Section 4: Hazard Identification

4.1 Introduction

The Albemarle Region is vulnerable to a wide range of natural hazards that threaten life and property. Current regulations and interim guidance under the Disaster Mitigation Act of 2000 (DMA 2000) require, at a minimum, an evaluation of a full range of natural hazards.

Upon a thorough review of the full range of natural hazards covered in the existing mitigation plans for the participating counties in the Albemarle area, the hazards suggested under FEMA mitigation planning guidance, and the hazards addressed in the North Carolina State Hazard Mitigation Plan, the participating jurisdictions in the Albemarle Region have identified 14 natural hazards that are to be addressed in the Albemarle Regional Hazard Mitigation Plan. These hazards were identified through an extensive process that included input from Albemarle Hazard Mitigation Planning Committee (HMPC) members.

Table 4.13 lists the full range of natural hazards initially considered for inclusion in the Plan. This table includes a total of 121 individual hazards and documents the evaluation process used for determining which of the initially identified hazards were considered significant enough for further evaluation in the Risk Assessment. For each hazard considered, the table indicates whether or not the hazard was identified as a significant hazard to be assessed further, how this determination was made, and why this determination was made. The table works to summarize not only those hazards that were identified (and why) but also those that were not identified (and why not).
The Albemarle Region and its communities are vulnerable to a wide range of natural and manmade hazards that threaten life and property. The hazards identified by the Albemarle Regional Mitigation Advisory Committee are profiled in this section. A rating system that evaluates the potential for occurrence for each identified threat is provided (**Table 4.13**). The following natural hazards were determined to be of concern for the Albemarle region:

Natural Hazards

- Hurricanes, Tropical Storms
- Nor'easters
- Floods
- Tornadoes
- Winter Storms
- Severe Thunderstorms
- Wildfire
- Erosion
- Drought/Heat Wave
- Earthquakes
- Landslides/Sinkholes
- Tsunami
- Dam/Levee Failure
- Rip Currents

Manmade Hazards

- Transportation Infrastructure Impacts
- Terrorism
- Active Shooter/Mass Casualties
- Cyber Attacks
- Pandemic Events
- Public Health Events

Some of these hazards are interrelated (for example, hurricanes and tropical storms can cause flooding, tornadoes and in some cases landslides), and some consist of hazardous elements that are not addressed separately (for example, severe thunderstorms can cause lightning and hail). It should be noted that some hazards, such as severe winter storms, may impact a large area causing little damage, while other hazards, such as a tornado, may impact a small area yet cause extensive damage. This section provides a general description for each of the hazards listed above along with their hazardous elements, written largely from a regional perspective.

The weather history summaries provided throughout this discussion have been compiled from the National Oceanic and Atmospheric Administration (NOAA) as provided through the National Climatic Data Center (NCDC). The NCDC compiles monthly reports that track weather events and any financial or life loss associated with a given occurrence. These reports are compiled and stored in an online database that is organized by state and county for the entire United States. The event summaries provided in this section (and in Appendix E) have been compiled using local storm reports, data from the National Weather Services and data from the National Climatic Data Center.

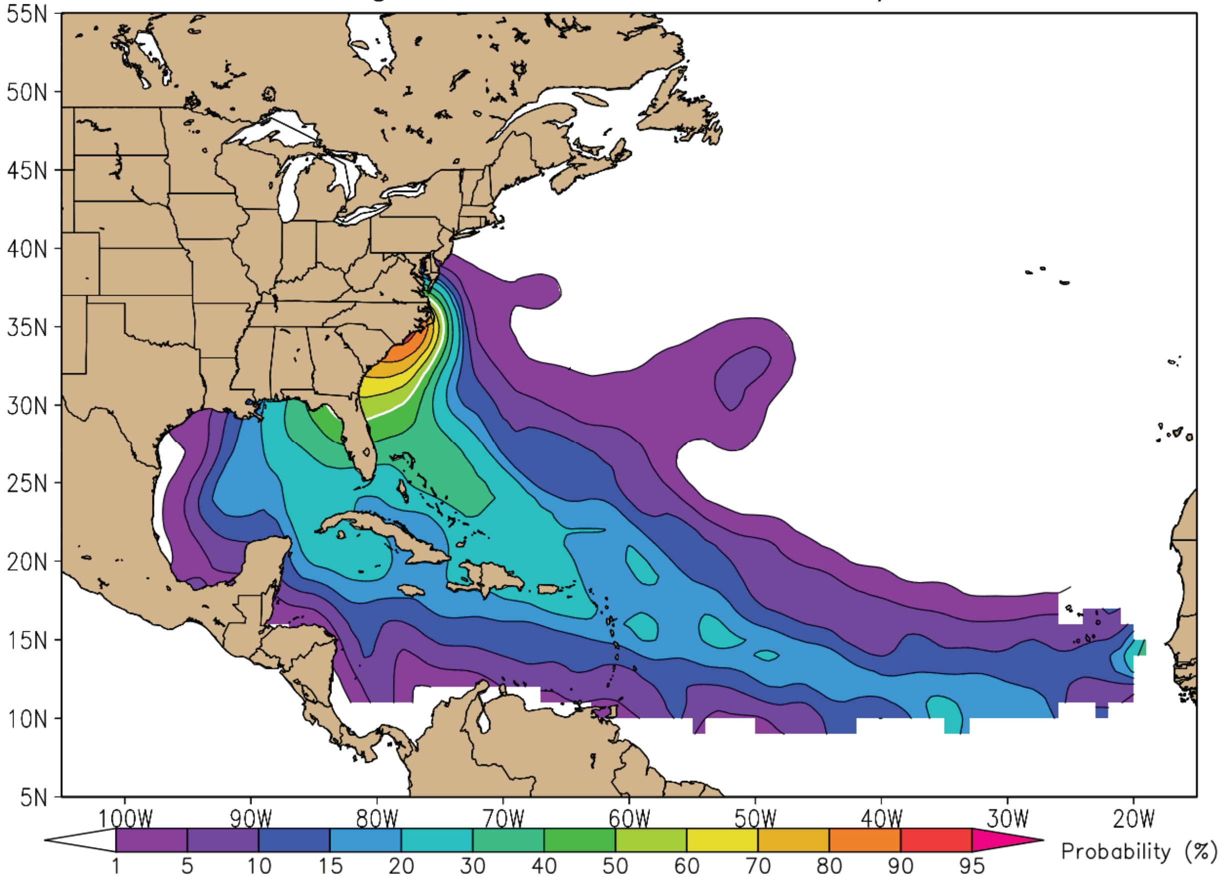
Hurricanes and Tropical Storms

Hurricanes and tropical storms also classified as cyclones are any closed circulation developing around a low-pressure center in which the winds rotate counter-clockwise in the Northern Hemisphere (or clockwise in the Southern Hemisphere) and whose diameter averages 10 to 30 miles across. A tropical cyclone refers to any such circulation that develops over tropical waters. Tropical cyclones act as a "safety-valve," limiting the continued build-up of heat and energy in tropical regions by maintaining the atmospheric heat and moisture balance between the tropics and the pole-ward latitudes. The primary damaging forces associated with these storms are high-level sustained winds, heavy precipitation, and tornadoes. Coastal areas are also vulnerable to the additional forces of storm surge, wind-driven waves, and tidal flooding which can be more destructive than cyclone wind.

The key energy source for a tropical cyclone is the release of latent heat from the condensation of warm water. Their formation requires a low-pressure disturbance, warm sea surface temperature, rotational force from the spinning of the earth, and the absence of wind shear in the lowest 50,000 feet of the atmosphere. The majority of hurricanes and tropical storms form in the Atlantic Ocean, Caribbean Sea, and Gulf of Mexico during the official Atlantic hurricane season, which encompasses the months of June through November with the peak of season occurring in early to mid-September.

Figure 4.1 shows the probability of a tropical cyclone eventually passing over North Carolina at any intensity based on a given position. This probability was derived using the 1886-2012 best track data.

Figure 4.1 North Carolina Landfall Probability



Source: http://moe.met.fsu.edu/tcprob/ - Florida State University, Department of Earth, Ocean, and Atmospheric Science

As a hurricane develops, barometric pressure (measured in millibars or inches) at its center falls and winds increase. If the atmospheric and oceanic conditions are favorable, it can intensify into a tropical depression. When maximum sustained winds reach or exceed 39 miles per hour, the system is designated a tropical storm, given a name, and is closely monitored by the National Hurricane Center in Miami, Florida. When sustained winds reach or exceed 74 miles per hour the storm is deemed a hurricane. Hurricane intensity is further classified by the Saffir-Simpson Scale which rates hurricane intensity on a scale of 1 to 5, with 5 being the most intense. The Saffir-Simpson Scale is shown in **Table 4.1.**

Table 4.1 - Saffir-Simpson Scale

CATEGORY	MAXIMUM SUSTAINED WIND SPEED (MPH)	MINIMUM SURFACE PRESSURE (MILLIBARS)	STORM SURGE (FEET)
1	74–95	Greater than 980	3–5
2	96–110	979–965	6–8
3	111–130	964–945	9–12
4	131–155	944–920	13–18
5	155 +	Less than 920	19+

Source: National Hurricane Center

The Saffir-Simpson Scale categorizes hurricane intensity linearly based upon maximum sustained winds, barometric pressure, and storm surge potential, which are combined to estimate potential damage. Categories 3, 4, and 5 are classified as “major” hurricanes, and while hurricanes within this range comprise only 20 percent of total tropical cyclone landfalls, they account for over 70 percent of the damage in the United States. **Table 4.2** describes the damage that could be expected for each category of hurricane.

Table 4.2 - Hurricane Damage Classifications

STORM CATEGORY	DAMAGE LEVEL	DESCRIPTION OF DAMAGES
1	MINIMAL	No real damage to building structures. Damage primarily to unanchored mobile homes, shrubbery, and trees. Also, some coastal flooding and minor pier damage.
2	MODERATE	Some roofing material, door, and window damage. Considerable damage to vegetation, mobile homes, etc. Flooding damages piers and small craft in unprotected moorings may break their moorings.
3	EXTENSIVE	Some structural damage to small residences and utility buildings, with a minor amount of curtain wall failures. Mobile homes are destroyed. Flooding near the coast destroys smaller structures, with larger structures damaged by floating debris. Terrain may be flooded well inland.
4	EXTREME	More extensive curtain wall failures with some complete roof structure failure on small residences. Major erosion of beach areas. Terrain may be flooded well inland.
5	CATASTROPHIC	Complete roof failure on many residences and industrial buildings. Some complete building failures with small utility buildings blown over or away. Flooding causes major damage to lower floors of all structures near the shoreline. Massive evacuation of residential areas may be required.

Source: National Hurricane Center; Federal Emergency Management Agency

Storm surge from tropical systems often arrive ahead of the storm's actual landfall and the more intense the storm, the sooner the surge arrives. Water rise can be very rapid, posing a serious threat to those who have not yet evacuated flood-prone areas. A storm surge is a wave that has outrun its generating source and become a long period swell. The surge is always highest in the right-front quadrant of the direction in which the hurricane is moving. As the storm approaches shore, the greatest storm surge will be to the north of the hurricane eye. Such a surge of high water topped by waves driven by hurricane force winds can be devastating to coastal regions, causing severe beach erosion and property damage along the immediate coast.

Storm surge heights and associated waves are dependent upon the shape of the continental shelf (narrow or wide) and the depth of the ocean bottom (bathymetry). A narrow shelf, or one that drops steeply from the shoreline and subsequently produces deep water close to the shoreline, tends to produce a lower surge but higher and more powerful storm waves. Storm surge areas can be mapped by the probability of storm surge occurrences using Sea, Lake, and Overland Surges from Hurricanes modeling (SLOSH). SLOSH is a computerized model run by the National Hurricane Center to estimate storm surge heights and winds resulting from historical, hypothetical, or predicted hurricanes by taking into account pressure, size, forward speed, track and winds. The SLOSH boundaries may differ from the base flood boundary on the FIRM. The SLOSH flood areas are determined by compositing the model surge values from 200-300 hypothetical hurricanes. The point of a hurricane's landfall is crucial to determining which areas will be inundated by the storm surge. Where the hurricane forecast track is inaccurate, SLOSH model results will be inaccurate. As a result, the SLOSH model is best used for defining the potential maximum surge for a location. Figures 4.2 and 4.3 show the potential storm surge inundation from slow and fast moving hurricanes.

Figure 4.2 – Slow Moving Storm

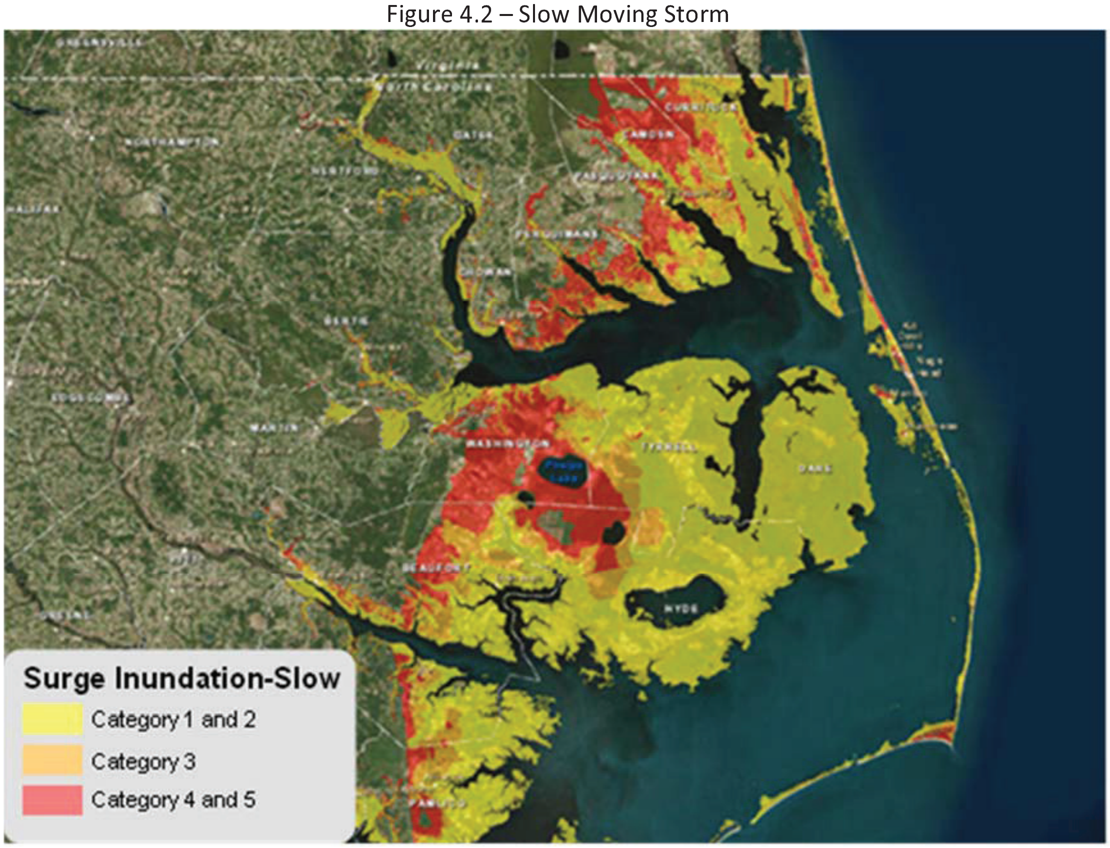
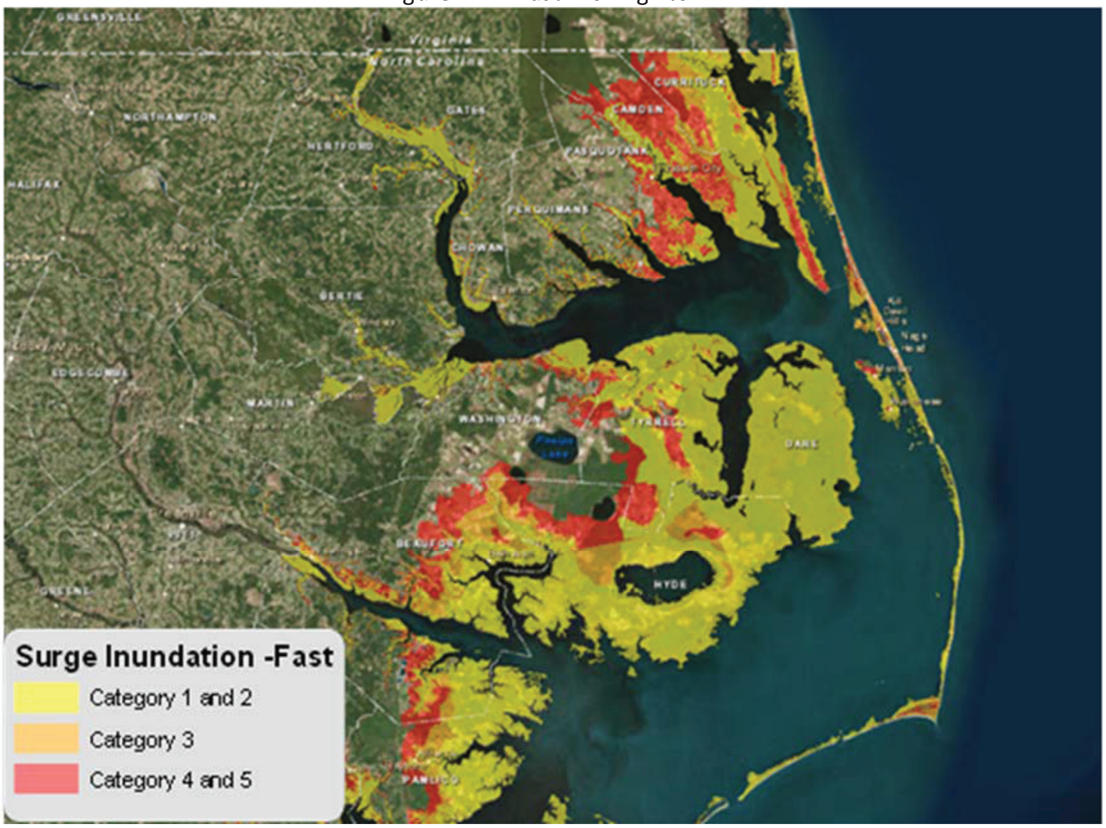


Figure 4.3 – Fast Moving Storm



Although storm surges typically occur during tropical events, several notable non-tropical storm surge events have occurred since 1960. For instance, the Ash Wednesday storm of 1962 affected over 620 miles of shoreline over 4 high tides. This storm caused $300 million in damages. The Halloween Nor'easter of 1991 also caused severe flooding and coastal erosion along the entire East Coast.

Most of the Region has a chance of being impacted by a storm surge, whether through high velocity waves, or flooding. The probability of the Region being impacted by storm surge is "possible" (see Table 40). This impact can be seen on the Hurricane Storm Surge Inundation Maps show above in **Figures 4.1 and 4.2**. The Region has experienced several storm surge events since 2004 as show in **Table 4.3.**

Table 4.3 – Storm Surge Event History

County/Zone	Date	Type	Deaths	Injuries	Property Damage	Crop Damage
EASTERN DARE (ZONE)	3/10/2004	Storm Surge/tide	0	0	10.00K	0.00K
EASTERN DARE (ZONE)	4/3/2005	Storm Surge/tide	0	0	0.00K	0.00K
EASTERN DARE (ZONE)	4/15/2005	Storm Surge/tide	0	0	50.00K	0.00K
EASTERN DARE (ZONE)	5/6/2005	Storm Surge/tide	0	0	0.00K	0.00K
EASTERN HYDE (ZONE)	5/6/2005	Storm Surge/tide	0	0	0.00K	0.00K
EASTERN DARE (ZONE)	9/9/2007	Storm Surge/tide	0	0	0.00K	0.00K
EASTERN DARE (ZONE)	7/20/2008	Storm Surge/tide	0	0	0.00K	0.00K
EASTERN DARE (ZONE)	10/19/2008	Storm Surge/tide	0	0	10.00K	0.00K
EASTERN DARE (ZONE)	9/2/2010	Storm Surge/tide	0	0	380.00K	0.00K
EASTERN DARE (ZONE)	8/26/2011	Storm Surge/tide	0	0	40.000M	0.00K
WESTERN DARE (ZONE)	8/26/2011	Storm Surge/tide	0	0	1.000M	0.00K
EASTERN DARE (ZONE)	10/28/2012	Storm Surge/tide	0	0	13.000M	0.00K
EASTERN DARE (ZONE)	6/6/2013	Storm Surge/tide	0	0	0.00K	0.00K
EASTERN DARE (ZONE)	7/3/2014	Storm Surge/tide	0	0	1.500M	0.00K

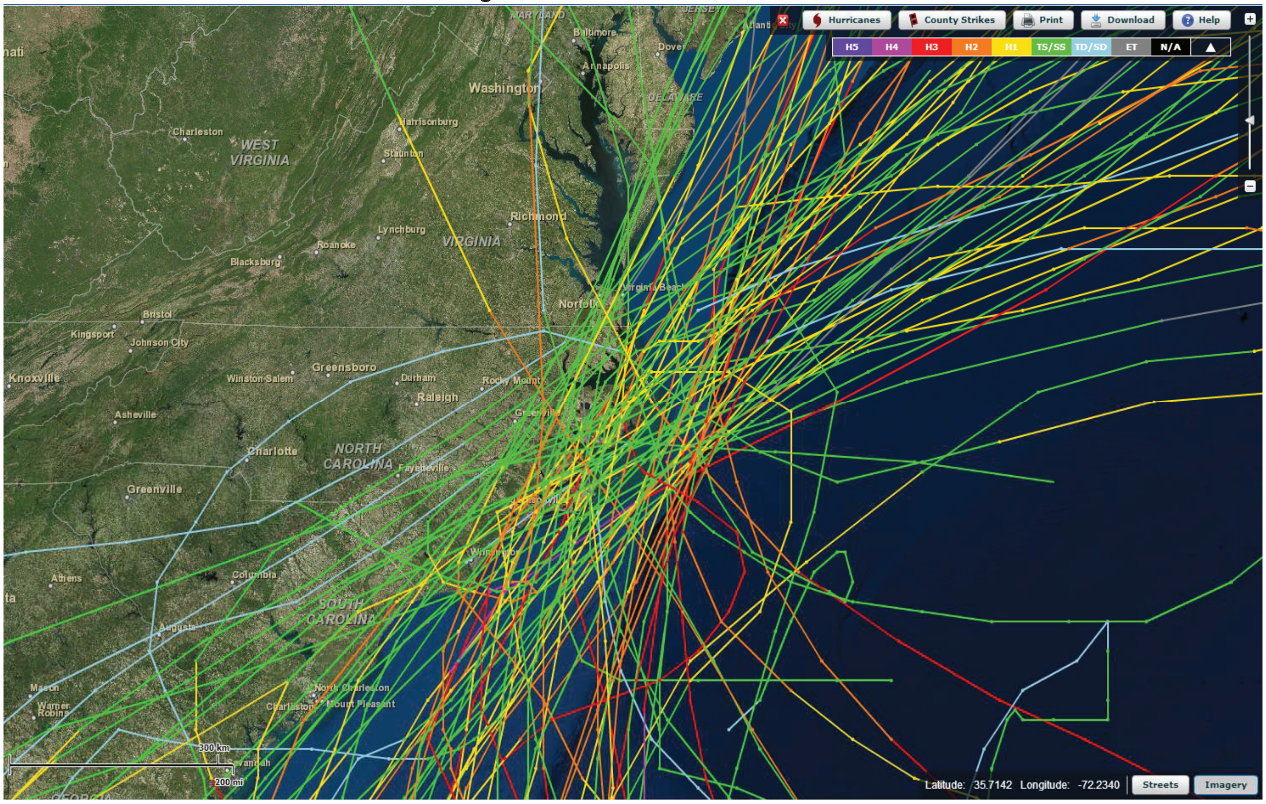
Source: National Oceanic and Atmospheric Administration.

Sea level rise may impact the frequency and severity of these hazards in the future. Sea level rise occurs when the oceans warm or ice melts, bringing more water into the oceans. Sea level rise caused by warming water or thermal expansion is referred to as steric sea level rise, while sea level rise caused by melting snow and ice is called eustatic sea level rise. The combination of steric and eustatic sea level rise is referred to as absolute sea level rise. Absolute sea level rise does not include local land movements. Additionally, while it is often represented as a global average, absolute sea level rise varies from place to place as a result of differences in wind patterns, ocean currents, and gravitational forces. There is strong evidence that global sea level is now rising at an increased rate and will continue to rise during this century.

According to the National Hurricane Center's historical storm track records, 83 hurricane or tropical storms have passed within 75 nautical miles of the Albemarle Region from 1850 to 2011. For the purposes of this graphic, the center of Dare County was used as the search location. These tracks include 24 Category 1 Hurricanes, 15 Category 2 Hurricanes, 6 Category 3 Hurricanes, 1 Category 4 Hurricane and 52 Tropical Storms.

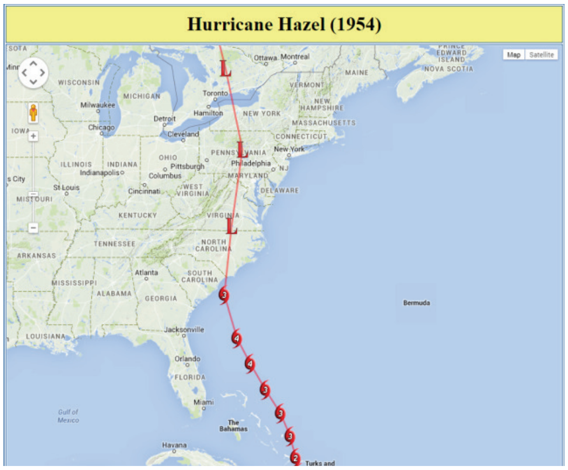
North Carolina has had an extensive hurricane history dating back to colonial times. During the nineteenth century, storms occurred in 1821, 1837, 1846, 1856, 1879, 1883, and 1899. During the years 1960-1990, there was a decrease in land falling hurricanes, with the exception of Hurricane Donna in 1960. However, during the 1950's North Carolina was ravaged by several hurricanes including Hazel, Connie, Diane, and Ione. Recent history has included several hurricanes as well, with Hugo (1989), Emily (1993), Opal (1996), Fran (1996), Eduardo (1996), Bonnie (1998), Dennis (1999), Floyd (1999), Irene (1999), Isabel (2003), Alex (2004), Ophelia (2005), Ernesto (2006), Irene (2011), Sandy (2012) and Arthur (2014) all leaving a mark on North Carolina. However these storms had varying impacts across the Albemarle Region. **Figure 4.4** shows the tracks of storms that have passed within 75 Nautical Miles of the Albemarle Region.

Figure 4.4 – Historical Tracks



The following is a historic look at some of the storms that have impacted North Carolina and the Albemarle Region.

October 5 to 18, 1954 – Hurricane Hazel



Hurricane Hazel was the most destructive storm in the history of North Carolina. The storm crossed the coast just north of Myrtle Beach, South Carolina, as hurricane winds hit the Atlantic coast between the City of Georgetown, South Carolina, and Cape Lookout, North Carolina. Storm tides (i.e., hurricane surge0 devastated the immediate ocean from of this stretch of coast. Every fishing pier along 170 miles of coast, from Myrtle Beach, South Carolina, to Cedar Island, North Carolina, was destroyed. The waterfront between the South Carolina – North Carolina state line and Cape Fear was completely destroyed. Grass-covered dunes, some 20 feet high, along and behind which beach homes had been built in a continuous line five miles long, simply disappeared-dunes, houses, and all. From Cape Fear to Cape Lookout, the degree of devastation was not great, but ocean front property was damaged an average of 50-precent along this entire stretch. North of Cape Lookout, damage was relatively light.

Storm surge of 16.6 feet above the NGVD was observed at Holden Beach Bridge and the Town of Calabash, North Carolina. The lowest recorded barometric pressure of the storm was 938 millibars (mb), reported at Little River Inlet on the North Carolina – South Carolina border. Maximum wind speeds were 83 miles per hour (mph), with gusts recorded at 98 mph at the City of Wilmington, North Carolina; 106 mph at Myrtle Beach, South Carolina; and estimated 150 mph at Cape Fear. The storm continued inland through North Carolina causing widespread damage as a result of high winds and record rainfall. Nineteen people were killed and 200 injured during this storm.

August 3 to 14, 1955 – Hurricane Connie

Hurricane Connie entered North Carolina close to Cape Lookout at about 8:30 a.m. on August 12, 1955. The prolonged pounding of high waves against the coast caused tremendous beach erosion, probably worse than that caused by Hurricane Hazel in 1954. Storm tides along the coast from the City of Southport to the Town of Nags Head were reported to be about 7 feet NGVD (6.9 feet NGVD at Wrightsville Beach and 7.5 feet NGVD at Kure Beach). Water in sounds and near the mouths of rivers was five to eight feet above normal. At the City of Wilmington were reported at 72 mph, gusting to 83 mph. At Fort Macon, winds of 75 mph, gusts of 100 mph, and a barometric pressure of 962 mb were reported. The storm also brought torrential rains with the maximum rainfall; around 12 inches in 48 hours, occurring near the City of Morehead City. Total damage throughout the state was estimated at $50 million.

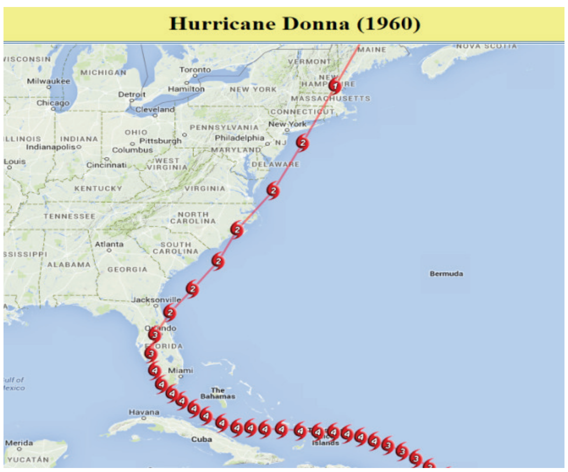
September 10 to 23, 1955 – Hurricane Ione

Hurricane Ione moved up from the south and crossed the North Carolina coast near Salter Path, ten miles west of Morehead City, at about 5 a.m. on September 19, 1955. It then slowly curved to the northeast and went out to sea near the Virginia border early on September 20, 1955. When Hurricane Ione entered North Carolina, winds gusted to over 100 mph. Wind speeds of 75 mph with gusts to 107 mph were recorded at Cherry Point. The minimum barometric pressure recorded over North Carolina during this storm was 960 mb. Heavy rains also accompanied Hurricane Ione. At the same time, prolonged easterly winds drove tidal water onto beaches and into sounds and estuaries to heights of 3 to 10 feet above normal. The result was the largest inundation of eastern North Carolina ever known to have occurred. Hurricane Ione made landfall near Salter Path on Bogue Banks on September 19, 1955, killing seven people and causing $88 million in property damage.

<u>September 21 to October 3, 1958 – Hurricane Helene</u>

Hurricane Helene was one of the most powerful storms of recent history; fortunately for the people of North Carolina, the storm center was well out to sea as it moved north on September 26 and 27, 1958. Nevertheless, high winds were recorded at Wilmington, with the highest winds measured at 85 mph and peak gusts recorded at 135 mph, the lowest reported central pressure of the storm was 93 mb; this measurement was recorded south-southeast of Cape Fear early on the morning of September 27, 1958. There was some beach erosion, which resulted from seas and tides, but this erosion was minimized because the storm occurred at the time of low astronomical tides. High tides were estimated at 3 to 5 feet above normal; a high tide of 5.1 feet NGVD was reported at Wrightsville Beach. Tides were higher on the southern end of Pamlico Sound, where the wind shifts as the storm center passed brought the tides seven to eight feet above normal.

<u>August 29 to September 13, 1960 – Hurricane Donna</u>



Hurricane Donna crossed the North Carolina coast between Wilmington and Morehead City on September 11, 1960. The center of the storm passed a few miles east of Wrightsville Beach, although the City of Wilmington and Wrightsville Beach were each in the eye for about an hour. The lowest barometric pressure recorded during this storm was 962 mb at the City of Wilmington. High tides, six to eight feet above normal, and high winds caused severe damage at many points. Winds of hurricane force, up to 97 mph, were reported at the City of Wilmington.

During the night of September 11, 1960, the storm center moved northward, parallel and slightly east of a line drawn between Wilmington, North Carolina and Norfolk, Virginia. Wind gusts were in excess of 97 mph, and tides were 4 to 8 feet above normal. High tides of 10.3 and 8.3 feet NGVD were reported at Atlantic Beach and Wrightsville Beach, respectively. Coastal communities from the City of Wilmington to the Town of Nags Head suffered heavy structural damage and considerable beach erosion. Eight deaths and approximately 100 injuries were attributed to the storm. Damages were estimated at millions of dollars.

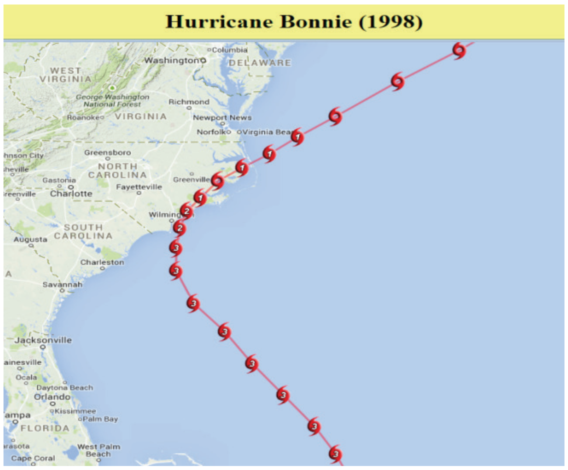
<u>August 26 to 31, 1993 – Hurricane Emily</u>

The first major hurricane of the 1993 season formed on August 22nd about 600 miles east-northeast of the Leeward Islands. It became a tropical storm on August 26th and strengthened to a hurricane the same day. Following a course that varied between west-northwest, Emily would eventually bring the western part of its eye wall over the Outer Banks. The National Hurricane Center upgraded Emily to a Category 3 hurricane. Hurricane force winds (e.g., 90 – 107 mph), strongest from the north then backing to the northwest, were experienced for an hour and a half as the eastern eye wall moved slowly north. This storm caused extensive flooding and destroyed several homes throughout the region

<u>July 5 to 12, 1996 – Hurricane Bertha</u>

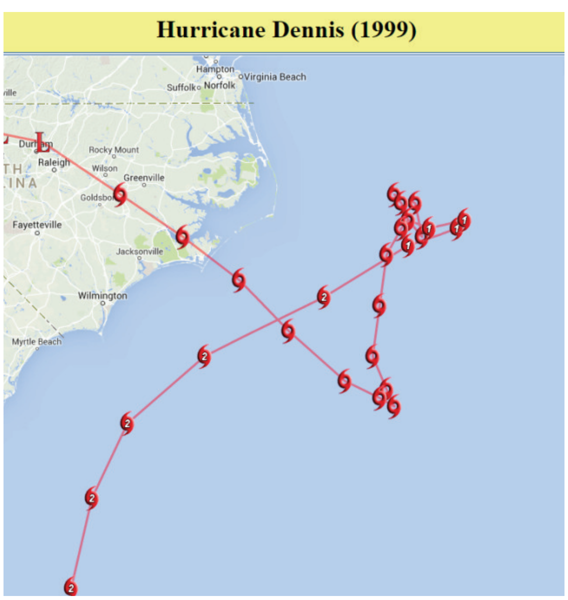
Hurricane Bertha formed on July 5, 1996. As a Category One hurricane, Bertha moved across the northeastern Caribbean. The storm's highest sustained winds received 115-mph north of Puerto Rico. Bertha made landfall near Wilmington on July 12 as a Category Two hurricane, with estimated winds of 105 mph. Bertha claimed two lives in North Carolina and did substantial damage to agriculture crops and forestland. Storm surge flooding and beach erosion were severe along the coast. Damages throughout the state were estimated to exceed $60 million for homes and structures, and over $150 million in agriculture. Corn, tobacco, and other crops received server damage from the storm. Rainfall totals of over 5 inches were common in eastern North Carolina.

August 27, 1998 – Hurricane Bonnie



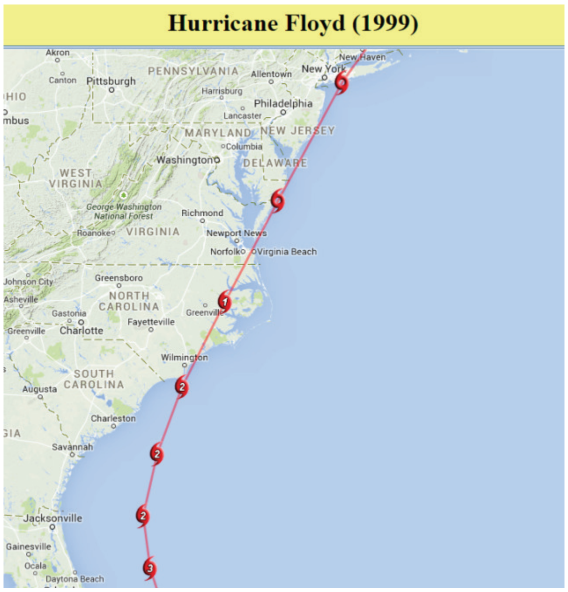
Hurricane Bonnie was a Category 2 storm when it came ashore on August 27, 1998, near Cape Fear. Storm tides of 5 to 8 feet above normal were reported mainly in eastern beaches of Brunswick County NC, while a storm surge of 6 feet was reported at Pasquotank Three people died as a consequence of Bonnie. A 12-year old girl was killed when a large tree fell on her home in Currituck County, NC. Another person was caught in rip currents and drowned in Rehoboth Beach, Delaware. The third person died in Cape Cod in a rowboat accident when choppy seas overturned the boat. The last one may have been indirectly related to Bonnie. The Property Claim Services Division of the American Insurance Services Group reports that Bonnie caused an estimated $ 360 million in insured property damage to the United States. This estimate includes $ 240 million in North Carolina, $ 95 million in Georgia, and $ 25 million in South Carolina. A conservative ratio between total damage and insured property damage, compared to past land falling hurricanes, is two to one. Therefore, the total U.S. damage estimate is $ 720 million.

August 30, 1999 – Hurricane/Tropical Storm Dennis



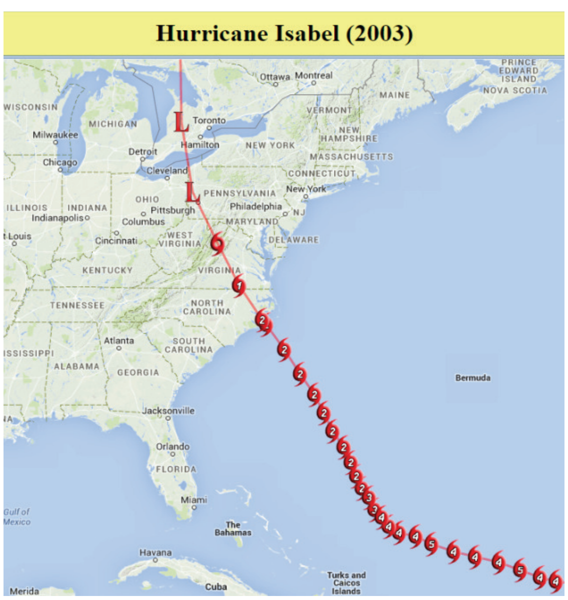
Hurricane Dennis' first pass near the coast of the Carolinas on August 30, 1999, caused sustained tropical storm force winds with gusts to hurricane force in coastal North Carolina and gusts to tropical storm force in coastal South Carolina from Charleston northward. Dennis drifted just east of the North Carolina Outer Banks for several days before coming ashore again on September 4, 1999. Dennis was just below hurricane strength when it made landfall over the Cape Lookout National Seashore just east of Harkers Island, NC. Storm tides of 3 to 5 ft above normal were reported along much of the North Carolina coast on both August 30th and September 4th. Areas along the Neuse River reported tides of 8 to 10 ft above normal tide level on August 30th, while areas along the Currituck River reported similar values on September 4th. Portions of the South Carolina and southeastern Virginia coast experienced 2 to 4 ft above normal tides during Dennis. Since Dennis meandered off the North Carolina coast for several days, the above normal tides were unusually prolonged. This led to extensive beach erosion along portions of the North Carolina and southeastern Virginia coasts. The Property Claims Services Division of the Insurance Services Office reports insured losses due to Dennis totaled $60 million in North Carolina and Virginia. Press reports indicate that agricultural losses in North Carolina and Virginia were $37 million. Combining these reports gives a total estimated damage from Dennis of $157 million.

<u>September 16, 1999 – Floyd</u>



Hurricane Floyd made landfall near Cape Fear, North Carolina in the early morning hours of September 16, 1999, as a Category 2 hurricane with estimated maximum winds near 90 knots. Floyd was losing its eyewall structure as it made landfall. Continuing to accelerate north-northeastward, Floyd's center passed over extreme eastern North Carolina on the morning of the 16th and over the greater Norfolk, Virginia area in the afternoon. Storm surge values as high as 9 to 10 feet were reported along the North Carolina coast. Rainfall totals as high as 15 to 20 inches were recorded in portions of eastern North Carolina and Virginia. A number of tornadoes were sighted in eastern North Carolina. There was a confirmed tornado in Bertie County and another in Perquimans County. The latter tornado destroyed two houses and damaged three or four others. At least ten tornadoes were reported by spotters in the Newport/Morehead City County Warning area, and these apparently caused some structural damage. Four tornadoes or funnel clouds were seen in the Wilmington area, but no damage was apparent. Total damage estimates range from 3 to over 6 billion dollars.

<u>September 18, 2003 – Hurricane Isabel</u>



Hurricane Isabel was the costliest and deadliest hurricane of the 2003 Atlantic Hurricane season. Isabel formed from a tropical wave on September 6 in the tropical Atlantic Ocean and moved northwestward steadily gaining strength reaching peak winds of 165 MPH on September 11. After fluctuating in intensity for four days, Isabel gradually weakened and made landfall on the Outer Banks of North Carolina with winds of 105 MPH on September 18. In North Carolina, the storm surge from Isabel washed out a portion of Hatteras Island to form what was unofficially known as Isabel Inlet. Damage was greatest along the Outer Banks.

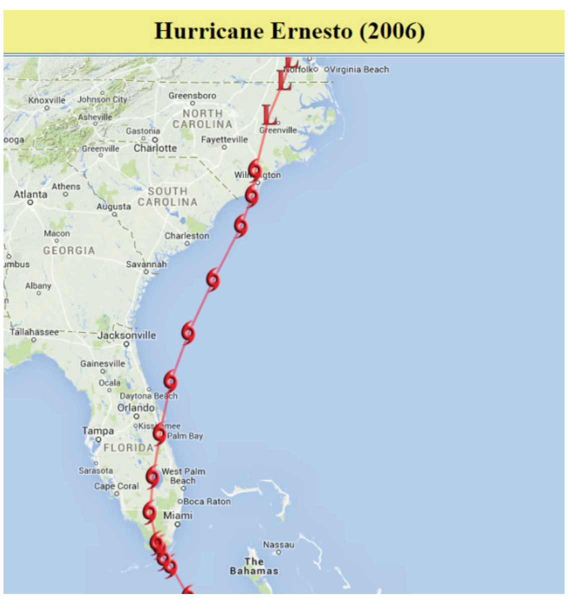
The highest sustained wind speed recorded was 73 mph at Duck. Other sustained wind speeds included 59 mph, recorded in Elizabeth City. The highest gusts recorded were 97 mph at Elizabeth City (as measured at the Clemson University observation site there), 92 mph at Duck, and 74 mph at Elizabeth City. Mandatory evacuations were ordered for parts of Currituck County, with approximately several thousand residents evacuated and housed in numerous shelters across coastal parts of northeast North Carolina. The unusually large wind field uprooted many thousands of trees, downed many power lines, damaged hundreds of residential structures, and snapped thousands of telephone poles and cross arms. Hundreds of roads, including major highways, were blocked by fallen trees. Local power companies reported many thousands of customers had lost power. Duck water levels peaked at 7.8 feet MLLW before data was lost. On the Albemarle Sound, storm surge values around 7 feet occurred at Edenton, with a surge around 5 feet observed on the Pasquotank River in Elizabeth City. The lowest sea level pressure recorded was 984 mb, at Duck.

Isabel will be remembered for the greatest wind and storm surge to occur in the region since Hurricane Hazel in 1954, and the 1933 Chesapeake-Potomac Hurricane before that. Also, Isabel will be remembered for the extensive power outages it caused in northeast North Carolina, and the permanent change its storm surge and fallen trees left on the landscape. Rainfall amount ranged from 2 to 5 inches across coastal parts of northeast North Carolina. Inland flooding due to heavy rainfall occurred over coastal parts of northeast North Carolina. Significant beach erosion occurred across Currituck County

August 4, 2004 – Hurricane Alex

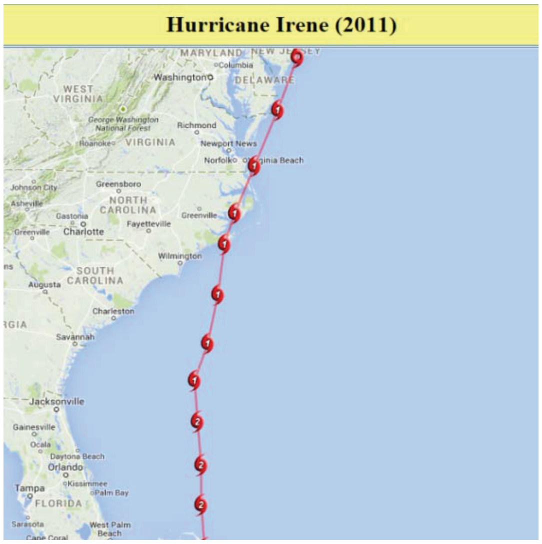
Hurricane Alex was the first storm of the 2004 hurricane season. The hurricane reached Category 2 intensity as it tracked between just offshore from Cape Lookout and Cape Hatteras, North Carolina. Alex reached hurricane intensity at 0200 a.m. on Tuesday, August 3, while centered about 75 miles south-southeast of Wilmington, NC. The hurricane quickly intensified Tuesday with the center of the storm remaining just offshore. The western fringe of the eye wall skirted the Outer Banks from Cape Lookout to Cape Hatteras. Peak wind gusts of 102 MPH were observed at Hatteras Village.

September 1, 2006 - Hurricane Ernesto



Ernesto formed from a tropical wave that emerged from the west coast of Africa on the 18th of August and moved westward across the tropical Atlantic during the following days. The cyclone became a tropical storm on August 25th and gradually turned toward the northwest and continued to intensify as it moved into the central Caribbean Sea on the 26th. After landfall in Florida, the storm intensified into a strong tropical storm as it continued north-northeastward. The center of Ernesto came ashore on September 1 on Oak Island, NC a few miles south-southwest of Wilmington and just west of Cape Fear. At the time of final landfall, Ernesto was very near the threshold between tropical storm and hurricane status, with an intensity of 60 kt and a minimum pressure of 985 mb. The storm reached the North Carolina/Virginia border later on September 1, although by that time it had transformed into an extra-tropical cyclone. Storm total rainfall amounts exceeded 5 inches throughout eastern portions of South Carolina, North Carolina and Virginia as well as Maryland. More than 10 inches of rain fell in several locations in North Carolina and Virginia, including a maximum of 14.61 at Wrightsville Beach, North Carolina. The heavy rains led to river, coastal and surge flooding for several days after Ernesto's landfall.

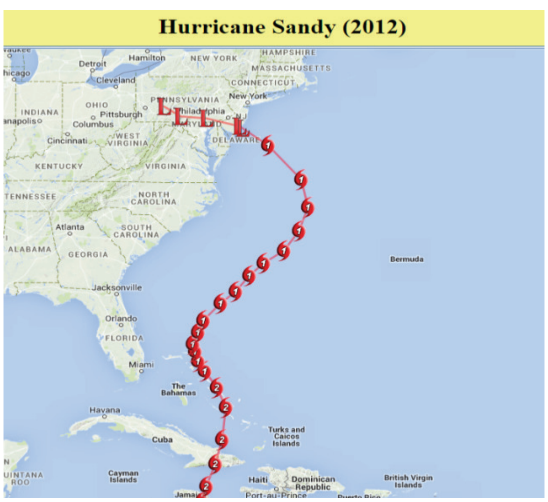
August 26-27, 2011 – Hurricane Irene



Hurricane Irene made landfall on August 27 near Cape Lookout, North Carolina. As the eye wall moved ashore, sustained winds of 73 mph and wind gusts to 115 mph were observed at the Cedar Island Ferry Terminal. Strong winds and driving rains pounded most of Eastern North Carolina. Torrential rainfall amounts in excess of 10 inches were widespread. Storm surge levels of over 10 feet were observed at Ocracoke and several breaches of Highway 12 were noted all along the Outer Banks. Millions of dollars in damages were reported across the state. These damages to property and crops were estimated to be around 381 million dollars. Storm surge related damages exceeded 240 million dollars.

Hurricane Irene left downed and denuded trees, impassable roadways, damaged municipal buildings, and widespread flooding on its way. In Bay Drive in Kill Devil Hills, debris from the Albemarle Sound covered the street after overflowing with overnight rainfall. Storm surge from Hurricane Irene spilled over Kitty Hawk Bay in Albemarle Sound and Roanoke Island, Hatteras Island, Collington, Duck, and other parts of the islands were simply inundated by the Albemarle and Pamlico Sounds. In addition, heavy rains contributed to minor crop damage. Storm total rainfall generally ranged from ten to fourteen inches. Sound side flooding across the Albemarle region was significant, including reports of 5 feet or more water inside homes. Oceanside damage was minimal due to the inland track of the storm. Irene was attributed with at least 56 fatalities.

October 27-30, 2012 – Hurricane Sandy



Hurricane Sandy was the deadliest and most destructive hurricane of the 2012 Atlantic hurricane season and the second costliest hurricane in United States history. Classified as the eighteenth named storm, tenth hurricane and second major hurricane of the year, Sandy was a Category 3 storm at its peak intensity when it made landfall in Cuba While it was a Category 2 storm off the coast of the Northeastern United States, the storm became the largest Atlantic hurricane on winds spanning 1,100 miles. Damage estimates were over $68 billion, a total surpassed only by Hurricane Katrina. At least 286 people were killed along the path of the storm in seven countries.

The majority of the damage that occurred in the region was the result of ocean driven wind, wave action and ocean over wash. The sound side flooding that occurred caused widespread and ground flooding, yet caused very minimal flooding to structures. Beach erosion and loss of dune systems was experienced in Dare and Currituck counties.

July 3-4, 2014 – Hurricane Arthur

Hurricane Arthur (2014)

Hurricane Arthur became the earliest known hurricane to make landfall in the U.S. state of North Carolina. The first named storm of the 2014 Atlantic hurricane season, Arthur developed from an initially non-tropical area of low pressure over the Southeastern United States that emerged into the western Atlantic Ocean on June 28. The system was classified a tropical depression on July 1. The system continued to strengthen and was declared a tropical storm later that day. Drifting northward, the storm reached hurricane status early on July 3. Further structural organization resulted in additional intensification, and on July 4, the system attained its peak winds of 100 mph as a Category 2 hurricane. Arthur made landfall North Carolina's Shackleford Banks, positioned between Cape Lookout and Beaufort. The storm moved swiftly northward and exited the region passing over Nags Head. A state of emergency was declared for 26 counties in eastern North Carolina and both mandatory and voluntary evacuations were ordered. The storms fast forward speed limited the extent of damages which were mainly due to sound side flooding and wind.

North Carolina’s geographic location on the Atlantic Ocean and it proximity to the warm waters of the Gulf Stream make it prone to impacts from Hurricane and Tropical Storms. North Carolina ranks fourth behind Florida, Texas and Louisiana in land falling Hurricanes. The Albemarle Region is located in North Eastern North Carolina and is bordered by the Albemarle Sound to the south and the Atlantic Ocean to the east. The proximity of this region to the coast greatly increases the likelihood of occurrences for these types of coastal storms. As noted in **Table 4.13** and determined by the Albemarle Regional Hazard Mitigation Planning Team, Hurricanes and Tropical Storms are “highly likely” to occur in the Albemarle Region.

Nor’easters

Similar to hurricanes, nor’easters are ocean storms capable of causing substantial damage to coastal areas in the Eastern United States due to their associated strong winds and heavy surf. Nor'easters are named for the winds that blow in from the northeast and drive the storm up the East Coast along the Gulf Stream, a band of warm water that lies off the Atlantic coast. They are caused by the interaction of the jet stream with horizontal temperature gradients and generally occur during the fall and winter months when moisture and cold air are plentiful.

Nor’easters are known for dumping heavy amounts of rain and snow, producing hurricane-force winds, and creating high surf that causes severe beach erosion and coastal flooding. There are two main components to a nor'easter: (1) a Gulf Stream low-pressure system (counter-clockwise winds) generated off the southeastern U.S. coast, gathering warm air and moisture from the Atlantic, and pulled up the East Coast by strong northeasterly winds at the leading edge of the storm; and (2) an Arctic high-pressure system (clockwise winds) which meets the low-pressure system with cold, arctic air blowing down from Canada. When the two systems collide, the moisture and cold air produce a mix of precipitation and have the potential for creating dangerously high winds and heavy seas. As the low-pressure system deepens, the intensity of the winds and waves will increase and cause serious damage to coastal areas as the storm moves northeast. **Table 4.4** shows an intensity scale proposed for nor’easters that is based upon levels of coastal degradation.

Table 4.4 - Dolan-Davis Nor'easter Intensity Scale

STORM CLASS	BEACH EROSION	DUNE EROSION	OVERWASH	PROPERTY DAMAGE
1 WEAK	Minor changes	None	No	No
2 MODERATE	Modest; mostly to lower beach	Minor	No	Modest
3 SIGNIFICANT	Erosion extends across beach	Can be significant	No	Loss of many structures at local level
4 SEVERE	Severe beach erosion and recession	Severe dune erosion or destruction	On low beaches	Loss of structures at community-scale
5 EXTREME	Extreme beach erosion	Dunes destroyed over extensive areas	Massive in sheets and channels	Extensive at regional-scale; millions of dollars

Source: North Carolina Division of Emergency Management

A number of notable nor'easters have impacted North Carolina in recent decades, including the Ash Wednesday Storm of March 1962, but those events were typically only of local concern. One exception to this was the nor'easter that occurred in late October and early November 1990, which loosened a dredge barge that struck and destroyed approximately five roadway segments of the Bonner Bridge in Dare County. Another nor'easter struck the Outer Banks on Oct. 31, 1991, causing substantial beach erosion. Others that have impacted the region are the Nor'easters that occurred on November 21-22, 2006, November 11-14, 2009 and December 8, 2014.

North Carolina's geographic location on the Atlantic Ocean makes it prone to impacts from Nor'easters. The Albemarle Region is located in North Eastern North Carolina and is bordered by the Albemarle Sound to the south and the Atlantic Ocean to the east. The proximity of this region to the coast greatly increases the likelihood of occurrences for these types of coastal storms. The most intense Nor'easter to impact the Albemarle Region was the Ash Wednesday Storm in 1962. This storm was deemed a Class 5 Storm on the Dolan-Davis Intensity Scale. As noted in **Table 4.13** and determined by the Albemarle Regional Hazard Mitigation Planning Team, Nor'easters are "highly likely" to occur in the Albemarle Region.

Floods

Flooding is a coast-to-coast threat to the United States and its territories in all months of the year. Floods are generally the result of excessive precipitation, and can be classified under two categories: general floods, precipitation over a given river basin for a long period of time; and flash floods, the product of heavy localized precipitation in a short time period over a given location. The severity of a flooding event is determined by the following: a combination of stream and river basin topography and physiography; hydrology, precipitation and weather patterns, recent soil moisture conditions, and the degree of vegetative clearing. Approximately seventy-five percent of all Presidential disaster declarations are associated with flooding. Table 4.5 shows flood damage values by fiscal year from a national perspective.

Table 4.5- National Flood Damage & Fatalities by Fiscal Year (October–September)

Fiscal Year	Damages (in 2013 Dollars)	Fatalities	Fiscal Year	Damages (in 2013 Dollars)	Fatalities
1960	$1,077,235,282	169	1987	$3,129,316,353	70
1961	$1,736,190,143	93	1988	$475,972,562	31
1962	$823,724,357	53	1989	$2,235,868,095	85
1963	$1,885,516,606	41	1990	$3,301,565,249	142
1964	$6,646,609,160	142	1991	$3,354,345,855	61
1965	$7,748,172,154	188	1992	$1,460,800,163	62
1966	$1,096,209,213	56	1993	$29,997,022,163	103
1967	$3,335,387,566	53	1994	$1,977,734,842	91
1968	$2,805,404,548	57	1995	$8,918,494,693	80
1969	$6,790,888,682	445	1996	$10,399,577,678	131
1970	$1,558,580,587	131	1997	$14,306,418,749	118
1971	$1,736,243,627	68	1998	$4,026,769,784	136
1972	$24,317,537,847	555	1999	$8,595,708,180	68
1973	$9,544,445,737	178	2000	$2,054,477,262	38
1974	$2,723,272,298	111	2001	$11,001,413,129	48
1975	$5,927,033,971	127	2002	$1,768,836,561	49
1976	$11,928,779,675	193	2003	$3,540,162,804	86
1977	$4,817,973,602	210	2004	$18,745,995,413	82
1978	$2,407,384,726	125	2005	$53,864,306,063	43
1979	$11,127,039,627	121	2006	$4,612,313,236	76
1980	$4,424,003,707	82	2007	$2,858,648,287	87
1981	$2,700,707,214	84	2008	$6,569,352,174	82
1982	$6,239,869,281	155	2009	$1,070,407,611	56
1983	$9,392,031,481	204	2010	$5,465,668,984	103
1984	$8,635,130,246	126	2011	$8,861,880,649	113
1985	$1,137,902,265	166	2012	$515,642,043	29
1986	$13,336,903,376	94	2013	$2,152,417,080	82

Source: FEMA

General floods are usually long-term events that may last for several days. The primary types of general flooding include riverine, coastal and urban flooding. Riverine flooding is a function of excessive precipitation levels and water runoff volumes within the watershed of a stream or river. Coastal flooding is typically a result of storm surge, wind-driven waves, and heavy rainfall produced by hurricanes, tropical storms, nor'easters, and other large coastal storms. Urban flooding occurs where man-made development has obstructed the natural flow of water and decreased the ability of natural groundcover to absorb and retain surface water runoff.

Most flash flooding is caused by slow-moving thunderstorms in a local area or by heavy rains associated with hurricanes and tropical storms. However, flash flooding events can also occur from accelerated snow melt due to heavy rains, a dam or levee failure within minutes or hours of heavy amounts of rainfall, or from a sudden release of water held by an ice jam. Although flash flooding occurs often along mountain streams, it is also common in urbanized areas where much of the ground is covered by impervious surfaces. Flash flood waters move at very high speeds—"walls" of water can reach heights of 10 to 20 feet. Flash flood waters and the accompanying debris can uproot trees, roll boulders, destroy buildings, and obliterate bridges and roads.

The periodic flooding of lands adjacent to rivers, streams, and shorelines (land known as floodplain) is a natural and inevitable occurrence that can be expected to take place based upon established recurrence intervals. The recurrence interval of a flood is defined as the average time interval, in years, expected between a flood event of a particular magnitude and an equal or larger flood. Flood magnitude increases with increasing recurrence interval.

Floodplains are designated by the frequency of the flood that is large enough to cover them. For example, the 10-year floodplain will be covered by the 10-year flood and the 100-year floodplain by the 100-year flood. Flood frequencies such as the 100-year flood are determined by plotting a graph of the size of all known floods for an area and determining how often floods of a particular size occur. Another way of expressing the flood frequency is the chance of occurrence in a given year, which is the percentage of the probability of flooding each year. For example, the 100-year flood has a 1 percent chance of occurring in any given year. The following are the flood hazards zones as defined by FEMA in the Flood Insurance Studies for the counties in the Albemarle Region.

Table 4.6 - Flood Zone Descriptions

Zone	Description
A	Zone A is the flood insurance rate zone that corresponds to the 1% annual chance floodplains that are determined in the FIS Report by approximate methods. Because detailed hydraulic analyses are not performed for such areas, no Base Flood Elevations or depths are shown within this zone.
AE	Zone AE is the flood insurance rate zone that corresponds to the 1% annual chance floodplains that are determined in the FIS Report by detailed methods. In most instances, whole-foot Base Flood Elevations derived from the detailed hydraulic analyses are shown at selected intervals within this zone.
V	Zone V is the flood insurance rate zone that corresponds to the 1% annual chance coastal floodplains that have additional hazards associated with storm waves. Because approximate hydraulic analyses are performed for such areas, no Base Flood Elevations are shown within this zone.
VE	Zone VE is the flood insurance rate zone that corresponds to the 1% annual chance coastal floodplains that have additional hazards associated with storm waves. Whole-foot Base Flood Elevations derived from the detailed hydraulic analyses are shown at selected intervals within this zone.
X	Zone X is the flood insurance rate zone that corresponds to areas outside the 0.2% annual chance floodplain, areas within the 0.2% annual chance floodplain, and to areas of 1% annual chance flooding where average depths are less than 1 foot, areas of 1% annual chance flooding where the contributing drainage area is less than 1 square mile, and areas protected from the 1% annual chance flood by levees. No Base Flood Elevations of depths are shown within this zone.

Source: FEMA

Flood hazard varies by location and type of flooding. Coastal areas are most at risk from flooding caused by hurricanes, tropical storms, and nor'easters. Low-lying coastal areas in close proximity to the shore, sounds, or estuaries are exposed to the threat of flooding from storm surge and wind-driven waves, as well as from intense rainfall. Areas bordering rivers may also be affected by large discharges caused by heavy rainfall over upstream areas.

Inland areas are most at risk from flash flooding caused by intense rainfall over short periods of time. Urban areas are particularly susceptible to flash floods. Large amounts of impervious surfaces in urban areas increase runoff amounts and decrease the lag time between the onset of rainfall and stream flooding. Manmade channels may also constrict stream flow and increase flow velocities.

Coastal flooding is typically a result of storm surge, wind-driven waves, and heavy rainfall. These conditions are produced by hurricanes during the summer and fall, and nor'easters and other large coastal storms during the winter and spring. Storm surges may overrun barrier islands and push sea water up coastal rivers and inlets, blocking the downstream flow of inland runoff. Thousands of acres of crops and forestlands may be inundated by both saltwater and freshwater. Escape routes, particularly from barrier islands, may be cut off quickly, stranding residents in flooded areas and hampering rescue efforts.

From 2004-2014, the Albemarle region experienced thirty-two (32) flooding events that were reported to the National Climatic Data Center (see Appendix E for a detailed description of these hazard events). The significant events that impacted the area are listed below.

<u>November 21-23, 2006</u>

An intense low pressure system off the North Carolina coast combined with an upper level cutoff low to provide very strong winds, heavy rains, and moderate coastal flooding across portions of northeast North Carolina from late Tuesday November 21st into early Thursday morning November 23rd. Strong onshore winds resulted in moderate to severe coastal flooding during times of high tide. Tidal departures were 4 to 5 feet above normal during the event. Route 12 was flooded with overwash in many areas.

<u>November 11-13, 2011</u>

The remnants of Tropical Storm Ida interacted with a strong upper level disturbance to produce a deep, slow moving, low pressure system off the Carolina coast November 11th through the 13th. This system produced widespread heavy rain, gusty winds, and coastal flooding across portions of eastern North Carolina. By far, the most significant impact was coastal flooding over the northern Outer Banks where over five million dollars in damage was reported. The large waves from the storm continued to batter the Outer Banks for several days after the storm system moved away. Several streets, homes and businesses were flooded in low lying areas of the county close or directly exposed to the Currituck Sound. Moyock experienced the heaviest flooding due to rising Sound waters. Moyock area had 3 neighborhoods that flooded, and flood water going into some of the homes. Significant ocean over-wash and coastal flooding developed over the northern Outer Banks during the early morning hours of November 12th and continued through the early morning hours of November 14th. Areas from Buxton north to Duck had several episodes of coastal flooding, mainly during the high tide cycle. 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 over-wash. Damage from the coastal flooding was estimated to be 5.8 million dollars.

<u>October 28-29, 2012</u>

Tropical Cyclone Sandy moving northward well off the Mid Atlantic Coast produced very strong northeast winds which caused moderate to severe coastal flooding across portions of northeast North Carolina. Water levels reached 3.0 feet to 4.0 feet above Atlantic Ocean resulting in moderate to severe coastal flooding. Duck reached a tide height of 6.98 feet MLLW. The combination of storm surge and extreme waves caused major damage to coastal dunes, and flooded areas in northern portions of the Currituck Outer Banks. Storm surge on the Currituck Sound was less than Irene, and mostly less than 2 feet above normal.

The dominant sources of flooding in the Albemarle Region are storm surge inundation, riverine flooding, and local ponding of stormwater runoff. Storm surge from the Atlantic Ocean moves into the Albemarle Sound, which further then moves into rivers and creeks throughout the region; riverine flooding from heavy rainfall also occurs throughout he many creeks and streams within the region. Not all storms which pass through the Albemarle Region produce extremely high surge. Flooding extent varies throughout the region with most impacts coming from the combination of storm surge and rainfall. Flood heights ranging from 2 feet above normal tide to almost eight feet above have been recorded during events. Similarly, storms which produce flooding conditions in one area may not necessarily produce flooding conditions in other parts of the region. Based on **Table 4.13** the likelihood of occurrence of flooding in the Albemarle Region is "highly likely."

Tornadoes

A tornado is a violent windstorm characterized by a twisting, funnel-shaped cloud extending to the ground. Tornadoes are most often generated by thunderstorm activity when cool, dry air intersects and overrides a layer of warm, moist air forcing the warm air to rise rapidly. Tornadoes can also occur during Hurricanes and other coastal storms. The damage caused by a tornado is a result of the high wind velocity and wind-blown debris, also accompanied by lightning or large hail. According to the National Weather Service, tornado wind speeds normally range from 40 to more than 300 miles per hour. The most violent tornadoes have rotating winds of 250 miles per hour or more and are capable of causing extreme destruction and turning normally harmless objects into deadly missiles.

Tornadoes are more likely to occur during the spring and early summer months of March through June and can occur at any time of day, but are likely to form in the late afternoon and early evening. Most tornadoes are a few dozen yards wide and touch down briefly, but even small short-lived tornadoes can inflict tremendous damage. Highly destructive tornadoes may carve out a path over a mile wide and several miles long.

Waterspouts are weak tornadoes that form over warm water and are most common along the Gulf Coast and Southeastern states. Waterspouts occasionally move inland, becoming tornadoes that cause damage and injury. However, most waterspouts dissipate over the open water, causing threats only to marine and boating interests. Typically, waterspouts are weak and short-lived and, because they are so common, most go unreported unless they cause damage.

The destruction caused by tornadoes ranges from light to inconceivable depending on the intensity, size, and duration of the storm. Typically, tornadoes cause the greatest damages to structures of light construction such as residential homes (particularly mobile homes), and tend to remain localized in impact. Tornado intensity and associated damage is measured using the Enhanced Fujita Scale (Table 4.7) which was implemented by the National Weather Service in 2007.

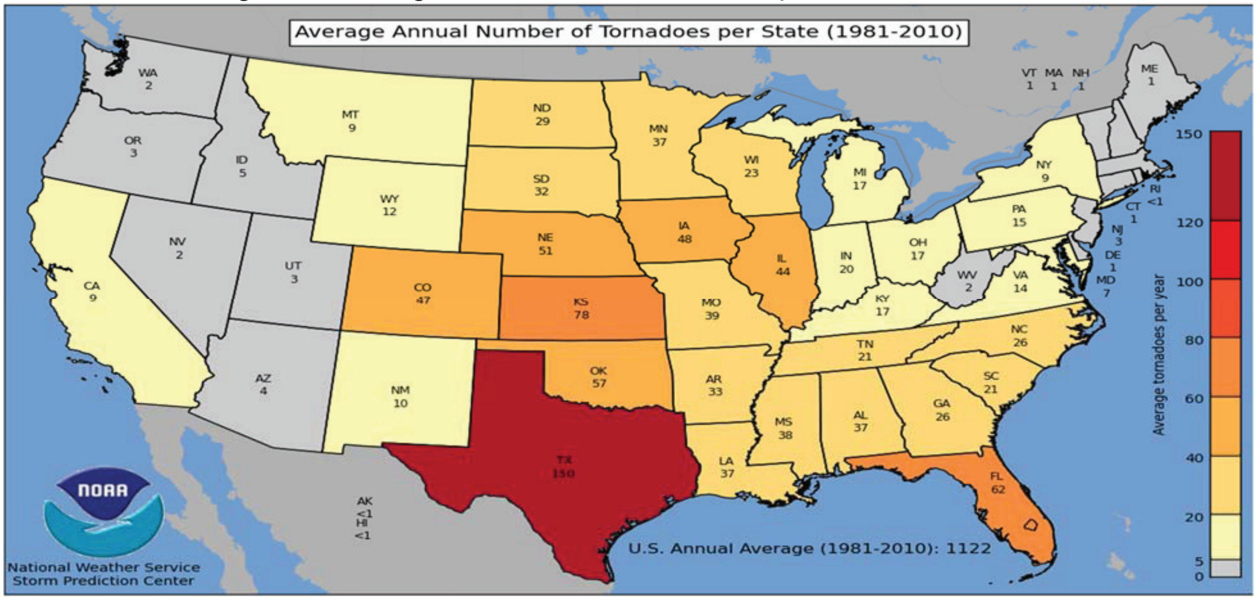
Table 4.7 - Enhanced Fujita Scale

Category	Wind Speed	Potential Damage
EF-0	65-85 mph	Light Damage
EF-1	86-110 mph	Moderate Damage
EF-2	111-135 mph	Considerable Damage
EF-3	136-165 mph	Severe Damage
EF-4	166-200 mph	Devastating Damage
EF-5	200+ mph	Incredible Damage

Source: National Weather Service

According to the National Weather Service Storm Prediction Center (SPC), the highest concentration of tornadoes in the United States has been in the Great Plains region of the Central United States. This area is affectionately known as Tornado Alley. **Figure 4.5** shows tornado activity in the United States based on the annual average occurrence in each state from 1981-2010.

Figure 4.5 - Average Annual Number of Tornadoes per State (1981-2010)



Source: NWS Storm Prediction Center

The tornadoes associated with tropical cyclones are most frequent in September and October when the incidence of tropical storm systems is greatest. This type of tornado usually occurs around the perimeter of the storm, and most often to the right and ahead of the storm path or the storm center as it comes ashore. These tornadoes commonly occur as part of large outbreaks and generally move in an easterly direction.

A total of seventeen (17) tornado events have been documented by the National Climatic Data Center in the Albemarle Sound Region since 2004, resulting in four injuries and one fatality. The region suffered approximately $7.25 million in property damage and $2 million in crop damage. (See Appendix E for detailed descriptions of hazard events). The greatest magnitude reported was an EF2 tornado, which touched down on April 16, 2011, in Hertford and Gates counties, resulting in seven (3) injuries and over $2.2 million in total damages. Another EF2 touched down on April 25, 2014 in Chowan, Pasquotank and Perquimans counties, resulting in over $4 million in damages. A fatality was also associated with this storm. In conclusion, tornados represent a significant threat to the Albemarle Sound Region due primarily to their relative frequency and large impact. Based **Table 4.13**, the likelihood of occurrence is "possible."

Winter Storms

A winter storm can range from a moderate snow over a period of a few hours to blizzard conditions with blinding wind-driven snow that lasts for several days. Some winter storms may be large enough to affect several states, while others may affect only a single community. Many winter storms are accompanied by low temperatures and heavy and/or blowing snow, which can severely impair visibility.

Winter storms may include snow, sleet, freezing rain, or a mix of these wintry forms of precipitation.

Sleet—raindrops that freeze into ice pellets before reaching the ground—usually bounce when hitting a surface and do not stick to objects; however, sleet can accumulate like snow and cause a hazard to motorists. Freezing rain is rain that falls onto a surface with a temperature below freezing, forming a glaze of ice. Even small accumulations of freezing rain can cause a significant hazard, especially on power lines and trees. An ice storm occurs when freezing rain falls and freezes immediately upon impact. Communications and power can be disrupted for days, and even small accumulations of ice may cause extreme hazards to motorists and pedestrians.

A freeze is weather marked by long periods of sustained low temperatures, especially when below the freezing point (zero degrees Celsius or thirty-two degrees Fahrenheit). Agricultural production is seriously affected when temperatures remain below the freezing point.

Severe winter weather is typically associated with much colder climates; however, in some instances winter storms do occur in the warmer climate of North Carolina. On occasion, the Albemarle Region has had moderate winter weather as a result of a nor'easter originating in the Gulf Stream and producing frozen precipitation. Winter storms can paralyze a community by shutting down normal day-to-day operations. Winter storms produce an accumulation of snow and ice on trees and utility lines resulting in loss of electricity and blocked transportation routes. Frequently, especially in rural areas, loss of electric power means loss of heat for residential customers, which poses an immediate threat to human life. Because of the rare occurrence of these events, central and eastern North Carolina communities are often not prepared because they cannot afford to purchase expensive road and debris clearing equipment for these relatively rare events.

There were significant coastal winter storms in 1979, 1789 and 1993. From 2004-2014, there were ten (10) occurrences of severe winter weather within the Albemarle Region (see Appendix E for a detailed description of hazard events). The extent of winter storms can be measured by the amount of snowfall received (in inches). Several significant events occurred during this period including February 8-9, 2011 which produced 11 inches of snow across Gates and Hertford counties, January 30, 201 which also produced 11 inches of snow across parts of Gates and Hertford counties and December 26, 2010 with upwards of 12 inches falling across parts of Gates, Hertford, Pasquotank and Perquimans counties.

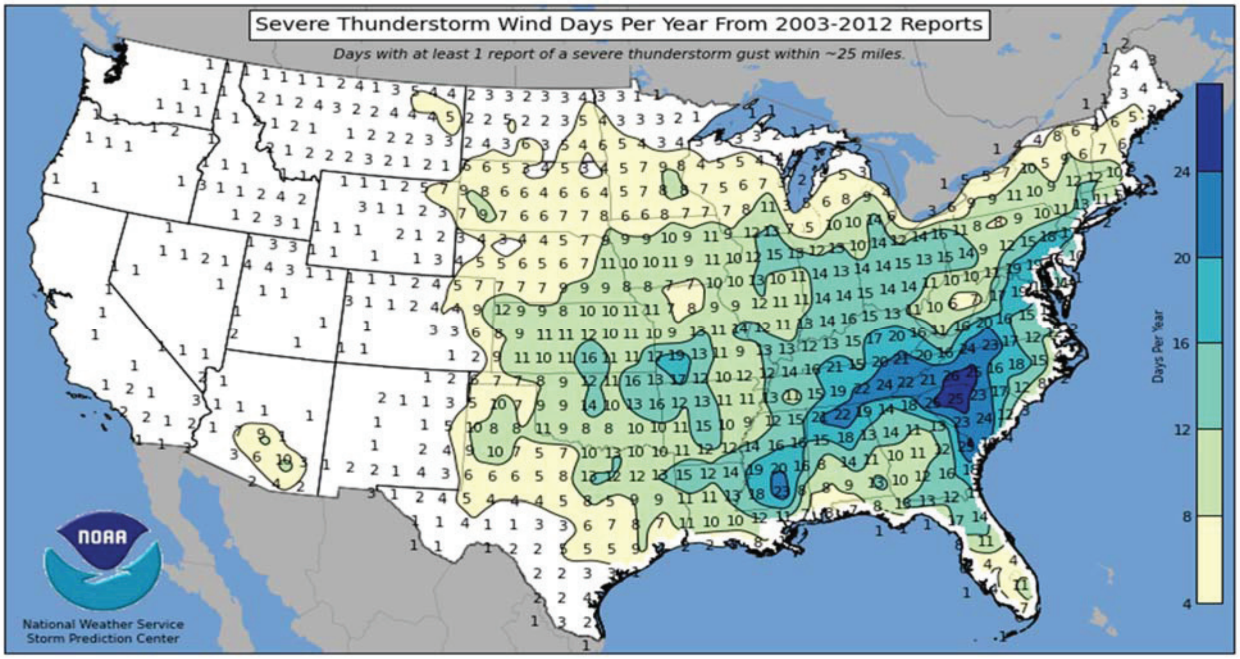
The Albemarle Region is unlikely to be hit with severe blizzard conditions (i.e., high winds and blowing snow), but is subject to freezing rain, icing, and snowfall. Based on historic information and the geographic location of the Albemarle Region, the likelihood of occurrence for a severe winter storm is "likely."

Severe Thunderstorms

According to the National Weather Service, more than 100,000 thunderstorms occur each year, though only about 10 percent of these storms are classified as "severe." Although thunderstorms generally affect a small area when they occur, they are very dangerous because of their ability to generate tornadoes, hailstorms, strong winds, flash flooding, and damaging lightning. While thunderstorms can occur in all regions of the United States, they are most common in the central and southern states because atmospheric conditions in those regions are most ideal for generating these powerful storms.

Thunderstorms are caused when air masses of varying temperatures meet. Rapidly rising warm moist air serves as the "engine" for thunderstorms. These storms can occur singularly, in lines, or in clusters. They can move through an area very quickly or linger for several hours. Figure 4.7 shows the number of Severe Thunderstorm Wind Days per Year from 2003-2012.

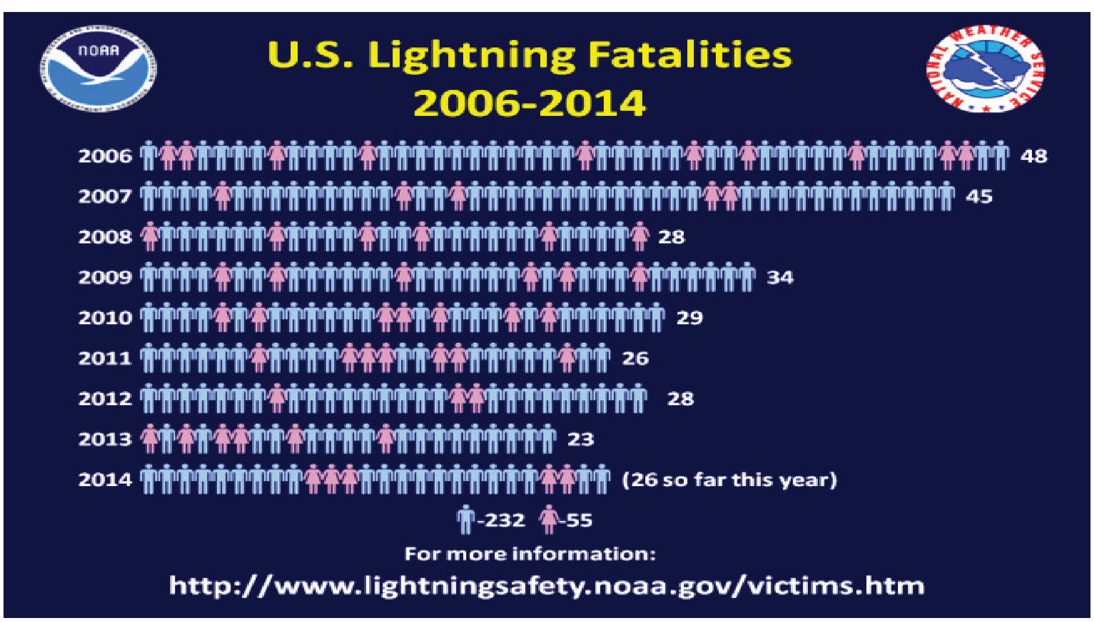
Figure 4.6 - Severe Thunderstorm Wind Days 2003-2012



Source: NWS Storm Prediction Center

Lightning is a discharge of electrical energy resulting from the buildup of positive and negative charges within a thunderstorm, creating a “bolt” when the buildup of charges becomes strong enough. This flash of light usually occurs within the clouds or between the clouds and the ground. A bolt of lightning can reach temperatures approaching 50,000 degrees Fahrenheit. Lightning rapidly heats the sky as it flashes, but the surrounding air cools following the bolt. This rapid heating and cooling of the surrounding air causes thunder. On average, 51 people are killed each year by lightning strikes in the United States. Figure 4.7 shows U.S Lightning Fatalities from 2006-2014.

Figure 4.7- U.S Lightning Fatalities 2006-2014



Source: www.lightningsafety.noaa.gov/fatalities.htm

Thunderstorm winds also cause widespread damage and death. Thunderstorm “straight line” wind occurs when rain-cooled air descends with accompanying precipitation. According to the National Weather Service, a severe thunderstorm is a storm which produces tornados, hail 0.75 inches or more in diameter, or winds greater than 58 mph. At the very extreme, winds of 160 mph have been recorded. These winds can smash buildings and uproot and snap trees, and are often mistaken for tornados.

The Albemarle Region is susceptible to severe thunderstorms and windstorms, suffering 67 such events from 2004 to 2014. These storms resulted in one death and almost $189,000 in property damage regionally. The highest wind speed recorded during a Thunderstorm event was 61 kts. on May 11, 2008. Thunderstorm extent is defined by the number of thunder events and wind speeds reported. Additionally, the Albemarle Sound Region suffered 52 hail events from 2004-2014 (see Appendix E for detailed descriptions of hazard events). Hail extent can be defined by the size of the hail stone. The largest hail stone reported in the Albemarle Sound region was 2 inches. Based on **Table 4.13**, the likelihood of occurrence is “highly likely.”

Wildfires

A wildfire is any fire occurring in a wildland area (i.e., grassland, forest, brush land) except for those started as part of a controlled burn. Wildfires are part of the natural management of the Earth’s ecosystems, but may also be caused by natural or human factors. Over 80 percent of forest fires are started by negligent human behavior such as smoking in wooded areas or improperly extinguishing campfires. The second most common cause for wildfire is lightning.

There are three classes of wildland fires: surface fire, ground fire, and crown fire. A surface fire is the most common of these three classes and burns along the floor of a forest, moving slowly and killing or damaging trees. A ground fire (muck fire) is usually started by lightning or human carelessness and burns on or below the forest floor. Crown fires spread rapidly by wind and move quickly by jumping along the tops of trees. Wildland fires are usually signaled by dense smoke that fills the area for miles around.

State and local governments can impose fire safety regulations on home sites and developments to help curb wildfire. Land treatment measures such as fire access roads, water storage, helipads, safety zones, buffers, firebreaks, fuel breaks, and fuel management can be designed as part of an overall fire defense system to aid in fire control. Fuel management, prescribed burning, and cooperative land management planning can also be encouraged to reduce fire hazards.

Fire probability depends on local weather conditions, outdoor activities such as camping, debris burning, and construction, and the degree of public cooperation with fire prevention measures. Drought conditions and other natural disasters (i.e., tornadoes, hurricanes, etc.) increase the probability of wildfires by producing fuel in both urban and rural settings. Forest damage from hurricanes and tornadoes may block interior access roads and fire breaks, pull down overhead power lines, or damage pavement and underground utilities.

Many individual homes and cabins, subdivisions, resorts, recreational areas, organizational camps, businesses, and industries are located within high fire hazard areas. The increasing demand for outdoor recreation places more people in wildlands during holidays, weekends, and vacation periods. Unfortunately, wildland residents and visitors are rarely educated or prepared for the inferno that can sweep through the brush and timber and destroy property in minutes.

As population densities spread out into areas surrounding the forestland, citizens and private property increasingly become more susceptible to the effects of wildfires. While the incorporated government jurisdictions in the Albemarle Region have significantly less forestland within their corporate limits and extraterritorial jurisdictions (ETJs) than in the unincorporated areas, the municipal governments' boundaries exist at the "urban/wildland interface" - the area where human development meets undeveloped, forested areas which provide fuel for fires. This "urban/wildland interface" presents the greatest risk to life and property from wildfires.

North Carolina, with its large amount of wooded areas, is included among the states with a high risk of wildfire. As development has spread into areas of North Carolina which were previously rural, new residents have been

Relatively unaware of the hazards posed by wildfires and have used highly flammable material for construction buildings. This has increased the threat of loss of life and property, and has also resulted in a greater population of people less prepared to cope with wildfire hazards. The southern coastal plain is particularly vulnerable to wildfire hazard. The mountain region has also experienced wildfires. The Albemarle Region is a moderate risk to wildfire according to the National Climatic Data Center. The area of concern is the urban interface with woodland areas that are heavy with accumulated fire load from overgrowth or decaying vegetation from hurricane wind damage.

The risk of wildfire damages in the Albemarle Region as a whole is mitigated by the fact that forested tracts are generally of manageable size, accessible to firefighting equipment and personnel, and circumscribed by roadways or waterways that limit the extent and severity of wildfires. Some communities within the Region are more susceptible to wildfires due to the amount the interface of developed land with the woodland environment. The largest Wildfire to impact the Albemarle Region from 2010-2014 occurred in Dare County in 2010. This wildfire burned 281 acres which accounted for approximately 75% of all acreage burned in Dare County that year. For these communities, actions have been taken to minimize the potential by including buffers and setbacks from these wooded areas. Based on **Table 4.13**, the likelihood of occurrence is "likely."

Table 4.8 Historical Occurrences of Wildfire

County	5-Year Average Number of Fires	5-Year Average Number of Acres Burned
Camden	17	53
Chowan	5.8	6.2
Currituck	33.8	20.2
Dare*	28.8	73.2
Gates	18	1.4
Hertford	23.6	64.2
Pasquotank	15.5	18.7
Perquimans	2.8	17.32
TOTAL ALBEMARLE		

Drought/Extreme Heat

Drought is a natural climatic condition caused by an extended period of limited rainfall beyond that which occurs naturally in a broad geographic area. High temperatures, high winds, and low humidity can worsen drought conditions, and can make areas more susceptible to wildfire. Human demands and actions can also hasten drought-related impacts.

Droughts are frequently classified as one of following four types:

- Meteorological;
- Agricultural;

- Hydrological; and
- Socio-economic.

Meteorological droughts are typically defined by the level of "dryness" when compared to an average, or normal amount of precipitation over a given period of time. Agricultural droughts relate common characteristics of drought to their specific agricultural-related impacts. Emphasis tends to be placed on factors such as soil water deficits, water needs based on differing stages of crop development, and water reservoir levels. Hydrological drought is directly related to the effect of precipitation shortfalls on surface and groundwater supplies. Human factors, particularly changes in land use, can alter the hydrologic characteristics of a basin. Socio-economic drought is the result of water shortages that limit the ability to supply water-dependent products in the marketplace.

While drought mostly impacts land and water resources, extreme heat can pose a significant risk to humans. Extreme heat can be defined as temperatures that hover 10 degrees or more above the average high temperature for the region, last for prolonged periods of time, and are often accompanied by high humidity. Under normal conditions, the human body's internal thermostat produces perspiration that evaporates and cools the body. However, in extreme heat and high humidity, evaporation is slowed and the body must work much harder to maintain a normal temperature. Elderly persons, young children, persons with respiratory difficulties, and those who are sick or overweight are more likely to become victims of extreme heat. Because men sweat more than women, they are more susceptible to heat-related illness because they become more quickly dehydrated. Studies have shown that a significant rise in heat-related illness occurs when excessive heat persists for more than two days. Spending at least two hours per day in air conditioning can significantly reduce the number of heat-related illnesses.

In addition to the classifications listed above, the Palmer Drought Severity Index (PDSI) attempts to measure the duration and intensity of the long-term drought-inducing circulation patterns. Long-term drought is cumulative, so the intensity of drought during the current month is dependent on the current weather patterns plus the cumulative patterns of previous months. Since weather patterns can change frequently from a long-term drought pattern to a long-term wet pattern, the PDSI can respond fairly rapidly. PDSI index values generally range from -6 to +6, where negative values denote dry spells, and positive values denote wet spells. The following graph depicts the PDSI ratings throughout the region since adoption of the last plan.

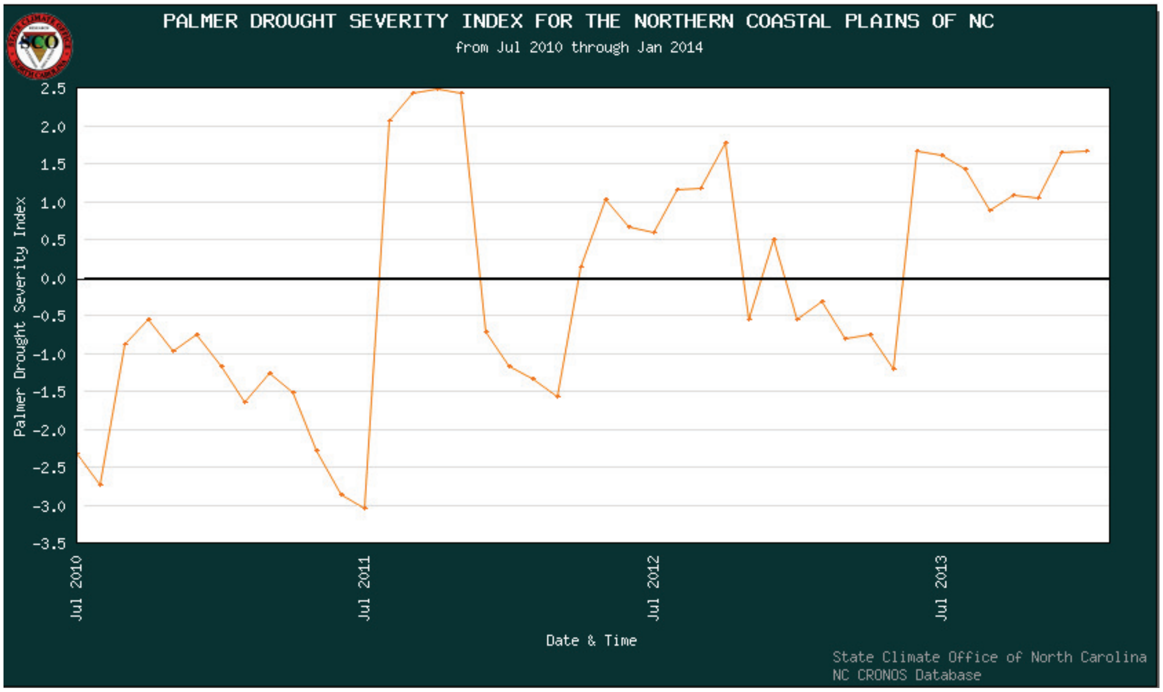


Figure 4.8 Palmer Drought Severity Index for the Northern Coastal Plains of N.C.

The PDSI graph above will be utilized to determine extent of impacts from drought. The National Climatic Data Center indicated that all the counties within the Albemarle Sound Region experienced severe drought conditions during the summer months of 2011 (-3.0 PDSI in July 2011). Drought effects are often severe. Drought can last for extended periods and it affects all citizens, businesses and government. However, there is not a strong history of droughts in the Region. The counties and municipalities within the region have the authority to restrict use of certain water resources. Based on **Table 4.13**, the likelihood of occurrence for drought is "unlikely."

Erosion/Coastal Erosion

Erosion is the gradual breakdown and movement of land due to both physical and chemical processes of water, wind, and general meteorological conditions. Natural, or geologic, erosion has occurred since the Earth's formation and continues at a very slow and uniform rate each year.

There are two types of soil erosion: wind erosion and water erosion. Wind erosion can cause significant soil loss. Winds blowing across sparsely vegetated or disturbed land can pick up soil particles and carry them through the air, thus displacing them. Water erosion can occur over land or in streams and channels. Water erosion that takes place over land may result from raindrops, shallow sheets of water flowing off the land, or shallow surface flow, which is concentrated in low spots. Stream channel erosion may occur as the volume and velocity of water flow increases enough to cause movement of the streambed and bank soils.

An area's potential for erosion is determined by four factors: soil characteristics, vegetative cover, climate or rainfall, and topography. Soils composed of a large percentage of silt and fine sand are most susceptible to erosion. As the content of these soils increases in the level of clay and organic material, the potential for erosion decreases. Well-drained and well-graded gravels and gravel-sand mixtures are the least likely to erode. Coarse gravel soils are highly permeable and have a good capacity for absorption, which can prevent or delay the amount of surface runoff. Vegetative cover can be very helpful in controlling erosion by shielding the soil surface from falling rain, absorbing water from the soil, and slowing the velocity of runoff. Runoff is also affected by the topography of the area including size, shape and slope. The greater the slope length and gradient, the more potential an area has for erosion. Climate can affect the amount of runoff, especially the frequency, intensity and duration of rainfall and storms. When rainstorms are frequent, intense, or of long duration, erosion risks are high. Seasonal changes in temperature and rainfall amounts define the period of highest erosion risk of the year.

Major storms such as hurricanes may cause significant erosion by combining high winds with heavy surf and storm surge to significantly impact the shoreline. Coastal erosion is the wearing away of the land surface by detachment and movement of soil and rock fragments, during a flood or storm over a period of years, through the action of wind, water or other geologic processes. Wind, waves and longshore currents are the driving forces behind coastal erosion. This removal and deposit of sand permanently changes beach shape and structure. Sand may be transported to land-side dunes, deep ocean trenches, other beaches and deep ocean bottoms. Additional factors involved in coastal erosion include human activity, sea-level rise, seasonal fluctuations and climate change.

Erosion is caused by coastal storms and flood events; changes in the geometry of tidal inlets, river outlets, and bay entrances; man-made structures and human activities such as shore protection structures and dredging; long-term erosion; and local scour around buildings and other structures. Coastal Erosion maps for Currituck and Dare counties, as provided by the Division of Coastal Management, are included in Appendix H and Appendix I respectively.

Shoreline erosion is a natural hazard within the Albemarle Region. Erosion of coastal and estuarine shorelines is an ongoing and natural process within the northeastern North Carolina coastal system. Erosion rates are extremely variable, but the majority of the coastal/estuarine shorelines are currently eroding. Given the Albemarle Region's proximity to the Atlantic Ocean and the large number of waterbodies in and surrounding the counties, the likelihood of occurrence for coastal/estuarine erosion is "highly likely."

Earthquakes

An earthquake is the motion or trembling of the ground produced by sudden displacement of rock in the Earth's crust. Earthquakes result from crustal strain, volcanism, landslides, or the collapse of caverns. Earthquakes can affect hundreds of thousands of square miles; cause damage to property measured in the tens of billions of dollars; result in loss of life and injury to hundreds of thousands of persons; and disrupt the social and economic functioning of the affected area.

Most property damage and earthquake-related deaths are caused by the failure and collapse of structures due to ground shaking. The level of damage depends upon the amplitude and duration of the shaking, which are directly related to the earthquake size, distance from the fault, site and regional geology. Other damaging earthquake effects include landslides, the down-slope movement of soil and rock (mountain regions and along hillsides), and liquefaction, in which ground soil loses the ability to resist shear and flows much like quick sand. In the case of liquefaction, anything relying on the substrata for support can shift, tilt, rupture, or collapse.

Most earthquakes are caused by the release of stresses accumulated as a result of the rupture of rocks along opposing fault planes in the Earth's outer crust. These fault planes are typically found along borders of the Earth's ten tectonic plates. These plate borders generally follow the outlines of the continents, with the North American plate following the continental border with the Pacific Ocean in the west, but following the mid-Atlantic trench in the east. As earthquakes occurring in the mid-Atlantic trench usually pose little danger to humans, the greatest earthquake threat in North America is along the Pacific Coast.

The areas of greatest tectonic instability occur at the perimeters of the slowly moving plates, as these locations are subjected to the greatest strains from plates traveling in opposite directions and at different speeds. Deformation along plate boundaries causes strain in the rock and the consequent buildup of stored energy. When the built-up stress exceeds the rocks' strength, a rupture occurs. The rock on both sides of the fracture is snapped, releasing the stored energy and producing seismic waves, generating an earthquake.

Earthquakes are measured in terms of their magnitude and intensity. Magnitude is measured using the Richter Scale, an open-ended logarithmic scale that describes the energy release of an earthquake through a measure of shock wave amplitude (see Table 4.7). Each unit increase in magnitude on the Richter Scale corresponds to a ten-fold increase in wave amplitude, or a 32-fold increase in energy. Intensity is most commonly measured using the Modified Mercalli Intensity (MMI) Scale based on direct and indirect measurements of seismic effects. The scale levels are typically described using roman numerals, with a I corresponding to imperceptible (instrumental) events, IV corresponding to moderate (felt by people awake), to XII for catastrophic (total destruction). A detailed description of the Modified Mercalli Intensity Scale of earthquake intensity and its correspondence to the Richter Scale is given in Table 4.9.

Table 4.9- Richter Scale

RICHTER MAGNITUDES	EARTHQUAKE EFFECTS
Less than 3.5	Generally not felt, but recorded.
3.5–5.4	Often felt, but rarely causes damage.
Under 6.0	At most slight damage to well-designed buildings. Can cause major damage to poorly constructed buildings over small regions.
6.1–6.9	Can be destructive in areas up to about 100 kilometers across where people live.
7.0–7.9	Major earthquake. Can cause serious damage over larger areas.
8 or greater	Great earthquake. Can cause serious damage in areas several hundred kilometers across.

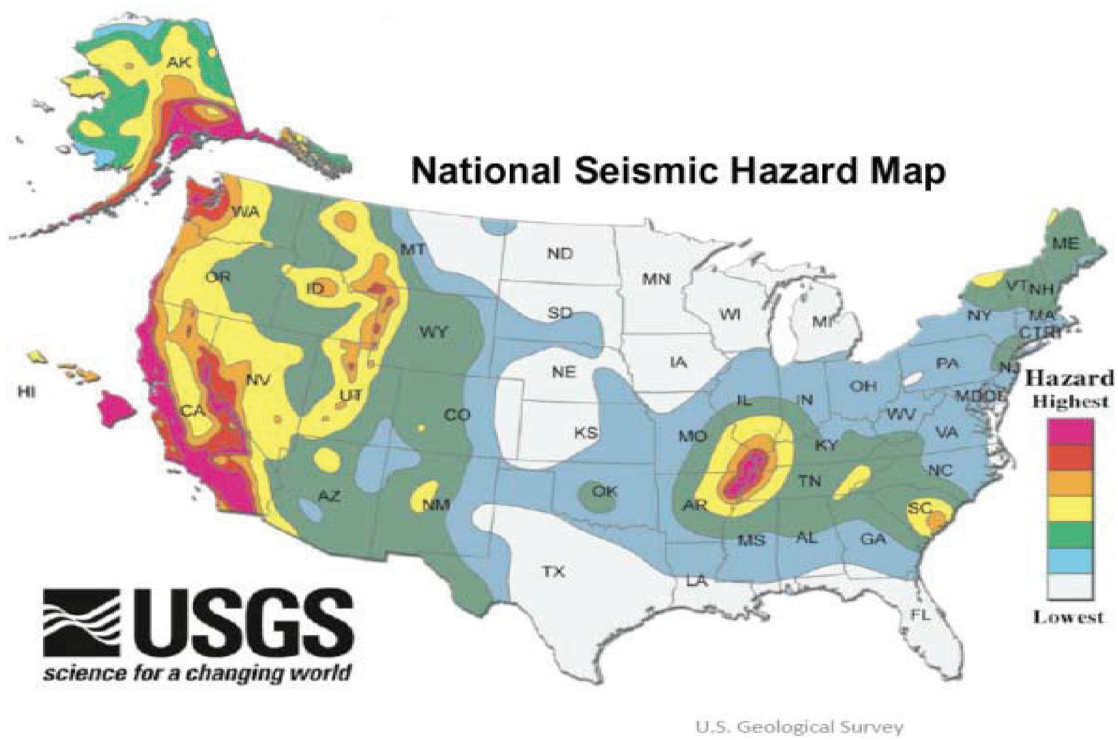
Table 4.10 - Modified Mercalli Intensity Scale for Earthquakes

SCALE	INTENSITY	DESCRIPTION OF EFFECTS	CORRESPONDING RICHTER SCALE MAGNITUDE
I	INSTRUMENTAL	Detected only on seismographs	
II	FEEBLE	Some people feel it	<4.2
III	SLIGHT	Felt by people resting; like a truck rumbling by	
IV	MODERATE	Felt by people walking	
V	SLIGHTLY STRONG	Sleepers awake; church bells ring	<4.8
VI	STRONG	Trees sway; suspended objects swing, objects fall off shelves	<5.4
VII	VERY STRONG	Mild Alarm; walls crack; plaster falls	<6.1
VIII	DESTRUCTIVE	Moving cars uncontrollable; masonry fractures, poorly constructed buildings damaged	
IX	RUINOUS	Some houses collapse; ground cracks; pipes break open	<6.9
X	DISASTROUS	Ground cracks profusely; many buildings destroyed; liquefaction and landslides widespread	<7.3
XI	VERY DISASTROUS	Most buildings and bridges collapse; roads, railways, pipes and cables destroyed; general triggering of other hazards	<8.1
XII	CATASTROPHIC	Total destruction; trees fall; ground rises and falls in waves	>8.1

Source(s): North Carolina Division of Emergency Management

Figure 4.9 is a National Seismic Hazards Map that was compiled by the U.S. Geological Survey (USGS) Geologic Hazards Team, which conducts global investigations of earthquake, geomagnetic, and landslide hazards.

Figure 4.9 - National Seismic Hazard Map



The earliest North Carolina earthquake on record is that of March 8, 1735, near Bath in Beaufort County. During the great earthquake of 1811, centered in the Mississippi Valley near New Madrid, Missouri, tremors were felt throughout North Carolina. The most property damage in North Carolina ever attributed to an earthquake was caused by the August 31, 1886, centered in or near Charleston, SC.

North Carolina's susceptibility to earthquakes decreases from west to east in relation to the Eastern Tennessee Seismic Zone. Generally, there are three different zones of seismic risk in North Carolina. The eastern portion of the State faces minimal effects from seismic activity. Locations in the middle and southeastern areas of the State face a moderate hazard from seismic activity, while the area from Mecklenburg County west through the Blue Ridge faces the greatest risk from seismic activity.

These different levels of risk correspond to proximity to areas with historical seismic activity and changes in topography. The Albemarle region is located in the portion of North Carolina that is less susceptible to the effects of earthquakes. The likelihood of occurrence for earthquakes is "unlikely."

Tsunami

The word tsunami is Japanese and means "harbor wave." A tsunami is one or a series of great waves that are created by an earthquake, landslide, volcanic eruption, submarine earthquake or other undersea disturbances. From the area of disturbance, tsunami waves will travel outward in all directions. Tsunamis can originate hundreds or even thousands of miles away from coastal areas. A tsunami is not the same as a tidal wave.

The time between wave crests may be five to 90 minutes and the open ocean wave speed may average 450 miles per hour. As tsunami waves approach shallow coastal waters, they appear to be of normal size. Although the waves slow down as they reach shallow water, the energy remains constant. When tsunami waves crash into the shoreline, they may be as high as 100 feet. Areas at greatest risk are less than 50 feet above sea level and within one mile of the shoreline. Rapid changes in the ocean water level may indicate that a tsunami is approaching. Most deaths during a tsunami are the result of drowning. Associated risks include flooding, polluted water supplies, and damaged gas lines.

In the United States, tsunamis have historically affected the West Coast but the threat of tsunami inundation is also possible on the Atlantic Coast. However, there is a fault line in the Atlantic Ocean off the coast of the United States, and cracks have recently been discovered on the continental shelf off the coast of North Carolina and Virginia. According to NCEM, these cracks suggest instability in the continental shelf. If the sea floor falls, it could result in a tsunami along the coast. Based on **Table 4.13**, the likelihood of occurrence for tsunamis in the Albemarle Region is "unlikely."

Landslides/Sinkholes

A landslide is the downward and outward movement of slope-forming soil, rock, and vegetation, which is driven by gravity. Landslides may be triggered by both natural and human-caused changes in the environment, including heavy rain, rapid snow melt, steepening of slopes due to construction or erosion, earthquakes, volcanic eruptions, and changes in groundwater levels.

There are several types of landslides: rock falls, rock topple, slides, and flows. Rock falls are rapid movements of bedrock, which result in bouncing or rolling. A topple is a section or block of rock that rotates or tilts before falling to the slope below. Slides are movements of soil or rock along a distinct surface of rupture, which separates the slide material from the more stable underlying material. Mudflows, sometimes referred to as mudslides, mudflows, lahars or debris avalanches, are fast-moving rivers of rock, earth, and other debris saturated with water. They develop when water rapidly accumulates in the ground, such as heavy rainfall or rapid snowmelt, changing the soil into a flowing river of mud or "slurry." Slurry can flow rapidly down slopes or through channels, and can strike with little or no warning at avalanche speeds. Slurry can travel several miles from its source, growing in size as it picks up trees, cars, and other materials along the way. As the flows reach flatter ground, the mudflow spreads over a broad area where it can accumulate in thick deposits.

Landslides are typically associated with periods of heavy rainfall or rapid snow melt and tend to worsen the effects of flooding that often accompanies these events. In areas burned by forest and brush fires, a lower threshold of precipitation may initiate landslides. Some landslides move slowly and cause damage gradually, whereas others move so rapidly that they can destroy property and take lives suddenly and unexpectedly.

Among the most destructive types of debris flows are those that accompany volcanic eruptions. A spectacular example in the United States was a massive debris flow resulting from the 1980 eruptions of Mount St. Helens, Washington. Areas near the bases of many volcanoes in the Cascade Mountain Range of California, Oregon and Washington are at risk from the same types of flows during future volcanic eruptions.
Areas that are generally prone to landslide hazards include previous landslide areas; the bases of steep slopes; the bases of drainage channels; and developed hillsides where leach-field septic systems are used. Areas that are typically considered safe from landslides include areas that have not moved in the past; relatively flat-lying areas away from sudden changes in slope; and areas at the top or along ridges, set back from the tops of slopes.

In the United States, it is estimated that landslides cause up to $2 billion in damages and from 25 to 50 deaths annually. Globally, landslides cause billions of dollars in damage and thousands of deaths and injuries each year

Sinkholes are a natural and common geologic feature in areas with underlying limestone and other rock types that are soluble in natural water. Most limestone is porous, allowing the acidic water of rain to percolate through their strata, dissolving some limestone and carrying it away in solution. Over time, this persistent erosional process can create extensive underground voids and drainage systems in much of the carbonate rocks. Collapse of overlying sediments into the underground cavities produces sinkholes.

The three general types of sinkholes are: subsidence, solution, and collapse. Collapse sinkholes are most common in areas where the overburden (the sediments and water contained in the unsaturated zone, surficial aquifer system, and the confining layer above an aquifer) is thick, but the confining layer is breached or absent. Collapse sinkholes can form with little warning and leave behind a deep, steep sided hole. Subsidence sinkholes form gradually where the overburden is thin and only a veneer of sediments is overlying the limestone. Solution sinkholes form where no overburden is present and the limestone is exposed at land surface.

Sinkholes occur in many shapes, from steep-walled holes to bowl or cone shaped depressions. Sinkholes are dramatic because the land generally stays intact for a while until the underground spaces get too big. If there is not enough support for the land above the spaces, then a sudden collapse of the land surface can occur. Under natural conditions, sinkholes form slowly and expand gradually. However, human activities such as dredging, constructing reservoirs, diverting surface water, and pumping groundwater can accelerate the rate of sinkhole expansions, resulting in the abrupt formation of collapse sinkholes.

Although a sinkhole can form without warning, specific signs can signal potential development:

- Slumping or falling fence posts, trees, or foundations;
- Sudden formation of small ponds;
- Wilting vegetation;
- Discolored well water; and/or

- Structural cracks in walls, floors.

Sinkhole formation is aggravated and accelerated by urbanization. Development increases water usage, alters drainage pathways, overloads the ground surface, and redistributes soil. According to FEMA, the number of human-induced sinkholes has doubled since 1930, insurance claims for damages as a result of sinkholes has increased 1,200 percent from 1987 to 1991, costing nearly $100 million. . Based on **Table 4.13**, the likelihood of occurrence for landslides/sinkholes in the Albemarle Region is "unlikely."

Dam/Levee Failure

Worldwide interest in dam and levee safety has risen significantly in recent years. Aging infrastructure, new hydrologic information and population growth in floodplain areas downstream from dams and near levees have resulted in an increased emphasis on safety, operation and maintenance.

There are about 80,000 dams in the United States today, the majority of which are privately owned. Other owners include state and local authorities, public utilities, and federal agencies. The benefits of dams are numerous: they provide water for drinking, navigation, and agricultural irrigation. Dams also provide hydroelectric power, create lakes for fishing and recreation, and save lives by preventing or reducing floods.

Though dams have many benefits, they also can pose a risk to communities if not designed, operated, and maintained properly. In the event of a dam failure, the energy of the water stored behind even a small dam is capable of causing loss of life and great property damage if development exists downstream of the dam. If a levee breaks, scores of properties are quickly submerged in floodwaters and residents may become trapped by this rapidly rising water. The failure of dams and levees has the potential to place large numbers of people and great amounts of property in harm's way.

According to "Success and Challenges: National Dam Safety Program 2002" completed in 2002 by the Association of State Dam Safety Officials, forty (40) dams failed in North Carolina following Hurricane Floyd in September of 1999 and over 100 dams overtopped, causing property damage and requiring evacuation of downstream areas to avoid injury and loss of life.

According to data obtained from the North Carolina Dam Safety Program within the Division of Land Resources of the NC Department of Environmental and Natural Resources, there are fifteen dams located in the Albemarle Region. The majority of these dams (14) are located in Hertford County and (1) in Gates County. **Table 4.11** provides information regarding those dams.

Table 4.11 – Dams

Status	Hazard Potential	County	River/Stream	River Basin
IMPOUNDING	High	Gates	Benntees Creek	Chowan
BREACHED	Low	Hertford	Hares Branch	Chowan
BREACHED	Low	Hertford	Chowan River-Tr	Chowan
EXEMPT	Low	Hertford	Deep Creek	Chowan
IMPOUNDING	High	Hertford	College Branch	Chowan
IMPOUNDING	High	Hertford	College Branch	Chowan
IMPOUNDING	High	Hertford	College Branch	Chowan
EXEMPT-HB_SIZE	Low	Hertford	Whiteoak Swamp-Tr	Chowan
BREACHED	Low	Hertford	Hares Branch	Chowan
EXEMPT-HB_SIZE	Intermediate	Hertford	Meherrin River-Tr	Chowan
EXEMPT-HB_SIZE	Low	Hertford	Potecasi Creek-Tr	Chowan
EXEMPT-HB_SIZE	Low	Hertford	Banks Creek-Tr	Chowan
EXEMPT-HB_SIZE	Low	Hertford	Buckhorn Creek-Tr	Chowan
EXEMPT-HB_SIZE	Low	Hertford	Tp-Potecasi Creek	Chowan
EXEMPT-HB_SIZE	Low	Hertford	Meherrin River	Chowan

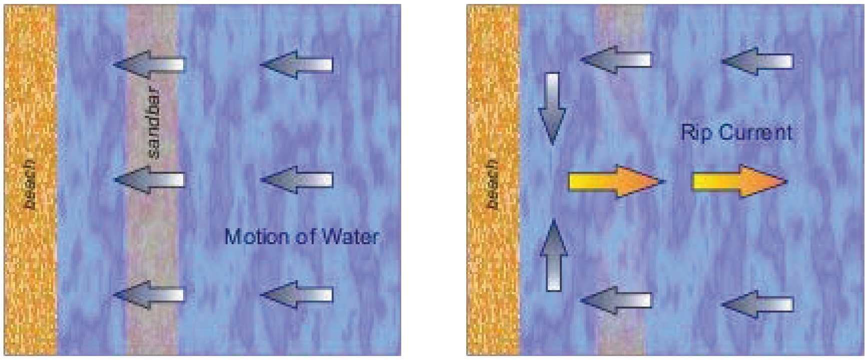
Source: NC Dam Safety Program

Eight (8) of the dams are considered exempt. Exempt status means that a dam is not regulated by dam safety laws because of the size of the dam and/or a low hazard classification. Ten of the fifteen dams have a low hazard classification, one has an intermediate classification, and four have a high classification.

As of 2010, North Carolina had 1,152 "high hazard" dams – the largest number of "high hazard" dams in the United States. Another 748 dams in the State are classified as "intermediate hazard," meaning that significant property damage would occur in the event of a dam failure. There have been no historical occurrences of dam/levee failure impacting the Albemarle Sound region. Thus, no data has been reported regarding this issue. In the event of a dam breech or levee failure, the extent of flooding would be similar to that of a flooding event which on average was reported to be 12 feet. The likelihood of occurrence of a dam failure affecting the Albemarle Region is "unlikely."

Rip Currents

Rip currents are the leading cause of aquatic rescues in the United States. Of the 604 rescues in 2013 in North Carolina, as reported by the United States Lifesaving Association, at 366 of the rescues were a result of rip currents. Rip currents are channels of water running seaward from the shore through holes in the sandbar. Rip currents do not pull down, but they do flow out, and while they vary in strength and size, they often are too strong to allow swimmers to swim back through them to shore. Rip currents can change throughout the seasons depending on how water movement affects the topography of the sandbar. Generally speaking, rip currents only pull 20 to 50 yards off-shore, depending on where the sandbar is located.



Source: NWS Southern Region Headquarters

Rip currents can be found on many surf beaches every day. Under most tide and sea conditions the speeds are relatively slow. However, under certain wave, tide, and beach profile conditions the speeds can quickly increase to become dangerous to anyone entering the surf. The strength and speed of a rip current will likely increase as wave height and wave period increase. They are most likely to be dangerous during high surf conditions as the wave height and wave period increase. Rip currents most typically form at low spots or breaks in sandbars, and also near structures such as groins, jetties and piers. Rip currents can be very narrow or extend in widths to hundreds of yards.

The National Weather Service issues a Surf Zone Forecast that includes the rip current risk for many beaches. Rip current risk definitions are as follows:

- Low Risk: Wind and/or wave conditions are not expected to support the development of rip currents. However, rip currents may occur at any time, especially in the vicinity of groins, jetties, and piers. Typically, rip currents that form during these days are weak and may only pose threats to very weak swimmers or toddlers. During low risk days the potential for life threatening rip currents is at a minimum and rescues by area life guards would be very low if any at all.

- Moderate Risk: Some or all of the conditions that support stronger rip currents are becoming factors, thus the magnitude of rip currents will likely increase. At this stage, persons entering the surf are urged to exercise caution. The number of rescues by area life guards may increase proportionally on moderate risk days.

- High Risk: Wind and/or wave conditions are expected to support the development of very strong rip currents. This category implies that rip currents are life threatening to all people who enter the surf. There may be a high number of rescues on high risk days.

The United States Lifesaving Association estimates that the annual number of deaths due to rip currents on the nation's beaches exceeds 100. Rip currents account for over 80% of rescues performed by surf beach lifeguards. **Table 4.12** provides a description of the rip currents which have occurred in the Albemarle Region since 2004.

Table 4.12

Location	St.	Date	Type	Deaths
NAGS HEAD	NC	8/5/2004	Rip Current	1
COROLLA	NC	9/22/2004	Rip Current	1
COROLLA	NC	9/23/2004	Rip Current	1
KILL DEVIL HILLS	NC	5/27/2005	Rip Current	1
NAGS HEAD	NC	6/22/2005	Rip Current	1
EASTERN DARE (ZONE)	NC	9/22/2006	Rip Current	1
EASTERN HYDE (ZONE)	NC	5/27/2007	Rip Current	1
EASTERN DARE (ZONE)	NC	7/1/2007	Rip Current	1
EASTERN HYDE (ZONE)	NC	7/4/2007	Rip Current	1
EASTERN DARE (ZONE)	NC	7/24/2009	Rip Current	1
EASTERN DARE (ZONE)	NC	9/18/2009	Rip Current	1
WESTERN HYDE (ZONE)	NC	8/7/2010	Rip Current	1
EASTERN DARE (ZONE)	NC	6/20/2012	Rip Current	1
EASTERN DARE (ZONE)	NC	6/26/2013	Rip Current	0

Source: National Climatic Data Center

As show in Table 4.12, 2004 and 2007 were the most active years for Rip Currents in the Albemarle Region. There were three Rip Current events reported in both 2004 and 2007 with a total of 6 fatalities. The probability of rip currents impacting the Albemarle Region coastline is “highly likely” (see Table 4.13).

Non-Natural Hazards

Terrorism

Terrorism is not new, and even though it has been used since the beginning of recorded history it can be relatively hard to define. Terrorism has been described variously as both a tactic and strategy; a crime and a holy duty; justified reaction to oppression and an inexcusable abomination. Obviously, a lot depends on whose point of view is represented.

Terrorism has often been an effective tactic for the weaker side in a conflict. As an asymmetric form of conflict, it confers coercive power with many of the advantages of military force at a fraction of the cost. Due to the secretive nature and small size of terrorist organizations, they often offer opponents no clear organization to defend against or to deter.

The National Strategy for Homeland Security characterizes terrorism as any premeditated, unlawful act dangerous to human life or public welfare that is intended to intimidate or coerce civilian populations or governments. This description captures the core concepts shared by the various definitions of terrorism contained in the U.S. Code, each crafted to achieve a legal standard of specificity and clarity. This description covers kidnappings; hijackings; shootings; conventional bombings; attacks involving chemical, biological, radiological, or nuclear weapons; cyber-attacks; and any number of other forms of malicious violence. Terrorists can be U.S. citizens or foreigners, acting in concert with others, on their own, or on behalf of a hostile state

Description

There are three perspectives of terrorism: the terrorist's, the victim’s and the genera l publics'. The phrase "one man’s terrorist is another man’s freedom fighter" is a view terrorist themselves would accept. Terrorist do not see themselves as evil. They believe they are legitimate combatants, fighting for what they believe in, by whatever means possible. A victim of a terrorist act sees the terrorist as a criminal with no regard for human life. The general publics' view is the most unstable. The terrorists take great pains to foster a "Robin Hood" image in hope of swaying the general publics' point of view toward their cause. This sympathetic view of terrorism has become an integral pat1of their psychological warfare and needs to be countered vigorously.

Terrorism has demonstrated increasing abilities to adapt to counter-terrorism measures and political failure. Terrorists are developing new capabilities of attack and improving the efficiency of existing methods. Additionally, terrorist groups have shown significant progress in escaping from a subordinate role in nation-state conflicts, and becoming prominent as international influences in their own right. They are becoming more integrated with other sub-state entities, such as criminal organizations and legitimately chartered corporations, and are gradually assuming a measure of control and identity with national governments. Terrorist are improving their sophistication and abilities in virtually all aspects of their operations and support. The aggressive use of modern technology for information management, communications and intelligence has increased the efficiency of these activities. Weapons technology has become more increasingly available, and the purchasing power of terrorist organizations is on the rise. The ready availability of both techno logy and trained personnel to operate it for any client with sufficient capital allows the well - funded terrorist to equal or exceed the sophistication of governmental counter-measures. Likewise, due to the increase in information outlets and competition with increasing numbers of other messages, terrorism now requires a greatly increased amount of violence or novelty to attract the attention in now requires. The tendency of major media to compete for ratings and the subsequent revenue realized from increases in their audience size and share produces pressures on terrorists to increase the impact and violence of their actions to take advantage of the sensationalism terrorist violence requires.

Terrorism in the Albemarle Region

There has never been an act of Terrorism in Albemarle Region, however given the number of visitors to the many national sites/monuments in the region and the ability of terrorist to strike at will in most any area it is prudent for the communities in the Albemarle Region to recognize the terrorist threat. Built into several county Emergency Response Plans is the ability to respond to all hazards emergency situations. The Albemarle Regional hazard mitigation risk table includes terrorism as a potential hazard and this category includes mass casualties/active shooters and cyber security attacks to reflect the potential for internet viruses and other cyber threats to government computer systems and private sectors systems.

<u>Transportation (Bridge) and Transportation Infrastructure Impacts</u>

The loss of any bridge would be described as the physical interruption of travel on the roadway, either man-made or natural. The Albemarle Region contains several waters bodies that have bridge crossings, including the Albemarle Sound, the Croatan Sound, the Roanoke Sound, the Currituck Sound, Oregon Inlet, the Pasquotank River, the Perquimans River and the Chowan River. Access to the area is gained by crossing bridges making the loss of any bridge a potential economic disaster to the area. Identifying a bridge as a natural hazard may be misunderstood, but in terms of economic loss as described in the analysis determining what is considered as a disaster, the Mitigation Planning team felt this was representative.

Loss of Bridge Use in the Albemarle Region

The following events can be used to demonstrate this:

- The Croatan Sound Bridge was closed for approximately 10 weeks in 1986 due to a vessel striking the bridge and collapsing the navigation span.
- The Oregon Inlet Bridge was closed for approximately three weeks in 1988 when a section of the bridge collapsed due to maintenance problems.
- The Oregon Inlet Bridge was closed for six months in 1990 when a dredge collapsed a span in the bridge.
- In December 2013, the Oregon Inlet Bridge was closed for several weeks to allow emergency bridge piling work after NCDOT discovered extensive scouring had occurred around some of the bridge support pilings.

This category was expanded by the Albemarle Regional Hazard Mitigation Planning team to include transportation infrastructure and not just bridge closures. There have been several storm events on Hatteras Island that have resulted in the loss of sections of NC 12 Highway through Pea Island. A temporary steel bridge was installed after Hurricane Irene demolished sections of NC 12. The road was closed for several weeks until repairs could be made by NC 12 which included the construction of temporary steel bridge in a portion of the damaged highway. There are also several Ferry routes in the Region that are impacted during hazard events and the loss of these important transportation routes will similarly impact the local economy. These include the Knotts Island Ferry in Currituck County and the Hatteras Island Ferry in Dare County. Also included is the emergency ferry route between Stumpy Point and Hatteras Island that is used during emergency situations.

<u>Pandemic and Public Health Events</u>

According to the World Health Organization (WHO), a pandemic is an epidemic of infectious disease that spreads through populations across a large region; for instance a continent, or even the world. A pandemic can start when three conditions have been met:

- Emergence of a disease new to a population Agents infect humans, causing serious illness
- Agents infect humans, causing serious illness
- Agents spread easily and sustain ably among humans

A pandemic occurs when a new virus appears against which the human population has no immunity, resulting in epidemics world-wide with enormous numbers of deaths and illness. With the increase in global transport, as well as urbanization and overcrowded conditions, epidemics due to the new influenza virus are likely to quickly take hold around the world. If an influenza pandemic were to occur today, we could expect: The pandemic virus to spread rapidly due to the high level of global traffic. Vaccines, antiviral agents and antibiotics to treat secondary infections to be in short supply, with a period of several months before vaccine becomes available.

Medical facilities to be overwhelmed with demands to care for both influenza and non-influenza patients. Widespread illness to result in sudden and potentially significant shortages of personnel to provide essential community services. In the past, pandemics have resulted in increased morbidity and mortality and great social disruption. In the 20th century, the most severe pandemic occurred in 1918 and caused an estimated 40-50 million deaths worldwide. Current epidemiological models project that a pandemic could result in 2 to 7.4 million deaths globally.

In addition to pandemics, other public health events can occur. During the 2014 annul summary meeting of the Dare County Hazard Mitigation Planning Committee, it was noted that these events should be added to the list of hazards that may impact Dare County. Wide-spread contamination of public water supplies is one such example.

Pandemic and Public Health Events in the Albemarle Region

There have been no recorded Pandemics outbreaks or public health events in the Albemarle Region to date.

The table below shows the Hazard Identification and corresponding Hazard Index scores. In Bold are the most threatening natural hazards to Albemarle Region.

Table 4.13 HAZARDS RANKING

Hazard Type	Likelihood of Occurance (Highly Likely, Likely, Possible, Unlikely)	Intensity Rating (Relative Terms)	Impacts (Catostrophic, Critical, Limited, Negligible)	Conclusion Rank
Earthquake	Unlikely	Low	Negligible	2
Floods	**Highly Likely**	**High**	**Critical**	**5**
Hurricanes	**Highly Likely**	**High**	**Catostrophic**	**5**
Land Slides	Unlikely	Low	Negligible	1
Nor'Easters	**Highly Likely**	**High**	**Critical**	**4**
Thunderstorms	Highly Likely	Moderate	Negligible	2
Tornadoes	Possible	Moderate	Limited	3
Wildfires	Likely	Moderate	Limited	4
Winterstorms	Likely	Moderate	Limited	3
Dam/Levee Failure	Unlikely	Moderate	Limited	2
Tsunami	Unlikely	High	Critical	1
Erosion	**Highly Likely**	**Moderate**	**Critical**	**5**
Rip Currents	Highly Likely	High	Limited	3
Drought	Unlikely	Low	Negligible	1
Bridge Collapse	Possible	Moderate	Critical	3
Transportation Infrastructre Impacts	Possible	Moderate	Critical	3
Terrorism Event	Unlikely	Low	Negligible	1
Active Shooter/Mass Casualties	Possible	Moderate	Critical	3
Cyber Security Attacks	Likely	High	Critical	4
Pandemic Event	Unlikely	Moderate	Critical	1
Public Health Event	Possible	Moderate	Critical	2

Likelihood of Occurrence- estimates the likelihood of each type of hazard occurring in the Albemarle Region. Highly likely= near 100% probably in the next year. Likely = between 10 and 100% probability in the next 100 years. Possible=between 1and 10% probability in the next year, or at least one chance in the next 100 years. Less than 1% probability in the next year, or at least one chance in the next 100 years.

Intensity Rating- varying levels of potential intensity using relative terms.

Impacts- A combination of the severity of the event, its magnitude, and the density of human activity in the affected areas. Catastrophic= >50% magnitude, multiple deaths, complete shutdown of critical facilities for >30 days, >50% of property is severely damaged. Critical=25% to 50% magnitude, multiple sever injuries, complete shutdown of critical facilities for >13 days, >25% of property is severely damaged. Limited= 10% to 25% magnitude, some injuries, complete shutdown of critical facilities for> 7 days, > 10 % of property is severely damaged. Negligible=<10% magnitude, minor injuries, shutdown of critical facilities for < 24 hours, <10% of property is severely damaged.