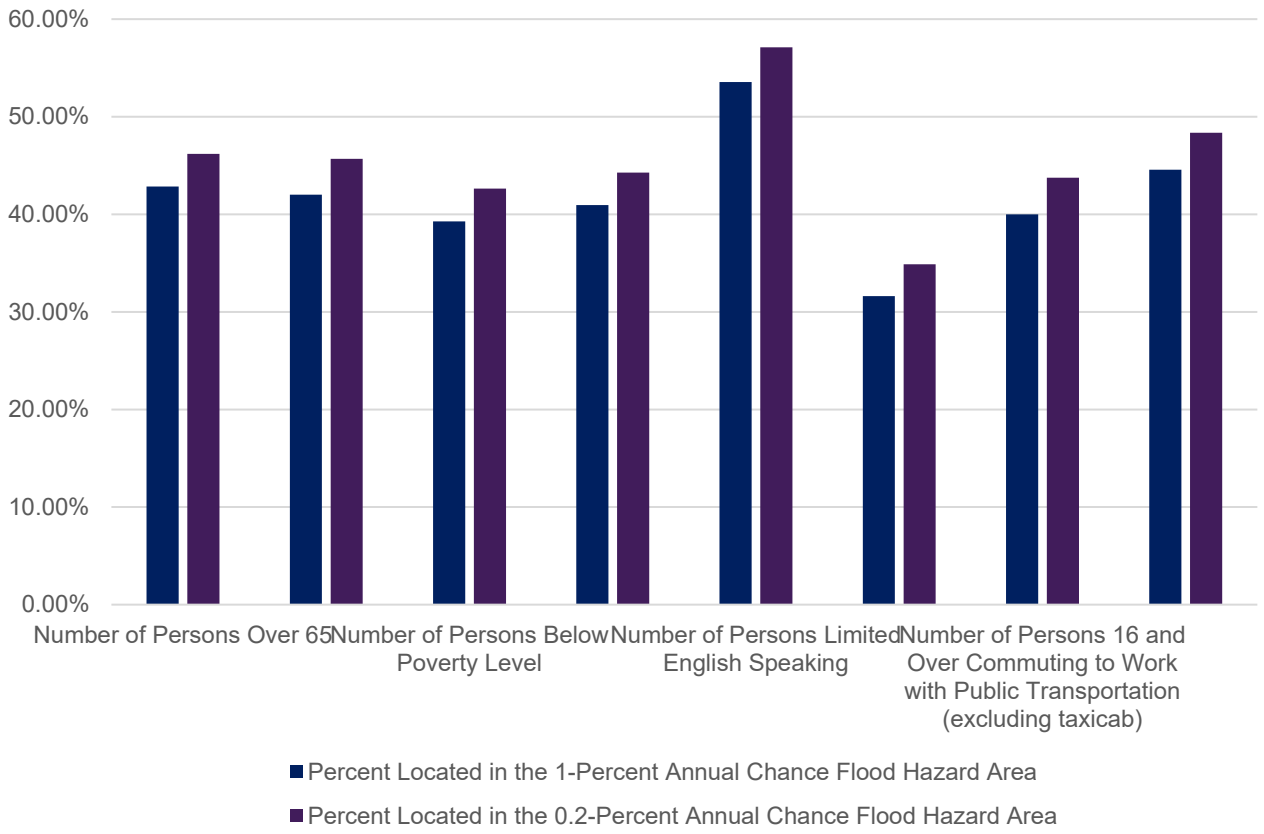
County	Total Population	Total Population in 1% Annual Chance Flood Hazard Area	% of Total Population in 1% Annual Chance Flood Hazard Area	Total Population in 0.2% Annual Chance Flood Hazard Area	% of Total Population in 0.2% Annual Chance Flood Hazard Area
Camden	10,355	5,711	55.15%	6,072	58.64%
Chowan	13,708	1,898	13.85%	2,027	14.79%
Currituck	28,100	14,186	50.48%	15,324	54.53%
Dare	36,915	29,974	81.20%	31,695	85.86%
Gates	10,478	3,374	32.20%	3,436	32.79%
Hyde	4,589	3,519	76.68%	3,658	79.71%
Pasquotank	40,568	10,805	26.63%	12,794	31.54%
Perquimans	13,005	1,989	15.29%	2,116	16.27%
Tyrrell	3,245	2,555	78.74%	2,712	83.57%
Washington	11,003	1,724	15.67%	2,038	18.52%
Albemarle Region (Total)	**171,966**	**75,735**	**44.04%**	**81,872**	**47.61%**

Sources: NCFRIS 2022; (FEMA 2018); ACS 2019; (US Census Bureau 2020)

Research has shown that some populations, while they may not have more hazard exposure, may experience exacerbated impacts and prolonged recovery if/when impacted. This estimation is due to many factors, including their physical and financial ability to react or respond during a hazard. Of the population exposed, the most vulnerable include the economically disadvantaged and the population over the age of 65. Economically disadvantaged populations are more vulnerable because they are likely to evaluate their risk and make decisions to evacuate based on the net economic impact to their family. Low-income families may have a harder time finding the resources necessary to fully recover following a flood. This population may include struggling to get rid of the flood related mold, causing cascading impacts from poor indoor air quality. The population over the age of 65 is more vulnerable because they

are more likely to seek or need medical attention, which may not be available to due isolation during a flood, and they may have more difficulty evacuating. Other socially vulnerable populations include persons below 5 years old, persons with a disability, persons with limited ability to speak English, and persons without a vehicle. Special consideration should be taken when planning for disaster preparation, response, and recovery for these vulnerable groups. ***Figure 27*** displays the total vulnerable populations living in the 1 percent- and 0.2 percent annual-chance floodplains in the Albemarle Region.

Figure 27. Total Vulnerable Populations Living in the 1 Percent- and 0.2 Percent Annual-Chance Floodplains in the Albemarle Region



Sources: North Carolina Flood Risk Information System (NCFRIS) 2022; FEMA 2020; ACS 2019; US Census Bureau 2020

Heavy Rainfall and Flash Flooding

The entire population of the Albemarle Region is exposed to the heavy rain and flash flooding. Populations that live or work in areas with limited ingress and egress, have evacuation routes prone to flooding, have poor stormwater systems, or are low-lying are the most likely to be impacted by flooding associated with heavy rainfall. Flash flooding associated with heavy rainfall presents a risk of injury and drowning (FEMA 1997). Damage to the region's agricultural industry and soil loss may result in crop losses and food security issues.

Flash flooding can displace populations along steep topography, particularly in cases when floodwaters surge into residential properties or alter the terrain into unsafe conditions requiring evacuation.

Stormwater and Urban Flooding

Urban and stormwater flooding has been reported at various locations in the Albemarle Region. Impacts are generally limited to roadways with underlying culverts. In various communities, poor drainage and rainstorms lead to localized flooding on various streets and in residential developments. This type of flooding could cause persons to become isolated or displaced from their homes.

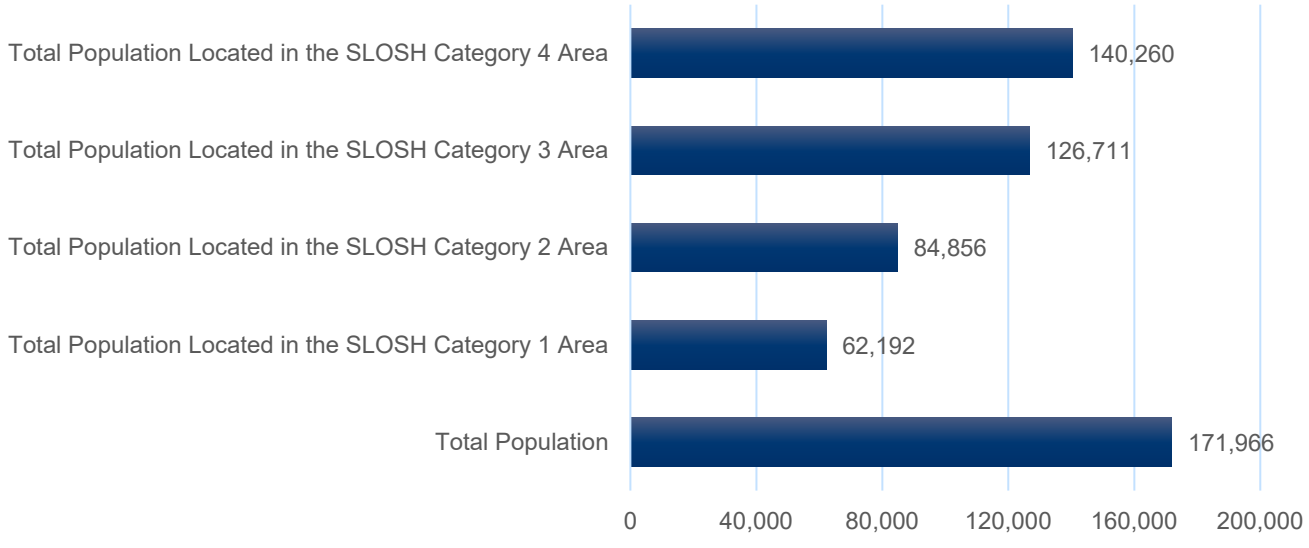
Coastal Flooding

The impact of a coastal storm surge on health and safety is dependent on several factors, including the severity of the event and whether adequate warning time is provided to residents. Approximately 81.56 percent of the Albemarle Region's residents (140,260 people) live in a Category 4 hurricane storm surge inundation area (NOAA 2022) (US Census Bureau 2020). Further, approximately 36.17 percent of the population is exposed to Category 1 storm surge impacts. Coastal storms can displace the population and/or require temporary to long-term sheltering. In addition, downed trees, damaged buildings, and debris carried by high winds can lead to injury or loss of life.

The estimated population living in the Category 1 through 4 SLOSH inundation zones is summarized by county in ***Figure 28***. Overall, Pasquotank County has the greatest number of residents in SLOSH inundation areas (39,802). Additional tables illustrating the vulnerable populations located in the Category 1 through 4 SLOSH inundation zones can be found in ***Appendix B***.

As with the SFHA, some populations, while they may not have more hazard exposure, may experience exacerbated impacts and prolonged recovery if/when impacted. This exposure is due to many factors, including their physical and financial ability to react or respond during a hazard. Clusters of potentially underserved communities exposed to storm surge exist along the entire North Carolina coastline and throughout the sounds, including Elizabeth City (NCDEQ 2020).

Figure 28. Estimated Number of Persons in the Albemarle Region Living in the Category 1 through Category 4 Storm Surge Hazard Areas



Sources: NOAA 2022; ACS 2019; US Census Bureau 2020

The impacts associated with coastal storms can vary across the region. Secondary flooding associated with the torrential downpours during hurricanes/tropical storms is also a concern.

Sea level rise

Furthermore, to estimate the population exposed and vulnerable to sea level rise, a spatial analysis was conducted using the projected expanded SFHA in 2050 caused by 1-foot of sea level rise (***Figure 26***). ***Table 24*** breaks down the expansion of the SFHA due to sea level rise by county. Overall, a minor change in exposure is estimated based on the expansion of the SFHA, with an additional 163 people (0.1 percent of the total population) being added to the SFHA in 2050.

Table 24. Estimated Number of Persons in the Albemarle Region Living in the Projected 2050 SFHA (current SFHA plus 1 foot)

County	Total Population	Total Population Located in the current SFHA	% of total population in current SFHA	Total Population Located in the Projected 2050 SFHA	% of total population in the Projected 2050 SFHA
Camden	10,355	5,711	55.15%	5,711	55.15%
Chowan	13,708	1,898	13.85%	1,916	13.98%
Currituck	28,100	14,186	50.48%	14,189	50.49%
Dare	36,915	29,974	81.20%	30,176	81.74%
Gates	10,478	3,374	32.20%	3,374	32.20%
Hyde	4,589	3,519	76.68%	3,474	75.70%
Pasquotank	40,568	10,805	26.63%	10,808	26.64%
Perquimans	13,005	1,989	15.29%	1,990	15.30%
Tyrrell	3,245	2,555	78.74%	2,555	78.74%
Washington	11,003	1,724	15.67%	1,705	15.50%
Albemarle Region (Total)	**171,966**	**75,735**	**44.04%**	**75,898**	**44.14%**

Sources: NOAA 2014; ACS 2019; Census 2020

E. Impact on Housing, Critical Infrastructure and Community Support Systems

In the Albemarle Region, there are 30,529 buildings (20.36 percent of total buildings) located in the 1 percent annual-chance flood boundary. In addition, there are 41,192 buildings (27.48 percent of total buildings) located in the 0.2 percent annual-chance flood boundary. ***Table 25*** and ***Table 26*** display the number of buildings by occupancy type in the 1 percent and 0.2 percent annual-chance flood hazard areas.

Table 25. Number of Buildings by Occupancy Type Located in the 1 Percent Annual-Chance Flood Hazard Area

Counties	Total Number of Buildings per County	Number of Buildings by Occupancy Type Located in the 1 Percent Annual-Chance Flood Hazard Area								
		Occupancy Type								Total Number of Buildings
		Residential	Commercial	Agricultural	Education	Religion	Government	Industrial	Vacant	
Camden	7,228	1,124	56	188	2	11	8	33	41	1,463
Chowan	11,347	373	30	26	1	-	4	15	-	449
Currituck	23,272	2,268	80	45	-	5	41	12	38	2,489
Dare	41,439	11,645	788	39	7	41	100	75	230	12,925
Gates	9,694	279	21	101	-	2	-	-	-	403
Hyde	7,716	4,382	237	459	16	59	26	51	-	5,230
Pasquotank	22,743	2,802	312	134	9	50	19	81	-	3,407
Perquimans	11,070	579	19	38	2	10	9	6	-	663
Tyrrell	3,955	1,669	120	489	21	23	37	2	-	2,361
Washington	11,453	825	71	194	3	12	7	27	-	1,139
Albemarle Region (Total)	**149,917**	**25,946**	**1,734**	**1,713**	**61**	**213**	**251**	**302**	**309**	**30,529**

Sources: NCFRIS 2022; FEMA 2018, 2019, 2020; NC One Map 2021, 2022

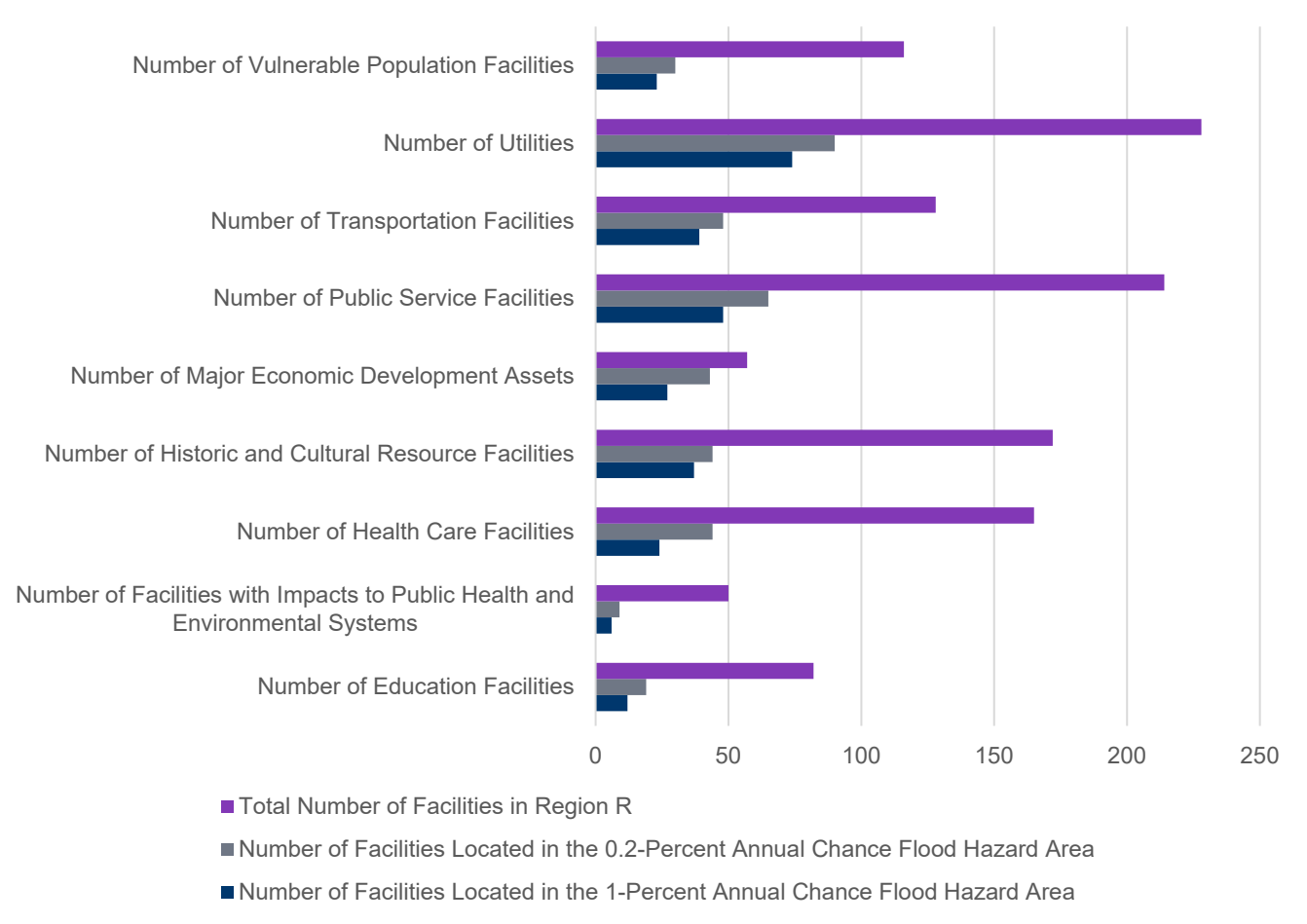
Table 26. Number of Buildings by Occupancy Type Located in the 0.2 Percent Annual-Chance Flood Hazard Area

Counties	Total Number of Buildings per County	Number of Buildings by Occupancy Type Located in the 0.2-Percent Annual-Chance Flood Hazard Area								
		Occupancy Type								Total Number of Buildings
		Residential	Commercial	Agricultural	Education	Religion	Government	Industrial	Vacant	
Camden	7,228	1,739	80	241	6	17	13	53	46	2,195
Chowan	11,347	497	39	34	2	-	4	19	-	595
Currituck	23,272	3,193	118	75	3	9	45	19	56	3,518
Dare	41,439	15,330	959	44	13	56	171	89	263	16,925
Gates	9,694	314	25	115	-	3	-	-	-	457
Hyde	7,716	4,886	262	660	24	63	45	64	-	6,004
Pasquotank	22,743	5,009	453	200	19	72	46	103	-	5,902
Perquimans	11,070	877	33	45	4	12	13	6	-	990
Tyrrell	3,955	1,783	125	531	21	25	39	2	-	2,526
Washington	11,453	1,540	132	338	9	20	8	33	-	2,080
Albemarle Region (Total)	**149,917**	**35,168**	**2,226**	**2,283**	**101**	**277**	**384**	**388**	**365**	**41,192**

Sources: NCFRIS 2022; FEMA 2018, 2019, 2020; NC One Map 2021, 2022

Figure 29 displays the number of critical facilities located in the 1 percent and 0.2 percent annual-chance flood hazard areas.

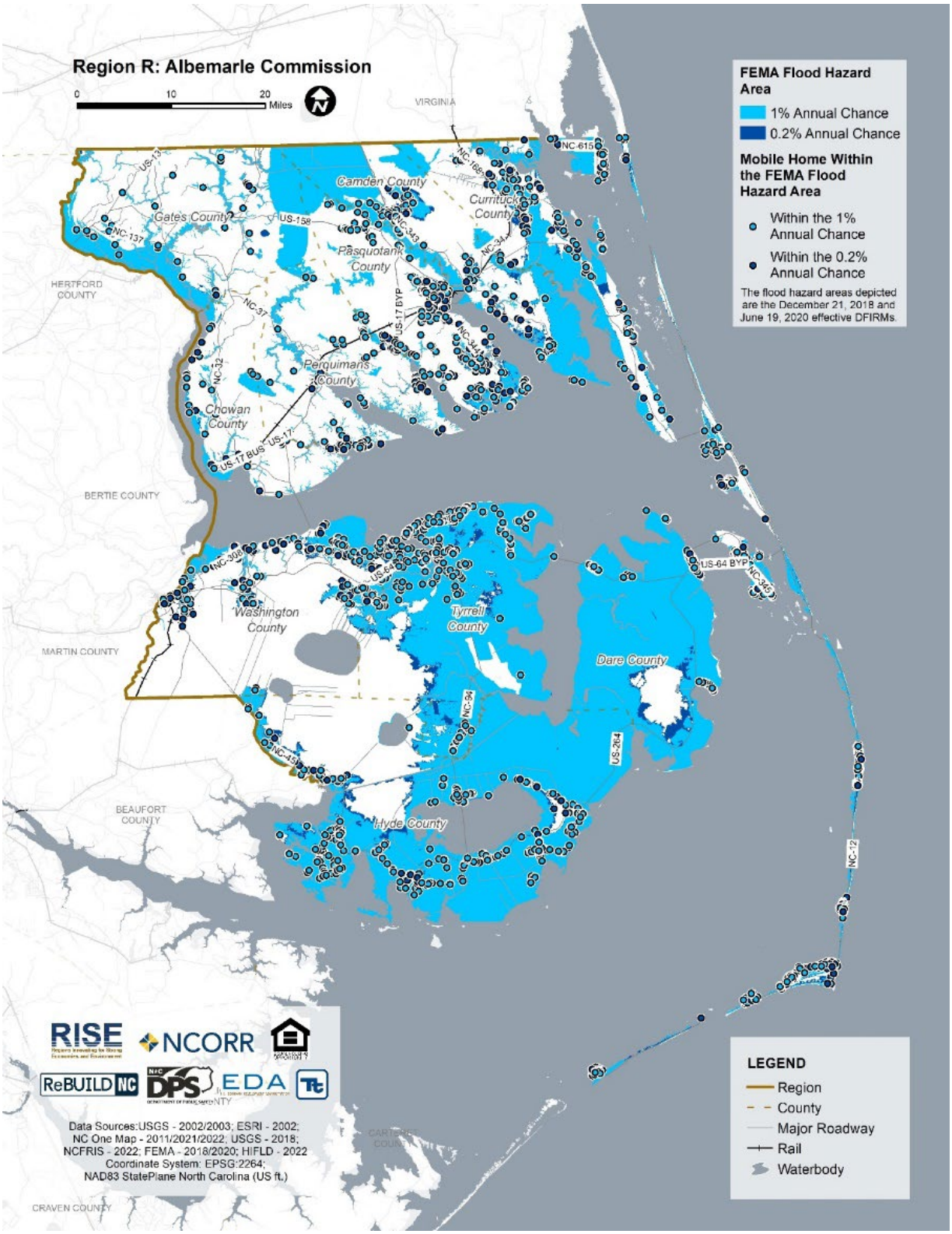
Figure 29. Number of Critical Facilities Located in the 1 and 0.2 Percent Annual-Chance Flood Hazard Area



Sources: NCFRIS 2022; FEMA 2018, 2019, 2020; NC One Map 2021, 2022

While mobile homes are designed to be moved, a lack of transportation, permanent, degradation of mobile components, or the permanent installation of the mobile home may prevent the evacuation of mobile homes before a flood event. Sudden flood events also eliminate the likelihood of evacuating mobile homes. ***Figure 30*** shows the mobile homes located in the 1 percent and 0.2 percent annual-chance flood hazard areas. In the 1 percent annual-chance flood hazard area in the Albemarle Region, 10 mobile home parks and 4,193 mobile homes are exposed. In the 0.2 percent annual-chance flood hazard area, 11 mobile home parks and 5,348 mobile homes are exposed. The northern shoreline of Tyrrell County contains a high concentration of mobile homes in the 1percent annual-chance flood hazard area.

Figure 30. Mobile Homes Located in the 1 Percent and 0.2 Percent Annual-Chance Flood Hazard Areas in the Albemarle Region

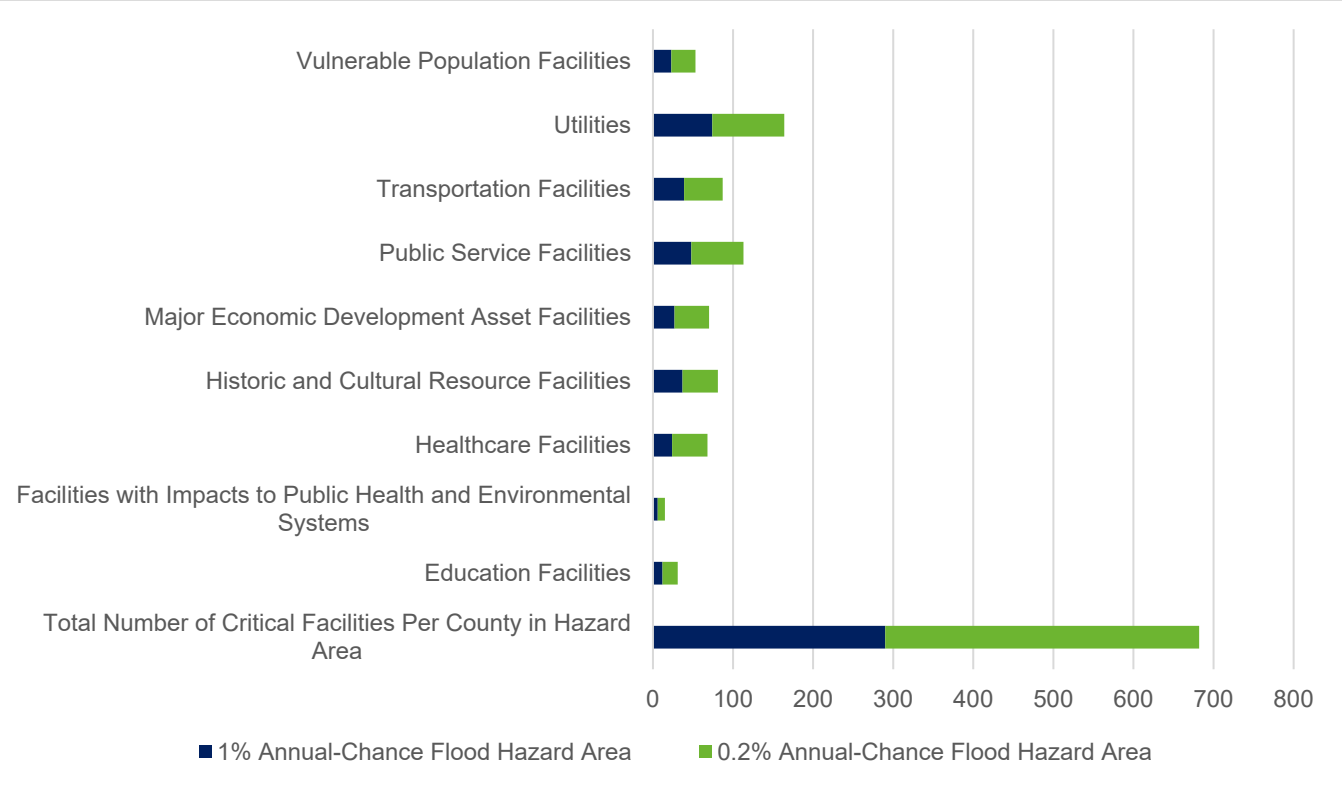


It is important to determine the critical facilities and infrastructure that may be at risk to flooding and who may be impacted should damage occur. Critical services during and after a flood event may not be available if critical facilities are directly damaged or transportation routes to access these critical facilities are impacted. Blocked or damaged roads can isolate residents and can prevent access to many service providers needing to reach vulnerable populations or make repairs. Within the Albemarle Region, 290 critical facilities are located in the 1 percent annual-chance flood event boundary and 392 critical facilities located in the 0.2 percent annual-chance flood event boundary.

In cases where short-term functionality is impacted by flooding, other facilities of neighboring municipalities may need to increase support response functions during a disaster event. Mitigation planning should consider means to reduce flood impacts on critical facilities and ensure sufficient emergency and school services remain open when a significant event occurs.

Figure 31 provide an overview of facilities in the 1 percent and 0.2 percent annual-chance flood areas. A further breakdown by facility type can be found in ***Appendix E***.

Figure 31. Total Number of Critical Facilities within the Albemarle Region Located in the 1 and 0.2 Percent Annual-Chance Flood Hazard Area



Sources: NCFRIS 2022; FEMA 2018, 2019, 2020; NC One Map 2021, 2022

Critical infrastructure, such as roadways and railroad, are often exposed to flooding. Evacuation routes often have a very high exposure to flooding as they are positioned to evacuate coastal locations with high flood risk. 183 miles of evacuation routes are located in the 1-percent annual chance flood hazard area. ***Table 27*** documents the miles of critical infrastructure in the 1-percent and 0.2-percent annual chance flood hazard areas.

Table 27. Miles of Critical Infrastructure within the Albemarle Region by General Category in the Flood Hazard Area

Miles of Critical Infrastructure within the Albemarle Region by General Category in the Flood Hazard Area		
Transportation Routes	**1-Percent Annual Chance**	**0.2-Percent Annual Chance**
NC Route	127	159
US Route	113	136
Interstate	-	-
Railroad	14	27
Albemarle Region (Total)	**253**	**322**
Evacuation Routes		
Evacuation Roadways	183	226

Sources: North Carolina Department of Natural and Cultural Resources (NCDCR) 2022; NC One Map 2019/2020/2021; Homeland Infrastructure Foundation Level (HIFLD) 2016/2021/2022; FEMA 2019/2020/2021; NCFRIS 2022

Heavy rainfall can cause damage to roofing and gutters. Properties that do not have proper drainage can also experience structural damage to foundations. Heavy rainfall and associated flash flooding are responsible for damage to culverts and bridges and can result in roadway washouts. Vehicles left in or driving through flash flooding are likely to experience damage (Center for Disaster Resilience 2016).

In coastal areas, the 1 percent and 0.2 percent floods incorporate flooding frequency and severity from storm surge events. However, the SLOSH model allows for analysis by each Category storm's potential flood exposure to buildings. Approximately 18.9 percent of buildings in the region are exposed to a Category 1 storm surge event. The percent of the region's buildings exposed to storm surge flooding goes up as the category of the storm increases with Category 2 at 40.3 percent, Category 3 at 58.4 percent, and Category 4 at 67.2 percent.

Error! Reference source not found.*Table 28* through ***Table 31*** display the storm surge exposure by building type for each county in the Albemarle Region.

Table 28. Number of Buildings by Occupancy Type Located in the SLOSH Category 1 Hazard Area

County	Total Number of Buildings per County	Number of Buildings by Occupancy Type Located in the SLOSH Category 1 Hazard Area							
		Occupancy Type							
		Residential	Commercial	Agricultural	Education	Religious	Government	Industrial	Vacant
Camden	7,228	671	41	69	5	9	5	20	9
Chowan	11,347	283	22	8	1	-	3	6	-
Currituck	23,272	1,888	75	40	-	4	36	13	33
Dare	41,439	11,033	868	39	17	50	124	84	252
Gates	9,694	43	7	11	-	-	-	-	-
Hyde	7,716	4,855	254	641	20	62	39	57	-
Pasquotank	22,743	2,591	228	127	15	42	24	45	-
Perquimans	11,070	405	13	5	3	4	5	1	-
Tyrrell	3,955	1,664	82	556	21	26	29	2	-
Washington	11,453	526	23	148	4	6	5	14	-

County	Total Number of Buildings per County	Number of Buildings by Occupancy Type Located in the SLOSH Category 1 Hazard Area							
		Occupancy Type							
		Residential	Commercial	Agricultural	Education	Religious	Government	Industrial	Vacant
Albemarle Region (Total)	**149,917**	**23,959**	**1,613**	**1,644**	**86**	**203**	**270**	**242**	**294**

Sources: NOAA 2014; NC One Map 2021/2022

Table 29. Number of Buildings by Occupancy Type Located in the SLOSH Category 2 Hazard Area

County	Total Number of Buildings per County	Number of Buildings by Occupancy Type Located in the SLOSH Category 2 Hazard Area							
		Occupancy Type							
		Residential	Commercial	Agricultural	Education	Religious	Government	Industrial	Vacant
Camden	7,228	2,701	128	352	16	24	16	86	40
Chowan	11,347	618	40	34	2	2	3	6	-
Currituck	23,272	5,913	207	133	12	14	48	38	98
Dare	41,439	22,197	1,384	44	43	92	277	152	319
Gates	9,694	81	10	26	-	-	-	-	-
Hyde	7,716	5,474	276	828	24	69	49	60	-
Pasquotank	22,743	9,455	916	391	55	138	199	194	-
Perquimans	11,070	1,334	36	23	5	12	31	4	-
Tyrrell	3,955	2,007	136	688	21	31	46	2	-
Washington	11,453	1,840	129	706	11	40	12	28	-
Albemarle Region (Total)	**149,917**	**51,620**	**3,262**	**3,225**	**189**	**422**	**681**	**570**	**457**

Sources: NOAA 2014; NC One Map 2021/2022

Table 30. Number of Buildings by Occupancy Type Located in the SLOSH Category 3 Hazard Area

County	Total Number of Buildings per County	Number of Buildings by Occupancy Type Located in the SLOSH Category 3 Hazard Area							
		Occupancy Type							
		Residential	Commercial	Agricultural	Education	Religious	Government	Industrial	Vacant
Camden	7,228	4,487	198	649	26	45	90	142	143
Chowan	11,347	1,003	77	69	2	3	5	15	-
Currituck	23,272	9,888	589	281	32	35	73	99	178
Dare	41,439	28,504	1,786	49	70	112	356	203	361
Gates	9,694	164	13	57	-	-	-	-	-
Hyde	7,716	5,511	282	861	24	70	51	62	-
Pasquotank	22,743	15,530	1,331	779	97	205	220	326	-
Perquimans	11,070	3,591	102	132	17	46	86	10	-
Tyrrell	3,955	2,080	143	734	23	34	53	2	-
Washington	11,453	3,685	248	1,268	36	67	21	54	-
Albemarle Region (Total)	**149,917**	**74,443**	**4,769**	**4,879**	**327**	**617**	**955**	**913**	**682**

Sources: NOAA 2014; NC One Map 2021/2022

Table 31. Number of Buildings by Occupancy Type Located in the SLOSH Category 4 Hazard Area

County	Total Number of Buildings per County	Number of Buildings by Occupancy Type Located in the SLOSH Category 4 Hazard Area							
		Occupancy Type							
		Residential	Commercial	Agricultural	Education	Religious	Government	Industrial	Vacant
Camden	7,228	4,816	200	771	26	45	90	161	162
Chowan	11,347	1,466	102	196	2	6	8	24	-
Currituck	23,272	14,059	845	377	45	50	117	154	232
Dare	41,439	30,718	1,889	49	81	113	377	207	372
Gates	9,694	193	21	72	-	1	-	-	-
Hyde	7,716	5,515	283	860	24	70	51	62	-
Pasquotank	22,743	16,011	1,373	877	108	211	220	338	-
Perquimans	11,070	6,120	264	247	30	110	172	20	-
Tyrrell	3,955	2,115	143	740	23	34	53	2	-
Washington	11,453	4,685	331	1,426	43	94	36	76	-
Albemarle Region (Total)	**149,917**	**85,698**	**5,451**	**5,615**	**382**	**734**	**1,124**	**1,044**	**766**

Sources: NOAA 2014; NC One Map 2021/2022

Exposure of mobile home parks and mobile homes to storm surge was also analyzed. Pasquotank (10) and Dare County (9) have the largest number of mobile home parks. All but one of those mobile home parks is exposed to flooding at the Category 3 and Category 4 storm surge levels. In total, 73.0 percent of the region's mobile homes are exposed to storm surge at the Category 4 level. ***Table 32*** displays the mobile home parks and mobile home buildings exposed to the storm surge hazard by county.

Table 32. Number of Mobile Home Parks and Mobile Home Buildings Located in the SLOSH Category 1-4 Hazard Areas

County	Total Number of Mobile Home Parks per County	Total Number of Mobile Home Buildings per County	Number of Mobile Home Parks and Mobile Home Buildings Located in the SLOSH Category 1 Hazard Area		Number of Mobile Home Parks and Mobile Home Buildings Located in the SLOSH Category 2 Hazard Area		Number of Mobile Home Parks and Mobile Home Buildings Located in the SLOSH Category 3 Hazard Area		Number of Mobile Home Parks and Mobile Home Buildings Located in the SLOSH Category 4 Hazard Area	
			Number of Mobile Home Parks	Number of Mobile Home Buildings	Number of Mobile Home Parks	Number of Mobile Home Buildings	Number of Mobile Home Parks	Number of Mobile Home Buildings	Number of Mobile Home Parks	Number of Mobile Home Buildings
Camden	1	611	-	83	1	315	1	512	1	565
Chowan	3	1,668	-	21	-	52	-	110	-	195
Currituck	1	3,366	-	302	-	1,042	1	1,730	1	2,647
Dare	9	2,948	4	1,548	6	2,251	8	2,646	8	2,732
Gates	2	1,629	-	2	-	5	-	14	-	18
Hyde	1	726	1	593	1	702	1	706	1	707
Pasquotank	10	3,519	1	386	2	1,549	10	3,313	10	3,499
Perquimans	3	2,226	-	105	-	422	-	1,106	-	1,734
Tyrrell	1	755	1	603	1	697	1	730	1	743
Washington	4	1,586	-	172	-	504	-	892	-	1,068
Albemarle Region (Total)	**35**	**19,034**	**7**	**3,815**	**11**	**7,539**	**22**	**11,759**	**22**	**13,908**

Sources: NOAA 2014; NC One Map 2021/2022; HIFLD 2022

Storm surge events at the highest category have very low frequency. While it may not be cost-effective to protect all buildings at the highest potential storm surge levels, it is important that critical facilities that have storm surge exposure are identified for emergency planning purposes. The location of emergency shelters in particular should be noted to ensure that evacuation procedures avoid the opening of shelters that have a chance of flooding in a storm surge event that exceeds surge forecasts. In total, 46 of the region's emergency shelters could be exposed to storm surge impacts.

Table 33 displays the number of shelters by county that are exposed to storm surge for each category hurricane event.

Table 33. Total Number of Emergency Shelters in the Albemarle Region Located in the SLOSH Category 1-4 Hazard Areas

County	Total Number of Emergency Shelters Located in the SLOSH Category 1 Hazard Area	Total Number of Emergency Shelters Located in the SLOSH Category 2 Hazard Area	Total Number of Emergency Shelters Located in the SLOSH Category 3 Hazard Area	Total Number of Emergency Shelters Located in the SLOSH Category 4 Hazard Area
Camden	-	2	3	3
Chowan	-	-	-	-
Currituck	-	-	2	7
Dare	-	4	8	9
Gates	-	-	-	-
Hyde	4	4	4	4
Pasquotank	3	11	13	13
Perquimans	2	2	2	6
Tyrrell	1	1	1	1
Washington	-	2	3	3
Albemarle Region (Total)	**10**	**26**	**36**	**46**

Sources: NC One Map 2019/2020/2021; NOAA 2014

F. Impact on Economy

Floods can significantly impact the local and regional economies. This number includes general building stock damages and associated tax loss, impacts to utilities and infrastructure, business interruption, impacts on tourism, and impacts on the tax base for municipalities in the Albemarle Region. In areas that are directly flooded, renovations of commercial and industrial buildings may be necessary, disrupting associated services. Other important economic components, such as loss of facility use, functional downtime, and socio-economic factors, are less easy to measure with a high degree of certainty.

Flooding can cause extensive damage to public utilities and disruptions to the delivery of services. Loss of power and communications may occur and drinking water and wastewater treatment facilities may be temporarily out of operation. Debris management may also be a large expense after a flood.

Economically important facilities that are connected to the water, such as ports, have a higher likelihood of flooding impacts. Analysis showed that 27 port facilities in the region are in the 1 percent annual-chance flood hazard area, and 43 port facilities fall within the 0.2 percent annual-chance flood hazard area.

Heavy rainfall can impact agriculture through flood damage and soil loss. Based on the 2017 Census of Agriculture, there were 1,062 farms in the Albemarle Region. The average farm size was 594 acres. Albemarle Region farms had a total market value of products sold of $508.5 million (United States Department of Agriculture [USDA] 2017). Damage to the region's agricultural industry will result in economic losses.

Sea level rise and its impact on storm surge severity is likely to have significant impacts on the region's coastal tourism areas. Locations like the Outer Banks are likely to experience increasing flooding that may result in a reduction in visitors. Sea level rise may also result in abandonment of the buildings with the highest flood risk as permanent inundation occurs.

Public feedback during a workshop of the Climate Risk Assessment and Resilience Plan noted that flooding has economic impacts on revenue collection since property tax values decrease in areas where property is inaccessible for extended periods of time or is considered a repetitive loss property (NCDEQ 2020).

G. Impact on Natural Environmental Systems

Flood extents for the 1 and 0.2 percent annual flooding will continue to evolve alongside natural occurrences, such as sea level rise, climate change, and/or severity of storms. Further, residents living in and around areas of wildfire may be at increased risk of flooding in the future due to changes in the natural landscape. Flooding could lead to loss of critical habitat and further stresses on some threatened and endangered species (Kopp et al 2019). Heavy rainfall and flash flooding can cause habitat damage through soil loss. Runoff can cause damage to aquatic systems through overloading of sediment and chemicals from non-point source pollution. Flooding could cause the release of environmentally damaging pollutants from facilities such as septage facilities, solid landfills, and yard waste facilities.

Sea level rise can result in the loss of low-lying coastal ecosystems like wetlands and the conversion of uplands to wetlands. In addition, sea level rise can result in saltwater intrusion, which can damage or kill salt-intolerant plant life. For more information on saltwater intrusion, refer to ***Section X.***

H. Impact on Historical and Cultural Resources

The Albemarle Region is home to many historic districts. Across the region there are 238 historic and cultural resource facilities located in the 1-percent floodplain and 260 historic and cultural resource facilities located in the 0.2-percent floodplain. Numerous historic and cultural resource facilities are at risk for flooding during storm surge. 21 historic sites are located in the SLOSH Category 1 zone, 62 sites are located in the SLOSH Category 2 zone, 90 sites are located in the SLOSH Category 3 zone, and 115 sites are located in the SLOSH Category 4 zone.

I. Cascading Impacts

Stormwater runoff caused by heavy rainfall can increase the amount of pollutants transferred from land to local waterways. Public feedback during a workshop of the Climate Risk Assessment and Resilience Plan noted that prolonged flooding and runoff leads to harmful algal blooms and septic issues (NCDEQ 2020). For further discussion of water quality issues, refer to ***Section X***.

Coastal erosion is considered a cascading hazard for flood in coastal areas. Heavy rainfall can also erode land features such as stream banks and coastal features that provide protection from flooding and coastal

erosion. Coastal erosion is discussed in ***Section VI***. Flooding can also increase the likelihood of landslides and put additional strain on dams, which may lead to dam failure.

According to NOAA, sea level rise can amplify factors that currently contribute to coastal flooding: high tides, storm surge, high waves, and high runoff from rivers and creeks. All of these factors change during extreme weather and climate events (NOAA 2012). Other secondary hazards that could occur along the coast in response to sea level rise:

- **Bluff and upland erosion** – shorelines composed of older geologic units that form headland regions of the coast will retreat landward with rising sea level. As sea level rises, the uplands are eroded, and sandy materials are incorporated into the beach and dune systems along the shore and adjacent compartments (Gutierrez, et al 2007). High bank shorelines are common in Chowan in Perquiman Counties for which erosion rates are high (Albemarle HMP 2020).
- **Overwash, inlet processes, shoreline retreat, and barrier island narrowing** – as sea level rise occurs, storm overwash will become more likely. Tidal inlet formation and migration will become important components of future shoreline changes. Barrier islands are subject to inlet formation by storms. If the storm surge produces channels that extend below sea level, an inlet may persist after the storm. The combination of rising sea level and stronger storms can create the potential to accelerate shoreline retreat in many locations. Assessments of shoreline change on barrier islands have shown barrier island narrowing has been observed on some islands over the last 100 years (Gutierrez, et al 2007).
- **Threshold behavior** – changes in sea level can lead to conditions where a barrier system becomes less stable and crosses a geomorphic threshold, making the potential for rapid barrier-island migration or segmentation/disintegration high. Unstable barriers may be defined by rapid landward recession of the ocean shoreline, decrease in barrier width and height, increased over washing during storms, increased barrier breaching and inlet formation, or chronic loss of beach and dune sand volume. With the rates of sea level rise and climate change, these conditions will likely worsen (Gutierrez, et al 2007).

An increase in sea level will cause further issues as stormwater recharge is challenged as sea levels submerge discharge points, resulting in increases in flooding (Kopp et al 2019).

Flood events can exacerbate the impacts of disease outbreak. After a flooding event, runoff can pick up and transport pollutants from wildlife and soils. Such organisms can then appear in drinking water facilities and transmit water-borne and vector diseases to the population (World Health Organization 2021).

Cascading impacts to health may also include exposure to pathogens such as mold. After flood events, excess moisture and standing water contribute to mold growth in buildings. Mold may present a health risk to building occupants, especially those with already compromised immune systems, such as infants, children, the elderly, and pregnant women. The degree of impact will vary and is not strictly measurable. Mold spores can grow in as short a period as 24 to 48 hours in wet and damaged areas of buildings that have not been properly cleaned. Very small mold spores can easily be inhaled, creating the potential for allergic reactions, asthma episodes, and other respiratory problems. Buildings should be properly cleaned and dried to safely prevent mold growth (Centers for Disease Control and Prevention [CDC] 2020).

Molds and mildews are not the only public health risk associated with flooding. Floodwaters can be contaminated by pollutants, such as sewage, human and animal feces, pesticides, fertilizers, oil,

asbestos, and rusting building materials. Common public health risks associated with flood events also include:

- Unsafe food
- Contaminated drinking and washing water and poor sanitation
- Mosquitos and animals
- Carbon monoxide poisoning
- Secondary hazards associated with re-entering/cleaning flooded structures
- Mental stress and fatigue

J. Future Changes that May Impact Regional Vulnerability to Hazard

Projected Development

Development is likely to continue to focus on coastal areas within the Albemarle Region, mainly within Currituck and Dare County, increasing the need for flood related emergency response and recovery within these regions. While Coastal Area Management Act requirements help to prevent new development in areas with the highest coastal flood risk, an increase in development, particularly in low-lying and coastal areas, will worsen already existing flooding issues. Paved surfaces, such as roads and parking lots, contribute significantly to urban and stormwater flooding. When urban flooding occurs in areas where the water table is high, water has nowhere to go but up, creating numerous incidents of localized flooding across the region.

Projected Changes in Population

The North Carolina Office of State Budget & Management (NCOSBM) projects the Albemarle Region will see population growth through 2050, with an expected increase in population of 38,271 (22.2 percent). Overall trends in growth from the last decade are likely to continue, with significant population increases expected in Currituck County (108.9 percent growth) and Dare County (33.3 percent growth) and modest growth or population loss in other counties (NCOSBM 2022). Both Currituck and Dare County have extensive floodplains. As the population increases, so may the number of people impacted by flood hazards if an increased number of residents move to or development occurs in the floodplain.

K. Key Gaps in Data and Understanding

Key gaps in data and understanding that were identified during review of available scientific information and public and stakeholder meetings included:

- Better stormwater modeling tied to anticipated development is needed to determine future stormwater management needs.
- Mapping of stormwater/urban flooding locations is needed to identify problem areas within the region. This type of flooding is not included in FIRMs and is constantly changing due to clogging, failure, and repair of stormwater systems.
- Modeling is needed to better understand the potential extent and severity of a combined riverine and coastal flooding.
- Better climate projections for the future occurrence of coastal storms and hurricanes in the Albemarle Region is needed to inform the future frequency and severity of storm surge.

- Mapping of areas of anticipated future development would allow for better understanding of changes in exposure to flooding, especially for location specific flood risk like coastal and riverine flooding.

IX. HURRICANE AND SEVERE STORMS

A. Hazard Description

Severe storms are a common occurrence in the Albemarle Region. A variety of severe storm types, such as thunderstorms, lightning, hail, tornadoes, high winds, nor'easters/coastal storms, and hurricanes/tropical storms, have damaged property and infrastructure, downed trees and power lines, and caused injuries and fatalities. The following sections focus on the impacts of wind from severe storms. For a discussion on flooding from severe storms and storm surge as a result of hurricanes and coastal storms, refer to Section VIII.

While hurricanes and coastal storms are likely to increase in frequency and intensity in a warming climate, other changing conditions that stifle storm development may counteract these increases. However, a general increase in impacts from these storms is expected in the future.

B. Location and Extent

All of the Albemarle Region is exposed to hurricanes and severe storms. The Albemarle Region is located in FEMA Wind Zone III, where wind speeds can reach up to 200 miles per hour (mph) (FEMA 2012). Additionally, the region is located within a "Hurricane Susceptible Region," meaning the region is susceptible to hurricanes and other tropical cyclones.

Thunderstorms are common occurrences during North Carolina's summer afternoons and evenings. The popup showers experienced during this time of year are generally small (one to a few miles across) and produce very intense, local rainfall. During the spring and summer, thunderstorms are often associated with the passage of warm and cold fronts as storms develop along the frontal line and can impact all parts of the state. Thunderstorms in North Carolina bring strong winds and intense rain that can lead to localized flash flooding. Sometimes these storms also produce hail and tornadoes or damaging straight-line winds (North Carolina State University 2022).

The Albemarle Region is often impacted by coastal storms in the fall and winter, some of which become powerful storms known as nor'easters as they move northward up the eastern seaboard. While these coastal storms may impact the region several times a year, on average, the North Carolina coast sees a hurricane every 5 to 7 years (NOAA National Hurricane Center 2021). The region often receives remnants of tropical storms and hurricanes that make landfall in other parts of the country (North Carolina State University 2022).

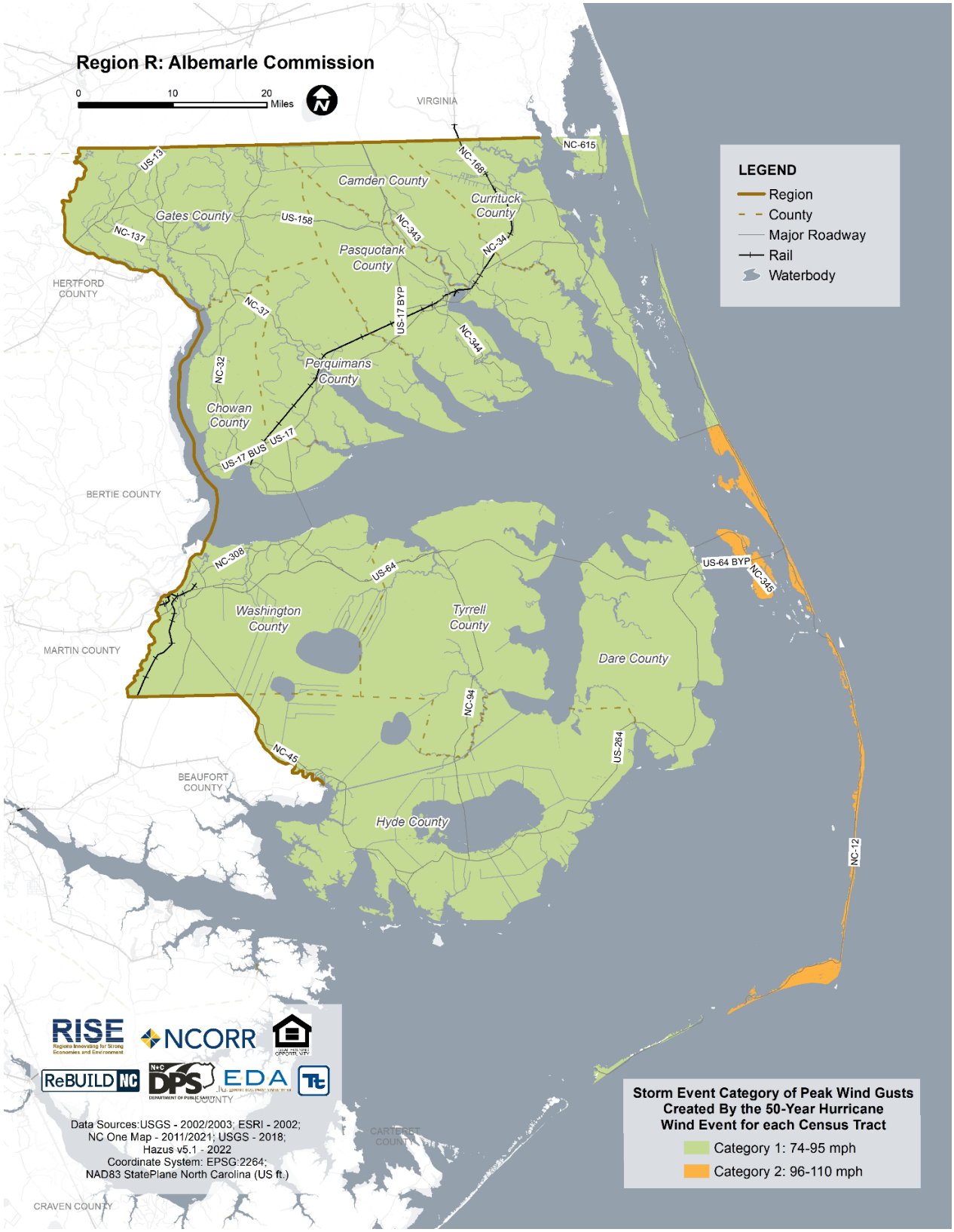
Hurricanes are one of the most impactful hazards facing the Albemarle Region. On September 18, 2003, Hurricane Isabel made landfall as a Category 2 hurricane. Major ocean overwash and beach erosion occurred along the North Carolina Outer Banks, where waves up to 20 feet accompanied a 6–8-foot storm surge.

Roughly $375 million in damage occurred. Almost $350 million in damage occurred in Dare County, where several thousand homes and businesses, several piers, and sections of Highway 12 were damaged or washed away.

Wind damage was significant across Hyde, Washington, Tyrell, Martin, and the Outer Banks Counties, where wind gusts of around 100 mph occurred. Hurricane force winds resulted in structural damage to homes. Numerous trees and power lines were downed across these areas, resulting in a loss of electricity for several weeks in some locations (NOAA NCEI 2022).

The probability that weather will occur is often discussed through mean return period. Mean return period is the interval between events of similar size or intensity. The maximum 3-second gust wind speeds for a 50-year mean return period for eastern portions of the Outer Banks are estimated to be between 96 and 110 mph (Category 2-force winds) and between 74 and 95 mph (Category 1-force winds) for the rest of the Albemarle Region. ***Figure 32*** illustrates the wind speeds for the 50-Year mean return period of hurricane winds.

Figure 32. Wind Speeds for the 50-Year Mean Return Period Hurricane Wind



C. Climate Change Impacts

A warmer atmosphere means storms have the potential to be more intense (Guillbert, J., A.K. Betts, D.M. Rizzo, B. Beckage, and A. Bomblies 2015) and occur more often (Guillbert, J., A.K. Betts, D.M. Rizzo, B. Beckage, and A. Bomblies 2015). Severe thunderstorms will likely increase in frequency in the Coastal Plain (NCICS 2020).

As oceans warm, the length of hurricane season is expanding. The past six hurricane seasons have featured a tropical system occurring before the official start (June 1) of the season. In 2016, a very rare winter hurricane named Alex developed in the middle of January (BBC 2019). According to NOAA's database, 40 storms formed in the Atlantic Basin before June 1 from 1851 through 2021, a long-term average of one early storm every four to five years. The 2010s had the most preseason storms, and there has been a steady increase since the 1990s. However, the 1950s had six preseason storms, the 1930s had four, and there was a streak of a preseason storm each year from 1887 through 1890. It is likely there were other preseason storms in the era before satellites (before the mid-1960s) that were missed by ship observations or reports from impacted areas. It remains to be seen if the expansion of the traditional hurricane season is a long-term trend or a common occurrence (Weather Channel 2020). The National Hurricane Center is currently considering expanding the official hurricane season to begin in May rather than June because of the frequency of preseason events (Highlands News-Sun 2021).

Temperatures are predicted to increase in the Albemarle Region, and ocean temperatures are forecast to continue to increase, which may lead to an increase in intensity and frequency of hurricanes. As temperatures increase, so will the energy in a storm system, increasing the potential for more intense tropical storms (Huang, H., J.M. Winter, E.C. Osterbert, R.M. Horton, and B. Beckage 2017), especially Category 4 and 5 storms (Melillo, J.M., T.T. Richmond, and G. Yobe 2014). It remains to be seen if other factors, such as steering currents, atmospheric sheer, and the presence of Saharan dust in the atmosphere over the Atlantic Ocean (which stifles tropical cyclone development), will increase or decrease the risk of hurricanes in the region.

D. Impact on Social Vulnerability and Equity, Health, and Safety

The entire population of the Albemarle Region is exposed to severe storms (US Census Bureau 2020). Residents may be displaced or require temporary to long-term shelter due to severe weather. In addition, downed trees, damaged buildings, and debris carried by high winds can lead to injury or loss of life.

The impact of a hurricane or nor'easter wind on life, health, and safety is dependent upon several factors, including the severity of the event and whether adequate warning time is provided to residents. All residents of the Albemarle Region are at risk to the impacts caused by hurricane and nor'easter wind, with the strongest wind potential in coastal areas. Nor'easter has a longer duration (potentially lasting days) than a hurricane or tropical storm, which normally passes through an area in a matter of hours (although the impacts from these storms are long-lasting).

According to the US Census Bureau, 34,021 persons over the age of 65, 27,103 persons with a disability, 22,727 persons living below the poverty level, 702 persons of limited English proficiency, and 4,143 persons without a vehicle live within the Albemarle Region.

Research has shown that some populations, while they may not have more hazard exposure, may experience exacerbated impacts and prolonged recovery if/when impacted. Socially vulnerable populations are most susceptible based

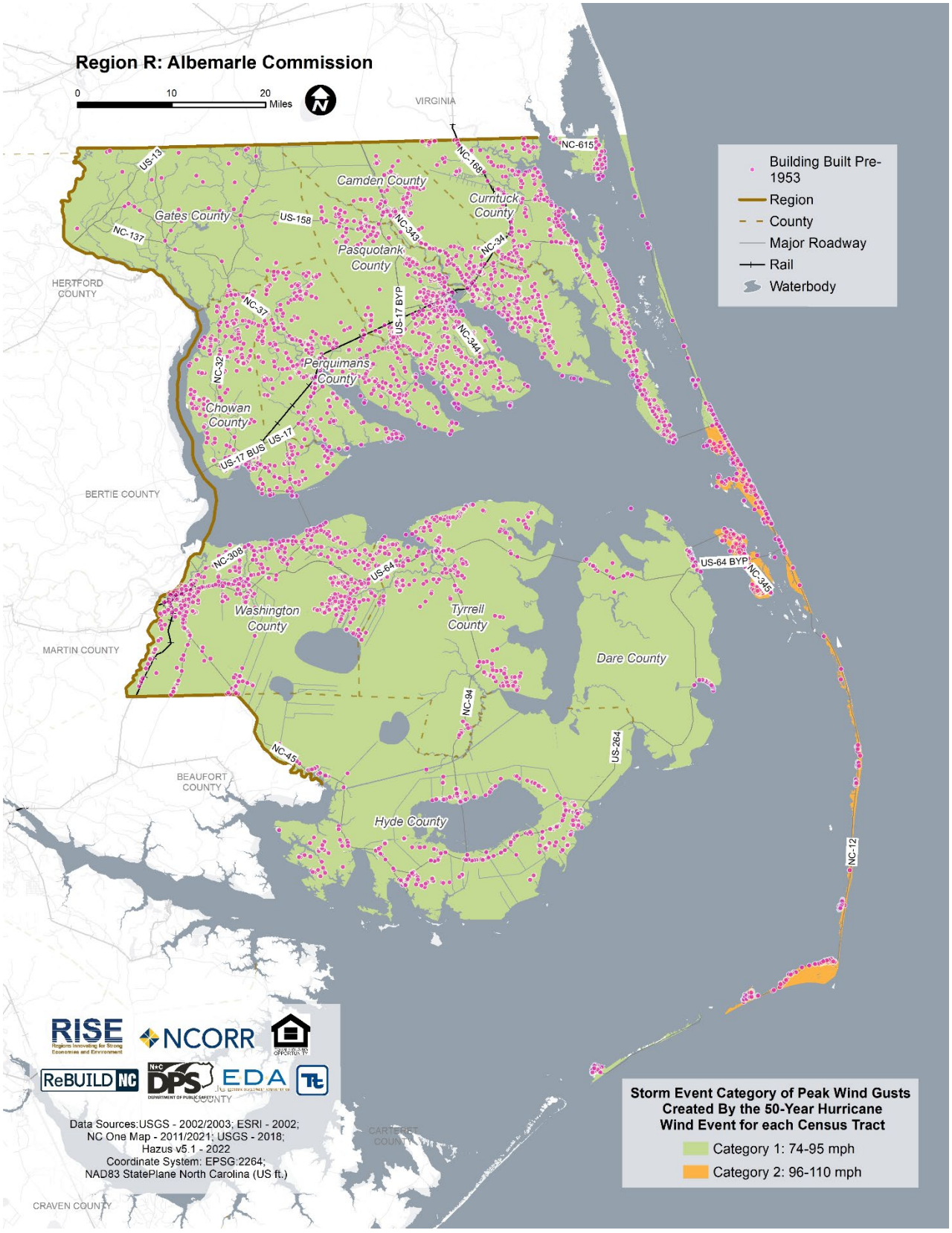
on several factors, including their physical and financial ability to react or respond during a hazard and the location and construction quality of their housing. Vulnerable populations include homeless persons, the elderly (over 65 years old), low-income or linguistically isolated populations, people with life-threatening illnesses, and residents living in areas that are isolated from major roads. The elderly are considered vulnerable because they require extra time or outside assistance during evacuations and are more likely to seek or need medical attention, which may not be available due to isolation during a storm. Emergency personnel, such as police, fire, and Emergency Medical Services (EMS), may not be able to effectively respond and maintain the safety of its residents. Residents who have limited English proficiency may be difficult to reach with typical emergency messaging. Residents who lack transportation may have difficulty evacuating ahead of severe storms. Vulnerable populations may be more vulnerable if power loss results in heating and cooling service interruption, stagnated hospital operations, and potable water supply shortages. Please refer to ***Section III*** for the statistics of these vulnerable populations.

Additionally, people located outdoors for extended periods of time (i.e., recreational activities and farming) are considered vulnerable to hailstorms, thunderstorms, and tornadoes as there may be little to no warning, and shelter may not be available. Moving to a lower-risk location will decrease a person's vulnerability.

E. Impact on Housing, Critical Infrastructure and Community Support Systems

The entire building stock of the Albemarle Region is exposed to the severe storm and wind hazard. Damage to buildings is dependent upon several factors, including wind speed, storm duration, and the path of the storm track. Building construction also plays a major role in the extent of damage resulting from a coastal storm. Due to differences in construction, residential structures are generally more susceptible to wind damage than commercial and industrial structures. Mobile/manufactured homes and structures constructed of wood and masonry buildings tend to experience more damage than concrete or steel buildings. Modern building codes were adopted in North Carolina in 1953. Buildings constructed prior to 1953 are less likely to have used construction techniques that adequately protect from wind damage. Roughly 12 percent of buildings in the region were constructed pre-1953 and have a higher likelihood of experiencing wind damage. ***Figure 33*** shows the location of these buildings compared to the 50-year mean return period hurricane wind. These buildings are clustered around Albemarle Sound and Lake Mattamuskeet. An overlap of the higher wind risk and older construction exists in the Kitty Hawk through Nags Head, Roanoke Island, and Buxton.

Figure 33. Buildings Built Pre-1953 in the Albemarle Region



Critical facilities may experience structural damage directly from high winds, falling tree limbs, or flying debris, which can also result in the loss of power. Power loss can greatly impact households, business operations, public utilities, and emergency personnel.

Transportation lifelines are not considered particularly vulnerable to the wind hazard; they are more vulnerable to cascading effects of severe storms, such as flooding, falling debris, etc. Impacts to transportation lifelines affect both short-term (e.g., evacuation activities) and long-term (e.g., day-to-day commuting) transportation needs.

F. Impact on Economy

Severe storms can have short- and long-lasting impacts on the economy. When a business is closed during storm recovery, there is lost economic activity in the form of day-to-day business and wages to employees. Overall, economic impacts can include the loss of business function (e.g., tourism and recreation), damage to inventory (utility outages), relocation costs, wage loss, and rental loss due to building repair/replacement. Public feedback during a workshop of the Climate Risk Assessment and Resilience Plan noted that storms have significant economic impact on tourism-based economies, specifically a decrease in occupancy tax collected following an evacuation order and subsequent storm recovery (NCDEQ 2020). Damages to buildings can impact a community's economy and tax base.

Utility infrastructure (power lines, gas lines, electrical systems) could suffer damage and result in the loss of power, which can impact business operations and heating or cooling services to the population.

Economic losses include direct building losses and business interruption losses, which are the estimated costs to repair or replace the damage caused to the building and the losses associated with the inability to operate a business because of the wind damage or the temporary living expenses for those displaced from their home because of the event.

Extreme winds may create several tons of debris. Debris management for downed vegetation and removal of damaged construction materials can also be costly.

G. Impact on Natural Environmental Systems

Severe storms can be destructive to the natural and local environment. National organizations, such as the United States Geological Survey (USGS) and the National Oceanic and Atmospheric Administration (NOAA), have been studying and monitoring the impacts of extreme weather phenomena as it impacts long-term climate change, streamflow, river levels, reservoir elevations, rainfall, floods, landslides, erosion, etc. (USGS n.d.). For example, severe weather that creates longer periods of rainfall can erode natural banks along waterways and degrade soil stability for terrestrial species. Tornadoes can tear apart habitats causing fragmentation across ecosystems. Researchers also believe that more diseases will spread across ecosystems because of severe weather and climate change impacts on water supplies (USGS n.d.). Overall, as the physical environment becomes more altered, species will begin to contract or migrate in response, which may cause additional stressors to the ecosystems within the Albemarle Region.

H. Impact on Historical and Cultural Resources

As noted earlier, modern building codes were adopted in North Carolina in 1953. Historical buildings constructed prior to 1953 are less likely to have used construction techniques that adequately protect

from wind damage such as stronger requirements for wall bracing. Cultural events such as outdoor fairs, festivals, and farmers markets that do not provide adequate protection from severe storms and high winds are likely to be cancelled when these events occur.

I. Cascading Impacts

Severe storms often result in secondary hazards such as flooding. Lightning can ignite wildfires. Strong winds can contribute to the rapid spread of a wildfire once ignited. Coastal storms can impact various natural land resources that can be easily uprooted by major wind and storm surge, increasing the potential for erosion (USGS n.d.).

J. Future Changes that May Impact Regional Vulnerability to Hazard

Projected Development

It is anticipated that any new development and new residents will be exposed to the severe storm hazard. However, due to increased standards and codes, new development might be less vulnerable to wind-related hazards compared to the aging building stock.

Projected Changes in Population

The North Carolina Office of State Budget and Management (NCOSBM) projects the Albemarle Region will see population growth through 2050, with an expected increase in population of 38,271 (22.2 percent). Overall trends in growth from the last decade are likely to continue, with significant population increases focused in Currituck County (108.9 percent growth) and Dare County (33.3 percent growth) and modest growth or population loss in other counties (North Carolina Office of State Budget & Management [NCOSBM] 2022).

Population growth trends in the Albemarle Region will increase the region's overall risk to severe storms. Increased population trends along the coastline, particularly in Dare County, where peak wind gusts for the 50-year mean return period event are higher than the rest of the region, will change the region's overall risk to severe hurricane winds.

K. Key Gaps in Data and Understanding

Key gaps in data and understanding that were identified during review of available scientific information and public and stakeholder meetings included:

- Better climate projections for the future occurrence of coastal storms and hurricanes in the Albemarle Region are needed. These projections are currently less certain than other climate-related projections due to the complexity of conditions necessary for coastal storms and hurricanes to form, intensify, and track over the Albemarle Region.
- Mapping of areas of anticipated future development would allow for better understanding of changes in exposure to wind damages from hurricanes and other severe storms.

X. INVASIVE SPECIES

A. Hazard Description

Invasive species have two main characteristics: they are non-native (exotic/alien) to the ecosystem they occupy, and their existence in that ecosystem causes or is likely to cause harm to the economy, environment, or human health. These species can include plant, animal, fish, or invertebrate. If left unchecked, invasive species can threaten native species, biodiversity, ecosystem services, recreation, water resources, agricultural and forest production, cultural resources, economies and property values, public safety, and infrastructure (U. S. Forest Service [USFS], U.S. Department of Agriculture [USDA] n.d.). Some invasive species also can carry disease and serve as a vector for transmission to humans.

A changing climate is likely to result in conditions that will result in the easier introduction and spread of invasive species in the Albemarle Region.

Invasive species are a common occurrence in the Albemarle Region. *Phragmites australis*, also known as common reed, is an invasive wetland grass found in tidal and nontidal brackish and freshwater marshes, river edges, and shores of lakes and ponds within the coastal plain of North Carolina. It commonly occurs in disturbed areas and is particularly common in roadside ditches.

Phragmites australis damages ecosystems by outcompeting native wetlands vegetation without providing the same habitat for aquatic life. This invasive species can clog stormwater infrastructure, thereby increasing flood risk (North Carolina Forest Service 2010).

B. Location and Extent

In the Albemarle Region, invasive species have been identified in various ecosystems, including uplands, wetlands, freshwater, and saltwater. The magnitude of invasive species ranges from nuisance to widespread. The threat is typically intensified when the ecosystem is already stressed, such as during periods of drought or changing climatic conditions. The already weakened state of the ecosystem causes it to more easily be impacted by invasive species.

The Albemarle Region has numerous invasive species of concern that have significant potential impacts, including:

- **Spotted Lanternfly** (*Lycorma delicatula*), an insect that damages plants anticipated to impact the region in the next few years)
- ***Phragmites australis***, also known as common reed which grows in wetlands and disturbed land
- **Hydrilla**, a particularly aggressive aquatic plant that infests many aquatic systems throughout North Carolina
- **Eurasian Watermilfoil** (*Myriophyllum spicatum*), another species of aquatic weed
- **Feral swine** (*Sus scrofa*), also known as wild boar

More information on these species can be found in **Appendix C.**

C. Climate Change Impacts

Climate change will exacerbate the impacts of invasive species in the region. Changing weather patterns could change the migration patterns of animals in and out of the Albemarle Region. For example, a 2017

study found that rising water temperatures in coastal waters off North Carolina increased the density of the invasive lionfish (*Pterois volitans*) (Whitfield et al 2017).

Coastal waters have warmed during the last century and are very likely to continue to warm in the 21st century (United States Global Change Research Program [USGCRP] 2014; Intergovernmental Panel on Climate Change [IPCC] 2014), potentially by as much as 4°F to 8°F (USGCRP 2009). This warming may lead to big changes in coastal ecosystems, affecting species that inhabit these areas.

Warming coastal waters cause suitable habitats of temperature-sensitive species to shift poleward. Some areas have recently seen range shifts in both warm- and cold-water fish and other marine species. (USGCRP 2014; IPCC 2013). Suitable habitats of other species may also shift because they cannot compete for limited resources with the southern species moving northward (FEMA 2008).

A warmer climate would extend the active insect season and allow for species that are not as cold tolerant to move north and expand their range, increasing potential negative impacts.

D. Impact on Social Vulnerability and Equity, Health, and Safety

The impact of invasive species on health and safety is determined by the individual species and how it interacts with humans. Typical health concerns involve the spread of disease from insects or potentially venomous species like the lionfish (Phs Org 2009). The impact on socially vulnerable populations will also be determined by individual species.

Invasive species could potentially infest crops and other agricultural products. Not only can the livelihood of farmers become affected by crops that are infested, consumers which rely on the goods and services that are infested may also be impacted.

E. Impact on Housing, Critical Infrastructure and Community Support Systems

No structures are anticipated to be directly affected by infestation or invasive species; however, some species could lead to the death of vegetation and trees throughout the region, which could result in stream bank instability, erosion, and increased sedimentation, impacting ground stabilization and possibly causing foundation issues for nearby structures. Additionally, with an increased number of dead trees, there is an increased risk of trees falling on roadways, power lines, and buildings.

Some invasive plants have been shown to destabilize soil due to high densities and shallow root systems, negatively impacting nearby buildings and septic systems. Other invasive plant species have been known to clog culverts and streams, increasing flood risk.

Impacts on critical facilities and lifelines are specific to the type of facility and the species impacting it. Water treatment plants could be impacted by invasive species because of similar issues the general building stock may experience. Water that becomes polluted due to increased sedimentation and erosion will require additional treatment. If the system becomes clogged with these pollutants, the ability of water treatment plants to operate may become impaired. Additionally, soil that becomes unstable due to decaying vegetation can impact critical facilities built on or around these soils.

F. Impact on Economy

Impacts of invasive species on the economy and estimated dollar losses are difficult to measure and quantify. Damages from invasive species have been estimated as high as $138 billion per year in the

United States (USEPA 2022). Potential impacts to the economy include agricultural losses, closure of recreation and tourism locations, and indirect damage to infrastructure. Invasive insect species can infect nursery stock and mature trees, which could reduce the timber value of hardwood exports (Canadian Food Inspection Agency 2015).

Invasive species monitoring and removal programs can be costly.

G. Impact on Natural Environmental Systems

The impact of invasive species is dependent on the behavior of the individual species. Invasive species often displace a whole suite of native species to become dominant. Invasive species are thought to have been involved in 70 percent of this century's extinctions of native aquatic species, and 42 percent of current endangered species are impacted significantly by invasive species. In January 2003 the Director of the US Fish and Wildlife Service (USFWS) called invasive species, "the biggest environmental threat to this country... it's something everyone needs to take very, very seriously" (USEPA 2022).

Invasive species can cause eventual destabilization of soil, such as invasive insects that destroy plants or invasive plants that outcompete native vegetation but have less effective root systems, which can increase runoff into waterbodies. Soil destabilization can also increase the likelihood of mudslides in areas with a steep slope.

Currituck Sound is an example of the impact of invasive species on ecosystems already stressed by development and climate change. The marshes of Currituck Sound are increasingly at risk due to threats such as habitat loss and fragmentation, sea level rise, and proliferation of invasive aquatic plants—all of which may be exacerbated by climate change (North Carolina Audubon 2019).

Several invasive species are known to exist in Currituck Sound marshes, including plants (common reed and alligator weed), invertebrates (red swamp crayfish), and mammals (nutria). Three of these taxa are considered high-priority, and the fourth (nutria) is considered a medium priority, concerning their potential ecological and economic impact and management difficulty (North Carolina Aquatic Nuisance Species Management Plan [NCANSMP] 2015). Numerous other invasive species are potentially present or could easily be introduced but are presently undocumented. The presence of invasive species in marshes is known to alter habitat structure, decrease biodiversity, change nutrient cycling and productivity, and modify food webs (Zedler, J.B. and S. Kercher 2004)

H. Impact on Historical and Cultural Resources

Historic and cultural resources are likely to have the same level of impact that other structures are likely to experience from invasive species. No direct impacts are expected but indirect impacts such as falling trees or increased flood risk are possible.

I. Cascading Impacts

Invasive species that disrupt soil or kill vegetation can increase runoff, which can lead to increased harmful algal blooms and negative impacts on drinking water supplies. For more information on water quality, refer to ***Section X***. Invasive species that disrupt soil near streams or clog stormwater components could increase the likelihood of flooding. For more information on flooding, refer to ***Section VIII***. Invasive species that kill trees increase the likelihood of wildfire. For more information on wildfire, refer to ***Section VII***.

J. Future Changes that May Impact Regional Vulnerability to Hazard

Projected Development

Additional development is likely to increase the infrastructure that could be impacted by invasive species. Invasive species that thrive in disturbed land, such as *Phragmites australis*, are likely to become more widespread throughout the region with additional development.

Projected Changes in Population

The North Carolina Office of State Budget & Management (NCOSBM) projects that the Albemarle Region will see population growth through 2050, with an expected increase in population of 38,271, or 22.2 percent (NCOSBM 2022). Population increases also increase the likelihood of an accidental release of potentially invasive species in the Albemarle Region. Furthermore, infestation of cropland can have a wider impact on persons outside of the Albemarle Region if the farmers within the region supply resources to neighboring communities. Being aware of trends occurring around the region may reveal that infestations within agricultural commodities provided by the region impact a greater number of persons.

K. Key Gaps in Data and Understanding

Key gaps in data and understanding that were identified during review of available scientific information and public and stakeholder meetings included:

- Region-specific economic assessments are needed to determine the impacts of invasive species within the Albemarle Region.
- Identification of additional invasive species that are not impacted the Albemarle Region but likely to spread to the region in the future due to current rate of spread or climate change impacts is needed to determine the future vulnerability of the region to this hazard.

XI. WATER QUALITY ISSUES

A. Hazard Description

The Albemarle Region can be impacted by groundwater and inland surface water quality issues and coastal water impacts such as harmful algal blooms.

Groundwater Contamination

Groundwater is a natural resource that is used for drinking water, recreation, industry, and crops. It is water found underground in the cracks and spaces in soil, sand, and rock. Groundwater is stored in – and moves slowly through – layers of soil, sand, and rocks called "aquifers." Aquifers typically consist of gravel, sand, sandstone, or fractured rock, like limestone. These materials are permeable because they have large, connected spaces that allow water to flow through. In areas where material above the aquifer is permeable, pollutants can readily sink into groundwater supplies (Groundwater Foundation 2020 2020).

Surface Water Contamination

Surface water is made up of freshwater lakes, rivers, and streams and brackish or saltwater coastal waters such as the region's sounds and the Atlantic Ocean. Surface water can be contaminated by non-point source pollution or spills. Surface water contamination can damage ecosystems, threaten fisheries, and negatively impact recreation and tourism.

Harmful Algal Bloom

Algae blooms, also called cyanobacteria, are caused by an excess of nutrients available in a waterbody, resulting in rapid growth and reproduction of algae in what is commonly referred to as a "bloom." When waterbodies are inundated by water runoff with high levels of naturally occurring and manmade nutrients, the waterbodies become more vulnerable to algal blooms.

Like plants, algae photosynthesize, forming the basis of many aquatic and marine food chains. However, unlike plants, algae do not have roots for nutrient intake. Instead, algae draw their nutrients directly from the surrounding environment. Due to this phenomenon, high nutrients, warm temperatures, and low turbulence at the water's surface all increase the risk of algal blooms.

Harmful algal blooms are a common occurrence in the Albemarle Region. During the summer of 2019, officials with the North Carolina Department of Health and Human Services issued warnings urging the public to stay out of the Chowan River near Indian Creek due to high levels of cyanotoxins. Test results indicated this HAB was producing microcystins at a level state officials considered extremely high risk for acute health effects based on studies and recommendations from the World Health Organization (Waterkeepers NC n.d.).

More than 40 cyanobacterial species are confirmed or suspected to produce toxins (Graham and Wilcox 2000). When these populations of algae grow out of control and produce toxins or have harmful effects, it is typically referred to as a "Harmful Algal Bloom" (HAB). Human contact with water containing HABs can cause various health effects, including diarrhea, nausea or vomiting; skin, eye, or throat irritation; and allergic reactions or breathing difficulties (United States Environmental Protection Agency [USEPA] 2021).

Saltwater Intrusion

Rising sea level will cause saltwater to enter coastal aquifers, a phenomenon known as saltwater intrusion. Aquifers, which are like large underground lakes, are important sources of drinking water. With saltwater intrusion, the water in the aquifer becomes contaminated with salt and turns undrinkable. Saltwater intrusion is a very serious problem because it threatens the availability of drinking water and can make soils too salty for native plants to grow, creating problems for coastal forests and agriculture. Saltwater intrusion is one of the first impacts that the coast is expected to face with an increase in sea level (NC Department of Environmental Quality [NCDEQ], Division of Coastal Management n.d.).

Climate change is likely to increase the occurrence of water quality issues through warmer temperatures, drought, and sea level rise driven saltwater intrusion.

B. Location and Extent

The ability to provide safe and reliable drinking water now and into the future and maintain environmental water quality are paramount in the region. There are nine county-wide, one regional, and several municipal water systems in the region. Due to a decrease in available groundwater, several local governments in the region are engaging in prolonged and expensive reverse osmosis projects (Albemarle Commission 2018).

The capacity for wastewater treatment plants and septic systems continues to hinder development growth in the region. Because of the high-water table and the distance between residences and businesses, the expense and the environmental factors within the region also impose wastewater and septic system expansion difficulties (Albemarle Commission 2018).

The region's Stakeholder Partnership noted that leaks in aging sewer lines lead to inflow and infiltration issues from high water tables and unintended capture of stormwater. Wastewater plants note higher volumes of wastewater during and immediately after heavy rainstorms. Public feedback during a workshop of the Climate Risk Assessment and Resilience Plan also noted that water flowing into manhole covers during storms negatively affects the treatment process (NCDEQ 2020). High rates of inflow and infiltration increase the likelihood of potential spills or overflows of wastewater into nearby waters.

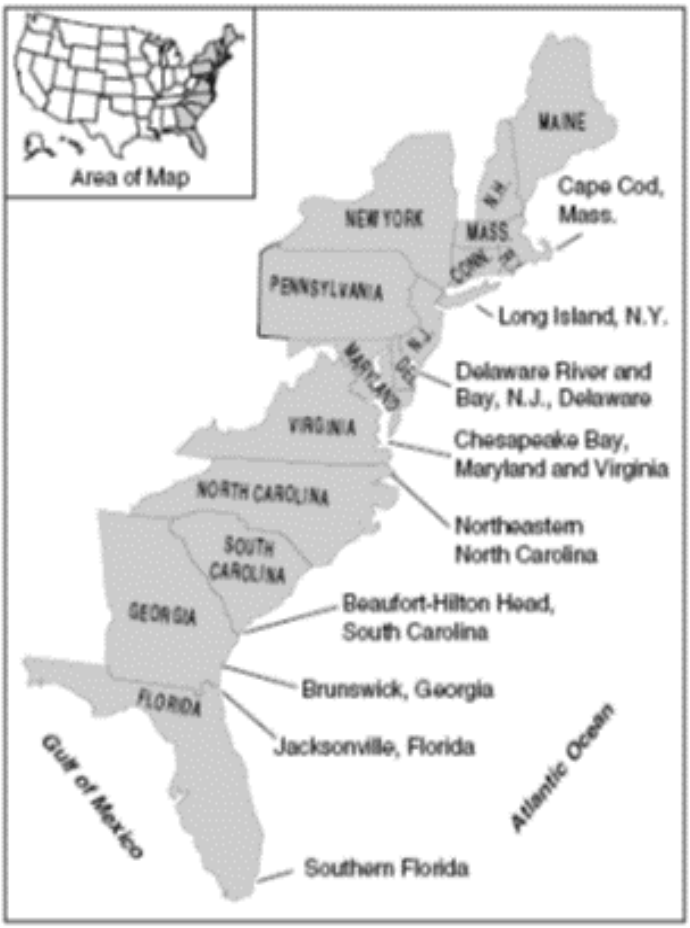
According to the USEPA, rivers and streams of the Albemarle Region are nutrient-sensitive and require nutrient input controls such as upgrades for wastewater treatment plants and septic systems. Both strategies are being pursued by state and local officials. Much of the area is unsuitable for conventional gravity-flow individual systems due to low-permeability clay soils and high water tables. In past decades, these limitations prompted the extensive use of sand-lined trench leaching systems in the region. A 1991 study found that 30 percent of those systems were malfunctioning and posing risks to groundwater and surface water quality (USEPA n.d.)

As a result of this sensitivity, HABs have the potential to impact waterbodies throughout the Albemarle Region. Waterbodies that are calm and have issues with eutrophication (overloading of nutrients) are the most susceptible to HABs. Wind currents can play a large role in the concentrations of algae that float at or near the water surface. Consistent winds can accumulate algae at downwind shorelines. Shorelines containing coves or other features that could capture floating algae may be more susceptible to HABs. In instances where freshwater intakes are impacted by these blooms, the extent may also include the area that is serviced by the impacted water utility or the private/residential intake. In 2021, HABs were reported in the Chowan River, Perquimans River, Little River, and Pasquotank River (NCDEQ 2022).

Changes in the geomorphology of the coast in northeastern North Carolina over time (particularly the closing of inlets connecting Currituck Sound to the Atlantic Ocean) have resulted in significant shifts in the sound's hydrological regime (North Carolina Audobon 2021). In a 2011 study, the US Army Corps of Engineers (USACE) identified four primary threats to water quality in Currituck Sound: nutrient loading associated with agricultural and urban runoff and septic wastewater contamination, increased turbidity, saltwater intrusion, and increased pollution from draining basins in Virginia (USACE 2011). In 2014, Currituck Sound was listed on the 303d list as impaired for Enterococcus, a bacteria that is associated with fecal matter. The state does not conduct ambient water quality sampling in Currituck Sound, North Landing River, or Northwest River watersheds (NCDEQ n.d.).

Like HABs, saltwater intrusion is also already occurring in the Albemarle Region. The Region has been identified as one of the numerous areas of the Atlantic coast where saltwater has intruded into freshwater aquifers. Saltwater intrusion has also been identified as an issue in shallow coastal aquifers by stakeholders and members of the public during this planning process. Farms along the coast have experienced saltwater intrusion, which has resulted in the abandonment of sections of fields that have become too salty to support crops. ***Figure 34*** shows selected areas along the Atlantic Coast where saltwater is known to have intruded into freshwater aquifers.

Figure 34. Selected Areas Along the Atlantic Coast Where Saltwater has Intruded into Freshwater Aquifers.



Source: Barlow and Wild 2002

C. Climate Change Impacts

Climate change is likely to bring heavier rainfall to some coastal areas, which would increase runoff and flooding. In addition, warmer temperatures in mountain areas could lead to more spring runoff due to snow melting. In turn, contaminated flood waters and increases in runoff may threaten the health and quality of coastal waters. Some coastal areas, such as the Gulf of Mexico and the Chesapeake Bay, are already experiencing "dead zones." Dead zones occur when land-based sources of pollution (e.g., agricultural fertilizers) contribute to algal blooms. When the algae sink and decompose, the process depletes the oxygen in the water. As increases in spring runoff bring more nitrogen, phosphorus, and other pollutants into coastal waters, many aquatic species could be threatened (USEPA 2017).

Droughts are projected to become more severe in the future due to climate change. Decreases in precipitation could also increase the salinity of coastal waters. Droughts reduce freshwater input into tidal rivers and bays, which raises salinity in estuaries, and enables saltwater to mix further upstream (United States Global Change Research Program [USGCRP] 2014). Droughts can cause deficits in surface and groundwater used for drinking water. If the region experiences an increased draw on freshwater aquifers due to drought conditions and limited supply of surface water, saltwater infusion may become exacerbated, further contaminating groundwater supplies.

D. Impact on Social Vulnerability and Equity, Health, and Safety

In general, private well owners/users are more vulnerable to natural groundwater contamination. USEPA regulates the public water system and sets standards for contaminants in drinking water that may pose health risks. However, USEPA does not have the authority to regulate private drinking water wells. Private well water quality testing and water treatment are the responsibility of the well owner. In general, private well water quality is not tested as frequently as required by public water suppliers. Additionally, areas that rely on private wells for drinking water often use septic systems for sanitary wastewater disposal, which may be another source of contamination.

People who drink contaminated water may, immediately or over time, suffer from a variety of health problems depending upon the type of contamination. Depending on the contaminant of concern, infants, young children, and individuals with compromised immune systems may be more susceptible to illnesses from contaminated groundwater. It is difficult to measure and quantify the health costs that might be incurred due to groundwater contamination.

Impacts of HABs on life, health, and safety depend on several factors, including the severity of the event and whether citizens and tourists have become exposed to waters suspected of containing a HAB. Routes of exposure include consumption, inhalation, and dermal exposure. The population living near waterbodies is at risk for exposure to HABs, as well as those who use those waterbodies for recreation, fishing, and water supply. Contact with water containing HABs can cause various health effects, including diarrhea, nausea, or vomiting; skin, eye, or throat irritation; and allergic reactions or breathing difficulties (New York State Department of Health [NYSDOH] 2017; North Carolina Department of Health and Human Services 2020).

Cyanobacteria blooms are one of the most common freshwater HABs. Cyanobacteria are known to produce toxins from the following classes:

- **Endotoxins:** Endotoxins associated with cyanobacteria have been tied to fever and inflammation in humans that have come in contact with water that contains cyanobacterial blooms.

- **Hepatotoxins:** Hepatotoxins are commonly tied to animal poisonings that are associated with cyanobacterial blooms. Animals may exhibit weakness, heavy breathing, paleness, cold extremities, vomiting, diarrhea, and bleeding in the liver. In humans, hepatotoxins have been indicated to promote tumors and may lead to increases in liver cancer. Some types of hepatotoxins, such as microcystin, can persist in freshwater for up to 2 weeks before being naturally broken down (algae).
- **Neurotoxins:** Neurotoxins act to block transfers between neurons. Extreme cases can result in paralysis.

Locations in the Albemarle Region that rely on surface water intake for drinking water are most exposed to the impacts of HABs. Where utility companies purchase water from outside sources, users may be more vulnerable if the utility has less control over the quality of the source. Coordinating with the supplier to ensure the water is clear of toxins from harmful algae, thus maintaining the safety of users of the purchased water, is recommended.

Drinking water is also likely to be impacted by saltwater intrusion in coastal areas. Saltwater intrusion could result in the elimination of safe drinking water if the aquifers accessed by potable wells are rendered too salty to drink. This is usually addressed by using a different aquifer, installing desalinization plants, or shipping water in from outside sources. However, these measures are often costly and can cause significant financial stress on socially vulnerable populations.

E. Impact on Housing, Critical Infrastructure and Community Support Systems

No structures or critical facilities are anticipated to be directly damaged by groundwater contamination. However, groundwater contamination can lead to the failure of services provided by potable water wells and aquifers.

The typical impact HABs have on critical facilities are shutdowns of water intakes from the surface waters that are impacted by blooms and associated toxins. Water treatment plants can remove variable amounts of microcystin from drinking water depending on the active removal process used by the water treatment plant (USEPA 2020). However, applying the wrong treatment process at a specific state in treatment could damage the facility and release cyanotoxins rather than remove them. More information on the USEPA's summary of effective treatment options for harmful algal blooms can be found in ***Appendix D.***

No structures are anticipated to be directly affected by saltwater intrusion. However, saltwater intrusion can lead to the failure of services provided by potable water wells and aquifers or result in the need to build costly desalinization plants.

F. Impact on Economy

Groundwater contamination can impact the economy in many ways. When groundwater becomes polluted, property values can drop, and land may become unsellable. The price to remediate contaminated groundwater can be expensive, and taxpayers may be burdened with this cost. Clean-up costs depend on many factors, including the type of contaminant, its concentrations, and the extent. In many cases, the full cost of remediation is not realized, even after years have passed. Increased demand for bottled water may result in shortages and higher costs. Industries that rely on water for business may also be impacted (e.g., agriculture).

Long-term groundwater contamination can lead to the need to build new wells outside of the contaminated area. Saltwater intrusion can result in the need to build costly desalinization plants. Costs of construction of new wells or treatment facilities may negatively impact local economies (NC Department of Health and Human Services [NCDHHS] 2015).

HAB-related economic impacts in the Albemarle Region would largely focus on the recreation sector. News of a body of water or beach closure can result in visitors avoiding the area. Even after closures are lifted, negative public reactions can persist and continue to impact local revenue and property values. HABs also reduce the amount of dissolved oxygen in the water, which can lead to fish kills, impacting subsistence fishing communities and recreation (NCDHHS 2015).

As mentioned, there is a price tied to programs that protect waterbodies from harmful algal blooms. The cost to operate and monitor these programs will vary depending on the extent of the blooms. Additional costs may include money spent on purchasing backup water sources and costs to implement advanced drinking water treatment.

Saltwater intrusion can result in the need to build costly desalinization plants. Construction costs of new wells or treatment facilities may have negative impacts on local economies.

As noted above, saltwater intrusion has already resulted in the abandonment of impacted farmland. These farms in the Albemarle sell $508,573,000 worth of products annually. Farming in the Albemarle Region supports 1,674 workers. According to the United States Department of Agriculture (USDA), 91 of the farms in the Albemarle Region are family-owned (USDA 2017). The continued loss of farmland would heavily impact these workers and farm owners. While only low-lying coastal farms are likely to be impacted by saltwater intrusion, the continued spread of saltwater intrusion in farmland represents a significant risk to the agricultural sector of the region's economy.

G. Impact on Natural Environmental Systems

Groundwater contamination can be harmful to the habitat where species are sensitive to pollutants or changes in the water chemistry. Aquatic species that live in groundwater-fed habitats that become contaminated are at risk of disease or death. Impacted species may choose to migrate to other locations, which has residual impacts on the surrounding habitat.

Surface water contamination can result in eutrophication and aquatic plant and animal die-offs in severe contamination cases.

HABs can release toxins that can kill fish and invertebrates. Animals that prey on fish and invertebrates in surface waters, such as birds and mammals, may be affected if they ingest impacted prey. Both harmful and non-harmful algal blooms can have drastic impacts on oxygen levels in surface waters. When algae begin to die off following a bloom, bacteria begin to decompose the organic material. This decomposition consumes dissolved oxygen and releases carbon dioxide. If the bloom and die-off are large enough, dissolved oxygen levels in aquatic systems can rapidly crash. Anoxic conditions connected to algal blooms have resulted in large fish and invertebrate kills.

Saltwater intrusion can result in the conversion of freshwater wetlands to saltwater wetlands where the impacted aquifer is shallow. Coastal forests that cannot tolerate saltwater may die off and become "ghost forests" if saltwater intrusion reaches their root system. For more information on wetlands migration, refer to ***Section VI***.

H. Impact on Historical and Cultural Resources

Water quality issues are unlikely to have direct impacts on historical or cultural resources within the Albemarle Region. Water quality issues that impact drinking water may limit tourism to some locations. HABs and water contamination may negatively impact eco-tourism and historical fishing communities in the region.

I. Cascading Impacts

Water quality issues are often a cascading impact from other man-made and natural hazards such as heavy rainfall. Water quality issues can lead to drinking water shortages and health concerns if contaminated water is ingested or comes in contact with skin.

Saltwater intrusion can result in fewer potable wells, increasing the potential for severe drought to impact the drinking water supply.

J. Future Changes that May Impact Regional Vulnerability to Hazard

Projected Development

It is anticipated that higher density development will increase the likelihood of unintended releases of pollutants and non-point source pollution, which may lead to an increase in water quality issues within the Albemarle Region. As development is likely to focus near coastal areas, water quality issues associated with coastal surface water, such as HABs, may become more severe. Development in coastal areas can also increase the draw on freshwater aquifers and increase the likelihood of saltwater intrusion.

Projected Changes in Population

Areas experiencing population growth are likely to experience increased water quality issues without proper mitigation techniques. Population growth can increase the draw on freshwater aquifers and increase the likelihood of saltwater intrusion. As population growth is forecast to be focused in coastal areas, the impacts of saltwater intrusion are likely to increase.

K. Key Gaps in Data and Understanding

Key gaps in data and understanding that were identified during review of available scientific information and public and stakeholder meetings included:

- Expanded water quality testing is needed to identify hotspot locations of contamination, nutrient loading of local waterways, and harmful algal blooms.
- Increased tracing of point source and non-point source pollution pathways are needed to identify the sources of contamination.
- Mapping of areas of anticipated future development would allow for better understanding of potential downstream increases in water quality issues due to additional runoff and non-point source pollution.

XII. WILDFIRE

A. Hazard Description

Wildfires are any non-structural fire that occurs in the wildland. Three distinct types of wildfires have been defined and include: naturally occurring wildfire, human-caused wildfire, and prescribed fire. Many wildfires are highly destructive and difficult to control. They occur in forested, semi-forested, or less developed areas. Wildland fires can be caused by lightning, human carelessness, and arson. According to the North Carolina Forest Service, careless debris burning is the leading cause of wildfires in North Carolina (NC Forest Service 2022). Wildfires result in the uncontrolled destruction of forests, brush, field crops, grasslands, real estate, and personal property and have secondary impacts on other hazards, such as flooding, by removing vegetation and destroying watersheds.

Wildfires in the Albemarle Region can be small and short lived or very large and long lasting. In June 2008, the record-breaking Evans Road Wildfire, a smoldering peat fire caused by a lightning strike during a major drought, lasted for 3 months and burned 41,534 acres inside the Pocosin Lakes National Wildlife Refuge (NCDEQ 2019). The wildfire resulted in $20 million in suppression costs (NCDPS 2018).

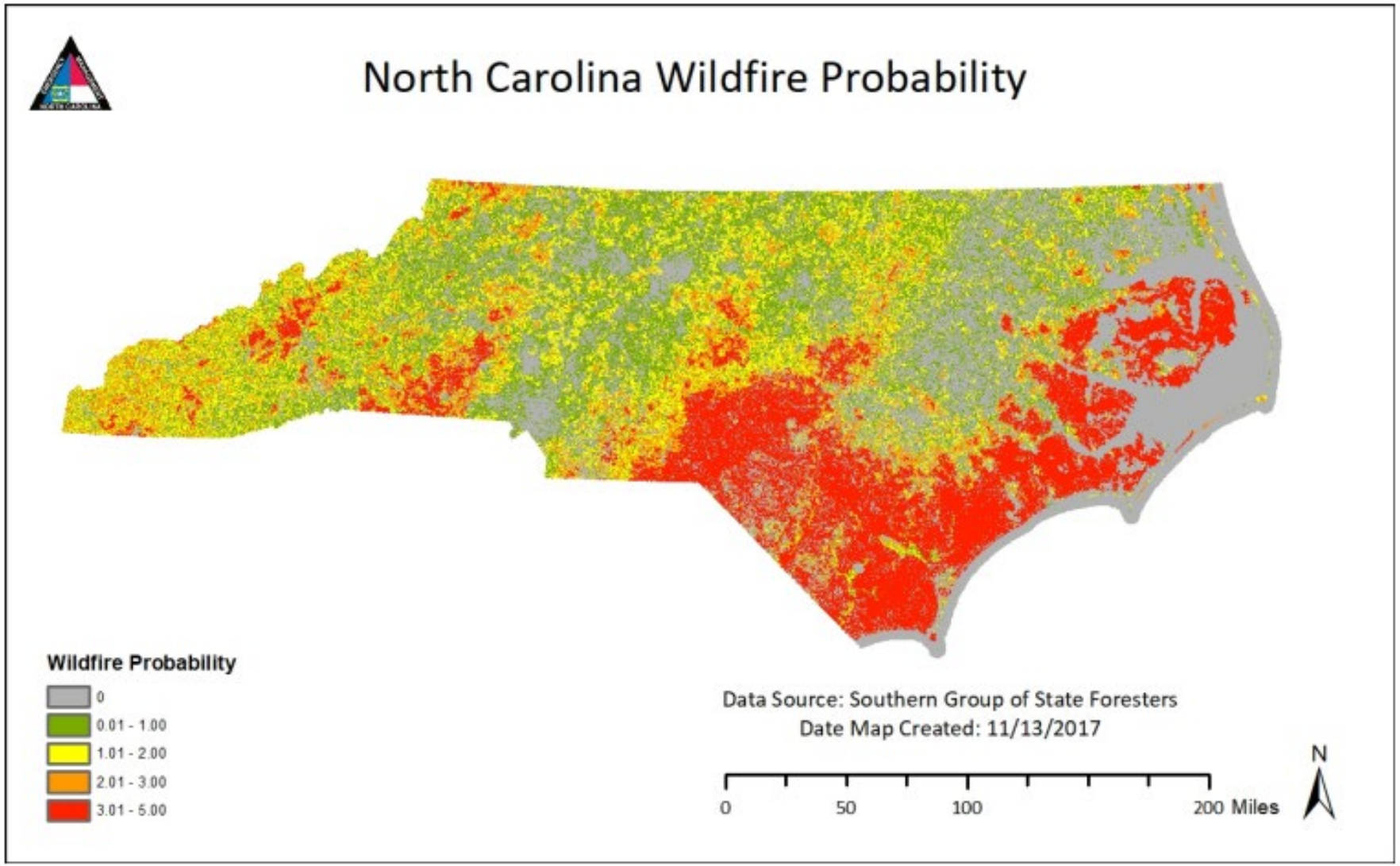
Extreme temperature and drought driven by climate change are likely to increase the frequency and severity of wildfires in the future.

B. Location and Extent

Wildfires can occur in natural areas such as wetlands and forests and adjacent development areas throughout the Albemarle Region. Areas where vegetation and trees have died due to drought or saltwater intrusion (ghost forests) have an increased risk of wildfire (New York Times 2019). In North Carolina, there has been a long-term upward trend in the number of wildfires but a downward trend in the acreage burned. These long-term changes involve numerous non-climatic factors, while year-to-year changes are influenced by climate factors (NCICS 2020).

According to mapping provided by the Southern Group of State Foresters for the State Hazard Mitigation Plan (***Figure 35***), Dare, Hyde, Tyrrell, and Washington Counties have a higher wildfire probability than the rest of the Region (North Carolina Department of Public Safety [NCDPS] NC HMP 2018).

Figure 35. North Carolina Wildfire Probability

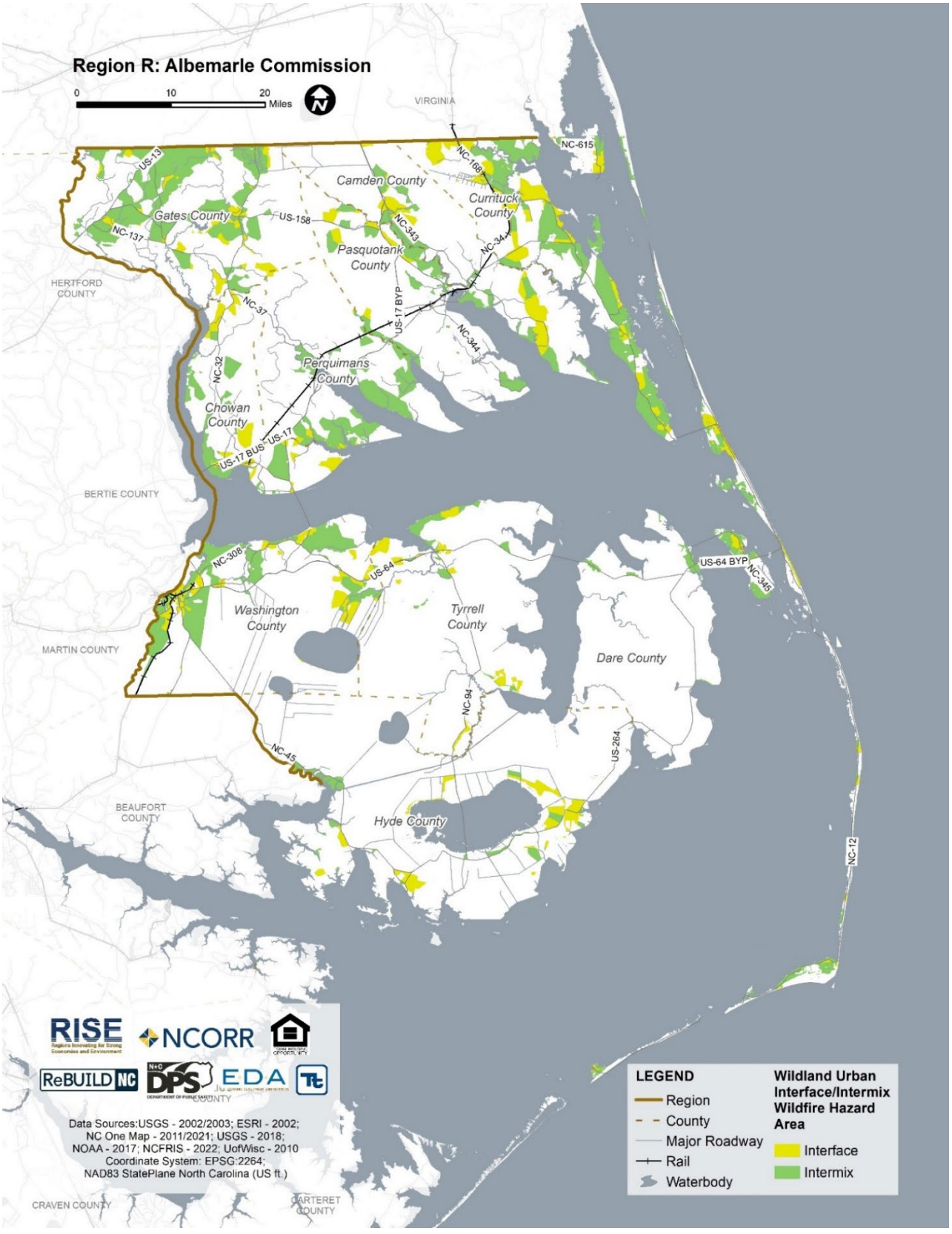


Source: NCDPS 2018

The Wildland-Urban Intermix are areas where housing and vegetation intermingle; the Wildland-Urban Intermix are areas with housing in the vicinity of contiguous wildland vegetation.

The Wildland-Urban Interface is the zone of transition between unoccupied land and human development. It is the line, area, or zone where structures and other human development meet or intermingle with undeveloped wildland or vegetative fuels. According to the U.S. Fire Administration, North Carolina ranks number four on the list of states with the greatest number of houses in the Wildland-Urban Interface (U.S. Fire Administration 2022). Areas of interface and intermix are spread throughout the Albemarle Region (see ***Figure 36***).

Figure 36. Wildland-Urban Interface and Intermix in the Albemarle Region



To explore the location specific exposure to the wildfire hazard, visit Albemarle Commission Region - Resilience Portfolio Web Map (arcgis.com).

C. Climate Change Impacts

The Albemarle Region can expect warmer and drier conditions, which may increase the frequency and intensity of wildfires (NC Climate Science Report 2020). While an increase in annual precipitation is expected, warmer temperatures may lead to longer dry seasons and multi-year droughts, creating triggers for wildfires, insects, and invasive species (U.S. Department of Agriculture [USDA] 2012).

A gradual change in temperatures will alter the growing environment of many tree species throughout the United States, reducing the growth of some trees and increasing the growth of others. Tree growth and regeneration may be affected more by extreme weather and climatic conditions than by gradual changes in temperature or precipitation.

Increased temperature and change in precipitation will also affect fuel moisture during wildfire season and the length of time when wildfires can burn during a given year. Climate change may also increase the frequency of lightning strikes. A warmer atmosphere holds more moisture, which is one of the key factors for triggering a lightning strike. Lightning strikes cause approximately half the wildfires in the United States. If the frequency of lightning strikes increases, the potential for wildfires from these strikes also increases (National Geographic 2014). Wildfire incidents are predicted to increase throughout the United States due to climate change, causing at least a doubling of areas burned within the next century (USDA 2017).

It is projected that higher summer temperatures will likely increase the high fire risk in the United States by 10 to 30 percent. Fire occurrence and/or area burned could increase across the U.S. due to the increase of lightning activity, the frequency of surface pressure and associated circulation patterns conductive to surface drying, and fire-weather conditions in general, which is conductive to severe wildfires. Warmer temperatures will extend fire seasons and areas burned (U.S. Forest Service [USFS] 2020).

D. Impact on Social Vulnerability and Equity, Health, and Safety

Wildfires have the potential to impact human health and life of residents and responders, structures, infrastructure, and natural resources.

Wildfire smoke contains particulate matter, carbon monoxide, nitrogen oxides, and various volatile organic compounds (which are ozone precursors) and can significantly reduce air quality, both locally and in areas downwind of fires. Smoke exposure increases respiratory and cardiovascular hospitalizations; emergency department visits; medication dispensations for asthma, bronchitis, chest pain, chronic obstructive pulmonary disease (COPD), and respiratory infections; and medical visits for lung illnesses (Centers for Disease Control and Prevention [CDC] 2020). The North Carolina State Climate Office and the North Carolina Division of Air Quality have developed an Air Quality Portal for North Carolina to monitor and display air quality conditions in the state.

The most vulnerable populations include emergency responders and those within a short distance of the interface between the built environment and the wildland environment. First responders are exposed to the dangers from the initial incident and after-effects from smoke inhalation and heat stroke.

In the Albemarle Region, 9,295 people live within the wildland-urban interface hazard area (5.40 percent of total population) and 26, 662 people live within the wildland-urban intermix hazard area (15.50 percent of total population). ***Table 34*** displays the vulnerable populations located in the wildland-urban interface hazard area for each county in the Albemarle Region. ***Table 35*** displays the same information for populations located in the wildland-urban intermix hazard area.

Table 34. Total Vulnerable Population Located in the Wildland-Urban Interface Wildfire Hazard Area

County	Total Population (2020 Decennial Census Population)	Total Vulnerable Population Located in the Wildland-Urban Interface Wildfire Hazard Area								
		Total Population in Hazard Area	Vulnerable Population Category							
			Number of Persons Over 65	Number of Persons Below 5	Number of Persons Below Poverty Level	Number of Persons with a Disability	Number of Persons Limited English Speaking	Number of Persons Without Vehicle	Number of Persons 16 and Over Commuting to Work with Public Transportation (excluding taxicab)	Number of Persons 16 and Over Commuting to Work by Walking
Camden	10,355	747	133	35	70	107	1	8	-	9
Chowan	13,708	1,363	340	64	219	232	5	63	3	21
Currituck	28,100	3,717	553	189	328	506	4	35	1	19
Dare	36,915	871	177	37	76	106	7	10	-	10
Gates	10,478	458	100	20	68	114	1	10	-	1
Hyde	4,589	118	26	6	29	20	2	-	-	1
Pasquotank	40,568	1,251	201	81	179	187	5	39	1	13
Perquimans	13,005	115	32	5	18	20	-	3	-	1
Tyrrell	3,245	96	24	4	22	22	-	3	-	1
Washington	11,003	559	143	28	133	130	1	39	-	5
Albemarle Region (Total)	**171,966**	**9,295**	**1,729**	**469**	**1,142**	**1,444**	**26**	**210**	**5**	**81**

Source: University of Wisconsin 2010; ACS 2019; Census 2020

Table 35. Total Vulnerable Population Located in the Wildland-Urban Intermix Wildfire Hazard Area

County	Total Population (2020 Decennial Census Population)	Total Vulnerable Population Located in the Wildland-Urban Intermix Wildfire Hazard Area								
		Total Population in Hazard Area	Vulnerable Population Category							
			Number of Persons Over 65	Number of Persons Below 5	Number of Persons Below Poverty Level	Number of Persons With a Disability	Number of Persons Limited English Speaking	Number of Persons Without Vehicle	Number of Persons 16 and Over Commuting to Work with Public Transportation (excluding taxicab)	Number of Persons 16 and Over Commuting to Work by Walking
Camden	10,355	1,103	197	52	103	158	1	12	-	13
Chowan	13,708	2,108	525	98	339	359	8	98	4	33
Currituck	28,100	9,516	1,415	483	840	1,295	11	89	2	48
Dare	36,915	3,079	625	131	269	374	23	36	1	35
Gates	10,478	2,662	580	117	393	663	8	56	-	4
Hyde	4,589	80	18	4	20	14	1	-	-	1
Pasquotank	40,568	4,010	644	258	573	599	16	125	2	41
Perquimans	13,005	2,374	664	109	366	406	8	60	-	17
Tyrrell	3,245	88	22	4	20	20	-	3	-	1
Washington	11,003	1,642	420	82	390	381	2	114	-	14
Albemarle Region (Total)	**171,966**	**26,662**	**5,110**	**1,338**	**3,313**	**4,269**	**78**	**593**	**9**	**207**

Source: University of Wisconsin 2010; ACS 2019; Census 2020

In total, the total vulnerable population with an overall SVI ranking of 0.5001-0.75 in the Albemarle Region is 6,385 in the wildland-urban interface hazard area (3.7 percent of the total region population) and 35,776 in the wildland urban intermix hazard area (20.8 percent of the total region population). The total vulnerable population with an overall SVI ranking greater than 0.7501 is 4,869 in the wildland-urban interface hazard area (2.8 percent of the total region population) and 10,744 in the wildland-urban intermix area (6.2 percent of the total region population). These populations are most likely to require additional assistance during and after a wildfire event. For a breakdown of SVI ranking in the wildland-urban interface and intermix areas by county, refer to **Appendix F**.

E. Impact on Housing, Critical Infrastructure and Community Support Systems

Buildings and critical facilities located in or adjacent to vegetated areas are exposed and considered vulnerable to wildfires. Buildings constructed of wood or vinyl siding are generally more likely to be impacted by the fire hazard than buildings constructed of brick or concrete.

A total of 28,836 buildings in the Albemarle Region are located in the wildland-urban interface hazard area (19.23 percent of all buildings).

Table 36 displays the number of buildings located in the wildland-urban interface hazard area by occupancy type for each county in the region.

Table 36. Number of Buildings by Occupancy Type Located in the Wildland-Urban Interface Wildfire Hazard Area

County	Total Number of Buildings per County	Number of Buildings by Occupancy Type Located in the Wildland-Urban Interface Wildfire Hazard Area							
		Occupancy Type							
		Residential	Commercial	Agricultural	Education	Religious	Government	Industrial	Vacant
Camden	7,228	1,008	33	164	-	11	4	53	14
Chowan	11,347	2,498	250	118	11	28	8	64	-
Currituck	23,272	4,529	358	195	15	33	27	71	65
Dare	41,439	9,370	571	1	27	37	55	30	46
Gates	9,694	918	76	223	12	34	21	10	-
Hyde	7,716	1,796	113	146	8	22	18	15	-
Pasquotank	22,743	443	31	57	-	5	-	8	-
Perquimans	11,070	369	10	-	-	4	-	2	-
Tyrrell	3,955	699	85	129	16	15	27	2	-
Washington	11,453	3,100	237	334	23	80	29	25	-
Albemarle Region (Total)	**149,917**	**24,730**	**1,764**	**1,367**	**112**	**269**	**189**	**280**	**125**

Sources: University of Wisconsin 2010; NC One Map 2021/2022

A total of 34,328 buildings in the Albemarle Region are located in the wildland-urban intermix hazard area (22.90 percent of all buildings). ***Table 37*** displays the number of buildings located in the wildland-urban intermix hazard area by occupancy type for each county in the region.

Table 37. Number of Buildings by Occupancy Type Located in the Wildland-Urban Intermix Wildfire Hazard Area

County	Total Number of Buildings per County	Number of Buildings by Occupancy Type Located in the Wildland-Urban Intermix Wildfire Hazard Area							
		Occupancy Type							
		Residential	Commercial	Agricultural	Education	Religious	Government	Industrial	Vacant
Camden	7,228	1,308	44	112	-	13	10	40	14
Chowan	11,347	1,500	100	226	1	6	-	41	-
Currituck	23,272	6,157	373	223	20	30	35	84	88
Dare	41,439	9,490	607	31	48	49	134	119	202
Gates	9,694	3,047	133	841	24	51	17	27	-
Hyde	7,716	1,164	43	47	-	9	4	16	-
Pasquotank	22,743	1,747	129	123	15	7	2	14	-
Perquimans	11,070	2,069	64	58	6	23	16	4	-
Tyrrell	3,955	462	20	93	2	6	1	-	-
Washington	11,453	2,413	84	373	6	34	3	26	-
Albemarle Region (Total)	**149,917**	**29,357**	**1,597**	**2,127**	**122**	**228**	**222**	**371**	**304**

Sources: University of Wisconsin 2010; NC One Map 2021/2022

Mobile home parks are often located in forested areas and may have higher exposure to wildfire. 9 mobile home parks and 3,983 mobile home buildings are located in the wildland-urban interface hazard area. 16 mobile home parks and 6,794 mobile home buildings are located in the wildland-urban intermix hazard area. ***Table 38*** displays the number of mobile home parks and mobile home buildings located in the wildland-urban interface and intermix for each county in the region.

Table 38. Number of Mobile Home Parks and Mobile Home Buildings Located in the Wildland-Urban Interface and Intermix Wildfire Hazard Areas

County	Total Number of Mobile Home Parks per County	Total Number of Mobile Home Buildings per County	Number of Mobile Home Parks and Mobile Home Buildings Located in the Wildland-Urban Interface Wildfire Hazard Area		Number of Mobile Home Parks and Mobile Home Buildings Located in the Wildland-Urban Intermix Wildfire Hazard Area	
			Number of Mobile Home Parks	Number of Mobile Home Buildings	Number of Mobile Home Parks	Number of Mobile Home Buildings
Camden	1	611	1	209	-	112
Chowan	3	1,668	3	288	-	374
Currituck	1	3,366	-	1,300	-	1,282
Dare	9	2,948	3	737	5	1,794
Gates	2	1,629	-	249	1	877
Hyde	1	726	-	182	1	188
Pasquotank	10	3,519	1	223	5	593
Perquimans	3	2,226	-	140	-	671
Tyrrell	1	755	-	206	1	202
Washington	4	1,586	1	449	3	701
Albemarle Region (Total)	**35**	**19,034**	**9**	**3,983**	**16**	**6,794**

Sources: University of Wisconsin 2010; NC One Map 2021/2022

It is recognized that a number of critical facilities are located in the wildfire hazard area and are also vulnerable to the threat of wildfire. Many of these facilities are the locations for vulnerable populations (i.e., schools, senior facilities) and responding agencies to wildfire (i.e., fire, police).

There are 234 critical facilities located in the wildland-urban interface hazard area. The majority of these facilities are utility facilities (55). ***Table 39*** displays the number of critical facilities located in the wildland-urban interface per critical facility type for each county in the region.

Table 39. Total Number of Critical Facilities within the Region Located in the Wildland-Urban Interface Wildfire Hazard Area

County	Total Critical Facilities Per County	Total Number of Critical Facilities within the Region Located in the Wildland-Urban Interface Wildfire Hazard Area									
		Total Number of Critical Facilities Per County in Hazard Area	Facility Type								
			Education Facilities	Healthcare Facilities	Historic and Cultural Resource Facilities	Facilities with Impacts to Public Health and Environmental Systems	Major Economic Development Asset Facilities	Public Service Facilities	Transportation Facilities	Utilities	Vulnerable Population Facilities
Camden	49	5	-	1	2	-	-	1	1	-	-
Chowan	121	3	-	-	-	-	-	-	-	1	2
Currituck	145	55	3	3	4	17	-	6	6	13	3
Dare	272	74	8	7	1	3	2	14	6	20	13
Gates	59	21	2	-	3	-	-	4	5	3	4
Hyde	102	8	-	-	-	-	1	2	-	4	1
Pasquotank	211	28	2	5	1	2	-	2	5	4	7
Perquimans	102	20	1	3	2	-	-	5	3	6	-
Tyrrell	44	3	-	-	-	1	-	-	1	-	1
Washington	107	17	-	3	1	5	1	-	-	4	3
Albemarle Region (Total)	**1,212**	**234**	**16**	**22**	**14**	**28**	**4**	**34**	**27**	**55**	**34**

Sources: NCDCR 2022; NC One Map 2019/2020/2021; HIFLD 2016/2021/2022; University of Wisconsin 2010

There are 268 critical facilities located in the wildland-urban intermix hazard area. The majority of these facilities are public service (63), healthcare (54), and utility facilities (47). ***Table 40*** displays the number of critical facilities located in the wildland-urban intermix per critical facility type for each county in the region.

Table 40. Total Number of Critical Facilities within the Region Located in the Wildland-Urban Intermix Wildfire Hazard Area

County	Total Critical Facilities Per County	Total Number of Critical Facilities within the Region Located in the Wildland-Urban Intermix Wildfire Hazard Area									
		Total Number of Critical Facilities Per County in Hazard Area	Facility Type								
			Education Facilities	Healthcare Facilities	Historic and Cultural Resource Facilities	Facilities with Impacts to Public Health and Environmental Systems	Major Economic Development Asset Facilities	Public Service Facilities	Transportation Facilities	Utilities	Vulnerable Population Facilities
Camden	49	7	-	1	1	-	-	3	-	1	1
Chowan	121	59	-	18	17	-	3	5	5	5	6
Currituck	145	30	2	4	5	2	-	9	-	5	3
Dare	272	54	5	5	7	-	-	12	6	13	6
Gates	59	12	1	2	2	1	-	5	-	-	1
Hyde	102	28	1	4	1	1	-	10	1	8	2
Pasquotank	211	4	-	-	-	-	-	-	1	2	1
Perquimans	102	2	-	-	-	-	-	-	-	2	-
Tyrrell	44	23	2	7	2	-	-	10	-	2	-
Washington	107	49	3	13	5	1	-	9	3	9	6
Albemarle Region (Total)	**1,212**	**268**	**14**	**54**	**40**	**5**	**3**	**63**	**16**	**47**	**26**

Sources: NCDCR 2022; NC One Map 2019/2020/2021; HIFLD 2016/2021/2022; University of Wisconsin 2010

197 acres of historic district (all located in Chowan County) are located within the wildland-urban interface hazard area. No historic districts are located in the intermix area in the region (NCHPO 2022; University of Wisconsin 2010). Of the region's 62 emergency shelters, 12 are located in the wildland-urban interface hazard zone (19.35 percent of the region's total). 14 shelters are located in the wildland-urban intermix hazard zone (22.58 percent of the region's total).

Table 41 shows the breakdown of the Albemarle Region's emergency shelters in the wildland-urban interface and intermix zones by county.

Table 41. Total Number of Emergency Shelters within the Region Located in the Wildland-Urban Intermix Wildfire Hazard Area

County	Total Number of Emergency Shelters Located in the Wildland-Urban Interface Wildfire Hazard Area	Total Number of Emergency Shelters Located in the Wildland-Urban Intermix Wildfire Hazard Area
Camden	-	-
Chowan	1	2
Currituck	2	3
Dare	3	6
Gates	1	2
Hyde	1	-
Pasquotank	-	1
Perquimans	-	-
Tyrrell	-	-
Washington	4	-
Albemarle Region (Total)	**12**	**14**

Sources: NC One Map 2019/2020/2021; University of Wisconsin 2010

F. Impact on Economy

Wildfire can have major economic impacts on a community, from the initial loss of structures to the subsequent loss of revenue from destroyed businesses. These events may cost thousands of taxpayer dollars to suppress and control and may involve hundreds of operating hours and thousands of volunteer hours from the volunteer firefighters. The 2008–2009 Pocosin Lakes National Wildlife Refuge wildfire resulted in $20 million in suppression costs (NCDPS NCHMP 2018). There are also many direct and indirect costs to local businesses that excuse staff that volunteer to fight these fires.

Agricultural land often is located in the wildland-urban interface and intermix hazard zones. While not all of the region's agricultural lands are exposed, 8.07 percent of the Albemarle Region's agricultural land is located in the wildland-urban interface hazard area, and 9.08 percent is located in the wildland-urban intermix hazard area. ***Table 42*** displays the agricultural land area by county located in the wildland-urban interface and intermix hazard areas.

Table 42. Area of Agricultural Land Located in the Wildland-Urban Interface and Intermix Wildfire Hazard Areas

County	Total Agricultural Land per County (Acres)	Area of Agricultural Land Located in the Wildland-Urban Interface Wildfire Hazard Area (Acres)	Area of Agricultural Land Located in the Wildland-Urban Intermix Wildfire Hazard Area (Acres)
Camden	53,919	7,517	3,799
Chowan	48,263	5,224	5,460
Currituck	46,445	11,332	11,620
Dare	5,207	35	253
Gates	49,108	4,961	16,061
Hyde	98,426	7,483	737

County	Total Agricultural Land per County (Acres)	Area of Agricultural Land Located in the Wildland-Urban Interface Wildfire Hazard Area (Acres)	Area of Agricultural Land Located in the Wildland-Urban Intermix Wildfire Hazard Area (Acres)
Pasquotank	79,143	2,982	3,755
Perquimans	79,927	599	9,961
Tyrrell	65,904	4,058	1,346
Washington	95,547	6,046	8,269
Albemarle Region (Total)	**621,889**	**50,237**	**61,261**

Sources: USGS/NLCD 2021; NC One Map 2022; University of Wisconsin 2010

G. Impact on Natural Environmental Systems

According to the United States Geological Survey (USGS), post-fire runoff polluted with debris and contaminants can be extremely harmful to the ecosystem and aquatic life. Studies show that urban fires are more harmful to the environment than forest fires (USGS 2018). Chemicals and contaminants can be released from burning infrastructure. These chemicals, such as iron lead, and zinc, may leach into the storm water, contaminate nearby streams, and impair aquatic life.

H. Impact on Historical and Cultural Resources

Historical buildings are likely at higher risk to wildfire than the general building stock due to greater use of combustible construction materials and lack of fire suppression systems. Outdoor cultural events and assets, such as festivals and markets, could be exposed to health impacts from smoke and may require cancellation.

Wildfire events can spread more readily in areas that are undeveloped, including parks and wildlife refuges. The 2008–2009 Pocosin Lakes National Wildlife Refuge wildfire was largely contained within the Pocosin Lakes Wildlife Refuge (NCDPS NCHMP 2018).

I. Cascading Impacts

Wildfires can increase the probability of other natural disasters, specifically floods and mudflows. Wildfires (particularly large-scale fires) can dramatically alter the terrain and ground conditions, making land already devastated by fire susceptible to floods and mudflow. Normally, vegetation absorbs rainfall, reducing runoff. However, wildfires leave the ground charred, barren, and unable to absorb water, thus creating conditions perfect for flash flooding and mudflows. Flood risk in these impacted areas remains significantly higher until vegetation is restored, which can take up to 5 years (FEMA 2013).

Flooding after a wildfire is often more severe, as debris and ash left from the fire can form mudflows. During and after a rain, as water moves across charred and denuded ground, it can collect soil and sediment and carry it in a stream of floodwaters. These mudflows have the potential to cause significant damage to impacted areas. Areas directly affected by fires and those located below or downstream of burn areas are most at risk of flooding (FEMA 2013). For more information on flooding, refer to ***Section VIII***.

Wildfire can result in an increase in runoff rates due to loss of vegetation and creation of debris and ash. This wildfire impact can result in poor water quality and potentially increase nutrient loading of waterways that contribute to HABs. For more information on water quality, refer to ***Section XI***.

Sea level rise is expected to accelerate in rate of increase in the future. Rising sea levels will inundate inland areas that are currently dry coastal uplands. Historic sea level rise has contributed to the phenomenon of "ghost forests" in the Albemarle Region, where stands of dead trees result from saltwater infiltration. Continued saltwater intrusion will result in dead vegetation that serves as fuel for wildfire. For more information on impacts of sea level rise on vegetation, refer to the discussion of saltwater intrusion in ***Section XI***.

J. Future Changes that May Impact Regional Vulnerability to Hazard

Projected Development

Additional development increases the building stock and infrastructure that could be exposed to the wildfire hazard. The Albemarle Region is predominantly rural, but development in the wildland-urban interface/intermix increases the likelihood of wildfire impacts.

Projected Changes in Population

The North Carolina Office of State Budget & Management (NCOSBM) projects that the Albemarle Region will see population growth through 2050, with an expected increase in population of 38,271 or 22.2 percent (NCOSBM 2022). An increase in the population throughout the Albemarle Region, particularly in the wildand urban interface/intermix zone will increase the region's risk of wildfire. Population increases may create greater strain on water resources needed to fight wildfires throughout the Albemarle Region.

K. Key Gaps in Data and Understanding

Key gaps in data and understanding that were identified during review of available scientific information and public and stakeholder meetings included:

- State-level fire statistics were used as the best available data. Region-specific statistics would provide a more thorough assessment.
- Mapping of areas of anticipated future development would allow for better understanding of changes in exposure to the WUI.

XIII. KEY TAKEAWAYS FOR REGIONAL CLIMATE HAZARD RESILIENCE VULNERABILITY ASSESSMENT

The Albemarle Region has a long history of hazard impacts. Hurricanes and floods have caused major impacts that are often quantifiable and easily recognized by the public. These events have caused repetitive damages in the region and have long recovery times, resulting in substandard housing and degraded critical community services.

Other hazards have had less visible impacts, as they present as small, incremental changes or cause indirect damages. Over time and with magnification of effects due to changing conditions from new development and climate change, current hazards that are of low concern today may become just as impactful as the better-known marquee events, like coastal storms.

A. Areas of Greatest Concern

While climate hazards as a whole pose a regional concern, each hazard discussed in this assessment has unique impacts focused in specific locations. The following sections document the areas of greatest concern in the Albemarle Region for each hazard.

Drought

- The area north of Elizabeth City on the Pasquotank River is reliant on surface water and is at higher risk to the impacts of severe drought.
- Droughts could pose significant risk to the region's agricultural industry.

Erosion

- Numerous areas along the Outer Banks experience erosion rates of more than two meters per year, placing oceanfront development at risk.
- Wetland migration due to sea level rise is likely to lead to significant loss of tidal wetlands in the region.

Extreme Temperature

- Due to climate change, extreme heat is likely to become more frequent and severe in the entire region, while extreme cold events should become less frequent and severe.
- Human populations without proper heating and cooling opportunities are most at risk to the ill effects of extreme temperature.
- High heat nights will increase cooling costs and present significant health risks to socially vulnerable populations that lack heating, ventilation, and air condition systems (HVAC).

Flood

- The region is exposed to various types of flooding, with coastal flooding and stormwater flooding being the largest concerns.
- Forty-four percent of the region's population and 20 percent of the region's buildings are in the 1 percent annual-chance floodplain.
- Sea level rise is likely to increase the frequency and severity of coastal flooding. Flood maps do not account for sea level rise and therefore under-represent future risk. The region's rate of sea

level rise (roughly 0.18 inches per year) is higher than the global average and roughly twice as fast as the southern portions of the state (NC Climate Science 2020).
- Stormwater components are not designed to handle larger rainfall and can be damaged or contribute to stormwater flooding.

Hurricane and Severe Storms

- The region experiences a variety of severe weather, including numerous secondary hazards like wind, lightning, and hail.
- These events, such as Hurricane Matthew, have led to significant damages and impacts, many taking years to recover from.
- The frequency and severity of these events are likely to increase in the future due to climate change.

Invasive Species

- While impacts from each invasive species are unique, with extensive agriculture and sensitive ecosystems, invasive species pose significant risk to the region.
- Changing conditions due to climate change other types of habitat disruption may increase the likelihood of invasive species moving into the Albemarle Region.

Water Quality Issues

- Hazards such as storms and floods can result in accidental spills and releases that can contaminate groundwater and surface water.
- Runoff of nutrients can cause a growing environment for harmful algal blooms, which are environmentally damaging and pose health risks for humans.
- Warming temperatures and increasing heavy precipitation increase the likelihood of harmful algal blooms.
- Rising sea levels and groundwater withdrawal contribute to saltwater intrusion in the region's coastal areas and is likely to worsen over time.
- Saltwater intrusion is leading to the abandonment of some agricultural land and may necessitate expensive treatment measures to maintain drinking water in impacted areas.

Wildfire

- Increasing frequency and severity of wildfire in will lead to increased damages of natural systems and potential damages to structures
- Projected increases in wildfire risks and associated emissions can have harmful impacts on health.

B. Future Conditions and Concerns

Understanding future changes that affect vulnerability can assist in planning for future development and establishing appropriate mitigation, planning, and preparedness measures. Changes in the natural environment and built environment and how they interact can also provide insight into ways to plan for the future. As temperature increases due to climate change, the likelihood of increased frequency and severity of many hazards also increases. Current services, protections, and infrastructure designs may not be adequate for future levels of risk. The entire region is exposed to these changes, but socially vulnerable populations are most likely to bear significant health and financial impacts. Projected

population growth focused in Currituck and Dare Counties increases the likelihood of coastal hazards having a larger impact on the region in the next 30 years.

C. Considerations for Resilience Portfolio Development

The time to invest in resilience actions in the Albemarle Region is now. There exists a tremendous need to:

- Strengthen the region's capacity to prepare for and respond to disasters;
- Reduce threats of injury and death from severe events;
- Reduce repetitive damages to the region's building stock, particularly critical facilities and lifelines;
- Protect and strengthen the region's economy;
- Increase and enhance natural ecosystems across the region to better withstand sudden hazard events and long term changes;
- Provide resilience education to residents, migrant farmworkers, tourists, businesses, government staff, and elected officials;
- Secure funding for and implement projects that will enhance the region's capacity to withstand and recover from disasters while simultaneously building a strong regional economy; and
- Commit to equitable solutions to current and future risks on a regional scale.

By investing in regional resilience, the Albemarle Region can increase safety for residents and businesses, enhance its natural resources, continue building a strong regional economy, and upgrade infrastructure and utilities to serve today's and tomorrow's needs. The development of a strong resilience portfolio is an opportunity for the Albemarle Region to build a strong, safe, and prosperous future.

Appendix A: Regional Profile

The following maps and tables provide additional context to the information included the Regional Profile. This information can be used to better understand potential exposure of population and critical assets in the Albemarle Region.

Table 43. Population Projections for the Albemarle Region

County	2020 Population	2030 Projected Population	2040 Projected Population	2050 Projected Population
Camden	10,355	11,038	11,260	11,331
Chowan	13,708	13,625	13,644	13,662
Currituck	28,100	38,407	48,553	58,700
Dare	36,915	40,995	45,094	49,192
Gates	10,478	9,421	9,303	9,291
Hyde	4,589	3,972	3,449	2,980
Pasquotank	40,568	41,556	41,720	41,746
Perquimans	13,005	12,460	12,387	12,375
Tyrrell	3,245	2,871	2,633	2,418
Washington	11,003	9,693	8,927	8,542
Albemarle Region	**171,966**	**184,038**	**196,970**	**210,237**

Source: (US Census Bureau 2020); (North Carolina Office of State Budget & Management [NCOSBM] 2022)

Figure 37. Social Vulnerability in the Albemarle Region

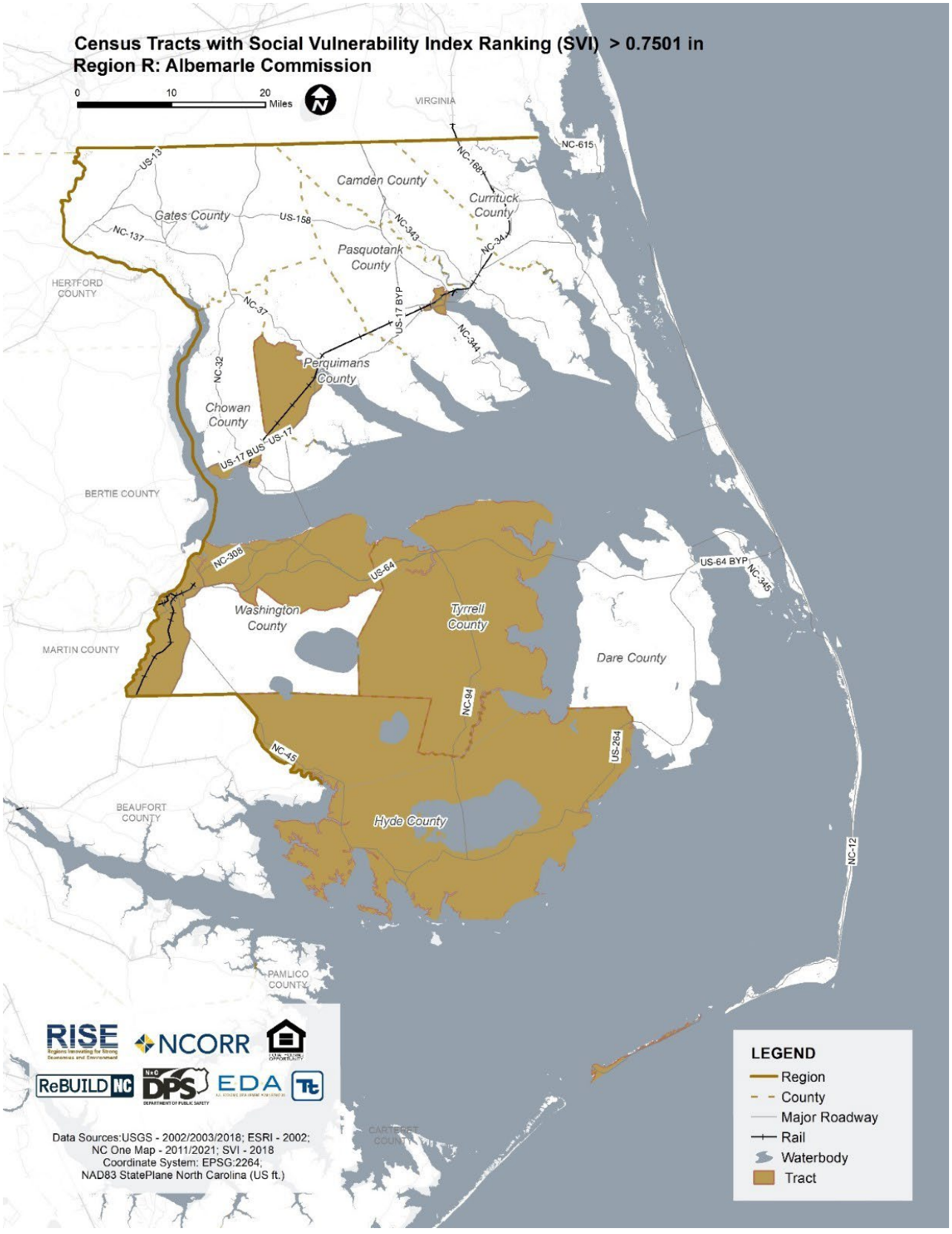


Table 44. Emergency Facilities in the Albemarle Region

Emergency Facility	Total Emergency Facilities
EMS	65
EOC	9
Fire Stations	71
Police	44
Albemarle Region (Total)	**189**

Sources: North Carolina Department of Natural and Cultural Resources (NCDCR) 2022; NC One Map 2019/2020/2021; Homeland Infrastructure Foundation Level (HIFLD) 2016/2021/2022

Table 45. Health Care Facilities in the Albemarle Region

Health Care Facility	Total Health Care Facilities
Hospital	4
Medical Facility	111
Pharmacy	50
Public Health Department	12
Albemarle Region (Total)	**177**

Sources: NCDCR 2022; NC One Map 2019/2020/2021; HIFLD 2016/2021/2022

Table 46. Education Facilities in the Albemarle Region

Education Facility	Total Education Facilities
College and University	3
Private School	14
Public School	65
Albemarle Region (Total)	**82**

Sources: NCDCR 2022; NC One Map 2019/2020/2021; HIFLD 2016/2021/2022

Table 47. Emergency Shelters in the Albemarle Region

Total Number of Emergency Shelters in the Albemarle Region	
Camden	3
Chowan	7
Currituck	8
Dare	9
Gates	5
Hyde	4
Pasquotank	13
Perquimans	6
Tyrrell	1
Washington	6
Albemarle Region (Total)	**62**

Sources: NC One Map 2019/2020/2021

Table 48. Government Buildings in the Albemarle Region

County	Total Government Buildings
Camden	108
Chowan	40
Currituck	139
Dare	415
Gates	51
Hyde	51
Pasquotank	223
Perquimans	211
Tyrrell	53
Washington	62
Albemarle Region (Total)	**1,353**

Sources: NC One Map 2021/2022

Table 49. Miles of Critical Infrastructure by General Category in the Albemarle Region

Transportation Routes	Miles of Infrastructure
NC Route	416
US Route	444
Interstate	-
Railroad	191
Albemarle Region (Total)	1,051
Evacuation Routes	
Roadway	587
Ferry	91
Albemarle Region (Total)	**678**

Sources: North Carolina Department of Transportation (NCDOT) 2015/2020/2021

Table 50. Historic and Cultural Resource Facilities in the Albemarle Region

Historic and Cultural Resource Facility	Total Historic and Cultural Resource Facilities
Historical Site	172
Library	13
Religious Facilities	1,085

Sources: NCDCR 2022; NC One Map 2019/2020/2021; HIFLD 2016/2021/2022

Appendix B: Flooding

The following tables provide additional context to the information included in Section VIII Flood. This information can be used to better understand the flood exposure of populations and assets present in the Albemarle Region.

Table 51. Total Vulnerable Population in the Albemarle Region Living in the 1 Percent Annual-Chance Flood Event Hazard Area

County	Total Population in 1% Annual Chance Flood Hazard Area	Number of Persons Over 65	Number of Persons Below 5	Number of Persons Below Poverty Level	Number of Persons With a Disability	Number of Persons Limited English Speaking	Number of Persons Without Vehicle
Camden	5,711	1,019	267	534	819	6	63
Chowan	1,898	473	88	306	324	7	88
Currituck	14,186	2,109	720	1,252	1,931	17	133
Dare	29,974	6,089	1,273	2,623	3,638	227	351
Gates	3,374	735	148	498	840	10	71
Hyde	3,519	776	194	863	610	53	5
Pasquotank	10,805	1,736	696	1,545	1,614	44	337
Perquimans	1,989	556	92	307	340	6	50
Tyrrell	2,555	645	102	590	580	3	93
Washington	1,724	441	86	409	400	3	119
Albemarle Region	**75,735**	**14,579**	**3,666**	**8,927**	**11,096**	**376**	**1,310**

Sources: North Carolina Flood Risk Information System (NCFRIS) 2022; FEMA 2020; American Community Survey (ACS) 2019; US Census Bureau 2020

Table 52. Total Vulnerable Population in the Albemarle Region Living in the 0.2 Percent Annual-Chance Flood Event Hazard Area

County	Total Population in 0.2% Annual Chance Flood Hazard Area	Number of Persons Over 65	Number of Persons Below 5	Number of Persons Below Poverty Level	Number of Persons With a Disability	Number of Persons Limited English Speaking	Number of Persons Without Vehicle
Camden	6,072	1,083	284	568	871	6	67
Chowan	2,027	505	94	326	346	7	94
Currituck	15,324	2,278	778	1,352	2,085	18	143
Dare	31,695	6,439	1,346	2,773	3,847	240	371
Gates	3,436	749	151	508	856	10	72
Hyde	3,658	807	202	897	635	55	5
Pasquotank	12,794	2,056	824	1,829	1,911	52	399
Perquimans	2,116	592	97	327	362	7	54
Tyrrell	2,712	684	108	626	616	3	99
Washington	2,038	521	102	484	473	3	141
Albemarle Region	**81,872**	**15,714**	**3,986**	**9,690**	**12,002**	**401**	**1,445**

Sources: North Carolina Flood Risk Information System (NCFRIS) 2022; FEMA 2020; American Community Survey (ACS) 2019; US Census Bureau 2020

Table 53. Total Population in SLOSH Category 1-4 Hazard Areas

County	Total Population	Total Population Located in the SLOSH Category 1 Area	% of total population in SLOSH Category 1 Area	Total Population Located in the SLOSH Category 2 Area	% of total population in SLOSH Category 2 Area	Total Population Located in the SLOSH Category 3 Area	% of total population in SLOSH Category 3 Area	Total Population Located in the SLOSH Category 4 Area	% of total population in SLOSH Category 4 Area
Camden	10,355	2,861	27.63%	5,035	48.62%	8,408	81.20%	9,969	96.27%
Chowan	13,708	1,167	8.51%	1,578	11.51%	1,983	14.47%	3,240	23.64%
Currituck	28,100	11,990	42.67%	17,070	60.75%	22,108	78.68%	24,972	88.87%
Dare	36,915	30,494	82.61%	33,366	90.39%	34,238	92.75%	34,593	93.71%
Gates	10,478	1,091	10.41%	1,221	11.65%	2,058	19.64%	2,689	25.66%
Hyde	4,589	2,874	62.63%	3,480	75.83%	3,835	83.57%	3,852	83.94%
Pasquotank	40,568	6,756	16.65%	15,051	37.10%	37,344	92.05%	39,802	98.11%
Perquimans	13,005	814	6.26%	1,525	11.73%	5,714	43.94%	9,369	72.04%
Tyrrell	3,245	2,747	84.65%	3,113	95.93%	3,178	97.94%	3,182	98.06%
Washington	11,003	1,398	12.71%	3,417	31.06%	7,845	71.30%	8,592	78.09%
Albemarle Region	**171,966**	**62,192**	**36.17%**	**84,856**	**49.34%**	**126,711**	**73.68%**	**140,260**	**81.56%**

Sources: (NOAA 2022); ACS 2019; (US Census Bureau 2020)

Table 54. Total Vulnerable Population Located in the SLOSH Category 1 Hazard Area

County	Total Population (2020 Decennial Census Population)	Total Vulnerable Population Located in the SLOSH Category 1 Hazard Area								
			Vulnerable Population Category							
		Total Population in Hazard Area	Number of Persons Over 65	Number of Persons Below 5	Number of Persons Below Poverty Level	Number of Persons With a Disability	Number of Persons Limited English Speaking	Number of Persons Without Vehicle	Number of Persons 16 and Over Commuting to Work with Public Transportation (excluding taxicab)	Number of Persons 16 and Over Commuting to Work by Walking
Camden	10,355	2,861	510	134	268	410	3	32	1	35
Chowan	13,708	1,167	291	54	188	199	4	54	2	18
Currituck	28,100	11,990	1,782	608	1,058	1,632	14	112	2	61
Dare	36,915	30,494	6,195	1,295	2,668	3,701	231	357	7	348
Gates	10,478	1,091	238	48	161	272	3	23	-	2
Hyde	4,589	2,874	634	158	705	498	43	4	4	28
Pasquotank	40,568	6,756	1,086	435	966	1,009	28	211	4	68
Perquimans	13,005	814	228	37	126	139	3	21	-	6
Tyrrell	3,245	2,747	693	109	634	624	3	100	5	19
Washington	11,003	1,398	357	70	332	324	2	97	-	12
Albemarle Region (Total)	**171,966**	**62,192**	**2,014**	**2,951**	**7,105**	**8,808**	**335**	**1,009**	**26**	**596**

Sources: (NOAA 2022); ACS 2019; (US Census Bureau 2020)

Table 55. Total Vulnerable Population Located in the SLOSH Category 2 Hazard Area

County	Total Population (2020 Decennial Census Population)	Total Vulnerable Population Located in the SLOSH Category 2 Hazard Area								
			Vulnerable Population Category							
		Total Population in Hazard Area	Number of Persons Over 65	Number of Persons Below 5	Number of Persons Below Poverty Level	Number of Persons With a Disability	Number of Persons Limited English Speaking	Number of Persons Without Vehicle	Number of Persons 16 and Over Commuting to Work with Public Transportation (excluding taxicab)	Number of Persons 16 and Over Commuting to Work by Walking
Camden	10,355	5,035	898	236	471	722	5	56	1	61
Chowan	13,708	1,578	393	74	254	269	6	73	3	25
Currituck	28,100	17,070	2,537	866	1,506	2,323	20	160	3	87
Dare	36,915	33,366	6,778	1,417	2,919	4,049	253	390	8	381
Gates	10,478	1,221	266	54	180	304	4	26	-	2
Hyde	4,589	3,480	768	192	853	604	52	5	5	33
Pasquotank	40,568	15,051	2,418	970	2,152	2,248	62	469	9	152
Perquimans	13,005	1,525	427	70	236	261	5	39	-	11
Tyrrell	3,245	3,113	786	124	719	707	4	113	6	21
Washington	11,003	3,417	874	171	811	793	5	236	-	29
Albemarle Region (Total)	**171,966**	**84,856**	**16,145**	**4,174**	**10,101**	**12,280**	**416**	**1,567**	**35**	**802**

Sources: (NOAA 2022); ACS 2019; (US Census Bureau 2020)

Table 56. Total Vulnerable Population Located in the SLOSH Category 3 Hazard Area

County	Total Population (2020 Decennial Census Population)	Total Vulnerable Population Located in the SLOSH Category 3 Hazard Area								
			Vulnerable Population Category							
		Total Population in Hazard Area	Number of Persons Over 65	Number of Persons Below 5	Number of Persons Below Poverty Level	Number of Persons With a Disability	Number of Persons Limited English Speaking	Number of Persons Without Vehicle	Number of Persons 16 and Over Commuting to Work with Public Transportation (excluding taxicab)	Number of Persons 16 and Over Commuting to Work by Walking
Camden	10,355	8,408	1,500	394	787	1,206	8	93	2	102
Chowan	13,708	1,983	494	92	319	338	7	92	4	31
Currituck	28,100	22,108	3,286	1,122	1,950	3,009	26	207	4	113
Dare	36,915	34,238	6,955	1,454	2,996	4,155	260	401	8	390
Gates	10,478	2,058	448	91	304	512	6	43	-	3
Hyde	4,589	3,835	846	211	940	665	58	5	6	37
Pasquotank	40,568	37,344	6,000	2,406	5,339	5,578	153	1,164	23	378
Perquimans	13,005	5,714	1,598	263	882	976	18	145	-	41
Tyrrell	3,245	3,178	802	126	734	722	4	116	6	22
Washington	11,003	7,845	2,006	393	1,862	1,820	11	543	-	66
Albemarle Region (Total)	**171,966**	**126,711**	**23,935**	**6,552**	**16,113**	**18,981**	**551**	**2,809**	**53**	**1,183**

Sources: (NOAA 2022); ACS 2019; (US Census Bureau 2020)

Table 57. Total Vulnerable Population Located in the SLOSH Category 4 Hazard Area

County	Total Population (2020 Decennial Census Population)	Total Vulnerable Population Located in the SLOSH Category 4 Hazard Area								
			Vulnerable Population Category							
		Total Population in Hazard Area	Number of Persons Over 65	Number of Persons Below 5	Number of Persons Below Poverty Level	Number of Persons With a Disability	Number of Persons Limited English Speaking	Number of Persons Without Vehicle	Number of Persons 16 and Over Commuting to Work with Public Transportation (excluding taxicab)	Number of Persons 16 and Over Commuting to Work by Walking
Camden	10,355	9,969	1,778	467	933	1,430	10	111	2	121
Chowan	13,708	3,240	807	151	522	552	12	150	6	51
Currituck	28,100	24,972	3,712	1,267	2,203	3,398	29	234	4	127
Dare	36,915	34,593	7,027	1,469	3,027	4,198	262	405	8	395
Gates	10,478	2,689	586	118	397	670	8	56	-	4
Hyde	4,589	3,852	849	212	944	668	58	5	6	37
Pasquotank	40,568	39,802	6,395	2,565	5,691	5,946	163	1,240	25	403
Perquimans	13,005	9,369	2,620	432	1,447	1,601	30	237	-	67
Tyrrell	3,245	3,182	803	127	735	723	4	116	6	22
Washington	11,003	8,592	2,197	430	2,040	1,994	12	594	-	72
Albemarle Region (Total)	**171,966**	**140,260**	**26,774**	**7,238**	**17,939**	**21,180**	**588**	**3,148**	**57**	**1,299**

Sources: (NOAA 2022); ACS 2019; (US Census Bureau 2020)

Table 58. Number of Mobile Home Parks and Mobile Homes Located in the 1 Percent and 0.2 Percent Annual-Chance Flood Hazard Area

County	Total Number of Mobile Home Parks per County	Total Number of Mobile Home Buildings per County	Number of Mobile Home Parks and Mobile Homes Located in the 1 Percent Annual-Chance Flood Hazard Area		Number of Mobile Home Parks and Mobile Homes Located in the 0.2 Percent Annual-Chance Flood Hazard Area	
			Number of Mobile Home Parks	Number of Mobile Homes	Number of Mobile Home Parks	Number of Mobile Homes
Camden	1	611	1	150	1	234
Chowan	3	1,668	-	39	-	50
Currituck	1	3,366	-	424	-	597
Dare	9	2,948	5	1,278	5	1,645
Gates	2	1,629	-	39	-	44
Hyde	1	726	1	526	1	602
Pasquotank	10	3,519	2	667	3	872
Perquimans	3	2,226	-	203	-	286
Tyrrell	1	755	1	605	1	638
Washington	4	1,586	-	262	-	380
Albemarle Region (Total)	**35**	**19,034**	**10**	**4,193**	**11**	**5,348**

Sources: NCFRIS 2022; FEMA 2018, 2020; NC One Map 2021, 2022; HIFLD 2022

Table 59. Total Number of Historic and Cultural Resource Facilities in the Albemarle Region Located in the Flood Hazard Area

Total Number of Historic and Cultural Resource Facilities Located in the Flood Hazard Area		
Historic and Cultural Resource Facility	**1-Percent Annual Chance**	**0.2-Percent Annual Chance**
Historical Site	37	44
Albemarle Region (Total)	**37**	**44**

Sources: NCDCR 2022; NC One Map 2019/2020/2021; HIFLD 2016/2021/2022; FEMA 2019/2020/2021; NCFRIS 2022

Table 60. Total Area of Historic Districts in the Albemarle Region Located in the Flood Hazard Area

Total Area of Historic District in the Hazard Area (Acres)		
County	**1-Percent Annual Chance**	**0.2-Percent Annual Chance**
Camden	-	-
Chowan	207	207
Currituck	-	-
Dare	-	-
Gates	-	-
Hyde	-	-
Pasquotank	31	53
Perquimans	-	-
Tyrrell	-	-
Washington	-	-
Albemarle Region (Total)	**238**	**260**

Sources: NCHPO 2022; FEMA 2019, 2020, 2021; NCFRIS 2022

Table 61. Total Number of Facilities in the Albemarle Region with Impacts to Public Health and Environmental Systems Located in the Flood Hazard Area

Total Number of Facilities with Impacts to Public Health and Environmental Systems Located in the Flood Hazard Area		
Facility with Impacts to Public Health and Environmental Systems	**1-Percent Annual Chance**	**0.2-Percent Annual Chance**
Septage Facility	1	1
Solid Landfill	4	6
Yard Waste Facility	1	2
Albemarle Region (Total)	**6**	**9**

Sources: NCDCR 2022; NC One Map 2019/2020/2021; HIFLD 2016/2021/2022; FEMA 2019/2020/2021; NCFRIS 2022

Table 62. Total Number of Utilities in the Albemarle Region Located in the Flood Hazard Area

Total Number of Utilities Located in the Flood Hazard Area		
Utility	1-Percent Annual Chance	0.2-Percent Annual Chance
AM Transmission Tower	1	1
Cellular Tower	36	41
FM Transmission Tower	12	14
Gas Plant	1	1
Power Plant	1	3
Sewer Treatment Plant	4	5
Substation	19	25
Albemarle Region (Total)	**74**	**90**

Sources: NCDCR 2022; NC One Map 2019/2020/2021; HIFLD 2016/2021/2022; FEMA 2019/2020/2021; NCFRIS 2022

Table 63. Total Number of Emergency Shelters in the Albemarle Region Located in the 1-Percent and 0.2-Percent Annual Chance Flood Hazard Areas

County	Total Number of Emergency Shelters Located in the 1-Percent Annual Chance Flood Hazard Area	Total Number of Emergency Shelters Located in the 0.2-Percent Annual Chance Flood Hazard Area
Camden	-	-
Chowan	-	-
Currituck	-	-
Dare	2	2
Gates	-	-
Hyde	2	4
Pasquotank	4	5
Perquimans	2	2
Tyrrell	1	1
Washington	-	-
Albemarle Region (Total)	**11**	**14**

Sources: NCDCR 2022; NC One Map 2019/2020/2021; HIFLD 2016/2021/2022; FEMA 2019/2020/2021; NCFRIS 2022

Table 64. Total Length of Critical Infrastructure within the Albemarle Region Located in the 1 and 0.2 Percent Annual Chance Flood Hazard Area

County	Roadway in the 1% Annual Flood Chance Hazard Area	Roadway in the 0.2% Annual Flood Chance Hazard Area	Rail in the 1% Annual Flood Chance Hazard Area	Rail in the 0.2% Annual Flood Chance Hazard Area	Evacuation (Road) in the 1% Annual Flood Chance Hazard Area	Evacuation (Road) in the 0.2% Annual Flood Chance Hazard Area	Evacuation (Ferry) in the 1% Annual Flood Chance Hazard Area	Evacuation (Ferry) in the 0.2% Annual Flood Chance Hazard Area
Camden	5	8	-	-	4	7	-	-
Chowan	1	2	-	-	1	1	-	-
Currituck	10	13	7	15	6	7	-	-
Dare	98	112	-	-	96	109	0.2	0.5
Gates	8	9	-	-	6	6	-	-
Hyde	54	73	-	-	44	62	0.3	0.5
Pasquotank	10	15	-	-	3	5	-	-
Perquimans	3	3	-	-	2	2	-	-
Tyrrell	43	50	-	-	17	22	-	-
Washington	7	11	6	12	4	5	-	-
Albemarle Region (Total)	**239**	**296**	**14**	**27**	**183**	**226**	**0.5**	**1**

Sources: NCDCR 2022; NC One Map 2019/2020/2021; HIFLD 2016/2021/2022; FEMA 2019/2020/2021; NCFRIS 2022

Table 65. Total Number of Major Economic Development Asset Facilities in the Albemarle Region Located in the Flood Hazard Area

Total Number of Major Economic Development Asset Facilities Located in the Flood Hazard Area		
Major Economic Development Asset Facility	**1-Percent Annual Chance**	**0.2-Percent Annual Chance**
Port Facility	27	43
Albemarle Region (Total)	**27**	**43**

Sources: NCDCR 2022; NC One Map 2019/2020/2021; HIFLD 2016/2021/2022 FEMA 2019/2020/2021; NCFRIS 2022

Appendix C: Invasive Species

An overview of the invasive species analyzed for this vulnerability assessment and their potential impacts are provided below. These species represent examples of some of the invasive species that currently or are likely to impact the Albemarle Region.

- The Spotted Lanternfly (*Lycorma deliculta*) is an Asian plant hopper insect that could be very devastating to some crops and hardwood trees in the Region. This insect was accidentally introduced into Pennsylvania and was confirmed in September 2014. Since then, Spotted Lanternfly has spread throughout the mid-Atlantic (New Jersey Agricultural Experiment Station 2020). It is likely to impact the Region in the next few years as it spreads south.
- *Phragmites australis*, also known as common reed, is a tall wetland grass found in tidal and nontidal brackish and freshwater marshes, river edges, and shores of lakes and ponds within the coastal plain of North Carolina. It commonly occurs in disturbed areas and is particularly common in roadside ditches. *Phragmites* outcompetes native wetlands vegetation without providing the same habitat for aquatic life and can clog stormwater infrastructure to increase flood risk (North Carolina Forest Service 2010).
- Hydrilla (*Hydrilla verticillata*) is a particularly aggressive aquatic plant that infests many aquatic systems throughout North Carolina from ponds to lakes and even some rivers. The loss of recreational use of waters, intake fouling, and habitat alterations are the major concerns. Watercraft get hung-up in dense stands of hydrilla to the point where docks and slips become unusable. Heavy infestations discourage or even inhibit swimming and fishing activities. Advanced infestations alter habitat and drive ecological shifts like changes in fish population dynamics (North Carolina Department of Environmental Quality n.d.). Removal programs in the Albemarle Region have been expensive.
- Eurasian Watermilfoil (*Myriophyllum spicatum*) is another aquatic weed with similar impacts to Hydrilla. It forms a dense canopy along the surface and shades out the vegetation below. It is considered to have less value as a food source for waterfowl compared to native plants. Water quality is degraded by the senescence of watermilfoil. Recreational activities are hindered. Water intakes get obstructed, and decaying mats can foul lakeside beaches (North Carolina Department of Environmental Quality n.d.).
- Feral swine (*Ses scrofa*), also known as wild boar, are wild pigs that are capable of severe impacts on the Region's native wildlife and plants and agricultural areas. A group of pigs can root through and damage large areas overnight. Swine disturbance around stream and river edges can lead to erosion and water contamination. Feral swine also carry at least 30 diseases and nearly 40 parasites that can affect humans, pets, livestock, and other wildlife. Diseases like brucellosis, pseudorabies, and African swine fever are some of the concerns for wildlife managers when feral swine and people or livestock interact (North Carolina Wildlife Resource Commission (NCWRC) 2019).

Appendix D: Water Quality

The U.S. Environmental Protection Agency (USEPA) has summarized the effectiveness of treatment options for harmful algal blooms. The table below provides an overview of the treatment processes and relative effectiveness. ***Table 66*** can be used to better understand the effectiveness to determine potential costs for treatment of harmful algal blooms.

Table 66. Treatment Options for Harmful Algal Blooms

Treatment Process	Relative Effectiveness
Intracellular Cyanotoxins Removal (Intact Cells)	
Pre-treatment oxidation	Oxidation often stresses or lyses cyanobacteria cells releasing the cyanotoxin to the water. If oxidation is required to meet other treatment objectives, consider using lower doses of an oxidant less likely to lyse cells. If oxidation at higher doses must be used, sufficiently high doses should be used to not only lyse cells but also destroy total toxins present (see extracellular cyanotoxin removal).
Coagulation/ Sedimentation/ Filtration	Effective for the removal of intracellular toxins (cyanobacteria cells). Ensure that captured cells accumulated in sludge are removed frequently to release toxins. Ensure that sludge supernatant is not returned to the supply after sludge separation.
Membranes	Effective for removal of intracellular cyanotoxins (cyanobacteria cells). Microfiltration and ultrafiltration are effective when cells are not allowed to accumulate on membranes for long periods of time. More frequent cleaning may be required during a bloom event.
Flotation	Flotation processes, such as Dissolved Air Flotation (DAF), are effective for removal of intracellular cyanotoxins since many of the toxin-forming cyanobacteria are buoyant.
Extracellular (Dissolved) Cyanotoxins Removal	
Membranes	Depends on the type of cyanotoxin, membrane material, membrane pore size distribution, and influent water quality. Nanofiltration is generally effective in removing extracellular microcystins. Reverse osmosis filtration is generally applicable for removal of microcystins and cylindrospermopsin. Cell lysis is highly likely. Further research is needed to characterize performance.
Potassium Permanganate	Effective for oxidizing microcystins and anatoxins. Further research is needed for cylindrospermopsin. Not effective for oxidizing saxitoxin.
Ozone	Very effective for oxidizing microcystins, anatoxin-a, and cylindrospermopsin. Not effective for oxidizing saxitoxin.
Chloramines	Not effective.
Chlorine dioxide	Not effective at doses typically used in drinking water treatment.
Free Chlorine	Effective for oxidizing microcystins as long as the pH is below 8. Effective for oxidizing cylindrospermopsin and saxitoxin. Not effective for oxidizing anatoxin-a.
UV Radiation	UV radiation alone is not effective at oxidizing microcystins and cylindrospermopsin at doses typically used in drinking water treatment. When UV radiation is coupled with ozone or hydrogen peroxide (called “advanced oxidation”), the process is effective at oxidizing anatoxin-a, cylindrospermopsin, and with high UV doses, microcystins.
Activated Carbon Adsorption	Powdered activated carbon (PAC): Effectiveness of PAC adsorption varies based on type of carbon, pore size, type of cyanotoxin, and other water quality parameters such as natural organic matter (NOM) concentration. Wood-based activated carbons are generally the most effective at microcystins adsorption. More research is needed to evaluate PAC’s effectiveness at adsorbing cylindrospermopsin, anatoxin-a, and saxitoxin, however the limited research has demonstrated promising results. Doses in excess of 20mg/L may be needed for complete toxin removal, especially if NOM concentrations are high. Granular activated carbon (GAC): Effectiveness of GAC adsorption varies based on type of carbon, pore size, type of cyanotoxin, and other water quality parameters such as NOM concentration. GAC is effective for microcystins, and likely effective for cylindrospermopsin, anatoxin-a and saxitoxin. The condition of the carbon is an important factor in determining GAC’s effectiveness for cyanotoxin removal. GAC may need to be regenerated more frequently to ensure adequate adsorption capacity for HAB season.

Source: (US Environmental Protection Agency [USEPA] 2017)

Appendix E: Storm Surge Housing, Critical Infrastructure and Community Support Systems

After considering the population exposed and potentially vulnerable to the storm surge hazard, the built environment was evaluated. Exposure includes those buildings, mobile homes, critical facilities, emergency shelters, and critical infrastructure located in the SLOSH model zones for Category 1-4 hurricanes. Better understanding of exposure can lead the region to make decisions for regional emergency management, evacuation planning, and potential storm surge protection measures. ***Table 67*** through ***Table 74*** show the number of critical facilities in SLOSH model zones.

Table 67. Total Number of Critical Facilities within the Albemarle Region Located in the SLOSH Category 1 Hazard Area

Total Number of Critical Facilities within the Region Located in the SLOSH Category 1 Hazard Area											
			Facility Type								
County	Total Number of Critical Facilities Per County	Total Number of Critical Facilities Per County in Hazard Area	Education Facilities	Facilities with Impacts to Public Health and Environmental Systems	Healthcare Facilities	Historic and Cultural Resource Facilities	Major Economic Development Asset Facilities	Public Service Facilities	Transportation Facilities	Utilities	Vulnerable Population Facilities
Camden	49	1	-	-	-	1	-	-	-	-	-
Chowan	121	7	-	-	-	1	6	-	-	-	-
Currituck	145	5	-	-	-	1	-	1	3	-	-
Dare	272	77	1	2	3	6	2	18	4	37	4
Gates	59	-	-	-	-	-	-	-	-	-	-
Hyde	102	71	3	2	7	7	2	15	12	17	6
Pasquotank	211	35	4	-	6	3	3	4	2	9	4
Perquimans	102	5	-	-	-	-	-	-	3	-	2
Tyrrell	44	28	3	-	6	2	-	10	2	3	2
Washington	107	2	-	-	-	-	-	-	1	1	-
Albemarle Region (Total)	**1,212**	**231**	**11**	**4**	**22**	**21**	**13**	**48**	**27**	**67**	**18**

Sources: North Carolina Department of Natural and Cultural Resources (NCDCR) 2022; NC One Map - 2018/2019/2020/2021/2022; HIFLD - 2016/2018/2021/2022; NOAA - 2014

Table 68. Total Number of Critical Facilities within the Albemarle Region Located in the SLOSH Category 2 Hazard Area

Total Number of Critical Facilities within the Region Located in the SLOSH Category 2 Hazard Area											
			Facility Type								
County	Total Number of Critical Facilities Per County	Total Number of Critical Facilities Per County in Hazard Area	Education Facilities	Facilities with Impacts to Public Health and Environmental Systems	Healthcare Facilities	Historic and Cultural Resource Facilities	Major Economic Development Asset Facilities	Public Service Facilities	Transportation Facilities	Utilities	Vulnerable Population Facilities
Camden	49	25	3	2	3	3	-	6	2	3	3
Chowan	121	11	-	-	-	3	6	2	-	-	-
Currituck	145	33	-	3	-	2	-	12	3	13	-
Dare	272	156	5	2	15	25	3	37	9	50	10
Gates	59	1	-	-	-	-	1	-	-	-	-
Hyde	102	83	4	3	7	9	2	17	15	20	6
Pasquotank	211	115	14	2	27	14	3	14	9	17	15
Perquimans	102	11	-	-	-	-	-	4	4	-	3
Tyrrell	44	38	3	1	7	2	-	12	2	9	2
Washington	107	21	2	-	3	4	-	2	1	7	2
Albemarle Region (Total)	**1,212**	**494**	**31**	**13**	**62**	**62**	**15**	**106**	**45**	**119**	**41**

Sources: NCDCR 2022; NC One Map - 2018/2019/2020/2021/2022; HIFLD - 2016/2018/2021/2022; NOAA – 2014

Table 69. Total Number of Critical Facilities within the Albemarle Region Located in the SLOSH Category 3 Hazard Area

Total Number of Critical Facilities within the Region Located in the SLOSH Category 3 Hazard Area											
			Facility Type								
County	Total Number of Critical Facilities Per County	Total Number of Critical Facilities Per County in Hazard Area	Education Facilities	Facilities with Impacts to Public Health and Environmental Systems	Healthcare Facilities	Historic and Cultural Resource Facilities	Major Economic Development Asset Facilities	Public Service Facilities	Transportation Facilities	Utilities	Vulnerable Population Facilities
Camden	49	37	5	2	5	5	1	10	2	3	4
Chowan	121	14	-	-	1	4	7	2	-	-	-
Currituck	145	64	2	5	5	3	-	19	6	21	3
Dare	272	203	10	3	17	43	3	48	9	54	16
Gates	59	2	-	-	-	-	1	-	1	-	-
Hyde	102	84	4	3	8	9	2	17	15	20	6
Pasquotank	211	186	22	3	42	16	3	21	20	31	28
Perquimans	102	25	-	1	1	4	-	6	5	5	3
Tyrrell	44	39	3	1	7	2	-	12	2	10	2
Washington	107	57	4	1	9	4	-	13	7	14	5
Albemarle Region (Total)	**1,212**	**711**	**50**	**19**	**95**	**90**	**17**	**148**	**67**	**158**	**67**

Sources: NCDCR 2022; NC One Map - 2018/2019/2020/2021/2022; HIFLD - 2016/2018/2021/2022; NOAA - 2014

Table 70. Total Number of Critical Facilities within the Albemarle Region Located in the SLOSH Category 4 Hazard Area

Total Number of Critical Facilities within the Region Located in the SLOSH Category 4 Hazard Area											
			Facility Type								
County	Total Number of Critical Facilities Per County	Total Number of Critical Facilities Per County in Hazard Area	Education Facilities	Facilities with Impacts to Public Health and Environmental Systems	Healthcare Facilities	Historic and Cultural Resource Facilities	Major Economic Development Asset Facilities	Public Service Facilities	Transportation Facilities	Utilities	Vulnerable Population Facilities
Camden	49	41	5	2	5	5	1	10	5	4	4
Chowan	121	21	-	1	5	5	7	3	-	-	-
Currituck	145	99	8	10	9	6	-	24	9	24	9
Dare	272	232	12	3	23	53	3	54	13	54	17
Gates	59	2	-	-	-	-	1	-	1	-	-
Hyde	102	84	4	3	8	9	2	17	15	20	6
Pasquotank	211	195	22	4	43	17	4	21	20	36	28
Perquimans	102	71	5	1	7	12	-	14	15	9	8
Tyrrell	44	39	3	1	7	2	-	12	2	10	2
Washington	107	72	4	1	15	6	-	18	7	16	5
Albemarle Region (Total)	**1,212**	**856**	**63**	**26**	**122**	**115**	**18**	**173**	**87**	**173**	**79**

Sources: NCDCR 2022; NC One Map - 2018/2019/2020/2021/2022; HIFLD - 2016/2018/2021/2022; NOAA - 2014

Table 71. Total Length of Critical Infrastructure within the Albemarle Region Located in the SLOSH Category 1 Hazard Area

Total Miles of Critical Infrastructure Per County within the Region in SLOSH Category 1 Hazard Area				
County	**Roadway**	**Rail**	**Evacuation (Road)**	**Evacuation (Ferry)**
Camden	5	-	5	-
Chowan	3	-	2	-
Currituck	12	7	7	-
Dare	100	-	97	-
Gates	1	-	1	-
Hyde	68	-	58	0
Pasquotank	8	-	2	-
Perquimans	1	-	1	-
Tyrrell	39	-	12	-
Washington	3	4	2	-
Albemarle Region (Total)	**239**	**11**	**187**	**0**

Sources: North Carolina Department of Transportation (NCDOT) 2015/2020/2021; NOAA 2014

Table 72. Total Length of Critical Infrastructure within the Albemarle Region Located in the SLOSH Category 2 Hazard Area

Total Miles of Critical Infrastructure Per County within the Region in SLOSH Category 2 Hazard Area				
County	**Roadway**	**Rail**	**Evacuation (Road)**	**Evacuation (Ferry)**
Camden	22	-	20	-
Chowan	4	-	3	-
Currituck	29	21	16	-
Dare	132	-	129	-
Gates	4	-	3	-
Hyde	82	-	73	0.3
Pasquotank	27	-	9	-
Perquimans	3	-	2	-
Tyrrell	48	-	17	-
Washington	12	6	3	-
Albemarle Region (Total)	**364**	**27**	**273**	**0**

Sources: NCDOT 2015/2020/2021; NOAA 2014

Table 73. Total Length of Critical Infrastructure within the Albemarle Region Located in the SLOSH Category 3 Hazard Area

Total Miles of Critical Infrastructure Per County within the Region in SLOSH Category 3 Hazard Area				
County	**Roadway**	**Rail**	**Evacuation (Road)**	**Evacuation (Ferry)**
Camden	45	-	39	-
Chowan	5	-	3	-
Currituck	46	37	25	-
Dare	150	-	146	-
Gates	8	-	7	-
Hyde	84	-	74	0.3
Pasquotank	60	-	37	-
Perquimans	11	-	7	-
Tyrrell	55	-	23	-
Washington	48	10	24	-
Albemarle Region (Total)	**511**	**46**	**385**	**0**

Sources: NCDOT 2015/2020/2021; NOAA 2014

Table 74. Total Length of Critical Infrastructure within the Albemarle Region Located in the SLOSH Category 4 Hazard Area

Total Miles of Critical Infrastructure Per County within the Region in SLOSH Category 4 Hazard Area				
County	**Roadway**	**Rail**	**Evacuation (Road)**	**Evacuation (Ferry)**
Camden	51	-	46	-
Chowan	7	-	3	-
Currituck	64	44	39	-
Dare	155	-	152	-
Gates	10	-	9	-
Hyde	84	-	75	0.3
Pasquotank	79	-	53	-
Perquimans	23	-	13	-
Tyrrell	57	-	24	-
Washington	66	14	36	-
Albemarle Region (Total)	**597**	**57**	**449**	**0.3**

Sources: NCDOT 2015/2020/2021; NOAA 2014

Appendix F: Wildland-Urban Interface/Intermix Exposure

Exposure of Wildland-Urban Interface and Intermix were compared to vulnerable populations with overall Social Vulnerability Index (SVI) rankings of 0.5001 - 0.75 and greater than 0.7501 in the Albemarle Region. These results are broken out by county below in ***Table 75*** through ***Table 78***.

Table 75. Total Vulnerable Population with Overall SVI Ranking 0.5001 - 0.75 Located in the Wildland-Urban Interface Wildfire Hazard Area

County	Total Population (2020 Decennial Census Population)	Total Vulnerable Population with Overall SVI Ranking 0.5001 - 0.75 Located in the Wildland-Urban Interface Wildfire Hazard Area								
		Total Population in Hazard Area	Vulnerable Population Category							
			Number of Persons Over 65	Number of Persons Below 5	Number of Persons Below Poverty Level	Number of Persons With a Disability	Number of Persons Limited English Speaking	Number of Persons Without Vehicle	Number of Persons 16 and Over Commuting to Work with Public Transportation (excluding taxicab)	Number of Persons 16 and Over Commuting to Work by Walking
Camden	10,355	-	-	-	-	-	-	-	-	-
Chowan	13,708	1,229	188	37	79	151	1	24	-	4
Currituck	28,100	2,122	48	11	26	52	2	6	-	-
Dare	36,915	2,783	155	47	116	141	7	16	-	14
Gates	10,478	251	16	3	16	13	-	3	-	-
Hyde	4,589	-	-	-	-	-	-	-	-	-
Pasquotank	40,568	-	-	-	-	-	-	-	-	-
Perquimans	13,005	-	-	-	-	-	-	-	-	-
Tyrrell	3,245	-	-	-	-	-	-	-	-	-
Washington	11,003	-	-	-	-	-	-	-	-	-
Albemarle Region (Total)	**171,966**	**6,385**	**407**	**98**	**237**	**357**	**10**	**49**	**-**	**18**

Source: UofWisc 2010; ACS 2019; SVI 2018; Census 2020

Table 76. Total Vulnerable Population with Overall SVI Ranking 0.5001 - 0.75 Located in the Wildland-Urban Intermix Wildfire Hazard Area

County	Total Population (2020 Decennial Census Population)	Total Vulnerable Population with Overall SVI Ranking 0.5001 - 0.75 Located in the Wildland-Urban Intermix Wildfire Hazard Area								
		Total Population in Hazard Area	Vulnerable Population Category							
			Number of Persons Over 65	Number of Persons Below 5	Number of Persons Below Poverty Level	Number of Persons With a Disability	Number of Persons Limited English Speaking	Number of Persons Without Vehicle	Number of Persons 16 and Over Commuting to Work with Public Transportation (excluding taxicab)	Number of Persons 16 and Over Commuting to Work by Walking
Camden	10,355	-	-	-	-	-	-	-	-	-
Chowan	13,708	1,877	287	56	120	231	1	37	-	6
Currituck	28,100	19,969	451	106	247	489	16	52	-	4
Dare	36,915	10,488	584	177	437	532	25	61	-	53
Gates	10,478	2,961	191	40	194	159	-	38	-	-
Hyde	4,589	-	-	-	-	-	-	-	-	-
Pasquotank	40,568	481	17	6	15	14	-	3	-	2
Perquimans	13,005	-	-	-	-	-	-	-	-	-
Tyrrell	3,245	-	-	-	-	-	-	-	-	-
Washington	11,003	-	-	-	-	-	-	-	-	-
Albemarle Region (Total)	**171,966**	**35,776**	**1,530**	**385**	**1,013**	**1,425**	**42**	**191**	**-**	**65**

Source: UofWisc 2010; ACS 2019; SVI 2018; Census 2020

Table 77. Total Vulnerable Population with Overall SVI Ranking > 0.7501 Located in the Wildland-Urban Interface Wildfire Hazard Area

County	Total Population (2020 Decennial Census Population)	Total Vulnerable Population with Overall SVI Ranking > 0.7501 Located in the Wildland-Urban Interface Wildfire Hazard Area								
		Total Population in Hazard Area	Vulnerable Population Category							
			Number of Persons Over 65	Number of Persons Below 5	Number of Persons Below Poverty Level	Number of Persons With a Disability	Number of Persons Limited English Speaking	Number of Persons Without Vehicle	Number of Persons 16 and Over Commuting to Work with Public Transportation (excluding taxicab)	Number of Persons 16 and Over Commuting to Work by Walking
Camden	10,355	-	-	-	-	-	-	-	-	-
Chowan	13,708	3,720	358	62	360	176	12	100	7	46
Currituck	28,100	-	-	-	-	-	-	-	-	-
Dare	36,915	-	-	-	-	-	-	-	-	-
Gates	10,478	-	-	-	-	-	-	-	-	-
Hyde	4,589	118	26	6	29	20	2	-	-	1
Pasquotank	40,568	0	-	-	-	-	-	-	-	-
Perquimans	13,005	3	-	-	-	-	-	-	-	-
Tyrrell	3,245	96	24	4	22	22	-	3	-	1
Washington	11,003	932	210	37	197	182	1	57	-	6
Albemarle Region (Total)	**171,966**	**4,869**	**618**	**109**	**608**	**400**	**15**	**160**	**7**	**54**

Source: UofWisc 2010; ACS 2019; SVI 2018; Census 2020

Table 78. Total Vulnerable Population with Overall SVI Ranking > 0.7501 Located in the Wildland-Urban Intermix Wildfire Hazard Area

County	Total Population (2020 Decennial Census Population)	Total Vulnerable Population with Overall SVI Ranking > 0.7501 Located in the Wildland-Urban Intermix Wildfire Hazard Area								
		Total Population in Hazard Area	Vulnerable Population Category							
			Number of Persons Over 65	Number of Persons Below 5	Number of Persons Below Poverty Level	Number of Persons With a Disability	Number of Persons Limited English Speaking	Number of Persons Without Vehicle	Number of Persons 16 and Over Commuting to Work with Public Transportation (excluding taxicab)	Number of Persons 16 and Over Commuting to Work by Walking
Camden	10,355	-	-	-	-	-	-	-	-	-
Chowan	13,708	6,224	600	104	603	294	20	168	12	78
Currituck	28,100	-	-	-	-	-	-	-	-	-
Dare	36,915	-	-	-	-	-	-	-	-	-
Gates	10,478	-	-	-	-	-	-	-	-	-
Hyde	4,589	79	17	4	19	14	1	-	-	1
Pasquotank	40,568	1,320	38	29	81	54	2	22	-	6
Perquimans	13,005	449	20	8	18	18	-	4	-	-
Tyrrell	3,245	87	22	3	20	20	-	3	-	1
Washington	11,003	2,585	583	103	547	503	4	157	-	16
Albemarle Region (Total)	**171,966**	**10,744**	**1,280**	**251**	**1,288**	**903**	**27**	**354**	**12**	**102**

Source: UofWisc 2010; ACS 2019; SVI 2018; Census 2020

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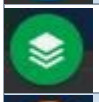
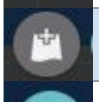
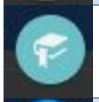
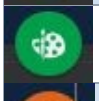
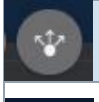
Appendix H: Mapping Solution

The RISE Regional Resilience Portfolio program aims to support resilience efforts throughout the region by engaging local leaders and the community. The web map in combination with the vulnerability assessment bridges science and local knowledge to identify current and future hazards impacting the region. The vulnerability assessment profiles natural hazards and climate risks, provides an analysis of the hazards' impacts on the region, and provides key takeaways for building resilience across the region. The web map is a companion tool to allow users to further explore hazard data and the exposure of critical assets throughout the region. The webmap can be accessed at: Albemarle Commission Region - Resilience Portfolio Web Map (arcgis.com)

The table below provides an overview of the symbols available in the application:

Table 79: Map Symbology

Icon	Explanation
	Click on this tool to view the legend of layers shown in the web map.
	Click on this tool to turn layers on and off, open the attribute table, or view the layer's information to download the data.
	Click on this tool to change the basemap.
	Click on this tool to print out a static copy of the web map.
	Click on this tool to add data to the web map.
	Click on this tool to bookmark a location on the web map.
	Click on this tool to measure a length on the web map.
	Click on this tool to draw on the web map.
	Click on this tool to swipe one or more layers on the web map.
	Click on this tool for more information about the tools available in this web map.
	Click on this tool to share this web map.
	Click on this tool to add a note or delete a note you have added to the web map. You are encouraged to add comments about the data shown in the web map, which will be shared with other viewers of the web map.
	Click on this tool to select data shown on the web map. You may use this tool to extract and export data.

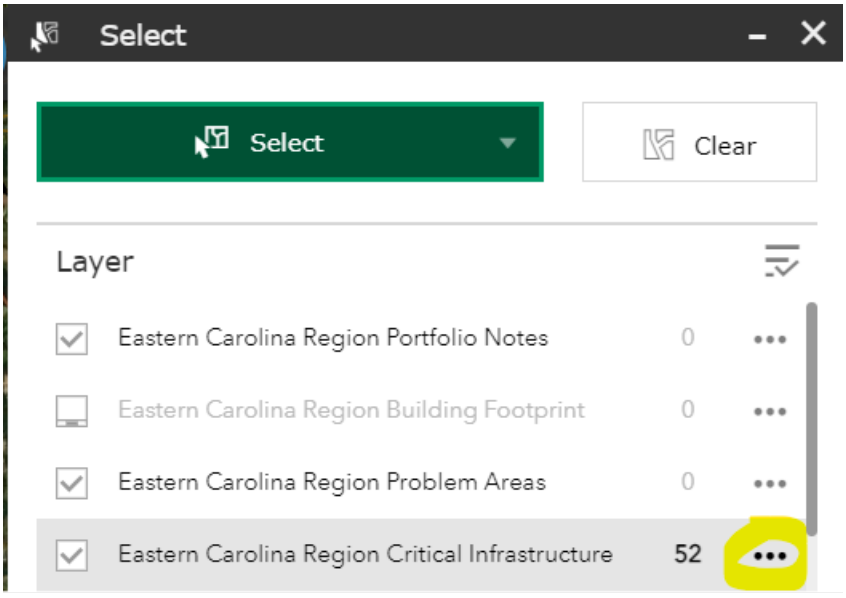
The following layers are available on the maps to visualize the identified hazards:

Table 80: Map Layers and Hazards

Layer	Hazard
• Urban Heat Island	Extreme Temperature
• Wildland Urban Interface Wildfire Hazard Area • Wildland Urban Intermix Wildfire Hazard Area	Wildfire
• Storm Surge SLOSH Category 1 • Storm Surge SLOSH Category 2 • Storm Surge SLOSH Category 3 • Storm Surge SLOSH Category 4 • Projected 2050 1-Percent Annual Chance Flood Event • 1-Percent Annual Chance Flood Event • 0.2-Percent Annual Chance Flood Event	Flood
• Short-Term (~30 Year) Historical Shoreline Change Rates • Short-Term (~30 Year) Historical End Point Shoreline Change Rates • Marsh Migration Zone with 1-Foot Sea Level Rise • Marsh Migration Zone with 0-Foot Sea Level Rise	Erosion

Once you have selected the features using the Select Tool, click on the ellipses next to the layer you would like to extract. You can only extract layers that have a value greater than 0 next to the ellipses.

Figure 38: Layer Extraction



The following data sources were used to build the webmap application:

Table 81: Data Sources for Webmap

Data	Source	Date
Social Vulnerability Index	CDC/ATSDR SVI	2018
Building Footprints	NCEM	2020
Parcel Boundaries	NC One Map	2021/2022
Critical facilities	NC OneMap; HIFLD	2011/2016/2018/2019; 2020/2021/2022
2019 Land Cover	USGS/NLCD	2021
Marsh Migration	NOAA	2016
Erosion Rate	USGS; NC Division of Coastal Management	2017;2020
Urban Heat Island	The Trust for Public Land	2019
Digitized Effective FIRM maps	NCFRIS; FEMA	2022; 2018/2019/2020/2021
Sea Level Rise	NOAA	2017
Sea-Lake Overland Surge from Hurricanes (SLOSH) Model	NOAA	