CHAPTER 12: Hazard Vulnerability Assessment








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1: Purpose

The purpose of the Hazard Vulnerability Assessment is to identify hazards and vulnerability in the Swannanoa area in order to understand where risk is, who is at risk, and what ability the community has to withstand hazards. The U.S. Climate Resilience Toolkit defines 'vulnerability' as the probability that a given community or asset, such as a structure or road) will be negatively affected by hazards. Vulnerability is determined by looking at three main criteria: exposure, sensitivity, and adaptive capacity.

Exposure + Sensitivity – Adaptive Capacity = VULNERABILITY

Exposure: Understand level of exposure (probability a hazard will occur).

Sensitivity: Identify how much the community will be impacted by hazards (Identify structures, functions and services, and populations that could be impacted).

Adaptive Capacity: Understand the ability of the community to adjust to a hazard through changes in characteristics or behavior.

Resilience planning efforts are focused on multiple hazards and vulnerabilities, such as flooding, wildfires, landslides, wind damage, extreme heat, and so on. The geographic extent of our resilience planning efforts is the Swannanoa Policy Map; however, while the short-term aftermath of a disaster event relies on hyper-local resilience, long-term resilience requires community-wide and ultimately, regional thinking.

'Resilience' is the capacity of a community or business to prevent, withstand, respond to, and recover from a disruption.

-NC Resilient Communities Planning Guide



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2: Background

Between 2011 and 2024, 95.5% of people in the United States lived in a county that had a Federally-declared major weather disaster, with 80% of states having more than 10 disaster declarations. Climate change projections forecast that these major disasters will continue to increase in number and become more extreme over time. While we cannot always predict when or where a disaster will occur, communities should prepare for the possibility.

Starting in 2025, threats to funding and support for disaster mitigation and response at the Federal level raises questions about the ability to rely on Federal disaster assistance in the future. State and local governments may end up taking on more of the cost and logistical burden of extreme events.

Every $1 not invested in disaster resilience today can cost communities up to $33 in lost future economic activity.

-U.S. Chamber of Commerce

Data shows that investing in resilience to disasters ahead of time can save significant resources after a disaster occurs. Economic losses also do not take into account physical, emotional, social, and environmental losses that can cause damage for decades after. Increasing local resilience to future disasters is vitally important.

Buncombe County experienced 3 federally declared extreme weather disasters between 2011 to 2024, including the following:

- **2013:** Severe Storms, flooding, landslides, and mudslides totaling over $2 million in FEMA obligations
- **2021:** Remnants of Tropical Storm Fred
- **2024:** Tropical Storm Helene, totaling over $54 million in FEMA obligations



Water distribution by the Army after T.S. Helene in Buncombe County, 2024.

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Damages in Swannanoa from T.S. Helene, 2024.

3. Exposure

This section reviews the level of exposure to risk in Swannanoa. Exposure is the probability that a hazard will occur in the area. While spatial considerations are reviewed for each hazard type, particular attention should be given to how disasters may impact communities differently. For example, vulnerability and risk will have different impacts based on income level, language barriers, historic marginalization, rental vs. ownership status, citizenship status, health, ability and disability, rural vs. urban location, and proximity to community hazards. Local governments should be aware of how resilience measures may impact different types of community members to identify gaps in resilience and support.

NOTE:
Disaster funding and resources from FEMA are a critical component of immediate disaster response and ongoing recovery, but Federal changes may mean future disasters will have less access to assistance. Local governments may need to rely more on local, regional, or state assistance in the future.

Hazard Characteristics & Risk Priority

Hazard Characteristics and risk priority has been analyzed based on historical records and data from multiple sources. The Land of Sky Regional Council's AccelAdapt Hazard Vulnerability Risk Assessment provides data based on low, medium, and high risk vulnerability as it relates to asset exposure. In other words, how many structures are located within known risk areas, to what extent are they at risk, and what is their dollar value. The system includes risk analysis for flood, wildlife, and landslides.

The Hazards of concern table shown below summarizes the top environmental hazards for Swannanoa, including past occurrences, future projects, effects and spatial considerations, and a priority rating based on the likelihood of the hazard to occur and the potential impacts.

Table X: HAZARDS OF CONCERN

Hazards and Key Characteristics	Past Occurrences and Future Projections	Effects and Spatial Considerations	Priority
HURRICANES Key Characteristics: High winds, erosion, flooding, heavy precipitation	Eight (8) hurricanes within 80 miles of the center of Swannanoa since 2000. Hurricanes are expected to increase in frequency, severity, and amount of rainfall.	Structure and property damage, tree blow-down, road and bridge washouts, landslides, utility loss, habitat destruction, crop loss.	Medium
TORNADOES Key Characteristics: High winds	Five (5) tornados within 15 miles of the center of Swannanoa between 1950-2024. Tornadoes may become more common with climate change.	High winds, danger from flying or falling objects, structure and property damage, utility loss.	Low
FLOODING Key Characteristics: Erosion, stream bank loss, habitat loss	This area has a consistent history of flooding. Flooding is expected to increase as the climate warms.	Structure and property damage, road and bridge washouts, utility loss, habitat destruction, crop loss.	High
SNOW STORMS Key Characteristics: High winds, heavy snow, low visibility	Disruptive snowstorms are uncommon, and snow in general is expected to decrease over time.	Tree and structure damage, impaired road conditions, landslides, utility loss.	Low
EXTREME HEAT Key Characteristics: High heat	Extreme heat has been less an issue in higher elevations, but the number of days over 90 degrees will increase over time.	Impaired transportation network, utility loss, crop loss, drought.	Medium
LANDSLIDES Key Characteristics: Erosion	Landslides are common in the mountains and may increase as rainfall and development increases.	Road and bridge damage, infrastructure damage, utility loss, structure and property damage.	High
WILDFIRE Key Characteristics: High heat, fire damage, poor air quality, low visibility	No significant wildfires identified. More dry days and hotter temperatures means dryer vegetation and more fuel for wildfires.	Impaired transportation, infrastructure damage, utility loss, habitat destruction, structure and property damage, crop loss.	High
DROUGHT Key Characteristics: Water scarcity	Precipitation is expected to increase, however the number of days without rain may also increase, creating an opportunity for drought.	Water scarcity, crop loss, wildfire risk.	Low

A. HURRICANES & TORNADOES

Past Occurrences

Since the year 2000, eight (8) Tropical Storm tracks have come within 80 miles from the center of Swannanoa (see Figure X). While Tropical Storm Helene in 2024 was further from Swannanoa compared to other storms, it was more damaging in many ways due to two primary factors: The storm was able to maintain more of its intensity as it passed over land, and two days of intense rain prior to the storm meant that soils and water bodies were already inundated and unable to store additional water, leading to catastrophic flooding.

Table X: Hurricane Tracks near Swannanoa, 1990-2024

Year	Storm Name	Distance to Swann. center	Wind Speed near Swann.
2024	Helene	77 miles	45 mph
2020	Bertha	80 miles	25 mph
2020	Zeta	20 miles	45 mph
2018	Florence	0 miles	25 mph
2005	Cindy	16 miles	20 mph
2004	Frances	60 miles	25 mph
2004	Ivan	35 miles	20 mph
2003	Bill	40 miles	20 mph

Some of the major impacts from T.S. Helene included loss of life, flooding, tree blowdowns, infrastructure and structure damage, environmental destruction, landslides, and blocked or destroyed road and bridge access.

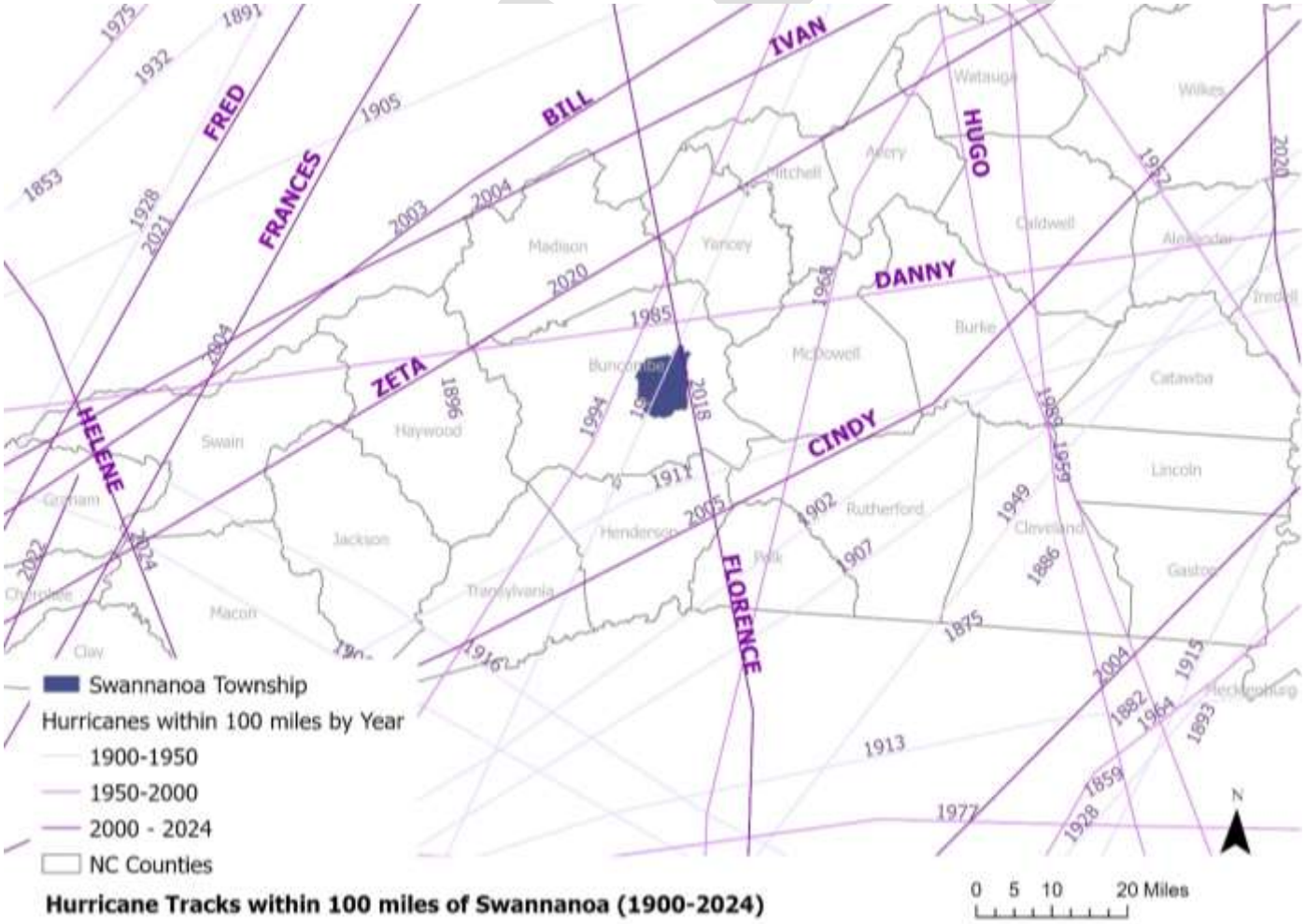


Figure X: Hurricane tracks near Swannanoa, 1900 to 2024.

Between 1950 to 2024, five (5) tornado tracks came within 15 miles of the center of Swannanoa. Four of the five tornadoes occurred in the late 1970's.

None were above an EF-1 on the tornado rating scale, meaning that top speeds did not exceed 110 mph, and damages were light to moderate.

Table X: Tornados near Swannanoa, 1950-2024

Year	Scale	Distance to Swann. Center	Wind speed (mph)	Width	Damage level
2024	EF-0	5 miles	>=85	30 yards	Light
1977	EF-1	7.5 miles	>= 110	50 yards	Moderate
1977	EF-1	13.3 miles	>= 110	50 yards	Moderate
1977	EF-1	12.5 miles	>= 110	40 yards	Moderate
1976	EF-1	11 miles	>= 110	50 yards	Moderate

Future projections

Tornadoes are considered rarer in higher elevation mountains due to lower temperatures and more stable air, though they are still possible under the right conditions. They occur most frequently from April to June, but are possible any time of the year. As climate change increases temperatures in the mountains, tornadoes are expected to become more common in the future, with cooler seasons becoming more prone to tornadoes, especially by the end of the century.

Hazard effects

Hazard effects are primarily due to flooding and wind damage that can have far reaching impacts, such as the examples below:

- Infrastructure damage
  - Blocked or destroyed roads, bridges, and culverts
  - Power or water outages
  - Sewer system impacts
  - Private septic system and well impacts
  - Drinking water contamination from chemical or microbial exposure
- Structure and property damage
- Health Impacts
  - Living in flood damaged homes with mold and moisture issues
  - Exposure to toxic dust
  - Exposure to flood water contamination from hazardous substances or sewage
- Environmental destruction
  - Tree blowdowns
  - Landslides
  - Loss of habitat
- Agricultural crop losses

Spatial considerations

There are important spatial considerations for the Swannanoa area regarding vulnerability to hurricanes: The US 70 Hwy transportation corridor is the primary way in and out of Swannanoa for most people, with many residents living off of one-way in and out roads. Development has encroached into rural areas where people are more exposed to hazards and have access to fewer resources and emergency services. In addition, many properties are served by undersized private bridges and culverts that can cut off access. The highway is also located adjacent to the Swannanoa river in several sections and is within the valley where all surrounding streams drain to, making it especially vulnerable to flooding.

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B. FLOODING

Flood hazards are categorized based on the annual chance that a flood will occur in an area. 100-year and 500-year flood areas are most commonly shown on maps, but data is also available for more frequent floods (25 year) and rarer flood events (1,000 year). **A 100-year, 1% annual chance flood area is around a 26% chance over 30 years.** Flooding from T.S. Helene in 2024 was considered a 1,000 year event.



Bridge damage from T.S. Helene Flooding on the Swannanoa river, 2024

Frequency of flooding is an estimate and not guaranteed to occur. New development within regulated 100-year flood areas are required to meet minimum flood development standards that can help reduce the loss of property and life from flooding events. One example of a flood development standard is requiring buildings to be elevated above the minimum base flood elevation expected from a typical (not historic) flood event.

These standards may provide some protection from an average flood. Many older structures were built prior to regulations and are not equipped to handle flooding. Structures without a mortgage are not legally required to have flood insurance to help cover the cost of flood damage or a total loss. Development within unregulated flood hazard areas, such as the 500 or 1,000 year flood, is not required to meet flood standards; however, awareness of these areas can provide valuable information for communities looking to reduce risk, especially as flooding events become more frequent and extreme.

Past occurrences

The earliest recorded large flood on the Swannanoa River occurred in April 1791, with evidence that the river crest height exceeded that of the famous 1916 flood. Flooding has been part of the history of the Swannanoa valley forever, continuously reshaping the landscape. However, data shows that there was a 30 to 39% increase in normal precipitation in this region between 1958 to 2016. One of the closest active river gauges to Swannanoa is below Hendersonville Road in Biltmore Village. This gauge is directly impacted by upstream flooding that passes through the Swannanoa Valley into Asheville. The table below shows some of the highest river crests at that gauge location, in the order of highest to lowest crest height.

Table X: Flooding Impacts in the Swannanoa Valley

Record River Crest in ft *(Biltmore Village Gauge)*	**Date**	**Record River Crest in ft** *(Biltmore Village Gauge)*	**Date**
27.33 *(T.S. Helene)*	2024-09-27	17	1975-05-01
20.7	1916-07-16	16.74	2004-09-17
19.22	2004-09-08	16	1901-05-21
19	1940-08-13	15.79	1995-01-15
18.74	1928-08-16	15.34	1940-08-30
18	1945-05-01	15.12	1978-11-06

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Data for precipitation levels (the amount of rain that falls during an observation period) shows that during Tropical Storm Helene in September 2024, the 4-day precipitation total was 14.7 inches in the Swannanoa area, which is around the average compared to rain levels seen in other parts of Buncombe County. That level exceeded the amount expected for a 1,000-year event. Directly upstream of Swannanoa in Black Mountain and Montreat, 4-day precipitation levels were higher, over 20 inches.

Table X: Precipitation Levels During Tropical Storm Helene, Sept. 2024		
Location	**4-Day Max.**	**24 Hour Max.**
Black Mountain Station: City-12	20.84”	12.81”
Montreat Station: City-48	20.23”	12.55”
Fairview Station: City-26	15.15”	8.53”
Swannanoa Station: City-63	**14.79”**	**8.45”**
Biltmore Village Station: 03451000	13.9”	8.56”
Asheville Merrimon Station: City-10	13.86”	8.61”
Enka Station: City-25	13.59”	7.61”
Weaverville Station: City-68	11.79”	6.85”

Current Conditions

There are around 1,512 structures within a 25-1,000 year flood hazard area in Swannanoa; however, not all structures are considered high vulnerability or risk. Vulnerability and risk are calculated for existing structures based on the Land of Sky Regional Council’s AccelAdapt system. Vulnerability is determined from an analysis of the potential impact to a structure (ex: is the structure in a flood inundation area?) compared to the adaptive capacity of that structure to withstand hazards (ex: was the structure built before or after flood standards?).

There are 1,299 medium to high flood vulnerability/ risk assets, with a combined value of $551 million dollars.

Risk is determined from a combination of the probability that a hazard event will occur (ex: 25 year vs. 1,000 year flood risk), and the anticipated consequences of that risk (ex: how exposed to the risk is the structure based on location?). The vulnerability rating and risk rating (high, medium, or low) is then combined to form the overall risk rating for each property.

High vulnerability/risk asset areas are along the US 70 Hwy corridor, especially around the historic Beacon Village, and on industrial sites adjacent to Old Bee Tree and Warren Wilson Road. Around 34 bridges in Swannanoa create potential choke-points for flooding, increasing the risk of upstream flooding. A proliferation of public and private culverts increases flooding and puts access to neighborhoods and homes at risk due to blowouts that may eliminate road access.

Table X: Flood Hazard Areas & Impacts in Swannanoa					
Flood Area	**Regulated Flood Area**	**# of acres**	**% of Swann. acreage**	**Parcels Impacted**	**Structures Impacted**
25-year	No	903	3%	1,279	550
100-year (1% annual chance)	Yes	1,052	3%	765	659
500-year (0.2% annual chance)	No	1,252	4%	920	912
1,000-year	No	1,796	6%	1,919	1,382

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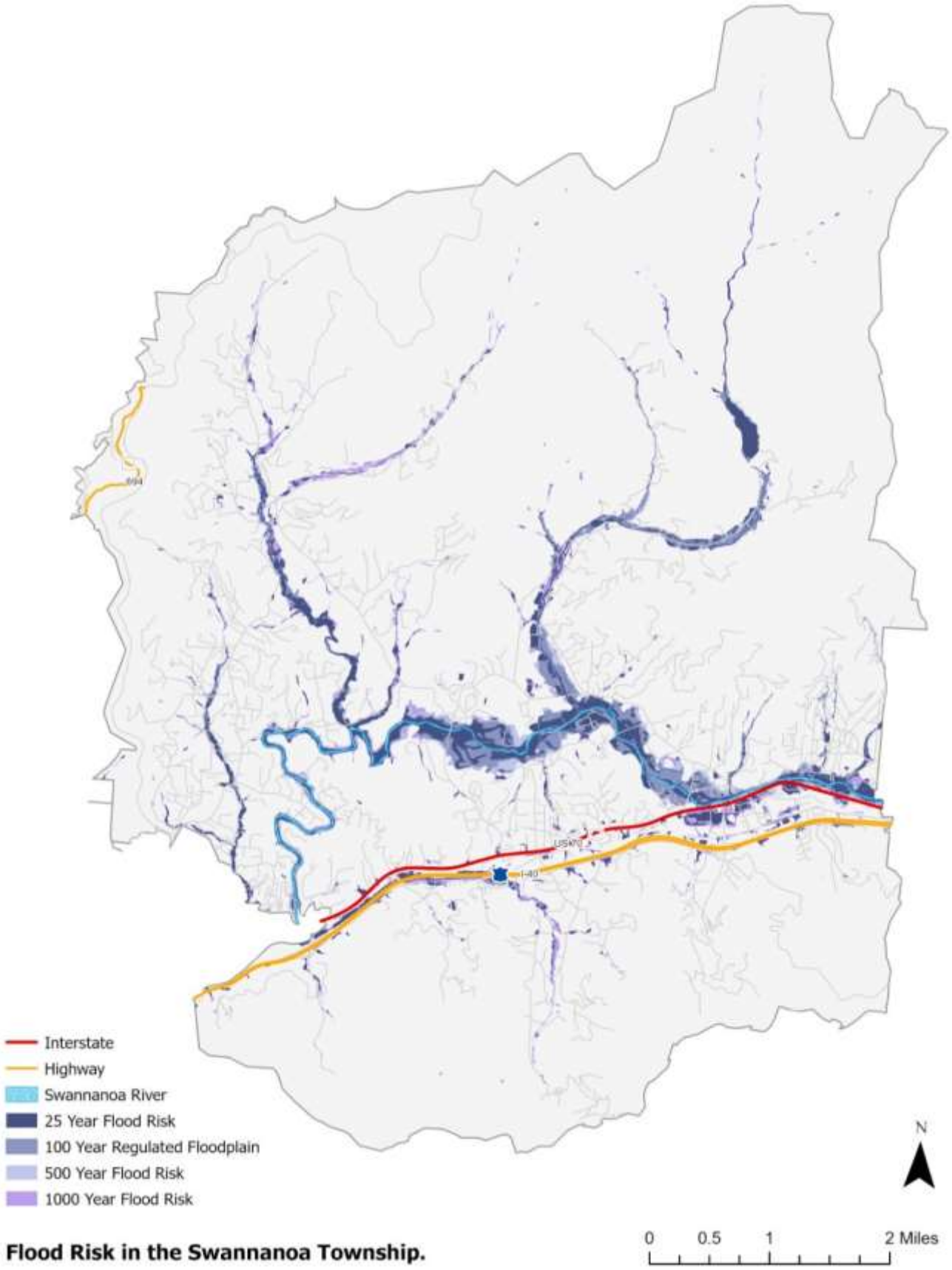
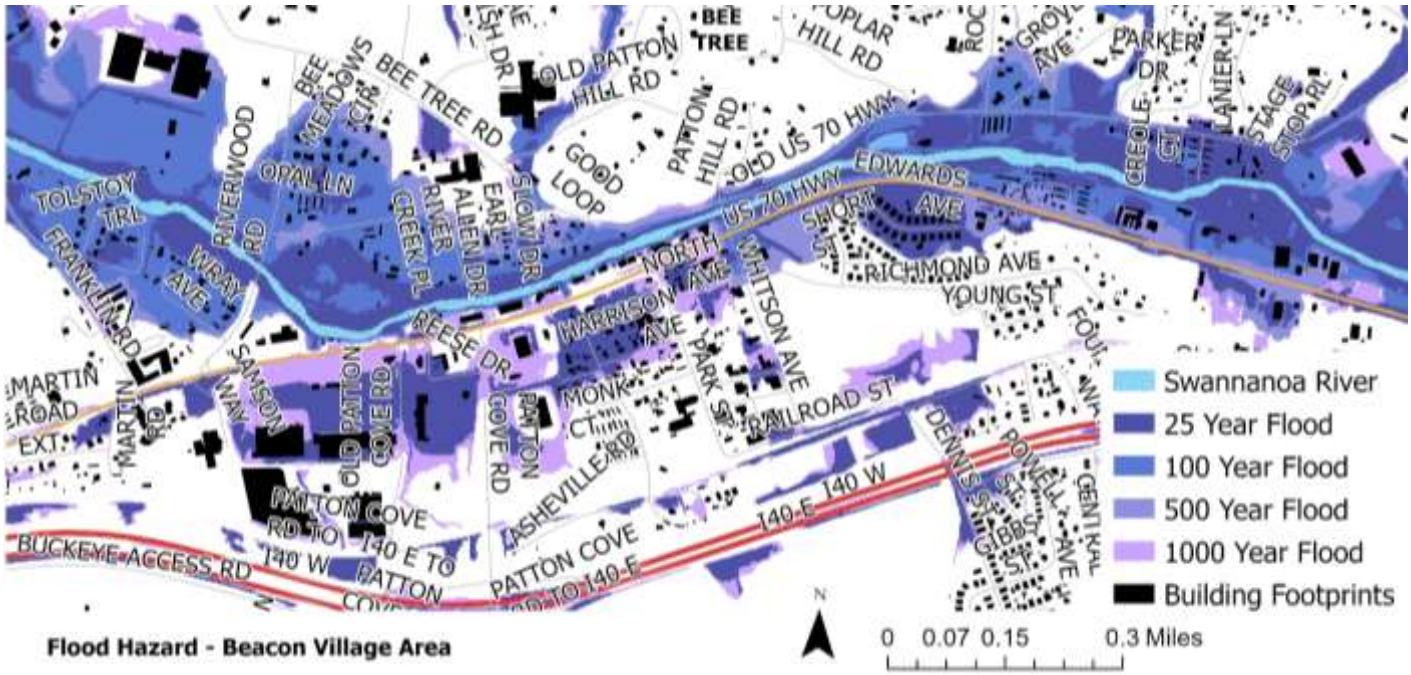


Figure X: Flood Hazard Areas in the Swannanoa Township (25 to 1,000-year flood risks)

Risk Snapshot

Areas around the US 70 Hwy corridor in the east of Swannanoa have a unique risk of flooding due to higher concentrations and values of structures that are located within flood hazard areas. The following map shows 25 to 1,000-year flood hazards and building footprints around the transportation corridor near downtown Swannanoa and the historic Beacon village area. There are more than 300 residential, commercial, and government or critical facility assets in this roughly 1,500 acre area, with an estimated asset value of almost $155 million.



Medium to High vulnerability/risk assets within the area shown in Figure X are summarized in the table below. Based on this data, commercial assets in the snapshot area account for 42% of all commercial assets in the Swannanoa Township.

Table X: Medium & High Flood Risk Assets shown in Figure X
Downtown Swannanoa and surrounding US 70 Hwy area

Type	# of Assets in area	$ Value of Assets in area	% of Swannanoa's med/high risk Assets	% of all Swannanoa assets *(at-risk & no risk)*
Residential	227	$27.9 million	21%	3%
Commercial	67	$28 million	65%	42%
Government-owned & Critical Facilities	13	$98.7 million	25%	13%

Future projections

In 1963, the Tennessee Valley Authority estimated that future flooding on the Swannanoa River could exceed the historic 1916 flood by an additional 12 feet or more in height (33 feet at crest), causing many buildings and bridges to be destroyed while endangering resident's lives. Increased flooding risk was predicted to be due to land development, floodplain constrictions, bridge obstructions, and filling low lying areas. It is notable to mention that the 1791 flood is thought to have reached approximately 26 feet in height, almost the same height as flooding during Tropical Storm Helene in 2024.

Since the beginning of the 1900's, record-setting flood levels on the Swannanoa river have occurred on average every 2 years, with the largest time span between historic events being 12 years apart.

Between 2022 and 2050, Appalachia is expected to experience an outsized burden of new flooding from climate change compared to other areas of the U.S. The average annual total precipitation is expected to increase by 1.8 to 2.2 additional inches of rain per year by 2044. Increased inland flood risk is due to three climate factors:

1) More intense rainfall caused by warmer air will increase flood severity;

2) Drier soils and longer droughts can decrease flooding in some areas, but also makes flooding from intense downpours worse because of runoff from hardened soils;

3) Less snow will reduce snowmelt-driven floods, but earlier melt periods can result in more intense floods in cold regions.

In addition to changes to the climate, development patterns will also increase risk. Additional impervious surfaces from new development will further increase stormwater runoff and continued building in flood-prone areas will put more property and lives at risk. As flooding increases in both intensity, frequency, and location, flood events will continue to be deadly and expensive.

Hazard effects

Flooding is a risk to infrastructure, ecosystems, essential services, property, health, and life. In addition to the immediate dangers of flood waters, flooding also exposes communities to waterborne diseases such as cholera, vector-borne diseases from mosquitoes, mental health trauma, electrocution from damaged electrical systems, and pollution from sewage, chemicals, and other debris.

For vulnerable populations, such as people with disabilities, the loss of potable water or electricity from flood damage can be especially dangerous.



Damage and dust from T.S. Helene flooding in 2024

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Damage to property, infrastructure, and agriculture presents significant economic impacts that extend well beyond flooded areas. Displacement of residents from their homes can exacerbate housing access and affordability, disrupt community connections and resources, and negatively impact mental and physical health. Damage to bridges and culverts can eliminate access to evacuation routes, emergency services, and resources like food and water. Reduced road access is especially dangerous for vulnerable populations such as the elderly or people with disabilities.

Flood events and the subsequent stormwater runoff from impervious surfaces and erosion increase sedimentation and contamination of aquatic systems. Increased stormwater runoff will increase in loading of sediments, nutrients, and contaminants into streams and potential negative effects on plants and wildlife. The intensity of the flood event can alter stream flow patterns and channel hydrodynamics. Aquatic species and ecosystems dependent upon stream velocity, depth, quality, and substrate have the potential to be severely affected by flood events.

Spatial considerations

There are several important spatial considerations for the Swannanoa area regarding flood vulnerability. Due to a combination of steep topography, stream and river barriers, and developments with single entrances, a large number of residents have only one way in or out to access their homes. Undersized/under engineered private bridges and culverts are common, making residents more vulnerable to becoming trapped or unable to reach their homes. Access to and from the Swannanoa area is limited, with the US 70 Hwy corridor and Interstate 40 being the primary ways in and out. Residents living further north are most at risk for having their access cut off.

The Swannanoa River is part of a large drainage area that funnels through the narrow valley where most buildable land is located. Development pressures in this area may result in more structures and lives being at risk as development in hazard areas increases over time. The area is impacted by both upstream flooding as well as downstream flooding, which can cause water to back up, especially around blocked bridges. Two upstream water reservoirs rely on the Swannanoa valley for regular and emergency water releases, requiring management and careful planning.



Flood damaged areas after T.S. Helene, 2024. Swannanoa

C. SNOW STORMS

Past occurrences

According to the NC State Climate Office, the top one-day snowfall events in Swannanoa occurred between 1906 to 1993, with 16 inches of snow being the one-day record. National Oceanic & Atmospheric Administration (NOAA) data shows that since 2008, the highest snowfall events were 14 inches in 2018, and 10 inches in 2009. The 2024/2025 winter season experienced a maximum snowfall event of up to 2 inches.



Swannanoa train station, 1936 snowstorm
Photo credit: Swannanoa Valley Museum

In May of 1992 an unusual storm brought up to 12.2 inches of snow to the Swannanoa area at a time when spring was in full effect, causing downed and damaged trees and power lines. Average annual snowfall, as measured in inches of snow, has been slowly declining in the area over time. Between the late 1800s to 2025 the lowest temperature recorded was negative 17 degrees in 1985.

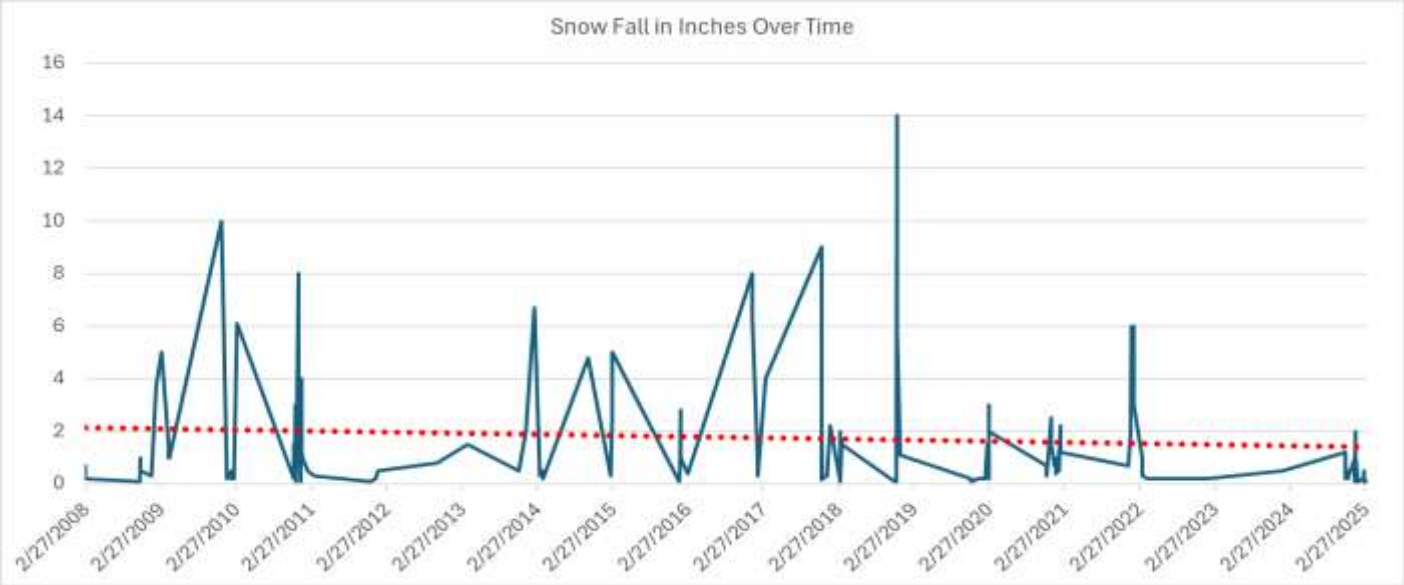


Figure X: Snow fall in inches over time

Future projections

The National Oceanic and Atmospheric Administration's (NOAA) National Center for Environmental Information (NCEI) office has archived data of snowfall in inches for Swannanoa dating back to February 15th, 2008. Figure x graphs the inches of snowfall overtime from 2008 through 2025. The average amount of snow in inches during that time period was 1.78 inches. The average amount of snow fall in 2025 is 0.52 inches, which is 1.26 inches less than the running average. However, outliers such as the 14 inches of snowfall on December 9th, 2018, can contribute to inflated averages.

The trend line presented in figure x shows a gradual decrease in snowfall in Swannanoa over time, though high snowfall outlier events will remain a possibility. Climate change projections predict that by 2044 the area could see 2 fewer days per year below 32 degrees Fahrenheit.

Hazard effects

Snowstorms can pose a variety of hazards depending on the severity of the storm, such as freezing of water reservoirs and its pipes preventing access to water, electrical outages causing disruptions in the heating systems of some homes leading to hypothermia, frozen roads can render common means of transportation difficult which impedes emergency services' ability to reach their ultimate destination. In some cases, large quantities of snow could damage structures from their weight alone. Increased amount of snow, when mixed with high wind speeds, creates conditions for blizzards adding decreased visibility to the list of possible hazards. With each of the burdens on infrastructure caused by severe snowstorms there are cascading effects that can pose a threat to people's wellbeing.

Spatial considerations

There are several important spatial considerations for the Swannanoa area regarding hazard vulnerability. Swannanoa, being in a valley, limits the number of routes in and out of the area. The two main thoroughfares that connect Swannanoa to all areas west of it are Interstate 40 and U.S Route 70. If the conditions on Interstate 40 and U.S Route 70 are made unsafe to drive due to ice, decreased visibility, or large amounts of snow, it would restrict Swannanoa residents' access to critical facilities like the hospital. It would also hinder emergency services ability to respond to calls from people in the area. Another consideration would be the amount of time and effort it would take to ensure resources are brought into the area.

Hazards for your community

Snowstorms at extreme severities can pose significant hazards to the Swannanoa area and its residents. However, considering the relatively mild amount of snowfall the area receives on average (<2 inches per instance of snowfall) the hazard should not be considered a top priority for planning efforts.

In the event of outlier instances of high snowfall Swannanoa residents should be mindful of road conditions and stay prepared with access to canned goods, bottled water, and means to remain warm in instances of power outages. In all, snowstorms can prove to be dangerous to Swannanoa, but the area does not regularly receive excessive amounts of snowfall and trends do not indicate an increased amount of snowfall overtime.



Slippery road conditions in North Asheville, 2024
Photo credit: Ryley Ober, Citizen Times

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D. EXTREME HEAT

According to the Environmental Protection Agency of the United States, the number of extremely hot days is expected to continue to increase over time due to climate change. Extreme heat has a number of detrimental impacts, including being the leading cause of weather-related death in the U.S. Heat can worsen pre-existing conditions, cause heat exhaustion or heat stroke, and has been linked to increased risk of suicide and violence.

"Extreme heat is the number one weather-related cause of death in the United States."

-Klinenberg 2015

Past occurrences

NC State's Climate Office maintains climate trend data based on weather gauges. The closest gauges to Swannanoa are the North Fork 2 station (located at 2,480 ft in elevation) and the Asheville station. Between the late 1800s to 2025 the highest temperature recorded was 100 degrees in 2012. Over the last 60 years the United States has experienced a gradual increase in heat wave frequency, duration, and intensity.

Future projections

Heat projections are based on four scenarios of a change in global temperatures between 1.5 to 4 degrees Celsius. The scenario that ends up occurring depends on what actions governments take to reduce emissions now. Based on past political and economic decisions, it is reasonable to assume that the most extreme heat scenarios are to be expected.



A government cooling center in western states

At the most extreme scenario of 4 degrees of global climate change (an increase of 7.2 degrees Fahrenheit), Buncombe County could expect to see 13 additional days per year over 95 degrees by the early century. This is a relatively lower heat increase compared to surrounding counties at lower elevations. See Figure X below. By the end of 2044 the total days over 90 degrees are projected to be up to 29 days per year, and by the year 2064 projections are up to 60 days per year.

Table X: Annual days with maximum temperatures over 90 degrees.

Time Period	Min. Projection	Avg. Projection	Max. Projection
2015-2044	5.2 days	15.4 days	29 days
2035-2064	9.2 days	28.8 days	60.1 days
2070-2099	21.1 days	65.4 days	104.6 days

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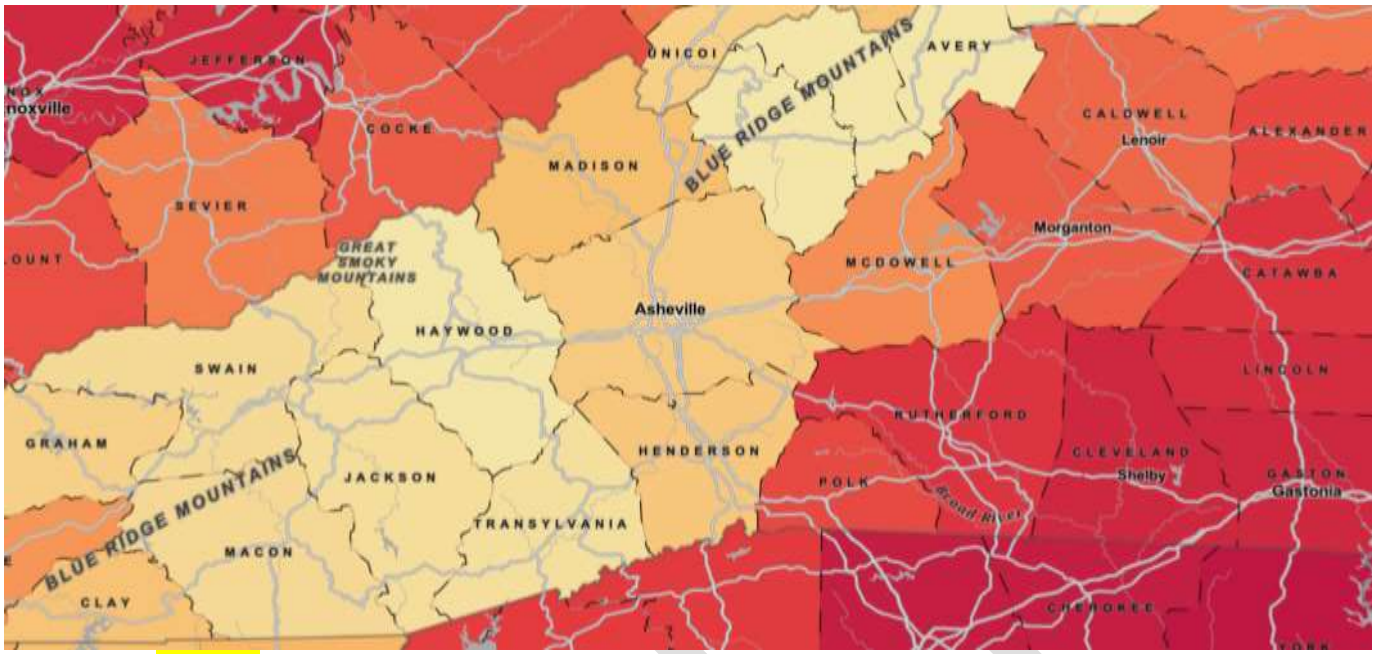


Figure X: Global Warming Level 4 deg. C. Change in the number of days over 95 degrees F.

HEALTH:

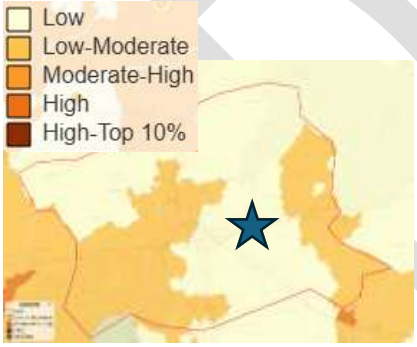
Swannanoa is expected to experience a lower heat risk for health outcomes compared to other parts of Buncombe County, such as areas to the east and in the Woodfin and Candler areas which tend to have higher heat related health risks.

NATURAL & BUILT ENVIRONMENT:

Swannanoa has a low to moderate heat risk for impacts to the natural and built environment. Areas to the west of Swannanoa have more moderate to high risks, while areas to the east of Swannanoa have low risks.

SOCIODEMOGRAPHIC:

Sociodemographics are based on aspects such as age, gender, income, education, ethnicity, etc. Swannanoa has a moderate to high level of sociodemographic indicators, meaning that more individuals are at risk of extreme heat due to demographic factors that make them more vulnerable.







Figures X, X, X: CDC Heat Index. Historical Heat and Health Burden Percentile Rank, Natural & Built Environment Percentile Rank, and Socio-Demographic Percentile Rank.

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Hazard effects

While not as obvious as a wildfire or flood, the hazard effects of extreme heat are far reaching. High temperatures have been shown to reduce learning in educational settings that have insufficient or no air conditioning. It can make outdoor recreation unsafe, impacting child development and the tourism economy. Health impacts from extreme heat include dehydration, heat stroke, and injury from chronic illness and disease that is susceptible to heat.



Roads buckling from a heat wave in NC

Infrastructure impacts include damage to powerlines and vehicle tires, vehicles overheating, and buckling or expanding of roads, airport runways, and rail lines, potentially cutting off key transportation networks.

Labor impacts include lost work hours and wages from high temperature days for outdoor workers, as well as higher costs for consumers from increased electricity use, cooling costs, and construction delays.

The food supply is also impacted, with drought, changes to seasonal planting, livestock stress, reduced agricultural yields, and other impacts causing food to become scarcer and more expensive. Water temperature in aquatic systems causes lower dissolved oxygen levels, stressing coldwater-adapted species. Significant increases in temperature and declines in dissolved oxygen can lead to fish kills and loss of aquatic communities. Increased temperatures are expected to affect upland areas by increasing the frequency of drought conditions and increasing wildfire risk. Warmer temperatures are expected to significantly affect higher elevation forests as these communities tend to occur in over smaller, disjunct areas and contain a high number of endemic species. Generalized increases in global temperatures is also expected to increase northern ranges of invasive insect species affecting forests and wildlife.

Spatial considerations

There are several spatial considerations for the Swannanoa area regarding extreme heat vulnerability. Roughly 17% of occupied housing units in the Swannanoa Township were built prior to air conditioning being widely available, and some units built into the 60's and 70's may still lack cooling options in the event of extreme heat. Residents in higher elevations may be less impacted by sweltering temperatures, but are more at risk of higher solar radiation. Fewer public facilities in the area may mean that residents seeking a place to cool down will need to travel outside of their community. The elderly, people with disabilities or heat-sensitive health issues, and those lacking a car are at higher risk. Areas with large amounts of impervious surface, few trees, and at lower elevations, such as Downtown Swannanoa, are most at risk of extreme heat.

Hazards for your community

While extreme heat effects will be slower to impact residents of Swannanoa compared to other parts of North Carolina, vulnerable populations should be aware of risks and prepared to take action to keep themselves safe. Examples include identifying nearby cooling locations and evacuation plans if power goes out or if cooling is unavailable where they live and having an emergency contact who can assist them. Public facilities, such as schools, libraries, and community shelters, may be appropriate locations for emergency cooling centers.

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E. LANDSLIDES

Landslide refers to the relatively rapid downhill movement of soil, rock, and vegetation, and other debris driven by gravity. In Western North Carolina, landslides are closely tied to the amount and duration of precipitation, with heavy rainfall, rapid snowmelt, or wildfire burn scars often triggering slope failures. They also commonly start/occur below old logging roads located on steep slopes. They may occur slowly, causing gradual damage, or move so rapidly that they destroy property and threaten lives. Like flooding and wildfire, landslides can block roadways, disrupting supply chains and emergency services, while the movement of debris can impair drinking water supplies and degrade streams important for fisheries and recreation.

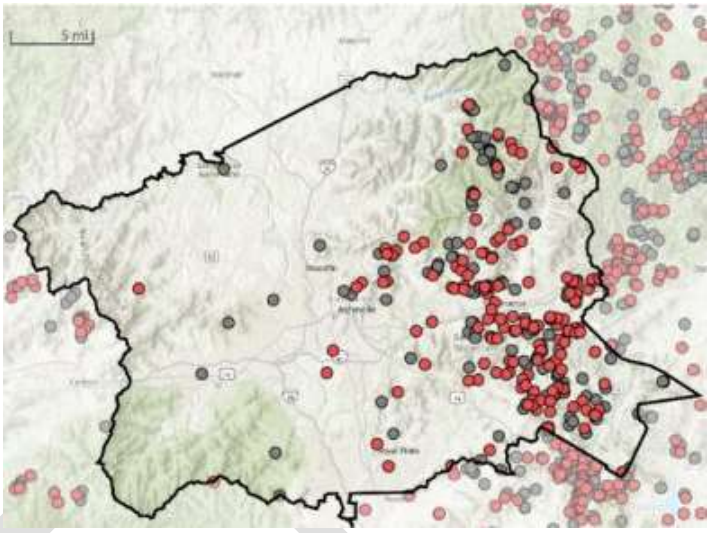


Figure X: Landslides in Buncombe County from T.S. Helene, October 2024

Map source: U.S. Geological Survey / AVL Watchdog

Landslides often follow drainage flowpaths and stream channels, which can result in severe sedimentation of aquatic habitat and also rerouting of the stream channel given the sudden deposition. The erosion and sediment produced by a landslide will eventually end up entering a waterbody, which adds to the ongoing issues WNC has with sediment pollution in its streams and rivers. The frequency and severity of landslides in the region are exacerbated by steep terrain, the underlaying geology, frequent heavy precipitation, and human activities such as development and vegetation removal on unstable slopes. In recognition of these risks, Buncombe County adopted a steep slope ordinance in 2008 to help limit development on high-risk terrain and reduce exposure to landslide hazards.

Past occurrences

Historic slope deposits include accumulations of earth, rock, and debris primarily as a result of previous landslides or debris flows. In the Swannanoa township area, 82 locations of historical slope deposits have been identified amounting to 2,114 acres.

In addition, more recent slope movements (pre-Helene) have also been identified for the area and include 12 distinct locations amounting to about nine (9) acres of land.



Landslide north of Grovemont, 2024

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A multi-agency effort has mapped the recent landslide events from Hurricane Helene. This effort has identified 47 landslides within the Swannanoa area, which includes 9 landslides formed above the Grovemont neighborhood. Landslides occurred heavily in the eastern part of Buncombe County.

Future projections

For this assessment, two products developed by the N.C. Geological Survey were used to define landslide hazards: **probability of sliding**, a susceptibility metric that indicates low, moderate, and high probabilities of slope failure in response to intense rainfall (about 5-6 inches within 24 hours) and **potential debris pathways**, which identify general areas that could be affected by future landslide impacts based on landscape characteristics.

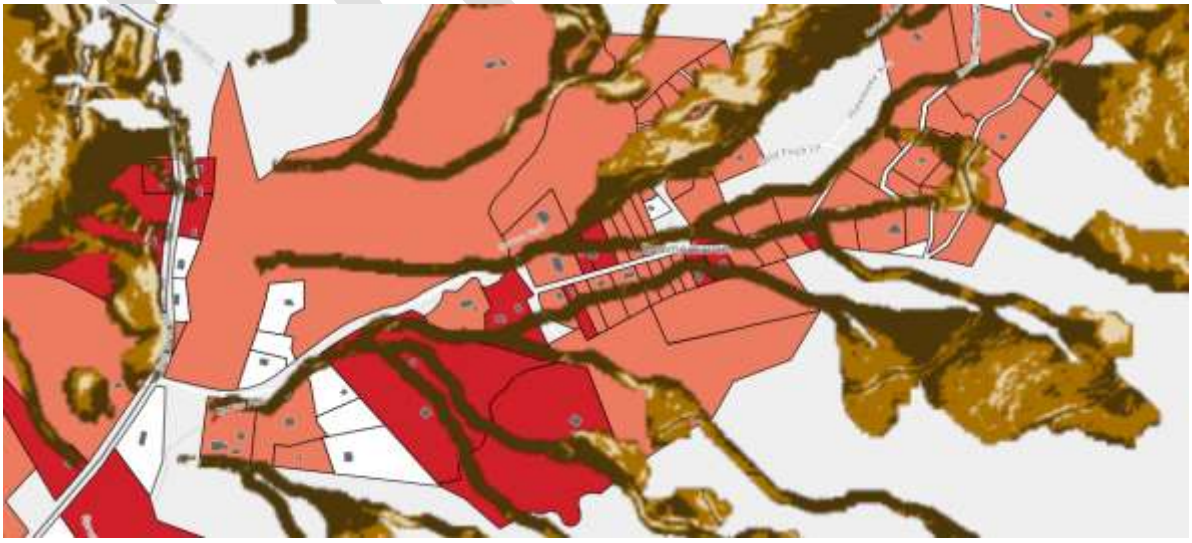
In Swannanoa, 26% of residential homes and 24% of commercial buildings had a medium to high vulnerability and risk to landslides.

Note: 2020 ACS data

To evaluate landslide adaptive capacity for each asset, the assessment considered Buncombe County's steep slope ordinance as a measure of regulatory protection intended to reduce development pressure and exposure on high-risk terrain. An increase in landslides can be expected due to a number of factors, such as climate change-related increases in precipitation and wildfires, and ongoing development activities that can trigger slides. Roughly 26% (7,955 acres) of Swannanoa's land area is within a potential debris flow pathway (See Figure X). The following data summarizes landslide risk based on the presence of structure and property assets that are vulnerable:

Table X: Landslide Vulnerability & Risk Assets, Swannanoa

ASSET TYPE	# OF ASSETS	$ VALUE
COMMERCIAL	38	$23.4 million
RESIDENTIAL	1,939	$407 million
NATURAL & AGRICULTURAL LAND	144	$265,000
CRITICAL FACILITY & GOVERNMENT	31	$111 million
TOTAL	**2,152**	**$541.6 million**



Example of high (red) and medium (orange) vulnerability and risk residential assets along Summer Haven Rd. Landslide hazard areas are in brown.

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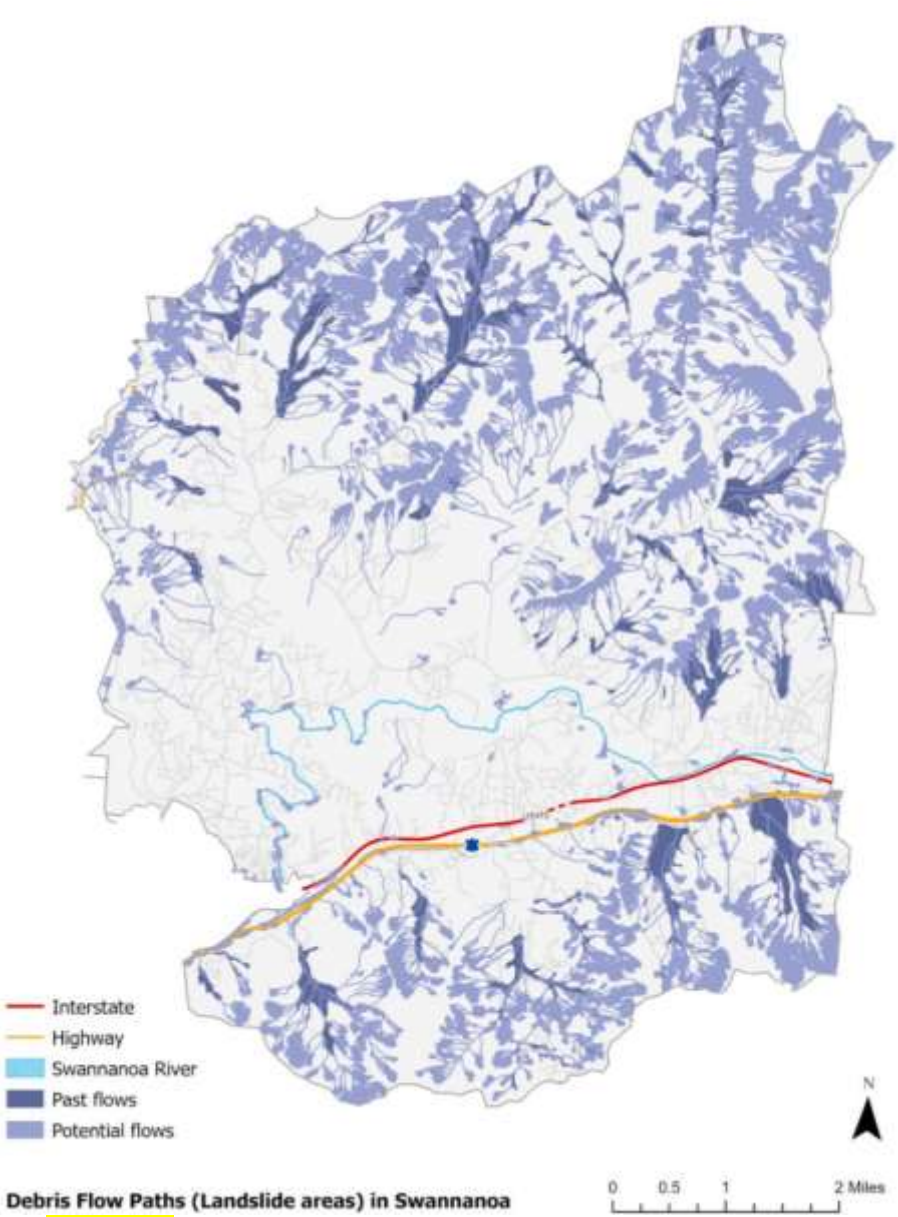


Figure X: Debris Flow Pathways (Landslide Hazard Areas) Map



Figure X: Slope Stability Hazard areas (Unstable soils) in Swannanoa

As a separate hazard data source compared to debris flow pathways, the stability of slopes (called the Slope Stability Index, see Figure X) is categorized by low, moderate, and high hazard risks based on the type of soils on the site. The higher the hazard rating, the more likely that the ground could shift, causing structure or infrastructure damage, or a landslide. Nearly 150 structures in Swannanoa (2% of all of Swannanoa structures) are located on a moderate to high hazard soil area. This does not account for structures that are directly adjacent to hazard soils.

Commercial Risk

38 commercial assets, valued at $23.4 million, are at risk of landslides in the Swannanoa Township, primarily along the US 70 Hwy Corridor. Commercial buildings are less likely to be located in steeper and more rural areas, making them less susceptible to landslide risk.

Landslide hazards in the transportation corridor area result primarily from cut and fill slopes from past road construction, as well as large debris flow areas along uphill streams and drainage flows from nearby higher elevation slopes. Areas along US 70 Hwy can be impacted by landslides occurring higher up on the mountains, especially to the south of Interstate 40



Medium vulnerability/risk commercial assets on Patton Cove Rd.
Landslide hazard areas in brown.

Residential Risk

1,939 residential assets, with an estimated value of $407 million, are at risk of landslides in the Swannanoa Township. A primary driver of risk is development sprawl into rural and steeper slope areas. Risk is most obvious in the northern and southern parts of the Township where elevations and slope steepness increase. Some of the highest levels of vulnerability and risk are located in communities around the following areas:

Table X: Examples of High Vulnerability & Risk Areas by Primary Road Name	
South of U.S. 70 Hwy	**North of US 70 Hwy**
• Christian Creek Road • Patton Cove Road • Dennis Street • Fountain Way • Wilson Cove Road • Jims Branch Road • Lytle Cove Road *(Black Mtn. Township)*	• Wilson & Hawthorne Ave. • Alpine Way • Riddle Road • Woodland Drive • Summer Haven Road • Shope Creek Road • Bull Creek Road • Jones Cove Road

Natural & Agricultural Land Risk

144 natural and agricultural land assets are located in Swannanoa. Landslide risks to these areas are most pronounced in the northwest, and to the southeast. Unlike residential and commercial vulnerability, natural and agricultural lands often do not have an at-risk structure. Risk is typically a result of the high likelihood that a landslide could occur. While structures may be less at risk, landslides in natural and agricultural areas can damage ecosystems, food systems, water sources, and utilities that people rely on.

Critical Facility & Government-Owned Risk

31 medium to high vulnerability/risk government-owned or critical facilities are located in the Swannanoa Township, with an estimated asset value of $111 million.

The Beetree reservoir is one example of a critical facility within Swannanoa that faces multiple landslide hazards, including to the dam and water source, and having a low adaptive capacity score, high vulnerability, and high risk.



Potential (green) landslide hazard areas, and areas of past landslide activity (orange) around the Bee Tree reservoir

Grovemont Slide, 2024

In 2024 Tropical Storm Helene caused an unprecedented number of landslides across Western North Carolina, including Swannanoa. One landslide cluster is located to the north of Sassafras Valley Road in the Grovemont neighborhood. Initial project reports indicate that all 500+ homes and over 100 businesses are at threat from 9 active landslides that sit above the community.

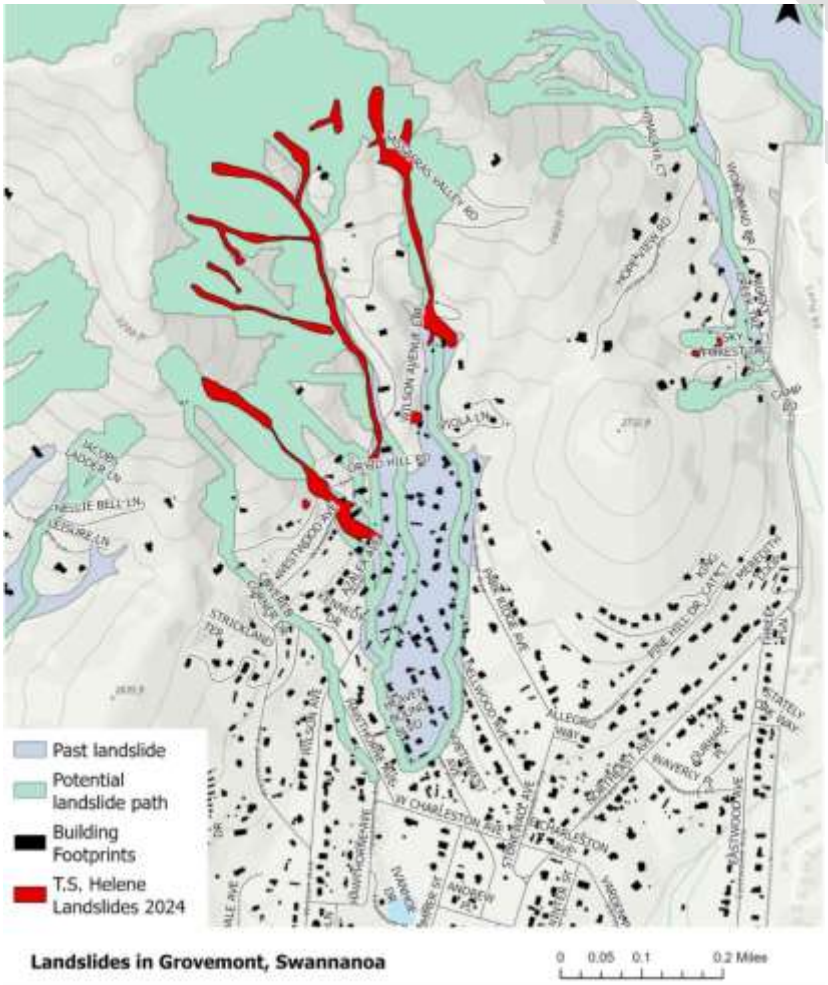


Figure X: Past and potential future landslides in Grovemont.

At the time of this report Buncombe County Government was working with FEMA and the State of North Carolina to complete an engineering study to determine the level of risk from the landslides, and recommend stabilization options.

Roughly 82 residential homes are directly within an area of past debris flow pathway or potential future landslide in this neighborhood. See Figure X.



A landslide above Grovemont, 2024

Hazard effects

While debris flow pathways are mapped, predicting when and where a landslide will happen is difficult. Landslide impacts can extend far beyond mapped areas, meaning that many more structures and lives are at risk than are known. In addition, the hazards associated with moderately sloped areas is often underestimated, causing a false sense of security in less steep communities.

Landslide risk to natural lands includes effects to forest structure, potential loss of rare wildlife and plant populations, degradation or loss of intact habitat, and sedimentation and contamination of aquatic systems degrading water quality. High elevation forests are most at risk of landslides, which can be devastating for rare and endemic species living in small, disjunct populations. Debris flows into natural aquatic systems change the structure of substrate, water velocity, and depth, potentially affecting water temperature and benthic insect community structure required by coldwater species. Natural systems recovering from landslides are often at greater risk to invasive species, ongoing erosion, and land use changes.

Spatial considerations

There are important spatial considerations for the Swannanoa area regarding landslide risks. Many residents of Swannanoa live in or around known landslide hazard areas. Whole neighborhoods in Swannanoa have been built on the remnants of past landslides due to the often gentler slope associated with prior landslide fill.

A high number of limited access roads and driveways makes the community more vulnerable to being cut off during a landslide event, even when their own property is not specifically involved.



A neighborhood built on past landslide debris

Hazards for your community

Landslide hazards are a serious, ongoing risk for many areas of Swannanoa. While landslides are part of the natural process of downslope movements of mountains over time, development in and around these areas puts human lives and property at risk. Community awareness about landslide hazards is important, including knowing how to spot the signs of certain types of landslides before they occur, having evacuation routes and emergency safety plans in place, and being aware of high and moderate landslide hazard areas when developing or purchasing property.

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F. WILDFIRE

A wildfire is an unplanned fire that originates in natural or wildland areas. Wildfires can damage critical natural resources as well as communities located in the wildland–urban interface (National Wildfire Coordinating Group, 2012). As the climate warms, wildfires are projected to increase in both frequency and extent, driving up costs associated with public health impacts, fire suppression, and the loss of homes and infrastructure (USGCRP, 2017). Reports published by the Intergovernmental Panel on Climate Change (IPCC) support these projections, noting that rising temperatures and longer, more intense droughts are expected to increase wildfire occurrence and reduce the effectiveness of prescribed fire.



Great Smoky Mountains wildfire, 2016
Photo credit: Blue Ridge Outdoors

While the western United States experiences the largest total area burned by wildfire, the Southeast records the highest number of wildfire events. Rapid urban expansion near managed forests further reduces opportunities to use prescribed fire, increasing the likelihood of wildfire occurrence and amplifying impacts on the economy and public health (USGCRP, 2017). Wildfire risk is based on the likelihood of a fire occurring in a certain area, the intensity that a fire could achieve from available vegetative fuel and topography, what communities could be exposed to the fire, and the susceptibility of homes or communities to be damaged. Risk may also consider the emergency response facility location (distance of a fire station from structures) and average response times. Together these factors create wildfire risk.

Past occurrences

No significant wildfires were identified inside of the Swannanoa Township based on FEMA, NCSU, and USDA historical records. In 2009 a small, 0.2 acre fire was caused by lightning strike on private property in Riceville near Independence Blvd.

Current conditions

Swannanoa's overall wildfire risk is medium to very high depending on which risk type is being analyzed:

Table X: Swannanoa Wildfire Risk Levels

Risk Type	Risk Level	Comparison
Risk to homes	Medium	Higher than 68% of communities in the U.S.
Likelihood of wildfire	High	Higher than 71% of communities in the U.S.
Risk Reduction Zone	Very High	Structures are mostly in a Direct Exposure Zone
Vulnerable Populations	Very High	Social and economic factors make the population vulnerable

Wildfire risk reduction areas are calculated based on level of structure exposure. Structure exposure is broken into 3 categories: Minimal exposure (home is unlikely to experience a wildfire), Indirect exposure (Home may catch on fire from embers or nearby homes on fire), and direct exposure (Home may catch on fire from nearby vegetation, embers, or other homes on fire). Figure X shows that the majority of structures within the Swannanoa Township have a direct exposure risk, with some structures along the US 70 Hwy corridor having indirect exposure risks.

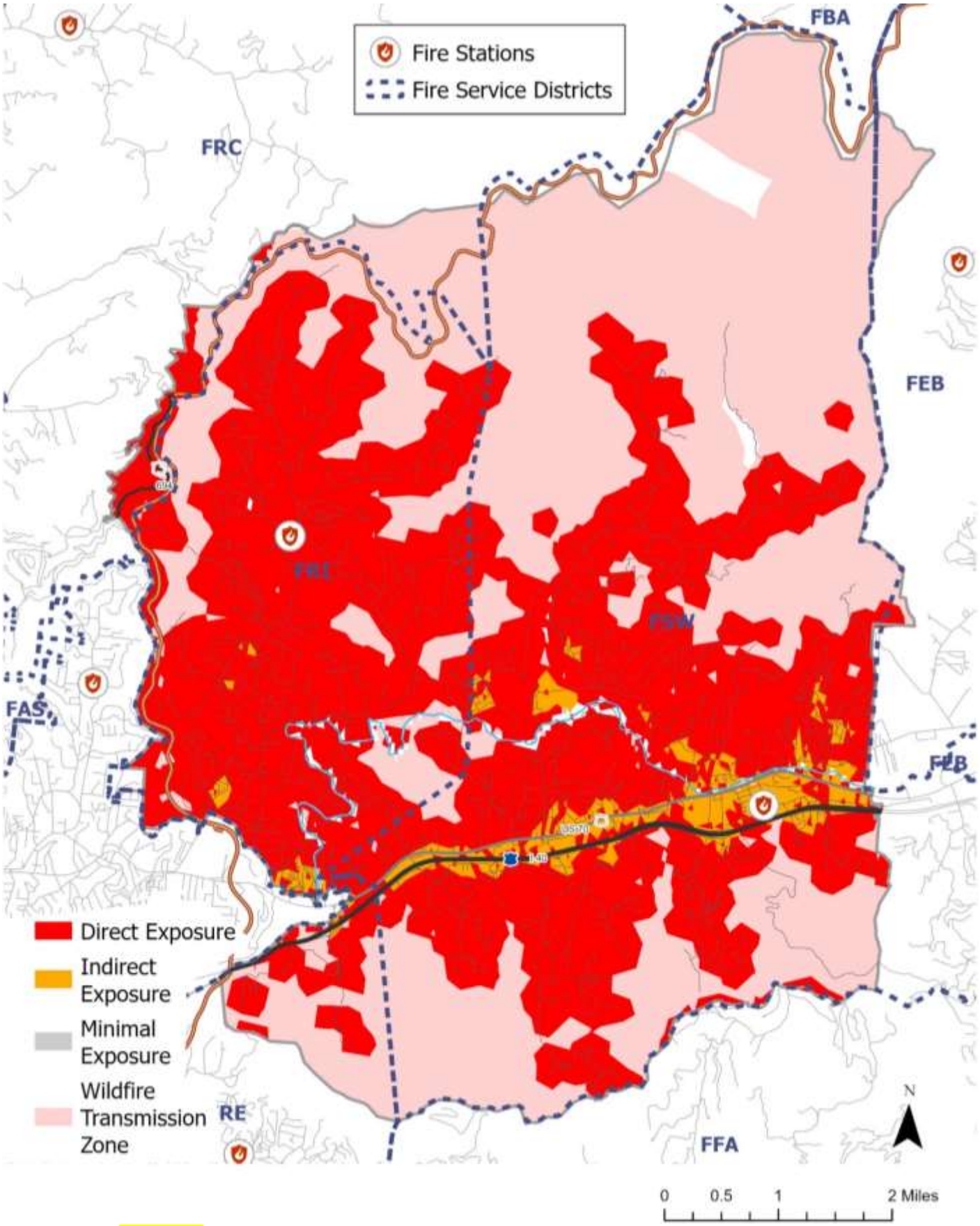


Figure X: Wildfire Hazard Risk to Structures. *Data source: USDA U.S. Forest Service.*

There are two fire stations located within the Swannanoa Township: One to the northwest quadrant on Riceville Road, and the second adjacent to Beacon Village on Hughes Street in the southwest quadrant of Swannanoa. The area is bisected by five Fire Service Districts: East Buncombe, Swannanoa, Riceville, Reems Creek, and Reynolds Fire Districts. Districts and stations are shown above in Figure X. The average fire service response time is XYZ.

Future projections

Between 2015 to 2044, the annual number of days with no precipitation is expected to increase by 1.7 days at both the lower and higher climate change emissions projections. In addition, the number of days per year over 90 degrees is projected to increase by almost 12 additional days. Taken together, more dry days and hotter temperatures means dryer vegetation and more fuel for wildfires.

The number and intensity of wildfires is expected to increase, and as development continues to encroach into forested areas, the number of structures and people that are at risk is also expected to increase.

Significant tree blowdown during Tropical Storm Helene in 2024 has also resulted in an unprecedented amount of wildfire fuel in the form of ground debris. As these fuels dry out over time they will become more susceptible to fire risks.

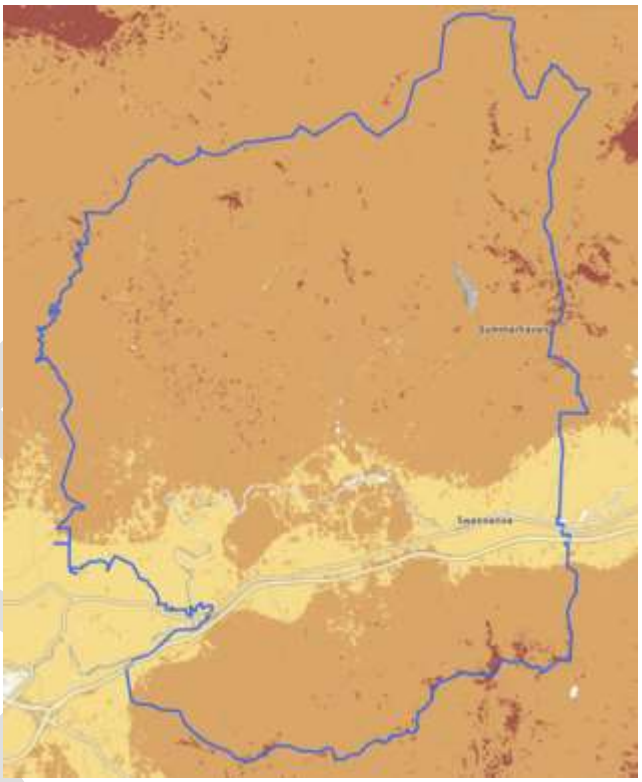


Figure X: Wildfire Hazard Risk to Homes. USDA U.S. Forest Service.

Hazard effects

Wildfire effects include direct impacts from fire to vulnerable structures, property, and human and animal health, as well as secondary impacts from smoke, high temperatures, and pollution. Smoke exposure can impact large areas far beyond where fires burn, causing respiratory issues, lung damage, carbon monoxide poisoning, and lead to other health problems or death. Fire can release toxic substances into the air, soil, and water, causing long term hazardous conditions. Trauma from wildfire events can increase cases of PTSD, anxiety, and depression in the community.

Much of North Carolina's native forests are fire adapted and benefit from periodic low intensity fires. However, wildfires increase tree mortality, and areas that have not benefited from periodic fires are more prone to larger, hotter fires that may damage or eliminate ecosystems. Soil erosion from the loss of vegetation from wildfires also negatively impacts water bodies.

Spatial considerations

There are several important spatial considerations for the Swannanoa area regarding wildfire vulnerability: As outlined in other hazard sections above, limited road access in and out of many communities increases the risk to residents in the event that they need to evacuate the area from a wildfire. When roads are cut off, people may be forced to shelter in place or walk to safety. This is especially problematic for individuals with children,

disabilities, mobility challenges, and the elderly. Proximity to Pisgah National Forest and other heavily wooded areas is also a risk factor, as these locations are more likely to experience large fire events. Tree blowdown areas from Tropical Storm Helene in 2024 added significant wildfire fuel to the forests from debris, increasing the risk of future large fire events.

Hazards for your community

The risk of wildfires in Swannanoa is high, and many areas of the community are especially vulnerable due to development patterns that put people in higher wildfire risk areas with limited access. Individual property owners and neighborhoods can take actions to strengthen their homes and properties from fire, such as by using ignition-resistant building materials, and creating space around structures that can be a buffer between the home and a fire.

G. HIGH WIND AREAS

The North Carolina State Building Code designates High Wind Zones as being areas with an elevation at or above 2,700 feet above sea level. These zones are used to determine the minimum building design standards for withstanding certain wind speeds. High Wind Zones can pose dangers to the integrity of under-hardened structures, or from a higher likelihood of flying debris or falling trees. Buildings located on the leeward side of a mountain are at an increased risk due to conditions that concentrate wind forces in ways that further threaten buildings. Almost all moderate to severe tree blowdowns that occurred during Tropical Storm Helene occurred within high wind zones.

48% (14,565 acres) of the Swannanoa Township land area is located within a High Wind Zone, specifically to the north around the Blue Ridge Parkway corridor and Pisgah National Forest, and to the south of Interstate 40.

As of 2025 there were 290 structures built in a high wind zone, the majority of which are in communities at the end of Long Branch Road, Summer Haven Road, High Hickory Trail, Bryant Road, Big Level Drive, and Peach Knob Drive. About 17,250 acres have been identified to have either moderate or severe tree blowdowns or loss in the Swannanoa area.

Climate changes to high wind zones in the future will vary based on regional and local conditions. Some areas may experience a decrease in wind speeds, while others will experience an increase. Stronger hurricanes can exacerbate the hazards associated with higher elevation properties.

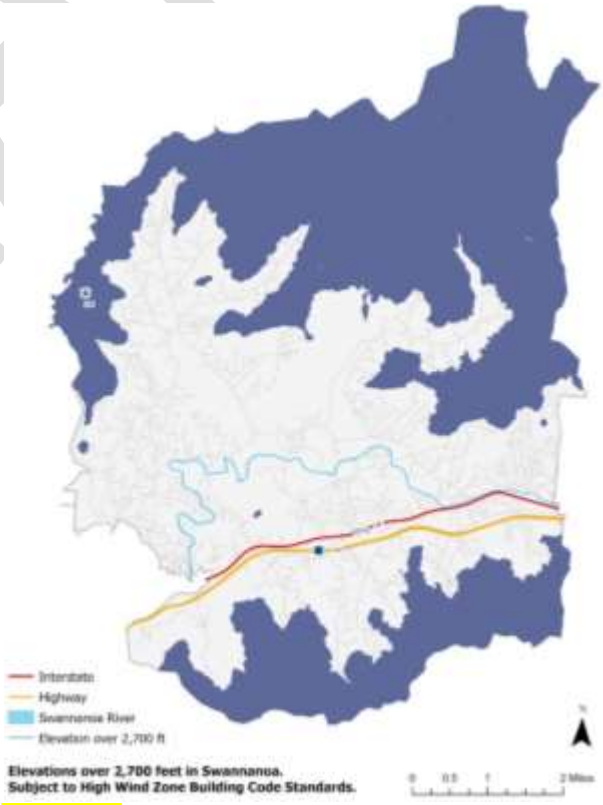


Figure X: Areas with elevations over 2,700 feet, subject to High Wind Zone building codes.

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4. SENSITIVITY

Hazard sensitivity is defined as the degree to which a system, population, or asset is likely to be affected by a hazard. It reflects how vulnerable something is to damage or disruption if a hazard occurs, with higher sensitivity indicating a greater likelihood of negative impacts. The sensitivity of an asset is determined by both its physical location in relation to a hazard area and the criticality of the service it provides. For example, a school or emergency facility located within a flood zone is considered highly sensitive because disruption would have significant consequences for the community. In comparison, assets such as outdoor recreation fields may be less sensitive to the same flood hazard because the impacts are less severe. Ultimately, assets with structures located inside a hazard extent and with critical uses are categorized as having the highest sensitivity.

For this assessment, sensitivity was examined for three primary natural hazards: flooding, landslides, and wildfire. Flooding sensitivity was evaluated by determining where building footprints overlapped with flood extents and whether the use of the structure was critical to community operations. Landslide sensitivity focused on assets located on or downslope of steep, unstable terrain, where slope failure could damage structures or block access routes. Wildfire sensitivity accounted for both the presence of assets in fire-prone areas and the importance of their use, such as facilities that serve vulnerable populations.

Community Asset (Parcel) Categories

Asset Category	Description
Residential	Homes and other residential property, including single family homes, multifamily homes, and specialty housing (like group homes or mobile home parks).
Commercial	Any property that is primarily commercial (offices, supermarkets, retail, etc.).
Critical Infrastructure & Government Owned	Services and facilities that are important for community wellbeing and functioning, such as government owned properties, utility infrastructure, schools, and emergency response assets.
Natural and Agricultural Land	Land that includes agricultural property (crops, livestock, etc.) or natural green space (conservation land, locally managed protected land, etc.).
Vacant Land	Undeveloped or vacant property.

The 2024 Buncombe County property parcel dataset from NC OneMap (originally sourced from the Buncombe County Tax Assessor's Office) was the foundational asset data for the assessment, and it is supplemented with other point or polygon data sources from NC OneMap, the USGS Protected Areas Database (PAD-US), US Cropland Data Layer (USGS), North Carolina State Historic Preservation Office (NCHPO), and local datasets. The supplemental data were spatially intersected with the parcel data to add granularity to the parcel use codes and represent specific community asset types identified by the project team and community

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Summary of Assets Included by Asset Category

Swannanoa is home to many valuable assets, from protected green space to critical emergency response facilities. The 600 acres of land near Warren Wilson College preserved as protected forests and trails, the Swannanoa River Greenway, and local parks like Charles D. Owen Park are critical natural assets for the community. Some assets, like the Bee Tree Dam, the Swannanoa Library, and the two Swannanoa Fire Service District fire stations are important for emergency response during a hazard event for both residents and first responders.

Additionally, commercial and residential property that supports everyday life for Swannanoa residents includes a wide range of manufactured housing locations and small businesses that provide essential services and are critical to the stability and economic activity of the town. Individual asset types were categorized and identified to provide a granular view of the area's vulnerability. Each individual asset type is given an asset 'tag' based on available data, which was then assessed at the parcel level.

Asset Category	Tags Included
Residential	Single family homes, multifamily homes, condominiums, miscellaneous residential property, group homes, mixed use residential property, manufactured housing, mobile home parks.
Commercial	Industrial property, offices, daycares, supermarkets, warehouses, mixed-use commercial property, miscellaneous commercial property, retail, restaurants, lodging, gas stations, SNAP retailers, automotive services.
Critical Infrastructure & Government Owned	Emergency services, police, libraries, schools, higher education, medical facilities, educational facilities, communications, water utility infrastructure, dams, energy, government owned property, correctional facilities, fire stations, miscellaneous transportation, animal care facilities, parks, recreation, faith-based institutions, cultural property, nonprofits, cemeteries, mortuaries, community centers, shelters, historic.
Natural and Agricultural Land	Conservation, locally managed land, state/private/federal managed land, cropland.
Vacant Land	Vacant agricultural, vacant commercial, vacant government-owned, undeveloped land.

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Summary of Vulnerability Assessment by Asset Category

In the Swannanoa Township, the highest vulnerability and risk were for vacant land wildfire exposure, natural/agricultural land wildfire and landslide exposure, commercial flooding, and residential wildfire.

Asset Category	Total	Highly Vulnerable and at-Risk			
		FEMA Floodplain (500-yr or 0.2% annual chance)	NCEM Advisory Floodplain (1,000-yr or 0.1% annual chance)	Wildfire	Landslide (Potential Debris Flow Pathways)
Residential	7,412	430 (6%)	1,059 (14%)	3,809 (51%)	1,938 (26%)
Commercial	159	42 (26%)	104 (65%)	68 (43%)	37 (23%)
Critical Infrastructure & Government Owned	325	66 (20%)	107 (33%)	150 (46%)	100 (31%)
Natural and Agricultural	380	58 (15%)	116 (31%)	265 (70%)	198 (52%)
Vacant Land (Exposure)	1,961	221 (11%)	445 (23%)	1,961 (100%)	805 (41%)

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Summary of Vulnerability Assessment for Specific Asset Types

Some assets are considered to have higher sensitivity based on their criticality to community function and response in an emergency. While not an exhaustive list, the table below highlights some assets that provide critical services to the community and their vulnerability in different hazard scenarios.

Asset Category	Asset Type	Total	Highly Vulnerable and at-Risk			
			FEMA Floodplain (500-yr or 0.2% annual chance)	NCEM Advisory Floodplain (1,000-yr or 0.1% annual chance)	Wildfire	Landslide (Potential Debris Flow Pathways)
Residential	Manufactured Homes & Mobile Home Parks	733	696 (95%)	704 (96%)	726 (99%)	693 (95%)
	Multifamily Homes	386	39 (10%)	99 (26%)	307 (80%)	134 (35%)
Critical & Government Owned	Schools	1	1 (100%)	1 (100%)	1 (100%)	0 (0%)
	Daycares	1	0 (0%)	1 (100%)	1 (100%)	0 (0%)
	Medical Facilities	1	0 (0%)	0 (0%)	0 (0%)	0 (0%)
	Emergency services	3	2 (67%)	3 (100%)	2 (67%)	0 (0%)
	Fire Stations	4	3 (75%)	4 (100%)	3 (75%)	0 (0%)
	Police	4	3 (75%)	4 (100%)	3 (75%)	0 (0%)
	Government Owned	3	1 (33%)	1 (33%)	2 (67%)	0 (0%)
	Cultural Properties	380	58 (15%)	116 (31%)	265 (70%)	198 (52%)
Natural and Agricultural Land	Conservation (Exposure)	18	1 (6%)	5 (28%)	18 (100%)	17 (94%)
	Locally Managed Land (Exposure)	35	18 (51%)	16 (46%)	35 (100%)	21 (60%)

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Geographic Areas & Socioeconomic Conditions

Socioeconomic metrics may include populations such as older adults, children, people with health challenges, and households with limited financial resources. These groups may face greater challenges preparing for, responding to, and recovering from hazard events. In some areas, they may also live in areas that are more prone to flooding, wildfire, extreme heat or other risks, or they may have fewer resources to recover when hazard events occur. Based on the results shown above, almost all (between 95% and 99%) manufactured homes and mobile home parks are highly vulnerable to all three of the natural hazards evaluated in this study.

To assess social vulnerability, the assessment utilizes social and economic metrics at the block group levels from the 2021 American Community Survey (5-year estimates) and through the Centers for Disease Control and Prevention (CDC) Social Vulnerability Index (SVI), which measures social vulnerability through four themes at the census tract level: household composition and disability; socioeconomic status; minority status and language; and housing type and transportation (CDC, 2024). A few individual metrics are illustrated in the following maps as an overlay, **shown in hatched purple lines**, at the census block group level. This visualization helps highlight where higher levels of social vulnerability coincide with areas of risk, making it easier to see patterns of concern across the community.

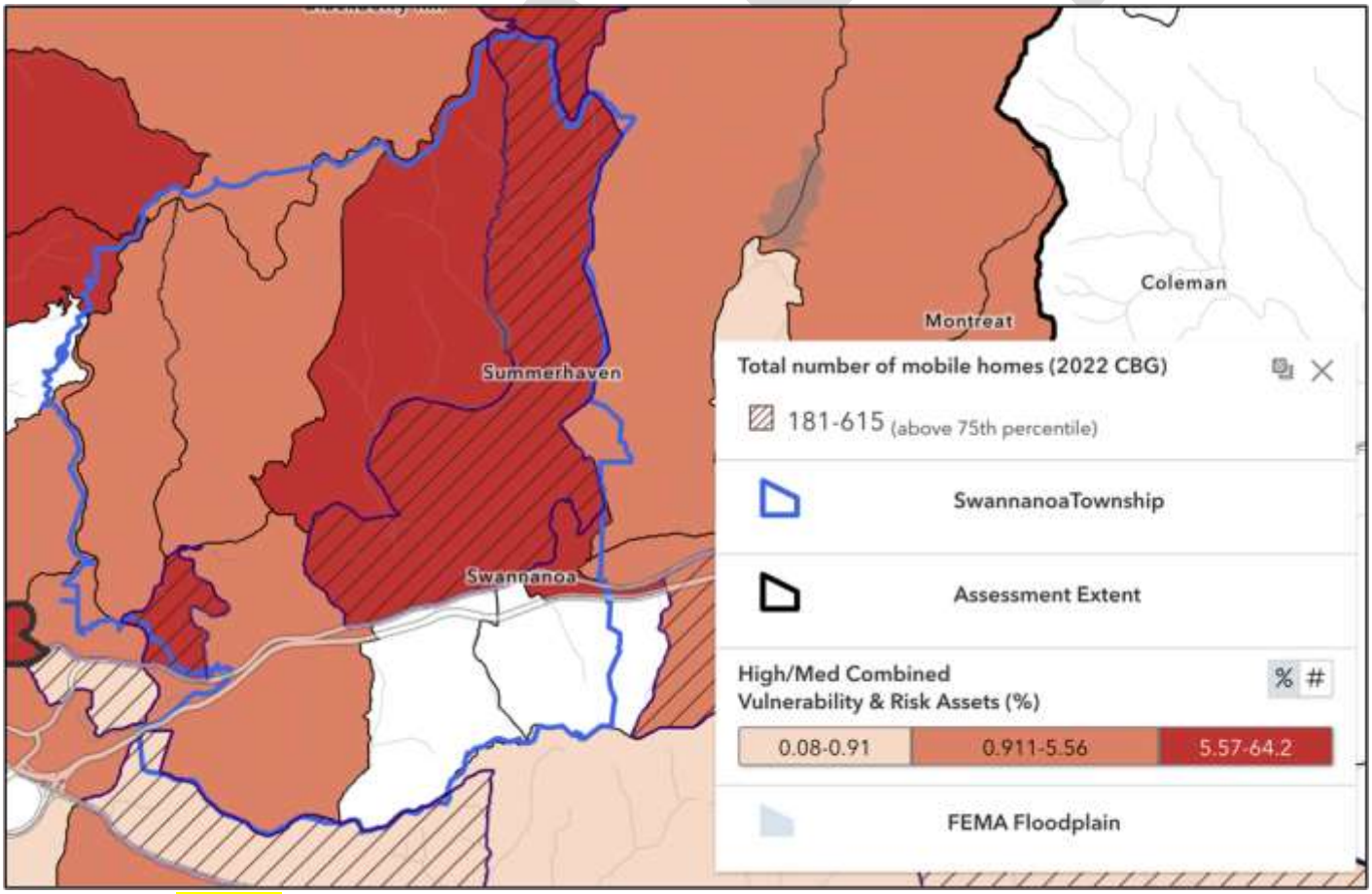


Figure X: Social Vulnerability, Mobile Homes and high/medium vulnerability and risk

Four census block groups in the study area show high levels of residential vulnerability due to being within the FEMA-mapped floodplains. The census block groups in dark red represent areas where 7-15% percent of all residences are considered highly vulnerable.

Two block groups stand out with especially high numbers of mobile homes, ranking above the 75th percentile in the region for this housing type. Many of these mobile home clusters are situated in close proximity to the Swannanoa River, placing them within areas identified as vulnerable to FEMA-mapped flooding. As a result of Tropical Storm Helene in September 2024, many mobile homes in these vulnerable areas were destroyed or badly damaged by flooding, confirming what the pre-storm census data had predicted.

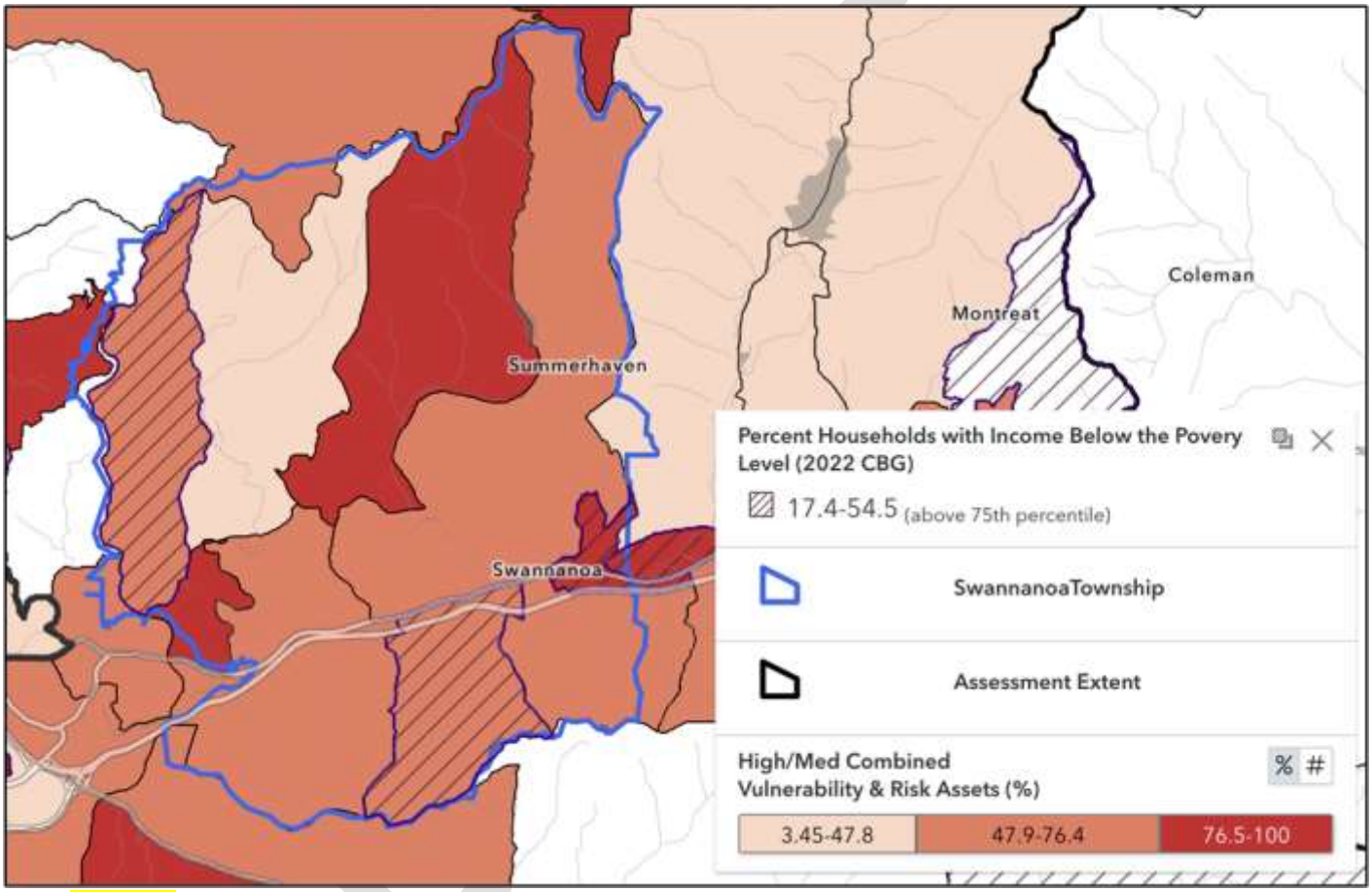


Figure X: Social Vulnerability, Households below poverty level and high/medium vulnerability and risk

Figure X shows three census blocks with high vulnerability to NCEM-mapped floodplains. The greatest concentration of highly vulnerable commercial properties is along the Swannanoa River and US 70 where 90% of commercial properties are highly vulnerable. This is also an area that also overlaps with a high percentage of households living below the poverty line.

This map shows multiple census block groups with high residential landslide vulnerability in the study area, with the highest concentration of debris pathways in the northern and southern parts of Swannanoa. Each dark red census block group has more than 31% of residential properties that are vulnerable to potential debris flow pathways. In southern Swannanoa, some of the areas with higher concentrations of exposure also overlap with households living below the poverty level, which can compound challenges related to

preparedness and recovery. While many of the exposed parcels are identified as residential, sections of I-40, as well as dispersed commercial, government-owned and critical facilities also face vulnerabilities.

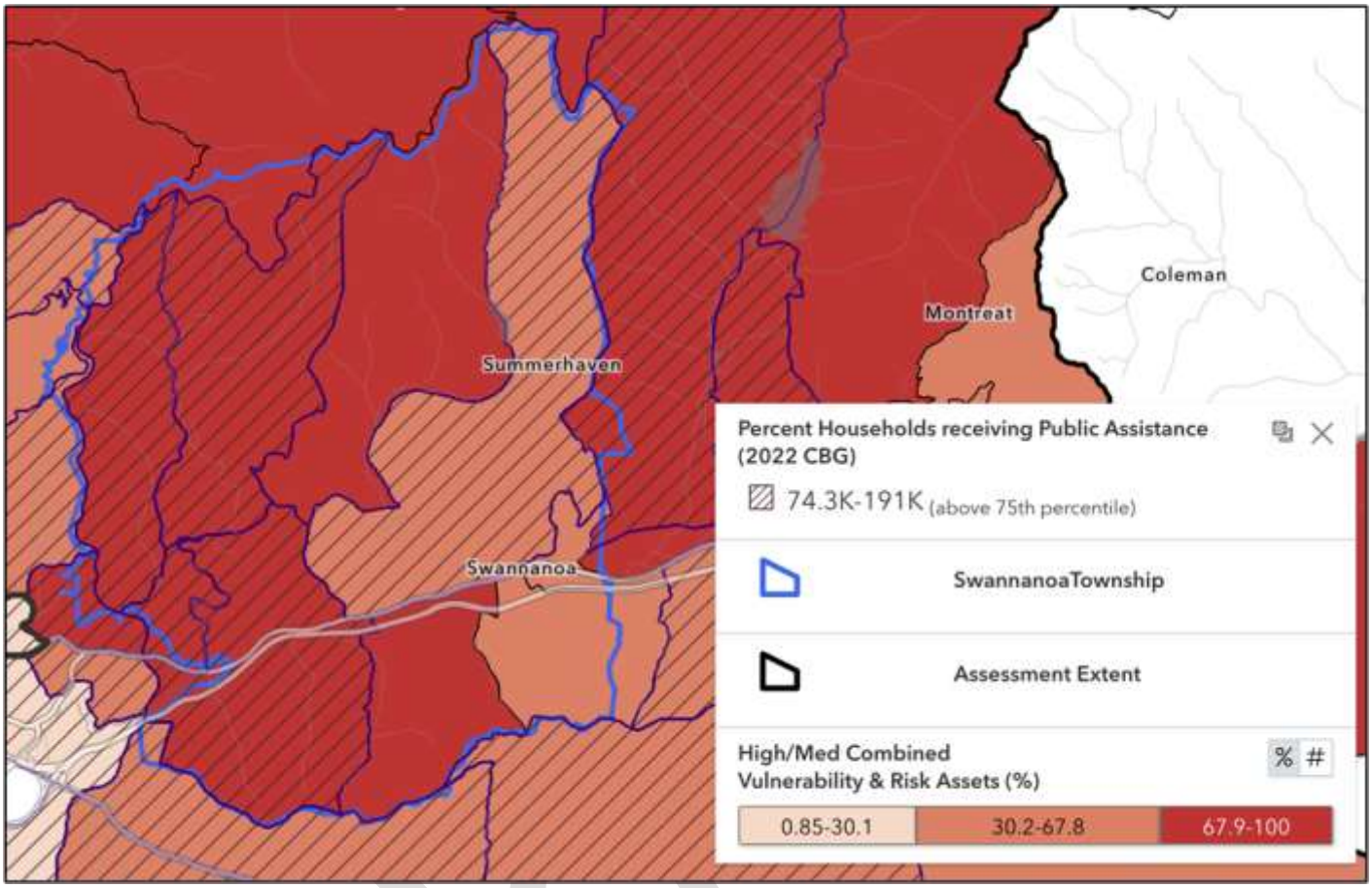


Figure X: Social Vulnerability, Receiving public assistance and high/medium vulnerability and risk

The majority of census blocks in the study area have high wildfire vulnerability for Natural and Agricultural Lands with more than 67% of the natural or agricultural lands being highly vulnerable. Many of the highly vulnerable blocks in the east also have a high percentage of households receiving public assistance. This overlap highlights how wildfire impacts on agricultural lands can intensify socioeconomic consequences for residents who already have fewer resources to prepare for or recover from a potential wildfire event.

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Road Connectivity

The Swannanoa area has limited road access. Figure X shows the 8 primary vehicle access points, or points of ingress and egress for the area. The majority are clustered around the Tunnel Road/US 70 Hwy areas to the east and west of the major transportation corridor. Access points include the following locations:

West into City of Asheville	1. Interstate 40 exit at Porters Cove Rd 2. Lower Grassy Branch and Tunnel Road intersection 3. Riceville Rd and Blue Ridge Parkway intersection
East into Black Mountain	4. Old Lytle Cove Rd and US 70 Hwy intersection 5. Interstate 40 exit at Patton Cove Rd 6. Eastwood Ave and Old US 70 intersection 7. Camp Rd and Woodland Dr intersection
Southeast into Fairview	8. High Carolina Pkwy and Wildflower Cove intersection

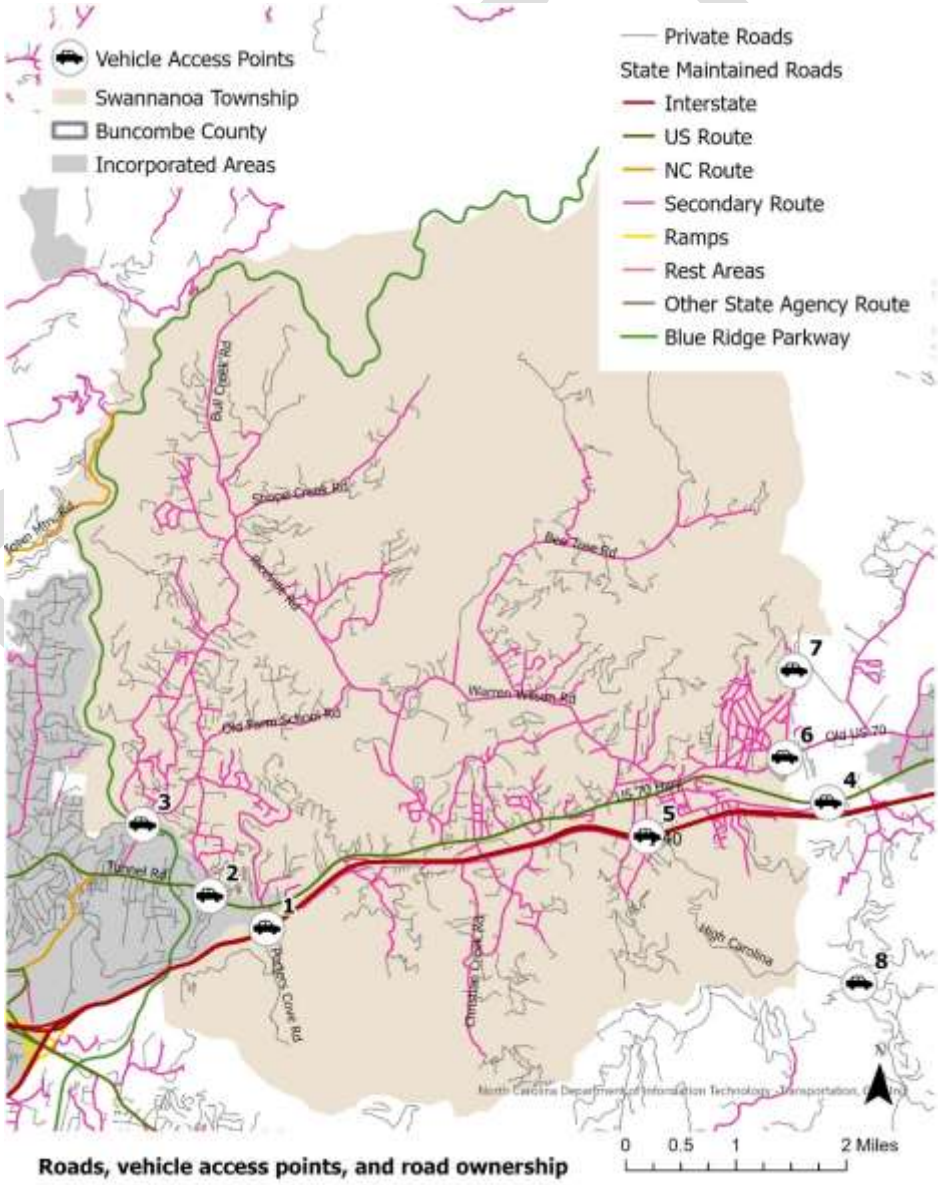


Figure X: Vehicular Facilities and Access Points to the Swannanoa Township

A road connectivity assessment identified major and minor roads that are potentially inaccessible (isolated) due to hazards in terms of “lane miles” (e.g. a road with 2 lanes, one for each direction of traffic, with a length of 1 mile is 2 lane miles). Accessibility is determined by being accessible from any fire station, used as a general measure of connectivity. Additionally, potentially inaccessible properties were identified (regardless of the type of property).

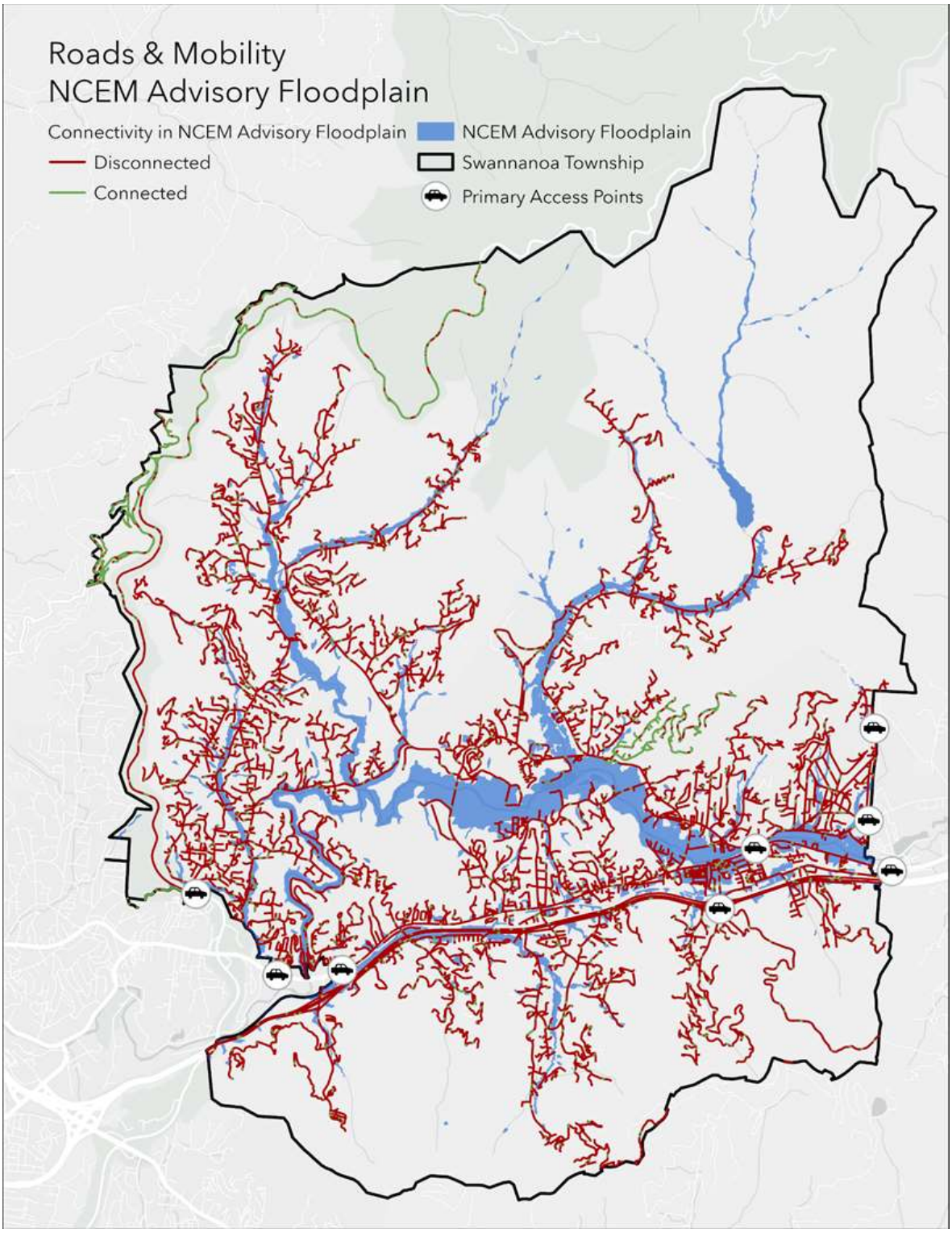


- The primary vehicle access points in Swannanoa are significantly affected by flooding hazards. The vast majority of roads within a half mile of a primary access point are potentially inaccessible due to flooding, and as a result, create significant pockets of isolation for road segments further into the township.

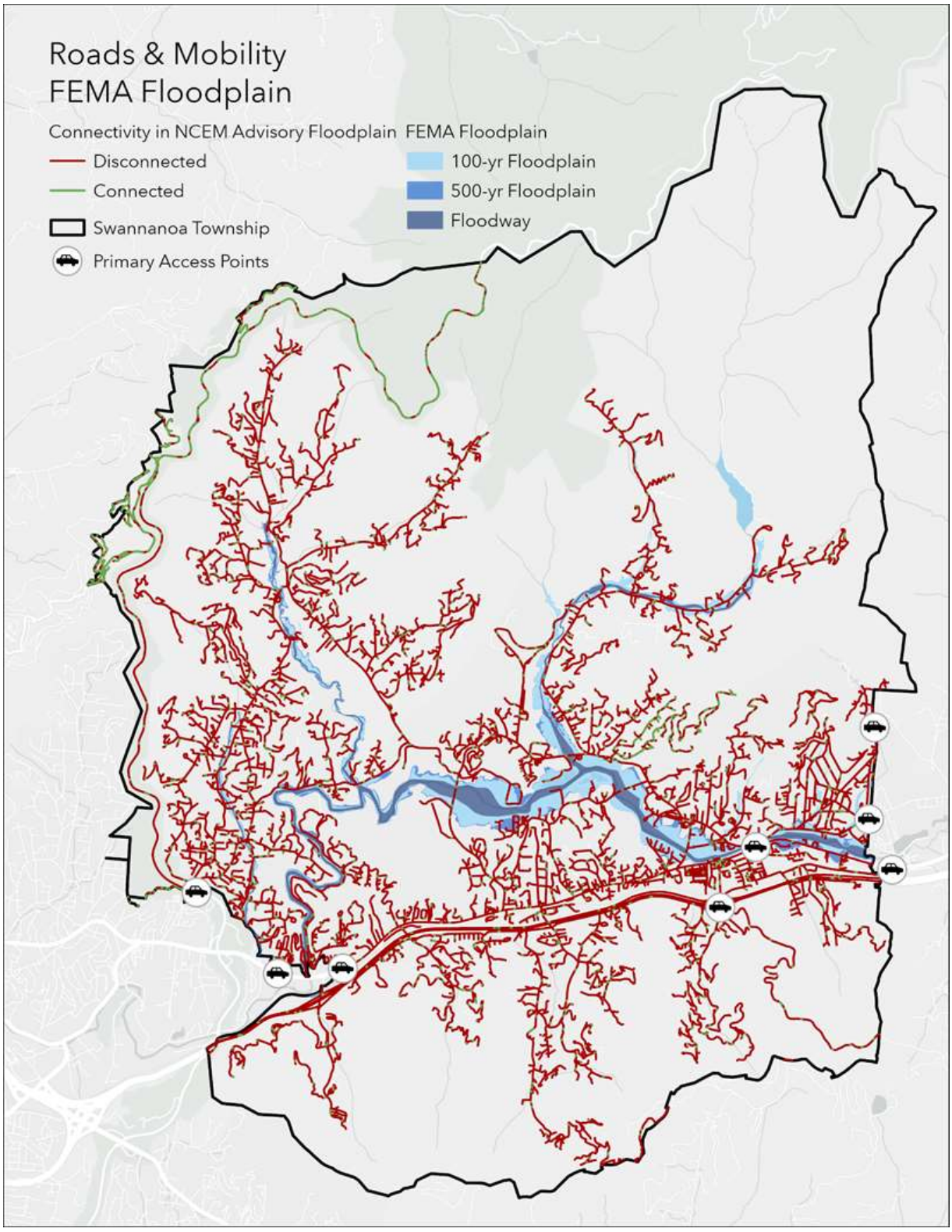
- While direct road exposure to flooding may be somewhat lower (13% in the NCEM 1,000-yr Advisory Floodplain), the potential for inaccessibility due to the nature of the road networks location and access points is extremely high (94% of roads potentially inaccessible in the NCEM Advisory Floodplain). Similarly, FEMA 500-yr floodplain exposure is only 5% for Swannanoa roads, but approximately 43% of roads are potentially isolated based on inundation at early access points. This finding speaks to the potential for significant portions of the road network being inaccessible to emergency responders, evacuees, or other critical response needs in a hazard event.

- While it is unlikely that every road potentially exposed to landslides would be affected at the same time, the number of road segments at risk of being isolated due to landslides is significant. While only 18% of roads are exposed, 58% will be potentially inaccessible due to landslides along the road network. Even minor landslide events can cause lane closures, weight restrictions, or detours, increasing travel time for citizens and emergency response operations and reducing the network’s connectivity overall.

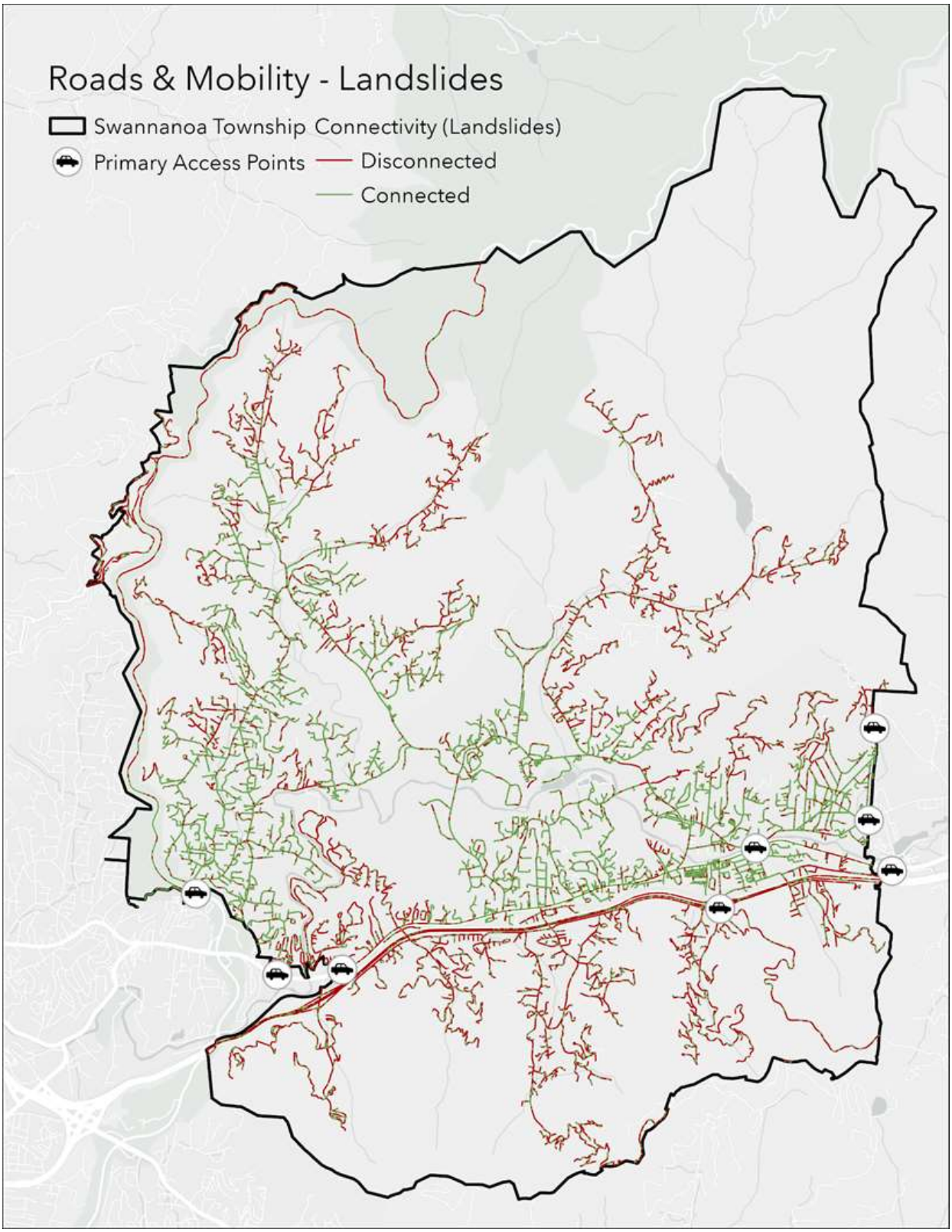
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Map of all potentially disconnected roads in Swannanoa in a flood scenario (NCEM 1,000-yr, or 0.1% annual chance Advisory Floodplain). Approximately 13% of roads in the Swannanoa Township are exposed to the NCEM Advisory Floodplain, but 94% are considered potentially inaccessible in a flood event due to the location of flood inundation and the access points that connect road segments to each other. In addition to the road segments themselves, 93% of parcels in the township are potentially isolated due to road inundation.



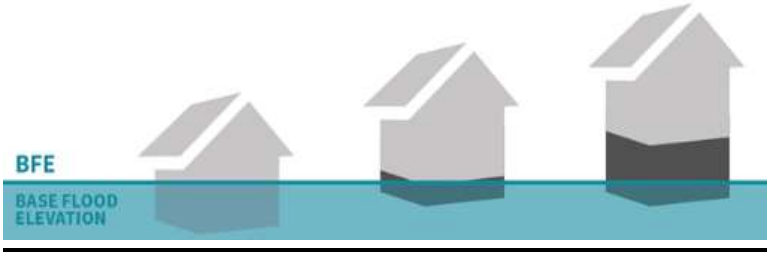
Map representing all roads in the Swannanoa Township, indicating which roads may be inaccessible in the event of a flood. While only about 5% of roads are exposed to the FEMA 500-yr floodplain, 43% of roads are considered potentially inaccessible in a flood event due to the location of flood inundation and the access points that connect road segments to each other. Additionally, about 43% of Swannanoa parcels are considered potentially isolated (inaccessible based on flood exposure) in FEMA inundation.



Map showing road accessibility based on landslide vulnerability. 18% of roads in the township are exposed to potential debris flow pathways, but over 58% are potentially inaccessible based on all potential debris flows pathways. Additionally, 43% of parcels in Swannanoa are at risk of being inaccessible as a result of landslides.

5: ADAPTIVE CAPACITY

Adaptive capacity refers to the ability of an asset, population, or system to adjust to hazards, cope with impacts, and continue functioning with minimal disruption or loss.



In this assessment, adaptive capacity is evaluated by characteristics that strengthen resilience, such as design standards and maintenance practices. For example, a newer building constructed to modern codes typically has greater adaptive capacity than an older structure because it is better equipped to withstand hazard impacts. Similarly, infrastructure improvements, such as enlarging culverts to manage heavier rainfall, can enhance adaptive capacity by reducing vulnerability to flooding.
For this assessment, adaptive capacity was evaluated in relation to the characteristics relevant to the region that influence how well assets can withstand or adjust to flooding, landslides, and wildfire. Key variables considered include:

Flooding: Whether assets were built to or above base flood elevation or have floodproofing measures, which reduces potential impacts from inundation.

Landslides: The presence of steep slope ordinances or similar measures that limit development in high-risk terrain and reduce exposure.

Wildfire: Access for emergency response, including the ability of fire services to reach and protect assets and homes.

The summary of adaptive capacity of assets in the table below highlights the overall conditions for each of the three hazard types based on land use type. **Low adaptive capacity** means that the assets in the area have less resilience to hazards. **High adaptive capacity** means that the assets have characteristics that make them more able to withstand hazard effects.

Table X: Summary of Adaptive Capacity of Assets in the Swannanoa Area

Hazard	Housing	Commercial	Critical Facilities & Government Owned	Natural Lands & Agriculture
Flooding	TBD	TBD	xx	xxx
Landslides	TBD	TBD	xx	x
Wildfire	TBD	TBD	TBD	xx

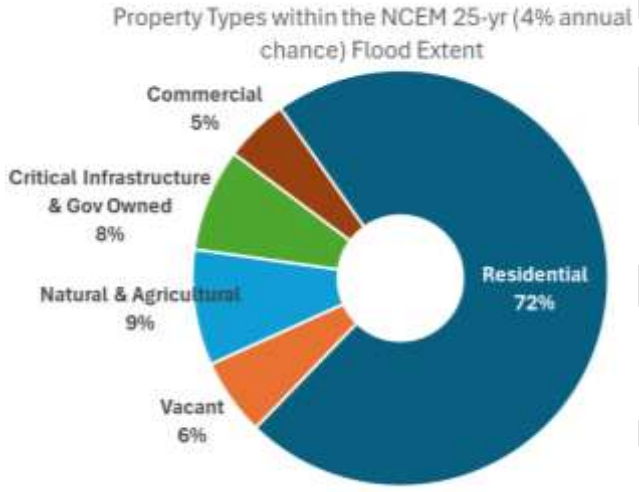
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Flooding

Properties constructed pre-FIRM—constructed before Flood Insurance Rate Maps (FIRM) were used to regulate floodplain development—and properties outside the regulatory floodplain are assumed to have lower adaptive capacity to flooding because they are not required to be built with flood-proofing measures. Floodplain development ordinance requirements generally only apply to the FEMA Special Flood Hazard Area (SFHA), which includes the floodway and the 100-yr FEMA mapped floodplain extent. The SFHA is often synonymous with the regulatory floodplain, however some communities define the regulatory floodplain as a larger extent than the SFHA, e.g. include the 500-yr floodplain boundary in development restrictions.

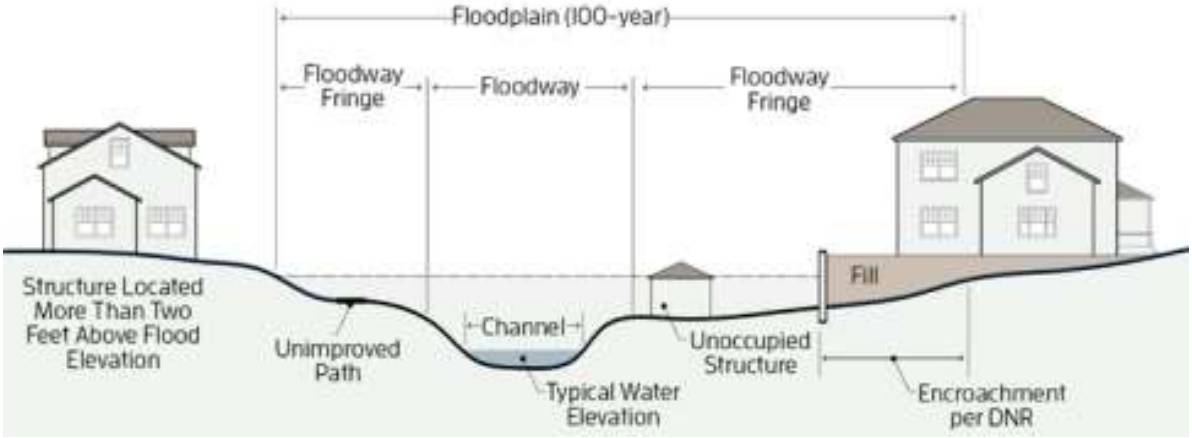
Supplemental data from the NCEM Flood Advisory product provides additional flood risk information that helps in understanding the potential for flooding beyond the regulatory flood zone. In Swannanoa, 699 properties are in the FEMA 100-year floodplain, and 1,777 are in the NCEM 1,000 year floodplain. Additionally, of the 699 properties in the FEMA 100-yr floodplain, NCEM identifies 80% of those (560 properties) as being in the 25-year (4% annual chance) flood extent. The chart below shows a breakdown of the types of properties that are within the 25-yr (4% annual chance) flood extent.

1,512 structures are within a flood hazard area (25 to 1,000 year).



This information is useful in understanding flood risk of a given area. It helps to inform what levels of flood frequency and severity should be planned for and identifies what types of adaptive measures will be most effective.

The extent of the 1,000-year (0.1% annual chance) and high number of properties in the higher 25-yr (4% annual chance) flood zone points to the need for coping with floods at a greater frequency than the regulatory 100-yr event.



Landslides

Structurally, most buildings have little or no ability to cope with severe landslides or direct debris flows. Properties within the steep slope ordinance are regulated to have limited slope modifications and vegetation removal, making them more adaptive than properties constructed before the ordinance was in place. However, properties may be outside of steep slope areas but may still be down-slope from potential initiation points and within debris flow pathways. In addition, cut and fill slopes for roads and driveways can also increase the risk of destabilizing a slope.

There are 3,130 structures within a High/Moderate Slope Stability area or Debris Flow Pathway.

Of all properties exposed to potential debris flow pathways in the study area, 80% have structures constructed outside the potential debris flow pathways. Of the 20% with structures in potential debris flow pathways, many were constructed before 2009 when the steep slope ordinance was not in effect.

Wildfire

For this assessment, wildfire adaptive capacity was evaluated by considering drive time from an asset to a fire station. Properties with less adaptive capacity include those in areas with longer drive times and more limited access to emergency response due to longer drive times from wildfire response locations. Since Helene, the presence of tree blowdowns adds a new challenge to wildfire managers due to the increase in fuel for wildfire but also in terms of access by wildfire managers.

More than half of properties (54%) in Swannanoa are within moderate or severe tree blowdown areas.

Based on the USFS HiForm remote sensing imagery post-Helene, many areas in Swannanoa were found to have moderate to severe tree blowdowns. About 17,250 acres have been identified to have either moderate or severe tree blowdowns or loss in the Swannanoa area (shown as orange and red in the map below). Some of these areas are along streambanks that may have lost trees due to streambank failures.

The analysis of the road network in Swannanoa also finds that more than half of the properties in the area (56%) are outside of an 8-minute drive time from the nearest fire station. Properties in these more remote areas may benefit from targeted fuel management to reduce the risk of wildfire spread.

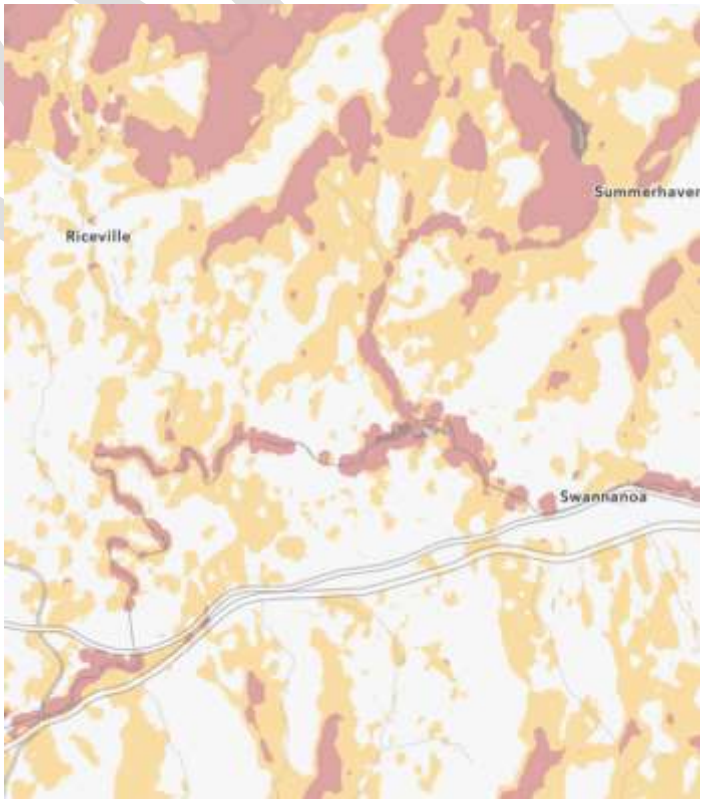
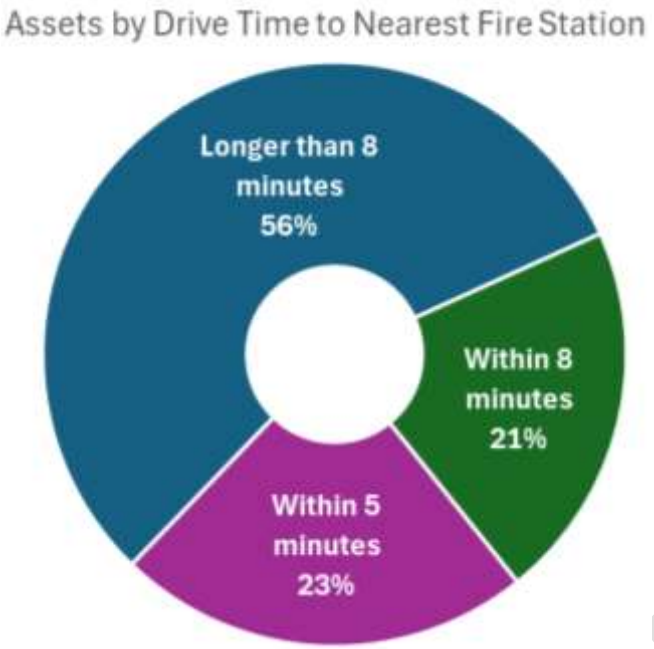


Figure X: Moderate and Severe Tree Blowdown (Red and Orange) from T.S. Helene, 2024

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A total of about 2,000 properties experienced recent tree blowdowns and are outside of an 8-minute wildfire response drive time. However, only about 9% of these (about 170 properties) are in areas with high baseline wildfire risk.

Additional response assets may still be appropriate to consider in order to increase the response capacity, especially during times of high wildfire risk.

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5. SAMPLE STRATEGIES

Note: Recommendations for policies and actions will be outlined in the Swannanoa Small Area and Resilience Plan based on public feedback and preferences.

This section provides an example of how the community's risk tolerance level could impact which policies and actions are recommended to address hazard risk and vulnerability. Risk tolerance is being discussed based on a 'minor, moderate, or major changes' framework. Minor changes may be associated with less upfront costs or community development impacts, but less risk reduction and ongoing or increased vulnerability. Major changes are expected to increase community safety from hazards over time, potentially reducing overall costs to the community.

Finding a balance between community needs and benefits, private property rights, and affordability are important considerations. Decision makers should also take into consideration the increasing cost of recovery from natural disasters, and the possibility that local and state governments may need to pick up more of the tab in the future. Reducing risk and vulnerability before a disaster happens has been shown to be significantly less expensive compared to disaster response, recovery, and rebuilding efforts.

Table X: Examples of Policy & Action Options Based on Minor to Major Change Preferences

Hazard	Minor Changes	Moderate Changes	Major Changes
Flooding	Increase how high new structures must be built in the floodplain	Prohibit filling in the floodplain	Prohibit new development in the 1% annual chance (100 year) floodplain
Landslides	Require notice of landslide hazards on development plats	Require a geotechnical report for development in landslide areas	Prohibit new road construction in landslide hazard areas
Wildfires	Create a public awareness campaign about wildfire risk reduction options	Require new subdivisions with only 1 access to have an evacuation plan	Require structures to have some protections from fires

Characteristics of Strong Resilience Strategies

The North Carolina Resilient Communities Planning Guide outlines 6 characteristics of strong resilience strategies that should be part of the development of recommendations in the final Plan document:

1. Multiple strategies to address a single vulnerability
2. Strategies that have multiple benefits
3. Nature-based strategies
4. Strategies that reflect local strengths
5. Strategies that build on the vulnerability assessment
6. Strategies that do not make a problem worse elsewhere.

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