Guilford County

Hazard Identification and Risk Assessment

2021

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ADMINISTRATIVE HANDLING INSTRUCTIONS

1. The title of this document is the *Guilford County Hazard Identification and Risk Assessment*.

2. The information outlined in this document is categorized as **Unclassified** and should be handled as a public document. This document may be distributed to the general public and placed on public access websites.

3. For more information, please consult Guilford County Emergency Management (GCEM):

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RECORD OF REVISIONS

To maintain the highest level of all-hazard preparedness, it is necessary to review and update this document on a regular basis. Guilford County Emergency Management is also responsible for incorporating all changes to the document. Such revisions will be prepared based upon an annual review process or as the result of incidents and events.

Date	Part Affected	Item Changed	Revised By

SECTION 1: INTRODUCTION

The *Hazard Identification and Risk Assessment* (HIRA) is a critical component of the planning processes in Guilford County. It contains assessments on the hazards in the county and the potential impact of the hazards should they occur. Findings from this document guide key emergency plans for the county which include the Emergency Operations Plan, Hazard Mitigation Plan, Recovery Framework, Continuity of Operations Plans, and Continuity of Government Plans, amongst others.

The 2021 HIRA update process was conducted as a part of the *2020 Guilford County Multi-Jurisdictional Hazard Mitigation Plan* update process. The information in this document was extracted from the Mitigation Plan itself in order to create a streamlined reference to the hazards identified in Guilford County and their associated risks. Through the mitigation planning process the Emergency Management Program was able to utilize the Hazard Mitigation Planning Team's expertise to aid in the hazard identification and risk assessment. A comprehensive description of the hazard identification and risk assessment process as a part of the overall hazard mitigation planning process can be found in the *2020 Guilford County Multi-Jurisdictional Hazard Mitigation Plan,* Section 2: Planning Process. The HIRA incorporates historical data using a broad range of sources to identify and evaluate hazards and their associated risks, and is designed to evaluate all hazard types to include natural, biological, technological, and man-made/intentional hazards.

To identify and evaluate which hazards are present in Guilford County, Section 2 of this document explains the evaluation process used for determining which of the initially identified hazards are considered significant enough to warrant further evaluation in the risk assessment. For each hazard considered, this section indicates whether or not the hazard was identified as a significant hazard to be further assessed, how this determination was made, and why this determination was made. Section 2 works to summarize not only those hazards that were identified (and why) but also those that were not identified (and why not).

In order to draw some meaningful planning conclusions on hazard risk for Guilford County, Section 3 explains in detail the hazard profiling process that was utilized to generate countywide hazard classifications according to a "Priority Risk Index" (PRI). The purpose of the PRI was to categorize and prioritize all potential hazards for Guilford County as high, moderate, or low risk. The summary hazard classifications generated through the use of the PRI allows for the prioritization of those high hazard risks for planning purposes. Based on the PRI process the top eight (high) hazards identified in Guilford County are as follows:

1. Winter Storm
2. Hurricane / Other Tropical Disturbance
3. Thunderstorm (Wind/Lightning)
4. Flooding
5. Hazardous Materials Incident

6. Tornado
7. Public Health / Emerging Disease Threat
8. Communications Systems Disruption / Failure

A comprehensive list of high, medium, and low risk hazards identified in Guilford County can be found in the Section 4 of this document.

Document Maintenance

The HIRA will be reviewed at the annual Hazard Mitigation Planning Team meeting and updated as warranted by any changes and new or outdated vulnerabilities or impacts. At a minimum, the HIRA will be updated every five years as a part of the Guilford County Multi-Jurisdictional Hazard Mitigation Plan update process. It is the responsibility of Guilford County Emergency Management to facilitate the HIRA review and revision process.

SECTION 2: HAZARD IDENTIFICATION

Guilford County is vulnerable to a wide range of natural, biological, technological, and man-made/intentional hazards that threaten life, property, and the environment. Upon a review of the full range of all-hazards, Guilford County has identified a number of hazards that are to be addressed in the HIRA. These hazards were identified through an extensive process that utilized input from the Guilford County Hazard Mitigation Planning Team members[1], research of past disaster declarations in the county, and review of the North Carolina State Hazard Mitigation Plan. Readily available information from reputable sources (such as federal and state agencies) were also evaluated to supplement information from these key sources. In addition, public survey data was used in the hazard identification and risk assessment portions of the HIRA process[2].

Table 2.1 lists the full range of hazards initially identified for inclusion in the HIRA and provides a brief description for each. This table includes 33 individual hazards. Some of these hazards are considered to be interrelated or cascading, but for preliminary hazard identification purposes these individual hazards are broken out separately.

Next, **Table 2.2** documents the evaluation process used for determining which of the initially identified hazards are considered significant enough to warrant 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 further assessed, how this determination was made, and why this determination was made. The final determinations were made by the Hazard Mitigation Planning Team based off of the perceived risk and vulnerability of people, property, the environment, and the Emergency Management Program's operations utilizing the evaluated data. The table works to summarize not only those hazards that were identified (and why) but also those that were not identified (and why not). Hazard events not identified for inclusion at this time may be addressed during future evaluations and updates of the risk assessment if deemed necessary by Emergency Management Program.

Lastly, **Table 2.3** provides a summary of the hazard identification and evaluation process noting that 26 of the 34 initially identified hazards are considered significant enough for further evaluation through this documents risk assessment (marked with a "☑").

Description of Hazards

TABLE 2.1: DESCRIPTIONS OF THE FULL RANGE OF INITIALLY IDENTIFIED HAZARDS

Hazard	Description
Natural Hazards	

[1] A description of the Hazard Mitigation Planning Team and their duties as it relates to the HIRA process can be found in Appendix A of this document.
[2] The public survey data utilized in the HIRA process can be found in Appendix B of this document.

Avalanche	A rapid fall or slide of a large mass of snow down a mountainside.
Drought	A prolonged period of less than normal precipitation such that the lack of water causes a serious hydrologic imbalance. Common effects of drought include crop failure, water supply shortages, and fish and wildlife mortality. High temperatures, high winds, and low humidity can worsen drought conditions and also make areas more susceptible to wildfire. Human demands and actions have the ability to hasten or mitigate drought-related impacts on local communities.
Earthquake	A sudden, rapid shaking of the Earth caused by the breaking and shifting of rock beneath the surface. This movement forces the gradual building and accumulation of energy. Eventually, strain becomes so great that the energy is abruptly released, causing the shaking at the earth's surface which we know as an earthquake. Roughly 90 percent of all earthquakes occur at the boundaries where plates meet, although it is possible for earthquakes to occur entirely within plates. 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.
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.
Expansive Soils	Soils that will exhibit some degree of volume change with variations in moisture conditions. The most important properties affecting degree of volume change in a soil are clay mineralogy and the aqueous environment. Expansive soils will exhibit expansion caused by the intake of water and, conversely, will exhibit contraction when moisture is removed by drying. Generally speaking, they often appear sticky when wet, and are characterized by surface cracks when dry. Expansive soils become a problem when structures are built upon them without taking proper design precautions into account with regard to soil type. Cracking in walls and floors can be minor, or can be severe enough for the home to be structurally unsafe.
Extreme Cold	Extreme cold is generally considered to occur when the temperature is at or below freezing for a period of time. Often these events are associated with winter storms and other winter weather, but extreme cold events can occur on their own. Dangers associated with extreme cold events include frostbite and hypothermia among other impacts to people and these events can often last for several days or weeks in a row.
Extreme Heat	A heat wave may occur when temperatures hover 10 degrees or more above the average high temperature for the region and last for several weeks. Humid or muggy conditions, which add to the discomfort of high temperatures, occur when a "dome" of high atmospheric pressure traps hazy, damp air near the ground. Excessively dry and hot conditions can provoke dust storms and low visibility. A heat wave combined with a drought can be very dangerous and have severe economic consequences on a community.

Fire/Wildfire	A wildfire is an uncontrolled fire burning in an area of vegetative fuels such as grasslands, brush, or woodlands. Heavier fuels with high continuity, steep slopes, high temperatures, low humidity, low rainfall, and high winds all work to increase risk for people and property located within wildfire hazard areas or along the urban/wildland interface. Wildfires are part of the natural management of forest ecosystems, but most are caused by 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. A structure fire is any fire in or on a building or other structure, even if the structure itself was not damaged. Mobile property used as a fixed structure, such as manufactured homes and portable buildings, are considered structures. These fires occur frequently in today's world and are often caused by humans within their homes or businesses.
Flooding	The accumulation of water within a water body which results in the overflow of excess water onto adjacent lands, usually floodplains. The floodplain is the land adjoining the channel of a river, stream ocean, lake or other watercourse or water body that is susceptible to flooding. Most floods fall into the following three categories: riverine flooding, coastal flooding, or shallow flooding (where shallow flooding refers to sheet flow, ponding and urban drainage).
Hail	Any storm that produces hailstones that fall to the ground; usually used when the amount or size of the hail is considered significant. Hail is formed when updrafts in thunderstorms carry raindrops into parts of the atmosphere where the temperatures are below freezing.
Hurricane/Other Tropical Disturbance	Hurricanes and tropical storms are classified as cyclones and defined as 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 with a diameter averaging 10 to 30 miles across. 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. When sustained winds reach or exceed 74 miles per hour the storm is deemed a hurricane. 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 majority of hurricanes and tropical storms form in the Atlantic Ocean, Caribbean Sea and Gulf of Mexico during the official Atlantic hurricane season, which extends from June through November.
Landslide	The movements of a mass of rock, debris, or earth down a slope when the force of gravity pulling down the slope exceeds the strength of the earth materials that comprise to hold it in place. Slopes greater than 10 degrees are more likely to slide, as are slopes where the height from the top of the slope to its toe is greater than 40 feet. Slopes are also more likely to fail if vegetative cover is low and/or soil water content is high.
Land Subsidence	The gradual settling or sudden sinking of the Earth's surface due to the subsurface movement of earth materials. Causes of land subsidence include groundwater pumpage, aquifer system compaction, drainage of organic soils, underground mining, hydrocompaction, natural compaction, sinkholes, and thawing permafrost.

Nor'easter	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.
Storm Surge	A storm surge is a large dome of water often 50 to 100 miles wide and rising anywhere from four to five feet in a Category 1 hurricane up to more than 30 feet in a Category 5 storm. Storm surge heights and associated waves are also dependent upon the shape of the offshore 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 arrives ahead of a storm's actual landfall and the more intense the hurricane is, the sooner the surge arrives. Storm surge can be devastating to coastal regions, causing severe beach erosion and property damage along the immediate coast. Further, water rise caused by storm surge can be very rapid, posing a serious threat to those who have not yet evacuated flood-prone areas.
Thunderstorm (Wind and Lightning)	Thunderstorms are caused by air masses of varying temperatures meeting in the atmosphere. Rapidly rising warm moist air fuels the formation of thunderstorms. Thunderstorms may occur singularly, in lines, or in clusters. They can move through an area very quickly or linger for several hours. Thunderstorms may result in hail, tornadoes, or straight-line winds. Windstorms pose a threat to lives, property, and vital utilities primarily due to the effects of flying debris and can down trees and power lines. 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, 73 people are killed each year by lightning strikes in the United States.
Tornado	A tornado is a violently rotating column of air that has contact with the ground and is often visible as a funnel cloud. Its vortex rotates cyclonically with wind speeds ranging from as low as 40 mph to as high as 300 mph. 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. The destruction caused by tornadoes ranges from light to catastrophic depending on the intensity, size and duration of the storm.

Tsunami	A series of waves generated by an undersea disturbance such as an earthquake. The speed of a tsunami traveling away from its source can range from up to 500 miles per hour in deep water to approximately 20 to 30 miles per hour in shallower areas near coastlines. Tsunamis differ from regular ocean waves in that their currents travel from the water surface all the way down to the sea floor. Wave amplitudes in deep water are typically less than one meter; they are often barely detectable to the human eye. However, as they approach shore, they slow in shallower water, basically causing the waves from behind to effectively "pile up", and wave heights to increase dramatically. As opposed to typical waves which crash at the shoreline, tsunamis bring with them a continuously flowing 'wall of water' with the potential to cause devastating damage in coastal areas located immediately along the shore.
Volcano	A mountain that opens downward to a reservoir of molten rock below the surface of the earth. While most mountains are created by forces pushing up the earth from below, volcanoes are different in that they are built up over time by an accumulation of their own eruptive products: lava, ash flows, and airborne ash and dust. Volcanoes erupt when pressure from gases and the molten rock beneath becomes strong enough to cause an explosion.
Winter Storm	Winter storms may include snow, sleet, freezing rain, or a mix of these wintry forms of precipitation. Blizzards, the most dangerous of all winter storms, combine low temperatures, heavy snowfall, and winds of at least 35 miles per hour, reducing visibility to only a few yards. Ice storms occur when moisture falls and freezes immediately upon impact on trees, power lines, communication towers, structures, roads and other hard surfaces. Winter storms and ice storms can down trees, cause widespread power outages, damage property, and cause fatalities and injuries to human life.
Biological Hazards	
Bioterrorism	Bioterrorism is defined by the Centers for Disease Control as an attack wherein there is a deliberate release of viruses, bacteria, or other germs (agents) used to cause illness or death in people, animals, or plants. These agents are typically found in nature, but it is possible that they could be changed to increase their ability to cause disease, make them resistant to current medicines, or to increase their ability to be spread into the environment.
Public Health/Emerging Disease Threat	Public health threats are often defined by an infectious disease that involves a biological agent/disease that may result in mass casualties or an outbreak of symptoms in those affected. Often emerging diseases are the greatest threat because they are new or varied iterations of existing threats and the population may not have built up a collective immunity to the disease.
Technological Hazards	

Building/Structure Collapse	According to the United States Department of Labor, a collapsed structure occurs when internal load bearing structural elements fail and the building collapses into itself with the exterior walls being pulled into the falling structure. This scenario may be caused by construction activity, an earthquake, or fire, and may result in a dense debris field with a small footprint. Alternatively, if the structural failure is caused by an explosion or natural forces such as weather, the building may collapse in an outward direction, resulting in a less dense and more scattered debris field.
Communications Systems Disruption/Failure	The failure or disruption of communications systems occurs when emergency response personnel or government officials are unable to utilize their existing communications equipment due to overload of the system or impacts from a hazard. These events can have a critical impact because they may result in lengthened response times and cause miscommunication among responders, resulting in additional impacts that may otherwise have been avoided.
Energy/Power/Utility Failure	Energy/power/utility failures often occur hand in hand with other hazards and are often caused by rising flood waters or high winds. These events most commonly occur when wind events knock down power lines or water treatment plants are flooded by rising waters, thereby shutting down these utilities. The impacts from these failures are often widespread and can affect thousands of people even when small areas of this infrastructure is affected.
Hazardous Materials Incident	Hazardous material (HAZMAT) incidents can apply to fixed facilities as well as mobile, transportation-related accidents in the air, by rail, on the nation's highways and on the water. HAZMAT incidents consist of solid, liquid and/or gaseous contaminants that are released from fixed or mobile containers, whether by accident or by design as with an intentional terrorist attack. A HAZMAT incident can last hours to days, while some chemicals can be corrosive or otherwise damaging over longer periods of time. In addition to the primary release, explosions and/or fires can result from a release, and contaminants can be extended beyond the initial area by persons, vehicles, water, wind and possibly wildlife as well.
Nuclear Power Plant Emergency	A nuclear and radiation accident is defined by the International Atomic Energy Agency as "an event that has led to significant consequences to people, the environment or the facility. Often, this type of incident results from damage to the reactor core of a nuclear power plant which can release radioactivity into the environment. The degree of exposure from nuclear accidents has varied from serious to catastrophic.
Pipeline Failure	In the case of this plan, a pipeline incident generally refers to a spill, explosion, or fire caused in the transport of flammable liquid or gas being carried by fixed pipes across the United States. These pipes often carry petroleum-based products that are dangerous to health and safety of people as well as the environment if exposed in large quantities.
Resource Shortage (Water/Fuel)	A resource shortage occurs whenever supplies of a resource have been depleted to the point that there is very little to none of the resource available to the public. Most commonly resource shortages occur when there has been a steady decrease in the amount of available resource over time, but these shortages can also be the result of a major event that quickly reduces supply.

Transportation Incident	Transportation incidents come in many forms in the United States, especially given the many forms of transportation available today. The most common types of transportation incidents are motor vehicle accidents, but plane, train, and watercraft accidents occur as well and often have higher magnitude impacts.
Man-Made/Intentional Hazards	
Civil Disturbance	Public unrest has been evident in society from the earliest recordings of civilization. Most of these disturbances have been related to political or social issues. Insurrection has framed much of history, dictating the governance and progression of society. In recent years, most of the publicized disturbances have been protests and riots. Rioting does not occur very often in the United States; however, marches and protests are common and could subsequently lead to riots.
Cyber Terrorism	Cyber terrorism is a deliberate attack on an individual or group using the internet. In the past few decades, society has become dependent on computers and internet connections for much of daily life. This dependence has opened up the avenue for crime to be committed from afar, often from a different country. Some common examples of cyber terrorism include a hacker accessing bank accounts by hacking into a bank's website, infecting a computer system with a virus, Trojan horse, or worm to inflict damage to the information in the system, or disseminating incorrect or otherwise flawed information, also called "misinformation." Also, denial-of-service attacks could occur against prominent websites, which prevent legitimate users from accessing information or services
Terrorism	Terrorism is defined by FEMA as, "the use of force or violence against persons or property in violation of the criminal laws of the United States for purposes of intimidation, coercion, or ransom." Terrorist acts may include assassinations, kidnappings, hijackings, bomb scares and bombings, cyber-attacks (computer-based), and the use of chemical, biological, nuclear and radiological weapons.

Hazard Evaluation

TABLE 2.2: DOCUMENTATION OF THE HAZARD EVALUATION PROCESS

Hazards Considered	Addressed in the HIRA?	How was this determination made?	Why was this determination made?
Natural Hazards			
Avalanche	NO	• Review of FEMA's Multi-Hazard Identification and Risk Assessment • Review of the NC State Hazard Mitigation Plan • Review of the previous Guilford County hazard mitigation plan • Review of US Forest Service National Avalanche Center website	• The United States avalanche hazard is limited to mountainous western states including Alaska, as well as some areas of low risk in New England. • Avalanche hazard was removed from the North Carolina State Hazard Mitigation Plan after determining the mountain elevation in Western North Carolina did have enough snow to produce this hazard. • Avalanche is not included in the previous Guilford County hazard mitigation plan. • There is no risk of avalanche events in North Carolina.
Drought	YES	• Review of FEMA's Multi-Hazard Identification and Risk Assessment • Review of the NC State Hazard Mitigation Plan • Review of the previous Guilford County hazard mitigation plan • Review of the US Drought Monitor website	• Drought is a normal part of virtually all climatic regimes, including areas with high and low average rainfall. • Droughts are discussed in NC State Hazard Mitigation Plan as a threat to Guilford County. • Drought is included in the previous Guilford County hazard mitigation plan. • There are reports of moderate to extreme drought conditions in 15 of the last 19 years in Guilford County, according to the US Drought Monitor.

Earthquake	YES	• Review of FEMA's Multi-Hazard Identification and Risk Assessment • Review of NC State Hazard Mitigation Plan • Review of the previous Guilford County hazard mitigation plan • USGS Earthquake Hazards Program website	• Although the zone of greatest seismic activity in the United States is along the Pacific Coast, eastern regions have experienced significant earthquakes. • Earthquake events are discussed in the NC State Hazard Mitigation Plan and Guilford County is considered to be at low to moderate risk to an earthquake event. • Earthquake was included in the previous Guilford County hazard mitigation plan. • Earthquakes have occurred in and around the State of North Carolina in the past. The state is affected by the Charleston and the New Madrid (near Missouri) Fault lines which have generated a magnitude 8.0 earthquake in the last 200 years. • According to USGS seismic hazard maps, the peak ground acceleration (PGA) with a 10% probability of exceedance in 50 years for Guilford County is approximately 2 to 5%g. FEMA recommends that earthquakes be further evaluated for mitigation purposes in areas with a PGA of 3%g or more.
Erosion	NO	• Review of NC State Hazard Mitigation Plan • Review of the previous Guilford County hazard mitigation plan	• Coastal erosion is discussed in the NC State Hazard Mitigation Plan but only for coastal areas. Guilford County is not located in a coastal area. • Erosion is not included as a hazard in the previous Guilford County hazard mitigation plan. • Riverine erosion remains a natural, dynamic, and continuous process that has the potential to affect Guilford County since several rivers/streams run through the county. But, upon evaluation, this did not warrant inclusion for further hazard evaluation.

Expansive Soils	NO	• Review of FEMA's Multi-Hazard Identification and Risk Assessment • Review of NC State Hazard Mitigation Plan • Review of the previous Guilford County hazard mitigation plan • Review of USDA Soil Conservation Service's Soil Survey	• The effects of expansive soils are most prevalent in parts of the Southern, Central, and Western U.S. • Expansive soils are not specifically identified in the NC State Hazard Mitigation Plan. • Guilford County is located in an area that has little to no clay swelling potential. • The previous Guilford County Hazard Mitigation Plan did not identify expansive soils as a potential hazard.
Extreme Cold	YES	• Review of FEMA's Multi-Hazard Identification and Risk Assessment • Review of the North Carolina State Hazard Mitigation Plan • Review of the previous Guilford County hazard mitigation plan • Review of NOAA NCEI Storm Events Database	• Many areas of the United States are susceptible to extreme cold, including North Carolina. • Extreme cold was included in the previous Guilford County hazard mitigation plan under the extreme temperatures hazard. • The county has experienced extreme cold events a number of times in the past.
Extreme Heat	YES	• Review of FEMA's Multi-Hazard Identification and Risk Assessment • Review of the North Carolina State Hazard Mitigation Plan • Review of the previous Guilford County hazard mitigation plan • Review of NOAA NCEI Storm Events Database	• Many areas of the United States are susceptible to heat waves, including North Carolina. • Extreme heat was included in the previous Guilford County hazard mitigation plan under the extreme temperatures hazard. • The county has experienced extreme heat events a number of times in the past.

Fire/Wildfire	YES	• Review of FEMA's Multi-Hazard Identification and Risk Assessment • Review of NC State Hazard Mitigation Plan • Review of the previous Guilford County hazard mitigation plan • Review of Southern Wildfire Risk Assessment (SWRA) Data • Review of the NC Division of Forest Resources website	• Wildfires occur in virtually all parts of the United States. Wildfire hazard risks will increase as low-density development along the urban/wildland interface increases. • Wildfires are discussed in the state plan, though Guilford County, is located in an area with relatively lower risk compared to other parts of the state. • The previous Guilford County hazard mitigation plan addressed wildfire. • A review of SWRA data indicates that there are some areas of elevated concern in Guilford County. • According to the North Carolina Forest Service,over the period of 2010-2019, Guilford County experienced an average of 65 fires each year which burned an average of 40.0 acres each year. • Structure fires happen across the United States in all areas of the country and can impact any building. Many structure fires have occurred in Guilford County historically.
Flood	YES	• Review of FEMA's Multi-Hazard Identification and Risk Assessment • Review of NC State Hazard Mitigation Plan • Review of the previous Guilford County hazard mitigation plan • Review of NOAA NCEI Storm Events Database • Review of historical disaster declarations • Review of FEMA's NFIP Community Status Book and Community Rating System (CRS)	• Floods occur in all 50 states and in the U.S. territories. • The flood hazard is thoroughly discussed in the NC State Hazard Mitigation Plan. Much like a majority of the state, Guilford County was found to have vulnerability to flooding. • The previous Guilford County hazard mitigation plan addresses flood hazard. • NCEI reports that Guilford County has been affected by 92 flood events since 1996. In total, these events caused 1 death and an estimated $18.8 million (2019 dollars) in property damages. • None of the county's Presidential Disaster Declarations were specifically flood-related; however, several declarations were hurricane-related which caused flooding issues. • All jurisdictions in the county participate in the NFIP and Guilford County (unincorporated area) and the City of Greensboro also participate in the CRS.

Hail	YES	• Review of FEMA's Multi-Hazard Identification and Risk Assessment • Review of NC State Hazard Mitigation Plan • Review of the previous Guilford County hazard mitigation plan • Review of NOAA NCEI Storm Events Database	• Although hailstorms occur primarily in the Midwestern states, they do occur in every state on the mainland U.S. Most inland regions experience hailstorms at least two or more days each year. • Hailstorm events are discussed in the NC State Hazard Mitigation Plan under the Tornadoes/Thunderstorms. • Hail is included in the previous Guilford County hazard mitigation plan. • NCEI reports 177 hailstorm events (0.75 to 2.75 inch size hail) for Guilford County since 1950.
Hurricane and Tropical Storm	YES	• Review of FEMA's Multi-Hazard Identification and Risk Assessment • Review of NC State Hazard Mitigation Plan • Review of the previous Guilford County hazard mitigation plan • Analysis of NOAA historical tropical cyclone tracks and National Hurricane Center Website • Review of NOAA NCEI Storm Events Database • Review of historical presidential disaster declarations	• The Atlantic and Gulf regions are most prone to landfall by hurricanes and tropical storms. • Hurricane and tropical storm events are discussed in the NC State Hazard Mitigation Plan and are listed as a hazard that can affect any area of the state. • Hurricanes and tropical weather were addressed in the previous Guilford County hazard mitigation plan. • NOAA historical records indicate 58 hurricanes/tropical storms have come within 75 miles of Guilford County since 1850. • NCEI reports 4 hurricane events since 1996 for Guilford County. • Numerous disaster declarations in Guilford County were directly related to hurricane events.

Landslide	NO	• Review of FEMA's Multi-Hazard Identification and Risk Assessment • Review of NC State Hazard Mitigation Plan • Review of the previous Guilford County hazard mitigation plan • Review of USGS Landslide Incidence and Susceptibility Hazard Map • Review of the North Carolina Geological Survey database of historic landslides	• Landslides occur in every state in the U.S, and they are most common in the coastal ranges of California, the Colorado Plateau, the Rocky Mountains, and the Appalachian Mountains. • Landslide/debris flow events are discussed in the state plan, but Guilford County does not have much risk. • The previous Guilford County hazard mitigation plan did not address landslides. • USGS landslide hazard maps indicate that a moderate incidence rate is found across the northwestern half of the county. • Data provided by NCGS indicate there are no recorded landslide events in the Guilford County.
Land Subsidence	NO	• Review of FEMA's Multi-Hazard Identification and Risk Assessment • Review of NC State Hazard Mitigation Plan • Review of the previous Guilford County hazard mitigation plan	• Land subsidence affects at least 45 states, including North Carolina. However, because of the broad range of causes and impacts, there has been limited national focus on this hazard. • The state plan identifies certain areas that are susceptible to land subsidence hazards in North Carolina; however Guilford County does not have soil types that are highly susceptible to subsidence. • The previous Guilford County hazard mitigation plan did not identify land subsidence as a potential hazard.
Nor'easter	NO	• Review of NC State Hazard Mitigation Plan • Review of the previous Guilford County hazard mitigation plan • Review of NOAA NCEI Storm Events Database	• Nor'easters are not identified as a hazard in the state plan. • Nor'easters were not identified in the previous Guilford County hazard mitigation plan. • NCEI does not report any nor'easter activity for Guilford County. However, nor'easters may have affected the area as severe winter storms. In this case, the activity would be reported under winter storm events.

Storm Surge	NO	• Review of FEMA's Multi-Hazard Identification and Risk Assessment • Review of NC State Hazard Mitigation Plan • Review of the previous Guilford County hazard mitigation plan • Review of NOAA NCEI Storm Events Database	• Given the inland location of Guilford County, storm surge would not affect the area. • Storm surge is discussed in the NC State Hazard Mitigation Plan under the hurricane hazard and Guilford County does not have any vulnerability to storm surge. • The previous Guilford County hazard mitigation plan did not address storm surge. • No historical events were reported by NCEI.
Thunderstorm (Wind and Lightning)	YES	• Review of FEMA's Multi-Hazard Identification and Risk Assessment • Review of NC State Hazard Mitigation Plan • Review of the previous Guilford County hazard mitigation plan • Review of NOAA NCEI Storm Events Database • Review of Vaisala's NLDN Lightning Flash Density Map	• Severe thunderstorm events were addressed in the previous Guilford County hazard mitigation plan. • NCEI reports 311 thunderstorm/high wind events in Guilford County since 1950. These events have resulted $2.6 million (2019 dollars) in property damage. • The central region of the Florida has the highest density of lightning strikes in the mainland U.S.; however, lightning events are experienced in nearly every region. • Lightning events are discussed in the NC State Hazard Mitigation Plan as part of the tornade/thunderstorm hazard. • Lightning is included in the previous Guilford County hazard mitigation plan. • According to Vaisala's U.S. National Lightning Detection Network, Guilford County is located in an area that experienced an average of 6 to 12 lightning flashes per square mile per year.

Tornado	YES	• Review of FEMA's Multi-Hazard Identification and Risk Assessment • Review of NC State Hazard Mitigation Plan • Review of the previous Guilford County hazard mitigation plan • Review of NOAA NCEI Storm Events Database • Review of historical presidential disaster declarations	• Tornado events are discussed in the NC State Hazard Mitigation Plan. Since there is risk of tornadoes across the state, Guilford County is at risk. • Tornado events were addressed in the previous Guilford County hazard mitigation plan. • NCEI reports 15 tornado events in Guilford County since 1950. These events have resulted in $87.9 million (2019 dollars) in property damage with the most severe being an EF3. • Two of the county's disaster declarations were directly related to tornadoes.
Tsunami	NO	• Review of FEMA's Multi-Hazard Identification and Risk Assessment • Review of NC State Hazard Mitigation Plan • Review of the previous Guilford County hazard mitigation plan • Review of FEMA "How-to" mitigation planning guidance (Publication 386-2, "Understanding Your Risks – Identifying Hazards and Estimating Losses).	• No record exists of a catastrophic Atlantic basin tsunami impacting the mid-Atlantic coast of the United States. • Tsunami inundation zone maps are not available for communities located along the U.S. East Coast. • Tsunamis are not identified as a hazard in the state plan and Guilford County is not as coastal community so has no tsunami hazard risk. • The previous Guilford County hazard mitigation plan did not address tsunamis. • FEMA mitigation planning guidance suggests that locations along the U.S. East Coast have a relatively low tsunami risk.
Volcano	NO	• Review of FEMA's Multi-Hazard Identification and Risk Assessment • Review of NC State Hazard Mitigation Plan • Review of USGS Volcano Hazards Program website	• More than 65 potentially active volcanoes exist in the United States and most are located in Alaska. The Western states and Hawaii are also potentially affected by volcanic hazards. • There are no active volcanoes in North Carolina. • There has not been a volcanic eruption in North Carolina in over 1 million years. • No volcanoes are located near Guilford County.

Winter Storm and Freeze	YES	• Review of FEMA's Multi-Hazard Identification and Risk Assessment • Review of NC State Hazard Mitigation Plan • Review of the previous Guilford County hazard mitigation plan • Review of NOAA NCEI Storm Events Database • Review of historical presidential disaster declarations	• Winter storms affect every state in the continental U.S. and Alaska. • Severe winter storms, including snow storms and ice storms, are discussed in the NC State Hazard Mitigation Plan and can affect all areas of the state. • Winter snow and ice storm events were addressed in the previous Guilford County hazard mitigation plan. • NCEI reports that Guilford County has been affected by 69 snow and ice events since 1996. These events resulted in $9.4 million (2019 dollars) in damages. • Seven of the county's declarations were directly related to winter storm events.
Biological Hazards			
Bioterrorism	YES	• Review of FEMA's Multi-Hazard Identification and Risk Assessment • Review of the Guilford County HIRA • Discussions with local officials	• The previous Guilford County hazard mitigation plan included bioterrorism and it is a hazard addressed in the County's Hazard Identification and Risk Assessment document. • There have been no major bioterrorism events in the county, however, these kinds of events are often unpredictable and Guilford County could be affected.
Public Health/Emerging Disease Threat	YES	• Review of FEMA's Multi-Hazard Identification and Risk Assessment • Review of the Guilford County HIRA • Discussions with local officials	• The previous Guilford County hazard mitigation plan included public health/emerging disease threat and it is a hazard addressed in the County's Hazard Identification and Risk Assessment document. • Public health emergencies are often unpredictable and can ramp up quickly depending on how quickly they are recognized. These threats will potentially impact the county in the future.

Technological Hazards			
Building/Structure Collapse	YES	• Review of FEMA's Multi-Hazard Identification and Risk Assessment • Review of the Guilford County HIRA • Discussions with local officials	• The previous Guilford County hazard mitigation plan included building/structure collapse and it is a hazard addressed in the County's Hazard Identification and Risk Assessment document. • Building/structure collapse is a hazard that often happens on a very localized level, but the impacts can be severe and could potentially occur anywhere.
Communications Systems Disruption/Failure	YES	• Review of FEMA's Multi-Hazard Identification and Risk Assessment • Review of the Guilford County HIRA • Discussions with local officials	• The previous Guilford County hazard mitigation plan included communications systems disruption/failure and it is a hazard addressed in the County's Hazard Identification and Risk Assessment document. • Communications systems disruptions can happen in any location throughout the United States and throughout the county.
Energy/Power/Utility Failure	YES	• Review of FEMA's Multi-Hazard Identification and Risk Assessment • Review of the Guilford County HIRA • Discussions with local officials	• The previous Guilford County hazard mitigation plan included energy/power/utility failure and it is a hazard addressed in the County's Hazard Identification and Risk Assessment document. • Energy/Power/Utility failures occur frequently in the county, especially during winter storms or high wind events. These will continue to impact the county going forward.

Hazardous Materials Incident	YES	• Review of FEMA's Multi-Hazard Identification and Risk Assessment • Review of the Guilford County HIRA • Review Facility Registry Service Data • Review of USDOT Pipeline and Hazardous Materials Safety Administration (PHMSA) incident database	• Cities, counties, and towns where hazardous materials fabrication, processing, and storage sites are located, and those where hazardous waste treatment, storage or disposal facilities operate are at risk for hazardous materials events. • The previous Guilford County hazard mitigation plan included hazardous materials incidents and it is a hazard addressed in the County's Hazard Identification and Risk Assessment document. • Fifty PHMSA-reported HAZMAT incidents in the county were classified as "serious" incidents. In total, these incidents have resulted in over $2.9 million (2019 dollars) in property damages.
Nuclear Power Plant Emergency	YES	• Review of IAEA data on the location of nuclear reactors • Review of the Guilford County HIRA • Discussion with local officials about location of nuclear power stations • Discussions with local officials	• The Shearon Harris Nuclear Power Plant is located within 50 miles of the southeastern corner of Guilford County. • The previous Guilford County hazard mitigation plan included nuclear power plant emergency and it is a hazard addressed in the County's Hazard Identification and Risk Assessment document. • A nuclear accident is unlikely to occur, but could cause severe damage in the event of a major incident.
Pipeline Failure	YES	• Review of FEMA's Multi-Hazard Identification and Risk Assessment • Review of the Guilford County HIRA • Discussions with local officials	• The previous Guilford County hazard mitigation plan included pipeline failure and it is a hazard addressed in the County's Hazard Identification and Risk Assessment document. • There have been several pipeline failures that occurred within the county,including two in 1978 on a line leading eastward from Greensboro's tank farm and one caused by digging near Lake Brandt in 1987.

Resource Shortage (Water/Fuel)	YES	• Review of FEMA's Multi-Hazard Identification and Risk Assessment • Review of the Guilford County HIRA • Discussions with local officials	• The previous Guilford County hazard mitigation plan included resource shortage and it is a hazard addressed in the County's Hazard Identification and Risk Assessment document. • Resource shortages of both fuel and water have occurred in the county in the past and are likely to occur again in the future.
Transportation Incident	YES	• Review of FEMA's Multi-Hazard Identification and Risk Assessment • Review of the Guilford County HIRA • Discussions with local officials	• The previous Guilford County hazard mitigation plan inlcuded transportation incident and it is a hazard addressed in the County's Hazard Identification and Risk Assessment document. • Given the number of transportation corridors and hubs located within Guilford County, it is highly likely that more transportation incidents will occur in the future.
Man-Made/Intentional Hazards			
Civil Disturbance	YES	• Review of FEMA's Multi-Hazard Identification and Risk Assessment • Review of the Guilford County HIRA • Discussions with local officials	• The previous Guilford County hazard mitigation plan included civil disturbance and it is a hazard addressed in the County's Hazard Identification and Risk Assessment document. • Although there have not been any major civil disturbances in the county in many years, there is some possibility that this could impact the county in the future.
Cyber-Security Threat	YES	• Review of FEMA's Multi-Hazard Identification and Risk Assessment • Review of the Guilford County HIRA • Discussions with local officials	• The previous Guilford County hazard mitigation plan included cyber security threats and it is a hazard addressed in the County's Hazard Identification and Risk Assessment document. • Cyber security threats that can occur without regard to specific location, so it was evaluated in this plan.

Terrorism	YES	• Review of the Guilford County HIRA • Review of local official knowledge • Discussions with local officials	• The previous Guilford County hazard mitigation plan included terrorism and it is a hazard addressed in the County's Hazard Identification and Risk Assessment document. • There are several high profiles targets in the area that caused the planning team to determine that the hazard should be evaluated further.

Hazard Identification Results

TABLE 2.3: SUMMARY RESULTS OF THE HAZARD IDENTIFICATION AND EVALUATION PROCESS

NATURAL HAZARDS	BIOLOGICAL HAZARDS
☐ Avalanche	☑ Bioterrorism
☑ Drought	**TECHNOLOGICAL HAZARDS**
☑ Earthquake	☑ Building/Structure Collapse
☐ Erosion	☑ Communications Systems Disruption/Failure
☐ Expansive Soils	☑ Energy/Power/Utility Failure
☑ Extreme Cold	☑ Hazardous Materials Incident
☑ Extreme Heat	☑ Nuclear Power Plant Emergency
☑ Fire	☑ Pipeline Failure
☑ Flooding	☑ Resource Shortage (Water/Fuel)
☑ Hail	☑ Transportation Incident
☑ Hurricane/Other Tropical Disturbance	**MAN-MADE/INTENTIONAL HAZARDS**
☐ Landslide	☑ Civil Disturbance
☐ Land Subsidence	☑ Cyber-Security Threat
☐ Nor'easter	☑ Terrorism
☐ Storm Surge	
☑ Thunderstorm (Wind and Lightning)	
☑ Tornado	
☐ Tsunami	
☐ Volcano	
☑ Winter Storm	

☑ = Hazard considered significant enough for further evaluation in the Guilford County hazard risk assessment.

SECTION 3: RISK ASSESSMENT

Overview

This section includes detailed hazard profiles for each of the hazards identified in the previous section (*Hazard Identification*) as significant enough for further evaluation. Each hazard profile includes a general description of the hazard, its location and extent, notable historical occurrences, the probability of future occurrences, and a consequence analysis. Each profile also includes specific items noted by members of the Guilford County Hazard Mitigation Planning Team as it relates to unique historical or anecdotal hazard information for Guilford County or a participating municipality within it.

The following hazards were identified:

- **Natural**
  - Drought
  - Earthquake
  - Extreme Cold
  - Extreme Heat
  - Fire/Wildfire
  - Flooding
  - Hail
  - Hurricane / Other Tropical Disturbance
  - Thunderstorm (wind and lightning)
  - Tornado
  - Winter Storm
- **Biological**
  - Bioterrorism
  - Public Health / Emergency Disease Threat
- **Technological**
  - Building / Structure Collapse
  - Communications Systems Disruption / Failure
  - Energy / Power / Utility Failure
  - Hazardous Materials Incident
  - Nuclear Power Plant Emergency
  - Pipeline Failure
  - Resource Shortage (Water / Fuel)
  - Transportation Incident
- **Man-Made / Intentional**
  - Civil Disturbance
  - Cyber-Security Threat
  - Terrorism

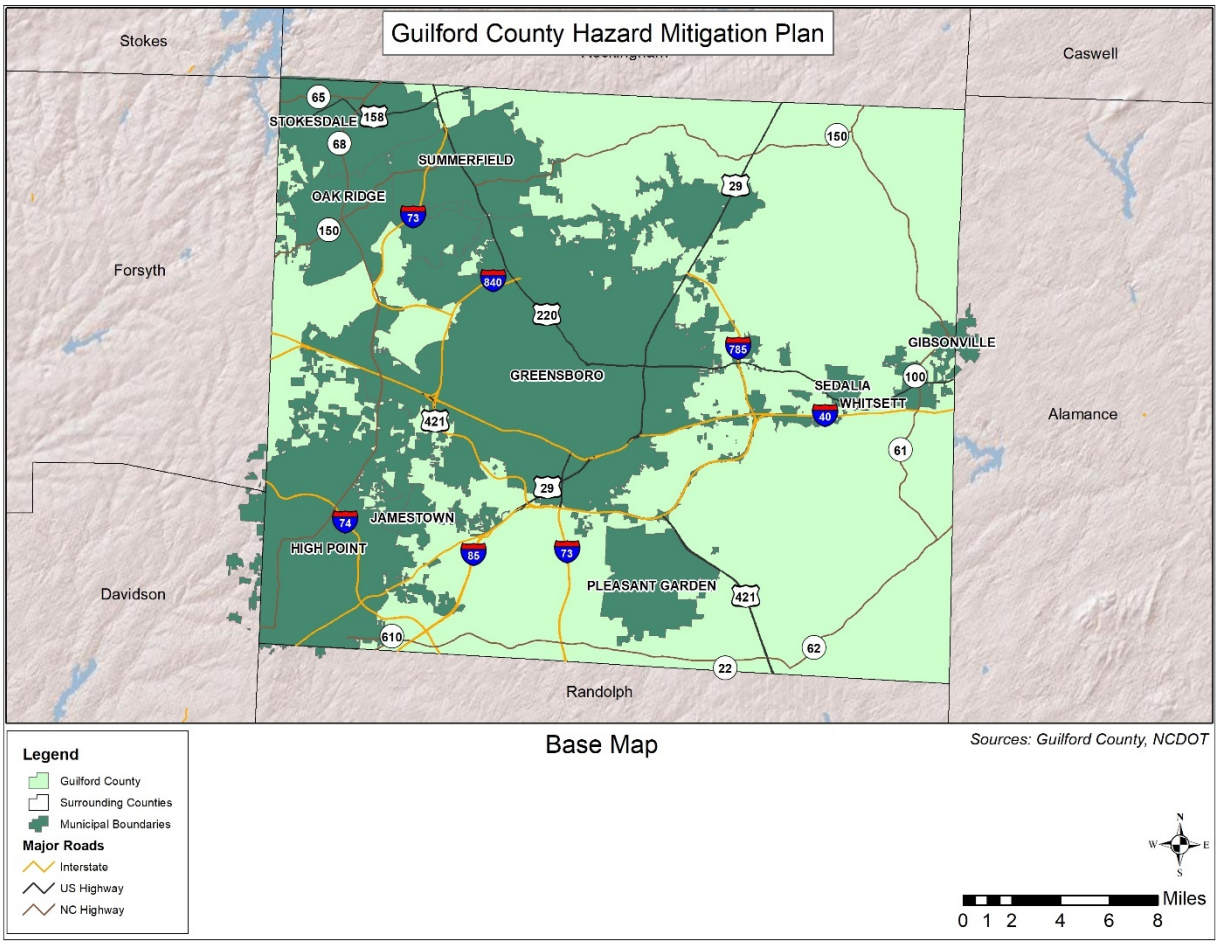
Study Area

Guilford County includes 10 municipalities: Gibsonville, Greensboro, High Point, Jamestown, Oak Ridge, Pleasant Garden, Sedalia, Stokesdale, Summerfield, and Whitsett. **Table 3.1** provides a summary table of the municipal jurisdictions. In addition, **Figure 3.1** provides a base map, for reference, of Guilford County.

TABLE 3.1: STUDY AREA JURISDICTIONS

Guilford County	
Gibsonville	Pleasant Garden
Greensboro	Sedalia
High Point	Stokesdale
Jamestown	Summerfield
Oak Ridge	Whitsett

FIGURE 3.1: GUILFORD COUNTY BASE MAP



Hazard Profile Methodology

The hazard profiles presented in this section were developed using best available data and result in what may be considered principally a qualitative assessment as recommended by FEMA in its "How-to" guidance document titled *Understanding Your Risks: Identifying Hazards and Estimating Losses* (FEMA Publication 386-2). It relies heavily on historical and anecdotal data, stakeholder input, and professional and experienced judgment regarding observed and/or

anticipated hazard impacts. It also carefully considers the findings in other relevant plans, studies, and technical reports.

Special Considerations

Climate Adaptation

The *Piedmont Together Climate Adaptation Report* is a climate adaptability report that has been developed for the Piedmont Triad Region (including Guilford County) and is based upon a wealth of information and data analysis.[3] Much of the data indicates that the primary factor in altering the global climate is greenhouse gas emissions from human activities. Guilford County appears to be fundamentally changing due to climate change which has resulted in more violent thunderstorms, higher temperatures, increased drought risk, greater winter precipitation, and more intense hurricanes. These changes are expected to continue in the foreseeable future for the county and the region. Primary public health concerns as a result of climate change impacts in the Piedmont Triad include impacts of the urban heat island effect upon city residents and outdoor workers, impacts to rural workers (primarily farmworkers), health of elderly in both rural an urban communities, and impacts to local ecosystems.

Compared to other regions of the nation and world, the impacts of climate change on Guilford County may less dramatically alter lifestyles and the environment from today's "normal," but there will be fundamental changes to the Piedmont Triad which are discussed (where applicable) in the hazard profiles found in this section.

Special Events

Guilford County hosts numerous special events throughout the year that draws in large crowds from across the world. During these events, the population in Guilford County has the potential to increase exponentially, which can increase the degree of impact a disaster has on the community. For example, special event attendees are more susceptible to natural hazards for the fact that countless special events are held outdoors where severe weather sheltering areas are limited. In addition, some special events increase the potential of certain hazards. Political events and gatherings for specific causes for example can be targets for man-made/intentional activity.

Natural Hazards

Drought

Background

Drought is a normal part of virtually all climatic regions, including areas with high and low average rainfall. Drought is the consequence of a natural reduction in the amount of precipitation expected over an extended period of time, usually a season or more in length. High temperatures,

[3] https://www.ptrc.org/Home/ShowDocument?id=7238

high winds, and low humidity can exacerbate drought conditions. In addition, human actions and demands for water resources can hasten drought-related impacts. Drought may also lead to more severe wildfires.

Droughts are typically classified into one of four types: 1) meteorological, 2) hydrologic, 3) agricultural, or 4) socioeconomic. **Table 3.2** presents definitions for these types of drought.

TABLE 3.2 DROUGHT CLASSIFICATION DEFINITIONS

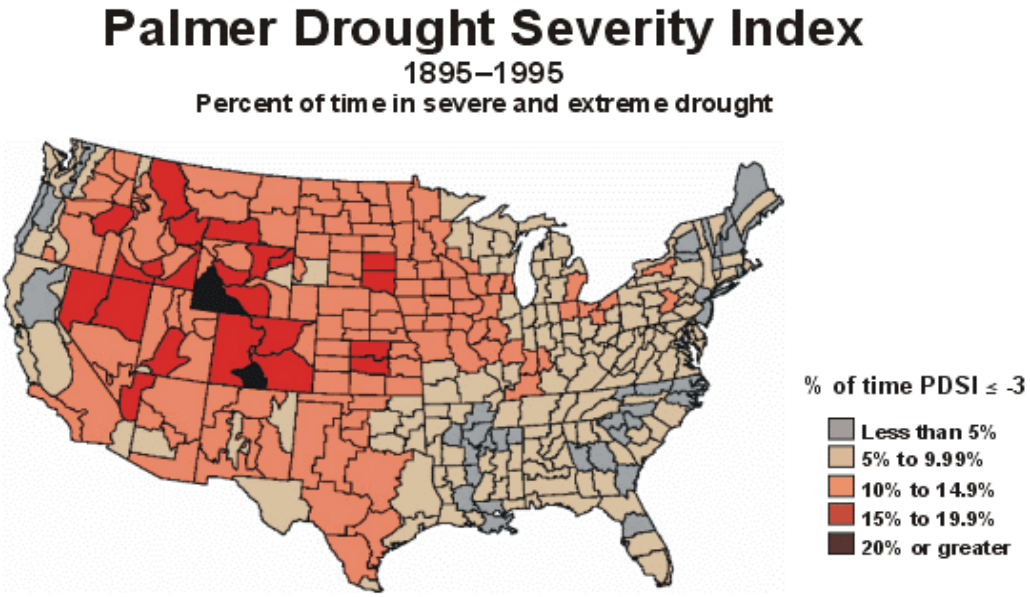
Meteorological Drought	The degree of dryness or departure of actual precipitation from an expected average or normal amount based on monthly, seasonal, or annual time scales.
Hydrologic Drought	The effects of precipitation shortfalls on stream flows and reservoir, lake, and groundwater levels.
Agricultural Drought	Soil moisture deficiencies relative to water demands of plant life, usually crops.
Socioeconomic Drought	The effect of demands for water exceeding the supply as a result of a weather-related supply shortfall.

Source: Multi-Hazard Identification and Risk Assessment: A Cornerstone of the National Mitigation Strategy, FEMA

Droughts are slow-onset hazards, but, over time, can have very damaging affects to crops, municipal water supplies, recreational uses, and wildlife. If drought conditions extend over a number of years, the direct and indirect economic impact can be significant.

The Palmer Drought Severity Index (PDSI) is based on observed drought conditions and range from -0.5 (incipient dry spell) to -4.0 (extreme drought). Evident in **Figure 3.2**, the Palmer Drought Severity Index Summary Map for the United Stated, drought affects most areas of the United States, but is less severe in the Eastern United States.

FIGURE 3.2: PALMER DROUGHT SEVERITY INDEX SUMMARY MAP FOR THE UNITED STATES



Source: National Drought Mitigation Center

Location and Spatial Extent

Drought typically covers a large area and cannot be confined to any geographic or political boundaries. According to the Palmer Drought Severity Index, North Central North Carolina has a relatively low risk for drought hazard. However, local areas may experience much more severe and/or frequent drought events than what is represented on the Palmer Drought Severity Index map. Furthermore, it is assumed that Guilford County would be uniformly exposed to drought, making the spatial extent potentially widespread. It is also notable that drought conditions typically do not cause significant damage to the built environment.

Historical Occurrences

The United States Drought Monitor reports data on North Carolina drought conditions from 2000 to 2019. It classifies drought by county on a scale of D0 to D4 where: . The North Carolina State Climate Office reports PDSI data for North Carolina from 2000 to 2013. It classifies drought conditions by region on a scale of -6.00 to 6.00 where:

- D0: Abnormally Dry
- D1: Moderate Drought
- D2: Severe Drought
- D3: Extreme Drought
- D4: Exceptional Drought

According to the United States Drought Monitor records, Guilford County experienced at least moderate drought occurrences in 15 of the last 19 years (2000-2018). **Table 3.3** shows the most severe drought condition reported for each year in Guilford County and **Figure 3.3** shows historic data on these drought conditions in time-series format. However, it should be noted that the most severe classification reported is based on monthly regional averages, and conditions in Guilford County may actually have been less or more severe than what is reported.

TABLE 3.3: HISTORICAL DROUGHT OCCURRENCES IN GUILFORD COUNTY

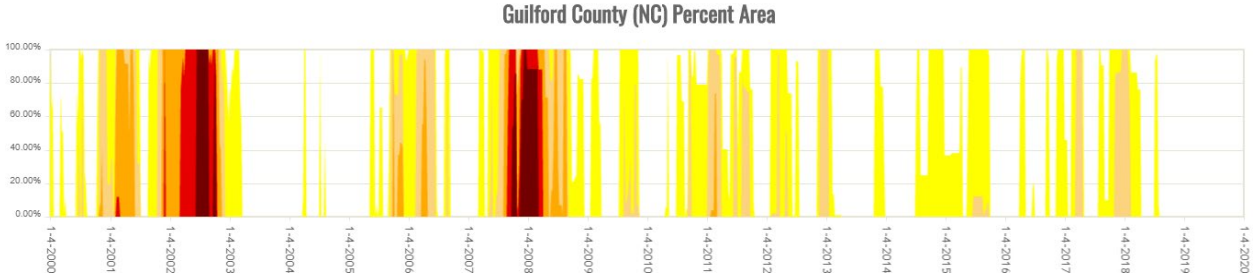
Year	Drought Level
2000	SEVERE
2001	EXTREME
2002	EXCEPTIONAL
2003	ABNORMAL
2004	ABNORMAL
2005	SEVERE
2006	SEVERE

Year	Drought Level
2007	EXCEPTIONAL
2008	EXCEPTIONAL
2009	MODERATE
2010	MODERATE
2011	SEVERE
2012	MODERATE
2013	MODERATE
2014	ABNORMAL
2015	MODERATE
2016	ABNORMAL
2017	MODERATE
2018	MODERATE
2019*	NONE

Source: United States Drought Monitor

**Data only available through 7/2/19*

FIGURE 3.1: HISTORIC DROUGHT CONDITIONS IN GUILFORD COUNTY



Data from the National Centers for Environmental Information (NCEI) was also reviewed to obtain additional information on historical drought events in the county, but no events were reported in Guilford County. However, according to the *Piedmont Together Climate Adaptation Report*, 2012 was the year in which 64% of the continental U.S. experienced drought that directly led to over 100 deaths. Additionally, the report found that in the 2007-2008 drought, North Carolina recorded heat stress levels of almost 16 hospitalizations per 100,000 people and almost 13 deaths per 100,000, with 84% of these hospitalizations occurring between June and August.

Probability of Future Occurrences

Based on historical occurrence information, it is assumed that all of Guilford County has a probability level of likely (10 to 100 percent annual probability) for future drought events. This hazard may vary slightly by location but each area has an equal probability of experiencing a drought. However, historical information also indicates that there is a much lower probability for extreme, long-lasting drought conditions. Additionally, according to the *Piedmont Together Climate Adaptation Report*, the increased likelihood of drought due to climate change will result in greater agricultural losses and more water supply shortages in the county.

Consequence Analysis

People (The Public and Public Confidence)

During drought, the general public must contend with a few issues of inconvenience, but generally are not at great risk in terms of safety. Shortages in water supply may cause enforcement of rationing, mandating limits in using water for lawn care or for washing vehicles. Limiting outside burning as a means for ridding of trash and waste could also help prevent fires during drought conditions.

Drought can have a detrimental effect on the livelihood of farmers and agricultural producers in Guilford County. Efforts to mitigate against drought, such as using irrigation equipment, have a high initial cost, including the need for an increase in management requirements, cost of operation and maintenance, and the lack of good quality water resources—which during times of drought would be severely affected.

Public confidence would likely not be impacted severely; however, during drought conditions, the public will have expectations on the management of the situation and decisions made regarding the usage of water for critical and noncritical activities. Precedence drawn from past events will factor into these expectations, with added influence from the media and its reporting of the drought.

Responders

Although drought would have many of the same impacts on responders as it would on the public, the overall effects would be relatively limited when compared to other hazards. During drought conditions, there generally will not be any life safety concerns directly related to the drought, especially with bottled drinking water readily available. Drought can also reduce the water available for firefighting. This would inhibit the ability to draft water from ponds and streams or dry hydrants.

Continuity of Operations

Drought would have minimal impacts on continuity of operations due to the relatively long warning time that would allow for plans to be made to maintain continuity of operations.

Built Environment (Property, Facilities, and Infrastructure)

Water Use

Drought has the potential to affect Guilford County's water supply for residential, commercial, institutional, industrial, and government-owned areas. Drought can reduce water supply in wells and reservoirs. When drought conditions persist with no relief, local or State governments often institute water restrictions.

Irrigation

Drought would affect irrigation and outdoor landscaping efforts around residential, commercial, institutional, industrial, and government-owned land. Water conservation strategies can limit the amount of water used to maintain the aesthetic environment around buildings, businesses, and areas such as golf courses. This would include automatic and non-automatic spray irrigation systems, hose-end sprinklers, handheld hoses, bucket watering, drip irrigation, athletic field irrigation, swimming pools, car washing, pressure washing, and reuse water.

Economy

Drought can have a detrimental effect on agricultural and agribusiness industry sectors which account for more than one-fifth of North Carolina's income and employees.[4] Extreme drought has the potential to depress local businesses and industries such as landscaping, recreation and tourism, and public utilities. Nursery and landscape businesses can also face significant losses from a drought. Losses include reduction of output and sales of nursery crops, reduction in plant sales, and an increase in watering costs. This can lead to the closing of many business locations, lay-off of employees, and increases in bankruptcy filing.

Environment

Agriculture

The agriculture sector of Guilford County is particularly susceptible to drought damage. **Table 3.4** shows there are 963 farms in Guilford County, with 96,519 acres of 413,565 acres total being farmland.[5] Agricultural drought has the potential to directly affect much of the land in Guilford County. Agricultural areas at particular risk are cropland and pastures.

TABLE 3.4: GUILFORD COUNTY FARMLAND OVERVIEW

Census of Agriculture (2012)	
Number of Farms	962
Total Land in Farms, Acres	90,750
Average Farm Size, Acres	94

Source: United States Department of Agriculture

[4] North Carolina State University College of Agriculture and Life Sciences. (2003). *Agriculture and agribusiness in Wake County.* Retrieved May 7, 2012, from http://www.cals.ncsu.edu/cfprod/apps/calswebsite/documents/County/wake.pdf
[5] Guilford *County: Census of agriculture—2007*. Retrieved May 7, 2012, from http://www.ncagr.gov/stats/codata/guilford.pdf

Crops

Prolonged periods of dry weather are the most difficult and damaging problem faced by crop growers and agricultural suppliers. According to the USDA's Census of Agriculture, Guilford County has 36,234 acres of harvested cropland.

Short- or long-term moisture deficits—even with the use of irrigation methods—during critical stages of crop development can severely reduce yields, with the amount of yield lost depending on when the drought occurs (see Table 3.5 for a list of Guilford County crop specific information), the growth stage of the crop, the severity of dry conditions, and the amount of available water that the soil can hold.

TABLE 3.5: GUILFORD COUNTY CROP INFORMATION

Crops	Acres Harvested	Farms
Corn for Grain	3,761	70
Corn of Silage or Greenchop	1,961	21
Wheat for grain, all	5,256	104

Crops	Acres Harvested	Farms
Corn for Grain	3,761	70
Corn of Silage or Greenchop	1,961	21
Wheat for grain, all	5,256	104

Source: United States Department of Agriculture

Livestock[6]

Table 3.6 shows the type of livestock in Guilford County, including the quantity of livestock and the county's rank compared to other counties in the state. These are at risk for being affected by drought conditions in the county.

Livestock losses from drought will most likely be confined to forage-based production systems. Losses in beef and dairy systems will potentially be of a single-season or multiyear variety. Single-season losses will include lost forage production (on both hay and grazing land), reduced weaning weights, reduced milk production, and increased mortality.

Multiyear losses could include the cost of reestablishing pastures and reduced meat or milk production in subsequent years due to forced sales in the drought year. In addition, drought conditions could result in poor pasture conditions, reduced drinking water supplies, and a critical hay shortage that directly affects livestock and poultry health.

[6] North Carolina Division of Water Resources. (2009). *The water connection: Water resources, drought and the hydrologic cycle in North Carolina*. Retrieved May 7, 2012, from http://www.ncwater.org/Reports_and_Publications/primer/The_Water_Connection_Booklet_9x12_150dpi.pdf

TABLE 3.6: GUILFORD COUNTY LIVESTOCK (2012)

Livestock	Number	Farms
Cattle and calves inventory	14,861	378
Beef cows	5,293	300
Milk cows	1,484	11
Hogs and pigs	14,502	29
Layers inventory	306,500	83
Broilers and other meat-type chickens sold	Information withheld	5

Environmental Degradation

Drought may also lead to pollution of water sources as a result of lack of rain water to dilute industrial and agricultural chemical runoff. This poses a risk to plants and animals and makes it difficult to maintain a clean drinking water supply.

Lack of water reaching the soil may also cause the ground to become dry and unstable. Erosion can increase and loss of topsoil can be severe if a high-intensity rain falls on ground lacking a ground cover of plants. As a result of these environmental impacts, habitats may be degraded through a loss of wetlands, lake capacity, and vegetation.

Earthquake

Background

An earthquake is movement 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.

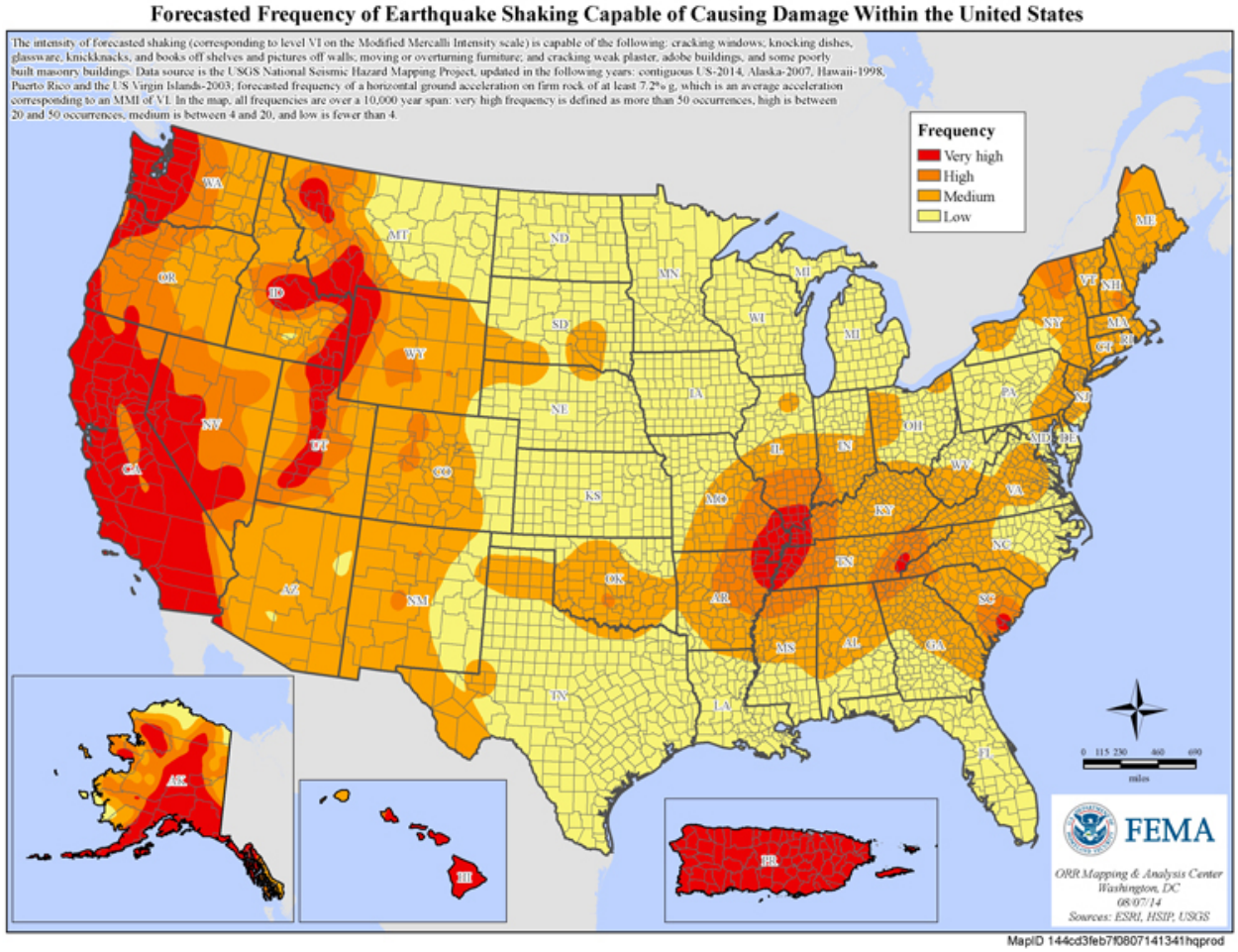
Most property damage and earthquake-related deaths are caused by the failure and collapse of structures due to ground shaking. The level of damage depends upon the amplitude and duration of the shaking, which are directly related to the earthquake size, distance from the fault, site, and regional geology. 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 10 tectonic plates. 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.

The greatest earthquake threat in the United States is along tectonic plate boundaries and seismic fault lines located in the central and western states; however, the Eastern United State does face moderate risk to less frequent, less intense earthquake events. **Figure 3.4** shows relative seismic risk for the United States.

FIGURE 3.4: UNITED STATES EARTHQUAKE HAZARD MAP



Source: Federal Emergency Management Agency, 2014

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 (**Table 3.7**). Each unit increase in magnitude on the Richter Scale corresponds to a 10-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, ranging from "I" corresponding to imperceptible

(instrumental) events 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 3.8**.

TABLE 3.7: RICHTER SCALE

RICHTER MAGNITUDES	EARTHQUAKE EFFECTS
< 3.5	Generally not felt, but recorded.
3.5 - 5.4	Often felt, but rarely causes damage.
5.4 - 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 >	Great earthquake. Can cause serious damage in areas several hundred kilometers across.

Source: Federal Emergency Management Agency

TABLE 3.8: 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

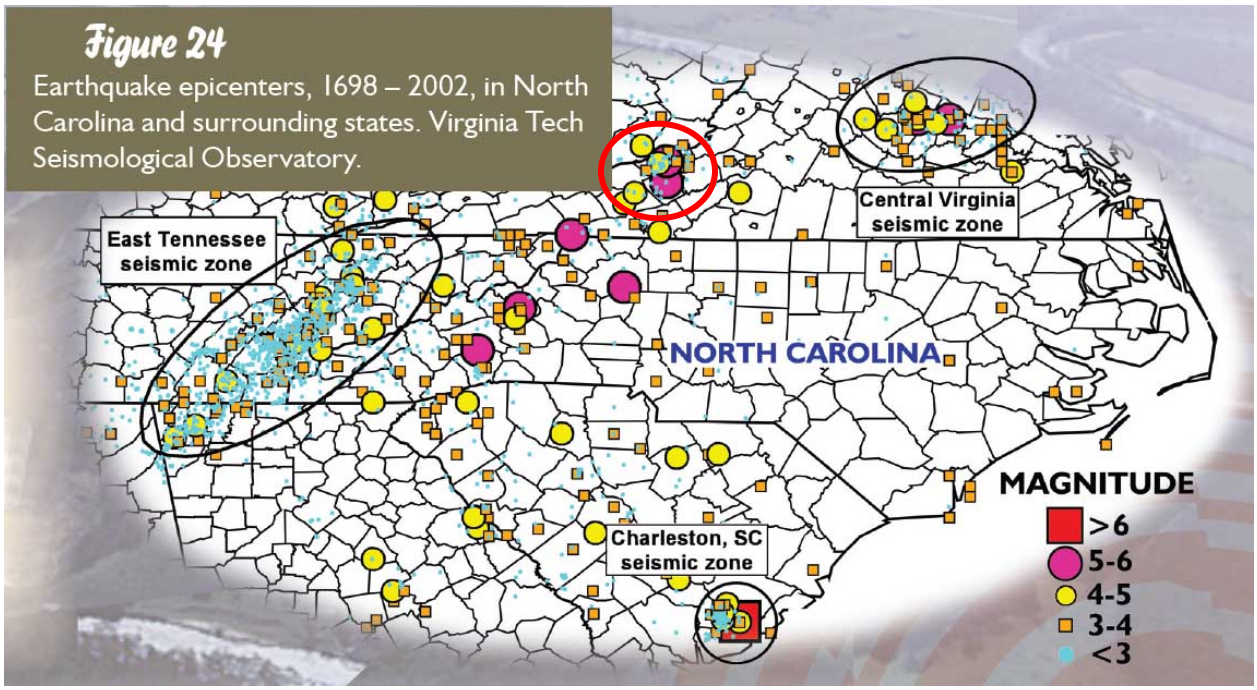
SCALE	INTENSITY	DESCRIPTION OF EFFECTS	CORRESPONDING RICHTER SCALE MAGNITUDE
XI	VERY DISASTROUS	Most buildings and bridges collapse; roads, railways, pipes and cables destroyed; general triggering of other hazards.	< 8.1
XII	CATASTROPHIC	Total destruction; trees fall; ground rises and falls in waves.	> 8.1

Source: Federal Emergency Management Agency

Location and Spatial Extent

Much of North Carolina is subject to earthquakes, with the western and southeast region most vulnerable to a very damaging earthquake. The state is affected by the Charleston seismic zone in South Carolina, the East Tennessee seismic zone in Tennessee, and the Central Virginia seismic zone in Virginia. The Charleston fault has generated earthquakes measuring greater than 8 on the Richter Scale during the last 200 years. In addition, there are several smaller fault lines throughout North Carolina.. **Figure 3.5** is a map showing geological and seismic information for North Carolina.

FIGURE 3.5: GEOLOGICAL AND SEISMIC INFORMATION FOR NORTH CAROLINA

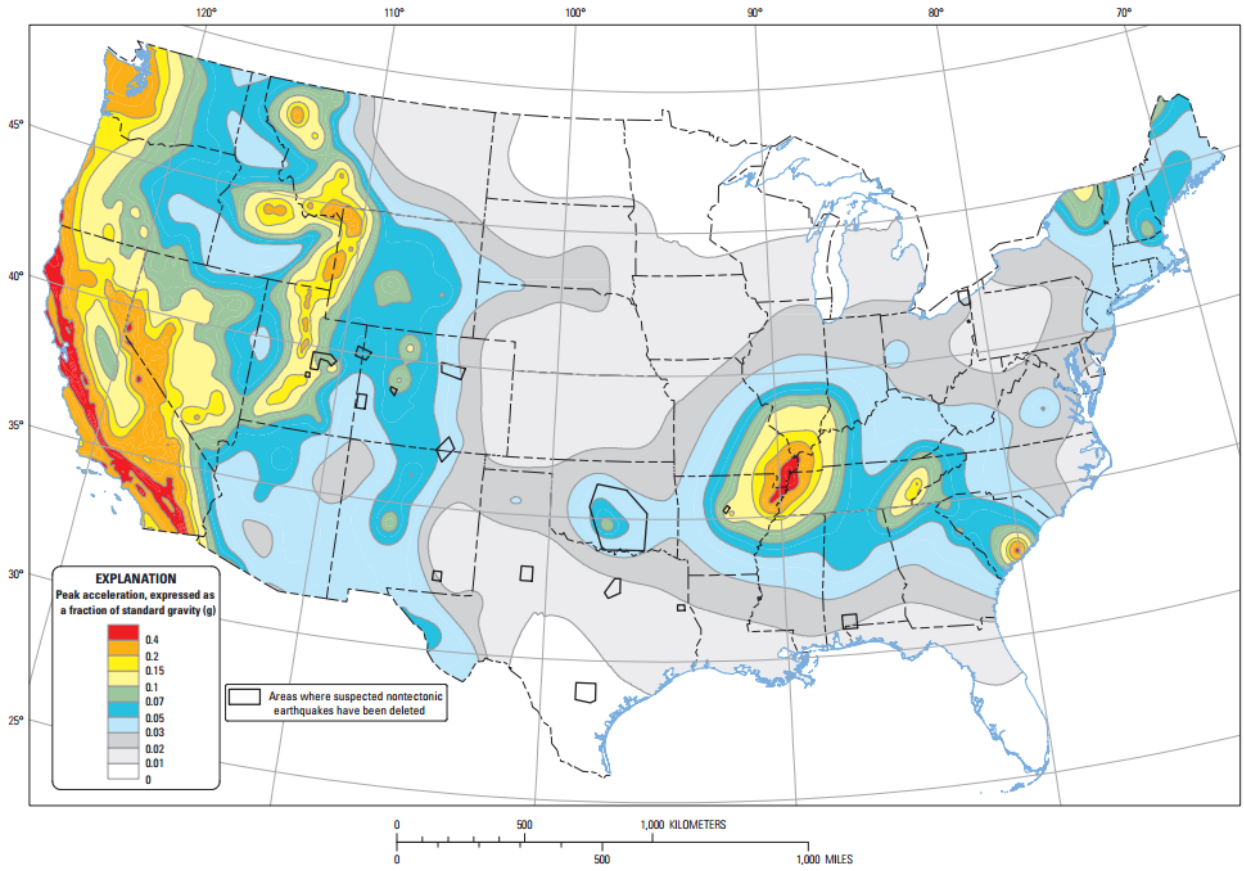


Source: North Carolina Geological Survey

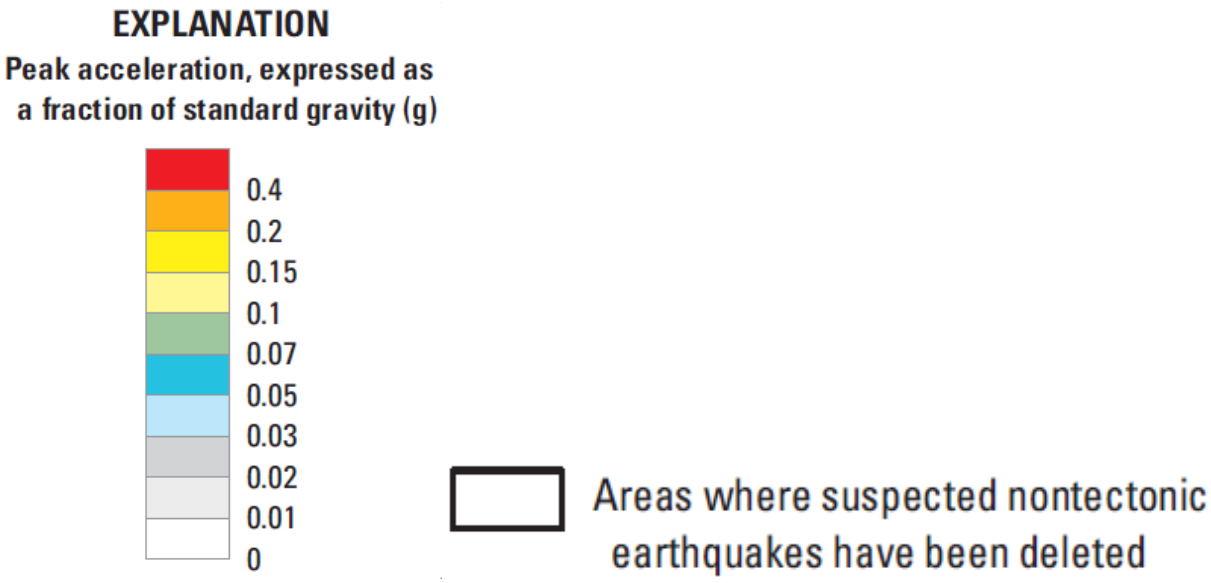
Figure 3.6 shows the intensity level associated with Guilford County, based on the national USGS map of peak acceleration with 10 percent probability of exceedance in 50 years. It is the probability that ground motion will reach a certain level during an earthquake. The data show

peak horizontal ground acceleration (the fastest measured change in speed, for a particle at ground level that is moving horizontally due to an earthquake) with a 10 percent probability of exceedance in 50 years. The map was compiled by the U.S. Geological Survey (USGS) Geologic Hazards Team, which conducts global investigations of earthquake, geomagnetic, and landslide hazards. According to this map, Guilford County lies within an approximate zone of 0.02 to 0.05 peak ground acceleration. This indicates that the county as a whole exists within an area of low to moderate seismic risk.

FIGURE 3.6: PEAK ACCELERATION WITH 10 PERCENT PROBABILITY OF EXCEEDANCE IN 50 YEARS



Ten-percent probability of exceedance in 50 years map of peak ground acceleration



Source: United States Geological Survey, 2014

Historical Occurrences

At least five earthquakes are known to have affected Guilford County since 1852. The strongest of these measured an IV on the Modified Mercalli Intensity (MMI) scale. **Table 3.9** provides a summary of earthquake events reported by the National Geophysical Data Center between 1638 and 1985. **Table 3.10** presents a detailed occurrence of each event including the date, distance from the epicenter, magnitude, and Modified Mercalli Intensity (if known).[7]

TABLE 3.9: SUMMARY OF SEISMIC ACTIVITY IN GUILFORD COUNTY

Location	Number of Occurrences	Greatest MMI Reported	Richter Scale Equivalent
Gibsonville	0	--	--
Greensboro	5	IV	4.3
High Point	0	--	--
Jamestown	0	--	--
Oak Ridge	0	--	--
Pleasant Garden	0	--	--
Sedalia	0	--	--
Stokesdale	0	--	--
Summerfield	0	--	--
Whitsett	0	--	--
Unincorporated Area	0	--	--
GUILFORD COUNTY TOTAL	**5**	**IV**	**4.3**

Source: National Geophysical Data Center

TABLE 3.10: SIGNIFICANT SEISMIC EVENTS IN GUILFORD COUNTY (1638-1985)

Location	Date	Epicentral Distance	Magnitude	MMI
Gibsonville				
None Reported	--	--	--	--

[7] Due to reporting mechanisms, not all earthquakes events were recorded during this time. Furthermore, some are missing data, such as the epicenter location, due to a lack of widely used technology. In these instances, a value of "unknown" is reported.

Location	Date	Epicentral Distance	Magnitude	MMI
Greensboro				
Greensboro	4/29/1852	--	--	III
Greensboro	12/23/1875	205.0	--	IV
Greensboro	2/21/1916	252.0	--	III
Greensboro	3/12/1960	348.0	--	IV
Greensboro	11/20/1969	183.0	4.3	IV
High Point				
None Reported	--	--	--	--
Jamestown				
None Reported	--	--	--	--
Oak Ridge				
None Reported	--	--	--	--
Pleasant Garden				
None Reported	--	--	--	--
Sedalia				
None Reported	--	--	--	--
Stokesdale				
None Reported	--	--	--	--
Summerfield				
None Reported	--	--	--	--
Whitsett				
None Reported	--	--	--	--
Unincorporated Area				
None Reported	--	--	--	--

Source: National Geophysical Data Center

In addition to those earthquakes specifically affecting Guilford County, a list of earthquakes that have caused damage throughout North Carolina is presented below in Table 3.11.

TABLE 3.11: EARTHQUAKES WHICH HAVE CAUSED DAMAGE IN NORTH CAROLINA

Date	Location	Richter Scale (Magnitude)	MMI (Intensity)	MMI in North Carolina
12/16/1811 - 1	NE Arkansas	8.5	XI	VI
12/16/1811 - 2	NE Arkansas	8.0	X	VI
12/18/1811 - 3	NE Arkansas	8.0	X	VI
01/23/1812	New Madrid, MO	8.4	XI	VI
02/071812	New Madrid, MO	8.7	XII	VI
04/29/1852 *	Wytheville, VA	5.0	VI	VI
08/31/1861	Wilkesboro, NC	5.1	VII	VII
12/23/1875 *	Central Virginia	5.0	VII	VI
08/31/1886	Charleston, SC	7.3	X	VII
05/31/1897	Giles County, VA	5.8	VIII	VI
01/01/1913	Union County, SC	4.8	VII	VI
02/21/1916 *	Asheville, NC	5.5	VII	VII
07/08/1926	Mitchell County, NC	5.2	VII	VII
11/03/1928	Newport, TN	4.5	VI	VI
05/13/1957	McDowell County, NC	4.1	VI	VI
07/02/1957	Buncombe County, NC	3.7	VI	VI
11/24/1957	Jackson County, NC	4.0	VI	VI
10/27/1959 **	Chesterfield, SC	4.0	VI	VI
07/13/1971	Newry, SC	3.8	VI	VI
11/30/1973	Alcoa, TN	4.6	VI	VI
11/13/1976	Southwest Virginia	4.1	VI	VI
05/05/1981	Henderson County, NC	3.5	VI	VI
08/23/2011	Louisa County, VA	5.8	VII	V

*This event is accounted for in the Guilford County occurrences.

** Conflicting reports on this event, intensity in North Carolina could have been either V or VI

Source: This information compiled by Dr. Kenneth B. Taylor and provided by Tiawana Ramsey of NCEM. Information was compiled from the National Earthquake Center, Earthquakes of the US by Carl von Hake (1983), and a compilation of

newspaper reports in the Eastern Tennessee Seismic Zone compiled by Arch Johnston, CERI, Memphis State University (1983).

The Charleston, South Carolina earthquake on August 31, 1886 caused the most property damage in the history of North Carolina. Charlotte, Hillsborough, and Raleigh were just a few of the cities affected by property damage; the shaking was felt elsewhere including Guilford County but no damage was reported.[8]

An earthquake that occurred on August 26, 1916 was centered just west of Winston-Salem, NC. This is the closest recorded epicenter to Guilford County. There was no damage from this event, but it was felt in an area that was 9,800 square kilometers.[9]

On August 23, 2011, a 5.8 earthquake struck near Mineral and Louisa, Virginia. This quake and several aftershocks were felt across the eastern seaboard, including in Guilford County. There was no damage reported locally.

Probability of Future Occurrences

The probability of significant, damaging earthquake events affecting Guilford County is unlikely. However, it is possible that future earthquakes resulting in light to moderate perceived shaking and damages ranging from none to very light will affect the county. The annual probability level for the county is estimated between 1 and 10 percent (possible).

Consequence Analysis

People (The Public and Public Confidence)

Earthquakes in Guilford County generally are not high impact events that cause injury or death as most are moderate. The public typically experiences some shaking in these events and the greatest threat to health and well-being is often from objects falling from shelves. An additional concern is public panic as the event takes place, dependent on the severity of the seismic activity.

Public confidence would likely not be affected in the event of an earthquake.

Responders

There would be little impact on responders in the event of an earthquake, again, because Guilford County is only likely to experience a moderate earthquake magnitude at a maximum. Since there would be very little damage to infrastructure, responders would likely not be impacted in their ability to respond to an earthquake. If there were any major collapses of buildings or infrastructure however, responders will need to take care when accessing these structures in case they have become structurally unstable and unsafe. It should also be noted that because earthquakes can knock items such as candles off shelves or damage gas lines, fires are

[8] United States Geological Survey, *North Carolina,* http://earthquake.usgs.gov/earthquakes/states/north_carolina/history.php
[9] United States Geological Survey, *North Carolina,* http://earthquake.usgs.gov/earthquakes/states/north_carolina/history.php

possible directly after an event. This may cause additional emergency calls for responders and create a burden on response operations.

Continuity of Operations

During and after an earthquake, continuity of operations could relatively easily be maintained and there would likely be little disruption to services or operations. The most likely impact may be downed communication networks which could cause interruptions to normal operations.

Built Environment (Property, Facilities, and Infrastructure)

Ground shaking is the primary cause of damage to the built environment during an earthquake. There are three important variables that determine the amount of damage: the intensity of the quake, local soil characteristics, and the quality of the impacted structures. The amount of damaged caused by an earthquake is strongly influenced by soil characteristics. The velocity at which the rock or soil transmits shear waves is the main contributor to ground shaking. Shaking is increased by soft, thick, or wet soil types.

Certain building types are particularly vulnerable to earthquake damage: wood-frame multi-unit buildings, single-family homes, mobile homes, and unreinforced masonry buildings.[10] The most susceptible structures are wood-frame, multi-story, mixed-use buildings that have large openings on the first floor for garages or commercial space and housing on the upper floors. During an earthquake, these types of structures could sway or even collapse.

Single-family homes built prior to the 1970s are often not bolted to their foundations, and walls surrounding crawl spaces are not braced (i.e., cripple walls). Typical earthquake damage to these structures include cracked foundations, chimneys breaking at the roof line, wood frames coming off their foundations, and racking of cripple walls.

Mobile homes that are built of light-weight metal or a combination of steel frame and wood are easily damaged by a quake. Mobile homes installed prior to 1995 were often not attached to their foundations and could shift off their supports.

The last type of susceptible building material is unreinforced masonry—masonry walls that have not been reinforced with steel. These buildings were often built before 1960 in an era when reinforcing was not generally used, anchorage to floors and roofs was missing, and use of low-strength lime mortar was common. Earthquake damage to these buildings can be severe. A lack of reinforcement and tie-downs can result in substantial damage in the form of cracked or leaning walls. Damage may also occur between the walls, and separation between the framing and walls could lead to full collapse due to a lack of vertical support.

Critical Infrastructure and Key Resources

Critical infrastructure and key resources within Guilford County include assets, systems, and networks that are vital to the continued operation of government services. The

[10] Association of Bay Area Governments. (2012). *Guide to housing vulnerable resources*. Retrieved March 11, 2012, from http://quake.abag.ca.gov/housing/

incapacitation or destruction of these resources would have a debilitating effect on the county's security, economy, and/or public health. There are a handful of key resource categories that could be impacted by an earthquake including transportation systems, communication systems, and utility systems. Historically, the county has not been impacted by an earthquake with more than a moderate intensity so damage to these resources would be very minor; however, an inspection of certain features after a strongly felt earthquake may be necessary.

Economy

There are three sources of economic loss associated with an earthquake: property damage and business interruption costs; cost to repair public transportation, communication, or utility systems; and debris removal costs. Historically, there have been no economic losses from earthquakes felt within the county.

Environment

There would be no substantial impacts to the environment following a large earthquake that is felt in Guilford County with a moderate intensity. Secondary effects from the damage of the key resources mentioned above (e.g., utility systems) could impact the environment, but the probability of this type of situation is very small. For instance, a ruptured pipeline could release dangerous materials that could damage the surrounding environment, but the likelihood of an earthquake causing this in Guilford County is relatively low.

Extreme Cold

Background

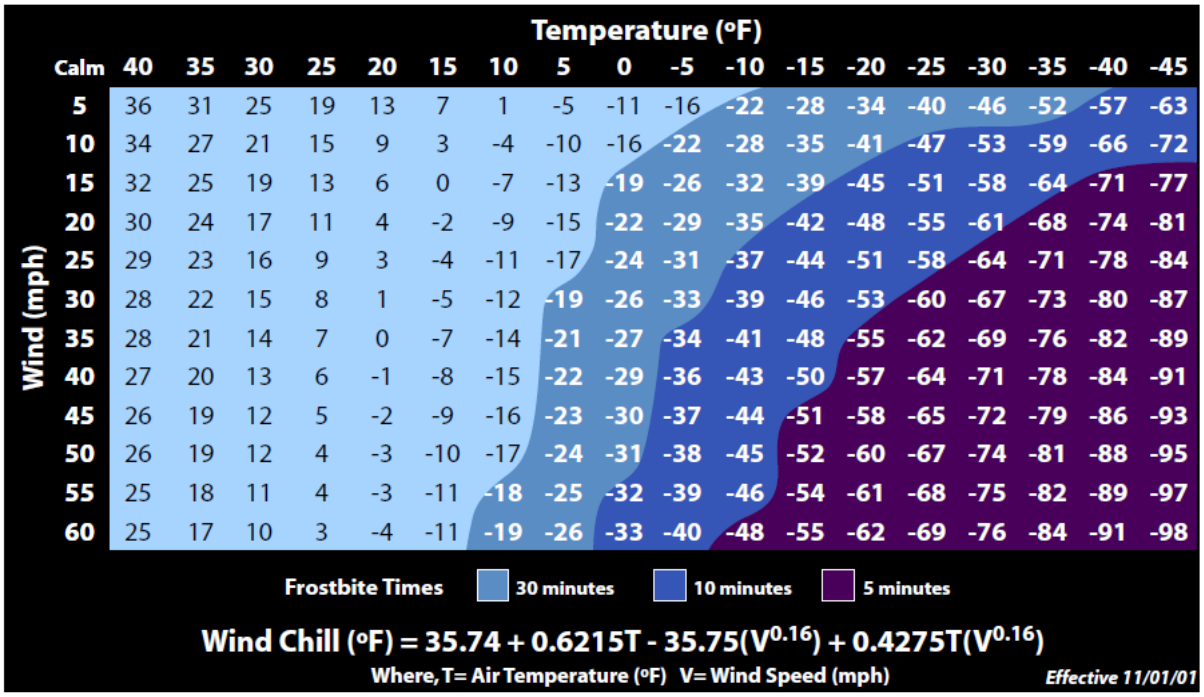
What constitutes extreme cold and its effect varies across different regions of the United States, according to the NWS. In the South and other areas relatively unaccustomed to winter weather, temperatures near or below freezing (32°F) are considered extreme cold. Freezing temperatures in these areas may cause damage to citrus fruit crops and other vegetation and may cause pipes to freeze and burst in homes that are poorly insulated or without heat. However, in the North, temperatures well below 0°F are considered extreme cold, and long cold spells can cause rivers to freeze, which can disrupt shipping, and ice jams to form, which can lead to flooding.

Prolonged exposure to extreme cold temperatures can lead to serious health problems, including hypothermia, cold stress, frostbite, or freezing, and infants and the elderly are most susceptible to these conditions. Extreme cold events are most likely to occur during January and February, and even areas that normally experience mild winters can be hit with extreme cold.

Extreme cold conditions can be the result of cold temperatures and high winds, a combination known as "wind chill." The Wind Chill Temperature index, in **Figure 3.6**, shows the apparent temperature combining the effect of wind and air temperatures on exposed skin.

Figure 3.7: Wind Chill Temperature Index

Wind Chill Chart



Source: National Weather Service, National Oceanic and Atmospheric Administration

The NWS issues wind chill advisories when wind chill hazards are potentially hazardous. Wind chill warnings are issued when wind chill temperatures are life threatening. Criteria for issuing wind chill warnings and advisories are set locally. For example, in Rochester, New York, wind chill advisories are issued when the wind chill temperature is expected to fall between -15°F to -24°F, and wind chill warnings are issued when wind chill temperature is expected to fall at or below -25°F. Again, this warning system should not be mistaken as describing the extent or magnitude of extreme cold; rather, it is intended to provide advanced notice of excessive cold conditions for the protection of life and property.

Location and Spatial Extent

Extreme cold typically impacts a large area and cannot be confined to any geographic or political boundaries. The entire county is susceptible to extreme cold conditions.

Historical Occurrences

Data from the National Centers for Environmental Information was used to determine historical extreme cold events in Guilford County. One event was reported:

February 3, 1996 – *Cold/Wind Chill* – a cold/wind chill event impacted Guilford County for two days.

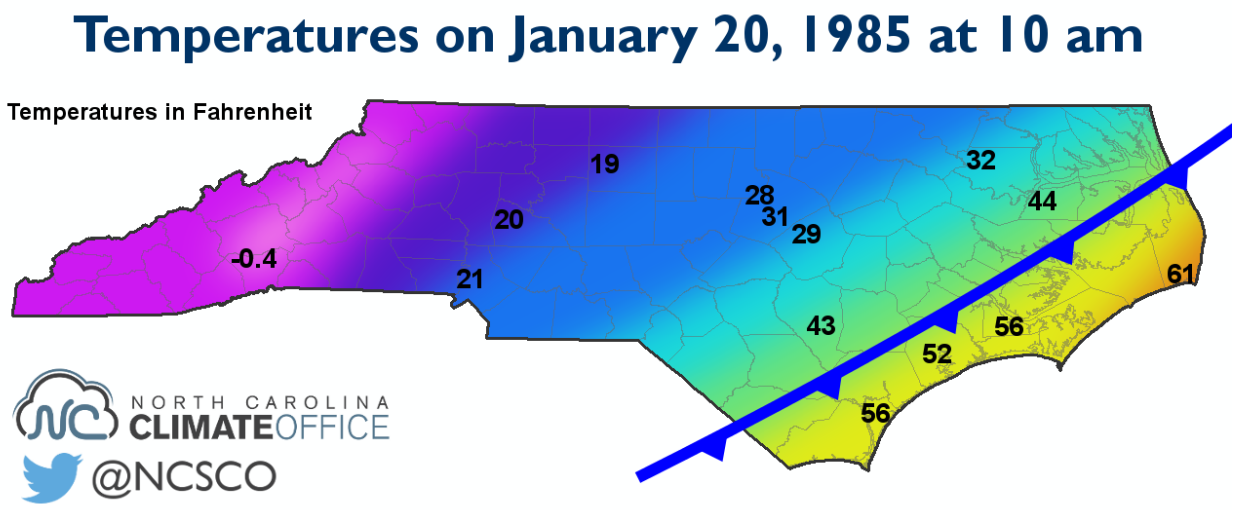
In addition, information from the State Climate Office of North Carolina was reviewed to obtain historical temperature records in the county. Temperature information has been recorded in Guilford County since 1903. The recorded minimum for the county can be found below in **Table 3.12**. **Figure 3.8** shows temperatures across the state on the day when the coldest temperature was recorded.

TABLE 3.12: LOWEST RECORDED TEMPERATURE IN GUILFORD COUNTY

Location	Date	Temperature (°F)
Greensboro Airport	01/21/1985	-8
Greensboro Airport	01/27/1940	-7
Greensboro Airport	01/29/1940	-7
High Point	01/21/1985	-7
Greensboro Airport	01/20/1985	-6

Source: State Climate Office of North Carolina

FIGURE 3.8: RECORDED TEMPERATURES ON COLDEST DAY IN GUILFORD COUNTY



The State Climate Office also reports average minimum temperatures at various stations in the county. The most centralized location is in Greensboro. **Table 3.13** shows the average minimum temperatures from 1971 to 2000 at the Greensboro Airport observation station which can be used as a general comparison for the county.

TABLE 3.13: AVERAGE MINIMUM TEMPERATURE IN GUILFORD COUNTY

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Avg. Max (°F)	28.2 °F	30.6 °F	37.8 °F	45.5 °F	54.7 °F	63.5 °F	68.1 °F	66.8 °F	60.1 °F	47.5 °F	38.6 °F	31.4 °F

Source: State Climate Office of North Carolina

Probability of Future Occurrences

Based on historical occurrence information, it is assumed that all of Guilford County has a probability level of possible (1 to 10 percent annual probability) for future extreme cold events to impact the county.

Consequence Analysis

People (The Public and Public Confidence)

Extreme cold can affect many people and to varying degrees. The general public is at risk when they are outdoors or when heating systems are unavailable or not working properly. Homeless populations are especially vulnerable to extremely cold temperatures, frostbite, and hypothermia. Often the elderly and very young are susceptible to the most detrimental impacts, but hypothermia and frostbite can plague anyone.

Like extreme heat, public confidence is unlikely to be altered significantly during an extreme cold event. Numerous instances of individuals being exposed to and affected by the cold for extended periods of time may influence public confidence some. This is especially dependent on how the media interprets and reports the events. Proactive dissemination of cold-related tips and information may lessen or prevent negative publicity during extreme cold weather conditions.

Responders

Extreme cold can also affect responders who are often more susceptible to the effects of cold weather because they are forced to be exposed to the elements to complete tasks for their jobs. In these cases, responders could be negatively impacted by extreme cold. In addition, temperatures below 32 degrees Fahrenheit can result in water that is used in firefighting operations to freeze and create slippery conditions from water runoff.

Continuity of Operations

Extreme cold would likely have few impacts on continuity of operations as the warning time for these events is usually long and direct impacts to large numbers of personnel or other resources necessary to maintain operations are unlikely.

Built Environment (Property, Facilities, and Infrastructure)

Extreme cold would likely have a minor effect on the built environment, although low temperatures could potentially put a strain on infrastructure such as power generation due to higher demand.

Economy

An extreme cold event could potentially have a negative impact on the economy in the short term as the public may be advised to stay inside, causing them to reduce overall spending and negatively impact businesses in the community. Extended periods of extreme cold may also disrupt the local economy if agricultural, dairy, and livestock production declines, resulting in income loss for famers and others affected.

Environment

The environment would be impacted by extreme cold as many plants and animals that are not able to withstand lower temperatures may die off and crops and livestock may be impacted by unusually low temperatures, resulting in death or illness.

Extreme Heat

Background

Extreme heat, like drought, poses little risk to property. However, extreme heat can have devastating effects on health. Extreme heat is often referred to as a "heat wave." According to the National Weather Service, there is no universal definition for a heat wave, but the standard U.S. definition is any event lasting at least three days where temperatures reach ninety degrees Fahrenheit or higher. However, it may also be defined as an event at least three days long where temperatures are ten degrees greater than the normal temperature for the affected area. Heat waves are typically accompanied by humidity but may also be very dry. These conditions can pose serious health threats causing an average of 1,500 deaths each summer in the United States[11].

According to the National Oceanic and Atmospheric Administration, heat is the number one weather-related killer among natural hazards, followed by frigid winter temperatures[1]. The National Weather Service devised the Heat Index as a mechanism to better inform the public of heat dangers. The Heat Index Chart, shown in **Figure 3.9**, uses air temperature and humidity to determine the heat index or apparent temperature. **Table 3.14** shows the dangers associated with different heat index temperatures. Some populations, such as the elderly and young, are more susceptible to heat danger than other segments of the population.

[11] http://www.noaawatch.gov/themes/heat.php

FIGURE 3.9: HEAT INDEX CHART

Air Temp (in F) \ Relative Humidity (in percent)	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100
140	125																				
135	120	128																			
130	117	122	131																		
125	111	116	123	131	141																
120	107	111	116	123	130	139	148														
115	103	107	111	115	120	127	135	143	151												
110	99	102	105	108	112	117	123	130	137	143	150										
105	95	97	100	102	105	109	113	118	123	129	135	142	149								
100	91	93	95	97	99	101	104	107	110	115	120	126	132	138	144						
95	87	88	90	91	93	94	96	98	101	104	107	110	114	119	124	130	136				
90	83	84	85	86	87	88	90	91	93	95	96	98	100	102	106	109	113	117	122		
85	78	79	80	81	82	83	84	85	86	87	88	89	90	91	93	95	97	99	102	105	108
80	73	74	75	76	77	77	78	79	79	80	81	81	82	83	85	86	86	87	88	89	91
75	69	69	70	71	72	72	73	73	74	74	75	75	76	76	77	77	78	78	79	79	80
70	64	64	65	65	66	66	67	67	68	68	69	69	70	70	70	70	71	71	71	71	72

Source: National Oceanic and Atmospheric Administration

TABLE 3.14: HEAT DISORDERS ASSOCIATED WITH HEAT INDEX TEMPERATURE

Heat Index Temperature (Fahrenheit)	Description of Risks
80°- 90°	Fatigue possible with prolonged exposure and/or physical activity
90°- 105°	Sunstroke, heat cramps, and heat exhaustion possible with prolonged exposure and/or physical activity
105°- 130°	Sunstroke, heat cramps, and heat exhaustion likely, and heatstroke possible with prolonged exposure and/or physical activity
130° or higher	Heatstroke or sunstroke is highly likely with continued exposure

Source: National Weather Service, National Oceanic and Atmospheric Administration

In addition, NOAA has seventeen metropolitan areas participating in the Heat HealthWatch/Warning System in order to better inform and warn the public of heat dangers. A Heat HealthWatch is issued when conditions are favorable for an excessive heat event in the next 12 to 48 hours. A Heat Warning is issued when an excessive heat event is expected in the next 36 hours. Furthermore, a warning is issued when the conditions are occurring, imminent, or have a high likelihood of occurrence. Urban areas participate in the Heat Health Watch/Warning System because urban areas are at greater risk to heat affects. Stagnant atmospheric conditions trap pollutants, thus adding unhealthy air to excessively hot temperatures. In addition, the "urban heat island effect" can produce significantly higher nighttime temperatures because asphalt and concrete (which store heat longer) gradually release heat at night.

Location and Spatial Extent

Excessive heat typically impacts a large area and cannot be confined to any geographic or political boundaries. The entire county is susceptible to extreme heat conditions. Additionally, according to the *Piedmont Together Climate Adaptation Report*, the Piedmont Triad has the state's largest elderly and aging populations—the fastest growing age demographic both nationally and regionally—making heat stress one of the leading climate adaptability priorities for the region and Guilford County.

Historical Occurrences

According to the *Piedmont Together Climate Adaptation Report*, the 10 warmest years in recorded history have occurred since 1997. Data from the National Climatic Data Center was used to determine historical extreme heat and heat wave events in Guilford County. Two events were reported:

> **July 22, 1998** –*Heat* – Excessive heat plagued central North Carolina during July 22 through July 23. Maximum temperatures reached the 98 to 103 degree range combined with dew points in the 78 to 80 degree range with little wind to give heat index values of around 110 degrees for several hours each afternoon. To make matters worse, the minimum temperatures did not fall below 80 at several locations and those that did achieved that feat for only an hour or two. Strong thunderstorms ended the 2 day excessive heat ordeal on the evening of the 23 when rain cooled the environment enough to send temperatures into the lower 70s at most locations.
>
> **May 27, 2008** –*Heat* – NC A&T State University Senior Chad Wiley collapsed after a voluntary football workout on campus Tuesday May 27th. Chad was 22 years old.

In addition, information from the State Climate Office of North Carolina was reviewed to obtain historical temperature records in the county. Temperature information has been recorded in Guilford County since 1903. The recorded maximum for the county can be found below in **Table 3.15**. In addition, **Figure 3.10** shows the number of times the heat index value was recorded at over 100°F at Greensboro Airport since 1972.

TABLE 3.15: HIGHEST RECORDED TEMPERATURE IN GUILFORD COUNTY

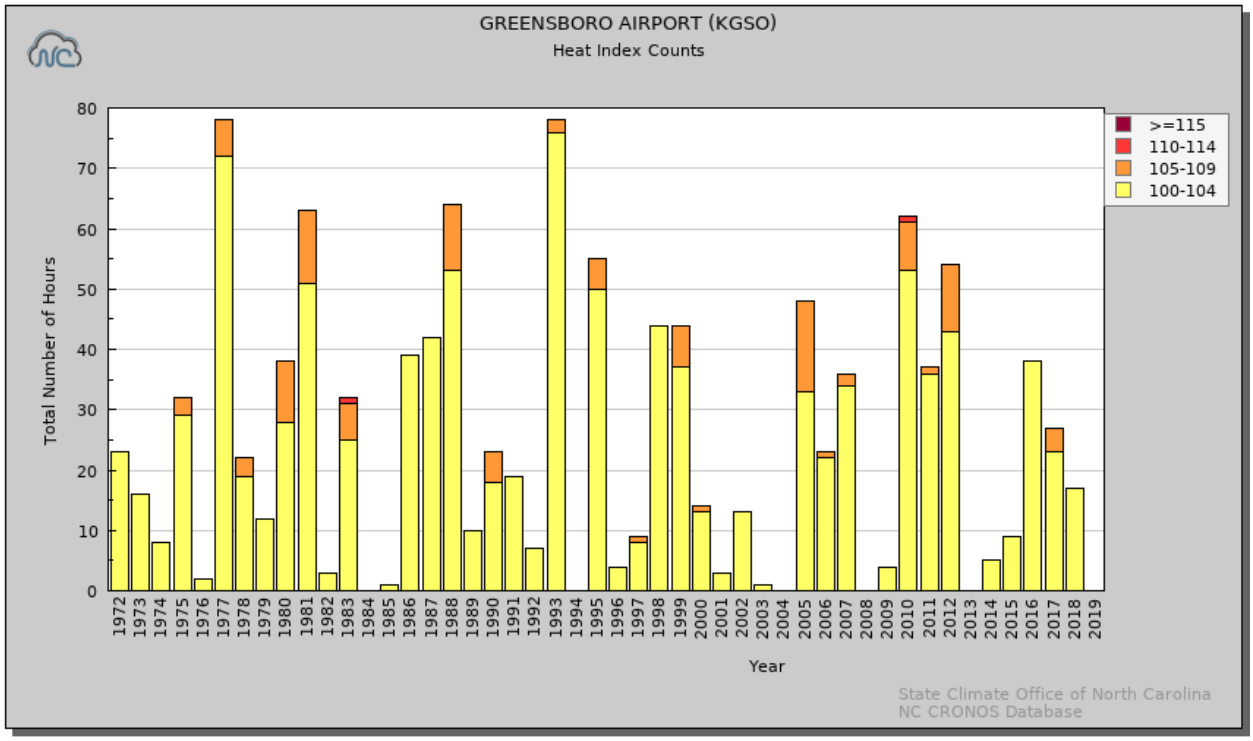
Location	Date	Temperature (°F)
High Point	07/20/1926	106
High Point	07/29/1952	106
High Point	06/28/1934	105
High Point	07/15/1954	105
High Point	08/31/1932	105

Source: State Climate Office of North Carolina

Figure 5.2: Heat Index Counts at Greensboro Airport (1972-2019)

Heat Index Counts* for Greensboro Airport (KGSO)

1972 through 2019



*Counts are defined as the number of hours in a given year where the heat index reached or exceeded 100 degrees Fahrenheit

The State Climate Office also reports average maximum temperatures at various stations in the county. The most centralized location is in Greensboro. **Table 3.16** shows the average maximum temperatures from 1971 to 2000 at the Greensboro Airport Observation Station which can be used as a general baseline for the county.

TABLE 3.16: AVERAGE MAXIMUM TEMPERATURE IN GUILFORD COUNTY

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Avg. Max (°F)	47.2 °F	51.7 °F	60.3 °F	69.7 °F	76.9 °F	83.8 °F	87.6 °F	85.7 °F	79.4 °F	69.6 °F	59.9 °F	50.6 °F

Source: State Climate Office of North Carolina

Probability of Future Occurrences

Based on historical occurrence information, it is assumed that all of Guilford County has a probability level of likely (10 to 100 percent annual probability) for future extreme heat events to impact the county. Additionally, according to the *Piedmont Together Climate* Adaptation Report, the average increase in annual temperature for the Piedmont Triad is estimated to be 5°F and higher annual average temperatures will likely create a longer growing season that may be supportive of agriculture. However, these hot, dry summers and wetter winter conditions could stress farms. Furthermore, the increased likelihood of heat waves due to climate change will result in a higher number of rolling brown/blackouts and decreased air quality in the county.

Consequence Analysis

People (The Public and Public Confidence)

Extreme heat can affect many people and to varying degrees. Often the elderly and very young are susceptible to the most detrimental impacts, but heat stroke and exhaustion can plague anyone. People who are overweight, who overexert during work or exercise, and who are ill or are on certain medications are also at greater risk of suffering from heat-related illness. Risks from exposure to extreme heat include heat cramps, heat exhaustion, heat stroke, and death. Many of the impacts of extreme heat on people are the result of heat exhaustion or improperly functioning air conditioning units.

A heat wave or extreme heat event would have minimal effects on public confidence as these events are frequent and the public likely understands the potential impacts. However, if an extreme heat event results in a large number of illnesses and fatalities, government organizations may be accused of failing to properly prepare for or respond to the threat, and public confidence could suffer.

Responders

Extreme heat can also affect responders who are often more susceptible to heat stroke and exhaustion due to the nature of their work. This work forces police and emergency medical providers to be exposed to the elements, physically exert themselves, or wear heavy personal protective equipment. In these cases, responders could be negatively impacted by extreme heat and will need to protect themselves and prepare accordingly.

Continuity of Operations

Extreme heat would likely have few impacts on continuity of operations as the warning time for these events is usually long and direct impacts to large numbers of personnel or other resources necessary to maintain operations are unlikely. If air conditioning systems in operations centers break down due to overuse, operations could be interrupted or forced to move to secondary facilities.

Built Environment (Property, Facilities, and Infrastructure)

Extreme heat would likely have a minor effect on the built environment, although high temperatures could potentially put a strain on infrastructure such as power generation and water systems due to higher demand. During times of extreme heat, air conditioning units work harder and require more electricity, making brownouts and blackouts possible if electricity demands exceed generation. Extreme heat can also cause transportation infrastructure such as roads, bridges, railways, and runways to buckle, crack, or shatter.

Economy

An extreme heat event could potentially have a negative impact on the economy in the short term as the public may be advised to stay inside, causing them to reduce overall spending and negatively impact businesses in the community. Additionally, extreme heat events can also result in decreased worker productivity as high temperatures can result in decreased energy, loss of concentration, and heat-related illness in workers. This can cause disruptions to the regular working of the local economy. Extended periods of extreme heat may also disrupt the local economy if agricultural, dairy, and livestock production declines, resulting in income loss for farmers and other related industries as well as increased prices for consumers.

Environment

The environment would be impacted by extreme heat as many plants and animals that are not able to withstand the heat may die off and crops and livestock may be impacted by unusually high temperatures, resulting in death or illness. Heat waves can also contribute to higher levels of air pollution since air becomes stagnant and traps emitted pollutants, often causing increased levels of surface ozone.

Fire/Wildfire

Background

A wildfire is any outdoor fire (i.e. grassland, forest, brush land) that is not under control, supervised, or prescribed.[12] Wildfires are part of the natural management of forest ecosystems, but may also be caused by human factors.

Nationally, 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. In North Carolina, a majority of fires are caused by debris burning.

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. Wildfires are usually signaled by dense smoke that fills the area for miles around.

Wildfire 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 hazards (such as tornadoes, hurricanes, etc.) increase the probability of wildfires by producing fuel in both urban and rural settings.

Many individual homes and cabins, subdivisions, resorts, recreational areas, organizational camps, businesses, and industries are located within high wildfire hazard areas. Furthermore, 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 wildfire events that can sweep through the brush and timber and destroy property within minutes.

Wildfires can result in severe economic losses as well. Businesses that depend on timber, such as paper mills and lumber companies, experience losses that are often passed along to consumers through higher prices and sometimes jobs are lost. The high cost of responding to and recovering from wildfires can deplete state resources and increase insurance rates. The economic impact of wildfires can also be felt in the tourism industry if roads and tourist attractions are closed due to health and safety concerns.

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

12 Prescription burning, or "controlled burn," undertaken by land management agencies is the process of igniting fires under selected conditions, in accordance with strict parameters.

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.

Structure Fire

According to the National Fire Protection Association (NFPA), any fire in or on a building or other structure is considered a structure fire even if the structure itself was not damaged. Mobile property used as a fixed structure, such as manufactured homes and portable buildings, are considered structures. In general, structure fires occur frequently in the United States and can have serious impacts such as death, injury and economic loss. Although structure fires can be caused by wildfires, in this plan, structure fires are categorized separately as a fires that are typically localized to the built environment and have generally been caused by humans.

The NFPA reports that, in 2018, structure fires that were not related to wildfire caused around $11 billion in property damage in the United States, with an average loss of around $22,244. Among the deadliest of these are fires that occur in nightclubs and other social establishments because they allow large numbers of people to congregate in a single location, thereby making egress difficult in situations where fires occur.

Location and Spatial Extent

The entire county is at risk to a wildfire occurrence. However, several factors such as drought conditions or high levels of fuel on the forest floor, may make a wildfire more likely. Furthermore, areas in the urban-wildland interface are particularly susceptible to fire hazard as populations abut formerly undeveloped areas. The Wildland Urban Interface Risk Index data shown in **Figure 3.4** below gives an indication of areas where there is higher risk to wildfire for people/property in Guilford County.

Figure 3.12: Wildland Urban Interface Risk Index in Guilford County

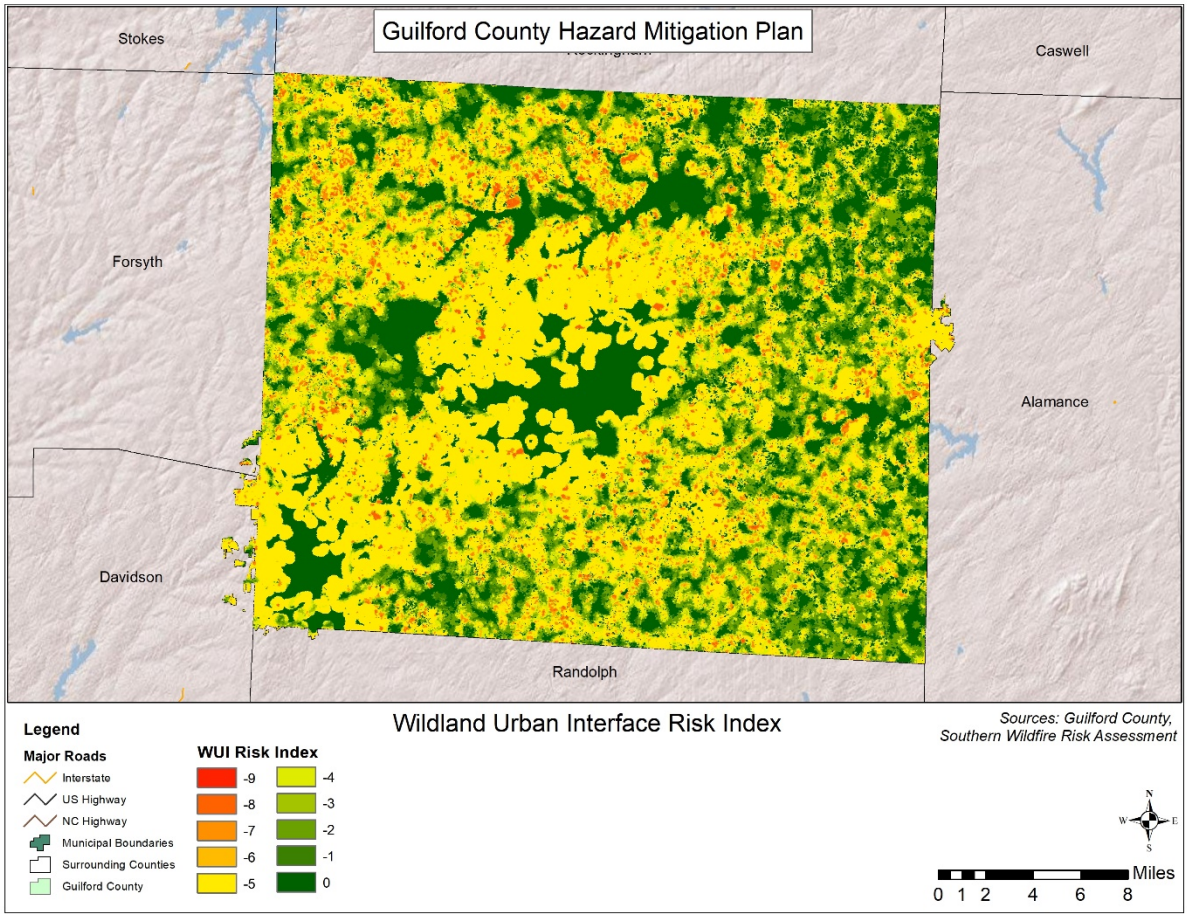
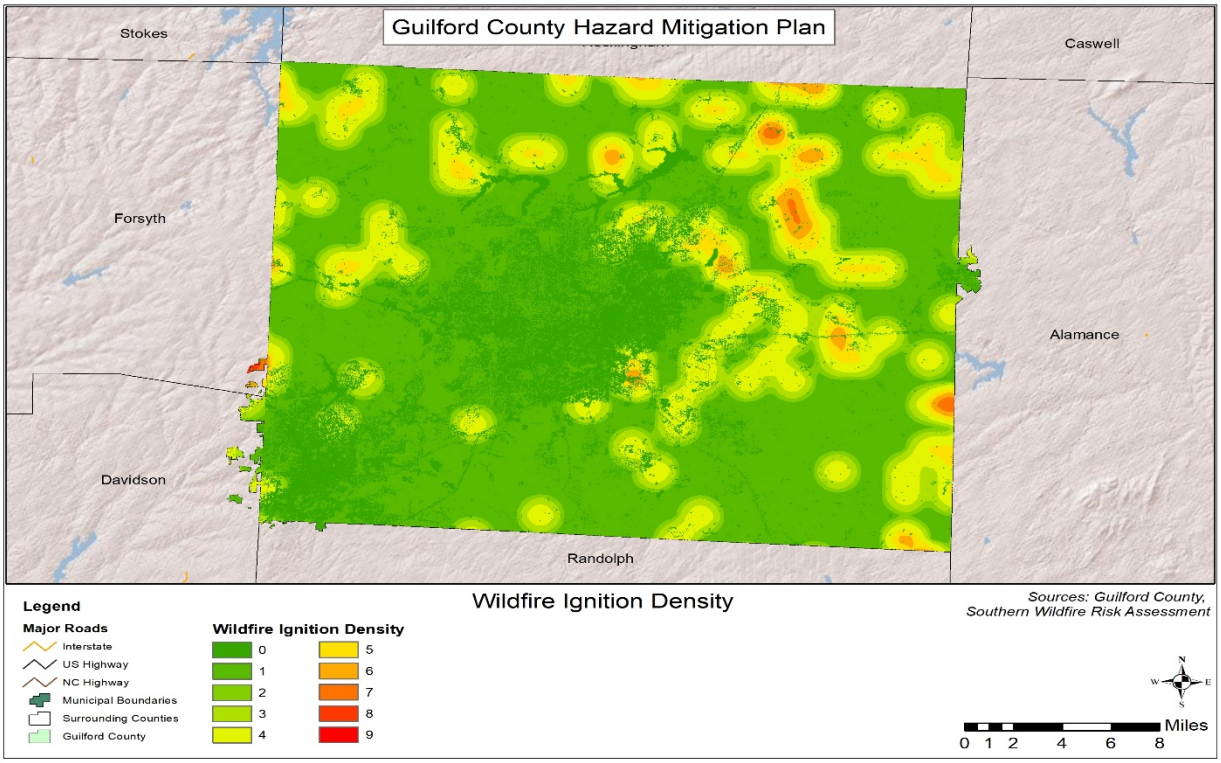


Figure 3.5 shows the Wildfire Ignition Density in Guilford County based on data from the Southern Wildfire Risk Assessment. This data is based on historical fire ignitions and the likelihood of a wildfire igniting in an area. Occurrence is derived by modeling historic wildfire ignition locations to create an average ignition rate map. This is measured in the number of fires per year per 1,000 acres.[13]

[13] Southern Wildfire Risk Assessment, 2014.

FIGURE 3.13: WILDFIRE IGNITION DENSITY IN GUILFORD COUNTY



Structure Fire

Structure fires can occur anywhere within the county because there are structures located throughout the county and all structures are potentially vulnerable to a structure fire. A higher concentration of structure fires typically occurs in areas that are more densely populated because there are more structures in those areas, and therefore a higher likelihood that a fire will occur in any given structure. Therefore, areas in Guilford County with the densest concentration of urban development, such as Greensboro, are likely to be impacted most often by structure fires.

Historical Occurrences

Wildfire

Based on data from the North Carolina Forest Service (NCFS) from 2010 to 2019, Guilford County experienced an average of 65 wildfires annually which burn an average of 40.0 acres per year. The data indicates that most of these fires are small, averaging less than 1 acre per fire. **Table 3.17** lists the number of reported wildfire occurrences in the county between the years 2010 and 2019.

TABLE 3.17: HISTORICAL WILDFIRE OCCURRENCES IN GUILFORD COUNTY

Year	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019*
Guilford County										
Number of Fires	27	61	41	52	139	89	61	88	53	41
Number of Acres	17.6	40.9	36.5	42.4	53.8	58.4	33.6	74.3	23.6	19.1

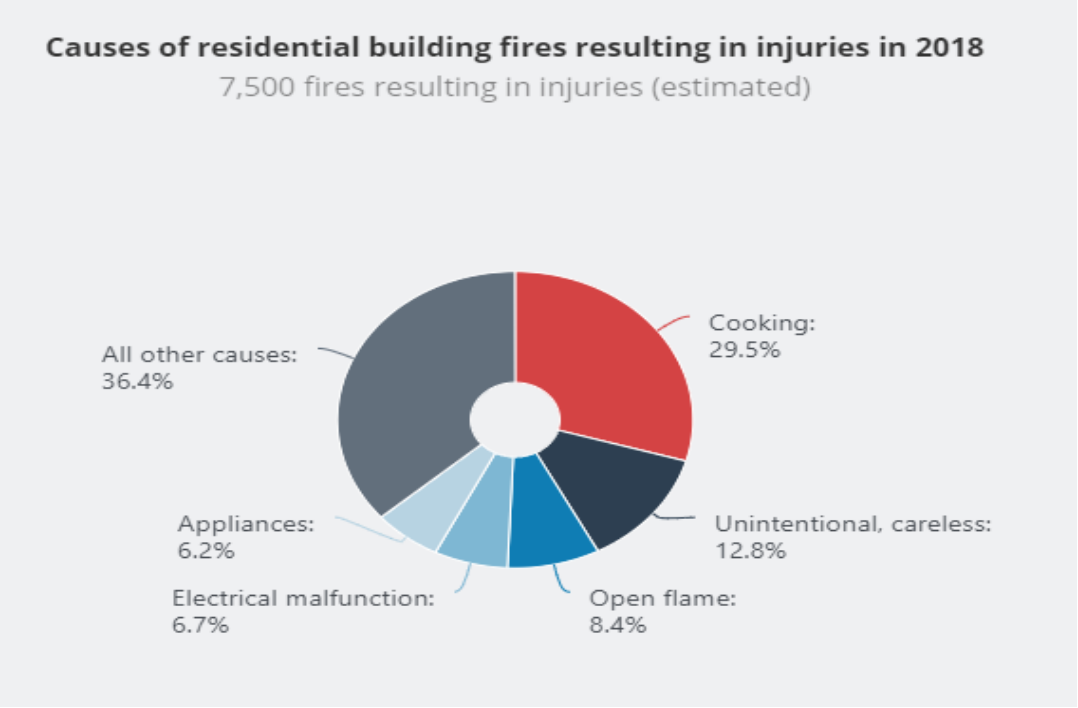
**Through November 2019*
Source: North Carolina Division of Forest Resources

Structure Fire

As mentioned above, structure fires occur frequently throughout the United States and in Guilford County. In 2018, the NFPA reported that there were almost 500,000 structure fires in the United States, causing around $11 billion in damages. These numbers are on par with statistics from previous years as there were no less than 480,000 structure fires in any of the ten years prior to 2018.

Figure 3.6 shows the primary causes of building fires in the United States in 2018. As the figure shows, almost one third of these fires are caused by cooking, which is the highest single-identified cause. It is also notable that the United States Fire Association (USFA) reports that the leading property type for fire deaths is residential. The result of this is that most deaths, injuries, and dollar losses from fires across the country occur in residential fires.

FIGURE 3.3: BUILDING FIRE CAUSES IN THE UNITED STATES

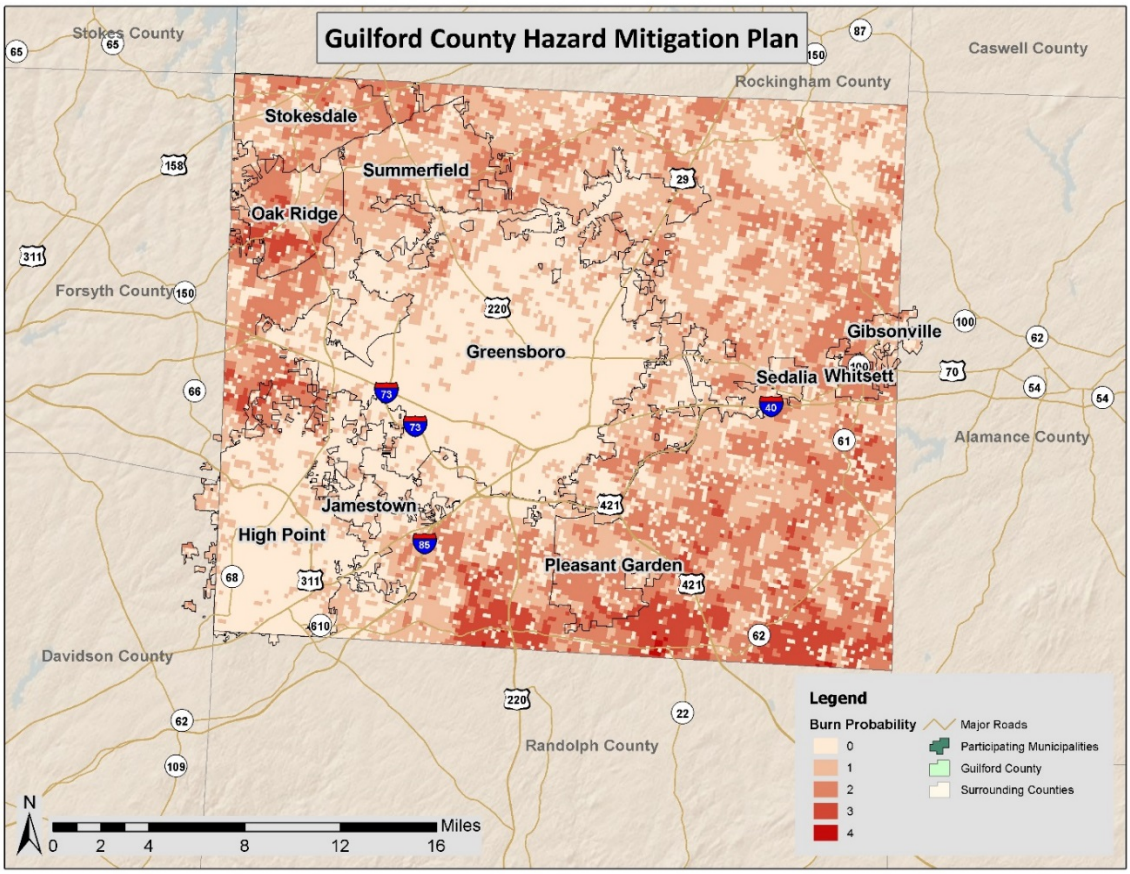


Probability of Future Occurrences

Wildfire

Wildfire events will be an ongoing occurrence in Guilford County. **Figure 3.15** shows that there is some probability a wildfire will occur throughout the county. However, the likelihood of wildfires increases during drought cycles and abnormally dry conditions. Fires are likely to stay small in size but could increase due local climate and ground conditions. Dry, windy conditions with an accumulation of forest floor fuel (potentially due to ice storms or lack of fire) could create conditions for a large fire that spreads quickly. It should also be noted that some areas do vary somewhat in risk. For example, highly developed areas are less susceptible unless they are located near the urban-wildland boundary. The risk will also vary due to assets. Areas in the urban-wildland interface will have much more property at risk, resulting in increased vulnerability and need to mitigate compared to rural, mainly forested areas. The probability assigned to Guilford County for future wildfire events is likely (10 to 100 percent annual probability). Additionally, according to the *Piedmont Together Climate Adaptation Report*, the increased likelihood of wildfire due to climate change will result in greater structural/property damage and decreased air quality in the county.

FIGURE 3.15: BURN PROBABILITY IN GUILFORD COUNTY



Source: Southern Wildfire Risk Assessment

Structure Fire

Structure fires are very common and have occurred frequently in Guilford County in the past. As the county continues to grow, the built environment will expand and there will be more structures that could potentially be impacted by a fire. This will result in more human lives at risk and the potential for costly property damage. The probability of structure fires in the futures remains high and is likely to continue to increase going forward as the county grows.

Consequence Analysis

People (The Public and Public Confidence)

There are a number of potential losses from a wildland fire in Guilford County. Potential losses include human life, structures, and natural resources. Health hazards from smoke caused by wildland fires within or outside the county can include breathing difficulties and worsening of chronic breathing and/or cardiovascular disease. Smoke and air pollution pose a risk for children, the elderly, and those with respiratory and cardiovascular problems. First responders are also at risk for exposure to dangers from the initial incident and after-effects such as smoke inhalation and/or heat stroke. Wildfire tends to create some issues with public confidence because of the very visible impacts that the fire has on the community.

Responders

Responders are often at great risk when addressing fires or wildfire, especially firefighters who are responsible for putting out the blaze. All response personnel are potentially at risk when dealing with a wildfire and often changing winds and a number of other factors can cause a fire to spread rapidly. Although much of Guilford County has been urbanized and is not at a high risk to wildfire, the more rural areas that are located in the wildland urban interface may require response personnel to be ready to act. Like the general public, first responders are also at risk for exposure to dangers from the initial incident and after-effects such as smoke inhalation and/or heat stroke. However, their risk is often more prominent as they are often in the middle of an incident through their responsibilities as a responder.

Continuity of Operations

Since wildfire often moves quickly and can affect infrastructure that is important to maintaining continuity of operations, there is some level of concern for maintaining continuity. However, operations in Guilford County, which are generally run from urbanized areas, will probably not be impacted in a major way.

Built Environment (Property, Facilities, and Infrastructure)

Wildland fires have the potential to substantially burn forested areas as well as private residences. Damage and destruction to State, county, private, and municipal structures and facilities are major losses that are attributed to wildland fires. Private residences and communities that are located within the WUI are particularly susceptible to the threat. Population

increases in North Carolina's WUI areas, for example, can create significant challenges for firefighters and residents.

Many new homes are constructed without considering community wildland fire planning. This creates neighborhoods with limited accessibility, flammable building construction, and landscaping. A lack of firewise planning can also greatly increase the probability of a wildland fire occurrence with more homes and emergency personnel being threatened.

Impacts to agricultural crops are other direct property losses that Guilford County could face in the event of a wildland fire. Some structural losses that might result include private property. These include business properties and homes, vehicles, and livestock. Damage to capital goods and equipment as well as evacuation expenses and other losses are directly related to fire and smoke damage. Additional potential losses include building and landscape maintenance expenses, firefighting equipment purchases, and fire-related business closures. Additional post-fire losses include cleanup, rehabilitation and repair expenses, equipment and capital goods replacement, drinking water pollution, smoke damage, deflated real estate values, and an increase in fire insurance premiums.

Economy

Given the fact that some homes, businesses, and infrastructure are located in areas that could be impacted by wildfire, there could be some significant economic impacts of a wildfire in Guilford County. If homes or businesses are burned, the cost of rebuilding could be substantial. Impacts to agricultural crops are another economic loss that the state could face in the event of a wildland fire. Wildfires can be particularly damaging to the lumber and Christmas tree farming industries which are important to the state in general and may impact Guilford County.

Environment

Wildland fires have the potential to damage or destroy forage on grazing lands, secondary forest products destruction, and/or degradation and loss of wildlife habitat on public lands. On private lands, vegetation losses could include agricultural crops that are either burned or impacted by wildland fire smoke. Indirect losses could include loss of growing stock as well as irrigation systems. Another potential loss includes damage and destruction to a wide variety of common or protected habitats in Guilford County. Finally, the release of smoke from wildfires can pollute the air and reduce air quality.

Additional factors that contribute to wildland fire susceptibility in Guilford County include long growing seasons with frequent rainfall and wind, which can significantly affect vegetation growth.

It should also be noted, however, that wildfires are a naturally occurring element of the environment and have played an important part in the development of many ecosystems in that they are regenerative and provide vital nutrients for the soil which can help sustain a forest habitat and all of the organisms living within it. Therefore, although there are some negative impacts of wildfire, there are also some positive impacts on the environment.

Flooding

Background

Flooding is the most frequent and costly natural hazard in the United States and is a hazard that has caused more than 10,000 deaths since 1900. Nearly 90 percent of presidential disaster declarations result from natural events where flooding was a major component.

Floods generally result from excessive precipitation and can be classified under two categories: general floods, precipitation over a given river basin for a long period of time along with storm-induced wave action, 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 typically determined by a combination of several major factors, including stream and river basin topography and physiography, precipitation and weather patterns, recent soil moisture conditions, and the degree of vegetative clearing and impervious surface.

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, and other large coastal storms. Urban flooding occurs where manmade 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 may also occur from a dam or levee failure within minutes or hours of heavy amounts of rainfall or from a sudden release of water held by a retention basin or other stormwater control facility. Although flash flooding occurs most often along mountain streams, it is also common in urbanized areas where much of the ground is covered by impervious surfaces.

The periodic flooding of lands adjacent to rivers, streams, and shorelines (land known as a 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 and the 500-year flood has a 0.2 percent chance of occurring in any given year.

Location and Spatial Extent

Special flood hazard areas in Guilford County were mapped using Geographic Information System (GIS) and FEMA Digital Flood Insurance Rate Maps (DFIRM).[14] This includes Zone A (1-percent annual chance floodplain), Zone AE (1-percent annual chance floodplain with elevation) and Zone X500 (0.2-percent annual chance floodplain). According to GIS analysis, of the 657.6 square miles of land that make up Guilford County, there are 41.3 square miles of land in zone A and AE (1-percent annual chance floodplain/100-year floodplain) and 5.1 square miles of land in zone X500 (0.2-percent annual chance floodplain/500-year floodplain). The county totals are presented below in **Table 3.18**.

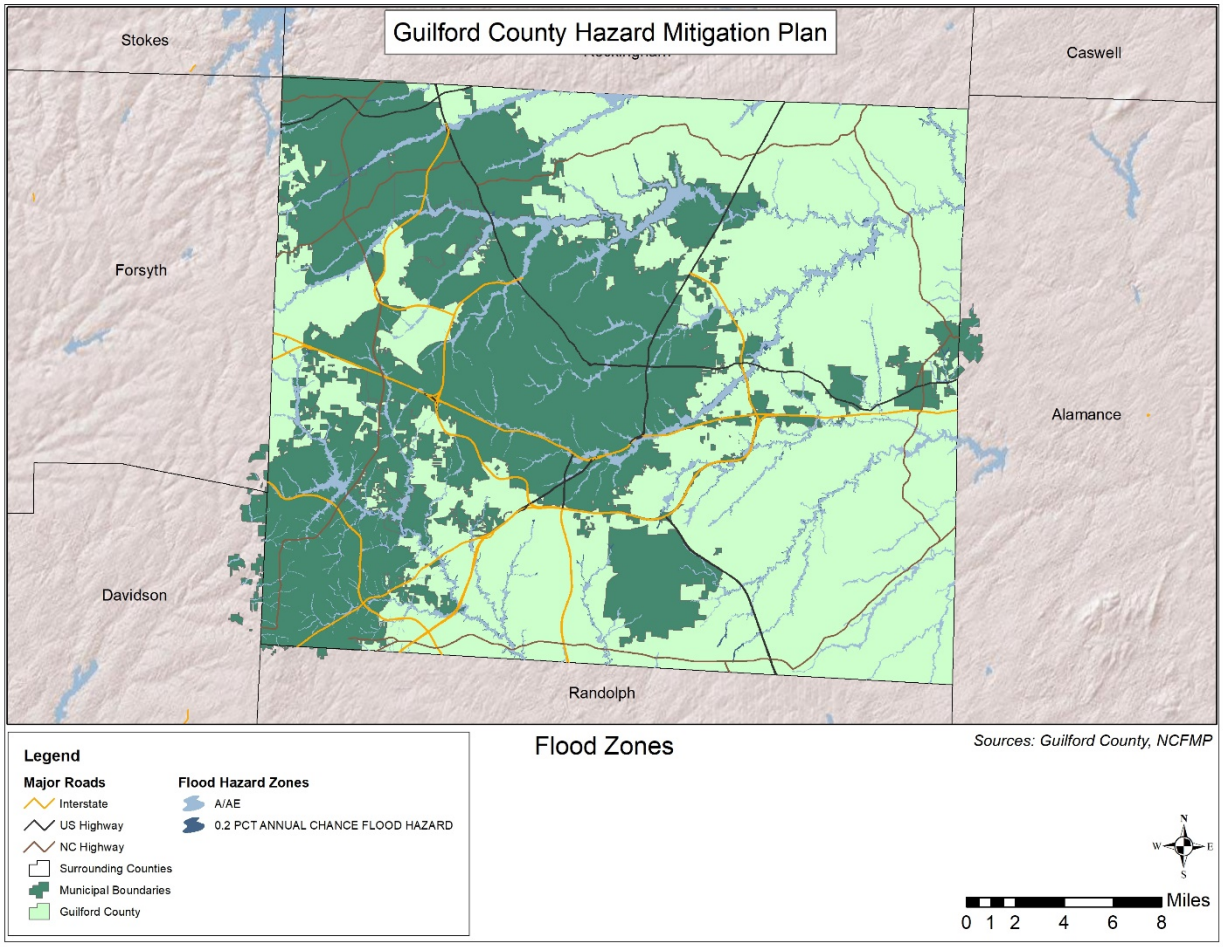
TABLE 3.18: SUMMARY OF FLOODPLAIN AREAS IN GUILFORD COUNTY

Location	100-year area (square miles)	500-year area (square miles)
Gibsonville	0.5	0.0
Greensboro	15.3	1.0
High Point	6.0	0.5
Jamestown	0.9	0.1
Oak Ridge	1.5	0.3
Pleasant Garden	0.4	0.1
Sedalia	0.1	0.0
Stokesdale	1.0	0.2
Summerfield	2.7	0.3
Whitsett	0.0	0.0
Unincorporated Area	12.9	2.6
GUILFORD COUNTY TOTAL	**41.3**	**5.1**

These flood zone values account for 7.1 percent of the total land area in Guilford County. It is important to note that while FEMA digital flood data is recognized as best available data for planning purposes, it does not always reflect the most accurate and up-to-date flood risk. Flooding and flood-related losses often do occur outside of delineated special flood hazard areas. **Figure 3.16** illustrate the location and extent of currently mapped special flood hazard areas for Guilford County and its municipalities based on best available NCFMP/FEMA DFIRM data.

[14] The county-level DFIRM used for Guilford County was updated in 2009.

FIGURE 3.16: SPECIAL FLOOD HAZARD AREAS IN GUILFORD COUNTY



Source: Federal Emergency Management Agency

Historical Occurrences

Information from the National Centers for Environmental Information was used to ascertain historical flood events. The National Centers for Environmental Information reported a total of 73 events throughout Guilford County since 1996.[15] A summary of these events is presented in **Table 3.19**. These events accounted for over $2.6 million (2014 dollars) in property damage throughout the county and 1 death.[16] Specific information on flood events for each jurisdiction, including date, type of flooding, and deaths and injuries, can be found in **Table 3.20**.

[15] These flood events are only inclusive of those reported by the National Climatic Data Center (NCDC) from 1996 through August 2014. It is likely that additional occurrences have occurred and have gone unreported in Guilford County.
[16] Adjusted dollar values were calculated based on the average Consumer Price Index for a given calendar year. This index value has been calculated every year since 1913. For 2014, the October 2014 monthly index was used.

TABLE 3.19: SUMMARY OF FLOOD OCCURRENCES IN GUILFORD COUNTY

Location	Number of Occurrences	Deaths / Injuries	Property Damage (2014)	Annualized Property Loss
Gibsonville	0	0/0	$0	$0
Greensboro	26	1/0	$2,391,245	$66,438,818
High Point	11	0/0	$570,591	$1,307,473
Jamestown	1	0/0	$0	$0
Oak Ridge	2	0/0	$0	$0
Pleasant Garden	2	0/0	$0	$0
Sedalia	0	0/0	$0	$0
Stokesdale	0	0/0	$0	$0
Summerfield	6	0/0	$0	$0
Whitsett	0	0/0	$0	$0
Unincorporated Area	44	0/0	$15,813,140	$148,870
GUILFORD COUNTY TOTAL	**92**	**1/0**	**$18,7774,976**	**$67,895,161**

Source: National Climatic Data Center

TABLE 3.20: HISTORICAL FLOOD OCCURRENCES IN GUILFORD COUNTY

	Date	Type	Deaths / Injuries	Property Damage*
Gibsonville				
None Reported	--	--	--	--
Greensboro				
GREENSBORO	7/25/1996	Flash Flood	0/0	$0
GREENSBORO	6/19/2000	Flash Flood	0/0	$0
GREENSBORO	8/27/2000	Flash Flood	0/0	$0
GREENSBORO	8/28/2000	Flash Flood	0/0	$0
GREENSBORO	9/1/2000	Flash Flood	0/0	$0

	Date	Type	Deaths / Injuries	Property Damage*
GREENSBORO	7/4/2001	Flash Flood	0/0	$0
GREENSBORO	8/17/2003	Flash Flood	0/0	$16,647
GREENSBORO	8/31/2003	Flash Flood	0/0	$0
GREENSBORO	9/23/2003	Flash Flood	0/0	$0
GREENSBORO	7/17/2004	Flash Flood	0/0	$0
GREENSBORO	9/8/2004	Flash Flood	0/0	$0
GREENSBORO	9/27/2004	Flash Flood	0/0	$0
GREENSBORO	12/10/2004	Flash Flood	0/0	$0
GREENSBORO	6/14/2006	Flash Flood	0/0	$0
GREENSBORO	8/30/2006	Flash Flood	0/0	$0
GREENSBORO	4/15/2007	Flash Flood	0/0	$0
GREENSBORO	6/27/2007	Flash Flood	0/0	$0
GREENSBORO	6/27/2007	Flash Flood	0/0	$0
GREENSBORO	6/27/2007	Flash Flood	0/0	$0
GREENSBORO	6/3/2009	Flash Flood	1/0	$2,374,597
GREENSBORO	11/12/2009	Flash Flood	0/0	$0
GREENSBORO	1/25/2010	Flash Flood	0/0	$0
GREENSBORO	7/13/2010	Flash Flood	0/0	$0
GREENSBORO	8/11/2010	Flash Flood	0/0	$0
GREENSBORO	5/21/2016	Flash Flood	0/0	$0
High Point				
HIGH PT	7/25/1996	Flash Flood	0/0	$0
HIGH POINT	9/3/1996	Flash Flood	0/0	$32,458
HIGH PT	4/17/1998	Flood	0/0	$0
HIGH PT	9/18/2002	Flash Flood	0/0	$0
HIGH PT	6/23/2006	Flash Flood	0/0	$0
HIGH PT	6/23/2006	Flash Flood	0/0	$0

	Date	Type	Deaths / Injuries	Property Damage*
HIGH PT	6/27/2006	Flash Flood	0/0	$0
HIGH PT	8/30/2006	Flash Flood	0/0	$0
HIGH PT	9/30/2010	Flash Flood	0/0	$0
HIGH POINT	9/29/2015	Flood	0/0	$538,133
HIGH POINT	5/23/2018	Flash Flood	0/0	$0
Jamestown				
JAMESTOWN	9/30/2010	Flash Flood	0/0	$0
Oak Ridge				
OAK RIDGE	9/14/2000	Flash Flood	0/0	$0
OAK RIDGE ARPT	8/17/2013	Flash Flood	0/0	$0
Pleasant Garden				
PLEASANT GARDEN	9/3/2012	Flash Flood	0/0	$0
PLEASANT GARDEN	6/27/2015	Flash Flood	0/0	$0
Sedalia				
None Reported	--	--	--	--
Stokesdale				
None Reported	--	--	--	--
Summerfield				
SUMMERFIELD	7/13/2003	Flash Flood	0/0	$0
SUMMERFIELD	7/30/2007	Flash Flood	0/0	$0
SUMMERFIELD	7/30/2007	Flash Flood	0/0	$0
SUMMERFIELD	7/30/2007	Flash Flood	0/0	$0
SUMMERFIELD	1/25/2010	Flash Flood	0/0	$0
SUMMERFIELD	11/12/2018	Flash Flood	0/0	$0
Whitsett				
None Reported	--	--	--	--

	Date	Type	Deaths / Injuries	Property Damage*
Unincorporated Area				
SE PTN	4/28/1997	Flash Flood	0/0	$0
WEST PORTION	2/22/2003	Flash Flood	0/0	$0
GUILFORD (ZONE)	3/20/2003	Flood	0/0	$0
GUILFORD (ZONE)	4/10/2003	Flood	0/0	$0
CLIMAX	8/4/2003	Flash Flood	0/0	$0
GUILFORD	6/23/2006	Flash Flood	0/0	$0
TERRA COTTA	6/22/2008	Flash Flood	0/0	$0
(GSO)GREENSBORO RGNL	8/27/2008	Flash Flood	0/0	$35,067
GREENSBORO MAY ARPT	8/27/2008	Flash Flood	0/0	$175,337
HAMILTON LAKES	11/11/2009	Flash Flood	0/0	$0
RANKIN	1/25/2010	Flash Flood	0/0	$0
HAMILTON LAKES	6/16/2010	Flash Flood	0/0	$0
TERRA COTTA	7/27/2010	Flash Flood	0/0	$0
FOUR MILE	9/30/2010	Flash Flood	0/0	$0
DEEP RIVER	9/30/2010	Flash Flood	0/0	$0
BESSEMER	6/11/2011	Flash Flood	0/0	$0
GUILFORD CO.	6/11/2011	Flash Flood	0/0	$0
GREENSBORO MAY ARPT	6/28/2011	Flash Flood	0/0	$0
GUILFORD CO.	6/28/2011	Flash Flood	0/0	$0
BESSEMER	7/8/2011	Flash Flood	0/0	$0
BESSEMER	9/6/2011	Flash Flood	0/0	$0
TERRA COTTA	9/23/2011	Flash Flood	0/0	$0
BATTLE GROUND	6/22/2012	Flash Flood	0/0	$0
HAMILTON LAKES	7/9/2012	Flash Flood	0/0	$111,780
TERRA COTTA	8/19/2012	Flash Flood	0/0	$0
RANKIN	8/22/2012	Flash Flood	0/0	$0

	Date	Type	Deaths / Injuries	Property Damage*
PINECROFT	9/3/2012	Flash Flood	0/0	$0
HAMILTON LAKES	6/10/2013	Flash Flood	0/0	$0
BROADVIEW	6/25/2013	Flash Flood	0/0	$0
GUILFORD	7/10/2013	Flash Flood	0/0	$54,815
BROADVIEW	7/21/2013	Flash Flood	0/0	$21,926
HAMILTON LAKES	8/6/2015	Flash Flood	0/0	$0
HAMILTON LAKES	8/6/2015	Flash Flood	0/0	$0
HAMILTON LAKES	12/30/2015	Flash Flood	0/0	$0
GUILFORD	7/16/2016	Flash Flood	0/0	$0
BATTLE GROUND	8/5/2016	Flash Flood	0/0	$0
GUILFORD	8/27/2016	Flash Flood	0/0	$0
GUILQUARRY	10/8/2016	Flash Flood	0/0	$0
SEDGEFIELD	6/19/2017	Flash Flood	0/0	$5,227
GUILQUARRY	8/2/2018	Flash Flood	0/0	$10,157
DEEP RIVER	8/2/2018	Flash Flood	0/0	$50,782
BROADVIEW	9/1/2018	Flash Flood	0/0	$0
GUILQUARRY	9/17/2018	Flash Flood	0/0	$0
GUILFORD CO.	9/17/2018	Flood	0/0	$14,841,708
GUILQUARRY	10/11/2018	Flash Flood	0/0	$506,341

*Property damage is reported in 2019 dollars; All damage may not have been reported.

Source: National Climatic Data Center

Historical Summary of Insured Flood Losses

According to FEMA flood insurance policy records as of March 2019, there have been 372 flood losses reported in Guilford County through the National Flood Insurance Program (NFIP) since 1978, totaling over $4.9 million in claims payments. A summary of these figures for each jurisdiction is provided in **Table 3.21**. It should be emphasized that these numbers include only those losses to structures that were insured through the NFIP policies, and the payments columns

only include instances in which claims were received . It is likely that many additional instances of flood loss in Guilford County were either uninsured, denied claims payment, or not reported.

TABLE 3.21: SUMMARY OF INSURED FLOOD LOSSES IN GUILFORD COUNTY

Location	Number of Flood Claims	Building Claims Payments ($)	Contents Claims Payments ($)
Gibsonville	5	$56,566	$17,110
Greensboro	439	$4,973,510	$816,310
High Point	86	$271,713	$15,538
Jamestown	3	$47,298	$4,321
Oak Ridge	1	$13,230	$4,720
Pleasant Garden	2	$0	$0
Sedalia	0	$0	$0
Stokesdale	0	$0	$0
Summerfield	0	$0	$0
Whitsett	2	$19,124	$6,452
Unincorporated Area	38	$300,355	$17,638
GUILFORD COUNTY TOTAL	**576**	**$5,681,796**	**$882,089**

Source: Federal Emergency Management Agency, National Flood Insurance Program

Repetitive and Severe Repetitive Loss Properties

FEMA defines a Repetitive Loss (RL) property is any insurable building for which two or more claims of more than $1,000 were paid by the National Flood Insurance Program (NFIP) within any rolling ten-year period, since 1978. A RL property may or may not be currently insured by the NFIP.

Severe repetitive loss properties are defined as any insurable building for which: 1) four or more claims of more than $5,000, with the cumulative amount of such claims exceeding $20,000, were paid by the NFIP or 2) at least two claims exceeding the market value of the structure were paid by the NFIP, since 1978. A severe repetitive loss property may or may not be currently insured by the NFIP.

As of January 2019, there are 54 repetitive loss properties and 11 severe repetitive loss properties located in Guilford County, which accounted for over 300 losses and over $7 million in claims

payments under the NFIP. Most of the properties are single-family residential buildings, and the remaining are a mix of other residential and commercial properties. **Table 3.22** and **Table 3.23** presents detailed information on repetitive and severe repetitive loss properties and NFIP claims for Guilford County.

TABLE 3.22: SUMMARY OF REPETITIVE LOSS PROPERTIES IN GUILFORD COUNTY

Location	Number of Properties	Types of Properties	Number of Losses	Building Payments	Content Payments	Total Payments	Average Payment
Gibsonville	1	1 single-family residential	2	$13,065	$1,111	$14,177	$7,089
Greensboro	49	30 single-family residential; 11 other residential; 2 condo; 6 commercial	205	$3,910,497	$565,811	$4,476,308	$21,836
High Point	0	--	0	$0	$0	$0	$0
Jamestown	0	--	0	$0	$0	$0	$0
Oak Ridge	0	--	0	$0	$0	$0	$0
Pleasant Garden	0	--	0	$0	$0	$0	$0
Sedalia	0	--	0	$0	$0	$0	$0
Stokesdale	0	--	0	$0	$0	$0	$0
Summerfield	0	--	0	$0	$0	$0	$0
Whitsett	0	--	0	$0	$0	$0	$0
Unincorporated Area	4	4 single-family residential	17	$243,077	$27,905	$270,982	$1,322
GUILFORD COUNTY TOTAL	**54**		**224**	**$4,166,639**	**$594,828**	**$4,761,466**	**$23,227**

Source: National Flood Insurance Program

TABLE 3.23: SUMMARY OF SEVERE REPETITIVE LOSS PROPERTIES IN GUILFORD COUNTY

Location	Number of Properties	Types of Properties	Number of Losses	Building Payments	Content Payments	Total Payments	Average Payment
Gibsonville	0	--	0	$0	$0	$0	$0
Greensboro	11	5 single-family residential; 6 other residential	72	$2,447,857	$25,184	$2,473,040	$34,348
High Point	0	--	0	$0	$0	$0	$0
Jamestown	0	--	0	$0	$0	$0	$0
Oak Ridge	0	--	0	$0	$0	$0	$0
Pleasant Garden	0	--	0	$0	$0	$0	$0
Sedalia	0	--	0	$0	$0	$0	$0
Stokesdale	0	--	0	$0	$0	$0	$0
Summerfield	0	--	0	$0	$0	$0	$0
Whitsett	0	--	0	$0	$0	$0	$0
Unincorporated Area	0	--	0	$0	$0	$0	$0
GUILFORD COUNTY TOTAL	**11**		**72**	**$2,447,857**	**$25,184**	**$2,473,040**	**$34,348**

Source*: National Flood Insurance Program*

FIMAN Gage Data

North Carolina Emergency Management has developed a statewide website that is at the forefront of the field called the Flood Inundation Mapping and Alert Network (FIMAN). The goal of the site is to provide rain and stage gage data, flood inundation maps, flooding impacts and alerts in real-time to support risk-based decisions regarding flooding.

The site provides a clearinghouse for more than 500 gages across the state and pulls data from gages that are owned and operated at all levels of government. Many are managed by NCEM, while others are operated by USGS, local governments, and private organizations.

One of the key components that the site provides in terms of planning is the inundation mapping at gage sites. Using historic gage data and elevation data, inundation maps have been created around many gage sites and can show the impacts on buildings, roads, and infrastructure from various incremental rises in flood waters. **Table 3.24** presents information on several gages, but additional detailed data is available on the FIMAN website: https://fiman.nc.gov/. **Figure 3.7** shows an example of how the platform looks for the inundation mapping from the South Buffalo Creek near Pomona gage in Greensboro.

TABLE 3.24: FIMAN GAGES WITH INUNDATION MAPPING IN GUILFORD COUNTY

Location	Maximum Historic Gage Height (ft)	FIMAN Scenario #1 Stage (ft)	FIMAN Scenario #1 Elevation (NAVD 88)	FIMAN Scenario #1 Number of Buildings Damaged	FIMAN Scenario #2 Stage (ft)	FIMAN Scenario #2 Elevation (NAVD 88)	FIMAN Scenario #2 Number of Buildings Damaged
South Buffalo Creek near Pomona	15.45	15.4	786.5	17	18.9	790.0	42
South Buffalo Creek at US 220 near Greensboro	16.77	16.7	738.0	2	23.7	745.0	32
N Buffalo Creek at Westover Terrace at Greensboro	14.07	14.0	749.5	8	16.5	752.0	29
N Buffalo Creek at Church St at Greensboro	17.81	17.5	734.5	14	31.5	748.5	165

Source: NC FIMAN

Figure 3.17: Inundation Mapping at the South Buffalo Creek near Pomona Gage (Stage Level 15.4 ft)

Source: NC FIMAN

Dam Failures

A dam failure is a special consideration as it relates to flood risk. Many of the impacts of a dam failure would be similar to those of a major flood event, but may include some distinctions, particularly the velocity of the flood waters.

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. The failure of a dam has the potential to place large numbers of people and great amounts of property in harm's way.

The North Carolina Department of Environmental Quality provides information on dams, including a hazard potential classification. There are three hazard classifications—high, intermediate, and low—that correspond to qualitative descriptions and quantitative guidelines. **Table 3.25** explains these classifications. It should be noted that these classifications do not pertain to the condition of the dam, only the potential impact that the dam would have if it were to fail. So, a high hazard dam is not more likely to fail or breach than a low hazard dam, but its impacts if it were to fail would potentially be greater.

TABLE 3.25: NORTH CAROLINA DAM HAZARD CLASSIFICATIONS

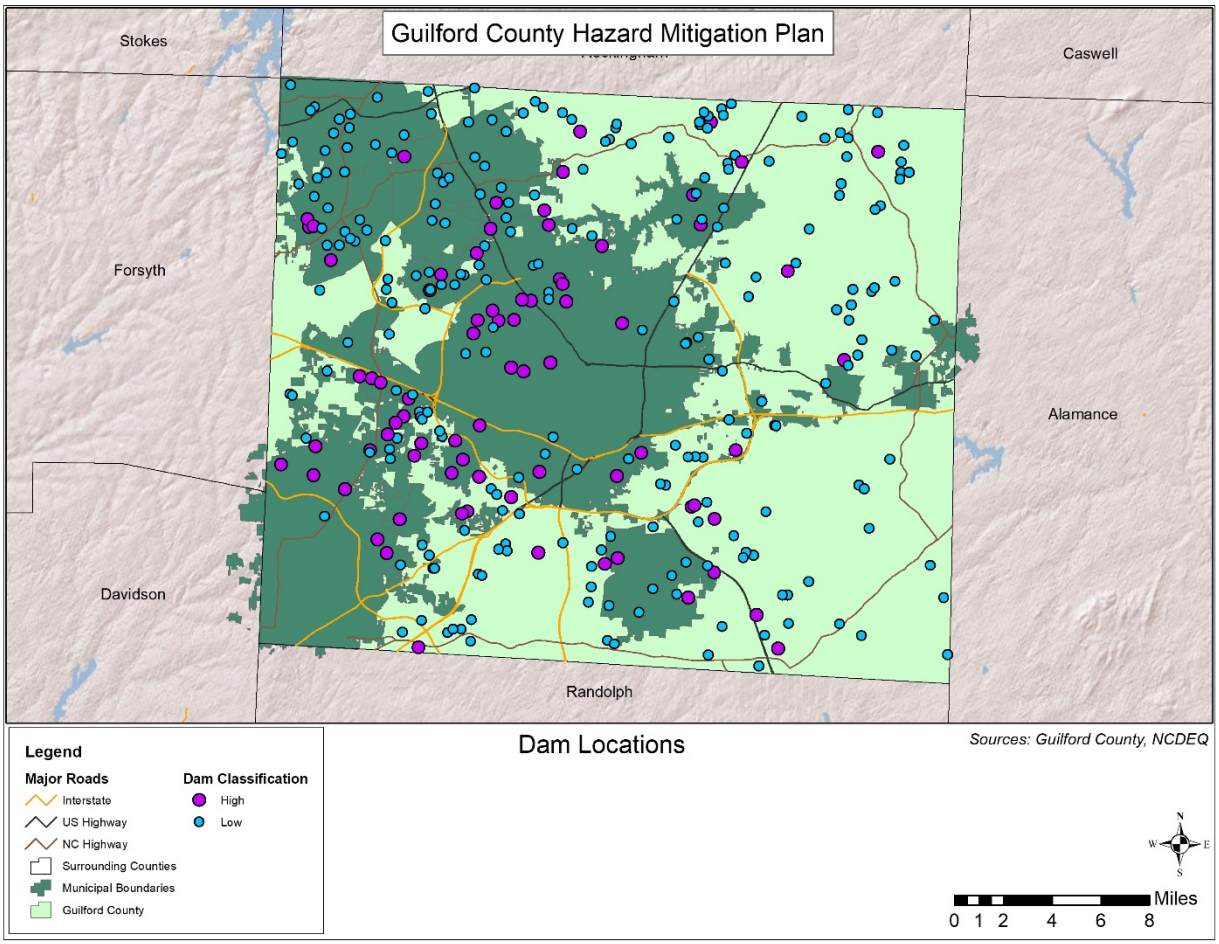
Hazard Classification	Description	Quantitative Guidelines
Low	Damage to low volume roads, Interruption of service	Less than 25 vehicles per day
	Economic damage	Less than $30,000
Intermediate	Damage to primary roads, Interruption of service	25 but less than 250 vehicles per day
	Economic damage	$30,000 to less than $200,000
High	Damage to highways/major roads, Interruption of service	More than 250 vehicles per day
	Economic damage	More than $200,000
	Loss of human life	Probable loss of 1 or more human lives

Source: North Carolina Department of Environmental Quality

According to the North Carolina Department of Environmental Quality, there are 320 dams in Guilford County.[17] **Figure 3.8** shows the dam location and the corresponding hazard ranking for each. Of these dams, 76 are classified as high hazard potential, none as intermediate hazard potential, and 244 as low hazard potential.

[17] The latest update to the North Carolina dam inventory, dated July 16, 2018, was retrieved from the North Carolina Department of Environmental Quality on October 30, 2019: https://deq.nc.gov/about/divisions/energy-mineral-land-resources/energy-mineral-land-permits/dam-safety .

Figure 3.4: Dam Location and Hazard Classification



Source: North Carolina Department of Environmental Quality, 2018

Probability of Future Occurrences

Flood events will remain a threat in Guilford County, and the probability of future occurrences will remain highly likely (100 percent annual probability). The probability of future flood events based on magnitude and according to best available data is illustrated in the figure above, which indicates those areas susceptible to the 1-percent annual chance flood (100-year floodplain) and the 0.2-percent annual chance flood (500-year floodplain). Additionally, according to the *Piedmont Together Climate Adaptation Report*, the increased likelihood of extreme participation events due to climate change will result in greater risks of flash flooding and impacts from storm water runoff in the county.

It can be inferred from the floodplain location maps, previous occurrences, and severe repetitive loss properties that risk varies throughout Guilford County. For example, Greensboro has more

floodplain and thus a higher risk of flood than the other municipalities. Mitigation actions may be warranted, particularly for severe repetitive loss properties.

Consequence Analysis

People (The Public and Public Confidence)

During flood events, people are often stranded and have to be rescued by first responders. Often lives are lost or people are injured. Even when injuries and fatalities are avoided, the impact on the public can be great as many people will be forced into shelters or will need to find temporary lodging as they wait for flooding to recede. They may be unable to return to their homes if the damage is great and may find their homes uninhabitable if personal property has become waterlogged and is unusable.

Another major impact on the public can be the deteriorating health conditions that result from flooding. After floodwaters recede, homes and personal property that were covered in water may begin to become infested with mold which can create serious health risks. Additionally, waterborne diseases can be pervasive in areas impacted by flooded sewer and water systems. Mosquitoes and other carriers of illnesses often thrive in post-flood conditions, increasing the chances of transmitting vector-borne diseases.

Public confidence is often impacted by flood events, especially when impacted people do not have flood insurance and are not covered by their home insurance policy. This can create public relations issues for the government and a loss of public confidence..

Responders

Responders are often affected by flooding because floods can trap people in their homes or in other locations, forcing responders to put their lives at risk to return members of the public to safety. Often responders in flood situations face blocked roads and have difficulty safely protecting citizens. Water rescues can be some of the most dangerous as rapidly moving flood waters are difficult to navigate. Rescuers are typically at high risk to loss of life or personal injury during flood events, especially compared to other types of natural hazards.

Continuity of Operations

Flooding can impact continuity of operations by knocking out power sources and preventing emergency management personnel from being able to do their jobs properly. Floods typically have some impact on continuity of operations as they can cause severe disruption to normal operations and have done so in the past in Guilford County. Operations would be most impacted at a localized level as areas that are flooded would experience the most disruption to normal operations.

Built Environment (Property, Facilities, and Infrastructure)

Many buildings and structures could be impacted by a flood event, but critical infrastructure and key resources (CIKR) within the county are especially important to identify. When these facilities are located in flood-prone areas, there is a substantial risk to important functions of government

such as law enforcement and medical care. This also includes any assets, systems, and networks that are vital to the continued operation of government services such as power generation facilities, transmission infrastructure, and road networks, among others. The incapacitation or destruction of these resources would have a debilitating and costly effect on many aspects of the state's normal functionality.

Often, in the case of flooding, water and wastewater infrastructure are some of the most prominently impacted. Since these types of infrastructure deal directly with water, often they are located in the most flood prone areas and are severely impacted during flood events. When these facilities or infrastructure are flooded, it complicates recovery and impacts people who are unable to utilize normal water sources for drinking, sanitation, and other everyday uses.

In addition, personal property such as homes and businesses have been impacted to a large degree by past flooding events and are a major concern in future flooding events. Although a great deal of effort has been undertaken to reduce the number of properties at risk through the use of progressively improved risk assessment and mitigation techniques, there are still a significant number of structures throughout the county which are located in flood zones or which have not been properly mitigated to reduce risk. These properties may sustain significant costs due to damage during future flood events and are often a major focus of post-disaster recovery efforts.

Economy

There are a variety of economic impacts that could result from a large-scale flood event. One major impact is on soil that is covered by flood waters, causing the rapid depletion of oxygen, which is essential for plant growth and development. This can hurt agricultural production in areas where that is a key economic driver. Secondly, flooding often causes the shutdown of businesses, many of which never re-open after a flood event. Indeed, FEMA reports that almost 40 percent of small businesses never reopen their doors after a disaster because only small amounts of flood waters can cause thousands of dollars of damage.[18] The shutdown of these small businesses in many communities can be devastating as many communities rely heavily on these small businesses as economic drivers and the base of the local economy.

Environment

The fluctuation of water levels in a wetland, especially flood waters, supports the biological diversity of low-lying areas by releasing nutrients into the soil and germinating wetland flora. Flooding also offers some control of invasive water weeds. Most features of the environment have come to adapt to the effects of a flood event and respond quickly, although it is possible that some species may not be resilient enough to survive and will experience population loss.

[18] FEMA. (2017). *Protecting Your Businesses*. Retrieved October9, 2019, from https://www.fema.gov/protecting-your-businesses

However, areas that have been modified by human activity tend to suffer more negative consequences from flooding which can result from modifying stream banks or removing vegetation from riverside. When these modifications are present, flooding can cause unnatural erosion of sediment into the waterway and create an imbalance of nutrients in the water which may harm ecosystems and have a negative impact on downstream water quality.[19]

Hail

Background

Hailstorms are a potentially damaging outgrowth of severe thunderstorms. Early in the developmental stages of a hailstorm, ice crystals form within a low-pressure front due to the rapid rising of warm air into the upper atmosphere and the subsequent cooling of the air mass. Frozen droplets gradually accumulate on the ice crystals until they develop to a sufficient weight and fall as precipitation. Hail typically takes the form of spheres or irregularly-shaped masses greater than 0.75 inches in diameter. The size of hailstones is a direct function of the size and severity of the storm. High velocity updraft winds are required to keep hail in suspension in thunderclouds. The strength of the updraft is a function of the intensity of heating at the Earth's surface. Higher temperature gradients relative to elevation above the surface result in increased suspension time and hailstone size. **Table 3.26** shows the TORRO Hailstorm Intensity Scale which is a way of measuring hail severity.

TABLE 3.26: TORRO HAILSTORM INTENSITY SCALE

	Intensity Category	Typical Hail Diameter (mm)*	Probable Kinetic Energy, J-m^2	mm to inch conversion (inches)	Typical Damage Impacts
H0	Hard Hail	5	0-20	0 - 0.2	No damage
H1	Potentially Damaging	5-**15**	>20	0.2 - 0.6	Slight general damage to plants, crops
H2	Significant	10-**20**	>100	0.4 - 0.8	Significant damage to fruit, crops, vegetation
H3	Severe	20-**30**	>300	0.8 - 1.2	Severe damage to fruit and crops, damage to glass and plastic structures, paint and wood scored

[19] Office of the Queensland Australia Chief Scientist (2017). *What are the consequences of floods?* Retrieved October 9, 2019, from: http://www.chiefscientist.qld.gov.au/publications/understanding-floods/flood-consequences

	Intensity Category	Typical Hail Diameter (mm)*	Probable Kinetic Energy, J-m^2	mm to inch conversion (inches)	Typical Damage Impacts
H4	Severe	25-**40**	>500	1.0 - 1.6	Widespread glass damage, vehicle bodywork damage
H5	Destructive	30-**50**	>800	1.2 - 2.0	Wholesale destruction of glass, damage to tiled roofs, significant risk of injuries
H6	Destructive	40-**60**		1.6 - 2.4	Bodywork of grounded aircraft dented, brick walls pitted
H7	Destructive	50-**75**		2.0 - 3.0	Severe roof damage, risk of serious injuries
H8	Destructive	60-**90**		1.6 - 3.5	(Severest recorded in the British Isles) Severe damage to aircraft bodywork
H9	Super Hailstorms	75-**100**		3.0 - 3.9	Extensive structural damage. Risk of severe or even fatal injuries to persons caught in the open
H10	Super Hailstorms	>100			Extensive structural damage. Risk of severe or even fatal injuries to persons caught in the open

Source: http://www.torro.org.uk/site/hscale.php

Location and Spatial Extent

Hailstorms frequently accompany thunderstorms, so their locations and spatial extents coincide. It is assumed that Guilford County is uniformly exposed to severe thunderstorms; therefore, all areas of the county are equally exposed to hail which may be produced by such storms.

Historical Occurrences

According to the National Centers for Environmental Information , 164 recorded hailstorm events have affected Guilford County since 1967.[20] **Figure 3.9** illustrates the location and magnitude of historic hailstorms that have occurred in the county. **Table 3.24** is a summary of the hail events in Guilford County. **Table 3.25** provides detailed information about each event that occurred in the county.

[20] These hail events are only inclusive of those reported by the National Climatic Data Center (NCDC) from 1956 through August 2014. It is likely that additional hail events have affected Guilford County. In addition to NCDC, the North Carolina Department of Insurance office was contacted for information. As additional local data becomes available, this hazard profile will be amended.

In all, hail occurrences resulted in around $2,000 (2019 dollars) in recorded property damages.[21] Hail ranged in diameter from 0.75 inches to 2.75 inches. It should be noted that hail is notorious for causing substantial damage to cars, roofs, and other parts of the built environment that may not be reported to the National Centers for Environmental Information. It is likely that damages are greater than the reported value.

FIGURE 3.5: HISTORIC HAIL EVENTS (1950-2019)

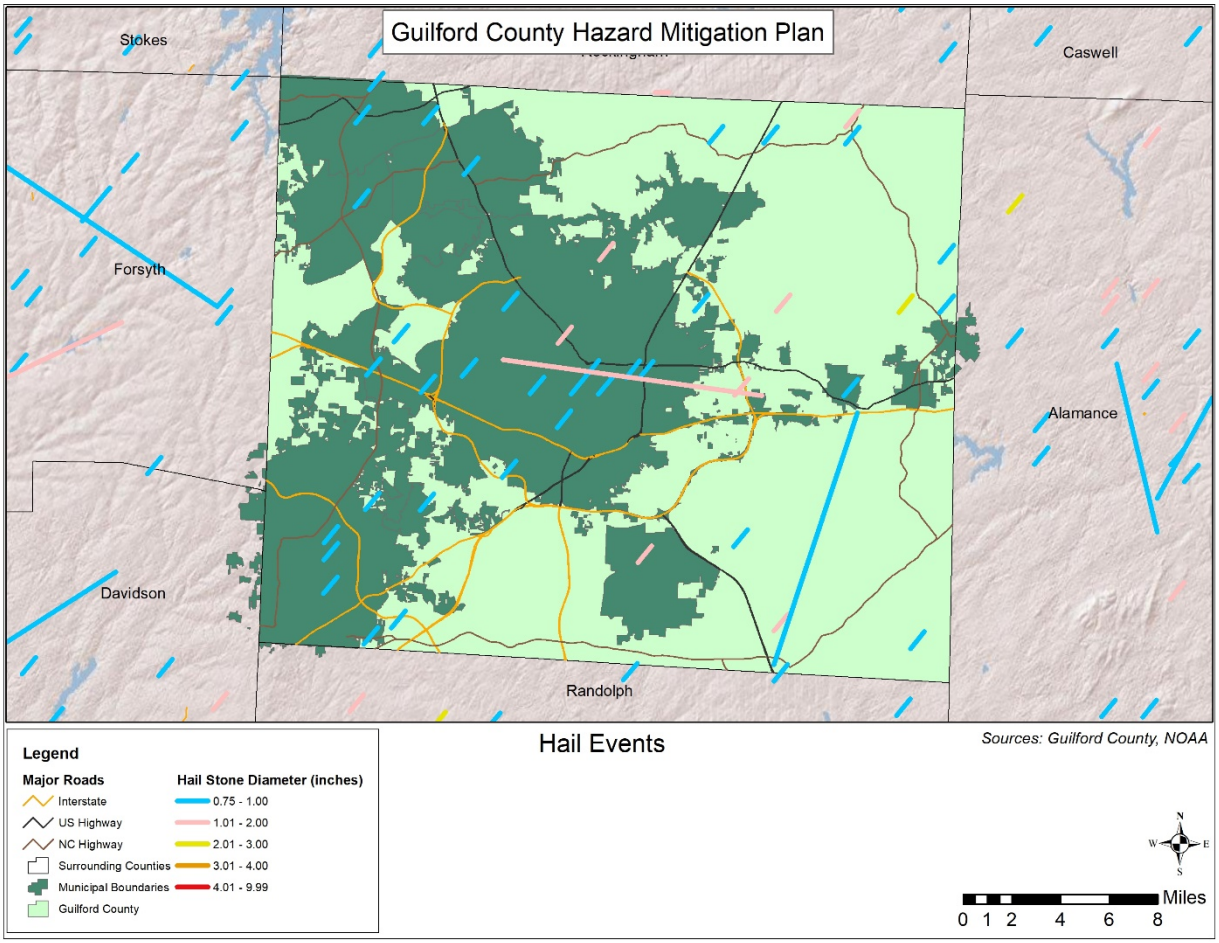


TABLE 3.24: SUMMARY OF HAIL OCCURRENCES IN GUILFORD COUNTY

Location	Number of Occurrences	Deaths / Injuries	Property Damage (2019)	Annualized Property Loss
Gibsonville	4	0/0	$0	$0

[21] Adjusted dollar values were calculated based on the Consumer Price Index for All Urban Consumers (CPI-U) U.S. city average series for all items, not seasonally adjusted. This data represents changes in the prices of all goods and services purchased for consumption by urban households. This monthly index value has been calculated every year since 1913. The 2019 dollar values were calculated based on buying power in May 2019.

Location	Number of Occurrences	Deaths / Injuries	Property Damage (2019)	Annualized Property Loss
Greensboro	43	0/0	$0	$0
High Point	16	0/0	$0	$0
Jamestown	1	0/0	$0	$0
Oak Ridge	4	0/0	$0	$0
Pleasant Garden	4	0/0	$0	$0
Sedalia	3	0/0	$0	$0
Stokesdale	7	0/0	$0	$0
Summerfield	5	0/0	$0	$0
Whitsett	1	0/0	$0	$0
Unincorporated Area	89	0/0	$2,019	$39
GUILFORD COUNTY TOTAL	**177**	**0/0**	**$2,019**	**$0**

Source: National Climatic Data Center

TABLE 3.25: Historical Hail Occurrences IN GUILFORD COUNTY

	Date	Magnitude	Deaths / Injuries	Property Damage*
Gibsonville				
GIBSONVILLE	4/3/1998	0.75 in.	0/0	$0
GIBSONVILLE	5/23/2004	0.88 in.	0/0	$0
GIBSONVILLE	5/14/2006	0.88 in.	0/0	$0
GIBSONVILLE	5/14/2006	0.88 in.	0/0	$0
Greensboro				
GREENSBORO	9/13/1996	0.75 in.	0/0	$0
GREENSBORO	3/5/1997	0.75 in.	0/0	$0
GREENSBORO	8/25/1997	0.75 in.	0/0	$0
GREENSBORO	5/20/1998	1.75 in.	0/0	$0

	Date	Magnitude	Deaths / Injuries	Property Damage*
GREENSBORO	5/26/1998	0.75 in.	0/0	$0
GREENSBORO	6/15/1998	0.75 in.	0/0	$0
GREENSBORO	5/25/2001	1.00 in.	0/0	$0
GREENSBORO	5/25/2001	1.00 in.	0/0	$0
GREENSBORO	7/4/2002	0.88 in.	0/0	$0
GREENSBORO	7/4/2002	0.75 in.	0/0	$0
GREENSBORO	4/26/2003	1.25 in.	0/0	$0
GREENSBORO	5/31/2003	1.00 in.	0/0	$0
GREENSBORO	8/5/2003	0.75 in.	0/0	$0
GREENSBORO	8/22/2003	0.88 in.	0/0	$0
GREENSBORO	5/9/2004	0.75 in.	0/0	$0
GREENSBORO	3/23/2005	1.75 in.	0/0	$0
GREENSBORO	4/3/2006	0.75 in.	0/0	$0
GREENSBORO	5/14/2006	0.88 in.	0/0	$0
GREENSBORO	5/14/2006	0.88 in.	0/0	$0
GREENSBORO	5/14/2006	0.88 in.	0/0	$0
GREENSBORO	5/14/2006	1.00 in.	0/0	$0
GREENSBORO	5/14/2006	0.88 in.	0/0	$0
GREENSBORO	5/14/2006	1.00 in.	0/0	$0
GREENSBORO	5/14/2006	1.75 in.	0/0	$0
GREENSBORO	5/14/2006	1.75 in.	0/0	$0
GREENSBORO	5/15/2006	0.75 in.	0/0	$0
GREENSBORO	5/26/2006	1.00 in.	0/0	$0
GREENSBORO	6/11/2006	0.75 in.	0/0	$0
GREENSBORO	6/11/2006	1.50 in.	0/0	$0
GREENSBORO	6/11/2006	0.75 in.	0/0	$0
GREENSBORO	6/23/2006	0.88 in.	0/0	$0
GREENSBORO	6/23/2006	1.00 in.	0/0	$0

	Date	Magnitude	Deaths / Injuries	Property Damage*
GREENSBORO	6/23/2006	1.00 in.	0/0	$0
GREENSBORO	6/23/2006	0.75 in.	0/0	$0
GREENSBORO	8/30/2006	0.75 in.	0/0	$0
GREENSBORO	9/28/2006	0.88 in.	0/0	$0
GREENSBORO	4/15/2007	0.88 in.	0/0	$0
GREENSBORO	6/27/2007	0.75 in.	0/0	$0
GREENSBORO	6/27/2007	0.75 in.	0/0	$0
GREENSBORO	5/31/2008	1.00 in.	0/0	$0
GREENSBORO	8/19/2009	0.75 in.	0/0	$0
GREENSBORO	6/1/2012	1.75 in.	0/0	$0
GREENSBORO	9/28/2016	1.75 in.	0/0	$0
High Point				
HIGH POINT	8/27/1994	0.75 in.	0/0	$0
HIGH POINT	7/18/1996	0.75 in.	0/0	$0
HIGH POINT	4/17/1998	0.88 in.	0/0	$0
HIGH POINT	5/7/1998	0.88 in.	0/0	$0
HIGH POINT	6/3/2000	1.75 in.	0/0	$0
HIGH POINT	7/2/2002	0.88 in.	0/0	$0
HIGH POINT	4/30/2003	0.75 in.	0/0	$0
HIGH POINT	5/2/2003	0.75 in.	0/0	$0
HIGH POINT	7/4/2004	0.75 in.	0/0	$0
HIGH POINT	7/17/2004	1.00 in.	0/0	$0
HIGH POINT	5/14/2006	1.00 in.	0/0	$0
HIGH POINT	6/8/2006	0.75 in.	0/0	$0
HIGH POINT	6/23/2006	0.88 in.	0/0	$0
HIGH POINT	8/30/2006	1.00 in.	0/0	$0
HIGH POINT	8/30/2006	0.75 in.	0/0	$0
HIGH POINT	4/20/2008	1.00 in.	0/0	$0

	Date	Magnitude	Deaths / Injuries	Property Damage*
Jamestown				
JAMESTOWN	4/26/2003	0.88 in.	0/0	$0
Oak Ridge				
OAK RIDGE	5/12/2001	0.88 in.	0/0	$0
OAK RIDGE	3/23/2005	1.00 in.	0/0	$0
OAK RIDGE ARPT	7/20/2009	1.75 in.	0/0	$0
OAK RIDGE ARPT	4/20/2015	1.00 in.	0/0	$0
Pleasant Garden				
PLEASANT GARDEN	7/1/2002	1.50 in.	0/0	$0
PLEASANT GARDEN	8/7/2006	0.75 in.	0/0	$0
PLEASANT GARDEN	5/9/2009	0.88 in.	0/0	$0
PLEASANT GARDEN	4/19/2013	1.00 in.	0/0	$0
Sedalia				
SEDALIA	9/20/2005	0.75 in.	0/0	$0
SEDALIA	9/28/2016	1.00 in.	0/0	$0
SEDALIA	9/28/2016	1.25 in.	0/0	$0
Stokesdale				
STOKESDALE	7/24/1997	1.00 in.	0/0	$0
STOKESDALE	7/3/2002	1.75 in.	0/0	$0
STOKESDALE	7/19/2003	0.88 in.	0/0	$0
STOKESDALE	6/11/2006	0.75 in.	0/0	$0
STOKESDALE	6/11/2006	0.75 in.	0/0	$0
STOKESDALE	7/4/2006	1.00 in.	0/0	$0
STOKESDALE	9/28/2006	0.75 in.	0/0	$0

	Date	Magnitude	Deaths / Injuries	Property Damage*
Summerfield				
SUMMERFIELD	8/18/2000	2.50 in.	0/0	$0
SUMMERFIELD	7/13/2003	0.88 in.	0/0	$0
SUMMERFIELD	10/21/2005	0.75 in.	0/0	$0
SUMMERFIELD	9/28/2006	0.75 in.	0/0	$0
SUMMERFIELD	5/31/2008	0.75 in.	0/0	$0
Whitsett				
WHISTETT	6/22/2008	0.75 in.	0/0	$0
Unincorporated Area				
GUILFORD CO.	8/7/1967	0.75 in.	0/0	$0
GUILFORD CO.	6/22/1978	1.00 in.	0/0	$0
GUILFORD CO.	8/21/1979	1.00 in.	0/0	$0
GUILFORD CO.	4/27/1982	1.00 in.	0/0	$0
GUILFORD CO.	5/29/1982	1.75 in.	0/0	$0
GUILFORD CO.	4/2/1983	2.75 in.	0/0	$0
GUILFORD CO.	4/14/1984	1.75 in.	0/0	$0
GUILFORD CO.	5/6/1984	1.75 in.	0/0	$0
GUILFORD CO.	5/15/1985	0.75 in.	0/0	$0
GUILFORD CO.	5/22/1985	2.50 in.	0/0	$0
GUILFORD CO.	6/3/1985	1.00 in.	0/0	$0
GUILFORD CO.	6/5/1985	1.25 in.	0/0	$0
GUILFORD CO.	6/5/1985	1.00 in.	0/0	$0
GUILFORD CO.	4/12/1987	1.75 in.	0/0	$0
GUILFORD CO.	6/1/1987	1.75 in.	0/0	$0
GUILFORD CO.	5/16/1988	0.75 in.	0/0	$0
GUILFORD CO.	5/17/1988	0.75 in.	0/0	$0
GUILFORD CO.	5/17/1988	0.75 in.	0/0	$0
GUILFORD CO.	5/17/1988	0.75 in.	0/0	$0

	Date	Magnitude	Deaths / Injuries	Property Damage*
GUILFORD CO.	5/17/1988	1.00 in.	0/0	$0
GUILFORD CO.	6/21/1988	0.75 in.	0/0	$0
GUILFORD CO.	7/10/1988	1.75 in.	0/0	$0
GUILFORD CO.	4/27/1989	0.75 in.	0/0	$0
GUILFORD CO.	6/2/1989	1.00 in.	0/0	$0
GUILFORD CO.	5/1/1990	1.00 in.	0/0	$0
GUILFORD CO.	5/1/1990	1.00 in.	0/0	$0
GUILFORD CO.	5/27/1990	1.00 in.	0/0	$0
GUILFORD CO.	5/27/1990	1.75 in.	0/0	$0
GUILFORD CO.	7/1/1990	1.75 in.	0/0	$0
GUILFORD CO.	4/30/1992	0.75 in.	0/0	$0
GUILFORD CO.	6/26/1992	0.75 in.	0/0	$0
Julian	10/27/1995	1.50 in.	0/0	$0
JULIAN	5/29/1996	1.75 in.	0/0	$0
JULIAN,CLIMAX	10/18/1996	0.75 in.	0/0	$0
MONTICELLO	5/1/1998	0.75 in.	0/0	$0
GUILFORD	5/20/1998	1.00 in.	0/0	$0
MC LEANSVILLE	6/23/2006	1.75 in.	0/0	$0
CLIMAX	3/4/2008	0.75 in.	0/0	$0
GREENSBORO MAY ARPT	3/4/2008	0.75 in.	0/0	$0
COLFAX	3/4/2008	0.75 in.	0/0	$0
BROWNS SUMMIT	5/8/2008	0.75 in.	0/0	$0
BATTLE GROUND	5/8/2008	1.75 in.	0/0	$0
BROWNS SUMMIT	5/9/2008	0.75 in.	0/0	$0
SHERWOOD VLG	5/20/2008	0.88 in.	0/0	$0
BATTLE GROUND	5/31/2008	0.75 in.	0/0	$0
BATTLE GROUND	5/31/2008	0.88 in.	0/0	$0

	Date	Magnitude	Deaths / Injuries	Property Damage*
GUILFORD	5/31/2008	1.00 in.	0/0	$0
BATTLE GROUND	5/31/2008	0.88 in.	0/0	$0
PINECROFT	5/31/2008	1.00 in.	0/0	$0
BATTLE GROUND	5/31/2008	1.25 in.	0/0	$0
BATTLE GROUND	5/31/2008	1.00 in.	0/0	$0
GUILFORD	6/22/2008	0.75 in.	0/0	$0
BATTLE GROUND	6/22/2008	0.75 in.	0/0	$0
HAMILTON LAKES	6/22/2008	0.88 in.	0/0	$0
HAMILTON LAKES	6/22/2008	0.88 in.	0/0	$0
BATTLE GROUND	6/3/2009	1.00 in.	0/0	$0
BROADVIEW	6/3/2009	0.75 in.	0/0	$0
BESSEMER	6/3/2009	1.00 in.	0/0	$0
CLIMAX	6/9/2009	1.00 in.	0/0	$0
HILLSDALE	7/20/2009	0.75 in.	0/0	$0
BROWNS SUMMIT	3/28/2010	1.00 in.	0/0	$1,361
DEEP RIVER	5/15/2010	1.00 in.	0/0	$0
DEEP RIVER	5/15/2010	1.00 in.	0/0	$0
VANDALIA	5/15/2010	1.00 in.	0/0	$0
GREENSBORO ARPT	4/27/2011	0.75 in.	0/0	$0
HAMILTON LAKES	4/27/2011	0.75 in.	0/0	$0
GREENSBORO ARPT	4/27/2011	0.88 in.	0/0	$0
BROWNS SUMMIT	6/9/2011	1.50 in.	0/0	$0
FOUR MILE	9/27/2011	1.00 in.	0/0	$0
GREENSBORO ARPT	3/24/2012	1.00 in.	0/0	$0
GROOMTOWN	3/24/2012	1.00 in.	0/0	$0
CLIMAX	3/24/2012	1.00 in.	0/0	$0

	Date	Magnitude	Deaths / Injuries	Property Damage*
PINECROFT	6/1/2012	1.00 in.	0/0	$0
POMONA	6/25/2013	1.75 in.	0/0	$510
GROOMTOWN	6/10/2014	1.25 in.	0/0	$0
KOONTZVILLE	6/16/2014	1.25 in.	0/0	$0
BRIGHTWOOD	6/16/2014	1.25 in.	0/0	$0
BRIGHTWOOD	6/16/2014	1.75 in.	0/0	$0
BRIGHTWOOD	6/16/2014	1.50 in.	0/0	$0
BROADVIEW	6/16/2014	1.00 in.	0/0	$0
SCALESVILLE	4/28/2016	1.00 in.	0/0	$0
GREENSBORO ARPT	5/2/2016	0.88 in.	0/0	$0
GUILFORD	5/2/2016	0.88 in.	0/0	$0
(GSO)GREENSBORO RGNL	5/2/2016	1.00 in.	0/0	$0
GUILFORD	5/2/2016	1.00 in.	0/0	$0
GUILQUARRY	5/12/2016	1.00 in.	0/0	$0
GUILQUARRY	6/29/2016	1.00 in.	0/0	$0
OSCEOLA	9/28/2016	1.00 in.	0/0	$0
CLIMAX	4/6/2017	1.00 in.	0/0	$0

*Property damage is reported in 2019 dollars; All damage may not have been reported.

Source: National Centers for Environmental Information

Probability of Future Occurrences

Based on historical occurrence information, it is assumed that the probability of future hail occurrences is highly likely (100 percent annual probability). Since hail is an atmospheric hazard (coinciding with thunderstorms), it is assumed that the entire county has equal exposure to this hazard. It can be expected that future hail events will continue to cause minor damage to property and vehicles throughout the county.

Consequence Analysis

People (The Public and Public Confidence)

Hail can have a negative impact on the public as it can often cause injury if people are struck by hail stones. Often the impoverished are detrimentally impacted if they cannot find shelter, but hail can impact anyone. There would be little negative impact on public confidence.

Responders

Hail can also affect responders who are often more susceptible to hail events due to the nature of their work which often forces police and emergency medical providers to be exposed to the elements. In these cases, responders could be negatively impacted by hail.

Continuity of Operations

Hail would likely have some impacts on continuity of operations as the warning time for these events is usually shorter and hail stones could potentially knock out power supplies or other critical resources which would affect operations.

Built Environment (Property, Facilities, and Infrastructure)

Hail can often have a significant effect on the built environment, depending on the size of the hail stones. Often these can damage roofs or other parts of homes and businesses as they are essentially rocks that are being propelled at high speeds. Hail can affect most any type of facility or infrastructure as well, causing damage to the structure.

Economy

A hailstorm could negatively impact the economy to some degree if the damage from the storm is large enough. Often hail causes a great deal of damage to personal property such as cars and homes, and these impacts would hurt the overall economy due to recovery efforts.

Environment

Hail often has a serious effect on crops and has been known to cause millions of dollars' worth of damage to farmers. It can also negatively impact livestock, as well as any flora or fauna that is not properly sheltered.

Hurricane / Other Tropical Disturbance

Background

Hurricanes and tropical storms are classified as cyclones and defined as 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.

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. The peak of the Atlantic hurricane season is in early to mid-September and the average number of storms that reach hurricane intensity per year in the Atlantic basin is about six.

As an incipient 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 (**Table 3.26**), which rates hurricane intensity on a scale of 1 to 5, with 5 being the most intense.

TABLE 3.26: SAFFIR-SIMPSON SCALE

Category	Maximum Sustained Wind Speed (MPH)	Minimum Surface Pressure (Millibars)
1	74–95	Greater than 980
2	96–110	979–965
3	111–129	964–945
4	130–156	944–920
5	157 +	Less than 920

Source: National Hurricane Center (2012)

The Saffir-Simpson Scale categorizes hurricane intensity linearly based upon maximum sustained winds and barometric pressure, 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 3.27** describes the damage that could be expected for each category of hurricane. Damage during hurricanes may also result from spawned tornadoes, storm surge, and inland flooding associated with heavy rainfall that usually accompanies these storms.

TABLE 3.27: HURRICANE DAMAGE CLASSIFICATIONS

Storm Category	Damage Level	Description of Damages	Photo Example
1	MODERATE	**Very dangerous winds will produce some damage:** Well-constructed frame homes could have damage to roof, shingles, vinyl siding and gutters. Large branches of trees will snap and shallowly rooted trees may be toppled. Extensive damage to power lines and poles likely will result in power outages that could last a few to several days.	
2	EXTENSIVE	**Extremely dangerous winds will cause extensive damage:** Well-constructed frame homes could sustain major roof and siding damage. Many shallowly rooted trees will be snapped or uprooted and block numerous roads. Near-total power loss is expected with outages that could last from several days to weeks.	
3	MAJOR	**Devastating damage will occur:** Well-built framed homes may incur major damage or removal of roof decking and gable ends. Many trees will be snapped or uprooted, blocking numerous roads. Electricity and water will be unavailable for several days to weeks after the storm passes.	
4	EXTREME	**Catastrophic damage will occur:** Well-built framed homes can sustain severe damage with loss of most of the roof structure and/or some exterior walls. Most trees will be snapped or uprooted and power poles downed. Fallen trees and power poles will isolate residential areas. Power outages will last weeks to possibly months. Most of the area will be uninhabitable for weeks or months.	
5	CATASTROPHIC	**Catastrophic damage will occur:** A high percentage of framed homes will be destroyed, with total roof failure and wall collapse. Fallen trees and power poles will isolate residential areas. Power outages will last for weeks to possibly months. Most of the area will be uninhabitable for weeks or months.	

Source: National Hurricane Center

Location and Spatial Extent

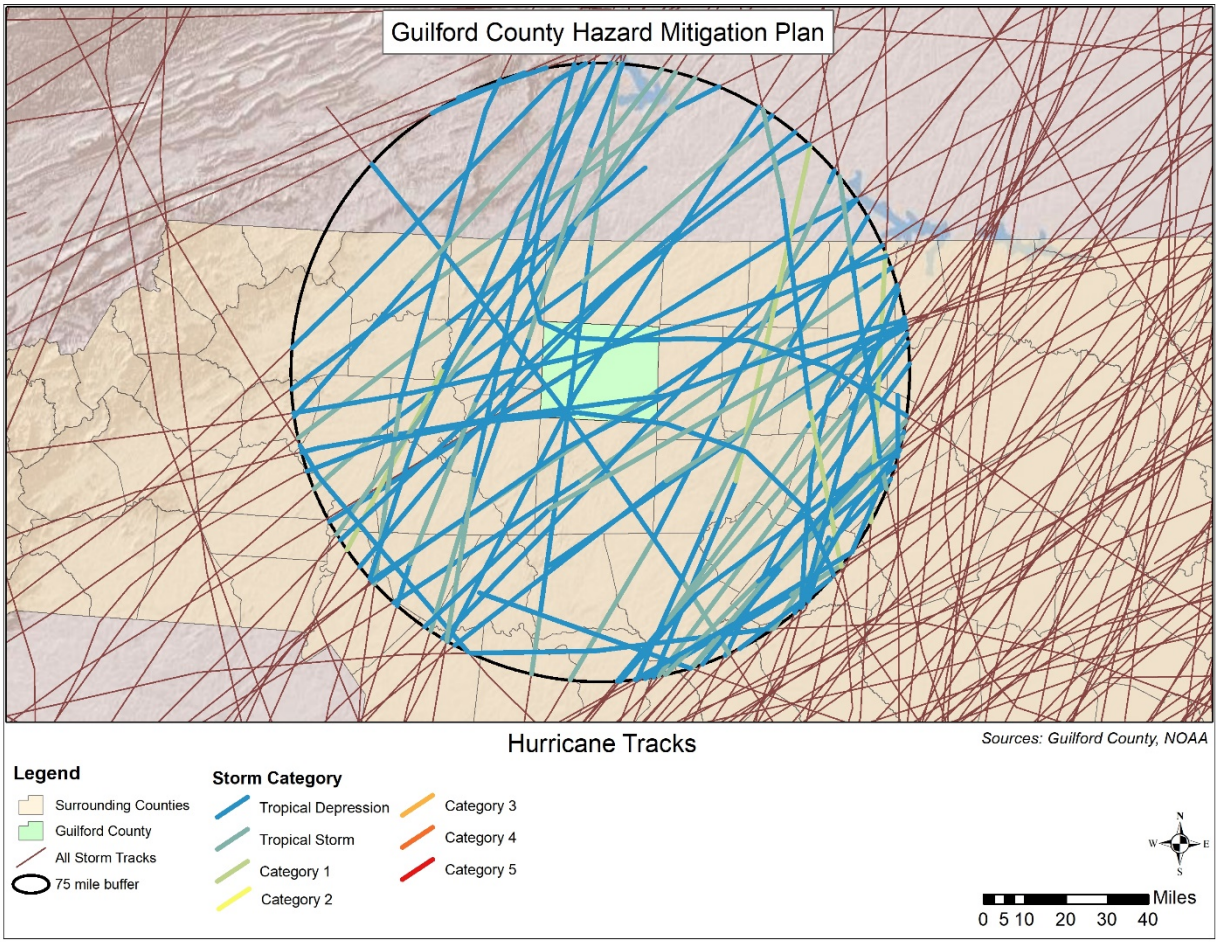
Hurricanes and tropical storms threaten the entire Atlantic and Gulf seaboard of the United States. While coastal areas are most directly exposed to the brunt of landfalling storms, their impact is often felt hundreds of miles inland and they can affect Guilford County. All areas in Guilford County are equally susceptible to hurricane and tropical storms.

Historical Occurrences

According to the National Hurricane Center's historical storm track records, 60 hurricane/tropical storm tracks have passed within 75 miles of Guilford County since 1850.[22] This includes 6 hurricanes, 31 tropical storms, and 22 tropical depressions.

Of the recorded storm events, 13 have traversed directly through Guilford County as shown in **Figure 3.20**. **Table 3.28** provides the date of occurrence, name (if applicable), maximum wind speed (as recorded within 75 miles of Guilford County), and Category of the storm based on the Saffir-Simpson Scale for each event.

FIGURE 3:20: HISTORICAL HURRICANE STORM TRACKS WITHIN 75 MILES OF GUILFORD COUNTY



Source: National Oceanic and Atmospheric Administration; National Hurricane Center

22 These storm track statistics do not include extra_tropical storms. Though these related hazard events are less severe in intensity, they may cause significant local impact in terms of rainfall and high winds.

TABLE 3.28: HISTORICAL STORM TRACKS WITHIN 75 MILES OF GUILFORD COUNTY (1850–2014)

Date of Occurrence	Storm Name	Maximum Wind Speed (knots)	Storm Category
9/10/1854	NOT NAMED	40	Tropical Storm
9/17/1859	NOT NAMED	40	Tropical Storm
11/2/1861	NOT NAMED	0	Tropical Depression
9/18/1863	NOT NAMED	0	Tropical Depression
10/2/1863	NOT NAMED	0	Tropical Depression
6/23/1867	NOT NAMED	0	Tropical Depression
9/19/1875	NOT NAMED	0	Tropical Depression
10/4/1877	NOT NAMED	50	Tropical Storm
9/12/1878	NOT NAMED	60	Tropical Storm
9/11/1882	NOT NAMED	40	Tropical Storm
10/13/1885	NOT NAMED	40	Tropical Storm
6/22/1886	NOT NAMED	35	Tropical Storm
7/2/1886	NOT NAMED	40	Tropical Storm
9/10/1888	NOT NAMED	35	Tropical Storm
9/24/1889	NOT NAMED	40	Tropical Storm
8/28/1893	NOT NAMED	65	Category 1
10/13/1893	NOT NAMED	80	Category 1
6/12/1895	NOT NAMED	0	Tropical Depression
9/30/1896	NOT NAMED	70	Category 1
10/31/1899	NOT NAMED	0	Tropical Depression
6/16/1902	NOT NAMED	35	Tropical Storm
10/12/1902	NOT NAMED	35	Tropical Storm
9/14/1904	NOT NAMED	60	Tropical Storm
9/23/1907	NOT NAMED	35	Tropical Storm

Date of Occurrence	Storm Name	Maximum Wind Speed (knots)	Storm Category
8/31/1911	NOT NAMED	25	Tropical Depression
9/3/1913	NOT NAMED	40	Tropical Storm
8/4/1915	NOT NAMED	40	Tropical Storm
9/23/1920	NOT NAMED	35	Tropical Storm
10/3/1927	NOT NAMED	35	Tropical Storm
8/11/1928	NOT NAMED	30	Tropical Depression
10/2/1929	NOT NAMED	50	Tropical Storm
9/6/1935	NOT NAMED	45	Tropical Storm
10/20/1944	NOT NAMED	45	Tropical Storm
9/18/1945	NOT NAMED	45	Tropical Storm
8/29/1949	NOT NAMED	50	Tropical Storm
8/31/1952	ABLE	40	Tropical Storm
8/28/1952	NOT NAMED	30	Tropical Depression
8/17/1955	DIANE	55	Tropical Storm
7/10/1959	CINDY	30	Tropical Depression
8/31/1964	CLEO	25	Tropical Depression
6/9/1968	ABBY	25	Tropical Depression
5/26/1970	ALMA	25	Tropical Depression
9/16/1976	NOT NAMED	25	Tropical Depression
9/5/1979	DAVID	45	Tropical Storm
7/25/1985	BOB	45	Tropical Storm
8/18/1985	DANNY	25	Tropical Depression
9/8/1987	NOT NAMED	0	Tropical Depression
8/29/1988	CHRIS	20	Tropical Depression
9/22/1989	HUGO*	85	Category 2
9/6/1996	FRAN	65	Category 1

Date of Occurrence	Storm Name	Maximum Wind Speed (knots)	Storm Category
7/24/1997	DANNY	30	Tropical Depression
9/16/1999	FLOYD*	90	Category 2
9/5/1999	DENNIS	30	Tropical Depression
9/19/2000	GORDON	20	Tropical Depression
7/2/2003	BILL	0	Tropical Depression
8/30/2004	GASTON	30	Tropical Depression
9/18/2004	IVAN	20	Tropical Depression
9/28/2004	JEANNE	20	Tropical Depression
7/7/2005	CINDY	20	Tropical Depression
9/7/2018	FLORENCE*	50	Tropical Storm
10/11/2018	MICHAEL	45	Tropical Storm

*Although the track of these storms traversed just outside of the 75 mile buffer area, they were included in the hazard history since a federal disaster area was declared for Guilford County as a result of the storm's impact.

Source: National Hurricane Center

The National Centers for Environmental Information reported four events associated with a hurricane or tropical storm in Guilford County since 1996. Additionally, Federal records indicate that five disaster declarations were made in 1989 (Hurricane Hugo), 1996 (Hurricane Fran), 1999 (Hurricane Floyd), 2004 (Hurricane Ivan), 2018 (Hurricane Florence) for the county.

Flooding is often the greatest hazard of concern with hurricane and tropical storm events in Guilford County. Most events do not carry winds that are above that of the thunderstorms and straight line winds received by the county. Some anecdotal information is available for the major storms that have impacted that area as found below:

> **Hurricane Hugo** – September 22-24, 1989
> Hurricane Hugo was one of the largest storms on record in the Atlantic Basin that produced high winds and dumped heavy rains over much of North Carolina and South Carolina. Hugo reached a peak level of Category 5 on the Saffir-Simpson scale and made landfall near Isle of Palms in South Carolina as a Category 4, eventually passing over Charlotte and much of the surrounding area as a Category 1 storm. Although the storm caused its greatest damage in South Carolina, over 1,000 structures were destroyed or severely damaged in North Carolina, causing over $1 billion dollars in damages. Wind gusts reached over 40 mph and numerous trees were downed throughout much of south and western North Carolina.

Hurricane Fran – September 5-6, 1996
After being hit just a few weeks earlier by Hurricane Bertha, North Carolina was impacted by the one of the most devastating storms to ever make landfall along the Atlantic Coast. Fran dropped more than 10 inches of rain in many areas and had sustained winds of around 115 miles per hour as it hit the coast and began its path along the I-40 corridor central North Carolina. In the end, over 3 billion dollars in damages were reported in the state. Damages to infrastructure and agriculture added to the overall toll and more than 1.7 million people in the state were left without power.

Hurricane Floyd – September 16, 1999
Hurricane Floyd, combined with the weather conditions before and immediately after this hurricane, resulted in the most severe flooding and devastation in North Carolina history. In North Carolina, the storm resulted in 35 fatalities, over $3 billion in damages, 7,000 destroyed homes, 56,000 damaged homes, 1,500 people rescued from flooded areas, and more than 500,000 customers without electricity. Additionally, the flooding caused an estimated $813 million in agricultural losses affecting 32,000 farmers. There was also significant loss of livestock including 2,860,827 poultry, 28,000 swine, and 619 cattle.

Hurricane Ivan – September 16-17, 2004
Just a week and a half following Tropical Storm Frances, the remnants of Hurricane Ivan hit western North Carolina when many streams and rivers were already well above flood stage. The widespread flooding forced many roads to be closed and landslides were common across the mountain region. Wind gusts reached between 40 and 60 mph across the higher elevations of the Appalachian Mountains resulting in numerous downed trees. More than $13.8 million of federal aid was dispersed across North Carolina following Ivan.

Hurricane Florence – September 12-15, 2018
Florence produced extensive wind damage along the North Carolina coast from Cape Lookout, across Carteret, Onslow, Pender and New Hanover counties. Thousands of downed trees caused widespread power outages to nearly all of eastern North Carolina. The historic legacy of Hurricane Florence will be record breaking storm surge of 9 to 13 feet and devastating rainfall of 20 to 30 inches, which produced catastrophic and life-threatening flooding. The hardest hit areas included New Bern, Newport, Belhaven, Oriental, North Topsail Beach and Jacksonville, along with Downeast Carteret County, or basically south of a line from Kinston to Cedar Island. A storm total rainfall of 34.00 inches was reported in Swansboro, while the NWS office in Newport recorded 25.20 inches. Wind gusts of 106 mph were reported at Cape Lookout with 105 mph at Fort Macon.

Probability of Future Occurrences

Given the inland location of the county, it is more likely to be affected by remnants of hurricane and tropical storm systems (as opposed to a major hurricane) which may result in flooding or high winds. The probability of being impacted is less than coastal areas, but still remains a real threat to Guilford County due to induced events like flooding and erosion. Based on historical evidence, the probability level of future occurrence is likely (between 10 and 100 percent annual

probability). Given the regional nature of the hazard, all areas in the county are equally exposed to this hazard. However, when the county is impacted, the damage could be catastrophic, threatening lives and property throughout the planning area. Additionally, according to the *Piedmont Together Climate Adaptation Report*, the increased likelihood of hurricanes due to climate change will result in greater wind damage and increased flooding in the county.

Consequence Analysis

People (The Public and Public Confidence)

During previous hurricane events in Guilford County, there have been significant losses of life and injuries to citizens. A number of people may be displaced from their homes and will require accommodations in temporary public shelters due to a hurricane. Many people may also be permanently displaced and require longer term housing after a major event. In addition, many of the same health and property damage effects listed under the flood hazard would also likely occur as a result of a hurricane. A major difference is that hurricanes can also bring negative effects from high winds. High winds can shatter glass and cause personal injury during the event and can cause loss of life if members of the public are not cautious and fail to take proper precautions prior to and during an event.

This hazard could potentially have a large negative effect on public confidence due to the possibility of a high magnitude event and the difficulties that might arise for local governments in terms of response and recovery. As has been the case with several previous events, members of the public who are displaced or whose homes/property are damaged may be frustrated causing a failure of confidence in the government's ability to respond to disasters.

Responders

The impacts on responders from this type of storm could potentially be very high as responders may be physically injured or killed during a storm event by flooding or high winds. In addition, their homes and personal effects could also be impacted which would limit their response capability.

In terms of their actual response capacity, downed trees in the wake of a hurricane often block roads and make ingress and egress difficult, thereby causing issues with response time. This is also often true of the resulting floodwaters. Moreover, due to the large scale spatial impact of hurricanes and the number of citizens affected by the storm, response time will be reduced because of the number of incidents that require emergency responders.

Continuity of Operations

Continuity of operations in a hurricane event can be severely affected if power is lost or if critical facilities or infrastructure are damaged during an event. Although Guilford County has a plan in place to maintain continuity of operations in the event of a storm, a hurricane with a high magnitude would likely disrupt operations to some degree due to the impacts it would have on personnel. Some may experience damage from the storm themselves and be unable to work putting a strain on staff who are working as they will be forced to take on additional

responsibilities during and after an event. In major events, all staff will likely be called on to work additional hours to maintain continuity of operations, which may result in fatigue and a reduced capability of employees in the long run.

Built Environment (Property, Facilities, and Infrastructure)

Many buildings and structures could be impacted by a hurricane or tropical storm event including many local and state critical facilities such as police stations, fire stations, medical facilities, and other key buildings. Large-scale damage to infrastructure such as bridges and roads could occur from flood waters. Stormwater infrastructure such as culverts could also be damaged if they are clogged with debris from the storm or their design capacity is overrun. Many utilities including water/wastewater may be affected as a result of their location near rivers and other water sources. Power lines may be downed by falling trees or limbs and, due to high demand across the state, utility companies may face challenges in restoring power in a timely manner.

Economy

In general, the economy would be severely impacted by a hurricane or tropical storm event. Due to the massive scale of these events and multiple types of impacts from flooding and high winds, commerce would definitively slow down as efforts to rebuild are undertaken. Businesses may be shut down for long periods as owners try to rebuild after damage from flood waters, downed trees, or wind. Even business owners without direct physical damage to their workplaces may be shut down temporarily by loss of power or because employees are unable to come in to work as a result of roads that are shut down or personal property damage. As mentioned in the flooding analysis, many businesses that shut down after a major disaster never re-open their doors, which can have a major negative impact on local economies, especially in smaller communities.

Environment

Flooding and wind damage are the main impacts that would be felt by a hurricane in North Carolina. Hurricane winds can down trees and cause disruptions to local ecosystems, particularly if damage is heavy in areas where endangered or protected species are present. As mentioned in the flood analysis, flood waters may cause some losses in species population. Hurricane events can also sometimes cause spills of hazardous materials which would have damaging effects on the environment (as detailed further in the hazardous materials analysis below).

Thunderstorm (Wind and Lightning)

Background

Thunderstorms can produce a variety of accompanying hazards including wind (discussed here), hail, and lightning (discussed here).[23] Although thunderstorms generally affect a small area, they are very dangerous and may cause substantial property damage.

Three conditions need to occur for a thunderstorm to form. First, it needs moisture to form clouds and rain. Second, it needs unstable air, such as warm air that can rise rapidly (this often referred to as the "engine" of the storm). Third, thunderstorms need lift, which comes in the form of cold or warm fronts, sea breezes, mountains, or the sun's heat. When these conditions occur simultaneously, air masses of varying temperatures meet, and a thunderstorm is formed. These storm events can occur singularly, in lines, or in clusters. Furthermore, they can move through an area very quickly or linger for several hours.

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." A severe thunderstorm occurs when the storm produces at least one of these three elements: 1) hail at least one inch in diameter, 2) a tornado, or 3) winds of at least 58 miles per hour.

Wind

Thunderstorm events have the capability of producing straight-line winds that can cause severe destruction to communities and threaten the safety of a population. Such wind events, sometimes separate from a thunderstorm event, are common throughout Guilford County. Therefore, high winds are also reported in this section.

High winds can form due to pressure of the Northeast coast that combines with strong pressure moving through the Ohio Valley. This creates a tight pressure gradient across the region, resulting in high winds which increase with elevation. It is common for gusts of 30 to 60 miles per hour during the winter months.

Downbursts are also possible with thunderstorm events. Such events are an excessive burst of wind in excess of 125 miles per hour. They are often confused with tornadoes. Downbursts are caused by down drafts from the base of a convective thunderstorm cloud. It occurs when rain-cooled air within the cloud becomes heavier than its surroundings. Thus, air rushes towards the ground in a destructive yet isolated manner. There are two types of downbursts. Downbursts less than 2.5 miles wide, duration less than 5 minutes, and winds up to 168 miles per hour are called "microbursts." Larger events greater than 2.5 miles at the surface and longer than 5 minutes with winds up to 130 miles per hour are referred to as "macrobursts."

[23]The hail hazard is discussed as separate a hazard in this section.

Lightning

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 the thunder which often accompanies lightning strikes. While most often affiliated with severe thunderstorms, lightning may also strike outside of heavy rain and might occur as far as 10 miles away from any rainfall.

Lightning strikes occur in very small, localized areas. For example, they may strike a building, electrical transformer, or even a person. According to FEMA, lightning injures an average of 300 people and kills 80 people each year in the United States. Direct lightning strikes also have the ability to cause significant damage to buildings, critical facilities, and infrastructure largely by igniting a fire. Lightning is also responsible for igniting wildfires that can result in widespread damages to property.

Location and Spatial Extent

Wind

A wind event is an atmospheric hazard, and thus has no geographic boundaries. It is typically a widespread event that can occur in all regions of the United States. However, thunderstorms are most common in the central and southern states because atmospheric conditions in those regions are favorable for generating these powerful storms. Also, Guilford County typically experiences several straight-line wind events each year. These wind events can and have caused significant damage. It is assumed that Guilford County has uniform exposure to a thunderstorm/wind event and the spatial extent of an impact could be large.

Lightning

Lightning occurs randomly, therefore it is impossible to predict where and with what frequency it will strike. It is assumed that all of Guilford County is uniformly exposed to lightning.

Historical Occurrences

Wind

According to NCEI, there have been 311 reported thunderstorm wind and high wind events since 1950 in Guilford County.[24] These events caused over $2.6 million (2019

[24] These thunderstorm events are only inclusive of those reported by the National Centers for Environmental Information (NCEI) from 1955 through March 2019 and these high wind events are only inclusive of those reported by NCEI from 1996 through

dollars) in damages.[25] There were also reports of at least two fatalities and two injuries. **Table 3.29** summarizes this information. **Figure 3.21** shows historic thunderstorm and high wind events as reported by NCEI. **Table 3.30** provides detailed thunderstorm wind and high wind event reports, including date, magnitude, and associated damages for each event.

TABLE 3.29: SUMMARY OF THUNDERSTORM / HIGH WIND OCCURRENCES IN GUILFORD COUNTY

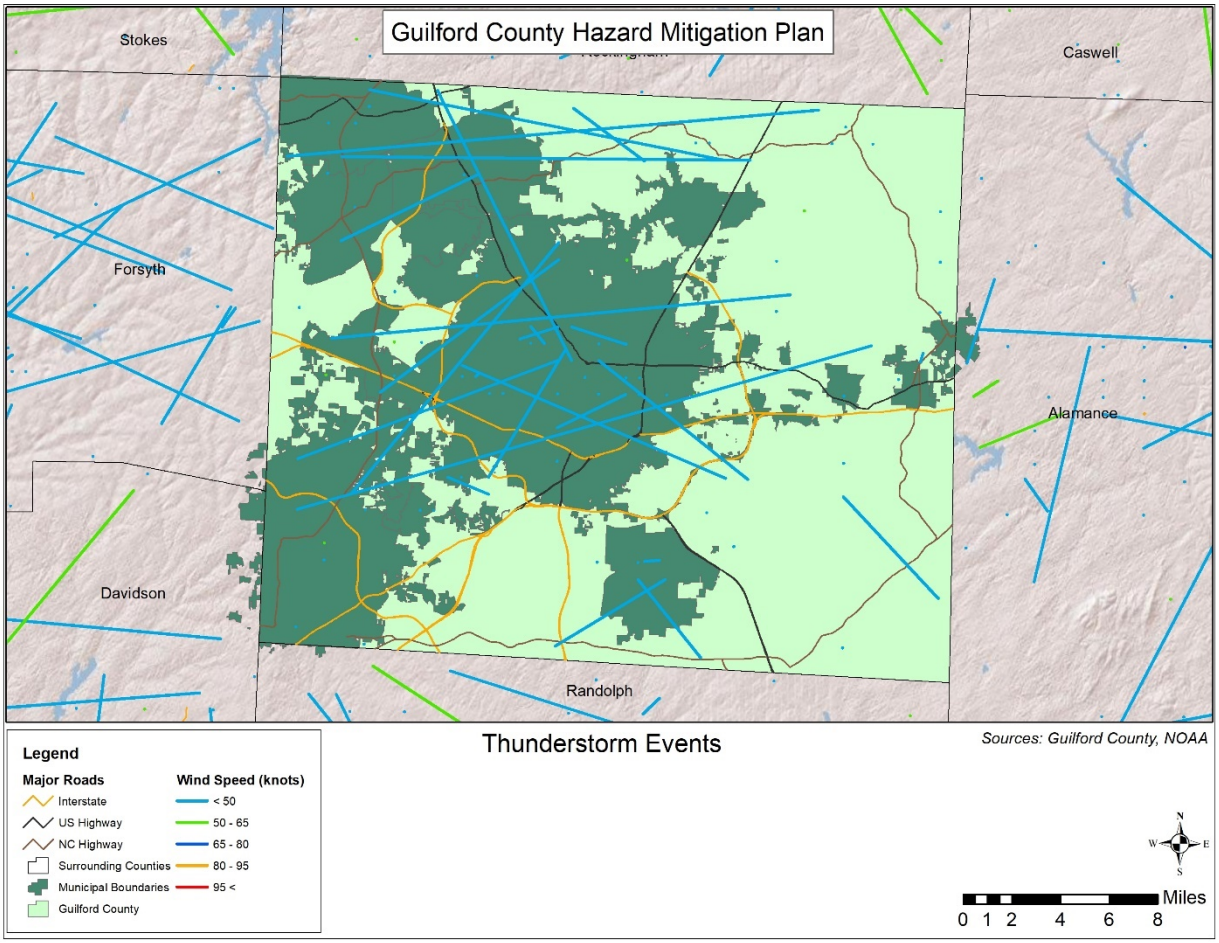
Location	Number of Occurrences	Deaths / Injuries	Property Damage (2014)	Annualized Property Loss
Gibsonville	8	0/0	$50,814	$1,954
Greensboro	38	0/1	$423,050	$16,271
High Point	13	0/0	$312,132	$16,428
Jamestown	5	0/0	$0	$0
Oak Ridge	12	0/0	$2,190	$115
Pleasant Garden	9	0/0	$5,875	$309
Sedalia	4	0/0	$2,541	$159
Stokesdale	5	0/0	$0	$0
Summerfield	10	0/0	$13,881	$631
Whitsett	2	0/0	$0	$0
Unincorporated Area	205	2/1	$1,837,585	$29,168
GUILFORD COUNTY TOTAL	**311**	**2/2**	**$2,648,068**	**$65,036**

Source: National Climatic Data Center

March 2019. It is likely that additional thunderstorm and high wind events have occurred in Guilford County. As additional local data becomes available, this hazard profile will be amended.

[25] Adjusted dollar values were calculated based on the Consumer Price Index for All Urban Consumers (CPI-U) U.S. city average series for all items, not seasonally adjusted. This data represents changes in the prices of all goods and services purchased for consumption by urban households. This monthly index value has been calculated every year since 1913. The 2019 dollar values were calculated based on buying power in May 2019.

FIGURE 3.6: HISTORIC THUNDERSTORM/HIGH WIND EVENTS (1950-2019)



Source: National Centers for Environmental Information

TABLE 3.30: HISTORICAL THUNDERSTORM / HIGH WIND OCCURRENCES IN GUILFORD COUNTY

	Date	Type	Magnitude†	Deaths / Injuries	Property Damage*
Gibsonville					
GIBSONVILLE	8/26/1993	Thunderstorm Wind	0 kts.	0/0	$0
GIBSONVILLE	5/20/2000	Thunderstorm Wind	60 kts. E	0/0	$0
GIBSONVILLE	8/18/2000	Thunderstorm Wind	50 kts. E	0/0	$0
GIBSONVILLE	7/20/2006	Thunderstorm Wind	50 kts. EG	0/0	$0
GIBSONVILLE	6/11/2007	Thunderstorm Wind	50 kts. EG	0/0	$0
GIBSONVILLE	6/27/2007	Thunderstorm Wind	50 kts. EG	0/0	$0

	Date	Type	Magnitude†	Deaths / Injuries	Property Damage*
GBSNVLL MC LEAN ARPT	8/8/2012	Thunderstorm Wind	50 kts. EG	0/0	$0
GIBSONVILLE	9/2/2012	Thunderstorm Wind	50 kts. EG	0/0	$0
GIBSONVILLE	6/20/2018	Thunderstorm Wind	50 kts.	0/0	$50,814
Greensboro					
GREENSBORO	8/12/1993	Thunderstorm Wind	0 kts.	0/0	$0
GREENSBORO	8/17/1993	Thunderstorm Wind	65 kts.	0/0	$0
GREENSBORO	8/26/1993	Thunderstorm Wind	0 kts.	0/0	$0
GREENSBORO	4/20/1996	Thunderstorm Wind	0 kts.	0/0	$0
GREENSBORO	5/11/1996	Thunderstorm Wind	60 kts.	0/0	$302,655
GREENSBORO	5/24/1996	Thunderstorm Wind	0 kts.	0/0	$0
GREENSBORO	3/5/1997	Thunderstorm Wind	50 kts.	0/0	$73,967
GREENSBORO	7/28/1997	Thunderstorm Wind	50 kts.	0/0	$14,793
GREENSBORO	6/16/1998	Thunderstorm Wind	50 kts.	0/0	$0
GREENSBORO	6/30/1998	Thunderstorm Wind	50 kts.	0/1	$0
GREENSBORO	7/7/1999	Thunderstorm Wind	50 kts.	0/0	$0
GREENSBORO	5/25/2000	Thunderstorm Wind	70 kts. E	0/0	$0
GREENSBORO	8/10/2000	Thunderstorm Wind	50 kts. E	0/0	$0
GREENSBORO	6/1/2002	Thunderstorm Wind	50 kts. E	0/0	$0
GREENSBORO	6/27/2003	Thunderstorm Wind	52 kts. MG	0/0	$0
GREENSBORO	6/27/2003	Thunderstorm Wind	50 kts. EG	0/0	$0
GREENSBORO	4/3/2006	Thunderstorm Wind	50 kts. EG	0/0	$0
GREENSBORO	4/17/2006	Thunderstorm Wind	50 kts. EG	0/0	$0
GREENSBORO	6/11/2006	Thunderstorm Wind	50 kts. EG	0/0	$0
GREENSBORO	6/11/2006	Thunderstorm Wind	50 kts. EG	0/0	$0
GREENSBORO	6/11/2006	Thunderstorm Wind	52 kts. EG	0/0	$0
GREENSBORO	6/11/2006	Thunderstorm Wind	50 kts. EG	0/0	$0
GREENSBORO	6/11/2006	Thunderstorm Wind	50 kts. EG	0/0	$0

	Date	Type	Magnitude†	Deaths / Injuries	Property Damage*
GREENSBORO	8/3/2006	Thunderstorm Wind	50 kts. EG	0/0	$0
GREENSBORO	8/30/2006	Thunderstorm Wind	50 kts. EG	0/0	$0
GREENSBORO	9/28/2006	Thunderstorm Wind	50 kts. EG	0/0	$0
GREENSBORO	11/16/2006	Thunderstorm Wind	50 kts. EG	0/0	$0
GREENSBORO	4/15/2007	Thunderstorm Wind	50 kts. EG	0/0	$0
GREENSBORO	6/4/2007	Thunderstorm Wind	50 kts. EG	0/0	$0
GREENSBORO	6/4/2007	Thunderstorm Wind	50 kts. EG	0/0	$0
GREENSBORO	6/4/2007	Thunderstorm Wind	50 kts. EG	0/0	$0
GREENSBORO	6/5/2007	Thunderstorm Wind	50 kts. EG	0/0	$0
GREENSBORO	8/21/2007	Thunderstorm Wind	50 kts. EG	0/0	$0
GREENSBORO	6/3/2009	Thunderstorm Wind	50 kts. EG	0/0	$0
GREENSBORO	6/22/2011	Thunderstorm Wind	50 kts. EG	0/0	$0
GREENSBORO	7/21/2013	Thunderstorm Wind	50 kts. EG	0/0	$0
GREENSBORO	5/5/2017	Thunderstorm Wind	50 kts.	0/0	$0
GREENSBORO	9/1/2018	Thunderstorm Wind	50 kts.	0/0	$0
High Point					
HIGH PT	5/20/2000	Thunderstorm Wind	60 kts. E	0/0	$0
HIGH PT	5/25/2000	Thunderstorm Wind	60 kts. E	0/0	$0
HIGH PT	3/8/2005	Thunderstorm Wind	54 kts. MG	0/0	$0
HIGH PT	4/17/2006	Thunderstorm Wind	50 kts. EG	0/0	$0
HIGH PT	4/17/2006	Thunderstorm Wind	50 kts. EG	0/0	$0
HIGH PT	7/19/2006	Thunderstorm Wind	50 kts. EG	0/0	$0
HIGH PT	7/13/2009	Thunderstorm Wind	50 kts. EG	0/0	$16,601
HIGH PT	4/5/2011	Thunderstorm Wind	50 kts. EG	0/0	$263,886
HIGH PT	6/1/2012	Thunderstorm Wind	50 kts. EG	0/0	$0
HIGH PT	6/19/2014	Thunderstorm Wind	50 kts. EG	0/0	$0
HIGH PT	6/19/2014	Thunderstorm Wind	50 kts. EG	0/0	$0

	Date	Type	Magnitude†	Deaths / Injuries	Property Damage*
HIGH PT	8/5/2015	Thunderstorm Wind	50 kts.	0/0	$4,298
HIGH PT	5/3/2016	Thunderstorm Wind	50 kts.	0/0	$5,330
Oak Ridge					
OAK RIDGE	6/15/2000	Thunderstorm Wind	50 kts. E	0/0	$0
OAK RIDGE	7/4/2006	Thunderstorm Wind	50 kts. EG	0/0	$0
OAK RIDGE ARPT	6/27/2007	Thunderstorm Wind	50 kts. EG	0/0	$0
OAK RIDGE	5/26/2011	Thunderstorm Wind	50 kts. EG	0/0	$0
OAK RIDGE	5/27/2011	Thunderstorm Wind	50 kts. EG	0/0	$0
OAK RIDGE ARPT	9/8/2012	Thunderstorm Wind	50 kts. EG	0/0	$0
OAK RIDGE ARPT	4/19/2013	Thunderstorm Wind	50 kts. EG	0/0	$0
OAK RIDGE ARPT	8/10/2013	Thunderstorm Wind	50 kts. EG	0/0	$0
OAK RIDGE	8/10/2013	Thunderstorm Wind	50 kts. EG	0/0	$1,019
OAK RIDGE	8/10/2013	Thunderstorm Wind	50 kts. EG	0/0	$1,019
OAK RIDGE	6/19/2014	Thunderstorm Wind	50 kts. EG	0/0	$0
OAK RIDGE ARPT	7/21/2018	Thunderstorm Wind	50 kts.	0/0	$0
Pleasant Garden					
PLEASANT GARDEN	3/11/2000	Thunderstorm Wind	50 kts. E	0/0	$0
PLEASANT GARDEN	5/22/2001	Thunderstorm Wind	50 kts. E	0/0	$0
PLEASANT GARDEN	8/7/2006	Thunderstorm Wind	50 kts. EG	0/0	$0
PLEASANT GARDEN	7/8/2008	Thunderstorm Wind	50 kts. EG	0/0	$0
PLEASANT GARDEN	5/9/2009	Thunderstorm Wind	50 kts. EG	0/0	$0
PLEASANT GARDEN	6/23/2010	Thunderstorm Wind	50 kts. EG	0/0	$5,444
PLEASANT GARDEN	7/20/2010	Thunderstorm Wind	50 kts. EG	0/0	$0
PLEASANT GARDEN	4/28/2011	Thunderstorm Wind	50 kts. EG	0/0	$0
PLEASANT GARDEN	8/5/2015	Thunderstorm Wind	50 kts.	0/0	$0
Sedalia					
SEDALIA	7/13/2003	Thunderstorm Wind	50 kts. EG	0/0	$0

	Date	Type	Magnitude†	Deaths / Injuries	Property Damage*
SEDALIA	3/8/2005	Thunderstorm Wind	50 kts. EG	0/0	$0
SEDALIA	7/4/2011	Thunderstorm Wind	50 kts. EG	0/0	$0
SEDALIA	7/6/2018	Thunderstorm Wind	50 kts.	0/0	$2,541
Stokesdale					
STOKESDALE	9/14/2000	Thunderstorm Wind	50 kts. E	0/0	$0
STOKESDALE	8/12/2004	Thunderstorm Wind	50 kts. EG	0/0	$0
STOKESDALE	6/19/2007	Thunderstorm Wind	50 kts. EG	0/0	$0
STOKESDALE	6/27/2007	Thunderstorm Wind	50 kts. EG	0/0	$0
STOKESDALE	8/21/2007	Thunderstorm Wind	50 kts. EG	0/0	$0
Summerfield					
SUMMERFIELD	7/28/1997	Thunderstorm Wind	50 kts.	0/0	$0
SUMMERFIELD	6/15/2000	Thunderstorm Wind	50 kts. E	0/0	$0
SUMMERFIELD	5/13/2002	Thunderstorm Wind	50 kts. E	0/0	$0
SUMMERFIELD	7/28/2006	Thunderstorm Wind	50 kts. EG	0/0	$0
SUMMERFIELD	8/30/2006	Thunderstorm Wind	50 kts. EG	0/0	$0
SUMMERFIELD	6/24/2010	Thunderstorm Wind	50 kts. EG	0/0	$0
SUMMERFIELD	6/24/2010	Thunderstorm Wind	50 kts. EG	0/0	$10,889
SUMMERFIELD	7/24/2011	Thunderstorm Wind	50 kts. EG	0/0	$0
SUMMERFIELD	5/21/2016	Thunderstorm Wind	50 kts.	0/0	$2,132
SUMMERFIELD	7/21/2018	Thunderstorm Wind	50 kts.	0/0	$0
Whitsett					
WHITSETT	8/14/2011	Thunderstorm Wind	50 kts. EG	0/0	$0
WHITSETT	7/21/2012	Thunderstorm Wind	50 kts. EG	0/0	$0
Unincorporated Area					
GUILFORD CO.	8/2/1956	Thunderstorm Wind	0 kts.	0/0	$0
GUILFORD CO.	7/17/1957	Thunderstorm Wind	0 kts.	0/0	$0
GUILFORD CO.	5/25/1960	Thunderstorm Wind	60 kts.	0/0	$0

	Date	Type	Magnitude†	Deaths / Injuries	Property Damage*
GUILFORD CO.	8/9/1962	Thunderstorm Wind	0 kts.	0/0	$0
GUILFORD CO.	3/19/1963	Thunderstorm Wind	50 kts.	0/0	$0
GUILFORD CO.	7/3/1964	Thunderstorm Wind	0 kts.	0/0	$0
GUILFORD CO.	7/13/1964	Thunderstorm Wind	0 kts.	0/0	$0
GUILFORD CO.	4/27/1965	Thunderstorm Wind	0 kts.	0/0	$0
GUILFORD CO.	7/4/1965	Thunderstorm Wind	55 kts.	0/0	$0
GUILFORD CO.	5/1/1966	Thunderstorm Wind	0 kts.	0/0	$0
GUILFORD CO.	5/29/1967	Thunderstorm Wind	0 kts.	0/0	$0
GUILFORD CO.	8/4/1967	Thunderstorm Wind	0 kts.	0/0	$0
GUILFORD CO.	6/24/1969	Thunderstorm Wind	0 kts.	0/0	$0
GUILFORD CO.	7/4/1970	Thunderstorm Wind	0 kts.	0/0	$0
GUILFORD CO.	6/29/1971	Thunderstorm Wind	0 kts.	0/0	$0
GUILFORD CO.	3/24/1975	Thunderstorm Wind	0 kts.	0/0	$0
GUILFORD CO.	2/18/1976	Thunderstorm Wind	54 kts.	0/0	$0
GUILFORD CO.	7/15/1976	Thunderstorm Wind	84 kts.	0/0	$0
GUILFORD CO.	8/14/1976	Thunderstorm Wind	60 kts.	0/0	$0
GUILFORD CO.	8/14/1976	Thunderstorm Wind	0 kts.	0/0	$0
GUILFORD CO.	7/4/1979	Thunderstorm Wind	0 kts.	0/0	$0
GUILFORD CO.	8/21/1979	Thunderstorm Wind	0 kts.	0/0	$0
GUILFORD CO.	8/1/1980	Thunderstorm Wind	50 kts.	0/0	$0
GUILFORD CO.	8/15/1980	Thunderstorm Wind	0 kts.	0/0	$0
GUILFORD CO.	6/6/1981	Thunderstorm Wind	0 kts.	0/0	$0
GUILFORD CO.	7/28/1981	Thunderstorm Wind	0 kts.	0/0	$0
GUILFORD CO.	5/29/1982	Thunderstorm Wind	52 kts.	0/0	$0
GUILFORD CO.	3/6/1983	Thunderstorm Wind	0 kts.	0/0	$0
GUILFORD CO.	7/10/1984	Thunderstorm Wind	50 kts.	0/0	$0
GUILFORD CO.	7/26/1984	Thunderstorm Wind	0 kts.	0/0	$0

	Date	Type	Magnitude†	Deaths / Injuries	Property Damage*
GUILFORD CO.	7/26/1984	Thunderstorm Wind	0 kts.	0/0	$0
GUILFORD CO.	6/3/1985	Thunderstorm Wind	0 kts.	0/0	$0
GUILFORD CO.	6/5/1985	Thunderstorm Wind	0 kts.	0/0	$0
GUILFORD CO.	6/5/1985	Thunderstorm Wind	0 kts.	0/0	$0
GUILFORD CO.	7/4/1985	Thunderstorm Wind	0 kts.	0/0	$0
GUILFORD CO.	7/4/1985	Thunderstorm Wind	0 kts.	0/0	$0
GUILFORD CO.	7/10/1985	Thunderstorm Wind	55 kts.	0/0	$0
GUILFORD CO.	10/15/1985	Thunderstorm Wind	52 kts.	0/0	$0
GUILFORD CO.	10/15/1985	Thunderstorm Wind	0 kts.	0/0	$0
GUILFORD CO.	6/28/1986	Thunderstorm Wind	52 kts.	0/0	$0
GUILFORD CO.	7/29/1986	Thunderstorm Wind	0 kts.	0/0	$0
GUILFORD CO.	7/29/1986	Thunderstorm Wind	0 kts.	0/0	$0
GUILFORD CO.	4/15/1987	Thunderstorm Wind	0 kts.	0/0	$0
GUILFORD CO.	6/1/1987	Thunderstorm Wind	0 kts.	0/0	$0
GUILFORD CO.	9/10/1987	Thunderstorm Wind	0 kts.	0/0	$0
GUILFORD CO.	5/10/1988	Thunderstorm Wind	0 kts.	0/0	$0
GUILFORD CO.	5/17/1988	Thunderstorm Wind	0 kts.	0/0	$0
GUILFORD CO.	5/23/1988	Thunderstorm Wind	50 kts.	0/0	$0
GUILFORD CO.	6/26/1988	Thunderstorm Wind	0 kts.	1/0	$0
GUILFORD CO.	7/10/1988	Thunderstorm Wind	0 kts.	0/0	$0
GUILFORD CO.	7/10/1988	Thunderstorm Wind	0 kts.	0/0	$0
GUILFORD CO.	4/26/1989	Thunderstorm Wind	0 kts.	0/0	$0
GUILFORD CO.	5/5/1989	Thunderstorm Wind	0 kts.	0/0	$0
GUILFORD CO.	5/5/1989	Thunderstorm Wind	0 kts.	0/0	$0
GUILFORD CO.	5/6/1989	Thunderstorm Wind	0 kts.	0/0	$0
GUILFORD CO.	5/6/1989	Thunderstorm Wind	0 kts.	0/0	$0
GUILFORD CO.	5/6/1989	Thunderstorm Wind	0 kts.	0/0	$0

	Date	Type	Magnitude†	Deaths / Injuries	Property Damage*
GUILFORD CO.	5/23/1989	Thunderstorm Wind	0 kts.	0/0	$0
GUILFORD CO.	6/16/1989	Thunderstorm Wind	0 kts.	1/0	$0
GUILFORD CO.	6/16/1989	Thunderstorm Wind	0 kts.	0/0	$0
GUILFORD CO.	7/12/1989	Thunderstorm Wind	0 kts.	0/0	$0
GUILFORD CO.	2/10/1990	Thunderstorm Wind	0 kts.	0/0	$0
GUILFORD CO.	5/1/1990	Thunderstorm Wind	0 kts.	0/0	$0
GUILFORD CO.	7/1/1990	Thunderstorm Wind	0 kts.	0/0	$0
GUILFORD CO.	7/11/1990	Thunderstorm Wind	0 kts.	0/0	$0
GUILFORD CO.	8/29/1990	Thunderstorm Wind	0 kts.	0/0	$0
GUILFORD CO.	10/18/1990	Thunderstorm Wind	0 kts.	0/0	$0
GUILFORD CO.	4/9/1991	Thunderstorm Wind	0 kts.	0/0	$0
GUILFORD CO.	4/29/1991	Thunderstorm Wind	0 kts.	0/0	$0
GUILFORD CO.	7/3/1991	Thunderstorm Wind	50 kts.	0/0	$0
GUILFORD CO.	7/3/1991	Thunderstorm Wind	0 kts.	0/0	$0
GUILFORD CO.	3/10/1992	Thunderstorm Wind	0 kts.	0/0	$0
GUILFORD CO.	3/10/1992	Thunderstorm Wind	0 kts.	0/0	$0
GUILFORD CO.	4/24/1992	Thunderstorm Wind	0 kts.	0/0	$0
GUILFORD CO.	8/11/1992	Thunderstorm Wind	0 kts.	0/0	$0
GUILFORD CO.	8/11/1992	Thunderstorm Wind	57 kts.	0/0	$0
GUILFORD CO.	11/22/1992	Thunderstorm Wind	0 kts.	0/0	$0
BROWNS SUMMIT	6/8/1995	Thunderstorm Wind	0 kts.	0/0	$0
JUILIAN	10/27/1995	Thunderstorm Wind	0 kts.	0/0	$0
COUNTYWIDE	1/19/1996	Thunderstorm Wind	0 kts.	0/0	$0
CLIMAX	7/16/1997	Thunderstorm Wind	50 kts.	0/0	$0
GUILFORD (ZONE)	2/16/1998	High Wind	45 kts.	0/0	$0
GREENSBORO ARPT	5/25/2000	Thunderstorm Wind	71 kts. M	0/0	$0
GREENSBORO ARPT	9/14/2000	Thunderstorm Wind	52 kts. M	0/0	$0

	Date	Type	Magnitude†	Deaths / Injuries	Property Damage*
COLFAX	8/17/2003	Thunderstorm Wind	50 kts. EG	0/0	$0
GUILFORD (ZONE)	3/7/2004	High Wind	50 kts. EG	0/0	$0
MONTICELLO	7/13/2005	Thunderstorm Wind	50 kts. EG	0/0	$0
CLIMAX	5/18/2006	Thunderstorm Wind	50 kts. EG	0/0	$0
MC LEANSVILLE	7/19/2006	Thunderstorm Wind	50 kts. EG	0/0	$0
GUILFORD (ZONE)	4/16/2007	High Wind	54 kts. MG	0/0	$0
MC LEANSVILLE	6/27/2007	Thunderstorm Wind	50 kts. EG	0/0	$0
GUILFORD (ZONE)	2/10/2008	Strong Wind	43 kts. EG	0/0	$5,514
GUILFORD	3/4/2008	Thunderstorm Wind	52 kts. MG	0/0	$0
DEEP RIVER	3/4/2008	Thunderstorm Wind	51 kts. MG	0/0	$0
HAMILTON LAKES	3/4/2008	Thunderstorm Wind	50 kts. EG	0/0	$0
(GSO)GREENSBORO RGNL	5/8/2008	Thunderstorm Wind	54 kts. MG	0/0	$0
MONTICELLO	5/8/2008	Thunderstorm Wind	50 kts. EG	0/0	$0
GREENSBORO MAY ARPT	6/23/2008	Thunderstorm Wind	50 kts. EG	0/0	$0
GUILFORD (ZONE)	1/7/2009	Strong Wind	39 kts. MG	0/0	$1,107
COLFAX	5/6/2009	Thunderstorm Wind	50 kts. EG	0/0	$0
RUDD	6/3/2009	Thunderstorm Wind	50 kts. EG	0/0	$0
HAMILTON LAKES	6/3/2009	Thunderstorm Wind	50 kts. EG	0/0	$0
DEEP RIVER	6/3/2009	Thunderstorm Wind	58 kts. EG	0/0	$0
GUILQUARRY	6/10/2009	Thunderstorm Wind	50 kts. EG	0/0	$0
CLIMAX	8/5/2009	Thunderstorm Wind	50 kts. EG	0/0	$0
BRIGHTWOOD	8/20/2009	Thunderstorm Wind	50 kts. EG	0/0	$0
BROWNS SUMMIT	9/28/2009	Thunderstorm Wind	50 kts. EG	0/0	$0
BROWNS SUMMIT	9/28/2009	Thunderstorm Wind	50 kts. EG	0/0	$0
GUILFORD (ZONE)	11/11/2009	Strong Wind	35 kts. EG	0/0	$1,107
GUILFORD (ZONE)	12/9/2009	Strong Wind	40 kts. EG	0/0	$1,107

	Date	Type	Magnitude†	Deaths / Injuries	Property Damage*
GUILFORD (ZONE)	2/10/2010	High Wind	50 kts. EG	0/0	$1,089
COLFAX	4/8/2010	Thunderstorm Wind	50 kts. EG	0/0	$0
POMONA	6/14/2010	Thunderstorm Wind	50 kts. EG	0/0	$1,089
PINECROFT	6/14/2010	Thunderstorm Wind	50 kts. EG	0/0	$0
SCALESVILLE	6/15/2010	Thunderstorm Wind	50 kts. EG	0/0	$0
GREENSBORO MAY ARPT	6/15/2010	Thunderstorm Wind	50 kts. EG	0/0	$0
HAMILTON LAKES	6/16/2010	Thunderstorm Wind	50 kts. EG	0/0	$0
GUILFORD	7/13/2010	Thunderstorm Wind	50 kts. EG	0/0	$0
DEEP RIVER	7/16/2010	Thunderstorm Wind	50 kts. EG	0/0	$5,444
HILL TOP	8/5/2010	Thunderstorm Wind	50 kts. EG	0/0	$0
GREENSBORO ARPT	8/11/2010	Thunderstorm Wind	50 kts. EG	0/0	$0
COLFAX	11/16/2010	Thunderstorm Wind	50 kts. EG	0/0	$0
GUILFORD (ZONE)	2/25/2011	Strong Wind	44 kts. MG	0/0	$1,055,544
HILLSDALE	4/28/2011	Thunderstorm Wind	50 kts. EG	0/0	$0
BESSEMER	4/28/2011	Thunderstorm Wind	50 kts. EG	0/0	$0
MONTICELLO	4/28/2011	Thunderstorm Wind	50 kts. EG	0/0	$0
GUILFORD (ZONE)	4/28/2011	Strong Wind	49 kts. EG	0/0	$1,056
GREENSBORO MAY ARPT	5/26/2011	Thunderstorm Wind	50 kts. EG	0/0	$0
MC LEANSVILLE	6/11/2011	Thunderstorm Wind	50 kts. EG	0/0	$0
HILLSDALE	6/18/2011	Thunderstorm Wind	50 kts. EG	0/0	$0
GREENSBORO MAY ARPT	6/18/2011	Thunderstorm Wind	50 kts. EG	0/0	$0
BESSEMER	6/22/2011	Thunderstorm Wind	50 kts. EG	0/0	$0
GUILFORD CO.	6/28/2011	Thunderstorm Wind	50 kts. EG	0/0	$0
COLFAX	7/24/2011	Thunderstorm Wind	50 kts. EG	0/0	$0
GUILQUARRY	2/22/2012	Thunderstorm Wind	50 kts. EG	0/0	$0

	Date	Type	Magnitude†	Deaths / Injuries	Property Damage*
GREENSBORO MAY ARPT	2/22/2012	Thunderstorm Wind	50 kts. EG	0/0	$0
BATTLE GROUND	2/24/2012	Thunderstorm Wind	50 kts. EG	0/0	$0
GREENSBORO ARHRBR AR	3/24/2012	Thunderstorm Wind	50 kts. EG	0/0	$0
TERRA COTTA	6/1/2012	Thunderstorm Wind	50 kts. EG	0/0	$15,512
BATTLE GROUND	6/22/2012	Thunderstorm Wind	50 kts. EG	0/0	$0
CLIMAX	7/20/2012	Thunderstorm Wind	50 kts. EG	0/0	$0
BATTLE GROUND	9/2/2012	Thunderstorm Wind	50 kts. EG	0/0	$0
PINECROFT	9/2/2012	Thunderstorm Wind	50 kts. EG	0/0	$0
HILLSDALE	10/18/2012	Thunderstorm Wind	50 kts. EG	0/0	$0
GUILFORD (ZONE)	1/30/2013	Strong Wind	40 kts. EG	0/0	$2,038
DEEP RIVER	1/30/2013	Thunderstorm Wind	50 kts. EG	0/0	$510
GROOMTOWN	4/19/2013	Thunderstorm Wind	50 kts. EG	0/0	$510
GUILFORD	6/10/2013	Thunderstorm Wind	50 kts. EG	0/0	$0
GUILQUARRY	6/13/2013	Thunderstorm Wind	50 kts. EG	0/1	$203,843
BATTLE GROUND	6/25/2013	Thunderstorm Wind	50 kts. EG	0/0	$0
SEDGEFIELD	6/28/2013	Thunderstorm Wind	50 kts. EG	0/0	$2,038
SEDGEFIELD	8/10/2013	Thunderstorm Wind	50 kts. EG	0/0	$0
GUILFORD CO.	9/1/2013	Thunderstorm Wind	50 kts. EG	0/0	$1,019
HAMILTON LAKES	2/21/2014	Thunderstorm Wind	50 kts. EG	0/0	$3,000
(GSO)GREENSBORO RGNL	3/12/2014	Thunderstorm Wind	53 kts. MG	0/0	$5,000
HAMILTON LAKES	6/10/2014	Thunderstorm Wind	50 kts. EG	0/0	$1,000
BRIGHTWOOD	6/16/2014	Thunderstorm Wind	50 kts. EG	0/0	$0
GUILQUARRY	6/19/2014	Thunderstorm Wind	50 kts. EG	0/0	$0
BATTLE GROUND	9/16/2014	Thunderstorm Wind	50 kts.	0/0	$0
HILLSDALE	4/20/2015	Thunderstorm Wind	50 kts.	0/0	$0
DEEP RIVER	6/30/2015	Thunderstorm Wind	52 kts.	0/0	$26,829

	Date	Type	Magnitude†	Deaths / Injuries	Property Damage*
MCLEANSVILLE	6/30/2015	Thunderstorm Wind	50 kts.	0/0	$0
(GSO)GREENSBORO RGNL	7/13/2015	Thunderstorm Wind	64 kts.	0/0	$0
SEDGEFIELD	8/5/2015	Thunderstorm Wind	50 kts.	0/0	$0
VANDALIA	8/5/2015	Thunderstorm Wind	50 kts.	0/0	$0
GREENSBORO MAY ARPT	8/5/2015	Thunderstorm Wind	50 kts.	0/0	$0
GUILFORD (ZONE)	10/2/2015	Strong Wind	35 kts.	0/0	$538
GUILFORD (ZONE)	10/2/2015	Strong Wind	35 kts.	0/0	$538
GUILFORD (ZONE)	10/2/2015	Strong Wind	35 kts.	0/0	$538
GUILFORD (ZONE)	10/3/2015	Strong Wind	35 kts.	0/0	$538
SEDGEFIELD	2/24/2016	Thunderstorm Wind	50 kts.	0/0	$0
GUILFORD (ZONE)	4/9/2016	Strong Wind	41 kts.	0/0	$21,407
GUILFORD	5/2/2016	Thunderstorm Wind	50 kts.	0/0	$5,330
BATTLE GROUND	5/2/2016	Thunderstorm Wind	50 kts.	0/0	$0
GUILFORD	5/2/2016	Thunderstorm Wind	50 kts.	0/0	$26,651
GREENSBORO MAY ARPT	5/12/2016	Thunderstorm Wind	50 kts.	0/0	$1,066
OSCEOLA	6/24/2016	Thunderstorm Wind	50 kts.	0/0	$531
BATTLE GROUND	7/8/2016	Thunderstorm Wind	50 kts.	0/0	$0
COLFAX	7/8/2016	Thunderstorm Wind	50 kts.	0/0	$0
GUILQUARRY	7/27/2016	Thunderstorm Wind	50 kts.	0/0	$5,321
COLFAX	7/27/2016	Thunderstorm Wind	50 kts.	0/0	$0
FOUR MILE	8/27/2016	Thunderstorm Wind	50 kts.	0/0	$2,658
VANDALIA	8/27/2016	Thunderstorm Wind	50 kts.	0/0	$0
GUILFORD (ZONE)	10/8/2016	Strong Wind	30 kts.	0/0	$105,942
BATTLE GROUND	5/5/2017	Thunderstorm Wind	50 kts.	0/0	$10,464
MONTICELLO	5/5/2017	Thunderstorm Wind	50 kts.	0/0	$10,464
BROWNS SUMMIT	5/5/2017	Thunderstorm Wind	50 kts.	0/0	$104,641

	Date	Type	Magnitude†	Deaths / Injuries	Property Damage*
TERRA COTTA	5/5/2017	Thunderstorm Wind	50 kts.	0/0	$0
HILLSDALE	5/5/2017	Thunderstorm Wind	50 kts.	0/0	$10,464
OSCEOLA	5/31/2017	Thunderstorm Wind	50 kts.	0/0	$2,093
GUILQUARRY	6/13/2017	Thunderstorm Wind	50 kts.	0/0	$10,455
GUILFORD	6/13/2017	Thunderstorm Wind	50 kts.	0/0	$3,136
BATTLE GROUND	6/14/2017	Thunderstorm Wind	50 kts.	0/0	$5,227
ALLEN JAY	6/18/2017	Thunderstorm Wind	50 kts.	0/0	$523
PINECROFT	6/18/2017	Thunderstorm Wind	50 kts.	0/0	$0
MCLEANSVILLE	7/13/2017	Thunderstorm Wind	50 kts.	0/0	$5,231
HILL TOP	7/23/2017	Thunderstorm Wind	50 kts.	0/0	$5,231
GUILFORD (ZONE)	1/23/2018	Strong Wind	35 kts.	0/0	$10,332
GUILFORD (ZONE)	3/2/2018	Strong Wind	35 kts.	0/0	$20,524
GUILFORD (ZONE)	3/2/2018	Strong Wind	35 kts.	0/0	$8,210
BESSEMER	7/6/2018	Thunderstorm Wind	50 kts.	0/0	$0
MONTICELLO	7/22/2018	Thunderstorm Wind	50 kts.	0/0	$2,541
MCLEANSVILLE	8/7/2018	Thunderstorm Wind	50 kts.	0/0	$0
BROADVIEW	9/1/2018	Thunderstorm Wind	50 kts.	0/0	$1,522

*Property damage is reported in 2019 dollars; All damage may not have been reported.
Source: National Centers for Environmental Information

Lightning

According to the National Centers for Environmental Information, there have been a total of nine recorded lightning events in Guilford County since 1996, as listed in summary **Table 3.31**.[26] These events resulted in almost $2.6 million (2019 dollars) in damages.[27] Detailed information on historical lightning events can be found in **Table 3.32**.

[26] These lightning events are only inclusive of those reported by the National Climatic Data Center (NCDC) from 1997 through August 2014. It is certain that additional lightning events have occurred in Guilford County. The State Fire Marshall's office was also contacted for additional information but none could be provided. As additional local data becomes available, this hazard profile will be amended.
[27] Adjusted dollar values were calculated based on the average Consumer Price Index for a given calendar year. This index value has been calculated every year since 1913. For 2014, the October 2014 monthly index was used.

It is certain that more than nine events have impacted the county. Many of the reported events are those that caused damage, and it should be expected that damages are likely much higher for this hazard than what is reported.

TABLE 3.31: SUMMARY OF LIGHTNING OCCURRENCES IN GUILFORD COUNTY

Location	Number of Occurrences	Deaths / Injuries	Property Damage (2014)	Annualized Property Loss
Gibsonville	0	0/0	$0	$0
Greensboro	1	0/0	$315,102	$18,535
High Point	1	0/0	$9,954	$586
Jamestown	0	0/0	$0	$0
Oak Ridge	2	0/0	$7,118	$324
Pleasant Garden	0	0/0	$0	$0
Sedalia	0	0/0	$0	$0
Stokesdale	0	0/0	$0	$0
Summerfield	0	0/0	$0	$0
Whitsett	0	0/0	$0	$0
Unincorporated Area	5	0/0	$2,325,236	$136,779
GUILFORD COUNTY TOTAL	**9**	**0/0**	**$2,657,410**	**$156,223**

Source: National Centers for Environmental Information

TABLE 3.32: HISTORICAL OCCURRENCES IN GUILFORD COUNTY

	Date	Deaths / Injuries	Property Damage*	Details
Gibsonville				
None Reported	--	--	--	--
Greensboro				
GREENSBORO	3/26/2002	0/0	$315,102	Lightning started a fire that destroyed the third floor of a home.

	Date	Deaths / Injuries	Property Damage*	Details
High Point				
HIGH PT	7/1/2002	0/0	$9,954	A lightning strike caused minor damage to a public library.
Jamestown				
None Reported	--	--	--	--
Oak Ridge				
OAK RIDGE	7/28/1997	0/0	$0	LIGHTNING HIT A HOME IN OAK RIDGE. NO DAMAGE DETAILS WERE AVAILABLE.
OAK RIDGE	6/26/2002	0/0	$7,118	At least four house fires were started by lightning strikes in the Oak Ridge area.
Pleasant Garden				
None Reported	--	--	--	--
Sedalia				
None Reported	--	--	--	--
Stokesdale				
None Reported	--	--	--	--
Summerfield				
None Reported	--	--	--	--
Whitsett				
None Reported	--	--	--	--
Unincorporated Area				
SEDGEFIELD	5/1/2002	0/0	$427,295	A lightning strike started a fire that severely damaged a historic home.

	Date	Deaths / Injuries	Property Damage*	Details
HAMILTON LAKES	6/12/2010	0/0	$1,762,384	Lightning struck a large fuel tank at the Colonial Pipeline gasoline tank farm resulting in a large fire destroying the tank and resulting in the closure of Interstate 40 for four hours. The tank contained 840,000 gallons of gasoline at the time of the fire.
(GSO)GREENSBORO RGNL	6/16/2010	0/0	$117,492	Lightning struck the runway at the Piedmont Triad International Airport creating a hole two feet wide and 18 inches deep in the runway.
DEEP RIVER	8/11/2010	0/0	$17,596	A home on Windstream Court in High Point sustained roof damage due to a lightning strike. The damages were estimated.
BESSEMER	8/11/2010	0/0	$469	A lightning strike damaged an outbuilding at 3865 Arbor Drive in Greensboro. The damage was estimated at $300 and the content loss was $100.

*Property Damage is reported in 2014 dollars; all damage may not have been reported.
Source: National Climatic Data Center

Probability of Future Occurrences

Wind

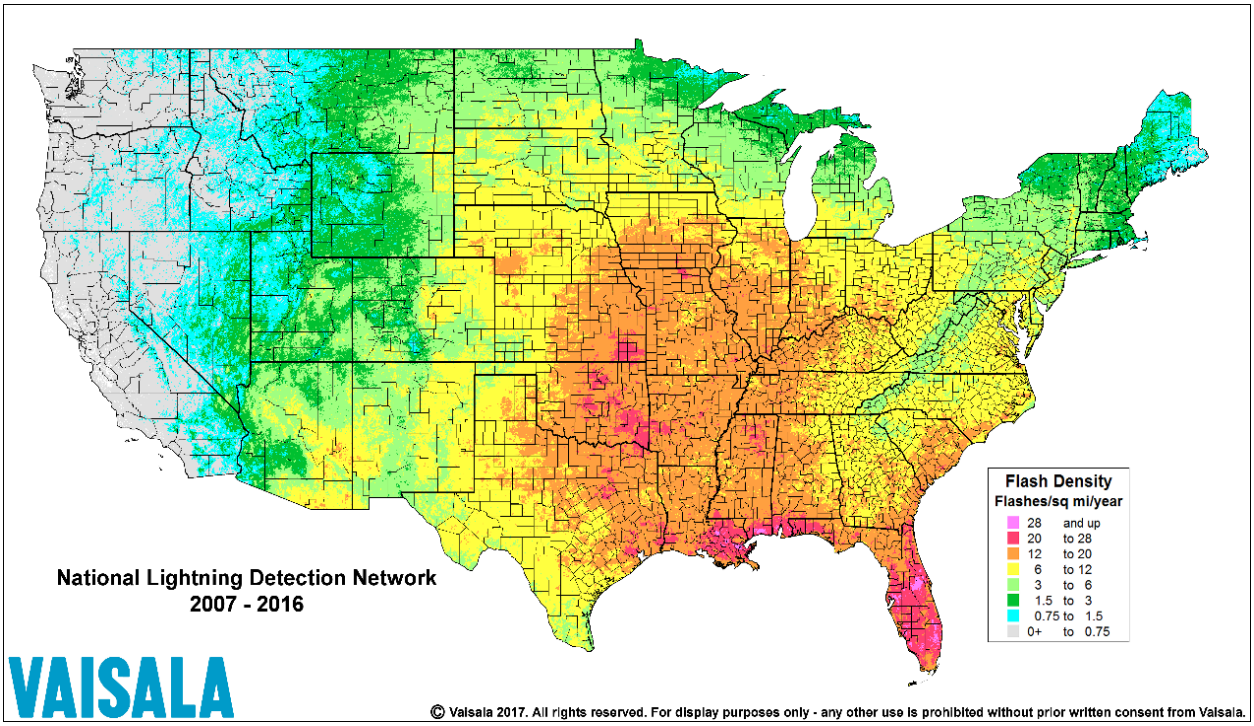
Given the high number of previous events, it is certain that wind events, including straight-line wind and thunderstorm wind, will occur in the future. This results in a probability level of highly likely (100 percent annual probability) for future wind events for the entire county. Additionally, according to the *Piedmont Together Climate Adaptation Report*, storm wind speeds are estimated to increase at a proportional rate of 1-8 percent based upon rising global ocean temperatures.

Lightning

Although there was not a high number of historical lightning events reported throughout Guilford County via NCEI data, it is considered a regular occurrence, especially accompanied by thunderstorms. **Figure 3.10** shows the lightning flash density map for

the years 2007-2016 based upon data provided by Vaisala's U.S. National Lightning Detection Network (NLDN®). Guilford County is located in an area of the country that experienced an average of 6 to 12 lightning flashes per square mile per year between 2007 and 2016. Therefore, the probability of future events is highly likely (100 percent annual probability). It can be expected that future lightning events will continue to threaten life and cause minor property damages throughout the county.

FIGURE 3.22: LIGHTNING FLASH DENSITY IN THE UNITED STATES



Source: Vaisala United States National Lightning Detection Network

Consequence Analysis

People (The Public and Public Confidence)

Wind

Thunderstorms are generally associated with several other hazards such as high wind and flooding, the latter of which is caused by torrential rain. As such, the public could be impacted in a number of ways by a thunderstorm event. High wind can cause trees to fall and potentially result in injuries or death and rising floodwaters can lead to drowning or other serious injury. Although often not as severe as hurricanes or tornadoes, the impacts on the public from thunderstorms can be significant. However, the public confidence is usually not affected to a large degree as a result of thunderstorms.

Lightning

Although relatively rare when compared to other hazards, the impacts of lightning on people can be severe, resulting in death or severe injury if a person is struck. Fatalities and injuries from lightning events most often occur when a person is exposed and in outdoor conditions during a thunderstorm. Exposure to water and open areas also increases the likelihood that a person will be struck. Lightning generally has a low probability of impacting public confidence.

Responders

Wind

Responders are not generally affected to any great degree by thunderstorm events, although it should be noted that they could be impacted in many of the same ways as the public. Otherwise, responders could be affected by road blockages caused by downed trees or floodwaters, which would ultimately reduce their response time.

Lightning

Although responders are generally aware of the effects of lightning and take precautions to avoid being impacted by a lightning strike, it is possible that they could be struck. Moreover, taking the necessary precautions to avoid a lightning strike can often reduce response times as staying inside and away from lightning is the best way to avoid injury from the hazard.

Continuity of Operations

Wind

In general, continuity of operations during a thunderstorm event can be maintained. Thunderstorm events often affect power in much the same way as tornadoes and hurricanes, which ultimately may impact operations. However, thunderstorm events are typically not large enough and their impacts are not wide enough to disrupt continuity of operations in Guilford County.

Lightning

Most critical facilities and infrastructure are protected against lightning via surge protectors and lightning rods. However, if lightning were to shut down large parts of the power grid due to blowing a transformer, operations would be detrimentally impacted. In general, however, continuity of operations during a lightning event would not be affected.

Built Environment (Property, Facilities, and Infrastructure)

Wind

Thunderstorms often have their greatest impact on the built environment as they can cause damage to homes via strong winds or flooding and will often impact facilities and infrastructure in the same way. Power losses often occur due to damage to power lines and roads can flood and cause damage as well. In fact, thunderstorms are often considered one of the greater hazards of concern even though any given event will cause relatively little damage, because damaging events occur so frequently.

Lightning

Lightning generally does not have a major impact on property, facilities, or infrastructure. However, it has been known to affect power and energy sources through strikes which can shut down power for hours and sometimes days. Lightning is also responsible for igniting fires that can result in widespread damage to property.

Economy

Wind

Economic impacts from thunderstorm events can often be far reaching as the damage from these events are often widespread, affecting both homes and businesses. This damage can result in business and economic disruption through the recovery process.

Lightning

Since lightning events generally pass through the area quickly and cause relatively little property damage when compared to other hazards, effects on the economy will likely be minimal. Nevertheless, if power-related infrastructure is damaged, this could cause some economic strain to replace and get the system back to full capacity.

Environment

Wind

Thunderstorms can impact crops via high wind and flooding and can also impact the natural environment through these elements. Flooding can kill plants and animals as well as contaminate drinking water supplies for human populations. High wind can harm forests by bringing down trees and cause fires from downed power lines that impact the environment.

Lightning

The environmental effects of lightning are relatively minimal, although lightning has been known to cause wildfires which can lead to widespread damage. For more details on these impacts, please see this section of the wildfire hazard.

Tornado

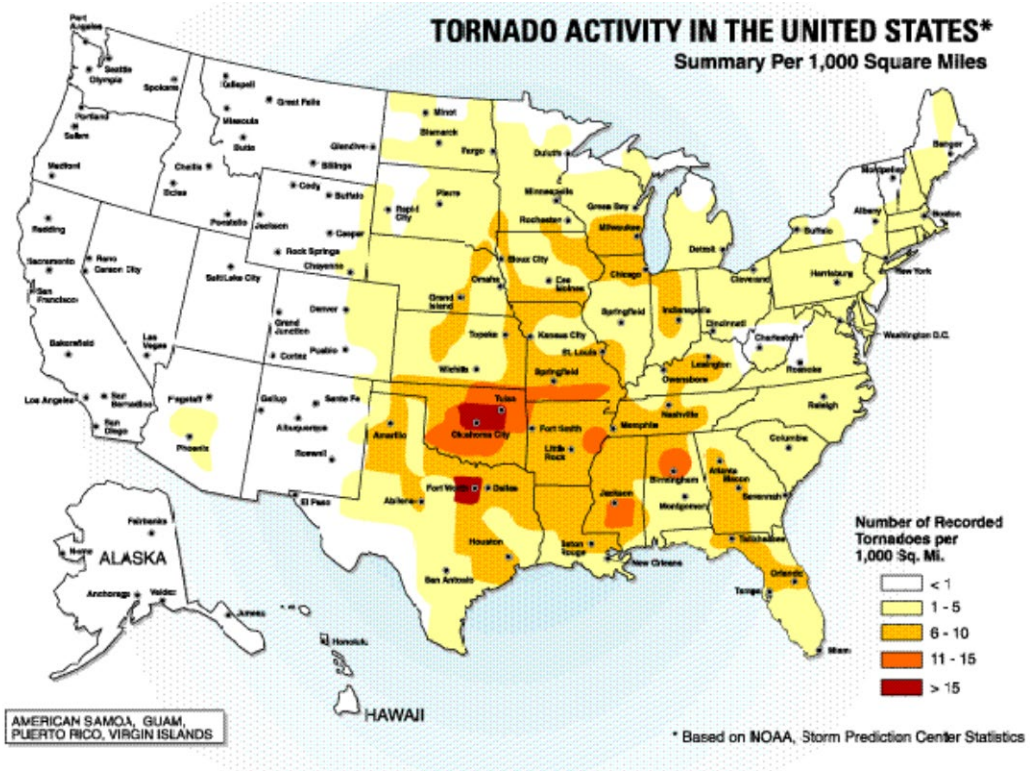
Background

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 (but sometimes result from hurricanes and other tropical storms) when cool, dry air intersects and overrides a layer of warm, moist air forcing the warm air to rise rapidly. 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 miles per hour 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.

Each year, an average of over 800 tornadoes is reported nationwide, resulting in an average of 80 deaths and 1,500 injuries.[28] According to the NOAA Storm Prediction Center (SPC), the highest concentration of tornadoes in the United States has been in Oklahoma, Texas, Kansas, and Florida respectively. Although the Great Plains region of the Central United States does favor the development of the largest and most dangerous tornadoes (earning the designation of "tornado alley"), Florida experiences the greatest number of tornadoes per square mile of all U.S. states (SPC, 2002). **Figure 3.23** shows tornado activity in the United States based on the number of recorded tornadoes per 1,000 square miles.

[28] NOAA, 2009.

FIGURE 3.23: TORNADO ACTIVITY IN THE UNITED STATES



Source: Federal Emergency Management Agency

Tornadoes are more likely to occur during the months of March through May and are most 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.

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 damage to structures of light construction, including residential dwellings (particularly mobile homes). Tornadic magnitude is reported according to the Fujita and Enhanced Fujita Scales. Tornado magnitudes prior to 2005 were determined using the traditional version of the Fujita Scale (**Table 3.33**). Tornado magnitudes that were determined in 2005 and later were determined using the Enhanced Fujita Scale (**Table 3.34**).

TABLE 3.33: THE FUJITA SCALE (EFFECTIVE PRIOR TO 2005)

F-SCALE NUMBER	INTENSITY	WIND SPEED	TYPE OF DAMAGE DONE
F0	GALE TORNADO	40–72 MPH	Some damage to chimneys; breaks branches off trees; pushes over shallow-rooted trees; damages to sign boards.
F1	MODERATE TORNADO	73–112 MPH	The lower limit is the beginning of hurricane wind speed; peels surface off roofs; mobile homes pushed off foundations or overturned; moving autos pushed off the roads; attached garages may be destroyed.
F2	SIGNIFICANT TORNADO	113–157 MPH	Considerable damage. Roofs torn off frame houses; mobile homes demolished; boxcars pushed over; large trees snapped or uprooted; light object missiles generated.
F3	SEVERE TORNADO	158–206 MPH	Roof and some walls torn off well-constructed houses; trains overturned; most trees in forest uprooted.
F4	DEVASTATING TORNADO	207–260 MPH	Well-constructed houses leveled; structures with weak foundations blown off some distance; cars thrown and large missiles generated.
F5	INCREDIBLE TORNADO	261–318 MPH	Strong frame houses lifted off foundations and carried considerable distances to disintegrate; automobile sized missiles fly through the air in excess of 100 meters; trees debarked; steel re-enforced concrete structures badly damaged.
F6	INCONCEIVABLE TORNADO	319–379 MPH	These winds are very unlikely. The small area of damage they might produce would probably not be recognizable along with the mess produced by F4 and F5 wind that would surround the F6 winds. Missiles, such as cars and refrigerators would do serious secondary damage that could not be directly identified as F6 damage. If this level is ever achieved, evidence for it might only be found in some manner of ground swirl pattern, for it may never be identifiable through engineering studies.

Source: National Weather Service

TABLE 3.34: THE ENHANCED FUJITA SCALE (EFFECTIVE 2005 AND LATER)

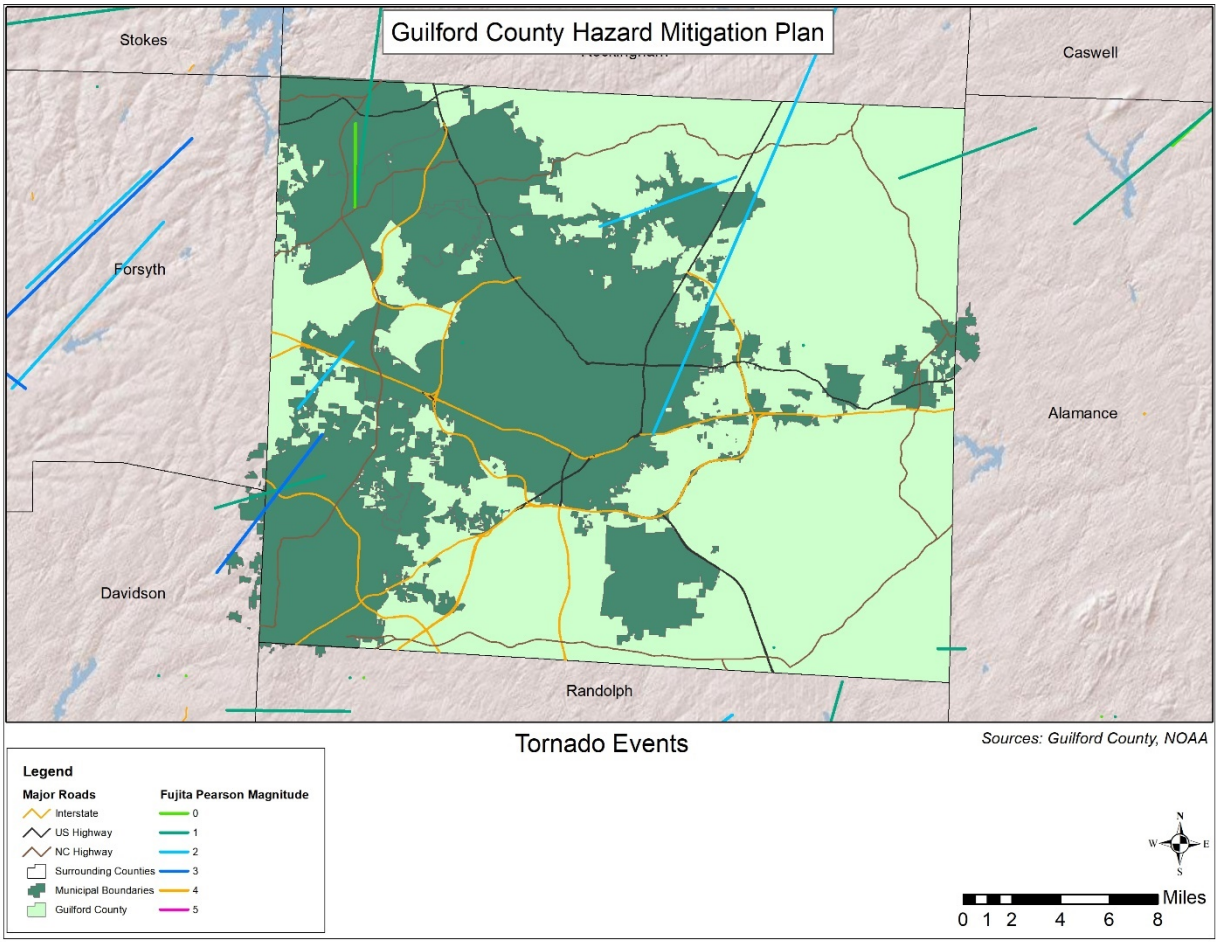
EF-SCALE NUMBER	INTENSITY PHRASE	3 SECOND GUST (MPH)	TYPE OF DAMAGE DONE
EF0	GALE	65–85	Some damage to chimneys; breaks branches off trees; pushes over shallow-rooted trees; damages to sign boards.
EF1	MODERATE	86–110	The lower limit is the beginning of hurricane wind speed; peels surface off roofs; mobile homes pushed off foundations or overturned; moving autos pushed off the roads; attached garages may be destroyed.
EF2	SIGNIFICANT	111–135	Considerable damage. Roofs torn off frame houses; mobile homes demolished; boxcars pushed over; large trees snapped or uprooted; light object missiles generated.
EF3	SEVERE	136–165	Roof and some walls torn off well-constructed houses; trains overturned; most trees in forest uprooted.
EF4	DEVASTATING	166–200	Well-constructed houses leveled; structures with weak foundations blown off some distance; cars thrown and large missiles generated.
EF5	INCREDIBLE	Over 200	Strong frame houses lifted off foundations and carried considerable distances to disintegrate; automobile sized missiles fly through the air in excess of 100 meters; trees debarked; steel re-enforced concrete structures badly damaged.

Source: National Weather Service

Location and Spatial Extent

Tornadoes occur throughout the state of North Carolina, and thus in Guilford County. Tornadoes typically impact a relatively small area, but damage may be extensive. Event locations are completely random and it is not possible to predict specific areas that are more susceptible to tornado strikes over time. Therefore, it is assumed that Guilford County is uniformly exposed to this hazard. With that in mind, **Figure 3.24** shows tornado track data for many of the major tornado events that have impacted the county. While no definitive pattern emerges from this data, some areas that have been impacted in the past may be potentially more susceptible in the future.

FIGURE 3.24: HISTORICAL TORNADO TRACKS IN GUILFORD COUNTY



Source: National Centers for Environmental Information

Historical Occurrences

Tornadoes were responsible for two disaster declarations in Guilford County in 1989 and 2018.[29] According to the National Centers for Environmental Information, there have been a total of 15 recorded tornado events in Guilford County since 1950 (**Table 3.35**), resulting in $87.9 million (2019 dollars) in property damages.[30] [31] In addition, one death and five injuries were reported (**Table 3.36)**. The magnitude of these tornadoes ranges from EF0 to EF3 in intensity, although an EF4 or EF5 event is possible. It is important to note that only tornadoes that have been reported

[29] A complete listing of historical disaster declarations can be found in Section 4: *Hazard Profiles*.
[30] These tornado events are only inclusive of those reported by the National Centers for Environmental Information (NCEI) from 1950 through March 2019. It is likely that additional tornadoes have occurred in Guilford County. As additional local data becomes available, this hazard profile will be amended.
[31] Adjusted dollar values were calculated based on the Consumer Price Index for All Urban Consumers (CPI-U) U.S. city average series for all items, not seasonally adjusted. This data represents changes in the prices of all goods and services purchased for consumption by urban households. This monthly index value has been calculated every year since 1913. The 2019 dollar values were calculated based on buying power in May 2019.

are factored into this risk assessment. It is likely that at least some occurrences have gone unreported.

TABLE 3.35: SUMMARY OF TORNADO OCCURRENCES IN GUILFORD COUNTY

Location	Number of Occurrences	Deaths / Injuries	Property Damage (2014)	Annualized Property Loss
Gibsonville	0	0/0	$0	$0
Greensboro	1	0/0	$66,438,818	$66,438,818
High Point	1	0/0	$11,767,257	$1,307,473
Jamestown	0	0/0	$0	$0
Oak Ridge	2	0/0	$0	$0
Pleasant Garden	0	0/0	$0	$0
Sedalia	0	0/0	$0	$0
Stokesdale	1	0/0	$0	$0
Summerfield	0	0/0	$0	$0
Whitsett	0	0/0	$0	$0
Unincorporated Area	10	1/5	$9,676,555	$148,870
GUILFORD COUNTY TOTAL	**15**	**1/5**	**$87,882,630**	**$67,895,161**

Source: National Climatic Data Center

TABLE 3.36: HISTORICAL TORNADO OCCURRENCES IN GUILFORD COUNTY

	Date	Magnitude	Deaths/ Injuries	Property Damage*	Details
Gibsonville					
None Reported	--	--	--	--	--
Greensboro					
GREENSBORO	4/15/2018	EF2	0/0	$66,438,818	The tornado initially touched down on the north side of I-40 near where Willow Road crosses I-40. Damage at this point consisted of snapped trees and was consistent with 90 mph wind speeds, or EF-1 on the Enhanced Fujita Scale. The tornado remained on the ground as it traveled north toward Peeler Elementary School. Numerous homes in this area were damaged along with substantial tree

					damage. The tornado wind speeds at this location were estimated to be approximately 100 mph. The tornado continued traveling north and reached a peak intensity and maximum path width in the Hampton Community and near Hampton Elementary School. At this school a large portion of the roof was blown off and three adjacent portable classroom buildings (manufactured buildings) were completely destroyed and leveled. The damage to the main school building was consistent with wind speeds around 110 mph (DI 15/DOD 6), while the damage to the adjacent portable units was consistent with wind speeds of 135 mph (DI 4/DOD 12), which is a high-end EF2 on the Enhanced Fujita Scale. It is worth noting that the neighborhoods adjacent to this school experienced a wide and substantial path of devastation which included snapped and uprooted trees, snapped power poles, homes that were pushed off of their foundation, numerous homes that lost most or all of their roof cover, and several homes with exterior walls blown out. The survey found the width of the tornado, and particularly the width of the EF1 and EF2 wind speeds, contributed to a particularly wide path of destruction. The tornado then continued north-northeast and mostly remained on the ground all the way to the Guilford/Rockingham County line. Along the way, the damage consisted mostly of snapped and uprooted trees, and roof and siding damage to several additional homes. The tornado appeared to produce minor tree damage (with wind speeds 80 mph or less) just before crossing into Rockingham County. Finally, the aforementioned path length (16 miles) consists of just the Guilford County path. The tornado continued into Rockingham County, and remained on the ground for an additional 17.6 miles.
High Point					
HIGH PT	3/28/2010	EF3	0/0	$11,767,257	The tornado initially touched down as an EF1 with winds around 100 mph near Old Plank Road in southwest Guilford County. It was in this area where the Apple Tree Academy sustained significant damage and two vehicles including a small bus were rolled 50 yards across the street. From this point the tornado continued northeast across Highway 311. The next area to experience damage was just north of Highway 311 and south of Old Mill Road along Langdale, Imperial and Impala Drives. Tornado damage in this area continued to indicate EF1 winds with numerous trees down along with a number of home with roof and siding damage. The tornado intensified to an EF2 as it crossed Old Mill Road towards Johnson Street. The EF2 tornado severely damaged numerous homes along Brandon Drive. In one instance, an entire bedroom was blown off a single story home. Three individuals who were taking shelter in a bedroom closet were carried 50 feet and were buried under the debris. One individual experienced

					several broken bones but overall injuries were not serious. The remainder of the house was shifted off the foundation approximately 8 inches. EF2 tornado damage continued north of Old Mill Road to Skeet Club Road along either side of Johnson Road with winds around 130 mph for most of its duration but briefly reached EF3 intensity with winds of 138 mph near Hampton Park Drive at 1278 Silverstone Court where the upper level of a two story home was blown off. Fifty to sixty homes along Hampton Park Drive, Scarlet Drive, Ruskin Drive and Johnson Road were severely damaged. The tornado crossed Johnson Road as an EF2 crossing Elmwood Avenue, Oakforest Drive and Maplewood Avenue. Nearly every home in this highly urbanized area experienced minor to moderate damage. The upper floor of a two story home on Elmwood Avenue was blown off. The tornado weakened to an EF1 as it crossed Maplewood Avenue and Wellingham Lane, where numerous homes experienced roof and siding damage. The tornado finally lifted off the ground north of Kendale Road. In total 603 single family homes were damaged with 21 homes being completely destroyed. Thirty-one multifamily homes were damaged with 16 reported destroyed. Finally, eleven businesses sustained damage, with 3 businesses completely destroyed.
Jamestown					
None Reported	--	--	--	--	--
Oak Ridge					
OAK RIDGE	7/7/2005	F0	0/0	$0	A tornado blew down trees from Oak Ridge to Stokesdale.
OAK RIDGE	9/14/2007	Funnel Cloud	0/0	$0	A funnel cloud was reported by the public at Highway 150 and Union Grove Road near Oak Ridge.
Pleasant Garden					
None Reported	--	--	--	--	--
Sedalia					
None Reported	--	--	--	--	--
Stokesdale					
STOKESDALE	9/17/2004	F1	0/0	$0	A tornado touched down near the intersection of Harrell Road and Lee's Glen Road. Three garages lost their roofs and numerous trees were snapped or uprooted. The tornado then tracked north across Meadows Drive and Haw Meadows Drive where falling trees caused significant damage to at least three well-built homes, one of which was a total loss. The tornado continued north to Prince Edward road where about 70 percent of the trees in a heavily wooded area were snapped or downed. Along

					Kelly Court, a garage was destroyed. At South Point Drive, the roof was blown off a house resulting in major structural damage. Other houses lost shingles, siding and porches. The tornado then continued across the county line into Rockingham County. In Guilford County, three houses suffered total losses, nine homes sustained major damage, and 52 sustained minor damage.
Summerfield					
None Reported	--	--	--	--	--
Whitsett					
None Reported	--	--	--	--	--
Unincorporated Area					
GUILFORD CO.	6/16/1954	F2	0/1	$23,800	
GUILFORD CO.	4/5/1957	F1	0/1	$2,294,731	
GUILFORD CO.	9/29/1959	F1	0/0	$218,509	
GUILFORD CO.	6/12/1962	F1	0/0	$21,200	Small tornado near McLeansville. Funnel moved northeastward, remaining just above ground level and making a noise like a diesel locomotive. Trees broken off above ground, roofs damaged. No evidence of high winds outside immediate path of storm.
GUILFORD CO.	4/17/1967	F1	0/0	$193,423	Storm moved southwest-northeast across field near Whitsett. Porch ripped off a home, several outbuildings demolished. Apple orchard severely damaged. Hail and heavy rain with storm. Meteorologist visited scene, reported damage apparently caused by tornado moving on a skipping path.
GUILFORD CO.	5/14/1967	F1	0/0	$1,928,404	
GUILFORD CO.	10/8/1976	F1	0/0	$110,575	A tornado skipped along near Vickery Chapel Road off Highway I-85 near Greensboro. A trailer truck was damaged, trees, and some homes. Damage about $15,000.
GREENSBORO ARPT	5/7/1998	F1	0/0	$157,305	A tornado touched down approximately 1 mile southeast of the Piedmont-Triad International Airport near Greensboro. The first damage occurred just south of West Friendly Avenue. The tornado moved to the southeast and lifted at Jamestown Road approximately 1.5 miles from its initial touchdown. Damage was rated at F1 initially and F0 at the point it rose back into the thunderstorm. This tornado was produced by the same parent storm that produced the Clemmons tornado less than an hour before this one.
CLIMAX	5/7/1998	F1	0/0	$0	A tornado touched down in extreme southeast Guilford county and tracked to the southeast for approximately 2.5

					miles. It moved into extreme northeast Randolph county before lifting about 2 miles north of Liberty. The tornado produced F1 damage. The exact path stretched from Lake Juno Road to Liberty Grove Road.
DEEP RIVER	5/8/2008	EF2	1/3	$4,728,609	The tornado, originally an EF-0, initially touched down just north of Squire Davis Park near the intersection of Sandy Ridge Road and Johnson Street. From there the tornado tracked northeast and intensified to EF-1 intensity as it approached the Farmers Market and Interstate 40. The tornado overturned several cars and tractor trailers as it crossed Interstate 40. A roof was blown off of an office building just north of the interstate as the tornado continued to intensify. As the tornado moved further northeast into an industrial complex, it further strengthened to EF-2 with winds estimated around 130 mph based on damage to warehouses. Numerous warehouses along Little Santee Road, Capital Drive, and West Market Street sustained significant damage. Numerous vehicles and tractor trailers were also overturned in the industrial complex. At its widest point, the tornado was just over 200 yards wide. The tornado quickly lifted off of the ground after crossing West Market Street near the post office. The tornado was on the ground for about four miles. One fatality occurred along West Market Street next to the Lamination Service Building located at 8717 West Market Street. The fatality occurred as a 51 year old man slept in the rig of his tractor trailer. Three other injuries were reported, two of which occurred in automobiles and another in the I.H. Caffey Warehouse Distribution Center.

*Property damage is reported in 2014 dollars; All damage may not have been reported.

Source: National Climatic Data Center

Probability of Future Occurrences

According to historical information, tornado events are not an annual occurrence for the county. However, given the county's location in the southeastern United States and history of tornadoes, an occurrence is possible every few years. While the majority of the reported tornado events are small in terms of size, intensity, and duration, they do pose a significant threat should Guilford County experience a direct tornado strike. The probability of future tornado occurrences affecting Guilford County is likely (10 to 100 percent annual probability).

Consequence Analysis

People (The Public and Public Confidence)

The entire Guilford County population is vulnerable to the impacts of a tornado regardless of the measured magnitude. Because it cannot be predicted where a tornado will touch down, it cannot be said which areas of the population within the county are most vulnerable. However, injuries

as well as deaths resulting from tornadoes are the most significant impacts. Tornadoes often have a high likelihood of affecting public confidence due to their destructive and highly visible impacts.

Responders

Responders could be critically affected by tornado events as the onset is often very rapid and unpredictable, thereby putting response personnel potentially in harm's way. Due to the unpredictability of such events, response may also be hindered as responders may be unable to access those that have been affected if storm conditions persist and they are unable to safely enter affected areas.

Continuity of Operations

Continuity of operations could be greatly impacted by a tornado as personnel may be harmed and critical resources damaged or destroyed during a tornado. In many ways, since the impacts of a tornado are unpredictable, it is also difficult to predict and plan for the appropriate ways to ensure a continuity of operations. Although Guilford County is well prepared for such an event, disruption of operations will likely take place to some degree.

Built Environment (Property, Facilities, and Infrastructure)

Building Inventory

According to the NCEI, North Carolina has been impacted by tornadoes ranging in intensity from F0/EF0 to F4/EF4 based on the Fujita scale. An F5/EF5 has never been experienced, but it is certainly possible. Because it cannot be predicted where a tornado may touch down, all buildings, facilities, and infrastructure within Guilford County are considered exposed to the hazard and at risk for being impacted. Older buildings that are constructed with less-advanced building techniques are at higher risk, as are mobile homes.

Building materials play a role in how well a structure can withstand tornado force winds. Buildings that use structural steel, reinforced concrete, or load-bearing masonry have the best change of withstanding a tornado event. Homes constructed of wood or manufactured material are most at risk. Non-engineered structures are far more vulnerable than engineered buildings to damage from tornado winds. It is also notable that materials that are well-tied to all other building components are also more likely to survive extreme wind events.[32] The magnitude of the tornado will determine the extent of damage and impacts that are felt throughout the county. These impacts can include structural failure, debris damage, and loss of facility functionality.

[32] Federal Emergency Management Agency. *Tornado Protection: Selecting Refuge Areas in Buildings. FEMA P-431, Second Edition, October 2009.* Retrieved August 21, 2017 from: https://www.fema.gov/media-library-data/20130726-1456-20490-4099/fema_p_431.pdf

Critical Facilities and Key Resources

All critical facilities and key resources are equally vulnerable to the impacts of a tornado. The magnitude of the tornado will determine the extent of damage and impacts that are felt throughout the county. These impacts can include structural failure, debris damage, and loss of facility functionality.

Critical Infrastructure

The state's infrastructure system is also vulnerable to the impacts of a tornado. This includes critical infrastructure such as roads, railroads, bridges, utilities (power and gas), and pipelines. Any number of these infrastructure systems could be damaged in the event of a tornado, although often power lines are the most common assets that are affected during a tornado. Impacts could include structural damage, impassable or blocked roadways, failed utility lines, railway failure, and impassable bridges.

Key Resources

The county's key resources are equally vulnerable to the impacts of a tornado. Any number of key resources could be damaged or lost in the event of a tornado. Impacts could include structural damage, and loss of power and utilities.

Economy

A tornado can impact any area of Guilford County at any time and brings with it significant property and crop damage costs. After past events, there has been a substantial halt to many economic activities and losses to businesses have often been high. The loss of power can also interrupt local economies and have a strong negative impact on daily functioning of business activities.

Environment

Downed trees and other forms of vegetation are often one of the most visible impacts to the environment from a tornado. Additionally, building material or other debris can be carried or thrown great distances by the force of wind and end up spread out in unexpected places such as natural areas. Coordinated statewide cleanup efforts after a tornado can include removal of debris, but much debris ends up remaining in local habitats. Finally, if hazardous materials facilities are impacted by the tornado, these may release dangerous chemicals into the environment that can cause long-term harm.

Winter Storm

Background

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. Events may include snow, sleet, freezing rain, or a mix of these wintry forms of precipitation. Some winter storms might be large enough to affect several states, while others might affect only localized areas. Occasionally, heavy snow might also cause significant property damages, such as roof collapses on older buildings. All winter storm events have the potential to present dangerous conditions to the affected area.

Snow Storms

Larger snowfalls pose a greater risk, reducing visibility due to blowing snow and making driving conditions treacherous. A heavy snow event is defined by the National Weather Service as an accumulation of 4 of more inches in 12 hours or less. A blizzard is the most severe form of winter storm. It combines low temperatures, heavy snow, and winds of 35 miles per hour or more, which reduces visibility to a quarter mile or less for at least 3 hours. Winter storms are often accompanied by sleet, freezing rain, or an ice storm. Such freeze events are particularly hazardous as they create treacherous surfaces.

Ice Storms

Ice storms, which are much more common in Guilford County than snow storms, are defined as storms with significant amounts of freezing rain and are a result of cold air damming (CAD). CAD is a shallow, surface-based layer of relatively cold, stably-stratified air entrenched against the eastern slopes of the Appalachian Mountains. With warmer air above, falling precipitation in the form of snow melts, then becomes either super-cooled (liquid below the melting point of water) or re-freezes. In the former case, super-cooled droplets can freeze on impact (freezing rain), while in the latter case, the re-frozen water particles are ice pellets (or sleet). Sleet is defined as partially frozen raindrops or refrozen snowflakes that form into small ice pellets before reaching the ground. They typically bounce when they hit the ground and do not stick to the surface. However, it does accumulate like snow, posing similar problems and has the potential to accumulate into a layer of ice on surfaces. Freezing rain, conversely, usually sticks to the ground, creating a sheet of ice on the roadways and other surfaces.

All of the winter storm elements – snow, sleet, ice, etc. – have the potential to cause significant hazard to a community. Even small accumulations can down power lines and tree limbs and create hazardous driving conditions. Furthermore, communication and power may be disrupted for days.

Location and Spatial Extent

Nearly the entire continental United States is susceptible to winter storm events. Some ice and winter storms may be large enough to affect several states, while others might affect limited,

localized areas. The degree of exposure typically depends on the normal expected severity of local winter weather. Guilford County is accustomed to severe winter weather conditions and often receives winter weather during the winter months. Given the atmospheric nature of the hazard, the entire county has uniform exposure to a winter storm.

Historical Occurrences

Winter weather has resulted in six disaster declarations in Guilford County. This includes the Blizzard of 1996, one subsequent 1996 winter storm, a severe winter storm in 2000, ice storms in 2002 and 2003, and a severe winter storm in 2014. The National Climatic Data Center does not report winter storm events at the municipal level, however, there have been a total of 69 recorded winter storm events and in Guilford County since 1996 (**Table 3.37**).[33] These events resulted in almost $9.4 million (2019 dollars) in damages.[34] Detailed information on the recorded winter storm events can be found in **Table 3.38**.

TABLE 3.38: SUMMARY OF WINTER STORM EVENTS IN GUILFORD COUNTY

Location	Number of Occurrences	Deaths / Injuries	Property Damage (2014)	Annualized Property Loss
Guilford County	69	0/0	$9,407,685	$409,030

Source: National Centers for Environmental Information

TABLE 3.39: HISTORICAL WINTER STORM EVENTS IN GUILFORD COUNTY

	Date	Type of Storm	Deaths / Injuries	Property Damage*
Guilford County				
GUILFORD (ZONE)	1/6/1996	Heavy Snow	0/0	$0
GUILFORD (ZONE)	1/11/1996	Ice Storm	0/0	$0
GUILFORD (ZONE)	2/2/1996	Ice Storm	0/0	$0
GUILFORD (ZONE)	2/16/1996	Heavy Snow	0/0	$0
GUILFORD (ZONE)	1/8/1997	Winter Storm	0/0	$0
GUILFORD (ZONE)	2/13/1997	Winter Storm	0/0	$0
GUILFORD (ZONE)	12/29/1997	Winter Storm	0/0	$0
GUILFORD (ZONE)	12/23/1998	Ice Storm	0/0	$0

[33] These ice and winter storm events are only inclusive of those reported by the National Centers for Environmental Information (NCEI) from 1996 through March 2019. It is likely that additional winter storm conditions have affected Guilford County.
[34] Adjusted dollar values were calculated based on the average Consumer Price Index for a given calendar year. This index value has been calculated every year since 1913. For 2014, the October 2014 monthly index was used.

	Date	Type of Storm	Deaths / Injuries	Property Damage*
GUILFORD (ZONE)	1/2/1999	Ice Storm	0/0	$0
GUILFORD (ZONE)	1/18/2000	Winter Storm	0/0	$0
GUILFORD (ZONE)	1/20/2000	Winter Storm	0/0	$0
GUILFORD (ZONE)	1/22/2000	Winter Storm	0/0	$0
GUILFORD (ZONE)	1/24/2000	Winter Storm	0/0	$0
GUILFORD (ZONE)	1/28/2000	Winter Storm	0/0	$0
GUILFORD (ZONE)	11/19/2000	Heavy Snow	0/0	$0
GUILFORD (ZONE)	2/12/2001	Winter Storm	0/0	$0
GUILFORD (ZONE)	1/3/2002	Winter Storm	0/0	$0
GUILFORD (ZONE)	1/6/2002	Winter Storm	0/0	$0
GUILFORD (ZONE)	12/4/2002	Winter Storm	0/0	$0
GUILFORD (ZONE)	2/16/2003	Winter Storm	0/0	$0
GUILFORD (ZONE)	2/27/2003	Winter Storm	0/0	$0
GUILFORD (ZONE)	12/13/2003	Winter Weather	0/0	$0
GUILFORD (ZONE)	1/26/2004	Winter Storm	0/0	$0
GUILFORD (ZONE)	2/15/2004	Winter Storm	0/0	$0
GUILFORD (ZONE)	2/26/2004	Winter Storm	0/0	$0
GUILFORD (ZONE)	1/30/2005	Winter Storm	0/0	$0
GUILFORD (ZONE)	12/15/2005	Winter Storm	0/0	$0
GUILFORD (ZONE)	1/18/2007	Winter Weather	0/0	$0
GUILFORD (ZONE)	1/21/2007	Winter Weather	0/0	$0
GUILFORD (ZONE)	12/7/2007	Winter Weather	0/0	$24,386
GUILFORD (ZONE)	1/17/2008	Winter Weather	0/0	$0
GUILFORD (ZONE)	2/13/2008	Winter Weather	0/0	$0
GUILFORD (ZONE)	1/22/2009	Winter Weather	0/0	$0
GUILFORD (ZONE)	2/3/2009	Winter Weather	0/0	$0
GUILFORD (ZONE)	3/1/2009	Winter Storm	0/0	$0
GUILFORD (ZONE)	12/18/2009	Winter Storm	0/0	$0

	Date	Type of Storm	Deaths / Injuries	Property Damage*
GUILFORD (ZONE)	12/30/2009	Winter Weather	0/0	$0
GUILFORD (ZONE)	1/29/2010	Winter Storm	0/0	$0
GUILFORD (ZONE)	2/5/2010	Winter Storm	0/0	$59,078
GUILFORD (ZONE)	2/12/2010	Winter Weather	0/0	$0
GUILFORD (ZONE)	3/2/2010	Winter Storm	0/0	$0
GUILFORD (ZONE)	12/4/2010	Winter Weather	0/0	$0
GUILFORD (ZONE)	12/16/2010	Winter Weather	0/0	$0
GUILFORD (ZONE)	12/25/2010	Winter Storm	0/0	$0
GUILFORD (ZONE)	1/10/2011	Winter Weather	0/0	$0
GUILFORD (ZONE)	1/17/2013	Winter Storm	0/0	$0
GUILFORD (ZONE)	11/26/2013	Winter Weather	0/0	$0
GUILFORD (ZONE)	1/21/2014	Winter Weather	0/0	$0
GUILFORD (ZONE)	1/28/2014	Winter Weather	0/0	$0
GUILFORD (ZONE)	2/12/2014	Winter Storm	0/0	$0
GUILFORD (ZONE)	3/3/2014	Winter Weather	0/0	$0
GUILFORD (ZONE)	3/6/2014	Winter Storm	0/0	$0
GUILFORD (ZONE)	3/6/2014	Ice Storm	0/0	$8,778,699
GUILFORD (ZONE)	3/17/2014	Winter Weather	0/0	$0
GUILFORD (ZONE)	1/13/2015	Winter Weather	0/0	$0
GUILFORD (ZONE)	2/16/2015	Winter Storm	0/0	$0
GUILFORD (ZONE)	2/24/2015	Winter Weather	0/0	$0
GUILFORD (ZONE)	2/25/2015	Winter Storm	0/0	$545,522
GUILFORD (ZONE)	3/1/2015	Winter Weather	0/0	$0
GUILFORD (ZONE)	1/22/2016	Winter Storm	0/0	$0
GUILFORD (ZONE)	2/14/2016	Winter Storm	0/0	$0
GUILFORD (ZONE)	1/6/2017	Winter Storm	0/0	$0
GUILFORD (ZONE)	12/8/2017	Winter Storm	0/0	$0
GUILFORD (ZONE)	1/17/2018	Winter Storm	0/0	$0

	Date	Type of Storm	Deaths / Injuries	Property Damage*
GUILFORD (ZONE)	3/12/2018	Winter Storm	0/0	$0
GUILFORD (ZONE)	3/21/2018	Winter Weather	0/0	$0
GUILFORD (ZONE)	3/24/2018	Winter Weather	0/0	$0
GUILFORD (ZONE)	12/9/2018	Winter Storm	0/0	$0
GUILFORD (ZONE)	1/12/2019	Winter Storm	0/0	$0

*Property damage is reported in 2019 dollars; All damage may not have been reported.
Source: National Centers for Environmental Information

There have been several severe winter weather events in Guilford County. The text below describes two of the major events (one snow and one ice event) and associated impacts on the county. Similar impacts can be expected with most severe winter weather.

1996 Winter Storm – January 6-8, 1996

This storm left two feet of snow in some areas and several thousand citizens without power for up to nine days. Although shelters were opened, some roads were impassible for many days. This event caused considerable disruption to business, industry, schools, and government services.

2002 Ice Storm – December 4-5, 2002

An ice storm produced up to an inch of freezing rain in central North Carolina impacting 40 counties. A total of 24 people were killed, and as many as 1.8 million people were left without electricity. Additionally, property damage was estimated at almost $100 million. New records were also set for traffic accidents and school closing durations. The scale of destruction was comparable to that of hurricanes that have impacted the state, such as Hurricane Fran in 1996. The storm cost the state $97.2 million in response and recovery.

2014 Ice Storm – March 7, 2014

A significant ice storm impacted the region with between a tenth and a half of an inch of ice accumulation across the county along with between a trace and 7 inches of snow. The county was quickly affected by hazardous road conditions and numerous downed trees and power lines. Based on the number of reported power outages, a warming center was opened in the City of Greensboro and this eventually transitioned over to an emergency shelter that remained open for several days, finally closing on Monday, March 10th in the evening. A Point of Distribution (POD) was established on March 9th in Pleasant Garden to provide bottled water for the community. Over 5,000 gallons of bottled water was provided over a two-day period. As a result of this incident Guilford County received a presidential disaster declaration for Public Assistance (PA).

Winter storms throughout the planning area have several negative externalities including hypothermia, cost of snow and debris cleanup, business and government service interruption, traffic accidents, and power outages. Furthermore, citizens may resort to using inappropriate heating devices that could to fire or an accumulation of toxic fumes.

Probability of Future Occurrences

Winter storm events will remain a regular occurrence in Guilford County due to its location in the western half of the state. According to historical information, Guilford County generally experiences several winter storm events each year. Therefore, the annual probability is highly likely (100 percent). Additionally, according to the *Piedmont Together Climate Adaptation Report*, the increased likelihood of ice storms due to climate change will result in a higher number of automobile accidents (injuries, fatalities, and traffic jams) as well as more power outages in the county.

Consequence Analysis

People (The Public and Public Confidence)

Winter storms most often impact people indirectly. Winter storms can create dangerous driving conditions by limiting visibility for drivers or creating slick conditions that make maneuverability difficult. Loss of power can create very cold conditions for residents, making it difficult to stay warm. Residents may try to heat their home using alternative means, which runs the risk of carbon monoxide poisoning caused by improperly ventilated heating sources. In addition, dangerously cold temperatures increase the risk of wind chill, frostbite, and hypothermia.

Another indirect impact of winter weather on the public is its potential to impact public and private school schedules through closings and delays. Poor driving conditions, lack of power and heat, and mechanical problems with school buses and equipment due to cold weather conditions are potential concerns. School closures and delays can lead to logistical problems for teachers and school administrators, especially in the event of end-of-term exams and standardized testing schedules. It can also result in logistical problems for making up school days.

Winter storms generally do not have a large impact on public confidence, but it could be impacted if road clearing or response operations are slow.

Responders

Responders in winter storm and freeze events face a variety of hazards themselves including slick or icy roads that could cause harm to responders if they are attempting to quickly respond to an emergency as is often the case. Crashed emergency vehicles and injuries to responders are always a possibility, but their chances increase during a winter storm event. Winter storms can also make it difficult to access more rural areas if roads are snowed over and vehicles cannot pass through.

Continuity of Operations

Generally, continuity of operations can be maintained during a winter storm event in Guilford County. However, winter weather does have the potential to affect power transmission as the weight of ice and snow can cause trees and limbs to fall and damage transmission lines. Winter precipitation can also freeze to roadways or create slick conditions that make it difficult for local

government employees to get to work. As a result, there will likely be some disruption of operations during a winter weather event.

Built Environment (Property, Facilities, and Infrastructure)

One of the primary identified impacts of winter weather in North Carolina is the disruption of utilities. Utilities that are at risk of being affected include telephone, internet, cable, and water. Newspaper reports typically cite trees falling on electrical wires—as well as trees that have already been damaged from previous incidents that fall during a winter storm—or the stress caused by ice accumulation as main causes for power outages. Damage to this infrastructure is one of the major consequences of a winter weather event in the state and can lead to life-threatening situations if the public is unable to utilize central heating systems to keep warm during the concurrent cold weather that often accompanies winter weather.

Winter weather also has the potential to create hazardous driving conditions leading to accidents on roadways. The North Carolina Climate Office reports that 70 percent of winter-weather–related injuries are a result of accidents on the road.[35] The North Carolina Highway Patrol call volume can double during a winter storm compared to a typical 24-hour period. This creates significant problems for emergency workers. Accidents can cause highways to become "large parking lots" as well as cause motorists to strand their vehicles, making it difficult for emergency workers to reach those who need assistance. In general, major and local roadways become severely impacted when temperatures drop, making pre-treatment solutions ineffective. Transportation impacts can be minimized during early- and late-season events when paved surfaces are able to warm sufficiently to prevent winter precipitation accumulation. Winter weather can also cause delays and cancellations of flights at airports in the state due to slick conditions on runways. There is also the potential of a loss of power that can close the airport.

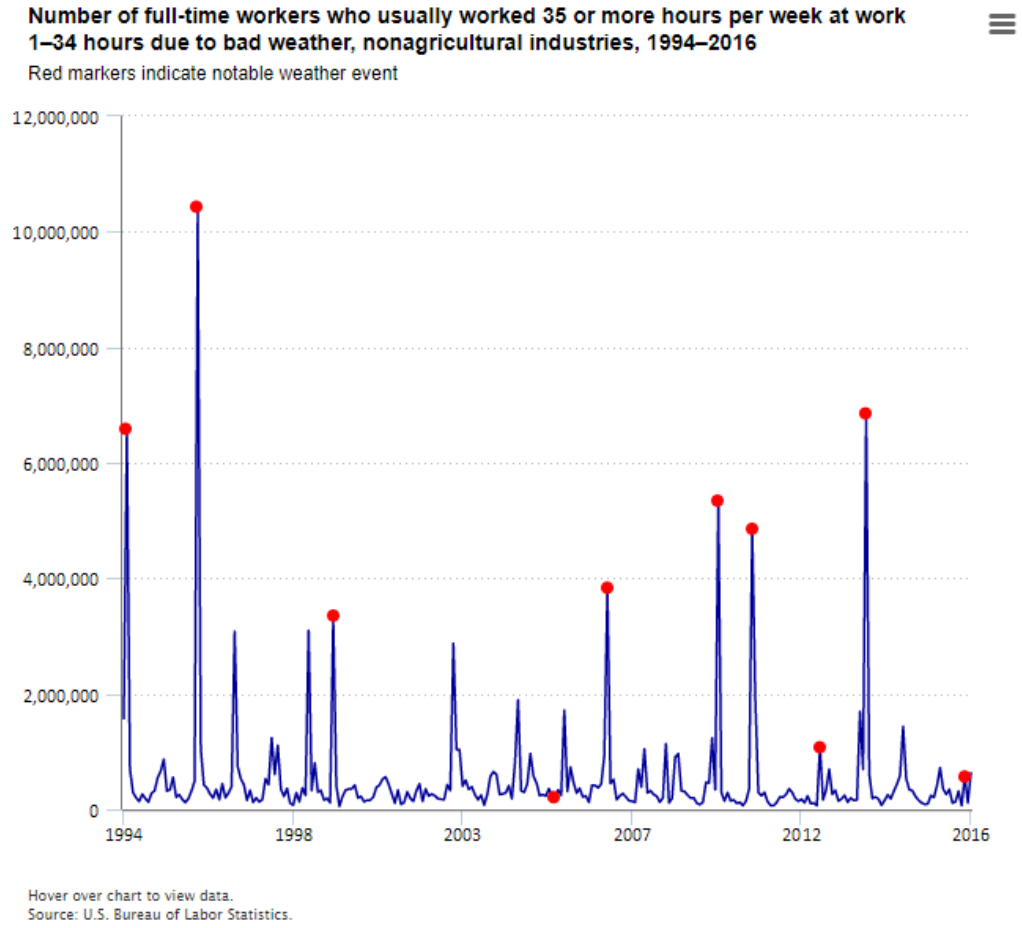
Economy

In the event of winter weather, there is a high potential of business and office closures, modified business and office hours, and cancellation or postponement of sporting and other planned events in the state. This can be attributed to poor road conditions (including icy and slick conditions) that result in fewer people using the roads to get to their destination or a loss of power and heat that result in a loss of operations at specific facilities. In general, absenteeism is higher during winter weather events as many employers rightly encourage employees to stay home and avoid potential injury in unsafe driving conditions. As can be seen in **Figure 3.11** below, the Bureau of Labor Statistics[36] notes that although any major weather event can cause absences at work, workers are more likely to be absent because of bad weather during winter months because

[35] State Climate Office of North Carolina. *Winter weather—impacts*. Retrieved August 21, 2017, from http://www.nc-climate.ncsu.edu/climate/winter_wx/Impacts.php
[36] United States Bureau of Labor Statistics. *Work Absences Due to Bad Weather from 1994 to 2016*. Retrieved August 21, 2017, from https://www.bls.gov/opub/ted/2017/work-absences-due-to-bad-weather-from-1994-to-2016.htm

winter weather tends to impact much larger areas and makes travel difficult throughout much more of the transportation network.

Figure 3.25: IMPACTS FROM WINTER WEATHER ON WORKER ABSENTEEISM



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Environment

Winter storms have an impact on the environment through the clearing of roadways. Snow on the roads can pick up contaminants from chemicals and oil products in traffic as well as the salt mixture that is used to de-ice the roads. These contaminants can be carried to nearby waterways, which, contaminates water sources and is absorbed by groundwater.

In addition, vegetation can be damaged by these storm types. Vegetation destruction reduces available habitats, and threatens wildlife.

Biological Hazards

Bioterrorism

Background

While there are many biological agents to be concerned with as they exist in nature, there are some that can also be used as a weapon. It is very difficult to spread many of these diseases to large populations of people. There have been few instances of bioterrorism to this point. While it is likely that another bioterrorism event will be attempted, it is unlikely that a large population will be exposed or that it will affect Guilford County and its citizens. However, consideration and planning must still address the possibility, no matter how slight.

Examples of agents identified by the Center for Disease Control and Prevention (CDC) that have been or have the potential to be used in bioterrorism form include anthrax, botulism, brucellosis, plague, smallpox, tularemia, and viral hemorrhagic fevers, among others.

Anthrax, a serious disease caused by Bacillus anthracis, a bacterium that forms spores, was used as a biological weapon in the United States in 2001 when it was deliberately spread through the postal system. Botulism, a muscle-paralyzing disease caused by a toxin made by a bacterium called Clostridium botulinum, could potentially be released into food sources, causing foodborne illnesses. Brucellosis is a rare infectious disease caused by the bacteria Brucella; used a biological weapon, the bacteria could also be introduced into a food source for human consumption.

Plague, a disease caused by Yersinia pestis, a bacterium found in rodents and their fleas in many areas around the world, could be used in an aerosol attack through its pneumonic form. Because of the delay in exposure and becoming sick, those infected with the disease could travel around the globe transmitting the disease to others before knowing they were sick. This could have dire consequences in controlling the outbreak of the disease in large populations.

Smallpox is a serious, contagious infectious disease caused by the variola virus; no treatment exists and the only prevention is vaccination. According to the CDC, the disease is now eradicated after a successful worldwide vaccination program; however, there is still concern that the variola virus could still be used as an agent of bioterrorism through the development of the disease in a laboratory setting.

Tularemia is a highly infectious disease caused by the bacterium Francisella tularensis, which is found in animals. Used as a biological weapon, the bacteria would likely be made airborne for exposure by inhalation. Because the bacterium is widely found in nature, the disease could be grown in large quantity in a laboratory; however, an effective aerosol weapon has yet to be manufactured to release it in a bioterrorism event.

Viral hemorrhagic fevers (VHFs) refer to illnesses caused by specific viruses that cause severe multisystem syndromes. Many of these have been considered for bioterrorism. The Marburg and Ebola viruses are well-known examples of VHFs.

Location and Spatial Extent

Due to the nature of a bioterrorism event, it would be difficult to predict a precise location where this type of event would occur. Moreover, a large-scale event may have impacts that spread throughout the county. Therefore, all areas in Guilford County are considered equally susceptible to bioterrorism.

Historical Occurrences

No major incidents have ever been recorded as affecting those within the bounds of Guilford County.

Probability of Future Occurrence

Although no incidents have been recorded in Guilford County, future occurrences are considered possible.

Consequence Analysis

Additional details on consequences of disease threats and terrorist events are described in the Public Health/Emerging Disease Threat and Terrorism sections below. Most of the consequences outlined in those sections are also applicable to a Bioterrorism event.

People (The Public and Public Confidence)

The general public can be exposed to emerging diseases through different means based on the particular threat and its potential transmission routes. Vaccinations, when available, are the best means of preventing transmission and infection. Public Health information messages will be disseminated via the media in order to provide preventive measures to limit or avoid exposure.

A bioterrorism event may or may not elicit a large-scale response from government and nongovernmental organizations, dependent on the scope of the attack. For major incidents, public notification and information will be important to prevent further exposure and ensure the public that efforts are underway to handle the situation. Communicating with the media will not only assist in this dispersal of information, but also ensure that appropriate information is getting out. These efforts can help bring about positive outcomes and positive public perception.

Responders

During a disease outbreak, responders can expect an increase in workload and should practice a higher level of precaution toward exposure than they would normally. Plans exist for first response and health care to address the needs of such situations. Communication between these agencies regarding plans and procedures maximize the efficiency and effectiveness of the combined efforts.

Continuity of Operations

Continuity of operations may be impacted if those in governmental or other key roles are impacted by the bioterrorism event and cannot perform their normal duties. Although plans are

in place to ensure continuity of operations, a large-scale event or one that has significant impacts on operational-level staff could affect continuity of operations.

Built Environment (Property, Facilities, and Infrastructure)

Hospitals are a key component of the built environment that may be impacted by a bioterrorism event. The primary impacts for hospitals during bioterrorism events are an increase in patients due to infected and exposed individuals and the spread of the biological substance within the facility. Additionally, the workload of emergency services may be increased as individuals infected and exposed to the biological substance may require transport to a hospital facility.

Economy

The economic impact of a bioterrorism event is dependent on where it took place, the severity of the incident, and if the threat of another event seems likely. Tourism could be significantly impacted in some areas, affecting commerce and large public gatherings.

Environment

The environmental impact is dependent on the particular biological substance being transmittable to animal or plant life, or if it can be distributed through the water supply. Also, the delivery method of the agent's release could cause physical harm to the environment as well.

Public Health Emerging Disease

Background

Communicable, or infectious, diseases are conditions that result in clinically evident illness which are transmissible directly from one person to another or indirectly through vectors such as insects, air, water, blood or other objects. The impact of communicable disease can range from the mild effects of the common cold to the extreme lethality of pneumonic plague or anthrax. The public health system in the United States was developed in large part as a response to the often urgent need to respond to or prevent outbreaks of communicable diseases. Through public health methods of disease reporting, vaccinations, vector control, and effective treatments, most communicable diseases are well controlled in the United States and Guilford County. However, control systems can fail and when people come together from locations outside of the county, state, and the country, outbreaks can occur, even in the most modern of communities. In this section, some of the more significant potential communicable disease concerns are described.

The threats discussed in this section usually do not occur on a regular basis, though some are more frequent. The diseases described herein do not originate from intentional exposure (such as through terrorist actions) but do present significant issues and concerns for the public health community. There are numerous infectious diseases that rarely, if ever, occur in Guilford County, such as botulism or bubonic plague. Some highly dangerous diseases which could potentially be used as biological weapons, such as anthrax, pneumonic plague, and smallpox, are safely housed and controlled in laboratory settings such as at the Center for Disease Control and Prevention (CDC). Other diseases have not (yet) mutated into a form that can infect humans, or

otherwise lie dormant in nature. Many of these threats were discussed in the "Bioterrorism" section.

Below, several types of threats are described that may face the county. All may be of national and international importance as any emerging disease threat may impact large populations beyond the immediate areas where the threat originated.

Viral outbreaks, such as the West Nile Virus, are typically passed to humans or animals by mosquitoes and can often be spread widely as many of those infected experience no symptoms. Those who do may experience fever, fatigue, or, in serious cases, central nervous system inflammation. Another example of a virus that has had impacts on large populations is Severe Acute Respiratory Syndrome (SARS), which is a respiratory syndrome that is transmitted by airborne droplets. This virus was first reported in Asia in the early 2000s and while both of these conditions caused a great deal of public health concern when they were first identified, SARS has all but disappeared, while West Nile Virus occurs with low frequency and causes serious disease in only a very small percentage of cases.

Other communicable diseases pose a greater threat to the residents of Guilford County. Some of the infectious diseases of greatest concern include influenza, particularly in a pandemic form, as well as norovirus, and multiple antibiotic-resistant tuberculosis. Even in one of its normal year-to-year variants, influenza (commonly referred to as "flu") can result in serious illness and even death in young children, the elderly and immune-compromised persons. But there is always the potential risk of the emergence of influenza in one of the pandemic H1N1 forms, such as in the "Spanish Flu" outbreak of 1918-19, which killed over 50 million people worldwide. Every year, Guilford County sees hundreds of cases of influenza, leading to hundreds of hours of lost productivity in businesses due to sick employees. Of note, a vaccine for influenza is produced every year and, according to the CDC, is highly effective in preventing the disease.

Norovirus is recognized as the leading cause of foodborne-disease outbreaks in the United States. The virus can cause diarrhea, vomiting, and stomach pain, and is easily spread from person to person through contaminated food or water and by surface to surface contact. Especially vulnerable populations to this virus include those living or staying in nursing homes and assisted living facilities and other healthcare facilities such as hospitals. Norovirus could also be a threat in the event of large public gatherings such as sporting events, concerts, festivals, and so forth. Guilford County and the state of North Carolina experience numerous norovirus outbreaks every year. No vaccine or treatment exists for the Norovirus, making it especially dangerous for the public in the event of an outbreak.

Tuberculosis (TB) is a bacterial infection that originates from airborne exposure. Currently there are only a couple of dozen new tuberculosis cases in Guilford County each year. However, multiple drug-resistant strains, and even new extreme drug-resistant strains, are showing up with increasing frequency. Since Guilford County has a large and varied immigrant and refugee population of persons coming from countries with drug-resistant strains, TB is a disease that could become a cause of greater concern in coming years.

Public health threats can occur at any time and can have varying impacts. Discussions between public health professionals, planning officials, and first response agencies are essential in order to facilitate safe, effective, and collaborative efforts toward outbreaks.

Location and Spatial Extent

Due to the nature of a public health/emerging disease event, it would be difficult to predict a precise location where this type of event would occur. Moreover, a large-scale event may have impacts that spread throughout the county. Therefore, all areas in Guilford County are considered equally susceptible to public health/emerging diseases.

Historical Occurrences

In 2003, the SARS outbreak that began in Southeast Asia began showing up in the United States. There was a single confirmed case of SARS in North Carolina in 2003, with 8 suspected cases, as described by Guilford County Department of Public Health.

An outbreak of the West Nile Virus began showing up in the United States in 1999, with Guilford County reporting its first infected bird in 2000. One individual with ties to Guilford County was confirmed as being infected with West Nile Virus in South Carolina in 2002. No other cases have been reported in Guilford County.

As stated previously, influenza, norovirus, and tuberculosis are regularly occurring health issues in Guilford County. With the exception of tuberculosis, these conditions are not legally reportable to county or state public health agencies, so data on disease incidence is not readily available. However, these diseases are monitored through local epidemiological surveillance systems in hospitals and health departments, and any potential outbreaks are investigated promptly.

During events involving outbreaks, as stated in NCGS § 130A – 145, the State Health Director and a local health director are empowered to exercise quarantine and isolation authority. Quarantine and isolation authority shall be exercised only when and so long as the public health is endangered, all other reasonable means for correcting the problem have been exhausted, and no less restrictive alternative exists.

Probability of Future Occurrence

Due to some recent incidents that have been recorded in Guilford County, future occurrences are considered possible.

Consequence Analysis

People (The Public and Public Confidence)

The general public can be exposed to emerging diseases through different means based on the particular threat and its potential transmission routes. Vaccinations, when available, are the best means of preventing transmission and infection. Public Health information messages will be

disseminated via the media in order to provide preventive measures to limit or avoid exposure. According to the North Carolina Public Health Department, in terms of vaccine-preventable diseases, in 2016 there was a slightly higher occurrence rate of Hepatitis A and Mumps in 2016 compared to the five-year average from 2011-2015.[37] There were also increased rates of non-vaccine-preventable diseases like Zika which have become more prominent across the United States in recent years.

Public confidence in government organizations may be impacted by public health outbreaks. The level of confidence the public possesses is based upon societal expectations, media influence, and past experience following other outbreaks. An effective response to the outbreak can help to guide public confidence toward a favorable level. Collaboration with media outlets can also assist in keeping the public informed and helping to protect them from exposure.

Responders

During a disease outbreak, responders can expect an increase in workload and should practice a higher level of precaution toward exposure than they would normally. Plans exist for first response and health care to address the needs of such situations. Communication between these agencies regarding plans and procedures maximize the efficiency and effectiveness of the combined efforts. Responders are much more likely on the whole to be impacted by an infectious disease since they will be working directly with those affected to help treat the disease (especially EMS personnel). This will make them more susceptible to becoming infected and, as such, it is critical that they wear the appropriate personal protective equipment to minimize their risk and ensure they can continue providing the care and assistance that is needed to help the public.

Continuity of Operations

Continuity of operations may be impacted if those in governmental or other key roles are impacted by the disease or public health threat and cannot perform their normal duties. Although plans are in place to ensure continuity of operations, a large-scale event or one that has significant impacts on operational-level staff could affect continuity of operations. Since many diseases are spread through some form of contact with others who have already been infected, a disease event could rapidly disable many of those who are working together to carry out normal operations. Due to their close proximity to one another and need to communicate and coordinate on a daily basis, it is incredibly important to try to reduce the spread of the disease among key personnel once an outbreak has been identified.

Built Environment (Property, Facilities, and Infrastructure)

An infectious disease would likely have little direct impact on the built environment itself as the disease would not affect the structural stability of any buildings or infrastructure. However, an infectious disease would have a major impact on the functioning of many structures that would be operating at a high capacity during an infectious disease event, especially medical care facilities.

[37] North Carolina Department of Public Health (2016). Vaccine-Preventable Diseases Reported in North Carolina, 2016. Retrieved August 21, 2017 from: http://epi.publichealth.nc.gov/cd/figures.html

Hospitals and Medical Care Facilities
The primary impacts for hospitals/medical facilities during disease outbreaks are an increase in patients and the spread of disease within hospitals. It is highly likely that those affected by the disease will make their way to a medical care facility and it may be necessary to implement quarantines or other measures to reduce the risk of disease spreading. Hospitals and other medical care facilities should have plans in place to deal with such a scenario and also reduce risk of spreading the disease to medical care providers whose workload may be increased as individuals infected with disease may require treatment.

Economy

One of the more significant economic impacts that could be seen in Guilford County involves absenteeism at local businesses which could have a significant impact as the absence of several employees at a small business could force temporary shutdowns or reduced hours of availability. There would also likely be an impact on the local government budget as officials try to respond to the disease and assist those impacted.

City centers and downtown areas tend to be where large masses of people congregate and thus may be where the likelihood of disease spread is more prominent. Many people may realize this and avoid these key economic hubs which would result in reduced revenue and a negative impact on the economy overall. Additionally, large events may have to be cancelled if the outbreak is large enough or has the potential to be spread easily and quickly. This would also reduce revenue for many local economies.

Environment

The environmental impact is dependent on whether the particular biological substance or disease is transmittable to animal or plant life or if it can be distributed through the water supply. If the infectious disease in question can be transmitted to other species, there could be an extremely negative impact on species populations. Since animal life does not have the same capacity as humanity to understand the spread of disease and reduce transmission rates, the disease may spread more quickly through animal populations and cause larger-scale loss of life.

Technological Hazards

Building / Structure Collapse

Background

A building or structure collapse, also called a structural failure, can be defined as any significant compromise of a standing, built enclosure, including its roof, walls, floors (in multi-story structures), or other large areas. Any material used to build structures has a strength limit that once passed can lead to a structural failure.

Building/structure collapses have a variety of causes, typically occurring as a secondary impact following the incidence of another hazard. The most common occurrences of structure collapse are external in nature, including explosions (both accidental and purposeful) and vehicles striking the structure and destroying key supports. Buildings that are under construction are more likely to experience a structure collapse from the effects of another hazard.

Location and Spatial Extent

A building or structure collapse is an uncommon occurrence anywhere, especially as structural engineering has continued to progress throughout time. Most of the structure collapses that occur are at construction sites but occasionally can be due to outside forces. Some areas near fault lines or other hazards are more prone to collapse, as not all residences and businesses are built to withstand the hazard(s) that are associated with fault lines.

Historical Occurrences

Collapses in general are especially uncommon in Guilford County. Several calls per year include vehicles striking structures, where a rescue of those within the vehicle or structure is necessary. Most of these collapses do not cause significant impact to the county as a whole, but there is potential for greater impact if the incidence were at a location of interest such as one of the hospitals, the Greensboro Coliseum, a large employer during business hours, or a mall.

Probability of Future Occurrence

There have been few past incidents of structure collapse in Guilford County, though future occurrences are considered possible.

Consequence Analysis

People (The Public and Public Confidence)

The collapse of an occupied building is a highly dangerous situation to occupants and passersby. Falling debris and debris that is carried out by the pressure of the collapse can injure those outside the building. Those persons who are inside the structure are most likely to be injured. Generally, these occupants will have more severe injuries, which can include death. Following a collapse anyone inside the structure is likely to be trapped and could suffer further injury while awaiting rescue and removal from the structure.

During and after a building collapse, the public will be influenced by the perceived effectiveness of the response to the collapse. This perception could be impacted by eyewitness accounts, victims, and in particular the reporting of the event by the media. Expectations may or may not be met, affecting public confidence in the ability of government and other involved entities to make decisions and act in emergency situations.

Responders

First responders will be impacted by a building collapse, as they are required to respond to such incidents. The possibility exists for secondary collapses to occur during rescue operations. If

such secondary instances occur, rescuers could be injured and the condition of those trapped may worsen. Highly-trained teams such as Urban Search and Rescue teams exist for these situations and should be activated early and utilized fully to minimize the impact. Until these teams arrive, rescuers must be cognizant of the dangers associated with secondary collapses and proceed with caution.

Continuity of Operations

Generally, continuity of operations can be relatively easily maintained during a structure collapse in Guilford County. Since the effects will be very localized and are not likely to directly impact availability of personnel, there is a low risk of impact on continuity of operations.

Built Environment (Property, Facilities, and Infrastructure)

Building Stock

In cases of structure collapse, homes may become uninhabitable or require significant repair and displace residents. Building collapses in business settings could lead to disruptions to normal operations or closures and work stoppages. Structural issues at hazardous materials sites could not only bring about the operational issues noted in business settings but could also cause hazardous material releases or spills.

Critical Facilities and Personnel

Structural issues at a hospital could significantly impact hospital operations. Some departments may close completely and force patients to be sent to other facilities. In some areas, biohazards or other hazardous materials may be released or spilled. Structural failures in emergency services facilities could lead to the use of alternative operating areas or the need for mutual aid assistance. In some buildings, critical systems may be housed and could experience disruptions. Shelters may be activated if there are numerous displaced persons from large businesses or residential areas that experience collapses (for example, due to an earthquake).

Critical Utilities

There can be impacts if the building that collapses is directly tied to the functioning or management of power. If the building collapses on equipment or structures that are part of the power distribution network, it could also have significant impact on the delivery of services.

Economy

The economic impact of a building collapse is ultimately dependent on what structures collapse and the extent of the damage. If the collapse occurs in a business district and forces other businesses to be closed for cleanup or inspected for possible damage, this further impacts the local economy. Of greatest economic concern are large employers that have a significant stake in the local economy such as any of the hospitals, schools, or colleges. A structural collapse at a

financial institution could also be especially problematic to the local economy, depending on what equipment and systems are impacted.

It should also be noted that building collapses in city centers could lead to disruptions in everyday commerce or bring about closures and work stoppages. Similarly, a collapse of a large arena or event center can have a significant impact on the local economy, as significant revenue is generated by large events.

Environment

The environmental impact of a building collapse would most likely be minimal. Run off from the collapsed building could contaminate nearby wildlife and/or water supplies if it is not controlled.

Communications System Disruption / Failure

Background

The widespread failure or disruption of communications systems is uncommon. In most cases, there are backup systems in place to keep communication lines flowing. Extreme situations or the presence of several significant hazards would be necessary for an incident that would affect multiple communications systems. Communications infrastructure is designed to withstand high winds and other weather elements; however, failure is always a possibility and must be planned for regardless of the unlikelihood. In Guilford County, one issue that can cause or exacerbate a communications system disruption is that numerous facilities in the county are constructed in a way that radio coverage is greatly diminished within the building. This kind of disruption can occur without a precipitating event and result in similar impacts to communication among response personnel.

Disruptions are more likely to occur than actual failures. Overloaded systems due to other hazards or disaster circumstances may cause temporary connectivity issues, especially in cell phone networks. The public and some government and business operations have become more reliant on cell phones for communicating. During large-scale events or emergencies when cell phone traffic is high, it can cause overload situations and disruptions could result.

Location and Spatial Extent

Since a communications disruption/failure would generally have impacts throughout the county's entire network, the location for this hazard is considered countywide.

Historical Occurrences

In Wilmington, North Carolina, Hurricane Floyd caused a temporary outage of the county's 800 megahertz (MHz) radio system. Guilford County had a similar instance in the spring of 2011 when the 800 MHz radio system entered into Failsoft mode. This significantly impacted radio transmissions as multiple sets of talk groups were consolidated into single channels, a result of the system losing "trunking" capability. Occasional impediments in radio transmissions can be expected in these situations. Many digital talk groups in Greensboro had disruptions, especially

those associated with law enforcement. Decision makers may ultimately decide to switch operational communications over to a backup system until the primary system's issues are corrected.

During and immediately after Hurricane Katrina, the city of New Orleans, Louisiana and adjacent areas experienced significant communications issues as flooding impacted multiple systems. Cell phone towers and their generators, landline infrastructure, and other communications equipment and structures were temporarily out of service. Much of this scenario was due to the strength of the storm and the area's topographical characteristics. A similar incident is unlikely to occur in Guilford County due to its geographic location and topography.

Probability of Future Occurrence

Since there have been some previous occurrences of communication disruption/failure and future occurrences are probable, the probability is considered to be likely.

Consequence Analysis

People (The Public and Public Confidence)

The public has become increasingly reliant on cell phone communications. Many households have decided to forgo landline services completely in exchange for cell phones. In large-scale emergencies, many calls will be made to dispatch centers, loved ones, etc. that may cause overloading of the cell phone networks. These disruptions can cause issues that range from slight nuisances to the end user to preventing an emergency from being reported. Extended disruptions or complete outages can significantly impact communications and in extreme cases, put some in danger during emergencies as responders will be delayed or may not receive notification at all.

Public confidence may be impacted based upon societal expectations, media influence, and past experience with issues or failures in communication systems. Public confidence can be gained when the public's expectations of response and recovery services are met or exceeded. Public confidence may be impacted by media interpretation and reporting of the event, whether positively or negatively. Lastly, the public's experience with prior incidents of like type and scope will affect confidence because the public may compare services rendered from one communications interruption or failure to another.

Responders

Impact may center more on operational information passing rather than performing physical tasks such as rescue, patient care, and firefighting. Communication is vital to efficient and effective service, and disruptions or breakdowns could impact the service provided. Backup forms of communication must be identified and maintained in order to provide a means for critical communications while primary systems are repaired and restored. Once the primary systems are operational, an appropriate transition away from the backup system should be implemented to lessen the transition's impact on ongoing operations.

Continuity of Operations

A communications disruption/failure would potentially have extensive impacts on continuity of operations because of the loss of ability for responders and other emergency personnel to communicate effectively. This could cause a great deal of stress to operations and create some level of disorder in terms of continuity.

Built Environment (Property, Facilities, and Infrastructure)

Most of the built environment (e.g. homes, buildings, roadways) would not be directly impacted in any way by this type of event. However, if power or communications systems are damaged or temporarily shut down, some aspects of the built environment may be impacted such as traffic lights, street lights, and cell phone towers that may rely on communications equipment to function properly. At many key facilities, there are backup systems in place and many facilities utilize radios that allow for continued communication within the facility. There may be more significant impacts when trying to communicate outside of the facility.

Airports and other transportation facilities can be particularly impacted by communications issues, especially if the communication failure is internal. Such communications failures could impact travel locally, regionally, and potentially at a national level, especially if the failures are widespread. External communications failures may delay the reporting of general conditions or promote compounding incidents and in turn delay the dispatch of appropriate personnel.

Economy

Significant economic impact is unlikely unless communications systems are down for extended periods of time. Days or weeks of outages will affect businesses and commerce significantly and may require numerous resources to fix, replace, or temporarily take the place of the current system in place. Large employers can be significantly impacted depending on the communications system involved and the length of the incident. Backup systems may limit or eliminate any impact but will still cause some disruption.

Environment

There will likely be relatively minimal impacts on the environment from a communications system failure. These types of events do not directly impact plants or animals and typically do not have any effect on water systems or other natural areas. There may be indirect impacts if, for example, communications systems are damaged at facilities that house hazardous materials which, in turn, results in releases into the environment. However, the likelihood of this occurring is relatively low.

Energy / Power / Utility Failure

Background

A failure in the power distribution network can happen for varying reasons. Some possible examples include the physical failure of power lines due to hazards as discussed in the Critical Utilities sections throughout this document, as well as problems within the network itself

including faults at a power station, shorts or overloading in a circuit(s), or physical damages at a substation.

There are three different types of power outages - transient faults, brownouts, and blackouts. A transient fault is a brief outage caused by a fault in a power line. The issue is corrected when the power flow clears the faulty part of the circuit, and power is returned. A brownout occurs when voltage falls to an inadequate level. A blackout occurs when there is a complete loss in the power supply. Blackouts are generally longer lasting outages than the previous two examples and may involve significant repairs. These outages can range from minutes to weeks or more depending on the significance of the failure in the network.

Location and Spatial Extent

Due to the unpredictable nature of where exactly a power or utility outage will occur, the entire county is considered to be equally susceptible to this hazard. However it should be noted that in more urbanized areas, the effects of an outage at a single location or facility would likely impact larger numbers of people.

Historical Occurrences

Most of the lengthy power outages that have occurred in Guilford County have been due to winter storms with ice accumulation, as the area occasionally experiences this type of weather during the winter months. This accumulation can make travel dangerous and also cause branches, trees, and power lines to break or fall, causing power disruptions or outages in the affected area. Power outages can vary depending on the amount of precipitation, its location, and its form.

On February 25, 2010, one such ice accumulation event occurred, as ¼ of an inch of icing followed a 3 inch snowfall. The weight of the icepack and snow during this storm caused the downing of trees and power lines, resulting in over 12,000 homes without power. More recently, in 2014 a major ice storm impacted the county and many areas of the state knocking down power lines and causing power outages for several days in some cases. In 2018, Hurricanes Florence and Michael caused widespread outages in the county as hundreds of thousands lost power in these storms.

Guilford County experienced record power outages during an ice storm on December 4, 2002. Almost a million people in central North Carolina lost power due to ½ an inch to an inch of ice accumulation causing power line failures and downed trees. Some areas lost power for a week or more in this event.

Power outages do not occur only during weather-related events. In 2003, the Northeast Blackout showed how vulnerable large networks are to widespread outage. An estimated 55 million people were without power after a critical failure in the system, as many power plants in Ontario, Canada and the Northeast went offline. A single cause could not be attributed to this incident, but several issues led to a cascading failure. Overload protection was unable to keep a small problem

in the system from affecting other parts of the system, which led to the power outage affecting a larger area.

In October 2018, Guilford County experience a widespread power outage due to Tropical Storm Michael. More than 145,000 power outages were reported in the Greensboro area following the impact of the storm.

Probability of Future Occurrence

Based on the high number of outages that have occurred in past years, the probability of a power or utility failure is considered likely.

Consequence Analysis

People (The Public and Public Confidence)

Some issues that need to be considered during a power outage include transportation tie-ups and accidents, medical emergencies, and communications disruptions. The transportation problems would likely be related to traffic lights and signals not working or from decreased visibility during the night. Medical emergencies could stem from homes not having power to operate heating and air conditioning systems, particularly during conditions of extreme temperatures. Also medical equipment that relies on power could shut off, no longer providing a patient with treatment he or she requires. The communications issues could prevent the public from being able to call emergency services. Business disruptions could also impact services that the public wants or needs. Lastly, well pumps would not function without power unless on backup generator power.

Public perception during any incident involving public utility systems depends on the impacts that are presented and how government and nongovernmental entities act. Extended, widespread outages could have the potential for pressure from the public. The media's reporting of the incident and the response could significantly influence public expectations and perception. Passing information to the public about ongoing efforts and when service restoration can be expected could assist in maximizing the confidence and satisfaction of the public.

Responders

As mentioned above, there may be issues relating to transportation, medical equipment, extreme weather temperatures, and communications issues in the event of a power outage. Any of these issues could impact the call volume for emergency responders. If communications disruptions are present, it could affect notification processes and increase response times. Until power is restored, some critical facilities may need generators to provide backup power. Law enforcement may become strained if additional personnel are needed to deal with unusual circumstances such as unrest, looting, or traffic control if signals are not operating appropriately.

Continuity of Operations

Generally, continuity of operations can be maintained during a power or utility outage event in Guilford County. However, when utilities go down, it can make it difficult for local government employees to get to work. Furthermore, there is a limited supply of both permanent and mobile emergency generators available in the county to maintain power during an outage. As a result, there will likely be some disruption of operations during an outage.

Built Environment (Property, Facilities, and Infrastructure)

Many residential structures do not have backup generators in place. If power fails, the residents of these homes may not be able to refrigerate their food, regulate medical equipment properly (such as oxygen), etc. until power is restored. Power outages can also sometimes lead to sparks that may rarely ignite fires or damage other components of the electric grid, causing extensive damage. Other utility failures may also cause damage when they go down, such as sewer systems. Shut downs or damage to these systems can result in hazardous environments that expose the built environment to waste products.

In terms of transportation infrastructure, airports may have to ground flights and suspend operations as a result of a power outage until power can be restored. Extended outages may cause more significant impacts on flight patterns. Signals at railroad crossings may not work appropriately and in more severe cases, networks may be stopped until power is restored to prevent incidents.

Communications infrastructure may also be damaged or disrupted. Cellular telephone towers generally have backup power to function during power outages. However, depending on the presence of other hazards or lengthy outages, cell phone reception may be impacted. Internet connections that originate from or are linked to energy sources in affected areas will likely see effects from a power outage.

Economy

Extended utilities outages could shut down businesses and have significant financial impacts depending on the area of the outage, the period of time the outage occurs, and the nature of the business(es) that are affected. Outages would have particularly major effects if they occur during business hours. Power outages could also have a significant impact on facilities like the Greensboro Coliseum if an event is taking place and is disrupted. This could deprive the local economy of a great deal of commercial activity.

Environment

The impacts to the environment from a utility outage will likely be minimal. Most utility outages do not affect environmental features, despite having a major effect on humans and the built environment. It is possible that some outages may cause spillover effects from cascading events such as fires or sewer backups, but these would likely have a relatively minor impact.

Hazardous Materials Incident

Background

Hazardous materials can be found in many forms and quantities that can potentially cause death; serious injury; long-lasting health effects; and damage to buildings, homes, and other property in varying degrees. Such materials are routinely used and stored in many homes and businesses and are also shipped daily on the nation's highways, railroads, waterways, and pipelines. This subsection on the hazardous material hazard is intended to provide a general overview of the hazard, and the threshold for identifying fixed and mobile sources of hazardous materials is limited to general information on rail, highway, and FEMA-identified fixed HAZMAT sites determined to be of greatest significance as appropriate for the purposes of this plan.

Hazardous material (HAZMAT) incidents can apply to fixed facilities as well as mobile, transportation-related accidents in the air, by rail, on the nation's highways, and on the water. HAZMAT incidents are caused when solid, liquid, and/or gaseous contaminants are released from fixed or mobile containers, whether by accident or by design (as with an intentional terrorist attack). A HAZMAT incident can last hours to days, and some chemicals can be corrosive or otherwise damaging over longer periods of time. In addition to the primary release, explosions and/or fires can result from a release, and contaminants can be extended beyond the initial area by persons, vehicles, water, wind, and possibly wildlife as well.

HAZMAT incidents can also occur as a result of or in tandem with natural hazard events, such as floods, hurricanes, tornadoes, and earthquakes. In addition to causing incidents, these can also hinder response efforts. In the case of Hurricane Floyd in September 1999, communities along the Eastern United States were faced with flooded junkyards, disturbed cemeteries, deceased livestock, floating propane tanks, uncontrolled fertilizer spills, and a variety of other environmental pollutants that caused widespread toxological concern.

Hazardous material incidents can include the spilling, leaking, pumping, pouring, emitting, emptying, discharging, injecting, escaping, leaching, dumping, or disposing into the environment of a hazardous material, but exclude: (1) any release which results in exposure to poisons solely within the workplace with respect to claims which such persons may assert against the employer of such persons; (2) emissions from the engine exhaust of a motor vehicle, rolling stock, aircraft, vessel or pipeline pumping station engine; (3) release of source, byproduct, or special nuclear material from a nuclear incident; and (4) the normal application of fertilizer.

Location and Spatial Extent

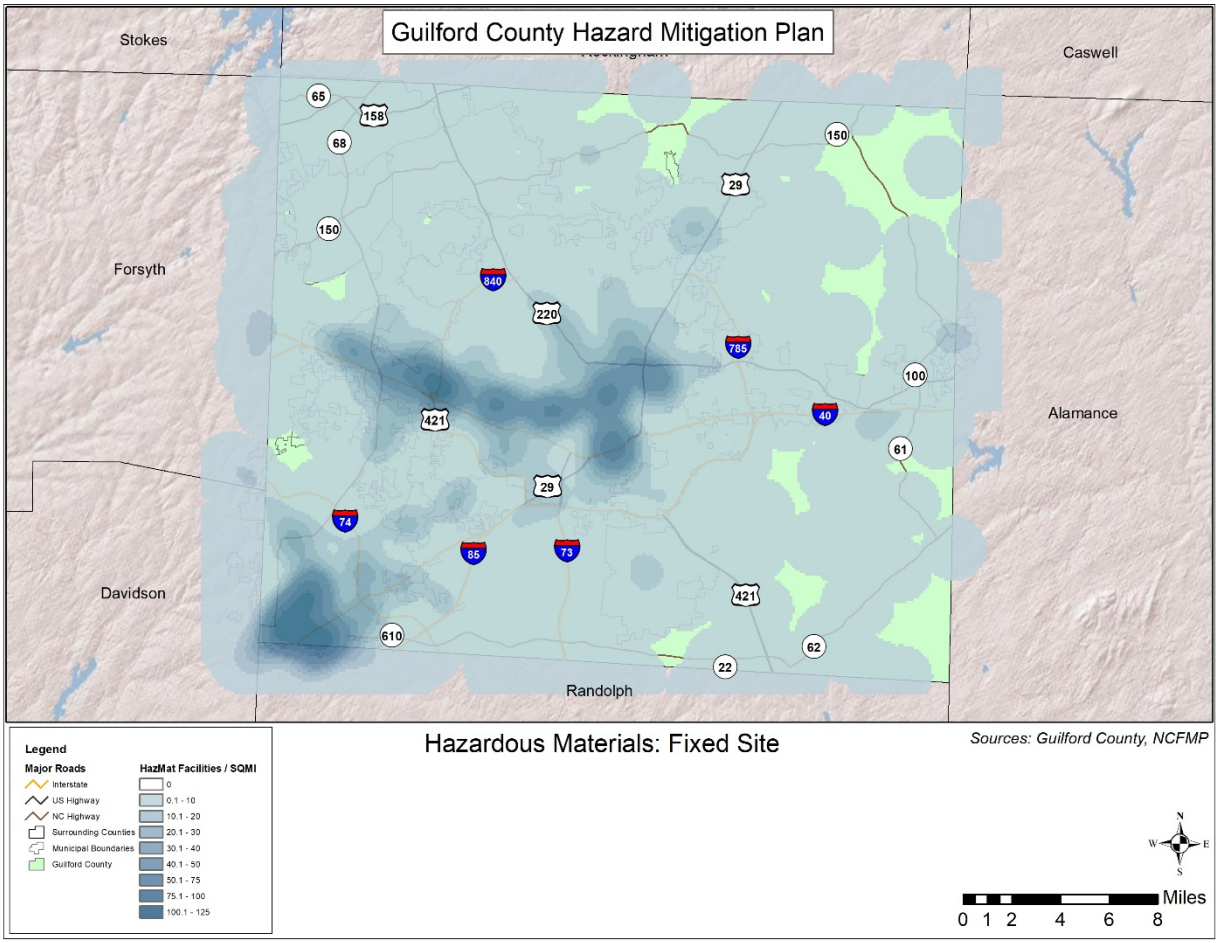
As a result of the 1986 Emergency Planning and Community Right to Know Act (EPCRA), the Environmental Protection Agency (EPA) provides public information on hazardous materials. One facet of this program is to collect information from industrial facilities on the releases and transfers of certain toxic agents. In addition, a number of other environmental laws (CAA, CWA, RCRA, etc) require facilities to report on the housing of potentially hazardous materials. The information collected through this reporting process is housed in the Facility Registry Service (FRS). FRS sites indicate where hazardous materials or places of environmental interest are located.

Guilford County currently has thousands of sites listed on the FRS. As such, it would be overwhelming to list all of these facilities in the plan or show them all on a single map. Instead, all of these fixed hazardous materials sites are summarized in **Table 3.40** and shown in **Figure 3.26.** Additionally, facilities that use extremely hazardous substances are required to develop a Risk Management Plan (RMP) that must be revised and resubmitted to the EPA ever five years. There are 13 RMP facilities in Guilford County and these are identified as critical facilities and are assessed in that section of the plan.

TABLE 3.40: SUMMARY OF FIXED HAZARDOUS MATERIALS SITES IN GUILFORD COUNTY

Location	FRS Facilities
Gibsonville	33
Greensboro	2,904
High Point	1,458
Jamestown	52
Oak Ridge	27
Pleasant Garden	47
Sedalia	2
Stokesdale	48
Summerfield	28
Whitsett	4
Unincorporated Area	944
GUILFORD COUNTY TOTAL	**5,547**

FIGURE 3.26: FACILITY REGISTRY SERVICE SITES HEAT MAP



Source: Environmental Protection Agency

In addition to "fixed" hazardous materials locations, hazardous materials may also impact the county via roadways and rail. Many roads in the county are subject to hazardous materials transport and all roads that permit hazardous material transport are considered potentially at risk to an incident.

Historical Occurrences

The U.S. Department of Transportation Pipeline and Hazardous Materials Safety Administration (PHMSA) lists historical occurrences throughout the nation. A "serious incident" is a hazardous materials incident that involves:

- a fatality or major injury caused by the release of a hazardous material,
- the evacuation of 25 or more persons as a result of release of a hazardous material or exposure to fire,
- a release or exposure to fire which results in the closure of a major transportation artery,
- the alteration of an aircraft flight plan or operation,
- the release of radioactive materials from Type B packaging,
- the release of over 11.9 gallons or 88.2 pounds of a severe marine pollutant, or

- the release of a bulk quantity (over 199 gallons or 882 pounds) of a hazardous material.

However, prior to 2002, a hazardous materials "serious incident" was defined as follows:

- a fatality or major injury due to a hazardous material,
- closure of a major transportation artery or facility or evacuation of six or more person due to the presence of hazardous material, or
- a vehicle accident or derailment resulting in the release of a hazardous material.

There have been a total of 2,739 recorded HAZMAT incidents in Guilford County since 1971 (**Table 3.41**). These events resulted in over $2.9 million of property damage as well as 1 death and 30 injuries. **Table 3.42** presents detailed information on historical HAZMAT incidents in Guilford County as reported by the U.S. Department of Transportation Pipeline and Hazardous Materials Safety Administration (PHMSA). However, due to the high number of reported incidents, detailed information is only provided for those incidents that are classified as serious incidents.

TABLE 3.41: SUMMARY OF HAZMAT INCIDENTS IN GUILFORD COUNTY

Location	Number of Occurrences	Deaths / Injuries	Property Damage
Gibsonville	2	0/0	$28,462
Greensboro	2,610	1/27	$2,380,529
High Point	113	0/3	$12,719
Jamestown	8	0/0	$328,600
Oak Ridge	0	0/0	$0
Pleasant Garden	0	0/0	$0
Sedalia	1	0/0	$2,800
Stokesdale	2	0/0	$194,500
Summerfield	0	0/0	$0
Whitsett	3	0/0	$0
Unincorporated Area	10	0/0	$16,768
GUILFORD COUNTY TOTAL	**2,749**	**1/30**	**$2,964,378**

Source: Untied States Department of Transportation Pipeline and Hazardous Materials Safety Administration

TABLE 3.42: SERIOUS HAZMAT INCIDENTS IN GUILFORD COUNTY

Report Number	Date	City	Mode	Serious Incident?	Fatalities / Injuries	Damages ($)*	Quantity Released
Gibsonville							
None Reported	--	--	--	--	--	--	--
Greensboro							
I-1976030738	3/1/1976	GREENSBORO	Highway	Yes	0/0	$0	300 LGA
I-1977070198	6/28/1977	GREENSBORO	Highway	Yes	0/0	$0	300 LGA
I-1979041231	4/14/1979	GREENSBORO	Highway	Yes	0/0	$0	300 LGA
I-1979061010	5/1/1979	GREENSBORO	Highway	Yes	0/0	$0	385 LGA
I-1979120614	11/8/1979	GREENSBORO	Highway	Yes	0/0	$0	805 LGA
I-1980090308	8/18/1980	GREENSBORO	Highway	Yes	0/0	$0	563 LGA
I-1980100440	9/20/1980	GREENSBORO	Highway	Yes	0/0	$0	5,869 LGA
I-1980101010	9/25/1980	GREENSBORO	Highway	Yes	0/0	$0	930 SLB
I-1982030735	2/20/1981	GREENSBORO	Highway	Yes	0/0	$0	750 LGA
I-1982100088	9/22/1982	GREENSBORO	Highway	Yes	0/0	$0	0
I-1982100088	9/22/1982	GREENSBORO	Highway	Yes	0/0	$0	13,000 SLB
I-1987110100	10/30/1987	GREENSBORO	Highway	Yes	1/4	$0	8,000 LGA
I-1990080042	7/26/1990	GREENSBORO	Highway	Yes	0/0	$0	600 LGA
I-1991090582	9/8/1991	GREENSBORO	Highway	Yes	0/0	$0	129 LGA
I-1991110412	9/26/1991	GREENSBORO	Highway	Yes	0/0	$0	55 LGA
I-1992090751	8/20/1992	GREENSBORO	Highway	Yes	0/0	$0	700 LGA
I-1993090117	8/24/1993	GREENSBORO	Highway	Yes	0/0	$0	5,000 LGA
I-1995071369	7/5/1995	GREENSBORO	Highway	Yes	0/0	$0	0.264172 LGA
I-1997100017	9/4/1997	GREENSBORO	Highway	Yes	0/0	$36,983	1,300 LGA
I-1997100623	9/5/1997	GREENSBORO	Highway	Yes	0/0	$0	200 LGA
I-1999101169	9/30/1999	GREENSBORO	Highway	Yes	0/1	$0	9,000 LGA
I-2000040521	3/30/2000	GREENSBORO	Rail	Yes	0/3	$0	5,300 LGA
I-2001060345	11/13/2000	GREENSBORO	Highway	Yes	0/0	$0	4,500 LGA

Report Number	Date	City	Mode	Serious Incident?	Fatalities / Injuries	Damages ($)*	Quantity Released
I-2003050215	8/28/2002	GREENSBORO	Highway	Yes	0/0	$0	5,500 LGA
I-2003090170	1/30/2003	GREENSBORO	Highway	Yes	0/0	$0	260 LGA
I-2003100511	9/25/2003	GREENSBORO	Highway	Yes	0/0	$0	324.14 LGA
I-2003120134	10/2/2003	GREENSBORO	Highway	Yes	0/0	$0	175 LGA
E-2009020080	12/23/2008	GREENSBORO	Highway	Yes	0/0	$0	500 LGA
E-2009110327	10/27/2009	GREENSBORO	Highway	Yes	0/0	$0	387.5 LGA
I-2011010037	12/10/2010	GREENSBORO	Highway	Yes	0/0	$0	300 LGA
I-2012040248	11/29/2011	GREENSBORO	Highway	Yes	0/0	$0	200 LGA
I-2012040248	11/29/2011	GREENSBORO	Highway	Yes	0/0	$0	1,000 LGA
I-2014120003	11/14/2014	GREENSBORO	Highway	Yes	0/0	$2,450	200 LGA
I-2015040484	12/5/2014	GREENSBORO	Highway	Yes	0/0	$59,806	2021 LGA
I-2016100044	9/7/2016	GREENSBORO	Highway	Yes	0/0	$73,512	57.1875 LGA
I-2016100044	9/7/2016	GREENSBORO	Highway	Yes	0/0	$73,512	108.25 LGA
E-2019010304	12/13/2018	GREENSBORO	Highway	Yes	0/0	$153,000	8499 LGA
E-2019050725	4/8/2019	GREENSBORO	Highway	Yes	0/0	$0	130 LGA
I-2019070105	4/30/2019	GREENSBORO	Highway	Yes	0/0	$4,500	150 LGA
E-2019070319	5/9/2019	GREENSBORO	Highway	Yes	0/0	$0	249 LGA
High Point							
I-1977010157	12/31/1976	HIGH POINT	Highway	Yes	0/0	$0	5,200 LGA
I-1985060263	5/29/1985	HIGH POINT	Highway	Yes	0/0	$0	150 LGA
I-2011010135	11/10/2010	HIGH POINT	Highway	Yes	0/0	$0	181 LGA
Jamestown							
I-1989040054	3/15/1989	JAMESTOWN	Rail	Yes	0/0	$0	2,600 LGA
I-2001050986	3/19/2001	JAMESTOWN	Highway	Yes	0/0	$4,022	300 LGA
E-2013030384	3/27/2013	JAMESTOWN	Highway	Yes	0/0	$0	100 LGA

Report Number	Date	City	Mode	Serious Incident?	Fatalities / Injuries	Damages ($)*	Quantity Released
Oak Ridge							
None Reported	--	--	--	--	--	--	--
Pleasant Garden							
None Reported	--	--	--	--	--	--	--
Sedalia							
None Reported	--	--	--	--	--	--	--
Stokesdale							
I-1978020301	1/31/1978	STOKESDALE	Highway	Yes	0/0	$0	6,000 LGA
I-2002120039	11/12/2002	STOKESDALE	Highway	Yes	0/0	$13,198	4,000 LGA
Summerfield							
None Reported	--	--	--	--	--	--	--
Whitsett							
None Reported	--	--	--	--	--	--	--
Unincorporated Area							
None Reported	--	--	--	--	--	--	--

Source: Untied States Department of Transportation Pipeline and Hazardous Materials Safety Administration

Probability of Future Occurrence

Given the location of numerous FRS and RMP facilities in Guilford County as well as prior roadway, railway, air, and other incidents it is highly likely that a hazardous material incident may occur in the county (100 percent annual probability). However, county and municipal officials are mindful of this possibility and take precautions through pre-planning to respond to an occurrence.

Consequence Analysis

People (The Public and Public Confidence)

The accidental or intentional release of a hazardous material could have both immediate and long lasting effects on the health of the public. Any release needs to be quickly identified and the proper response guidelines followed to reduce the possible impact on the public. Evacuation is always a consideration when dealing with harmful substances. The public should be aware that hazards exist from the presence of hazardous substances and should take preparedness actions at home and in the workplace to act should a release of substances occur.

Hazardous materials incidents can have a significant effect on public confidence in government as incidents often cause serious harm to people via long-term health impacts, contamination of soil or drinking water, and even death. Because of the dangers associated with many hazardous materials and the level of control that humans have over hazardous material incidents compared to natural hazards, public confidence could be damaged severely in the event of an incident.

Responders

First responders must be vigilant when hazardous materials are suspected to be involved. The proper protective apparel must be worn and protocols must be followed to ensure that contaminated individuals and objects go through appropriate decontamination procedures prior to being moved away from the incident, regardless of the situation. Contamination of other responders or citizens must be avoided. The appropriate personnel, such as Hazardous Materials teams, must be notified to ensure that the proper measures are taken to prevent further harm and other related impacts.

Continuity of Operations

During a hazardous materials incident, normal operations could likely be maintained with some additional stress on daily operations. In the event of a larger scale hazardous materials spill, there could be some loss of continuity of operations as a result of strain on personnel and equipment, but typically this will not be the case.

Built Environment (Property, Facilities, and Infrastructure)

Hazardous Materials Facilities

A hazardous materials event is most likely to take place where the substance is created or stored. Hazardous materials facilities have their own highly-trained personnel for handling and cleaning up the particular materials stored onsite. The facility's plans are highly specific to the substances stored there, thus providing for effective responses to incidents that involve these substances. Some facilities contain hazardous materials that can spread or leak quickly or are held in extremely dangerous concentrations. There can still be significant effects on workers and others in close proximity despite having good planning in place.

Utilities

Natural gas distribution lines can be problematic with some hazardous substances if contact is made with the natural gas supply. Most of the natural gas infrastructure is located underground, making exposure highly unlikely. However, natural gas itself can be the hazardous substance

involved in the incident. One example of how this may occur is if a utility, work crew, or citizen strikes a gas line causing a leak. Degradation of the line may also be the cause of a release. A gas leak would cause an immediate threat and explosions and fires would be significant concerns for the immediate vicinity.

Transportation Systems

Hazardous substances can have an impact on transportation infrastructure if a release occurs on or in the vicinity of a roadway, which may be the case if a truck or other vehicle carrying hazardous materials is involved in a traffic accident. Significant traffic disruptions may occur, slowing commerce or forcing alternative routing and further congestion of other areas. Similarly, rail lines are one of the more prominent places that hazardous substances are transported. A hazardous substance event on the rail system can impact rail traffic and the overall system. Cleanup efforts wherever the event occurred could be costly and go on for extended periods, shutting down that part of the rail system for a time.

Critical Facilities

Hospitals utilize and store some hazardous substances on site. Biological materials and radioactive wastes are the primary concerns in a hospital setting. Plans are in place to manage these concerns in both routine and emergency situations. An external hazardous materials event that occurs near the hospital or directly impacts a hospital could create service disruptions such as patient care. A large event may also create a high demand on hospital services and cause an overload on resources. Similarly, some emergency services facilities such as emergency shelters may be opened if homes have been exposed to hazardous substances and evacuations occur.

Other Structures

Commercial, industrial, and residential buildings all may have hazardous substances contained within them that are not reported through the official facility reporting system but which could still present a smaller scale hazard. Proper containers and labeling can prevent inappropriate use, but accidents can still cause workers to be exposed. Cleaning products, fertilizers, and pesticides are common examples of supplies that are considered hazardous substances and which could cause a smaller incident.

Economy

The economic impact of a hazardous materials related incident can be significant locally. Affected commerce is the greatest concern, as spills and releases can force businesses such as shopping centers, markets, and financial centers to be shut down for indeterminate periods of time. Contaminated water can be especially problematic as it can cause extensive shutdowns and put many people in danger. The overall costs depend on the substance(s) involved, how much is released, the processes and time used to manage the spill or release, who or what is contaminated, whether a fire takes place, etc. Cleanup can be a less significant cost and is typically handled by the party responsible for the spill or release.

A hazardous materials incident could occur at any large gathering if it was the target of a terrorism event (see Terrorism below). Also, a large event arena could be forced to deal with a hazardous substance incident if it is located in close proximity to them. Arenas and other major event venues may be at significant threat as they are often situated along transportation routes where vehicles transporting such substances could become involved in an accident.

Environment

The environmental impact is highly dependent on the location and the severity of the event. Some of the substances involved in these incidents can be cleaned up or do not have lasting impacts on the areas affected. Others may cause crops and other vegetation to be destroyed, sometimes beyond the ability to grow back, and animal populations may become displaced or killed. Some areas may be deemed uninhabitable or not fit for development. Water sources may also be impacted by hazardous materials releases or spills, which can affect fish, animal, and plant populations as well as humans that come in contact with contaminated water. The threat to water sources is perhaps the greatest potential threat of a hazardous materials spill on the environment. Water can rapidly transport the substance great distances and expand the scope of the incident. This can make it difficult to respond to the incident and cause serious health impacts.

Nuclear Power Plant Emergency

Background

A nuclear and radiation accident is defined by the International Atomic Energy Agency as "an event that has led to significant consequences to people, the environment or the facility. Often, this type of incident results from damage to the reactor core of a nuclear power plant which can release radioactivity into the environment. The degree of exposure from nuclear accidents has varied from serious to catastrophic.

By some estimates, over 50 percent of nuclear accidents that have ever occurred were in the United States.[38] However, it is also important to note that generally, nuclear accidents are a rare occurrence. Many incidents are extremely well known due to their large-scale impact and serious effects on people and the environment.

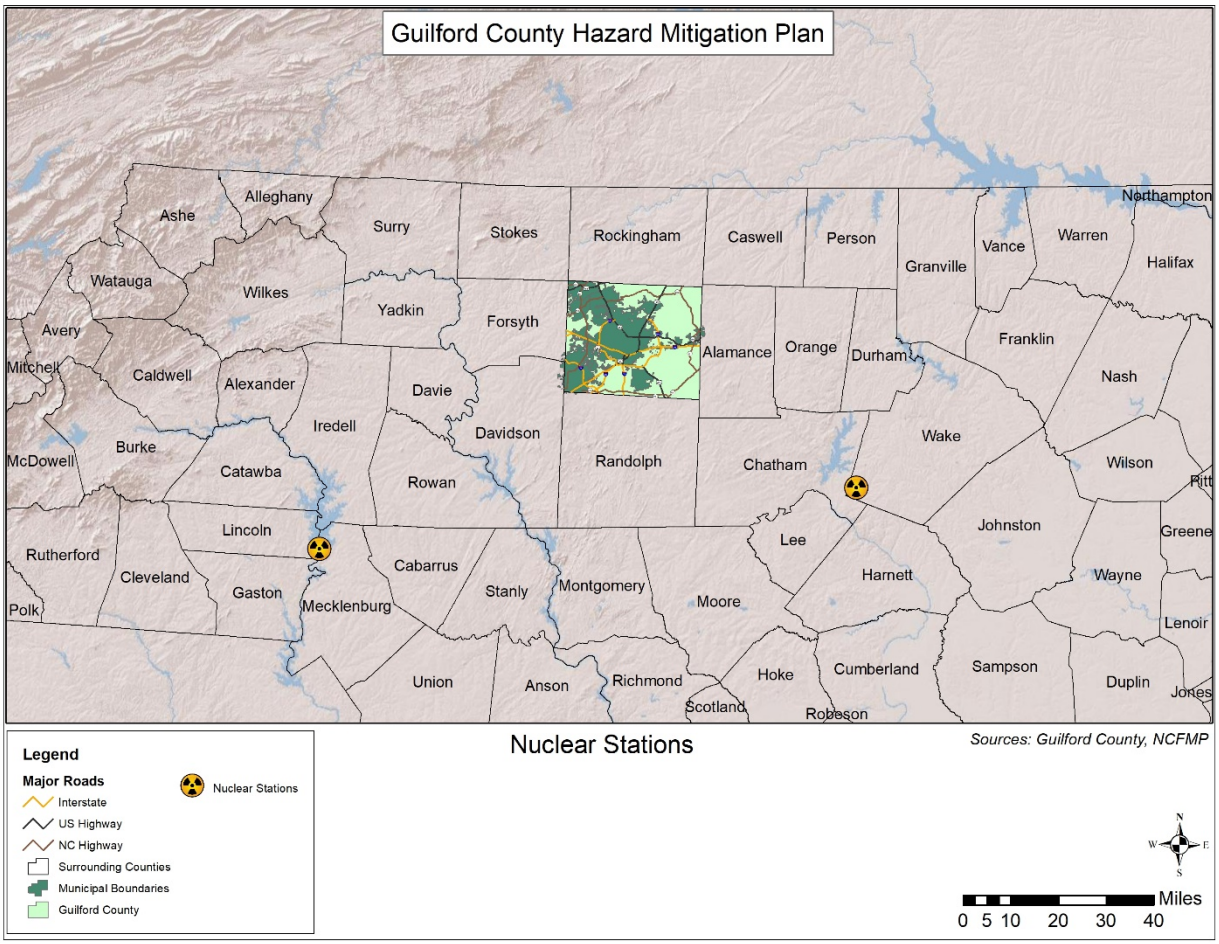
One of the most notorious accidents in the United States was the Three Mile Island accident which occurred in 1979 and released small amounts of radioactive gases and iodine into the environment. Although no deaths have been directly attributed to the accident, it invoked a strong public reaction and demonstrated the potential dangers associated with nuclear power generation.

Shearon Harris Nuclear Power Plant, which is the plant located closest to Guilford County, is a 2,948 megawatt power plant that began commercial operation in 1987. It has pressurized water

[38] Benjamin K. Sovacool. A Critical Evaluation of Nuclear Power and Renewable Electricity in Asia *Journal of Contemporary Asia*, Vol. 40, No. 3, August 2010, pp. 393–400.

reactors and operates with a very high level of security. **Figure 3.12** shows the plants' locations in relation to Guilford County.

FIGURE 3.7: NUCLEAR POWER PLANTS LOCATED NEAR GUILFORD COUNTY

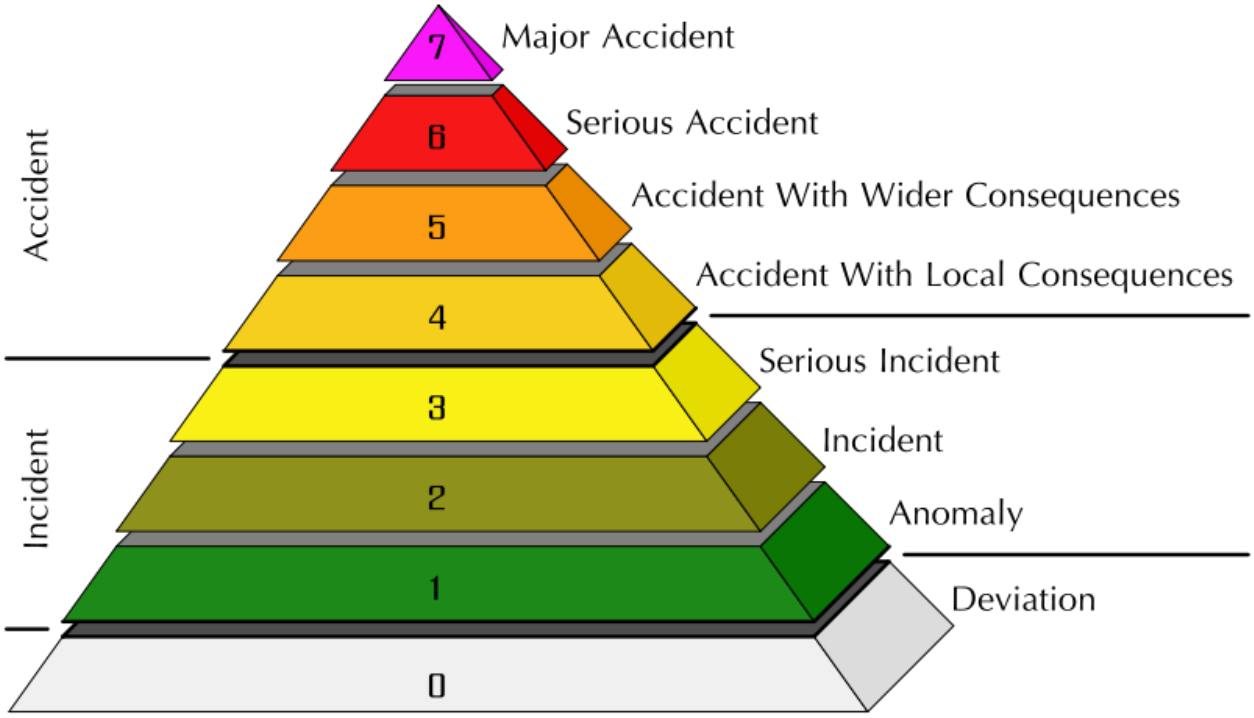


Source: International Atomic Energy Agency

Location and Spatial Extent

The southeastern portion of Guilford County is at risk to impacts from a nuclear incident at the Shearon Harris Nuclear Power Plant. Areas in this part of the county are susceptible due to their relative proximity to the Shearon Harris Nuclear Power Plant. The International Atomic Energy Association has developed a scale called the International Nuclear and Radiological Event Scale (INES) which provides a quantitative means of assessing the extent of a nuclear event. This scale, like the MMI used for earthquakes, is logarithmic which means that each increasing level on the scale represents an event 10 times more severe than the previous level (**Figure 3.28**).

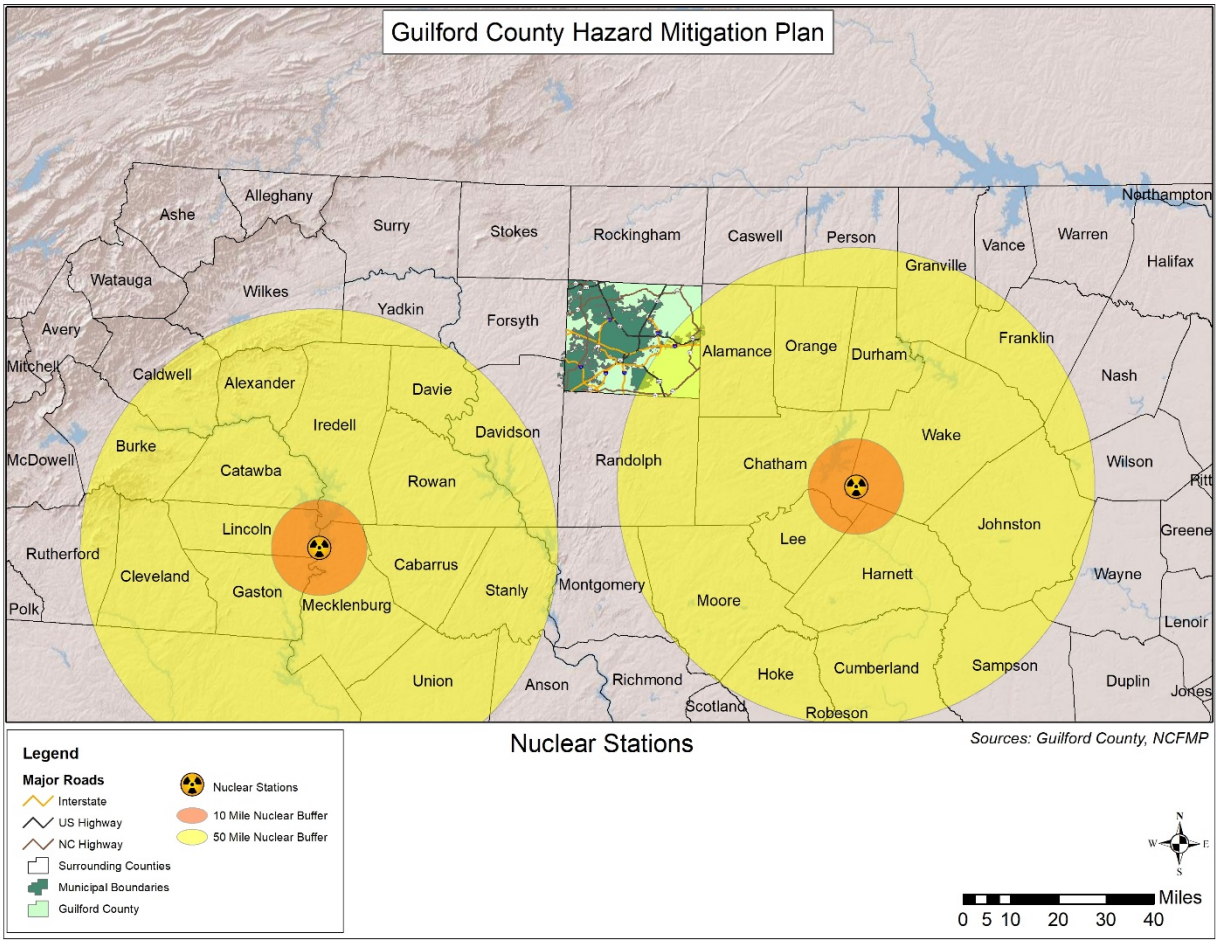
FIGURE 3.28: INTERNATIONAL NUCLEAR EVENT SCALE



Source: International Atomic Energy Agency

The Nuclear Regulatory Commission defines two emergency planning zones around nuclear plants. Areas located within 10 miles of the station are considered to be within the zone of highest risk to a nuclear incident and this radius is the designated evacuation radius recommended by the Nuclear Regulatory Commission. Within the 10-mile zone, the primary concern is exposure to and inhalation of radioactive contamination. The most concerning effects in the secondary 50-mile zone are related to ingestion of food and liquids that may have been contaminated. None of the county is located within the 10-mile radius of the power plant; however, a portion of the county is located within this 50-mile radius which is still considered to be at risk from a nuclear incident (**Figure 3.29**).

FIGURE 3.29: NUCLEAR POWER PLANT EXPOSURE ZONES IN RELATION TO GUILFORD COUNTY



Source: International Atomic Energy Agency

Historical Occurrences

Although there have been no major nuclear events at the Shearon Harris Nuclear Power Plant, there is some possibility that one could occur as there have been incidents in the past in the United States at other facilities and at facilities around the world.

Probability of Future Occurrences

A nuclear event is a very rare occurrence in the United States due to the intense regulation of the industry. There have been incidents in the past, but it is considered unlikely (less than 1 percent annual probability).

Consequence Analysis

People (The Public and Public Confidence)

In the 50-mile zone, the public would be most impacted from ingesting the material(s) through home grown crops, milk produced from livestock which have fed on contaminated grasses, and consuming contaminated surface water. Ingestion of radiological materials may result in internal contamination if ionizing radiation is released in the body. This can cause serious health risks, especially if critical organs are affected. Some organs such as the thyroid take in certain isotopes. It is extremely difficult to purge the material from the body.

The public will be extremely concerned about their health and safety during and after a nuclear incident. Confidence will be dependent upon the availability of information and perceived quality of response by government and non-government service providers, but it is likely that confidence in the county's governance will be a significant concern.

Responders

First responders are vulnerable to the same impacts as the general public but also may be at greater risk due to their need to function outdoors, operating in contaminated environments. These responders will likely need to operate in personal protective equipment and limit their outdoor exposure. Proper decontamination is likely to be necessary to reduce the spread of contamination. Since responders will be first on the scene and directly dealing with the issues of an incident, their risk will potentially be very high.

Continuity of Operations

In the wake of a nuclear accident, continuity of operations in Guilford County would likely be maintained relatively well since the county is only impacted in some areas by the 50 mile buffer area. Generally, operations may need to proceed from outside their normal location, as there are plans at all stations for setting up command posts outside of high-risk areas when incidents occur. This will likely impact continuity of operations to some degree, though exercises on incidents are carried out frequently by government officials in conjunction with plant operators.

Built Environment (Property, Facilities, and Infrastructure)

It is unlikely that a radiological incident would cause the kind of damage that is typical of many other hazards identified in this plan as there would be minimal destruction of buildings and other infrastructure as a result of this type of incident. However, many structures and facilities could potentially be contaminated with radioactivity, rendering it extremely dangerous for humans to be near them or live/work there. In this sense, a major nuclear event may cause significant damage to the built environment and result in large areas that must be quarantined or considered off-limits to the public after an incident, though that is less likely in Guilford County than in counties closer to nuclear facilities. Further, checkpoints and decontamination stations may need to be set up along routes that leave the evacuation zones, resulting in increased travel times along major roadways and necessitating traffic re-routes.

Economy

Economies within and nearby the risk zones are likely to see decreased spending as evacuation takes place. Travel and tourism across the region may be limited for an extended period of time due to travelers associating the entire area with the incident. Interstate commerce may be impacted as decontamination stations may need to be established and some drivers may elect to attempt to circumnavigate the region altogether, extending travel times and increasing the time to market for products on a regional and statewide level. Employers in the surrounding areas may see increased absenteeism and requests for leaves of absence to deal with the aftermath of the event and some employees may self-evacuate, resulting in a loss of productivity.

Environment

Environmental impacts as a result of a nuclear incident may be very serious. Contaminants may impact the land and water for many years and wildlife may experience increased likelihood of cancer and other health problems. In general, habitats and ecosystems will suffer long-term from a radiological incident as the organisms within these areas will face similar impacts to those that humans experience, but since they are unable to evacuate or permanently migrate to new locations, they will be exposed for longer periods and be impacted to a greater degree.

Pipeline Failure

Background

Pipelines in the United States are used to transport and distribute a number of products from their extraction point to sites where those materials are utilized throughout the country. Pipelines are most commonly used to transport energy sources such as natural gas and petroleum products, but are also often used in the transportation of other hazardous liquids. Transportation of these products via pipeline is abundant in the United States due to the cost-effectiveness of the process which allows quick movement with relatively minimal cost.

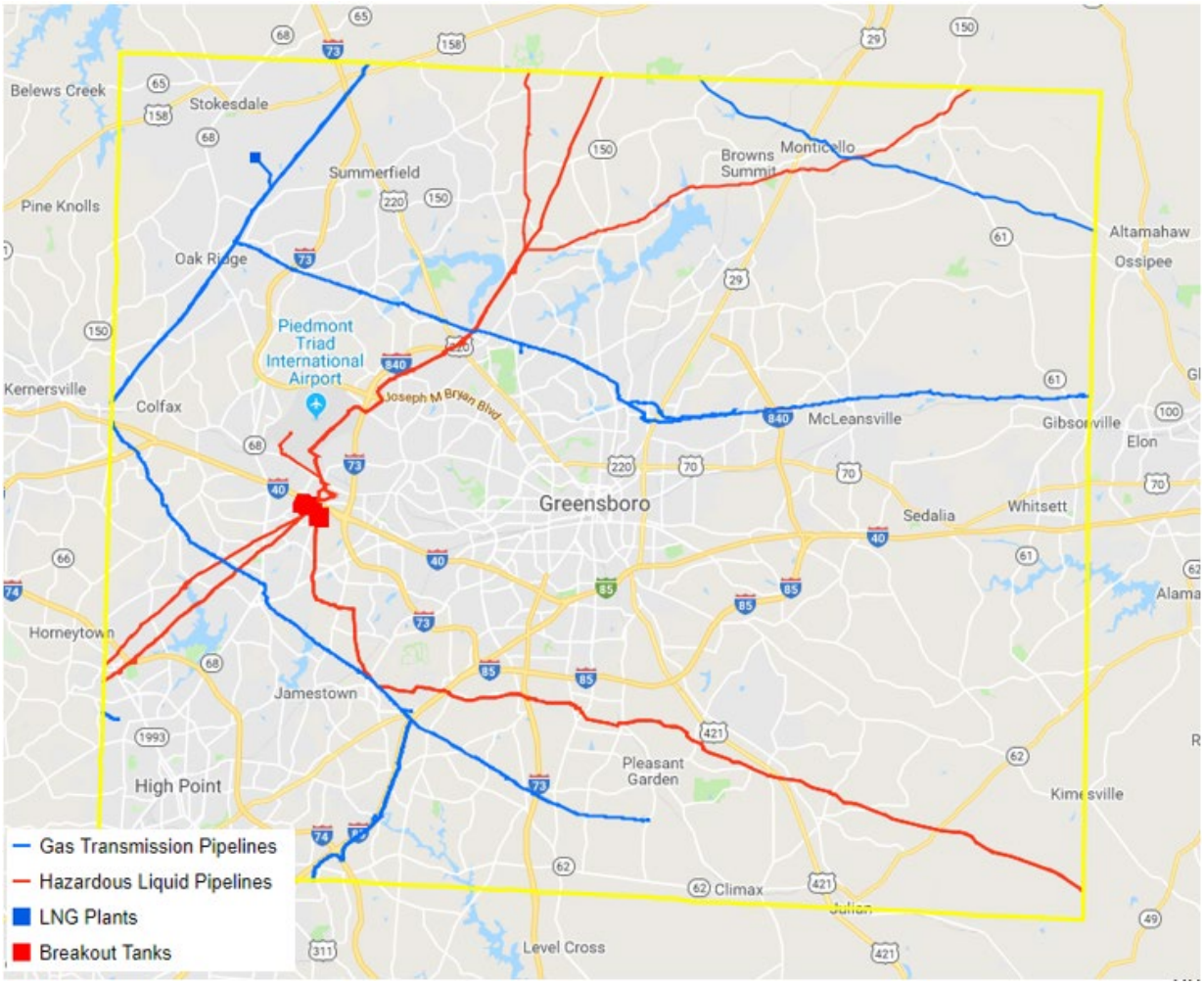
Generally pipelines are safe and effective, transporting materials where they are needed without incident. However, many pipelines in the United States were installed over 60 years ago and were made with materials such as cast and wrought iron or bare steel which degrade over time. This presents a definitive danger to people and property as a leak or spill of hazardous products from a degraded pipeline could prove disastrous, causing costly damage to property and injury or death.

As a result, there has been a recent movement to replace many of these older pipelines with newer materials such as plastics that can reduce the risk of a pipeline failure and a hazard incident. In 2011, the Pipeline Safety, Regulatory Certainty, and Job Creation Act was passed and called for the US Department of Transportation to conduct a state by state survey of pipelines and accelerate repairs of aging infrastructure. The following website provides a state by state update of the progress of this initiative: http://primis.phmsa.dot.gov/comm/states.htm?nocache=4496.

Location and Spatial Extent

Pipelines exist throughout the state of North Carolina and in Guilford County. Across the state, there are over 192,000 miles of hazardous liquid line, 17,591 miles of gas transmission gathering lines, and 1,263,987 miles of gas distribution main lines. In Guilford County, there are 1,248 miles of gas lines and 822 miles of hazardous liquid lines. For more specific description of the location of pipelines in Guilford County, see **Figure 3.30** below.

FIGURE 3.30: PIPELINES IN GUILFORD COUNTY



Source: Pipeline and Hazardous Material Safety Administration

Historical Occurrences

There have been some reported incidents of pipeline disruptions/failures within Guilford County, dating back to the 1970s. In 1978 there were two spills that occurred on a line connected to the Greensboro tank farm. As a result of these spills, 14,700 gallons and 8,400 gallons of gas were spilled, respectively. In 1987, a 17,000 gallon spill occurred near Lake Brandt on the Plantation

Pipeline that was caused by digging in the area. As a result, there was leakage into the nearby neighborhood of Guilford Green, although fortunately the fuel did not reach the lake itself.

Additionally, the events of Hurricane Katrina in September 2005 led to significant disruptions in the distribution networks of both liquid petroleum products and natural gas throughout the Southeast, including Guilford County. The impacts were significant as motorists lined up at gas stations trying to acquire fuel while it was available. Some stations could not keep up with the demand and ran out of fuel.[39] Natural gas customers experienced significant price hikes as a result of the pipeline disruptions and other network damages caused by the hurricane.[40]

Finally, in 2010, a lightning strike near one of the storage tanks along Interstate 40 in Greensboro caused a fire in the early hours of June 13. The fire was brought under control quickly but caused closures of several roads and destroyed the tank that was impacted and which contained over 800,000 gallons of gasoline.

Probability of Future Occurrence

Since there have been some reported incidents of major pipeline disruptions or failures within Guilford County, future occurrences are possible.

Consequence Analysis

People (The Public and Public Confidence)

The main concerns for the public with natural gas/pipeline incidents include fire ignition, explosions, and service loss. Any part of the distribution network that contains product may experience some form of failure as discussed above. The release of natural gas has the potential to spark fires or cause explosions due to the material's characteristics. This is especially hazardous in residential or other populated areas.

Public confidence will be impacted depending on the severity of the incident and location. If the incident occurs in an area where it has major impacts on the population and there are fatalities or injuries, there may be a loss of confidence in the government. Smaller incidents that only impact transmission or storage facilities of the product will likely result in less impact on public confidence.

Responders

First responders would be primarily tasked with evacuating people within potentially hazardous environments, treating and transporting patients, containing any releases, and preventing and/or extinguishing fires or explosions. Responders will likely be the first on the scene to these types of events and so will likely face the most potential impacts as they try to assist in efforts to address the incident.

[39] Jad Mouawad, 2005. "Katrina's Shock to the System," *New York Times*. http://www.nytimes.com/2005/09/04/business/04oil.html?pagewanted=all

[40] Desmond Lachman, 2005. "Katrina Has Had an Impact on Natural Gas and Electricity Production as well as Crude Oil Supplies," *Financial Times*. http://www.aei.org/article/energy-and-the-environment/conventional-energy/katrina-has-had-an-impact-on-natural-gas-and-electricity-production-as-well-as-crude-oil-supplies/

Continuity of Operations

Continuity of operations can typically be maintained during a pipeline event in Guilford County. However, a large-scale pipeline explosion or failure would certainly put a strain on operations, requiring a great deal of attention from responders. This could certainly disrupt continuity of operations to some degree.

Built Environment (Property, Facilities, and Infrastructure)

Building Stock

The primary concerns with residential buildings during a pipeline failure include gas inhalation, fires, explosions, and loss of heating. Natural gas leaks could lead to asphyxia in some cases. The natural gas that is used in home heating has the compound mercaptan, which has a distinctly strong odor that can detect a leak before the environment becomes hazardous to health. The fire and explosion risks are present due to the presence of methane in natural gas, which is highly flammable and can be explosive in certain conditions. Gasoline is also flammable but is not an explosive risk. Lastly, some homes may lose their primary heat source when natural gas service is disrupted.[41]

Some businesses in Guilford County have natural gas heating systems or rely on natural gas for some of their food preparation processes. A pipeline failure would interrupt these processes, thus having a negative impact on business. If a facility or business containing hazardous materials is located near a natural gas release, the potential exists for interactions between the hazardous materials stored on the site and the natural gas. Also, any fires or explosions caused by a release of fuels or natural gas could cause containment failures for the hazardous materials on the site(s). The I-40 Fuel Farm is a key facility in the distribution of these materials and could potentially be the site of an incident in the future as it has experienced incidents in the past.

If there is a pipeline break near an interstate or other component of the transportation infrastructure, responders may have to shut traffic down until the release is contained. Lanes of travel may be blocked by vehicles that run out of fuel during shortages.

Economy

A major concern with the pipelines in Guilford County is the distribution and availability of fuels. A shortage in gasoline and/or diesel could have drastic impacts on the local economy and potentially the national economy depending on the breadth or duration of the shortage. Much of the impact would be from lost commerce, as the travel of cargo, workers, and visitors could be limited or completely stopped depending on the severity of the supply issues. The primary financial effects of a significant natural gas incident in the pipeline system would be on the natural gas industry and businesses that rely on natural gas for heating or other services. The costs of lost service and repairs could be severe in the case of a pipeline failure for the natural gas providers. Business closures could have a significant impact on the local economy. Some restaurants may rely on natural gas for some of their food preparation as well.

[41] National Institute of Health, 2011, *What You Need to Know About Natural Gas Detectors*. http://www.nidcd.nih.gov/health/smelltaste/pages/gasdtctr.aspx

Environment

Impacts would be confined to the immediate area of the pipeline failure, including exposure of vegetation and wildlife. Fires or other contamination on the environment may have similar impacts as those described in the Hazardous Materials Incident section above.

Resource Shortage (Water / Fuel)

Background

Society relies on many resources to conduct routine activities. Without the most critical resources in ample supply, the public's way of life can be severely hampered. Water, electricity, and fuel are among the most critical resources and occasionally may be subject to supply issues. Electrical disruptions and outages were addressed in the Energy/Power/Utility Failure section. This section will address water and fuel shortages.

While most of the Earth's surface is covered by water (70%), a mere 3% of that water is freshwater. More than 68% of this freshwater is found in glaciers and ice caps, while only 1.2% is surface water. Fresh, potable water is in even more limited supply.[42] In the case of a water shortage, rationing or elimination of nonessential activities or events could become viable options to limit unnecessary consumption of water during times of concern.

Fuel, or petroleum, is also a limited resource that is used globally for many different purposes. Petroleum alone makes up about 40% of the total energy consumption in the United States.[43] When there are shortages of this valuable commodity, the activities and commerce of impacted areas could be significantly slowed. Decisions must be made to sustain critical operations, such as first response capabilities. Rationing or the elimination of nonessential activities or events could become viable options to limit unnecessary consumption of fuel during times of concern.

Location and Spatial Extent

Since a water or fuel shortage would impact the entire county when it occurs, the location of this hazard is considered to be countywide.

Historical Occurrences

In July of 2002, there was a major water shortage throughout North Carolina. This shortage was exacerbated by exceptional drought conditions over an extended period of time. The majority of the years between 1998 and 2002 were marked as under some level of drought. The shortage led to a significant water emergency for Guilford County, in particular in the City of Greensboro. At its worst point, the city had only a 67 day water supply and emergency conservation measures were put in place.

[42] United States Geological Survey, *Where Is Earth's Water,* https://www.usgs.gov/special-topic/water-science-school/science/where-earths-water?qt-science_center_objects=0#qt-science_center_objects
[43] The National Academy of Sciences, *What You Need to Know About Energy – Supply and Demand,* http://www.nap.edu/reports/energy/supply.html

In September of 2008, the impacts of Hurricanes Gustav and Ike caused shortages of fuel in Guilford County and many other parts of the Southeast. Oil refineries in the Gulf of Mexico and the pipelines that deliver the product to various distribution points experienced significant disruptions or damages. Three years prior in August of 2005, Hurricane Katrina caused major shortages of fuel after it damaged or shut down many of the refineries and pipelines in the same region. In both shortages, there were long lines of vehicles at gas stations as the public attempted to fill up gas tanks before the supply ran out. Some stations were completely out of diesel and regular unleaded gasoline.

The fuel situation in the area was also critical during the OPEC fuel crisis in 1973 and 1974. Some gas stations in Greensboro implemented limits on refueling, including one station recorded as asking customers to purchase a maximum of 10 gallons. This illustrates how the geopolitical climate with respect to oil in the Middle East and other major oil reserves can have a significant impact on the price and supply of fuel.

Probability of Future Occurrence

Fuel and water shortages have occurred a number of times in Guilford County over the past several decades. Water shortages were more common in recent years but fuel shortages have certain impacted the county as well. As a result, the probability of future occurrences is likely.

Consequence Analysis

People (The Public and Public Confidence)

During events such as drought that cause water shortages or emergencies, the public is given limitations on using water for non-essential purposes such as watering lawns or washing vehicles. Water shortages beyond this are possible but unlikely. Greater restrictions could be implemented and enforced in extreme water emergencies. Due to these impacts to the public, first response agencies may require additional resources to deal with heightened public safety or medical emergency concerns.

Fuel shortages are not as critical to life safety but could impact decisions made about travel and routine life activities. When concerns about fuel supply are voiced, the public often resorts to panic buying, and lines become long at gas stations. Before the shortage even takes place, gas stations may be overtaxed, as fuel is dispensed faster than it can be replenished. In extreme shortages, limitations could be placed on consumers and in some cases businesses, jurisdictions, and other groups. Rationing at gas stations may be implemented and non-essential business or governmental activities may be put on hold or eliminated completely.

Water and other resource shortages can influence the public and the outlook on how the government and any related nongovernmental organizations respond to the shortage. If rationing and restrictions are put in place, it will impact the public and its confidence in the entities responsible for dealing with these occurrences. Collaboration with the media could have some influence on what is reported and could lessen or prevent any negative perception.

Responders

Water shortages are more likely to present life safety issues than fuel shortages. In the event of a water shortage, more health-related emergencies such as dehydration can be expected, particularly if mechanisms are not in place to effectively obtain water from other areas. The concern is heightened during warm weather conditions, especially with extreme temperatures. Water shortages may also hamper firefighting.

Continuity of Operations

The nature of a resource shortage generally means that there is some recognition that the shortage will occur in advance of major issues. The county generally has plans in place to ensure that continuity of operations can be maintained during a resource shortage. Still, a long-term resource shortage could have an impact on operations as it begins to affect staff in the same ways as the general public is affected.

Built Environment (Property, Facilities, and Infrastructure)

Building Stock

In the midst of a water shortage, the prime concerns for a residence would deal with hydration, preparation of food, and personal hygiene. In a fuel shortage, generators that run on fuel may not be operational. In both water and fuel shortage scenarios, there may be limitations put on property maintenance. Water intensive processes may be disrupted during water shortages for commercial and industrial operations. Accommodations such as restrooms for employees may not be operational. During fuel supply shortages, generators may not be able to be used, and property maintenance may be limited. Also, business operations that require transportation could be impacted significantly.

Critical Facilities

During water or fuel shortages, there could be significant impacts on medical facilities and operations. Water intensive processes within the facility may be disrupted. Some medical procedures may need to be postponed or altered. In the event of a fuel shortage, interfacility transportation of patients may be impacted and backup generators may not be operational if needed. The major concern for emergency services during water shortages deals with firefighting. At the emergency services facilities, accommodations such as restrooms or showers and gear washing machines may not have the water needed for use. Fuel shortage events would spur concerns about emergency vehicles' consumption of fuel, as well as equipment and generators that run off of fuel.

The primary concern at the I-40 Fuel Farm during water supply emergencies is fire protection on site. Some water-intensive processes or basic accommodations for employees may be affected as well. The Fuel Farm's operations could be significantly impacted by the shortage of fuel. Productivity and profit would be of concern, but security issues may be an additional concern. There may be attempts of theft at the site when the fuel supply becomes critically low.

Transportation Systems

There would be few expected impacts on the transportation system during a water shortage. However, these systems could see significant impacts during a fuel shortage. Many travelers' vehicles may breakdown due to running out of fuel, which could block roadways for others. Maintenance and response mechanisms could be limited or unavailable depending on whether fuel is available as well. There could also be significant impacts on airport operations. Maintenance measures or accommodations on the airplanes that require water may not be able to be carried out. Accommodations such as restrooms for patrons and employees at the airport may not be operational, which could force the facility to shut down operations until the crisis is resolved. A fuel crisis can be equally as problematic as, without fuel, the airplanes cannot fly and again operations could be shut down.

Economy

Shortages dealing with critical resources such as water and fuel can have detrimental impacts on the economy. Governmental entities, businesses and the public may be forced to make significant and drastic decisions in order to deal with the complexities of shortages. Water supply disruptions could impact tourism and commerce if water is needed in key processes. Businesses such as hotels and restaurants may have to consider having water hauled in or closing. The transport and delivery of goods and supplies can be severely impacted by fuel shortages, causing significant disruptions in economic activity. The overall impact is dependent on the severity and the duration of the shortage. It is also dependent on the availability of the resource from other sources and the ability to effectively get these resources to the intended end user. Workers may not be able to commute to work, bringing about productivity concerns and significant costs.

Environment

In the case of a severe water shortage, vegetation and crops, livestock, and aquatic wildlife may experience some impact. Livestock may not be given adequate water and could experience illness or death. Typical or alternative sources of water may be tapped for more water, affecting ecosystems as water levels drop. There are no expected impacts to the environment during a fuel shortage.

Transportation Incident

Background

While transportation accidents occur on a daily basis, large-scale incidents involving commerce or mass transit are uncommon. This section will focus on these large-scale incidents, which will include incidents involving airplanes on and off airport properties in Guilford County and incidents involving trains or major highways as when these do occur, they can have significant impacts on the community. The area has experienced several incidents in the past, but occurrence is relatively infrequent and significant impacts are rare. The most common impacts involve how the incident will impact daily life, such as travel and commerce.

In Guilford County, the most prominent site for air travel is Piedmont Triad International Airport (PTIA) located in Greensboro. There are smaller airports within the county such as Southeast Greensboro Airport which have much smaller operations that are of very low significance to national air travel. Incidents have and will occur both on and off of airport properties, as will be discussed in the "Historical Data" section.

Guilford County is also a major thoroughfare for rail commerce and travel. A major rail line passes through the downtown areas of both Greensboro and High Point. Norfolk Southern and Amtrak are the two major carriers of cargo and passengers.

There are also several major highways and interstate highways that run through Guilford County including Interstate-40, Interstate-73, Interstate-74, Interstate-85, and Interstate-840.

Location and Spatial Extent

Transportation incidents are most likely to occur along major transportation corridors such as highways, interstates, or railways. However, transportation incidents can occur throughout the county, especially given the number of planes that take flight in and out of regional and local airports and the many roads that are found throughout the county.

Historical Occurrences

There have been numerous incidents in Guilford County involving airplanes. Some of these incidents have occurred at PTIA while others were outside of any airport's boundaries. The following incidents are just a sample of some of the incidents that have occurred within the county. Much of this information is from response records in the Guilford Metro 9-1-1 system archive.

- In 1989, the left main gear in the landing gear system of a 737 airplane was not functioning correctly. The plane made an emergency landing at PTIA with 107 occupants. There were no injuries or deaths.
- In August of 2000, a DC-9 airplane made an emergency landing at PTIA due to smoke in the cockpit. Of the 63 crew and passengers, no one was injured during the landing or the fire that resulted, which damaged the plane substantially.[44]
- In November of 2002, a small plane struck trees while in flight and crashed near Route 421 near Southeast Greensboro Airport. The pilot was the only occupant and the only injury/fatality in the incident.
- In January of 2004, a plane went off of the runway during its takeoff attempt. There were no significant injuries or deaths.
- In October of 2011, a small private plane crashed into a home in a subdivision in Colfax. There was no one inside the home at the time, but the occupants of the airplane did not survive.

[44] Aviation Safety Network, 2000, ASN Aircraft accident McDonnell Douglas DC-9-32 N838AT Greensboro, NC. http://aviation-safety.net/database/record.php?id=20000808-0

- On February 11, 2015, there was a plane crash at 150 Air Harbor Road. This was a single engine aircraft and there was one fatality.
- In December 2018, a fuel tanker crashed resulting in a fire that damaged the Interstate 73 Overpass and requiring the highway to be closed for repairs.

There have also been several incidents within Guilford County that involved trains.

- In December of 2005, 11 cars derailed in Greensboro. No one was injured.[45]
- In May of 2010, a derailment occurred in downtown Greensboro. No one was injured in the incident, where six of the train's cars derailed.[46]

Trains also have collided with other travelers.

- In 1979, another train struck a gasoline tanker in Greensboro.
- In October of 1987, a 57-car train struck a gasoline tanker in Greensboro.

Both of these incidents occurred near the Interstate 40 Fuel Farm, where fuel is continuously being distributed to and from the facility.

Probability of Future Occurrence

Transportation incidents are a highly likely event given that automobile accidents occur nearly every single day to some degree. However, these smaller-scale transportation incidents would have a relatively low impact overall on the community. That said, transportation incidents are fairly common and the probability of a major future occurrence is likely.

Consequence Analysis

People (The Public and Public Confidence)

In the event of a transportation incident such as a car accident, plane crash or train derailment, there is a possibility of injury or death. The first concern in any incident is toward life safety, and emergency services will respond to not only assist those directly involved, but to monitor for fire or hazardous materials that could impact others. A car accident or train derailment could impact the normal operations of the transportation system, as other cars or trains attempting to pass through the area of the incident may be stopped or redirected. A plane crash on the site of an airport could drastically alter operations, also causing stoppages or redirection. An offsite plane crash may not impact other flights, but could impact businesses, homes, and other parts of everyday life depending on where the incident takes place.

Public confidence in the response to a transportation incident is dependent on the expectations of the public and past experience with such incidents. . If the incident is major and there are many casualties, public confidence could be reduced, but in most smaller scale cases, there will be little impact to public confidence.

[45] WXII 12 News, 2005, *Officials Investigate Train Derailment*.
[46] News and Record, May 25, 2010. *Roads Reopen in Greensboro Following Train Derailment.*

Responders

During any transportation-related incident, first responders will be responsible for public safety and returning the area of the scene back to normal as best as possible. Some of the concerns that may be present during and after an incident include the injured, fatalities, and the protection of others from hazards that result from the incident. Hazardous materials (fuel or cargo), entrapped passengers, fires, and explosions are some examples of these hazards, both for airplanes and trains. Response agencies are trained to identify, monitor, and react to any of these possibilities to provide an effective public safety response.

Continuity of Operations

Since these types of events occur on a relatively regular basis and their impact is generally fairly localized, there would probably be little disruption to continuity of operations from a transportation incident. However, if it is a major incident, staff resources may be strained and there could be some effect on continuing normal operations.

Built Environment (Property, Facilities, and Infrastructure)

Building Stock

A transportation incident having an impact on any given residence is highly unlikely. If it were to occur, there could be structural damage to the residence and the potential for fire and severe localized damage to the particular structure impacted. If the incident involves hazardous materials release the impact on homes could be more widespread.

Critical Facilities and Personnel

Similarly, impacts to any given critical facility are unlikely. However, a transportation incident could increase the volume of patients at a hospital and strain the ability of responders. Facilities may be located in close proximity to rail lines or roadways, and a major incident near one of those facilities could have an impact on the community overall.

Transportation Systems

Transportation infrastructure will be directly affected by incidents. Short term or potentially long-term closures are possible depending on the magnitude of the incident. For example, while Piedmont Triad International Airport is not one of the major national travel hubs, any disruptions to its operations will have some impact on air travel and commerce.

Economy

The economic impact of a transportation incident would be relatively minor. Plane crashes may discourage some from traveling while a train derailment may have a temporary impact on commerce. However, operations are expected to return to normal in a short period of time following the incident.

There are some rail lines that pass through the downtown Greensboro area, which makes it possible for impacts from a derailment incident to a more widespread economy, but these would

likely remain fairly localized. For example, a rail line runs very close by the Greensboro Coliseum and impacts are possible. These impacts could vary from access issues to the arena to a complete closure due to hazardous materials or other significant safety concerns.

Environment

The impacts of a transportation incident vary on the types of materials contained. Most transportation vehicles use some type of fuel that may be spilled during an incident and these fuels are hazardous to plant and wildlife populations and may also be harmful if spilled into a water source. Other contained chemicals and materials that are being transported by freight vehicles can be hazardous to these populations as well, depending on the characteristics of the substance(s). These are described above in the Hazardous Materials Incident section.

Man-Made / Intentional Hazards

Civil Disturbance

Background

Public unrest has been evident in society from the earliest recordings of civilization. Most of these disturbances have been related to political or social issues. Insurrection has framed much of history, dictating the governance and progression of society. In recent years, most of the publicized disturbances have been protests and riots. Rioting does not occur very often in the United States; however, marches and protests are common and could subsequently lead to riots.

Location and Spatial Extent

Civil disturbance or unrest can occur in any location in the county but is more likely to take place in or near prominent locations such as government buildings or significant landmarks.

Historical Occurrences

In Guilford County, there have not been any major civil disturbances in recent years. While there are occasional marches and protests that take place in its bounds, they have not had significant threat of violence associated with them.

On November 3, 1979, an event since named the Greensboro Massacre saw members of the Ku Klux Klan and American Nazis clash with members of the Communist Party marching for African-American industrial workers. The event climaxed with Klansmen opening gunfire on marchers, five of whom died.[47]

A disturbance near North Carolina Agricultural and Technical State University in Greensboro led to the shooting death of a college student on May 22, 1969. African American student protestors clashed with city police and members of the National Guard for three days (May 21-23), leading

[47] University of North Carolina at Greensboro Libraries: Civil Rights Greensboro, *The Greensboro Massacre,* http://library.uncg.edu/dp/crg/topicalessays/greensmassacre.aspx

to several civilian and nine officer injuries in addition to the fatality. Dozens of students were arrested for disturbing the peace on public school property.[48]

Downtown Greensboro is well-publicized for its part in the non-violent, sit-in protests during the civil rights movement. In 1960, a group of four freshmen from North Carolina Agricultural and Technical College were denied service for being African Americans at a lunch counter in the business F.W. Woolworth. In response, they sat at the counter for several days, with others later joining in on the protest. A large boycott of the business followed, resulting in substantial losses for the company before it relented and enacted changes in policy chain-wide.[49]

Probability of Future Occurrence

Despite some history of civil disturbance in Guilford County historically, there have been few recent events, so the probability of future occurrences is possible.

Consequence Analysis

People (The Public and Public Confidence)

The United States and Guilford County are relatively stable politically and socially. However, there are United States citizens who hold extremist opinions and ideals. There is always the likelihood of some incident sparking some form of violence or disobedience. Most incidences of civil disturbance or insurrection have specific targets, unlike terrorism where maximum effect (including casualties) is desired. Therefore, collateral damage is not as likely but still possible.

The public confidence in government and nongovernmental organizations response is paramount during these incidents. There will be high emotions already present within the community; an effective, organized, and professional response is crucial to instill confidence in community members. Working with the media is also an important component, as the messages disseminated can influence public perception. The incident response, the media, and also societal expectations will all factor into the positive or negative outcome in the minds of the public.

Responders

During riots and events that become violent, first responders are put into a situation of extreme danger. This is especially true of those employed by local, state, or federal governments as they may actually be targeted in such events. Law enforcement personnel are trained and equipped to deal with such situations and would be utilized to provide for public safety during these events. Other operations may be put on hold in areas of unrest until the situation improves.

Continuity of Operations

[48] University of North Carolina at Greensboro Libraries: Civil Rights Greensboro, *Dudley High School/NC A&T University Disturbances, May 1969,* http://library.uncg.edu/dp/crg/topicalessays/dudleyatprotest.aspx
[49] Library of Congress, *Greensboro Lunch Counter Sit-In,* http://www.loc.gov/exhibits/odyssey/educate/lunch.html

Continuity of operations could be disrupted by a civil disturbance, especially if the aim of the unrest is aimed at government buildings or officials. Plans to maintain continuity of operations are in place, but operations would likely be disrupted to some degree civil disturbance.

Built Environment (Property, Facilities, and Infrastructure)

Building Stock

If disturbances occur in residential areas, residents may be unable to access their homes and neighborhoods without putting their safety in jeopardy. Destruction of property is also possible in such a scenario. In commercial areas, civil unrest can lead to the destruction of property or theft of goods and equipment. Workers may not be able to access the workplace or may not be able to work at all if the business is shut down during the disturbance. Industrial facilities are similarly vulnerable to the destruction of property, theft of goods or equipment, or sabotage of the equipment and systems housed in the facility(ies).

Critical Facilities and Personnel

During incidences of civil disturbance, the hospitals may expect higher volume of patients. While hospitals are unlikely to be targeted during civil unrest, there could be some impacts if the violence is nearby. These impacts include the possibility of limited access to the hospital for workers, patients, and emergency/patient transportation crews. Incidents of violence in emergency departments and other sections of hospital are also more likely to occur. A civil disturbance event will likely increase call volume for emergency services, and increase the potential for the targeting of responders, or cause access issues relating to emergency scenes and the transportation of patients to hospitals.

Transportation Systems

Transportation systems may be blocked or otherwise damaged during a civil disturbance event, including damage to traffic lights, signs, etc. However, generally there would not be major impacts to the infrastructure itself.

Economy

The economic impact of civil disturbances is dependent on the extent of media coverage of the event and people's feelings of safety in the area(s) affected. Tourism can be negatively affected, causing potential visitors to go somewhere else or not travel at all. . Businesses or homeowners may choose to shut down and real estate values could potentially fall as well if there are frequent incidents. These effects are dependent on the severity, the scope, and the nature of the disturbance(s). Civil disturbances can lead to work stoppages, which results in loss of productivity. Targeting of financial institutions could lead to significant economic hardship through the impairment of financial transactions. City centers could be the nexus of civil disturbance activity. This activity could limit access to businesses or services in the area, impairing commerce.

Environment

Impacts are unlikely as natural resources and the environment are not generally targeted and collateral impacts are not typical, unless other hazards are caused by violent acts .

Cyber-Security Threat

Background

Cyber-security threats are deliberate attacks on an individual or group using the internet. In the past few decades, society has become dependent on computers and internet connections for much of daily life. This dependence has opened up the avenue for crime to be committed from afar, often from a different country or outside group. Some common examples of cyber threats include a hacker accessing bank accounts by hacking into a bank's website, infecting a computer system with a virus, Trojan horse, or worm to inflict damage to the information in the system, or disseminating incorrect or otherwise flawed information, also called "misinformation." Also, denial-of-service attacks could occur against prominent websites, which prevent legitimate users from accessing information or services.

Location and Spatial Extent

Cyber-security threats could occur anywhere within the county and because of the pervasiveness of information technology systems, the impacts could be widespread throughout the community and difficult to predict.

Historical Occurrences

In Guilford County, large-scale cyber threats or attacks have not been reported, though there have been several breaches of other nearby, similar communities in North Carolina in recent years. These ransomware attacks impacted Charlotte-Mecklenburg County in 2017 and Davidson County in 2018.

In addition, the recently published 2016 Data Breach Investigation Report[50] shows that most of the major breaches that take place across the country are in the Finance sector and the Accommodation sector. A full breakdown of the number of breach incidents by industry sector can be found in **Figure 3.13**.

[50] Data Breach Investigations Report. Verizon. 2016. Retrieved on January 3, 2017 from http://www.verizonenterprise.com/verizon-insights-lab/dbir/2016/

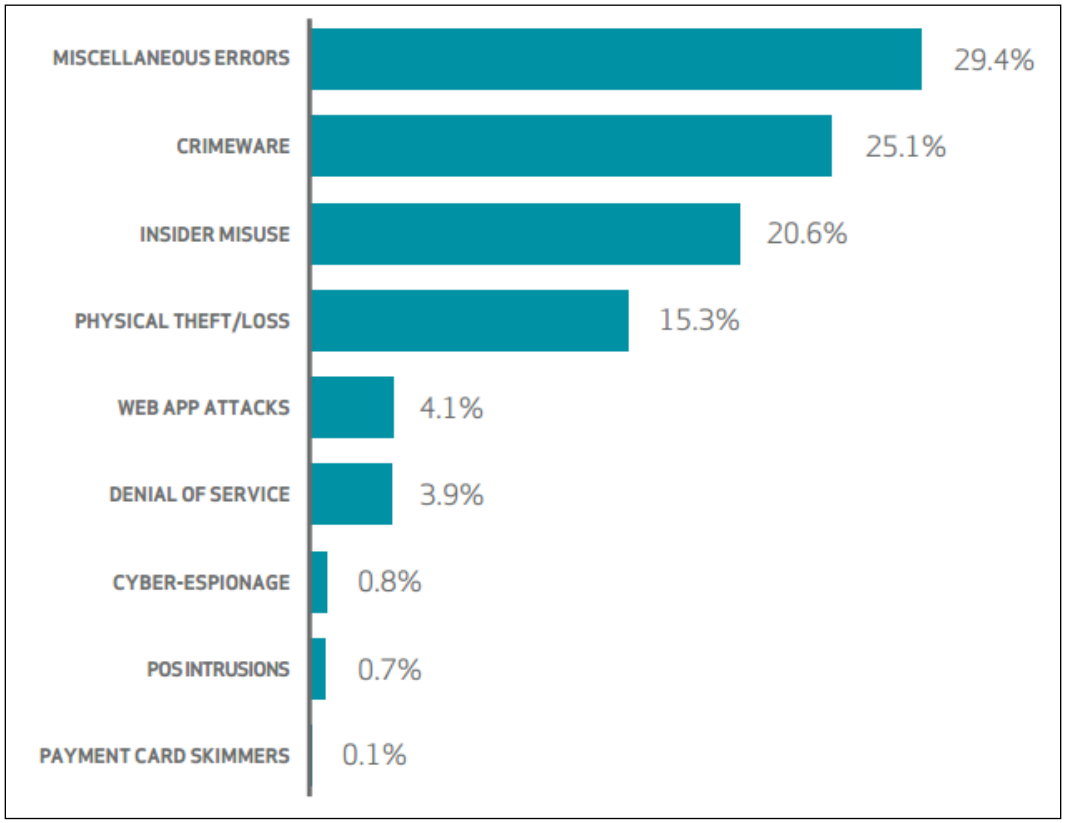
FIGURE 3.31: NATIONWIDE CYBER-BREACHES BY INDUSTRY SECTOR

Industry	Total	Small	Large	Unknown
Accommodation (72)	282	136	10	136
Administrative (56)	18	6	2	10
Agriculture (11)	1	0	0	1
Construction (23)	4	0	1	3
Educational (61)	29	3	8	18
Entertainment (71)	38	18	1	19
Finance (52)	795	14	94	687
Healthcare (62)	115	18	20	77
Information (51)	194	12	12	170
Management (55)	0	0	0	0
Manufacturing (31-33)	37	5	11	21
Mining (21)	7	0	6	1
Other Services (81)	11	5	2	4
Professional (54)	53	10	4	39
Public (92)	193	4	122	67
Real Estate (53)	5	3	0	2
Retail (44-45)	182	101	14	67
Trade (42)	4	2	2	0
Transportation (48-49)	15	1	3	11
Utilities (22)	7	0	0	7
Unknown	270	109	0	161
Total	2,260	447	312	1501

Source: Data Breach Investigations Report, 2016

As can be seen in **Figure 3.14**, Crimeware and Miscellaneous Errors together account for more than 50 percent of the data breaches. According to the Verizon report, crimeware represents malware infections that defy exact classification and are less likely to receive an intense investigation or involve law enforcement. These attacks tend to be motivated by financial gain and are opportunistic in nature. Miscellaneous Errors are basically an error on the part of a user that results in a breach of data. Examples of this include sensitive information reaching the wrong recipient, publishing nonpublic data to public servers, and insecure disposal of personal data (such as medical records).

FIGURE 5.8: BREAKDOWN OF BREACHES BY TYPE



Source: Data Breach Investigations Report, 2016

Probability of Future Occurrence

Although there have been no previous cyber threats in the county of significant impact, it is possible that the county could be impacted in the future.

Consequence Analysis

People (The Public and Public Confidence)

The aim of a cyber-security threat is typically to corrupt or exploit protected information. Depending on the target of the ploy, a significant number of people can be victims of identity theft, fraud, or other forms of technology-based crime. Anyone with an account, membership, or other relationship with an entity that requires the storage of information is vulnerable. An individual/user must rely on the entity of affiliation to create and maintain safeguards against the intrusion of computerized systems. However, even the strongest of safeguards can be corrupted or evaded. Continual monitoring of attempted or successful attempts at cyberterrorism is warranted to lessen the potential impacts.

Public confidence in government and nongovernmental organizations may be impacted by an event based upon societal expectations and media influence with respect to cyber threats. There may be an expectation that government entities should do a better job of patrolling cyber crime

and hold those responsible accountable. Public confidence may be impacted by media interpretation and reporting of the event, positive or negative.

Responders

Cyber threats may be used to try to intrude into electronic safety equipment or systems. This may increase call volume, block systems, or otherwise hinder emergency operations. Although responders are not likely to be at risk to a cyber attack in a physical sense, they may be impacted financially or through identity theft, much like members of the public.

Continuity of Operations

In the event of a cyber threat, continuity of operations could be impacted if many of the services (such as internet or other IT programs) that are required to maintain daily operations are shut down by the attack. This could cause considerable disruption to normal operations in the state and could make the state potentially vulnerable to other events that may be occurring simultaneously. In some past cases, entire IT operating systems have been held for ransom and carrying out normal operations is not possible. In these cases, continuity planning is critical to ensure basic functions can still be carried out.

Built Environment (Property, Facilities, and Infrastructure)

Cyber threats may have the effect of disrupting life sustaining equipment or systems in hospitals or medical facilities by causing technological disruptions. These attacks may also sabotage information networks and communications equipment that could disrupt services within medical facilities. Normal operations in communications equipment such as telephones, cell phones, and internet could all be severely impacted by a cyber threat which would impact large numbers of people including critical facilities operators.

Economy

Freezing, redirecting, or stealing financial assets can have drastic impacts on a business. Banking and credit institutions are commonly affected or targeted by fraudulent activities and often store a great deal of information on businesses, so large-scale intrusions can have significant impacts on the local economy. Large employers are more likely to be targeted by cyber attacks than individuals or small businesses. Larger businesses generally have greater assets to exploit and store more personal information on private individuals or employees.

Environment

Because cyber attacks occur in cyberspace and would not truly have any impacts outside of the physical sphere, there are no expected environmental impacts from this type of event .

Terrorism

Background

Terrorism is defined in the United States by the Code of Federal Regulations as: “the unlawful use of force and violence against persons or property to intimidate or coerce a government, the

civilian population, or any segment thereof, in furtherance of political or social objectives."[51] Academic literature identifies some overarching political goals that terrorism seeks to achieve, including spreading anxiety and alarm among immediate victims, families, and the general public; eliminating opponents and destroying symbolic targets; and generating direct damage on society, such as affecting business confidence. In the following sections, some general background information about terrorism is presented prior to the county's hazard identification and risk assessment findings.

There are two general types of terrorist groups: network and hierarchical. The type of organization a group adopts largely depends on how long the group has existed. More recently developed groups tend to organize or adapt to the possibilities of the network model. Older, more established groups lean toward the hierarchical structure and are often more associated with violence of a political nature.[52] Terrorist acts can be committed by large, formally organized groups with terrorist cells in different parts of the world, or they can originate from smaller groups or individuals from a small city or domestic "homegrown" location. In the United States, terrorists that are "homegrown" do not belong to a defined group, may operate very effectively "under the radar," and may pose the biggest threat initially at the local level.[53]

Location and Spatial Extent

A terror threat could potentially occur at any location in the county. However, the very definition of a terrorist event indicates that it is most likely to be targeted at a critical or symbolic resource/location/event. Ensuring and protecting the continuity of critical infrastructure and key resources (CIKR) of the United States is essential to the Nation's security, public health and safety, economic vitality, and way of life. CIKR includes physical and/or virtual systems or assets that, if damaged, would have a detrimental impact on national security, including large-scale human casualties, property destruction, economic disruption, and significant damage to morale and public confidence. **Table 3.43** lists the U.S. Department of Homeland Security's (DHS) identified main critical infrastructure sectors.

[51] U.S. Code of Federal Regulations. 23 C.F.R. Section 0.85
[52] Terrorism Research. *Terrorist groups*. Retrieved December 27, 2011, from http://www.terrorism-research.com/groups/
[53] *Ibid*.

TABLE 3.43: U.S. DEPARTMENT OF HOMELAND SECURITY CRITICAL INFRASTRUCTURE SECTORS

- Agriculture and Food
- Banking and Finance
- Chemical
- Commercial Facilities
- Communications
- Critical Manufacturing
- Dams
- Defense Industrial Base
- Emergency Services
- Energy
- Government Facilities
- Healthcare and Public Health
- Information Technology
- National Monuments and Icons
- Nuclear Reactors, Materials, and Waste
- Postal and Shipping
- Transportation Systems
- Water

Although all critical facilities are at a heightened level of risk in Guilford County, there are several facilities and events in the county that have been identified as the likely primary targets. Guilford County Emergency Management maintains a list of facilities and events at elevated risk of terror threat.

Historical Occurrences

Although there have been no major terror events in Guilford County, there is some possibility that one could occur in the future as there have been incidents in the United States in the past and there are several facilities/events that could be potential targets.

Probability of Future Occurrences

Guilford County has had no recorded terrorist events. Due to no recorded incidents against the county, the probability of future occurrences of a terrorist attack is unlikely (less than 1 percent annual probability).

Consequence Analysis

People (The Public and Public Confidence)

In addition to the clear impacts that terrorism can have on human life and safety, there are a number impacts on the public that will be more widespread if major events take place. As seen after the attacks on September 11, 2001 in New York City and Washington, D.C., there can be significant impacts far away from the site of the incident. Fear and worry about additional attacks or for loved ones in areas affected are just a couple examples of impacts that could occur. Other impacts include discrimination or changed interactions between people of differing nationalities depending on the nature and intent of the attack(s) and who perpetrated the attack(s).

During and after a terrorism event, the public will be expecting services to be provided despite the uncertainty of any existing hazards or further impacts. The partnership and involvement of the media is crucial not just for public guidance information, but also for keeping the public informed of the efforts underway or of any obstacles or concerns hindering response efforts.

Effective planning and partnerships developed prior to the incident will provide for smoother operations, even during times of chaos like a major terrorism incident. Agencies and organizations working together in an efficient and effective way will provide for the best chance of positive public perception in these government and nongovernmental organizations. Although public confidence will almost certainly be shaken, agencies and organizations in the government working together in an efficient and effective way will provide for the best chance of positive public perception of the government.

Responders

The danger to human life in a terrorist event is dependent on the form of attack utilized, as well as its location, severity, and scope. In any terror incident, responders must conduct a scene size up to determine hazards to themselves and then others. Decisions must be made about how to handle victims and those in close proximity that may have been victimized or exposed. If hazardous materials are present, it could change the strategy completely. Fear and panic will be significant in the case of a terrorist act, whether it occurs in Guilford County or elsewhere in the state or nation. As front-line government officials, responders will be at a significant risk during an attack and may even be the object of the attack in some cases.

Depending on the location, the scope, and the nature of the event(s), response efforts could last hours, days, or potentially longer. Collaboration at all levels can provide for the most stable, effective, and efficient effort in returning to normal activities and operations. Identification of further threats and open communication lines can prevent further harm or detriment to response and recovery operations.

Continuity of Operations

A terrorist event would likely have a high impact on continuity of operations, especially due to the disorder that would result and the unpredictability of this kind of event. Emergency personnel may be directly affected or targeted, which would cause definitive harm to maintaining continuity of operations.

Built Environment (Property, Facilities, and Infrastructure)

Major Events/Centers

Often terrorist events are targeted at major events or at large event centers in an attempt to create widespread loss on a large number of people. Therefore, large arenas, convention centers, and event spaces may be at higher risk of a terrorist attack than most other buildings. Similarly, prominent or symbolic structures may also be at an elevated risk for targeting..

Critical Facilities

At hospitals, the primary concern with a terrorism event is the influx of patients requiring care. Terrorism may pose a specific hazard to a hospital structure itself, but it is more likely to be impacted when in close proximity to a target. Many patients could be injured or their medical condition worsened by the impacts of a terrorism event. In general, emergency

services buildings are not considered high probability targets for terrorists to strike. In other countries, ambulance services and 9-1-1 centers have been targets; however, that pattern has not been seen here in the United States. Alternate locations should be set up so that emergency operations can continue if an emergency services facility was affected or targeted by a terrorism event. Shelters may need to be activated in a terrorism event to house and care for displaced individuals.

Transportation Systems

Bridges found throughout the interstate system may be targeted by terrorism. Not only would the actual structural failure affect those on, under, or near the bridge, but the loss of its functionality would also significantly hinder travel and commerce. Past experiences with using airplanes for terrorist activity suggest a need for planning and collaboration with all parties of interest at airports including local, state, and federal agencies. In terms of railway transportation, the most likely means of disrupting these lines would be the derailing of a train, primarily by sabotage of the rail or the switching control system. Using explosives would be more likely because hacking into systems to cause collisions and other undesired actions to moving rail cars would be more complex operations. In addition to disrupting rail traffic, a derailing can impact other means of travel such as a nearby road or airport. The rail cars involved in an incident could contain hazardous materials, which would add an element of complexity to the situation.

Utilities

Damage to high voltage lines or power plant structures could disrupt power distribution for a large area, affecting emergency response and other facets of government and business. The economic impacts may also be significant as extended outages can be costly. Natural gas lines are also a concern as a target for terrorists. Major pipelines run through the county, but natural gas itself must be exposed to oxygen before it could cause an explosion. Most natural gas explosions are small and rarely deadly. The real concern is in shutting off natural gas to end consumers. Sabotage of a pipeline could disconnect a significant number of homes and businesses for considerable periods of time.

Other Structures

Single-family dwellings and small businesses or industries are not likely to be targets for terrorism. However, areas that have high concentrations of certain targeted populations could be vulnerable to an attack. These populations may relate to a person or group's ethnicity, religion, and socioeconomic status. Dwellings in close proximity to a targeted event center may also be more likely to experience indirect impacts. Depending on the method of attack, impacts could include stray bullets or debris from explosions. These could affect people, electrical systems, water systems, cause structural collapse, or fires. Also, the presence of chemical agents can create health hazards through dangerous reactions with water sources or building materials.

Economy

The economic impact of a terrorist attack can vary from minimal to severe. If the incident occurs in Guilford County, it could hinder the county's economy, but may not have an impact at the national level. Tourism and some commerce could decline significantly if people, events, or businesses are hesitant to come to the area following an incident. An incident in a major city or a financial hub could affect the entire country. For example, the events of September 11, 2001 had an immediate impact on local, state, and national economies. This event and other large-scale attacks like it can drastically alter the economy in both the short- and long-term.

Major Events/Centers

Terrorism would mostly likely occur in city centers during large public gatherings or during business hours to cause the most harm and promote the most fear. Political gatherings would be high priority targets as well. Arenas can be targeted by terrorism, particularly during events that may have some form of political, cultural, or historical value, or simply any event with a large number of people in attendance. These could all have a negative impact economically on the county.

Environment

Impacts on the environment depend on the type of attack utilized by terrorists. A biological, chemical, or other hazardous material can have impacts on human, animal, and plant populations alike. The impacts can vary depending on the particular hazard(s) at play, but there will certainly be at least some negative impacts from a terrorist attack including potentially the release of smoke, chemicals, or debris into the environment.

Hazard Extent

Table 3.44 describes the extent of each hazard identified for Guilford County. The extent of a hazard is defined as its severity or magnitude, as it relates to the planning area.

TABLE 3.44:EXTENT OF GUILFORD COUNTY HAZARDS

Natural Hazards	
Drought	Drought extent is defined by US Drought Monitor classifications which include None, Abnormal, Moderate, Severe, Extreme, Exceptional classifications. According to these classifications, the most severe drought condition is Exceptional. Guilford County has experienced at least Severe ranking 8 times over the 20-year reporting period.
Earthquake	Earthquake extent can be measured by the Richter Scale and the Modified Mercalli Intensity (MMI) scale and the distance of the epicenter from Guilford County. According to data provided by the National Geophysical Data Center, the greatest MMI to impact the county was IV (moderate) with a correlating Richter Scale measurement of approximately 4.3 (last reported on November 20, 1969). The epicenter of this earthquake was located 183.0 km away.

Extreme Cold	The extent of extreme cold can be defined by the minimum temperature reached. The lowest temperature recorded in Guilford County is -8 degrees Fahrenheit (reported on January 21, 1985).
Extreme Heat	The extent of extreme heat can be defined by the maximum temperature reached. The highest temperature recorded in Guilford County is 106 degrees Fahrenheit (reported on July 29, 1952).
Fire	Wildfire data was provided by the North Carolina Division of Forest Resources and is reported annually by county from 2010-2019. Analyzing the data indicates the following wildfire hazard extent for the county. • The greatest number of fires to occur in any year was 139 in 2014. • The greatest number of acres to burn in a single year occurred in 2015 when 58.4 acres were burned. Although this data lists the extent that has occurred, larger and more frequent wildfires are possible throughout the county.

Flooding

Flood extent can be measured by flood height and velocity. Flood depth and velocity are recorded via United States Geological Survey stream gages throughout the county. While a gage does not exist for each participating jurisdiction, there is one at or near many areas. The greatest peak discharge recorded for the county was reported on September 25, 1947. Water reached a discharge of 11,600 cubic feet per second. The greatest gage height in the county was recorded on October 15, 1954 at 24.20 feet. Additional peak discharge readings and gage heights are in the table below.

Location	Date	Peak Discharge (cfs)	Gage Height (ft)
Guilford County			
Reedy Fork near Gibsonville	9/25/1947	11,600	20.77
South Buffalo Creek near Pomona	9/23/2003	3,350	15.45
South Buffalo Creek at US 220 near Greensboro	9/17/2018	3,340	16.77
South Buffalo Creek near Greensboro*	7/15/1949, 3/20/2003	10,000	14.37
West Fork Deep River near High Point	9/24/1947	8,450	19.92
East Fork Deep River near High Point*	9/24/1947, 9/23/2003	6,300	13.46
Reedy Fork near Oak Ridge*	10/10/1959, 9/22/1979	3,950	12.41
Haw River near Summerfield	10/15/1954	1,310	24.20
Rock Creek near Whitsett	10/15/1954	5,860	24.02
Candy Creek near Monticello	4/16/1987	356	6.77
Brush Creek at Muirfield Rd at Greensboro	9/17/2018	902	11.08
Brush Creek at Fleming Rd at Greensboro*	3/29/2001, 9/15/2000	221	8.96
Horsepen Creek at US 220 near Greensboro*	9/23/2003, 9/17/2018	2,800	11.99
Horsepen Creek at Battle Ground	9/24/1947	6,400	10.36

	<table><tr><td>Ryan Creek below US 220 at Greensboro</td><td>7/13/2003</td><td>1,060</td><td>12.53</td></tr><tr><td>N Buffalo Creek at Westover Terrace at Greensboro</td><td>9/23/2003</td><td>2,520</td><td>14.07</td></tr><tr><td>N Buffalo Creek at Church St at Greensboro</td><td>9/23/2003</td><td>3,520</td><td>17.81</td></tr><tr><td>N Buffalo Creek near Greensboro</td><td>9/22/1979</td><td>9,140</td><td>20.12</td></tr><tr><td>Buffalo Creek at SR 2819 near Mcleansville</td><td>3/20/2003</td><td>6,720</td><td>19.35</td></tr></table> *Peak discharge and peak gage height occurred on different dates.
Hail	Hail extent can be defined by the size of the hail stone. The largest hail stone reported in Guilford County was 2.75 inches (reported on April 2, 1983). It should be noted that future events may exceed this.
Hurricane and Tropical Storm	Hurricane extent is defined by the Saffir-Simpson Scale which classifies hurricanes into Category 1 through Category 5. The greatest classification of hurricane/tropical storm within 75 miles of Guilford County was an unnamed storm in October 1893 which reached a maximum wind speed of 80 knots as a Category 1 hurricane. Although the county is much more likely to be impacted by the remnants of a hurricane or tropical storm, it is possible that a storm with hurricane-force winds can impact the county directly.
Thunderstorm – Wind	Thunderstorm extent is defined by the number of thunder events and wind speeds reported. The strongest recorded wind event in Guilford County was reported on July 15, 1976 at 84 knots (approximately 97 mph). It should be noted that future events may exceed these historical occurrences.
Thunderstorm – Lightning	According to the Vaisala flash density map, Guilford County is located in an area that experiences 6 to 12 lightning flashes per square mile per year.
Tornado	Tornado hazard extent is measured by tornado occurrences in the US provided by FEMA as well as the Fujita/Enhanced Fujita Scale. The greatest magnitude reported in Guilford County was an EF3 (reported on March 28, 2010). It should be noted that in 2018, an EF2 tornado caused extensive damage in the county.
Winter Storm	The extent of winter storms can be measured by the amount of snowfall received (in inches). The greatest 24-hour snowfall reported in the county was 20.0 inches on March 2, 1927. Due to unpredictable variations in snowfall throughout the county, extent totals will vary for each participating jurisdiction and reliable data on snowfall totals is not abundantly available.
Biological Hazards	

Bioterrorism	A bioterrorism event would have significant consequences on the general public and could potentially cause major strain to hospitals and medical care providers. In some more severe scenarios, quarantines may be required as public health officials attempt to restrict the spread of infectious disease. The extent for this could be widespread, impacting thousands of people.
Public Health / Emerging Disease Threat	A public health/emerging disease threat could have a large –scale effect throughout the county and may cause illness in many people. Possible impacts from a disease threat depend largely on the impacted population, but might include anything from absenteeism and loss of productivity in the workplace to death or serious illness to humans or livestock. A serious disease threat could affect many thousands of people.
Technological Hazards	
Building / Structure Collapse	A building or structure collapse would most likely occur to a building that is under construction. The impacts would be relatively localized, but could be very serious, causing death or injury to anyone in or around the structure. Depending on the size of the structure, possibly hundreds of people could be affected even though in this type of event, generally only a single structure would collapse and the area of impact would be relatively small.
Communications Systems Disruption / Failure	For a communications systems disruption or failure, the greatest extent that is possible is a complete shutdown of all communications equipment. However, this is unlikely to occur as it is more likely that a loss of one form of communication (radio, cell phone) will be shut down, causing emergency personnel to seek out other forms of communication and delaying/disrupting response time.
Energy / Power/ Utility Failure	There are many impacts that would occur as a result of an energy/power/utility failure. Among other impacts, traffic lights could be down, residents might lose heat or air conditioning, medical equipment may be non-operational, and well pumps could be shut down limiting access to clean water. These failures could potentially be widespread, leaving tens of thousands of homes and businesses without power or utilities.
Hazardous Materials Incident	According to USDOT PHMSA, the largest hazardous materials incident reported in the county was 9,000 LGA released on the highway on September 30, 1999 and 13,000 SLB released on the highway on September 22, 1982. It should be noted that larger events are possible.
Nuclear Power Plant Emergency	Although there is no history of a nuclear accident at the Shearon Harris Power Plant, other events across the globe and in the United States in particular indicate that an event is possible. Since several national and international events were Level 7 events on the INES, the potential for a Level 7 event at Shearon Harris is possible.
Pipeline Failure	A pipeline failure could be caused in several different ways. If an explosion or fire were the cause of the incident, the impacts might include fatalities or injuries as well as loss of a fuel source and damage to personal property. However, the impacts could also be less fatal in which case the more immediate effects might be down time for services and significant price hikes for consumers.

Resource Shortage (Water / Fuel)	A resource failure would likely have widespread impacts that cause a strain on the local economy and on everyone in the county. In the past, the county has experienced events wherein there was less than 70 days of water supply available which is very low. Similarly, the county has experienced rationing of fuel supplies. Both of these types of events could occur again and the extent could be similar or somewhat worse.
Transportation Incident	A transportation incident might cause death or injury to those involved in the accident as well as to bystanders near the site of the incident. The main effects of a transportation incident might be fire or explosions and a shutdown of transportation corridors. Although these events are relatively common and emergency officials deal with them fairly often, the impacts to individuals might be severe with disruption to daily life at a minimum.
Man-Made / Intentional Hazards	
Civil Disturbance	Often one of the greatest impacts from civil disturbances is collateral damage to people and property. During civil disturbances, property can be destroyed or stolen and citizens can be injured due to violence that erupts. First responders may also be targeted and many times are more likely to be injured as a result of civil unrest that the typical citizen.
Cyber-terrorism	While there is seldom physical damage inflicted from a cyber-security event, the effects of such an event are often damaging in other ways. For example, theft, denial of service attacks, and dissemination of misinformation can all result from a cyber-security event. Moreover, these events are often aimed at shutting down IT systems which can result in loss of productivity and damage to IT infrastructure.
Terrorism	There is no history of terror threats in Guilford County; however; it is possible that one of these events could occur. If this were to take place, the magnitude of the event could range on the scale of critical damage with many fatalities and injuries to the population.

Priority Risk Index

In order to draw some meaningful planning conclusions on hazard risk for Guilford County, the results of the hazard profiling process were used to generate countywide hazard classifications according to a "Priority Risk Index" (PRI). The purpose of the PRI is to categorize and prioritize all potential hazards for Guilford County as high, moderate, or low risk. The summary hazard classifications generated through the use of the PRI allows for the prioritization of those high hazard risks for planning purposes.

The prioritization and categorization of identified hazards for Guilford County is based principally on the PRI, a tool used to measure the degree of risk for identified hazards in a particular planning area. The PRI is used to assist the Guilford County Emergency Management Program in gaining consensus on the determination of those hazards that pose the most significant threat to the county based on a variety of factors. The PRI is not scientifically based,

but is rather meant to be utilized as an objective planning tool for classifying and prioritizing hazard risks in Guilford County based on standardized criteria.

The application of the PRI results in numerical values that allow identified hazards to be ranked against one another (the higher the PRI value, the greater the hazard risk). PRI values are obtained by assigning varying degrees of risk to five categories for each hazard (probability, impact, spatial extent, warning time, and duration). Each degree of risk has been assigned a value (1 to 4) and an agreed upon weighting factor, as summarized in **Table 3.45**. To calculate the PRI value for a given hazard, the assigned risk value for each category is multiplied by the weighting factor. The sum of all five categories equals the final PRI value, as demonstrated in the example equation below:

PRI VALUE *= [(PROBABILITY x .30) + (IMPACT x .30) + (SPATIAL EXTENT x .20) + (WARNING TIME x .10) + (DURATION x .10)]*

According to the weighting scheme and point system applied, the highest possible value for any hazard is 4.0. When the scheme is applied for Guilford County, the highest PRI value is 3.1 (winter storm). Prior to being finalized, PRI values for each identified hazard were reviewed and accepted by the members of the Hazard Mitigation Planning Team.

TABLE 3.45: PRIORITY RISK INDEX FOR GUILFORD COUNTY

PRI Category	Degree of Risk			Assigned Weighting Factor
	Level	Criteria	Index Value	
Probability	Unlikely	Less than 1% annual probability	1	30%
	Possible	Between 1 and 10% annual probability	2	
	Likely	Between 10 and 100% annual probability	3	
	Highly Likely	100% annual probability	4	
Impact	Minor	Very few injuries, if any. Only minor property/environmental damage and minimal disruption on quality of life. Temporary shutdown of critical facilities. No effect on emergency operations.	1	30%
	Limited	Minor injuries only. More than 10% of property/environment in affected area damaged or destroyed. Complete shutdown of critical facilities for more than one day. Limited effect on emergency operations.	2	
	Critical	Multiple deaths/injuries possible. More than 25% of property/environment in affected area damaged or destroyed. Complete shutdown of critical facilities for more than one week. Significant impact on emergency operations.	3	
	Catastrophic	High number of deaths/injuries possible. More than 50% of property/environment in affected area damaged or destroyed. Complete shutdown of critical facilities for 30 days or more. Devastating effect on emergency operations.	4	
Spatial Extent	Negligible	Less than 1% of area affected	1	20%
	Small	Between 1 and 10% of area affected	2	
	Moderate	Between 10 and 50% of area affected	3	
	Large	Between 50 and 100% of area affected	4	
Warning Time	More than 24 hours	Self explanatory	1	10%
	12 to 24 hours	Self explanatory	2	
	6 to 12 hours	Self explanatory	3	
	Less than 6 hours	Self explanatory	4	
Duration	Less than 6 hours	Self explanatory	1	10%
	Less than 24 hours	Self explanatory	2	
	Less than one week	Self explanatory	3	
	More than one week	Self explanatory	4	

Priority Risk Index Results

Table 3.46 summarizes the degree of risk assigned to each category for all initially identified hazards based on the application of the PRI. Assigned risk levels were based on the detailed hazard profiles developed for this section, as well as input from the Hazard Mitigation Planning Team. The results were then used in calculating PRI values and making final determinations for the risk assessment.

TABLE 3.46: SUMMARY OF PRI RESULTS FOR GUILFORD COUNTY

Hazard	Category/Degree of Risk					
	Probability	Impact	Spatial Extent	Warning Time	Duration	PRI Score
Natural Hazards						
Drought	Likely	Minor	Large	More than 24 hours	More than 1 week	2.5
Earthquake	Possible	Minor	Moderate	Less than 6 hours	Less than 6 hours	2.0
Extreme Cold	Possible	Minor	Large	More than 24 hours	Less than 1 week	2.1
Extreme Heat	Likely	Minor	Large	More than 24 hours	Less than 1 week	2.4
Fire	Likely	Minor	Small	Less than 6 hours	Less than 1 week	2.3
Flooding	Highly Likely	Limited	Small	6 to 12 hours	Less than 1 week	2.8
Hail	Highly Likely	Minor	Moderate	6 to 12 hours	Less than 6 hours	2.5
Hurricane / Other Tropical Disturbance	Likely	Limited	Large	More than 24 hours	Less than 24 hours	2.6
Thunderstorm – Wind	Highly Likely	Limited	Moderate	6 to 12 hours	Less than 6 hours	2.8
Thunderstorm – Lightning	Highly Likely	Limited	Negligible	6 to 12 hours	Less than 6 hours	2.4
Tornado	Likely	Critical	Small	Less than 6 hours	Less than 6 hours	2.7
Winter Storm	Highly Likely	Critical	Moderate	More than 24 hours	Less than 1 week	3.1
Biological Hazards						
Bioterrorism	Unlikely	Critical	Negligible	Less than 6 hours	Less than 1 week	2.3
Public Health / Emerging Disease Threat	Possible	Critical	Negligible	Less than 6 hours	More than 1 week	2.7
Technological Hazards						
Building / Structure Collapse	Possible	Limited	Negligible	Less than 6 hours	Less than 6 hours	1.9
Communications Systems Disruptions / Failures	Possible	Limited	Large	Less than 6 hours	Less than 1 week	2.7
Energy / Power / Utility Failure	Likely	Limited	Small	Less than 6 hours	Less than 1 week	2.6
Hazardous Materials Incident	Likely	Critical	Small	Less than 6 hours	Less than 24 hours	2.8

Hazard	Category/Degree of Risk					
	Probability	Impact	Spatial Extent	Warning Time	Duration	PRI Score
Nuclear Power Plant Emergency	Unlikely	Limited	Moderate	6 to 12 hours	Less than 1 week	2.1
Pipeline Failure	Possible	Limited	Moderate	Less than 6 hours	Less than 1 week	2.5
Resource Shortage (Water / Fuel)	Possible	Limited	Large	More than 24 hours	More than 1 week	2.5
Transportation Incident	Likely	Critical	Negligible	Less than 6 hours	Less than 24 hours	2.6
Man-Made / Intentional Hazards						
Civil Disturbance	Possible	Limited	Small	12 to 24 hours	More than 1 week	2.2
Cyber-Security Threat	Possible	Critical	Small	Less than 6 hours	Less than 24 hours	2.5
Terrorism	Unlikely	Critical	Small	Less than 6 hours	Less than 24 hours	2.2

SECTION 4: CONCLUSION

The conclusions drawn from the hazard profiling process for Guilford County, including the PRI results and input from the Hazard Mitigation Planning Team, resulted in the classification of risk for each identified hazard according to three categories: High Risk, Moderate Risk, and Low Risk (**Table 4.1**). For purposes of these classifications, risk is expressed in relative terms according to the estimated impact that a hazard will have on human life, property, the environment, and the Emergency Management Program's operation throughout all of Guilford County. It should be noted that although some hazards are classified below as posing low risk, their occurrence of varying or unprecedented magnitudes is still possible in some cases and their assigned classification will continue to be evaluated during future plan updates.

TABLE 4.1: CONCLUSIONS ON HAZARD RISK FOR GUILFORD COUNTY

HIGH RISK	Winter Storm Hurricane/Other Tropical Disturbance Thunderstorm(Wind/Lightning) Flooding Hazardous Materials Incident Tornado Public Health/Emerging Disease Threat Communications Systems Disruption / Failure
MODERATE RISK	Energy/Power/Utility Failure Transportation Incident Drought Resource Shortage (Water/Fuel) Pipeline Failure Cyber-Security Threat Hail Extreme Heat
LOW RISK	Fire Bioterrorism Civil Disturbance Terrorism Extreme Cold Nuclear Power Plant Emergency Earthquake Building / Structure Collapse

APPENDIX A: HAZARD MITIGATION PLANNING TEAM

In order to guide the development of this Plan, Guilford County and its jurisdictions created the Guilford County Hazard Mitigation Planning Team (Hazard Mitigation Planning Team or Planning Team). The Hazard Mitigation Planning Team represents a community-based planning team made up of representatives from various county and municipal departments, and other key stakeholders identified to serve as critical partners in the planning process.

Beginning in May 2019, the Hazard Mitigation Planning Team members engaged in regular discussions as well as local meetings and planning workshops to discuss and complete tasks associated with preparing the Plan. This working group coordinated on all aspects of plan preparation and provided valuable input to the process. In addition to regular meetings, committee members routinely communicated and were kept informed through an e-mail distribution list.

Specifically, the tasks assigned to the Hazard Mitigation Planning Team members included:

- participate in Hazard Mitigation Planning Team meetings and workshops
- provide best available data as required for the risk assessment
- support the creation of the Guilford County HIRA.

Table A.1 lists the members of the Hazard Mitigation Planning Team who were responsible for participating in the development of the Plan. Committee members are listed in alphabetical order by first name.

TABLE A.1: MEMBERS OF THE GUILFORD COUNTY HAZARD MITIGATION PLANNING TEAM

Name	Position	Organization
Steven Grose	Emergency Management Coordinator	Guilford County
Catherine Hughes	Emergency Management Coordinator	Guilford County
Taylor Jones	Emergency Management Coordinator	Guilford County
Ken Jacobs	Town Administrator	Whitsett
Rachel Faucette	Emergency Management Coordinator	Guilford County

Name	Position	Organization
Chris Susi	Battalion Chief	Greensboro
Don Campbell	Emergency Management Division Director	Guilford County
Kenny Cole	Town Manager	Jamestown
Chris York	Town Planner	Summerfield
Thearon Hooks	Mayor Pro Term	Stokesdale
Alisa Houk	Town Clerk	Stokesdale
Aldoud Heron	Deputy Sheriff	GCSO
Jason Geary	Engineering Supervisor	Greensboro
Vivian Bou Gomez	Engineering Specialist	Greensboro
Perry Hall	Emergency Manager	High Point
Brandon Parker	Town Planner	Gibsonville
Frank Park	Chief Plans Engineer	Guilford County
Angela Deal	Town Clerk	Pleasant Garden
Paul Blanchard	Public Services Director	Jamestown
Ashley Royal	Deputy Clerk	Oak Ridge
Teresa Andrews	Stormwater Program Administrator	Guilford County
Bobby Carman	Deputy Fire Marshal	Guilford County
Stephen Dew	GIS Manager	Guilford County
Matthew Smith	Fire Captain	Greensboro
Bobbie Hatley	Town Clerk	Pleasant Garden
Conor Baker	Emergency Management Coordinator	Guilford County
Kenny Stewart	Emergency Management Coordinator	UNCG

Name	Position	Organization
Ben Baxley	Town Manager	Gibsonville
Cam Dungee	Town Clerk	Sedalia

Name	Position	Organization
Steven Grose	Emergency Management Coordinator	Guilford County
Catherine Hughes	Emergency Management Coordinator	Guilford County
Taylor Jones	Emergency Management Coordinator	Guilford County
Ken Jacobs	Town Administrator	Whitsett
Rachel Faucette	Emergency Management Coordinator	Guilford County
Chris Susi	Battalion Chief	Greensboro
Don Campbell	Emergency Management Division Director	Guilford County
Kenny Cole	Town Manager	Jamestown
Chris York	Town Planner	Summerfield
Thearon Hooks	Mayor Pro Term	Stokesdale
Alisa Houk	Town Clerk	Stokesdale
Aldoud Heron	Deputy Sheriff	GCSO
Jason Geary	Engineering Supervisor	Greensboro
Vivian Bou Gomez	Engineering Specialist	Greensboro
Perry Hall	Emergency Manager	High Point
Brandon Parker	Town Planner	Gibsonville
Frank Park	Chief Plans Engineer	Guilford County
Angela Deal	Town Clerk	Pleasant Garden

Name	Position	Organization
Paul Blanchard	Public Services Director	Jamestown
Ashley Royal	Deputy Clerk	Oak Ridge
Teresa Andrews	Stormwater Program Administrator	Guilford County
Bobby Carmon	Deputy Fire Marshal	Guilford County
Stephen Dew	GIS Manager	Guilford County
Matthew Smith	Fire Captain	Greensboro
Bobbie Hatley	Town Clerk	Pleasant Garden
Conor Baker	Emergency Management Coordinator	Guilford County
Kenny Stewart	Emergency Management Coordinator	UNCG
Ben Baxley	Town Manager	Gibsonville
Cam Dungee	Town Clerk	Sedalia

As noted above, a number of representatives outside of municipal and county level government participated directly on the planning team during this process. These representatives were from cities(Greensboro), towns (Pleasant Garden), and other stakeholder groups, such as the university community. All of these stakeholders were invited to participate in the process via email along with many other stakeholders who did not directly participate on the planning team.

Finally, it should be noted that many neighboring communities were offered the opportunity to participate in the planning process by being invited to meetings, through phone conversations, and in-person discussions. Among those invited to participate were representatives from Emergency Management offices in several of the counties that surround Guilford County including Forsyth, Davidson, Stokes, Rockingham, and Caswell Counties. During these discussions, no major comments or suggestions were received concerning the plan.

APPENDIX B: PUBLIC PARTICIPATION SURVEY

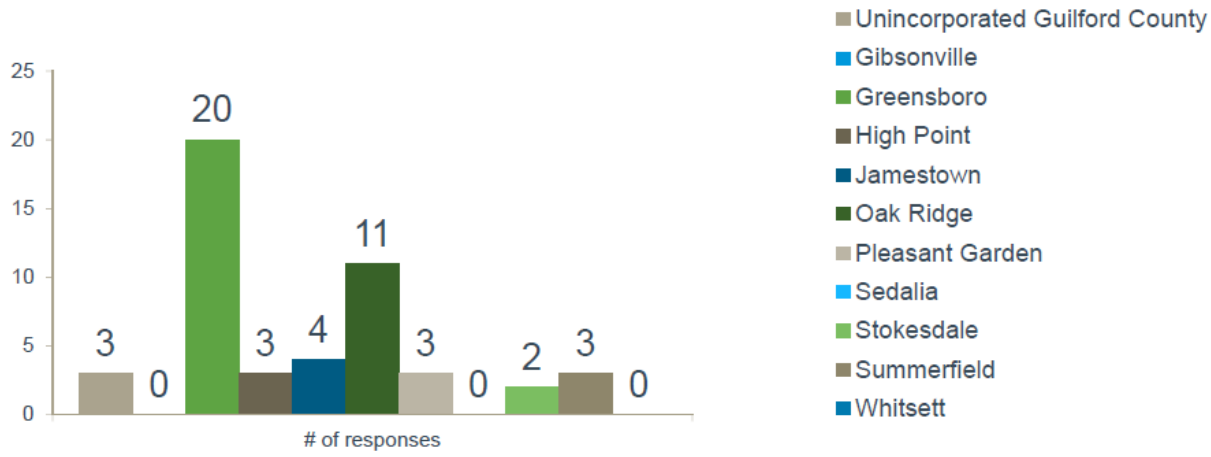
The Hazard Mitigation Planning Team was successful in getting citizens to provide input to the HIRA process through the use of the *Public Participation Survey*. The *Public Participation Survey* was designed to capture data and information from residents of Guilford County.

Copies of the *Public Participation Survey* were distributed to the Hazard Mitigation Planning Team to be made available for residents to complete at local public offices. A link to an electronic version of the survey was also posted on the county and municipal websites. A total of 50 survey responses were received, which provided valuable input for the Hazard Mitigation Planning Team to consider in the development of the plan update. Selected survey results are presented below which include updated information that was not presented at the 2nd Hazard Mitigation Planning Team meeting.

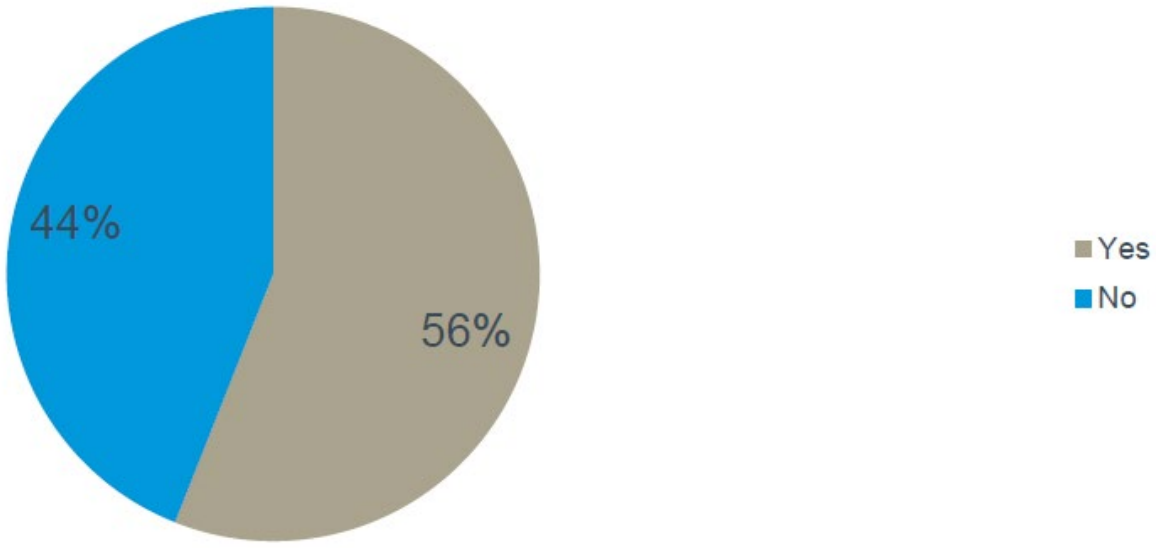
- Approximately 56 percent of survey respondents had been impacted by a disaster, mainly floods, hurricanes, thunderstorms, and winter storms.
- Respondents ranked hurricane/other tropical disturbance as the hazard of greatest concern, followed by thunderstorm, tornado, and winter storm.
- Approximately 48 percent of respondents have taken actions to make their homes more resistant to hazards and 92 percent are interested in making their homes more resistant to hazards.
- 62 percent of respondents do not know what office to contact regarding reducing their risks to hazards.
- Natural Resource Protection and Prevention were ranked as the most important activities for communities to pursue in reducing risks.

Survey Data Results

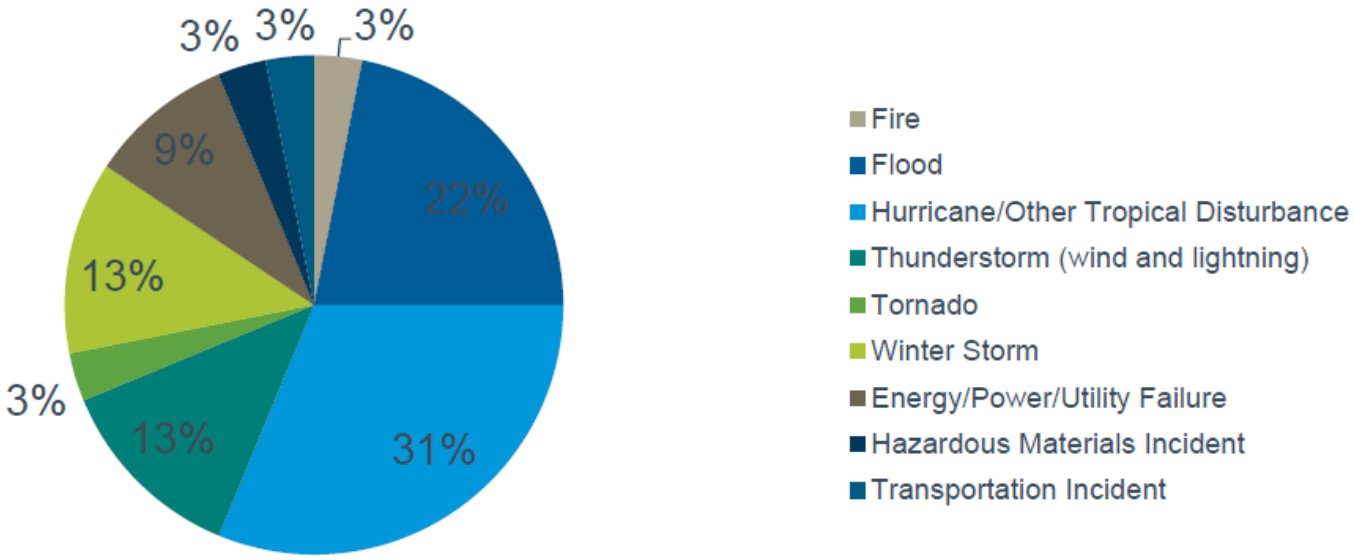
Q1. Where do you live?



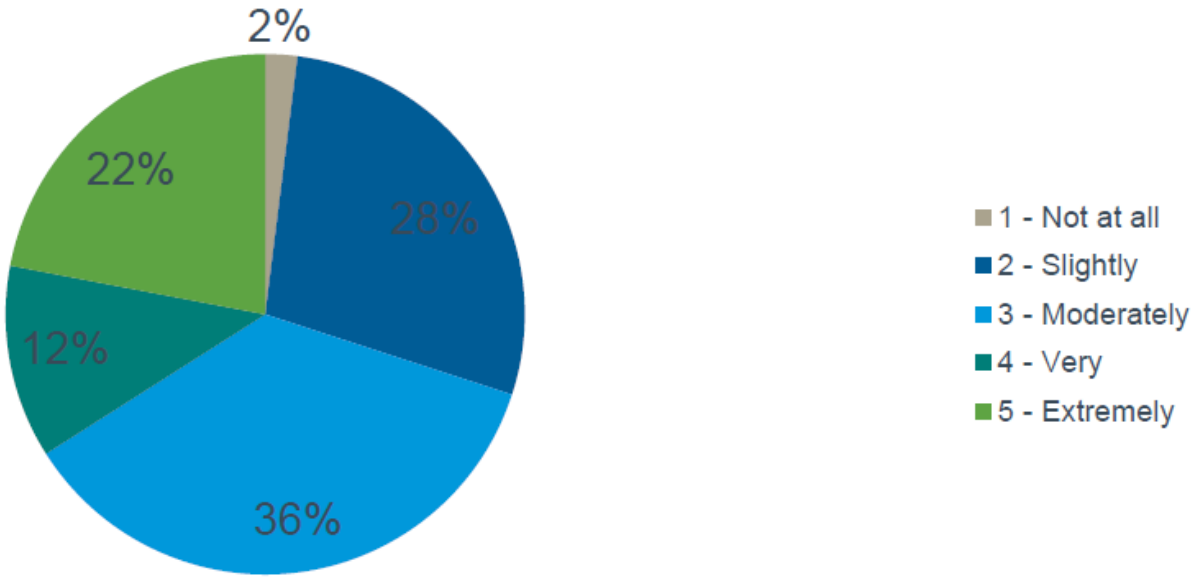
Q4. Have you experienced a disaster?



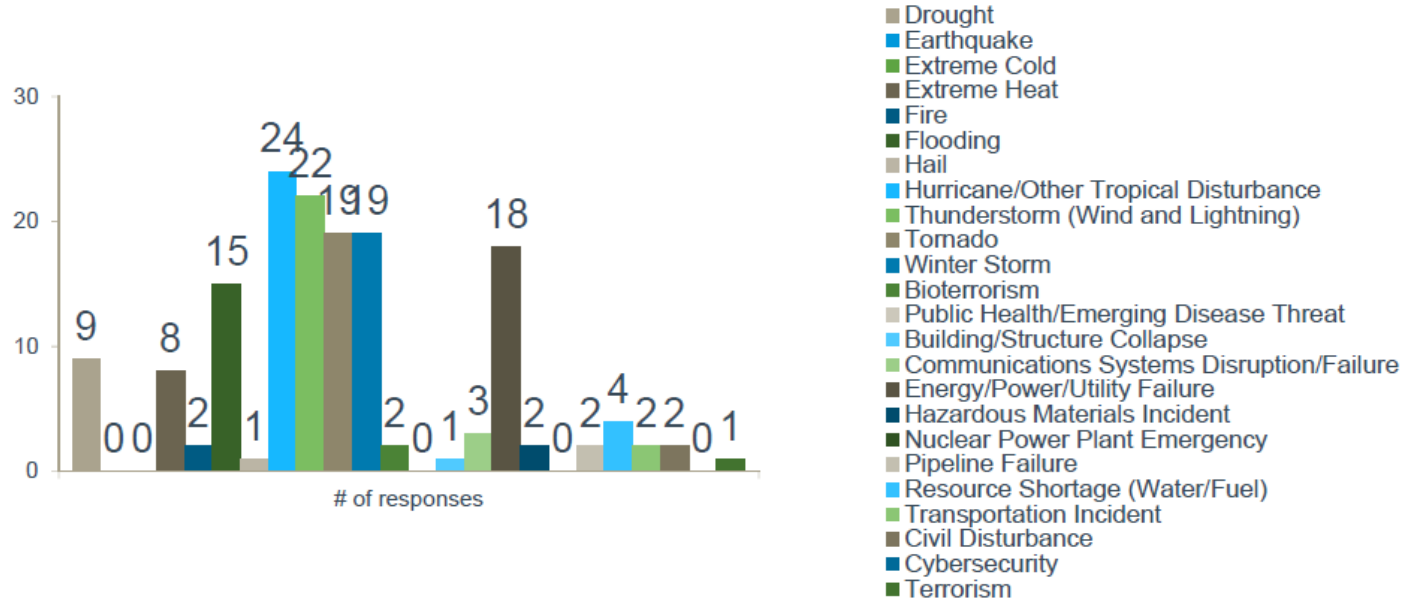
Q4a. Example of disasters experienced.



Q5. How concerned about possibility of being impacted by a disaster?



Q6. Hazards of greatest concern?



Q7. Other hazards not listed?

- Climate Change
- Home Invasion/Theft