FLOOD DYNAMICS IN THE BERTIE WATER CRESCENT

INTEGRATING THE DYNAMICS OF COMPLEX DRAINAGE SYSTEMS TO MINIMIZE STORM IMPACTS AND MAXIMIZE AQUATIC ENVIRONMENT VIABILITY, BERTIE COUNTY, NC

FLOOD DYNAMICS IN THE BERTIE WATER CRESCENT

INTEGRATING THE DYNAMICS OF COMPLEX DRAINAGE SYSTEMS TO MINIMIZE STORM IMPACTS AND MAXIMIZE AQUATIC ENVIRONMENT VIABILITY, BERTIE COUNTY, NC

NORTH CAROLINA LAND OF WATER (NC LOW)
www.nclandofwater.org

NC LOW TEAM
Dr. Stanley Riggs: North Carolina Land of Water (NC LOW)
Dr. Robert Christian: North Carolina Land of Water (NC LOW)

Additional Contributions By:
Ms. Dorothea Ames: North Carolina Land of Water (NC LOW)
Dr. David Mallinson: ECU Department of Geological Sciences
Dr. B. Duffy, Dr. J. Dame, Ms. K. Bolam, & Ms. S. Kylander: Chowan University

FUNDED BY
BERTIE COUNTY
TOWN OF WINDSOR
EAST CAROLINA UNIVERSITY
KENAN INSTITUTE OF ENGINEERING, TECHNOLOGY, AND SCIENCE

August 20, 2019

COVER PHOTOGRAPHS: Top panel shows the Cashie River flood waters flowing over the King Street Bridge in the Town of Windsor as a result of Hurricane Matthew on October 10, 2016. Photograph is by S. Sauer. Bottom panel shows the sheet flow across the Weeping Mary Road during the six month period from mid-September 2018 to mid-March 2019 when the USACE was discharging over 30,000 cfs from the upstream dams to the Lower Roanoke River. Photograph is by S. Riggs.

TABLE OF CONTENTS

APPENDICES

STORMS, FLOODING, AND EROSION: BERTIE WATER CRESCENT AND PENINSULA

SUMMARY

Small towns in North Carolina's Land of Water are hard-pressed to create new economic opportunities. Today they face major challenges that include destructive floods, rising sea level, loss of jobs, population declines, high poverty rates, and crumbling infrastructure. In an effort to stimulate new economic opportunities, NC LOW's strategy is to focus on the natural and cultural, resource-based science, eco-tourism and environmental education as a means of diversifying the rural economy while minimizing the stifling impact of flooding and drought. NC LOW brings this vision to the Bertie County region with the expectation of improving the local quality of life through sustainable economic development that enhances and protects the environment and culture of the region.

Bertie County is water-bound by a complex of different kinds of drainage systems encircling three sides of the county and dissecting it through the interior. The great Roanoke River forms the entire western and southern boundary, while the estuarine waters of Albemarle Sound and the Chowan River embayed estuary forms the southeastern and entire eastern boundary, respectively. The interior of Bertie County is dominated by the dendritic valley of the Cashie River and its tributary network. Several smaller and incised, black-water tributary streams flow into Albemarle Sound and include the Salmon, Black Walnut, and Cashoke creeks. The high, east-facing bluffs of the Wicomoco and Talbot Terraces contain numerous small and deeply incised, ephemeral drainages characterized by small delta plains and cypress headlands where they discharge into the Chowan River and Albemarle Sound. The dynamics of this world-class, integrated water system is generally passive and beautiful, while at certain times it can become extremely energetic and angry. This report considers the complex interactions and dynamic responses that occur to turn this positive situation into a negative one for the regions inhabitants. The general findings are based on the patterns of water-level dynamics through time at water-level gages and on available weather data throughout the Bertie region.

1. The lower Roanoke River has two major parts, joined by a fluctuating transition zone, that function differently. The region from the Roanoke Lake dam in Roanoke Rapids to Williamston is totally dependent on the dam discharge that is a function of upstream weather in combination with management policies associated with the engineered dam system. The Roanoke River from Williamston east to Westover Hwy 45 is generally the transition zone. Flooding is controlled by the dam discharge.

2. The river segment from Westover Hwy 45 to Albemarle Sound is dominated by the dynamics of Albemarle Sound (storm surge, wind tides, and astronomical tides that overwhelms a minor base signal from dam discharge). Flooding is minimal except when there is a major storm surge.

3. The Cashie River also has two major parts joined by a fixed transition zone. The upper Cashie River is riverine with a moderate gradient and totally dependent on rainfall to feed the stream system, which the School Rd. gage measures.

4. The Town of Windsor occupies the transition zone which is generally between the Hwy 17 Bypass Bridge and the Hwy 17 King St. Bridge. The lower Cashie River is an estuary that is basically at sea level and is driven by the dynamics of Albemarle Sound. The Windsor King St. gage more closely records Albemarle Sound signals that are similarly recorded at two other downstream sites (Bowling Farm and Westover Hwy 45). Only when there is a major rainfall on the School Rd. gage is there a significant upstream record at the King St. gage.

5. Thus, flooding on the Cashie River in Windsor appears to be generally dependent on the interaction of a large rain water input at the same time that there is either a major wind set up or storm surge on the Albemarle Sound that produces a backflow up the Cashie River.

6. Consequently, when large-scale upstream (rainfall) and/or downstream (storm surge) events occur, then the smaller-scale processes can affect the extent of flooding. Inches to feet of increase or decrease in vertical water levels translate into significantly larger or smaller flooded areas.

7. Thus, it makes a substantial difference in flooding potential if water levels in the lower Cashie River channel are low and there is a dry primary floodplain with abundant storm-water storage capacity or if there has been a prior and/or extended wet weather period with a high groundwater level, full river channels, and wet primary floodplains. When the latter situation exists there is a substantial potential for increased flooding in Windsor and the lower Cashie River.

8. Flooding and shoreline erosion on the eastern banks of Bertie County are totally dependent on the interaction of storm dynamics (storm surge, wind, and rainfall) and associated weather patterns through time on the very large water bodies of the Albemarle and Chowan estuaries.

RECOMMENDATIONS

1A. Status of Water-Level Recorders and Local Weather Stations.

In coastal NC, floods don't just happen in response to upstream rainfall. Any given flood event is dictated by a complex of interacting dynamics between all interconnected water bodies and their response to the changing weather system, and human modifications. The present monitoring sites within the Bertie Water Crescent are as follows.

a. The US Geological Survey operates 8 relevant water-level gages on the lower Roanoke River between the Roanoke River dam at Roanoke Rapids and Westover Hwy 45 bridge located just west of where the lower Roanoke River enters Albemarle Sound.

b. The US Geological Survey operates 1 water-level gage on the upper Cashie River north of Windsor at School Rd. Bridge. This gage is located high enough above mean sea level that it only measures upstream rain input into the Cashie River and rarely records any activity from the Roanoke River, Albemarle Sound, Chowan River, or lower Cashie River.

c. The NC Division of Emergency Management operates 1 FIMAN water-level gage on the King St. Bridge (Hwy 17 Business) over the Cashie River in Windsor. This gage is basically at sea level and records the wind tides and astronomical tides of the Albemarle Sound and Chowan River.

d. No permanent water-level recorders are located on the lower Cashie River, in western Albemarle Sound, or within the Chowan River Estuary. It is very clear that Albemarle-Chowan water does move upstream on the Cashie River and can turn a moderate flood into a catastrophic event. The downstream dynamics can not only add feet of flood water, but can slow down the discharge of flood waters.

e. Obtaining water level and weather data on these water bodies is critical for understanding the interaction between the downstream and upstream components of the Cashie River, predicting potential impacts of future storms, and minimizing the flooding potential for the town of Windsor, lower Cashie River, and western Chowan River and Albemarle Sound shore zones.

f. Only a few scattered weather stations occur throughout the Bertie region that are owned by specific organizations (small air strips, TV stations, or private groups) who do not have direct connections to specific water-level gages, nor do they make their data readily available or store their data.

1B. Recommendations: Water-Level Recorders and Local Weather Stations.
Install four new and/or upgrade permanent water-level recorders and weather stations to monitor the downstream water systems relevant to the Cashie River flooding and to be utilized in combination with the upstream Cashie River and Roanoke River data.

a. Install one system on the lower Cashie River at the Sans Souci Ferry House on NC Dept. of Transportation property.

b. Install one system in western Albemarle Sound at the Salmon Creek State Natural Area on property of the NC Division of State Parks. This location is semi-protected area just inside the mouth of Salmon Creek and on a heavy duty dock.

c. Either reactivate an existing water-level gage or install a new one in central Albemarle Sound at Leonard's Point on the south side of the NC highway 32/94 bridge over the Sound. Supposedly there already is a water-level gage located at Leonard's Point, but a NC DEM site states that there has been no data collected for the past 7 months or more.

d. Install a water-level recorder on the west bank of the Chowan River, possibly on the Colerain waterfront. There is a possibility of cooperating with a private beach club at the east end of NC Hwy 42 where there is a major boat dock inside two rock jetties.

e. Each of these stations should have electronic feeds to the various local emergency management centers. It is essential to provide adequate personnel and funding not only to maintain the new gages, but aid in interpreting and managing the data.

2. Recommendations: The Lower Roanoke River

The summary recommendation is to approach the entire regional system with a more holistic management approach that equally includes the tripartite of waterscape, landscape, and atmoscape within the entire Roanoke Drainage Basin (upper and lower Roanoke Rivers) and not just lake levels, power supply, or rain on the ground.

a. The present policy of "no dam water discharge until there is rain on the ground" is not an adequate policy in this day and age of weather science. Storm science has now become relatively good so that policy decisions can be modified sooner than previously when "rain on the ground" was adequate.

b. At the time when storm water decisions need to be made, the policy of weekly discharge schedules should be shifted to daily scheduling. This would allow more flexibility in ramping up or ramping down discharge patterns.

c. The dam discharge should not be operated as an on-off switch. But rather as a variable switch where the discharge can be slowly ramped up well before there is "rain on the ground". This could alleviate the possibility of getting to the "fishbowl effect" where the dams can't hold any more water, forcing massive dumping.

d. In making dam discharge decisions, it is equally important to consider lower Roanoke River water level conditions as considering the Kerr Lake water levels. Discharging large volumes on top of a normal to full river channel will exacerbate downstream flooding.

e. The Roanoke River stakeholder groups should work with each downstream county to help evaluate and develop a geo-zone plan for Roanoke floodplain based upon potential flooding and best land-uses.

f. The geo-zone plan should recommend policies for specific land-use practices for each part of the most flood-prone lands within the lower Roanoke River system. This plan should include the potential for reclaiming the lowest and most seriously flooded agricultural fields from production utilizing procedures such as buyouts, conservation easements, and/or partnerships for eco-tourism, recreation, and educational-research programs.

g. Dam discharge policies should factor in the downstream valley geometry and geomorphology based upon a geo-zone plan for the lower Roanoke River floodplain.

3A. The Cashie River

The Doll et al. report (2018) recommendations for flooding in the Town of Windsor considered the hydrologic dynamics within the upstream portion of the Cashie River. However, it is equally critical to focus on the downstream dynamics. Thus, an integrated approach should be built around both upstream and downstream hydrologic dynamics, the unique physical and environmental settings of inter-connected water bodies, and the ongoing changes in climate and sea level. These efforts must be integrated with a well-defined land-use management plan that includes geo-zoning and preserving substantial natural buffer areas along each stream channel, particularly in the broad upland headwaters.

3-1. Recommendations: Upper Cashie River

a. Utilize an integrated set of natural and historic water control structures in the upstream portions of the black-water drainage systems (e.g., conservation easements, vegetation buffer zones, design road dams to slow down the water and create temporary holding ponds, etc.). The purpose is to temporarily slow down and/or store portions of flood-waters in the upstream wetlands and let the groundwater reservoir store and evapotranspiration processes utilize major portions of storm water runoff. This will slow down flash-flooding discharges, store water for periods of drought, and provide opportunities of expanding sustainable ecosystems and their services. This should build on findings of the NCSU 2018 report.

b. Develop community partnerships with one or more non-profit, land conservancy groups to implement an integrated drainage system program of conservation easements and best-land use management practices.

c. Revisit the Hoggard mill dam site, as well as other historic mill dam locations in the upper Cashie watershed to determine if re-occupation of one or more sites would work as water storage facilities to manage both flood and drought waters and to provide a basis for expanding sustainable ecotourism opportunities similar to Merchants Mill Pond State Park.

3-2. Recommendations: Town of Windsor

a. Define the "geo-zones" for the Town of Windsor based upon detailed topographic features of both the drainage system and the upland "Windsor Ridge". High- and low-risk zones and past flooding history for the town should determine future land use. Structures within the high-risk geo-zone should be demolished, raised, or moved with development of a set of land uses for these vacated risk zones that are compatible with flooding and can lead to expanding sustainable businesses (see NC LOW 2018 report on the Windsor Water Hub).

b. In order for a long-term flood management program to happen, there should be a series of public workshops to increase the understanding of inter-relationships between the basics of coastal system science, healthy resource systems, and high quality, sustainable economics. The business and agricultural communities, as well as private land owners, must buy into the program or it won't work. This component should partner with pre-existing programs such as NCSU extension and outreach programs, as well as ECU, CU, and the regional community colleges.

c. Develop a regionally focused concentration/curriculum within the STEM education programs for teachers in the regional schools. This program should integrate the coastal landscape, hydrology, climate change, and cultural history of the unique northeastern NC coastal region. A major field component should be included to get students involved in their backyard with mapping and various types of monitoring projects (see NC LOW "Rivers to Sounds" Science Education Report, 2019).

d. The NCSU (2018) report had its most downstream boundary condition at Windsor and did not address downstream controls on water levels and flooding in Windsor. Their conclusions were not based on the possibility that downstream water levels do fluctuate independently of upstream flows. Possibly a re-evaluation should be undertaken to determine the impact of Hwy 17 Business bridge (King Street Bridge) on floodplain connectivity, flushing, and water quality during various flow conditions.

e. If the re-evaluation warrants it, work with both the NC and US DOT to remove segments of the Hwy 17 Business (King Street) road dam across the primary floodplain of the Cashie River to allow a larger portion of the primary floodplain to be used for moderate flow river discharges that don't overtop the road dam.

f. Develop an emergency management protocol that includes observations of downstream conditions along with the upstream monitoring. If possible, develop a mathematical model that includes both conditions to aid in predictions of flooding.

3-3. Recommendations: Lower Cashie River Estuary

The lower Cashie River channel at Windsor drops well below sea level making it a "drowned-river estuary" that is in sync with the dynamics of Albemarle Sound. With its low gradient and strong tidal signal (storm surges, wind tides, and astronomical tides), the valley floor has produced an exceptionally wide floodplain dominated by a vast swamp forest. Consequently, the lower Cashie represents a critical "water sponge" that plays a significant role in buffering storm dynamics, upgrading water quality, and supplying a sustainable future.

a. Consequently, the recommendation is to establish both policies and organizational oversight structures that will 1) protect the resource, 2) preserve the ecosystem function, 3) prepare the resource for utilization as a key part of a sustainable eco-tourism destination, and 4) partner with key land trusts, government agencies, and non-profits to help build the "Bertie Water Crescent" (the 4 P's).

b. Foster education of residents about the importance of the riverine resources and swamp forest ecosystems of the Cashie and Roanoke river systems.

4A. The Chowan and Albemarle Shorelines

4-1. Wicomoco and Talbot Terrace Shorelines

From Colerain south to Batchelor Bay, the shoreline consists of 20- to 80-foot high bluffs and associated narrow strand-plain beaches. Erosion of the Wicomoco and Talbot terrace bluffs respond to rain, wind, and storm surges causing massive slumps that are subsequently reworked into the associated beaches. Along with the land slumps is abundant vegetation that can regrow and form natural vegetation buffers that temporarily protect the shoreline. The bluffs are generally composed of marine strata including a basal bed of highly burrowed clay that often grades upward into an extremely fossiliferous marine bed full of finger corals, scallops, oysters, and clams. Above the clay is a thick layer of sand that is often cross-bedded and full of crab burrows. The contact between the sand and clay beds are many small springs that continuously weep water and precipitate orange iron oxide that forms a bed of ironstone up to two to three feet thick. The bluffs are more susceptible to erosion than the cypress headlands and result in a series of cuspate-shaped embayments between the headlands.

4-2. Ravines, Delta Flats, and Cypress Headlands

The drainage system off the eastern side of the Wicomoco and Talbot terraces (east of hwy 45) is dominated by dozens of short steep ravines deeply incised into the bluffs and filled with upland hardwood forests. Each ravine flows into the Chowan River estuary with a shallow delta flat deposited into the river. The deltas are generally surrounded and protected by a cypress fringe where many of the older shoreline communities occur.

4-3. Remnant Riverine Swamp Forests

The Cow Island Swamp Forest acts as a natural storm buffer for the Wicomoco Bluff and associated uplands to the west and should be protected as a "significant natural area". With its vast and wild wetlands, riddled with creeks and fronted by an extensive cypress fringe, it is a key natural resource as a portion of a sustainable eco-tourism program for recreation, education, and scientific investigation.

4B. Recommendation for Chowan and Albemarle Shorelines

a. The Albemarle and Chowan River shoreline environments are limited natural resources that are being bulldozed and converted into developments due to their awesome waterfronts and associated viewscapes. This is in spite of the severe erosion, major flooding, and potential total loss of these unique ecosystems. Consequently, the following approach is recommended.

b. Due to the extreme dynamics, spectacular geology, and unique ecology, it is recommended to establish the policies and organizational oversight structure that will 1) protect some of the remaining natural resource, 2) preserve the ecosystem function and dynamics, 3) prepare for utilization as key components of a sustainable eco-tourism destination, and 4) partner with key land trusts, government agencies, and non-profits to help build the "Bertie Water Crescent" (the 4 P's).

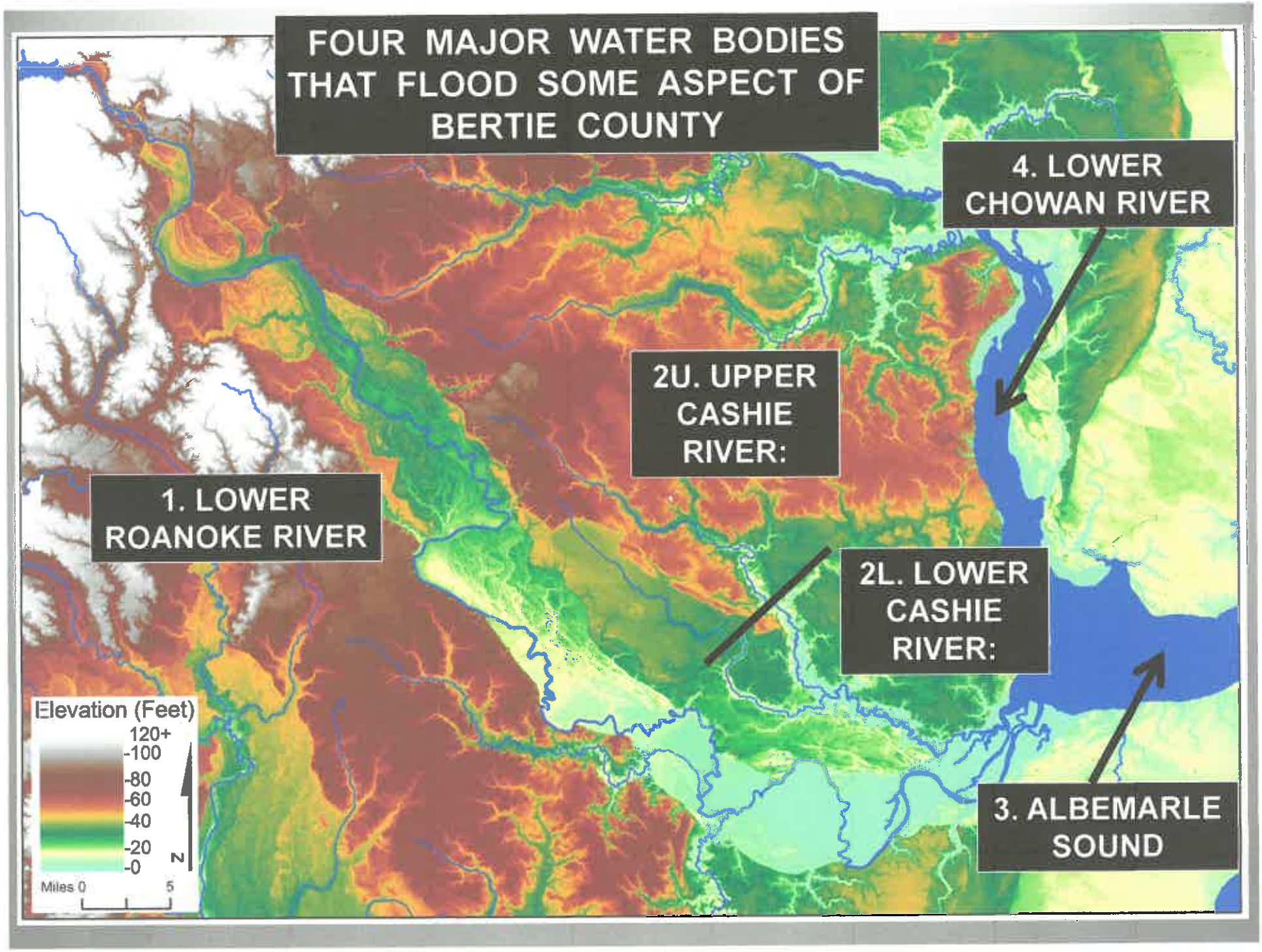
5. Recommendations: Modern and Historic Storm Data

The detailed historical water level and storm data from events during the 20th century, and even into the first decade of the 21st century (Barnes, 2013), is scattered, poorly preserved, or totally non-existent. Consequently, it is recommended that Bertie County and the Town of Windsor either invest in a professional weather person or collaborate with the NC Climate Center at NCSU and the NC Emergency Management Division to explore and mine preserved historic data for the events that were catastrophic within the Bertie region. There are critical lessons to be learned in the history of each event.

a. Secure adequate funding to maintain the new gages, make live data available to the public and emergency management personnel, and archive and preserve all data as historical records for future use.

b. Use the resources cited in Appendices A and B to extend the amount of information for both short-term and long-term decision making. Sources should include existing NOAA weather and storm data, Kerr Lake water level and US ACE dam discharge data, USGS and NC DEM water gage stations, data from the NC Climate Office, regional weather data from local airports, military sites, and other agencies for changing environmental conditions within the Bertie region.

c. Mine historical storm data for the Bertie region from pre-existing sources including the US Geological Survey, US NOAA, US DOA, Library of Congress, NC Archives and History and any other potential source of detailed storm information. Historical data represents a gold mine of understanding!


FOUR MAJOR WATER BODIES THAT FLOOD SOME ASPECT OF BERTIE COUNTY
4. LOWER CHOWAN RIVER
2U. UPPER CASHIE RIVER:
1. LOWER ROANOKE RIVER
2L. LOWER CASHIE RIVER:
3. ALBEMARLE SOUND
Elevation (Feet)
120+
-100
-80
-60
-40
-20
-0
N
Miles 0
5